SUMMER-2014 EXAMINATION **Total Pages-10**

Subject Code : 17420

Model Answer : Geotechnical Engineering

Important instruction to examiners:

1) The answers should be examined by key words and not as word to word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by the candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given stepwise for numerical problems. In some cases the assumed constant values may be vary and there may be some difference in the candidates answer and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q .NO	SOLUTION	MARKS
1 a)	**Attempt any six of the following**	**12 M**
i)	Define geology **Geology** : is the science that deals with the study of the earth as a planet. Thus, it includes essence of scientific studies dealing with the origin, age and structure of the earth.	2 M
ii)	**State classification of rocks based on their genesis** : i) Igneous rock ii) Sedimentary rock iii) Metamorphic rock	2 M
iii)	**Define Faults** : The fractures along which there has been relative movements of the blocks past each other are termed as faults.	2 M
iv)	**State any two points stating importance of structural geology.** i) Geology provides a systematic knowledge of construction materials, their structure and properties. ii) The knowledge of erosion, transportation and deposition of surface water helps in soil conservation, river control, coastal and harbor works. iii) The knowledge about the nature of the rocks is very necessary in tunneling , constructing roads and in determining the stability of cuts and slopes. iv) The foundation problems of dams, bridges and buildings are directly related with geology of the area where they are to be built.	2 M (any two)
v)	**Enlist two methods used to determine bulk density and dry density.** i) Core cutter method ii) Sand replacement method	1 M 1 M
vi)	**State IS code definition of soil** Soil is defined as the sediment or other unconsolidated accumulation of solid particles produced by physical and chemical disintegration of rock.	2 M
vii)	**State any four field applications of geotechnical engineering.** i) In foundation design ii) In pavement design iii) In earth retaining structures iv) In design of earthen dams i) In design of embankments ii) In design of under ground structures	Any four points (1/2 each) 2 M
viii)	**Define water content.** It is defined as the ratio of the weight of water to the weight of solids in a given soil mass W = (Ww/ Ws) * 100	2 M

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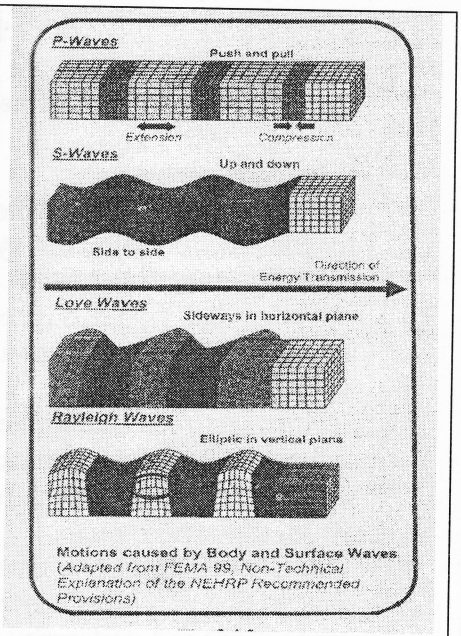
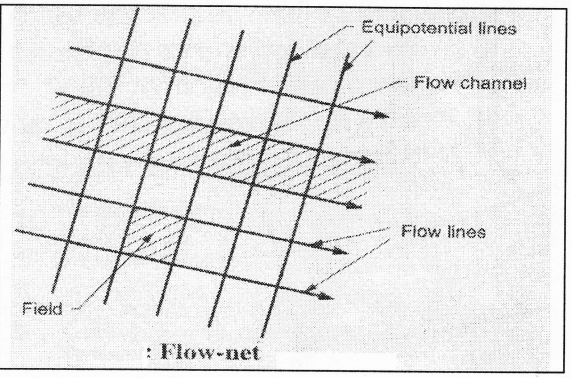
1 b	**Attempt any two of the following**	**08**
i)	Explain various types of rocks with respect to their engineering uses. Types of rocks **i) Igneous rock : ii) Sedimentary rock : iii) Metamorphic rocks :** **i) Igneous rock :** Many of igneous rocks , where available in abundance are extensively used as material for construction. Granites, syenites and dolerites are characterized by very high crushing strength and hence can be easily trusted in most of construction works. Basalts and other dark coloured igneous rocks, through equally strong not be used in residential building but find much use as foundation and road stones **ii) Sedimentary rock :** Sedimentary rocks are formed by accumulation , compaction and consolidation of sediments. Sedimentary rocks possesses good water and oil holding capacity due to which rocks can be used in reservoir or dam construction. **iii) Metamorphic rocks :** Slate is a extremely fine grained metamorphic rock is used locally (where available) for construction purpose. Quartzite are granular metamorphic rocks is generally very hard, strong dense and uniformity grained. It finds extensive use in building and road construction	1M 1 M 1M 1 M
ii)	State any four types of folds and explain any one i) Symmetrical folds ii) Asymmetrical folds iii) Overturned folds iv) Isoclinal folds v) Recumbent folds vi) Conjugate folds	1 (types) 3 (explain any one)
iii)	Explain salient features of earthen dam in Maharashtra (any two dams)	Any four points (1/2each) for each dam 4 M

Sr. No.	Features	Panset	Chaskaman
1	Length of dam	1039 m	1045 m
2	Volume content of Dam (10^3 m^3)	4190	2903
3	Gross Storage capacity (10^3 m^3)	303000	318.17
4	Reservoir area (10^3 m^3)	15645	18218
5	Effcetive storage capacity (10^3 m^3)	294000	210.99
6	Purpose	Irrigation and water supply	Irrigation and power generation
7	Designed spillway capacity (m^3/sec)	1162	3962

Q. 2	**Attempt any four of the following**	**16 Marks**
a)	**Classify soil in details :** **a) Coarse grained soils :** i) Gravel ii) Sand - Well graded clean (W) - Well graded with excellent clay binder (C) - Poorly graded , fairly clean (P) - Not covered in other groups **b) Fine grained soils :** i) Inorganic silt an very fine sands (M) ii) Inorganic clay (C) iii) Organic silt and clay (O) **c) Highly organic soils and other miscellaneous soil matter**	1 ½ M 1 ½ M 1 M
b)	**Explain two causes and two effects of earthquake** **Causes of earthquake:** i) Movement of tectonic plates ii) Volcanic eruptions iii) Anthropogenic sources iv) Dams v) Use of explosives vi) Injection and Extraction of fluids **Effects of earthquake :** i) Shaking and ground rupture ii) Landslides and avalances iii) Fires iv) soil liquefaction v) Tsunamis vi) Human impact vii) River water	2 (Explain any two) 2 (Explain any two)

c)	**Classify seismic waves in Indian earthquake** **P - Waves :** These are the primary waves by which material particle undergo extensional and compressional strains along the direction of the energy transmission due to which the particles vibrates in the longitudinal direction **S - Waves :** These are the secondary waves by which material particles oscillate at right angle to the direction of the energy transmission due to which the shearing of particles occurs in the transmission direction. **L - Waves :** These are the surface waves, called as Love waves, by which the displacement of material particles is practically horizontal due to which shearing rupture takes place. **Rayleigh Waves :** These are the surface waves by which the material particles oscillates in an elliptic path in the vertical plane. These are travels faster than L –Waves.  Motions caused by Body and Surface Waves (Adapted from FEMA 99, Non-Technical Explanation of the NEHRP Recommended Provisions)	1 M 1 M 1 M 1 M
d)	**Explain what do you mean by earthquake resistance structures** Earthquake damages the structures like dam, buildings, kills people. The conventional buildings instantly collapse without any warning , during the unpredictable and sudden earthquake. For the safe earthquake resistance design, follow design principles and zoning as per the provision made in various codes published by Bureau of Indian Standards. The Indian seismic codes are IS : 1893, IS:4326 , IS : 13827 , IS : 13828, IS : 13920 and IS : 13935. Some of the following points are to be followed to construct the safe earthquake resistance structures. i) The foundation should be provided over the hard rock with no sign of faults. ii) The building should be symmetrical and rectangular in plan.. iii) Minimum 16 mm diameter reinforcing bar should be used in all structural member of RCC building. iv) Ductile material should be provided to construct the structures	2 M 2 M
e)	**Define Focus and epicenter** **Focus :** The focus of an earthquake, also called its "hypocenter", is the point below ground level where the earthquake originates and generates shock waves which generates in all direction, e.g. where the snag on the fault shears. **Epicenter:** The epicenter is the point at the ground level, immediately above the focus.	2 M 2 M
f)	**Define – Atterberg's limit of consistency** **Atterbergs limits** : The water content at which the soil changes from one state to another are known as Consistency limits or Atterbergs limits. **Liquid Limit :** The water content at which the soil changes from the liquid state to plastic state is known as liquid limit (LL, w_L). In other wards the liquid limit is the water content at which the soil ceases to be liquid. **Plastic Limit :** The water content at which the soil becomes semisolid is known as the plastic limit. (PL,w_p).The plastic limit is the water content at which the soil just fails to behave plastically. Soil begins to crumble when rolled into a thread of 3 mm diameter. The numerical difference between the liquid limit and the plastic limit is known as plasticity index. (PI, Ip), PI = LL – PL. **Shrinkage limit:** The water content at which the soil changes from a semisolid state to	1M 1M 1M

	the solid state is known as the shrinkage limit (SL, w_S). Shrinkage limit is the smallest water content at which a reduction in water content will not cause a decrease in the volume of the soil mass. At this water content the shrinkage ceases.	1M
Q.3	**Attempt any four of the following**	**16 M**
a)	**A 5 kg. soil sample is given to you, explain how will you carryout mechanical sieve analysis as per IS code method.** Procedure of Mechanical Sieve analysis for fine grained soil **Materials and Equipment:** Balance accurate to 1 gm, set of sieves 4.75 mm, 2.36 mm, 1.18mm, 600 micron, 300 micron, 150 micron, 75micron, receiver, metal trays, mechanical sieve shaker etc. **Procedure:** -Take a representative sample of soil received from the field and dry it in the oven. Break the clods of the sample by means of hand. -Weigh the required amount of sample for testing say 5 kg. - The sample is sieved through the set of sieves arranged in descending order of their sieves. - The portion retained on 4.75 mm sieve is gravel fraction. - The portion passed through 4.75 mm and retained on 75 micron sieve is sand fraction. These fractions are expressed by weight of original sample to give gravel content and sand content in percentage. -The weight of the soil portion retained on each sieve and pan is obtained to the nearest 0.1 gm. - The weight of the retained soil is checked against the original weight. **Note:** If the soil contains appreciable fine (75%) aggregates and hard to break in to elementary particles soak the sample for 24 hours and wash through 75 microns sieve. The residue on the sieve is weighed.	**1 M** **3 M**
b)	**Explain Darcy's law of permeability** It states that for laminar flow, the rate of flow or discharge per unit time is directly proportional to the hydraulic gradient. Mathematically , **q = Kia** where, q = discharge per unit time. K = Darcy's coefficient of permeability , i = Hydraulic gradient a = Total cross section of soil mass perpendicular to the direction of flow.	**2 M** **2 M**
c)	**Explain various factors affecting permeability** i) Grain size ii) Properties of pore fluid iii) Temperature iv) Void ratio v) Stratification of soil vi) Entrapped air and organic impurities vii) Adsorbed water viii) Degree of saturation ix) Shape of particles x)Structures of soil mass	**4** **(explain any 4, 1 mark each)**
d)	**Define phreatic line and flow line. Draw neat sketch of flow net.** **Phreatic Line** : When the earthen structures are constructed to retain water, the topmost flow line through the soil mass is called as phreatic line. **Flow net :** The grid mesh or net formed by the intersection of equipotential lines and flow lines is called as flow net.  : Flow-net	**1 M (Def.)** **1 M (Def.)** **2 Fig**
e)	**Show graphically and state shear strength equation for cohesive and cohesive less**	

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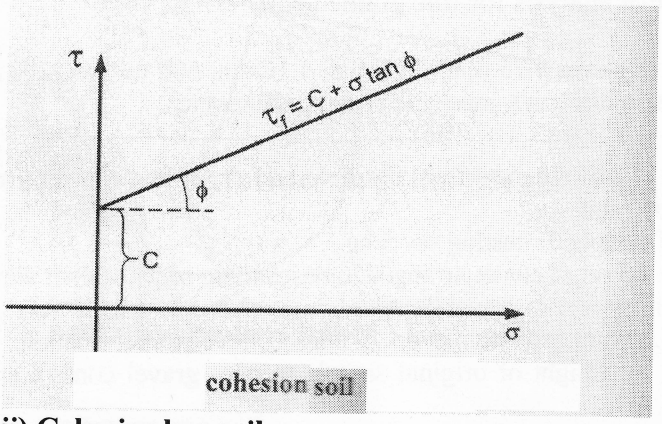
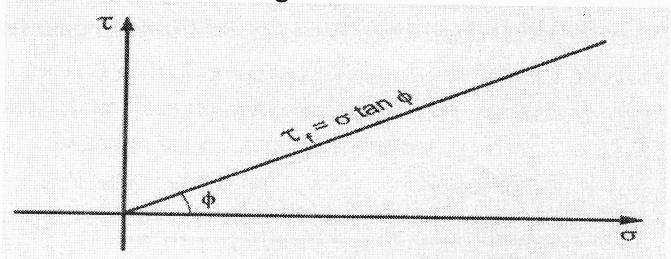
	soil. **i) Cohesive soil :** $\tau_f = C + \sigma \tan \phi$ where , τ_f = Shear strength σ = Nornal stress ϕ = Angle of shearing resistance C = Cohesion	**1M**
	 cohesion soil	**1M**
	ii) Cohesive less soil. $\tau_f = \sigma \tan \phi$ where , τ_f = Shear strength σ = Nornal stress ϕ = Angle of shearing resistance	**1M**
	 Cohesionless soil	**1M**
f)	**Define earth pressure. Enlist and define its types.** **Earth pressure** : Retaining structure does resist the lateral pressure exerted by the soil mass. This lateral pressure is known as earth pressure. Types : **i) Lateral earth pressure :** Soil in contact with any vertical or inclined face of structure exert force on structure which is known as lateral earth pressure. **ii) Active earth pressure :** As pressure exerted on retaining wall resulting from slight movement of wall away from filling **iii) Passive earth pressure :** When movement of the retaining wall is such that the soil tends to compress horizontally .	**1M** **1M** **1 M** **1 M**

Q .	SOLUTION	MARKS

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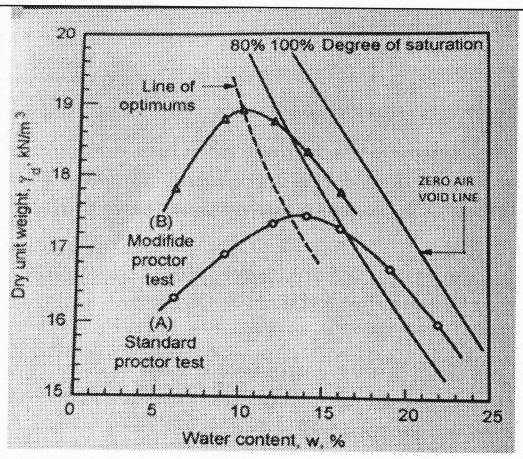
Q.	SOLUTION	MARKS
Q.4 . a) Sol =>	Effect of water table on bearing capacity of soil:- 1. The rise in water table from below the foundation results in decrease in bearing capacity in granular soil. 2. When the water table reaches the ground where the depth is greater of equal to width of footing the bearing capacity is reduced by 50% or more. 3. The bearing capacity is not affected for purely cohesive soil. 4. The bearing capacity for non-granular soil decreases with presence of water table. 5. Presence of water table for shallow depth give poor bearing capacity as compared for larger depth foundation.	Any Four 1M each
Q.4 . b) Sol =>	**Assumptions in Terzaghis analysis** 1. The soil is homogeneous and isotropic and its shear strength is represents by Coulomb's equation. 2. The strip footing has rough base and the problem in essentially two dimensional. 3. The shear strength of soil above the base of footing is neglected. The soil above the base is replaced by a uniformity surcharge γD_f 4. The load on the footing is vertical and is uniformly distributed. 5. The footing is long i.e. L/B ratio is infinite, where B is the width and L is the length of footing. 6. The elastic zone has straight boundaries inclined at $\psi = \varphi$ to the horizontal, and the plastic zones fully developed.	Any Four 1M each
Q.4 . c) Sol =>	**Sr.No. / Compaction / Consolidation** 1 — Instant compression of soil under dynamic load is called as compaction — Gradual compression under steady load is called as consolidation. 2 — The settlement of structure of prevented due to compaction. — The settlement of structure takes place due to consolidation. 3 — Compaction is carried out for improving properties of soil. — Consolidation occurs naturally due to structural load and it does not improve properties of soil. 4 — Compaction is an artificial process. — Consolidation is a natural process. 5 — Compaction is done before constructing any structure. — Consolidation takes place after constructing the structure.	Any Four 1Mark each
Q.4 . d) Sol =	Compaction Curve : - 1. If the soil is 100% saturated then the dry density of soil is calculated for 100% saturation and resulting line on compaction curve is called as Zero air void line. 2. The zero air void line indicates that the actual dry density cannot reach theoretical value even after heavy compaction. 3. Depending upon the compactive efforts on soil the graph can be plotted for light compaction and for heavy compaction	Any Two 1Mark each Dig 2Marks



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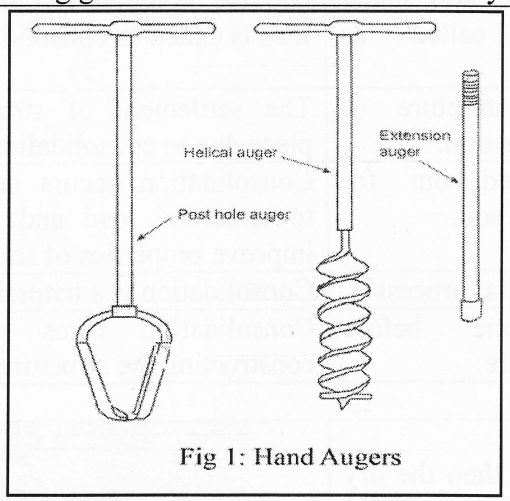
Q.4 . e) Sol =>	Types of Compaction Equipment: - **i) Compaction by Rolling: -** **a) Smooth wheel rollers :** **Suitability:** These rollers best suitable for 5ubgrade or base coarse compaction of cohesion less soils. , **b) Pneumatic tyred rollers:** **Suitability:** Pneumatic tyred rollers are effective for compacting cohesive as well as cohesion less soils. Light rollers are effective for compacting soil layers of small thickness **c) Sheep foot roller :** **Suitability :** Suitable only for fine grained soil **ii) Compaction by Rammers:** Rammers or tampers are mainly two types, hand operated and mechanical rammer. A hand operated rammer consists of a block of iron or stone about 3 to 5 kg in mass, attached to a wooden rod. The tamper is lifted for about 0.3 m and dropped on the soil to be compacted. A mechanical rammer is operated by compressed air or gasoline power. It is much heavier, about 30 to 50 kg. Ramming equipment's consists of three types: dropping weight type, internal combustion type and pneumatic type. Rammers or tampers are used to compact the soil. **Suitability:** Suitable for all types of soil **iii) Compaction by vibratory compactors :** 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. **Suitability:** Suitable for compacting granular soils. with no fines in layer up to 1 m thickness	Any 2 2Mark each
Q.4 . f) Sol =>	Hand Operated Augers: -  Fig 1: Hand Augers	2 mark Each
Q.5 . a) Sol =>	Given : - V= 100cc , G= 2.68, W= 190gm, W_s= 160gm. e = ? , W = ? S= ? $W = \frac{W_w}{W_s} = \frac{30}{160} = 18.75\ \%$ $\gamma = \frac{W}{V} = \frac{190}{100} = 1.90$ gm/cc $\gamma_d = \frac{W_s}{V} = \frac{160}{100} = 1.6$ gm/cc $\gamma_d = \frac{G\gamma_w}{(1+e)}$, $e = \frac{G\gamma_w}{\gamma_d}$-1 $e = \frac{2.68 \times 1}{1.6} - 1 = 0.675$ $S = \frac{W \times G}{e} = \frac{0.1875 \times 2.68}{0.675} = 0.744\ \%$	2 M 1 M 1 M 2 M 2M

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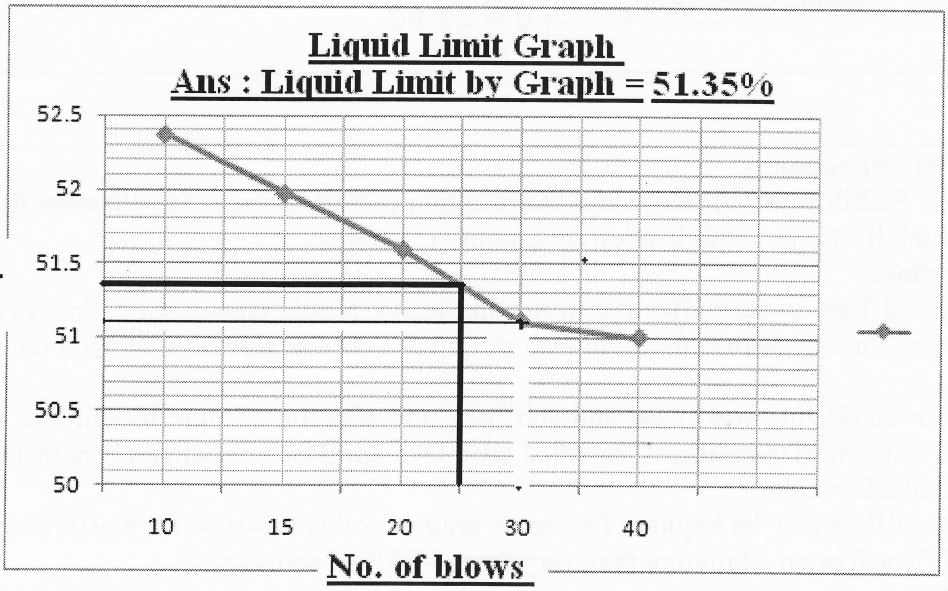
Q.5 . b) Sol =>

Observation Table :

Sr. No	Determination Number	1	2	3	4	5	
1	Number of blows	40	30	20	15	10	4 M
2	Container No.	1	2	3	4	5	
3	Mass of container (g) W3	5	5	5	5	5	
4	Mass of container + Wet soil (g) W1	30.67	32.2	31.3	32.75	30.05	
5	Mass of container + Dry soil (g) W2	22	23	22.35	23.26	21.44	
6	Mass of water (g) W1 -W2	8.67	9.2	8.95	9.49	8.61	
7	Mass of oven dry soil (g) W2 - W3	17	18	17.35	18.26	16.44	
8	$\frac{W1 - W2}{W2 - W3}$ x 100	51.00	51.11	51.59	51.97	52.37	



4M

Q.5 . c) Sol =>

Well Graded Soil: -

1. If a soil contains grains of all sizes in significant amount then it is called as well graded.
2. A well graded soil is structurally superior as it can be compacted to very density.
3. As it contains all sizes of particles, the voids between bigger particles are filled with smaller particles and vice versa.

1M for each

Coefficient of Uniformity: -

1. It is defined as the ratio of D_{60} to D_{10} size of given soil.
2. The coefficient of uniformity is nearly unity.
3. $C_u = \frac{D_{60}}{D_{10}}$

1M each

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Where
D_{10} = 10% of particles are finer than that size.
D_{60} = means that soil for which the total smaller particles in given soil are 60%

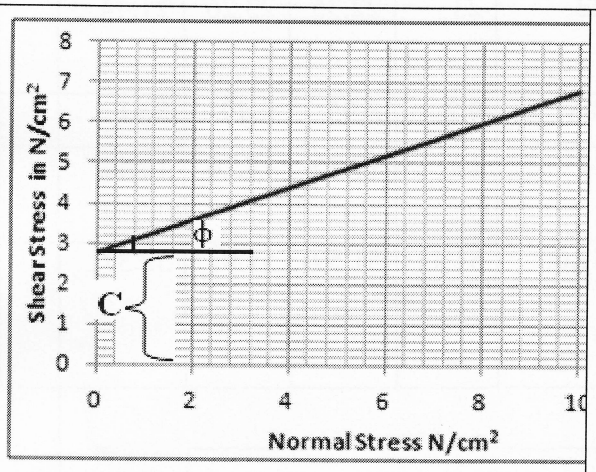
Coefficient of Curvature: - — 2 M

1. It represents shape of particle size distribution curve.
2. C_c = 1 to 3 for well graded soil.
   C_c > 4 for well graded gravel.
   C_c > for well graded sand.

$$C_c = \frac{D_{30}^2}{D_{10} \; X \; D_{60}}$$

Q.6 .a)

Sol =>



i)Angle of Shearing Resistance: - Ø = 22° from graph

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6.8 - 3.6}{10 - 2}$

$Ø = tan^{-1}(m)$

$Ø = tan^{-1}(0.4)$

Ø = 21.80

ii)Cohesion : -

S=C+σ tanØ

3.6= C+2 x 0.4

Cohesion C= 2.8N/mm²

From Graph :

Ø = 21.80

C = 2.8

4 M for graph

4M for analytical calculation

Q.6 . b)

Sol =>

Methods of Soil Stabilization: -

a) Mechanical Stabilization b) Soil Lime Stabilization c) Soil Cement Stabilization d) Soil Bitumen Stabilization e) Stabilization by heating f) Stabilization by grouting

2 Mark for any four types

a) Lime Stabilization:-

1. Hydrated or slaked lime is very effective in treating heavy plastic clayey soil. Lime may be used alone or in combination with cement, fly-ash etc. sandy soil can also be stabilized with this combination.
2. Lime is used for stabilizing road base and sub base. On addition of lime to soil two main reactions occurs a) alteration in nature of absorbed layer through Base Exchange phenomenon b) cementing or puzzolanic action.
3. Generally 2-8% of lime may be required for coarse grained soil and 5-10% for plastic soil.
4. The amount of fly ash as an admixture may vary from 8-20% of soil sample.

2 Mark for any two points

b) Fly Ash Stabilization : -

1.Fly ash forms filler or pozzolana material when used in soil stabilization.
2.When it is used in soil stabilization it hydrates.
3.It is cheap and eco-friendly material.
4.Fly ash is rarely used in soil stabilization as it is used as an admixture to enhance stabilization.

2Marks for any two points

C) Cement Stabilization: -

1.The soil stabilization with cement is called as soil cement stabilization.
2.When Cement stabilization is used there is large increase in strength.
3.Cement stabilization is used for loose soil and non-cohesive soil.
4.Cement stabilization is not useful for clay, organic soil and expansive soil.

2 Marks for any

10/10

	Note:- For Explaining any other method use same marking scheme	two points
Q.6 . C) Sol =>	**Assumptions of Rankines Theory: -** 1. The soil is semi infinite, homogenous, dry and cohesion less. 2. The soil element is in the state of plastic equilibrium. 3. The ground surface is plane which may be horizontal. 4. The back of is vertical and smooth. 5. The wall yield about the base thus satisfies deformation condition for plastic equilibrium. **Rankines theory for cohesion less backfill: -** a) Dry Backfill b) Submerged Backfill c) Surcharge for horizontal Plane surface.	Any four 4M
	b) Submerged backfill : - 1. In submerged backfill the land behind the wall is saturated with water and lateral pressure is having pressure due to submerged unit weight and water. 2. If water is present on both side of wall then the pressure is not to be considered.	2M for two points each
	c) Surcharge for horizontal plane pressure: - 1. The back fill is horizontal and carries a surcharge of uniform intensity as per unit area. 2. The pressure at the base of retaining wall consists of pressure made of unit weight of backfill and pressure due to uniform surcharge.	2M for two points
	Note:- For Explaining any other method use same marking scheme	