

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Kartik

Exam.	BE	Full Marks	80
Level	BCE	Pass Marks	32
Programme	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Discuss soil formation and its effects on soil behavior. [2]
2. a) Define the term void ratio, unit weight, degree of saturation and water content. Establish the relationship between them. [2+2]
 - b) The liquid limit and plastic limit of soil is 50% and 25% respectively. When soil is dried from its state at liquid limit, the decrease in volume was 40% of the volume at liquid limit. When it was dried from its state at plastic limit, volume decrease was 20% of volume at plastic limit. Determine shrinkage limit. [4]
3. a) Draw and describe the plasticity charts used in USCS and ISSC. [3]
 - b) Based on USCS, the soil is classified as SW-SC. Explain the conditions for this classification. [5]
4. What are the various minerals in the clay soil? Draw the structure of Montmorillonite layer and explain why does the soil containing a large amount of mineral montmorillonite exhibits high swelling characteristics. [4]
5. a) Draw the representative compaction curves for Standard and Modified Proctor tests and point out key features. [2]
 - b) Two embankments; embankment I (Volume = 2000 m³, $\gamma_d = 17 \text{ kN/m}^3$ and $w = 12\%$) and embankment II (Volume = 4,000 m³, $\gamma_d = 16 \text{ kN/m}^3$ and $w = 14\%$), were constructed by compacting the soil brought from the borrowing pit having water content of 10 % and bulk unit weight of 15.5 kN/m³. Find the amount of soil (both volume and weight) necessary to be excavated for the construction of embankments. Also, comment on the amount of water to be adjusted for construction of embankments. [4]
6. a) What is quick sand condition? Derive the expression for critical hydraulic gradient for quicksand condition? [1+2]
 - b) The subsoil strata at a site consist of fine sand 1.8 m thick overlying a stratum of clay 1.6 m thick. Under the clay stratum lies a deposit of coarse sand extending to a considerable depth. The water table is 1.5 m below the ground surface. Assuming the top fine sand to be saturated by capillary water, calculate the effective stress at the different depths up to 5 m below the ground surface and draw total stress, neutral stress and pore pressure diagrams. Assume for fine sand $G_s = 2.65$, $e = 0.8$ and coarse sand $G_s = 2.66$, $e = 0.5$. The unit weight of clay may be assumed as 19.32 kN/m³. What is change in effective stress at 5m depth if there is no capillary rise in fine sand? Take bulk unit weight for the case to be 16.88 kN/m³. [7]
7. a) Derive Laplace equation for two-dimensional flow through soil. [4]
 - b) A soil stratum with permeability $k = 4.5 \times 10^{-7} \text{ cm/s}$ overlies an impermeable stratum. Water stands to a height of 10 m on upstream side of sheet pile wall and 1.5 m on downstream side. The number of flow channel is 5 and number of potential drops is 9. Find the quantity of seepage. For average length of exit field adjacent to sheet pile, $l_e = 2.8$; find the exit gradient. [4]

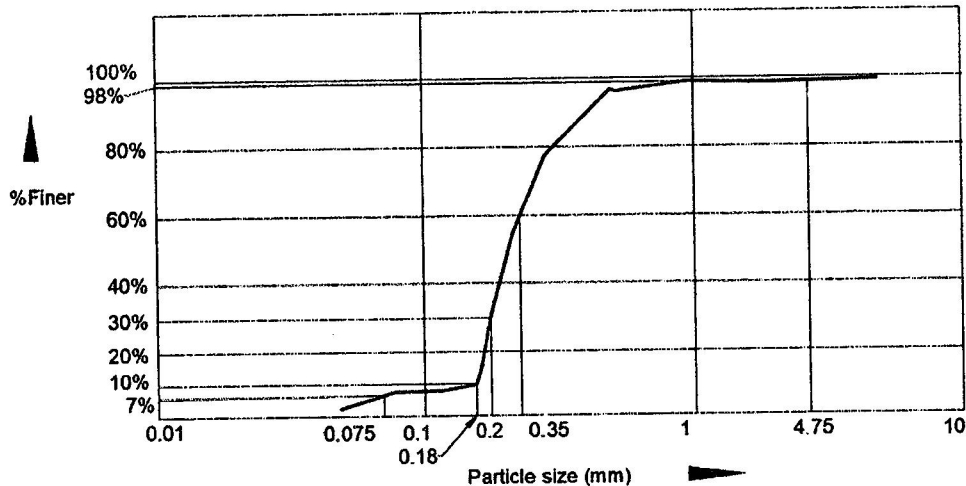
8. a) Write down the limitation of Bousinesq's Theory. [2]
- b) Three parallel fence footings are 5 m apart center to center transmit loading intensity of 600 kN/m, 450 kN/m and 300 kN/m respectively. Calculate the vertical stress increment due to the combined loads beneath the centers of each footing at a depth of 3 m below the base. Assume the footings are placed at a depth of 2 m below the ground surface. Provided that loading intensity from Fence footing can be assumed as line loads. [6]
9. a) Explain with phase diagram the immediate compression, primary consolidation and secondary consolidation at ideal condition. [3]
- b) Determine the pre-consolidation pressure using graphical method. [3]
- c) Clay layer 6m thick is in between rock layer and sand layer in site. The loading applied increases the average effective vertical stress from 200 kN/m^2 to 300 kN/m^2 . Given $m_v = 0.00025 \text{ m}^2/\text{kN}$; $C_v = 0.75 \text{ m}^2/\text{year}$; Determine the total settlement and settlement at the end of 1 year. [2+2]
10. a) List out the merits of tri-axial tests. Draw stress paths for tri-axial test. [2+2]
- b) When an unconfined compression test is conducted on a cylindrical specimen of soil, it fails under axial stress of 1.4 kg/cm^2 . The failure plane makes an angle of 54° with horizontal. Draw the Mohr circle and determine the cohesion and angle of shearing resistance of the soil sample. [6]
11. a) How are the infinite and finite slopes differentiated? Also write down the associated failures. [2+1]
- b) An infinite slope ($c = 10 \text{ kPa}$, $\phi = 26^\circ$) is inclined at 25° . Calculate critical height for the soil layer in dry and steady state seepage conditions. [2+1]

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1. Explain geotechnical problems in civil engineering and infrastructure development. [2]
2. a) How does engineering properties of soil differ from Index properties? Mention different tests done for coarse and fine grained soils for index properties. [1+2]
- b) Explain the detailed procedure for determination of specific gravity using Pycnometer. [2]
- c) A sample of soil with liquid limit of 60% was found to have a Liquidity Index of 1.3 and water content of 75%. What are its plastic limit and plasticity index? [2+1]
3. a) What are the basic requirements of soil classification? [2]
- b) Classify the following soil as per USCS. The grain size distribution is shown below. Liquid Limit and Plastic Limit of fines are 60% and 20%, respectively. [6]

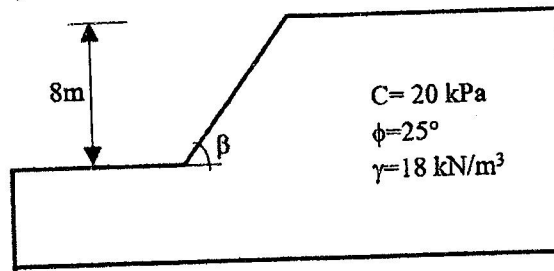


4. Compare the structures of Kaolinite, Illite and Montmorillonite based on clay minerals. [4]
5. a) Explain factors affecting soil compaction in field. [2]
- b) A compaction of an embankment of small area is carried out in 300 mm thickness layers. The rammer used for compaction has foot area of 0.05 square meters. The rammer has weight of 20 kg and dropped through a height of 2 m. Neglecting the overlapping of energy in subsequent drops, calculate the number of drops required to impart energy equivalent to standard compaction test for each layer. [4]
6. a) State Darcy's Law. Also, write down the relationship between discharge velocity and seepage velocity. [3]
- b) A sand deposit consists of two layers. The top layer is 3.5 m ($\gamma_t=18 \text{ kN/m}^3$) and bottom layer is 4.5 m thick ($\gamma_{\text{sat}}=20 \text{ kN/m}^3$). The ground water table is at a depth of 4.5 m below the ground surface and zone of capillary saturation is 1 m above the ground water table. Draw neat soil profile and stress diagrams showing the variation of total stress, pore water pressure and effective stress. [7]

7. Prove that flow lines and equipotential lines satisfy the condition of the Laplace equation of 2D flow. Discuss how flow net is constructed in case of unconfined flow in homogeneous earthen dams provided with horizontal filter? [3+5]
8. a) What is Isobar? Draw the vertical stress distribution on a horizontal plane for $Q = 200 \text{ kN}$ and $z = 4\text{m}$. [1+4]
 b) Explain in detail the procedure to find out vertical stress at the point outside the uniformly loaded rectangular area. [3]
9. a) Discuss the statement "Soil has memory of stresses" with suitable sketches. [3]
 b) In a laboratory tests, 5mm settlement was recorded in a soil specimen of 25 mm thickness when pressure was increased by 100 kPa. The initial water content and specific gravity of the specimen was 60% and 2.7, respectively. Calculate the final settlement of a building foundation on a 2 m thick clay layer with the identical loading conditions. [7]
10. a) Write down the names of shear strength tests. Which type of shear strength test is most suitable for purely cohesive soil and why? [2+2]
 b) The following results were obtained in a Consolidated Undrained tri-axial test of an undisturbed soil samples of over consolidated clay. Determine the shear strength parameters in terms of effective stress. [6]

Cell Pressure (kN/m^2)	100	200	400	600
Deviator stress at failure (kN/m^2)	300	400	600	800
Pore water pressure (kN/m^2)	-50	-20	60	100

11. Determine the appropriate slope for the factor of safety of 1.5. (Note: Taylor Stability Chart should be provided) [6]



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1. Explain Complexity nature of soil. [2]
2. a) Establish the relationships between the percentage air voids, soil moisture content, specific gravity of the soil particles and the dry density. [4]
 - b) What do you understand about the index and engineering properties of the soil and their importance? [2]
 - c) The liquids limit and plastics limit of a soil are 75% and 33% respectively. Upon oven drying, the void ratio of the soil was found to be 0.63. Calculate the shrinkage limit and plasticity index, if grain specific gravity is 2.7. [2]
3. List out the basic differences between USCS system and AASTHO system of soil classification. What are the applications of soil classification system? [4+4]
4. Explain the structure of montmorillonite mineral with neat sketch. Why does montmorillonite undergo large volume change in contact with water? [3+1]
5. The soil from borrows pit area having an average in-situ unit weight of 15.5 kN/m^3 and water content of 10% was used for the construction of finished volume of embankment of 6000 m^3 . In half of embankment, due to improper control during rolling, the dry unit weight achieved was slightly lower. If the dry unit weight in two parts were 16.5 kN/m^3 and 16 kN/m^3 , find the volume and weight of soil from borrow area used in each part. Take Specific Gravity of Solids to be 2.7. [6]
6. Why is the concept of effective stress more important than total stress during soil capacity analysis? [2]

A layer of sand which is 5 m deep is over a thick bed of clay. Draw total, effective stresses and pore water pressure on horizontal planes to a depth of 9 meters below the ground surface in the following cases:

 - a) If the water table is at the ground level.
 - b) If the water table is at 2 meters below ground level and the sand above remains saturated with capillary moisture.
For Sand: $\gamma_{\text{sat}} = 20.9 \text{ kN/m}^3$, $\gamma_{\text{dry}} = 17.4 \text{ kN/m}^3$
For Clay: $\gamma_{\text{sat}} = 17.8 \text{ kN/m}^3$
7. Define critical hydraulic gradient and Phreatic line. A homogeneous earth dam has a top width of 6 m and a height of 42 m with side slopes of 3 to 1 and 4 to 1 (H to V) on the upstream side and downstream side respectively. The free board is 2 m. There is a horizontal filter at the base on the downstream side extending for a length of 60 m from the toe. If the coefficient of permeability of the soil is $9 \times 10^{-2} \text{ mm/s}$, find the quantity of seepage per day for 100m length of the dam. [2+6]

8. Describe the procedure for the construction of Newmark's Influence Chart. How it is used to find the additional vertical stresses under irregular shaped uniformly loaded area? [8]
9. a) Define 'preconsolidation pressure'. In what ways is its determination important in soil engineering practice? [2]
- b) The void ratio of clay A decreased from 0.572 to 0.505 under a change in pressure from 120 to 180 kg/m^2 . The void ratio of clay B decreased from 0.612 to 0.597 under the same increment of pressure. The thickness of sample A was 1.5 times that of B. Nevertheless, the time required for 50% consolidation was three times longer for sample B than for sample A. What is the ratio of the coefficient of permeability of A to that of B? [8]
10. a) Explain the Mohr-Coulomb failure criteria to define shear strength of soil. [3]
- b) In direct shear test on a sand specimen, the normal stress was 200 kN/m^2 and the sample failed at shear stress of 120 kN/m^2 . Draw the Mohr circle and the strength envelop. Determine the angle of shearing resistance of soil, magnitude of major and minor principal stresses and the orientation of principal planes. [7]
11. a) What are the different causes of slope failures? Under what conditions a base failure and a toe failure are expected? Explain. [1+2]
- b) A cutting is to be made in a clay for which the cohesion is 35 kN/m^2 and $\phi = 0^\circ$. The density of the soil is 20 kN/m^3 . Find the maximum depth for a cutting of side slope 1.5 to 1 if the factor of safety is to be 1.5. Take the stability number for a 1.5 to 1 slope and $\phi = 0^\circ$ as 0.17. [3]

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1. Differentiate between residual and transported soils. In what way does this knowledge help in soil engineering practice? [1+1]
2. Define flow index and liquidity index. A proposed earth dam requires 7500m³ of compacted soil with relative density of 94%. Two borrow pits are available as described in the following table having maximum void ratio of 0.73, minimum void ratio of 0.4 and specific gravity (Gs)=2.67. Choose the best borrow pit with minimum cost. [2+6]

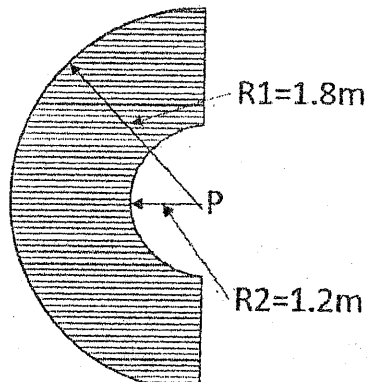
Borrow Pit	S (%)	w (%)	Cost (\$/m ³)
A	82	18.43	10
B	100	24.34	5

3. a) Compare the AASTHO classification system and Unified soil classification system [4]
- b) What are the field identification tests to distinguish between clay and silt? [2]
- c) The sieve analysis of a soil gave the following results: % passing 75 μ sieve = 4, % retained on 4.75 mm sieve = 35, Coefficient of curvature = 2, Coefficient of Uniformity = 7, LL=15% and PI = 3%. Classify the soil as per USC System. [2]
4. Why lime is used for treatment of sodium Montmorillonite? Describe different soil fabrics. [4]
5. A standard Proctor test was conducted on a silty clay soil collected from a proposed construction site. The results are shown in the following table. [6]

Trial Number	Mass of moist soil in the mold(g)	Moisture content (%)
1	1689	12.7
2	1752	15.0
3	1800	17.8
4	1845	20.6
5	1844	23.8

- a) Determine the maximum dry density (kg/m³) of compaction and the optimum moisture content. Given: Mold volume = 943.3 cm³.
- b) If specification calls for 99% relative compaction in the field, what would be the field dry density and the range of acceptable moisture content?
6. a) List down the factors that influence Darcy's Coefficient of Permeability. [2]
- b) The water table at a building site is at depth of 6m below ground surface. The soil strata have average Liquidity Index of 0.75 and Liquid Limit is 60% and Plastic Limit is 38%. Assume saturated soil condition and specific gravity of solids be 2.74, calculate effective stress at depth of 9m below ground level. Draw profile of total stress, effective stress and neutral stress up to 9m. [8]
7. Define stream function and equipotential function. Prove that streamlines and equipotential lines are orthogonal to each other in the flow net. [2+6]

8. a) Explain the concepts of pressure bulb and its applications in soil engineering practice. [2]
 b) What do you understand by contact pressure? A foundation as shown in the figure transmits a uniform pressure of 135 kN/m^2 . Calculate the vertical stress at a depth of 1.8 m directly beneath the point P. [2+4]



9. Following results were recorded from a one-dimensional consolidation test on a specimen of clay, each load being maintained constant for 24 hours before addition of next increment. [8+2]

Applied stress (kN/m^2)	0	50	100	200	400	800	0
Sample Thickness (mm)	19.7	19.3	19.15	18.85	18.56	18.36	18.9

The water content of the sample at the end of test was 28% and Specific gravity of solids is 2.72. Calculate void ratio at end of each stress range and plot e - $\log \sigma$ curve and determine the compression index and pre-consolidation pressure. Also, determine the consolidation settlement that may be expected in 4m thick clay layer for stress increase from 150 to 350 kN/m^2 . [Note: Semi-Log graph should be provided]

10. a) Define shear strength of soil. What are the three standard triaxial shear tests with respect to drainage conditions? Explain with reasons the situations for which each test is to be preferred. [1+1+2]
 b) What is the shearing strength of soil along a horizontal plane at a depth of sand having angle of internal friction 35° , dry unit weight 17 kN/m^3 , and specific gravity of soil solids 2.7? Assume a ground water table at a depth of 2.5 m from the ground surface. Also find the change in shear strength when the water rises to the ground surface. [6]
 11. a) What do you understand by instability of slopes? [2]
 b) An infinite slope is to be constructed of a clay soil at slope angle of 30° . The ground water level is at surface itself with seepage parallel to ground. The soil properties are $c' = 15 \text{ kN/m}^2$, $\phi' = 22^\circ$, $\gamma = 20 \text{ kN/m}^3$. What is the factor of safety against movement along a plane parallel to ground surface at depth of 4m. [4]

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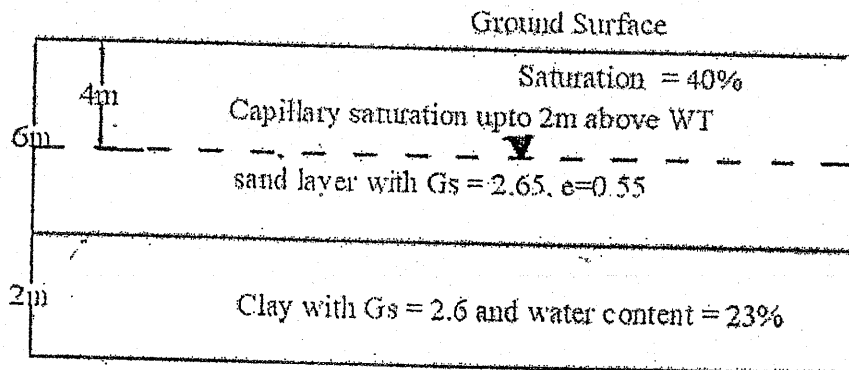
1. "Knowledge of soil mechanics helps in civil engineering practice". Explain this statement. [2]
2. a) Draw phase diagram of soil for compaction and consolidation process. What is the practical significance of consistency index and liquidity index? [1+2]
- b) From a core-cutter method, dry density of soil obtained is 15 kN/m^3 . Initially the mould was taken of 947 gm and 1000 cc volume. After hammering the mould into the ground, the mould with soil sample weighs 2700 gm. What would be the water content of the soil, if specific gravity of solids is 2.67? Calculate void ratio, degree of saturation and percentage air void. [5]
3. a) What are the basic difference between USCS and AASHTO soil classification system? [3]
- b) Following information of particle size distribution has been obtained from sieve analysis. [5]

Sieve Size (mm)	Percentage Finer
4.750	82
2.000	64
1.000	49
0.600	44
0.425	38
0.212	32
0.150	16
0.075	4

Plot the grain size distribution and classify soil using ISSCS.

4. Why Montmorillonite swells more than Kaolinite? Explain with structural diagram. What kind of soil structure can be seen on coarse grained soil? [3+1]
5. a) Define the terms, placement water content, relative compaction and theoretical maximum dry density. [3]
- b) An embankment for a highway is to be constructed from a soil compacted to a dry unit weight of 18 kN/m^3 . The clay has to be trucked to the site from a borrow pit. The bulk unit weight of the soil in the borrow pit is 17 kN/m^3 and its natural water content is 5%. Calculate the volume of clay from the borrow pit required for a 1 cubic meter of embankment. Assume $G_s = 2.7$. [3]

6. Define quick sand condition. For the subsoil conditions shown in figure below, draw total, effective and pore water pressure distribution diagram. [2+8]



Take Unit weight of water = 10 kN/m^3

7. List out the uses of flow net. Prove that velocity potential and stream function satisfy the Laplace's equation. [2+6]
8. Define pressure bulb. A circular ring foundation for an overhead tank transmits a contact pressure of 300 kN/m^2 . Its internal diameter is 6 m and external diameter 10m. Compute the vertical stress on the center line of the footing due to the imposed load at a depth of 6.5 m below the ground level. The footing is founded at a depth of 2.5 m. [1+7]
9. a) Define normally consolidated, over consolidated and under consolidated soil. Discuss the factors that govern consolidation. [2+2]
- b) An open layer of clay 4m thick is subjected to loading that increases the average effective vertical stress from 185 kPa to 310 kPa. Determine [6]
- The total settlement.
 - The settlement at end of 1 year.
 - Time in days for 50% Consolidation.
 - Time in days for 25 mm settlement to occur.
- $m_v = 0.00025 \text{ m}^2/\text{kN}$, $c_v = 0.75 \text{ m}^2/\text{year}$
10. a) Why it is difficult to define failure point in soil? Explain with respect to stress strain diagrams. Discuss on practical problems when Consolidated Drained parameters are required. [2+2]
- b) An unconfined compression test was performed on an undisturbed sample of normally consolidated clay, having a diameter of 3.75 cm and height of 7.5 cm, failure occurred under a vertical compressive load of 116.3 kg. The axial deformation recorded at failure was 0.9 cm. A remolded sample of the same soil failed under a compressive load of 68.2 kg and the corresponding axial deformation was 1.15 cm. Determine the unconfined strength and cohesion of the soil in the undisturbed as well as remolded state. Also determine the sensitivity of the soil. [6]
11. What is Taylor's stability number? Highlight its significance in slope stability analysis. Explain in detail about friction circle method. [1+2+3]

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1. Describe the process of formation of soil. [2]
2. a) A natural soil deposit has a natural water content of 30%. What will be its state of consistency if Liquid Limit = 62%, Plastic Limit = 41% and Shrinkage Limit = 25%. Illustrate consistency limits of soil with suitable diagram. [3]
 - b) A dry sample of mass 50 gm is mixed with distilled water to prepare a suspension of 1000 ml for hydrometer analysis. The reading of the hydrometer taken after 5 minutes was 25 and the depth of the centre of the bulb below the water surface when the hydrometer was in the jar was 150 mm; the volume of the hydrometer was 62 ml and area of cross section of the jar was 55 cm². Assuming $G = 2.68$ and viscosity $\eta = 9.81$ millipoise, determine the particle size and percentage finer corresponding to the above observations. [5]
3. a) Describe the concept of boundary classification of soil. Enlist the various categories. [3]
 - b) Classify the soil according to USCS using following information:
 - i) Soil passing from 75 μ sieve = 62%, Liquid Limit = 54%, plastic limit = 23% [5]
 - ii) Soil passing from 75 μ sieve = 4%, soil passing from 4.75 mm sieve = 62%, coefficient of uniformity = 5 and coefficient of curvature = 2.6. [5]
4. Describe the different types of clay minerals. [4]
5. a) How can you control compaction in the field? [2]
 - b) How do you achieve the dry density of the compacted soil in field to that of the maximum dry density obtained in the laboratory? [4]
6. With the help of proper example, prove that the effect of the capillary rise on the effective stress is similar to that of surcharge. [10]
7. What is the role of the boundary conditions in seepage analysis? Draw a neat flownet of the concrete dam. Explain the design consideration of filter. [2+4+2]
8. a) How do you calculate the vertical stress under any point located outside the loaded rectangular area? [3]
 - b) Water tank is supported on 3 columns which form an equilateral triangle configuration. Total load of the water tank is 3000 kN. The spacing of the column is 3 m. Assuming that the load on each footing as point load, find the vertical stress induced at a depth of 4 m under any of the footing of columns. [5]
9. a) Describe the procedure of calculation of final void ratio (any one method) of the soil sample tested in the consolidation cell for each load increment. [4]

- b) A consolidation settlement of a new structure founded on a 5 m thick layer is estimated as 6.5 cm. The structure is founded to have settled by 1.6 cm in 6 months after the completion of the construction. If the clay layer is underlain by a rock and overlain by a layer of coarse sand. Determine:
- i) The time required for 50% consolidation.
 - ii) The amount of settlement which will take place in next 6 months. [6]
10. a) State the Mohr's failure theory and give the reasons behind the Mohr envelope being tangent to Mohr's circle. [1+2]
- b) The subsoil at a site consists of 10 m thick homogenous layer of dense sand having the following properties: $\gamma_d = 16 \text{ kN/m}^3$, $G = 2.70$ and $\Phi = 33^\circ$. The natural ground water table lies at 2 m below the ground surface. Assume that the soil above the water table is dry. Determine:
- i) Shear strength of the soil along a horizontal plane at 5 m below the ground surface.
 - ii) The change in the shear strength along the same plane if the water table rises up to the ground surface. [4+3]
11. Define stability number and depth factor. With the help of neat sketch describe the procedure of determining factor of safety by friction circle method. [2+4]

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1. Explain the importance of Soil Mechanics in relation to different Civil Engineering Problems. Briefly describe the how soils are formed. [1+1]
2. a) How does engineering properties of soil differ from Index properties? Mention different index tests done for coarse and fine grained soils. [3]
- b) Draw stress-strain curves for soil at different consistency states. [2]
- c) The in-situ field unit weight and water content of soil are 18 kN/m^3 and 10% respectively. Soil is excavated from this in-situ site is used for embankment construction. The dry unit weight and water content of the soil at compaction site are 19 kN/m^3 and 18% respectively. Determine the amount of soil to be excavated for 1 m^3 of compaction. Assume necessary conditions. [3]
3. a) Describe the soil classification according to MIT classification system. [3]
- b) The sieve analysis of a soil gave the following results:
 % passing 75 micron sieve = 4
 % retained on 4.75 mm sieve = 35
 Coefficient of curvature = 2
 Coefficient of uniformity = 5
 Classify the soil according to USCS system. [5]
4. Describe the different types of clay minerals with neat sketches. [4]
5. a) What is relative compaction? [1]
- b) Explain the effect of compaction on engineering behavior of soil. [2]
- c) The maximum dry unit weight of a compacted soil mass is found to be 17 kN/m^3 with optimum water content being 16%. Determine void ratio and degree of saturation of this soil after compaction. Also, find the value of the maximum dry unit weight on the zero air void line at that optimum water content? Take specific gravity of soil solid as 2.65. [3]
6. a) State quick sand condition. [2]
- b) The water table in a deposit of uniform sand is located at 2m below the ground surface. Assuming the soil above the water table is dry,
 (i) Determine the effective stress at a depth of 5 m below the ground surface. Take bulk unit weight of sand as 18 kN/m^3 .
 (ii) If the soil above the water table is saturated by capillary action, what is the effective stress at that depth?
 Also, plot the variation of total pressure and effective pressure over the depth of 5 m in both the cases. [8]

7. Define flow net. Write its properties and uses. Prove that the discharge through an earth

$$\text{mass is given by } q = k \times h \times \left(\frac{N_f}{N_d} \right)$$

where, k = coefficient of permeability; h = head; N_f = number of flow channels and N_d = number of equipotential drops [1+2+5]

8. a) How the scaling is done in Newmark's Analysis method? [2]

- b) An excavation $3\text{ m} \times 6\text{ m}$ for foundation is made. The depth of foundation is at 2.5 below the ground surface. The bulk unit weight of the soil is 2 kN/m^3 . Determine the effect of this excavation on the effective vertical stress at the depth of 6 m from the ground surface for (i) vertically below the center of the foundation and (ii) 6 m away from the center of the foundation. [6]

9. a) How does excess pore water pressure differ from hydrostatic pore water pressure? [2]

- b) The soil profile of the ground shows that sand layer (3.5 m thick void ratio = 0.98, Specific gravity, $G_s = 2.62$) lies above the clay layer (3.5 m thick, void ratio = 0.62, specific gravity, $G_s = 2.7$, $w_L = 50\%$). Ground water table lies 1.5 m below the ground surface. Assume impervious layer lies below the clay layer. If a uniformly distributed load, 110 kPa is applied on the ground surface of this soil, find the primary settlement of the clay layer. For compressibility index, use $C_c = 0.0099$ (LL-10). [5]

- c) How does two way drainage and one way drainage affect the time of consolidation if degree of consolidation and coefficient of consolidation for that clay layer are same? [3]

10. a) State Mohr-Coulomb's failure criterion. [2]

- b) A series of shear tests was performed on a soil. Each test was carried out until the soil sample sheared and the stresses for each test are as follows.

Test	Cell pressure σ_3 (kN/m ²)	Deviator stress (kN/m ²)
1	300	875
2	400	1160
3	500	1460

Plot the Mohr circle of stress and the strength envelope and determine the angle of internal friction of the soil. [8]

11. a) Derive an equation for calculating factor of safety for infinite slope of dry cohesive soil. Assume necessary conditions. [3]

- b) Find factor of safety of slope using $\phi = 0$ analysis method. Assume necessary conditions. [3]

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2079 Jestha

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Define Soil Mechanics. Explain the significance of fluid mechanics in soil mechanics. [1+2]
2. a) What are index and engineering properties of soil? Which property is significant for identification and classification of soil and why? [2+2]
 - b) Define relative consistency. The values of liquid limit, plastic limit and shrinkage limit of a soil were reported as follows:
 $\omega_L = 60\%$, $\omega_P = 30\%$, $\omega_S = 20\%$
 If a sample of this soil at liquid limit has a volume of 40 cc and its volume measured at shrinkage limit was 23.5 cc, determine the specific gravity of the solids. What is its shrinkage ratio? Also draw the phase diagram for the soil at liquid limit and at shrinkage limit as per given reported values. [1+5]
3. What is the purpose of soil classification? A soil sample on laboratory test gives the following results. Classify the soil and give symbol as per USCS classification system. [2+6]

Passing through 75-micron sieve = 8%
 Passing through 4.75 mm sieve = 42%
 Coefficient of uniformity = 6
 Coefficient of curvature = 4
 Plasticity index = 4
4. What are the building blocks of clay minerals? Explain the common group of clay minerals. [1+2]
5. What is compaction? How does it differ from consolidation? Describe briefly different methods of compaction with their relative merits and demerits. [1+2+3]
6. A layer of 6m thick fine sand is overlain by a clay deposit of 4m and water table is 2m below the surface. The unit weight of clay above and below the water level is 18kN/m^3 and 22kN/m^3 respectively. The layer of fine sand has the porosity of 44% and specific gravity of 2.65. If there is capillary rise of 1m above the water table, draw total stress, pore water pressure and effective stress diagram. [8]
7. a) What is flow net? Explain the mechanism of piping in hydraulic structure. [2+2]
 - b) The discharge through the pervious soil is 200 cc/day. The flow net shows 5 flow channels and 10 equipotential drops. If the net head causing the flow is 2.5m, calculate the permeability of the soil. [3]
8. The annular ring foundation of external and internal diameter 4m and 6m respectively transmits a pressure of 100kN/m^2 . Compute the vertical stresses at the depth 0.5m, 1m, 2m, 4m and 8m below the center. Also draw stress distribution curve along depth. [8]

9. a) Explain the factors that affect the degree of consolidation. [4]
- b) In one dimensional consolidation test the time required for 50% consolidation has been measure at 154 seconds (through the observation and measurement of pore water pressure). The settlement of the sample at the end of the test was 2.5 mm. [6]
- $\sigma_0' = 60$ kPa, $\sigma_1' = 120$ kPa, $e_0 = 0.65$, $H_0 = 20$ mm, Take: $\tau_v = 0.197$ and 0.848 for 50% and 90% consolidation respectively. Determine:
- (i) the time required for 90% consolidation
 - (ii) the coefficient of permeability in m/s
 - (iii) the compression index

10. a) Explain the advantage of triaxial shear test over direct shear test. [2]
- b) On which type of soil unconfined shear test is conducted? Explain with the help of Mohr circles how shear strength parameters are determined using unconfined compressive strength test. [1+2]
- c) The results of drained and consolidated-undrained triaxial tests on two samples of normally consolidated clay are shown below: [6]

Type of test	σ_3 (kPa)	$\sigma_3 - \sigma_3$ at peak (kPa)
Drained	300	650
Consolidated-undrained	200	250

Determine:

- (i) ϕ' from the drained test,
 - (ii) ϕ from the consolidated-undrained test,
 - (iii) the pore pressure in the consolidated-undrained test at failure
11. What are the basic modes of the failure of the earth slopes? Briefly describe any two with sketch. What are the probable causes of increase in shear stress to trigger the instability of soil? [4+2]

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2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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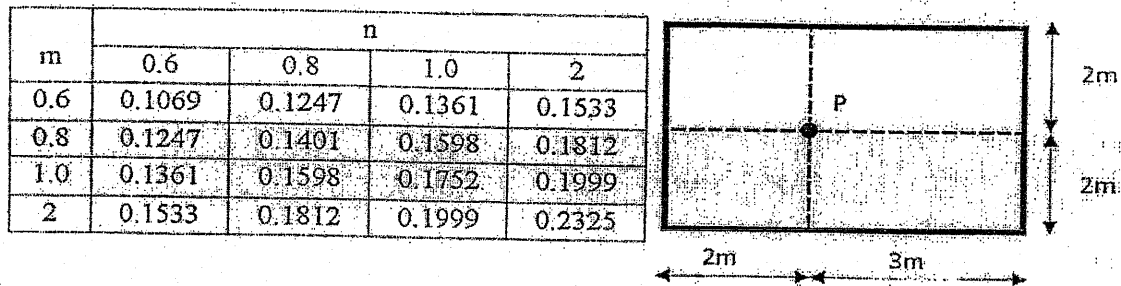
1. Define soil. What are the various soil engineering problems? [2]
2. a) Describe toughness index, coefficient of curvature, activity of soil and air content. [4]
b) A mass of moist soil mass is 20 kg and its volume is 0.011 m^3 . After oven drying, the mass reduce to 16.5 kg. Assume $G = 2.70$. Determine water content, dry density, degree of saturation and porosity. [4]

3. Describe the importance of soil classification. Classify the soil A and B with the properties as shown below according to unified soil classification soil. [3+5]

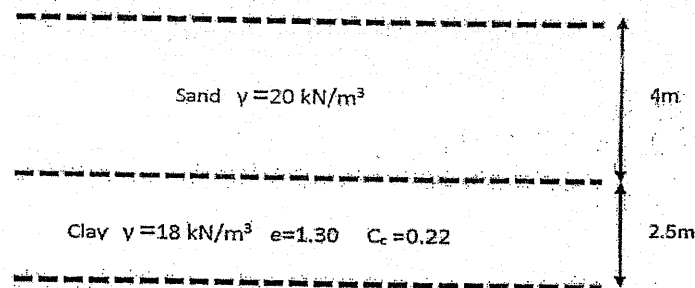
Soil	$w_L(\%)$	$I_p(\%)$	% passing through 4.75 mm sieve	% passing through 75μ sieve
A	45	29	100	59
B	55	15	100	85

4. a) Describe basic structural units of clay minerals. Point out the difference between Kaolinite, Illite and Montmorillonite clays structures. [3]
b) Explain double diffuse layer in clay minerals. [1]
5. a) Discuss the factors affecting compaction of soil. [3]
b) Describe the following: [3×1]
 - i) Placement water content
 - ii) Relative compaction
 - iii) Theoretical Maximum dry density
6. a) Define the following: [4×1]
 - i) Coefficient of transmissibility
 - ii) Seepage pressure
 - iii) Quick sand condition
 - iv) Held water
- b) The following data were recorded in a constant head permeability test.
Internal diameter of the permeameter = 7.5 cm, porosity of sample = 44%
Quality of water collected in 60s = 626 ml and head loss over a sample length of 18 cm = 24.7 cm. Calculate the permeability, flow velocity and seepage velocity. Also calculate the permeability of soil at porosity of 39%. [6]
7. Explain the flow net construction procedure of sheet pile. Describe the graded filter design method with the help of neat sketch. [8]

8. Describe the Boussinesq's limitations. A rectangular foundation 4 m by 5 m carries a uniformly distributed load of 200 kN/m^2 . Determine the vertical stress at a point 'P' as shown in figure and at a depth of 2.5 m. [3+5]



9. a) With the help of neat sketch, describe the method of determination of coefficient of consolidation by square root of time method. [4]
 b) Calculate the final settlement of clay layer as shown in figure below due to increases of pressure of 30 kN/m^2 at mid height of layer. [3]



- c) A compressible layer whose total settlement under a given loading is expected to 20 cm, settles 4 cm at end of 2 months. How many months will be required to reach a settlement of 10 cm. Assume double drainage. [3]
 10. a) State the Mohr's failure theory and derive the Mohr coulomb equation. [1+3]
 b) The series of consolidated undrained tests on undisturbed samples of an overconsolidated clay were as below. Determine the shear parameter in terms of effective stresses. [6]

Cell pressure (kN/m^2)	100	200	400	600
Deviator stress at failure (kN/m^2)	300	410	610	850
Pore water pressure (kN/m^2)	-45	-15	50	110

11. a) Describe the process of determining the most critical circles in Swedish circle method. [3]
 b) Analyse the infinite slope of cohesionless soil for a steady seepage condition. [3]

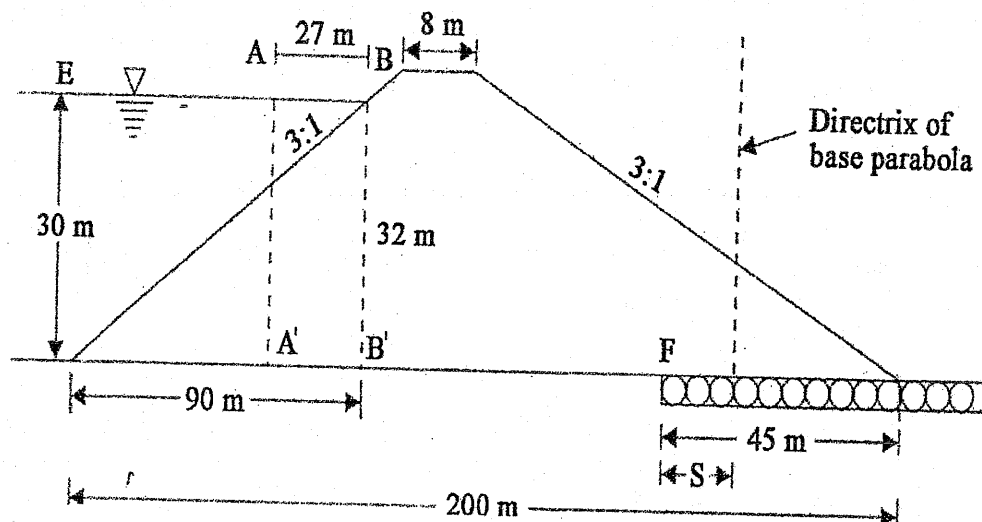
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2078 Poush

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Differentiate between residual and transported soils. What would be the solution of different soil engineering problem? [2]
2. a) Describe different methods of determination of in-situ density based on site conditions. [4]
- b) Undisturbed sample of saturated clay has volume of 20cc and weighs 38 gm. After oven drying the weight reduces to 28 gm. Calculate the void ratio and specific gravity. [4]
3. How do you distinguish between clay and silt in the field? State the purpose of identification and classification of soils. List any three important engineering classification systems and describe one in detail, clearly bringing out its limitations. [2+2+1+3]
4. a) Define basic structural units of clay minerals and show the structure of Kaolinite, Illite and Montmorillonite minerals.
- b) Describe different types of soil structures. [2+2]
5. a) Mention the factors that affect the compaction. [1]
- b) Explain the effect of compaction on soil Properties. [2]
- c) A cylindrical specimen of a cohesive soil of 10 cm diameter and 20 cm in height was prepared by compaction in a mold. Taking the specific gravity of soil solid as 2.65 and the wet weight of this specimen as 30kN and water content as 15%, find the followings:
 - (i) Dry unit weight, Void ratio and Degree of saturation of this cylindrical specimen.
 - (ii) If 95% of relative compaction is to be achieved in the field, what should be the dry unit weight of compacted soil so same soil specimen in the field. [3]
6. a) Describe the effect of surcharge and capillary action in the effective stress. [4]
- b) A drainage pipe is clogged with the soil having coefficient of permeability 10 m/day. Due to clogging water level in the tank is raised to 20 m and discharge is reduced to 0.15 m³/day. If the cross section of the pipe is 200 cm², what is the volume of soil in the pipe? [6]
7. a) With neat sketch describe the method to find top flow line for an earthen dam with horizontal filter. [3]
- b) An earth dam of homogeneous section with a horizontal filter is shown in figure below. If the coefficient of permeability of the soil is 3×10^{-3} mm/s, find the quantity of seepage per unit length of the dam. [5]



8. a) Describe approximate stress distribution methods for loaded areas. [3]
- b) A ring foundation is of 3.60 m external diameter and 2.40 m internal diameter. It transmits a uniform pressure of 135 kN/m^2 . Calculate the vertical stress at a depth of 1.80 m directly beneath the centre of the loaded area. [5]
9. a) A structure built on a 3 m thick single drained clay layer settled 5 cm in 60 days after it was built. If this settlement corresponds to 20 percent average consolidation of the clay layer, plot the time settlement curve of the structure for a period of 3 years from the time it was built. [8]
- b) Explain the different methods of accelerating consolidation settlement. [2]
10. a) What are the advantages and disadvantages of a triaxial compression test? Briefly explain how you conduct the triaxial test and compute the shear parameters for the soil from the test data. [4]
- b) Calculate the potential shear strength on a horizontal plane at a depth of 3 m below the surface in a formation of cohesionless soil when the water table is at a depth of 3.5 m. The degree of saturation may be taken as 0.5 on the average. Void ratio = 0.50; grain specific gravity = 2.70; angle of internal friction = 30° . What will be the modified value of shear strength if the water table reaches the ground surface? [6]
11. An embankment 10 m high is inclined at an angle of 36° to the horizontal. A stability analysis by the method of slices gives the following forces per running meter:
 - Σ Shearing forces = 450 kN
 - Σ Normal forces = 900 kN
 - Σ Neutral forces = 216 kN
 The length of the failure arc is 27 m. Laboratory tests on the soil indicate the effective values c' and ϕ' as 20 kN/m^2 and 18° respectively.
 Determine the factor of safety of the slopes with respect to (a) shearing strength and (b) cohesion

[3+3]

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Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary tables are attached herewith.
- ✓ Assume suitable data if necessary.

1. Differentiate between physical and chemical disintegration process. [2]
2. a) What do you mean by index and engineering properties? Why is it necessary to determine index properties of soil? [4]
 - b) You are appointed as a supervisor for a road construction project. During the construction process, the contractor compacted the base course of the road and the average water content for the test samples was found to be 15%, the specific gravity of soil grains = 2.7 and unit weight of soil = 18 kN/m. The specification requires that void ratio < 0.75. If you have to pass the bill for that task according to the specification, Would you pass the bill for that work? [4]
3. a) Point out similarities and differences between USCS system and AASHTO system of soil classification. [2]
 - b) What are the basic requirements of soil classification? [2]
 - c) Classify the given soil according to USCS classification system [4]

% of soil passing through sieve no. 200 (0.075 mm) = 40%

% of soil retained in sieve no. 4 (4.75 mm sieve) = 55%

The grading characteristics of soil were: $D_{10} = 1.2$ mm, $D_{60} = 3.8$ mm, $D_{30} = 2.6$ mm
4. What do you mean by adsorbed water? Describe double diffusive layer formation. [1+3]
5. a) Is it practically possible to maintain the optimum moisture content during compaction at field? Give reason. [1]
 - b) The following results were obtained from a standard compaction test [3+2]

Test No.	1	2	3	4	5	6
Water Content(%)	11.0	12.1	12.8	13.6	14.6	16.3
Mass of compacted soil (gm)	1920.5	2051.5	2138.5	2147.0	2120.0	2081.5

The specific gravity of solids is 2.7 and volume of the compaction mould is 1000 cm³. A field compacted soil sample showed water content of 35% and unit weight of 2.318 Mg/m³.

- (i) Draw compaction curve and determine the maximum dry unit weight and OMC
- (ii) Find the relative compaction (RC)
6. a) Sand deposit consists of two layers. Top layer is 3 m thick with bulk unit weight 18 kN/m³ and saturated unit weight of 21 kN/m³ and the bottom layer is 4 m thick with saturated density of 20 kN/m³. Ground water table is at a depth of 4 m below the ground surface and zone of capillary saturation is 1 m above the water table. Calculate and plot effective stress, total stress and neutral stress. [6]

- b) What is quick sand condition? At a site, the initial investigation showed that the soil is cohesive (clay). If you have to determine coefficient of permeability of the soil, which method is most appropriate in laboratory and why? Also write the expression to determine the coefficient of permeability. [2+1+1]
7. a) A deposit of cohesionless soil with a permeability of 4×10^{-2} cm/s has a depth of 10 m with an impervious ledge below. A sheet pile wall is driven into this deposit to a depth of 7 m. The wall extends above the surface of the soil and a 3 m depth of water acts on one side. Sketch the flow net and determine the seepage quantity per metre length of the wall. [4]
- b) Explain the filter requirements for controlling piping. Describe the properties and application of flow net. [2+2]
8. a) Define significant depth and its importance. Construct an isobar for significant depth. [4]
- b) A strip footing of width 2m carries a load of 500kN/m. Calculate the maximum stresses at a depth of 5m below the center of footing. Compare the result with 2:1 Distribution method. [2+2]
9. a) A 3m thick clay layer beneath a building is overlain by a permeable stratum and is underlain by a impervious rock. The coefficient of consolidation of the clay was found to be $0.025 \text{ cm}^2/\text{min}$. The final expected settlement for the layer is 8cm. Determine [6]
- i) How much time will it take for 80% of the total settlement
 ii) The required time for a settlement of 2.5 cm to occur
 iii) the settlement that would occur in 1 year
- b) Discuss the limitations of Terzaghi's theory of consolidation. State the difference between primary and secondary consolidation. [2+2]
10. a) List out all the field and lab tests for determining the shear strength parameters of the soil. Also state which tests are appropriate for which type of soil. [3]
- b) Point out the limitations Mohr-Coulomb theory. [2]
- c) The following result were obtained from a consolidated – undrained test on normally consolidated clay. Plot the strength envelope in terms of total stress and effective stress and determine the strength parameters. [5]

Sample No.	Cell pressure (KN/m ²)	Deviator Stress (KN/m ²)	Pore Water Pressure (KN/m ²)
1	200	244	55
2	300	314	107
3	400	384	159

11. An infinite slope is made of clay with the following properties:
 $\gamma_t = 18 \text{ KN/m}^3$, $\gamma' = 9 \text{ KN/m}^3$, $c = 25 \text{ KN/m}^2$ and $\phi' = 28^\circ$. If the slope has an inclination of 35° and height equal to 12m, determine the stability of the slope, when [6]
- i) The slope is submerged
 ii) There is seepage parallel to the slope

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Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.
- ✓ Necessary figure is attached herewith.

1. a) Explain the importance of studying Soil Mechanics. [1]
b) Point out the types of soil based on its formation, grain size and cohesiveness. [1]
2. a) Sketch the phase diagram for a soil and indicate the volumes and weights of the phases on it. Define 'Void ratio and Degree of saturation'. [2]
b) A field density test was conducted by core cutter method and the following data was obtained.
 Weight of empty core-cutter = 22.80N
 Weight of soil and core-cutter = 50.05N
 Inside diameter of the core-cutter = 90.0mm
 Height of core-cutter = 180.0mm
 Weight of wet sample for moisture determination = 0.5405N
 Weight of oven-dry sample = 0.5112N
 Specific gravity of soil grains = 2.72
 Determine (i) dry density, (ii) void-ratio, and (iii) degree of saturation. [6]
3. a) Name the tests generally done to identify sandy soil and clayey soil in the field. [2]
b) Name the soil classification systems which use both particle size and plasticity characteristics of soil. [2]
c) Classify the following soil if the test results obtained from Sieve Analysis and Consistency Tests are given below:
 Percentage passing No. 4 Sieve (4.75 mm) = 70%, Percentage passing No. 200 Sieve (0.075mm) = 30%; Liquid limit = 33% and Plastic Limit = 11%. [4]
4. Define soil fabrics and soil structure. Explain with clear sketches the 1:1 and 2:1 types of clay minerals. [1+3]
5. Evaluate the construction of embankment if required degree of compaction is 95% and the dry density of the embankment was found as 1.78gm/cc. The result of compaction test performed in the laboratory for the same material using 950cc mould are as follows. [6]

w%	7.7	11.5	14.6	17.5	19.7	21.2
Mass of wet soil (kg)	1.70	1.89	2.03	1.99	1.96	1.92
6. a) Fluctuation of water level in the sea affects the effective stress of the soil lying in the sea bed. Do you agree with this statement? Answer the question with proper explanation. [2]
b) A soil profile consists of 4m and 3m thick clay layer and sand layers, respectively. Clay layer lies above the sand layer and the ground water table is seen at 2m depth from the ground surface. Above the water table, there lies 1m thick capillary saturated

zone. Determine effective vertical stress at 0m, 1m, 2m, 4m, and 7m depths from the ground surface. Take bulk unit weight and saturated unit weight of clay as 20kN/m^3 and 20kN/m^3 respectively. Take saturated unit weight of sand as 19kN/m^3 . [4]

- c) Explain Darcy's law in regard with discharge velocity. Write down the names of different tests done to find the coefficient of permeability of the soil both in the laboratory and field. [2]
- d) Explain Quick sand condition. [2]
7. a) What is flow net? Describe its properties and applications. [1+2]
- b) Prove that the discharge per unit width of an earthen dam with a horizontal filter at its toe is equal to the coefficient of permeability times the focal length. [5]
8. a) A water tower (10^6kN including foundation) is supported by three columns in triangular pattern (each side 10m long). Calculate the stress 5m below the foundation level at the center of water tank and each footing. [6]
- b) Describe the limitations of Boussinesq's and Westergaard's theory. [2]
9. a) Explain what is meant by normally consolidated clay stratum and over-consolidated clay stratum. Sketch typical results of consolidation test data to a suitable plot relating the void ratio and consolidation pressure in each case and show how pre-consolidation can be estimated. [2+2+1]
- b) There is a bed of compressible clay of 4m thickness with previous sand on top and impervious rock at the bottom. In a consolidation test on an undistributed specimen of clay from this deposit 90% settlement was reached in 4 hours. The specimen was 20mm thick. Estimate the time in years for the building founded over this deposit to reach 90% of its final settlement. [5]
10. a) Define major and minor principle stresses. What happens if the value of major principle stress increases while minor principle stress remains constant? Draw Mohr circle of stresses at failure with Mohr-Coulomb Failure line for soil having only angle of internal friction. [3]
- b) Name the laboratory and field tests conducted to find the strength parameters of a soil. [1]
- c) Draw final test results of Unconfined Compression Tests and Direct Shear Test for the same soil so that strength parameters of the soil could be obtained. [2]
- d) At confining pressure of 100kPa and deviator stress of 200kPa, a cohesionless soil sample was failed in a triaxial test. Determine the deviator stresses if the sample of same soil when failed under confining pressure of 200kPa. Also, Mohr circles of stress along with Mohr-coulomb failure envelop. [4]
11. A cut 10m deep is to be made in a stratum of cohesive soil ($c=35\text{kN/m}^2$, $\gamma=18.5\text{kN/m}^3$ and $\phi=0$). The bed rock is located 15m below the original ground surface. [6]

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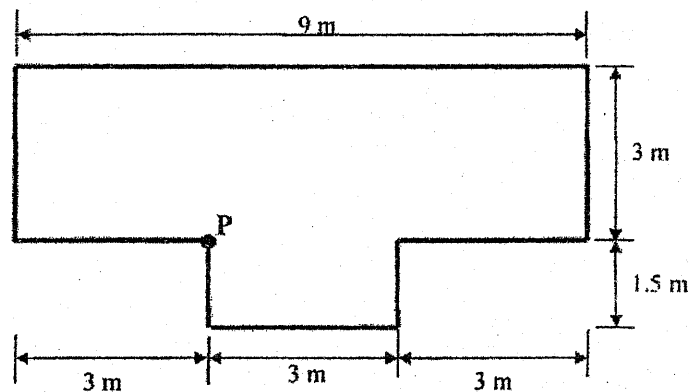
Exam.	Regular		
Level	BE	Full Marks	80
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Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE 552)

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1. Briefly describe the process of soil formation. [2]
2. a) Draw phase diagrams for dry soil sample and saturated soil sample before and after the compaction and consolidation processes, respectively. [2]
- b) Explain the field tests generally done to find the dry unit weight of soil. [2]
- c) Dry sand is poured into a cylindrical container (internal diameter, 0.2m and height, 0.2m) and just filled up to its top. The weight of the dry sand in the container is found to be 10kg. By adding water, this dry sand sample is fully saturated with water. Let the void ratio of this sand sample be 0.54 which remains constant throughout the saturation process. Taking the value of specific gravity of soil solid as 2.65, find the followings:
 - (i) The amount of water needed to fully saturate the dry sand sample and its water content at full saturation.
 - (ii) Also, find the amount of water to be added in the dry sand sample to achieve 80% degree of saturation. Mention the assumed condition if any. [4]
3. a) Differentiate between cohesive and cohesion less soil with their uses in Civil Engineering field. [2]
- b) Describe field identification test to distinguish between clay and silt. [4]
- c) Draw neatly the IS plasticity chart and label the symbol of various soils. [2]
4. Compare the montmorillonite and kaolinite minerals of clay in the basis of chemical and physical characteristics and how they affect the geotechnical behavior of soil. [4]
5. A soil in the borrow pit is at a dry density of 17kN/m^3 with a moisture content of 10%. The soil is excavated from this pit and compacted in an embankment to a dry density of 18kN/m^3 with a moisture content of 15%. Compute the quantity of soil to be excavated from the borrow pit and the amount of water to be added for 100m^3 of compacted soil in the embankment. [6]
6. Define 'neutral' and 'effective' pressure in soils. What is the role of effective stress in shear strength of soil? The discharge of water collected from a constant head permeameter in a period of 15 minutes is 500ml. The internal diameter of the permeameter is 5cm and measured difference in head between two gauging points 15cm vertically apart is 40cm. Calculate the coefficient of permeability. If the dry weight of the 15cm long sample is 4.86N and the specific gravity of the solids is 2.65, calculate the seepage velocity. [2+1+7]
7. Draw a flow net diagram for the given earthen dam data and compare the discharge with the theoretical calculation.
Top width = 15m upstream and downstream slope = 2H:1V, height of dam = 30m, free board = 5m, length of drain = 30m and coefficient of permeability = 40m/day. [6+2]
8. a) Using Boussinesq's equation for point load, determine the increment in vertical stress below the center of the uniformly loaded circle. Assume all necessary conditions. [3]

- b) Name different methods used to determine the increment in vertical stress at any point below the ground surface due to external load applied on the ground surface. [1]
- c) A T-shaped foundation as shown in figure is loaded with a uniform load of 120kPa. Determine the vertical stress at the point P at a depth of 5m. [4]
 [Take $I_N=0.0629$ for $m = 0.6$ and $n=0.3$; $I_N=0.1431$ for $m=0.6$ and $n=1.0$; and $I_N=0.1069$ for $m=0.6$ and $n=0.6$]



9. a) Define consolidation, degree of consolidation, pre-consolidation pressure and over-consolidation ratio. [2]
- b) At a certain depth below the foundation of a building there exists a clay layer of thickness 10m. Above and below the clay layer there are incompressible permeable soils. In a consolidation test on the clay sample with drainage at top and bottom, a sample with initial thickness 2.54cm was compressed under a steady pressure. Half of the final settlement value? Take Time factor, $T_v=0.196$ for 50% degree of consolidation. [5]
- c) Draw isochrones for a clay layer of thickness, H under one-way drainage and two way drainage conditions at different elapsed times after loading ($t=0$, $t=t$ and $t=\infty$). Assume necessary conditions. [2]
- d) What are the possible methods for accelerating consolidation process? [1]
10. a) What is the shear strength of soil along a horizontal plane at a depth of 4m in a deposit of sand having $\phi=35^\circ$, $\gamma_d=17\text{kN/m}^3$, $G_s=2.7$. Assume the ground water table is at a depth of 2.5m from the ground surface. Also find the change in shear strength when the water table rises to the ground surface. [7]
- b) Describe briefly the practical application of UU, CU and CD triaxial test. [3]
11. Carry out the stability analysis for an infinite dry slope with strength properties of $c=10\text{kPa}$ and $\phi=25^\circ$. Assume the plane failure surface lies at a depth of 5m from the slope surface. Take the unit weight of soil above the failure plane as 16kN/m^3 and the inclination of the slope as 10° . What happens if the cohesion of the soil reduces to zero? [6]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

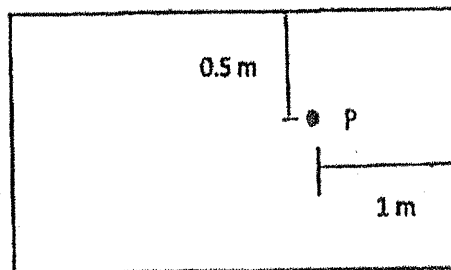
Subject: - Soil Mechanics (CE 552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Describe the process of formation of soil. [2]
2. a) What is particle size distribution curve? What is its use in soil engineering? [2]
b) Moist clayey soil has initial void ratio of 1.5, dry mass of 80 gm and specific gravity of solid particle of 2.5. The sample is exposed to atmosphere so that the sample volume decreases to one half of its initial volume. Calculate new void ratio and mass of water if degree of saturation became 25%. [6]
3. a) Mention the significance and requirement of soil classification. [3]
b) Classify the soil "A" and "B" with the properties given below as per the USC system. [5]

Soil	w_L	I_p	% passing 4.75 mm sieve	% passing 75 μ m sieve
A	45	29	100	59
B	55	15	100	85

4. Differentiate between soil structures and soil fabric. Describe different type of soil structures. [4]
5. What is compaction specification? Describe the methods to control compaction in field. List out possible field method of compaction with their suitability. [1+3+2]
6. Justify with an example that the effective stress of saturated soil remains unchanged even after the submergence of soil. Enlist the Dupuit's assumption and limitations. [6+4]
7. What is flow net? Describe its properties and uses. Explain the mechanism of piping in hydraulic structures. What methods are used to increase the factor of safety against piping? [2+2+2+2]
8. A rectangular foundation $3\text{m} \times 1.5\text{m}$ carries a uniform load of 40 kN/m^2 as shown in figure below. Determine the vertical stress at point "P" which is 2.5 m below the ground level. [4+4]



- a) Equivalent point load method
- b) Boussinesq's method

Table for I_N for rectangular loaded area

M	n			
	0.2	0.4	0.6	0.8
0.2	0.0179	0.0328	0.0435	0.0504
0.4	0.0328	0.0602	0.0801	0.0931
0.6	0.0435	0.0801	0.1069	0.1247
0.8	0.0504	0.0931	0.1247	0.1401

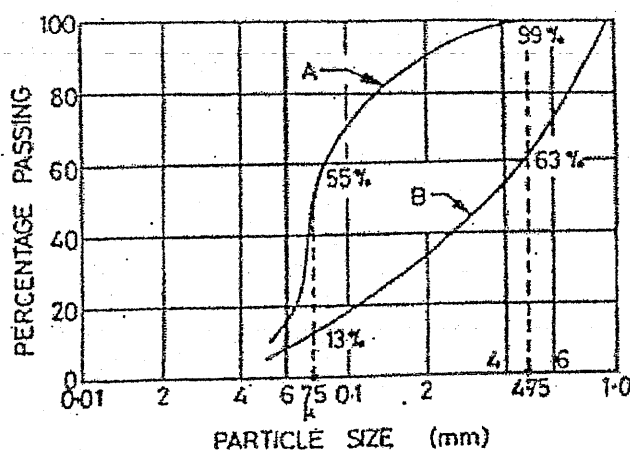
9. a) Derive Terzaghi's one dimensional consolidation equation. [5]
 b) Define coefficient of volume change and coefficient of compressibility. In a consolidation test, a fully saturated clay sample was subjected to a load of 500 kN/m^2 . After 12 hours, the average pore water pressure was found to be 200 kN/m^2 . Find the time required for the 50% consolidation to take place. [2+3]
10. a) State the Mohr failure theory and derive the Mohr coulomb equation. [3]
 b) A dry sand specimen failed in a triaxial test when the major and minor principal stresses were respectively 900 kN/m^2 and 250 kN/m^2 . Determine the angle of shearing resistance of sand. If the same specimen would have been tested in a direct shear test a normal stress of 200 kN/m^2 , what would have been the shear stress at failure? [3+4]
11. a) Describe possible measure (prevention) of slope failure. [3]
 b) Describe the relation of factor of safety to analyze infinite slope. [3]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. What are the different geotechnical problems in civil engineering and infrastructure development? What would be a solution of such problem? [1+1]
2. a) Define phase diagram. Draw the phase diagram for the saturated, partially saturated and dry soil. [3]
 b) Enlist the index properties and Engineering properties of soil. [2]
 c) Draw the stress strain curve for different consistency states of soil. [3]
3. a) Write down the names of soil classification systems based on particle size and plasticity of soil. Define plasticity chart of a soil based on ISSCS (Indian Standard Soil Classification System). [3]
 b) Particle size distribution curves for two types of soil; Soil A and Soil B are shown in figure below. Water contents measured at the boundaries between the liquid state-plastic state and plastic state-semi solid for soil A are 45% and 15% respectively. Similarly, for Soil B, they are 25% and 10% respectively. Classify these soil based on Unified Soil Classification System. Draw plasticity chart if required. [5]



4. What are the various minerals in the clay soil? Describe them. Define specific surface and diffuse double layer. [3+1]
5. a) What happens if soil is compacted? How does compaction affect engineering properties of soils? [2]
 b) Write down the names of different methods of compaction those are carried out in the field. Draw compactions curves for Standard Proctor Test and Modified Proctor Test. [2]
 c) The maximum dry density of a compacted soil mass is found to be 18 kN/m^3 with optimum water content being 15%. Find the degree of saturation of this compacted soil if specific gravity of soil of this soil is given as 2.65. What will be the value of the maximum dry density it can be further compacted to? [2]

6. State quick sand condition. A sand deposit consists of two layers. The top layer is 3.0 m thick ($\gamma = 17 \text{ KN/m}^3$) and bottom layer is 4.0 m thick ($\gamma_{\text{sat}} = 21 \text{ KN/m}^3$). The water table is at a depth of 4.0 m from the surface and zone of capillary saturation is 1 m above the water table. Draw the diagrams, showing the variation of total stress, neutral stress and effective stress. [2+8]
7. What is confined and unconfined flow in seepage flow? Why a filter is used on the downstream of earth dam? Prove that flow lines intersect the equipotential line at right angles. [2+2+4]
8. Write down the conditions for using Boussinesq's analysis and Westergaard's analysis. A ring footing of external diameter 8 m and internal diameter 4 m rests at a depth 2 m below the ground surface. It carries a load intensity of 150 kN/m^2 . Find the vertical stress at depths of 8 m along the axis of the footing below the footing base. Neglect the effect of the excavation on the stress. [2+6]
9. a) Explain the different methods of accelerating consolidations settlement. [3]
 b) Derive an expression for one dimensional consolidation theory suggested by Terzaghi. [7]
10. a) What are the differences between drained and undrained shear strength? [3]
 b) Define Mohr-coulomb theory. Draw the Mohr-Coulomb strength envelope for cohesive soil, Cohesion less soil and purely cohesive soil. [3]
 c) A sample of dry cohesion less soil was tested in triaxial machine. If the angle of Shearing resistance was 36° and the confining pressure, 100 KN/m^2 , determine the deviator stress at which the sample failed. [4]
11. Differentiate between finite and infinite slope. What are the factors that cause the failure of the slope? Write down the types of slope failures and explain the measures that can be taken to prevent slope failure. [1+2+3]

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

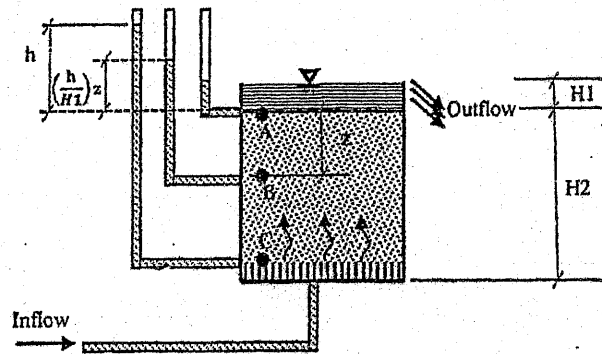
1. Differentiate between residual and transported soils. What would be a solution of different soil engineering problem? [2]
2. a) How does Index property of a soil differ from its Engineering property?
b) Mention Index tests those are generally done to find the properties of individual soil grains and soil mass as a whole.
c) Draw stress strain behaviour of different consistency states of soils.
d) An embankment is made by compacting the soil. For compaction, 1,00,000 m³ of the soil is excavated from the borrow pit having void ratio equal to 0.8. Calculate the volume of the embankment if its void ratio after compaction is 0.6. [1+2+2+3]
3. How is the plasticity chart useful for classifying fine-grained soils? a soil has the following characteristics:
a) Percentage of soil passing No. 200 sieve = 55
b) Percentage of coarse fraction passing No.4 sieve = 60
c) Liquid limit = 68%
d) Plastic limit = 22%
Classify given soil according to ISSCS. [2+6]
4. a) Describe basic structural units of clay minerals. Point out the difference between Silica sheet, Gibbsite sheet and Brucite sheet.
b) Briefly Describe flocculated and dispersed structures of soils in regard with compaction. [2+2]
5. In the construction of a road, the compaction specification required was 95% of Proctor maximum dry density at a field moisture content within 2% of the optimum moisture content. The maximum dry density and optimum moisture content obtained in the laboratory from the Standard Proctor test were 1.95 Mg/m³ and 13.5% respectively. A site engineer conducted sand cone test at two locations and obtained the following results.

Location No.	Mass of soil removed (gm)		Mass of sand used (gm)
	Wet	Dry	
1	43.86	38.46	39.51
2	37.38	32.21	32.39

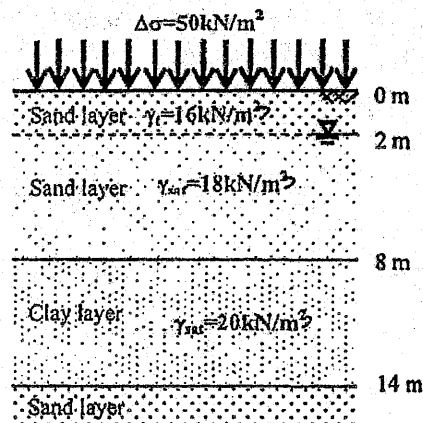
The density of sand used was 1.86 Mg/m³. Check whether the specification was satisfied or not. [6]

6. a) Explain the variation of effective stress due to the flow of water through the soil mass in downward and upward directions. What is discharge velocity? [2+1]
- b) In a variable head permeability test on a soil of length L_1 , the head of water in the standpipe takes 5 seconds to fall from 900 to 135 mm above the tail water level. When another soil of length $L_2 = 60$ mm is placed above the first soil, the time taken for the head to fall between the same limits is 150 seconds. The permeameter has a cross sectional area of 4560 mm² and a standpipe area of 130 mm². Calculate the permeability of the second soil. [7]

7. a) What do you understand by Flow net in regard with seepage through soils?
 b) Derive a Laplace equation for Two-dimensional flow in the soil.
 c) In the figure below, upward seepage is shown. The rate of water supply from the bottom is kept constant. The total loss of head during upward seepage between points B and A is h . Keeping in mind the total stress at any point in the soil is solely determined by the weight of the soil and the water above it, draw the variation of total stress, pore water pressure and effective stress with depth. Take points A, B and C as reference. [1+4+3]



8. What is Isobar Diagram? Draw Isobar Diagram of 0.1Q. What is the limitation of Boussinesq's theory? [1+5+2]
 9. a) What is compressibility and what are the possible causes of compression in the soil?
 b) Define consolidation settlement, preconsolidation pressure (maximum overburden pressure), degree of consolidation and coefficient of consolidation?
 c) A soil profile is shown in below figure. If a uniformly distributed load 50 kPa is applied on the ground surface having preconsolidation pressure, compression index and recompression index are 125 kPa, 0.36 and 0.06, respectively. Calculate the amount of settlement of the clay layer due to primary consolidation. Take $\gamma_w = 10 \text{ kN/m}^3$.
 d) How can you accelerate consolidation settlement? [2+3+4+1]



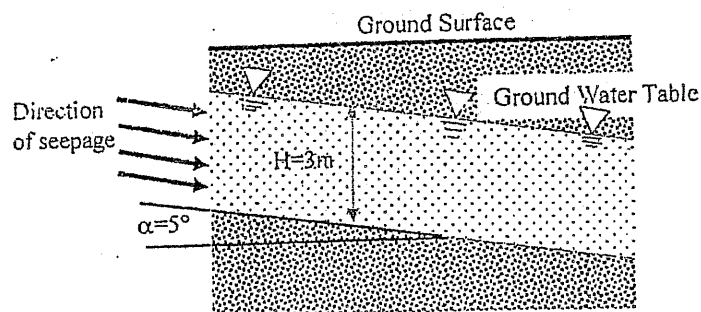
10. What is stress path? What are the limitations of direct shear test? A specimen of fine dry sand, when subjected to a triaxial compression test failed at a deviator stress of 500 kN/m^2 . It failed with a pronounced failure plane with an angle of 25° to the axis of sample. Compute the lateral pressure (σ_3) to which the specimen would have been subjected. [1+2+7]
 11. What are the causes of the failure of earth slopes? A slope of very large extent of soil with properties $c' = 0$, $e = 0.7$, $G = 2.7$ and $\phi = 35^\circ$ is likely to be subjected to seepage parallel to the slope with water level at the surface. Determine the maximum angle of slope for a factor of safety of 2.0. What will be the factor of safety if the water level were to come down well below the surface for this angle of slope? [2+4]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. What do you understand by soil mechanics and why do you need to study this? What would be a solution of different soil Engineering problem? [2]
2. A relative density test conducted on a sandy soil obtained the following results: maximum void ratio = 1.25, minimum void ratio = 0.45, relative density = 40% and $G = 2.65$. Find the dry density of the soil in the present state. If a 3 m thickness of this stratum is densified to a relative density of 60%, how much will the soil reduce in thickness? What will be the new density in dry and saturated conditions? [8]
3. a) How do you identify fine grain soils in the field?
b) Write down the types of soil classifications.
c) For finding the suitability of soils as subgrade for highways, which soil classification is generally used? Write down the name of each group according to that classification. Show the general rating of those groups as a suitability of subgrade.
d) Draw the plasticity chart incorporated in an USCS and give the group symbols of the various region in the chart. [1+2+2+3]
4. What is specific surface area and what is its effect on fine grained soil? [3+1]
5. a) What is Zero Airvoid (Z_{Av})?
b) Write down the factors that affect soil compaction.
c) The maximum dry unit weight of a compacted soil mass is found to be 18 kN/m^3 with optimum water content being 15%. Find the values of porosity and degree of saturation of this compacted soil. Also, find the value of the maximum dry unit weight on the zero air void line at that optimum water content? Take specific gravity of soil solid as 2.7. [1+2+3]
6. a) Define the meaning of capillarity in regard with normal soil ground. Also, explain the effect of water table variation on the effective stress.
b) As shown in below figure, an inclined permeable soil layer is underlain by an impervious layer. The coefficient of permeability of the permeable soil layer is equal to $4.8 \times 10^{-5} \text{ m/sec}$. If seepage of water in this soil layer occurs in the direction shown in the figure below, then calculate (i) Hydraulic gradient and (ii) rate of water flow (seepage) for that soil layer. Take the thickness of soil layer, $H = 3 \text{ m}$ and the angle of inclination of that soil layer, $\alpha = 5^\circ$. Assume any other necessary conditions.



- c) Write down the names of testing method for determining coefficient of permeability in the laboratory and field. [2+4+2+2]
- d) Differentiate between discharge velocity and seepage velocity. [2+6]
7. What are the properties of flow net? Prove that flow lines intersect the equipotential line at right angles. [2+6]
8. a) Vertical stress due to a point load can be calculated based on Boussinesq's and Westergaard's solutions. What is the basic difference between these two solutions? [2+3+3]
- b) Briefly explain Newmark's Influence Chart. What is the main use of this Chart?
- c) Describe approximate stress distribution methods for loaded areas. [1+2]
9. a) What are the methods of accelerating consolidation settlement? What are the different causes of preconsolidation of soil? [7]
- b) Derive a governing differential equation for one dimensional consolidation theory by Terzaghi?
10. a) Write down the names of shear strength tests that can be performed in the laboratory? How do you calculate shear strength in direct shear test?
- b) If direct shear is conducted for loose and dense sands, then plot graphs of Shear stress and Change in height of specimen versus Shear displacement.
- c) Unconfined compression test is a special type of unconsolidated undrained triaxial test. Why?
- d) Derive an expression for principal stresses at failure conditions. [2+2+1+5]
11. a) Explain finite slope and infinite slopes in regard with slope stability.
- b) Find Factor of Safety of slope using $\phi = 0$ analysis method. Assume necessary conditions. [2+4]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	H / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. What are the various field of application of soil mechanics? Write the factors that determine the characteristics of a residual soil. [1+1]
2. Define thixotropy and flow index. A sample of saturated clay has a volume of 97 cm^3 and mass of 202 gm. When completely dried, its volume is 87 cm^3 and mass of 167 gm. Determine: [2+6]
 - i) Initial water content
 - ii) Specific gravity of soil solids
 - iii) Shrinkage limit
3. Classify the following soils a, b and c as per unified soil classification system: [3+3+2]
 - i) Soil passing from 75μ sieve = 4%, soil passing from 4.75mm sieve (Coarse fraction) = 62%, coefficient of uniformity = 5, coefficient of curvature = 2.6
 - ii) Soil passing from 75μ sieve = 62%, liquid limit = 54%, plastic limit = 23%
 - iii) Soil passing from 75μ sieve = 39%, liquid limit = 33%, plastic limit = 18%
4. What is isomorphous substitution? Compare between 1:1 and 2:1 minerals. [1+3]
5. a) Draw compaction curve for a soil showing maximum dry density, optimum water content, zero-air void line, dry side and wet side of optimum water content. [3+3]
 - b) Compare the compaction characteristic curve for sand and clay.
6. What are the factors that influence the height of capillary rise in soils? Establish the relationship between seepage velocity and superficial velocity. A soil stratum having thickness of 1.15 m, porosity = 30% and $G = 2.7$ is subjected to an upward seepage head of 1.95 m. Determine the thickness of coarse material required above the soil stratum to provide a factor of safety of 2 against piping assuming that the coarse material has the same specific gravity and porosity as the soil and head loss in the coarse material is negligible. [1+3+6]
7. a) Derive the relationship for the seepage discharge through anisotropic soil.
 - b) If the upstream and downstream heads of an impervious dam are 8 m and 1 m respectively, then find the seepage discharge when seepage of water takes place from upstream to downstream via the isotropic soil lying below the impervious dam. Take total number of flow channels and equipotential drops as 9 and 12, respectively. Also, take coefficient of permeability of the soil layer, $k = 3 \times 10^{-4} \text{ cm/s}$. [4+4]
8. What is Newmarks influence chart? A water tank is supported by a ring foundation having outer diameter of 10 m and inner diameter of 7.5 m. The ring foundation transmits uniform load intensity of 160 kN/m^2 . Compute the maximum vertical stress induced at a depth of 4 m below the foundation using Boussinesq's theory. [2+6]

9. Distinguish between normally consolidated and over consolidated soil deposits. A 5 m thick saturated soil layer has a compression index of 0.25 and coefficient of permeability 3.2×10^{-3} mm/s. If the void ratio is 1.9 at vertical stress of 0.15 N/mm^2 , calculate the void ratio when the vertical stress is increased to 0.2 N/mm^2 . Also calculate settlement due to above stress increase and time required for 65% consolidation. [2+8]
10. a) Write down the names of shear strength tests. [2]
- b) Consolidated undrained triaxial test was performed for a normally consolidated saturated clay and cell pressure, $\sigma_3 = 200 \text{ kN/m}^2$, axial stress, $\sigma_1 = 550 \text{ kN/m}^2$ and pore water pressure, $u_w = 80 \text{ kN/m}^2$ were measured. Answer the followings: [2+2+2+2]
- Plot the Mohr circle of stresses in regard with Total stress.
 - Plot the Mohr circle of stresses in regard with effective stress.
 - Assume the condition of normal consolidation and $c' = 0$. Then obtain the value of ϕ' .
 - If Mohr-Coulomb's failure criterion is assumed to be valid, then determine the direction of failure plane that might occur within the specimen
11. An infinite slope is made of clay with the following properties: [6]
- $\gamma_t = 18 \text{ kN/m}^3$, $\gamma' = 9 \text{ kN/m}^3$, $c = 25 \text{ kN/m}^2$ and $\Phi' = 28^\circ$. If the slope has an inclination of 35° and height equal to 12m, determine the stability of the slope, when (a) the slope is submerged and (b) there is seepage parallel to the slope.

Exam.	New Batch (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

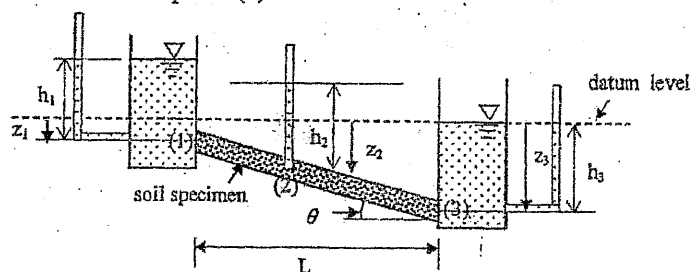
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. What are the different civil engineering problems related to soils? What would be a solution of such problems? [2+1]
2. a) Draw a graph showing different states of consistency of soil in reference to stress strain behavior.
- b) An embankment of $1,00,000 \text{ m}^3$ volume has to be constructed by compacting the soil brought from excavation site. After the compaction, dry unit weight of compacted soil (embankment) will be 16 kN/m^3 . Also, bulk unit weight and water content of the soil at the excavation site are 12 kN/m^3 and 15% , respectively. Find the volume and weight of soil to be excavated from the excavation site. Take specific gravity of soil solid as 2.70 . [3+5]
3. Give the grain size ranges of different soil types according to (MIT). Explain the different field identification methods for fine-grained soils. [3+5]
4. Explain double diffuse layer. Among Kaolinite, Montmorillonite and Illite clay minerals, which one swells the most and why? [4]
5. The following results were obtained from a standard compaction test. [6]

Test No.	1	2	3	4	5	6
Water content (%)	11.0	12.1	12.8	13.6	14.6	16.3
Mass of compacted soil (gm)	1920.5	2051.5	2138.5	2147.0	2120.0	2081.5

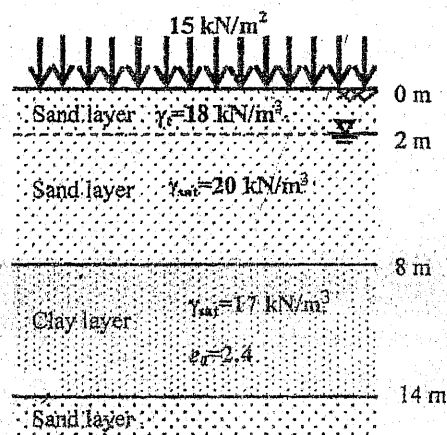
The specific gravity of solids is 2.7 and volume of the compaction mould is 1000 cm^3 . A field compacted soil sample showed water content of 35% and unit weight of 2.318 Mg/m^3 .

- i) Draw compaction curve and determine the maximum dry unit weight and OMC.
- ii) Find the relative compaction (RC)
- iii) Find the degree of saturation at the maximum dry unit weight
6. a) In the figure below, water flows from point (1) to point (3) via the soil specimen which is inclined at an angle θ . Piezometers inserted at points 1, 2 and 3 show piezometric heights h_1 , h_2 and h_3 respectively. In the figure below z_1 , z_2 and z_3 represent the distance of points 1, 2 and 3 from datum level. [4+1]
 - i) Find total heads at points 1, 2 and 3 from datum level.
 - ii) Find the hydraulic gradient for this case when water enters the specimen from point (1) and exits from point (3).



- b) Obtain the expression for the critical hydraulic gradient necessary for quick condition to develop. Why there is more likelihood of quick conditions in sand than in clay? [4+1]

7. What are the basic requirements for the design of protective filters? Is the flow through an earth dam confined flow or unconfined flow? Prove that flow lines intersect the equipotential line at right angle. [2+1+5]
8. State the assumptions of Boussinesq's equation. A water tower has circular foundation of diameter 10 m. Total weight of tower including foundation is 1800 tonnes. A very weak stratum having bearing capacity of 10 t/m^2 lies 3 m below the foundation level. Calculate the stress due to foundation load at the top of the weak stratum and as certain whether it will be safe to construct the water tower at that place with given foundation size.
9. a) A surcharge load of 15 kPa was applied on the ground surface having the soil profile as shown in figure below Consolidation settlement took place in the clay layer. Consolidation test was done for the clay layer and following results were obtained: Coefficient of consolidation, $c_v = 3.25 \times 10^{-7} \text{ m}^2/\text{s}$, Compression index, $C_c = 1.2$ and Coefficient of permeability, $k = 3.5 \times 10^{-9} \text{ m/s}$. Assume that the consolidation of clay layer is solely due to the change in stress at the center of the clay layer. Also, consider that there is no change in ground water level before and after the consolidation Take $\gamma_w = 10 \text{ kN/m}^3$.



- Determine total, effective and pore water pressure at the center of the clay layer (i) before applying the surcharge load, (ii) immediately after applying the surcharge load and (iii) sufficiently after a long time of applying the surcharge load.
- b) What will be the final settlement of the clay layer after the primary consolidation? Also, determine the settlement of clay layer after 0.5 year. [For $U = 70\%$, $T_v = 0.403$, for $U = 80\%$, $T_v = 0.569$, for $U = 90\%$, $T_v = 0.848$] [5+4]
10. How are the drainage conditions adopted in a triaxial shear test realized in the field? Derive the general formula that gives the value of the major principal stress σ_1 as a function of minor principal stress σ_3 , the cohesion and angle of internal friction. [3+7]
11. a) What are the probable types of failure of slope?
 b) Write down the possible causes of increase in shear stress or decrease in shear strength of soil in regard with slope instability.
 c) Explain remedial measures that can be used to prevent slope failure. [2+3+1]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary log-scale and simple graph papers are provided.
- ✓ Assume suitable data if necessary.

1. Explain briefly the different Civil engineering and infrastructure development problem related to soils. [2]
2. Sandy soil in a borrow pit has unit weight of solids as 25.8 kN/m^3 , water content equal to 11% and bulk unit weight equal to 16.4 kN/m^3 . How many cubic meter of compacted fill could be constructed of 3500 m^3 of sand excavated from borrow pit, if required value of porosity in the compacted fill is 30%. Also calculate the change in degree of saturation. [8]
3. What is the purpose of classifying soils? What are the basic requirements of a soil classification? Draw the plasticity chart incorporate in Indian standard soil classification system and give group symbols of various regions in the chart. [1+2+5]
4. Describe the types of possible soil structures. [4]
5. What are the factors affecting compaction? How will you control the compaction in the field? [2+4]
6. Obtain the expression for the critical hydraulic gradient necessary for a quick condition to develop by using effective stress approach. Why is there more likelihood of quick condition in sands than in clay? For a field pumping test, a well was sunk through a horizontal stratum of sand 14.5 m thick and underlain by a clay stratum. Two observation wells were sunk at horizontal distances of 16 m and 34 m respectively from the pumping well. The initial position of the water table was 2.2 m below ground level. At a steady state pumping rate of 925 liters/minute, the drawdowns in the observation wells were found to be 2.45 m and 1.20 m respectively. Calculate the coefficient of permeability of the sand. [3+1+6]
7. What is unconfined flow in seepage flow? Show the process of calculation of uplift force at base of concrete dam due to seepage flow between dam and impervious layer using flow net. [2+6]
8. A water tank is supported by a ring foundation having outer diameter of 10 m and inner diameter of 7.5 m. The ring foundation transmits uniform load intensity of 160 kN/m^2 . Compute the vertical stress induced at depth of 4 m, below the center of ring foundation. [8]

9. What is the governing differential equation in one dimensional consolidation theory? [3+3+4]

The results of a laboratory consolidation test on a clay sample are given below:

Pressure P ((kN/m ²))	void ratio, e
23.94	1.112
47.88	1.105
95.76	1.080
191.52	0.985
383.04	0.850
766.08	0.731

- Draw an e-log p plot.
- Determine the pre-consolidation pressure (p_c).
- Find the compression index (c_c).

(Provide log scale graph paper)

10. Two identical soil specimen were tested in a triaxial apparatus. First specimen failed at a deviator stress of 770 kN/m² when the cell pressure was 2000 kN/m². Second specimen failed at a deviator stress of 1370 kN/m² under a cell pressure of 400 kN/m². Determine the value of c and ϕ analytically. If the same soil is tested in a direct shear apparatus with a normal stress of 600 kN/m², estimate the shear stress at failure. [10]

11. What types of slope failures are common in soils? What factors provoke slope failure? What methods of analysis are used to estimate the factor of safety of a slope? [1+2+3]

✓ x x

Exam.	New Batch (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary log-scale and simple graph papers are provided.
- ✓ Assume suitable data if necessary.

1. In what way does the knowledge of soil mechanics help in civil engineering practice? [2]
2. A project engineer receives a laboratory report with tests performed on central material testing laboratory, IOE, Pulchowk. The engineer suspects that one of the measurements is in error. Are the engineers suspicions correct? If so, which one of these values is wrong and what should be its correct value? [8]

$$\gamma = \text{unit weight of sample} = 18.4 \text{ kN/m}^3$$

$$\gamma_s = \text{unit weight of solids} = 26.1 \text{ kN/m}^3$$

$$w = \text{water content} = 40\%$$

$$e = \text{voids ratio} = 1.12$$

$$S = \text{degree of saturation} = 95\%$$

3. Compare the Plasticity chart provided to classify fine grained soil in USCS, ISSCS and BSCS. [8]
4. What is the effect of increased surface area on the properties of soils? Illustrate by schematic diagrams how the clay minerals Kaolinite, Illite and Montmorillonite are formed. [1+3]
5. An embankment for a highway 30 m wide and 1.5 m compacted thickness is to be constructed from a sandy soil trucked from a borrow pit. The water content of the sandy soil in the borrow pit is 15% and its void ratio is 0.69. The specification requires the embankment be compacted to a dry unit weight of 18 kN/m^3 . Determine for 1 km length of embankment, the following: [2+2+2]
 - i) The weight of sandy soil from the borrow pit required to construct the embankment
 - ii) The number of 10 m^3 truck loads of sandy soil required for the construction
 - iii) The degree of saturation of the sandy soil in -situ
6. Determine the effective stress at 2m, 4m, 6m 8m and 10m in a soil mass having $\gamma_{\text{sat}} = 21 \text{ kN/m}^3$. Water table is 2 m below ground surface. Above water table there is capillary rise up to ground surface. Also draw total stress diagram up to 10.00m. [10]
7. What is a flow net? Describe its properties and uses. Prove that the discharge through an earth mass is given by, $q = K \cdot h \cdot (N_f / N_d)$ [1+2+5]

K = coefficient of permeability
 h = head
 N_f = number of flow channels
 N_d = Number of equipotential drops

8. An elevated structure with a total weight of 10,000 KN is supported on a tower with 4 legs. The legs rest on piers located at the corners of a square 6 m on a side. What is the vertical stress increment due to this loading at point 7 m beneath the center of the structure? [8]
9. A building is constructed in site having 4 m thick clay layer. The effective stress in mid of clay layer is 60 KN/m^2 . The oedometer test analysis gives preconsolidation pressure of clay is 100 KN/m^2 , coefficient of compression 0.32, coefficient of recompression 0.12 and initial void ratio 0.27. Calculate the settlement due to consolidation if [5+5]
- Building increase 30 KN/m^2 stress at mid of clay layer
 - Building increase 80 KN/m^2 stress at mid of clay layer
10. Draw a typical stress-strain and volume change characteristics curves for loose sands and dense sands from consolidated drained test. An unconfined compression test was carried out on a saturated clay sample. The maximum load the clay sustained was 127 N and the vertical displacement was 0.8 mm. The size of the sample was 38 mm diameter and 76mm long. Determine the undrained shear strength. Draw Mohr's circle of stress for the test and locate undrained shear strength (c_u). [3+7]
11. Define factor of safety. How can you calculate the factor of safety in C- ϕ analysis? [1+5]

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

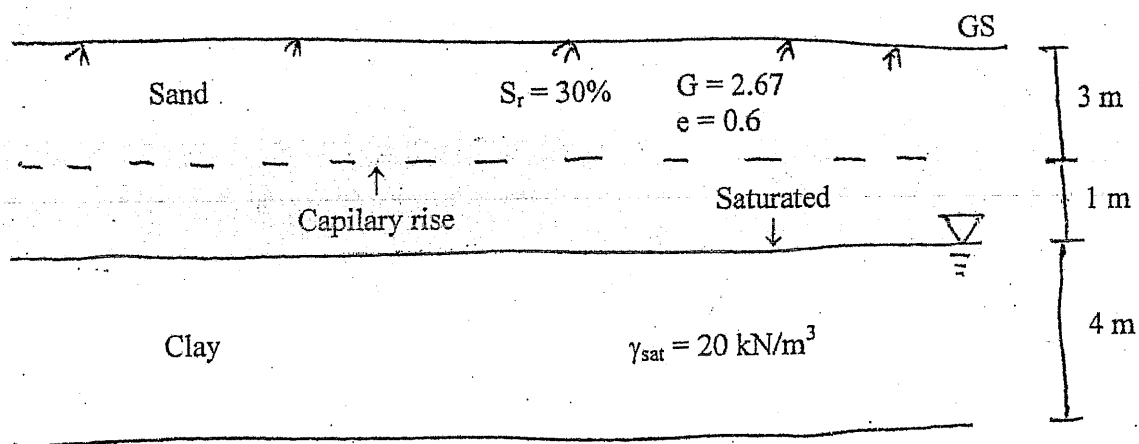
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Compare the soil classification criteria for fine soil in Indian standard soil classification system and unified soil classification system. [8]
2. The following results refer to the liquid limit test. [8]

No. of blow	33	23	18	11
Water content (%)	41.5	49.5	51.5	55.6

The plastic limit from two tests were 23% and 24% respectively. Determine the plasticity index and toughness index for the soil.

3. List the types of soil depending on its formation. Describe the possible soil structures in natural soil mass. [2+4]
4. What is the effect of compaction on the engineering properties of the soil? How would you decide whether the soil should be compacted the dry of the optimum or the wet of optimum? [6]
5. For the subsoil conditions as shown in figure below, plot the total, neutral and effective stress distribution up to the bottom of the clay layer. [10]



6. Derive an equation for topmost flow line in case of a homogeneous earth dam. [8]
7. A rectangular area 4 m × 2 m is uniformly loaded with a load intensity of 100 kN/m² at a ground surface. Determine the vertical pressure at a depth 3 m below a point within the loaded area 1 m away from the short edge and 0.5 m away from the long edge. Use equivalent point load method. [8]

8. A 25 mm thick clay sample was used in oedometer consolidation test. During test it takes one month for 50% consolidation. If same clay of 5 m thick is in between rock layer and sand layer in site. Calculate the time required for 90% consolidation in site after construction of building in site.

[10]

9. A consolidated undrained test was conducted on a clay specimen and the following result were obtained.

[10]

Cell pressure (KN/m ²)	200	400	600
Deviator stress (KN/m ²)	118	240	352
Pore water pressure at failure (KN/m ²)	110	220	320

Determine the shear strength parameter with respect to effective stress.

10. An embankment is to be made from a soil with $C_u = 20 \text{ kN/m}^2$, $\phi_u = 20^\circ$ and $\gamma = 20 \text{ kN/m}^3$. If a factor of safety of 1.5 with respect to shear strength is required for the embankment slope, determine the limiting height of the slope, if built at a slope angle of 25° .

[6]

70/m 10/15 M.

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define Soil Mechanics and write its importance. What type of Geo-technical problems may occur in Civil Engineering and Infrastructure Development, describe in brief. [2+3+3]
b) A clay sample, containing its natural moisture content, weighs 0.333 N. The specific gravity of solids of this soil is 2.70. After oven-drying, the soil sample weighs 0.2025 N. The volume of the moist sample, before oven-drying, found by displacement of mercury is 24.30 cm³. Determine the moisture content, void ratio and degree of saturation of the soil. [8]
2. a) What is compaction? Explain the salient features of modified AASHTO compaction test. How will you control the compaction in the field? [1+2+5]
b) A permeameter of diameter 82.5 mm contains a column of fine sand 460 mm long. When water flows through it under constant head at a rate of 191 ml/min, the loss of head between two points 250 mm apart is 380 mm. Calculate coefficient of permeability. If falling head test is made on same sample using a stand pipe of diameter 30 mm, in what time the water level in stand pipe will fall from 1560 mm to 1060 mm? [4+4]
3. a) Define phreatic line and write down the procedure to construct phreatic line on any Earthen Dam with neat sketch. [8]
b) A point load of 140 kN is applied at the ground surface. Construct a pressure bulb when the stress imposed becomes 20% of the applied load. [8]
4. a) Define shear strength of soil. Using the result of triaxial test, derive the relation for major principle stress (σ_1) in terms of minor principle stress (σ_3) and shear strength parameters (i.e. c and ϕ). [8]
b) An open layer of clay 4 m thick is subjected to loading that increases the average effective vertical stress from 185 kPa to 310 kPa. Given $m_v = 0.00025 \text{ m}^2/\text{KN}$, $C_v = 0.75 \text{ m}^2/\text{year}$, determine [8]
 - i) the total settlement,
 - ii) the settlement at the end of 1 year,
 - iii) the time in days for 50% consolidation,
 - iv) the time in days for 25 mm of settlement to occur.
5. a) Draw the void ratio effective stress diagram and define coefficient of compressibility and compression Index. Define Normally Consolidated and Over Consolidated Clay. [3+2+3]
b) An infinite slope has an inclination of 26° with the horizontal. It is underlain by a firm cohesive soil having $G_s = 2.72$ and $e = 0.52$. There is a thin weak layer 6 m below and parallel to the slope ($c' = 25 \text{ kPa}$, $\phi' = 16^\circ$). Compute the factors of safety when (i) the slope is dry, and (ii) ground water flows parallel to the slope at the slope level. [8]

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Define soil and soil mechanics. Also define flow index and toughness index of soil. [2+2]
b) A sample of soil with liquid limit of 72.8% was found to have a liquidity index of 1.21 and water content of 81.3%. What are its plastic limit and plasticity index? [6]
2. A sample of inorganic soil has the following grain size characteristics. [8]

Size (mm)	Percent passing
0.075 (No. 200)	55

The liquid limit is 50% and plastic limit 40%.

Classify the soil according to the AASHTO classification system.
3. What are soil structure and fabrics? Explain electrical charges on clay minerals. [4]
4. Enlist the reasons for the maximum dry density obtained in field not being equal to that obtained in the laboratory. Also prove that the energy applied in the modified proctor test is 4.56 times greater than that of the standard proctor test. [4+2]
5. a) Mention the effect of the seepage flow on the effective stress. [4]
b) A tube well is driven in a confined aquifer of 24 m thick. The aquifer is met 25 m below ground level. The static water table is 15 m below ground level. The discharge of tube well is found to be 6000 m³/day when the draw down in the well is 12.25 m. Find the diameter of the tube well when the radius of the circle of influence (R) is 300 m. Take the permeability 24.5 m/day. [6]
6. Derive an equation for topmost flow line in case of a homogeneous earth dam with horizontal filter at the base. [8]
7. What is significant depth? Draw the stress contour for the significant depth for a single concentrated load of 1000 kN acting at the ground surface. [2+6]
8. a) Explain the factors that affect the degree of consolidation. [4]
b) A stratum of clay is 2 m thick and has an initial overburden pressure of 50 KN/m² at its middle. Determine the final settlement due to an increase in pressure of 40 KN/m² at the middle of the clay layer. The clay is over consolidated, with a pre-consolidation pressure of 75 KN/m². The values of the coefficients of recompression and compression index are 0.05 and 0.25 respectively. Take the initial void ratio as 1.40. [6]
9. a) Explain Mohr Coulomb failure criterion. State major principle plane, intermediate plane and minor principle plane. [5]
b) Explain with figure the procedure of triaxial shear test. [5]
10. a) Explain the various types of factor of safety related in stability of slope. Write differences between finite and infinite slope. [2+1]
b) Explain friction circle method of stability of slope. [3]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Soil Mechanics (CE552)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain the types of problems that geotechnical engineer faces. What are the types of clay minerals of engineering interest? [2+4]

- b) The following results refer to the liquid limit test [8]

No of blows	33	23	18	11
Water content (%)	41.5	49.5	51.5	55.6

The plastic limit from two tests were 23% and 24% respectively. Determine the plasticity index and toughness index for the soil.

2. How do you identify the fine grain soil in the field? Explain the process of the classification of the fine soil with the help of plasticity chart. [4+4]

3. a) What is difference between compaction and consolidation? [3]

- b) How will engineering properties of soil be improved by compaction. [3]

4. State quick sand condition. A sand deposit consists of two layers the top layer is 3 m thick ($\rho = 1800 \text{ kg/m}^3$) and the bottom layer is 3.5 m thick ($\rho_{\text{sat}} = 2500 \text{ kg/m}^3$). The water table is at a depth of 4 m from the surface and zone of capillary saturation is 1 m above the water table. Draw the diagram showing the variation of total stress, neutral stress and effective stress. [2+8]

5. State the flow net in a non-homogeneous soil mass. Prove that the stream function satisfies the laplace equation. Explain the protective filters for prevention of erosion. [2+4+2]

6. a) Mention the process of the drawing the pressure bulb. [4]

- b) A strip footing of width 2 m carries a load of 400 KN/m. Calculate the maximum stress at a depth of 5 m below the center line of the footing. Compare the results with 2:1 distribution method. [2+2]

7. Drive the general equation for the calculation of settlement from one-dimensional primary consolidation. How can you differentiate log time method with square root of time method? [6+4]

8. a) State the Mohr failure theory and derive the Mohr Coulomb equation. [4]

- b) In a CD test, a specimen of saturated sand fails under an additional stress of 250 KN/m^2 when the cell pressure was 100 KN/m^2 . Draw the Mohr circle and determine: [6]

- i) Angle of shearing resistance
- ii) Inclination of failure plane with the horizontal
- iii) Values of shear and normal stress on the Failure plane.

9. A granular soil has $\gamma_{\text{sat}} = 19 \text{ KN/m}^3$, $\phi = 35^\circ$. A slope has to be made of this material. If a factor of safety of 1.30 is needed against the failure, determine the safe angle of the slope. [6]

- i) When the slope is dry
- ii) If the seepage occurs at and parallel to the surface of the slope