USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION - A

There are FOUR questions in this section. Answer any THREE.
Assume reasonable data, if missing.

1. (a) By using trapezoidal rule of numerical integration, compute the discharge when width of the rectangular channel is 5.0 m, the mean velocity for the following velocity measurements are obtained for the depth of flow 3.6 m.

<table>
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<th>0.0</th>
<th>0.60</th>
<th>1.20</th>
<th>1.80</th>
<th>2.20</th>
<th>2.60</th>
<th>3.00</th>
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<tr>
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<td>0.79</td>
<td>1.65</td>
<td>1.98</td>
<td>2.65</td>
<td>3.07</td>
<td>2.41</td>
<td>1.15</td>
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</tbody>
</table>

(b) Using the Lacey method, design a stable alluvial channel when \( d_{50} = 5.0 \) mm and \( Q = 8.0 \) m\(^3\)/s.

(c) For laminar flow the velocity distribution in a vertical can be approximated by

\[
\frac{u}{y} = 4 \left( \frac{z}{y} \right)^{\frac{1}{2}}
\]

Where \( u \) is the velocity at a distance \( z \) from the channel bottom, \( y \) is the depth of flow. Compute the velocity distribution coefficients \( \alpha \) and \( \beta \) for this channel.

(d) Show that the total pressure head can be expressed as

\[
\text{Total pressure head} = y \left( 1 + \frac{v^2}{2g} \right)
\]

(e) Define: (i) Stage, (ii) Artificial channel, and (iii) Hydraulic radius.

2. (a) Define specific energy. Draw a specific energy curve and list up all the characteristics of the curve.

(b) Prove that for a triangular channel \( y_c = \sqrt{\frac{2\alpha Q^2}{g z^2}} \).

(c) Water is flowing at a velocity of 1.50 m/s and a depth of 1.10 m in a long rectangular channel 3.0 m wide. Compute (i) the height of a smooth upward step in the channel bed that will produce critical flow in the channel, and (ii) the depth and change in water level produced by (a) a smooth upward step of 0.35 m, (b) a smooth upward step of 0.95 m. In all cases, neglect energy losses and take \( \alpha = 1.05 \).

(d) A trapezoidal channel is given with \( b = 2.0 \) m, side slope \( 2H : 1V \) and \( Q = 10 \) m\(^3\)/s. Calculate the critical depth and velocity by Bi-section method. Given \( \alpha = 1.00 \).

Contd ............ P/2
WRE 301

3. (a) The values of initial depth and sequent depth in connection with a hydraulic jump in a horizontal rectangular channel are 0.22 m and 3.48 m respectively. Compute the values of V₁ (m/s), V₂ (m/s), Fr₁, Fr₂, q (m³/s/m) and h_L. (12)

(b) Prove that for a hydraulic jump in a horizontal rectangular channel the efficiency of the jump can be computed by using the initial Froude no only. (11)

(c) Define: (i) submerged jump, (ii) length of the jump, and (iii) energy loss in a jump. (9)

(d) A rectangular channel is 1.5 m wide and inclined at an angle of 4° with the horizontal. Determine the type of jump when the discharge is 0.50 m³/s, the initial depth of flow section (d₁) is 0.05 m and tail water depth is 0.75 m. Also determine d₂ and y₂*. (14 2/3)

4. (a) Prove that the best hydraulic trapezoidal section is one half of a regular hexagon. (8)

(b) List up material used in the construction of a rigid boundary channel and also mention the choice of selecting a material. (5)

(c) A lined channel with n = 0.022 is to be laid on a slope of 1 in 1200. The side slope of the channel is to maintained at 2.0H : 1.0V. Determine the section dimensions of a practical trapezoidal section with rounded corners to carry a discharge of 62 m³/s when the maximum permissible velocity is 2.5 m/s. (12)

(d) A trapezoidal channel is to be laid on a slope of 1 in 1000 and carry a discharge of 18 m³/s. It is to be excavated in earth containing slightly rounded coarse non-cohesive material with d₅₀ = 2.2 cm, d₇₅ = 2.54 cm and n = 0.024. Determine the section dimension of the channel. (see Figure 1 and Figure 2) [Use 1 trial only]. (16 2/3)

(e) Why Lacey's method is better than Kennedy's method in design of regime channel. (5)

SECTION – B

There are FOUR questions in this section. Answer any THREE. Use reasonable value of any missing data. Notations have their usual meanings. Draw sketches where necessary.

5. (a) Define uniform, steady-gradually varied, unsteady-gradually varied and steady-rapidly varied flow, unsteady-rapidly varied flow. (10)

(b) Derive the condition for the establishment of uniform flow and hence show that uniform flow cannot occur in a frictionless channel. (10)

(c) If a stone is thrown into the flowing water of a wide rectangular channel whose bed slope is 0.0001, n = 0.025 and q = 50 m³/s/m, show the resulting small amplitude waves in sketches. What happens if the slope is increased to 0.01. (12)

(d) Velocity at the water surface of a 50 m wide channel is measured to be 2 m/s, water depth = 4 m and the bed roughness height or effective mean bed diameter = 0.01 m. Compute the bed stress and the bed slope. (14 2/3)

Contd .......... P/3
6. (a) Briefly describe the vertical velocity distribution in a laminar sublayer and turbulent boundary layer.

(b) Discuss the factors affecting Manning's n.

(c) The sides of a rectangular laboratory flume is made of glass (C = 60) and the bottom is made of steel (C = 50). Compute the discharge in the flume if \( h_n = 0.4 \) m and \( S_0 = 0.001 \).

(d) For a trapezoidal channel with \( b = 6 \) m, \( s = 2 \), \( n = 0.025 \), and \( S_o = 0.001 \), \( Q = 40 \) m\(^3\)/s. Compute normal depth by the Newton-Raphson method.

7. (a) Briefly describe the procedure to compute discharge in a channel of compound cross-section with two subsections.

(b) Derive the Belanger equation for gradually varied flow (GVF) in a wide channel from the dynamic equation of GVF.

(c) Discuss the behavior of flow profiles in different regions of a horizontal channel with sketches.

(d) Draw the possible flow profiles for the following serial arrangement of channels:
   
   - (i) steep-mild-milder
   - (ii) adverse-steep-free-overfall
   - (iii) mild-critical steep

8. (a) Briefly describe the procedure to compute the GVF profiles using the standard step method.

(b) A trapezoidal channel with \( b = 6 \) m, \( s = 2 \) is laid on a slope of 0.0025 and carries a discharge of 30 m\(^3\)/s. The depth produced by a dam immediately upstream of it is 2.5 m. Compute the flow depth at 100 m upstream of the dam using the modified Euler method. Use \( \alpha = 1.12 \) and \( n = 0.025 \).

(c) A wide channel having \( C = 47 \) m\(^{1/2}\)/s has two reaches arranged serially. The normal depth of the reaches are 3.13 m and 2.63 m respectively for \( q = 2 \) m\(^3\)/s/m. Compute the resulting flow profile(s).
Fig. 1: Angle of repose of non-cohesive materials (Lane, 1955)

Fig. 2: Maximum shear stresses on (a) sides and (b) bottom of trapezoidal channels
SECTION - A

There are FOUR questions in this section. Answer any THREE.

Assume reasonable values for missing data, if any.

1. (a) Write down the fundamentals assumptions used for the behaviour of reinforced concrete. (7)
   (b) What are the sources of uncertainties in analysis, design and construction of RC structures? Discuss how safety is ensured against these uncertainties in USD method. (7)
   (c) A simply supported beam (as shown in Fig. 1) with a cross-section of 12" x 20" is reinforced with 3 (three) no. 8 bars at a depth of 7 inch. The beam is subjected to a uniform distributed load, w on a span length of 20 ft. Given: concrete compressive strength = 4 ksi, yield strength of steel = 60 ksi and n = 8.
   (i) Determine the load, w at which the first flexural crack will develop on the beam. (10)
   (ii) Determine stresses in concrete and steel caused by a bending moment of 140 k-ft. (11)

2. (a) Why is concrete cover over rebar important. What are the recommended values of 'cover' as per ACI code? (7)
   (b) Explain the meaning of "over reinforced" and "under reinforced" beams? (7)
   (c) For the beam cross-section shown in Fig. 2,
      (i) Determine whether the failure of the beam will be initiated by crushing of concrete or yielding of steel. Given: \( f'_c = 3 \) ksi, \( f_y = 60 \) ksi. (21)
      (ii) Calculate the nominal moment capacity of the beam section.
      (iii) Calculate the safe distributed load intensity that the beam can carry if the beam is simply supported with a span of 26'.

3. (a) A rectangular beam must carry a service live load of 2 k/ft and a calculated dead load of 1.5 k/ft on a 20 ft simple span. The beam section is limited to a width of b = 10 inch and total depth, h = 22 inch. Calculate the required reinforcements. Given: \( f'_c = 4 \) ksi and \( f_y = 60 \) ksi. (25)
   (b) Give reasons for minimum bar spacing requirements in the ACI code. (5)
   (c) Show with neat sketches cut off or bends point for bars in approximately equal span with uniformly distributed loads. (5)

Contd .......... P/2
4. (a) A reinforced concrete one-way slab is built integrally with its supports and consists of two-equal spans, each with a clear span of 16 ft. Given: Live load = 40 psf; Floor finish = 25 psf; Partition wall load = 45 psf; $f'_c = 4$ ksi and $f_y = 60$ ksi. Design the slab by USD and show the reinforcements with neat sketches. (25)

(b) A doubly reinforced rectangular beam (Fig. 3) having cross-section of $12'' \times 20''$ is reinforced with 3 (three) No. 10 bars for tension reinforcements and 2 (two) No. 8 bars for compression reinforcements. The effective depth of the beam is 17'' and compression reinforcement is located 2.5 inch below from the top of the beam. Calculate the development lengths for both the top and the bottom bars. Given: $f'_c = 4$ ksi and $f_y = 60$ ksi. (10)

**SECTION – B**

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A tensile reinforcement T beam is to be designed to carry a uniformly distributed load on a 20 ft simple span. The total factored moment to be carried is $M_u = 500$ kip-ft. Concrete dimension, governed by web shear and clearance requirements, are $b_w = 10$ inch, $b_r = 5$ inch and $d = 20$ inch. If $f_y = 60$ ksi and $f'_c = 4$ ksi, what tensile reinforcement is required at midspan? (26)

(b) Draw sketches for stress and strain distribution diagrams of a reinforced concrete beam section when subjected to bending for uncracked, cracked and ultimate condition. (9)

6. (a) In moment coefficient method, positive moment coefficients are different for dead and live loads – explain. (5)

(b) Design the slab system shown in Figure 4, the slab is to carry a service live load of 60 psf; as for dead load assume floor finish load to be 25 psf and permanent partition wall load to be 60 psf in addition to self weight of slab. Given: $f'_c = 3$ ksi, $f_y = 60$ ksi. Use moment coefficient method. Assume beams are stiff ($\alpha_m$ is greater than 2.0). Show all reinforcements in sketches. (30)

7. (a) Describe the mechanism of shear resistance in a RC beam with vertical stirrups. (7)

(b) Discuss the locations of critical section for shear design for different support condition with sketches. (7)

(c) Using USD method, design shear reinforcement at the beam as shown in Figure 5. The load shown in the figure are factored. Show the reinforcement in a neat sketch. Given, $f'_c = 3.5$ ksi and $f_y = 60$ ksi. (21)

8. (a) What is the purpose of providing minimum amount of flexural steel in a beam? Write ACI/BNBC code provisions for minimum reinforcement ratios. (5)

(b) At failure, determine whether the precast section shown in Figure 6 will act similarly to rectangular section or as flanged section. Given, $f'_c = 4$ ksi, $f_y = 60$ ksi. Also, calculate the nominal moment strength of this section. (30)
Figure 4

LL = 60 psf
FF = 25 psf
pavilion = 60 psf
f'c = 3 ksi
f'v = 60 ksi

Figure 5

Given: f'c = 3 ksi
f'v = 60 ksi

Figure 6

4 in. (101.6 mm)
12 in. (304.8 mm)
4 No. 9 bars
### Table 12.3 Coefficients for negative moments in slabs

\( M_{p, m} = C_{m, n} M_{d} \) where \( M_{d} = \) total dead load

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<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
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<th>Case 6</th>
<th>Case 7</th>
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</table>

- A hatched edge indicates that the slab continues across, or is fixed at, the support; an unrestated edge indicates a support at which torsional restraint is negligible.

### Table 12.4 Coefficients for dead load positive moments in slabs

\( M_{p, m} = C_{m, n} M_{d} \) where \( M_{d} = \) total uniform dead load

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
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- A hatched edge indicates that the slab continues across, or is fixed at, the support; an unrestated edge indicates a support at which torsional restraint is negligible.
Table 12.5 Coefficients for live load positive moments in slabs

\( M_{SL,PL} = C_{SL,PL} M \) where \( m = \) total uniform live load

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<td>0.068</td>
<td>0.064</td>
<td>0.064</td>
<td>0.064</td>
<td>0.064</td>
</tr>
<tr>
<td>0.60</td>
<td>0.081</td>
<td>0.057</td>
<td>0.071</td>
<td>0.071</td>
<td>0.076</td>
<td>0.072</td>
<td>0.072</td>
<td>0.072</td>
<td>0.072</td>
</tr>
<tr>
<td>0.55</td>
<td>0.088</td>
<td>0.062</td>
<td>0.080</td>
<td>0.080</td>
<td>0.085</td>
<td>0.081</td>
<td>0.081</td>
<td>0.081</td>
<td>0.081</td>
</tr>
<tr>
<td>0.50</td>
<td>0.095</td>
<td>0.066</td>
<td>0.088</td>
<td>0.087</td>
<td>0.092</td>
<td>0.087</td>
<td>0.087</td>
<td>0.087</td>
<td>0.087</td>
</tr>
</tbody>
</table>

Table 12.6 Ratio of load \( W \) in \( l_1 \) and \( l_2 \) directions for shear in slab and load on supports

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Case 6</th>
<th>Case 7</th>
<th>Case 8</th>
<th>Case 9</th>
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<tbody>
<tr>
<td>1.00</td>
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<td>0.50</td>
<td>0.17</td>
<td>0.50</td>
<td>0.83</td>
<td>0.71</td>
<td>0.29</td>
<td>0.33</td>
<td>0.67</td>
</tr>
<tr>
<td>0.95</td>
<td>0.55</td>
<td>0.55</td>
<td>0.20</td>
<td>0.55</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.90</td>
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<td>0.60</td>
<td>0.20</td>
<td>0.60</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.85</td>
<td>0.68</td>
<td>0.68</td>
<td>0.20</td>
<td>0.68</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.80</td>
<td>0.71</td>
<td>0.71</td>
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<td>0.71</td>
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<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
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<td>0.75</td>
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<td>0.80</td>
<td>0.20</td>
<td>0.80</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
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</tr>
<tr>
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<td>0.85</td>
<td>0.20</td>
<td>0.85</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.65</td>
<td>0.89</td>
<td>0.89</td>
<td>0.20</td>
<td>0.89</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.60</td>
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<td>0.92</td>
<td>0.20</td>
<td>0.92</td>
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<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>0.55</td>
<td>0.95</td>
<td>0.95</td>
<td>0.20</td>
<td>0.95</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
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<td>0.99</td>
<td>0.20</td>
<td>0.99</td>
<td>0.83</td>
<td>0.71</td>
<td>0.33</td>
<td>0.35</td>
<td>0.71</td>
</tr>
</tbody>
</table>

* A crosshatched edge indicates that the slab continuity stress at load is \( m \), the support; an unmarked edge indicates a support at which longitudinal moment is negligible.
GRAPH A.4
Interpolation charts for lateral distribution of slab moments.
SECTION – A

There are FOUR questions in this section. Answer any THREE.

1. (a) Compute the change in slope of the cross bar at point D of the frame due to the loads as shown in Fig. 1(a). All the members have properties as follows: E = 29 \times 10^3 \text{ ksi, } I = 54 \text{ in}^4, A = 18 \text{ in}^2.  
   \hspace{1cm} (28)

   (b) Determine the absolute maximum bending moment for the simply supported beam with 100 ft span, due to the moving wheel loads as shown in Fig. 1(b).  
   \hspace{1cm} (18 \frac{2}{3})

2. (a) Determine vertical deflection of point 'c' in the truss shown in Fig. 2 due to the combined effect of the following–  
   (i) the load shown in Fig. 2.  
   (ii) a drop in temperature by 50° F in the top chord only, \( \alpha_t = 1/150000 \text{ per } ^\circ \text{ F} \)  
   (iii) a horizontal displacement of support 'b' by 4 inch to the right and a vertical displacement of support 'a' by 3 inch upwards.  
   (b) For the frame in Fig. 1(a), draw the influence lines for all the reactions at 'A' if the load can only move between point 'B' to point 'D'. Also draw influence line for shear and moment at mid-height of the member 'AC'.  
   \hspace{1cm} (18 \frac{2}{3})

3. (a) Determine maximum positive bending moment at section a-a of the beam due to the series of wheel loads shown in Fig. 3(a).  
   \hspace{1cm} (23)

   (b) Draw influence lines for axial force in members 'U3U4', 'U3L3', 'L3L4' and 'U4L3' of the truss shown in Fig. 3(b). Unit load moves along the top chord of the truss.  
   \hspace{1cm} (23 \frac{2}{3})

4. (a) Draw influence lines for all the floor beam reactions and reactions at A and B of the plate girder shown in Fig. 4(a). Also draw influence lines for \( V_{2-3} \) and \( M_3 \).  
   \hspace{1cm} (26)

   (b) A suspension bridge with stiffening truss is shown in Fig. 4(b). Determine the forces in the bars (that are marked) due to the loads imposed on the bridge.  
   \hspace{1cm} (20 \frac{2}{3})

Contd ............ P/2
There are **FOUR** questions in this section. Answer any **THREE**.
Assume any reasonable value of missing data.

5. (a) The span and rise of an arch are 40m and 10m, respectively. The equation of the three-hinged parabolic arch is \( y = x - \frac{x^2}{40} \) with the origin at the left support and x-axis directed towards the right and y-axis upwards. A uniformly distributed load of 15 kN/m is applied on the left half of the arch as shown in Fig. 5. Draw a moment diagram of the arch and determine the location of the maximum negative moment.

(b) Determine the bar force "a" of the truss as shown in Fig. 6.

6. (a) A 7-storied RC residential building has a plan dimension of 80 ft × 70 ft and typical floor-to-floor height of the building is 10 ft except the ground floor. The height of the ground floor is 12 ft. The building is an intermediate moment resisting frame having slab thickness of 6 inch. Floor finish, partition wall load, service live load are 25 psf, 80 psf and 40 psf, respectively. Determine the shear force distribution along the height of the building for Earthquake resistant design. Given: \( R = 8, I = 1.25, S = 1.25 \) and \( Z = 0.15 \).

(b) Determine the axial forces in members "x" and "y" of the truss shown in Fig. 7 assuming that the shear in each panel is divided equally between the diagonals.

7. (a) Draw the shear force and bending moment diagrams for the building frame loaded as shown in Fig. 8.

(b) Draw the shear force and bending moment diagrams of the columns for the building frame as shown in Fig.9. Use Portal method.

8. Using Cantilever method, draw the axial force, shear force and bending moment diagrams of the beams and columns for the building as shown in Fig. 10. Relative column cross-sectional areas are given beside the columns.
\( \text{CE 321} \)

\[ \begin{array}{c}
\text{Figure - 1(a)} \\
\end{array} \]

\[ A = 1 \text{ in}^2 \text{ for all members} \]
\[ E = 29000 \text{ ksi} \]

\[ \begin{array}{c}
\text{Figure - 2(a)} \\
\end{array} \]

\[ \begin{array}{c}
\text{Figure - 3(a)} \\
\end{array} \]

\[ \begin{array}{c}
\text{Figure - 4(a)} \\
\end{array} \]
1. (a) Draw neatly the plasticity chart according to Unified Soil Classification System (USCS). (10)
(b) A sample of clayey soil was tested for liquid limit in a cone penetrometer and the following results were obtained.

<table>
<thead>
<tr>
<th>Core Penetration (mm)</th>
<th>16</th>
<th>18</th>
<th>22</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content (%)</td>
<td>33</td>
<td>40</td>
<td>54</td>
<td>63</td>
<td>83</td>
</tr>
</tbody>
</table>

Determine liquid limit of the sample and also check the results for single point method using the data relevant. (13 2/3)

(c) Define Darcy's law and mention the factors affecting coefficient of permeability of soils. Also estimate the value of coefficient of permeability of a loose sand with rounded grains if the effective grain size is 0.25 mm. (13)

(d) In a clay deposit, it has been proposed to adopt a circular ring type of foundation with inner diameter of 7 m and outer diameter of 9 m at a depth of 1.5 m below the ground levels. If the foundation is subjected to a loading intensity of 50 kN/m², find the vertical stress along a vertical line. Passing through the centre of the foundation at a depth of 5 m from the ground level. (10)

2. (a) Classify the following two inorganic soils according to USCS:

Soil A: Percent finer No. 200 sieve (0.075 mm) = 90
Liquid limit = 45%
Plastic limit = 21%

Soil B: Percent finer No. 4 sieve (4.75 mm) = 91
Percent finer No. 10 sieve (2.0 mm) = 60
Percent finer No. 40 sieve (0.425 mm) = 30
Percent finer No. 200 sieve (0.075 mm) = 10
Liquid limit = 38%
Plastic limit = 25%

(b) What are the characteristics of a flow net? For the flow net of a spillway as shown in Fig. 1, find the following:

(i) the quantity of seepage if the value of coefficient of permeability, \( K = 3 \times 10^{-5} \) m/sec.
(ii) the seepage pressure at a point A located 7 m below the surface of the soil layer, and
(iii) the hydrostatic pressure at A. (14)
Contd ... Q. No. 2

(c) Unconfined compression test was carried out on an undisturbed cohesive sample of height 3 inch and diameter 1.5 inch. It was found that the sample failed at an axial strain of 10%. The failure compressive load was 35.4 lb. What will be the sensitivity of the sample if the unconfined compressive strength of the same sample in the remoulded state at an unaltered water content is 6 lb/in²?

(d) Describe briefly the behaviour of saturated clay samples in unconsolidated undrained (UU) triaxial compression test. Also show with neat sketches two examples of UU analysis in clays.

3. (a) A clay sample (liquid limit = 55% and plastic limit = 28) was collected from a depth of 5 m below the ground level. The water table is at the ground level and saturated unit weight of the sample is 18.6 kN/m³ from a laboratory consolidation test the preconsolidation pressure of the sample was found to be 176 kN/m². Estimate the undrained shear strength of the sample at that depth.

(b) A series of consolidated undrained (CU) triaxial compression test were conducted on saturated specimens of an overconsolidated clay and the following results were obtained at failure:

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Cell pressure (kN/m²)</th>
<th>Deviator stress (kN/m²)</th>
<th>Pore pressure (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>125</td>
<td>510</td>
<td>-70</td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>620</td>
<td>-10</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
<td>850</td>
<td>120</td>
</tr>
</tbody>
</table>

Draw Mohr Circles in terms of effective stresses and hence determine the values of effective shear strength parameters c' and φ' of the sample. Also write down the Mohr-Coulomb equation for the effective stress failure envelope.

(c) Draw the following qualitative curves:

(i) Pore pressure change versus axial strain for saturated samples of normally consolidated and overconsolidated clays in CU triaxial compression tests.

(ii) Volumetric strain versus axial strain for saturated samples of normally consolidated and overconsolidated clays in consolidated drained (CD) triaxial compression tests.

(iii) Variation of pore pressure parameter B with degree of saturation.

(iv) Variation of pore pressure parameter A at failure (Aₜ) with overconsolidation ratio (OCR).
4. (a) A foundation trench is to be excavated in a 6 m thick clay layer which is underlain by a bed of sand. The water table is at a depth of 1 m from the ground surface. Find the depth to which excavation can be safely carried out without the danger of the bottom becoming unstable under the uplift pressure of ground water. The saturated unit weight of the clay is 19.62 kN/m$^3$. It excavation is to be carried out safely to a depth of 4.5 m, how much should the water table be lowered in the vicinity of the excavation?

(b) A 6 m by 3 m rectangular footing is loaded by 30 KN/m$^2$. Find the vertical stress at a depth of 3 m below the points A, B and C as shown in Fig. 2.

(c) Briefly discuss the advantages of triaxial compression test over direct shear test.

(d) Two identical specimens of a saturated normally consolidated clay sample were fully consolidated in the triaxial cell under a cell pressure of 150 kN/m$^2$. Pore pressure within each specimen at the end of consolidation was zero. One specimen was then sheared under undrained condition and the other under drained condition until failure took place. The values of deviator stress at failure in the undrained and drained tests were found to be 175 kN/m$^2$ and 250 kN/m$^2$, respectively. Compute the values of $\psi'$ and $\phi_u$. Also calculate the value of pore pressure parameter $A$ at failure ($A_f$).

5. (a) State the lateral earth pressure conditions for the following cases with brief reasoning: (8+$\frac{2}{3}$+$4$)

(i) Design of a basement wall

(ii) Design of a free-standing cantilever wall

Differentiate between the states of elastic and plastic equilibrium with respect to lateral earth pressure of soil.

(b) Show graphically, using Mohr circle failure envelop, changes in stress conditions in a soil as its transitions from the at rest condition to the active condition. Also show the development of shear failure planes in the soil behind a wall as its transitions from the at rest condition to the passive condition.

Derive the equation (symbols have their usual meanings):

\[ \sigma' = yz \tan^2 \left( \frac{45 - \phi'}{2} \right) - 2c' \tan \left( \frac{45 - \phi'}{2} \right) \]

(c) A wall with a smooth vertical back 3 m high retains a mass of dry cohesionless sand that has a horizontal surface. The sand weighs 18 kN/m$^3$ and has an angle of internal friction of 36°. What is the approximate resultant pressure against the wall, if the wall is prevented from yielding? If the wall can yield far enough to satisfy the deformation condition for the active Rankine state?

What is the resultant lateral pressure against the yielding wall for active Rankine state, if the sand mass supports a uniformly distributed load of 20 kPa? At what height above the base of the wall is the center of pressure?
CE 381/WRE

6. (a) How do you determine permeability of clay using 1-D consolidation test results? (15)

(b) The current $\sigma'_z$ at a certain point in a saturated clay is 181 kPa. This soil is to be covered with a 2.5 m thick fill that will have a unit weight of 19.3 kN/m$^3$. What will be the value of $\sigma'_z$ at this point immediately after the fill is placed (i.e., before any consolidation has occurred)? What will be after the consolidation settlement is completed? Also show graphically

(i) the variation of the degree of consolidation with depth (length of drainage path) for different $T_v$ values.

(ii) the relationship between the average degree of consolidation and time factor $T_v$.

(c) For a normally consolidated clay, the following values are given:

\[
\begin{align*}
e &= e_0 = 1.21 & \sigma'_0 &= 2 \text{ tsf} \\
e_1 &= 0.96 & \sigma'_0 + \Delta \sigma &= 4 \text{ tsf}
\end{align*}
\]

The hydraulic conductivity $k$ of the clay for the preceding loading range is $1.8 \times 10^{-4}$ ft/day.

(i) How long in days will it take for a 9-ft thick clay layer (drained on one side) in the field to reach 60% consolidation?

(ii) What is the settlement at the time (i.e., at 60% consolidation)?

7. (a) Write down the properties of Modified Proctor test. How do you use the information of laboratory compaction test result of a clay in the field in quality control scheme? (15)

(b) A proposed embankment fill requires 5000 m$^3$ of compacted fill. The void ratio of the compacted fill is specified as 0.7. Four borrow pits are available as described in the following table, which lists the respective void ratios of the soil and the cost per cubic meter for moving the soil to the proposed construction site. Make necessary calculations to select the pit from which the soil should be brought to minimize the cost. Assume $G_s$ to be the same at all the pits. (14)

<table>
<thead>
<tr>
<th>Borrow pit</th>
<th>void ratio</th>
<th>Cost (Tk/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.85</td>
<td>720</td>
</tr>
<tr>
<td>B</td>
<td>1.2</td>
<td>480</td>
</tr>
<tr>
<td>C</td>
<td>0.95</td>
<td>560</td>
</tr>
<tr>
<td>D</td>
<td>0.75</td>
<td>800</td>
</tr>
</tbody>
</table>

(c) State graphically typical variation of dry density ($\gamma_d$) of clay soil with moisture content, $\omega$. In the same plot, also show the followings: (8)

(i) Variation of $\gamma_d$ ~ $\omega$ with compaction efforts.

(ii) Locus of the optimum states

(iii) Zero-air-void density with $\omega$

Name various methods for field density determination. Describe any one.

Contd ........... P/5
8. (a) What are the three most common clay minerals? Make a comparison of properties of these minerals and obtain a conclusion that delineates the main cause of a mineral to become the most problematic for geotechnical engineers. Also, state which one is the stable clay mineral? Why it is so?

Using basic definition (don't use phase diagram), derive the following equation for a soil element:

\[ S_r = \frac{\omega G_s}{e} \]

(b) A loose, un-compacted sand fill 2 m in depth has a relative density of 40%. Laboratory tests indicated that the minimum and maximum void ratios of the sand are 0.46 and 0.90, respectively. The specific gravity of the solids of the sand is 2.65. Compute:

(i) dry unit weight of the sand

(ii) if the sand is compacted to a relative density of 75%, what is the decrease in thickness of the 2 m fill?

(c) A 10,000 ft³ mass of saturated clay had a void ratio of 0.962 and a specific gravity of soil solids of 2.71. A fill was then placed over the clay, causing it to compress. During this process, some of water was squeezed out of the voids. However, volume of solids remains unchanged. After the consolidation was complete, the void ratio had become 0.758. Compute:

(i) initial and final moisture content of water

(ii) new volume of the clay, and

(iii) volume of water squeezed out
Impermeable stratum

Fig. 1

Fig. 2
Chart 1 Plot of $\beta$ versus Overconsolidation Ratio
Chart 2 Fadum's chart for obtaining Newmark's influence coefficient, $l$ in terms of $m$ and $n$. 