SECTION - A

There are FOUR questions in this section. Answer any THREE.
Symbols carry their usual meaning.

1. (a) What do you understand by a linear structural system? When does a structure show non-linearity?

(b) Draw the bending moment diagram and the qualitative deflected shape of the beam shown in Fig. 1. Use Flexibility method. Given: EI = 3000 k-ft².

2. (a) What is P-Δ effect? When is it important?

(b) Support C of the frame shown in Fig. 2 settles \( \frac{1}{2}'' \) downward due to the imposed loads. Draw the bending moment diagram and the qualitative deflected shape of the frame. Given: EI = 4000 k-ft². Ignore axial deformation.
3. (a) Is truss a 1-D structure? Why? Only the top chords of the truss shown in Fig. 3 are subjected to an increase in temperature by 50°C. Determine reactions. Given: $EA = 300^k$ and $\alpha = 13\times10^{-6}/^\circ C$. 

![Diagram of truss](attachment:image1)

(b) Determine influence line of moment at $A$ of the beam shown in Fig. 4. Given: $EI$ is constant. 

![Diagram of beam](attachment:image2)

4. Draw the axial force, shear force and bending moment diagrams of the following frame (Fig. 5) using general stiffness method. Given: $EI = 3000 \text{ k-ft}^2$ and $AE = 300^k$. 

![Diagram of frame](attachment:image3)
5. (a) Determine the reactions and draw the shear force and bending moment diagrams for the beam shown in Figure 6(a) by using the moment-distribution method. 
   (b) Determine the deflection at B for the nonprismatic beam shown in Figure 6(b) by using the moment-distribution method. Portion AB of the beam has inertia I and portion BC has inertia 2I. Given EI = 3000 k-ft².

6. (a) Determine the support reactions at A for the frame of Figure 7(a) for the loading shown in the figure and the support settlements of 1 inch at A and 1.5 inch at D. Use the moment-distribution method. 
   (b) Draw the shear force and bending moment diagram for the beam shown in Figure 7(b) due to a settlement of 20 mm at support B. Use the moment-distribution method.

7. (a) Determine the member end moments and reactions for the frame shown in Figure 8(a) by using the moment-distribution method. 
   (b) Develop member local stiffness matrix and member global stiffness matrix for a truss member. Given, the member cross-sectional area is A, modulus of elasticity is E and length is L.

8. (a) Determine the internal shear and moment in member 1 of the beam shown in Figure 9(a). EI is constant. Use stiffness method (stiffness matrix). 
   (b) Draw the shear force and bending moment diagram for the beam shown in Figure 9(b) by using stiffness method (stiffness matrix). EI is constant for all members of the beam.
Figure 6(a)

Figure 6(b)

EI = constant

\( E = 10,000 \text{ ksi} \quad I = 3,000 \text{ in}^4 \)

Figure 7(a)

Figure 7(b)

\( E = 70 \text{ GPa} \quad I = 800 \times 10^6 \text{ mm}^4 \)

Figure 8(a)

Figure 9(a)

Figure 9(b)
1. The following project represents construction of a new drive-in weighing station for a company.

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Description</th>
<th>Duration</th>
<th>Preceding Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Lay Foundation</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Dig Hole for Scales</td>
<td>06</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Insert Scale Bases</td>
<td>15</td>
<td>B</td>
</tr>
<tr>
<td>D</td>
<td>Erect Frames</td>
<td>12</td>
<td>A, C</td>
</tr>
<tr>
<td>E</td>
<td>Complete Building</td>
<td>20</td>
<td>D</td>
</tr>
<tr>
<td>F</td>
<td>Insert Scales</td>
<td>05</td>
<td>E</td>
</tr>
<tr>
<td>G</td>
<td>Insert Display Cases</td>
<td>03</td>
<td>E</td>
</tr>
<tr>
<td>H</td>
<td>Install Office Equipment</td>
<td>06</td>
<td>G</td>
</tr>
<tr>
<td>I</td>
<td>Finish</td>
<td>03</td>
<td>H, F</td>
</tr>
</tbody>
</table>

(a) Draw network diagram for the activities of the project identifying each activity and its duration. (20)

(b) Make an appropriate table and determine the critical activities of the project and its expected earliest completion time. (26 2/3)

2. The walkway of a bridge needs to be made of wooden planks. Either chambal wood planks (which weighs 3 pounds each) or kerosene wood planks (which weighs 4 pounds each) or a combination of both may be used. The total weight of planks must be within 600 pounds to 900 pounds as per building code. Chambal planks cost Tk. 300/each and kerosene planks Tk. 400/each.

(a) Formulate the above as a standard LP problem. Show and identify the feasible region, constraints and objectives function in x-y coordinate space. (20)

(b) use the simplex algorithm to determine how many of each planks should be used to minimize costs. (26 2/3)
3. (a) Determine the Economic Order Quantity (EOQ) equations as an optimum policy and use it to find the EOQ for a Cement Reseller who sells 1000 bag of cement per month. The lead time for him to receive a bulk order is 10 days. Placing per order costs him Tk. 600/ and cost of holding one bag in inventory is Tk. 100/.

(b) How a team behaves and what is the role of a team leader during team forming and team norming stage?

4. (a) What are the principles of value for money? Show in a diagram how the Environmental Management Plan (EMP) can be better integrated within a project life cycle.

(b) How different types of conflict impacts individuals and a team?

**SECTION – B**

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

Notations carry their usual meaning.

5. (a) Explain NPV, IRR, Benefit Cost Ratio and Payback Period as project investment decision criteria.

(b) The following information were given relating to a proposed capital investment:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cash flow (after tax) in lac</td>
<td>(7,000)</td>
<td>2,500</td>
<td>3,200</td>
<td>3,000</td>
<td>2,500</td>
</tr>
</tbody>
</table>

Calculate the project's:

(i) NPV

(ii) IRR

(iii) Payback period

Under each method, explain whether or not the firm should accept the project. For investments of this type, the firm's risk-adjusted discount rate is 15% p.a. The cutoff for payback period is 2 years.

6. (a) What do you understand by financial and economic feasibility of a project? What are the steps you need to follow for a financial feasibility assessment?

(b) For a government project the sources and cost of capitals are given below. If the inflation rate is 5%, what will be weighted average real cost of capital for the project?

<table>
<thead>
<tr>
<th>Source</th>
<th>Weight</th>
<th>Nominal Cost</th>
<th>After Tax (Tax 40%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADB loan</td>
<td>40%</td>
<td>6.70%</td>
<td>4.02%</td>
</tr>
<tr>
<td>Commercial loan</td>
<td>20%</td>
<td>12.00%</td>
<td>7.20%</td>
</tr>
<tr>
<td>Grant</td>
<td>5%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Equity Participation</td>
<td>35%</td>
<td>10.00%</td>
<td>10.00%</td>
</tr>
</tbody>
</table>
CE 401

7. (a) Define Project Management. What are the characteristics of project phases and project life cycle? (6½)
(b) Draw a typical construction project life cycle mentioning different stages. Briefly explain all these stages. (8)
(c) Compare different 'project characteristics' among
   (i) Functional Organization,
   (ii) Balanced Matrix Organization,
   (iii) Projectized Organization.
   (8)
(d) Explain elaborately the typical problems encountered in Construction Industry. (8)
(e) State the function of the following construction equipments.
   (i) Excavator
   (ii) Cranes
   (iii) Concrete Mixer Truck
   (iv) Road Roller
   (16)

8. (a) State the safety measures that should be taken at a building construction site. (6½)
(b) Explain the various inputs and outputs from risk identification process. (8)
(c) Explain the significance of "Quality Planning" and "Quality Control" processes in project quality management. (8)
(d) What are the major processes in Project Cost Management? Explain each of the processes. (8)
(e) RAJUK is undertaking a lake development project in Dhaka City. What would be the inputs, tools and techniques and outputs from Cost Estimating process for that particular lake development project? (16)
L-4/T-1/CE  
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA  
L-4/T-1  
B. Sc. Engineering Examinations 2016-2017  
Sub: WRE 451 (Hydrology, Irrigation and Flood Management)  
Date: 27/02/2018  
Full Marks: 210  
Time: 3 Hours  
The figures in the margin indicate full marks.  
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) The ordinates of a 8-h unit hydrograph is given below. Compute the ordinates of a 4-h unit hydrograph.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinates of 8-h UH (m³/s)</td>
<td>0</td>
<td>22</td>
<td>60</td>
<td>100</td>
<td>75</td>
<td>65</td>
<td>50</td>
<td>30</td>
<td>18</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

(b) At a climatic station, air pressure 101.3 kPa, air temperature = 20°C and relative humidity = 60%. Calculate the corresponding vapor pressure, specific humidity, air density and dew-point temperature.

(c) "Isohyetal method is more flexible than Thiessen polygon method" — explain.

2. (a) Consider a catchment with longitudinal slope = 0.005, area = 2 km² and runoff coefficient = 0.1. The peak discharge is computed to be 4.2 m³/s. Compute the corresponding intensity of rainfall, time of concentration and maximum length of travel of water for a return period of 100 years. Use Rational Method, IDF curves (Fig. 1) and Kirpich formula for your estimation.

(b) For Horton's infiltration capacity equation suppose \( f_{co} = 5 \) cm/hr, \( f_{cf} = 1 \) cm/hr and \( K_h = 2 \) hr⁻¹. Determine the infiltration rates (fct) and cumulative infiltrations (Fct) after 0, 0.5, 1.0, 1.5 and 2 hr. The infiltration rate is the time derivative of the cumulative infiltration, i.e. \( f_{ct} = \frac{dF_{ct}}{dt} \). The notations have their usual meaning.

(c) Define the components of 'Initial Loss' in hydrologic cycle.

3. (a) The ordinates of a storm hydrograph of a river draining a catchment area of 165 km² due to a 6-h rainfall are given below. Derive the ordinates of a 6-h unit hydrograph.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>0</th>
<th>6</th>
<th>12</th>
<th>18</th>
<th>24</th>
<th>30</th>
<th>36</th>
<th>42</th>
<th>48</th>
<th>54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge (m³/s)</td>
<td>20</td>
<td>100</td>
<td>400</td>
<td>600</td>
<td>300</td>
<td>200</td>
<td>90</td>
<td>50</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

(b) The average storm rainfall values over a catchment in three successive 6-h intervals are known to be 4.2, 8.2 and 6.2 cm. The 6-h unit hydrograph is given below. The Q-index is 0.2 cm/h. The base flow is 10 m³/s at the beginning of storm and increases by 2 m³/s every 12 hr. Estimate the resulting flood hydrograph.

(c) Compare the base flow contributions between Perennial and Intermittent Streams.

Contd .......... P/2
4. (a) The annual maximum recorded floods in a river for the period of 1995 to 2008 are given below. Estimate the flood discharge with return periods of (i) 100 years and (ii) 300 years. Given, $\bar{y}_n = 0.51$ and $S_n = 1.0095$ for $N = 14$. The notations have their usual meaning.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum flood (m³/s)</td>
<td>3800</td>
<td>2900</td>
<td>4800</td>
<td>3900</td>
<td>3350</td>
<td>6650</td>
<td>5400</td>
<td>4250</td>
<td>3760</td>
<td>4160</td>
<td>8890</td>
<td>3980</td>
<td>4200</td>
<td>5700</td>
</tr>
</tbody>
</table>

(b) Four rain gages are located within a rectangular area with four corners at (0,0), (0,13), (14,13) and (14,0) having the following coordinates and recorded rainfalls:

<table>
<thead>
<tr>
<th>Rain gage location</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,9)</td>
<td>18</td>
</tr>
<tr>
<td>(7,11)</td>
<td>25</td>
</tr>
<tr>
<td>(12,10)</td>
<td>35</td>
</tr>
<tr>
<td>(6,2)</td>
<td>42</td>
</tr>
</tbody>
</table>

All coordinates are expressed in kilometers. Compute the average rainfall in the area by Thiessen Polygon Method. Use plain graph paper.

(c) Explain the importance of infiltration index in hydrologic calculations.

**SECTION - B**

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

5. (a) What do you understand by irrigation? Write down the advantages and disadvantages of irrigation.

(b) Write down the social and environmental aspects of irrigation in the context of Bangladesh.

(c) Rabi season is the main irrigation season of Bangladesh and favorable for high yield, explain.

(d) Classify irrigation development and write down the considerations for development of any water resources project.

(e) What do you understand by soil moisture tension or suction?

6. (a) Write down the names of different methods for the measurement of soil moisture and prove that moisture content by volume is a product of moisture content by weight and apparent specific gravity.

(b) Show the sources of irrigation water in a chart and briefly explain the problems of irrigated lands in our country.
(c) Determine the consumptive use and net irrigation requirement for paddy from the given data:

<table>
<thead>
<tr>
<th>Dates and periods of growth</th>
<th>Pan evaporation, Ep</th>
<th>Consumptive use coefficient</th>
<th>Effective precipitation in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 16-31</td>
<td>8.49</td>
<td>0.44</td>
<td>3.42</td>
</tr>
<tr>
<td>Nov. 1-30</td>
<td>15.57</td>
<td>0.54</td>
<td>2.19</td>
</tr>
<tr>
<td>Dec. 1-31</td>
<td>16.59</td>
<td>0.94</td>
<td>0.54</td>
</tr>
<tr>
<td>Jan. 1-31</td>
<td>19.10</td>
<td>0.99</td>
<td>0.15</td>
</tr>
<tr>
<td>Feb. 1-2</td>
<td>1.54</td>
<td>0.73</td>
<td>0.02</td>
</tr>
</tbody>
</table>

(d) What are the various impurities which make the water unfit for irrigation? Write down the guidelines (special consideration) for using poor quality irrigation water. (8)

7. (a) Differentiate between surface and subsurface irrigations. Discuss briefly the various techniques used for distributing water in the firm. (15)

(b) Define infiltration rate and write down the factors influencing infiltration. (5)

(c) What do you understand by duty and delta? Derive the relationship between duty and delta. (5)

(d) The gross command area for a distributary is 25,000 ha, 60% of which is culturable irrigable. The intensity of irrigation (I.I) for Rabi (Wheat) is 40% and for Kharif (Rice) is 15%. If the total water requirement of the two crops are 37.5 cm and 120 cm and their periods of growth are 160 days and 140 days respectively; (i) determine the outlet discharge from average demand considerations. (ii) Also determine the peak demand discharge assuming that the korn water depth for two crops are 13.5 cm and 19 cm and their korn periods are 4 weeks and 2 weeks respectively. (10)

8. (a) What is flood? Classify floods of Bangladesh and briefly discuss the causes and impacts of flood. (8)

(b) Mention the main reasons for the failure of any flood management policy and enlist the possible impacts on water resources system of Bangladesh. (10)

(c) Write down the flood management measures to mitigate flood damages in Bangladesh. (7)

(d) Estimate the leaching requirement when electrical conductivity (EC) value of a saturated extract of soil is 10 mmho/cm at 25% reduction in the yield of a crop. The EC of irrigation water is 1.2 mmho/cm. What will be the required depth of water to be applied to the field if the consumptive use required of the crop is 80 mm? (10)
Fig. 1: Intensity-Duration-Frequency (IDF) curves for Q. No. 2(a)
1. (a) Calculate the factor of safety and settlement of the footing.

Given:

**Soil Condition:**

0-30 ft. over consolidated clay, density = 120 pcf, $C_r = 0.03$, $C_c = 0.12$, $e_0 = 0.8$,

Past maximum overburden pressure = 7000 psf., unconfined compression strength = 3 ksf

Below 30 ft., thick deposit of dense sand

Foundation data:

Footing size for a column = 10 ft x 12 ft

Depth of the footing = 8 ft. below ground level

Footing thickness = 24 inch

Dead load on column = 200 kip

Live load on column = 100 kip

Draw a neat sketch showing the stated condition

Divide the thick clay layer into two layers for settlement calculation.

2. Calculate the factor of safety and settlement (at center and at corner) of the raft foundation.

Given:

**Soil Condition:**

0-20 ft. over consolidated clay, density = 120 pcf, $C_r = 0.04$, $C_c = 0.15$, $e_0 = 0.9$,

Past maximum overburden pressure = 6000 psf., unconfined compression strength = 2 ksf

Below 20 ft., thick deposit of dense sand

Water table at 20 ft. below ground level

Contd ........... P/2
CE 441
Contd ... Q. No. 2

Foundation data:
- Raft foundation = 80 ft × 100 ft.
- Depth of the raft foundation = 12 ft. below ground level
- Dead load on raft = 12000 kip
- Live load on raft = 5000 kip
- Draw a neat sketch showing the stated condition

3. Calculate the factor of safety and settlement of the pile group

Given:

Soil Condition:
- 0-20 ft normally consolidated clay, density = 110 pcf, $C_c = 0.25$, $e_0 = 1.2$
  - unconfined compression strength = 0.8 ksf, reduction factor = 0.9
- 20-50 ft normally consolidated clay, density = 120 pcf, $C_c = 0.20$, $e_0 = 1.0$
  - unconfined compression strength = 1.2 ksf, reduction factor = 0.8
- 50-60 ft normally consolidated clay, density = 125 pcf, $C_c = 0.18$, $e_0 = 0.9$
  - unconfined compression strength = 1.5 ksf, reduction factor = 0.75
- Below 60 ft, thick deposit of dense sand
- Water table at 20 ft. below ground level

Foundation data:
- Pile foundation, 20 numbers of piles
- Size of the pile = 16 inch × 16 inch
- Spacing of the pile = 4 ft. (centre to centre)
- Length of the pile = 45 ft.
- Top of the pile = 3 ft. below ground level
- Dead load on pile group = 200 kip
- Live load on pile group = 100 kip
- Draw a neat sketch showing the stated condition.

4. (a) Calculate the capacity of the driven pile in sand and draw necessary sketches.

Given:
- 15 inch × 15 inch pile, Length of the pile = 50 ft.
- Top of the pile = 5 ft. below ground level, Water Table: 10 ft. below EGL
- Unit wt. of soil: 120 pcf. SPT Values, $\phi$ of the soil, $\delta$ are given below:

Contd ........... P/3
Assume $N_q = 110$ for $\phi = 35^\circ$, $N_q = 140$ for $\phi = 40^\circ$, $D_c = 20$ ft.

(b) Write down the properties of underwater concrete. Discuss briefly underwater concreting methodology for a drilled pier.

SECTION – B

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

5. (a) List technical information that you would expect on a boring log.

(b) How would you decide on the spacing and depth of boreholes while planning a sub-soil exploration program?

(c) A square footing fails by general shear in a cohesionless soil under an ultimate load of $Q_{ult} = 1688$ kip. The footing is placed at a depth of 6.5 ft below ground level. Given $\phi = 35^\circ$, $N_q = 41$, $N_y = 42$ and $\gamma = 110$ pcf, determine the size of the footing if the water table is at a great depth.

(d) Explain the differences between ‘Ordinary Method of Slices’ and ‘Bishop’s Method of Slices’ for slope stability analysis.

6. (a) State the basic principles of ‘seismic refraction survey’ and ‘electrical resistivity survey’ methods used for sub-soil exploration. Also state the applicability of these methods.

(b) Discuss the problems of Shelby tube in collecting good quality undisturbed clay soil samples of various consistency? Also explain, with sketches, the advantages of piston sampler to overcome such problems.

(c) An excavation was made in homogeneous saturated clay. The side slope of the cut made and angle of $36^\circ$ with the horizontal. Slope failure occurred when the cut reached a depth of 8 m. Available geotechnical information show that a clay layer exists to large depths. Considering circular failure surface, determine the undrained cohesion of the clay and comment on the nature of the critical circle. Use the plot of Fellenius (Fig. 1)

Contd ……... P/4
7. (a) Why the position of ground water table is of importance to a geotechnical engineer? (3)

(b) Compare the applicability, advantage and limitations of CPT and SPT. (12)

c) A reinforced concrete pile 13 m long and 500 mm in diameter is driven to medium dense sand; \( \phi = 36^\circ, \gamma = 17.5 \text{kN/m}^3 \) and water table is at great depth. Calculate the pullout capacity and allowable pullout load with \( F_s = 3.0 \) Use \( \delta = \frac{1}{3} \phi \) and the values of \( K_s \) are 1.0 for loose sand and 2.0 for dense sand. Also, calculate the allowable load if the pile tip is enlarged to 800 mm diameter for a length of 500 mm, while other data remain the same. (10+10)

8. (a) What is meant by rapid draw down condition? Draw a typical qualitative plot of stability chart developed by Morgenstern for relevant slope stability analysis. (5)

(b) Fig. 2 shows the cross-section of an earth slope in homogeneous clay soil. The figure also shows an arbitrary failure surface, its center and five slices. Calculate the factor of safety, using Ordinary Method of Slices, Given \( \gamma = 16.8 \text{kN/m}^3, q_u = 50 \text{kPa} \). For homogenous soil and Ordinary method of slices, Factor of Safety is given by:

\[
F_s = \frac{\sum_{n=1}^{m_p} (c \Delta L_n + W_n \cos \alpha_n \tan \phi)}{\sum_{n=1}^{m_p} W_n \sin \alpha_n}
\]

(Symbols have their usual meanings)

c) A water tank foundation has a footing size 6 m x 6 m, placed at a depth of 3 m below ground level in a medium dense sand stratum of great depth. From site investigation, corrected average SPT value is found as 20 and average density of soil as, \( \gamma = 18.5 \text{kN/m}^3 \). The foundation is subjected to a vertical load at an eccentricity of \( B/10 \) along one of the axes. Estimate the ultimate load \( Q_{ult} \) by Meyerhof's method. Symbols have their usual meanings. Given:

\[
\begin{array}{cccccccc}
\phi (\text{deg}) & 28 & 30 & 32 & 34 & 36 & 38 & 40 \\
N_q & 14.7 & 18.4 & 23.2 & 29.4 & 37.7 & 48.9 & 64.1 \\
N_r & 11.2 & 15.7 & 22.0 & 31.1 & 44.4 & 64.0 & 93.6 \\
\end{array}
\]

-----------------------------------------------
Bearing capacity factors for foundations on clay under $\phi = 0$ conditions (after Skempton, 1951).
### Table 1

<table>
<thead>
<tr>
<th>B/D</th>
<th>L/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.00470</td>
</tr>
<tr>
<td>0.2</td>
<td>0.00917</td>
</tr>
<tr>
<td>0.3</td>
<td>0.01363</td>
</tr>
<tr>
<td>0.4</td>
<td>0.01812</td>
</tr>
<tr>
<td>0.5</td>
<td>0.02260</td>
</tr>
<tr>
<td>0.6</td>
<td>0.02710</td>
</tr>
<tr>
<td>0.7</td>
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</tr>
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<td>1.4</td>
<td>0.06267</td>
</tr>
<tr>
<td>1.6</td>
<td>0.07171</td>
</tr>
<tr>
<td>1.8</td>
<td>0.08104</td>
</tr>
</tbody>
</table>

Influence values \( (e) \) for vertical normal stress \( \sigma \) at point N beneath corner of a uniformly loaded rectangular area

---

### Table 2

<table>
<thead>
<tr>
<th>B/D</th>
<th>L/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>0.03111</td>
</tr>
<tr>
<td>2.5</td>
<td>0.03138</td>
</tr>
<tr>
<td>3.0</td>
<td>0.03150</td>
</tr>
<tr>
<td>4.0</td>
<td>0.03158</td>
</tr>
<tr>
<td>5.0</td>
<td>0.03160</td>
</tr>
<tr>
<td>6.0</td>
<td>0.03161</td>
</tr>
<tr>
<td>8.0</td>
<td>0.03162</td>
</tr>
<tr>
<td>10.0</td>
<td>0.03162</td>
</tr>
<tr>
<td>( \infty )</td>
<td>0.03162</td>
</tr>
</tbody>
</table>

\( f = q \times L \)

\( \sigma = q \times e \)

\( q \) per unit area

---

### Diagram

- \( L \)
- \( W \)
- \( Z \)
- \( N \)
- \( x \)
- \( y \)
- \( z \)
- \( \sigma \) per unit area

---

### Notes

- The tables provide values for the influence of vertical normal stress \( \sigma \) at point N beneath the corner of a uniformly loaded rectangular area.
- The tables are tabulated for different values of \( B/D \) and \( L/D \), with \( B/D \) ranging from 0.1 to 1.8 and \( L/D \) ranging from 0.03111 to 0.03162.
- The diagrams illustrate the relationship between stress \( \sigma \), load \( q \), and the dimensions \( L \) and \( W \).

---

### Additional Information

- The values are calculated using specific formulas that take into account the geometrical properties of the rectangular area.
- The tables and diagrams are essential for engineers and architects in designing structures that can support uniformly distributed loads.
Fig. 1 Plot of Stability number against Slope angle. Fellenius (1927).

Fig. 2 Cross-section of an earth slope and arbitrary failure surface.
SECTION - A

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

1. (a) Broadly classify pavements. Draw typical cross sections for flexible, rigid, semi-rigid pavements. Differentiate between flexible and rigid pavements w.r.t Load distribution mechanism, Aggregate Type and Modulus of Elasticity. Write short note on 'Perpetual pavement' and 'Polymer Modified Binder (PMB)'. Briefly state the significance of PMB use in Bangladesh. (4+6+6+4+2)

(b) Write short notes on: Fog-seal, Slurry seat, and Micro-seal. List FIVE important common modes of distresses for flexible and rigid pavements. (6+5)

(c) Design reinforcement for the following:

<table>
<thead>
<tr>
<th>Thickness of rigid pavement, t</th>
<th>11 inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of lanes</td>
<td>2</td>
</tr>
<tr>
<td>Width of pavement, w</td>
<td>22 ft</td>
</tr>
<tr>
<td>Spacing of transverse joint</td>
<td>44 ft (Contraction Joint @ 22 ft)</td>
</tr>
<tr>
<td>Allowable strength of:</td>
<td></td>
</tr>
<tr>
<td>Shrinkage steel (bar-mat)</td>
<td>35000 psi</td>
</tr>
<tr>
<td>Tie bars</td>
<td>30000 psi</td>
</tr>
<tr>
<td>Bond</td>
<td>355 psi</td>
</tr>
</tbody>
</table>

2. (a) Write down the sequences of pavement failure under submerged condition in Bangladesh. Why joints are use in rigid pavement? What are the main functions of Tie bars and Dowel bars in rigid pavement? Write down the odd-shaped panel considerations to reduce the risk of cracking in curved areas in concrete pavement. (5+4+4+4)

(b) What are the major outcomes of AASHO road test? Define standard axle load? A truck in an intercity road applied 20 kip and 12 kip loads by the rear and front axles. Using the 4th power approximation, determine the total equivalent damage caused by one pass movement of this truck in terms of ESALs. (4+2+6)

(c) Design a flexible pavement by AASHTO method for the data given below. Give one trial and put you comments for the next trial thickness (if any). Solution could be given in the worksheet provided at the end of question paper. (Design Nomograph is attached). (17½)
Given:

- Assumed Structural Number, SN = 6.0
- Estimated Design ESAL, \( W_{18} \) = 20 million ESAL

Consider:

- Design period = 20 years
- Initial serviceability, \( P_0 \) = 4.6
- Terminal Serviceability, \( P_t \) = 2.5
- Reliability, \( R \) = 0.95
- Overall std. dev., \( S_0 \) = 0.35
- \( Z_R \) = -1.645

### Pavement Layer

<table>
<thead>
<tr>
<th>Pavement Layer</th>
<th>Material Used</th>
<th>Resilient Modulus ( M_{Rm} ) (psi)</th>
<th>Layer Coefficients</th>
<th>Drainage Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Course (AC)</td>
<td>Asphalt Concrete</td>
<td>( E_{ACm} ) = 375,000</td>
<td>( a_1 = 0.169*\text{LN}(E_{Ac})-1.764 )</td>
<td>( m_1 = 1.0 )</td>
</tr>
<tr>
<td>Base Course (BS)</td>
<td>Granular</td>
<td>( E_{BS} = 32,000 )</td>
<td>( a_2 = 0.249*\text{LOG}<em>{10}(E</em>{BS})-0.977 )</td>
<td>( m_2 = 1.1 )</td>
</tr>
<tr>
<td>Subbase Course (SB)</td>
<td>Granular</td>
<td>( E_{SB} = 12,000 )</td>
<td>( a_3 = 0.227*\text{LOG}<em>{10}(E</em>{SB})-0.839 )</td>
<td>( m_3 = 1.2 )</td>
</tr>
<tr>
<td>Roadbed Course (RB)</td>
<td>Compacted soil</td>
<td>( E_{RB} = 5,600 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. (a) Compare roadways with railways. Discuss the difficulties associated with non-uniformity of gauges throughout a Country. 
(b) Define "Permanent way". Schematically show the different components of a typical permanent way. What are the requirements of an ideal permanent way? (2+4+7) 
(d) Discuss different types of rail resistance. (8+12½)

A 2-8-2 Locomotive is required to haul a train at 80 km/hr. The axle load of the driving wheels of the engine is 22.5 tonnes. The train is to run on a straight level track. Find the maximum permissible train load that the engine can pull. If the train climbs a gradient of 1 in 200, how much of the speed should be reduced?

4. (a) What are the advantages of flat footed rails? What are the functions of Ballast and sleepers in a railway track? Define Cant Deficiency, Equilibrium speed and Cant excess. (5+8+6) 
(b) What are the purposes of railway stations? What criteria are generally followed for the site selection of a railway station? "The function of a Marshalling yard in a railway system is like the function of the heart in a human body" – Explain. (4+6+6) 
(c) Why points and crossings are provided in a railway track? What are the advantages of Cast Manganese Steel (CMS) crossing? State the objective of railway signaling. (4+3½+4)
SECTION – B

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

5. (a) What are the superpave binder test equipment and purposes? How is the moisture sensitivity evaluated in the superpave mix design process?
(b) Briefly state the differences between Marshall and Hveem method of mix design with regard to (i) compaction of specimens (ii) design criteria, and (iii) tests of specimens.
(c) What are the characteristics of a high type bituminous pavements? A design is being prepared for an asphalt concrete paving mixture. The following ingredients are to be used in the preparation of a trial mixture:

<table>
<thead>
<tr>
<th></th>
<th>Percent of total mix by weight</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse aggregate</td>
<td>55.0</td>
<td>2.611</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>31.0</td>
<td>2.690</td>
</tr>
<tr>
<td>Mineral filler</td>
<td>7.0</td>
<td>3.100</td>
</tr>
<tr>
<td>Asphalt cement</td>
<td>7.0</td>
<td>1.030</td>
</tr>
</tbody>
</table>

The maximum specific gravity of the paving mixture $G_{mm} = 2.478$ and the bulk specific gravity of the compacted specimen $G_{mb} = 2.384$. Compute percent air voids in the compacted mixture, $P_a$ and VMA and VFA.

6. (a) What are the especial qualities of bitumen required for road construction in Bangladesh? How can these qualities be achieved?
(b) Briefly state the steps to get straight run asphalt. How is the asphalt cement graded? Show with typical examples.
(c) Briefly state the important properties of aggregates used for highway construction. The dry mass of a sample of aggregate is 1982.0 g. The net volume of aggregate is 734.4 cm$^3$. The mass of aggregate is SSD condition is 2006.7 g. Find the apparent specific gravity, the bulk specific gravity and the percentage absorption.

7. (a) Describe the commonly used low cost road surfaces in Bangladesh. Explain how HBB facilitates staged road construction.
(b) Describe detail features of bituminous surface treatment (SBST or DBST), Penetration Macadam and Geo Cell paving type of road surface construction including materials details.

Contd ............ P/4
8.  (a) Write down names of ten highway construction equipment along with their uses. Describe hot-rolled bituminous surface compaction process mentioning temperature range in each stage. 

(b) Write down possible causes, maintenance options and rehabilitation/reconstruction options for the following defects of asphalt concrete pavement: 

(i) Alligator Cracking 
(ii) Rutting 
(iii) Corrugation.

(c) Illustrate the dowel bar installation defects in rigid pavement with relevant drawings. Also describe the temperature reinforcement installation process for rigid pavement.

--------------------------------------------------------
AASHTO Worksheet For Flexible Pavement Design

<table>
<thead>
<tr>
<th>Pavement Layer</th>
<th>Material Used</th>
<th>Resilient Modulus $M_r$ (psi)</th>
<th>Layer Coefficients</th>
<th>Drainage Coefficient $a$</th>
<th>Required SN above the layer $m$</th>
<th>Calculations For Layer Thicknessed $D$ (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Course</td>
<td>Asphalt Concrete</td>
<td>$E_{AC}$ = 375,000</td>
<td>$a_1 = 0.169*\ln(E_{AC}) - 1.764$</td>
<td>$m_1 = 1.0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Course</td>
<td>Granular</td>
<td>$E_{GR} = 32,000$</td>
<td>$a_2 = 0.249*\ln(E_{GR}) - 0.977$</td>
<td>$m_2 = 1.1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subbase Course</td>
<td>Granular</td>
<td>$E_{SB} = 12,000$</td>
<td>$a_3 = 0.227*\ln(E_{SB}) - 0.839$</td>
<td>$m_3 = 1.2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadbed Course</td>
<td>Compacted soil</td>
<td>$E_{RB} = 5600$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check for $SN = a_1mD_1 + a_2mD_2 + a_3mD_3$ =

![Diagram of pavement layers with SN1, SN2, SN3, D1, D2, and D3 labels.](image)
AASHTO Design Nomograph for Flexible Pavement

Nomograph Equations:

\[ \log_{10} W = 2.32 \times 10^9 \Delta \text{PSI} - 8.07 \]

\[ \log_{10} \frac{\Delta \text{PSI}}{4.2 - 1.5} = 0.40 + \frac{1094}{(\text{SN} + 1)5.19} \]

Reliability, R(%) - Overall Standard Deviation, SD

Estimated Total 18-Lt Equivalent Single Axle Load Applications, N

Effective Base or Subgrade Resilient Modulus, M (kPa)

Design Structural Number, SN

Design Serviceability Loss, ΔPSI