L-4/T-2/CE Date : 17/04/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **CE 403** (Socio-Economic Aspects of the Development Projects)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume reasonable values for any missing data.

1. Padma Bridge Rail Link Project (BPRLP) is jointly funded by Government of the Republic of China and the Government of Bangladesh. Bangladesh Railway is the Executing Agency of the project. The primary objective of the project is to construct a new railway track of 169 km from Capital City Dhaka to Jashore via Padma Multipurpose Bridge to establish a new Broad Gauge railway connectivity with the south-west part of Bangladesh. **Figure 1** shows the geographical location of Padma Bridge Rail Link Project. Upon implementation, the project may improve national connectivity, facilitate national, regional, and international freight transport, reduce travel time, provide a higher quality of transportation service to passenger, contribute a GDP growth of approximate 1%, and contribute to regional socio-economic development and thus minimizing regional disparity. The phase-I of the project requires a total 358.41 ha of land (about 82.35 km long strip with approximately 40 m width). This includes 120.54 ha of public land, and 237.87 ha are private land to be acquired. About eight thousand persons could be directly affected by the land-acquisition related impacts of the project within the right of way.

   (a) What are the relevant social and economic impacts you may need to consider for assessing the socio-economic impacts of Padma Bridge Rail Link Project, explicitly, associated with land acquisition, relocation, and resettlement? List at least ten factors. (15)

   (b) How do you collect relevant socio-economic data to assess the impacts related to land acquisition, relocation and resettlement of this project? (10)

   (c) Comment on the role of public consultation and participation for an effective implementation of land acquisition and resettlement action plans of this project. (10)

2. (a) Propose a set of feasible mitigation measures to minimize the land acquisition, relocation and resettlement related negative impacts of Padma Bridge Rail Link Project described in Question 1. (20)

   (b) Propose a framework for implementing your proposed mitigation measures that you identified in 2(a). Your proposed framework should consider institutional aspect, monitoring requirement, and grievance redress mechanism. (15)

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3. (a) Gender Inequality Index (GII) of Bangladesh along with several selected countries is given in **Table 1**. Suppose you are asked to prepare a gender action plan (GAP) for the Padma Bridge Rail Link Project (described in Question 1). Propose considerations and a framework for the GAP of this project that can help to reduce gender inequality. Briefly justify your selection. (15)

   (b) What is the difference between Gross Domestic Product (GDP) and Gross National Income (GNI)? Discuss the limitations of GDP or GNI as an Indicator of Welfare. Why does purchasing power parity (PPP) dollar used for expressing GNI per capita? (15)

   (c) "Sound development plans require good projects; just as good projects require sound planning" – Explain. (5)

4. (a) What is sustainable development? What are the key elements of sustainable development? Differentiate between the traditional economic view of development and the concept of sustainable development. (15)

   (b) To foster sustainable development, United Nations (UN) has adopted the 17 Sustainable Development Goals (SDGs). These goals are given in **Table 2**. The Government of Bangladesh is implementing various development projects to achieve SDGs. Identify which SDGs can be addressed by implementing the Padma Bridge Rail Link Project (described in Question 1) and describe how. (20)

## SECTION – B

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

5. (a) Briefly describe the different levels of community participation with the example of arsenic mitigation program for the rural areas of Bangladesh. (20)

   (b) What is a client Centered approach? Explain this as a strategic issue for the WSS policies of Bangladesh. (15)

6. (a) What are the major difficulties in conducting socio-economic assessments in developing countries? Explain with examples. (20)

   (b) Briefly discuss the methodologies in practice to ensure community participation. (15)

7. (a) What are the advantages and features of Social Impacts Assessment (SIA) process? (20)

   (b) Explain the following terms with explanations in the context of a WSS project in Bangladesh: (15)

   (i) Clientele groups, (ii) Clientele need, (iii) Clientele demand, (iv) Absorptive Capacity

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8. (a) Calculate Human Development Index (HDI) and Gender Development Index (GDI) of Bangladesh for 2019 using information in **Table 3**. (20)

(b) Human Development Index (HDI) is not "a comprehensive measure of human development". What are the major criticisms of the HDI? (10)

(c) What are the basic parameters of multidimensional poverty index? (5)

**Table 3 (for Question 8(a))**

| Indicator | Overall | Male | Female |
|---|---|---|---|
| Life expectancy at birth (years) | 72.6 | 70.9 | 74.6 |
| Expected years of schooling (years) | 11.6 | 11.2 | 12.0 |
| Mean years of schooling (years) | 6.2 | 6.9 | 5.7 |
| Gross national income (GNI) per capita 2017 PPP $)) | 4,976 | 7,031 | 2.873 |
| | | | |

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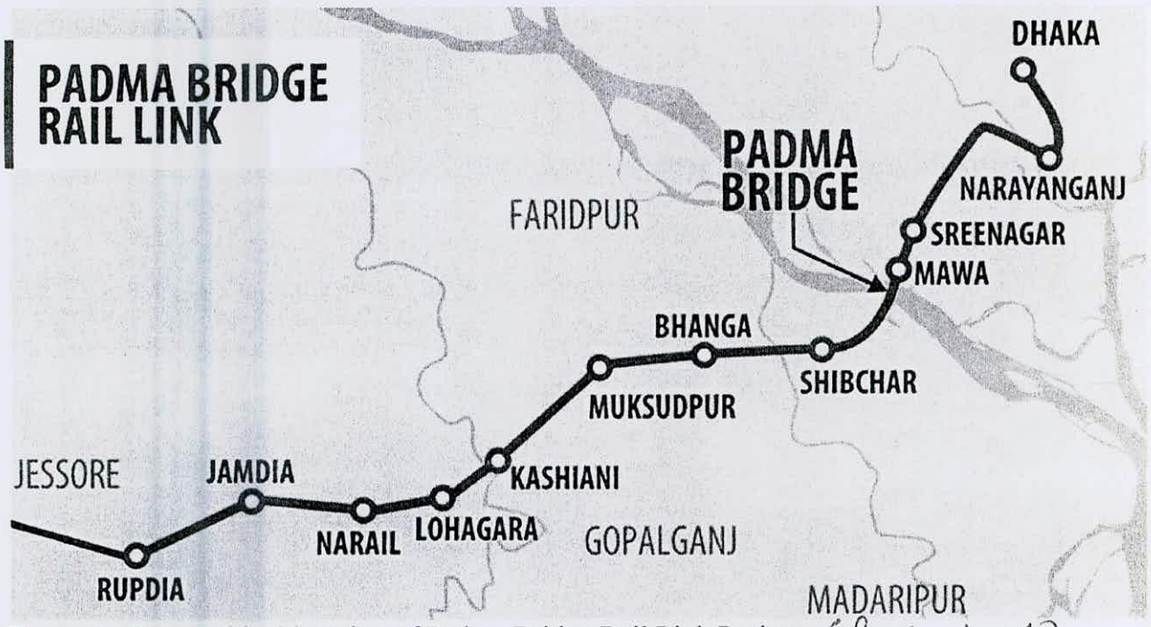


**Figure 1:** Geographical location of Padma Bridge Rail Link Project (for Question 1)

**Table 1:** Bangladesh Gender Inequality Index (GII) for 2015 relative to selected countries and group (for Question 3a)

| | GII value | GII Rank | Maternal mortality ratio | Adolescent birth rate | Female seats in parliament (%) | Population with at least some secondary education (%) | | Labour force participation rate (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Female | Male | Female | Male |
| Bangladesh | 0.520 | 119 | 176 | 83.0 | 20.0 | 42.0 | 44.3 | 43.1 | 81.0 |
| Nepal | 0.497 | 115 | 258 | 71.9 | 29.5 | 24.1 | 41.2 | 79.7 | 86.8 |
| Pakistan | 0.546 | 130 | 178 | 38.7 | 20.0 | 26.5 | 46.1 | 24.3 | 82.2 |
| South Asia | 0.520 | — | 175 | 33.7 | 17.4 | 36.9 | 58.6 | 28.3 | 79.4 |
| Medium HDI | 0.491 | — | 164 | 40.8 | 19.9 | 40.4 | 57.6 | 37.2 | 79.4 |

Maternal mortality ratio is expressed in number of deaths per 100,000 live births and adolescent birth rate is expressed in number of births per 1,000 women ages 15-19.

**Table 2: Sustainable Development Goals (SDGs).** (for Question 4b)

| | |
|---|---|
| SDG 1 | End poverty in all its forms everywhere. |
| SDG 2 | End hunger, achieve food security and improved nutrition and promote sustainable agriculture |
| SDG 3 | Ensure healthy lives and promote well-being for all at all ages |
| SDG 4 | Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all |
| SDG 5 | Achieve gender equality and empower all women and girls |
| SDG 6 | Ensure availability and sustainable management of water and sanitation for all |
| SDG 7 | Ensure access to affordable, reliable, sustainable and modern energy for all |
| SDG 8 | Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all |
| SDG 9 | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation |
| SDG 10 | Reduce inequality within and among countries |
| SDG 11 | Make cities and human settlements inclusive, safe, resilient and sustainable |
| SDG 12 | Ensure sustainable consumption and production patterns |
| SDG 13 | Take urgent action to combat climate change and its impacts |
| SDG 14 | Conserve and sustainably use the oceans, seas and marine resources for sustainable development |
| SDG 15 | Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss |
| SDG 16 | Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels |
| SDG 17 | Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels |

L-4/T-2/CE **Date: 23/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 413** (Introduction to steel concrete composite structures)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FIVE** questions in this section. Answer any **FOUR** questions.
Assume reasonable values for missing data.
Necessary tables & formulae are provided in **ANNEXURE**.

1. (a) For the composite floor system shown in **Fig. 1**, Calculate the service load flexural stresses in concrete and steel of the secondary beam SB (W18x65) for unshored construction. In addition to the self-weight of the slab and beam, consider 50 psf of partition wall load, 30 psf of floor finish, 20 psf of construction live load and 80 psf of service live load. The beam is connected to the main beam using shear connections. Assume, full interaction between steel and concrete and unshored construction method. **(14)**

   Given: $f_c^{'} = 4ksi$; $E_c = 3600\,ksi$; $F_y = 50\,ksi$ and $E_s = 29000\,ksi$.

   (b) Show the flexural stress distribution across the depth of the beam MB for pre-composite and composite stages of construction. **(3.5)**

2. (a) Why shear connectors are required in composite floor system? Name different types of shear connectors with sketches. **(3.5)**

   (b) (i) Evaluate the design ultimate moment capacity of the main beam MB (W21x93) as shown in **Fig.1** in positive bending for 75% composite action. Use AISC-LRFD method. **(14)**

   Given: $f_c^{'} = 4ksi$; $E_c = 3600\,ksi$; $F_y = 50\,ksi$ and $E_s = 29000\,ksi$.

   (ii) Determine the number and placement of the 1 inch diameter stud shear connectors for this beam to develop the design moment capacity under 75% composite action.

   Assume: $R_p = 0.75$, $R_g = 0.85$ and $F_u = 65$ ksi for shear connectors.

3. For the secondary beam SB (W18x65) in the floor system shown in **Fig. 1**, check the adequacy of this beam for serviceability limit conditions (i.e. deflection limits). Assume, full composite action and unshored construction method. The beam is connected to the main beam using shear connections. Use the loading conditions as specified in Q.1. **(17.5)**

   Given: $f_c^{'} = 4ksi$; $E_c = 3600\,ksi$; $F_y = 50\,ksi$ and $E_s = 29000\,ksi$.

4. A composite floor system uses a formed steel deck of the type shown in **Fig. 2**. The secondary beams supporting the floor are W21x93, and the slab has a total thickness of 5 inch from the top of the slab to the bottom of the deck. The effective slab width is 90 inch and the span length is 20 ft. The secondary beam is designed with two 0.75 inch diameter stud type of shear connectors per rib along the span of the beam (the deck rib is oriented perpendicular to the secondary beam). **(17.5)**

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**Contd... Q. No.4**

(i) Determine the percentage (%) of composite action for the composite beam.
Assume: $R_p = 0.60$, $R_g = 0.85$ and $F_u = 65$ ksi for shear connectors.

(ii) Calculate the nominal flexural strength of this partially composite beam.

Given: For concrete $f_c^{'} = 4ksi$; $E_c = 3600\,ksi$; for steel $F_y = 50\,ksi$ and $E_s = 29000\,ksi$.

5. For the composite beam section shown in **Fig. 3**, **(17.5)**

(i) Calculate the section properties of the composite section. Transform the section into equivalent steel section.

Given: For concrete $f_c^{'} = 4ksi$; $E_c = 3600\,ksi$; for steel $F_y = 50\,ksi$ and $E_s = 29000ksi$.

(ii) Find the yield moment capacity of the composite beam in positive bending.

**SECTION – B**

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

6. (a) Define Partially Encased Composite (PEC) column. Name the two types of PEC columns commonly used. Differentiate between the behavior of these two PEC columns. **(8)**

(b) A Partially Encased Composite (PEC) column is shown in **Figure 4**. **(15⅓)**

(i) Check the material and geometric properties of the given PEC column with the code specified limits.

(ii) Determine the axial capacity of the column.

Given: $f_y$ = 350 MPa; $f_c^{'}$ = 35 MPa; $E_s$ = 200 GPa; $E_c$ = 24 GPa and effective length of the column = 15 ft.

7. (a) State the advantages and disadvantages of Concrete Filled Tubular (CFT) columns over other composite columns. **(5)**

(b) The composite compression member shown in **Figure 5** has lateral support at mid-height in the weak direction only. Compute the nominal strength. Assume a concrete cover of 2.5 inches to the center of the longitudinal reinforcement. **(18⅓)**

Given: $F_y = F_{yr}$ = 60 ksi; $f_c^{'}$ = 8 ksi; $E_s$ = 29000 ksi; $E_c$ = 3600 ksi.

8. (a) Using basic principles, calculate the nominal axial load and bending moment for the four points in the P-M interaction diagram about strong axis bending of the Fully Encased Composite (FEC) column shown in Figure 5. Show the diagram in a neat sketch. Use the data provided in Question 7(b) as required. Follow AISC-LRFD method. **(17⅓)**

(b) Determine the design P-M interaction diagram for the FEC column including the global slenderness effect. Use AISC-LRFD. **(6)**

Contd ..... P/3

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9. (a) For the Concrete Filled Tubular (CFT) column shown in **Figure 6**, check the design adequacy for a factored axial compressive load of 220 kips and a factored bending moment of 130 kip-ft about weak axis using both interaction equation and basic principles. Consider the effective length of the column to be 12 ft. Use AISC-LRFD method. **(16⅓)**

Given: $f_y = 50$ ksi; $f'_c = 3.5$ ksi; $E_s = 29000$ ksi; $E_c = 3600$ ksi.

(b) Provide your comments on the adequacy check using both basic principle and plastic stress distribution method. Slenderness effects must be considered. **(7)**

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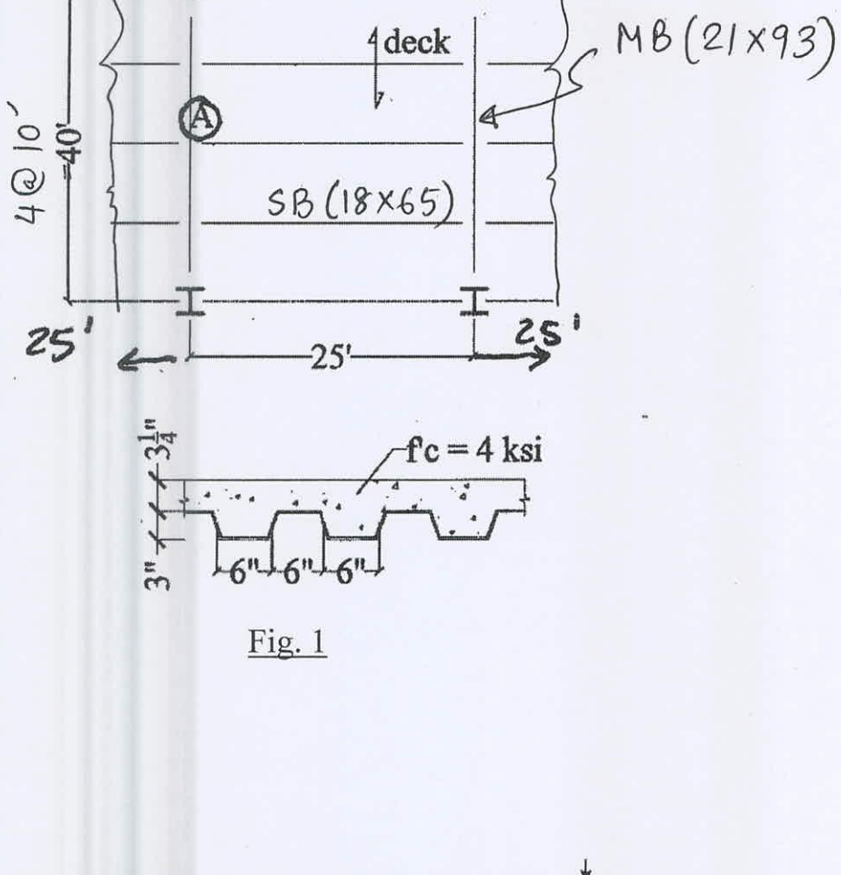


Fig. 1

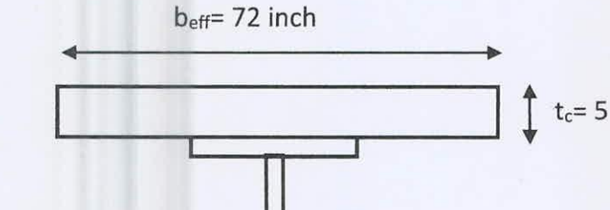


Fig. 2




Fig. 3

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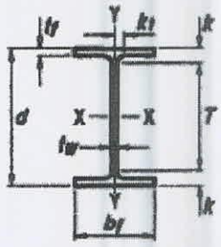


# Table 1–1 (continued)
## W Shapes
### Dimensions

| Shape | Area, A | Depth, d | | Web: Thickness, tw | | tw/2 | Flange: Width, bf | | Flange: Thickness, tf | | Distance: k kdes | Distance: k kdet | Distance: k1 | Distance: T | Distance: Workable Gage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in.² | in. | | in. | | in. | in. | | in. | | in. | in. | in. | in. | in. |
| W21×93 | 27.3 | 21.6 | 21 5/8 | 0.580 | 9/16 | 5/16 | 8.42 | 8 3/8 | 0.930 | 15/16 | 1.43 | 1 5/8 | 15/16 | 18 3/8 | 5 1/2 |
| ×83[c] | 24.3 | 21.4 | 21 3/8 | 0.515 | 1/2 | 1/4 | 8.36 | 8 3/8 | 0.835 | 13/16 | 1.34 | 1 1/2 | 7/8 | | |
| ×73[c] | 21.5 | 21.2 | 21 1/4 | 0.455 | 7/16 | 1/4 | 8.30 | 8 1/4 | 0.740 | 3/4 | 1.24 | 1 7/16 | 7/8 | | |
| ×68[c] | 20.0 | 21.1 | 21 1/8 | 0.430 | 7/16 | 1/4 | 8.27 | 8 1/4 | 0.685 | 11/16 | 1.19 | 1 3/8 | 7/8 | | |
| ×62[c] | 18.3 | 21.0 | 21 | 0.400 | 3/8 | 3/16 | 8.24 | 8 1/4 | 0.615 | 5/8 | 1.12 | 1 5/16 | 13/16 | | |
| ×55[c] | 16.2 | 20.8 | 20 3/4 | 0.375 | 3/8 | 3/16 | 8.22 | 8 1/4 | 0.522 | 1/2 | 1.02 | 1 3/16 | 13/16 | | |
| ×48[c,f] | 14.1 | 20.6 | 20 5/8 | 0.350 | 3/8 | 3/16 | 8.14 | 8 1/8 | 0.430 | 7/16 | 0.930 | 1 1/8 | 13/16 | | |
| W21×57[c] | 16.7 | 21.1 | 21 | 0.405 | 3/8 | 3/16 | 6.56 | 6 1/2 | 0.650 | 5/8 | 1.15 | 1 5/16 | 13/16 | 18 3/8 | 3 1/2 |
| ×50[c] | 14.7 | 20.8 | 20 7/8 | 0.380 | 3/8 | 3/16 | 6.53 | 6 1/2 | 0.535 | 9/16 | 1.04 | 1 1/4 | 13/16 | | |
| ×44[c] | 13.0 | 20.7 | 20 5/8 | 0.350 | 3/8 | 3/16 | 6.50 | 6 1/2 | 0.450 | 7/16 | 0.950 | 1 1/8 | 13/16 | | |
| W18×311[h] | 91.6 | 22.3 | 22 3/8 | 1.52 | 1 1/2 | 3/4 | 12.0 | 12 | 2.74 | 2 3/4 | 3.24 | 3 7/16 | 1 3/8 | 15 1/2 | 5 1/2 |
| ×283[h] | 83.3 | 21.9 | 21 7/8 | 1.40 | 1 3/8 | 11/16 | 11.9 | 11 7/8 | 2.50 | 2 1/2 | 3.00 | 3 3/16 | 1 5/16 | | |
| ×258[h] | 75.9 | 21.5 | 21 1/2 | 1.28 | 1 1/4 | 5/8 | 11.8 | 11 3/4 | 2.30 | 2 5/16 | 2.70 | 3 | 1 1/4 | | |
| ×234[h] | 68.8 | 21.1 | 21 | 1.16 | 1 3/16 | 5/8 | 11.7 | 11 5/8 | 2.11 | 2 1/8 | 2.51 | 2 3/4 | 1 3/16 | | |
| ×211 | 62.1 | 20.7 | 20 5/8 | 1.06 | 1 1/16 | 9/16 | 11.6 | 11 1/2 | 1.91 | 1 15/16 | 2.31 | 2 9/16 | 1 3/16 | | |
| ×192 | 56.4 | 20.4 | 20 3/8 | 0.960 | 15/16 | 1/2 | 11.5 | 11 1/2 | 1.75 | 1 3/4 | 2.15 | 2 7/16 | 1 1/8 | | |
| ×175 | 51.3 | 20.0 | 20 | 0.890 | 7/8 | 7/16 | 11.4 | 11 3/8 | 1.59 | 1 9/16 | 1.99 | 2 7/16 | 1 1/4 | 15 1/8 | |
| ×158 | 46.3 | 19.7 | 19 3/4 | 0.810 | 13/16 | 7/16 | 11.3 | 11 1/4 | 1.44 | 1 7/16 | 1.84 | 2 3/8 | 1 1/4 | | |
| ×143 | 42.1 | 19.5 | 19 1/2 | 0.730 | 3/4 | 3/8 | 11.2 | 11 1/4 | 1.32 | 1 5/16 | 1.72 | 2 5/16 | 1 3/16 | | |
| ×130 | 38.2 | 19.3 | 19 1/4 | 0.670 | 11/16 | 3/8 | 11.2 | 11 1/8 | 1.20 | 1 3/16 | 1.60 | 2 1/16 | 1 3/16 | | |
| ×119 | 35.1 | 19.0 | 19 | 0.655 | 5/8 | 5/16 | 11.3 | 11 1/4 | 1.06 | 1 1/16 | 1.46 | 1 15/16 | 1 3/16 | | |
| ×106 | 31.1 | 18.7 | 18 3/4 | 0.590 | 9/16 | 5/16 | 11.2 | 11 1/4 | 0.940 | 15/16 | 1.34 | 1 13/16 | 1 1/8 | | |
| ×97 | 28.5 | 18.6 | 18 5/8 | 0.535 | 9/16 | 5/16 | 11.1 | 11 1/8 | 0.870 | 7/8 | 1.27 | 1 3/4 | 1 1/8 | | |
| ×86 | 25.3 | 18.4 | 18 3/8 | 0.480 | 1/2 | 1/4 | 11.1 | 11 1/8 | 0.770 | 3/4 | 1.17 | 1 5/8 | 1 1/16 | | |
| ×76[c] | 22.3 | 18.2 | 18 1/4 | 0.425 | 7/16 | 1/4 | 11.0 | 11 | 0.680 | 11/16 | 1.08 | 1 9/16 | 1 1/16 | | |
| W18×71 | 20.8 | 18.5 | 18 1/2 | 0.495 | 1/2 | 1/4 | 7.64 | 7 5/8 | 0.810 | 13/16 | 1.21 | 1 1/2 | 7/8 | 15 1/2 | 3 1/2[g] |
| ×65 | 19.1 | 18.4 | 18 3/8 | 0.450 | 7/16 | 1/4 | 7.59 | 7 5/8 | 0.750 | 3/4 | 1.15 | 1 7/16 | 7/8 | | |
| ×60[c] | 17.6 | 18.2 | 18 1/4 | 0.415 | 7/16 | 1/4 | 7.56 | 7 1/2 | 0.695 | 11/16 | 1.10 | 1 3/8 | 13/16 | | |
| ×55[c] | 16.2 | 18.1 | 18 1/8 | 0.390 | 3/8 | 3/16 | 7.53 | 7 1/2 | 0.630 | 5/8 | 1.03 | 1 5/16 | 13/16 | | |
| ×50[c] | 14.7 | 18.0 | 18 | 0.355 | 3/8 | 3/16 | 7.50 | 7 1/2 | 0.570 | 9/16 | 0.972 | 1 1/4 | 13/16 | | |
| W18×46[c] | 13.5 | 18.1 | 18 | 0.360 | 3/8 | 3/16 | 6.06 | 6 | 0.605 | 5/8 | 1.01 | 1 1/4 | 13/16 | 15 1/2 | 3 1/2[g] |
| ×40[c] | 11.8 | 17.9 | 17 7/8 | 0.315 | 5/16 | 3/16 | 6.02 | 6 | 0.525 | 1/2 | 0.927 | 1 3/16 | 13/16 | | |
| ×35[c] | 10.3 | 17.7 | 17 3/4 | 0.300 | 5/16 | 3/16 | 6.00 | 6 | 0.425 | 7/16 | 0.827 | 1 1/8 | 3/4 | | |

[c] Shape is slender for compression with $F_y$ = 50 ksi.
[f] Shape exceeds compact limit for flexure with $F_y$ = 50 ksi.
[g] The actual size, combination, and orientation of fastener components should be compared with the geometry of the cross-section to ensure compatibility.
[h] Flange thickness greater than 2 in. Special requirements may apply per AISC Specification Section A3.1c.

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## Table 1–1 (continued)
## W Shapes
### Properties

W21 – W18

| Nominal Wt. | Compact Section Criteria | | Axis X-X | | | | Axis Y-Y | | | | $r_{ts}$ | $h_o$ | Torsional Properties | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\frac{b_f}{2t_f}$ | $\frac{h}{t_w}$ | $I$ | $S$ | $r$ | $Z$ | $I$ | $S$ | $r$ | $Z$ | | | $J$ | $C_w$ |
| lb/ft | | | in.$^4$ | in.$^3$ | in. | in.$^3$ | in.$^4$ | in.$^3$ | in. | in.$^3$ | in. | in. | in.$^4$ | in.$^6$ |
| 93 | 4.53 | 32.3 | 2070 | 192 | 8.70 | 221 | 92.9 | 22.1 | 1.84 | 34.7 | 2.24 | 20.7 | 6.03 | 9940 |
| 83 | 5.00 | 36.4 | 1830 | 171 | 8.67 | 196 | 81.4 | 19.5 | 1.83 | 30.5 | 2.21 | 20.6 | 4.34 | 8630 |
| 73 | 5.60 | 41.2 | 1600 | 151 | 8.64 | 172 | 70.6 | 17.0 | 1.81 | 26.6 | 2.19 | 20.5 | 3.02 | 7410 |
| 68 | 6.04 | 43.6 | 1480 | 140 | 8.60 | 160 | 64.7 | 15.7 | 1.80 | 24.4 | 2.17 | 20.4 | 2.45 | 6760 |
| 62 | 6.70 | 46.9 | 1330 | 127 | 8.54 | 144 | 57.5 | 14.0 | 1.77 | 21.7 | 2.15 | 20.4 | 1.83 | 5960 |
| 55 | 7.87 | 50.0 | 1140 | 110 | 8.40 | 126 | 48.4 | 11.8 | 1.73 | 18.4 | 2.11 | 20.3 | 1.24 | 4980 |
| 48 | 9.47 | 53.6 | 959 | 93.0 | 8.24 | 107 | 38.7 | 9.52 | 1.66 | 14.9 | 2.05 | 20.2 | 0.803 | 3950 |
| 57 | 5.04 | 46.3 | 1170 | 111 | 8.36 | 129 | 30.6 | 9.35 | 1.35 | 14.8 | 1.68 | 20.4 | 1.77 | 3190 |
| 50 | 6.10 | 49.4 | 984 | 94.5 | 8.18 | 110 | 24.9 | 7.64 | 1.30 | 12.2 | 1.64 | 20.3 | 1.14 | 2570 |
| 44 | 7.22 | 53.6 | 843 | 81.6 | 8.06 | 95.4 | 20.7 | 6.37 | 1.26 | 10.2 | 1.60 | 20.2 | 0.770 | 2110 |
| 311 | 2.19 | 10.4 | 6970 | 624 | 8.72 | 754 | 795 | 132 | 2.95 | 207 | 3.53 | 19.6 | 176 | 76200 |
| 283 | 2.38 | 11.3 | 6170 | 565 | 8.61 | 676 | 704 | 118 | 2.91 | 185 | 3.47 | 19.4 | 134 | 65900 |
| 258 | 2.56 | 12.5 | 5510 | 514 | 8.53 | 611 | 628 | 107 | 2.88 | 166 | 3.42 | 19.2 | 103 | 57600 |
| 234 | 2.76 | 13.8 | 4900 | 466 | 8.44 | 549 | 558 | 95.8 | 2.85 | 149 | 3.37 | 19.0 | 78.7 | 50100 |
| 211 | 3.02 | 15.1 | 4330 | 419 | 8.35 | 490 | 493 | 85.3 | 2.82 | 132 | 3.32 | 18.8 | 58.6 | 43400 |
| 192 | 3.27 | 16.7 | 3870 | 380 | 8.28 | 442 | 440 | 76.8 | 2.79 | 119 | 3.28 | 18.6 | 44.7 | 38000 |
| 175 | 3.58 | 18.0 | 3450 | 344 | 8.20 | 398 | 391 | 68.8 | 2.76 | 106 | 3.24 | 18.5 | 33.8 | 33300 |
| 158 | 3.92 | 19.8 | 3060 | 310 | 8.12 | 356 | 347 | 61.4 | 2.74 | 94.8 | 3.20 | 18.3 | 25.2 | 29000 |
| 143 | 4.25 | 22.0 | 2750 | 282 | 8.09 | 322 | 311 | 55.5 | 2.72 | 85.4 | 3.17 | 18.2 | 19.2 | 25700 |
| 130 | 4.65 | 23.9 | 2460 | 256 | 8.03 | 290 | 278 | 49.9 | 2.70 | 76.7 | 3.13 | 18.1 | 14.5 | 22700 |
| 119 | 5.31 | 24.5 | 2190 | 231 | 7.90 | 262 | 253 | 44.9 | 2.69 | 69.1 | 3.13 | 17.9 | 10.6 | 20300 |
| 106 | 5.96 | 27.2 | 1910 | 204 | 7.84 | 230 | 220 | 39.4 | 2.66 | 60.5 | 3.10 | 17.8 | 7.48 | 17400 |
| 97 | 6.41 | 30.0 | 1750 | 188 | 7.82 | 211 | 201 | 36.1 | 2.65 | 55.3 | 3.08 | 17.7 | 5.86 | 15800 |
| 86 | 7.20 | 33.4 | 1530 | 166 | 7.77 | 186 | 175 | 31.6 | 2.63 | 48.4 | 3.05 | 17.6 | 4.10 | 13600 |
| 76 | 8.11 | 37.8 | 1330 | 146 | 7.73 | 163 | 152 | 27.6 | 2.61 | 42.2 | 3.02 | 17.5 | 2.83 | 11700 |
| 71 | 4.71 | 32.4 | 1170 | 127 | 7.50 | 146 | 60.3 | 15.8 | 1.70 | 24.7 | 2.05 | 17.7 | 3.49 | 4700 |
| 65 | 5.06 | 35.7 | 1070 | 117 | 7.49 | 133 | 54.8 | 14.4 | 1.69 | 22.5 | 2.03 | 17.6 | 2.73 | 4240 |
| 60 | 5.44 | 38.7 | 984 | 108 | 7.47 | 123 | 50.1 | 13.3 | 1.68 | 20.6 | 2.02 | 17.5 | 2.17 | 3850 |
| 55 | 5.98 | 41.1 | 890 | 98.3 | 7.41 | 112 | 44.9 | 11.9 | 1.67 | 18.5 | 2.00 | 17.5 | 1.66 | 3430 |
| 50 | 6.57 | 45.2 | 800 | 88.9 | 7.38 | 101 | 40.1 | 10.7 | 1.65 | 16.6 | 1.98 | 17.4 | 1.24 | 3040 |
| 46 | 5.01 | 44.6 | 712 | 78.8 | 7.25 | 90.7 | 22.5 | 7.43 | 1.29 | 11.7 | 1.58 | 17.5 | 1.22 | 1720 |
| 40 | 5.73 | 50.9 | 612 | 68.4 | 7.21 | 78.4 | 19.1 | 6.35 | 1.27 | 10.0 | 1.56 | 17.4 | 0.810 | 1440 |
| 35 | 7.06 | 53.5 | 510 | 57.6 | 7.04 | 66.5 | 15.3 | 5.12 | 1.22 | 8.06 | 1.52 | 17.3 | 0.506 | 1140 |

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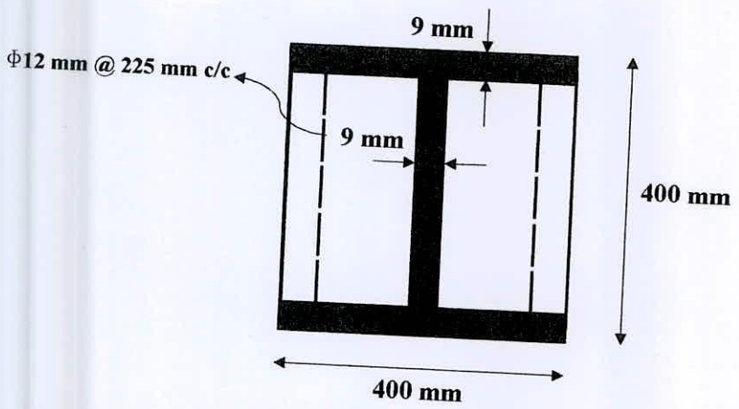



**Figure 4**

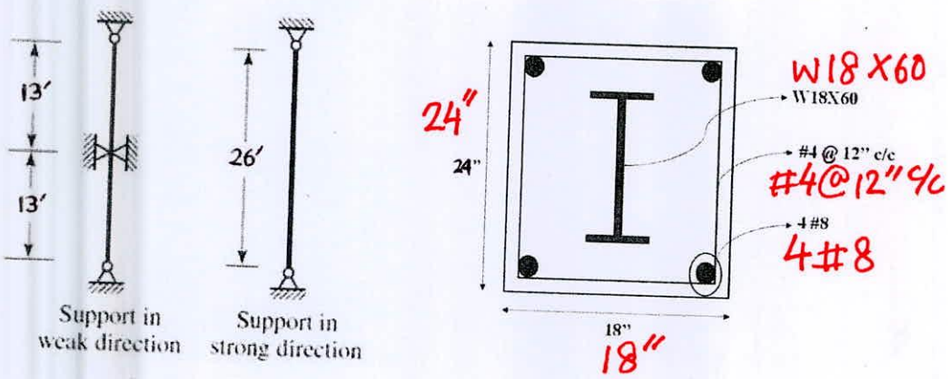



**Figure 5**

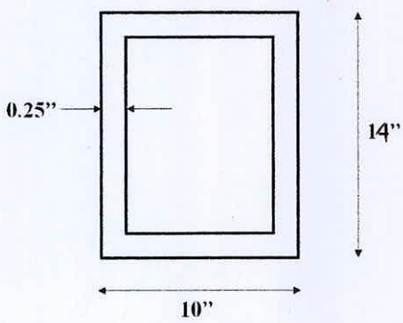



**Figure 6**

Contd... P/8

# ANNEXURE

## Design Specifications According to AISC 2010

**For CFT Columns:**

**TABLE I1.1A**
**Limiting Width-to-Thickness Ratios for Compression Steel Elements in Composite Members Subject to Axial Compression**
**For Use with Section I2.2**

| Description of Element | Width-to-Thickness Ratio | $\lambda_p$ Compact/ Noncompact | $\lambda_r$ Noncompact/ Slender | Maximum Permitted |
|---|---|---|---|---|
| Walls of Rectangular HSS and Boxes of Uniform Thickness | $b/t$ | $2.26\sqrt{\frac{E}{F_y}}$ | $3.00\sqrt{\frac{E}{F_y}}$ | $5.00\sqrt{\frac{E}{F_y}}$ |
| Round HSS | $D/t$ | $\frac{0.15E}{F_y}$ | $\frac{0.19E}{F_y}$ | $\frac{0.31E}{F_y}$ |

**TABLE I1.1B**
**Limiting Width-to-Thickness Ratios for Compression Steel Elements in Composite Members Subject to Flexure**
**For Use with Section I3.4**

| Description of Element | Width-to-Thickness Ratio | $\lambda_p$ Compact/ Noncompact | $\lambda_r$ Noncompact/ Slender | Maximum Permitted |
|---|---|---|---|---|
| Flanges of Rectangular HSS and Boxes of Uniform Thickness | $b/t$ | $2.26\sqrt{\frac{E}{F_y}}$ | $3.00\sqrt{\frac{E}{F_y}}$ | $5.00\sqrt{\frac{E}{F_y}}$ |
| Webs of Rectangular HSS and Boxes of Uniform Thickness | $h/t$ | $3.00\sqrt{\frac{E}{F_y}}$ | $5.70\sqrt{\frac{E}{F_y}}$ | $5.70\sqrt{\frac{E}{F_y}}$ |
| Round HSS | $D/t$ | $\frac{0.09E}{F_y}$ | $\frac{0.31E}{F_y}$ | $\frac{0.31E}{F_y}$ |

(a) For *compact sections*

$$P_{no} = P_p$$

where

$$P_p = F_y A_s + C_2 f_c' \left( A_c + A_{sr} \frac{E_s}{E_c} \right)$$

$C_2 = 0.85$ for rectangular sections and 0.95 for round sections

(b) For *noncompact sections*

$$P_{no} = P_p - \frac{P_p - P_y}{(\lambda_r - \lambda_p)^2} (\lambda - \lambda_p)^2$$

where

$\lambda$, $\lambda_p$ and $\lambda_r$ are slenderness ratios determined from Table I1.1a

$P_p$ is determined from Equation I2-9b

$$P_y = F_y A_s + 0.7 f_c' \left( A_c + A_{sr} \frac{E_s}{E_c} \right)$$

Contd ... P/9

# ANNEXURE

(c) For slender sections

$$P_{no} = F_{cr} A_s + 0.7 f_c' \left( A_c + A_{sr} \frac{E_s}{E_c} \right)$$

where

(i) For rectangular filled sections

$$F_{cr} = \frac{9E_s}{\left(\frac{b}{t}\right)^2}$$

(ii) For round filled sections

$$F_{cr} = \frac{0.72F_y}{\left(\left(\frac{D}{t}\right)\frac{F_y}{E_s}\right)^{0.2}}$$

$$EI_{eff} = E_s I_s + E_s I_{sr} + C_1 E_c I_c$$

$$C_1 = 0.6 + 2\left(\frac{A_s}{A_c + A_s}\right) \leq 0.9$$

$$If \ldots \frac{P_{no}}{P_e} \leq 2.25 \quad P_n = P_{no}\left[0.658^{\left(\frac{P_{no}}{P_e}\right)}\right]$$

$$Else \ldots \frac{P_{no}}{P_e} > 2.25 \quad P_n = 0.877 P_e$$

**For FEC Columns:**

$$P_o = A_s F_y + A_{sr} F_{yr} + 0.85 A_c f_c'$$

$$EI_{eff} = E_s I_s + 0.5 E_s I_{sr} + C_1 E_c I_c$$

$$C_1 = 0.1 + 2\left(\frac{A_s}{A_c + A_s}\right) \leq 0.3$$

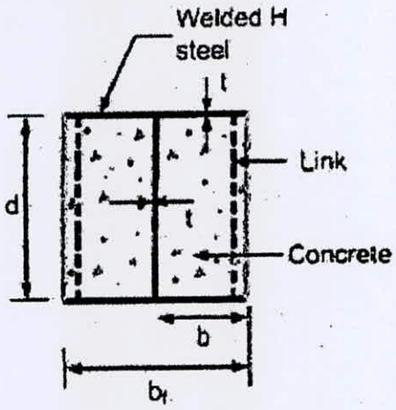
$$If \ldots \frac{P_o}{P_e} \leq 2.25 \quad P_n = P_o\left[0.658^{\left(\frac{P_o}{P_e}\right)}\right]$$

$$Else \ldots \frac{P_o}{P_e} > 2.25 \quad P_n = 0.877 P_e$$

Contd - - - P/10

# ANNEXURE

**For PEC columns with Non-compact section:**




$$C_r = A_{sc} F_y + 0.85 A_c f_c'$$

$$A_{sc} = (d - 2t + 2b_e)t$$

$$b_e = \frac{b_f}{\left(1 + \lambda_p^{2n}\right)^{1/n}} \le b_f \qquad \text{where, } n = 1.5$$

$$\lambda_p = \frac{b}{t}\sqrt{\frac{12\left(1-\nu_s^2\right)F_y}{\pi^2 E_s k}}$$

$$k = \frac{0.9}{(s/b_f)^2} + 0.2(s/b_f)^2 + 0.75, \qquad (0.5 \le s/b_f \le 1) \qquad \text{where, s = link spacing}$$

**AISC Interaction Equations:**

(a) When $\frac{P_r}{P_c} \ge 0.2$

$$\frac{P_r}{P_c} + \frac{8}{9}\left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \le 1.0$$

(b) When $\frac{P_r}{P_c} < 0.2$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \le 1.0$$

X

L-4/T-2/CE **Date: 23/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 415** (Prestressed Concrete)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume reasonable values for any missing data. Symbols carry their usual meanings.

1. (a) What are the advantages and disadvantages of pre-tensioning over post-tensioning? **(6 ⅓)**

(b) Consider that a simply supported one-way slab of 25 ft span and 8 ft wide is to be built where both reinforced and prestressed concrete are potential alternatives. Find out maximum steel area at the mid-section of the slab for the following cases, and briefly comment on the advantage of prestressing and eccentricity. Assume that no tension is allowed for prestressed member. **(17)**

(i) Reinforced concrete slab: USD approach

(ii) Prestressed concrete slab: uniform prestress when is no eccentricity ($e_o$=0)

(iii) Prestressed concrete slab: eccentric prestress (central kern) when $e_o$= h/6 and h is the slab thickness

(iv) Prestressed concrete slab: eccentric prestress with maximum eccentricity $e_o$=4 in.

Given, slab thickness h = 12 in, distance from extreme compressive fiber to c.g. of steel = 10 in, Live load = 125 psf, $\gamma_c = 150 pcf$, $f_c'$ = 5000 $psi$, $\overline{\sigma}_{cs} = 2000 psi$, $f_{pu} = 270 ksi$, $f_{pe} = 160 ksi$, $f_y = 60 ksi$.

2. (a) Plot typical variation of steel stress with time for pre-tensioned and post-tensioned member showing short- and long-term losses at different stages of loading. **(6 ⅓)**

(b) For the simply supported pretensioned beam with low relaxation strand shown in Fig. 1, compute elastic shortening loss, shrinkage loss, creep loss, stress relaxation losses before and after transfer of prestress. Use lump sum method for separate loss calculation. For elastic shortening loss, use accurate method. **(17)**

Given,

$E_{ps} = 28000 ksi$, $f_{pu} = 270 ksi$, $f_{py} = 230 ksi$, $f_{pj1} = lower\ of\ (0.8 f_{pu}, 0.94 f_{py})$,

$E_c = 33 \gamma_c^{1.5} \sqrt{f_c'}$, $f_c' = 5000 psi$, $f_{ci}' = 4000 psi$, $\gamma_c = 150 pcf$, $H = 75\%$.

Consider that transfer of prestress occurs 24 hours after tensioning, and that curing ends at the time of transfer.

You may use following formula for the calculation of losses, where symbols carry their usual meanings.

Contd ..... P/2

**CE 415**

**Contd... Q. No.2(b)**

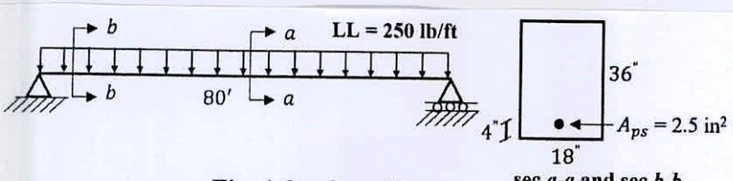



**Fig. 1 for Ques 2b**

$$\Delta f_{pES} = \frac{(f_{cgp})_{F_J}[f_{pJ2} - \Delta f_{pR}(t_o, t_t)] + (f_{cgp})_G f_{pJ2}}{f_{pJ2}/n_{pi} + (f_{cgp})_{F_J}}$$

$$F_J = A_{ps} f_{pJ2}$$

$$(f_{cgp})_{F_i+G} = (f_{cgp})_{F_i} + (f_{cgp})_G = \left(\frac{F_i}{A_c} + \frac{F_i e_o^2}{I}\right) - \left(\frac{M_G e_o}{I}\right)$$

$$\Delta f_{pS} = (17 - 0.15H) \text{ (ksi)}$$

$$\Delta f_{pC} = 12 f_{cgp} - 7\Delta f_{cdp} \geq 0$$

$$\Delta f_{pR1} = \frac{\log(24t)}{40}\left[\frac{f_{pJ2}}{f_{py}} - 0.55\right] f_{pJ2}$$

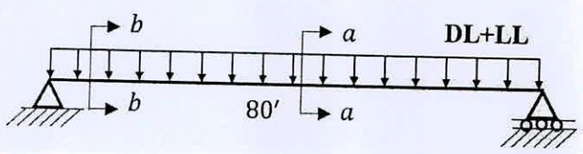
$$\Delta f_{pR2} = 20 - 0.3\,\Delta f_{pF} - 0.4\,\Delta f_{pES} - 0.2(\Delta f_{pS} + \Delta f_{pC}) \text{ (ksi)} \qquad \textit{(for stress relived strand)}$$

3. (a) Classify class U, class T and class C prestressed concrete flexural members based on the extreme fiber stress at service loads. **(6⅓)**

(b) For the simply supported pretensioned beam shown in Fig. 2, compute flexural stresses at the top and bottom fibers at transfer and final stages. Following information are given. Determine section's adequacy with respect to flexural stresses. **(17)**

$f_c' = 5000\ psi$, $f_{ci}' = 4000\ psi$, $\gamma_c = 150\ pcf$, $\overline{\sigma}_{ti} = -3\sqrt{f_{ci}'}$, $\overline{\sigma}_{ci} = 0.6 f_{ci}'$, $\overline{\sigma}_{ts} = -6\sqrt{f_c'}$, $\overline{\sigma}_{cs} = 0.6 f_c'$, $\overline{\sigma}_{csus} = 0.45 f_c'$.

Live load = 0.4 *k/ft*, superimposed dead load = 0.04 *k/ft*, self-weight = 0.573 *k/ft*, $E_{ps} = 28000\ ksi$, $f_{pu} = 270\ ksi$, $f_{pe} = 150\ ksi$, $A_{ps} = 1.53\ in^2$, $F$ = 229.5 kips, $F_i$ = 276.5 kips, $\eta = 0.83$, $e_{0(mp)} = y_b - 4$.



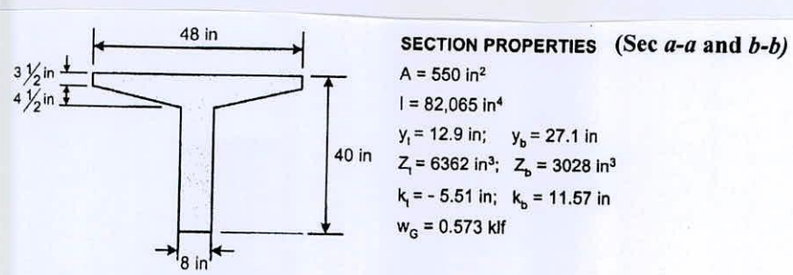




**Fig. 2 for Ques 3b**

Contd ..... P/3

## CE 415

**Contd... Q. No.3(b)**

**Table 1 for Ques 3b**

| Way | Stress condition | Inequality equation |
|---|---|---|
| 1 | I | $(F_i / A_c)[1-(e_o / k_b)]+M_{\min} / Z_t \geq \bar{\sigma}_{ti}$ |
| | II | $(F_i / A_c)[1-(e_o / k_t)]-M_{\min} / Z_b \leq \bar{\sigma}_{ci}$ |
| | III | $[(F \text{ or } \eta F_i) / A_c][1-(e_o / k_b)]+M_{\max} / Z_t \leq \bar{\sigma}_{cs}$ |
| | IV | $[(F \text{ or } \eta F_i) / A_c][1-(e_o / k_t)]-M_{\max} / Z_b \geq \bar{\sigma}_{ts}$ |
| 2 | I | $e_o \leq k_b+(1/F_i)(M_{\min}-\bar{\sigma}_{ti}Z_t)$ |
| | II | $e_o \leq k_t+(1/F_i)(M_{\min}+\bar{\sigma}_{ci}Z_b)$ |
| | III | $e_o \geq k_b+[1/(F \text{ or } \eta F_i)](M_{\max}-\bar{\sigma}_{cs}Z_t)$ |
| | IV | $e_o \geq k_t+[1/(F \text{ or } \eta F_i)](M_{\max}+\bar{\sigma}_{ts}Z_b)$ |

4. (a) Differentiate between limit kern and central kern. Define limit zone. Graphically show typical relationship between limit kern and limit zone. **(9 ⅓)**

(b) A feasibility domain of prestressed beam shown in Fig. 3a is plotted in Fig. 3b. From this feasibility domain graph, (i) determine the minimum required prestressing forcing at midspan section B (Fig. 3a) and corresponding number of strands where $f_{pe} = 150\,ksi$ and $A_{ps} = 0.153\,in^2$ (single strand). For the applied prestressing force derived from (i), determine eccentricity ranges at midspan section B support section C (Fig.3a). **(14)**

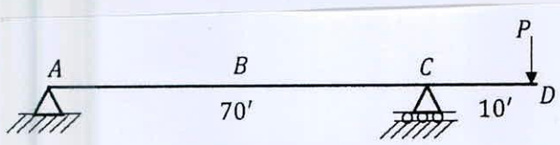



**Fig. 3a for Ques 4b**

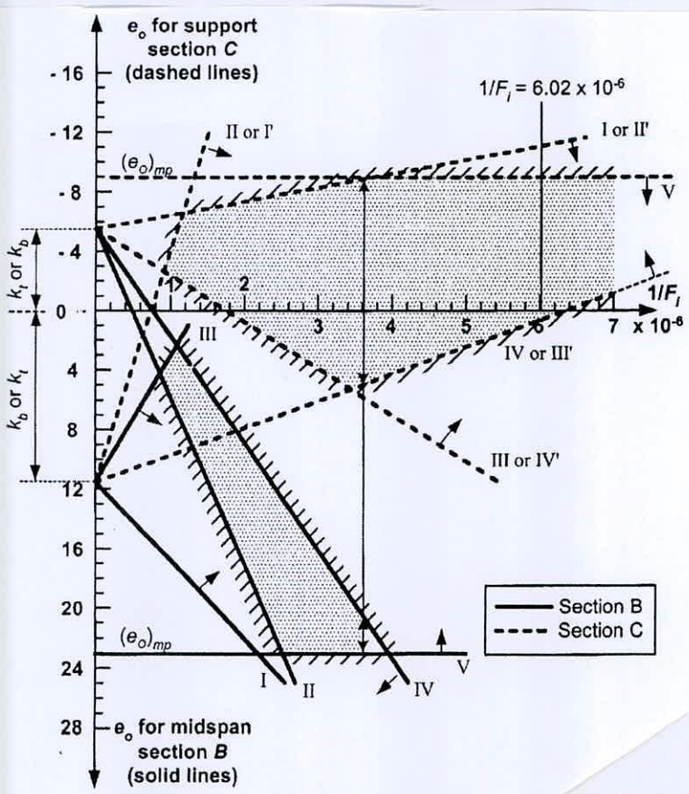



**Fig. 3b for Ques 4b**

Contd ..... P/4

**CE 415**

## SECTION – B

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

5. (a) Write down the ACI and AASHTO code recommended minimum reinforcement and minimum moment resistance for prestressed concrete flexural members. **(6⅓)**

(b) Determine nominal moment resistance of a partially prestressed concrete rectangular section with dimensions shown in Fig. 4a, for which $f_c' = 6000\ psi$, $\beta_1 = 0.80$, $\gamma_p = 0.4$, $f_r = -530.3\,psi$, $f_{pu} = 270\,ksi$, $f_{pe} = 148.5\,ksi$, $f_{py} = 0.85 f_{pu}$, $f_y = 60\,ksi$, $A_{ps} = 0.918\,in^2$, $A_s = 0.98\,in^2$, $d_p = 20.75\,in$, $d_s = 21.5\,in$, $width\ b = 15\ in$ (Symbols carry their usual meanings). In addition, check minimum reinforcement criteria for this partially prestressed beam. Assume that the prestressing tendors are bonded. **(17)**

Use following formulas for determining the nominal resistance and Fig. 4b for determining limit reinforcements.

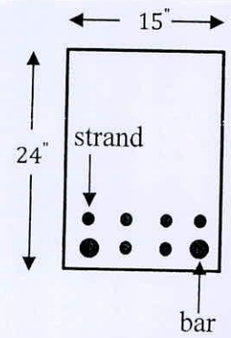



**Fig. 4a for Ques 5b**

$$f_{ps} = f_{pu}\left[1 - \frac{\gamma_p}{\beta_1}\left\{\rho_p \frac{f_{pu}}{f_c'} + \frac{d_s}{d_p}(\omega_s - \omega')\right\}\right]$$

$$a = \beta_1 c = \frac{A_{ps} f_{ps} + A_s f_y}{0.85 f_c' b}, \quad \rho_p = \frac{A_{ps}}{b d_p}, \quad \omega_s = \frac{A_s f_y}{b d_s f_c'}$$

$$M_n = A_{ps} f_{ps}\left(d_p - \frac{a}{2}\right) + A_s f_y\left(d_s - \frac{a}{2}\right)$$

$$M_{cr} = A_{ps} f_{pe}\left(e_o + \frac{Z_b}{A_c}\right) - f_r Z_b$$

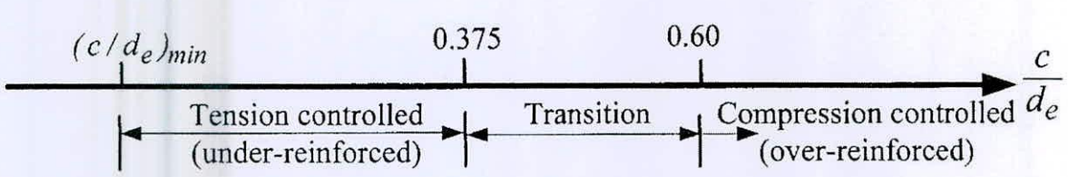



**Fig. 4b for Ques 5b: Comparison for limits of reinforcement in flexural members**

Contd ..... P/5

**CE 415**

6. (a) Derive formulas for computing deflection (camber) of simply supported beams with uniform cross section due to prestressing force $F_i$ having profiles shown in Fig. 5a and 5b. Consider that modulus of elasticity and moment of inertia of beam section are $E_c$ and $I$, respectively. **(16)**

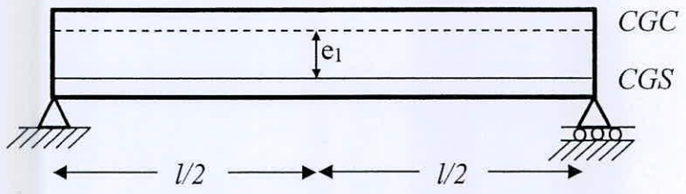



**Fig. 5a for Ques 6**

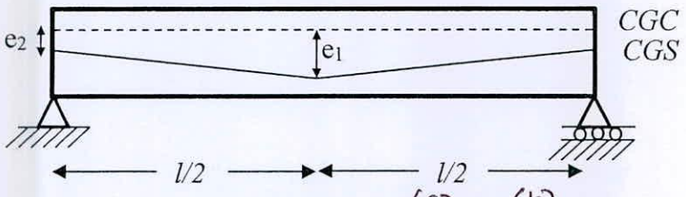



**Fig. 5b for Ques 6 (i) and (ii)**

(b) If a concentrated force $P$ = 10 kip is applied at midsection of the beam shown in Fig. 5b, what will be the net deflection due to prestressed force, self-weight and sustained load $P$. Given that $e_1$ = 20 *in*, $e_2$ = 4 *in*, $l$ = 30 ft, $F_i$ = 230 kip, $E_c = 3.834 \times 10^6$ psi, $I$ = 82065 in$^4$, $A_c$ = 550 in$^2$, $\Delta = \dfrac{PL^3}{48EI}$ for concentrated force $P$ at midsection and $\Delta = \dfrac{5wL^4}{384EI}$ for UDL $w$. Self-weight ($w$) of the beam is 0.573 k/ft. **(7⅓)**

7. (a) Write down the advantages of prestressed concrete over reinforced concrete in terms of serviceability, safety, and economy? **(6⅓)**

(b) A slab deck is composed of simply supported standard precast double T concrete beams as shown in Fig. 6, whose typical cross section and available dimensions are given in Table 2. Select the least weight beam from Table 2 which satisfies the working stress design requirements in flexure. Given, $f_{pu} = 270\,ksi$, $f_{pe} = 155\,ksi$, $f_c'$ = 5000 *psi*, $f_{ci}' = 3750\,psi$, span $L$ = 50 ft, $\bar{\sigma}_{ti} = -3\sqrt{f_{ci}'}$, $\bar{\sigma}_{ci} = 0.6 f_{ci}'$, $\bar{\sigma}_{ts} = -6\sqrt{f_c'}$, $\bar{\sigma}_{cs(sus)} = 0.45 f_c'$, $\eta = 0.85$, $(e_0)_{mp} = y_b - 3.5$ in . Superimposed dead and live load = 100 psf. Area of one strand is 0.153 in$^2$. Following formulas are given. **(17)**

$$Z_t \geq \frac{\Delta M + (1-\eta) M_{\min}}{\bar{\sigma}_{cs} - \eta \bar{\sigma}_{ti}}$$

$$Z_b \geq \frac{\Delta M + (1-\eta) M_{\min}}{\eta \bar{\sigma}_{ci} - \bar{\sigma}_{ts}}$$

Contd ..... P/6

**CE 415**

**Contd... Q. No.7(b)**

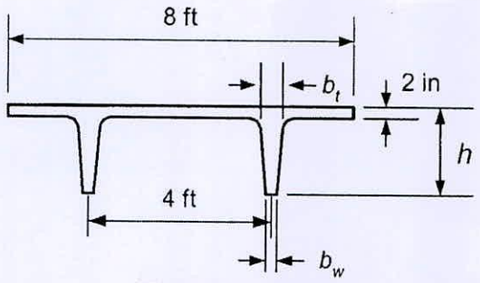



**Fig. 6 for Ques 7b**

**Table 2 for Ques 7b**

| $h$ in | $b_t$ in | $b_w$ in | $A$ $in^2$ | $I$ $in^4$ | $y_t$ in | $y_b$ in | $Z_t$ $in^3$ | $Z_b$ $in^3$ | $W_G$ plf |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 8.00 | 6.00 | 388 | 8,944 | 4.87 | 11.13 | 1,837 | 804 | 310 |
| 18 | 9.75 | 7.75 | 472 | 14,623 | 6.16 | 11.84 | 2,374 | 1,235 | 377 |
| 20 | 9.75 | 7.50 | 503 | 19,354 | 6.94 | 13.06 | 2,789 | 1,482 | 401 |
| 24 | 9.75 | 7.00 | 560 | 31,192 | 8.49 | 15.51 | 3,674 | 2,011 | 447 |
| 32 | 8.00 | 4.00 | 549 | 51,286 | 10.29 | 21.71 | 4,984 | 2,362 | 439 |

8. (a) "The benefits of continuity in prestressed concrete may be often offset by its drawbacks"- justify this statement for the continuous prestressed beams. **(6)**

(b) What are the standard AASHTO-PCI bridge I-beams and their span ranges? In addition, draw three typical precast sections for short to medium span bridges with their span ranges. **(6)**

(c) Write down three advantages of composite construction for prestressed concrete structures. **(6)**

(d) State limit state design philosophy. Differentiate between *Limit State Design* and *Limit Design*. **(5⅓)**

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L-4/T-2/CE **Date: 03/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 419** (Introduction to Finite Element Method)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FOUR** questions in this section. Answer **ALL** questions.

1. (a) What is constitutive relation? Write down the relation for a linear isotropic element. **(5.5)**

(b) What are the basic assumptions for analyzing a structure based on linear static analysis? **(6)**

(c) A bar element is subjected to an axially distributed force, q. The distribution is uniform along the length. Employ appropriate shape functions to equate the amount of work done with the energy and obtain the equivalent nodal forces. **(6)**

2. Answer "2(a) and 2(b)" **OR** "2(c) and 2(d)":

(a) An aircraft consists of fuselage, wings and tails. Introduce substructure concept to model an aircraft in finite element methods. In this process, explain the advantages of the substructure concept. **(10)**

(b) Explain the differences in approaches one will follow to model and to analyze the superstructure and the foundation of a building. **(7.5)**

**OR**

(c) "Finite element method is an approximate method for analyzing a structure". (i) Identify the domains/ systems where such approximations are made in the process of transitioning from a physical system to a numerical model. (ii) Please explain pictorially the areas where errors can affect your result and the ways to minimize those. **(11.5)**

(d) Write short notes on justifying the following statements: **(3+3)**

(i) Civil Engineers applied the finite element method later than the aerospace industry.

(ii) Capability of a finite element software depends not only on the solver but also on the pre-processor and post-processor modules.

3. Answer 3(a) **OR** 3(b):

(a) Introduce shape function by considering stored strain energy for deriving general formula for the element stiffness matrix $\underline{\underline{k}}$ in a spring element, **(17.5)**

$$k = \int \underline{\underline{B}}^T \underline{\underline{E}} \underline{\underline{B}} \, dv$$

In this process explain why the element stiffness you derive is unsuitable for stress analysis of the spring itself. **OR**

Contd ..... P/2

**CE 419**

**Contd... Q. No.3**

(b) Write down the fundamental points that you will have to check before relying on a result obtained from finite element method. **(17.5)**

4. Answer "4(a) and 4(b)" **OR** "4(c) and 4(d)":

(a) Generated stiffness in a civil engineering problem is usually banded in nature-explain the advantages of this property in obtaining an efficient solution. **(10)**

(b) What are the ways you may consider to reduce the band width while modeling a problem in finite element method? **(7.5)**

**OR**

(c) What are the basic conditions we do expect from a stiffness matrix to satisfy? Explain with examples, figures and equations. **(9)**

(d) Explain the differences and conditions between nonlinearities arising out of geometries and material properties. Explain with figures and examples. **(8.5)**

**SECTION – B**

There are **FOUR** questions in this section. Answer **ALL** questions.

5. (a) What are the basic components of a general purpose finite element software? **(5.5)**

(b) "A thin plate is subjected to forces in its plane only." Write down the stress-strain relation along with necessary assumptions. **(6)**

(c) "A long body is subjected to significant lateral forces but very little longitudinal forces". Write down stress-strain relations for this range of problem and consider necessary assumptions for the derivation. **(6)**

6. Answer "6(a) and 6(b)" **OR** "6(c) and 6(d)":

(a) Approximate the area of a circle by dividing it into a number of triangles. In this process show that $S_N = \pi R^2$ when $N \rightarrow \infty$. Where, $R$ = radius of the circle, $N$ = number of triangles, $S_N$ = Area of the circle. **(12)**

(b) Summarize the basic procedural steps that are followed in FEM for analyzing a structure. **(5.5)**

**OR**

(c) Explain the type of discontinuities that may occur in a finite element mesh? What are the ways to minimize such discontinuities? **(11.5)**

(d) Write short notes on: **(3+3)**

(i) Effect of element aspect ratio on accuracy

(ii) Numbering of nodes for bandwidth minimization.

Contd ..... P/3

**CE 419**

7. Answer 7(a) **OR** 7(b):

(a) Introduce shape function by considering stored strain energy for deriving general formula for the element stiffness matrix ($k$) in a beam element **(17.5)**

$$k = \int \underline{\underline{B}}^T \underline{\underline{E}} \underline{\underline{B}} \, dv$$

**OR**

(b) Introduce natural coordinate system and derive the Jacobbean Matrix $\underline{\underline{J}}$ for a constant strain triangle element. In this process also derive the strain-displacement matrix $\underline{\underline{B}}$. **(17.5)**

8. Answer "8(a) and 8(b)" **OR** "8(c) and 8(d)":

(a) Explain the isoparametric concept in Finite Element analysis. **(8.5)**

(b) State and explain the three basic laws on which the isoparametric concept is developed. **(9)**

**OR**

(c) Explain the following terms: **(9)**

(i) isoparametric elements

(ii) Subparametric elements

(iii) Superparametric elements

(d) Explain the following terms: **(8.5)**

(i) Nodes, Elements

(ii) Local coordinates, Global coordinates

(iii) Transformation matrix

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L-4/T-2/CE **Date: 03/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 421** (Dynamics of Structures)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Describe briefly the procedure to develop a deformation response spectrum curve. **(8 ⅓)**

   (b) Describe briefly different mechanical models of a dynamic system. **(5)**

   (c) Derive the equations of motion in matrix format of the two DOF dynamic system as shown in **Fig. 1**. **(10)**

2. (a) Find the steady-state response of a viscously damped system with m = 1 kg, k = 400 N/m, and c = 5 N-s/m subject to the periodic force shown in **Fig. 2**. Determine only the first four terms of the Fourier coefficients $a_o$, $a_n$, and $b_n$ of the periodic loading. **(20)**

   (b) What do you mean by Equivalent Static Force in Earthquake Engineering? **(3 ⅓)**

3. A single storey reinforced concrete (RC) building as shown in **Fig. 3** supporting a dead load of, W = 10 kip at the roof level is subjected to EL Centro ground motion in the horizontal direction. The ground acceleration as shown in **Table 1**. Each column is 10″× 10″ in cross-section. The beam is assumed to be rigid ($EI_b = \infty$). Assume, $E = 3 \times 10^3$ ksi and 2% damping of the system. Determine the peak displacement of the frame and plot the bending moment diagram at the instant of peak response. Given, gravity acceleration, g = 386 inch/s$^2$. Use Newmark's Beta method (constant average acceleration method). Given, initial displacement, $v_o = 0$ and initial velocity, $\dot{v}_o = 0$. Use equations (i) to (iv) given herewith. **(23 ⅓)**

(i) $\tilde{k}_c = k + \frac{2c}{h} + \frac{4m}{h^2}$ (ii) $\tilde{p}_{1c} = p_1 + c\left(\frac{2v_0}{h} + \dot{v}_0\right) + m\left(\frac{4v_0}{h^2} + \frac{4}{h}\dot{v}_0 + \ddot{v}_0\right)$

(iii) $\dot{v}_1 = \frac{2}{h}(v_1 - v_0) - \dot{v}_0$ (iv) $\ddot{v}_1 = \frac{1}{m}(p_1 - c\dot{v}_1 - kv_1)$

**Table 1.** El-Centro EQ Data (g = 386 inch/s^2)

| Time, t (s) | Acceleration, $\ddot{u}_g$ (Unit of g) |
|---|---|
| 0 | 0 |
| 0.02 | 0.003774 |
| 0.04 | 0.002615 |
| 0.06 | 0.00203 |
| 0.08 | 0.004129 |
| 0.1 | 0.005784 |
| 0.12 | 0.007635 |
| 0.14 | 0.005985 |

Contd ..... P/2

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4. Determine natural frequency, mode shape and the free vibration response of the two DOF shear frame as shown in **Fig. 4**. Given, $EI_1 = 10000$ k-in$^2$, $EI_2 = 8000$ k-in$^2$, $h_1 = 15$ ft, $h_2 = 12$ft, $m_1 = m_2 = 4$ kip/in/sec$^2$. **(23 ⅓)**

The initial condition is given as,

$$x(0) = \begin{bmatrix} -1/2 \\ 2 \end{bmatrix}, \quad \dot{x}(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

## SECTION – B

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

5. (a) The response of a single-degree-of-freedom system that is initially displaced and released is given by Eq (v). Determine the damping ratio, natural frequency, and the initial displacement of the system. **(13 ⅓)**

$$x(t) = 0.05e^{-6t}\sin(15t + 1.33332)\text{m} \quad \ldots\ldots \text{(v)}$$

(b) A sledgehammer strikes an anvil with a velocity of 15 m/s (**Fig. 5**). The hammer and the anvil have a mass of 6 kg and 50 kg, respectively. The anvil is supported on four springs, each of stiffness k = 17.5 kN/m. Find the resulting motion of the anvil (a) if the hammer remains in contact with the anvil and (b) if the hammer does not remain in contact with the anvil after the initial impact. **(10)**

6. (a) Derive the response of an under-damped SDOF dynamic system under ideal step loading? Given, initial condition u (0) = $\dot{u}$ (0) = 0. **(13 ⅓)**

(b) A video camera, of mass 2.0 kg, is mounted on the top of a bank building for surveillance. The video camera is fixed at one end of a tubular aluminum rod whose other end is fixed to the buildings as shown in **Fig. 6**. The wind-induced force acting on the video camera, f(t), is found to be harmonic with f(t) = 25 cos 75.3984t N. Determine the diameters of the aluminum tube (outer to inner diameter ratio =1.2) if the maximum steady state amplitude of vibration of the video camera is to be limited to 0.005 m. Assume 2% damping. $E_{Al} = 70$ GPa. **(10)**

7. (a) Design a hollow circular steel column for the water tank shown in **Fig. 7**. The weight of the tank (W) is 500 kN and the height is 20 m. The stress induced in the column should not exceed the yield strength of the material, which is 200 MPa, when subjected to a harmonic ground acceleration (due to an earthquake) of amplitude 0.5 g and frequency 15 Hz. In addition, the natural frequency of the water tank should be greater than 15 Hz. Assume a damping ratio of 0.15 for the column and column outer to inner diameter ratio = 1.2. $E_{steel} = 200$ GPa. **(13 ⅓)**

Contd ..... P/3

**CE 421**
**Contd... Q. No.7**

(b) Describe the bandwidth method to evaluate the damping of an SDOF dynamic system. **(7)**

(c) What do you mean by dynamic amplification factor? **(3)**

8. (a) What is the impulse response function? Write short notes on Duhamel's integrals. **(13 ⅓)**

(b) If the frame in **Fig. 8** is subjected to a step pulse, as shown in **Fig. 9**, having a force of 50 kips, which is applied at the top of the structure. Assume the girder of the frame is rigid. Determine the maximum displacement and the maximum base shear. **(10)**

Given: section modulus, S = 17.0 $in^3$, I = 69.2 $in^4$, and E = 30,000 ksi.

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Contd... P/4

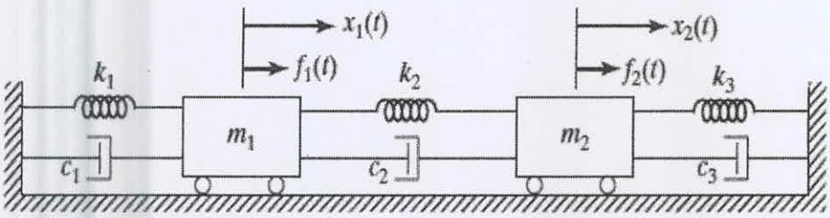



Fig. 1 (Q. NO. 1)

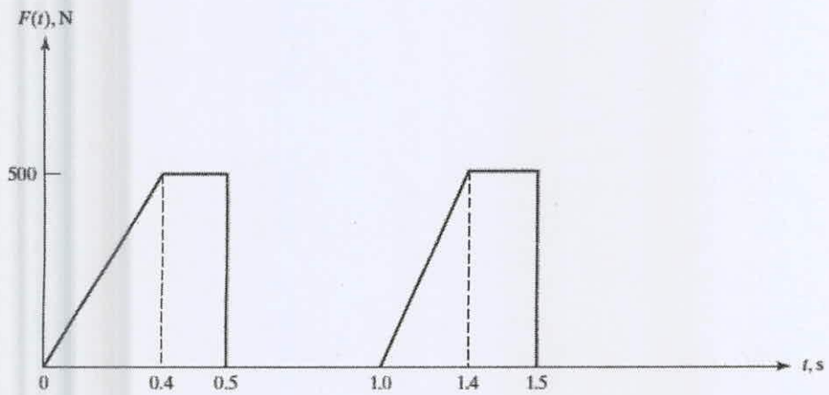



Fig. 2 (for Q. NO. 2)

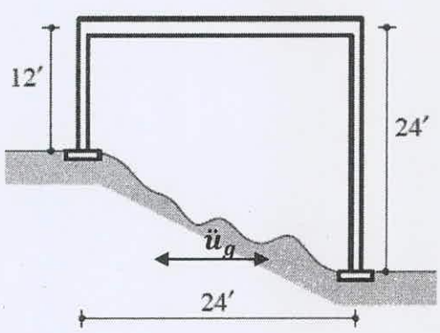
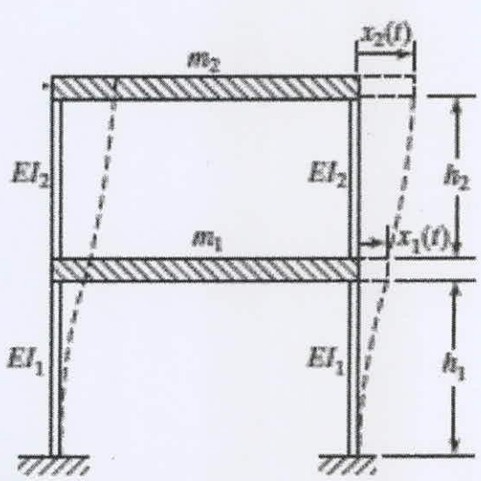



Fig. 3 (for Q. NO. 3)




(For Q. NO. 4)

Fig. 4

Contd... P/5

CE421

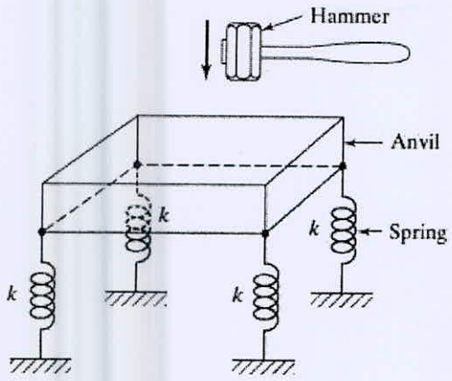



Fig. 1 5

(for Q. 5)

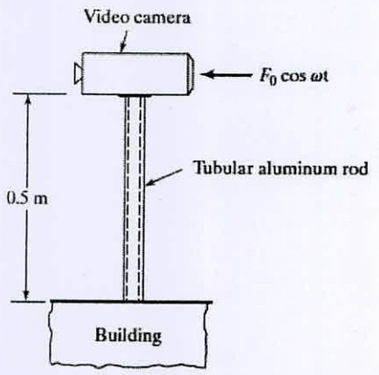



Fig. 1 6

(for Q. No. 6)

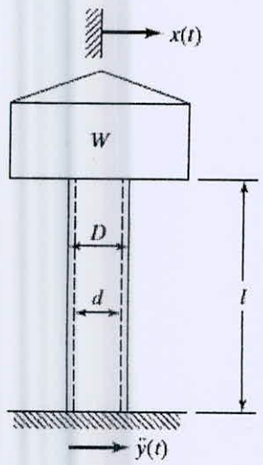



Fig. 3 1 7

(for Q. NO. 7)

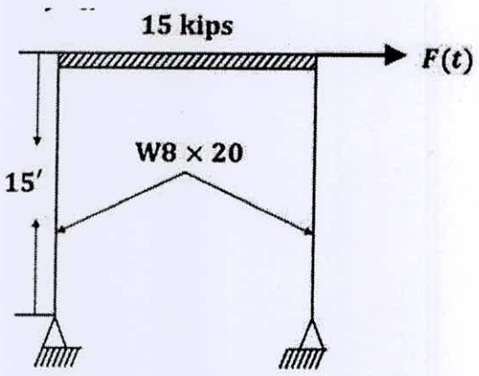



Fig. 4 1 8

(for Q. N. 8)

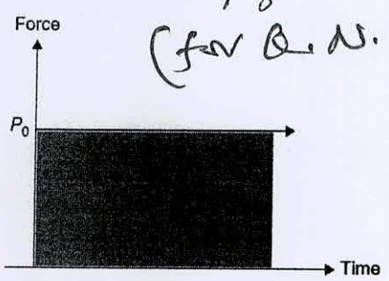



Fig. 5 1 9

(for Q. NO. 8)

L-4/T-2/CE **Date: 27/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 433** (Solid and Hazardous Waste Management)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) Draw the Standard Functional Element Diagram for Solid Waste Management System and briefly explain the inter-relationship among each element. Also, draw a similar Functional Element Diagram for Solid Waste Management for Dhaka city and show how it differs from the typical diagram. **(10)**

(b) As a consultant for a commercial waste collection agency you have suggested to set up its sorting facility to sort and transfer solid waste collected from the Motijheel C/A based on the Bio-degradability Factor (BF) of each component. Following Table provides the required information on the collected Solid Waste on a typical day and the data analysis. Determine the Total Solids (TS), Fixed Carbon (FC), Volatile Solids (VS) and BF of each component. Prepare a material flow diagram for this sorting facility showing the pathway for subsequent management of the collected wastes. It should be noted that there is no provision for storage of waste at this facility. **(13 ⅓)**

| Component | Wet Wt. (kg) | Dry Wt. (kg) after drying @ 105°C | Dry Wt. (kg) after ignition @ 550°C | Lignin Content (LC) as % of Volatile Solids (VS) |
|---|---|---|---|---|
| Food Waste | 150 | 52.5 | 1.9 | 0.4 |
| Newsprint | 28 | 26.3 | 3.0 | 21.9 |
| Office Paper | 260 | 249.3 | 17.5 | 0.4 |
| Cardboard | 400 | 379.2 | 46.6 | 12.9 |
| Yard Wastes | 60 | 24.0 | 2.3 | 4.1 |

2. Determine the chemical compositions (without Sulfur) and the amount of gas that can be derived from each unit weight of the rapidly and slowly decomposable organic constituents (**Separately**) of MSW given below. Assume 60% of the yard wastes will decompose rapidly. **(23 ⅓)**

Contd ..... P/2

**CE 433**

**Contd... Q. No. 2**

| Component | Food Waste | Paper | Cardboard | Textile | Rubber | Leather | Wood | Yard Waste |
|---|---|---|---|---|---|---|---|---|
| Wet Wt. (lb) | 9 | 34 | 6 | 2 | 0.5 | 0.5 | 2 | 18.5 |

Supplementary Information for Question # 2

| Component | Decomposition Rate | Moisture Content (%) | Percent by Wt. (Dry Basis) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | C | H | O | N | S | Ash |
| Food Wastes | Rapid | 70 | 48.0 | 6.4 | 37.6 | 2.6 | 0.4 | 5.0 |
| Paper | Rapid | 6 | 43.5 | 6.0 | 44.0 | 0.3 | 0.2 | 6.0 |
| Cardboard | Rapid | 5 | 44.0 | 5.9 | 44.6 | 0.3 | 0.2 | 5.0 |
| Textiles | Slow | 10 | 55.0 | 6.6 | 31.2 | 4.6 | 0.2 | 2.5 |
| Rubber | Slow | 2 | 78.0 | 10.0 | 0.0 | 2.0 | 0.0 | 10.0 |
| Leather | Slow | 10 | 60.0 | 8.0 | 11.6 | 10.0 | 0.4 | 10.0 |
| Wood | Slow | 20 | 49.5 | 6.0 | 42.7 | 0.2 | 0.0 | 1.5 |
| Yard Wastes | Rapid/Slow | 60 | 47.8 | 6.0 | 38.0 | 3.4 | 0.3 | 4.5 |

| | | C | H | O | N | S |
|---|---|---|---|---|---|---|
| Molecular Wt. | (lb/mole) | 12.01 | 1.01 | 16 | 14.01 | 32.06 |

- Specific Weight (in lb/ft$^3$) of $CH_4$ = 0.0448 and $CO_2$ = 0.1235

$$C_aH_bO_cN_d + \left(\frac{4a-b-2c-3d}{4}\right)H_2O \rightarrow \left(\frac{4a-b-2c-3d}{8}\right)CH_4 + \left(\frac{4a-b+2c+3d}{8}\right)CO_2 + dNH_3$$

3. (a) Separately list the functions and advantages of Transfer Stations. Also, compare these with those of the Secondary Transfer Station (STS) set up by the DNCC & DSCC. **(10)**

(b) A MSW collection agency, using a Hauled Container System (HCS) needs to decide on the type and number of collection vehicles to be deployed for two high-rise buildings A and B based on the statistical analysis of the waste generation data collected as shown in the table below. Suggest the type and number of collection vehicles from the reference table provided. **Use graphical method only to determine the statistical parameters for analysis.** **(13 ⅓)**

Contd ..... P/3

**CE 433**

**Contd... Q. No. 3(b)**

| Building A | |
|---|---|
| Week | Volume ($yd^3$/wk) |
| 1 | 1 |
| 2 | 7.4 |
| 3 | 10.4 |
| 4 | 22.2 |
| 5 | 12 |
| 6 | 17 |
| 7 | 15.8 |
| 8 | 12.6 |
| 9 | 20 |
| 10 | 11.3 |
| 11 | 6.6 |
| 12 | 1.9 |

| Building B | |
|---|---|
| Week | Volume ($yd^3$/wk) |
| 1 | 28.5 |
| 2 | 42 |
| 3 | 42.7 |
| 4 | 29.1 |
| 5 | 44.6 |
| 6 | 46.8 |
| 7 | 50.5 |
| 8 | 56 |
| 9 | 37.4 |
| 10 | 48.6 |

4. (a) What is the relationship between intrinsic permeability and the hydraulic conductivity of compacted solid waste in a landfill? Are the intrinsic permeability values in the horizontal and vertical direction of a compacted landfill similar? If not, why? How do the intrinsic permeability values in both directions control the design of protection measures against leachate movement? **(10)**

(b) Determine based on operating cost, the break-even points for a hauled and stationary system as compared with a system using transfer and transport operations for transporting wastes collected from Dhaka metropolitan area to a landfill site. Assume that the following cost data are applicable: **(13 ⅓)**

Operating costs:

HCS carrying compacted solid waste in 6 $m^3$ container = Tk.2275/-

SCS using 15 $m^3$ compactor = Tk.3400/-

Tractor semitrailer transport unit with a capacity of 80 $m^3$ = Tk.4000/-

Other costs:

Transfer station operating costs, including amortization = Tk.40/$m^3$

Extra cost for unloading facilities for Tractor semitrailer transport unit = 5/$m^3$

Other data:

Specific weight of wastes in HCS container (in kg/$m^3$) = 225

Specific weight of wastes in SCS (in kg/$m^3$) = 325

Specific weight of wastes in Transport unit (in kg/$m^3$) = 150

## SECTION – B

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

5. (a) What are the problems of indiscriminate dumping of solid wastes in and around cities. **(5)**

(b) List the indicators of sanitary landfill. Why is it the only acceptable method of solid waste disposal currently all over the world? **(9 ⅓)**

Contd ..... P/4

**CE 433**

**Contd... Q. No. 5**

(c) List the components of a sanitary landfill. **(4)**

(d) Calculate the landfill capacity for a town for the year 2030 from the following data: **(5)**

| | |
|---|---|
| Projected population for the year 2030 | = 15,00,000 |
| Per capita generation rate | = 6.8 lb/cap/d |
| Diversion fraction | = 0.20 |
| Compacted waste density | = 42.5 lb/ft$^3$ |

Assume a daily soil cover is applied that accounts for 18% of the landfill volume.

6. (a) Provide the list of area exclusion criteria for site selection of a sanitary landfill. **(5)**

(b) "Landfill can be considered as a natural biochemical reactor" — Explain the statement. **(5 ⅓)**

(c) Summarize the leachate treatment options. **(6)**

(d) Estimate the percolation of leachate through a landfill 25 m deep, with a 0.75 m cover of silty clay for the following data: **(7)**

| | |
|---|---|
| Precipitation | = 2300 mm/year |
| Runoff coefficient | = 0.30 |
| Evapotranspiration | = 835 mm/year |
| Silty clay field capacity | = 390 mm/m |
| Solid waste field capacity | = 280 mm/m |
| Moisture content of the soil cover when applied | = 330 mm/m |
| Moisture content of solid waste when deposited | = 160 mm/m |

7. (a) How will you manage stormwater for a landfill site? **(7)**

(b) Write down the typical composition of landfill gases. **(3)**

(c) Describe the methods of estimation of landfill gas generation. Which method do you prefer and why? **(8 ⅓)**

(d) Write a short note on recycling process of solid wastes in Bangladesh. **(5)**

8. (a) Show the pathways of human exposure to hazardous wastes. **(5)**

(b) What are the advantages, disadvantages and limitations of physical processes of hazardous waste treatment? **(7 ⅓)**

(c) What are the general modes of treatment and disposal of hazardous wastes from hospitals? **(8)**

(d) List the factors to be considered for sitting landfills for hazardous wastes. **(3)**

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Contd... P/5

CE433

=5=

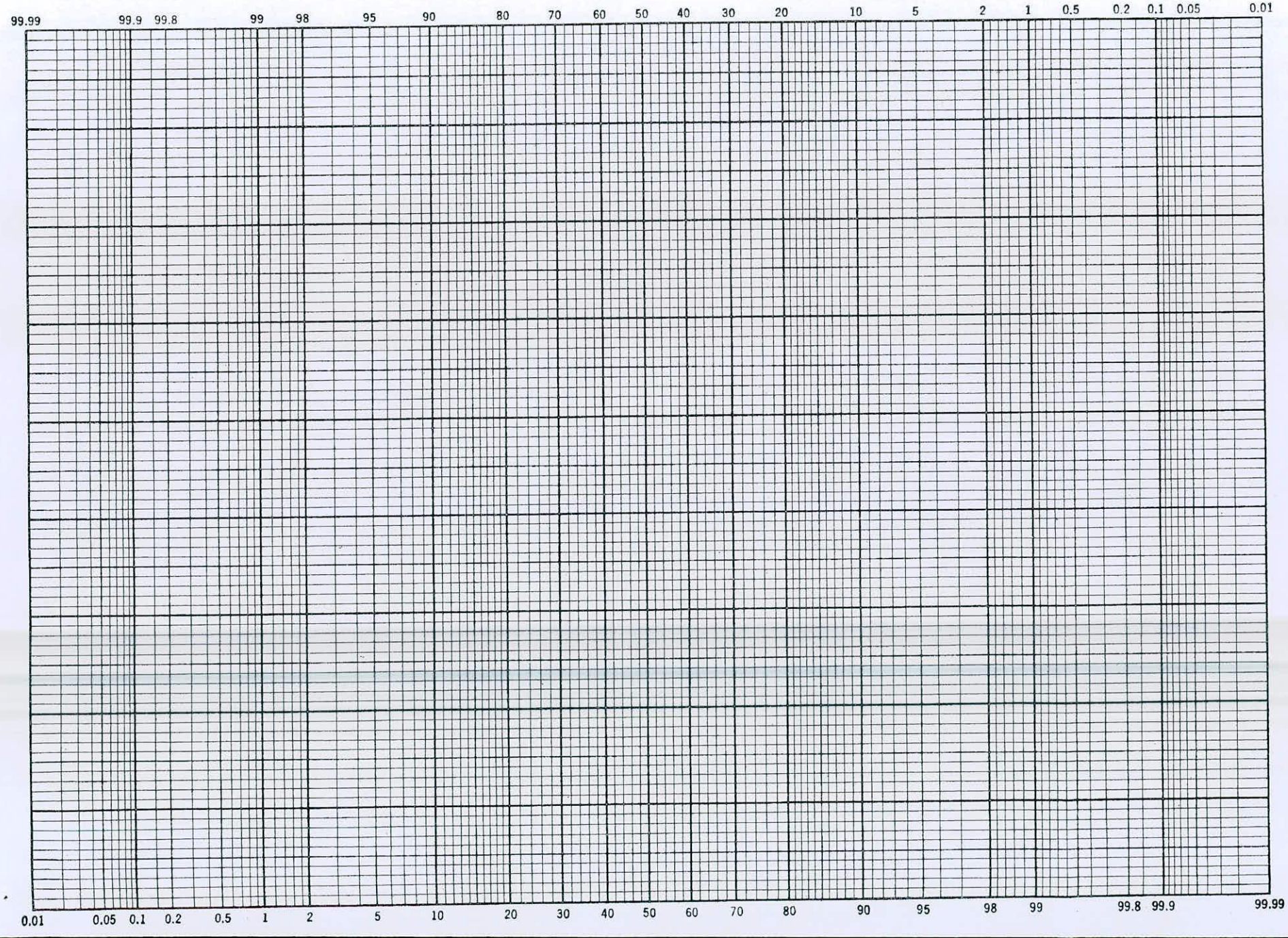
## Vehicles used for the collection of solid waste

| Collection vehicle | | | Typical overall collection vehicle dimensions | | | | |
|---|---|---|---|---|---|---|---|
| Type | Available container or truck body capacities,[a] $yd^3$ | Number of axles | With indicated container or truck body capacity,[b] $yd^3$ | Width, in | Height, in | Length,[c] in | Unloading method |
| *Hauled container systems* | | | | | | | |
| *Hoist truck* | 6–12 | 2 | 10 | 94 | 80–100 | 110–150 | Gravity, bottom opening |
| *Tilt-frame* | 12–50 | 3 | 30 | 96 | 80–90 | 220–300 | Gravity, inclined tipping |
| *Truck-tractor trash-trailer* | 15–40 | 3 | 40 | 96 | 90–150 | 220–450 | Gravity, inclined tipping |
| *Stationary container system* | | | | | | | |
| *Compactor (mechanically loaded)* | | | | | | | |
| *Front loading* | 20–45 | 3 | 30 | 96 | 140–150 | 240–290 | Hydraulic ejector panel |
| *Side loading* | 10–36 | 3 | 30 | 96 | 132–150 | 220–260 | Hydraulic ejector panel |
| *Rear loading* | 10–30 | 2 | 20 | 96 | 125–135 | 210–230 | Hydraulic ejector panel |
| Compactor (manually loaded) | | | | | | | |
| Side loading | 10–37 | 3 | 37 | 96 | 132–150 | 240–300 | Hydraulic ejector panel |
| Rear loading | 10–30 | 2 | 20 | 96 | 125–135 | 210–230 | Hydraulic ejector panel |

[a] See Tables 6-2 and 7-2.
[b] See Table 7-2 for dimensions of typical containers.
[c] From front of the truck to the rear of container or truck body.
Note: $yd^3 \times 0.7646 = m^3$
in $\times$ 0.0254 = m

Table for Q3(b)

arithmetic-probability paper
probability x 90 divisions



L-4/T-2/CE **Date: 06/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CE 435** (Environmental Pollution Management)

Full Marks: 140 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

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## SECTION – A

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

1. (a) A power plant emits 145 g/sec of $NO_2$ through a stack that has an effective height of 55 m. The wind speed is 3.1 m/sec (at 10 m height), and the atmosphere is characterized as "Slightly stable". Estimate: (i) ground level concentration of $NO_2$ at 1.5 km downwind along the center-line of the plume; and (ii) $NO_2$ concentration at the top of a 28 m high building located 1.5 km downwind and 0.5 km off the centerline of the plume. **(10)**

[Given: p = 0.20; Table for calculation of dispersion coefficient provided]

(b) What do you understand by SLCP? How do "black carbon" and other atmospheric particulates (including sulfate particles) affect global warming? Explain. **(7)**

(c) What do you understand by aerodynamic diameter of particulate matter (PM)? Give examples of "primary" and "secondary" PM. Why are the PM of anthropogenic origin considered more harmful compared to the PM of natural origin? Explain. **(6 1/3)**

2. (a) What do you understand by stoichiometric ratio, rich mixture and lean mixture? Determine the stoichiometric ratio for the fuel $C_7H_{16}$. **(9)**

Explain, with an appropriate figure, the effects of air/fuel ratio on automotive emissions of HC, CO and $NO_x$.

(b) What do you understand by stable, unstable and neutral atmosphere? Explain. **(8)**

On a particular day, ambient atmospheric temperature profile is given by the following equations:

$$A\ (°C) = 29 + 0.04\ z \quad ; z \leq 275\ m$$
$$= 40 - 0.005(z - 275)\ ; z > 275\ m$$

Where, z = altitude in m.

Determine, up to what height a plume is expected to rise if it is emitted under the following conditions: (a) Plume emitted at a temperature of 42 °C from the ground level; (b) A plume emitted at a temperature of 42 °C from the top of a 100 m high stack.

Contd ..... P/2

**CE 435**

**Contd... Q. No. 2**

(c) What are the primary indicators of climate change? What is the difference between global warming and climate change? What do you understand by "Global Warming Potential (GWP)" of greenhouse gas? **(6 1/3)**

3. (a) Write down the assumptions of the point source Gaussian plume model. **(10)**

On a particular day, cars are travelling along an elevated expressway at an average speed of 60 km/hr, and the average distance between the cars is 15 m. The height of the expressway is 10 m above the ground surface. Each carrier on an average emits Carbon Monoxide (CO) at a rate of 5.1 g/km. If wind speed is 2.3 m/sec perpendicular to the expressway, estimated ground-level CO concentration at 1.4 km downwind. Consider the atmosphere to be "neutral".

[Note: Table for calculation of dispersion coefficient provided.]

(b) How do hydrocarbons affect the $NO$-$NO_2$-$O_3$ photochemical reaction sequence, and help product $O_3$ and other secondary pollutants? Explain with appropriate equations. Can $SO_2$ and promote formation of photochemical smog? Explain? **(7)**

(c) What do understand by "thermal $NO_x$" and "fuel $NO_x$"? What kind(s) of $NO_x$ would generated from the burning of natural gas? Explain. What are the adverse effects of (stratospheric) ozone. **(6 1/3)**

4. (a) On a particular day, the Air Quality Index (AQI) corresponding to $O_3$ (1-hr) concentration is 180. Determine the $O_3$ (1-hr) concentration in $\mu g/m^3$. A 'table" for calculation AQI is provided [Given: Temperature = 25 °C, P = 1 atmosphere]. **(9)**

If air quality standard changes [for example, if standard for 24-hr $PM_{2.5}$ changes from 65 $\mu g/m^3$ to 24 $\mu g/m^3$], can you sue the same "table" for calculating AQI? Explain.

(b) Derive an expression for determining the diameter of a particle (dp*) that would be removed with 100% theoretical efficiency in a gravitational settling chamber of length L and height H. Also derive an expression for the fractional removal efficiency of particles with diameter dp (where dp < dp*) in this settling chamber. **(5)**

(c) How do different categories of helocarbons affect global warming wand the stratospheric ozone layer? Explain. **(7 1/3)**

How are tropospheric ozone and stropospheric ozone affecting global warming? Explain.

Contd ..... P/3

**CE 435**

## SECTION – B

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

Assume reasonable values of any missing data.

5. (a) How does productivity level of a lake affect its DO level during Summer and Winter stratification? Explain with neat sketches. **(5)**

(b) Explain, with neat sketches, the process of controlling contaminant plume in groundwater for effective extraction of contaminated water. **(5)**

(c) Write down the sources and effects of thermal pollution in water. **(4+9 1/3)**

Two-thirds of the energy content of fuel entering a 1000 MW nuclear power plant is removed by condenser cooling water that is withdrawn from a local river (there are no stack losses). The river has an upstream flow of 100 $m^3/s$ and a temperature of 20°C.

i. If the cooling water is only allowed to rise in temperature by 10°C, calculate the flow rate require to be withdrawn from the river.

ii. Determine the rive temperature after it receives the heated cooling water.

6. (a) Define "forever chemical" with examples. List the properties and health effects of "Forever Chemicals". **(5)**

(b) List the sources and sinks of dissolved oxygen in river water. **(3+15 1/3)**

Fishermen of Atlapur village on the bank of Shitalakkhya River has filed a complaint with the Department of Environmental (DoE). The fishermen claimed that, discharge of domestic sewage from a town, 156 km upstream of the village, is deteriorating the quality of water in the river, which threatened its fish population. You are assigned the task to assess whether the sewage discharge is a threat to the fish population near the Atlapur village. Your team collected the following data on the river water (just upstream of the sewage outfall) and sewage characteristics.

| **Swage:** | **River Water:** | |
|---|---|---|
| Flow rate = 0.15 $m^3/s$ | Flow rate = 1.1 $m^3/s$ | River depth = 3 m |
| Ultimate BOD = 120 mg/L | $BOD_5$ = 5 mg/L | River speed = 0.4 m/s |
| DO = 1 mg/L | DO = 6 mg/L | $DO_{sat}$(at 20°C) = 8.4 mg/L |
| Temperature = 23°C | Temperature = 23°C | BOD rate constant = 0.23 $d^{-1}$ (at 20°C) |

i) Do you think the sewage discharge is responsible for lowering of fish population in the river near the village area? Consider DO of the River near the village should be 5 mg/L for regular growth of fish.

Contd ..... P/4

**CE 435**

**Contd... Q. No. 6(b)**

ii) If DO near the village does not meet guideline, how much of BOD removal is required from the sewage to meet the guideline? Also, estimated the minimum DO when this additional BOD removal process is implemented.

7. (a) With neat sketches describe the effect of temperature and multiple point sources on DO sagg curve. **(5)**

(b) Environmental survey of a lake indicates that, there is no anthropogenic sources contributing to the nutrient level of the lake. It is also observed that the lake is highly turbid with abundant floating algae. Dissolved oxygen of hypolimnion zone is found to be around 1 mg/L. What productivity class would you assign to this lake and why? **(5)**

(c) A lake with surface area of $100 \times 10^6$ $m^2$ is fed by a stream having a flow rate of 8 $m^3/s$ and average total phosphorus concentration of 0.05 mg/L. A food processing industry discharges wastewater into the lake at a rate of 0.15 $m^3/s$ with 8 mg/L of phosphorus. In addition, effluent from a wastewater treatment plant, with flow rate of 0.25 $m^3/s$ and phosphorus concentration of 4 mg/L is discharged into the lake. **(13 1/3)**

i) If the phosphorus settling rate is 10 m/yr, calculate the available phosphorus concentration in the lake.

ii) If the industrial remains the same, will it be possible to keep the phosphorus concentration in the lake below 0.02 mg/L by removing phosphorus at the wastewater treatment plant only? Explain with necessary calculation.

8. (a) What is the source of arsenic in groundwater of Bangladesh? Briefly explain the role of "reduction" and "phosphate" in arsenic mobilization. **(5)**

(b) Water from tub contains 150 ppb of arsenic and 5 mg/L of iron. Select a treatment methods to remove arsenic from this water. Explain the reason for selecting the methods along with the basic principle of the method. **(5)**

(c) With neat sketch show the effect of retardation on contaminant flow in groundwater. **(3+10 1/3)**

An industry discharges chemical waste into a waste lagoon. A particular contaminant, with concentration of 50 mg/L, infiltrate into the ground from the lagoon. Estimate the required for the contaminant concentration to reach 2 mg/L at a depth of 5 m from the bottom of the lagoon. Seepage velocity is 0.5 m/d and dispersivity is 0.1 m. Assume the contaminant as conservative and ignore the molecular diffusion. [Note: Relevant table and equations are provided]

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## Table for calculation of AQI [for Question No. 4(a)]

| Breakpoints | | | | | | | AQI |
|---|---|---|---|---|---|---|---|
| $O_3$ (ppm) 8-hr | $O_3$(ppm) 1-hr (i) | $PM_{2.5}$ (µg/m$^3$) 24-hr | $PM_{10}$ (µg/m$^3$) 24-hr | CO (ppm) 8-hr | $SO_2$ (ppm) 24-hr | $NO_2$ (ppm) Annual | |
| 0.000-0.064 | -- | 0.0-15.4 | 0-54 | 0.0-4.4 | 0.000-0.034 | (ii) | 0-50 |
| 0.065-0.084 | -- | 15.5-40.4 | 55-154 | 4.5-9.4 | 0.035-0.144 | (ii) | 51-100 |
| 0.085-0.104 | 0.125-0.164 | 40.5-65.4 | 155-254 | 9.5-12.4 | 0.145-0.224 | (ii) | 101-150 |
| 0.105-0.124 | 0.165-0.204 | 65.5-150.4 | 255-354 | 12.5-15.4 | 0.225-0.304 | (ii) | 151 -200 |
| 0.125-0.374 | 0.205-0.404 | 150.5-250.4 | 355-424 | 15.5-30.4 | 0.305-0.604 | 0.65-1.24 | 201-300 |
| (iii) | 0.405-0.504 | 250.5-350.4 | 425-504 | 30.5-40.4 | 0.605-0.804 | 1.25-1.64 | 301-400 |
| (iii) | 0.505-0.604 | 350.5-500.4 | 505-604 | 40.5-50.4 | 0.805-1.004 | 1.65-2.04 | 401-500 |

(i) In some cases, in addition to calculating the 8-hr ozone index, the 1-hr ozone index may be calculated, and the maximum of the two values reported
(ii) $NO_2$ has no short-term air quality standard and can generate an AQI only above 200
(iii) 8-hr $O_3$ values do not define higher AQI values (≥301). AQI values of 301 or higher are calculated with 1-hr $O_3$ concentrations

## Table for estimation of dispersion coefficients [for Questions 1(a) and 3(a)]

| | | $x \leq 1$ km | | | $x \geq 1$ km | | |
|---|---|---|---|---|---|---|---|
| Stability | $a$ | $c$ | $d$ | $f$ | $c$ | $d$ | $f$ |
| A | 213 | 440.8 | 1.941 | 9.27 | 459.7 | 2.094 | −9.6 |
| B | 156 | 106.6 | 1.149 | 3.3 | 108.2 | 1.098 | 2.0 |
| C | 104 | 61.0 | 0.911 | 0 | 61.0 | 0.911 | 0 |
| D | 68 | 33.2 | 0.725 | −1.7 | 44.5 | 0.516 | −13.0 |
| E | 50.5 | 22.8 | 0.678 | −1.3 | 55.4 | 0.305 | −34.0 |
| F | 34 | 14.35 | 0.740 | −0.35 | 62.6 | 0.180 | −48.6 |

[a] The computed values of $\sigma$ will be in meters when $x$ is given in kilometers.

$\sigma_y = a.x^{0.894}$

$\sigma_z = c.x^d + f$

Table for Saturation values of dissolved oxygen in freshwater **(for Ques. 6(b))**

| Temperature (°C) | Oxygen Solubility (mg/L) |
|---|---|
| 0 | 14.62 |
| 5 | 12.80 |
| 10 | 11.33 |
| 15 | 10.15 |
| 20 | 9.17 |
| 25 | 8.38 |
| 30 | 7.63 |

$$D = \frac{k_d L_0}{k_r - k_d}(e^{-k_d t} - e^{-k_r t}) + D_0 e^{-k_r t}$$

$$t_c = \frac{1}{k_r - k_d} \ln\left\{\frac{k_r}{k_d}\left[1 - \frac{D_0(k_r - k_d)}{k_d L_0}\right]\right\}$$

$k_r = \frac{3.9\sqrt{u}}{H^{3/2}}$ ; at 20°C

Temperature correction,

$$k_{r,T} = k_{r,20}(1.024)^{T-20}$$

**Equations for Ques. 6(b)**

The complementary error function table **(for Ques. 8(c))**

| x | erfc(x) | x | erfc(x) |
|---|---|---|---|
| 0 | 1.0 | | |
| 0.05 | 0.943628 | 1.1 | 0.119795 |
| 0.1 | 0.887537 | 1.2 | 0.089686 |
| 0.15 | 0.832004 | 1.3 | 0.065992 |
| 0.2 | 0.777297 | 1.4 | 0.047715 |
| 0.25 | 0.723674 | 1.5 | 0.033895 |
| 0.3 | 0.671373 | 1.6 | 0.023652 |
| 0.35 | 0.620618 | 1.7 | 0.016210 |
| 0.4 | 0.571608 | 1.8 | 0.010909 |
| 0.45 | 0.524518 | 1.9 | 0.007210 |
| 0.5 | 0.479500 | 2.0 | 0.004678 |
| 0.55 | 0.436677 | 2.1 | 0.002979 |
| 0.6 | 0.396144 | 2.2 | 0.001863 |
| 0.65 | 0.357971 | 2.3 | 0.001143 |
| 0.7 | 0.322199 | 2.4 | 0.000689 |
| 0.75 | 0.288844 | 2.5 | 0.000407 |
| 0.8 | 0.257899 | 2.6 | 0.000236 |
| 0.85 | 0.229332 | 2.7 | 0.000134 |
| 0.9 | 0.203092 | 2.8 | 0.000075 |
| 0.95 | 0.179109 | 2.9 | 0.000041 |
| 1.0 | 0.157299 | 3.0 | 0.000022 |

$\text{erfc}(x) = 1 - (2/\sqrt{\pi})\int_0^x e^{-\epsilon^2} d\epsilon$

$\text{erfc}(-x) = 2 - \text{erfc}(x)$

[a] Adapted from Freeze and Cherry (1979).

For low velocities,

$$C(x,t) = C_0\left[erfc\left(\frac{x}{2\sqrt{D^* t}}\right)\right]$$

For large t or large velocity,

$$C(x,t) = \frac{C_0}{2}\left[erfc\left(\frac{x - \bar{v}_x t}{2\sqrt{D_x t}}\right)\right]$$

**Equations for Ques. 8(c)**

**L-4/T-2/CE** **Date: 27/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 437** (Environmental and Sustainable Management)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) What are the different environmental, health and safety provisions stated under the 'Hazardous Waste and Ship-breaking Waste Management Rules, 2011'? What amendments were made to 'Bangladesh Labour Law 2006' after the Rana Plaza incident? **(16)**

(b) Which of the following sites would be the most feasible option based on an assessment using the weighting-scaling checklist method: **(7 ⅓)**

| Environmental component | Relative weight (Total 100) | Impact of project on a particular site (on a scale of 0-10) | | |
|---|---|---|---|---|
| | | Site A | Site B | Site C |
| Air quality | 21 | 3 | 5 | 3 |
| Water quality | 42 | 6 | 2 | 5 |
| Noise | 9 | 5 | 7 | 9 |
| Ecosystem | 28 | 5 | 4 | 3 |

2. (a) What are the desirable characteristics of an EIA method? What are the drawbacks of the network method? **(10)**

(b) What are the salient features of the Environment Court Act? What are the guiding legislations of environmental court in Bangladesh? State the criticisms of environmental court. **(13 ⅓)**

3. (a) What are the practical considerations of conducting public consultations? How do you decide when to perform an IEE or an EIA? **(11 ⅓)**

(b) Summarize the mitigation measures suggested for the following environmental impacts for the implementation of the Bangabandhu Multipurpose Bridge Project: **(12)**

(i) Disruption of river navigation

(ii) Dredged spoils disposal

(iii) Noise pollution

(iv) Transmission of diseases among workers.

Contd ..... P/2

**CE 437**

4. (a) List the essential features of an Environmental Management Plan (EMP). How is the EMP related to EIA? **(11 1/3)**

   (b) Write short notes on: **(12)**

   (i) Leopold Interaction Matrix

   (ii) Public Interest Litigation

   (iii) Value Function Curve.

## SECTION – B

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

5. (a) Define Ecosystem. What are the services human get from the ecosystem? Describe. Explain with a Figure, the ecosystem carrying capacity with time. **(13)**

   (b) Explain the impacts on Environment by the equation IPAT. **(10 1/3)**

6. (a) Why is the conservation of Biodiversity important for a sustainable environment? How does the biodiversity loss occur and how can you restore it? Describe. **(14)**

   (b) Explain the importance of 3 pillars of Sustainable Development with examples. **(9 1/3)**

7. (a) How is Bangladesh preparing to tackle the challenges of Climate Change? What are the challenges and opportunities for Bangladesh to achieve SDGS? Describe. **(13)**

   (b) How does 'Ozone Layer Depletion' occur? Explain. List the measures to reduce the problem. **(10 1/3)**

8. (a) What is the role of Economics in Environmental Management? Describe.
   'Tax can be an effective tool in reducing pollution' — explain this with examples. **(11 1/3)**

   (b) Explain 'TEV' of environmental goods with an example.
   Describe the different methods for the valuation of environmental goods with examples. **(12)**

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L-4/T-2/CE **Date: 30/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 443** (Earth Retaining Structures)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

1. (a) List the causes that induce lateral load to foundations. How does lateral load affect the bearing capacity of a foundation? **(5)**

(b) What is the basic difference between a rigid retaining wall and a flexible retaining wall? Compare between counterfort retaining wall and cantilever retaining wall. **(5)**

(c) Derive the depth of tension crack, $h_c = \frac{2C}{\gamma\sqrt{K_a}}$; where, c = cohesion, $\gamma$ = Unit weight of soil, $K_a$ = Active earth pressure coefficient. Determine the factor of safety against sliding for the rectangular footing (2.2 m × 2.2 m) shown in Fig. 1. Assume that the water table is much below the footing. **(13 ⅓)**

2. (a) List the ultimate states of external instability for gravity retaining walls. Show the common proportions of: (i) cantilever retaining wall and (ii) counterfort retaining wall. **(5)**

(b) Why granular material is chosen as a backfill for constructing retaining structures? Why drainage is necessary for retaining wall. **(5)**

(c) Determine the factor of safety against overturning failure for the retaining wall shown in Fig. 2. Ignore the passive resistance in front of the wall. Comment on the safety against overturning. **(13 ⅓)**

Unit weight of concrete, $\gamma_{conc} = 24$ kN/m$^3$.

3. (a) Mention the force/stress that is necessary to consider for designing each component of the cofferdam. Explain the phenomenon 'failure by bottom heaving'? **(5)**

(b) Compare the earth pressure on braced cofferdam in 'Loose Sand' and 'Soft Clay'. Why does the earth pressure on braced cofferdam in stiff clay change over time? **(5)**

(c) A braced excavation system for an open cut in clay is shown in Fig. 3. Determine the force in the struts A, B, and C. The struts are spaced 4 m center-to-center in the plan. **(13 ⅓)**

Contd ..... P/2

**CE 443**

4. (a) Compare between the purposes of cofferdam and caissons. Compare the advantages of pneumatic caissons and box caissons. **(5)**

(b) List the permanent loads for designing a caisson. Write the assumption in designing deep caissons against vertical loading. List the corrective measures for minimizing titling of a caisson during construction. **(5)**

(c) Will the caisson shown in Fig. 4 be self-sinking? If not determine: (i) the required amount of ballast and (ii) the thickness for self-sinking. Calculate the allowable load capacity (Factor of Safety, FS = 3.0) of the caisson. **(13 ⅓)**

Given, for $\phi = 35°$, $N_c = 57.8$, $N_q = 41.4$, $N_y = 42.4$, $S_y = 0.6$.

## SECTION – B

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

5. (a) What are the objectives and different methods of construction dewatering? In one or two sentences, describe the main concepts of different methods of construction dewatering. **(11 ⅓)**

(b) A rectangular area of length 40 m and breadth 30 m is required to be excavated to a depth of 4 m. The water table is 1 m below EGL and height H of water table from bottom of impervious layer is 8.5 m. The average permeability of soil in the area is 2.5 mm/s. (Draw necessary figures identifying parameter used for computation.)

If the pumping capacity of a single well is 0.5 $m^3$/min, then compute the number of wells that will be required around the perimeter of the excavated area to keep it just dry during construction. (Use Sichardt's formula $R = 3000\, s\sqrt{k}$ , s = drawdown, to compute the radius of influence R). **(12)**

6. (a) Draw qualitative diagrams of variation of soil pressure and bending moment for fixed and free headed short piles in purely cohesive and cohesionless soils using Brom's approach. **(11 ⅓)**

(b) Using Brom's method, determine factor of safety against failure for a 30 inch diameter and 40 ft. long free headed pile subjected to a horizontal load of 15 kips applied 3 ft. above ground level. Also, determine factor of safety against failure if pile is fixed headed. Comment on whether pile will undergo structural or bearing failure. Assume ground water table is at GL. Soil properties are: Unit weight 115 pcf, effective angle of internal friction $\phi = 30°$, $n_u = 25{,}000$ lb/$ft^3$.

Pile properties are: Pile material and section yield moment 300 kip-ft, Young's modulus $E = 3.2 \times 10^6$ psi.

(Use attached figure for problem solution). **(12)**

Contd ..... P/2

**CE 443**

7. (a) Explain why maximum bending moment computed for anchored sheet pile using free earth support method reduced when designing the sheet pile section? Also explain how this maximum moment is reduced using Rowe's moment reduction curve. **(11 ⅓)**

(b) Show with a neat sketch the multi stage use of well points to dewater a construction. Also show using sketches the steps of installing well points and riser pipes. **(12)**

8. Determine anchor forces per unit length and embedment depth of sheet pile embedded in sandy soil and retaining sandy backfill supporting uniform surcharge q = 20 kPa. **(23 ⅓)**

Depth of anchor rod from GL = 1.5 m

Depth of water table from GL = 3.5 m

Depth of dredge line below GL = 8.5 m

Saturated unit weight of sandy backfill, $\gamma_{sat}$ = 20 kN/m$^3$

Effective friction angle of sandy backfill, $\phi_1 = 35°$

Saturated unit weight of sandy soil below dredge line, $\gamma_{2\,sat}$ = 10 kN/m$^3$

Effective friction angle of sandy soil below dredge line, $\phi_2 = 30°$.

(Assume unit weight of water $\gamma_w$ = 10 kN/m$^3$).

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Contd... P/4

**CE 443: Earth Retaining Structures (Sec. A)**

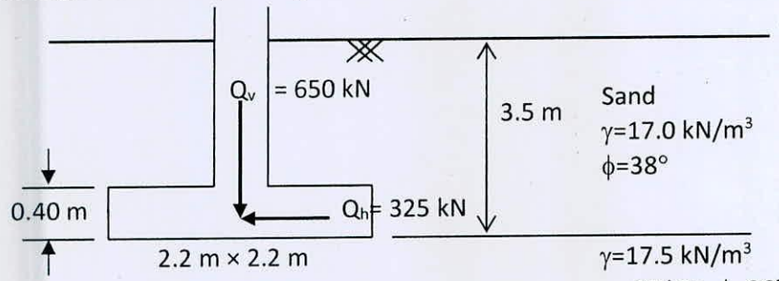



**Fig. 1. for Q. 1(c)**

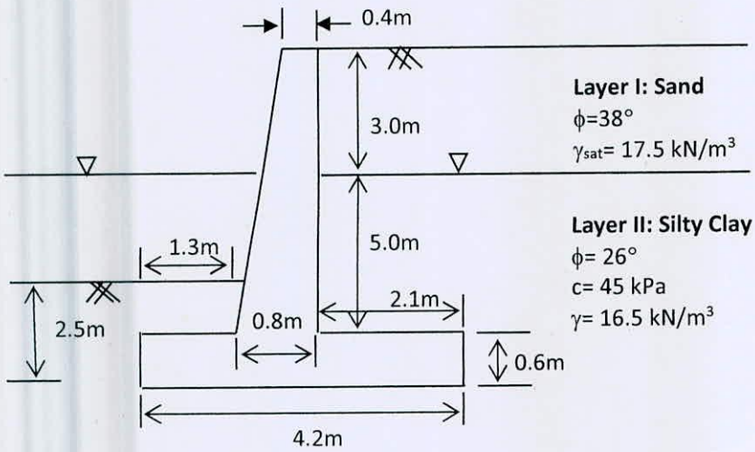



**Fig. 2. for Q. 2(c)**

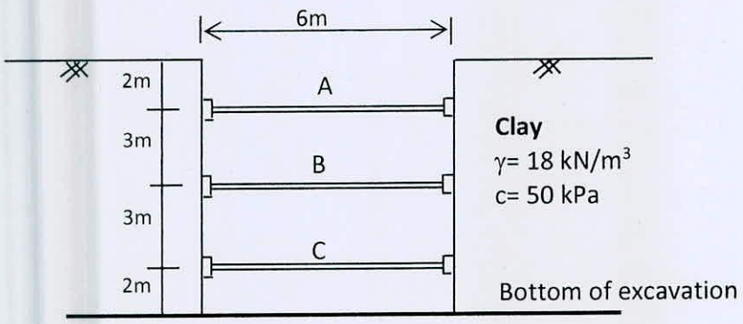



**Fig. 3. for Q. 3(c)**

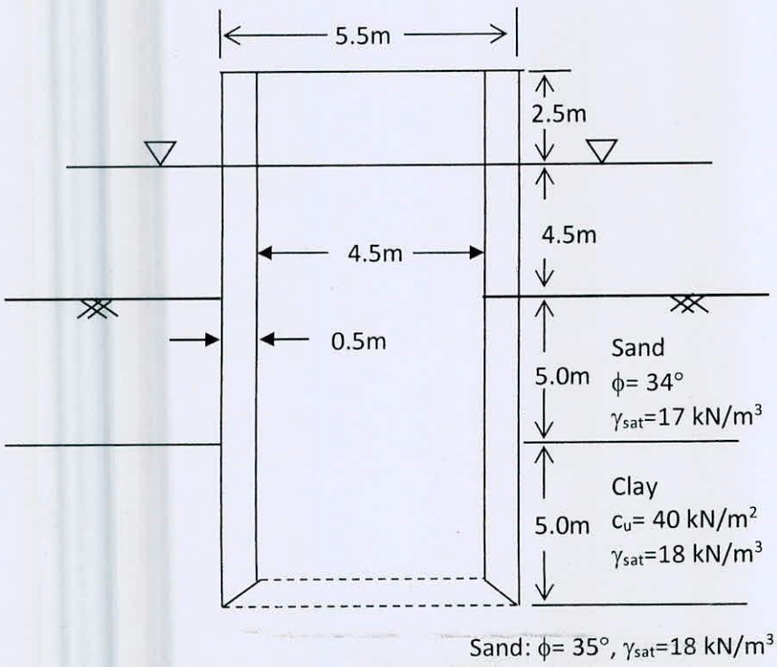
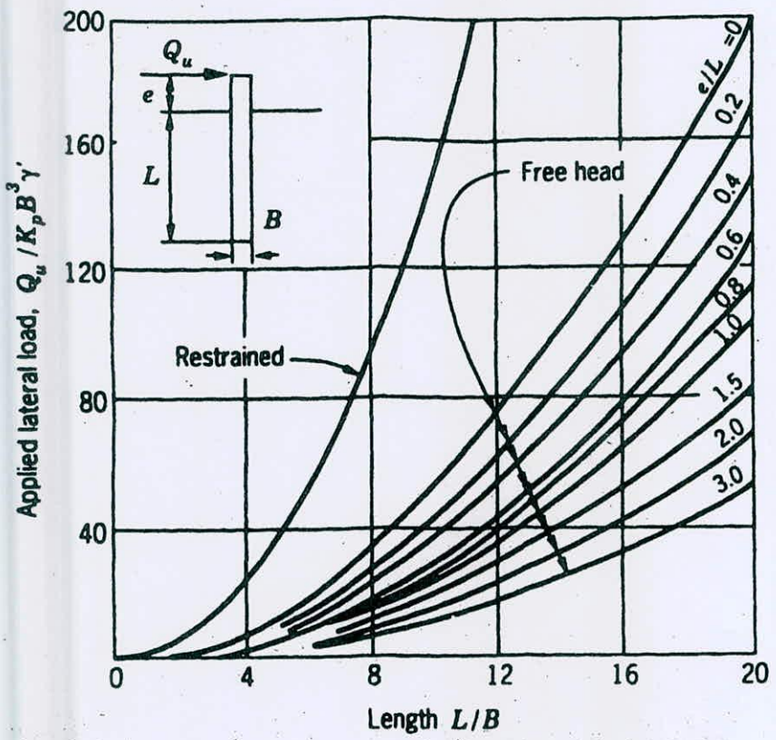
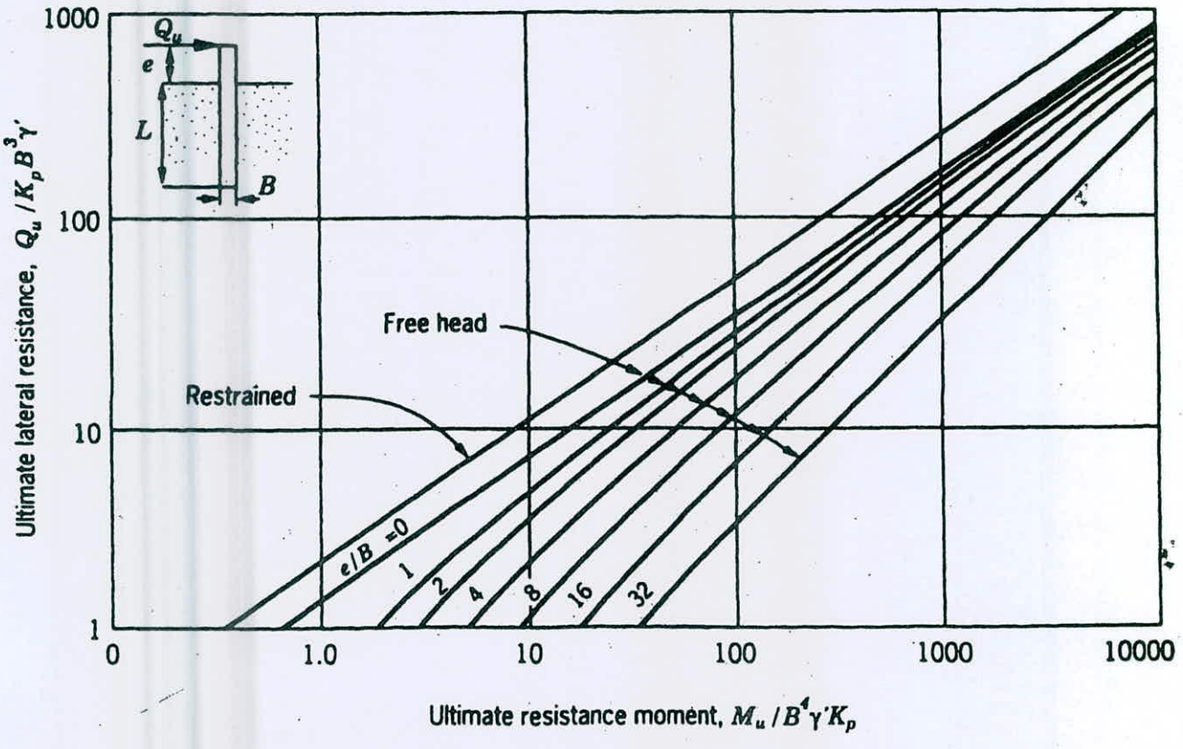



**Fig. 4. for Q. 4(c)**

Contd...P/5




(a)




(b)

**Figure 6.9** Ultimate lateral load capacity of short and long piles in cohesionless soils (Broms, 1964b). (a) Ultimate lateral resistance of *short piles in cohesionless* soil related to embedded length, (b) ultimate lateral resistance of *long piles in cohesionless* soil related to ultimate resistance moment.

**L-4/T-2/CE** **Date: 12/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 445** (Elementary of Soil Dynamics)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume any reasonable value for missing data.

1. (a) An electrical switch gear is supported by a crane through a steel cable (Fig. 1) of length 4 m and diameter 0.01 m. If the natural time period of the axial vibration of the switch gear is found to be 0.01 s, find the mass of the switch gear. E = 27,500 ksi for steel cable. Write down the relevant equation of motion. **(11 ⅓)**

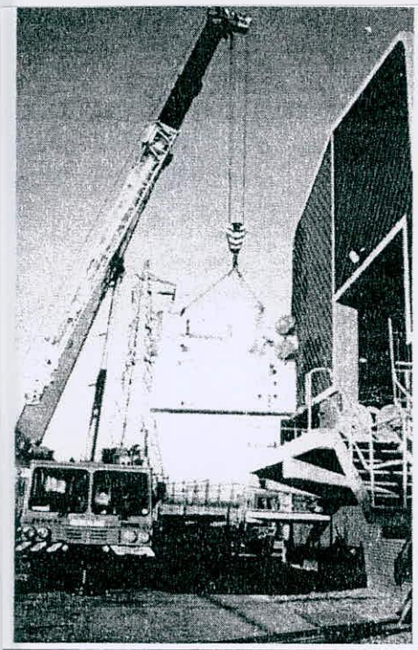

Fig. 1

(b) A one-story reinforced concrete building has a roof mass of 500 kip/g, and its natural frequency is 4 Hz. This building is excited by a vibration generator with two weights, each 50 lb, rotating about a vertical axis at an eccentricity of 12 inch. When the vibration generator runs at a natural frequency of the building, the amplitude of roof acceleration is measured to be 0.02g. Determine the damping of the structure. Also, find the amplitude of displacement vector at resonant frequency. **(12)**

2. (a) Show that, in frequency dependent excitations, the damping factor $\xi$ (defined as by $c/c_c$) is given by the following expression:

$\xi = \frac{1}{2}\left(\frac{f_1 - f_2}{f_n}\right)$, where $f_1$ and $f_2$ are frequencies at which the amplitude is $1/\sqrt{2}$ times the peak amplitude. **(11 ⅓)**

Contd ..... P/2

**CE 445**
**Contd... Q. No. 2**

(b) What is principle to determine damping ratio $\xi$ of a vibrating system under the damped free conditions? Develop the principle and describe briefly how do you use the principle to estimate $\xi$.

Also, prove that the entity $j_{50}$ representing the number of cycles elapsed for a 50% reduction of displacement amplitude in a damped free vibration case, as $j_{50} = 0.11/\xi$. **(12)**

3. (a) Define natural frequency of vibrating system. State how does it vary with the damping ratio in forced vibrations.

Describe steady state conditions of a vibrating system. Explain why it is so named? **(11 ⅓)**

(b) State the differential equation of motion of damped free vibration. With the help of a trial solution $z = e^{st}$, find the condition for critical damping state in motion and obtain an expression for the critical damping coefficient, and hence, establish the expression for solution of above motion (displacement) for an **over-damped** free vibrating system; then, apply the initial condition as: at time t = 0, displacement vector, $z = z_0$ and the velocity vector, $\dot{z} = \ddot{z}_0$ to obtain the solution for above motion as: $z = C_1 e^{s_1 t} + C_2 e^{s_2 t}$, where $C_1 = \dfrac{x_0 \omega_n \left(\xi + \sqrt{\xi^2 - 1}\right) + \dot{x}_0}{2\omega_n \sqrt{\xi^2 - 1}}$; Also, evaluate $s_1, s_2$, and $C_2$. **(12)**

4. (a) Write down the inference of the displacement response vector: $R_d = \dfrac{u_0}{u_{st}} = \dfrac{1}{\sqrt{\left(1 - r^2\right)^2 + \left(2\xi r\right)^2}}$ derived from constant-amplitude exciting force case for the following frequency ratio, r:

- when r >> 1
- When r << 1, and
- When r ≈ 1

Also, show that in above 3 conditions of r, the dynamic displacement $u_0$ is inversely proportional to either spring force, inertial force or viscous force. **(11 ⅓)**

(b) For the system represented by the following equation:

$$m\frac{d^2z}{dt^2} + c\frac{dz}{dt} + kz = m_e e \omega^2 \sin \omega t$$

Deduce, $Z_0 / \left(em_e / m\right) = Mr^2 = r^2 / \sqrt{\left(1 - r^2\right)^2 + \left(2\xi r\right)^2}$

Where, $r = \dfrac{\omega}{\omega_n}$ and M is the dynamic magnification factor for constant-force-amplitude case.

Also derive the expression for maximum amplitude in terms of $\left(Z_0 / \left(m_e e / m\right)\right)_{max}$.

And, hence, explain the phenomenon that adding more weight to a system vibrating above its resonant frequency can effectively reduce its vibration amplitude. **(12)**

Contd ..... P/3

**CE 445**

## SECTION – B

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

5. (a) Describe different types of intensity scales. **(15)**

(b) Estimate the probability of seismic hazard for a bridge for a return period of (i) 50 yr, (ii) 150 yr, (iii) 450 yr, and (iv) 950 yr. **(8⅓)**

6. (a) Write short notes on: **(15)**

(i) Earthquake Source Models

(ii) Attenuation Laws

(iii) Moment Magnitude

(b) Write down the salient features of an Intensity Scale. **(4)**

(c) What are the collateral effects of an earthquake? Explain one of them. **(4⅓)**

7. (a) Differentiate between Zonation and Microzonation with neat sketches. **(9⅓)**

(b) For the following data, shown in Table 1, estimate Liquefaction Resistance Factor and Liquefaction Potential Index for $a_{max}$ = 0.25g and M = 8.5. Ground Water Table is located at a depth of 1.5 m from the EGL. **(14)**

**Table 1**

| Soil Layer Thickness (m) | Soil Profile | $d_{50}$ (mm) | SPT-N Value |
|---|---|---|---|
| 0-8 | Coarse Sand | 0.85 | 7 |
| 8-14 | Medium Sand | 0.45 | 10 |
| 14-21 | Fine Sand | 0.14 | 13 |

8. (a) Write short notes on: **(9)**

(i) Gutenberg-Richter Relationship

(ii) Surface Waves

(iii) Reverse Faults

(b) There are four Seismoactive zones (Table 2) in and around a nuclear power plant site. Estimate SDE and SSE on the basis of cumulative intensity-frequency relation. **(14⅓)**

**Table 2**

| Zones | a | b | $I_{max}$ | Attenuation Value |
|---|---|---|---|---|
| 1 | 1.47 | 0.57 | XI | 1.1 |
| 2 | 0.27 | 0.36 | IX | 0.9 |
| 3 | 0.59 | 0.47 | X | 2.1 |
| 4 | 1.17 | 0.65 | VIII | 1.2 |

Contd... P/4

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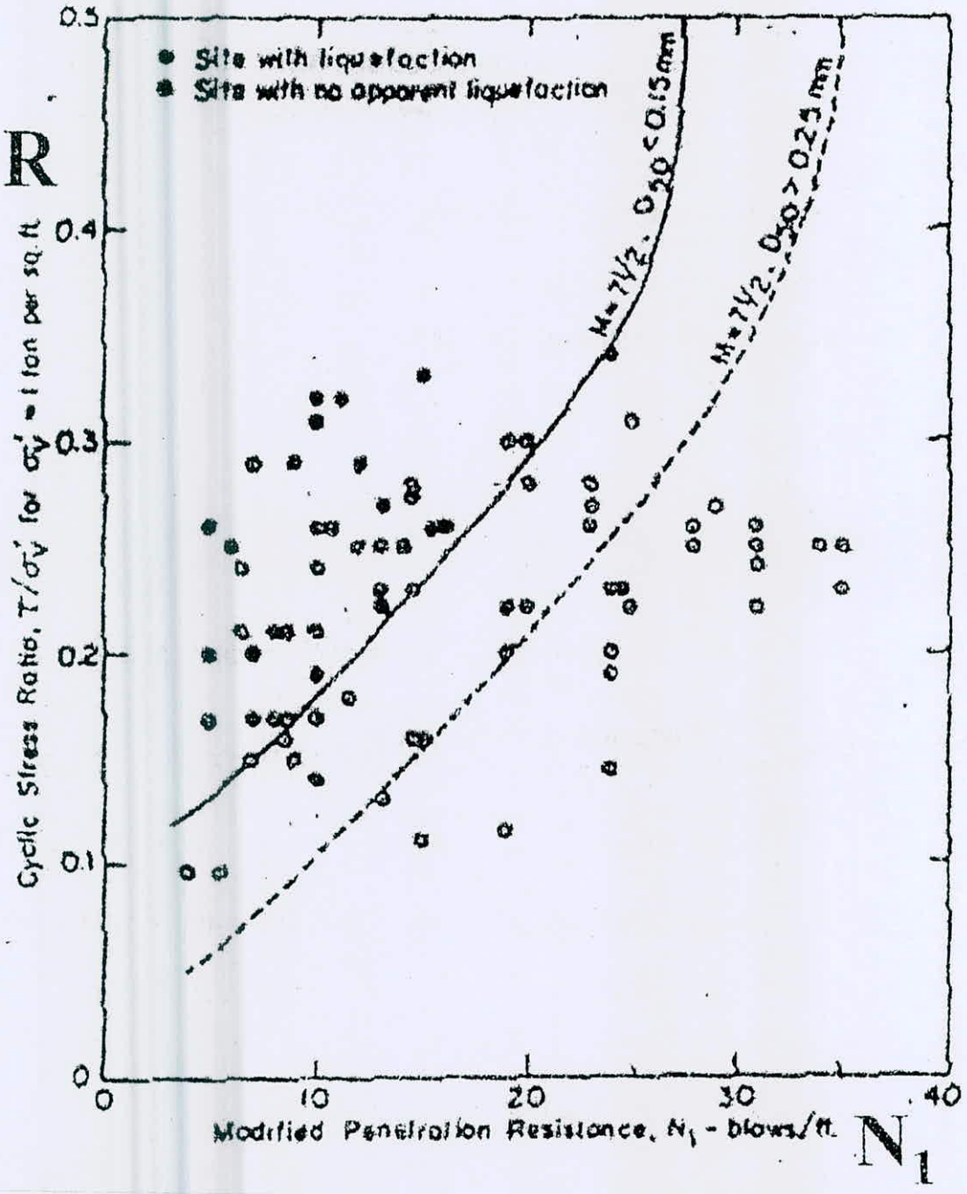
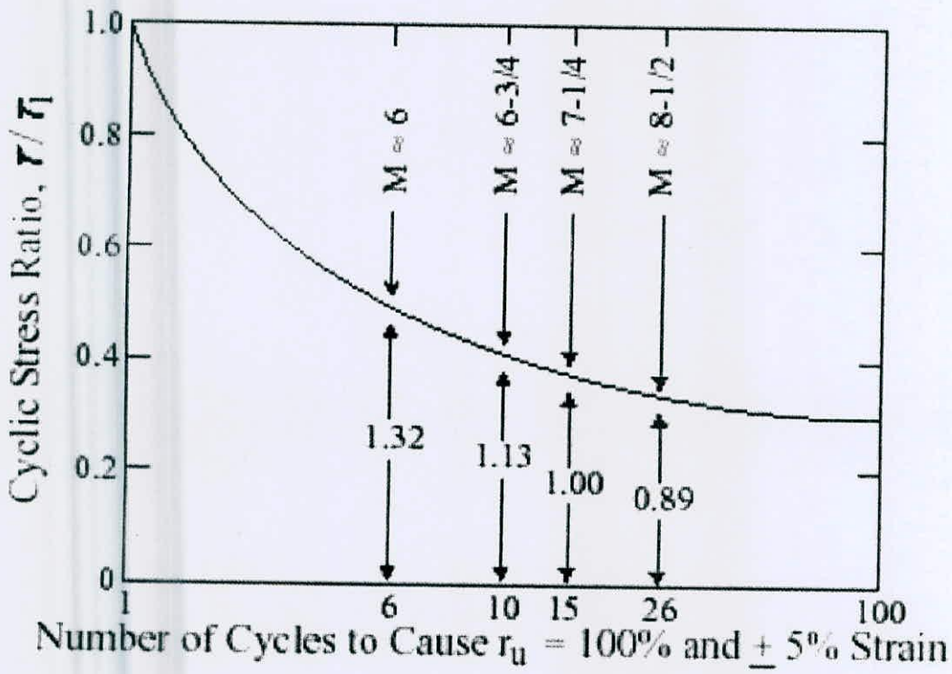

Site with liquefaction
Site with no apparent liquefaction
R
Cyclic Stress Ratio, $\tau/\sigma_v'$ for $\sigma_v'$ = 1 ton per sq. ft.
M = 7½; $D_{50}$ < 0.15 mm
M = 7½; $D_{50}$ > 0.25 mm
0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
Modified Penetration Resistance, $N_1$ - blows/ft.
$N_1$


Cyclic Stress Ratio, $\tau/\tau_1$
1.0
0.8
0.6
0.4
0.2
0
M = 6
M = 6-3/4
M = 7-1/4
M = 8-1/2
1.32
1.13
1.00
0.89
1
6
10
15
26
100
Number of Cycles to Cause $r_u$ = 100% and ± 5% Strain

**L-4/T-2/CE** **Date: 12/4/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **CE 447** (Soil-Water Interaction)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume reasonable value for missing data, if any. Use attached Chart where necessary.

1. (a) What are the basic assumptions used for deriving the governing differential equation for two dimensional fluid flow? Also, derive the equation of continuity in two dimension. **(7)**

   (b) Mention the principal reasons for non-Darcy behaviour in soils. With neat sketch define permeability parameters (n and C) and permeability change index ($C_k$). **(7)**

   (c) What are the basic assumptions for determination of permeability of soils in field by pumping test? With neat diagrams and equations briefly state the variable head borehole permeability tests for the following two cases: **(9 ⅓)**

   (i) Uncased hole.

   (ii) Cased hole with uncased or perforated extension to certain height.

2. (a) Derive Kozeny-Carman equation for coefficient of permeability of soil. Also, mention the limitations of this equation. **(8 ⅓)**

   (b) State the concepts of potential function and stream function. Also, show that both the potential function and stream function satisfy Laplace's equation in two dimension. **(6)**

   (c) A homogeneous embankment of height 12 m was constructed on an impervious foundation with side slopes 3 : 1 (horizontal : vertical). The embankment retains water to a height of 10 m. The crest width of the embankment is 3 m. The coefficient of permeability of embankment soil is $4 \times 10^{-5}$ m/sec. Calculate the rate of seepage through the embankment using Schaffernak and Van Iterson's method. **(4)**

   (d) Draw neatly the conditions for the point of entrance and point of discharge of the line of seepage (phreatic line) of an earth dam. **(5 ⅓)**

3. (a) Show with a neat figure the various components of a revetment on the slope of a river bank. Also, list different types of revetments with at least two examples of each type. **(7)**

   (b) A homogeneous embankment of height 10 m was constructed on an impervious foundation with side slopes 0.25 : 1 (horizontal : vertical). The embankment retains water to a height of 9 m. The crest width of the embankment is 2 m. Plot the line of seepage (phreatic line) using A. Casagrande's method. Use plain graph paper for plotting. **(9 ⅓)**

Contd ..... P/2

**CE 447**
**Contd... Q. No. 3**

(c) The upstream slope of an earth dam of height 6 m was constructed at an angle of 50°. The values of saturated unit weight, cohesion and angle of internal friction of the dam material are 20 kN/m$^3$, 23 kN/m$^2$ and 15°, respectively. Using Taylor's Method, compute the factor of safety of the slope when the reservoir is full to the top level of the slope and when a sudden drawdown occurs. If the same slope is to be excavated in a very deep layer of the soil with $\phi = 0$, then what will be the factor of safety of the slope? **(7)**

4. (a) Using Schaffernak and Van Iterson's Method, derive an expression for the rate of seepage through a homogeneous earth dam with inclined discharge face and without any filter. The base of the dam rests on an impervious foundation. Also, using this method state the procedure of plotting the line of seepage (phreatic line). **(6)**

(b) A dry cohesive deposit of clay of height 4 m exists at an infinite slope. The slope angle is 40°. The values of effective cohesion (c′) and effective angle of internal friction ($\phi'$) of the soil are 25 kN/m$^2$ and 20°, respectively. Dry unit weight of the clay deposit is 16.5 kN/m$^3$. **(6)**

Compute (i) factor of safety of the slope with respect to sliding and (ii) factor of safety of the slope with respect to cohesion assuming friction has been fully mobilized.

If the same slope is subjected to seepage parallel to the slope and occurring throughout the slope (i.e., water table is at surface), then what will be the factor of safety of the slope with respect to sliding? Saturated unit weight of the clay deposit is 20 kN/m$^3$.

(c) With neat sketch briefly describe a direct method of determining soil suction. **(4)**

(d) The following data were obtained for design of revetment using cement concrete (CC) blocks for protecting the bank slope against the erosive actions of currents and waves of the Meghna river at Chandpur site.

Average flow velocity = 3.0 m/sec; Specific gravity of CC block = 2.30

Mass density of CC block = 2300 kg/m$^3$; Angle of response of CC block = 40°

Ratio of water depth and revetment size = 5, Upstream Slope of earth dam = 2 : 1 (horizontal : vertical)

Wind speed = 30 m/sec; Wind duration = 2 hour; Fetch length = 15 km; Strength coefficient = 5 and Wind damage coefficient = 5.5.

CC blocks (cubical shape) will be hand-placed in single layer with geotextile filter. The edges of the CC blocks are exposed and the CC blocks are subjected to normal turbulence with very rough flow (Depth and velocity distribution factor, $K_h = 1$)

Characteristics of waves are shown in Table 1.

Estimate the size (thickness) of CC blocks capable of withstanding the actions of currents and waves. **(7 ⅓)**

Contd ..... P/3

**CE 447**

## SECTION – B

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

5. (a) 'The value of an ultimate property of a geotextile obtained from laboratory test must be suitably modified for in-situ conditions.' – Why this modification is necessary and how it is done? **(6⅓)**

(b) Discuss the applicability of: (i) dynamic compaction and (ii) vibro compaction for improvements of hydraulic fills. **(8)**

(c) Design the geotextile filter surrounding a graded stone aggregate that, in turn, surrounds a perforated pipe underdrain, as shown in the **Fig. 1**. The surrounding soil is a dense sandy silty (ML) with the relevant properties of 15% non-plastic fines, $C_c = 2.0$, $C_u = 5$, $d_{50} = 0.035$ and $k = 1 \times 10^{-5}$ m/s. The geotextile being considered is of needle punched non-woven type with laboratory tested values of $\psi = 1.5\ sec^{-1}$, and AOS = 0.212 mm. The maximum flow that will pass through the geotextile is estimated as 15 $m^3$/day per meter. Notice that water from the stone base will pass only through the geotextile above the underdrain. **(9)**

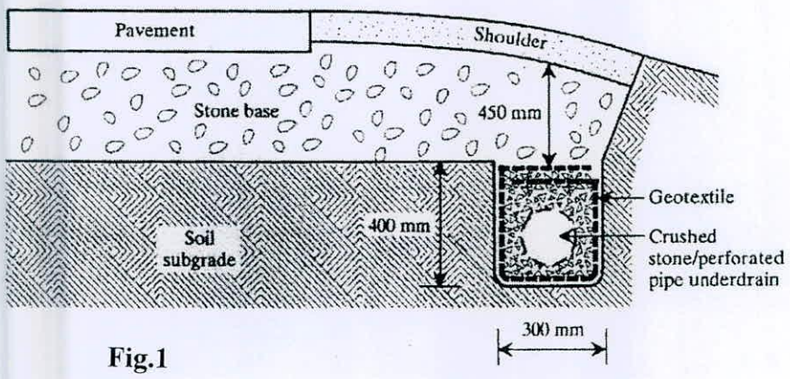


**Fig.1**

6. (a) Discuss the different ways by which water influences the engineering behavior of soils. **(6)**

(b) What are the different tensile strengths of geotextiles? Describe the relevant tests to determine them. **(9)**

(c) Discuss the information that should be collected for the design and construction of a hydraulic fill. **(8⅓)**

7. (a) Explain the mechanisms by which water affects (i) the stability of a slope and (ii) the performance of a road. **(8)**

(b) Mention the advantages and disadvantages of different types of filters used for river bank erosion control. **(5⅓)**

(c) Show, with neat sketch, various elements of river bank revetment. Also, sate the functions of these elements. **(10)**

Contd ..... P/4

**CE 447**

8. (a) Discuss the desirable characteristics of granular filter and the relevant design criteria to achieve these characteristics. **(8)**

(b) Discuss the initial state and properties of hydraulic fills for various types fill materials? **(8 ⅓)**

(c) In **Fig.2**, 'Curve a' represents the particle size distribution of soil on a slope. The figure also shows the particle size distributions of two granular soils as represented by 'Curve b' and 'Curve c'. Analyse the data and comment on the acceptability of the granular soils to be used in the filter layer for the slope. **(7)**

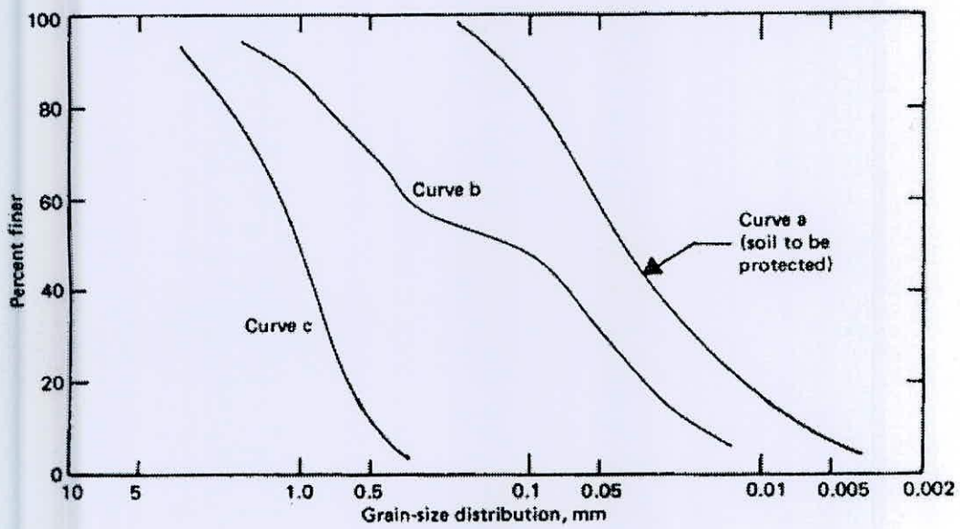


**Fig.2**

Contd... P/5

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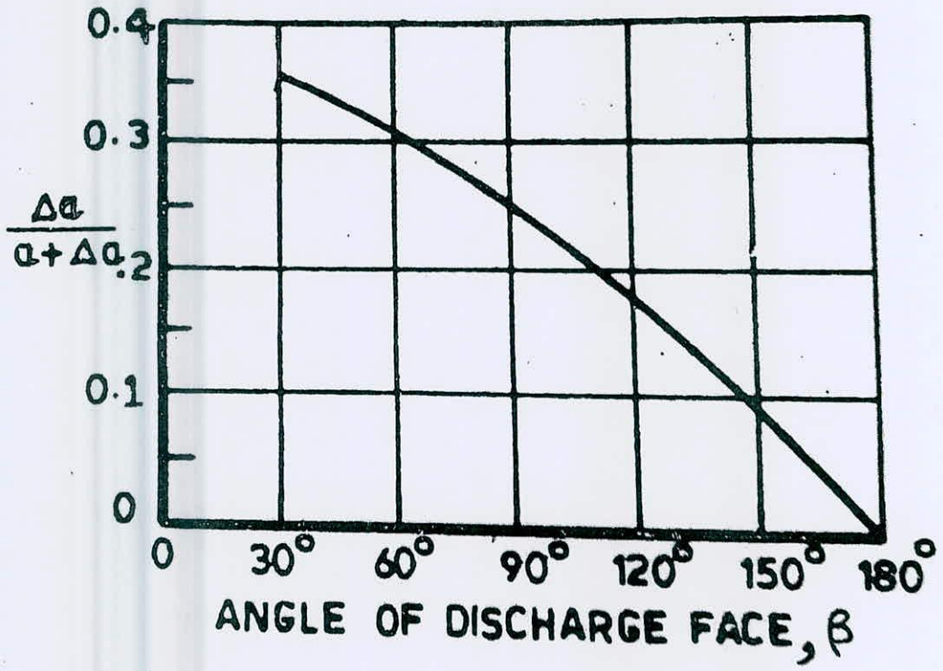


Chart 1

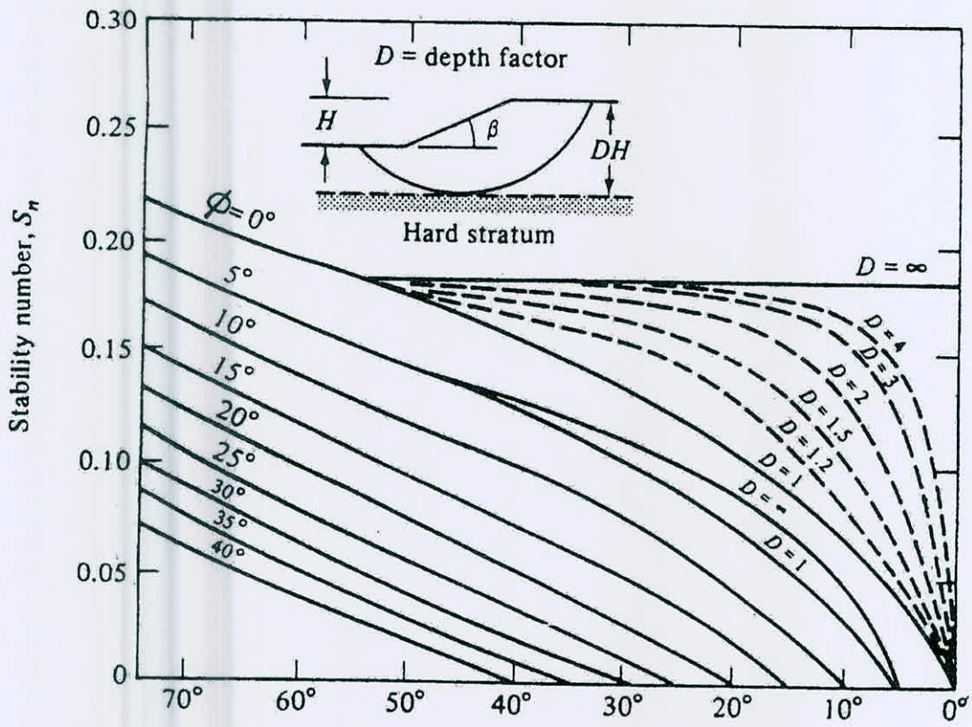


Chart 2 Taylor's Stability Chart

Contd... P/6

**Table 1 Characteristics of Waves**

| Wind speed (m/sec) | Minimum duration of wind (hour) | Fetch length (km) | Wave height (m) | Wave period (sec) |
|---|---|---|---|---|
| 15 | 1.00 | 5.0 | 0.7 | 2.8 |
| | 1.75 | 10.0 | 0.9 | 3.3 |
| | 2.25 | 15.0 | 1.2 | 3.8 |
| 30 | 0.75 | 5.0 | 1.3 | 3.5 |
| | 1.50 | 10.0 | 1.8 | 4.5 |
| | 2.00 | 15.0 | 2.0 | 5.0 |

**Note: The following Equations and Tables can used to solve Question No. 8(d)**

**(a) Stability of Revetment against Current Attack**

**(i) Neil (1972)**

$$D = 0.034V^2$$

$D = Spherical\ diameter\ of\ boulder$
$V = Velocity\ of\ current$
$D_n = 0.81D, \quad D_n = cubical\ dimension$

**(ii) JMBA (BWDB, 1993)**

$$D_n = \frac{0.7V^2}{2(S_s - 1)g} \times \frac{2}{\left\{log_{10}\left(6 \times \frac{h}{D}\right)\right\}^2} \times \frac{1}{\{1 - (sin\theta/sin\phi)^2\}^{0.5}}$$

$S_s = Specific\ gravity\ of\ revetment\ material$
$h = Depth\ of\ water$
$\theta = Bank\ slope\ in\ degree$
$\phi = Angle\ of\ repose\ of\ revetment\ material$

**(iii) Pilarczyk (BWDB, 1993)**

$$D = \frac{V^2}{36g(S_s - 1)\psi_{cr}\left(\frac{h}{D}\right)^{1/6}}$$

$\psi_{cr} = Critical\ Shields\ parameter\ or\ Shields\ constant$

**(iv) Pilarczyk (BRTC, 2010)**

$$D_n = \frac{0.035V^2}{2g\Delta_m} \times \frac{\phi_{sc}}{\psi_{cr}} \times \frac{K_T K_h}{K_S}$$

$\Delta_m = Relative\ density\ of\ revetment\ material$

$$\Delta_m = \frac{\rho_s - \rho_\omega}{\rho_\omega}$$

Contd... P/7

$\rho_s = Mass\ density\ of\ revetment\ material$
$\rho_\omega = Mass\ density\ of\ water$
$\phi_{sc} = Stability\ factor\ for\ current$
$\psi_{cr} = Critical\ Shields\ parameter\ or\ Shields\ constant$
$K_T = Turbulance\ intensity\ factor$
$K_h = Depth\ and\ velocity\ distribution\ factor$

$$K_S = Slope\ factor = \left\{1 - \left(\frac{sin\theta}{sin\phi}\right)^2\right\}^{1/2}$$

**(b) Stability of Revetment against Wave Attack**

**(i) Hudson's Formula (BWDB, 1993)**

$$D_n = \frac{H_s}{\Delta_m}\left(\frac{tan\theta}{K_D}\right)^{\frac{1}{3}}$$

$H_s = Significant\ wave\ height$
$\Delta_m = Relative\ density\ of\ revetment\ material$
$K_D = Damage\ coefficient$

**(ii) Pilarczyk's Formula (BWDB, 1993)**

$$D_n = \frac{H_s}{S_s - 1} \times \frac{1}{\beta} \times \frac{E^{\frac{1}{2}}}{cos\theta}$$

$\beta = Strength\ \ coefficient$
$E = \ Wave\ breaker\ similarity\ parameter\ or\ wave\ breaking\ parameter$

$$E = \frac{1.25T}{\sqrt{H_S}} tan\theta$$

$T = Wave\ period$

**(iii) Pilarczyk (BRTC, 2010)**

$$D_n = \frac{H_s \xi_z^b}{\Delta_m\, \psi_\mu\, \phi_{s\omega}\, cos\theta}$$

$\psi_\mu = System\ specific\ stability\ upgrading\ factor$
$\phi_{s\omega} = Stability\ factor\ for\ incipient\ motion\ due\ to\ wave\ loads$
$\xi_z = Wave\ breaker\ similarity\ parameter\ or\ wave\ breaking\ parameter$
$b = Wave\ structure\ interaction\ coefficient$

**Critical Shield's Parameter, $\Psi_{cr}$**

| Revetment Type | $\Psi_{cr}$ |
|---|---|
| Riprap, small bags | 0.035 |
| Placed blocks, geobags | 0.05 |
| Blockmats | 0.07 |
| Gabions | 0.07 to 0.10 |
| Geomattresses | 0.07 |

Contd... P/8

**Values of Stability Factor (Pilarczyk, 1998)**

| Revetment Type | Stability factor, $\phi_{sc}$ | |
|---|---|---|
| Cover layer | Continuous protection | Exposed edges transitions protection |
| Randomly placed, broken riprap and boulders | 0.75 | 1.5 |
| CC blocks, cubical shape, randomly placed in multi layer | 0.80 | 1.50 |
| CC blocks, cubical shape hand placed in single layer chess pattern | 0.65 | 1.25 |
| Riprap and placed blocks; Sand fill units | 1.0 | 1.50 |
| Block mats, gabions, washed-in blocks, geobags, concrete filled geobags and geomattresses, wiremesh mattress | 0.5 | 1.00 |
| Gabions/mattress filling by stones | 0.75 | 1.5 |

**Turbulence Intensity Factor $K_\tau$ (Current) (FAP 21/22)**

| Turbulence Intensity | $K_\tau$ (Gabions, Mattress) | $K_\tau$ (Others) |
|---|---|---|
| Normal turbulence in rivers | 1.0 | 1.0 |
| Non-uniform flow with increased turbulence, mild outer bends | 1.0 | 1.5 |
| High turbulence, local disturbances, sharp outer bends | 1.0 | 2.0 |
| Jet impact, screw race velocity, hydraulic jump | 3.0 - 4.0 | 3.0 - 4.0 |

**Coefficients for Design of Various Cover Materials against Wave Attack**

| Revetment type | Stability factor for incipient motion ($\varphi$) | Stability upgrading factor ($\psi_\mu$) | Interaction coefficient ($b$) |
|---|---|---|---|
| Randomly placed, broken riprap and boulders | 2.25 - 3.00 | 1.00 - 1.33 | 0.50 |
| CC blocks, cubical shape, randomly placed in multilayer | 2.25 - 3.00 | 1.33 - 1.50 | 0.50 |
| CC blocks, cubical shape, hand placed, single layer (geotextile filter) | 2.25 | 2.00 | 0.67 - 1.00 |
| CC blocks, cubical shape, hand placed in single layer, chess pattern (geotextile on sand) | 2.25 | 1.50 | 0.67 - 1.00 |
| CC blocks cable connected | 2.25 | 1.80 | 0.67 |
| Wire mesh mattress | 2.25 | 2.50 | 0.50 |
| Gabions/mattress filling by stone | 2.25 | 2.50 | 0.50 |

L-4/T-2/CE **Date : 09/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **CE 455** (Transportation Engineering IV: Pavement Management, Drainage and Airport )

Full Marks : 140 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume any reasonable value of missing data.

1. (a) Analyze the steps in overlay design. Explain the basic concepts of "Deflection Approach Method" of overlay design. (7 ⅓)

   (b) Determine the overlay requirements of the existing pavements from the following data.

| **Thickness of existing pavement** | **Thickness of new pavement** |
|---|---|
| Granular sub-base: 275 mm | Granular sub-base: 400 mm |
| Water-bound Macadam: 250 mm | Water-bound Macadam: 250 mm |
| Bituminous Binder: 90 mm | Bituminous Binder: 100 mm |
| Asphalt Concrete: 40 mm | Asphalt Concrete: 60 mm |

   Assume Asphalt Institute Conversion factors for different layers of new and old pavements. Sub0base (0.1 – 0.2), Base (0.2 – 0.3) and Asphalt Concrete (0.5 – 1.0). (8)

   (c) Analyze overview of HDM-4 use in Bangladesh. Explain HDM-4 Software System Architecture. (8)

2. (a) "A well designed Airport drainage system is a prime requisite for operational safety and efficiency as well as pavement durability", explain the statement in line with importance of airport drainage. Examine the Layout of Airport Surface drainage. (8)

   (b) The design of surface drainage system may be divided into two phases. What are these phases? Explain briefly. (9 ⅓)

   (c) State the major functions of Culverts. Draw the commonly used Culverts shapes. (6)

3. (a) The distance between the furthest point in the turf covered drainage (with an average slope of 1.0% towards the drain) and the point of entry to side drain is 275 meter. The weighted average value of the runoff co-efficient is 0.256. The length of the longitudinal open drain in a sandy clay soil from the inlet point to the cross drainage is 550 meter. The velocity of flow in the side drain may be assumed 0.55 m/s so that silting and erosion are prevented. Find the design quantity of flow on the side drain for a 50 years period of frequency of occurrence of the storm. (9 ⅓)

   (b) Diagnose the effects of maintenance and rehabilitation on pavement conditions. Break down the sources of surface water in highway drainage design. (8)

   (c) Explain Sub-surface drains for sub-grade drainage. (6)

Contd ..... P/2

**CE 455**

4. (a) The maximum quantity of water expected in on open longitudinal drains on clayey soil is 1.15 $m^3$/sec. Design the X-section and longitudinal slope of Trapezoidal drain assuming the bottom width to be 1.25 meter and cross slope to be 1V : 1.5H. Allowable velocity of flow in the drain is 1.15 m/sec and Manning's roughness co-efficient is 0.03. Assume free board = 0.145 m. (10)

   (b) Evaluate the importance of highway drainage. (6 ⅓)

   (c) What are the principles of selection of Culverts location? Differentiate bridges and culverts. (7)

**SECTION – B**

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

5. (a) What is efficient Transportation System? Discuss the concepts, 'Next Generation Air Transportation System' and 'Free Flight Air Traffic Control'. (4+4)

   (b) State the factors to be considered for the site selection of an airport. (4 ⅓)

   (c) Explain with diagrams different runway configurations. (7)

   (d) Differentiate between VFR and IFR conditions. (4)

6. (a) Discuss the trend of air travel demand in Bangladesh with qualitative diagrams. (5)

   (b) Show with a diagram the components of an airport system for a large airport. (6)

   (c) State the factors that affect runway orientation. (4 ⅓)

   (d) Mention the types of Airport markings. Discuss on the following runway markings: (i) Runway numbering; (ii) Runway centerline marking. (3+5)

7. (a) Compare the function of airport traffic control center and airway traffic control center. (4)

   (b) Mention the types of airport planning studies. Enlist the parameters used for forecasting in aviation and airport planning. (3+3)

   (c) Write short notes on: (i) Bypass taxiway; (ii) Displaced threshold marking. (3+3)

   (d) Define airway Beacon. Explain culvert and ICAO systems of runway approach lighting. (3 ⅓ +4)

8. (a) Define airways and discuss on the two types of airways. (2+4)

   (b) Write the considerations for environmental study in airport planning. (4 ⅓)

   (c) State the factors that affect size of the apron. Discuss the pier or finger system and satellite apron-gate system with neat sketches. (3+4)

   (d) Mention the kinds of landing aids available to aircrafts and discuss any two of them. (2+4)

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Contd... P/3

CE455

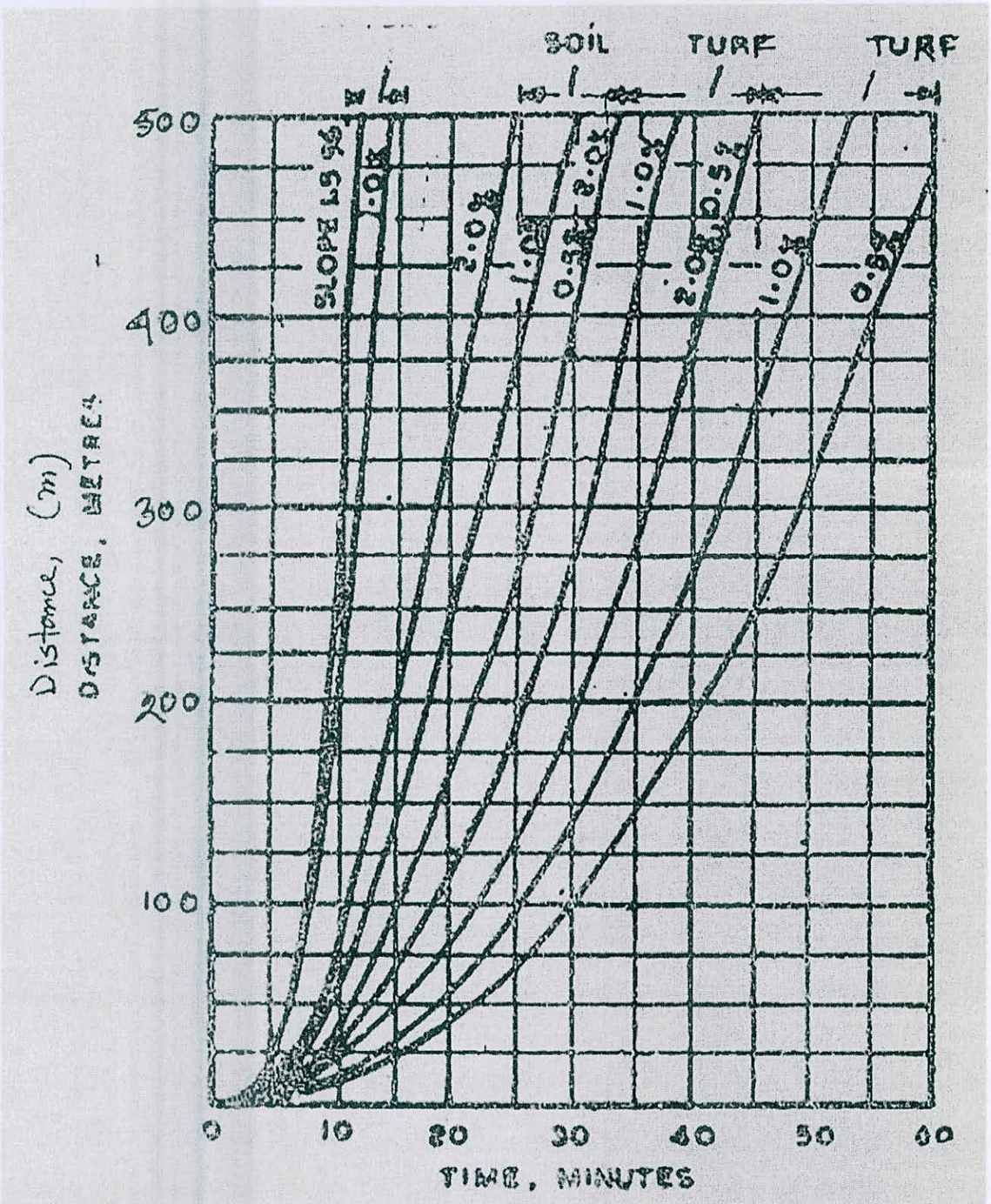


Fig. 1 Time of Flow to Inlet

for question No: (3(b))

Contd... P/4

CE455

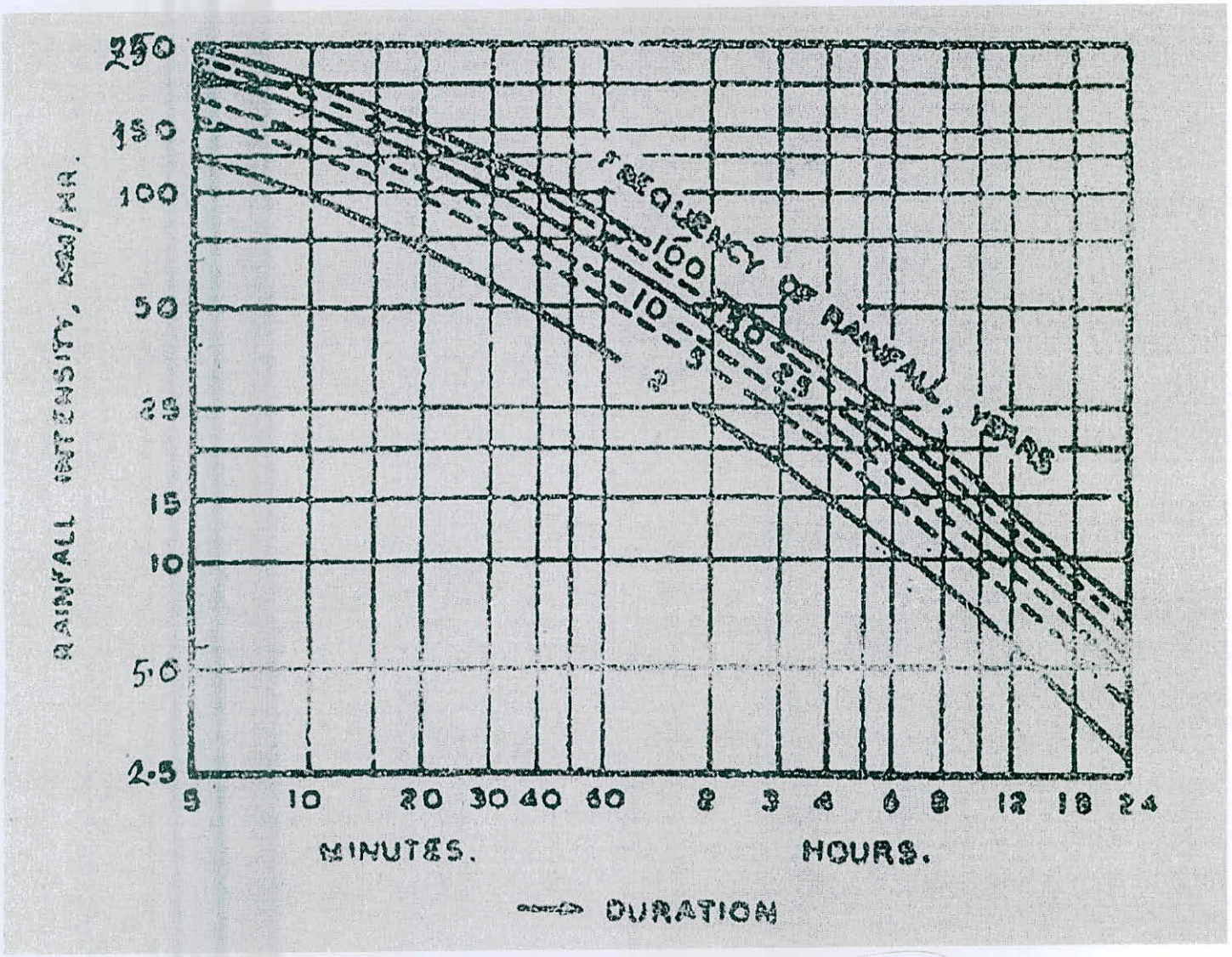


Fig. 2 for question No: (3(a))

L-4/T-2/CE **Date : 20/03/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub : **CE 457** (Transportation Engineering V: Urban Transportation Planning and Management )

Full Marks : 140 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

There are **FIVE** questions in this section. **Q. No. 1 is COMPULSORY**.

Answer any **THREE** questions from Q. No. 2, 3, 4 and 5.

1. **[COMPULSORY Question]**

(a) "Transit is predominantly an urban transportation mode" – discuss why? Elaborate the components of an urban transit system. How the introduction of self-driving vehicles may affect urban transit operations? (3+5+3)

(b) State the problems associated with the trucks movement and loading/unloading facilities in Bangladesh. State the issues and problems related to Urban Goods Movement (UGM). Discuss the concerns of different parties involved in UGM process. (3+3+4)

(c) Write down the negative impacts of truck terminals in an urban setting from safety point of view. What do you think will be the positive effects of the truck stops being developed beside Dhaka-Chittagong National Highway in creating safer road environment? (4+3)

2. (a) Identify some globally acknowledged urban transportation problems. Discuss the following factors in relation to urban traffic congestion: (i) Longer commuting; (ii) High infrastructure maintenance costs; and (iii) public transport inadequacy. (3+5)

(b) Briefly discuss the factors related to automobile dependency. Mention the present trend of car ownership and its probable consequence. (3+3)

3. (a) Mention three most relevant indicators of automobile dependency. Explain in brief two negative consequences of automobile dependency. (2+3)

(b) Explain different urban transport development paths. Also, identify those development paths in an ownership of passenger modes versus urban mobility level diagram. (7+2)

4. (a) Explain the statement – 'Congestion can be perceived as an unavoidable consequence of the usage of scarce transport resources, particularly if they are not priced'. Elaborate the project evaluation and decision-making procedure. (4+4)

(b) Explain the two major forms of congestion. Explain how alternate work schedule and ride sharing contribute to reducing peak period traffic congestion. (3+3)

Contd ..... P/2

**CE 457**

5. (a) Carefully identify the stakeholders who got either positively or negatively affected by the Dhaka-Chittagong Highway four-lane project. (3)

(b) Three transportation projects have been proposed to increase the safety at a major intersection in an urban area. The annual maintenance cost of the intersection in the present condition is $15,000 and the annual user cost is $500,000. The following Table 1 shows the initial construction costs, annual maintenance and operating costs, useful life and the salvage values for each alternative. Assume a discount rate of 9% and determine the preferred alternative based on the economic criteria. (11)

Table 1: Costs and benefits of different alternatives

| Alternative | Capital Costs ($) | Annual Maintenance ($) | Annual User Cost ($) | Useful Life (Years) | Salvage Value ($) |
|---|---|---|---|---|---|
| I | 45,000 | 10,000 | 401,000 | 10 | 15,000 |
| II | 95,000 | 9,000 | 350,000 | 10 | 11,000 |
| III | 255,000 | 8,000 | 400,000 | 15 | 5,000 |

## SECTION – B

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

6. (a) Mention the products of urban transport planning. Describe 'Classic' and 'New' urban transport planning sequences. Write differences between stratified random sampling and choice-based sampling in the context of urban transportation planning. (3+4+3)

(b) Write down the generalized road safety strategies. Define multimodal passenger transportation system. Discuss the components of multimodal transportation program. (6+2+5 ⅓)

7. (a) Write down the common core items of accident recording system. State the main principles of Safer Road Environment. (3+6)

(b) Differentiate between sampling error and bias. Draw a qualitative diagram showing model specification error and exogenous forecast error as a function of model detail. (3+3)

(c) Number of trips per households size by auto ownership obtained from regional study can be seen below: (8 ⅓)

| | | **Auto ownership** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **0** | | **1** | | **2+** | |
| | | **HH** | **Trips** | **HH** | **Trips** | **HH** | **Trips** |
| **Household Size** | 1 | 1200 | 2520 | 2560 | 6144 | 54 | 130 |
| | 2 | 874 | 2098 | 3456 | 9676 | 5921 | 20165 |
| | 3+ | 421 | 1137 | 2589 | 8026 | 8642 | 33704 |

Contd ..... P/3

## CE 457

**Contd ... Q. No. 7(c)**

Forecasted number of households in the same study zone by auto ownership and size can also be seen below:

| | | Auto ownership | | |
|---|---|---|---|---|
| | | 0 | 1 | 2+ |
| Household Size | 1 | 25 | 125 | 3 |
| | 2 | 32 | 175 | 254 |
| | 3+ | 10 | 89 | 512 |

Estimate total trip generated from that zone.

8. (a) Differentiate between Severity Level and Casualty Class related to accident studies. Define Hazardous Road Location (HRL) program and its goal. (3+5)

(b) For mode choice, a calibrated study resulted in the following utility function: (10+5 ⅓)

$$U_k = a_k - 0.03X_1 - 0.04X_2 - 0.015X_3 - 0.004X_4$$

where $X_1$ = access plus egress time, in min

$X_2$ = waiting time, in min

$X_3$ = line-haul time, in min

$X_4$ = out-of-pocket cost, in BDT

The trip-distribution forecast for a particular interchange was a target-year volume of $Q_{ij}$ = 8000 person-trips per day. During the target trip-makers on this particular interchange will have a choice between the private automobile (A) and a local bus system (B). The target-year service attributes of the two competing modes have been estimated to be:

| Attribute | $X_1$ | $X_2$ | $X_3$ | $X_4$ |
|---|---|---|---|---|
| Automobile | 5 | 0 | 20 | 350 |
| Local bus | 10 | 10 | 40 | 150 |

$a_{Auto} = 0$ and $a_{bus} = -0.20$, Apply the Multinational Logit (MNL) model to estimate

(i) The target-year market shares of the two modes.

(ii) The resulting fare-box revenue of the bus system.

9. (a) Differentiate between 'all-or-nothing' and 'capacity restraint' traffic assignment technologies. Which assignment technique would you use to assign trips into road network of Dhaka city? Why? (3+2+2)

(b) Mention the various accident data sources. Explain Haddon Matrix and Collision Diagram and their use in mitigating road safety problem. (3+7)

(c) State the importance of calibration for gravity model. The following data were used while determining gravity model adjustment factor for total attraction of zone 1: $A_1$ (desired) = 300, $A_1$ (first try) = 300, $A_1$ (after 1st iteration) = 379, and $A_1$ (after 2nd iteration) = 379. What was the $A_1$ (third try) value? (6 ⅓)

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L-4/T-2/CE **Date: 06/04/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **WRE 409** (River Engineering)

Full Marks: 140 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

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## SECTION – A

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

Assume any reasonable value where necessary.

1. (a) Explain why average width of Jamuna River is increasing every year. **(5 1/3)**

   (b) Describe in brief the preliminary design of earthen embankments with neat sketches. **(8)**

   (c) Measure the form ratio of a rectangular channel that will carry a bankfull discharge of 1000 $m^3/s$ if the bed consists of gravel ($d_{50}$ = 2.5 cm) and the slope of the bed is 0.001. **(10)**

2. (a) Write short note on "suspended sediment rating curve". **(4 1/3)**

   (b) Briefly explain different types of temporary measure to control river bed for navigation purposes. **(7)**

   (c) Follower a river, following data are given: **(12)**

   Maximum discharge = 73,000 $m^3/s$

   Highest flood level = 15.5 m PWD

   Bankfull water level = 10.5 m PWD

   Low water level = 5.2 m PWD

   Bed material size, $d_{50}$ = 0.15 mm.

   Design a guide bank. Sketch your design.

3. (a) Describe the following terms in brief with neat sketches, if necessary. **(6)**

   (i) Mattresses

   (ii) Gabions

   (b) A bridge is going to be built over the Khowai River where the section is 300 m wide. Here the maximum discharge is 6500 $m^3/s$ and upstream water depth is 5 m. Grain size of the bed materials ($d_{50}$) is found 0.15 mm. There will be 10 circular cylindrical piers of 10 m length and 2 m diameter each, and the vertical-wall abutments will protrude 20 m into the river. Assume the flow will attack the pier with 30° angle. **(7 1/3 +10)**

Contd ..... P/2

## WRE 409

**Contd... Q. No. 3(b)**

(i) Calculate abutment scour

(ii) Select design scour depth follower bridge pier using at least two difference formulas.

4. (a) How do you relate critical shear stress with sediment size? **(7 1/3)**

(b) Distinguish between **(16)**

(i) Attracting groyne and deflecting groyne

(ii) Constriction scour and local scour

(iii) Clear water scour and live bed scour.

(iv) Hydraulic failure and structural failure of earthen embankments.

**SECTION – B**

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

5. (a) Describe the process of 'cut-off' formation in a meandering river. **(7 1/3)**

(b) Briefly explain the Meandering parameters of a river with the help of a neat sketch. **(4)**

(c) Explain the helical movement of water in a river bend. How does it contribute to the development of 'cut-banks' and 'point bars'? **(12)**

6. (a) Draw a schematic diagram showing the typical vertical profile of flow velocity, suspended sediment concentration and sediment transport of a channel. **(5 1/3)**

(b) Consider a river channel with cross sectional area of 350 $m^2$ and water surface slope of 1 in 1000. Radius of curvature for this channel is 500 m. Calculate the (i) bankful discharge (ii) width of river (iii) depth of river (iv) velocity of water (v) transverse slope of the water surface at a bend. The channel has the following hydraulic geometric properties: **(18)**

Table 1 for Question no. 6(b)

| a | b | $C_a$ | $C_b$ |
|---|---|---|---|
| 0.55 | 0.4 | 8.95 | 0.25 |

7. (a) Define: (i) Channel forming discharge (ii) Meander crossings (iii) Regime channel (iv) Ephemeral river. **(6)**

(b) What is a river delta? Write down the conditions under which a delta forms, and the factors which influence the shape of a river delta. **(6 1/3)**

(c) Define 'confluence' and 'bifurcation', showing examples from Bangladesh. Write down the salient characteristics of river at confluences and bifurcations. **(11)**

8. (a) What are channel bed forms? Briefly describe the following types of bed forms with sketches: (i) Ripples (ii) Dunes (iii) Chutes and Pools **(7)**

(b) What are the typical causes of aggradation and degradation in river bed? **(5)**

(c) What is 'river restoration'? Briefly discuss the typical components of river restoration. **(11 1/3)**

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L-4/T-2/CE **Date: 23/3/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: **WRE 411** (Economics and Management of Chemical Process Industries.)

Full Marks: 140 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

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## SECTION – A

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

Assume any reasonable value where necessary.

1. (a) Discuss following governing factors for the selection of particular types of dam- (i) Geology and foundation condition, (ii) Spillway size and location. **(10)**

   (b) Draw a Typical cross section of a reservoir and show various storage zones. **(8⅓)**

   (c) Discuss the problems of dam construction. **(5)**

2. (a) Draw a typical cross section of, (i) Syphon type and (ii) Shaft type spillways. **(5)**

   (b) Following fig.1 shown the cross-section of a gravity dam. Neglecting earthquake forces, calculate- (i) Maximum vertical stress at heel and toe. (ii) Major principle stresses at heel and toe. Assume there is no tail water and the weight of concrete is 22 KN/cubic m. **(18⅓)**

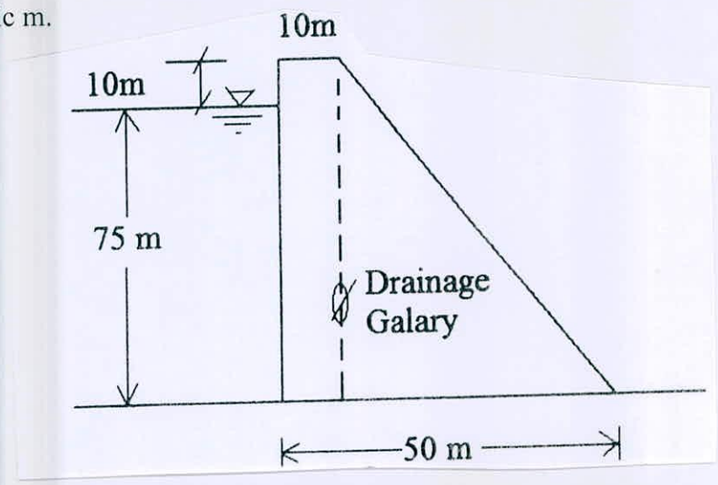


Figure-1 for Q-2(b)

3. (a) Monthly inflow rate during a low-water period at the site of a proposed dam are tabulated in Col-2 of the following table. Monthly pan evaporation and precipitation are given in the Col-3 & Col-4. Prior water rights make it obligatory to release full natural water flow or 13 hector-meter, whichever is minimum. Estimated monthly demands are shown in Col-5. The net increased pool area is 380 hectares. Assume pan evaporation coefficient to be 0.71. Determine the reservoir capacity to utilize the full inflow to meet the demand of the area. **(18⅓)**

Contd ..... P/2

**WRE 411/CE**

**Contd... Q. No.3(a)**

| Month | Inflow at Dam site (hec-m) | Pan evaporation (cm) | Precipitation (cm) | Demand (hec-m) |
|---|---|---|---|---|
| 1 | 1.3 | 1.5 | 1.3 | 14.3 |
| 2 | 0 | 1.8 | 1.7 | 14.3 |
| 3 | 0 | 2.6 | 0.6 | 9.6 |
| 4 | 0 | 10.2 | 0 | 4.8 |
| 5 | 0 | 15.4 | 0 | 3.5 |
| 6 | 0 | 1.6 | 1.1 | 3.4 |
| 7 | 260 | 10.8 | 16.1 | 5 |
| 8 | 410 | 11.7 | 16.2 | 5 |
| 9 | 1 | 10.8 | 2.2 | 10 |
| 10 | 0.6 | 9.6 | 0.7 | 15.6 |
| 11 | 0.5 | 7.9 | 0 | 15.8 |
| 12 | 0.2 | 2.2 | 0 | 16.0 |

(b) What is gravity dam? Write down different forces acting on a gravity dam. **(5)**

4. (a) Design the downstream portion of an Ogee spillway for a dam having following characteristics. The u/s is vertical and the downstream portion is having slope of 0.7H: 1V. The design discharge is 7700 cumecs. The height of spillway crest is kept at RL 280m. And the RL of bed elevation is 190m. Spillway length consists of 6 spans having clear width of 9m each. Pier thickness is 2.5m. Assume Kp=0.01, Ka=0.1. **(18⅓)**

(b) Differentiate between storage basin and retarding basin. **(5)**

## SECTION – B

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

5. (a) What are the main causes of failure of hydraulic structure constructed on permeable foundation and what remedial measures are taken to prevent them? **(6)**

(b) How does Khosla's theory differ from Bligh's theory with regard to the design of weirs on permeable foundation? **(6)**

(c) Do you think reducing the length of the weir will reduce the cost of structure? Discuss the reason to support you answer. **(5⅓)**

(d) Under what circumstances will you recommend the use of following cross drainage works: **(6)**

(i) Level Crossing

(ii) Inlet-Outlet

(iii) Type II Aqueduct

Contd ..... P/3

**WRE 411/CE**

6. (a) What are is critical exit gradient? **(4)**

(b) Use Khosla's seepage formulate to calculate percentage pressures at various key points of the barrage foundation profile shown in Figure 2 applying necessary corrections. Slope correction for 1 in 3 slope is 4.5 and for 1 in 5 is 2.8. Neglect the floor thickness and pile thickness. **(19 ⅓)**

For pile on u/s and d/s end, $\varphi_E = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda-2}{\lambda}\right)$; $\varphi_D = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda-1}{\lambda}\right)$;

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}\ ;\ \alpha = \frac{b}{d}$$

For intermediate piles, $\varphi_E = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1-1}{\lambda}\right)$; $\varphi_C = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1+1}{\lambda}\right)$; $\varphi_D = \frac{1}{\pi}\cos^{-1}\left(\frac{\lambda_1}{\lambda}\right)$;

$$\lambda = \frac{\sqrt{1+\alpha_1^2}+\sqrt{1+\alpha_2^2}}{2}\ ;\lambda = \frac{\sqrt{1+\alpha_1^2}-\sqrt{1+\alpha_2^2}}{2}\ ;\alpha_1 = \frac{b_1}{d}\ ;\ \alpha_2 = \frac{b_2}{d}$$

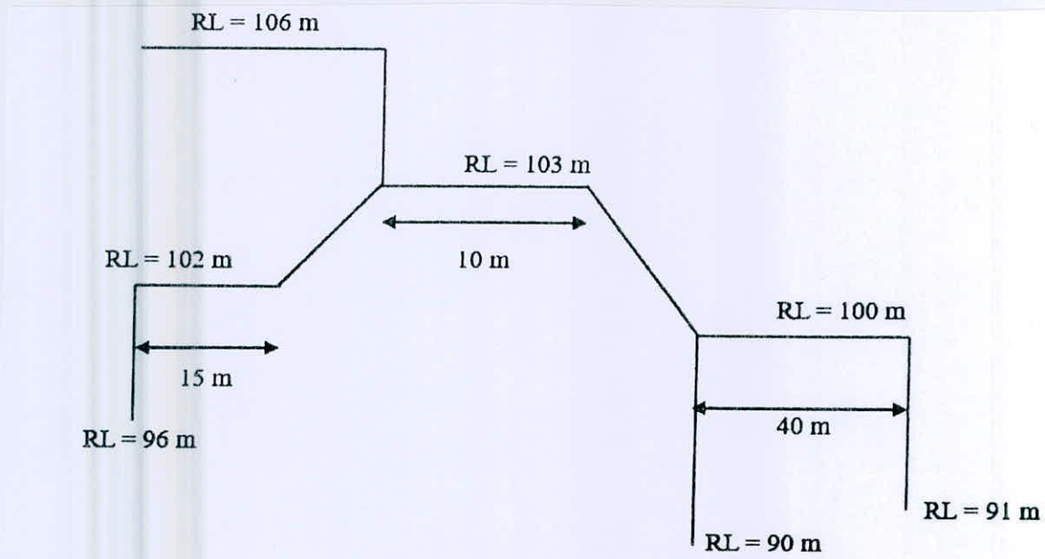


Figure no. 2 for 6(b)

7. (a) Explain the effects produced by weir on river regime. **(6)**

(b) A barrage is to be constructed on a river having a high flood discharge of about 8100 cumecs with the given data as follows: **(17 ⅓)**

Average bed level of the river = R.L. 257.0 m

High Flood Level (before construction of barrage) = R.L. 262.2 m

Permissible afflux = 1.0 m

Pond Level = = R.L. 260.6 m

Safe exit gradient for riverbed material 1/6

Stage discharge curve of the river at barrage site is given below in Figure 3

Contd ..... P/4

**WRE 411/CE**

**Contd... Q. No.7(b)**

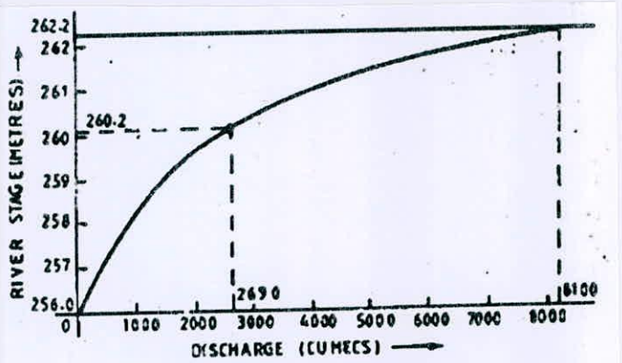


Figure no. 3 for 7(b)

Determine (i) the crest level of under-sluices and barrage bays portion, (ii) the waterway to pass the flood discharge and (iii) downstream floor level for under-sluices portion considering a retrogression of 0.5 m and 20% discharge concentration. Use Figure 4 for your calculation.

8. (a) Write short note with neat sketches on: **(8)**

(i) Super Passage

(ii) Level Crossing

(b) Which cross drainage work is suitable for the following data at the crossing of a canal and drainage? **(15⅓)**

| **Canal** | **Drainage** |
|---|---|
| Full supply discharge = 32 cumecs<br>Full supply level = R.L. 213.5 m<br>Canal bed level = R.L. 212.0 m<br>Canal bed width = 20 m<br>Trapezoidal canal section with 1.5 H : 1 V slopes<br>Canal water depth = 1.5 m | High flood discharge = 300 cumecs<br>High flood level = R.L. 210.0 m<br>High flood depth = 2.5 m<br>General ground level = R.L. 212.5 m |

Determine (i) Drainage Waterway, (ii) Canal Waterway and (iii) Bed Levels at different sections.

Unwin's Formula: $h = \left[1 + f_1 + f_2 \frac{L}{R}\right] \frac{V^2}{2g} - \frac{V_a^2}{2g}$.

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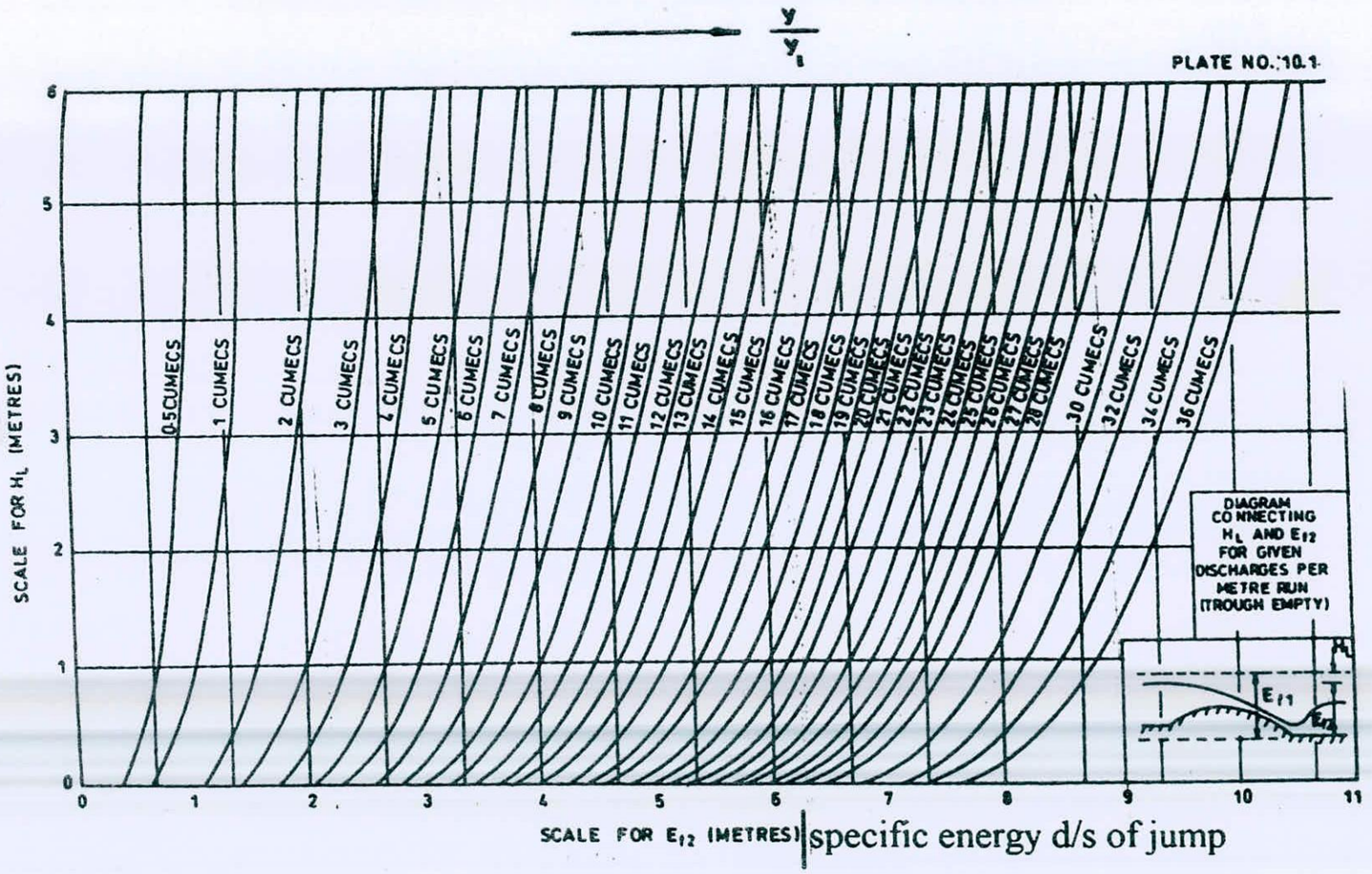
**11.1**: *Blench's design chart for the estimation of the specific energy $E_{f2}$ with known discharge intensity and total energy loss*




specific energy d/s of jump

Figure no. 4 for 7(b)