L-3/T-1/WRE Date : ~~30/04/2024~~ 13/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub : **WRE 301** (Open Channel Hydraulics)

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Show that for curvilinear flow the total pressure head can be expressed as

$$\text{total pressure head} = y\left(1 \pm \frac{v^2}{gr}\right)$$ **(10)**

(b) A 3.0 m wide rectangular channel carries a flow at 1.25 m depth. At a certain section the width is reduced to 2.5 m and the bed is raised by 0.20 m through a hump. (i) Estimate the discharge in the channel when the water surface drops by 15 cm over the hump. (ii) What change in bed elevation in the contracted section would make the water surface have the same elevation upstream and downstream of the contraction. The energy loss can be neglected. **(20)**

(c) A sluice gate in a 3 m wide rectangular channel releases a discharge of 18 m^3/s. The gate opening is 0.67 m and the coefficient of contraction can be assumed to be 0.6. If a hydraulic jump forms in this channel, determine the type of the jump when the tailwater depth is 5.00 m. Show necessary sketches. **($16\frac{2}{3}$)**

2. (a) A 2.5 m wide rectangular channel carries a discharge of 6.48 m^3/s, has a specific energy of 1.50 m. Calculate the alternate depths and critical depth for the channel section. **(16)**

(b) Define specific energy. Show that for a parabolic section, the critical depth can be expressed as, **(10)**

$$y_c = \sqrt[4]{\frac{27Q^2}{8gK^2}}$$

(c) Design a USBR stilling basin type II with neat sketch for the following data. **($20\frac{2}{3}$)**

Design discharge: 15870 m^3/s.

TW level: 17.26 m

Basin width: 227.1 m

Elevation of ground: 0.00 m

Velocity at the foot of the spillway: 24.70 m/s

Assume necessary values for any missing data.

3. (a) For the following velocity distribution profile estimate the discharge per unit width of the channel. Also calculate the velocity distribution coefficients. **($16\frac{2}{3}$)**

WRE 301
Contd...Q.No. 3(a)

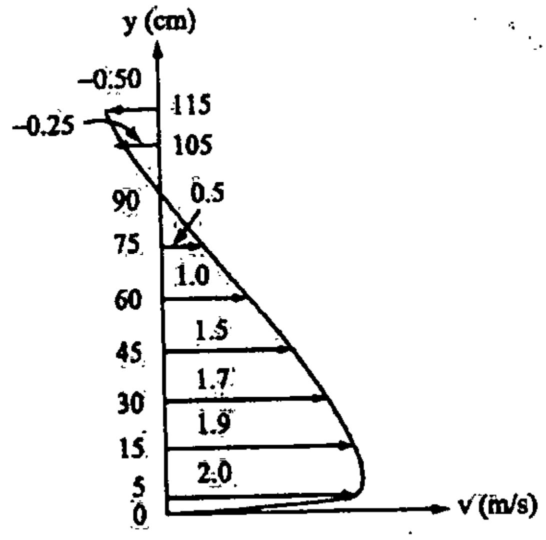

Figure 1 for question3(a)

(b) A rectangular channel is laid on a slope of 12° with the horizontal. When the channel carries a discharge of 15 $m^3/s/m$ at a depth of 0.7 m, a hydraulic jump is known to occur at a section. Calculate the sequent depth of the jump, length of the jump and energy loss in the jump. Also determine the type of the jump with necessary sketch. **(15)**

(c) A drainage channel has to be designed to carry a runoff from 200 km^2 area. If the flow per square kilometer is 0.5 $m^3/s/km^2$, design the drainage channel by tractive force method. The bottom slope is 0.00025 and the channel is excavated through fine gravel having particle size of 8 mm. Assume particles are moderately rounded and the water carries sediments at low concentrations. Use attached chart (Figure 2) if needed. **(15)**

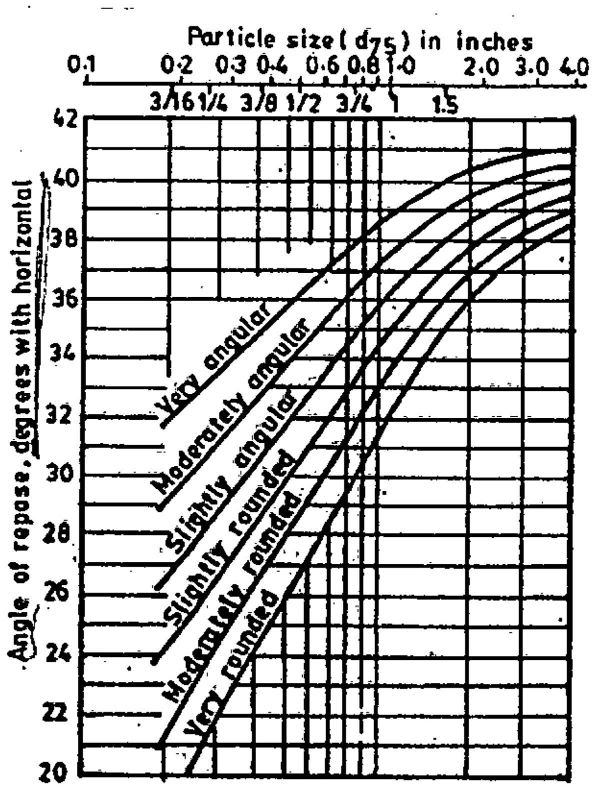

Figure 2 for question3(c)

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WRE 301

4. (a) Define the following terms. **($16\frac{2}{3}$)**
   (i) Maximum permissible velocity
   (ii) Angle of repose
   (iii) Final regime
   (iv) Afflux

   (b) An overflow spillway has its crest at 125.40 m elevation and a horizontal apron at an elevation of 95.00 m on the downstream side. Find the tailwater elevation required to form a hydraulic jump when the elevation of the energy line is 127.90 m. The C_d for the flow can be assumed as 0.755. The energy loss for the flow over the spillway can be neglected. **(10)**

   (c) Estimate the afflux for a bridge having four piers with semicircular noses and tails each 40 ft long and 10 ft wide. During a flood peak of 45000 cfs the total width of the stream was 390 ft and the average depth at downstream section was 19.4 ft. **(20)**

SECTION - B

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

Assume reasonable values if missing.

5. (a) Define with sketches and examples: (i) steady uniform flow, (ii) steady gradually varied flow, (iii) steady rapidly varied flow, (iv) unsteady rapidly varied flow. **(16)**

   (b) Sketch the possible gradually varied flow profiles in the following serial arrangement of channels and control. The flow is from left to right. **(12)**
   (i) Steep slope-mild slope-horizontal slope-sudden drop
   (ii) Steep slope-sluice gate in mild slope-adverse slope
   (iii) overflow weir on mild slope-steep slope-critical slope

   (c) A sharp crested weir is placed in a 6.0 m wide rectangular channel discharging water at 30.0 m^3/s. Estimate the energy loss due to the weir and force on the weir plate, when water depths measured at upstream and downstream section of the weir are 2.5 m and 1.0 m respectively. **($18\frac{2}{3}$)**

6. (a) Using the Chezy formula, determine the hydraulic exponent for uniform flow. N for the following channel sections. **(16)**
   (i) triangular channel
   (ii) wide rectangular channel

   (b) A rectangular channel with width, b = 5.0 m, energy correction co-efficient, α = 1.15 and Manning's roughness co-efficient, n = 0.025 has three reaches arranged serially. The bottom slopes of these reaches are 0.002, 0.008 and 0.009, respectively. For a discharge of 15 m^3/s in the channel, name, and sketch qualitatively the resulting flow profiles. **(12)**

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WRE 301
Contd...Q.No. 6

(c) During a flood flow, and depth of water in a 10.0 m wide rectangular channel was found to be 3.0 m and 2.9 m at two sections 200.0 m apart. The drop in water surface elevation was found to be 0.12 m. Assume Manning's roughness co-efficient, n= 0.025. Estimate the flood discharge through the channel by slope-area method. **($18\frac{2}{3}$)**

7. (a) Write short notes on the followings: **($10\frac{2}{3}$)**
   (i) Prandtl-Von Karman universal velocity distribution law
   (ii) Flow computation in a channel with composite roughness

   (b) Derive the dynamic equation of gradually varied flow in terms of depth for wide rectangular channel. Use the Chezy equation. **(14)**

   (c) A trapezoidal channel has a bottom width of 6.0 m, side slopes 1.5 H: 1V energy correction co-efficient, $\alpha = 1.1$ and Manning's roughness coefficient, n = 0.025. **(12)**
   (i) Determine the slope at normal depth of 1.0 m when the discharge is 20 m^3/s.
   (ii) Determine the critical slope at the critical depth of 1.0 m.

   (d) Explain the theoretical behavior of flow profile when the depth approaches: **(10)**
   (i) normal depth
   (ii) critical depth

8. (a) Write the various uniform flow equations and find the relation between Manning's roughness value (n), Durcy Weisbach's friction factor (f), and Chezy's C. **(12)**

   (b) A broad crested weir is placed in a 6.5 m wide rectangular channel (roughness co-efficient, n = 0.025) carrying water at 20 m^3/s. Water depth at the upstream end of the weir is 3.5 m. Longitudinal slope of the channel is given as 0.002. Find out the length of the backwater curve using the direct step method. **($18\frac{2}{3}$)**

   (c) A triangular channel of apex angle 90° and a rectangular channel of the same material have the same bed slope. If the rectangular channel has a depth of flow equal to the width of the channel and if the flow areas in both the channels are the same, find the ratio of discharges in the rectangular and triangular channels respectively. **(16)**

Date: ~~21/03/2024~~ 25/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **CE 321** (Structural Analysis and Design I)

Full Marks: 280 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **SEVEN** questions in this section. Answer **Q. No. 1** and any **FOUR** from the rest.

(Assume reasonable values for any missing data)

1. A 6-storied RC residential building (occupancy category II) located in Sylhet (site class: SC) is shown in Figure 1. The structure is a special reinforced concrete moment frame. The building has a plan dimension of 50 feet × 60 feet and the typical floor-to-floor height of the building is 10 feet. The height from the column pedestals to the ground floor is 8 feet. Determine the floor-wise load distribution and the story shear distribution along the height of the building following the equivalent static force method as per BNBC 2020. **(28)**

   Given, floor finish, dead load and partition wall load = 120 psf for typical floors (including self-weight of slab), live load on typical floor is 40 psf including ground floor and life load on roof is 25 psf. Typical beam size = 12 inch × 18 inch (all beams) and typical column size = 20 inch × 20 inch (all columns). Self-weight of all pedestals is 30 kips. (see the attached tables)

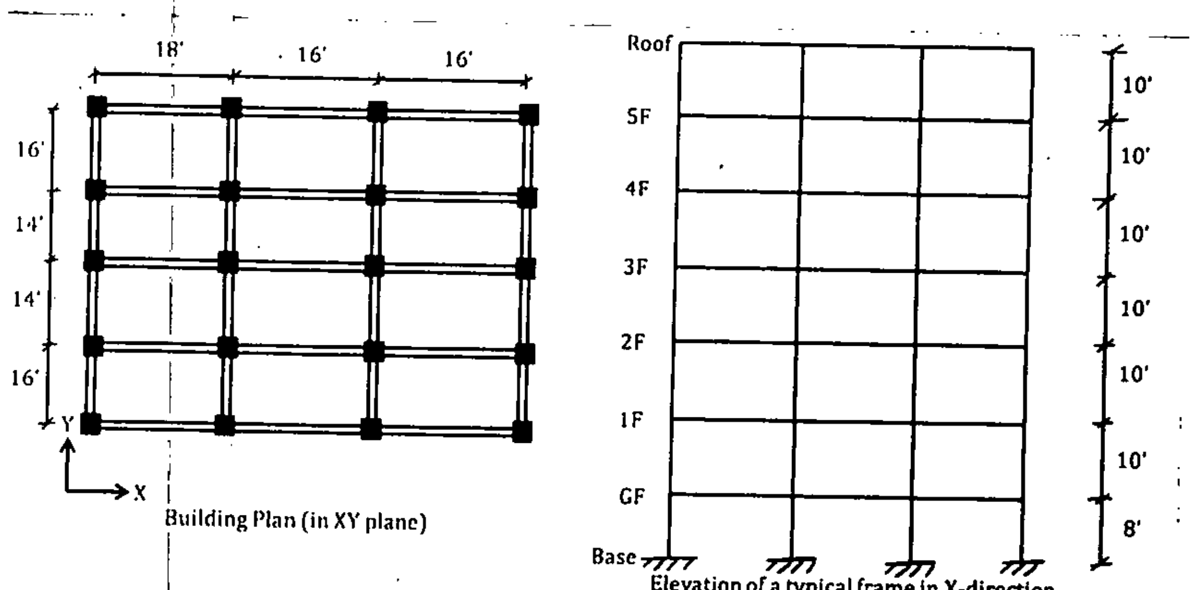

Figure 1.

2. Check the static determinacy of the frame shown below in Figure 2. Draw the axial force, shear force and bending moment diagram for the beam ***BCD*** of the frame. ***C*** is an internal hinge. **(28)**

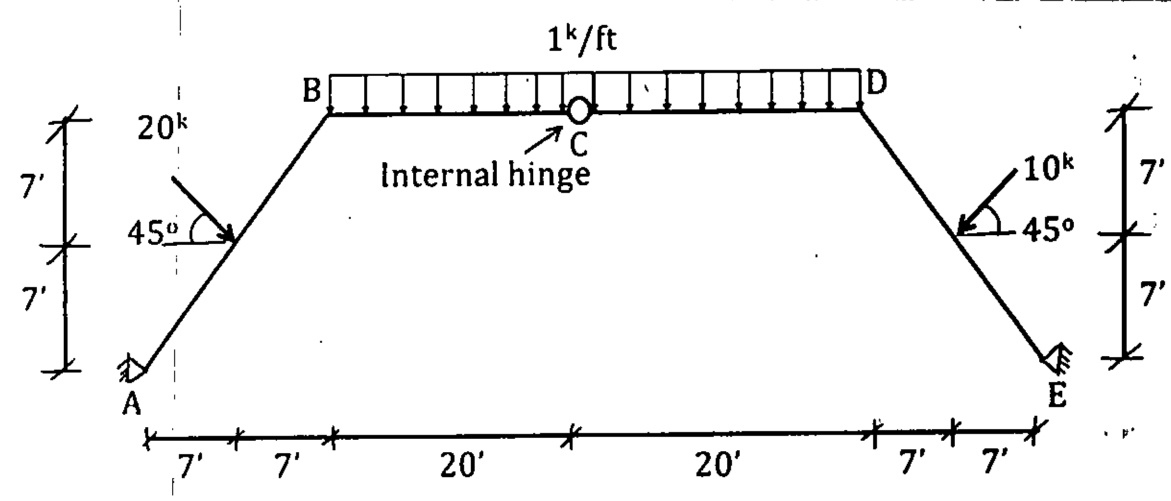

Figure 2.

3. For the multi-storied building frame under vertical loads as shown in Figure 3, using appropriate method of analysis, draw the shear force and bending moment diagrams for the beams and columns. **(28)**

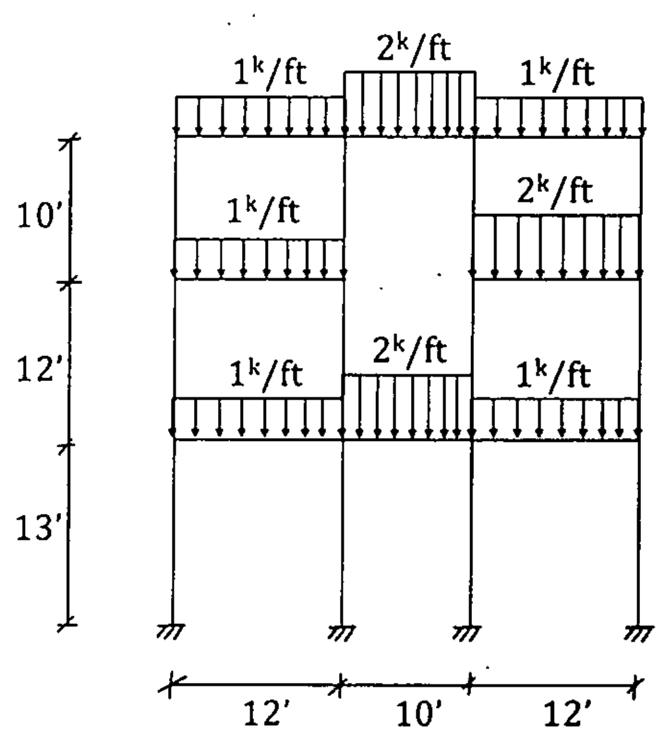

Figure 3.

4. For the mill-bent laterally loaded as shown in Figure 4, find out the reactions at supports *A* and *N*. Also, draw the shear force and bending moment diagrams for the columns *AC* and *NL*. Find the axial force in member ***DG***. **(28)**

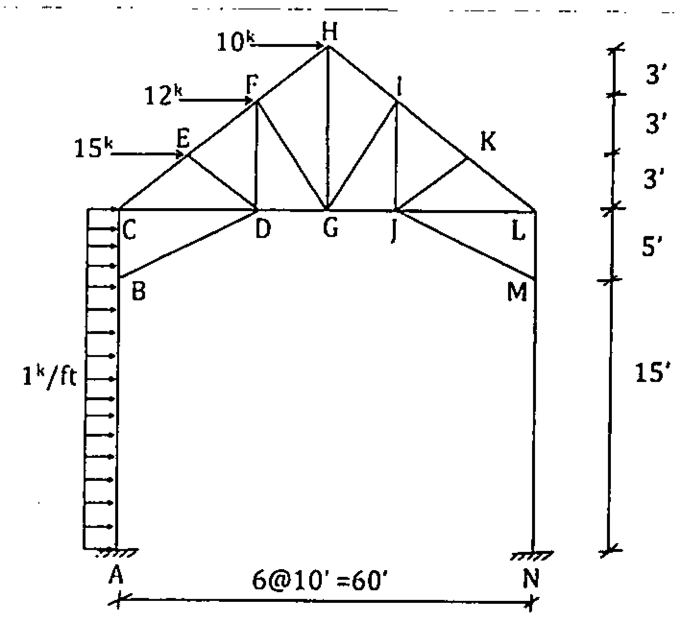

Figure 4.

5. Using the cantilever method, draw the shear force and bending moment diagrams for the building frame as shown in Figure 5. Relative column cross-sectional areas are given beside the columns. **(28)**

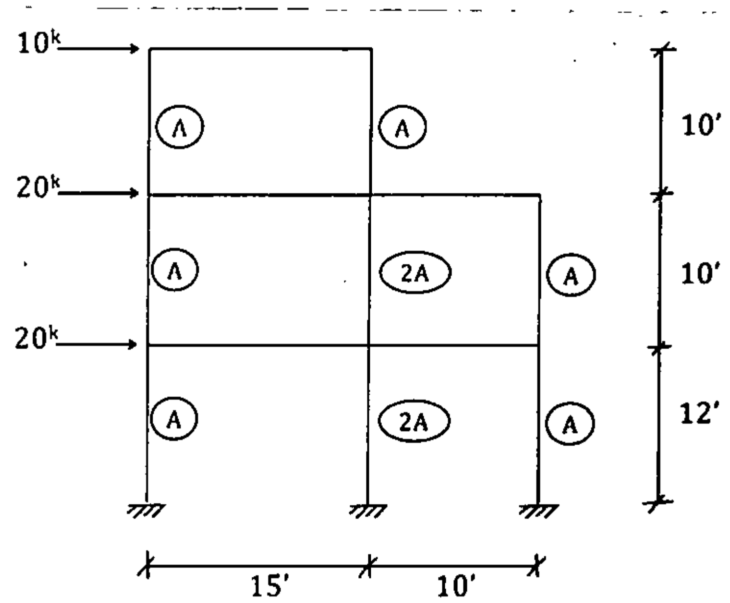

Figure 5.

6. Calculate all the bar forces for the truss shown in Figure 6. Assume that the diagonals can carry tension as well as compression. **(28)**

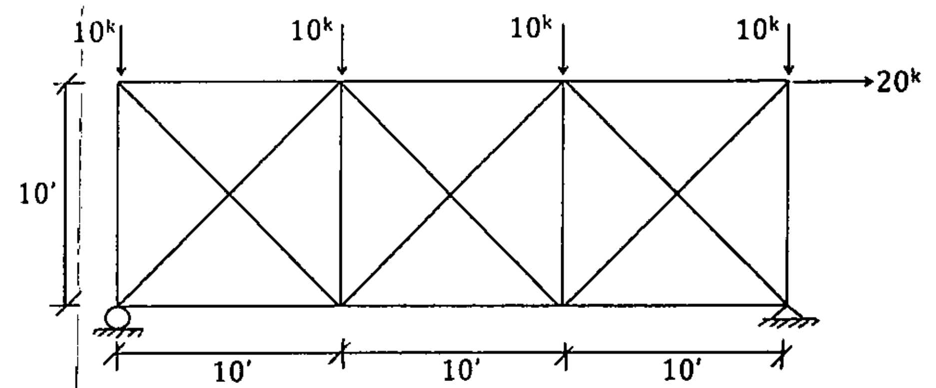

Figure 6.

7. A 5-storied RC residential building (enclosed building, occupancy category II) locate in Chittagong (exposure 'A') has plan dimensions of 50 feet × 60 feet as shown in Figure 7. The typical floor height of the building is 10 feet and column bases are located 8 feet below ground level. Determine the wind force distribution (in 'kip' unit) along the height of the building for the frame along gridline B-1-2-3-4-5. Use the analytical procedure for main wind force resisting system (BNBC 2020), considering negative internal pressure. Given, gust factor = 0.85, directionality factor = 0.85, topographic factor = 1. Conversion factors, 1 kip = 4.45 kN, 1 kN/m^2 = 20.88 psf, 1 meter = 3.28 ft. (see the attached tables)

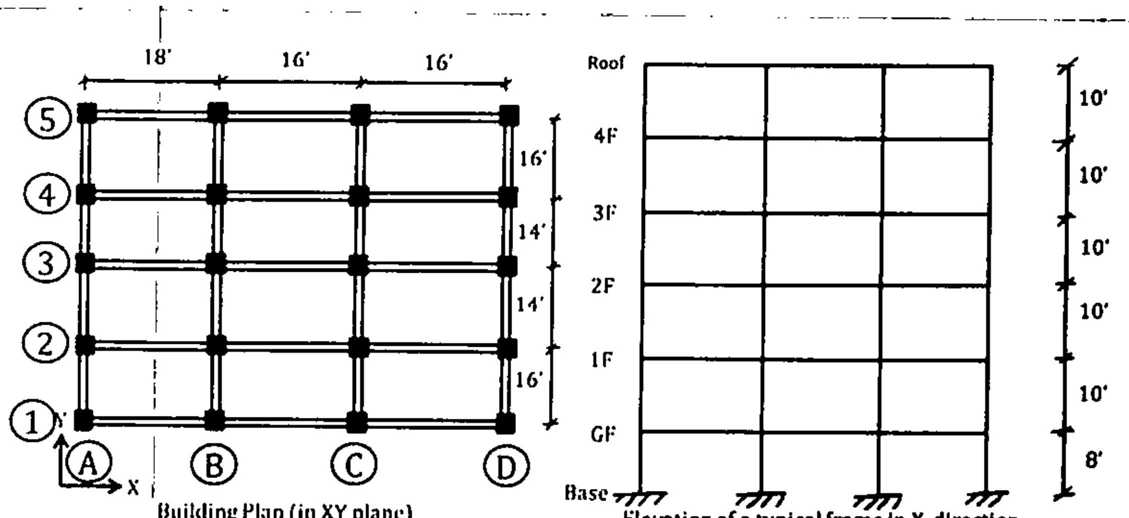

Figure 7.

SECTION – B

There are **SEVEN** questions in this section. Answer **Q. No. 8** and any **FOUR** from the rest.

8. Draw influence lines for (i) Reaction at A (ii) Moment at B (iii) Shear just left of support D and (iv) Reaction at D of the beam shown in Fig. 8. **(28)**

9. Find vertical deflection at B of the beam shown in Fig. 9. Given, E = 29000 ksi, I = 300 in^4. **(28)**

10. For the Girder with floor beams shown in Fig. 10, draw influence lines for (i) Floor Beam reaction at B (ii) Shear in panel DE (iii) Moment at panel point B of the Girder and (iv) Reaction at F of the Girder. **(28)**

11. For the beam shown in Fig. 8, calculate maximum shear and moment at B due to moving uniform load of 5 k/ft and concentrated load of 70 kip. **(28)**

12. For the moving loads shown in Fig. 11, determine maximum moment at quarter point of a simply supported beam with 60 ft. span. **(28)**

13. Compute maximum shear at 10 ft from the left support of a simply supported beam with 50 ft span. Moving loads are given in Fig. 11. **(28)**

14. Compute horizontal displacement of joint C of the frame shown in Fig. 12. Consider axial and flexural deformation only. Given E = 29000 ksi, A = 17 in^2, I = 400 in^4. **(28)**

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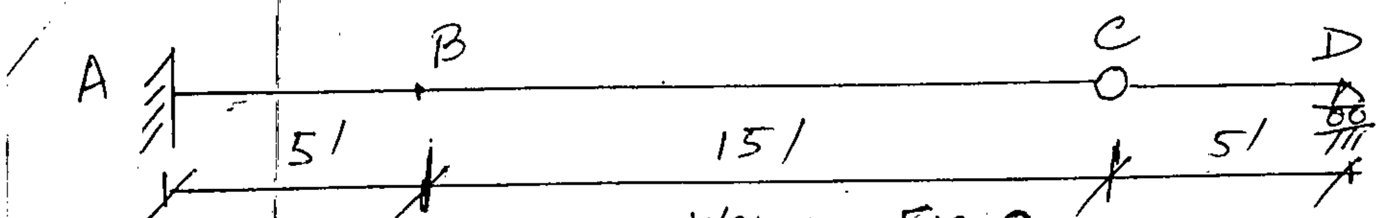

Fig. 8

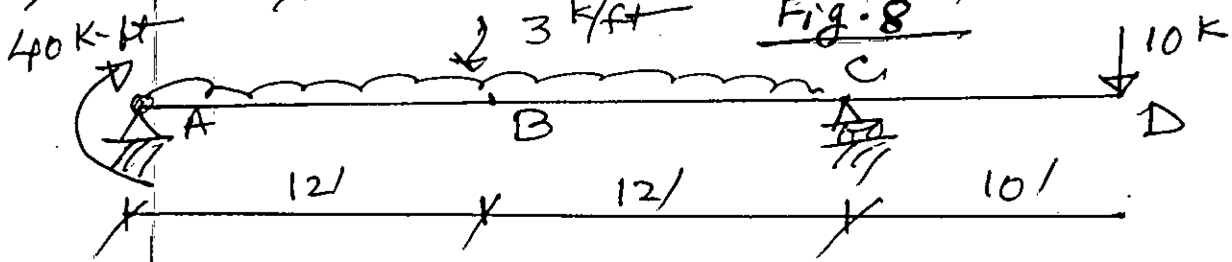

Fig-9

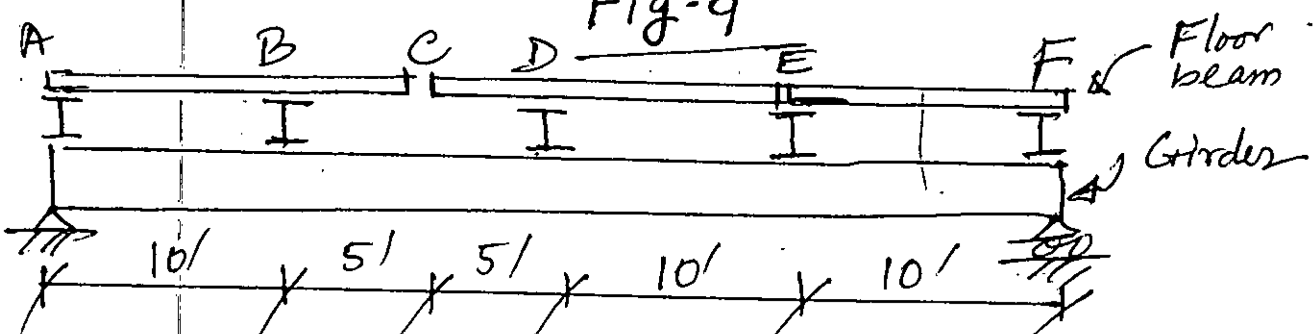

Fig. 10

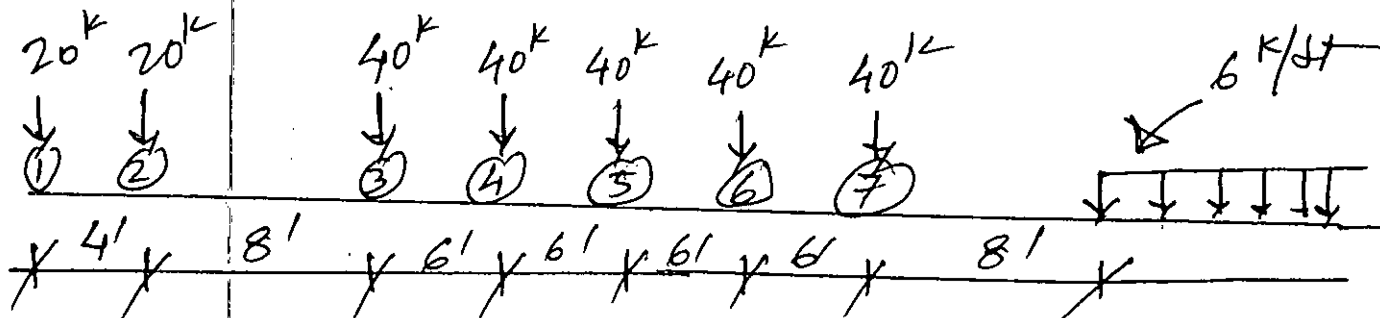

Fig. 11

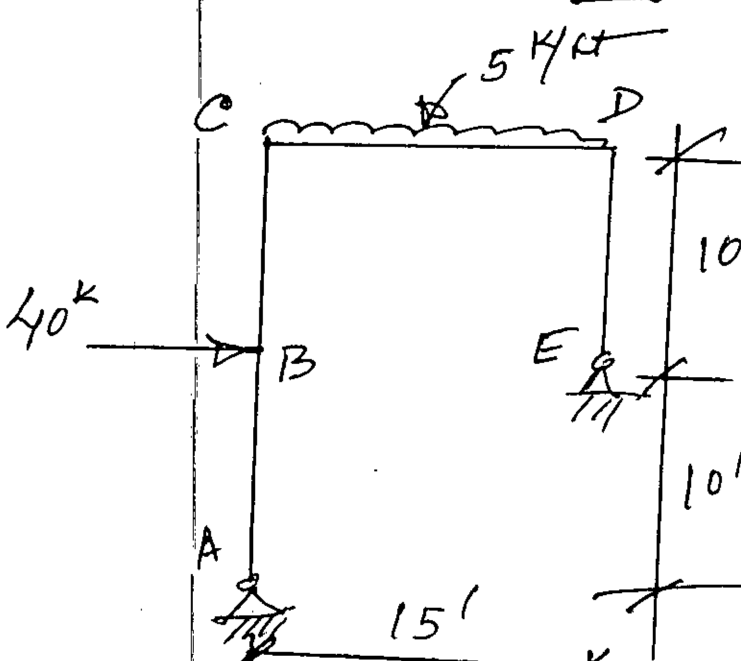

Fig. 12

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Annexure

Relevant Equations:

Spectral Acceleration, $S_a = \frac{2}{3}\frac{ZIC_s}{R}$

Base Shear, $V = S_a W$

Vertical Distribution of Base Shear, $F_x = V \frac{w_x h_x^{\,k}}{\sum_{i=1}^{n} w_i h_i^{\,k}}$, **k = 1 for structure period ≤0.5 seconds and k = 2 for structure period ≥ 2.5 seconds.**

Velocity pressure, $q_z = [0.000613\ K_z\ K_{zt}\ K_d\ V^2\ I]\ kN/m^2$

Design wind pressure, $p = q\ GC_p - q_i\ (GC_{pi})$

Table 1: Description of seismic zones

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, Z
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	0.12
2	Lower Central and Northwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	0.20
3	Upper Central and Northwestern part including Brahmanbaria, Sirajganj, Rangpur	Severe	0.28
4	Northeastern part including Sylhet, Mymensingh, Kurigram	Very Severe	0.36

Table 2: Importance factors for buildings and structures for earthquake design

Occupancy Category	Importance factor I
I, II	1.00
III	1.25
IV	1.50

Table 3: Seismic design category for buildings

Site Class	Occupancy Category I, II and III				Occupancy Category IV			
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
SA	B	C	C	D	C	D	D	D
SB	B	C	D	D	C	D	D	D
SC	B	C	D	D	C	D	D	D
SD	C	D	D	D	D	D	D	D
SE, S_1, S_2	D	D	D	D	D	D	D	D

Contd P/8

Table 4: Response reduction factors for different structural systems

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
C. MOMENT RESISTING FRAME SYSTEMS (no shear wall)						
4. Special reinforced concrete moment frames	8	3	5.5	NL	NL	NL
5. Intermediate reinforced concrete moment frames	5	3	4.5	NL	NL	NP
5. Ordinary reinforced concrete moment frames	3	3	2.5	NL	NP	NP

Table 5: Values for coefficients to estimate approximate period

$$T = C_t (h_n)^m$$

Where,

h_n = Height of building in metres from foundation or from top of rigid basement. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. C_t and m are obtained from Table 6.2.20

Structure type	C_t	m
Concrete moment-resisting frames	0.0466	0.9
Steel moment-resisting frames	0.0724	0.8
Eccentrically braced steel frame	0.0731	0.75
All other structural systems	0.0488	0.75

Table 6: Site dependent soil factor and other parameters defining elastic response spectrum

$$C_s = S\left(1+\frac{T}{T_B}(2.5\eta-1)\right) \quad \text{for} \quad 0 \le T \le T_B$$

$$C_s = 2.5S\eta \quad \text{for} \quad T_B \le T \le T_C$$

$$C_s = 2.5S\eta\left(\frac{T_C}{T}\right) \quad \text{for} \quad T_C \le T \le T_D$$

$$C_s = 2.5S\eta\left(\frac{T_C T_D}{T^2}\right) \quad \text{for} \quad T_D \le T \le 4 \text{ sec}$$

$$\eta = \sqrt{10/(5+\xi)} \ge 0.55$$

Soil type	S	T_B(s)	T_C(s)	T_D(s)
SA	1.0	0.15	0.40	2.0
SB	1.2	0.15	0.50	2.0
SC	1.15	0.20	0.60	2.0
SD	1.35	0.20	0.80	2.0
SE	1.4	0.15	0.50	2.0

Table 7: Importance factors for wind load calculation.

Occupancy Category[1] or Importance Class	Non-Cyclone Prone Regions and Cyclone Prone Regions with V = 38-44 m/s	Cyclone Prone Regions with V > 44 m/s
I	0.87	0.77
II	1.0	1.00
III	1.15	1.15
IV	1.15	1.15

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Table 8: Basic wind speeds, *V* for selected locations in Bangladesh.

Location	Basic Wind Speed (m/s)	Location	Basic Wind Speed (m/s)
Angarpota	47.8	Lalmonirhat	63.7
Bagerhat	77.5	Madaripur	68.1
Bandarban	62.5	Magura	65.0
Barguna	80.0	Manikganj	58.2
Barisal	78.7	Meherpur	58.2
Bhola	69.5	Maheshkhali	80.0
Bogra	61.9	Moulvibazar	53.0
Brahmanbaria	56.7	Munshiganj	57.1
Chandpur	50.6	Mymensingh	67.4
Chapai Nawabganj	41.4	Naogaon	55.2
Chittagong	80.0	Narail	68.6
Chuadanga	61.9	Narayanganj	61.1
Comilla	61.4	Narsinghdi	59.7
Cox's Bazar	80.0	Natore	61.9
Dahagram	47.8	Netrokona	65.6
Dhaka	65.7	Nilphamari	44.7
Dinajpur	41.4	Noakhali	57.1
Faridpur	63.1	Pabna	63.1

Table 9: Velocity pressure exposure coefficients, K_h and K_z

Table 6.2.10: Terrain Exposure Constants

Exposure	α	z_g (m)	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	l (m)	$\bar{\epsilon}$	z_{min} (m)*
A	7.0	365.76	1/7	0.84	1/4.0	0.45	0.30	97.54	1/3.0	9.14
B	9.5	274.32	1/9.5	1.00	1/6.5	0.65	0.20	152.4	1/5.0	4.57
C	11.5	213.36	1/11.5	1.07	1/9.0	0.80	0.15	198.12	1/8.0	2.13

*z_{min} = Minimum height used to ensure that the equivalent height $\bar{z}$ is greater of $0.6h$ or z_{min}.
For buildings with $h \leq z_{min}$, $\bar{z}$ shall be taken as z_{min}.

Notes:

1. Case 1:
   (a) All components and cladding.
   (b) Main wind force resisting system in low-rise buildings designed using Figure 6.2.10.

   Case 2:
   (a) All main wind force resisting systems in buildings except those in low-rise buildings designed using Figure 6.2.10.
   (b) All main wind force resisting systems in other structures.
2. The velocity pressure exposure coefficient K_z may be determined from the following formula:

   For $4.57 \text{ m} \leq z \leq z_g$: $K_z = 2.01 (z/z_g)^{2/\alpha}$

   For $z < 4.57$ m: $K_z = 2.01 (4.57/z_g)^{2/\alpha}$

   Note: z shall not be taken less than 9.1 m for Case 1 in exposure A.
3. α and z_g are tabulated in Table 6.2.10.
4. Linear interpolation for intermediate values of height z is acceptable.
5. Exposure categories are defined in Sec 2.4.6.3.

Height above ground level, z	Exposure (Note 1)			
	A		B	C
(m)	Case 1	Case 2	Case 1 & 2	Case 1 & 2
0-4.6	0.70	0.57	0.85	1.03
6.1	0.70	0.62	0.90	1.08
7.6	0.70	0.66	0.94	1.12
9.1	0.70	0.70	0.98	1.16
12.2	0.76	0.76	1.04	1.22
15.2	0.81	0.81	1.09	1.27
18	0.85	0.85	1.13	1.31
21.3	0.89	0.89	1.17	1.34
24.4	0.93	0.93	1.21	1.38
27.41	0.96	0.96	1.24	1.40
30.5	0.99	0.99	1.26	1.43

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Table 10: External pressure coefficients, C_p for main wind force resisting system

Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥ 4	-0.2	
Side Wall	All values	-0.7	q_h

Table 11: Internal pressure coefficients, C_p for main wind force resisting system

Enclosed, Partially Enclosed, and Open Buildings: Walls & Roofs

Enclosure Classification	GC_{pi}
Open Building	0.00
Partially Enclosed Building	+0.55 -0.55
Enclosed Building	+0.18 -0.18

Notes:

1. Plus and minus signs signify pressures acting toward and away from the internal surfaces, respectively.
2. Values of GC_{pi} shall be used with q_z or q_h as specified in Sec 2.4.11.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition:

   (i) a positive value of GC_{pi} applied to all internal surfaces

   (ii) a negative value of GC_{pi} applied to all internal surfaces.