L-3/T-2/CE **Date : 06/04/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **CE 351** (Transportation Engineering I)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Explain diagrammatically the basic movement to categorize travel pattern in a planning area. **(11)**

(b) Explain different types of traffic that are generally considered in transportation planning process in relation to land use transportation development. **(12)**

(c) Calculate the inter zonal trips using a simple gravity model from the following data. Assume exponent of travel time as 0.6. **(12)**

Production Zone i	Employment Zone	Employments	Travel time from Zone i
T_i = 450 work trips	1	750	9 minutes
	2	400	5 minutes
	3	300	7 minutes

2. (a) What are the functions of shoulder and median in a highway? Why roads are widened at highway curves? **(11)**

(b) Show diagrammatically the method of attaining super elevation considering pavement revolved about the centre line. **(12)**

(c) A driver moving at a speed of 65 mph on a 3 percent upgrade section of a highway sights an object 500 ft away on the highway and applied the brake. If the coefficient of friction for the pavement is 0.29 and acceleration due to gravity is 32.2 ft/sec^2, would the driver be able to stop the car before hitting the object? **(12)**

3. (a) State the advantages and disadvantages of a rotary intersection. **(11)**

(b) Show with neat sketches the minimum passing sight distance for a two-lane two-way highway for right-hand drive vehicle and keep-to-left convention. **(12)**

(c) What is the difference between the terms "Accident" and "Crash" in road safety study? Show the following action with collision diagram: **(12)**

(i) rear-end, (ii) right angle, (iii) side swipes and (iv) Head-on.

Contd P/2

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4. (a) Briefly describe why Traffic Engineering is so important now-a-days? What are the common ways of classifying roadway system? Define bottlenecks. Name the common tools to tackle congestion and safety related problems. **(3+4+2+6=15)**

(b) List the factors which affect driver's characteristics. Briefly characterize pedestrian crossing behavior. Define PIEV. List the factors that influence PIEV. **(4+5+2+3=14)**

(c) A traffic engineer urgently needs to determine AADT on a rural primary road that has the volume distribution characteristics shown in Table 1, 2 and 3. The engineer collected following data on a Monday during the month of May. Determine the AADT of the road. **(6)**

Hour	Volume
8:00 – 9:00 a.m.	500
9:00 – 10:00 a.m.	650

SECTION – B

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

5. (a) Explain the interrelationship among four major system elements of transportation system using System Model diagram. Also, explain how following categories of human behavior are affected by transportation: Feelings, Social interaction, Perception, Motivation and Health & Safety. **(9+10=19)**

(b) Differentiate among three major transportation modes (i.e., Road, Rail and Water) with respect to 3 main transport system evaluation parameter. Create a graph illustrating cumulative percent of vehicles miles vs. cumulative percent of road miles for evaluating the relative importance of various urban road categories using literature reported macro data of global cities. Also, explain importance of road hierarchy in this respect. **(8+8=16)**

6. (a) Make a comparison (for scope, purpose and technologies) among six ITS subsystems and also show their relationship flow chart. Illustrate following key words in case of transport system: Behavior, Transfer, Operation policy, Information flow and Performance measure. **(9+10=19)**

(b) Compare features, relative advantages and disadvantages of following public transport system: Elevated Metrorail, Underground Matrorail, Light Rail Transit and Bus Rapid Transit. **(16)**

7. (a) Prepare a comparative analysis of potential, constraints and opportunities for various business sector of Bangladesh railway. In road cross-section diagram show the geometric features as used by RHD of Bangladesh in their typical six design templates. **(10+9=19)**

(b) Write short notes on the following: **(4×4=16)**

(i) Urban transport problems of Bangladesh.
(ii) Bangladesh inland water transport.
(iii) Bangladesh Air transport.
(iv) Equity in Bangladesh transport sector funding.

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8. (a) Mention the problems associated with traffic signals in Bangladesh. Differentiate between simultaneous and progressive signal controllers. Under what circumstances all-red period is considered in signal design? **(9+10=19)**

Design a two-phase signal of an isolated cross-junction for following data.

	N-S phase	E-W phase
Inter green period =	4 s	3 s
Initial and final lost time =	3 s	2 s

	N	S	E	W
Flow (pcu/hr) =	700	450	800	650
Saturation flow (pcu/hr) =	2000	1900	2200	2100

Assume, any missing data. Draw phase and cycle time bar diagram.

(b) What type of traffic signs are required for priority type junction? State the new trends of roadway signs and markings. Write down the color and pattern convention of roadway markings. What are the objectives of street lighting? Write down the problems associated with larger sized vehicles. **(3+3+3+3+4=16)**

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Tables for Q 4 (c)

Table 1 Hourly Expansion Factors for a Rural Primary Road

Hour	Volume	HEF	Hour	Volume	HEF
6:00-7:00 a.m.	294	42.01	6:00-7:00 p.m.	743	16.62
7:00-8:00 a.m.	426	28.99	7:00-8:00 p.m.	706	17.49
8:00-9:00 a.m.	560	22.05	8:00-9:00 p.m.	606	20.38
9:00-10:00 a.m.	657	18.8	9:00-10:00 p.m.	489	25.26
10:00-11:00 a.m.	722	17.11	10:00-11:00 p.m.	396	31.19
11:00-12:00 p.m.	667	18.52	11:00-12:00 a.m.	360	34.31
12:00-1:00 p.m.	660	18.71	12:00-1:00 a.m.	241	51.24
1:00-2:00 p.m.	739	16.71	1:00-2:00 a.m.	150	82.33
2:00-3:00 p.m.	832	14.84	2:00-3:00 a.m.	100	123.5
3:00-4:00 p.m.	836	14.77	3:00-4:00 a.m.	90	137.22
4:00-5:00 p.m.	961	12.85	4:00-5:00 a.m.	86	143.6
5:00-6:00 p.m.	892	13.85	5:00-6:00 a.m.	137	90.15

Table 2 Daily Expansion Factors for a Rural Primary Road

Day of Week	Volume	DEF
Sunday	7895	9.515
Monday	10714	7.012
Tuesday	9722	7.727
Wednesday	11413	6.582
Thusrday	10714	7.012
Friday	13125	5.724
Saturday	11539	6.51

Table 3 Monthly Expansion Factors for a Rural Primary Road

Day of Week	ADT	MEF
January	1350	1.756
February	1200	1.976
March	1450	1.635
April	1600	1.482
May	1700	1.395
June	2500	0.948
July	4100	0.578
August	4550	0.521
September	3750	0.632
October	2500	0.948
November	2000	1.186
December	1750	1.355

L-3/T-2/CE Date : 10/04/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **CE 317** (Design of Concrete Structures II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Use USD Method of Design. Assume reasonable value for any missing data.

1. (a) Why is φ value for compression lower than those for flexure or shear? What does the horizontal cut-off in the ACI/BNBC design strength interaction diagram signify? **(7)**

(b) A 18 × 28 inch column is reinforced with Ten No. 9 bars as shown in Fig. 1. Construct the nominal strength interaction diagram for the column with five points corresponding to pure axial load, pure bending, balanced condition, $\varepsilon_s = 0.004$ (tensile) and $\varepsilon_s = 0.001$ (tensile). Also find corresponding ϕ for the above points. Assume bending about Y-Y axis. Given: $f'_c = 5$ ksi and $f_y = 60$ ksi. **(28)**

2. (a) A circular spirally reinforced column carries unfactored working loads: $P_{DL} = 750$ kip and $P_{LL} = 500$ kip. Design the column with about 2.5% reinforcement. Also design the ACI/BNBC spiral. Given: $f'_c = 4.5$ ksi and $f_y = 60$ ksi. **(11)**

(b) A ground floor column of a multistoried building is to be designed for the following load combinations (axial force and uniaxial bending) – **(18)**

Gravity load combination	$P_u = 3700$ kip, $M_u = 500$ kip-ft
Earthquake load combination	$P_u = 2500$ kip, $M_u = 1000$ kip-ft
Wind load combination	$P_u = 2700$ kip, $M_u = 1200$ kip-ft

Architectural considerations require that a circular tied column of 45 in. diameter is to be used. Material strengths are $f'_c = 4$ ksi and $f_y = 60$ ksi.

Find the required column reinforcement and show in sketch. Use supplied column strength interaction design chart assuming reinforcement distributed along the perimeter and $\gamma = 0.9$.

(c) What is a slender column? Write ACI/BNBC kl_u/r limits below which the effects of slenderness may be neglected for both sway and non-sway frames. **(6)**

Contd P/2

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3. (a) A 54″ × 54″ square pier of a bridge is reinforced with sixty No-9 bars arranged uniformly around the perimeter. Material strengths are $f'_c = 4.0$ ksi and $f_y = 60$ ksi. Check adequacy of the short column using Reciprocal Load Method for: **(18)**

$$P_u = 3000 \text{ kip}, M_{ux} = 4050 \text{ kip-ft}, M_{uy} = 2700 \text{ kip-ft}$$

Use supplied column strength interaction diagram chart assuming $\gamma = 0.9$.

(b) "Damage is allowed in Seismic Design" – Explain the Seismic Design Philosophy with allowed damage levels under different levels of earthquakes. **(7)**

(c) Write the seismic detailing provisions of a two-way slab without beam, which is part of an IMRF system, as per BNBC. **(10)**

4. (a) Discuss the variation of stress in prestressing steel as load increases on a beam. **(11)**

(b) Explain when a shear wall can be designed as a beam. Also, describe when it needs to be designed as a column and how it is done. **(6)**

(c) A shear wall of a 18-storey building is subjected to following factored loads: **(18)**

$P_u = 500$ kip

$V_u = 600$ kip

$M_u = 7000$ kip-ft

The wall is 20 ft long, 180 ft high and 12 inch thick. Design the shear wall with $f'_c = 4$ ksi and $f_y = 60$ ksi. Ignore axial force and design as a beam for shear and moment only.

SECTION – B

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

5. A commercial building is to be designed using a flat plate floor system. The interior columns are 21″ × 21″ and they are spaced 22 ft c/c in both directions. Specified live load 100 psf and superimposed dead load 150 psf including self weight of slab. Material strengths are $f'_c = 3500$ psi and $f_y = 60{,}000$ psi.

(a) Find the slab thickness for adequacy against punching shear failure, when no shear reinforcement is used. **(15)**

(b) Design a typical interior panel of the above building and show the reinforcements with neat sketches. **(20)**

Contd P/3

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6. (a) If flat plate floor of the building stated in Q. 1 has thickness h = 7.5″, design the shear reinforcement for the slab. Loads and material strengths are same as in Q. 1. **(15)**

   (b) Two interior columns for a structure are spaced 16 ft apart, and each carries service DL = 250 kip and LL = 220 kip. Column sizes are 20″ × 24″. They are supported on a rectangular combined footing with a long-side dimension twice that of the short side. The allowable soil bearing pressure is 4000 psf. The bottom of the footing will be 5 ft below grade. Design the footing for these columns and show the reinforcements in plan and section. Material strength for footing: f'_c = 3.5 ksi and f_y = 60 ksi. **(20)**

7. (a) The plan of a pile cap with 12 nos. 20″ diameter cast-in-situ piles with the column (24″ × 24″) is shown in Fig. 2. The column carries a DL= 900 kip and a LL = 500 kip (working). The individual pile capacity is adequate. Design the pile cap and show the reinforcements with neat sketches. Given: f'_c = 3500 psi and f_y = 60,000 psi. **(17)**

   (b) A post-tensioned bonded concrete beam as shown in Fig. 3 has a prestress of 1600 kN in the steel immediately after prestressing and reduces to 1400 kN due to losses. In addition to a self weight of 4.5 kN/m, there is a live load of 11.0 kN/m. Compute the extreme fibre stresses at midspan; (i) under the initial condition with full prestress and no live load, (ii) at final condition with live loads and considering losses. (iii) Compute also the live load that can be carried by the beam for zero tensile stress in the bottom fibre. **(18)**

8. (a) Explain why loss of prestress is more in pretensioned beam than that in post-tensioned beam? Give the losses in different items in percent for pretensioned and post-tensioned beams. **(10)**

   (b) Discuss the advantages of Prestressed concrete over Reinforced concrete. **(10)**

   (c) Make a preliminary design for a section of prestressed beam to resist a total moment of 400 kN-m. The overall depth of the section is given as 875 mm. The effective prestress force for steel is 850 MPa and allowable stress for concrete under working load is –12.0 MPa. **(15)**

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CE·317

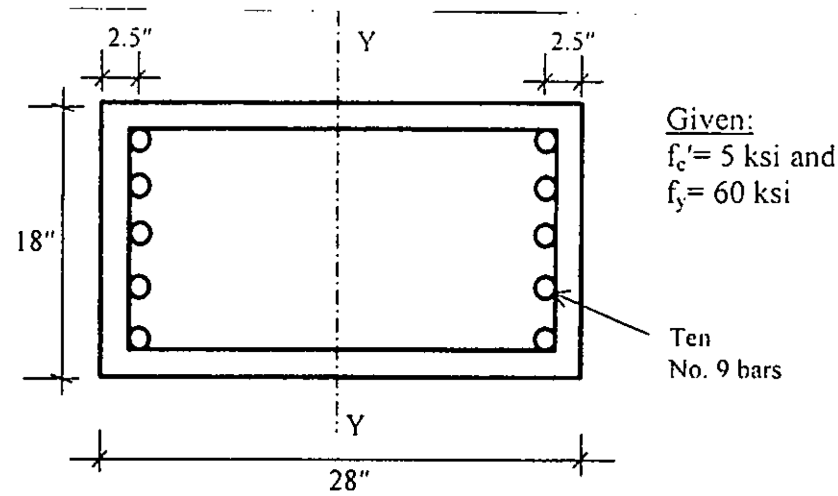
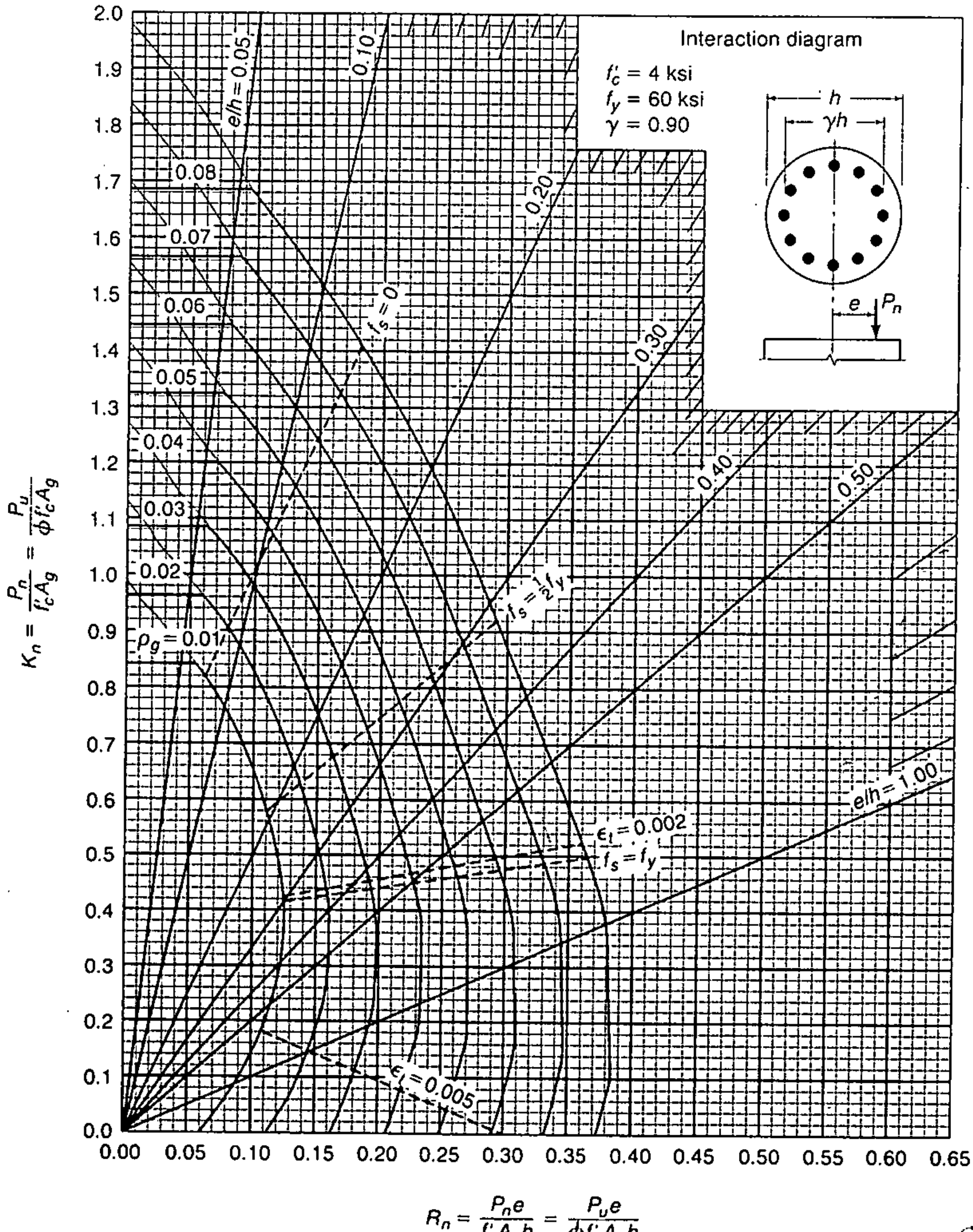


Fig. 1

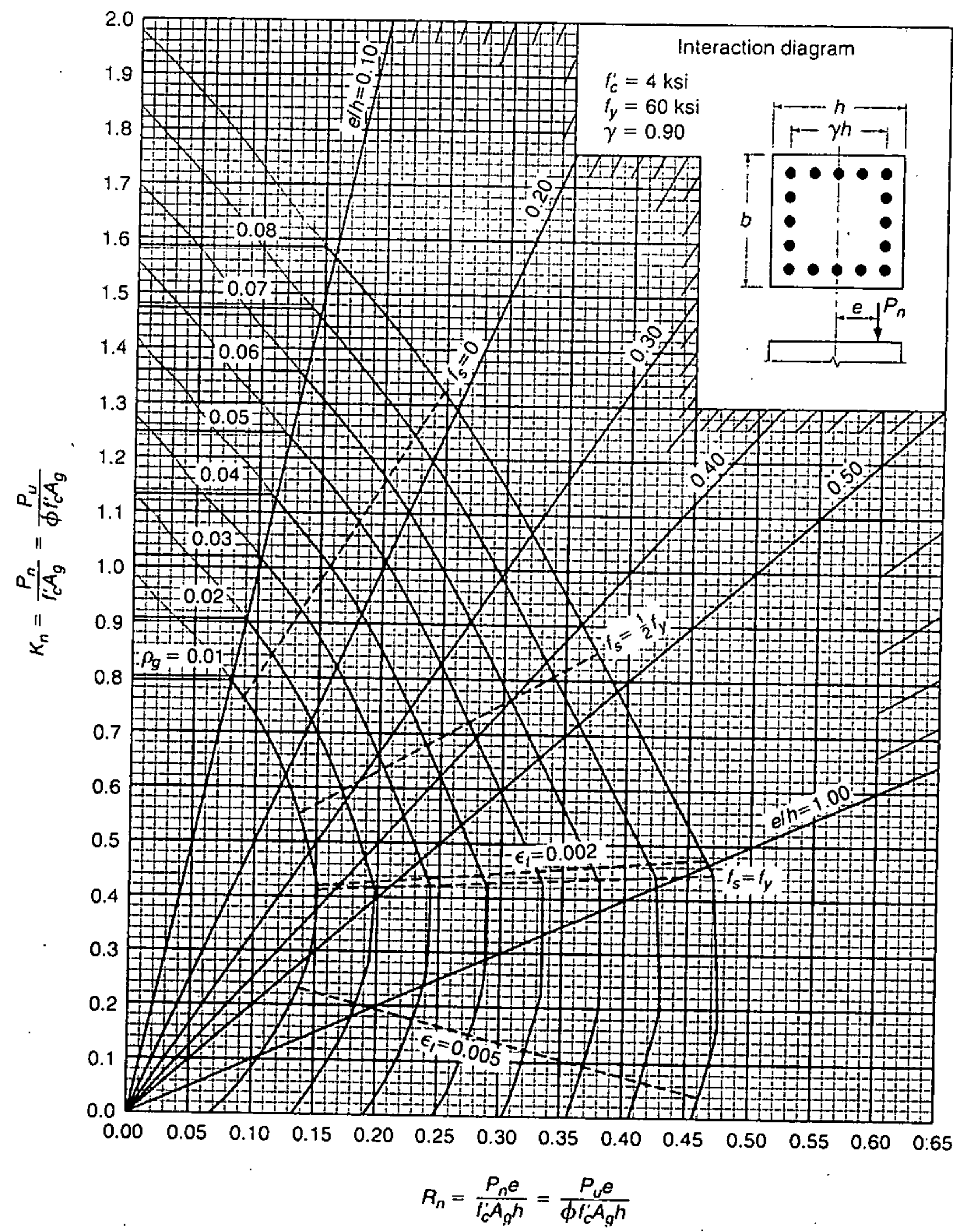
DESIGN AIDS



GRAPH A.16
Column strength interaction diagram for circular section with $\gamma = 0.90$.

Design of Concrete Structures – Darwin, Dolan, Nilson
15th Edition

Contd.... P/5



GRAPH A.8

Column strength interaction diagram for rectangular section with bars on four faces and $\gamma = 0.90$.

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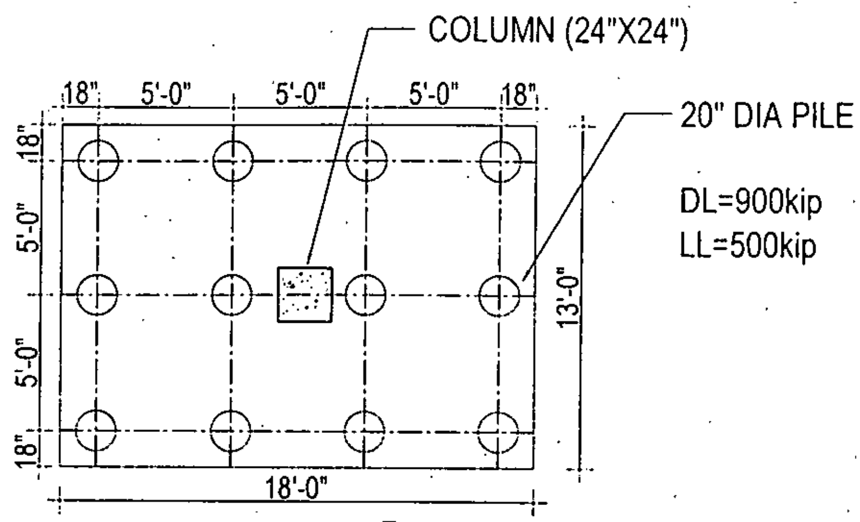
COLUMN (24"X24")
20" DIA PILE
DL=900kip
LL=500kip
18"
5'-0"
5'-0"
5'-0"
18"
13'-0"
18'-0"

Fig-2

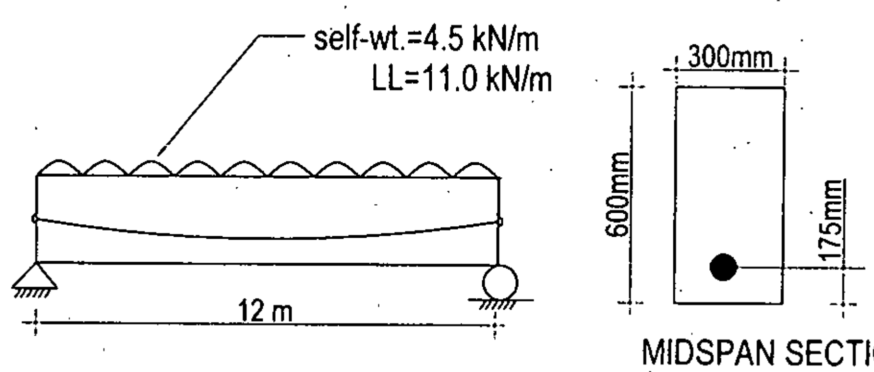
self-wt.=4.5 kN/m
LL=11.0 kN/m
12 m
300mm
600mm
175mm
MIDSPAN SECTION

Fig-3

L-3/T-2/CE **Date : 31/03/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **WRE 311** (Open Channel Flow)

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**.

1. (a) Classify and explain the following open channel flow situation: (i) Tidal flow in an estuary, (ii) Flow in a roadside gutter. **(7)**

   (b) Derive the equation $u^* = \sqrt{ghs_0}$ for a wide channel where the notations have their usual meaning. **(7)**

   (c) A trapezoidal channel has a bottom width of 6m, side slopes of 2H:1V and n = 0.025. Determine the critical slope when the discharge is 20 m^3/s and $\alpha = 1.2$. **(14)**

   (d) Water flows in an open channel at a depth of 1m and a mean velocity of 3 m/s. Compute discharge and determine the state of flow for the section shown in Fig. 1. If the elementary waves are created in this channel, determine the speed of the wave fronts upstream and/or downstream. **($18\frac{2}{3}$)**

2. (a) Deduce the expression for the length of the flow profile between two sections in a horizontal channel. **(7)**

   (b) Derive the expression for hydraulic exponent for uniform flow computations for triangular channel using cheyy formula. **(7)**

   (c) A dam raises the water level to 3m at the end of a wide rectangular channel. The normal depth and critical depth for a particular flow scenario are 2m and 2.5 m respectively. The longitudal slope for the channel is 0.0001. Compute the length of the resulting flow profile between the dam site and the location where the depth is 2.7 m. **(14)**

   Given, $\varphi = \frac{1}{6} lu \frac{u^2+u+1}{(u-1)^2} - \frac{1}{\sqrt{3}} tan^{-1}\left(\frac{\sqrt{3}}{2u+1}\right)$

   (d) A rectangular channel with b = 8m, n = 0.025 and $S_0 = 0.025$ carries a discharge of 40 m^3/s. At a section A of the channel the depth of flow is 1.5 m. How far upstream or downstream from this section will the depth be 1.25 m? Use direct step method. **($18\frac{2}{3}$)**

3. (a) Define: (i) Composite roughness, (ii) Compound cross-section. **(7)**

   (b) Derive the expression for normal depth in a triangular channel using Manning formula. **(7)**

Contd. P/2

WRE 311

Contd ... Q. No. 3

(c) A trapezodal channel has a bottom width of 5m, side slopes of 2V:1H and is laid on a slope of 0.001. The channel is made of concrete (K_s = 2mm) and carries water at a depth of 1m. Compute: (i) mean velocity of flow, (ii) Manning n. **(14)**

(d) For a channel shown in Fig. 2 with n = 0.025 and S_0 = 0.001, compute the normal depth by Newton-Raphson method if Q = 20m^3/s. Assume an initial value of depth of 1m. **($18\frac{2}{3}$)**

4. (a) Prove that H1 profile is not physically possible. **(7)**

(b) Prove that A2 profile is a drawdown curve. **(7)**

(c) A rectangular channel 6m wide and having n = 0.02 has four reaches arranged serially. The bottom slopes of the four reaches are 0.0064, 0.0, 0.015 and 0.0016 serially. For a discharge of 20 m^3/s through the channel, sketch the resulting flow profiles. **(14)**

(d) Draw the possible flow profiles in the following serial arrangement of channels: **($18\frac{2}{3}$)**

(i) critical-adverse-steep (with a weir)

(ii) mild-critical-horizontal

(iii) Steep-critical-mild (with a sluice gate below the critical depth)

(iv) critical-steep-mild-free overfall.

SECTION – B

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

5. (a) Explain qualitative profile of velocity distribution along a vertical of a channel with relevant figure Why energy and momentum coefficients are needed? **(10)**

(b) Differentiate between pressure distribution of 'concave flow' and 'convex flow' with neat sketches. Mathematically show how the effect of slope is considered in pressure distribution. **(10)**

(c) Compute the values of the velocity distribution coefficients along a vertical in a wide channel when the depth of flow in the channel is 5m. The velocity distribution is given as: $u = 1 + 2(h/z)^{-0.5}$. Determine the total discharge if the width of the channel is 100 m. **(16)**

(d) Compute the critical depth and velocity in a triangular channel with side slope of 1V:1.5H carrying a discharge of 20m^3/s. Also determine minimum specific energy. **($10\frac{2}{3}$)**

6. (a) Define specific energy and specific momentum. Briefly explain the salient features of E-h curve with the help of neat sketch. **(10)**

Contd. P/3

WRE 311

Contd ... Q. No. 6

(b) Show that at critical state of flow, the discharge is maximum for a given specific energy. **(8)**

(c) A broad crested weir is built in a rectangular channel of width 3 m. The height of the weir crest above the channel bed is 1.20 m and the head over the weir is 0.80 m. Compute the discharge of this channel. Take $\alpha = 1.15$. **(10)**

(d) A rectangular channel 3 m wide carries 3 m^3/s of water at a depth of 1 m. If the width is to be reduced to 2 m and bed raised by 10 cm, what would be the depth of flow in the contracted section? What maximum rise in bed level of the contracted section is possible without affecting the depth of flow upstream of the channel? **($18\frac{2}{3}$)**

7. (a) Explain the formation of hydraulic jump. What are the practical applications of hydraulic jump? **(8)**

(b) Derive the relationship for relative height of the hydraulic jump: **(8)**

$$\frac{h_j}{E_1} = \frac{\sqrt{1+8Fr_1^2} - 3}{2 + Fr_1^2}$$

(c) Water flows over a spillway and discharge into a rectangular plain basin having the same width as the spillway in Figure for Question 7(c). The spillway height is 45 m and designed energy head is 2.5 m. The discharge per unit width is given by the equation, $q = \frac{2}{3} C_d \sqrt{2g} H_d^{\frac{3}{2}}$, where H_d is the design head and C_d is the co-efficient of discharge to be taken as 0.738. Determine (i) the type of jump (ii) the horse-power dissipation in the jump (iii) efficiency (iv) length of the jump and (v) velocity after the jump. Neglect energy loss due to flow over the spillway. **($22\frac{2}{3}$)**

(d) Briefly explain different types of hydraulic jump on sloping channels. **(8)**

8. (a) What are the functions of the components of a stilling basin? Draw a schematic diagram of USBR Basin II showing its recommended proportion. **(10)**

(b) Show that mot efficient trapezoidal section of a canal is achieved when: **(12)**

(i) a semi-circle with depth of flow as radius is tangential to the bed and the sides of the section (ii) the side slope is 1V:0.577H.

(c) Design a non-scouring erodible boundary canal to carry 30 m^3/s of clear water through 2 mm gravel (angle of repose = 35°) on a slope of 2×10^{-4}. The canal is to be trapezoidal in shape having side slopes of 1V:1.5H. Given, $\Delta\rho_s = 1650$ kg/m^3. Relevant figures are provided in Figures for Question 8(c) **($24\frac{2}{3}$)**

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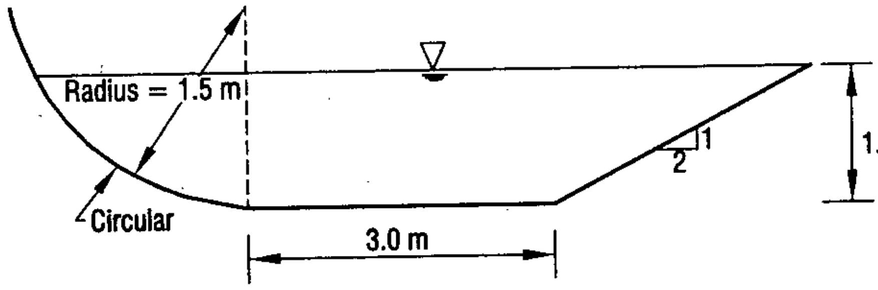


Fig.1 for Question No. 1(d)

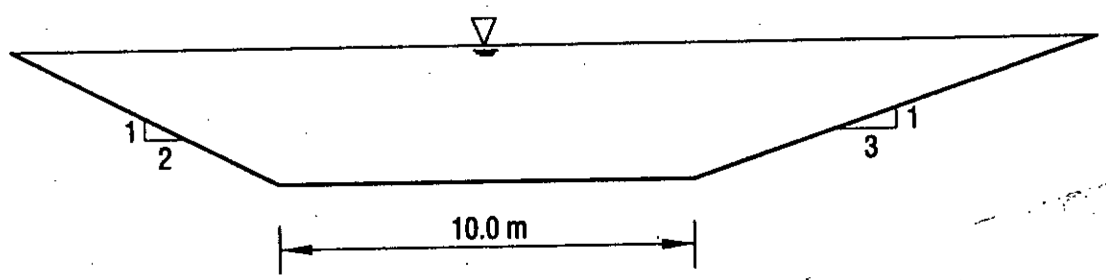


Fig. 2 for Question No. 9(d)

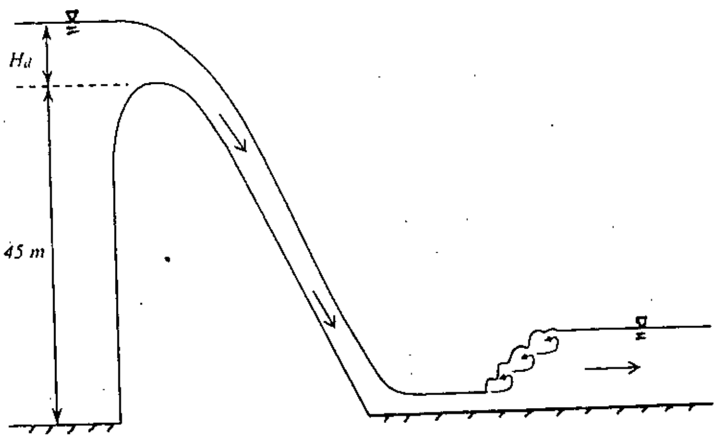
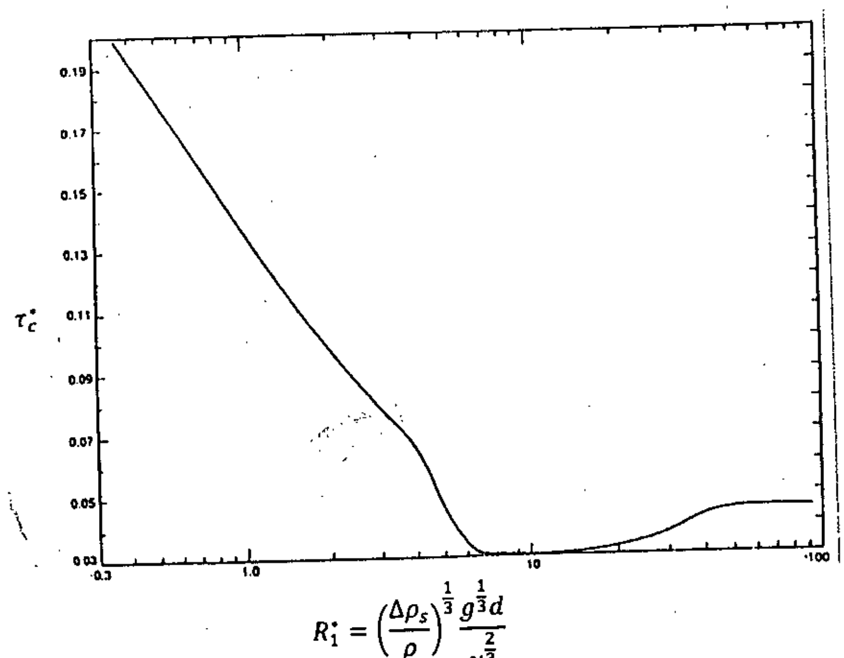
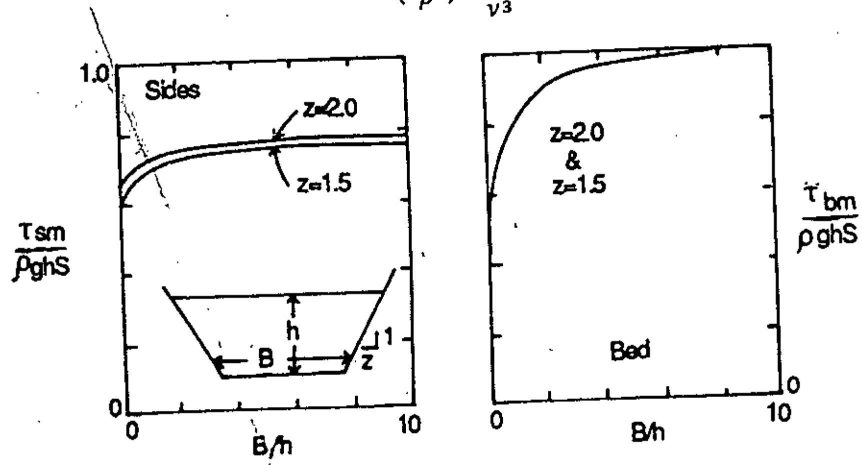


Figure for Question 7(c)





Figures for Question 8(c)

L-3/T-1/CE **Date : 25/03/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2017-2018

Sub : **CE 319** (Design of Steel Structures)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

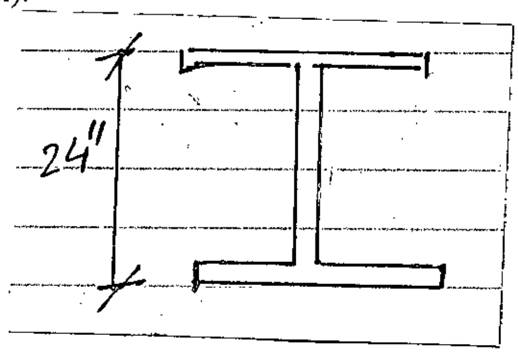
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Define overall buckling and local buckling of a column.. **(8)**

(b) Determine whether column shape in Fig. 1 will have local buckling. Assume A992 steel (Fy = 50 ksi). **(7)**



Flange width = 20″

Flange thickness = $\frac{1}{2}''$

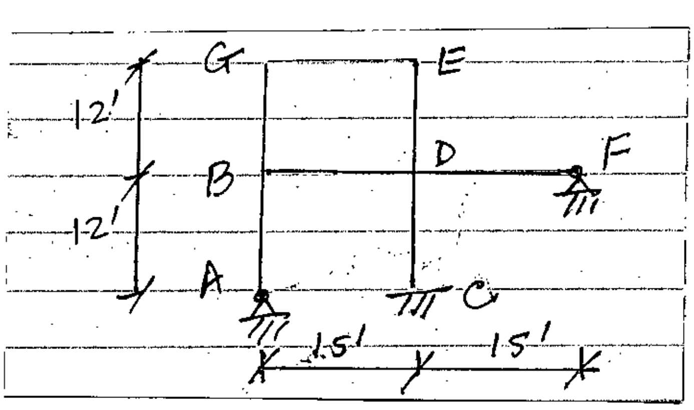
Web thickness = $\frac{1}{4}''$

Fig. 1

(c) Two plates (14″ × $\frac{1}{2}''$) are attached at two sides of flanges of a W12 × 58 section (see Annexure - 1 for dimensions) to form a build-up column section. Sketch the built-up column section, and determine ultimate compression capacity. Assume Fixed-Fixed end for buckling about weak axis and Fixed-Pinned end for buckling about strong axis. Length of column = 20 ft. **(20)**

2. (a) How does a slender column differ from a short column? Explain with sketches. **(6)**

(b) Calculate effective length factors for column AB, CD and DE shown in Fig. 2 **(9)**



Column : W 18 × 71

Beam : W21 × 68

Sectional properties in Annexure - 1

K-factor in Annexure -2

Fig. 2

Contd P/2

CE 319

Contd ... Q. No. 2

(c) Select lightest section for a column subjected to an axial compression of Dead load = 200 kip and Live load = 250 kip. Assume the column is hinged at the top and fixed at the bottom for both axes. Length of the column = 22 ft. Use AISC/ASD method and A36 steel. Sections with properties are given in Annexure - 1. **(20)**

3. (a) A 40 ft simply supported beam of W21 × 93 carries uniform load of "W" kip/ft. The beam is laterally supported at the ends and at mid-section. Determine the value of uniform load "w" if live load deflection is limited to L/360. Use AISC/LRFD method and A992 steel. Given: **(20)**

$$\Delta_{max} = \frac{5WL^4}{384EI}$$

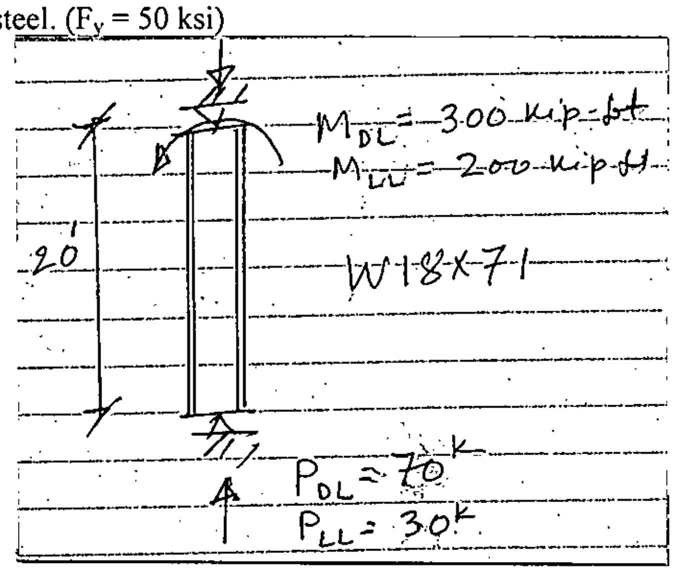
Sectional properties in Annexure -1.

(b) A W14×120 column on a concrete base transmit an axial dead load of 350 kip and Live load of 600 kip. The concrete base has a top surface area of 40″×70″. Calculate the base plate size and thickness. Use A36 steel and $f_c' = 4$ ksi concrete. Assume AISC/LRFD method. Sectional properties are included in Annexure-1 Given: **(15)**

$$f_{p(max)} = \left(0.85 f_c'\right)\sqrt{\frac{A_2}{A_1}} \leq 1.7 f_c'$$

4. (a) Investigate the adequacy of the beam-column section as shown in Fig. 3. The beam is laterally supported at the ends only. Consider bending about strong axis. Use AISC/LRFD method and A992 steel. (F_y = 50 ksi) **(20)**

Fig. 3



(b) Find the allowable capacity (ASD method) of the bearing-type connection shown in Fig. 4. The channel section C10×20 (Ag = 5.88 in^2 and tw = 0.379 inch) is attached to a gusset plate (1 inch thick) with 3/4 inch dia both of A325. Assume threads are excluded from shear plane. **(15)**

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Contd ... Q. No. 4(b)

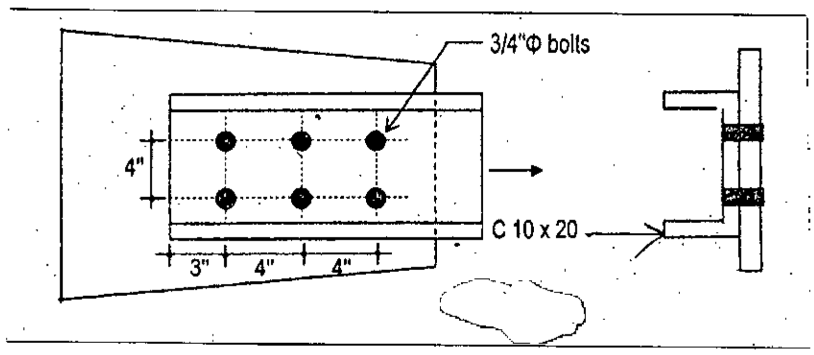


Fig. 4

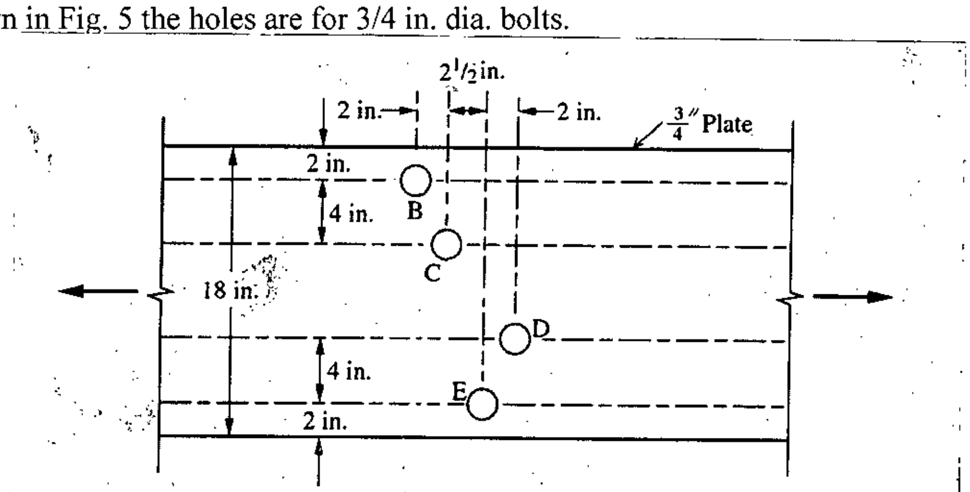
SECTION – B

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

Design of Steel Structures

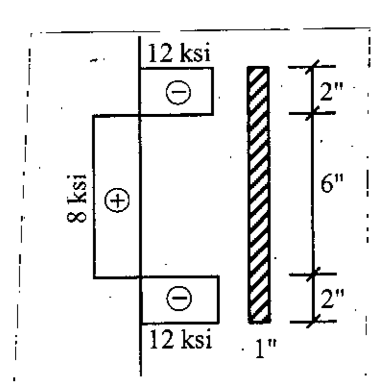
5. (a) Determine the LRFD tension capacity, φT_n, of the A36 (F_y = 36 ksi, F_u = 58 k) steel plate shown in Fig. 5 the holes are for 3/4 in. dia. bolts. **(17)**

Fig. 5



(b) A 1-in by 10-in steel plate of F_y = 40 ksi has residual stress distribution shown in Fig. 6. Draw the average stress vs. strain diagram of the plate under tension and show the diagram on a neat sketch. On the diagram, clearly indicate the stress and strain values of all transition points. Consider E = 30000 ksi. **(18)**

Fig. 6



6. (a) Determine the LRFD tension capacity, φT_n, of the tension splice shown in Fig. 7 considering all types of tension limit states for plate. Plates are A572 Grade 50 material (F_y = 50 ski, F_u = 65 ksi) and bolts are $\frac{3}{4}$-in. dia. type A325 (F_y = 90 ksi, F_u = 120 ksi). **(17)**

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Contd ... Q. No. 6(a)

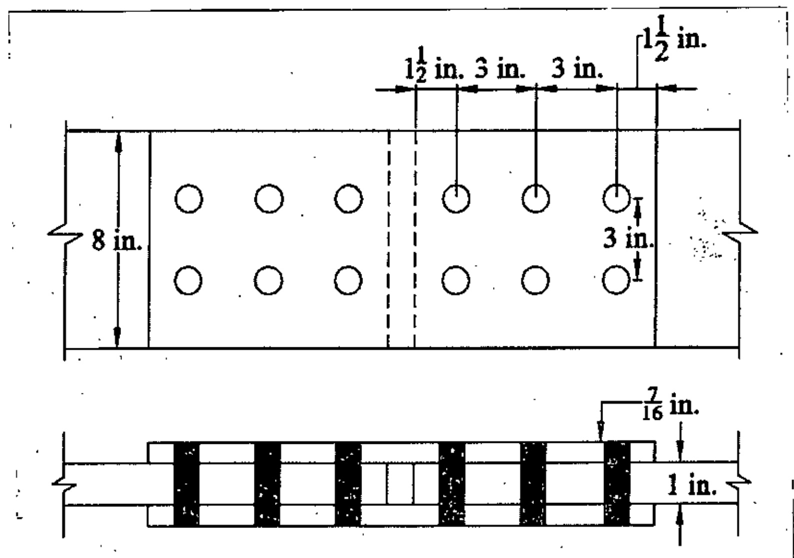

Fig.7

(b) For the welded bracket plate shown in Fig 8, determine the maximum stress (kip per inch) in the weld. **(18)**

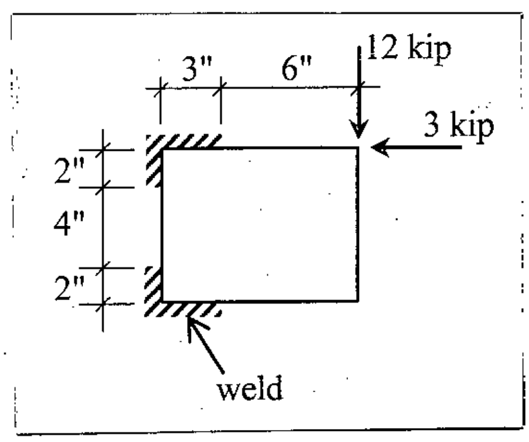

Fig.8

7. (a) Design a welded end connection to develop the full tensile strength of a C8×13.75 in a lap length of 4.5 in. as shown in Fig 9 (all dimensions are in inch). The channel is connected to a 3/8in. gusset plate, and the fillet weld size may not exceed 1/4-in Both the plate and the channel is A 572 Grade 50 steel (F_y = 50 ksi, F_u = 65 ksi). If necessary, use a slot weld as indicated in addition to fillet welds. Use LRFD principle. **(17)**

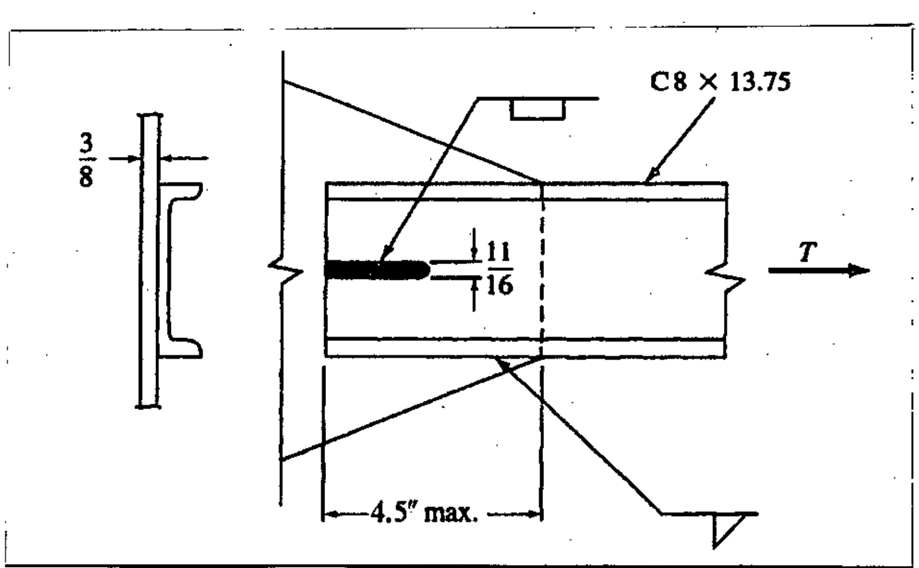

Fig.9

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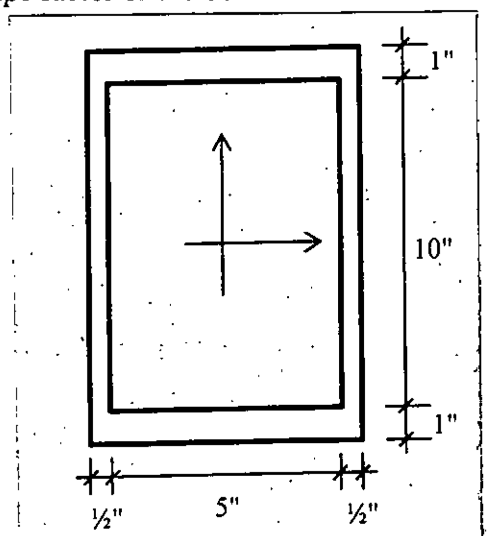
(b) Determine the shape factor of the box beam section shown in Fig. 10 **(18)**

Fig. 10



8. (a) A W2×73 beam (F_y = 50 ksi, F_u = 65 ksi) has to transfer 75 k-ft dead load and 140 k-ft live load moment on to a W21×201 (F_y =50 ksi, F_u =65 ksi) column on its strong axis through an extended end plate type connection. Suitably dimension the end plate and determine the bolt diameter and thickness of end plate (F_y=50 ksi, F_u =65 ksi). Use ASTM A325 bolts (F_y = 90 ksi, F_u = 120 ksi). Follow LRFD principle. **(29)**

(b) With neat sketches, briefly describe the possible defects in welds. **(6)**

Contd.... P/6

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Annexure - 1

W section properties chart

Table 1-1 (continued) W Shapes — Dimensions

Shape	Area, A (in.²)	Depth, d (in.)	Web Thickness, t_w (in.)	Flange Width, b_f (in.)	Flange Thickness, t_f (in.)	Distance k, k_{des} (in.)	Distance k, k_{det} (in.)	k_1 (in.)	T (in.)	Workable Gage (in.)
W21×201	59.2	23.0	0.910	12.6	1.63	2.13	2 1/2	1 5/16	18	5 1/2
×182	53.6	22.7	0.830	12.5	1.48	1.98	2 3/8	1 1/4		
×166	48.8	22.5	0.750	12.4	1.36	1.86	2 1/4	1 3/16		
×147	43.2	22.1	0.720	12.5	1.15	1.65	2	1 3/16		
×132	38.8	21.8	0.650	12.4	1.04	1.54	1 15/16	1 1/8		
×122	35.9	21.7	0.600	12.4	0.960	1.46	1 13/16	1 1/8		
×111	32.7	21.5	0.550	12.3	0.875	1.38	1 3/4	1 1/8		
×101[c]	29.8	21.4	0.500	12.3	0.800	1.30	1 11/16	1 1/8		
W21×93	27.3	21.6	0.580	8.42	0.930	1.43	1 5/8	15/16	18 3/8	5 1/2
×83[c]	24.3	21.4	0.515	8.36	0.835	1.34	1 1/2	7/8		
×73[c]	21.5	21.2	0.455	8.30	0.740	1.24	1 7/16	7/8		
×68[c]	20.0	21.1	0.430	8.27	0.685	1.19	1 3/8	7/8		
×62[c]	18.3	21.0	0.400	8.24	0.615	1.12	1 5/16	13/16		
×55[c]	16.2	20.8	0.375	8.22	0.522	1.02	1 3/16	13/16		
×48[c,f]	14.1	20.6	0.350	8.14	0.430	0.930	1 1/8	13/16		
W18×71	20.8	18.5	0.495	7.64	0.810	1.21	1 1/2	7/8	15 1/2	3 1/2[g]
×65	19.1	18.4	0.450	7.59	0.750	1.15	1 7/16	7/8		
×60[c]	17.6	18.2	0.415	7.56	0.695	1.10	1 3/8	13/16		
×55[c]	16.2	18.1	0.390	7.53	0.630	1.03	1 5/16	13/16		
×50[c]	14.7	18.0	0.355	7.50	0.570	0.972	1 1/4	13/16		
W14×132	38.8	14.7	0.645	14.7	1.03	1.63	2 5/16	1 9/16	10	5 1/2
×120	35.3	14.5	0.590	14.7	0.940	1.54	2 1/4	1 1/2		
×109	32.0	14.3	0.525	14.6	0.860	1.46	2 3/16	1 1/2		
×99[f]	29.1	14.2	0.485	14.6	0.780	1.38	2 1/16	1 7/16		
×90[f]	26.5	14.0	0.440	14.5	0.710	1.31	2	1 7/16		
W14×82	24.0	14.3	0.510	10.1	0.855	1.45	1 11/16	1 1/16	10 7/8	5 1/2
×74	21.8	14.2	0.450	10.1	0.785	1.38	1 5/8	1 1/16		
×68	20.0	14.0	0.415	10.0	0.720	1.31	1 9/16	1 1/16		
×61	17.9	13.9	0.375	10.0	0.645	1.24	1 1/2	1		
W14×53	15.6	13.9	0.370	8.06	0.660	1.25	1 1/2	1	10 7/8	5 1/2
×48	14.1	13.8	0.340	8.03	0.595	1.19	1 7/16	1		
×43[c]	12.6	13.7	0.305	8.00	0.530	1.12	1 3/8	1		
W12×58	17.0	12.2	0.360	10.0	0.640	1.24	1 1/2	15/16	9 1/4	5 1/2
×53	15.6	12.1	0.345	10.0	0.575	1.18	1 3/8	15/16	9 1/4	5 1/2
W12×50	14.6	12.2	0.370	8.08	0.640	1.14	1 1/2	15/16	9 1/4	5 1/2
×45	13.1	12.1	0.335	8.05	0.575	1.08	1 3/8	15/16		
×40	11.7	11.9	0.295	8.01	0.515	1.02	1 3/8	7/8		
W12×35[c]	10.3	12.5	0.300	6.56	0.520	0.820	1 3/16	3/4	10 1/8	3 1/2
×30[c]	8.79	12.3	0.260	6.52	0.440	0.740	1 1/8	3/4		
×26[c]	7.65	12.2	0.230	6.49	0.380	0.680	1 1/16	3/4		
W12×22[c]	6.48	12.3	0.260	4.03	0.425	0.725	15/16	5/8	10 3/8	2 1/4[g]
×19[c]	5.57	12.2	0.235	4.01	0.350	0.650	7/8	9/16		
×16[c]	4.71	12.0	0.220	3.99	0.265	0.565	13/16	9/16		
×14[c,v]	4.16	11.9	0.200	3.97	0.225	0.525	3/4	9/16		
W10×112	32.9	11.4	0.755	10.4	1.25	1.75	1 15/16	1	7 1/2	5 1/2
×100	29.4	11.1	0.680	10.3	1.12	1.62	1 13/16	1		
×88	25.9	10.8	0.605	10.3	0.990	1.49	1 11/16	15/16		
×77	22.6	10.6	0.530	10.2	0.870	1.37	1 9/16	7/8		
×68	20.0	10.4	0.470	10.1	0.770	1.27	1 7/16	7/8		
×60	17.6	10.2	0.420	10.1	0.680	1.18	1 3/8	13/16		
×54	15.8	10.1	0.370	10.0	0.615	1.12	1 5/16	13/16		
×49	14.4	10.0	0.340	10.0	0.560	1.06	1 1/4	13/16		

Table 1-1 (continued) W Shapes — Properties

Shape	Axis X-X I (in.⁴)	Axis X-X S (in.³)	Axis X-X r (in.)	Axis X-X Z (in.³)	Axis Y-Y I (in.⁴)	Axis Y-Y S (in.³)	Axis Y-Y r (in.)	Axis Y-Y Z (in.³)	r_{ts} (in.)	h_o (in.)	Torsional J (in.⁴)	Torsional C_w (in.⁶)
W21×201	5310	461	9.47	530	542	86.1	3.02	133	3.55	21.4	40.9	62000
×182	4730	417	9.40	476	483	77.2	3.00	119	3.51	21.2	30.7	54400
×166	4280	380	9.36	432	435	70.0	2.99	108	3.48	21.1	23.6	48500
×147	3630	329	9.17	373	376	60.1	2.95	92.6	3.45	20.9	15.4	41100
×132	3220	295	9.12	333	333	53.5	2.93	82.3	3.42	20.8	11.3	36000
×122	2960	273	9.09	307	305	49.2	2.92	75.6	3.40	20.7	8.98	32700
×111	2670	249	9.05	279	274	44.5	2.90	68.2	3.37	20.6	6.83	29200
×101[c]	2420	227	9.02	253	248	40.3	2.89	61.7	3.35	20.6	5.21	26200
W21×93	2070	192	8.70	221	92.9	22.1	1.84	34.7	2.24	20.7	6.03	9940
×83[c]	1830	171	8.67	196	81.4	19.5	1.83	30.5	2.21	20.6	4.34	8630
×73[c]	1600	151	8.64	172	70.6	17.0	1.81	26.6	2.19	20.5	3.02	7410
×68[c]	1480	140	8.60	160	64.7	15.7	1.80	24.4	2.17	20.4	2.45	6760
×62[c]	1330	127	8.54	144	57.5	14.0	1.77	21.7	2.15	20.4	1.83	5960
×55[c]	1140	110	8.40	126	48.4	11.8	1.73	18.4	2.11	20.3	1.24	4980
×48[c,f]	959	93.0	8.24	107	38.7	9.52	1.66	14.9	2.05	20.2	0.803	3950
W18×71	1170	127	7.50	146	60.3	15.8	1.70	24.7	2.05	17.7	3.49	4700
×65	1070	117	7.49	133	54.8	14.4	1.69	22.5	2.03	17.6	2.73	4240
×60[c]	984	108	7.47	123	50.1	13.3	1.68	20.6	2.02	17.5	2.17	3850
×55[c]	890	98.3	7.41	112	44.9	11.9	1.67	18.5	2.00	17.5	1.66	3430
×50[c]	800	88.9	7.38	101	40.1	10.7	1.65	16.6	1.98	17.4	1.24	3040
W14×132	1530	209	6.28	234	548	74.5	3.76	113	4.23	13.6	12.3	25500
×120	1380	190	6.24	212	495	67.5	3.74	102	4.20	13.5	9.37	22700
×109	1240	173	6.22	192	447	61.2	3.73	92.7	4.17	13.5	7.12	20200
×99[f]	1110	157	6.17	173	402	55.2	3.71	83.6	4.14	13.4	5.37	18000
×90[f]	999	143	6.14	157	362	49.9	3.70	75.6	4.11	13.3	4.06	16000
W14×82	881	123	6.05	139	148	29.3	2.48	44.8	2.85	13.5	5.07	6710
×74	795	112	6.04	126	134	26.6	2.48	40.5	2.82	13.4	3.87	5990
×68	722	103	6.01	115	121	24.2	2.46	36.9	2.80	13.3	3.01	5380
×61	640	92.1	5.98	102	107	21.5	2.45	32.8	2.78	13.2	2.19	4710
W14×53	541	77.8	5.89	87.1	57.7	14.3	1.92	22.0	2.22	13.3	1.94	2540
×48	484	70.2	5.85	78.4	51.4	12.8	1.91	19.6	2.20	13.2	1.45	2240
×43[c]	428	62.6	5.82	69.6	45.2	11.3	1.89	17.3	2.18	13.1	1.05	1950
W12×58	475	78.0	5.28	86.4	107	21.4	2.51	32.5	2.82	11.6	2.10	3570
×53	425	70.6	5.23	77.9	95.8	19.2	2.48	29.1	2.79	11.5	1.58	3160
W12×50	391	64.2	5.18	71.9	56.3	13.9	1.96	21.3	2.25	11.6	1.71	1880
×45	348	57.7	5.15	64.2	50.0	12.4	1.95	19.0	2.23	11.5	1.26	1650
×40	307	51.5	5.13	57.0	44.1	11.0	1.94	16.8	2.21	11.4	0.906	1440
W12×35[c]	285	45.6	5.25	51.2	24.5	7.47	1.54	11.5	1.79	12.0	0.741	879
×30[c]	238	38.6	5.21	43.1	20.3	6.24	1.52	9.56	1.77	11.9	0.457	720
×26[c]	204	33.4	5.17	37.2	17.3	5.34	1.51	8.17	1.75	11.8	0.300	607
W12×22[c]	156	25.4	4.91	29.3	4.66	2.31	0.848	3.66	1.04	11.9	0.293	164
×19[c]	130	21.3	4.82	24.7	3.76	1.88	0.822	2.98	1.02	11.8	0.180	131
×16[c]	103	17.1	4.67	20.1	2.82	1.41	0.773	2.26	0.982	11.7	0.103	96.9
×14[c,v]	88.6	14.9	4.62	17.4	2.36	1.19	0.753	1.90	0.962	11.7	0.0704	80.4
W10×112	716	126	4.66	147	236	45.3	2.68	69.2	3.07	10.1	15.1	6020
×100	623	112	4.60	130	207	40.0	2.65	61.0	3.03	10.0	10.9	5150
×88	534	98.5	4.54	113	179	34.8	2.63	53.1	2.99	9.85	7.53	4330
×77	455	85.9	4.49	97.6	154	30.1	2.60	45.9	2.95	9.73	5.11	3630
×68	394	75.7	4.44	85.3	134	26.4	2.59	40.1	2.91	9.63	3.56	3100
×60	341	66.7	4.39	74.6	116	23.0	2.57	35.0	2.88	9.54	2.48	2640
×54	303	60.0	4.37	66.6	103	20.6	2.56	31.3	2.86	9.48	1.82	2320
×49	272	54.6	4.35	60.4	93.4	18.7	2.54	28.3	2.84	9.42	1.39	2070

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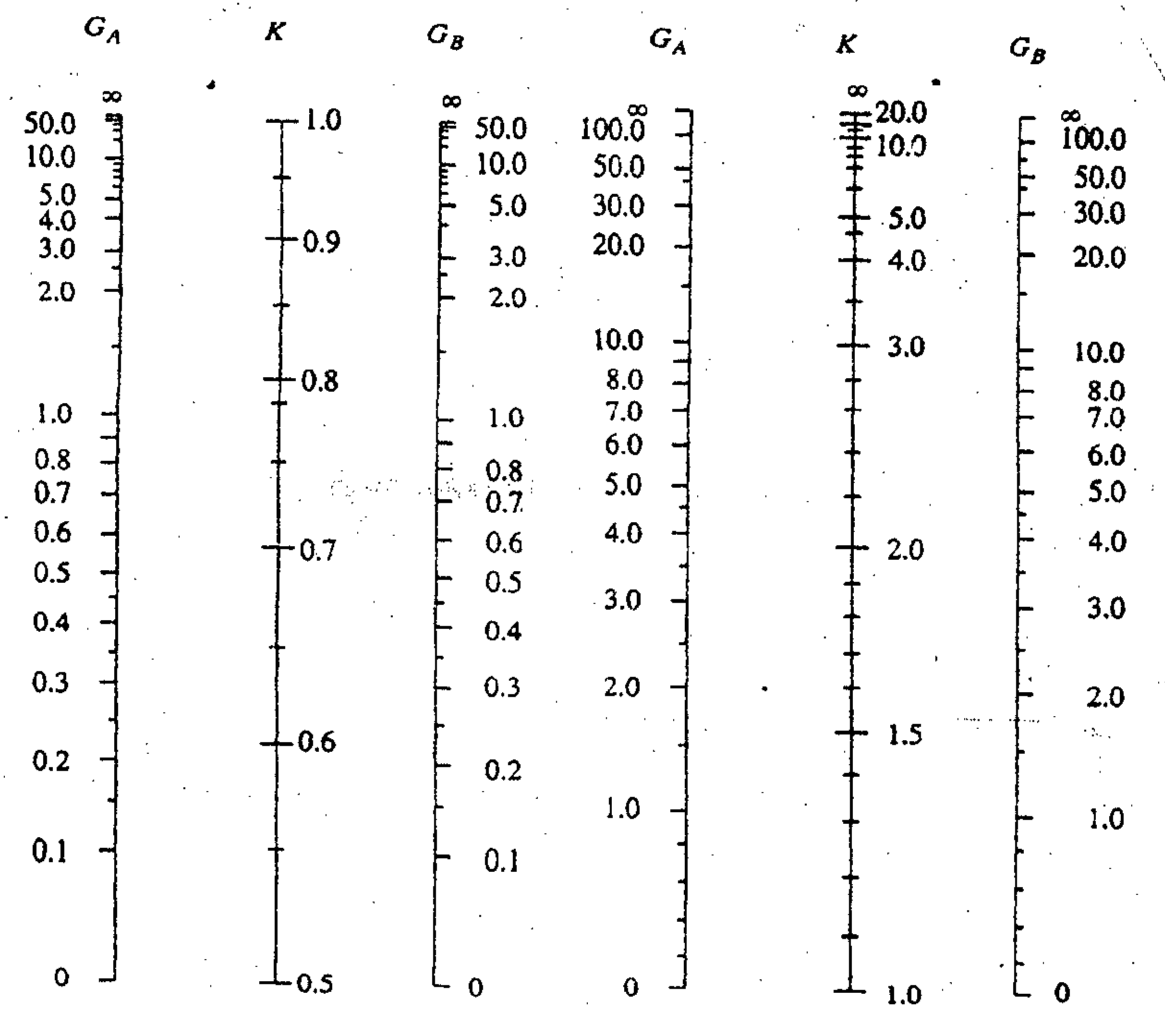
Annexure-2

Column alignment charts



Sidesway prevented (Braced frame)

Sidesway not prevented (Unbraced frame)

Column Formulae

$$F_{cr} = \left[0.658^{F_y/F_e}\right]F_y \text{ for } \frac{KL}{r} \le 4.71\sqrt{\frac{E}{F_y}} \text{ Or } F_e \ge 0.44F_y$$

$$F_{cr} = 0.877F_e \text{ for } \frac{KL}{r} > 4.71\sqrt{\frac{E}{F_y}} \text{ Or } F_e < 0.44F_y$$

$$F_e = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

Beam Formulae

$$M_n = C_b\left[M_p - (M_p - 0.7F_yS_x)\left(\frac{L_b - L_p}{L_r - L_p}\right)\right] \le M_p$$

$$M_n = M_p - (M_p - 0.7F_yS_x)\left(\frac{\lambda - \lambda_{pf}}{\lambda_{rf} - \lambda_{pf}}\right)$$

$$\frac{L_p}{r_y} = 1.76\sqrt{\frac{E}{F_y}} = \frac{300}{\sqrt{F_y, \text{ksi}}}$$

$$L_r = 1.95r_{ts}\frac{E}{0.7F_y}\sqrt{\frac{Jc}{S_xh_o}}\sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7F_y}{E}\frac{S_xh_o}{Jc}\right)^2}}$$

$$F_{cr} = \frac{C_b\pi^2E}{\left(\frac{L_b}{r_{ts}}\right)^2}\sqrt{1 + 0.078\frac{Jc}{S_xh_o}\left(\frac{L_b}{r_{ts}}\right)^2}$$

AISC LRFD beam-column interaction formula

$$\frac{P_u}{\phi_c P_n} + \frac{8}{9}\left[\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right] \le 1.0 \quad \text{For } \frac{P_u}{\phi_c P_n} \ge 0.2$$

$$\frac{P_u}{2\phi_c P_n} + \left[\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}}\right] \le 1.0 \quad \text{For } \frac{P_u}{\phi_c P_n} < 0.2$$

$$B = \frac{1}{1 - \frac{P_u}{P_e}}$$

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Properties of Channel Sections

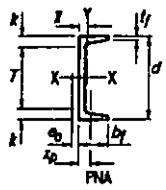

Table 1-5 C Shapes Dimensions / **Table 1-5 (continued) C Shapes Properties**

C SHAPES

Shape	Area, A	Depth, d		Web Thickness, t_w		$\frac{t_w}{2}$	Flange Width, b_f		Flange Thickness, t_f		Distance k	Distance T	Workable Gage	Shear Ctr, e_o
	in.²	in.		in.		in.	in.		in.		in.	in.	in.	in.
C9×20	5.87	9.00	9	0.448	7/16	1/4	2.65	2 5/8	0.413	7/16	1	7	1 1/2[g]	0.515
×15	4.41	9.00	9	0.285	5/16	3/16	2.49	2 1/2	0.413	7/16	1	7	1 3/8[g]	0.681
×13.4	3.94	9.00	9	0.233	1/4	1/8	2.43	2 3/8	0.413	7/16	1	7	1 3/8[g]	0.742
C8×18.7	5.51	8.00	8	0.487	1/2	1/4	2.53	2 1/2	0.390	3/8	15/16	6 1/8	1 1/2[g]	0.431
×13.7	4.04	8.00	8	0.303	5/16	3/16	2.34	2 3/8	0.390	3/8	15/16	6 1/8	1 3/8[g]	0.604
×11.5	3.37	8.00	8	0.220	1/4	1/8	2.26	2 1/4	0.390	3/8	15/16	6 1/8	1 3/8[g]	0.697
C7×14.7	4.33	7.00	7	0.419	7/16	1/4	2.30	2 1/4	0.366	3/8	7/8	5 1/4	1 1/4[g]	0.441
×12.2	3.60	7.00	7	0.314	5/16	3/16	2.19	2 1/4	0.366	3/8	7/8	5 1/4	1 1/4[g]	0.538
×9.8	2.87	7.00	7	0.210	3/16	1/8	2.09	2 1/8	0.366	3/8	7/8	5 1/4	1 1/4[g]	0.647

Shape	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X Z	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y $\bar{x}$	Axis Y-Y Z	Axis Y-Y x_p	Torsional J	Torsional C_w	Torsional $\bar{r}_o$	H
	in.⁴	in.³	in.	in.³	in.⁴	in.³	in.	in.	in.³	in.	in.⁴	in.⁶	in.	
C9×20	60.9	13.5	3.22	16.9	2.41	1.17	0.640	0.583	2.46	0.326	0.427	39.4	3.46	0.899
×15	51.0	11.3	3.40	13.6	1.91	1.01	0.659	0.586	2.04	0.245	0.208	31.0	3.69	0.882
×13.4	47.8	10.6	3.49	12.6	1.75	0.954	0.666	0.601	1.94	0.219	0.168	28.2	3.79	0.875
C8×18.7	43.9	11.0	2.82	13.9	1.97	1.01	0.598	0.565	2.17	0.344	0.434	25.1	3.05	0.894
×13.7	36.1	9.02	2.99	11.0	1.52	0.848	0.613	0.554	1.73	0.252	0.186	19.2	3.26	0.874
×11.5	32.5	8.14	3.11	9.63	1.31	0.775	0.623	0.572	1.57	0.211	0.130	16.5	3.41	0.862
C7×14.7	27.2	7.78	2.51	9.75	1.37	0.772	0.561	0.532	1.63	0.309	0.267	13.1	2.75	0.875
×12.2	24.2	6.92	2.60	8.46	1.16	0.696	0.568	0.525	1.42	0.257	0.161	11.2	2.86	0.862
×9.8	21.2	6.07	2.72	7.19	0.957	0.617	0.578	0.541	1.26	0.205	0.0996	9.15	3.03	0.846

W section properties chart

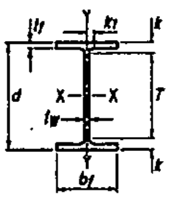

Table 1-1 (continued) W Shapes Dimensions / **Table 1-1 (continued) W Shapes Properties**

Shape	Area, A	Depth, d	Web Thickness, t_w	Flange Width, b_f	Flange Thickness, t_f	k_{des}	k_{det}	k_1	T	Workable Gage
	in.²	in.	in.	in.	in.	in.	in.	in.	in.	in.
W21×201	59.2	23.0	0.810	12.6	1.63	2.13	2 1/2	1 5/16	18	5 1/2
×182	53.6	22.7	0.830	12.5	1.48	1.98	2 3/8	1 1/4		
×166	48.8	22.5	0.750	12.4	1.36	1.86	2 1/4	1 3/16		
×147	43.2	22.1	0.720	12.5	1.15	1.65	2	1 3/16		
×132	38.8	21.8	0.650	12.4	1.04	1.54	1 15/16	1 1/8		
×122	35.9	21.7	0.600	12.4	0.960	1.46	1 13/16	1 1/8		
×111	32.7	21.5	0.550	12.3	0.875	1.38	1 3/4	1 1/8		
×101[c]	29.8	21.4	0.500	12.3	0.800	1.30	1 11/16	1 1/16		
W21×93	27.3	21.6	0.580	8.42	0.930	1.43	1 5/8	15/16	18 3/8	5 1/2
×83[c]	24.3	21.4	0.515	8.36	0.835	1.34	1 1/2	7/8		
×73[c]	21.5	21.2	0.455	8.30	0.740	1.24	1 7/16	7/8		
×68[c]	20.0	21.1	0.430	8.27	0.685	1.19	1 3/8	7/8		
×62[c]	18.3	21.0	0.400	8.24	0.615	1.12	1 5/16	13/16		
×55[c]	16.2	20.8	0.375	8.22	.0522	1.02	1 3/16	13/16		
×48[c,f]	14.1	20.6	0.350	8.14	0.430	0.930	1 1/8	13/16		

Shape	Axis X-X I	Axis X-X S	Axis X-X r	Axis X-X Z	Axis Y-Y I	Axis Y-Y S	Axis Y-Y r	Axis Y-Y Z	r_{ts}	h_o	Torsional J	Torsional C_w
	in.⁴	in.³	in.	in.³	in.⁴	in.³	in.	in.³	in.	in.	in.⁴	in.⁶
W21×201	5310	461	9.47	530	542	86.1	3.02	133	3.55	21.4	40.9	62000
×182	4730	417	9.40	476	483	77.2	3.00	119	3.51	21.2	30.7	54400
×166	4280	380	9.36	432	435	70.0	2.99	108	3.48	21.1	23.6	48500
×147	3630	329	9.17	373	376	60.1	2.95	92.6	3.45	20.9	15.4	41100
×132	3220	295	9.12	333	333	53.5	2.93	82.3	3.42	20.8	11.3	36000
×122	2960	273	9.09	307	305	49.2	2.92	75.6	3.40	20.7	8.98	32700
×111	2670	249	9.05	279	274	44.5	2.90	68.2	3.37	20.6	6.83	29200
×101[c]	2420	227	9.02	253	248	40.3	2.89	61.7	3.35	20.6	5.21	26200
W21×93	2070	192	8.70	221	92.9	22.1	1.84	34.7	2.24	20.7	6.03	9940
×83[c]	1830	171	8.67	196	81.4	19.5	1.83	30.5	2.21	20.6	4.34	8630
×73[c]	1600	151	8.64	172	70.6	17.0	1.81	26.6	2.19	20.5	3.02	7410
×68[c]	1480	140	8.60	160	64.7	15.7	1.80	24.4	2.17	20.4	2.45	6760
×62[c]	1330	127	8.54	144	57.5	14.0	1.77	21.7	2.15	20.4	1.83	5950
×55[c]	1140	110	8.40	126	48.4	11.8	1.73	18.4	2.11	20.3	1.24	4980
×48[c,f]	959	93.0	8.24	107	38.7	9.52	1.66	14.9	2.05	20.2	0.803	3950

End-plate connection design formulae

$$d_b = \sqrt{\frac{2M_u}{\pi \phi F_t \sum d_n}} \quad ; \qquad t_p = \sqrt{\frac{1.11\gamma_r \phi M_{np}}{\phi_b F_{py} Y}}; \ \varphi_b = 0.9$$

$\phi M_{np} = \phi\,[2P_t \Sigma d_n]$, where $P_t = \frac{\pi}{4} d_b^2 F_t$ and $\phi = 0.75$

ASTM Bolts diameters are: $1/2$, $5/8$, $3/4$, $7/8$, 1, $1\,1/8$, $1\,1/4$, $1\,3/8$, $1\,1/2$ inch

Contd.... P/9

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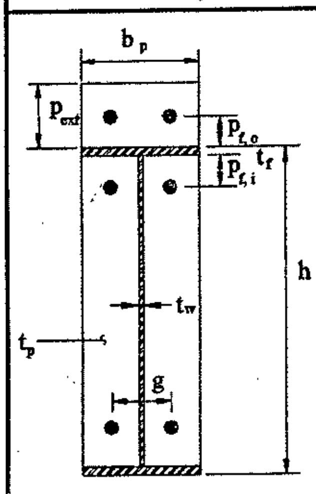
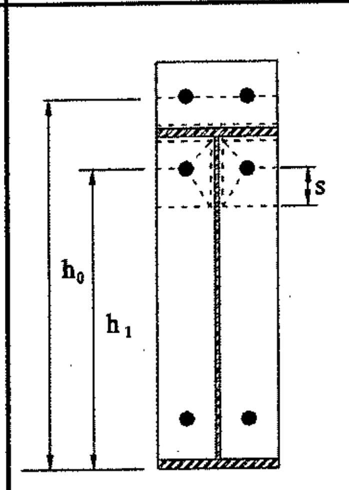
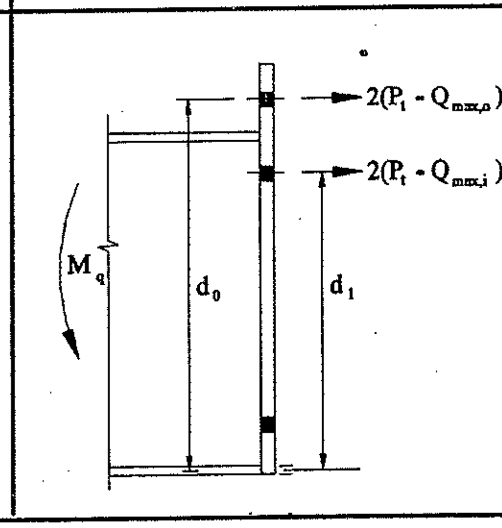
End-plate connection design charts

Geometry	Yield-Line Mechanism	Bolt Force Model
		

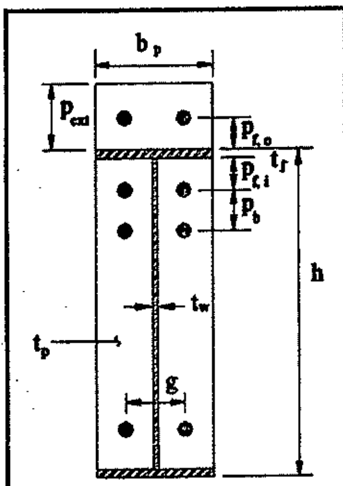
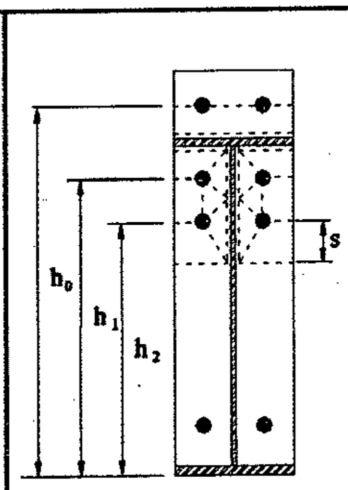
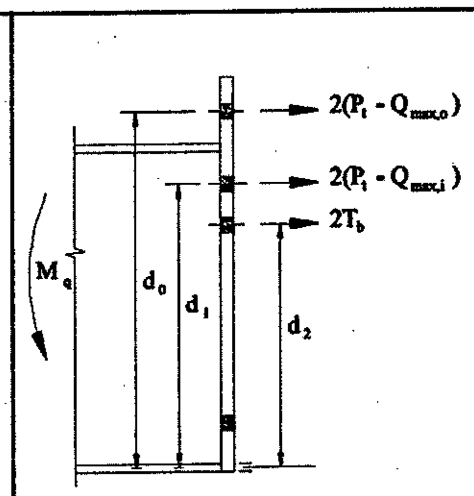
End-Plate Yield

$$\phi M_n = \phi_b M_{pl} = \phi_b F_{py} t_p^2 Y$$

$$Y = \frac{b_p}{2}\left[h_1\left(\frac{1}{p_{f,i}}+\frac{1}{s}\right)+h_0\left(\frac{1}{p_{f,o}}\right)-\frac{1}{2}\right]+\frac{2}{g}\left[h_1\left(p_{f,i}+s\right)\right]$$

Note: Use $p_{f,i} = s$, if $p_{f,i} > s$

$$s = \frac{1}{2}\sqrt{b_p g} \qquad \phi_b = 0.90$$

Geometry	Yield-Line Mechanism	Bolt Force Model
		

End-Plate Yield

$$\phi M_n = \phi_b M_{pl} = \phi_b F_{py} t_p^2 Y$$

$$Y = \frac{b_p}{2}\left[h_1\left(\frac{1}{p_{f,i}}\right)+h_2\left(\frac{1}{s}\right)+h_0\left(\frac{1}{p_{f,o}}\right)-\frac{1}{2}\right]+\frac{2}{g}\left[h_1\left(p_{f,i}+0.75p_b\right)+h_2\left(s+0.25p_b\right)\right]+\frac{g}{2}$$

$$s = \frac{1}{2}\sqrt{b_p g} \qquad \phi_b = 0.90$$

Note: Use $p_{f,i} = s$, if $p_{f,i} > s$

L-3/T-2/CE Date : 14/03/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **CE 333** (Environmental Engineering II)

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**.

1. (a) In a wastewater treatment plant a primary clarifier receives 20,400 m^3 wastewater per day. A settling column analysis (column depth = 2.2 m) of the untreated wastewater is carried out to observe overall removal performance. The following data is obtained during the test: **($16\frac{2}{3}$)**

Particle Concentration, mg/L	510	420	295	200	110	80	40
Time, (hr)	0	0.5	1.0	1.5	2.5	3.5	5.0

If mass fraction of particles with velocity exceeding the surface over flow rate found to be 58%, determine – (i) surface area of the primary clarifier and (ii) total removal efficiency (%).

(b) Show stoichiometric relationship among – UBOD, ThOD, COD and TOC. Also write a short note on nitrification of organic wastes. **(5+6)**

(c) How surface BOD loading is checked for facultative pond. Describe the removal kinetics of trickling filter method. **(5+7)**

(d) Distinguish between – (i) rotary vacuum filter and filter press method of sludge treatment. **(7)**

2. (a) State the goal of environmental engineering profession. What are the principles of waste treatment? **(9)**

(b) What do you mean by greenhouse effect and ozone layer depletion? State their consequences. **(15)**

(c) What are the basic considerations of water supply for tall building? **($8\frac{2}{3}$)**

(d) Calculate the permissible pressure loss per 100 ft in the riser pipe of the topmost floor of a seven storied building from the following data: **(14)**

– the water supply is intermittent

– the fixture pressure ranges from 5 psi to 10 psi

– floor to floor height is 10 ft

Assume reasonable value for any missing data.

Contd P/2

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3. (a) Discuss the development initiatives taken by GoB to improve overall wastewater (sewage) management system for Dhaka city. $(7\frac{2}{3})$

(b) A completely mixed activated sludge system is designed to treat wastewater produced by a community of 1.5 million people. Using the given data, calculate – (i) influent and effluent BOD concentration, (ii) hydraulic retention time and (iii) mean cell residence time. **(15)**

Given:

Wastewater flow rate = 1350 m^3/hr

Specific substrate utilization rate = 0.45/day

Net biomass growth rate = 325 mg/L-d

Volume of the aeration tank = 7400 m^3

Mixed liquor suspended solid concentration = 2750 mg/L

Removal efficiency = 97.5%

(c) Describe in brief the log growth phase of bacterial cell synthesis. Illustrate with neat diagram the metabolism process of bacterial growth. **(5+5)**

(d) Write down the purpose of using skimming tank and pre-cholorination process in wastewater treatment. **(8)**

(e) Define the forms of water that may remain in untreated sludge mass. **(6)**

4. (a) What is a fixture trap? What do you mean by strength of a trap and how will you measure it? **(7)**

(b) Differentiate between "self-siphonage" and "induced-siphonage". How those can be prevented? **(7)**

(c) What are the principal plumbing systems of drainage? Which system you prefer and why? **(12)**

(d) Draw a figure showing typical municipal solid waste management system. $(6\frac{2}{3})$

(e) What are the merits of community participation in the water supply and sanitation system? **(14)**

SECTION – B

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

Assume reasonable value for parameters not given.

5. (a) Neatly draw (and label) the schematic diagram of an ETP using the physico-chemical followed by Activated Sludge processes. Identify the reasons for each of the following problems occurring at different occasions and suggest appropriate remedial measures. **(5+6×3)**

(i) Flocs breaking-up in flocculation chamber

(ii) Excessive red-colored sludge in the sedimentation tank

(iii) Presence of flocs/solids in the treated effluent from final clarifier/sedimentation tank

(iv) Presence of high level of organic in the final effluent at the outlet

(v) Formation of foam blanket at the aeration tank

(vi) Formation of foam blanket at the equalization tank.

Contd P/3

CE 333

Contd ... Q. No. 5

(b) An STP reported following weekly BOD_5 (mg/L) data of treated effluent for 13 weeks. Plot these values on a Log-Probability paper using Blom's Transformation. **($8\frac{2}{3}$+3×5)**

(i) Determine the Mean and Standard Deviation from the plot.

(ii) Determine how many weeks in a year the STP will discharge effluent exceeding the ECR '97 regulations for BOD_5 discharge level.

(iii) Determine the annual maximum weekly BOD_5.

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
BOD_5	72	65	50	45	51	48	52	38	52	47	45	55	35

6. (a) Design a suitable latrine for a family having 9 members living in a village, where tubewell based water supply is available. Water use for the latrine is estimated at 12 lpcd. Long-term infiltration capacity of soil in the area is estimated at 26 L/m^2.day, and the highest groundwater level is about 4.0 m below ground surface. Two type of concrete rings are available for the construction of the toilet pit: 1.0 m in diameter, and 1.1 m in diameter; all rings are 0.3 m in depth. **($26\frac{2}{3}$)**

(i) What type of latrine would you suggest for the family? Explain.

(ii) Design the latrine (including venting system) using suitable concrete rings that would satisfy the design criteria, and estimate its design life. Show design calculations for both ring sizes.

(iii) Draw a neat sketch (both plan and section) showing all elements of the designed latrine. List the facilities that should be provided within the latrine.

(iv) Draw a neat sketch of the same latrine considering that it is located in a flood-prone area.

[Assume reasonable values for parameters not given]

(b) What is an ABR? Briefly describe the working principle of an ABR (with an appropriate sketch). Compare the typical performance of an ABR and a septic tank. **(10)**

(c) In recent time, detection of fecal coliform (FC) in shallow tubewell water is becoming common. What are the common reasons for fecal contamination of shallow well water? What measures should be taken to prevent such contamination, including in areas with high groundwater level? Explain with appropriate figures/sketches. **(10)**

7. (a) An engineering handbook lists "minimum" sewer slopes as follows given below. The general design practice is to provide sewer slope similar to the ground slope. However, this is not mandatory. If situation warrants, a designer should provide higher slope. **($23\frac{2}{3}$)**

Sewer Dia. (inch)	6	8	10	12	15	18	21	24
Sewer Dia. (mm)	150	200	250	300	375	450	525	600
Minimum Slope	0.0043	0.0033	0.0025	0.0019	0.0014	0.0011	0.00092	0.00077

Contd P/4

CE 333

Contd ... Q. No. 7(a)

In area with a ground slope of 0.0015, a 100 m long sanitary sewer is required to carry 0.50 m^3/min (0.29 ft^3/sec). What sewer size and slope should be used? If the designed sewer does not satisfy the design guidelines then provide at least two alternative sewer sizes nearest to the one required as per design and their corresponding slopes? Also, assess the difference in elevation between the crown at the upper end and the invert at the lower end of the sewers of both the sizes.

(b) You have been given the responsibility to plan crossing of a sewer line across the Airport road near Kuril Interchange to convey the sewage along the newly constructed canal. Which agencies do you need to contact during planning and construction stages. Provide brief reasons for contacting each of these agencies. **(10)**

(c) A WWTP employing biological treatment has been designed for long-term average inflow of 55 g/m^3 NH_3-N and 20 g/m^3 P. Given the average flow rate of 2 m^3/s, draw the sustained low-flow loading curves for NH_3-N and P using the typical curves provided in the figure for Q. 7(c). **(13)**

8. (a) Design a septic tank for 4 families living in a building; the average family size is 7. The estimated wastewater flow rate is 80 lpcd and the tank is to be desludged every two years. The hydraulic detention time of the tank should be at least 1 day in order to maintain acceptable effluent quality. Also draw: **($26\frac{2}{3}$)**

   (i) A plan view of the designed septic tank (consider two chambers)

   (ii) A section showing depths of different zones of the septic tank, and

   (iii) A section showing the positions and dimensions of inlet and outlet devices.

   [Consider a design temperature of 22°C; assume reasonable values for parameters not given]

   (b) In Bangladesh, the prevalence of open defecation has been brought down to below 1% through widespread use of onsite sanitation facilities. Do you think fecal matters are being "safely managed" through the use of these onsite facilities? Explain your answer. What do you understand by fecal sludge management (FSM)? With an appropriate flow diagram, show the major FSM system elements. **(10)**

   (c) What do you understand by a "hygienic latrine"? Explain. With an appropriate figure, show how disease is transmitted from excreta via different routes, along with sanitation barriers to prevent such transmission. **(10)**

Contd. . . P/5

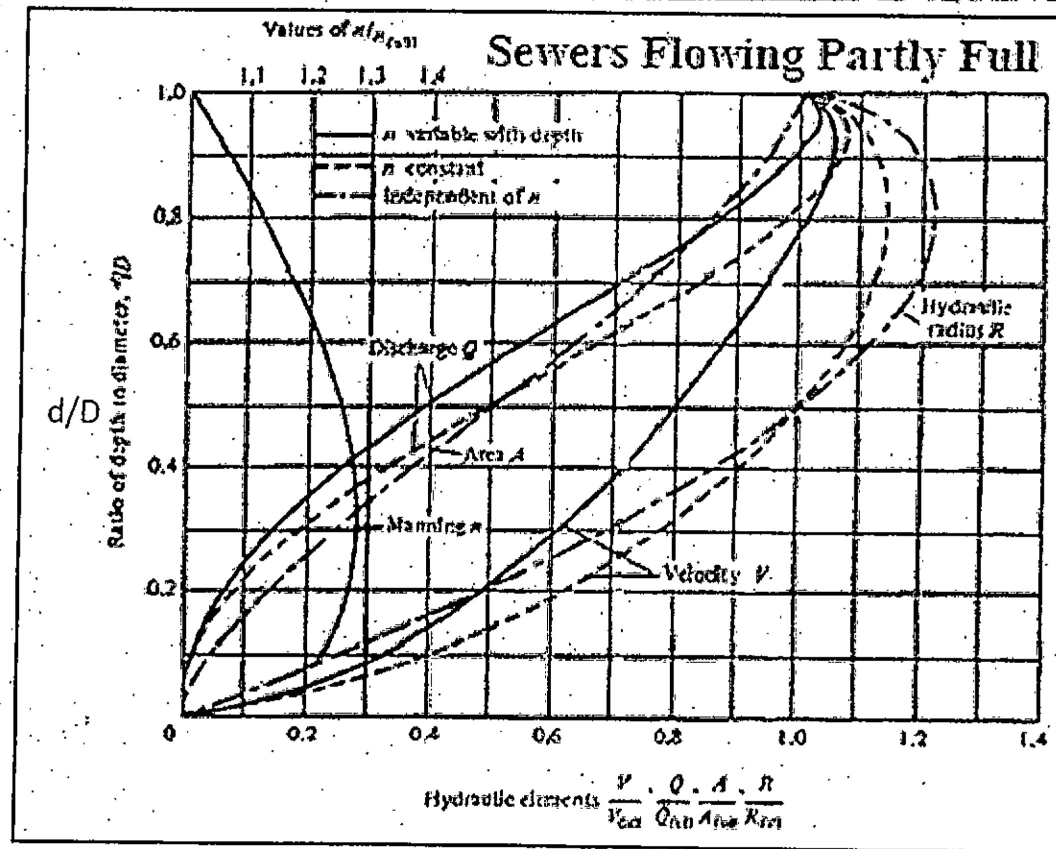

Figure for Question # 7(a)

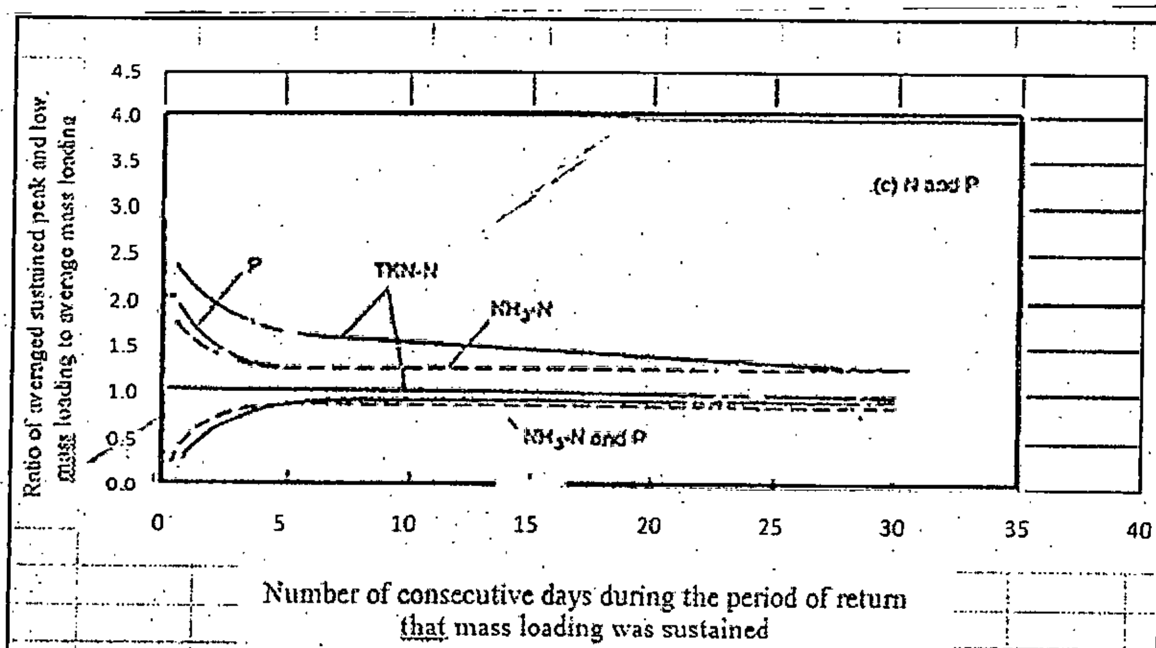

Figure for Question # 7(c)