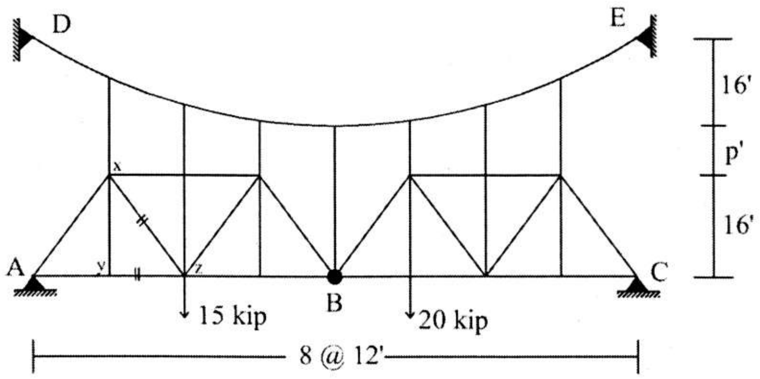
University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B. Sc. Engineering (Civil)

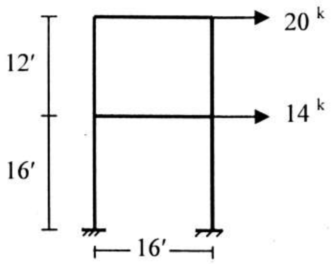
Course Title: Structural Analysis & Design I | Course Code: CE 311
Time: 3.00 Hours | Full Marks: 100 (=10×10)

*There are **fourteen (14)** questions in this paper. Answer any **ten (10)**.*
Assume any missing data reasonably.

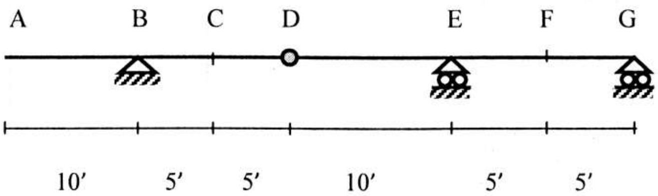
1. Calculate the force on each hanger and also find out the truss member force of *xz* and *yz* for the following cable suspension bridge.



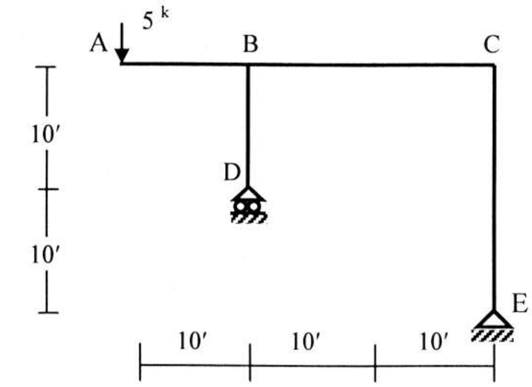
2. Draw shear force and bending moment diagrams of beams and columns of the two-storied frame subjected to lateral load as shown in the figure, assuming, equal share of story shear forces between columns and internal hinge at column mid spans.



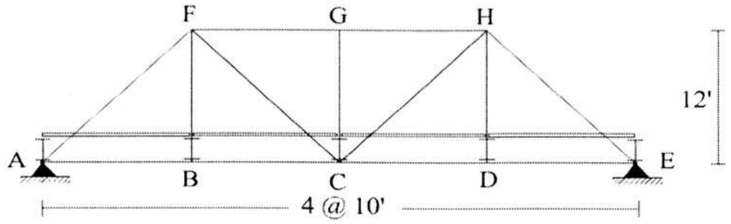
3. In the beam shown below (with internal hinge at D), draw the influence lines for
(a) $V_{E(L)}$, $V_{E(R)}$
(b) M_C , M_F
(c) R_B, R_E



4. For the frame shown below, draw the axial Force, shear Force and bending moment diagram.

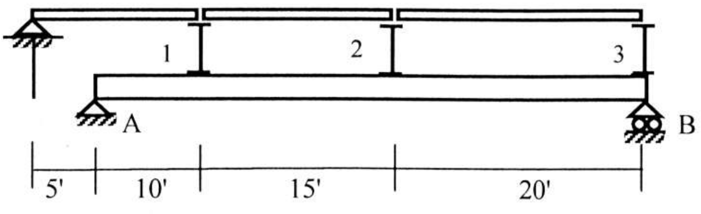


5. For the truss shown below, draw the influence lines for F_{BF}, F_{BC}, F_{CF}, and F_{GF}. Note, each bottom chord joint consists of a cross girder and load moves over the floor beam placed over the girders.



6. Girder AB supports a floor system as shown in the figure below. Draw the Influence line for

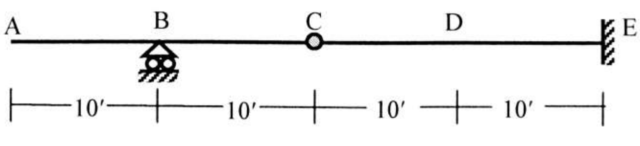
(i) Floor beam reaction at panel point 1 and 2.
(ii) Support reaction at A.
(iii) Shear in panel 1-2.
(iv) Bending moment for girder at panel point 1.



7. Determine - i) Maximum Reaction at support E
ii) Maximum Shear at point D
iii) Maximum Moment at point B

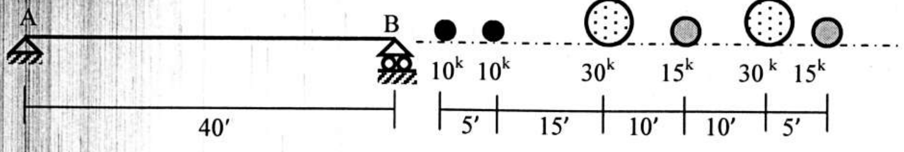
on the beam shown due to

- A single concentrated live load of 10 kips
- A uniform live load of 3 k/ft
- A beam weight of 1k/ft

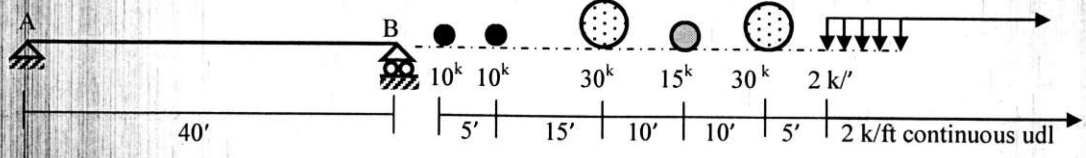


C is an Internal Hinge

8. Calculate the maximum value of R_A for the wheel load arrangement shown below.

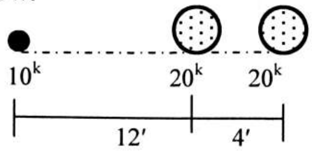


9. Calculate the maximum shear at 15′ right of support A for the beam and the wheel load arrangement shown below.

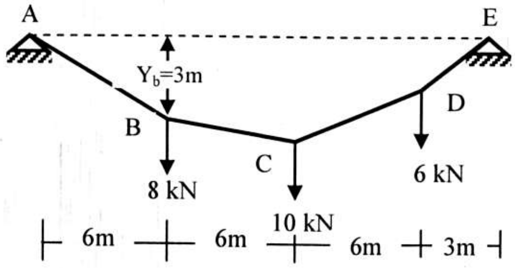


10. Calculate the maximum moment at mid span for the beam and the moving loads in *Question 08*.

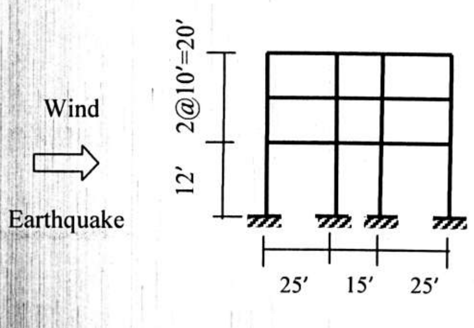
11. Calculate the absolute maximum bending moment of a simply supported beam of span 30 ft due to the wheel loads shown in the figure below.



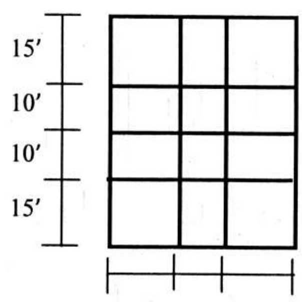
12. The cable shown below has supports A and E that lie at the same elevation. Point B on the cable is 3m below the chord AE. Use the general cable theorem to calculate the sags at C and D. Also, calculate maximum cable tension.



13. Calculate the wind load at each story (i.e. at joints) of a three-storied concrete made Industrial building (shown below) located at a flat terrain in Dhaka (Basic wind speed = 130 mph). Assume the structure to be subjected to Exposure A.



Side Elevation



Plan

14. Calculate the seismic load at each story (i.e. at joints) of a three-storied concrete made residential building located in Dhaka (Zone 2). Assume the structure to be a Ordinary Moment Resisting Frame (OMRF) built on soil condition S_1, carrying a Dead Load of 150 lb/ft^2 and Live load of 40 lb/ft^2. Use the same figure for building plan and elevation as of *Question 13*.

Annexure

Wind:

$q_z = 0.00256\ C_I\ C_z\ V_b^2$

$p_z = C_G\ C_t\ C_p\ q_z$

Category	C_I or I
Essential facilities	1.25
Hazardous facilities	1.25
Special occupancy	1.00
Standard occupancy	1.00
Low-risk structure	0.80

Height z (ft)	C_z		
	Exp A	Exp B	Exp C
0~15	0.368	0.801	1.196
50	0.624	1.125	1.517
100	0.849	1.371	1.743
150	1.017	1.539	1.890
200	1.155	1.671	2.002
300	1.383	1.876	2.171
400	1.572	2.037	2.299
500	1.736	2.171	2.404
650	1.973	2.357	2.547
1000	2.362	2.595	2.724

Overall **Pressure Co-efficient (C_P)** for rectangular buildings with flat roof:

h/B	L/B					
	0.1	0.5	0.65	1.0	2.0	≥ 3.0
≤ 0.5	1.40	1.45	1.55	1.40	1.15	1.10
1.0	1.55	1.85	2.00	1.70	1.30	1.15
2.0	1.80	2.25	2.55	2.00	1.40	1.20
≥ 4.0	1.95	2.50	2.80	2.20	1.60	1.25

Height z (ft)	C_G (for non-slender structures)		
	Exp A	Exp B	Exp C
0~15	1.654	1.321	1.154
50	1.418	1.215	1.097
100	1.309	1.162	1.067
150	1.252	1.133	1.051
200	1.215	1.114	1.039
300	1.166	1.087	1.024
400	1.134	1.070	1.013
500	1.111	1.057	1.005
650	1.082	1.040	1.000
1000	1.045	1.018	1.000

For Flat Terrain, $C_t = 1$

Earthquake:

$V = (ZIC/R)\ W$

$C = 1.25\ S/T^{2/3}$

$T = C_t (h_n)^{3/4}$

$F_j = (V - F_t)\ [w_j h_j / \sum w_i h_i]$

Soil Type	S
S_1	1
S_2	1.2
S_3	1.5
S_4	2

Response Modification Factor		R
Moment Resisting Frame System	SMRF (steel)	12
	SMRF (concrete)	12
	IMRF	8
	OMRF (steel)	6
	OMRF (concrete)	5

$C_t = 0.083$ for steel moment resisting frames
$= 0.073$ for RCC moment resisting frames, and eccentric braced steel frames
$= 0.049$ for all other structural systems

Z = 0.075, 0.15 and 0.25 for Seismic Zones 1, 2 and 3 respectively

Wheel Load:

1. $\Delta R = \{(\sum P)\ d_1 + P'e\}/L - P_1$
2. $\Delta V = \{(\sum P)\ d_1 + P'e + P_0\ e_0\}/L - P_1$
3. $\Delta M = (P_2\ d_1 + P'e)\ (i/b) - (P_1\ d_1 + P_0\ e_0)\ (i/a)$
4. $M_{(Max)} = (\sum P/L)\ (L/2 - a/2)^2 - P\ b$

Section A

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B.Sc. Engineering (Civil)

Course Title: Design of Concrete Structures I — Course Code: CE 315

Time: 3 hours — Full Marks: 70

*****Answer Section A and Section B on separate answer scripts*****

Section A

[Answer any **three** (03) out of following **four** (04) questions]

Full Marks: 30 [=3*(10)]

[Assume reasonable values for any missing data]

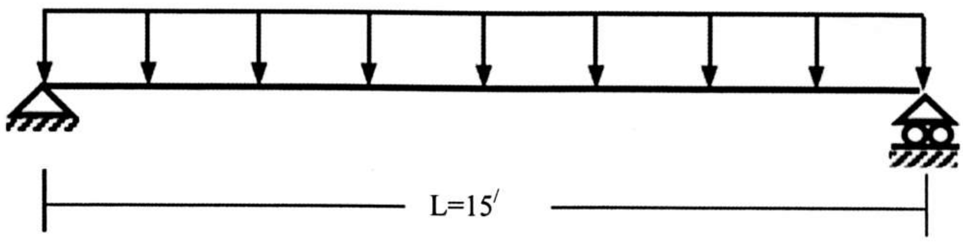
1. (a) What are the fundamental assumptions for reinforced concrete behavior? [2.5]

   (b) A rectangular column of 12″x16″ has 6#8 bars. Determine the axial compressive load if concrete undergoes a strain of 0.0004. [05]
   [Given that $f_c{}' = 4$ ksi, $f_y = 60$ ksi]

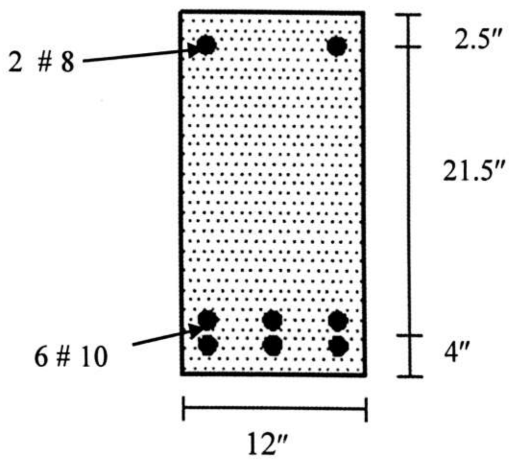
   (c) Why does the ACI recommend a maximum steel ratio less than ρ_b? [2.5]

2. Use WSD or USD Method to design the simply supported singly reinforced RC beam with working loads as shown for flexure only. Given that $f_c{}' = 3$ ksi, $f_y = 60$ ksi, $f_{call} =$ 1.35 ksi, f_{sall}= 24 ksi. [10]

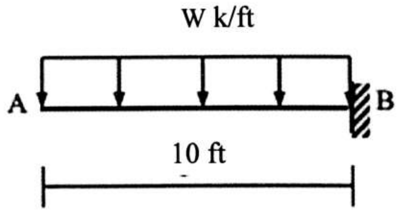
W_{DL}=1.0 k/ft (excluding self weight), W_{LL}=0.5 k/ft

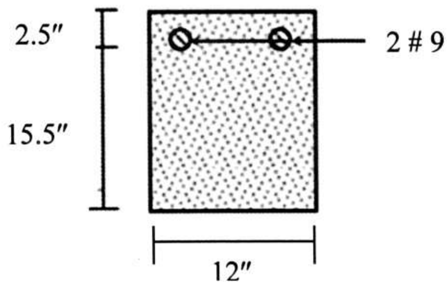


3. In the figure shown below, calculate the design positive moment capacity of the beam. Follow USD method [Given that $f_c{}' = 5$ ksi, $f_y = 60$ ksi]. [10]



4. (a) In the figures shown below, calculate the maximum distributed load w k/ft on the RC cantilever beam AB if the section at B is to remain uncracked. Neglect self weight of the beam [Given that f_y = 60 ksi and f_c' = 3 ksi]. [08]





(b) Differentiate between USD and WSD method. [02]

Section B

[Answer any four (04) out of following six (6) questions]

Full Marks: 40 [=4*10]

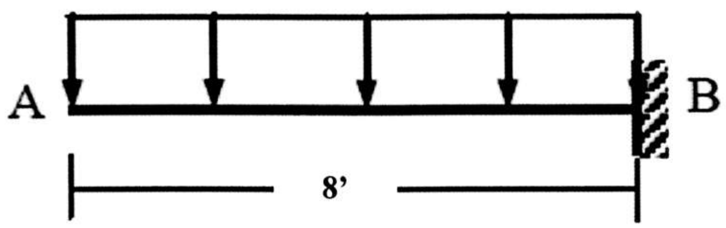
[Given: f_c' = 3 ksi, f_y = 60 ksi, f_{call} = 1.35 ksi, f_{sall}= 30, ksi for all questions unless stated otherwise]

[Assume reasonable values for any missing data]

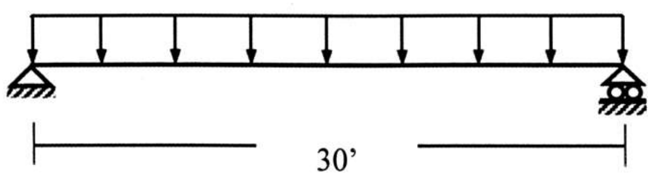
5. (i) Explain the difference between analysis and design of RC section (2)

(ii) Use the WSD or USD Method to design cantilever RC beam as doubly reinforced beam of (12″ × 16″) cross-section loaded as shown below, in addition to its self-weight assuming a steel ratio of $\rho_{max} = 0.75\,\rho_b$, and Ǿ =0.9 (8)

W_D=2 k/ft, W_{LL}=1.5 k/ft

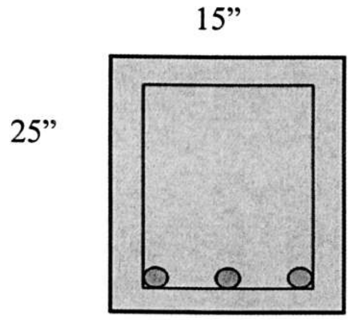


6. Using USD method, Design the following beam as T-beam loaded as shown below, in addition to its self-weight if it is part of a beam system at a transverse distance of 15′ c/c apart and carrying a 4″ thick slab (with FF = 45 psf, RW = 85 psf and LL = 150 psf, Ǿ =0.9) (10)



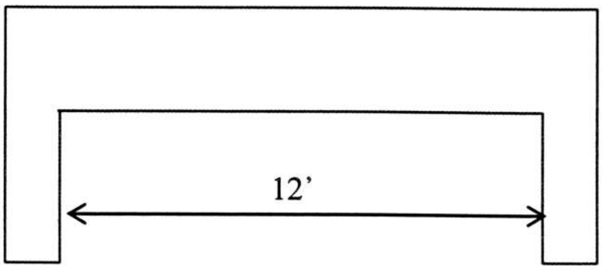
7. (i) What is Bond Force? Discuss the types of bond failure observed in bars RCC bars in tension. (2)

(ii) A beam section (b = 15″, h = 25″, d = 22″, clear cover for all sides = 1.5″), made of light-density concrete with f_c' = 4.5 ksi, is reinforced with epoxy coated 3#12 bars (f_y = 60 ksi), the reinforcement required from structural analysis is 4.25 in^2, in addition to #3 stirrups @6″c/c, Calculate the development length l_d of the bars, using given table in formula sheet. (*for transverse reinforcement, f_{tr} =50ksi, n=2*). (8)



8. (i) What is one-way slab? Narrate the necessity for temperature reinforcement in slabs. (2)

(ii)A RCC slab is built integrally with its support and consists of clear span of 12ft. Service live load is 120 psf. Design the slab by USD or WSD method. (8)



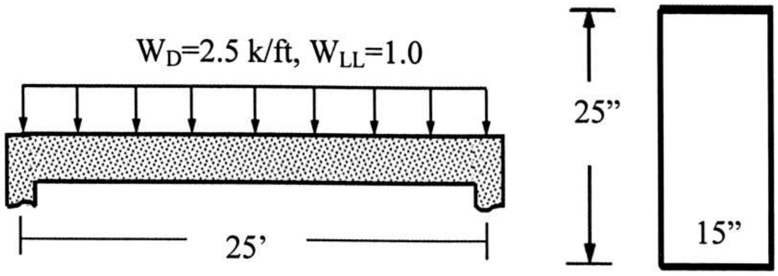
ACI moment coefficients for one-way slab -
At exterior face of interior support = -0.091wL^2
At interior face of exterior Support = -0.05wL^2
At mid span of the slab = +0.083wL^2

9. (i) A rectangular beam is to be designed to carry a shear force of V_u=35kip. What is the minimum cross section of beam if no web reinforcement is to be used? Ǿ =0.75 (2)

(ii) A simply supported rectangular beam of 20 inch width having an effective depth of 18.5 inch carries a total factored load of 11 k/ft on 25ft clear span. Determine the requirement of web reinforcement throughout the beam in WSD. Ǿ =0.75 (8)

10. (i) Explain Web-Shear crack and Flexure-Shear crack. Also explain which one of them is greater? (2)

(ii) Use the USD Method to design the vertical stirrups for the simply supported RC beam loaded as shown, in addition to self-weight. Column dimension =15” x15” (Assume, there are two layers of rod in main bar and Ǿ =0.75). (8)



List of Useful Formulae for CE 315

Fundamentals

* Tensile strength of concrete $f_t' = 7.5\sqrt{f_c'}$ $E_c = 57500\sqrt{f_c'}$ $E_s = 29 \times 10^6$ psi Modular ratio, $n = E_s/E_c$
* Within elastic limit, Flexural stress $f_c = M\,\bar{y}/\bar{I}$
* Steel Ratio $\rho_s = A_s/bd$ Minimum Steel Ratio $\rho_{min} = 3\sqrt{f_c'}/f_y$, often taken as $= 200/f_y$

WSD

* 'Cracked' elastic section Analysis: $k = -n\rho_s + \sqrt{[2n\rho_s + (n\rho_s)^2]}$ $j = 1 - k/3$

  Design: $k = n/(n + r)$ [where $r = f_{s(all)}/f_{c(all)}$] $j = 1 - k/3$
* Singly Reinforced Beam: $M_s = A_s f_s jd$ and $M_c = (f_c kj/2)\, bd^2 = R\, bd^2$
* Balanced Stress Steel Ratio $\rho_{sb} = k/2r$, when $M_s = M_c$
* Doubly Reinforced Beam: $M_1 = Rbd^2$, $A_{s1} = M_1/(f_s jd)$

  $M_2 = M - M_1$, $A_{s2} = M_2/[f_s(d-d')]$ and $A_s' = M_2/[f_s'(d-d')]$, where $f_s' = 2f_s(k - d'/d)/(1-k)$

f_c'(ksi)	≤ 4	4~8	≥ 8
α	0.72	$0.72 - 0.04\,(f_c' - 4)$	0.56
β	0.425	$0.425 - 0.025\,(f_c' - 4)$	0.325

* Balanced Steel Ratio $\rho_b = (\alpha f_c'/f_y)\,\{87/(87 + f_y)\}$

To calculate M_u, V_u, P_u, overload factors for DL, LL, W, EQ can be set as 1.2, 1.4, 1.6, 1.7, 1.87 respectively.

* Singly Reinforced Analysis: $a = A_s f_y/(0.85 f_c' b)$ $M_n = A_s f_y (d - a/2) = \rho_s f_y (1 - 0.59\,\rho_s f_y/f_c')\, bd^2$

  $c = A_s f_y/\alpha f_c' b$ $M_s = Tz = A_s f_y (d - \beta c)$
* Doubly Reinforced Analysis:

  $f_s' = 87\,(c - d')/c$ $a = (A_s - A_s')f_y/(0.85 f_c' b)$], and can be taken as $= A_s - A_s'$ to begin with]

  $A_{s2} = A_s' f_s'/f_y$, where $f_s' = E_s \times \varepsilon_t$

  from which A_{s1} can be revised as $= A_s - A_{s2}$ and a can also be revised accordingly

  $M_n = A_{s1} f_y (d - a/2) + A_{s2} f_y (d - d')$
* Design: Singly Reinforced if $M_n = \rho f_y (1 - 0.59\,\rho f_y/f_c')\, bd^2$

  $a = d\,[1 - \sqrt{\{1 - 2M_n/(f_c bd^2)\}}]$, $A_s = (0.85 f_c'\, ab)/f_y$

  Doubly Reinforced $M_1 = M_{max}$ $A_{s1} = \rho_{max}\, bd$,

  $M_2 = M_n - M_1$ $A_{s2} = M_2/f_y(d - d')$

  $c = A_{s1} f_y/(\alpha f_c' b)$ $c/d' = \varepsilon_c/(\varepsilon_c + \varepsilon_t)$ $A_s' = M_2/\{f_s'(d - d')\}$
* T-beam b_{eff} is the minimum of $L/4$, $(16t + b_w)$, and (c/c distance between adjacent beams)

  L-beam b_{eff} is the minimum of $(L/12 + b_w)$, $(6t + b_w)$, and (b_w + half the clear distance between adjacent beams)
* WSD Analysis: $k = \{n\rho_s + (t/d)^2/2\}/\{n\rho_s + (t/d)\}$ where $\rho_s\ (= A_s/b_{eff}d)$ $z = (3kd - 2t)/(2kd - t)\, t/3$

  $M_s = A_s f_s (d - z)$ $M_c = f_c\{1 - t/(2kd)\}(b_{eff}t)(d - z)$

  Design can start with $A_s \cong M_s/\{f_s(d - t/2)\}$ and follow the same equations
* USD Analysis: $A_{sf} = 0.85 f_c'(b_{eff} - b_w)t/f_y$ $M_{nf} = A_{sf} f_y (d - t/2)$

  $A_{sw} = A_s - A_{sf}$ $a = A_{sw} f_y/(0.85 f_c' b_w)$ $M_{nw} = A_{sw} f_y (d - a/2)$ } $M_n = M_{nf} + M_{nw}$

  Design: $A_{sf} = 0.85 f_c'(b_{eff} - b_w)t/f_y$, $M_{nf} = A_{sf} f_y (d - t/2)$; while A_{sw} can be obtained from $M_{nw} = M_n - M_{nf}$

  $a = d\,[1 - \sqrt{\{1 - 2M_n/(0.85 f_c' b_{eff} d^2)\}}]$ $\rho_s \le 0.75(\rho_b + \rho_{sf})$, and $\ge \rho_{min}$

$S = A_v f_v d (\sin\alpha + \cos\alpha)/(V_{ext} - V_c) = A_v f_v (\sin\alpha + \cos\alpha)/\{(v_{ext} - v_c) b\}$ for inclined stirrups

Summary of ACI Shear Design Provisions (Vertical Stirrups)

	WSD	USD	Additional Provisions
Design Shear Force	V_w	$V_n = V_u/\phi$ [$\phi = 0.75$]	Calculated at d from Support face
Min^m Section Depth	$V_w/5\sqrt{f_c'}b_w$	$V_u/8\sqrt{f_c'}b_w$	$f_y \le 60$ ksi
Concrete Shear Strength v_c	$1.1\sqrt{f'_c}$, $3\sqrt{f'_c}$, $5\sqrt{f'_c}$,	$2\sqrt{f'_c}$, $6\sqrt{f'_c}$, $10\sqrt{f'_c}$,	$\sqrt{f_c'} \le 100$ psi $Vd/M \le 1.0$
No Stirrup	$V_w \le V_c/2$	$V_n \le V_c/2$	
Max^m Spacing	d/2, 24" $S = A_v f_y /50 b_w$	d/2, 24" $S = A_v f_y /50 b_w$	To be halved if $V_n \ge 4\sqrt{f_c'}b_w d$ OR $V_w \ge 2\sqrt{f_c'}b_w d$ in WSD

$$l_d/d_b = (3/40)\,(f_y/\sqrt{f_c'})\,(\alpha\beta\gamma\lambda)/\{(c + K_{tr})/d_b\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots$$

where the term $(c + K_{tr})/d_b$ is ≤ 2.5. The terms in Eq. (10.1) are defined in Table 10.1

Table 10.1: Parameters of Development Length of Tension Bars

Symbol	Parameter	Variable	Value
α	Reinforcement Location Factor	* Horizontal Reinforcement over ≥ 12" concrete * Other Reinforcement	1.3 1.0
β	Coating Factor	* Epoxy-coated bars with cover <$3d_b$ or clear spacing <$6d_b$ * All other epoxy-coated bars or wires * Uncoated bars * Maximum value of $\alpha\beta$	1.5 1.2 1.0 1.7
γ	Reinforcement Size Factor	* ≥ #7 bars * ≤ #6 bars and deformed wires	1.0 0.8 (?)
λ	Lightweight Aggregate Concrete Factor	* When lightweight aggregate concrete is used * When normal-weight concrete is used	1.3 1.0
c	Spacing or Cover Dimension (in)	* Bar center to nearest concrete cover * One-half the c/c spacing of bars	Smaller than both
K_{tr}	Transverse Reinforcement Index	S = Maximum spacing of transverse reinforcement A_{tr} = Area of all transverse reinforcement within S f_{tr} = Yield strength of transverse reinforcement, ksi n = No. of bars being developed along the plane of splitting	$A_{tr}f_{tr}/(1.5Sn)$

Table 9.1: Minimum Thickness of Non-Prestressed One-way Slabs (for f_y = 60 ksi)

Simply Supported	One end continuous	Both ends continuous	Cantilever
$L/20$	$L/24$	$L/28$	$L/10$

Table 9.2: Minimum Ratios of Temperature and Shrinkage Reinforcement in Slabs

Slabs with f_y = 40 or 50 ksi	0.0020
Slabs with $f_y \ge 60$ ksi	$0.0018 \times (60/f_y) \ge 0.0014$

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B.Sc. Engineering (Civil)

Section B

Course Title: Design of Concrete Structures I
Time: 3.0 hr

Course Code: CE 315(B)
Full Marks: 70

******Answer Section A and Section B on separate answer scripts******

Section A

[Answer any three (03) out of following four (04) questions]

Full Marks: 10 [=3*(10)]

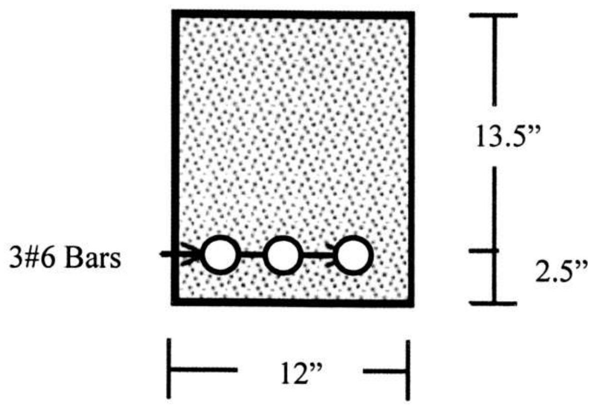
[Given: $f_c' = 3$ ksi, $f_y = 60$ ksi, $f_{call} = 1.35$ ksi, $f_{sall} = 30$ ksi, for all questions of this section unless stated otherwise]

[Assume reasonable values for any missing data]

1. (i) What is RC? Explain why steel and concrete are used in conjunction in RC. (2)

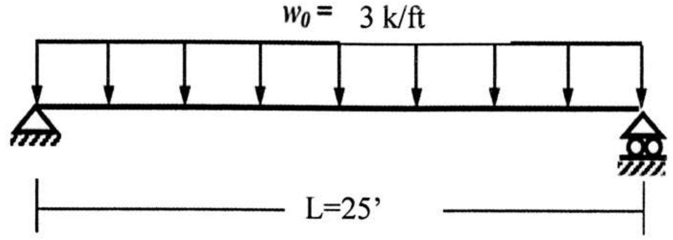
   (ii) Calculate the 'Cracking' positive moment capacity of the RC cross-sectional area shown. (4)

   (iii) Also calculate corresponding compressive stress in concrete and tensile stress in steel. (4)

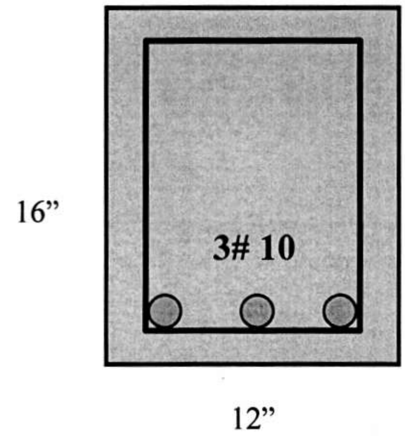


2. (i) What is USD method of RC design? Mention its differences from WSD method. (2)

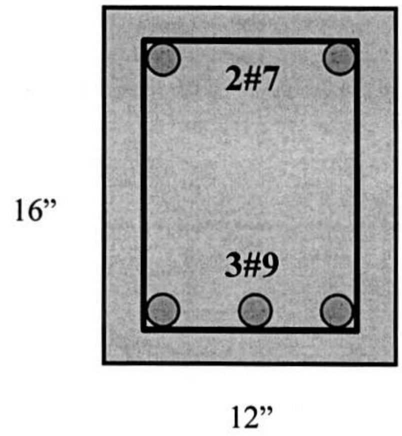
   (ii) Use WSD or USD Method to design the simply supported singly reinforced RC beam as shown, consider self-weight of the beam section. Check minimum steel ratio also. (8)



3. Calculate the Ultimate moment capacity of the reinforced beam sections shown below (Ó=0.9) (10)



Section 1



Section 2

4. (i) What is the balanced steel ratio? Why ACI recommends a maximum steel ratio less than ρ_b ? (2)

(ii) For a beam section (with beam width b = 15″) subject to applied ultimate moment M_u = 150 k-ft, calculate the

(a) Minimum depth of the section and steel area assuming steel ratio to be equal to $\rho_{max} = 0.75\,\rho_b$ (4)

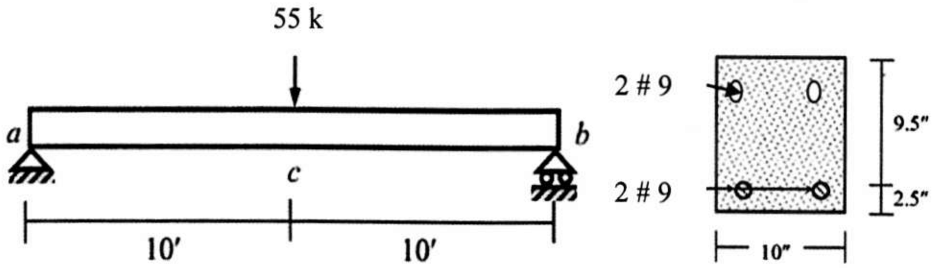
(b) Steel reinforcement if the beam height (h) is fixed at 20″ (4)

Section B

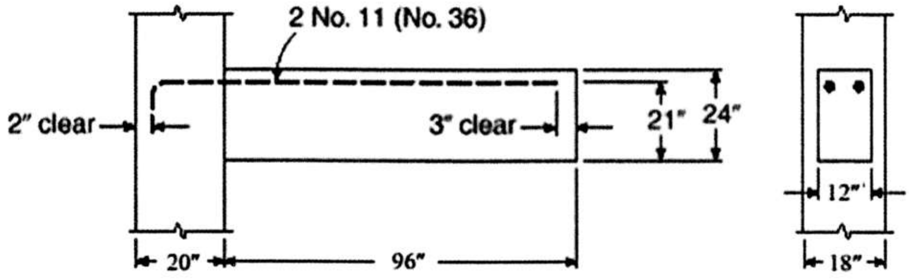
[Answer any **four** (04) out of following **Six** (06) questions]
Full Marks: 40 [=4*(10)]
[Assume reasonable values for any missing data]

5. A floor system consists of a 4 in. concrete slab supported by continuous T beams with a 25 ft span, 50 in. on centers. What tensile steel area is required at midspan to resist a factored moment of 550 k-ft? Follow USD method [Given that f_c' = 3 ksi, f_y = 60 ksi, b_w = 12″ and d=20″]. [10]

6. Design the web reinforcement for the beam shown below using USD or WSD method [Given that f_c' = 3 ksi, f_y = 60 ksi, f_{call} = 1.35 ksi, f_{sall}= 24 ksi]. [10]

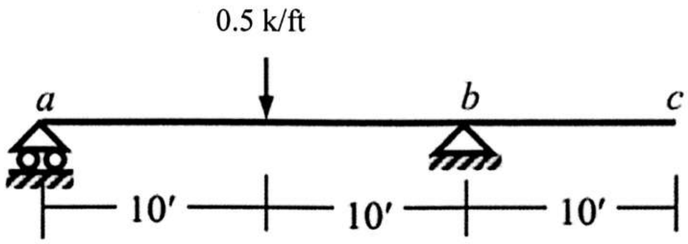


7. (a) The tensile flexural reinforcement required in the cantilever beam shown below is A_s = 2.80 in^2, which is provided by two #11 bars (for d = 21″), while #3 transverse reinforcements with 1.5″ cover are provided starting at 4″ from column face, with 3 @ 8″c/c and 5 @ 10″c/c. Check if the #11 bars (shown in figure below) are provided adequate development length in the beam. [07]



(b) Explain why the development length of compression bars is smaller than that of tension bars. [03]

8. Design the RC slab shown below supported on 10″ thick walls a and b (carrying FF = 30 psf, PW = 60 psf + 0.5 k/ft at midspan of ab, LL = 60 psf, in addition to self weight) using design moments. Follow USD or WSD method. [10]
[Given: Thickness of the slab = 9″, f_c' = 3 ksi, f_y = 60 ksi, f_{call} = 1.35 ksi, f_{sall}= 24 ksi, No need to check d_{req} and shear].



9. (a) Explain why flexural reinforcement bars are not cut off exactly where they are not theoretically required. [04]
(b) Do you think that T beam can be a doubly reinforced beam? Explain. [03]
(c) Mention the conditions where slab has to be designed as one way slab. [03]

10. A simply supported rectangular beam 14″ wide having an effective depth of 24″, carries a total factored load of 8 k/ft on a 16 ft clear span. If f_c' = 3 ksi and f_y = 60 ksi, throughout what part of the beam is web reinforcement required? [10]

List of Useful Formulae for CE 315

Fundamentals

* Tensile strength of concrete $f_t' = 7.5\sqrt{f_c'}$ $E_c = 57500\sqrt{f_c'}$ $E_s = 29 \times 10^6$ psi Modular ratio, $n = E_s/E_c$
* Within elastic limit, Flexural stress $f_c = M\,\bar{y}/\bar{I}$
* Steel Ratio $\rho_s = A_s/bd$ Minimum Steel Ratio $\rho_{min} = 3\sqrt{f_c'}/f_y$, often taken as $= 200/f_y$

WSD

* 'Cracked' elastic section Analysis: $k = -n\rho_s + \sqrt{[2n\rho_s + (n\rho_s)^2]}$ $j = 1 - k/3$

  Design: $k = n/(n + r)$ [where $r = f_{s(all)}/f_{c(all)}$] $j = 1 - k/3$
* Singly Reinforced Beam: $M_s = A_s f_s jd$ and $M_c = (f_c kj/2)\,bd^2 = R\,bd^2$
* Balanced Stress Steel Ratio $\rho_{sb} = k/2r$, when $M_s = M_c$
* Doubly Reinforced Beam: $M_1 = Rbd^2$, $A_{s1} = M_1/(f_s jd)$

  $M_2 = M - M_1$, $A_{s2} = M_2/[f_s(d-d')]$ and $A_s' = M_2/[f_s'(d-d')]$, where $f_s' = 2f_s(k - d'/d)/(1-k)$

USD

f_c'(ksi)	≤ 4	4~8	≥ 8
α	0.72	$0.72 - 0.04\,(f_c' - 4)$	0.56
β	0.425	$0.425 - 0.025\,(f_c' - 4)$	0.325

* Balanced Steel Ratio $\rho_b = (\alpha f_c'/f_y)\,\{87/(87 + f_y)\}$

To calculate M_u, V_u, P_u, overload factors for DL, LL, W, EQ can be set as 1.2, 1.4, 1.6, 1.7, 1.87 respectively.

* Singly Reinforced Analysis: $a = A_s f_y/(0.85 f_c' b)$ $M_n = A_s f_y (d - a/2) = \rho_s f_y (1 - 0.59\,\rho_s f_y/f_c')\,bd^2$

  $c = a/\beta_1$
* Dou $c = A_s f_y/\alpha f_c' b$ $M_s = Tz = A_s f_y (d - \beta c)$

  $a = A_{s1} f_y/(0.85 f_c' b)$ [where $A_{s1} = A_s - A_{s2}$, and can be taken as $= A_s - A_s'$ to begin with]

  $f_s' = 87\,(c - d')/c$ $a = (A_s - A_s')f_y/(0.85 f_c' b)$

  from which A_{s1} can be revised as $= A_s - A_{s2}$ and a can also be revised accordingly

  $M_n = A_{s1} f_y (d - a/2) + A_{s2} f_y (d - d')$
* Design: Singly Reinforced if $M_n = \rho f_y (1 - 0.59\,\rho f_y/f_c')\,bd^2$

  $a = d\,[1 - \sqrt{\{1 - 2M_n/(f_c bd^2)\}}]$, $A_s = (0.85 f_c'\,ab)/f_y$

  Doubly Reinforced $M_1 = M_{max}$ $A_{s1} = \rho_{max}\,bd$,

  $M_2 = M_n - M_1$ $A_{s2} = M_2/f_y(d - d')$

  $c = A_{s1} f_y/(\alpha f_c' b)$ $c/d' = \varepsilon_c/(\varepsilon_c + \varepsilon_t)$ $A_s' = M_2/\{f_s'(d - d')\}$

T beam

* T-beam b_{eff} is the minimum of L/4, $(16t + b_w)$, and (c/c distance between adjacent beams)

  L-beam b_{eff} is the minimum of $(L/12 + b_w)$, $(6t + b_w)$, and (b_w + half the clear distance between adjacent beams)
* WSD Analysis: $k = \{n\rho_s + (t/d)^2/2\}/\{n\rho_s + (t/d)\}$ where $\rho_s\,(= A_s/b_{eff}d)$ $z = (3kd - 2t)/(2kd - t)\,t/3$

  $M_s = A_s f_s (d - z)$ $M_c = f_c\{1 - t/(2kd)\}(b_{eff}t)(d - z)$

  Design can start with $A_s \cong M_s/\{f_s(d - t/2)\}$ and follow the same equations
* USD Analysis: $A_{sf} = 0.85 f_c'(b_{eff} - b_w)t/f_y$ $M_{nf} = A_{sf} f_y (d - t/2)$

  $A_{sw} = A_s - A_{sf}$ $a = A_{sw} f_y/(0.85 f_c' b_w)$ $M_{nw} = A_{sw} f_y (d - a/2)$ } $M_n = M_{nf} + M_{nw}$

  Design: $A_{sf} = 0.85 f_c'(b_{eff} - b_w)t/f_y$, $M_{nf} = A_{sf} f_y (d - t/2)$; while A_{sw} can be obtained from $M_{nw} = M_n - M_{nf}$

  $a = d\,[1 - \sqrt{\{1 - 2M_n/(0.85 f_c' b_{eff} d^2)\}}]$ $\rho_s \le 0.75(\rho_b + \rho_{sf})$, and $\ge \rho_{min}$

Table 10.1: Parameters of Development Length of Tension Bars

Symbol	Parameter	Variable	Value
α	Reinforcement Location Factor	* Horizontal Reinforcement over ≥ 12″ concrete * Other Reinforcement	1.3 1.0
β	Coating Factor	* Epoxy-coated bars with cover <$3d_b$ or clear spacing <$6d_b$ * All other epoxy-coated bars or wires * Uncoated bars * Maximum value of $\alpha\beta$	1.5 1.2 1.0 1.7
γ	Reinforcement Size Factor	* ≥ #7 bars * ≤ #6 bars and deformed wires	1.0 0.8 (?)
λ	Lightweight Aggregate Concrete Factor	* When lightweight aggregate concrete is used * When normal-weight concrete is used	1.3 1.0
c	Spacing or Cover Dimension (in)	* Bar center to nearest concrete cover * One-half the c/c spacing of bars	Smaller than both
K_{tr}	Transverse Reinforcement Index	S = Maximum spacing of transverse reinforcement A_{tr} = Area of all transverse reinforcement within S f_{tr} = Yield strength of transverse reinforcement, ksi n = No. of bars being developed along the plane of splitting	$A_{tr} f_{tr}/(1.5Sn)$

$$l_d/d_b = (3/40)\,(f_y/\sqrt{f_c'})\,(\alpha\beta\gamma\lambda)/\{(c + K_{tr})/d_b\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots$$

where the term $(c + K_{tr})/d_b$ is ≤ 2.5. The terms in Eq. (10.1) are defined in Table 10.1

Table 10.2: Simplified Equations for Basic Development Length (Tension)

Condition	$(c + K_{tr})/d_b$	l_d
Avoid pullout failure (Experimentally derived limit)	2.5	$0.03\,(f_y/\sqrt{f_c'})d_b$
* Clear cover and Clear spacing ≥ d_b + Code required stirrups * Clear cover and Clear spacing ≥ $2d_b$	1.5	$0.05\,(f_y/\sqrt{f_c'})d_b$ (≥ #7 Bars) $0.04\,(f_y/\sqrt{f_c'})d_b$ (≤ #6 Bars and deformed wires) (?)

TABLE A.1
Designations, diameters, areas, and weights of standard bars

Bar No. Inch-Pound[a]	SI[b]	Diameter, in.	Cross-Sectional Area, in^2	Nominal Weight, lb/ft
3	10	$\frac{3}{8}$ = 0.375	0.11	0.376
4	13	$\frac{1}{2}$ = 0.500	0.20	0.668
5	16	$\frac{5}{8}$ = 0.625	0.31	1.043
6	19	$\frac{3}{4}$ = 0.750	0.44	1.502
7	22	$\frac{7}{8}$ = 0.875	0.60	2.044
8	25	1 = 1.000	0.79	2.670
9	29	$1\frac{1}{8}$ = 1.128[c]	1.00	3.400
10	32	$1\frac{1}{4}$ = 1.270[c]	1.27	4.303
11	36	$1\frac{3}{8}$ = 1.410[c]	1.56	5.313
14	43	$1\frac{3}{4}$ = 1.693[c]	2.25	7.650
18	57	$2\frac{1}{4}$ = 2.257[c]	4.00	13.600

Shear Design

* $S = A_v f_v d/(V_{ext} - V_{cr}) = A_v f_v/\{(v_{ext} - v_c) b\}$ for vertical stirrups, and

$S = A_v f_v d (\sin\alpha + \cos\alpha)/(V_{ext} - V_c) = A_v f_v (\sin\alpha + \cos\alpha)/\{(v_{ext} - v_c) b\}$ for inclined stirrups

Summary of ACI Shear Design Provisions (Vertical Stirrups)

	WSD	USD	Additional Provisions
Design Shear Force	V_w	$V_n = V_u/\phi$ [$\phi = 0.75$]	Calculated at d from Support face
Min^m Section Depth	$V_w/5\sqrt{f_c'}b_w$	$V_u/8\sqrt{f_c'}b_w$	$f_y \le 60$ ksi
Concrete Shear Strength v_c	$1.1\sqrt{f_c'}$	$2\sqrt{f'_c}$, $6\sqrt{f'_c}$, $10\sqrt{f'_c}$,	$\sqrt{f_c'} \le 100$ psi $Vd/M \le 1.0$
No Stirrup	$V_w \le V_c/2$	$V_n \le V_c/2$	
Max^m Spacing	d/2, 24" $S = A_v f_y/50b_w$	d/2, 24" $S = A_v f_y/50b_w$	To be halved if $V_n \ge 4\sqrt{f_c'}b_w d$ OR $V_w \ge 2\sqrt{f_c'}b_w d$ in WSD

Table 9.1: Minimum Thickness of Non-Prestressed One-way Slabs (for f_y = 60 ksi)

Simply Supported	One end continuous	Both ends continuous	Cantilever
L/20	*L*/24	*L*/28	*L*/10

Table 9.2: Minimum Ratios of Temperature and Shrinkage Reinforcement in Slabs

Slabs with f_y = 40 or 50 ksi	0.0020
Slabs with $f_y \ge 60$ ksi	$0.0018 \times (60/f_y) \ge 0.0014$

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B. Sc. Engineering (Civil)

Course Title: Environmental Engineering I — Course Code: CE 331

Time- 3 hours — Full marks: 100

Question No. 1 is compulsory. Answer any FOUR from the rest. ***(20*5 = 100)***
(Note: Assume any missing data)

1. (a) A community needs to maintain a flow rate of 2 MGD in the treatment plant. Design a flocculation basis for the plant where flow is evenly split between two flocculator trains each with three tanks; Detention time 30 minutes; Depth 4 m; Flocculator G for tanks: 70, 50 and 30 s^{-1} (8)

(b) Explain the technique and parameters to be used to select the most productive zone of the aquifer. How can you clean the perforations of a tubewell screen and remove the incrustations near the screen? (4+3)

(c) Design a strainer for a 38 mm diameter tubewell to be operated by a No. 6 hand pump at the rate of 40 lpm. A 40 slot size strainer having a 20% opening area is to be used. The entrance velocity should be around 0.01 m/sec. (5)

2 (a) Define potable and palatable water. Which chemicals are suitable for water softening? (4)

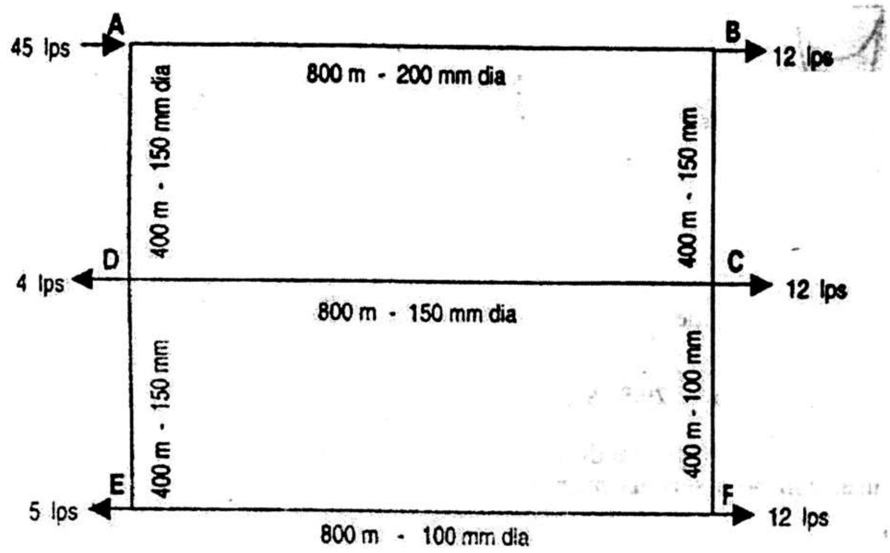
(b) What are the pump selecting considerations? Explain with figure that the operating capacity is not doubled when the two pumps are added in parallel. (7)

(c) What power must be supplied by the pump to the flow if water ($\nu = 10^{-6}$ m^2/s) is pumped through the 300 mm steel pipe ($\varepsilon = 0.046$ mm, L = 140 m) from the lower tank (Elevation = 200 m) to the upper one (elevation = 235 m) at a rate of 0.314 m^3/s? [Assume, $K_{entrance} = 0.03$, $K_{bend} = 0.35$, $K_{exit} = 1$] (9)

3. (a) What is break point chlorination? Explain with figure. (5)

(b) List down the methods of drilling of a tubewell. (2)

(c) Calculate the flow in each of the pipes in the following looped pipe network (using Hardy Cross method and two trials are required): (13)



4. (a) Compare between Branched network and looped network. (3)

(b) Write short notes on : i) Salt water intrusion in coastal areas; ii) Well development (6)

(c) Design the appropriate details of a well following the given steps and according to the data provided below:

i) Find out the water bearing/most productive part of the aquifer (depth range) from the given grain size distribution summary at different depths (table 1) showing suitable reasoning. (3)

ii) Find out the length of the casing pipe, considering static water level at 250 ft, drawdown of 15 ft with water level declination of 2.5 ft per year, design life of 30 years and a safe distance of 10 ft. Assume, 80% of the aquifer screening can be made and find out the length of the strainer. (2)

iii) Using a graph paper, design gravel pack material using the attached gradation chart for the finest layer and complete table 2 (also mention the diameter of the gravel pack. Find out the strainer size (slot size). (6)

5 (a) What are pump characteristics curves? Show them in a qualitative plot. (5)

(b) Mention the factors on which the dosage of a coagulant depends on. Design (indicate diameter and depth in meters) a circular settling basin for the plant mentioned in 1(a) using an overflow rate of 40 m^3/m^2-day and detention time of 4 hours. (2+7)

(c) Below is given the rain water availability mass curve which assumes that the cumulative consumption/demand at a constant rate is equal to total available (6) rainwater. From the figure, estimate the capacity of storage tank for full utilization of the rainwater and therefore determine the fraction (f) of the total available rainfall that is stored.

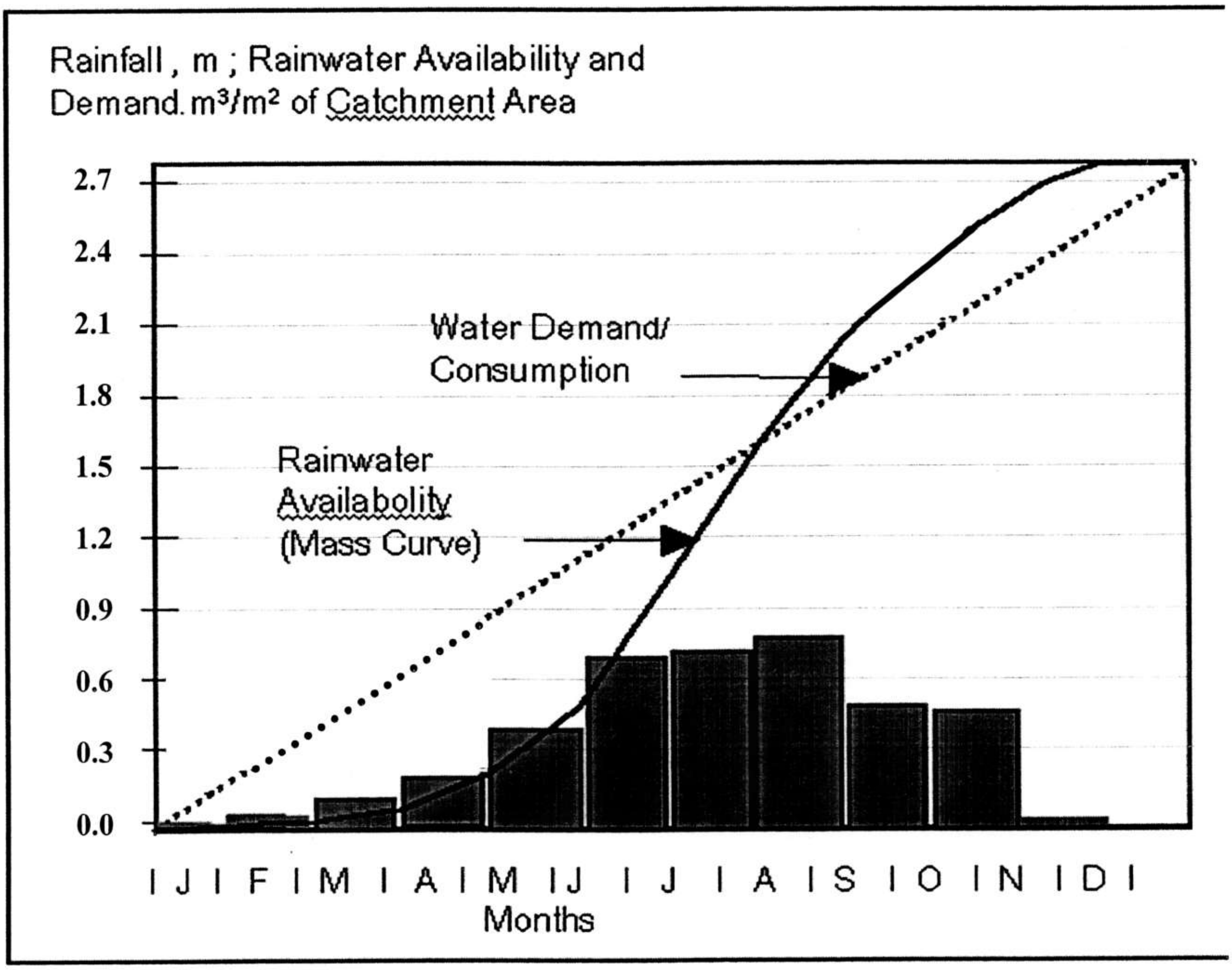


Figure: Rainfall intensity, cumulative rainwater availability and demand

Given Formulae:

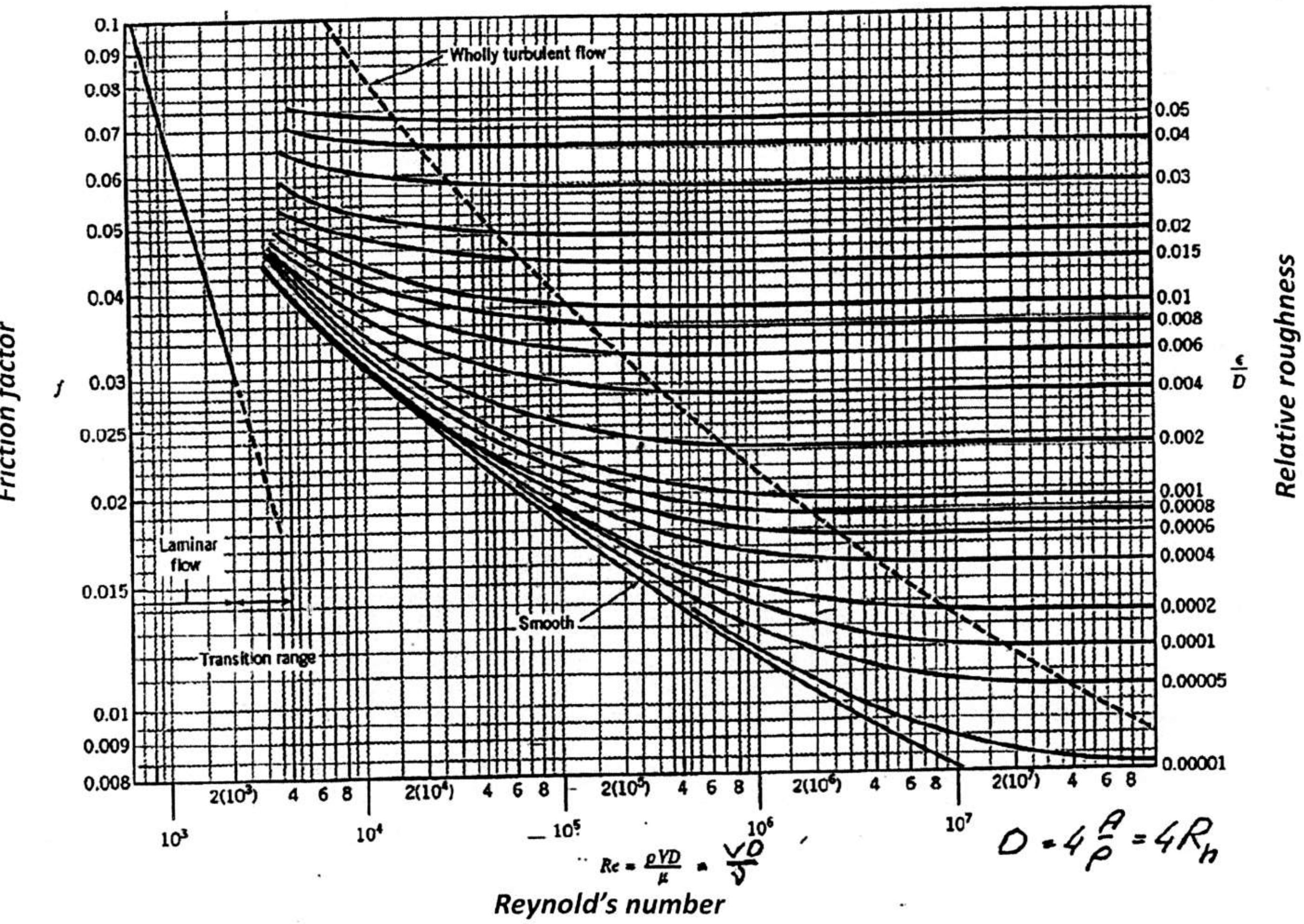
I. Water Horse Power of pump = (w. Q. H) / 75
Where, w = Specific weight of water in kg/m^3
Q = Pump discharge in m^3/sec

II. Brake Horse Power of pump = Water Horse Power / (efficiency of pump) x (efficiency of motor)

$$G = \sqrt{\frac{P}{uV}}$$

$$Q = \pi D L (0.01p) v_c$$

Moody's diagram



Head loss due to friction $= f \frac{L}{D} \frac{V^2}{2g}$

$$h_L = 1.39 \times 10^6 Q^{1.85} D^{-4.87}$$ *(when C = 130)*

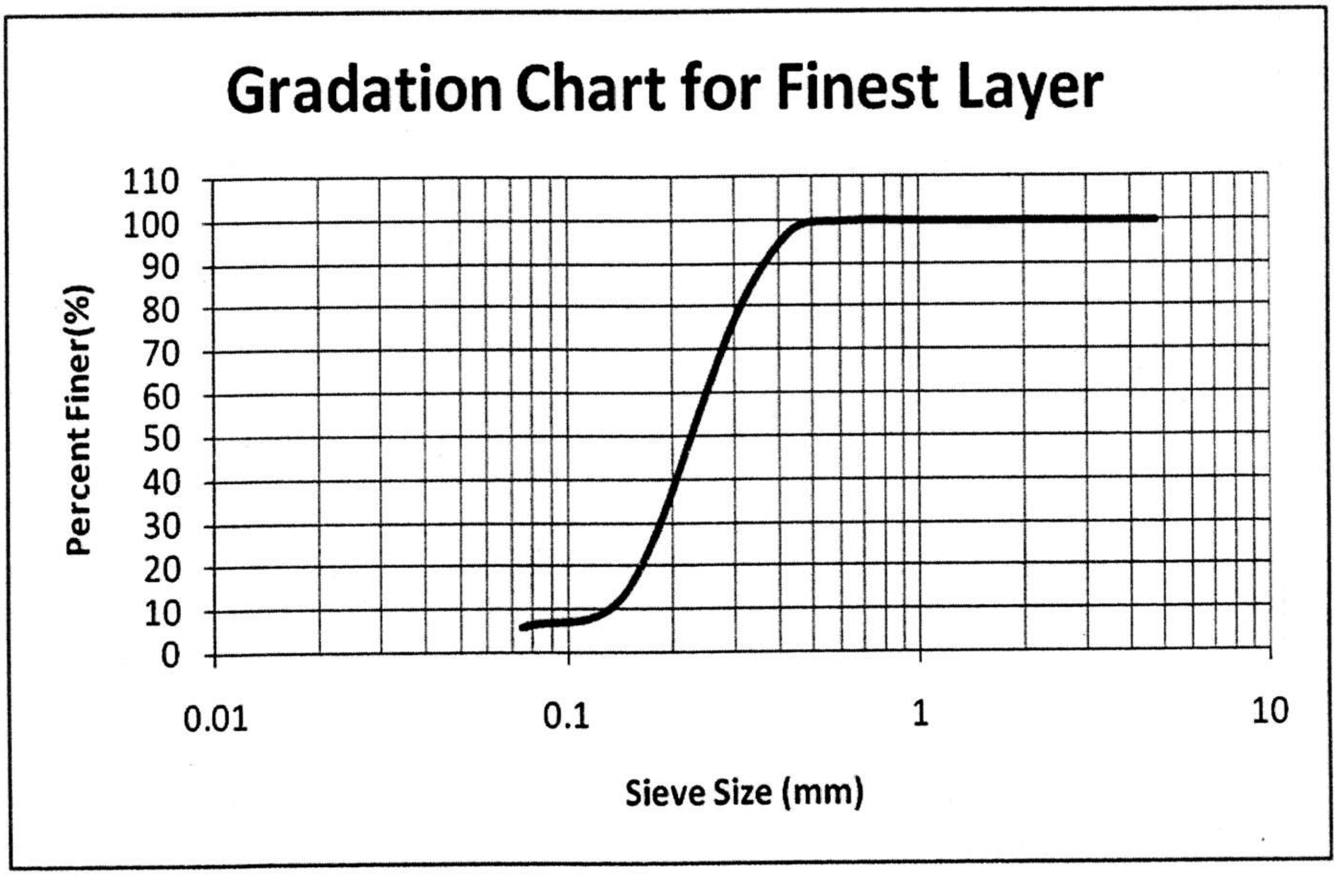
$$\Delta = -\frac{\sum H}{x \sum H / Q_a}$$

Table 1: Summary of Grain Size Test Results

Sample depth	D_{10}	D_{30}	$U= D_{60}/D_{10}$	% of Coarse Sand	% of Medium Sand	% of Fine Sand	FM
(ft)	mm	mm		%	%	%	
240	0.17	0.25	1.4	0.5	89.5	20	1.5
260	0.18	0.24	1.46	0.5	89.5	20	1.49
280	0.2	0.3	1.3	4	86	10	1.68
300	0.15	0.24	1.58	12	68	20	1.60
320	0.18	0.25	1.52	2	82	16	1.56
340	0.18	0.27	1.11	10	75	15	1.67
360	0.15	0.22	1.55	1	76	23	1.38
380	0.16	0.21	1.38	0.5	75	24	1.30

Table 2: The relevant size of sieves and further information for gravel pack material

Sieve No.	Size (mm)	% Finer from graph	Cumulative % retained	% reatained	Range of % reatained
4	4.75				
8	2.36				
16	1.18				
30	0.6				
40	0.425				
50	0.3				
100	0.15				
200	0.075				



University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B.Sc. Engineering (Civil)

Course Title: Geotechnical Engineering I — Course Code: CE 341
Time: 3 hours — Full Marks: 100

Section A

There are 5 questions. Answer any 4 questions. **(4x13=52 marks)**

1. (a) Briefly discuss on the gradation of coarse grained soil and different coefficients used for this purpose in unified soil classification system. 3
   (b) Derive the expression to calculate total flow-rate (per meter length) below the sheet pile wall, taking the advantage of flow-net. 5
   (c) Determine compression index, swelling index, coefficient of compressibility, coefficient of volume compressibility and coefficient of consolidation for the following records. 5
   In a consolidation test, the pressure on a sample was increased from 150 to 300 kN/m^2. The void ratio after 100% consolidation under 150 kN/m^2 was 0.845 and that under 300 kN/m^2 was 0.712. The coefficient of permeability was $2x10^{-6}$ mm/s.

2. (a) Differentiate between two types of consolidation settlement. Mention the field conditions of expecting each of these settlements. 3
   (b) Derive the expression of settlement calculation for a clay soil, which was initially in normally consolidated state. 5
   (c) Sketch (schematically) the test set up of direct shear test and show the directions of normal load (P) and shear load (Q). Draw the Mohr-Coulomb failure envelop from the results of direct shear test conducted on cohesionless soil. 3
   (d) Draw a typical Mohr circle representing the data of unconfined compressive strength test. Show the relation between unconfined compressive strength and unconfined cohesion. 2

3. (a) Draw the flow curves obtained from liquid limit test on soil A and soil B. Given that LL of soil A is higher than that of soil B. 3
   (b) Derive the expression of coefficient of passive earth pressure (K_p) for cohesionless soil. 5
   (c) Draw typical shear stress versus shear displacement curve for loose and dense sand. 2
   (d) Draw Mohr circles for at-rest, active and passive earth pressure conditions, and also the Mohr-Coulomb failure envelope for cohesionless soil. 3

4. (a) Calculate total stress and pore water pressure for the following levels. 4
   (i) Level-1: Effective stress is 120 kPa; Water table is below this level
   (ii) Level-2: Effective stress is 320 kPa; Water table is 2 m above this level
   Also find the location (depths below the ground level) of both the levels, if soil is homogeneous, $\gamma_{moist} = 15$ kN/m^3 and $\gamma_{sat} = 16.5$ kN/m^3.
   (b) Compute OCR and pre-consolidation pressure at point A in the following timeline. The 4

following data presents the stress-states of that point.

(a) In the year 2007, the soil, supporting a structure, was normally consolidated. $\sigma_{present}' = 650$ kPa.

(b) In 2010, the old structure was demolished. $\sigma_{present}' = 250$ kPa.

(c) In January 2011, new construction commenced. $\sigma_{present}' = 340$ kPa.

(d) In 2014, due to progress of the construction project, $\sigma_{present}' = 480$ kPa.

(c) Derive the relation between degree of saturation, void ratio, water content and specific gravity. 5

5. (a) A 3 m layer (double drainage) of saturated clay under a surcharge loading underwent 90% primary consolidation in 75 days. Find the coefficient of consolidation of clay for the pressure range. How long will it take to undergo 90% consolidation for a similar consolidation pressure range? The laboratory test sample will have two-way drainage. 4

(b) Write Bernoulli's equation and Darcy's law for a soil media. 2

(c) Briefly discuss on pressure bulb and Isobars, with sketch. 3

(d) Briefly discuss on the following for fine grained soil: 4

(i) Atterberg's Limits

(ii) Consolidation and permeability

Section B

There are seven questions. Answer any 6 questions. (6x8 = 48 marks)

6. A consolidated undrained test was conducted on a clay sample and the following results were obtained. 8

Determine the shear strength parameters for the given soil with respect to effective stress.

Deviator stress at failure (kN/m^2)	Confining pressure (kN/m^2)	Pore water pressure (kN/m^2)
118	200	110
240	400	220
352	600	320

7. A rectangular foundation (1.5 m x 2 m) transmits a uniform pressure 250 kN/m^2 to the underlying soil. Determine the vertical stress at a depth of 4 m below a point A shown in the figure. 8

Use the influence chart for vertical stress below corner of rectangular load attached.

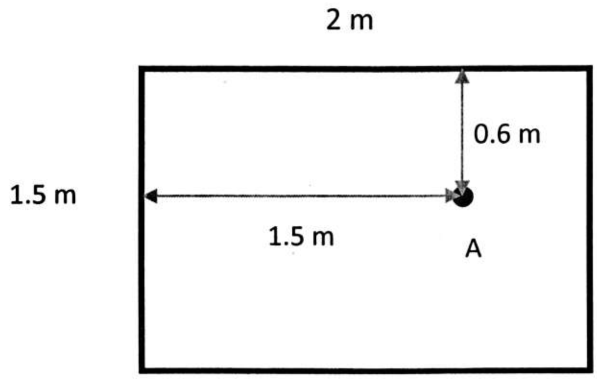


Figure 1

8. A soil stratum with permeability, k= 5×10^{-7} cm/sec overlies an impermeable stratum. The impermeable stratum lies at a depth of 7 m below the ground surface. A sheet pile wall penetrates 3.5 m into the permeable soil stratum. Water stands to a height of 3 m on upstream side and 1.75 m on downstream side, above the surface of soil stratum. Use the flownet sketched as below: 8
   - (i) Identify the boundary flowlines and the boundary equipotential lines of the flownet,
   - (ii) Determine the seepage pressure at point C (the lowest point of the sheet pile),
   - (iii) Determine the seepage loss per day (flow rate) considering the two-dimensional flow.
   - (iv) Determine the average hydraulic gradient below the sheet pile wall.

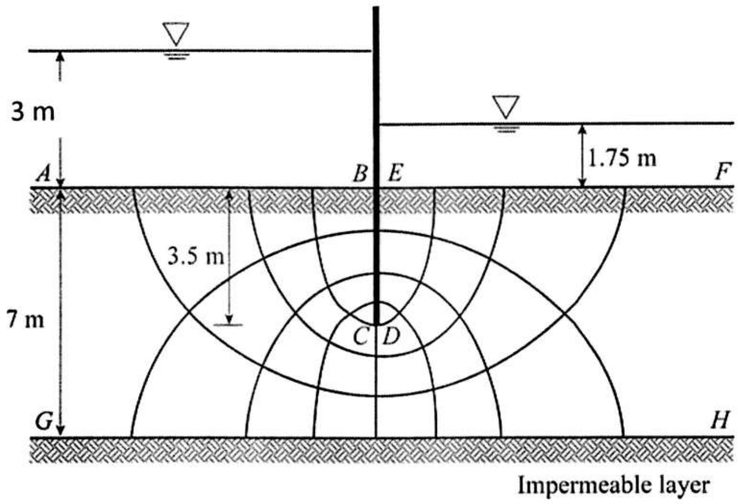


Figure 2

9. Classify the following soils:

(a) Percent finer than 0.075 mm = 62 4

Percent of coarse fraction passing 4.75 mm sieve = 62

Liquid limit = 45%

Plastic limit = 25%

(b) Percent of soil material in the pan = 4.5 **4**
Percent of coarse fraction passing 4.75 mm sieve = 60
30% of the total soil material having a diameter less than 1.18 mm
10% of the total soil material having a diameter less than 0.3 mm
Liquid limit = 23%
Plastic limit = 23%

10. Draw the lateral pressure diagrams on the sheet pile wall for the following conditions: **8**
(i) Active condition,
(ii) Passive condition.

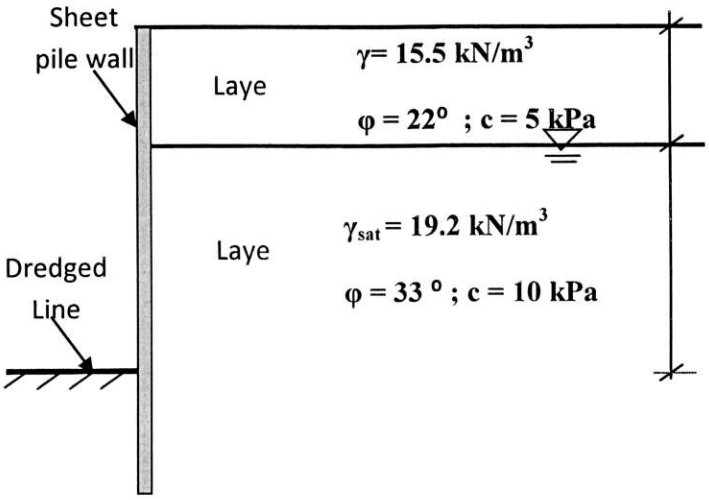


Figure 3

11. Calculate total consolidation settlement of soil profile composed of two different types of clay, i.e. Clay I and Clay II due to 150 kPa net foundation loading. Increase in stress at the mid depth of clay layer-I is 88 kPa; Increase in stress at the mid depth of clay layer II is 41 kPa. **8**

Note that σ'_p denotes pre-consolidation pressure.

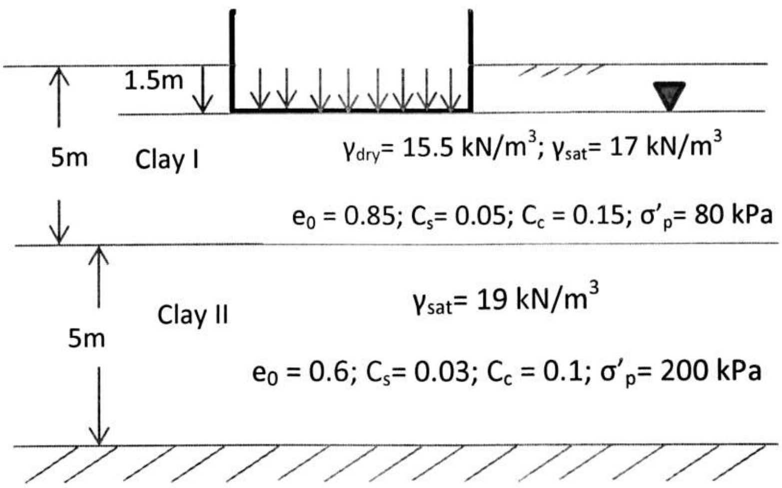


Figure 4

12. The following observations were made in a Standard Proctor Test. Determine maximum dry density and optimum moisture content. Also plot zero air void line. 8
Volume of Mold = 945 cc; G_s = 2.67.

Bulk density (kg/m^3)	**Water content (%)**
1799	7.7
2000	11.5
2149	14.6
2105	17.5
2074	19.7
2031	21.2

Use the equation of zero air void line as follows: $\gamma_d = \frac{G_s\,\gamma_w}{1+w.G_s}$

Table 5.2 Variation of Influence Value I [Eq. (5.6)][a]

m	n = 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4
0.1	0.00470	0.00917	0.01323	0.01678	0.01978	0.02223	0.02420	0.02576	0.02698	0.02794	0.02926	0.03007
0.2	0.00917	0.01790	0.02585	0.03280	0.03866	0.04348	0.04735	0.05042	0.05283	0.05471	0.05733	0.05894
0.3	0.01323	0.02585	0.03735	0.04742	0.05593	0.06294	0.06858	0.07308	0.07661	0.07938	0.08323	0.08561
0.4	0.01678	0.03280	0.04742	0.06024	0.07111	0.08009	0.08734	0.09314	0.09770	0.10129	0.10631	0.10941
0.5	0.01978	0.03866	0.05593	0.07111	0.08403	0.09473	0.10340	0.11035	0.11584	0.12018	0.12626	0.13003
0.6	0.02223	0.04348	0.06294	0.08009	0.09473	0.10688	0.11679	0.12474	0.13105	0.13605	0.14309	0.14749
0.7	0.02420	0.04735	0.06858	0.08734	0.10340	0.11679	0.12772	0.13653	0.14356	0.14914	0.15703	0.16199
0.8	0.02576	0.05042	0.07308	0.09314	0.11035	0.12474	0.13653	0.14607	0.15371	0.15978	0.16843	0.17389
0.9	0.02698	0.05283	0.07661	0.09770	0.11584	0.13105	0.14356	0.15371	0.16185	0.16835	0.17766	0.18357
1.0	0.02794	0.05471	0.07938	0.10129	0.12018	0.13605	0.14914	0.15978	0.16835	0.17522	0.18508	0.19139
1.2	0.02926	0.05733	0.08323	0.10631	0.12626	0.14309	0.15703	0.16843	0.17766	0.18508	0.19584	0.20278
1.4	0.03007	0.05894	0.08561	0.10941	0.13003	0.14749	0.16199	0.17389	0.18357	0.19139	0.20278	0.21020
1.6	0.03058	0.05994	0.08709	0.11135	0.13241	0.15028	0.16515	0.17739	0.18737	0.19546	0.20731	0.21510
1.8	0.03090	0.06058	0.08804	0.11260	0.13395	0.15207	0.16720	0.17967	0.18986	0.19814	0.21032	0.21836
2.0	0.03111	0.06100	0.08867	0.11342	0.13496	0.15326	0.16856	0.18119	0.19152	0.19994	0.21235	0.22058
2.5	0.03138	0.06155	0.08948	0.11450	0.13628	0.15483	0.17036	0.18321	0.19375	0.20236	0.21512	0.22364
3.0	0.03150	0.06178	0.08982	0.11495	0.13684	0.15550	0.17113	0.18407	0.19470	0.20341	0.21633	0.22499
4.0	0.03158	0.06194	0.09007	0.11527	0.13724	0.15598	0.17168	0.18469	0.19540	0.20417	0.21722	0.22600
5.0	0.03160	0.06199	0.09014	0.11537	0.13737	0.15612	0.17185	0.18488	0.19561	0.20440	0.21749	0.22632
6.0	0.03161	0.06201	0.09017	0.11541	0.13741	0.15617	0.17191	0.18496	0.19569	0.20449	0.21760	0.22644
8.0	0.03162	0.06202	0.09018	0.11543	0.13744	0.15621	0.17195	0.18500	0.19574	0.20455	0.21767	0.22652
10.0	0.03162	0.06202	0.09019	0.11544	0.13745	0.15622	0.17196	0.18502	0.19576	0.20457	0.21769	0.22654
∞	0.03162	0.06202	0.09019	0.11544	0.13745	0.15623	0.17197	0.18502	0.19577	0.20458	0.21770	0.22656

m	n = 1.6	1.8	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0	∞
0.1	0.03058	0.03090	0.03111	0.03138	0.03150	0.03158	0.03160	0.03161	0.03162	0.03162	0.03162
0.2	0.05994	0.06058	0.06100	0.06155	0.06178	0.06194	0.06199	0.06201	0.06202	0.06202	0.06202
0.3	0.08709	0.08804	0.08867	0.08948	0.08982	0.09007	0.09014	0.09017	0.09018	0.09019	0.09019
0.4	0.11135	0.11260	0.11342	0.11450	0.11495	0.11527	0.11537	0.11541	0.11543	0.11544	0.11544
0.5	0.13241	0.13395	0.13496	0.13628	0.13684	0.13724	0.13737	0.13741	0.13744	0.13745	0.13745
0.6	0.15028	0.15207	0.15326	0.15483	0.15550	0.15598	0.15612	0.15617	0.15621	0.15622	0.15623
0.7	0.16515	0.16720	0.16856	0.17036	0.17113	0.17168	0.17185	0.17191	0.17195	0.17196	0.17197
0.8	0.17739	0.17967	0.18119	0.18321	0.18407	0.18469	0.18488	0.18496	0.18500	0.18502	0.18502
0.9	0.18737	0.18986	0.19152	0.19375	0.19470	0.19540	0.19561	0.19569	0.19574	0.19576	0.19577
1.0	0.19546	0.19814	0.19994	0.20236	0.20341	0.20417	0.20440	0.20449	0.20455	0.20457	0.20458
1.2	0.20731	0.21032	0.21235	0.21512	0.21633	0.21722	0.21749	0.21760	0.21767	0.21769	0.21770
1.4	0.21510	0.21836	0.22058	0.22364	0.22499	0.22600	0.22632	0.22644	0.22652	0.22654	0.22656
1.6	0.22025	0.22372	0.22610	0.22940	0.23088	0.23200	0.23236	0.23249	0.23258	0.23261	0.23263
1.8	0.22372	0.22736	0.22986	0.23334	0.23495	0.23617	0.23656	0.23671	0.23681	0.23684	0.23686
2.0	0.22610	0.22986	0.23247	0.23614	0.23782	0.23912	0.23954	0.23970	0.23981	0.23985	0.23987
2.5	0.22940	0.23334	0.23614	0.24010	0.24196	0.24344	0.24392	0.24412	0.24425	0.24429	0.24432
3.0	0.23088	0.23495	0.23782	0.24196	0.24394	0.24554	0.24608	0.24630	0.24646	0.24650	0.24654
4.0	0.23200	0.23617	0.23912	0.24344	0.24554	0.24729	0.24791	0.24817	0.24836	0.24842	0.24846
5.0	0.23236	0.23656	0.23954	0.24392	0.24608	0.24791	0.24857	0.24885	0.24907	0.24914	0.24919
6.0	0.23249	0.23671	0.23970	0.24412	0.24630	0.24817	0.24885	0.24916	0.24939	0.24946	0.24952
8.0	0.23258	0.23681	0.23981	0.24425	0.24646	0.24836	0.24907	0.24939	0.24964	0.24973	0.24980
10.0	0.23261	0.23684	0.23985	0.24429	0.24650	0.24842	0.24914	0.24946	0.24973	0.24981	0.24989
∞	0.23263	0.23686	0.23987	0.24432	0.24654	0.24846	0.24919	0.24952	0.24980	0.24989	0.25000

[a] After Newmark, 1935.

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2015
Program: B.Sc. Engineering (Civil)

Course Title: Open Channel flow — Course Code: CE 361
Time: 3 Hours — Full Marks: 150

All notations are having usual meaning. Assume any reasonable data, if not given

Section A

Answer any 3 (Three) out of 4 (Four) questions

1. (a) Write down the difference between steady and unsteady flow. (05)

   (b) Write down the classifications of open channel. (05)

   (c) Using the trapezoidal rule of numerical integration, compute the discharge per unit width, the mean velocity and the values of α and β for the following velocity measurements (u is the velocity at a distance z from the channel bottom) along a vertical in a wide channel, when the total depth is 6 m. (15)

z (m)	0.0	1.0	2.0	3.0	4.0	5.0	6.0
u (m/s)	0.0	2.95	3.31	3.62	3.95	4.12	4.51

2. (a) Write momentum equation with explanation of all notations? (05)

   (b) Derive the relationship between Manning's "n" and Chezy's "C" (05)

   (c) Compute the hydraulic exponent for critical flow computation M for a trapezoidal channel with b=6.1 m, s=2 and h=2 m. (15)

3. (a) Write down the conditions implied for uniform flow in an open channel flow. (05)

   (b) Write short notes on laminar viscous sublayer. (05)

   (c) A trapezoidal channel with b= 6 m and s=2 carries a discharge of 120 m^3/s. If the upstream depth of flow is 1 m, Compute the downstream depth that will create a hydraulic jump. (15)

4. (a) The sides of laboratory flume are made of glass (n=0.012) and the bottom is made of wood (n=.016). The flume is rectangular with b=1.5 m and is laid on a slope of 1 in 1000. Compute the discharge in the flume if h= 0.5 m. (15)

(b) What is shear stress? Derive an expression of drag velocity of a channel. (10)

Section B

Answer any 3 (Three) out of 4 (Four) questions

5. (a) Write factors affecting Manning's n. (05)

   (b) Prove that best hydraulic trapezoidal section is one half of a regular hexagon. (20)

6. (a) What do you mean by permissible velocity in an open channel? Explain. (05)

   (b) A trapezoidal channel carrying 21 m^3/s is built with non- erodible bed having a slope in 1 in 1000 and n=0.025. Design the channel by the concept of best hydraulic section. Calculate the freeboard also. (15)

   (c) Write short notes on Reynolds number. (05)

7. (a) A rectangular channel is 6 m wide and laid on a slope of 0.25 %. The channel is made of concrete (Ks=2 mm) and carries water at a depth of 0.50 m. Compute the mean velocity of flow. (15)

   (b) Show that best hydraulic rectangular section is one half of a square. (05)

   (c) What do you mean by section factor and conveyance of an open channel flow? (05)

8. (a) Write down the practical applications of hydraulic jump in an open channel flow. (05)

   (b) A rectangular channel is 1 m wide and inclined at an angle of 3.5° with the horizontal. Determine the type of jump when the discharge is 0.15 m^3/s, the initial depth of flow section is 0.02 m and the tail water depth is found 0.70m. Also compute the energy loss in the jump if the length of the jump is 2 m. (20)