University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2017
Program: B.Sc. Engineering (Civil)

7-1

Course title: Irrigation and Flood Control | Course code: CE 461
Time: 3 Hours | Full marks: 100

There are TWO sections in the question paper namely "SECTION A" and "SECTION B". You have to answer from both sections according to the instruction mentioned on each section.

SECTION A
MARKS: 72

There are FIVE (5) questions. Answer <u>question no. 01 (COMPULSORY)</u> and any THREE (3) from the rest (18+ 3*18=72). (Assume any missing data.)

1. a) Summarize the benefits of irrigation and disadvantages of excess irrigation. 5
b) Specify four factors that you should consider while using ground water for irrigation. 3
c) Choose one irrigation method that is most appropriate for Bangladesh during non-monsoon period. Justify your choice and explain the selected irrigation method in detail. 6
d) Explain the delta formation process and how delta formation process relates to flood. 4

2. a) Justify the importance of cross-drainage work? 4
b) Categorize the irrigation water having the following characteristics: Concentration of Na, Ca and Mg are 27, 3 and 3 milli-equivalents per liter respectively, and the electrical conductivity is 700 μmhos/cm at 25° C? What problems might arise in using this water for irrigation? What remedies do you suggest to overcome this trouble? 10
c) Outline the criteria(s) that determines the classification and suitability of irrigation water. 4

3. a) Describe the objectives of diversion head works. 4
b) Derive the relationship between duty and delta for a given base period. 4
c) A stream of 120 liters per second was diverted from a canal and 95 liters per second were delivered to the field. An area of 2.5 hectares was irrigated in 9 hours. The effective depth of root zone was 1.7 m. The runoff loss in the field was 450 m^3 and deep percolation loss in the field is 30 m^3. The depth of water penetration varied linearly from 1.6 m at the head end of the field to 1.0 m at the tail end. Available moisture holding capacity of the soil is 24 cm per meter depth of soil. Irrigation was started at a moisture extraction level of 60% of the available moisture. 10
Calculate the following:

- water conveyance efficiency
- water application efficiency
- water storage efficiency
- water distribution efficiency

4. a) Draw the schematic diagram of soil-water-plant relationship. 3
   b) Graphically demonstrate the following (in one figure): 5
   - Capillary water
   - Hygroscopic water
   - Optimum moisture content
   - Readily available moisture
   - Permanent wilting point
   - Field capacity

   c) Estimate after how many days will you supply water to soil in order to ensure sufficient irrigation of the given crop, if, 10
   - Available moisture = 16%
   - Field capacity = 35 %
   - Optimum moisture content = 20%
   - Dry density of soil = 1.3 gm/cc
   - Effective depth of root zone = 75 cm
   - Daily consumptive use of water for the given crop = 13 mm

5. a) Distinguish between weir and barrage with neat sketch. 2.5
   b) Explain the procedures for determining the required discharge capacity and number of spillways. 3.5
   c) Design an unlined irrigation canal on alluvial soil with the following data (two trials are required): 12
   - Full supply discharge = 7 m^3/sec
   - Rugosity coefficient (n) = 0.0224
   - Critical velocity ratio (C.V.R) (m) = 1
   - Bed slope = 1 in 5000

   Assume other reasonable data for the design.

SECTION B
MARKS: 28

There are THREE (3) questions. Answer <u>question no. 06 (COMPULSORY)</u> and any ONE (1) from the rest (16+12=28). (Assume any missing data.)

6. a) Select three structural and three non-structural measures of flood control and management in Bangladesh that are most important in your opinion. Justify your answer. 6
   b) Explain different components of flood risk management 6
   c) A centrifugal pump is required to lift water at a rate of 135 liters/second. Design the diameter of the pipe from the following data: 4
      - Suction head = 7 m
      - Delivery head = 2 m
      - Coefficient of friction = 0.01
      - Efficiency of pump = 70%
      - Brake Horse Power of the engine = 17

7. a) Identify four reasons of water logging in front of UAP city campus during monsoon season. Justify your answer. 6
   b) Write six reasons why transboundary cooperation is needed for increasing food production and minimizing flood hazards along the Ganges and Brahmaputra rivers basins inside Bangladesh. Justify your answer. 6

8. a) Graphically explain how flood hazards vary with different geological conditions in Bangladesh. 6
   b) Explain the following:
      i. Integrated Water Resources Management 6
      ii. Polder
      iii. Dam
      iv. Flood

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2017
Program: B. Sc. Engineering (Civil)

Course Title: Geotechnical Engineering II (Foundation Engineering) — Course Code: CE 441
Time: 3 hours — Full Marks: 100

Answer **ALL** of the following questions.

1. (a) A soil profile obtained from the Standard Penetration Test (SPT) is shown in Fig. 1. It has been decided to provide individual shallow foundations to support the proposed structure which is a 10-storied residential building. What are the laboratory tests that required to obtain the necessary soil parameters so that the bearing capacity and the settlement of the foundations can be computed? [6]

   (b) If a clay soil sample from the soil profile shown in Fig. 1 has been obtained using a sampler having an outside diameter of 50 mm and wall thickness of 1.25 mm, do you think the sample can be used for consolidation test? [4]

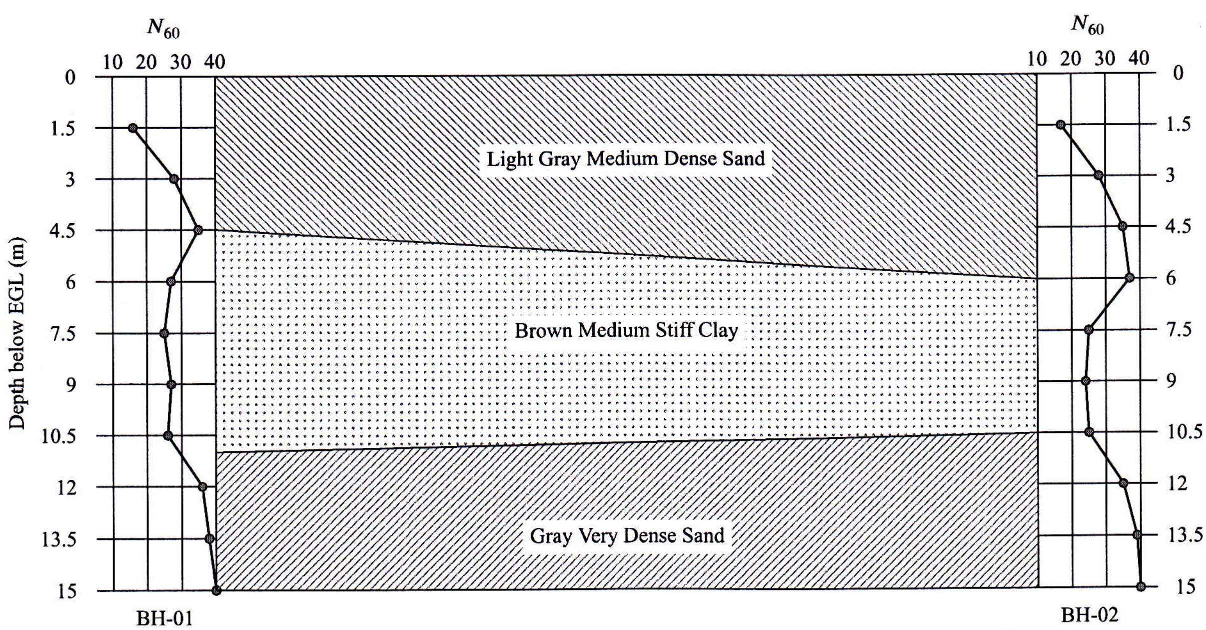


Figure 1

2. (a) An individual shallow square foundation having dimensions of 3 m × 3 m as shown in Fig. 2 is required to carry an allowable load of 15 MN. If the factor of safety is 3, will the foundation be able to carry that load? If not, what modifications do you suggest? Use general bearing capacity equation and Meyerhof's bearing capacity factors. [10]

   (b) Calculate the immediate settlement of the foundation shown in Fig. 2 using theory of elasticity. Given that, $E_s = 60000$ kN/m^2, and $\mu_s = 0.3$. Assume the foundation to be rigid. If the allowable settlement is 25 mm, do you think the foundation meets this requirement? If not, what changes do you suggest so that the settlement does not exceed 25 mm? [10]

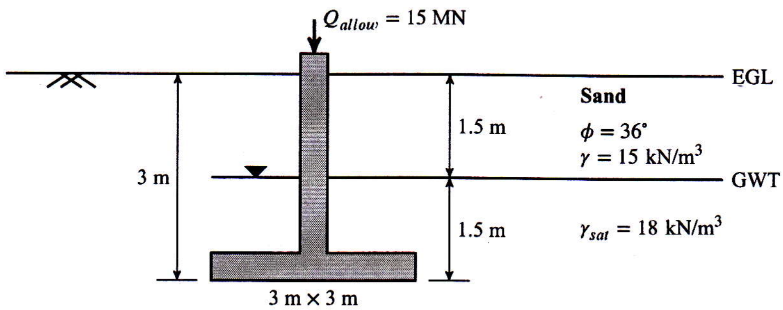


Figure 2

3. (a) A mat foundation on a saturated clay soil deposit has the dimensions of 15 m × 12 m. The total dead and live load on the mat is 24 MN. Determine the depth of the mat assuming that the mat is fully compensated. Given that, c =30 kN/m^2, and γ_{sat} = 18 kN/m^3. [3]

   (b) What will be the depth (D_f) of the mat in the previous question for a factor of safety of 3 against bearing capacity failure? Use Meyerhof's bearing capacity factors. [7]

4. (a) Determine the ultimate load carrying capacity (Q_u) of the circular pile as shown in Fig. 3. The diameter (D) of the pile is 400 mm. Use the α method to determine Q_s, and Meyerhof's method to calculate Q_p. Ignore the self weight of the pile. [10]

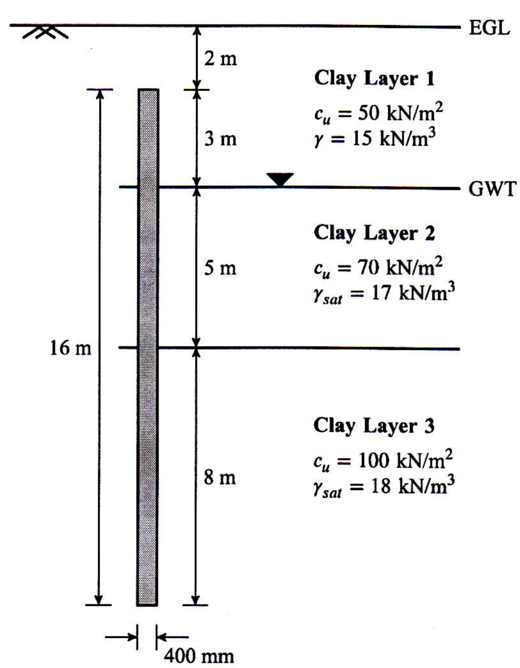


Figure 3

   (b) A pile group in layered saturated clay soil is shown in Fig. 4. The piles are circular in cross section (D = 400 mm). The center-to-center spacing (d) of the piles is 1000 mm (d = 2.5D). Determine the allowable load carrying capacity of the pile group. Use a factor of safety, FS = 4. [10]

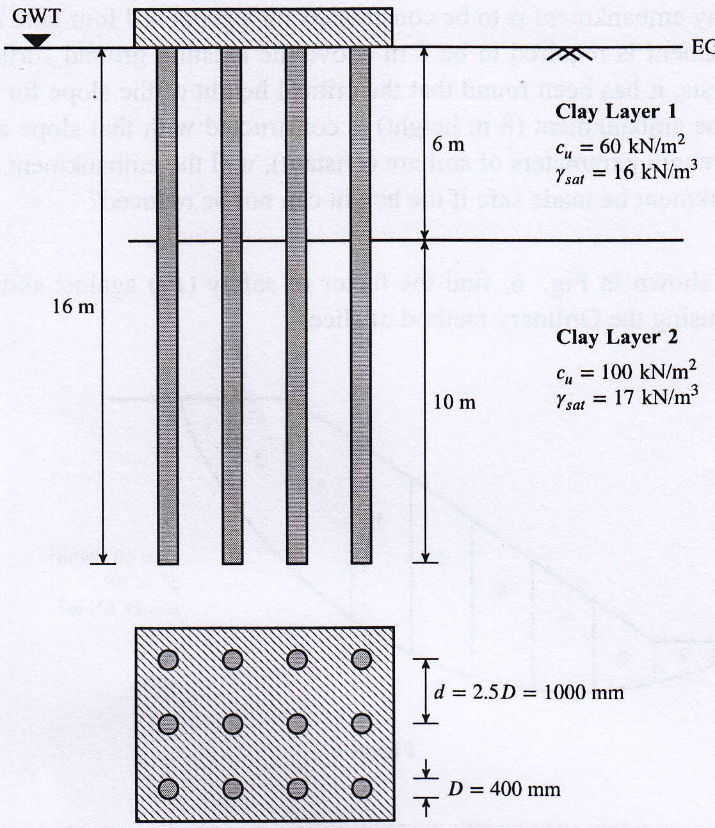


Figure 4

5. (a) Determine the immediate settlement of the individual shallow foundation as shown in Fig. 5 using the improved relationships. The thickness of the foundation is 0.3 m. [10]

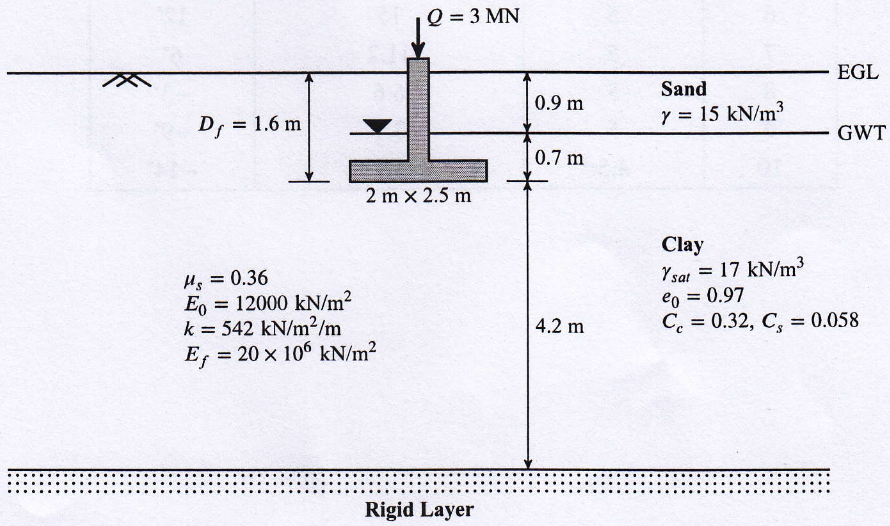


Figure 5

(b) Determine the primary consolidation settlement of the clay layer below the individual shallow foundation as shown in Fig. 5. The clay layer is over consolidated and $\sigma_c = 120$ kN/m^2. [10]

6. (a) A new highway embankment is to be constructed for a proposed four lane highway. The height of the embankment is required to be 8 m above the existing ground surface. From the slope stability analysis, it has been found that the critical height of the slope for a slope angle of 45° is 6.3 m. If the embankment (8 m height) is constructed with that slope angle (assuming that other shear strength parameters of soil are constant), will the embankment be safe? If not, how can the embankment be made safe if the height can not be reduced? [6]

(b) For the slope shown in Fig. 6, find the factor of safety (F_s) against sliding for the trial slip surface ABC using the Ordinary method of slices. [14]

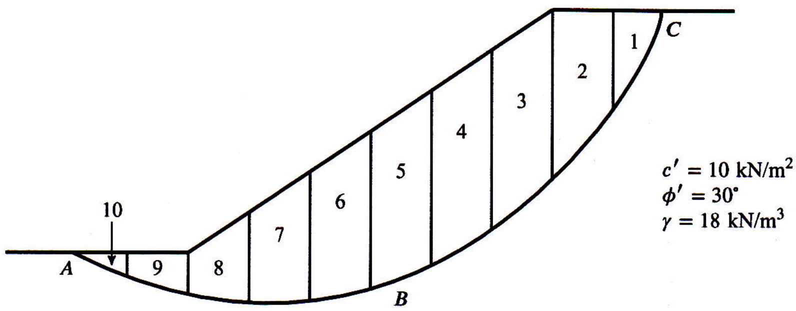


Figure 6

Slice No.	Width, b_n (m)	Average depth, z_n (m)	α_n (degrees)
1	4	9.5	78°
2	5	17.3	61°
3	5	20.5	44°
4	5	19.8	32°
5	5	17.9	21°
6	5	15	12°
7	5	11.2	6°
8	5	6.6	−3°
9	5	3.1	−9°
10	4.5	1.1	−14°

Table 1: Bearing Capacity Factors for General Bearing Capacity Equation

ϕ	N_c	N_q	N_γ (Meyerhof)	ϕ	N_c	N_q	N_γ (Meyerhof)	ϕ	N_c	N_q	N_γ (Meyerhof)
0°	5.10	1.00	0.00	17°	12.34	4.77	1.66	34°	42.16	29.44	31.15
1°	5.38	1.09	0.00	18°	13.10	5.26	2.00	35°	46.12	33.30	37.15
2°	5.63	1.20	0.01	19°	13.93	5.80	2.40	36°	50.59	37.75	44.43
3°	5.90	1.31	0.02	20°	14.83	6.40	2.87	37°	55.63	42.92	53.27
4°	6.19	1.43	0.04	21°	15.81	7.07	3.42	38°	61.35	48.93	64.07
5°	6.49	1.57	0.07	22°	16.88	7.82	4.07	39°	67.87	55.96	77.33
6°	6.81	1.72	0.11	23°	18.05	8.66	4.82	40°	75.31	64.20	93.69
7°	7.16	1.88	0.15	24°	19.32	9.60	5.72	41°	83.86	73.90	113.99
8°	7.53	2.06	0.21	25°	20.72	10.66	6.77	42°	93.71	85.37	139.32
9°	7.92	2.25	0.28	26°	22.25	11.85	8.00	43°	105.11	99.01	171.14
10°	8.34	2.47	0.37	27°	23.94	13.20	9.46	44°	118.37	115.31	211.41
11°	8.80	2.71	0.47	28°	25.80	14.72	11.19	45°	133.87	134.87	262.74
12°	9.28	2.97	0.60	29°	27.86	16.44	13.24	46°	152.10	158.50	328.73
13°	9.81	3.26	0.74	30°	30.14	18.40	15.67	47°	173.64	187.21	414.33
14°	10.37	3.59	0.92	31°	32.67	20.63	18.56	48°	199.26	222.30	526.46
15°	10.98	3.94	1.13	32°	35.49	23.18	22.02	49°	229.93	265.50	674.92
16°	11.63	4.34	1.37	33°	38.64	26.09	26.17				

Table 2: Shape, Depth & Load Inclination Factors for General Bearing Capacity Equation

Author	Factor	Condition	Equation
Meyerhof	Shape	$\phi = 0°$	$F_{cs} = 1 + 0.2\left(\frac{B}{L}\right)$ $F_{qs} = F_{\gamma s} = 1$
		$\phi \geq 10°$	$F_{cs} = 1 + 0.2\left(\frac{B}{L}\right)\tan^2\left(45 + \frac{\phi}{2}\right)$ $F_{qs} = F_{\gamma s} = 1 + 0.1\left(\frac{B}{L}\right)\tan^2\left(45 + \frac{\phi}{2}\right)$
	Depth	$\phi = 0°$	$F_{cd} = 1 + 0.2\left(\frac{D_f}{B}\right)$ $F_{qd} = F_{\gamma d} = 1$
		$\phi \geq 10°$	$F_{cd} = 1 + 0.2\left(\frac{D_f}{B}\right)\tan\left(45 + \frac{\phi}{2}\right)$ $F_{qd} = F_{\gamma d} = 1 + 0.1\left(\frac{D_f}{B}\right)\tan\left(45 + \frac{\phi}{2}\right)$

Theory of Elasticity

$$S_e = \Delta\sigma B\left(\frac{1-\mu_s^2}{E_s}\right)I_p$$

Table 3: Influence factors for foundations

		I_p		
		Flexible		
Shape	m_1	Center	Corner	Rigid
Circle	—	1.00	0.64	0.79
Rectangle	1	1.12	0.56	0.88
	1.5	1.36	0.68	1.07
	2	1.53	0.77	1.21
	3	1.78	0.89	1.42
	5	2.10	1.05	1.70
	10	2.54	1.27	2.10
	20	2.99	1.49	2.46
	50	3.57	1.80	3.00
	100	4.01	2.00	3.43

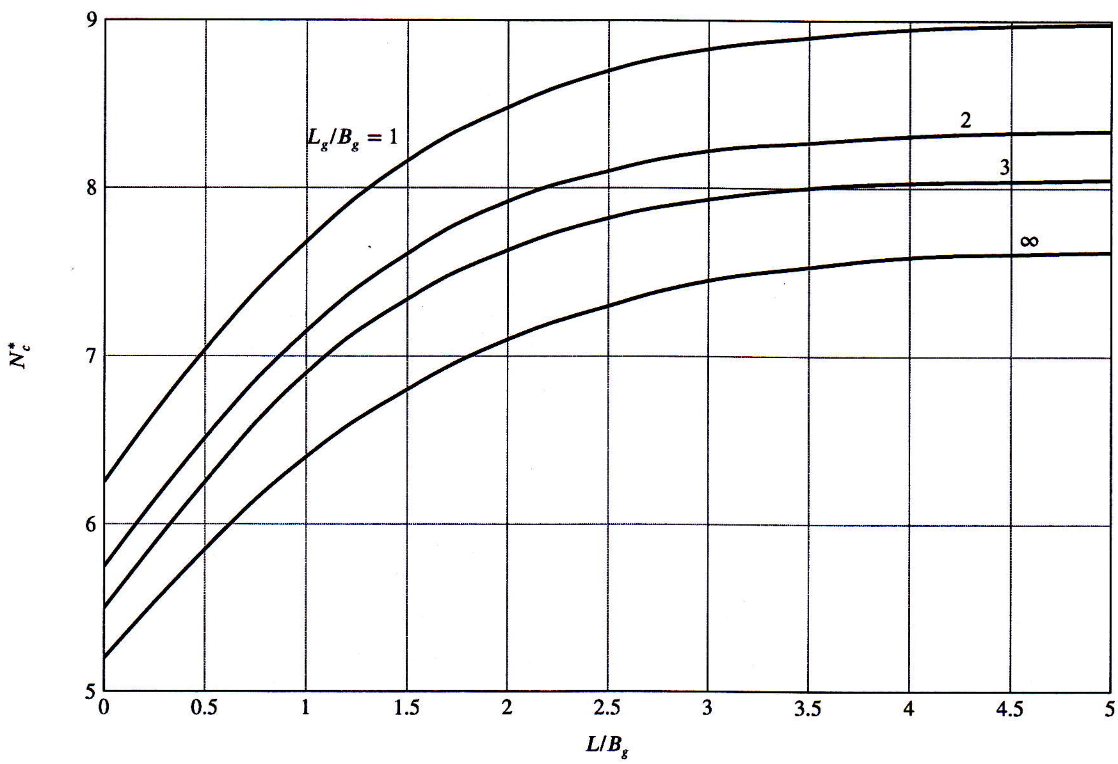
Table 4: Variation of α (interpolated values based on Terzaghi, Peck and Mesri, 1996)

c_u/p_a	α	c_u/p_a	α
≤ 0.1	1.00	1.2	0.42
0.2	0.92	1.4	0.40
0.3	0.82	1.6	0.38
0.4	0.74	1.8	0.36
0.6	0.62	2.0	0.35
0.8	0.54	2.4	0.34
1.0	0.48	2.8	0.34

Vertical Capacity of Pile Group in Saturated Clay

$$\sum Q_u = n_1 n_2 \left[9c_u A_p + \sum \alpha c_u p(\Delta L)\right]$$

$$Q_u = N_c^* c_u L_g B_g + \sum 2\left(L_g + B_g\right) c_u(\Delta L)$$



Improved Relationship By Mayne and Poulos (1999)

$$S_e = \frac{\Delta\sigma B_e I_G I_F I_E}{E_0}\left(1 - \mu_s^2\right)$$

$$B_e = \sqrt{\frac{4BL}{\pi}}$$

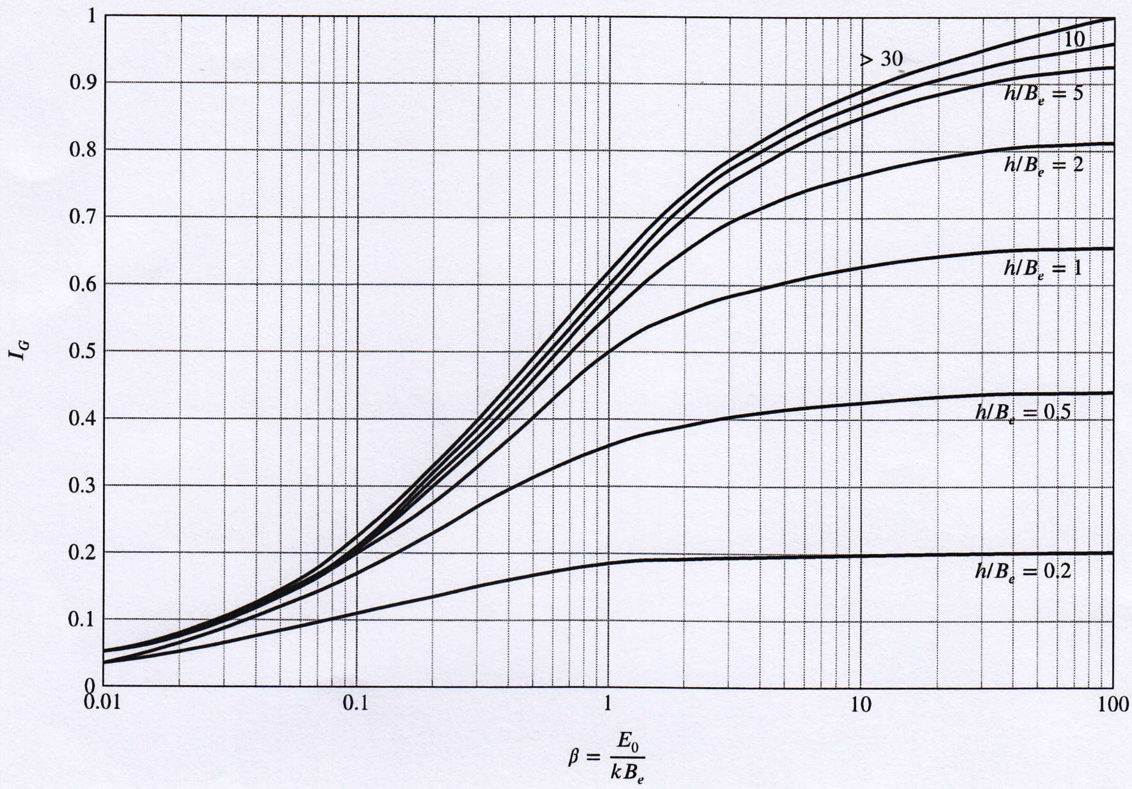
$$I_F = \frac{\pi}{4} + \frac{1}{4.6 + 10\left(\dfrac{E_f}{E_0 + \dfrac{kB_e}{2}}\right)\left(\dfrac{2t}{B_e}\right)^3}$$

$$I_E = 1 - \frac{1}{3.5\exp\left(1.22\mu_s - 0.4\right)\left(\dfrac{B_e}{D_f} + 1.6\right)}$$

Primary Consolidation Settlement

Normally Consolidated Clay

$$S_c = \frac{C_c H}{1 + e_0}\log\left(\frac{\sigma_0' + \Delta\sigma'}{\sigma_0'}\right)$$



Overconsolidated Clay

$$S_c = \frac{C_s H}{1+e_0}\log\left(\frac{\sigma_0' + \Delta\sigma'}{\sigma_0'}\right) \qquad \sigma_0' + \Delta\sigma' < \sigma_c'$$

$$S_c = \frac{C_s H}{1+e_0}\log\left(\frac{\sigma_c'}{\sigma_0'}\right) + \frac{C_c H}{1+e_0}\log\left(\frac{\sigma_0' + \Delta\sigma'}{\sigma_c'}\right) \qquad \sigma_0' + \Delta\sigma' > \sigma_c'$$

Ordinary Method of Slices

$$F_s = \frac{\sum_{n=1}^{n=p}\left(c'\Delta L_n + W_n \cos\alpha_n \tan\phi'\right)}{\sum_{n=1}^{n=p} W_n \sin\alpha_n} \qquad \Delta L_n = \frac{b_n}{\cos\alpha_n}$$

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2017
Program: B.Sc. Engineering (Civil)

Course Title: Transportation Engineering II — Course Code: CE 451
Time: 3 hour — Full Marks: 100

There are **Five** questions. Answer any **Four**.

1. (a) Briefly explain the design theories of flexible and rigid pavement. (05)
   (b) Explain the function of subbase course. When it is necessary to provide subbase course? (06)
   (c) You are constructing an urban highway, while selecting aggregates, what are the properties will you consider? (14)

2. (a) What is the classification of soil sample (AASHTHO Method) with 75% passing the 2.0 mm (No. 10) sieve, 55% passing the 0.425 mm (No. 40) sieve, and 12% passing the 0.075 mm (No. 200) sieve, a liquid limit of 20 and a plasticity index of 4? Also comment whether that can be used as subbase or base course. (10)
   (b) Explain plate bearing test of soil. (08)
   (c) You have to construct a railway track in a mountainous area, what are the factors you need to consider? (07)

3. (a) A given pavement rating method uses six distress types to establish the Distress Rating (DR). These are corrugation, alligator cracking, ravelling, longitudinal cracking, rutting, and patching. For a stretch of highway, the numbers of points assigned to each category were 6, 4, 2, 4, 3, and 3. If the weighing factors are 2, 1, 0.75, 1, 1, and 1.5, determine the DR for the section. (05)
   (b) As a pavement inspector you are assigned to assess the pavement condition. By manual survey the distresses you found are potholes, and fatigue cracking. Explain how will you understand the severity level of these distresses? (10)
   (c) What are the facilities required for: i) station where lines from 3 or more direction meet, and ii) station where a railway line or one of its branches terminates? (10)

4. (a) Determine the pavement layer thicknesses for an urban interstate pavement composed of a HMA over an untreated granular base, resting on an untreated granular subbase, on the in-situ soil. The 20-year design ESAL is 10 million. The HMA M_R = 450,000 psi. The CBR of the base and subbase are 100 and 40, respectively. The quality of the drainage for the base and subbase are good and fair, respectively. The pavement structure will be exposed to moisture levels approaching saturation approximately 20 percent of the time. The resilient modulus of the in-situ soil is 5000 psi. Adopt AASHTO method and explain step by step procedure to determine the (20)

pavement layer thicknesses.

(b) Explain the effect of maximum aggregate size on HMA and PCC. (05)

5. (a) An existing rural four-lane highway is to be replaced by a six-lane divided expressway (three lanes in each direction). Traffic volume data on the highway indicate that the AADT (both directions) during the first year of operation is 24,000 with the following vehicle mix and axle loads. Passenger cars = 50% , 2-axle single-unit trucks (12,000 lb/axle) =40%, and 3-axle single-unit trucks (16,000 lb/axle) =10%. Determine the design ESAL if the vehicle mix is expected to remain the same throughout the design life of 20 years, although traffic is expected to grow at a rate of 3.5% annually. Using the AASHTO design procedure, design a concrete pavement required for the design period of 20 years. Initial serviceability index 4.5, Terminal serviceability index 2.5, S_c = 650 lb/in^2, E_c= 5X10^6 lb/in^2, k=130 lb/in^3, J= 3.2, C_d=1.0, S_o = 0.3, R=95%. Explain step by step design process. (20)

(b) Explain Westergaards Modulus of Subgrade Reaction (k) and the factors upon which k value depends. (05)

Required Charts and Tables

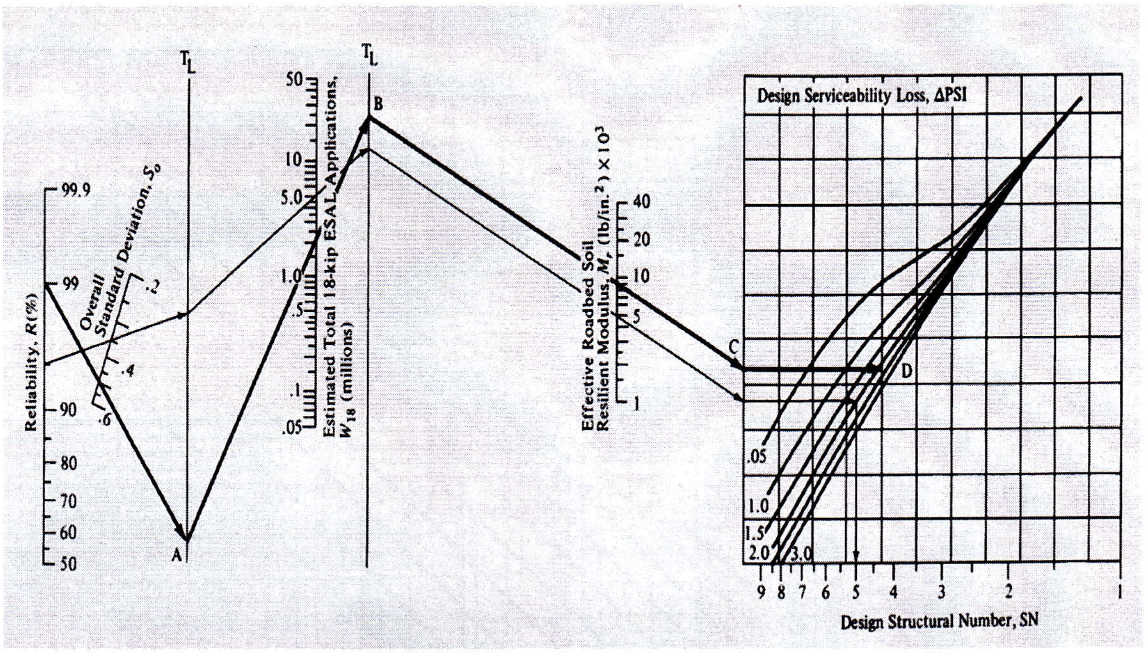


Figure 1: Design Chart for Flexible Pavements Based on Using Mean Values for each Input

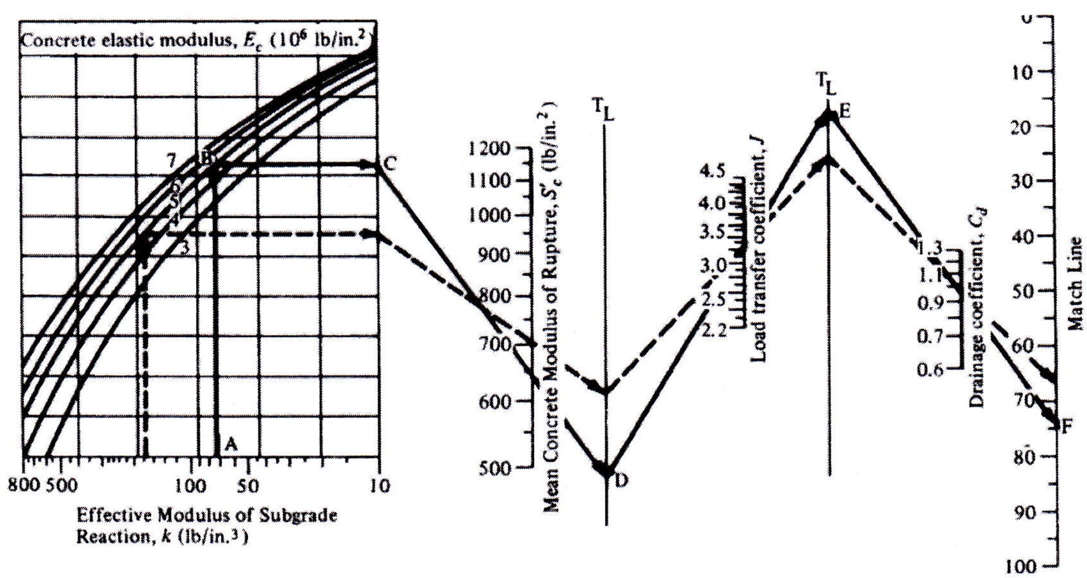


Figure 2: Design Chart for Rigid Pavement Based on Using Values for Each Input Variable (Segment 1)

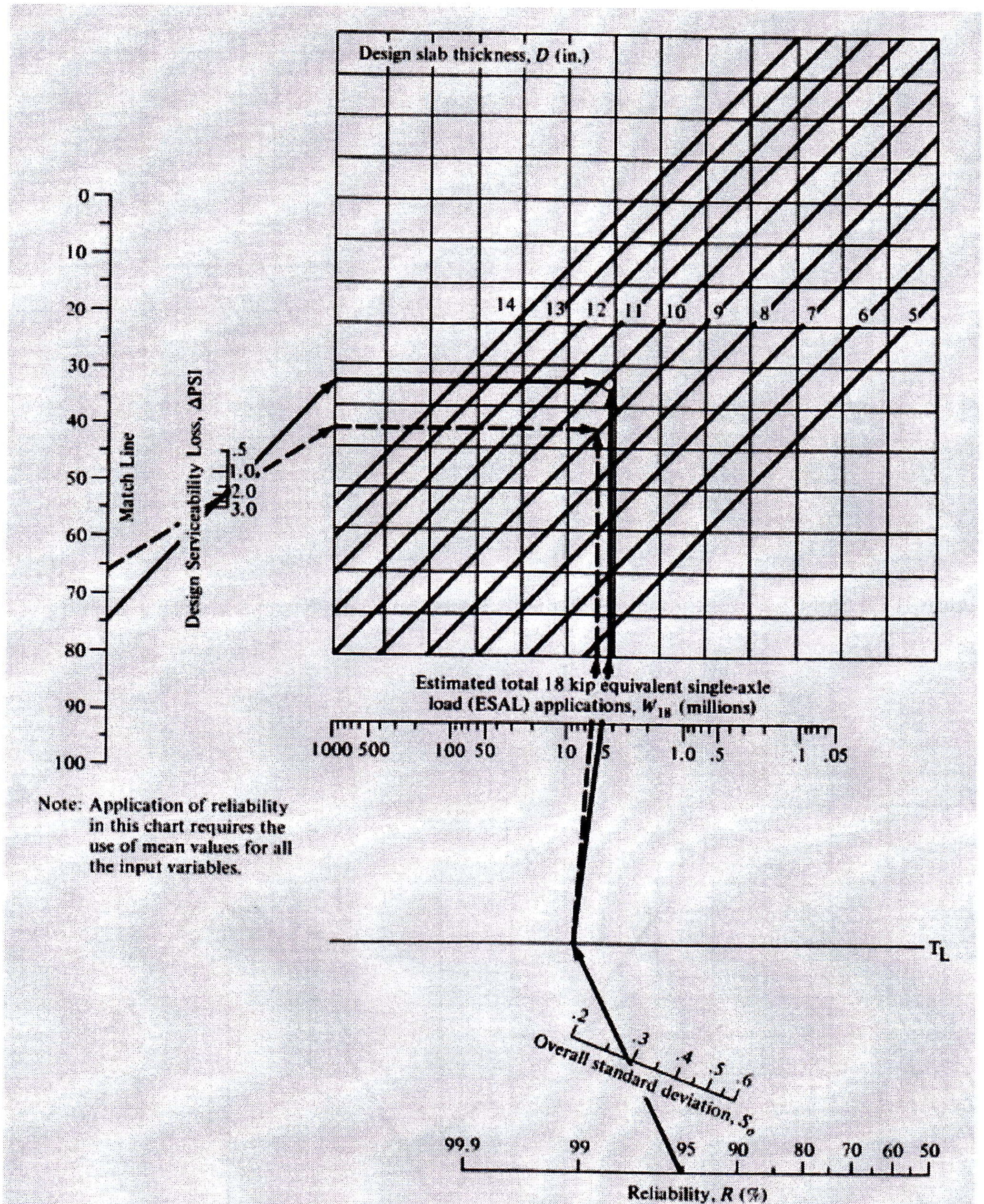


Figure 3: Design Chart for Rigid Pavement Based on Using mean Values for Each Input Variables.

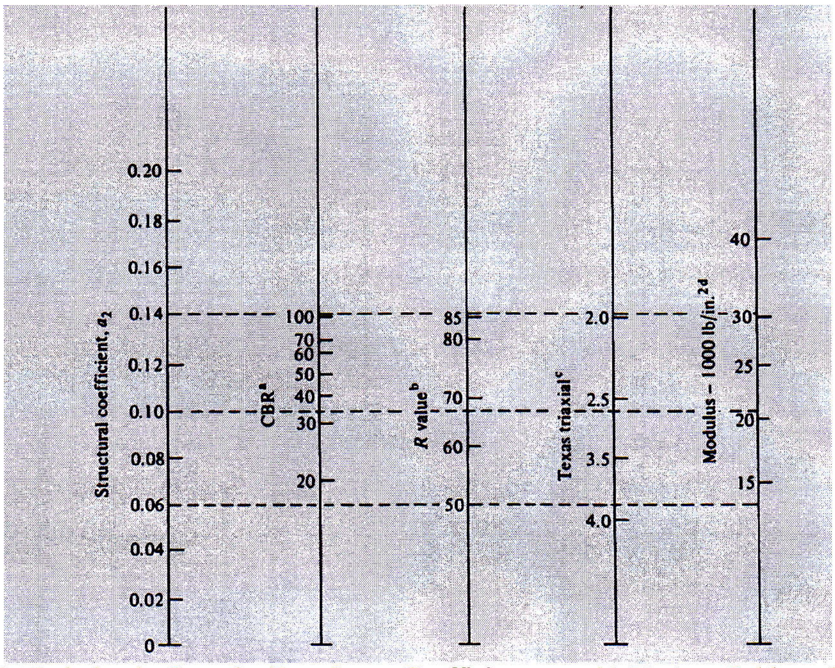


Figure 4: Variation in Granular Base Layer Coefficient, a_2, with Various Subbase Strength Parameters

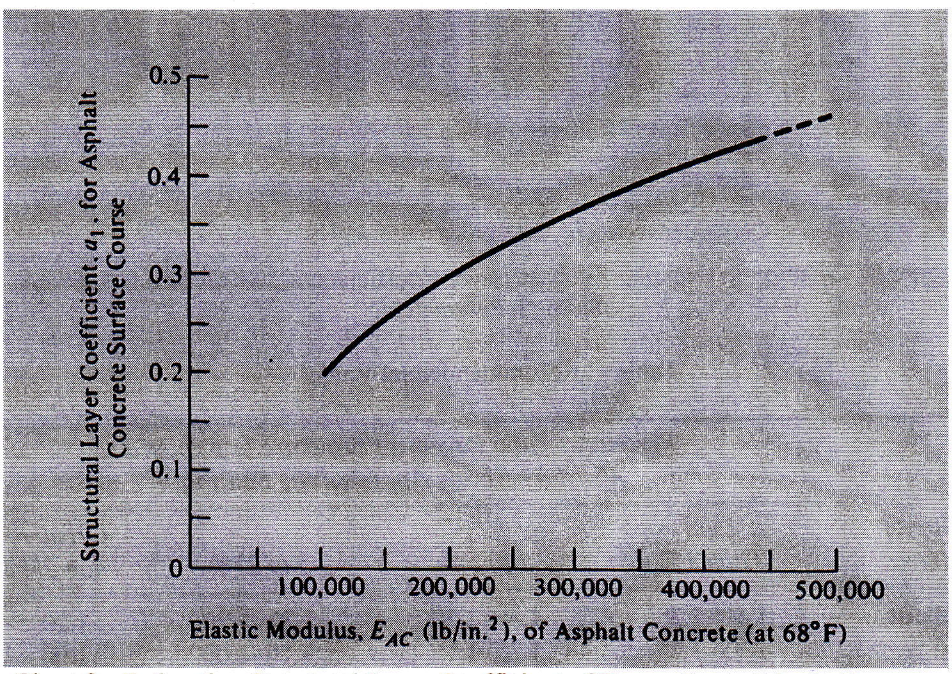


Figure 5: Chart for Estimating Structural Layer Coefficient of Dense-Graded/Asphalt Concrete Based on the Elastic (Resilient) Modulus

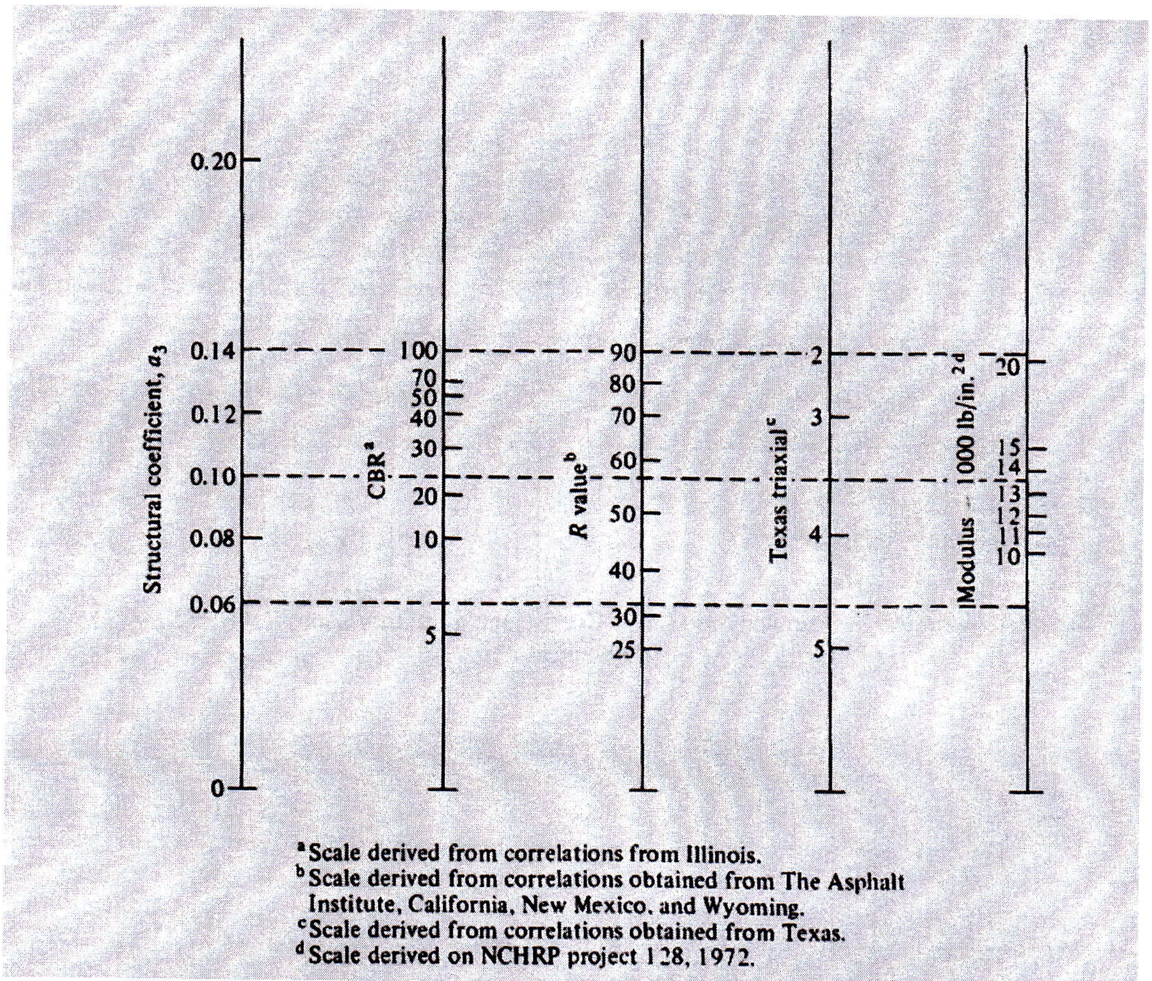


Figure 6: Variation in Granular Subbase Layer Coefficient, a_3, with Various Subbase Strength Parameters

Table 1: Recommended m_i Value

Quality of Drainage	*Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation*			
	Less Than 1%	*1 to 5%*	*5 to 25%*	*Greater Than 25%*
Excellent	1.40–1.35	1.35–1.30	1.30–1.20	1.20
Good	1.35–1.25	1.25–1.15	1.15–1.00	1.00
Fair	1.25–1.15	1.15–1.05	1.00–0.80	0.80
Poor	1.15–1.05	1.05–0.80	0.80–0.60	0.60
Very poor	1.05–0.95	0.95–0.75	0.75–0.40	0.40

Table 2: AASHTO Soil Classification System

General Classification	*Granular Materials (35% or Less Passing No. 200)*							*Silt-Clay Materials (More than 35% Passing No. 200)*			
	A-1			*A-2*							*A-7*
Group Classification	*A-1-a*	*A-1-b*	*A-3*	*A-2-4*	*A-2-5*	*A-2-6*	*A-2-7*	*A-4*	*A-5*	*A-6*	*A-7-5, A-7-6*
Sieve analysis											
Percent passing											
No. 10	−50 max.	—	—	—	—	—	—	—	—	—	
No. 40	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit	—		—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*Plasticity index of A-7-5 subgroup ≤ LL − 30. Plasticity index of A-7-6 subgroup > LL − 30.
SOURCE: Adapted from *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, 27th ed., Washington, D.C., The American Association of State Highway and Transportation Officials, copyright 2007. Used with permission.

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2017
Program: B.Sc. Engineering (Civil)

Course Title: Project Planning and Construction Management — Course Code: CE 401
Time: 3 hour — Full marks: 100

There are 6 (six) questions. Answer question 1 (one) and any 4 (four) from 2 to 6 (two to six) (20x5)

1. Project activity status of Mr. X, project manager for a hospital project, is shown below: (20)

Activity	Description	Activity Predecessor	Time (weeks)
A	Select admin staff	---	12
B	Site selection and survey	---	9
C	Select medical equipment	A	10
D	Prepare final construction plan	B	10
E	Bring utilities to sites	B	24
F	Interview for nursing and staff	A	10
G	Purchase and deliver equipment	C	35
H	Construct hospital	D	40
I	Develop information system	A	15
J	Install medical equipment	E,G,H	4
K	Train nurses and staff	F,I,J	6

i. Draw the network diagram
ii. Find the project completion time
iii. Find the critical path
iv. Find ES,EF and LS,LF time for each activity
v. If the time required for activity H and J are reduced by 1 week each, find the project completion time and critical path as well.

2. a. The sales of a certain product during each month of a year have been given below: (15)

Month 2010	Sales	Month 2010	Sales
January	20	July	40
February	22	August	39
March	21	September	42
April	23	October	43
May	32	November	49
June	36	December	53

Develop a regression analysis to forecast the demand and find the forecast for the months of June and August, 2011 (next year).

b. Compare quality control (QC) and quality assurance (QA). (5)

3. a. What do you understand by 'Inflation of money'? (3)
b. Consider the cash flow of two projects: (12)

Year	Cash Flow of A	Cash Flow of B
0	100,000	100,000
1	50,000	20,000
2	30,000	20,000
3	20,000	20,000
4	10,000	40,000
5	10,000	50,000
6	---	60,000

i. Construct the NPV profile for Projects A and B
ii. Construct the BCR for Projects A and B
iii. What is the IRR of each project?
iv. Which project would you choose if r is 12 percent?

c. Describe procurement management process. (5)

4. a. A firm manufactures three products A, B and C. The profits are Tk. 3, Tk. 2 and Tk. 4 respectively. The firm has two machines and the required processing time in minutes for each machine on each product is given below. (12)

Machine	Product		
	A	B	C
M1	4	3	5
M2	2	2	4

Machine M1 and M2 have 2,000 and 2,500 machine-minutes respectively. The firm must manufacture 100 A's, 200 B's and 50 C's but no more than 150 A's. Construct a mathematical linear programming model to maximize the profit.

b. What do you understand by 'defender' and 'challenger' in replacement studies? Explain with examples. (2)

c. Name the factors that affect capacity decision. The known investment cost for 8,000 units of capacity for the manufacture of a certain item is Tk. 1,000,000. What will be the investment cost for 12,000 units of capacity if the capacity-cost factor is 0.6? (3+3)

5. a. The standard weight of a special purpose brick is 5 kg and it contains two basic ingredients B1 and B2. B1 costs Tk. 5/kg (per kg) and B2 costs Tk. 8/ kg (per kg). Strength considerations dictate that the brick contains not more than 4 kg of B1 and a minimum of 2 kg of B2. Since the demand for the product is likely to be related to the price of the brick, formulate mathematical linear programming model to minimize the cost of the brick satisfying the above conditions. (12)

b. What are the four basic needs of material management? Describe Inventory control system. (2+6)

6. Write short notes on any 5 (five) of the following: (5x4)

a. OTM
b. OSHA
c. SIC
d. Salvage value
e. Qualitative methods of demand forecast
f. Critical path

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2017
Program: B.Sc. Engineering (Civil)

Course Title: Structural Engineering III | Credit Hours: 3.0 | Course Code: CE 411
Time: 3 hours | Full Marks: 100 (= 10 × 10)

[Answer **any 10 (ten)** of the following 14 questions]

1. Use Stiffness Method (neglecting axial deformation) to calculate the unknown rotation and deflection at joint ***d*** of the frame ***abcdef*** loaded as shown in ***Fig.1*** [Given: $EI = 16 \times 10^3$ kN-m^2].

2. Use Stiffness Method to calculate the unknown rotation and deflection at joint ***d*** of the frame ***abcdef*** loaded as shown in ***Fig.1*** considering flexural deformations only with geometric nonlinearity [Given: $EI = 16 \times 10^3$ kN-m^2].

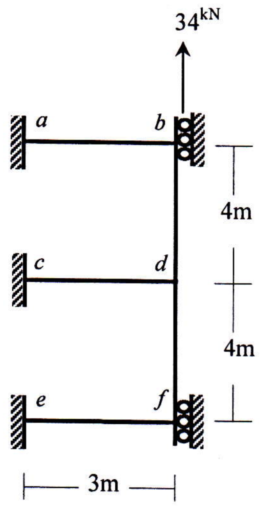


Fig. 1

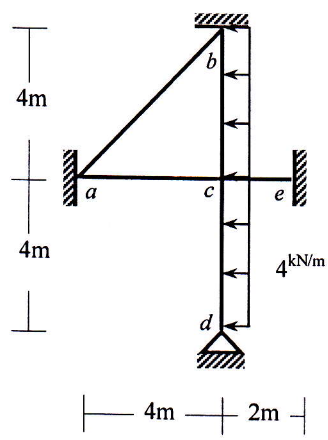


Fig. 2

3. Consider flexural deformations only (with consistent mass matrix) to calculate the natural frequencies of the frame ***abcde*** shown in ***Fig. 2*** [Given: $EI = 16 \times 10^3$ kN-m^2, Mass per length $\mu = 1.05$ kg-sec^2/m^2].

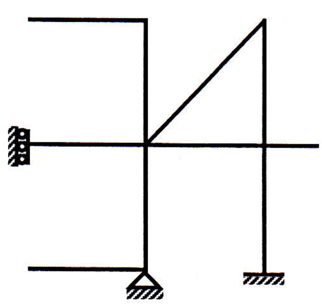


Fig. 3(a)

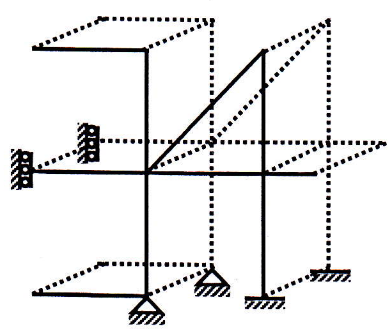


Fig. 3(b)

4. Determine the degree of kinematic indeterminacy (doki) and show the corresponding deflections and rotations of the 2D frame and 3D frame shown in ***Fig.3(a)*** and ***Fig. 3(b)***, for the following cases
   (i) Not considering boundary conditions
   (ii) Considering boundary conditions
   (iii) Neglecting axial deformations.

5. For the plane truss ***abcdefgh*** shown in ***Fig.4*** calculate (i) deflections at joints ***d*** and ***e***, (ii) Axial force in all members [Given: S_x = constant = 10^4 kN/m; P = 34^k].

6. For the plane truss ***abcdefgh*** shown in ***Fig.4***, S_x = constant = 10^4 kN/m, mass per length μ = 1.05 kg-sec^2/m^2. Calculate its natural frequencies (neglecting zero-force members) using consistent mass matrices.

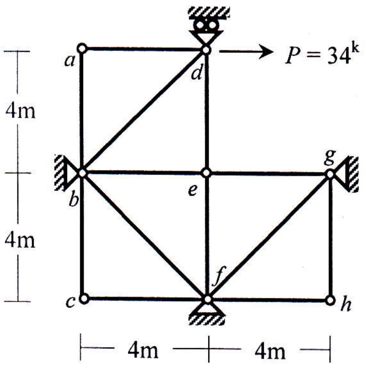


Fig. 4

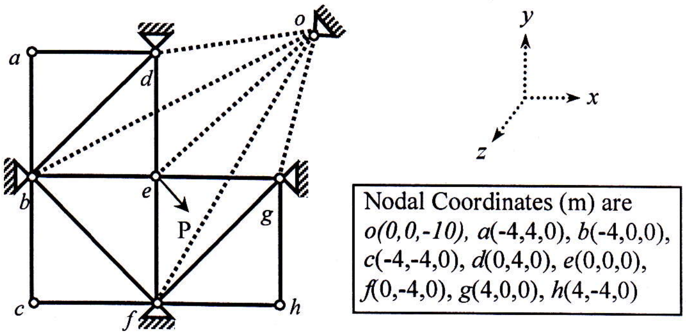


Fig. 5

7. Ignore zero-force members and apply boundary conditions to form the stiffness matrix of the space truss ***oabcdefgh*** shown in ***Fig. 5*** [Given: S_x= constant = 10^4 N/mm].

8. Frame structure ***abcdef*** shown in ***Fig.6*** is subjected to a dynamic load, w = 10 e^{3t} (k/ft). Use *Constant Average Acceleration* (*CAA*) Method to calculate the rotation of joint ***c*** at time t = 0.10 sec [Given: EI = 40 × 10^3 k-ft^2, μ = 0.0045 k-sec^2/ft^2, Damping ratio of the system = 8%].

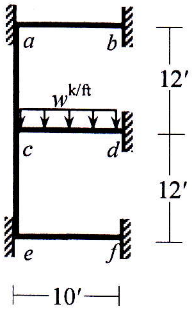


Fig. 6

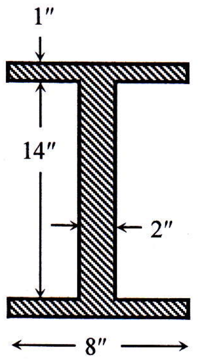


Fig. 7(a)

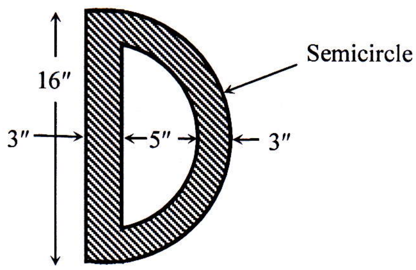


Fig. 7(b)

9. Calculate the Yield Moment and Plastic Moment capacity of the sections shown in ***Fig.7(a)*** and ***Fig.7(b)*** if they are made of elastic-fully plastic material [Given: $\sigma_y = \sigma_{yp}$ = 60ksi].

10. Briefly explain the
    (i) Possible ways to improve the buckling load calculated by Stiffness Method
    (ii) Difference between the yield moment (M_y) and plastic moment (M_p) of a cross-section
    (iii) Difference between the 'Beam Mechanism' and 'Side-sway Mechanism' for frames
    (iv) Basic assumption of Constant Average Acceleration method of numerical time-step integration
    (v) Effect of foundation flexibility on the structural response to seismic ground motion.

11. For the grid loaded as shown in ***Fig.8***, use the stiffness method to calculate the vertical deflection at ***b*** and rotation at ***c*** [Given: $EI = 15\times 10^3$ kN-m^2, $GJ = 10\times 10^3$ kN-m^2].

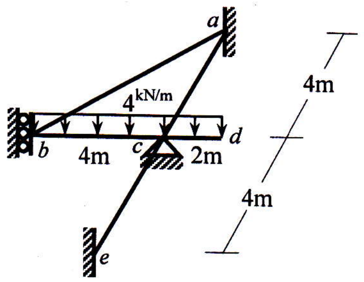


Fig. 8

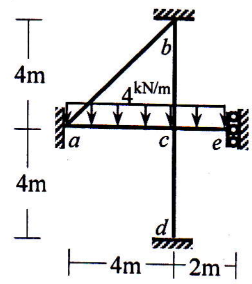


Fig. 9(a)

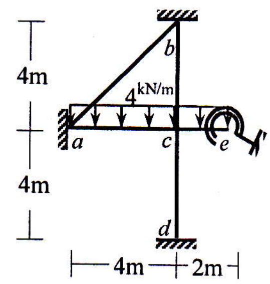


Fig. 9(b)

12. Use the Stiffness Method (neglect axial deformations) to calculate the vertical deflection at joint *e* and rotation at joint ***c*** of the frames loaded as shown in ***Fig.9***, if the support at ***e*** is a
   (i) Guided roller support [***Fig. 9(a)***]
   (ii) Circular foundation of radius 4-ft on the surface of sub-soil (half-space) with shear-wave velocity (v_s) equal to 150m/sec [***Fig. 9(b)***]

   [Given: $EI = 20\times 10^3$ kN-m^2, Unit weight of soil = 18 kN/m^3, Poisson's ratio = 0.25].

13. Consider flexural deformations and geometric nonlinearity to calculate the value of P required to cause buckling of the beam ***abcde*** loaded as shown in ***Fig. 10*** [Given: $2EI_{abcd} = EI_{de} = 40\times 10^3$ k-ft^2].

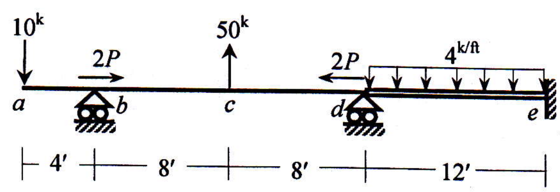


Fig. 10

14. Use the Energy Method to calculate the plastic moment M_p needed to prevent the development of plastic hinge mechanism in the beam ***abcde*** loaded as shown in ***Fig. 10***

   [Given: $M_{p(abcd)} = M_p$, $M_{p(de)} = 2M_p$].

List of Useful Formulae for CE 411

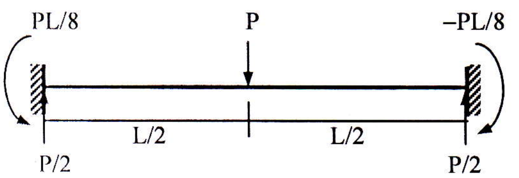
* The stiffness matrix $\mathbf{K_m}^G$ of a 2D truss member in the global axis system is given by

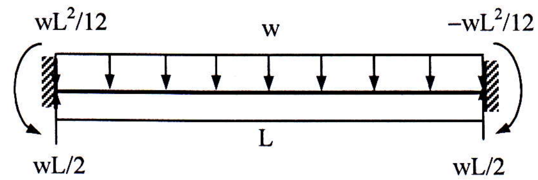
$$\mathbf{K_m}^G = S_x \begin{pmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ -CS & -S^2 & CS & S^2 \end{pmatrix}$$

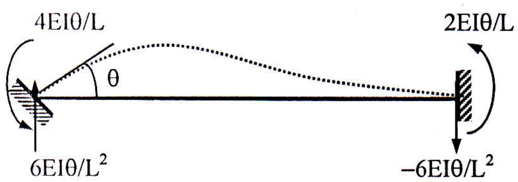
and Truss member force, $P_{AB} = S_x\,[(u_B-u_A)\,C + (v_B-v_A)\,S]$

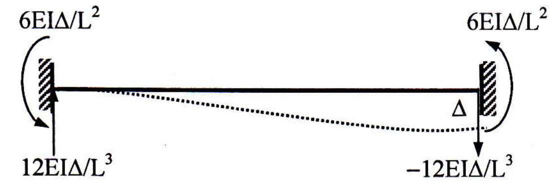
[where $C = \cos\theta$, $S = \sin\theta$]

Fixed End Reactions for One-dimensional Prismatic Members under Typical Loadings









* The stiffness matrix of a 3D truss member in the global axes system [using $C_x = \cos\alpha$, $C_y = \cos\beta$, $C_z = \cos\gamma$] is

$$\mathbf{K_m}^G = S_x \begin{pmatrix} C_x^2 & C_xC_y & C_xC_z & -C_x^2 & -C_xC_y & -C_xC_z \\ C_yC_x & C_y^2 & C_yC_z & -C_yC_x & -C_y^2 & -C_yC_z \\ C_zC_x & C_zC_y & C_z^2 & -C_zC_x & -C_zC_y & -C_z^2 \\ -C_x^2 & -C_xC_y & -C_xC_z & C_x^2 & C_xC_y & C_xC_z \\ -C_yC_x & -C_y^2 & -C_yC_z & C_yC_x & C_y^2 & C_yC_z \\ -C_zC_x & -C_zC_y & -C_z^2 & C_zC_x & C_zC_y & C_z^2 \end{pmatrix}$$

$C_x = L_x/L$, $C_y = L_y/L$, $C_z = L_z/L$ where $L = \sqrt{[L_x^2 + L_y^2 + L_z^2]}$

* Member force $P_{AB} = S_x\,[(u_B - u_A)\,C_x + (v_B - v_A)\,C_y + (w_B - w_A)\,C_z]$
* Torsional stiffness $T_1 = GJ/L$
* Ignoring axial deformations, the matrices $\mathbf{K_m}^L$ and $\mathbf{G_m}^L$ of a frame member in the local axis system are

$$\mathbf{K_m}^L = \begin{pmatrix} S_1 & S_2 & -S_1 & S_2 \\ S_2 & S_3 & -S_2 & S_4 \\ -S_1 & -S_2 & S_1 & -S_2 \\ S_2 & S_4 & -S_2 & S_3 \end{pmatrix} \qquad \mathbf{G_m}^L = (P/30L)\begin{pmatrix} 36 & 3L & -36 & 3L \\ 3L & 4L^2 & -3L & -L^2 \\ -36 & -3L & 36 & -3L \\ 3L & -L^2 & -3L & 4L^2 \end{pmatrix}$$

where $S_1 = 12EI/L^3$, $S_2 = 6EI/L^2$, $S_3 = 4EI/L$, $S_4 = 2EI/L$

* $\mathbf{K}_{total} = \mathbf{K} + \mathbf{G}$, buckling occurs (i.e., $P = P_{cr}$) when $|\mathbf{K}_{total}| = 0$

* For sections of Elastic-Fully-Plastic material, $A_t = A_c = A/2$, and $M_p = A_c\,\bar{y}_c + A_t\,\bar{y}_t$
* For RC sections, $M_p = A_s f_y (d-a/2)$, where $a = A_s f_y/(0.85 f_c'\,b)$
* Virtual work done by external forces (δW_E) = Virtual work done by internal forces (δW_I)
* For simply supported beams under (i) concentrated midspan load $P_u = 4\,M_p/L$, and (ii) UDL $w_u = 8\,M_p/L^2$
* For fixed-ended beams under (i) concentrated midspan load $P_u = 8\,M_p/L$, and (ii) UDL $w_u = 16\,M_p/L^2$
* For hinged-fixed ended beams under UDL $w_u = 11.66\,M_p/L^2$

* Using CAA Method, $(m + c\Delta t/2 + k\Delta t^2/4)a_{i+1} = f_{i+1} - ku_i - (c + k\Delta t)v_i - (c\Delta t/2 + k\Delta t^2/4)a_i$
  [m = Total mass, c = Damping = $2\xi\sqrt{(km)}$, where ξ = Damping Ratio]
  Also $v_{i+1} = v_i + (a_i + a_{i+1})\Delta t/2$, and $u_{i+1} = u_i + v_i\,\Delta t + (a_i + a_{i+1})\Delta t^2/4$, starting with $a_0 = (f_0 - cv_0 - ku_0)/m$

* Lumped- and Consistent-Mass matrix for axial rod

$$\mathbf{M_m} = (\mu L/2)\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \qquad \mathbf{M_m} = (\mu L/3)\begin{pmatrix} 1 & 0.5 \\ 0.5 & 1 \end{pmatrix}$$

Consistent-Mass matrix for beam [μ = Mass per unit length]

$$\mathbf{M_m} = (\mu L/420)\begin{pmatrix} 156 & 22L & 54 & -13L \\ 22L & 4L^2 & 13L & -3L^2 \\ 54 & 13L & 156 & -22L \\ -13L & -3L^2 & -22L & 4L^2 \end{pmatrix}$$

* At natural frequency (i.e., $\omega = \omega_n$), $|\mathbf{K} - \omega_n^2\mathbf{M}| = 0$
* Stiffness of Circular Surface Foundations on Half-Space

Motion	Horizontal	Vertical	Rotational	Torsional
$K_{Halfspace}$	$8G_sR/(2-\nu)$	$4G_sR/(1-\nu)$	$8G_sR^3/(3-3\nu)$	$16G_sR^3/3$