

**SECTION – A**

There are **EIGHT** questions in this section. Answer any **SIX**.

Further data required may be reasonably assumed.

1. Shrinkage limit of a soil may be defined as the saturated water content of the soil at its minimum volume during the process of drying. Following this definition, derive expressions for shrinkage limit for both the cases of known and unknown specific gravity of soil solids, and hence solve the following problem using the derived relations. (23 1/3)

A saturate clay sample had a volume of 90 cc and weight 22.0 gm. When completely oven dried its volume was measured as 80 cc and weight was found to be 18.5 gm. Calculate shrinkage limit of the soil and specific gravity of soil solids.

2. A 50 mm diameter normally consolidated clay sample with  $\phi' = 27^\circ$  was subjected to an unconfined compression test where it failed under an axial load of 157.1 N. Find the undrained shear strength and the pore pressure within the soil sample. (23 1/3)

3. Soil samples have been obtained from layer II and layer III as shown in Fig. 1. A series of shear strength tests were then performed on all the samples and strength parameters obtained are noted in Fig. 1. Using these data, compute the shear strength on the horizontal planes at point A and B, and on the vertical plane at point C. (23 1/3)

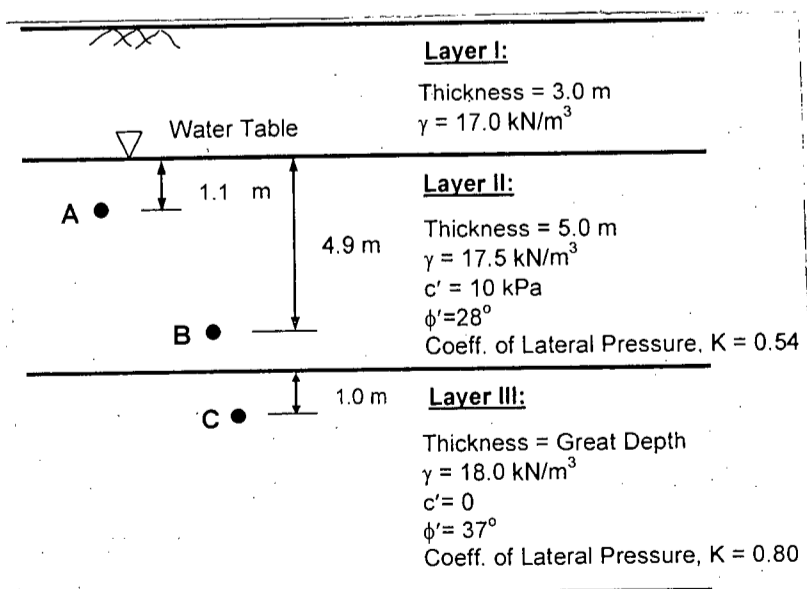


Fig. 1 for Question No. 3

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4. The following data were obtained from classification tests. When the oven dried sample of the same soil was tested for liquid limit, the value reduced to 55. Classify the soil as per USCS and AASHTO Classification System.

(23 1/3)

% passing No. 4 sieve = 100  
% passing No. 10 sieve = 90  
% passing No. 40 sieve = 80  
% passing No. 200 sieve = 60  
D<sub>30</sub> size = 0.02 mm  
D<sub>10</sub> size = 0.005 mm  
Liquid limit = 80  
Plastic limit = 44

5. At a site the soil profile was as follows with water table at a depth of 5 m. Using Rankine's theory draw the pressure distribution diagram for active pressure acting on a retaining structure with backfill of soil of similar nature. Also compute the total thrust coming on the retaining structure.

(23 1/3)

From ground surface to a depth of 5 m : SAND with  $\phi' = 33^\circ$ ,  $\gamma = 20 \text{ kN/m}^3$   
From depth of 5 m to a depth of 10 m : CLAY with  $c = 40 \text{ kN/m}^2$ ,  $\gamma = 19 \text{ kN/m}^3$   
From depth of 10 m to a depth of 12 m : SAND with  $\phi' = 40^\circ$ ,  $\gamma = 21 \text{ kN/m}^3$

6. Use Culmann's graphical construction to determine the active force against a vertical retaining wall 5.0 m high. The backfill is level with the top of the wall and is dry sand with a unit weight of  $16.2 \text{ kN/m}^3$  and a friction angle  $\phi'$  of  $36^\circ$ . Assume the friction angle  $\delta$  between the soil and the wall as  $0.67 \phi'$ . Compare the results with that obtained from Rankine's method and comment.

(23 1/3)

7. A retaining wall 10 m high retains granular fill, with level surface, weighing  $18.6 \text{ kN/m}^3$ . The active thrust on the wall is 200 kN per metre length of the wall. The height of the wall is to be increased and the forces on the wall to be kept within allowable limits. As such, the backfill is to be removed to a depth of 5 m and replaced by cinders that would also be used as backfill for increased height. What additional height may be allowed if it is required that the active thrust on the wall be limited to the initial value. The cinder may be assumed to weigh  $8.8 \text{ kN/m}^3$ , and to have the same friction angle as that of soil.

(23 1/3)

8. Write short notes on:

(23 1/3)

- (a) Water transported soil deposits;
- (b) Soil structure and fabric;
- (c) Vane shear test;
- (d) Earth Pressure at rest.

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**SECTION – B**

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

Assume reasonable value/values for missing data only.

9. (a) Why is compaction test done in the laboratory? Give the salient features of Standard and Modified Proctor methods. Establish a relationship between void ratio and porosity of a soil. (14  $\frac{2}{3}$ )
- (b) A relative density test conducted on a sandy soil yielded the following results: (16)  
Maximum void ratio = 1.23, Minimum void ratio = 0.48, Relative density = 42%, and  $G_s = 2.67$ .  
Find the dry density of the soil in the present state. If a 3.0 m thickness of thin stratum is densified to a relative density of 62%, how much will the soil reduce in thickness?
- (c) The undistributed soil at a given borrow pit is found to have a water content of 16.8%, a void ratio of 0.62 and  $G_s = 2.7$ . The soil from the borrow area is to be used to construct an embankment (fill area) having finished volume of 4,800 m<sup>3</sup>. The soil is excavated and dumped in trucks. In the construction process, the trucks dump their loads on the fill and the material is spread over and broken up after which water is added until the moisture content is 18.2%. The soil and water are thoroughly mixed and compacted until the wet density is 1.85 ton/m<sup>3</sup>. (16)
- (i) How many truck loads of solids were transferred if each truck load is 15 m<sup>3</sup>? Assume the void ratio of the excavated soil and the soil loaded in the truck are the same.
- (ii) If the fill becomes saturated at some time subsequent to construction and does not change in volume, what will be the saturation moisture content?
- (iii) What will be the saturation moisture content if the soil swells to increase its original finished volume by 15.8%.
10. (a) What is seepage pressure? Write down the expression, showing the effect of it (seepage pressure) on the magnitude of effective stress in soil. What is flow net diagram and write down the step by step procedure for constructing flow net diagram for confined flow condition. (10  $\frac{2}{3}$ )
- (b) Draw the flow net diagram for the confined flow problem as shown in Fig. 3. (Draw the diagram on Fig. 3 and attached it to answer script). (16)
- (c) How do you check the stability of sheet piles against heaving? (10)
- (d) Water flows at the rate of 100 mm<sup>3</sup>/sec in upward direction through a sand sample with a coefficient of permeability  $3.0 \times 10^{-2}$  mm/sec. If the thickness of the soil sample is 200 mm and the cross-sectional area is 3000 mm<sup>2</sup>, calculate the hydraulic gradient and the effective pressure at the bottom of the sample. Assume saturated unit weight of the sand = 20.5 kN/m<sup>3</sup>. (10)

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11. (a) Describe the construction procedure of field e-log(p) curve for over consolidated clay using Schmartzmann procedure. (10<sup>2/3</sup>)

(b) The foundation of a new structure is to be laid out on a bed of sand with 10 m thickness overlying a layer of saturated clay 1.5 m thick. Below the clay layer, there is another bed of sand. The effective overburden pressure at the middle of the clay layer before the construction of the foundation is 100 kPa. Due to the foundation loading, an additional increase of 100 kPa in the vertical direction is expected at the middle of clay layer. An undisturbed sample of same clay 20 mm thick was tested in a floating ring consolidation apparatus with both ways drainage. Under a pressure of 100 kPa, the total change in thickness was 0.60 mm and under 200 kPa, it was 1.00 mm. The time taken 40% of the total settlement of occur under 200 kPa pressure was 1.0 hour. Compute: (20)

- (i) Coefficient of volume compressibility,
- (ii) Final settlement of the clay layer,
- (iii) Time required for 80% settlement, and
- (iv) Time required to achieve 10 mm settlement.

(c) What is pre-consolidation pressure? What is swell index? How can you estimate swell index from the value of compression index? For what type of soil sand drain is effective? (16)

12. (a) Describe the step by step procedure for constructing instantaneous time vs. settlement curve of a foundation resting on saturated clay layer. (10<sup>2/3</sup>)

(b) Establish the relationship between seepage velocity and discharge velocity. (8)

(c) An infinitely long embankment is made on the surface of a homogeneous soil mass with a height of 3.0 m as shown in Fig. 2. If the unit weight the compacted soil used for making embankment is 20 kN/m<sup>3</sup>, find the increase in vertical stress due to embankment loading at P1 and P2. (14)

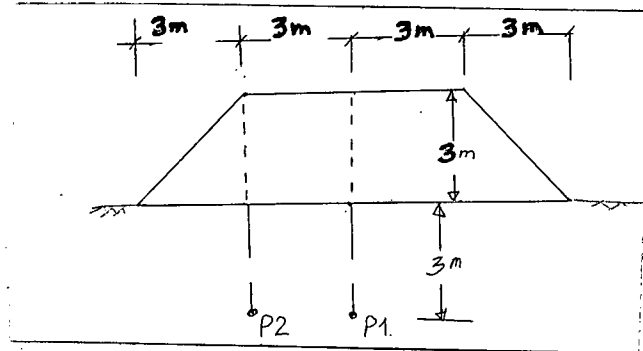
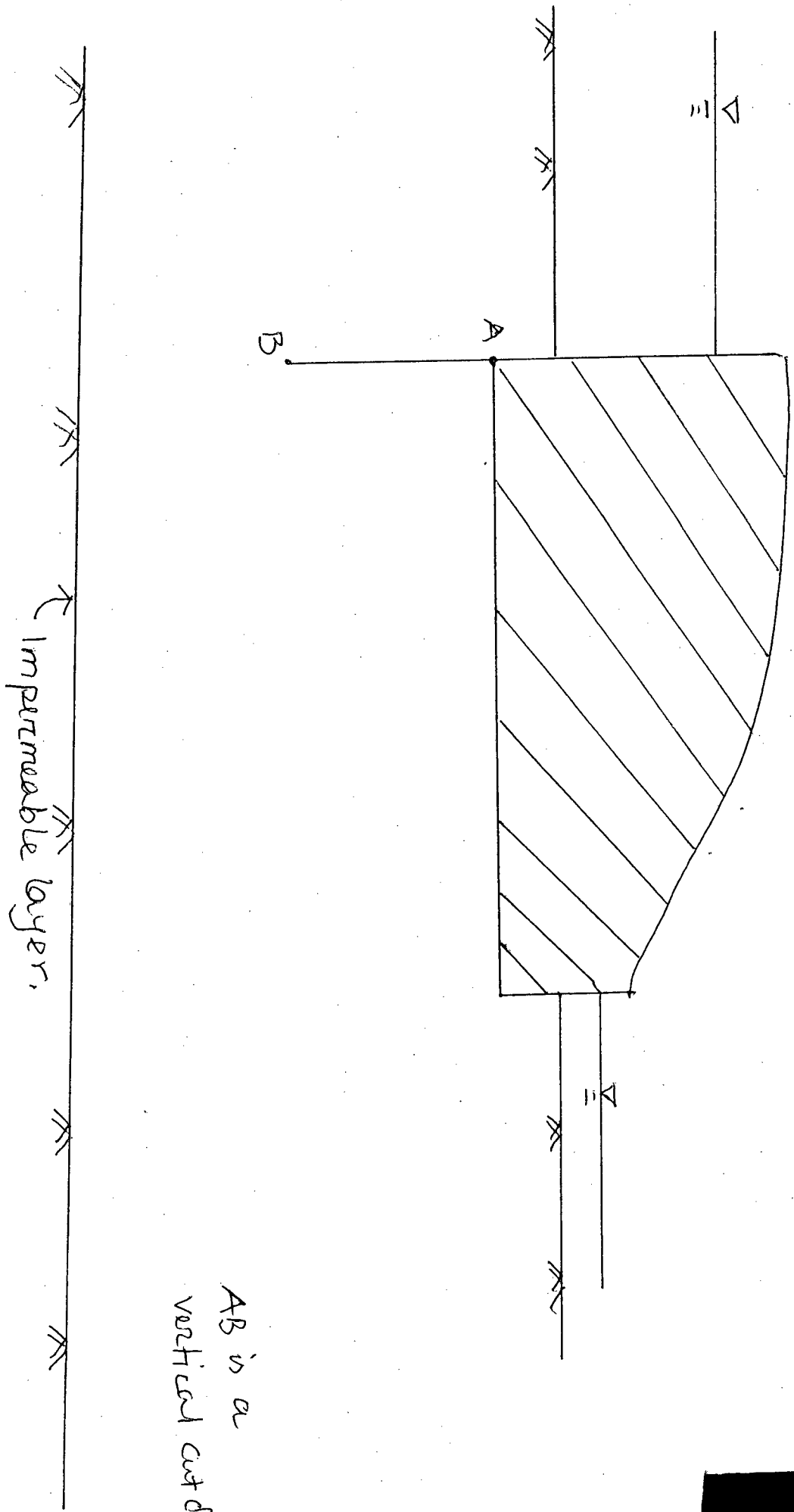


Fig. 2

(d) A rectangle raft of size 24 m × 12 m is subjected to a uniformly distributed load of 50 kPa at the surface. Calculate vertical stress below the centre of the raft at a depth of 6.0 m from the surface using Newmark Influence Chart. (14)



AB is a  
vertical cut off.

Fig. 3

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **CE 311** (Structural Analysis and Design I)

Full Marks : 280

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION – A**There are **SEVEN** questions in this Section. Answer any **FIVE**.

1. Using cantilever method draw shear force and bending moment diagrams for the girder ABC and columns PAQ of the building frame in Fig. 1. Also draw axial force diagram for the column PAQ. Cross sectional areas of the columns are mentioned by the side of the columns. (28)
2. The building frame in Fig. 2 carries a uniform vertical load of 3 kip/ft on each girder. Using approximate method draw bending moment diagrams for all the beams and columns. Also calculate the axial force in all the columns at the GF (Ground Floor). (Columns are of constant cross section over its height). (28)
3. Using approximate method determine the bar forces in A, B, C, and D of the truss in Fig. 3. (Diagonals can carry compression) (28)
4. For the beam in Fig. 4, draw influence lines for (a) reaction at C (b) shear force at D and just left of C and (c) bending moment at C and D. (28)
5. Draw shear force and bending moment diagram for the column ABC of the Mill Bent in Fig. 5 and find bar force in the knee braces BK and ME. (28)
6. Calculate the force (maximum tension and compression) in bars A and B of the truss in Fig. 6 due to a moving live load of 3 kips/ft accompanied by a roving concentrated load of 60 kip and the dead load of the truss of 2 kips/ft. (28)
7. Calculate the vertical distribution of earthquake forces for a 24 m high 8 storied hospital building with equal storey height for Dhaka city. The structural system will be special moment resisting frame in steel ( $R = 12$ ). The building will be 30m  $\times$  30m in plan. Use equivalent static force method as per BNBC.  
Given that: Dead load = 7 kN/m<sup>2</sup> for each floor; Partition wall load = 3 kN/m<sup>2</sup> for each floor;  $z = 0.15$ ,  $t = 1.25$ , site coefficient,  $s = 1.5$ ;  $c_t = 0.083$ ,  $c < 2.75$  and  $\frac{C}{R} > 0.075$  (28)

Notations convey usual meanings and assume any reasonable value of missing data.

**CE 311**

**SECTION – B**

There are **SEVEN** questions in this Section. Answer any **FIVE**.

8. Draw shear force and bending moment diagram for the stiffening girders of the suspension bridge shown in the Fig. 7. Also compute maximum tension in the Cable. (28)
  
  9. Calculate horizontal deflection at joint 'F' of the truss shown in Fig. 8 Given: Cross-sectional area of horizontal members =  $10 \text{ in}^2$  and cross-sectional area of other members =  $5 \text{ in}^2$ . Assume,  $E = 30,000 \text{ ksi}$ . (28)
  
  10. Compute vertical deflection and change in slope at 'A' of the beam shown in Fig. 9. Given:  $I_1 = 200 \text{ in}^4$  (AB),  $I_2 = 400 \text{ in}^4$  (BC) and  $E = 30,000 \text{ ksi}$ . (28)
  
  11. Find horizontal deflection at 'D' of the frame shown in Fig. 10. Given:  $A = 10 \text{ in}^2$ ,  $I = 400 \text{ in}^4$  for all member and  $E = 30,000 \text{ ksi}$ . (28)
  
  12. Compute maximum shear at quarter point of a simply supported beam of 80 ft due to the wheel load shown in Fig. 11. (28)
  
  13. Find maximum moment at One-third point of a simply supported beam of 90 ft for the load shown in Fig. 11. (28)
  
  14. Determine maximum compression for member "U<sub>3</sub>L<sub>4</sub>" of the truss shown in Fig. 12. Assume the loads given in Fig. 11. (28)
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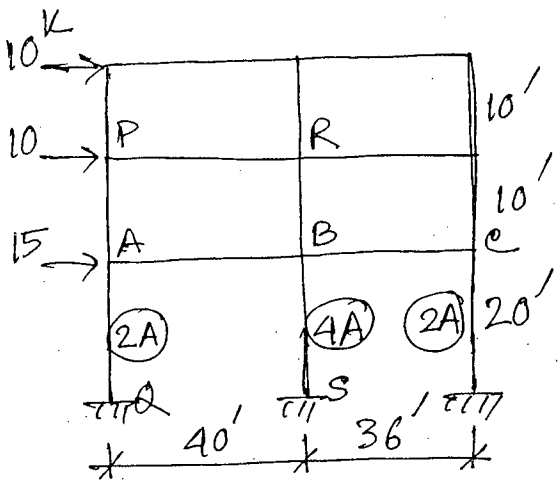


Fig. ①

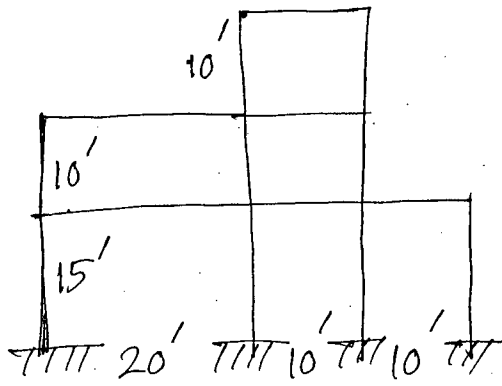


Fig. ②

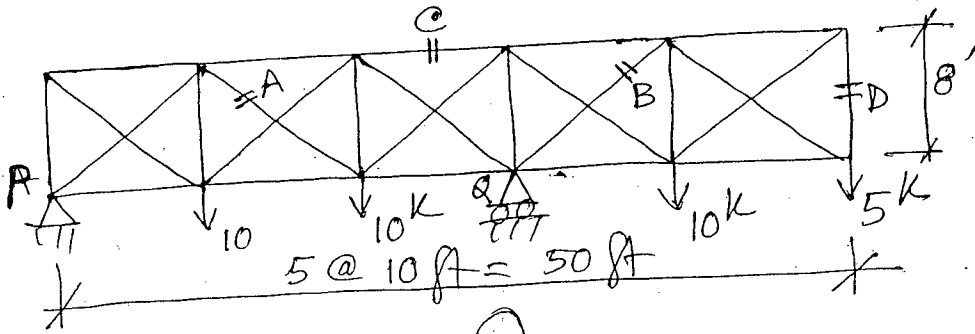


Fig. ③

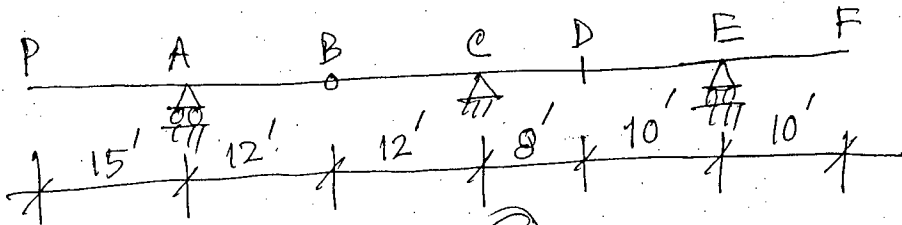


Fig. ④

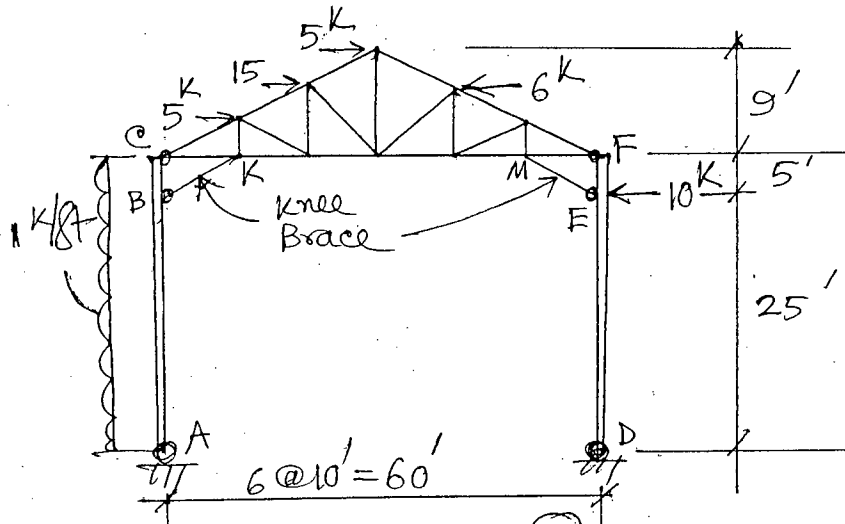


Fig. ⑤

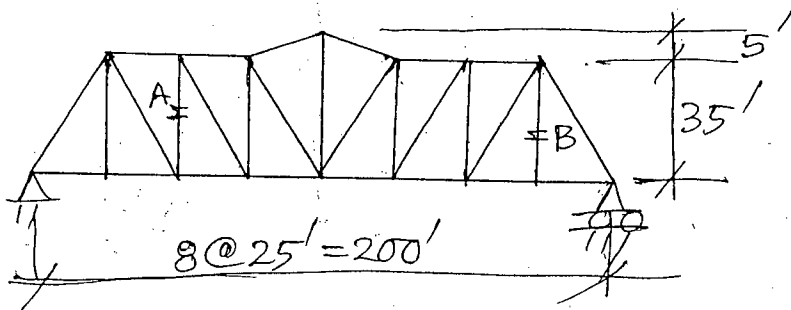


Fig. ⑥



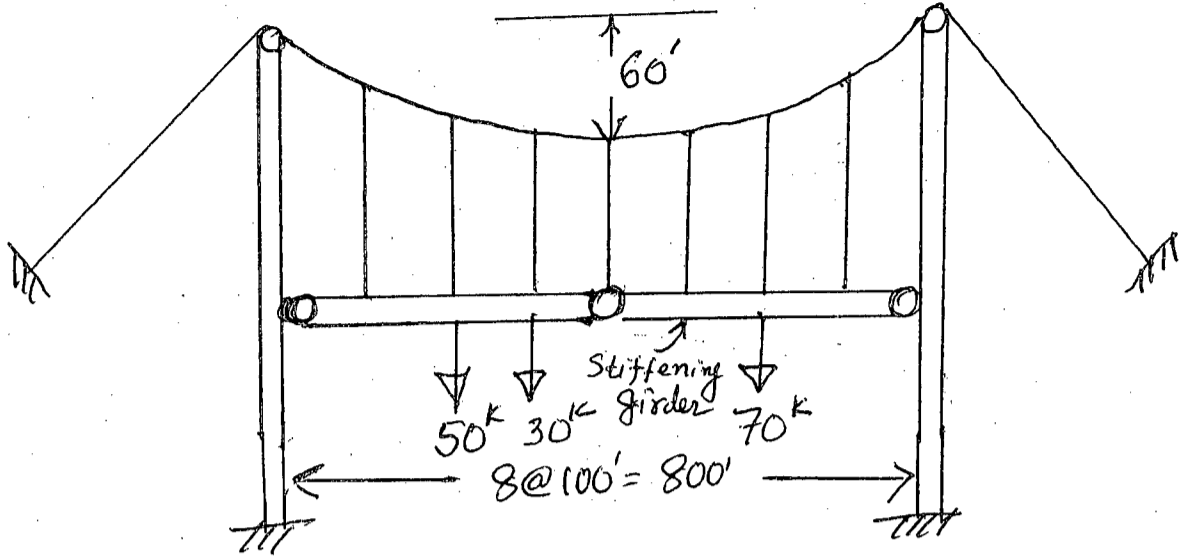


Fig. 7

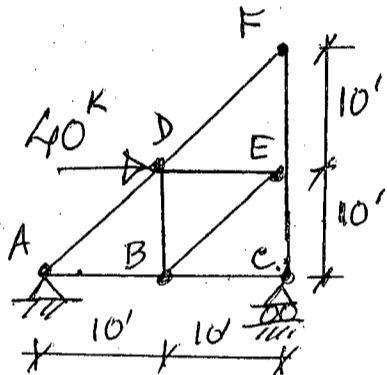


Fig. 8

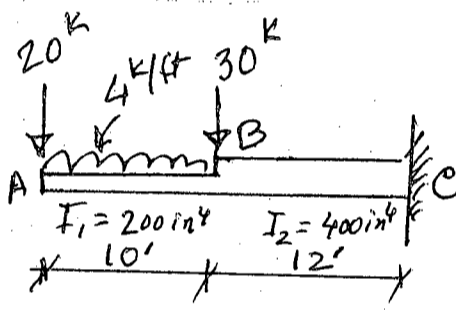


Fig. 9

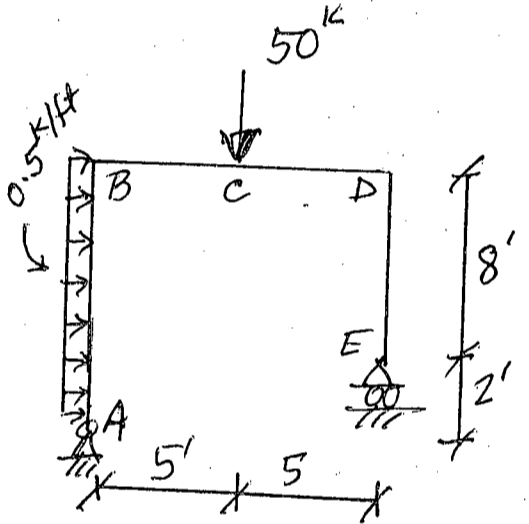


Fig. 10

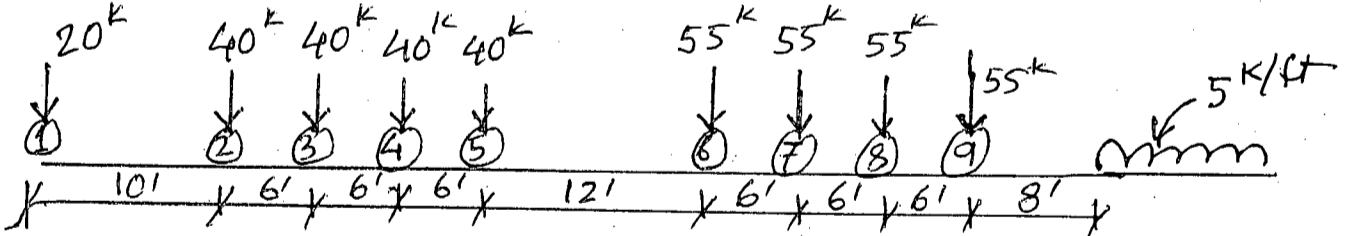


Fig. 11

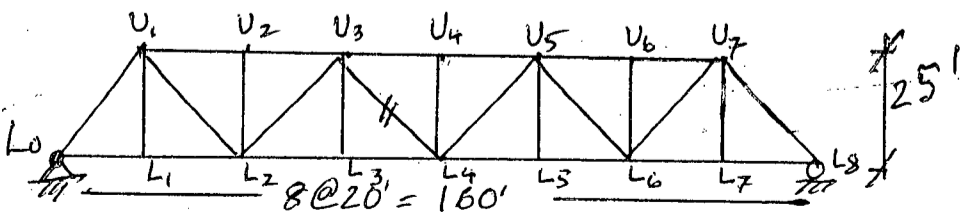


Fig. 12

**SECTION – A**

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

1. (a) What are the general impacts of climate change in Bangladesh? Briefly explain the causes of climate change. Describe the factors affecting 'per capita demand of water'? (18)  
 (b) The population of a city was 25 million in 1970, 29 million in 1980, 38 million in 1990, 55 million in 2000 and 80 million in 2010. Estimate the probable population of the city in 2020 and 2030 by the least square parabola method? Determine also the water demand for fire fighting for the city in 2020? (17)
2. (a) What are the different sources of water for water supply system? Briefly explain the hydrologic cycle. Show the essential elements of a surface water based supply system in a neat sketch. (18)  
 (b) A 300 mm diameter well in a water table aquifer is being pumped at a rate of 2,000 litre/min with a drawdown of 10 m. The static depth of water in the well is 50 m. During pumping, the depth of water in a similar well, not being pumped situated at a distance of 7.5 m is 47 m. At which rate could water be pumped from the two wells, if both the wells are being pumped together with a drawdown in each well of 9 m? (17)
3. (a) Explain briefly the three methods of arsenic removal from water through co-precipitation, followed by sedimentation and filtration processes depending on the raw water quality. Explain very briefly the 'theory of flocculation, sedimentation and adsorption processes' during flow through granular coarse media filter. (12)  
 (b) Design a tube well with the following sieve analysis data of a soil sample: (18)

Sieve No.	Sieve size (mm)	% material retained
30	0.6	0.5
40	0.425	1.0
50	0.3	4.4
100	0.15	64.8
200	0.075	27.1
Pan	-	2.2

The diameter of the well strainer is 100 mm and the opening area of the strainer is 15% of the total surface area of the strainer.

- (c) Draw a neat sketch of reverse rotary recirculation method of drilling wells. (5)

**CE 331**

4. (a) What are the Sanitary significance of (i) Arsenic, (ii) Sulfate, (iii) Nitrate and (iv) Turbidity in water? Explain the characteristics differences between Slow Sand and Rapid Sand Filters in respect of: (i) suitability (turbidity), (ii) Rate of filtration, (iii) size ( $D_{10}$ ), (iv) Cleaning Method and (v) Filter Run. (8+10)
- (b) Name the different methods of Aeration of water and how does 'Pre-chlorination' process differ from 'Post-chlorination' process? What are the advantages of Granular Activated Carbon (GAC) over Powder Activated Carbon (PAC)? When Re-carbonation process is required in a water 'Softening' process? (17)

**SECTION – B**

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

5. (a) What are the sources of origin, and WHO guide line values of the following impurities in water? (8)
- (i) Odour and Taste, (ii) Nitrate, (iii)  $CO_2$  and (iv) E. coil.
- (b) How pH value and alkalinity value affect Iron and Calcium Hardness removal from water? Explain. (10)
- (c) Explain briefly the three disinfection theories (hypothesis) through chlorination. (9)
- (d). How does bacteria removal in a slow sand filtration process differ from that in a rapid sand filtration process? (8)
6. (a) "If  $Fe(11) > Mn(11)$  rather than  $Mn(11)$  alone, removal mechanism then becomes predominantly a matter of sorption of  $Mn^{++}$  on incipient precipitates of Iron", Justify this statement with equation. (16)
- (b) What are the 4 major factors that influence plain sedimentation process? (4)
- (c) "A continuous method of water supply is always better than the intermittent method" – Justify the statement. (15)
7. (a) What are the purposes of using pumps in water supply systems? Explain. (5)
- (b) Discuss briefly the characteristics of centrifugal pumps with necessary diagrams. (10)
- (c) Design a pumping unit capable of lifting 5 mgd of water from an intake well to the treatment plant against a static head of 60 ft; length of suction main is 120 ft and that of rising main is 400 ft. The pump will work in two shifts of eight hours each. Assume velocity of flow = 6 fps, friction factor = 0.01, efficiency = 75%; and neglect minor losses. (20)
8. (a) Mention the factors to be considered in locating and designing of an intake for a Surface Water source. (10)
- (b) What is water hammer? Explain the phenomenon of water hammer with sketches. How can you reduce the water hammer effect in water works practices? (10)
- (c) What are the major activities involved in a water safety plan? Describe different categories of likelihood and impact of determining risk scores. State semi-quantative risk scoring (risk matrix). (15)
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **CE 301** (Professional Practice and Communication)

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) With reference to PPA-2006 clauses 31 and 32, state the tendering methods that can be utilised for procurement of goods and works – mentioning the particular situation of application for each of the method. (25)  
 (b) Why Open Tendering Method (OTM) is a preferred method of procurement? What are the requirements of PPA regarding use of OTM? (10)
2. (a) State the methods that can be used for procurement of intellectual services. With appropriate example explain suitability of applying these methods. (25)  
 (b) Under QCBS, the technical scores obtained by three participants A, B and C are 75, 85 and 90 respectively. The financial proposal submitted by each of the participants are Tk. 10 million, 12 million and 15 million respectively. Workout the total score and ranking of the applicants. The qualifying mark for technical score is 75% and weightage of technical score is 80%. (10)
3. (a) What are the requirements of a Joint Venture Tender? (10)  
 (b) With reference to condition of contract, state the relationship between GCC and PCC and prepare the corresponding GCC and PCC clauses for any five of the following issues: (25)
  - (I) Definition of (i) 'Employer' (ii) 'Contractor' and (iii) 'The Engineer'.
  - (II) Advance Payment
  - (III) Performance Security
  - (IV) Retention Money
  - (V) Liquidated Damage
  - (VI) Compensation Events
  - (VII) Arbitration
4. (a) Define Civil Engineers as per ASCE. Briefly describe the attributes of civil engineering profession. (10)  
 (b) Name the think twice contract clauses. (8)  
 (c) Briefly describe Conventional Proposal, Multiple Contracts, Negotiated Terms and Conditions, and Model Contracts. (17)

**CE 301**

**SECTION – B**

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

5. (a) Describe briefly the different types of business communication. **(15)**  
(b) Explain the following communication terms: **(20)**  
(i) Abstracting  
(ii) Inferring  
(iii) Denotations  
(iv) Connotations
6. (a) Define project. Briefly describe the Scope- Schedule- Budget triangular relationship.  
Describe project characteristics. **(2+6+9=17)**  
(b) Explain the communication terms Concreteness, Conciseness and Completeness of the seven C's of effective communication. **(18)**
7. (a) Define Liability Insurance, Professional Liability Insurance and Bond. Who are the principal players in the professional liability insurance industry and what are their roles?  
Name the specific concerns for professional liability insurance. **(6+9+5=20)**  
(b) Who are the participants in Project development? Show in a diagram the flow of work in project development. **(5+10=15)**
8. Briefly answer and explain the following questions based on the code of ethics for engineers.
- (i) According to section 2, what issues should the Engineer have proper regard to and what shall he do if observed conditions endanger those issues? **(7)**  
(ii) According to section 4, what should the Engineer endeavor to extend and what should he protect the engineering profession from? **(7)**  
(iii) According to section 6, when will an Engineer undertake engineering assignments and when should he engage or advise engaging experts? **(7)**  
(iv) According to section 8, what should an Engineer endeavor to do in case of conflict of interest? **(7)**  
(v) According to section 12, what should an Engineer NOT attempt to do regarding another engineer? **(7)**
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**SECTION – A**

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

1. (a) A 12 ft clear span one-way slab with an overhanging cantilever slab of 5 ft is shown in Fig. 1. The slab supports live load 60 psf in addition to its own self-wt. The live load can occupy any portion or any position on the slab. Assume partition wall load 50 psf and floor finish load 30 psf. Design the slab using USD method. Show reinforcement details in neat sketches. Material strength:  $f'_c = 3$  ksi and  $f_y = 60$  ksi. (23)
- (b) Show with neat sketches the following cracks in beam and slab: (12)
  - (i) shear crack, diagonal tension
  - (ii) shrinkage cracks
  - (iii) flexural cracks due to bending
  - (iv) bond cracks
2. (a) Design a simply supported rectangular beam with a span of 21 ft that is to carry a service DL of 1.8 kip/ft (including self-wt) and a service LL of 2.0 kip/ft. Follow USD method. Material strengths are :  $f'_c = 3$  ksi and  $f_y = 60$  ksi. (15)
- (b) From architectural considerations if the size of the beam is restricted to 12" width and 15" total depth, determine the flexural reinforcement for the beam including compressing steel if necessary. Assume  $d' = 2.5"$ ;  $f'_c = 3.5$  ksi and  $f_y = 60$  ksi. (15)
- (c) What is the effect of compression steel on the ultimate strength of beam? (5)
3. (a) A floor system consists of a 3.0 inch slab supported by continuous T-beams with 25 ft span, 48" on centres as shown in Fig. 2. Web dimensions as determined by negative moment requirement at the support area is  $b_w = 16"$  and  $d = 24"$ . What tensile area is required at midspan to resist a factored moment  $M_u = 720$  kip-ft; if  $f_y = 60$  ksi and  $f'_c = 3$  ksi? (17)
- (b) Design the slab system shown in Fig. 3. The slab is to carry a service live load of 60 psf. In addition to self-wt of slab, assume floor finish load to be 25 psf and partition wall load 50 psf. Given:  $f'_c = 3$  ksi and  $f_y = 40$  ksi. Use moment co-efficient method. Show all reinforcements in sketches. (18)
4. (a) Design the stirrups for the beam shown in Fig. 4. Use  $f'_c = 4$  ksi and  $f_y = 60$  ksi. Calculate stirrups with 3 sets of spacing. Show the stirrups in a neat sketch. (20)
- (b) Why ACI code recommends a lower limit for steel ratio of beams in flexure? Give the values of this limit for rectangular and T-beams. (8)
- (c) What do you mean by under-reinforced, balanced and over-reinforced section in RC design? (7)

**CE 315**

**SECTION – B**

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

Assume appropriate value(s) for any missing data.

5. (a) Draw the stress-strain curve of concrete in compression (for different strengths) and indicate different design parameters on it. (8)
- (b) Give reasons for the minimum cover requirements in the ACI code. (7)
- (c) The beam shown in Fig. 5, loaded by total working load of  $W$  kip/ft, has a rectangular section of width 10" and total depth 24". Bottom reinforcement consists of 3 No. 8 in one layer. Determine the maximum value of  $W$  - that can be applied without stressing concrete and steel beyond the allowable values. Given:  $f'_c = 4000$  psi and  $f_y = 60000$  psi. (20)
6. (a) State why the load factor for dead load and live load is different in USD method? (7)
- (b) Why strength reduction factor  $\phi$  is used in strength design method? Why the value is different for different cases? Explain briefly. (7)
- (c) A singly reinforced rectangular section has 12" width and 24" total depth. The tension reinforcement consists of 3 No. 9 bar. Given:  $f'_c = 4000$  psi,  $f_y = 60000$  psi,  $f_s = 24000$  psi,  $n = 9$  and  $f_r = 400$  psi. Determine, (21)
- (i) Cracking moment
- (ii) Maximum working moment
- (iii) Nominal flexural strength and design ultimate moment
7. (a) Explain briefly the factors which affect the development length of tension rebars. (7)
- (b) Explain briefly the class A and class B splices for tension rebars. (8)
- (c) Calculate the development length (for tension rebars) by USD method for # 6 and # 9 bars when used as (i) top bars (ii) other bars. Compare the values, when these rebars are 90° hooked. Given:  $f'_c = 4000$  psi,  $f_y = 60000$  psi, uncoated rebar and the beam section is 12" × 20". Use the simplified formula. (20)
8. (a) Design the singly reinforced beam shown in Fig. 6 (for flexure only) by USD method. Show the bar cut off points of rebars (if permitted by the code) using moment diagram. Given:  $f'_c = 4000$  psi and  $f_y = 60000$  psi. Use simplified equation for development length calculation. The loads are unfactored. (25)
- (b) Explain the procedure, you may require for the curtailment of rebars in a cantilever beam with variable depth. (10)
-

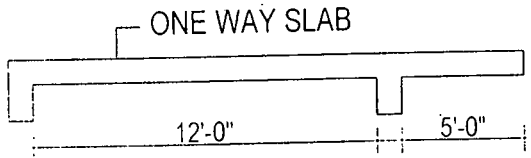


Fig- 1

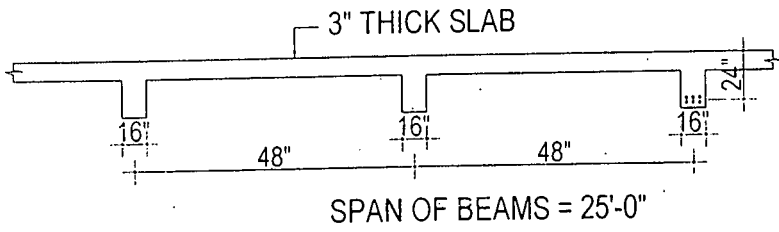


Fig- 2

Given:

- $f'_c = 3 \text{ ksi}$
- $f_y = 60 \text{ ksi}$
- $M_u = 720 \text{ kip-ft}$

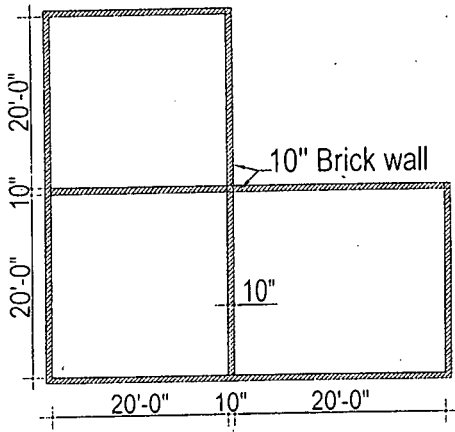


Fig- 3

Given:

- LL = 60 psf
- PW = 50 psf
- FF = 25 psf
- $f'_c = 3 \text{ ksi}$
- $f_y = 40 \text{ ksi}$

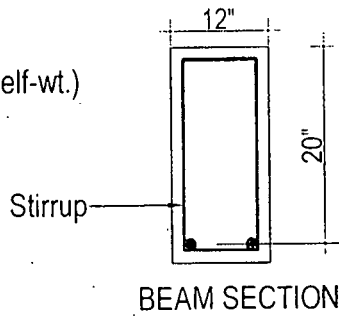
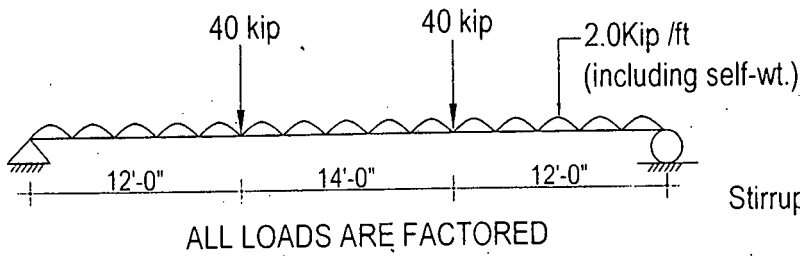


Fig- 4

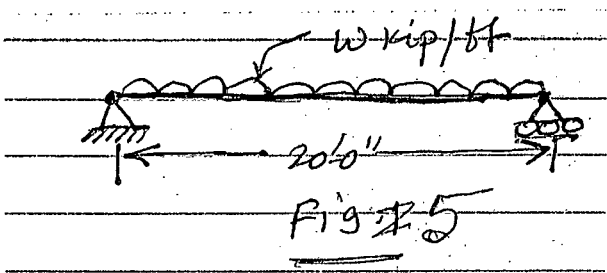


Fig- 5

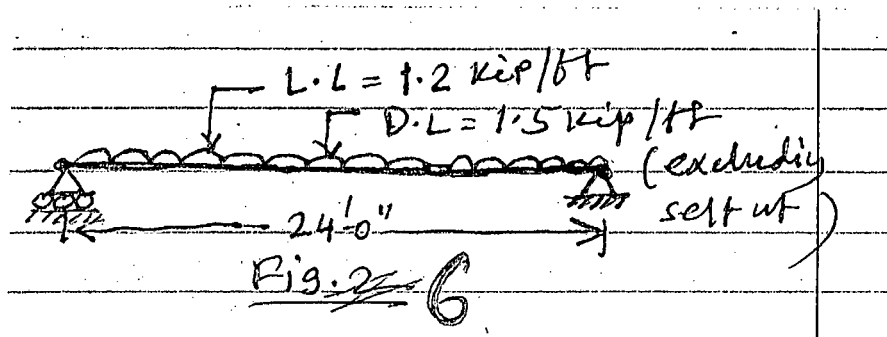


Fig- 6



\* Design of Concrete Structures - A. H. Nilson  
12th Edition, Pages 408-411.

TABLE 12.3  
Coefficients for negative moments in slabs<sup>a</sup>

$M_{a,neg} = C_{a,neg} w l_a^2$   
 $M_{b,neg} = C_{b,neg} w l_b^2$  where  $w$  = total uniform dead plus live load

Ratio	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
$m = \frac{l_a}{l_b}$	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.00 $C_{a,neg}$ $C_{b,neg}$		0.045 0.045	0.076	0.050	0.075	0.071	0.071	0.033 0.061	0.061 0.033
0.95 $C_{a,neg}$ $C_{b,neg}$		0.050 0.041	0.072	0.055	0.079	0.075	0.067	0.038 0.056	0.065 0.029
0.90 $C_{a,neg}$ $C_{b,neg}$		0.055 0.037	0.070	0.060	0.080	0.079	0.062	0.043 0.052	0.068 0.025
0.85 $C_{a,neg}$ $C_{b,neg}$		0.060 0.031	0.065	0.066	0.082	0.083	0.057	0.049 0.046	0.072 0.021
0.80 $C_{a,neg}$ $C_{b,neg}$		0.065 0.027	0.061	0.071	0.083	0.086	0.051	0.055 0.041	0.075 0.017
0.75 $C_{a,neg}$ $C_{b,neg}$		0.069 0.022	0.056	0.076	0.085	0.088	0.044	0.061 0.036	0.078 0.014
0.70 $C_{a,neg}$ $C_{b,neg}$		0.074 0.017	0.050	0.081	0.086	0.091	0.038	0.068 0.029	0.081 0.011
0.65 $C_{a,neg}$ $C_{b,neg}$		0.077 0.014	0.043	0.085	0.087	0.093	0.031	0.074 0.024	0.083 0.008
0.60 $C_{a,neg}$ $C_{b,neg}$		0.081 0.010	0.035	0.089	0.088	0.095	0.024	0.080 0.018	0.085 0.006
0.55 $C_{a,neg}$ $C_{b,neg}$		0.084 0.007	0.028	0.092	0.089	0.096	0.019	0.085 0.014	0.086 0.005
0.50 $C_{a,neg}$ $C_{b,neg}$		0.086 0.006	0.022	0.094	0.090	0.097	0.014	0.089 0.010	0.088 0.003

<sup>a</sup> A crosshatched edge indicates that the slab continues across, or is fixed at, the support; an unmarked edge indicates a support at which torsional resistance is negligible.

TABLE 12.4  
Coefficients for dead load positive moments in slabs<sup>a</sup>

$M_{a,pos,dl} = C_{a,dl} w l_a^2$   
 $M_{b,pos,dl} = C_{b,dl} w l_b^2$  where  $w$  = total uniform dead load

Ratio	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
$m = \frac{l_a}{l_b}$	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.00 $C_{a,dl}$ $C_{b,dl}$	0.036 0.036	0.018 0.018	0.018 0.027	0.027 0.027	0.027 0.018	0.033 0.027	0.027 0.033	0.020 0.023	0.023 0.020
0.95 $C_{a,dl}$ $C_{b,dl}$	0.040 0.033	0.020 0.016	0.021 0.025	0.030 0.024	0.028 0.015	0.036 0.024	0.031 0.031	0.022 0.021	0.024 0.017
0.90 $C_{a,dl}$ $C_{b,dl}$	0.045 0.029	0.022 0.014	0.025 0.024	0.033 0.022	0.029 0.013	0.039 0.021	0.035 0.028	0.025 0.019	0.026 0.015
0.85 $C_{a,dl}$ $C_{b,dl}$	0.050 0.026	0.024 0.012	0.029 0.022	0.036 0.019	0.031 0.011	0.042 0.017	0.040 0.025	0.029 0.017	0.028 0.013
0.80 $C_{a,dl}$ $C_{b,dl}$	0.056 0.023	0.026 0.011	0.034 0.020	0.039 0.016	0.032 0.009	0.045 0.015	0.045 0.022	0.032 0.015	0.029 0.010
0.75 $C_{a,dl}$ $C_{b,dl}$	0.061 0.019	0.028 0.009	0.040 0.018	0.043 0.013	0.033 0.007	0.048 0.012	0.051 0.020	0.036 0.013	0.031 0.007
0.70 $C_{a,dl}$ $C_{b,dl}$	0.068 0.016	0.030 0.007	0.046 0.016	0.046 0.011	0.035 0.005	0.051 0.009	0.058 0.017	0.040 0.011	0.033 0.006
0.65 $C_{a,dl}$ $C_{b,dl}$	0.074 0.013	0.032 0.006	0.054 0.014	0.050 0.009	0.036 0.004	0.054 0.007	0.065 0.014	0.044 0.009	0.034 0.005
0.60 $C_{a,dl}$ $C_{b,dl}$	0.081 0.010	0.034 0.004	0.062 0.011	0.053 0.007	0.037 0.003	0.056 0.006	0.073 0.012	0.048 0.007	0.036 0.004
0.55 $C_{a,dl}$ $C_{b,dl}$	0.088 0.008	0.035 0.003	0.071 0.009	0.056 0.005	0.038 0.002	0.058 0.004	0.081 0.009	0.052 0.005	0.037 0.003
0.50 $C_{a,dl}$ $C_{b,dl}$	0.095 0.006	0.037 0.002	0.080 0.007	0.059 0.004	0.039 0.001	0.061 0.003	0.089 0.007	0.056 0.004	0.038 0.002

<sup>a</sup> A crosshatched edge indicates that the slab continues across, or is fixed at, the support; an unmarked edge indicates a support at which torsional resistance is negligible.

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**TABLE 12.5**

**Coefficients for live load positive moments in slabs<sup>a</sup>**

$M_{a, pos, ll} = C_{a, ll} w l_a^2$   
 $M_{b, pos, ll} = C_{b, ll} w l_b^2$  where  $w$  = total uniform live load

Ratio	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
$m = \frac{l_a}{l_b}$									
1.00	$C_{a, ll}$ 0.036	$C_{a, ll}$ 0.027	$C_{a, ll}$ 0.027	$C_{a, ll}$ 0.032	$C_{a, ll}$ 0.032	$C_{a, ll}$ 0.035	$C_{a, ll}$ 0.032	$C_{a, ll}$ 0.028	$C_{a, ll}$ 0.030
	$C_{b, ll}$ 0.036	$C_{b, ll}$ 0.027	$C_{b, ll}$ 0.032	$C_{b, ll}$ 0.032	$C_{b, ll}$ 0.027	$C_{b, ll}$ 0.032	$C_{b, ll}$ 0.035	$C_{b, ll}$ 0.030	$C_{b, ll}$ 0.028
0.95	$C_{a, ll}$ 0.040	$C_{a, ll}$ 0.030	$C_{a, ll}$ 0.031	$C_{a, ll}$ 0.035	$C_{a, ll}$ 0.034	$C_{a, ll}$ 0.038	$C_{a, ll}$ 0.036	$C_{a, ll}$ 0.031	$C_{a, ll}$ 0.032
	$C_{b, ll}$ 0.033	$C_{b, ll}$ 0.025	$C_{b, ll}$ 0.029	$C_{b, ll}$ 0.029	$C_{b, ll}$ 0.024	$C_{b, ll}$ 0.029	$C_{b, ll}$ 0.032	$C_{b, ll}$ 0.027	$C_{b, ll}$ 0.025
0.90	$C_{a, ll}$ 0.045	$C_{a, ll}$ 0.034	$C_{a, ll}$ 0.035	$C_{a, ll}$ 0.039	$C_{a, ll}$ 0.037	$C_{a, ll}$ 0.042	$C_{a, ll}$ 0.040	$C_{a, ll}$ 0.035	$C_{a, ll}$ 0.036
	$C_{b, ll}$ 0.029	$C_{b, ll}$ 0.022	$C_{b, ll}$ 0.027	$C_{b, ll}$ 0.026	$C_{b, ll}$ 0.021	$C_{b, ll}$ 0.025	$C_{b, ll}$ 0.029	$C_{b, ll}$ 0.024	$C_{b, ll}$ 0.022
0.85	$C_{a, ll}$ 0.050	$C_{a, ll}$ 0.037	$C_{a, ll}$ 0.040	$C_{a, ll}$ 0.043	$C_{a, ll}$ 0.041	$C_{a, ll}$ 0.046	$C_{a, ll}$ 0.045	$C_{a, ll}$ 0.040	$C_{a, ll}$ 0.039
	$C_{b, ll}$ 0.026	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.024	$C_{b, ll}$ 0.023	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.022	$C_{b, ll}$ 0.026	$C_{b, ll}$ 0.022	$C_{b, ll}$ 0.020
0.80	$C_{a, ll}$ 0.056	$C_{a, ll}$ 0.041	$C_{a, ll}$ 0.045	$C_{a, ll}$ 0.048	$C_{a, ll}$ 0.044	$C_{a, ll}$ 0.051	$C_{a, ll}$ 0.051	$C_{a, ll}$ 0.044	$C_{a, ll}$ 0.042
	$C_{b, ll}$ 0.023	$C_{b, ll}$ 0.017	$C_{b, ll}$ 0.022	$C_{b, ll}$ 0.020	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.023	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.017
0.75	$C_{a, ll}$ 0.061	$C_{a, ll}$ 0.045	$C_{a, ll}$ 0.051	$C_{a, ll}$ 0.052	$C_{a, ll}$ 0.047	$C_{a, ll}$ 0.055	$C_{a, ll}$ 0.056	$C_{a, ll}$ 0.049	$C_{a, ll}$ 0.046
	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.014	$C_{b, ll}$ 0.019	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.013	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.020	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.013
0.70	$C_{a, ll}$ 0.068	$C_{a, ll}$ 0.049	$C_{a, ll}$ 0.057	$C_{a, ll}$ 0.057	$C_{a, ll}$ 0.051	$C_{a, ll}$ 0.060	$C_{a, ll}$ 0.063	$C_{a, ll}$ 0.054	$C_{a, ll}$ 0.050
	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.012	$C_{b, ll}$ 0.016	$C_{b, ll}$ 0.014	$C_{b, ll}$ 0.011	$C_{b, ll}$ 0.013	$C_{b, ll}$ 0.017	$C_{b, ll}$ 0.014	$C_{b, ll}$ 0.011
0.65	$C_{a, ll}$ 0.074	$C_{a, ll}$ 0.053	$C_{a, ll}$ 0.064	$C_{a, ll}$ 0.062	$C_{a, ll}$ 0.055	$C_{a, ll}$ 0.064	$C_{a, ll}$ 0.070	$C_{a, ll}$ 0.059	$C_{a, ll}$ 0.054
	$C_{b, ll}$ 0.013	$C_{b, ll}$ 0.010	$C_{b, ll}$ 0.014	$C_{b, ll}$ 0.011	$C_{b, ll}$ 0.009	$C_{b, ll}$ 0.010	$C_{b, ll}$ 0.014	$C_{b, ll}$ 0.011	$C_{b, ll}$ 0.009
0.60	$C_{a, ll}$ 0.081	$C_{a, ll}$ 0.058	$C_{a, ll}$ 0.071	$C_{a, ll}$ 0.067	$C_{a, ll}$ 0.059	$C_{a, ll}$ 0.068	$C_{a, ll}$ 0.077	$C_{a, ll}$ 0.065	$C_{a, ll}$ 0.059
	$C_{b, ll}$ 0.010	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.011	$C_{b, ll}$ 0.009	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.008	$C_{b, ll}$ 0.011	$C_{b, ll}$ 0.009	$C_{b, ll}$ 0.007
0.55	$C_{a, ll}$ 0.088	$C_{a, ll}$ 0.062	$C_{a, ll}$ 0.080	$C_{a, ll}$ 0.072	$C_{a, ll}$ 0.063	$C_{a, ll}$ 0.073	$C_{a, ll}$ 0.085	$C_{a, ll}$ 0.070	$C_{a, ll}$ 0.063
	$C_{b, ll}$ 0.008	$C_{b, ll}$ 0.006	$C_{b, ll}$ 0.009	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.005	$C_{b, ll}$ 0.006	$C_{b, ll}$ 0.009	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.006
0.50	$C_{a, ll}$ 0.095	$C_{a, ll}$ 0.066	$C_{a, ll}$ 0.088	$C_{a, ll}$ 0.077	$C_{a, ll}$ 0.067	$C_{a, ll}$ 0.078	$C_{a, ll}$ 0.092	$C_{a, ll}$ 0.076	$C_{a, ll}$ 0.067
	$C_{b, ll}$ 0.006	$C_{b, ll}$ 0.004	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.005	$C_{b, ll}$ 0.004	$C_{b, ll}$ 0.005	$C_{b, ll}$ 0.007	$C_{b, ll}$ 0.005	$C_{b, ll}$ 0.004

<sup>a</sup> A crosshatched edge indicates that the slab continues across, or is fixed at, the support; an unmarked edge indicates a support at which torsional resistance is negligible.

**TABLE 12.6**

**Ratio of load  $W$  in  $l_a$  and  $l_b$  directions for shear in slab and load on supports<sup>a</sup>**

Ratio	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
$m = \frac{l_a}{l_b}$									
1.00	$W_a$ 0.50	$W_a$ 0.50	$W_a$ 0.17	$W_a$ 0.50	$W_a$ 0.83	$W_a$ 0.71	$W_a$ 0.29	$W_a$ 0.33	$W_a$ 0.67
	$W_b$ 0.50	$W_b$ 0.50	$W_b$ 0.83	$W_b$ 0.50	$W_b$ 0.17	$W_b$ 0.29	$W_b$ 0.71	$W_b$ 0.67	$W_b$ 0.33
0.95	$W_a$ 0.55	$W_a$ 0.55	$W_a$ 0.20	$W_a$ 0.55	$W_a$ 0.86	$W_a$ 0.75	$W_a$ 0.33	$W_a$ 0.38	$W_a$ 0.71
	$W_b$ 0.45	$W_b$ 0.45	$W_b$ 0.80	$W_b$ 0.45	$W_b$ 0.14	$W_b$ 0.25	$W_b$ 0.67	$W_b$ 0.62	$W_b$ 0.29
0.90	$W_a$ 0.60	$W_a$ 0.60	$W_a$ 0.23	$W_a$ 0.60	$W_a$ 0.88	$W_a$ 0.79	$W_a$ 0.38	$W_a$ 0.43	$W_a$ 0.75
	$W_b$ 0.40	$W_b$ 0.40	$W_b$ 0.77	$W_b$ 0.40	$W_b$ 0.12	$W_b$ 0.21	$W_b$ 0.62	$W_b$ 0.57	$W_b$ 0.25
0.85	$W_a$ 0.66	$W_a$ 0.66	$W_a$ 0.28	$W_a$ 0.66	$W_a$ 0.90	$W_a$ 0.83	$W_a$ 0.43	$W_a$ 0.49	$W_a$ 0.79
	$W_b$ 0.34	$W_b$ 0.34	$W_b$ 0.72	$W_b$ 0.34	$W_b$ 0.10	$W_b$ 0.17	$W_b$ 0.57	$W_b$ 0.51	$W_b$ 0.21
0.80	$W_a$ 0.71	$W_a$ 0.71	$W_a$ 0.33	$W_a$ 0.71	$W_a$ 0.92	$W_a$ 0.86	$W_a$ 0.49	$W_a$ 0.55	$W_a$ 0.83
	$W_b$ 0.29	$W_b$ 0.29	$W_b$ 0.67	$W_b$ 0.29	$W_b$ 0.08	$W_b$ 0.14	$W_b$ 0.51	$W_b$ 0.45	$W_b$ 0.17
0.75	$W_a$ 0.76	$W_a$ 0.76	$W_a$ 0.39	$W_a$ 0.76	$W_a$ 0.94	$W_a$ 0.88	$W_a$ 0.56	$W_a$ 0.61	$W_a$ 0.86
	$W_b$ 0.24	$W_b$ 0.24	$W_b$ 0.61	$W_b$ 0.24	$W_b$ 0.06	$W_b$ 0.12	$W_b$ 0.44	$W_b$ 0.39	$W_b$ 0.14
0.70	$W_a$ 0.81	$W_a$ 0.81	$W_a$ 0.45	$W_a$ 0.81	$W_a$ 0.95	$W_a$ 0.91	$W_a$ 0.62	$W_a$ 0.68	$W_a$ 0.89
	$W_b$ 0.19	$W_b$ 0.19	$W_b$ 0.55	$W_b$ 0.19	$W_b$ 0.05	$W_b$ 0.09	$W_b$ 0.38	$W_b$ 0.32	$W_b$ 0.11
0.65	$W_a$ 0.85	$W_a$ 0.85	$W_a$ 0.53	$W_a$ 0.85	$W_a$ 0.96	$W_a$ 0.93	$W_a$ 0.69	$W_a$ 0.74	$W_a$ 0.92
	$W_b$ 0.15	$W_b$ 0.15	$W_b$ 0.47	$W_b$ 0.15	$W_b$ 0.04	$W_b$ 0.07	$W_b$ 0.31	$W_b$ 0.26	$W_b$ 0.08
0.60	$W_a$ 0.89	$W_a$ 0.89	$W_a$ 0.61	$W_a$ 0.89	$W_a$ 0.97	$W_a$ 0.95	$W_a$ 0.76	$W_a$ 0.80	$W_a$ 0.94
	$W_b$ 0.11	$W_b$ 0.11	$W_b$ 0.39	$W_b$ 0.11	$W_b$ 0.03	$W_b$ 0.05	$W_b$ 0.24	$W_b$ 0.20	$W_b$ 0.06
0.55	$W_a$ 0.92	$W_a$ 0.92	$W_a$ 0.69	$W_a$ 0.92	$W_a$ 0.98	$W_a$ 0.96	$W_a$ 0.81	$W_a$ 0.85	$W_a$ 0.95
	$W_b$ 0.08	$W_b$ 0.08	$W_b$ 0.31	$W_b$ 0.08	$W_b$ 0.02	$W_b$ 0.04	$W_b$ 0.19	$W_b$ 0.15	$W_b$ 0.05
0.50	$W_a$ 0.94	$W_a$ 0.94	$W_a$ 0.76	$W_a$ 0.94	$W_a$ 0.99	$W_a$ 0.97	$W_a$ 0.86	$W_a$ 0.89	$W_a$ 0.97
	$W_b$ 0.06	$W_b$ 0.06	$W_b$ 0.24	$W_b$ 0.06	$W_b$ 0.01	$W_b$ 0.03	$W_b$ 0.14	$W_b$ 0.11	$W_b$ 0.03

<sup>a</sup> A crosshatched edge indicates that the slab continues across, or is fixed at, the support; an unmarked edge indicates a support at which torsional resistance is negligible.

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