ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2019
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR CIVIL ENGINEERING

Date : October 13, 2019
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 Minutes (prior to examination time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is being provided to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions

     All questions under SECTION A are COMPULSORY.
   - **SECTION B** consists of two Case Studies. Choose only **ONE** case study and answer the questions of your choice.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the correct Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part in a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You are required to hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **15 printed pages**, including this instruction page.

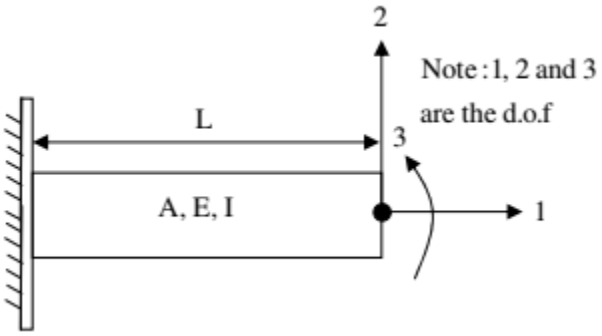
GOOD LUCK

SECTION A

PART I: Multiple Choice Questions (30 marks)

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. For the beam shown below, the stiffness coefficient K_{22} can be written as



a) $\frac{6EI}{L^2}$

b) $\frac{12EI}{L^3}$

c) $\frac{3EI}{L}$

d) $\frac{EI}{6L^2}$

2. Two pipes of diameters d_1 and d_2 converge to form a pipe of diameter 2d. If the liquid flows with a velocity of v_1 and v_2 in the two pipes, what will be the flow velocity in the third pipe?
   a) $v_1 + v_2$
   b) $v_1 + v_2/2$
   c) $v_1 + v_2/4$
   d) $2(v_1 + v_2)$

3. Which of the following statements are true?
   I. The displacement method is more useful when degree of kinematic indeterminacy is greater than the degree of static indeterminacy.
   II. The displacement method is more useful when degree of kinematic indeterminacy is less than the degree of static indeterminacy.
   III. The force method is more useful when degree of static indeterminacy is greater than the degree of kinematic indeterminacy.
   IV. The force method is more useful when degree of static indeterminacy is less than the degree of kinematic indeterminacy.

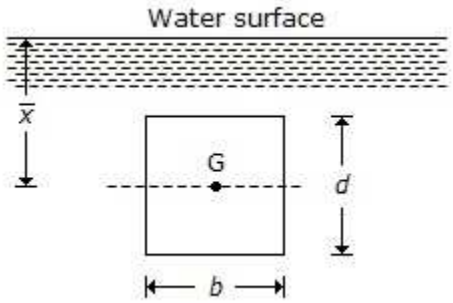
a) I and III
b) II and III
c) I and IV
d) II and IV

4. The R.L, of the point A which is on the floor is 100 m and back sight reading on A is 2.455 m. If the foresight reading on the point B which is on the ceiling is 2.745 m, the R.L. of point B will be
   a) 94.80 m
   b) 105.20 m
   c) 99.71 m
   d) 100.29 m

5. Rise of water table above the ground surface causes
   a) equal increase in pore water pressure and total stress.
   b) equal decrease in pore water pressure and total stress.
   c) increase in pore water pressure but decrease in total stress.
   d) decrease in pore water pressure but increase in total stress.

6. The design of horizontal and vertical alignments, super elevation, gradient is worst affected by
   a) Length of vehicle
   b) Width of vehicle
   c) Speed of vehicle
   d) Height of vehicle

7. A vertically immersed surface is shown in the below figure. The distance of its centre of pressure from the water surface is

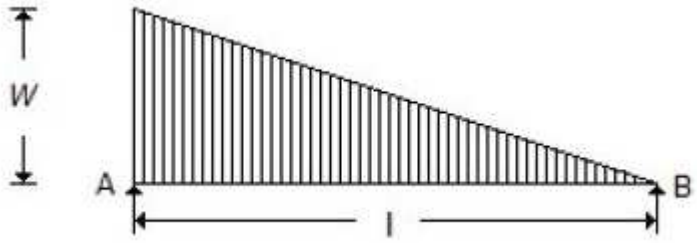


   a) $(bd^2/12) + \bar{x}$
   b) $(d^2/12\ \bar{x}) + \bar{x}$
   c) $b^2/12 + \bar{x}$
   d) $d^2/12 + \bar{x}$

8. Slenderness of a column is zero when
   a) Ends are firmly fixed.
   b) Column is supported on all sides throughout the length.
   c) Length is equal to radius of gyration.
   d) Length is twice the radius of gyration.

9. If there are m unknown member forces, r unknown reaction components and j number of joints, then the degree of static indeterminacy of a pin-jointed plane frame is given by
   a) $m + r + 2j$
   b) $m - r + 2j$
   c) $m + r - 2j$
   d) $m + r - 3j$

10. A simply supported beam with a gradually varying load from zero at 'B' and 'w' per unit length at 'A' is shown in the below figure. The shear force at 'B' is equal to



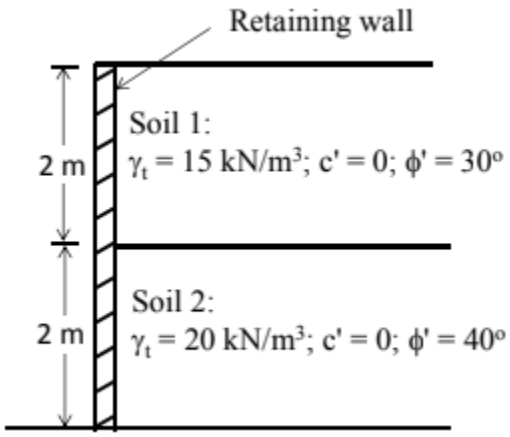
   a) wl/6
   b) wl/3
   c) wl
   d) 2wl/3

11. The most economical section of a rectangular channel is one which has hydraulic mean depth or hydraulic radius equal to
   a) half the depth.
   b) half the breadth.
   c) twice the depth.
   d) twice the breadth.

12. Select the correct statement:
   a) A contour is not necessarily a closed curve.
   b) A contour represents a ridge line if the concave side of lower value contour lies towards the higher value contour.
   c) Two contours of different elevations do not cross each other except in case of an overhanging cliff.
   d) All of the above statements are correct.

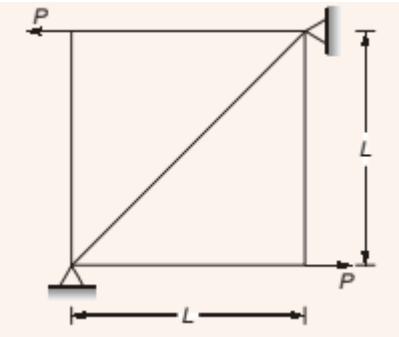
13. Wp and Wf are the weights of a cylinder containing partially compacted and fully compacted concrete. If the compaction factor (Wp/Wf) is 0.95, the workability of concrete is
    a) extremely low.
    b) high.
    c) very low.
    d) low.

14. Two different soil types (Soil 1 and Soil 2) are used as backfill behind a retaining wall as shown in the figure, where γ_t is total unit weight, and c' and ϕ' are effective cohesion and effective angle of shearing resistance. The resultant active earth force per unit length (in kN/m) acting on the wall is



    a) 31.7
    b) 35.2
    c) 51.8
    d) 57.0

15. All the members of the planar truss (see figure), have the same properties in terms of area of cross-section (A) and modulus of elasticity (E). For the loads shown on the truss, the statement that correctly represents the nature of forces in the members of the truss is:



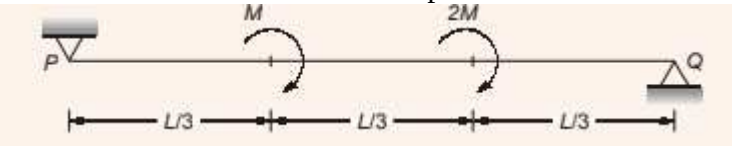
    a) There are 3 members in tension, and 2 members in compression.
    b) There are 2 members in tension, 2 members in compression, and 1 zero-force member.
    c) There are 2 members in tension, 1 member in compression, and 2 zero-force members.
    d) There are 2 members in tension, and 3 zero-force members.

16. The factor to be considered for the source of city water supply is
    a) quantity and quality of the available water.
    b) elevation of the source of water.
    c) general terrain intervening the area.
    d) All of the above.

17. When footings are to be placed adjacent to an existing structure, the line from the base of the new footing to the bottom edge of the existing footing should be
    a) 30 degree
    b) 45 degree
    c) 60 degree
    d) 90 degree

18. In a combined footing for two columns carrying unequal loads, the maximum hogging bending moment occurs at
    a) a point of zero shear force.
    b) less loaded column.
    c) more loaded column.
    d) A point of the maximum shear force.

19. The figure shows a simply supported beam PQ of uniform flexural rigidity EI carrying two moments M and 2M. The slope at P will be

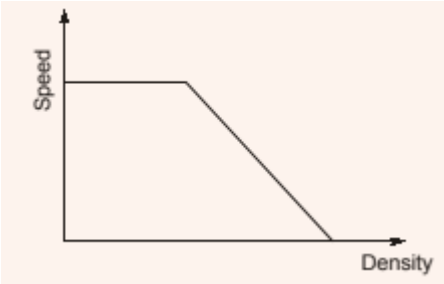


    a) **0**
    b) $\frac{ML}{9EI}$
    c) $\frac{ML}{6EI}$
    d) $\frac{ML}{3EI}$

20. The most commonly adopted method to provide super-elevation on roads is by pivoting the road surface about
    a) outer edge do that the inner edge is lowered.
    b) crown so that outer edge is raised and inner edge is lowered.
    c) inner edge so that outer edge is raised.
    d) None of the above.

21. Pick up the correct statement applicable to plate load test:
    a) Width of the test pit for plate load test is made five times the width of the plate.
    b) At the centre of the test pit, a hole is dug out whose size is kept equal to the size of the test plate.
    c) Bottom level of the hole dug at the centre of the test pit is kept at the level of actual formation.
    d) All of the above.

22. The speed-density relationship for a road section is shown in the figure below:



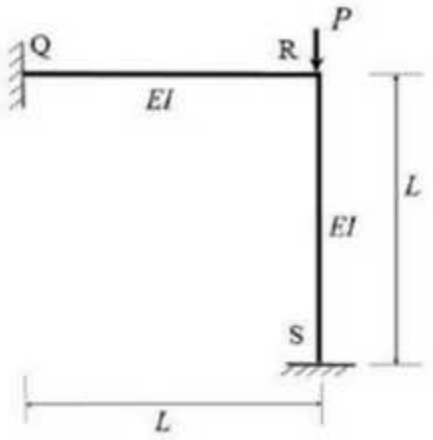
    The shape of the flow-density relationship is
    a) piecewise linear
    b) parabolic
    c) initially linear then parabolic
    d) initially parabolic then linear

23. An inflow hydrograph is routed through a reservoir to produce an outflow hydrograph. The peak flow of the inflow hydrograph is PI and the time of occurrence of the peak is t_I. The peak flow of the outflow hydrograph is P0 and the time of occurrence of the peak is t_0. Which one of the following statements is correct?
    a) PI < P0 and tI > t0
    b) PI > P0 and tI > t0
    c) PI < P0 and tI < t0
    d) PI > P0 and tI < t0

24. The equivalent axial tensile load Pe, which produces an average axial tensile stress in the section equivalent to the combined stress due to axial tension P and bending M, at the extreme fibre of the section, is given by (where Z is the section modulus of the section)
    a) $P_e = P + MA/Z$
    b) $P_e = P - MA/Z$
    c) $P_e = P - Z/MA$
    d) $P_e = P + Z/MA$

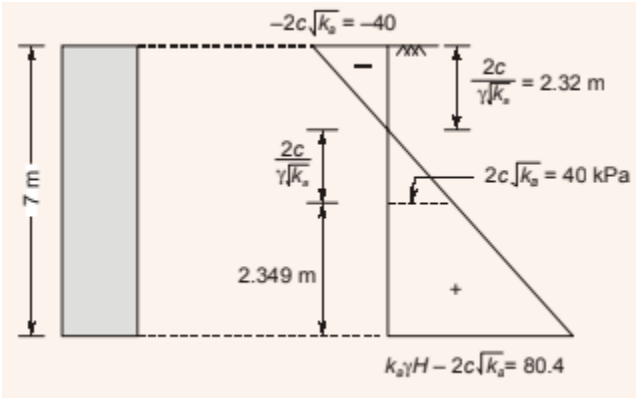
25. If V is total consumption of water in liters for a population of N individuals, per capita consumption or water allowance for the water supply Q, is given by
    a) Q = V/12N
    b) Q = V/24N
    c) Q = V/265N
    d) None of the above

26. The rigid-jointed plane frame QRS shown in the figure is subjected to a load P at the joint R. Let the axial deformations in the frame be neglected. If the support S undergoes a settlement of $\Delta = \frac{PL^3}{\beta EI}$, the vertical reaction at the supports will become zero when β is equal to



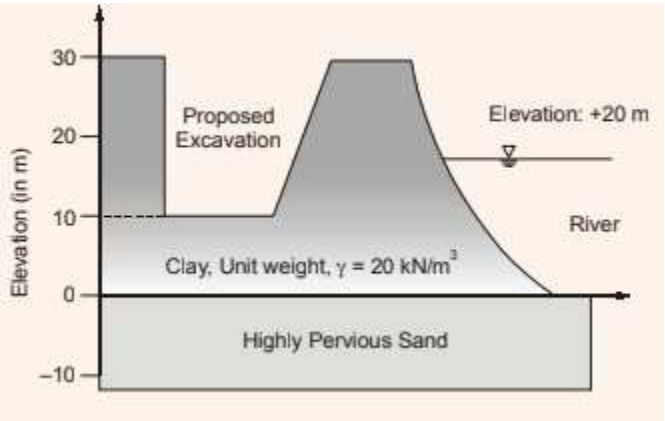
    a) 0.1
    b) 7.5
    c) 3.0
    d) 48.0

27. A rigid smooth retaining wall of height 7 m with vertical backface retains saturated clay as backfill. The saturated unit weight and un drained cohesion of the backfill are 17.2 kN/m3 and 20 kPa, respectively. The difference in the active lateral forces on the wall (in kN per meter length of wall, up to two decimal places), before and after the occurrence of tension cracks is



a) 46.72 kpa
b) 4.67 kpa
c) 0.467 kpa
d) - 46.72 kpa

28. At a construction site, a contractor plans to make an excavation as shown in the figure below. The water level in the adjacent river is at an elevation of +20.0 m. Unit weight of water is 10 kN/m3. The factor of safety (up to two decimal places) against sand boiling for the proposed excavation is

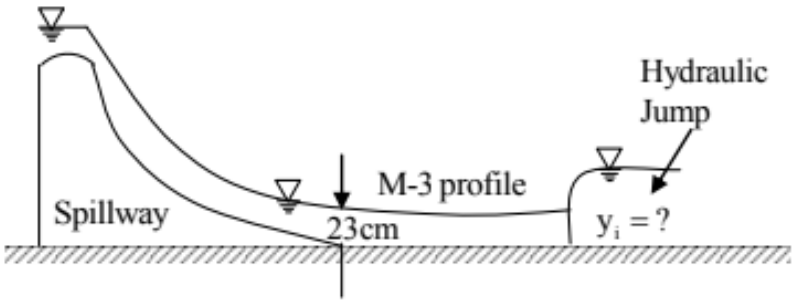


a) 1.0
b) 0.5
c) 2.0
d) 0.75

29. In Marshall method of mix design, the coarse aggregate, fine aggregate, fines and bitumen having respective values of specific gravity 2.60, 2.70, 2.65 and 1.01, are mixed in the relative proportions (% by weight) of 55.0, 35.8, 3.7 and 5.5 respectively. The theoretical specific gravity of the mix and the effective specific gravity of the aggregates in the mix respectively are

a) 2.42 and 2.78
b) 2.42 and 2.93
c) 2.42 and 2.63
d) 2.64 and 2.78

30. At the foot of a spill way, water flows at a depth of 23 cm with a velocity of 8.1 m/s, as shown in the figure. The flow enters as an M-3 profile in the long wide rectangular channel with bed slope $\frac{1}{1800}$ and Manning's n = 0.015. A hydraulic jump is formed at a certain distance from the foot of the spillway. Assume the acceleration due to gravity, g = 9.81 m/s^2. Just before the hydraulic jump, the depth of flow y1 (in m, round off to 2 decimal places) is



a) 00.420

b) 42.000

c) 04.200

d) 00.042

PART II – Short Answer Questions (20 marks)

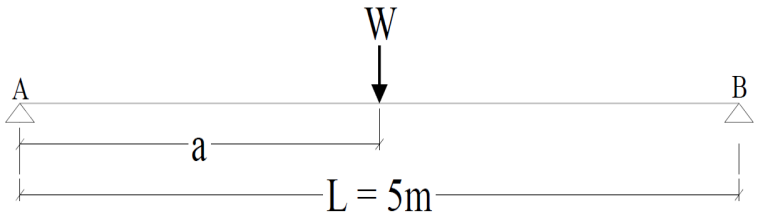
This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. A rectangular footing is founded at a depth of 2m below ground level in a (c-ϕ) soil having following properties:

   porosity η≈ 40 %
   G ≈ 2.67
   c ≈ 15 kN/m^2
   ϕ ≈ 30°

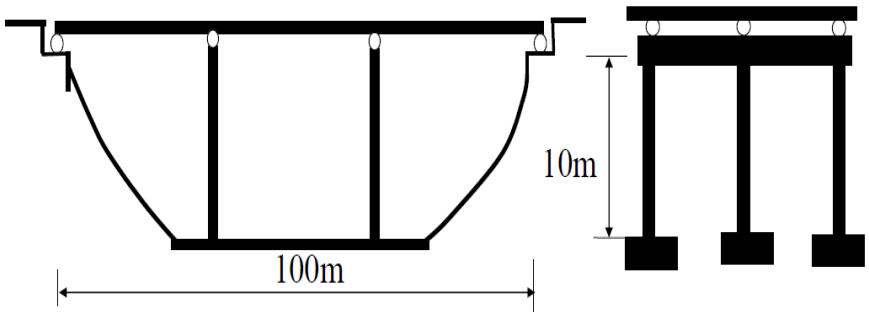
   The water table is close to the ground surface. If the width of the footing is 3m, what is the length required to carry a gross allowable bearing pressure, $q_a = 455\ kN/m^2$ with a factor of safety, $F_s = 3.0$. Use Terzaghi's theory of general shear failure.
   For $\emptyset = 30°, use\ N_c = 37.2, N_q = 22.5\ and\ N_\gamma = 19.7$

2. A wooden beam $150 \times 250mm$ is simply supported over a span of 5m. When concentrated load **'W'** is placed at a distance **'a'** from the left support, the maximum bending stress in beam is $11.2N/mm^2$ and the maximum shear stress is $0.7N/mm^2$. Determine the concentrated load 'W' and distance 'a' from left support as shown in figure?



3. A run-of-river hydel power plant with an installed capacity of 15,000 KW operates at 20% load factor when it serves as a peak load station. What should be the minimum discharge in the stream so that it may serve as the base load station? The plant efficiency may be taken as 80% when working under a head of 15m. Also calculate the maximum load factor of the plant when the discharge in the stream is 30 m3/sec?

4. A 100 m long concrete, box-girder bridge on four supports – two abutments and two bents as shown. The cross sectional area of the bridge deck is 11 m^2. The weight of the bridge is idealized as lumped at the deck level. The weight density of concrete is 25 kN/m^3. The weight of the bent can be neglected. Each bent consists of three 10 m tall columns of circular cross section with $I=1.122x10^{11}$ mm^4. The elastic modulus of concrete is E=30 GPa. Calculate the vibration frequency of the bridge in longitudinal direction?



SECTION B

Case Study

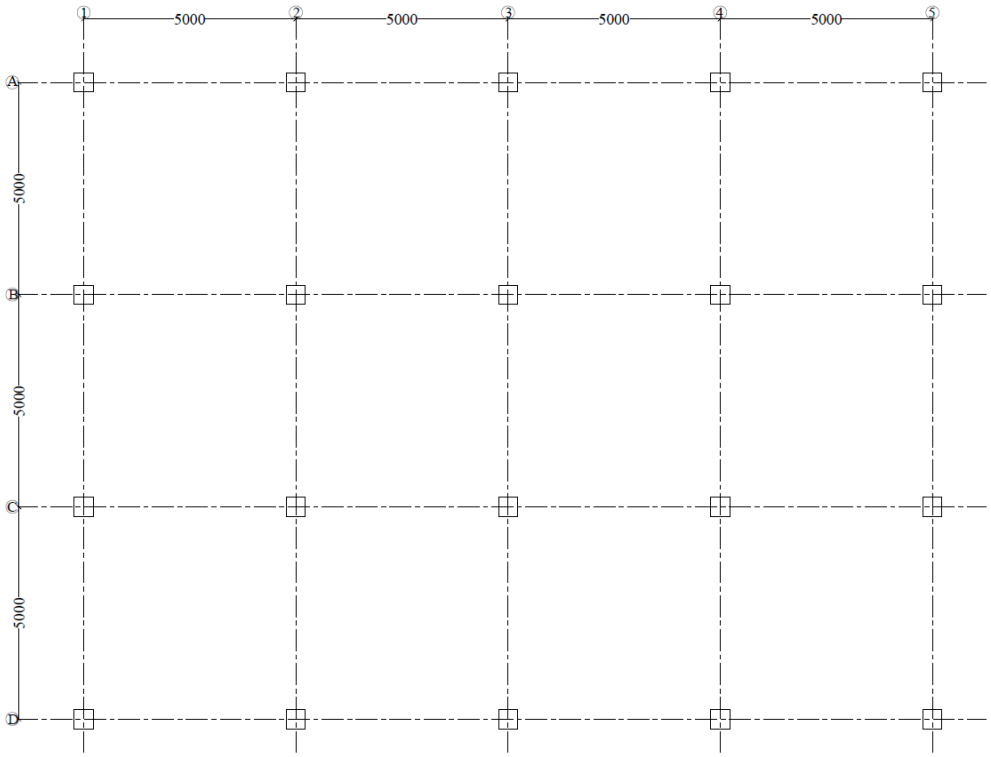
Choose either Case 1 or Case 2 from this Section. Each case carries 50 marks. Mark for each sub-question is indicated in the brackets.

Case 1

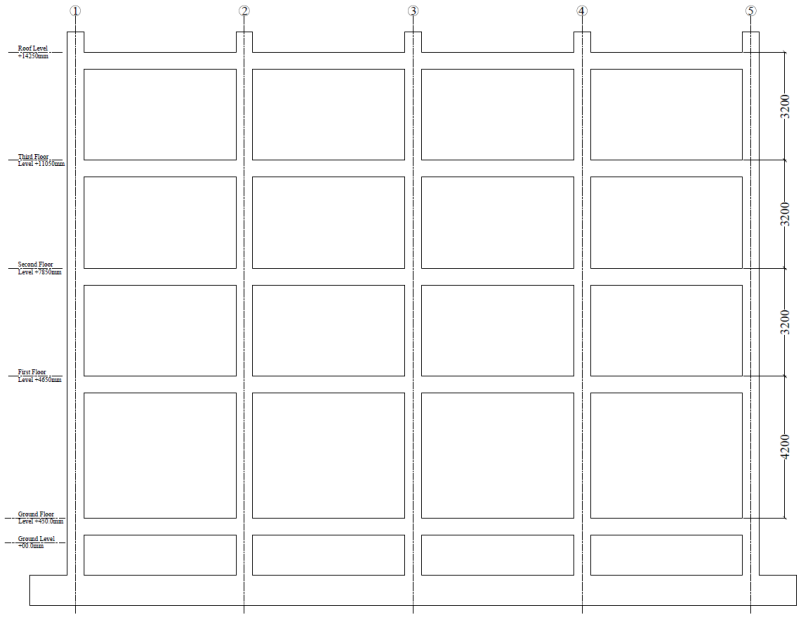
1. You are recruited as an engineer by a company who won a design competition to be involved for the design of infrastructure for Thimphu Thromde. One of the components of the infrastructure is to design a Thromde Office at Changangkha with finalized plan and section given below. The soil conditions are observed to be medium stiff and the entire building is supported on a raft foundation. The R. C. frames have infill walls as brick-masonry. The lumped weight due to dead loads is 12 kN/m2 on floors and 10 kN/m2 on the roof. The floors are to cater for a live load of 4 kN/m2 on floors and 1.5 kN/m2 on the roof.

   Determine following design seismic loads on the structure by Static Equivalent Static Analysis Method:

   i. Total Seismic Weight of the structure. (5 marks)
   ii. Design Base shear. (10 Marks)
   iii. Lateral Force on each floor. (15 Marks)



Plan



Section

c) All other buildings:

$$T_a = \frac{0.09h}{\sqrt{d}}$$

Table 3 Seismic Zone Factor *Z*
(*Clause* 6.4.2)

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

$$Q_i = \left(\frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2} \right) V_B$$

a) For use in equivalent static method [*see* Fig. 2(a)]:

$$\frac{S_a}{g} = \begin{cases} \text{For rocky or hard soil sites} \begin{cases} 2.5 & 0 < T < 0.40 \text{ s} \\ \dfrac{1}{T} & 0.40 \text{ s} < T < 4.00 \text{ s} \\ 0.25 & T > 4.00 \text{ s} \end{cases} \\ \text{For medium stiff soil sites} \begin{cases} 2.5 & 0 < T < 0.55 \text{ s} \\ \dfrac{1.36}{T} & 0.55 \text{ s} < T < 4.00 \text{ s} \\ 0.34 & T > 4.00 \text{ s} \end{cases} \\ \text{For soft soil sites} \begin{cases} 2.5 & 0 < T < 0.67 \text{ s} \\ \dfrac{1.67}{T} & 0.67 \text{ s} < T < 4.00 \text{ s} \\ 0.42 & T > 4.00 \text{ s} \end{cases} \end{cases}$$

6.4.2 The design horizontal seismic coefficient A_h for a structure shall be determined by:

$$A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

where

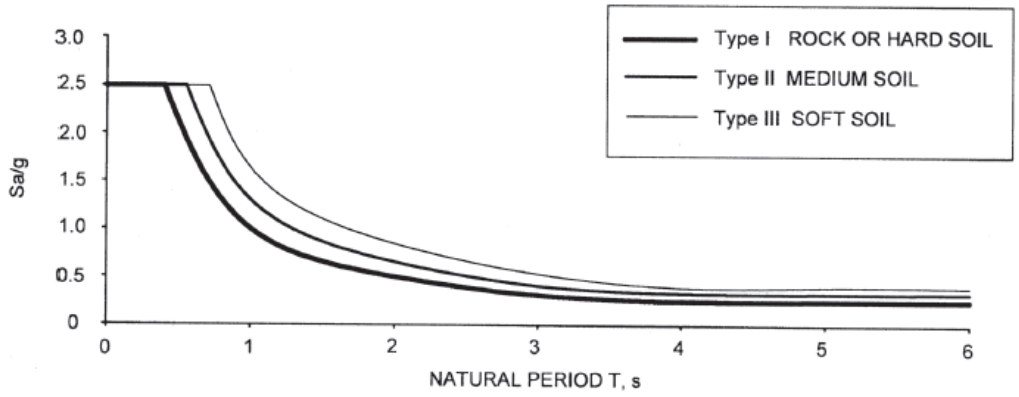
2. A neon sign board is attached to a 5-storey building in Thimphu. It is attached by two anchors at a height 12.0 m and 8.0 m. From the elastic analysis under design seismic load, it is found that the deflections of upper and lower attachments of the sign board are 35.0 mm and 25.0 mm, respectively. Find the design relative displacement. (20 marks)

Table 7 Minimum Design Earthquake Horizontal Lateral Force for Buildings
(*Clause* 7.2.2)

Sl No. (1)	Seismic Zone (2)	ρ Percent (3)
i)	II	0.7
ii)	III	1.1
iii)	IV	1.6
iv)	V	2.4

$$\frac{\Delta_{aA}}{h_{sx}} = 0.004$$

$$D_p = R(h_x - h_y)\frac{\Delta_{aA}}{h_{sx}}$$



2A SPECTRA FOR EQUIVALENT STATIC METHOD

7.2.3 *Importance Factor (I)*

In estimating design lateral force V_B of buildings as per **7.2.1**, the importance factor *I* of buildings shall be taken as per Table 8.

Table 8 Importance Factor (*I*)
(*Clause* 7.2.3)

Sl No. (1)	Structure (2)	*I* (3)
i)	Important service and community buildings or structures (for example, critical governance buildings, schools), signature buildings, monument buildings, lifeline and emergency buildings (for example, hospital buildings, telephone exchange buildings, television station buildings, radio station buildings, bus station buildings, metro rail buildings and metro rail station buildings), railway stations, airports, food storage buildings (such as warehouses), fuel station buildings, power station buildings, and fire station buildings), and large community hall buildings (for example, cinema halls, shopping malls, assembly halls and subway stations)	1.5
ii)	Residential or commercial buildings [other than those listed in Sl No. (i)] with occupancy more than 200 persons	1.2
iii)	All other buildings	1.0

Case 2

The Royal Government of Bhutan (RGoB) has given a top priority for **24x7 water supply** in all 20 Dzongkhags. Towards this, a water flagship project office has recruited you as a project engineer. You are given the following tasks as a part of your first assignment:

1. Compute a discharge in L/s (litres per second) from a rectangular intake weir to be constructed at water source across a running stream given the following parameters;
    a) Headwater Elevation = 501.00 m.
    b) Crest Elevation = 505.50 m.
    c) Tailwater Elevation = 500.00 m.
    d) Weir Coefficient = 1.84 m.
    e) Crest Length = 6.00 m.
    f) Number of Contractions = 0.00

    (15 marks)

2. If discharge of 1000 L/s is to be drawn through Trapezoidal Channel, Calculate the Normal Depth in mm using Manning formula given the following parameters;
    a) Roughness Coefficient (n) = 0.013
    b) Channel Slope = 0.001 m/m
    c) Left Side Slope (H:V) = 1
    d) Right Side Slope (H:V) = 1
    e) Bottom Width = 1.20 m
    f) Also, define flow type? (15 marks)

3. Calculate the frictional loss, residual pressure and hydraulic gradient at chainage of 0.00 m, 100.00m, 200.00m, 300.00m, 400.00m, 500.00m, 600.00m, 700.00m, 800.00m, 900.00m & 1000.00m if the discharge of 150 L/s of water is to be conveyed through plastic pipe (inner diameter of plastic pipe = 315mm & fiction loss = 0.002/m). Assume the ground elevation at starting point is 500.00m (Chainage = 0.00m) descending at the uniform slope of 1 in 100. Neglect incidental or other losses. (20 marks)

TASHI DELEK