

**ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2012
EXAMINATION CATEGORY: TECHNICAL**

PAPER III: SUBJECT SPECIALIZATION PAPER for CIVIL ENGINEERING

Date	: 14 October 2012
Total Marks	: 100
Examination Time	: 150 minutes (2.5 hours)
Reading Time	: 15 Minutes (prior to examination time)

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. Write your Roll Number clearly on the Answer Booklet in the space provided.
2. The first 15 minutes is being provided to check the number of pages, printing errors, clarify doubts and to read the instructions. You are NOT PERMITTED TO WRITE during this time.
3. Use either Blue or Black ink pen or ball point pen for the written part and Pencils for the sketches and drawings.
4. All answers should be written on the Answer Booklet provided. Candidates are not allowed to write anything on the question paper or any other materials.
5. It is divided into two sections-namely SECTION A and SECTION B.
6. SECTION A consists of two parts: Part I and Part II.

Part I consists of 30 Multiple-Choice Questions carrying one (1) mark each and is compulsory. The answer of your choice should be clearly written in whole along with the question and option number on your answer booklet. Eg. 31(c).

Part II consists of four (4) short answer questions of five (5) marks each and all questions are compulsory.
7. SECTION B consists of two Case Studies. Choose only ONE case study and answer the questions under your choice. Each case study carries fifty (50) marks in total.
8. This Paper consists of 12 pages including this page.

SECTION A

PART I - Multiple Choice Questions

Choose the correct answer and write down the letter of the correct answer chosen in the Answer Sheet against the question number. E.g. 31 (c). Each question carries ONE mark.

1. The plate loading test gives
 - a) the ultimate bearing capacity of the soil
 - b) safe bearing capacity of the soil
 - c) the depth of underlying rock
 - d) none of above

2. A brick masonry could fail due to
 - a) rupture along a vertical joint in poorly bonded walls
 - b) shearing along a horizontal plane
 - c) crushing due to overloading
 - d) any of the above

3. The characteristic strength of a material is defined as the strength below which
 - a) not more than 5% of the test results fall
 - b) not less than 5% of the test results fall
 - c) not more than 50% of the test results fall
 - d) not more than 15% of the test results fall

4. Likelihood of general shear failure of an isolated footing decreases with
 - a) decreasing footing depth
 - b) decreasing inter-granular packing of sand
 - c) increasing footing width
 - d) decreasing soil grain compressibility

5. If “p” is the precipitation, “a” is the area represented by a rainauge, and “n” is the number of rainauges in the catchment , then the weighted mean rainfall is given by
 - a) $\frac{\sum ap^3}{\sum a^2}$
 - b) $\frac{\sum ap}{\sum a}$
 - c) $\frac{\sum ap}{\sum n}$
 - d) $\frac{\sum ap^5}{\sum a^3}$

6. The value of specific weight for water in S.I units is equal to
- 981 N/m³
 - 1000 N/m³
 - 9810 N/m³
 - 98.1 N/m³
7. The number of members(n) and number of joints(j) in a perfect frame is given by
- $n=(2j-3)$
 - $n=(4j-2)$
 - $j=(2n-3)$
 - $j=(3n-2)$
8. The angle of banking provided on the curve roads depend upon
- the velocity of vehicle only
 - co-efficient of friction between vehicle and road contact point
 - the square of vehicle velocity only
 - the square of velocity of vehicle and radius of circular path
9. The centre of gravity of a quadrant of a circle is at a distance of
- $4r/3\pi$ from the axis
 - $3r/4\pi$ from the axis
 - $3r/8$ from the axis
 - $6r/4$ from the axis
10. The percentage elongation of a material from a direct tensile test indicates
- Ductility
 - strength
 - ultimate strength
 - yield stress
11. A beam is supported over three rollers lying in the same plane. The beam is stable for
- loading with no component in the direction of the beam
 - any general loading
 - loading with no component perpendicular to the direction of beam
 - only when no load except self-weight acts
12. The tensile, shearing and crushing stresses in a riveted joints are computed based on
- diameter of the rivet
 - diameter of the drilled hole
 - average of (a) and (b)

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- d) none of above
13. The peak ordinate of a 4 h unit hydrograph of a basin is $270 \text{ m}^3/\text{s}$. Then the peak ordinate of a 8 h unit hydrograph of the same basin will be
- equal to $270 \text{ m}^3/\text{s}$
 - less than $270 \text{ m}^3/\text{s}$
 - more than $270 \text{ m}^3/\text{s}$
 - difficult to tell
14. In the two point method of finding the average velocity using current meter across a vertical in a open channel, the velocity is measured below the free surface at
- 0.25 and 0.75 depth
 - 0.40 and 0.65 depth
 - 0.20 and 0.80 depth
 - 0.15 and 0.85 depth
15. A canal carries a discharge of $5 \text{ m}^3/\text{s}$ with the slope of $1/100$. For the same depth of flow its discharge carrying capacity will be doubled by increasing its slope to
- $1/50$
 - $1/25$
 - $1/10$
 - $1/75$
16. The Poisson's ratio is defined as
- axial stress/lateral stress
 - lateral strain/axial strain
 - lateral stress/axial stress
 - axial strain/lateral strain
17. Two bitumen samples "X" and "Y" have softening points 45°C and 60°C respectively. Consider the following statements.
- Viscosity of "X" will be higher than "Y" at same temperature
 - Penetration of "X" will be lesser than that of "Y" under standard condition
- The **CORRECT** option evaluating above statement is
- both I and II are TRUE
 - both I and II are FALSE
 - I is FALSE and II is TRUE
 - I is TRUE and II is FALSE

18. Which one of the following is considered as long-term loss of a prestress in a prestressed concrete member?
- a) loss due to elastic shortening
 - b) loss due to friction
 - c) loss due to relaxation of strands
 - d) loss due to anchorage slip
19. A waste water sample of 2 ml is made up to 300 ml in a BOD bottle with distilled water. Initial D.O of the sample is 8.0 and after 5 days it is 2.0. Therefore its BOD is
- a) 600 mg/l
 - b) 1800 mg/l
 - c) 900 mg/l
 - d) 2400 mg/l
20. In the passive state of earth pressure
- a) vertical stress is constant and horizontal stress decreases
 - b) vertical stress is constant and horizontal stress increases
 - c) vertical stress and horizontal stress decreases
 - d) vertical stress and horizontal stress increases
21. The cracks in the painted surface extending throughout the thickness of the paint are caused due to
- a) improper seasoning of painted wood
 - b) excessive use of drier
 - c) too many coats of paint resulting in excessive thickness
 - d) all the above
22. When a bitumen is graded 75/15, the figure 75 represents
- a) viscosity in centipoises
 - b) softening point in °c
 - c) fire point in °c
 - d) flash point in °c
23. The type of cement preferred in the construction of massive concrete dam is
- a) ordinary portland cement
 - b) rapid hardening cement
 - c) white cement
 - d) low heat cement

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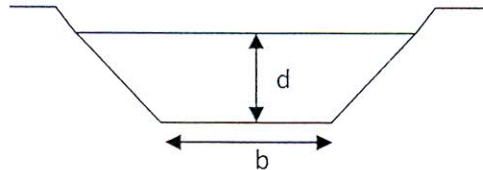
24. Workability of concrete mix having very low water-cement ratio has to be ascertained by
- slump test
 - bending test
 - compaction factor test
 - compression test
25. The rolled steel I-sections are most commonly used as beams because they provide
- large moment of inertia with less cross-sectional area
 - greater moment of resistance as compared to other sections
 - greater lateral stability
 - all the above
26. When the staff is held on B.M of RL 100.00, the staff reading was 2.000. When the staff is held on station P, the reading was 3.000. Hence the height of instrument is
- 100.000
 - 102.000
 - 103.000
 - 99.000
27. Which of the following statements is true?
- PERT is activity oriented and adopts deterministic approach
 - CPM is event oriented and adopts probabilistic approach
 - CPM is activity oriented and adopts probabilistic approach
 - PERT is event oriented and adopts probabilistic approach
28. The plan of building is in form of rectangle with centre line dimensions of outer walls as 9.7 m x 14.7 m. The thickness of the wall in super structure is 30 cm. The plinth area is
- 150 sqm
 - 147 sqm
 - 145.5 sqm
 - 135.36 sqm
29. Hydraulic jump occurs when the flow changes from
- supercritical to subcritical
 - subcritical to supercritical
 - critical to turbulent
 - laminar to turbulent

30. The distribution system in water supplies is designed on the basis of
- average daily demand
 - peak hourly demand
 - coincident draft
 - greater of (b) and (c)

PART – II : Short Answer Questions (20 marks)

Answer all the questions. Marks are given against each question in the brackets.

- A cantilever of length 3 m carries two point loads of 2 kN at the free end and 4 kN at a distance of 1 m from the free end. Find the deflection at the free end. Take $E=2 \times 10^5 \text{ N/mm}^2$ and $I=10^8 \text{ mm}^4$ (5 marks)
- A trapezoidal channel with side slope of 1 to 1 has to be designed to convey $10 \text{ m}^3/\text{s}$ at a velocity of 2 m/s so that the amount of concrete lining for the bed and sides is the minimum (i.e most economical trapezoidal section). Calculate the area of lining required for one metre length of canal. (5 marks)



- A rectangular settling tank is to treat 1.8 million litres per day of raw water. Using sedimentation period as 4 hours, velocity of flow as 8 cm/minute, depth of water and sediment as 4.0 m and depth of sediment as 1.0 m, find the length and width of the sedimentation tank. (5 marks)
- Explain following terms (2x2.5=5 marks)
 - Ruling and limiting road gradients
 - B.O.D and C.O.D

SECTION B : Case Study

Choose either Question 1 or Question 2 (not both) from this section. Each Question carries 50 marks and specific marks to each sub-question is given in the brackets.

Question 1

As a municipal civil engineer, you have been entrusted with the task of designing the signpost at the periphery of the municipal area. To avoid obstruction and to reduce the material, you came up with the signpost configuration as shown in Figure 1 below. The signpost consists of a 4 m by 2 m steel plate 10 mm thick, welded to a steel tube with an outside diameter of 200 mm and a wall thickness of 4 mm. The steel tube is rigidly fixed into a concrete footing. The unit weight of steel is 77 kN/m^3 and the unit weight of concrete is 25 kN/m^3 . Take elastic modulus of steel as $2 \times 10^5 \text{ MPa}$ and shear modulus of steel as 76920 MPa . Note $I = \frac{\pi}{64}(D_o^4 - D_i^4)$ for circular hollow section .

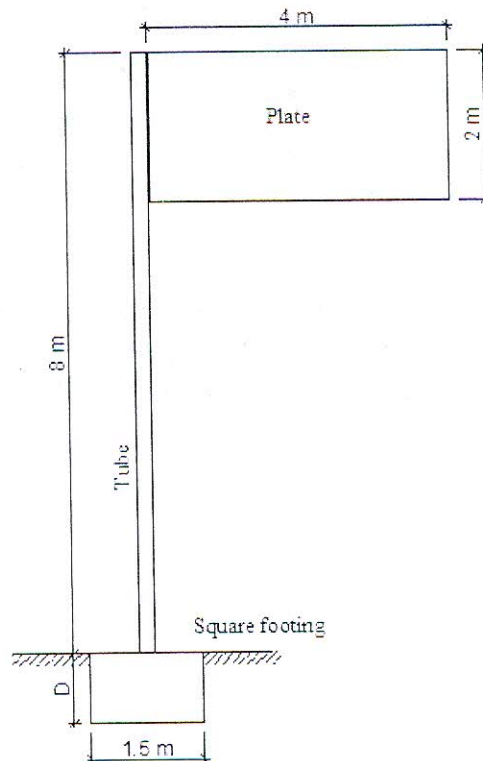


Figure 1 Signpost Elevation

Answer the following as part of your design calculations:

- a. Determine the axial load and bending moment at the base of the signpost due to its self-weight? (5 marks)
- b. If a uniform wind pressure of 1.25 kPa (kN/m²) acts over the surface of the steel plate, what is the moment and torsion generated at the base of the signpost? (5 marks)
- c. By how much the signpost would have twisted as a result of wind pressure acting over the plate surface? What is the deflection at the centre of plate due to twist if plate is assumed to be rigid? *Hint: $T=JG\theta/L$ and $J = \frac{\pi(R_0^4 - R_i^4)}{2}$ for hollow circular sections* (5 marks)
(Since torsion is comparatively small, it can be neglected in the subsequent calculations)
- d. Determine the minimum depth D of the concrete footing to just prevent overturning due to wind pressure? Ignore self-weight contribution from the signpost. (5 marks)
- e. If the coefficient of friction between soil and concrete footing is 0.35, will the footing dimension be safe against sliding force due to wind pressure? (5 marks)
- f. Calculate the maximum and minimum stresses at the base of signpost generated by the combined action of wind pressure and self-weight of signpost? Is the given steel tube section adequate if yield stress of steel is 600 MPa? (6 marks)
- g. Calculate the maximum and minimum stresses exerted on the footing by the combined action of bending due to wind pressure and self-weight of the signpost? (5 marks)
- h. If the allowable bearing capacity of the soil is 150 kN/m², would the foundation size of 1.5 m x 1.5 m x D (which you have calculated in c above) be adequate? What solution would you suggest to improve the foundation? (5 marks)
- i. What would be the passive force (due to passive pressure) per metre length generated in the soil due to wind pressure on the steel plate? Soil is sandy with unit weight of 16 kN/m³ and internal friction angle of 30°. (6 marks)
- j. List 3 possible modes of failure of steel tube section. (3 marks)

Question 2

Part A. A culvert in the form of a circular concrete pipe is to be constructed under a main access road leading to a large residential housing colony. The culvert is to drain the storm water from the 28 acres housing area. The culvert is to be designed for the average recurrence interval (return period) of the storm of 100 years. Under flood conditions the culvert can operate under a maximum head (difference in water levels) of 4.1 m. The cross-section of the road embankment is shown in Figure 2. The head loss occurring in the culvert is related to the flow rate Q by the following equation:

$$H = K_{ent} \frac{V^2}{2g} + \frac{fLV^2}{2gD} + K_{exit} \frac{V^2}{2g}$$

- where H = hydraulic head (Difference in water level)(m)
 K_{ent} = entrance loss coefficient (=0.5 in this case)
 K_{exit} = exit loss coefficient (=1.0 in this case)
 V = flow velocity in culvert (m/s)
 D = Culvert diameter (m)
 f = friction factor (=0.02 for concrete)
 L = Length of culvert (m)
 g = acceleration due to gravity (9.81 m/s^2)
 Q = VA (product of flow velocity and cross-sectional area of culvert)

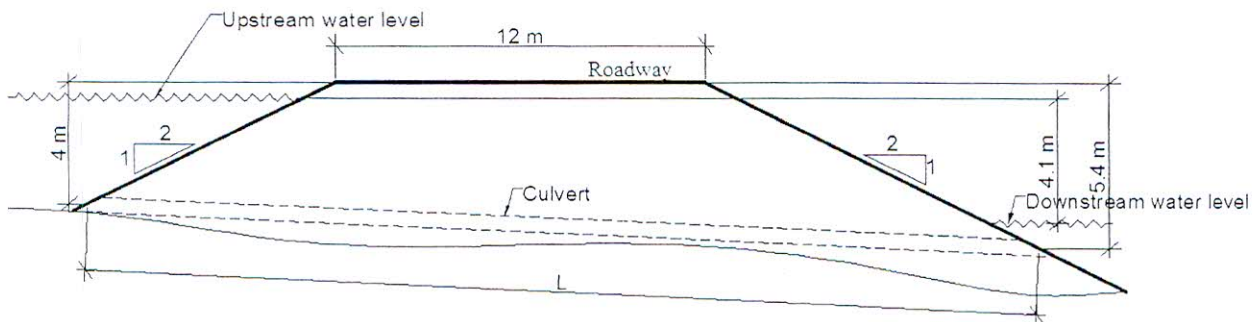


Figure 2 Road Embankment Cross-section

The Intensity-Duration-Frequency (IDF) curves for this area showing the relationship of intensity, duration and return period of the storm event is given in Figure 3 below.

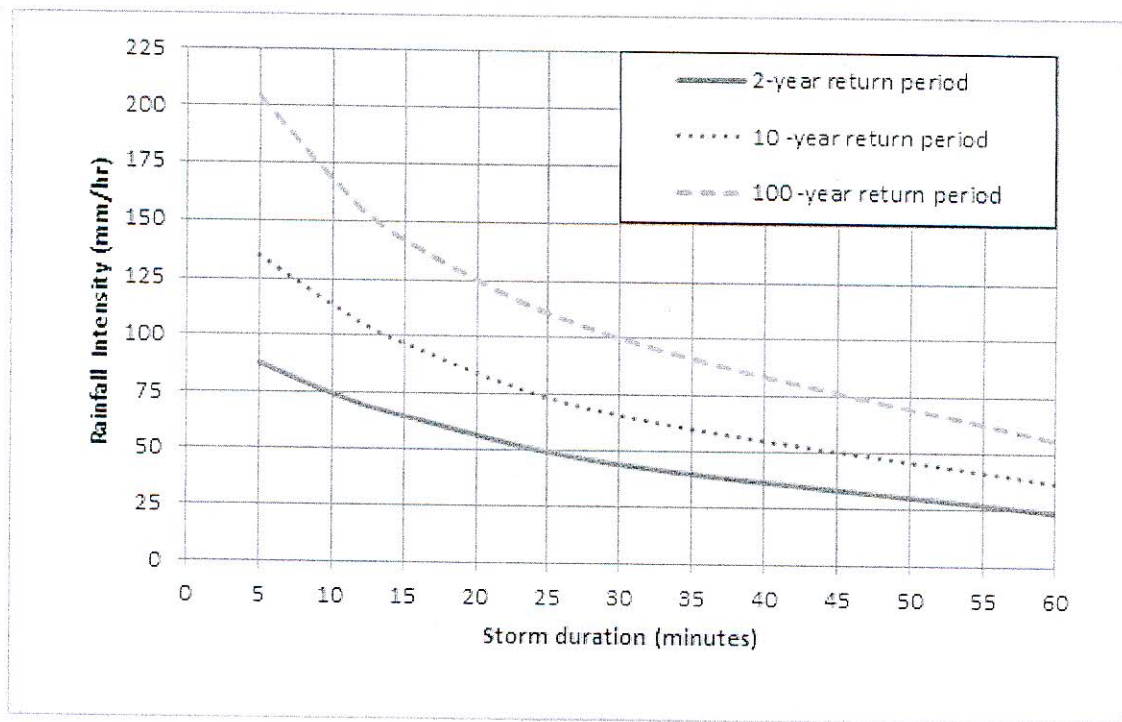


Figure 3 Intensity-Duration-Frequency Curve

The peak flow rate (m^3/s) of the runoff after the storm event is given by:

$$Q_p = 0.00278 C i A_d$$

- Where C = weighted rational coefficient for the drainage area (=0.4 in this case)
 i = rainfall intensity (mm/hr)
 A_d = drainage area (acres)

As a design engineer, you are to determine the size of concrete culvert required to drain the storm water from the housing area, for which you are required to undertake the following.

- Identify different head losses that are possible for the culvert in general. (2 marks)
- Determine the rainfall intensity from the IDF curve of Figure 3 considering the rainfall duration of 30 minutes and compute the peak flow rate for the housing area. (3 marks)
- Determine the length of concrete pipe from the given geometry of the embankment cross-section of Figure 2. (5 marks)
- Using peak flow rate from (b) above, solve the head loss equation for D, the culvert diameter, using trial and check method. Obtain a value of D to the nearest 0.01 m (15 marks)

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Part B. A pipe culvert is to be laid under a roadway as shown in Figure 4 to allow water to pass under the road. The centreline of the pipe culvert is 3 m below the centre of the roadway and is laid at a skew of 20° . The pipe culvert has a fall of 10% (1 in 10) and the embankments each side of the roadway have vertical slopes formed by concrete retaining walls.

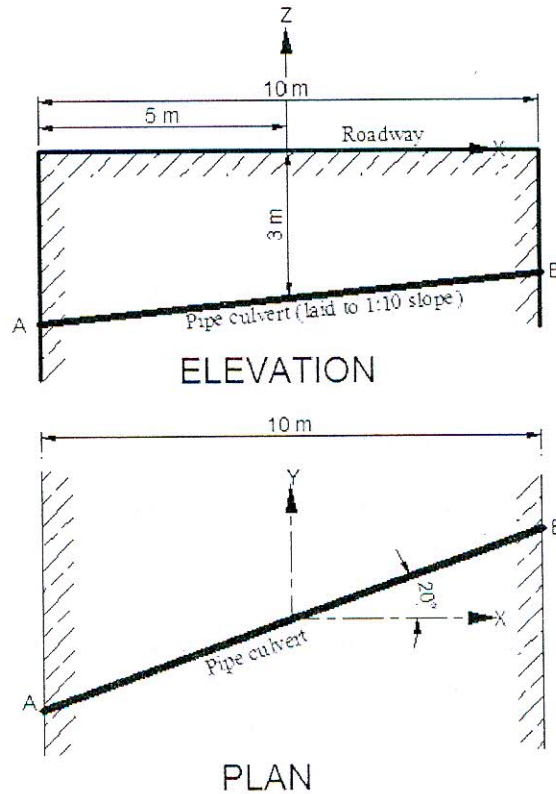


Figure 4 Elevation and Plan of Culvert

- Find the intersections (x, y, z coordinates of A and B) of the pipe culvert centreline with the two roadway embankments. (15 marks)
- Find the length of the pipe culvert needed. (10 marks)

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