

ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2010
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALIZATION PAPER for CIVIL ENGINEERING

Date : 24th November 2010
Total Marks : 100
Examination Time : 2.5 Hours
Reading Time : 15 Minutes

INSTRUCTIONS

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 **HB 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.
5. This Question Booklet consists of 11 pages. 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.
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.

SECTION A

PART I - Multiple Choice Questions (30 marks)

1. The load of dead body of a dog lying in the middle of a bridge is
 - a) Dead load
 - b) Live load
 - c) Design load
 - d) None of the above

2. The bearing capacity of a water logged soil can be improved by
 - a) Draining the soil
 - b) Compacting the soil
 - c) Grouting
 - d) Increasing the depth of the foundation

3. Expect ratio of building plan in seismic resistant design should be
 - a) Less than two
 - b) Less than or equal to three
 - c) Greater than three
 - d) Equal to one

4. Bearing capacity of soil depends on
 - a) Kind of load
 - b) Size of the footing
 - c) The nature of load
 - d) All of the above

5. A combine footing is adopted when
 - a) Number of columns is two and they are spaced close to each other
 - b) Number of columns is two and they are spaced far apart
 - c) Number of columns is more than two and they are spaced far apart
 - d) There is only one column

6. The longitudinal shearing stresses acting on the surface between the steel and concrete are called
 - a) Compressive stresses
 - b) Tensile stresses
 - c) Bond stresses
 - d) Shear stresses

7. Steel is preferred as reinforcing materials in concrete because
 - a) It is easily available
 - b) It is the cheapest and good in strength
 - c) The coefficient of thermal expansion of steel and concrete is almost same
 - d) It forms a good bond

8. A reinforced concrete beam is designed for the limit states of collapse in flexure and shear, which of the following limit states of serviceability have to be checked
 - a) Deflection
 - b) Cracking
 - c) Durability
 - d) Deflection and cracking

9. In a cantilever beam, tensile reinforcement is provided
 - a) On the bottom of the beam
 - b) In the middle of the beam
 - c) On the top and bottom of the beam
 - d) On the top of the beam

10. The structural frames which are casted monolithically are known as
 - a) Redundant frames
 - b) Portal frames
 - c) Pre stressed frames
 - d) Intermediate frames

11. Bleeding in concrete can be reduced by using
 - a) Lesser water
 - b) Finer sand
 - c) Adding finely ground inert materials
 - d) All of the above

12. The main advantage of steel member is that
 - a) It has high strength and long life
 - b) It can be replaced easily
 - c) It is watertight and gas leak proof
 - d) All of the above

13. Camber in road is provided for
 - a) Counteracting the centrifugal force
 - b) Effective drainage
 - c) Having proper sight distance
 - d) All of the above

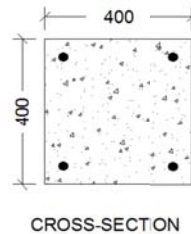
14. Abrasion test is conducted to find
- Toughness of aggregates
 - Hardness of aggregates
 - Durability of aggregates
 - Strength of aggregates
15. To transfer wheel load at expansion joints from one slab to the other
- Tie bars are used
 - Dowel bars are used
 - Hanger bars are used
 - Bitumen fillers are used
16. In a hilly road like ours, minimum sight distance required is
- Stopping sight distance
 - Passing sight distance
 - Breaking distance
 - All of the above
17. When bleaching powder is added to water its PH value
- Increases
 - Decreases
 - Remains unaffected
 - Increases or decreases depending on the characteristics of water
18. Disinfection of swimming pool water is usually done by
- Alum
 - Ultraviolet rays
 - Chlorine
 - Ozone
19. The salinity of water can be reduced by
- Filtration
 - Flocculation and sedimentation
 - Reverse osmosis
 - All of the above
20. The waste water from the bathrooms, kitchen, etc. is called
- Sullage
 - Refuse
 - Sewage
 - Garbage

21. Scale on which three dimensions can be measured is known as
- Plain scale
 - Diagonal scale
 - Chord scale
 - Vernier scale
22. Principle of surveying followed to prevent accumulation of errors is
- To work from whole to the part
 - To work from part to whole
 - To work from part to part
 - All of the above
23. The two or three point problems are methods of
- Orientation
 - Resection
 - Traversing
 - (a) and (b)
24. In a design mix concrete, the target mean strength of concrete should be at least equal to
- Characteristic strength plus 1.65 times standard deviation
 - Characteristic strength plus 1.5 times standard deviation
 - Characteristic strength plus 1.7 times standard deviation
 - None of the above
25. Which of the following is an activity
- Concrete cured
 - Wall plastered
 - Excavation for foundation
 - All of the above
26. The most serious type of water loss from a canal is
- Evaporation
 - Absorption
 - Percolation
 - All of the above
27. A ball of mass 10 kilogram is dropped from a height of 10 meter on to the cantilever beam. The energy is totally converted into kinetic energy. The velocity of the ball at the instant of hitting the cantilever beam is (Take $g=9.8\text{m/s}^2$)
- 14m/s
 - 14.5m/s
 - 15m/s
 - None of the above

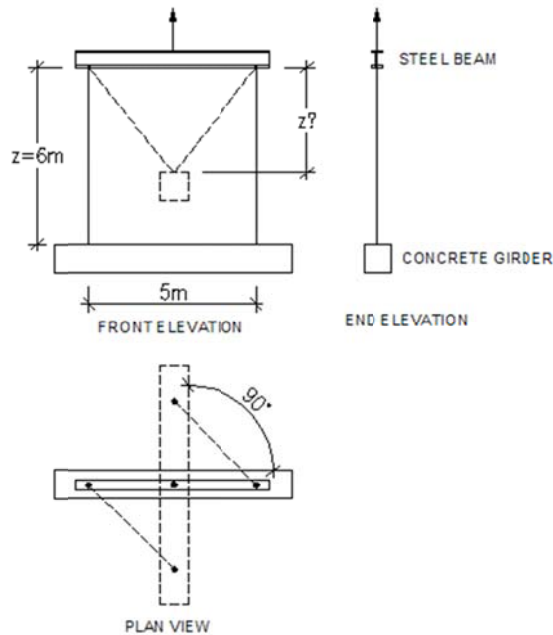
28. Hydraulic structures constructed across a canal are called
- a) Cross drainage
 - b) Cross communication works
 - c) Regulatory works
 - d) All of the above
29. If E_c and E_s are the modulus of elasticity of concrete and steel respectively, then the modular ratio can be calculated by
- a) E_c/E_s
 - b) E_s/E_c
 - c) $4E_c/E_s$
 - d) $4E_s/E_c$
30. Although the compressive strength of concrete cube tested in the laboratory is 26 MPa, yet the strength used for the structural design is much less than the above because of
- a) Statistical variation of strength of concrete cube
 - b) Size effect
 - c) Partial safety factor for the material
 - d) All of the above

PART – II Short Answer Questions (20 marks)

1. A reinforced concrete column of length 3.2 m has a cross-section 400 mm^2 as shown below. A steel bar of 25 mm diameter is embedded at each corner. The column is to withstand an axial load of 2500 kN. Assuming strain compatibility between the steel and concrete (no slip), what are the stresses in steel and concrete when the load is first applied. Determine the axial shortening of column. Assume elastic modulus of steel and concrete as 200,000 MPa and 30,000 MPa respectively. (5 marks)



2. A heavy concrete bridge girder is being lifted by two cables suspended from a steel I-beam such that the vertical separation, z between the two is 6 m as shown below. If the concrete girder is rotated 90 degrees relative to the steel beam, what now is the vertical separation z between the concrete girder and the steel beam? (5 marks)



3. Water flows in a 1 m wide open channel which has a horizontal bed except for a short section where it rises by 0.5 m over a distance of 10 m and then falls again over 10 m distance. The flow in the channel is $10 \text{ m}^3/\text{second}$ and the depth is 3.33 m. Calculate the depth and velocity at the crest of the bed rise. Sketch the profile of water surface along the channel. (5 marks)

4. In a deep deposit of clay the water table lies 3 m below the soil surface. Assuming that the soil remains fully saturated above the water table, and that saturated unit weight of soil is 16.5 kN/m^3 , what is the effective stress at the depth of 2 m, 3 m and 5 m below the surface? What is the pore pressure suction developed on the surface of the ground due to presence of water table at 3 m depth? (5 marks)

SECTION B (50 marks)

Case study - Choose either Question 1 or Question 2 (not both) from this section

Question 1. Four storeyed residential building was designed incorporating all seismic resistant features and in accordance with the latest design codes. The design was carried out assuming flat ground surface. Columns were designed as short. However, during the construction it was found that the land profile is not flat as assumed in the initial design but happened to be in the sloppy surface. Some of the footings needed to be placed at different levels. In doing so, some of the columns became slender. Moreover, septic tank design and drawings for the building was not included in the initial design. Owner of the building has requested for the possible impact on the structure due to change in land profile and asked for the additional design.

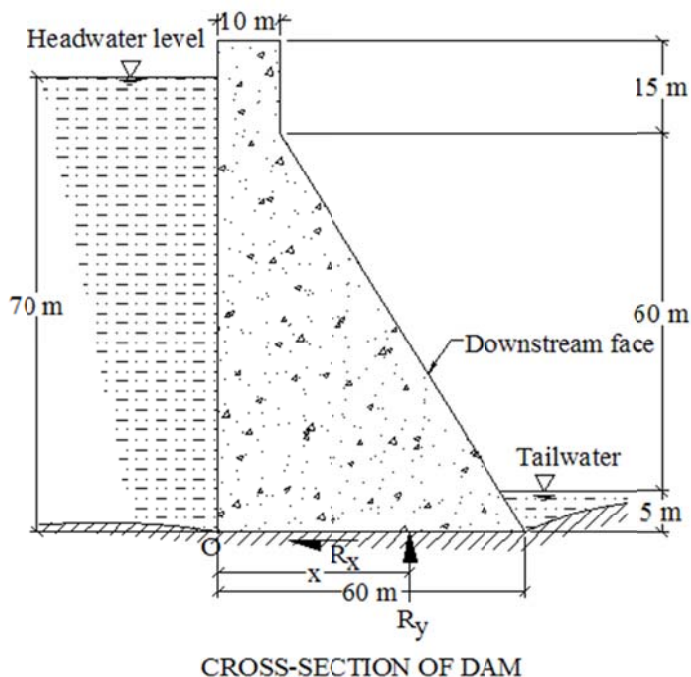
- a. How do you determine short and long columns? (2 marks)
- b. What is the possible mode of failure of long columns other than the material failure? (3 marks)
- c. As a civil engineer what solution would you propose at site to avoid slender columns? (3 marks)
- d. For the footing placed at different levels, how do you determine whether or not the upper level footing will impose additional load on to the lower level footing? (3 marks)
- e. Suppose the edge column falls next to the property line, how would provide footing for the column. Sketch the plan view as well as the elevation of the footing. (3 marks)
- f. What is the most likely mode of failure of the above footing? (3 marks)
- g. Design a square isolated footing to carry serviceable axial load of 1000 kN, moment about z-axis, $M_z=100$ kNm and moment about x-axis, $M_x= 110$ kNm. Load factor for the ultimate strength is 1.5. Size of column is 450 mm x 450 mm square. The safe bearing capacity of the soil is 150 kN/m^2 . Consider the base of the footing is 1500 mm below the ground level. The unit weight of the soil is 18 kN/m^3 . Use compressive strength of concrete, $f_{ck}= 20\text{MPa}$ and yield strength of steel reinforcement, $f_y= 415 \text{ MPa}$. Shear strength of concrete in punching is given by $\tau_c = 0.25\sqrt{f_{ck}}$ and design shear strength of concrete is given below: (20 marks)

$100A_s/bd$	≤ 0.15	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	2.25	$2.5 \geq$
τ_c	0.28	0.36	0.48	0.56	0.62	0.67	0.72	0.75	0.79	0.81	0.82

- h. List the modes of failure of the footing slab? (3 marks)
- i. Design a septic tank for a population of 150 persons. The rate of water supply is 135 liters/person/day. Also sketch the septic tank you have designed. (10 marks)

Question 2. Since early 1980s Government of Bhutan undertook several major hydropower projects notably at Chukha, Basochu, Kurichu and Tala. At present, Punatshangchu hydropower project is underway, and many such projects will be initiated in due course to meet the supply of power over 10,000 megawatt by 2020. As a Civil Engineer you are involved in one of the hydropower projects in the near future, and that you have been asked to provide comprehensive technical report on the establishment of such project at one particular location in Bhutan. As part of your report you are required to answer the following:

- a) What sorts of assessments you would require to undertake at the proposed project site prior to the commencement of project. (2 marks)
- b) List three major construction activities of hydropower project. (2 marks)
- c) Sketch a few possible types of dam that you might propose. (2 marks)
- d) Except for the dam, other major structures related to the hydropower projects in most cases are constructed beneath the surface of the earth. What could be the possible reasons? (2 marks)
- e) How can the construction of dam be achieved right in the middle of the fast-flowing river? (2 marks)
- f) What other benefits are expected from the dam once constructed besides generation of electricity? (2 marks)
- g) Suppose you proposed to provide concrete gravity dam for the project as shown below.



The possible forces acting on the dam are due to the concrete, the water, the foundation pressure, and the hydrostatic uplift. For the sake of simplicity, hydrodynamic pressure, earthquake loading, earth pressure, etc are ignored. Assume unit weight of concrete = 24 kN/m³; unit weight of water = 9.8 kN/m³. Consider unit length of dam in the following calculations.

- i. Sketch the profile of hydrostatic pressure and uplift for the dam assuming that hydrostatic uplift beneath the dam varies linearly between the upstream edge and the downstream edge of the dam. (3 marks)
- ii. Calculate the factor of safety against the overturning of dam. (8 marks)
- iii. Calculate the reaction R_x , R_y and position x of R_y (10 marks)
- iv. Although the pressure distribution beneath the foundation is complex in real life, it is customary to assume that the foundation pressure varies linearly under the base of the dam with minimum foundation pressure under the upstream edge and maximum foundation pressure under the downstream edge of the dam. Assuming that the pressure is trapezoid with a volume equal to reaction R_y , determine the minimum and maximum foundation pressure. If the allowable bearing capacity of the underlying stratum is 1000 kPa, will your dam fail in subsidence (bearing pressure)? Will there be tension at the upstream edge of the dam? (10 marks)
- v. If the coefficient of friction between concrete and riverbed is 0.55, will your proposed dam slide? If it slides, what possible solutions you will recommend to prevent it from sliding? (3 marks)
- vi. From your site assessment, you found that the stratum beneath the dam is permeable, and that you need to minimize the seepage loss. Suggest the structural modifications required to be made or other structural components required to be attached to the dam (with sketches) to minimize seepage loss. Roughly sketch the flow net beneath the dam after incorporating the modification. (4 marks)

-----XXXXXXXXXXXXX-----