DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

I SEMESTER 2006-2007 **MAJOR EXAM** **Time limit: 2 hrs.**
CEL 433N **ADVANCED STRUCTURAL DESIGN** **Max Marks = 40**
Course Coordinator: Dr. Alok Madan

Instructions: (a) This is a 'closed' book exam.
(b) Make suitable assumptions where necessary.

CONCRETE STRUCTURES

Instructions: (c) Attempt any questions with a total maximum marks of 30 in this section. Mention clearly the choice of your questions on the first page of the answer sheet

1. A T-shaped cantilever wall shown in Figure 1 is to retain a sloping earthfill with the earth's surface inclined at an angle of 15°. If the water table is 3.5 m below the top of the wall and there is an additional surcharge of uniform intensity 5 kN / m^2
   (i) Determine the minimum base width 'b' to ensure stability of the wall foundation. The passive earth pressure due to the earth in front of the wall may be neglected for conservative design. Show the distribution of soil bearing pressure at the wall base indicating the maximum and minimum values. (10 marks)
   (ii) For the base width 'b' calculated above, obtain the minimum required depth of shear key 'x' to ensure stability against sliding with a factor of safety of 1.55. (5 marks)
   (iii) Design and sketch the reinforcement in the base slab. (5 marks)

   Assume that the wall is NOT required to be designed as a water retaining structure and
   - Safe bearing capacity of soil = 150 kN / m^2
   - Angle of repose ϕ for soil above water table = 25°
   - Angle of repose ϕ' for soil below water table = 20°
   - Unit weight of soil γ_e above water table = 20 kN / m^3
   - Coefficient of friction μ at the base = 0.45
   - Unit weight of concrete γ_c = 25 kN / m^3
   - Unit weight of water γ_w = 10 kN / m^3
   - Grade of concrete: M 25
   - Grade of steel: Fe 415

2. (a) A single cell square tank with inner plan dimension L, height H and wall thickness 't' is fully filled with water. Considering H = 5 m, L = 8 and 't' = 300 mm,
      (i) Assuming that 't' << L, determine the hoop tension per unit height in the tank wall at mid-height. (2 mark)
      (ii) Obtain and clearly sketch the variation of bending moment per unit height along the width of the tank wall at mid-height of the water tank. Mention the values at critical locations. (3 marks)

   (b) The plan view of a single-story building with columns located on two circular arcs of radii 32 m and 40 m is shown in Figure 2. An earthquake load of 200 kN acts on the

building at the floor level along the axis of symmetry of the building. The stiffness of frames on the grid lines 3-3 is half that of frames on grid lines 1-1 and 2-2. Determine the lateral earthquake load shared by a frame on the grid line 1-1. (5 marks)

3. A four-story (G+3) office building is to be constructed in Gurgaon on soft soil as a reinforced concrete framed structure with floor slabs that act as rigid diaphragms (rigid in the horizontal plane) and isolated RCC footings (without tie beams) as foundation. The building has equal story heights of 3.0 m with a plan and elevation shown in Figure 3. The figure also illustrates the location of the frames. The remaining data for structural design is presented as follows:
   Column sizes: 0.23 x 0.23 m Beam sizes: 0.23 x 0.50 m Slab thickness = 0.100 m
   Dead load due to Flooring and Finishing: 1.25 kN/ m^2
   Dead load due to Roofing (terracing, tiling and finishing): 2.0 kN / m^2
   Live load on Floors: 3 kN / m^2 Live load on roof: 1.5 kN / m^2

   Obtain the lateral story forces on Frame 2-2 due to **wind loading** calculated in accordance with IS: 875 – 1987 (Part III). Assume that the building has a glass cladding and is located in a sparsely built-up suburb on a hill with a gradient of 25°. (10 marks)

4. A single story building is L shaped in plan as shown in Figure 4 and consists of a flat slab construeted monolithically with columns that are all identical with their lateral stiffness in x direction twice of that in the y direction. Determine the lateral load shared by (i) column A and (ii) column H under the under an earthquake load of 300 kN acting at the floor level at an angle of 30° to the x axis. (10 marks)
   Assume that
   - the slab acts as a rigid diaphragm
   - the dead and live loads are uniformly distributed over the slab area

STEEL STRUCTURES

1. Design a gantry girder (erane girder) to carry two cranes of capacity 300 kN each working in tandem. The span of the crane between the rails is 12m. The crane girder may be assumed as simply supported on the columns with a center-to-center spacing between the columns as 6 m (i.e. effective span of crane girder is 6 m). Use an economical built up beam with riveted connections. (10 marks)

   Assume that:
   - Weight of the rail is 0.3 kN/m
   - Span of the crane is 500 mm less than centre-to-centre span between the crane columns in the transverse direction.
   - Minimum distance between the wheels of adjacent cranes is 1000 mm.

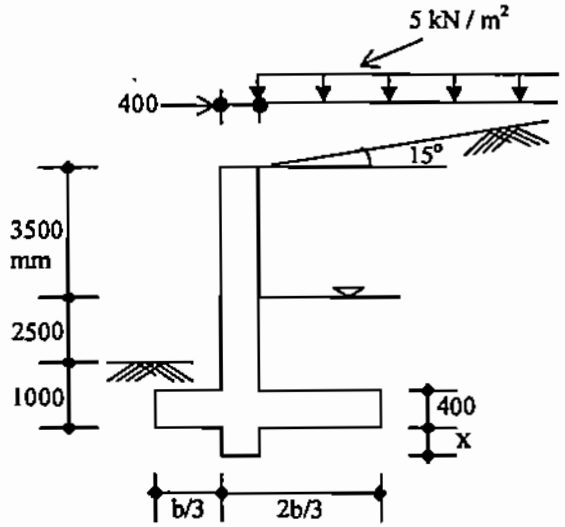


Figure 1

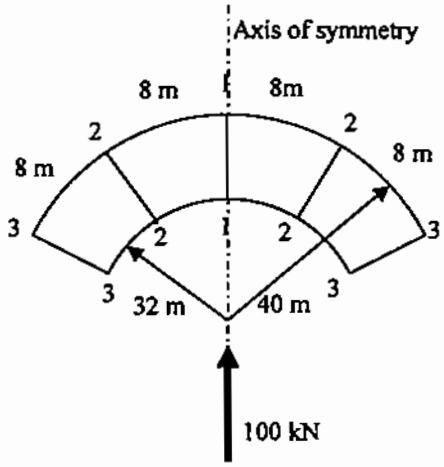
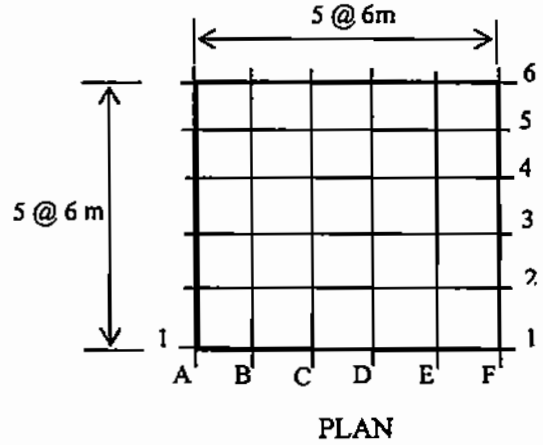
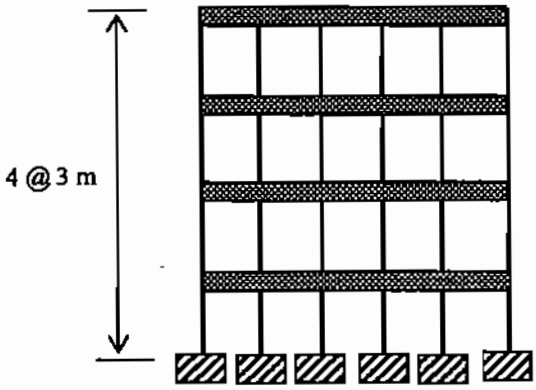


Figure 2



PLAN



ELEVATION

Figure 3

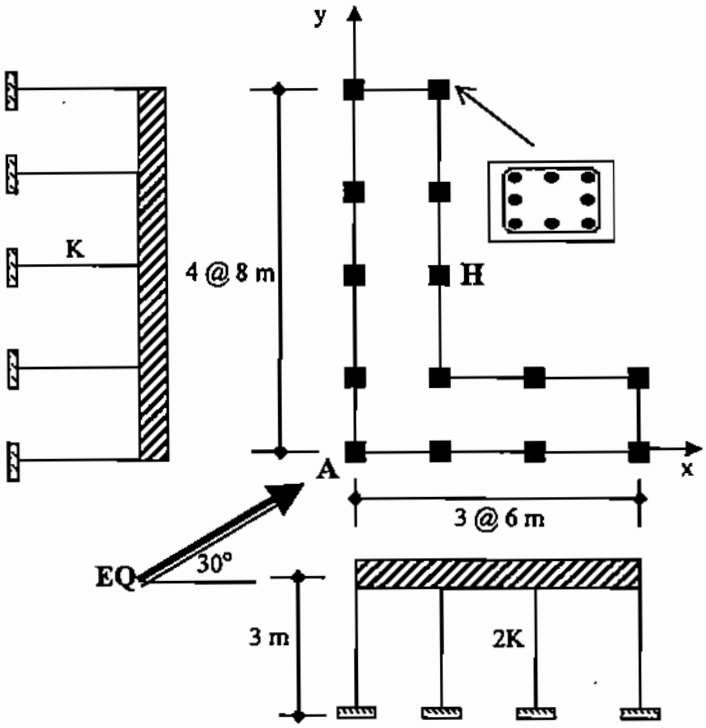


Figure 4