Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER– II(New course) • EXAMINATION (Remedial) – WINTER- 2015

Subject Code: 2722010 Date: 09/12/2015

Subject Name: Structural Dynamics and Earthquake Engineering

Time:2:30 pm to 5:00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of IS: 456, IS: 1893, IS: 4326 and IS: 13920 is permitted in exam hall, provided they do not contain anything other than the printed matter inside.**

Q.1 **(a)** Explain: Seismic design philosophy with neat sketches. **06**

(b) State with the proper justification whether the following statements are True/False/Maybe: **08**

(1) Short columns are most preferable elements in buildings as they are stiffer & attract larger forces during Earthquakes.

(2) In buildings, the columns & walls located at lower storeys experience lesser earthquake induced forces as the earthquake induced inertia force generates at mass/floor levels.

(3) Safety of non-structural elements cannot be assured in the building which is earthquake resistant.

(4) Strong column-weak beam design concept is preferred in earthquake resistant design.

Q.2 **(a)** Figure 1 shows the plan of a single storey building of height 3.5 m. Assume that the centre of mass and centre of stiffness of the building coincides with each other having the coordinates as (2.67 m, 3 m) from point ‘a’. The stiffness of each shear wall about its stronger axis is shown in figure in terms of ‘k’. Calculate the lateral load shared by each shear walls if the earthquake force of 300 kN acts in the *y*-direction at centre of mass. **07**

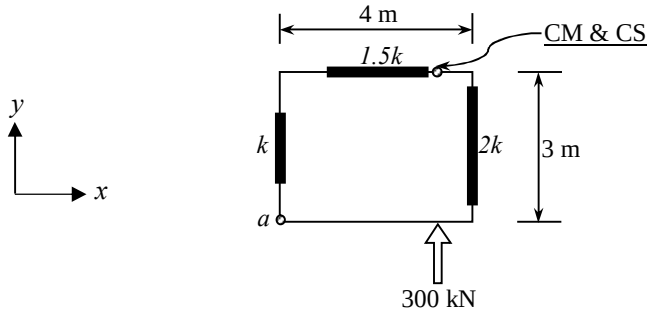


Figure 1

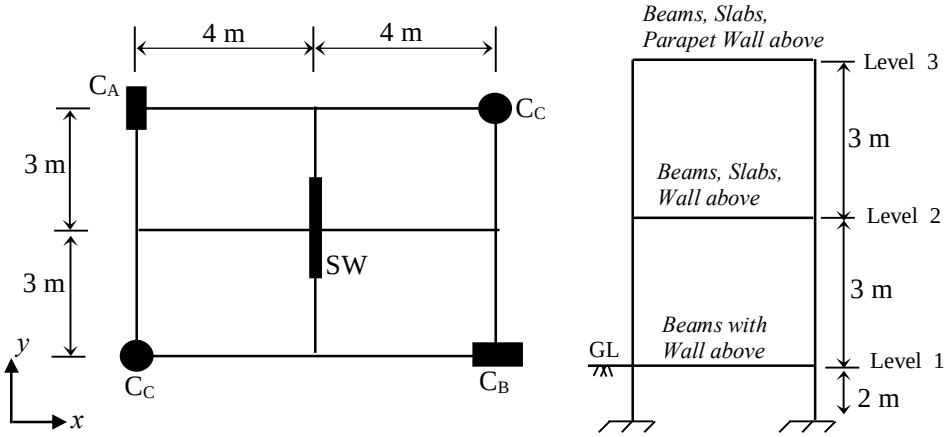
(b) A free vibration test is performed on the single degree-of-freedom system. The mass of the system is 300 kg which is displaced by 3 cm and suddenly released. The time required to complete 15 cycles of oscillations is 5 s. Calculate the stiffness of the system. Write the equation of motion for the system and calculate the displacement after 10 sec. Consider initial velocity as 1 m/sec. **07**

OR

(b) A single degree of freedom system is excited by a harmonic force. At resonance, the maximum amplitude of displacement is measured as 2 cm. Further at an exciting frequency of $1/10^{th}$ of the natural frequency of the system, the displacement is measured as 0.2 cm. Calculate the damping ratio. **07**

Q.3 Figure 2 shows the typical layout & section a building. Assume slab thickness = 120 mm, Live load = 4.0 kN/m^2 , floor finish = 1.0 kN/m^2. All beams have size 230 x 600 mm (including slab), Column C_A = 300 mm x 600 mm, C_B = 600 mm x 300 mm, C_C = 380 mm dia. and shear wall SW = 150 mm x 1500 mm. Consider 230 mm thick full height brick walls on beams around outer periphery of building and no interior walls. Further, consider 230 mm thick, 1 m height wall on outer periphery at roof level. The building has SMRF and it is hospital building at Ahmedabad rested on medium soil. Determine the joint loads on each frame at Level 2 when earthquake force acts along y-direction. Consider E = 22360 N/mm^2. Consider the coordinates of centre of mass are x_{cm} = 4 m, y_{cm} = 3 m and coordinates of centre of stiffness are x_{cs} = 3.682 m, y_{cs} = 1.682 m with reference to left corner column C_C. **14**

Figure 2



OR

Q.3 **(a)** What is the significance of ductile detailing? Discuss the important criteria to be considered for ductile detailing of beams and columns as per IS:13920. **07**

(b) Figure 3 shows the plan of a single storey building of height 3.5 m. Consider column, C_A = 600 mm x 300 mm and C_B = 300 mm x 600 mm. Consider load intensity of 15 kN/m^2 on area ñAò and 25 kN/m^2 on area ñBò as shown in figure. Ignore the weight of columns and beams and calculate the centre of mass. Also calculate the size of circular column ñC_Cò such that the eccentricity along *x*-direction becomes zero. (Take stiffness of column as 12EI/L^3 and E = 22360 N/mm^2) **07**

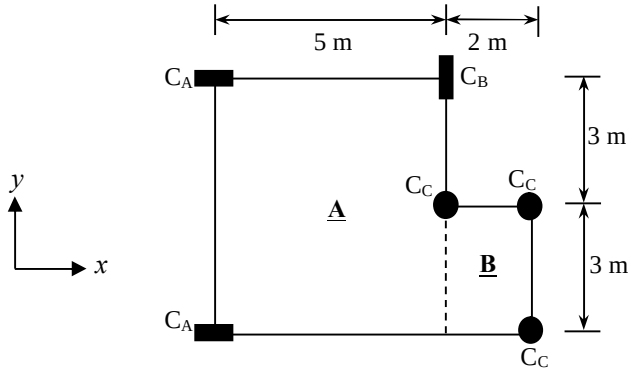


Figure 3

Q.4 A four storied building has lumped floor weights from bottom to top as 200 kN, 250 kN, 250 kN & 100 kN with storey stiffness of 500,000 N/m for all stories. From the free vibration analysis, the natural frequencies and corresponding mode shape coefficients are obtained as follows: **14**

ω_1 = 1.80 rad/sec, ω_2 = 5.32 rad/sec, ω_3 = 8.04 rad/sec and ω_4 = 9.14 rad/sec

$\{\phi_1\} = \{\phi_{11}, \phi_{21}, \phi_{31}, \phi_{41}\} = \{0.39, 0.71, 0.93, 1\}$

$\{\phi_2\} = \{\phi_{12}, \phi_{22}, \phi_{32}, \phi_{42}\} = \{-0.85, -0.75, 0.43, 1\}$

$\{\phi_3\} = \{\phi_{13}, \phi_{23}, \phi_{33}, \phi_{43}\} = \{1.08, -0.63, -0.29, 1\}$

$\{\phi_4\} = \{\phi_{14}, \phi_{24}, \phi_{34}, \phi_{44}\} = \{-0.33, 0.45, -0.66, 1\}$

Consider the building as residential building with ordinary RC moment-resisting frame (OMRF) proposed on medium soil at Ahmedabad. Calculate the design lateral force at each floor in each mode. Also calculate the storey shear force considering participation of all modes using modal combination method (SRSS or CQC).

OR

Q.4 **(a)** What is Duhamel's Integral? Write the steps involved to derive the displacement response of SDOF system subjected to constant step force 'F'. **07**

(b) A forced damped vibration system consists of fixed beam of 5 m span which supports a machine of total mass 200 kg placed at the centre of the span. The machine exerts the harmonic force of 270 N with the forcing frequency of 75 rad/sec. The damper of the system offers the resistance of 500 N at velocity of 4 m/sec. Calculate the maximum dynamic amplitude of vibration for the system. Consider moment of inertia of the beam as 8 x 10^7 mm^4 and modulus of elasticity, E = 2 x 10^5 MPa. **07**

Q.5 **(a)** What is base isolation? Which are the types of base isolations? **07**

(b) Discuss the important seismic provisions which are necessary to be considered for the earthquake resistant masonry buildings as per IS:4326. **07**

OR

Q.5 **(a)** Develop the equation of motion for free damped single degree of freedom system and derive the general solution of displacement response. **07**

(b) A SDOF consists of a 3 m high Column of 400 mm diameter which supports the heavy mass of 5000 kg at its top. The system is subjected to a harmonic force of 1000 sin(50)t N. consider the damping ratio as 0.5 & E = 2 x 10^4 N/mm^2. Calculate the maximum dynamic amplitude. Also state whether the system will have Resonance or not? **07**

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