STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING
(CIVL 3144)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

USE OF IS CODES ARE ALLOWED IN THE EXAMINATION HALL.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) A vibrating system consisting of a weight of W=15N and a spring with stiffness k=2N/m. The angular natural frequency of the system is
(a) 1.14 (b) 5.7 (c) 3.5 (d) 5.0.

(ii) A system is said to have over damped condition when
(a) $c > c_{cr}$ (b) $c = c_{cr}$ (c) $c < c_{cr}$ (d) $c \geq c_{cr}$

(iii) If time period is 5 second, initial displacement = 5 mm and initial acceleration is 10 mm/s^2 then calculate the phase difference in a free vibration system.
(a) 1.45 (b) 1.23 (c) 1.59 (d) 1.79

(iv) The equation of motion for undamped free vibration is:
(a) $m\ddot{u} + ku = 0$ (b) $m\ddot{u} + c\dot{u} + ku = 0$
(c) $m\ddot{u} + c\dot{u} + ku = f(t)$ (d) $m\ddot{u} + ku = f(t)$

(v) Consider a beam has two lumped mass and the corresponding mass points translate in vertical direction and rotational displacement. The number of dynamic degrees of freedom (DOF) is
(a) 2 (b) 12 (c) 4 (d) 8

(vi) In a single degree freedom damped forced vibration, magnification factor β is given by (if r=frequency ratio and ξ=damping ratio)
(a) $\frac{1}{\sqrt{\left(1-r^2\right)^2 + 4\xi^2 r^2}}$ (b) $\frac{1}{\sqrt{(1-r)^2 + 4\xi r}}$
(c) $\frac{1}{\sqrt{\left(1-r^2\right)^2 + 4\xi r}}$ (d) $\frac{1}{\sqrt{(1-r)^2 - 4\xi r}}$

(vii) The dynamic magnification factor is defined as the

(a) $\frac{Y_{st}}{Y}$ (b) $Y \times Y_{st}$ (c) $\frac{Y}{Y_{st}}$ (d) $\sqrt{\frac{Y}{Y_{st}}}$

Where, Y_{st} and Y are the static deflection and steady state amplitude.

(viii) Body waves consist of the

(a) P waves only (b) S waves only

(c) P and S waves (d) Surface waves

(ix) A vibrating system consists of a mass of 5kg, a spring stiffness of 5N/mm and a dashpot with a damping coefficient of 0.1 N-s/m. The damping ratio is

(a) 0.413 (b) 0.313 (c) 0.922 (d) 0.612

(x) The amount of ground displacement in an earthquake is called the

(a) Epicenter (b) Dip (c) Slip (d) Focus

Fill in the blanks with the correct word

(xi) Seismic zone factor of Delhi is _____.

(xii) Importance factor for residential building with occupancy more than 200 is_____.

(xiii) Among all the natural frequencies, _____ is of minimum magnitude.

(xiv) Response reduction factor for SMRF is _____.

(xv) Damping ratio of steel structures _____ %.

Group - B

2. (a) Explain Critical damping, Fundamental frequency and mode shape.

[(CO1)(Understand/LOCQ)]

(b) Develop the expression for equation of motion for underdamped free vibration for single degree of freedom system stating D'Alembert's principle. Explain the term phase difference. *[(CO1)(Apply/IOCQ)]*

5 + 7 = 12

3. (a) A mass M is attached at the free end of the beam as shown in Fig. 1. The beam is 10m long with flexural rigidity *EI* constant throughout. Determine the natural frequency, neglecting the mass of the beam.

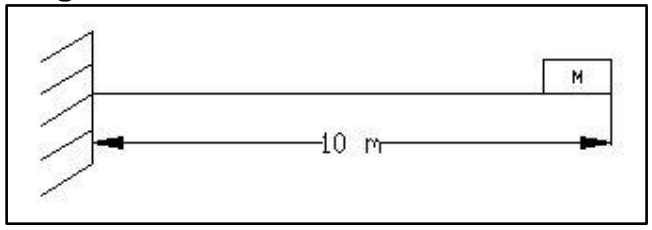

Fig.1 *[(CO2,CO3)(Evaluate/HOCQ)]*

(b) A concrete cube with unit weight 25kN/m^3 is attached at the mid point of the simply supported beam as shown in Fig. 2. The cube is 1m × 1m × 1.5 m is size. Neglect the self weight of the beam and evaluate the natural frequency of the assembly. The beam has constant flexural rigidity of *EI* throughout.

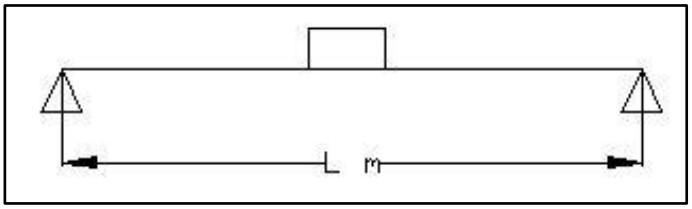

Fig.2

[(CO2,CO3)(Evaluate/HOCQ)]

(c) Explain the terms Periodic loading and Non-periodic loading.

[(CO1)(Understand/LOCQ)]

5 + 5 + 2 = 12

Group - C

4. (a) Derive an expression for the magnification factor for harmonic loading. Plot curves showing variation of dynamic magnification factor with frequency ratio, for different values of critical damping ratio. Hence explain the term resonance.

[(CO1,CO2)(apply/IOCQ)]

(b) A single degree of freedom damped system is composed of a mass of 10kg, a spring having a spring constant of 2000N/m, and a dashpot having a damping constant of 50Ns/m. The mass of the system is acted on by a harmonic force $F=F_0 \sin\omega t$ having a maximum value of 250N and a frequency of 5Hz. Determine the complete solution for the motion of the mass. *[(CO1,CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

5. (a) Determine the response at time $t > \tau$ of a single degree of system with spring (k), mass (m) due to the forcing function characterized as impulse load of magnitude F having duration $\partial\tau$ at time $t = \tau$. *[(CO1,CO2)(Evaluate/HOCQ)]*

(b) Using the result of above problem evaluate the response at any time t of a single degree spring (k), mass (m) system due to the forcing function characterised as

$F(t) = F_0$ for $0 \le t \le t_p$

$= 0$ for $t > t_p$. *[(CO1,CO2)(Evaluate/HOCQ)]*

8 + 4 = 12

Group - D

6. (a) Write short notes on the following:
I. Rayleigh waves II. Love waves

[(CO5) (Understand /LOCQ)]

(b) Define Richter magnitude, seismograph and different seismic zones of India.

[(CO5)(Remember/LOCQ)]

(3 + 3) + 6 = 12

7. Describe Plate Tectonic theory and Elastic rebound theory of earthquake. Describe various waves generated due to earthquakes. *[(CO5)(Understand /LOCQ)]*

6 + 6 = 12

Group - E

8. (a) Estimate seismic load acting at each floor for a G+3 residential building situated at Kolkata (medium stiff soil site) using Equivalent Static Method. The floor to floor heights are 3.5 m for each floor and the base of foundation is 1.6 m below GL. The total dead load intensity on each floor including roof is 36.5 kN/m^2. The dead load includes self-weight of slab, floor finish, ceiling plaster, beams and columns. The live load intensity on a typical floor is 2.0 kN/m^2 and on roof 1.5 kN/m^2. The building is 16 m × 20 m on plan and divided by beams @ 4 m c/c. Consider the building as OMRF. *[(CO6)(Create/HOCQ)]*

(b) Discuss the fundamental concept of ductile detailing. *[(CO6)(Understand/LOCQ)]*

10 + 2 = 12

9. Estimate the storey shear force in each mode for the residential building as shown in Fig.3 with following particulars:

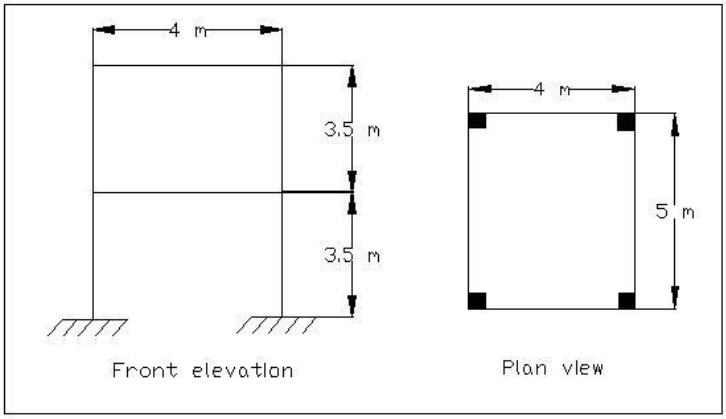

Fig.3

Beam dimensions: 200mm × 350mm
Column dimensions: 350mm × 350mm
Slab depth: 150mm
Location: Bhuj
Soil: Medium soil type
Consider OMRF for seismic design purpose.

[(CO4)(Create/HOCQ)]

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37	15.5	47.5

Course Outcome (CO):

After the completion of the course students will be able to
1. Convert structure into SDOF system
2. Find response of free and force vibration (harmonic, periodic and transient) of SDOF system
3. Find natural frequency and mode shapes of MDOF system
4. Carry out modal analysis of MDOF system
5. Understand the behavior of structures under earthquake
6. Design earthquake resistance design of structures

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*