GUJARAT TECHNOLOGICAL UNIVERSITY

BE-6 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:

EARTHQUAKE ENGINEERING (3160621)

Unit 1: Earthquake Basics

Repeated Questions:

1. Differentiate between Magnitude and Intensity of an earthquake. (S25 - Q1b(i), 04 marks), (W24 - Q1b(i), 04 marks), (W23 - Q1b(1), 04 marks), (S23 - Q1b(1), 04 marks), (S22 - Q1b(1), 04 marks)
2. Differentiate between Body Waves and Surface waves. (W25 - Q1b(ii), 04 marks), (S23 - Q1b(2), 04 marks)
3. What are the known causes of earthquake? Explain in terms of Plate Tectonic theory. (W24 - Q1a, 03 marks), (W23 - Q1a, 03 marks), (W22 - Q1a, 03 marks)

Other Important Questions:

1. Explain the following terms in Brief: (i) Meizoseismal and Isoseismal (ii) Focus of an Earthquake (iii) Seismograph. (W25 - Q1a, 04 marks)
2. Define Following terms: (1) Epicenter (2) Focus (3) Critical Damping. (S23 - Q1a, 03 marks)
3. Define Following terms: (1) Epicenter (2) Magnitude of Earthquake (3) Resonance. (S22 - Q1a, 03 marks)
4. Define Following terms : (1) Isoseismal (2) Hypocentre (3) Aftershocks. (S25 - Q1a, 03 marks)
5. Define (i) isoesimal (ii) soft storey (iii) epicenter (iv) magnitude (v) resonance (vi) seismogram (vii) Intensity. (W24 - Q1c, 07 marks)
6. Enlist various IS codes applicable to earthquake engineering. (W22 - Q1b, 04 marks)
7. Discuss the significance of MSK 9 Intensity earthquake. (W24 - Q1b(ii), 04 marks)
8. Discuss the physical significance of MSK 7 Intensity earthquake. (S25 - Q1b(ii), 04 marks)
9. Elaborate on the seismic waves developed during earthquake and its effects on structure. (W22 - Q1c, 07 marks)
10. Enlist the various seismic waves and explain about all. (W24 - Q2c, 07 marks)
11. What are plate tectonics and how are they related to continental drift and sea floor spreading? (W24 - Q5c, 07 marks)

Unit 2: Fundamentals of Earthquake Vibrations of Buildings

Repeated Questions:

1. Derive the equation of motion for displacement at any given time for damped free vibration of an SDOF system. (W25 - Q2(c), 07 marks), (W22 - Q2c, 07 marks), (S22 - Q1c, 07 marks)
2. In an experiment on a certain structure modelled as an SDOF system, the amplitude of free vibration decreased from 10 mm to 4 mm. If the logarithmic decrement was 0.1018 and undamped natural frequency is 40 rad/s, determine the damping ratio, damped period, and number of cycles completed. (S23 - Q3(c), 07 marks), (W24 - Q2(c), 07 marks), (S25 - Q2(c) OR, 07 marks)
3. Determine the free vibration response of an SDOF system shown in Fig. 1 at time t = 0.20 s for the following data: Natural circular frequency $\omega = 12$ rad/s; Damping factor $\xi = 0.15$; Initial velocity $\dot{x}(0) = 10$ cm/s; Initial displacement $x(0) = 5$ cm. (S23 - Q3(c) OR, 07 marks), (W24 - Q3(c) OR, 07 marks), (S25 - Q2(c), 07 marks)
4. Write short note on Logarithmic Decrement. (S23 - Q5a, 03 marks), (W24 - Q5a, 03 marks), (S22 - Q5b OR, 03 marks)

5. Differentiate between static and dynamic analysis for earthquake loading. (S23 - Q2c, 07 marks), (W24 - Q3c, 07 marks), (W23 - Q2c, 07 marks)

Other Important Questions:

1. "Frequency of a spring-mass system will decrease with the increase in mass of the system". State whether is statement is True or False giving proper justification. Also calculate the frequency of a spring mass system in Hertz if the mass of the system is 2 tonnes and stiffness is 200 N/mm. (W25 - Q2(b), 04 marks)
2. A free vibration test was performed on a single storey one bay portal frame having a mass of 200 kg, by displacing it horizontally and suddenly released. The initial displacement was observed to be 1.52 mm and after three cycles the displacement was recorded to be 0.371 mm. The time taken to finish three cycles of vibration was 0.285 second. Determine the stiffness 'k' and damping coefficient 'c' of the portal frame. (W25 - Q2(c) OR, 07 marks)
3. A 6.8 kg mass is suspended by a linear spring. The mass receives an impact resulting in motion with no initial displacement but with an initial velocity. The natural period of system was measured to be 0.25 sec, and the displacement amplitude of 50 mm. Find (a) the spring constant for the system, (b) the initial velocity imparted on the mass and displacement of the system at t = 0.63 sec considering an undamped system. (W25 - Q3(c), 07 marks)
4. Write short note on mathematical modeling. (W22 - Q2b, 04 marks)
5. A SDOF vibrating system is consisting of a mass = 160 kg, spring stiffness = 160 N/m, and c = 30 N-sec/m. determine (i) Natural frequency of damped vibration (ii) Damping ratio (iii) logarithmic decrement (iv) Ratio of two successive amplitudes. (W22 - Q2(c) OR, 07 marks)
6. A vibrating system consisting of a mass of 50 kg and a spring of stiffness $4x10^4$ N/m is viscously damped. The ratio of two consecutive amplitudes is 20:18. Determine the natural frequency of undamped system. Also determine the damping ratio and damped natural frequency. (W23 - Q3(c), 07 marks)
7. The properties mass m, stiffness k, and natural frequency ω of an undamped SDOF system are to be determined by a harmonic excitation test. At an excitation frequency of 4 Hz the response tends to increase without bound. Then, a weight W of 22 N is attached to the mass m, the resonance occurred at 3 Hz. Determine the dynamic properties of the system. (W23 - Q3(c) OR, 07 marks)
8. A spring mass model consists of 18 kg mass and spring of stiffness 25 N/mm was tested for viscous damped vibration. The test recorded two consecutive amplitude is 2.0 cm and 1.5 cm respectively. Determine (i) Natural frequency of un-damped system (ii) Logarithmic decrement (iii) Damping ratio (iv) Damping coefficient (v) Damped natural period. (S22 - Q2(c), 07 marks)
9. 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. (S22 - Q2(c) OR, 07 marks)
10. A mass of 0.07 kg is suspended from a spring of stiffness 45 N/m. The mass is pulled downwards by 15 mm from its equilibrium position and then released. The upward velocity observed was 25 mm/s. Determine the maximum velocity, maximum acceleration, and the phase angle. (S25 - Q3(c), 07 marks)
11. An SDOF system is modelled as shown in Fig. 2. It has the following properties.Mass, m = 2 kg; Stiffness, k = 15,000 N/m; Coefficient of damping, c = 45 N/m/s. Determine the natural circular frequency, damping factor, and damped frequency of the system shown in Fig. 2. Write the equation of free response for determining the time history response of the system. (S25 - Q3(c) OR, 07 marks)
12. A spring mass model consists of 6 kg mass and spring of stiffness 3 N/mm was tested for viscous damped vibration. The test recorded two consecutive amplitude is 1.5 cm and 1.2 cm respectively. Determine (i) natural frequency of undamped system (ii) logarithmic decrement (iii) damping ratio (iv) damping coefficient (v) damped natural frequency of system. (W24 - Q2(c) OR, 07 marks)

Unit 3: Design Philosophy

Repeated Questions:

1. Explain the earthquake resistant Design Philosophy and provide four virtues of a good earthquake resistant design. (W25 - Q1c, 07 marks), (S23 - Q1c, 07 marks), (W24 - Q1c, 07 marks)
2. Explain the four virtues of earthquake resistant design. (S25 - Q1c, 07 marks), (W22 - Q3c, 07 marks)
3. "Can you build an earthquake proof building?" Answer the question with proper justifications. (W25 - Q3(a) OR, 04 marks), (W22 - Q4(c), 07 marks) *[Note: W22 question asks to differentiate between proof and resistant design]*
4. Differentiate the following terms: (1) Storey drift and storey shear (2) Importance factor and response reduction factor. (S23 - Q3a, 03 marks), (W24 - Q3a, 03 marks), (W23 - Q3a, 03 marks), (W22 - Q3a, 03 marks), (S25 - Q3(a) OR, 03 marks)
5. Explain the procedure of Response spectrum method as per Indian Standards. (S23 - Q2c, 07 marks), (W24 - Q3c, 07 marks), (S25 - Q5(b) OR, 04 marks)

Other Important Questions:

1. "Can your house sustain an Earthquake having an magnitude of 8.0 on Ritcher Scale?" Answer this question giving suitable explanation. (W25 - Q2a, 04 marks)
2. Formulate the governing equation of motion for undamped vibrations for a three storey structure having mass of m_1, m_2, & m_3 and storey stiffness of k_1, k_2, & k_3 for first, second, and third storey respectively. (W25 - Q3(c) OR, 07 marks)
3. Explain the importance of ductility. (S22 - Q3a, 03 marks), (S25 - Q5(a) OR, 03 marks)
4. Write zone factor [Z] values as per IS 1893-part I. (W22 - Q3(a) OR, 03 marks)
5. List the four virtues of good earthquake resistance design and describe in detail. (W22 - Q3c, 07 marks)
6. Philosophy of earthquake resistant design. Give four virtue of good earthquake resistant design. (S22 - Q4c, 07 marks)
7. Explain importance of vibration analysis in detail. (S22 - Q4b, 04 marks)
8. Explain the criteria for earthquake resistant design & detailing of masonry structures. (S22 - Q5c OR, 07 marks)

Unit 4: Lateral Loads on Buildings

Repeated Questions:

1. Explain in detail with examples Rigid Diaphragm and Flexible Diaphragm. (W25 - Q3a, 07 marks), (W24 - Q2a, 03 marks), (S22 - Q4a, 03 marks), (S25 - Q5a, 03 marks)
2. How design eccentricity is calculated as per IS: 1893 (1)-2016? (S23 - Q4a, 03 marks), (W24 - Q4a, 03 marks), (S25 - Q3a, 03 marks), (W24 - Q4a, 04 marks)
3. Explain various irregularities found in the civil engineering structures from earthquake point of view. (S23 - Q4b, 04 marks), (W23 - Q4b, 04 marks), (S25 - Q4(a) OR, 03 marks), (S22 - Q5a OR, 03 marks)
4. Give assumptions made in cantilever method of lateral load analysis. (S23 - Q5a OR, 03 marks), (W24 - Q5a OR, 03 marks), (W23 - Q5a, 03 marks), (W22 - Q4a OR, 03 marks)
5. Consider a simple one-storey building having two shear walls in each direction as shown in Fig. 3. It has some gravity columns that are not considered for analysis. All four walls are in M25 grade concrete, 200 thick and 4 m long. Storey height is 4.5 m. Floor consists of cast-in-situ reinforced concrete. Design shear force on the building is 100 kN in either direction. Evaluate design lateral forces on different shear walls using the torsion provisions of IS 1893 (Part 1) 2016. (S23 - Q5c, 07 marks), (S25 - Q3c, 07 marks) *[Diagram given - refer Question paper of Verified Season Year]*
6. The plan and elevation of a three-storey RCC Community Hall is shown in Fig. 2/5. The building is located in seismic zone V. The type of soil encountered is medium stiff and it is proposed to design the building with a special moment resisting frame. The intensity of DL is 10 kN/m² and the floors are to cater to an IL of 3 kN/m². Determine the design seismic loads on the structure by static analysis/Seismic Coefficient Method. (S23 - Q4c, 07 marks), (S25 - Q5c, 07 marks), (W23 - Q5c, 07 marks) *[Diagram given - refer Question paper of Verified Season Year]*

Other Important Questions:

1. Explain in detail; (i) Soft Storey and Weak Storey (ii) Mass Irregularity and Stiffness Irregularity. (W25 - Q3b, 07 marks)
2. Compare torsionally coupled and uncoupled systems under lateral load. Explain, with sketches, how torsional irregularity affects structural response. (W25 - Q5c, 07 marks)
3. Differentiate the flexible and Rigid Diaphragm. (W24 - Q3(a) OR, 03 marks)
4. Distinguish between centre of mass and centre of stiffness. (S23 - Q4b, 04 marks), (W24 - Q5b, 04 marks), (S22 - Q4a OR, 03 marks)
5. A typical floor plan of an intermediate storey of multi-storeyed building is shown in Fig. 3. Floor masses acting on various columns are also shown in the same figure. All columns have 500 mm x 500 mm size and cast in M25 grade concrete. The floor is subjected to seismic load of 480 kN in the principal directions. The floor height is 5 m. Determine (i) Center of Mass and Center of Rigidity; (ii) accidental eccentricities and torsion induced in floor. (W24 - Q4b, 07 marks) *[Diagram given - refer Question paper of Verified Season Year]*
6. How torsionally couple system is differing from torsionally uncouple system? Discuss it with neat sketches. (W22 - Q4b, 04 marks)
7. Locate the center of mass and center of stiffness for the Fig-1. All column sizes are 350 mm x 650 mm. (W22 - Q5c OR, 07 marks), (W23 - Q4b, 04 marks) *[Diagram given - refer Question paper of Verified Season Year]*
8. Explain effect of structural irregularities under lateral loading. (W24 - Q4c, 07 marks)
9. Calculate the base shear for a five storey hospital building having special moment resisting frame (SMRF) located in Ahmedabad on medium soil with following data using seismic coefficient method. (i) No. of bay in x and y-direction = 4 (ii) Width of each bay = 5 m (iii) Thickness of slab = 150 mm (iv) Storey height = 3 m (v) Size of beam and column = 300 mm x 450 mm (vi) Amount of damping = 10% of critical damping (vii) Live load = 4 kN/m². (W24 - Q4(a) OR, 07 marks)
10. A two storied building has lumped floor weights from bottom to top as 95000 N & 78500 N with storey stiffness of $5x10^5$ N/m and $4x10^5$ N/m respectively. Perform the free vibration

analysis & determine natural frequencies and corresponding mode shape coefficients. Also sketch the mode shapes. (S22 - Q5c, 07 marks)

11. Consider a four-storey reinforced concrete office building shown in Fig. 6. The building is located in Shillong (seismic zone V). The soil conditions are medium stiff and the entire building is supported on a raft foundation. The R. C. frames are infilled with brick-masonry. The lumped weight due to dead loads is 12 kN/m² on floors and 10 kN/m² on the roof. The floors are to cater for a live load of 4 kN/m² on floors and 1.5 kN/m² on the roof. Determine design seismic load on the structure as per IS 1893-Part 1 (2016). (S25 - Q5(c) OR, 07 marks) *[Diagram given - refer Question paper of Verified Season Year]*

Unit 5: Ductile Detailing

Repeated Questions:

1. Explain ductile detailing of beam as per Indian standard 13920 (2016) with neat sketches. (S23 - Q4c, 07 marks), (S25 - Q4(c) OR, 07 marks), (S22 - Q4c OR, 07 marks)
2. Discuss the capacity design concept in ductile detailing. (S23 - Q5b, 04 marks), (S22 - Q5b, 04 marks)
3. Explain with neat sketches the techniques of Column Jacketing. (S23 - Q5b OR, 04 marks), (W24 - Q5b OR, 04 marks), (W23 - Q5b, 04 marks), (S25 - Q3b, 04 marks)
4. Describe the salient point of difference between ductile detailing and normal reinforced RCC Column. (W25 - Q5a, 03 marks)

Other Important Questions:

1. Explain the concept of ductility and describe the measures used to make RCC structures more ductile? (W25 - Q4a, 07 marks)
2. When an RCC building is designed with an intermediate storey having no walls, unlike the storeys above and below, a structural irregularity arises. Identify the type of irregularity caused in such a case and explain the remedial measures recommended by the IS:1893-2016 to mitigate it. (W25 - Q5(a) OR, 03 marks)
3. In a ductile detailing design, explain how the shear capacity of beams is ensured against brittle failure. (W25 - Q5b, 04 marks)
4. Discuss the strong column - weak beam concept. (S23 - Q3(a) OR, 03 marks), (W23 - Q2b, 04 marks)
5. Explain ductile detailing of Column as per Indian standard 13920 (2016) with neat sketches. (W23 - Q4(c) OR, 07 marks)
6. Explain how ductile design is helpful for better earthquake resistance. (W22 - Q5a, 03 marks)
7. Write a brief note on 'Beam Jacketing'. (W24 - Q3b, 04 marks)
8. How we can make Buildings Ductile for Good Seismic Performance? (W24 - Q5(b) OR, 07 marks)

Unit 6: Special Topics

Repeated Questions:

1. Explain the role of Base isolation and Dampers installed in structures. In which type of structures, base isolation will be ineffective and why? (W25 - Q3(b) OR, 07 marks)
2. Explain base isolation techniques in details. (S23 - Q3b, 04 marks), (W24 - Q5b OR, 04 marks), (W23 - Q3(a) OR, 03 marks), (S22 - Q3b, 04 marks), (S25 - Q5b, 03 marks)
3. Enlist required conditions for liquefaction. Also suggest remedial measures for the same. (S23 - Q3b OR, 04 marks), (W24 - Q3b, 04 marks), (W23 - Q5a OR, 03 marks), (S25 - Q3(b) OR, 04 marks)
4. State the reasons for the poor performance of masonry buildings in seismic areas. (W24 - Q4a, 10 marks), (S25 - Q3a, 03 marks)
5. Describe confined masonry structures and discuss why they perform better than normal brick masonry buildings. (W25 - Q4b, 07 marks)
6. Explain importance of various bands in masonry buildings? Support the answer with suitable sketches. (S23 - Q2(c) OR, 07 marks), (W24 - Q5c OR, 07 marks)

Other Important Questions:

1. Describe in detail about the various methods prescribed by IS: 1893-2016 for elastic analysis of structures to evaluate the design lateral forces during an earthquake. Also give the suitability of each method for different types of structures. (W25 - Q4c, 07 marks)
2. Write a short note on the possible damages to RC buildings in earthquake-prone urban regions. (W25 - Q4(a) OR, 07 marks)
3. Explain with neat sketches the various construction features that can be adopted to improve the earthquake resistance of brick masonry structures. (W25 - Q4(b) OR, 07 marks)
4. Differentiate between Passive and Active structural control systems installed in the structures. (W25 - Q5b, 04 marks)
5. Describe importance of shear wall in multistoried Buildings. (S23 - Q2a, 03 marks), (S25 - Q2a, 03 marks), (W22 - Q4b OR, 04 marks)
6. Give details of expected damages by Earthquake in structures with 1. Short columns, 2. Building frames without shear panels, 3. Floating columns, 4. Unsymmetrical plan. (W22 - Q3b, 04 marks), (W23 - Q3b, 04 marks)
7. Write short note on Short Column Effect. (S22 - Q2b, 04 marks)
8. Explain soft storey & discuss its performance of soft storey building in past earthquakes. How will you avoid soft storey? (W22 - Q3(b) OR, 04 marks)
9. Explain repair, restoration and retrofitting. (W22 - Q4(a) OR, 03 marks)
10. Write short note on liquefaction. Explain factors affecting liquefaction. (S22 - Q3c, 07 marks)
11. Enlist the different methods of structural control. (S22 - Q3(a) OR, 03 marks)
12. Explain how soft storey problems can be eliminated in the existing buildings. (S22 - Q3b OR, 04 marks)
13. What is soil liquefaction? Explain theory of liquefaction in detail. (W24 - Q3c, 07 marks)
14. Define repair, restoration and retrofitting of structures. (W24 - Q3(a) OR, 03 marks)
15. Discuss various dampers used for energy dissipation. (W24 - Q3(b) OR, 04 marks)
16. Explain torsionally coupled and torsionally uncoupled system. (W24 - Q3(c) OR, 07 marks)
17. What is base isolation? Explain concept of base isolation in structures. (W24 - Q4a, 03 marks)
18. Explain the earthquake resistance feature of masonry structures. (W24 - Q5(b) OR, 07 marks)
19. A 5-storey RCC structure located in Bhopal has storey height of 3.5 m and built up area of 350 m². The dead weight on each floors including partitions and structural members can be considered as 375 kN and 415 kN for terrace. Consider a live load of 3.5 kN/m² on each floor and 1.5 kN/m² for terrace. Assuming the structure is used as a Shopping Center, having foundation on medium soil and provisions of IS: 13920-2016 have been followed in detailing, evaluate the design lateral forces and base shear for each storey of the structure using equivalent static method as per the provisions of IS: 1893-2016. Mention the clause numbers of the provisions used from IS: 1893-2016. (W25 - Q4(c) OR, 07 marks)
20. Determine the frequency and design seismic coefficient for an ordinary masonry shear wall in

a school building at Allahabad, for the following data. Roof load P = 15 kN/m; Height of wall h = 3.0 m; Width of wall b = 0.2 m; Unit weight of wall w = 19.2 kN/m³. Soil is medium. (W23 - Q4(c) OR, 07 marks)

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