BIRLA INSTITUE OF TECNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER, 2022-2023
CE G615 EARTHQUAKE ENGINEERING, Comprehensive Examination (Closed Book)
Time: 180 min. Date: 17-05-2023 Maximum Marks:35

Q1. IS:1893 Part 1: 2016 specifies 5% damping ratio for concrete, steel, or masonry buildings. But Steel as a material exhibits lower damping (2% in other parts of IS1893) than concrete/ masonry and therefore, different damping should be specified for three types of building materials as specified in IS 1893-part 2, 4. However, as per IS 16700-2017, article 6.2.2.4 (page 6) "the damping ratio considered shall not be greater than 2 percent of critical for concrete buildings". Other IS codes are recommending 2% for steel structure. Which one is correct? Are these codes contradicting each other? Explain. Can we have less than 1% damping ratio for all type of structure during earthquake analysis, if yes provide details/ explain? Can we have damping of concrete structures more than 5%, explain? Draw neat sketches. **[3 marks]**

Q2. Why damping is neglected in free vibration analysis for determining natural frequency of the system? Can you neglect it in all cases? Why? Give reasons and explain by relevant equations/ examples. **[2 M]**

Q3. Soil/ site classification A, B, C and Type I, II, III are respectively same or different given in IS 1893-1:2016 and why? What is the need/ application of these soil/ site classification, explain and justify your answer? **[2 M]**

Q4. What are the reasons behind recommendation of IS 1893 Part 1: 2016 to increase the design base shear calculated using dynamic analysis if it's less than the base shear calculated using empirical fundamental period? Explain. **[2 Marks]**

Q5. Why allowable soil pressure (determined as per IS code of practices for static loads) is increased up to 50% as per IS1893-part1-2016, when considering earthquake in addition to dead load and live load? The soil stress below the machine foundations shall not exceed 80 percent of the allowable stress as per IS: 2974 (Part I) – 1982. Are these two codes (IS1893-part1-2016 and 2974) contradicting each other? Explain by assuming allowable soil pressure of 100kPa for static case as per IS codes. **[3 marks]**

Q6. Base isolation is effective for which type of structures (Long period or short period, give numerical values suggested by IS1893 codes)? Give reason for your answer. In which conditions base isolation system is more effective for buildings as per IS1893-part6-2022 and why? **[2 marks]**

Q7.A column of size 400 mm x 500 mm and unsupported length of 3 m is subjected to a factored axial load (*Pu*) of 1400 kN and factored moment *Mux* about major axis of 130 kNm and *Muy* about minor axis of 60 kNm. The column is provided with the following reinforcements:
Longitudinal bars: 8 numbers of 20 mm diameter equally distributed on all four sides.
Lateral Ties: 10 mm diameter, 90^o hook at the end with 60 mm extension
a) Confining zone: 80 mm c/c in a length of 500 mm from both the ends.
b) Remaining length: 250 mm c/c spacing
Check whether the provided longitudinal and transverse reinforcement satisfies the requirements of IS 13920:2016 and IS 456:2000. Adopt M30 concrete, Fe 500 grade steel, and clear cover as 45 mm. Exposure conditions are of moderate type. Also, draw reinforcement detailing diagram of column with the final adopted design values. **[6 Marks]**

Q8. A RCC Chimney 150 m high has a uniform cross section Ac = 8.5 m^2 and Moment of Inertia, I = 92.5 m^4. Evaluate base shear and moment under earthquake considering the soil structure interaction effects as per IS 1893-part4. Assume fixed based time period is 1.121 sec. The structure is located in Delhi and supported on raft foundation of diameter 18 m. The soil has a design SPT N value of 15 and dynamic shear modulus G_{max} = 45 MPa. Consider the strain level correction for shear modulus as per Eurocode 8-part5. Unit weight of soil is 19 kN/m^3 and Poisons Ratio, $\nu = 0.35$. The concrete used is having E_{conc} = 3.16 x 10^7 kPa and unit weight is 24 kN/m^3. [3 marks]

Q.9(a). An elevated water tank has RC frame staging detailed for ductility as per IS: 13920 and is located in seismic zone IV. Site of the tank has soft soil. Impulsive and convective time periods are 1.2 sec and 4.0 sec, respectively. Obtain base shear coefficient for impulsive and convective mode. **[1.5 mark]**
Q9(b). A ground supported steel tank has water height, h = 25 m, internal diameter, D = 15 m and wall thickness, t=15 mm. Find time period of impulsive mode. **[1 mark]**

Q10.A 160 kN boiler is to be installed on the roof of a twenty-storey building at Mumbai, India. It is attached by four anchored bolts, one at each corner of the equipment, embedded in a concrete slab. Floor to floor height of the building is 3.1 m, except the ground storey which is 4.0 m. Determine the shear force on each bolt during earthquake shaking. Refer IS 16700:2017, wherever required. **[2 Marks]**

Q11. A hill road gravity retaining wall 7.7 m high is inclined 15° (towards the backfill) to vertical and retains a horizontal dry cohesionless backfill. Backfill properties are, γ = 20 kN/m3, Φ' = 39°, c'=0. There is superimposed load intensity of 20 kN/ m^2 on the backfill Find static and seismic earth pressure with point of application for wall in seismic zone V, assume A_h=0.18, Av=0.12. with a permissible displacement of 50mm. Draw neat sketches and show all horizontal and vertical components with point of applications. Use IS-1893-(Part3) 2014 and IRC6-2017. **[4 Marks]**

Q12. A circular reinforced concrete pier of a bridge is having uniform cross-section throughout the height (3 m diameter), is partially submerged in the water for a depth of 5 m. Determine the total hydrodynamic force due to earthquake. Take design horizontal seismic coefficient, A_h as 0.16. Use IS:1893-part3-2014 **[2 marks]**

Q13. A cantilever steel tower is modelled as five lumped masses. Masses are 3000 kg, 1500 kg, 1000 kg, 4.5 kg, and 1.5 kg respectively from first floor to top floor. Tower is in Delhi and resting on sandy soil having SPT value 22.

Frequency (rad/s)	6.174	6.473	10.950	12.664	18.975
Period (sec)	1.018	0.971	0.574	0.496	0.331
Participation factor	1.525	P2 = ?	-0.116	-0.943	-0.316
Mode Shape	0.161	-0.172	-0.038	-0.420	-0.316
	0.327	-0.340	-0.039	-0.208	0.632
	0.502	-0.497	0.019	0.633	-0.317
	5.687	4.838	12.860	-1.046	0.099
	15.590	16.043	-12.879	0.625	-0.020

Determine base shear using response spectrum modal analysis as per 1893-part1-2016. Take R=4.5 and I=1, assume 2% damping ratio for steel structure and consider only first two modes for modal combination. **[5 Marks]**

Q14. A reinforced concrete (M35 grade) bored pile 1 m diameter in section constructed into a submerged sand to a depth of 5.5 m in high seismic area for a bridge on river Ganga. given: design SPT value 15.5. The submerged unit weight of the soil is 8.75 kN/m3. After seismic analysis, computed lateral load of 200 kN and a moment of 100 kN-m is acting on the pile head at ground level. If pile is free, compute the lateral deflection at ground level under applied load. Find the maximum moment in the pile and its location also. **[4marks]**

Q15. The saturated sandy soil having 35% fines is in Zone IV and water table is located at 6 m from ground level. Corrected SPT (N1)60 value of 14 was found at a depth of 10 m. Calculate the factor of safety for liquefaction at depth of 10 m from ground level using Youd et al. 2001 (IS1893-part1-2016) and check if soil is going to liquefy at 10 m. Are your results matching with the screening criteria given in 1893-part1? Give your comments/suggestions/ shortcomings in 1893-part1 on the basis of results obtained by you and codal provisions given in IS 1893 part1:2016, regarding liquefaction. Take γsat=19kN/m3 for soil and Mw=7 **[4marks]**

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