BIRLA INSTITUE OF TECNOLOGY & SCIENCE, PILANI
SECOND SEMESTER, 2021-2022
MID SEM TEST
CE G615 EARTHQUAKE ENGINEERING (CLOSED BOOK)
Duration: 90 min. Date: 14-03-2022 Maximum Marks:25

Instructions: IS codes and formula sheets allowed.

Q1. 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 Dehi 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 displacement of top floor 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. **[6 Marks]**

Q2. In a framed structure, a beam AB with rectangular section (b= 300; D= 500 mm; and d = 450 mm, effective cover to compression steel, d' = 45 mm) and having an effective span of 6 m, is subjected to characteristic loads of 10 kN/m and 5 kN/m due to DL and LL respectively. Based on different load combinations for DL, LL and EQ load, the design moments determined at supports 'A' and 'B' are as follows:

At support A: Positive Moment, $M_{A^+} = 23\ kNm$ Negative Moment, $M_{A^-} = -69\ kNm$
At support B: Positive Moment, $M_{B^+} = 3\ kNm$ Negative Moment, $M_{B^-} = -88\ kNm$

On the basis of flexural design of beam, the longitudinal reinforcements calculated for the beam for the sections located near the support A and B are:

At Support A : Reinforcement at top : $3 - 14\phi$; Reinforcement at bottom: $2{-}14\phi$
At Support B : Reinforcement at top: $4{-}14\phi$; Reinforcement at bottom: Nil

(i) Check whether the section dimensions and the longitudinal reinforcement determined based on flexural design (as mentioned above) satisfy the ductility requirement at Support-A and Support-B or not. If not, suggest the revised dimensions and determine the longitudinal reinforcement (s) to be provided in beam at Support-A and Support-B.
(ii) Determine the 'Design shear force' at Support-A and Support-B.

<u>Note:</u> For the beam sections containing percentage of steel in tension zone less than ≈0.6%, the effect of steel in compression zone may be ignored and the M_u may be determined by considering the steel in tension zone only using the following expression:

$$M_u = 0.87 f_y A_{st}\left(d - 0.42\frac{0.87 f_y A_{st}}{0.36 f_{ck} b}\right) = 0.87 f_y\, p_t\left(1 - \frac{f_y}{f_{ck}} p_t\right) b d^2; \quad where,\ p_t = \frac{A_{st}}{bd}$$

[6 Marks]

Q3. A hospital is to be constructed near a river in Zone III. Site is clean sandy soil with $N_{1})_{60CS}$ value of 9 only. It is proposed to improve soil to ensure safety against liquefaction. Find value of $N_{1})_{60CS}$ after soil improvement for no liquefaction as per IS 1893-part1-2016 (Youd et al. approach) at a depth of 4 m from ground level. Expected moment magnitude (Mw) is 7. Assume water table at 2 m from ground level and unit weight of sandy soil above and below water table is 18 kN/m^3. Is this value matching with screening criterion given in Indian codes? Comment on adequacy of screening criterion given in Indian codes based on similarity (or discrepancy) of results. **[5 Marks]**

Q4. Consider a 130 m tall RCC Cylindrical chimney like structure of uniform cross section ($A_c = 8.16\ m^2$, $I = 87.9\ m^4$) with a weight of 25 kN/m^3 and $E_c = 3.4 \times 10^4\ N/mm^2$. The structure is located in Pilani and is supported on raft foundation of diameter 20 m and thickness 0.8 m. Evaluate the design shear force and bending moment at mid height and at base of chimney under earthquake conditions using IS 1893 Part 4: 2015. Take average shear wave velocity of the soil as 770 m/s, unit weight of soil as 22 kN/m^3 and Poison's ratio as 0.30. **[3 Marks]**

Q5. What is the reason 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? **[2 Marks]**

Q6. IS 1893 Part 1: 2016 specifies 5% damping ratio for concrete, steel, or masonry buildings. But Steel as a material exhibits lower (2%) damping 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". Which one is correct? Are these codes contradicting each other? Explain. **[2 marks]**

Q7. Can we have response reduction factor 1 or less than 1? If, no, give reasons. If yes, explain with reason by giving R values for applicable cases? [**1 mark]**

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