BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
I Semester 2023-2024
Course: CE F419 GEOTECHNICAL EARTHQUAKE ENG. AND MACHINE FOUNDATION
Comprehensive Examination
Duration: 180 min. Dated: 18-12-2023 Max. Marks: 45 Weightage :45%

PART A CLOSED BOOK

Q1. Why allowable bearing pressure (determined as per IS:6403, IS:1888 for static loads) is increased up to 50% as per IS1904, when considering dynamic forces such as due to earthquake in addition to dead load and live load? Is dynamic bearing capacity (due to earthquake loading) of soil less or more compare to static bearing capacity? And why? As per IS: 2974 (Part I) – 1982, permissible soil stress below the machine foundations shall not exceed 80 percent of the allowable bearing pressure. Are these two codes (IS1904 and 2974) contradicting each other? Explain by numerical example to justify specific percentage increase or decrease in allowable bearing pressure. **[4 marks]**

Q2. Define liquefaction of soil during earthquake. During several events of liquefaction no structural damage was observed to buildings, even glass of windows remains intact, why? Explain. **[2 marks]**

Q3. What are the shortcomings of liquefaction screening criterion of IS1893-part1-2016? What are suggested guidelines based on international code of practices to address these shortcomings? **[3 Marks]**

Q4. What is the importance of strain for dynamic properties of soil such as shear modulus and damping in context of machine foundations and seismic analysis of foundations? Draw neat figures and explain. SPT is high strain test but shear modulus obtained by SPT correlation correspond to low strain (G_{max}), why? explain. **[3 marks]**

Q5. Which is most suitable anti-liquefaction measures for new industry away from existing habitation and why? Which technique is most suitable for a new multi-storey building in urban environment with environment protection and why? Soil is SP. **[2 Marks]**

Q6. List various ground improvement techniques as anti-liquefaction measures in the order of increasing cost. Mention relative cost for each method. **[2 marks]**

PART B OPEN BOOK (you are allowed to start part B in new sheet after submitting part A only)

Q1. Using Mayen and Rix, 1993, 1995 (FHWA, GEC 5, 2017) method find Shear modulus (Gmax) and shear wave velocity of normally consolidated clay deposit at depth of 18 m having cone tip resistance (q_t) = 850 kPa, void ratio = 1.7 and unit weight is 16 kN/m^3. **[2 marks]**

Q2. A 2 m wide strip footing is placed at depth of 1 m in seismic zone IV (take $A_h = 0.5*Z$ and $A_v = 0.5*A_h$) is to be checked for bearing failure. Soil investigation report shows soil is poorly graded sand SP (unit weight = 18 kN/m^3, Poison's ratio = 0.35) with a design SPT N value as 36 and corresponding angle of internal friction 38 degree. Find the safe seismic bearing capacity using Richards et al. method. Compare the results with guidelines in Indian seismic code (1893: Part 1-2016) and IS 1904. Give your comments on adequacy of Indian codes. Assume water table is very deep. What will be the change in results if it is in Zone II and comparison with IS 1893-part1-2016 guidelines, discuss? **[6 marks]**

Q3. A school is to be constructed near a river in Zone IV. Site is loose sandy soil (having 20% fines) with $N_1)_{60}$ value of 9 only. It is proposed to improve soil to ensure safety against liquefaction. Find value of $N_1)_{60}$ after soil improvement for no liquefaction as per IS 1893-part1-2016 (Youd et al. approach) at a depth of 3 m from ground level. Expected moment magnitude (Mw) is 7. Assume water table at 1 m from ground level. Soil is saturated above water table. Unit weight of saturated sandy soil above and below water table is 18 kN/m^3. Is this value matching with screening criterion given in IS 1893-part1-2016? Comment on adequacy of screening criterion given in IS 1893-part1-2016 based on similarity (or discrepancy) of results. **[6Marks**]

Q4. A free head reinforced concrete (M40) pile 2 m diameter in section is constructed into a dry sand to a depth of 14.9 m. The sand is in a dry state with design SPT value of 14. Due to design earthquake, a lateral load of 300 kN and moment 6000 kN-m is acting on the pile at ground level. (a)Compute the lateral deflection of the pile at ground level (b) Find maximum moment in pile and its location. At what depth moment will become zero. The unit weight of the soil is 18 kN/m^3 . To reduce deflection, design engineer provided fixed head condition, calculate reduction in deflection. **[7 marks]**

Q5. Find rotation of a rectangular footing (6 m x 18 m) subjected to a moment of 45000 kN-m, due to earthquake loading at the center of footing base. Moment is acting about an axis parallel to 6 m side and passing through center of footing base. The soil parameters are G_S = 15.7 MPa, υ = 0.26. **[2 Marks]**

Q6.A hill road gravity retaining wall 10 m high is inclined 12° (towards the backfill) to vertical and retains an inclined (i=8°) dry cohesionless backfill. Backfill properties are, γ = 20 kN/m^3, Φ' = 39°, c'=0. There is superimposed load intensity of 15 kPa on the backfill. Find static and seismic earth pressure with point of application for wall, assume A_h=0.18, Av=0.12. Draw neat sketches and show all horizontal and vertical components with point of applications. Use IS-1893-(Part3) 2014 and IRC6-2017. **[6 marks]**

Q7. A concrete foundation (unit weight = 24 kN/m^3) supporting a machine is 3.5 m x 2.5 m in plan and is subjected to a sinusoidal vibrating force (vertical) having an amplitude of 60 kN (not frequency dependent). The operating frequency is 2000 rpm. The weight of the machine and foundation is 400 kN. The soil properties are unit weight = 16 kN/ m3, soil shear modulus G applicable for foundation = 19 MPa, and Poisson' ratio = 0.35. Determine the amplitude of vertical vibration at operating frequency using elastic half space theory by including damping as per ACI351.3R-2018. Check design is safe or not?What is the amplitude at resonance? **[5 marks]**

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