CEL423 – Design of Foundations, Earth and Earth Retaining Structures
CVL431 – Design of Foundations and Retaining Structures

Major Examination **Date: 10.06.16**
Time: 120 minutes **Max. Marks: 60**

Important Note:
1. Answer all questions
2. Answer should be concise
3. Include neat sketch wherever necessary
4. Assume suitable data, if required

1. State *True* or *False* and justify your choice. **(2 × 2 = 4)**
   i. A linear elastic spring with negligible damping becomes ineffective while vibrating at resonance.
   ii. The design basis/concept is essentially same for both rigid and flexible retaining walls.
2. A radio antenna weighing 70 N is to be fixed on aircraft. This radio is to be isolated from engine vibrations at frequency of 30 cps (cycles per second). What static deflection must the elastic spring isolators have for 90% isolation? **(4)**
3. (a) Discuss how "Strain Level", "Number of cycles" and "Cycles of Dynamic Pre-Strain" affect the dynamic soil properties (modulus and damping). **(5)**

   (b) Why is it essential to develop site-specific modulus reduction and damping curves for designing important structures to dynamic loads? **(3)**
4. (a) Write a short note on: Modes of vibration of rigid block foundation and the nature of ground reaction to these vibrations. **(3)**

   (b) Explain how the mass ratio is related to damping of foundation-soil system in elastic half space approach. **(2)**

   (c) List the types of anchorage used in sheet piling with the neat sketch. **(3)**
5. Distinguish the following: **(6)**
   (i) High-tuned and Low-tuned machine foundations
   (ii) Motion transmissibility and Force transmissibility
   (iii) Visco-elastic damping and Hysteretic damping
   (iv) Free earth support and Fixed earth support
6. A low-speed rotary compressor is to be supported on a plain cement concrete foundation block 3 m x 3 m x 2 m thick, which is located on the surface of a sandy clay soil. The sandy clay has a density of 1900 kg/m^3, a Poisson's ration of 0.35 and a dynamic shear modulus of 15 MPa. The compressor has a total mass of 12,000 kg and an operating frequency of 1180 rpm. The total oscillating mass in the compressor is 200 kg at an eccentricity of 15 cm. The dominant vibration in the machine is rocking. **(10)**

   (a) Determine the dynamic constants of soil-foundation system using elastic half space method for rocking vibration.

   (b) Determine (i) the natural frequency and (ii) the amplitude of vibration in rocking mode, at operating frequency by assuming the whole system as SDOF system.
7. Using the free earth support method, check the adequacy of the depth of embedment of the anchored sheet pile wall driven into homogeneous clean dense sand. The anchor rod is located at 1.5 m from the ground surface. The water table is at 5 m on the dredging side and at 3 m on the opposite side. The excavation depth is 7 m and the total length of sheet pile is 9.5 m. Soil properties are: $c' = 0$; $\phi' = 38°$; $\gamma_b = 19$ kN/m^3; $\gamma_{sat} = 21$ kN/m^3. Neglect the effect of seepage. **(8)**

8. A 10 kN drop hammer is to be installed in an industrial complex. The hammer has the following specifications:

Gross weight of the hammer	=	10 kN
Weight of the falling part of hammer	=	8 kN
Height of fall of hammer	=	650 mm
Number of blows per minute	=	90
Hammer efficiency	=	65%
Weight of the anvil block	=	220 kN
Weight of the frame	=	80 kN
Bearing area of anvil block	=	1.5 m x 1.5 m
Permissible amplitude for anvil block	=	1.5 mm
Perm. Amplitude for foundation block	=	1.0 mm

It is proposed to use a rubber elastic pad of thickness 0.2 m below the anvil. The modulus of elasticity of pad material is 8 x 10^5 kN/m^2, and the allowable compressive stress in the pad is 4000 kN/m^2. Coefficient of elastic restitution is 0.5. Allowable Bearing Pressure of soil (ABP) is 200 kN/m^2 and the coefficient of elastic uniform compression of soil, C_u = 6x10^4 kN/m^3. The anvil block-rubber pad assembly is embedded into the foundation block to a depth of 0.5 m from the top and a small air gap is provided between them. The frame is mounted on the foundation block. The trial size of foundation block is arrived as 6.0 m x 4.0 m x 1.5 m deep. Check the adequacy of the foundation to support the drop hammer. **(12)**

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Table and Formulae

Mode of vibration (1)	Equivalent radius (2)	Mass (or inertia) ratio (3)	Damping factor (4)	Spring Constant (5)
Vertical	$r_{oz} = \sqrt{\frac{ab}{\pi}}$	$B_z = \frac{(1-\mu)}{4}\frac{m}{\rho r_o^3}$	$\xi_z = \frac{0.425}{\sqrt{B_z}}$	$k_z = \frac{4 G r_o}{1-\mu}$
Sliding	$r_{ox} = \sqrt{\frac{ab}{\pi}}$	$B_x = \frac{(7-8\mu)}{32(1-\mu)}\frac{m}{\rho r_o^3}$	$\xi_x = \frac{0.2875}{\sqrt{B_x}}$	$k_x = \frac{32(1-\mu) G r_o}{7-8\mu}$
Rocking	$r_{o\phi} = \left(\frac{ba^3}{3\pi}\right)^{1/4}$	$B_\phi = \frac{3(1-\mu)}{8}\frac{M_{mo}}{\rho r_o^5}$	$\xi_\phi = \frac{0.15}{(1+B_\phi)\sqrt{B_\phi}}$	$k_\phi = \frac{8 G r_o^3}{3(1-\mu)}$
Torsional	$r_{o\psi} = \left(\frac{ba(a^2+b^2)}{6\pi}\right)^{1/4}$	$B_y = \frac{M_{mz}}{\rho r_o^5}$	$\xi_\psi = \frac{0.5}{1+2B_\psi}$	$k_\psi = \frac{16}{3} G r_o^3$

$$\omega_n^4 - (1+\mu)(\omega_{nl1}^2 + \omega_{nl2}^2)\omega_n^2 + (1+\mu)\omega_{nl1}^2\omega_{nl2}^2 = 0$$

$$V_a = \frac{1+e}{1+s}V_T;\ Z_f = \frac{(\omega_{nl2}^2 - \omega_{n1}^2)(\omega_{nl2}^2 - \omega_{n2}^2)}{\omega_{nl2}^2(\omega_{n1}^2 - \omega_{n2}^2)\omega_{n2}}V_a;\ Z_a = \frac{(\omega_{nl2}^2 - \omega_{n1}^2)}{(\omega_{n1}^2 - \omega_{n2}^2)\omega_{n2}}V_a$$

$s = m_2/m_0$; $\mu = m_2/m_1$

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