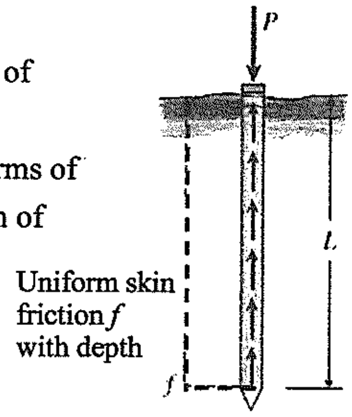
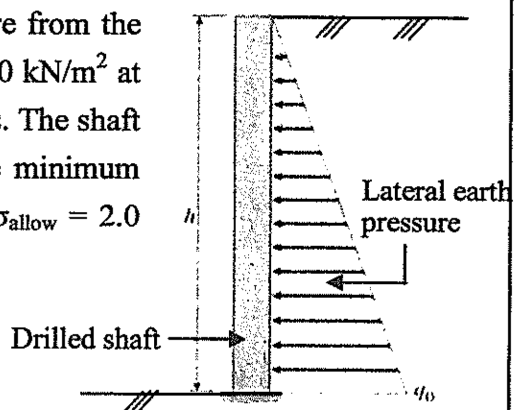
Question 1 (25%)

A steel pile supports a load P entirely by friction along its sides. The friction force f per unit length of pile is assumed to be uniformly distributed over the surface of the pile. The pile has length L, cross sectional area A, and modulus of elasticity E. Derive a formula for the shortening δ of the pile in terms of P, L, E, and A. Draw a diagram showing how the compressive stress σ_c varies throughout the length of the pile.



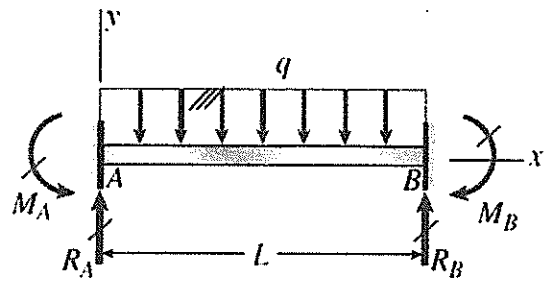
Question 2 (25%)

A series of drilled shafts is constructed as a tangent pile wall to resist lateral earth pressure from the retained soil. The lateral earth pressure is linearly distributed with depth and reaches $q_0 = 50$ kN/m^2 at the bottom. Because the shaft is embedded into the ground so that it acts as cantilever beams. The shaft has a circular cross-section with the diameter of d and height $h = 5.0$ m. Determine the minimum required dimension d of the shafts if the allowable bending stress of the pile material is $\sigma_{allow} = 2.0$ MPa.



Question 3 (25%)

A fixed-end beam AB of length L supports a uniform load of intensity q. Beginning with the second-order differential equation of the deflection curve (the bending-moment equation), obtain the reactions R_A, M_A, R_B, and M_B. Determine the slope and deflection of the beam at x = $L/2$. Construct the shear-force and bending-moment diagrams, labeling all critical ordinates.

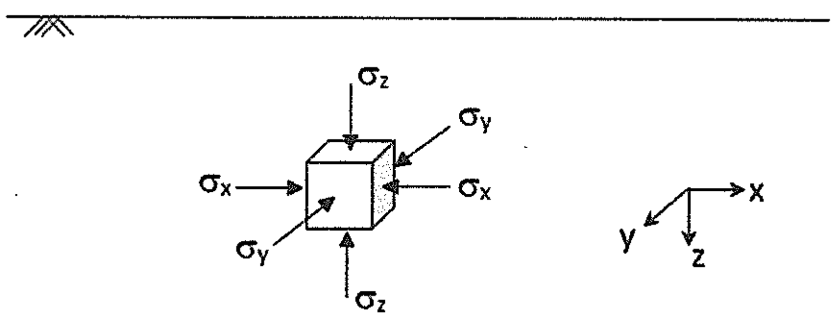


Question 4 (25%)

An underground soil element is subjected to principal stresses σ_x, σ_y, and σ_z. The σ_z is the effective soil overburden pressure and σ_x and σ_y are the effective soil lateral earth pressure ($\sigma_x = \sigma_y$). Use three-dimensional Hooke's law and assume soil is under at-rest conditions (no deformation in x and y direction), prove the following equation:

$$K_o = \frac{\nu}{1-\nu}$$

where K_o is at-rest earth pressure coefficient and ν is Poisson's ratio.



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