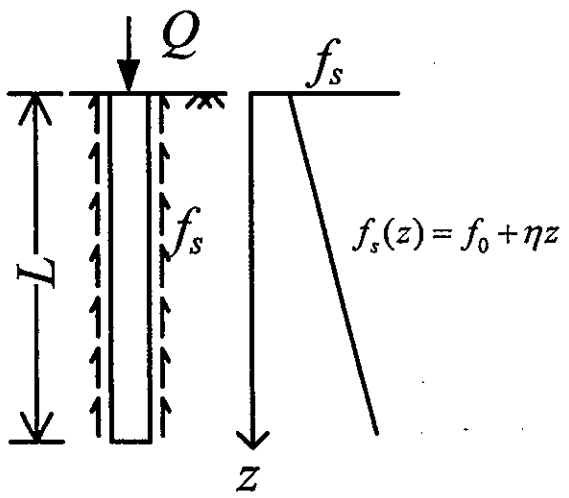
Problem 1 (25%)

A circular pile is subjected an axial load Q and skin frictions f_s as presented in the figure. The pile has a diameter D, Young's modulus E, and a length L. Given that the variation of skin friction per unit area $f_s(z)$ with depth is $f_s(z) = f_0 + \eta z$, derive the pile axial force distribution with depth and the pile deformation.

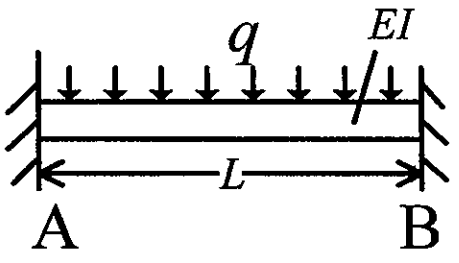


Problem 2 (25%)

A fixed-fixed beam of a flexural rigidity EI and a length L is subjected to a surcharge q as shown in the figure. Use the fourth-order differential beam equation to answer the following questions:

(i) (10%) Derive the fixed-end moments and shear forces of the beam. (The directions of the moment and shear force have to be noted.)

(ii) (15%) If end B is subjected to a downward displacement Δ, how do the moments and shear forces at ends A and B change due to this dislocation?



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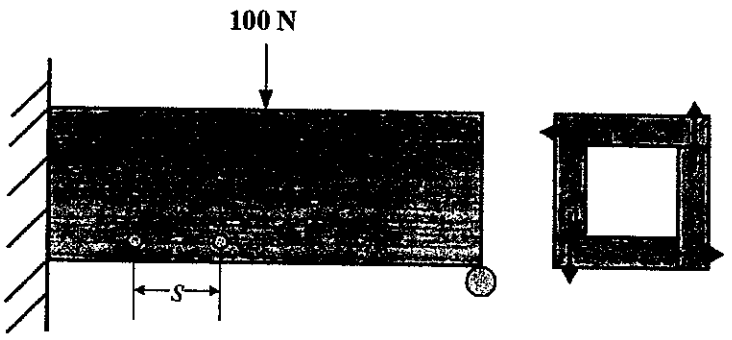
Problem 3 (25%)

A 1 m long box beam is to be constructed by using four wood boards (1.5 cm x 6.0 cm; elastic modulus = 10 GPa) nailed together as shown in the figure. Assuming that each nail can support a shear force of 25 N, determine the maximum spacing s of nails so that the beam can support a vertical force of 100 N at the middle of the beam.

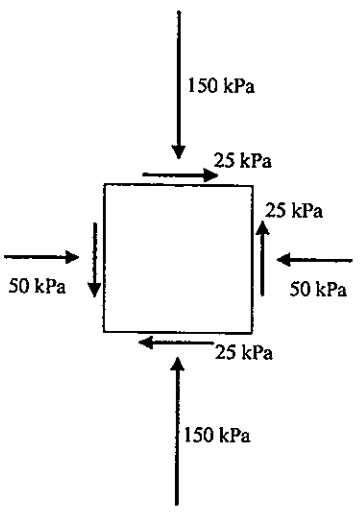


Problem 4 (25%)

The figure below presents the stresses of a soil element in a sandy stratum subjected to loading. Use Mohr's circle to answer the following questions:

(i) (10%) Find out the maximum and minimum principal stresses and indicate the planes they act on. (draw a soil element diagram to show them).

(ii) (15%) If this soil element is at failure, determine the shear strength parameters c and ϕ of the soil, the location of paired failure planes, and the stresses on the failure planes. (Draw a soil element diagram to show them).



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