Mechanics of Structural Concrete

Final Exam: July 25, 2005 10:40 — 12:10

Calculator is allowed to use. Closed book test. Answer by English or Japanese.

1. Consider a simply supported reinforced concrete beam which is subjected to the load P as shown in Fig. 1. The cross section of the beam is given in Fig. 2.

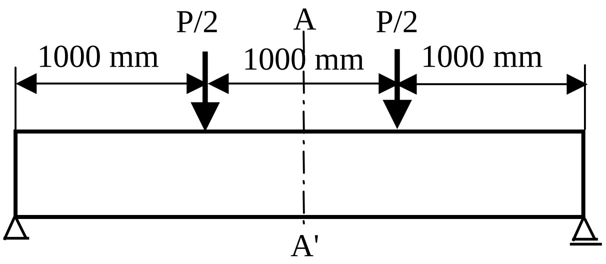

Fig. 1 RC beam subjected to the load

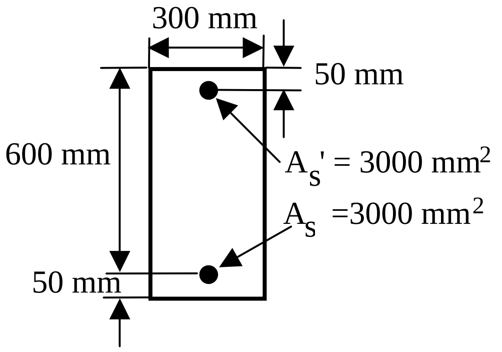

Fig. 2 Cross section of the beam

The material properties are as follows:
compressive strength of concrete $f_c' = 30$ N/mm^2, flexural strength of concrete $f_b = 4.5$ N/mm^2, Young's modulus of concrete $E_c = 25$ kN/mm^2, ultimate compressive strain of concrete $\varepsilon_{cu}' = 0.0035$, yield strength of reinforcing bars $f_y = 400$ N/mm^2, Young's modulus of reinforcing bars $E_s = 200$ kN/mm^2

With the increase in load P, the flexural crack will initiate at the section A-A' and propagate, and finally the beam will fail in flexure. Answer the following questions.
(70 points)

(1) Calculate the flexural cracking load, P_{cr} (kN). The effect of reinforcing bars can be neglected.
(2) Calculate the load, P (kN), which makes the stress of tensile reinforcing bar at the section A-A', $\sigma_s = 350$ N/mm^2. The contribution of concrete for tension can be neglected. The concrete in flexural compression zone can be assumed to be elastic.
(3) Calculate the yielding load, P_y (kN). Use the same assumptions as (2).
(4) Calculate the ultimate load, P_u (kN). The equivalent stress block ($0.85\ f_c' \times 0.8\ x$) can be used for the flexural compression force of concrete. The reinforcing bars can be assumed to be elastic-perfect plastic.

2. Answer the following questions.
(30 points)

(1) Explain the difference between the working stress design method (allowable stress design method) and the limit state design method.
(2) Explain how to evaluate the shear capacity of a reinforced concrete slender beam with shear reinforcement.
(3) Explain how to evaluate the torsion capacity of a reinforced concrete linear member with torsion reinforcement.