Tutorial 1: behaviour of beams in bending

Due 5 pm Friday 12th March

The purpose of this tutorial is to develop the skills to be able to apply the generic moment-curvature (M/χ) analysis technique. This skill is important because:

1) It is generic, and can be applied to quantify the flexural performance of RC members of all shapes and sizes constructed with any combination of materials, at all limit states.
2) Forms the basis for all simplified flexural design approaches.

Part I (5 marks)

As we progress through the Mobius questions we will conduct a single iteration of the (M/χ) analyses technique using more complex (and realistic) material properties as follows:

1) Linear elastic properties for both the reinforcement and the concrete (assuming that the concrete has no tensile strength and is therefore always cracked).
2) Linear elastic properties for both the reinforcement and the concrete (now assuming that the concrete has a finite tensile strength and so may either be cracked or uncracked), in this question we consider small curvatures such that the section is uncracked.
3) As for 2), but demonstrating the impact of higher curvatures which leads to the formation of an uncracked and cracked portion of the section.
4) Now assuming the reinforcement to be elastic plastic and that the concrete takes no tension – the elastic plastic assumption is commonly applied to reinforcement for ultimate limit state analysis
5) As for 4), but now assuming that the concrete is elastic plastic. Although not a very realistic approximation of the non-linear stress strain relationship of concrete, this assumption is often applied for simplicity.

Part II (10 marks)

Having established the procedure for conducting a single iteration, let us now apply the M/χ analysis technique to produce full M/χ relationships for a range of different material properties. In doing this we will establish an understanding of the influence of material properties on section properties (stiffness, strength and ductility).

6) For the cross sections in Figure 1(a) draw a full moment curvature relationship based on the concrete material properties in Figure 1(b) and the reinforcement material properties shown in Figure 1(c). Modify the concrete stress strain relationship as a function of compressive strength using the factors in Table 1.

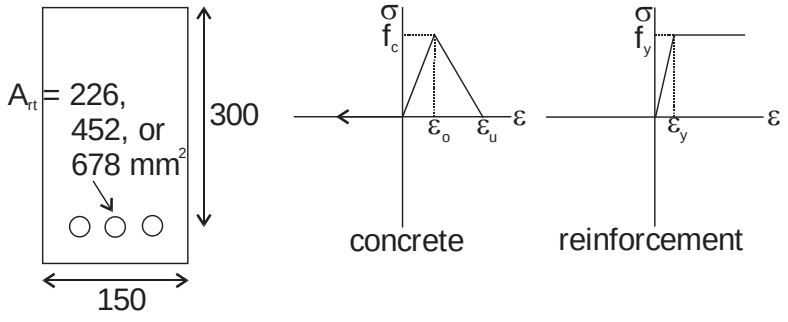

Figure 1: section and material properties

Table 1: concrete stress strain key points

f_c (MPa)	ε_0	ε_u
30	0.002	0.004
50	0.002	0.0035
70	0.002	0.003

a. For each of the three reinforcement areas (226, 452 and 678 mm^2) quantify the M/χ relationship when f_c = 30, 50 and 70 MPa. Take f_y = 500 MPa and ε_y = 0.0025 **[5 marks]**
b. Comment on the influence of the change in material properties on member behaviour and explain why the change in material property leads to a change in the sectional property. **[5 marks]**