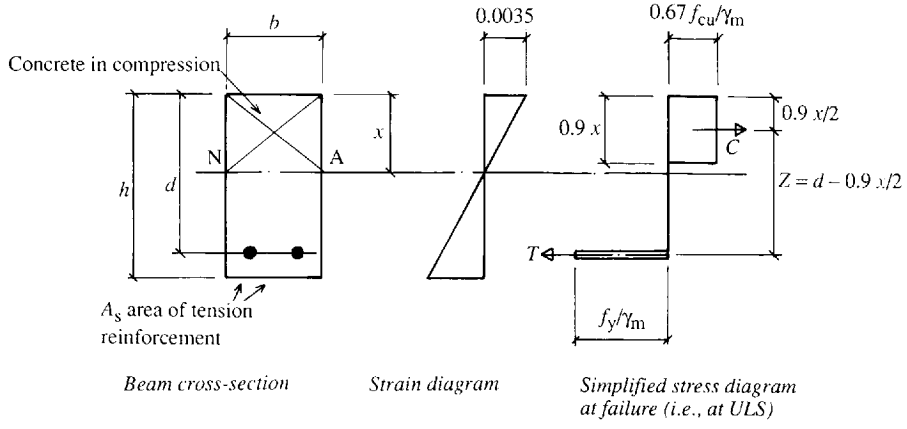

Figure 3.3 *Singly reinforced concrete beam diagrams*

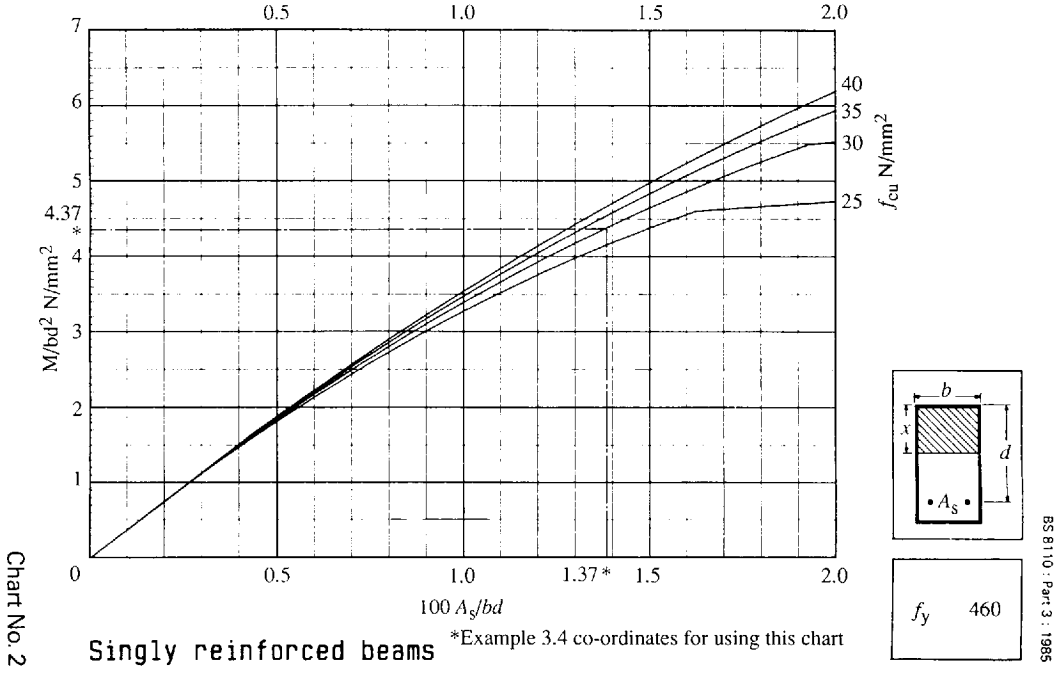

Figure 3.4 *BS 8110 Part 3 Chart 2 for singly reinforced beam design*

rectangular beams given in BS 8110 Part 1 can be derived. The relevant formulae for simply supported singly reinforced beams are as follows:

$$K = \frac{M}{bd^2 f_{cu}}$$

where for singly reinforced beams $K \leqslant K' = 0.156$,

$$z = d[0.5 + \sqrt{(0.25 - K/0.9)}] \geqslant 0.95d$$

$$x = \frac{d - z}{0.45}$$

$$A_s = \frac{M}{0.87 f_y z}$$

where

- A_s area of tension reinforcement
- b compression width of section
- d effective depth of tension reinforcement
- f_{cu} characteristic strength of concrete
- f_y characteristic strength of steel
- M design ultimate resistance moment: equals design ultimate moment M_u
- x depth to neutral axis
- z lever arm

It should be noted that the steel and concrete stresses used in these equations mean that the ultimate bending moment value M_u is in units N mm.

The manner in which a singly reinforced concrete beam fails in bending is influenced by the amount of reinforcement present in the section. If it is under-reinforced the tension steel will reach its yield stress before the concrete fails in compression. This would give ample warning of failure since excessive deflection would develop as failure approached. If it is over-reinforced then the concrete would fail prior to the tension steel reaching its yield stress. Such failure would occur suddenly without any significant deflection taking place.

To avoid sudden failure it is therefore important to ensure that the tension steel reaches its yield stress before the concrete fails in compression. Tests on beams have shown that the steel yields before the concrete crushes when the depth x to the NA does not exceed $0.5d$. By limiting K' to 0.156, BS 8110 implies that the NA depth does not exceed $0.5d$ and hence that the steel in tension will reach its ultimate stress before the concrete fails in compression.

If the value of K for a particular beam was found to be greater than the K' limit of 0.156 it would indicate that the concrete above the NA was overstressed in compression. Therefore either the beam would have to be increased in size, or compressive reinforcement would have to be introduced above the NA to assist the concrete. Design formulae and charts are given in BS 8110 for such beams, which are described as doubly reinforced.

When concrete roof or floor slabs are cast monolithically with the supporting beams, T or L beams are created as illustrated in Figure 3.5. Guidance is also given in BS 8110 for the design of these beams, which are collectively described as flanged beams.