cantilevers the distance between the end and the support does not exceed the lesser of $25b_c$ and $100\,b_c^2/d$, where b_c is the width of the compression face midway between restraints and d is the effective depth.

10.2.3 Design equations

Considering a rectangular cross-section subjected to bending and using the assumptions listed above the basic equations required for design can be derived as follows.

In Fig. 10.5 the strain distribution shows that the steel has reached yield strain and the maximum masonry strain is less than the ultimate value (assumption 7). Also the stress in the compressive zone is constant at f_k/γ_{mm} (stress-strain relationship for masonry).

Taking moments about the centroid of the compression block gives the design moment of resistance M_d

$$M_d = A_s z f_y/\gamma_{ms} \tag{10.1}$$

where

$$z = (d - d_c/2) \tag{10.2}$$

Equating the total tensile force to the total compressive force gives

$$A_s f_y/\gamma_{ms} = bd_c f_k/\gamma_{mm}$$

so that

$$d_c/d = A_s f_y \gamma_{mm}/bdf_k\gamma_{ms} \tag{10.3}$$

Substituting (10.3) into (10.2) gives

$$z = d(1 - 0.5A_s f_y \gamma_{mm}/bdf_k\gamma_{ms}) \tag{10.4}$$

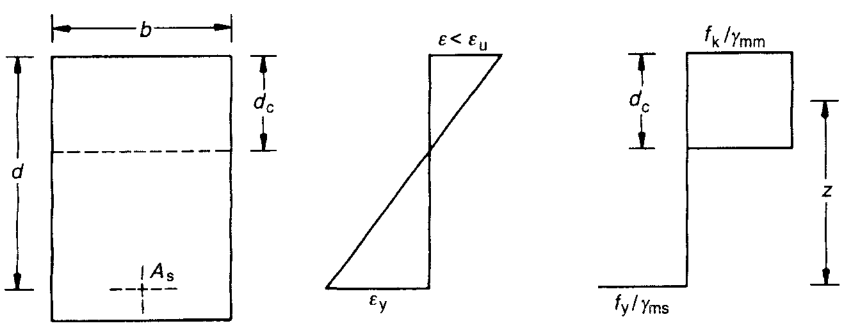

Fig. 10.5 Strain and stress distribution in section.

The design of sections for bending only can be carried out using equations (10.1) and (10.4) although it would be necessary to solve a quadratic equation in A_s to determine the area of reinforcement. This is considered to be inconvenient and the British code includes tables and charts for the direct solution. An alternative method is shown in section 10.2.4.

The assumption of a limiting strain distribution as shown in Fig. 10.4 imposes an upper bound to the value of M_d. Theoretically this limit can be determined from the ratio

$$d_c/d = \varepsilon_u/(\varepsilon_u + \varepsilon_y)$$

which is dependent on the maximum strain ε_u (taken as 0.0035 in the code) and ε_y (which is dependent on the type of steel). It can be shown that the theoretical limiting value of M_d/bd^2 for the assumed stress-strain distribution is given approximately by

$$M_d/bd^2 = 0.4 f_k/\gamma_{mm} \tag{10.5}$$

Adoption of this limit precludes brittle failure of the beam.

10.2.4 Design aid

Equations (10.1), (10.4) and (10.5) can be represented graphically, as shown in Figs 10.6 and 10.7 for particular values of f_k, γ_{mm} and γ_{ms}. The graphs relate the three parameters M_d/bd^2, f_k and ρ so that given any two the third can be determined directly from the graph. The steel ratio ρ is equal to A_s/bd.

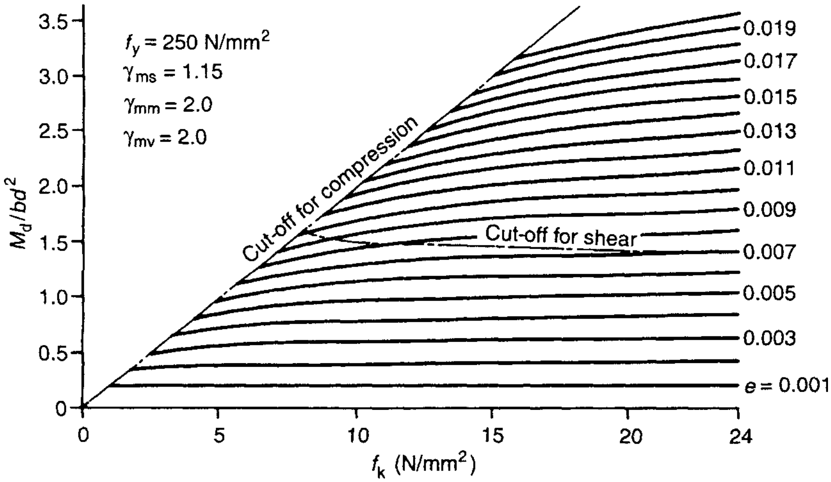

Fig. 10.6 Design aid for bending (f_y=250N/mm²).