4.4.5 Section design

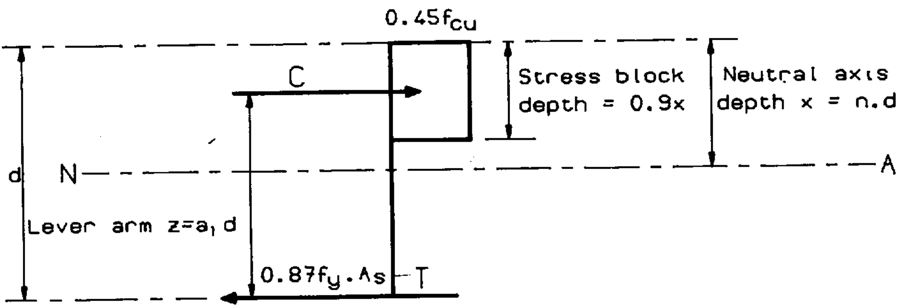
4.4.5.1 Bending

The most common beams have flanges at the top. At the supports they are designed as rectangular beams and in the spans as flanged beams. For upstand beams, the reverse applies.

If the applied moment M is less than the resistance moment M_u for the concrete, compression steel will not be needed.

The resistance moments of concrete sections that are required to resist flexure only can be determined from the formulas and Tables that are based on the stress diagram in Fig 11. The lever arm is assumed to be not greater than $0.95d$.

The effect of any small axial load on the beam can be ignored if the design ultimate axial force is less than $0.1\,f_{cu}bd$.



11 Stress diagram

Rectangular beams

The procedure for the design of rectangular beams is as follows:

(a) Calculate M_u for concrete $= K'f_{cu}bd^2$
where K' is obtained from Table 23.

Table 23 K' Factors for beams

% moment redistribution	0 to 10	15	20	25	30
Values K'	0.156	0.144	0.132	0.119	0.104

(b) If $M \leq M_u$ for the concrete, the area of tension reinforcement A_s is calculated from:

$$A_s = \frac{M}{(0.87 f_y)\, z}$$

where z is obtained from Table 24 for different values of K.

Table 24 Lever arm and neutral axis depth factors for beams

$K = M/bd^2f_{cu}$	0.05	0.06	0.07	0.08	0.09	0.100	0.104	0.110	0.119	0.130	0.132	0.140	0.144	0.150	0.156
$a_1 = (z/d)$	0.94	0.93	0.91	0.90	0.89	0.87	0.87	0.86	0.84	0.82	0.82	0.81	0.80	0.79	0.775
$n = (x/d)$	0.13	0.16	0.19	0.22	0.25	0.29	0.30	0.32	0.35	0.39	0.40	0.43	0.45	0.47	0.50
	30%							25%		20%		15%		0–10%	

Limit of Table for various % of moment redistribution

(c) If $M > M_u$ for the concrete then compression reinforcement is needed. The area of compression steel A'_s is calculated from:

$$A'_s = \frac{M - M_u}{0.87 f_y (d - d')}$$

where d' is the depth of the compression steel from the compression face.

If $d' > \left(1 - \frac{f_y}{800}\right) x$, use $700\left(1 - \frac{d'}{x}\right)$ in lieu of $0.87 f_y$.

The area of tension reinforcement A_s is calculated from:

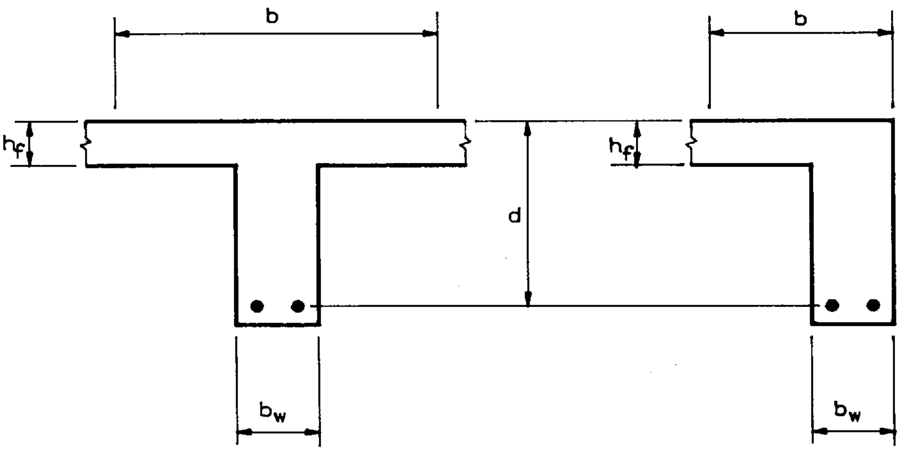
$$A_s = \frac{M_u}{0.87 f_y z} + A'_s$$

Flanged beams

For section design the effective width b of a flanged beam (see Fig. 12) should be taken as:

for T-beams: web width plus $0.2 l_z$ or actual flange width if less
for L-beams: web width plus $0.1 l_z$ or actual flange width if less

where l_z is the distance between points of zero moment. For a continuous beam this may be taken as 0.7 times the effective span.



12 Beam sections