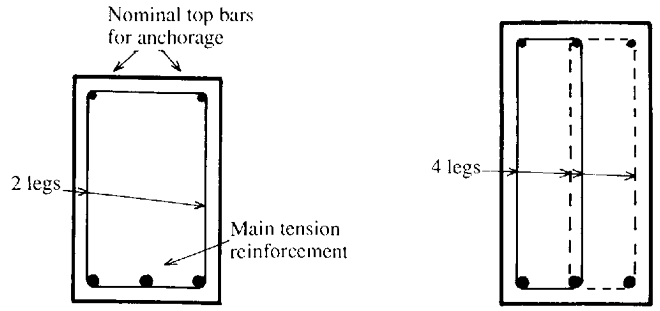
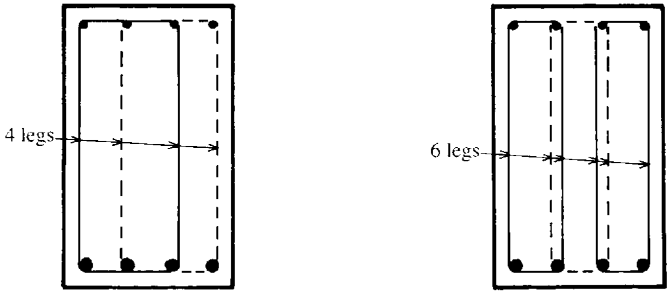


(a) Single links

(b) Double links



(c) Double links

(d) Triple links

Figure 3.17 *Details of shear reinforcement in the form of links*

For high yield links the f_{yv} would become 460 N/mm^2, and

$$A_{sv} \text{ required} = \frac{0.4 \times 250 \times 0.75 \times 500}{0.87 \times 460} = 93.7\,\text{mm}^2$$

Provide 8 mm diameter HY links at 375 mm centres (A_{sv} two legs = 101 mm^2).

Alternatively, if it were desired to use 8 mm diameter mild steel links the formula could be transposed to calculate the necessary centres s_v:

$$s_v = \frac{0.87 f_{yv} A_{sv}}{0.4 b_v} = \frac{0.87 \times 250 \times 101}{0.4 \times 250} = 220\,\text{mm} < 0.75d$$

Provide 8 mm diameter MS links at 200 mm centres.

If considered practical it is possible to provide double links or even triple links as shown in Figure 3.17. In this example it would not be practical to use triple links in a beam width of 250 mm, but double links could be provided. For mild steel double links, the total area of their four legs would have to be greater than the A_{sv} of 172.41 mm^2 previously calculated. Hence:

Provide 8 mm diameter MS double links at 375 mm centres (A_{sv} four legs = 201 mm^2).

Example 3.9

A reinforced concrete beam 300 mm wide with an effective depth of 450 mm supports an ultimate UDL of 880 kN. Determine the form and size of shear reinforcement required if the main tensile reinforcement area is 2368 mm^2 and the concrete is grade 35.

Ultimate design shear force at support $V = \frac{880}{2} = 440\,\text{kN}$

Maximum design shear stress occurring $v = \frac{V}{b_v d} = \frac{440 \times 10^3}{300 \times 450} = 3.26\,\text{N/mm}^2$

Hence

$$v = 3.26\,\text{N/mm}^2 < 0.8\sqrt{f_{cu}} = 4.73\,\text{N/mm}^2 < 5\,\text{N/mm}^2$$

Therefore the beam size is satisfactory.

Now

$$\frac{100A_s}{b_v d} = \frac{100 \times 2368}{300 \times 450} = 1.75$$

Thus the design concrete shear stress (from Table 3.12) $v_c = 0.76\,\text{N/mm}^2$. This is based on the maximum effective depth of 400 mm and is for grade 25 concrete. For grade 35 concrete,

$$\text{Coefficient} = (f_{cu}/25)^{1/3} = (35/25)^{1/3} = 1.119$$

Thus

$$\text{Grade 35 } v_c = 0.76 \times 1.119 = 0.85\,\text{N/mm}^2$$
$$(v_c + 0.4) = (0.85 + 0.4) = 1.25\,\text{N/mm}^2$$

Hence $(v_c + 0.4)$ is less than v which is less than $0.8\sqrt{f_{cu}}$. Therefore, by reference to Table 3.11, shear reinforcement in the form of either designed links alone or designed links combined with bent-up bars should be provided. Whilst 50 per cent of the shear resistance may be provided by bent-up bars they are not recommended as a practical choice and are usually avoided in favour of designed links alone.

Designed links alone will therefore be adopted. Their area is calculated from the relevant formula given in Table 3.11:

$$A_{sv} \geqq \frac{b_v s_v (v - v_c)}{0.87 f_{yv}}$$

Since s_v must not exceed $0.75d$ this may again be substituted in the formula as a trial:

$$A_{sv} = \frac{b_v 0.75d(v - v_c)}{0.87 f_{yv}}$$

Thus if mild steel links are to be provided with f_{yv} of 250 N/mm^2,

$$A_{sv} \text{ required} = \frac{300 \times 0.75 \times 450(3.26 - 0.85)}{0.87 \times 250} = 1121.89\,\text{mm}^2$$