The symbols are indicated in Figure 3.16 or have been referred to earlier.

Now let us look at some examples on the design of shear reinforcement.

Example 3.7

Determine the form of shear reinforcement to be provided in a 150 mm wide concrete lintel that has an effective depth of 200 mm and supports an ultimate UDL of 18.6 kN. The lintel is cast from grade 25 concrete and contains tensile reinforcement with an area of $226\,\text{mm}^2$.

Ultimate design shear force at support $V = \frac{\text{ultimate UDL}}{2} = \frac{18.6}{2} = 9.3\,\text{kN}$

Maximum design shear stress occurring $v = \frac{V}{b_v d} = \frac{9.3 \times 10^3}{150 \times 200} = 0.31\,\text{N/mm}^2$

Hence

$$v = 0.31\,\text{N/mm}^2 < 0.8\sqrt{f_{cu}} = 4\,\text{N/mm}^2 < 5\,\text{N/mm}^2$$

Therefore the beam size is satisfactory.
Now

$$\frac{100A_s}{b_v d} = \frac{100 \times 226}{150 \times 200} = 0.75$$

Thus the design concrete shear stress (from Table 3.12) $v_c = 0.68\,\text{N/mm}^2$, and $0.5v_c = 0.5 \times 0.68 = 0.34\,\text{N/mm}^2$. Hence $v = 0.31\,\text{N/mm}^2$ is less than $0.5v_c = 0.34\,\text{N/mm}^2$. Therefore, by reference to Table 3.11 note 1, it would be satisfactory to omit links from this member since it is a lintel.

Example 3.8

A reinforced concrete beam supporting an ultimate UDL of 240 kN is 250 mm wide with an effective depth of 500 mm. If the concrete is grade 30 and the area of tensile steel provided is $1256\,\text{mm}^2$, determine the form and size of shear reinforcement required.

Ultimate design shear force at support $V = \frac{\text{ultimate UDL}}{2} = \frac{240}{2} = 120\,\text{kN}$

Maximum design shear stress occurring $v = \frac{V}{b_v d} = \frac{120 \times 10^3}{250 \times 500} = 0.96\,\text{N/mm}^2$

Hence

$$v = 0.96\,\text{N/mm}^2 < 0.8\sqrt{f_{cu}} = 4.38\,\text{N/mm}^2 < 5\,\text{N/mm}^2$$

Therefore the beam size is satisfactory.
Now

$$\frac{100A_s}{b_v d} = \frac{100 \times 1256}{250 \times 500} = 1$$

Thus the design concrete shear stress (from Table 3.12) $v_c = 0.63\,\text{N/mm}^2$. This is based on the maximum effective depth limit of 400 mm and is for grade 25 concrete. As the concrete in this example is grade 30, the value of v_c may be multiplied by a coefficient:

$$\text{Coefficient} = (f_{cu}/25)^{1/3} = (30/25)^{1/3} = 1.062$$

Thus

$$\text{Grade 30 } v_c = 0.63 \times 1.062 = 0.669\,\text{N/mm}^2$$
$$0.5v_c = 0.5 \times 0.669 = 0.335\,\text{N/mm}^2$$

Also

$$(v_c + 0.4) = (0.669 + 0.4) = 1.069\,\text{N/mm}^2$$

Hence $0.5v_c$ is less than v, which is less than $(v_c + 0.4)$. Therefore, by reference to Table 3.11, shear reinforcement in the form of minimum links should be provided for the whole length of the beam.

Some of the alternative ways of providing shear reinforcement in the form of links are illustrated in Figure 3.17. When considering the most suitable arrangement for the links the following points should be taken into account:

(a) The horizontal spacing should be such that no main tensile reinforcing bar should be further than 150 mm away from a vertical leg of the links.
(b) The horizontal spacing of the link legs across the section should not exceed the effective depth d.
(c) The horizontal spacing along the span should not exceed $0.75d$.

The area of the minimum links to be provided is determined from the relevant formula given in Table 3.11:

$$A_{sv} \geqq \frac{0.4b_v s_v}{0.87f_{yv}}$$

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

$$A_{sv} = \frac{0.4b_v 0.75d}{0.87f_{yv}}$$

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

$$A_{sv} \text{ required} = \frac{0.4 \times 250 \times 0.75 \times 500}{0.87 \times 250} = 172.41\,\text{mm}^2$$

In order to provide an area A_{sv} greater than $172.41\,\text{mm}^2$ it would be necessary to use 12 mm diameter links with an A_{sv} for two legs of $226\,\text{mm}^2$. If for practical reasons it was desired to use smaller links, either high yield links could be used or the centres could be reduced to suit smaller diameter mild steel links.