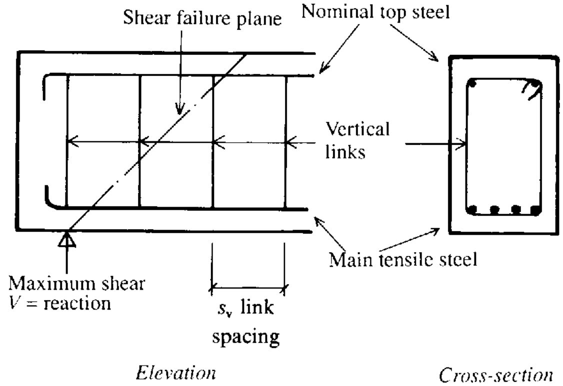

Figure 3.14 *Shear reinforcement in the form of vertical links*

as a trial, this limit may be substituted in the area formula as follows:

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

Should the resulting area prove impractical the link spacing may of course be reduced.

Designed links

When shear reinforcement greater than minimum links is necessary, it may be provided either as designed links alone or as designed links combined with bent-up bars. In both instances, it must be capable of resisting the difference between the applied design shear stress v and the design shear stress capacity of the concrete v_c.

Where designed links alone are to be provided, their area should be determined from the following expression:

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

The symbols and maximum spacing are as for minimum links.

Designed links and bent-up bars

Where shear reinforcement needs to be provided in the form of designed links combined with bent-up bars, the total shear resistance capacity will be the summation of the individual values for each system. In this context the contribution made by the bent-up bars should not be taken as more than 50 per cent of the total shear resistance. The shear resistance of the designed links may be determined from the information given above, whilst that of the bent-up bars is discussed in the following.

Bent-up bars, as their name implies, are main tension bars that are bent up at an angle from the bottom of the beam as shown in Figure 3.15. Such bars cannot be bent up unless they are no longer required to resist the bending moment in the tension zone. This is only likely to be the case near to a support where the bending moment is reducing and hence fewer bars are needed in tension. Their design shear resistance is based upon the assumption that they act as tension members in an imaginary truss system, whilst the concrete forms the compression members as shown in Figure 3.16. The truss should be arranged so that α and β are both greater than or equal to 45°, giving a maximum value s_t of $1.5d$.

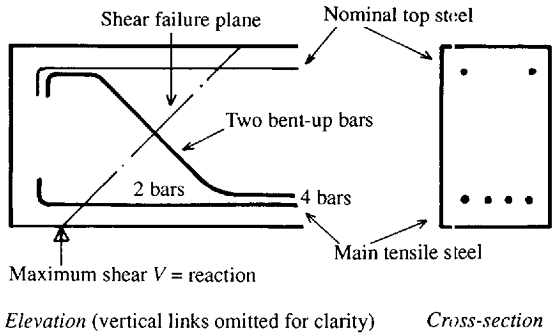

Figure 3.15 *Shear reinforcement in the form of bent-up bars*

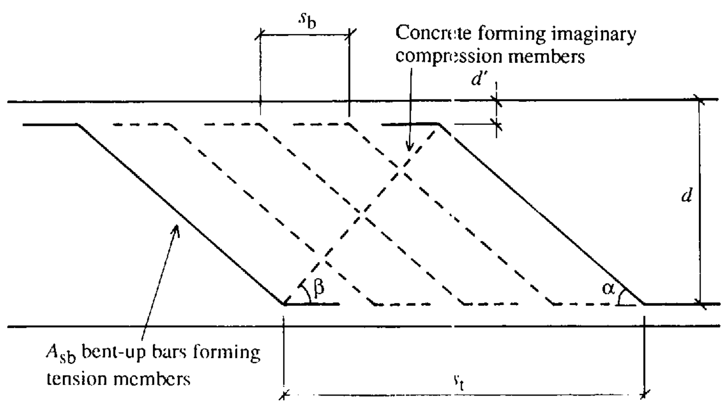

Figure 3.16 *Imaginary truss system of bent-up bars*

The shear resistance of bent-up bars in such systems should be calculated from the following expression:

$$V_b = A_{sb}(0.87f_{yv})(\cos\alpha + \sin\alpha\cot\beta)\frac{d-d'}{s_b}$$