(b) Shear ULS
(c) Deflection SLS.

Two other ultimate limit state factors that should be given consideration are:

(d) Web buckling resistance
(e) Web bearing resistance.

However, these are not usually critical under normal loading conditions, and in any case may be catered for by the inclusion of suitably designed web stiffeners.

Let us consider how each of these requirements influences the design of beams.

5.10.1 Bending ULS

When a simply supported beam bends, the extreme fibres above the neutral axis are placed in compression. If the beam is a steel beam this means that the top flange of the section is in compression and correspondingly the bottom flange is in tension. Owing to the combined effect of the resultant compressive loading and the vertical loading, the top flange could tend to deform sideways and twist about its longitudinal axis as illustrated in Figure 5.3. This is termed lateral torsional buckling, and could lead to premature failure of the beam before it reaches its vertical moment capacity.

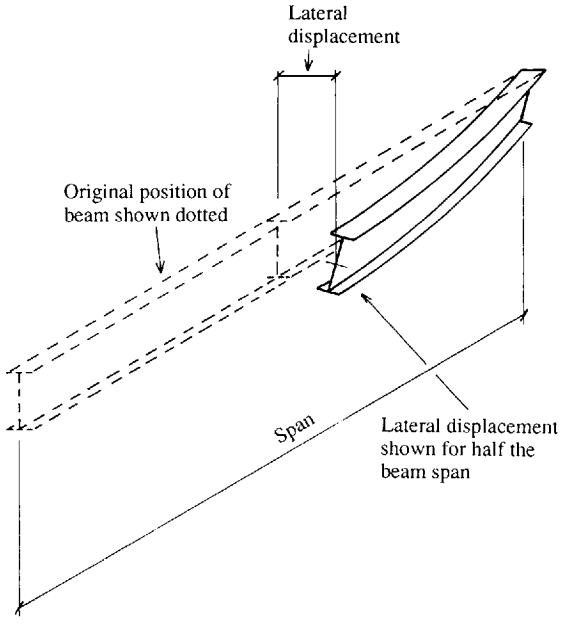

Figure 5.3 *Lateral torsional buckling*

Lateral torsional buckling can be avoided by fully restraining the compression flange along its entire length (Figure 5.4). Alternatively, transverse restraint members can be introduced along the span of the beam (Figure 5.5). These must be at sufficient intervals to prevent lateral torsional buckling occurring between the points of restraint. If neither of these measures are adopted then the beam must be considered as laterally unrestrained and its resistance to lateral torsional buckling should be checked. The requirements that must be fulfilled by both lateral and torsional restraints are described in BS 5950.

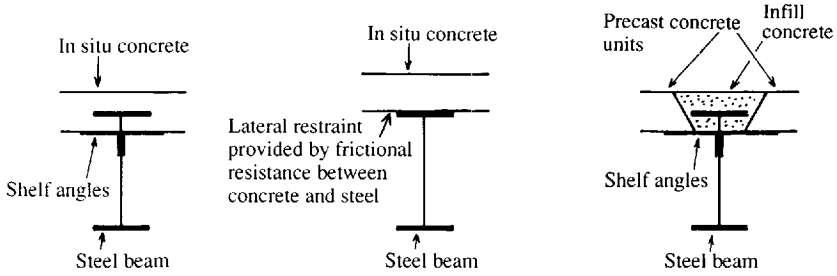

Figure 5.4 *Cross-sections through fully laterally restrained beams*

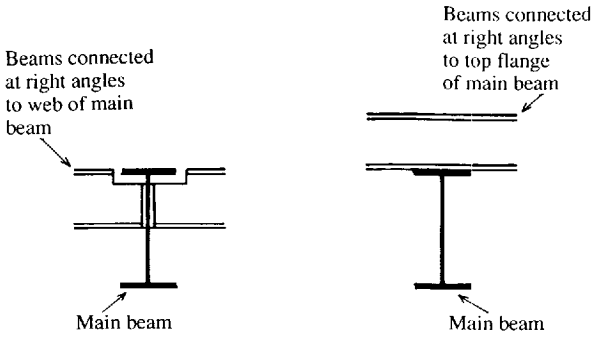

Figure 5.5 *Cross-sections through beams laterally restrained at intervals along their length*

It can be seen from the foregoing that it is necessary to investigate the bending ULS of steel beams in one of two ways: laterally restrained and laterally unrestrained. These are now discussed in turn.

5.10.2 Bending ULS of laterally restrained beams

It has already been shown in Chapter 1 that, in relation to the theory of bending, the elastic moment of resistance (MR) of a steel beam is given by

$$\mathrm{MR} = fZ$$