Ultimate limit states

Strength The individual structural elements should be checked to ensure that they will not yield, rupture or buckle under the influence of the ultimate design loads, forces, moments and so on. This will entail checking beams for the ULSs of bending and shear, and columns for a compressive ULS and when applicable a bending ULS.

Stability The building or structural framework as a whole should be checked to ensure that the applied loads do not induce excessive sway or cause overturning.

Fracture due to fatigue Fatigue failure could occur in a structure that is repeatedly subjected to rapid reversal of stress. Connections are particularly prone to such failure. In the majority of building structures, changes in stress are gradual. However, where dynamic loading could occur, such as from travelling cranes, the risk of fatigue failure should be considered.

Brittle failure Sudden failure due to brittle fracture can occur in steelwork exposed to low temperatures; welded structures are particularly susceptible. Since the steel members in most building frames are protected from the weather, they are not exposed to low temperatures and therefore brittle fracture need not be considered. It is more likely to occur in large welded structures, such as bridges, which are exposed to the extremes of winter temperature. In such circumstances, it is necessary to select steel of adequate notch ductility and to devise details that avoid high stress concentrations.

Serviceability limit states

Deflection Adequate provision must be made to ensure that excessive deflection which could adversely effect any components or finishes supported by the steel members does not occur.

Corrosion and durability Corrosion induced by atmospheric or chemical conditions can adversely affect the durability of a steel structure. The designer must therefore specify a protective treatment suited to the location of the structure. Guidance on the selection of treatments is given in BS 5493 'Code of practice for protective coating of iron and steel structures against corrosion'. Certain classes of grade 50 steel are also available with weather resistant qualities, indicated by the prefix WR, for example WR 50A. Such steel when used in a normal external environment does not need any additional surface protection. An oxide skin forms on the surface of the steel, preventing further corrosion. Provided that the self-coloured appearance is aesthetically acceptable, consideration may be given to its use in situations where exposed steel is permitted, although it should be borne in mind that it is more expensive than ordinary steel.

Fire protection Due consideration should also be given to the provision of adequate protection to satisfy fire regulations. Traditionally fire protection was provided by casing the steelwork in concrete. Nowadays a number of lightweight alternatives are available in the form of dry sheet

material, plaster applied to metal lathing, or plaster sprayed directly on to the surface of the steel. Intumescent paints are also marketed which froth when heated to produce a protective insulating layer on the surface of the steel.

Since this manual is concerned with the design of individual structural elements, only the strength ULS and the deflection SLS will be considered further.

5.6 Safety factors

In a similar fashion to concrete and masonry design, partial safety factors are once again applied separately to the loads and material stresses. Initially BS 5950 introduces a third factor, γ_p, related to structural performance. The factors given in BS 5950 are as follows:

γ_f for load
γ_p for structural performance
γ_m for material strength.

However, factors γ_f and γ_p when multiplied together give a single partial safety factor for load of γ_f. Hence the three partial safety factors reduce to the usual two of γ_f and γ_m.

5.7 Loads

The basic loads are referred to in BS 5950 as specified loads rather than characteristic loads. They need to be multiplied by the relevant partial safety factor for load γ_f to arrive at the design load.

5.7.1 Specified loads

These are the same as the characteristic loads of dead, imposed and wind previously defined in Chapters 3 and 4 in the context of concrete and masonry design.

5.7.2 Partial safety factors for load

To arrive at the design load, the respective specified loads are multiplied by a partial safety factor γ_f in relation to the limit state being considered:

$$\text{Design load} = \gamma_f \times \text{specified load}$$

5.7.3 Ultimate design load

The partial safety factors for the ULS load combinations are given in Table 2 of BS 5950. For the beam and column examples contained in this