Structural steelwork is either

*a single member*

*or*

*an assembly of a number of steel sections*

connected together to perform a specified function.
1. The Design of Structural Steel Elements

**Simple concept for design:** structural framework composed of a number of elements connected together. Loads are sustained by element, and its reactions transferred to other elements via the connections.

**Concept of overall stability:** provided by the bracing systems.

2. The Design of Structural Steel Frameworks

**Overall building concept:** action of the whole framework in three dimension including its behaviour under lateral loading.

**Types of construction:**
- frame action (continuous construction)
- connected element design (simple construction)

Main considerations are **cost** and **appearance**
2. The Design of Structural Steel Frameworks

**General Principles**

All structural parts and components in the overall design, including stability, should be compatible. Structure should

- transmit all loads directly to the foundations.
- be robust and stable
- not overturn or collapse progressively
- have good erection procedure
- be stable during construction

### 2. The Design of Structural Steel Frameworks

#### 1. Stability

**a) Multistorey braced structures**

- Provide *lateral stability* in two directions using horizontal and vertical bracing.
- The *combined shear centre* for bracings should preferably coincide with the resultant of the *applied overturning forces*, otherwise torsional moments may result
- Braced bays should be effective throughout the full height of the building

**b) Single-storey structures**

Provide *lateral stability* in two directions using

- rigid framing
- vertical braced bays + plan bracing
c) Forms of bracing
   Bracing may consist of any of the following:

   - **horizontal bracing**
     - triangulated steel members
     - concrete floors or roofs
     - adequately designed and fixed profiled steel decking
   - **vertical braced bays + plan bracing**
     - triangulated steel members
     - >180 mm thick RC walls
     - >150 mm thick masonry walls

2. Robustness
   - All members of a structure should be effectively tied together in three dimensions
   - Key members should be strong enough to prevent progressive collapse

3. Movement Joints
   - Minimizes the effects of movements due to temperature variations and settlement
   - Each part of structure should independently be stable and robust
   - Required where there is significant changes in foundation type, plan configuration or the height of the structure
   - 15 – 25 mm gap for every 50 m of structure
4. Loading - Unfactored loads

- Dead load, $G_k$, [BS 648]
  structure weight + finishes + fixtures + fixed partition
- Imposed loads, $Q_k$, [BS 6399 Part 1]
- Wind load, $W_k$, [BS 6399 Part 2]

Notional horizontal load, $N_k$, at each level should be the greater of

\[ 1\% \times 1.4 \ G_k \quad \text{or} \quad 0.5\% \times (1.4 \ G_k + 1.6 \ Q_k) \]

5. Limit State

a) Strength and stability limit state

- Use load combinations and load factors, $\gamma_f$
- Use “adverse” and “beneficial” factors to produce the most onerous condition

b) Servicability Limit State

**Deflection**

- Check for unfactored imposed and wind loads
- Check for unfactored dead + 80% of imposed and wind loads

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Limit Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cantilevers</td>
<td>length / 180</td>
</tr>
<tr>
<td>beams carrying brittle finish</td>
<td>span / 360</td>
</tr>
<tr>
<td>all other beams</td>
<td>span / 200</td>
</tr>
<tr>
<td>columns in single-storey buildings</td>
<td>height / 300</td>
</tr>
<tr>
<td>columns in multistorey buildings</td>
<td>height of storey / 300</td>
</tr>
</tbody>
</table>
**Fire Resistance [BS 5950: Part 8]**

**Table - Fire Protection**

<table>
<thead>
<tr>
<th>Type of protection</th>
<th>1 hour</th>
<th>2 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spray</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>2. Boarding</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>3. Intumescent paint</td>
<td>1-5</td>
<td>-</td>
</tr>
<tr>
<td>4. RC casing - load bearing</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>5. RC casing (1:2:4 mix) - non-load bearing</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

**Corrosion Protection**

**Vibration**

For simply supported beams Vibration can be minimized by limiting the unfactored dead load deflection to 12 mm.

**6. Material Properties**

Partial factor, \( \gamma_m = 1.0 \)

Modulus of elasticity, \( E = 205 \text{ kN/m}^2 \)

Coefficient of linear expansion, \( \alpha = 12 \times 10^{-6} \text{ per } ^\circ\text{C} \)

Poisson’s ratio, \( \nu = 0.30 \)
### Steel Design Strength

<table>
<thead>
<tr>
<th>Steel Grade BS EN 10025</th>
<th>Maximum Thickness (mm)</th>
<th>Design Strength, Sections, plates, hollow sections $p_y$ (N/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S275 43A, 43B, 43C</td>
<td>16 40 63 100</td>
<td>275 265 255 245</td>
</tr>
<tr>
<td>S355 50B, 50C</td>
<td>16 40 63 100</td>
<td>355 345 340 325</td>
</tr>
</tbody>
</table>

### 7. Loads

In the absence of firm details the following dead loads can be used.

- floor finish (screed) 1.8 kN/m$^2$ on plan
- ceiling and service loads 0.5 kN/m$^2$ on plan
- demountable lightweight partitions 1.0 kN/m$^2$ on plan
- blockwork partitions 2.5 kN/m$^2$ on plan
- curtain walling and glazing 0.5 kN/m$^2$ on elevation
- Cavity walls (lightweight block) 3.5 kN/m$^2$ on elevation

Density of normal weight aggregate concrete should be taken as **24 kN / m$^3$.**

Density of lightweight aggregate concrete should be taken as **19 kN / m$^3$.**
### 8. Flooring

<table>
<thead>
<tr>
<th>Floor type</th>
<th>Typical span range m</th>
<th>Typical depth mm</th>
<th>Construction time</th>
<th>Degree of lateral restraint to beams</th>
<th>Degree of diaphragm action</th>
<th>Main areas of usage and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber</td>
<td>2.5-4</td>
<td>150-300</td>
<td>medium</td>
<td>Poor</td>
<td>Poor</td>
<td>domestic</td>
</tr>
<tr>
<td>In situ concrete</td>
<td>3-6</td>
<td>150-250</td>
<td>Medium</td>
<td>Very good</td>
<td>Very good</td>
<td>All categories but not often used for multistorey steel const.</td>
</tr>
<tr>
<td>Precast concrete</td>
<td>3-6</td>
<td>110-200</td>
<td>Fast</td>
<td>Fair-good</td>
<td>Fair-good</td>
<td>All categories but carnage requirements and residual cambers should be considered</td>
</tr>
<tr>
<td>Profiled steel decking composite with concrete topping</td>
<td>2.5-3.6 Unpropped</td>
<td>110-150</td>
<td>Fast</td>
<td>Very good</td>
<td>Very good</td>
<td>All categories especially multistorey commercial</td>
</tr>
</tbody>
</table>

### Manufacturing

Steel Sections are rolled or formed into a variety of cross-sections:

- I - section
- H - section
- Channel section
- Angle section
- Hollow section
- Rolled section
- Compound section
- Heavy rolled and built-up section
- Threaded bar
- Flat
- Round strand rope
- Socked coil rope
Fabrication

Shaping of steel sections in a "fabricating works" or "shop"

For fabrication, drawings giving precise dimensions of the steelwork is required. These drawings are often prepared by the fabricator.

Erection

Putting together of the various elements on site to form the required framework