Structural steel

General

Function

Is steel construction material, a profile, formed with a specific shape or cross section and certain standards of chemical composition and mechanical properties. Structural steel shape, size, composition, strength, storage, etc., is regulated in most industrialized countries. Structural steel members, such as I-beams, have high second moments of area, which allow them to be very stiff in respect to their cross-sectional area.

In domestic building it is commonly used in the following.

- Column and beam work
- Lintels
- Purlins for sheet roofing
- Framing components for walls and floors

Steel is an alloy of iron and carbon and is created by separating a given amount of carbon from molten pig iron. Many other elements can be added to steel to improve its properties.

Grades

Steel is made in many grades, strengths and hardnesses. There are 3 main grades.

- Formable grades
- Structural grades
- Composition grades

In the building industry, steel is normally spoken about in terms of its yield strength in megapascals (mpa) or whether it is mild steel or high tensile steel. Mild tensil is usually notated G330 and high tensile steel G450 – G550

Sections

Steel is rolled while hot into slabs and then into various shapes including the following:

- Plate, rounds, square and flats.
- Sheets and coils
- Universal beams (UBs)
- Universal columns (UCs)
- Parallel flange channels (PFC’s)
- Tubular steel columns
- Angles and special shapes
- Channels

In addition, hollow sections are made such as:

- Rectangular hollow sections (RHS’s)
• Square hollow sections (SHS’s)
• Circular hollow sections (CH’s)

These shapes are generally called hot rolled steel sections and thicknesses range from 1.6mm to 20mm.

Another group of shapes are formed from coils of flat steel which are slit to the correct dimensions and rolled into shapes such as C’s and Z’s and range in thickness from 0.4 mm to 0.6 mm. These shapes are generally called cold rolled steel sections.

Protection

Function

If unprotected, steelwork will corrode depending in the extent of its exposure to the elements. In some situations corrosion occurs electrolytically, through the steel coming into contact with other metals. With steelwork in buildings, the degree of its exposure to the environment, moisture and other metals must be assessed and the appropriate protection applied.

Corrosion risk

The risk of corrosion of steel structures emanates from the surrounding atmospheric conditions. The nature and extent of any corrosion is linked to the amount of time that metal surfaces are exposed to moisture and to the amount of air pollution. The exposure time to moisture, which is the amount of time that the relative humidity of the air is > 80% at an ambient temperature of >0°C, is the main determinant as regards atmospheric corrosion and corrosion rate of metals. The absence of moisture considerably slows down the corrosion rate of steel and zinc even in the presence of high concentrations of gaseous (SO2, NOx etc) or solid polluters (dust containing aggressive particles).
Over the last few years, the complex influence of atmospheric polluters on the corrosion rate of unprotected structural steel and zinc has been analyzed as part of several European research programmers.

The result of this work has led to the drafting of the standard ISO 9223 “Corrosion of metals and alloys – Corrosivity of atmospheres – Classification”. The basic information containing the classifications for the corrosivity of atmospheres and the corrosion rates of plain carbon steel, zinc, copper, and aluminum, determined as a function of the corrosive load, is sufficiently accurate to allow the protection period of paints and zinc coatings to be calculated in a practical fashion.

<table>
<thead>
<tr>
<th>Corrosion risk category</th>
<th>Loss of thickness of zinc in the first year (µm)*</th>
<th>Examples of typical environments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Very low</td>
<td>Less than 0.1</td>
<td>-</td>
</tr>
<tr>
<td>C2 Low</td>
<td>0.1 – 0.7</td>
<td>Slightly polluted atmosphere, dry climate e.g. rural areas</td>
</tr>
<tr>
<td>C3 Medium</td>
<td>0.7 – 2.1</td>
<td>Urban or industrial atmosphere with low level of SO₂ pollution or coastal areas with low salinity</td>
</tr>
<tr>
<td>C4 High</td>
<td>2.1 – 4.2</td>
<td>Industrial or coastal atmosphere with low salinity</td>
</tr>
<tr>
<td>C5 Very high I</td>
<td>4.2 – 8.4</td>
<td>Industrial atmosphere with considerable humidity and aggressive atmospheres</td>
</tr>
<tr>
<td>C5 Very high M</td>
<td>4.2 – 8.4</td>
<td>Coastal area with high salinity</td>
</tr>
</tbody>
</table>

*can also be expressed in loss of mass (g/m²)

**Preparation**

Before applying protective coatings to steel, all secondary or residual rust or scale, as well as welding slag or grease, must be removed in accordance with the Australian standards. Methods of cleaning vary with, and are adapted to suit, the type of protective treatment being applied.

**Protective treatments**

The protective treatment to be applied to steelwork will vary according to its location as follows.

- Low-risk locations – theoretically, in dry, enclosed areas steel needs no protection. In practice, however, it is wise to use an anti-corrosive priming paint, as for medium-risk locations.
  
  Note: no treatment, other than cleaning, is required for steelwork encased in concrete.

- Medium-risk locations – wire-brush or blast cleaning of the steel should be followed by the application of one coat of basic red-oxide zinc chromate primer to provide a dry film thickness of between 38 and 50µm.
- Medium to high-risk locations – the steeks surfaces should be blast cleaned to Australia Standards and one coat of zinc silicate paint or a suitable proprietary zinc-rich coating applied. This is then left to air-dry. Where additional coats of paint are applied at a later date, the surface should be washed before spraying with chlorinated rubber paint.

- High-risk locations – steelworks should be picked and hot-dip galvanized to Australian Standards and a tar epoxy coat applied to any below ground.
  Note: all nuts and bolts should be galvanized and new welds zinc-coated.

**Coatings**

There are several reasons for selecting galvanizing as a coating system. For light fabrications and some medium structural applications, galvanizing can be the lowest cost coating system. It is usually also one of the lowest long-term cost coating system alternatives. Galvanizing does not adhere to the steel, but is actually metallurgically bonded to the base steel—forming an alloy layer between the surface zinc and the underlying base metal. Galvanizing is a tough coating system, providing high resistance to mechanical damage in transport, erection and in service. Finally, galvanizing eliminates maintenance for relatively long periods of time. This can be a significant factor if maintenance of the facility requires shutdowns or the area to be maintained is not easily accessible.

There are several types of galvanizing processes that are used throughout the industry including electric, zinc plating, mechanical plating and hot dip galvanizing. Hot-dip galvanizing is one of the oldest and most common types and has been used to fight corrosion for more than 200 years.

Hot-dip galvanizing is a process in which a steel article is cleaned in acid (pickled) and then immersed in molten zinc that is heated to approximately 850° Fahrenheit. This results in formation of zinc and a zinc-iron alloy coating that is metallurgically bonded to the steel. After the steel is removed from the galvanizing bath, excess zinc is drained or vibrated off the steel member. The galvanized member is then cooled in air or quenched in water. The zinc coating acts as a barrier that separates the steel from the environmental conditions that can cause corrosion. The galvanizing process precludes the possibility of coating improperly prepared steel surfaces, since the molten zinc will only react with clean steel. Due to the immersion process, galvanizing also provides complete protection of all galvanized parts—including recesses, sharp corners, and inaccessible areas.

Steelwork fabricators’ process routes vary. The sequence may be (a) Blast-Fabricate-Prime or (b) Blast Prime-Fabricate or (c) Fabricate-Blast-Prime. The choice of sequence depends on the facilities available to the fabricator or applicator, and the size of the structural members. A pre-fabrication primer may or may not be needed depending on the sequence chosen. Under certain circumstances some of the coats given in treatments as ‘site-applied’ may be applied in the shop if preferred, similarly some treatments given as shop-applied may be applied on site.
Beams and columns

Function

Precast beams and columns made with Elematic machinery offers an extremely wide range of technical possibilities. Beams have a rectangular cross-section and are used mostly horizontally for the structure of multi-storey buildings, and also for bridges. Columns have a rectangular or round cross-section and are used mostly vertically for structures and supports of multi-storey buildings, parking houses etc. With Elematic beams and columns can be either prestressed or reinforced.

Common sections

Common sections include the following.

- Universal sections:
  - Ref A: 310 UB 40 (304 x 165 x 40.4 kg/m);
  - Ref B: 250 UB 31 (252 x 146 x 31.4 kg/m);
  - Ref C: 200 UB 25 (203 x 133 x 25.4 kg/m);
  - Ref F: 100 UC 15 (97 x 99 x 14.8 kg/m).

- Taper flange beams:
  - Ref D: 178 x 89 x 22.4 kg/m;
  - Ref E: 152 x 76 x 17.9 kg/m.

- Rectangular hollow sections:
  - Ref C: 203 x 152 x 6.3 x 34 kg/m;
  - Ref D: 203 x 102 x 4.9 x 18.6 kg/m;
  - Ref E: 152 x 76 x 4.9 x 18.6 kg/m;
  - Ref F: 127 x 76 x 3.2 x 72 kg/m.

- Square hollow sections:
  - Ref G: 102 x 102 x 4.0 x 12.1 kg/m;
  - Ref H: 89 x 89 x 3.6 x 9.5 kg/m;
  - Ref J: 76 x 76 x 3.2 x 7.2 kg/m.

- Circular hollow sections:
  - Ref K: 114 diam. X 4.5 x 12.1 kg/m
- Ref L: 89 diam. X 4.0 x 8.5 kg/m
- Ref M: 76 diam. 3.6 x 6.5 kg/m

Size selection

Where beams support masonry above a 3-m span, or there is no lateral restraint, or a load is affected by wind, cyclones, earthquake, subsidence, point loads and dynamic loading conditions or deflection must be considered, seek the advice of a structural engineer.

Beam tables

In the tables below, the section required is indicated by the reference letter.

Note: 1KPa = 1 Kn/m.

Table 1: Total load 5 KPa
Typical of a domestic concrete floor up to 125 mm thick with a live load of 1.5 KPa.

<table>
<thead>
<tr>
<th>Beam spacing (m)</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>E</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Total load 2 KPa
Typical of a domestic timber-framed floor carrying a live of 1.5 KPa.

<table>
<thead>
<tr>
<th>Beam spacing (m)</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>F</td>
<td>E</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>E</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>E</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>E</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

Table 3: Total load 1 KPa
Typical of a domestic roof system of a mass of up to 50kg/m, plus 0.5 KPa allowance for download wind and other loads.

<table>
<thead>
<tr>
<th>Beam spacing (m)</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>F</td>
<td>F</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>E</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>E</td>
<td>D</td>
<td>C</td>
</tr>
</tbody>
</table>
Tubular columns

<table>
<thead>
<tr>
<th>Section</th>
<th>Max.height</th>
<th>Max. axial load</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>3.2m</td>
<td>158 Kn</td>
</tr>
<tr>
<td>H</td>
<td>2.8m</td>
<td>124 Kn</td>
</tr>
<tr>
<td>J</td>
<td>2.4m</td>
<td>95 Kn</td>
</tr>
<tr>
<td>K</td>
<td>3.1m</td>
<td>141 Kn</td>
</tr>
<tr>
<td>L</td>
<td>2.4m</td>
<td>98 Kn</td>
</tr>
<tr>
<td>M</td>
<td>2.1m</td>
<td>65 Kn</td>
</tr>
</tbody>
</table>

Deflection

The deflection of a spring beam depends on its length, its cross-sectional shape, the material, where the deflecting force is applied, and how the beam is supported.

The equations given here are for homogenous, linearly elastic materials, and where the rotations of a beam are small.

In the following examples, only loads applying at a single point or single points are considered – the application point of force F in the diagrams is intended to denote a model locomotive hornblock (or vehicle axlebox) able to move vertically in a hornguide, and acting against the force of the spring beam fixed to or carried by the locomotive or vehicle mainframes. The proportion of the total weight acting on each axle of a loco or vehicle will depend on the position of its centre of gravity in relation to the axle (or the chassis fixing points of equalising beams where these are used).

Cappings

The thickness and area of plate capping must be adequate to receive and distribute the load to bearings. All ends of hollow sections should be sealed to obviate internal corrosion. The grout under base plates should be a one-to-two (1:2) cement-sand grout.

Connections

Steel-to-steel connections may be achieved by bolting, welding or screwing, depending on the design requirements and/or the conviniene. New welds and holes should be protected with a zinc rich primer.
The availability of galvanized beam/column and column/slab brackets and improved tek screws have made connections much easier to achieve. Brackets can be simply dynabolted or chemical anchored to concrete footings as specified by an engineer, alleviating the need for accurate holding down bolts, resulting in savings in labour and materials.
**Cold-formed components**

**Function**

Is the common term for products made by rolling or pressing thin gauges of sheet steel into goods. Cold-formed steel goods are created by the working of sheet steel using stamping, rolling, or presses to deform the sheet into a usable product. Cold worked steel products are commonly used in all areas of manufacturing of durable goods like appliances or automobiles but the phrase cold form steel is most prevalently used to described construction materials. The use of cold-formed steel construction materials has become more and more popular since its initial introduction of codified standards in 1946. In the construction industry both structural and non-structural elements are created from thin gauges of sheet steel. These building materials encompass columns, beams, joists, studs, floor decking, built-up sections and other components. Cold-formed steel construction materials differ from other steel construction materials known as hot-rolled steel (see structural steel). The manufacturing of cold-formed steel products occurs at room temperature using rolling or pressing. The strength of elements used for design is usually governed by buckling. The construction practices are more similar to timber framing using screws to assemble stud frames.
Applications
Cold-formed steel framing components are used principally for the following.
- Framed floor members
- Framed wall plates, studs and noggins

- Ceiling and roof beams, joist, rafters, purlins and battens

Framing system include the following.
- Prefabricated beams
- Prefabricated roof truss
- Floor and wall frames
- Combined sheet roof and ceiling

Steel floor framing
A steel framed floor may result in substantial savings in construction for sites with rock, sloping sites and/or re-active soil conditions. Difficult sites will require major earthworks involving cut and fill, compaction, subsoil drains, retaining walls and engineer designed reinforced footings and slab.

Light weight steel floor framing causes minimum disturbance to the site, retains natural vegetation and requires minimal footings. The floor stumps can be attached directly to caprock, making the expensive operation of removing the rock unnecessary. Simple brackets attached to the rock or a concrete footing makes the stumping operation easy and fast. Steel stumps/column to bearer brackets are adjustable which makes leveling a simple operation. Where subsidence of a stump occurs, this system makes it a very simple operation to re-adjust the stump to level. Because of the large range of profiles, sizes, strengths and thicknesses of steel floor components fewer stumps, columns and bearers are required. Concrete slab on steel frame. You can also have a concrete floor slab if you wish. this is achieved by laying profiled steel sheeting on the steel floor frame and pouring the concrete slab on it. This system is known as Bondek. There are also available pre-cast concrete floor panels which can be placed on the steel floor frame. Substrates on steel frame. Many flooring substrate materials are available to attach to metal floor frames. These may be of compressed
timber, plywood or compressed fibre cement sheeting. Floor substrates to be used in wet areas should be waterproof. Tongue and groove (t&g) timber floor boards can also be fixed to steel floor frames.

Typical steel floor framed components are:

- **Columns/strumps**
  - 75 x 75 x 2 mm SHS duragal
  - 90 x 90 x 1.6 mm SHS duragal
  - 100 x 100 x 2 mm SHS duragal
  - 100 x 100 x 9 mm SHS duragal
  - 125 x 125 x 4 mm SHS duragal
  - 125 x 125 x 9 mm SHS duragal
  - 150 x 150 x 5 mm SHS duragal

- **Bearers**
  - 150 x 14 mm UB
  - 180 x 16 mm UB
  - 180 x 22 mm UB
  - 200 x 18 mm UB
  - 250 x 25 mm UB
  - 150 x 50 x 5 mm RHS duragal
  - 150 x 100 x 9 mm RHS duragal
  - 200 x 100 x 3 mm RHS duragal
  - 200 x 100 x 9 mm RHS duragal
  - 250 x 150 x 5 mm RHS duragal
  - C200 15 galvanized
  - C200 19 galvanized
  - C200 25 galvanized

- **Joists**
  - C100 12 galvanized
  - C100 1.5 galvanized
  - C100 19 galvanized
  - C150 12 galvanized
  - C150 15 galvanized
  - C150 24 galvanized
  - C200 1.5 galvanized

Steel floor framing can also be used for mezzanine floors in homes and for commercial applications. Design and engineering to suit the loads applied is essential.
Steel wall framing

Steel framing studs, which have been used to frame commercial buildings for generations, are now gaining in popularity in residential construction and are becoming available for use in homes at more affordable prices.

Benefits of Steel Framing

There are many benefits to utilizing steel framing in your new home:

- Steel frames are stronger than wood frames.
  Steel is stronger than wood and more resistant to fire, earthquake and tornado damage, and can cost less to insure. Steel also does not rot, warp, crack, split or change with the weather and it is termite- and vermin-proof.
- Steel-framed structures move less.
  Walls, floors and roofs consistently stay straight when built with steel framing. And, because the structure moves less than when wood framing is used, steel frames can reduce air leakage and energy costs.
- Steel framing is environmentally friendly.
  Steel is the most environmentally friendly choice, as it saves trees, is non-toxic and creates 100-percent recyclable waste.

<table>
<thead>
<tr>
<th>PROFILE</th>
<th>SECTION</th>
<th>DIMENSIONS D x B</th>
<th>STEEL BASE THICKNESS</th>
<th>MATERIAL TO AS 1397-1977 steel grade and zinc coating class</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Standard plate stud" /></td>
<td>STANDARD PLATE STUD</td>
<td>78 x 31 mm</td>
<td>1.2 mm</td>
<td>G300, A3150 G300, A3150 G300, A3150</td>
</tr>
<tr>
<td><img src="image" alt="Nogging light duty stud" /></td>
<td>NOGGING LIGHT DUTY STUD</td>
<td>75 x 32 mm</td>
<td>1.2 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>72 x 34 mm</td>
<td>1.2 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75 x 32 mm</td>
<td>0.8 mm</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Junction stud" /></td>
<td>JUNCTION STUD</td>
<td>75 x 38 mm</td>
<td>1.2 mm</td>
<td>G3900, 2275</td>
</tr>
<tr>
<td><img src="image" alt="Corner stud" /></td>
<td>CORNER STUD</td>
<td>75 x 38 mm</td>
<td>1.2 mm</td>
<td>G300, 2275</td>
</tr>
<tr>
<td><img src="image" alt="Stiffened plate" /></td>
<td>STIFFENED PLATE</td>
<td>79 x 76 mm</td>
<td>1.6 mm</td>
<td>G450, 2275</td>
</tr>
<tr>
<td><img src="image" alt="Angle head beam" /></td>
<td>ANGLE HEAD BEAM</td>
<td>100 x 70 mm</td>
<td>2.5 mm</td>
<td>G250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 x 70 mm</td>
<td>2.5 mm</td>
<td>G250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 x 72 mm</td>
<td>3.2 mm</td>
<td>G250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250 x 72 mm</td>
<td>3.2 mm</td>
<td>G250</td>
</tr>
</tbody>
</table>
Typical steel frame wall assembly

Stud fixing methods

2 fillet welds 12 mm minimum length (may be inside or outside nogging channel)

Welded frames

12 mm minimum length welds in two places

Two 4.8 mm diameter monel or steel blind rivets or two #10 wafer head self-tapping screws in each flange

15 mm long fillet weld each side

25 mm long fillet weld

Adjacent panels joined on site

Window opening using angle head beam

Holes for electrical and plumbing services

Door opening using trussed head

Head - use plate section

Use single or multiple studs at opening

Window sill - use plate section

Brick wall ties clipped to studs by bricklayer for brick veneer

Nogging section used as bracing

Continuous bottom wall plate
Nogging fixing

Where welding is not available

Plain wall panel

Strap bracing with tensioner

Locate straps as close as possible to centre line of stud

Wall panel with opening

Strap bracing of wall frame using 32 x 12 mm galvanised steel strap

Use 4.8 mm diameter blind rivets or wafer head self-drilling, self-tapping screws #10 x 16 mm

Two fasteners at top plate (strap ends to be extended to fix to roof framing)

Stud

After tensioning, fix one fastener at each intersection of a stud and strap

Typical strap tensioner located between studs

Two fasteners at bottom plate (extend strap and fix to floor frame using two 40 x 3.15 mm nails)

Strap fixing details