4. Industrial Buildings

4.1. Introduction

Steel-framed buildings in common use for industrial purposes can be classified into three broad categories:

- Warehouse and factory buildings.
- Large span storage buildings.
- Heavy industrial process plant structures.

In the design of industrial buildings, function more than any other factor will dictate the degree of complication and hence the economy possible. Towards this end, the designer should obtain as much knowledge as possible of the industrial process or purpose for which the building is intended, and of the limitations this might force on the structure.

In this way, an optimum balance between function and economy can be achieved.

The main dimensions of an industrial building are usually determined from a combination of functional and design considerations.

Its width is derived first from an owner's study of the space required to carry out the processing or storage operations. The designer then needs to consider whether this width can be provided economically by a single clear span, or whether multi-bay spans are feasible.

Likewise the overall length is usually readily determined by the owner, but the designer should give thought to the optimum bay length. Some of the factors affecting the choice are:

- Foundation conditions and their ability to accept the column loads.
- Crane runway girder considerations (see Clause 4.2.5).
- Purlin and girt capacities (see Clause 4.2.6).
- Masonry bond dimensions.
- Tilt-up concrete panel size and available cranage.

The building height is again usually a functional consideration; for buildings with overhead travelling cranes the critical dimension is the clearance required under the hook.

In most areas of Australia there is no snow and therefore fairly low roof pitches are practicable. The steeper the slope the better the structural action, but this benefit is usually outweighed by additional sheeting costs. In practice, roof pitches between 5 and 10 are preferred. These pitches are suitable for any of the continuous length steel sheet roofing profiles, some of which are adequate for pitches down to 1.

4.2 Warehouse and Factory Buildings

4.2.1 GENERAL

In the early days of steel-framed industrial buildings the economic solution was a column-and-truss configuration (Figure 4.2 (a)). However, since truss fabrication is inherently labour intensive, rising labour costs have excluded these truss systems from normal factory or warehouse applications.

Presently, rigid 'portal frames' fabricated from universal beams offer the most economic structural solution in the usual span range of 15 to 45 metres. For very large spans, portal trusses (see Figure 4.18) are often used in lieu of the portal frame.

Although the portal frame may require a greater mass of steel than the equivalent column-and-truss arrangement, the savings in the cost of fabrication and erection due to the relative simplicity of the work almost always make it the optimum system in the span range given above.

To minimise the overall cost of warehouse and factory buildings, designers should be aware of the major steelwork cost components. Effort can then be focused on cost components that can reduce the overall cost. Figure 4.1 shows the various cost components in relation to a warehouse.

4.2.2 STANDARDISED PORTAL FRAMES

Overseas, particularly in North America, the portal frame structure has been developed to the stage where many companies offer a standard range of buildings in spans up to as much as 50m. Economies of scale and production line manufacture have made these 'catalogue' buildings a cost-effective choice for many industrial as well as commercial applications.

The same manufacturing and marketing techniques have been attempted in Australia, but with limited success, probably due to our much smaller and more widespread demand. As a consequence, practically all larger portal frame structures built in Australia today are custom designed and manufactured. This is not as inefficient as it may sound, because there are many standardised routines in both the design office and the fabrication shop.

On the other hand, smaller buildings (sheds, garages, etc.) are widely available in Australia as standard catalogue items. Nowadays these are often manufactured entirely from cold-formed steel sections rather than from traditional hot-rolled sections.

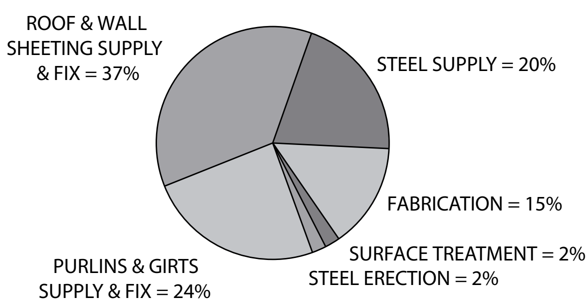

Figure 4.1: Steelwork cost components for warehouses

4. Industrial Buildings

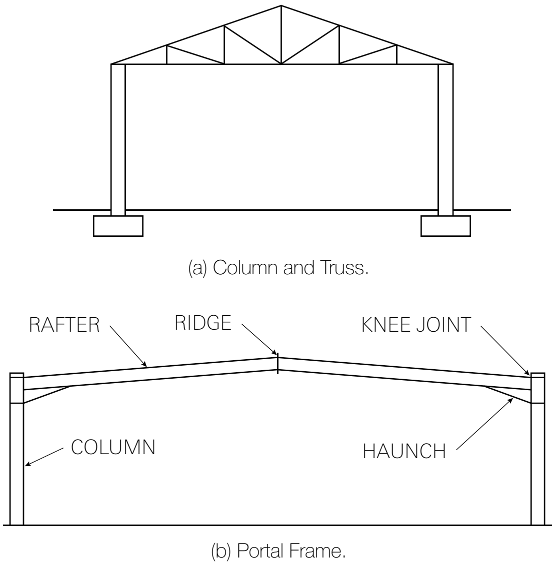

FIGURE 4.2: Configuration of framing systems for a factory building

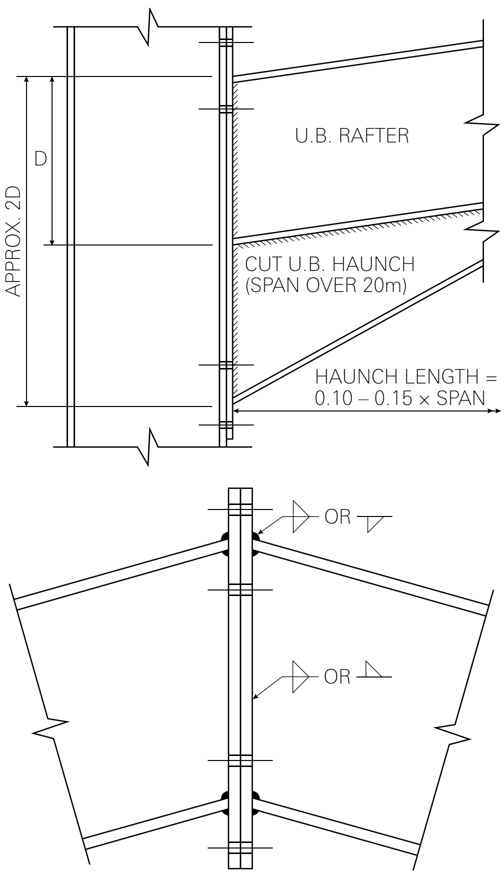

Figure 4.3: Details of bolted portal frame

4.2.3 CUSTOM DESIGNED PORTAL FRAMES

In this case, a client engages an Architect and Consulting Engineer who prepare design drawings and submit the project to tender. The contract is usually awarded to a builder who then sub-contracts the structural steelwork to a steel fabricator on the basis of the Consulting Engineer's drawings.

The portal frames will usually consist of universal sections in order to be economic in fabrication – see Figure 4.3. A variety of connection details are encountered, but only a limited number are truly economic for such frames. Figure 4.4 shows examples of economic details using bolted knee and apex joints, while Figure 4.5 shows examples of economic details for frames using shop welded knee and apex joints and bolted rafter splices.

For spans up to 20m a uniform column and rafter section is the most economic but for greater spans haunching of the rafter may provide a more economical system. Haunching is most economically achieved by using a cut universal beam section in the manner shown in Figure 4.3, with the depth of the section at the haunch about twice the rafter depth. The haunch length is usually of the order of 10%-15% of the span of the rafter.

The selection of either bolted or shop-welded knee and apex joints will be governed by the span of the frame and the transport and erection facilities available for a particular job.

It is important not to overspecify the welding e.g. specifying full penetration butt welds where fillet welds would be satisfactory as the cost is increased unnecessarily (refer Section 7.5). Appendix B of Ref. 2.12 provides recommended welding notes for small to medium sized building structures.

In general the dimensions given in Figure 4.5 are a guide to limitations on maximum size imposed by transportation considerations.

For frames of larger dimensions than those indicated in Figure 4.5, consideration would have to be given either to special transport facilities or additional field splices.

A further discussion on portal frame details can be found in Clause 8.5.

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