1 Introduction

1.1 KEY FEATURES OF PORTAL FRAMED BUILDINGS

Portal framed steel clad structures are the most common type of industrial buildings. They find extensive use as industrial factory and warehouse structures, and as indoor sporting venues. The major components of a portal frame building are a series of parallel portal shaped frames as the major framing elements. Each frame is rigid, and resists horizontal wind forces and gravity loads in the plane of the frame by flexural action. A typical portal frame is shown in Figure 1.1. Longitudinal wind forces that are perpendicular to the frames are generally resisted by triangulated bracing systems in the roof and walls which prevent the frames from falling over. An illustrative isometric view of the steel skeleton of a braced bay of a portal frame building is shown in Figure 1.2. This book presents limit state design procedures for the design of portal framed buildings based on Australian standards.

Large clear spans up to about 40 metres can be achieved economically using Universal Beam (UB) or Welded Beam (WB) rafters such as those manufactured by OneSteel [1]. The columns are generally larger than the rafters because the rafters are haunched near the columns to cater for the peak bending moments at the columns. For larger spans, some form of roof truss as shown in Figure 1.3 is often used in lieu of UB or WB rafters. As the span increases, the weight saving offered by trusses becomes more pronounced, until the higher cost per tonne for truss fabrication is eventually offset. The crossover point is difficult to nominate because of the many variables. One of the difficulties of the comparison is that a building with roof trusses is higher than a building with portal frames, assuming that the same internal height clearances are maintained. The main drawback of a trussed roof is the need for bracing of the bottom chords.

Nevertheless, it is recommended that the cost of using portalised trusses in preference to portal frames for a particular project be investigated where the span exceeds 30 metres or so.

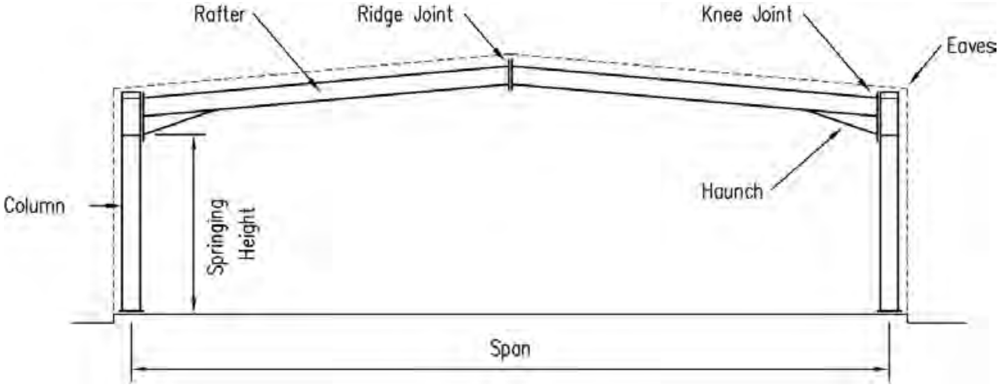

Figure 1.1 *Typical portal frame*

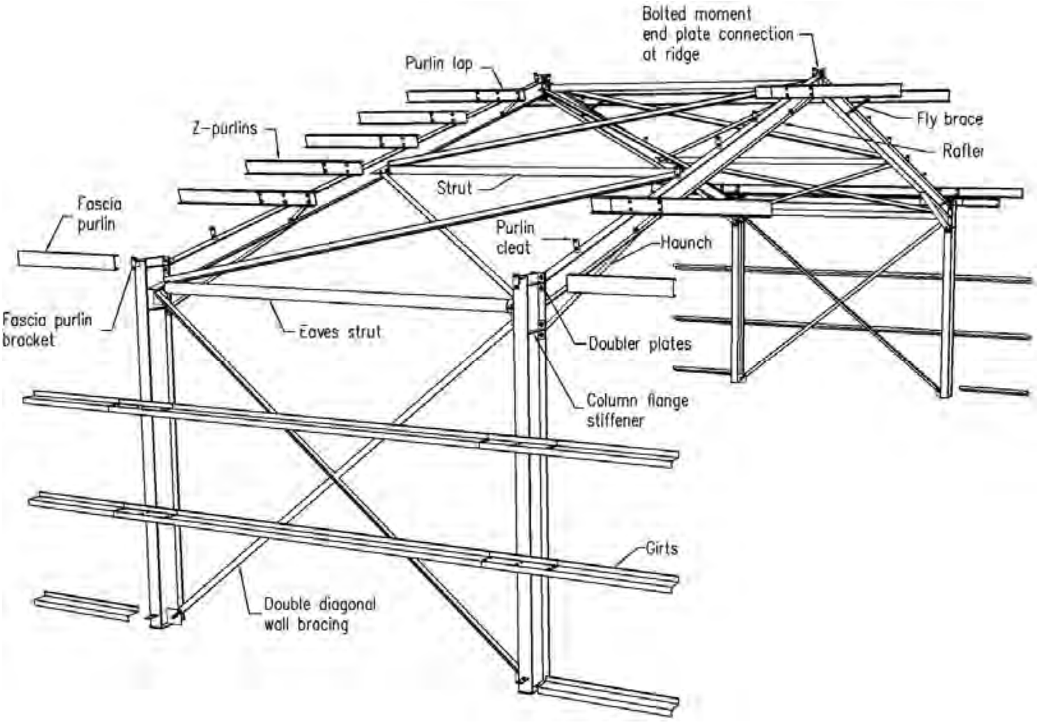

Figure 1.2 *Structural components in a braced bay*

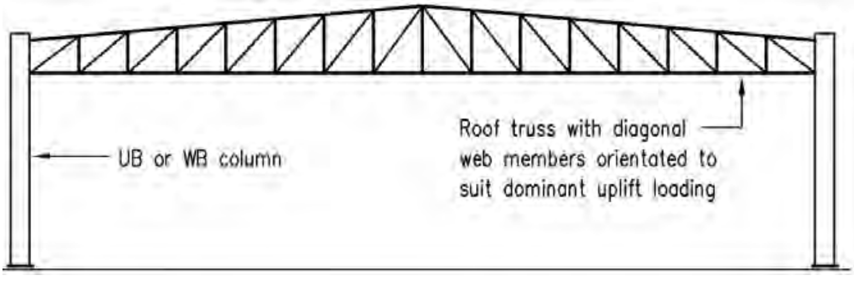

Figure 1.3 *Portalised Truss*

1.2 DESIGN ISSUES

1.2.1 General Design Criteria

The structural designer may be a member of design team with most of the building design parameters set by others such as an architect, project manager or managing contractor. Alternatively in mining or in some industrial projects, he or she may be primarily responsible for setting the plan layout, the building height, the frame spacing, the roof pitch, the wall bracing locations and other key features. In any case, the aim is generally to arrive at a low cost solution and so optimising the many design variables can involve the investigation of more than one design option.

For example, the selection of frame spacing is not always just a matter of dividing the length of the building into a number of equal bays. To achieve an economical design, the selection of frame spacing should involve investigation of an economical purlin and girt system and this may warrant the adoption of smaller end bays. The economics of the roof and wall bracing system should also be considered because adopting large bays can add significant cost to the bracing system.

Another example of optimising a structure lies in the selection of roof pitch. Adopting a steeper pitch will result in larger sidesway forces, taller end wall mullions and increased longitudinal forces, whereas adopting a lower pitched roof will warrant careful consideration of the capacity of the roof sheeting to carry stormwater. It is therefore important to check the information provided by the sheeting manufacturer with respect to minimum pitch and the maximum recommended length of sheeting for the appropriate rainfall intensity. The maximum recommended length of sheeting can be affected by penetrations such as roof vents which direct the flow upstream of the penetrations around to the sides. Lysaght’s roof installation manual [26] gives guidance on this. In general, it is important to set the nominal roof pitch steeper than the manufacturer’s minimum pitch in order to allow some margin for:

- frame deflections,
- differential purlin deflections particularly between the fascia purlin and the first internal purlin and
- penetrations.

For example, if the manufacturer’s minimum slope for a particular sheeting profile is 2º, it would be prudent to adopt a pitch of at least 2½º or 3º. Sometimes an architect or a building hydraulics consultant is responsible for the roof drainage, and if so, the structural designer should respect the demarcation of responsibilities while understanding his or her role in providing appropriate input.

1.2.2 Structural Design

1.2.2.1 INTRODUCTION

Although portal framed buildings are very common, the number of manuals and handbooks dealing with their design is comparatively small. This book considers the design of portal framed buildings in accordance with the Australian limit states steel structures code AS 4100 [2] which was first introduced in 1990 in response to an international trend towards limit state design. Prior to the mid-eighties, the design of structural steelwork in most western countries was undertaken using *permissible* or *working stress* methods. Little mention of these methods

Design of Portal Frame Buildings

including Crane Runway Beams and Monorails

Fourth Edition

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