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.
design of portal frame buildings

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

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Published by
Australian Steel Institute
Level 13, 99 Mount Street
North Sydney NSW 2060
www.steel.org.au
DESIGN OF PORTAL FRAME BUILDINGS
including Crane Runway Beams and Monorails

Published by
AUSTRALIAN STEEL INSTITUTE

Enquiries should be addressed to the publisher:
Business address – Level 13, 99 Mount Street, North Sydney, NSW 2060 Australia
Postal address – P.O. Box 6366, North Sydney, NSW 2059 Australia
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Website – www.steel.org.au

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Australian Steel Institute.

Previously published as:
Design of Portal Frame Buildings, 3rd edition, 1999 (to AS 4100)

National Library of Australia Cataloguing-in-Publication entry:
Design of portal frame buildings: including crane runway beams and monorails/ S.T. Woolcock … [et al.]

4th ed.
ISBN 9781921476266 (pbk.)
Includes bibliographical references and index.

Industrial buildings – Design and construction.
Woolcock, S.T.
Australian Steel Institute.

693.71

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# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONTENTS</strong></td>
<td>............................ i</td>
</tr>
<tr>
<td><strong>PREFACE</strong></td>
<td>................................ ix</td>
</tr>
<tr>
<td><strong>NOTATION</strong></td>
<td>................................ xi</td>
</tr>
<tr>
<td><strong>1 INTRODUCTION</strong></td>
<td>................................ 1</td>
</tr>
<tr>
<td>1.1</td>
<td>Key Features of Portal Framed Buildings</td>
</tr>
<tr>
<td>1.2</td>
<td>Design Issues</td>
</tr>
<tr>
<td>1.2.1</td>
<td>General Design Criteria</td>
</tr>
<tr>
<td>1.2.2</td>
<td>Structural Design</td>
</tr>
<tr>
<td>1.2.2.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>1.2.2.2</td>
<td>Grey Areas in Design</td>
</tr>
<tr>
<td>1.2.2.3</td>
<td>Aims of This Book</td>
</tr>
<tr>
<td>1.3</td>
<td>Limit States Design</td>
</tr>
<tr>
<td>1.3.1</td>
<td>Background</td>
</tr>
<tr>
<td>1.3.2</td>
<td>Design for the Strength Limit State</td>
</tr>
<tr>
<td>1.3.3</td>
<td>Design for the Serviceability Limit State</td>
</tr>
<tr>
<td>1.4</td>
<td>Design Examples</td>
</tr>
<tr>
<td>1.4.1</td>
<td>Building</td>
</tr>
<tr>
<td>1.4.2</td>
<td>Crane Runway Beams</td>
</tr>
<tr>
<td>1.4.3</td>
<td>Monorails</td>
</tr>
<tr>
<td>1.5</td>
<td>References</td>
</tr>
<tr>
<td><strong>2 LOADS</strong></td>
<td>................................ 15</td>
</tr>
<tr>
<td>2.1</td>
<td>Background</td>
</tr>
<tr>
<td>2.2</td>
<td>Dead Loads</td>
</tr>
<tr>
<td>2.3</td>
<td>Live Loads</td>
</tr>
<tr>
<td>2.4</td>
<td>Wind Loads</td>
</tr>
<tr>
<td>2.4.1</td>
<td>Regional Wind Speed</td>
</tr>
<tr>
<td>2.4.2</td>
<td>Site Wind Speeds</td>
</tr>
<tr>
<td>2.4.3</td>
<td>Terrain Category</td>
</tr>
<tr>
<td>2.4.4</td>
<td>Design Wind Speeds and Pressures</td>
</tr>
<tr>
<td>2.4.5</td>
<td>External Pressures</td>
</tr>
<tr>
<td>2.4.6</td>
<td>Internal Pressures</td>
</tr>
<tr>
<td>2.4.7</td>
<td>Area Reduction Factor ((K_a))</td>
</tr>
<tr>
<td>2.4.8</td>
<td>Action Combination Factor ((K_c))</td>
</tr>
<tr>
<td>2.4.9</td>
<td>Local Pressure Factors ((K_l))</td>
</tr>
<tr>
<td>2.5</td>
<td>Seismic Loads</td>
</tr>
<tr>
<td>2.6</td>
<td>Load Combinations</td>
</tr>
<tr>
<td>2.6.1</td>
<td>Strength Limit State</td>
</tr>
<tr>
<td>2.6.2</td>
<td>Serviceability Limit State</td>
</tr>
<tr>
<td>2.7</td>
<td>Design Example - Loads</td>
</tr>
<tr>
<td>2.7.1</td>
<td>Dead Loads</td>
</tr>
<tr>
<td>2.7.2</td>
<td>Live Loads</td>
</tr>
<tr>
<td>2.7.3</td>
<td>Wind Loads</td>
</tr>
<tr>
<td>2.7.3.1</td>
<td>Basic Wind Data</td>
</tr>
<tr>
<td>2.7.3.2</td>
<td>External Wind Pressures</td>
</tr>
<tr>
<td>2.7.3.3</td>
<td>Internal Wind Pressures</td>
</tr>
<tr>
<td>2.7.3.4</td>
<td>Peak Local Pressures</td>
</tr>
<tr>
<td>2.7.4</td>
<td>Seismic Loads</td>
</tr>
<tr>
<td>2.7.5</td>
<td>Load Cases for Portal Frames</td>
</tr>
<tr>
<td>2.7.6</td>
<td>Load Combinations</td>
</tr>
<tr>
<td>2.8</td>
<td>References</td>
</tr>
<tr>
<td><strong>References</strong></td>
<td>................................ 42</td>
</tr>
</tbody>
</table>
3 PURLINS & GIRTS ............................................................................................................ 43
  3.1 General ............................................................................................................. 43
  3.2 Roof and Wall Sheeting .................................................................................. 44
    3.2.1 Rainwater and Temperature ..................................................................... 44
    3.2.2 Cladding Capacity .................................................................................. 44
  3.3 Purlin Spans or Frame Spacing ........................................................................ 45
  3.4 Loads .............................................................................................................. 45
    3.4.1 Base Loads ............................................................................................... 45
    3.4.2 Peak Local Pressures ............................................................................... 46
      3.4.2.1 Summary of Code Provisions .............................................................. 46
      3.4.2.2 Aspect Ratio of Patches ..................................................................... 47
      3.4.2.3 Contributing Widths .......................................................................... 53
    3.4.3 Equivalent UDL’s For Peak Pressure .......................................................... 54
  3.5 Member Capacities .......................................................................................... 57
    3.5.1 Manufacturers’ Brochures ........................................................................ 57
    3.5.1.1 Design Capacity Tables ...................................................................... 57
    3.5.1.2 Bridging ............................................................................................... 57
    3.5.2 Manufacturers’ Software ........................................................................... 58
    3.5.3 R-Factor Method ...................................................................................... 58
    3.5.4 Stramit Method ........................................................................................ 58
  3.6 Deflections ....................................................................................................... 59
  3.7 Axial Loads ..................................................................................................... 59
  3.8 Purlin and Girt Cleats ...................................................................................... 59
  3.9 Purlin and Girt Bolts ....................................................................................... 60
  3.10 Design Example – Purlins ............................................................................ 60
    3.10.1 Methodology ............................................................................................ 60
    3.10.2 Select Purlin Spacing ............................................................................. 61
    3.10.3 Outward Purlin Loading – Transverse Wind ............................................ 62
      3.10.3.1 General ............................................................................................ 62
      3.10.3.2 Edge Zone 0 to 2600 mm from Eaves (TW- Excluding Fascia purlin) 62
      3.10.3.3 Fascia Purlin (Edge Zone 0 to 2600 mm from Eaves - TW) .............. 69
      3.10.3.4 Edge Zone 2600 mm to 5200 mm from Eaves (TW) ....................... 72
      3.10.3.5 Zone 5200 mm to 8350 mm from Eaves (TW) ............................... 72
      3.10.3.6 Zone between 8350 mm from Eaves and the Ridge (TW) .............. 73
    3.10.4 Outward Purlin Loading – Longitudinal Wind ......................................... 73
      3.10.4.1 Edge Zone 0 to 5200 mm from Eaves (LW) ..................................... 73
      3.10.4.2 Zone between 5200 mm from Eaves and the Ridge (LW) .............. 76
    3.10.5 Check Inward Loading ............................................................................. 80
      3.10.5.1 Zone 0 to 5200 mm from Eaves (LW) .............................................. 80
      3.10.5.2 Zone between 5200 mm from Eaves and the Ridge (LW) .............. 80
    3.10.6 Using Manufacturers’ Software ................................................................ 81
    3.10.7 R-Factor Method ..................................................................................... 81
    3.10.8 Purlin Summary ....................................................................................... 83
  3.11 Design Example – Girts ................................................................................. 84
    3.11.1 Long Wall Girts ...................................................................................... 84
      3.11.1.1 Coefficients & Girt Spacing ............................................................... 84
      3.11.1.2 Outward Loading ............................................................................ 84
      3.11.1.3 Inward Loading .............................................................................. 88
    3.11.2 End Wall Girts with Span of 6250 mm ...................................................... 90
      3.11.2.1 Coefficients and Girt Spacing ......................................................... 90
      3.11.2.2 Outward Loading ......................................................................... 90
      3.11.2.3 Inward Loading with 1700 mm Spacing ...................................... 91
    3.11.3 Girt Summary ........................................................................................ 93
  3.12 References .................................................................................................... 94
4 FRAME DESIGN ................................................................................................................ 95
   4.1 Frame Design by Elastic Analysis 95
   4.2 Computer Analysis 95
      4.2.1 Load Cases 95
      4.2.2 Methods of Analysis 96
      4.2.3 Moment Amplification for First Order Elastic Analysis 97
   4.3 Rafters 98
      4.3.1 Nominal Bending Capacity $M_{bn}$ in Rafters 98
         4.3.1.1 Simplified Procedure 98
         4.3.1.2 Alternative Procedure 99
      4.3.2 Effective Length and Moment Modification Factors for Bending Capacity 100
         4.3.2.1 General 100
         4.3.2.2 Top Flange in Compression 100
         4.3.2.3 Bottom Flange in Compression 101
      4.3.3 Major Axis Compression Capacity $N_{cx}$ 103
      4.3.4 Minor Axis Compression Capacity $N_{cy}$ 104
      4.3.5 Combined Actions for Rafters 104
      4.3.6 Haunches for Rafters 104
   4.4 Portal Columns 104
      4.4.1 General 104
      4.4.2 Major Axis Compression Capacity $N_{cx}$ 105
      4.4.3 Minor Axis Compression Capacity $N_{cy}$ 105
      4.4.4 Nominal Bending Capacity $M_{bn}$ in Columns 105
         4.4.4.1 General 105
         4.4.4.2 Inside Flange in Compression 105
         4.4.4.3 Outside Flange in Compression 106
   4.5 Combined Actions 106
      4.5.1 General 106
      4.5.2 In-Plane Capacity 106
         4.5.2.1 In-Plane Section Capacity 106
         4.5.2.2 In-Plane Member Capacity 107
      4.5.3 Out-of-Plane Capacity 108
         4.5.3.1 Compression Members 108
         4.5.3.2 Tension Members 108
   4.6 Central Columns 108
      4.6.1 General 108
      4.6.2 Effective Lengths for Axial Compression 109
         4.6.2.1 Top Connection Pinned 109
         4.6.2.2 Top Connection Rigid 110
      4.6.3 Combined Actions with First Order Elastic Analysis 110
      4.6.4 Combined Actions with Second Order Elastic Analysis 110
   4.7 End Wall Frames 110
      4.7.1 General 110
      4.7.2 End Wall Columns 111
      4.7.3 End Wall Columns to Rafter Connection 111
         4.7.3.1 General 111
         4.7.3.2 Continuous Rafter 111
         4.7.3.3 Discontinuous Rafter 112
   4.8 Rafter Bracing Design 113
      4.8.1 General 113
      4.8.2 Purlins as Braces 113
         4.8.2.1 AS 4100 Approach 113
         4.8.2.2 Eurocode Approach 114
         4.8.2.3 Conclusions 117
      4.8.3 Fly Braces 117
         4.8.3.1 General 117
         4.8.3.2 AS 4100 Approach 119
         4.8.3.3 Eurocode Approach 120
### 4.9 Deflections
- 4.9.1 General
- 4.9.2 Problems of Excessive Deflection

### 4.10 Design Example – Frame Design
- 4.10.1 Frame Analysis
- 4.10.1.1 Preliminary Design
- 4.10.1.2 Haunch Properties
- 4.10.1.3 Methods of Analysis
- 4.10.2 Frame Deflections
- 4.10.2.1 Sidesway Deflection
- 4.10.2.2 Rafter Deflection
- 4.10.3 Columns (460UB74)
  - 4.10.3.1 Column Section Capacities
  - 4.10.3.2 Column Member Capacities
  - 4.10.3.3 Column Combined Actions
- 4.10.4 Rafters (360UB45)
  - 4.10.4.1 Rafter Section Capacities
  - 4.10.4.2 Rafter Member Capacities
  - 4.10.4.3 Rafter Combined Actions
- 4.10.5 LIMSTEEL Results
- 4.10.6 End Wall Frames
- 4.10.7 End Wall Columns
  - 4.10.7.1 Inside Flange in Tension (Inward Loading)
  - 4.10.7.2 Inside Flange in Compression (Outward Loading)
  - 4.10.7.3 Axial Compression Under Gravity Loads

### 5 FRAME CONNECTIONS
- 5.1 General
- 5.2 Bolted Knee and Ridge Joints
- 5.3 Column Bases
  - 5.3.1 Holding Down Bolts
  - 5.3.2 Base Plates
- 5.4 Design Example - Frame Connections
  - 5.4.1 General
  - 5.4.2 Knee Joint
    - 5.4.2.1 General
    - 5.4.2.2 Calculate Design Actions
    - 5.4.2.3 Bottom Flange Connection
    - 5.4.2.4 Top Flange Connection
    - 5.4.2.5 Summary of Adopted Knee Connection Details
  - 5.4.3 Ridge Connection
    - 5.4.3.1 General
    - 5.4.3.2 Calculate Design Actions
    - 5.4.3.3 Carry Out Design Checks
    - 5.4.3.4 Summary of Adopted Ridge Joint Details
  - 5.4.4 Base Plates
- 5.4.5 End Wall Column Connections
  - 5.4.5.1 General
  - 5.4.5.2 Centre Column - Top Connection
  - 5.4.5.3 Quarter-Point Columns – Top Connection

### 6 ROOF & WALL BRACING
- 6.1 General
- 6.2 Erection Procedure
6.3 Roof and Wall Bracing Forces 216
6.3.1 Longitudinal Wind Forces 216
6.3.2 Rafters or Truss Bracing Forces 216
   6.3.2.1 General 216
   6.3.2.2 Quantifying Bracing Forces 217
6.4 Bracing Plane 219
6.5 Bracing Layout 221
6.6 Tension Rods 223
6.7 Tubes and Angles in Tension 226
6.8 Tubes in Compression 229
6.9 End Connections for Struts and Ties 231
   6.9.1 Tubes 231
      6.9.1.1 Tubes in Tension 231
      6.9.1.2 Tubes in Compression 233
   6.9.2 Angles 235
6.10 In-plane Eccentricity of Connection 235
6.11 Design Example - Roof and Wall Bracing 235
   6.11.1 Longitudinal Forces 235
      6.11.1.1 General 235
      6.11.1.2 Forces due to Longitudinal Wind 236
      6.11.1.3 Forces due to Rafters Bracing 238
      6.11.1.4 Forces in Roof Bracing Members 238
   6.11.2 Ties or Tension Diagonals 238
   6.11.3 Struts 241
   6.11.4 Connections 244
      6.11.4.1 End Connections for Struts 244
      6.11.4.2 Bolts 246
   6.11.5 Side Wall Bracing 247
6.12 References 268

7 FOOTINGS & SLABS ....................................................................................................... 269
7.1 General 269
7.2 Pad Footings 270
7.3 Bored Piers 270
   7.4.1 General 271
   7.4.2 Resistance to Vertical Loads 273
   7.4.3 Resistance to Lateral Loads 274
7.5 Holding Down Bolts 275
   7.5.1 General 275
   7.5.2 Design Criteria 276
   7.5.3 Grouting or Bedding 277
   7.5.4 Bolts in Tension 277
      7.5.4.1 Anchorage of Straight or Cogged Bars 277
      7.5.4.2 Cone Failure 278
      7.5.4.3 Embedment Lengths 279
      7.5.4.4 Minimum Edge Distance for Tensile Loads 280
   7.5.5 Bolts in Shear 282
   7.5.6 Corrosion 283
7.6 Slab Design 283
   7.6.1 Design Principles 283
   7.6.2 Slab Thickness 284
   7.6.3 Joints 284
      7.6.3.1 General 284
      7.6.3.2 Sawn Joints 284
      7.6.3.3 Cast-In Crack Initiators 285
      7.6.3.4 Keyed Joints 286
      7.6.3.5 Dowelled Joints 287
      7.6.3.6 Joint Spacing and Reinforcement 287
7.7 Design Example – Footings

7.7.1 Typical Portal Footings
  7.7.1.1 Bored Piers
  7.7.1.2 Pad Footings
7.7.2 End Wall Column Footings
7.7.3 Main Portal Footings in Bracing Bays
  7.7.3.1 Corner Columns
  7.7.3.2 Column on Grid B2
  7.7.3.3 Columns on Grids A2, A8 and B8
7.7.4 Holding Down Bolts for Portal Columns
7.7.5 Holding Down Bolts for End Wall Columns

7.8 Design Example - Slab

7.8.1 Design Criteria
7.8.2 Slab Thickness Design
7.8.3 Joints
7.8.4 Reinforcement

7.9 References

8 CRANE RUNWAY BEAMS

8.1 General
8.2 Design Procedure for Crane Runways and Supporting Structure
8.3 Design of Crane Runway Beams
  8.3.1 General
  8.3.2 Design Loads and Moments
  8.3.3 Member Capacity in Major Axis Bending $\phi M_{ax}$
    8.3.3.1 AS 4100 Beam Design Rules
    8.3.3.2 Proposed Monosymmetric Beam Design Rules
  8.3.4 Crane Runway Beam Deflections
8.4 Design of Supporting Structure
  8.4.1 Portal Frame Structure
  8.4.2 Portal Frame Loads
    8.4.2.1 General
    8.4.2.2 Serviceability Wind Speeds
  8.4.3 Portal Frame Deflection Limits
8.5 Design Example – Crane Runway Beams and Supporting Structure
  8.5.1 General
  8.5.2 Load Cases
  8.5.3 Crane Runway Beams
    8.5.3.1 Major Axis Bending Moments
    8.5.3.2 Minor Axis Bending Moments
    8.5.3.3 Combined Actions
    8.5.3.4 Check Major Axis Compound Section Moment Capacity $\phi M_{ax}$
    8.5.3.5 Deflections
    8.5.3.6 Vertical Shear Capacity
    8.5.3.7 Shear Buckling Capacity
    8.5.3.8 Shear and Bending Interaction
    8.5.3.9 Bearing Capacity of Crane Runway Beam
    8.5.3.10 Check Local Transverse Bending of Compression Flange
    8.5.3.11 Check Effect of Vertical Loads on Web
    8.5.3.12 Check Effect of Eccentric Rail Loading on Crane Runway Beam Web
    8.5.3.13 Check Effect of Web Buckling Under Vertical Loads
    8.5.3.14 Fatigue
    8.5.3.15 Check Effect of Eccentric Corbel Loading on Column
  8.5.4 Check Portal Frame
    8.5.4.1 General
    8.5.4.2 Loads
    8.5.4.3 Load Combinations
    8.5.4.4 Columns
MONORAILS................................................................................................................... 349
9.1 Introduction 349
9.2 Structural Design 350
9.2.1 General 350
9.2.2 Loads 350
9.2.2.1 General 350
9.2.2.2 Vertical Loads 351
9.2.2.3 Lateral Loads 352
9.2.2.4 Dynamic Factors 352
9.2.3 Member Capacity in Major Axis Bending $\phi M_{bx}$ 353
9.2.3.1 General 353
9.2.3.2 Segments Restrained at Both Ends 353
9.2.3.3 Cantilevers 354
9.2.4 Elastic Buckling Moment $M_{oa}$ – Effective Length Approach 354
9.2.4.1 General 354
9.2.4.2 Typical Values of $k_r$, $k_l$ and $k_t$ 355
9.2.5 Elastic Buckling Moment $M_{ob}$ – Design by Buckling Analysis 357
9.2.5.1 Advantages of Using Design by Buckling analysis 357
9.2.5.2 Single and Continuous Spans 357
9.2.5.3 Cantilevers 358
9.2.6 Member Capacity in Major Axis Bending $\phi M_{bac}$ for Curved Monorails 360
9.2.7 Local Bottom Flange Bending 361
9.2.8 Web Thickness 365
9.2.9 Deflections 365
9.3 Design Example I – 2 Tonne Single Span Monorail 366
9.3.1 Description 366
9.3.2 Design Loads 367
9.3.3 Preliminary Sizing 367
9.3.4 Check Flange Thickness 368
9.3.5 Check Member Bending Capacity 369
9.3.5.1 Design by Buckling Analysis 369
9.3.5.2 Effective Length Method 370
9.3.5.3 Comparison of Methods 370
9.3.6 Web Thickness 371
9.3.7 Deflections 371
9.3.7.1 Vertical 371
9.3.7.2 Horizontal 371
9.3.8 Summary 372
9.4 Design Example II – 1 Tonne Cantilever Monorail 372
9.4.1 Description 372
9.4.2 Design Load 373
9.4.3 Preliminary Sizing 374
9.4.4 Check Flange Thickness 374
9.4.5 Check Member Bending Capacity 375
9.4.5.1 Cantilever 375
9.4.5.2 Back Span 379
9.4.6 Check Web Thickness 380
9.4.7 Deflections 380
9.4.7.1 Vertical 380
9.4.7.2 Horizontal 381
9.4.8 Summary 381
9.5 Design Example III – 5 Tonne Single Span Monorail 381
9.5.1 Description 381
9.5.2 Design Loads 382
9.5.3 Preliminary Sizing 383
9.5.4 Check Flange Thickness 383
9.5.5 Check Member Bending Capacity 385
9.5.6 Check Web Thickness 385
9.5.7 Deflections 386
  9.5.7.1 Vertical 386
  9.5.7.2 Horizontal 386
9.5.8 Summary 386
9.6 References 386
Appendix 9.1 Design Capacity Tables 389
Appendix 9.2 Background to Design Capacity Tables 398
Appendix 9.3 Effective Length Factors 401
Appendix 9.4 Hoist & Trolley Data 404

APPENDIX I DRAWINGS ........................................................................................................ 409
APPENDIX II FRAME ANALYSIS OUTPUT ................................................................. 419
APPENDIX III LIMSTEEL OUTPUT .............................................................................. 439
APPENDIX IV LIMCON OUTPUT ............................................................................... 444
APPENDIX V OUTPUT FOR PORTAL FRAME WITH CRANE .................................... 461
SUBJECT INDEX .............................................................................................................. 467