

# 7 Footings & Slabs

## 7.1 GENERAL

Portal frames are commonly designed on the assumption of pinned bases, although it is sometimes an advantage to fix the bases. A pinned base is designed assuming no moment transfer, so that the only design forces at the base of the column are axial and shear forces. In reality, there will be some moment resistance at the base. Fixing or partially fixing the bases reduces the lateral frame deflections significantly and this can result in substantial savings in frame weight if the columns are tall. Of course, the savings in weight will be offset by the extra cost of footings and holding down bolts. Reductions in frame bending moments due to fixing of bases are not usually as significant as the reductions in deflections. Typical base plate and holding down arrangements for pinned and fixed bases are shown in Figure 5.5.

The most common footing type for a pinned base is the square pad footing as shown in Figure 7.1, although bored piers can be very economical in clayey soils because the adhesion of even soft clays to the sides of a bored pier can result in substantial holding down capacity. The lateral capacity also needs to be considered.

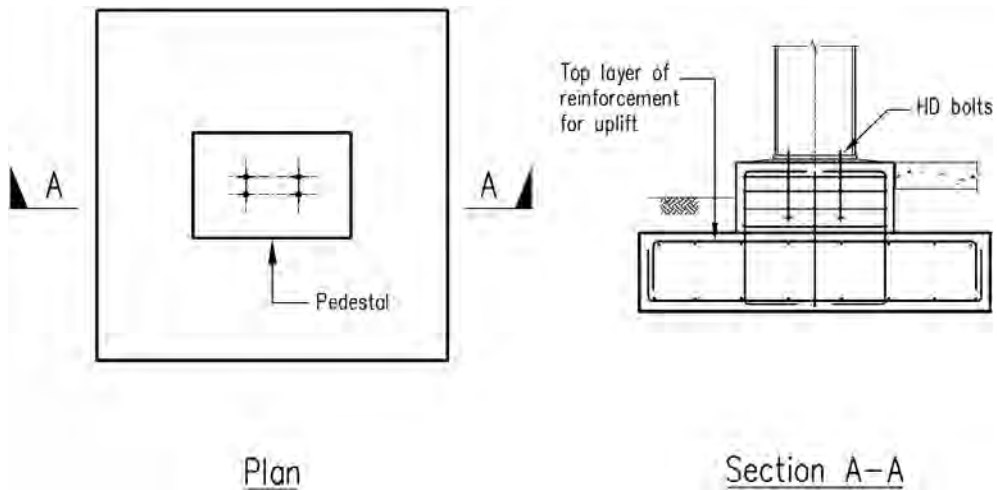


Figure 7.1 *Typical Pad Footing*

In expansive clays, it is usually much cheaper to design details for relative movement of the column footings and slab rather than to use a raft footing for the whole floor slab. Such detailing includes isolation joints between column footings and the floor slab. It may also be necessary to suspend the bridging for wall girts from the eaves rather than prop the bridging from the floor slab to allow the floor to move relative to the wall. Paved areas or concrete strips around the perimeter of the building will help maintain a more constant moisture content in the soil under the edge of the building. If masonry walls are used in some parts such as office and administration areas, it may be necessary to provide a raft foundation in these regions. If the masonry is restricted to reinforced block perimeter walls, the footings

and the blockwork can sometimes be designed to cater for differential ground movements along the length of the wall without resorting to a raft foundation.

It should be remembered that the expansiveness of clay soils cannot be realistically assessed from Atterberg Limits. This is because Atterberg Limits are determined for the clay fraction of the soil which might be a small proportion of the whole sample. Shrink/swell tests which are carried out using whole samples of soil give a much better indication of likely soil movements.

There are cases where it may be necessary to use a full raft or even a piled foundation for an industrial building. For example, full raft foundations have been used successfully in reclaimed areas where there have been two to three metres of compacted fill over marine mud and the site has been preloaded for many months. If a raft footing is used for a portal framed building, it may be beneficial to design the frames with fixed bases with the moments at the column bases resisted by ribs on the frame centrelines.

## 7.2 DESIGN UPLIFT FORCES

The frame computer analysis provides factored reactions for the design of footings. In uplift cases, the design uplift applied by the superstructure to the footings is  $W_u - 0.9G$ , where  $W_u$  is the limit state uplift and  $G$  is the dead load reaction. In calculating the resistance to uplift, the weight of footings must also be factored by 0.9.

## 7.3 PAD FOOTINGS

In industrial buildings without cranes, excessive bearing pressure under pad footings is not usually a problem because the footing size necessary to restrain uplift is often large enough to ensure that the bearing pressure under gravity loads is less than 100 kPa. An allowable bearing pressure of 100 kPa is readily achieved on all but the poorest of sites. If the allowable bearing pressure is less than 100 kPa, then a raft foundation, piers or even piles may be necessary.

One of the best collections of geotechnical data for foundations is contained in Section 3 of the superseded Bridge Design Code SA HB77.3-1996 [1] and its commentary SA HB77.3.1-1996 [2]. Ultimate limit state bearing pressures for cohesive and non-cohesive soils are tabulated, and principles for checking the serviceability limit state are given. However at this stage, the building industry has not fully embraced limit state bearing pressures for pad footings and allowable bearing pressures are still often provided in geotechnical reports.

In determining the weight of pad footings necessary to resist factored uplift forces, it is important to take advantage of the weight of the slab and any soil contributing. Apart from the weight of the slab and soil directly above the footing, the slab beyond the edge of the footing also contributes. A contribution of a one metre strip of slab beyond the edge of the pad footing would be a reasonable, perhaps conservative, assumption in the absence of detailed calculations. Such calculations could involve a yield line analysis of the slab. However this would be complex and subject to many variables such as joint layout, tolerance on mesh position in the slab and random cracking of the slab due to shrinkage. Realistically, therefore, it becomes a matter of engineering judgment as to how much of the slab will

# Design of Portal Frame Buildings

including  
Crane Runway Beams and Monorails

Fourth Edition

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# Contents

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CONTENTS .....	i
PREFACE.....	ix
NOTATION .....	xi
1 INTRODUCTION .....	1
1.1 Key Features of Portal Framed Buildings	1
1.2 Design Issues	3
1.2.1 General Design Criteria	3
1.2.2 Structural Design	3
1.2.2.1 Introduction	3
1.2.2.2 Grey Areas in Design	4
1.2.2.3 Aims of This Book	7
1.3 Limit States Design	7
1.3.1 Background	7
1.3.2 Design for the Strength Limit State	8
1.3.3 Design for the Serviceability Limit State	9
1.4 Design Examples	9
1.4.1 Building	9
1.4.2 Crane Runway Beams	11
1.4.3 Monorails	11
1.5 References	12
2 LOADS .....	15
2.1 Background	15
2.2 Dead Loads	15
2.3 Live Loads	16
2.4 Wind Loads	16
2.4.1 Regional Wind Speed	16
2.4.2 Site Wind Speeds	17
2.4.3 Terrain Category	18
2.4.4 Design Wind Speeds and Pressures	19
2.4.5 External Pressures	21
2.4.6 Internal Pressures	21
2.4.7 Area Reduction Factor ( $K_a$ )	24
2.4.8 Action Combination Factor ( $K_c$ )	24
2.4.9 Local Pressure Factors ( $K_l$ )	25
2.5 Seismic Loads	26
2.6 Load Combinations	27
2.6.1 Strength Limit State	27
2.6.2 Serviceability Limit State	28
2.7 Design Example - Loads	28
2.7.1 Dead Loads	28
2.7.2 Live Loads	29
2.7.3 Wind Loads	29
2.7.3.1 Basic Wind Data	29
2.7.3.2 External Wind Pressures	31
2.7.3.3 Internal Wind Pressures	33
2.7.3.4 Peak Local Pressures	35
2.7.4 Seismic Loads	36
2.7.5 Load Cases for Portal Frames	37
2.7.6 Load Combinations	41
2.8 References	42

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 $M_{bx}$ 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 $M_{bx}$ 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	120
4.9.1	General	120
4.9.2	Problems of Excessive Deflection	121
4.10	Design Example – Frame Design	124
4.10.1	Frame Analysis	124
4.10.1.1	Preliminary Design	124
4.10.1.2	Haunch Properties	125
4.10.1.3	Methods of Analysis	126
4.10.2	Frame Deflections	127
4.10.2.1	Sidesway Deflection	127
4.10.2.2	Rafter Deflection	127
4.10.3	Columns (460UB74)	127
4.10.3.1	Column Section Capacities	127
4.10.3.2	Column Member Capacities	128
4.10.3.3	Column Combined Actions	128
4.10.4	Rafters (360UB45)	132
4.10.4.1	Rafter Section Capacities	132
4.10.4.2	Rafter Member Capacities	133
4.10.4.3	Rafter Combined Actions	134
4.10.5	LIMSTEEL Results	145
4.10.6	End Wall Frames	145
4.10.7	End Wall Columns	145
4.10.7.1	Inside Flange in Tension (Inward Loading)	145
4.10.7.2	Inside Flange in Compression (Outward Loading)	147
4.10.7.3	Axial Compression Under Gravity Loads	148
4.10	References	149
5	FRAME CONNECTIONS .....	151
5.1	General	151
5.2	Bolted Knee and Ridge Joints	152
5.3	Column Bases	154
5.3.1	Holding Down Bolts	154
5.3.2	Base Plates	155
5.4	Design Example - Frame Connections	155
5.4.1	General	155
5.4.2	Knee Joint	156
5.4.2.1	General	156
5.4.2.2	Calculate Design Actions	157
5.4.2.3	Bottom Flange Connection	163
5.4.2.4	Top Flange Connection	185
5.4.2.5	Summary of Adopted Knee Connection Details	197
5.4.3	Ridge Connection	197
5.4.3.1	General	197
5.4.3.2	Calculate Design Actions	198
5.4.3.3	Carry Out Design Checks	200
5.4.3.4	Summary of Adopted Ridge Joint Details	205
5.4.4	Base Plates	206
5.4.5	End Wall Column Connections	211
5.4.5.1	General	211
5.4.5.2	Centre Column - Top Connection	211
5.4.5.3	Quarter-Point Columns – Top Connection	213
5.5	References	214
6	ROOF & WALL BRACING .....	215
6.1	General	215
6.2	Erection Procedure	216



6.3	Roof and Wall Bracing Forces	216
6.3.1	Longitudinal Wind Forces	216
6.3.2	Rafter 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 Rafter 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	Design Uplift Forces	270
7.3	Pad Footings	270
7.4	Bored Piers	271
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	288
7.7.1	Typical Portal Footings	288
7.7.1.1	Bored Piers	288
7.7.1.2	Compare Pad Footings	290
7.7.2	End Wall Column Footings	291
7.7.3	Main Portal Footings in Bracing Bays	292
7.7.3.1	Corner Columns	292
7.7.3.2	Column on Grid B2	292
7.7.3.3	Columns on Grids A2, A8 and B8	293
7.7.4	Holding Down Bolts for Portal Columns	293
7.7.5	Holding Down Bolts for End Wall Columns	294
7.8	Design Example - Slab	294
7.8.1	Design Criteria	294
7.8.2	Slab Thickness Design	294
7.8.3	Joints	295
7.8.4	Reinforcement	296
7.9	References	296
8	CRANE RUNWAY BEAMS .....	297
8.1	General	297
8.2	Design Procedure for Crane Runways and Supporting Structure	299
8.3	Design of Crane Runway Beams	300
8.3.1	General	300
8.3.2	Design Loads and Moments	300
8.3.3	Member Capacity in Major Axis Bending $\phi M_{bx}$	301
8.3.3.1	AS 4100 Beam Design Rules	301
8.3.3.2	Proposed Monosymmetric Beam Design Rules	302
8.3.4	Crane Runway Beam Deflections	305
8.4	Design of Supporting Structure	305
8.4.1	Portal Frame Structure	305
8.4.2	Portal Frame Loads	306
8.4.2.1	General	306
8.4.2.2	Serviceability Wind Speeds	306
8.4.3	Portal Frame Deflection Limits	307
8.5	Design Example – Crane Runway Beams and Supporting Structure	308
8.5.1	General	308
8.5.2	Load Cases	309
8.5.3	Crane Runway Beams	311
8.5.3.1	Major Axis Bending Moments	311
8.5.3.2	Minor Axis Bending Moments	312
8.5.3.3	Combined Actions	315
8.5.3.4	Check Major Axis Compound Section Moment Capacity $\phi M_{sy}$	315
8.5.3.5	Deflections	315
8.5.3.6	Vertical Shear Capacity	316
8.5.3.7	Shear Buckling Capacity	316
8.5.3.8	Shear and Bending Interaction	317
8.5.3.9	Bearing Capacity of Crane Runway Beam	317
8.5.3.10	Check Local Transverse Bending of Compression Flange	319
8.5.3.11	Check Effect of Vertical Loads on Web	321
8.5.3.12	Check Effect of Eccentric Rail Loading on Crane Runway Beam Web	321
8.5.3.13	Check Effect of Web Buckling Under Vertical Loads	324
8.5.3.14	Fatigue	325
8.5.3.15	Check Effect of Eccentric Corbel Loading on Column	325
8.5.4	Check Portal Frame	327
8.5.4.1	General	327
8.5.4.2	Loads	327
8.5.4.3	Load Combinations	329
8.5.4.4	Columns	329

8.6	References	334
Appendix 8.1	Design Capacity Tables	335
Appendix 8.2	Background to Design Capacity Tables	342
9	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 $k_t$ , $k_r$ and $k_l$	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 $\phi M_{bxc}$ 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