



Design of Structural Steelwork

W. M. C. McKenzie

19 x 25



© W.M.C. McKenzie 1998

All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission.

No paragraph of this publication may be reproduced, copied or transmitted save with written permission or in accordance with the provisions of the Copyright, Designs and Patents Act 1988, or under the terms of any licence permitting limited copying issued by the Copyright Licensing Agency, 90 Tottenham Court Road, London W1P 9HE.

Any person who does any unauthorised act in relation to this publication may be liable to criminal prosecution and civil claims for damages.

The author has asserted his right to be identified as the author of this work in accordance with the Copyright, Designs and Patents Act 1988.

First published 1998 by
MACMILLAN PRESS LTD
Houndmills, Basingstoke, Hampshire RG21 6XS
and London
Companies and representatives throughout the world

ISBN 0-333-71579-9

A catalogue record for this book is available from the British Library.

This book is printed on paper suitable for recycling and made from fully managed and sustained forest sources.

10 9 8 7 6 5 4 3 2 1
07 06 05 04 03 02 01 00 99 98

Printed in Malaysia

Contents

Preface	xii
Acknowledgements	xiii
1. Structural Steelwork	1
1.1 Introduction	1
1.2 The Design Process	5
1.2.1 Aims of Design	5
1.2.2 Structural Loading	6
1.2.3 Structural Analysis and Load Distribution	8
1.3 Example 1.1 Load distribution one-way spanning slabs	8
1.4 Example 1.2 Two-way spanning slabs	9
1.5 Example 1.3 Secondary beams	11
1.6 Example 1.4 Combined one-way, two-way slabs and beams	12
1.7 Limit State Design BS 5950:Part 1: 1990	13
1.7.1 Ultimate Limit State	14
1.7.2 Serviceability Limit State	14
1.7.3 Partial Safety Factors	14
1.7.4 Application of Partial Safety Factors	14
1.8 Example 1.5 Brewery part floor plan load distribution	15
1.9 Application of Wind Loads	18
1.10 Example 1.6 Storage hopper	18
1.11 Example 1.7 Industrial warehouse	22
1.12 Example 1.8 Radar reflector	32
2. Flexural Members	34
2.1 Introduction	34
2.1.1 Plastic Sections	37
2.1.2 Compact Sections	38
2.1.3 Semi-Compact Sections	38
2.1.4 Slender Sections	38
2.2 Shear Capacity (Clause 4.2.3)	39
2.3 Example 2.1 Shear check of a simply supported beam	40
2.4 Moment Capacity (Clause 4.2.5)	41
2.4.1 Compression Flange Restraint	41
2.4.2 Effective Length L_e (Clauses 4.3.5 and 4.3.6)	44
2.4.3 Moment Capacity (M_c) of Beams with Full Lateral Restraint	46
2.5 Example 2.2 Bending in fully restrained beam	47
2.6 Moment Capacity (M_b) of Beams without Full Lateral Restraint (Clause 4.3.7)	48
2.6.1 Rigorous Method (Clause 4.3.7.1)	48
2.7 Example 2.3 Beam with intermittent lateral restraint	49

2.8	Example 2.4	Beam with intermittent lateral restraint	53
2.9	Example 2.5	Rectangular hollow section as a beam	56
2.10	Example 2.6	Cantilever beam	57
2.11	Web Buckling and Web Bearing		60
	2.11.1	Web Buckling (Clause 4.5.2)	61
	2.11.2	Web Bearing (Clause 4.5.3)	62
2.12	Example 2.7	Web bearing and web buckling at support	63
2.13	Deflection of Beams (Clause 2.5.1)		65
	2.13.1	Equivalent UDL Technique	66
2.14	Example 2.8	Deflection of simply supported beam	68
2.15	Conservative Method for Lateral Torsional Buckling Moment Capacity (Clause 4.3.7.7)		70
2.16	Example 2.9	Simply supported beam 1 – conservative method	70
2.17	Example 2.10	Simply beam 2 – conservative method	71
2.18	Safe Load Tables		72
2.19	Example 2.11	Beam with intermittent lateral restraint - Use of safe load tables	73
	2.19.1	Shear	75
	2.19.2	Bending	75
	2.19.3	Web Buckling	75
	2.19.4	Web Bearing	76
	2.19.5	Deflection	76
2.20	Example 2.12	Pedestrian walkway	77
2.21	Solution to Example 2.2		78
2.22	Solution to Example 2.12		82
3.	Axially Loaded Members		86
3.1	Introduction		86
3.2	Pin-jointed Frames		87
3.3	Résumé of Analysis Techniques		90
	3.3.1	Method of Sections	90
3.4	Example 3.1	Pin-jointed truss	91
	3.4.1	Joint Resolution	93
	3.4.2	Tension Coefficients	96
3.5	Example 3.2	Two dimensional plane-truss	97
3.6	Example 3.3	Three dimensional space truss	98
3.7	Design of Tension Members (Clause 4.6)		99
3.8	Example 3.4	Lattice girder	105
3.9	Design of Compression Members (Clause 4.7)		106
	3.9.1	Slenderness (Clause 4.7.3)	107
	3.9.2	Compressive Resistance (Clause 4.7.4)	109
3.10	Example 3.6	Secondary bracing in lattice girder	114
3.11	Example 3.7	Concentrically loaded single storey column	118
3.12	Column Baseplates		120
3.13	Example 3.7	Slab base	121

Members Subject to Combined Axial and Flexural Loads	123
4.1 Introduction	123
4.1.1 <i>Combined Tension and Bending</i>	123
4.1.2 <i>Reduced Moment Capacity</i>	125
4.1.3 <i>Combined Compression and Bending</i>	127
4.2 Eccentricity of Loading	129
4.3 Section Classification	130
4.4 Example 4.1 Industrial unit	130
4.5 Columns in Simple Multi-Storey Construction (<i>Clause 4.7.7</i>)	135
4.6 Example 4.2 Multi-storey column in simple construction	136
4.7 Example 4.3 Lattice girder with secondary bending	141
Connections	145
5.1 Introduction	145
5.1.1 <i>Simple Connections</i>	146
5.1.2 <i>Moment Connections</i>	147
5.2 Bolted Connections	153
5.2.1 <i>Black Bolts</i>	153
5.2.2 <i>High Strength Friction Grip Bolts (H.S.F.G.)</i>	156
5.2.3 <i>Design of Simple Connections</i>	158
5.3 Welded Connections	159
5.3.1 <i>Fillet Welds</i>	160
5.3.2 <i>Butt Welds</i>	161
5.3.3 <i>Design of Fillet Weld Connections</i>	162
5.4 Beam End Connections	164
5.4.1 <i>Double-Angle Web Cleats</i>	164
5.4.2 <i>Flexible End Plates</i>	165
5.4.3 <i>Fin Plates</i>	165
5.5 Example 5.5 Web cleat, end plate and fin plate connections	166
5.6 Design of Moment Connections	167
5.6.1 <i>Typical Site Connection Using H.S.F.G. Bolts</i>	168
5.6.2 <i>Example 5.6 Moment connection in rectangular portal frame</i>	168
5.6.3 <i>Example 5.7 Crane bracket moment connection</i>	170
5.7 Splices	171
5.7.1 <i>Beam Splices</i>	171
5.7.2 <i>Example 5.8 Beam splice</i>	172
5.7.3 <i>Column Splices</i>	178
5.7.4 <i>Example 5.9 Column splice</i>	180
5.8 Solution to Example 5.1	183
5.9 Solution to Example 5.2	185
5.10 Solution to Example 5.5	187
5.11 Solution to Example 5.6	196

6. Plate Girders	198
6.1 Introduction	198
6.1.1 <i>Design Load Effects</i>	200
6.2 Initial Sizing	201
6.3 Moment and Shear Capacity	201
6.4 Deflection	203
6.5 Intermediate Stiffeners	203
6.6 Load Bearing Stiffeners	203
6.7 Example 6.1 Plate girder in multi-storey office block	203
6.7.1 <i>Design Loading</i>	205
6.7.2 <i>Column Loads</i>	205
6.7.3 <i>Initial Sizing</i>	206
6.7.4 <i>Section Classification (Clause 3.5)</i>	207
6.7.5 <i>Flanges</i>	207
6.7.6 <i>Web</i>	208
6.7.7 <i>Moment Capacity (Clause 4.4.4.2(a))</i>	209
6.7.8 <i>Shear Capacity (Clause 4.4.5.3)</i>	209
6.7.9 <i>Deflection (Clause 2.5)</i>	210
6.7.10 <i>Intermediate Stiffeners (Clause 4.4.6)</i>	212
6.7.11 <i>Load Bearing Stiffeners (Clause 4.5)</i>	213
6.7.12 <i>Flange to Web Connection</i>	217
6.8 Example 6.2 Plate girder with intermittent restraint to flange	218
6.9 Solution to Example 6.2	219
7. Concise Eurocode 3 C-EC3	230
7.1 Introduction	230
7.1.1 <i>National Application Document (NAD)</i>	230
7.1.2 <i>Concise EC3 (C-EC 3)</i>	230
7.2 Terminology, Symbols and Conventions	231
7.2.1 <i>Decimal Point</i>	231
7.2.2 <i>Actions</i>	231
7.2.3 <i>Resistance</i>	232
7.2.4 <i>Subscripts</i>	232
7.2.5 <i>Design Values</i>	232
7.2.6 <i>Partial Safety Factors</i>	232
7.2.7 <i>Symbols</i>	233
7.2.8 <i>Conventions</i>	234
7.2.9 <i>Materials</i>	235
7.3 Section Classification	236
7.4 Use of C-EC 3	236
7.4.1 <i>Example 7.1 Beam with full lateral restraint</i>	236
7.5 Lateral Torsional Buckling (LTB) (Clause 5.5.5)	246
7.6 Example 7.2 Beam with intermediate and end restraints	247
7.7 Example 7.3 Truss members with axial tension/compression	251
7.8 Example 7.4 Concentrically loaded single storey column	256

7.9 Axially Loaded Members with Moments	260
7.10 Example 7.5 Multi-storey column in simple construction	263

Bibliography	270
---------------------	-----

Index	272
--------------	-----