TABLE OF CONTENTS

FOREWORD xi

PREFACE xiii

Chapter 1

INTRODUCTION TO COLD-FORMED STEEL DESIGN 1

1.1 General 1

1.2 Cold-formed steel sections 4

1.2.1 Types of cold-formed steel sections 4

1.2.2 Manufacturing 9

1.2.3 Some peculiar characteristics of cold-formed steel sections 12

1.3 Peculiar problems of cold-formed steel design 15

1.3.1 Buckling strength of cold-formed steel members 15

1.3.2 Torsional rigidity 20

1.3.3 Web crippling 21

1.3.4 Ductility and plastic design 22

1.3.5 Connections 22

1.3.6 Design assisted by testing 23

1.3.7 Design standards 23

1.3.7.1 North American Cold-formed Steel Specification, 2001 Edition (AISI, 2001) and 2007 Edition (AISI, 2007) 23

1.3.7.2 Australian/New Zealand Standard – AS/NZS 4600, 2005 Edition (AS/NZS, 2005) 25

1.3.7.3 Eurocode 3 – Design of Steel Structures, Part 1.3 – General Rules, Supplementary Rules for Cold-formed Thin Gauge Members and Sheeting 26

1.3.8 Fire resistance 27

1.3.9 Corrosion 28

Bibliografische Informationen
http://d-nb.info/1008664189

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

1.3.10 Sustainability of cold-formed steel construction 28
1.4 Main applications of cold-formed steel 31
1.4.1 Advantages of cold-formed steel in building construction 31
1.4.1.1 Advantages during construction 31
1.4.1.2 Advantages in service 32
1.4.2 Applications 34

Chapter 2
BASIS OF DESIGN 47
2.1 General 47
2.2 Limit state design 49
2.3 Actions on structures. Combinations of actions 53
2.3.1 Verification at the Ultimate Limit State 54
2.3.2 Verification at the Serviceability Limit State 57
2.3.2.1 Deflections 60
2.3.2.2 Dynamic effects 63
2.4 Materials 65
2.4.1 General 65
2.4.2 Structural steel 67
2.4.2.1 Material properties of base material 67
2.4.2.2 Material properties of cold-formed sections and sheeting 68
2.4.2.3 Thickness and thickness tolerances 72
2.5 Methods of analysis and design 73
2.5.1 Methods of analysis – Global frame analysis 73
2.5.2 Finite Element Methods (FEM) for analysis and design 77
2.5.3 Design assited by testing 80
2.6 Imperfections 85
2.6.1 Imperfections for global analysis of frames 85
2.6.2 Imperfections for analysis of bracing systems 90
2.6.3 Role of imperfections in advanced numerical simulation 91
2.6.3.1 Section imperfections 93
2.6.3.2 Residual stresses 94

Chapter 3
BEHAVIOUR AND RESISTANCE OF CROSS SECTION 97
3.1 General 97
3.2 Properties of gross cross section 100
3.2.1 Nominal dimensions and idealisation of cross section 100
3.2.2 Net geometric properties of perforated sections 104
3.2.3 Dimensional limits of component walls of cold-formed steel sections 107
3.2.4 Modelling of cross section component walls for analysis 110
3.3 Flange curling 111
3.4 Shear lag 114
3.5 Local buckling 116
3.5.1 Sectional buckling modes in thin-walled sections 116
3.5.2 Elastic buckling of thin plates 118
3.6 Distortional buckling: analytical methods for predicting elastic distortional buckling stresses 129
3.6.1 The method given in EN 1993-1-3:2006 130
3.7 Design against local and distortional buckling according to EN 1993-1-3 132
3.7.1 General 132
3.7.2 Plane elements without stiffeners 133
3.7.3 Plane elements with edge or intermediate stiffeners 136
3.7.3.1 General 136
3.7.3.2 Plane elements with edge stiffeners 139
3.7.3.2.1 Conditions 139
3.7.3.3.2 General procedure 140
3.7.3.3 Plane elements with intermediate stiffeners 162
3.7.3.3.1 Conditions 162
3.7.3.3.2 General procedure 163
3.7.3.4 Trapezoidal sheeting profiles with intermediate stiffeners 165
3.7.3.4.1 General 165

3.7.3.4.2 Flanges with intermediate stiffeners 166
3.7.3.4.3 Webs with up to two intermediate stiffeners 169
3.7.3.4.4 Sheeting with flange stiffeners and web stiffeners 174
3.8 Resistance of cross sections 175
3.8.1 General 175
3.8.2 Axial tension 176
3.8.3 Axial compression 180
3.8.4 Bending moment 185
3.8.4.1 Elastic and elastoplastic resistance with yielding at the compressed flange 185
3.8.4.2 Elastic and elastoplastic resistance with yielding at the tension flange only 188
3.8.4.3 Effects of shear lag 188
3.8.5 Shear force 192
3.8.6 Torsional moment 194
3.8.7 Local transverse forces 203
3.8.7.1 General 203
3.8.7.2 Cross sections with a single unstiffened web 204
3.8.7.3 Cross sections with two or more unstiffened webs 214
3.8.7.4 Stiffened webs 217
3.8.8 Combined tension and bending 218
3.8.9 Combined compression and bending 220
3.8.10 Combined shear force, axial force and bending moment 224
3.8.11 Combined bending moment and local load or support reaction 231

Chapter 4

BEHAVIOUR AND DESIGN RESISTANCE OF BAR MEMBERS 239

4.1 General 239
4.2 Compression members 241
4.2.1 Theoretical background 241
4.2.1.1 Ideal elastic members 241

4.2.1.2 Imperfect member 248
4.2.1.3 Class 4 sections: local-global interactive buckling 253
4.2.2 Buckling resistance of uniform members in compression. Design according to EN 1993-1-3 259
4.2.2.1 Flexural buckling 260
4.2.2.2 Torsional buckling and flexural-torsional buckling 262
4.3 Buckling strength of bending members 277
4.3.1 Theoretical background 277
4.3.2 Design according to EN 1993-1-3 289
4.3.2.1 Lateral-torsional buckling of members subject to bending 289
4.3.2.2 Simplified assessment methods for beams with restraints in building 291
4.4 Buckling of members in bending and axial compression 299
4.4.1 Theoretical background 299
4.4.2 Design of beam-columns according to EN 1993-1-1 and EN 1993-1-3 303
4.4.2.1 General method for lateral and lateral-torsional buckling of structural components 311
4.5 Beams restrained by sheeting 324
4.5.1 General. Constructional detailing and static system 324
4.5.2 Modelling of beam-sheeting interaction 329
4.5.3 Design of beams restrained by sheeting according to EN 1993-1-3 333
4.5.3.1 Design criteria 334
4.5.3.2 Design resistance 336
4.5.3.3 Rotational restraint given by the sheeting 342
4.5.4 Simplified design of purlins 346
4.6 Design of beams at serviceability limit states 363

Chapter 5
SHEETING ACTING AS DIAPHRAGM 367
5.1 Introduction 367

5.2 General design considerations for diaphragm action 372
5.2.1 Conditions and restrictions for the use of stressed skin design 372
5.2.2 Types of diaphragms 375
5.2.3 Irregular roof chape 377
5.2.4 Design criteria 378
5.2.4.1 Diaphragm flexibility 378
5.2.4.2 Diaphragm strength 380
5.2.5 Interaction of diaphragm action and rigid-jointed frames 381
5.2.6 The danger of ignoring stressed skin action in conventional construction 381
5.3 Design procedures for sheeting acting as diaphragm 382
5.3.1 Design expressions for shear flexibility of diaphragm 382
5.3.1.1 Sheeting spanning perpendicular to length of diaphragm 382
5.3.1.2 Sheeting spanning parallel to length of diaphragm 394
5.3.2 Design expression for shear strength of diaphragms 397
5.3.2.1 Sheeting spanning perpendicular to length of diaphragms 397
5.3.2.2 Sheeting spanning parallel to length of diaphragm 402
5.3.2.3 Buckling strength of sheeting in shear 404
5.3.2.3.1 General 404
5.3.2.3.2 Global shear buckling 405
5.3.2.3.3 Local shear buckling 406
5.3.2.4 Effect of combined loads 407
5.3.3 Diaphragms with openings 407
5.3.3.1 Discrete openings 408
5.3.3.1.1 Requirements for discrete openings 408
5.3.3.1.2 Flexibility of diaphragms with discrete openings 409

5.3.3.1.3 Strength of diaphragms with discrete openings 409
5.3.3.2 Strip openings 410
5.3.4 Two skin envelopes 410
5.4 Interaction of the shear diaphragms with supporting framing 412
5.4.1 General 412
5.4.2 Elastic design of framing 413
5.4.2.1 Rectangular frames: all frames loaded 413
5.4.2.2 Pitched roof frames: all frames loaded 415
5.4.2.3 One frame loaded 417
5.4.3 Plastic design of framing 418
5.4.3.1 Rectangular frames 418
5.4.3.2 Pitched roof frames 419
5.4.4 Modelling of diaphragm effect for frame analysis 420
5.5 Diaphragm action of sandwich panels 422

Chapter 6
STRUCTURAL LINER TRAYS 437
6.1 Introduction 437
6.2 Design procedures for cassette sections 442
6.2.1 General 442
6.2.2 Axial compression 443
6.2.3 Moment resistance 444
6.2.3.1 Bending with the narrow flange in compression (wide flange in tension) 444
6.2.3.2 Bending with the wide flange in compression 447
6.2.4 Behaviour in shear 449
6.3 Design procedures for cassette panels acting as diaphragm 453
6.3.1 Cassettes spanning horizontal to the length of diaphragm (liner tray shear panels) 453
6.3.2 Some peculiar problems for design of wall panels of cassettes spanning vertically to the length of diaphragm 455
6.4 Combined effects 457

Chapter 7

CONNECTIONS 463

7.1 Introduction 463

7.2 Fastening techniques of cold-formed steel constructions 465

7.2.1 Mechanical fasteners 465

7.2.1.1 Mechanical fasteners for sections 466

7.2.1.2 Mechanical fasteners for sheeting 477

7.2.1.3 Mechanical fasteners for sandwich panels 478

7.2.2 Welding 480

7.2.2.1 Fusion arc welding 481

7.2.2.2 Resistance welding 483

7.2.2.3 Behaviour of cold-formed steel welds 484

7.2.3 Fastening based on adhesive bonding 486

7.3 Mechanical properties of connections 487

7.4 Design of connections 489

7.4.1 General design considerations 489

7.4.2 Design of connections with mechanical fasteners 491

7.4.2.1 General rules 492

7.4.2.2 Design of bolted connections 498

7.4.2.3 Design of connections with self-tapping screws 508

7.4.2.4 Design of connections with blind rivets 519

7.4.2.5 Design of connections with fired pins 520

7.4.3 Design of welded connections 523

7.4.3.1 General design and workmanship consideration 523

7.4.3.2 Design of spot welds 524

7.4.3.3 Fillet lap welds 526

7.4.3.4 Arc spot welds 528

7.5 Design assisted by testing of cold-formed steel connections 536

7.5.1 General 536

7.5.2 Fasteners in shear 537

7.5.3 Fasteners in tension 539

7.5.4 Evaluation of test results 540

7.5.4.1 General 540
7.5.4.2 Evaluation of tests results according to Annex A of EN 1993-1-3 541
7.5.4.3 Evaluation of test results under static loads according to European Recommendations 546

Chapter 8
BUILDING FRAMING 557
8.1 General information 557
8.2 Introduction 557
8.3 Construction systems 558
8.4 Stick built constructions 563
8.4.1 Foundation 563
8.4.2 Floors 564
8.4.3 Wall studs 567
8.4.4 Roof 569
8.4.5 On-site construction 570
8.5 Conceptual design 573
8.5.1 Architectural design 573
8.5.2 Thermal insulation 577
8.5.3 Soundproofing 578
8.5.4 Fire resistance 581
8.5.5 Vibration 583
8.5.6 Durability 584
8.5.7 Sustainability 587
8.6 Structural design 589
8.6.1 Structural conception 589
8.6.2 Design under vertical loads 592
8.6.2.1 Design of floors 593
8.6.2.2 Design of walls 595
8.6.2.3 Sheathing-braced design for vertical loads 597
8.6.3 Design under horizontal loads 598
8.6.3.1 "All-steel" lateral bracing 599
8.6.3.2 Structural behaviour of sheathed diaphragm 601
8.6.4 Specific design manuals 606

8.6.4.1 Prescriptive method for residential cold-formed steel framing 606
8.6.4.2 Workpack design for steel house 607
8.7 Case study: residential building 608
8.7.1 Architectural design 608
8.7.2 Conceptual design 611
8.7.2.1 Floor assembly 612
8.7.2.2 Wall assembly 614
8.7.3 Structural design 617
8.7.3.1 Reference codes 617
8.7.3.2 Loads 617
8.7.4 Design checking 620
8.7.4.1 Joist 620
8.7.4.2 Studs 624
8.7.5 Details 626

REFERENCES 633