TABLE OF CONTENTS

FOREWORD xiii

PREFACE xv

UK FOREWORD xix

NOTATION xxix

Chapter 1

INTRODUCTION 1

1.1 General 1
1.1.1 Aims of the book 1
1.1.2 Brief description of the contents of the book 10
1.1.3 Types of structural systems and joints covered 11
1.1.4 Basis of design 12

1.2 Definitions 12
1.2.1 Joint properties 14
1.2.2 Sources of joint deformation 15
1.2.3 Beam splices and column splices 19
1.2.4 Beam-to-beam joints 20
1.2.5 Column bases 21
1.2.6 Hollow section joints 22

1.3 Material choice 22

1.4 Fabrication and erection 26

1.5 Costs 27

1.6 Application of the “static approach” 27
1.6.1 Component approach 29
1.6.2 Hybrid joints aspects 35

1.7 Design tools 35
1.7.1 Types of design tools 36

1.7.2 Examples of design tools 37

1.8 Worked examples 40

Chapter 2

STRUCTURAL ANALYSIS AND DESIGN 43

2.1 Introduction 43
2.1.1 Elastic or elastoplastic analysis and verification process 44
2.1.2 First order or second order analysis 45
2.1.3 Integration of joint response into the frame analysis and design process 46

2.2 Joint modelling 47
2.2.1 General 47
2.2.2 Modelling and sources of joint deformation 49
2.2.3 Simplified modelling according to EN 1993 50
2.2.4 Concentration of the joint deformation 51

2.3 Joint idealisation 56
2.3.1 Elastic idealisation for an elastic analysis 57
2.3.2 Rigid-plastic idealisation for a rigid-plastic analysis 58
2.3.3 Non-linear idealisation for an elastic-plastic analysis 59

2.4 Joint classification 59
2.4.1 General 59
2.4.2 Classification based on mechanical joint properties 60

2.5 Ductility classes 62
2.5.1 General concept 62
2.5.2 Requirements for classes of joints 65

Chapter 3

CONNECTIONS WITH MECHANICAL FASTENERS 67

3.1 Mechanical fasteners 67

3.2 Categories of connections 69
3.2.1 Shear connections 69
3.2.2 Tension connections 71

3.3 Positioning of bolt holes 72

3.4 Design of the basic components 74
3.4.1 Bolts in shear 74
3.4.2 Bolts in tension 75
3.4.3 Bolts in shear and tension 76
3.4.4 Preloaded bolts 77
3.4.5 Plates in bearing 85
3.4.6 Block tearing 86
3.4.7 Injection bolts 87
3.4.8 Pins 88
3.4.9 Blind bolting 91
3.4.10 Nails 94
3.4.11 Eccentricity of angles 95

3.5 Design of connections 97
3.5.1 Bolted lap joints 97
3.5.2 Bolted T-stubs 101
3.5.3 Gusset plates 113
3.5.4 Long joints 117

Chapter 4

WELDED CONNECTIONS 119

4.1 Types of welds 119
4.1.1 Butt welds 119
4.1.2 Fillet welds 120
4.1.3 Fillet welds all round 121
4.1.4 Plug welds 122

4.2 Construction constraints 122
4.2.1 Mechanical properties of materials 122
4.2.2 Welding processes, preparation of welds and weld quality 123
4.2.3 Geometry and dimensions of welds 127

4.3 Design of welds 130
4.3.1 Generalities 130
4.3.2 Fillet welds 131
4.3.3 Fillet welds all round 134

4.3.4 Butt welds 135
4.3.5 Plug welds 136
4.3.6 Concept of full strength fillet weld 136

4.4 Distribution of forces in a welded joint 139
4.4.1 Generalities 139
4.4.2 Particular situations 141

Chapter 5

SIMPLE JOINTS 147

5.1 Introduction 147

5.2 Beam-to-column and beam-to-beam joints 149
5.2.1 Introduction 149
5.2.2 Scope and field of application 150
5.2.3 Joint modelling for frame analysis and design requirements 153
5.2.4 Design resistance 156
5.2.5 Practical ways to satisfy the ductility and rotation requirements 163

5.3 Column bases 174
5.3.1 Introduction 174
5.3.2 Basis for the evaluation of the design resistance 176
5.3.3 Resistance to axial forces 177
5.3.4 Resistance to shear forces 185

Chapter 6

MOMENT-RESISTING JOINTS 189

6.1 Introduction 189

6.2 Component characterisation 190
6.2.1 Column web panel in shear in steel or composite joints 190
6.2.2 Column web in transverse compression in steel or composite joints 192
6.2.3 Column web in transverse tension 196
6.2.4 Column flange in transverse bending 197
6.2.5 End plate in bending 203

6.2.6 Flange cleat in bending 205
6.2.7 Beam or column flange and web in compression 207
6.2.8 Beam web in tension 209
6.2.9 Plate in tension or compression 210
6.2.10 Bolts in tension 211
6.2.11 Bolts in shear 212
6.2.12 Bolts in bearing (on beam flange, column flange, end plate or cleat) 213
6.2.13 Concrete in compression including grout 213
6.2.14 Base plate in bending under compression 214
6.2.15 Base plate in bending under tension 214
6.2.16 Anchor bolts in tension 215
6.2.17 Anchor bolts in shear 215
6.2.18 Anchor bolts in bearing 215
6.2.19 Welds 216
6.2.20 Haunched beam 216

6.3 Assembly for resistance 217
6.3.1 Joints under bending moments 217
6.3.2 Joints under axial forces 225
6.3.3 Joints under bending moments and axial forces 226
6.3.4 $M - N - V$ 233
6.3.5 Design of welds 234

6.4 Assembly for rotational stiffness 238
6.4.1 Joints under bending moments 238
6.4.2 Joints under bending moments and axial forces 247

6.5 Assembly for ductility 249
6.5.1 Steel bolted joints 250
6.5.2 Steel welded joints 252

6.6 Application to steel beam-to-column joint configurations 253
6.6.1 Extended scope 253
6.6.2 Possible design simplifications for end plate connections 256
6.6.3 Worked example 257

6.7 Application to steel column splices 281
6.7.1 Common splice configurations 281

6.7.2 Design considerations 283

6.8 Application to column bases 284
6.8.1 Common column basis configurations 284
6.8.2 Design considerations 287

Chapter 7

LATTICE GIRDER JOINTS 295

7.1 General 295

7.2 Scope and field of application 296

7.3 Design models 298
7.3.1 General 298
7.3.2 Failure modes 299
7.3.3 Models for CHS chords 300
7.3.4 Model for RHS chords 301
7.3.5 Punching shear failure 302
7.3.6 Model for brace failure 303
7.3.7 *M-N* interaction 304

Chapter 8

JOINTS UNDER VARIOUS LOADING SITUATIONS 305

8.1 Introduction 305

8.2 Joints in fire 306

8.3 Joints under cyclic loading 307

8.4 Joints under exceptional events 308

Chapter 9

DESIGN STRATEGIES 311

9.1 Introduction 311

9.2 Traditional design approach 314

9.3 Integrated design approach 317

9.4 Economic considerations 319

9.4.1 Fabrication and erections costs 319
9.4.2 Savings of material costs 322
9.4.3 Summary and conclusions 323

BIBLIOGRAPHIC REFERENCES 325

Annex A Practical values for required rotation capacity 337

Annex B Values for lateral torsional buckling strength of a fin plate 339