

TABLE OF CONTENTS

FOREWORD	xi
PREFACE	xiii
ACKNOWLEDGMENTS	xv
SYMBOLGY	xvii
TERMINOLOGY	xxi
Chapter 1	
INTRODUCTION	1
<hr/>	
1.1 Basis of fatigue design in steel structures	1
1.1.1 General	1
1.1.2 Main parameters influencing fatigue life	3
1.1.3 Expression of fatigue strength	7
1.1.4 Variable amplitude and cycle counting	10
1.1.5 Damage accumulation	13
1.2 Damage equivalent factor concept	15
1.3 Codes of Practice	18
1.3.1 Introduction	18
1.3.2 Eurocodes 3 and 4	18
1.3.3 Eurocode 9	21
1.3.4 Execution (EN 1090-2)	23
1.3.5 Other execution standards	29
1.4 Description of the structures used in the worked examples	30
1.4.1 Introduction	30
1.4.2 Steel and concrete composite road bridge (worked example 1)	31

TABLE OF CONTENTS

1.4.3 Chimney (worked example 2)	34
1.4.4 Crane supporting structures (worked example 3)	39

Chapter 2

APPLICATION RANGE AND LIMITATIONS

2.1 Introduction	43
2.2 Materials	44
2.3 Corrosion	44
2.4 Temperature	45
2.5 Loading rate	47
2.6 Limiting stress ranges	47

Chapter 3

DETERMINATION OF STRESSES AND STRESS RANGES

3.1 Fatigue loads	51
3.1.1 Introduction	51
3.1.2 Road bridges	52
3.1.3 Railway bridges	57
3.1.4 Crane supporting structures	59
3.1.5 Masts, towers, and chimneys	61
3.1.6 Silos and tanks	70
3.1.7 Tensile cable structures, tension components	70
3.1.8 Other structures	71
3.2 Damage equivalent factors	72
3.2.1 Concept	72
3.2.2 Critical influence line length	75
3.2.3 Road bridges	76
3.2.4 Railway bridges	82
3.2.5 Crane supporting structures	84
3.2.6 Towers, masts and chimneys	92

3.3 Calculation of stresses	93
3.3.1 Introduction	93
3.3.2 Relevant nominal stresses	94
3.3.3 Stresses in bolted joints	96
3.3.4 Stresses in welds	96
3.3.5 Nominal stresses in steel and concrete composite bridges	99
3.3.6 Nominal stresses in tubular structures (frames and trusses)	100
3.4 Modified nominal stresses and concentration factors	104
3.4.1 Generalities	104
3.4.2 Misalignments	107
3.5 Geometric stresses (Structural stress at the hot spot)	113
3.5.1 Introduction	113
3.5.2 Determination using FEM modelling	115
3.5.3 Determination using formulas	117
3.6 Stresses in orthotropic decks	119
3.7 Calculation of stress ranges	122
3.7.1 Introduction	122
3.7.2 Stress range in non-welded details	123
3.7.3 Stress ranges in bolted joints	125
3.7.4 Stress range in welds	131
3.7.5 Multiaxial stress range cases	133
3.7.6 Stress ranges in steel and concrete composite structures	137
3.7.7 Stress ranges in connection devices from steel and concrete composite structures	142
3.8 Modified Nominal stress ranges	146
3.9 Geometric stress ranges	148
Chapter 4	
FATIGUE STRENGTH	157
4.1 Introduction	157

TABLE OF CONTENTS

4.1.1 Set of fatigue strength curves	157
4.1.2 Modified fatigue strength curves	162
4.1.3 Size effects on fatigue strength	163
4.1.4 Mean stress influence	165
4.1.5 Post-weld improvements	165
4.2 Fatigue detail tables	166
4.2.1 Introduction	166
4.2.2 Non-welded details classification (EN 1993-1-9, Table 8.1)	166
4.2.3 Welded plated details classification (general comments)	168
4.2.4 Longitudinal welds, (built-up sections, EN1993-1-9 Table 8.2), including longitudinal butt welds	169
4.2.5 Transverse butt welds (EN1993-1-9 Table 8.3)	170
4.2.6 Welded attachments and stiffeners (EN 1993-1-9 Table 8.4), and load-carrying welded joints (EN 1993-1-9 Table 8.5)	171
4.2.7 Welded tubular details classification (EN 1993-1-9 Tables 8.6 and 8.7)	174
4.2.8 Orthotropic deck details classification (EN 1993-1-9 Tables 8.8 and 8.9)	175
4.2.9 Crane girder details (EN 1993-1-9 Table 8.10)	176
4.2.10 Tension components details (EN 1993-1-11)	176
4.2.11 Geometric stress categories (EN 1993-1-9, Annex B, Table B.1)	179
4.2.12 Particular case of web breathing, plate slenderness limitations	180
4.3 Determination of fatigue strength or life by testing	180
 Chapter 5	
RELIABILITY AND VERIFICATION	183
5.1 Generalities	183
5.2 Strategies	185
5.2.1 Safe life	185
5.2.2 Damage tolerant	185

5.3 Partial factors	186
5.3.1 Introduction	186
5.3.2 Action effects partial factor	187
5.3.3 Strength partial factor	188
5.4 Verification	192
5.4.1 Introduction	192
5.4.2 Verification using the fatigue limit	193
5.4.3 Verification using damage equivalent factors	201
5.4.4 Verification using damage accumulation method	207
5.4.5 Verification of tension components	209
5.4.6 Verification using damage accumulation in case of two or more cranes	210
5.4.7 Verification under multiaxial stress ranges	212
Chapter 6	
BRITTLE FRACTURE	221
6.1 Introduction	221
6.2 Steel quality	223
6.3 Relationship between different fracture toughness test results	224
6.4 Fracture concept in EN 1993-1-10	229
6.4.1 Method for toughness verification	229
6.4.2 Method for safety verification	231
6.4.3 Flaw size design value	234
6.4.4 Design value of the action effect stresses	236
6.5 Standardisation of choice of material: maximum allowable thicknesses	238
REFERENCES	247
ANNEX A STANDARDS FOR STEEL CONSTRUCTION	257
ANNEX B FATIGUE DETAIL TABLES WITH COMMENTARY	263

TABLE OF CONTENTS

B.1 Plain members and mechanically fastened joints (EN 1993-1-9, Table 8.1)	264
B.2 Welded built-up sections (EN 1993-1-9, Table 8.2)	267
B.3 Transverse butt welds (EN 1993-1-9, Table 8.3)	269
B.4 Attachments and stiffeners (EN 1993-1-9, Table 8.4)	272
B.5 Load carrying welded joints (EN 1993-1-9, Table 8.5)	274
B.6 Hollow sections ($T \leq 12.5$ mm) (EN 1993-1-9, Table 8.6)	277
B.7 Lattice girder node joints (EN 1993-1-9, Table 8.7)	279
B.8 Orthotropic decks - closed stringers (EN 1993-1-9, Table 8.8)	281
B.9 Orthotropic decks - open stringers (EN 1993-1-9, Table 8.9)	283
B.10 Top flange to web junction of runway beams (EN 1993-1-9, Table 8.10)	284
B.11 Detail categories for use with geometric (hot spot) stress method (EN 1993-1-9, Table B1)	286
B.12 Tension components	288
B.13 Review of orthotropic decks details and structural analysis	290

ANNEX C MAXIMUM PERMISSIBLE THICKNESSES TABLES 295

C.1 Maximum permissible values of element thickness t in mm (EN 1993-1-10, Table 2.1)	295
C.2 Maximum permissible values of element thickness t in mm (EN 1993-1-12, Table 4)	296
