Contents

Foreword i
List of symbols iv
Scope 1
1. The behaviour of the composite section 5
1.1 Introduction 5
1.1.1 Normal stresses 8
1.1.2 Shear stresses 10
1.1.3 Torsion 11
1.1.4 Interactions of different stress components in the same cross section 11
1.2 Section under axial and eccentric force 11
1.2.1 General hypotheses. 12
1.2.3 Ductility 19
1.2.4 Resistant capacity of composite sections under normal stresses 25
1.3 Section under shear force 35
1.4 Section under torsion moment 38
1.5 References 41
1.6 Further reading 42
2. Composite structural systems and shear connection 43
2.1 Description and conceptual motivations 43
2.2 Full and partial interaction 45
2.3 Shear connection in steel-concrete composite beams 48
2.3.1 Common devices 48
2.3.2 Innovative connectors 50
2.3.3 Analytical models for shear connection 51
2.4 Full and partial connection 52
2.4.1 Bending capacity and shear connection 53
2.4.2 Interface slip demand 54
2.5 Simplified sectional formulation including partial shear interaction 56
2.5.1 Generalised moment-curvature relationship 56
2.5.2 Graphical representation of the generalised moment curvature relationship 57
2.6 Behaviour of shear connections under cyclic actions 61
2.7 References 63

3. Instability of structural members 65
3.1 Introduction 65
3.2 Steel columns 70
3.3 Concrete columns 73
3.4 Composite columns 81
3.5 Final considerations 84
3.6 References 86
4. Creep and shrinkage effects in composite elements 87
4.1 Introduction 87
4.2.1 Development of modulus of elasticity and strength with time 88
4.2 Outline of time-dependent effects in concrete 88
4.2.2 Creep and shrinkage 89
4.3 Creep and shrinkage effects in composite girders 94
4.3.1 General overview 94
4.4 Structural analysis accounting for time-dependent effects 104
4.4.1 General step-by-step procedure 104
4.4.2 Algebraic methods 106
4.4.3 Accuracy of the algebraic methods applied to evaluate creep effects in composite beams 109
4.4.4 Modular ratio method for practical design 111
4.4.5 Example of application of the modular ratio method 112
4.5 References 115
5. Structural analysis 117
5.1 General aspects 117
5.2 Beams 118
5.2.1 Non-linear analysis 119
5.2.2 Linear analysis 122
5.2.3 Plastic analysis 125
5.3 Frames 126
5.3.1 Mechanical and geometrical idealisation 126
5.3.2 No sway frames 127
5.3.3 Sway frames 127
5.3.4 Second order effect 128
5.3.5 Elastic analysis including partial interaction 130
5.3.6 Connections between members 135
5.4 References 137

6. Fire design of composite structures 138
6.1 Introduction 138
6.2 Thermal flux on structural members 138
6.3 Thermo-mechanical analysis of structures subjected to fire 139
6.3.1 Type of analysis and solution methods 140
6.3.2 Thermal properties of the structural materials 140
6.3.3 Mechanical properties of the structural materials 142
6.4 Fire resistance of composite members 146
6.4.1 Composite beams and slabs 146
6.5 Fire analysis of composite structures 154
6.6 Appendix: Applications and comparisons on composite columns 156
6.6.1 Application of the general procedure to concrete filled composite columns 156
6.6.2 Comparison between fire resistance of different types of columns 159
6.7 References 161