DIN EN 1998-1:2010-12 (E)

Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings (includes Corrigendum AC:2009) English translation of DIN EN 1998-1:2010-12

Contents

Page

FOREWORD TO EN 1998-1:2004 + AC:2009 8

1 GENERAL 15

1.1 SCOPE 15
1.1.1 Scope of EN 1998 15
1.1.2 Scope of EN 1998-1 15
1.1.3 Further Parts of EN 1998 16
1.2 NORMATIVE REFERENCES 16
1.2.1 General reference standards 16
1.2.2 Reference Codes and Standards 17
1.3 ASSUMPTIONS 17
1.4 DISTINCTION BETWEEN PRINCIPLES AND APPLICATION RULES 17
1.5 TERMS AND DEFINITIONS 17
1.5.1 Terms common to all Eurocodes 17
1.5.2 〚AC〉 Further terms used in EN 1998-1 〈AC〛 18
1.6 SYMBOLS 19
1.6.1 General 19
1.6.2 Further symbols used in Sections 2 and 3 of EN 1998-1 19
1.6.3 Further symbols used in Section 4 of EN 1998-1 20
1.6.4 Further symbols used in Section 5 of EN 1998-1 21
1.6.5 Further symbols used in Section 6 of EN 1998-1 24
1.6.6 Further symbols used in Section 7 of EN 1998-1 25
1.6.7 Further symbols used in Section 8 of EN 1998-1 27
1.6.8 Further symbols used in Section 9 of EN 1998-1 27
1.6.9 Further symbols used in Section 10 of EN 1998-1 28
1.7 S.I. UNITS 28

2 PERFORMANCE REQUIREMENTS AND COMPLIANCE CRITERIA 29

2.1 FUNDAMENTAL REQUIREMENTS 29
2.2 COMPLIANCE CRITERIA 30
2.2.1 General 30
2.2.2 Ultimate limit state 30
2.2.3 Damage limitation state 31
2.2.4 Specific measures 32
2.2.4.1 Design 32
2.2.4.2 Foundations 32
2.2.4.3 Quality system plan 32

3 GROUND CONDITIONS AND SEISMIC ACTION 33

3.1 GROUND CONDITIONS 33
3.1.1 General 33
3.1.2 Identification of ground types 33
3.2 SEISMIC ACTION 35
3.2.1 Seismic zones 35
3.2.2 Basic representation of the seismic action 36
3.2.2.1 General 36
3.2.2.2 Horizontal elastic response spectrum 37
3.2.2.3 Vertical elastic response spectrum 40
3.2.2.4 Design ground displacement 41
3.2.2.5 Design spectrum for elastic analysis 41
3.2.3 Alternative representations of the seismic action 42
3.2.3.1 Time - history representation 42
3.2.3.2 Spatial model of the seismic action 43
3.2.4 Combinations of the seismic action with other actions 44

4 DESIGN OF BUILDINGS 45

4.1 GENERAL 45

4.1.1 Scope 45
4.2 CHARACTERISTICS OF EARTHQUAKE RESISTANT BUILDINGS 45
4.2.1 Basic principles of conceptual design 45
4.2.1.1 Structural simplicity 45
4.2.1.2 Uniformity, symmetry and redundancy 45
4.2.1.3 Bi-directional resistance and stiffness 46
4.2.1.4 Torsional resistance and stiffness 46
4.2.1.5 Diaphragmatic behaviour at storey level 46
4.2.1.6 Adequate foundation 47
4.2.2 Primary and secondary seismic members 47
4.2.3 Criteria for structural regularity 48
4.2.3.1 General 48
4.2.3.2 Criteria for regularity in plan 49
4.2.3.3 Criteria for regularity in elevation 50
4.2.4 Combination coefficients for variable actions 52
4.2.5 Importance classes and importance factors 52
4.3 STRUCTURAL ANALYSIS 53
4.3.1 Modelling 53
4.3.2 Accidental torsional effects 54
4.3.3 Methods of analysis 54
4.3.3.1 General 54
4.3.3.2 Lateral force method of analysis 56
4.3.3.3 Modal response spectrum analysis 59
4.3.3.4 Non-linear methods 61
4.3.3.5 Combination of the effects of the components of the seismic action 64
4.3.4 Displacement calculation 66
4.3.5 Non-structural elements 66
4.3.5.1 General 66
4.3.5.2 Verification 67
4.3.5.3 Importance factors 68
4.3.5.4 Behaviour factors 68
4.3.6 Additional measures for masonry infilled frames 68
4.3.6.1 General 68
4.3.6.2 Requirements and criteria 69
4.3.6.3 Irregularities due to masonry infills 69
4.3.6.4 Damage limitation of infills 70
4.4 SAFETY VERIFICATIONS 71
4.4.1 General 71
4.4.2 Ultimate limit state 71
4.4.2.1 General 71
4.4.2.2 Resistance condition 71
4.4.2.3 Global and local ductility condition 72
4.4.2.4 Equilibrium condition 74
4.4.2.5 Resistance of horizontal diaphragms 74
4.4.2.6 Resistance of foundations 74
4.4.2.7 Seismic joint condition 75
4.4.3 Damage limitation 76
4.4.3.1 General 76
4.4.3.2 Limitation of interstorey drift 76

SPECIFIC RULES FOR CONCRETE BUILDINGS 78

5.1 GENERAL 78
5.1.1 Scope 78
5.1.2 Terms and definitions 78
5.2 DESIGN CONCEPTS 80
5.2.1 Energy dissipation capacity and ductility classes 80
5.2.2 Structural types and behaviour factors 81
5.2.2.1 Structural types 81
5.2.2.2 Behaviour factors for horizontal seismic actions 82
5.2.3 Design criteria 84
5.2.3.1 General 84
5.2.3.2 Local resistance condition 84
5.2.3.3 Capacity design rule 84
5.2.3.4 Local ductility condition 84

5.2.3.5 Structural redundancy 86
5.2.3.6 Secondary seismic members and resistances 86
5.2.3.7 Specific additional measures 86
5.2.4 Safety verifications 87
5.3 DESIGN TO EN 1992-1-1 87
5.3.1 General 87
5.3.2 Materials 88
5.3.3 Behaviour factor 88
5.4 DESIGN FOR DCM 88
5.4.1 Geometrical constraints and materials 88
5.4.1.1 Material requirements 88
5.4.1.2 Geometrical constraints 88
5.4.2 Design action effects 89
5.4.2.1 General 89
5.4.2.2 Beams 89
5.4.2.3 Columns 91
5.4.2.4 Special provisions for ductile walls 92
5.4.2.5 Special provisions for large lightly reinforced walls 94
5.4.3 ULS verifications and detailing 95
5.4.3.1 Beams 95
5.4.3.2 Columns 97
5.4.3.3 Beam-column joints 100
5.4.3.4 Ductile Walls 100
5.4.3.5 Large lightly reinforced walls 104
5.5 DESIGN FOR DCH 106
5.5.1 Geometrical constraints and materials 106
5.5.1.1 Material requirements 106
5.5.1.2 Geometrical constraints 106
5.5.2 Design action effects 107
5.5.2.1 Beams 107
5.5.2.2 Columns 107
5.5.2.3 Beam-column joints 107
5.5.2.4 Ductile Walls 108
5.5.3 ULS verifications and detailing 109
5.5.3.1 Beams 109
5.5.3.2 Columns 111
5.5.3.3 Beam-column joints 112
5.5.3.4 Ductile Walls 114
5.5.3.5 Coupling elements of coupled walls 119
5.6 PROVISIONS FOR ANCHORAGES AND SPLICES 120
5.6.1 General 120
5.6.2 Anchorage of reinforcement 120
5.6.2.1 Columns 120
5.6.2.2 Beams 120
5.6.3 Splicing of bars 122
5.7 DESIGN AND DETAILING OF SECONDARY SEISMIC ELEMENTS 123
5.8 CONCRETE FOUNDATION ELEMENTS 123
5.8.1 Scope 123
5.8.2 Tie-beams and foundation beams 124
5.8.3 Connections of vertical elements with foundation beams or walls 125
5.8.4 Cast-in-place concrete piles and pile caps 125
5.9 LOCAL EFFECTS DUE TO MASONRY OR CONCRETE INFILLS 126
5.10 PROVISIONS FOR CONCRETE DIAPHRAGMS 127
5.11 PRECAST CONCRETE STRUCTURES 127
5.11.1 General 127
5.11.1.1 Scope and structural types 127
5.11.1.2 Evaluation of precast structures 128
5.11.1.3 Design criteria 129
5.11.1.4 Behaviour factors 130
5.11.1.5 Analysis of transient situation 130
5.11.2 Connections of precast elements 131
5.11.2.1 General provisions 131
5.11.2.2 Evaluation of the resistance of connections 132
5.11.3 Elements 132

5.11.3.1 Beams ... 132
5.11.3.2 Columns ... 132
5.11.3.3 Beam-column joints ... 133
5.11.3.4 Precast large-panel walls ... 133
5.11.3.5 Diaphragms ... 135

6 SPECIFIC RULES FOR STEEL BUILDINGS ... 137

6.1 GENERAL ... 137
6.1.1 Scope ... 137
6.1.2 Design concepts ... 137
6.1.3 Safety verifications ... 138
6.2 MATERIALS ... 138
6.3 STRUCTURAL TYPES AND BEHAVIOUR FACTORS ... 140
6.3.1 Structural types ... 140
6.3.2 Behaviour factors ... 143
6.4 STRUCTURAL ANALYSIS ... 144
6.5 DESIGN CRITERIA AND DETAILING RULES FOR DISSIPATIVE STRUCTURAL BEHAVIOUR COMMON TO ALL STRUCTURAL TYPES ... 144
6.5.1 General ... 144
6.5.2 Design criteria for dissipative structures ... 144
6.5.3 Design rules for dissipative elements in compression or bending ... 145
6.5.4 Design rules for parts or elements in tension ... 145
6.5.5 Design rules for connections in dissipative zones ... 145
6.6 DESIGN AND DETAILING RULES FOR MOMENT RESISTING FRAMES ... 146
6.6.1 Design criteria ... 146
6.6.2 Beams ... 146
6.6.3 Columns ... 147
6.6.4 Beam to column connections ... 149
6.7 DESIGN AND DETAILING RULES FOR FRAMES WITH CONCENTRIC BRACINGS ... 150
6.7.1 Design criteria ... 150
6.7.2 Analysis ... 151
6.7.3 Diagonal members ... 152
6.7.4 Beams and columns ... 152
6.8 DESIGN AND DETAILING RULES FOR FRAMES WITH ECCENTRIC BRACINGS ... 153
6.8.1 Design criteria ... 153
6.8.2 Seismic links ... 154
6.8.3 Members not containing seismic links ... 157
6.8.4 Connections of the seismic links ... 158
6.9 DESIGN RULES FOR INVERTED PENDULUM STRUCTURES ... 158
6.10 DESIGN RULES FOR STEEL STRUCTURES WITH CONCRETE CORES OR CONCRETE WALLS AND FOR MOMENT RESISTING FRAMES COMBINED WITH CONCENTRIC BRACINGS OR INFILLS ... 159
6.10.1 Structures with concrete cores or concrete walls ... 159
6.10.2 Moment resisting frames combined with concentric bracings ... 159
6.10.3 Moment resisting frames combined with infills ... 159
6.11 CONTROL OF DESIGN AND CONSTRUCTION ... 159

7 SPECIFIC RULES FOR COMPOSITE STEEL – CONCRETE BUILDINGS ... 161

7.1 GENERAL ... 161
7.1.1 Scope ... 161
7.1.2 Design concepts ... 161
7.1.3 Safety verifications ... 162
7.2 MATERIALS ... 163
7.2.1 Concrete ... 163
7.2.2 Reinforcing steel ... 163
7.2.3 Structural steel ... 163
7.3 STRUCTURAL TYPES AND BEHAVIOUR FACTORS ... 163
7.3.1 Structural types ... 163
7.3.2 Behaviour factors ... 165
7.4 STRUCTURAL ANALYSIS ... 165
7.4.1 Scope ... 165
7.4.2 Stiffness of sections ... 166

7.5 DESIGN CRITERIA AND DETAILING RULES FOR DISSIPATIVE STRUCTURAL BEHAVIOUR COMMON TO ALL STRUCTURAL TYPES 166
7.5.1 General 166
7.5.2 Design criteria for dissipative structures 166
7.5.3 Plastic resistance of dissipative zones 167
7.5.4 Detailing rules for composite connections in dissipative zones 167
7.6 RULES FOR MEMBERS 170
7.6.1 General 170
7.6.2 Steel beams composite with slab 172
7.6.3 Effective width of slab 174
7.6.4 Fully encased composite columns 176
7.6.5 Partially-encased members 178
7.6.6 Filled Composite Columns 179
7.7 DESIGN AND DETAILING RULES FOR MOMENT FRAMES 179
7.7.1 Specific criteria 179
7.7.2 Analysis 180
7.7.3 Rules for beams and columns 180
7.7.4 Beam to column connections 181
7.7.5 Condition for disregarding the composite character of beams with slab. 181
7.8 DESIGN AND DETAILING RULES FOR COMPOSITE CONCENTRICALLY BRACED FRAMES 181
7.8.1 Specific criteria 181
7.8.2 Analysis 181
7.8.3 Diagonal members 181
7.8.4 Beams and columns 181
7.9 DESIGN AND DETAILING RULES FOR COMPOSITE ECCENTRICALLY BRACED FRAMES 181
7.9.1 Specific criteria 181
7.9.2 Analysis 182
7.9.3 Links 182
7.9.4 Members not containing seismic links 183
7.10 DESIGN AND DETAILING RULES FOR STRUCTURAL SYSTEMS MADE OF REINFORCED CONCRETE SHEAR WALLS COMPOSITE WITH STRUCTURAL STEEL ELEMENTS 183
7.10.1 Specific criteria 183
7.10.2 Analysis 185
7.10.3 Detailing rules for composite walls of ductility class DCM 185
7.10.4 Detailing rules for coupling beams of ductility class DCM 186
7.10.5 Additional detailing rules for ductility class DCH. 186
7.11 DESIGN AND DETAILING RULES FOR COMPOSITE STEEL PLATE SHEAR WALLS 186
7.11.1 Specific criteria 186
7.11.2 Analysis 187
7.11.3 Detailing rules 187
7.12 CONTROL OF DESIGN AND CONSTRUCTION 187

8 SPECIFIC RULES FOR TIMBER BUILDINGS 188

8.1 GENERAL 188
8.1.1 Scope 188
8.1.2 Definitions 188
8.1.3 Design concepts 188
8.2 MATERIALS AND PROPERTIES OF DISSIPATIVE ZONES 189
8.3 DUCTILITY CLASSES AND BEHAVIOUR FACTORS 190
8.4 STRUCTURAL ANALYSIS 191
8.5 DETAILING RULES 191
8.5.1 General 191
8.5.2 Detailing rules for connections 192
8.5.3 Detailing rules for horizontal diaphragms 192
8.6 SAFETY VERIFICATIONS 192
8.7 CONTROL OF DESIGN AND CONSTRUCTION 193

9 SPECIFIC RULES FOR MASONRY BUILDINGS 194

9.1 SCOPE 194
9.2 MATERIALS AND BONDING PATTERNS 194

9.2.1 Types of masonry units....194
9.2.2 Minimum strength of masonry units....194
9.2.3 Mortar....194
9.2.4 Masonry bond....194
9.3 TYPES OF CONSTRUCTION AND BEHAVIOUR FACTORS....195
9.4 STRUCTURAL ANALYSIS....196
9.5 DESIGN CRITERIA AND CONSTRUCTION RULES....197
9.5.1 General....197
9.5.2 Additional requirements for unreinforced masonry satisfying EN 1998-1....198
9.5.3 Additional requirements for confined masonry....198
9.5.4 Additional requirements for reinforced masonry....199
9.6 SAFETY VERIFICATION....200
9.7 RULES FOR "SIMPLE MASONRY BUILDINGS"....200
9.7.1 General....200
9.7.2 Rules....200

10 BASE ISOLATION....203

10.1 SCOPE....203
10.2 DEFINITIONS....203
10.3 FUNDAMENTAL REQUIREMENTS....204
10.4 COMPLIANCE CRITERIA....205
10.5 GENERAL DESIGN PROVISIONS....205
10.5.1 General provisions concerning the devices....205
10.5.2 Control of undesirable movements....206
10.5.3 Control of differential seismic ground motions....206
10.5.4 Control of displacements relative to surrounding ground and constructions....206
10.5.5 Conceptual design of base isolated buildings....206
10.6 SEISMIC ACTION....207
10.7 BEHAVIOUR FACTOR....207
10.8 PROPERTIES OF THE ISOLATION SYSTEM....207
10.9 STRUCTURAL ANALYSIS....208
10.9.1 General....208
10.9.2 Equivalent linear analysis....208
10.9.3 Simplified linear analysis....209
10.9.4 Modal simplified linear analysis....211
10.9.5 Time-history analysis....211
10.9.6 Non structural elements....211
10.10 SAFETY VERIFICATIONS AT ULTIMATE LIMIT STATE....211

ANNEX A (informative) **ELASTIC DISPLACEMENT RESPONSE SPECTRUM....213**

ANNEX B (informative) **DETERMINATION OF THE TARGET DISPLACEMENT FOR NONLINEAR STATIC (PUSHOVER) ANALYSIS....215**

ANNEX C (normative) **DESIGN OF THE SLAB OF STEEL-CONCRETE COMPOSITE BEAMS AT BEAM-COLUMN JOINTS IN MOMENT RESISTING FRAMES....219**