

# 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
<b>FOREWORD TO EN 1998-1:2004 + AC:2009</b> .....	<b>8</b>
<b>1 GENERAL</b> .....	<b>15</b>
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
<b>2 PERFORMANCE REQUIREMENTS AND COMPLIANCE CRITERIA</b> .....	<b>29</b>
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
<b>3 GROUND CONDITIONS AND SEISMIC ACTION</b> .....	<b>33</b>
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
<b>4 DESIGN OF BUILDINGS</b> .....	<b>45</b>
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
	<b>SPECIFIC RULES FOR CONCRETE BUILDINGS .....</b>	<b>78</b>
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
<b>6</b>	<b>SPECIFIC RULES FOR STEEL BUILDINGS.....</b>	<b>137</b>
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
<b>7</b>	<b>SPECIFIC RULES FOR COMPOSITE STEEL – CONCRETE BUILDINGS.....</b>	<b>161</b>
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
<b>8</b>	<b>SPECIFIC RULES FOR TIMBER BUILDINGS.....</b>	<b>188</b>
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
<b>9</b>	<b>SPECIFIC RULES FOR MASONRY BUILDINGS.....</b>	<b>194</b>
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
<b>10</b>	<b>BASE ISOLATION .....</b>	<b>203</b>
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
	<b>ANNEX A (informative) ELASTIC DISPLACEMENT RESPONSE SPECTRUM .....</b>	<b>213</b>
	<b>ANNEX B (informative) DETERMINATION OF THE TARGET DISPLACEMENT FOR NONLINEAR STATIC (PUSHOVER) ANALYSIS.....</b>	<b>215</b>
	<b>ANNEX C (normative) DESIGN OF THE SLAB OF STEEL-CONCRETE COMPOSITE BEAMS AT BEAM-COLUMN JOINTS IN MOMENT RESISTING FRAMES .....</b>	<b>219</b>