

DIN EN 1992-1-1:2025-09 (E)

Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings, bridges and civil engineering structures

Contents		Page
European foreword		12
0	Introduction	14
1	Scope	17
1.1	Scope of EN 1992-1-1	17
1.2	Assumptions.....	17
2	Normative references	17
3	Terms, definitions and symbols	19
3.1	Terms and definitions.....	19
3.2	Symbols and abbreviations.....	31
3.2.1	Latin upper case letters.....	31
3.2.2	Latin lower case letters	36
3.2.3	Greek letters.....	45
3.3	Symbols in Annex A.....	53
3.3.1	Latin upper case letters.....	53
3.3.2	Latin lower case letters	54
3.3.3	Greek lower case letters	54
3.4	Symbols in Annex I.....	54
3.4.1	Latin upper case letters.....	54
3.4.2	Latin lower case letters	54
3.4.3	Greek lower case letters	55
3.5	Symbols in Annex J.....	55
3.5.1	Latin upper case letters.....	55
3.5.2	Latin lower-case letters.....	56
3.5.3	Greek lower-case letters.....	57
3.6	Symbols in Annex L.....	58
3.6.1	Latin upper case letters.....	58
3.6.2	Latin lower case letters	58
3.6.3	Greek letters.....	59
3.7	Symbols in Annex R	59
3.7.1	Latin upper case letters.....	59
3.7.2	Latin lower case letters	60
3.7.3	Greek letters.....	60
3.8	Abbreviations	60
3.9	Units	61
3.10	Sign conventions.....	61
4	Basis of design	61
4.1	General rules.....	61
4.1.1	Basic requirements.....	61
4.1.2	Structural reliability and quality management.....	62
4.1.3	Design service life	62
4.2	Basic variables.....	62
4.2.1	Actions and time-dependent effects.....	62
4.2.2	Geometric data	64
4.3	Verification by the partial factor method.....	64
4.3.1	Partial factor for shrinkage action.....	64
4.3.2	Partial factors for prestress action	64
4.3.3	Partial factors for materials	65
4.4	Requirements for connection of elements to concrete members.....	65

5	Materials.....	66
5.1	Concrete.....	66
5.1.1	General.....	66
5.1.2	Properties and related conditions.....	66
5.1.3	Strength.....	67
5.1.4	Elastic deformation.....	68
5.1.5	Creep and shrinkage.....	68
5.1.6	Design assumptions.....	70
5.2	Reinforcing steel.....	72
5.2.1	General.....	72
5.2.2	Properties.....	72
5.2.3	Welding of reinforcing bars.....	73
5.2.4	Design assumptions.....	73
5.2.5	Reinforcement bar couplers.....	74
5.2.6	Headed bars for reinforcement.....	74
5.3	Prestressing steel.....	74
5.3.1	General.....	74
5.3.2	Properties.....	75
5.3.3	Design assumptions.....	76
5.4	Prestressing systems.....	77
5.4.1	General.....	77
5.4.2	Anchorage zones.....	78
6	Durability and concrete cover.....	78
6.1	General.....	78
6.2	Requirements for durability.....	78
6.3	Environmental exposure conditions.....	79
6.4	Exposure resistance classes.....	83
6.5	Concrete cover.....	84
6.5.1	Nominal cover.....	84
6.5.2	Minimum cover.....	84
6.5.3	Allowance in design for deviation in cover.....	88
7	Structural analysis.....	89
7.1	General.....	89
7.2	Structural modelling for analysis.....	89
7.2.1	Geometric imperfections.....	89
7.2.2	Idealisation of the structure.....	93
7.2.3	Geometric data.....	93
7.3	Methods of analysis.....	95
7.3.1	Linear elastic analysis.....	95
7.3.2	Linear elastic analysis with redistribution.....	96
7.3.3	Plastic analysis.....	98
7.3.4	Non-linear analysis.....	98
7.4	Second order structural analysis of members and systems with axial force.....	99
7.4.1	General.....	99
7.4.2	Creep.....	100
7.4.3	Methods of analysis.....	100
7.4.4	Compression member with biaxial bending.....	102
7.5	Lateral instability of slender beams.....	103
7.6	Prestressed members and structures.....	103
7.6.1	General.....	103
7.6.2	Prestressing force.....	104
7.6.3	Immediate losses of prestress.....	104

7.6.4	Time dependent losses of prestress	106
7.6.5	Effects of prestressing at ultimate limit state	107
8	Ultimate Limit States (ULS)	108
8.1	Bending with or without axial force	108
8.1.1	General	108
8.1.2	Stress distribution in the compression zones.....	110
8.1.3	Bending in slabs	110
8.1.4	Confined concrete	111
8.2	Shear	113
8.2.1	General verification procedure	113
8.2.2	Detailed verification for members without shear reinforcement.....	117
8.2.3	Members with shear reinforcement.....	121
8.2.4	In-plane shear and transverse bending	126
8.2.5	Shear between web and flanges.....	127
8.2.6	Shear at interfaces	129
8.3	Torsion and combined actions	134
8.3.1	General considerations for torsion	134
8.3.2	Internal forces due to torsion in compact or closed sections.....	134
8.3.3	Internal forces due to torsion in open sections.....	135
8.3.4	Torsional resistance of compact or closed sections	135
8.3.5	Design procedure for combination of actions.....	136
8.3.6	Interaction formula	137
8.4	Punching.....	137
8.4.1	General	137
8.4.2	Shear-resisting effective depth, control perimeter and shear stress.....	138
8.4.3	Punching shear resistance of slabs without shear reinforcement.....	142
8.4.4	Punching shear resistance of slabs with shear reinforcement.....	145
8.5	Design with strut-and-tie models and stress fields.....	148
8.5.1	General	148
8.5.2	Struts and compression fields	150
8.5.3	Ties	152
8.5.4	Nodes	152
8.5.5	Transfer of concentrated forces into a member	155
8.6	Partially loaded areas.....	157
9	Serviceability Limit States (SLS)	160
9.1	General	160
9.2	Stress limitations and crack control.....	161
9.2.1	General considerations	161
9.2.2	Minimum reinforcement areas to avoid yielding.....	163
9.2.3	Refined control of cracking.....	165
9.3	Deflection control.....	171
9.3.1	General consideration	171
9.3.2	Simplified deflection control by span/depth-ratio for buildings	171
9.3.3	Simplified calculation of deflections for reinforced concrete building structures	173
9.3.4	General method for deflection calculations.....	174
9.4	Vibrations.....	175
10	Fatigue	176
10.1	General	176
10.2	Combination of actions.....	176
10.3	Internal forces and stresses for fatigue verification	176
10.4	Simplified verification of reinforcing or prestressing steel.....	178

10.5	Simplified verification of concrete under compression.....	178
10.6	Simplified verification of concrete under shear	179
10.7	Simplified verification of shear at interfaces.....	179
11	Detailing of reinforcement and post-tensioning tendons	180
11.1	General.....	180
11.2	Spacing of bars	180
11.3	Permissible mandrel diameters for bent bars	181
11.4	Anchorage of reinforcing steel in tension and compression.....	182
11.4.1	General.....	182
11.4.2	Anchorage of straight bars.....	183
11.4.3	Anchorage of bundles	186
11.4.4	Anchorage of bars with bends and hooks.....	187
11.4.5	Anchorage of bars with welded transverse reinforcement	187
11.4.6	Anchorage of U-bar loops	188
11.4.7	Anchorage of headed bars in tension.....	188
11.4.8	Anchorage of bonded post-installed reinforcing steel	190
11.5	Laps of reinforcing steel in tension and compression and mechanical couplers ...	191
11.5.1	General.....	191
11.5.2	All types of laps	191
11.5.3	Laps of bundles	195
11.5.4	Laps using U-bar loops	196
11.5.5	Laps using headed bars.....	198
11.5.6	Mechanical couplers	200
11.5.7	Full penetration butt weld and fillet weld splices.....	200
11.6	Post-tensioning tendons.....	201
11.6.1	General.....	201
11.6.2	Minimum spacing of ducts	201
11.6.3	Minimum radius of curvature and straight length of tendons adjacent to anchorages	202
11.6.4	Anchorage, couplers and deviators of post-tensioning tendons.....	203
11.7	Deviation forces due to curved tensile and compressive chords	203
12	Detailing of members and particular rules	204
12.1	General.....	204
12.2	Minimum reinforcement rules.....	204
12.3	Beams	206
12.3.1	General.....	206
12.3.2	Longitudinal reinforcement.....	208
12.3.3	Shear and torsion reinforcement.....	209
12.3.4	Suspension reinforcement for indirect support.....	211
12.4	Slabs	211
12.4.1	General.....	211
12.4.2	Shear reinforcement	213
12.5	Slab-column connections and column bases.....	213
12.5.1	Punching shear reinforcement.....	213
12.5.2	Integrity reinforcement against progressive collapse of flat slabs.....	216
12.6	Columns	217
12.7	Walls and deep beams.....	218
12.8	Foundations	219
12.9	Tying systems for robustness of buildings	221
12.9.1	General.....	221
12.9.2	Dimensioning of ties	222
12.9.3	Required resistances for ties	222

12.10	Supports, bearings and expansion joints.....	223
13	Additional rules for precast concrete elements and structures.....	226
13.1	General.....	226
13.2	Specific requirements.....	226
13.3	Concrete.....	226
13.3.1	Strength for heat curing.....	226
13.3.2	Creep and shrinkage.....	226
13.4	Structural analysis.....	227
13.4.1	General.....	227
13.4.2	Losses of prestress during heat curing.....	227
13.5	Design and detailing of pre-tensioning tendons.....	228
13.5.1	Arrangement of tendons.....	228
13.5.2	Anchorage zones.....	229
13.5.3	Transfer of prestress.....	229
13.5.4	Anchorage of tensile force at ULS.....	230
13.5.5	Shear resistance of precast members without shear reinforcement.....	231
13.6	Floor systems for buildings.....	232
13.6.1	Distribution of loads.....	232
13.6.2	Diaphragm action.....	233
13.6.3	Tying systems for buildings.....	233
13.7	Connections and supports.....	234
13.7.1	Connections.....	234
13.7.2	Supports.....	236
13.8	Pocket foundations for buildings.....	236
13.8.1	General.....	236
13.8.2	Pocket foundations with keyed surface.....	236
13.8.3	Pocket foundations with smooth or rough surfaces.....	237
14	Plain and lightly reinforced concrete structures.....	238
14.1	General.....	238
14.2	Concrete.....	238
14.3	Structural analysis.....	238
14.4	Ultimate limit states.....	239
14.4.1	General.....	239
14.4.2	Design resistance to bending with axial force.....	239
14.4.3	Shear.....	239
14.4.4	Torsion.....	240
14.4.5	Ultimate limit states induced by structural deformation (buckling).....	240
14.5	Serviceability limit states.....	242
14.6	Detailing of members and particular rules.....	243
14.6.1	Structural members.....	243
14.6.2	Construction joints.....	243
14.6.3	Strip and pad footings.....	243
Annex A (informative)	Adjustment of partial factors for materials.....	244
A.1	Use of this annex.....	244
A.2	Scope and fields of application.....	244
A.3	General.....	244
Annex B (normative)	Time dependent behaviour of materials: strength, creep, shrinkage and elastic strain of concrete and relaxation of prestressing steel.....	251
B.1	Use of this annex.....	251

B.2	Scope and field of application.....	251
B.3	General.....	251
B.4	Development of concrete strength and stiffness with time	252
B.5	Basic formulae for determining the creep coefficient.....	253
B.6	Basic formulae for determining the shrinkage strain	256
B.7	Tests on elastic deformations, creep and shrinkage.....	258
B.8	Detailed analysis for creep at variable loading.....	259
B.9	Relaxation of prestressing steel.....	260
Annex C (normative) Requirements for materials		262
C.1	Use of this annex.....	262
C.2	Scope and field of application.....	262
C.3	Concrete.....	262
C.4	Reinforcing steel.....	262
C.5	Prestressing steel.....	265
C.6	Couplers.....	268
C.7	Headed bars	269
C.8	Post-installed reinforcing steel systems.....	269
Annex D (informative) Evaluation of early-age and long-term cracking due to restraint .		271
D.1	Use of this annex.....	271
D.2	Scope and field of application.....	271
D.3	General.....	271
D.4	Assessment of temperature history	272
D.5	Stress calculations	274
D.6	Crack width calculations	275
Annex E (normative) Additional rules for fatigue verification		276
E.1	Use of this annex.....	276
E.2	Scope and field of application.....	276
E.3	General.....	276
E.4	Verification using damage equivalent stress range.....	276
E.5	Explicit verifications using <i>Palmgren-Miner</i> Rule.....	278
Annex F (informative) Safety formats for non-linear analysis.....		281
F.1	Use of this annex.....	281
F.2	Scope and field of application.....	281
F.3	General.....	281
F.4	Partial factor method (PFM)	282
F.5	Global factor method (GFM).....	283

F.6	Full probabilistic method	284
F.7	Model uncertainty	284
	Annex G (normative) Design of membrane-, shell- and slab elements.....	286
G.1	Use of this annex	286
G.2	Scope and field of application	286
G.3	Design of membrane elements in ULS	286
G.4	Design of shell- and slab elements in ULS.....	288
G.5	Refined control of cracking in membrane elements in SLS	291
	Annex H (informative) Guidance on design of concrete structures for water-tightness	293
H.1	Use of this annex	293
H.2	Scope and field of application	293
H.3	General	293
H.4	Tightness classes	293
	Annex I (informative) Assessment of Existing Structures.....	296
I.1	Use of this annex	296
I.2	Scope and field of application	296
I.3	General	296
I.4	Basis of assessment	297
I.5	Materials	299
I.6	Durability - Minimum cover for bond	301
I.7	Structural analysis	302
I.8	Ultimate Limit States (ULS).....	303
I.9	Serviceability Limit States (SLS)	310
I.10	Fatigue	310
I.11	Detailing of reinforcement and post-tensioning tendons	311
I.12	Detailing of members and particular rules - Minimum reinforcement rules.....	314
	Annex J (informative) Strengthening of Existing Concrete Structures with CFRP.....	315
J.1	Use of this annex	315
J.2	Scope and field of application	315
J.3	General	315
J.4	Basis of design	315
J.5	Materials	316
J.6	Durability	318
J.7	Structural analysis	318
J.8	Ultimate Limit States (ULS).....	319
J.9	Serviceability Limit States (SLS)	324

J.10	Fatigue.....	325
J.11	Bond and anchorage of CFRP systems	326
J.12	Detailing of members and particular rules	332
J.13	Additional rules for precast concrete elements and structures	333
J.14	Lightly reinforced concrete structures	333
J.15	Material requirements for ABR strengthening systems	333
Annex K (normative) Bridges.....		334
K.1	Use of this annex.....	334
K.2	Scope and field of application.....	334
K.3	Terms, definitions and symbols.....	334
K.4	Basis of design	334
K.5	Materials.....	334
K.6	Durability and concrete cover.....	334
K.7	Structural analysis.....	336
K.8	Ultimate limit states (ULS).....	336
K.9	Serviceability limit states (SLS)	336
K.10	Fatigue verification	337
K.11	Detailing of reinforcement and post-tensioning tendons	346
K.12	Detailing of members and particular rules	346
K.13	Additional rules for precast concrete elements and structures	348
K.14	Plain and lightly reinforced concrete structures.....	349
K.15	Amendments to Annex G	349
Annex L (informative) Steel Fibre Reinforced Concrete Structures.....		350
L.1	Use of this annex.....	350
L.2	Scope and field of application.....	350
L.3	General.....	350
L.4	Basis of design - Partial factors for materials	350
L.5	Materials.....	351
L.6	Durability - Minimum cover	354
L.7	Structural analysis - Plastic analysis.....	354
L.8	Ultimate Limit States (ULS)	355
L.9	Serviceability Limit States (SLS) - Crack control.....	358
L.10	Fatigue.....	359
L.11	Detailing of reinforcement and post-tensioning tendons	359
L.12	Detailing of members and particular rules	359
L.13	Additional rules for precast concrete elements and structures	361

L.14	Lightly reinforced SFRC structures	361
L.15	Requirements for Materials: SFRC	362
Annex M (normative) Lightweight aggregate concrete structures		364
M.1	Use of this annex	364
M.2	Scope and field of application	364
M.3	General	364
Annex N (informative) Recycled aggregates concrete structures		367
N.1	Use of this annex	367
N.2	Scope and field of application	367
N.3	General	367
Annex O (informative) Simplified approaches for second order effects		370
O.1	Use of this Annex	370
O.2	Scope and field of application	370
O.3	Critical load of building structures	370
O.4	Critical load of isolated members	371
O.5	Slenderness ratio and effective length of isolated members	372
O.6	Slenderness criteria for isolated members	373
O.7	Simplified analysis of isolated members based on nominal curvature	373
O.8	Second order elastic method	376
Annex P (informative) Alternative cover approach for durability		378
P.1	Use of this Annex	378
P.2	Scope and field of application	378
P.3	Minimum cover	378
P.4	Indicative strength classes for durability	380
Annex Q (normative) Stainless reinforcing steel		381
Q.1	Use of this annex	381
Q.2	Scope and field of application	381
Q.3	General	381
Q.4	Minimum cover for durability	382
Q.5	Fatigue verification	383
Annex R (informative) Embedded FRP reinforcement		384
R.1	Use of this annex	384
R.2	Scope and field of application	384
R.3	General	384
R.4	Verification- Partial factors for FRP reinforcement	384
R.5	Materials	385

R.6	Durability - Concrete cover.....	387
R.7	Structural analysis.....	387
R.8	Ultimate Limit States (ULS)	387
R.9	Serviceability Limit States (SLS) - Special rules for FRP reinforcement	389
R.10	Fatigue.....	390
R.11	Detailing of FRP reinforcement	390
R.12	Detailing of members and particular rules	392
R.13	Additional rules for precast concrete elements and structures	394
R.14	Lightly reinforced concrete structures	394
R.15	Material requirements for FRP reinforcement	395
R.16	Surface reinforcement for large diameter bars	395
Annex S (informative) Minimum reinforcement for crack control and simplified control of cracking		396
S.1	Use of this annex.....	396
S.2	Scope and field of application.....	396
S.3	Minimum reinforcement areas for crack width control	396
Bibliography		400