

DIN EN 1994-1-1:2010-12 (E)

Eurocode 4: Design of composite steel and concrete structures - Part 1-1: General rules and rules for buildings (includes Corrigendum AC:2009)

Contents		Page
Foreword		8
Section 1 General		12
1.1 Scope		12
1.1.1 Scope of Eurocode 4		12
1.1.2 Scope of Part 1.1 of Eurocode 4		12
1.2 Normative references		13
1.2.1 General reference standards		13
1.2.2 Other reference standards		13
1.3 Assumptions		14
1.4 Distinction between principles and application rules		14
1.5 Definitions		14
1.5.1 General		14
1.5.2 Additional terms and definitions used in this Standard		14
1.6 Symbols		15
Section 2 Basis of design		22
2.1 Requirements		22
2.2 Principles of limit state design		23
2.3 Basic variables		23
2.3.1 Actions and environmental influences		23
2.3.2 Material and product properties		23
2.3.3 Classification of actions		23
2.4 Verification by the partial factor method		23
2.4.1 Design values		23
2.4.1.1 Design values of actions		23
2.4.1.2 Design values of material or product properties		23
2.4.1.3 Design values of geometrical data		24
2.4.1.4 Design resistances		24
2.4.2 Combination of actions		24
2.4.3 Verification of static equilibrium (EQU)		24
Section 3 Materials		24
3.1 Concrete		24
3.2 Reinforcing steel		25
3.3 Structural steel		25
3.4 Connecting devices		25
3.4.1 General		25
3.4.2 Headed stud shear connectors		25
3.5 Profiled steel sheeting for composite slabs in buildings		25
Section 4 Durability		25
4.1 General		25
4.2 Profiled steel sheeting for composite slabs in buildings		26
Section 5 Structural analysis		26

5.1	Structural modelling for analysis	26
5.1.1	Structural modelling and basic assumptions	26
5.1.2	Joint modelling	26
5.1.3	Ground-structure interaction	26
5.2	Structural stability	27
5.2.1	Effects of deformed geometry of the structure	27
5.2.2	Methods of analysis for buildings	27
5.3	Imperfections	28
5.3.1	Basis	28
5.3.2	Imperfections in buildings	28
5.3.2.1	General	28
5.3.2.2	Global imperfections	29
5.3.2.3	Member imperfections	29
5.4	Calculation of action effects	29
5.4.1	Methods of global analysis	29
5.4.1.1	General	29
5.4.1.2	Effective width of flanges for shear lag	29
5.4.2	Linear elastic analysis	30
5.4.2.1	General	30
5.4.2.2	Creep and shrinkage	31
5.4.2.3	Effects of cracking of concrete	32
5.4.2.4	Stages and sequence of construction	33
5.4.2.5	Temperature effects	33
5.4.2.6	Pre-stressing by controlled imposed deformations	33
5.4.3	Non-linear global analysis	33
5.4.4	Linear elastic analysis with limited redistribution for buildings	34
5.4.5	Rigid plastic global analysis for buildings	35
5.5	Classification of cross-sections	36
5.5.1	General	36
5.5.2	Classification of composite sections without concrete encasement	37
5.5.3	Classification of composite sections for buildings with concrete encasement	37
Section 6 Ultimate limit states		38
6.1	Beams	38
6.1.1	Beams for buildings	38
6.1.2	Effective width for verification of cross-sections	40
6.2	Resistances of cross-sections of beams	40
6.2.1	Bending resistance	40
6.2.1.1	General	40
6.2.1.2	Plastic resistance moment M_{pl}, R_d of a composite cross-section	40
6.2.1.3	Plastic resistance moment of sections with partial shear connection in buildings	42
6.2.1.4	Non-linear resistance to bending	43
6.2.1.5	Elastic resistance to bending	44
6.2.2	Resistance to vertical shear	45
6.2.2.1	Scope	45
6.2.2.2	Plastic resistance to vertical shear	45
6.2.2.3	Shear buckling resistance	45
6.2.2.4	Bending and vertical shear	45
6.3	Resistance of cross-sections of beams for buildings with partial encasement	46
6.3.1	Scope	46
6.3.2	Bending resistance	46
6.3.3	Resistance to vertical shear	47
6.3.4	Bending and vertical shear	48
6.4	Lateral-torsional buckling of composite beams	48
6.4.1	General	48
6.4.2	Verification of lateral-torsional buckling of continuous composite beams with cross-sections in Class 1, 2 and 3 for buildings	49
6.4.3	Simplified verification for buildings without direct calculation	51
6.5	Transverse forces on webs	52
6.5.1	General	52
6.5.2	Flange-induced buckling of webs	52

6.6	Shear connection	52
6.6.1	General	52
6.6.1.1	Basis of design	52
6.6.1.2	Limitation on the use of partial shear connection in beams for buildings	53
6.6.1.3	Spacing of shear connectors in beams for buildings	54
6.6.2	Longitudinal shear force in beams for buildings	55
6.6.2.1	Beams in which non-linear or elastic theory is used for resistances of one or more cross-sections	55
6.6.2.2	Beams in which plastic theory is used for resistance of cross-sections	55
6.6.3	Headed stud connectors in solid slabs and concrete encasement	55
6.6.3.1	Design resistance	55
6.6.3.2	Influence of tension on shear resistance	56
6.6.4	Design resistance of headed studs used with profiled steel sheeting in buildings	56
6.6.4.1	Sheeting with ribs parallel to the supporting beams	56
6.6.4.2	Sheeting with ribs transverse to the supporting beams	57
6.6.4.3	Biaxial loading of shear connectors	58
6.6.5	Detailing of the shear connection and influence of execution	58
6.6.5.1	Resistance to separation	58
6.6.5.2	Cover and concreting for buildings	58
6.6.5.3	Local reinforcement in the slab	59
6.6.5.4	Haunches other than formed by profiled steel sheeting	59
6.6.5.5	Spacing of connectors	60
6.6.5.6	Dimensions of the steel flange	60
6.6.5.7	Headed stud connectors	60
6.6.5.8	Headed studs used with profiled steel sheeting in buildings	61
6.6.6	Longitudinal shear in concrete slabs	61
6.6.6.1	General	61
6.6.6.2	Design resistance to longitudinal shear	61
6.6.6.3	Minimum transverse reinforcement	62
6.6.6.4	Longitudinal shear and transverse reinforcement in beams for buildings	62
6.7	Composite columns and composite compression members	63
6.7.1	General	63
6.7.2	General method of design	65
6.7.3	Simplified method of design	66
6.7.3.1	General and scope	66
6.7.3.2	Resistance of cross-sections	67
6.7.3.3	Effective flexural stiffness, steel contribution ratio and relative slenderness	69
6.7.3.4	Methods of analysis and member imperfections	70
6.7.3.5	Resistance of members in axial compression	70
6.7.3.6	Resistance of members in combined compression and uniaxial bending	71
6.7.3.7	Combined compression and biaxial bending	73
6.7.4	Shear connection and load introduction	74
6.7.4.1	General	74
6.7.4.2	Load introduction	74
6.7.4.3	Longitudinal shear outside the areas of load introduction	77
6.7.5	Detailing Provisions	78
6.7.5.1	Concrete cover of steel profiles and reinforcement	78
6.7.5.2	Longitudinal and transverse reinforcement	78
6.8	Fatigue	78
6.8.1	General	78
6.8.2	Partial factors for fatigue assessment for buildings	79
6.8.3	Fatigue strength	79
6.8.4	Internal forces and fatigue loadings	80
6.8.5	Stresses	80
6.8.5.1	General	80
6.8.5.2	Concrete	80
6.8.5.3	Structural steel	80
6.8.5.4	Reinforcement	81
6.8.5.5	Shear connection	81
6.8.6	Stress ranges	82
6.8.6.1	Structural steel and reinforcement	82
6.8.6.2	Shear connection	82

6.8.7	Fatigue assessment based on nominal stress ranges	83
6.8.7.1	Structural steel, ~reinforcement and concrete TM	83
6.8.7.2	Shear connection	83
Section 7 Serviceability limit states		84
7.1	General	84
7.2	Stresses	84
7.2.1	General	84
7.2.2	Stress limitation for buildings	85
7.3	Deformations in buildings	85
7.3.1	Deflections	85
7.3.2	Vibration	86
7.4	Cracking of concrete	86
7.4.1	General	86
7.4.2	Minimum reinforcement	87
7.4.3	Control of cracking due to direct loading	88
Section 8 Composite joints in frames for buildings		89
8.1	Scope	89
8.2	Analysis, modelling and classification	90
8.2.1	General	90
8.2.2	Elastic global analysis	90
8.2.3	Classification of joints	90
8.3	Design methods	91
8.3.1	Basis and scope	91
8.3.2	Resistance	91
8.3.3	Rotational stiffness	91
8.3.4	Rotation capacity	91
8.4	Resistance of components	92
8.4.1	Scope	92
8.4.2	Basic joint components	92
8.4.2.1	Longitudinal steel reinforcement in tension	92
8.4.2.2	Steel contact plate in compression	92
8.4.3	Column web in transverse compression	93
8.4.4	Reinforced components	93
8.4.4.1	Column web panel in shear	93
8.4.4.2	Column web in transverse compression	93
Section 9 Composite slabs with profiled steel sheeting for buildings		94
9.1	General	94
9.1.1	Scope	94
9.1.2	Definitions	95
9.1.2.1	Types of shear connection	95
9.1.2.2	Full shear connection and partial shear connection	95
9.2	Detailing provisions	96
9.2.1	Slab thickness and reinforcement	96
9.2.2	Aggregate	97
9.2.3	Bearing requirements	97
9.3	Actions and action effects	97
9.3.1	Design situations	97
9.3.2	Actions for profiled steel sheeting as shuttering	98
9.3.3	Actions for composite slab	98
9.4	Analysis for internal forces and moments	98
9.4.1	Profiled steel sheeting as shuttering	98
9.4.2	Analysis of composite slab	98
9.4.3	Effective width of composite slab for concentrated point and line loads	99
9.5	Verification of profiled steel sheeting as shuttering for ultimate limit states	100
9.6	Verification of profiled steel sheeting as shuttering for serviceability limit states	100
9.7	Verification of composite slabs for ultimate limit states	100

9.7.1	Design criterion	100
9.7.2	Flexure	101
9.7.3	Longitudinal shear for slabs without end anchorage	102
9.7.4	Longitudinal shear for slabs with end anchorage	104
9.7.5	Vertical shear	104
9.7.6	Punching shear	104
9.8	Verification of composite slabs for serviceability limit states	104
9.8.1	Control of cracking of concrete	104
9.8.2	Deflection	105
Annex A (informative) Stiffness of joint components in buildings		106
A.1	Scope	106
A.2	Stiffness coefficients	106
A.2.1	Basic joint components	106
A.2.1.1	Longitudinal steel reinforcement in tension	106
A.2.1.2	Steel contact plate in compression	106
A.2.2	Other components in composite joints	108
A.2.2.1	Column web panel in shear	108
A.2.2.2	Column web in transverse compression	108
A.2.3.1	Column web panel in shear	108
A.2.3.2	Column web in transverse compression	108
A.3	Deformation of the shear connection	109
Annex B (informative) Standard tests		110
B.1	General	110
B.2	Tests on shear connectors	110
B.2.1	General	110
B.2.2	Testing arrangements	110
B.2.3	Preparation of specimens	111
B.2.4	Testing procedure	112
B.2.5	Test evaluation	112
B.3	Testing of composite floor slabs	113
B.3.1	General	113
B.3.2	Testing arrangement	114
B.3.3	Preparation of specimens	115
B.3.4	Test loading procedure	115
B.3.5	Determination of design values for m and k	116
B.3.6	Determination of the design values for u_{Rd}	117
Annex C (informative) Shrinkage of concrete for composite structures for buildings		118
Bibliography		118
A.2.3	Reinforced components	108