Structural Eurocodes – an overview

Total of 58 documents

EN 1990 – Eurocode: Basis of structural design

EN 1991 – Eurocode 1: Actions on structures
- EN 1991-1-1: Densities, self weight and imposed loads
- EN 1991-1-2: Actions on structures exposed to fire
- EN 1991-1-3: Snow loads
- EN 1991-1-4: Wind loads
- EN 1991-1-5: Thermal actions
- EN 1991-1-6: Actions during execution
- EN 1991-1-7: Accidental loads due to impact and explosions
- EN 1991-2: Traffic loads on bridges
- EN 1991-3: Actions induced by cranes and machinery
- EN 1991-4: Actions in silos and tanks

EN 1992 – Eurocode 2: Design of concrete structures
- EN 1992-1-1: Common rules for buildings and civil engineering structures
- EN 1992-1-2: Structural fire design
- EN 1992-2: Bridges
- EN 1992-3: Liquid retaining and containment structures

EN 1993 – Eurocode 3: Design of steel structures
- EN 1993-1-1: General rules and rules for buildings
- EN 1993-1-2: Structural fire design
- EN 1993-1-3: Cold formed thin gauge members and sheeting
- EN 1993-1-4: Structures in stainless steel
- EN 1993-1-5: Strength and stability of planar plated structures without transverse loading
- EN 1993-1-6: Strength and stability of shell structures
- EN 1993-1-7: Strength and stability of plate structures loaded transversally
- EN 1993-1-8: Design of joints
- EN 1993-1-9: Fatigue strength
- EN 1993-1-10: Fracture toughness assessment
- EN 1993-1-11: Design of structures with tension components made of steel
- EN 1993-1-12: Use of high strength steels
- EN 1993-2: Bridges
- EN 1993-3-1: Towers, masts and chimneys – towers and masts
- EN 1993-3-2: Towers, masts and chimneys – chimneys
- EN 1993-4-1: Silos, tanks and pipelines – silos
- EN 1993-4-2: Silos, tanks and pipelines – tanks
- EN 1993-4-3: Silos, tanks and pipelines – pipelines
- EN 1993-5: Piling
- EN 1993-6: Crane supporting structures

EN 1994 – Eurocode 4: Design of composite steel and concrete structures
- EN 1994-1-1: General – common rules
- EN 1994-1-2: Structural fire design
- EN 1994-2: Bridges

EN 1995 – Eurocode 5: Design of timber structures
- EN 1995-1-1: General rules and rules for buildings
- EN 1995-1-2: Structural fire design
- EN 1995-2: Bridges

EN 1996 – Eurocode 6: Design of masonry structures
- EN 1996-1-1: Rules for reinforced and un-reinforced masonry
- EN 1996-1-2: Structural fire design
- EN 1996-2: Selection and execution of masonry
- EN 1996-3: Simplified calculation methods and simple rules for masonry structures

EN 1997 – Eurocode 7: Geotechnical design
- EN 1997-1: General rules
- EN 1997-2: Ground investigation and testing

EN 1998 – Eurocode 8: Design of structures for earthquake resistance
- EN 1998-1: General rules, seismic actions and rules for buildings
- EN 1998-2: Bridges
- EN 1998-3: Strengthening and repair of buildings
- EN 1998-4: Silos, tanks and pipelines
- EN 1998-5: Foundations, retaining structures and geotechnical aspects
- EN 1998-6: Towers, masts and chimneys

EN 1999 – Eurocode 9: Design of aluminium structures
- EN 1999-1-1: Common rules
- EN 1999-1-2: Structural fire design
- EN 1999-1-3: Structures subjected to fatigue
- EN 1999-1-4: Trapezoidal sheeting
- EN 1999-1-5: Shell structures

Status August 2009 NSAI Publication Dates

	Eurocode	National Annex
EN 1990	1/12/08	24/3/05
EN 1991-1-1	1/3/09	24/3/05
EN 1991-1-3	1/3/09	27/3/09
EN 1991-1-4	22/6/05	
EN 1992-1-1	1/1/08	

EN 1993-1-1	10/5/06	27/3/07
EN 1993-1-5	1/4/09	
EN 1993-1-8	29/1/07	
EN 1995-1-1	13/8/08	
EN 1996-1-1	15/5/06	
EN 1997-1	4/8/08	4/8/08

http://www.ice.org.uk/downloads//Eurocodes%20briefing.pdf
SCOSS, ICE: Structural Eurocodes The importance of the underlying assumptions

http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Eurocodes/The-BSI-Companion-to-the-Structural-Eurocodes/
BSI Structural Eurocodes Companion

Principles

- General statements and definitions for which there is no alternative
- Requirements and analytical rules for which no alternative is permitted unless specifically permitted

Clause numbers followed directly by 'P'

Application rules
Rules that satisfy principles – alternative rules may be used

Normative: Mandatory part of code
Informative: For information purposes

National Annex
Some values are decided by national standards authorities in individual countries. These values are known as Nationally Determined Parameters and are provided in a National Annex that is published by the NSAI (Ireland) or BSI (UK).

Nationally Determined Parameters – values left open in Eurocodes

- values and/or classes where alternatives are given in the Eurocode;
- values to be used where a symbol only is given in the Eurocode;
- country specific data (geographical, climatic, etc.), e.g. snow map;
- procedure to be used where alternative procedures are given in the Eurocode.

National Annex may also contain:

- decisions on the application of informative annexes,
- references to non-contradictory complementary information (NCCI) to assist the user to apply the Eurocode.

Axes
X – along member
Y – major axis (horizontal)
Z – minor axis (vertical)

Actions – loads (**F**)
Permanent action: G
Variable action (imposed, wind): Q
Accidental action: A

Design situations
Transient: construction loads
Persistent: normal use
Accidental: fire, explosion, impact
Fire
Seismic

Effects – moments etc. (**E**)

Design working life: Table NA. 1

Resistance (eg moment capacity) (**R**)
Strength (material strength)

Symbols:

γ	gamma	partial factor
ψ	psi	'combination' factor
ξ	xi	reduction factor
η	eta	conversion factor

6.3.3 Material Properties
Design value (X_d) = Characteristic value (X_k) * η/γ_m

6.3.5 Design Resistance
(3) $R_d = R_k/\gamma_M$

6.4 Ultimate Limit States
EQU Equilibrium
STR Strength
GEO Geotechnical
FAT Fatigue

6.4.2 Verifications of static equilibrium and resistance
(1) $E_{d,dst} \leq E_{d,stb}$ EQU
(3) $E_d \leq R_d$ STR

6.4.3 Combination of actions

6.5 Serviceability Limit States
E_d (design value of the effects) ≤ C_d (limiting design value of the relevant serviceability criterion)

Disproportionate Collapse
EN 1991-7 Annex A
Table A.1 - Categorisation of consequences classes
6.4.3.3 Combinations of actions for accidental design situations

$$\sum_{j\geq1}\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \qquad 6.10$$

$$\sum_{j\geq1}\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}\psi_{0,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \qquad 6.10a$$

$$\sum_{j\geq1}\xi_j\gamma_{G,j}G_{k,j}"+"\gamma_P P"+"\gamma_{Q,1}Q_{k,1}"+"\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \qquad 6.10b$$

$$\sum_{j\geq1}G_{k,j}"+"P"+"A_d"+"(\psi_{1,1} or \psi_{2,1})Q_{k,1}"+"\sum_{i>1}\psi_{2,1}Q_{k,i} \qquad 6.11b$$

Table A1.1/ NA.2 Values of ψ factors for buildings

Action	ψ_0	ψ_1	ψ_2
Imposed loads in buildings, category (see EN 1991-1-1)			
Category A: domestic, residential areas	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.6
Category D: shopping areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic area, Vehicle weight < or = 30 kN	0.7	0.7	0.6
Category G: traffic area, 30 kN < vehicle weight < or = 160 kN	0.7	0.5	0.3
Category H: roofs	0.6	0.0	0.0
Snow loads on buildings (see EN 1991-1-3)	0.5	0.2	0.0
Wind loads on buildings (see EN 1991-1-4)	0.6	0.2	0.0
Temperature (non-fire) in buildings (see EN 1991-1-5)	0.6	0.5	0.0

ψ_0 Factor for combination value of a variable action – takes account of reduced probability of simultaneous occurrence of two actions
ψ_1 Factor for frequent value of a variable action – load exceeded for short period only; used for accidental ULS and reversible limit states (e.g. cracking in pre-stressed concrete)

ψ_2 Factor for quasi-permanent value of a variable action – average load over time; used for long-term serviceability calculations (e.g. creep in timber)

Clause A1.3
Equilibrium: Table NA 3 EQU (Set A) – Equation 6.10

$\gamma_{Gj,sup} = 1.10$ $\gamma_{Gj,inf} = 0.90$
$\gamma_{Q,1} = 1.5$ $\gamma_{Q,i} = 1.5$

Unfavourable: $\gamma_{Gj,sup}G_{kj,sup}$ 1.1 * Dead Load
Favourable: $\gamma_{Gj,inf}G_{kj,inf}$ 0.9 * Dead Load

Lead variable action $\gamma_{Q,1}Q_{k,1}$ 1.5 * Imposed Load
Accompanying variable action $\gamma_{Q,i}\psi_{0,i}Q_{k,I}$ 1.5 * 0.7 * Wind Load (Cat. A-D)

Structural Design: Table NA 4 STR/GEO (Set B)

$\gamma_{Gj,sup} = 1.35$ $\gamma_{Gj,inf} = 1.00$
$\gamma_{Q,1} = 1.5$ $\gamma_{Q,i} = 1.5$ ξ =0.85 (0.925 in UK)

Equation 6.10
Unfavourable $\gamma_{Gj,sup}G_{kj,sup}$ 1.35 * Dead Load
Favourable $\gamma_{Gj,inf}G_{kj,inf}$ 1.0 * Dead Load

Lead variable action $\gamma_{Q,1}\psi_{0,1}Q_{k,1}$ 1.5 * Imposed Load
Accompanying variable action $\gamma_{Q,i}\psi_{0,i}Q_{k,I}$ 1.5 * 0.7 * Wind Load (Cat. A-D)

Equation 6.10a
Unfavourable $\gamma_{Gj,sup}G_{kj,sup}$ 1.35 * Dead Load
Favourable $\gamma_{Gj,inf}G_{kj,inf}$ 1.0 * Dead Load

Accompanying variable action (main) $\gamma_{Q,1}Q_{k,1}$ 1.5 * 0.7 * Imposed Load
Accompanying variable action (other) $\gamma_{Q,i}\psi_{0,i}Q_{k,I}$ 1.5 * 0.7 * Wind Load (Cat. A-D)

Equation 6.10b
Unfavourable $\xi\gamma_{Gj,sup}G_{kj,sup}$ 0.85 * 1.35 * Dead Load
Favourable $\gamma_{Gj,inf}G_{kj,inf}$ 1.0 * Dead Load

Lead variable action $\gamma_{Q,1}Q_{k,1}$ 1.5 * Imposed Load
Accompanying variable action $\gamma_{Q,i}\psi_{0,i}Q_{k,I}$ 1.5 * 0.7 * Wind Load (Cat. A-D)

Example
Dead, Imposed, Wind – all unfavourable

6.10
1.35*D + 1.5*I + 1.5*0.7*W **or** 1.35*D + 1.5*0.7*I + 1.5*W

6.10a
1.35*D + 1.5*0.7*I + 1.5*0.7*W

6.10b
0.85*1.35*D + 1.5*I + 1.5*0.7*W **or** 0.85*1.35*D + 1.5*0.7*I + 1.5*W

Dead, Imposed
6.10
1.35*D + 1.5*I

6.10a
1.35*D + 1.5*0.7*I

6.10b
0.85*1.35*D + 1.5*I

Example;
Dead load: 6 kN/m^2 Imposed Load: 5 kN/m^2
Eqn 6.10: 1.35 * 6 + 1.5 * 5 = 15.6 kN/m^2
Eqn 6.10a: 1.35 * 6 + 1.5 * 0.7 * 5 = 13.35 kN/m^2
Eqn 6.10b: 0.85 * 1.35 * 6 + 1.5 * 5 = 14.385 kN/m^2

Geotechnical:
Approach 1: Size foundations: Table NA5 (Set C)
Structural design: Table NA4 (Set B)
$\gamma_G = 1.0$ $\gamma_Q = 1.3$ (or 0)
Approach 2: Geotechnical and other structural actions Table NA4 (Set B)

Approach 3: Geotechnical Actions: Table NA5 (Set C)
Other structural actions: Table NA4 (Set B)

Table NA. 6 Accidental

Favourable $G_{kj,sup}$
Unfavourable $G_{kj,inf}$

Accidental	A_d
Accompanying (main)	$\psi_{1,1}Q_{k,1}$
Accompanying (other)	$\psi_{2,i}Q_{k,i}$

$\psi_{1,1}$ = 0.5 (category A,B)

$\psi_{2,i}$ = 0.3 (category A,B)

Imposed Loads I.S. EN 1991-1-1:2002

Table 6.1/ NA. 1 Categories of Use

Category	Specific Use	Example
A1 A2	Areas for domestic activities Areas for residential activities	Rooms in houses and dwellings Hospitals, residential buildings
B	Office areas	
C	Areas where people may congregate (with the exception of areas defined under category A, B, and D1))	**C1**: Areas with tables, etc. e.g. areas in schools, cafés, restaurants, dining halls, reading rooms, receptions. **C2**: Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms. **C3:** Areas without obstacles for moving people, e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals, railway station forecourts. **C4**: Areas with possible physical activities, e.g. dance halls, gymnastic rooms, stages. **C5**: Areas susceptible to large crowds, e.g. in buildings for public events like concert halls, sports halls including stands, terraces and access areas and railway platforms.
D	Shopping areas	**D1:** Areas in general retail shops **D2**: Areas in department stores

Table NA.2 - Imposed loads on floors, balconies and stairs in buildings

Categories of loaded areas	**qk [kN/m^2]**	**Qk [kN]**
Category A1		
- Floors	1,5	2,0
- Stairs	2,0	2,0
- Balconies	2,5	2,0
Category A2		
- Floors	2,0	2,0
- Stairs	2,0	2,0
- Balconies	2,5	2,0
Category B	3,0	4,5
Category C		
- C1	3,0	4,0
- C2	4,0	4,0
- C3	5,0	4,0
- C4	5,0	7,0
- C5	5,0	4,5
Category D		
- D1	4,0	4,0
- D2	5,0	7,0

Table NA.4 - Imposed loads on roofs of Category H

0.6 kN/m^2; 1.0 kN

6.2.2 Columns and Walls

(1) For the design of columns or walls, loaded from several storeys, the total imposed loads on the floor of each storey should be assumed to be distributed uniformly. 'Pattern bending need not be considered'.

6.3.1.2 (8) Partitions

< 1 kN/m: 0.5 kN/m^2; 1 kN/m -2 kN/m: 0.8 kN/m^2; 2 kN/m – 3 kN/m: 1.2 kN/m^2

6.3.1.2 (10) Reduction factors for imposed loads

$\alpha_A = (5/7)*\psi_0 + A_0/A$ (≤ 1) $A_0 = 10$ m^2 $\alpha_A \geq 0.6$ (Category C, D)

$\alpha_n = (2+(n-2)*\psi_0)/n$ ($n>2$)

Different values/formulas in UK annex

Area (m^2)	α_A (Eurocode)	α_A (UK)
0	1	1
50	.7	.95
100	.6	.9
150	.567	.85
>250	.54	.75

No. of floors	α_n (Eurocode)	α_n (UK)
1	1	1
2	1	.9
3	.9	.8
4	.85	.7
5	.82	.6
10	.76	.5

EN 1991-1-4 Wind

1.1 (2) Buildings ≤ 200 m in height
4.2 (1) Fundamental basic wind velocity $v_{b,0}$ (National Annex) characteristic 10 minutes mean wind velocity at 10 m above ground in open country (terrain category II)
4.2 (2) Basic wind velocity $v_b = c_{dir} * c_{season} * v_{b,0}$ (Eq 4.1)
c_{dir}: Direction factor (recommended value 1)
c_{season}: Season factor (recommended value 1)
4.3.1 Mean wind velocity $v_m(z) = c_r(z) * c_o(z) * v_b$
$c_r(z)$ roughness factor
$c_o(z)$ orography factor – 1 generally except where hills, cliffs result in increased velocities. Annex A3 gives guidance on calculation of $c_o(z)$
4.3.2 Terrain roughness
$c_r(z) = k_r \ln(z/z_0)$ $z_{min} < z < z_{max}$ Eq 4.4

$c_r(z) = k_r\,(z_{min})$ $z < z_{min}$
k_r (terrain factor) = $0.19 * (z_o/z_{oII})^{0.07}$ Eq 4.5
$z_{max} = 200$ m $z_{oII} = 0.05$ m

Table 4.1 Terrain categories and parameters

	Category	z_o (m)	z_{min} (m)
O	Sea or coastal area exposed to the open sea	.003	1
I	Lakes or flat and horizontal area with negligible vegetation and without obstacles	.01	1
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	.05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	.3	5
IV	Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1	10

4.4 Wind turbulence
$I_v(z)$ (turbulence intensity) = $k_1/(c_0(z) * \ln(z/z_0))$ $z_{min} < z < z_{max}$ Eq 4.7
$I_v(z)$ (turbulence intensity) = $I_v(z_{min})$ $z < z_{min}$
k_1: turbulence factor – recommended value 1.0

4.5 Peak velocity pressure
$q_p(z)$ (peak velocity pressure) = $[1 + 7 * I_v] * ½ * \rho * v^2_m(z) = c_e(z) * q_b$ Eq 4.8
$c_e(z)$ (exposure factor) = $q_p(z)/\ q_b$ Eq 4.9
q_b (basic velocity pressure) = $½ * \rho * v^2_b$ Eq 4.10
$\rho = 1.25 kg/m^3$
$c_e(z) = [1 + 7 * I_v] * (c_r(z) * c_o(z))^2$
Figure 4.2: Illustrations of the exposure factor $c_e(z)$ for $c_0 = 1.0$, $k_1 = 1.0$

5.2 Wind pressure on surfaces
w_e (wind pressure) = $q_p(z_e) * c_{pe}$ Eq. 5.1
w_i (wind pressure) = $q_p(z_i) * c_{pi}$ Eq. 5.2
z_e, z_i: reference heights (actual heights generally)

c_{pe}: Tables 7.1-7.5
$c_{pe,10}$: Area = 10 m^2 – overall coefficient
$c_{pe,1}$: Area = 1 m^2 – local coefficient
7.2.1, Figure 7.2: Interpolation of c_{pe}
c_{pi}: 7.2.9, Figure 7.13: +0.2, -0.3 could be taken as default values (Note 2: 7.2.9(6))

5.3 Wind forces
External forces $F_{w,e} = c_s c_d * \Sigma w_e * A_{ref}$ Eq. 5.5
Internal forces $F_{w,i} = \Sigma w_i * A_{ref}$ Eq. 5.6
Friction forces $F_{fr} = c_{fr} * q_p(z_e) * A_{fr}$ Eq. 5.7
A_{ref}: Area perpendicular to wind

A_{fr}: Area parallel to wind located beyond a distance 2b or 4h from upwind corner
Friction force can be ignored if area parallel to wind < 4 times area perpendicular to wind
c_s: size factor c_d: dynamic factor Section 6; Annex D
Table 7.10: c_{rf} = 0.01 (smooth), .02 (rough), .04 (very rough)

Section 6: Structural factor: $c_s c_d$
6.2 (1) a) Buildings less than 15 m $c_s c_d = 1$
6.2 (1) c) Buildings less than 100 m where $h/d < 4$ $c_s c_d = 1$
6.3 Detailed procedure

7.2.2 (3) Lack of correlation between wind pressures on windward and leeward faces
$h/d \geq 5$ Multiply by 1
$h/d \leq 1$ Multiply by 0.85

National AnnexMap

German and UK National Annexes suggest that mean hourly wind speed be multiplied by 1.06 to obtain 10 minute mean wind velocity

UK National Annex incorporates several variations, generally in terms of providing different formulas for various coefficients where permitted in EN 1991-1-4:

c_{alt}, c_{dir}, c_{season}, $c_r(z)$, turbulence factor, c_s, c_d

Terrain categories are reduced from five in EN 1991-1-4 to three (sea, country, town)
$q_p(z)$ (peak velocity pressure) $= [1 + 3 * I_v]^2 * ½ * \rho * v^2_m(z) = c_e(z) * q_b$ (NA3)
$\rho = 1.226$ kg/m^3