RUHR-UNIVERSITÄT BOCHUM

Eurocode 1: Action on structures

Part 1-1: General Actions
Densities, self-weight, imposed loads for buildings

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EN 1991-1-1 Densities, self weight, imposed loads for buildings

EN 1991-1-1 gives design guidance and actions for the structural design of buildings and civil engineering works including some geotechnical aspects for the following subjects:

- **densities of construction materials and stored materials**
- **self-weight of construction works**
- **imposed loads for buildings**

Background documents:

- ISO 9194 Basis for Design of Structures – Actions due to Self-Weight of Structures, non Structural Elements and Stored materials – Density;
- CIB Report 115/89 *Int. Council for research and innovation in building and construction Actions on* Structures, Self-Weight Loads;
- CIB Report 116/89 *Int. Council for research and innovation in building and construction Actions on* Structures, Live Loads in Buildings;
- National Standards of CEN member states;

EN 1991-1-1 Densities, self weight, imposed loads for buildings

National annex for EN 1991-1-1

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices have to be made, therefore the National Standard implementing EN 1991-1-1 should have a National Annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

National choice is allowed in EN 1991-1-1 through:

2.2(3)	**Dynamic effects due to rhythmical movement of people**
5.2.3(1) to 5.2.3(5)	Non-structural parts and ballast on bridges
6.3.1.1 (Table 6.1)	**Residential, social, commercial, administration areas**
6.3.1.2(1)P (Table 6.2)	**Values of imposed loads on floors, balconies, stairs**
6.3.1.2(10) & (11)	**Reduction factor α_A**
6.3.2.2 (1)P (Table 6.4)	**Values of imposed loads on floors due to storage**
6.3.2.2 (3)	Horizontal forces due to stored materials after Annex A
6.3.3.2(1) (Table 6.8)	**Imposed loads on garages and vehicle traffic areas**
6.3.4.2 (Table 6.10)	**Imposed loads on roofs of category H**
6.4 (1)(P) (Table 6.12)	**Horizontal loads on partition walls and parapets**

6.3.1 Imposed loads on residential, social, commercial, administr. areas

Category	Specific Use	q_k [kN/m²]	Q_k [kN]	q_k [kN/m]
A	Areas for domestic and residential activities (floors)	1.5 to **2.0**	**2.0** to 3.0	0.2 to 1.0 (**0.5**)
B	Office areas	2.0 to **3.0**	1.5 to **4.5**	
C	Areas where people may congregate:			
	C1: Areas with tables (e.g. restaurants, cafés…)	2.0 to **3.0**	3.0 to **4.0**	0.2 to 1.0 (**0.5**)
	C2: Areas with fixed seats (e.g. areas in churches, theatres or cinemas…)	3.0 to **4.0**	2.5 to 7.0 (**4.0**)	0.8 to **1.0**
	C3: Areas without obstacles for moving people (e.g. museums, exhibition rooms…)	3.0 to **5.0**	**4.0** to 7.0	
	C4: Areas with possible physical activities (e.g. dance halls, gymnastic rooms…)	4.5 to **5.0**	3.5 to **7.0**	
	C5: Areas susceptible to large crowds (e.g. concert halls…)	**5.0** to 7.5	3.5 to **4.5**	**3.0** to 5.0
D	Shopping areas:			
	D1: Areas in general retail shops	**4.0** to 5.0	3.5 to 7.0 (**4.0**)	0.8 to **1.0**
	D2: Areas in department stores	4.0 to **5.0**	3.5 to **7.0**	

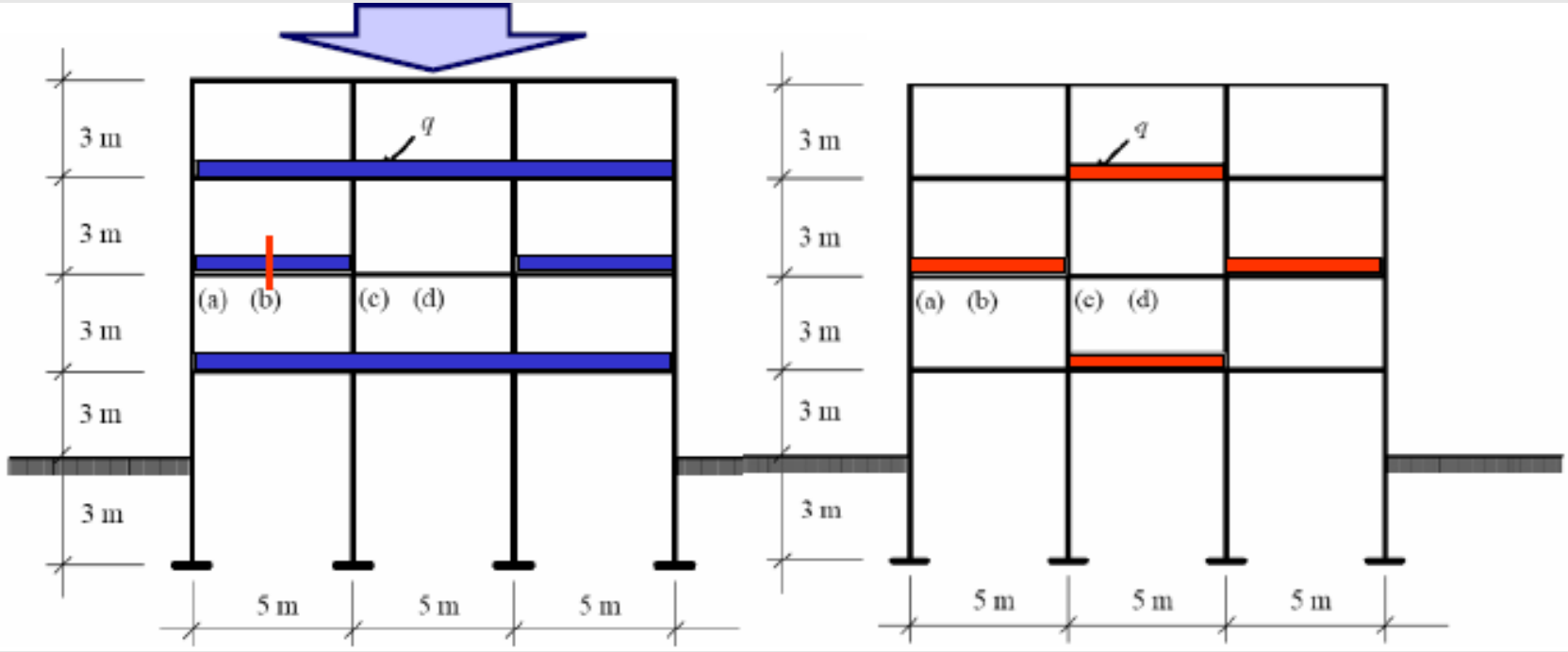
After EN 1991-1-1:2002-4, Tables 6.1 and 6.1

recommended values undelined

6.2.1 Floors Beams and Roofs

(1)P For the design of a floor structure within one storey or a roof, the imposed load shall be taken into account as a free action applied at the most unfavourable part of the influence area of the action effects considered.

(2) Where the loads on other storeys are relevant, they may be assumed to be distributed uniformly (fixed actions).



Formichi, P.: EUROCODE 1, Actions on Building Structures. in: CEN/TC250/SC1 : EU-Russia cooperation on standardisation for construction, Moscow, 9-10 October 2008.

6.2.1 Reduction factor α_A

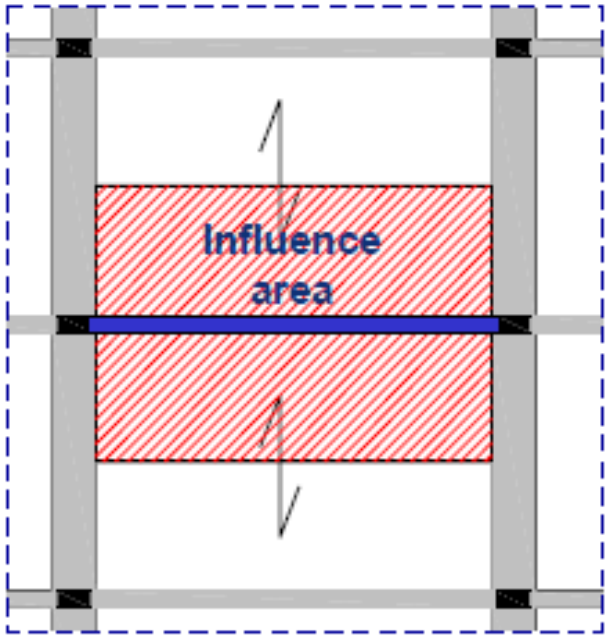
Specific rules for the reduction of the imposed load on **an appropriate supporting member**

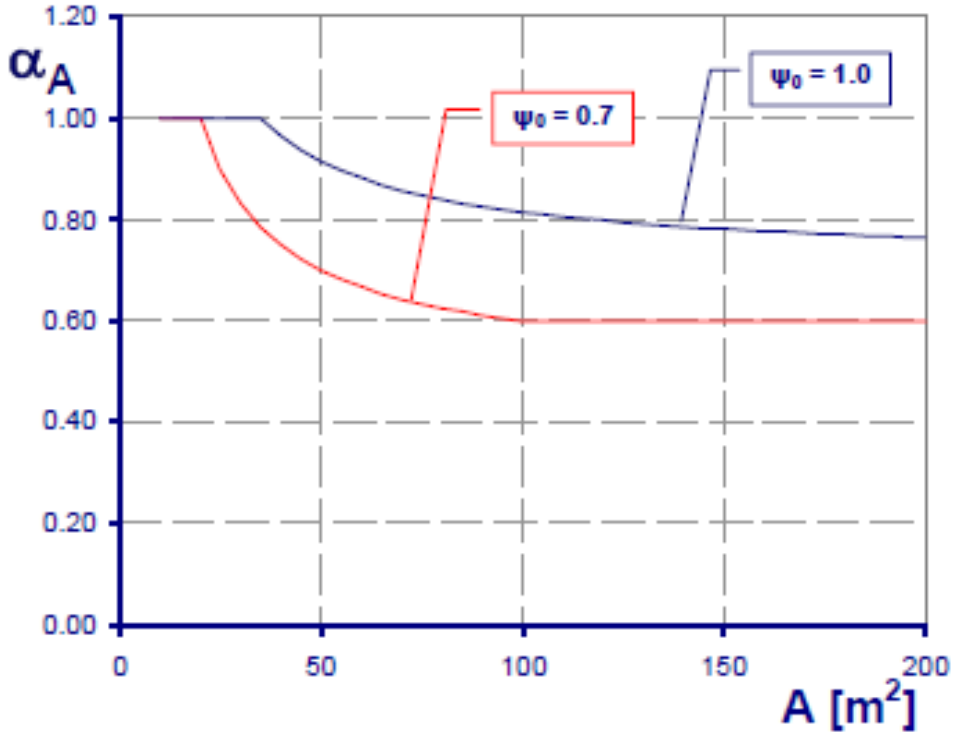
$$\alpha_A = \frac{5}{7}\psi_0 + \frac{A_0}{A} \leq 1{,}0$$

ψ_0 is the combination factor according to EN 1990, may be taken as:
- 0,7 for residential, social and commercial areas
- 1,0 for storage and industrial areas

A_0 = 10,0 m²

A is the influence area





Formichi, P.: EUROCODE 1, Actions on Building Structures. in: CEN/TC250/SC1 : EU-Russia cooperation on standardisation for construction, Moscow, 9-10 October 2008.

6.2.1 Reduction factor α_n

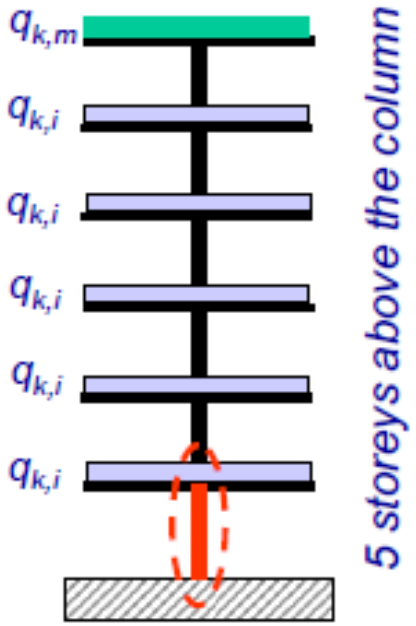
Specific rules for the reduction of the imposed load on **Columns** in residential areas, offices, areas with congregation of people and shopping centres.

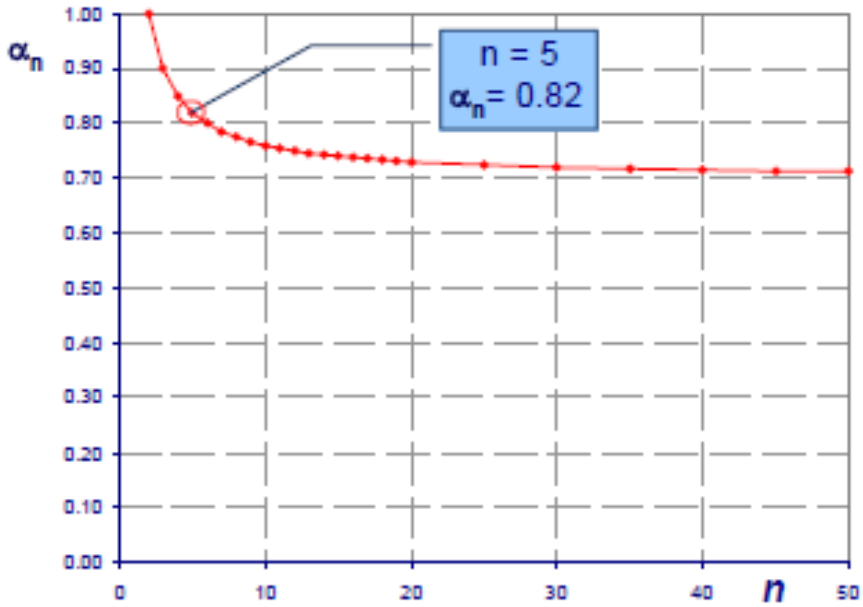
The total imposed load from several storeys may be multiplied by a reduction factor α_n

$$\alpha_n = \frac{2 + (n-2)\psi_0}{n}$$

n is the number of storeys (> 2) above the loaded structural elements from the same category.

ψ_0 is in accordance with EN 1990 (may be taken equal to 0,7).





Formichi, P.: EUROCODE 1, Actions on Building Structures. in: CEN/TC250/SC1 : EU-Russia cooperation on standardisation for construction, Moscow, 9-10 October 2008.

Table 6.8 Imposed loads on garages and vehicle traffic areas

Categories of traffic areas	q_k [kN/m^2]	Q_k [kN]
Category F Gross vehicle weight: ≤ 30 kN	q_k	Q_k
Category G 30 kN < gross vehicle weight ≤ 160 kN	5,0	Q_k

NOTE 1 For category F. q_k may be selected within the range 1,5 to 2,5 kN/m^2 and Q_k may be selected within the range 10 to 20 kN.

NOTE 2 For category G, Q_k may be selected within the range 40 to 90 kN.

NOTE 3 Where a range of values are given in Notes 1 & 2, the value may be set by the National annex.
The recommended values are underlined.

(2) The axle load should be applied on two square surfaces with a 100 mm side for category F and a 200 mm side for Category G in the possible positions which will produce the most adverse effects of the action.

After EN 1991-1-1:2002-4, Table 6.8

Table 6.10 Imposed loads on roofs of category H

Roof	q_k [kN/m^2]	Q_k [kN]
Category H	q_k	Q_k
NOTE 1 For category H q_k may be selected within the range 0,00 kN/m^2 to 1,0 kN/m^2 and Q_k may be selected within the range 0,9 kN to 1,5 kN. Where a range is given the values may be set by the National Annex. The recommended values are: $q_k = 0{,}4$ kN/m^2, $Q_k = 1{,}0$kN NOTE 2 q_k may be varied by the National Annex dependent upon the roof slope. NOTE 3 q_k may be assumed to act on an area A which may be set by the National Annex. The recommended value for A is 10 m^2, within the range of zero to the whole area of the roof. NOTE 4 See also 3.3.2 (1)		

(2) The minimum values given in Table 6.10 do not take into account uncontrolled accumulations of construction materials that may occur during maintenance.

NOTE See also EN 1991-1-6: Actions during execution.

(3)P For roofs separate verifications shall be performed for the concentrated load Q_k and the uniformly distributed load q_k, acting independently.

After EN 1991-1-1:2002-4, Table 6.10

Table 6.12 Horizontal loads on partition walls and parapets

Loaded areas	q_k [kN/m]
Category A	q_k
Category B and C1	q_k
Categories C2 –to C4 and D	q_k
Category C5	q_k
Category E	q_k
Category F	See Annex B
Category G	See Annex B

NOTE 1 For categories A, B and C1, q_k may be selected within the range 0,2 to 1,0 (0,5).

NOTE 2 For categories C2 to C4 and D q_k may be selected within the range 0,8 kN/m –to 1,0 kN/m.

NOTE 3 For category C5 q_k may be selected within the range 3,0 kN/m to 5,0 kN/m.

NOTE 4 For category E q_k may be selected within the range 0,8 kN/m to 2,0 kN/m. For areas of category E the horizontal loads depend on the occupancy. Therefore the value of q_k is defined as a minimum value and should be checked for the specific occupancy.

NOTE 5 Where a range of values is given in Notes 1, 2, 3 and 4, the value may be set by the National Annex. The recommended value is underlined.

NOTE 6 The National Annex may prescribe additional point loads Q_k and/or hard or soft body impact specifications for analytical or experimental verification.

After EN 1991-1-1:2002-4, Table 6.12

Probabilistic model of self weight

Self-weight G of structural members may be usually determined as a product of the volume Ω and the density γ:

$$G = \Omega \gamma \tag{3}$$

Both, the volume Ω and the density γ, are random variables that may be described by normal distributions [9]. The mean of the volume Ω is approximately equal to the nominal value (as a rule slightly greater), the mean of the density γ is usually well defined by the producer. Informative coefficients of variation are indicated in Table 1; more extensive data are available in [9].

The coefficient of variation V_G of the resulting self-weight may be estimated using approximate expression for coefficients of variation

$$V_G^2 = V_\Omega^2 + V_\gamma^2 \tag{4}$$

Generally the self-weight G is described by the normal distribution.

Table 1. Examples of coefficients of variation (indicative values only).

Material	Coefficient of variation of		
	Ω	γ	G
Steel (rolled)	0,03	0,01	0,031
Concrete (plate 300 mm thick, ordinary)	0,02	0,04	0,045
Masonry unplastered	0,04	0,05	0,080
Timber (sawn beam 200 mm thick, dry)	0,01	0,10	0,100

Probabilistic model of imposed loads

[9] JCSS: Probabilistic model code. JCSS working materials, http://www.jcss.ethz.ch/, 2001.

The imposed load Q is usually described by a Gumbel distribution (in [9] also Gamma and exponential distributions are used for sustained and intermittent loads respectively). In general, the total imposed load Q consists of the sustained (long-term) component q and the intermittent (short-term) component p. The sustained load q is always present while the intermittent component p may be absent and in fact may be active only very rarely (for example few days a year only). The parameters of both components including jump rate λ of sustained load, ν jump rate of intermittent load and d duration time of intermittent load are indicated in Table 2, which is taken from JCSS materials [9].

Probabilistic model of imposed loads (cont.-d)

IMPLEMENTATION OF EUROCODESHANDBOOK 3: ACTION EFFECTS FOR BUILDINGS. Guide to basis of structural reliability and risk engineering related to Eurocodes supplemented by practical examples. LEONARDO DA VINCI PILOT PROJECT CZ/02/B/F/PP-134007, DEVELOPMENT OF SKILLS FACILITATING IMPLEMENTATION OF EUROCODES

Table 2. Parameters of imposed loads in accordance with loading areas.

Category	A_0 [m^2]	Sustained load q				Intermittent load p			
		μ_q [kN/m^2]	σ_V [kN/m^2]	σ_U [kN/m^2]	$1/\lambda$ [years]	μ_p [kN/m^2]	σ_U [kN/m^2]	$1/\nu$ [years]	d [days]
Office	20	0,5	0,3	0,6	5	0,2	0,4	0,3	1-3
Lobby	20	0,2	0,15	0,3	10	0,4	0,6	1	1-3
Residence	20	0,3	0,15	0,3	7	0,3	0,4	1	1-3
Hotel rooms	20	0,3	0,05	0,1	10	0,2	0,4	0,1	1-3
Patient room	20	0,4	0,3	0,6	5-10	0,2	0,4	1	1-3
Laboratory	20	0,7	0,4	0,8	5-10				
Libraries	20	1,7	0,5	1	10				
Classroom	100	0,6	0,15	0,4	10	0,5	1,4	0,3	1-5
Stores									
first floor	100	0,9	0,6	1,6	1-5	0,4	1,1	1,0	1-14
upper floor	100	0,9	0,6	1,6	1-5	0,4	1,1	1,0	1-14
Storage	100	3,5	2,5	6,9	0,1-1				
Industrial									
- light	100	1	1	2,8	5-10				
- heavy	100	3	1,5	4,1	5-10				
Concentration of peoples	20					1,25	2,5	0,02	0,5