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DS/EN 1996-1-1:2022 DK NA 202X

**National Annex to: Eurocode 6 – Design of masonry structures –
Part 1-1: General rules for reinforced and unreinforced masonry structures**

**Nationalt Anneks til: Eurocode – Murværkskonstruktioner –
Del 1-1: Generelle regler for armeret og uarmeret murværk**

Foreword

Published [måned og år].

This National Annex (NA) to DS/EN 1996-1-1:2022 forms part of the Danish national annexes to the second generation of Eurocodes.

This NA supersedes DS/EN 1996-1-1 DK NA:2019 upon its implementation in the Building Regulations (Bygningsreglementet 2018 – BR18) as an appendix.

During the transition period stated in the Building Regulations, both the first generation and the second generation of the Eurocodes and NAs may be applied.

This NA cannot be used in conjunction with the first generation of Eurocodes.

This NA lays down the conditions for the Danish implementation of DS/EN 1996-1-1:2022 for construction works in conformity with the Danish Building Regulations; Bygningsreglementet 2018 (BR 18). Other parties may bring this NA into force by reference.

The Eurocodes establish the principle that certain parameters are left open for national determination. These parameters are referred to as *Nationally Determined Parameters* (NDP) and specifies the nationally applicable values, classes or methods. Furthermore, the NA may provide *Non-Contradictory, Complementary Information* (NCCI), i.e. additional guidance and alternative methods or values that support the application of the Eurocode without altering or contradicting its provisions.

Further, this National Annex includes NOTES. Notes have the status of guidance and provide additional information intended to assist the understanding or use of text of the national annex.

In conformity with the Danish Building regulations, the verbal forms used in this Eurocode and NA are to be understood as follows:

- “shall” expresses a requirement to be followed
- “should” expresses a recommendation. Alternative approaches could be used if technically justified
- “may” expresses permission within the limits of Danish Building Regulations
- “can” expresses a possibility or capability
- “is/are” expresses a statement of certainty or a fact

This NA includes:

- Foreword;
- An overview of clauses with possible Nationally Determined Parameters (NDPs) and of Non-Contradictory Complementary Information (NCCI);
- National choice to national Determined Parameters (NDP), and Non-Contradictory Complementary Information (NCCI)

Valid versions of the NAs as well as previous versions, addenda can be found at www.bygningsreglementet.dk.

Overview of possible Nationally Determined Parameters (NDPs) and Non-Contradictory Complementary Information (NCCI)

The list below identifies the clauses where Nationally Determined Parameters (NDPs) are possible, and whether a national choice is made, and if an informative annex is applicable or not applicable. Furthermore, clauses providing complementary information (NCCI) are identified in the list below.

Clause	Subject	Nationally Determined Parameter	Non-Contradictory Complementary Information
3.1.1.1	Masonry		Complementary information
3.1.1.3	Reinforced masonry		Complementary information
3.1.3.1	Masonry unit		Complementary information
4.4.4(2)	Ultimate limit states – Partial factors on materials for masonry buildings	National choice Awaiting	
5.2.1(1)	Type of masonry mortar		Complementary information
5.2.2(2)	Specification of masonry mortar	National choice	
5.7.1.2(1)	Characteristic compressive strength of non-shell bedded masonry	National choice	
5.7.1.2(1)	Characteristic compressive strength of non-shell bedded masonry		Complementary information
5.7.1.3(2)	Characteristic compressive strength of non-shell bedded masonry, based on test	Unchanged	
5.7.2.1(1)	Characteristic shear strength of masonry	Unchanged	
5.7.2.1(2)	Characteristic shear strength of masonry	Unchanged	
5.7.2.2(4)	Characteristic initial shear strength	National choice	
5.7.4(4)	Characteristic flexural strength of masonry	National choice	Complementary information
5.7.5(4)	Characteristic anchorage strength of reinforcement		Complementary information
5.8.2(3)	Modulus of elasticity	National choice	
5.8.4(3)	Creep, moisture expansion or shrinkage and thermal expansion	Unchanged	

Clause	Subject	Nationally Determined Parameter	Non-Contradictory Complementary Information
6.3.3(2)	Reinforcing steel	Unchanged	
6.3.3(3)	Reinforcing steel	Unchanged	
7.5.1.1(3)	Masonry walls subjected to mainly vertical loading – general		Complementary information
7.5.1.1(4)	Masonry walls subjected to mainly vertical loading – general		Complementary information
7.5.1.3(10)(ii)	Effective height of masonry walls		Complementary information
7.5.1.4(4)	Effective thickness of masonry walls	Unchanged	
7.5.2(1)	Unreinforced masonry walls subjected to mainly vertical loading		Complementary information
7.5.3.6(1)	Limiting span of reinforced masonry beams		Complementary information
7.5.7.3(2)	Dimensions		Complementary information
8.2.2	Reduction factor for slenderness and eccentricity		Complementary information
8.2.2(4)	Reduction factor for slenderness and eccentricity		Complementary information
8.2.3(2)	Concentrated loads		Complementary information
8.3.1(2)	In-plane shear resistance	National choice	
8.4.2(5)	Walls in flexure		Complementary information
8.8.3(2)	Beams subjected to shear loading		Complementary information
8.10.3.1(2)	In-plane shear resistance	Unchanged	
10.1.2(2)	Minimum thickness of wall	Unchanged	
10.2.5.1	Anchorage of tension and compression reinforcing steel		Complementary information
10.5.1.4(1)	Ring ties and ring beams		Complementary information
10.5.2.2(2)	Cavity and veneer walls	National choice	

Clause	Subject	Nationally Determined Parameter	Non-Contradictory Complementary Information
10.5.2.3(2)	Double-leaf and collar jointed walls	National choice	
10.6.2(1)	Vertical chases and recesses	Unchanged	
10.6.3(1)	Horizontal and inclined chases	Unchanged	
10.6.3(6)	Horizontal and inclined chases		Complementary information
Annex A	Consideration of partial factor for materials relating to execution	Not applicable	
A.4 NA	Cut units		Complementary information
A.5 NA	Deviation in positioning		Complementary information
A.6 NA	Joints		Complementary information
A.7 NA	Bond pattern		Complementary information
A.8 NA	Chases and recesses		Complementary information
A.9 NA	Acceptance inspection		Complementary information
A.10 NA	Execution control		Complementary information
Annex B	Method for calculating the second order effect	Informative	
Annex C	Simplified methods for calculating the out-of-plane eccentricity of loading on walls	Not applicable	
C.5 NA	Determination of eccentricities		Complementary information
C.6 NA	Examples		Complementary information
Annex D	Bending moment coefficients, α_2 , in single leaf laterally loaded wall panels	Informative	
Annex E	Limiting height and length to thickness ratios for unreinforced walls and walls with only bed joint reinforcement under the serviceability limit state	Informative	

Clause	Subject	Nationally Determined Parameter	Non-Contradictory Complementary Information
Annex F	Capacity reduction factor for slenderness and eccentricity	Informative	
Annex G	Adjustment of lateral load for walls supported on three or four edges subjected to out-of-plane horizontal loading and vertical loading	Informative	
Annex H	Reinforced masonry members subjected to shear loading: enhancement of the design shear strength of masonry, f _{vd}	Not applicable	
Annex I	A design method for complex shaped members subjected to mainly vertical loading	Informative	Complementary information
Annex J	Method for walls under combined lateral and vertical loading taking buckling due to vertical loading and flexural strength into account	Informative	
Annex K	Mean material properties	Informative	
NOTE Unchanged: Recommendations in the Eurocode to be followed. National choice: A National Determined Parameter is chosen and defined. Complementary information: (Non-contradictory) complementary information on how to use the Eurocode. Normative: The Annex shall be used. Informative: The Annex may be used. Not applicable: The Annex cannot be used. No further information: The Eurocode allows further information. No further information is given.			

National Determined Parameter (NDP) and Non-contradictory complementary Information (NCCI)

3.1.1.1 Masonry

(NCCI)

Bonded masonry units connected with mortar and including at least one bed joint.

3.1.1.3 Reinforced masonry

(NCCI)

Random bond does not follow any predetermined pattern.

3.1.3.1 Masonry unit

(NCCI)

Lightweight concrete is a designation covering autoclaved aerated concrete (AAC) and concrete with lightweight aggregates.

Masonry units of clay include burned and unburned clay blocks.

4.4.4(2) Ultimate limit states – Partial factors on materials for masonry buildings

(NDP)

[Awaiting – new partial factors are currently developed]

5.2.1(1) Type of masonry mortar

(NCCI)

In various product and testing standards, etc., 28-day strengths are used. It is generally permitted to extend the curing time, provided that the curing time is specified in the accompanying declarations/DOP/etc. At the time of commissioning, it must be ensured that the curing time has been achieved.

5.2.2(2) Specification of masonry mortar

(NDP)

For prescribed mortars, the compressive strengths and flexural strengths specified in Table 5.a NA shall be assumed if the constituents of the mortar fulfil the following requirements:

1. Hydrated lime is to conform to the requirements of EN 459-1 and shall not contain slakeable particles;
2. Cement should at least be of strength class 42,5 and fulfil the requirements specified in EN 197-1;
3. Aggregates for mortars shall fulfil the requirements in EN 12620 and be fractioned in such a way that the grading curve determined as specified in EN 933-1 lies within the limit curves shown in Figure 5.a NA. If the aggregate is polluted with organic substances, the colour reaction when evaluating the humus content according to the test method given in EN 1744-1 should not be darker than 1 proportion of standard colour diluted with 3 proportions of water, unless documented justification is provided.
4. Admixtures are not to be used, however ethanol (denatured alcohol) and blended products of ethanol and isopropanol containing up to 40 % isopropanol may be used as an antifreeze admixture for KC

60/40/850 and KC 50/50/700 produced as prescribed mortar, provided that at least 1 and no more than 4 L are added per 100 L of mortar. In such cases, a 20 % reduction shall be assumed for all strength parameters of the mortar.

5. In the finished mortar the dry mass of the individual constituents should not deviate by more than 5 % from the quantity considered.

If the requirements specified in 1., 2., 3., 4. and 5. are not fulfilled, it is necessary to determine the mortar strength experimentally, and the mortar is to be declared as designed masonry mortar.

Figure 5.a NA – Limit curves for sand

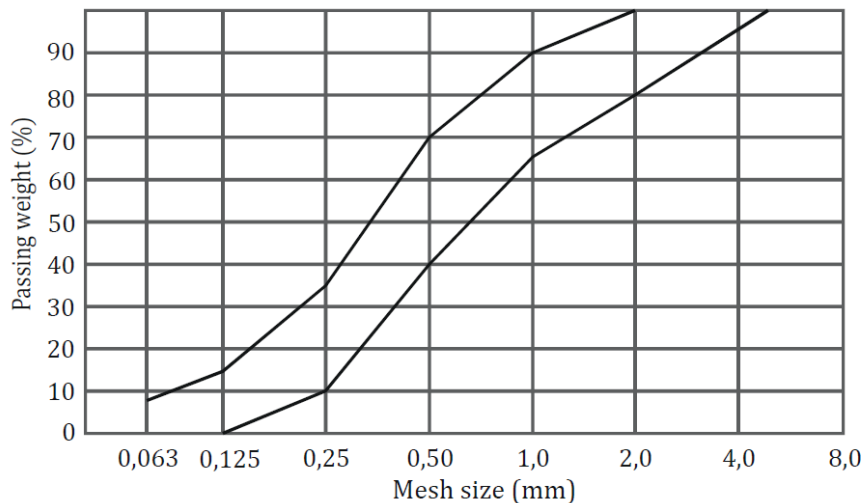


Table 5.a NA – Ratio between the compressive strength and mix proportion of mortar

Mix proportion	Minimum compressive strength MC/ML	f_m
LC 60/40/850	ML 0,8 MPa	0,4 MPa
LC 50/50/700	MC 0,9 MPa/ML 1,8 MPa	0,9 MPa
LC 35/65/650	MC 2 MPa	2,0 MPa
LC 20/80/550	MC 4,5 MPa	4,5 MPa

5.7.1.2(1) Characteristic compressive strength of non-shell bedded masonry

(NDP)

Both method (i) and method (ii) shall be used to determine the characteristic compressive strength of masonry; where:

- i. Evaluation of results of tests as described in 5.7.1.3
- ii. Rules as described in 5.7.1.4

Both 5.7.1.3 and 5.7.1.4 are applicable.

5.7.1.2(1) Characteristic compressive strength of non-shell bedded masonry

(NCCI)

Method (i) in 5.7.1.2(1) in DS/EN 1996-1-1:2022 shall be used provided either that documentation of the parameters in equation 5.1 is given or that Table 5.b DK NA is applied subject to the related conditions. Method (ii) in 5.7.1.2(1) can be used without further documentation.

The compressive strength of the header of the bricks may be determined as $0,5 \cdot f_k$, where f_k is the usual compressive strength perpendicular to the bed joint.

Table 5.b NA specifies characteristic basic compressive strengths for masonry of solid lightweight concrete units (group 1) and solid autoclaved aerated concrete masonry units (group 1) of height ≥ 185 mm and nominal joints of 10 mm, the compressive strength ML of the mortar corresponding to the basic compressive strength of the masonry and the compressive strength MC corresponding at least to 0,5 times the basic compressive strength of the masonry. Tabulated values apply to category I units with a documented coefficient of variation for the compressive strength of no more than 10 % for compression perpendicular to the bed face.

In the middle of joints in unreinforced masonry of lightweight concrete with a thickness equal to and larger than 190 mm, a 50 mm mortar free zone is permitted e.g. in connection with an embedded thermal insulation strip.

Table 5.b NA - Basic compressive strengths f_k in MPa for solid lightweight aggregate concrete unit masonry and autoclaved aerated concrete unit masonry of a height ≥ 185 mm

Compressive strength of units – f_c 5 % fractile	Basic compressive strength – f_k 5 % fractile
2,0	1,8
2,5	2,2
3,0	2,6
3,5	3,1
4,0	3,5
4,5	3,9
5,0	4,4
Compressive strength of units – f_m ^a 50 % fractile	Basic compressive strength – f_k 5 % fractile
2,0	1,5
2,5	1,9
3,0	2,3
3,5	2,7
4,0	3,0
4,5	3,4
5,0	3,8

- a f_m is the mean value of the compressive strength according to EN 771-3. The designation should not be confused with the corresponding designation in EN 1996-1-1 for the compressive strength of masonry mortar.

5.7.2.2(4) Characteristic initial shear strength

(NDP)

The design shear strength, f_{vd} , shall be determined using the following expression:

$$f_{vd} \leq \frac{\mu_k}{\gamma_m} \cdot \sigma + \frac{f_{vk0}}{\gamma_m} \quad (5.a \text{ NA})$$

NOTE γ_m has two different values in 5.a NA one for each property.

where σ is the design compressive stress, if any, in sections parallel to the bed joints due to the actual combination of actions for the structure considered;

μ_k is the characteristic friction coefficient;

f_{vk0} is the characteristic shear strength;

γ_m is the partial factor pertaining to the property;

k_m is 0,07 for clay units;

k_m is 0,20 for lightweight aggregate units

f_{vd} can maximum be:

$$f_{vd} = \min \begin{cases} k_m f_b \\ 1,5 \text{ MPa} \end{cases} \quad (5.b \text{ NA})$$

Where cohesion and friction coefficients are not known, the values given in Table 5.c NA may be applied.

Table 5.c NA - Characteristic friction coefficient and cohesion

Type of joint	μ_k	f_{vk0} [MPa]
Mortar joint ($f_m < 0,5$ MPa)	0,6	f_{xk1}^a
Mortar joint ($f_m \geq 0,5$ MPa)	1,0	f_{xk1}^a
Mortar joint (adverse)	2,0	$2,5 f_{xk1}^a$
Mortar joint on damp proof course	0,4	0
Mortar joint on damp proof course (adverse)	0,7	0.03

Type of joint	μ_k	f_{vk0} [MPa]
a	f_{xk1} is the characteristic flexural strength having a plane of failure parallel to the bed joint.	

5.7.4(4) Characteristic flexural strength of masonry

(NDP)

In cases where the flexural strengths, f_{xk1} and f_{xk2} , or the bond strength, $f_{m,xk1}$, are not specified or determined experimentally, the values given in Tables 5.d NA, - 5.e NA, -5.f NA and -5.g NA shall be applied.

Table 5.d NA specifies values of the flexural strengths, f_{xk1} and f_{xk2} , for masonry of units of a height ≥ 185 mm. If admixtures have been added to the mortar, either directly or by the binders used, it cannot be assumed that the values apply to the mortar used.

NOTE The flexural strength f_{xk1} for permanent mainly lateral loading (e.g. from lateral earth and water pressure) may be taken into account provided that the load-bearing capacity is not based on an L/h ratio greater than 2,5.

Table 5.d NA - Basic flexural strengths, f_{xk1} and f_{xk2} , for masonry of units of a height ≥ 185 mm

Masonry units			Mortar	
	Minimum compressive strength		Compressive strength MC $\geq 3,5$ MPa Compressive strength ML ≥ 7 MPa	
	f_c MPa	f_m MPa ¹	f_{xk1} MPa	f_{xk2} MPa
	5 % fractile	50 % fractile		
Lightweight concrete	2,4	2,9	0,20	0,45
Aerated concrete	2,4	2,9	0,20	0,45
Clay	10	15	0,20	0,45
a	In Table 5.d NA, f_m is the mean value of the compressive strength according to EN 771-3. The designation should not be confused with the corresponding designation in EN 1996-1-1 for the compressive strength of masonry mortar.			

Table 5.e NA specifies values of the bond strength, $f_{m,xk1}$, for clay unit masonry. If admixtures have been added to the mortar, either directly or by the binders used, it cannot be assumed that the values apply to the mortar used.

Table 5.e NA – Bond strength, $f_{m,xk1}$, for clay unit masonry

Mix ratio	Compressive strength	
KC50/50/700 (NCI.1) ^a K _h 100/400 ^b KK _h 20/80/475 ^b	MC > 1,5 MPa ML > 3 MPa	MC > 1,5 MPa ML > 3 MPa
$f_{m,xk1}$ (MPa)	$f_{m,xk1}$ (MPa)	$f_{m,xk1}$ (MPa)
0,10	0,15	0,25
^a The mortar is to be produced according to clause 5.2.2(2), Specification for masonry mortar, of this NA. ^b The mortar is to be made from hydraulic lime designated HL5 or NHL5 according to EN 459-1 and to 1., 3., 4. and 5. of clause 5.2.2(2), Specification for masonry mortar of this NA.		

In cases where f_{xk1} for a mortar has been declared on the basis of EN 1052-2, or where the bond strength, $f_{m,xk1}$, has been declared on the basis of EN 1052-5 or is specified in Table 5.e NA, f_{xk1} and f_{xk2} shall be determined for clay units of a height lower than 60 mm from Table 5.f NA and Table 5.g NA.

Table 5.f NA Basic flexural strength, f_{xk1} , in MPa determined on the basis of the bond strength, $f_{m,xk1}$, and the normalised compressive strength of masonry units, f_b

$f_{m,xk1}$	Normalised compressive strength of masonry units, f_b (MPa)								
MPa	5	10	15	20	25	30	35	40	45
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,10	0,06	0,08	0,09	0,10	0,10	0,10	0,10	0,10	0,10
0,15	0,08	0,11	0,13	0,14	0,14	0,14	0,14	0,14	0,14
0,20	0,10	0,13	0,16	0,18	0,19	0,19	0,19	0,19	0,19
0,25	0,13	0,16	0,19	0,21	0,23	0,24	0,24	0,24	0,24
0,30	0,15	0,18	0,21	0,24	0,26	0,28	0,28	0,28	0,28
0,35	0,17	0,20	0,23	0,26	0,28	0,31	0,32	0,32	0,32
0,40	0,18	0,22	0,26	0,28	0,31	0,34	0,36	0,38	0,38
0,45	0,18	0,23	0,28	0,31	0,33	0,36	0,38	0,41	0,44
0,50	0,18	0,24	0,29	0,33	0,36	0,39	0,41	0,43	0,46
0,55	0,18	0,24	0,30	0,35	0,38	0,41	0,43	0,46	0,48
0,60	0,18	0,24	0,30	0,35	0,40	0,43	0,45	0,48	0,51
0,65	0,18	0,24	0,30	0,35	0,40	0,45	0,48	0,50	0,53
0,70	0,18	0,24	0,30	0,35	0,40	0,45	0,50	0,53	0,55
NOTE Interpolation may be used between values.									

Table 5.g NA - Basic flexural strength, f_{xk2} , in MPa determined on the basis of the flexural strength, f_{xk1} , and the normalised compressive strength of masonry units, f_b

f_{xk1}	Normalised compressive strength of masonry units, f_b (MPa)								
MPa	5	10	15	20	25	30	35	40	45
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,06	0,21	0,21	0,21	0,21	0,21	0,21	0,21	0,21	0,21
0,10	0,29	0,32	0,34	0,34	0,34	0,34	0,34	0,34	0,34
0,15	0,32	0,39	0,44	0,49	0,50	0,50	0,50	0,50	0,50
0,20	0,36	0,43	0,48	0,54	0,60	0,64	0,66	0,66	0,66
0,25	0,40	0,47	0,52	0,59	0,64	0,69	0,74	0,79	0,82
0,30	0,44	0,51	0,57	0,63	0,68	0,73	0,78	0,84	0,89
0,35	0,49	0,56	0,61	0,67	0,73	0,77	0,82	0,88	0,93
$\geq 0,40$	0,53	0,60	0,65	0,71	0,77	0,82	0,87	0,92	0,98
NOTE Interpolation may be used between values.									

5.7.4(4) Characteristic flexural strength of masonry

(NCCI)

For vertical loading on masonry, as an input value in row 1 instead of f_{xk1} , the following may be applied:

$$f_{xk1} + 0,25 \cdot \sigma_d \quad (5.c \text{ NA})$$

where σ_d is any design compressive stress in a section parallel to the bed joints resulting from the relevant load combination under consideration

For wall panels/sections/segments predominantly subjected to horizontal loading, executed with thin (unfilled) head joints, the following may be assumed:

$$f_{xk2,app} = \frac{1}{2} \cdot f_{xk2} \quad (5.d \text{ NA})$$

5.7.5(4) Characteristic anchorage strength of reinforcement

(NCCI)

For reinforcement embedded in mortar, the characteristic anchorage strength f_{bok} given in Table 5.8 NA may be applied.

Table 5.8 NA — Characteristic anchorage strength for reinforcement in mortar not confined within masonry units

Strength class (f_{bok}) for:	MC2	MC5	MC10	MC15	MC20
Plain carbon steel reinforcement (N/mm ²)	0,5	0,7	1,2	1,4	1,4
Ribbed carbon steel reinforcement and ribbed stainless-steel reinforcement (N/mm ²)	0,5	1,0	1,5	2,0	2,4
NOTE Interpolation is permitted between mortar strengths.					

NOTE 1 Table 5.8 NA does not apply to reinforcement systems (e.g. ladder reinforcement, zig-zag reinforcement).

NOTE 2 For plain stainless steel reinforcement, the anchorage strength is not known.

5.8.2(3) Modulus of elasticity

(NDP)

Where test data for the short-term secant modulus of elasticity are not available, the value of K_E is to be determined as follows:

- for clay unit masonry and/or calcium silicate unit masonry made with lime mortar with no cement content:

$$K_E = 500 f_m \quad (5.e \text{ NA})$$

- for clay unit masonry and/or calcium silicate unit masonry made with mortar using other binder materials (such as cement):

$$K_E = \min \begin{cases} 20 f_b \\ 400 f_m \\ 1000 \end{cases} \quad (5.f \text{ NA})$$

where

f_k	is the characteristic basic compressive strength of masonry in MPa;
f_b	is the normalised mean compressive strength of the masonry units in MPa;
f_m	is the compressive strength of the mortar in MPa.

- for lightweight aggregate concrete unit masonry:

$$K_E = 1000 \quad (5.g \text{ NA})$$

- for autoclaved aerated concrete unit masonry:

$$K_E = 450 \quad (5.h \text{ NA})$$

7.5.1.1(3) Masonry walls subjected to mainly vertical loading – general

(NCCI)

The value for $e_{init} = \frac{h_{ef}}{450}$ can be assumed lower if precautions are given and implemented in the project. Precautions should include an additional supervisory body that measures walls and columns.

7.5.1.1(4) Masonry walls subjected to mainly vertical loading – general

(NCCI)

The value for $e_{init} = \frac{h_{ef}}{450}$ can be assumed lower if precautions are given and implemented in the project. Precautions should include an additional supervisory body that measures walls and columns.

7.5.1.3(10)(ii) Effective height of masonry walls

(NCCI)

If the value $\rho_2 = 0,75$ is used, it should be ensured that the required rotational stiffness of the floor slab is present, and the actual eccentricity shall be applied unfavourably for the structure, for example as indicated in Annex A.

7.5.2(1) Unreinforced masonry walls subjected to mainly vertical loading

(NCCI)

Maximum slenderness ratio of an unreinforced wall, see 7.5.1.2, can be determined by calculation, and exceed the maximum value of 27.

7.5.3.6(1) Limiting span of reinforces masonry beams

(NCCI)

For beams that are not bonded to the surrounding masonry, the limitations given in Table 7.2 in EN 1996-1-1:2022 may be disregarded.

For prefabricated beams with increased stiffness, the values in Table 7.2 in EN 1996-1-1:2022 shall be increased correspondingly.

For masonry beam the maximum length is 4,5 meters, unless documented separately

7.5.7.3(2) Dimensions

(NCCI)

Maximum ratio of $\frac{l_{ef}}{t_{ef}}$, see Table 7.3 in EN 1996-1-1:2022 can be determined by calculation.

8.2.2 Reduction factor for slenderness and eccentricity

(NCCI)

For the verification of unreinforced masonry subjected predominantly to vertical loading, the following method may be used as an alternative to the method given in DS/EN 1996-1-1:2022, section 8.2.2.

For a column or wall, the effect of compressive loading, possibly combined with transverse loading, may be taken into account by examining the cross-sections within the middle third of the column that have the largest resulting load eccentricity. When determining the resulting eccentricity, load eccentricities, initial imperfections, and transverse loading perpendicular to the column axis shall be considered.

The design resistance N_{Rd} of the column is determined as the resistance of the compressed part of the cross-section only:

$$N_{Rd} = k_s k_t f_d A_c \quad \text{(Ritter formula)} \quad (8.a \text{ NA})$$

$$k_s = \frac{1}{1 + \frac{1}{k_E \pi^2} \left(\frac{h_s}{i_c} \right)^2} \quad (8.b \text{ NA})$$

where k_r is the Ritter constant, see below

k_t is 0,7 for solid walls with $t < 90$ mm

k_t is 0,9 for solid walls with $t > 90$ mm

h_s is the column height

i_c is i_c/A_c is the radius of gyration of the compressed part of the cross-section

A_c is the area of the compressed part of the cross-section

For a rectangular cross-section, the compressed part is:

$$A_c = l_{eff}(t_d - 2e_t) \quad (8.c \text{ NA})$$

$$\left(\frac{h_s}{i_c}\right)^2 = 12 \left(\frac{h_s}{t_d - 2e_t}\right)^2 \quad (8.d \text{ NA})$$

where l_{eff} is the effective length of the cross-section
 e_t is the resulting eccentricity in the thickness direction
 t_d is the design column thickness

The Ritter constant is given by:

$$k_r = \frac{E}{f_{cnd}} \frac{E}{f_{cnk}} \quad (8.d \text{ NA})$$

Modulus of elasticity. When determining the Ritter constant k_r , reference shall be made to NA 1996-1-1 regarding the modulus of elasticity, unless more accurate information is available for the actual combination of masonry units and mortar.

When determining the stiffness of masonry structures and its influence on the distribution of internal forces, the modulus of elasticity E_c shall be used. E_c may be taken as:

- $E_c = \frac{1}{2}E_0$ for pure bending.
- $E_c = \frac{3}{8}E_0$ for determining column deflection (eccentrically loaded or transversely loaded columns)

Unless more accurate values are documented.

In cases where transverse loading in a compressed member is resisted by bending action, it shall be verified that the combined compressive and flexural tensile stresses do not exceed the design strengths.

8.2.2(4) Reduction factor for slenderness and eccentricity

(NCCI)

In (Formula 8.6 in DS EN 1996-1-1:2022) the requirement for $e_i \geq 0,05 t$ can be disregarded if the eccentricity in top and bottom is optimized to minimize e_i .

8.2.3(2) Concentrated loads

(NCCI)

Splitting forces in vertical sections shall be taken into account in case of concentrated loads.

For eccentricities in Figure 8.2, bottom right, in DS/EN 1996-1-1:2022 greater than $t/4$, a value of $1,0 \times f_k$ may be used.

8.3.1(2) In-plane shear resistance

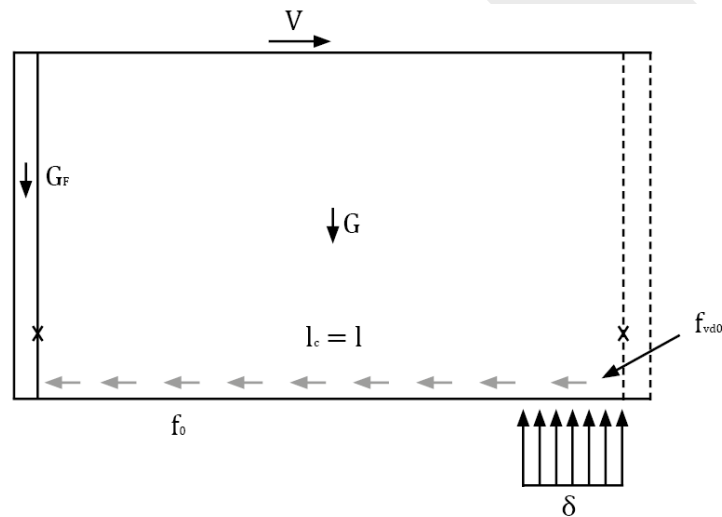
(NDP)

Expression (8.11) $V_{Rd} = f_{vd} \cdot t \cdot l_c$ can always be applied.

Expression (8.a) $V_{Rdlt} = f_{vd} \cdot t \cdot l$ may be used, provided that it is ensured that no part of the wall is in tension.

NOTE A plastic stress distribution where no part of the wall is in tension could be a square positive compression distribution representing the reaction - combined with zero compression stresses on the remaining part. See Figure 8.a NA below.

Figure 8.a NA, Stress distribution



8.4.2(5) Walls in flexure

(NCCI)

It shall be ensured that the walls possess sufficient deformation capacity when the load-bearing capacity of the cavity wall is determined as the sum of the capacities of the individual leaves. Sufficient deformation capacity for the cavity wall as a whole may be assumed when the ratio between the theoretical linear-elastic deflections is less than a factor of 3. That is:

$$\frac{1}{3} \leq U_f = \frac{U_1}{U_2} = \frac{E_2 \cdot t_{2,eff} \cdot f_{xk1,1}}{E_1 \cdot t_{1,eff} \cdot f_{xk1,2}} \leq 3 \quad (8.f \text{ NA})$$

where indices 1 and 2 refer to the outer and inner leaf, respectively.

8.8.3(2) Beams subjected to shear loading

(NCCI)

The requirement for $f_{vd} < 0,3 \text{ MPa}$ can be disregarded.

10.2.5.1 (whole section) Anchorage of tension and compression reinforcing steel

(NCCI)

Anchorage can be performed by other means than bending, hooking, looping, etc. when documented.

10.5.1.4(1) Ring ties and ring beams

(NCCI)

The minimum design tensile force can be determined by calculation.

10.5.2.2(2) Cavity and veneer walls

(NDP)

The number of tie-wires is determined via calculation.

10.5.2.3(2) Double-leaf and collar jointed walls

(NDP)

The minimum number of ties connecting the leaves of double-leaf walls is taken as $j = 16$ pr. m^2 of the wall area considered.

10.6.3(6) Horizontal and inclined chases

(NCCI)

The width of chase can exceed half the residual thickness of the wall unless when the chase eventually is filled with an appropriate mortar.

Annex A NA Consideration of partial factor for materials relating to execution

Annex A is not applicable.

Following clauses presents complementary information.

In connection with the determination of partial safety factors, a distinction is made between reduced, normal and enhanced control in the following situations and under the following assumptions:

A.4 NA Cut units

(1) Cut units shall be prepared such that the requirements for joint dimensions, as specified in Table A.2.a NA, are satisfied. If cracks occur in the masonry units during cutting, these units shall not be built into the masonry.

(2) Reduced and normal control - Cut units may be produced from whole units by sawing, clipping or chiselling.

(3) Enhanced control - Cut units produced from whole units shall be prepared by sawing or clipping only.

NOTE During cutting, care shall be taken to ensure that neither dust nor moisture reduces the bond.

A.5 NA Deviation in positioning

(1) Setting out shall be carried out for each storey in such a way that the accumulation of errors is avoided.

(2) Reduced control - The distance between the centre planes of two walls or columns placed one above the other shall not deviate by more than 20 mm from the distance assumed in the design.

(3) Normal control - The distance between the centre planes of two walls or columns placed one above the other shall not deviate by more than 15 mm from the distance assumed in the design.

(4) Enhanced control - The distance between the centre planes of two walls or columns placed one above the other shall not deviate by more than 10 mm from the distance assumed in the design.

A.6 NA Joints

(1) Masonry constructed from masonry units shall comply with the joint thickness requirements given in Table A.2.a NA. The nominal joint dimension shall be specified in the design or determined no later than at the start of construction, taking into account the tolerances of the masonry units used. During construction, the final joint thickness shall comply with the nominal joint dimension, plus or minus the permitted tolerances for the relevant control class.

Table A.2.a NA — Requirements for finished joint thickness (in mm)

Joint thickness	Permitted range of the nominal joint thickness	Bed joint			Head joint		
		Enhanced control	Normal control	Reduced control	Enhanced control	Normal control	Reduced control
Thick joint	14	$n \pm 5$	$n \pm 6$	$n \pm 7$	$n \left\{ \begin{smallmatrix} +10 \\ -5 \end{smallmatrix} \right.$	$n \left\{ \begin{smallmatrix} +12 \\ -6 \end{smallmatrix} \right.$	$n \left\{ \begin{smallmatrix} +14 \\ -7 \end{smallmatrix} \right.$
Standard joint	9-13	$n \pm 3$	$n \pm 4$	$n \pm 5$	$n \left\{ \begin{smallmatrix} +6 \\ -3 \end{smallmatrix} \right.$	$n \left\{ \begin{smallmatrix} +8 \\ -4 \end{smallmatrix} \right.$	$n \left\{ \begin{smallmatrix} +10 \\ -5 \end{smallmatrix} \right.$

Thin joint mortar	3-8	$n \pm 2$	$n \pm 3$	$n \pm 4$	$n \pm 2$	$n \pm 3$	$n \pm 4$
Adhesive joint	3	$n \pm 1$	$n \begin{Bmatrix} + 2 \\ - 2,5 \end{Bmatrix}$	$n \begin{Bmatrix} + 2 \\ - 2,5 \end{Bmatrix}$	$n \pm 1$	$n \pm 2$	$n \pm 3$

(2) The type of mortar shall be selected based on the nominal joint thickness as follows:

- For thick bed joints and standard bed joints (nationally defined classes), a general-purpose mortar shall be used (“general purpose mortar” in accordance with EN 998-2).
- For thin layer joints (nationally defined class), a mortar specifically developed for this particular application shall be used.
- For adhesive joints (nationally defined class), a thin layer mortar shall be used (“thin layer mortar” in accordance with EN 998-2).

(3) Requirements for the degree of joint filling, depending on the execution control class, are given in Table A.3.a NA below.

Table A.3.a NA — Contact area in finished joints

Control class	Reduced	Normal	Enhanced
Contact area between mortar and masonry units, calculated relative to each of the unit's faces towards the bed joints and perpend joints, excluding any area resulting from a specified recessed:	At least 75 %	At least 85 %	At least 95 %
Mortar-free zone in unreinforced masonry of lightweight concrete with a thickness of 190 mm or greater:	A mortar-free zone up to 50 mm in the middle of the joint is permitted, for example to accommodate an inserted thermal insulation strip.		No mortar-free zone is permitted.

(4) Deviations from 100 % joint filling shall not result in any significant reduction of the assumed strength, watertightness or durability that is relevant to the performance of the structure.

(5) Missing contact areas shall, for example, not take the form of continuous voids extending from the front to the back of the wall, or voids that prevent effective compression of the joint, nor shall they occur predominantly on one side (e.g. the rear side) of the masonry unit.

A.7 NA Bond pattern

(1) All masonry structures shall be built with a bond pattern unless otherwise specified.

(2) When vertical toothing is used, it shall be ensured that forces can be satisfactorily transferred in the completed structure.

(3) Reduced control - Drawings or other documentation indicating any special interlocking details and any special positioning of wall ties shall be available on site. For buildings with a height up to 8.5 m, vertical toothing without further verification is permitted, provided it is executed with projecting units (i.e. the usual form of vertical toothing and not open toothing). The joints shall be carefully compacted over the full cross-section.

(4) Normal control - Drawings or other documentation indicating the bond pattern, required interlocking details and the placement of necessary wall ties shall be available on site. For buildings with a height up to 8.5 m, vertical toothing without further verification is permitted, provided it is executed with projecting units (i.e. the usual form of vertical toothing and not open toothing). The joints shall be carefully compacted over the full cross-section.

(5) Enhanced control - Drawings indicating the bond pattern, required interlocking details and the placement of wall ties shall be available on site.

A.8 NA Chases and recesses

(1) Chases and recesses may only be formed where it can be demonstrated that the load-bearing capacity of the reduced cross-section remains adequate. As a general rule, individual small vertical chases may be formed without further verification, provided they have a maximum depth of 25 mm and a maximum width of 50 mm, as well as small recesses for electrical installation boxes.

(2) Reduced control - Any chases formed in the completed wall are permitted to be made by chiselling.

(3) Normal control - Any chases formed in the completed wall shall be made by mechanical routing.

(4) Enhanced control - Chases and recesses may only be formed to the extent shown on the drawings. Any chases formed in the completed wall shall be made by mechanical routing.

A.9 NA Acceptance inspection

A.9.1 NA General

(1) Upon receipt of deliveries on site, a visual inspection of the materials, any marking and accompanying documents shall be carried out. This inspection shall ensure that the delivered materials correspond to those whose product declarations comply with the assumptions adopted in the design calculations and structural detailing.

(2) For deliveries of materials whose production is not covered by third-party control, an additional incoming inspection shall be carried out in accordance with the procedures specified in points A.9.2, A.9.3, A.9.4, A.9.5 and A.9.6.

(3) Annex D of DS/EN 1990 describes the statistical principles for the verification of material properties.

A.9.2 NA Supplementary incoming inspection for masonry units

(1) Normal and enhanced control - For masonry units with a height < 185 mm, one test shall be carried out for each quality to verify the declared properties for the first 25000 units delivered (or part thereof), and thereafter one test for each subsequent 100000 units delivered (or part thereof).

(2) Normal and enhanced control - For masonry units with a height ≥ 185 mm, one test shall be carried out for each quality to verify the declared properties for the first 3500 units delivered (or part thereof), and thereafter one test for each subsequent 14000 units delivered (or part thereof).

A.9.3 NA Supplementary incoming inspection for mortar

(1) Normal control - For factory-made mortar used in structures erected under normal control, one mortar test shall be carried out for each mortar type to verify the declared properties for the first 20 m³ of ready-mixed mortar delivered in the fresh state (or part thereof), and thereafter one test for each subsequent 60 m³ delivered (or part thereof).

(2) Enhanced control - For factory-made mortar used in structures erected under enhanced control, one mortar test shall be carried out for each mortar type to verify the declared properties for every 20 m³ of ready-mixed mortar delivered in the fresh state (or part thereof).

A.9.4 NA Supplementary incoming inspection for mortar constituents

(1) For the mortar constituents, binders and aggregates, testing shall verify that the declared properties of the mortar materials are consistent with the assumptions adopted in the design calculations and structural detailing. The verification shall be carried out with the same frequency as specified for factory-made mortar.

A.9.5 NA Supplementary incoming inspection for prefabricated lintels and beams in accordance with EN 845-2

(1) Normal control - For prefabricated lintels and beams used in structures erected under normal, three units (or the delivered quantity if fewer) shall be selected from each delivery for verification of the declared dimensions. In addition, a visual inspection shall be carried out of the following checkpoints: quality of the concrete infill, cracking, embedded components for the attachment of brackets, and straightness in all planes where no camber or deflection is intended.

(2) Enhanced control - The procedure shall be the same as for normal control, except that five units shall be selected from each delivery for verification.

A.9.6 NA Supplementary incoming inspection for support brackets (ancillary components) in accordance with EN 845-1

(1) Normal control - For support brackets used in structures erected under normal control, one unit shall be selected for testing for every 500 units delivered, but at least three units (or the delivered quantity if fewer) shall be selected for verification of the declared dimensions. In addition, a visual inspection shall be carried out of the following checkpoints: straightness of the bracket body, welds, and any pitting corrosion or contamination on stainless steel brackets.

(2) Enhanced control - The procedure shall be the same as for normal control, except that five units shall be selected from each delivery for verification.

A.10 NA Execution control

A.10.1 NA General

(1) It shall be verified that all requirements in the project documentation relating to the design and execution of the structure in this Eurocode are complied with

A.10.2 NA Site-made mortar

(1) For mortar produced on site, it shall be verified that the applicable requirements of EN 1996-2, clause 5.3.1, regarding mortar and mortar materials are satisfied. Where an NCCI related to 4.2.3, Specification of mortar types for masonry, has been applied, the requirements stated therein shall also be verified.

(2) Reduced control - For site-made mortar, documentation shall be provided demonstrating that the produced mortar complies with the assumed mix proportions or the assumed properties. The documentation shall be carried out for the first batch of mortar produced.

(3) Normal control - For site-made mortar, documentation shall be provided demonstrating that the produced mortar complies with the assumed mix proportions or the assumed properties. The documentation shall be carried out for the first 15 m³ of mortar produced (or part thereof), and thereafter for every subsequent 40 m³ produced (or part thereof). Any use of admixtures shall be documented.

(4) Enhanced control - For site-made mortar, documentation shall be provided demonstrating that the produced mortar complies with the assumed mix proportions or the assumed properties. The

documentation shall be carried out for every 15 m³ of mortar produced (or part thereof). Any use of admixtures shall be documented.

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Annex C NA Simplified methods for calculating the out-of-plane eccentricity of loading on walls

Annex C is not applicable.

Following clauses presents complementary information.

C.5 NA Determination of eccentricities

The eccentricity may be calculated using the two simplified methods described in (1) and (2):

(1) The eccentricities at the top and the bottom of the wall may be assessed on the basis of the relative rotational stiffnesses of the structural elements involved, i.e. the rotational stiffness of the floor or roof slab and the foundation in relation to the rotational stiffness of the wall.

(2) When verifying the load-bearing capacity of axially compressed masonry, the determination of the actual eccentricities may be limited to identifying the eccentricities acting at the supports and the largest eccentricity occurring within the wall.

C.6 NA Examples

In the following, examples are given showing how the resulting eccentricities may be determined.

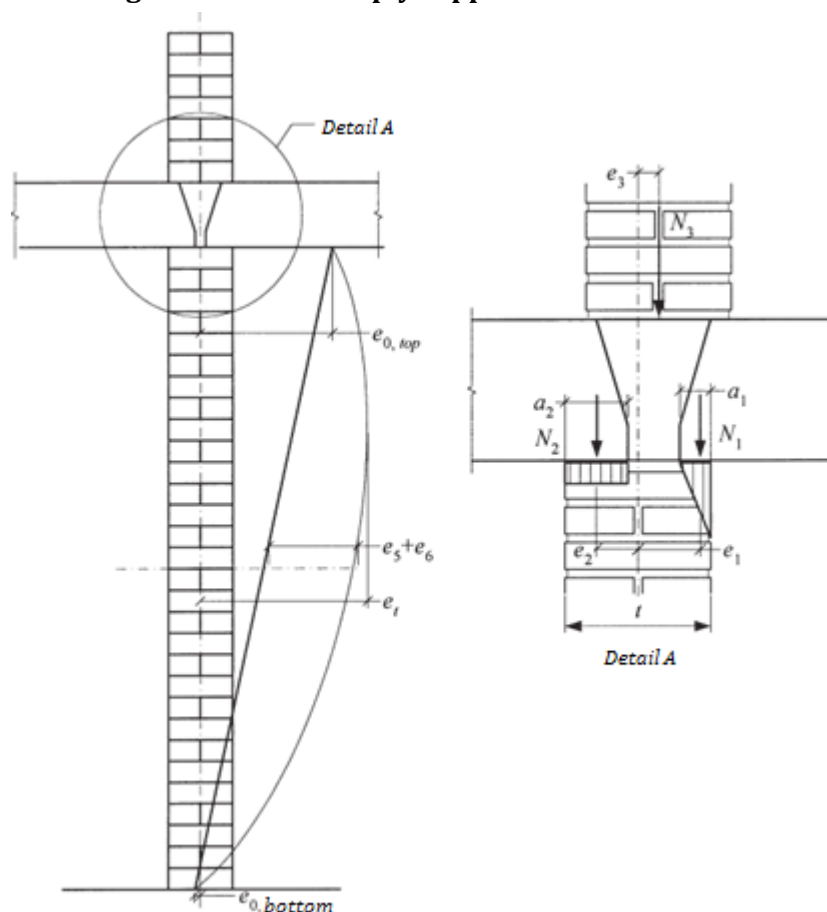
Only significant contributions to the total eccentricity need to be included.

The following symbols are used:

$e_{0,top}$	is the resulting eccentricity of the load at the top of the wall.
$e_{0,bottom}$	is the resulting eccentricity acting favourably at the support at the bottom of the wall.
e_1	is the eccentricity of axial forces from floors or beams bearing directly on the wall. Depending on the unfavourable case, the forces are assumed to act either at the third-points of the bearing area (triangular stress distribution with maximum stress at the wall edge) or at the centre of the bearing area (uniform stress distribution).
e_2	is the same as for e_1 .
e_3	is the eccentricity arising from possible displacement of the centroid of the wall or column in the storey above.
e_4	is the eccentricity arising from partial fixity of floors or beams which are not continuous.
e_5	is the eccentricity arising from possible deviations of the wall from a perfectly plane geometry.
e_6	is the eccentricity due to any transverse actions, e.g. wind loads, earth pressure or temperature differences.
e_t	is the resulting maximum eccentricity within the middle third of the wall.

C.6.1 Example 1: Eccentricities from simply supported floors or beams

Figure C.a NA — Simply supported floor or beam



Assuming the floors are simply supported, a_2 is the specified bearing depth and a_1 the minimum permitted bearing depth. For the case $N_1 \geq N_2$, the eccentricity is given as:

$$e_1 = \frac{t}{2} - \frac{1}{3}a_1 \quad (\text{C.a NA})$$

$$e_2 = \frac{t}{2} - \frac{1}{2}a_2 \quad (\text{C.b NA})$$

The value of $e_{0,bottom}$ may at most be taken as $t/6$ when the wall is placed on a rigid foundation.

The following values apply:

e_3 is 20 mm for reduced control, 15 mm for normal control, and 10 mm enhanced control

e_4 is 0 mm

e_5 is 10 mm

The largest eccentricity at the top of the wall is:

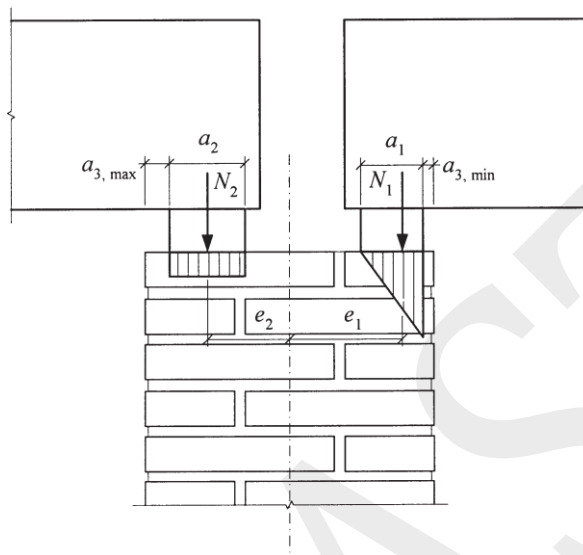
$$e_{0,top} = \frac{1}{N_1 + N_2 + N_3} (e_1 N_1 - e_2 N_2 + e_3 N_3) + e_4 \quad (\text{C.c NA})$$

The largest eccentricity within the middle third of the wall becomes, in this case, $e_{0,bottom} = 0$, since:

$$e_t = \frac{2}{3} e_{0,top} + e_5 + e_6 \quad (\text{C.d NA})$$

C.6.2 Example 2: Eccentricities from floors and beams supported on bearing plates

Figure C.b NA — Floor or beam supported by bearing plates



Since $N_1 > N_2$ eccentricities are obtained as follows:

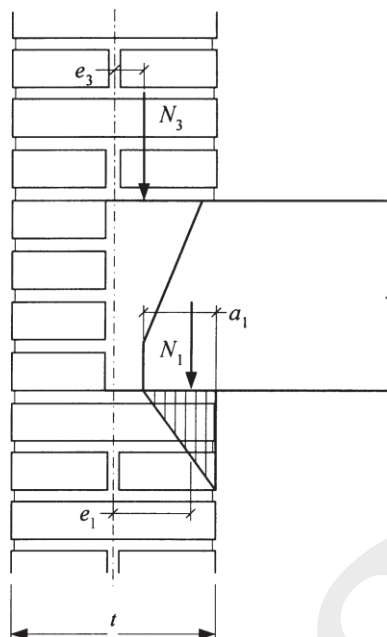
$$e_1 = \frac{t}{2} - a_{3,min} - \frac{1}{3} a_1 \quad (\text{C.e NA})$$

$$e_2 = \frac{t}{2} - a_{3,max} - \frac{1}{2} a_2 \quad (\text{C.f NA})$$

Otherwise as in C.6.1 Example 1.

C.6.3 Example 3: Eccentricities from one-sided support of floors and beams

Figure C.c NA — One-sided supported floor



The eccentricity e_1 is given by:

$$e_1 = \frac{2}{t} - \frac{1}{3}a_1 \quad (\text{C.g NA})$$

The following values apply:

e_3 is 20 mm for reduced control, 15 mm for normal control, and 10 mm enhanced control

e_5 is 10 mm

The largest eccentricity at the top of the wall is

$$e_{0,top} = \frac{1}{N_1 + N_3} (e_1 N_1 + e_3 N_3) \quad (\text{C.h NA})$$

The largest eccentricity within the middle third of the wall becomes, in this case, $e_{0,bottom} = 0$, since:

$$e_t = \frac{2}{3}e_{0,top} + e_5 \quad (\text{C.i NA})$$

Annex I A design method for complex shaped members subjected to mainly vertical loading

Informative.

NOTE Equivalent cross-section can be found for the complex cross-sections using recognized methods.