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Professional paper

WALL CONSTRUCTIONS ACCORDING TO EUROCOD 6 - MASONRY SYSTEMS

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Abstract

Purpose: Wall constructions represent the type of the oldest building materials that are used in construction today. The first bricks were made of unbaked mud or clay, later baked ones, and were used in the process of building buildings in the form of walls, this material has been used a lot, especially in the past, and they have found wide application in different social environments for the reason that the process of production and use has been quite simple without the need for any special technology. In the country, considering the fact that the new standards, in addition to the old JUS standards, there are temporary-regular principles for these types of building material, but following the steps of the countries of the European Union, which in its member countries use norms for walled constructions and that these problems are handled by EURCOD 6. The need to follow the contemporary trend of construction forces us to follow these norms and, in the future, to be able to design, and calculate structures from this type of material which is used all over us and the world.

Methods: In this paper, the methods and principle of calculation of masonry structures according to European Norms (EUROCOD 6) are presented, treating and calculating two types of bricks with brands M10 and M15 and two types of mortar as binders with brands M5 and M10. And the condition and calculation methods are given.

Design: Part of the wall of a residential building with masonry is presented and two examples are given where the principle of calculation according to Euronorms-EURCOD 6 is shown.

Results: From the comparison of the two variants, from the given static influences with stress control in a masonry wall. The obtained results, for comparative data where we have:

- Wall thickness: 25cm and 38cm
- Mortar brand: MM5 and MM10

- Brand of wall element: MO10 and MO15 Results were given for: - Control of pressure (compression); Control of cracks; Sync Control:

Conclusions: During the calculations and comparisons of the results, we concluded that the thickness of the wall for which the calculation was determined does not meet the condition of cracks in the wall, which means that we have to increase the thickness of the bricks or increase the brand of mortar, however, the difference will be very similar to the previous comparative values, therefore, it is necessary to adopt a material that accepts these forces in the crack or to think about a more meritorious solution for the construction where other types of bricks will have to be used, the reduction of loads, reducing the distances between the walls of the building, etc.

Keywords: Masonry, wall, brick, mortar, norms.

PROVISIONS SOLUTION OF RESIDENTIAL BUILDING CONSTRUCTION WITH MASONRY

MASONRY SYSTEMS – VERTICAL SUPPORT SYSTEM

1.1 GENERALLY

Masonry systems consist of:

BUILDING ELEMENT

- hard brick - a product made of baked clay dimensions L=25cm; W=12cm; h=6.5cm
- hollow brick - a baked clay product with vertical cavities dimensions L=25cm; W=12cm; h=6.5cm

MORTAR - binding agent usually lime-cement mortar

1.2 WALL THICKNESSES

The thickness of the brick walls is formed by combining the length (25 cm) and width (12 cm) of the brick and amounts to: 12 cm; 25 cm; 38 cm; 51 cm; 64 cm...

Shear walls must meet certain geometric requirements - EN 1998-1:2004 (9.5.1 (5)P):

the effective thickness of the tef wall must not be less than the minimum tef,min;

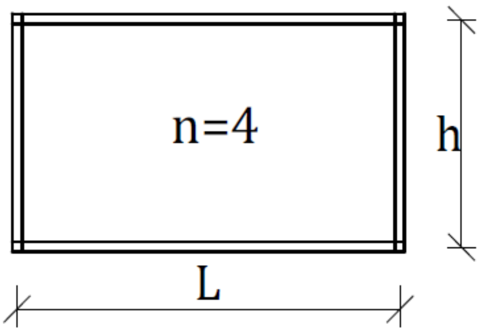
teff, min=240mm = 24cm

Effective wall height - EN 1996-1-1:2004 (5.5.1.2 (10))

$$h_{ef}=\rho_n \cdot h$$

h – clear (clear) height of the floor of the wall

ρ_n – reduction factor, then n=2, 3 or 4 depending on the contour conditions, i.e. the number of shortened edges of the wall.



I. For walls connected at the top and bottom with reinforced concrete inter-story structures or with roof structures bearing in both directions or with reinforced concrete inter-story structures bearing in one direction and supported in at least 2 /3 of the wall thickness: **ρ_2 = 0.75**

unless the load eccentricity at the top of the wall is greater than 1/4 of the wall thickness, in which case it is: **ρ_2 = 1.0**

II. For walls connected at the top and bottom with wooden mezzanine structures or roof structures bearing in both directions, or with wooden mezzanine structures bearing in one direction and supported by at least 2 /3 of the wall thickness, but not less than 85 mm: **ρ_2 = 1.0**

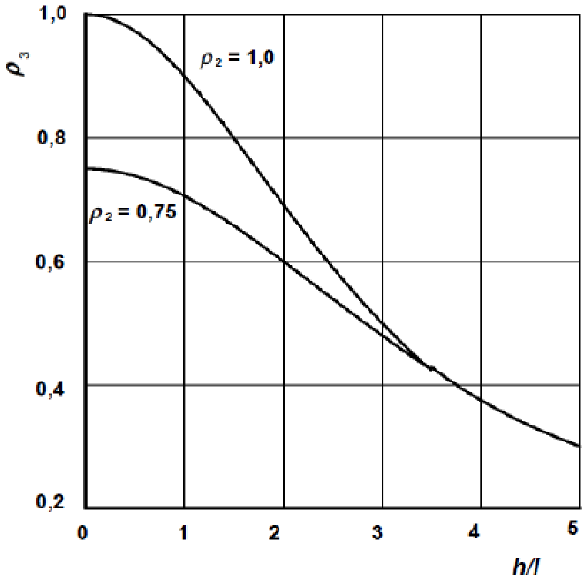
III. For walls connected at the top and bottom stiffened only along one vertical edge (the other vertical edge is free):

h ≤ 3.5l:

h > 3.5l:

$$\rho_3 = \frac{1}{1+\left[\frac{\rho_2 \cdot h}{3 \cdot l}\right]^2} \cdot \rho_2$$

$$\rho_3 = \frac{1{,}5 \cdot l}{h} \geq 0{,}30$$

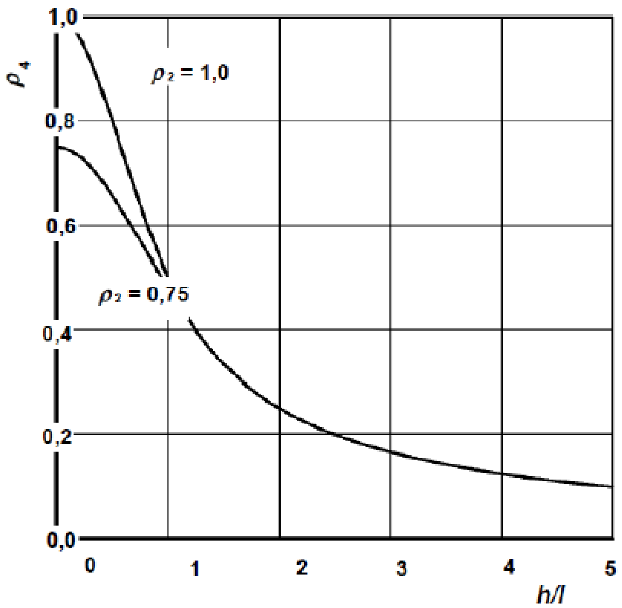


• the expression for the length of 'l' - the graphic part

IV. For walls connected at the top and bottom stiffened with two vertical ends

h ≤ 1,15l: $$\rho_4 = \frac{1}{1+\left[\frac{\rho_2 \cdot h}{l}\right]^2} \cdot \rho_2$$

h >1,15l: $$\rho_4 = \frac{0{,}5 \cdot l}{h}$$



- expression for the length of 'l' - the graphic part

Effective wall thickness according to - EN 1996-1-1:2004 (6.1.5 (1))

ρ2=0.75

zidovi	l	d	h	h/l	ρ_4	h_{ef}	h_{ef} / t_{ef}
Z1	10,46	0,38	3	0,2868	0,7168	2,1505	5,6592
Z2	2,28	0,38	3	1,3158	0,3800	1,1400	3,0000
Z3	1,78	0,25	3	1,6854	0,2967	0,8900	3,5600
Z4	2,52	0,25	3	1,1905	0,4200	1,2600	5,0400
Z5	1,58	0,25	3	1,8987	0,2633	0,7900	3,1600
Z6	4,83	0,25	3	0,6211	0,6163	1,8488	7,3952
Z7	4,59	0,38	3	0,6536	0,6047	1,8141	4,7739
Z8	7,21	0,38	3	0,4161	0,6834	2,0503	5,3956
Z9	1,6	0,38	3	1,8750	0,2667	0,8000	2,1053
Z10	4,4	0,38	3	0,6818	0,5945	1,7836	4,6937
Z11	2,78	0,38	3	1,0791	0,4532	1,3595	3,5776
Z12	2,8	0,25	3	1,0714	0,4557	1,3672	5,4687
Z13	1,85	0,38	3	1,6216	0,3083	0,9250	2,4342
Z14	1,18	0,38	3	2,5424	0,1967	0,5900	1,5526
Z15	5,8	0,38	3	0,5172	0,6519	1,9557	5,1465

The ratio of the length of the wall l to the largest clear height of the opening h next to the wall must not be less than the minimum (l/h) min

(l/h) min =0.30

2. HORIZONTAL AND VERTICAL CERCLAZES

Horizontal cerclage

- RC (Reinforced Concrete) horizontal elements in masonry walls

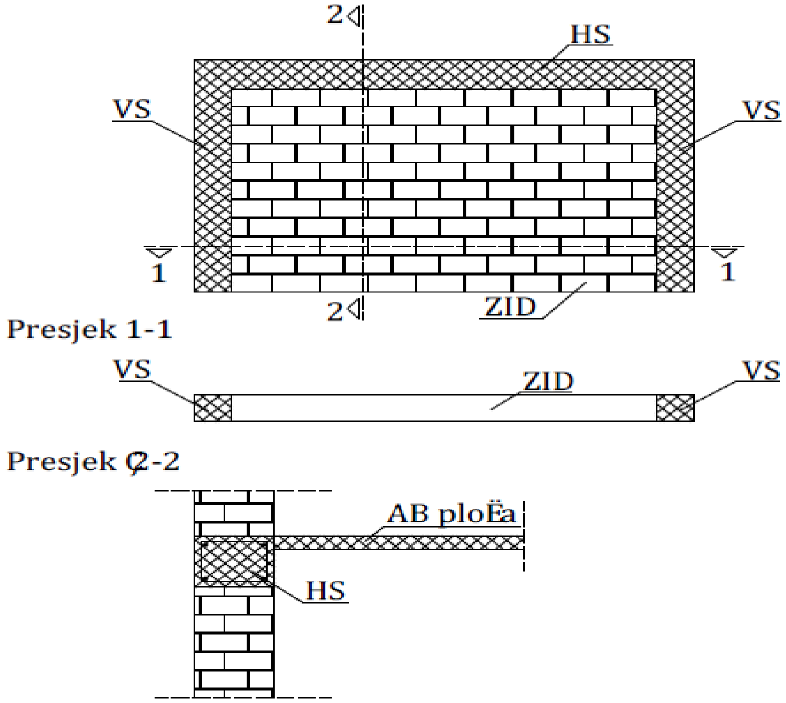
- b=dz (width = wall thickness)

- The height is = min 20cm >dp (plate thickness)

Vertical cerclage

- Vertical element AB in masonry walls

- Dimensions VS = wall thickness



- The horizontal and vertical frames must be interconnected and anchored to the elements of the main structural system

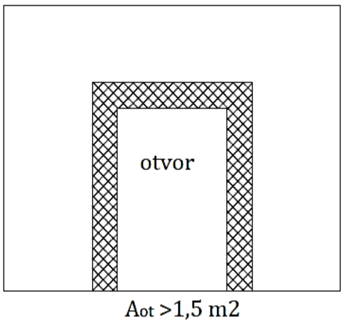
- min d = 15 cm

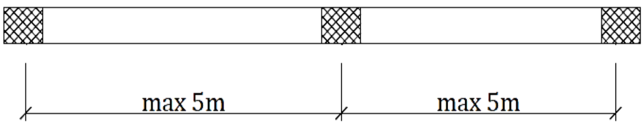
- Vertical wall bracing must be installed: at the free ends of all structural elements, on both sides of any opening in the wall whose area is greater than 1.5 m2

- Inside the wall, if necessary, without the distance between the cerclages more than 5 m at each intersection of the walls.

- The longitudinal reinforcement of the vertical and horizontal cerclages must not be less than minAa=300 mm2 = 3 cm2, nor less than 1% of the cross-sectional area of the cerclage minAc=1%As

- Stirrups minϕ=5mm; $_{min}$e=15cm





Characteristics of hardness of materials

For brick brand M10

For brick brand M10 - Average normalized value of compressive strength of giter bricks: fb= 10 Mpa

Wall element height (mm)	The smallest horizontal dimension of the wall element (mm)				
	50	100	150	200	≥250
40	0.80	0.70	-	-	-
50	0.85	0.75	0.70	-	-
65	0.95	0.85	0.75	0.70	0.65
100	1.15	1.00	0.90	0.80	0.75
150	1.30	1.20	1.10	1.00	0.95
200	1.45	1.35	1.25	1.15	1.10
≥250	1.55	1.45	1.35	1.25	1.15

sample height after surface preparation

For mortar brand M5

For mortar brand M5 - Mortar compressive strength: fm= 5 Mpa

The characteristic compressive strength of masonry is defined as follows (EN 1996-1 1:2005 3.6.1.2(2)):

(2) The relationship between the characteristic compressive strength of masonry, f_k, the normalised mean compressive strength of the units, f_b, and the mortar strength, f_m, may be obtained from:

— equation (3.2), for masonry made with general purpose mortar and lightweight mortar;

— equation (3.3), for masonry made with thin layer mortar, in bed joints of thickness 0,5 mm to 3 mm, and clay units of Group 1 and 4, calcium silicate, aggregate [AC1) concrete (AC1] and autoclaved aerated concrete units;

— equation (3.4), for [AC1) masonry made (AC1] with thin layer mortar, in bed joints of thickness 0,5 mm to 3 mm, and clay units of Group 2 and 3.

NOTE EN 998-2 gives no limit for the thickness of joints made of thin layer mortar; the limit on the thickness of bed joints of [AC1) 0,5 mm (AC1] to 3 mm is to ensure that the thin layer mortar has the enhanced properties assumed to exist to enable equations (3.3) and (3.4) to be valid. The mortar strength, f_m, does not need to be used with equation (3.3) and (3.4).

[AC1) $f_k = K\, f_b^{0,7}\, f_m^{0,3}$ (3.2) (AC1]

$$f_k = K\, f_b^{0,85} \quad (3.3)$$

$$f_k = K\, f_b^{0,7} \quad (3.4)$$

where:

K is a constant according to table 3.3, and where relevant, modified according to 3.6.1.2(3) and or 3.6.1.2(6)

provided that the following requirements are satisfied:

— the masonry is detailed in accordance with section 8 of this EN 1996-1-1;

— all joints satisfy the requirements of 8.1.5 (1) and (3) so as to be considered as filled;

— f_b is not taken to be greater than 75 N/mm² when units are laid in general purpose mortar

— f_b is not taken to be greater than 50 N/mm² when units are laid in thin layer mortar;

— f_m is not taken to be greater than 20 N/mm² nor greater than 2 f_b when units are laid in general purpose mortar;

— f_m is not taken to be greater than 10 N/mm² when units are laid in lightweight mortar;

— the thickness of the masonry is equal to the width or length of the unit, so that there is no mortar

$\boldsymbol{F_k = K \cdot F_b^{0.7} \cdot F_b^{0.3}}$**-** for all groups of elements and mortars for general purposes and easily assembled mortars.

K- Constant according to 3.3 of EN 1996-1-1.

According to EC 6, expression 3.3

-$\boldsymbol{F_k = K \cdot F_b^{0.85}}$ elements from groups 1 and 4 and plaster with thin layers.

According to EC 6, expression 3.4

$\boldsymbol{F_k = K \cdot F_b^{0.7}}$ - elements from groups 2 and 3 and plaster with thin layers.

Where are:

K – constant taken from the table

fb - average normalized compressive strength of the masonry element

fm - compressive strength of masonry mortar

$$\boldsymbol{F_k = K \cdot F_b^{0.7} \cdot F_b^{0.3} = 0.45 \cdot 10^{0.7} \cdot 5^{0.3} = 3.65MPa}$$

K=0.45 according to table 3.3. from EN 1996 - for bricks belonging to group 2 and mortar for general purposes.

Table 3.3 — Values of K for use with general purpose, thin layer and lightweight mortars

Masonry Unit		General purpose mortar	Thin layer mortar (bed joint ≥ 0,5 mm and ≤ 3 mm)	Lightweight mortar of density	
				$600 \leq \rho_d \leq 800$ kg/m^3	$800 < \rho_d \leq 1\,300$kg/m^3
Clay	Group 1	0,55	0,75	0,30	0,40
	Group 2	0,45	0,70	0,25	0,30
	Group 3	0,35	0,50	0,20	0,25
	Group 4	0,35	0,35	0,20	0,25
Calcium Silicate	Group 1	0,55	0,80	‡	‡
	Group 2	0,45	0,65	‡	‡
Aggregate Concrete	Group 1	0,55	0,80	0,45	0,45
	Group 2	0,45	0,65	0,45	0,45
	Group 3	0,40	0,50	‡	‡
	Group 4	0,35	‡	‡	‡
Autoclaved Aerated Concrete	Group 1	0,55	0,80	0,45	0,45
Manufactured Stone	Group 1	0,45	0,75	‡	‡
Dimensioned Natural Stone	Group 1	0,45	‡	‡	‡
‡ Combination of mortar/unit not normally used, so no value given.					

According to EC 6. Tab. 3.3. K values for use with general-purpose, thin-layer, and light-weight mortars

The modulus of elasticity E for masonry is determined as follows based on (EN 1996-1-1:2005 3.7.2(2)):

According to EC 6. In the absence of a value determined by tests in accordance with EN 1052-1, the modulus of elasticity of masonry, E, for use in structural analysis, can be taken as $K_E \cdot f_k$.

NOTE The K_E values used in a country can be found in its National Annex. The recommended

K_E value is 1000.

Wall pressure control

At the bearing limit state, the design value of the vertical load acting on the wall, NEd, must be less than or equal to the design value of the pressure-bearing capacity of the wall, NRd:

$$\mathbf{N_{Ed} \leq N_{Rd}}$$

Calculated value of bearing capacity of the wall under pressure:

$$\mathbf{N\_{Rd}=\phi \cdot A \cdot f_d}$$

Where are:

ϕ-bending coefficient

A-cross-sectional area of the wall

f_d-calculated value of compressive strength of the wall

$$\boldsymbol{N_{Ed} = 1.35 \cdot N_g + 1.5 \cdot N_p = 1.35 \cdot 420 + 1.5 \cdot 210 = 882\ \mathrm{kN}}$$

$A = t \cdot L = 38 \cdot 430 = 16340\ cm^2$

$f_d = \frac{f_k}{\gamma_{m0}} = \frac{3,65}{2,5} = 1,464\ \text{MPa} = 0,1464\ kN/cm^2$

The bending factor taking into account slenderness and eccentricity is determined in accordance with EN 1996-1-1:2005 6.1.2.2.

The value of the bending coefficient *Φi* in the upper and lower part of the wall is determined as a function of the eccentricity:

$$\phi_i = 1 - 2 \cdot \frac{e_i}{t}$$

Where is:

ei-is the eccentricity at the top or bottom of the wall, as the case may be, calculated using the following equation.

$$e_i = \frac{M_{id}}{N_{id}} + e_{he} + e_{init} \geq 0.05t$$

Where are:

Mid-is the design value of the bending moment at the top or bottom of the wall resulting from the eccentricity of the floor load on the supports, analyzed according to 5.5.1 (see figure 6.1) according to EC6.

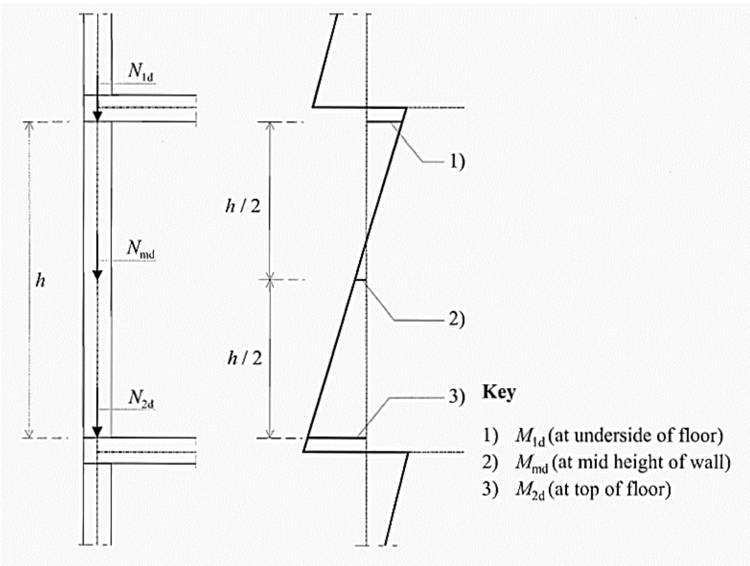


Figure 6.1 Moments from the calculation of eccentricities

Nid-calculated value of the vertical load on the upper or lower part of the wall

ehe-is the eccentricity in the upper or lower part of the wall, if any, resulting from horizontal loads (for example, wind); ***ehe=0***

einit-is the initial eccentricity with a sign increasing the absolute value of ***ei***

(see 5.5.1.1); The initial eccentricity, einip may be assumed to be **hc/450**, where hcf is the effective height of the wall, calculated from 5.5.1.2.

$$e_{init} = \frac{h_{ef}}{450};\ h_{ef} = \rho_n \cdot h$$

t – wall thickness

$$M_1 = \frac{\frac{n_1 \cdot E_1 \cdot l_1}{h_1}}{\frac{n_1 \cdot E_1 \cdot l_1}{h_1} + \frac{n_2 \cdot E_2 \cdot l_2}{h_2} + \frac{n_3 \cdot E_3 \cdot l_3}{h_3} + \frac{n_4 \cdot E_4 \cdot l_4}{h_4}} \left[\frac{w_3 \cdot l_3^2}{4(n_3 - 1)} - \frac{w_4 \cdot l_4^2}{4(n_4 - 1)} \right]$$

Where are:

n_1- the stiffness coefficient of element i, i=2,3 or ,4, which can be taken as equal to 4, for elements clamped on both sides, and if it is not the case, it is taken as equal to 3.

E1- Modulus of elasticity of element i, i=1, 2, 3 or 4.

Note: It would normally be accurate enough to assume the value of the modulus of elasticity Esi 1000 ***fk***, for all masonry elements.

ι_1- the moment of inertia of the section of element i, i=1, 2, 3 or 4 (in the case of a two-layer wall with openings, where only one layer is equal, 1 should be defined as the moment of inertia of only i protective layer).

h1- Pure purity of element 1

h2- Pure purity of element 2

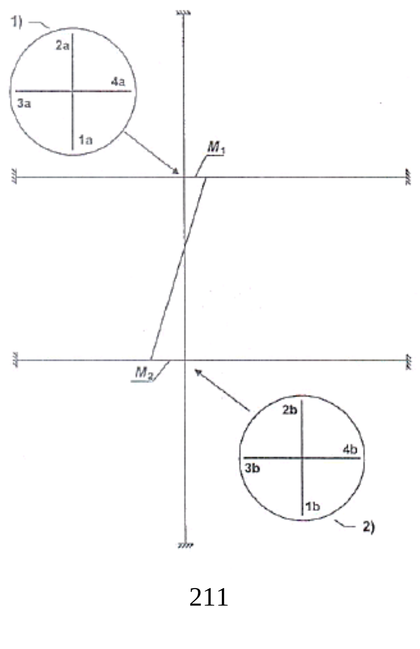
l3- pure space of element 3

l4- pure space of element 4

W3- calculation of load values divided equally by element 3, with the partial application of security according to EN 1990, for negative impact.

W4- calculation of load values divided equally by element 4, with the partial application of security according to EN 1990, for negative impact.

Determination of the average M_{id} of the calculation of the bending moment of the upper or lower part of the wall in accordance with the complaint C EN 1996-1-1: 2005.



Legend:

1) Rami a

2) Rami b

Note: Moment M_1 is determined by frame **a,** while moment M_2 is determined by frame **b**.

Photo. C.1. Simplified ram model

Index: 1, 2 refer to wall: 3,4 refer to reinforced concrete slabs .

$$n_1 = n_2 = n_3 = n_4 = 4;$$
$$E_1 = E_2 = 3655\ MPa;$$
$$E_3 = E_4 = 31000\ MPa$$
$$h_1 = h_2 = 3.0m;$$
$$l_3 = 6.1\ m\ l_4 = 4.3\ m$$
$$I_1 = I_2 = \frac{0.38 \cdot 4.4^3}{12} = 2.697m^4;$$
$$I_3 = I_4 = \frac{1.0 \cdot 1.12^3}{12} = 1.44 \cdot 10^{-4} m^4$$

$$M_1 = \frac{\frac{n_1 \cdot E_1 \cdot l_1}{h_1}}{\frac{n_1 \cdot E_1 \cdot l_1}{h_1} + \frac{n_2 \cdot E_2 \cdot l_2}{h_2} + \frac{n_3 \cdot E_3 \cdot l_3}{h_3} + \frac{n_4 \cdot E_4 \cdot l_4}{h_4}} \left[\frac{w_3 \cdot l_3^2}{4(n_3 - 1)} - \frac{w_4 \cdot l_4^2}{4(n_4 - 1)}\right]$$

$$M_{1d} = M_{2d} = \frac{\frac{4 \cdot 2.518 \cdot 3655}{3}}{\frac{4 \cdot 2.518 \cdot 3550}{3.0} \cdot 2 + \frac{4 \cdot 1.44 \cdot 10^{-4} \cdot 31000}{6.1} + \frac{4 \cdot 1.44 \cdot 10^{-4} \cdot 31000}{4.3}} \cdot \left[\frac{9.1 \cdot 6.1^2}{4(4-1)} - \frac{9.1 \cdot 4.3^2}{4(4-1)}\right] = 7.1\ kNm$$

$$e_i = \frac{M_{id}}{N_{id}} + e_{init} = \frac{7.1}{882} + \frac{h_{ef}}{450} = 0.008 + \frac{0.60 \cdot 3.0}{450} = 0.008 + 0.004 = 0.0120m \leq 0.05t = 0.05 \cdot 0.38 = 0.019m$$

$$e_i = 0.019m$$
$$h_{ef} = \rho_4 \cdot h;$$

$\rho_4 = \frac{1}{1+\left[\frac{\rho_2 \cdot h}{L}\right]^2} \cdot \rho_2$ **kur është** $h \leq 1.15 \cdot L$

$$\rho_4 = \frac{1}{1 + \left[\frac{\rho_2 \cdot h}{L}\right]^2} \cdot \rho_2 = \frac{1}{1 + \left[\frac{0.75 \cdot 3}{4.4}\right]^2} \cdot 0.75 = 0.60$$

$$h_{ef} = 0.6 \cdot 3 = 1.8m$$

Kur është $h = 3.0m \leq 1.15 \cdot L = 4.95m$

$$\Phi_i = 1 - 2 \cdot \frac{e_i}{t} = 1 - 2 \cdot \frac{0.019}{0.38} = 0.9$$

$A = t \cdot l = 38 \cdot 440 = 16340 cm^2$

$f_d = \frac{f_k}{\gamma_m} = \frac{3.66}{2.5} = 1.46 MPa = 0.146 kN/cm^2$

$N_{Rd} = \Phi \cdot A \cdot f_d = 0.9 \cdot 16340 \cdot 0.146 = 2153 kN$

For the control of compressive stresses in the wall, it is important to combine the influence of the permanent load and the temporary load with the appropriate safety coefficients:

$$N_{Ed} = 1.35 \cdot N_g + 1.5 \cdot N_p$$

$$N_{Ed} = 1.35 \cdot N_g + 1.5 \cdot N_p = 1.35 \cdot 420 + 1.5 \cdot 210 = 412.5 \text{ kN}$$

$$N_{Rd} = 2153 kN > N_{Ed} = 882 \text{ kN}$$

Compression control at the wall edges is satisfactory.

Control of cracks in the wall

At the bearing limit state, the design value of the shear load acting on the slot-framed wall, **V_{Ed},** must be less than or equal to the design value of the shear load capacity of the wall-framed wall, **V_{Rd},** so:

$$V_{ed} \leq V_{Rd}$$

The design value of the shear capacity of the wall framed by cerclage V_{Rd} is taken as the sum of the shear capacity of the wall and the concrete of the cerclage:

$$V_{Rd} = V_{Rd,mur} + V_{Rd,c}$$

The design value of the shear capacity of a framed wall with hanging walls V_{Rd}, is determined according to EN 1996-1-1:2005 6.2(2), i.e. as I for the case of unreinforced walls, respectively:

Characteristics of hardness of materials

For brick brand M15

For brick brand M15

- The average normalized value of compressive strength of either bricks: fb= 15 Mpa

For mortar brand M10

For mortar brand M10 - Mortar compressive strength: fm= 10 Mpa

$F_k = K \cdot F_b^{0.7} \cdot F_b^{0.3}$ elements from groups 1 and 4 and plaster with thin layers.

According to EC 6, expression 3.4

$F_k = K \cdot F_b^{0.7}$ - elements from groups 2 and 3 and plaster with thin layers.

$$F_k = K \cdot F_b^{0.7} \cdot F_b^{0.3} = 0.45 \cdot 15^{0.7} \cdot 10^{0.3} = 5.977 MPa$$

K=0.45 according to table 3.3. from EN 1996 - for bricks belonging to group 2 and mortar for general purposes.

Comparison of results

From the comparison of the two variants, from the given static influences with stress control in a masonry wall. We compare the obtained results, whereas comparative data we have:

Wall thickness: 25cm and 38cm

Mortar brand: MM5 and MM10

Wall element brand: MO10 and MO15

And we have these static influences on these elements:

Ng=420 and 520 kN

Np=210 and 300 kN
Vs=550 and 700 kN
Ms=2200-2800 kNm

For variant **I**, with these acquired data, the thickness of the wall is **25 cm**, the brand of mortar **MM5** and the brand of element **MO10**. With these static influences **Ng**=420 kN, **Np**=210 kN, **Vs**=550 kN and **Ms**=2200 kNm. We got these results.

Pressure control:

$$\mathbf{N_{Ed} \leq N_{Rd}}$$
$$\boldsymbol{N_{Ed}} = \mathbf{412.5\ kN}$$
$$\boldsymbol{N_{Rd} = 2197 kN}$$
$$\boldsymbol{N_{Rd} = 2197 kN > N_{Ed}} = \mathbf{882.0\ kN}$$

Crack control:

$$\boldsymbol{V_{Ed} \leq V_{Rd}}$$
$$\boldsymbol{N_{Ed} = 483.0\ kN}$$
$$\boldsymbol{V_{Rd} = 550.0\ kN}$$
$$\boldsymbol{V_{Ed} = 550.0 \leq V_{Rd} = 554.12 kN}$$

Minimum reinforcement:

$$VS1\ \rightarrow minA_s = 1\% \cdot A_{vs1} = 0.01 \cdot 51 \cdot 38 = 19.3cm^2 \geq 3cm^2 \rightarrow p\ddot{e}rv. 10R\phi16$$
$$VS2\ \rightarrow minA_s = 1\% \cdot A_{vs2} = 0.01 \cdot 51 \cdot 25 = 12.7cm^2 \geq 3cm^2 \rightarrow p\ddot{e}rv. 6R\phi16$$

Flex control:

$$\boldsymbol{M_{Ed} \leq M_{Rd}}$$
$$\boldsymbol{M_{Ed} = 1.0 \cdot M_s = 1.0 \cdot 2000 = 2000\ kN}$$
$$\boldsymbol{M_{Rd} = 3240\ kNm}$$
$$\boldsymbol{M_{Ed} = 2200\ kNm \leq M_{Rd} = 3231\ kNm}\ \mathbf{(VS1)}$$
$$\boldsymbol{M_{Ed} = 2200\ kNm \leq M_{Rd} = 2350\ kNm}\ \mathbf{(VS2)}$$

For variant **II**, with these acquired data, the thickness of the wall is **38 cm**, the mortar brand is **MM10**, and the element brand is **MO15**. With these static influences **Ng**=520 kN, **Np**=300 kN, **Vs**=700 kN and **Ms**=2800 kNm. We got these results.

Pressure control:

$$\mathbf{N_{Ed} \leq N_{Rd}}$$
$$\boldsymbol{N_{Ed}} = \mathbf{1152.0\ kN}$$
$$\boldsymbol{N_{Rd} = 3518.8 kN}$$
$$\boldsymbol{N_{Rd} = 3518.8 kN > N_{Ed}} = \mathbf{1152.0\ kN}$$

Checking cracks in the wall:

$$\boldsymbol{V_{Ed} \leq V_{Rd}}$$
$$\boldsymbol{V_{ed} = 700.0\ kN}$$
$$\boldsymbol{V_{Rd} = 436.4\ \ kN}$$
$$\boldsymbol{V_{Ed} = 700.0 \leq V_{Rd} = 436.4\ kN}$$
$$VS1\ \rightarrow minA_s = 1\% \cdot A_{vs1} = 0.01 \cdot 51 \cdot 38 = 19.3cm^2 \geq 3cm^2 \rightarrow përv.10R\phi 16$$
$$VS2\ \rightarrow minA_s = 1\% \cdot A_{vs2} = 0.01 \cdot 51 \cdot 25 = 12.7cm^2 \geq 3cm^2 \rightarrow përv.6R\phi 16$$

So, during the calculations and comparisons of the results, we concluded that the thickness of the wall for which the account was determined does not meet the condition of cracks in the wall, which means that we need to increase the thickness of the bricks or increase the brand of mortar, however, the difference will be very similar to the preliminary comparative values, therefore, a material that accepts these cracking forces must be adopted! or it should be considered for a more meritorious construction solution where other types of bricks will have to be used, the reduction of loads, the reduction of the distances between the walls of the building.

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