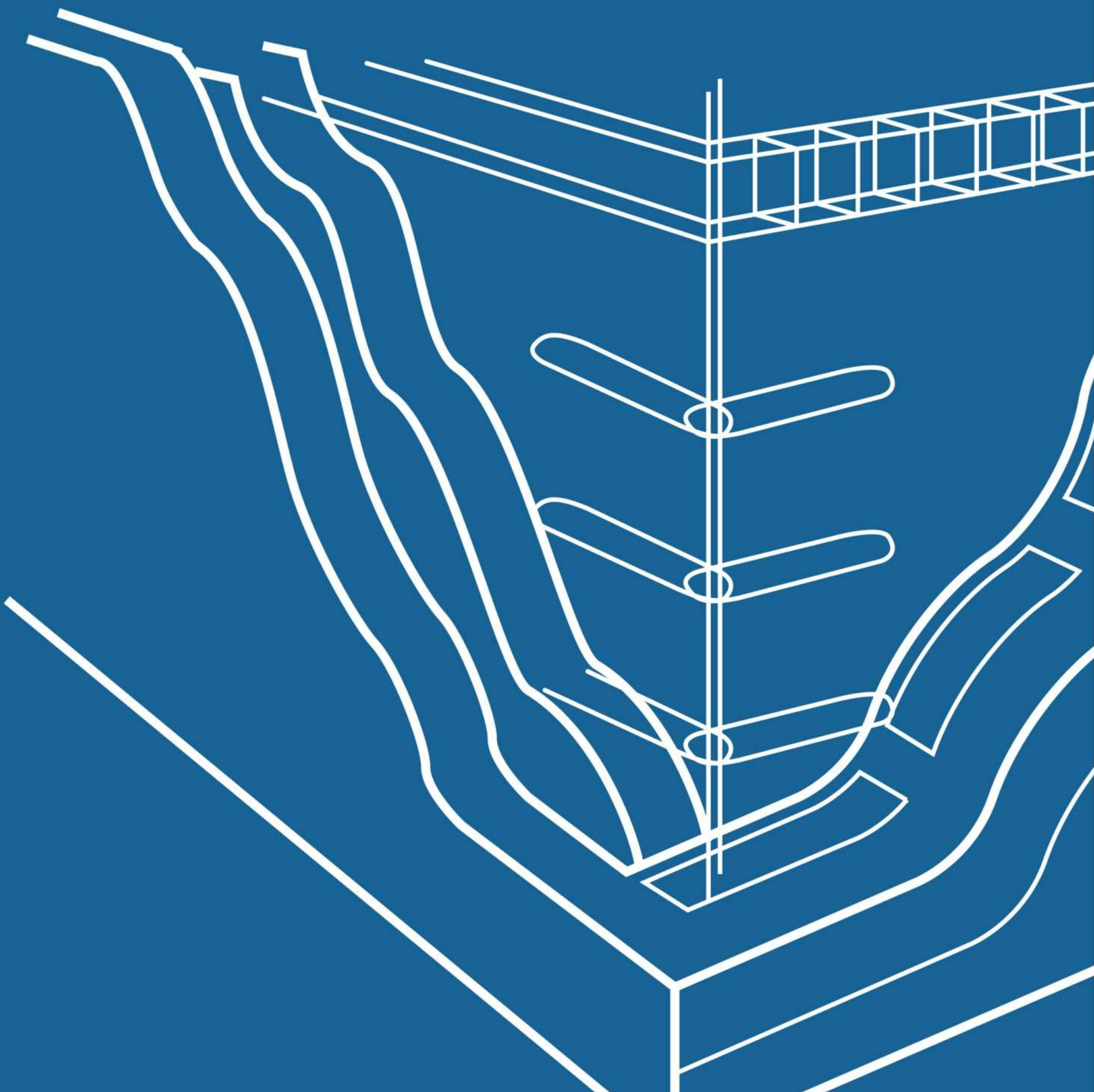
Informational Brochure

Izodom 2000 Polska

Design and calculation guidelines for walls of „Izodom 2000 Poland" system.

No2



www.izodom2000polska.com

Design and calculation guidelines for walls
of „Izodom 2000 Polska" system.

The extracts from studies and other own materials prepared by Department of Concrete Structures of Technical University of Lodz (a team composed of Prof. Maria Kamińska i MSc Jacek Filipczak) were used in this publication.

The basis of this report is PN-EN 1992-1-1harmonized with EUROCODE 2 and PN-EN 12350-3:2001.

June 2011
Łódź, Polska

Izodom 2000 Polska
Spółka z o.o.
98-220 Zduńska Wola, ul. Ceramiczna 2
Tel. 043 823 23 68, fax. 043 823 41 88
www.izodom2000polska.com
e-mail: biuro@izodom2000polska.com

List of available publications:
Issue No. 1: Basic information on material and erection technology of "Izodom 2000 Polska" system
Issue No. 2: Design and calculation guidelines for walls of "Izodom 2000 Polska" system. "Richtlinien für die Berechnung und Konstruktion der Wände im System Izodom 2000 Polska"; [German version of Issue No. 2, based on German National Standards]
Issue No. 3: Floors of "Izodom 2000 Polska" system
Issue No. 4: Halls, cold stores, warehouses of „Izodom 2000 Polska" system
Issue No. 5: Design and calculation guidelines for tiny aggregate concrete walls of „Izodom 2000 Polska" system.
Issue No. 6: Design and calculation guidelines for swimming pools of "Izodom 2000 Polska" system.
Issue No. 7: Roofs of „Izodom 2000 Polska" system. Principles of application of thermal insulation for wooden rafter roofs and flat reinforced roofs
Issue No. 8: Foundation slabs of „Izodom 2000 Polska" system
Issue No. 9: The use of walls of „Izodom 2000 Polska" system in seismically active areas

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Deutsches Institut für Bautechnik

Anstalt des öffentlichen Rechts

Kolonnenstr. 30 L
10829 Berlin
Deutschland

Tel.: +49(0)30 787 30 0
Fax: +49(0)30 787 30 320
E-mail: dibt@dibt.de
Internet: www.dibt.de

Ermächtigt und notifiziert gemäß Artikel 10 der Richtlinie des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte (89/106/EWG)

DIBt

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Europäische Technische Zulassung ETA-07/0117

Handelsbezeichnung *Trade name*	Verlorener Schalungsbausatz "IZODOM 2000 POLSKA" *Permanent shuttering kit "IZODOM 2000 POLSKA"*
Zulassungsinhaber *Holder of approval*	izodom 2000 polska ul. Ceramiczna 2 98-220 Zdunska Wola POLEN
Zulassungsgegenstand und Verwendungszweck	Nicht lasttragender verlorener Schalungsbausatz "IZODOM 2000 POLSKA" bestehend aus EPS-Schalungselementen
Generic type and use of construction product	*Non-load bearing permanent shuttering kit "IZODOM 2000 POLSKA" based on shuttering elements of EPS*
Geltungsdauer: vom *Validity: from*	8. Juni 2007
bis *to*	8. Juni 2012
Herstellwerk *Manufacturing plant*	izodom 2000 polska ul. Ceramiczna 2 98-220 Zdunska Wola POLEN
Diese Zulassung umfasst *This Approval contains*	93 Seiten einschließlich 77 Anhänge *93 pages including 77 annexes*

EOTA

Europäische Organisation für Technische Zulassungen
European Organisation for Technical Approvals

1 General principles of design and calculation for walls of "Izodom 2000 Polska" system

The basic documents which define the scope and technique of application of "Izodom 2000 Polska" system elements are:

- European technical specification ETA 07/0117 by German Institute for Construction Technology (DIBt, Berlin);
- Certificate No. Og-247/92 "External walls of insulating-boarding Izodom 2000 system elements", published by Institute for Construction Technology in Warsaw;
- "Sanitary certificate No. 843/B-638/91 of styrofoam bricks filled with concrete, produced according to Izodom 2000 system technology", by National Hygiene Institution;
- Technical information on IZODOM construction system, by producer.

Insulating-boarding elements of IZODOM 2000 POLSKA system are fabricated with tree different types of hardened self-extinguishing foam materials (EPS, Neopor, Peripor) in form of styrofoam bricks.

The offer of the company can be divided into four „systems" with different thickness of insulating layer and therefore also different insulating parameters. The elements can be equipped with foam-material fasteners (MC elements), plastic fasteners plunged into boarding element (MCF) or also plastic ones but installed at construction site (MCFU). The variety of styrofoam bricks let construct concrete walls with the nominal thickness of the core of 15cm, 20cm or 40cm. Each of the systems – regardless of thickness of the insulating layer and the concrete core – is a set of wall forms - MC, MCF or MCFU, corner forms - ML, supports of floor - MP, corner forms at angle of 90* or 45* - E45 E90, and additional elements. MCF 0,7 are „hinge" elements which simplify constructing of corner connections of walls at any angle. The company produce about one hundred types of styrofoam bricks for constructing of walls – see „ Issue No. 1" or www.izodom2000polska.com .

IZODOM 2000 POLSKA elements are put into wall in layers with a shift in the vertical weld, whereas horizontal connection is ensured by special locks shaped at the surface of the bricks. At concreting phase, they act as a form-work filled with concrete (or reinforced concrete), and afterwards they become an external insulating layer of the finished wall. Thus, the load-bearing structure is concrete or reinforced wall with holes (Fig. 1.1) in places of applying the fasteners. The holes which reduce the design depth of the wall are included in calculations.

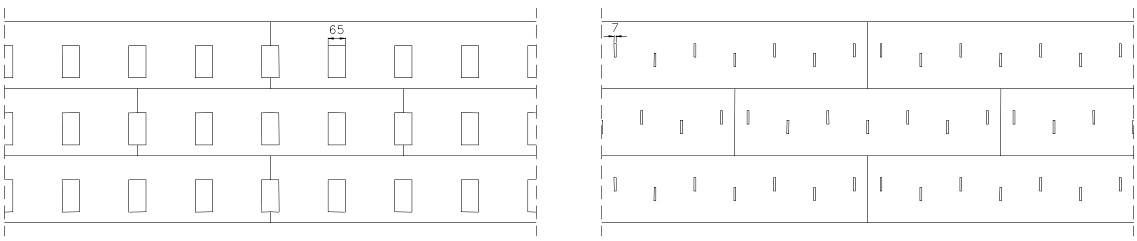
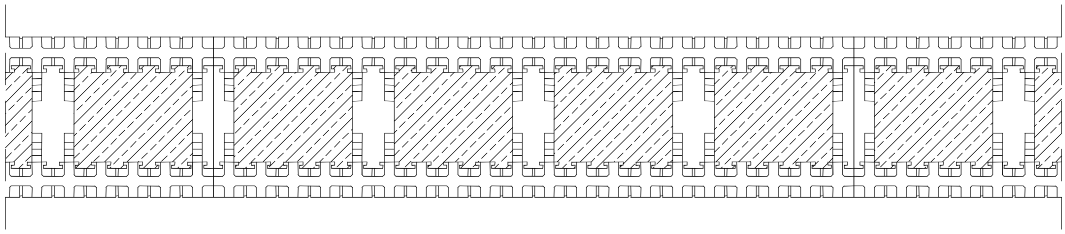
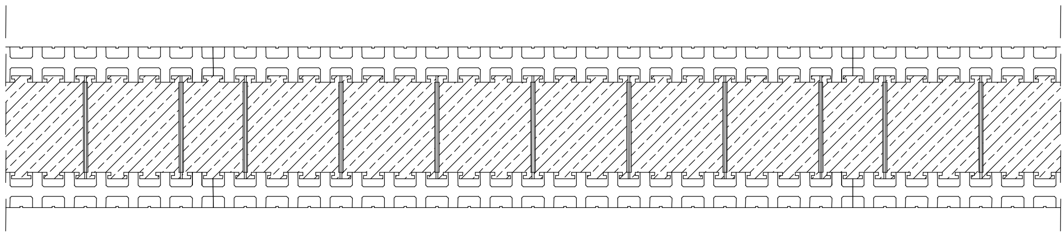


Fig. 1.1. Vertical views of walls made of styrofoam bricks with fasteners:
a) of foam material, b) of plastic

Styrofoam bricks let construct concrete walls with three different nominal thicknesses of the core (Fig. 1.2) – 150mm, 200mm and 400mm, that makes it possible to satisfy various construction requirements.



MC2/25 element with nominal thickness of the core of 150mm.



MCFU element with nominal thickness of the core of 150mm (an application of longer fasteners increase the thickness to 200mm or 400mm – depending on the needs).

Fig. 1.2. Sections of walls of IZODOM 2000 POLSKA system

The load-bearing capacity of concrete and reinforced cross-section of the wall was determined according to PN-EN 1992-1-1 (Eurocode 2). The reduction of design wall dimensions by fasteners and brick locks assumed in calculations is presented in Table 1.1.

Table 1.1. Reduced design wall dimensions

<table>
<tr><th rowspan="2">Nominal wall thickness (depth of the cross-section)</th><th rowspan="2">Nominal design depth of the wall cross-section , h_w</th><th colspan="2">Design width of the wall cross-section, in relation to 1m, b_w</th></tr>
<tr><th>Fasteners of foam material</th><th>Fasteners of plastic</th></tr>
<tr><td>mm</td><td>mm</td><td>mm / m</td><td>mm / m</td></tr>
<tr><td>150</td><td>140</td><td>748</td><td rowspan="3">950</td></tr>
<tr><td>200</td><td>190</td><td rowspan="2">-</td></tr>
<tr><td>400</td><td>390</td></tr>
</table>

It was assumed that the concrete and reinforced walls are made of concrete of at least C20/25 class. Deformed steel class B or C with characteristic yield strength not lower than f_{yk} = 500MPa is required to be used as the reinforcement. Partial factors assumed in study:

- for concrete γ_c = 1,50,
- for reinforcing steel γ_s = 1,15.

The results of calculations are presented in the form of diagrams where it can be verified if the load-bearing capacity of a wall is enough to bear the design load.

2 Concrete walls

2.1 Slenderness of walls

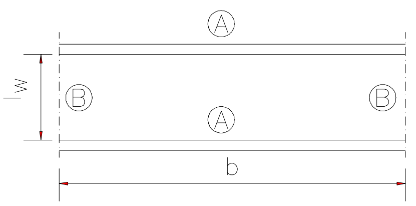
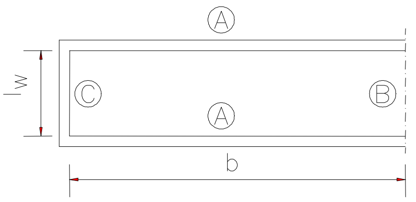
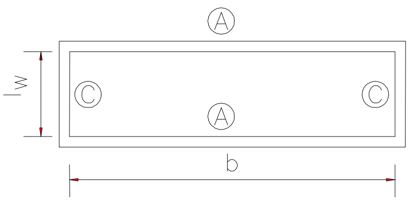
The slenderness of a wall should be determined according to PN-EN 1992-1-1, p. 12.6.5.1, in relation to effective length of the wall l_0:

$$l_0 = \beta l_w$$

where: l_w- clear height of the wall

β- coefficient which depends on the support conditions, given in Table 1.2.

Table 1.2. Values of β for different edge conditions

<table>
<tr><th>Lateral restraint</th><th>Sketch</th><th>Expression</th><th colspan="2">Factor β</th></tr>
<tr><td>Along two edges</td><td></td><td></td><td colspan="2">β = 1,00
for any ratio of l_w /b</td></tr>
<tr><td rowspan="9">Along three edges</td><td rowspan="9"></td><td rowspan="9">$$\beta = \frac{1}{1+\left(\frac{l_w}{3b}\right)^2}$$</td><td>b / l_w</td><td>β</td></tr>
<tr><td>0,2</td><td>0,26</td></tr>
<tr><td>0,4</td><td>0,59</td></tr>
<tr><td>0,6</td><td>0,76</td></tr>
<tr><td>0,8</td><td>0,85</td></tr>
<tr><td>1,0</td><td>0,90</td></tr>
<tr><td>1,5</td><td>0,95</td></tr>
<tr><td>2,0</td><td>0,97</td></tr>
<tr><td>5,0</td><td>1,00</td></tr>
<tr><td rowspan="9">Along four edges</td><td rowspan="9"></td><td rowspan="9">if b ≥ l_w, to
$$\beta = \frac{1}{1+\left(\frac{l_w}{b}\right)^2}$$
if b < l_w, to
$$\beta = \frac{b}{2l_w}$$</td><td>b / l_w</td><td>β</td></tr>
<tr><td>0,2</td><td>0,10</td></tr>
<tr><td>0,4</td><td>0,20</td></tr>
<tr><td>0,6</td><td>0,30</td></tr>
<tr><td>0,8</td><td>0,40</td></tr>
<tr><td>1,0</td><td>0,50</td></tr>
<tr><td>1,5</td><td>0,69</td></tr>
<tr><td>2,0</td><td>0,80</td></tr>
<tr><td>5,0</td><td>0,96</td></tr>
</table>

A- floor slab B – free edge C – transverse wall

To simplify, the advantageous influence of transverse walls on the effective length of the wall can be omitted and the coefficient value of β = 1,00 can be assumed.

The slenderness of a wall can defined as l_0 / h_w, with h_w assumed according to Table 1.1.

The slenderness of walls in plain concrete cast in-situ should not exceed:

$$l_0 / h_w = 25.$$

2.2 Load-bearing capacity of walls

The design resistance in terms of axial force for a slender wall in plain concrete may be calculated according to the simplified method from PN-EN 1992-1-1, p. 12.6.5.2, as follows:

$$N_{Rd} = b_w h_w f_{cd,pl} \Phi$$

where: **b_w**- design width of the cross-section of a wall, according to Table 1.1,

h_w- design depth of the cross-section of a wall, according to Table 1.1,

$$f_{cd,pl} = \frac{\alpha_{cc,pl} f_{ck}}{\gamma_C} = \frac{0{,}8 \times 20}{1{,}5} = 10{,}67\text{MPa},$$

where $\alpha_{cc,pl}$ = 0,8 is assumed due to ductility of plain concrete which is lower than for reinforced concrete.

For elements braced with floors and/or foundations, the factor Φ may be taken as:

$$\Phi = 1{,}14\left(1 - 2\frac{e_{tot}}{h_w}\right) - 0{,}02\frac{l_0}{h_w} \le 1 - 2\frac{e_{tot}}{h_w}$$

where: **$e_{tot} = e_0 + e_i$**

e_0- is the first order eccentricity including, where relevant, the effects of floors and horizontal actions,

e_i- is the additional eccentricity covering the effects of geometrical imperfections

$e_i = l_0 / 400$.

Nomograms that simplify the verification of load-bearing capacity of walls include three nominal wall thicknesses (NB-0,15, NB-0,20, NB-0,40). The load-bearing capacity of a cross-section with a nominal length of 1m, expressed as kN/m, is presented in relation to l_0 / h, for relative eccentricities:

e_{tot} / h_w = 0,00 do 0,30.

NUMBER EXAMPLE

A pillar of internal carrying wall 0,20m thick and b=1,20m in width is loaded with force N_{Ed} = 450kN. The height of the wall is 3,20m. According to Table 1.2 the coefficient value of β = 1,00 was assumed, therefore:

$l_0 = 1{,}0 \times 3{,}20 = 3{,}20$m

$l_0 / h = 3{,}20 / 0{,}19 = 16{,}84$

The eccentricity is caused only by the effects of geometrical imperfections:

$e_{tot} = 3{,}20 / 400 = 0{,}008mm$

$e_{tot} / h_w = 0{,}008 / 0{,}19 = 0{,}042$

The styrofoam bricks with foam material fasteners were applied.

According to an appropriate diagram:

for NB-0,20 we find

$N_{Rd} = 1080kN/m$

so the pillar axial resistance is:

$N_{Rd} = 1{,}2 \times 1080 = 1296kN$

and the value $N_{Ed} = 450kN$ does not exceed the limit.

3 RC walls

3.1 Slenderness of walls

The effective slenderness of a wall according to Eurocode 2, simplified in the safety direction, can be taken as:

a) for walls braced with floors (or foundation at the bottom):

$$l_0 = l_w$$

b) for walls braced only at one edge (one support) with the other edge free:

$$l_0 = 2{,}1 l_w$$

The limit values of the slenderness $(l_0 / h_w)_{lim}$, concerning both cases (a) and (b), are presented as a chart in NZ-0 diagram. The volues $(l_0 / h_w)_{lim}$ depend on a relative axial force:

$$n = \frac{N_{Ed}}{b_w h_w f_{cd}}$$

where: **N_{Ed}**-design axial force, kN,

b_w- design width of the cross-section of a wall, according to Table 1.1,

h_w- design depth of the cross-section of a wall, according to Table 1.1,

f_{cd} $= 20000 / 1{,}5 = 13330kPa$

If the condition is satisfied

$$l_0 / h_w \leq (l_0 / h_w)_{lim}$$

the influence of slenderness on the load-bearing capacity can be omitted.

3.2 Load-bearing capacity of RC walls

The load-bearing capacity of the nominal cross-section was determined according to PN-EN 1992-1-1, a parabola-rectangle diagram $\sigma_c - \varepsilon_c$ for concrete under compression was assumed. As for reinforcing steel, stress-strain diagram $\sigma_s - \varepsilon_s$ with a horizontal top branch was used.

Three types of reinforcement for three different values of nominal wall thickness – 0,15, 0,20 i 0,40m were considered.

The impact of slenderness of a wall on its load-bearing capacity was included by means of the method based on nominal stiffness. The coefficient "m" which increases the value of moment was determined according to formula (5.28) PN-EN 1992-1-1. The total design moment M_{Ed} is expressed as:

$$M_{Ed} = m \times M_{0Ed}$$

where: **M_{0Ed}**- is the first order moment; including the effects of geometrical imperfections.

The imperfections as an additional eccentricity of the axial force in a cross-section:

$$e_i = l_0 / 400$$

The coefficient "m" values were calculated for two combinations of quasi-permanent load of a wall. Two relations of the first order moment caused by a quasi-permanent combination to moment caused by design combination: 0,3 and 0,7 were assumed.

The results of calculations are presented in the form of diagrams NZ. There are 6 diagrams, each for a different type of a wall cross-section.

NUMBER EXAMPLE

The basement wall in a 5-floor building is loaded with earth. The height of the wall between the strip foundation and the floor is 2,75m, the length of the wall is 5,0m. The scheme of the wall, load, axial force and moment diagrams are presented in Fig. 3.1.

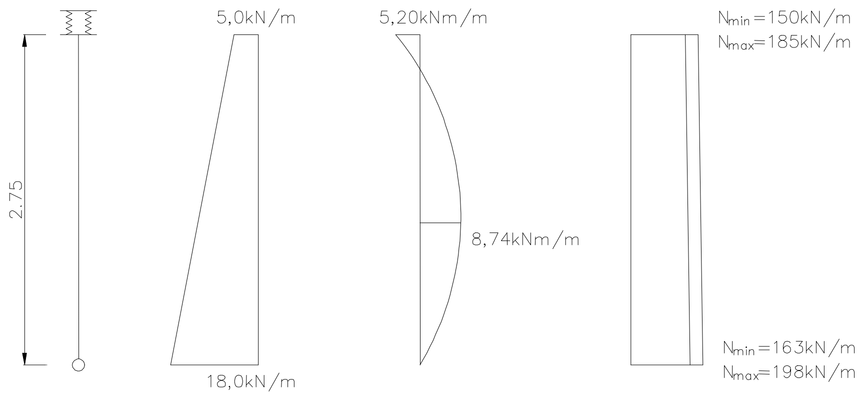


Fig. 3.1. Example data

The wall with plastic fasteners with nominal thickness of 0,20m was assumed. The slenderness of the wall is: l_0 / h_w = 1,0 × 2,75 / 0,19 = 14,50, and a relative axial force:

$$n = \frac{198}{0,95 \times 0,19 \times 13330} = 0,082$$

Diagram NZ-0 shows that

$$(l_0 / h_w)_{lim} = 10,87 < 14,50$$

so the influence of slenderness on the load-bearing capacity must be included.

The design I order moment, considering the additional eccentricity covering the effects of geometrical imperfections of:

$$e_i = 2,75 / 400 = 0,0069m$$

can be calculated as about (the axial force at the maximum moment is about N_{Ed}≈190kN):

$$M_{0Ed} = 8,74 + 0,0069 \times 190 = 10,1kNm/m$$

The reinforcement of 4∅10mm for each 1m at both surfaces of the wall is assumed.

According to NZ-0,20 diagram, the coefficient m = 1,20 should be taken, therefore the total design moment, including the influence of slenderness, can be calculated as:

M_{Ed} = 10,1 × 1,2 = 12,1kNm

More over according to the same diagram, it can be noticed that the load point defined by values M_{Ed} = 12,1kN and N_{Ed} = 190kN is located inside the interaction curve described as „a" (2× 4∅10), what means that ultimate limit state is satisfied.

We can also examine, if in this case a plain concrete wall is enough. We use NB-0,20 diagram. The total relative first order eccentricity is:

$$e_{tot}/h_w = M_{0Ed} / N_{Ed} / h_w = 10,1 / 190 / 0,19 = 0,280$$

According to diagram, for e_{tot} / h_w = 0,28 and l_0 / h_w = 14,5 load-bearing capacity of the cross-section is about 260kNm/m. It means that we can apply plain concrete wall.

3.3 Load bearing capacity of wall pillars

Applying the styrofoam bricks offered in this system we can construct wall pillars – columns supporting e.g. floor binders or acting as bracing walls. The load-bearing capacity should be determined like for typical reinforced columns. The reduction of the cross-section by left pieces of bricks should be included in calculations.

The example of a column construction solution can be found in K-11 drawing.

4 Wall headers

Bending and shear resistance in relation to design load were considered. Constant load along the length of the header was assumed.

Calculation assumptions:

- C20/25 concrete class
- B or C class steel with $f_{yk} \geq$ 500MPa as longitudinal and transverse reinforcement

The procedure for verifying load-bearing capacity with bending and shear are presented in the form of diagrams named NNZ-1 and NNZ-2.

5 Construction requirements

5.1 Requirements for concrete and RC walls

1. The corner connection between external carrying walls should be reinforced with U-shaped #6mm bars, placed in each level of bricks. The detail of this kind of connection is shown in K1 drawing.

2. In the corner connections between external carrying walls, meeting at angle higher than 90°, #6mm bars should be slung to brick fasteners. This detail is shown in K2 drawing. If the corner is loaded with a concentrated force, the corner core of the wall should be calculated a part of a wall according to p. 3.

3. The corner connections between external and internal walls (Draw. K3) and between partition walls (Draw. K4) should be constructed in the analogous way.

4. The bond beams should be constructed at the floor levels – Draw. K5, K6 i K7.

5. Considering the anchorage of precast beams for rib-and-slab floors, the maximum reinforcement diameter up to 10mm and the maximum design shear force at the support up to $V_{Rd,c}$ (according to PN-EN 1991-1-1) should be ensured.

6. For hollow core slabs applied as carrying floor elements, the support zone of the slab at a wall must be strengthened for shear. For this reason, a bond beam should be constructed at the carrying wall (Draw. K6 and K7) and special #12mm reinforcement should be concreted in slab hollow cores (Draw. K8.)

5.2 Requirements for concrete walls

1. The partial fixed connection between floors and concrete walls should not be designed in this case.

2. The wall cores situated by openings should be reinforced with minimum 2#10mm bars placed by the edge of the opening with #6mm stirrups used at each level of the bricks.

3. Single installation ducts can be executed in the wall but only within one wall core area and provided that horizontal reinforcement 2#6mm is applied at each level of the bricks. The reinforcement should be anchored at full length of the next two wall cores at both sides of the installation duct - Draw. K12.

Notice: The reduced wall design depth should be included in calculations.

5.3 Requirements for RC walls

1. The vertical reinforcement should be joined with horizontal minimum #8mm bars at both wall surfaces placed at each level of the bricks (every 250mm). And the reinforcement meshes at the two sides of the section should be joined with #6mm bars - minimum 4 pcs/1m^2 of the wall surface. The horizontal reinforcement at the corner connections and by the openings should be made in the shape of „U" letter (see Draw. K1 and K2).
2. Considering partial fixity of floors and walls, the additional reinforcement in the wall at the support zone should be applied, according Draw. K4.
3. Single installation ducts can be executed in the wall but only within one wall core area and provided that the horizontal reinforcement remains continuous. The axial distance between the ducts can not be smaller than 0,75m.

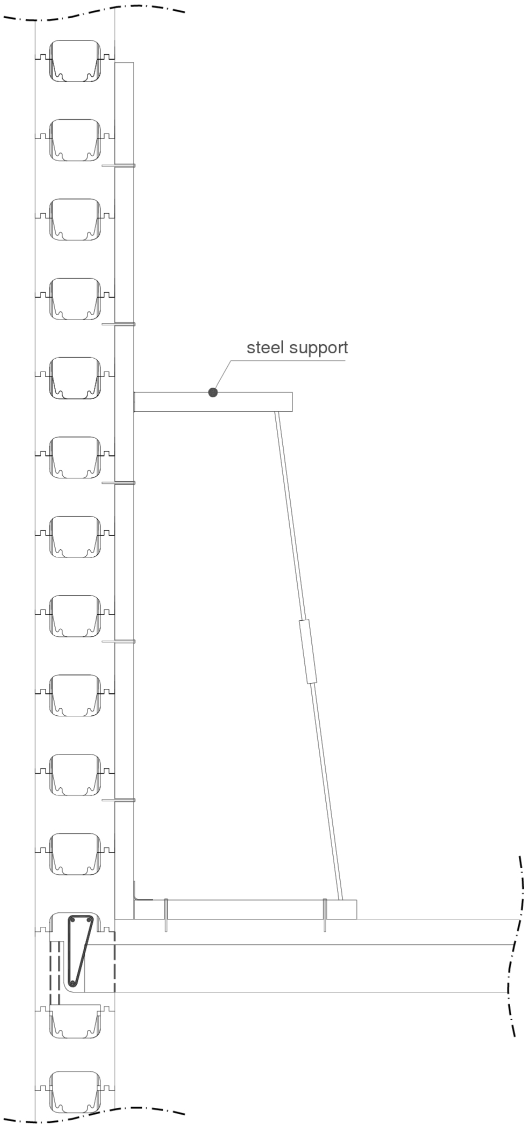
Notice: The reduced design depth of carrying wall should be included in calculations.

6 Technology conditions

6.1 Wall bracing at concreting phase

The bracing elements should be taken to fulfil the geometry conditions defined in 7.2. Special steel braces design by Izodom can be used. The steel support is equipped with a horizontal beam to fasten it to the base, a vertical pole that braces the wall during concreting and a horizontal cantilever that simplify concreting at height. The hinged connection between the horizontal and the vertical beam allows to set the vertical position of the wall and to brace it at the proper level regardless of possible roughness of the floor.

AUXILIARY STRUCTURES - Figure 3



All dimensions are given in mm

IZODOM 2000 POLSKA	**Annex 60** of European Technical Approval **ETA-07-0117**
AUXILIARY STRUCTURES Instalation diagram of steel support for pumps concreting	

6.2 Casting of concrete

The aggregate size greater than 8mm should not be applied.

Executing the wall, the concrete mixture should not be pour from height greater than 1,5m. Moreover the concrete must be compacted by tamping or rod etched.

The styrofoam leak-proof form visibly reduce the possibility of draining of superfluous water out of concrete and therefore decrease in amount of water in the concrete mixture is essential. It can be achieved with application of plasticizer. It should be batched and used according to the producer specification.

The concrete mixture consistency requirements must be strictly observed – application of the too wet mixture is not allowed, because high concrete pressure can lead to deformation of styrofoam wall framework.

The concrete mix consistency V1 or V2 are allowed to be used according to PN–EN 206-1: 2003 Concrete - Part 1: Specification, Performance, Production And Conformity. They correspond to thick-plastic and plastic consistencies in accordance with the former classification. The consistency measurement should be conducted according to PN-EN 12350-3:2001 Testing Fresh Concrete - Part 3: Vebe Test. The determined Vebe time should be between 11 and 30 seconds.

In the case of concrete cast at different time, if the next concrete layer is poured more than 6 hours after the previous one, the well integration of the two concrete layers should be ensured. For this reason, the consecutive layers should not be smoothed. And the final surface concrete should be removed and the new surface cleared and watered.

The cast can be done by hand using a concrete storage bin or a pump. The speed of pouring for the pump should not exceed 15m^3/h. The recommended value is 8-10m^3/h. The form work should be filled with concrete in the circularly way up to 1m. It lets the mixture be cast properly and gives the time to control the form works, consolidate the concrete and make the concrete pressure more stable. The pump pipe should be placed as close as possible to reduce the height of falling of concrete. The second way is to place the final part of the pipe in horizontal position to allow concrete to come up free – it slow the speed of the filling but protect the form work from being broken.

7 Quality control of wall execution

7.1 Quality control of concrete production

For concrete mixtures prepared at a construction site, during the cast phase every 24h three samples of concrete should be taken. The specimens should be tested in the authorized laboratory.

For industry concrete the certificate should be attached to the relevant document.

7.1 Control of wall geometry

The wall should satisfy the following requirements concerning dimensional and position deviations:

- surface and its crossing lines deflection from its designed position:

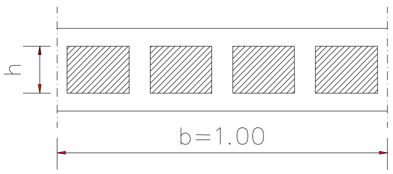
  a) per 1m of height ≤5mm

  b) per floor height ≤15mm
- local surface deflection ±4mm.

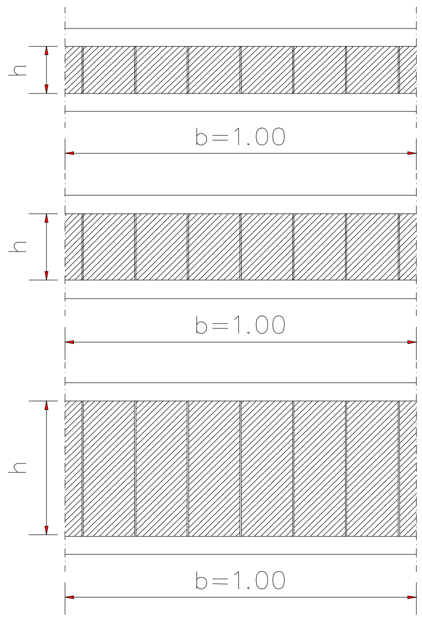
8 Diagrams

Carrying walls

Styrofoam bricks with styrofoam fasteners



Styrofoam bricks with plastic fasteners



Nominal depth of a cross-section

h = 0,15m

h = 0,20m

h = 0,40m

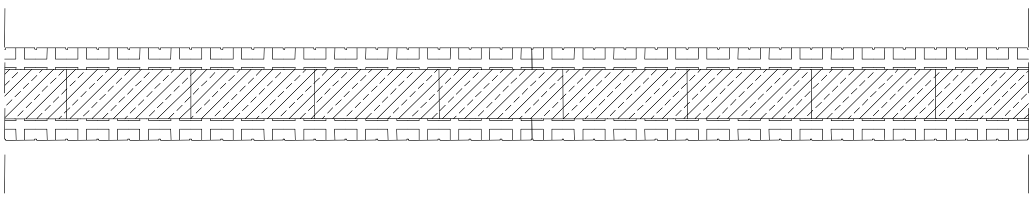
Effective dimensions of wall

Nominal depth of a cross-section, h	Effective depth of a cross-section , h_w	Effective width of wall cross-section, with reference to 1m, b_w	
		Styrofoam fasteners	Plastic fasteners
mm	mm	mm / m	mm / m
150	140	748	950
200	190	–	
400	390		

Characteristic weight of 1m^2 wall area [kN/m^2]

Fasteners	Nominal depth of wall cross-section					
	h = 0,15m		h = 0,20m		h = 0,40m	
	Plain concrete	RC concrete	Plain concrete	RC concrete	Plain concrete	RC concrete
Styrofoam	3,15	3,30	-	-	-	-
Plastic	3,60	3,75	4,80	5,00	9,60	10,00

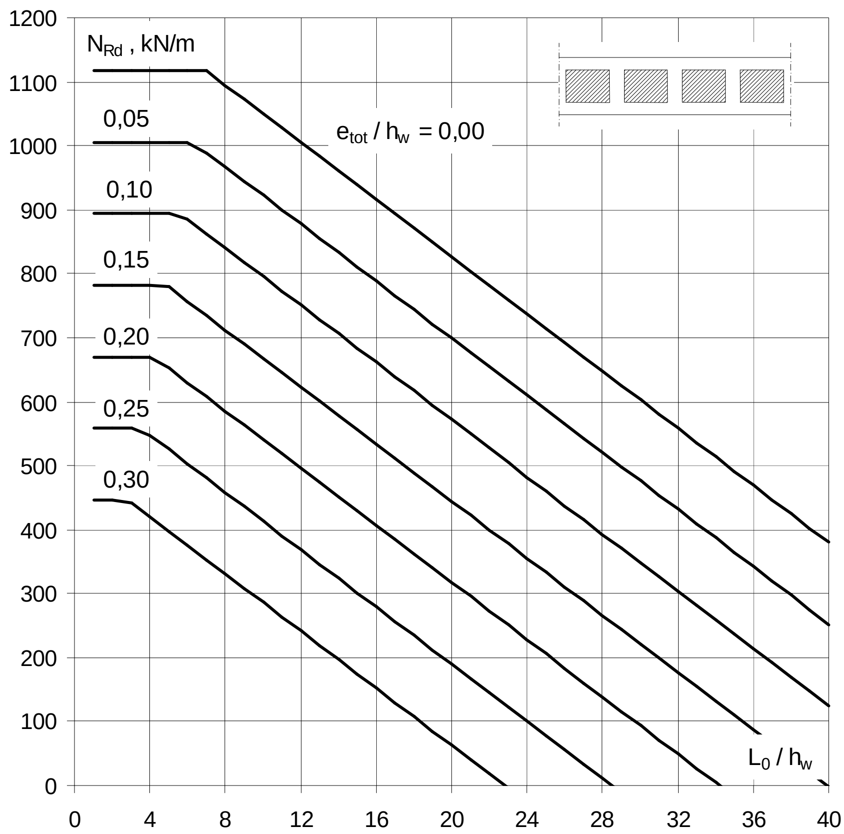
Partition walls



Characteristic weight of 1m^2 wall area 2,00kN/m^2

GENERAL DATA

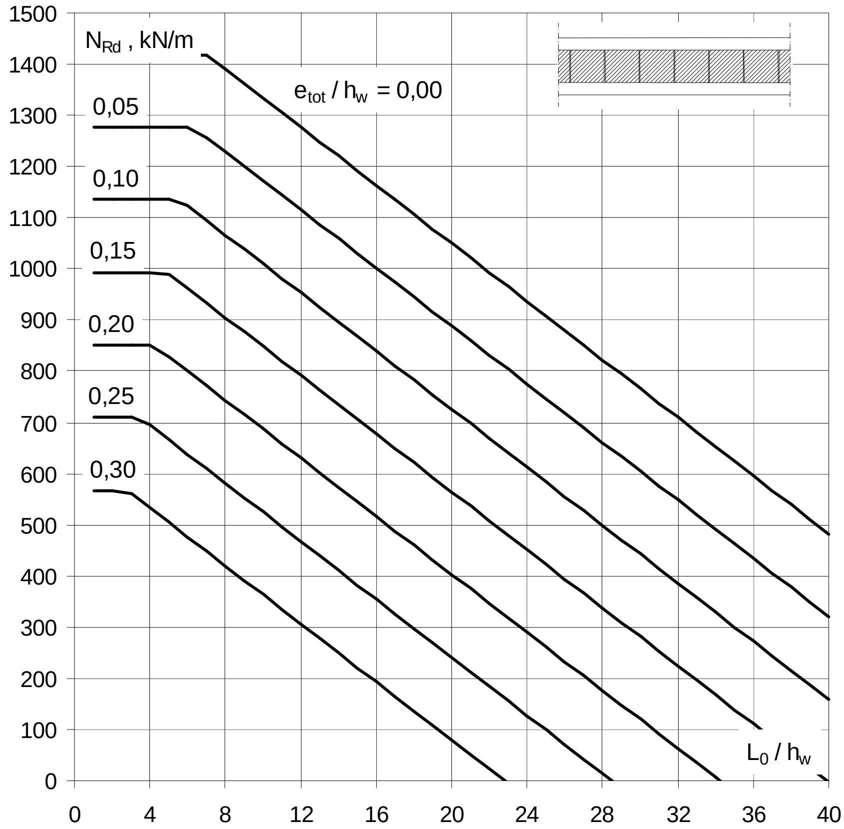
N-0



Concrete C20/25

h_w = 0,14m

Styrofoam bricks
with styrofoam
fasteners



Concrete C20/25

h_w = 0,14m

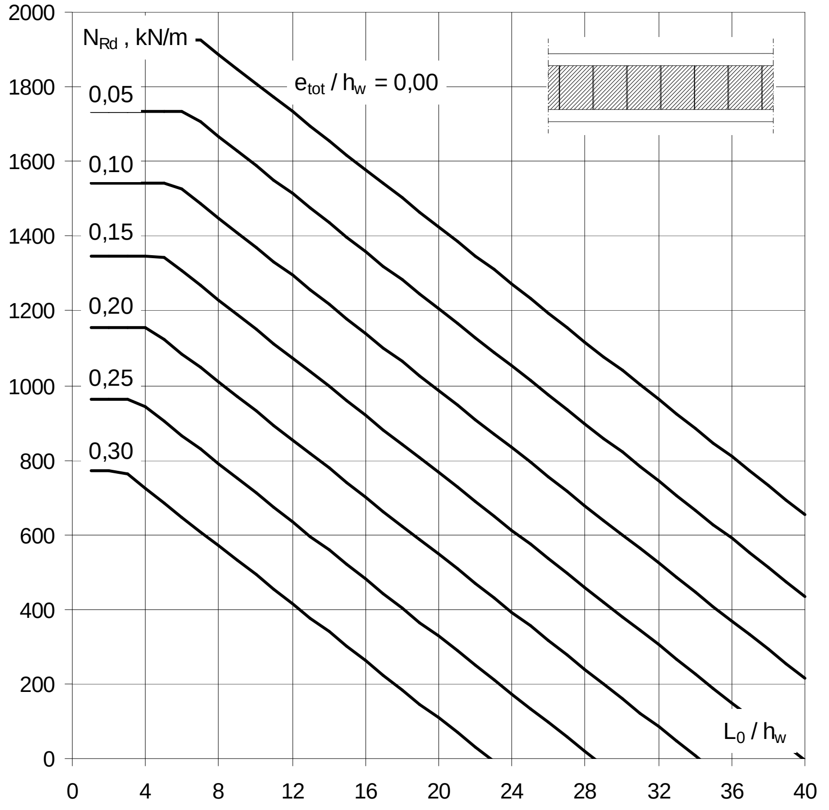
Styrofoam bricks
with plastic
fasteners

Nominal depth
of wall cross-section

0,15m

DESIGN RESISTANCE OF CONCRETE WALL

NB-0,15



Concrete C20/25

$h_w = 0,19m$

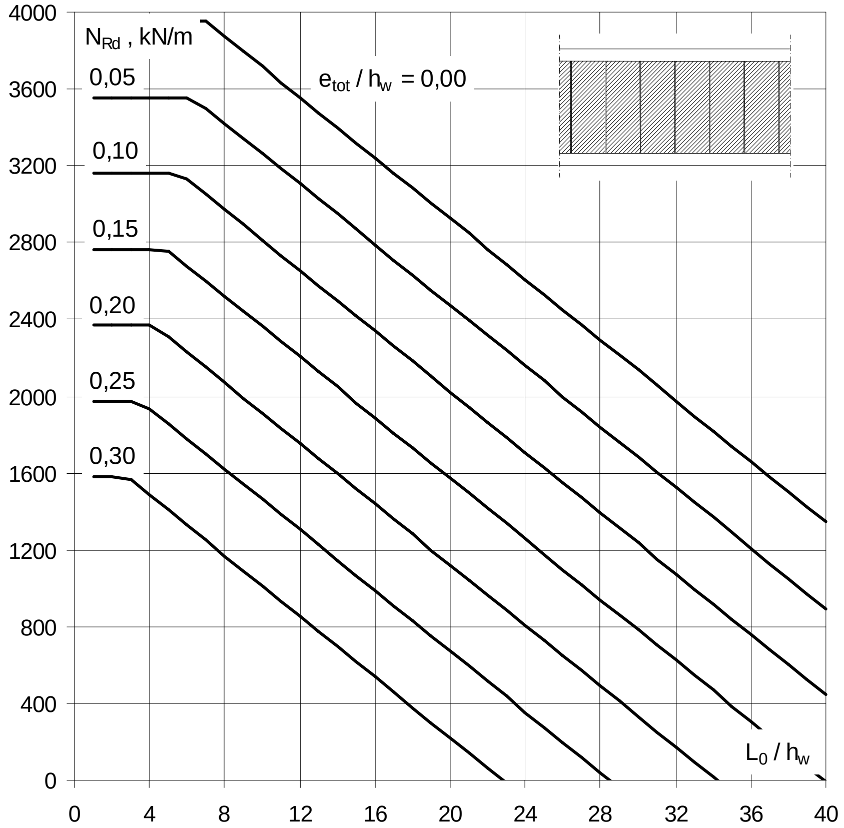
Styrofoam bricks
with plastic
fasteners

Nominal depth
of wall cross-section

0,20m

DESIGN RESISTANCE OF CONCRETE WALL

NB-0,20



Concrete C20/25

$h_w = 0,39m$

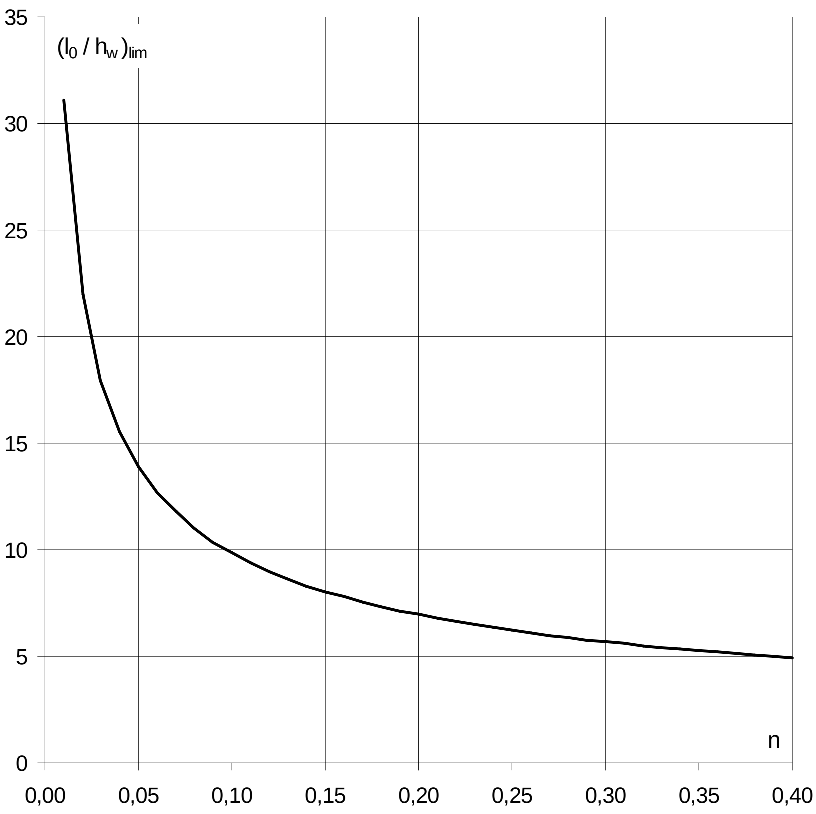
Styrofoam bricks
with plastic
fasteners

Nominal depth
of wall cross-section

0,40m

DESIGN RESISTANCE OF CONCRETE WALL

NB-0,40



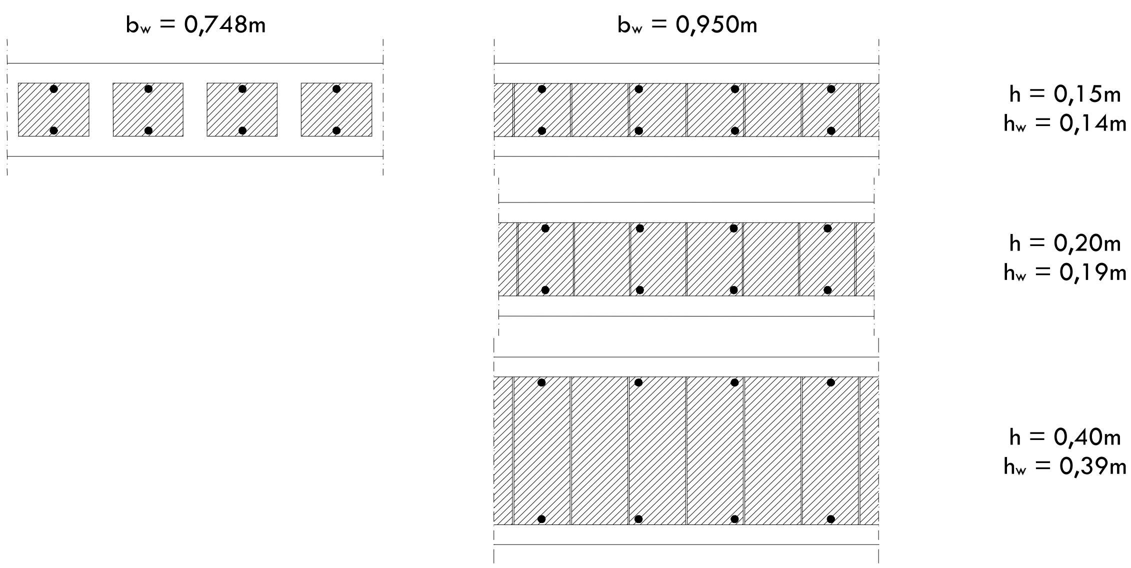
Slenderness criterion for isolated walls

$$(L_0 / h_w)_{lim} = \frac{10{,}78}{\sqrt{12n}} \qquad n = \frac{N_{Ed}}{b_w h_w f_{cd}}$$

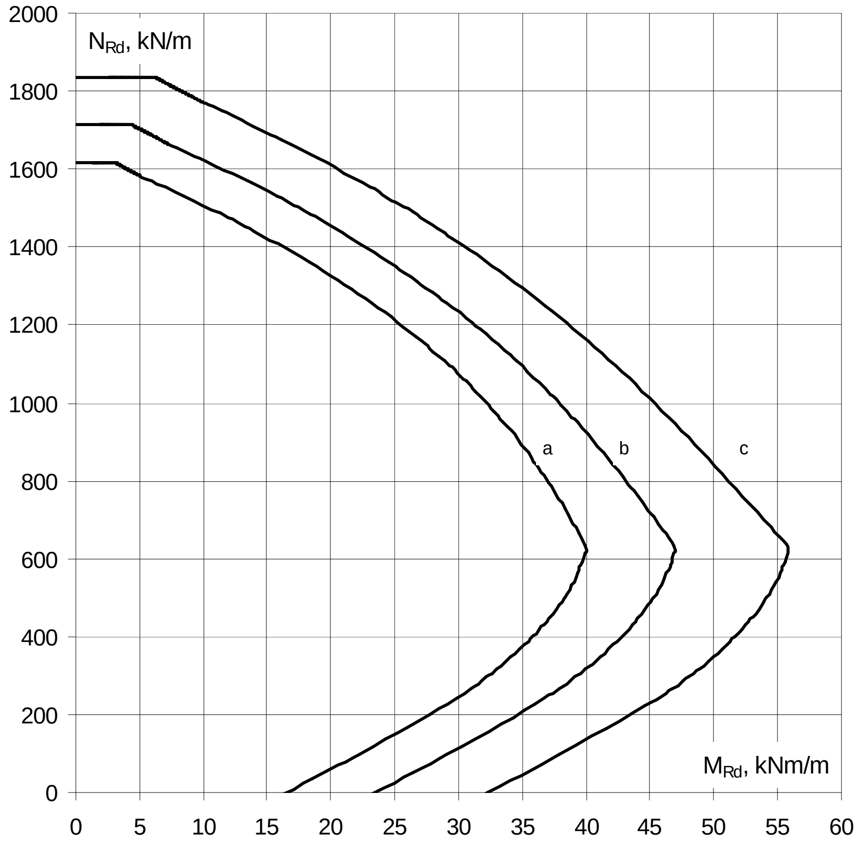
Concrete C20/25, f_{cd} = 13,33MPa

N_{Ed} – design value of axial load, kN/m,

b_w, h_w – effective value of cross-section dimensions



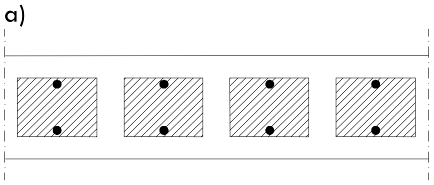
SLENDERNESS RATIO OF RC WALL **NZ-0**



Interaction diagram under bending and axial force

Order of reinforcement:

a)

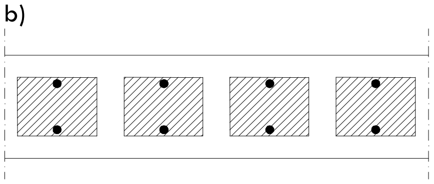


Reinforcement
2× 4∅10

Concrete C20/25

Effective depth
of cross-section
h_w = 0,14m

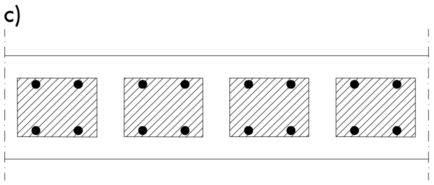
b)



Reinforcement
2× 4∅12

Styrofoam bricks
with styrofoam
fasteners

c)



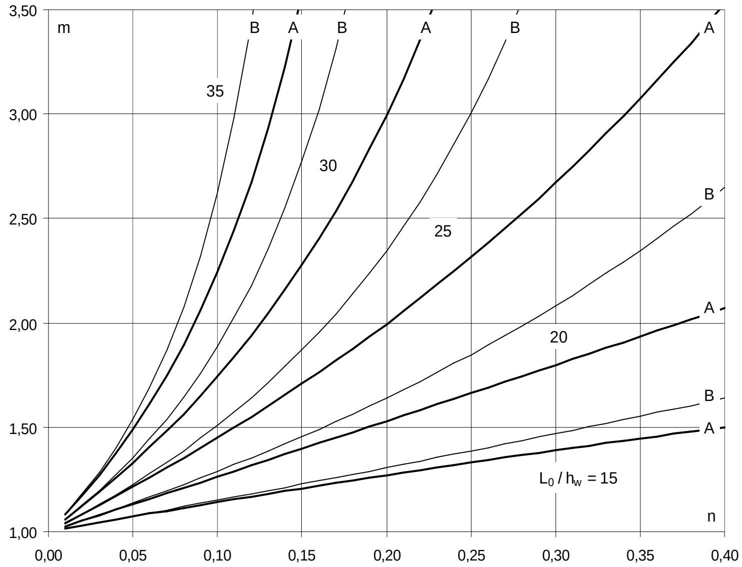
Reinforcement
2× 8∅10

**Nominal depth
of wall cross-section
0,15m**

DESIGN RESISTANCE OF RC WALL

NZ-0,15/1

a)

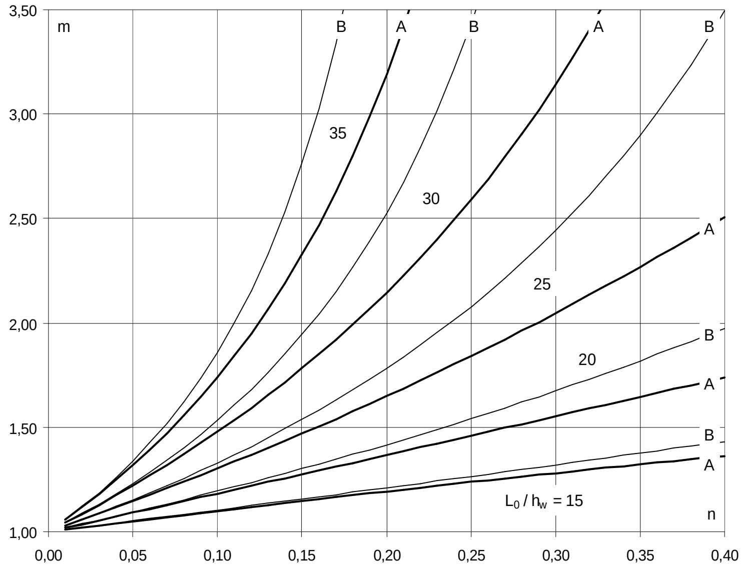


Reinforcement
2× 4∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

b)

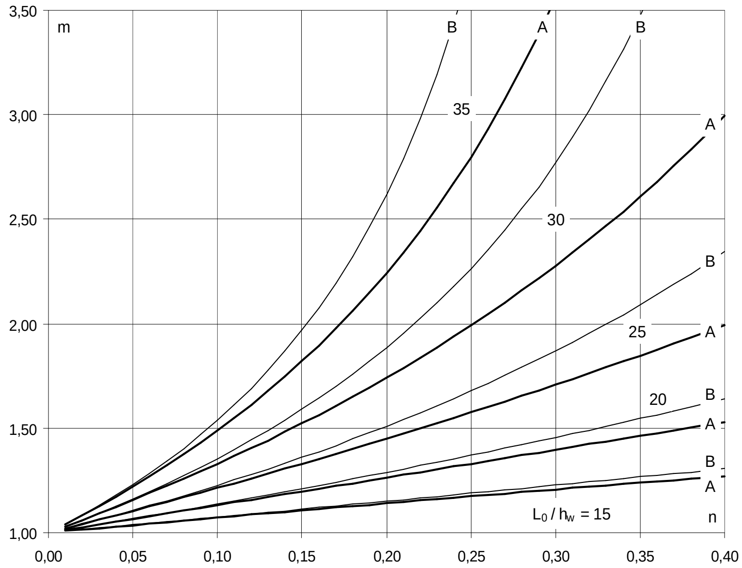


Reinforcement
2× 4∅12

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

c)



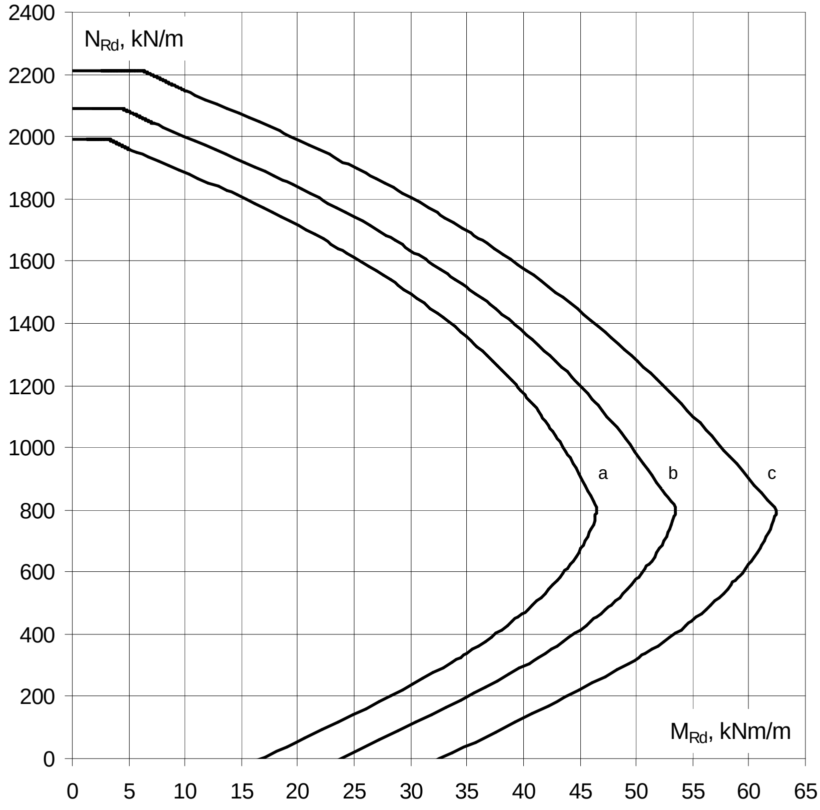
Reinforcement
2× 8∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

COEFFICIENT m

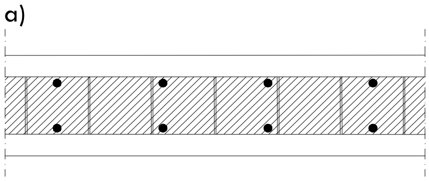
NZ-0,15/1



Interaction diagram under bending and axial force

Order of reinforcement:

a)

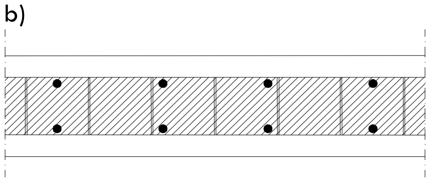


Reinforcement
2× 4∅10

Concrete C20/25

Effective depth
of cross-section
h_w = 0,14m

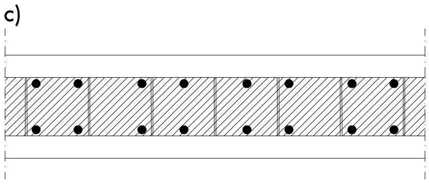
b)



Reinforcement
2× 4∅12

Styrofoam bricks
with styrofoam
fasteners

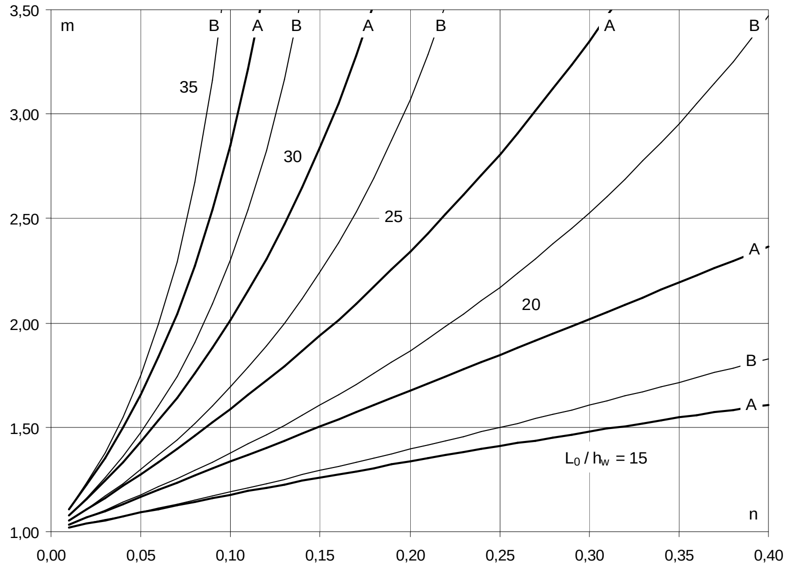
c)



Reinforcement
2× 8∅10

Nominal depth of wall cross-section 0,15m

a)

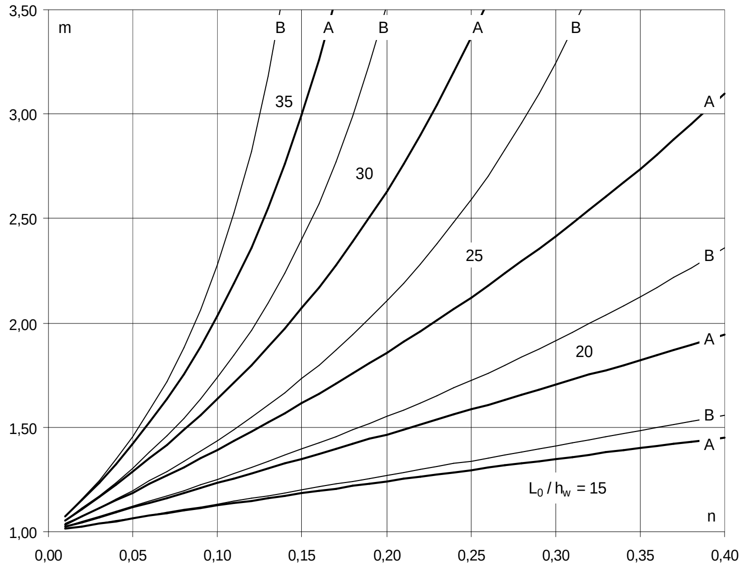


Reinforcement
2× 4∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

b)

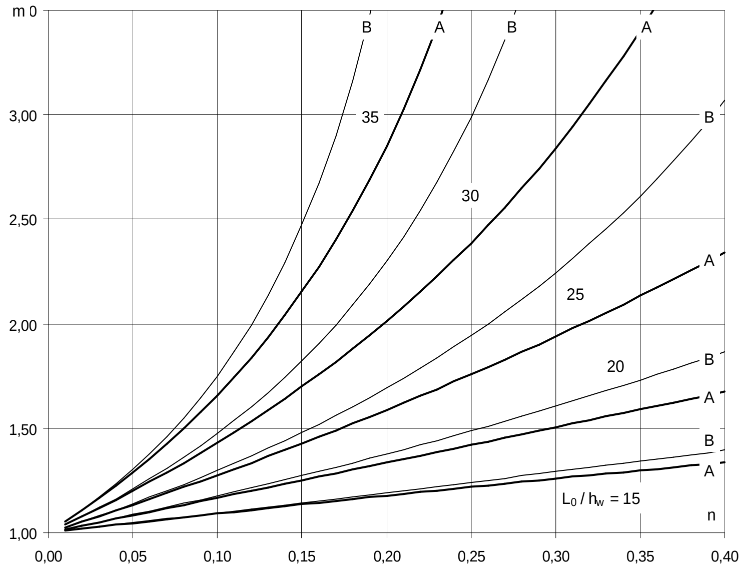


Reinforcement
2× 4∅12

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

c)



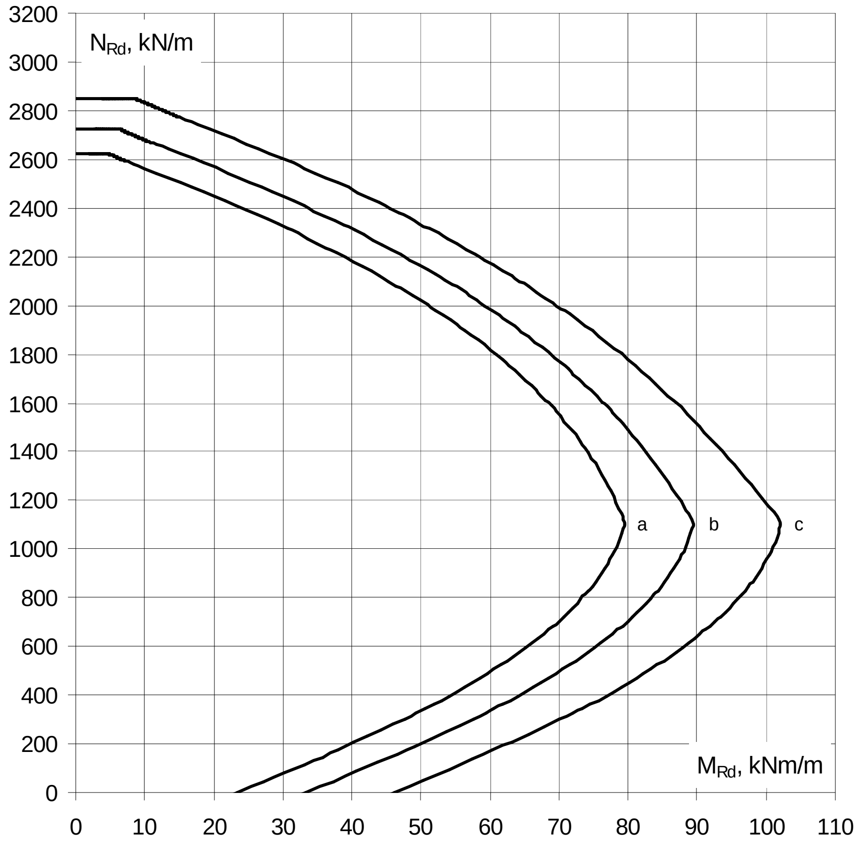
Reinforcement
2× 8∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

COEFFICIENT m

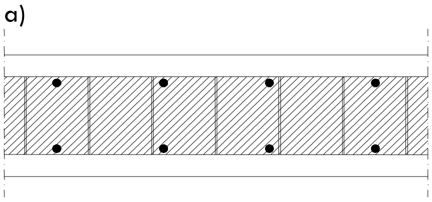
NZ-0,15/2



Interaction diagram under bending and axial force

Order of reinforcement:

a)

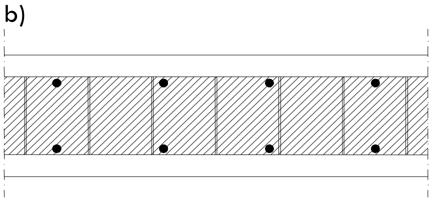


Reinforcement
2× 4∅10

Concrete C20/25

Effective depth
of cross-section
h_w = 0,19m

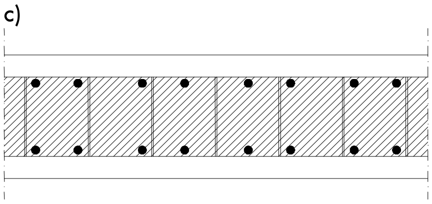
b)



Reinforcement
2× 4∅12

Styrofoam bricks
with styrofoam
fasteners

c)



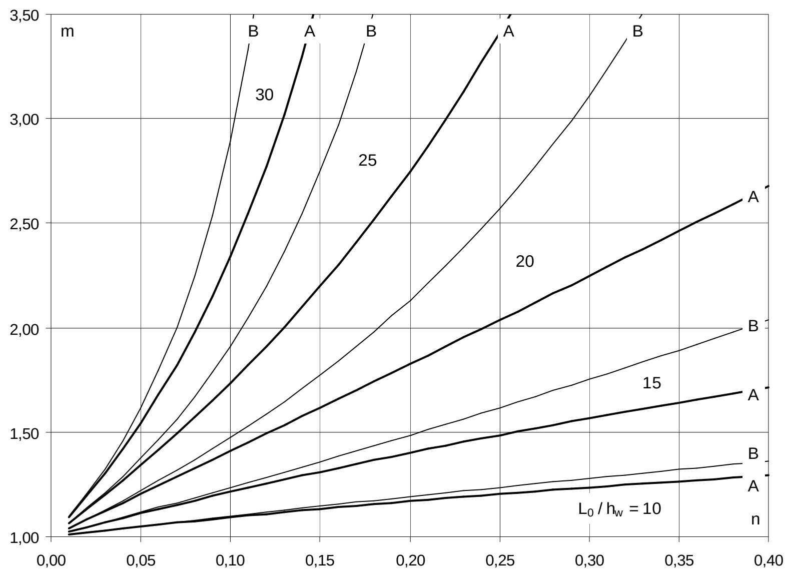
Reinforcement
2× 8∅10

**Nominal depth
of wall cross-section
0,20m**

DESIGN RESISTANCE OF RC WALL

NZ-0,20

a)

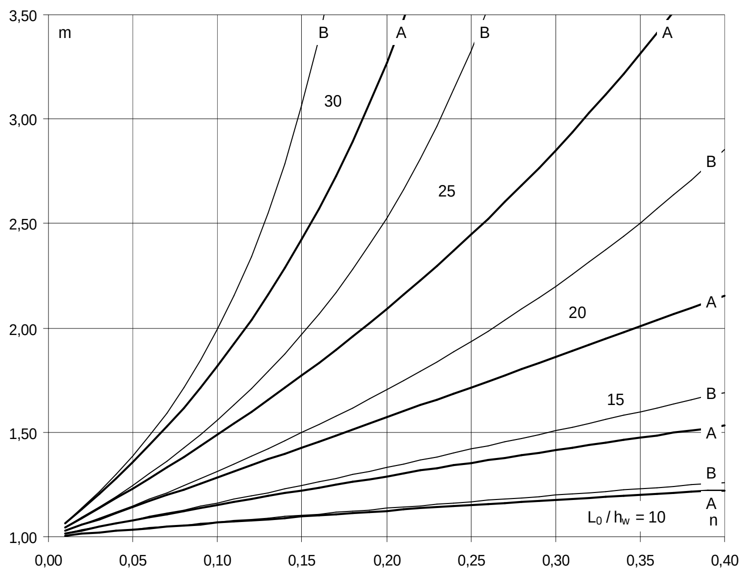


Reinforcement
2× 4∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

b)

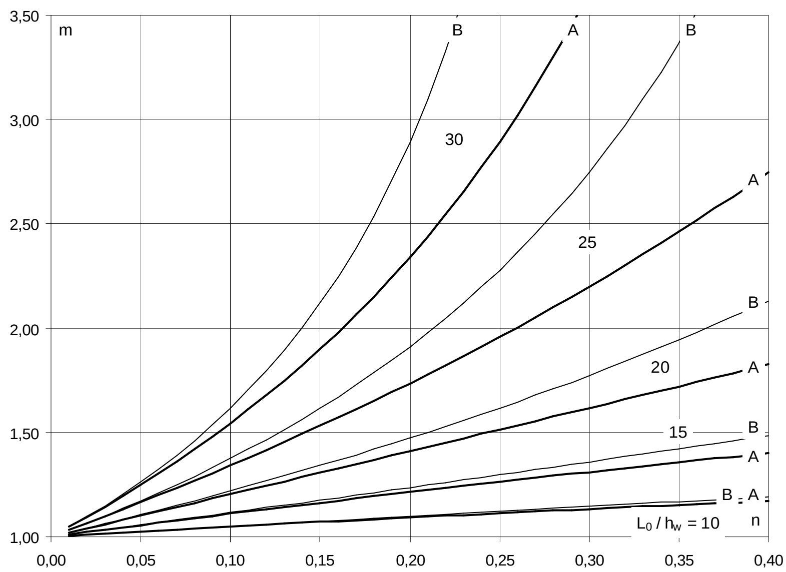


Reinforcement
2× 4∅12

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

c)



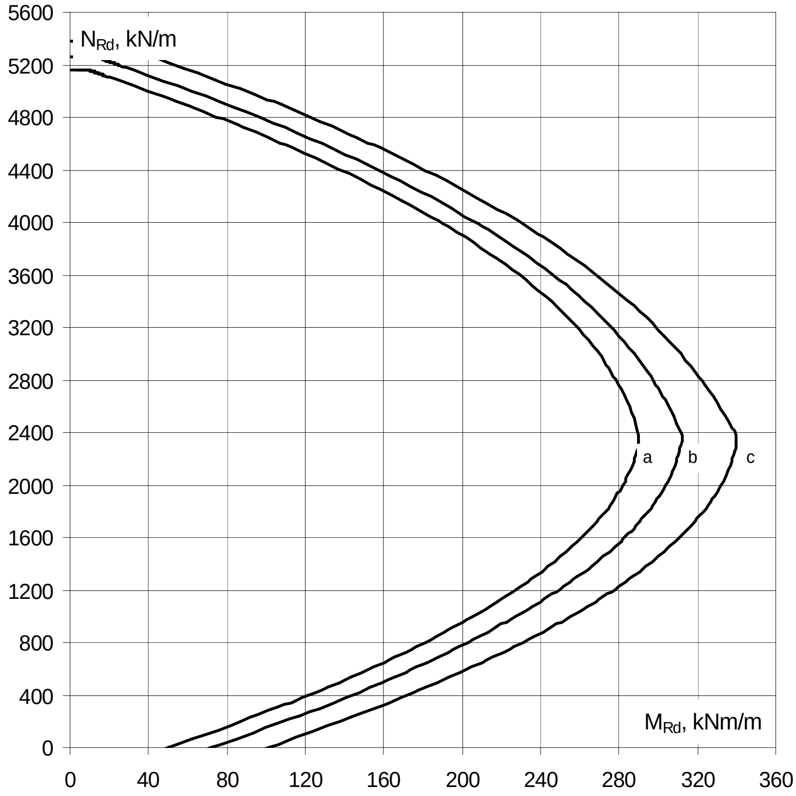
Reinforcement
2× 8∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

COEFFICIENT m

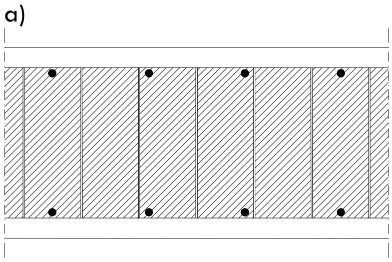
NZ-0,20



Interaction diagram under bending and axial force

Order of reinforcement:

a)

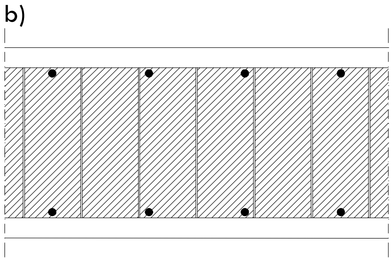


Reinforcement
2× 4∅10

Concrete C20/25

Effective depth
of cross-section
h_w = 0,39m

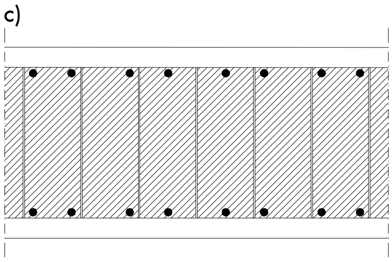
b)



Reinforcement
2× 4∅12

Styrofoam bricks
with styrofoam
fasteners

c)



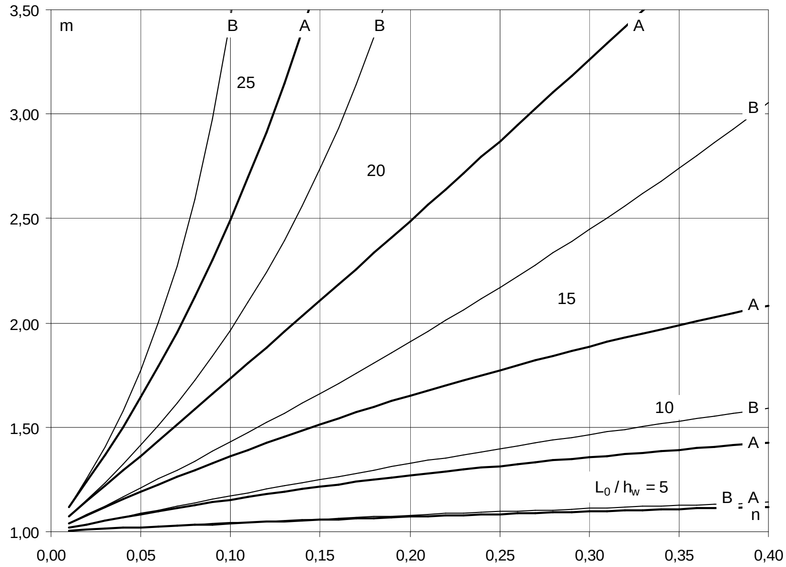
Reinforcement
2× 8∅10

**Nominal depth
of wall cross-section
0,40m**

DESIGN RESISTANCE OF RC WALL

NZ-0,40

a)

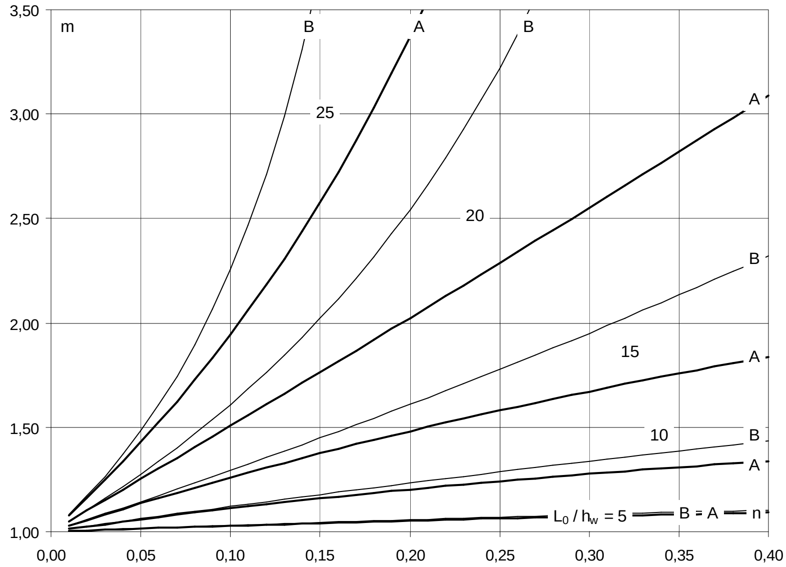


Reinforcement
2× 4∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

b)

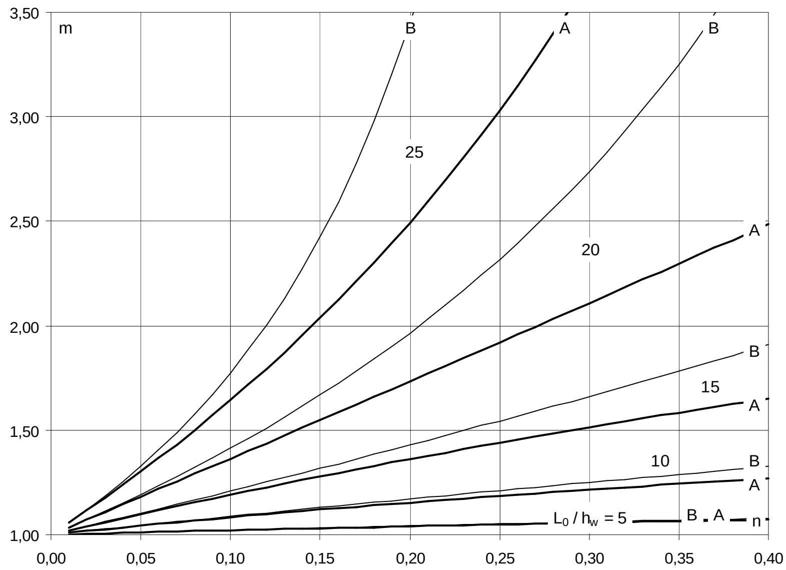


Reinforcement
2× 4∅12

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

c)



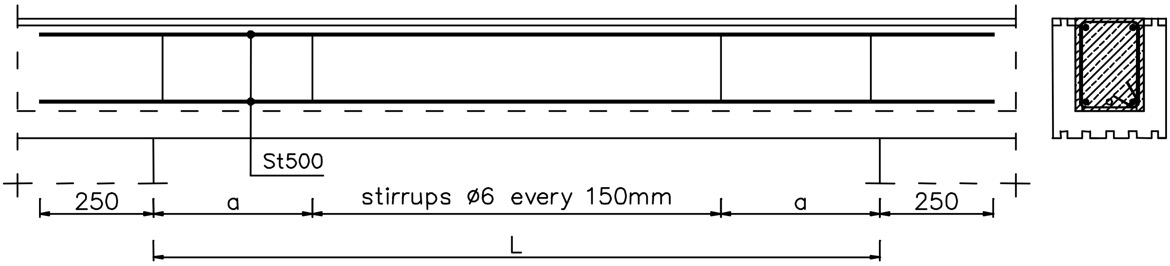
Reinforcement
2× 8∅10

A quasi-permanent load is equal 30% of the total load

B quasi-permanent load is equal 70% of the total load

COEFFICIENT m

NZ-0,40



Design assumptions

Concrete C20/25
B or C reinforcement class, $f_{yk} \geq 500$MPa
Total design load of header, q_{Ed}, is uniformly distributed

Checking resistance

$M_{Ed} = q_{Ed} L^2 / 10 \leq M_{Rd}$
$V_{Ed} = q_{Ed} L / 2 \leq V_{Rd,max}$

If

$V_{Ed} - 0{,}18 q_{Ed} > V_{Rd,c}$,

that at a distance „a” from the face of the support, where

$a = (V_{Ed} - V_{Rd,c}) / q_{Ed}$

∅6mm two-legged closed stirrups should be provided with spacing in order that

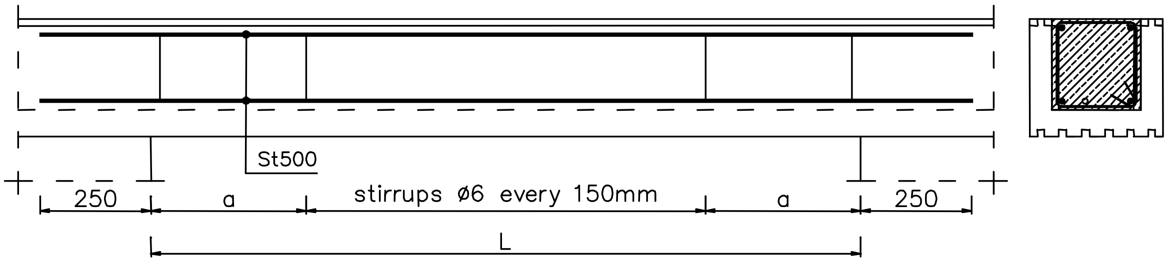
$V_{Ed} - 0{,}18 q_{Ed} \leq V_{Rd,s}$.

Outside distance „a” should be provided ∅6mm two-legged closed stirrups with spacing 150mm.

Design bending and shear resistance (at cotΘ = 1,5)

Reinforcement of cross-section		M_{Rd}	$V_{Rd,max}$	$V_{Rd,c}$	$V_{Rd,s}$, kN ∅6 two-legged closed stirrups St500 with spacing, mm		
bottom	**top**	**kNm**	**kN**	**kN**	**100**	**125**	**150**
2∅8	2∅8	7,60	79,15	12,00	60,84	48,67	40,56
2∅10		11,78		13,96			
2∅12		16,68		15,75			
2∅14		21,88		17,47			
2∅16		26,95		19,09			

Nominal depth of a wall cross-section 0,15m



Design assumptions

Concrete C20/25
B or C reinforcement class, $f_{yk} \geq 500MPa$
Total design load of header, q_{Ed}, is uniformly distributed

Checking resistance

$$M_{Ed} = q_{Ed}\, L^2 / 10 \leq M_{Rd}$$
$$V_{Ed} = q_{Ed}\, L / 2 \leq V_{Rd,max}$$

If

$$V_{Ed} - 0{,}18 q_{Ed} > V_{Rd,c},$$

that at a distance „a” from the face of the support, where

$$a = (V_{Ed} - V_{Rd,c}) / q_{Ed}$$

∅6mm two-legged closed stirrups should be provided with spacing in order that

$$V_{Ed} - 0{,}18 q_{Ed} \leq V_{Rd,s}.$$

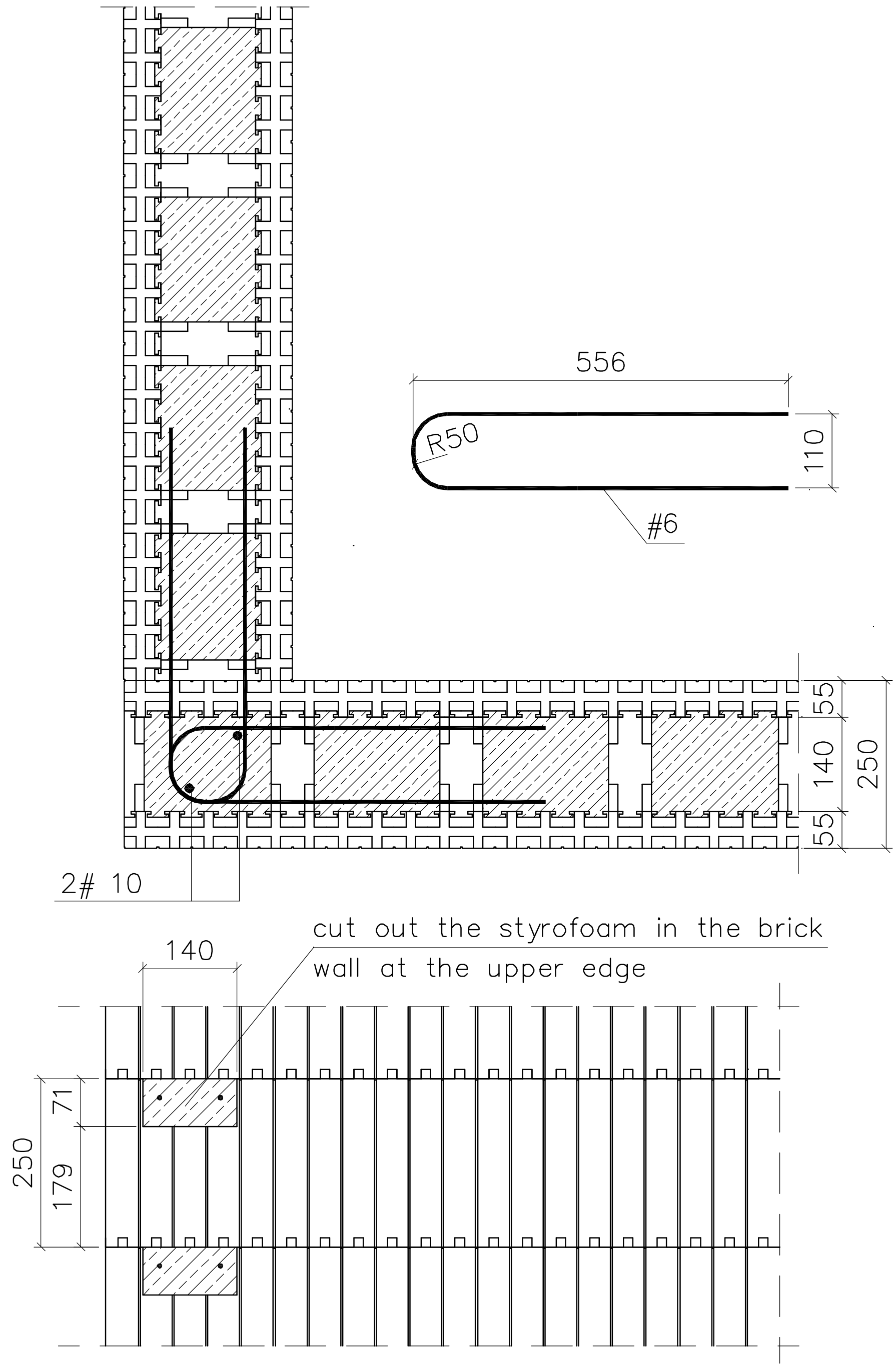
Outside distance „a” should be provided ∅6mm two-legged closed stirrups with spacing 150mm.

Reinforcement of cross-section		M_{Rd}	$V_{Rd,max}$	$V_{Rd,c}$	$V_{Rd,s}$, kN ∅6 two-legged closed stirrups St500 with spacing, mm		
bottom	top	kNm	kN	kN	bottom	top	kNm
2∅8		7,67		14,80			
2∅10	2∅8	11,87		17,10			
2∅12		16,85	107,40	19,43	81,12	60,84	48,67
2∅14		22,47		21,54			
2∅16		28,20		23,54			

Nominal depth of a wall cross-section 0,20m

9 Construction drawings

CORNER CONNECTION BETWEEN EXTERNAL WALLS



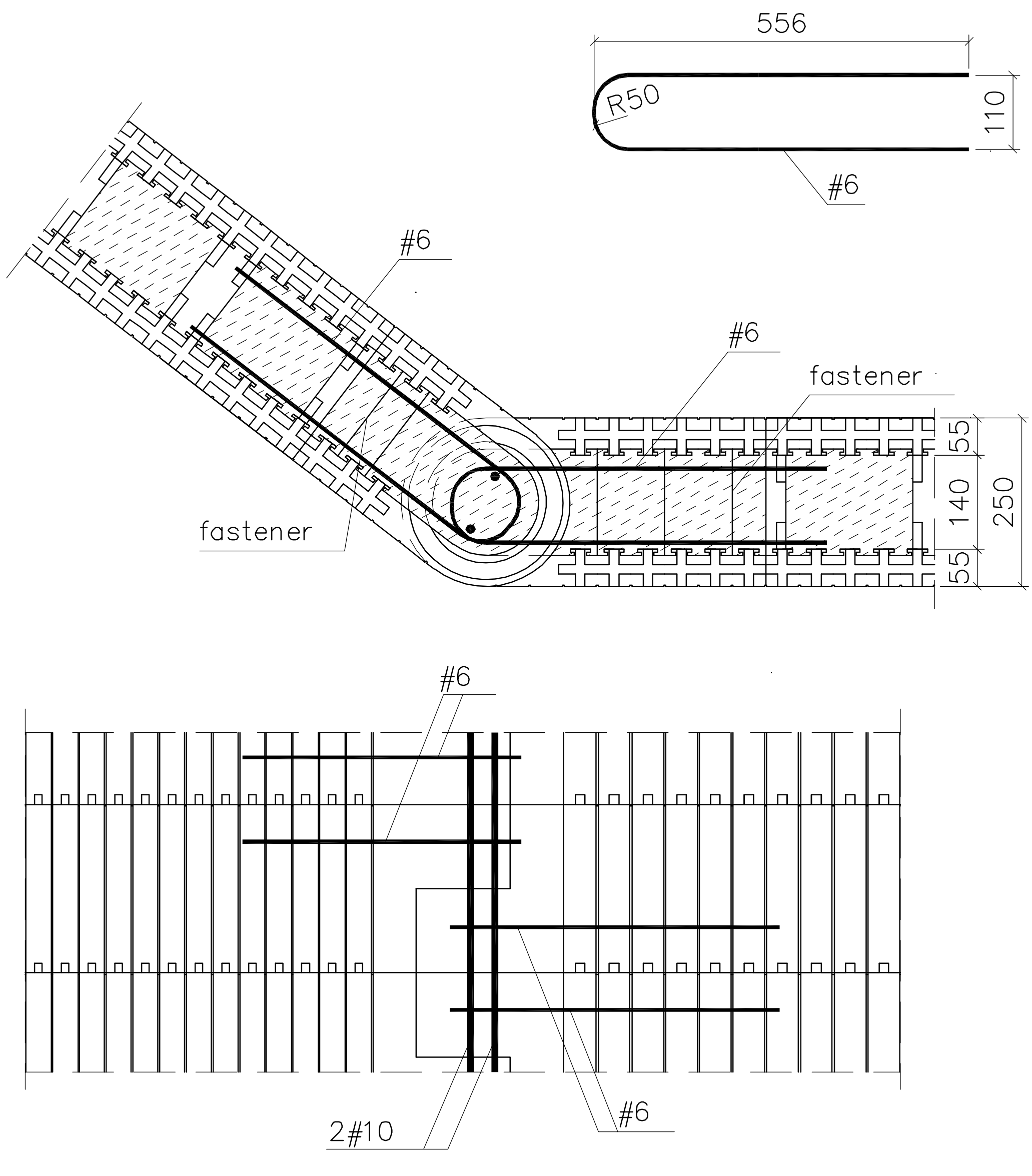
NOTICE:

Reinforcement at each level of styrofoam bricks

By Department of Concrete Structures Technical University of Lodz

K 1

CORNER CONNECTION BETWEEN EXTERNAL WALLS AT ANY ANGLE



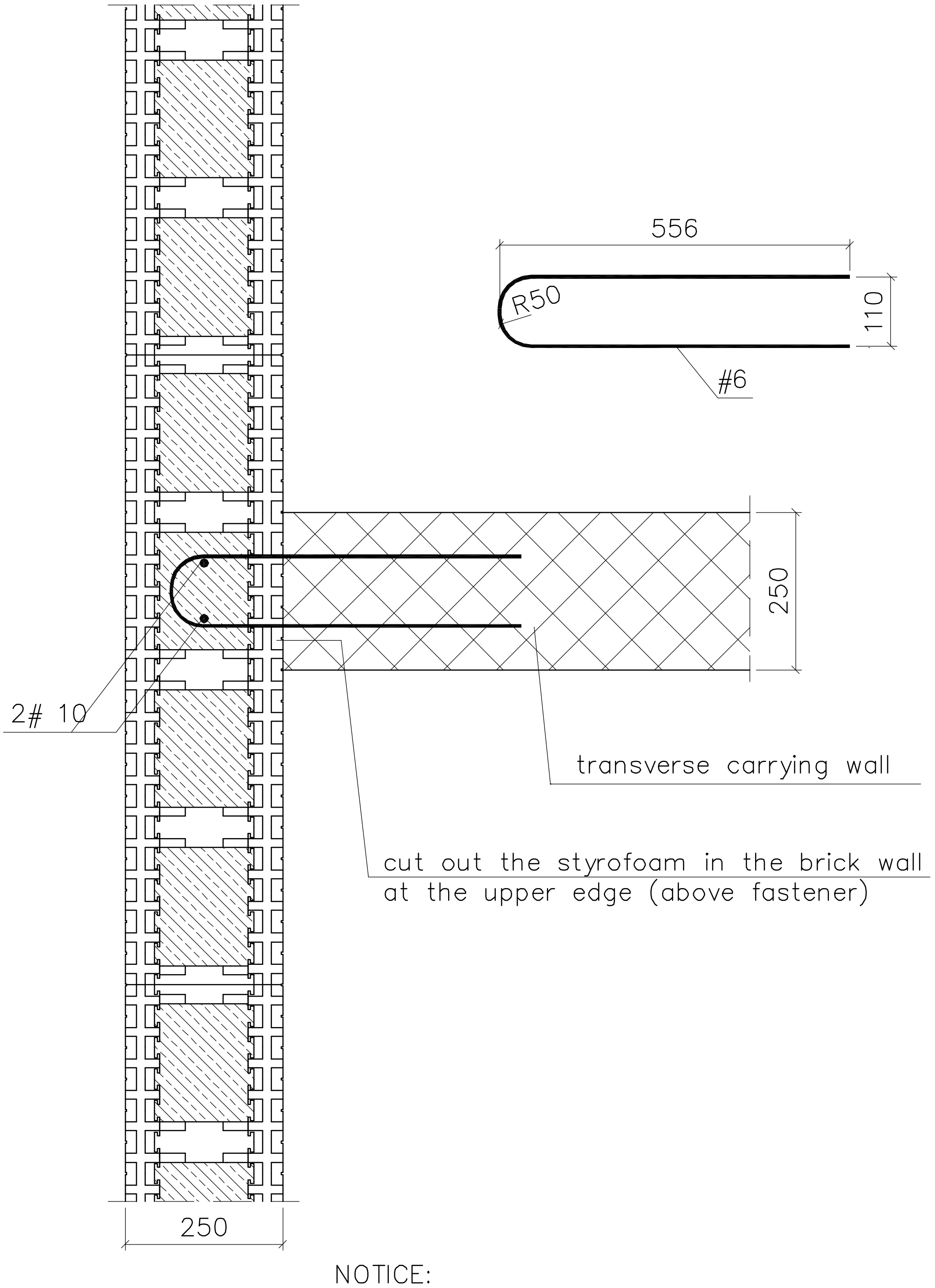
NOTICE:

Reinforcement at each level of styrofoam bricks

By Department of Concrete Structures Technical University of Lodz

K 2

EXTERNAL AND INTERNAL CARRYING WALL CONNECTION



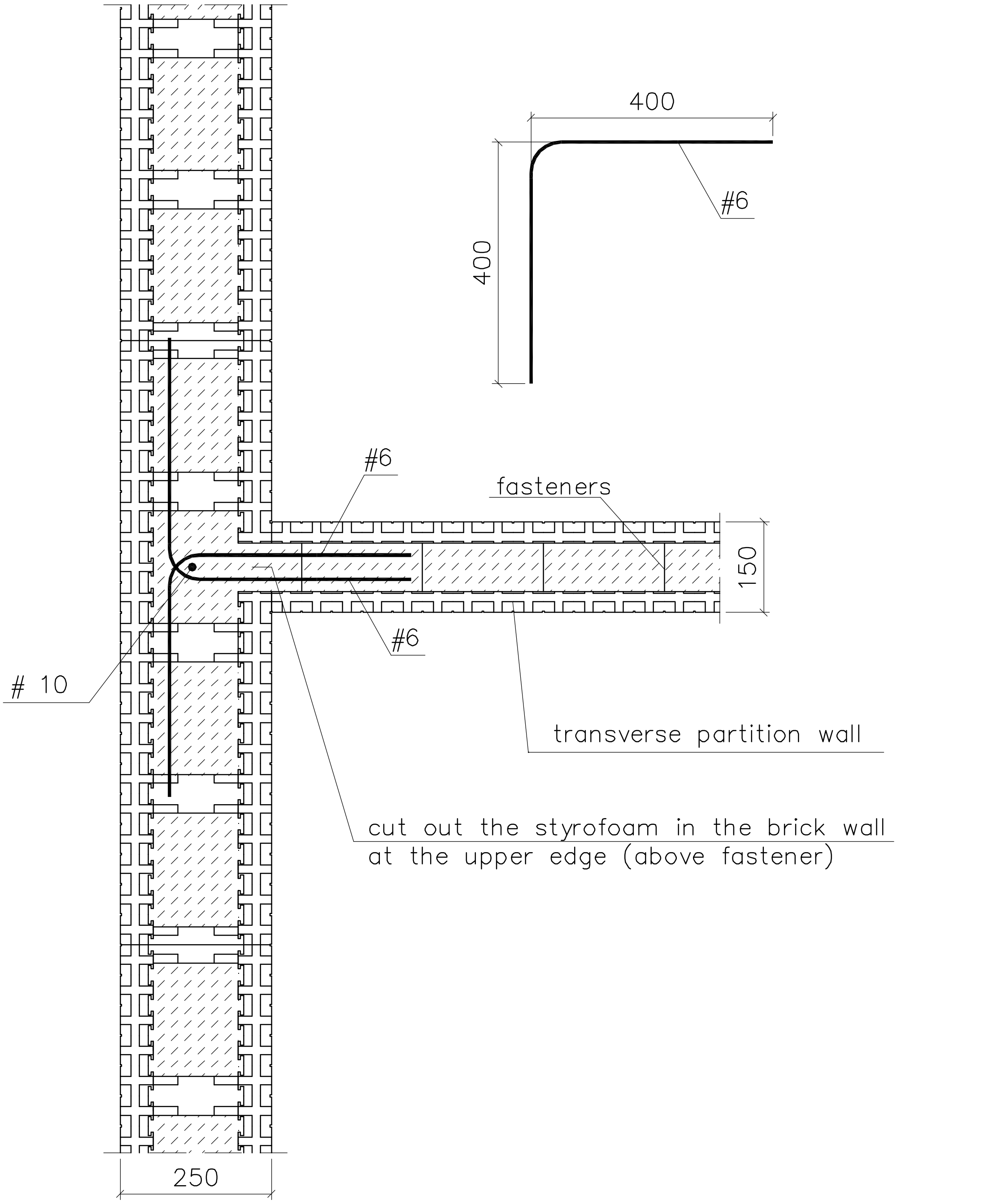
NOTICE:

Reinforcement at each level of styrofoam bricks

By Department of Concrete Structures Technical University of Lodz

K 3

EXTERNAL AND PARTITION
WALL CONNECTION

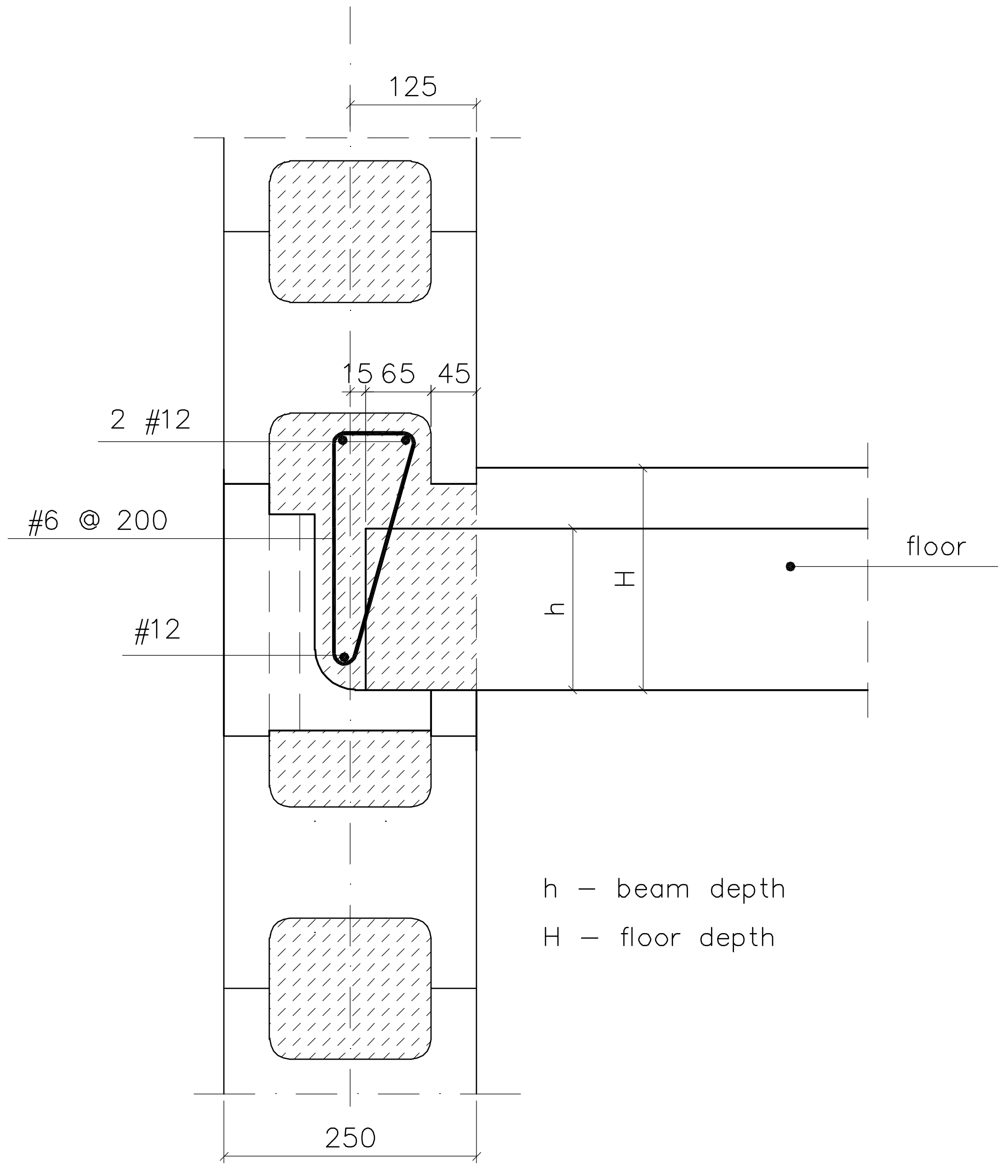


NOTICE:
Reinforcement at each level of styrofoam bricks

By Department of Concrete Structures Technical University of Lodz

K 4

BOND BEAM REINFORCEMENT



h – beam depth

H – floor depth

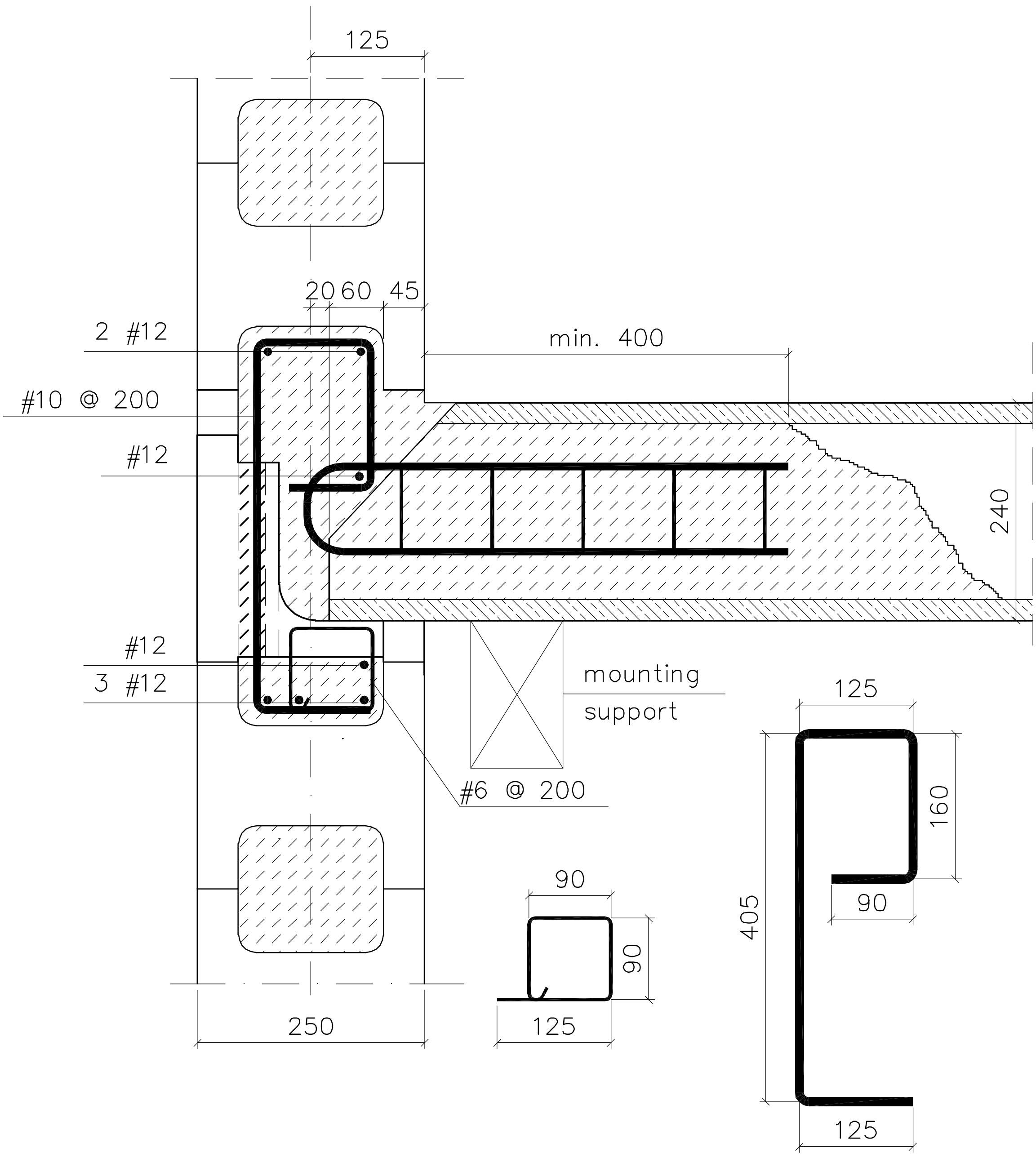
NOTICE:

Keep the bond beam longitudinal reinforcement continuous

By Department of Concrete Structures Technical University of Lodz

K 5

HC SLABS SUPPORT ON THE EXTERNAL WALLS

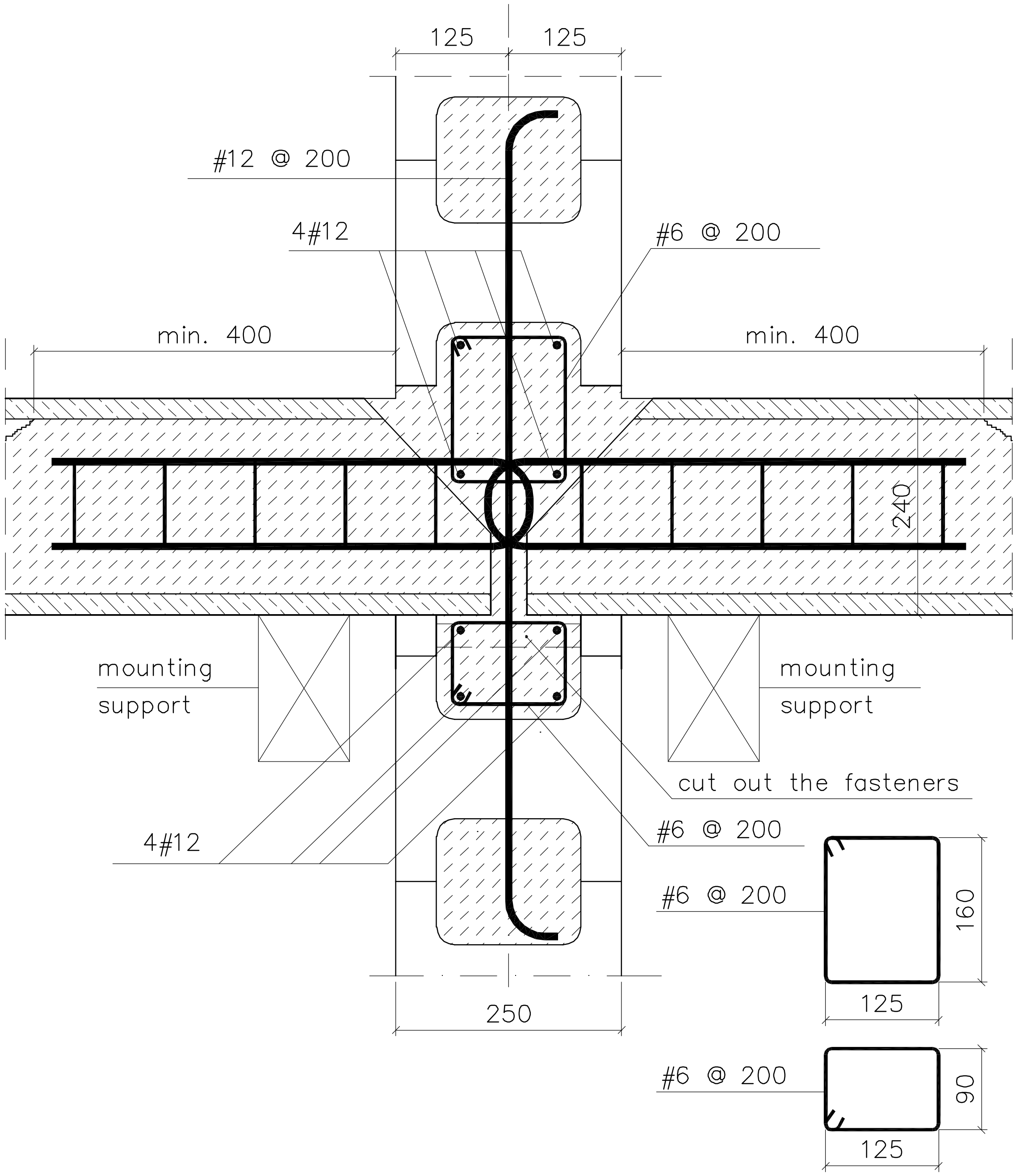


NOTICE:

Keep the bond beam longitudinal reinforcement continuous

Reinforcemet of cores in the HC slabs according to Figure K8

HC SLABS SUPPORT ON THE INTERNAL WALL



NOTICE:

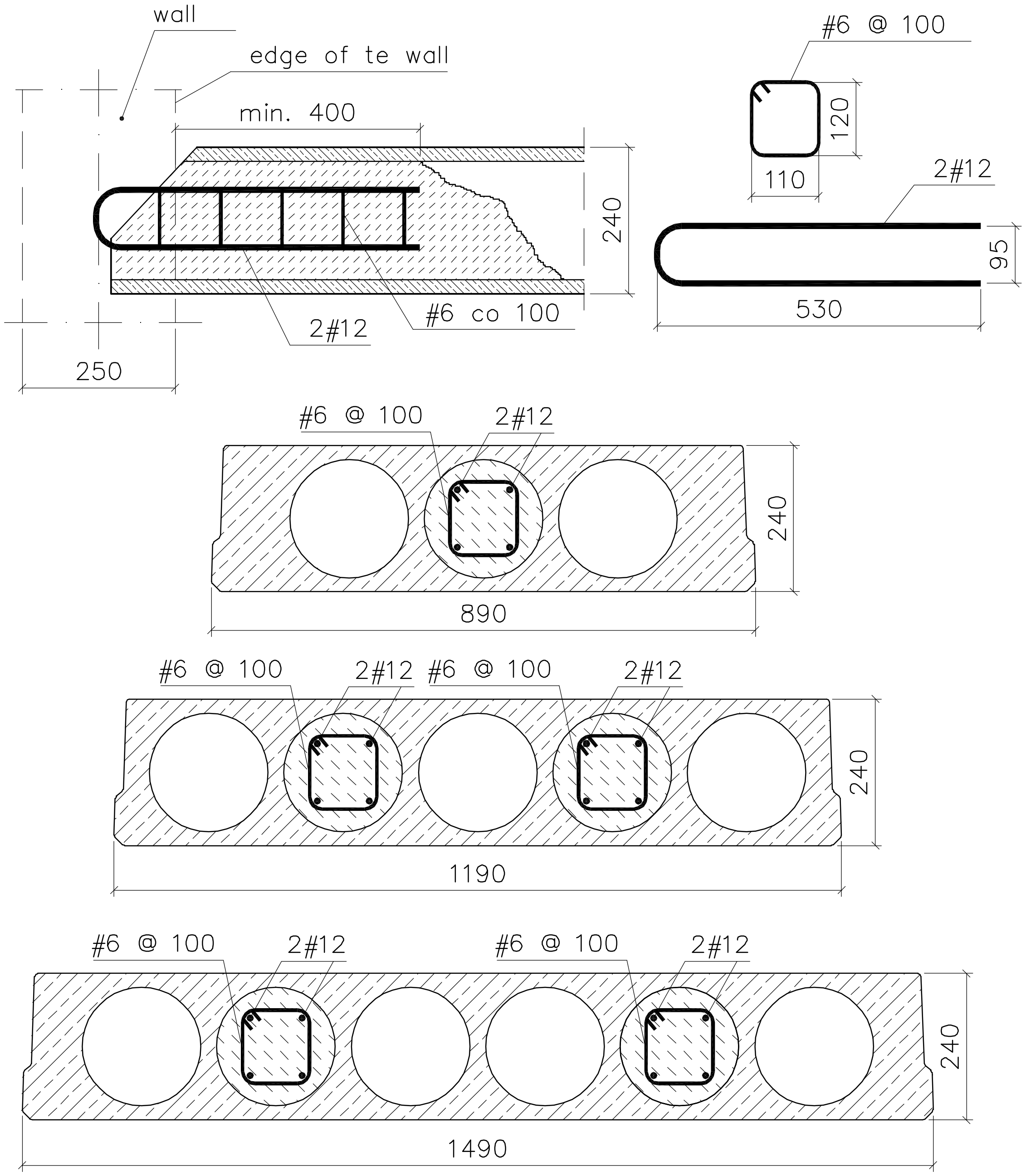
Keep the bond beam longitudinal reinforcement continuous

Reinforcement of cores in the HC slabs according to Figure K8

By Department of Concrete Structures Technical University of Lodz

K 7

HC SLABS CORES REINFORCEMENT



NOTICE:

Bond beam longitudinal reinforcement according to Figure K6, K7

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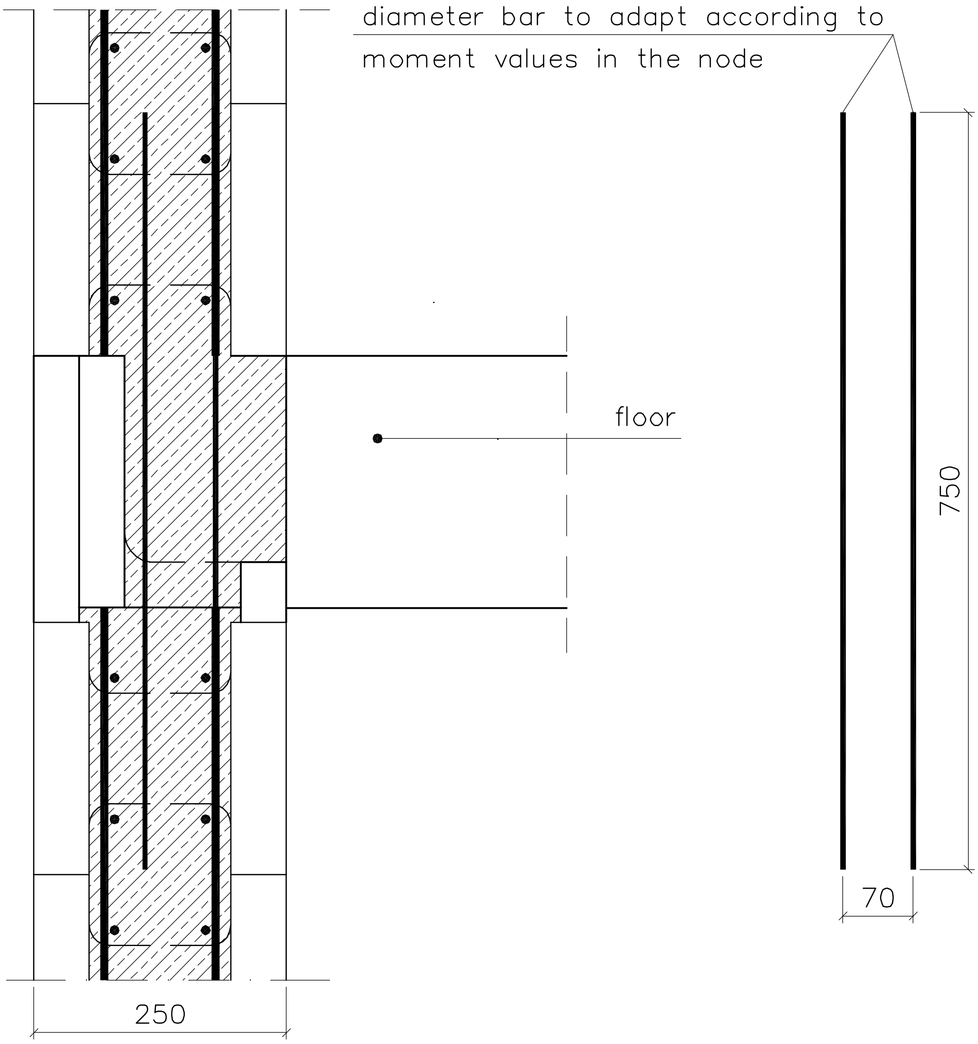
K 8

CONCRETE WALL REINFORCEMENT IN THE NODE WALL – FLOOR



NOTICE:

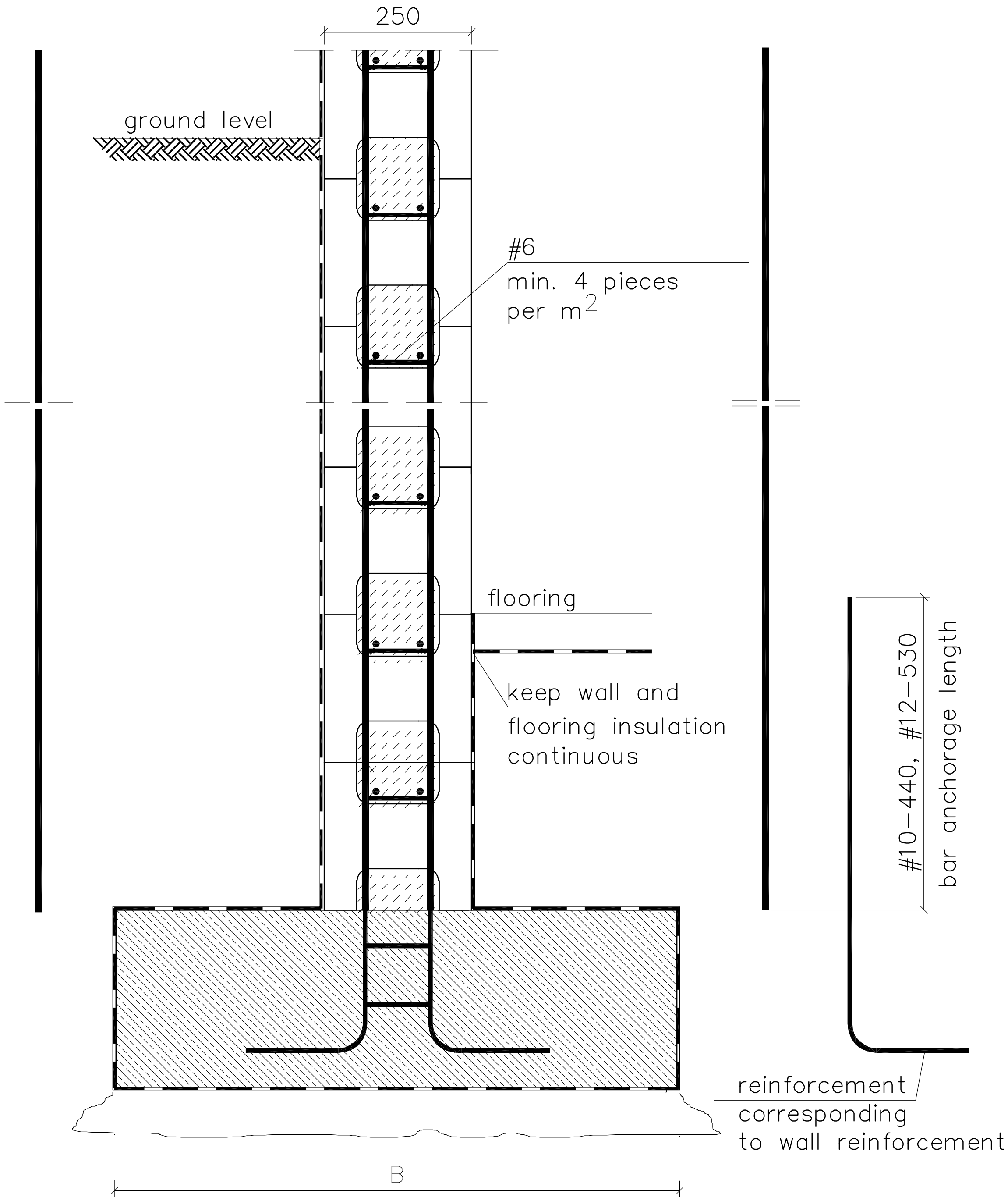
Horizontal wall reinforcement in accordance with the diagrams

Bond beam longitudinal reinforcement according to Figure K5

By Department of Concrete Structures Technical University of Lodz

K 9

RC WALL AND STRIP FOUNDATION CONNECTION

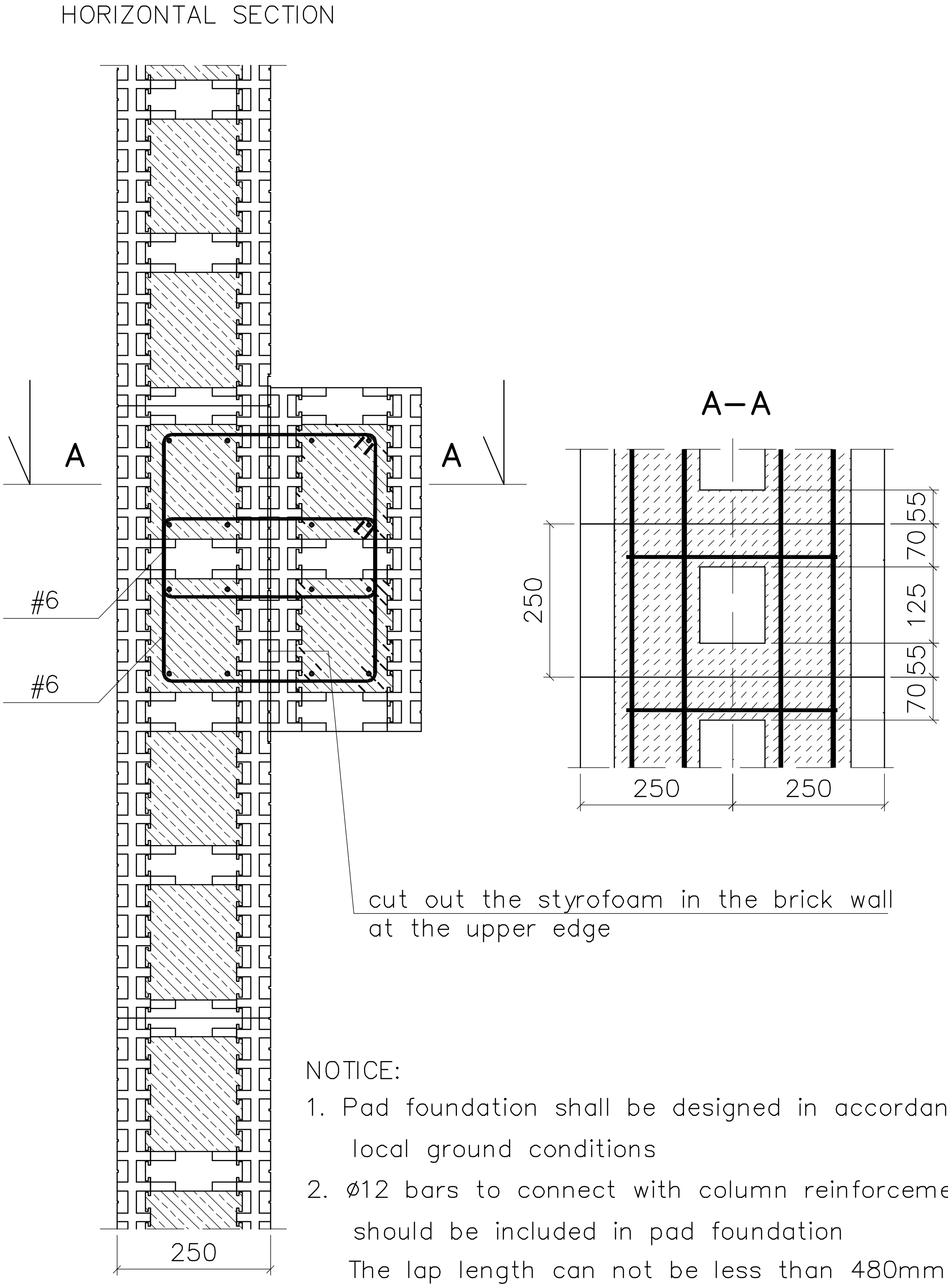


NOTICE:
Width of strip foundation assume to ensure partial fixity of the wall

By Department of Concrete Structures Technical University of Lodz

K 10

WALL–PILLAR REINFORCEMENT



NOTICE:

1. Pad foundation shall be designed in accordance with local ground conditions
2. Ø12 bars to connect with column reinforcement should be included in pad foundation
   The lap length can not be less than 480mm

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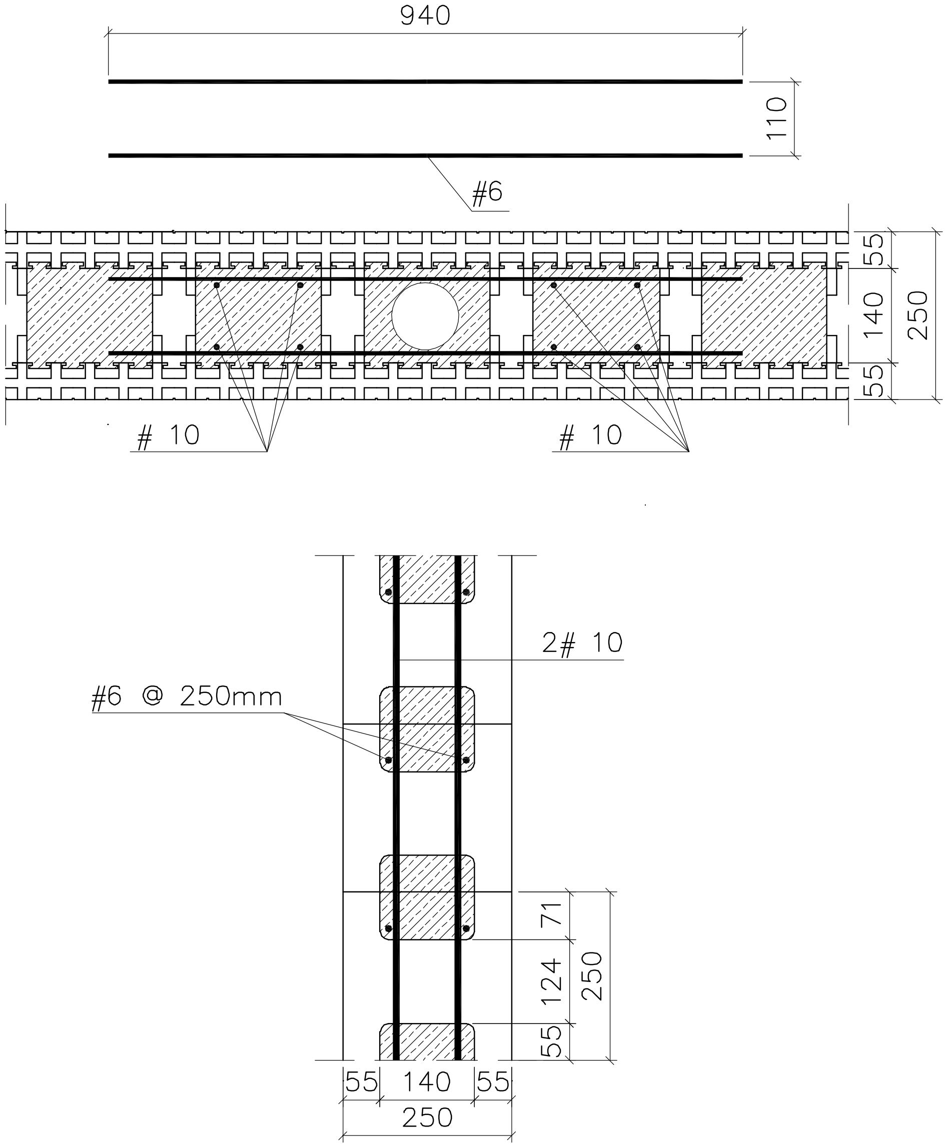
K 11

INSTALLATION DUCT REINFORCEMENT



NOTICE:
Reinforcement at each level of styrofoam bricks

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Izodom 2000 Polska
Zduńska Wola, ul.Ceramiczna 2
tel.: 48 43 823 41 88 / 48 43 823 89 47
tel./fax: 48 43 923 23 68
e-mail: biuro@izodom2000polska.com
www.izodom2000polska.com