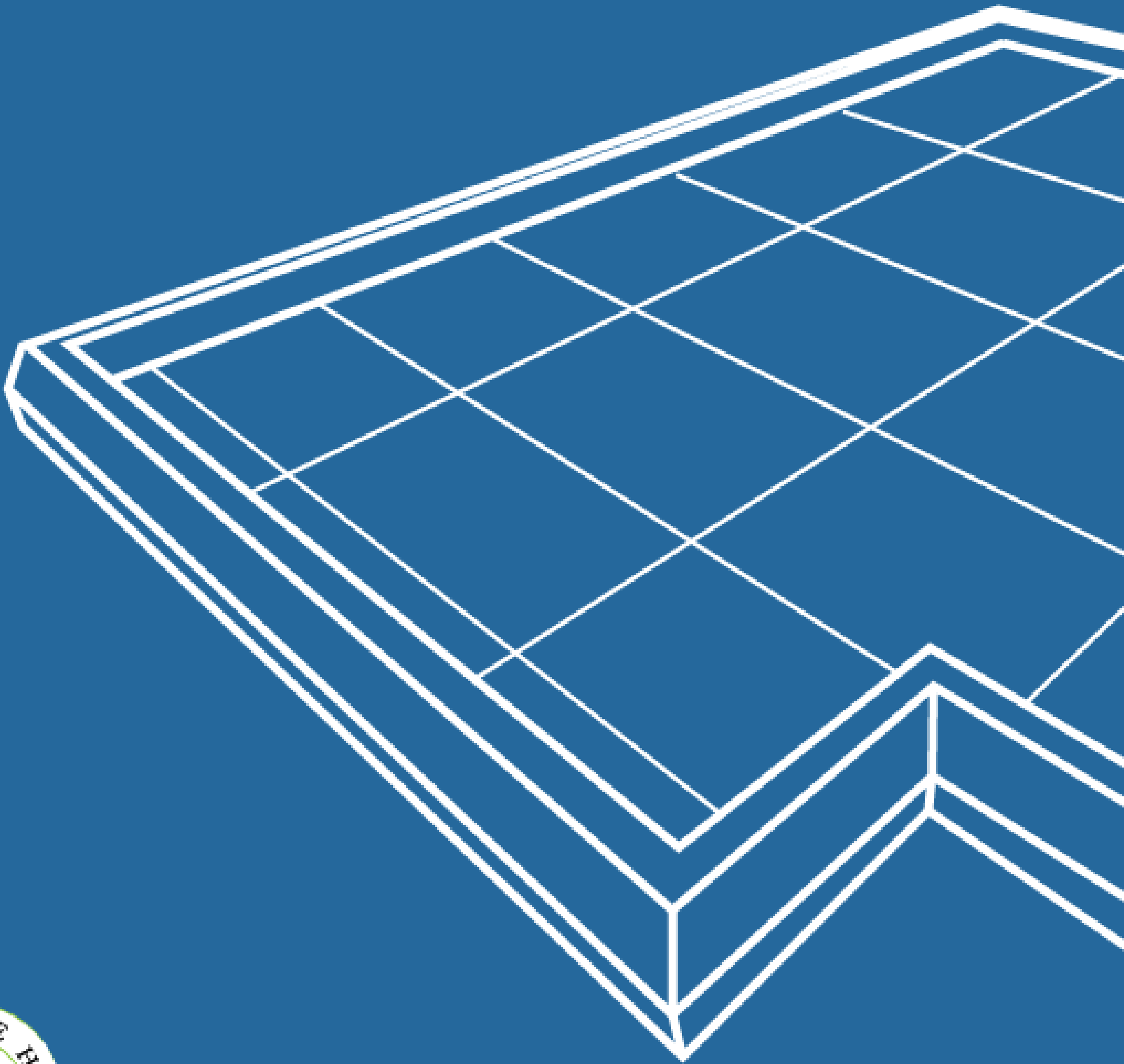
Informational Brochure

Izodom 2000 Polska

Guidelines for calculations and design of ground slabs in the Izodom 2000 Polska system

No8



IDEAL FOR PASSIVE HOUSES

www.izodom.pl

Guidelines for calculations and design of ground slab in the Izodom 2000 Polska System

Authors:
Dr inż. Jan Kozicki
Mgr inż. Jacek Filipczak

Department of Concrete Structures Technical University of Lodz,
93-590 Łódź, 6 Politechniki Av.,
phone (+48 42) 631-35-75
fax. (+48 42) 631-35-84

August 2013
Łódź, Poland

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

Content

1. General information

IZODOM 2000 POLSKA offers a way of supporting a building on a ground slab, located on ground level. Such a solution enables to avoid many arduous and costly operations – excavating, removal of large amounts of ground from these excavations, renting, installation and removal of formwork, laying of insulation for foundation walls.

The structural component of the foundations consists in a slab, poured from concrete in the form shaped by Styrofoam insulation panels and edge fittings (optionally also by complementary fittings). Styrofoam elements should be laid on a tamped and levelled layer of gravel or bedding concrete (also called lean concrete), covered with insulating foil. The idea of the solutions is explained in Fig. 1.1.

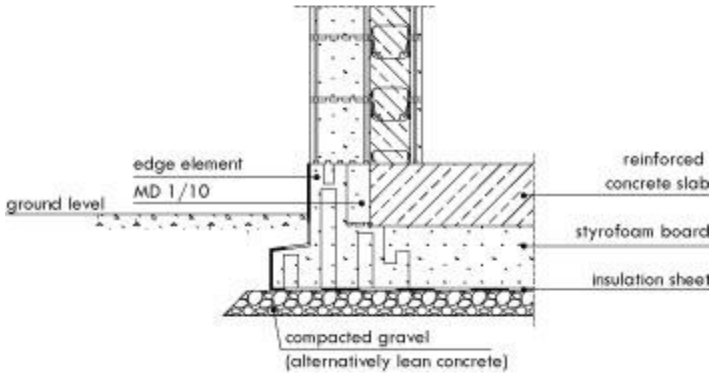


Fig. 1.1 A ground slab in the IZODOM 2000 POLSKA system

Such method of supporting may be used for buildings with the height of two usable floors. In case of taller buildings, it is necessary to verify the ground slab's load bearing capacity and the subgrade strength by calculations.

Direct supporting of a building on a subgrade should be excluded in case of unsuitable soils, with permissible base compression lower than 150 kPa. In such case, the subgrade should be strengthened first, using one of the known methods (replacement of soil, stabilisation by grouting, sand piles, etc.).

2. Foundation forming

Surface preparation

Removal of layers of unsuitable soils is required within the footprint area of the building being constructed, to the level planned in the design. A layer of gravel with 16/32mm fraction, 150-mm thick should be laid on the exposed subsoil, and compacted mechanically to the compaction index of J_s = 0.95. Plate compactors or rammer compactors with the mass of 30-60 kg should be used for the compaction. A proper compaction is obtained after 2-4 passages of the device over the gravel layer. Verification of the compaction index may be carried out using a light dynamic plate. On the gravel, a layer of sand with the thickness of 30-50 mm should be laid. The layers of gravel and sand may be replaced with lean concrete (concrete containing 100 kg cement at minimum in 1 m^3 of the concrete).

In both cases the upper surface of the sand (lean concrete) should be precisely levelled (±5 mm). It is a requirement for proper realization of damp insulation in the form of plastic PE sheet with the minimum thickness of 0.3 mm, laid onto this surface (see Fig. 1.1).

Laying of Styrofoam forms

Styrofoam boards constituting an underlay for the ground slab and forming its edges, are shown in Fig. 2.1, 2.2, 2.3, and 2.4.

The set of elements includes:

- basic board panels with the thickness of 250 mm and nominal dimensions of 900×1900 mm (Fig. 2.1);
- edge elements with the height of 500 mm, forming the edge of the slab (Fig. 2.2), and its inside (Fig. 2.3) and outside corners (Fig. 2.4);
- additional board panels, which allow for increasing the thickness of the insulation layer by 60, 80, 100, or 120 mm (Fig. 2.5);
- complementary elements with the thickness of 50, 100, or 150 mm, put on the edge elements, which allow for increasing the thickness of the concrete slab (see Fig. 2.8 and 2.9),
- MD 1/10 elements with a thickness of 100 mm for increasing the thickness of the insulation in the edge element (comp. Fig. 2.6).

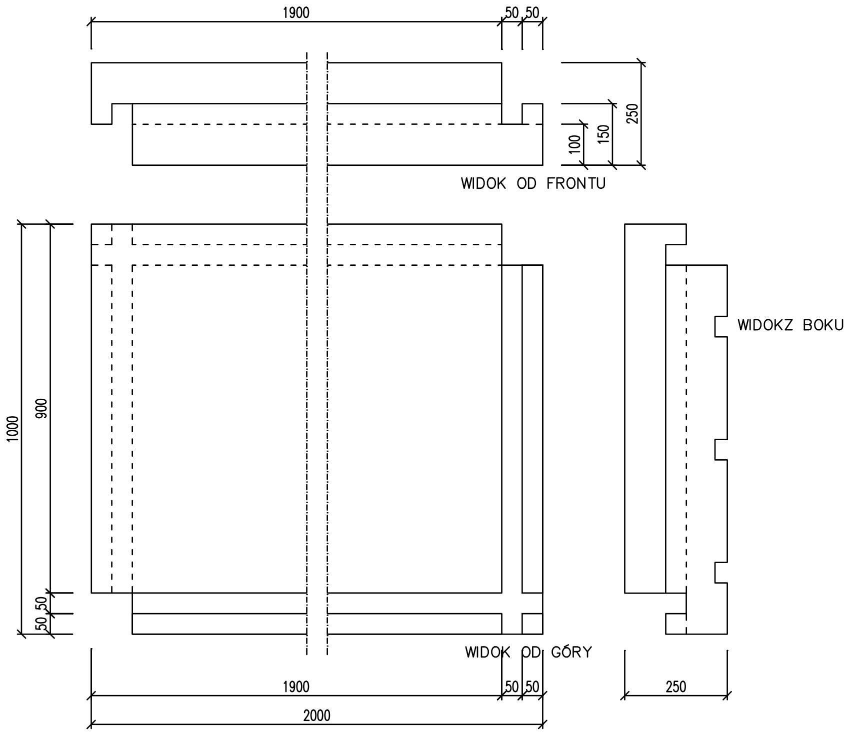


Fig. 2.1 1900×900×250 insulation panel (front and side view)

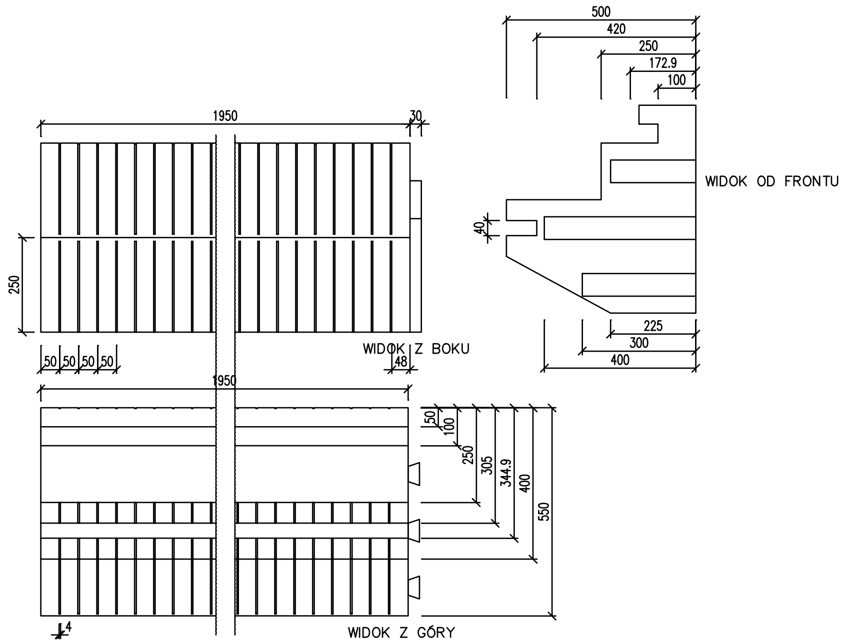


Fig. 2.2 1950×550×500 edge stone (front and side view)

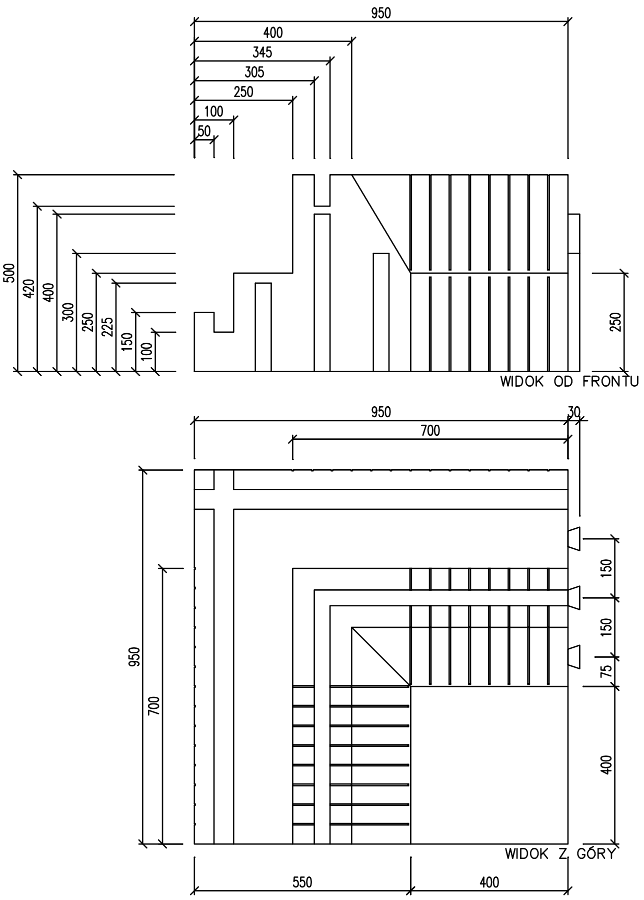


Fig. 2.3 950×950×500 inner corner (front and side view)

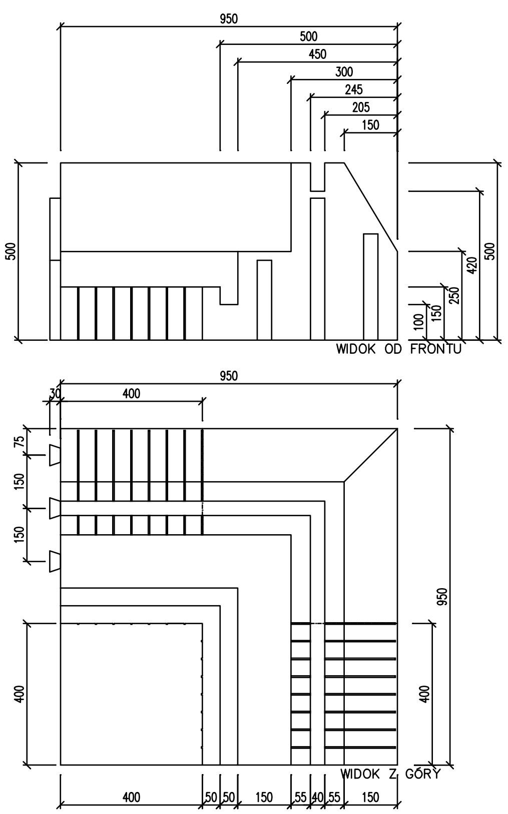


Fig. 2.4 950×950×500 outer corner (front and side view)

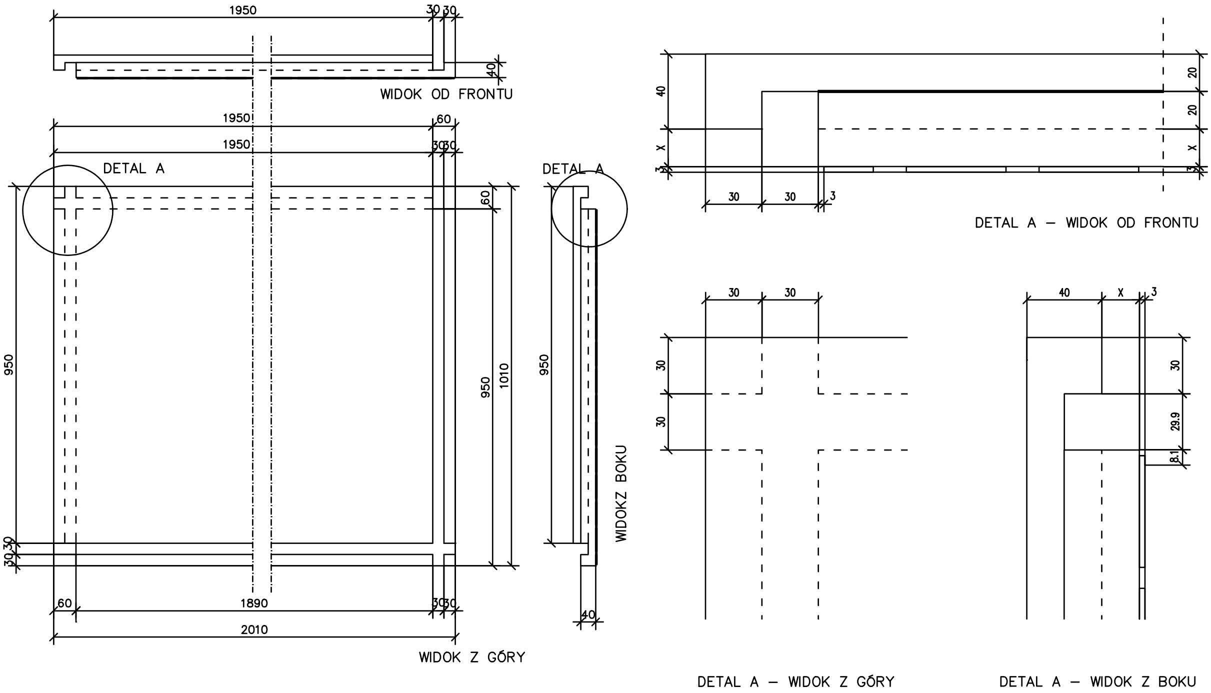


Fig. 2.5 Additional board panels; x = 20, 40, 60, and 80 mm (front and side view)

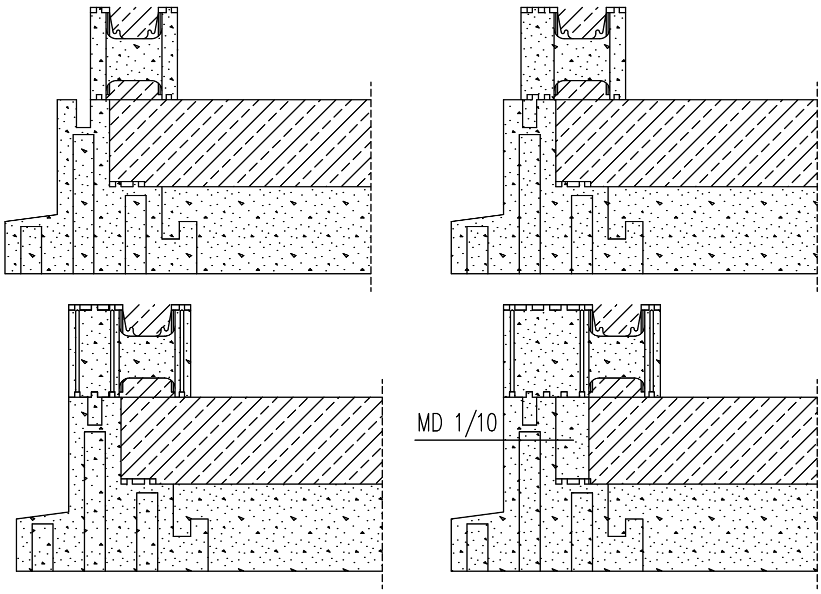


Fig. 2.6 Configuration of edge elements depending on the wall thickness;

250, 300, 350, and 450 mm, respectively

The forms are made by expansion of Peripor Styrofoam, with favourable properties:

- pressed density 40 kg/m^3,
- thermal conductivity coefficient 0.032 W/(mK),
- heat-transfer coefficient U 0.13 W/(m^{2}K),
- absorbability approx. 0%.

Designing of distribution of Peripor elements begins with determination of locations of edge elements depending on locations and thickness of walls (Fig. 2.6).

Board and edge panels are distributed on the building plan to enable using as many elements as possible without a necessity to cut them. It is also important that the locks (tongue and groove connections) of the board and edge panels are shifted with respect to each other (Fig. 2.7).

If the walls of the building are to be made in a system other than IZODOM 2000 POLSKA, the backing layer of the wall must be entirely positioned on the concrete slab of the foundation.

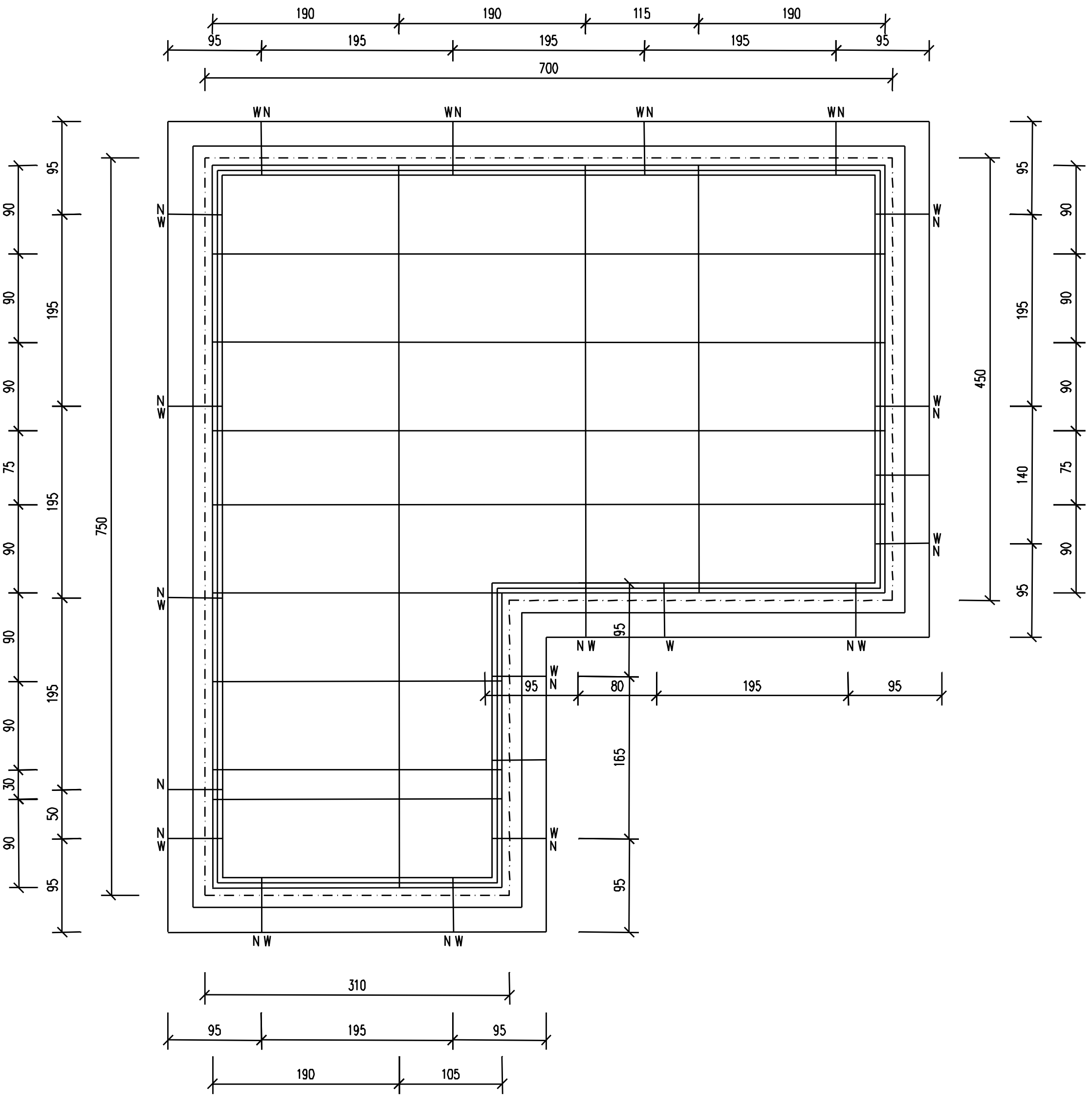


Fig. 2.7 Example of distribution of Styrofoam elements on the building plan

Thickness of the insulation may be increased by laying additional panels with selected thickness under or over the main panels (Figs. 2.8 and 2.9).

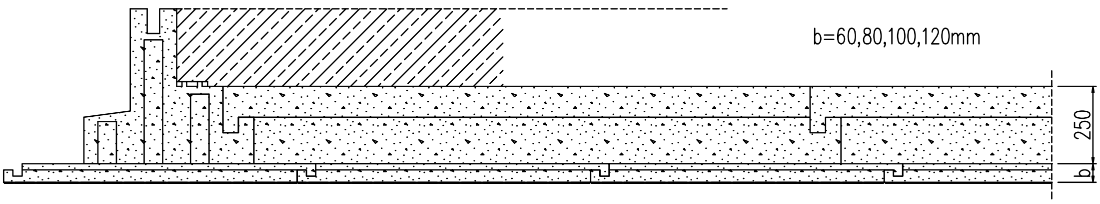


Fig. 2.8 Example of extension of the thermal insulation thickness

Then, the laid fittings should be supplemented with additional insulation in the form of MD 1/10 elements – if a wall with the thickness of 450 mm is used (see Fig. 2.6) – as well as with elements increasing the thickness of the concrete slab (if it has been assumed in the design). This solution is shown in Fig. 2.9.

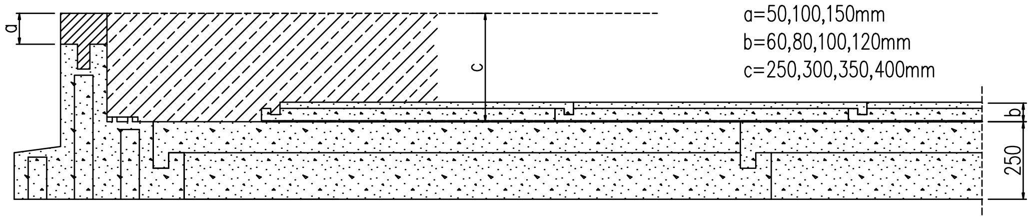


Fig. 2.9 A possibility to increase the ground slab thickness

Execution of the support slab

The supporting section of the ground slab may be made as:

- unreinforced concrete,
- steel fibre-reinforced concrete,
- concrete reinforced with steel rod

In all above cases, an additional reinforcement of the slab locally with steel rods is necessary – under door openings or high window openings (reaching the floor). Additional rod reinforcement is also necessary in spots where the slab is locally loaded – for instance by the effect of a column or a stair flight. It is also recommended to place ring beams in the forming reinforcement slab, under all supporting walls, if the walls are realized in a system other than IZODOM 2000 POLSKA. Details are discussed in section 4.

Casting of the whole slab should done without working joints. Remember about careful curing of concrete for 7 days after casting at minimum.

3. Verification of load bearing capacity and service limit states

In order to simplify the calculations, a uniform distribution of passive earth pressure under the ground slab may be assumed.
Values of bending moments may be determined assuming that the walls of the building are rigid linear supports of the ground slab.

Calculated values of the bending moments, defined by maximum loads of the building, cannot exceed the calculated load bearing capacity of the slab's cross-section.

Load bearing capacity of the slab's profile

Below, calculated capacity of a profile of the slab's strip with a width of b = 1.0 m are provided.

The capacity was determined for three cases:

- unreinforced slab,
- steel fibre-reinforced slab,
- slab reinforced with steel rod made of RB 500 W steel.

Unreinforced slab

According to item 12.3.1 of the PN-EN 1992-1-1-2008 standard [11], the capacity of an unreinforced concrete element may be determined based on the following dependence

$$f_{ctd,pl} = \alpha_{ct,pl} \frac{f_{ctk,0,05}}{\gamma_C}$$

$$M_{Rd} = f_{ctd,pl} \frac{bh^2}{6}$$

where:

$f_{ctk,0,05}$	characteristic concrete resistance to tension, quantile 5%,
$\alpha_{ct,pl} = 0,8$	calculation coefficient,
$\gamma_C = 1,5$	partial safety factor of the material,
$b = 1,0m$	width of the slab's strip,
h	thickness of the slab.

The load bearing capacities of a concrete profile of the ground slab, depending on the assumed slab's thickness and concrete capacity class, are gathered in Table 3.1.

Table 3.1 Calculated capacity of the slab's strip with a width of 1.0 m

No.	Slab height, mm	Capacity M_{Rd}, kNm/m		
		C 20/25	C 25/30	C 30/37
1	250	8.33	10.00	11.11
2	300	12.00	14.40	16.00
3	350	16.33	19.60	21.78
4	400	21.33	25.60	28.44

Steel fibre-reinforced slab

In order to improve properties of the concrete, particularly its resistance to tension and „ductility", an addition of steel fibres may be used [1].

Steel fibres inhibit development of scratches, and owing to this, the scratches forming and developing in the cement matrix do not lead to a sudden destruction as a result of a separative fracture, as the capacity loss is gradual because of the fibres. Utilization of steel fibres leads to:

- an increase in resistance to tension and bending,
- an increase in impact resistance,
- a significant increase in energy of destruction, enabling a quasi-ductile deformations of the concrete,
- a reduction of shrinkage in the initial phase of hardening of concrete.

In order to use ground slabs made of steel fibre-reinforced concrete, the following requirements must be met:

- support on an elastic subgrade with the groundwater table below the support level; in case of support on thermal insulation layer, the layer's pressure strength cannot be lower than 120 kPa at 10% deformation;
- thickness of the ground slab from 150 mm to 400 mm;
- maximum distances between expansion joints not larger than 15 m;
- application of additional reinforcement in spots with elevated loads (columns, slab corners, intensively loaded walls) according to the design.

In foundations slabs made of steel fibre-reinforced concrete, also additional rods may be used.

Standards and regulations [2-14] impose further limitations:

- in foundations reinforced with steel fibres only, as well as in those reinforced in combination with rods, concrete of grade not higher than C50/60 may be used;
- steel fibre-reinforced concrete without rods may be used in case of XS2, XD2, XS3, and XD3 exposure classes; for XC1 and XC2 exposure classes, C20/25 is the minimum concrete grade;
- in calculations of elements with steel fibres, partial safety factors of the material should be used for interactions in the ultimate limit state, according to Table 3.2;
- working joints are not allowed in steel fibre-reinforced concrete;
- in case of steel fibre- and rod-reinforced concrete, sizes of rod reinforcement covers are the same as in reinforced concrete; surface corrosion of steel fibres is acceptable.

Table 3.2 Partial safety factors [12]

	Partial safety factor	Steel fibre-reinforced concrete	Steel fibre-reinforced concrete with steel spacers
1	Steel fibre-reinforced concrete's resistance to tension after scratching	1.25	1.25
2	Steel fibre-reinforced concrete, not scratched	1.8	–
3	Non-linear calculations	1.4	1.35

Bekaert steel fibres of Dramix type, with minimum length of 45 mm are recommended for fibre reinforcement. The fibres must be added to the concrete mix during mixing of components.

A concrete mix with a low shrinkage should be used, and the slab should be carefully cured.

While designing a steel fibre-reinforced slab, further requirements should be taken into account:

- slabs without additional rod reinforcement, with lengths up to 12.0 m, should be cast without working joints;
- in ground slabs with rod reinforcement, working joints may be used, while introducing proper additional rod reinforcement; in these cases, favourable influence of steel fibre reinforcement on the load bearing capacity of the slab's cross-section should be omitted in calculations for this zone;
- if an expansion joint is required, then the distance between the expansion joint located in parallel to the wall from this wall's face should not be shorter than six widths of the wall.

The increase of the concrete resistance to tension resulting from application of steel fibre reinforcement depends on numerous factors: composition of the concrete mix, type and strength of the concrete, type of the steel fibres and their content in the concrete, conditions for concrete curing [12].

In order to simplify the calculations, it may be assumed that the increase in strength is at the value of 5%, and the calculation values of M_{Rd} provided in Table 3.1 may be increased correspondingly.

Also, another way for determination of the load bearing capacity of the slab may be used, adopted based on the publication [15]. Calculation values of loads for the walls at the ground slab level or point loads (concentrated loads) are determined, and these values are compared with those provided in the publication [15].

Below, auxiliary tables according to [15] may be found, which facilitate designing slabs with steel fibre reinforcement (Tables 3.3 and 3.4), using the method described above.

The tables were prepared with the following assumptions:

- no water pressure may occur, no special requirements for scratch opening width;
- the building has no more than two floors plus the cellar; maximum dimensions of the slab are 15.0×15.0 m;
- there is foil (0.3 mm) laid under the slab, with 500-mm wide overlaps,
- additional rod reinforcement has been used in the slab corners: 3∅10 bottom and top;
- the slab is cast in one operation.

Table 3.3 Permissible calculated loads of the ground slab; C20/25 concrete [14]

Valid ONLY for: Dramix 3D 80/60BG					
Permissible pressure on the ground 150 kN/m² (k ≥ 0.03 N/mm³)					
		Calculated wall loads		Calculated point loads	
Thickness of the slab (mm)	Dosing of the fibres (kg/m³)	external wall	internal wall	middle zone	edge
		q_1 (kN/m)	q_2 (kN/m)	q_1 (kN)	q_2 (kN)
200	**20**	40	60	40	25
	25	45	70	45	30
	30	55	80	55	30
250	**20**	50	70	70	40
	25	55	85	75	40
	30	60	100	80	45
300	**20**	60	90	90	60
	25	65	105	100	60
	30	70	120	110	65
k – subsoil support value					
Does not replace a structural design					

Table 3.4 Permissible calculated loads of the ground slab; C25/30 concrete [14]

Valid ONLY for: Dramix 3D 80/60BG					
Permissible pressure on the ground 150 kN/m² (k ≥ 0.03 N/mm³)					
		Calculated wall loads		Calculated point loads	
Thickness of the slab (mm)	Dosing of the fibres (kg/m³)	internal wall	internal wall	middle zone	edge
		q_1 (kN/m)	q_2 (kN/m)	q_1 (kN)	q_2 (kN)
200	**20**	45	70	45	30
	25	55	80	55	30
	30	60	90	60	35
250	**20**	55	85	75	40
	25	60	100	80	45
	30	65	110	85	50
300	**20**	65	105	100	60
	25	70	120	110	65
	30	75	130	120	70
k – subsoil support value					
Does not replace a structural design					

If the subsoil support value does not reach 0.03 N/mm³, steel fibre reinforcement is insufficient, and additional rebar reinforcement should be used at the whole surface of the slab.

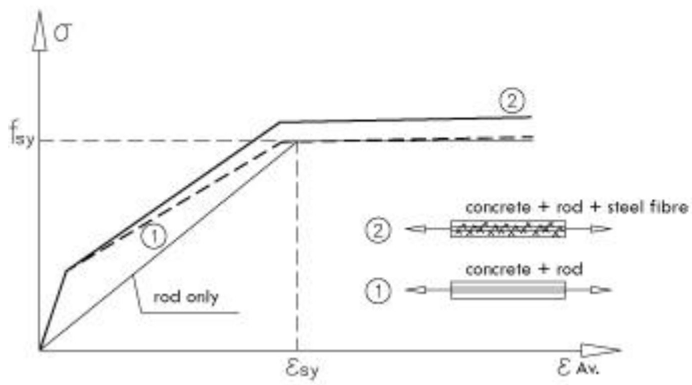


Fig. 3.1 Stress vs. deformation of an element with rod-only reinforcement and with rod and steel fibre reinforcement

The way of joint action of steel fibre and rod reinforcements is explained in Fig. 3.1. As one may see, presence of a steel fibre reinforcement increases the load bearing capacity of a rod reinforced profile only slightly. Thus, it is justified to omit this influence and determine the profile's capacity based on the cross-sectional area of the rod reinforcement only (see Table 3.5). However, a reduction in the development of scratches by the steel fibre reinforcement may be expected, therefore omit determination of the scratches width by calculations.

Reinforced concrete slab

Reinforcing the slab with a fabric mesh or weldmesh is recommended, placed near the bottom and top surface of the slab. The reinforcement covers should be determined according to the PN-EN standard [10]. The load bearing capacity of a slab profile with a width of b = 1.0 m, at various diameters of steel bars with a plasticity limit of f_{yk} = 500 MPa, and various spacing values, are specified in Table 3.5.

Table 3.5 Calculated load bearing capacity of the slab's profile reinforced with steel rods of RB 500 W steel

Thickness of the slab (mm)	Class of the concrete	Capacity of a slab's strip M_{Rd} (kNm/m) with a reinforcement					
		∅8/150	∅10/250	∅10/200	∅10/150	∅12/200	∅12/150
250	C20/25 C25/30 C30/37	31.1	29.5	36.6	48.5	52.3	68.8
300	C20/25 C25/30 C30/37	*)	*)	45.3	59.9	64.6	85.2
350	C20/25 C25/30 C30/37	*)	*)	*)	71.2	76.8	101.6
400	C20/25 C25/30 C30/37	*)	*)	*)	82.6	89.1	118.0
Cross-sectional area of the reinforcement, cm^2/m		3.33	3.14	3.92	5.23	5.65	7.53
Bar length of the reinforcement, m/m		6.67	4.00	5.00	6.67	5.00	6.67
*) reinforcement below minimum according to the PN-EN standard [10]							

Partial safety factor of $\gamma_c = 1.50$ and distance to the reinforcement axis of 30 mm were assumed for the calculations. The same M_{Rd} values were assumed for three concrete classes shown in the table, because in bending elements with weak reinforcement, the class of the concrete has a very low influence on the calculated capacity.

The reinforcement of the slab may be diversified depending on the direction (x or y) and location (top or bottom mesh), correspondingly to the values of bending moments.

4. Structural details

The IZODOM 2000 POLSKA foundation system allows for easy solving of non-typical construction sites. Below, cases most frequently met in the designing practice are discussed.

Basecourse

A gravel verge around the building is proposed, in order to protect walls from rainwater splashes (Fig. 4.1).

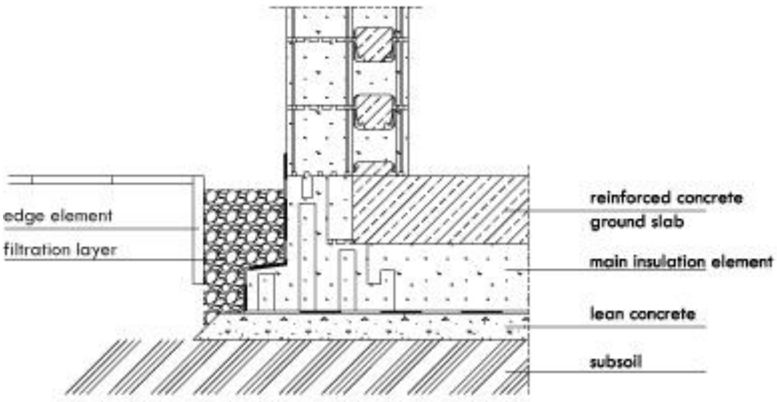


Fig. 4.1 Configuration of the basecourse;
IZODOM 2000 POLSKA wall with a thickness of 450 mm

In case when thr IZODOM 2000 POLSKA walls with total thickness lower than 450 mm are used, the basecourse is wider than the building in the ground floor outline (Fig. 4.2). In such case, hydrophobic reinforced plaster coating or ceramic frost-resistant tiles should be laid on the slant surface of the basecourse.

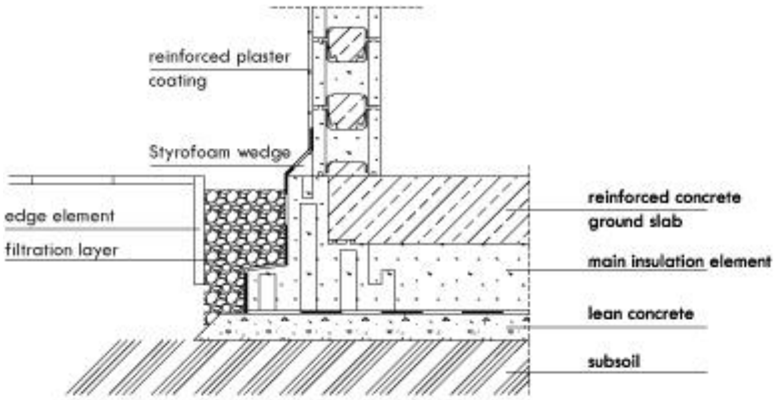


Fig. 4.2 Configuration of the basecourse;
IZODOM 2000 POLSKA wall with a thickness lower than 450 mm

Ground slab within an opening

Placing a cover strip made of treated wood within the opening is recommended, with a thickness adjusted to the total thickness of the flooring (Fig. 4.3). The strip should be anchored in the support rebar-reinforced part of the wall using mechanical fasteners.

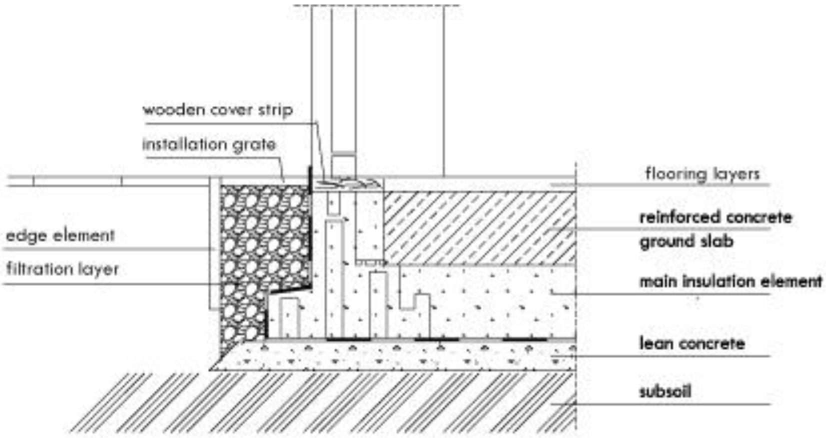


Fig. 4.3 Placement of a capping strip within the opening

Additional rod reinforcement should be laid below the opening if the opening's width exceeds 1.0 m. Reinforcement in the form of four ∅10 mm rods with ∅10 mm stirrups with 200-mm spacing (Fig. 4.4) should be extended by 0.5 m on both sides of the opening.

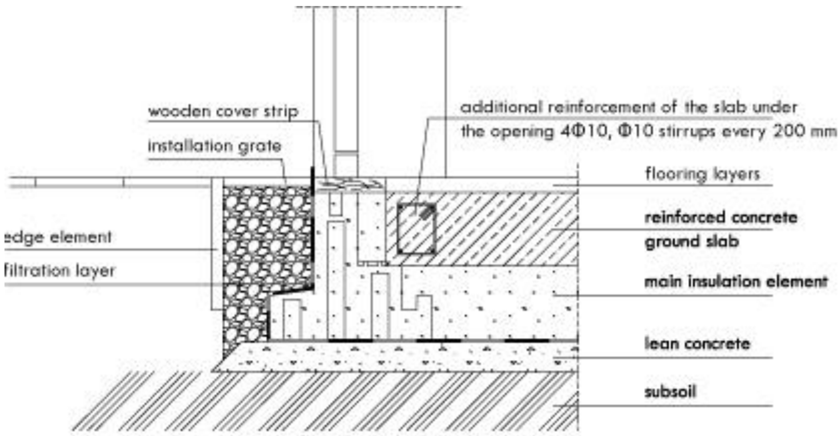


Fig. 4.4 Additional reinforcement of the slab below an opening with a width larger than 1.0 m

Tie beam of the ground slab

If the load-bearing walls of the building will be built in the IZODOM 2000 POLSKA system, construction of a tie beam in the slab is not required.

In other cases, for instance when clay brick walls or aerated concrete walls are used, a tie beam with a reinforcement shown in Fig. 4.5 should be provided in the slab on its entire outline. Remember about maintaining the continuity of the reinforcement in all corners of the tie beam.

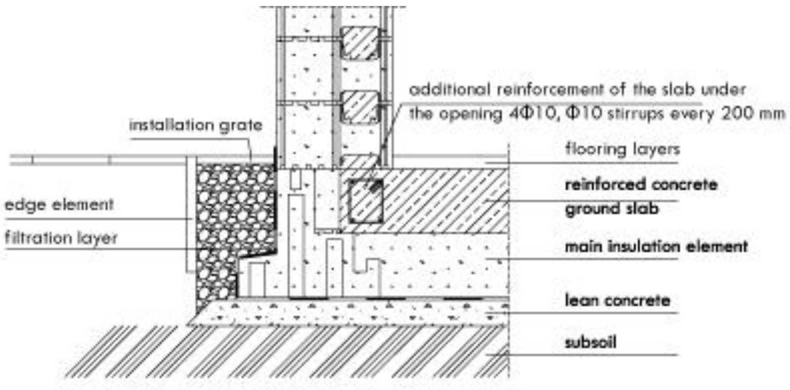


Fig. 4.5 Reinforcement of a circumferential tie beam of the slab

Step change of the ground slab positioning

An idea for a solution useful with a 500-mm change of the ground slab positioning is explained in Fig. 4.6. While laying the insulation of the slab located at a higher level, top and external parts of the edge element forms should be cut out. Reinforcement of the vertical part of the slab should consist of at least 6 ∅10 mm bars, connected with stirrups.

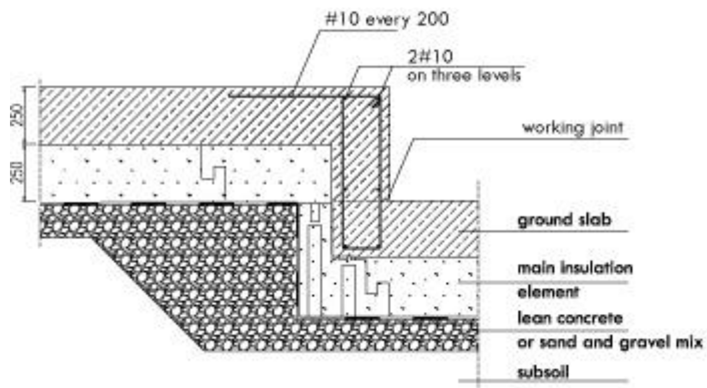


Fig. 4.6 A change of the foundation depth by 500 mm

A change of the foundation depth by more than 500 mm requires laying additional elements on the bottom edge fittings which increase their height (Fig. 4.7).

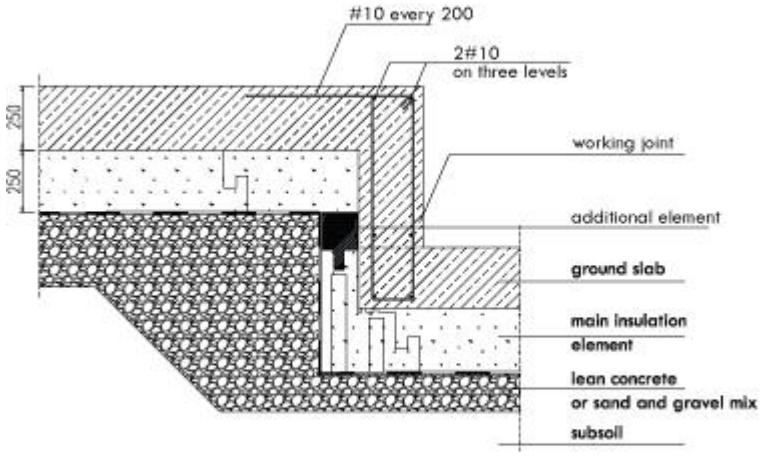


Fig. 4.7 A change of the foundation depth by more than 500 mm

If the foundation depths need to be changed by more than 500 mm, the edge element forms the bottom part of the slab should be cut correspondingly.

Additional point-reinforcement of the slab with rods

In the case of a unreinforced concrete slab or a steel fibre-reinforced slab, areas with point loads (e.g. by a column) or linear loads (by an edge of a stair flight) should be additionally reinforced with rods.

The additional reinforcement should be realized in the form of top and bottom meshes made of ∅10 mm rods, laid with spacing of 150 to 200 mm. The reinforced zone should include at least 4 thicknesses of the slab from the edge of the load field in every direction.

Also, the corners of the slab require additional reinforcement – 3 ∅10 mm rods should be laid aslant both at the top and in the bottom.

References

[1] Tragverhalten und Sicherheit betonstahlbewehrter Stahlfaserbetonbauteile Deutscher Ausschuss für Stahlbeton, Heft 501, Berlin 2000

[2] Ławy fundamentowe DRAMIX®SF. Rekomendacja techniczna ITB RT ITB-1044/2007, Instytut Techniki Budowlanej, Warszawa 2007

[3] Podłogowe płyty podkładowe na gruncie DRAMIX®DMB oraz płyty nadbetonu stropów gęstożebrowych DRAMIX®DR. Rekomendacja techniczna ITB RT ITB-1037/2007, Instytut Techniki Budowlanej, Warszawa 2007

[4] Fundamentplatten aus Stahlfaserbeton für Wohnungsbau. Bescheid über die Verlängerung der Geltungsdauer der allgemeinen bauaufsichtlichen Zulassung Vom 21. Februar 2000, Nr Z-71.3-18. Deutsches Institut für Bautechnik. 31. Dezember 2008

[5] Fundamentplatten aus Stahlfaserbeton für Wohnungsbau. Bescheid über die Verlängerung der Geltungsdauer der allgemeinen bauaufsichtlichen Zulassung Vom 21. Februar 2000, Nr Z-71.3-18. Deutsches Institut für Bautechnik. 31. Dezember 2009

[6] Ogólna aprobata nadzoru budowlanego Z-71. 3-36 Płyty fundamentowe z betonu zbrojonego stalowym włóknem rozproszonym. Deutsches Instytut für Bautechnik, 25 marca 2009r, sygnatura I 18-1.71.3-1/09.

[7] Expandierte Polystyrol – Hartschaumplatten „WTM – Bodendämmplatten" für die Anwendung als lastabtragende Wärmedämmung unter Grüdungsplatten innerhalb der Abdichtung, 28. Allgemeine bauaufsichtliche Zulassung nr Z-23.34-1644 Deutsches Institut für Bautechnik. Februar 2010.

[8] Fundamentenplatten aus Stahlfaserbeton. Allgemeine bauaufsichtliche Zulassung. DIBt, Deutsche Institut für Bautechnik, März 2011

[9] Zbrojenie Dramix® READY, płyty fundamentowe, BEKAERT

[10] PN-EN 1922-1-1, September 2008. Eurocod 2. Projektowanie konstrukcji z betonu. Część 1-1: Reguły ogólne i reguły dla budynków.

[11] DIN 1045-1:2008 Konstrukcje z betonu, żelbetu i betonu sprężonego

[12] DAfStb- Richtlinie Stahlfaserbeton Deutscher Ausschuss für Stahlbeton. Issued March 2010

[13] DIN EN 206-1 (2008): Beton – układanie, właściwości, wytwarzanie i zgodność

[14] Dramix® SFRC płyta fundamentowa dla budynków mieszkalnych. Przedprojektowa tabela dla najczęstszych przypadków. Bekaerd, 2013.

izodom 2000 polska®

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