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Applying "Izodom 2000 Polska" wall systems in regions of seismic risk

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Applying "IZODOM 2000 POLSKA" wall system in regions of seismic risk

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1. General

Insulating - shuttering elements IZODOM 2000 POLSKA are made of foamed polystyrene hollow tiles. Broad set of brick elements lets us to construct buildings with various views projection and different as 90 degrees angles.

IZODOM 2000 POLSKA elements are lined up in horizontal layer in wall with displacement of vertical joints. Bricks connection assures by fasteners shaped on contact surfaces of each element. Brick elements lined up on empty stomach fulfil wasted shuttering and heat insulation filled of concrete. Due to various thickness of outer side of brick (50, 150, 250 and 300mm) thermal conductivity equals from 0.29W/m^{2}K to 0.11W/m^{2}K.

Buildings made of IZODOM 2000 POLSKA system walls and reinforced concrete floors have a three-dimensional stiffness and for this reason the system fulfils requirements of buildings in region of seismic risk.

This opinion was worked out on base of "Seismic Design of Reinforced Concrete Structures for Controlled Inelastic Response" (Committee Euro-International du Beton), Thomas Telford 1998, and Building Code Requirements for Structural Concrete (ACI 318-99) and Commentary (ACI 318R-99).

2. Building Code Requirements

2.1. Eurocode No 8 Requirements

The European seismic code: Eurocode 8 allows for three alternative ductility classes. Each class has it own design forces, capacity design rules and factors, and rules for detailing.

Comparison of EC8 ductility class requirements

Columns	**Ductility class L**	**Ductility class M**	**Ductility class H**
Min. mechanical volumetric ratio $\omega_{wd,min}$	0.05	0.09	0.13
Min. dimension	200mm	250mm	300mm
Walls	**Ductility class L**	**Ductility class M**	**Ductility class H**
Critical height	Max. of (l_w, H_w/6) < $2h_s$ and $2l_w$		
Min. web thickness	Min of (150mm, ql_w/60, h_s/20)		
Min. horizontal and vertical web reinforcement in critical height: %	0.2		
Min. total vertical reinforcement in critical height: %	0.4		
Boundary elements	Within each ductility class, detailing requirements for longitudinal and transverse reinforcement as for columns as above		
Min. boundary element length	$0.15l_w$ or $1.50b_w$		
Coupling beams	**Ductility class L**	**Ductility class M**	**Ductility class H**
Bi-diagonal reinforcement	Detailed according to column provisions if $V_s > 4db\tau$		
Max. hoop spacing	100mm		

2.2. ACI 318-99 Requirements

There are no special requirements for structural walls provided to resist lateral effects of wind and earthquake in regions of moderate seismic risk. Structural walls proportioned by the main body of the code are considered to have sufficient toughness at anticipates drift levels in regions of moderate seismicity.

For building located in regions of high seismic risk all building components, structural and non-structural should satisfy special requirements.

Concrete and reinforcement in members resisting earthquake - included force

Compressive strength f_c of the concrete shall be not less than 20MPa.

The actual yield strength based on mill tests does not exceed the specified yield strength by more than 125MPa (retests shall not exceed this value by more than an additional 20MPa) and the ratio of the actual ultimate tensile strength to the actual tensile yield strength is not less than 1.25.

Special reinforced concrete structural walls and coupling beams

The distributed web reinforcement ratios ρ_v and ρ_n, for structural walls shall not be less than 0.0025, except if the design shear force does not exceed $A_{cv}\sqrt{f_c}$, the minimum reinforcement for structural walls shall be permitted to be reduced. Reinforcement spacing each way in structural walls shall not exceed 0.45m. Reinforcement provided for shear strength shall be continuous and shall be distributed across the shear plane.

At least two curtains of reinforcement shall be used in a wall the in-plane factored shear force assigned to the wall exceeds $2A_{cv}\sqrt{f_c}$ (A_{cv} - gross area of concrete section bounded by web thickness and length of section in the direction of shear force considered [in^2], f_c - specified compressive strength of concrete [psi]).

All continuous reinforcement in structural walls shall be anchored or spliced in accordance with the provisions for reinforcement in tension.

Boundary elements of special reinforced concrete structural walls

The approach assumes that special boundary elements are required to confine the concrete where the strain at the extreme compression fiber of the wall exceeds a critical value when the wall is displaced to the design displacement. The horizontal dimension of the special boundary element is intended to extend at least over the length where the compression strain exceeds the critical value. The height of the special boundary element is based on upper bound estimates of plastic hinge length and exceeds beyond the zone over which concrete spalling is likely to occur.

The addition of hooks or U-stirrups at the ends of horizontal wall reinforcement provides anchorage so that the reinforcement will be effective in resisting shear forces. It will also tend to inhibit the buckling of the vertical edge reinforcement. In walls with low in-plane shear, the development of horizontal reinforcement is not necessary.

Coupling beams

Coupling beams connecting structural walls can provide stiffness and energy dissipation. In many cases, geometric limits results in coupling beams that are deep in relation to their clear span. Deep coupling beams may be controlled by shear and may be susceptible to strength and stiffness deterioration under earthquake loading.

Experiments show that diagonally oriented reinforcement is effective only if the bars are placed with a large inclination. Therefore, diagonally reinforced coupling beams are restricted to beams having aspect ratio $l_n/d<4$.

When coupling beams are not used as part of the lateral force resisting system, the requirements for diagonal reinforcement may be waived.

3. Wall reinforcement of IZODOM 2000 POLSKA System

Mode of wall reinforcement shown below fulfils requirements of both recommended codes.

All walls must be made like reinforced concrete walls reinforced with vertical and horizontal steel bars.

Minimum vertical and horizontal steel reinforcement area equals 5.6cm^2/m running metre of wall (2x#10 every 250mm, fig. 1). Vertical and horizontal reinforcement must be continuous.

Minimum overlap of steel bars should equals 450mm and connection sections should be located next to a half of store height.

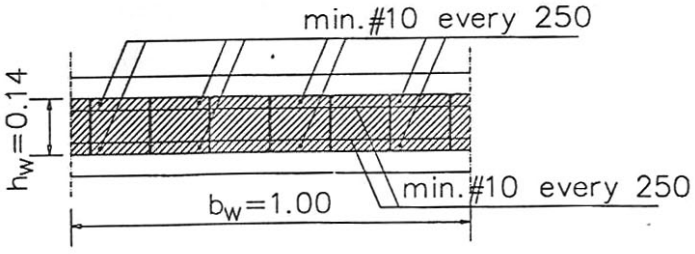

Fig. 1. Main steel reinforcement of wall

Additional vertical, horizontal and diagonal steel bars with U-shaped stirrups should be located next to openings in walls (fig. 2). Vertical steel bars (minimum 2#16) should be anchored in each edge of the opening. Horizontal steel reinforcement area located above the opening should be omitted in calculation of bending reinforcement of the coupling beam. Stirrups of #10mm bars should be located in each layer of bricks (cross-section A-A).

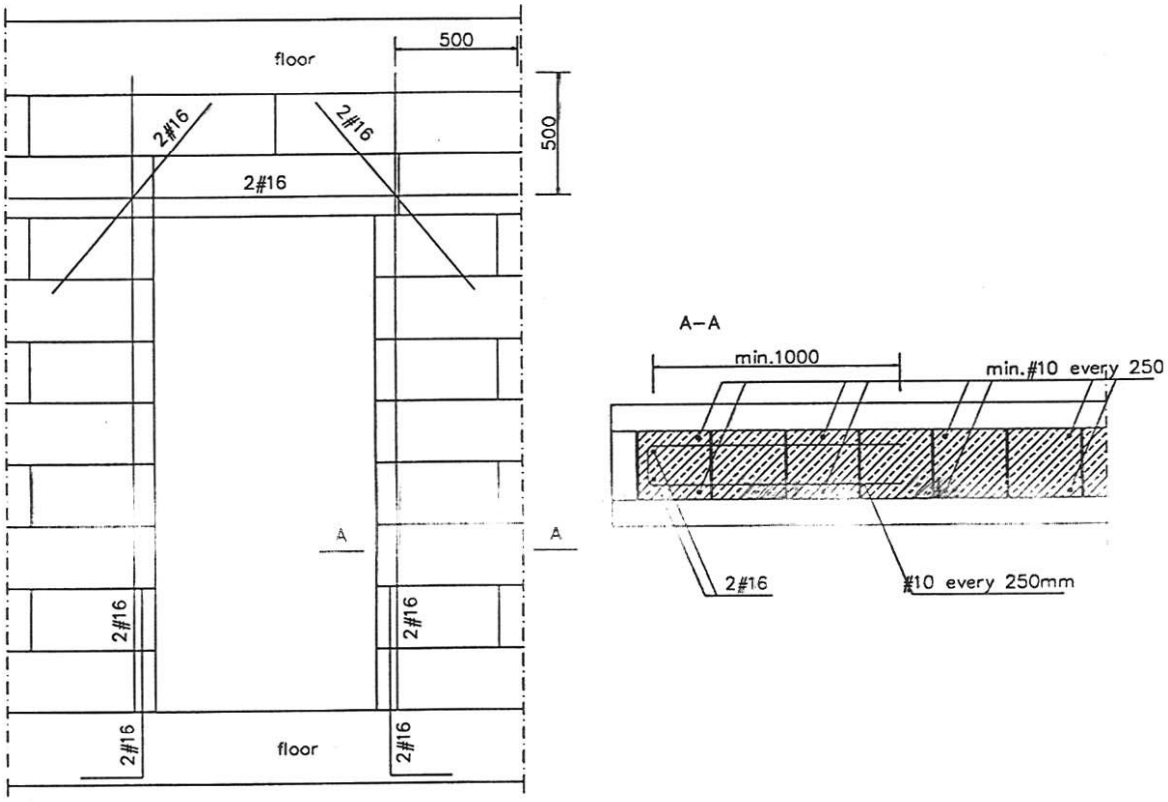

Fig. 2. Guideline of steel reinforcement next to the opening

Steel reinforcement must be continuous in all corners. It can be achieved by additional U-shaped reinforcement in corners, located in each layer of bricks in the wall.

Some pieces of polystyrene should be removed from sides of the brick (fig. 3).

If the wall is additionally loaded by pressure of ground the main reinforcement area should be suitably calculated.

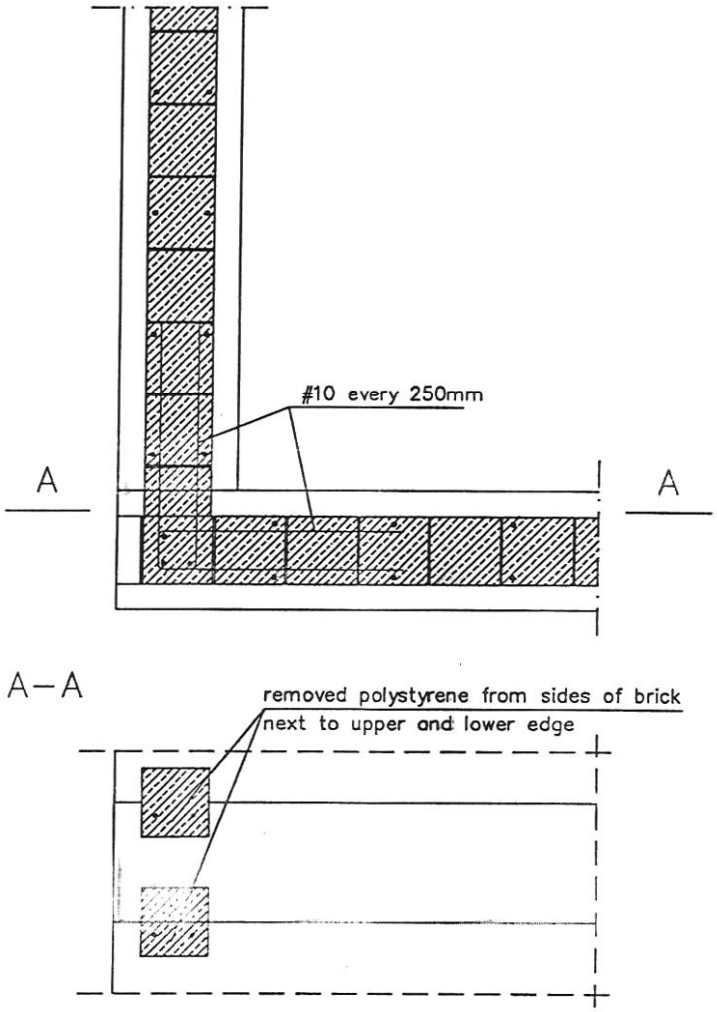

Fig. 3. Reinforcement of wall corners

Reinforced concrete crown should be construct in floor level with the minimum reinforcement of 4#12mm. Steel reinforcement of the all crown must be continuous and located in corners especially.

The floor must be connected with walls according to Eurocode 2. Reinforcement area should be calculated from condition of transferred force equals 40kN running metre of wall length.

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