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# THERMAL INSULATION ON THE INTERIOR SURFACE OF EXTERIOR WALLS – A NEW PREFABRICATED INSULATING PANEL
## ANALYSIS OF THE SOLUTIONS EFFECTIVENESS

BY

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**Abstract.** The outer walls have a significant share in a building envelope (surface separating the outdoor heated volume). Thermal insulation of exterior walls can be achieved by laying insulating layer on the outside or inside them. In terms of thermal insulation capacity location on the inner surface is less efficient, resulting in restricted use of this solution. Compensation is achieved by implementing simple technology installation, lower cost price and unchanged façade.

Through setting the thermal insulating layer on the interior surface of external walls with polystyrene insulation experimentally proved to be a solution resulting in improved thermal comfort of the room by a decreased heat loss through exterior walls. Reduced heat loss through exterior walls (building envelope) varies depending on the solution of the inner cladding and on insulation type and thickness (2...4 cm).

Following *in situ* (in the field) measurements, it was demonstrated that by using coating on the inside of external walls to improve their inner surface temperature on average by 0.5°C for each 1 cm increase in thickness of the insulation used. Checks *in situ* have shown that to obtain a real temperature on the inner/outer exterior walls, one should introduce a correction factor ($C_c$) applied to the formula.

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**Key words:** plaster layer; polystyrene layer; tongue; groove; inner cladding; historical monuments; unchanged façades.

## 1. Introduction

Hygrothermal rehabilitation takes place in the accommodation or social-cultural buildings as a priority to save fuel used for heating in cold season. Studies have shown that a standard residential building, most of the heat (between 25% and 40% of total) is lost through external walls.

In some cases, rehabilitation of existing buildings on the inner surface of external walls is required.

The exterior wall covering solution on the inner surface can be applied to buildings that have façades with ornaments, to be kept for general aesthetic image, heritage buildings, tall buildings (over 10 floors) with complex façades, the joints between sections of walls, short term use rooms during cold season or buildings with external insulation program funding delay (3...5 years with partial energy savings).

## 2. A New Prefabricated Insulating Panel

Insulated coating on the inner surface of external walls can be done now, as compositions similar to those of modern easy bulkheads.

Between the pillars that form the resistance skeleton fixed on the inner surface of the exterior walls, the insulating layer is disposed (thickness of 2....4 cm) and it is protected on the interior of the room with reinforced plaster panels, which are finished after sealing-off the joints.

We are suggesting the insulation of exterior walls of buildings on the inner surface with a new prefabricated insulating two-layers panel (Fig. 1 *a*). The new element is composed of two layers, one of resistance, plaster reinforced with fiberglass dispersed (120 × 60 cm) with profiles on the longitudinal and transverse edges and the other one of insulating polystyrene layer having the thickness of 2...4 cm determined by degree of thermal insulation, which usually ranges between 0.035 and 0.040 W/m.K, fitted with tongue-and-groove joints and decreasing the effect of thermal bridges (Fig. 1 *b*). Best materials, insulation such as expanded polystyrene graphite provides thermal conductivity (0.032 W/m.K), which provides 20% higher thermal efficiency.

Insulating layer, usually made of polystyrene, must be continuous, waterproof and to remove any thermal bridges (Figs. 1 *c* and 1 *d*).

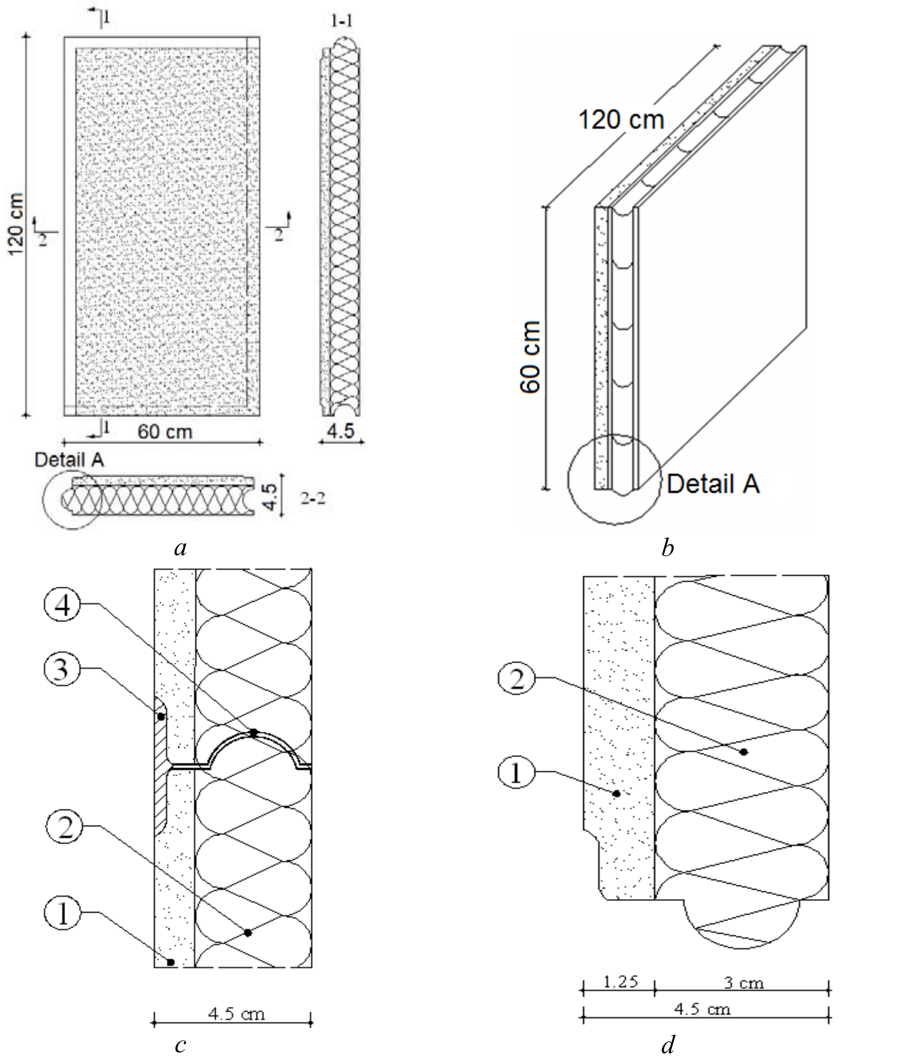


Fig. 1 – *a* – Prefabricated two-layer panel; *b* – perspective view of prefabricated two-layer panel; *c* – tongue and groove joint detail; *d* – end detail of prefabricated two-layer panel.

The manufacturing technology of the new prefabricated two-layer panel consists of on horizontal casting of the plaster paste, reinforced dipersed with glass fibers (*1*).

After casting, the insulating layer is sticked (*2*), and the prefabricated two-layers panels is naturally or artificially dryed (in a dryer at 40°C).

According to existing external wall – brick masonry, or monolithic concrete diaphragm/prefabricated – panels will have different assembly technologies.

After assembling the prefabricated two-layer panels on masonry/ concrete wall surface, the plaster layer reinforced dispersed with glass fibers will be cored for clamping (Fig. 2). In space cores, the plastic dowels for anchoring the prefabricated insulating two-layer panels will be introduced.

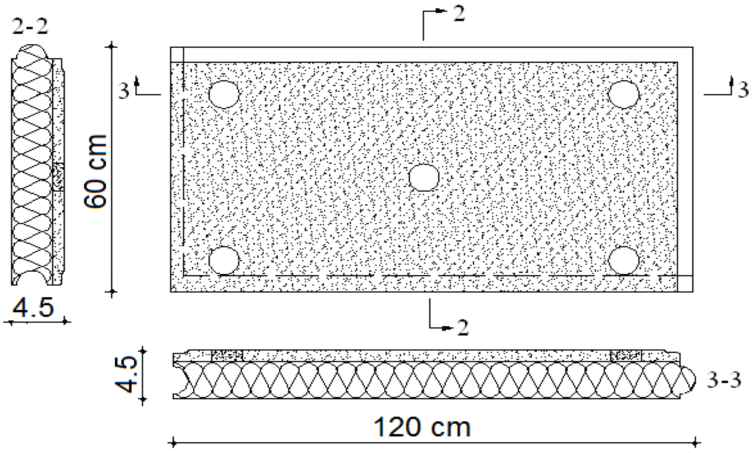


Fig. 2 – Prefabricated two-layer panel with cores for mounting and fixing.

For laying on the masonry wall, the new prefabricated two-layers (*1* and *2*) will be stocked with adhesive (*7*) applied as a bead contour on the prefabricated plates and on three points in the middle so that all variations of expansion material to be taken within the perimeter of each plate in part, without generating cracks in joints.

By the arrangement of the adhesive on the bead contour and in the middle in three points, the air remains closed in each panel perimeter (Fig. 3).

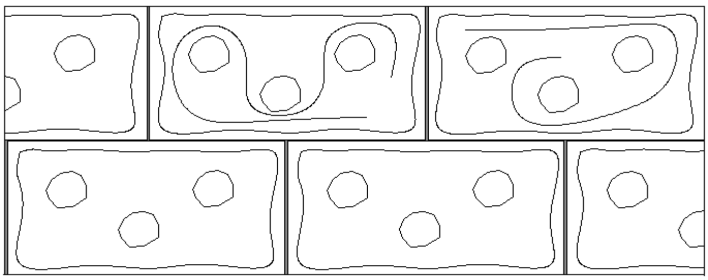

Fig. 3 – The arrangement of the panels and adhesive position.

Anchors are usually applied at an average distance of 6 anchors / $m^2$, placed in the "T" or "W" system; the anchoring with dowels follows prefabricated plates setting on all over corners and the means to limit the accumulation of material dilation field wall.

Setting is completed by anchoring the plastic plugs (*7*) like in Fig. 4.

Resistance in time of the prefabricated insulation system inside the exterior walls may be conferred only by system cohesion (adhesion, resistance to tearing) and the compatibility of its components (outlet, drying, permeability equivalent).

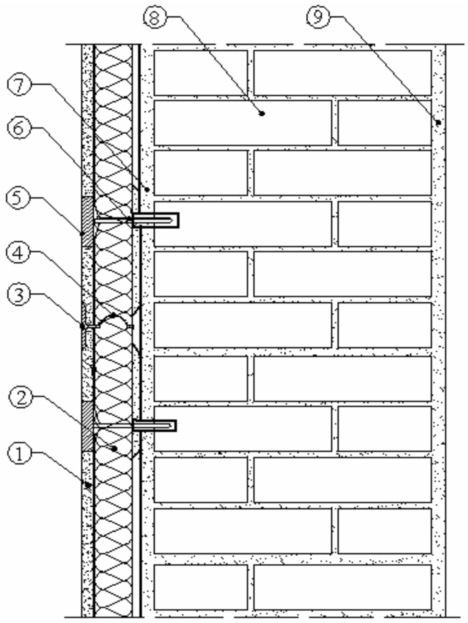

Fig. 4 – Setting the prefabricated two-layer panels on the masonry walls:
1 – reinforced dispersed plaster board; 2 – insulation polystiren layer; 3 – sealing and finishing the joints; 4 – tongue and groove joints; 5 – sealing and finishing the cores; 6 – plastic dowels; 7 – interior plaster; 8 – brick wall; 9 – exterior plaster.

For the monolithic/precast concrete walls (2) plated on the exterior with B.C.A (1) mounting of the prefabricated two-layers panels on the interior consists of: installation of wooden slats (5), fixing insulating boards (6) on the network consists of wooden slats with own-thread srews, sealing and finishing the joints and mounting the wooden rulers with holes for air ventilation.

Installing wooden slats (20 × 50 mm) on concrete wall with ventilated air interspaces (4) is achieved by setting the vertical with dowels and tapping screws spaced 60 cm from each other (Fig. 5). Before mounting the wooden slats, they will be treated antiseptically.

Wooden rulers are equipped with air ventilation holes set on the floor and ceiling to ensure natural ventilation of the wall. The ventilation air is ventilated through the opening that is formed between the wall of reinforced concrete and prefabricated two-layers insulating panels and inside circulate convective currents that will eliminate the potential water vapour.

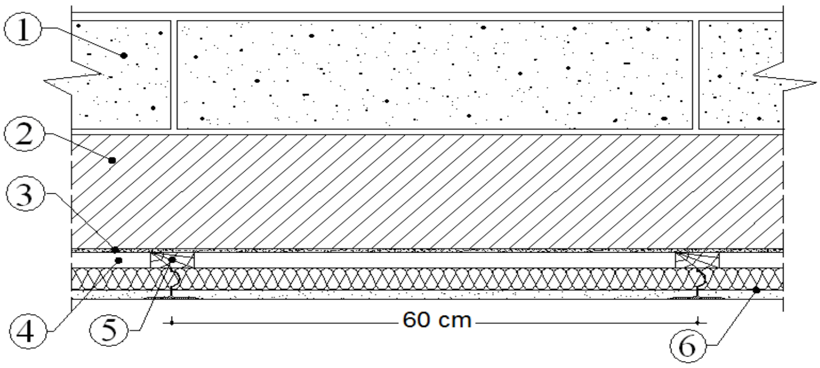


Fig. 5 – Setting the prefabricated two-layer panels on the concrete walls.

## 3. Measurements

To analyse the effectiveness of proposed solutions as regards the concept of thermal insulation on the inside of the external walls, a residential building located in climate zone III, the district Păcurari in Iaşi was used.

Fig. 6. – The *in situ* residential building.

a) *Structural composition* – bearing confined masonry and reinforced concrete floors-basement, ground floor and attic floor (Fig. 6).

On the floor plan of the residential building, the outer walls of two rooms located between the axes *1*, *2* string *D*, *G*, were plated inside and partially outside. (Fig. 7 *a*).

*a*

*b*

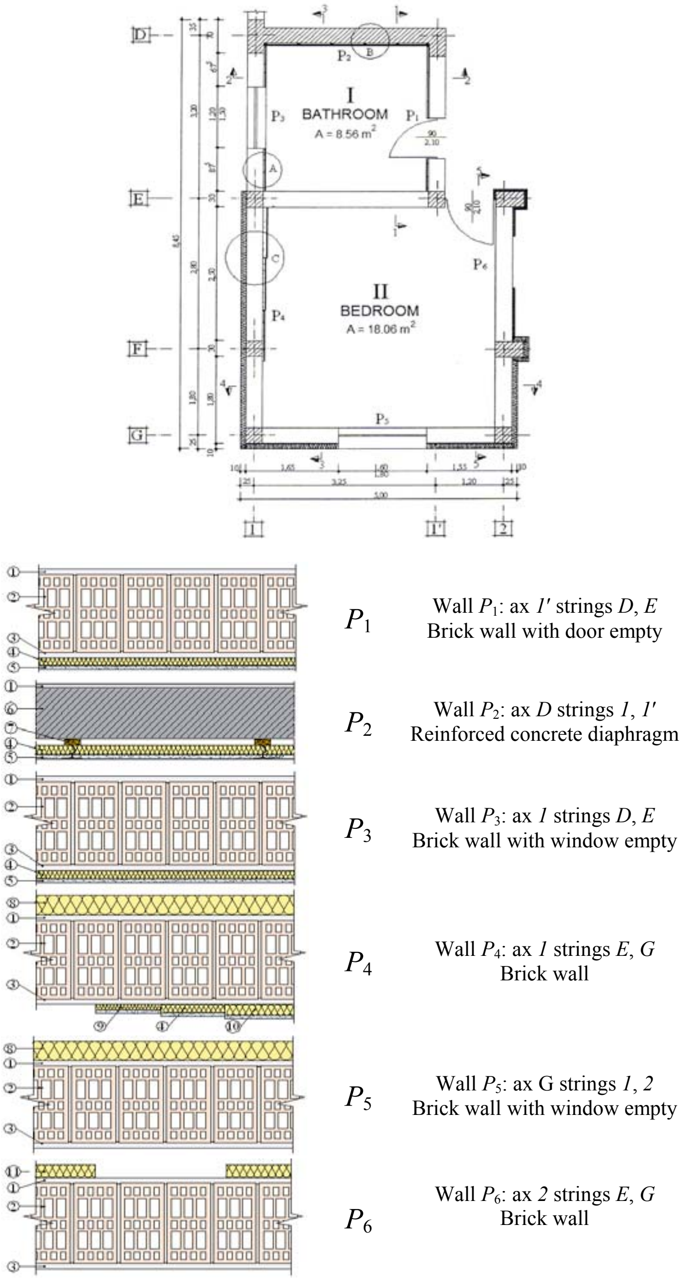


Fig. 7 – *a* – Residential building groundfloor; *b* – the horizontal sections for each type of tested wall: *1* – interior plaster; *2* – brick wall; *3* – interior plaster; *4* – polystyren of 3 cm thickness; *5* – reinforced plaster plates; *6* – reinforced concrete diaphragm; *7* – wooden slats; *8* – polystyren of 10 cm thickness; *9* – polystyren of 2 cm thickness; *10* – polystyren of 4 cm thickness; *11* – polystyren of 5 cm thickness.

For an acurate analysis of the situation created in the field, a partially external wall cladding was made with 50 mm and 100 mm expanded polystyrene pannels (EPS panels).

Inside the outer walls, there was used the partial cladding with prefabricated two-layers plates, newly created, with dimensions of 600 × × 1,200 mm, tongue-and-groove joint with thermal coating thicknesses of 20, 30 and 40 mm, resulting in the plated walls, with the composition as shown in Fig. 7 *b*.

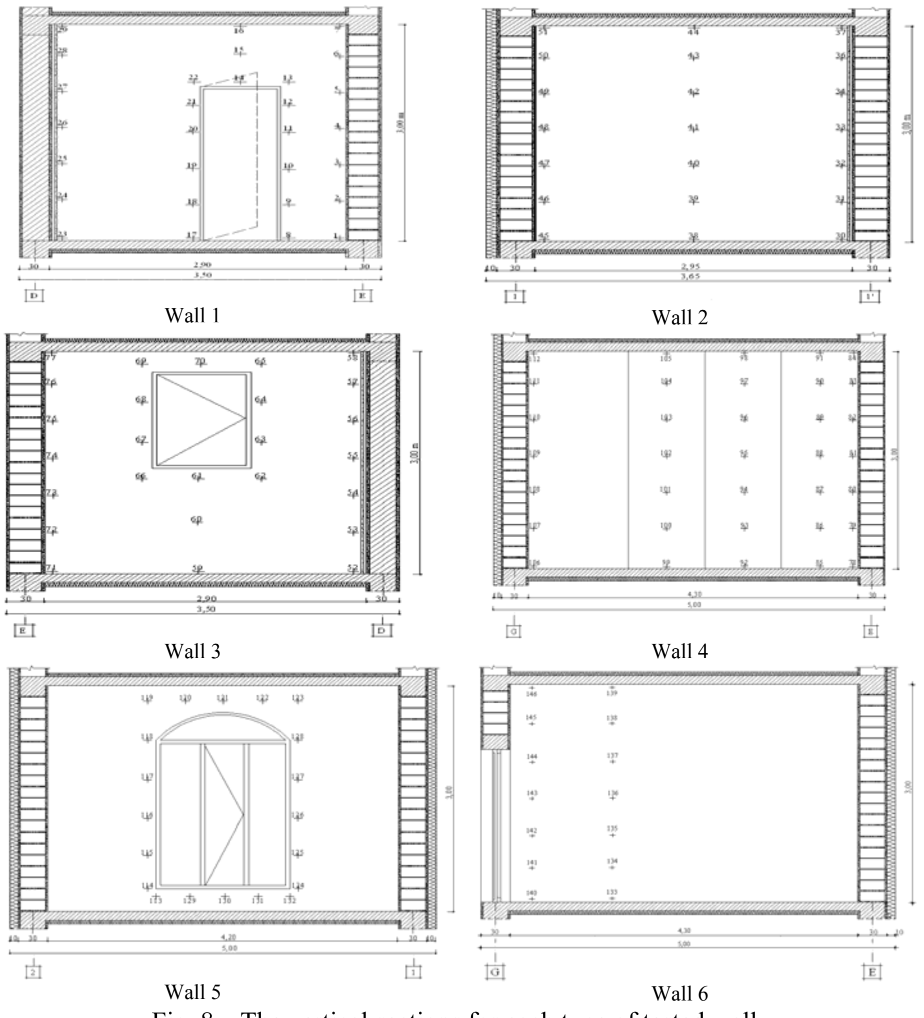


Fig. 8 – The vertical sections for each type of tested wall.

For thermal protection there was coated both the underside of the basement floor and upper floor over ground floor with 50 mm expanded polystyrene.

Measurements of the temperatures on the indoor and outdoor surfaces were performed by means of a thermometer with thermocouples (special probes) in predetermined points (Fig. 8).

Measurements were made on February 9, 2012, with the outside temperature of $-18\ {}^{0}$C; the inner temperature in both rooms was raised by space heating at $18^{0}$C.

Following *in situ* measurements made with DATALOGGING device (Fig. 9), temperatures graphics, imaging confirmed by thermo-graphic measurement and control equipment using infrared rays were obtained. The images were confirmed, according to the proposed temperature differences insulation solution.

The resulting measurements with thermal imaging (infrared camera) came to confirm the data obtained using thermocouples and thermometer, which also shows that the inner cladding of external walls bring a clear improvement in terms of thermal comfort.

Fig. 9 – The *in situ* measurements device.

Temperature on the inner surface of exterior walls depends on the increase of the interior/exterior insulation and on the insulation thickness (Fig. 10).

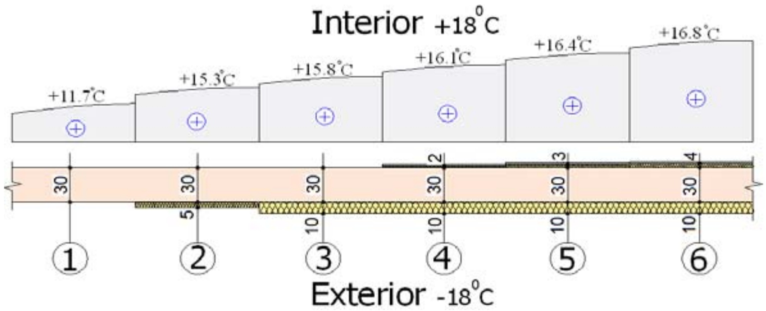


Fig. 10 – The *in situ* obtained inner surface temperatures.

Following *in situ* (in the field) measurements taken by means of the thermocouple thermometer, high real temperatures were obtained that are lower than the ones resulting from the next formulas:

$$T_{si} = T_i - m\frac{R_i}{R_0}\cdot\frac{T_i - T_e}{R} \quad (1), \qquad T_{se} = T_i - m\frac{R_e}{R_0}\cdot\frac{T_i - T_e}{R}, \quad (2)$$

where: $T_{si}$ is the temperature on the inner surface, [°C]; $T_{se}$ – temperature on the outer surface, [°C]; $T_i$ – temperature of the inner air, [°C]; $T_e$ – conventional calculus temperature of the exterior air, [°C]; $m$ – masivity coefficient; $R_i$ – thermal resistance of the inner layer; $R_e$ – total thermal resistance, [m$^2$.K/W].

## 4. Conclusions

The proposed prefabricated insulating panels presents the following advantages:

a) It is achieved by simple technology of the assembly execution.

b) Lower costs.

c) Architectural façades remain unchanged.

d) Due to warm air circulation inside the inner surface temperatures of the upper exterior walls of the rooms are slightly higher than those in the lower floor.

e) By making vertical temperature diagram, it may observe that the inner surface temperature is highest in the neutral room.

f) Graphic character of the temperature both vertically and horizontally appears as a spherical cap, with lower temperature to room extremities.

g) Temperature difference obtained by measurements *in situ* and those obtained by calculation can be materialized by a correction factor that we propose, noted $C_c$, which has values close to 0.96. According to this, resulting formula will have the following form classical calculation:

$$T_{si} = C_c\left(T_i - m\frac{R_i}{R_0}\cdot\frac{T_i - T_e}{R}\right) \quad (3), \qquad T_{se} = C_c\left(T_i - m\frac{R_e}{R_0}\cdot\frac{T_i - T_e}{R}\right). \quad (4)$$

Obtained correction coefficient is the ratio of indoor temperature/ outdoor measurements and surface temperature indoor/outdoor calculated according to relations (1) and (2).

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## IZOLAREA TERMICĂ PE SUPRAFAŢA INTERIOARĂ A PEREŢILOR EXTERIORI – O NOUĂ PLACĂ TERMOIZOLATOARE PREFABRICATĂ
### Analiza eficienţei soluţiilor

(Rezumat)

Pereţii exteriori au o pondere importantă în cadrul anvelopei unei clădiri (suprafaţa ce separă volumul încălzit de exterior). Izolarea termică a pereţilor exteriori se poate realiza prin pozarea stratului izolator la exteriorul/interiorul acestora. Din punct de vedere al capacităţii de izolare termică, amplasarea pe suprafaţa interioară este mai puţin eficientă, ceea ce conduce la o utilizare restrictivă a acestei soluţii. Compensarea se realizează printr-o tehnologie de execuţie simplă la montaj, preţ de cost mai redus şi faţade nemodificate.

Pozarea stratului izolator la interior pe pereţii exteriori cu termoizolaţie din polistiren expandat, s-a dovedit, experimental, a fi o soluţie ce conduce la îmbunătăţirea confortului termic din interiorul încăperii printr-o micşorare a pierderilor de căldură înregistrate prin pereţii exteriori. Micşorarea pierderilor de căldură prin pereţii exteriori (anvelopa clădirii) diferă funcţie de soluţia de placare interioară dar şi de tipul şi grosimea termoizolaţiei (2...4 cm).

În urma măsurătorilor *in situ* s-a demonstrat că prin utilizarea placării la interior a pereţilor exteriori s-a obţinut o îmbunătăţire a temperaturii pe suprafaţa interioară în medie cu 0.5°C la fiecare creştere în grosime cu 1 cm a termoizolaţiei utilizate. Verificările *in situ* au arătat că pentru obţinerea unei temperaturi reale pe suprafaţa interioară/exterioară a pereţilor exteriori se impune introducerea unui coeficient de corecţie, $C_c$, aplicat la formula de calcul.