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Application of Thermal Insulation Materials on Facade Envelopes with Materials from Ading - Ad Skopje Production Program

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Abstract
The function of an exterior façade wall can be multi-purpose: constructive, static, aesthetic, functional, resisting the appropriate climatic conditions etc.With the rapid development of technology in the building materials industry, there is an expansion of new building materials, which are characterized by outstanding new qualities, they are lightweight, good sound and heat insulators, suitable for transport and installation and provide new opportunities for architectural aesthetic design.These new building materials are more and more often replacing the traditional building materials (brick, stone and concrete) because they successfully take on the required functions of an exterior façade wall.Each of the constituent elements of exterior façade walls has a specific function to resist one or more external climatic influences.In general, traditional façade walls are still used in many countries, and in recent times sandwich wall panels, thermal insulated façade walls are still in their initial stage. The application of thermal insulation materials on façade envelopes from the production program of ADING - AD SKOPJE such as Adingterm and Ading system as elements for thermal protection of buildings and exterior façade materials is a big step in the modern technology of construction chemistry.
Keywords: traditional building materials, thermal protection, sandwich wall panel, thermal insulated wall, climatic influences
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INTRODUCTION

In the first half of the 20th century no special attention was paid to the thermal properties of exterior walls. However, if the wall does not have sufficient heat protection, the heating in the rooms increases. Due to the energy crisis, every building must meet the required standards of thermal insulation.

Architects should have sufficient knowledge of thermodynamics as a concept and function in architecture. When designing any building, thermal insulation must be taken into account depending on the climate zones, where each zone has its own coefficient.

With reference to the climatic conditions and the relatively low energy production, the designers and contractors should inevitably focus on design and construction of good thermally insulated systems on the façade envelope. The sandwich panel, styrofoam, thermal insulated panels system has been used in many countries in Europe and around the world for just over three decades.

The energy efficiency of buildings, as one of the largest consumers of energy, is of particular interest at a time when we are facing an energy crisis, starting from the fact that energy losses in existing energy inefficient buildings reach up to 40%.

FACADES, CHARACTERISTICS AND MATERIALS

The façade is the image of every building. The word façade comes from the Latin word *facies* which means face. The face of the building can be attractive, the existing one can be decorated or completely changed. In parallel with the development of construction, façades have also developed, both in shape and in the way they were made. One of the main tasks of every architect is the façade design. The aim is to attract the observer's attention. The well-designed façade suggests an interesting interior and at the same time suggests the quality of the fulfilled technical characteristics.

Façades are a very important segment in the construction of any building. The greatest attention should be paid to the hydro, thermal and sound insulation, as well as to the final decorative layer. There are usually two types of thermal façades, and the difference is in the type of materials used. The cheapest façades are made of styrofoam thermal insulated panels. Stone wool is the best solution for thermal insulation. It is the most expensive material, but also the best thermal insulator and thus contributes to great savings in heating and cooling of premises. The final layer of the façade depends on the desire in a decorative sense. The most common materials are used, but other materials are applied as well, such as various plastic mortars etc.

Buildings are constantly exposed to various weather influences such as: extreme temperatures, rain, snow and more. A good façade must be able to withstand natural disasters, such as hail or extremely strong winds, but also fire.

There are several types of façade walls: sandwich panel walls, thermal insulated walls, glass walls, etc. But the facade is evaluated based on the following characteristics: types of insulation, quality of the material, method

of installation, etc. The façade choice is based on the available finances, the type of construction and the aesthetic requirements. One of the basic functions of the facade is the best possible thermal insulation. The high costs of heating, global warming and environmental protection have led to the adoption of strict laws and regulations for application of various thermally insulated systems in residential, commercial and other types of buildings.

SANDWICH PANEL WALLS

Sandwich panel walls and concrete façade walls were dominant in a certain period of the 20th century, however, sandwich panel walls have major negative properties in thermal insulation and energy consumption. Concrete walls are also susceptible to acidic air and other atmospheric influences.

Exterior wall surfaces are areas where heat loss is the greatest, so it is very important that they are thermally insulated. Sandwich panel walls, concrete and stone façades are one of the most expensive ways of finishing, taking into account the additional costs of applying the insulation etc.

The negative characteristics of sandwich panel walls are:

- Poor thermal and sound material;
- High specific weight of the building material;
- High costs for materials, construction and transport;
- Large amount of building materials.

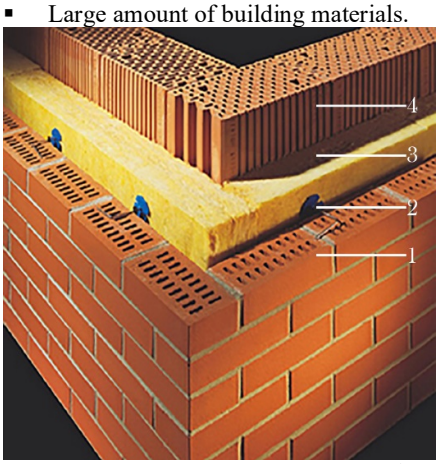

Figure 1 Sandwich panel wall structure[1]

Legend:

1. Brick 25x12x6.5 cm;
2. Rawlplug;
3. Thermal insulation 6 cm;
4. Hollow clay block 19 cm.

THERMAL INSULATED WALLS

Until the first half of the 20th century, little attention was paid to the thermal characteristics of exterior façade walls, which were built mainly as sandwich panel walls, concrete walls, made of stone or some other building material. Exterior façade walls were built without good thermal insulation. In this way, a large amount of energy was consumed for heating in the winter period and cooling in the summer period.

In many countries throughout the world, thermal insulation is not considered with a special care and is rarely applied in buildings.

With reference to the climatic conditions and global temperature changes (cold winters, hot summers) and the relatively low and expensive energy production in the world, the application of a good thermally insulated system on the façade envelope is crucial.

The advantages of thermal insulation materials are great from an economic, technical and environmental point of view. The most important advantages are:

- Heat saving up to 35%;
- Preventing condensation;
- Highest value of thermal conductivity coefficient K = 0.90 W/m^{3}K;
- The value of K on a thermally insulated wall (Adingterm system) of hollow brick, K = 0.61 W/m^{3}K.

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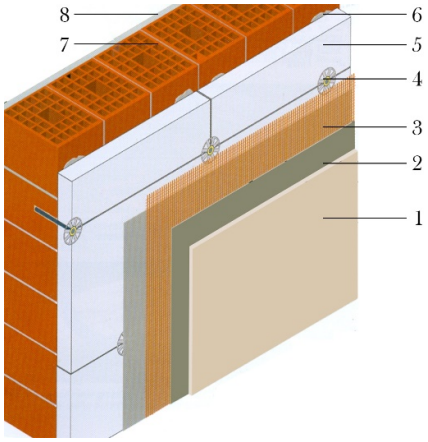

Figure 2 Structure of thermal insulated wall[1]

Legend:

1. Acrylate emulsion-based decorative mortar with coarse grained structure 0.2 cm (Hidrofas-Z);
2. One-component cement-based adhesive 0.1 cm (Stirokol-P);
3. Glass fiber mesh;
4. Rawlplug;
5. Expanded polystyrene styrofoam panel 10 cm;
6. One-component cement-based adhesive for styrofoam 2 cm (Stirokol-P);
7. Hollow clay block 19 cm;
8. Ready-mix mortar (Termal).

The large temperature difference in non-insulated walls causes stress in the walls and permanently damages the building materials.

Thermally insulated façades are applied in the construction of many buildings with different purposes. The principle of application is the following: an insulating panel is placed on the exterior wall, which is fastened with a grid, and then the façade paint or decorative façade mortar is applied.

The share of energy consumption in buildings, varying from country to country, is around 40% of primary energy production per year. The domestic sector is the largest single consumer, accounting for 30% of primary energy. Other public buildings (schools, hospitals, public administration facilities, etc.) spend about 20%. Furthermore, in the European countries, 60% of energy in buildings is spent on heating and 22% on water heating, which emphasizes the importance of improving the thermal insulation of buildings. The global temperature changes worldwide and cold nights indicate the fact that the application of thermodynamics should be carefully researched and applied as needed.

The heat losses of a thermally non-insulated building are: 38% through the walls, 24% through the roof, 12% through the windows, 9% through the floors and 17% through the ventilation of the rooms. Energy savings will obviously depend on the type of building. However, the achievement of a satisfactory thermal insulation must be considered, and in particular the method of insulation and the insulation process to be applied, as well as the selection of materials and the application system.

TECHNICAL CONDITIONS FOR DESIGN AND CONSTRUCTION OF BUILDINGS

The country is divided into three construction, climate zones, according to the average value of the lowest annual temperatures observed in individual parts. The maximum allowed value for the thermal conductivity coefficient (K) for exterior structural elements and partition walls, for the three mentioned climate zones is presented in Table 1.

Table 1. Climate zones and maximum allowed coefficient of thermal conductivity[2]

No.	Thermal characteristics	Highest value of K	Average value of the lowest annual temperatures
01	I Construction climate zone	1.20 W/M^{2}k	-12^{0}C
02	II Construction climate zone	0.9 W/M^{2}k	-18^{0}C
03	III Construction climate zone	0.8 W/M^{2}k	-24^{0}C

The maximum allowed thermal conductivity coefficients K for different structural parts of a building are

[1] Author
[2] Trebojević, 2003, 81

determined for each climate zone.

The following table presents the smallest average section of the walls, the strength of which does not depend on the size of the component and the thermal conductivity coefficients of classically constructed walls and walls thermally insulated with Adingterm system (two-layer).

Table 2. Largest average section of walls on a classic and insulated wall with Adingterm system[1]

No.	Constructive material of the wall	Weight	Interiorl mortar 2.0 см Wall thickness Exterior mortar 3 см	W/m²k Uninsulated wall with interior and exterior mortar	W/m²k Wall with interior mortar and Adingterm system
01	Concrete	2400 kg/m³	2+15+3 2+15+3	3.20 2.70	0.71 0.67
02	Concrete blocks	2400 kg/m³	2+20+3	2.05	0.63
03	Solid brick	2400 kg/m³	2+25+3 2+38+3	1.78 1.36	0.60 0.54
04	Hollow brick	2400 kg/m³	2+20+3 2+25+3	1.83 1.74	0.61 0.53

Table 2 gives the coefficients of heat transfer and application in climate zones I, II and III of those walls whose thickness is conditioned by the largest component of which the wall is built.

Table 3 Technical data of Adingterm panels[2]

No.	Type of Adingterm panel	Total thickness cm.	Aprit layer mm.	Tthermal conductivity coefficient K/W/m² K
01	AP 4	4	10+0	0.95
02	AP 5	5	10+0	0.77
03	AP 4-3	4	10+10	1.10
04	AP 5-3	5	10+10	0.82
05	AP 7-3	7	10+10	0.64

Table 3 presents Adingterm panel - type AP 7-3 with a thickness of 7 mm has the lowest thermal conductivity coefficient which is 0.64 K/W/m²K, compared to Adingterm panel AP4-3 with a thickness of 4 mm. where the thermal conductivity coefficient is 1.10 K/W/m²K.

The wall that is not thermally insulated not only does not protect the interior space from the cold, but because it is cold itself, there is a condensation inside (it develops more or less in all places where people live and work), which in contact with the cold wall creates condensation in the podium.

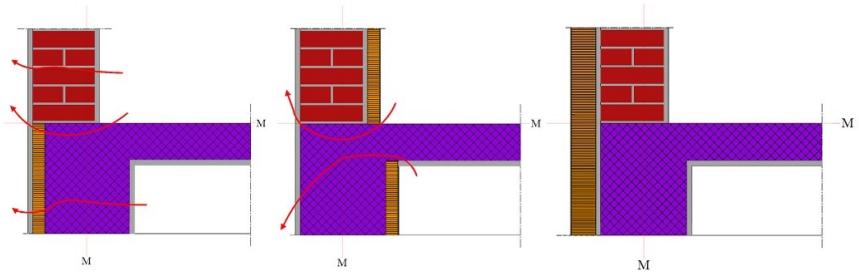

Figure 3 Thermal bridges - errors in the construction of external insulation and the advantage of exterior thermal insulation[3]

[1] Trebojević, 2003, 82
[2] Ading, informat 5, 1994, 14
[3] Author

Table 4 thickness of classic walls according to regulations for climate protection depending on the climate zones[1]

No.	Constructive material of the wall	Dimensions	Weight Kg/m²	W /m²k	Exterior façade wall		
					I Zone	II Zone	III Zone
01	Brick wall	25 см	1600	1.79	-	-	-
02	Brick wall	38 см	1600	1.31	-	-	-
03	Brick wall	51 см	1600	1.04	+	-	-
04	Wall made of hollow clay block with vertical perforations	25 см	1200	1.54	-	-	-
05	Wall made of hollow clay block with vertical perforations	38 см	1200	1.12	+	-	-
06	Wall made of hollow clay block with vertical perforations	51 см	1200	0.87	+	+	-
07	Wall made of thermal blocks	19 см	1200	1.87	-	-	-
08	Wall made of thermal blocks	24 см	1200	1.57	-	-	-
09	Wall made of thermal blocks	29 см	1200	1.38	-	-	-
10	Wall made of Durisol blocks	30 см	-	0.72	+	+	+
11	Wall made of gas-formed concrete blocks	25 см	600	0.67	+	+	+
12	Wall made of gas-formed concrete blocks	30 см	600	0.57	+	+	+

Table 4 shows the classic 38 cm thick brick walls do not meet the regulations for thermal protection for any climate zone. Walls made of hollow clay block with vertical perforations of 38 cm and brick walls with a thickness of 51 cm are found only in the first climate zone, while the same brick wall can be used in the second and third climate zone.

ELEMENTS FOR THERMAL PROTECTION OF BUILDINGS

Thermal insulation materials should not only have good thermal properties, but also good overall stability, resistance to joint development and high moisture resistance. There are different materials for protection of building materials, especially on the exterior façade walls, such as: Adingterm panels and Ading system from the production program of ADING - AD SKOPJE.

Adingterm panels:

Adingterm system (sandwich panels) is a successful combination of two materials: expanded polystyrene (styrofoam) and light mortar prepared with rice husk and binder, cement (Arpit). These panels are produced with dimensions 50/100 cm, as double layer Styrofoam + Arpit + Styrofoam + Arpit, where the thickness of the Arpit is constant 1 cm, and the thickness of the Styrofoam ranges from 5 to 10 cm, depending on the climate zone and the thermal conditions, i.e. on the previous construction calculation.

The Adingterm panels are light and solid, and the surface of the arpit is suitable for applying any type of mortar. They are resistant to construction binders and coatings. They attach easily and quickly to any type of wall and can be cut into all shapes and sizes.

[1] Trebojević, 2003, 83

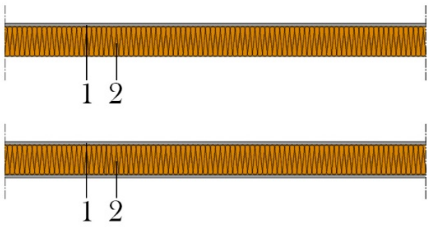

Figure 4 Section of single-layer and double-layer element of Adingterm panels[1]

Legend:
1. Aprit 1 cm;
2. Expanded polystyrene styrofoam panel 6, 8 cm.

Adingterm panels are most often used for thermal insulation of exterior elements of buildings (façade walls, flat roofs), basement walls and floors in residential, industrial, public and other types of buildings.

In addition to the role of thermal insulator, Adingterm panels are also a good base for the façade finishing. This system is used with equal success for thermal protection of new buildings, as well as for rehabilitation of old ones, where the removal of the existing façade mortar is not possible. Adingterm panels are especially widely used in construction as a solution for thermal bridges in concrete elements, they are directly applied on the facade (beams and columns).

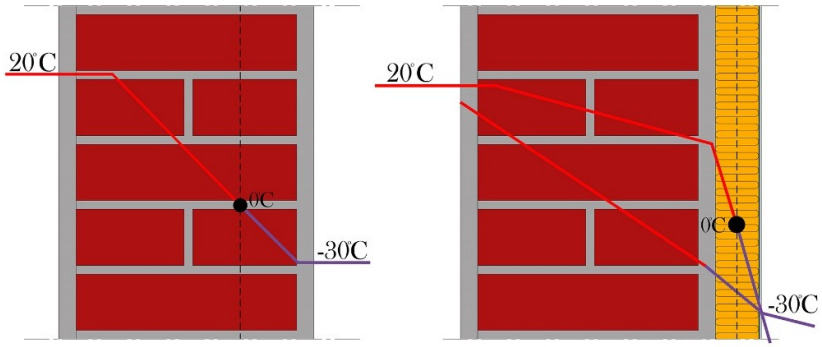

Figure 5 With the application of Adingterm system the cold air is kept outside and the heat inside[2]

The installation of Adingterm boards is done in several ways:

- When constructing horizontal or vertical elements of new buildings (concrete walls, beams, ceilings, columns, etc.) the most favorable way of installation is by applying the three-layer Adingterm panels in the cladding before the concrete pour. The fastening is done by pouring concrete in the mould;
- Adingterm panels can be installed after the construction of the mentioned elements of concrete brick or other building material by fastening with previously installed anchorages (F 2-3 mm) or by additional anchoring in concrete or brick walls (6 pieces / m2);
- When intervention for thermal protection is performed on already constructed buildings (plastered and façade processed), the installation is performed on a previously constructed grill of impregnated and vertically placed laths.

Adingterm panels are fastened so that the vertical joints between the panels are interchangeable. In this way an additional air insulation layer is obtained. In addition to this method, the installation of Adingterm panels can be performed by direct anchoring, combined with the use of the adhesive Stirokol and Hidrokol-S.

Ordinary mortar of appropriate quality is used for plastering the surfaces cladded with Adingterm panels. Before plastering, all joints and corners must be bandaged with wire netting, or impregnated glass fiber mash.

Plastering is done in the usual way as with brick walls. Decorative façade finishing can be applied with any material Adingfas-Z (decorative mortars with rustic or coarse grained structure) or façade paint.

Ceramic tiles can also be applied on Adinterm panels, the only condition is to coat the whole surface previously with wire mash.

[1] Author
[2] Author

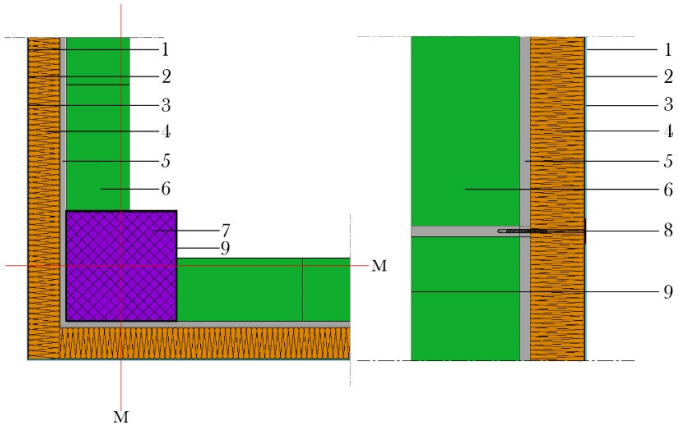

Figure 6 Vertical and horizontal section of an exterior façade wall using Adingterm panels[1]

Legend:
1. Acrylate emulsion-based decorative mortar with coarse grained structure. 0.2 cm (Hidrofas-Z);
2. One-component cement-based adhesive 0.1 cm (Stirokol-P);
3. Glass fiber mesh;
4. Expanded polystyrene styrofoam 10 cm;
5. Aprit 1 cm;
6. Itong block 20 cm;
7. Reinforced concrete column;
8. Rawlplug;
9. Internal surface leveling compound (Hidroglet-V).

Adingsystem:

Adingsystem is a compact façade system for thermal insulation of all types of buildings. This system protects the building from climate change and meets all the conditions for permanent stability and functionality during its utilization.

Expanded polystyrene-styrofoam serves as a thermal insulator, made with a thickness of 5, 8 and 10 cm, with groove cutting along the length and width of the panel.

The installation of styrofoam panels on the façade surfaces is done by gluing with two-component polymer, cement adhesive and anchoring in the walls with special stainless steel screws. The surface of the styrofoam is protected with a special two-component polymer mortar, applied in two layers with a total thickness of 4-5 mm and reinforced with a glass fiber mesh. This plaster is followed by the finishing of the façade surfaces with appropriate façade paints or decorative plastic mortar 3-4 mm.

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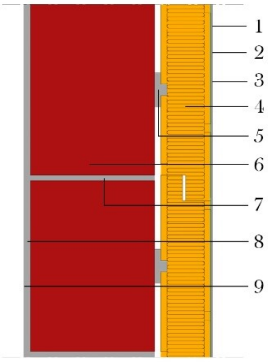

Figure 7 Structure of an exterior façade wall using Adingsystem[1]

Legend:
1. Decorative acrylate façade mortar with coarse grained structure 0.2 cm (Hidrofas-Z);
2. One-component adhesive 0.1 cm (Stirokol-P);
3. Glass fiber mesh;
4. Expanded polystyrene styrofoam 10 cm;
5. One-component cement-based adhesive for styrofoam 2 cm (Stirokol-P);
6. Hollow clay block 19 cm;
7. Cement mortar 1 cm;
8. Cement mortar 1 cm;
9. Internal surface leveling compound (Hidroglet-V).

The components A / gray powder mixture and B / white polymer emulsion are mixed in a precisely defined ratio for about 3 minutes. The mixture should rest for 20-30 minutes with occasional stirring. The prepared mixture is stirred again and can be applied afterwards.

The installation of façade styrofoam panels is done by applying the prepared adhesive along the groove cuttings of the panels. Then anchoring is done in the load-bearing wall using special bolts.

The first layer of the prepared polymer mortar follows on the installed styrofoam panels, which is applied with a steel trowel. A glass fiber mesh is pressed into the fresh layer, and then the second layer of mortar is applied. It is followed by the decorative protection with (Adingfas-Z), (Adingfas-R) or with (Adingcolor-F).

CONCLUSION

The necessity of energy efficient buildings is of particular importance. Because of the fact that energy consumption increases costs, developing a good thermal performance of a building is always worthwhile. The future market of insulation materials is the most promising, because it remains open for better insulation materials, not only with thermal properties, but also fire resistant, non-corrosive, resistant to climatic conditions etc.

It can be concluded that the type and quality of the façade depends on how to solve the problem of static load, thermal and sound insulation, condensation, glass bearing, sealing, fixing systems, expansion joints, fire resistance and, of course, aesthetic purposes. Combination of light and heavy layers in the application is always feasible.

However, lately technology has provided a second chance to change the appearance of sandwich panel walls, as well as exterior concrete façades. By applying thermal insulation panels to form thermally insulated façade systems, we can achieve a satisfactory degree of thermal and sound insulation and aesthetic quality in terms of color and exterior surface.

Today, we often have the opportunity to see a building with an old façade, whose aesthetic qualities do not respond to the demands of the new time and the new modern needs. Usually, such buildings need to get a completely new look, the classic masonry facades should be covered with good thermal insulation materials. The complete replacement of the façade brick wall, concrete or plastered facades by applying thermal insulation materials will provide the function of energy protection and good sound insulation and give a new image to a larger number of buildings, which has a positive impact on changing the image of the city.

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[1] Author