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THE RECOVERY TIME OF THE EMBEDDED ENERGY IN THE ADDITIONAL INSULATION FOR EXTERNAL WALLS OF BUILDINGS

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Abstract: *The paper presents the possibility for calculation the recovery time of the embedded energy in the additional insulation for external walls of buildings. This insulation can be realized from various materials and at various thicknesses. The energy consumption is function of the external temperature variation and the duration of the heating period of the year. So, it can result various recovery times for each climatic zone.*

Key words: *embedded energy, building, external wall, additional insulation..*

1. Introduction

The energetic audit of existing buildings represents the activity of identifying the technical solutions of energetic rehabilitation of buildings and its afferent installations, based on the real characteristics of the system composed by the buildings and installations as well as technical solutions optimization through its energetic efficiency analysis. The energetic audit represents an obligatory stage in the preparation of the modernization design.

The energetic audit of an existing building supposes the achievement of two obligatory stages:

The 1st stage consists in the evaluation of the probabilistic energetic consumption of the building in normal living conditions and based on the real characteristics of the building and its installations.

The 2nd stage consists in the economic efficiency evaluation and the energetic audit elaboration.

The decision for adopting one measure for energetic modernization is the economic efficiency:

$$VNA_{(m)} < VNA_{(a)} \qquad (1)$$

in which $VNA_{(m),(a)}$ is the updating net values of investments and exploitation for the modernized/non modernized building, during the lifetime [1].

Really, this method is very good for the optimal decision of the investor but from the pure energetic point of view it is not realistic. The energy costs are conventional and determined by a certain conjuncture. It can contain excises and other taxes that have non relationship with the real embedded energy.

The energetic efficiency of an energy process production (conversion) can be evaluated by the energetic efficiency coefficient expressed by the ratio between the input energy (consumed) and output

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energy (useful). The final energy can be used in a product fabrication. The energetic intensity of products is correctly characterized by its overall contain of energy so named the embedded energy. It is expressed by the overall energy from various types consumption.

2. The Energetic Analysis

In order to realize an overall analysis of the energetic intensity of the various products it can utilizes its hierarchy from the point of view of the embedded energy. However, these hierarchy has a relative character because the dynamic character of the technology. Table 1 presents the overall energy consumption for a few products [2].

Table 1.

Product	Embedded energy MWh/To
PVC objects	31.827…42.654
Expanded polystyrene	63.492
Cement	1.074…2.849
Mineral wool plates	12.047…18.559

The common solution for increasing the thermal resistance of external opaque walls is to add on the external side a thermal insulation serried with an adhesive based on cement and secured with PVC nails.

The outer surface of the thermal resistance must to be reinforced with fiber glass screen serried with the same adhesive and afterwards a smooth thick plaster based on cement too.

It supposes an external wall composed by walling masonry with solid brick. The temperature distribution in this wall without insulation is presented in figure 1.

The temperature distribution shape if it is added a thermal insulation is presented in figure 2.

The heat transfer coefficients [3] are presented in the table 2.

The masonry wall thickness is supposed to be $\delta_m = 0.3m$. For the thermal insulation thickness are supposed four values: $\delta_i = 0.05; 0.1; 0.15; 0.2m$, so resulting four variants of wall insulation: A1…A4, for expanded polystyrene and B1…B4 for mineral wood plates. The thermal resistances of the thick plaster and the fiber glass screen are neglected.

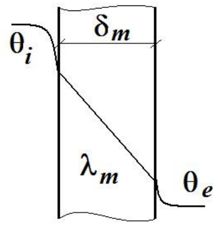

Fig. 1. *Temperature distribution in the wall without insulation*

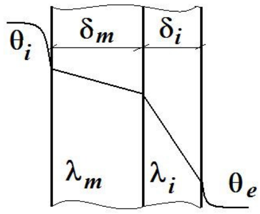

Fig. 2. *Temperature distribution in the wall with external insulation*

Table 2.

Heat transfer coefficient	Sym bol	Unity of measure	Value
Internal convection coef.	α_i	$\frac{W}{m^2 \cdot K}$	8
External convection coef.	α_e	$\frac{W}{m^2 \cdot K}$	24
Masonry wall heat conductivity	λ_m	$\frac{W}{m \cdot K}$	0.8
Expanded polystyrene heat conductivity	λ_i	$\frac{W}{m \cdot K}$	0.04
Mineral wood plates heat conductivity	λ_i	$\frac{W}{m \cdot K}$	0.036

The heat flow rate density in the case of the wall without thermal insulation can be expressed by the relation [3]:

$$\dot{q} = \frac{\theta_e - \theta_i}{\frac{1}{\alpha_i} + \frac{\delta_m}{\lambda_m} + \frac{1}{\alpha_e}} \left[\frac{W}{m^2}\right] \quad (2)$$

in which θ_e, θ_i are the external and respectively internal temperature. It results the thermal conductance of the masonry wall and of the insulated wall:

$$G_m = \frac{1}{\frac{1}{\alpha_i} + \frac{\delta_m}{\lambda_m} + \frac{1}{\alpha_e}} \; [W/(m^2 \cdot K)] \quad (3)$$

$$G_i = \frac{1}{\frac{1}{\alpha_i} + \frac{\delta_m}{\lambda_m} + \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_e}} \left[\frac{W}{m^2 \cdot K}\right] \quad (4)$$

The yearly heat requirement for heating a unity (m^3) of heated volume is [4]:

$$Q = \frac{24}{1000} \cdot C \cdot N_{12}^{20} \cdot G \left[kWh/\left(m^3 \cdot year\right)\right] \quad (5)$$

in which $G\left[W/\left(m^3 \cdot K\right)\right]$ is the insulation overall coefficient of the building, $N_{12}^{20}[K \cdot day]$ - nominal number of yearly Kelvin day corresponding at a locality (place), calculated for the internal temperature $\theta_i = 20°C$, and for the external average temperature from that begins and stops the heating $\theta_{e,0} = +12°C$ and C .- a correction coefficient function of N_{12}^{20} and the type of heating installations. It is considered installations having thermostatic control devices that pursues to the optimal heating control and energy saving.

Because there are considered the opaque external wall surface only, the insulation overall coefficient of the building G will be replaced by the heat conductance (G_m or G_i). For example, for the wall without thermal insulation, the relation (5) becomes:

$$Q = \frac{24}{1000} \cdot C N_{12}^{20} G_m \left[kWh/\left(m^2 \cdot year\right)\right] \quad (6)$$

From [4], in Romania, the nominal number of yearly Kelvin day varies between $2840 K \cdot day/year$ (Constanța) and $5650 K \cdot day/year$ (Sinaia, cota 1500).

3. The Embedded Energy in the Thermal System

The embedded energy in the thermal insulation is composed by the embedded energy in the thermal insulation materiel (expanded polystyrene or mineral wood plates), in the PVC nails and in the adhesive for thermal insulation and fiber glass screen thick plaster. It results the overall embedded energy presented in the table 3.

Table 3.

Variant	Embedded energy, E kWh/m^2
A1 / B1	162.91 / 102.12
A2 / B2	233.97 / 140.19
A3 / B3	360,50 / 178.17
A4 / B4	459.34 / 216.23

The recovery time of the embedded energy in the additional insulation for external walls of buildings results from the relation:

$$\tau = \frac{E}{Q} \; [year] \quad (7)$$

Table 4 presents the results for the expanded polystyrene insulation and table 5 the results for mineral wood plates.

Table 4

N_{12}^{20}	A1	A2	A3	A4
2600	2,42	2,91	4,20	5,17
3000	2,09	2,52	3,63	4,47
3500	1,78	2,15	3,10	3,81
4000	1,55	1,86	2,69	3,31
4500	1,36	1,64	2,36	2,91
5000	1,21	1,45	2,10	2,58
5500	1,08	1,30	1,88	2,31
5600	1,06	1,28	1,84	2,27
5650	1,04	1,26	1,82	2,24

Table 5.

N_{12}^{20}	B1	B2	B3	B4
2600	1,42	1,68	2,02	2,39
3000	1,23	1,45	1,75	2,06
3500	1,05	1,24	1,49	1,76
4000	0,91	1,08	1,29	1,53
4500	0,80	0,94	1,14	1,34
5000	0,71	0,84	1,01	1,19
5500	0,64	0,75	0,90	1,07
5600	0,62	0,74	0,88	1,04
5650	0,61	0,73	0,87	1,03

4. Conclusion

For the entire period of heating, using the nominal values of the number of yearly Kelvin day, the thermo-system realized with expanded polystyrene recovers the embedded energy during a longer time then the mineral wood plates. Moreover, the mineral wood is a very good materiel. However, the cost is higher.

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