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INCREASING PASSIVE HOUSES PERFORMANCES BY USING ECOLOGICAL STRUCTURES

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Abstract: *Energy and diminishing pollution level are the two priorities in European and national strategies. Within the framework of energetic and climatic strategies of European Union the building structure energetics constitutes a priority. The increase of energetic efficiency, the use of renewable sources of energy and diminishing the greenhouse effect emissions represent a national priority in Romania too. In this respect, a decisive role is played by energetically efficient buildings. The present paper focuses on passive buildings with special emphasis on increasing energetic efficiency of their enveloping and the ecological characteristics of their structures.*

Key words: *energy efficiency, passive house, ecological buildings, insulation materials.*

1. Introduction

The economic and demographic development, the general overall progress confers, at present, a decisive role to energy and environmental protection. The increase of energy consumption, in the future, imposes the application of some European and national strategies with strict observance of the rules and terms of achieving the objectives. If the achievements until 2015 as the 20/20/20 objectives lie on an ascending slope, new directions, in view of achieving the objectives of 2030 policies which are to be valid in 2050, as well.

In view of the essential role played by building energetics, a thorough investigating research in the field of energy efficient buildings and their ecological character.

2. General Characteristics Concerning the Passive House Standard

Developed in Germany, in 1988, by professors Bo Adamson and Wolfgang Feist, the passive house standard represents, at the present, one of the highest standards in the field of energy efficient and ecological buildings, providing, at the same time the highest standards of internal comforts:
"A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to fulfill sufficient indoor air quality conditions (DIN 1946) – without a need for recirculated air" [2].

Counting on components optimization and reduction of losses by the use of

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performant materials and innovative technologies of turning to value the renewable resources, the standard of passive house can be applied in both residential houses and business and institutional buildings, in any climate area.

The general criteria of passive houses are presented in Table 1.

Energy performance targets for passive house standard [5] Table 1

Specific Heating Demand Or Specific Heating Load	≤ 15 kWh/m^2 year ≤ 10 W/m^2
Specific Cooling Demand	≤ 15 kWh/m^2 year
Specific Primary Energy Demand	≤ 120 kWh/m^2 year
Air Changes Per Hour	≤ 0.6 (n50)

An extremely important role in meeting the criteria of passive house standards is played by building enveloping. In view of diminishing heat losses, the enveloping elements will have to accomplish the following requirements:

- the global heat transfer coefficients (U) for opaque components of the envelope to lie between the limits 0.10 - 0.15 W/m^{2}K (depending on the climate zone);
- the global heat transfer coefficients (U) for windows/external doors should not exceed 0.8 W/m^{2}K.

In view of limiting energetic consumption and providing internal conditions of comfort, at building envelope level some solutions and performant materials should be employed to achieve thermo-insulating properties.

From constructive point of view, there are several ways of executing the enveloping of a passive building: large walls with external insulation, prefab elements, wooden structures with internal thermal insulation (see Fig.1), but irrespective of the solution adopted, the essential role will be played by the insulating material.

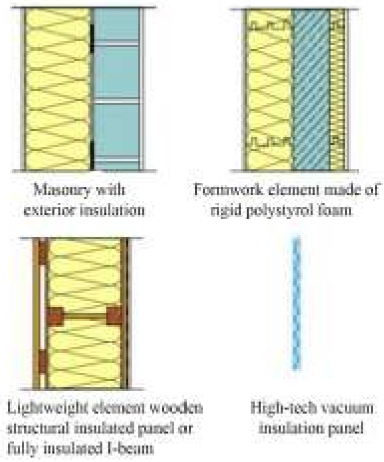


Fig. 1. *Wall constructions suitable for passive house standard [6]*

The choice of the thermal insulation will depend on two criteria: the energetic performance (thermal conductivity as low as possible) and the impact upon environment (a value as low as possible of kg CO_2 eq).

An energetical and ecological characterization of main insulating materials proper for passive houses is synthetically presented in table 2.

As the vitrified elements of the enveloping is concerned, in order to meet the requirements of a passive house, a high efficiency window systems are recommended, made of triple glass panes, with two layers of low emissivity, with the interspaces filled with noble gases and insulating frames and spacer profiles with thermal barriers.

3. Ecological Structures Suitable for Passive Houses. Case Study.

As a result of energetic and ecological strategies of diminishing energy consumption and polluting greenhouse emission effects, there was an increasing preoccupation for developing passive and ecological houses which along with a marked reduction of energetic consumption would reduce the negative impact upon the environmental by using more ecological materials.

Energetical and ecological characteristics for various insulating materials [1], [3],[4],[7] Table 2

Thermal insulation materials	Thermal conductivity λ [W/mK]	Impact upon environment [kg CO_2 eq]
Expanded polystyrene	0.033-0.040	7.36
Extruded polystyrene	0.032-0.038	14.26
Mineral wool	0.040	1.5
Rockwool	0.035-0.040	1.04
Wood fiber	0.038-0.052	0.43
Cellulose	0.038-0.040	0.39
Hemp	0.038-0.040	-
Wool	0.034-0.039	-
Straw bales	0.052	-

A classic example of renewable material used in ecological buildings is wood. As regarding the life time analysis of a building, starting from the production of the building material until its replacement and recycling, wood represents an alternative to replace metallic structures and massive concrete structural elements characterized by large amounts of CO_2 emissions.

Besides the ecological advantages, the wooden structural elements exhibit thermo-energetic advantages, improving internal comfort conditions, are more readily executed being safer in case of seismic events.

Taking into account the advantages of wood and the insulating materials previously presented and also the characteristics of passive buildings of providing a high degree of thermal insulation by limiting global thermal transfer coefficient through walls to 0.10 - 0.15 W/m^{2}K, three variants of external wall structures were proposed for analysis.

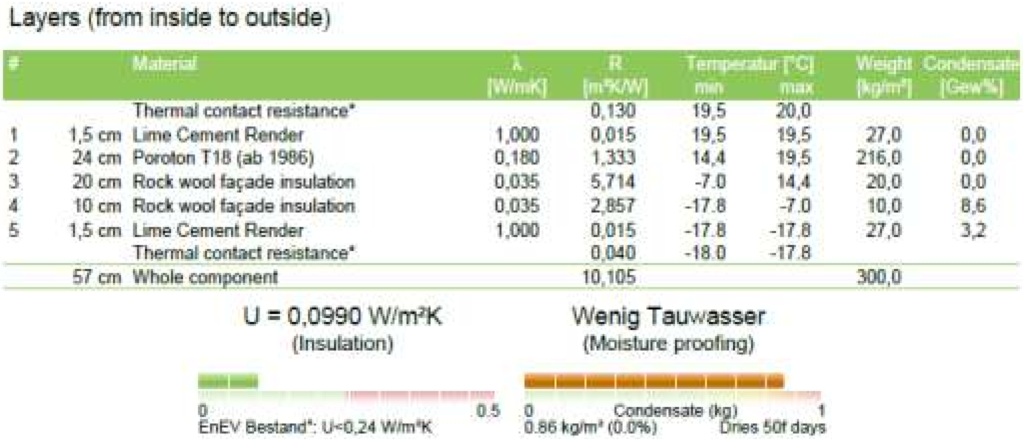
To be considered having a passive house standard, analysed for 3rd climate zone (external temperature -18 ^{0}C), the thermal transfer coefficient U was imposed to the limit 0.1 W/m^{2}K.

Case 1 – a passive structure made of brick wall (240 mm) and rock wool (300 mm), followed by two versions of eco-passive structures :

- case 2: oriented strand board (OSB 15mm), wool insulation (340mm), wood fibre sheathing board (60mm) and curtain wall;
- case 3: cross laminated timber (CLT 94mm), wool insulation (60mm), wood fibre insulation (300mm) and wood fibre insulation board (40mm).

Determining thermal transfer coefficient U was accomplished by means of the U-value calculator.

For case 1 – brick wall structure and rock wool thermal insulation of 57 cm in thickness and 300 kg/m^2 weight, a thermal transfer coefficient U=0.0990 W/m^{2}K has resulted (see fig.1). As a result of analyzing temperature and humidity variation through walls, the following things have been observed: the temperature in the walls varies between 19.5 ^{0}C and -17.8 ^{0}C, the freezing point being situated in the insulating layer and the condensate



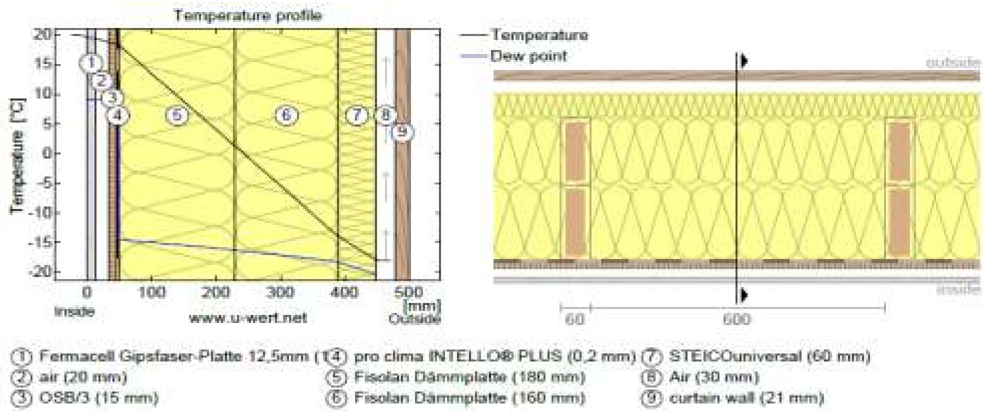
Layers (from inside to outside)

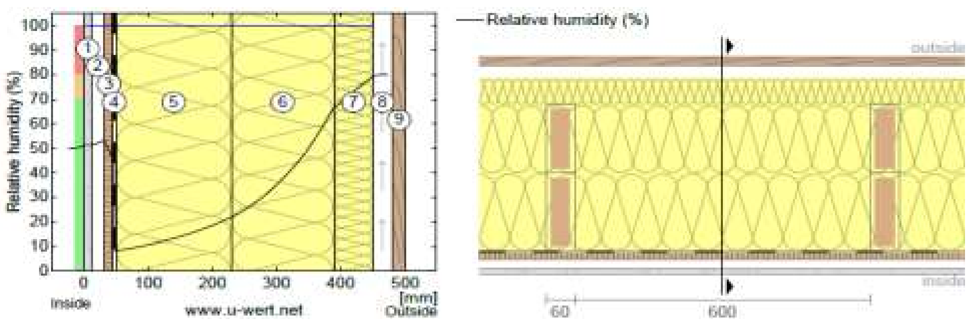
#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance*		0,130	19,5	20,0		
1	1,5 cm	Lime Cement Render	1,000	0,015	19,5	19,5	27,0	0,0
2	24 cm	Poroton T18 (ab 1986)	0,180	1,333	14,4	19,5	216,0	0,0
3	20 cm	Rock wool façade insulation	0,035	5,714	-7.0	14,4	20,0	0,0
4	10 cm	Rock wool façade insulation	0,035	2,857	-17.8	-7.0	10,0	8,6
5	1,5 cm	Lime Cement Render	1,000	0,015	-17.8	-17.8	27,0	3,2
		Thermal contact resistance*		0,040	-18.0	-17.8		
	57 cm	Whole component		10,105			300,0	

Fig. 2. *Detail of the structure wall for case 1 [7]*

is likely to appear outside the insulating layer (0.86 kg/m^2).

The structural details of the two cases on wooden structures as well as the temperature and humidity profile are presented in figures 3 and 4.





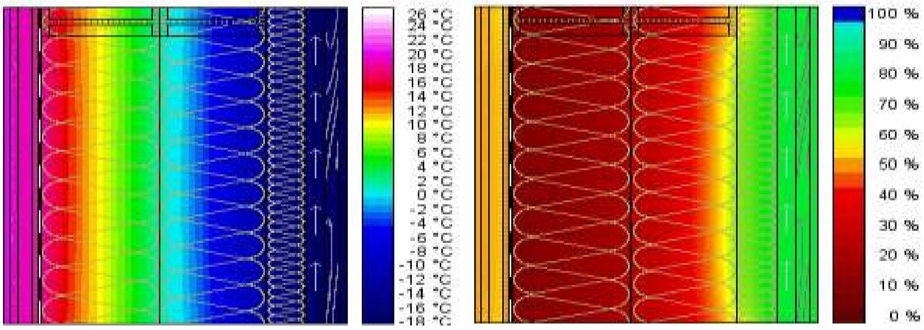


Fig. 3. *Detail of the structure wall, temperature and humidity profile for case 2[7]*

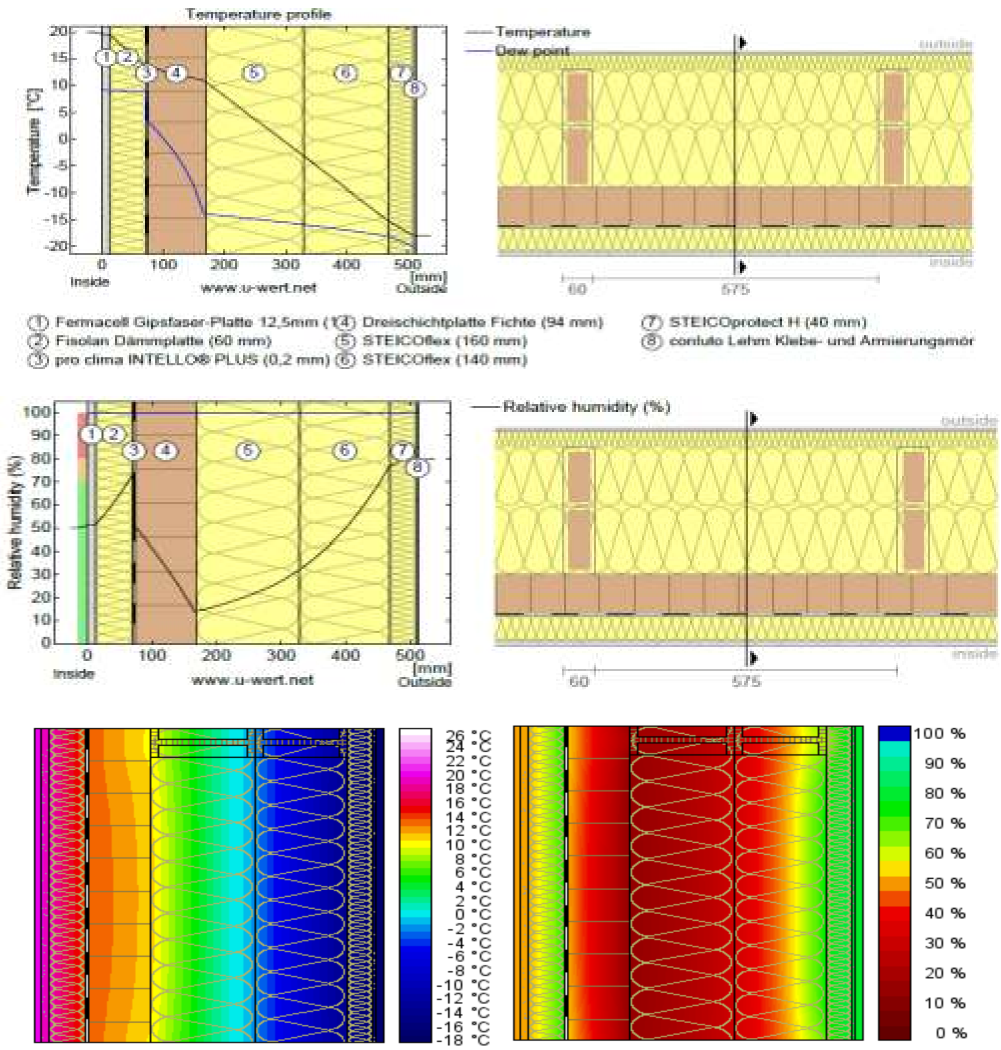


Fig. 4. *Detail of the structure wall, temperature and humidity profile for case 3 [7]*

As a result of the analysis the following are observed:

- by replacing the massive walls (case 1) with wooden structures and thermal ecological insulation lighter (case 2: 66.2 kg/m^2; case 3:101.4 kg/m^2), much smaller structures were obtained (case 2: 49.87 cm; case 3: 51.17cm) with better thermal transfer coefficients (case 2: U=0.0955 W/m^{2}K; case 3: U=0.0949 W/m^{2}K);
- a temperature variation in the wall from 19.5 ^{0}C to -17.8 ^{0}C, the freezing point being situated in the insulation layer;
- total elimination of condensate in the wall.

Taking into account the limitation of thermal transfer coefficient at walls level to 0.10 - 0.15 W/m^{2}K (in accordance to climatic zone), starting from the structures proposed, the minimum thickness of the thermal insulation were calculated so that U<0.15 W/m^{2}K. After simulations the following results were noticed:

- for the case of massive brick walls (case 1) by providing a rock wool insulation of minimum 200 mm, a coefficient U=0.138 W/m^{2}K was obtained;
- for case 2, by providing a wool insulation of minimum 200 mm, a coefficient U=0.145 W/m^{2}K was obtained;
- for case 3 by providing a wood fibre insulation of minimum 140 mm (+60 mm wool insulation) a coefficient U=0.148 W/m^{2}K was obtained.

As a result of using some ecological materials with low thermal conductivity (wool 0.036 W/mK, wooden fibre 0.039 W/mK, CLT/OSB 0.13 W/mK) a multitude of ecological constructive structures can be obtained, all close to passive houses standards

4. Conclusions

Taking into account the requirements imposed by the standards of passive houses of diminishing energy consumptions alongside with improving internal comfort conditions, diversifying the solutions of designing the enveloping by using performant materials as thermo-insulating and ecological properties are concerned, eco-passive constructions will come into existence, thus fulfilling the energetic and ecological objectives at European level of standards.

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