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Modern Concepts for Constructive Solutions in Dobrogea

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***Abstract* – In the summary published at the international conference WATER 2018, entitled "Modern concepts for constructive solutions in Dobrogea" [11], the authors briefly referred to the theoretical considerations and the case study on the concept of a "passive house" in the Dobrogea region - Romania, Constanta county, more precisely in the Mangalia area. In this article we will present this subject in great detail.**

Keywords – constructive system, geothermal energy, passive house, thermal bridge

1. INTRODUCTION

In this chapter we will present the general elements regarding the used concepts, which were worked on in the case study presented in the second chapter.

1.1. Describing the concept "Passive House/Building"

Human society, in its evolution, has forced the increase in quality requirements on the concept of "construction". Increasing the level of quality has, however, led to an increase in conventional energy consumption, both in the manufacturing process and later in the post-use process.

Thus, the necessity of conceiving and developing sustainable constructive systems has emerged to capitalize on the local energy potential of each region. In this context, the concept of "passive house" has also been developed.

"Passive House" is the building that respects the principle of "almost zero energy consumption," as it can be seen that in this case the energy consumption for heating the house can be reduced by up to 75% compared to the consumption for a conventional building [1]. This type of building is characterized by the following parameters:

- high thermal comfort - constant temperature throughout the building, without risk of airflow or dampness;
- indoor air quality - maintained by the existing ventilation system

High energy efficiency certified by the PH standard [1], the standard for the world's highest energy efficient buildings.

The initiative to define a concept called "passive house" first appeared in Germany, based on the principles developed by Dr. Wolfgang Feist. These principles materialized by building the first passive house prototype. Subsequently, based on these principles, the Passive House Institute was founded and the PH standard was developed. [1]

At the moment, in the EU level [2], there is a legislative package, as follows:

Directive 2012/27 / EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125 / EC and 2010/30 / EU and repealing Directives 2004/8 / EC and 2006/32 / EC (OJ L 315, 14.11.2012, p. 1). [2]

Directive 2010/31 / EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (OJ L 153, 18.6.2010, p. 13). [2]; Directive 2010/31 / EU required the Commission to carry out a review by 1 January 2017, building on the experience gained and progress made during the implementation of that Directive and, if necessary, presenting proposals. [2]

The Directive 2010/31 / EU, which entered into force in July 2010, have the role of strengthening energy efficiency requirements for the application of minimum requirements for the energy performance of new buildings.

1.2. Presentation of the concept „Structural system"

The concept of a structural system refers to the structure of resistance of the construction, together with the exterior enclosures and the building architecture. Also the structural system includes the materials used to build the construction.

The structural system can be seen from the viewpoint of tensions and actions that manifest themselves in a structure, as presented by conf. Florin Onea Tepes in his article [3]. Also, the structural system can be defined by the chosen materials and the architectural design solutions found to achieve the chosen purpuse.

1.3. Presentation of the concept of „Thermal bridge" si „Thermal resistance of the external wall"

The thermal bridge, in the case of a building element, is identified by an unevenness of the transmitted heat flow, meaning the more intense transfer of thermal energy through a certain area of that element. It is characterized by significant heat losses in the area. Thermal losses occur due to the composition of the material from which the element is made and, last but not least, due to a defective execution. [4]

The thermal resistance of the outer wall is defined by the relation [4]:

$$R_{PE} = R_i + R_e + \sum_k R_k = \frac{1}{\alpha_i} + \frac{1}{\alpha_e} + \sum_k \frac{\delta_k}{\lambda_k} \quad (1)$$

unde:

- α_i [W/m2K] = Convective thermal transfer coefficient at the inner face of the wall;
- α_e [W/m2K] = Convective thermal transfer coefficient at the exterior face of the wall;
- δk [m] = the thickness of the wall layer k;
- λk [W/mK] = the thermal conductivity of the wall layer k;

Equation (1) is defined in the C107-2002 design and calculation normative group and together with other adjacent relationships was used in the calculation of the case study parameters.

1.4. Presentation of the concept „Geothermal energy”

It is known from the published literature that the temperature, inside the Earth, rises towards the center. Geothermal energy is a form of renewable energy, obtained from the heat accumulated in the rocks and in the fluids that fill the pores of the rocks. Thus, steam and hot water are trapped in volcanic and tectonic areas - the tectonic plate joint areas and initially used only in the form of natural springs and thermal baths [5].

Geothermal energy is presented in two forms [5], as:

low temperature – specific for any part of the earth; it has been shown that it increases in depth by 3℃ at enery 100 m;

high temperature – specific to volcanic zones, the drilling depth being very high, reaching up to 10.000 meters deep;

Currently, due to the development of capture technology, the use of geothermal energy can be expanded to a dual purpose, both for heating homes and for producing electricity.

Figure no. 1 presents the map with the favorable areas for geothermal energy.

Fig.1 The map showing the favorable areas for geothermal energy [6]

"The potential of solar radiation" refers to the capacity of capturing solar radiation in a certain geographical area. From this point of view, Romania is divided into three areas of particular potential, thus [7]:

- The first area, wich includes the areas with the highest potential, covers the region of Dobrogea and a large parte of the Romanian Plain;
- The second area, with a good potential, includes the North of Romanian Plain, the Getin Plateau, the Subcarpathians of Oltenia and Muntenia, a large part of Danube Plain, the south and the center of the Moldovian Plateau and the Plain and Western Hills and the Western Plateau of Transylvania, where the value of solar radiations are between 1300 şi 1400 MJ / m^2;
- The third area, with a moderate potensial, has less than 1300 MJ / m^2 and covers most of the Transylvanian Plateau, the northen Moldavian Plateau and the Carpathian Rama[7]

Figure no. 2 presents the map of solar radiations.

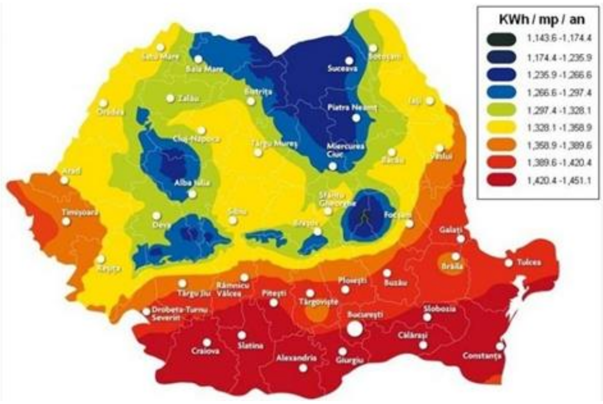

Fig. 2 The map of solar radiations [8]

2. DESCRIPTION OF THE THEORETICAL MODEL

Nowadays, the world economy relies heavily on energy that comes from non-renewable energy sources such as nuclear power or the energy generated by burning fossil fuels (crude oil, coal, natural gas). Due to the fact that these energy sources are limited to the existence of the respective deposits and their extraction, processing and transport to consumers implies additional costs and some negative influences on the environment, it should be paid more attention to the study of renewable energies.

The „Passive House" represents a concept that incorporates the characteristics necessary for a modern, ecological, economic lifestyle, as: efficiency, comfort, sustainability, inovation and accesibility.

A passive construction can use the resources it benefits in order to be energy-independent. A building that can be framed within this term must produce at least the amount of energy it consumes.

The technologies by which energy independence can be achieved, vary from one case to another, so each building has its peculiarities depending on the area in which it is located and depending on the meterials it is built with.

Regarding the structural system, used for the passive house model, two systems will be compared, one is a structure formed by reinforced concrete frames with brick masonry and the second one is metallic structure with exterior walls made of sandwich panels.

Considering the potential of the area, in order to ensure the energy efficiency of a building located in Constanta County, Mangalia area, we will study the energy production solutions using photovoltaic solar panels and using geothermal energy. In both situations, the exterior walls are finished by applying the architectural "wall with solar energy reservoir", a solution described in extenso by the authors Daniela Enz and Robert Hastings in the book "Innovative Wall Building". (Daniela Enz, Robert Hastings - Innovative Wall Constructions, Matrixrom Publishing House, 2012, pages 38-46).

The system consists of several layers, on the outer face with wooden lamellas. The system is balanced for the façade because during sunny days, the sun is capturing through the wood and the solar glass, component part, and in cloudy days or night period it gradually releases the accumulated heat. This maintains an almost constant temperature inside the enclosure regardless the temperature variation.[9]

The parameters characterizing the two types of structures are presented in Table no.1.

Tabel 1 The properties of the two types of structures

Properties	Type 1	Type 2
Resistance structure	Reinforced concrete frames with brick masonry	Metallic structure with exterior walls made of sandwich panels
Foundations	Reinforced concrete beams	Insulated under pillars, stiffened by concrete beams
Roof	Uncirculated terrace	Metal framing and cover - sandwich panels
The usable area	1105,20 mp	
The developed area	1498 mp	
Building volume	3962,70 mc	
The building cover surface	1365,02 mp	
The heated surface	1105,20 mp	
The heated volume	3205,08 mc	
The surface of opaque walls	354,16 mp	
Glazed surface	278,47 mp	
No. of persons	64	

3. RESULTS AND SIGNIFICANCES

3.1. Calculation of the thermal resistance of an outer wall for brick-built concrete frames

Table 2 Parameters for the calculation of heat transfer and transfer resistance, in case of frame structure [10]

Element	Material	thickness	ʎ	αi	αe	Ri	Re	R	R ele-ment	U Ele-ment
		m	W/ mK	W/ mpK	W/ mpK	mpK/ W	mpK/ W	mpK/W	mpK/ W	W/ mpK
External walls with wall system with solar energy reservoir	Exterior plaster	0,005	0,92	8	24	0,125	0,042	0,005	8,503	0,117
	Insulating layer	0,08	0,04					2		
	Brick	0,25	0,04					6,25		
	Interior plaster	0,03	0,84					0,036		
Floor on the ground	Concrete screed	0,05	1,16					0,043	3,224	0,310
	Concrete	0,1	1,74					0,057		
	Polystyrene	0,1	0,04					2,500		
	Ballast	0,25	0,7					0,357		
	Soil	0,2	2					0,100		
Uncirculated terrace	Interior plaster	0,03	0,84					0,036	5,505	0,182
	Concrete	0,15	1,74					0,086		
	Underlay	0,015	0,17					0,088		
	Polystyrene	0,2	0,04					5,000		
	Underlay	0,01	0,17					0,059		
	Concrete screed	0,08	1,16					0,069		
Double-glazed windows (with double-glazed windows with air layer)									0,570	1,754

The calculation was performed by applying equation (1). The data taken into consideration for the study of the whole solution is presented in Table no. 2 [10]

In this case, according to the equation (1): $\mathbf{R}_{PE}$ = 8,503m^{2}K/W.

3.2. *Calculation of the thermal resistance of a metallic structure with outer walls made of sandwich panels*

The calculation was performed by applying equation (1). The data taken into consideration for the study of the whole solution is presented in Table no. 3 [10]

Table 3 Parameters for the calculation of heat transfer and transfer resistance, in case of metallic structure [10]

<table>
<tr><th rowspan="2">Element</th><th rowspan="2">Material</th><th>thickness</th><th>ʎ</th><th>αi</th><th>αe</th><th>Ri</th><th>Re</th><th>R</th><th>R element</th><th>U Element</th></tr>
<tr><th>m</th><th>W/ mK</th><th>W/ mpK</th><th>W/ mpK</th><th>mpK/ W</th><th>mpK/ W</th><th>mpK/ W</th><th>mpK/ W</th><th>W/ mpK</th></tr>
<tr><td rowspan="3">External walls with wall system with solar energy reservoir</td><td>Plasterboard</td><td>0,0125</td><td>0,39</td><td rowspan="12">8</td><td rowspan="12">24</td><td rowspan="12">0,125</td><td rowspan="12">0,042</td><td>0,032</td><td rowspan="3">2,544</td><td rowspan="3">0,393</td></tr>
<tr><td>Insulating layer</td><td>0,08</td><td>0,04</td><td>2,000</td></tr>
<tr><td>Sandwich panel</td><td>0,10</td><td>0,29</td><td>0,345</td></tr>
<tr><td rowspan="5">Floor on the ground</td><td>Concrete screed</td><td>0,05</td><td>1,16</td><td>0,043</td><td rowspan="5">3,224</td><td rowspan="5">0,310</td></tr>
<tr><td>Concrete</td><td>0,1</td><td>1,74</td><td>0,057</td></tr>
<tr><td>Polystyrene</td><td>0,1</td><td>0,04</td><td>2,500</td></tr>
<tr><td>Ballast</td><td>0,25</td><td>0,7</td><td>0,357</td></tr>
<tr><td>Soil</td><td>0,2</td><td>2</td><td>0,100</td></tr>
<tr><td rowspan="3">Roof</td><td>Plasterboard</td><td>0,0125</td><td>0,39</td><td>0,032</td><td rowspan="3">1,794</td><td rowspan="3">0,557</td></tr>
<tr><td>Mineral wool</td><td>0,05</td><td>0,04</td><td>1,25</td></tr>
<tr><td>Sandwich panel</td><td>0,10</td><td>0,29</td><td>0,345</td></tr>
<tr><td>Double-glazed windows (with double-glazed windows with air layer)</td><td></td><td></td><td></td><td></td><td>0,570</td><td>1,754</td></tr>
</table>

In this case, according to the equation (1): $\mathbf{R}_{PE\ parter}$ = 2,544 m^{2}K/W

Sandwich panels embedded in the "wall with solar energy reservoir" system have some important features, centralized by the authors, but not presented in this article due to lack of space.

3.3.Establishing the power supply system

From the study of the potential of solar radiation and the study of geothermal energy, for the Dobrogea region, namely the Mangalia area, it was established that geothermal energy is used for heating, and solar energy is used to produce hot water. The building will be equipped with a ventilation system that will adjust the temperature of the indoor air and its capacity.

Currently, the power supply will also be made from the national system. It is mentioned that the installation for capturing and producing heat from geothermal energy can be designed also with the equipment related to the production of electric power. If the Romanian legislation does not allow this to be achieved, then for the production of electricity, the possibility of using wind energy, which also has a great potential in Dobrogea, will be studied.

4. CONCLUSIONS

Passive houses, as it can be seen from this case study, can represent a viable, future solution for the Dobrogea - Romania area. Furthermore, Directive 2010/31 / EU of July 2010 provides, among others, that by 31 December 2020 all new buildings must have almost zero energy consumption. [2]

In this regard, in Romania, has been developed the "Plan to Increase the number of buildings with almost zero energy consumption" issued by MDRAP [12], a plan for imposing taxes on new buildings with different functions related to the maximum primary energy consumption from conventional sources [kwh /mp, year] and CO_2 emissions into the atmosphere [kg /mp, year] as a result of the operating precesses of the buildings.

It is demonstrated and reconfirmed that the "passive energy house" system uses alternative energy sources, materials and environment-friendly installation systems. The maintenance costs, during their existence, as well as the waste they generate, are lower compared to the costs of a similar classical building. In this way, although the costs for the basic investment may be higher, by 25%, compared to the cost of a similar classical construction, they are justified by the lower costs during the exploitation period.

Construction systems in the civil engineering industry must be designed in such a way that the resulting buildings are compatible with the materials used, the building systems and the energy supply system - to obtain a passive building.

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Note:

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