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EXPERIMENTAL RESEARCH UPON BEHAVIOUR OF HIGH EFFICIENCY MATERIALS FOR THE BUILDING ENVELOPE IN NON-STEADY REGIME

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Abstract: *Rehabilitation of buildings was discussed when it was considered necessary to increase the thermal resistance of exterior building components while decreasing the rate of fuel related housing solution that led to the worsening situation in the apartments. "Sustainable Building" is one of the main priorities of European Union programs. This priority is due to the fact that the construction sector's energy consumption in EU member states representing 40% of total energy consumption.*

Experimental research performed and whose results are presented in this paper tries to answer questions related to achieving "sustainable building".

Key words: *rehabilitation, efficiency, materials, non-steady regime, research, building.*

1. INTRODUCTION

The building is an ensemble of apartments, running spaces and other common spaces, bounded by a number of surfaces that make up the building envelope and where heat loss occurs.

Rehabilitation of buildings was discussed when it was considered necessary to increase the thermal resistance of exterior building components while decreasing the rate of fuel related housing solution that led to the worsening situation in the apartments.

Solving the problem of rehabilitation of existing buildings is quite difficult due mainly to relatively low financing possibilities.

It is estimated that energy savings could be achieved more than 50% of current fuel consumption, which corresponds to a reduction in consumption of approx. 5000-6000 tons of conventional fuel / year.

"Sustainable Building" is one of the main priorities of European Union programs. This priority is due to the fact that the construction sector's energy consumption in EU member states representing 40% of total energy consumption.

Thus, the panels subjected to experimentation are made from the materials used for about 80 % of existing buildings that require an immediate improvement in energy performance.

2. PANELS DESCRIPTION

The five segments of panels that have been tested, following the contour conditions and method of attachment of thermocouples have the following composition:

1.Mono-layer structure –B1

- made of block masonry BCA-GBN.35 with mortar M 25, 40 cm thickness and plastered inside and outside with mortar M.50 1 cm respectively 2 cm thickness.

2. Bi-layer structure–B2

- made of 15 cm concrete B 250, reinforced on inside and blocks masonry BCA.GBN.35 25 cm thickness and plastered inside and outside with mortar M.50 1 cm respectively 2 cm thickness.

3. Triple-layer structure–B4

- made of two concrete layers B.250 , reinforced, inside layer 12 cm outside layer 7 cm with a thermal insulation made in mineral wool G.100 8 cm thickness.

4.Monolayer structure (used only for thermal insulation) –A5

- made of expanded polistyrene.

5. Monolayer structure (using only for thermal insulation) –A6

- made in mineral wool G.100 8 cm

3. CHARACTERISTICS OF STEADY AND NON STEADY THERMAL REGIME

The response and behaviour of closure elements in general and of the building under the action of variable external factors, the real clue is the thermal efficiency and constitutes a higher stage of experimental research until recently only based on establishing steady state response

The panel five distinct segments analyzed (three single-layer structure, a bi-layer structure and a tri-layer structure) aimed at assessing the steady state and non-stationary, each representing a specific structure, composition, or a certain material.

Achievement of the steady regime means the determination in the conditions of the climate area II (t_e = -15^0 C), of the following characteristics:

- inside surface temperature of each area;
- specific thermal resistance for each area.

The non steady regime is being achieved under the same winter conditions, with a sinusoid variation of the external temperature, with a 24 h period and interior temperature t_i = +18^{0}C, determining the following characteristics:

- the damping coefficient for the exterior air temperature oscillation;
- phase shift value;
- thermal inertia index.

Experimentally the values of installing duration of permanently variable regime, by passing from steady to non steady regime, and the experimental data were comparatively analysed against the one resulting from calculations

The permanent non steady regime maintains constant the parameters from the table 1, on the entire duration of the test or test sequence where measurements were prescribe in the designing phase. Through the initial designing of the test the precise parameters have been established- air temperature, relative humidity and air speed. They have to characterize the climatic area, aim of test and appreciation of effects by element behaviour. Considering the recommendation of the STAS 12057, achievements of the described conditions for the permanent regime is being tracked through hourly measurements, after starting the starting of stage of achievement of interior and exterior climate.

The steady regime is being considered as settled and all the measurements can be done when the difference between two successive values of the test surfaces temperature in different characteristic areas does not differ more by 0,1^0 C during the last 4 hours.

The tests are being made by means of thermistors and thermometers installed in the control points.

Table 1

Climate parameters simulated in steady and non steady regime

Simulated climate parameter	Symbol	Measuring unit	Parameter value
Steady regime			
a) inside climate*			
Air temperature	T_i	^{0}C	18 ± 0,1
Relative humidity	ρ_i	%	60 ± 1 %
Air speed***	V_i	m/s	0,10
b) outside climate			
Air temperature	T_e	^{0}C	−15 ± 0,1
Relative humidity	ρ_e	%	85 ± 2 %
Air speed***	v_e	m/s	1,00 ± 0,1 %
Non steady regime			
a) inside climate*			
Air temperature	T_i	^{0}C	18 ± 0,1
Relative humidity	ρ_i	%	60 ± 1 %
Air speed***	v_i	m/s	0,10
b) outside climate			
Air temperature** $T_e = T_{em} + A_{Te} \sin\omega\tau$	$T_e = f(\tau)$	^{0}C	Time function
Relative humidity	$\rho_e (T_e)$	%	100 → 23 %
Air speed***	v_e	m/s	1,00 ± 0,1 %

Note:

[*]according to STAS 1907/2-97 – measured and regulated values are at 2,0m of panel and 0,75 height from floor (regulation point)

[**]the exterior air temperature is variable following a sinus function with average value $t_{em} = -10^0C$, period T = 24 h, amplitude $A_{Te} = 10^0C$, $\omega = 2\pi/T$, τ – momentum of instant value measurement

Regime duration is 8 period (192 hours)

[***] air speed v_i at measuring and regulating point is according to STAS 1907/2 – 97.

The final result is being considered by averaging the last three measurements at 4 hours interval after establishing the permanent steady regime

During the experiment the climate condition in steady regime, according to climate area II have been compared to the parameters of current use of panels in the building, (table 1), and for non steady regime the exterior climate variable have been simulated following the a sinus function for 24 hours following the parameters in table (1).

The non steady regime may generate any variation function of the climate parameters.

4. EXPERIMENTAL RESULTS. ANALYSIS OF EXPERIMENTAL RESULTS

Switching to non-steady regime was achieved directly from the steady thermal regime without interruption, in order to determine, for each of the five compositions and the effect of climate change in external conditions as a sine function of period t = 24 h and when installing variable thermal regime Characterized as non-stationary thermal regime that values instant same repeatable accuracy limits imposed successive periods ($0,10^0$ C).

Non-steady thermal regime duration was 192 hours (8 hours of variation of 24 h) of the last five with continuously variable temperature control during which he made and determining the amplitude of the oscillation damping values of air temperature on the inner and outer phase shift.

Hygrothermal behavior under nonstationary regime

Non-stationary thermal regime is characterized by the sinusoidal variation with the oscillation period T = 24 hours.

The transition from stationary thermal regime in non-stationary thermal regime is done periodically through a transient state, actually present in any form of transition from steady to periodic variable regime.

Non-stationary thermal regime under which the proceedings are determined thermal characteristics must satisfy the condition of dynamic stability for the purposes of overcoming the transitional arrangements and obtaining a steady variable size so that the instantaneous response $T_{si}(\tau)$,for a given moment τ to be repetable (with error level γ) in successive periods of function variation

Based on the above considerations the condition for accomplishing the permanent variable regime, dynamically stable is:

$$T_{si}(\tau_r) = T_{si}(\tau_r + T) = T_{si}(\tau_r + nT) = const. \pm \gamma \quad (1)$$

where:

τ_r represents the duration of transitory regime;

γ - allowable error level.

Thus the response function answer $T_{si}(\tau)$ to the action of temperature variation of exterior air, $T_e(\tau)$ is also a periodic function, which, under dynamic stability conditions is characterized by the following law:

$$T_{si}(\tau) = T_{si_m} + A_{T_{si}} \sin \omega(\tau + \varepsilon) \pm \gamma \quad (2)$$

where:

T_{sim} represents the average temperature of interior surface;

A_{Tsi} – interior surface temperature oscillation amplitude;

ε - phase shift of the response function T_{si} compared to excitation function T_{se}

In the concrete conditions of the experiments conducted, the installation of permanent variable regime was found by tracing the inner surface temperatures continue to change the panel segments studied and that the following conditions:

- value of interior surface at a given moment τ during the oscillation period T remains constant within precision limits ± 0,05^{0}C and the value to be repeatable in the successive periods;

-phase shift value ε to remain constant within precision limits ± 5 % from the constant value for the respective area and the value to be repeatable in the successive periods.

They also determined the transient times τ, then, from the start of the action outside air temperature variation, have fulfilled the two conditions above.

A graph of the variation $T_e(\tau)$ and $T_{si}(\tau)$ based on equation 2 knowing all the defining elements (following the tests and measurements performed) for the 5 segments of panels studied is shown in figures 1, 2, 3, 4 and 5.

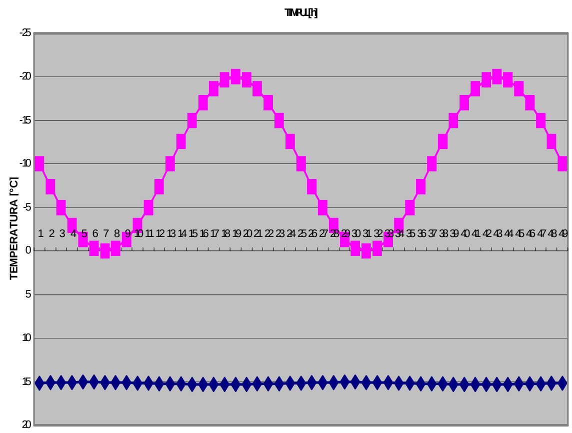

Fig. 1. Measured values of interior and exterior temperatures in time for the monolayer panel used as structural element B1

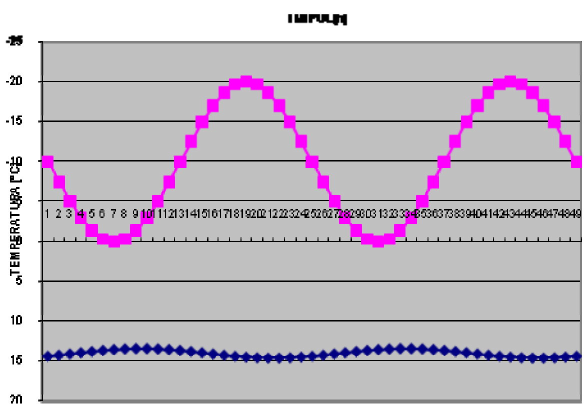

Fig. 2. Measured values of interior and exterior temperatures in time for the bi-layer panel B2

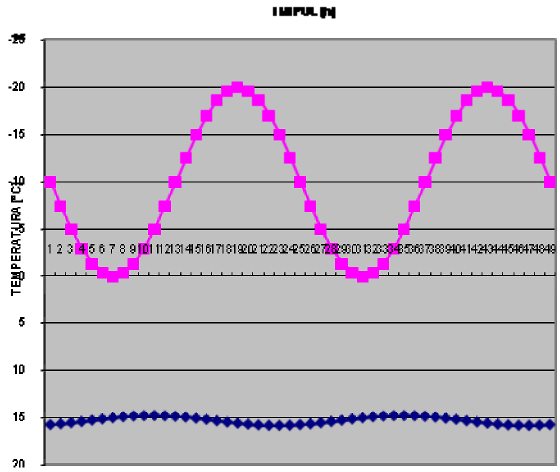

Fig. 3. Measured values of interior and exterior temperatures in time for the tri-layer panel B4

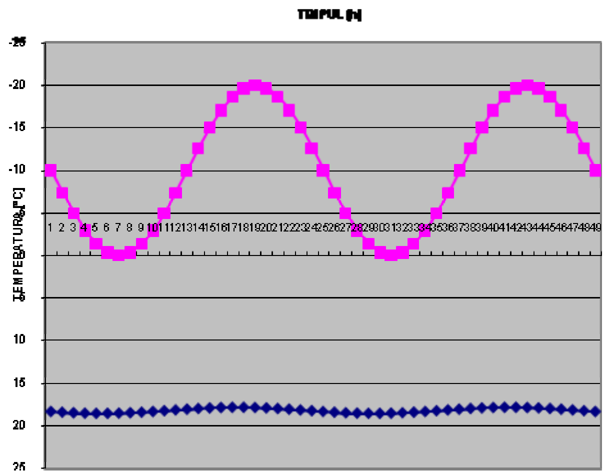

Fig. 4. Measured values of interior and exterior temperatures in time for the monolayer panel A5

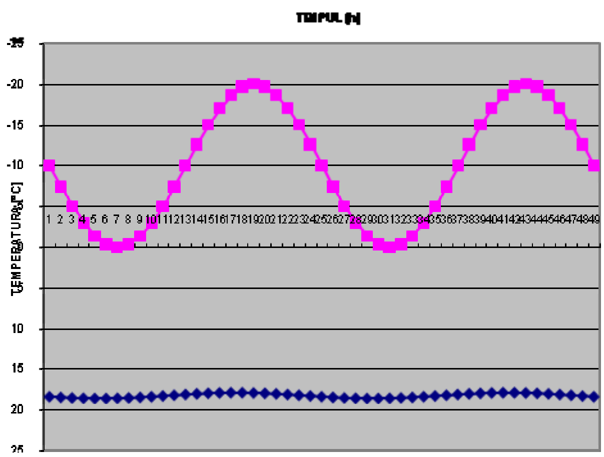

Fig. 5. Measured values of interior and exterior temperatures in time for the monolayer panel A6

Figure 6 shows the variation of interior temperature, in time, for the 5 studied panels.

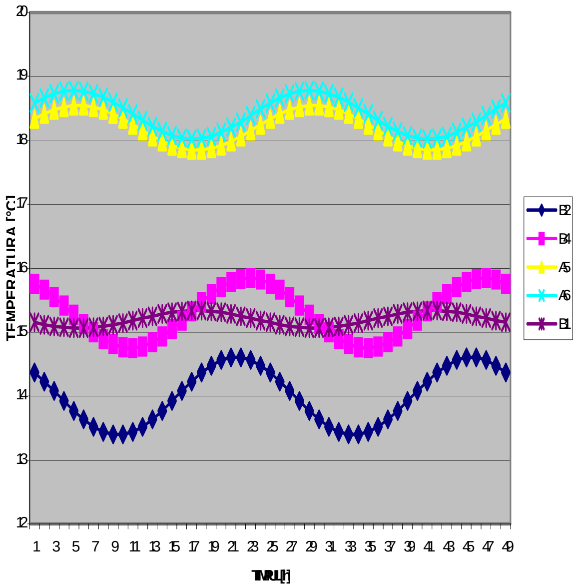

Fig.6. Measured values of interior and exterior temperatures in time for 5 studied panels

5. CONCLUSION

The comparison quality and quantity wise the analysed panel segments (made from several materials – BCA-GBN 35, concrete B.250, mineral wool and polystyrene – and having different structures mono, bi and tri layer) from the efficiency characteristics point of view in stationary and non-stationary regime.

Analysing the measured values of exterior and interior temperatures, in time, for the 5 segments of panel presented in the figures 1-5, and the variations and the variation of interior temperature value shown in figure 6, it can be noticed that the values of the interior temperature variation for thermo insulating elements are very close (average temperatures for the monolayer panel segments A_5 being $18,2^0$C while the one for the segment panel A_6, being $18,4^0$C); for segments of panel making the structure of building of exterior walls B_1, B_2 and B_4, the parameters defining the variation in time of the interior temperature is different due to the materials composing them (average of interior temperatures for the panel monolayer B_1 being $15,1^0$C , the one for the segment of bi-layer panel B_2 , $13,9^0$C, and the one for the segment of tri-layer panel B_4, $15,3^0$C).

It has been observed that in certain measuring points the values for interior temperature for mono and tri-layer panel segments from the structure are crossing. The interior value of temperature of monolayer structure is in certain measuring points above the one of the tri-layer structure, but not exceeding its upper value. For approximate the same average interior temperature ($15,1^0$C for B_1 respectively $15,3^0$C for B_4), the oscillation amplitude is much reduced in the case of monolayer structure, thus revealing that the monolayer structure ensures a higher comfort compared to the tri-layer one.

A direct consequence of this behaviour is the uniform load of the heating installation by keeping relatively constant the temperature of the thermal fluid, imposed by the real exterior temperature in the case of a qualitative regulation.

6. REFERENCES

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CERCETĂRI EXPERIMENTALE ASUPRA COMPORTĂRII UNOR MATERIALE EFICIENTE PENTRU REALIZAREA ANVELOPEI CLĂDIRII ÎN REGIM TERMIC NESTAȚIONAR

Reabilitarea clădirilor s-a luat în discuție în momentul în care s-a considerat necesară creşterea rezistenţei termice a elementelor de construcție exterioare concomitent cu scăderea cotei de combustibil aferente locuinţelor.

"Clădirea durabilă" reprezintă una din principalele priorități ale programelor Uniunii Europene. Această prioritate este datorată faptului că, consumul de energie al sectorului construcții din statele membre UE reprezintă 40% din consumul total de energie.

Cercetările experimentale realizate şi a căror rezultate sunt prezentate în lucrarea de față încearcă să răspundă întrebărilor legate de realizarea "clădirii durabile".

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