CASE STUDY IN THE THERMAL REHABILITATION PROCESS

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Abstract:
The thermal rehabilitation national norms for existing building stock are correlated with the European Community standards that provide the determination of the thermal performance of residential buildings for the calculation of the energy necessary for heating, in accordance with EN ISO 13790:2004. The norms consider that the annual heating duration (D12) starts when the exterior temperature (θe) drops below 12°C. This study was conducted to illustrate that the determination of the energy necessary for heating the building must be made by taking into account the daily variation of the site-specific exterior climatic parameters, and by taking into account in calculations the thermal inertia characteristics of the building envelope materials. This provides results closer to the actual heat loss phenomena occurring in a thermal rehabilitated or unrehabilitated building.

Keywords: Mathematical modeling, simulation, heat transfer, building energy performance

INTRODUCTION

From our research team experience in the thermal rehabilitation process of more than 200 buildings, we saw a decrease in total costs for energy necessary in heating the building during a whole year, at a rate of 35-45%. For unrehabilitated buildings heating costs are highest in February and decrease progressively until the end of April. But for thermal rehabilitated buildings we observed low heating costs but with relatively constant value, extended until May. The paper presents comparative results of the energy necessary for heating a collective apartment block, determined for the calculation assumptions provided by the SR EN ISO 13790:2005 normative and also determined based on the temperature field in dynamic thermal conditions.

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The paper presents a case study made on a residential building that exists in Plopilor neighborhood from Cluj-Napoca, Romania. The building has a system of height GF+ 4F, made of vertical perforations brick masonry of 29 cm. The building has 2 apartments on each floor, each having 3 rooms, kitchen, bathroom, and vestibule and daylight staircase. The height of the concrete floors is of 19 cm and 14 cm. Reinforced concrete columns exist at the intersections of load-bearing walls, and at each level the floor is supported by a reinforced concrete beam. The terrace is insulated with expanded slag having a medium height of 30 cm. The building has an east-west orientation with the main façade south oriented.

As contour conditions, the interior temperature is taken in accordance with SR 1907/2 standard and the exterior temperature is considered in accordance with the C107/3-2005 norm.

Fig.1. Building case study
The SR 1907/2 standard gives interior design temperatures for all types of functions in a building. The C107/3-2005 norm gives the exterior temperature values for the 4 climatic zones existing in Romania. The studied building is situated in the IIIrd climatic zone, which means an exterior temperature calculation value equal to -18°C.

MATERIAL AND METHOD

In the first calculation variant the annual energy needs for heating was performed considering the hypothesis of standard calculation in steady state regime, for the actual building and for the thermal rehabilitated one. This involves a calculation made in one step throughout the annual heating duration, considering that the calculation temperatures have a constant value, namely the comfortable indoor temperature \( \theta_i \) and the average exterior temperature during the heating duration.

For the second stage of research, the annual heating necessary calculation was done using a computer program developed by the building physics team, program used in current practice for more than 20 years. The program takes into consideration building site conditions and nature of the terrain, and also the variable daily climatic conditions specific for the location: outside temperature, wind speed and solar radiation. The
calculation was made in the unsteady state regime taking into consideration the thermal inertia of the building.

Determination of heat loss for the building was made based on the dynamic spatial temperature field determined with the computer program. In order to use the computing program, the building as a whole together with the land on which it is located, between horizontal and vertical cutting plans, was divided with the help of sectioning plans forming a spatial orthogonal computing network of the temperature field. The computing network is generated automatically by the computer program.

The numerical method used is that of energy balance in each node of the spatial discretization network of the assembly. The computing program takes into consideration the stipulations from the EN ISO 10211/1-2007 norm, regarding the way that the discretization network is obtained and the requirements for the estimation of the flows equilibrium in the computing network nodes.

From the many studied cases are presented. the results obtained for the real building and for 3 variants of thermal insulation with 10 cm, 15 cm and 20 cm. For windows the following thermal resistances were considered:
for the real building $R_W = 0,50 \text{ m}^2\text{K/W}$, for the thermal insulated building with 10 cm $R_W = 0,55 \text{ m}^2\text{K/W}$, for the thermal insulated building with 15 cm $R_W = 0,65 \text{ m}^2\text{K/W}$ and for the thermal insulated building with 20 cm $R_W = 0,75 \text{ m}^2\text{K/W}$.

RESULTS

The four variants presented before were studied for 2 calculation hypothesis, respectively the hypothesis foreseen by the SR EN ISO 13790-2005 norm and the hypothesis when the determination of the heating energy necessary is done based on the spatial temperature field in dynamic thermal regime. Below are presented the graphs with the daily variation of the energy necessary for heating the analyzed building, for the heating period in a whole year. In the graph from figure 6 are presented the results obtained for standard conditions for the town where the building is located. For Cluj-Napoca the heating period is considered to start on the 27th of September and ends on the 2nd of May, which means $D_1=218$ days. For the same building in the second graph are presented the results obtained when the heating energy necessary was determined based on a dynamic regime.

![Fig. 5. Examples of isothermal surfaces in vertical section through the building](image-url)
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The results given by the program are under numerical and graphical form. For a better understanding of the obtained results the program generates spatial temperature fields and also isothermal surfaces in plane sections through the building, at various intervals set by the user.

**Fig. 6.** Energy necessary for heating the building in steady-state regime

**Fig. 7.** Energy necessary for heating the building in unsteady-state regime
DISCUSSIONS

Keeping heating costs over the standard duration (2\textsuperscript{nd} of May), is due to the thermal insulation disposed on the exterior of the building envelope which emphasizes its contact with the ground and blocks the absorption of solar radiation by the opaque area of the buildings and its storage in the building structure.

When determining the energy necessary for heating in unsteady regime the operation of the heating device starts earlier, respectively in September, and in the case on thermal insulating the building with 20 cm it begins at the end of August and ends in late May.

As seen in figure 7, for ensuring the comfortable interior temperature, the real heating duration increases for the thermal rehabilitated buildings compared to the standard one.

Results obtained by using the developed dynamic calculation program has a degree of uncertainty between 10-20\% compared to the 20-35\% uncertainty degree obtained for calculating the heat necessary under normative conditions.

CONCLUSIONS

The results show that the annual heating duration is greater than the standard one if the building is thermal insulated. The number of heating days increases with the increase of the building thermal protection layer. It is worth noting that for thermal insulated buildings although that the heating duration increases, the annual energy necessary for heating decreases compared to the one calculated under standard conditions.

This study stemmed from the need of explaining the phenomenon found in practice, that for the thermal rehabilitated building the heating installations operate longer than for the same unrehabilitated building.

Taking into account the thermal inertia of the building envelope in heating energy necessary calculation, permits the determination of the real heating duration with a high degree of accuracy and of the energy necessary for ensuring the comfortable indoor temperature throughout the entire heating period. As a result of such calculations, the obtained results allow a correct choice of a suitable heating installation for the real thermal behavior of the building.

Therefore, the results presented in the paper allow recommending the use of dynamic analysis in assessing the energy necessary, by specialists and researchers in the field.

REFERENCES

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