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NUMERICAL RESEARCH CONCERNING THE THERMAL BEHAVIOR OF BUILDINGS

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Abstract: *Numerical modeling of thermal behavior of buildings allows both analysis of the influence of various external factors and optimizing technical solutions for sealing elements. As far as real phenomenon modeling approaches, namely experimental conditions, the simulation results obtained are comparable with experimental results.*

This work aims to answer some questions related to the using in numerical research concerning the thermal behavior of buildings.

Key words: *research, building envelope, software, temperature, iso-lines, iso-curves*

1. INTRODUCTION

Numerical modeling of thermal behavior of buildings allows both analysis of the influence of various external factors and optimizing technical solutions for sealing elements. This paper presents research conducted using the computer program RDM6 upon data structures, using finite element method.

Analysis by this method consist of six structures of the materials studied revealed its enormous advantages for the study of complex thermal structures. The method allows rapid and accurate calculations can be performed by modeling the structure.

2. GENERAL CONSIDERATION

Numerical modeling allows analysis of the influence of various factors both external and optimizing technical solutions for sealing elements.

As far as real phenomenon modeling approaches, namely experimental conditions, the simulation results obtained are comparable with experimental results.

Computer program used for numerical modeling is a mesh and automatically enters the data, software to write the equations of elementary, assembling them into the overall system and solving the system of data obtained.

Below, the computer program is being explained, the steps taken in formulating the problem and the results achieved.

3. USING THE RDM 6 SOFTWARE

The RDM6 software can calculate structures by finite element method.

The accepted hypothesis was stationary and non-stationary thermal regime, leading to good results in hygro-thermal design of buildings. There are the situations that occur in operation, corresponding to variable thermal regime and which is solved by numerical calculation methods, namely by solving the differential equation under non-stationary heat conduction for unidirectional heat flow. For their determination, using the finite element method, with a contour conditions governing the temperature variation in time to limit screened and the contact area between the layers of different materials.

Thus, the differential equation form:

$$\frac{\partial T}{\partial \tau} = a\frac{\partial^2 T}{\partial x^2} \qquad (1)$$

where:

$\frac{\partial T}{\partial \tau}$ is the partial derivative of temperature with respect to time;

$\frac{\partial^2 T}{\partial x^2}$ - second order derivative of temperature in relation to material layer thickness x;

$a = \frac{\lambda}{c\delta}$ - material thermal diffusivity [m^2/s], becomes the order of finite difference calculation.

$$\frac{\Delta_x T}{\Delta \tau} = a \frac{\Delta_x^2 T}{\Delta x^2} \qquad (2)$$

The continuous domain of construction element is being meshed into strips perpendicular to heat flow, taking a step of splitting constant or variable

Temperature variation in different planes - including on the inner $T_{Si}^{\tau+\Delta\tau}$ and outer $T_{Se}^{\tau+\Delta\tau}$ - is based on heat balance written to limit those areas.

Write and solve the system of equations determining the temperature status of construction element under the program variable is being made with RDM6, which enables different shape conditions.

Thus, the internal temperature can be:
- constant;
- variable sine or cosine with period 6, 12, 18 and 24 hours;
- variable as polynomial functions;
- with some variations, brought meshed after measurements.

Outside temperature can be:
- variable sine or cosine with period 24 hours.;
- variable as polynomial functions;
- with some variation introduced by measurements discretized.

After completion of the geometrical model, mesh structure follows.

3.1 CALCULATION MODEL EXPLANATION

Obtaining thermal model itself includes three distinct phases:

- Modeling
- Calculation itself
- Visualisation

Modeling involves the introduction of material types (name, Young's modulus, Poisson's ratio, density, expansion coefficient, thermal conductivity, volumetric heat capacity), their dimensions and thermal loads). The program allows the introduction of point loads and surface temperature and heat flux and convection loads (temperatures and conductive heat transfer coefficients).

The calculation itself is performed in a very short time and depends on the scattering matrix stiffening.

Visualisation (drawing graphics) makes drawing iso-lines and iso-values of the heat flux density and temperature. Also, sections can be made for viewing heat flow and temperature along the section, as well as in each node obtained by meshing.

4. THE RESULTS OF NUMERICAL ANALYSIS OF THERMAL BEHAVIOR OF BUILDINGS

For the structure of BCA-GBN.35 masonry blocks, heat transfer mathematical model has been performed. Thus, considering that the segment is one of the monolayer toughened pane, one materials used for several existing buildings that require an immediate improvement in their energy performance, I considered as being insulated at the outside with polystyrene and mineral wool thermal insulation materials considered usual. In this way we obtained two different structures whose production is still done.

OPTION 1

The building consists of masonry block structure BCA-GBN.35, 40 cm thickness, plastered inside and outside with mortar M.50 thickness of 1 cm to 2 cm insulated with **expanded polystyrene** (15 cm) on the outside configuration is shown in Figure 1:

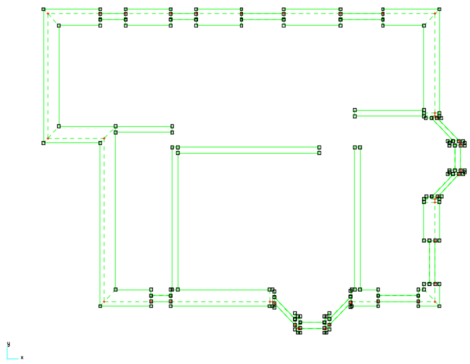

Fig.1 Building plan made of masonry BCA-GBN.35 insulated on the outside with expanded polystyrene

To discretize this section were used triangular 2D finite elements with 4088 nodes and 1694 elements (Figure 2).

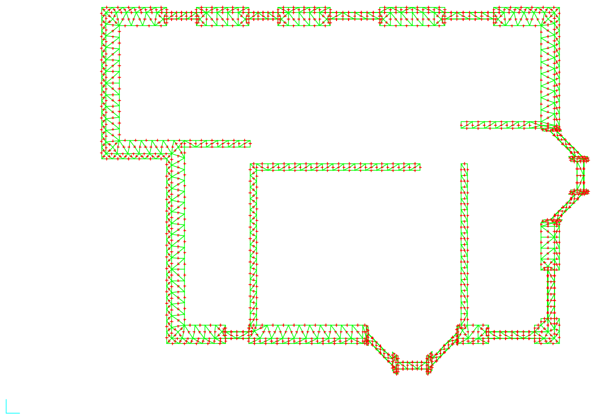

Fig. 2 Mode using the finite element mesh of triangular 2D sections

The section contains four types of materials (Figure 3) which are: BCA masonry GBN.35, expanded polystyrene insulation, glass windows and air between the windows.

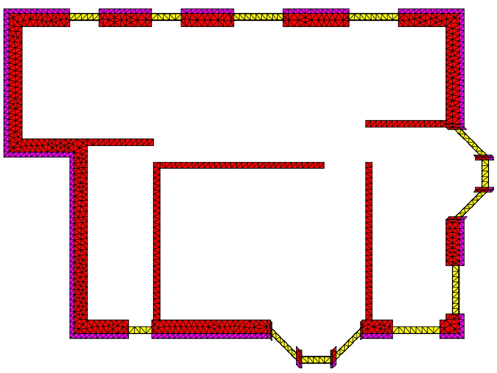

Fig. 3 Presentation materials used in the case data structure

Variation of temperature inside the structure was determined in the worst case (winter) the variation of temperature between indoors and outdoors is greater. Thus, considering that the building analyzed temperature is 18 degrees C and the outside of -15 degrees C (Figure 4).

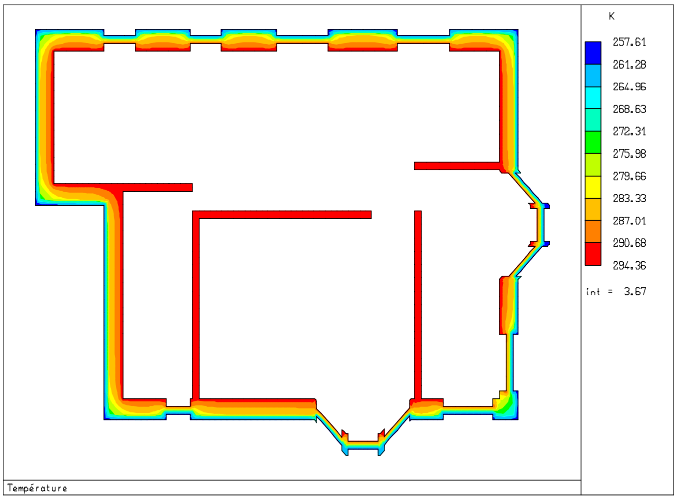

Fig. 4 Temperature variation considering the inner temperature, $T_i = 18\ ^0C$ and the outer one $T_e = -15\ ^0C$

In figure 5 are representative temperatureiso-curves obtained with the RDM 6 software.

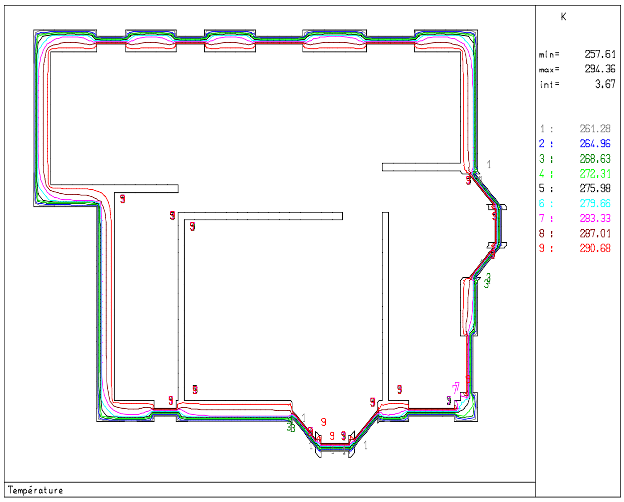

Fig. 5 Temperature iso-curves

Following analysis shows that the maximum heat flows occur in contact areas between the windows and the outer wall (Figure 5), and a detail is shown in Figure 6.

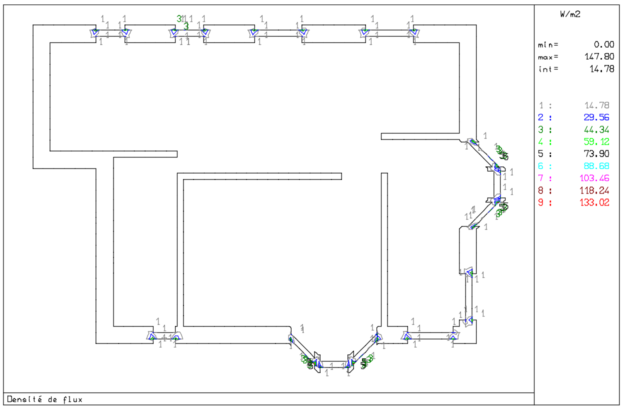

Fig. 6 Iso lines of the thermal flux density

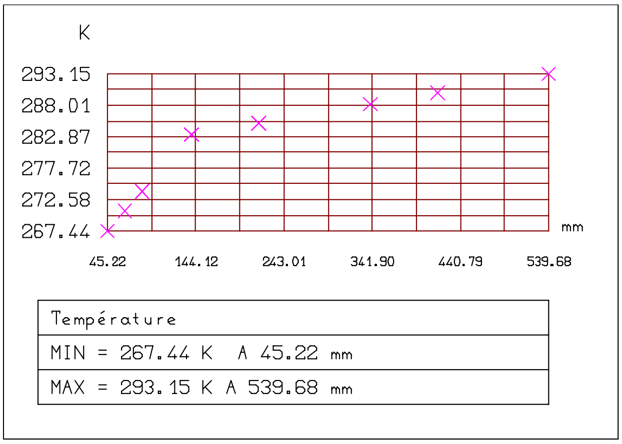

Fig. 7 Temperature variation curve in the most unfavorable orientation wall

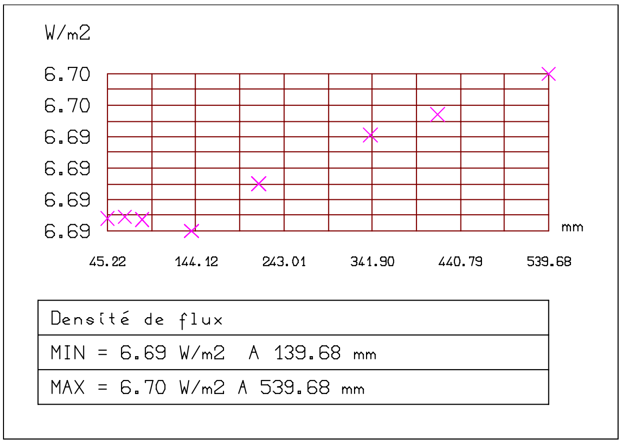

Fig. 8 Graph of the heat flow variation curve in the most unfavorable orientation wall

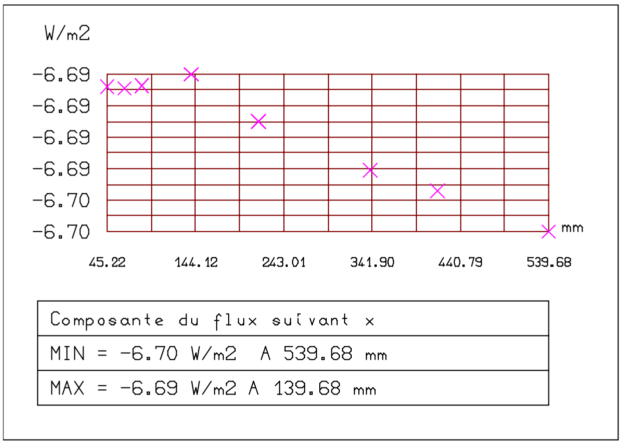

Fig. 9 Graph of the heat flow variation on the x axis in the most unfavorable position wall

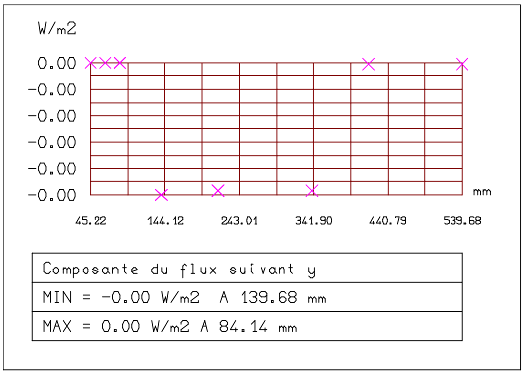

Fig. 10 Graph of the heat flow variation on the y axis in the most unfavorable position wall

OPTION 2

It is considered the same monolayer structure consisting of BCA-GBN.35 masonry blocks with a thickness of 40 cm exterior and interior plastered with mortar M.50 thickness of 1 cm to 2 cm and fitted with insulation of **mineral wool slabs G.100 rigid exterior.**

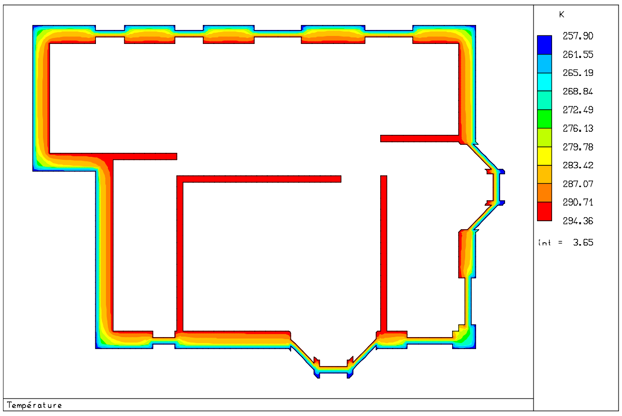

Fig. 11 Temperature iso lines for the given structure

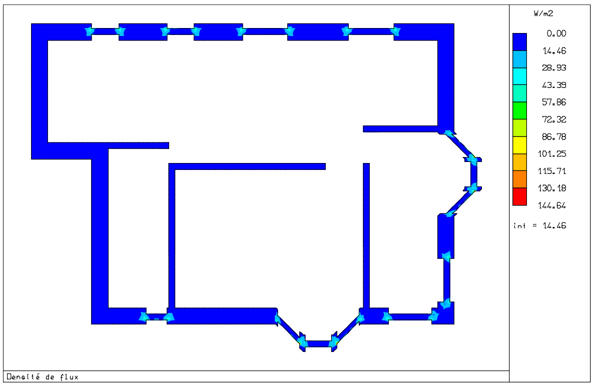

Fig.12 Isovalues of heat flow for the given structure

Exterior wall thickness, in this case is the same as in option 1. The temperature difference between inside and outside walls are the same (as the outside temperature of -15 deg. C, and the inner 18 deg. C). Figures 7 and 8 are presenting the iso values for temperature and heat flow density for this section.

Figures 13 and 14 are iso-lines of temperature and heat flux density for the given structure.

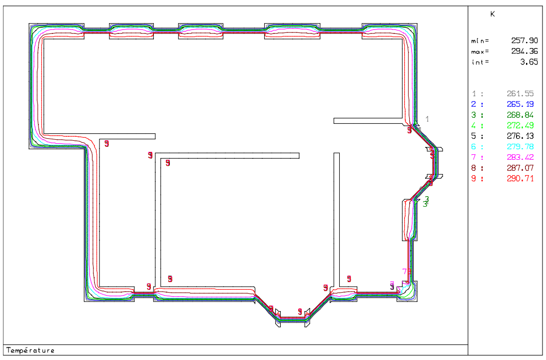

Fig.13 Temperature iso-lines for the given section

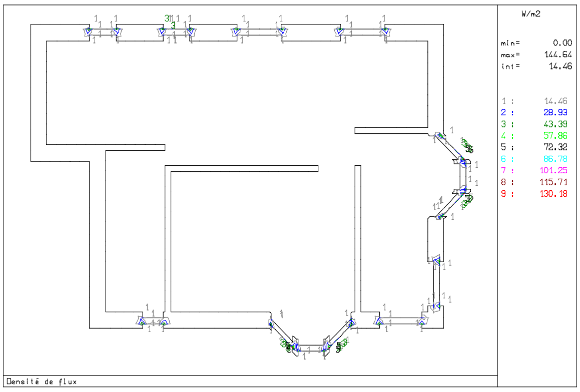

Fig. 14 Heat flow density isolines for the given structure

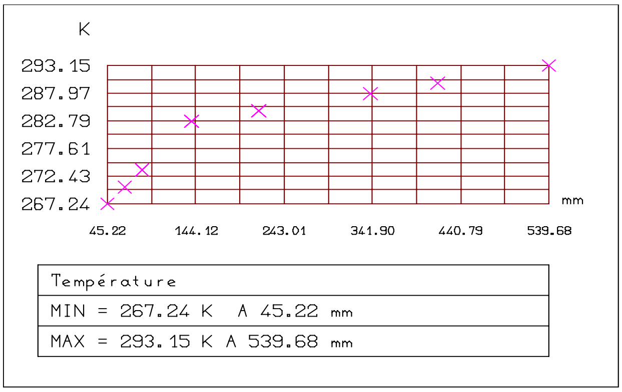

Fig. 15 Graph of the temperature variation in the most unfavorable position wall

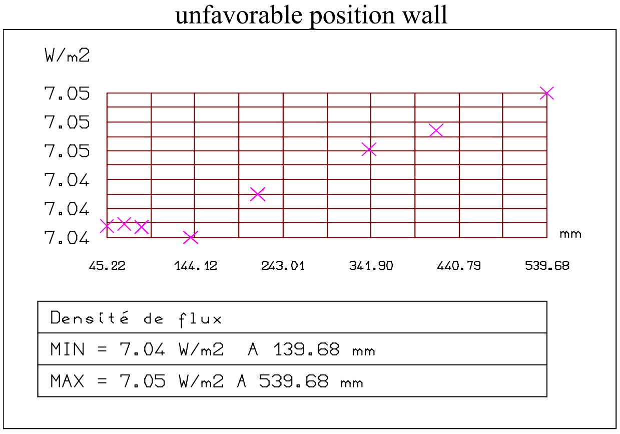

Fig. 16 Graph of the haet flow density variation in the most unfavorable position wall

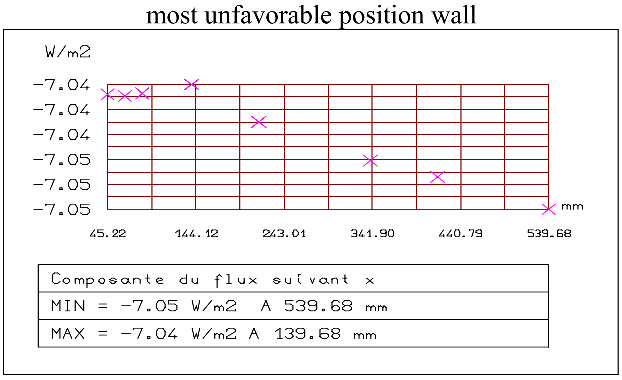

Fig. 17 Graph of the heat flow density variation on x axis in the most unfavorable position wall

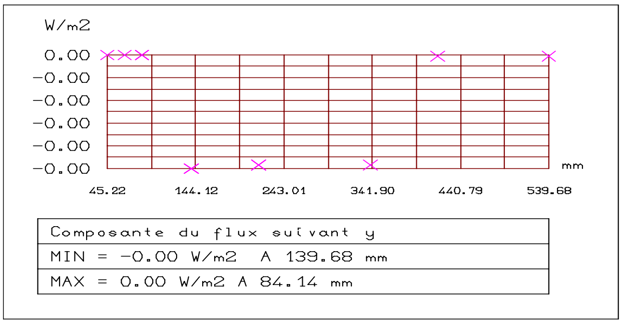

Fig. 18 Graph of the heat flow density variation on y axis in the most unfavorable position wall

5. CONCLUSION

Comparing the two variants in the structure of resistance has the same composition (BCA GBN.35 masonry blocks and mortar M25, with a thickness of 40 cm exterior and interior plastered with mortar M.50 thickness of 1 cm to 2 cm) but insulation is composed of expanded polystyrene and the first variant in the second variant of mineral wool (the two but with the same thickness, 15 cm), we observe that for the same building as the same indoor and outdoor thermal conditions, heat flux density is almost identical, the deviation being 0.2%. Maximum heat flux for both cases is the same point of the section (in the joints of windows to wall).

Analyzing graphs of variation of temperature, heat flow density and its two components x and y direction, the same point of the wall facing north, under the same conditions of temperature inside and outside wall of the same thickness (15 cm both polystyrene insulating material as well as wool) have very similar values, as follows: the first variant, the minimum temperature is 267.44 K, 293.15 K and the maximum, the second variant, these temperatures have value 267.24 293.15 respectively. Heat flux density, the first possibility is that the minimum maximum values equal to 6.69 W/m^2 and 6.70 respectively in the second variant are 7.04 and 7.05 W/m^2.

Temperature iso-lines derived from mathematical modeling of different forms in different parts of the wall. It is noted that in areas where thermal stress and material properties are homogeneous, iso-lines are almost parallel. In areas where different materials (instead of blending the various components of the wall material) and in the joints between walls and windows and corners, they change shape depending on their characteristics.

Heat flux density iso-lines in the structure reveals its time variation. Changing the heat flux density is evident in the areas of intersection of the elements of construction around openings for windows and doors and where the structure elements involved sealing materials.

Corroborating the above assertions, we conclude that, in terms of thermal behavior of buildings, there is a need to eliminate or at least reducing any thermal bridges, particularly in the areas of intersection construction elements and around openings windows and doors.

6. REFERENCES

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CERCETĂRI NUMERICE PRIVIND COMPORTAREA TERMICĂ A CLĂDIRILOR

Modelarea numerică privind comportarea termică a clădirilor permite atât analiza influenței diferiților factori exteriori cât şi optimizarea soluțiilor tehnice pentru elementelor de închidere. În măsura în care modelarea se apropie de fenomenul real, respectiv de condițiile de experimentare, rezultatele obținute în urma simulării sunt comparabile cu rezultatele obținute experimental.

Lucrarea de față îşi propune să răspundă unor probleme legate de utilizarea programelor de calcul existente în cercetările privind comportarea termică a clădirilor.

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