ENERGY PERFORMANCE ASSESSMENT FOR EXISTENT SINGLE FAMILY DWELLINGS

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Summary

The Romanian regulations concerning the energy performance assessment of existent buildings are mainly focused on collective buildings, blocks of flats, because these are characterised by a low level of thermal insulation and they require quick rehabilitation measures. The adoption of an assessment methodology for single family dwellings, that knew a significant development in the last 20 years, involves the taking into account of some specific aspects.

The paper presents the results of a case study for a single family dwelling, for which it was evaluate the energy performance when the building was put into operation, on the design base, and then after 4 years, on the base of the information from the owner and on the base of a thermo-energetic analysis.

Keywords: energy performance, thermal insulation, compactness index, thermal bridge, yearly specific energy

1 Introduction

The Romanian regulations concerning the estimation of a building energy performance especially refer to blocks of flats and social and cultural buildings, without peculiar specifications for single family dwellings; this program knows now a large development. As a consequence to the restriction existent before 1990 that the whole population must live in multistoried buildings, in Romania the building of single family dwellings knew unexpected extension.

The regulations concerning the energy efficiency and energy performances valuation as well, must have in view also the specific issues for single family dwellings, because these buildings have some peculiar features:

- low compactness index;
- important share of the roof and slab over basement/on the ground in the general energy balance;
- multitude of thermal bridges generated by the plan and spatial shape and by the relative low spans.

The energetic and thermal analysis of a building put into operation in 2006 emphasizes the aspects mentioned above.

The present paper wants to emphasize the importance of different factors in the estimation of a building energy performance on the base of an analysis of more single family dwelling with different geometric and insulation characteristics. A case study confirms the analysis conclusions.

2 Analysis of factors that contribute to the settlement of energy performance of dwellings

The main assessment criterion for the energy performance of buildings is the yearly specific necessary energy for heating the spaces. From this point of view, in this study were analyzed 10 single dwellings (**Tab.1**).

Tab. 1 Energy performance parameters for the analyzed buildings

No.	S_u [m^2]	A/V [m^2/m^3]	A_w/A_o [%]	G[W/m^{3}K]	Q_s [kwh/m^{2}a]	q [kWh/m^{2}a]
1	116,40	1,13	10	0,717	15,03	128,4
2	74,71	0,76	10,5	1,19	20,4	81,9
3	98,5	1,22	13,1	1,79	22,4	221,01
4	222,2	0,68	18,8	0,74	29,2	87,8
5	282	0,82	27	0,68	27,1	69,4
6	234	0,75	16,7	0,63	25,2	91,2
7	153	0,91	11,5	0,86	19,2	89,7
8	158,7	0,98	17,6	0,42	21,4	116,8
9	117	0,77	14,5	0,71	24,8	100,7
10	186	0,68	28	0,66	42,7	125

Where:

- S_u = heated area;
- A/V = compactness index;
- A_w/A_o = glazed areas and opaque area ratio;
- G = global thermal insulation coefficient;
- Q_s = solar gain;
- q = yearly specific energy necessary for heating.

It can be noticed that although the thermal insulation measures are approximately the same (excepting the building number 3, where the walls are not insulated) the energy performance differs with 85% (128,4 kWh/m^{2}a for building 1 compared with 69,4 kWh/m^{2}a for building 5).

The global coefficient of thermal insulation is especially influenced by the compactness index and by the ratio A_w/A_0. However not the buildings with the lowest values of the G coefficient present also the lowest values for the yearly specific energy for heating q. So the building number 6, that presents the lowest value for the parameter q, does not present also the lowest value for the coefficient G. On the other hand, the solar gain has the highest value. It results that another important factor that influences the energy performance of a building is the solar gain determined by the orientation toward the cardinal points and the ratio between the glazed areas and the opaque one.

It can be noticed also that from the whole number of analyzed buildings, many of them have the yearly specific energy necessary for heating with a value smaller than 100 kWh/m^{2}a.

3 Case study

From the energy performance point of view, it has been analysed a single dwelling building with two floors, ready for use in 2006 (**Fig.1** and **Fig.2**).

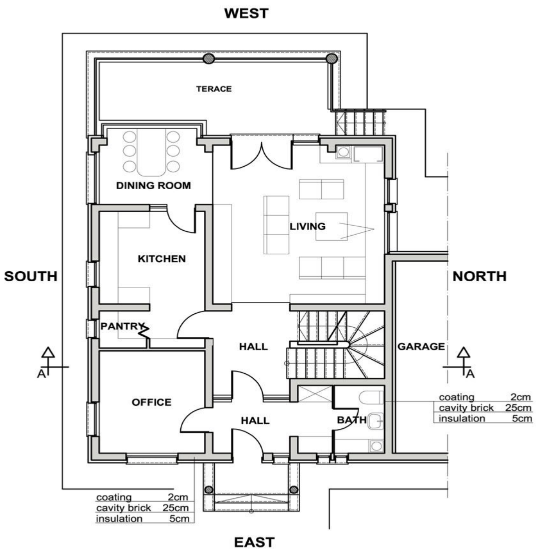

Fig. 1 First floor plan

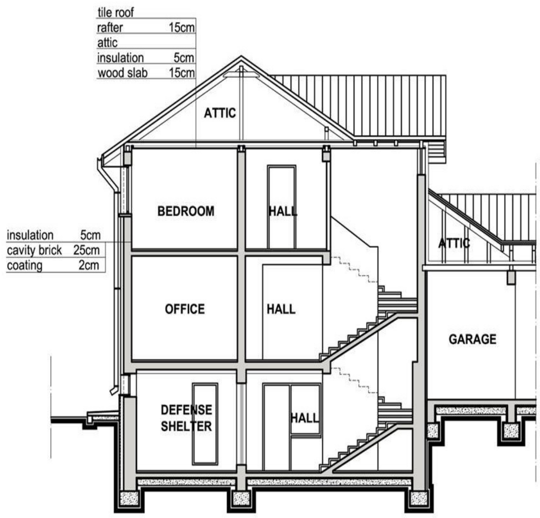

Fig. 2 Section A-A

The vertical closing elements are made of masonry units with holes and an additional layer of thermal insulation of expanded polystyrene of 5cm thickness. This solution is adopted at the basement foundation wall level too. At the garret level, the thermal insulation has 15cm thickness of mineral wool, and the glazed areas have PVC frames and thermopane glass.

The characteristic energy performance parameters estimated on the design base are the following:

- heated area - $S_u = 186m^2$
- compactness index - $A/V = 0,68m^2/m^3$
- mean thermal resistance - $R_{0M} = 1,5m^2K/W$
- glazed areas and opaque area ratio - $A_w/A_o = 28\%$
- global thermal insulation coefficient – $G = 0,66W/m^3K$
- solar gain - $Q_s = 42,7\ kWh/m^2a$
- yearly specific energy necessary for heating – $q = 110,8\ kWh/m^2a$

It can be noticed that even though the thermal insulation degree of the building is not too high, the yearly specific energy necessary for heating is quiet low, inferior to other similar buildings with a higher insulation level (building 1 and 8). This can be explained by the low compactness index and orientation toward the cardinal points.

It was made also another analysis concerning the real energy performance of the building. It consisted in a thermographic study of the thermal insulation level and in the assessment of the yearly specific energy necessary for heating and hot water, based on the invoice given by the owner.

The thermographic study emphasized a correct realization of the thermal insulation, without discontinuities corresponding to the concrete columns and girdles regions. It results a good correction of thermal bridges, excepting the balcony area (**Fig.3** and **Fig.4**), the intersection with the eaves (**Fig.5** and **Fig.6**) and the basement foundation wall region (**Fig.7** and **Fig.8**). Some tightness imperfections can be seen around the glazed areas **(Fig.9** and **Fig.10**).

Fig. 3 Main façade view

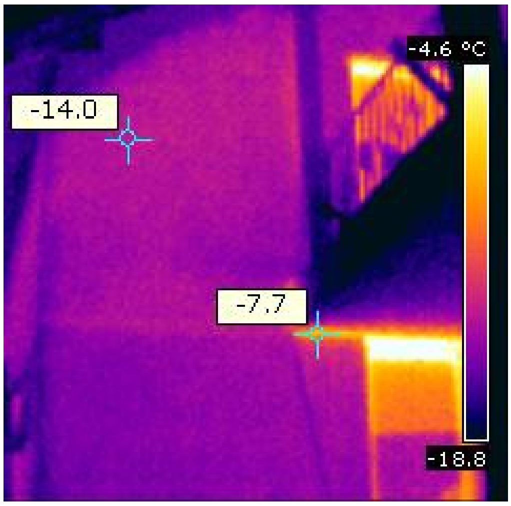

Fig. 4 I.R. image of the thermal bridge created by the balcony slab

The value quite small of the yearly specific necessary energy for heating, considering that the thermal insulation level is inferior to other analyzed buildings, can be explained by the building orientation with the façade strongly glazed toward South, the glazed area oriented to North being very reduced and in direct contact with the garage, which is a buffer space.

All these aspects lead to the conclusion that a better thermal insulation would place the building into a higher energy class.

Fig. 5 View of the façade

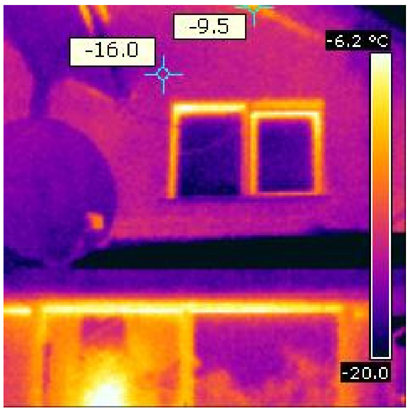

Fig. 6 Thermal bridge at the eaves level

Fig. 7 Photo of the down side of the building

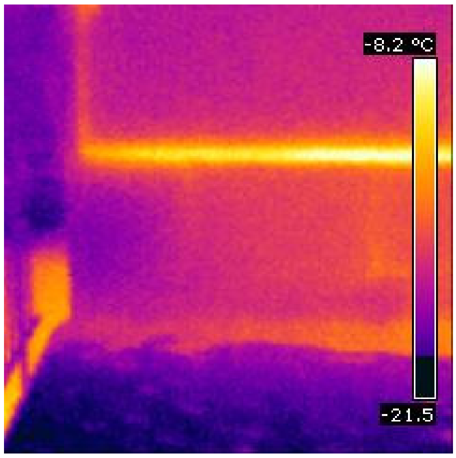

Fig. 8 I.R. image of the thermal bridge created by the basement wall

The yearly specific energy necessary for heating assessed on the invoice base is $q=122kWh/m^2a$, which is a very closed value to that resulted by calculus. The energy necessary for hot water and food preparation is $q_h = 94{,}29kWh/m^2a$. The real energy consumption, according to the invoice is shown in Table 2.

Fig. 9 Photo window

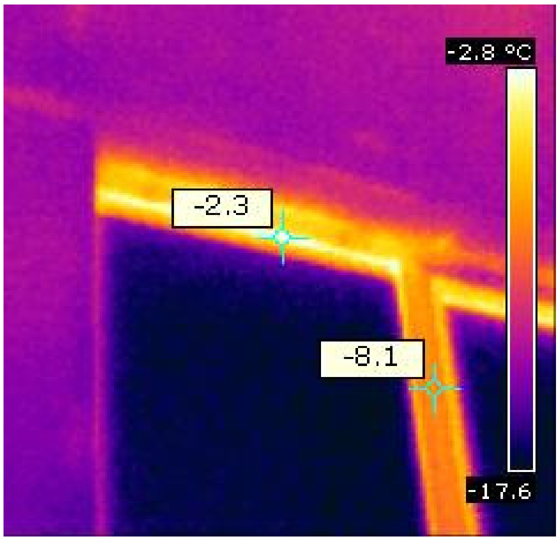

Fig. 10 Tightness imperfections around the glazed area

Tab. 2 The real energy consumption according to the owner's invoice

Month	Total energy consumption [kWh]	Energy consumption for heating [kWh]
January	6584	5094
February	5672	4326
March	4521	3031
April	2737	1295
May	1547	-
June	1190	-
July	1190	-
August	1230	-
September	1547	-
October	2856	1366
November	4521	3079
December	6067	4577
Total	39662	27770

The yearly energy consumption for heating is 27770 kWh, which related to the heated area of 186m^2, means a specific consumption of 122, 4 kWh/m^{2}a.

4 Conclusions

In the assessment process of the energy performance of single dwellings, besides the thermal insulation level, an important influence has also the compactness index and the building orientation toward the cardinal points.

The analyzed building is characterized by a low compactness index, a favorable orientation and a good work of the thermal insulation, which lead to an energy performance similar to other buildings with a superior thermal insulation degree.

The present estimation methodology for collective dwellings may be adopted also for single dwellings, the results being in a good concordance with the real consumptions given by the invoices.

References

[1] EN 14683 - *Thermal bridges in building construction – Linear thermal transmitance – Simplified methods and default values*

[2] EN ISO 13789:2007 – *Thermal performance of buildings – Transmission and ventilation heat transfer coefficients – Calculation method*

[3] ISO 6947:2007 – *Building components and building elements – Thermal resistance and thermal transmitance – Claculation method*

[4] BLIUC I., BARAN I., LEPĂDATU C., FÂRTĂȚESCU M.- *Aspects concerning the energy consumption and the conception and design of the single family dwellings* International Conference VSU'2007 15-16 May 2007 Sofia, Bulgaria, ISBN 978-954-331-016-6,vol I.

[5] BLIUC I., BARAN I. LEPĂDATU C., FARTATESCU M., AVRAM C.- *The IR Thermography Utilization for the Energetic Audit of Buildings* 15th International Conference on the Thermal Engineering and Thermogrammetry, 27-29 iunie 2007, Budapesta, Ungaria ISBN 978-963-06-3722-0, pp 65.