Thermal insulation of old and new buildings in Romania

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ABSTRACT: Once Romania has joined the European Community, environmental protection and energy saving have become top priority domains. European standards have become Romanian reference standards and norms. The present-day housing stock in Romania was mostly built between 1960 and 1989, without the adoption of any efficient solutions for thermal insulation. The operation of buildings more than 30 years old, has led to the occurrence of certain damages, because of the condense phenomenon into the walls. In Romania a governmental programme is carried out for the thermal rehabilitation of blocks of flats built before 1989. The investment for the thermal rehabilitation of buildings is financed equally by the government and the owners. This paper presents the situation of the housing stock in Romania, the requirements regarding the resistance to heat flow for the elements of the building envelope as well as the latest tendencies concerning the erection of durable constructions.

1 GENERAL PRESENTATION

An essential element of the sustained development of constructions is the promotion of efficiency and the rational use of energy. As the specific heat consumption and the consumptions involved in the hot water preparation in Romania are rather double compared to the ones found in the Western countries of the European Union, it seems of outmost necessity that special programmes designed for the increase of the energetic efficiency of buildings should be developed.

The experience of Western European countries, and especially Northern countries, that have carried out, after the energetic crisis they had to face in 1973, national programmes designed for thermal protection, stand out as real examples for the national politics regarding the implementation of thermal rehabilitation of the Romanian housing stock.

Based on the statistic data gathered through the census survey carried out for population and residences in Romania in 2002, the total number of housing stock is 4,846,572 buildings that practically comprise 8,110,407 residences. Out of the mentioned number, 1,138,945 buildings that comprise 4,257,964 residences are situated in the urban areas. 97% of the residences are private property. Most of the residences are situated in buildings aged between 15 and 55 years, with a reduced level of thermal insulation and a high degree of run-out. The structure of the Romanian housing stock depending on the age is illustrated in Figure 1.

The heating supply is being ensured for blocks of flats, at a rather high rate (90%), through a centralized system. In large Romanian cities, there have been created and extended, along the latest 40 years, centralized heating systems, that have as a source either thermal-electric power plants (urban central heating), or a local heating plant, responsible for the area, the neighborhood or a group of blocks. Most of the urban heating supply is connected to sources of heating production that belong to the national private power plant, the rest of the systems belonging to the local administrations and being managed by specialized enterprises controlled by the municipalities.

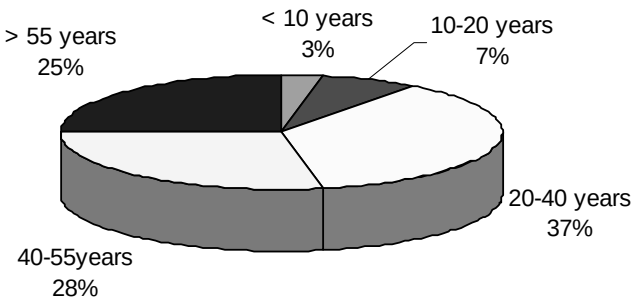
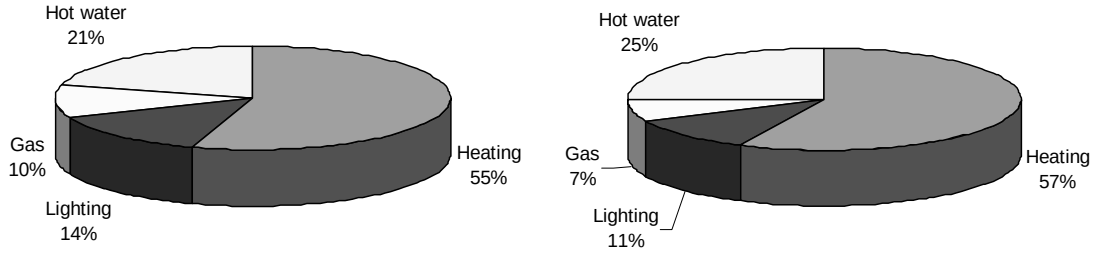


Figure 1. Status of the Romanian housing stock

2 STRUCTURE OF THE ENERGY CONSUMPTION WITHIN THE RESIDENTIAL SYSTEM

The weight of the energy consumption within the annual energetic balance of a medium-size apartment built between 1970-1985 is shown in Figure 2:



a. Romania b. Western European countries

Figure 2. Structure of energy consumptions for an apartment

Considering the whole Romanian housing stock, the efficiency of the heat use for heating, hot water and cooking rises to only 43% from the total quantity of heat supplied by the sources. There can be noticed that the heating of the space is by far the largest final consumer of energy, both in Romanian and in Western European buildings.

3 TYPES OF ENVELOPE ELEMENTS USED FOR RESIDENTIAL BUILDINGS BETWEEN 1960-1989

The types of walls used for civil buildings until 1984 are different, therefore there are different thermal performances that depend on the composition of the walls. The main types of design used for the envelope walls of buildings built until 1984 are presented in Fig.3. A comparative study of the minimum resistances to heat flow required and the effective resistances to heat flow of the types of exterior walls used shows that the latter didn't meet the minimum requirements of thermal insulation. The walls show resistances to heat flow between the limits R_o=0,54...0,97 m^2K/W, that is 45...81% from $R_{o,nec}$. Table 1 shows the ratios between the effective resistances to heat flow and the resistances to heat flow required by the standards in force on the mentioned date, for each type of wall.

Tabel 1 The ratios between the effective resistances to heat flow and the resistances to heat flow required

Exterior wall type	A	B	C	D	E	F	G
Thermal resistance $R_{0,ef}$ [m^2K/W]	0.68	0.57	0.54	0.57	0.97	0.93	0.67
Ratio $R_{0,ef}$ / $R_{0,nec}$	0.57	0.48	0.45	0.48	0.81	0.77	0.56

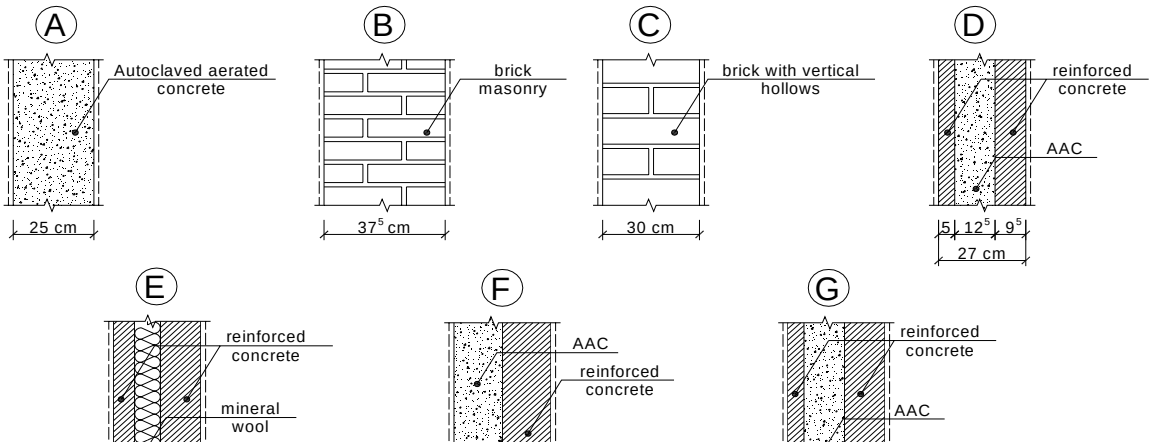


Figure 3. Design details for walls used until 1984

After 1984, the imposing of energy saving has led to a change of the design solutions for exterior walls used in residential buildings. The new solutions adopted have led to the exceeding of the minimum resistances required for envelope elements. Fig.4 gives the design details for exterior walls used for residence buildings starting with 1985.

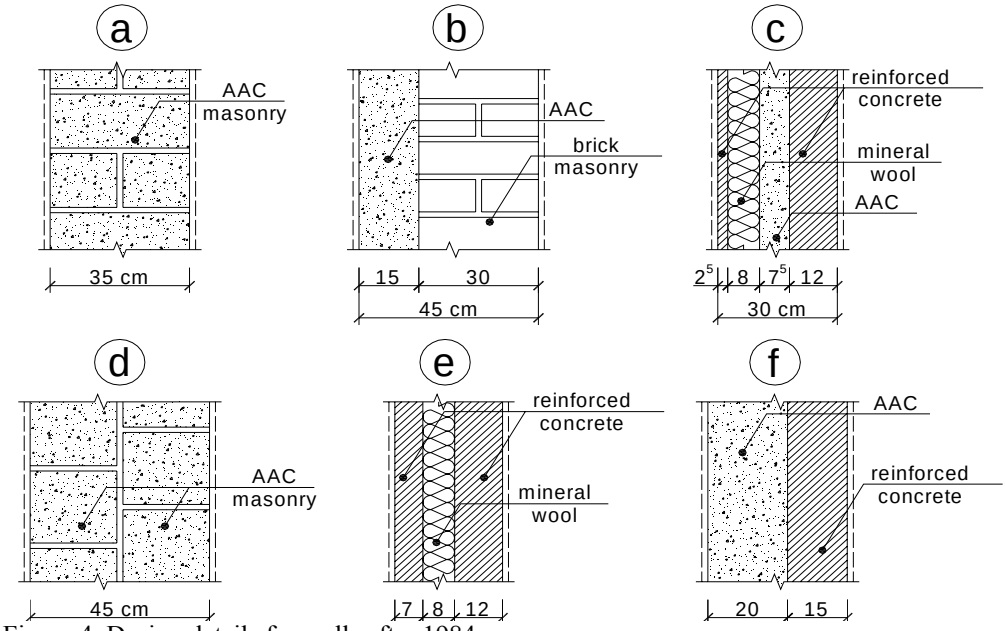


Figure 4. Design details for walls after 1984

Table 2 Comparative ratios between the effective and required resistances to heat flow

Exterior wall type	A	B	C	D	E	F
Thermal resistance $R_{0,ef}$ [m^2K/W]	1.84	1.38	1.63	2.43	1.56	1.61
Ratio $R_{0,ef}$ / $R_{0,nec}$	1.53	1.15	1.35	2.02	1.30	1.34

Table 2 shows the comparative ratios between the effective resistances to heat flow and the resistances to heat flow required according to the standards in force on the given date. There can be noticed that the principle solutions proposed for the improvement of the heat flow resistance exceeded the minimum resistance required, but in practice the solutions were not observed, this

resulting in short-comings of the envelope elements, regarding energetic and comfort performances. The thermal insulation materials used were the cellular autoclaved concrete and the mineral wool, with various hygro-thermal characteristics. Polystyrene was considered as an expensive material at the time.

Therefore, we can conclude that, for most of the buildings, the elements of the envelope in contact with the exterior do not meet the thermal and hygro-thermal requirements, and a general rehabilitation is needed, with consequences on the hygro-thermal comfort and the energy saving.

4 THE EVOLUTION OF ROMANIAN STANDARDS REGARDING THERMAL INSULATION

Along the years, the Romanian standards that concern thermo-technics have introduced different values for the minimum resistances to heat flow, but also additional conditions regarding the diffusion of moisture within the constructional elements. The codes valid until 1989 comprised the following requirements regarding the envelope elements:

- the effective resistance to heat flow should be higher than the minimum resistance required determined upon the climate zone that the building is being erected and interior climate parameters;

$$R_0 > R_{0,nec} \tag{1}$$

R_o –Total resistance to heat flow [m^2K/W];
R_{oc} –Total resistance to heat flow taking into account the massiveness of the material [m^2K/W];
m – massiveness coefficient in function of the thermal inertia;
$R_{o\,nec}$ – Minimum required resistance to heat flow [m^2K/W].

- preventing the condense to occur on the interior surface of the envelope element, meaning to satisfy the following condition:

$$T_{si} > \tau_r \tag{2}$$

T_{si} –Temperature on interior surface [°C];
t_r – Temperature of dew point [°C].

- limiting the mass of condensed water inside the exterior envelope element, that corresponds to the satisfying of the following conditions:

$$m_w - m_v \leq 0 \tag{3}$$

$$\Delta W_{ef} \leq \Delta W_{allowed} \tag{4}$$

m_w – Mass of water condensed during the cold period of the year;
m_v – Mass of water evaporated during the hot period of the year.
ΔW_{ef} – Increase of water percentage condensed during the cold period of the year;
$\Delta W_{allowed}$ – Increase of water percentage allowed.

Tables 3 shows the time variation of the requirements regarding the resistance to heat flow of the envelope elements of Romanian buildings.

In the past 10 years, there have been developed in Romania a series of new standards, along with their specific guidelines for application. It is essential that there has been introduced a new concept regarding the thermal insulation of buildings, through the evaluation of the global insulating coefficient of the building, respectively through energetic certification.

Table 3 Time variation of the requirements regarding the resistance to heat flow

PERIOD	CODE	R_{min} [m^2K/W]			R' [m^2K/W]		
		Exterior walls	Flat roof	Floors over base-ment	Exterior walls	Flat roof	Floors over base-ment
1950 … 1961	-	-	-	-	-	-	-
1962 … 1968	STAS 6472 – 61	0.76	0.96	0.82	-	-	-
1969 … 1973	STAS 6472 – 68	0.80	1.02	0.87	0.60	-	-
1974 … 1975	STAS 6472/3 – 73	0.80	1.02	0.87	0.60	-	-
1976 … 1984	STAS 6472/3 – 75	0.80	1.02	0.87	0.60	-	-
1985 … 1987	STAS 6472/3 – 84	0.76	0.87	0.56	0.76	0.87	0.56
	NP 15 - 84	1.20	1.55	1.08	1.20	1.55	1.08
1988 … 1989	STAS 6472/3 – 84	0.76	0.87	0.56	0.76	0.87	0.56
	NP 15 – 87	1.20	1.55	1.08	1.20	1.55	1.08
1990 … 1997	STAS 6472/3 – 89	1.00	1.24	0.67	1.00	1.24	0.67
1998 … 2000	C107/3 – 1997	-	-	-	1.09	1.46	1.25
	C107/1 – 1997	-	-	-	1.40	3.00	1.65

The Romanian law states that, until the year 2010, all buildings should be energetically certified. Based on the energetic certification, advantages will be obtained concerning the systems of insurance, loans, taxes etc. The graph shown in Figure 5 presents the variation of the standards number and design guides that refer to the requirements of energetic performance.

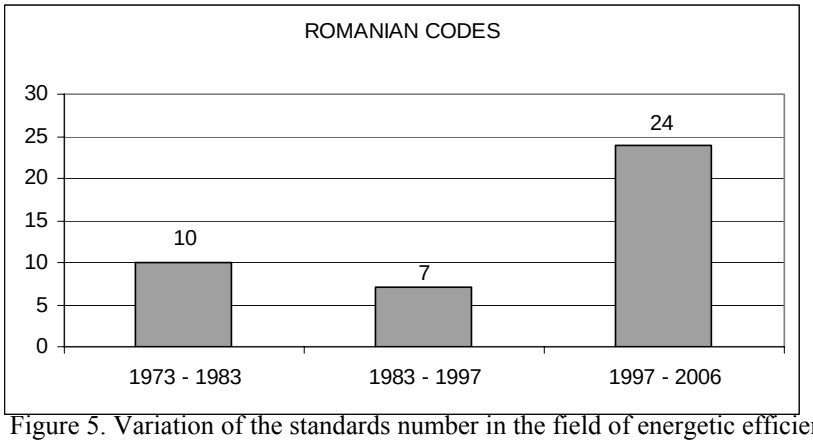


Figure 5. Variation of the standards number in the field of energetic efficiency in Romania

4.1 *Politics regarding the energetic efficiency. National programme for the rehabilitation of residence buildings*

From the analysis of the graph presented in Figure 5, there can be clearly noticed the last decade's trend to also introduce in Romania the concept of sustainable development directly referring to the energetic efficiency of new and existing buildings.

The Romanian Government has issued the Government Order no. 29/2000 regarding the thermal rehabilitation of the existing buildings and the stimulation of thermal energy saving; the provision sets up the legal framework for the thermal rehabilitation and modernization of all existing buildings and the installations thereof, aiming to the improvement of the conditions of hygiene and thermal comfort, to the decrease of the heat flow, the energetic consumptions, the cost of heating and hot water, and the polluting emissions generated by the production, the transportation and the consumption of energy. It is about the buildings situated in urban and rural areas (residences, public buildings, productions halls, etc.), where there are performed activities that require a certain degree of thermal comfort, according to the technical requirements in

force. Based on the legislation in force, the local administrations financially support the investments that aim to the thermal rehabilitation of the housing stock, by supporting 50% of the investment, the other half being imposed on the owner.

The Government's programme for thermal rehabilitation of the existing housing stock also comprises some fiscal facilities for the owners. Thus, the ones who decide to rehabilitate their building shall beneficiate of an expertise, an energetic audit and projected design for thermal rehabilitation funded by the state budget, the relief from taxation when it comes to the issuing of the energetic certificate of the building and of the construction permit regarding the thermal rehabilitation works, respectively the relief from taxation regarding the residence all along the period of reimbursement of the credit obtained for the purpose of thermal rehabilitation.

5 EFFICIENT SOLUTIONS USED IN THE CONSTRUCTION OF THE „IULIUS MALL" COMMERCIAL CENTRE OF TIMISOARA

After 1989, one of the most important investment in the Western part of Romania is the "Iulius Mall" commercial centre. The completion of the building structure was a decisive stage of the investment. The quality control of the building erection is a component of the quality system.

The commercial centre is made up of several sections, each of them with an independent structure. The first development stage of the area and the building of the commercial centre consists in the construction of 15 blocks and one technical block. The building has a constructed area of 73, 000 square meters distributed on 3 levels and one terrace, hosting over 200 shops. Beside the shops, there is a movie theatre with several halls, a supermarket, restaurants, food courts, bars, kids land and sports centers.

A general view of the "Iulius Mall" Commercial Centre at the end of the construction works is presented in Figure 6.

Figure 6. General view of the main entrance of "Iulius Mall" Centre of Timişoara

The photos included in Figure 7 show aspects from the execution of the exterior walls.

a. Detail from the installation of the envelope walls on the Southern facade

b. General view of the Southern facade

Figure 7. Aspects from the execution of the exterior walls

The application of the thermal protection and hydro-protection on the terrace is shown in Figure 8.

a. Terrace hydro protection

b. Terrace thermal protection

Figure 8. Details from the execution of the terrace hydro and thermal protection.

The most important material used for the constructional work of Iulius Mall Center is presented in the table 4.

Table 4 Materials used for the constructional work of Iulius Mall Center

No.	Material	Quantity
1.	Reinforcements and structural steel	> 3.000 t
2.	Concrete cast in site	> 80.000 m^3
3.	Mineral wool 5 cm thickness	13.847 m^2
4.	Sandwich panels 6 cm thickness	13.847 m^2
5.	Polystyrene 10 cm thickness	18.500 m^2
6.	Windows and doors	> 4.200 m^2

Based on the characteristics of the materials used and on the execution details of the „Iulius Mall" commercial centre, there was drafted the certificate of energetic performance of the building, presented in Figure 9.

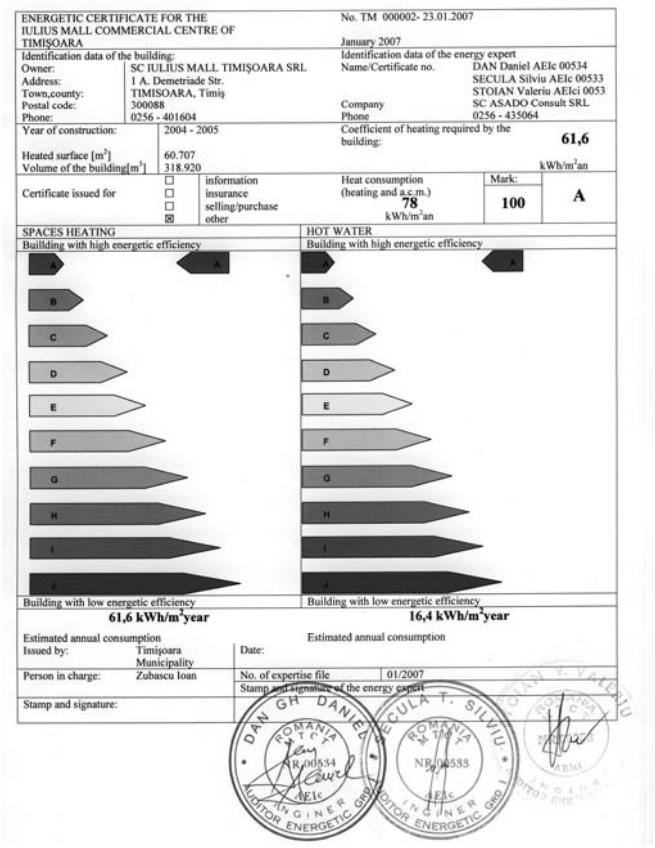


Figure 9. The certificate of energetic performance of the building

6 CONCLUSIONS

The reduction of heat loss through the construction elements is necessary in order to increase the energetic efficiency of a building. National and international programmes now in force aim to the thermal rehabilitation of residence buildings, as a priority measure within the sustained development of constructions.

The energetic performances of residential buildings are being evaluated in Romania by authorized energy experts who issue the certificates of energetic performances of a building. The energetic audit of a building requires, beside the energetic certification, the establishment of intervention measures and execution details designed for the improvement of thermal comfort.

The reduction of heat loss leads to the reduction of pollution and of the costs caused by the building maintenance.

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