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RENOVATION OF APARTMENT BUILDINGS WITH RESPECT TO ENERGY SAVINGS AND GREATER EFFICIENCY

RENOWACJA BUDYNKÓW MIESZKALNYCH ZE WZGLĘDU NA OSZCZĘDNOŚCI ENERGII I WIĘKSZĄ EFEKTYWNOŚĆ

Abstract

Within the framework of mass home production in Slovakia as many as 25 different basic models or systems of construction can be distinguished according to various criteria (e.g. the period of construction, materials used in cladding structures and their thickness, etc.). In terms of the present state of affairs, it can be said that despite their inferior technical condition, the above mentioned number of apartments are practically irreplaceable in the future decades.

Keywords: thermostatic, construction system, rationalization measure, thermal insulation

Streszczenie

W ramach słowackiego budownictwa uprzemysłowionego można wyróżnić 25 podstawowych modeli albo systemów konstrukcyjnych, biorąc pod uwagę różne kryteria (np. okres wzniesienia, materiały okładzinowe, ich grubość itp.). Wg stanu obecnego można powiedzieć, że niezależnie od ich słabego stanu technicznego mieszkania znajdujące się w tych budynkach nie mogą być zastąpione nowymi.

Słowa kluczowe: termostat, system konstrukcyjny, metoda usprawnienia, izolacja cieplna

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1. Introduction

There are nearly 1.8 million apartments registered in Slovakia nowadays. Approximately half of them exist in apartment buildings, 95% of which were built after the year 1945. 85% of these buildings came into being during the mass-housing development in the last century the majority of them was constructed with the use of panel technologies [1, 2]. Housing development in the Slovak Republic coincided with the development of construction theories as well as technological and material development. Housing construction followed the extensive development of the national economy, while its main goal was the planned provision of mass-constructed residences. A typical feature of such mass home construction is the maximum construction rationalisation and minimum investment costs. Apartment buildings were built in compliance with the relevant technical standards and regulations. Apart from some negative aspects, the technological level, engineering services and equipment of the mass-produced housing stock were of a relatively high quality, as compared to the housing in other countries known for high housing standards. As many as 94% of apartments were centrally heated, centrally supplied with hot water and had an average useful floor area of 62.29 m².

2. Description of mass-constructed apartment buildings in Košice

The housing development in Košice after the year 1945 is actually identical to the development in other industrially developed towns in Slovakia.

The most intensive construction development occurred between the years 1958 and 1985 accompanied by a corresponding structure of basic types and a variety of construction systems as given in Tab. 1.

Table 1

The overview of basic types and construction systems of apartment buildings in Košice supplemented with the values of air-to-air heat-transmission coefficients U [W/(m²·K)] used in the calculations for buildings in the original condition and after additional thermal insulation [3]

Type/Model Construction system	Original condition				Condition after thermal insulation			
	wall			roof	wall			roof
	front	flank	balcony		front	flank	balcony	
T 01 B to T 03 B	1.428	1.428	–	1.214	0.392	0.395	–	0.278
T 11 to T 16	1.369	1.369	–	1.477	0.391	0.391	–	0.211
PV–2	0.866	0.866	–	0.674	0.335	0.335	–	0.236
G – 57	2.,215	2.215	2.565	0.987	0.439	0.439	0.422	0.268
LB (MB)	1.879	1.303	–	0.826	0.423	0.385	–	0.255
T 06 B KE	1.597	1.403	1.403	0.943	0.408	0.393	0.393	0.263
T 08 B	0.780	0.639	0.780	0.465	0.322	0.294	0.322	0.207
P1. 14 6.5 RP	0.688	0.688	–	0.555	0.304	0.304	–	0.219
P1. 14 7. 5RP	0.688	0.688	0.587	0.577	0.304	0.304	0.587	0.224
P1. 15	0.660	0.605	0.581	0.552	0.299	0.287	0.587	0.221

The structure of apartment buildings erected in Košice between the years 1945 and 1990 is shown in Fig. 1.

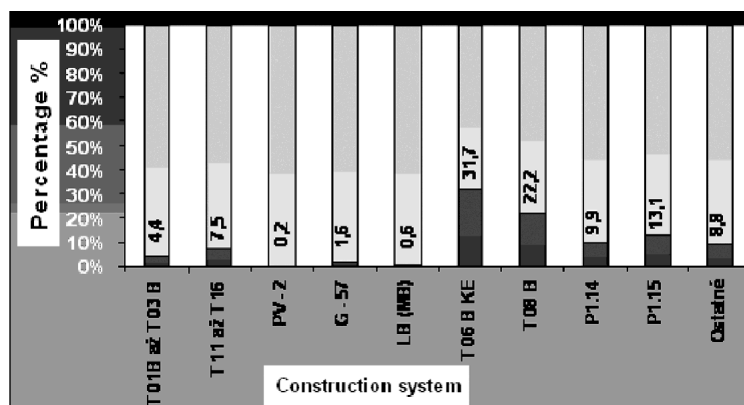


Fig. 1. The structure of apartment buildings in Košice according to the prevailing construction systems and/or models
Rys. 1. Struktura budynków mieszkalnych w Koszycach wg dominujących systemów konstrukcyjnych i/lub typów

The apartment buildings erected during the period of mass housing production have been analysed in detail with respect to their physical condition. The findings of scientific and technological projects co-ordinated by VVÚPS – NOVA, s.r.o. Bratislava have shown that in the majority of cases their state of repair was much poorer than it should have been with respect to their age. The research has specified structural, hygienic and utility failures of both objective and subjective nature. Among the objective reasons one may cite the level of knowledge in those days, inaccessibility of modern building materials, technological development and more lenient legal requirements of that period. Construction failures of this kind can now be defined as systematic. Subjective defects were due to human errors, improper manufacturing of structural elements, non-observance of technological procedures in construction, inaccurate modification of structural details in the process of execution and finally, insufficient maintenance of apartment buildings. In view of the present state of affairs, another serious defect is high energy demand in such buildings arising from their insufficient thermal protection and poor technological condition of heating systems and their operation. One can identify predominantly objective reasons for such situation. First of all, until 1979 there were no official regulations to encourage lower energy consumption for heating. Only then were the first precisely defined standard requirements imposed, and only in 1997 did they reach a level comparable to the requirements of developed European countries both in terms of quantity and quality (STN 73 0540: Amendment 5).

One of the attendant phenomena of societal and economic changes in Slovakia in 1989 was the liberalisation of energy and heat prices, which resulted in a number of questions related to the reduction of energy costs in buildings. The Ministry of Construction prepared a draft programme for reducing the apartment building energy demand. Consequently, in 1991 the government adopted a nation-wide programme of apartment building thermal insulation. Up to 80% of budgetary costs of this programme were subsidised with a limit of SKK 60,000.00 per apartment. In 1991 the Ministry of Economy passed Decree No. 206/91

Coll. stipulating that heat suppliers were to install heat consumption measurement systems at the entrances to apartment buildings and the owners or administrators of apartments were to hydraulically control the heating systems in the buildings and install thermal control valves on all heating elements/radiators within the apartments.

However, these measures did not bring forth the expected response, except for those heat suppliers who, in the overwhelming majority, ensured that heat consumption measurement systems were installed at the building entrances.

The reasons for such situation can be found mainly in the following areas:

- a new administration structure was created due to the apartment transfer into private ownership, which was not economically motivated and relied on state heat subsidies,
- as a result, heat subsidies deformed the way the apartment owners viewed the actual heat prices and the economic benefits of necessary cost-cutting measures,
- poor legal effectiveness of the above mentioned legislation,
- the lack of practically verified input data or information on the energetic or economic effectiveness of such measures.

Table 2

The overview of actual specific heat consumption values for selected apartment buildings between 1995 and 2006

Constructional system	Actual specific heat consumption values in selected apartment buildings between 1995 and 2006 (in GJ/m ²)												
	Apartment building	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
T 01 B to T 03 B	A	0.558	0.578	0.671	0.492	0.460	0.445	0.432	0.467	0.475	0.455	0.450	0.435
	B	0.614	0.644	0.743	0.545	0.495	0.438	0.479	0.489	0.510	0.469	0.502	0.477
	C	0.678	0.719	0.704	0.579	0.584	0.539	0.584	0.556	0.534	0.508	0.494	0.478
	D	0.620	0.604	0.578	0.483	0.487	0.446	0.471	0.459	0.457	0.432	0.427	0.417
T 06 B b	A	0.558	0.583	0.511	0.427	0.444	0.419	0.365	0.438	0.431	0.429	0.400	0.380
	B	0.558	0.582	0.517	0.429	0.448	0.410	0.431	0.448	0.414	0.331	0.310	0.280
	C	0.519	0.587	0.519	0.427	0.445	0.424	0.428	0.408	0.342	0.305	0.303	0.288
	D	0.441	0.480	0.511	0.420	0.421	0.365	0.315	0.310	0.325	0.314	0.306	0.282
T 06 B bd	A	0.476	0.557	0.603	0.482	0.487	0.462	0.487	0.477	0.490	0.496	0.451	0.434
	B	0.533	0.549	0.542	0.457	0.438	0.411	0.411	0.432	0.446	0.372	0.348	0.333
	C	0.575	0.641	0.548	0.520	0.515	0.482	0.482	0.472	0.464	0.384	0.333	0.303
	D	0.501	0.559	0.589	0.504	0.491	0.444	0.451	0.474	0.497	0.454	0.367	0.317
T 08 B	A	0.513	0.473	0.480	0.378	0.364	0.338	0.361	0.319	0.307	0.274	0.226	0.254
	B	0.487	0.479	0.496	0.400	0.382	0.354	0.362	0.356	0.359	0.301	0.237	0.215
	C	0.447	0.418	0.470	0.365	0.357	0.331	0.360	0.358	0.360	0.332	0.270	0.289
	D	0.472	0.487	0.420	0.359	0.341	0.331	0.331	0.330	0.310	0.280	0.236	0.211
P 1.15	A	0.552	0.793	0.690	0.511	0.501	0.493	0.512	0.472	0.481	0.424	0.403	0.378
	B	0.473	0.515	0.491	0.354	0.355	0.322	0.370	0.373	0.363	0.348	0.336	0.315
	C	0.403	0.534	0.533	0.423	0.443	0.424	0.466	0.445	0.449	0.426	0.406	0.376
	D	0.543	0.577	0.577	0.449	0.456	0.434	0.486	0.489	0.507	0.463	0.445	0.403
	Data	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	D	3689	3950	3936	3562	3509	3271	3538	3587	3680	3683	3506	3394
	⊙ _{32m}	3.15	2.52	3.10	3.20	3.60	5.06	3.99	4.13	2.64	2.70	2.64	3.20

Some progress in the implementation of energy cost-cutting measures was made between 1996 and 1997 when, due to a dramatic increase in heat prices, new projects regarding the hydraulic thermal control of heating systems in apartment buildings were launched (the process of so-called thermo-regulation of heating systems). The highly positive aspect of the present situation is that the projects are carried out in a holistic way: **heat sources → external heat distribution systems → internal distribution pipelines in the apartment buildings**. In the majority of cases the installation of thermal control valves and proportional distributors of heating costs per heating element/radiator was a part of that hydraulic thermo-regulation of heat distribution systems. The installation of additional

exterior thermal insulation of apartment buildings began (with the exception of a few pilot projects) in the years 2000/2001. These projects were set up mainly in tandem with the panel apartment building complete renovation programmes. It is necessary to mention in this respect that an important role has been played by the state subsidies for panel apartment building systematic failures remedying as well as favourable long-term credit terms of the State Fund of Housing Development.

The development of specific heat consumption in selected apartment buildings is shown in Tab. 2.

3. Energetic cost-effectiveness of apartment buildings renovation

The process of apartment buildings complete renovation and the related reduction of energy costs is a long-term process. It is estimated that the investment costs of the apartment buildings additional thermal insulation and these of non-implemented hydraulic thermal regulation of heating systems in such buildings approximately amount to 65 billion SKK calculated at the price level of 2006. The objective/independent evaluation of the energetic cost-effectiveness of these measures, based on the comparison of specific heat consumption values in long-term time intervals before and after their implementation, plays an essential role in the more flexible implementation of the cost-cutting measures concerned. Table 3 presents the above-mentioned specific heat consumption values from Tab. 2 transformed into the so-called number of day-degrees "D" in a particular year, which reflects in a relatively reliable way the development in heating demand.

Table 3

The overview of transformed specific heat consumption values for selected apartment buildings between 1995 and 2006

Construction system	Apartment building	Transformed specific heat consumption values in selected apartment buildings between 1994 and 2006 (in $\text{kJ}/\text{m}^2 \text{D}$)											
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
T 01 B to T 03 B	A	0.161	0.146	0.170	0.138	0.131	0.136	0.122	0.130	0.129	0.124	0.128	0.128
	B	0.166	0.163	0.189	0.153	0.141	0.134	0.135	0.136	0.139	0.127	0.143	0.141
	C	0.184	0.182	0.151	0.163	0.166	0.165	0.165	0.155	0.145	0.138	0.141	0.141
	D	0.168	0.153	0.147	0.136	0.139	0.136	0.133	0.128	0.124	0.117	0.122	0.123
T 06 B b	A	0.151	0.148	0.130	0.120	0.127	0.128	0.103	0.122	0.117	0.116	0.114	0.112
	B	0.151	0.147	0.131	0.120	0.128	0.125	0.122	0.125	0.113	0.090	0.088	0.082
	C	0.141	0.149	0.132	0.120	0.127	0.130	0.121	0.114	0.093	0.083	0.085	0.085
	D	0.120	0.122	0.130	0.118	0.120	0.112	0.089	0.086	0.088	0.085	0.087	0.083
T 06 B bd	A	0.129	0.141	0.153	0.135	0.139	0.141	0.138	0.133	0.133	0.135	0.129	0.128
	B	0.144	0.139	0.138	0.128	0.125	0.126	0.116	0.120	0.121	0.101	0.099	0.098
	C	0.156	0.162	0.139	0.146	0.147	0.147	0.136	0.132	0.126	0.104	0.095	0.089
	D	0.136	0.142	0.150	0.141	0.140	0.136	0.127	0.132	0.135	0.123	0.105	0.093
T 08 B	A	0.139	0.120	0.122	0.106	0.104	0.103	0.102	0.089	0.083	0.074	0.064	0.075
	B	0.132	0.121	0.128	0.112	0.108	0.108	0.102	0.089	0.088	0.082	0.068	0.063
	C	0.121	0.106	0.119	0.102	0.102	0.101	0.102	0.100	0.098	0.090	0.077	0.085
	D	0.128	0.123	0.107	0.101	0.097	0.101	0.094	0.082	0.084	0.076	0.067	0.062
P 1.15	A	0.150	0.201	0.175	0.143	0.143	0.151	0.146	0.132	0.131	0.115	0.115	0.111
	B	0.128	0.130	0.125	0.099	0.101	0.098	0.105	0.104	0.104	0.094	0.096	0.093
	C	0.109	0.135	0.135	0.119	0.126	0.130	0.132	0.124	0.122	0.116	0.116	0.111
	D	0.147	0.146	0.147	0.128	0.130	0.133	0.137	0.136	0.138	0.126	0.127	0.119

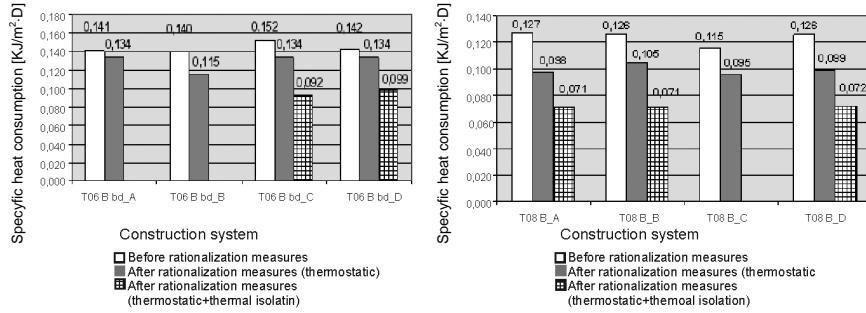


Fig. 2. Transformed specific heat consumption values for the construction systems T 01 B to T 03 B and transformed specific heat consumption values for the construction systems T 06 B b

Rys. 2. Transformowane jednostkowe zużycie energii w budynkach systemu T 01 B do T 03 B i transformowane jednostkowe zużycie energii w budynkach systemów T 06 B b

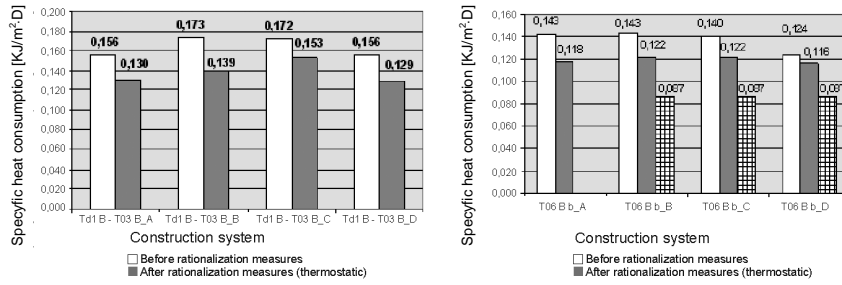


Fig. 3. Transformed specific heat consumption values for the construction system T 06 B bd and transformed specific heat consumption values for the construction system T 08 B

Rys. 3. Transformowane jednostkowe zużycie energii w budynkach systemu T 06 B bd i transformowane jednostkowe zużycie energii w budynkach systemów T 08 B

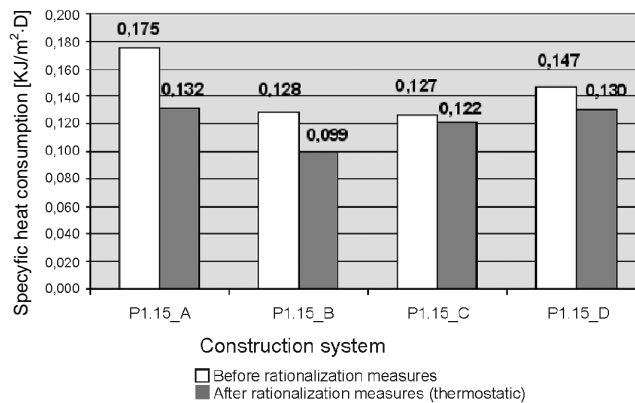


Fig. 4. Transformed specific heat consumption values for the construction system P 1.15

Rys. 4. Transformowane jednostkowe zużycie energii w budynkach systemu P 1.15

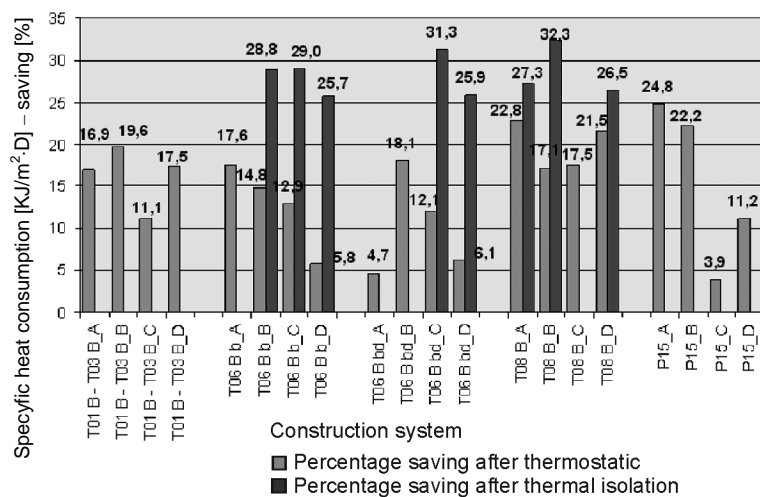


Fig. 5. Specific heat consumption values (savings) for individual construction systems expressed per cent after the implementation of cost-cutting measures. Specific heat consumption [KJ/m²·D] – savings [%]

Rys. 5. Jednostkowe zużycie energii (oszczędności) po wprowadzeniu zmian obniżających koszty eksploatacyjne dla poszczególnych systemów konstrukcyjnych. Jednostkowe zużycie energii [KJ/m²·D] – oszczędności [%]

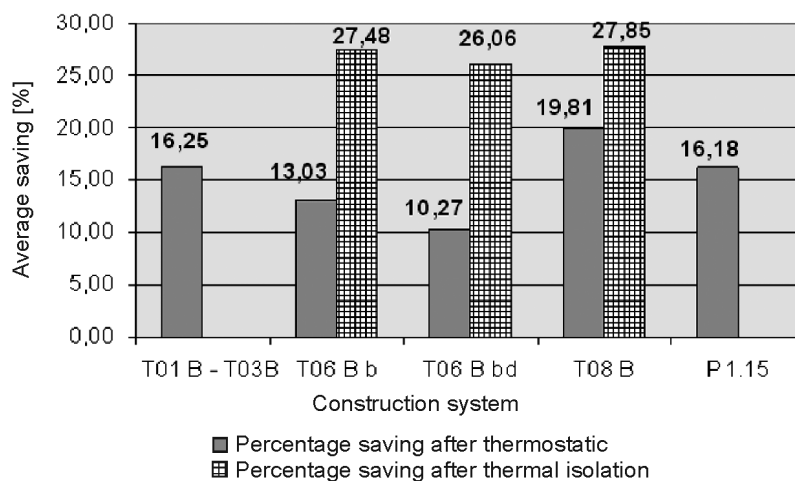


Fig. 6. Average heat savings for individual construction systems after the implementation of cost-cutting measures

Rys. 6. Średnie oszczędności energii dla poszczególnych systemów konstrukcyjnych po wprowadzeniu zabiegów obniżających koszty

4. Conclusion

On the basis of the presented results and their analysis, it can be concluded that the renovation of apartment buildings, besides the permanent preservation of older housing stock, is of great significance with respect to the radical reduction of heating demand. The results disprove the common public argument that traditional brick types and construction systems are “better quality” in terms of thermal characteristics than the panel apartment buildings. In view of the facts one must admit that the situation is exactly opposite in most cases. The substantial differences in measured and calculated and transformed heat consumption values in the apartment buildings in question point to the necessity of an individualistic approach in the evaluation of heating demand and consequently, to the economic efficiency of cost-cutting measures tailored to each specific apartment building, at least as far as the type or construction system is concerned.

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