Upgrading of Panel-Built Residential Houses

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Summary

The majority of the apartment houses in Slovakia were built in the 1960-1985 period. These residential buildings have been implemented, in more than 70 % of cases, by the construction systems using concrete panel blocks. The outer shells of apartment houses were constructed as single layer jackets and, only after introduction of new buildings standards with tougher specifications covering thermal technical properties of buildings objects in 1983, the multi-layer building jackets with polystyrene thermal insulation layer came in use. As seen by current standards, all constructions have low thermal insulation quality. As a result of reduction of indoor temperatures to 20-21 °C, the thermal insulation inhomogeneous begin to influnce mildew develops. The obtaining of thermal comfort conditions in the flats is energy-intensive. A complex refurbishment of building structures is necessary (depending on the form factor of a building) which can bring as much as 50 % savings in heat energy consumption of the building.

Keywords: residential buildings, U-value, energy consumption for heating, hygenic problems, in-situ-data of existing buildings

1. Assessment of Thermal Insulating Properties of Building Structures

1.1 Thermal Resistance of Building Structures

The outer walls and roofing jacket of buildings have been designed according to the applicable thermal insulation specifications of the constructions. The changing requirements set on the thermal resistance and/or U-value of building outer jacket, have influenced the application of the materials. The ever more demanding refuirements have influenced the technologies used in the building outer jackets constructions.

The design value of the densitivity of cellular concrete used for outer wall structural elements in designs was 1.350-1.450 kg/m^3. However, the actual value as confirmed by the diagnostic tests performed on the existing buildings was 1.630-1.920 kg/m^3 which means that the thermal insulation parameters of the outer jacket are similar to those of normal concrete. For example, by taking the design value of the densitivity of 1.450 kg/m^3 for slagpemseconcrete used by panel blocks outer jacket, we arrive a theoratical value of $\lambda = 0,66$ W.m^{-1}.K^{-1}. The actual measured value of densitivity of built-in panel blocks is 1700 kg/m^3, which in turn gives an actual value of $\lambda = 0,84$ W.m^{-1}.K^{-1}. In this particular example the change in thermal insulation quality of material caused the thermal resistance value drop of 30 %. Through this effect the calculated temperature of building indoor surfaces (for the assumed outdoor temperature t_e = -15 °C) would be equal to the dew point temeprature 12 °C. For buildings located in the temperature zone with t_e = -18 °C, the indoor surfaces would be even lower. Thus the panel block construction of houses does not meet the hygenic criterion (considering the samllest possible safety margin, the indoor surface temperature should be at least t_{ip} = 12,2 °C).

The influence of thermal inhomogenity is more pronounced in multilayered building outer jackets. Thermal conductivity of foam polystyrene is λ = 0,044 $W.m^{-1}.K^{-1}$. As consequence of protruding reinforcement bars of the „M" anchors (for multi-layered panel blocks of P1.14 type used in building constructions in 1965-1970 period) made from stainless steel bars of 8 mm diameter, pins of 2 mm diameter and cement milk and concrete spills poured into thermal insulation layer, the thermal conductivity attains higher values up to λ_{ekv} = 0,07 $W.m^{-1}.K^{-1}$. The increase in the thermal conductivity value by almost 60 % would mean, at the same time, that thermal resistance of the insulatiom layer is 60 % lower. The value of thermal resistance of panel blocks for bulding structures with inhomogenous layers is equal R = 1,07 $m^2.K.W^{-1}$. If a homogenous thermal insulation layer, which is exposed to unidirectional heat flow, is considered, then the thermal resistivity of panel block would be as high as 1,86 $m^2.K.W^{-1}$. The assessed thermal resistivity values of individual peripheral wall jacket and roofing structure, based on the performed diagnostic testing are given in the following table. The inhomogenity of the structures for the respective building types was verified by the thermovision diagnostics.

Table 1 : Assessment of Various Building Types of Housing Blocks

Construction System	Thermal Resisitivity R ($m^2.K.W^{-1}$)	U-value ($W.m^{-2}.K^{-1}$)	% [1] of Heat-Exchange Surface	Form Factor (row-rise houses) (m^{-1})
PV - 2	0,694	1,16	70	0,43
G - 57	0,280	2,23	57	0,41
BA	0,550	1,39	81	0,31
LB	0,390	1,79	51-66	0,31
T06B KE	0,503	1,49	46-62	0,42
T06B ŽA	0,414	1,72	57-72	0,27
T06B NA	0,923	0,92	51-54	0,45
T06B BB	0,450	1,62	52-60	0,43
ZTB	0,353	1,92	63	0,39
T08 B	0,923	0,92	49	0,32
BA - BC	0,802	1,03	70	0,38
B - 70	0,990	0,86	61	0,37
BA NKS	0,960	0,89	57-65	0,40
P1.14	1,07	0,81	65-75	0,31
P1.15	1,08	0,81	65-75	0,31

1) The values given for stand-alone and in-line attached houses, subject to construction system used for the selected building

The real thermo-technical properties of the building roofing jacket are influnced by the moisture contents of individual layers. The results of diagnostic tests have shown that the increased moisture contents is not caused by the water vapour condensation in the thermal insulation layer in winter period, but it is consequence of the rain water pouring into the structure, due to workmanship defect in construction details and due to damaged hydroinsulating foils.