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ENERGY-EFFICIENT CONSTRUCTION OF APARTMENT HOUSES IN SLOVAKIA

BUDOWNICTWO ENERGOOSZCZĘDNE NA PRZYKŁADZIE BUDYNKÓW APARTAMENTOWYCH NA SŁOWACJI

Abstract

The latest revision of national standards, aimed at the thermal performance of structures, conformed to internationally applicable standards of energy-efficient construction, low-energy construction, ultra-energy construction, and nearly zero-energy construction. This paper analyzes the requirements of thermal revised standards in the context of the construction of apartment buildings. The mentioned required standards involve improved and more detailed project planning, leading to the comprehensive realization of building projects as they are intended. Currently, in addition to traditional ways of building, there is an increasing prevalence of modern methods of construction. MMC are using the potential of prefabricated parts of structures. In this article, the aforementioned methods will be compared from an energy conservation and economic point of view.

Keywords: modern methods of construction, apartment buildings, case studies

Streszczenie

Ostatnia zmiana norm krajowych (na Słowacji) miała na celu dostosowanie wydajności termicznej budynków i budowli do międzynarodowych standardów budownictwa energooszczędnego, budownictwa nisko-energetycznego, ultraenergetycznego i bliskiego zeru budownictwa energetycznego. Artykuł analizuje wymagania zmienionych norm cieplnych w kontekście budowy budynków apartamentowych. Wymienione wymagania normatywne narzucają przygotowanie projektu na wyższym poziomie szczegółowości i większą jakość realizacji. Obecnie, oprócz tradycyjnych systemów budowlanych, coraz częściej są stosowane nowoczesne sposoby realizacji. MMC wykorzystują potencjał prefabrykowanych elementów konstrukcji budowlanych. W artykule zostaną porównane powyższe metody budowy z punktu widzenia efektywności energetycznej i ekonomicznej.

Słowa kluczowe: nowoczesne metody budowy, apartamentowce, studium przypadków

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1. Introduction

On 17 November 2009 [1] the European Parliament and Council set the year 2020 as a deadline for all new buildings to be nearly zero-energy buildings (*Action Plan for Energy Efficiency: Realising the Potential*). Buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the EU. It is estimated that, by strengthening the provisions of the Directive on energy performance, the EU could achieve a reduction in its greenhouse gas emissions equivalent to 70% of the current EU Kyoto target.

Therefore from 1 January 2013 the newly revised Thermal STN 73 0540-2: 2012 came into force, from which time only new low-energy buildings can be built, and only ultralow-energy buildings may be built from 1 January 2015. New buildings constructed after 2015 will need to meet the standards for ultralow-energy buildings, and after 2020 the standard will be zero-energy. Therefore, the conditions under which the new buildings must be designed are clearly set out. This applies to all forms of construction, including apartment buildings. There is presently an increasing need for the design and realization of new apartment buildings, as the existing residential structures are insufficient at meeting the demands of the housing market. Consequently, modern methods of construction (MMC) have been developed to replace traditional methods of construction (TMC). MMC are based on prefabricated construction materials consisting of interconnecting components, which are made from a variety of materials, such as wood, steel, concrete, or any combination of these, along with others. MMC have become fast, high-quality, and affordable means of construction, resulting in structures that satisfy the highest energy requirements.

The focus of this paper is a comparison of a group of apartment buildings according to their methods of construction. It also provides context on the purchasing and operating costs of construction.

2. Standards in the area of energy-efficient buildings

From 1 of January 2013 the newly revised standard thermal STN 73 0540-2: 2012 came into force [2]. It includes, among other things, clearly defined terms such as energy-efficient buildings, low-energy buildings, ultralow-energy buildings and buildings with nearly zero-energy needs. **Energy-efficient buildings (the minimum requirement)**, are buildings which reduce the need for heating compared to the earlier generation of buildings and fulfil requirements for the thermal performance of building structures. **Low-energy buildings (the desired requirement)** are buildings where heat energy demand is at least 50% less than conventional buildings, which were constructed after 1983 and unable to comply with the heat and technical regulations that were passed in 1992). **Ultralow-energy buildings (the recommended requirement)** are buildings designed so that the maximum heat demand is less than half of what is intended for low-energy buildings. **Buildings with nearly zero-energy needs (the target recommended requirement)** are buildings with very high energy performance. These buildings use a large portion of energy from renewable resources inside of the buildings themselves or in their vicinity. The more commonly used term, passive building (energy consumption ≤ 15 kWh/m^2), is not used in the the text of the Slovakian law concerning construction regulations.

It is necessary to note that for apartment houses, there are different limits on energy consumption.

According to STN 73 0540-2: 2012, the minimum performance of thermal properties of building structures involve five criteria [2]:

– minimal thermal insulation construction (maximum value of heat transfer coefficient U structures),
– minimum temperature of the inner surface (hygiene criterion),
– minimum average air exchange in the room (air exchange rate criterion),
– maximum specific heat demand for heating (energy criterion),
– heat consumption (criterion of minimum energy performance requirements for buildings).

New buildings should therefore comply with the thermal performance requirements for buildings from 1 January 2013. Standard requirements also stipulate major renovations of outdated buildings. If this is not functionally or technically feasible, all renovated buildings must meet at least the minimum energy-efficient requirements.

The **energy performance of buildings** is defined as the amount of energy needed to fulfil all the energy needs during the typical use of the building, particularly the energy required for heating and hot water, cooling and ventilation, and lighting. **Energy certification** is a process by which a building is classified according to its energy class (A to G). **Energy performance certificates** are issued for a maximum duration of 10 years.

3. The implementation of modern methods of construction in residential buildings

The boom in panel construction lasted for approximately 50 years, until to 1995. The absence of state subsidies in housing construction caused a decrease not only in panel construction but in the construction of any types of residential buildings. Regardless, the demand for new housing grew. The construction industry is constantly growing and requires a fast, high-quality, and economically feasible option, which became the goal of every construction project. Other requirements have involved a philosophy of building sustainability, especially in the energy and environmental fields. These requirements can be fulfilled by MMC. The costs incurred for the construction and maintenance of buildings, as well as the critical state of the environment and the finiteness of natural resources, means that before construction begins, it is necessary to consider the selection of construction methods for realization. Today it is no longer unusual to build apartment houses using timber frame construction, modular construction, or prefabricated skeletal structure with masonry infill. Studies on MMC technology in the construction of apartment houses are numerous.

A **study in Malaysia** [3] presented an analysis of the energy- and cost-effectiveness of three lightweight construction systems – wood frames, light steel frames and SIP sandwich panels. A **study in Sweden** [4] dealt with wood construction systems for apartment buildings designed to achieve a high level of energy efficiency. Another **Swedish study** [5] analyzed the material bases of apartment buildings and the impacts of different insulation materials on issues such as primary energy and CO_2 emissions created during their production. A **study from South Korea** [6] has advanced another idea to ensure the high energy efficiency of new apartment buildings By conducting the operational evaluation in the early design phase. The study developed a methodology for the measurement of dynamic service ratings of new apartment buildings using advanced assessments and considerations, as well as stochastic methods. The issue of MMC implementation methods for apartment buildings is also the subject **of research in Slovakia**. MMC potential in this segment of construction was studied for comparison on 8 selected types of buildings [7]. The first five studies involve MMC building technologies. The last three involve traditional building technology. The results demonstrate that MMC can be used I the construction of energy-efficient buildings in addition to lower construction costs.

3.1. Construction of energy-efficient apartment buildings in Slovakia – case studies

The purpose of these case studies is to prove that the apartment buildings are capable of being built in energy-efficient ways. It also examined MMC potential in the realization of apartment buildings and energy savings. A group of selected types of apartment buildings was studied in reference to their energy efficiency, which has a direct impact on the purchasing and operating costs. The group consisted of six apartment buildings erected by different construction methods. **Case study No. 1 – Zelené átrium, Trnava [8]**: The apartment building construction is designed as a reinforced concrete frame with masonry infill. It belongs to the "passive" house energy class (ultralow-energy). It offers 45 apartments on four storeys (with a floor space of 39–88 m^2). **Case study No. 2 – Petržalské dvory, Bratislava II.etapa [9]**: This apartment house is one of the first apartment buildings with regenerative ventilation in Bratislava. The apartment house construction is designed as a reinforced concrete frame with masonry infill. There are 5 floors with 56 apartments (44–81 m^2). **Case study No. 3 – Jedlička apartment house, Poprad [10]**: The low-energy Jedlička apartment house consists of 4 floors and offers 18 new apartments with variable floor areas (30–92 m^2). The supporting structure consists of a reinforced concrete frame with fillings made of bricks and additional thermal insulation in the building envelope. **Case study No. 4 – Apartment house, Moldava nad Bodvou [11]**: The low-energy apartment building was constructed through the VELOX system. It has 5 floors and 28 apartment units (44–151 m^2). **Case study No. 5 – Apartment house, Selice [12]**: The apartment house contains three storeys and 13 apartments (29–57 m^2). The apartment house is designed as a wood frame construction. **Case study No. 6 – Orechov Dvor apartment house, Nitra [13]**: The Orechov Dvor apartment house was constructed through the KOMA container system. It has 28 housing units with a standard floor area of 49 m^2. The house has low-energy status.

3.2. Comparison and evaluation of case studies

The collected data are arranged in Table 1. The first two buildings were constructed as ultralow-energy buildings (max. 27 kWh/m^2 per year), whereas other buildings are low-energy (max. 55 kWh/m^2 per year). Buildings are assigned to energy classes on the basis of their total energy needs. Current buildings that comply with energy efficiency and carbon dioxide emissions standards are assigned to the energy classes from A to G. Class A includes the most economical buildings, and class G includes the least economical buildings. Buildings No. 1, 2, 3 are structurally designed as reinforced concrete frames with masonry infill, which is a traditional method of construction (TMT). Buildings No. 4, 5, 6 are designed using MMC. Apartment prices were collected and calculated on the basis of floor area, with values rendered as the price per single square meter. The annual energy consumption for each square meter of each apartment was also computed. Annual energy costs were recalculated based on the price of 0.78 EUR/month (9.36 EUR/year). This price was selected from the electricity supplier price list. The average apartment size is determined by dividing the total area of all dwellings to the total number of apartments.

Table 1

Comparison of selected apartment buildings

No.	Construction technology	Energy class	Average apartment size (m^2)	Energy consumption (kW/m^2per year)	Average price of m2 floor (EUR)	Annual energy costs (EUR per year)
1	TMT	A	74.67	13.5	1142	126.00
2	TMT	A	62.84	10.8	1702	101.00
3	TMT	B	51.04	28.2	1017	264.00
4	MMC	B	74.59	35.0	977	328.00
5	MMC	B	43.53	49.0	701	459.00
6	MMC	B	48.99	50.0	1312	468.00

TMT – traditional methods of construction
MMC – modern methods of construction

The savings on operating costs for ultralow-energy apartment houses is clear. This confirms their nature and the requirements of their design. The costs of purchasing ultralow-energy apartments are on average, higher than in low-energy energy class. Apartment building No. 2 has both the highest energy savings and the highest price per square meter of floor space. The optimal balance between operating and purchase costs belong to apartment building No. 4, built through the VELOX system. The modular apartment house (No. 6) has the highest operating costs as well as a high price per square meter of floor area, which explains the low interest in this method of construction for residential buildings, in addition to the lack of information about this modern method of construction with the public and developers.

If we want to know which method of construction is most cost effective, we can clearly observe in Table 1 that MMC (No. 4) and TMT (No. 1) are almost the same size. However, the average price for each square meter of floor space is radically different. MMC methods are preferable to TMT.

4. Conclusions

This paper deals with the construction of energy-efficient apartment buildings in Slovakia. There were six residential buildings selected as case studies, built according to both traditional and modern methods of construction and belonging to classes A and B, in terms of energy efficiency. The research confirmed that buildings with higher energy standards have higher prices, but the operating costs are lower. Apartment houses with lower energy savings have lower prices, but the operating costs are higher. Both the choice of construction method and energy standards variously influence purchase and operating costs. Traditional methods of construction have the ability to achieve high standards of energy efficiency (mainly due to their insulation). Due to the structural differences (wood frame construction and modular construction), modern methods of construction involve a wide variation of purchasing and operating costs. Among selected modern methods, wood construction appears to be the most energy-efficient. They have the potential for buildings in higher classes of energy efficiency, while the price per square meter of floor space would be lower than with traditional technologies.

In residential housing it is difficult to find many buildings constructed by the same MMC method. Traditional methods still have a strong market position, but this article demonstrates that MMC methods are not far behind them. They present a challenge to the current construction industry concerning how to build efficient and economical buildings.

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