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# PROCUREMENTS OF MODERN METHODS OF CONSTRUCTION BASED ON WOOD

In the last years we have witnessed increasingly frequent interest in an individual way of living in family houses. This provides a more natural way of living and living freely in contrast to the impersonal and restrictive living in panel housing estates. On this change largely responded companies offering a variety of system construction and technological solutions. With traditional and proven construction materials, the company also new, modern and fully-fledged alternative housing. One of them is the modern prefabricated structural systems based on wood. Even despite undeniable advantages that are associated with wooden buildings, preventing their more widespread low level of knowledge and awareness on the part of consumers and investors, as well as strong ties to traditional brick technology. An important factor in deciding the most building owners in choosing the construction of wooden houses is a measure of coping and recovery advantages of individual design systems that will mainly be reflected in the costs, quality and speed of construction. For this reason, we have decided to carry out a survey aimed at examining the impact of the procurement method on existing wood buildings in the context of construction time and acquisition costs.

**Keywords:** modern methods of construction, wood, construction costs, construction time

Generally, the modern methods of construction are technologies which make use of structures or their components manufactured in factory [1]. The production of more or less completed components of building structures in the plants has a high potential for increasing the construction efficiency at the production stage of building components as well as in the process of their integration in the site. The MMC [2] presents the technologies that provide effective procedures of construction preparation and execution, resulting in a larger volume of production with higher quality and reduced time of their

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procurement. The advantages of the MMC are shorter construction time, fewer errors in construction, and reduced demands on energy consumption or reducing of construction waste generation. Their ambition by [3] is to enhance the construction efficiency through reducing of construction time, improvement of quality, sustainability and impact of the building and of the building process on environment [4]. Authors [5] claim that the MMC in the construction industry have a higher productivity and better quality, as well as some benefits such as reduced construction time, lower overall construction costs, better quality, more durable and better architectural appearance, increased health protection at work and safety, reduce materials consumption, less construction waste, fewer emissions into the environment and reduce energy and water consumption.

A range of materials is used for MMC, the most common being wood, steel and concrete. The choice of basic building materials is a vital part of each project and is usually based on professional judgment taking into consideration the importance of such criteria as economic, environmental, functional, aesthetic and health-related [6]. Responses for efficient, economic and sustainable solutions are modern methods of based on wood. Regarding the modern methods of construction implementation in Slovakia, assembled buildings based on wood seem to be the most preferred construction system. This system is designed to build multi-storey buildings, apartment buildings, office buildings and houses [7]. By [8] they can be built as prefabricated panel constructions, framed constructions, timbered constructions, skeleton and half-timbered constructions. One of the advantages of wooden houses is the variability of structures and composition of the walls, which can be designed as a low cost, low energy and passive models. In addition, they are perceived as structures for the "healthy" housing, their main advantages are short construction time, lower the environmental impact of the construction and used materials, lower realization costs and costs of operation [9].

Despite the undeniable advantages associated with the use of modern wood-based construction systems, by Štefko [10,16] prevents a wider expansion of timber structures in the Slovak Republic from a low level of knowledge and information from customers and investors, as well as strong links to traditional brick technologies.

An important factor in deciding most builders when choosing a wooden construction system is the degree to master and reap the benefits of individual construction systems, which are reflected in the cost, quality and speed of construction. For this reason, we decided to carry out a survey aimed at examining the impact of the procurement method on the already wood constructions in the context of construction time and procurement costs.

This paper presents the partial results of the socio-economic exploration of modern wood-based construction methods. The results assess the impact of the procurement process on parameters construction time and the procurement costs of the wood buildings. The subject of the study was the real wood used already.

A total of 80 buildings were monitored on behalf of two of the most widespread wooden construction systems realized in Slovakia (Wooden frame system, Panel construction system). The comparison parameter was subjected to a correlation analysis to determine the dependence between the analyzed parameters.

## 2.1. Selected construction systems buildings based on wood

### 2.2.1. Wooden frame system

Wooden frame system originates from USA and Canada, where it is still the most widely used building system. The basic element of such a construction is supporting frame perimeter and partition walls of various timber profiles (Fig.1). Ceiling structure is composed of different profiles of timber and wood based materials. The stability is provided by the cladding of large agglomerated materials such as OSB board or gypsum board. Thermal requirements are secured by inserting thermal insulation (Fig.1). Standard construction of the walls is similar to panel construction system, but the individual elements and layers of walls are completed directly on site.

Fig. 1. Wooden frame system [10]

Construction and assembly of wooden frame system is less demanding on a large mechanization. All layers of the structure and operation of installations are carried out on site, resulting in higher labor demands a higher proportion of the on-site works. This causes a greater probability of low quality work, including the impact of climatic conditions [17].

### 2.2.2. Panel construction system

Panel construction system is a main off-site construction method based on wood. Structural elements - panels (wall, ceil, roof, gable, partition wall) are produced in different stages of completion in the production hall and subsequently transported to the construction site where they are assembled to the structure. Build-up process is characterized by speed and precision. The panel

generally consists of a wooden frame of profiled timber, covered on both sides with large-scale plates, filled with thermal insulation material. Instalations are prearranged in the panels during the manufacturing.

Fig. 2. Construction of panel construction system [12]

Prefabricated construction panel system fully utilizes construction, manufacturing and assembly advantages of their production to the efficiency of the entire construction process. The key moment to increase the efficiency and degree of prefabrication is panel's finalization. Panel system has enormous potential for increasing efficiency in the design, production and construction phase [18]. Manufacturing can be automated, thus increasing the quality of production. Load bearing system of prefabricated wooden houses could be completed within a few days (Fig. 2). Other finishing and plumbing work follows the assembly of the individual elements.

On the basis of the correlation analysis, we found a statistically significant dependence between the method of procurement and construction time ($p = 0.5570$), the method of procurement and the procurement costs for procurement of wood building (EUR) ($p = -0.2776$), the method of procurement and the type of construction system ($p = 0.3553$). We also noticed the dependence between the type of construction system and the construction time ($p = 0.6903$).

A more detailed interpretation of the correlations between the construction system and the procurement of realization pointed out that the users of the panel construction systems prefer the realization of their construction mostly through the construction company and on the contrary, the users of the columnal wooden constructions used the way of realization self-help in combination with the realization of the construction through the construction company. A statistically significant impact has been observed between the type of timber construction system and the construction time, which suggests that panel timber constructions were realized in a shorter time horizon than a column construction system.

Table 1 presents a comparison of the average construction time of the individual construction systems broken down by the method of procurement,

indicating the declared construction time from woodworking producers. The table shows the breakdown according to the method of procurement, due to the fact that correlation analysis revealed statistically significant differences in terms of type of construction system and method of procurement (P = 0.3553). Declared values of construction time parameters (Table 1) and procurement costs (Table 2) from producers are determined based on the findings made on promotional materials, websites and personal interviews with representatives of companies operating in the construction sector. From the findings from the mentioned sources, the most frequently mentioned declared parameters of timber constructions can be summarized as: construction time, investment acquisition costs and energy standard, which are subsequently determined by an individual arrangement, specified and anchored in the works contract. Manufacturers also state that the construction time of the assembled dwelling completely made depends on a number of factors such as the technology used, the size of the building, the number of floors, the severity of the foundation and the construction, and, last but not least, the annual construction period. Acquisition

Table 1. Analysis construction time of the comparative wood construction systems

| **Construction system** | **Mode of procurement (number of buildings)** | **Average of construction time (months)** | **Construction time declared by suppliers (months)*** (complete building) |
|---|---|---|---|
| **Panel construction system** | Through the supply company (40) | **4.26** | 3 – 6* |
| | Realization by self-help (3) | **7** | - |
| | Combination (2) | **10** | - |
| **Wooden frame system** | Through the supply company (20) | **10.47** | 3 - 6* |
| | Realization by self-help (13) | **17.91** | - |
| | Combination (2) | **16** | - |

*depending on the complexity of the project

costs as well as construction time depends on the particular technical and design. The material composition also has a significant impact on the price, the other cost is if you use a diffusion-sealed polystyrene-insulating construction and the cheapest rendering system, or if a wood-based thermal insulation with a vented wood facade is used in the diffusion-open structure. Of course, such qualitative variants apply to all construction parts of the building.

From the data in Table 1 it can be stated that the shortest construction time was recorded in the panel construction system in all three ways of realization compared to the comparative construction system. The representative of the on-site construction system (wooden frame system) is largely implemented on

a building site with a higher workflow and a higher demand for craftsmanship of workers, not excluding the weathering effects of the environment. By comparing the average construction time of the construction systems and the declared construction times by the manufacturers it can be stated that only the panel construction system has actually fulfilled the predefined parameter.

Table 2 presents a comparison of the average procurement costs of individual construction systems in terms of conversion per $m^2$ of useful area. On the basis of considerable data dissemination, there was no statistically significant effect between the procurement cost and the building energy standard, therefore we did not calculate the recalculated cost per $m^2$ of useful space in terms of the energy standards of the monitored buildings in Table 2.

Table 2. Analysis procurement costs of the comparative wood construction systems

| **Construction system** | **Mode of procurement (number of buildings)** | **Average of procurement costs** (EUR) per $m^2$ of floor space | **Procurement costs declared by suppliers** (EUR)* per $m^2$ of floor space plochy (complete building) with DPH | |
|---|---|---|---|---|
| | | Overall without a difference in the energy standard | Low energy standard | Passive Energy Standard |
| **Panel construction system** | Through the supply company (40) | **933** | 900 – 1200* | 1400 – 1600* |
| | Realization by self-help (3) | **647** | - | - |
| | Combination (2) | **1046** | - | - |
| **Wooden frame system** | Through the supply company (20) | **925** | 900 – 1400* | 1400 – 1600* |
| | Realization by self-help (13) | **635** | - | - |
| | Combination (2) | **694** | - | - |

*depending on the complexity of the project

By correlation analysis we recorded a statistically significant negative dependence between the method of realization and investment costs for the procurement of constructions (p=-0.2776), which means that if the construction was carried out by the supply company, the acquisition costs increased, whereas the decrease was made when the construction was realized either alone or in combination. These findings have also been guessed as they are a standard in practice. On the basis of the average values calculated per $m^2$ in Table 2 it can be stated that in almost all methods of realization of panel and column woodwork comparable cost of acquisition per $m^2$ was recorded, except for the combined realization of the construction.

In the present article, we analyzed the impact of the procurement method on the building time parameters and the procurement cost of real woodworks. They were analyzed two of the most widespread wooden construction systems realized in Slovakia (Wooden frame system, Panel construction system). On the basis of the correlation analysis, we found a statistically significant dependence between the method of realization and the time of construction (p=0.5570), the realization method and the investment costs for procurement of wood buildings (EUR) (p=-0.2776), the realization method and the timber construction system (p=0.3553). We also noticed the dependence between the type of construction system and the construction time (p=0.6903). The conclusions of the analysis of the assessed wood construction parameters point to the fact that the timber construction based panels are the most effective in terms of construction time and are realized through a supply company. The least efficient in terms of the construction period is the construction carried out by a combined construction method (a combination of the way of realization through a supplier company and self-realization). From the point of view of procurement costs, panel and column construction system were comparable in almost all ways of realization.

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