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TRANSPORT COSTS OF PREFAB WOOD AND BRICK CONSTRUCTION – COMPARATIVE STUDY

KOSZTY TRANSPORTU PREFABRYKATÓW Z DREWNA I CEGŁY – STUDIUM PORÓWNAWCZE

A b s t r a c t

Construction industry has a large share in environmental pollution. In the context of building industry, it is also the transport of building materials and products, which largely contributes to environmental degradation. Construction increasingly promotes wood-based construction systems, thanks to faster construction, better environmental, energy and economic parameters. Prefabricated wood-based panel construction system fully utilizes construction, manufacturing and assembly advantages of the production to the efficiency of the entire construction process. The key moment to increase the efficiency and degree of prefabrication is panel's finishing. Creation of structural elements in the factories allows a reduction in rides to the site. The paper analyzes the transport costs of the model house constructed by the system of traditional brick and panel system based on wood in the context of transport and manipulation of materials in both bearing systems.

Keywords: *wood construction, brick construction, costs analysis*

S t r e s z c z e n i e

Duży udział w zanieczyszczeniu środowiska naturalnego ma przemysł i budownictwo. Produkcja budowlana, jak również transport materiałów i produktów budowlanych, w dużym stopniu przyczyniają się do degradacji środowiska naturalnego. Do budowy obiektów coraz częściej stosuje się prefabrykowane systemy oparte na drewnie strukturalnym. Systemy te charakteryzują się krótszym czasem budowy, mniejszym zużyciem energii i lepszymi parametrami ekonomicznymi. System ściany prefabrykowanej to budownictwo wykorzystujące drewno. Kluczowymi elementami procesu są: zwiększenie wydajności, skrócenie czasu prefabrykacji elementów oraz ich transportu. Tworzenie komponentów konstrukcyjnych w zakładach pozwala na skrócenie czasu transportu na miejsce w stosunku do pojedynczych elementów. W artykule analizowane są koszty transportu i materiałów domów modelowych z drewna i cegły.

Słowa kluczowe: *konstrukcje z drewna, budynek z cegły, analiza kosztów*

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1. Introduction

The growth in freight transport increases the demand for non-renewable sources of energy and increases the production of greenhouse gases. According to the Statistical institute of the Slovak Republic the largest share in emissions and polluting substances within the transport operation in Slovakia is road transport. Individual automobile transport and road freight transport makes up 87% of total emissions.

The building industry has a large proportion in the environmental pollution. Especially it is the transportation of building materials and products which is largely involved in damaging the environment within the building industry. In accordance to the European Directive No. 2010/31 EU, which establishes a common goal to reduce by 2020 the production of greenhouse gases by 20%, the construction sector is highly promising in terms of potential energy savings and greenhouse gas emissions reduction.

In Slovak Republic and in the whole Central Europe as well we are observing an increasing interest in the construction of environmentally friendly materials. These materials certainly include wood, wood-based products and wood-based composites. Besides the fact that wood is one of the so-called renewable raw materials, environmental benefits of modern wood versus heavy ceramic and silicate structure also save the total costs of construction and related production and transport.

2. Wood-based panel construction system

Building constructions based on wood are capable of becoming economically interesting also in our regions, if they effectively manage design, technology, logistics, quality management system in manufacturing and construction. According to Stefko [1] the wooden buildings can be divided into: prefabricated panel constructions, columnar constructions, timbered constructions, skeleton and half-timbered constructions. According to the Association of Wood Processors of Slovak Republic, the most widely used structural systems of prefabricated wooden buildings constructed in Slovakia include panel constructions and columnar construction systems. Therefore, the contribution deals with the panel construction system.

Structural elements – panels (wall, ceil, roof, gable, partition wall) are produced in different stages of completion in the production hall (Fig. 1, Fig. 2) 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. During the manufacturing of the panels the preparation for installations is incorporated.

Prefabricated construction panel system fully utilizes construction, manufacturing and assembly advantages of the production to the efficiency of the entire construction process. The key moment to increase the efficiency and degree of prefabrication is panel’s finishing.

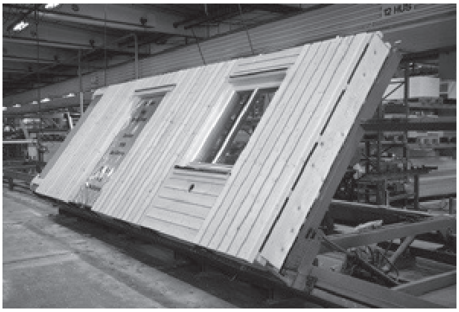

Fig. 1. Production hall of sandwich wall panels (La Vardera)

Fig. 2. Loading wall panels onto a vehicle (Nesbau)

Panel system has enormous potential for increasing efficiency in the design, production and construction phase. Manufacturing can be automated, however to increase the quality of production and to re-implement the construction workmanship is necessary. Bearing system of prefabricated wooden houses is completed within a few days. Other finishing and plumbing work is performed after the assembly of individual elements.

2.1. The proportion of transport costs of panel construction system based on wood

In Slovakia, contribution to the total cost is presented within 1–4% in the low and 2–6% in a high level of completion of design elements. A low level of construction elements completion is a panel without surface treatment, doors and windows with pre-treatments for the installations. The high level of completion is a panel with doors and windows and pre-treatments for the installations and surface treatment. The percentage also depends on the energy standard. The higher mass elements have greater demands on carrying capacity transport mechanisms or need multiple rides to the site. The percentage increases in proportion to the distance of transportation of components.

2.2. Comparative analysis of costs of transporting panel construction system based on wood and traditional brick system

This part of the paper presents a comparative analysis of the two alternatives: constructional and technological systems, applied to the house model. The comparison consisted of a prefabricated panel system and traditional brick system. For this purpose a real project of prefabricated wooden houses was used, on which alternatively the traditional brick system of ceramic fittings was created. The difference between the systems is in vertical and horizontal structures and the thickness of the external insulation. Build-up areas, the finishing work and technical equipment including energy standard were the same.

Building model is designed as a semi-detached house. It has a simple shape with two floors and a flat roof. Building area is in the shape of a square 12 × 12 m floor area of one flat 144 m^2 and a building space of all building 864 m^3. The house is based on the foundation strips. In a brick building a more massive foundation strips are intended. External wooden walls are 270 mm width and a thickness of masonry construction is 440 mm. Contact insulation system is chosen on the wall for both variants, on wooden house at 120 mm thick and 180 mm on masonry construction. The ceiling structure of wooden system consists of a wooden beam ceiling; the brick ceiling structure is reinforced with concrete slab. Roof structure in both variants is a flat roof with a slope of 5%. The roof has a wooden structure with thermal insulation, which guarantees the required thermal resistance. In both variants there is waterproofing on reinforced concrete floor slabs, 100 mm insulation and 70 mm concrete screed. Windows and entrance doors are glazed with insulating triple glazing. The house has electric underfloor heating.

The analysis focuses on the cost of the machine for transport and installation of materials and products needed for construction of buildings implemented by the assembled construction of a traditional brick construction system. On the basis of calculations derived from the weight of materials and structural elements necessary for the rough construction Fig. 3 is compiled. Comparison between the weight of the materials needed to construct rough construction is disaggregated down in vertical structures, horizontal structures and roofing.

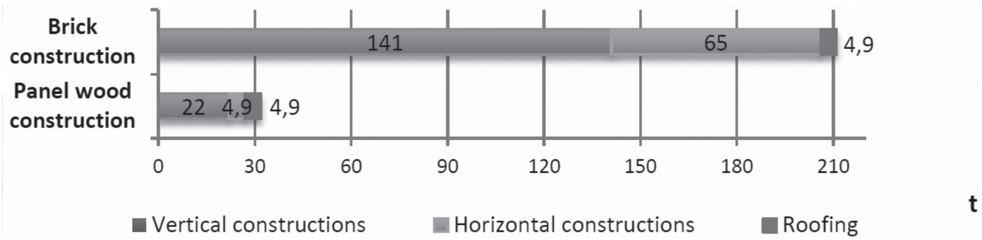

Fig. 3. Compare the weight of construction materials and products

Fig. 3 shows lower weight of wood rough construction in comparison with classic wooden brick by up to 85%. Significantly lower weight of wood construction is favourably reflected in the transport, in decreasing of harmful emissions and energy consumption. Also, lower weight wood construction reduces complexity of foundation and thus the financial cost.

Table 1 presents the costs of transporting of building materials and products, calculated per 1 km and rent mechanisms necessary for landing and incorporation of materials and components in construction.

Comparison of transport costs involved in the foundation structures and rough construction, the implementation of prefabricated wooden and brick buildings shown in Table 1 presents the 44% difference between structural variants calculated per 1 km of transport in favour of wooden houses. Other (fixed) costs independent of the number of km, the design of these systems at almost the same. Number of rides of mechanisms for wooden variation is reduced by 37%. In both scenarios a concrete mixer is needed, as well as a concrete pump, truck with hydraulic boom to manipulation with reinforcements and timber for foundation and roofing. The main differences are the transport and manipulation with masonry materials and wall panels.

Table 1

Comparative analysis of costs of transporting panel construction system based on wood and traditional brick system

Specification of mechanism				UM	Volume	The number of rides (the quantity transported)	Costs of UM (EUR)	Costs of wood construction (EUR)		Costs of brick construction (EUR)	
								to 1 [km]	others (fixed) costs	to 1 [km]	others (fixed) costs
Foundations, vertical constructions	Concrete	Transport	mobile concrete mixer	[m^3]	110	19	7,2	×	792	×	×
					145	25		×	×	×	1044
		Car delivery		[km]	1	–	2	38	×	×	×
					1	–		×	×	50	×
		Assembly	putzmeister	[hour]	4	–	80	×	320*	×	×
					10	–		×	×	×	800*
		Car delivery		[km]	1	1	2	2	×	–	×
					1	3		×	×	6	×
	Armature	Transport	truck with hydraulic boom	[km]	1	1 (5,5 [t])	5	5	×	×	×
					1	1 (9 [t])		×	×	5	×
		Unloading		number of unloading	1	–	30	×	30	×	×
					1	–		×	×	×	30
	Shuttering	Transport	truck with hydraulic boom	[km]	–	–	5	×	×	×	×
					1	1 (165 [m^2])		×	×	5	×
		Unloading		number of unloading	–	–	30	×	×	×	×
					1	–		×	×	×	30
	Ceiling panels of wood construction	Transport	truck	[km]	**	** (4,9 [t])	–	**	×	×	×
					–	–		×	×	×	×
		Unloading, manipulation	lifting mechanism	[hour]	***	–	–	***	×	×	×
					–	–		×	×	×	×
Vertical constructions	Wall panels of wood construction	Transport	truck	[km]	1	2 (22 [t])	5	10	×	×	×
					–	–		×	×	×	×
		Unloading, manipulation	lifting mechanism	[hour]	16	–	60	×	960*	×	×
					–	–		×	×	×	×
	Masonry material	Transport	truck with hydraulic boom	[km]	–	–	5	×	×	×	×
					1	7 (141 [t])		×	×	35	×
		Unloading		number of unloading	–	–	30	×	×	×	×
					7	–		×	×	×	210
Roofing	Timber	Transport	truck with hydraulic boom	[km]	1	1 (4,9 [t])	5	5	×	×	×
					1	1 (4,9 [t])		×	×	5	×
		Unloading		number of unloading	–	–	30	×	***	×	×
					1	–		×	×	×	30
Total transport costs to 1 km and others (fixed) costs								**60**	**2102**	**106**	**2144**
The number of rides								24		38	

Note: UM – unit of measure, * lease, ** transported together with wall panels, *** unloading with wall panels

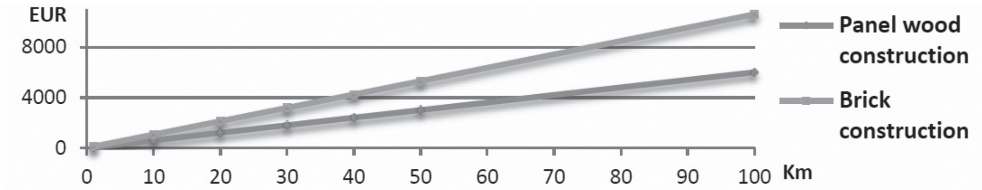

Fig. 4. Effect of distance on transport costs of wooden panel and brick construction

Fig. 4 shows a significant difference between variants depending on transport distance. For example, in this case, at a distance of 100 km, the difference is 4600 EUR.

3. Conclusions

The presented comparative case study has revealed differences between prefabricated wooden buildings made of prefabricated wall panels and classic brick building in the context of the cost of transport of building materials and structures, including their installation. Significant advantages of the prefabricated wooden houses are lower weight compared to traditional masonry construction by about 85% in favor of the wood construction. Significantly lower weight of wood construction is very favourably reflected in transport, decrease of harmful emissions and energy consumption. Also, lower weight wood construction reduces complexity foundation and thus the financial cost. Prefabrication of structural components can reduce the number of rides to the construction site by 37%. The share of transport costs of construction elements in the context of the total cost of wooden houses is not significant for smaller transport distances, but at larger distances, this proportion increases proportionally and is reflected in the total cost of construction.

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