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Innovative Design with Engineered Wood Products in Contemporary Architecture

Marija M. Janakieska

Abstract

Macedonian vernacular architecture prominently featured wood as one of the primary and widely utilized building material, owing to its abundance, versatility, ease of construction, and captivating aesthetic allure. Therefore, the wood industry in Macedonia has a long tradition of producing a wide range of wood and wood-based products. Despite a rich and prosperous history, the wood products sector has experienced a consistent decline in profitability, diminished capacity to enhance value through downstream manufacturing, and a decline in overall competitiveness over the past two decades.

Engineered wood products (EWPs) are building materials that have been used since the early 1980s as replacements for, or in conjunction with, concrete and steel. They provide increased design flexibility for ambitious construction and advanced manufacturing technologies. This study will present modern and contemporary architectural designs using EWPs. Furthermore, it will introduce conceptual project proposals from students, showcasing innovative design ideas that leverage the advantages offered by EWPs as exceptional building materials.

Keywords: Engineered wood products (EWPs); design; projects; contemporary architecture

Introduction

Wood is a great construction material due to its great flexibility and low weight, simple construction, good strength in relation to weight, and reduced environmental impact. It is also a natural and sustainable material that brings people closer to nature, has carbon-capture benefits, improved air quality, and high insulating capacity (Akpan et al., 2021; Svajlenka & Kozlovska, 2021)

Wood has always been in a high position, both as a structural and non-structural material in Macedonian architecture since ancient times. In Macedonian vernacular architecture, wood served as one of the most important materials for wall structures, slabs, roofs, doors, window frames, stairs, and exterior and interior decoration. Some examples of houses from the vernacular Macedonian architecture are represented in Figure 1.

Figure 1

Houses in Krushevo and Ohrid as examples of the vernacular architecture in Macedonia – wood as one of the main materials for construction

Unfortunately, in the modern Macedonian architecture wood is mostly used in small houses in mountain regions, in the interior design or as a decorative element on the façades due to its amazing aesthetics. In recent years, material choices in Macedonia have become increasingly limited. The application of steel and concrete, particularly following the 1963 earthquake in Skopje, dominated over the usage of timber.

Engineered Wood Products

Engineered Wood Products (EWPs) are new contemporary products with improved characteristics based on wood (Kitek Kuzman et al., 2018). Advanced construction practices across Europe are mostly focused on environmentally friendly materials, such as various EWPs. However, the introduction of new products within the Macedonian construction industry is often met with limited awareness and uncertainty among architects, designers, clients, and investors (Miloshevska et al., 2021).

Table 1

Engineered Wood Products (EWPs)

GLT Glulam-glued laminated timber	**CLT** Cross-laminated timber	**PSL** Parallel strand lumber	**LSL** Laminated strand lumber	**LVL** Laminated veneer lumber
				
EGP Solid wood panel	**PB** Plywood	**LDF/MDF/ HDF** Low/medium/ high-density fiberboard	**VP** Veneered particleboard	**PB** P articleboard
				

OSB Oriented strand board	**LS** Light sandwich (honeycomb) panels	**WPC** Wood plastic composites	**TM** Thermally modified timber	**WFI** Wood fibre insulation boards
				

The limited adoption of EWPs in Macedonia can be partly explained by the absence of cross-laminated timber (CLT) or glued-laminated timber (GLT) production facilities within the country, which leads to higher prices for these products. The final decision for the building materials is mostly made by investors who are motivated by economic viability.

However, the situation has slowly changed in the last few years, because of the influence of European trends, and wood application is increasing in Macedonia. People's awareness is increased, and they are looking for more sustainable building solutions.

Methodology

The method in this study for exploring innovative design with engineered wood products in contemporary architecture includes examining different projects and constructed buildings, where EWPs are used. By analyzing these examples, the advantages and disadvantages of EWPs as building materials can be detected. Furthermore, recommendations for increased application of these products in Macedonia can be made.

Examples' Review

The BUGA Wood Pavilion (Figure 2) represents a new approach to digital timber construction. Its structure consists of segmented wood shells, which are based on biological principles found in the plate skeleton of sea urchins, which have been studied by the Institute for Computational Design and Construction (ICD) and the Institute for Building Structural Design (ITKE) at the University of Stuttgart. A robotic manufacturing platform was developed for the automated assembly of the pavilion's 376 bespoke hollow wood segments. This fabrication process ensures

that all segments fit together like a big, three-dimensional puzzle. The stunning wooden roof has a span of 30 meters (www.icd.uni-stuttgart.de).

Figure 2

BUGA Wood Pavilion 2019

Source: www.icd.uni-stuttgart.de

This pavilion is a great example of sustainable biophilic design, completely constructed with natural materials, mimicking biological principles found in nature. In addition, it is aligned with the principles of the circular economy, since the pavilion can be easily dismounted and positioned in a different location. Compared to a solid wood structure, the BUGA Wood Pavilion is made of hollow segments, which significantly reduce weight and material. However, this increases the number of building parts and leads to more complex manufacturing.

The Urbach Tower (Figure 3) is another example of a structure with self-shaping curved wood components. The shape of the tower is driven by the wood's characteristic shrinking during a decrease in moisture content, which is usually taken as a disadvantage of the wood as a structural material. The tower's components are designed and produced in a flat state. Afterwards, they transform autonomously into the final, calculated curved shapes during industry-standard technical drying (www.icd.uni-stuttgart.de).

Figure 3

Urbach Tower

Source: www.icd.uni-stuttgart.de

The Urbach Tower is marvelous proof of how disadvantages of a material can be used in a positive way to shape the structure. However, moisture typically causes problems with cracking and deformation in the wooden components, which demands full control of the moisture changes and stress development.

A project for a Botanical Garden in Skopje, by Faton Kalisi, Master Student at International Balkan University, is presented in Figure 4. It is inspired by natural structures and patterns from the fractal geometry of nature. The structure is designed from Cross Laminated Timber (CLT) carriers that form a spacious 3D truss. The chosen material is perfectly aligned with the function of the building – botanical garden. Glass is used as a façade envelope, which ensures transparency, natural daylight, and connection of the inner space with the outer environment. The CLT gives a warm and pleasant feeling to the interior design.

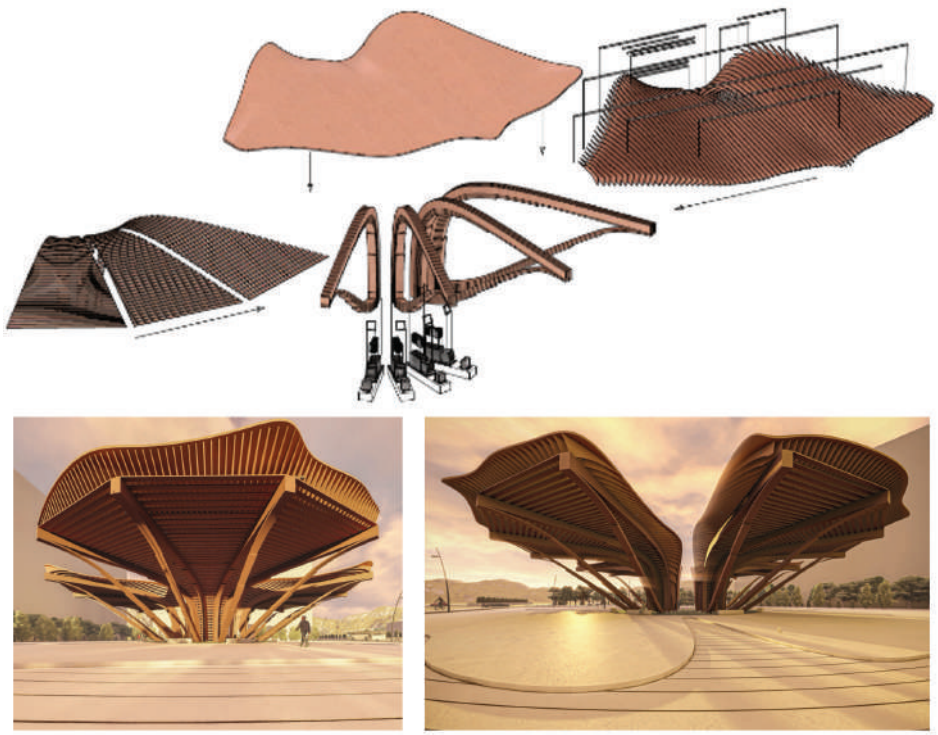
Figure 4

Project for Botanical Garden in Skopje with a structure from GLT, designed by Faton Kalisi, Master Student at International Balkan University

Figure 5 is a representation of a Project for a Pavilion, a Canopy design in Skopje, designed by Eldin Fazliu, a Master's Student at International Balkan University. The Pavilion has a unique, symmetrical structure that consists of curved timber carriers attached to the foundations, while the roof structure has a complex curved geometry formed with secondary wooden carriers.

Figure 5

Orchid Tree Pavilion, a Canopy design in Skopje, designed by Eldin Fazliu, Master Student at International Balkan University



Discussion

Wood as a construction material offers numerous sustainability benefits, as demonstrated by various studies, including the socio-economic research conducted by Svajlenka & Kozlovska (2020).

Moreover, wood has an important role in biophilic design by creating a natural connection between buildings and nature, with its organic textures, warm natural tones, and different colors. These features increase the functionality and the aesthetic of the architectural spaces. The application of wood is not only contributing to sustainability, but also to the comfort and well-being of the users. Exposure to natural elements like wood can reduce stress, improve mood, and increase pro-

ductivity. This aligns with the biophilic principles (Biophilic Design, n.d.; Kellert, 2018).

The beautiful aesthetic appeal of wood is one of the main reasons architects often choose it for their projects. One example is the redesign of the facade of Hotel Montana in Krushevo, designed by Fatih Sejfulla, a master's student at International Balkan University (Figure 6). In this project, wood was used as a cladding material on the façade to improve the visual aesthetic of the building, attract people, connect with the surrounding area, and highlight the biophilic aspect.

Figure 6

Project for a re-design of a facade of Hotel Montana in Krushevo, designed by Fatih Sejfulla, Master Student at International Balkan University

Besides its numerous advantages, wood also has disadvantages. It is not resistant to pests, fire, moisture and it has limited load bearing capacity. In some cases, such as the Urbach Tower, these disadvantages are used in the design of the structure in

a positive way. This makes the Urbach Tower a great example of how negative sides of one material can be used as an advantage in the design.

A new generation of wood products was developed so that these disadvantages can be overcome. EWPs are different products based on timber with improved characteristics that can find different applications in building construction. For example, Cross Laminated Timber (CLT) and Glued Laminated Timber (GLT) can overcome the limited load-bearing capacity of traditional wood; Wood Plastic Composites (WPC) and Thermally Modified Timber (TM) can be used for floors; and Plywood (PB) can be used for furniture.

Conclusions

The interest in Engineered Wood Products (EWPs) is slowly increasing, especially among young architects and students, particularly due to their appealing aesthetic and sustainable aspects. Designers and architects are becoming more aware of the positive features of wood as a construction material. Moreover, they are motivated to follow the principles of biophilic design and circular economy, which leads to a more responsible approach in architectural design and building construction.

On the other hand, wood as a natural material has disadvantages, such as susceptibility to pests, rot and flammability, variable volume due to moisture content, as well as limited load-bearing capacity. These negative sides can be addressed in different ways, through treatments, protective coatings, and innovative design solutions, which are shown in some case studies above.

By applying sustainable practices and overcoming wood's limitations, architects and engineers play a vital role in more mindful and conscious building designs. Architects, with their ideas and creativity, should find solutions to overcome the disadvantages and further enhance the use of wood and EWPs in construction.

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