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Structural Performance Of I-Shaped Timber Beams Composed of Solid Wood and OSB

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Abstract: This study investigates the structural performance, physical–mechanical properties, and fabrication technology of I-shaped timber beams composed of solid wood flanges and an OSB (Oriented Strand Board) web. The proposed composite beam system is aimed at improving load-bearing capacity, bending stiffness, and serviceability performance while maintaining environmental sustainability and economic efficiency. The interaction between timber flanges and the OSB web is analyzed using analytical expressions for bending, shear, and deflection. Composite action is ensured through the combined use of PVA-based adhesive bonding and bolted mechanical connections. The analytical model confirms that the I-shaped timber beam provides high structural efficiency and is suitable for application in lightweight and medium-span building structures.

Keywords: I-shaped timber beam; OSB; composite timber structures; bending stiffness; shear resistance.

INTRODUCTION

The growing demand for environmentally friendly and resource-efficient construction materials has intensified research into timber-based structural systems. In recent decades, innovative technologies for the production of load-bearing structures using timber and other natural materials have gained increasing importance in the global construction industry. Timber structures combine ecological safety, low self-weight, and favorable mechanical properties, making them competitive alternatives to traditional steel and reinforced concrete systems. [1].

Despite these advantages, the full structural potential of timber as a load-bearing material has not yet been completely realized. One of the key limiting factors is the lack of sufficiently effective joint systems capable of ensuring reliable force transfer while accounting for the anisotropic and heterogeneous nature of wood. Improving connection efficiency and enhancing the structural behavior of composite timber elements therefore remains a critical research task. [2].

I-shaped timber beams represent an advanced structural solution aimed at increasing bending stiffness and reducing material consumption. By relocating the majority of material to zones of maximum stress, the I-shaped cross-section significantly increases the moment of inertia, resulting in reduced deflections and improved load-bearing performance. The integration of OSB as a web material further enhances shear resistance and structural stability. [3].

2. Materials and Structural Configuration

The investigated structural system is an I-shaped composite timber beam consisting of solid wood flanges and an OSB web. The flanges are manufactured from grade II timber, selected for its high bending and compressive strength along the grain. The web is made of OSB panels with a thickness of 8 mm, providing effective resistance to shear forces.

The overall height of the beam section is 500 mm, while the web dimensions are 50 × 67 mm. This configuration ensures a rational balance between material consumption, bending stiffness, and load-bearing capacity. Such beams are intended for use in roof structures, floors, terraces, mansard spaces, and medium-span buildings with spans of up to 9–12 m. [4].

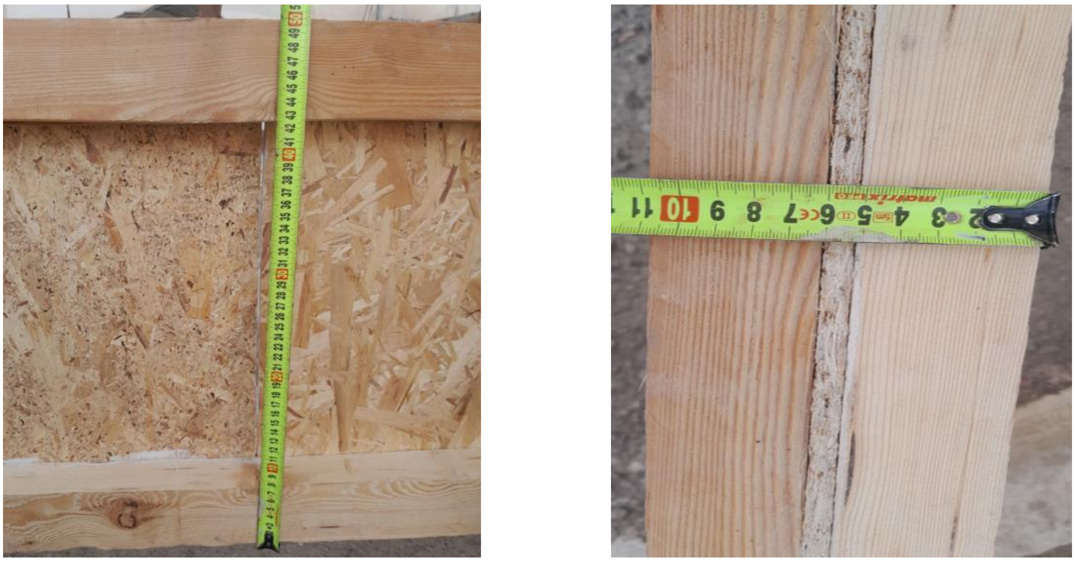

Figure 1. ***Model of an I-shaped timber beam***

3. Connection System

Composite action between the timber flanges and the OSB web is achieved through a combined connection system. Adhesive bonding is performed using Kokhsaroy PVA-801 adhesive, which penetrates timber fibers and forms a continuous polymer layer after curing. This reduces interfacial slip and ensures elastic behavior under variable loading conditions.

In addition to adhesive bonding, bolted mechanical connections with a bolt diameter of 10 mm are used to enhance load transfer and long-term reliability. Washers are applied to distribute bearing stresses and prevent local crushing of timber. The combined adhesive–bolted system provides both stiffness and structural redundancy.

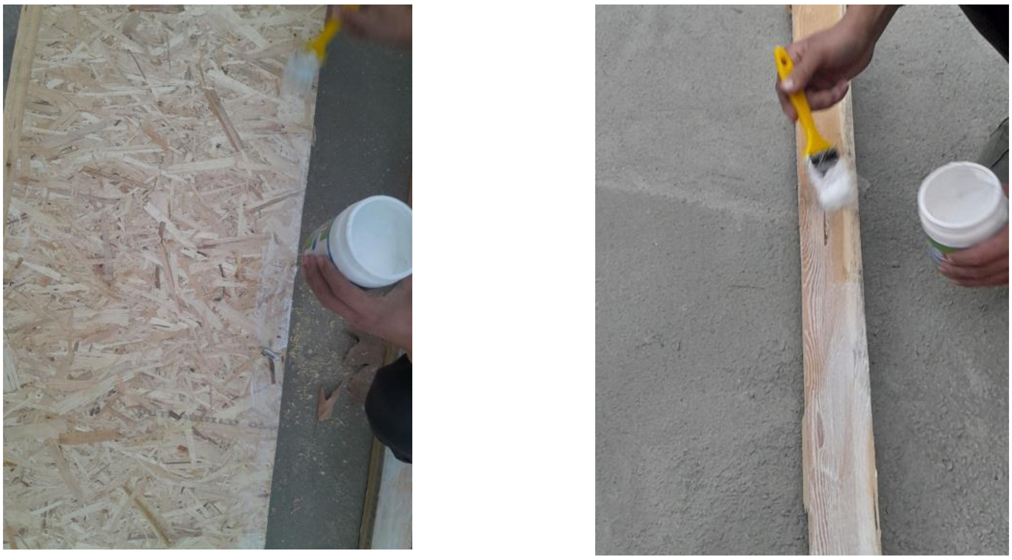

Figure 2. Use of PVA-801 adhesive during the fabrication of the timber beam model

4. Mathematical Model of Structural Behavior

The structural behavior of the I-shaped timber beam is analyzed within the framework of classical beam theory, assuming linear elastic material behavior and effective composite interaction between the components.

4.1 Bending Stress

The allowable stress for timber structures depends on the timber species, moisture content, service conditions, and application area. For grade 2 timber, the allowable stress is typically taken as 12–14 MPa in bending and 14 MPa in both compression and tension.

$$\sigma=\frac{M}{W^x} \qquad (1)$$

4.2 Shear Stress

Shear stresses acting in the beam web are calculated using:

$$\tau=\frac{QS_f}{I_x\delta} \qquad (2)$$

where (Q) is the transverse shear force, (S) is the first moment of area, and (b) is the thickness of the OSB web. In the proposed configuration, the OSB web carries the dominant portion of the shear forces, while the timber flanges primarily resist bending moments.

4.3 Deflection Criterion

Serviceability performance is evaluated by the maximum mid-span deflection under a uniformly distributed load:

$$\frac{f}{l} = \frac{5q_1 l^3}{384EI_x k_f} \quad (3)$$

where (q) is the distributed load and (l) is the span length. The increased bending stiffness of the I-shaped section results in reduced deflections and compliance with serviceability limit state requirements.

4.5 Verification of Bolted Connections

The load-bearing capacity of bolted joints is verified by the condition:

$$N \le R_b \quad (4)$$

and by checking bearing stresses in timber:

$$\sigma_b = \frac{N}{dt} \quad (5)$$

where (N) is the applied force, (d) is the bolt diameter, and (t) is the thickness of the timber element. The use of washers ensures uniform stress distribution and prevents excessive local deformation.

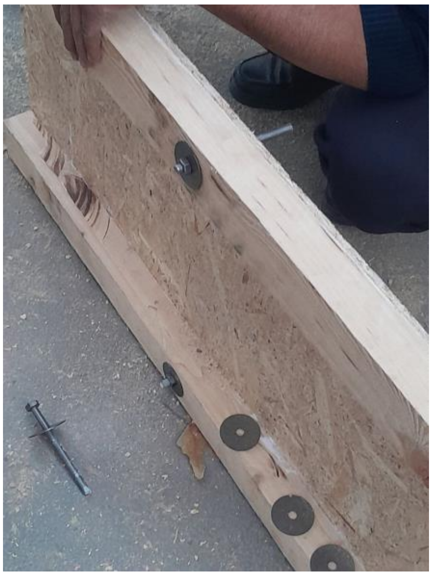
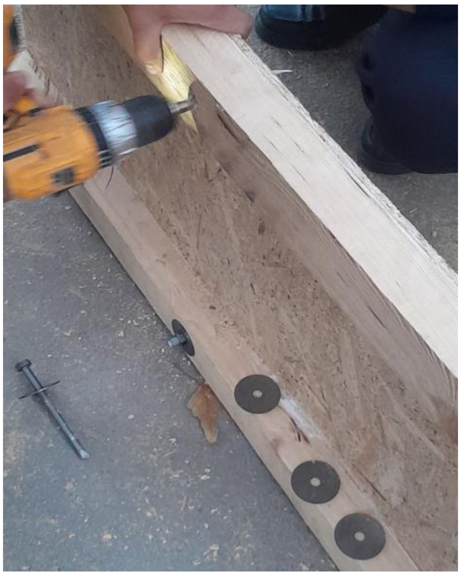

Figure 3. Use of bolted connections during the fabrication of the timber beam model

5. Conclusions

The analytical investigation confirms that I-shaped timber beams composed of solid wood flanges and an OSB web exhibit high structural efficiency. The optimized cross-sectional geometry significantly increases bending stiffness and reduces deflections. Effective composite action, ensured by adhesive bonding and bolted connections, allows reliable transfer of bending and shear forces. Compared to steel and reinforced concrete beams, the proposed system offers substantial weight reduction and economic advantages. These characteristics make timber–OSB I-shaped beams suitable for widespread application in modern lightweight building structures.

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