# JOINING SOLID WOOD WITH EPOXY RESINS

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## Abstract

The paper deals with the analysis of the suitability of selected woods (acacia, oak, meranti) for bonding with casting epoxy resin. The main objective is to evaluate the influence of the thickness of the cast joint on the strength properties of the formed joints. The investigated wood species differ in their physical and mechanical properties, which can significantly affect the resulting cohesion and strength of the joint. In addition to the interaction between the wood and the epoxy resin itself, the cohesive strength of the cured resin, which plays an important role in the mechanical behaviour of the joint, was also investigated. The experiments focused on measuring the strength at different cast joint thicknesses, which provided valuable information on the optimum parameters for joint formation. The results of this study provide new insights for the structural and design applications of epoxy resins in conjunction with natural materials such as wood and contribute to the development of efficient methods for producing strong and reliable joints.

Keywords: casting epoxy resin, joint width, shear strength, tensile load, impact strength, acacia, oak, meranti

## INTRODUCTION

For centuries, wood has been the basic material for furniture production. However, in recent years, with the development of technology and the search for new aesthetic and functional solutions, there has been a shift towards modern materials and innovative production processes. These new trends include composites, which are created by combining solid wood and cast epoxy resin. This approach enables the creation of unique and unconventional furniture designs that are gaining popularity not only among craftsmen but also in the wider industry.

Initially, this method of using composites was popular mainly overseas, but gradually found its way to Europe, where it began to be applied in medium and large enterprises. However, the successful application of epoxy resin in conjunction with solid wood requires not only precise working procedures, but also thorough surface preparation of both materials, which is key to achieving a strong and durable bond.

Despite the growing popularity of these materials and technologies, there is still a lack of research into their long-term behaviour, both in terms of exposure to different stresses and climatic conditions. This paper presents the results of an experimental study that aims to increase the knowledge in this area and provide insight into the stress-strain behaviour of these joints, and to observe the effect of the cast joint thickness on the strength of.

### Epoxy Resins

Epoxy resins are polymeric materials from the group of reactive plastics, characterized by the presence of epoxy (oxirane) groups with high reactivity. These groups allow a crosslinking process that produces strong and durable structures without by-products and with minimal shrinkage. Due to these properties, epoxy resins find a wide range of applications, for example as adhesives, potting compounds, laminates or protective coatings [1][2].

Cured epoxy resins have high adhesion to a variety of materials including metals, glass, ceramics and wood. They are also resistant to mechanical stress, chemicals, corrosion and extreme temperatures. Exceptional electrical and insulating properties remain constant even with environmental changes [2][3].

Thanks to these properties, epoxy resins have become a key material for modern applications in industrial and craft manufacturing, especially where durability, strength and resistance are required.

### Curing of Epoxy Resins

The curing of epoxy resins is a key process that fundamentally affects the final material properties. This process involves a chemical reaction between the resin and hardener molecules that results in the formation of a three-dimensional cross-linked structure. Depending on the curing system used, three main curing methods can be distinguished: polyaddition, polymerisation and polycondensation [4][5].

Polyaddition is an exothermic process that uses amines - primary, secondary or tertiary - and is known for its speed. Polymerization uses organic or inorganic peroxides and is associated with the release of heat during the reaction. Polycondensation, on the other hand, is a slow process in which the resin molecules react with, for example, acid anhydrides or phenol formaldehyde resins, with no heat being released [6][7].

The choice of hardener depends on the requirements of the final product. Amines are popular for their fast cure and strong adhesion, peroxides provide high temperature resistance, acid anhydrides offer excellent chemical and thermal properties, while phenol formaldehyde resins excel in mechanical resistance [8][9].

### Modifications

The modification of epoxy resins is carried out to improve their properties such as toughness, flame retardancy and thermal stability. Common techniques include the addition of fillers, pigments and plasticizers to the epoxy matrix. Current trends are not only to improve properties for specific applications, but also to promote sustainability and waste recovery [10][11].

One innovative approach is the use of carbon fibres derived from recycled hemp fibres, which opens up new possibilities for environmentally friendly composites. Another important aspect is the development of affordable and efficient fillers that can improve the properties of epoxy systems without substantially increasing production costs [12][13].

### The use of Casting Epoxy Resins in Furniture

In recent years, joining solid wood with cast epoxy resins has seen a significant increase in popularity, particularly in the creation of tables, lamps, cutting boards and storage furniture. Originating in Canada and the USA, this trend quickly spread to Europe and is now commonly presented at major furniture fairs. The resulting products are prized for their aesthetic appeal and unique combination of natural wood with translucent or pigmented resin.

For these applications, modified casting epoxy resins are used, which are adapted for larger casting widths and provide sufficient joint strength. In addition, the use of pigments eliminates the visibility of air bubbles, which can still occur even with highly sophisticated manufacturing techniques. The complexity of the process involves not only the preparation of the wooden parts and moulds, but also the casting itself, which is both time-consuming and costly.

Despite the higher material and production costs, these products have found their place in the market thanks to their unique aesthetics and ability to compete with traditional furniture. The most popular applications are conference and writing tables that combine functionality with modern design [14].

## MATERIALS AND METHODS

### Materials Used

Three wood species were used for testing: oak, acacia and meranti. While oak and acacia represent common domestic woods, meranti was chosen to represent tropical woods. All samples had a moisture content in the range of 7–8%, which ensures stable properties during casting and curing.

A two-component primer from a domestic manufacturer, commonly used to close the pores of the wood and reduce the risk of air bubbles, was used to prepare the surface. The penetrating compound is mixed at a ratio of 100 (A) : 26 (B) and further diluted with water at a ratio of 100 (compound) : 50 (water). After mixing, the mixture is workable for 60 minutes and cures within 24 hours.

A low viscosity system, also from a domestic manufacturer, was used as the casting epoxy resin. The resin is mixed with amine hardener in a ratio of 100 : 30 and allows casting up to 50 mm thickness or 10 litres volume. The processing time is less than 60 minutes at 25 °C, with a minimum curing time of 2 days. This system has been chosen for its suitability in handling larger volumes and its precision in achieving the required mechanical properties.

### Samples

For this research, special samples and moulds were designed to create these samples. Due to material availability and variability, wooden moulds separated by PP adhesive tape were used. The basic dimensions of the sample were 12 × 20 × 90 mm. The specimens were placed in the mould to match the required thickness of the poured joint (5, 10 and 20 mm), with the length of the poured joint being 30 mm. This procedure allowed the creation of specimens with different joint widths for testing their mechanical properties. The dimensions of the base specimen and the final cast specimen are shown in Fig. 1.

### Sample Preparation

The preparation of the samples started with grinding the basic dimensions of the samples using P80, P120 and P150 roughness sandpaper. After sanding, a primer was applied and allowed to cure. The samples were then sanded again with a P150 grit. The specimens were then placed in the mould, fixed, sealed and cast with casting epoxy resin. The mixed resin/hardener mixture was left in an ultrasonic cleaner to improve viscosity and eliminate air bubbles. After curing, the samples were conditioned for 28 days under normal conditions and then formatted to a thickness of 12 mm. The deposition of the samples in the mould is shown in Fig. 1.

### Measurement Methodology

The shear strength test was carried out according to the principles of the test ČSN EN 1465 Adhesives - Determination of shear strength under tensile stress of refastened bonded assemblies. The specimens were placed in clamps so as to correspond exactly to the actual stresses of the products in use. The moisture content of the wood was also determined for all specimens according to ČSN EN 322 Wood panels - Determination of moisture content. This procedure was carried out to ensure the accuracy of the measurements and the correctness of the results [15][16].

## RESULTS

### Evaluation of the Shear Strength Test

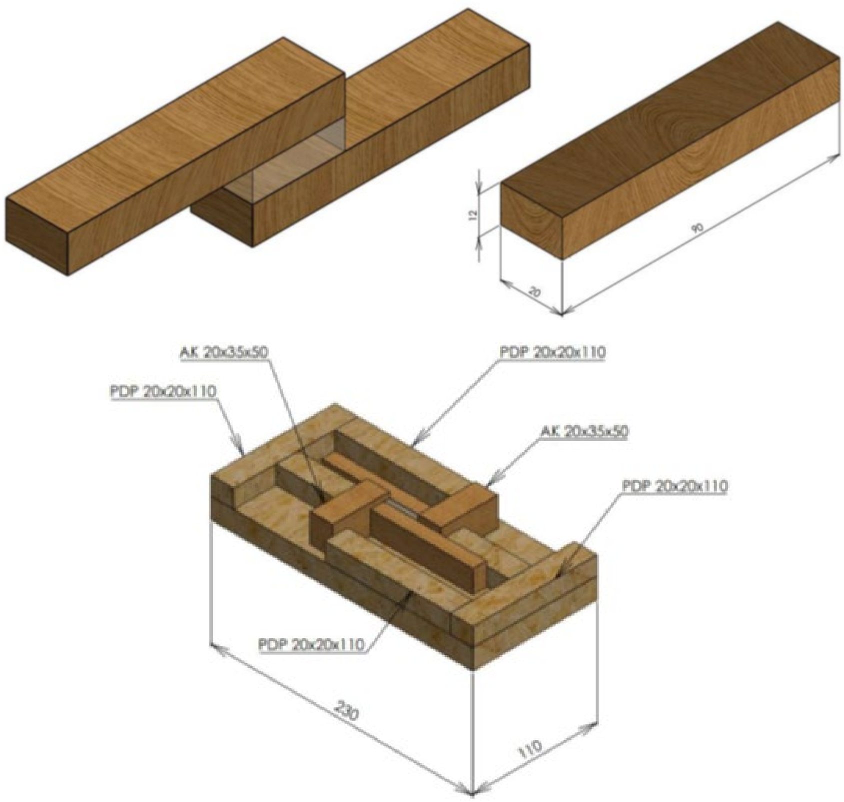
The investigation of the effect of the thickness of the cast joint on the shear strength showed that for all tested timbers the shear strength decreased with increasing joint thickness. For acacia, the average shear strength values were found to be 5.13 MPa at 5 mm joint thickness, 3.35 MPa at 10 mm thickness and 1.90 MPa at 20 mm thickness. This decrease was statistically confirmed and the results are graphically shown in Fig. 2.

A similar trend was also observed for oak, where the average shear strength values were 4.85 MPa at a joint thickness of 5 mm, 3.47 MPa at 10 mm and 2.13 MPa at 20 mm. We also observe a larger scatter in the measured data compared to acacia. The test results are clearly shown in Fig. 3.

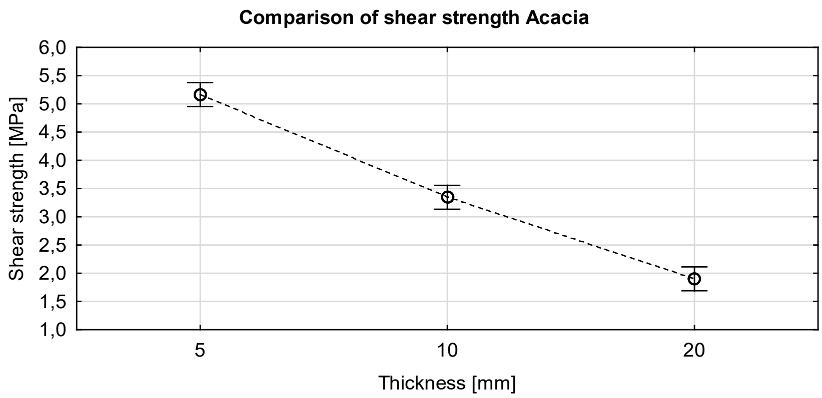
Meranti also shows a decrease in shear strength with increasing thickness of the cast joint. The average strength values are 5.30 MPa at 5 mm joint thickness, 3.48 MPa at 10 mm thickness and 2.06 MPa at 20 mm thickness. If we focus on the scatter of the measured data, the scatter is the largest observed for meranti wood. All of the above is shown graphically in Fig. 4.

### Link Quality Evaluation

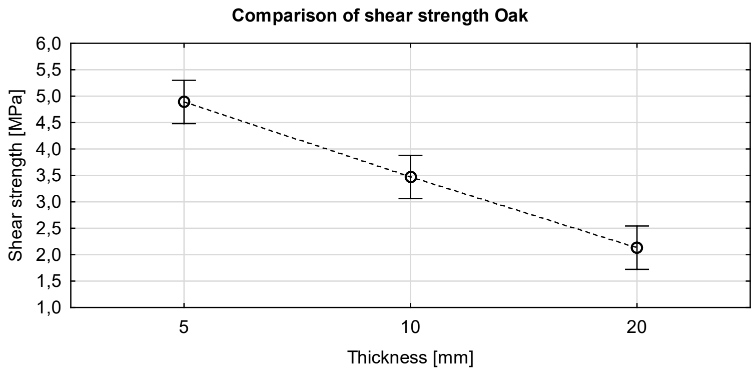
In the evaluation of the quality of the bond between the casting epoxy resin and the solid wood, it was found that the highest percentage of defective joints was found in acacia, where a defective bond was recorded in 86.67% of cases. This result points to the problematic compatibility of this wood with the casting resin used. On the contrary, the lowest percentage of defective joints was observed in meranti, where the ratio of joints without defects prevailed, namely in 56.67% of cases. The results can be observed in Fig. 5.



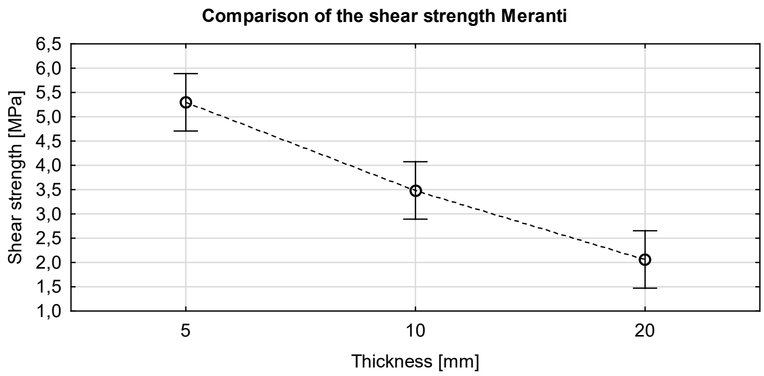

1: *Samples*



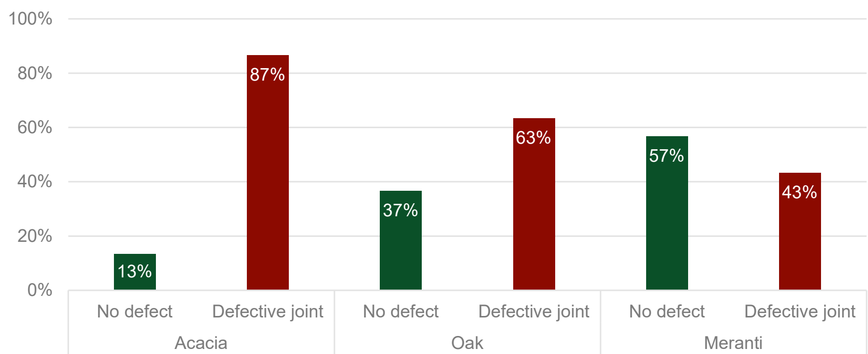

2: *Comparison of shear strength Acacia*




3: *Comparison of shear strength Oak*




4: *Comparison of shear strength Meranti*




5: *Comparison of the percentage of defective connections*

## CONCLUSION

The measurements show that the thickness of the cast joint significantly affects the strength of the shear-stressed joint, with a decrease in strength with increasing cast joint thickness. This negative effect was demonstrated for all tested timbers, indicating that careful selection of the thickness of the cast joint is crucial to maintain the desired mechanical properties of the joint. In addition to the effect of thickness, the percentage of defective joints was also evaluated, suggesting that acacia wood is not ideal for epoxy resin casting technology. Oak and, among the exotic woods, meranti were found to be more suitable due to their specific structure. Overall, the joints produced by this technology achieve adequate shear strength values that are applicable in the furniture industry. However, it is essential that the preparation and application procedures recommended by the manufacturer are followed precisely in order to maintain the aesthetic and mechanical properties of the joints. This technology therefore represents an interesting alternative to traditional bonding, particularly for design and visually attractive applications.

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