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BIO-BASED ADHESIVE SYSTEMS FOR ENGINEERED WOOD PRODUCTS APPLICATION

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ABSTRACT: The objective of the present work was the improvement of the synthesis process of environmentally-friendly, sustainable adhesive systems, to enhance performance during their application on the production of engineered wood products (mainly glulam), in order to successfully replace synthetic adhesives made from petrochemicals. Actually, this is a continuation of a previous work, regarding the development of such bio-based adhesive systems for engineered wood applications, which was presented at the previous WCTE in August 2016, in Vienna, Austria. Lignin-based adhesive systems were proved to provide industrial glulam products with performance comparable or even better, in some cases, to the products produced with conventional gluing systems.

KEYWORDS: cold-set wood adhesives, bio-based wood adhesives, lignin adhesives, glulam, glued laminated timber, structural panels, building construction

1 INTRODUCTION

Engineered Wood Products, including glued laminated timber, finger joints, plywood, stressed skin panels, mechanically and adhesive bonded web beams and connected and nail plated trusses, have been in existence for at least 40 years [1]. Engineered wood products or panels are products dedicated for use in structural applications or else building construction. All of them are manufactured by combining wood strands, veneers, lumber or other wood elements with adhesive to form a larger composite structural unit [4].

The evolution of engineered wood products has greatly expanded building options and methods in all forms of residential and commercial construction and offered environmentally-friendly, green, building products.

A significant ecological aspect is to decrease the energy that is needed to manufacture laminated timber, comparing to that needed for similar construction elements, made from metal or concrete. Comparing materials with similar structural role, laminated timber is much lighter than concrete and metal and the energy needed for its production is way lower than that needed for metal. Laminated timber also performs better than concrete and metal regarding tensile strength and compressive strength.

Recently, there have been significant developments in the range of EWPs for structural applications with materials such as laminated veneer lumber (LVL), parallel strand lumber (PSL), laminated strand lumber (LSL), prefabricated I-beams, metal web joists and ‘massive’ or cross-laminated timber (CLT) becoming more widely available. [1].

Glued laminated timber (Glulam) is also called laminated timber or multi-layered timber, is obtained by bonding together two or more softwood lamellas in well determined temperature and pressure conditions. The special adhesives used for bonding lamellas are structurally stable and resistant to moisture. Lamellas, in their turn, are obtained by successively lengthwise combining through a milling joint system, some selected pieces of timber of various lengths, thus obtaining lamellas with a homogeneous structure and coloration which will be processed on contact sides before gluing and pressing in the package [2].

The laminated structural elements thus obtained are used in construction, especially in the manufacture of roofs, timber houses and industrial buildings but we frequently meet this special material used also for constructions such as bridges and high-tension poles [2].

The adhesive is probably the most important parameter in the production of engineered wood products like the afore-mentioned described. The adhesives used today for the production of engineered wood products are still mostly based on synthetic resins, like phenolic, melamine, phenol-resorcinol, polyurethane and isocyanate adhesives. These resins are synthesised from petroleum and natural gas derived chemicals and therefore their prices are directly dependent on the fluctuation of the oil prices. Moreover, given the finite nature of the oil deposits, the long-term availability of petroleum-derived products is not guaranteed. Adhesives from renewable (non-petroleum) raw materials have a noteworthy role to play in relieving the reliance of wood products on petrochemicals and promoting the sector’s sustainability. The lignin-based phenolic resin used in this work, is dedicated to reach this target and offer a green alternative for these products.

In the last decade, MUF (melamine-urea-formaldehyde), a light-coloured adhesive, has made a place for itself, and represents about 60% of the Scandinavian adhesive market for glulam (the remaining 40% being made up of PRF, phenol-resorcinol-formaldehyde). One problem with light-coloured glue lines is the difficulty in

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evaluating a delamination, as it is hard to distinguish light-coloured softwood from the adhesive [3]. This is much easier with the LPF resin, which has a dark colour.

2 EXPERIMENTAL

The R&D team of CHIMAR HELLAS has investigated the use of various biomass products like tannin, lignin, cellulose, starch, plant proteins, extraction-liquefaction-thermolysis products of forest and agriculture wastes and biomass treatment by-products in the production of adhesives for wood-based panels [5-6] with **the aims to:**

- reduce the demand on fossil fuels and promote sustainable development by using renewable raw materials for adhesives
- develop adhesives with the same or even enhanced bonding quality over conventional ones
- provide safe, emission-free wood products
- offer cost-effective solutions to the adhesive and wood panel industry.

As mentioned, this is a two-part study and the present paper is dedicated to the second part of the whole work performed. During the first part of this study, the R&D team was focused on bio-derived adhesives suitable for the production of engineered wood products like glulam, LVL and CLT.

In this second part, the attempts are focused exclusively on glulam products. Actually, this paper discusses the development of lignin-based adhesive systems which can be effectively used in the production of glulam products with performance comparable to the products produced with conventional gluing systems. The successful performance of such adhesive systems was proven in industrial scale tests.

2.1 MATERIALS AND METHODS

The objective was to develop an adhesive with a green character capable of setting in cold pressing conditions in order to be used as binder for engineered wood products building materials. CHIMAR HELLAS R&D team developed and tested various binders based on natural raw materials so as to find the most promising ones for such an application. The various adhesive systems were evaluated at lab scale during the first part of the study, in accordance with the prevailing European standards. The best performing adhesive system was further tested at industrial environment. The resulted glulam products would undergo the delamination test, according to the standard prEN 391-method B.

2.2 RESULTS AND DISCUSSION

The adhesive system comprising a lignin-based resin and an appropriate hardener, that promoted the cold setting of the system, was the most satisfactory one, fulfilling the standard requirements for glulam application. The resin and the hardener are used in a so called "honeymoon" gluing system. The resin is spread on the one side of the wooden beam, while on the other side the hardener is spread, so, depending on the final product targeted, 3 to 6 beams are placed one above the other and the column created is pressed at a suitable press clamp system for a specific time.

This specific resin is of the phenol–formaldehyde type where 50% of phenol has been substituted by lignin. This new lignin-based gluing system cures at room temperature within only a few hours, depending on the weather conditions and can be effectively used in the production of glulam beams and columns with a performance comparable to the products produced with conventional gluing systems. The optimization step that was followed based on the findings of the previous part of the study was that the lignin-based resin was cooked so that its final viscosity was higher than initially, so that it would not flow outside the glue line but, at the same time, it would be adequately absorbed by the wood part and mixed with the hardener.

This system displayed equal and/or higher bonding performance compared with commercial melamine-urea-formaldehyde resin and is a more environmentally-friendly and possibly cheaper solution.

3 CONCLUSIONS

Both parts of the study proved that a binder system comprising a cold setting PF resin modified with renewable lignin and a suitably formulated resin hardener was developed for application in the production of glulam beams with performance comparable to the products produced with conventional gluing systems.

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