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REVIEW

Review on antibacterial biocomposites of structural laminated veneer lumber

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Abstract In this review, the characteristics and applications of structural laminated veneer lumber made from planted forest wood is introduced, and its preparation is explained, including various tree species and slab qualities, treatments for multiple effects and reinforced composites. The relevant factors in the bonding technology and pressing processes as well as the mechanical properties, research direction and application prospects of structural laminated veneer lumber made from planted forest wood are discussed.
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1. Introduction

The planted forests in China already cover an area of 800 million acres, though plantation wood has yet provided little benefit in the long run for the current backward process technology. With the rapid development of the Chinese economy, however, construction of timber structures such as homes and bridges calls for a large amount of engineered materials for wooden structures (Tenorio et al., 2011). There is, therefore, a huge potential for plantation wood to produce high value-added wood composite engineered materials on a large scale owing to its fast growth, low price and good shape (Peng et al., 2015). High-end products from wood composite engineered materials for wood structures provide an important means to process and use plantation wood efficiently. Engineered materials for wood structures with high additional value are primarily made by gluing and laminating wood (Rasheed et al., 2015). Plantation wood as-harvested cannot typically be applied to heavy timber construction because of its uncertain material quality, which limits its load bearing capacity. Moreover, plantation wood used as-harvested is apt to decay and burn and outdoor conditions can speed up its aging, splitting and deformation can occur, and its service life can be shortened, reducing its already low usage value and impairing its engineering safety. The most cost-effective way to manufacture engineered materials for wood structures is from laminated veneer lumber, where the material properties of fast-growing plantation wood are synthetically considered (Sultana et al., 2015).

Laminated veneer lumber (LVL) is a high-performance product that is made by splicing and pressing multilayer rift grain veneer (or cross-grain veneer) from thick rotary-cut veneer. Laminated veneer lumber is often divided into the two categories of structural and non-structural use, where structural LVL is used in the high-bearing-capacity field and non-structural LVL is applied to areas protected from loads or which require a low carrying capacity (Qureshi et al., 2015). The process procedure for LVL includes log truncating, log steaming, log skinning, veneer peeling, veneer clipping, veneer drying, veneer scarf-jointing, veneer blending, laying up, prepressing, hot pressing, sawing, stacking, checking and packaging (Özçifçi, 2009).

2. Applications

Structural LVL is presently one of the fastest growing wood-based groups in North America, where 61% of structural LVL is used for I-shaped floor joists and 31% is used as trusses and beam-columns, while the rest is used for sleeper and load-bearing walls. Research on LVL in the architectural field has reached the large-scale industrialization level, especially in countries such as the United States of America, Japan and Canada. In these countries, the USA is the largest producer and consumer of structural LVL around the world with six companies manufacturing construction-grade LVL. There are three firms producing structural LVL in Canada, while Japan has four full sets of product lines and a production capacity about twice that of Canada. The annual production of LVL in China is presently about two million cubic meters, (Nasreen et al., 2015) the production and application of which remains limited to non-structural use in low value-added fields such as furniture and interior applications. With the large-scale development of wood structures in China, however, there is an increasing demand for structural LVL (Javed et al., 2015).

3. Characteristics

There are many advantages of construction-grade LVL. First, natural flaws such as gnarls, cracks and cross-grains generally existing in sawn timber are distributed at random over the veneers, causing its strength to be uniform. Second, the dimensions of construction-grade LVL are not limited by the size of the log and its resulting veneer because of the special production method, where the product dimensions are flexible and may be freely chosen (Hashemi et al., 2015). Third, warpage and distortion are less likely to occur in the laminated structure, leading to enhanced stability. Fourth, the processing of construction-grade LVL is convenient, and it can be sawn, sliced, drilled and mortised in the same fashion as wood. Fifth, the shock resistance of constructional LVL is strong and can resist the fatigue rupture that can arise from cyclic stress. Sixth, the timeliness of wood pyrolysis and the glued structure of LVL create a flame resistance superior to that of steel. Seventh, construction-grade LVL is made by laminating and gluing veneer with waterproof adhesive, making its weather resistance higher than that of other wood materials (Mateen et al., 2015).

4. Antibacterial preparation

4.1. Tree species and slab qualities

Timber resources are the key raw materials for wood-based panels and determine the properties thereof, and there has been much research exploring the feasibility of manufacturing LVL using different types of materials. For instance, Ozarska has confirmed that laminated wood and LVL could be produced by replacing hardwood with eucalyptus after comparison of the properties of the two different kinds of wood (Ozarska, 1999). Mathieu et al. took advantage of blackbutt (*Eucalyptus pilularis*) to prepare LVL whose bonding strength met the performance requirements for durable structural materials (Mathieu et al., 2004). De Souza et al. have tested the physical properties and biological performances of LVL using *Pinus oocarpa* and *Pinus kesiya* veneers as raw materials and have shown that, though both types of boards have broad prospects for development, the mechanical properties of *P. kesiya* LVL are higher than those of *P. oocarpa* LVL (De Souza et al.,

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