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Abstract (Doctor)

Title of Thesis	Research on the Composite Method of LVL Timber and CFRP to Improve Strength and Stiffness
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Approx. 800 words

Investigating timber materials in civil infrastructure is essential nowadays for several compelling reasons. Timber is a renewable resource that offers significant environmental advantages compared to other building materials such as concrete and steel. However, timber properties are often inappropriate for heavy loads construction applications. Natural timber logs are restricted by their maximum cross-sectional size and length, which limits their application as structural components. To address these limitations, engineered timber techniques have been developed. In recent decades, laminated veneer lumber (LVL) was commonly used as an engineered wood product in the construction industry due to its high strength-to-weight ratio and dimensional stability compared to solid timber. LVL materials consist of thin layers of bonded wood, forming engineered wood product veneers. This composition enhances their strength and durability, making them an ideal substitute for traditional solid wood beams construction. The applications of LVL in modern construction are diverse and continually developing. It is widely used in both residential and commercial projects for key structural components. However, as structures evolve and loading requirements increase, it is often necessary to further strengthen existing LVL elements to meet contemporary performance standards or to extend their service life.

One promising technique for enhancing the structural capacity of the element is the Near Surface Mounted (NSM) reinforcement method. This approach involves cutting grooves into the material's surface and embedding reinforcing materials within the grooves. When applied to LVL, NSM reinforcement provides several advantages over externally bonded reinforcement, such as improved protection against environmental factors, enhanced aesthetics, and the possibility of a more efficient stress transfer between the reinforcement and the LVL substrate. The selection of appropriate reinforcement materials is crucial for the success of the NSM technique, with CFRP becoming increasingly significant due to its outstanding mechanical properties. CFRP offers advantages, including exceptional tensile strength, lightweight, resistance to environmental degradation, and flexibility in application methods. The NSM technique for strengthening timber structures with CFRP also provides considerable advantages regarding fire protection. This technique, which involves embedding CFRP materials into grooves cut into the timber surface, enhances the fire resistance of CFRP material. Utilizing LVL as a construction material, NSM as the strengthening method, and CFRP as the reinforcing material presents a promising approach to improving the structural performance of engineered timber. Given this research context, this study aims to contribute new

insights to the field by exploring the variation of reinforcement parameters in NSM-CFRP reinforcement for LVL timber structures.

An experimental investigation on the bending test of LVL timber beams strengthened with CFRP plate was conducted. A total of twenty-seven 60 x 200 x 2400 mm LVL timber beams were tested in full scale four-point bending method. In this experiment, two beams were left unstrengthened while the remaining beams were strengthened with varying lengths, depths and numbers of CFRP plates. Two groups were investigated to study the effect of reinforcement by NSM technique on the increase of the flexural behaviour of the beams. The first group consisted of twenty-two specimens reinforced with CFRP plate placed on the compression side (BC Group), while the second group consisted of five specimens reinforced with CFRP plate on the tensile side (BT Group).

The beams load deflection relationship, ultimate load capacity, stiffness, failure mode, and strain profile distribution were analysed based on experimental results. The use of CFRP plates in the compression zone of LVL beams has been found to improve their strength and stiffness. The test result showed timber beams strengthened with CFRP plates with a reinforcement ratio ranging from 1.67 % to 5.00 % experienced a significant increase in bending strength of 19.24 – 54.81 % and an increase in bending stiffness of 16.49 – 62.51 %. These results indicate that NSM CFRP plates can effectively strengthen timber materials, offering improved bending performance and durability. In other hand, the tensile strengthening effect can increase the deformability of timber materials to produce a more ductile reinforced structural element. Strengthening the compression side typically results in a stiffer element, while strengthening the tension side generally leads to more ductile behavior, especially in the post-elastic range. The CFRP plates number, length, and depth significantly influence the effectiveness of strengthening LVL beams. Increasing the depth and length of the CFRP plates leads to a higher strengthening effect by increasing the cross-sectional area and providing a more uniform stress distribution, respectively. While increasing the number of plates also enhances the strengthening effect, it has a lower impact than the depth and length variables.

In conclusion, the results presented in this dissertation clearly demonstrate that the use of CFRP plate as a strengthening method for LVL timber material can effectively improve bending behaviour. Based on these findings, several promising studies for future research have been identified and are recommended to further advance the understanding in this area.