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The physical and mechanical properties of polyurethane-bonded cross laminated timber made with *Pinus roburghii* wood

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INTRODUCTION & AIM

Cross Laminated Timber (CLT) is an innovative engineered wood product widely used in structural applications due to its lightweight, high strength, environmental benefits, and aesthetic appeal. Its use has rapidly expanded in the global construction industry. However, while CLT has primarily been developed and tested using European softwoods, limited research exists on its performance when manufactured from non-European species. Particularly, there is a lack of information on the use of indigenous Indian species, which have unique properties that may influence the performance of CLT.

The aim of this study is to evaluate the mechanical and physical properties of polyurethane-bonded CLT produced from *Pinus roxburghii* (chir pine), an indigenous Indian species. By examining key parameters such as modulus of elasticity, modulus of rupture, compression strength, block shear strength, delamination, and swelling behavior, the study seeks to assess the suitability of chir pine CLT for use in low load-bearing structures. This investigation will provide critical insights into the material's potential for broader adoption in the construction industry.

METHOD

Cross Laminated Timber (CLT) panels were fabricated using Pinus roxburghii (chir pine) and bonded with polyurethane adhesive. The CLT preparation and testing followed the guidelines of the EN 16351 standard. Panels were constructed by layering boards with alternating grain directions to form multi-layered structures.Mechanical properties such as modulus of elasticity (MOE), modulus of rupture (MOR), compression parallel to grain, and block shear strength were tested in accordance with EN 16351 procedures.

Additionally, physical properties like delamination, thickness swelling, water absorption, and volumetric swelling were evaluated to assess durability under moisture exposure conditions.The density of the CLT samples was also measured. The collected data were analyzed to provide a comprehensive understanding of the mechanical and physical performance of chir pine CLT for potential use in low load-bearing construction applications.

RESULTS & DISCUSSION

The mechanical testing of *Pinus roxburghii* (chir pine) CLT revealed promising structural properties. The modulus of elasticity (MOE) and modulus of rupture (MOR) indicated that chir pine CLT has sufficient stiffness and strength for low load-bearing applications. Compression parallel to grain and block shear strength also met acceptable performance levels, demonstrating the material's ability to handle compressive forces and resist shear stresses.

Physical tests showed moderate delamination under moisture exposure, with total delamination and maximum delamination percentages within tolerable limits. Swelling and shrinkage behaviors, as measured through thickness swelling, water absorption, and volumetric swelling, highlighted the CLT’s potential durability in humid environments, though these characteristics may require further optimization for higher moisture resistance.

The mechanical properties of polyurethane-bonded CLT made from *Pinus roxburghii* (chir pine) demonstrate promising results for low load-bearing applications. The modulus of elasticity (MOE) of 4.2 GPa indicates a reasonable stiffness, while the modulus of rupture (MOR) of 36.20 MPa highlights its capacity to withstand bending forces. Additionally, the compression strength parallel to grain, recorded at 15 MPa, and block shear strength of 3.5 MPa suggest the material's ability to handle compressive and shear forces, respectively. These results underscore the potential of chir pine CLT for structural use in low-stress conditions.

CONCLUSION

This study investigated the mechanical and physical properties of Polyurethane-bonded Cross-Laminated Timber (CLT) fabricated from Pinus roburghii (Chirpine), an indigenous Indian pine species. The results demonstrate the promising potential of Chirpine CLT as a sustainable construction material, particularly for low-load bearing structures.
This research bridges the knowledge gap on Indian species in CLT research, highlighting Chirpine's viability as an engineered wood product.

FUTURE WORK / REFERENCES

Future work will focus on developing hybrid CLT panels by combining Chirpine with other Indian species, optimizing manufacturing processes, and assessing performance under various environmental conditions.