Development of Bamboo-Timber Hybrid Beams

Splicing techniques of beams made from thermo-hydro-mechanically modified bamboo

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Introduction

There is currently limited research into the splicing techniques of thermo-hydro-mechanically (THM) densified bamboo, particularly splices tested in tension.

THM densified bamboo is a form of engineered bamboo that during production creates little waste whilst also increasing the density of the bamboo (Archila Santos 2015).

The main goal of this study is to further develop bamboo as an effective beam product, previous research found that using THM densified bamboo in the tension strip of a glulam beam could increase in the strength of the beam.

The limiting factor of these previous studies was that a maximum length of around 1.0m could be tested due to constraints in the manufacturing of THM densified bamboo.

Therefore, this study tested the THM densified bamboo with different splicing methods in tension to allow for longer lengths to be joined and used as a tensile strip in a hybrid glulam beam.

Objectives

The aim of the project is to determine the best method to splice thermo-hydro-mechanically modified bamboo and to establish the best performing adhesive for the splicing techniques when the joint is tested in tension.

The intention is that the optimal splicing method could then be applied to a hybrid timber and bamboo glulam beam.

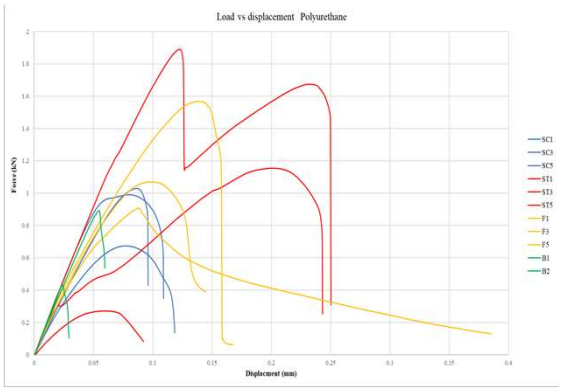
An unjointed specimen with a thinner central gauge section, specimens without a splice were tested so the performance of the joints could be directly measured.

Method

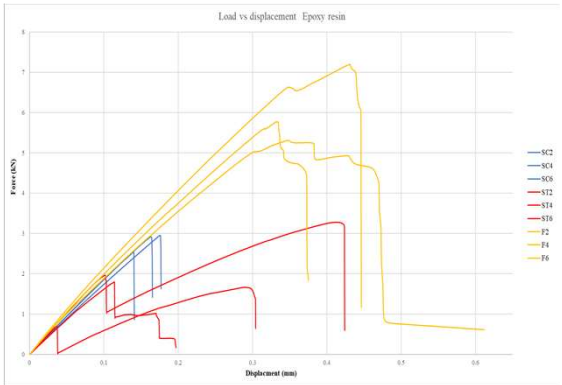
The joints and reference samples were then tested in tension using an Instron 5985 uniaxial tensile testing machine, using the draft finger jointing standard BS ISO 10983 (BSI 2013). Whilst this is a specific structural timber standard for finger joints, the specific bamboo-testing standard BS ISO 22157:2019 (BSI 2019) is only for raw bamboo, i.e. culms which have undergone minimal transformation.

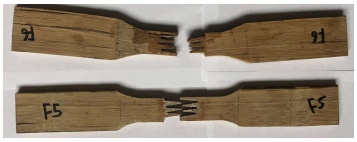
THM strips have a rectangular cross section and have undergone significant transformation, which makes them more akin to timber, therefore all joints and reference samples were tested to the same BS ISO 10983 standard (BSI 2013) to ensure comparable results were obtained.

Results

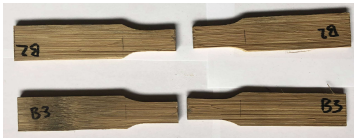


The results of the research indicated that finger joints were the most suitable joint for THM densified bamboo under tensile stresses. The research also suggested that epoxy resin used with any joint type had higher tensile stress at failure. The average tensile stress of unjointed specimens was 125.94 N/mm².

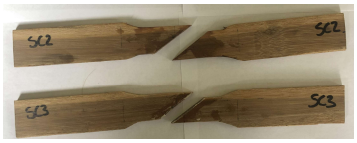




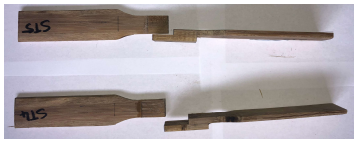
Failure of finger joints with both adhesive types



Failure of butt joints with both adhesive types



Failure of scarf joints with both adhesive types



Failure of staggered joints with both adhesive types, sample rotated to show top piece still attached

Experimental notation; (SC) Scarf joint, (ST) Staggered joint, (F) Finger joint, (B) Butt joint

An example of a softwood and bamboo hybrid beam failing after a bending test (Kaboli and Clouston 2019).

Conclusions

- The optimum splicing technique for THM densified bamboo under tensile loading is considered to be finger joints, this was found to be the case for both epoxy resin and polyurethane.
- Epoxy resin was thought to be the best adhesive for tensile loaded finger jointed THM densified bamboo, epoxy resin also appeared to perform better than polyurethane for all splicing techniques.
- Collectively, all the splices tested were considerably worse at bearing tensile loads than unjointed samples. The average tensile stress of finger joints with epoxy resin only achieving 34.15% of the unjointed average at failure.

Further work

Further work into the use of THM densified bamboo as part of a hybrid timber beam should be considered, as one of the objectives of this study, to build and test a hybrid beam, was not met.

Archila Santos, F. (2015) *Thermo-hydro-mechanically modified cross-laminated Guadua-bamboo panels.* PhD thesis. Bath: University of Bath

British Standards Institution (2013) Draft *Timber - finger joint - minimum production requirements and testing methods*. BS ISO 10983:2013. London: British Standards Institution

British Standards Institution (2019) *Bamboo structures — Determination of physical and mechanical properties of bamboo culms — Test methods.* BS ISO 22157:2019. London: British Standards Institution

Kaboli, H. and Clouston, L P. (2019) 'Eastern Hemlock in Bamboo-Reinforced Glulam' *Journal of material civil engineering 31 (1)*

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