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<td><strong>Author(s)</strong></td>
<td>Mehra, Sameer; Guan, Zhongwei; Harte, Annette M.</td>
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<tr>
<td><strong>Publication Date</strong></td>
<td>2018-08-20</td>
</tr>
<tr>
<td><strong>Publisher</strong></td>
<td>NUI Galway</td>
</tr>
<tr>
<td><strong>Link to publisher's version</strong></td>
<td><a href="https://doi.org/10.13025/S86057">https://doi.org/10.13025/S86057</a></td>
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<td><strong>Item record</strong></td>
<td><a href="http://hdl.handle.net/10379/15042">http://hdl.handle.net/10379/15042</a></td>
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<tr>
<td><strong>DOI</strong></td>
<td><a href="http://dx.doi.org/10.13025/S86057">http://dx.doi.org/10.13025/S86057</a></td>
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EVALUATION OF THE STRUCTURAL BEHAVIOUR OF BEAM-BEAM CONNECTION SYSTEMS USING COMPRESSED WOOD DOWELS AND PLATES

Sameer Mehra¹, Zhongwei Guan², Annette M. Harte³

ABSTRACT: To support the transition to a bio-based society, it is preferable to substitute metallic fasteners and adhesives in timber construction with an eco-friendly alternative. Recent studies have identified compressed wood dowels and plates as a possible substitute for metallic fasteners in contemporary and mainstream applications. In this study, a spliced beam-beam connection system using compressed wood dowels and slotted in compressed wood plates was examined under four-point bending. The study has considered specimens with compressed wood dowels of two different diameters, 10 mm and 15 mm. The load carrying capacity of connection using compressed wood dowels and plates were compared to connections utilising steel dowels and plates of equivalent capacity. Typical failure modes, moment resistance and bending stiffness of both connection systems are evaluated on the basis of the experimental results.

KEYWORDS: Connections, Compressed wood dowels, compressed wood plates, experimental characterisation.

1. INTRODUCTION:

The widespread use of metallic fasteners and adhesives in modern timber construction has negative implications for the end-of-life disposal or re-use of the structural components. Emission of volatile organic compounds during manufacture of synthetic adhesives may have human health impacts in addition to the environmental impact. To cope with the upcoming transition to bio-based society, it is preferable to substitute metallic fasteners and adhesives with an eco-friendly alternative such as wood-based connectors.

The use of wood-based connectors is not new. In some of the early Egyptian and Polynesian boats, wooden pegs and treenails were used to fasten together the various pieces of the hull [1]. Treenails or trunnels were used as connector in wooden shipbuilding, timber framing and covered bridge constructions [2]. Dense hardwood has traditionally been used for connectors in timber structures. However, the use of hardwood fasteners is limited due to resource availability and the fact that hardwood connectors undergo stress relaxation, which causes loosening of the joint over time necessitating regular tightening [3].

The mechanical and physical properties of underutilized softwood species can be easily modified by chemical and thermal treatments. In recent years, densification of wood by compression, thermal and chemical treatments has been the subject of several research programmes. Examples include viscoelastic thermal compression wood, thermo-hydro-mechanical densified wood, oil-heated treatment and acetylated wood.

Compression of wood results in increased density, decreased porosity and improved material strength, stiffness, hardness and dimensional stability [5]. Compressed Sitka spruce (Picea sitchensis) had shown increased Young’s modulus with increasing compression ratio in bending [6]. Compressed wood (CW) of Japanese cedar was used as substitute of high density hardwood for making shear dowels. CW with its annual ring radial perpendicular to the loading direction (0°) had shown good properties as a dowel material in terms of its enhanced strength and ductility [7].

Compressed wood friction joints were found to have a satisfactory high initial stiffness, load carrying capacity and ductility, where compressed wooden wedges were used together with the conventional bolt-and-bearing-plate joint [8]. Jung et al. [9] demonstrated that large moment resistance and ductility can be achieved in column-beam joints utilising CW plates and dowels. The high embedding performance of the CW plates contributed to the rotational stiffness, and the high shearing performance of the CW dowels to the axial stiffness.

Current design codes do not adequately address the design of timber connections using wood-based connectors. The objective of this study is to investigate feasibility of CW dowels and CW plates as eco-friendly substitutes of metallic fasteners in moment resisting connections. The study comprises experimental evaluation of typical failure modes, load carrying capacity and bending stiffness of both compressed wood

¹Sameer Mehra, National University of Ireland Galway, Ireland, s.mehra@nuigalway.ie
²Zhongwei Guan, University of Liverpool, UK, Zhongwei.Guan@liverpool.ac.uk
³Annette M. Harte, National University of Ireland Galway, Ireland, annette.harte@nuigalway.ie
and the steel-fastened moment connections.

2. EXPERIMENTAL STUDY

Equal numbers of beam - beam connections using compressed wood and steel fasteners were produced and tested under pure bending. The dimension lumber used in this study was C24 Douglas Fir (Pseudotsuga menziesii). Glulam beams, 70 mm wide and 67.5 mm deep, were manufactured using three 22.5 mm thick laminates and cut to lengths of 670 mm. Pairs of glulam beams were connected using CW dowels and plates as illustrated in Figure 1.

The CW dowels and plates were manufactured using C24 grade Scots Pine (Pinus sylvestris) wood compressed in radial direction with a compression ratio of 68%. Two different CW dowels diameters were examined: 10 mm and 15 mm. To assess the performance of CW fastened connections, beam - beam connections using equivalent capacity steel dowels and steel plates were produced as control specimens.

![Figure 1: Dimensions of the connection](image)

Figure 1 shows the specimen with the spliced connection at mid-span. Specimens were tested in flexure over a simply supported span in four-point bending. This ensures that the connection was subject to a pure bending load. The applied load and displacements were measured by the load cell and displacement transducers, respectively. The failure mode, load carrying capacity and bending stiffness of connections were determined.

3. CONCLUSION

The bending test results delivered insights into the effects of CW dowels and plate configurations on the load carrying capacity and bending stiffness of the connection. The performance compared favourably with the equivalent steel connections. The results obtained have substantiated CW fasteners as potential green alternative to adhesives and metallic fasteners. In order to understand the effect of connection geometry, dowel diameter, number of dowels, spacing of dowels, number and spacing of plates, further research is needed.

ACKNOWLEDGEMENT

The study had been conducted within the framework of project “Towards Adhesive Free Timber Buildings - AFTB” at the College of Engineering and Informatics, National University of Ireland Galway, Ireland. The AFTB project is funded by Interreg North West Europe via the European Regional Development Fund (ERDF).

REFERENCES:


