Interreg North-West Europe
Adhesive-Free Timber Buildings
European Regional Development Fund

Technical Note 7

Adhesive Free and Non-metallic Connections

One of a series of short briefings on timber technology produced by the towards Adhesive-Free Timber Buildings (AFTB) research project. The project is co-funded by Interreg NWE, 2016-2020. This note summarises structural applications of compressed wood connectors in moment resisting timber-timber connections.

Compressed wood connectors: potential alternative to adhesives and metallics fasteners

The AFTB project is focused on reducing the use of adhesives and metallic fasteners in the construction of modern timber buildings. Generally, metallic fasteners and adhesives are widely used in the production of engineered wood products and connections between timber elements. In an effort to improve the environmental performance and recyclability of timber construction systems, the AFTB project has designed and experimentally tested an all-wood connection solution utilising modified wood in the form of plates and dowels to connect timber elements and form structures. The use of wood-based materials in the construction industry fits well with the ongoing global transition towards a bio-based and circular economy. Timber is modified by means of thermal compression to form a high-density, high-strength timber product known as compressed wood (CW).

CW with superior mechanical properties is an ideal choice for manufacturing of adhesive free and non-metallic connectors such as CW dowels, CW plates, densified threaded bolts and nuts. These connectors can be used for the development of dowel laminated timber (DLT) products and connections.

Connections using compressed wood connectors

The feasibility of all-wood connections was assessed for typical beam-beam and beam-column connection types.

1. Beam-beam connections

Moment resisting beam-beam connections were fabricated using CW dowels and CW plates, as seen in Figure 1, and their structural performance was compared with moment connections using steel dowels and steel plates.

Figure 1 - Orientation of CW connectors in beam-beam connections

The mean failure load for CW-timber connection is only 20% less than that achieved for the steel-timber connections. The mean rotational stiffness of the steel-timber is 19% higher than that of CW-timber connection.

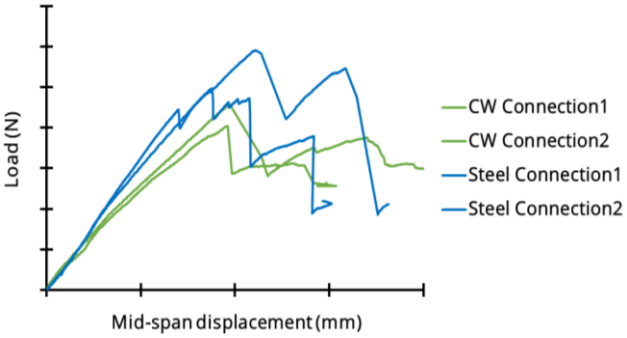

Figure 2 - Four-point bending test results (EN 408: 2012)

2. Beam-column connections

Novel adhesive free and non-metallic structural beam and column elements were also developed and connected together using CW connectors. To evaluate the feasibility of CW connections in modern timber construction, their structural performance was compared using both glued and dowel laminated timber members.

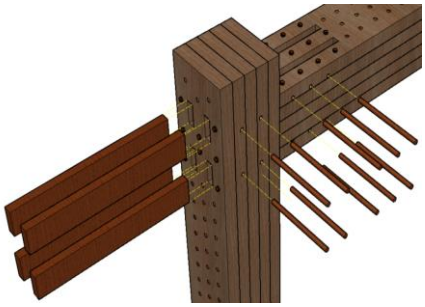

Figure 3 - 3-D model of the beam-column connection showing orientation of CW connectors within DLT elements

To assemble the connections, the columns and beams were routed at one end to accommodate the CW plates. Once routed, members were clamped together and connected using CW dowels as illustrated in Figure 3. Threaded CW dowels were used in the connection area to avoid separation of the laminations.

Figure 4 - Non-metallic and adhesive free beam-column connections using CW connectors

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In tests on small-scale specimens (Figure 4), CW connections using DLT members showed approximately similar load carrying capacity and moment resistance to connections using glued members. However, the lower bending stiffness of DLT members resulted in larger displacement during the tests.

3. Portal Frame

Following the successful implementation of CW connections in small scale beam-beam and beam-column connections, their structural performance in large scale applications such as portal frames was then investigated. A total of 4 frames comprising 2 frames using conventional glued members and 2 frames using DLT members (Figure 5) were manufactured and subjected to lateral loading (racking). In all portal frames, the connection design remained constant and only the type of structural members (dowel laminated or glued) was varied.

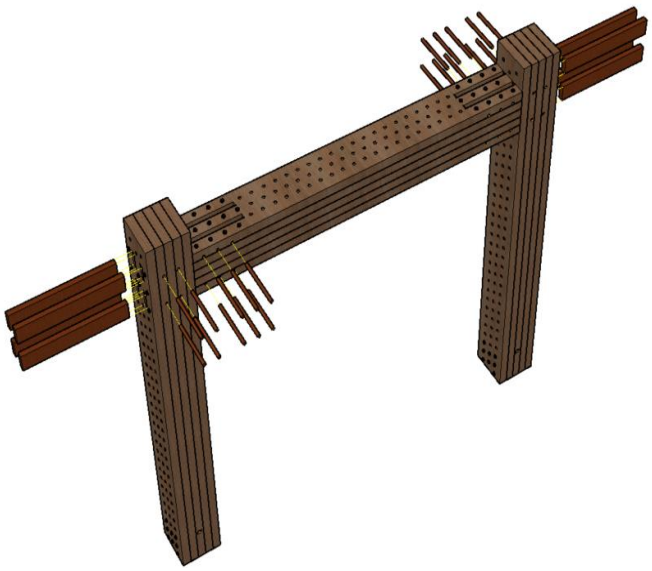

Figure 5 - Adhesive free and non-metallic portal frame using compressed wood connectors

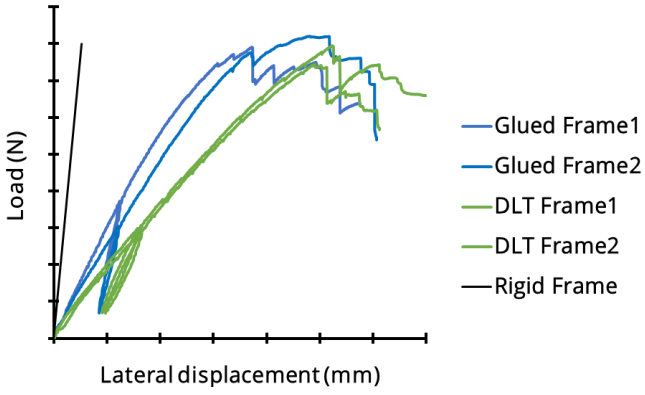

Figure 6 - Test results as per EN 26891: 1991

As seen in Figure 6, the mean load carrying capacity of the DLT frame using CW connections was only 4% lower than that of the glued frames. The mean system stiffness of the DLT frames was 35% lower than the glued frames, which is attributed to the lower bending stiffness of the DLT members. Both frame types showed failure in the connections.

Figure 7 - Testing of adhesive free and non-metallic timber frame

Conclusion

The research has demonstrated that CW connectors could be a viable alternative to high embodied energy steel connectors and synthetic adhesives in the timber construction industry. Adhesive Free Engineered wood products (AFEWPs) and CW connections will be 100% reusable and recyclable after end-of-life.

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Stakeholders Welcome

A key aim of the project is to engage with businesses, regulators and other interested parties. Adhesive-free timber building technology could be of interest to your business. Please get in touch via the e-mail addresses below:

For more information please visit the Adhesive Free Timber Buildings (AFTB) project website http://www.nweurope.eu/AFTB or use the contacts.

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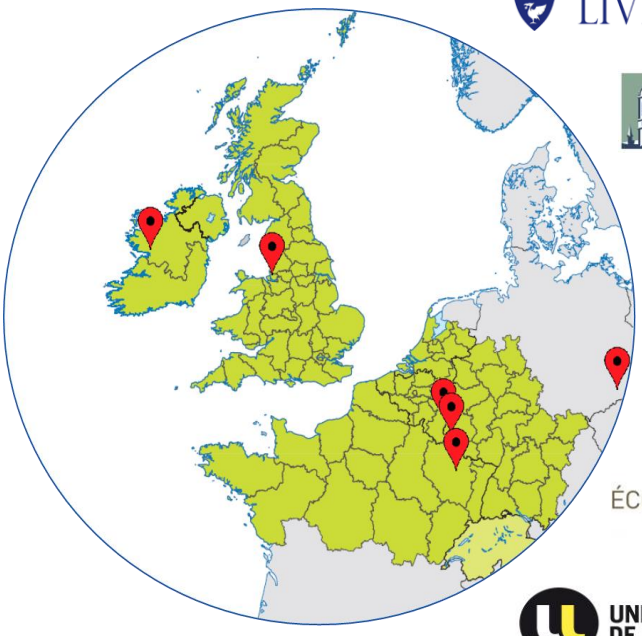

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