# Composite Beams of Steel and Timber

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## Abstract

Composite steel-concrete buildings are commonplace, but they are incompatible with low-carbon construction technologies. This is because the manufacture of the cement used in the flooring slabs, which is cast *in-situ* around headed stud connectors, is associated with the production significant $CO_2$ emissions, and deconstruction of such a building is environmentally intrusive with little possibility of re-use of the structural elements. The use of engineered timber in lieu of cast *in-situ* concrete is proposed, connected to a bolted steel frame by shear connectors. A series of short-term tests are reported on composite steel-timber beams, and it is shown that the shear connection is robust and associated with ductile and predictable modes of failure. Numerical modelling of the beams, verified and validated against the results of the tests, is also undertaken and used for a parametric study that demonstrates the potential of this innovative use of steel and timber in composite construction.

**Keywords:** bending test, composite, CLT, ductility, numerical analysis, steel-timber beam.

## 1 Introduction

The potential use of engineered timber instead of reinforced concrete for the slabs in steel-framed composite construction provides many advantages. These include a robust structural response, lower construction costs, reduced self-weight and benign environmental impacts. Moreover, timber is a natural carbon sink, and such slabs thus have a significantly lower carbon footprint compared with concrete. When connected to the steel with bolted or screwed shear connectors, steel-timber frames may be deconstructed at service life-end [1].

The use of timber in steel-framed buildings as slabs is a very new technology, with Loss *et al.* [2, 3] and Hassanieh *et al.* [4-6] appearing to be the only researchers to report push-out testing on steel-timber composite beams. This paper focuses on the beam components of innovative steel-timber composite (STC) buildings, having prefabricated cross-laminated timber (CLT) panels and steel beams connected by different types of shear connectors to develop the composite action. The structural behaviour is studied in four-point bending tests, and with 1-D and 2-D finite element (FE) models that are calibrated against the test results.

## 2 Experimental Program

The geometry and details of the STC beams and setup of the 4-point bending tests are shown in Fig. 1 and in Table 1. The main variables in the 4-point bending tests are the connection type (coach screw, dog screw and high strength bolts with grouted pockets), the direction of loading in the CLT panels (i.e. parallel and perpendicular to the grain) and the size of the steel girders.

The CLT panels were made of five layers of Spruce lamellae having a C24 strength class according to the specifications of BS EN338, and were 2 m long. The average moisture content and density of the CLT panels were 12% and 490 kg/m$^3$ respectively.

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