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Experimental behaviour of LVL–concrete composite floor beams at strength limit state

D. Yeoh [a,*], M. Fragiacomo [b], B. Deam [c]

[a] Faculty of Civil and Environmental Engineering, University of Tun Hussein Onn Malaysia, Malaysia

[b] Department of Architecture, Design and Urban Planning, University of Sassari, Alghero, Italy

[c] Department of Natural Resources and Civil Engineering, University of Canterbury, New Zealand

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ABSTRACT

This paper reports the outcomes of short-term collapse tests performed on eleven laminated veneer lumber (LVL)–concrete composite floor T-beams. Different variables such as span length (8 and 10 m), connection and concrete types, and design level (well- and under-designed, in terms of connector numbers) were investigated. During 4-point bending tests, mid-span deflection, connection slips and strains were measured. Connection types investigated include triangular and rectangular (150 mm and 300 mm long) notches cut in the timber and reinforced with a coach screw, and modified toothed metal plates pressed on the edge of the LVL joists. All of the beam specimens were designed using the effective bending stiffness or γ-method, in accordance with Annex B of Eurocode 5. The same method was used for an analytical–experimental comparison of the beam's performance at ultimate (ULS) and serviceability (SLS) limit state.

All well-designed beams provided more than 95% composite action even though there were relatively few connectors (e.g. six 300 mm long notches on the 8 m span beam). The ULS and SLS live load capacity of the beams was found to be approximately 90% of that of a fully composite beam. Correction factors providing a 15% increase for deflection and a 13% reduction of the effective bending stiffness are proposed for calculations using the transformed section method for all well-designed beams, i.e. beams designed using the γ-method according to Annex B of Eurocode 5. Although the γ-method was found to be significantly underestimate the ULS strength, it provided an accurate prediction of the short-term deflection. In terms of the connection type, the 300 mm rectangular notches provided the best performance, with high stiffness and strength beyond the ULS load level, and requiring fewer connectors along the beam. The triangular notch was found to be a viable alternative, with more connectors but was easier and faster to cut than a rectangular notch. Metal plate connectors provide a practical construction possibility, but the beam stiffness was found to rapidly deteriorate beyond the ULS load level.

1. Introduction

Timber–concrete composite (TCC) systems are a construction technique used to improve the strength and stiffness of existing timber floors as well as for new construction such as multi-storey buildings and short-span bridges. The combination of the two materials, exploits their best qualities, with the timber positioned in the tension region of the composite section and the concrete in the compression region. The presence of timber, due to its lower density in comparison with reinforced concrete, decreases the total weight of this flooring system, giving several advantages over reinforced concrete floors, including better efficiency in terms of load for a given self-weight, better seismic performance, and a lower carbon footprint. Compared to a wood-only floor, the concrete topping increases the thermal mass and fire resistance, improves the acoustic separation, and enhances the in-plane rigidity, which is particularly important in seismic regions. All the aforementioned advantages can be achieved only if the composite system is structurally effective, with a stiff and strong shear connection system. A wide range of connection systems is available, each with a different level of rigidity [1]. Seven types of connectors were tested in shear by Lukaszewska et al. [2], out of which the best two systems were chosen to build five fully prefabricated TCC floors tested to failure under 4-point bending [3,4].

A semi-prefabricated LVL–concrete composite system has been developed at the University of Canterbury, New Zealand, comprising "M" section panels built with laminated veneer lumber (LVL) beams acting as floor joists and a plywood interlayer as

* Corresponding author. Tel.: +60 127476500.
E-mail addresses: dyec@rocketmail.com, david@uthm.edu.my (D. Yeoh).

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