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Experimental investigation of the stiffness of critical components in a moment-resisting composite connection

A.P. Gardner[a,*], H.M. Goldsworthy[b]

[a] *Faculty of Engineering, University of Technology, Sydney, PO Box 123 Broadway, NSW 2007, Australia*
[b] *Department of Civil and Environmental Engineering, University of Melbourne, Victoria 3010, Australia*

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Abstract

This paper discusses results of experiments on an element of a proposed moment-resisting composite connection. The element is subjected to cyclic tension. A feature of this element is the use of blind bolts and extensions to these bolts into the concrete-filled CHS column. The test specimens with extensions failed at a higher load and showed increased initial stiffness compared to the specimen without extensions. The experimentally derived values of initial stiffness are also compared to the initial stiffness values derived from a mechanical component model of the connection element.

Keywords: Concrete-filled steel tube; CHS; Beam-to-column connection; Moment-resisting composite connection; Blind bolt; Stiffness; Bolted end-plate; Cyclic loading; Bolt extensions

1. Introduction

Hollow structural sections have become popular because of their structural efficiency, increased availability, reliability of manufacture, and aesthetics. Concrete-filled circular

* Corresponding address: 27 Eighth Avenue, 2232 Loftus, NSW, Australia.
E-mail address: Anne.Gardner@uts.edu.au (A.P. Gardner).

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steel tubes have been found to be more ductile than their rectangular counterparts. In regions of low seismicity such as Australia, plastic hinges would typically be expected to form in the column at interior joints of moment-resisting frames and at the base of columns in the lowest storey, i.e. a mixed mode energy-dissipating mechanism. If the column is ductile it can maintain its strength while deforming plastically.

For some years it has been recognised that a concrete floor slab acting compositely with steel beams is one of the most economical structural steel systems for low-rise to medium-rise structures. The composite action generated by shear studs on the steel beams, significantly increases the strength and stiffness of a steel beam when the steel is in tension and the concrete is in compression [1]. Thus this system is particularly suited to braced frames with short beam spans where gravity loads govern the design and nominally pinned connections are used at the ends of the beams. However, as the beam spans increase, serviceability criteria begin to become critical. These criteria include crack widths, deflections, and vibrations. One way to counteract this is to provide some continuity at the supports. This reduces deflections and vibrations and “ . . . improves the ability of the structure to redistribute loads and survive accidental overloads” [1].

This paper discusses stiffness results from initial testing on a critical element of a moment-resisting connection between a concrete-filled circular steel tube column and a conventional composite beam (i.e. a steel UB section composite with a concrete slab on a metal deck). A mechanical component model of the connection element is then constructed and the initial stiffness values from the test specimens are compared to the respective values from the component model.

2. Description of proposed connection

The connection detail proposed is shown in Fig. 2.1 for an exterior joint. The beam flanges are connected to the column by a built-up T-type element consisting of a curved end-plate and a fan-shaped horizontal web-plate. This web-plate of the T-type element is assumed to be bolted to the beam flange, and will hereafter simply be referred to as *the web-plate*. The beam’s web is attached to the column using another built-up T-section with the T-section’s web being vertical. This provides redundancy for the transfer of vertical shear at the connection.

Reinforcement is provided in the concrete slab which forms part of the top flange of the concrete beam. This reinforcement is continuous on both sides of the column and complies with the Australian Concrete Code AS3600 [2].

The end-plates of the T-sections are attached to the column by Ajax blind bolts, which may include extensions into the concrete of the column. For the design of the bolts and the end-plates, the beam flanges are assumed to transmit all the bending moment, the compression force being resisted by bearing and the tension force being resisted by the bolts, or bolts and extensions, and membrane action in the tube. These bolts are inserted into the hollow steel section prior to concreting. The head of the bolt and a folded washer are fed through an oversized hole in the tube using a special insertion tool (see http://www.ajaxfast.com.au). The nut on the outside is then tightened with the insertion tool still in place.