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Section moment capacity design rules for rivet fastened rectangular hollow flange channel beams

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ABSTRACT

The rivet fastened Rectangular Hollow Flange Channel Beam (RHFCB) is a new type of cold-formed steel section, made of two torsionally rigid rectangular hollow flanges, connected to a web via intermittent rivet fastening. The hollow flanges and the absence of free edges in the RHFCB contribute to improved structural performance. The structural behaviour of the RHFCB is unique compared to other conventional cold-formed steel sections and its moment capacity reduces with increasing rivet spacing. The current cold-formed steel design standards do not provide a calculation method to include the effects of intermittent fastening. In this research an extensive parametric study was conducted using validated finite element models to investigate the section moment capacity of RHFCBs. This paper presents the findings from the parametric study and proposes new design equations for the section moment capacity of RHFCBs in the Direct Strength Method format. The parametric study considers various slenderness regions, section dimensions and rivet spacing. In the new design equations, a reduction factor parameter is included to calculate the section moment capacity of RHFCBs at any rivet spacing up to 200 mm. Optimum rivet spacing was also recommended for RHFCBs.

1. Introduction

The use of cold-formed steel in the construction industry today is becoming increasingly important and widespread. The benefits of cold-formed steel construction are fast erection speed, ease of transportation, lightweight and reduced construction cost. In the past, traditional cold-formed sections such as the simple channels (Cs) and zeds (Zs), are used as purlins. Today, as fabrication technology improves, more unique cold-formed sections are introduced.

Significant to this development is the cold-formed and welded hollow flange beam, which has been shown by researchers to have capacities similar to those of hot-rolled steel beams. This superior quality of the section compared to other cold-formed steel sections, which are normally governed by local buckling due to free edges, has garnered much interest even after it was discontinued due to the expensive dual-electric resistance welding used in its fabrication. In the past, the structural application of hollow flange beams is mainly as flexural members such as bearers and joists in the residential, industrial and commercial buildings. The first type of hollow flange beams is known as the Triangular Hollow Flange Beam shown in Fig. 1(a). With improved manufacturing process and capacity, the second type of hollow flange beam was developed, known as the LiteSteel beam (LSB) (Fig. 1(b)). Compared to the first triangular hollow flange beam, the rectangular flanges of the LSBs provide better connectivity to other members. Today, both hollow flange beams are discontinued due to expensive dual electric resistance welding used in the fabrication. However, there are still interests and demands in the industry for such sections.

As part of continuing research in this area, a new type of hollow flange beam known as the rivet fastened Rectangular Hollow Flange Channel Beam (RHFCB) was proposed (Fig. 2) and investigated. Two cold-formed rectangular hollow flanges are connected to a web plate using self-pierce rivets at suitable spacings along the length to form the new hollow flange beam sections. Experimental and numerical investigations of the section moment capacity of RHFCBs subject to local buckling have been reported in [1,2]. The intermittently rivet fastened RHFCB serves as an inexpensive alternative by eliminating the electric resistance welding process, but still exhibits the torsionally rigid hollow flange characteristics of hollow flange beams.

The section moment capacities of the RHFCBs subject to local buckling effects have been investigated using four-point bending arrangement [1]. In the experimental investigation of its section moment capacity, the behaviour of 50 mm rivet fastened RHFCB has been shown to be comparable to welded hollow flange steel beam (Fig. 1(b)) investigated in Anapayan et al. [3]. Unlike other conventional cold-formed steel sections, the hollow flange beams have improved moment

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Fig. 1. Hollow flange beams.

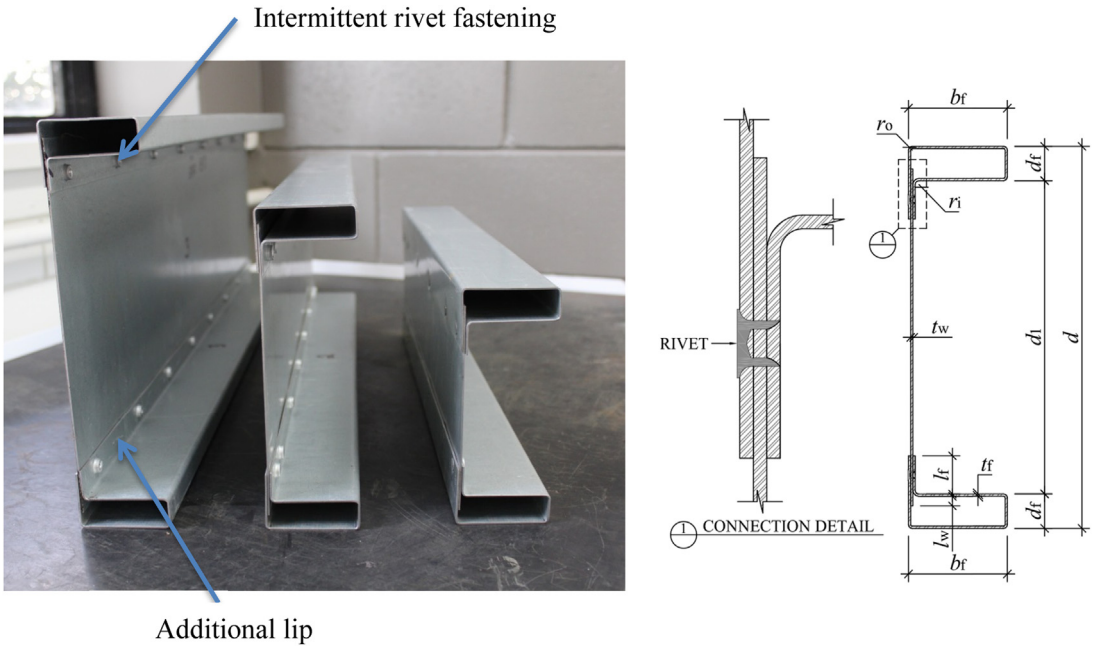

Fig. 2. Rivet fastened rectangular hollow flange channel beam.

capacities due to the presence of torsionally rigid hollow flanges. Further the additional lips in the RHFCB (Fig. 2) contribute to additional stiffening of the beam. However, the section moment capacity of RHFCBs reduced with increasing rivet spacing. Subsequently, finite element models were developed and validated by comparison with the test results [2]. However, they were limited to a few RHFCB sections and three rivet spacings, and the results are inadequate to develop accurate design rules for their section moment capacity as a function of RHFCB sizes and rivet spacing. In this paper, an extensive numerical parametric study of RHFCBs was conducted using the validated finite element model. The study considered various factors including RHFCB dimensions, rivet spacing and slenderness of the overall section. It also provided proposal of optimum rivet spacing that can be adopted in the design of the RHFCBs as flexural members in the construction industry.

Local buckling of cold-formed steel sections has been investigated by various researchers [3–6]. In comparison, studies regarding the flexural behaviour of intermittently fastened cold-formed steel sections are limited. Karunakaran and Santi [7] investigated the behaviour of cold-formed steel rectangular hollow flanged “Z” beams. The study compares the moment capacity of intermittently welded (spot-weld) and riveted sections at 50 mm spacing. The failure mode of the section was governed by distortional buckling. Although the findings from [7] are limited, it is noted that the fabrication of the hollow flanges of this section would be similar to the RHFCB, showing that currently available fabrication method exists that supports hollow flange sections. Magnucka-Blandzi et al. [8] studied the behaviour of riveted double-