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Effect of web holes on the web crippling capacity of cold-formed LiteSteel beams under End-Two-Flange load case

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ABSTRACT

LiteSteel (LSB) beams are made of two rectangular hollow flanges and a slender web. Although the flexural capacity and bending stiffness are enhanced due to hollow flanges, they are vulnerable to the web crippling failure under concentrated loads and reactions due to high web slenderness values. In current steel buildings, cold-formed steel sections with web holes have been used to accommodate service ducts in floor systems. These LiteSteel beams (LSBs) are innovative new sections, hence current web crippling equations cannot be used to predict the web crippling capacities of them. Keerthan et al. (2014, 2016) and Steau et al. (2015) proposed coefficients to the unified web crippling equation which is available in Australian/New Zealand standard (AS/NZS 4600) and North American Specification (AISI S100) for unfastened and fastened supports, respectively for LSB sections without web holes under four load cases based on their experimental studies. However web crippling behaviour of these sections with web holes is still unknown under all four load cases. In past studies, the web holes are classified into two groups such as centred beneath and offset web holes to investigate their effect on the web crippling behaviour. This study investigates web crippling behaviour of LiteSteel beams with centred beneath and offset circular web holes with unfastened supports under End-Two-Flange load case (ETF) using finite element analysis in ANSYS. Accurate validations have been performed for five different web crippling datasets, and the parametric study was conducted using validated FE models. Web crippling equations were proposed for LiteSteel beams with centred beneath and offset web holes and without web holes based on 1067 FE model values.

1. Introduction

Cold-formed steel sections have increasingly used in low and medium-rise buildings due to their high strength to weight ratio, ease of fabrication and accuracy in dimensions. In cold-formed steel floor systems, the significant drawbacks of conventional cold-formed steel lipped and unlipped channel sections are inadequate flexural capacity and excess deflection due to a low stiffness. Rectangular hollow flange channel beam section (RHFCBs) also commercially known as LiteSteel beam (LSB) section was introduced in the Australian building industry with enhanced flexural capacity and bending stiffness as a solution to the problem mentioned above. As shown in Fig. 1, LiteSteel Beam is made of a slender web and two rectangular hollow flanges located away from their neutral axis, which is the primary reason for their enhanced flexural capacity and bending stiffness. Although these sections exhibit high flexural capacity, these sections are subjected to web crippling failures under concentrated loading and reactions due to their slender webs. Web crippling behaviour of cold-formed steel sections without web holes has been investigated experimentally in the past due to involved complexities such as non-uniform stress distribution under load, local yielding under the load application and initial out of plane imperfection. Web crippling behaviour of cold-formed steel sections with web holes will be more complicated. Hence it should also be investigated experimentally or using finite element analysis. However, finite element analysis is less expensive and less time consuming with proper validation.

AISI standard web crippling test method [2], Australian/New Zealand standard (AS/NZS 4600) [3], North American Specification (AISI S100) [4] and Eurocode 3 Part 1–3 (EC3, 2006) [5] distinguishes web crippling failures of cold-formed steel sections without and with web holes into four load cases such as (i) EOF: End-One-Flange (ii) ETF: End-Two-Flange (iii) IOF: Interior-One-Flange and (iv) ITF: Interior-Two-Flange based on failure locations and loading conditions as shown in Fig. 2. Load case is considered as two-flange if the distance between applied loads is less than $1.5d_1$. Otherwise, it is one-flange load case. The load case is considered as end load if the load is within $1.5d_1$ from

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