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Non-linear 3D finite element analysis of built-up cold-formed steel section beam subjected to four-point bending load

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A B S T R A C T

The behaviour of cold-formed steel (CFS) built-up section beams under the flexural load has become an attentive area for search, especially with associated complex failure modes, such as local, distortional, lateral-torsional, and global buckling. Previous studies in this area have primarily focused on the compression capacity of CFS members, neglecting their flexural behaviour. Moreover, the CFS beam flexural analysis is more complex in terms of failure mode form and design. This study conducted A 3D non-linear finite element analysis (FEA) run on ABAQUS software on a CFS built-up section beam that was tested under four-point bending. This study examines the bending response of the built-up beam in terms of its load-bearing capacity, the ways in which it fails, and the stress distribution among its cold-formed steel components. The constitutive material laws for CFS, the screws modelling strategy and the contact interaction between the CFS components were considered in this study. The finite element model was verified by comparing it to the experimental results from a previously published study, focusing on the load–deflection response and how the beam failed. The results demonstrated that the FEA could replicate the flexural response of the CFS built-up section beam with an acceptable level of accuracy. Furthermore, the stress profile evaluation showed that the compression flange was the most affected component during the four-point bending loading. Overall, the FEA model developed in this study is a valid tool for predicting the bending behaviour of a CFS built-up section beam and assessing design variables for this type of beam under flexural loading.

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1. Introduction

Cold-formed steel (CFS) is a popular choice in the construction industry because it is cost-effective, lightweight, easy to install and maintain, corrosion-resistant, portable, recyclable, and can be easily fabricated. These benefits make CFS a versatile and sustainable building material that is well-suited for a wide range of construction projects. CFS is widely used in low-rise residential and commercial infrastructures as wall panels, roof truss systems, frames, storage racks, and highway applications, and it has been designated as a sustainable green material that contributes to environmental preservation [1]. Recently, the usage of CFS has been broadened from only being applied in a single section to also being applied to built-up sections. The CFS assembled sections can be either open or closed sections. These sections can be constructed using a combination of both conventional methods, like bolting and arc-welding, and more robust techniques, such as blind rivets and self-tapping, self-drilling screws. As a result, these assembled members effectively utilize cross-sectional strength, making the use of steel as a construction material more efficient. [2]. Several studies [2–5] have recently focused on the flexural performance of the CFS assembled section beam, with a specific emphasis on related issues such as distortional, local and lateral-torsional buckling and their interactions. However, these studies have revealed that when the load is applied, the bending stresses in the beams tend to increase at the upper flange that is under compression; this

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