

INVESTIGATING THE EFFECT OF BEARING STIFFENERS ON THE WEB CRIPPLING CAPACITY OF LIPPED CHANNEL BEAMS

S.P.S.M. Subhasinghe, H.M.S.T. Herath *

Department of Civil Engineering, University of Moratuwa, Moratuwa

Cold-Formed Steel (CFS) sections are readily used in modern construction because of their structural efficiency, cost-effectiveness, and ease of fabrication. Applications such as wall studs, floor joists, and roof purlins rely heavily on CFS members, where their excellent strength-to-weight ratio provides significant advantages. However, the thin-walled geometry of these sections makes them vulnerable to local instabilities, among which web crippling is a particularly critical failure mode. Web crippling arises as a localized buckling phenomenon under concentrated loads or support reactions and can govern the ultimate strength of members in practical applications. The severity of this failure is further amplified by the presence of service openings required for utilities, as they reduce the effective load-resisting area and generate stress concentrations. While international design standards such as AISI S100-16 and AS/NZS 4600 provide predictive equations, their scope remains limited to perforated members subjected to End One Flange (EOF) and Interior One Flange (IOF) load cases. They do not adequately account for more complex situations, such as Interior Two Flange (ITF) loading in beams with web perforations and transverse stiffeners, which are increasingly common in modern construction systems. The primary objective of this study was to investigate the web crippling behaviour of CFS lipped channel beams under ITF loading, with particular emphasis on the combined influence of web openings and transverse stiffeners. To achieve this, an experimental programme was conducted using sixteen-channel specimens fabricated with different stiffener configurations and web openings. The tests were performed following the AISI S909 standard web crippling methodology, and realistic boundary conditions were maintained by leaving the flanges unfastened. Load–deflection responses, ultimate strengths, and failure modes were recorded for each configuration. To complement the experimental work, advanced finite element (FE) models were developed in ABAQUS/CAE. Shell elements were employed to capture thin-walled behaviour, and a quasi-static explicit integration scheme was used for accurate simulation of concentrated loading. The FE models were validated against experimental results by comparing load–displacement curves and observed failure modes. Following validation, parametric study can be carried out to explore the influence of variables such as web thickness, hole size, and stiffener placement on web crippling strength. The results confirmed that web perforations considerably reduce the web crippling capacity. However, the inclusion of transverse stiffeners markedly improved strength by redistributing stresses and delaying the onset of local buckling. Experimental results indicated that stiffeners could enhance capacity by 58.1–117.6% compared to unstiffened beams without web openings. In beams with web openings, stiffeners restored capacity by approximately 60.2–119.4%, depending on hole location. These findings provide reliable quantitative evidence of the beneficial role of stiffeners in mitigating the adverse effects of web holes. In conclusion, this study highlights the inadequacy of current design provisions in addressing ITF loading scenarios involving perforated and stiffened sections. The combined experimental and numerical results offer a robust foundation for improving predictive models and revising design guidelines.

Keywords: Cold-formed steel, Interior Two Flange loading, Experimental testing, Finite element analysis, Web openings

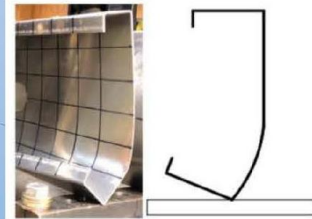
* Correspondence: sumuduh@uom.lk

Investigating the Effect of Bearing Stiffeners on the Web Crippling Capacity of Lipped Channel Beams



Web Crippling?

A localized failure mode that typically occurs in cold-formed steel structural members under transverse concentrated loads or reactions at supports



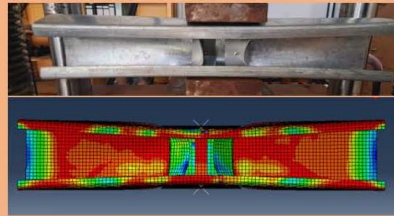
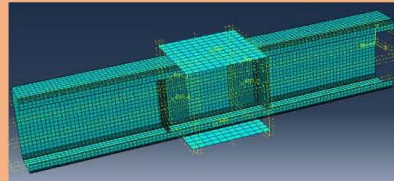
Experimental Studies

- 16 specimens comprising 8 without web openings and 8 with circular web openings
- Stiffener type - L-angle sections
- Loading condition - Interior-Two-Flange (ITF) loading
- Connections – Rivets

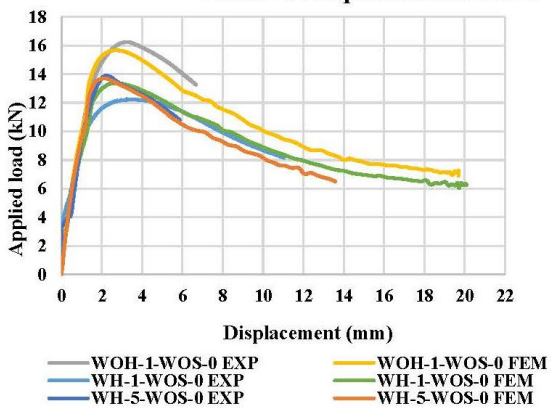


Numerical Studies

- Quasi-static analysis using the explicit integration method in ABAQUS/CAE



Load vs Displacement curve



Conclusion!

Strength enhancement due to stiffeners

Sections without web openings

•58.1% - 117.6%

Sections with web openings

•60.2% - 119.4%

