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Review on Web Opening in Shear Analysis of a Cold-Formed Stainless-Steel Beam

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ABSTRACT: In the recent years, an increase in the use of stainless steel in the construction industry has been witnessed, more specifically in exposed architectural applications and where total life economics, durability, improved resistance to aggressive environment etc. are prime deciding criteria. However, limited research has been undertaken on the shear behaviour and strength of cold-formed stainless-steel beam with web openings. Hence a numerical study was undertaken to investigate the shear behaviour and strength of cold-formed stainless steel with web openings. Finite element models of simply supported cold-formed stainless steel Lipped Channel Beams with web openings were developed under a mid-span load. They were then validated with currently available shear test results and further used in a detailed parametric study. In this research, both stocky and slender cross-sections were considered. The ultimate shear capacities from finite element analyses confirmed that currently available design equations are inadequate to determine the shear capacities of stainless-steel beams with web openings.

KEYWORDS: Finite element modelling, Cold-formed stainless steel, Lipped channel beams, Web Openings.

I.INTRODUCTION

Stainless steels have been used for structural applications ever since they were invented. They are attractive and highly corrosion resistant, whilst at the same time having good strength, toughness and fatigue properties alongside low maintenance requirements. They can be fabricated using a wide range of commonly available engineering techniques. Both austenitic and duplex stainless steels are commonly used for structural applications. Austenitic stainless steels provide a good combination of corrosion resistance, forming and fabrication properties.

Stainless steel structural members behave similarly to carbon steel members, although there are some important differences arising from the material's distinctive strength, stiffness and physical properties. The major difference between the mechanical properties of carbon and stainless steel is the stress-strain relationship: stainless steel has a continuous, but non-linear relationship between stress and strain, whereas carbon steel has a clearly defined yield point. This means that different section classification limits and buckling curves apply, and a different approach to estimating beam deflections is necessary to account for the non-linear stiffness.

II.LITERATURE REVIEW

2.1. P. Keerthan and M. Mahendran (2012), "Finite Element Analysis of Lipped Chanel Beams with Web Openings in Shear."

Cold-formed steel members are increasingly used as primary structural elements in buildings due to the availability of thin and high strength steels and advanced cold-forming technologies. Cold-formed lipped channel beams (LCB) are commonly used as flexural members such as floor joists and bearers. Shear behaviour of LCBs with web openings is more complicated and their shear capacities are considerably reduced by the presence of web openings. However, limited research has been undertaken on the shear behaviour and strength of LCBs with web openings. Hence a numerical study was undertaken to investigate the shear behaviour and strength of LCBs with web openings. Finite element models of simply supported LCBs with aspect ratios of 1.0 and 1.5 were considered under a mid-span load. They were then validated by comparing their results with test results and used in a detailed parametric study. Experimental and numerical results showed that the current design rules in cold-formed steel structures design codes are very conservative for the shear design of LCBs with web openings. Improved design equations were therefore proposed for the shear strength of LCBs with web openings. This paper presents the details of this numerical study of LCBs with web openings, and the results.

2.2. P. Keerthan and M.Mahendran (2014) "Improved shear design rules for lipped channel beams with web openings"

Cold-formed steel Lipped Channel Beams (LCB) with web openings are commonly used as floor joists and bearers in building structures. The shear behaviour of these LCBs with web openings is complicated and their shear capacities are considerably reduced by the presence of web openings. However, limited research has been undertaken on the shear behaviour and strength of LCBs with web openings. Hence a detailed numerical study was undertaken to investigate the shear behaviour and strength of LCBs with unreinforced circular web openings. Finite element models of simply supported LCBs under a mid-span load with aspect ratios of 1.0 and 1.5 were developed and validated by comparing their results with test results. They were then used in a detailed parametric study to investigate the effects of various influential parameters. Experimental and numerical results showed that the current design rules in cold-formed steel structures design codes are very conservative. Improved design equations were therefore proposed for the shear strength of LCBs with web openings based on both experimental and numerical results. This paper presents the details of finite element modelling of LCBs with unreinforced circular web openings, validation of finite element models, and the development of improved shear design rules. The proposed shear design rules in this paper can be considered for inclusion in the future versions of cold-formed steel design codes.

2.3. R. Mark Lawson et al. (2015), "Design of stainless-steel sections with circular openings in shear"

This paper addresses the design of stainless-steel sections with large circular openings subject to shear and bending. A total of nine tests on pairs of C sections using 2 and 3 mm thick stainless steel in austenitic 1.4301 and lean duplex 1.4162 grades was performed. The tests showed that the shear resistance at an opening is controlled by local compression at a radial cross-section at approximately 25° to the vertical. For closely spaced openings, the angle of highest stress increases to about 65° to the vertical. The shear resistance of a Class 4 web is also affected by local buckling around the opening, which is a function of its diameter to steel thickness ratio. An equilibrium model is presented which predicts the normal stress on the radial planes around an opening. A simplified formula for the local buckling strength around circular web openings is also presented, which agrees well with the test results.

2.4. Sonu J.K and KonjengbamDarunkumar Singh (2017), "Shear characteristics of Lean Duplex Stainless Steel (LDSS) rectangular hollow beams."

A numerical investigation on the shear characteristics of Lean Duplex Stainless Steel (LDSS) rectangular hollow beams are presented in this paper, through a parametric study, using the commercial finite element software, Abaqus. Effects of key cross-sectional parameters viz., flange thickness (tf), flange width (wf), web thickness (tw) and shear span (a) have been considered, keeping the height of the web (hw) constant. It is observed that increasing flange thickness for the same web thickness can enhance both shear capacity and ductility. The effect of increasing flange width is found to be relatively significant for stockier cross sections as compared to that of slender sections. In general, both EN 1993- 1-4 (2006/A1:2015) and DSM are found to be applicable for the shear design of LDSS rectangular hollow beams. Possible modifications to both EN 1993-1-4 (2006/A1:2015) and DSM have been suggested by bifurcating into two span ratios: 1) $a / hw \leq 1.0$ and 2) 1 b $a / hw \leq 2.0$.

2.5. R.Mark Lawson and Antoine Basta (2018), "Deflection of C section beams with circular web openings"

The deflection of steel beams with circular openings is dependent on the loss of bending stiffness and shear area of the web, which adds to the deflection of the solid web beam. The additional deflection is a function of the ratio of opening diameter, ho, to section depth, h, and also of the spacing of the openings. This paper presents derived formulae for the additional deflection of beams with circular web openings that are expressed as a function of the pure bending deflection of the unperforated beam. The formulae are calibrated against finite element models and against short span beam tests with opening diameters, ho, of 0.6 h and 0.72 h, in which the additional defection is mainly due to the effects of shear. Further simplified design formulae for additional deflection are also presented which are shown to be accurate for C-section beams with a span: depth ratio exceeding 15. It is also shown that circular openings may be represented for analysis purposes as an equivalent rectangle of width x depth equal to 0.75 ho x ho.

2.6. Karma Hissey Lepcha1 et al. (2019), "Behaviour and Design of Lean Duplex Stainless Steel (LDSS) Beams with Web Openings under Pure Bending"

The flexural behaviour of lean duplex stainless steel tubular beams with web openings is presented. A finite element study is carried out on lean duplex stainless steel sections with web openings to determine the effects of the perforations on the bending capacity, deformed shapes and local buckling characteristics. The study also aims in

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particular for a comparison between sections having circular or extended openings with a wide range of section slenderness. The bending capacities from the finite element results are also compared with the American specification, European specification along with direct strength method. Both ASCE and EN can give a good prediction of the design strengths, however, the direct strength method showed conservative predictions. Modifications have been proposed to both the ASCE specification and the direct strength method for LDSS sections with web openings.

III.CONCLUSION

1. Ultimate load-carrying capacity and the stiffness decrease with increase in opening area. Failure modes were found same for all the beams with web openings.
2. The shear resistance of stainless-steel beam is affected by local buckling around the opening, which is a function of its diameter to steel thickness ratio.
3. To evaluate the shear capacity and failure modes of lipped channel stainless-steel beam in static loading conditions.
4. Experimental studies have shown that relatively short span LCBs without straps are subjected to a relatively new combined shear and flange distortion action due to the distortional buckling and unbalanced shear flow when flanges are not restrained.

IV. ACKNOWLEDGEMENT

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REFERENCES

1) P. Keerthan and M. Mahendran (2012) “Finite Element Analysis of Lipped Chanel Beams with Web Openings in Shear.”International Specialty Conference on Cold-Formed Steel Structures. 4.
2) P. Keerthan and M.Mahendran (2014) “Improved shear design rules for lipped channel beams with web openings” Journal of Constructional Steel Research 97 (2014) 127–142
3) R. Mark Lawson et al. (2015), “Design of stainless-steel sections with circular openings in shear”Journal of Constructional Steel Research 112 (2015) 228–241
4) Sonu J.K and KonjengbamDarunkumar Singh (2017) “Shear characteristics of Lean Duplex Stainless Steel (LDSS) rectangular hollow beams.”Structures 10 (2017) 13–29
5) R.Mark Lawson and Antoine Basta (2018) “Deflection of C section beams with circular web openings”Thin-Walled Structures 134 (2019) 277–290
6) Karma Hissey Lepcha1 et al. (2019) “Behaviour and Design of Lean Duplex Stainless Steel (LDSS) Beams with Web Openings Under Pure Bending”International Journal of Steel StructuresOnline ISSN 2093-6311
7) American Iron and Steel Institute (AISI)(2012), North American Specification for the Design of Cold-formed Steel Structural Members, AISI, Washington, DC, USA.
8) BSI.Euro code 3: Design of Steel Structures – Part 1–4: General Rules – Supplementary Rules for Stainless Steels. Brussels: British Standards Institution, 2006.

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