Review Paper on Cold Formed Steel Beams

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Abstract- *This paper deals with review of earlier published research papers on Cold Formed Steel I beams. Selected papers covering area of study like sections, its various buckling modes along with analysis done by different methods and software's viz. ANSYS, ABAQUS, THINWALL, CUFSM etc. This paper also deals with the review of research papers showing properties of cold formed steel beams. At the end, literature gap found in research paper is also been pointed out.*

Keywords- Cold Formed Steel, ABAQUS, THINWALL, CUFSM, Literature gap etc.

I. INTRODUCTION

Generally, these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are Cold Formed, i.e. their manufacturing process involves forming steel sections in a cold state (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title Cold Formed Steel Sections. Sometimes they are also called Light Gauge Steel Sections or Cold Rolled Steel Sections. The thickness of steel sheet used in cold formed construction is usually 1 to 3 mm and can vary up to 8mm in particular cases. The method of manufacturing is important as it differentiates these products from hot rolled steel sections. Normally, the yield strength of steel sheets used in cold-formed sections is at least 280 N/mm2, although there is a trend to use steels of higher strengths, and sometimes as low as 230 N/mm2.

Commonly, cold formed steel (CFS) structural elements have traditionally been employed as secondary load-carrying members such as stud walls, roof purlins, wall girts and cladding. However, in a more recent trend, CFS members are also increasingly being employed as primary structural elements in low- to mid-rise multi-storey buildings and CFS portal frames with short to intermediate spans. Compared to hot-rolled members, CFS thin-walled members offer several advantages, such as a high strength for a lightweight, a relatively straightforward manufacturing process, a high flexibility in obtaining various cross-sectional shapes, and an ease of transportation and faster construction. However, as a result of the limitations of the manufacturing process, CFS components usually have 6–8 mm thickness, which makes them susceptible to local, distortional and global buckling, as well as their interactions.

II. LITERATURE REVIEW

General

This division is mainly focussed on list of literatures collected and important concepts that has been figured from each literature of getting idea about the buckling behaviour of cold-formed steel beams.

Sudha.K, Sukumar.S (2014) - presents an experimental and numerical investigation on the bending strength and behaviour of cold-formed (CF) steel built-up flexural members. The experimental results show the modes of buckling and their influence on the bending strength and behaviour of CF built-up I sections.

To avoid bearing failure vertical stiffeners are required at support and at the loading points .By stiffening the web element of each chord member the capacity of the beam is further improved. Local buckling, distortional buckling and interaction between local and distortional buckling were observed. The results show that the buckling mode has greater influence on the strength of the specimens.

Cheng Yu, Benjamin W. Schafer (2006) did Simulation of cold-formed steel beams in local and distortional buckling with applications to the direct strength method. A nonlinear FE model was developed (in ABAQUS) and verified against previously conducted flexural tests on cold formed steel C- and Z-section beams. The FE analysis was extended to beams not included in the tests; in particular, yield stress was varied from 228 to 506 MP. The results indicated that the Direct Strength Method yields reasonable strength predictions for both local and distortional bucking failures of Z and C-section beams with a wide range of industry standard geometries and yield stresses of steel. The FE model was also utilized to study the distortional buckling and post buckling behavior of cold formed steel beams under moment gradient. Moment gradients were achieved by applying a single concentrated load in the middle of simply supported beams. The FE results showed that overly conservative predictions will be made if the moment gradient effect was ignored in distortional buckling. It was also shown that by using the appropriate elastic buckling moments, the Direct Strength Method was a conservative predictor of the increased strength due to moment gradient in distortional buckling.

The elastic distortional buckling moment under a moment gradient can be determined by finite element analysis, or by the empirical equation. DSM provided reliable and conservative predictions for the bending strength of cold formed steel beams. The local buckling strength predictions was more scattered than those of distortional buckling, and significant inelastic reserve was ignored.

LuísLaim: has presented, CFS members can be easily shaped and sized to meet any particular design requirement. These are usually formed in channel (U) sections, lipped channel (C) sections, zed (Z) sections and omega (2) sections as well as most studies in this field are concerned with these sections. The low torsional stiffness, the low flexural rigidity about the minor axis, the high slenderness and the geometric imperfections are some of the main causes for their high susceptibility to buckling phenomena. In order to eliminate, or at least minimize, the local and distortional buckling phenomenon, edge and intermediate stiffeners are becoming used in CFS members at the expense of a little extra material. Note that the edge stiffeners used must have adequate rigidity to prevent out-of-plane deflections of the edge and the intermediate stiffeners to prevent out-of-plane deflections in the plate element in the region of the stiffener, thus allowing that under uniform compression this area of the section becomes fully stressed. Also, the yield strength of steel can be strengthened by forming edge and intermediate stiffeners in the sections due to the manufacturing process.

Luis Laim (et al) 2013[6] carried out a research wors on the structural behaviour of cold formed steel beams with open and closed cross sections such as C-, I-, R- and 2R at ambient temperature and concluded that the use of hollow sections can increase the load carrying capacity of beams by 1.45 times when compared to the open sections.

Meza et al (2016)[7] an experimental program was carried out on built up I beams constructed by bolting four plain channels together. Three different connector spacing were used to study their effect on the ultimate capacity of the built up specimens. The tests revealed that by reducing the spacing between connector results in an increase of the ultimate capacity.

Imanfaridmehr et al (2016)[10] investigated the behaviour and design of cold formed steel C-sections with cover plates under bending. Cover plates with three different thickness were used to evaluate the slenderness effects on the performance of the sections installed at top flanges only where it would be predicted to fail by local and distortional buckling. The result explicitly showed that the cover plate reduced the slenderness which resulted in improving buckling capacity.In current scenario, only little work has been carried out on the structural behaviour of built up sections as flexural members. So the proposed work aims to study the structural behaviour and moment capacity of the cold formed steel built up I beams.

Liping Wang: An experimental investigation built-up beams with different sectional configurations has been conducted under both four point bending and three- point bending. Intermediate stiffeners were employed to the webs of built-up sections to improve the buckling strength that is susceptible to local buckling and/or distortional buckling. In this study, The moment capacities and observed failure modes of the beam tests are presented, and no failure was found in the screws. The local and distortional buckling behavior of the built-up section beam specimens was found to be different from the single profiles.

Francisco J.Meza: This paper describes a Experimental program on CFS built-up I beams with two different cross sectional geometries. This work aimed to experimentally investigate the interaction between the individual components under increasing loading and to quantify the effect of the connector spacing on the cross-sectional moment capacity and the behaviour of beams. The experimental results showed clear evidence of interaction between the local buckling patterns of the components, with the interaction being affected by connector spacing and the type of geometry. However, the connector spacing showed a less significant effect on the ultimate capacity when failure was governed by local instabilities of the components.

K. Mehar Sai: Flexural investigation on innovative cold formed steel built up beams using direct strength method. In the experimental program the main objective was to analysis the strength of built up I section beam on screw spacing under bending.

The parametric study is to investigate the effect of the bolt arrangements on structural and strength of CFS built up open section beam failed by both local and distortional buckling where within the moment span the FE beam model was failed. For the CFS structures the numerical and test results are compared with design strengths which was predicted by direct strength method. And the two rows of screw arrangements of built up open I sections beam the design strengths are stated by DSM equations. Finite elements modelling of built up I sections beams are created and performing of non-linearity due to geometry, contact and material are included for developing in SAP-2000 design software which commend the good results in terms of moments with no lipped and screws arrangements and that was about 2800KNmm. Also specimen failed in web crippling under the point of load application which is common type of failure in CFS beams under point loads. Web crippling failure load is not given by DSM moment design equations that why results are not matching. FEA results are 14% more than experimental, also failure mode is web crippling due to point load effect under applied load. If pure moment is applied then it is possible to may get the desired behaviour, moment-curvature behaviour and the experimental and numerical results are in precisely good in quality of forming a consistent ultimate moments.

Jun Ye: An advanced numerical model has been developed to study the local/distortional buckling behaviour of CFS lipped back-to-back channel beams. The ultimate capacity of the sections predicted by the FE models was on average less than 2 % in variation from the experimental results. The numerical results showed that local and distortional buckling was observed, while no lateral-torsional buckling. While DSM usually led to underestimated results, EC3 predictions were up to 10% overestimated with a standard deviation of 5% and 9% respectively. However, using linear elastic full cross-sectional properties provides consistent underestimation of the deflection about 8% average. EC3 design methods were up to 20 % higher than standard lipped channel sections. At the end taking geometric imperfections into account can change the FE predictions by 7% and the strain hardening effects at the round corners due to the cold-working process can be ignored when improving the capacity and stiffness of CFS beams.

S Vijay Anand: the open section beams are susceptible to failure by lateral- torsional buckling due to the position of its centre of shear and centroid of the cross- section. To overcome this issue, open doubly- symmetric built-up sections or built-up closed sections have been used by many researchers. The study reveals that there are no proper design guidelines available in the current Eurocode and North American specifications. Therefore, the paper provides an outline of research works done on various CFS sections by the researchers and their design recommendations to the codal specifications were also reviewed.

S. A. Kakade et.al this paper provides an experimental investigation for the compressive strength of Cold – Formed light gauge steel plain (stiffened) tubular sections. In their project, the test specimens were brake pressed from high strength structural steel sheets and were designed by several different methods viz. Allowable Stress Design (ASD), Load and Resistance Factor-Design (LRFD), Working Stress Method (WSM) and Limit Stress Method (LSM). As the steel is tested for all types of tests viz, compressive, tensile test, shear test, torsion test, etc. In addition, they compared test strengths with the design strengths calculated using the Indian Standard and North American Specification for Cold –Formed steel structures.

A. Jayaraman et.al. their paper presents a study on behaviour and economical of cold formed steel (CFS) built up channel section using different codes. This paper provides an experimental investigation for the bending strength of Cold – Formed light gauge steel plain (stiffened) rectangular sections. The test strengths were compared with the design strengths calculated using the Indian Standard and Euro codes Specification for Cold –Formed steel structures. The theoretical data were calculated using Indian Standard code IS 801-1975 and the section properties of the specimens were obtained using IS 811-1975. The specimens were designed under uniformly distributed loading with simply supported condition. They found that the theoretical investigations of limit state methods (SI method) have high bending strength, high load caring capacity, maximum deflection and minimum local buckling & distortional buckling compare to the other codes.

Deenadhayalan S et.al. This paper focused on using cold formed steel as primary compression member. Paper study reveals that, back to back channel section with spacing is used. It says that as this kind of sections may fail by local buckling due to their short length, cold-formed steel sections can be strengthened by forming edge and web stiffeners in the I-shaped sections. Moreover, by providing spacing 25mm between two channels strength can be increased. Ultimate load was predicted from ABAQUS then it was compared with experimental result. They found maximum load carried by the specimen was 229 KN with spacing. In the discussion, it is clear that the load carrying capacity of the column has been increased by 21.8 % due to the provision of spacing.

S. Vallabhy et.al. in their project work, they altered channel section with provision of lip and compared their buckling modes under axial load using the software CUFSM. The buckling behaviour of the channel sections have effectively analysed using CUFSM. On study, one can say that this software uses finite strip method which is comparatively less precise than finite element method but provides acceptable results in a understandable format. Therefore, they have concluded that CUFSM is a reliable software that is available for free and with the help of it we can effectively analyse the buckling behaviour of columns. Their research paper also gives overview of manufacturing process in details along with different modes of buckling in brief.

III. LITERETURE GAP

We found that Cold Formed Steel sections are weak in Buckling. That's why there is a lot of scope to reduce or eliminate buckling problem of cold formed steel sections and consequently, to increase its strength. .

IV. CONCLUSION

After studying the above research papers, we can conclude that

- There are several methods of design for Cold formed Steel.
- There are several applications are being used for analysis of the steel sections viz. ABAQUS, THINWALL, CUFSM etc.
- Cold Formed Steel Sections should be strengthened against buckling so that preventive measures in the field of buckling can lead its more use in the construction.

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