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Review on Light Gauge Steel I- Section under Compression with Flange Stiffener

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Abstract: ***Cold-formed steel structures has increased rapidly in recent times due to significant improvements to manufacturing technologies and development of thin, high strength steels. The use of cold-formed thin walled steel structures has greater than before in recent years, and some built-up section members are aggravated and widely used for their excellent structural behaviors. The differences of global, local and distortional buckling behaviors among members with built-up and single sections are investigated. This paper presents a detailed review on cold-formed steel channel sections, which are subjected to both axial and eccentric compressive forces. Different cross-sections with single and built-up configurations are presented in this paper. Literature pertaining to experimental, theoretical and numerical investigations is reviewed in detail. The main objective of this literature survey is to study the available literature and to propose the required research work for the development of various other single and compound cold-formed steel sections. Research in cold-formed steel channel sections subjected to compressive forces shows the importance of channel sections and compares with other possible sections.***
Keywords: Cold form steel, Light gauge steel, I section, Compression.

I. INTRODUCTION

Nowadays, a multiplicity of widely different products, with a tremendous diversity of shapes, sizes, and applications are produced in steel using the cold forming process. The use of cold formed steel members in building construction began in about the 1850s. However, such steel members are not widely used in buildings. It has been recognized that cold-formed steel sections can be used effectively as primary framing components. Cold-formed steel in the form of profiled decking has gained widespread acceptance over the past fifteen years as a basic component, along with concrete, in composite slabs. Cold-formed steel members are efficient in terms of both their stiffness and strength. In addition, because the steel may be even less than 1 mm thick, the members are light weight. The use of cold-formed steel structures is increasing throughout the world with the production of more economic steel coils particularly in coated form with zinc or aluminium/zinc coatings. These coils are subsequently formed into thin-walled sections by the cold-forming process.

The range of use of cold-formed steel sections specifically as load-bearing structural components is very wide, taking in the Automobile industry, Ship building, Rail transport, the Aircraft industry, Highway engineering, Agricultural and Industry equipment, Office equipment, Chemical, Mining, Petroleum, Nuclear and Space industries. In building construction, cold-formed steel products are mainly used as structural members, diaphragms and coverings for roofs, wall, and floors. Cold formed steel members are also used when the requirements on the shape to prevent the use of hot-rolled steel members. In addition, they are most easily fabricated into a greater variety of sections and may be formed in small machine shops. Cold formed steel members are fabricated from thin cold or hot rolled steel sheets of maximum thickness of 6mm to a required shape either by press-braking or by roll forming

A. Advantages of Light Gauge Sections

1) As compared with thicker hot-rolled shapes, cold-formed light members can be manufactured for relatively light loads and short spans.
2) Nest able sections can be produced, allowing for compact packaging and shipping.
3) Freedom from corrosion, in internal environments.
4) Unusual sectional configurations can be produced economically by cold-forming operations and consequently favourable strength-to-weight ratios can be obtained.
5) Recycled and recyclable material.
6) Lintels over door and window openings in masonry construction.

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7) Cross sectional shapes are formed to close tolerances and these can be consistently repeated for as long as required.
8) They are usually light making it easy to transport and erect.
9) Storage racking.
10) Coefficient of thermal expansion comparable with that of concrete.

II. LITERATURE REVIEW

1) Nikhil N. Yokar, Pratibha M. Alandkar, (2014) The research paper is to determine the capacity of cold formed steel sections under compression subjected to concentrated loading for different lengths. Study under this title includes comparison of mid line and Indian standard design methods to check safe carrying capacity of C shaped compression members with lips. In this study, cold-formed C shaped channel sections arestudiedto get compression capacity under concentrate loading. Two different approaches are used mid line dimensions and IS 801:1975. For different lengths pinned connections are used so as to have overall length as its effective length. The main conclusions obtained from these results can be summarized as follows. Comparing two design methods first one is according to IS 801: 1975, and another one mid line dimension particularly followed by British standard BS: 5950- 5:1998. Even though the base is effective width method consideration of corner effect due to cold forming makes them different. Effective width method is on safer side to find compression capacity of section compared to direct strength method.

2) V. C. Prabha, A. Shalini, S. Saravanaganesh, (2015) The use of cold-formed steel structures is increasing throughout the world as they are efficient in terms of stiffness and strength. Structural instability of the section is more likely to occur. To improve their strength and to eliminate local buckling of web elements, trapezoidal corrugated web is used. There are totally 8 beams in that; the four-trial beam having aspect ratio varies from 0.5, 1, 1.5, and 2. Another four trial beam having angle of corrugation varies from 15°, 30°, 45°, 60° and the other parameters such as length of span (3000 mm), flange width (100 mm), thickness of flange (2 mm), thickness of web (1.2 mm), lip size (15 mm) and depth of web (300) are constant for all the eight trial beams. Four beams were fabricated and experimented under two-point loading. A tension test was done for three series of specimens with 2 mm thickness to determine the young's modulus and yield stress. It was observed that the load carrying capacity of AR2 having aspect ratio 1 and DC3 angle of corrugation 45° specimen's increases more, when compared to other specimens and it also reaches maximum deflection, which does not undergo any major failure. Hence, the cold-formed steel section with trapezoidal corrugated web beams can be applicable in structural components.

3) B. P. Gotluru, B.W. Schafer and T. Pekoz, (2000) Thin-walled cold-formed steel members have wide applications in building structures. They can be used as individual structural framing members or as panels and decks. In general, cold formed steel beams have open sections where centred and shear centre do not coincide. When a transverse load is applied away from the shear centre it causes torque. Because of the open nature of the sections, torsion induces warping in the beam. This paper summarizes the research on the behaviour of cold-formed steel beams subject to torsion and bending. The attention is focused on beams subject to torque, because of the effect of transverse loads not applied at the shear centre. A simple geometric nonlinear analysis method, based on satisfying equilibrium in the deformed configuration, is examined and used to predict the behaviour of the beams. Simple geometric analyses, finite element analyses and finite strip analyses are performed and compared with experimental results. The influence of typical support conditions is studied and they are found to produce partial warping restraint at the ends. This effect is accounted for by introducing hypothetical springs. The magnitude of the spring stiffness is assessed for commonly used connections. Other factors that affect the behaviour of cold-formed steel members, such as local buckling, are also studied.

4) W. M. Quach And J. F. Huang, (2011) Inferred advanced numerical modelling for cold-formed light gauge steel structures, from manufacturing to the structural response under the applied loading, requires the knowledge of the stress-strain behaviour of the material over the full range of tensile strains. Existing stress-strain models for carbon steels are either only capable of accurate predictions over a limited strain range or defined by many material parameters and the values of some material parameters are not available in most of existing design codes. In the present study, the stress-strain data obtained from tensile coupon tests reported in existing literatures have been collected and analyzed, and these tested coupons were cut from both virgin steel sheets and cold-formed steel sections. The new models have been developed by a careful interpretation of these existing experimental data. The accuracy of the proposed models has been demonstrated by comparing their predictions with experimental stress-strain curves.

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5) Thanuja Ranawaka and Mahen Mahendran, (2010) Fire safety design of building structures has received greater attention in recent times due to continuing loss of properties and lives during fires. However, fire performance of light gauge cold-formed steel structures is not well understood despite its increased usage in buildings. Cold-formed steel compression members are susceptible to various buckling modes such as local and distortional Buckling and their ultimate strength behaviour is governed by these buckling modes. Therefore, a research project based on experimental and numerical studies was undertaken to investigate the distortional buckling behavior of light gauge cold-formed steel compression members under simulated fire conditions. Lipped channel sections with and without additional lips were selected with three thicknesses of 0.6, 0.8, and 0.95 mm and both low and high strength steels (G250 and G550 steels). More than 150 compression tests were undertaken first at ambient and elevated temperatures. Finite element model soft he tested compression members were then developed by including the degradation of mechanical properties with increasing temperatures. Comparison of finite element analysis and experimental results showed that the urbanized finite element models were capable of simulating the distortional buckling and strength behaviour at ambient and elevated temperatures up to 800 1C. The validated model was used to determine the effects of mechanical properties, geometric imperfections and residual stresses on the distortional buckling behaviour and strength of cold-formed steel columns. This paper presents the details of the numerical study and the results. It demonstrated the importance of using accurate mechanical properties at elevated temperatures in order to obtain reliable strength characteristics of cold-formed steel columns under fire conditions.

6) J. Pavithra,J. Vijayakumar, (2017) A comparison of buckling behaviour of stiffened and unstiffened angle section using cold formed steel members are concentrically loaded subjected to compression members is presented in this paper. The size of stiffened and unstiffened equal angle specimens of various dimensions 40mm x 40mm x3mm, 60mm x 60mm x 3mm, 80mm x 80mm x 3mm and lip of the specimen is 10mm and the three various lengths of column is300mm, 450mm, 600mm. are tested between fixed end conditions. Interaction of different modes of buckling behaviours is observed in the column analysis. The limiting values of slenderness ratio for the equivalent radius of gyration with the least radius of gyration are discussed to establish the buckling behaviours of stiffened and unstiffened equal angles. Analytical investigation of with and without lipped equal angles are compared with IS 801:1975 and European standard code provisions. The buckling behaviour and load carrying capacity of the compression members are compared to European code and direct strength method. The distortional buckling behaviour is observed for the stiffened section only. Stiffened and unstiffened equal angle section load compared to this paper stiffened section is increased to load capacity.

7) Hassan Moghimi and Hamid R. Ronagh (2009) The performance of cold-formed steel (CFS) strap-braced walls is evaluated by experimental tests on full- scale 2:4 m 2:4 m specimens, and techniques to improve their behaviour are presented. Different strap arrangements have been introduced, and their performance investigated by means of cyclic loading of a total of twenty full-scale walls. Several factors affecting the performance of cold-formed steel frame shear wall have been considered for each arrangement. This paper presents the failure modes of each system and the main factors contributing to the ductile response of the CFS walls to ensure that the diagonal straps yield and respond plastically with a significant drift and without any risk of brittle failure, such as connection failure or stud failure. Discussion of the advantages and disadvantages of including the non-structural gypsum board on lateral performance of the walls is also presented.

8) Tadeh Zirakian and David Boyajian (2008) Distortional buckling of I-beams can occur in two lateral and restrained modes. Lateral-distortional mode of buckling is classified as local-global coupling which involves local changes in the cross-section geometry in addition to lateral displacement and twist. Restrained distortional mode of buckling, also, can occur due to applied restraints against rigid cross-sectional movements of one of the flanges. Compared to the two well-known local and lateral tensional buckles, distortional buckling is relatively more complicated and less documented. Hence, further research work is still required to better understand and properly address this mode of buckling. This paper presents a review of some recently-published studies by the first author on the subject of distortional buckling of I-beams with the aim of providing some potential research avenues for fruitful future investigations. In this paper, some of the published research works undertaken byte first author on the distortional buckling of I-beams was summarized. It is important to note that distortional buckling is by and large more complicated relative to the two well-known local and lateral modes of buckling. It is characterized by the distortion of the cross-section, especially the web of an I-section. On this basis, the main objective was to gather and briefly discuss the different experimental, numerical, and theoretical investigations as well as analysis tools in a single paper to provide the researchers and engineer with information regarding some of the fundamental steps taken towards identification, analysis, and design for distortional buckling. In addition, this work introduced some areas of future research that will consequently resulting accurate performance assessment and efficient design of I-section beams undergoing distortional mode of buckling.

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9) W. Leonardo Cortes-Puente's, Dan Palermob, Alaa Abdulridhaa, (2016) In this paper, the axial compressive strength capacity of concrete-filled light gauge steel composite columns was assessed through an experimental program involving twelve long and fourteen stub columns with width-to-thickness ratio of 125 for the encasing steel section. A comparison between concrete-only and confined stub columns demonstrated that the stub column experiences an increase of strength of up to 16% due to confinement. The compressive strength contribution of the light gauge steel section was limited by local buckling. Specifically, the steel-only stub column sections lacking the concrete core experienced, on average, approximately 33% of its full compressive strength. The axial compression strength capacity of the full-scale composite columns was satisfactorily predicted based on end bearing resistance of the concrete core and local strains in the light gauge steel. Furthermore, the 33% strength contribution established from the steel-only sections provided a satisfactory lower bound estimate for the calculation of axial compressive strength. The compressive strength capacity of concrete-filled light gauge steel composite columns was experimentally determined in this study by testing fourteen stub columns and twelve full-scale columns. Results from the stub columns were used to assess the effect of confinement, local buckling, and individual contributions of the components to the axial capacity of the full-scale light gauge composite columns.

10) A.I. El-Sheikh, E.M.A. El-Kansas, R.I. Mackie, (2001) This paper describes cast light onto the behaviour of stiffened and unstiffened channel members in various conditions of use. After discussing the section properties and how they change with1 the use of stiffeners, the section's structural performance is assessed according to British Standard specifications, BS5950 (British Standards Institution BS5950—Structural use of steelwork in building, Part 5: Code of practice for design of cold-formed sections, BSI, 1999). The work involves a wide parametric study in which channel members with various aspect ratios, stiffeners' sizes and slenderness ratios are analysed. The results reveal how the members could be profiled to obtain the optimum performance in various applications, and for this reason, the results can be of significant value to future designs of cold-formed channel members.

III. CONCLUSION

Based on the results presented herein, it looks reasonable to draw out the following conclusions.

1) Using the smallest size possible of flange stiffener leads to significant improvements in the channel members buckling strength under concentric and eccentric forces.

2) The developed finite element model efficiently simulated the buckling behaviour of axially loaded stiffened partially closed complex channel section.

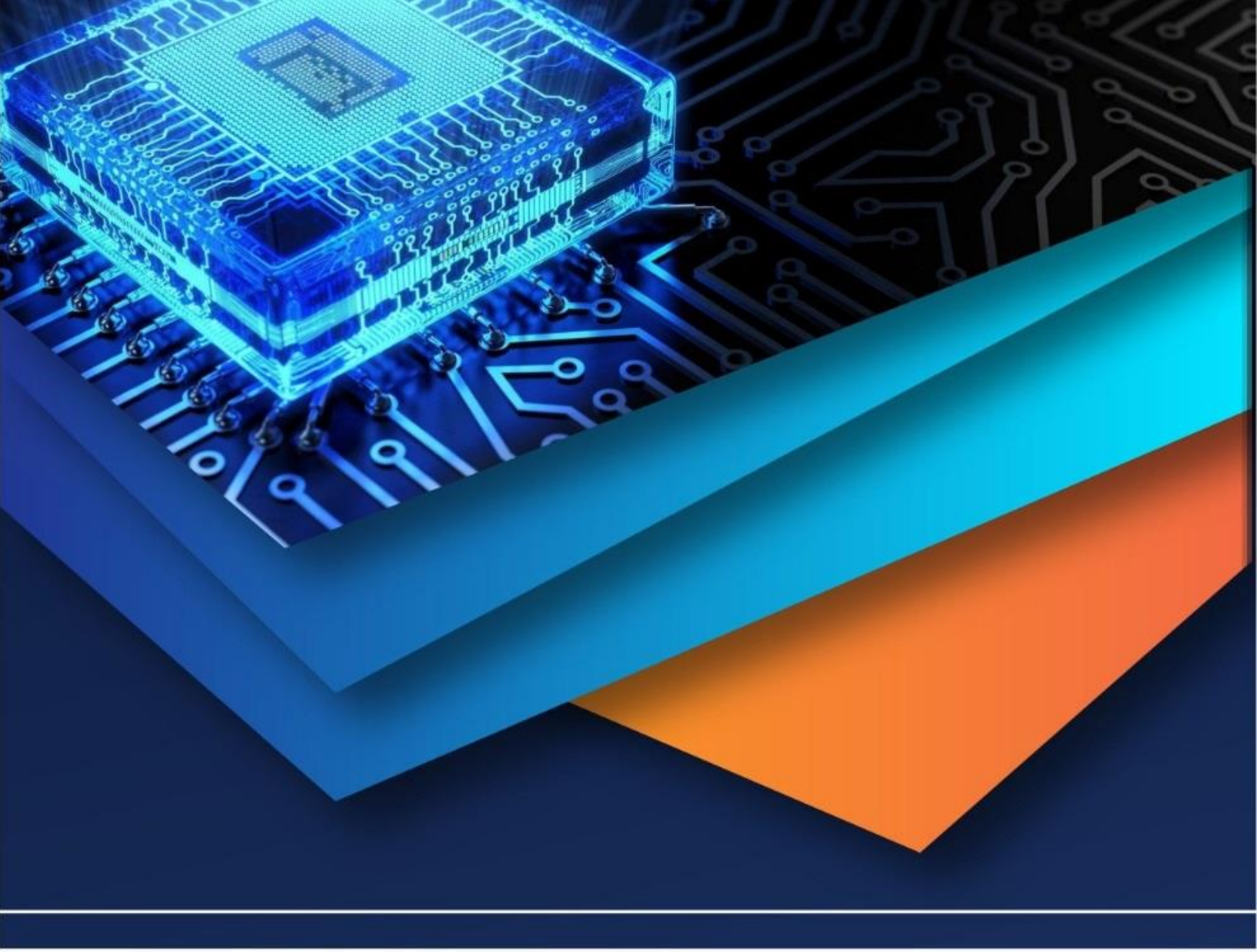
3) The developed finite element model efficiently simulated the buckling behaviour of axially loaded intermediate stiffened partially closed complex channel section.

4) Load eccentricity in the weak direction leads to significant losses in the buckling strength of channel members. Members with large stiffeners were particularly sensitive to this effect.

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