Behaviour of Light Gauge Stiffener under Axial Compression Loading

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Abstract – Light gauge steel lipped channel sections are being used popularly in shops, factories, automobile engineering and industries on account of their high strength to width ratio, simplicity in construction, flexibility in fabrication and high structural efficiency. A lot of research work has been carried out to study the structural behavior of axially loaded light gauge steel lipped column sections considering different parameters. The present paper focuses on the experimental study of structural behavior of light gauge steel channel sections under axial compression loading .Finite element analysis of the section is also done using Abaqus software of same load. In this work we have studied the behaviour of the light gauge section under axial compression loading.different specimens of the section where considered with and without lip, v- stiffeners and rectangular stiffeners for deriving the load carrying capacity of section. The analysis and design of the I section was done using previous work while the analytical work was carried out using finite element method with ABAQUS software.

Further the experimental validation was done using true length specimen and setup was prepared and tested under axial compression loading. The results of this experimental investigation indicated that the load carrying capacity of the light gauge channel section is enhanced by using different stiffener and lips.

Keywords—Cold Form Steel, Column Compression Buckling, Stiffener

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1. INTRODUCTION

Cold formed steel products are found in all aspects of modern life; in the home, the shop, the factory, the office, the car, the petrol station, the restaurant, and indeed in almost any imaginable location. The uses of these products are many and varied, ranging from “tin” cans to structural piling, from keyboard switches to mainframe building members. Nowadays, a multiplicity of widely different products, with a tremendous diversity of shapes, sizes, and applications are produces in steel using the cold forming process. Cold formed steel products such as sections have been commonly used in the metal building construction industry for more than 40 years. The popularity of these products has dramatically increased in recent years due to their wide range of application, economy, and ease of fabrication, and high strength to weight ratios. In market various shapes of these products are available C sections are predominantly used in light load and medium span situations such as roof systems. Their manufacturing process involves forming steel sections in a cold state (i.e. without application of heat) from steel sheets of uniform thickness. 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. They are commonly called “Light gauge sections” since their thickness has been normally less than 2.0 mm. However, more recent developments have allowed sections up to 25 mm to be cold formed, and open sections up to approximately 8mm thick are becoming common in building construction. The steel used for these sections may have a yield stress ranging from 250 MPa to 550 MPa. The higher yield stress steels are also becoming more common as steel manufacturers produce high strength steel more efficiently. Further, the shapes which can be cold formed are often considerably more complex than hot rolled steel shapes such as I sections and unlipped channel sections. The cold formed sections commonly have mono symmetric or point symmetric shapes, and normally have stiffening lips on flanges and intermediate stiffeners in wide flanges and webs.

Special design standards have been developed for these sections.

The market share of cold formed structural steelwork continues to increase in the developed world. The reasons for this include the improving technology of manufacture and corrosion protection which leads, in turn, to the increase competitiveness of resulting products as well as new applications. Recent studies have shown that the coating loss for galvanized steel members is sufficiently slow, and indeed slows down to effectively zero, than a design life in excess of 60 years can be guaranteed. The range of use of cold formed steel sections specifically as load bearing structural components is very wide, taking in the Automobile industry, Shipbuilding, Rail transport, the Aircraft industry, Highway engineering, Agricultural and Industry equipment, Office equipment, Chemical, Mining, Petroleum, Nuclear and Space industries.

The development and use of cold-formed steel structural members in building construction began in the mid eighteenth century in the United States and Great Britain. However, such steel structural members were not widely used in the building industry until in the mid nineteenth century where the first edition of the American Iron and Steel Institute (AISI 1946) Specification for the design of cold-formed steel structural members was published. The use of cold-formed steel structural members has increased rapidly in recent years. Cold formed members can be used economically in domestic and small industrial building construction and other light gauge structures.

As compared to thicker hot-rolled members, cold-formed members provide enhanced strength to weight ratio and ease of construction. The manufacturing process of fabricating cold-formed members usually involves brake-pressing and roll-forming of steel sheets and strip to produce a wide range cross-section shapes. Cold formed sections are normally thinner than hot-rolled sections and have a different forming process. Therefore, the buckling and material behaviour can be quite different.

Cold-formed columns commonly fail in two distinct modes of buckling; they are local buckling and overall buckling. Interaction of these two modes may occur in some cases. Both local and overall instability represent common causes of structural failure. Distortional buckling is also one of the modes of failure for some sections.

As a consequence, structural instability has grown into a major research area, where both analytical and experimental investigation have been undertaken to overcome the difficulties of the design of cold-formed steel structural members. Local buckling plays an important role in the design of slender sections. There is a fundamental different on the behaviour of pin-ended and fixed-ended locally buckled singly symmetric columns. This is due to the shift of effective centroid of singly symmetric slender sections.

2. REVIEW OF LITERATURE

S.P.Keerthana and K.Jothibaskar [2016], Cold form steel is also called as light gauge steel sections. In this paper investigation made on the built-up section to calculate the buckling loads using experimentally and theoretically. The built-up section is formed by two types of channel section with or without lip was tested as under axial compression. The Finite strip method is developed by CUFSM software. The buckling load value will be taken from GBTUL software. The sections have been chosen from IS 811:1975 for specifications. The column strength determined by Direct Strength Method based on AISI-S100:2007. The load carrying capacity of column compared with numerical, theoretical and experimental results.

W. Leonardo Cortes-Puentes, Dan Palermob, Alaa Abdulridhaa [2016], 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 fourteen casing 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 section slacking the concrete core experienced, on average, approximately 33% of its full compressive strength. The full-scale composite columns illustrated that the axial compressive strength capacity was controlled by end bearing capacity and local buckling of the light gauge steel. 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.

P. B. Patil1 and P. D. Kumbhar [2015], Light gauge steel lipped channel sections are being used popularly in shops, factories, automobile engineering and industries on account of their high strength to width ratio, simplicity in construction, flexibility in fabrication and high structural efficiency. A lot of research work has been carried out to study the structural behavior of axially loaded light gauge steel lipped column sections considering different parameters. However, structural behavior of light gauge steel lipped channel sections under eccentric loading has not received much attention. The present paper focuses on the experimental study of structural behavior of light gauge steel lipped channel sections under eccentric loading by varying loading position in between center of gravity and shear center of channel column section. Finite element analysis of the section is also done using Abaqus software for different positions of the load. The results indicate that, load carrying capacity of the section increases as the loading position shifts towards supported edge of the section. The failure of the section occurs in the form of local-distortional buckling approximately between 1/3rd - ½ of the height of column. Results obtained by software are found to be in good agreement with experimental results.

W. M. Quach And J. F. Huang [2011], Advanced numerical modeling for cold-formed light gauge steel structures, from manufacturing to the structural response under the applied loading, requires the knowledge of the stress-strain behavior 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. Therefore, a new stress-strain relationship for light gauge carbon steels up to the ultimate strength is required for the advanced numerical modeling and needs to be modelled on the basis of three basic material parameters, the so-called Ramberg-Osgood parameters (the 0.2% proof stress 0.2, the initial elastic modulus E0 and the strain-hardening exponent n). This paper presents such new stress-strain models for light gauge carbon steels, which are able to describe the stress-strain relationship over the full range of tensile strains by using only three basic Ramberg-Osgood parameters. 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.

M. Meiyalagan, M. Anbarasu and Dr. S. Sukumar [2010], The Present thesis work aims at the study of buckling behavior of open web Open cross section with intermediate stiffener & corner Lips under compression. Introduction deals with the general idea about cold formed steel members, problems on investigation need for this Thesis, objective of the investigation, scope of the thesis methodology. Literature review details the review of the literature on torsional flexural buckling, Distortional buckling, Channel section with Stiffened Lip and Cold formed members and Open web sections. Expressions for distortional buckling stress & flexural torsional buckling stress has been obtained for mono symmetric open cross section compression members. Four test specimens have been fabricated with geometry of C Section with stiffened both Web and Flange with various thickness and experimented. Numerical analysis using FEM Software ANSYS 11 is performed on the tested models and the results are compared with the Experimental results. Design for maximum Limit strength of Columns using Indian Standard (IS 801 1975) is to be calculated. Comparison of experimental and analytical results using ANSYS and Indian Standard method values are presented under results and discussion. Finally Conclusion and scope for future work is presented based on the results.

3. EXPERIMENTAL WORK

For the experimental tests, twelve cold-formed steel compression members analyzedwith fixed-end support conditions. Two types of cold-formed sections (Types A and B sections–lipped I-sections without and with additional lips) were modeled with thicknesses of 2mm,flange width 80mm, web width 100mm and steel grade of G250 (minimum yield strengths of 250).12 specimens of cold form light gauge steel sections are manufactured from Kupwad M.I.D.C,Dist-Sangli. Among the 12 specimens,6 specimens are of 450mm length and other 6 specimens are of 350mm length.Different types of I sections are fabricated as lip length 20mm,rectangular stiffener length 20mm and V stiffener length 30mm. The 12 specimens are tested on UTM 100Tonne capacity in Walchand College Of Engineering, Sangli. In experimental studies the section geometry was chosen so that local buckling is not critical while the specimen length was chosen to eliminate any global buckling effects.

The geometric centroid of the specimen and the end plates were kept the same to eliminate eccentric loading. Due to the presence of symmetry in loading and boundary conditions, a full length column model was selected in this study.

Test Sample of cold form of 450mm length

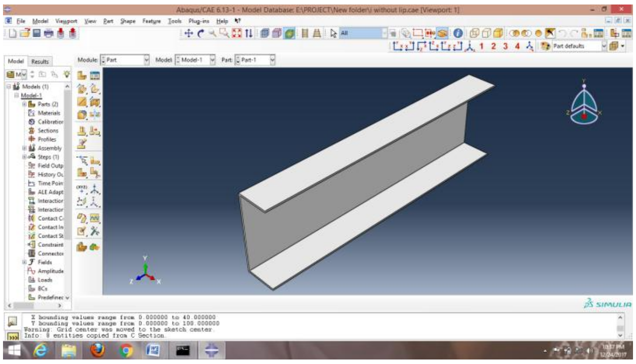
Arrangement of experimental setup

Arrangement of Strain Gauge

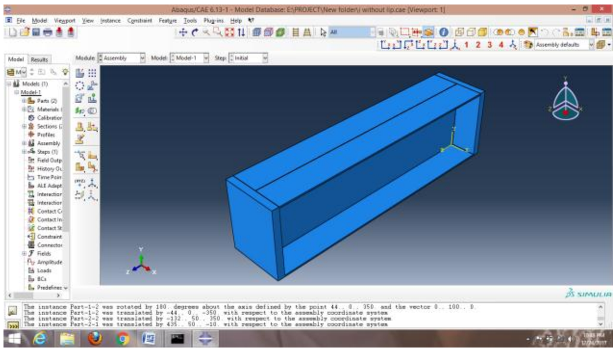
Failure of Sample

4. ANALYTICAL WORK

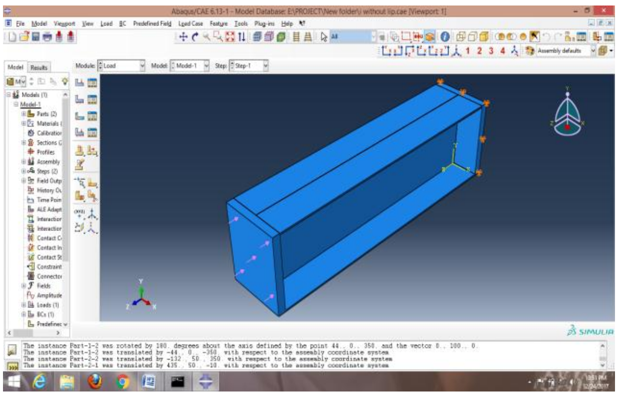
Numerous finite element analysis programs are available for research purposes that can eliminate the excessive resource and time requirements of experimental studies.The finite element analysis programme (ABAQUS) is a very efficient tool to analyse the behavior of steel structures. In this research, ABAQUS standard version 6.13 was used to simulate behaviour of light gauge cold-formed steel compression member.Today any type of problems can be analysed using the ABAQUS. It is relatively inexpensive and time efficient compared with physical experiments. The following sections are drawn on the AUTO-CAD software having same dimension of test sample of experiments.The additional plate of 80X100mm is attached to the sections for distributing the load uniformly on I Section



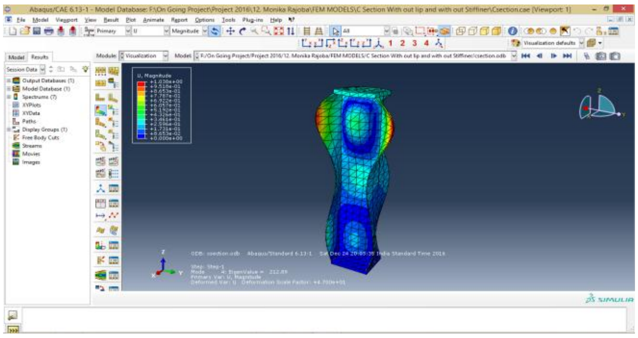
Preparing a Part model of I section without lip and without stiffener



Assembly of Model of I Section Without Lip and without stiffener



Loading and Boundary condition of I Section without Lip and without stiffener

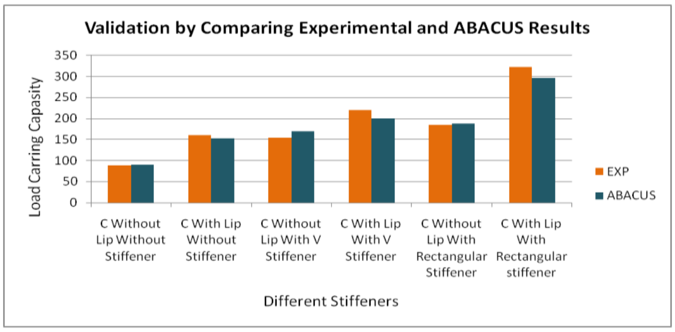


Failure of I without Lip and without stiffener

5. VALIDATION OF RESULT

Different Types of I Section Used	I Without Lip Without Stiffener	I With Lip Without Stiffener	I Without Lip With V Stiffener	I With Lip With V Stiffener	I Without Lip With Rectangular Stiffener	I With Lip With Rectangular stiffener
Load carrying capacity of Experimental Results (KN)	88.87	160.9	155.02	219.6	184.53	322.25
Load carrying capacity of ABACUS Software (KN)	90.2	153.2	169.12	200.36	187.25	296.58
Percentage difference in bet^n Load carrying capacity. %	1.50	4.79	9.10	8.76	1.47	7.97

Validation for load carrying capacity by Comparing Experimental and ABAQUS Results for Column of Length 450mm



Validation for load carrying capacity by Comparing Experimental and ABAQUS Results for Column of Length 450mm

6. CONCLUSION

The developed finite element model efficiently simulated the buckling behaviour of axially loaded intermediate stiffened partially closed complex channel section. The section was prepared combining two channel section & increase the capacity in compression.

1. The open column fails by pure distortional buckling whereas due the column fails by mixed local and flexural torsional buckling

2. From this experimental work it concludes that load carrying capacity of rectangular stiffener is more than the other stiffener and this is validated as per the ABAQUS.

3. It was seen that the load carring capacity of the rectangular stiffener was 26% more than that of V & 47% more than without stiffener for both length.

4. The experimental and the analytical results show the good agreement as the percentage error is within the limit less than 15%.

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