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Comparison of Light Gauge Steel I Section with Flange Stiffener

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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. However, structural behavior of light gauge steel lipped channel sections under eccentric loading has not received much attention. The present paper focuses on the comparative study of the light gauge column section under compression loading. Results conclude double D stiffener with and without lip are carry more load as compare to other types of light gauge section.

Keywords: Cold form steel, Light gauge steel, I section, Compression.

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 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.

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.

1.1. Light Gauge Steel History

Cold-formed thin-walled steel structures have been increasingly used in low rise residential buildings, as well as other public Buildings, such as the portal steel frame system. Some built-up Cross sections consisted of two single C-sections, such as built-up I and sections, are commonly used as columns for several advantages:

a. Comparing to single section, the built-up section can span more distance and carry more loads;

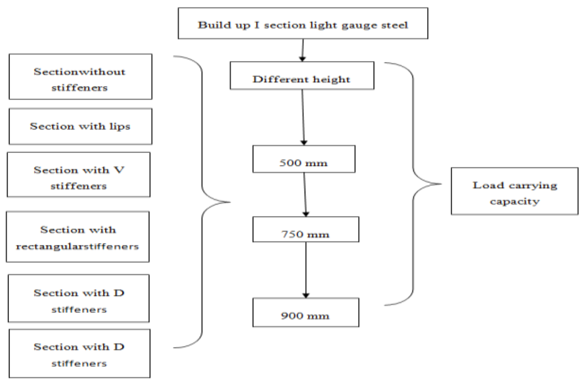
b. The tensional stiffness of a built-up section, due to biaxial-symmetrical, is much higher than that of a single symmetrical single section;

c. Many kinds of built-up sections can be formed by one kind of “standard” single C-section, which is helpful to achieve industrialized production; and

d. The connection of the members can be more convenient. However, the provisions about the strength design of built-up members in related codes are quite rough up to now.

1.2. Research Methodology

The proposed study involves the analysis and design of a section under loading, with a specific focus on its distortional buckling behavior using finite element (FE) software, ABAQUS. The methodology follows a structured approach, beginning with the design of the section under applied loading conditions. The section is then analyzed using FE simulations to assess its structural performance. The obtained results will be compared with the section properties, load-carrying capacity, and failure effects to evaluate its stability and efficiency. Further, the analytical findings will be validated by comparing them with data from previous literature studies. Finally, the analytical results will be cross-verified with experimental findings to ensure accuracy and reliability in the assessment of distortional buckling behavior.



Flowchart of Methodology

2. LITERATURE REVIEW

1. Comparison Of Buckling Behaviour Of Stiffened And Unstiffened Cold Formed Steel Angle Section Subjected To Compression

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. 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.

2. Performance Of Light-Gauge Cold-Formed Steel Strap-Braced Stud Walls Subjected To Cyclic Loading

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.

3. Compressive Strength Capacity Of Light Gauge Steel Composite Columns

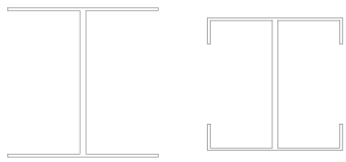
In this paper, the axial compressive strength capacity of concrete-filled light gauge steel composite columns was assessed through an experimental program involving twelve long and fourteen stub columns with width-to-thickness ratio of 125 for the encasing steel section. A comparison between concrete-only 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. 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.

4. Ultimate Capacity Of Innovative Cold-Formed Steel Columns

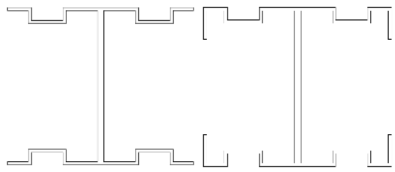
This paper describes the distortional buckling behaviour of a series of innovative cold-formed steel columns. More than 15 laboratory experiments were undertaken first on these innovative steel columns of intermediate length under axial compression. All of these columns failed by distortional buckling with very little post-buckling strength. The section and buckling properties of the columns were determined using the finite strip analysis program THINWALL. The distortional buckling and non-linear ultimate strength behaviour of the columns was investigated in detail using finite element analyses (ABAQUS). The finite element analyses included relevant geometric imperfections and residual stresses. The deflection and strain results from the experiments compared well with those from the analyses.

5. METHODOLOGY

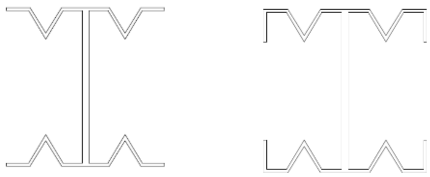
Cold-formed steel members can lead to a more economical design for low-rise buildings than hot-rolled steel members, as a result of their advantages, such as superior strength to weight ratio, various sections shapes, ease of fabrication. The square and rectangular hollow sections are superior to conventional structures in torsion, compression, bending, fatigue, tension and shear. It has other functional advantages owing to lesser susceptibility to corrosion, lower drag co-efficient, ease of fabrication, concrete filling transportation, maintenance and aesthetics etc. In the past, few test data were available for cold-formed pin ended stub box columns with different hollow cross sections. Besides tests, finite element analysis (FEA) is another powerful tool for investigation. FEA is more economical than physical experiments provided than physical experiments, provided that the finite element analysis (FEA) is accurate. Henceforth it becomes important to verify the FEA with some experimental results.



Cold-Formed Steel I Section with & without Lip



Cold-Formed Steel I Section with Rectangular stiffener with& without Lip



Cold-Formed Steel I Section with V stiffener with & without Lip

The main process of cold-formed steel structural elements involves forming steel sections in a cold state from steel sheets of uniform thickness. The thickness of steel members ranges from 0.4mm to 6.0mm. The cold forming operation increases the yield point and the ultimate strength of the steel sections. Their large strength to weight ratio. Versatility Non-combustibility with appropriate measures and ease of production has attracted architects, engineers, builders and manufactures of building products with the promise, that it can help them provide improved function and greater aesthetic appearance for many applications at low cost. The wide range of available cold formed steel products has expanded their use to primary beams, floor units, roof trusses, wall panels and building frames. Cold –formed steel members can be produced in a wide variety of sectional profiles such as angles, channels, hat sections, zed sections and sigma sections.

5.1 Buckling Phenomenon Of Cold Formed Steel Elements

Axial load is very common and very important type of loading and the requirement to deal with this type of loading in cold formed steel members vary according to type of loading, tension or compression and geometry and use of the member. For axially loaded cold formed steel, compression member should be designed for the following limit states:

- Local Buckling
- Distortional Buckling

ABAQUS Result	Increase in Load	Increase in Load

									Carrying Capacity Due to Lip		
	Combination	**Without Lip**	**500**	**750**	**900**	**500**	**750**	**900**	**500**	**750**	**900**
With lip without stiffener	20X20	214.52	259.72	108.09	120.3	45.2	106.43	94.22	0.21	0.50	0.44
V Stiffener	20X20	178.8	214.12	155.68	131.42	35.32	23.12	47.38	0.20	0.13	0.26
Double V Stiffener	10X10	356.5	403.15	341.51	197.88	46.65	14.99	158.62	0.13	0.04	0.44
Rectangular Stiffener	20X10	536.11	539.62	273.37	202.27	3.51	262.74	333.84	0.01	0.49	0.62
Double Rectangular Stiffener	10X10	526.53	616.66	508.3	427.8	90.13	18.23	98.73	0.17	0.03	0.19
D Stiffener	R=10	238.9	312.85	184.06	141.01	73.95	54.84	97.89	0.31	0.23	0.41
Double D Stiffener	R=5	680.64	772.62	418.48	313.52	91.98	262.16	367.12	0.14	0.39	0.54
Trapezoidal Stiffener	37.69X19.32	356.02	456.88	266.47	269.62	100.86	89.55	86.4	0.28	0.25	0.24
Double Trapezoidal	20X10.66	254.9	269.06	301.37	145.41	14.16	46.47	109.49	0.06	0.18	0.43

- Flexural Buckling
- Distortional-flexural Buckling
- Yielding

In the case of light gauge members, the width to thickness ratio (w/t) is quite large and hence failure of member occurs invariably by buckling. For light gauge plate elements, the buckling occurs at low stresses resulting due to compression, or bending or shear or bearing.

The critical stress of a plate in compression is given by

$$f_{cr} = k\frac{\pi^2 E}{12(1-u^2)(\omega\ /\ t)^2}$$

Where, f_{cr}= critical stress
E = modulus of elasticity
u = Poisson's ratio
w = width of the plate

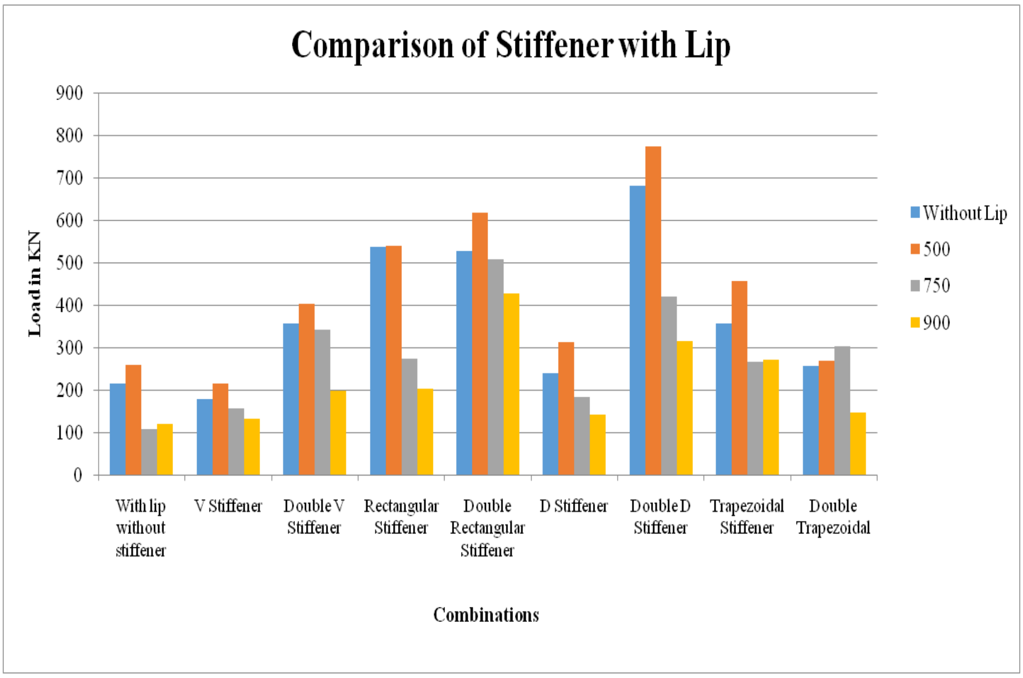
t = thickness of the plate
k = constant depends on support conditions
When the edge parallel to the compression stress are simply supported, the value of k = 4. Hence for such case, the critical stress id given by

$$f_{cr} = \frac{\pi^2 E}{12(1 - u^2)(\omega / t)^2}$$

RESULT AND DISCUSSION

5.2 Comparison of Stiffener With and Without Lip

Table: 1 Comparison Of Stiffener With Lip



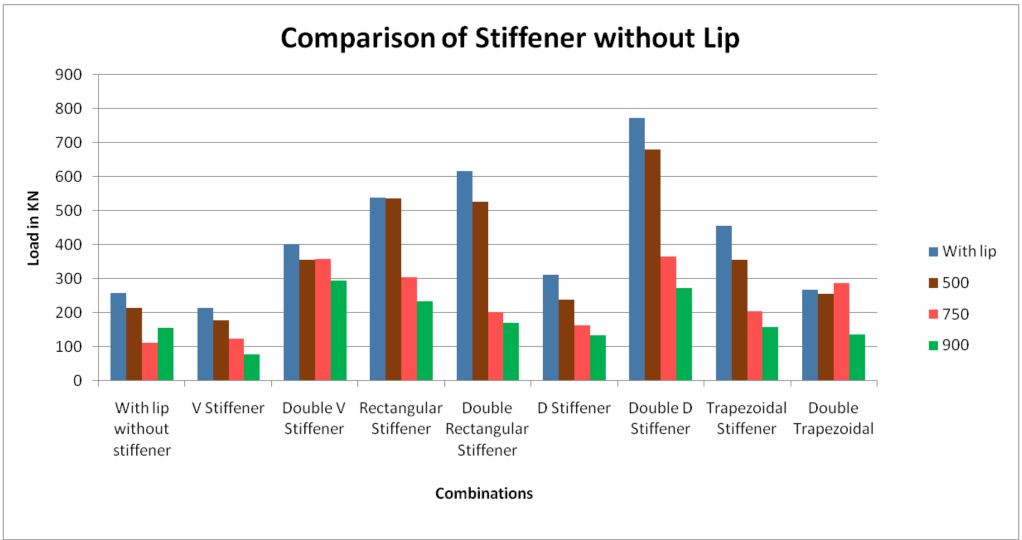
Comparison Of Decrease in Load carrying capacity with Lip

In this figure shows comparison of load carrying capacity of stiffeners with lip. Result is concluded that Double D stiffener of length 500 mm have maximum load carrying capacity as 772.62 KN

Table 1 Comparison Of Stiffener Without Lip

Abaqus Result						Increase in Load			Increase in Load Carrying Capacity Due to Lip		
	Combination	With lip	500	750	900	500	750	900	500	750	900
With lip without stiffener	20X20	259.72	214.52	112.05	155.34	45.2	147.67	104.38	0.17	0.57	0.40
V Stiffener	20X20	214.12	178.8	125.25	78.467	35.32	88.87	135.653	0.16	0.42	0.63

Double V Stiffener	10X10	403.15	356.5	359.46	295.79	46.65	43.69	107.36	0.12	0.11	0.27
Rectangular Stiffener	20X10	539.62	536.11	305.6	233.78	3.51	234.02	305.84	0.01	0.43	0.57
Double Rectangular Stiffener	10X10	616.66	526.53	202.07	171.08	90.13	414.59	445.58	0.15	0.67	0.72
D Stiffener	R=10	312.85	238.9	164.32	134.38	73.95	148.53	178.47	0.24	0.47	0.57
Double D Stiffener	R=5	772.62	680.64	364.74	272.54	91.98	407.88	500.08	0.12	0.53	0.65
Trapezoidal Stiffener	37.69X19.32	456.88	356.02	204.08	157.9	100.86	252.8	298.98	0.22	0.55	0.65
Double Trapezoidal	20X10.66	269.06	254.9	287.98	136.3	14.16	18.92	132.76	0.05	0.07	0.49



Comparison Of Increase In Load Carrying Capacity Without Lip

In this figure shows comparison of load carrying capacity of stiffeners without lip. Result is concluded that Double D stiffener of length 500 mm have maximum load carrying capacity as 680.64 KN

6. Paper Validation

In this research the developed finite element models were validated by comparing ABAQUS and research paper results of load carrying capacity of different sections. The load carrying capacity of different sections show that validate and ABAQUS results agree reasonably well. This agreement is attributed to the use of accurate mechanical properties in ABAQUS. Since there is good agreement in terms of load carrying capacity of different section, the developed finite element model was used in further investigations on behavior of light gauge cold-formed steel members.

- **Paper 1**

In recent years, little research work has been published on the design of cold formed channel section with different stiffener in this paper experimental and numerical investigation into strengths and behaviour of cold formed single and double channels both with and without lips with their support conditions as ends hinged, using finite element analysis is presented.

- **Material properties**

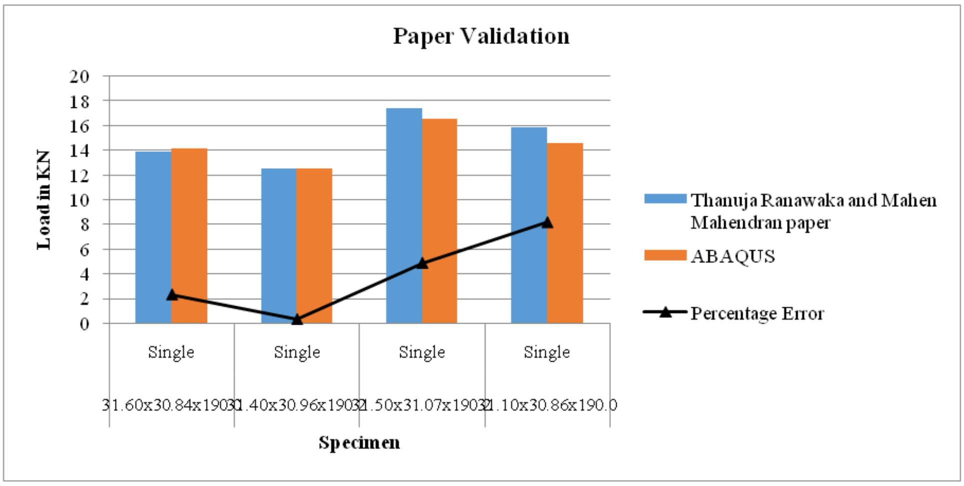
Light steel cold rolled steel, essentially hot rolled, which has an additional processing Cold formed light gauge steel is further processed in the cold reduction mills, where the material is cooled to room temperature.

Mechanical Properties

Temperature	Young's Modulus (MPa)	Yield Strength	
		G250 steel	G550 steel
20	200000	300	630
200	172000	283	596.3

Result for Load Carrying Capacity Of I Section Model In Research Paper

Specimen		Load carrying capacity			Percentage Error
		Thanuja Ranawaka and Mahen Mahendran paper	ABAQUS Results from Research paper	ABAQUS Results	
31.60x30.84x190.0	Single	13.87	14.2	9.45	2.32
31.40x30.96x190.2	Single	12.54	12.5	8.22	0.32
31.50x31.07x190.2	Single	17.4	16.55	9.58	4.89
31.10x30.86x190.0	Single	15.9	14.6	8.26	8.18



Comparison of ABAQUS and Research paper

7. CONCLUSION

A series of compression tests on the cold-formed steel lipped I sections and I sections with stiffeners in flange and lip to study the ultimate strength of columns were conducted. In the case of sections where local buckling was the critical buckling, local buckling and distortional buckling occurred simultaneously only for the columns. For the intermediate and long columns where local buckling was the critical buckling, the interaction between local buckling and overall buckling was the final failure mode. However, for the sections where distortional buckling was the critical buckling, the interaction modes of local and distortional buckling were the critical failure mode for the 500 mm, 750 mm and 900 mm length columns. From the study, the following conclusions are drawn:

1 The analytical results giving load carrying capacities of cold formed channel section provided with various stiffeners under compression loading, is found to be almost similar to that of the result obtained in the research paper using software and a percentage variation in load carrying capacity is found to be approximately. Hence, it can be concluded that the results of ABACUS are validated with the results obtained by using software in research paper.

2 The study is revise final obtimized section is 500 mm length of with lip with double D stiffener and with lip with double rectangular section are carry more load is 772.62, 616.66 KN respectively.

7.1 Future Scope

- To study the compression behaviour of the light gauge steel column under the cyclic loading for pure torsion condition.
- To optimize the stiffener to sustain the axial and torsion capacity of the light gauge steel section.

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