Comparison study on cold formed steel of coupled channel section based on abaqus and cufsm by simple-simple end condition

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Abstract. Cold formed steel (CFS) channel sections are the sections which are widely using from last few decades and are designated as light gauge sections. Such sections are being widely utilized in industrial, commercial and residential purposes as a secondary bearing member. Further developments of thin walled members made it possible to use the CFS Sections as preliminary load carrying structural members. The reason is hot-rolled steel sections posses' very low strength to weight ratio on CFS sections, and the production process of these sections is cost-effective and simple. This paper is about comparing the analysis results from CUFSM and ABAQUS of different channel sections. The loads will be applied at the edges of the members axially i.e., as a compression member with different boundary conditions.

Keywords: Cold formed steel, ABACUS, CUFSM, sustainable, simple end, Innovation.

1 Introduction

CFS sections are being utilized widely in industries, mercantile and domestic buildings and utilized as secondary bearing member. In recent times the developments in analysis and fabrication of thin walled members made it possible to use the CFS Sections are structural components bearing a primary load. Hot-rolled steel sections posses' very low strength to weight ratio on per with CFS sections. Production process of CFS sections is very easy. CFS sections are gaining the required structural qualities at a particular room temperature the CFS element is molded into different shapes, and substantial rigidity, strength. To produce CFS sections, three methods are utilized such as break operation, roll forming and press break operation. Roll forming technique is utilized to produce huge quantities from a single section and press braking technique is utilized to produce lesser quantities from

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different sections.The press braking method is cost effective than roll forming method. Continuous strength method is also considered one of the methods which also improve the strain hardening of the sections, the reliability of the CFS sections can also observed [1]. The CFS members when analyzed by using FEM by the thermal properties of the sections showed the results related to the buckling of the members when the temperature parameters are considered [2]. The flexibility of the CFS of different cross section shapes improves the capacity of load of the elements, for the efficient structural systems. When Z section was analyzed, the increase in strength of nearly 60 to 180% increase in strength of beam column was observed [3]. As per some studies CFS when subjected to experimental procedures, it is observed that they are limited to columns [4]

Because of the rapid utilization of CFS for structural applications, research has been significantly increased to identify and understand the structural response of the sections. The first CFS design was furnished by AISI in the year 1946. The light gauge CFS members have some design drawbacks which are not generally identified in the conventional thick hot-rolled steel sections. For example, the aspect of buckling, this is a serious issue that leads to failure of the sections [5]. The thickness range of light weight CFS sheets ranges from 0.4-6.4 mm and the nominal yield strength typically falls between 250-550 MPa. The yield strength is identified depending on 0.2% of proof stress. The young's modulus of elasticity (E) for CFS sheets is 200,000 MPa [6]. In case of slender and unslender exhibit, the direct Strength technique delivers the best test-to-predicted ratio. The test findings show that there have been numerous advances in elastic buckling. Cs and Zs can still be calculated with their effective widths. The writers' goal is to continue to test and analyze to find the distortional buckling capacity of Cs and Zs, as well as the role of fasteners and other elements are all more clearly defined [7]. Elasticity modulus and yield strength of lightgauge cold-formed steels were severely reduced in an experimental research employing tensile coupon tests at increased temperatures. For light gauge cold-formed steels, the factors for reduction used in existing steel design standards for hot-rolled steels were found to be too cautious [8].

The CFS sections are basically thin and are symmetric in nature therefore they are susceptible for a range of buckling modes, the steel sections with rigidity of torsion is the solution for these kind of problems [9]. The Direct Strength Method does not use effective width or iteration to determine the strength of a member design. Instead, the engineer must calculate the elastic buckling load in three different ways: local, distortional, and global buckling. This data, combined with the load that causes the first yield, is then analyzed used to "directly" provide the strength in a series of simple equations prediction. The method's main problem is figuring out how to do it. Elastic local, distortional, and global buckling loads; if these values are known, they can be calculated[11]. An enabling first step in the process is to do a numerical stability study in conjunction with a precise identification of the buckling modes. New design methodologies, such as the Direct Strength Method, are being implemented. In this work, we use the same finite strip method that was used described above CUFSM is a system based on first principles. The process is very similar to that. Engineers commonly employ basic matrix methods for structural analysis. It can be easily programmed by the reader who is interested. An illustration of the A stability solution is presented for an industry standard lipped channel. Recently, The application of the constrained finite strip has been added to CUFSM method [12]. Light gauge Cold-formed steel members have been widely used in the construction of low and mid-rise residential buildings. Built-up box girders are utilized in numerous applications in cold-formed steel design to resist load induced in a structure when a component fails. The design load cannot be carried by a single section. The box girders are made of cold-formed steel. When the load is applied to the web of one of the portions, it may be subjected to eccentric loading and sends it to another area via the link [13].Plumbing, electrical, and heating conduits are routinely installed in the walls and ceilings of buildings using cold-formed steel (CFS) structural elements with holes. Engineers now have prescriptive design methods for forecasting the strength of CFS members with holes, which are confined to specified perforation sites, spacings, and sizes. With the elastic buckling properties of the member cross-section (e.g., plate buckling) and the Euler buckling load, the Direct Strength Approach (DSM), a relatively recent design method for CFS members validated for members without holes, predicts the ultimate strength of a typical CFS column or beam (e.g., flexural buckling) [14].

2 Methodology:

The buckling analysis was performed by using the finite strip method (FSM) and finite element method (FEM) analysis techniques. The utilization of FSM is quite easy to obtain various buckling modes. With FEM analysis, non-linear buckling or ultimate failure loads can be estimated. However, extraction of different buckling modes/loads for the purpose of design is quite challenging. So as to understand both elastic buckling and post- buckling performance, both the techniques' i.e., FSM and FEM are used in the current study. The Finite Strip Method (FSM) on a Matlab platform can be adopted for study the elastic buckling behavioral aspect of CFS sections.

Well established CUFSM software is used for this purpose. The analysis procedure is furnished below:

- Numerical analysis by using CUFSM,
- Input the coordinates of each node on the cross-section (c/s).
- Set material properties.
- Specify the boundary conditions.
- Define loads on the c/s.
- Calculation and the post-processing of results.

1. After arriving at the critical load values from the above analysis, DSM (Direct Strength Method) is used to calculate the design load.

2.The Finite Element Method (FEM) is used and nonlinear analysis is performed to study the ultimate failure of CFS beams. ABAQUS software is used for this purpose

Numerical analysis by using ABAQUS,

- A simulation based on the CFS shell element is used.
- Firstly, buckle analysis is done to determine the critical load.
- Next step is to perform static analysis to identify the strength of the section for above obtained critical load.

3 Results and Discussions:

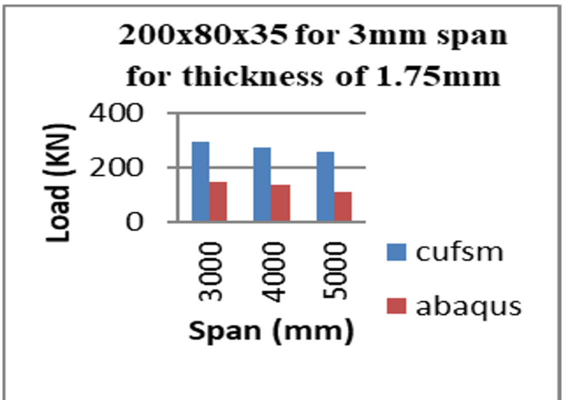
In this research the simple –simple end conditions of beam of sizes 200x80x35 for 3mm span thickness of 1.75mm, 2mm, and 2.5mm has been analyzed by CUFSM and ABACUS

Below is a discussion of the lipped linked channel sections' geometry. The numerical simulation of several coupled channel sections has been done using the connections between each channel as well as by modifying various parameters including section thickness, span, and web depths. Therefore, coupled channel sections with web depths of 200 and 250 mm, flange widths of 80 and 100 mm, lip sizes of 35 mm, and thicknesses of

1.75, 2 and 2.5 mm were selected for the current study. The link is positioned one-third and two-thirds of the way from the origin of the web's two channels.

3.1 Bar diagram

The bar diagrams that are presented in this section represents the comparison of results of all the sections that are analyzed in CUFSM and ABAQUS for different spans and thicknesses by simple-simple end condition



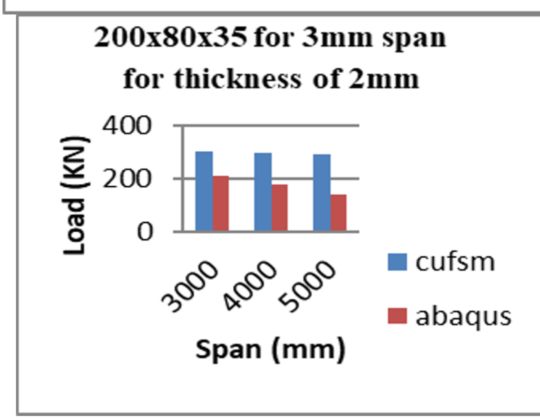


Fig. 1. (a) (b)Dimensions of a CFS member 200x80x35 for span lengths of 3mm of thickness 1.75mm, 2mm

The elasticity modulus did not differ significantly for low and high strength steels, nevertheless yield strength was affected by grade of steel. According to experimental studies examinations of cold-formed steel compression members subjected to local buckling of stiffened web, unstiffened flange, and stiffened web and flange elements, these cold-formed compression members retained 74 percent of their capacity at 400°C. Since the loss of mechanical properties is the key factor determining structural behavior under fire, these observations and advancements are extremely relevant and beneficial in many ways

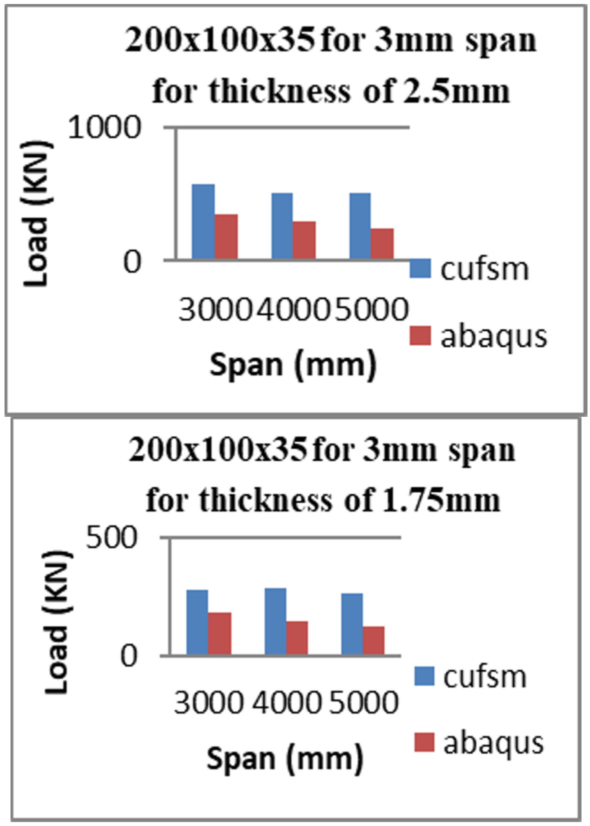
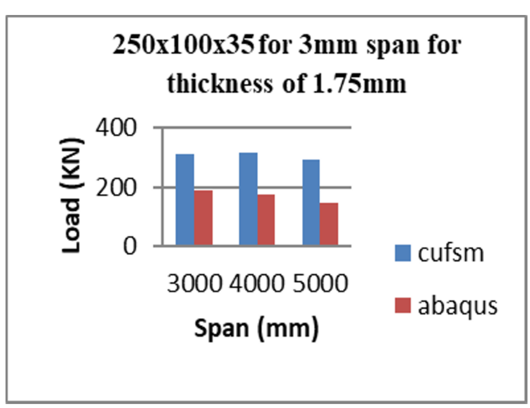


Fig. 2 .(a)(b) Dimensions of a CFS: 200x100x35 for span lengths of 3mm of thickness 1.75mm, 2.5mm

For high temperatures the compressive strengths were estimated using machinery parameters acquired at certain degrees and collate to determined compressive strength values. The existing effective width standards were found to be adequate in forecasting the ultimate strength of low-strength cold-formed steel members, but insufficient in predicting the ultimate strength of high-strength steel compression members susceptible to local buckling effects at ambient temperature.



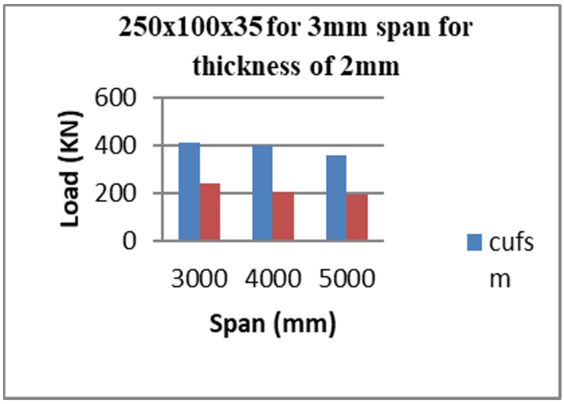


Fig. 3. (a)(b) Dimensions of a CFS member: 250x100x35 for span lengths of 3mm of thickness 1.75mm, 2mm

Because of members failure before attaining the ultimate strength of materials, then discovered that the ultimate strength of CFS compression members subjected to local buckling effects was little increased even when the strain hardening effect was incorporated. To simplify finite element modelling, it is fair to neglect the strain hardening effect.

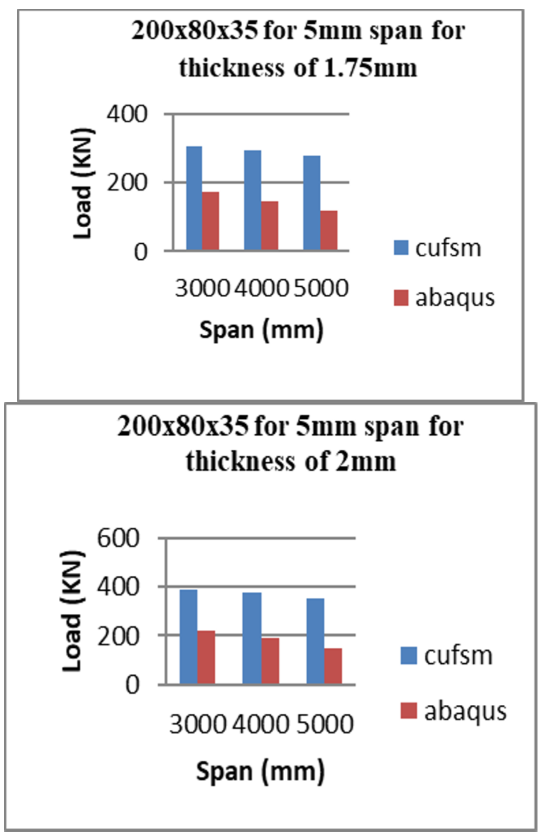
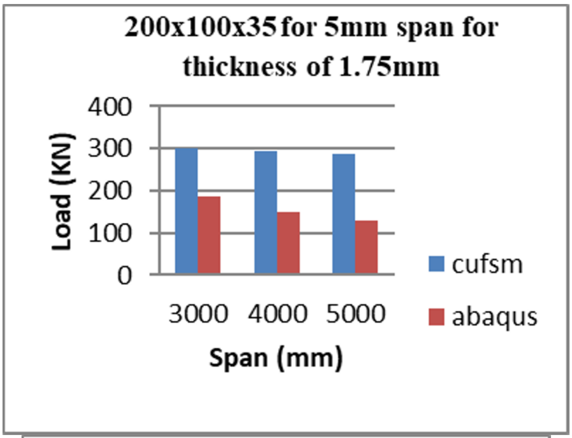


Fig. 4. (a)(b) Dimensions of a CFS member: 200x80x35 for span lengths of 5mm of thickness 1.75mm, 2mm

Field choice values based on actual stress-strain curves imitate the plastically behaved mechanical characteristics of CFS at elevated degrees for CFS compression members. At high temperatures, the initial geometric defects and residual stresses were also successfully integrated.



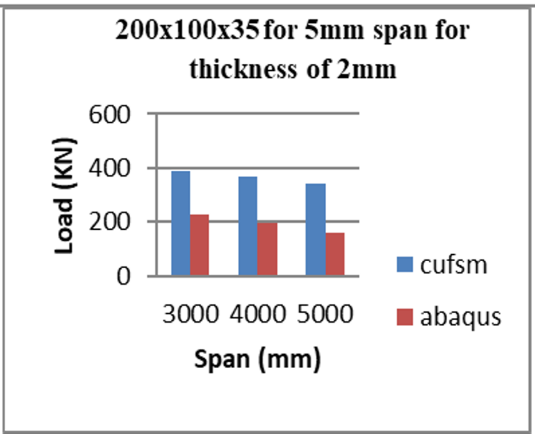


Fig. 5. (a)(b) Dimensions of a CFS member: 200x100x35 for span lengths of 5mm of thickness 1.75mm, 2mm

For unlipped and lipped channel members subjected to local buckling of unstiffened flange elements, stiffened web elements, and interactive local buckling of stiffened web and flange elements at high temps, three types of finite element models were established. Full length (experimental model), half length (experimental model), and quarter-wave buckling length model were the models used (ideal model). The maximum strength and buckling stress for unlipped channel elements sensitive to flange local buckling effects were found to differ very little seen between three modelling methods.

The ideal model's end boundary conditions are formed by the rigid body, whereas the experimental model's end boundary conditions are created by the multi point constraints. Due to lesser rotational constraint, this effect was minimal for unlipped channel elements subject to flange local buckling. The half-length model was used to compare experimental data, whereas the quarter-wave buckling length model was utilised to evaluate and formulate design principles because it simulates ideal conditions.

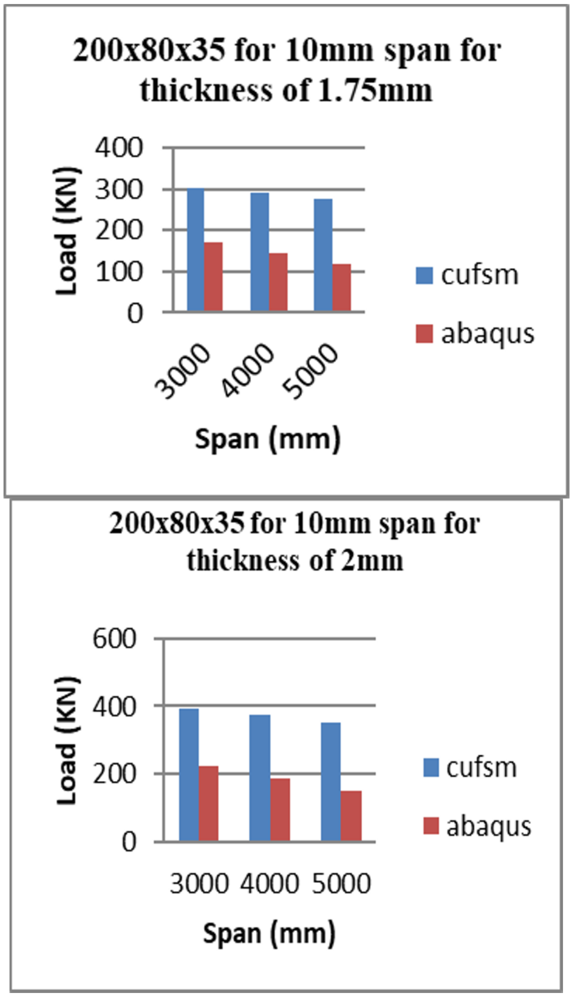


Fig. 7. (a)(b) Dimensions of a CFS member: 200x80x35 for span lengths of 10mm of thickness 1.75mm, 2m

From above represented graphs for three different sections varying in spans and thicknesses following observations are made

- For simply-simply boundary condition the axial capacity of the sections obtained from ABAQUS and axial capacity from CUFSM varying with 10.3%- 11.5%
- For clamped-clamped boundary condition the axial capacity of the sections obtained from ABAQUS and axial capacity from CUFSM varying with 11.9%- 12.3
- This research could be one of the innovations for the purpose of analysis of the members for their ultimate strength

4 Conclusions

- For axial capacity of the sections obtained from ABAQUS and axial capacity from CUFSM varying with 10.3%-11.5%.
- As spacing increases for built-up sections there is an increase of 10% -12%.
- For flange width of 80mm distortion becomes critical for spacing of 10mm and strength is not increasing from that of 5mm spacing.

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