A Comparative Study of Hot Rolled Section (HRS) and Cold Formed Section under Combined Bending and Shear using ANSYS.16

Sankhla Kalpak[1] Dr. Shelke Nagesh[2] Deosarkar Manoj[3]
[1,2,3]Dr. D.Y. Patil School of Engg. & Technology, Charholi Budru, Lohegaon, Pune-412105, India

Abstract— In upcoming era of light weight construction light gauge steel construction is the prominent demand of the time. The sections used are light in weight as the thickness is less than the hot rolled section. This type of construction reduced the 30% of overall weight of structure without compromising in strength and stability. In this study the light gauge channel section is considered to compare behaviour of CFS section with and without stiffeners. Initially the capacity of the CFS section is carried out using provisions of IS 801-1975 for flexure. The specimen is analytically studied using ANSYS software. The specimen is then experimentally investigated for the flexural behaviour of CFS sections with and without stiffener. The main target for this study is to make the behavior of CFS equal to HRS.

Key words: Cold Formed Steel (CFS), Hot Rolled Section (HRS), ANSYS 16

I. Introduction

Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. 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 3mm. Much thicker material up to 8 mm can be formed if pre-galvanized material is not required for the particular application. 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. In this study the light gauge channel section is considered to compare behaviour of CFS section with and without stiffeners. Initially the capacity of the CFS section is carried out using provisions of IS 801-1975 for flexure. The specimen is analytically studied using ANSYS software for the flexural behaviour of CFS sections with and without stiffener. Following procedure is adopted for project work

- The results where compared to the experimental work carried out for the true length specimen. Design the section under loading using Indian code guidelines.
- Analyzing the section using the FE software.
- Study the failure pattern of the section in bending shear and torsion
- Comparison of the section properties with the torsion effect.
- Validating the analytical work with the experimental work.

II. Objectives

- To compare Hot rolled steel section and cold formed steel section under deformation in ANSYS
- To compare Hot rolled steel section and cold formed steel section under normal stress and shear stress in ANSYS
- To compare natural frequency and time period for 6 mode shapes for HFS and CFS

III. Methodology

A. Introduction

The finite element method (FEM) is the most popular simulation method to predict the physical behavior of systems and structures. Since analytical solutions are in general not available for most daily problems in engineering sciences numerical methods like FEM have been evolved to find a solution for the governing equations of the individual problem. Much research work has been done in the field of numerical modeling during the last thirty years which enables engineers today to perform simulations close to reality. Nonlinear phenomena in structural mechanics such as nonlinear material behavior, large deformations or contact problems have become standard modeling tasks. Because of a rapid development in the hardware sector resulting in more and more powerful processors together with decreasing costs of memory it is nowadays possible to perform simulations even for models with millions of degrees of freedom. In a mathematical sense the finite element solution always just gives one an approximate numerical solution of the considered problem. Sometimes it is not always an easy task for an engineer to decide whether the obtained solution is a good or a bad one. If experimental or analytical results are available it is easily possible to verify any finite element result. However, to predict any structural behavior in a reliable way without experiments every user of a finite element package should have a certain background about the finite element method in general. In addition, he should have fundamental knowledge about the applied software to be able to judge the appropriateness of the chosen elements and algorithms. This paper is intended to show a summary of ANSYS capabilities to obtain results of finite element analyses as accurate as possible. Many features of ANSYS are shown and where it is possible we show what is already implemented in ANSYS.14 Workbench.

B. Material Modeling

The definition of the proposed numerical model was made by using finite elements available in the ANSYS code default library. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior.

The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elasto-plastic materials, and fully incompressible hyper-elastic materials. The geometrical representation of is show in SOLID186 fig 4.

This SOLID186 3-D20-node homogenous/layered structural solid were adopted to discretize the concrete slab, which are also able to simulate cracking behavior of the concrete under tension (in three orthogonal directions) and crushing in compression, to evaluate the material non-linearity and also to enable the inclusion of reinforcement (reinforcement bars scattered in the concrete region). The element SHELL43 is defined by four nodes having six degrees of freedom at each node. The deformation shapes are linear in both in-plane directions. The element allows for plasticity, creep, stress stiffening, large deflections, and large strain capabilities the representation of the steel section was made by the SHELL 43 elements, which allow for the consideration of non-linearity of the material and show linear deformation on the plane in which it is present. The modeling of the shear connectors was done by the BEAM 189 elements, which allow for the configuration of the cross section, enable consideration of the non-linearity of the material and include bending stresses as shown in fig 4. CONTA174 fig1 is used to represent contact and sliding between 3-D "target" surfaces (TARGE170) and a deformable surface, defined by this element. The element is applicable to 3-D structural and coupled field contact analyses. The geometrical representation of CONTA174 is show in fig 1. Contact pairs couple general axisymmetric elements with standard 3-D elements. A node-to-surface contact element represents contact between two surfaces by specifying one surface as a group of nodes. The geometrical representation of is show in TARGET 170 fig 2.

The TARGET 170 and C0NTA 174 elements were used to represent the contact slab-beam interface. These elements are able to simulate the existence of pressure between them when there is contact, and separation between them when there is not. The two material contacts also take into account friction and cohesion between the parties.

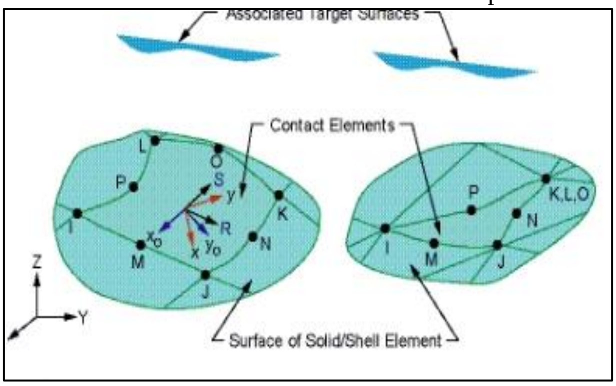

Fig. 1: CONTA 174”

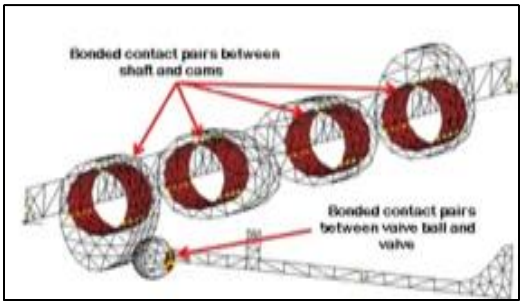

Fig. 2: TARGET 170”

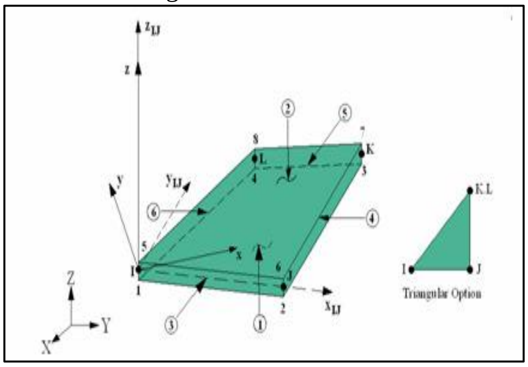

Fig. 3: Shell 43”

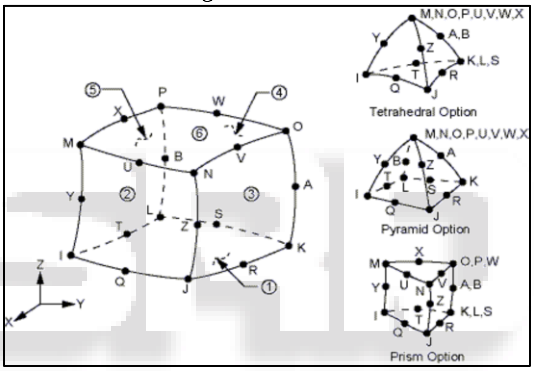

Fig. 4: Solid 186

C. *Failure Criteria*

Two limits are established to define the ultimate load for each finite element investigation: a lower and an upper bound, corresponding to concrete compressive strains of 0.2%, and 0.35%, respectively. These two limits define an interval in which the composite beam collapse load is located. A third limit condition, hereinafter referred to as the stud failure point, can also be reached when the composite beam’s most heavily loaded stud reaches its ultimate load, as defined from the appropriate push-out tests. If the stud failure point is located before the lower bound of concrete (i.e., the corresponding load of the stud failure point is smaller than the lower bound load) then the mode of failure of the composite beam is considered as being stud failure. Conversely, if the stud failure point is located after the upper bound of concrete, the mode of failure is assumed as being concrete crushing. For the intermediate case, where the stud failure point lies between the lower and upper bounds of concrete, than the mode of failure could be either of them. Therefore, the proposed finite element model is able to predict the failure modes associated with either slab crushing or stud failure.

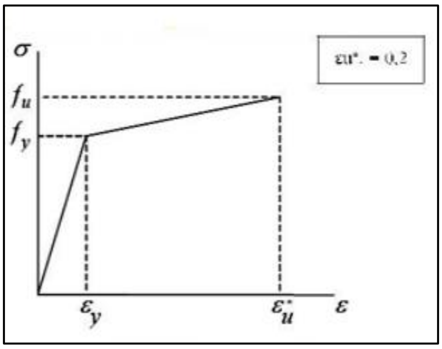

Fig. 5: Constitutive relation for the shear connectors for steel"

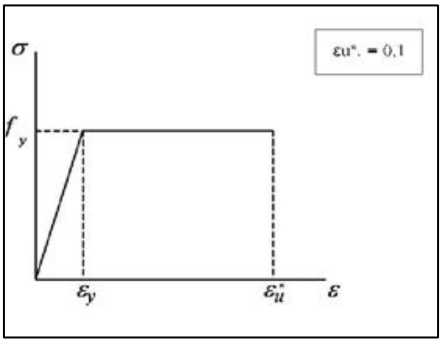

Fig. 6: Constitutive relation for the steel of the reinforcement"

D. *Finite Elements Mesh*

The model designed for the numerical analysis was defined by four types of elements that form the concrete slab with added reinforcements, such as steel beam, shear connectors and the pair of contact at the slab-beam interface. The elements were established separately, but the nodes were one by one coupled on the interface between them. The finite element mesh developed for all elements followed the same methodology and degree of refinement .shows the finite element mesh for the components cited, where Fig 6 Finite Element Meshing of I section

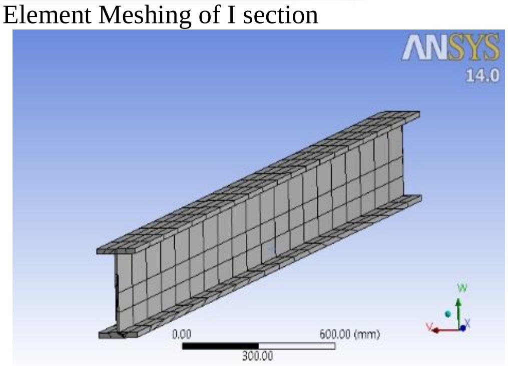

Fig. 7: Finite Element Meshing of I section"

IV. PROBLEM STATEMENT

A. For comparison 2.5m beam is modeled in ANSYS for HRS and CFS.

1) Hot Rolled Steel Section

ISHB =300
Depth of a section (d) =300mm
Width of a section (b_f) =250mm
Thickness of bottom flange (t_f) =20mm
Thickness of top flange (t_f) =20mm
Web thickness (t_w) =20mm
Modulus of elasticity (e) =200000 mpa
Density (ρ) =7850 kg / m3
Poisson ratio (μ) =0.3
Pressure (p) =3 Kn/m^2

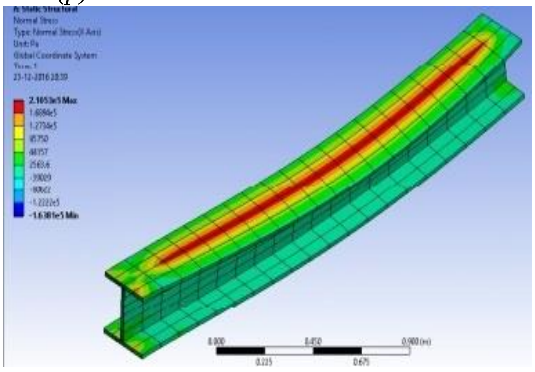

Fig. 8: Normal stresses in X-Y plane Hot Rolled steel section"

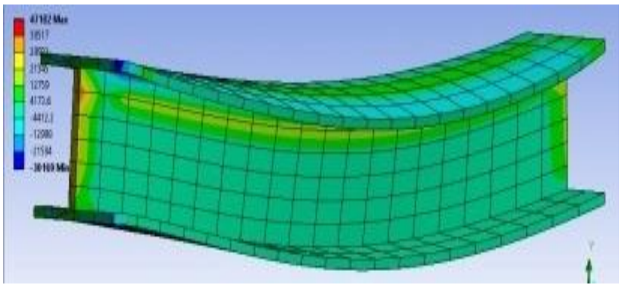

Fig. 9: Shear stress in X-Y plane Hot Rolled steel section"

2) Cold Rolled Steel Section

ISHB =300
Depth of a section (d_f) =300mm
Width of a section (b_f) =250mm
Thickness of bottom flange (t_f) =20mm
Thickness of top flange (t_f) =20mm
Web thickness (t_w) =20mm
Modulus of elasticity (e) =203395.33 mpa
Density (ρ) =7849.05 kg / m3
Poisson ratio (μ) =0.3
Pressure (P) =3 Kn/m^2

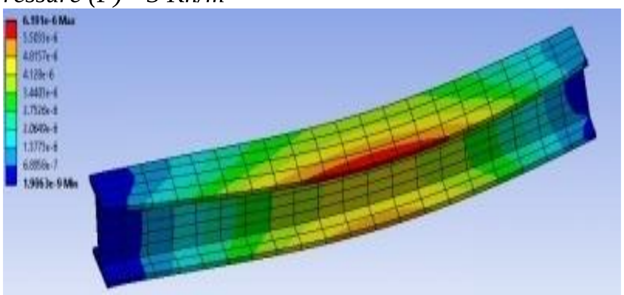

Fig. 10: Total Deformation in X-Y plane Cold Rolled steel section"

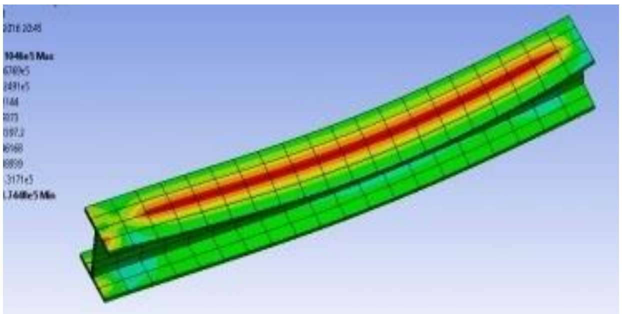

Fig. 11: Normal stress in X-Y plane cold formed steel section"

3) Mode shapes of Cold Form and Hot Rolled Steel Sections

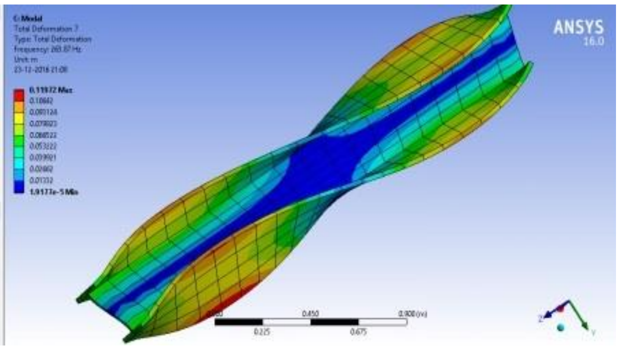

Fig. 12: Mode shape No. 7 for deformation 0.19"

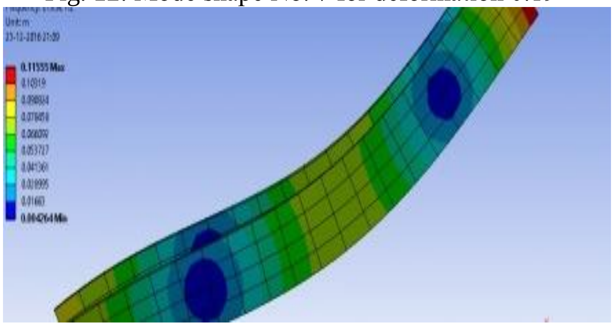

Fig. 13: Mode shape No. 6 for deformation 0.15"

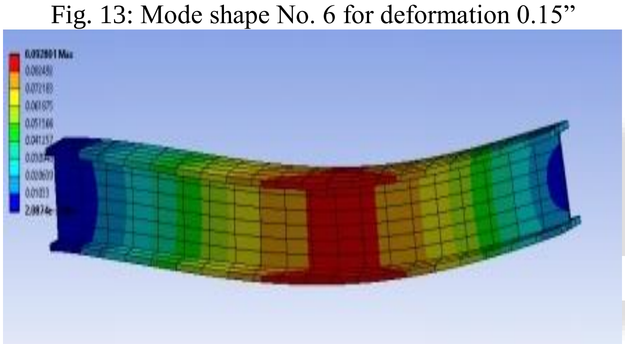

Fig. 14: Mode shape No. 5 for deformation 0.19"

V. RESULTS

Following results are obtained while comparing hot rolled steel section and cold formed steel section

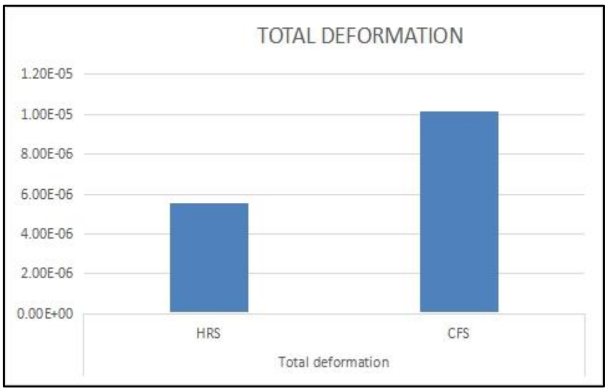

Fig. 15: Total deformation"

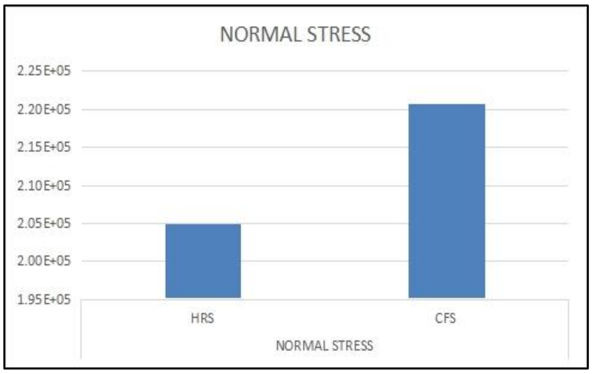

Fig. 16: Normal stress"

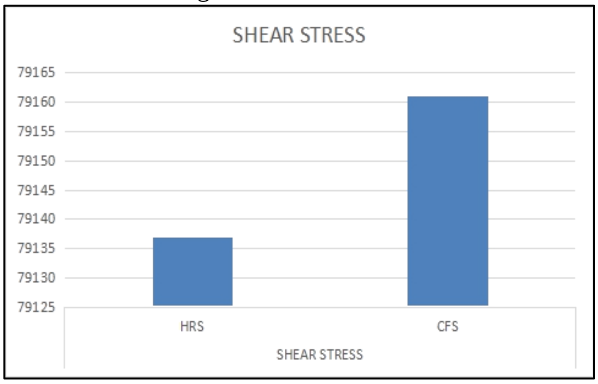

Fig. 17: Shear stress"

Modes Shape no	Cold formed steel	Hot rolled steel
1	7.78 E^{-02}	7.68 E^{-02}
2	42.502	41.917
3	114.98	113.56
4	198.81	196.30
5	219.92	216.90
6	263.87	260.69

Table 1: Comparisons of mode shape of CFS and HRS

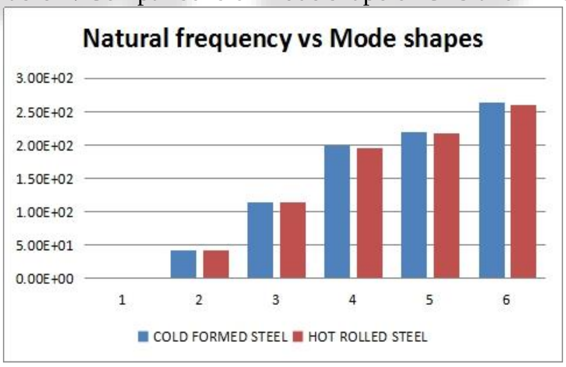

Fig. 18: Natural frequency Vs. Mode shapes"

VI. CONCLUSION

In the present study HRS and CFS is studied under combined bending and shear and following results were obtained

- Total deformation is observed 15-20% more in CFS section than HRS section
- Normal stress and shear stress is observed more in CFS, Hence stiffeners need to provide in CFS section to reduce deformation and stress
- There is no abrupt change in natural frequency and time period is observed in both sections.

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