Finite Element Analysis on Parametric Behaviour of Hybridised Cold Formed Steel in Multi Storey Frames

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Abstract - *Cold formed steel members are made from structural quality sheet steel and formed into shapes, either through press breaking blanks sheared from sheets or coils or more commonly, by roll forming the steel through a series of dies. In this paper different types of cold formed steel sections are studied through FEM (finite element method) numerical analysis. These sections include supacee section, supazed section and sigma section. Various section geometries according to IS code is adopted and analysed in ANSYS workbench 16.1. From the analysis cold formed steel with sigma section showed good ductility and load carrying property compared with other types. So for analysis of hybridised frame cold formed steel with sigma section is selected. To achieve the nonlinear behaviour of models, nonlinear static (pushover) analysis are used by FEM.*

Key Words: **Cold formed steel, Supacee section, Sigma section, Supazed section, Hybridised frame, Pushover analysis.**

1. INTRODUCTION

1.1 General Background

During a severe earthquake, the main structural elements like beams and columns are seriously affected. When a building is subjected to seismic wave, large amount of energy is distributed within in the building and the level of damage sustained by the building depends on the dissipation of this energy. Therefore a great concern is to be given for earthquake resisting systems to dissipate energy effectively from the structure. The primary function of an energy dissipation element is to reduce the damage in main structural components.

In steel construction, there are primarily two types of structural members: hot-rolled steel shapes and cold-rolled steel shapes. Hot-rolled steel shapes are formed at elevated temperatures while cold formed steel shaped are formed at room temperature, thus the name cold-formed steel. Cold-formed steel members are made from structural quality sheet steel and formed into shapes, either through press-braking blanks sheared from sheets or coils or more commonly, by roll forming the steel through a series of dies.

The idea behind cold formed steel frame members is to use shape rather than thickness to support load. Due to the relatively easy method of manufacturing, a large number of different configurations can be produced to fit the demand of optimized design for both structural and economical purposes. Figure 1 shows typical cold-formed steel shapes.

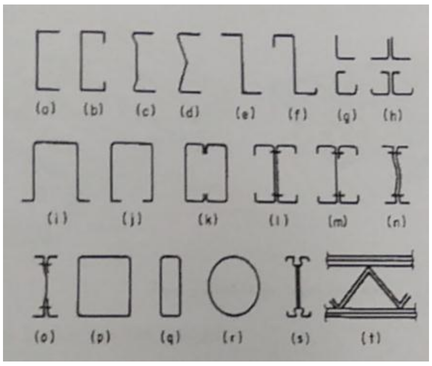

Fig -1: Common cold formed steel shapes

2. NUMERICAL INVESTIGATION USING ANSYS WORKBENCH 16.1

2.1 Base Model

Numerical modelling of cold formed steel with different sections were done using ANSYS 16.1 WORKBENCH, a finite element software for mathematical modelling and analysis. The dimensions and material properties of all the 3 models are same and is given in Table 1 and Table 2 respectively. These sections were created using 3D shell elements while loading and support bearing plates were modeled with discrete rigid elements. All the shell elements used were of type S4R which is a linear four-node reduced integration shell element with finite strains.

Boundary conditions were assigned to ETF models in the bearing plates placed at the end of the specimen. Loading plate was allowed to move vertically with a displacement limit of 20 mm towards the beam. The test beam had pinned supports at the top and bottom.

Table -1: Geometry of Sections

MEMBER	ETF-SC20015	MEMBER	ETF-SC20015
L_b (mm)	50	i (mm)	22.6
f_y (MPa)	541	j (mm)	18.6
t_w (mm)	1.53	s (mm)	12
r_i (mm)	5	k (mm)	3.6
b_f (mm)	69.5	L (mm)	609
b_l (mm)	22.9	D (mm)	204.9
f (mm)	14.5	g (mm)	32.4
h (mm)	55.9		

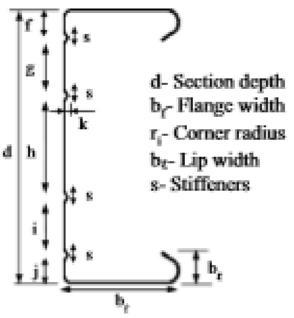

Fig -1: Web Stiffened Channel Section.

Table -2: Material Properties of Steel.

Young's modulus of Steel (GPa)	200
Poisson's ratio of Steel (v)	0.3
Yield stress of hot rolled steel (MPa)	240
Yield Stress of cold formed steel (MPa)	541

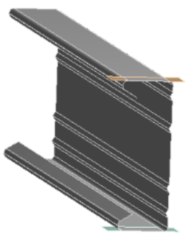

Fig -2: Modelled view of supacee section.

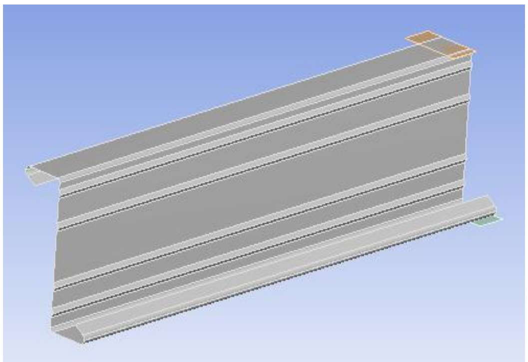

Fig -3: Modelled view of supazed section.

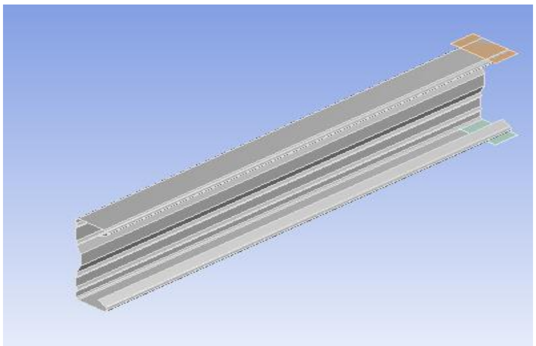

Fig -4: Modelled view of sigma section.

In case of hybrid wall panel, a wall panel completely made of hot rolled steel and a hybrid wall with outer panel as hot rolled steel and inner panels as cold formed steel was modelled. The width and height of wall panel is 3.6m and 3m respectively. It is divided into six panels and each panel is 600mm wide. Total height is also divided into three parts, each with 1m height. Fixed support is provided at the bottom and push over analysis is carried out. In the finite element analysis fine mesh was adopted for accuracy. The modeled view of these sections were shown in the figures given below.

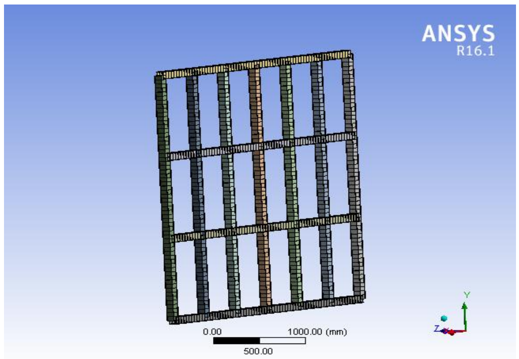

Fig -5: Modelled view of wall panel with hot rolled section.

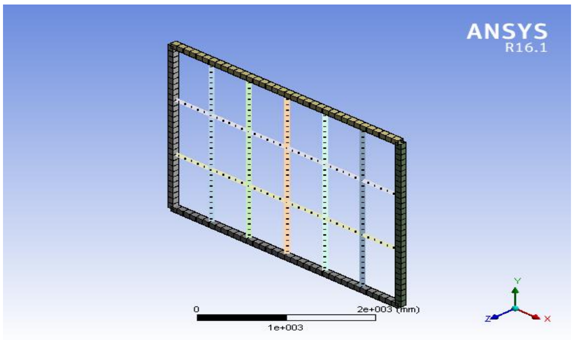

Fig -6: Modelled view of wall panel with sigma section.

3. RESULTS AND DISCUSSIONS

The load and corresponding displacements of cold formed steel with different sections geometries as well as wall panel with hot rolled steel and sigma sections were obtained. The load vs deflection graph of the three types of section as well as wall panels were shown below in Figure 6 and 7 respectively.

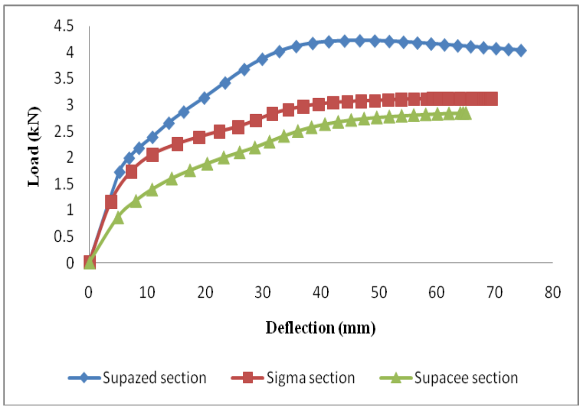

Fig -7: Load vs deflection graph of different sections.

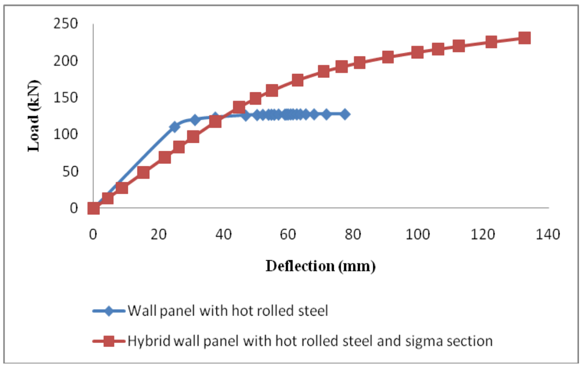

Fig -8: Load vs deflection graph of wall panels with hot rolled steel and hybrid with sigma section.

Figure 9 to Figure 13 shows the total deformation of all the models obtained from ansys. Figure 14 to Figure 18 shows the equivalent von mises stress of all the models from ansys.

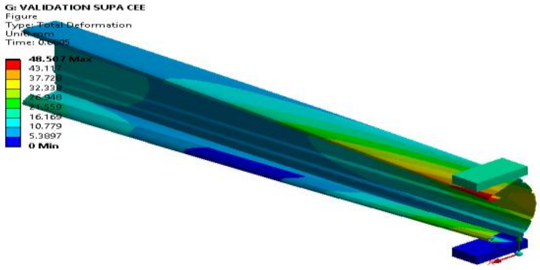

Fig -9: Total deformation of supacee section.

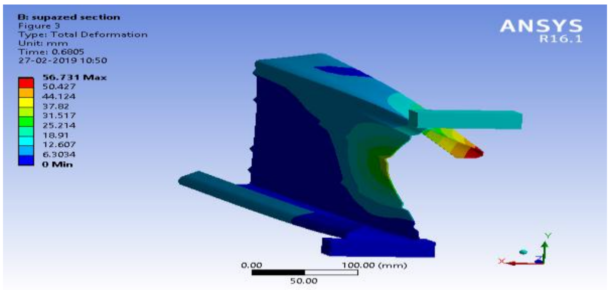

Fig -10: Total deformation of supazed section.

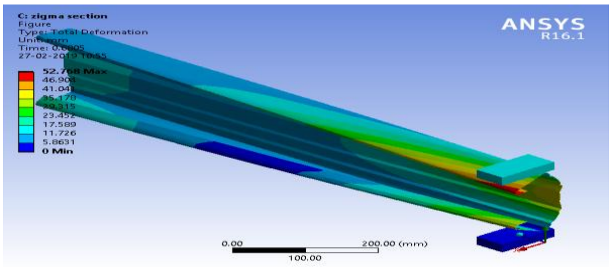

Fig -11: Total deformation of sigma section.

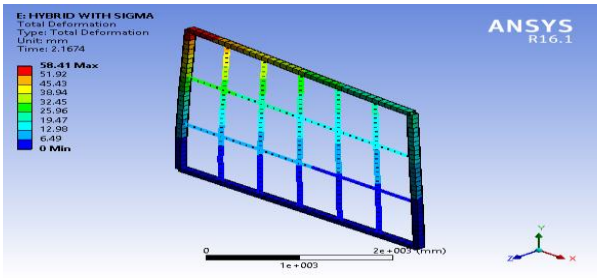

Fig -12: Total deformation of hybrid wall panel with sigma section.

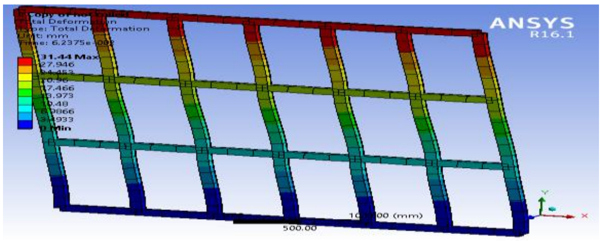

Fig -13: Total deformation of wall panel with hot rolled steel.

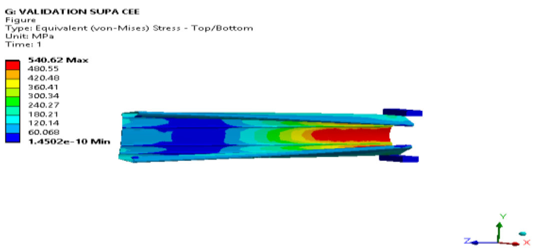

Fig -14: Equivalent von mises stress of supacee section.

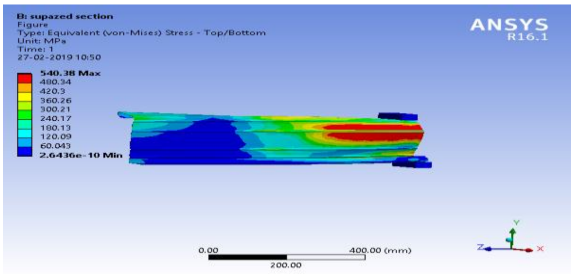

Fig -15: Equivalent von mises stress of supazed section.

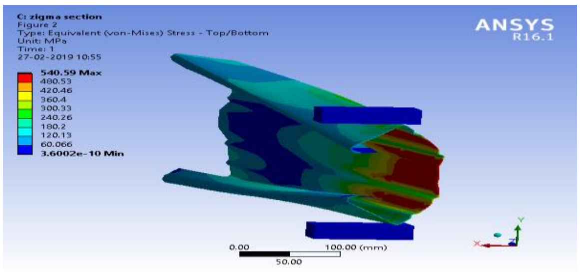

Fig -16: Equivalent von mises stress of sigma section.

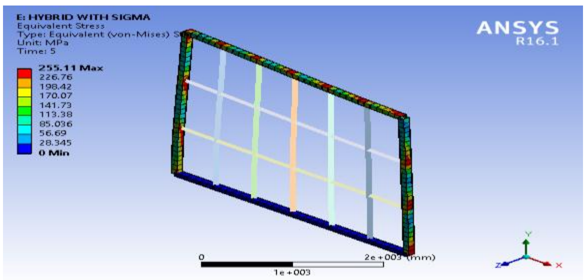

Fig -17: Equivalent von mises stress of hybrid wall panel with sigma section.

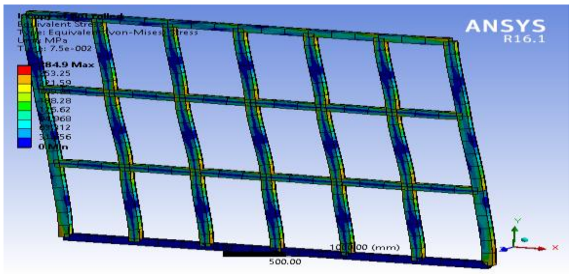

Fig -18: Equivalent von mises stress of wall panel with hot rolled steel.

Table representing maximum load and deflections of various sections and wall panels were illustrated below.

Table -3: Maximum load and deflections of different sections

MODELS	SUPACEE SECTION	SUPAZED SECTION	SIGMA SECTION
ULTIMATE LOAD (kN)	2.845	4.226	3.126
DEFORMATION(mm)	64.965	46.71	64.029

Table -4: Maximum load and deflections of wall panels

MODELS	HYBRID SIGMA SECTION	HOT ROLLED SECTION
ULTIMATE LOAD (kN)	239.78	127.89
DEFORMATION(mm)	151.86	77.43
WEIGHT(kg)	224.96	341.74

4. CONCLUSIONS

This study proposed a new configuration of different cold formed sections and their application in multi storey structure, the conducted analytical study on cold formed steel result in following conclusions:

- Cold formed steel with supazed section shows more load bearing capacity when compared with other sections. But ductility of this section is less.
- Cold formed steel with supacee and sigma section shows almost same ductility. But sigma section is considered as best as its load carrying capacity is more when compared with supacee section.

On comparing the hybrid wall panel with supacee section and sigma section, its been observed that:

- The ultimate load carrying capacity of hybrid sigma section is increased by 5.7%. The deformation of hybrid sigma section is 8.2% more when compared with hybrid sigma section. So wall panel with hybrid sigma section is considered as the best section.

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REFERENCES

[1] Beshara B, Schuster RM. “Web crippling data and calibrations of cold formed steel members”. AISI Research Report. Canadian Cold Formed Steel Research Group, University of Waterloo, Canada; 2006.

[2] Natário P. “Localized failure of thin-walled steel members subjected to concentrated loads: analysis, behaviour and design PhD Thesis”. Portugal: Instituto Superior Técnico, Universidade de Lisboa; 2015.

[3] Natário P, Silvestre N, Camotim D. “Direct strength prediction of web crippling failure of beams under ETF loading”. Thin-Walled Struct 2016;98:360–74.

[4] Natário P, Silvestre N, Camotim D. “Web crippling of beams under ITF loading: a novel DSM-based design approach”. J Constr Steel Res 2017;128:812–24.

[5] Prabakaran K. “Web Crippling of Cold-formed Steel Sections”. Project Report. Department of Civil Engineering, University of Waterloo, Ontario, Canada; 1993.

[6] Uzzaman A, Lim JBP, Nash D, Rhodes J, Young B.” Web crippling behaviour of cold-formed steel channel sections with offset web holes subjected to interior two-flange loading”. Thin-Walled Struct 2013(50):76–86.

[7] Uzzaman A, Lim JBP, Nash D, Rhodes J, Young B.” Effect of offset web holes on web crippling strength of cold-formed steel channel sections under end-two flange loading condition”. Thin-Walled Struct 2013(65):34–48.