Structural behavior of cold formed steel in hybrid wall frame

Nahna A ,Durgalakshmi

Abstract— Nowadays Hybrid structures are commonly used around the world. A Hybrid is a combination of two or more different materials to get the most out of each material. In this paper investigating the lateral performance of a hybrid wall frame made of high strength of cold formed steel (CFS) and hot rolled steel (HRS). CFS have high strength to weight ratio compared to HRS. Square hollow section of hot rolled steel are used as outer elements and high strength CFS as inner elements. Four variants of cold formed zed section are analysed and out of this improved z section with web stiffeners and curved lips are used as inner elements. Analysis is carried out using ANSYS software.

Index Terms— Hot rolled steel, Cold formed steel, Hybrid wall frame, Lateral performance, Web stiffeners, improved z section, ANSYS.

1INTRODUCTION

In steel construction there are mainly two types of steel are using. One is hot rolled steel (HRS) and other is cold formed steel (CFS). Both are differing based on their manufacturing method. HRS are manufactured by hot rolling process that is rolling the steel at high temperature above re-crystallization temperature, so that it can easily shaped and formed. HRS steel is processed further in cold reduction mills, where the material is cooled at room temperature followed by annealing or tempers rolling. This leads to the formation of CFS. Both steel have their own advantages and disadvantages.

Use of CFS products are important and effective in the constructions carried out especially in seismic areas; lightweight structural system, flexibility, short execution period, high quality end product, minimum impact on the environment are some of the important properties of CFS which make them suitable for seismic areas.

Since the CFS is thin like sheet, they can be converted to any desirable shape. CFS elements are more liable to buckling like local, distortional, flexural, torsional buckling and interaction of these above. The commonly used open CFS sections are channel, zed, Hat. The load carrying capacity of plain CFS section is less. Many researchers were studied the strengthening of CFS elements.So in order to increase their load carrying capacity, providing different shapes of grooves on the web, flange and lip on the edges. Thus these stiffened sections can be used as primary structural elements. While plain sections are applicable as secondary members.

HRS wall frames are a traditional in building construction. But their weight results in increase in foundation cost. So to reduce the weight some HRS elements are replaced by the high strength CFS elements. When these two steel are mixed to form a system, it get most out of each material. The combination of two or more different material can be called as hybrid. If the introducing CFS section is a better section, whole frame will also show a better performance.

2ANALYTICAL STUDY

2.1 Wall frame

In this paper wall frame of length 3.6 m and height 3 m considered. Entire length is divided in to six segment, with 600 mm spacing. And total height is divided into three, with a spacing of 1 m.

2.1.1 Materials used in wall frame

Two wall frames, one is fully hot rolled steel and other is hybrid wall frame are modeled. Material property used in the analysis is given table no. 1

Table 1
Material property of frames

Material	Yield strength F_Y (MPa)
Hot rolled steel	240
Cold formed steel	534

2.1.2 Loading condition

For the lateral resistance**,** Bottom elements are fixed to the ground and lateral load is applied on the top of frame in a specific direction.

2.1.3 Section property

2.1.3.1Fully Hot rolled frame

In this Frame Square section of hot rolled steels are used. Sectional area of outer element taken as higher than that of inner elements. Sections are taken from IS 4923 :1997 and is given in table 2.

Table 2
Section property of hot rolled wall frame

Section	Size (mm x mm x mm)
Outer square section	100 x 100 x 4
Inner square section	75 x 75 x 3.2

International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019
ISSN 2229-5518

TABLE 3
Geometrical and mechanical properties of zed section

no	Member	l_b mm	f_y MPa	t_w mm	r_i mm	b_{f1} mm	b_{f2} mm	b_l mm	D mm	F mm	G mm	H mm	I mm	J mm	S mm	K mm	L mm
1	ZPW	50	534	1.53	5	60.9	60.9	19.4	152.6	_	_	_	_	_	_	_	900
2	ZSW	50	534	1.53	5	60.9	60.9	19.4	152.6	15.3	30.6	8.7	30	14.8	10	2.8	900
3	ZSWL UNEQUEL FLANGE	50	534	1.53	5	60.9	45.3	19.6	152.6	15.3	30.6	8.7	30	14.8	10	2.8	900
4	ZSWL EQUEL FLANGE	50	534	1.53	5	60.9	60.9	19.6	152.6	15.3	30.6	8.7	30	14.8	10	2.8	900

Where L_b= bearing length f_y= yield strength
t_w= thickness of web D= Section depth
r_i = inside bend radius L= length
b_{f1}= top flange length b_{f2}= bottom flange length
b_l= Lip width

2.1.3.2 Hybrid wall frame

In this frame outer beam and column elements are used as hot rolled steel. The section used is 100 x 100 x 4 (mm). And inner frame elements are made up of high strength cold formed zed section. Section details are represented in fig 1.

2.2 CFS zed section

Finite element models of four different cold formed high strength zed section steel as shown in fig 1 are developed and analyzed as beam and column. Sectional dimensions were chosen from a previous work which is given in table 3. The zed section on which test is carried out aregiven below.

1. Plain web without lip having equal flange and without curved lip (ZPW)

2. Web stiffened zed section with a ribbed web and curved lips having equal flange (ZSWL)

3 Web stiffened zed section with a ribbed web and without curved lips having equal flange (ZSW)

4 Web stiffened zed section with a ribbed web and curved lipshaving unequal flange (ZSWL).

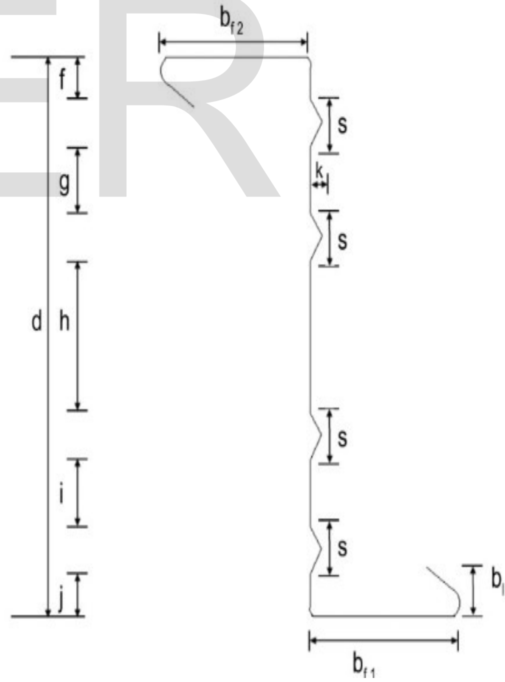
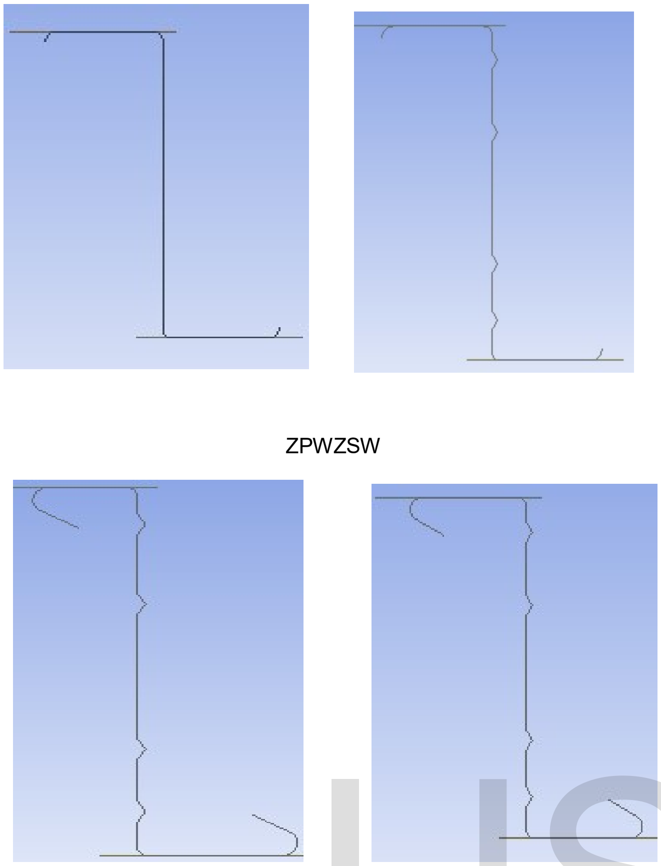


Fig 1 Cross section of zed



ZPWZSW

ZSWL UNEQUAL FLANGEZSWL EQUAL FLANGE

Fig 2 Zed section

2.2.1Loading condition on zed section

End two flange loading is carried out on the beam of zed sections to test their compressive strength. Fig 3 showing ETF loading arrangement in the beam. And concentric axial loads are applied on the column of zed sections to find out their stiffness as shown in fig 4.

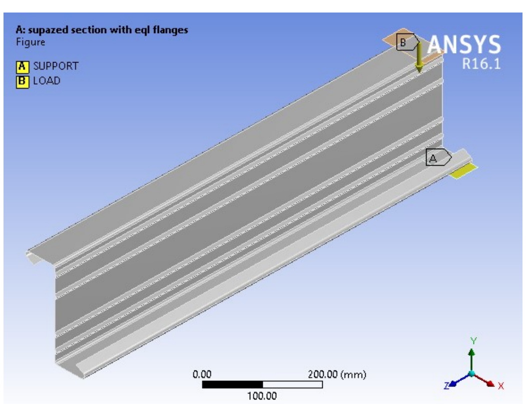


Fig 3 End two flange loading(ETF)

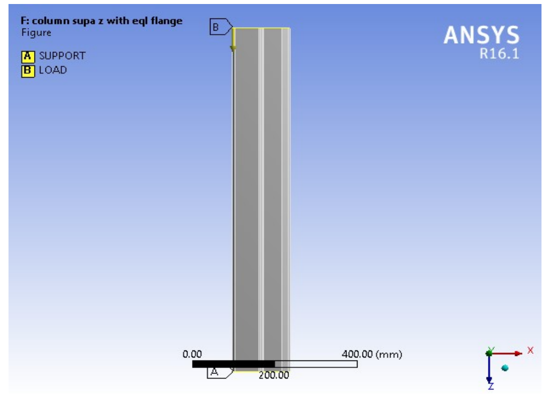


Fig 4 Zed column axial loading

2.3 Frame analysis

Based on the results obtained on various z beams and columns best section is selected as the inner elements in hybrid wall frame. Then Lateral resistance of the both hot rolled and hybrid frames are analyzed. Hybrid wall frame modeled is given in fig 5.and fig 6 showing the fully hot rolled frame.

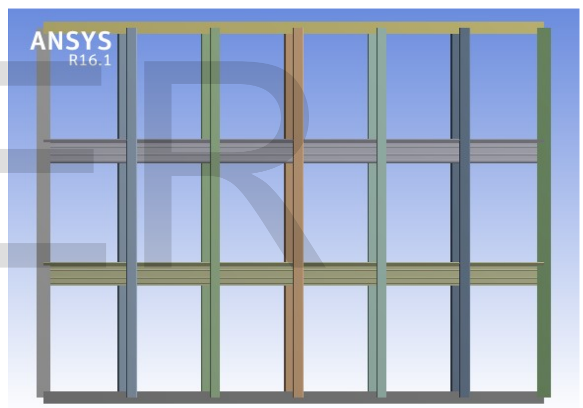


Fig 5 Model of hybrid wall frame

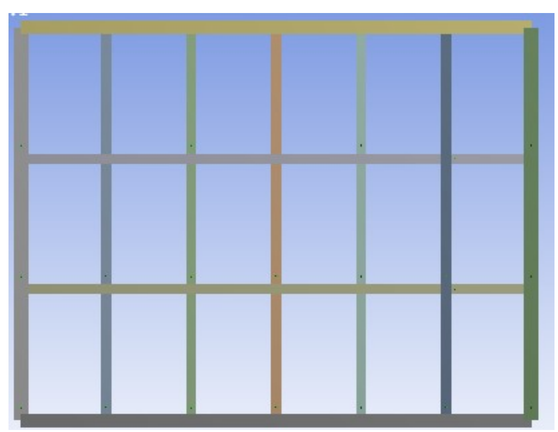


Fig 6 Model of hot rolled wall frame

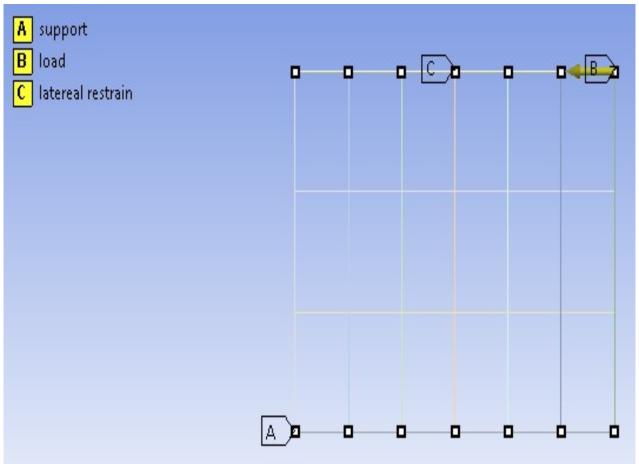


Fig 7 Loading and support condition of wall frame

3 RESULTS AND DISCUSSION

Case 1.Cold formed zed beam
Load and deflection obtained Under end two flange loading on zed beams is given in table 4. and the corresponding load deflection graph is shown in fig 8.

Table 4
Results of zed beam

Beam	D(mm)	F(kN)
ZPW	3.7127	3.8678
ZSW	48.879	3.4736
ZSWL unequal flanges	32.27	4.6496
ZSWL equal flange	46.71	4.2269

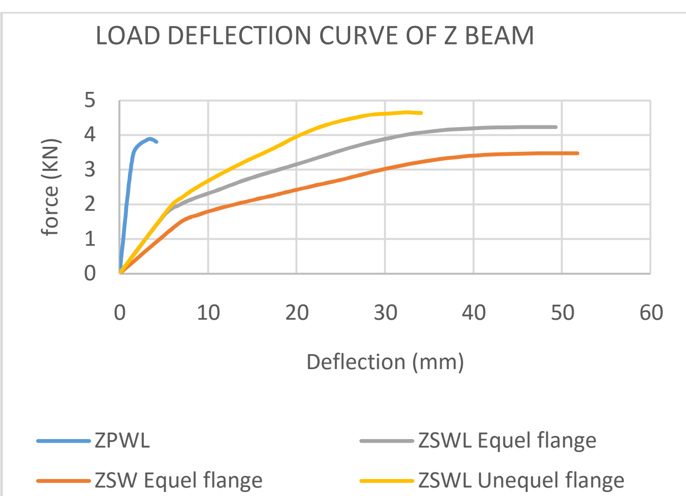


Fig 8 Load deflection curve

Case 2.Cold formed zed column
Results obtained Under concentric axial loading on zed beams is given in table 5. And the corresponding load deflection graph is shown in fig 9.

Table 5
Results of zed column

COLUMN	D(mm)	F (KN)
ZPW	0.8294	52.874
ZSW	10.347	91.221
ZSWL unequal flanges	9.2799	145.94
ZSWL with lip and equal flange	8.1556	148.39

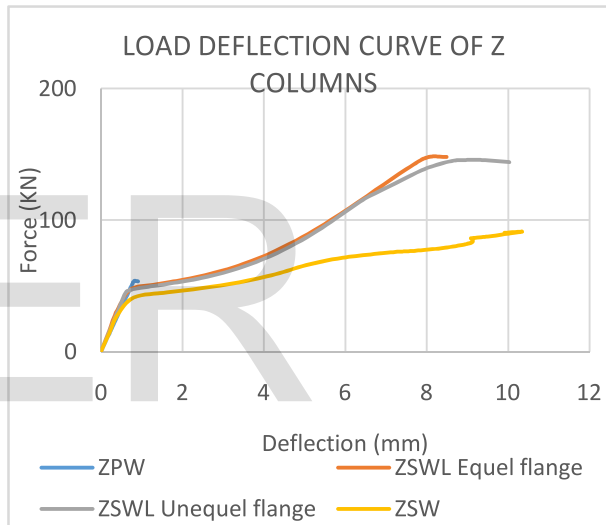


Fig 9 Load deflection curve

Case 3 .Frame analysis
Results obtained under the lateral load application on the both hot rolled and hybrid wall frame is given in table 6.and corresponding load deflection curve is plotted as shown in fig 10. Total deformation obtained on the hybrid wall frame is given in fig 11.

Table 6
Results of frames

FRAME	D(mm)	F(kN)
Hot rolled frame	50.745	85.893
Hybrid wall frame	134.49	181.4

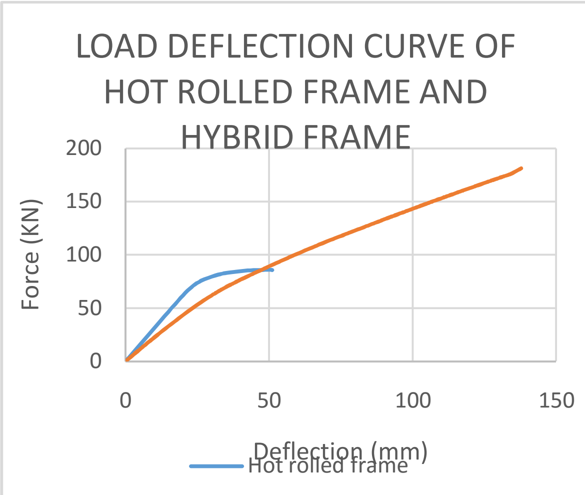


Fig 10 Load deflection curve

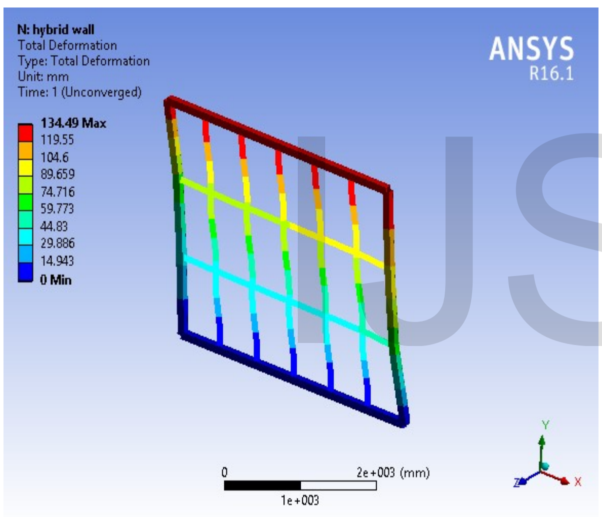


Fig 11 Deflection of hybrid wall frame

Case 4. Total weight of frame

Table 7 showing the total weight of both frames were modeled

Table 7
Weight of frames

FRAME	WEIGHT (Kg)
Hot rolled wall frame	319.32
Hybrid wall frame	258.51

CONCLUSION

This paper has described the lateral resistanceof two wall frames, fully hot rolled and hybrid wall frames. Frame elements used in fully hot rolled frame is square section and in hybrid wall frame outer frame elements are hot rolled square section and inner frame elements are of high strength cold formed complex stiffened zed section.
Four different zed section, that is zed with stiffened web and curved lip with equal flange, zed with stiffened wed and curved with unequal flange, Zed with stiffened web and without curved lip, zed without stiffened web and curved lip are analyzed as beam and column.

From case 1;
It is obtained that ZSWL have high compressive strength compared to ZPW.This indicating the positive effect of ribbed web stiffners and curved lips. From ZSWL for different flange condition, it is obtatained that unequal flange of ZSWL is little bit better than ZSWL equal flange in their load carrying capacity.but in ductility ZSWL equal flange is best one.

From case 2 ;
Column of ZSWL with equal flange have high load carrying capacity and also high stiffness. And ZPW have lesser load carrying capacity. The presence of web stiffeners and curved lip are helps to provide increased strength and more economy compared to the conventional z section.

From case 3 ;
From the analysis of both wall frames, lateral load carrying capacity is higher for hybrid wall frame compared to hot rolled frame. And ductility is also higher for hybrid frame.so this wall frame is suitable in seismic areas. There is 52.64 % increment in the lateral resistance.

From case 4 ;
Since the cold formed steel are light weight material the weight of hybrid frame is less compared to fully hot rolled wall frame.it results the reduction in construction cost like foundation and labour cost. The percentage of reduction in weight is 19.04 %

REFERENCES

1. **Cao Hung Pham and Gregory J. Hancock (2013)** “Experimental Investigation and Direct Strength Design of High-Strength, Complex C-Sections in Pure Bending” J. Struct. Eng.139:1842-1852.
2. **Cheng. Yu (2010)** “Shear resistance of cold-formed steel framed shear walls with 0.686 mm, 0.762 mm, and 0.838 mm steel sheet sheathing” Engineering Structures 32 ,1522–1529.
3. **Cheng. Yu , Schafer (2006)** Distorsional buckling test on cold formed steel beams.journal of structural engineering © asce.515.
4. **E.F. Gad, C.F. Duffield, G.L. Hutchinson, D.S. Mansell, G. Stark (1999)** “Lateral performance of cold-formed steel-framed domestic structures”

Engineering Structures 21, 83–95.

5. **El-Sheikh A, El-Kassas E M A, Mackie R,(2001)** "Performance of stiffened and unstiffened cold-formed channel members in axial compression" Engineering Structures, vol. 23, pp.1221–1231.
6. **J. Lange, B. Naujoks (2006)** "Behaviour of cold-formed steel shear walls under horizontal and vertical loads" Thin-Walled Structures 44 .1214–1222.
7. **Jun Yea, Iman Hajirasouliha , Jurgen Becque (2018)** "Experimental investigation of local-flexural interactive buckling of cold formed steel channel columns". Thin-Walled Structures 125, 245–258.
8. **Krisda Piyawat, et al. (2013)** "Development of an Axial Load Capacity Equation for Doubly Symmetric Built-Up Cold-Formed Sections" J. Struct. Eng. 139(12): 04013008.
9. **Lavan sundararajah, Mahen mahendran, poologanathan keerthan (2017)** "Web crippling studies of supacee sections under two flange load cases".Engineering Structures 153, 582–597.
10. **Mina mortazavi, Pezhman sharafi, Hamid ronagh, Bijan samali, Kamyar kildhasthi (2018)** "Lateral behavior of hybrid cold formed and hot- rolled steel wall systems: experimental investigation"Journal of Constructional Steel Research 147422-432.
11. **Mohammad reza haidarali, david A nethercot (2012)** "Local and distorsional buckling of cold formed steel beams with both edge and intermediate stiffener on their compression flange". Thin-Walled Structures 54 106–112.
12. **Pezhman Sharafi, Mina Mortazavi, Nima Usefi (2018)** "Lateral force resisting systems in lightweight steel frames: Recent research advances".Thin-Walled Structures 130, 231–253.
13. **Schafer B W, Sarawit A, Peköz T (2006)** "Complex edge stiffeners for thin-walled members" Journal of Structural Engineering, vol. 132, pp. 212–226.

IJSER © 2019
http://www.ijser.org