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# COMPARISON OF SINGLE SKIN CORRUGATED HOLLOW STEEL COLUMN AND CONVENTIONAL HOLLOW STEEL COLUMN

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**Abstract -** *Corrugated steel sections are having variety of applications in engineering fields like civil, mechanical etc. The novel properties of corrugated steel sections make them a better idea compared to the conventional thin sections. Out of the existing studies, limited studies were conducted on strengthening the corrugated hollow column, especially on the load carrying capacity of the column. HSC is strengthened using single skin pattern. Stiffeners like corner, middle, diagonal and diaphragm plate stiffeners are used to strengthen the HSC in single skin pattern. These types of strengthening are a promising way to make structural members stiffer and stronger. In this paper the strengthening of hollow corrugated steel column is investigated under finite element analysis using ANSYS.*

***Key Words*: Stiffeners, hollow corrugated steel column, single skin corrugated hollow steel column, corrugated plates**

## 1. INTRODUCTION

In the past four decades, the structural engineers have given considerable attention on investigating the response of structural members subjected to accidental loads such as impact and blast. These loads may be resulted from faulty practice, terrorist attack or vehicle impact, etc. Nowadays, lighter steel structures are extensively used in building and construction industry. The main advantages of steel structure over reinforced concrete are its intrinsic strength, prefabrication and quicker transportability to the work site and faster erection. With increased use of steel, the varieties of steel sections are used. The Hollow structural sections (HSS) or Structural hollow sections were most reliable one. A hollow structural section (HSS) is a type of metal profile with a hollow tubular cross section. HSS members can be circular, square, or rectangular sections. Corrugated plates have a wide range of application in various engineering fields. They are lightweight, economical, and have much higher load carrying capacities than flat plates, which ensure their popularity and have attracted research interest since they were introduced. The corrugation shape provides continuous stiffening which permits the use of thinner plates. A corrugated plate can easily be bent in one direction, whereas it retains its rigidity in the other direction. Corrugated steel is a building material composed of sheets of hot-dip galvanized mild steel, cold-rolled to produce a linear corrugated pattern in them. The corrugations increase the bending strength of the sheet in the direction perpendicular to the corrugations, but not parallel to them. Normally each sheet is manufactured longer in its strong direction. Corrugated steel is lightweight and easily transported. A trapezoidal corrugated unit is shown in Fig. 1

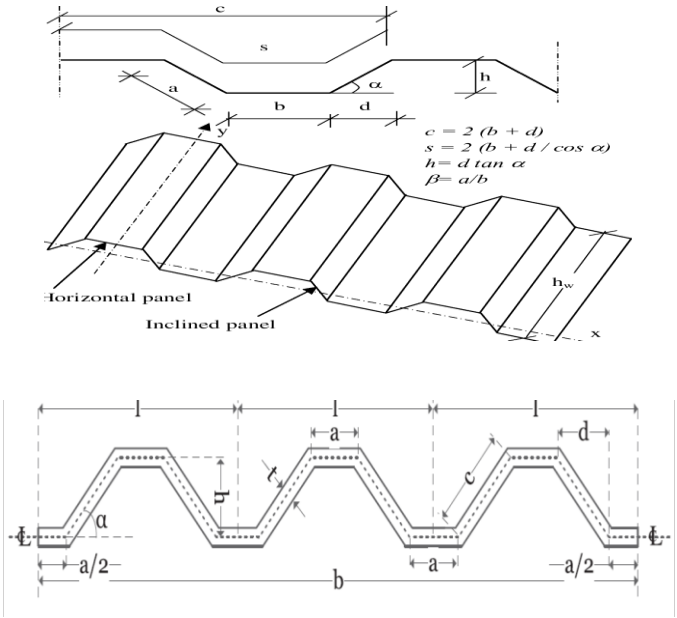



**Fig. 1 A trapezoidal corrugated unit profile**

### 1.1 Methodology

- Conduct literature review on structural performance of hollow corrugated steel columns.
- Modelling and analysis of hollow corrugated steel column and single skin corrugated hollow steel column using middle, diagonal, corner stiffeners

under axial and lateral loading cases using ANSYS 16.1.

- Interpretation of results

## 2. FINITE ELEMENT MODELLING

Modelling of the composite column was done using ANSYS WORKBENCH 16.1. For analysis, two hollow corrugated steel column and six single skin corrugated hollow steel column were used. Hollow corrugated steel column and single skin corrugated hollow steel column were compared and analysed. Material properties are given in Table 1.

### 2.1 FE Model of corrugated hollow steel columns

A trapezoidal corrugated hollow steel column of dimension 210x210 mm having a length of 1 m and having a thickness of 3mm is used. The HSC subjected to two type of loading like axial loading and lateral loading. Lateral loads are applied at top of the column

**Table 1** Parameters considered for modelling

| **Parameters** | **variables** |
|---|---|
| Grade of steel | 250 MPa |
| Type of corrugation | Trapezoidal corrugated profile |
| Type of welding | Butt weld |
| Angle of corrugation α | $45^0$ |
| a | 20 mm |
| b | 210 mm |
| h | 15 mm |
| L | 210 mm |
| I | 24.27x $10^6$ $mm^4$ |
| t | 3 mm |
| c | 21.21 mm |
| l | 70 |

### 2.2 FE model of single skin corrugated hollow steel columns

In SSC HSC models the specimen was strengthened by incorporation of 3 types of stiffeners, corner stiffeners, middle stiffeners, and diagonal stiffeners. All the stiffeners are butt welded inside the column. The material properties of stiffeners used are shown in table 2 the figure of middle stiffened, corner stiffened and diagonal stiffened column is given in fig 2,3, and 4 respectively. Each column is subjected to two type of loading, axial and lateral loading. Lateral loads are applied at top of the column

**Table 2** Material properties of stiffeners used for modelling

| | **Breadth** | **Length** | **Thickness** |
|---|---|---|---|
| **Corner stiffener** | 148.5 mm | 1000 mm | 3 mm |
| **Middle stiffener** | 105 mm | 1000 mm | 3 mm |
| **Diagonal stiffener** | 148.5 mm | 1000 mm | 3 mm |

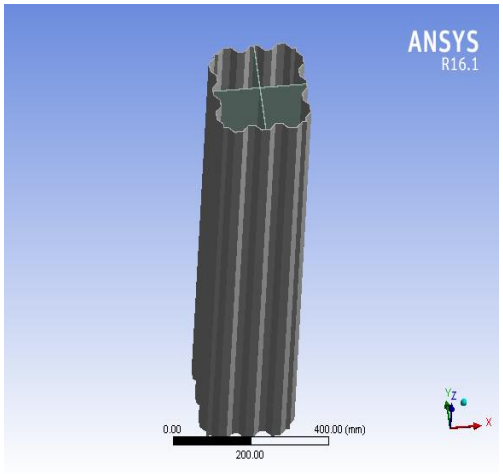



**Fig. 2 Middle stiffened corrugated steel column**

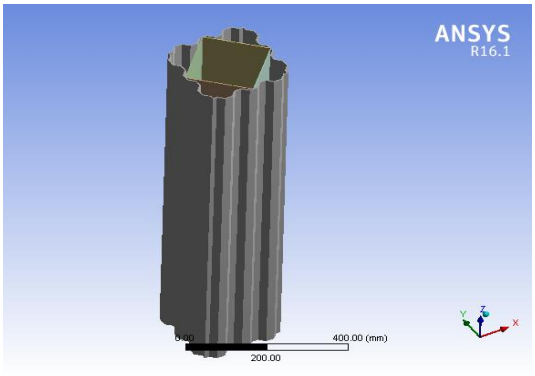



**Fig. 3 Corner stiffened corrugated steel column**

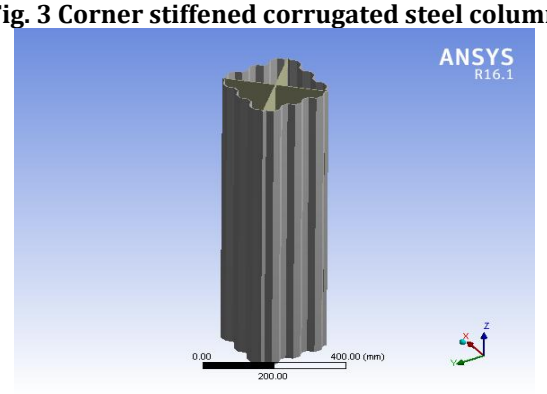



**Fig. 4 Diagonal stiffened corrugated steel column**

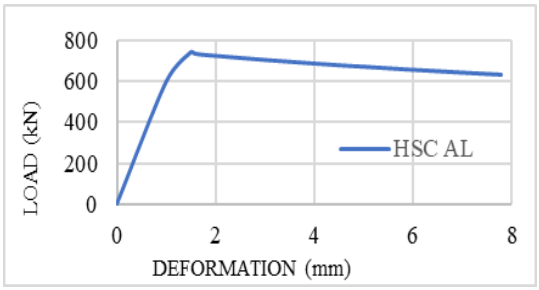
## 3. RESULTS AND DISCUSSION

### 3.1 Analytical results of corrugated hollow steel column

The load intensity is a key parameter for determining the deformation of the column. After analyzing the specimens, the deformations at each and every load were obtained from ANSYS. Non-linear analysis was carried out for all the specimens. Table 3 represents the load-deformation and stiffness values obtained for corrugated hollow steel column under axial loading, and lateral loading cases. Chart- 1 plots the load deformation curve of corrugated hollow steel column models.

**Table 3.** Ultimate loads corresponding deformations and stiffness of HSC models

| Column specimen | Load(kN) | Deformation (mm) | Stiffness (kN/mm) |
|---|---|---|---|
| HSC subjected to axial loading | 740 | 1.5 | 493.33 |
| HSC subjected to lateral loading | 128.17 | 40.12 | 3.194 |



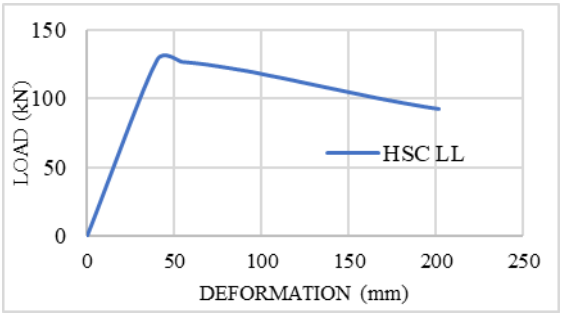




**Chart- 1** Load deformation curve of HSC

### 3.2 Analytical results of single skin corrugated hollow steel column

Table 4 represents the load-deformation and stiffness values and the percentage variation of load intensity of various single skin models with HSC models subjected to axial loading. And table 5 represents the load-deformation and stiffness values and the percentage variation of load intensity of various single skin models with HSC models subjected to lateral loading. Chart-2 plots the load deformation curve of single skin models with various stiffeners under axial loading cases. And the deformed shape of corner stiffened SSC model under axial loading is given in fig 5. Chart-3 plots the load deformation curve of single skin models with various stiffeners under lateral loading cases. And the deformed shape of corner stiffened SSC model under lateral loading is given in fig 6

**Table 4.** Ultimate loads corresponding deformations and stiffness under axial loading

| SSC Column specimen | Load (kN) | Deformation (mm) | Stiffness (kN/mm) | % variation of load intensity with HSC |
|---|---|---|---|---|
| With middle stiffener | 1118 | 14 | 79.85 | 33.81 |

| | | | | |
|---|---|---|---|---|
| with corner stiffener | 1252.1 | 1.60 | 782.51 | 40.89 |
| with diagonal stiffener | 1190.8 | 1.58 | 753.67 | 37.85 |

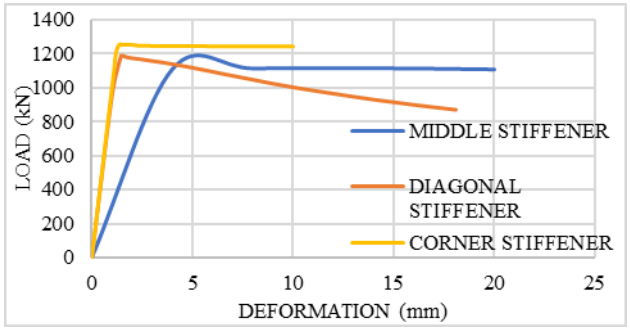



**Chart-2** Load deformation curve of various SSC models under axial loading

It can be seen that the load carrying capacity of columns with stiffeners is improved with respect to HSC. The load carrying capacity of column with corner stiffener is high as comparing to the load carrying capacity of column having other types of stiffeners. The corner stiffener introduced in the column increases the load carrying capacity due to its particular shape. Which indicates that the energy absorption capacity of the column with corner stiffener is more as compared with the columns with other types of stiffeners. Similarly, the corrugation introduced in the column is also enhanced the energy absorption and ductility of the column. The ultimate load of the column with corner stiffener is 1252.1 kN, column with middle stiffener is 1118 kN, diagonal stiffener is 1190.8 kN, it is clear that the stiffener arrangement has great influence in the load carrying capacity. The load carrying capacity of the HSC model sample under axial loading is 740 kN. While comparing with the behaviour of base model the corner stiffened column has improved the load carrying capacity by 40.89%. The corner stiffened column shows more value of stiffness also. The stiffness value of corner stiffened column is 782.51kN/mm. The increasing order of stiffness in the column is, the corner stiffened column has more stiffness then diagonal stiffened column and then middle stiffened column.

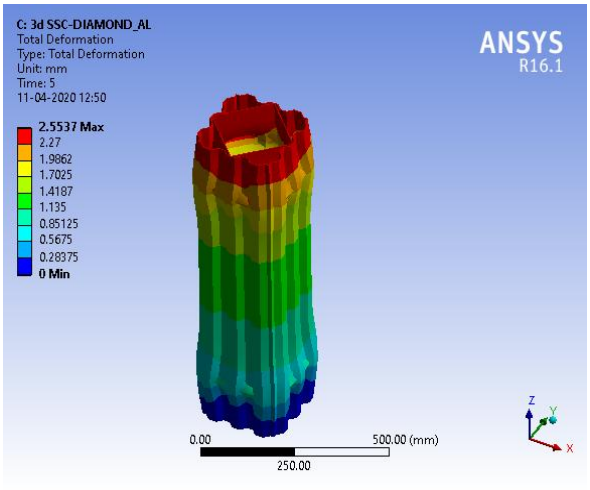



**Fig 5. Deformed shape of corner stiffened SSC under axial loading cases**

**Table 5.** Ultimate loads corresponding deformations and stiffness under lateral loading

| SSC Column specimen | Load (kN) | Deformation (mm) | Stiffness (kN/mm) | % variation of load intensity with HSC |
|---|---|---|---|---|
| With middle stiffener | 164.26 | 129.82 | 1.265 | 21.97 |
| with corner stiffener | 200.9 | 23.854 | 8.42 | 36.20 |
| with diagonal stiffener | 186.39 | 24.59 | 7.57 | 31.23 |

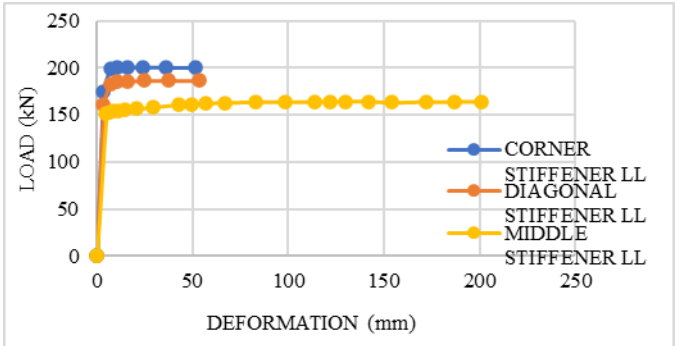



**Chart-3** Load deformation curve of various SSC models under lateral loading

It can be seen that the load carrying capacity of column with corner stiffener is high as comparing to the load carrying capacity of column having other types of stiffeners. The ultimate load of the column with

corner stiffener is 200.9 kN, column with middle stiffener is 164.26 kN, and with diagonal stiffener is 186.39 kN.. The load carrying capacity of the HSC model sample is 128.17 kN. While comparing with the behaviour of corner stiffened column with HSC column the corner stiffened column has improved the load carrying capacity by 36.20%. The corner stiffened column shows more value of stiffness also. The stiffness value of corner stiffened column is 8.42 kN/mm.

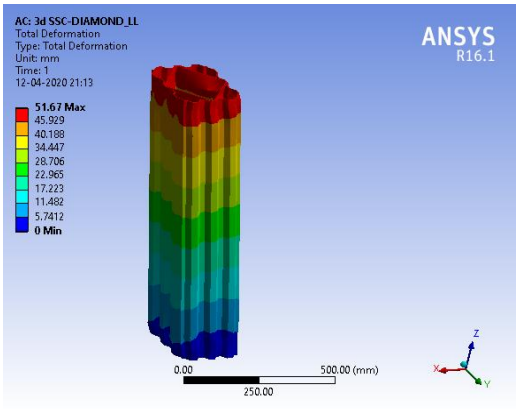



**Fig 6. Deformed shape of corner stiffened SSC under lateral loading cases**

## 4. CONCLUSIONS

The following major conclusions are drawn based on the studies carried out under this investigation.

- The analysis result shows that when the hollow steel column subjected to axial and lateral loading cases, the maximum load carrying capacity is obtained when subjected to axial loading case.
- The load carrying capacity of hollow steel column is improved when stiffeners are incorporated in to the core of them.
- The SSC hollow steel column models exhibit maximum load carrying capacity when corner stiffeners used under axial and lateral loading cases.
- The stiffness of hollow steel column is also improved when the column is strengthened by using corner stiffeners.
- The maximum value of stiffness 782.51 kN/mm which is obtained when the column subjected to axial loading.
- When HSC strengthened by using corner stiffeners the load carrying capacity has been improved by 40.89%,36.20%, under axial, and lateral loading cases.

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