Numerical analysis of connectors in cold formed steel beams for the modular building system

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Abstract – *Recently, using of Cold-formed steel sections in construction have shown rapid growth due to their lightness, high strength and stiffness .They offers easy construction and faster erection. This paper aims to investigate the structural efficiency of modular building beams with innovative sigma sections. The sigma sections have high strength-weight ratios as compared to others. In this study, innovative sigma connectors placed in beams of the modular building and analyze it. Here taken the three sigma sections such as open flange sigma (sigma-1) , closed flange sigma(sigma-2) , closed super sigma(sigma-3) . Moreover, the connectors made up of composite steel–CFRP material and again analyze the building structure. Then comparing the results and optimized section placed into the building*

Key Words: Cold-formed sections, ANSYS, optimization, CFRP, Steel, sigma sections, numerical analysis

1. INTRODUCTION

Cold-formed steel members are widely used in the construction industry. These CFS sections are thin and light-weight. There erection and installation procedure is very easy and transportation cost is lower as the light-weight sections are available. Being light weight and able to provide high performance structurally, cold-formed steel sections are suitable for building construction. With thickness ranges from 1.2 mm to 3.2 mm and yield strength of from 250 to 450 N/mm^2.There are mainly design recommendations of cold-formed steel sections available for application in building constructions such as AISI and Euro code 3: PART 1.3. light steel framing is referred to as steel frame building constructed with galvanized cold-formed steel sections as one of the industrialized building systems ,light steel framing has become a popular construction choice in low to medium rise building and residential house construction.

2. MODELLING OF SPECIMENS

The connector of various sigma sections are taken from European Standard EN 1993-1.Eurocode 3: Design of steel structures: part 1-3.The model was formed in ANSYS Workbench 2022. Material ``properties and section dimensions are discussed below.

2.1 Material Properties

Steel consist of following properties.

Poisson s ratio = 0.3

Yield strength =450MPa

Young's modulus =2 x10^{11}Nm^{-2}

Steel-CFRP composite consist of following properties.

Poisson's ratio =0.48

Density =9.27x10^{6} kgmm^{-3}

Thermal conductivity = 6.05 x10^{-2}

2.2 section properties

Section is made up of steel and steel-CFRP composite. Here three innovative models of sigma sections such as open sigma section, closed super sigma section, closed flange super sigma sections are used for the analysis.

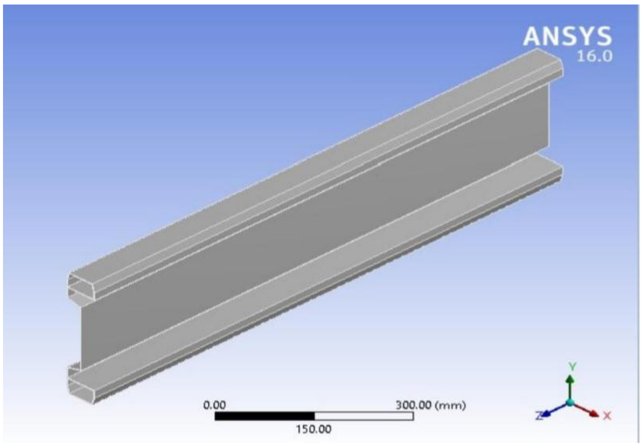

Fig 1: Geometrical Diagram

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

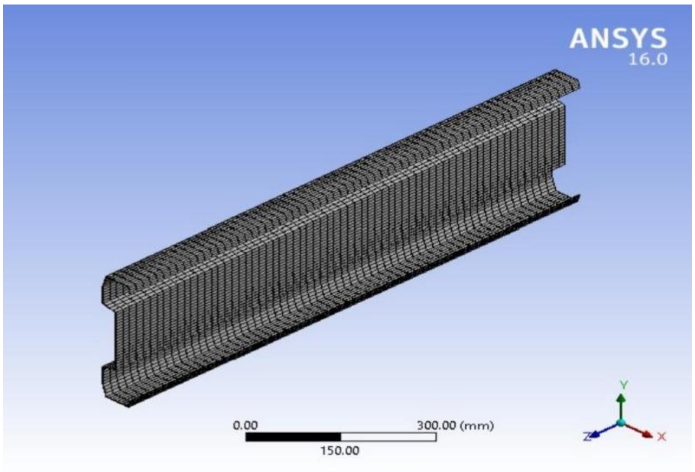

Fig 2: Meshing Diagram

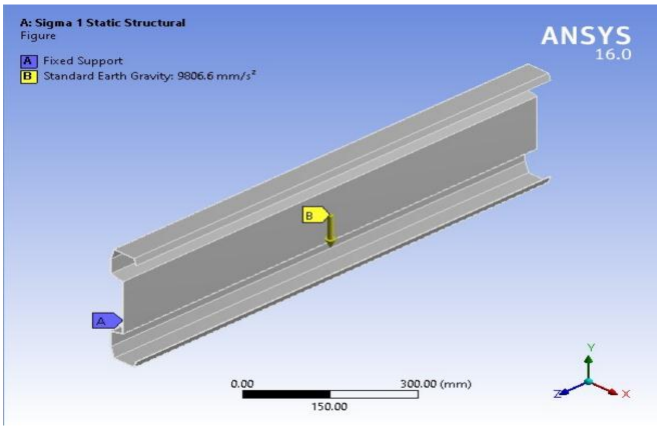

Fig 3: Loading and supporting Diagram

3. NUMERICAL ANALYSIS

The various model of sigma section is to be taken. The model was analyzed using ANSYS software. Here thermal, structural, explicit analysis was carried out in the sigma sections

3.1 Structural Analysis

The connectors of various sigma sections using the material steel-CFRP composite was taken for the analysis. The deformation and stress shall be determined.

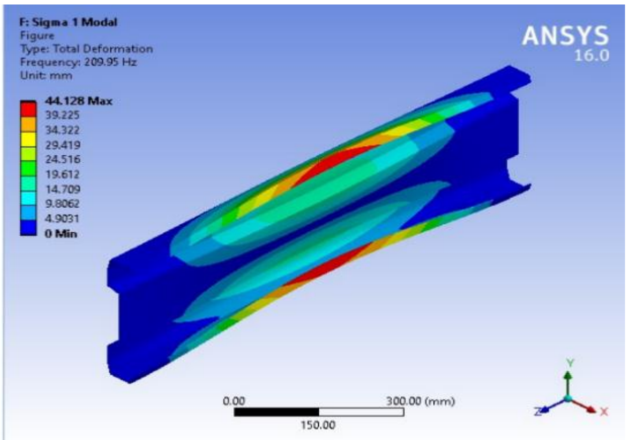

Fig 4: Deformation of open sigma section

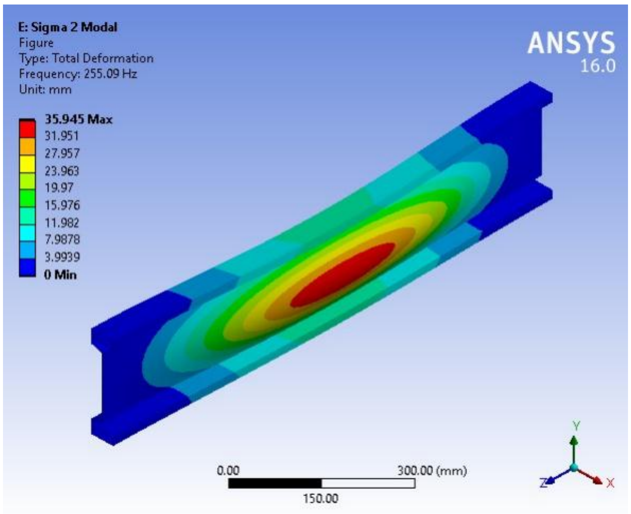

Fig 5: Deformation of closed super sigma section

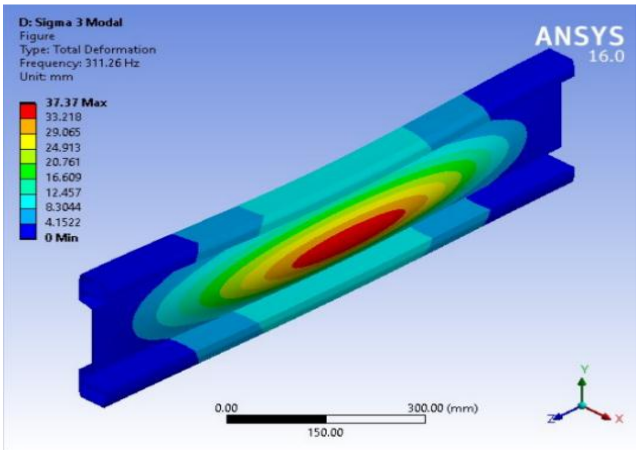

Fig 6: Deformation of closed super sigma section

From the analysis, open sigma sections whose deformation about 44.128mm, closed super sigma section and closed flange section are 35.99 mm, 37.37mm respectively.

3.2 Explicit Analysis

Stress due to blast load is to be analyzed. Here 1Kg TNT is used for the analysis and obtained the equivalent stress in each of the sigma section.

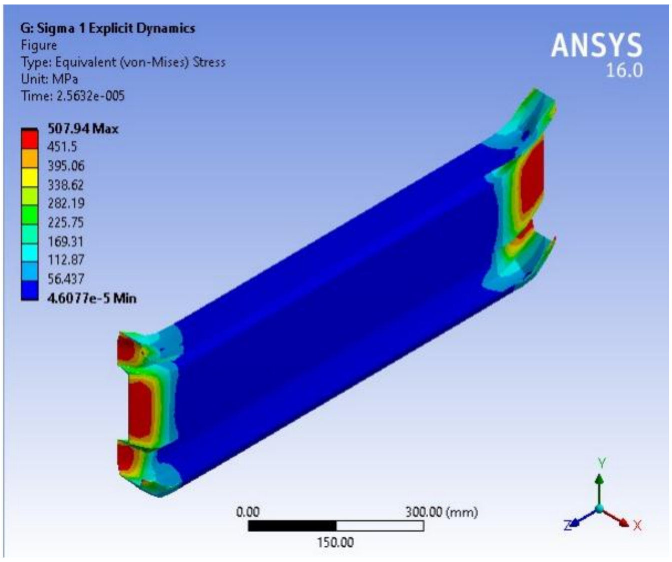

Fig 7: Stress in open sigma section

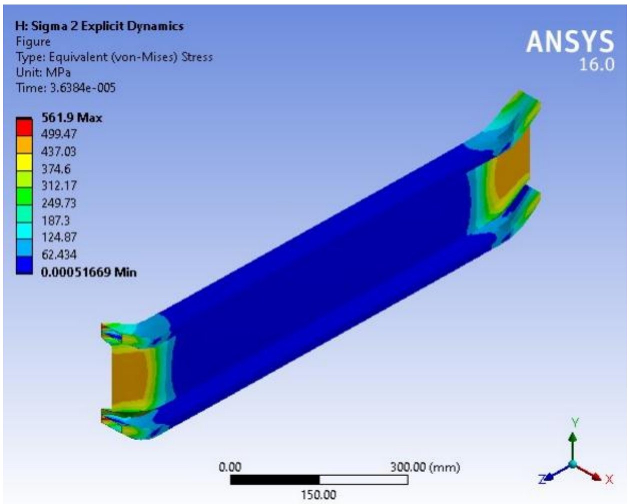

Fig 8: Stress in closed super sigma section

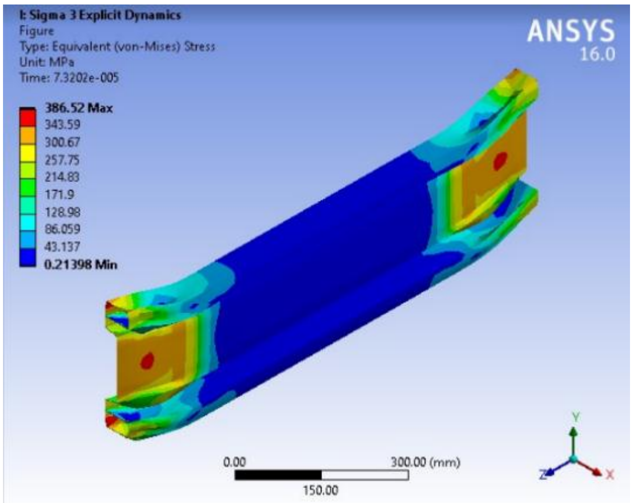

Fig 9: Stress in closed flange super sigma section

4. COMPARISON OF RESULTS

The results obtained from the numerical analysis of composite connectors such as open sigma , closed sigma and closed flange super sigma are compared below.

Table -1: comparison of various sigma sections

Sections	Deformation (mm)	Stress (MPa)
Open sigma section	44.128	507.94
Closed super sigma section	35.945	561.9
Closed flange super sigma section	37.37	386.52

From the numerical analysis, the maximum stress was obtained in the closed flange super sigma section and the value is 561.9 MPa.

5. Optimization of Connectors in Modular Building

The different sections were analyzed and the suitable section was selected for the further analysis of building. Then, obtain the stress and deformation of the structure.

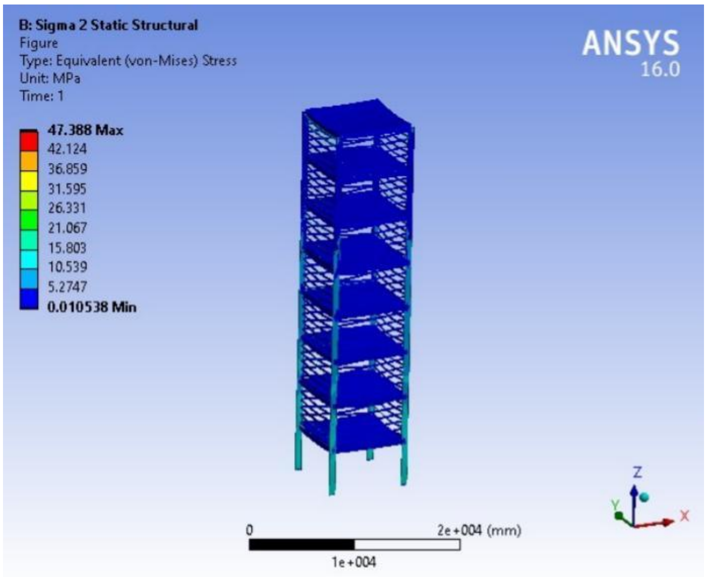

Fig 10: Stress in closed super sigma section

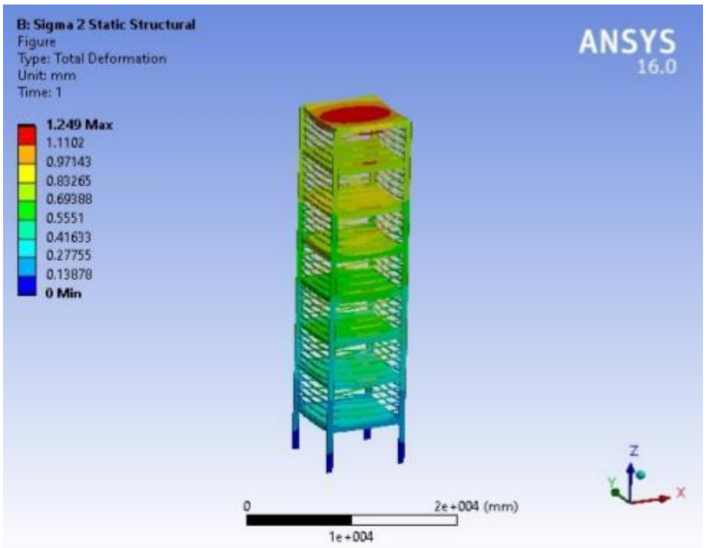

Fig 11: Stress in closed super sigma section

6. CONCLUSIONS

From this , the behavior of steel-CFRP composite connector is better than the normal structural steel. In modern construction all the components get modular and it get attached with the connectors to get assembly all the section. This method of construction is reliable and easy to get operate and reduces the resources consumption and cost.

- In structural steel, closed flange sigma section as compared to open flange section deformation varies 28.9 % and closed flange super sigma 51 % respectively
- In open flange sigma section the heat flux value is $1.8322x10^{-2}$W/mm^2
- In closed super sigma section the heat flux value is $5.99x10^{-12}$ W/mm^2
- In closed flanged super sigma section the heat flux value is $2.902x10^{-12}$ W/mm^2
- In closed super sigma section whose deformation is 0.313 mm and corresponding stress is 561.9MPa.
- In closed flange super sigma section whose deformation is 0.667 mm and corresponding stress is 386.52 MPa.
- In the case of building, the minimum deformation is 1.249 mm and stress about 47.388 MPa

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