Behaviour of Cold Formed Steel Column with Complex Edge Stiffened Web Openings

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Abstract. Cold-Formed Steel (CFS) sections have gained in popularity due to numerous favourable properties, and with continued research into the various restrictions of such members, their utility in the construction industry has increased dramatically. CFS sections were widely utilised in structural and non-structural applications as they offer lightweight constructions, high strength-to-weight ratios, greater stiffness due to improved sectional profiles, simplicity of installation and assembly, and so on. Optimising these CFS aspects will enable the building of structures at extremely cheap costs. Buckling occurs when the column strength exceeds the cross-section yield. Owing to CFS material characteristics, edge or double stiffeners are used as a best strategy for strengthening the CFS. The primary objective of this research is to examine the strengthening method for CFS G-section columns with edge stiffened hole sections using CATIA software. The results suggest that adding edge reinforced holes to the column enhances its rigidity. The test findings revealed that CFS channel sections with edge-stiffened web apertures had a greater compression resistance than plain channel sections. The G section column with three edge reinforced holes has a low stiffness and utilised as a support element in seismically active structures.

1 Introduction

Within the realm of cold-formed thin-walled steel (CFTWS) components, C- and Z-sections are prevalent in residential, commercial, and industrial construction. Unlike C-section columns, which are characterized by lipped channels, G-section columns exhibit an additional inward return lip [1]. Consequently, G-sections fall into the category of channels with intricate edge stiffeners. In contrast to C-section columns, G-section columns boast a superior elastic buckling stress and ultimate load-bearing capacity [2]. It's widely acknowledged that distortional buckling is disadvantageous due to its reduced post-buckling resilience and heightened sensitivity to imperfections, compared to local buckling [3]. The presence of complex edge stiffeners enhances the rotational restraint of the flange, rendering the column more resistant to distortional buckling a primary motivation for utilizing complex edge stiffeners [4].

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The utilization of cold-formed steel (CFS) channel sections is gaining popularity as load-bearing components in building structures. These channel sections often incorporate web openings to facilitate the installation of various services. Traditionally, web openings have been created through punching and are left unstiffened, which can limit the size and spacing of these openings [5]. Recently, a new generation of CFS channel sections featuring edge-stiffened web openings has emerged and found widespread use in New Zealand. However, there is a noticeable absence of experimental investigations in the existing literature regarding the compression behavior of such channel sections [6,7,8,10]. This study presents a comprehensive analysis, comprising a total of seven results, including three axial compression tests and seven finite element analysis outcomes. The focus is on assessing the compression resistance of CFS channel sections, specifically G-section columns, equipped with both edge-stiffened and unstiffened web openings. The primary objective of this study is to design the different CFS G-section column with edge stiffened holes sections with Catia Software and to investigate the structural analysis of CFS G-section column [9] with edge stiffened holes.

2 Geometry of the Specimen

In this study, a total of 3 CFS channel sections were tested to failure under axial compression in ANSYS. Nominal cross-sections and longitudinal sections of test specimens considered in this paper are shown in fig 1 and 2.

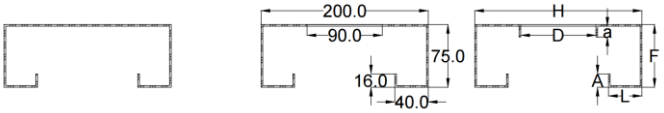

Fig. 1. Top view of Stiffened G-section columns.

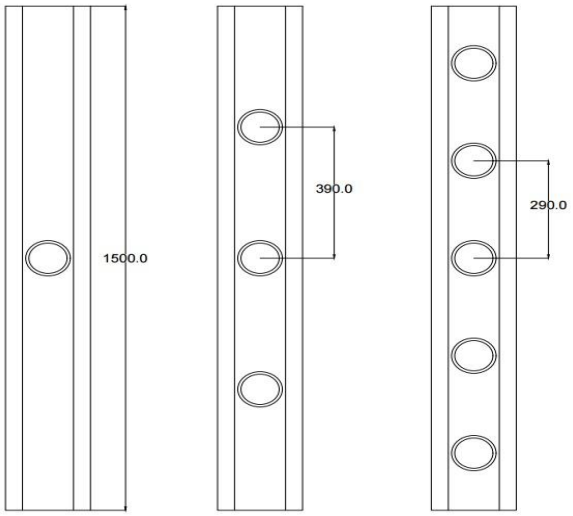

Fig. 2. Front view of Stiffened G-section columns.

3 Modelling of Column using CATIA

CATIA, developed by Dassault Systems is a robust multi-platform software suite used for computer-aided design (CAD). It enables the creation, simulation, analysis, and optimization

of complex 3D designs. Its features include parametric and surface modelling, assembly design, and drafting, making it a powerful tool for comprehensive product development and visualization.

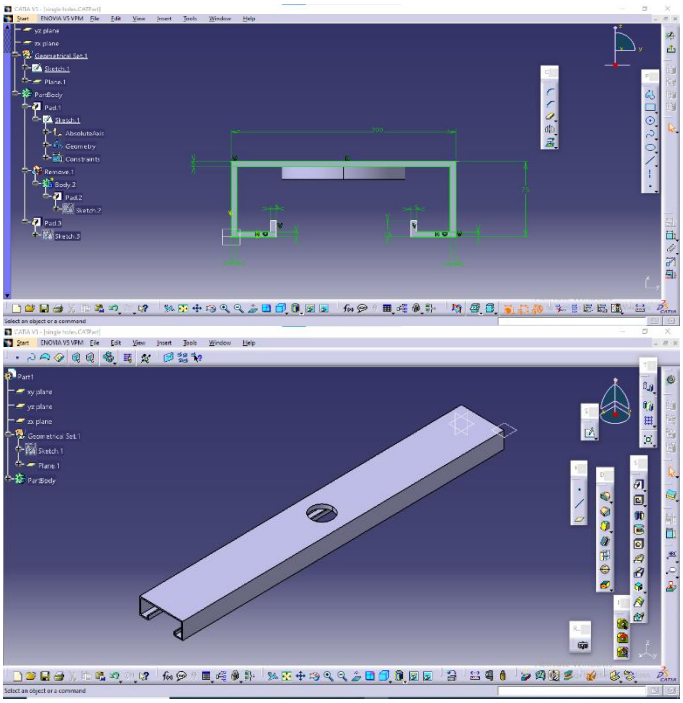

Fig. 3. Top and Front View of Stiffened G-section columns with single hole.

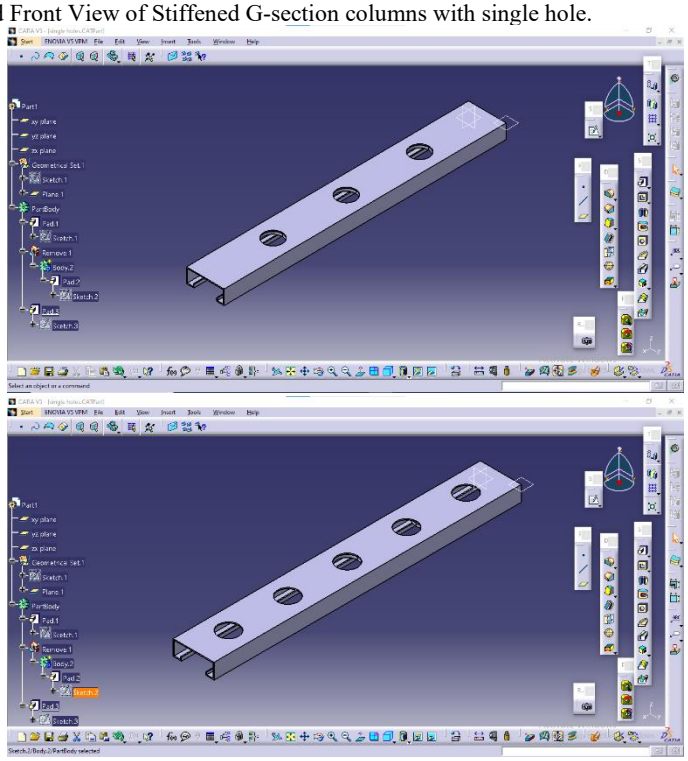

Fig. 4. 3D View of Stiffened G-section columns with three and five holes.

The G section column with edge stiffened single hole model is modelled in CATIA and imported to ANSYS, Design modeler. Figure 3 shows the geometry of the stiffened single hole column. The Geometry of specimen, the G section column with edge stiffened three hole model is modelled in CATIA and imported to ANSYS, Design modeler. Figure 4 shows the geometry of the stiffened three and five holes column.

4 Analysis of Column using ANSYS

For the analysis of column using ANSYS, the input parameters assigned are the mechanical properties of column section such as density, poisson's ratio, bulk modulus, young's modulus, shear modulus, tensile strength, compressive strength under the engineering data as per code IS 513:2008 are assigned. The Table 1 shows the material property for Steel of Grade IS 513.

Table 1. Properties of Steel (Grade IS 5130).

Property	**Value**	**Unit**
Density	7850	Kg/m^3
Young's modulus	2×10^5	N/mm^2
Poisson's ratio	0.3	-
Bulk modulus	1.67×10^5	N/mm^2
Shear modulus	7.69×10^5	N/mm^2
Yield strength	240	N/mm^2
Tangent modulus	1450	N/mm^2
Tensile yield strength	240	N/mm^2
Compressive yield strength	240	N/mm^2
Tensile ultimate strength	370	N/mm^2

The end of the column is assigned as a fixed support condition at bottom. and the axial compressive force of 1000N is applied from the top end. The Total deformation of the column is calculated by the substantial increase of loading of 20 N. Figure 5 represents the Total Deformation of G-section Column with Edge Stiffened web opening with single, three and five Holes.

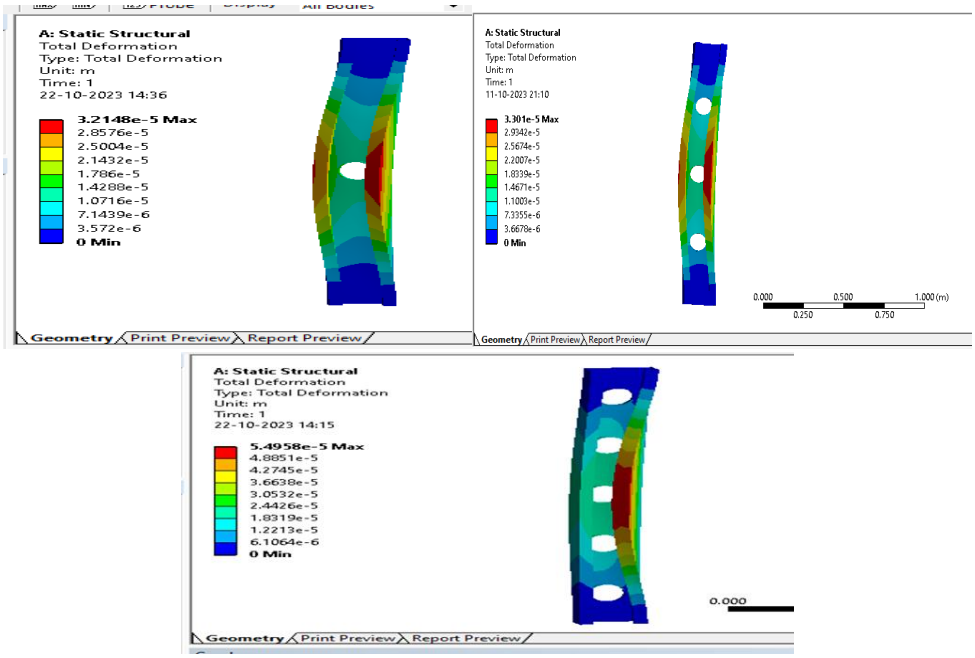

Fig. 5. Total Deformation of G-section Column with Edge Stiffened web opening with single, three and five Holes.

5 Results and Discussion

The structural performance of G section-edge stiffened column is studied, results between edge stiffened single hole column, edge stiffened three holes column and edge stiffened five hole column under axial compression is compared. The fig 6 shows the graphical representation of the results obtained in ANSYS.

From figure 6, the variation of normal stress for G-section edge stiffened column with single hole is observed to be higher than G-section column stiffened with three and five holes. The equivalent stress for G-section edge stiffened column with five hole is found to be higher than G-section column stiffened with one and three holes. The variation of normal elastic strain for G-section edge stiffened column with single hole is observed to be higher than G-section column stiffened with three and five holes. The variation of equivalent elastic strain for G-section edge stiffened column with five hole is observed to be higher than G-section column stiffened with one and three. The directional deformation and total deformation for G-section edge stiffened column with single hole is observed to be minimal than G-section column stiffened with three and five. The findings of the investigation reveals that the column stiffened with single hole has high resistance to compression. Increase in the number of stiffened holes in the Cold forms steel column decreases the rigidity or stiffness property, thereby reduces the durability of the column members.

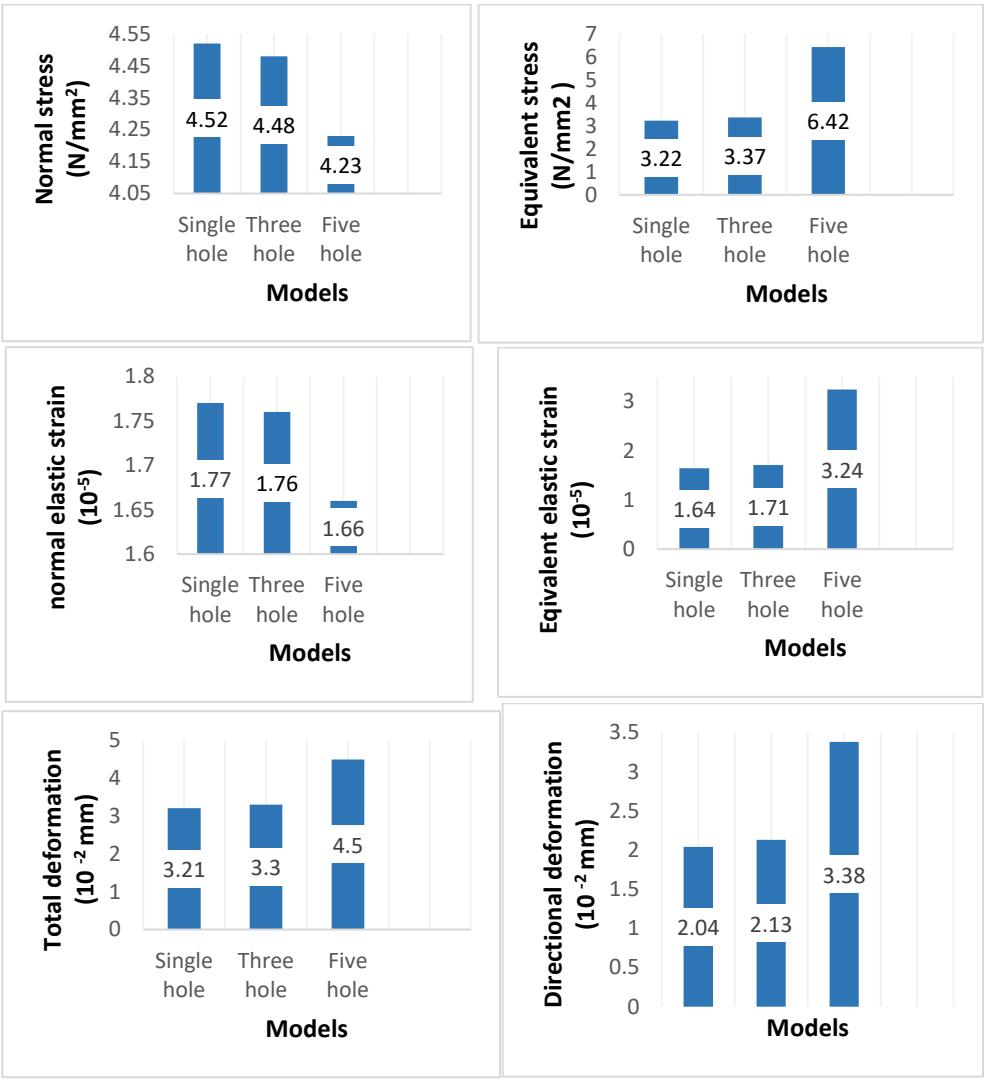

Fig. 6. Stress, Strain and Deformation Characteristics of Stiffened G-section columns with Single, three and five holes.

6 Conclusion

The nature of the G section column is better than the conventional channel with lipped in buckling properties. The column with edge stiffened holes improves the stiffness of the column. The test results showed that for the case of CFS channel sections having edge-stiffened web openings, the compression resistance was higher than the plain channel sections. The G section column with edge stiffened single hole has high compression resistance can be used as a support member in buildings. The G section column with edge stiffened three holes has low stiffness can be used has a support member in buildings to be built in seismic zones.

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