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FLEXURAL BEHAVIOR OF PAIRS OF LAMINATED UNEQUAL CHANNEL BEAMS WITH DIFFERENT INTERFACIAL CONNECTIONS IN CORNER-SUPPORTED MODULAR STEEL BUILDINGS

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Abstract: In this study, the combined bending action of pairs of laminated unequal channel beams with different interfacial connections was introduced into corner-supported modular steel buildings to enhance the interactions between the adjacent beams and modules in modular buildings. These laminated beams consist of C sections acting together by bolts through their flanges. First, a series of experiments were conducted on three laminated beams, i.e. a channel beam with simple interfacial contact interactions (LB-C), a channel beam with four additional shear bolt connections (LB-C-4B), and a channel beam with eight shear bolt connections (LB-C-8B). Mechanical testing on an independent bending channel beam (ICB) was also performed as a control specimen to evaluate the structural performance of LB-C, LB-C-4B, and LB-C-8B, respectively. To further understand the flexural behavior of the laminated unequal channel beams, finite element models of the beams were developed and validated by using the experimental results. The results show that the mechanical performance of LB-C, LB-C-4B, and LB-C-8B is significantly better than that of ICB. In addition, the failure modes of the laminated beams are largely dependent on the stiffness of the interfacial connection between the floor and ceiling beams. Strengthening the interfacial interactions could enhance the flexural performance of the laminated beams. Most importantly, this study presents an analytical procedure for rapid prediction of the initial bending stiffness of the laminated beams.

Index Terms **–FEA**

1. INTRODUCTION.

General Background

Due to their revolutionary prefabricated building structure, reduced construction time, low impact on the environment, low cost, and high quality, modular steel buildings (MSB) are a popular choice for urban development. Because it allows for the creation of open-plan areas and has a clear load transfer in the structural system, corner-supported MSB is employed in healthcare and educational institutions. In corner-supported MSB, three pairs of laminated unequal channel beams with various interfacial connections were used: a channel beam with simple interfacial contact interactions (LB-C), an LB-C with four additional shear bolt connections

(LB-C-4B), and an LB-C-8B. Finite element models of the beams were created and verified using the experimental data in order to better understand the flexural behavior of the laminated unequal channel beams. This demonstrates that the mechanical performance of the LB-C, LB-C-4B, and LB-C-8B is notably superior to that of an isolated bending channel beam. Additionally, the stiffness of the interfacial connection between the floor and ceiling beams has a significant impact on the failure modes of the laminated beams.

2. OBJECTIVE

To analyze the flexural performance of channel beams with appropriate dimensions.

To investigate the efficiency of web positioning and opening in order to conduct a more thorough analysis of stability

SCOPE

MSB joints mainly use interconnection plates or plug-in devices, which ignore the practical difficulties to hoist and install the modular unit. Some of the challenges faced by MSB are the need for lightweight materials, more access space, transportation facilities, and fire and energy performances associated with their use are yet to be addressed.

2.1 To investigate the flexural performance of channel beams with appropriate dimensions.

RESULTS AND DISCUSSIONS

To analyze the flexural performance of channel beams with appropriate dimensions

Parametric study of channel sections modeling and analysis.

S. NO	LENGTH(L)	BREADTH(B)	L/B RATIO
1	315mm	150mm	2.1
2	330mm	150mm	2.2
3	345mm	150mm	2.3
4	360mm	150mm	2.4
5	375mm	150mm	2.5

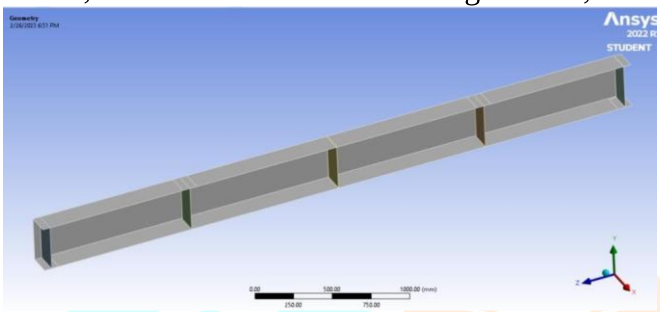
Table 2.1 Dimensions of the section

In ANSYS, many models are developed and examined. Parametric research uses channel sections. Consideration is given to channel section web sizing. Five models are created for this, and the outcomes are compared.

C section	Yield strength - 351kg/m3
	Tensile ultimate strength - 409kg/m3
	Elastic modulus Ec – 205 × 1010 Pa
	Bulk modulus, B – 1.708 × 1011 Pa
	Poisson’s ratio, μ – 0.3

Table 2.2 Dimensional details of section

A channel portion measuring 315mm, B a channel section measuring 330mm, C a channel section measuring 345mm, D a channel section measuring 360mm, and E a channel section measuring 375mm. Shell 181 elements



used Shell 181 elements are used.

Fig-1 Geometry of the section having web length 315mm

2.1 .1 Boundary Condition

Both ends of the boundary condition are hinged. The upper edge is where the loading is applied. Each model's boundary condition is the same. Horizontal movement is prohibited

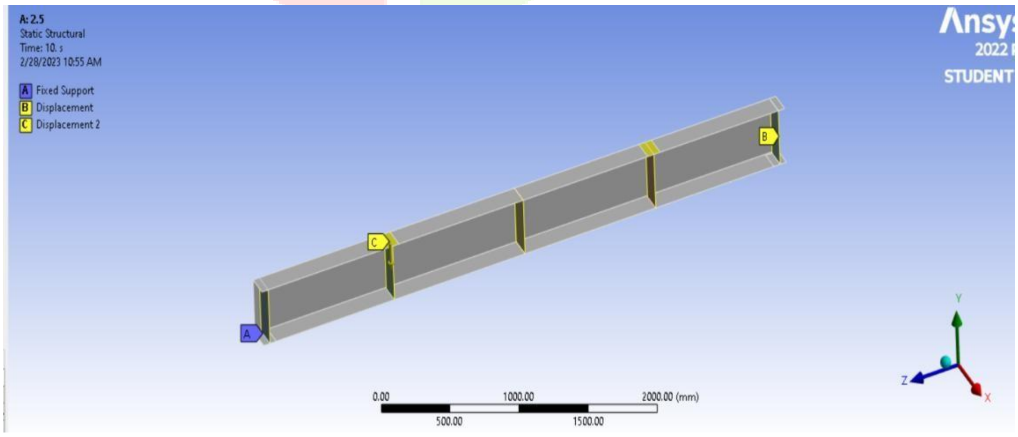


Fig-2 Boundary condition of the section with length 375mm

2.1.2 Meshing

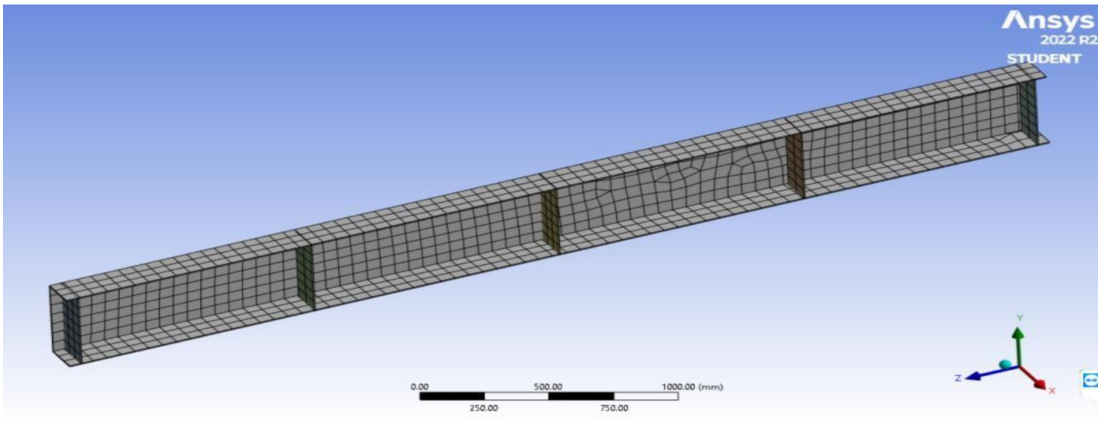


Fig-3 Mesh generated in the section having 375mm length

2.1.3 Results

Analyses are done on all five models. It is possible to acquire the resulting deformation diagrams and equivalent stress diagrams. Chart.1 and Chart.2 display the deformation and equivalent stress diagrams for the models The maximum value of equivalent stress is 353.98Mpa. Maximum equivalent stress occurredat the center. The minimum value of equivalent stress is 0Mpa.

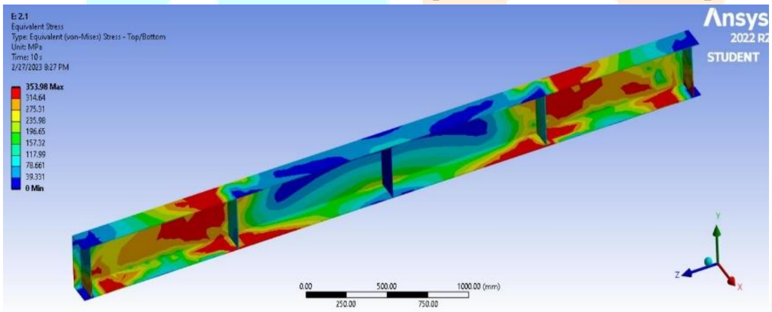


Fig-4 Equivalent stress

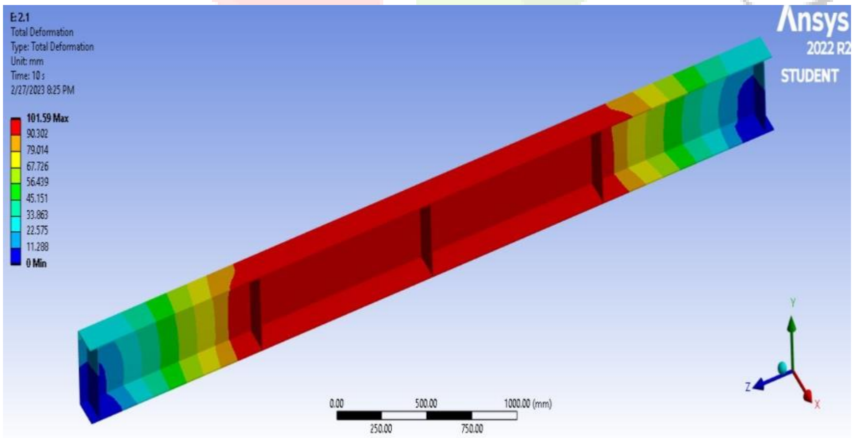


Fig-5 Total deformation

The total deformation is shown in **Fig-5.** Maximum deformation is at the center shown in yellow to orange shades and minimum at the edge shown in blue shades. The maximum total deformation is about 101.98mm.

2.1.4 Comparison of Results

Equivalent stress comparison

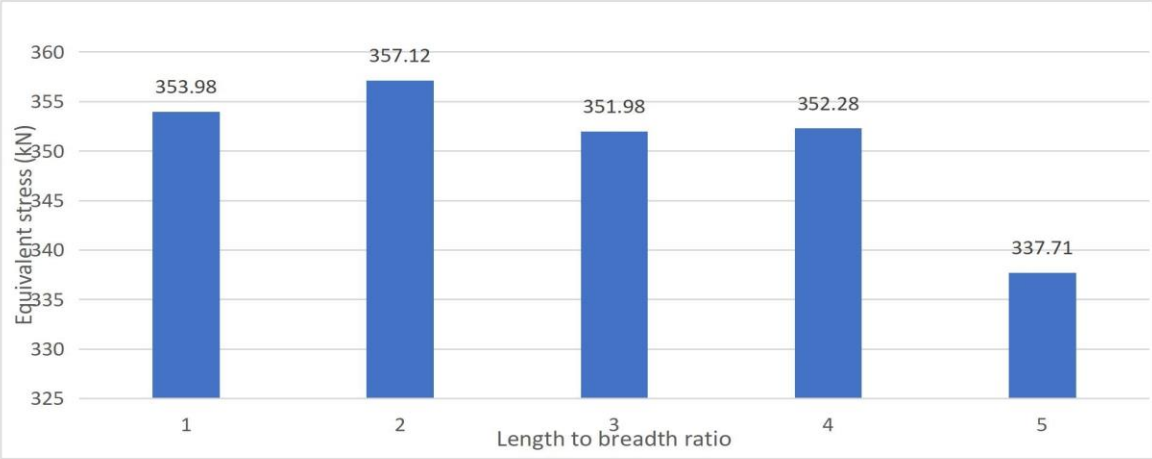


Chart.1 Equivalent stress comparison

Chart.1 shows the equivalent stress of the five models. The section with length to breadth ratio 2.5 has the least stress with a value of 337.71KN and the section with length to breadth ratio 2.2 has the highest stress value of 357.12KN.

Chart.2 shows the load-deflection diagrams. Higher load-carrying capacity is obtained for sections with a higher aspect ratio. A symmetric wave is obtained for load-carrying capacity.

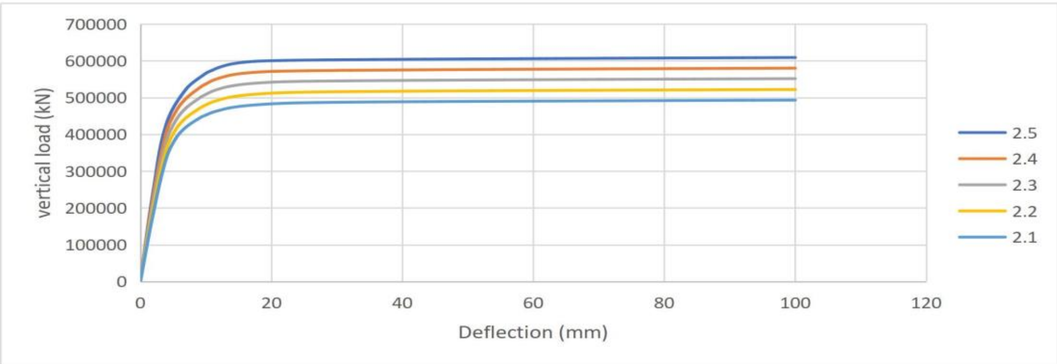
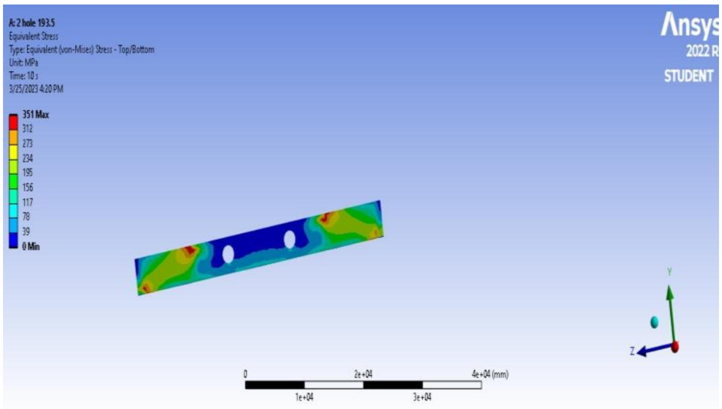


Chart.2 Comparison of load-deflection diagram of the section with a length

2.2 To investigate the efficiency of web positioning and opening to conduct a more thorough analysis of stability

Circular web openings are provided. Diameters of the web section are

1. 197.37mm diameter 2. 201.24mm diameter
3. 189.63mm diameter 4. 185.76mm diameter



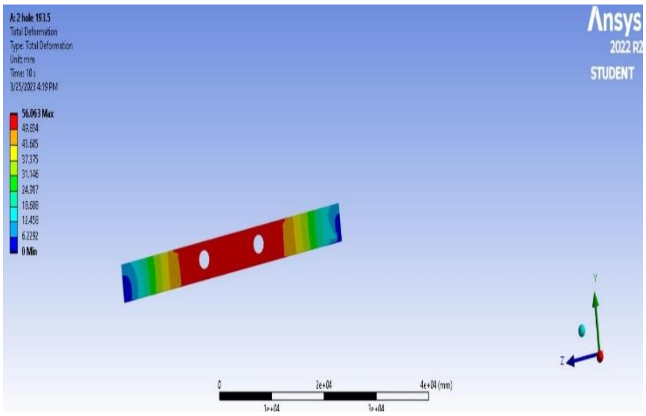
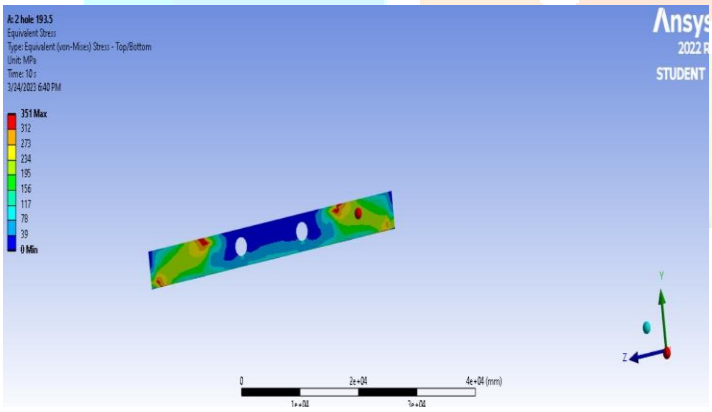


Fig.6 Equivalent stress in the section having a diameter of 197.37mm with two holes **Fig.7** Total deformation in the section having a diameter of 197.37mm with two holes



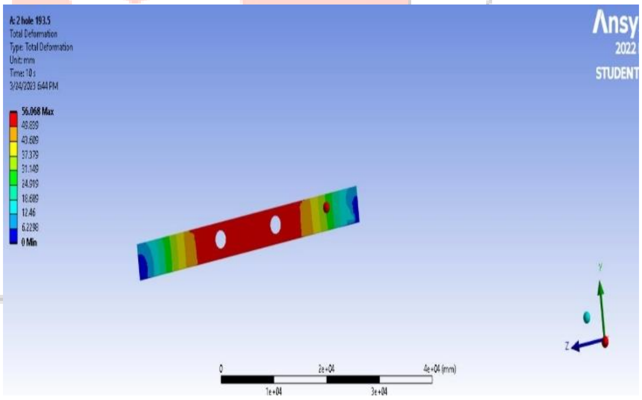
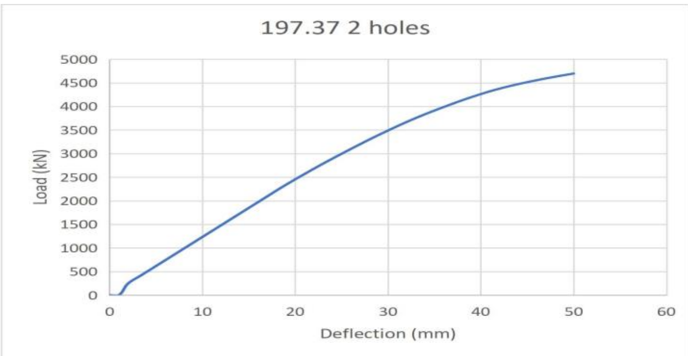


Fig.8 Total deformation in the section having a diameter 201.24mm with 2 holes
Fig.9 Total deformation in the section having a diameter 201.24mm with 2 holes



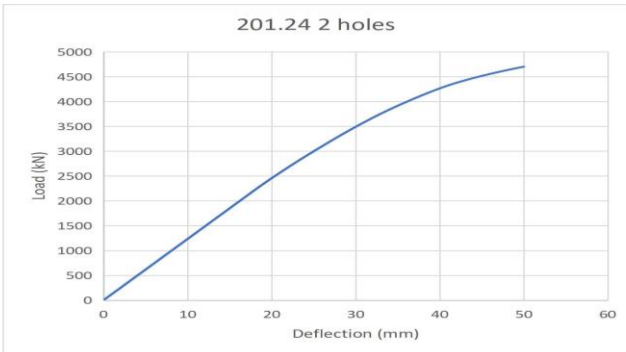
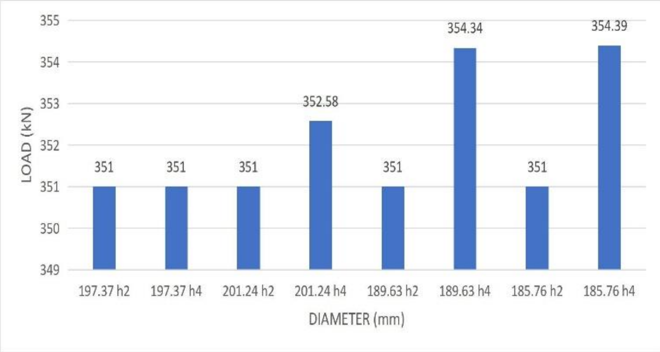


Fig.10 Load deflection diagram of web section with diameter 201.24mm with two holes.
Fig.11 Load deflection diagram of web section with diameter 197.37mmwith two holes



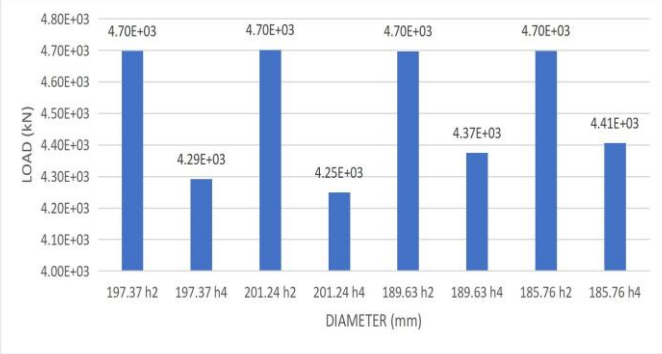


Fig.12 Comparison of equivalent stress of section with diameters
Fig.13 Comparison of load carrying capacity

3. CONCLUSION

All five models are analyzed and their load-deflection behavior is studied. Among these, we have to choose an optimum model with a higher load-carrying capacity. Load carrying capacity is a symmetric wave. The load-carrying capacity is increased as the aspect ratio is increased. But stress values are in disorder. By stress failure theory, lower stress is better. The C section with an aspect ratio of 2.5 shows the least value of stress with 337.71kN. The difference in stress between sections with aspect ratios 2.1 and 2.3 is minimum, but a large difference in stress is obtained for sections with aspect ratios 2.2 and 2.5. Also, the C section wan with an aspect ratio of 2.2 has a higher stress value of 357.12kN. Therefore, the C section with an aspect ratio of 2.5 is taken as the optimum model. Circular web openings are provided on C sections with diameters 197.37mm, 201.24mm, 189.63mm, and 185.76mm. Circular web openings usually absorb energy and have higher load-carrying capacity. As whole diameter varies stress is higher and lower values which stress is not Increasing in a symmetric manner. Web openings with a diameter of 185.76mm with two holes is having less equivalent stress and more load-carrying capacity. Web openings of C sections with less stress and higher load-carrying capacity are better.

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