

Analytical Investigation of Cold-Formed Steel Built-Up Columns with Various Section Configurations under Static Loading

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Abstract - Cold-formed steel (CFS) combines a lightweight nature with superior load-bearing capability, making it a preferred choice for modern structural applications. This study utilizes finite element analysis through ANSYS to investigate the behavior of built-up CFS members—specifically back-to-back (B2B) and back-to-back with lip stiffener (B2B+C1) arrangements—developed in accordance with AISI specifications. Accurate meshing and controlled loading conditions were applied to simulate both axial and bending responses, allowing for precise observation of stress distribution and deformation characteristics. The comparative study reveals that the lip-stiffened model achieves around a 15% increase in ultimate capacity while reducing deflection. These findings provide valuable insights for refined design practices, enhancing the performance and dependability of CFS systems in structural engineering.

Key Words: Built-Up Sections, ANSYS, AISI Standards, Cold-Formed Steel, Finite Element Analysis, Back-to-Back Configuration, Stress Distribution, Deformation Analysis, Structural Optimization

1. INTRODUCTION

Cold-formed steel (CFS) has seen significant adoption in the construction industry due to its distinct benefits over conventional materials. Its light weight, high strength-to-weight ratio, cost efficiency, and long-lasting performance make it a preferred choice for various structural applications. CFS sections are generally slender, with thicknesses ranging from about 0.75 mm to 4 mm, and commonly exhibit yield strengths between 230 MPa and 340 MPa. To enhance their corrosion resistance, these sections are often coated with zinc or zinc-aluminum alloys.

In most applications, CFS serves as secondary structural components such as roof purlins, side rails, partition studs, and wall claddings. These members are typically joined using screws, bolts, rivets, or specially designed fasteners. The performance of the structure is heavily influenced by the selection and layout of these connectors, as they facilitate the transfer of loads and moments between primary framing and support elements. In certain cases, supplementary stiffeners or specialized connections are incorporated to optimize load transfer.

This analytical study focuses on evaluating the structural behavior of built-up CFS columns and beams under combined thermal and mechanical loads. Unlike hot-rolled steel, CFS is produced at ambient temperature by shaping thin steel strips or sheets into specified profiles without applying external heat. Manufacturing processes, such as continuous roll forming or press braking, are used to create lipped channels (C-sections), Z-sections, angles, and other advanced built-up section profiles

1.1 Cold formed Steel

Cold-formed steel (CFS) is produced by mechanically shaping thin steel sheets into specific profiles at ambient temperature. Unlike the hot-rolling process, which requires high-temperature deformation above the recrystallization point, cold forming retains the original microstructure of the steel, resulting in distinct mechanical and geometric advantages. These characteristics include:

- Low self-weight
- High strength-to-density ratio
- Excellent dimensional accuracy
- Smooth and uniform surface finish

1.2 Cold Formed Build-up Member

Built-up sections are formed by connecting two or more cold-formed steel (CFS) profiles—commonly channel sections—using screws, bolts, or welds so that they function as a unified structural element. This assembly enhances overall strength, stiffness, and stability compared to individual members. In column applications, channels are typically joined either back-to-back or face-to-face, while in beams, lipped channels are spaced and fastened together to effectively resist bending forces.

The structural response of built-up CFS members is largely influenced by the detailing of their connections, including:

- Screw spacing
- Number of screws per unit length
- Edge distance from screw lines
- Staggered or aligned screw layout

2. OBJECTIVES

- To evaluate the structural performance and buckling behavior of built-up cold-formed steel sections under axial loading using finite element analysis in ANSYS.
- To examine the effects of geometric parameters, such as screw spacing and connection types, on the stability and load-carrying capacity of cold-formed steel built-up columns.
- To establish reliable design criteria and propose optimization strategies for cold-formed steel built-up members that improve safety, efficiency, and economic feasibility in modern construction practices.

3. METHODOLOGY

This research presents a detailed finite element study of built-up cold-formed steel (CFS) sections subjected to combined static and thermal loads. Different configurations, including back-to-back and stiffened assemblies, were precisely modelled with accurate geometry and material properties using SolidWorks and ANSYS. Simulations incorporated linear elastic behaviour and fixed boundary conditions to reflect real structural scenarios. Loading conditions considered axial compression, bending, temperature increases, and varying screw spacing's to evaluate connection effects. Critical regions were carefully meshed to ensure result accuracy, and both linear and nonlinear buckling analyses were performed to determine failure points and load limits. The models were validated through comparisons with experimental data and design standards. Parametric investigations demonstrated how design choices, screw arrangements, and thermal factors influence strength, stiffness, and stability, providing practical insights for optimizing CFS built-up members in lightweight steel construction.

4. OBSERVATION AND RESULTS

The study investigates the structural performance of cold-formed steel (CFS) built-up members, focusing on back-to-back (B2B) and back-to-back with lip stiffener (B2B+C1) sections under axial and thermo-mechanical loads. The analyzed sections—350S162-43, 400S162-43, 550S162-43, and 600S162-43—were modeled with defined geometric parameters such as web height, flange width, lip size, and thickness. Consistent material properties including Young's modulus, yield strength, and density were used to ensure realistic simulations.

Stress-strain curves indicated that smaller profiles like 350S162-43 and 400S162-43 achieved higher stress levels across all strain ranges, showing superior load-carrying ability compared to the larger 550S162-43 and 600S162-43 sections. Deformation results demonstrated that larger

sections undergo greater deflection, with 600S162-43 showing the highest and 350S162-43 the least deformation.

Introducing lip stiffeners in the B2B+C1 configuration significantly enhanced performance by reducing deflection and increasing ultimate strength by nearly 15%, proving the benefit of stiffening elements in improving section stability. The analysis further revealed that varying screw spacing—particularly between 12-inch and 24-inch configurations—affected stress distribution and deformation patterns, highlighting the role of fastener arrangement in member performance and buckling resistance.

Overall, the research provides meaningful insights into efficient CFS member design, emphasizing the importance of section geometry, stiffening, and connection detailing. The predicted stress, strain, and deformation patterns aid in developing safer and more economical lightweight steel structures suited for modern construction practices

4.1. COMPARISON BETWEEN SECTIONS 12" SPACING BACK TO BACK SECTIONS

Table 1. Comparison between Sections

| Strain (mm/mm) | 350S162-43 | 400S162-43 | 550S162-43 | 600S162-43 |
|----------------|------------|------------|------------|------------|
| 0 | 0 | 0 | 0 | 0 |
| 0.005 | 3000 | 2550 | 2050 | 1500 |
| 0.01 | 6000 | 5550 | 3200 | 2500 |
| 0.015 | 8500 | 7300 | 4400 | 3500 |
| 0.02 | 10000 | 8800 | 5700 | 4500 |
| 0.025 | 11000 | 9500 | 6700 | 5200 |
| 0.03 | 11210 | 9410 | 7300 | 5700 |

Unit: The pound per square inch (abbreviation: psi)

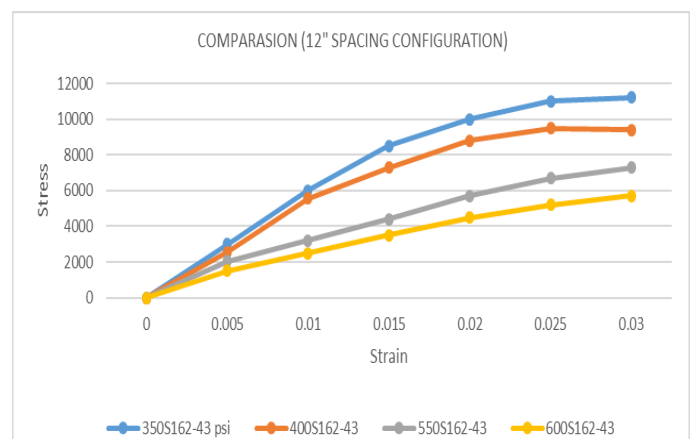


Fig 1. Comparison between Different Sections respective to its strength

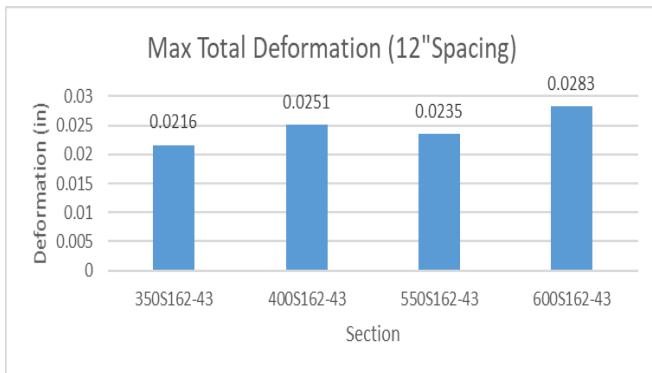


Fig 2. Graphical Representation of Deformation Comparison between Sections

4.2. COMPARISON BETWEEN SECTIONS 24" SPACING BACK TO BACK SECTIONS

Table 2. Comparison between 24" Spacing Back to Back Sections

| Strain (mm/mm) | 350S162-43 | 400S162-43 | 550S162-43 | 600S162-43 |
|----------------|------------|------------|------------|------------|
| 0 | 0 | 0 | 0 | 0 |
| 0.005 | 2800 | 2550 | 2300 | 2100 |
| 0.01 | 5800 | 5200 | 3500 | 3300 |
| 0.015 | 7900 | 7000 | 5300 | 4800 |
| 0.02 | 9700 | 8800 | 6500 | 5800 |
| 0.025 | 10500 | 9500 | 7400 | 6500 |
| 0.03 | 9936 | 8836 | 8000 | 7200 |

Unit: The pound per square inch (abbreviation: psi)

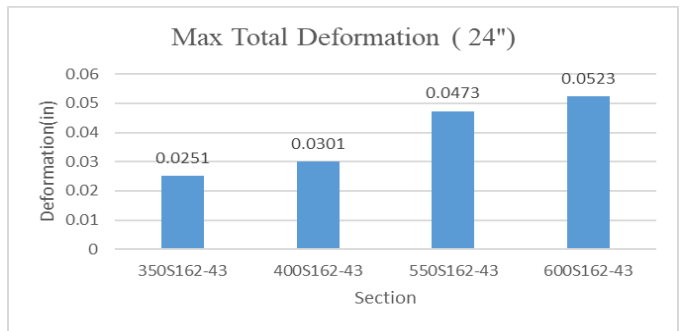


Fig 4. Graphical Representation of Deformation Comparison between 24" Spacing Back to Back Sections

4.3. COMPARISON BETWEEN SECTIONS 12" SPACING BACK TO BACK + C1 SECTIONS

Table 3. Comparison between 12" Spacing Back to Back+C1 Sections

| Strain (mm/mm) | 350S162-43 | 400S162-43 | 550S162-43 | 600S162-43 |
|----------------|------------|------------|------------|------------|
| 0 | 0 | 0 | 0 | 0 |
| 0.005 | 3000 | 2700 | 1800 | 1500 |
| 0.01 | 6000 | 5300 | 3200 | 2500 |
| 0.015 | 8500 | 7500 | 4500 | 3500 |
| 0.02 | 10000 | 8900 | 5600 | 4500 |
| 0.025 | 11000 | 9840 | 6360 | 5200 |
| 0.03 | 11210 | 10100 | 6800 | 5700 |

Unit: The pound per square inch (abbreviation: psi)

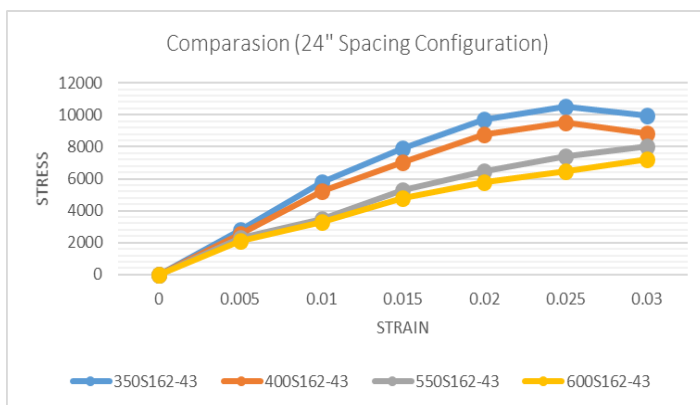


Fig 3. Comparison between 24" Spacing Back to Back Sections

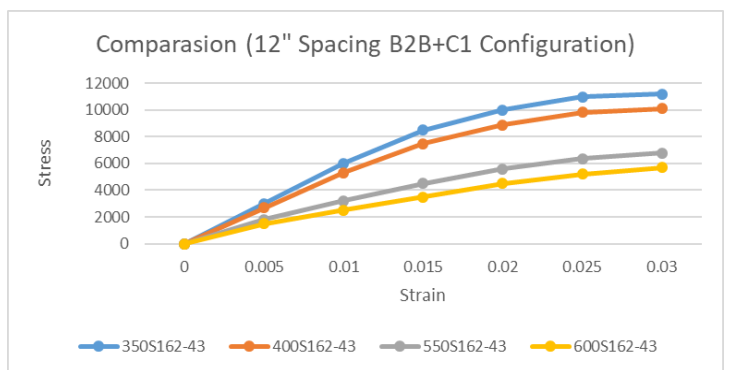


Fig 5. Comparison between 12" Spacing Back to Back+C1 Sections

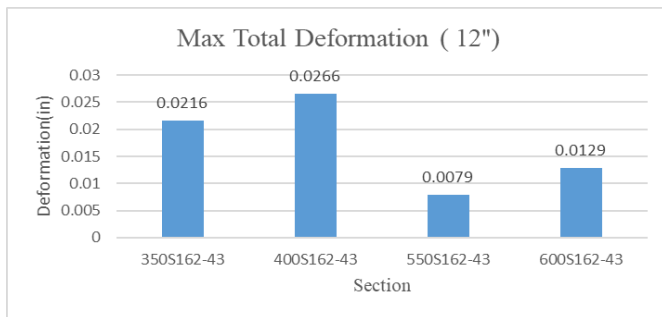


Fig 6. Graphical Representation of Deformation Comparison between 12" Spacing Back to Back+C1 Sections

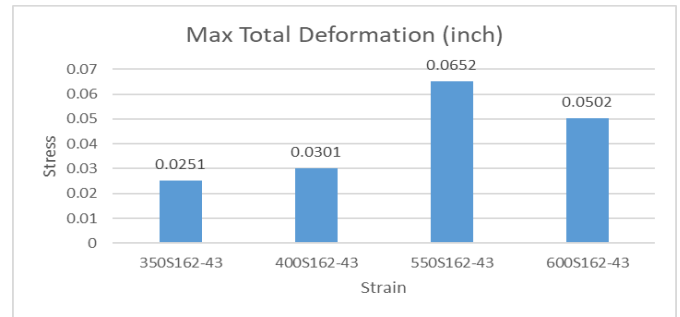


Fig 8. Graphical Representation of Deformation Comparison between 24" Spacing Back to Back+C1 Sections

4.4. COMPARISON BETWEEN SECTIONS 24" SPACING BACK TO BACK + C1 SECTIONS

Table 4. Comparison between 24" Spacing Back to Back+C1 Sections

| Strain (mm/mm) | 350S162-43 | 400S162-43 | 550S162-43 | 600S162-43 |
|----------------|------------|------------|------------|------------|
| 0 | 0 | 0 | 0 | 0 |
| 0.005 | 2800 | 2660 | 2340 | 2100 |
| 0.01 | 5800 | 5300 | 3800 | 3300 |
| 0.015 | 7900 | 7280 | 5420 | 4800 |
| 0.02 | 9700 | 8920 | 6580 | 5800 |
| 0.025 | 10500 | 9840 | 7860 | 6500 |
| 0.03 | 9936 | 9388 | 7747 | 7200 |

Unit: The pound per square inch (abbreviation: psi)

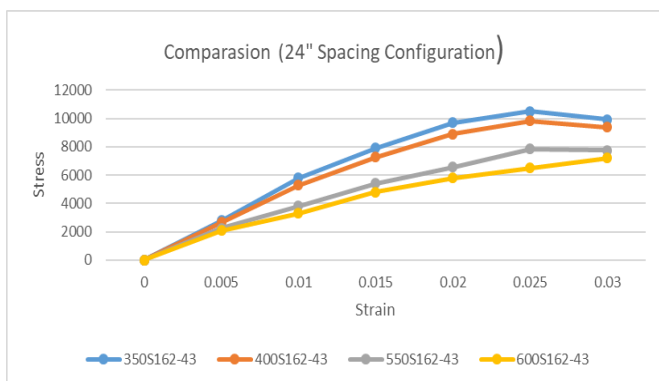


Fig 7. Comparison between 24" Spacing Back to Back+C1 Sections

5. CONCLUSION

This study conducted a detailed analysis of cold-formed steel (CFS) built-up columns with different section types under static and combined thermal loads. Using finite element modeling in ANSYS, it was found that back-to-back built-up sections equipped with lip stiffeners notably improved structural capacity by about 15% and decreased overall deflections. These performance gains are largely due to the careful optimization of connection details such as screw spacing, which play a critical role in enhancing stability and preventing buckling. The tests indicated that smaller section profiles have greater load capacity and experience less deformation, making them more effective for structural use in demanding applications. The results contribute valuable guidance for improving design and construction methods for CFS built-up members, promoting their efficient, safe, and cost-effective use in modern lightweight steel construction.

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