Flexural Behavior of Lite Steel I-Section Beams with Plain and Corrugated Webs

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Abstract

This paper investigates the flexural behavior and failure patterns of lite steel I-section beams (LSBs) featuring plain and corrugated web designs. Experimental studies were conducted using a 4-point bending test to analyze the load-bearing capacity and deflection characteristics of beams with different web configurations. The study primarily focuses on the performance of plain and corrugated webs, incorporating intermediate flange stiffeners to assess their impact on structural performance. The results demonstrate that corrugated web sections significantly enhance the load-bearing capacity and reduce deflection compared to plain web sections.

1. Introduction

Cold-formed steel (CFS) sections have gained popularity in construction due to their lightweight, high strength-to-weight ratio, and ease of fabrication. Among these sections, Lite Steel Beams (LSBs) offer unique advantages due to their hollow flanges and slender webs. However, the slender nature of the webs makes them prone to buckling.

Figure 0. Cold-Formed Steel Sections after Cutting and Punching

This study aims to explore the flexural behavior of LSBs with plain and corrugated webs under loading conditions. Specifically, the effect of intermediate flange stiffeners in mitigating buckling is analyzed to improve flexural strength and overall structural stability.

2. Literature Review

Previous studies have demonstrated that buckling behavior, especially in thin-walled steel sections, can significantly impact structural performance. Researchers like Amarsingh Jamdar et al. have shown that corrugated webs improve the buckling resistance of beams. However, limited studies focus on LSBs with intermediate flange stiffeners. This paper builds upon these findings by experimentally evaluating the role of web corrugation and stiffeners in enhancing the structural performance of LSBs.

3. Objectives of the Study

The primary objectives of this study are:

1. To assess the flexural strength and failure pattern of LSBs with a plain web.

2. To assess the flexural strength and failure pattern of LSBs with various corrugated webs, incorporating an intermediate flange stiffener.

4. Experimental Setup

4.1 Materials

Five LSB configurations were selected for this experimental study:

1. LSB with a plain web using an intermediate flange stiffener.

2. LSB with triangular corrugated web.

3. LSB with trapezoidal corrugated web.

4. LSB with semi-circular corrugated web.

5. LSB with hybrid corrugated web.

Each beam had a uniform section of 200 mm depth, 160 mm flange width, and 2 mm thickness.

4.2 Test Procedure

The beams were tested using a 4-point bending setup on a Universal Testing Machine (UTM) with a 1000 kN capacity. The load was applied at two points, 300 mm apart, to create a pure bending moment over the middle span.

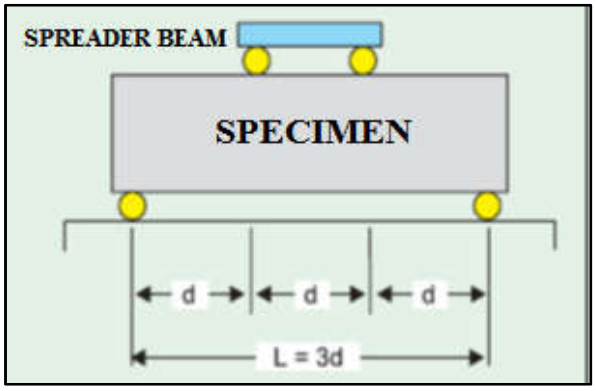

Figure 2. Schematic test set-up for 4-point bending test

Deflections were recorded using three dial gauges placed at the top flange, bottom flange, and web mid-span. Load increments of 5 kN were applied, and the deflections were continuously monitored.

5. Results and Discussion

5.1 Flexural Behavior of LSB with Plain Web

The load-deflection response of the LSB with a plain web indicated early lateral-torsional buckling at an ultimate load of 45 kN. The plain web exhibited significant lateral displacement under increasing loads, leading to buckling failure. The displacement results showed a

maximum lateral displacement of 8.60 mm at the web. Despite the presence of an intermediate flange stiffener, the plain web could not prevent buckling under high loads.

5.2 Flexural Behavior of LSB with Corrugated Webs

The LSBs with corrugated webs exhibited superior flexural strength compared to the plain web. The triangular corrugated web demonstrated the highest load-bearing capacity at 139.8 kN and the least lateral displacement of 1.90 mm at a load of 45 kN. Other corrugated webs, such as the trapezoidal, semi-circular, and hybrid configurations, also showed improved performance over the plain web but did not match the triangular configuration in terms of load capacity and stiffness.

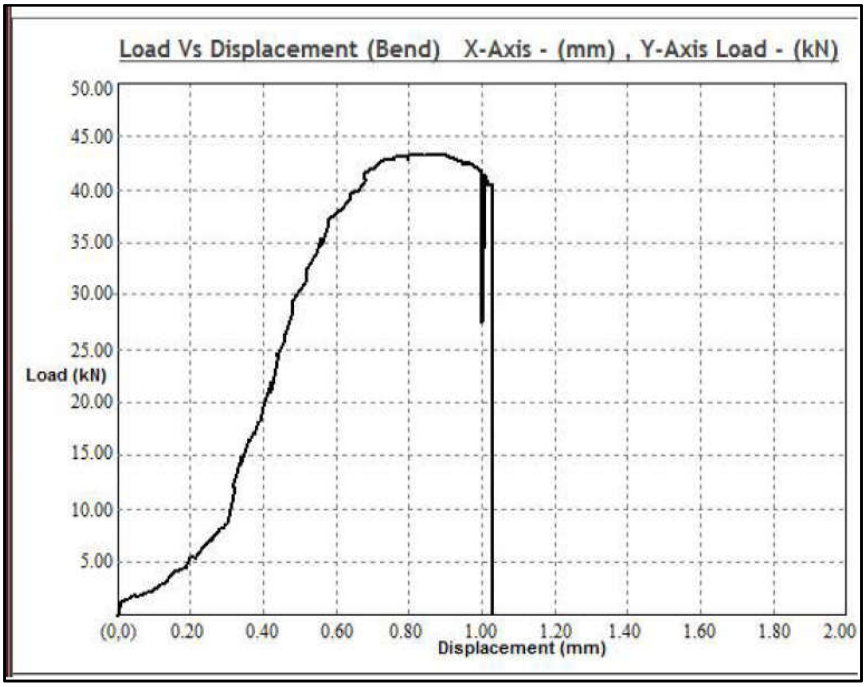

Figure 0. Computerized UTM generated load vs. deflection graph

The introduction of corrugations in the web increased the web's resistance to buckling and enhanced its ability to distribute loads more evenly. The intermediate flange stiffener effectively reduced distortional buckling in the compression flange, further improving the overall structural stability of the beams.

6. Conclusion

The experimental investigation confirms that corrugated web designs significantly improve the flexural strength and reduce deflection in Lite Steel I-section beams. Among the different configurations tested, the triangular corrugated web exhibited the best performance, achieving the highest load capacity and lowest deflections. The incorporation of intermediate flange stiffeners further enhanced the resistance to buckling and improved the structural performance. Future studies should explore optimizing corrugation patterns and stiffener designs for even better performance in lightweight steel structures.

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