EXPERIMENTAL STUDY ON THE SHEAR CAPACITY OF COLD-FORMED STEEL LIPPED CHANNEL BEAMS

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ABSTRACT

Cold-formed steels (CFS) or light gauge steels (LGS) are steel sections created through processes without heat application, such as roll forming or press-braking. CFS studies have focused on many research areas, including designing and analysing members and systems, connections, sustainability, residual stresses and post-fire data. Cold-formed high strength steel members are increasingly used as primary load bearing components in low-rise buildings. Lipped channel beam (LCB) is one of the most commonly used flexural members. The literatures were collected and studied based on the previous investigations in the field of shear behaviour and design of ultra-high strength cold-formed steel lipped channel beams. For experimental study, two sections were selected of thickness 1.5 mm for three aspect ratio 1.0, 1.5 and 2.0 and yield strength of 250 MPa. Sections were fabricated without using angle straps at top and bottom flanges of the section. Ultimate shear capacity and failure modes were obtained.

KEYWORDS: **Cold-formed steel, Lipped channel beams, Shear capacity, Stiffener**

1. INTRODUCTION

Over the past couple of decades, the use of cold-formed high strength steel members has been progressively integrated in steel construction as primary load bearing components. Thin sheet steel products are extensively used in building industry. These thin steel sections are **Cold-formed steel**. Cold-formed steel is manufactured at room temperature without application of heat by rolling or pressing. They are also called as **Light Gauge Steel Sections** or **Cold Rolled Steel Sections.**

2. ADVANTAGES OF COLD-FORMED STEEL STRUCTURES

Some of the main advantages of cold-formed sections, as compared with their hot-rolled sections.

- Cold rolling can be employed to produce almost any desired shape to any desired length.
- All conventional jointing methods, (i.e., riveting, bolting, welding and adhesives) can be employed.
- High strength to weight ratio is achieved in cold-rolled products.
- High strength, stiffness and lightness
- Fast and easy erection and installation
- More accurate detailing
- Recyclable material
- Ease of pre-fabrication and mass production

- Economy of transportation and handling
- High structural efficiency

3. APPLICATIONS

- Cold-formed steel structural members have been effectively and widely used around the world in such applications as **wall studs, girts, steel housing frames, roof systems.**
- **Lipped channel beams (LCB)** with web openings are commonly used as **floor joists and bearers** in building structures. Many applications in steel floor systems include openings in the web of joists or bearers so that building services can be located within them.

4. COUPON TEST

- Performing a coupon test for 1.5mm thickness cold-formed steel specimens using a Universal Testing Machine (UTM) involves conducting tensile testing to evaluate mechanical properties.

Fig 1 coupon specimen

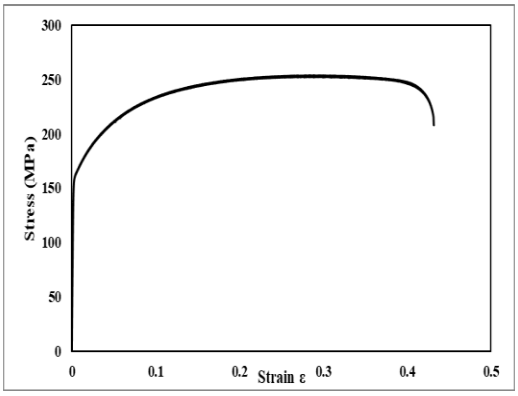

Fig 2 Average stress vs strain curve

5. TEST SPECIMEN AND TEST SET-UP

- In this experimental study, a series of primarily shear tests of simply supported Lipped Channel Beams (LCBs) subjected to a mid-span load was conducted. Two LCB sections were bolted back-to-back using three 12 mm thick T-shaped stiffeners between them and six 6 mm full height web side plates on both sides, which were located at the end supports and the loading point in order to eliminate any torsional loading of test beams, web crippling and flange bearing failures.

- In order to stimulate a primarily shear condition, relatively short test beams were selected based on suitable aspect ratios (shear span, a/ clear web height,d_1) of 1.0,1.5 and 2.0. The LCB sections were chosen so that they represented the more commonly used sections in the building industry. They were made of thickness of 1.5 and steel grades of Fe 250. Young's modulus (E) and Poisson's ratio(μ) were taken as 200 GPa and 0.3 respectively.

- The LCB sections were loaded via the central T-shaped stiffener at the mid-span loading point. This method of loading has the added advantage of loading through the shear center thus avoiding eccentric loading and web crippling. Similar T-shaped stiffeners were also located at the supports, and were bolted to the two LCBs and the full web side plates on either side of the web element. The support system was designed to ensure that the test beam acted as a simply supported beam with pinned supports at each end. The ends of the test beams were free to rotate and it was therefore seen that simply supported conditions were simulated accurately at the end supports. The applied load at the mid-span of the test beam was an important parameter.

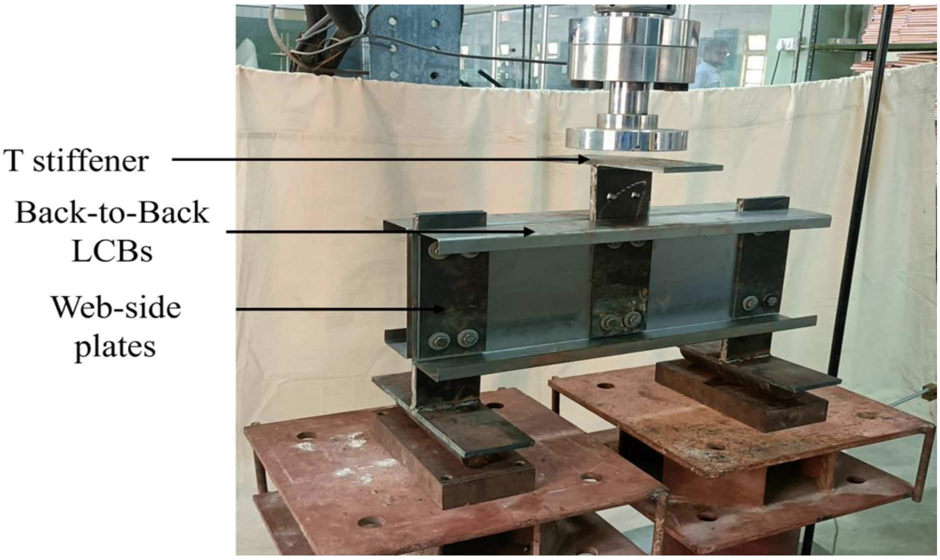

Fig 3 Experimental set-up of back-to-back LCBs

Table 1 Ultimate shear capacities for aspect ratio – 1.0, 1.5 and 2.0

S.NO	Specimen ID (mm)	Aspect ratio (a/d_1)	V_{EXP} (kN)
1	200X75X20X1.5	1.0	19.55
2	200X75X20X1.5	1.5	14.82
3	200X75X20X1.5	2.0	11.70
4	200X125X20X1.5	1.0	21.47
5	200X125X20X1.5	1.5	14.05
6	200X125X20X1.5	2.0	12.11

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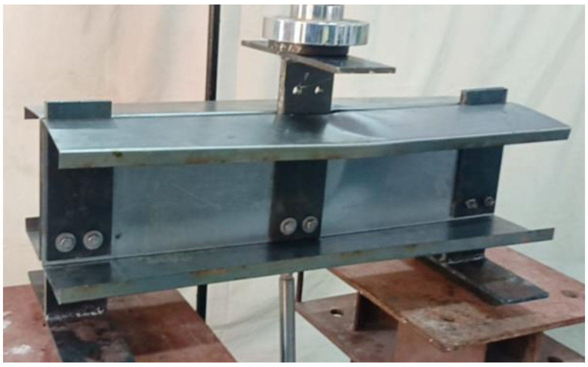
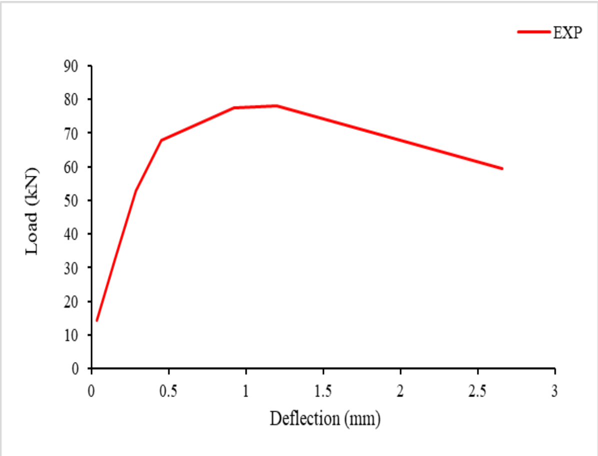
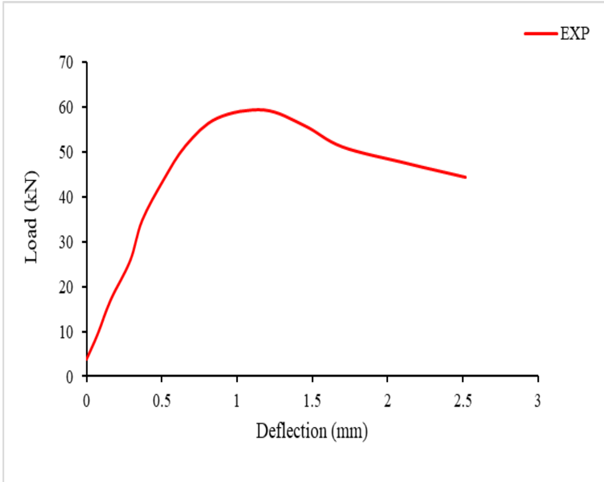
Deformed shape	Experimental deformed shape
200x125x20x1.5-573 mm 	200x75x20x1.5-573 mm 
200x125x20x1.5-767 mm 	200x75x20x1.5-767 mm 
200x125x20x1.5-961 mm 	200x75x20x1.5-961 mm 

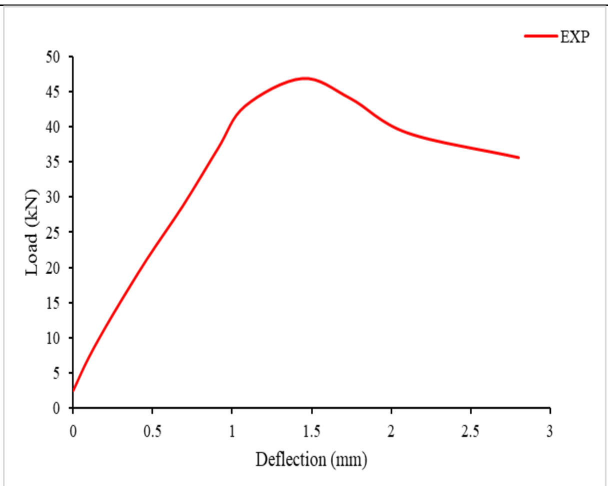
Fig 4 shear failure modes from test at ultimate load

Table 2 Load Vs Deflection curve from test

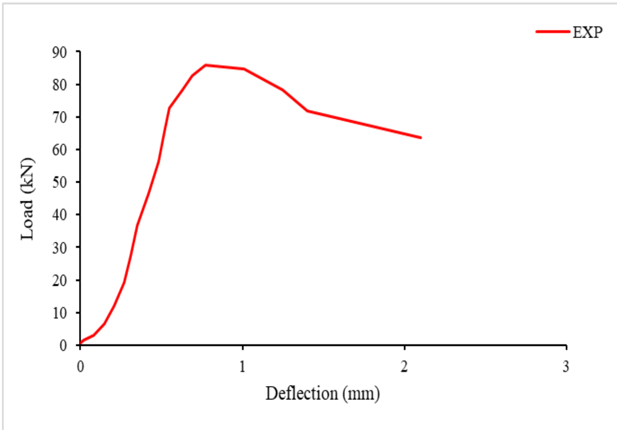


200X75X20X1.5-573 mm

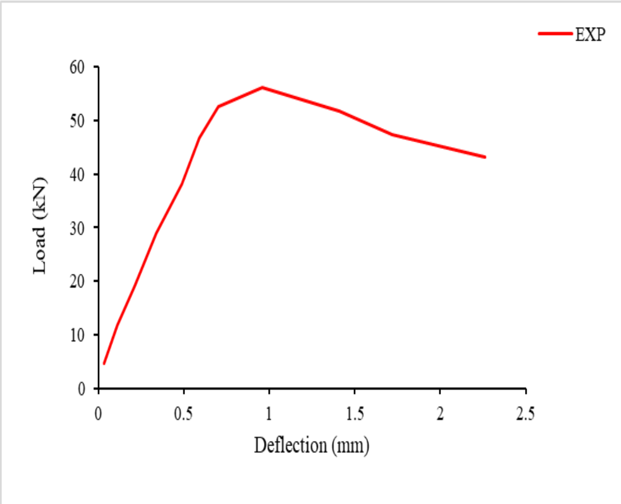




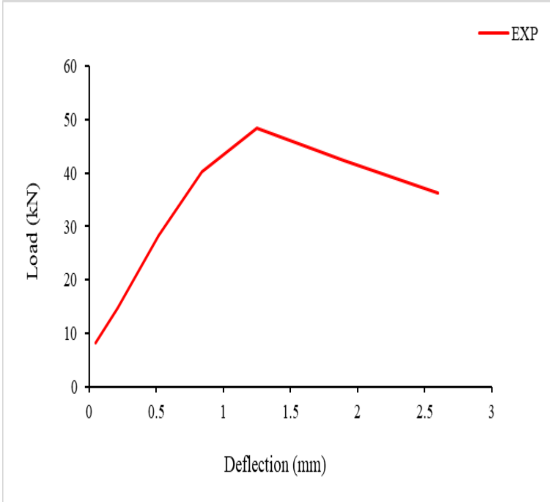
200X75X20X1.5-961 mm



200X125X20X1.5-573 mm



200X125X20X1.5-767 mm



200X125X20X1.5-961 mm

6. CONCLUSION

Based on the literature review of the experimental, numerical and theoretical studies, though many studies have been discussed based on the investigations in the field of shear behaviour and design of ultra-high strength cold-formed steel lipped channel beams. Ultimate shear capacities and shear failure modes were obtained from experimental results. As the aspect ratio increases, shear capacity of the section decreases due to combined effect of bending and shear. Flange distortion can be avoided by providing angle straps at top and bottom flanges of LCB section.

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