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Efficiency of Bending Behavior by Alter the Spacing of Lacing using the Cold Formed Steel I – Section Light Beam

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Abstract : Thin walled cold-formed steel members have wide applications in building structures. In cases where beams carry less moment it is uneconomical to use traditional hot rolled steel[2,5]. Cold formed steel is an apt solution for this case. For a latticed cold formed steel flexural member, the moment carrying capacity may be affected mainly by local, distortional or lateral torsional buckling. In this paper, the impact of web opening and lacing spacing on the flexural behaviour of Cold formed built-up I section under two point loading is investigated for the simply supported end conditions. Experimental investigation has been carried out on 7 specimens by varying the depth of the built-up beam. Numerical investigations have also been carried out using finite element analysis software ANSYS13.0. Load vs. Deflection curve, failure modes and ultimate load carrying capacity of specimens are presented in this work.

Index Terms : cold formed steel, built-up, latticed, flexural member, two point loading etc…

1.0 Introduction

One of the issues raised since the steel structure was introduced in the construction industry is how to reduce the weight and cost of the component parts such as girder and beams. Cold-formed steel members are widely employed in steel construction because they are lighter and more efficient than traditional hot-rolled ones[6,7.] Nowadays the easy availability and accessible cost of high-strength low-alloy steels, weathering steels, and zinc-coated steels have led to members with height/thickness ratios, rendering them even more susceptible to local buckling and to another buckling mode called distortional, Z sections[1,3], hat, rack, etc.

The primary objective of this research is to study on the impact of web opening and lacing spacing on the flexural behaviour of latticed built up I section. Seven specimens are experimentally tested by applying two point loading and the failure behaviour is studied. The possible modes of failure of the members under static loading by performing non –linear analysis are performed using ANSYS 13.0 software. The numerical method includes material and geometrical non-linearity. The geometric imperfections are also included in the model. The experimental test results are compared with the numerical analysis done using ANSYS package. The effect of web opening and lacing spacing on the flexural behavior is discussed here.

2.0 Experimental Analysis

Experimental study is carried out on the built-up I section in loading frame.

Section Preparation

CFS: Cold Formed Sheets of thickness 1.2mm of length 2400mm are cut and bent to angle 50×50×15mm using hydraulic machines.
Stiffener: 50×3mm plates are used.
Lacing Rod: Hot rolled reinforcement bar of 8mm diameter is used. Rod is inclined at 35 ^{o},45^{o}, 55 ^{o} along length.
Process: Four angles are welded to the lacing rod so that built-up I section member is prepared.
Testing: Testing is done on beam in loading frame.
Support condition: Simply supported at both ends.
Loading: Two point loading

The built-up section is modeled by connecting equal angles back-to-back latticed by 8mm diameter bars. 50×50mm angle with lip 15mm is used. Length of the specimen is taken 2400mm for all specimens. Lacing is inclined at an angles 35 ^{o},45^{o} ,55 ^{o}. Seven specimens were casted by varying the web opening. 1.2mm thick sheets were used to fabricate the angles. Web opening ranges from 50mm to 200mm. Intermediate stiffeners are used at end supports and points of application of load. 3mm thick plate is used as stiffener plate. Two point loading is preferred in order to obtain pure bending without shear.

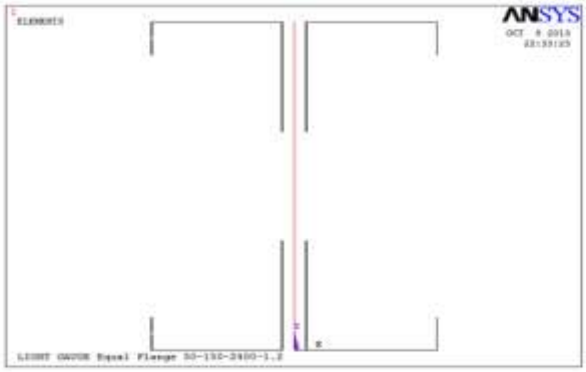


Figure 1: Cross section of Built up section

Figure 2:3D model

1: Proving Ring 2: Hydraulic Jack 3: Spreader Beam 4: Specimen 5: LVDT at L/36: LVDT at L/2

Figure 3: Experimental Setup

Table 1: Specimen Details

Specimen	**Spacing of latice D(mm)**	**Thickness (mm)**
LBC 150-2400-45	150	1.2
LBC 150-2400-35	105	1.2
LBC 150-2400-55	215	1.2
LBC 200-2400-45	200	1.2
LBC 300-2400-45	300	1.2
LBC 300-2400-35	210	1.2
LBC 300-2400-55	430	1.2

Built-up beam is placed over the steel column with roller support so that the edge stiffener coincides with the mid portion of the roller support. The span of the beam is 2.4m. The lateral displacement is arrested at the supports. Loading is applied by hydraulic jack and the load value is observed in proving ring. Below hydraulic jack, spreader beam is placed. The load applied through hydraulic jack is thus carried by hollow beam and this load is divided into two at mid third portion of beam. Linear Variable Differential Transducer (LVDT) is used to measure vertical deflection at L/2 and L/3 points. Load vs. Deflection are determined.

Failure Modes

LBC300-2400-35

LBC 300-2400-45

LBC 300 2400 55

LBC250-2400-45

LBC150-2400-35

LBC 150-2400-45

Table 2: Experimental Results

Specimen (mm)	**Ultimate Load(kN)**	**Ultimate Moment (kN m)**	**Type of Buckling**
LBC 150-2400-45	18.201	7.280	D
LBC 150-2400-35	20.216	8.086	L
LBC 150-2400-55	23.276	9.31	D SF
LBC 200-2400-45	20.291	8.116	D LF
LBC 300-2400-45	36.536	14.614	D L
LBC 300-2400-35	48.266	19.306	D LF
LBC 300-2400-55	36.026	14.41	C LT LF

LF- Lacing failure L- Local SF- Stiffener failure
C- Crushing LT- Lateral Torsion D- Distortion

Fig 4(a)

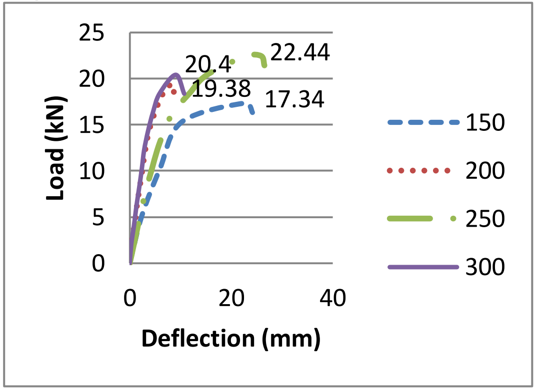


Fig 4(b)

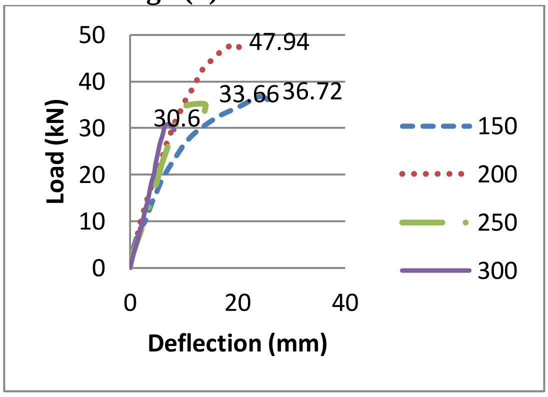


Figure 4(a): Load vs. deflection at L/2 for 1.2mm specimens.

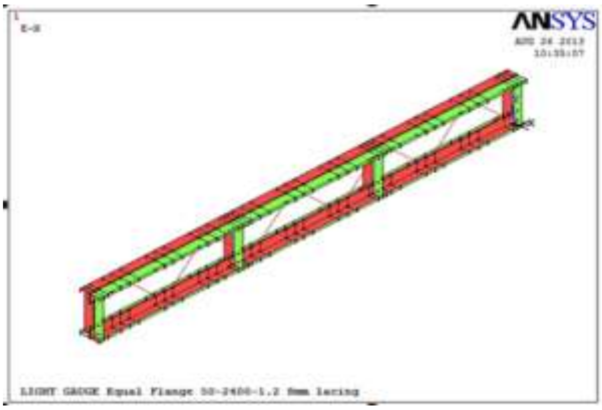
Figure 4(b):Load vs. deflection at L/2 for 2mm specimens

3.0 Numerical Analysis

The finite element method is a numerical analysis technique for obtaining approximate solutions to wide variety of Engineering problems. Most of the engineering problems today make it necessary to obtain approximate numerical solutions to problems rather than exact closed form solutions. The basic concept behind the finite element analysis is that structure is divided into a finite number of elements having finite dimensions and reducing the structure having infinite degrees of freedom to finite degrees of freedom[2]. The original body of structure is then considered as an assemblage of these elements connected at a finite number of joints called Nodes or Nodal points.

Analytical study is carried out by using the Finite Element software ANSYS13.0

Linear and Non-linear analysisis carried out.The properties of the material were determined by coupon test. The value of Young's modulus 'E' is given as 2.01x10^5 N/mm^2. The Poisson's ratio is given as 0.3. The yield stress of the cold formed angle is taken as 300N/mm^2 and that of lacing bar is given as 500N/mm^2.Density of steel material is given as 7850x10^{-9}N/mm^3.Load Deflection curve,Load carrying capacity and failure pattern of the specimen is observed.



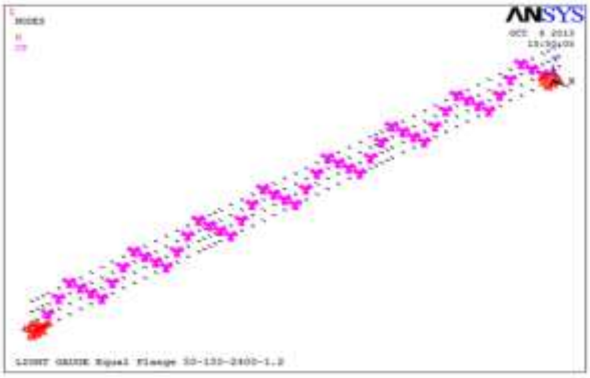
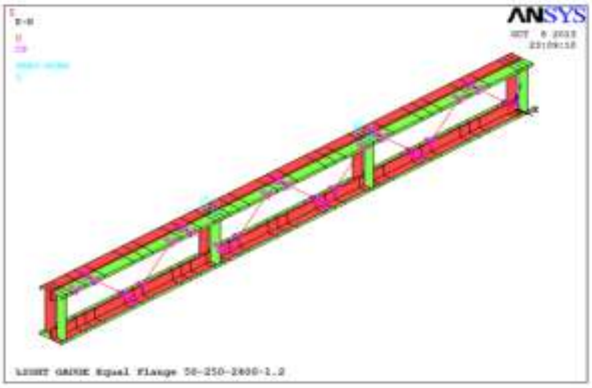


Figure 5: Model of Built-up I section BeamFigure 6: Coupling



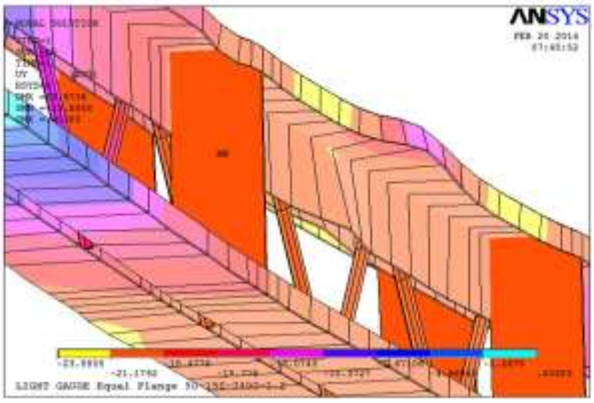


Figure 7: Two Point LoadingFigure 8: Deformed shape of specimen

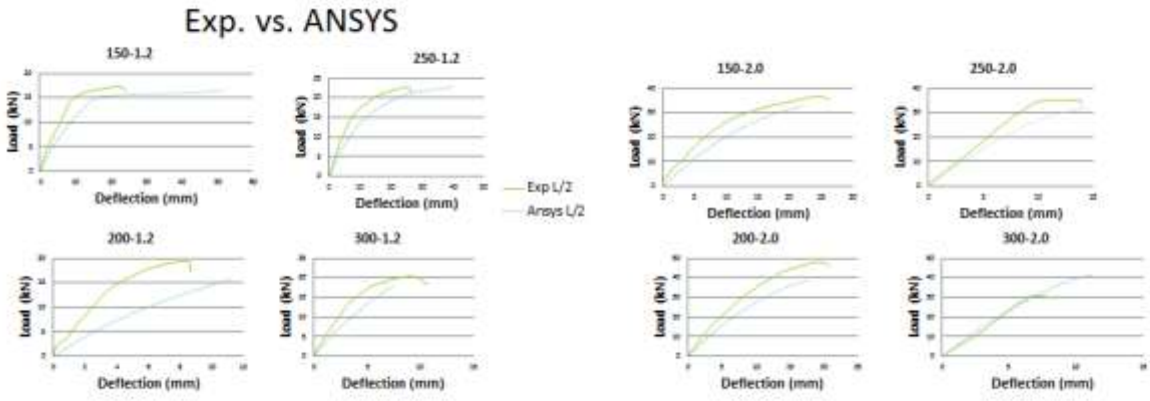


Figure 9: Load deflection graph

4.0 Conclusion

From the numerical and experimental study, the behavior of built-up cold formed I steel sections with equal flanges was observed. The impact of web opening and lacing spacing on performance of built-up section under static loading was compared. It is observed that the member LBC 300-2400-35carries maximum moment while comparing 1.2mm thick specimens. This is because stiffener takes up load in this specimen. This shows that web opening to depth ratio of 0.5 would carry maximum moment. Also lacing failure is common in 55 ^{o} specimens with maximum web opening.

Even though a lateral displacement is arrested at support, lateral torsion is unavoidable

5.0 References

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