© November 2023| IJIRT | Volume 10 Issue 6 | ISSN: 2349-6002

An Experimental Investigation on Structural behaviour of Cold Formed Steel Double Channel Hat Section with Two Plates

Rooba N[1], Mrs. D.Amali[2]
[1]PG Scholar, Department of Structural Engineering, Government college of Engineering – Salem-11, Tamilnadu, India
[2]Assistant Professor,Department of Civil Engineering, Government college of Engineering – Salem-11, Tamilnadu, India

INTRODUCTION

- GENERAL

In steel construction, there are two main families of structural members

- Hot rolled members
- Cold formed members

The use of hot-rolled steel sections become uneconomical for the steel structures subjected to light and moderate loads and for the structural members of short span lengths (e.g., joists, purlins, girts, roof trusses, complete framing of one and two storey residential, commercial and industrial structures). So the study on behaviour of COLD-FORMED STEEL members reduces the cost of a building made up of steel structures.

- ADVANTAGES OF COLD-FORMED STEEL STRUCTURES

Cold forming has the effect of increasing the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range.

1. Cross-sectional shapes are formed to close tolerances and these can be consistently repeated as long as required.
2. Cold rolling can be employed to produce almost any desired shape to any desired length.
3. All conventional jointing methods, (i.e. riveting, bolting, welding and adhesives) can be employed.
4. High strength to weight ratio is achieved in cold-rolled products.
5. High strength to weight ratio is achieved in cold-rolled products.
6. High strength , stiffness and lightness .
7. Fast and easy erection and installation.

BUCKLING:

The sudden change in shape of structural component under load is called buckling. Types of buckling

1. Local buckling
2. Distortional buckling
3. Lateral bucking.

LOCAL BUCKLING:

It is the modes involve the buckling of cross-section walls. this failure mode commonly observed in thin-walled structural steel elements.

DISTORTIONAL BUCKLING: It is a mode characterized by rotation of the flange at the flange/web junction in members with edge stiffened elements.

LATERAL TORSIONAL BUCKLING:

Buckling that does not involve distortion of the cross-section, instead translation (flexure) and/or rotation (torsion) of the entire cross-section occurs. When a beam fails by lateral torsional buckling, it buckles about its weak axis, even though it is loaded in strong plane. It is also known as global buckling.

SELECTION OF SECTION:

The dimensions of the built up I section is selected as per Euro code specifications as shown in figure.

The elements of the sections are chosen by the way the value satisfies the limits provided in Euro code standards for comparison.

As per European standards (EN-1993-1-3) for the design of cold- formed steel structural members, the flat between limits are available for single section only

Based on these limitations, suitable section is selected.

Material Properties:
- ✓ Yield strength (fy) is 250 N/mm2
- ✓ Young's Modulus (E) is 2.1 x 105 N/mm2
- ✓ Poisson's Ratio is 0.3
- ✓ Material model – Elastic-Perfectly plastic.

Member Properties:
- Thickness of section (t) is 1.6 mm.
- Length of the specimen is 2400 mm with constant moment span of 1000 mm.
- Spacing between the two channels – B/4
- End condition is simply-supported.

ABAQUS SOFTWARE

ABAQUS 6.13 is software suitable for finite element analysis. It can be used for both static and dynamic problems. The abaqus product suite consists of five core software products.

1. Abaqus/CAE (Complete Abaqus Environment) – It is a software application used for both the modeling and analysis of components and assembling (pre- processing) and visualizing the finite element analysis result. A subset of abaqus/CAE including only the post-processing module can be launched independently in the abaqus/viewer product.
2. Abaqus/standard – a general purpose finite element analyzer that employs implicit integration scheme.
3. Abaqus/explicit – a special purpose finite element analyzer that employs explicitintegration scheme to solve highly non-linear systems with many complex contactsunder transient loads.
4. Abaqus/CFD – a computational fluid dynamics software application which provides advanced computational fluid dynamics capabilities with extensive support for pre-processing and post-processing provided in abaqus/CAE. Abaqus/electromagnetic – a computational electromagnetics software application which solves advanced computational electromagnetic problems.

3.3 PROCESSING STEPS IN ABAQUS

The three common processing steps in Abaqus are:
1. Pre-processing
2. Simulation
3. Post processing

4.3.1Pre-processing

In this stage, the model of the physical problem is defined and an Abaqus input file was created. The model is usually created graphically using Abaqus/CAE.

4.3.2Simulation

The simulation, which normally is run as a background process, is the stage in which Abaqus/Standard or Abaqus/Explicit solves the numerical problem defined in the model.

4.3.3 Post-processing

The results can be evaluated once the simulation has been completed and the displacements, stresses, or other fundamental variables have been calculated. The evaluation is generally done interactively using the Visualization module of Abaqus/CAE or another postprocessor. The Visualization module, which reads the neutral binary output database file, has a variety of options for displaying the results, including colour contour plots, animations, deformed shape plots, and X-Y plots.

4.4 ANALYSING STAGES IN ABAQUS

The two important stages in Abaqus are:
1. Linear analysis (Eigen value buckling analysis)
2. Non- Linear buckling analysis

4.4.1Linear analysis (Eigen value buckling analysis)
- Steps has assigned in linear perturbation buckle mode.
- No. of Eigen values and maximum no. of iteration were entered.
- The transverse load is applied on the loading points as -1.
- Then the section is analyzed.
- Then the Eigen buckling analysis is carried out.
- The minimum buckling load and buckling shape is carried out.
- In post processing mode, result summary shows the linear analysis load and inread result the first set was selected and the deformed shape is viewed.

4.4.2Non-Linear buckling analysis

Non-linear buckling analysis is more accurate than

Eigen value analysis because it employs non-linearity, large deflection, and static analysis to predict buckling loads. Its mode of operation is very simple.

It gradually increases the applied load until a load level is found whereby the structure becomes unstable. The true nature of this analysis thus permits the modeling of geometric imperfection, load perturbations, material non-linearities and gaps.

The graphs were plotted for the moment Vs deflection and moment capacities of section were found.

EXPERIMENTAL INVESTICATION

5.1 GENERAL

In this Experimental program totally 4 built-up beam specimens were fabricated. The table below shows the section details of selected specimens for experimental study.

Table –Section details for Experimental Study

S.NO	Specimen ID DC-B-D-T-L	Length (mm)	Measured Dimension	
			Width (mm)	Length (mm)
1	90 X 90 X 1.6 - 2400	2400	90	2400
2	90 X112.5 X1.6-2400	2400	112.5	2400
3	90X135X1.6-2400	2400	135	2400
4	90X157.5X1.6-2400	2400	157.5	2400

5.2 COUPON TEST

The tension test carried out in the computerized UTM in the Structural Engineering laboratory of GCE, Salem to find out the material properties such as Yield Stress (fy), Modulus of Elasticity (E), Ultimate Stress (σult), Percentage of elongation, ect.

IS 1608 – 2005 (Part –I) prescribes the method of conducting tensile test on steel strip less than 3 mm and not less than 0.5 mm thick. The dimensions of test specimen as mentioned in IS 1608 – 2005(Part –I) is given below.

1. The test piece has a width 'b' of 50mm and gauge length 'Lt' of 240mm.

However, if the nominal thickness 'a' is not greater than 2mm, the test piece may have a width of 16mm and a gauge length 'Lo' of 90mm.

2. The ends of the test piece metal held in suitable grips in the testing machine in such a way that the centre line of pull coincides with the longitudinal axis of the test piece.
3. The parallel length is kept between "Lo +b/2 & Lo +2b".

The dimensions of the coupon test specimen are illustrated in fig. below

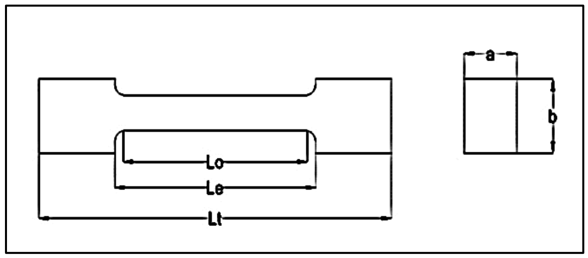


Fig.4.1 – Dimensions of Coupon Teat Specimen

Where,

Lo -Original Gauge Length

Le -Parallel length

Lt -Total length

b - width of the test piece

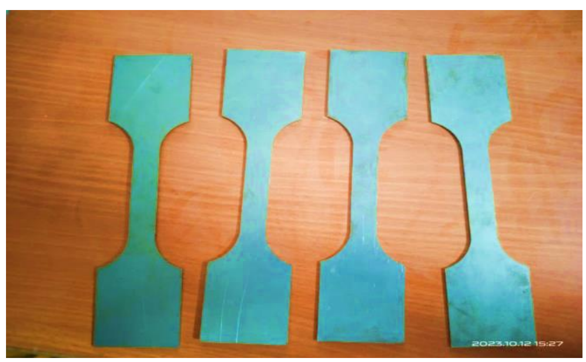
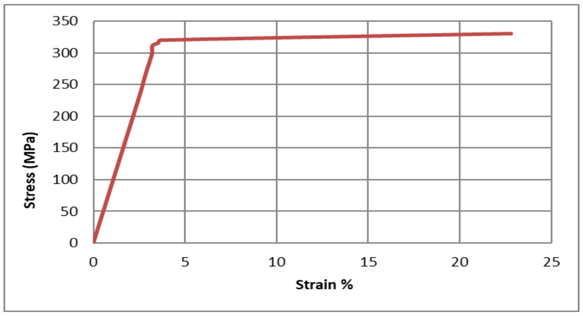


Fig. – Coupons



Average stress-strain curve of Tensile Coupon

The coupons are tested under the rate of loading of 0.1mm/min above fig shows the average stress-strain curve obtained from tensile coupon test. There was no well-defined yield point. Tensile coupon results are shown in below table.

Results from coupon test:-

Specimen	E (N/mm^2)	σ0.2 (N/mm^2)	σ ult(N/mm^2)	Percentage of elongation
Average of 4 specimens	2 X 10 5	250	350	23.637

FABRICATION OF SPECTIONS:

The cold formed built-up beam fabrication starts with the purchase of the CFS sheet. The details of the cold formed steel sheet purchased, place of purchase and place of fabrication are shown in the table below.

Details of CFS Sheet:

S.NO	DESCRIPTION	DETAILS
1	Type of sheet	Cold Rolled Sheet
2	Thickness of sheet	1.6 mm
3	Size of Sheet	8' X 4'
4	Place of Purchase	Golden Steels, Salem
5	Place of Fabrication	Velmurugan Engineering Works, Salem

TEST SETUP AND PROCEDURE

The moment capacities of the beams were determined based on four-point bending tests. Below Fig shows the line diagram of the set-up and the actual four – point bending test set-up in the laboratory. End bearing was provided on either side of the supports. Total length, L=2450 mm, the effective span, L= 2400 mm. The Four –point bending tests were conducted in a convenient 500kN capacity loading frame.

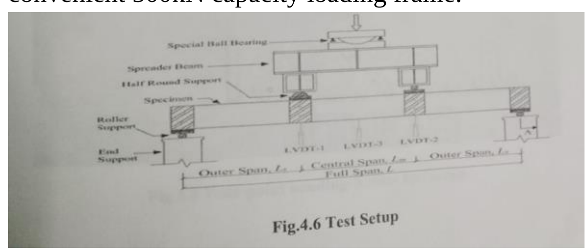


FIG- Four – Point Bending –Actual test setup

Experimental Test Results

S.NO	SPECIMEN NAME DC-B-D-T-L	EXPERIMENTAL LOAD (KN)
1	90 X 90 X 1.6-2400	10.3
2	90X112.5X1.6-2400	13.8
3	90X135X1.6-2400	14.1
4	90X157.5X1.6-2400	14.6

Comparison of Experimental and Numerical results:

Sl.NO	D/B RATIO	SECTION (mm)	Thickness t(mm)	f_y N/mm2	Maximum Load kN Experimental	Maximum Load kN Numerical	Mode of failure L - (Local Buckling)
1	1	90X90	1.6	250	10.3	7.6	L
2	1.25	90X112.5			13.8	12.36	
3	1.5	90X135			14.1	13.05	
4	1.75	90X157.5			14.6	13.48	

CONCLUSIONS

- In this thesis, the moment capacity and failure modes of built up sections have been studied numerically. Procedure for numerical analysis using ABAQUS software was studied. The dimensions were chosen based on Euro code specification (EN 1993-1-3(2006)).
- The tensile coupons were prepared and tested; stress-strain curve for the material was obtained.
- For experimental study 4 specimens were fabricated with 1.6 mm thickness. These specimens were tested with Four-point bending configuration. All the specimens were observed to fail by local buckling of compression flange.
- A nonlinear finite element analysis was developed and verified against the experimental results.

REFERENCE

[1] ABAQUS (2013). Dassault systems simuliacorp, ABAQUS standarduser's Manual version 6.13. USA.

[2] AISI – S100:2012 North American specification for the design of cold-formed steel structural members specification, Washington, DC, USA, (2007).