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The Flexural Behaviour of Light Grade Metal Corrugated Section Filled with Concrete

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ABSTRACT

This research paper deals with the investigation on the behaviour of cold formed steel section with triangular web corrugation of different angles. Compared to hot rolled sections, steel sections with thin wall have greater tendency towards failure by local buckling. Providing corrugated triangular section acts as a stiffener and increases the resistance towards local buckling.

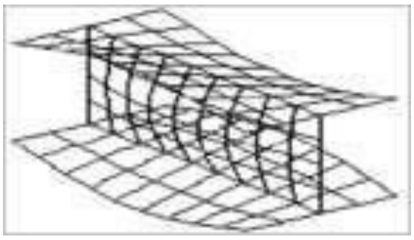
A corrugated I-beam is built by welding two flanges with a thin walled corrugated web. Corrugations may be of different sections such as rectangular, trapezoidal, triangular or sinusoidal. This situation leads to the corrugation in web. Investigation has been carried out on the influence of triangular corrugated web in shear zone of cold formed lipped I section. Four specimens with triangular corrugation in the different zones of the web portion were used to conduct the study. To develop experimental method to study the influence of corrugated web in pure bending zone of cold formed lipped I section. To obtain experimental data of section and member capacities of the triangular corrugated I section subjected to flexural load (bending and lateral-Torsional buckling). To determine the maximum load carrying capacity of the specimens by using AISI code. To study the possible modes of failure of the members under static loading. To analyze the results of the experimental test in comparison with theoretical calculation and with numerical analysis using ANSYS.

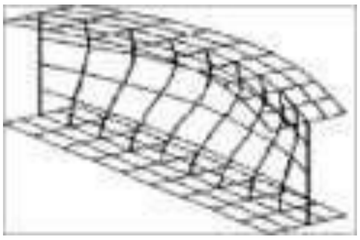
KEYWORDS: Cold formed steel, AISI, ASNSYS, Local buckling

I.INTRODUCTION

Beams with corrugated webs have been used in buildings and have been proven to be economical. It could eliminate the usage of larger thickness and stiffeners that contributed to the reduction in beam weight and cost. The use of corrugated webs will increase the lateral stiffness of the beam. Through the use of light steel framing, massive construction works are shifted into factory, leaving the construction site cleaner and safer.

The typical design strengths for cold-formed steel section are 350 N/mm2, 450 N/mm^2 and 550 N/mm^2. The cold-formed sections are composed of steel plates or sheets in roll-forming machines Light steel framing that utilized cold-formed steel section has some highlighted benefits such as high strength-to-weight ratio as compared to hot-rolled sections and concrete block, accelerating sustainable construction development as cold formed steel is a reusable green material and rapid construction compared with conventional concrete structures. There are three methods of forming, namely cold-roll forming, press brake operation and bending brake operation





II.TENSION TEST ON STEEL SHEET

IS 1663 – 1960 part I prescribes the method of conducting tensile test on steel sheet strip less than 3 mm and not less than 0.5 mm thick

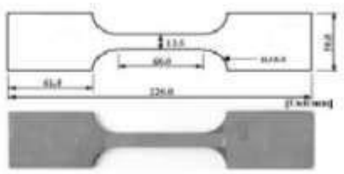


Fig.No.1 Tension Test on Steel Sheet

III.ANALYSIS BASED ON IS: AISI.S100-2007 Nominal flexural section strength

The nominal flexural strength (resistance) Mn, shall be minimum of

- Lateral torsional buckling strength Mne,
- Local buckling strength Mnl, distortional buckling Mnd.

Effective initial yield moment, My = Se X Fy

Where, Se = Effective section modulus

Fy = yield stress

Lateral Torsional buckling strength

The nominal flexural strength (resistance) Mne, for lateral-torsional buckling shall be calculated in accordance with the following:

a) For Mcre > 2.78 My

b) For 2.78 My ≥ Mcre ≥ 0.56 My $Fe = C_b \pi^2 E d I_{yc} / S_f (K_y.L_y)^2$

F_Y=10/9 Fy (1-(10Fy/36Fe)

Distortional Buckling Strength

$Mn = [1-0.22(Mcrd/My)^{0.5}] (Mcrd/My)^{0.5}. My$

$Fd = \beta.kd. [\pi^2 E/12(1-\mu^2)] [t/b_0]^2$

Mcrd = Sf x Fy

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My = Sfy x Fy

ANALYSIS BASED ON IS:801-1975

Computation of basicdesign stress:**fb=0.6*fy**

Load determination, effective width is given by**b/t = (658/f0.5) (1-(145/(w/t) *f0.5))**

Determination of safe load**M=f * Z**

IV.ANALYSIS BASED ON BS:5950-1998

Determination of Moment Carrying Capacity(M_c)

Comp. Stress

P_o=(1.13-0.0019(Dw/t) $(Ys/280)^{0.5}$) P

Specimen No	$Load(P)_{IS}$ (N)	$Load(P)_{BS}$ (N)	$Load(P)_{AISI}$ (N)		
			Lateral torsion bucking strength	Nominal flexural strength	distortion bucking strength
ITCBZ-1	37032.23	41575.54	61108.04	61053.73	22809.58
ITCBZ-2	38307.89	46446.04	64572.40	64513.16	26974.08
ITCBZ-3	42238.68	52090.64	70129.64	71064.47	27571.49
ITCBZ-4	49042.98	55767.38	82144.06	81071.64	32746.10

Theoretical results of CFS beam

Numerical Investigation of Cold Formed Steel Step by Step Procedure for an ANSYS Package

In all the finite element analysis, engineering problem can be solved in many steps. In the finite element analysis software ANSYS 12, problems are solved in three phases such us:

1. Preprocessing
2. Solution
3. Post processing

(Applicable for Shell 63 Only)

Preferences□Structural

Preprocessor: Element type □ Add/Edit/Delete □ Add□Shell

Material Props□Material Model□Structural□ Linear □ Elastic□Isotropic □Density□**7850*10-9**

Ex	$2*10^5$
PRXY	0.3

Nonlinear□ Elastic□Multi-linear

Modeling:

Create □ Key points □ in Active Cs

Create □ Line □ Straight line

Extrude: Lines □ along lines

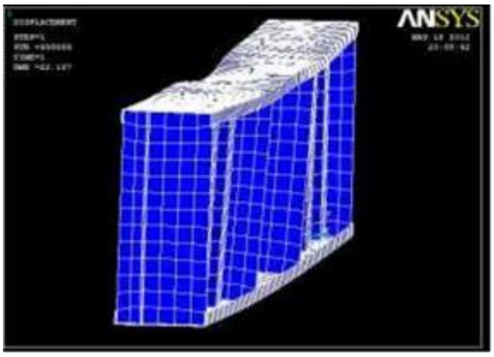
Coupling: Coupled DOFs□ Select nodes □ All DOFs (constrain)

Meshing: Mesh tool □ Areas

Loads: Apply □ Structural □ Displacement (Constrain)

Apply □ Structural □ Force/Moment (Point Load)

Solution: New Analysis □ Static displacement



Deflection at failure mode **Static displacement in CFS beam**

Experimental Investigation of Cold Formed Steel beam Coupen Test

Thickness (mm)	Young's Modulus (N/mm²)	Yield Stress (N/mm²)
2.0	2×10^5	220
1.2	2×10^5	220

Tension (Coupen)test result on Steel Sheet**Specimen details of cold formed steel Beam varyingbending zone**

Specimen No	Length (mm)	Flange (a) (mm)	Web (b) (mm)	Lip (c) (mm)	Pure Bending Zone (mm)	Flange Thickness (t) (mm)	Web Thickness (t) (mm)
ITCBZ-1	2000	100	300	15	600	2	1.2
ITCBZ-2	2000	100	300	15	700	2	1.2
ITCBZ-3	2000	100	300	15	800	2	1.2
ITCBZ-4	2000	100	300	15	900	2	1.2

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A 50T capacity self-straining loading frame is used to conduct experiment for all specimens. A 5T load cell is used to measure the load. A clamping arrangement is used to arrest the lateral rotation of specimen during testing. Specimens are tested under simply supported end condition Totally four LVDT are used to measure the deflection at various points. Strain values are obtained from the strain gauges which are affixed at various points in the specimens. The load cell, four LVDT and three strain gauges are connected to Data Logger using channel board. Two-point loads are applied at L/3 distance from either ends of the specimen. Load is applied gradually up to maximum; the deflection and strain values are recorded using data logger. Using the recorded readings, the following graphs are plotted.

V. CORRUGATION CONFIGURATION

Corrugation Details Cold Formed Steel beams.

corrugation				
S(mm)	b(mm)	d(mm)	h_r	q(mm)
240	60	42.42	42.42	204.84
240	60	42.42	42.42	204.84
240	60	42.42	42.42	204.84
240	60	42.42	42.42	204.84

SPECIMEN: ITCBZ-1

I section having corrugation in shear zone(ITCBZ-1)

Specimen in Loading Condition

The maximum load carried by the specimen under two-point loading is 22580N

Load vs. Deflection at top lip

The maximum value of deflection and strain at various locations are listed below.

(ITCBZ-1) Specimen

Deflection at right end support (top)71.mm, Mid span deflection 3.1mm, Deflection at lip 12.2mm

L/3 deflection 3.1mm, Strain at top flange 1036µm/m, Strain at web (shear zone),78 µm/m Strain at bottom flange1680µm/mLoad vs. Deflection at Mid span.

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(ITCBZ-2) Specimen

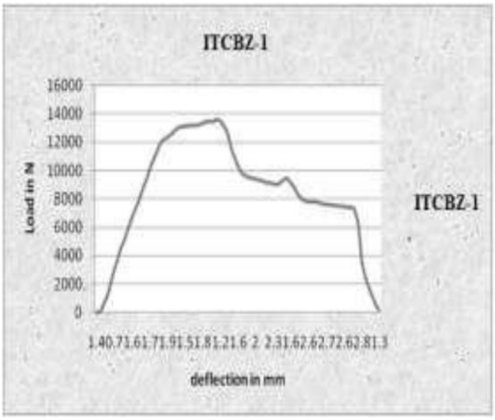
Deflection at right end support (top)17.4 mm, Mid span deflection 9.4 mm, Deflection at lip 14.7 mm, L/3 deflection 1.3 mm, Strain at top flange 697µm/m, Strain at web (shear zone) 5682µm/m Strain at bottom flange 176 µm/m.

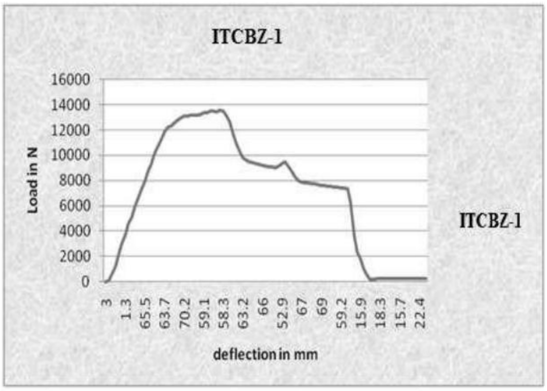
(ITCBZ-3) Specimen

Deflection at right end support (top) 15. 7mm.Mid span deflection 13.6mm, Deflection at lip4.2mm, L/3 deflection 1.3 mm, Strain at top flange1211µm/m, Strain at web (shear zone) 256µm/m, Strain at bottom flange 2084 µm/m

(ITCBZ-4) Specimen

Deflection at right end support (top) 90.6 mm, Mid span deflection 20.7 mm Deflection at lip 26.8 mm, L/3 deflection 2.7 mm, Strain at top flange 2045µm/m, Strain at web (shear zone)117 µm/m, Strain at bottom flange 1520µm/m





Load vs. Deflection- right end support at top

VI.RESULT DISCUSSION

Numerical investigation results

Specimen No	Length (mm)	Flange (a) (mm)	Web (b) (mm)	Lip (c) (mm)	Pure Bending Zone (mm)	Web Thickness (t) (mm)	ANSYS Result In N
ITCBZ-1	2000	100	300	15	600	1.2	33685
ITCBZ-2	2000	100	300	15	700	1.2	35590
ITCBZ-3	2000	100	300	15	800	1.2	39610
ITCBZ-4	2000	100	300	15	900	1.2	48936

Specimen No	Experimental Load(P) (N)	Numerical Load(P) (N)	Theoretical Load(P) (N)		
			IS code	BS code	AISI code
ITCBZ-1	22580	34685	35032	41575	24809
ITCBZ-2	22763	36590	37307	56446	26974
ITCBZ-3	32331	37610	42238	50090	27571
ITCBZ-4	27097	47936	47042	57767	32746

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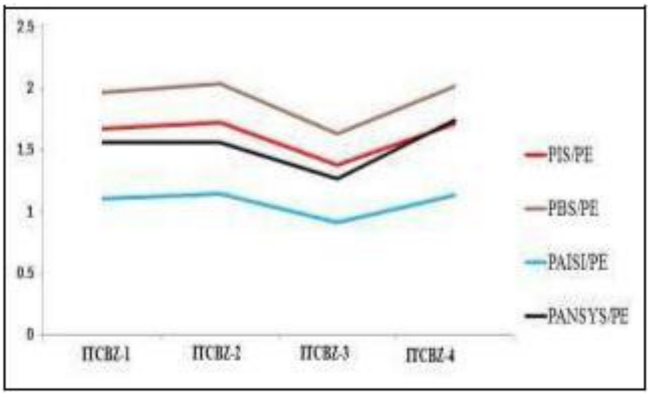
Comparison of Load Carrying Capacity of Beams

Specimen No	P_{IS}/P_E	P_{BS}/P_E	P_{AISI}/P_E	P_{ANSYS}/P_E
ITCBZ-1	1.67	1.97	1.10	1.56
ITCBZ-2	1.72	2..04	1.14	1.56
ITCBZ-3	1.38	1.63	0.912	1.26
ITCBZ-4	1.71	2.02	1.13	1.74

Load Carrying Capacity of Beams

The load carrying capacity of cfs beam with varying bending zone is obatined by result, the load of specimen ITCBZ-3 is increases with the deflection of mid span bottom 13.6 mm is low as possible compared to all three specimens. The results are slightly same for ANSYS and experimental test set up.

Ratio of Load Carrying Capacity of Beams Vs Experimental Load



VII.CONCLUSION

The experimental and theoretical investigation (AISI code) shows that all member undergoes distortional buckling. The numerical analysis result does not hold good. when compared with experimental and theoretical result Due to the corrugation provision shear capacity is higher than flat web, therefore no failure in shear zone. The two loading point distance increases, the strength also increases. The corrugation is ineffective in pure bending zone and effective in shear zone only.

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