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# STUDY ON BEHAVIOUR OF COLD FORMED BUILT UP SECTION WITH CORRUGATED WEB FOR VARYING PURE BENDING ZONE

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## ABSTRACT

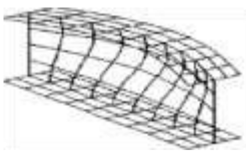
*Thin walled steel sections tend to be more sensitive to local buckling effects than typical hot rolled sections. Cross sections are generally stiffened to improve resistance to local buckling.*

*Corrugated web beams are built up one with a thin walled corrugated web and two flanges connected by welding. Web corrugations are of different types such as rectangular, trapezoidal or sinusoidal profiles. A thin web may be sufficient to take care of shear stresses developed due to external loads, but sometimes thin web shows instability and hence stiffeners are necessary to account for such type of stability problems. Instead of using stiffeners, corrugation in the web portion is created. This situation leads to the corrugation in web.Investigation has been carried out on the influence of trapezoidal corrugated web in shear zone of cold formed lipped I section. Four specimens with trapezoidal 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 trapezoidal 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, ANSYS, To Local Buckling, Sinusoidal Profiles.***

## 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



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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 utilised 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 coldformed 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

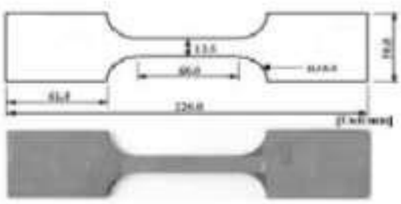
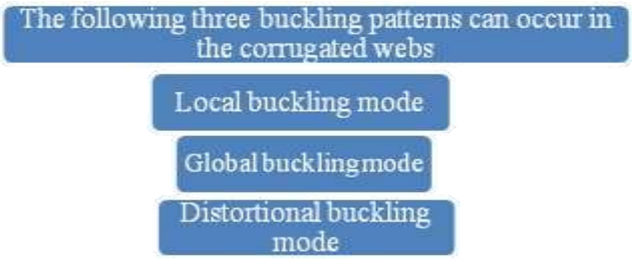
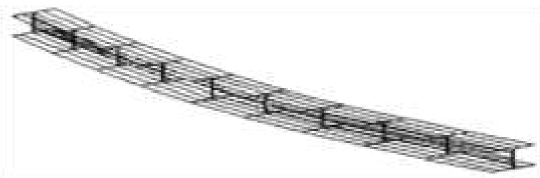


**Fig.No.1 Tension Test on Steel Sheet**

## Theoretical Investigation of Cold Formed Steel



### 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

Mne = My(No lateral buckling at bending moments less than or equal to 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 xFy

My =Sfy x Fy

### ANALYSIS BASED ON IS:801-1975

Computation of basic

design stress: $\mathbf{f_b=0.6*f_y}$

Load determination, effective width is given by $\mathbf{b/t=(658/f^{0.5})(1-(145/(w/t)*f^{0.5})}$

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)$_{ns}$ (N) | Load(P)$_{ns}$ (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 63

Real constant → Add→ Give Thickness of the Specimen

Material Props→ Material Model→Structural→ Linear → Elastic→ Isotropic → Density →**7850*10$^{-9}$**

| Ex | 2*10$^5$ |
|---|---|
| PRXY | 0.3 |

Non linear → 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

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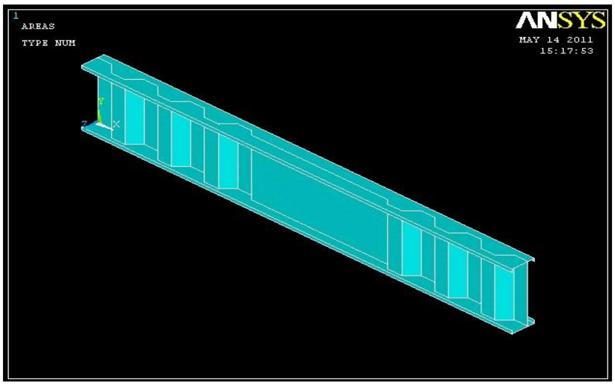
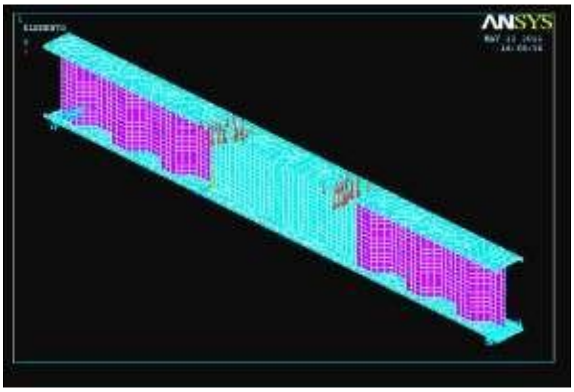
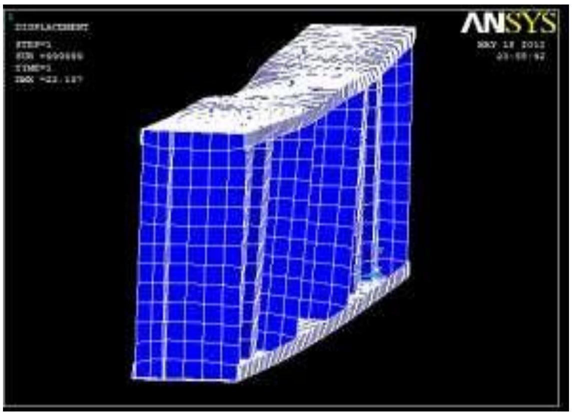
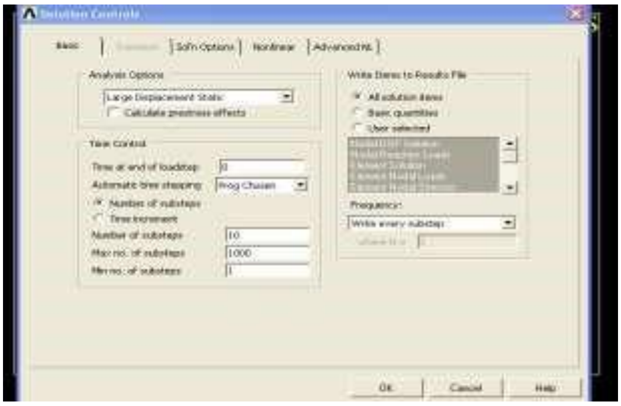



**Finite element model of the specimen** **Model with meshing and loading condition**




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

**Experimental Investigation of Cold Formed Steel beam Coupen Test**

| Thickness (mm) | Young's Modulus ( $N/mm^2$) | Yield Stress ($N/mm^2$ ) |
|---|---|---|
| 2.0 | $2 \times 10^5$ | 220 |
| 1.2 | $2 \times 10^5$ | 220 |

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Tension (Coupen)test result on Steel sheet **Specimen details of cold formed steel Beam varying bending 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 |

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

Test specimen

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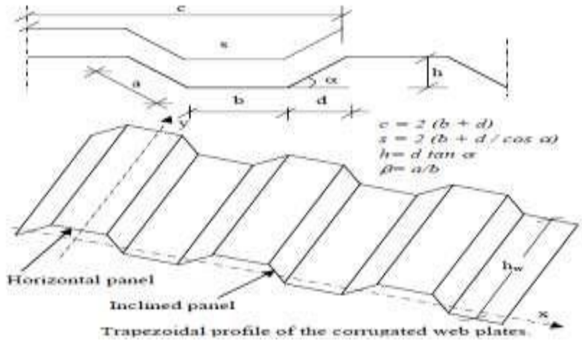
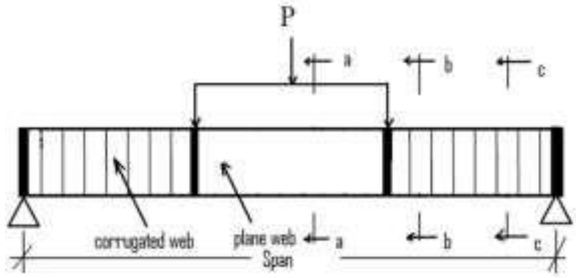
## V. CORRUGATION CONFIGURATION




### 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 |

### Test set up for CFS Beam




- Load vs. L/3 deflection
- Load vs. Mid span deflection
- Load vs. Deflection- right end support at top
- Load vs. Deflection at top lip
- Load vs. Strain at bottom flange
- Load vs. strain at web(shear zone)
- Load vs. strain at top flange

SPECIMEN: ITCBZ-1

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

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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.

**(ITCBZ-2)Specimen**

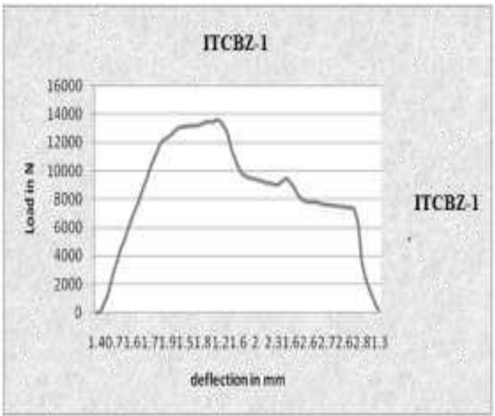
Deflection at right end support (top)17.4 mm,Mid span deflection 9.4 mm,Deflection at lip 14.7 mm, L/3 deflection 1.3 mm, Strain at top flange 697µm/m, Strain at web(shear zone) 5682µm/m Strain at bottom flange 176 µm/m.

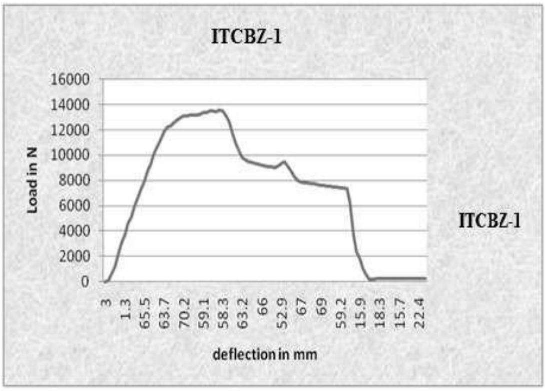
**(ITCBZ-3)Specimen**

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**

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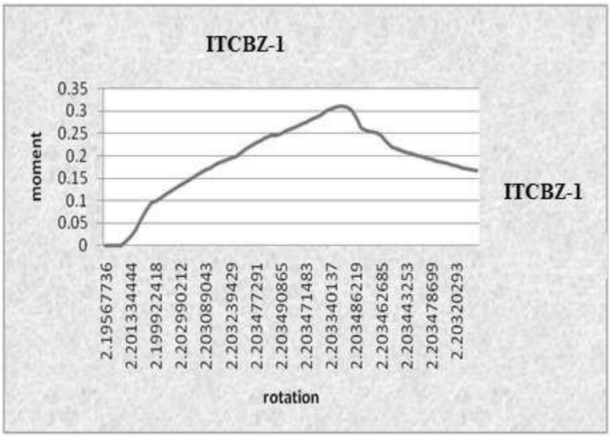



**Moment vs. Rotation@ Mid span deflection**

## VI.RESULT DISCUSSION

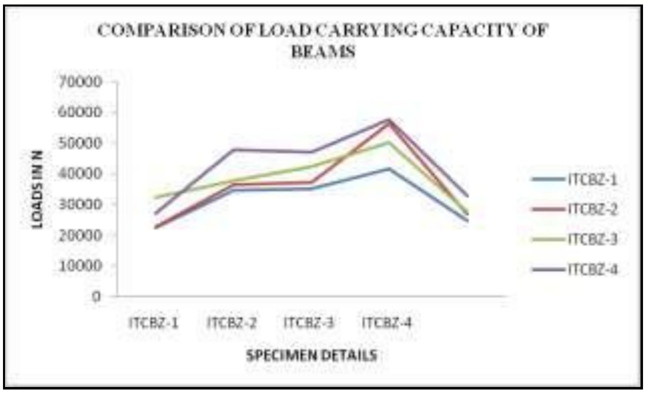
### Numerical investigation results

| 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 |

### Comparison of Load Carrying Capacity of Beams

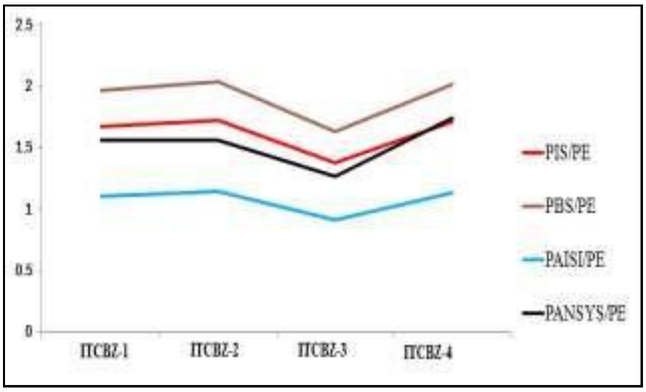
| Specimen No | $P_{IS}/P_E$ | $P_{BS}/P_E$ | $P_{AISI}/P_E$ | $P_{ANSYS}/P_E$ |
|---|---|---|---|---|
| ITCBZ-1 | 1.67 | 1.97 | 1.10 | 1.56 |
| ITCBZ-2 | 1.72 | 2..04 | 1.14 | 1.56 |
| ITCBZ-3 | 1.38 | 1.63 | 0.912 | 1.26 |
| ITCBZ-4 | 1.71 | 2.02 | 1.13 | 1.74 |




### Load Carrying Capacity of Beams

The load carrying capacity of cfs beam with varying bending zone is obatined by result ,the load of speciment 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 experimenal test set up.

### Ratio of Load Carrying Capacity of Beams Vs Experimental Laod




## VII.CONCLUSION

The experimental and theoretical investigation(AISI code) shows that all member undergo 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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