

Analytical Study on Flexural Behaviour of Cold formed Hollow Flanged Z – Sections

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ABSTRACT: The Cold formed sections have become a paramount importance in modern construction methods, because of their ability to produce them in very thin cross sections which are not quite possible in conventional hot rolled steel sections. Also the yield strength of the cold formed sections can be increased due to cold working on steel. These cold formed sections are used in almost all structures to carry significant loads, since it is possible to carry these loads at much lesser self-weight. This is because of the fact these sections can be made thinner than hot rolled sections for the same load carrying capacity. One prominent area where cold formed sections are used are in trusses, specifically roof or floor trusses. Purlins which is an important member in these trusses are designed preferably as continuous beams for moment and shear resistance. Thus to resist moment there is a demand of appreciable amount of moment of inertia about axis of bending. Hollow flange Z - Sections serves this purpose very well, since the moment of inertia is relatively higher than in normal Z – Sections. However finding the possibilities of shapes of these flange that offer higher load carrying capacity is questionable. This paper enumerates the results of various cross sections that have been analysed under ANSYS (Version 18.2) for the maximum load carrying capacity with deflection limit as the benchmark.

KEYWORDS: Cold formed steel, Z –sections, Purlins, Hollow flanged Sections, ANSYS, Flexural Deflection, Finite Element analysis.

I. INTRODUCTION

Cold formed sections are said to be particularly efficient in all steel constructions because of two main criteria's. Those are, the cold formed sections have high strength/weight ratio because of their ability to be rolled into very thin sections and the yield strength of the cold formed sections can be increased, at least 15%. These factors influence the choice of using cold form sections in the place of hot rolled sections, significantly. Truss elements can be said as the immediate beneficiaries of these cold formed sections because, those structures would require high load and moment handling capacity with a less dead weight as possible. Also cold formed sections are easy to work with, which makes it easier to bend them into any custom shape at the location itself which may be specifically required for structures. This easy handling is not possible in hot rolled structures. Elements of the truss which bears immediate loads are purlins. Purlins are primarily bending members where loading is transverse to the span. Purlins are designed preferably as continuous beams for moment and shear resistance. Thus to resist moment that occurs, there is a demand of appreciable amount of moment of inertia about major axis, the bending axis. Z section and I section have higher moment of inertia as compared to angle section for same area. Also for attaching roof sheathing, top **flange** aids to accommodate the connections.

In order to increase the moment of inertia of the sections, hollow flange sections are used, which would have higher moment resisting capacity. Deflection limits of the sections is used as an indicative tool to compare various sections for better performance by considering a constant load and studying the deflection component or by considering a constant deflection and studying the load component. The cold rolled sections used in these analysis are analysed using ANSYS version 18.2 considering the sections as a static structural component.

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II. METHODOLOGY**A. CROSS SECTION**

The increase in yield strength of the cold formed steel being the consequence of cold working into the strain-hardening range. Z - Section offers more resistance to the lateral distortion. Therefore, four type of Z - section is considered for the comparative analysis. The sections differ in the cross section selected. Though 3 of them are considered to be hollow flanged sections, the shape of the hollow flange differentiates the section characteristics and behaviour. Another one is regular Z - section. The shapes of the flange are rectangular and triangular. They are,

Rectangular Hollow Flange

Triangular Hollow Flange (apex outward)

– Type 1 Triangular Hollow Flange (apex inward) – Type 2 Normal Flange section

B. SPECIFICATION

The simulation of the section is related to the steel purlin member on the steel roof trusses. Thus the section depth is

considered on a practical approach. Therefore the depth of the section is limited according to the real scenario.

Also the section specifications such as depth and the width of the Z - sections are taken in the analysis based on the IS 811-1987: 'Code of practice for Cold formed light gauge structural steel section'. However the flange depth is taken from the works done by Karunakaran and Helen on 'Rectangular hollow flanged sections' [4]. They proposed analytical results on the hollow flanged rectangular Z-section and its optimum benefit to resist large load and its effective flange depth for the same. As per that, the selected depth of flange should be one fourth of the total depth of the section.

The section specification for the Z - Sections and the hollow flanged Z-section are,

Total Depth = 140 mm

Width of Flange = 60 mm

Thickness of Section = 2
mm Depth of Flange = 35
mm

Span Length = 1000 mm

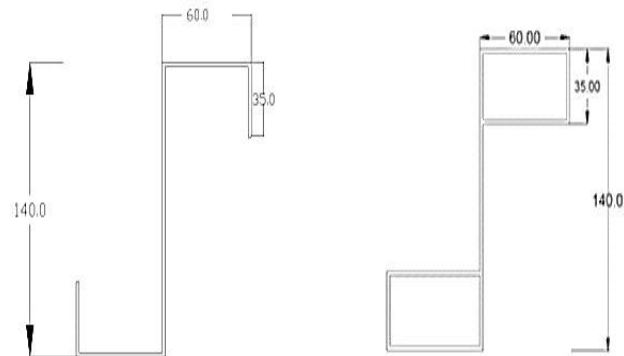


Fig 1 – Cross Section of normal and Rectangular hollow Flanged Z – sections

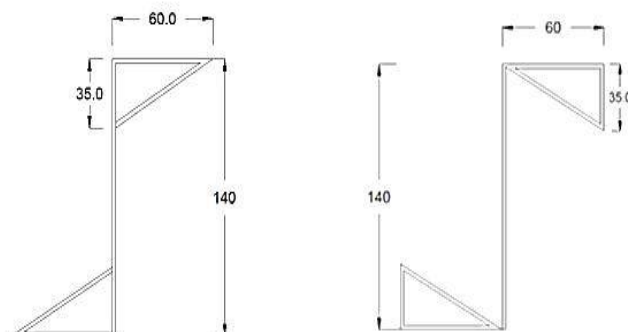


Fig 2 – Cross Section of Triangular Hollow Flanged (Type - 1 & Type - 2) Z – Sections

C. SUPPORT CONDITION

The support conditions that are employed in purlin connections are generally bolt or riveted. Occasionally welded connections are also used.

Bolted connections allows rotation and restricts displacement, therefore it can be termed as a pinned connection. Pinned connections are more relevant to purlin's supporting system because it is much easier, efficient and repairable. Generally sheathing is attached in top flange and the web is bolted to the bracing system.

III. ANALYSIS

A. Simulation

The adopted sections are studied and analysed in a reliable finite element oriented software, for which there are several software available.

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We have selected ANSYS for the simulated analysis purpose due to the following factors,

- Flexible step by step work procedure.
- Ability to modify designs at later stages.
- Possibility of iterative analysis refinement.
- Distinguished geometry and model making possibilities

The analysis system adopted for this simulation in ANSYS is static structural and the version of the software used for analysis is ANSYS 18.2

B. Engineering Data

The engineering Specifications of the cold formed sections are given as an analysing material's input in ANSYS. These data

input plays an important role in analysing the behavior of the structure during the analysis. These data inputs are based on Indian Standards as well as on British standards.

Poisson's ratio - 0.287

Tensile yield strength - 320mpa (min. 260mpa)

Young's modulus - 2.303×10^5

C. Meshing

The meshing operation of the section involves separation of the section into several smaller finite elemental fragments for

efficient interaction. In simple terms, more the number of elements, more reliable and accurate the results are. However too finer elements have higher simulation time restriction. Therefore adopting an appropriate element refinement and size is necessary.

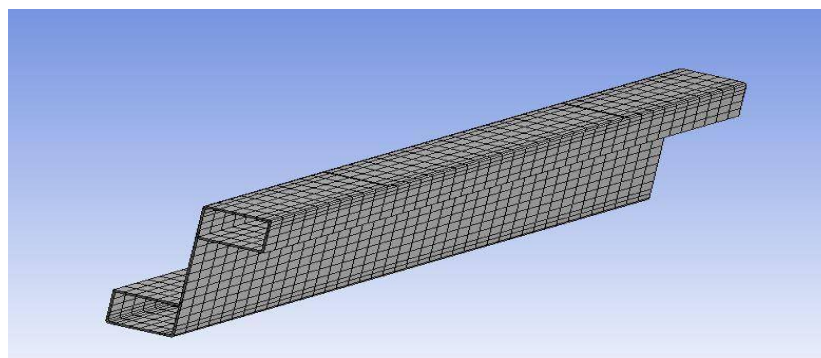


Fig 3 – Meshing for Rectangular hollow flanged section

We have analysed the sections using quadratic elements and a uniform arrangement of meshing with a smoother transition along the surfaces for better results.

D. Loading Condition

In general, the purlins are subjected to loads due to roof sheathing and other environmental conditions such as wind load and snow load depending on the regional conditions. These purlin structures are subjected to experimental analysis for determining the efficient section characteristics for which a laboratory testing is often done. In this paper, the exact laboratory

testing scenario is adopted for determining the efficiencies of the sections. Also the self-weight is also included by adding acceleration due to earth gravity

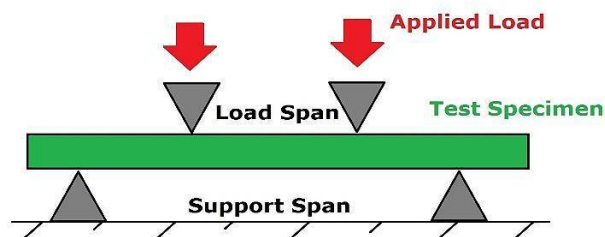


Fig 4 – Laboratory testing method (2 point loading)

Therefore two point load testing is being simulated in the analysis with pinned conditions. However to predict the real scenario of testing rather than testing with a simple point load, we simulated a pressure acting at one and two third of the spans for a very small area of 3mm thickness, across the flange width.

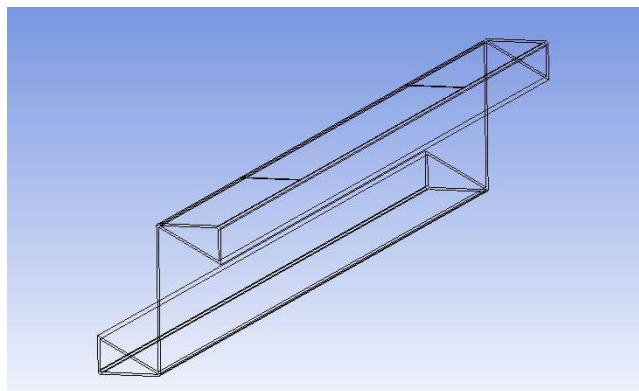


Fig 5 – Type 2 THFB Wireframe showing pressure imposed areas in top flange at 1/3rd and 2/3rd of span length

E. Supporting conditions

The sections are supported on both ends under pinned condition by fixing the lower edge of the bottom flange alone. Therefore the span length of the all sections are maintained as 1.0 m with supports at L = 0 mm and L = 1000mm.

F. Limiting criteria

The limiting criteria refers to a normalized scale or value, which is used to compare the results of the various sections to analyse the efficiency of the sections on a common scale. In this paper, deflection is used as a normalized value for comparing the load carrying capacity of the sections. The deflection limit is taken as span / 300 as per BS 5950 – part 5.

IV. SIMULATION

The sections are imposed to pressure at a distance of one quarter of the length from each end. The pressure is applied on the face of top flange at an area of 3 mm x 55 mm cross section, which is too small as compared to the running length of flange, which is small enough to be called as a point load imposed system.

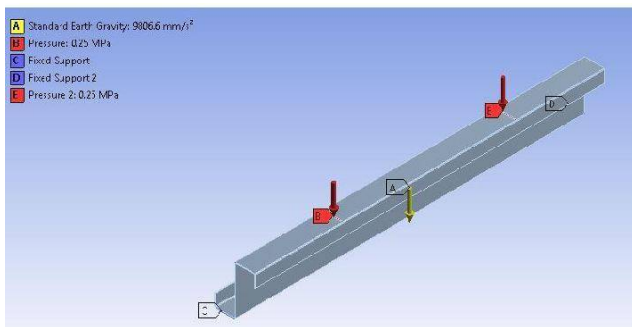


Fig 6 Pre-processing of Normal Z-section analysis

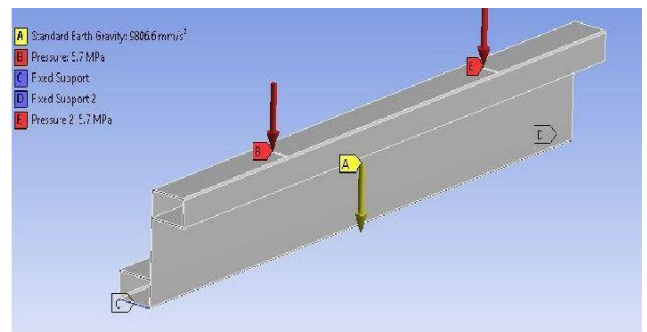


Fig 6 – Pre-processing of RHFB section analysis

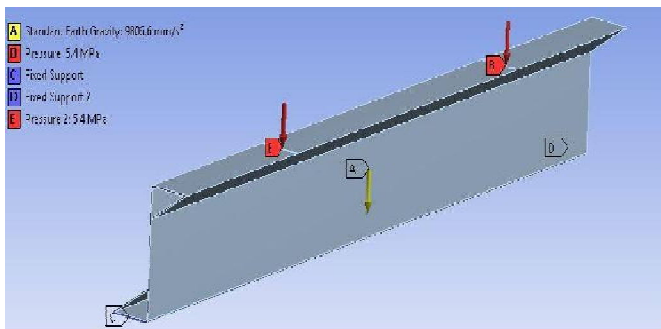


Fig 6 Pre-processing of THFB Type - 1 section analysis

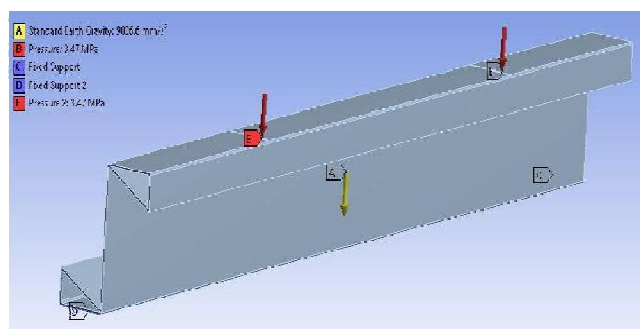


Fig 6 – Pre-processing of THFB Type – 2 section analysis

V. RESULTS

The Deflection limit calculated for the section limitation accounts to 3.33mm. This deflection limit is guided for tiled roof condition, which is a common occurrence in Indian scenario. The pressure imposed on the sections for this analysis can also be converted into direct loads for better interpretation.

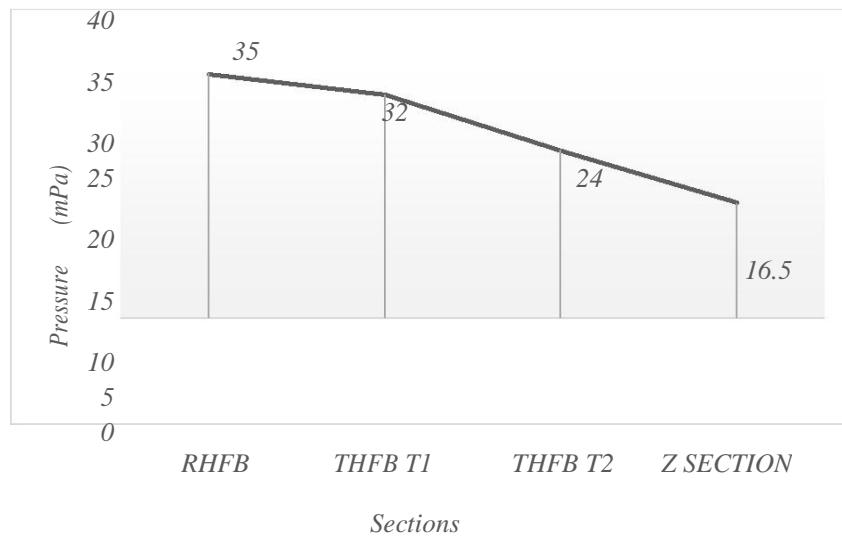


Fig 10 – Pressure sustained for 3.33mm deflection

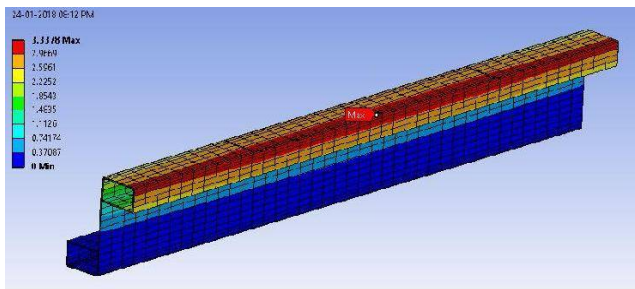


Fig 12 – Deflection gradient of RHFB section

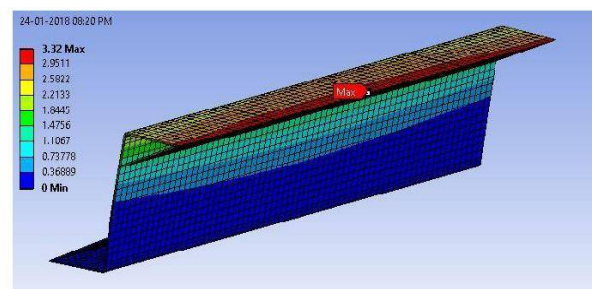


Fig 11 – Deflection gradient of THFB T-1 section

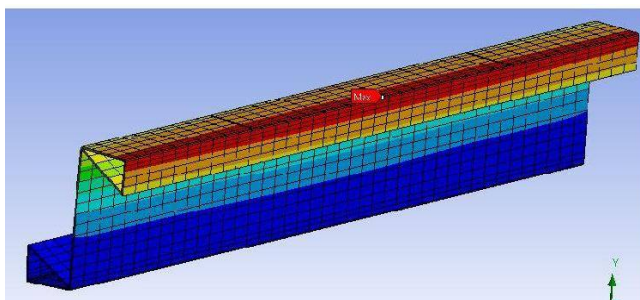


Fig 14 – Deflection gradient of THFB T-2 section

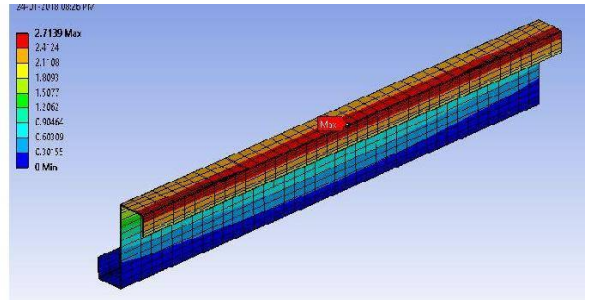


Fig 13 – Deflection gradient of Normal Z-section



Sections

Fig 15 – Deflection experienced for imposed load

These graphs shows that of all the sections rectangular hollow flanged section performed well.

However this does not mean that this section is efficient. While comparing weight to strength ratio, the Triangular Hollow Flanged Beam Type -1 is said to perform efficient, which can be seen from the below table,

Section	Weight (Kg)	Maximum load sustained (KN)	Load/Weight ratio
RHFB	7.07	35	4.95
THFB T1	6.26	32	5.11
THFB T2	7.36	24	3.26
NORMAL Z	5.18	16.5	3.19

TABLE 1 – Section Comparison for Efficiency

Pressure/weight ratio is used as a tool for determining the efficiency of the sections. This ratio means that the amount of pressure that can be sustained per increase in self-weight of the section, which means that higher the ratio, greater the performance of the section. This indicates Triangular Hollow Flange Type-1 section is better than RHFB section any considered section.

VI. CONCLUSION

The comparative study of the considered sections have yielded results which are thoughtful to be concluded as,

Triangular hollow flanged type -1 section is more efficient because it serves better, when the weight of the material is kept in consideration.

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The Rectangular hollow flanged section performs better, however not much improvement from triangular hollow flanged type -1 section.

The performance to sustain maximum load, RHFB over THFB type -1 section is 9% increase.

But by considering overall effectiveness of the sections THFB type -1 section shows 3.2 % increase in efficiency over RHFB.

Though the buckling behavior of THFB and RHFB are significantly different, the THFB type 1 plays importance in structures which would require less self-weight consideration.

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