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Analytical Study on Delta Hollow Flange Steel Beam with and without Stiffeners

Aishwarya. M. B¹, Sattainathan Sharma. A²

P.G. Student, Department of Civil Engineering, SRM Valliammai Engineering College, SRM Nagar, Kattankulathur,
Tamil Nadu, India¹

Assistant Professor, Department of Civil Engineering, SRM Valliammai Engineering College, SRM Nagar,
Kattankulathur, Tamil Nadu, India²

ABSTRACT: In recent years of construction, steel has been considered as the most commonly used construction materials. Structural steel has many structural benefits like high strength, greater stiffness, high ductility with excellent structural properties and fire resistance. It also reduce the cross section of a section. They were highly used in various application which includes purlins, girts, portal frames and steel frame structures. Steel structure are faster in construction. The main aim of this paper is to study new steel beam. Rather than normal I-shaped beam, it is innovated to form Triangular Hollow Flange Beam (THFB) with slender web using required welded connection to improve the flexural capacity. THFB is also called as Delta Hollow Flange Beam (DHFB). In I-Beam to increase the thickness of the web, instead DHFB can be proposed. In this paper a review on various research papers are investigated and use of stiffeners are added to the Delta Hollow Flange Beam. The analytical study using ANSYS were done for five different specimens with and without stiffeners.

KEYWORDS: DHFB, Flexural strength, Stiffeners, ANSYS.

I. INTRODUCTION

Steel members are strong in Tension. Hence they are used in various applications. Generally, structural steels are of two types, namely Hot Rolled steel and Cold Formed steel. The major difference between these two steels are in the manufacturing process. Cold formed steel has 20% higher strength than Hot rolled steel and the finishing of the surface in cold formed steel are better. And the major advantage is, it is easy to bend in any desirable shapes with high strength to weight ratio. Hence they can be used in various day to day application in residential, commercial, industrial buildings, etc., Triangular Hollow Flange Beam (THFB) is otherwise known as Delta Hollow Flange Beam (DHFB). Hollow Flange Beams are more efficient than normal flange Bean. The Same strength with same mass of solid section can be achieved with lesser mass of Hollow section that is Strength to weight ratio is higher for Hollow section, and the resistance against torsion is high in Hollow Sections. This DHFB can be used mainly in bridge applications and Gantry Girders. The objective of the paper is the flexural-torsional resistance is increased with increase Moment of Inertia. Based on the literature study, the strength of DHFB is further more increased by using vertical stiffeners to improve the buckling capacity of the slender beam. As to make the study cost effective, stiffener are placed at largely spaced distance. Five different specimens with and without stiffeners were analyzed. The analytical process has been done using the FEA software ANSYS. Different parameters like stress, strain, deflection and buckling properties are studied.

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Element of Delta Hollow Flange Beam

The following are the elements of a typical Delta Hollow Tubular flange Beam,

- Web
- Flanges
- Stiffeners

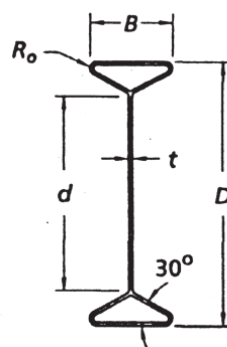


Figure 1. (a) Cross Section of Delta Hollow Flange Beam

Webs

In I-shaped steel Beam, the slender, tall and vertical portion is called web. It will resist all the shear in the beam and to provide separation for the coupled forces of bending. Webs of adequate depth and thickness are generally provided to distance the two flange plates and they resist the shear force in the beam.

Flange

The Horizontal sections of the I-Beam are called Flanges. It will resist the bending and web will resist the shear force. Wide flange beam makes the element a lighter building material. Flanges with adequate width and thickness can resist bending moment on the beam by developing compressive force in one flange and tensile force in another flange.

Stiffeners

Stiffeners are the secondary plates used in beam to its web or flanges to strengthen them against out of plane deformations. Mainly all type of bridge beams will have stiffeners. There are two types of stiffeners namely,

- Longitudinal stiffeners
- Transverse stiffeners.

Most of the bridge beam will have only transverse stiffeners. It is also called as vertical stiffeners. Deep beams will have longitudinal web stiffeners. Flange stiffeners can be used in some cases like large span box girder bridges. Generally web is subjected to shear force which leads to web buckling when the height of the web exceeds the limits. In that cases, web stiffeners are used. Longitudinal stiffeners are also called as Horizontal stiffeners. If the depth of the web increases the buckling also increases more rapidly and in such cases provision of largely spaced vertical stiffeners are good and economical.

Inference from Literature Review

I shaped beam with tubular flange includes large local buckling resistance, lateral stability, large torsional stiffeners and reduce web slenderness. Reinforced by transverse stiffeners will eliminate the web crippling. Three stiffeners can increase about 20%-25 % strength compared to unstiffened girders. If the transverse stiffeners are closely spaced the mechanism involves web strength as well as flange strength. Transverse stiffeners were welded to supports and at load points in order to prevent web buckling or web crippling or web crushing.

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Objective

- It is aimed to study a new innovative cold- formed steel section called Delta Hollow Flange Beam (DHFB).
- To study different concepts regarding DHFB published in different papers were studied.
- To analyze the model using ANSYS software.
- To determine the ultimate load carrying capacity of the section.
- To find the stress, strain, and deformation of the section.
- Further, the results obtained from ANSYS software are to be compared with experimental results.

The Beam section selected for the analysis is taken from the paper published by P.Avery and M. Mahendran. Delta Hollow Flange section is not available in IS codal provisions. The following section is taken by the Authors from Australian code. The Authors were analyzed beam sizes from depth of 200mm to 450mm. I have selected the depth size of 400mm depth cross section because the experiment work is not done for that size.

Table 1. Stiffener Specification

Number of stiffener	3
Position of stiffener	0.3m, 0.6m, 0.9m
Thickness of stiffener	4 mm
Connection used	Welding

B1 – Conventional I Steel Beam

B2 – Hollow Flange at top and bottom with Stiffeners

B3 – Hollow Flange at top and bottom without stiffeners

B4 - Hollow Flange at top only with stiffeners

B5 - Hollow Flange at top only without stiffeners

II. SOFTWARE ANALYSIS

FEA is one of the most widely used method to analyze a structural member. In FEA, the member is analyzed by dividing the element into infinitely small elements, so that the result accuracy is more. In this paper, ANSYS is used to analyze various parameters of Delta Hollow Flange Beam. Mainly, the stresses in a body is uniformly distributed which can be clearly shown through FEA. The stress concentrated Area can be clearly located. Models with complex geometry can be easily analyzed through ANSYS.

ANSYS Workbench

ANSYS Workbench is a platform used to deliver a comprehensive and integrated simulation. FEM is the most commonly used method to solve tedious mathematical and Engineering Problems in different areas like structural analysis, heat transfer, Fluid flow and electromagnetic potential. ANSYS can perform the analysis based on contact algorithms; time based loading and other parameters with unique automation. Modelling is the first process in ANSYS workbench, then corresponding loading conditions with boundary conditions are given, after that the analysis is performed and the results are generated with greater accuracy

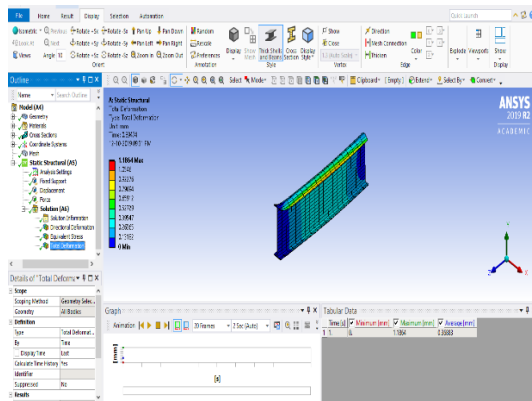
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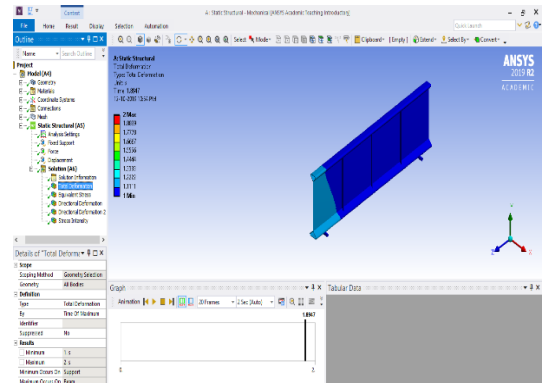
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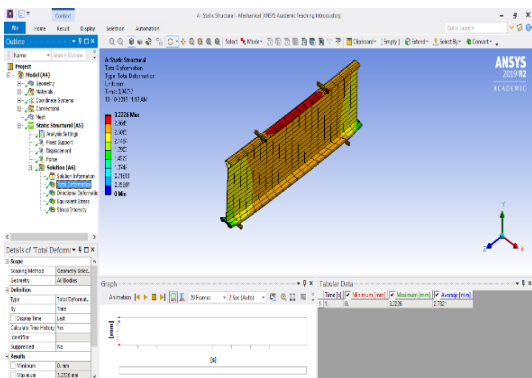
Total Deformation



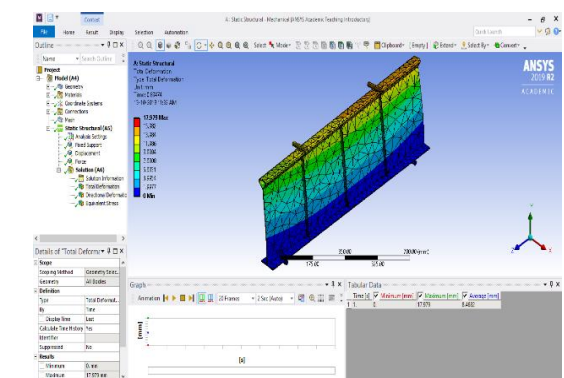
(a)



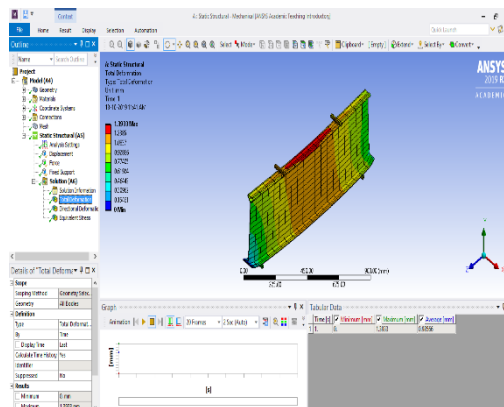
(b)



(c)



(d)



(e)

Figure 2. Total Deformation (a) Total Deformation of B1 (b) Total Deformation of B2 (c) Total Deformation of B3 (d) Total Deformation of B4 (e) Total Deformation of B5

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III. ANALYTICAL RESULTS

Table 2 Results from ANSYS Analysis

		B1	B2	B3	B4	B5
Total Deformation (mm)	Min	0	1	0.35	-3.6	0
	Max	1.18	2	3.26	1.55	1.39
Equivalent Stress (M Pa)	Min	0.017	0	0.0378	0.0185	0.0450
	Max	0.0208	0.0642	0.0498	0.0552	0.0311
Equivalent strain	Min	0	0	0	0	0
	Max	0.0025	0.00089	0.0288	0.011	0.0052
Y Directional Deformation	Min	-1.185	-0.170	-3.123	-3	-1.344
	Max	0.00191	0.057	0.0313	1.55	0.0175
Stress Intensity (M Pa)	Min	0.0213	0.0519	0.0413	0	0.0180
	Max	0.240	0.0698	0.0558	0.0593	0.0367
Buckling (mm)	Min	0	0	0	0	0
	Max	2.009	1.0029	1.004	1.075	1.085

IV. CONCLUSION

From the above table it is found that the maximum deformation is found on both hollow flanges with stiffener (B2) which is 3.266mm. Among five specimen B2 is having the high load carrying capacity so that it has higher equivalent stress and strain. In B1, the conventional beam, web crippling is happened. B2, the beam with hollow flanges at both top and bottom with stiffener is the specimen which carries high load that all other 4 specimen. B2, the failure in the web is controlled by the stiffeners and the failure is started at the loading points. B3, beam with hollow flanges at both top and bottom without stiffeners carries almost equal load like B2. From the above results it is found that B2, B3 and B4 are almost carries equal amount of deformation. It is found that Hollow Flange Beam carries about 40% of higher load than normal I Beam. Mostly all five specimens fails by torsion. The web crippling can be controlled by the use of stiffeners. But it does not create more variation in the beam with hollow flange without stiffeners. Hollow Flange at top with stiffener (B4) is considered as the most efficient and economically better specimen among all five specimens. Comparing B2 and B3, 85% of the result was same, that is DHFB without stiffener can carry about more or less equal load like DHFB with stiffeners. So it is not so necessary to provide the stiffener in case of the load consideration. But taking torsion into consideration, DHFB without stiffener will fail due to torsion and web will fail under local buckling. To solve such problems it is important to provide stiffeners. Comparing the results from ANSYS analysis it is seen that, the failure in works the failure was seen along the web. Web crippling is the major problem in I sections, by using stiffeners the failure in web can be reduced and is clearly seen in the results

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