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A PARAMETRIC STUDY ON EFFECT OF TRAPEZOIDAL WEB PROFILE ON THE ANGLE OF TWIST OF STEEL I-BEAM FOR ECCENTRIC LOADING

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ABSTRACT

The term lateral torsional buckling belongs to deflection and angle of twist of a beam. The structural action of a regular beam under loading is predominantly bending, with other effects such as, warping, rotation and lateral torsional buckling. Different cross sectional web profiles are used to eliminate the lateral torsional effect of beam. Corrugated steel plate is a widely used structural element in many fields of application because of its numerous favorable properties. This paper presents a parametric study of trapezoidal web profile on the angle of twist of steel I beam for eccentric loading. Comparison is made with conventional beams with same dimensioned flat web. The study only includes angle of twist.

It is concluded that steel beam with trapezoidal web section have higher resistance to angle of twist. The result shows that not only the thickness, but also the corrugation angle, length of infill corrugated plate and corrugation width influences the resistance to the angle of twist.

Keywords: Angle Of Twist, Bending, Lateral Torsional Buckling, Trapezoidal Web, Web Thickness, Corrugation Angle, Corrugation Width And Length Of Infill Corrugated Plate.

I. INTRODUCTION

When a cantilever beam is loaded, it will deflect vertically. If the beam does not have sufficient lateral stiffness or lateral support along its length, the beam will also deflect out of the plane of loading. These two deformations are interdependent: when the beam deflects laterally, the applied moment exerts a component torque about the deflected longitudinal axis which causes the beam to twist. This behavior, which is important for long unrestrained, I-beams whose resistances to lateral bending and torsion are low, is called lateral torsional buckling [2].

The conventional method which uses intermediate stiffeners welded to the web to allow the use of thin webs has two disadvantages i.e. high cost of fabrication and reduced service life of the element. The use of corrugated sheets to replace flat sheets as webs of a beam eliminates both disadvantages. In addition, it reduces the total weight of the structure, thus allowing longer spans and savings in foundation design [2].

A trapezoid web steel section is built up by welding flanges and a web of trapezoidal corrugated profile (Figure 1). The main purpose in particular is to increase the out-of-plane stiffness and shear buckling strength without the use of vertical stiffeners. It allows the use of thin plate webs without the need of stiffeners, thus considerably reducing the cost of fabrication. Since there is no standard design method for the new section, this research has been carried out to develop a complete design guide based on analytical and experimental study [1].

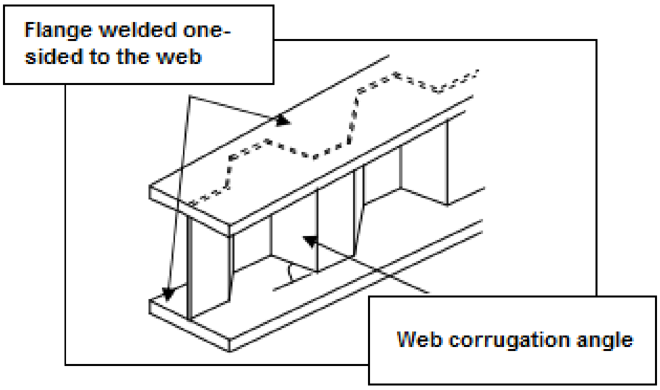

Figure 1: Trapezoidal Web Profile

The design concept of TWP sections is not much different from the design of conventional welded steel sections. In almost all cases, the webs for both sections are classified as slender while the flanges are semi-compact section. The derivation of the design shear capacity of TWP sections is based on the results of experimental and theoretical study, and is the major part of the research program [1].

II PARAMETER SELECTION FOR STUDY

1. Web thickness (t_w) – 5.7, 6.7 mm
2. Corrugation angle (θ) – 30^0, 45^0, 60^0, 75^0
3. Corrugation plate length (b) – 300, 350 mm
4. Corrugation web width (h) – 20, 30 mm

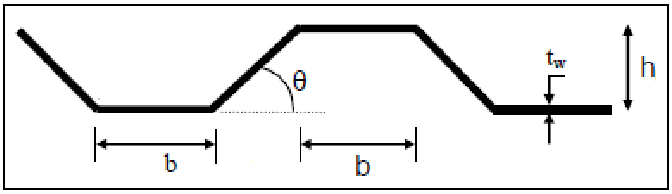

Figure 2: Geometrical Nomination of Trapezoid Web

III. METHODOLOGY

A literature study performed in order to understand the mechanism behind bending & lateral-torsional buckling. Failure analysis of regular I beam for direct & eccentric loading. Study & analysis of various parameters of trapezoidal web for the evaluation of angle of twist by CAE software.

IV. FINITE ELEMENT ANALYSIS

This section explains the assumptions on finite element (FE) modeling and evaluates the methodology selected for validation of simulation in the software modeling.

4.1 Assumptions of Modeling

In this part of the study, the beam with trapezoidal web plate is investigated under point loading at free end. The geometric properties of the beam with trapezoidal web on software are shown in Figure 4 and Table I & II. ANSYS is used to create the models and are defined in terms of geometric features that must be subdivided into finite elements for a solution. This process of sub division is called meshing. Mesh datasets contain information about element types, element discretisation and mesh type. The I-beam models were assigned ungraded mild steel for its material property with Young's modulus, E= $2.1x10^5$ N/mm^2, shear modulus, G = $79x10^3$ N/mm^2 and Poisson ratio of 0.3. The convergence of the mesh was established by independently increasing the mesh density in each part of the model beam section.

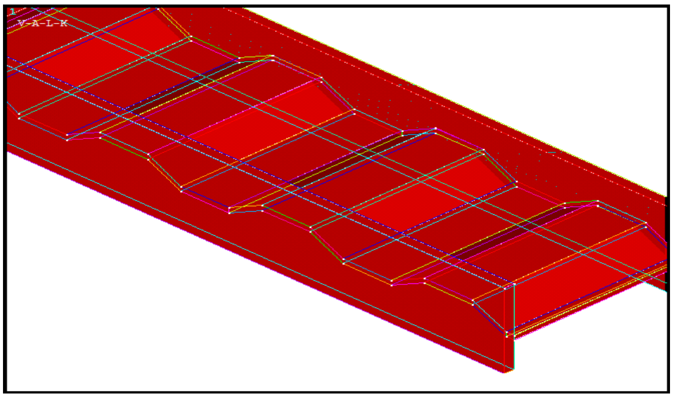

Figure 3: Model of Trapezoidal Web Section

4.2 Eigen value Buckling Analysis

A finite element study was carried out on the trapezoidal and straight web sections using ANSYS. In this study, all models were assumed to buckle under perfect conditions, where there is no initial imperfectness and eccentric load. Loading conditions are also same for all models, two types of loads are considered, one is point load at the free end and self weight of the beam. To ensure the load is applied through the web, the nodes for the support will be constrained in its x, y, and z translation at the support. The assumptions used in the linear buckling analysis are that the linear stiffness matrix does not change prior to buckling and that the stress stiffness matrix is simply a multiple of its initial value.

The main objective of an Eigen value analysis is to obtain the values of lateral torsional buckling resistance, bending capacity. Without considering membrane tensile and flange capacity, the modeling techniques used in the Eigen value buckling analysis were employed. This technique is reliable to be used in the study of shear capacity of triangular web compared to the normal flat web. Eigenvalue buckling analysis is a linear analysis that may be applied to relatively stiff structures in order to estimate the maximum load that can be supported to structural instability or collapse.

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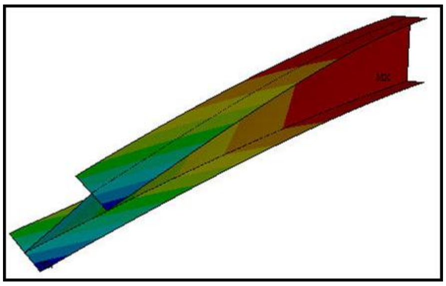

Figure 4: FEA of Straight Web Section

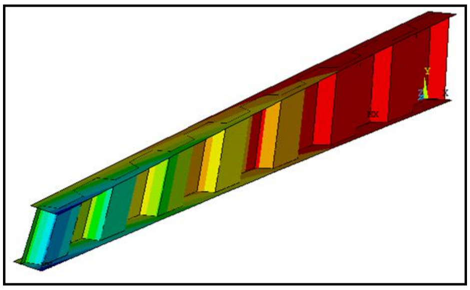

Figure 5: FEA of Trapezoidal Web Section

4.3 FEA Results

Table 1 FEA Results of LTB in Z-axis (mm) for Beams with Trapezoid & Straight Web for Eccentric Loading (e = 100 mm).

Span (mm)	CP length (mm)	WC width (mm)	Web Thk (mm)	Lateral Torsional Buckling in Z-axis (mm)				
				Trapezoidal Beam				
				TW 30^0	TW 45^0	TW 60^0	TW 75^0	FW
5000	300	40	5.7	26.22	20.69	24.36	20.25	33.33
			6.7	24.11	18.19	22.76	19.02	32.17
		50	5.7	24.18	18.65	22.32	18.21	33.33
			6.7	21.68	15.76	20.33	16.59	32.17
	350	40	5.7	27.97	22.44	26.11	22	33.33
			6.7	25.96	20.04	24.61	20.87	32.17

V. RESULTS AND DISCUSSION

The effect of some geometric properties on the performance of cantilever beam loaded with eccentric point load at free ends such as effect of web thickness (t_w), corrugation angle (θ), length of Infill Corrugated Plates (b), and width of the corrugated web (h), and web openings were investigated and the other geometric parameters such as B = 100 mm, D = 200 mm and t_f = 10 mm are kept constant. In the following paragraphs, the results of these parameters are presented in detail.

5.1 Corrugated Web Plate Thickness (t_w)

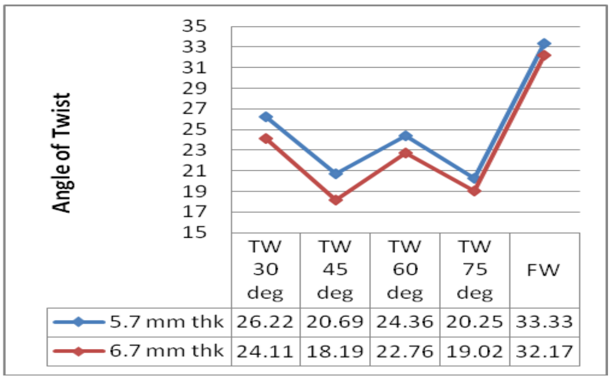

Figure 6: Effect of Corrugated Web Plate Thickness on the Angle of Twist

5.2 Width of Corrugated web (h)

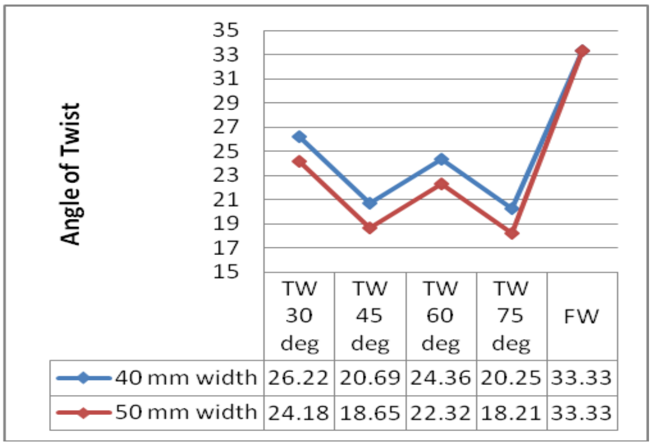

Figure 7: Effect of Width of Corrugated Web on the Angle of Twist

5.3 Length of Infill Corrugated Plates (b)

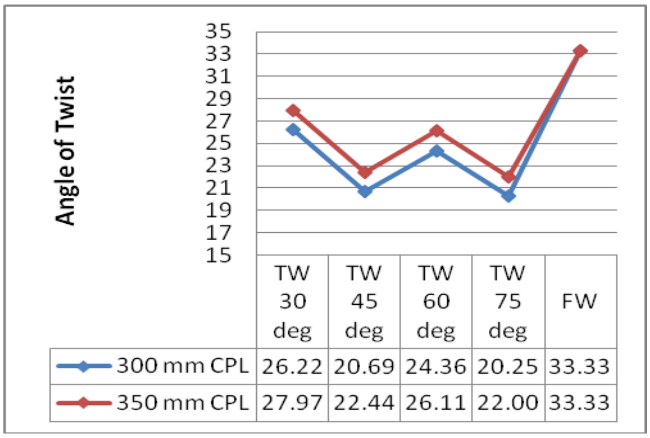

Figure 8: Effect of Infill Corrugated Plate Length on the Angle of Twist

5.4 Corrugated Web Angle (θ)

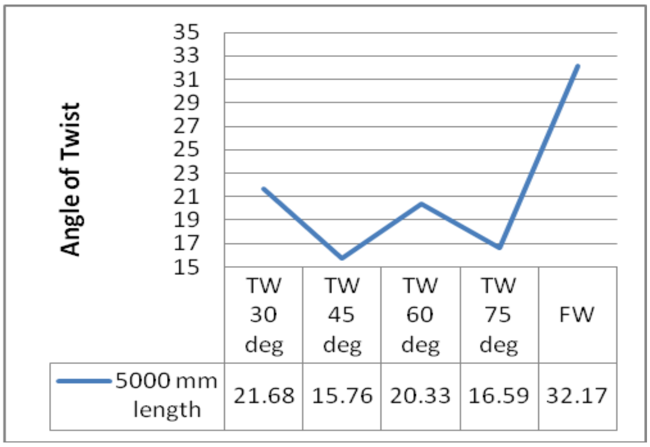

Figure 9: Effect of Corrugation Angle on the Angle of Twist

VI. CONCLUSION

A finite element analysis is done on the behavior of trapezoidal web steel section and compared the same with regular steel section when applied a load at the free end, and the following points are concluded:

1. The trapezoidal web steel section has higher resistance to angle of twist compared to that of section with flat web section cantilever beam.
2. Trapezoidal web thicknesses, web angle, length of infill corrugated plate, width of the corrugated web influences the resistance to twist of a cantilever beam,
   a. Higher trapezoidal web thickness gives the highest resistance to angle of twist.
   b. With trapezoidal web angle 45^0 and 75^0 will get higher resistance to angle of twist.
   c. Increasing size of the length of infill corrugated plate reduces the resistance to angle of twist.
   d. Increasing size of the width of the corrugated web increases the resistance to angle of twist.

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