Behavior of Trapezoidal Corrugated Web Steel Built-up Beam Under Point Load Condition

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Abstract - *A corrugated web steel beam has a thinner web as compared to conventional steel beams. The corrugated profile enables increased utilization of plastic limit loading by preventing the failure of the beam due to loss of stability. Thus, even without stiffeners, the beam has considerably stiffness and can achieve adequate bending resistance. Using of thinner web material results in a reduction of weight of the beam and ultimately decreased the dead load of the structure along with the reduced material consumption resulting in reduced cost. Thus, by comparing the performance of trapezoidal corrugated steel beams with a different angle between the diagonal and the parallel strip of the web, the angle that provides adequate strength characteristics along with material saving is found. For this, steel beams with the trapezoidal corrugated web with corrugation angle 25°, 30°, 35°, 45° and 60° are compared for their central deflection and lateral displacement up to an elastic limit. Out of these five beams, beam with the corrugated web with corrugation angle of 35° is found to be having maximum strength characteristics along with optimal use of material compared to other beams*

Key Words: Corrugated Steel Beams; Trapezoidal Web; Angle of Corrugation; Lateral Displacement; Central Vertical Deflection

1. INTRODUCTION

Steel sections are one of the most widely used structural component used specifically for load bearing, taking in account various industries like automobile, Agriculture, Railways and many others. Structural Steel provides high strength but has significant downsides like being less resistant to buckling, excessive deflection and vibration. One of the motive to build corrugated web steel beams was to overcome this unfavourable circumstances. In beams with flat webs, web loses its stability before reaching critical point of compressive stress and thus deforms transversely. Whereas in beams with corrugated web, the stability of web increases due to its profile and so eliminates use of additional stiffeners and gives equivalent performance at comparatively thinner web.

As a result, the strength to weight ratio is improved drastically. The performance of this type of beam is analogous to a lattice girder where flange transfers force and moments whereas lattice girder transfers transverse forces, as do corrugated web in this case.

Over the years various types of corrugation pattern are developed and tested. But the use of trapezoidal web has found to lower the concentration of stresses at the flange-web joint, thus increasing the fatigue strength. In trapezoidal web beams the angle of corrugation was observed to be playing a major part in its behavior.

In this paper, experimental study is conducted to understand the effect of different angle of corrugation of web on lateral-torsional buckling of beam on point loading. In order to analyze this behavior lateral and central deflections of different beams were studied in detail

2. MATERIAL AND METHODS

2.1 Test Specimens

Five steel beams with trapezoidal corrugated web were fabricated for experimentation. These beams are designated as TCW-25, TCW-30, TCW-35, TCW-45, TCW-60 having corrugation angles 25°, 30°, 35°, 45° and 60° respectively. Details of specification of these specimens are mentioned in Table [I] and in Fig[I].

The material used for fabrication of these beams is galvanized iron hot rolled sheet. Web and flange are joined using thin small L-section made-up of same material as web by spot welding these sections. The electrode tip of spot weld had a diameter of 10mm and each L-section was welded at 3 spots on web side and at spots on flange side of the L section. The weld current was kept 40 Ampere.

Table -1: SPECIFICATIONS OF THE BEAM

Thickness of Flange	1 mm
Thickness of Web	0.2 mm
Width of Flange	85 mm
Width of Web	150 mm
Modulus of Elasticity	199.78 GPa

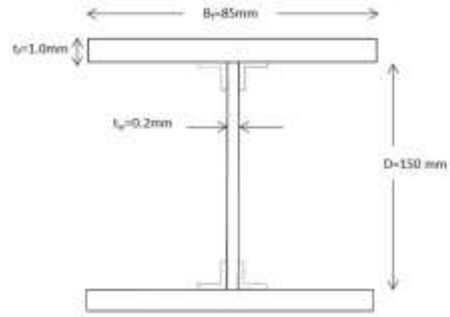


Fig -1: Section of web

Fig -2: Specimens to be tested

Table -2: DETAILED DIMENSIONS OF BEAM PROFILES

Profile	Length of web (mm)	Length of flange (mm)	Corrugation angle (θ)	a(mm)	b(mm)	c(mm)	d(mm)
TCW-25	910	880	25°	115	75	80	35
TCW-30	910	880	30°	115	60	71	35
TCW-35	910	880	35°	115	50	60	35
TCW-45	910	880	45°	115	50	50	35
TCW-60	910	880	60°	115	70	40	35

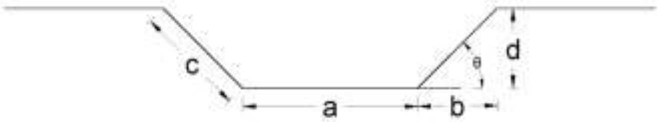


Fig -3: Typical diagram of Web Profile

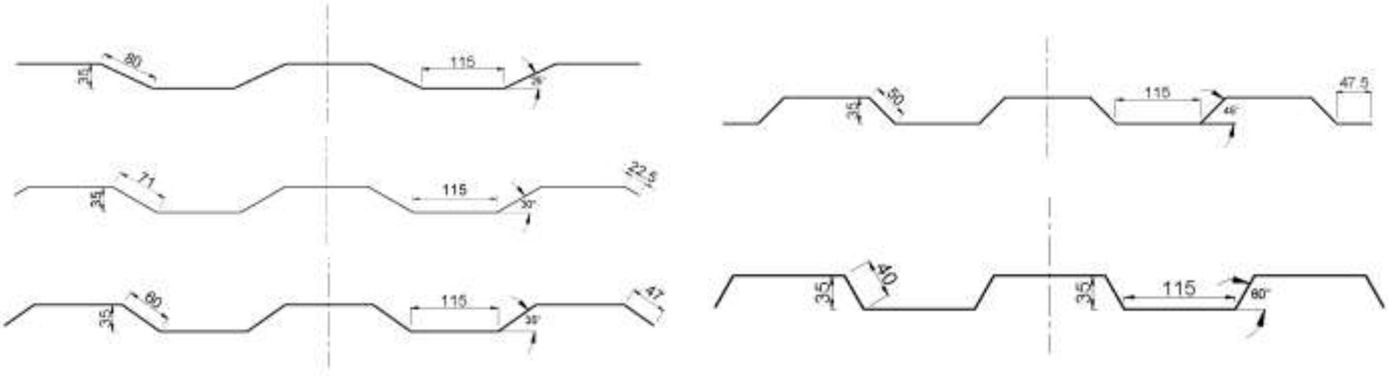


Fig -4: Detailed Diagrams of Web Profiles with angle of corrugation as 25°, 30°, 35°, 45° and 60°

2.1 Test Setup

A test setup was designed to test the specimens under three-point bending condition as shown in Fig [5]. The setup consists of a hydraulic jack with 30KN capacity, a digital display, and frame to hold dial gauges. The dial gauges used had least count of 0.01 mm and were setup to measure displacement of beams in horizontal as well as vertical direction. As shown in Fig [6], the arrangement of the dial gauges was such that it can measure horizontal displacement at the end to check lateral torsional twist and also three dial gauges were arranged on the bottom to measure the vertical deflection to ascertain uneven settlement due to loading.

Fig -5: Test Setup

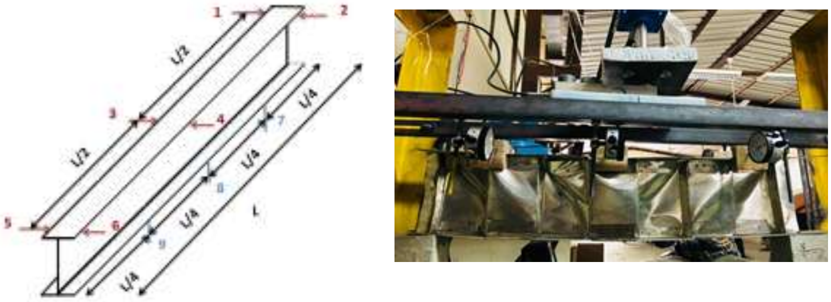


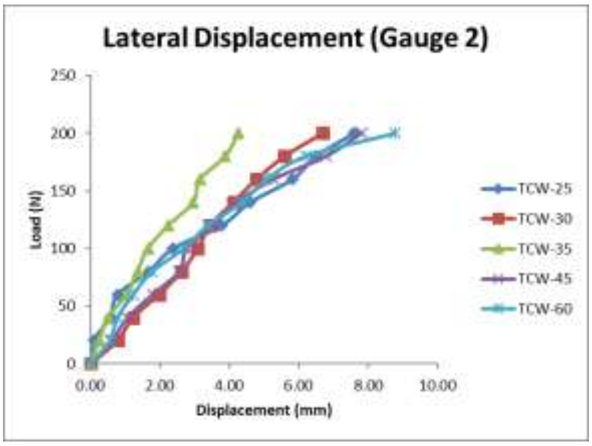
Fig -6: Arrangement of Dial Gauges and Beam loaded into the setup

2.2 Loading and Measurement

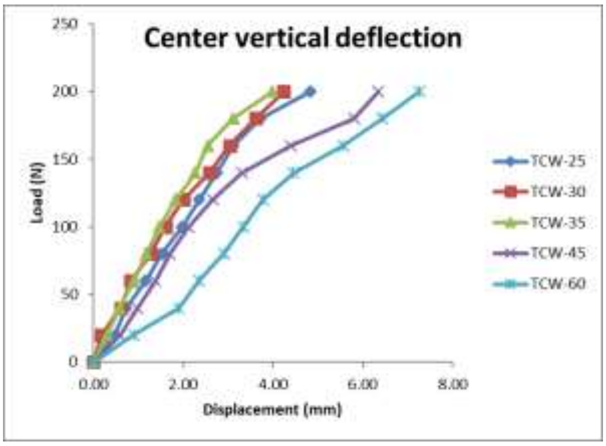
The test was carried out in Structural Engineering Laboratory of Pandit Deendayal Petroleum University. The point load was applied at the center of the beam using a hydraulic jack as shown in Fig [6]. The test was conducted as load-controlled testing as reading were taken from the dial gauges after every increment of 20N through hydraulic jack. The beams were tested up to 200N to get the reading in elastic limit. Stiffeners were used at the two ends of the beam to prevent the local buckling of the web. The beam was tested with simply support condition.

3. RESULTS

•The comparison between TCW-25, TCW-30, TCW-35, TCW-45 and TCW-60 for their central vertical deflection and lateral displacement is shown in Graph. 1, 2 & 3.
•It was found that corrugated web with 350 corrugation angle has 21%, 7%, 59% and 82% less load deflection at center than 25°, 30°, 45° and 60° respectively.
•It is also to notice that corrugated web with 350 corrugation angle has 78%, 56%, 83% and 104% less lateral displacement at gauge 2 than 25°, 30°, 45° and 60° respectively.
•Also, the lateral displacement at gauge 5 for corrugated web with 350 corrugation angle has 31%, 19%, 49% and 84% less lateral displacement than 25°, 30°, 45° and 60° respectively.
•While making specimen there could be a possible error due to improper weld bid, whereas while taking reading of deflection, there could be human error while reading analog dial gauge.



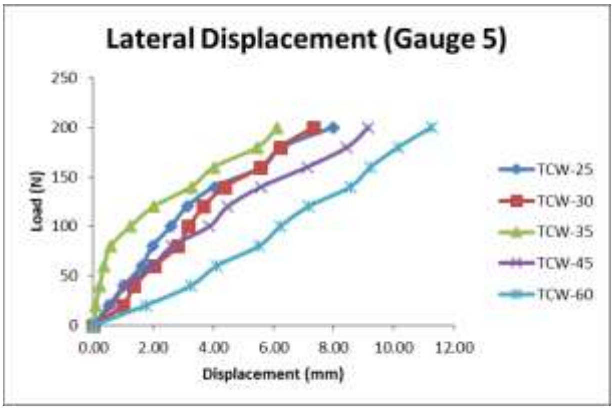
Graph -1: Load vs Lateral Displacement



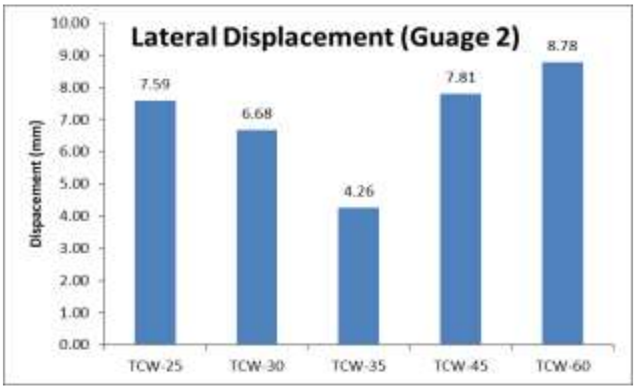
Graph -2: Load vs Central Vertical Deflection

Table -2: RESULTS

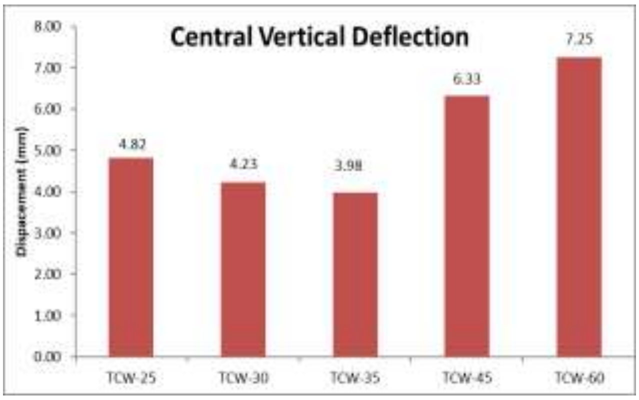
Profile	Central Vertical Deflection(mm)	Lateral displacement (Gauge 2) (mm)	Lateral displacement (Gauge 5) (mm)
TCW-25	4.82	7.59	7.98
TCW-30	4.23	6.68	7.33
TCW-35	3.98	4.26	6.12
TCW-45	6.33	7.81	9.15
TCW-60	7.25	8.78	11.26



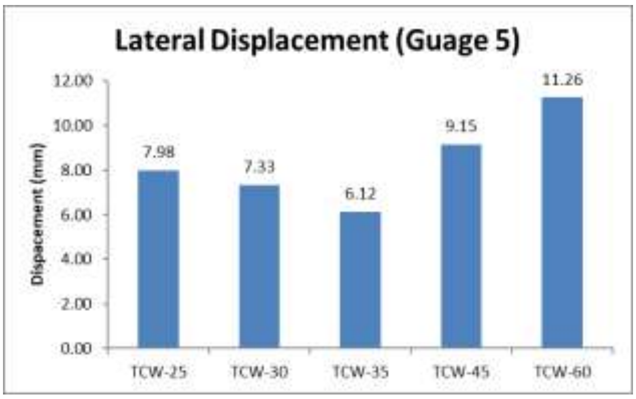
Graph -3: Load vs Lateral Displacement



Graph -4: Maximum Lateral Displacement



Graph -5: Maximum Central Vertical Deflection



Graph -6: Maximum Lateral Displacement

3. CONCLUSIONS

From the observed data obtained from the experimentation conducted on five steel built-up beam with trapezoidal corrugated web having different angles of corrugation, following conclusions are derived. All beams showed lateral torsional buckling effect. When the load is applied on the center of beam, there occurs compression in upper flange and tension in lower flange. It is interesting to note here that the lower flange tries to hold member straight whereas the upper flange tries to deflect in lateral direction from its original position. Thus, a restoring force is generated to oppose this movement. These forces are however small to actually stop the lateral deflection. So, when load is applied, there occurs lateral displacement along with twisting of the member, thus causing lateral torsional buckling. The magnitude of lateral torsional buckling is significantly affected by the distance between point of load application and shear center of the beam.

As per above discussion and data obtained from experimentation it can be asserted that TCW-35 profile having angle of corrugation 35 shows minimum deflection and lateral displacement among the other tested profiles. Thus, using trapezoidal corrugated web with angle of corrugation 35 can result in better structural behavior

ACKNOWLEDGEMENT

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