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Analysis of Trapezoidal Corrugated Steel Web Beam for It's Strength and Deflection

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Abstract

The objective of the project is to show efficiency of the corrugated web beam as compare to I-beam. Now a day's weight optimization is very efficient tool for obtain maximum efficiency, some of failure modes of the I-section beam are Bending failure by yielding, Bending failure by lateral torsional buckling, Bending failure by local buckling, Shear failure, Vibration. There are various shapes vertical direction, one arc and two arc sinusoidal along vertical direction and horizontal direction, trapezoidal corrugated shape for horizon direction of web. Strength of the beam can be increased by using different shapes of corrugation for beam which also optimize the material of web and is useful for the application for many construction. There are various methods of fabrication such bending and welding, hot rolling and cold rolling. Experimental analysis will be carry out by using UTM to find the failure modes of corrugated web beam. Verification of testing will be carry out by using various software's such as ANSYS.
Keywords: Trapezoidal beam, ANSYS

I. Introduction

Now a day's building and civil infrastructures are becoming larger and higher, the demand for horizontal structure members, which are suitable for long spans so structural steel require high strength but steel member also have many weaknesses, such as less resistance to bucking, excessive deflection, fatigue strength, vibration. To overcome these disadvantages various types corrugated web beam are developed. Some of points of interest to utilize creased web bar are solidness against asymmetrical loads in light of the fact that the shear buckling quality in-plane and Out-of-plane load is more prominent than I-section beam. Especially for the main frames of single-storey steel buildings the use of corrugated web beams, mainly with sinusoidal corrugation, has been increased very much during the last years. On account of the thin web of 2 or 3 mm, diminishment in weight of corrugated web is conceivable as contrasted and hot moved profiles or welded I-sections. Buckling failure of the web is avoided by the corrugation. In development application, the web for the most part in load conveying application, the web as a rule bears the vast majority of the compressive stress and transmits shear in the shaft while the flanges bolster the significant external loads. The web resists shear forces, while the flanges resist most of the bending moment experienced by the beam. I-molded section is an exceptionally effective shape for transferring both bending and shear loads in the plane of the web. On the other hand, the cross-section has a reduced capacity in the transverse direction, and is also inefficient in carrying torsion, thus, by using greater part of the material for the flanges and thinner web, materials saving could be achieved without weakening the load-carrying capability of the beam. Nevertheless, as the compressive stress in the web has exceeded the critical point prior to the occurrence of yielding, the flat web loses its stability and deforms transversely. This could be enhanced by utilizing corrugated web, a contrasting option to the plane web, which produces higher dependability and quality without extra stiffener and utilization of bigger thickness. The tallest structures today (commonly called "skyscrapers" or high-rise) are constructed using structural steel due to its constructability, as well as its high strength-to-weight ratio. In comparison, concrete, while being less dense than steel, has a much lower strength-to-weight ratio. This is due to the much larger volume required for a structural concrete member to support the same load; steel, though denser, does not require as much material to carry a load. However, this advantage becomes insignificant for low-rise buildings, or those with several stories or less. Low-rise buildings distribute much smaller loads than high-rise structures, making concrete the economical choice. This is especially true for simple structures, such as parking garages, or any building that is a simple, rectilinear shape. Structural steel and reinforced concrete are not always chosen solely because they are the most ideal material for the structure. Companies rely on the ability to turn a profit for any construction project, as do the designers. The price of raw materials (steel, cement, coarse aggregate, fine aggregate, lumber for form-work, etc.) is constantly changing. If a structure could be constructed using either material, the cheapest of the two will likely control. Another significant variable is the location of the project. The closest steel fabrication facility may be much further from the construction site than the nearest concrete supplier. The high cost of energy and transportation will control the selection of the material as well. All of these costs will be taken into consideration before the conceptual design of a construction project is begun. Typically, under gravity loads, the original length of the beam is slightly reduced to enclose a smaller radius arc at the top of the beam, resulting in compression, while the same original beam length at the bottom of the beam is slightly stretched to enclose a larger radius arc, and so is under tension. The same original length of the middle of the beam, generally halfway between the top and bottom, is the same as the radial arc of bending, and so it is under neither compression nor tension, and defines the neutral axis (dotted line in the beam figure). Above the supports, the beam is exposed to shear stress. There are some reinforced concrete beams in which the concrete is entirely in compression with tensile forces taken by steel tendons. These beams are known as pre-stressed concrete beams, and are fabricated to produce a compression more than the expected tension under loading conditions. High strength steel tendons are stretched while the beam is cast over them. Then, when the concrete has cured, the tendons are slowly released and the beam is immediately under eccentric axial loads. This eccentric loading creates an internal moment, and, in turn, increases the moment carrying capacity of the beam. They are commonly used on highway bridges.

The primary tool for structural analysis of beams is the Euler–Bernoulli beam equation. Other mathematical methods for determining the deflection of beams include "method of virtual work" and the "slope deflection method". Engineers are interested in determining deflections because the beam may be in direct contact with a brittle material such as glass. Beam deflections are also minimized for aesthetic reasons. A visibly sagging beam, even if structurally safe, is unsightly and to be avoided. A stiffer beam (high modulus of elasticity and high second moment of area) produces less deflection.

Mathematical methods for determining the beam forces (internal forces of the beam and the forces that are imposed on the beam support) include the "moment distribution method", the force or flexibility method and the direct stiffness method.

II. LITERATURE REVIEW

Siva Prakash V et. al. (2015), the objective of this paper is study the behaviour of cold formed built up I –section with different corrugation web. The effect of web corrugation on the bending strength or flexural strength of cold formed steel (CFS) I section is presented in this paper. Totally three specimens are experimented with flat, trapezoidal, triangular corrugation in web. The length of the specimen is kept constant for 2000 mm. Similarly keeping all other parameters constant. All specimens are experimented under two point loading with simply supported condition. The experimental results are verified with finite element analysis using ANSYS software. Experimental and Analytical results are compared with the predicted resistance by code provision of AISI S100-07 Specification. The experimental result shows that the bending capacity or flexural capacity of the corrugated web (trapezoidal, triangular) is larger than flat web. Within the parametric study the effect corrugation in web on the flexural strength capacity or bending capacity is discussed and presented.

Qi Cao et.al.(2015), They conducted experiment incorporated with finite element analysis, the stability of H shape beam welded with corrugated webs was tested and three failure modes were observed. Then data related load-deflection, load-strain, and shear capacity of tested beam specimens were collected and compared with FEM analytical results by ANSYS software.

R.Divahar et.al. (2014), Lateral buckling may occur in an unrestrained beam where its compression flange is free to displace laterally. This paper presents the results of the experimental study of the lateral buckling behaviour of cold-formed steel section with trapezoid web. A total of six cold-formed steel beams with plain webs and corrugated webs were tested. The moment carrying capacity of cold-formed steel beam with plain web is studied and compared with the moment carrying capacity of beam with trapezoidal corrugated web having 30^0 and 45^0 corrugations. The specimens were tested under two point loading for its pure flexural behaviour. From the study, it is found that the cold-formed steel beam with trapezoidal corrugated web section have higher resistance to lateral buckling compared to that of section with plain web. It is also found that the corrugation angles influence the resistance to lateral buckling.

Fatimah De'nan et.al.(2012), This paper develops a three-dimensional finite element model using LUSAS 14.3 to investigate the effects of web corrugation angle on bending behavior of Triangular Web Profile (TRIWP) steel sections. They also checked the flexural strength of corrugated web beam with different angle of bending. It was noted that deflection of 45^0 and 75^0 web corrugations angle be the lowest deflection value either in minor or major axis of TRIWP steel section. It means that the TRIWP steel section is stiffer when the web corrugation angle is 450 or 750. In other word, TRIWP steel section has a higher resistance to bending in minor and major axis when the web is used in both corrugation angles.

Jae-Yuel oh et.al. (April 2012), Various types of composite members have been developed to utilize the combined advantages of existing reinforced concrete and steel structures, and to actively improve ductility and serviceability of structural members. One of them is the hybrid-type steel beam, in which the prestressing method is applied to a steel beam. Introducing prestress to the existing I-shaped steel beam, however, results in a very low prestress efficiency due to the large axial stiffness of the section. On the other hand, if corrugated webs are used, the prestress introduced to the main flexural-resistant elements—the upper and lower flanges—gets larger due to the accordion effect, so that it is very advantageous not only in terms of serviceability, but also of achieving the improved flexural strength. Most previous studies on steel members with corrugated webs, however, have focused on the shear buckling strength of the corrugated webs, and few studies have been conducted on the accordion effect of the corrugated webbed beam to which prestress is introduced. Therefore, this research proposed two rational and theoretical models to quantitatively estimate the accordion effect, which is induced by the introduction of prestress to corrugated webbed steel beams, and performed experiments on two steel beams with corrugated webs and one with typical wide flange section. The experimental results showed that the prestressing efficiency of steel beams with corrugated webs increased more significantly than that of the steel beam with a typical web, and it is verified that the proposed methods are very simple and provide good agreements with the experimental results.

Khalid et. al.(Feb 2014), The paper is devoted to the behavior of mild steel structural beams with corrugated web subjected to three-point bending. Semicircular web corrugation in the cross-sectional plane (horizontal) and across the span of the beam (vertical) were investigated both experimental and computationally using finite element technique. In the finite element analysis, test specimen was modeled using commercially available finite element software LUSAS and a non-linear analysis was performed.

Corrugation radius of 22.5 and 4 mm thickness, with constant corrugation amplitude to cycle length ratio (H/λ) and flange thickness of 6 mm were selected as the base sizes. The plane web beams, welded and ordinary rolled, were also tested with both methods to develop the benchmark results. The comparisons between the experimental and the finite element analysis results were satisfactory. It was noted that the vertical-corrugated web beam (VCR_x) could carry between 13.3 and 32.8% higher moment comparing to the plane and horizontal-corrugated web beams, for the range of corrugation radius taken. Besides that, larger corrugation radius could sustain higher bending load up to the yielding stage. This attributed to the increment of the second moment of area (I) that has influence on the direct bending stresses (σ_{zz}). In addition, reduction in weight could be achieved by using the vertical-corrugated web. This is true for the corrugation shapes and sizes taken throughout this structure.

III. METHODOLOGY

1) The design of Trapezoidal corrugated web beam and selection of standard I-section beam as per BIS (808:1989),(Reaffirmed 2004)
2) To build up a 3-D solid model of trapezoidal corrugated web beam and I-section beam as per BIS (808:1989),(Reaffirmed 2004) by using suitable modelling software such as CATIA.
3) To perform stress analysis of trapezoidal corrugated web beam and I-section beam as per BIS (808:1989) (Reaffirmed 2004) by using FEA software, such as ANSYS.
4) Redesign and fabrication of trapezoidal corrugated web beam and standard I-section beam to get deformation/stress induced in critical location will be carried out.
5) By using suitable Experimental set up Stress analysis of trapezoidal corrugated web beam and I-section beam as per BIS (808:1989) (Reaffirmed 2004) will be carried out.
6) To compare and validate the result obtained by using software analysis with results obtained by experimental Analysis for strength for trapezoidal corrugated web beam and I-section beam as per BIS (808:1989) (Reaffirmed 2004).

IV. CONCLUSION

Realizing the fact, I-section beam have been extensively used whenever standard I-section could not satisfy the moment carrying and shear capacities desired. To build up an I-section it has been common practice to use more steel in webs rather flanges. This results in uneconomical sections as steel is an expensive material. The strength of I-section beam against lateral-tensional buckling along the length of the beam, and local buckling of the beam cross-section can be enhanced by using corrugation along horizontal direction and vertical direction. Different shapes of corrugation as like one arc and two arc sinusoidal along vertical direction and horizontal direction, trapezoidal corrugated shape for horizon direction of web. Strength of the beam can enhance by using corrugation of beam which also optimization the material of web is useful for the application for many construction

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