IMPROVEMENT OF SHEAR CAPACITY OF WELDED I-SECTION GIRDER WITH THIN STRUCTURED WEB

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1. INTRODUTION

The failure of I-girders with flat and slender webs under shear force is observed as a consequence of buckling of the web. After elastic bucking a tension field develops over the whole web, and plastic hinges are formed in the flange. I-girders have large geometrical moment of inertia and small cross section area. It is possible to reduce weight and cost of I-girders by decreasing thickness of the web plates, but these compromises the buckling strength. The corrugated webs without stiffeners have been used to reduce weight, and to increase the strength of I-girders, but there is no research available on structured webs. In this paper, hence shear capacity of I-girders with thin wave-structured webs is investigated through loading tests and numerical analyses. The steel I-girder with structured webs was tested to failure under shear. Nonlinear analysis was performed and the proper mesh size was selected to examine their effects on the shear capacity. The results obtained from the analysis and test are then compared with the plate girder with plane web of the same depth. Various parameters such as shear capacity and weight are compared.

2. LABORATORY TESTS AND RESULT

Loading tests of I-girders with flat web and structured web were carried out. The objective of the loading tests was to determine the ultimate load of I-girder with structured web as well as the corresponding flat web. The dimensions and details of web shape of the structured web specimen are shown in Fig.1 Three point bending loading is applied to both specimens as shown in Fig 2 and 3.
In the test procedure, three types of measurements were carried out: (a) load measuring with a load cell, (b) measurement of vertical and out of plane displacement and (c) strain measurement with two and three directional strain gauges.

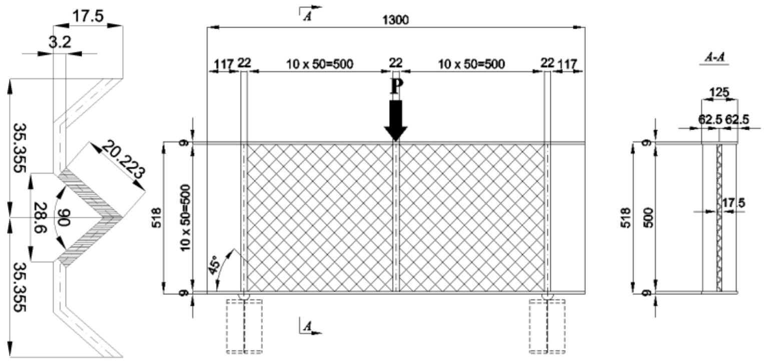

Fig 1: Geometric and Profiles of test specimen

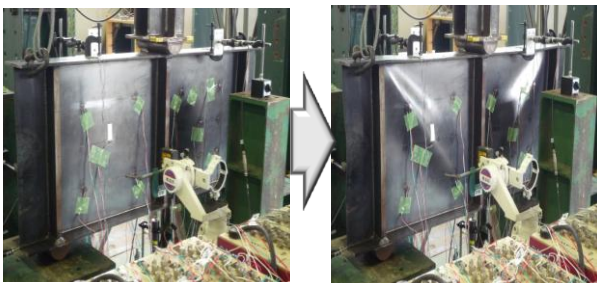
Fig 2: Specimen during the shear loading test

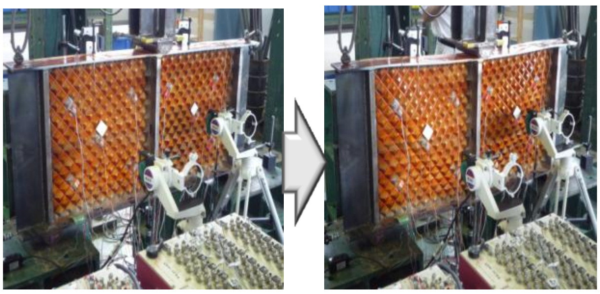
Fig 3: Specimen during the shear loading test

3. TEST RESULT

Fig. 4 shows the load-deflection curves obtained from tests (girders with flat web and structured web). The vertical displacements are measured with the transducer at the span center. The higher shear capacity was attained by a flat web girder, and the girder with structured web had lower ultimate load at large displacement. The buckling mode indicates the development of the diagonal tension field.

4. FINITE ELEMENT MODEL AND ANALYSIS

In order to study the effect of the webs configuration, the web panel aspect ratio, and the web/flange interaction on the ultimate shear capacity of structured webs, numerical analysis using finite elements model is conduced. A typical finite element model is shown in Fig. 5. A nonlinear finite element analysis was carried out using ABAQUS/CAE. In the analysis, a large displacement theory was employed. The girders were modeled with four node shell elements with reduced integration method (S4R). The loading was controlled by the vertical displacement of the upper flanges nodes at the load application points. The measured initial geometric imperfection was

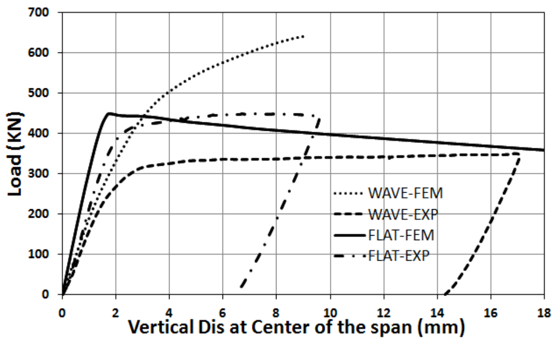

Fig 4: Load Dis curve (Flat & Wave)

Keywords: Buckling strength, Structured webs, FEM analysis, Load carrying capacity, plate girder
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applied to the whole girder web. The structural steel was modeled as an elastic-plastic material. Fig. 6 illustrates the stress-strain curves for different plate thicknesses used in FE analyses. The Young's modulus was taken as E=200000MPa and the Poisson ratio as v=0.3. The initial imperfection was measured at the real test sample (imp concave-convex=1.4mm and imp planer=2.4mm).

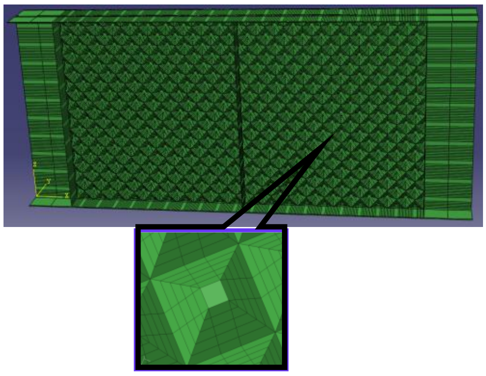

Fig 5: Numerical model & meshing
Of wave web per one V

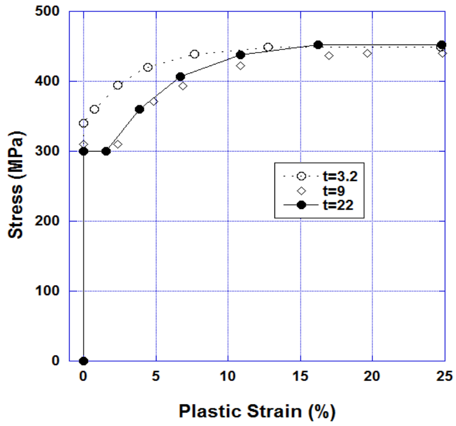

Fig 6: SS Curve

5. FEA ANALYSIS RESULT

Fig. 7 shows comparison of load-displacement curves for FE analysis and test results. The structured web plate girder has low stiffness and strength as compare to plane plate girder. From Fig. 7, a good agreement between the numerical results and the test results can be seen. It is observed that both experiment and analysis results exhibit similar behavior within the elastic region. The difference in capacities is in the range of 5% in the case of wave web girder remain, which is slightly large. From the test and FEA results we have seen that the girder with wave web has lower load capacity than that with plane plate girder, the application of these structured sheet requires further investigations regarding their strength and deformation behavior in welded I-girder, therefore we carried out analysis with two another shapes of web (case30110, case40110) Fig. 8 and Fig. 9. Case 30110 have better result (Fig.10), but it has high weight corresponding to plane plate girder, the different in weight is in the range of 17.94%.

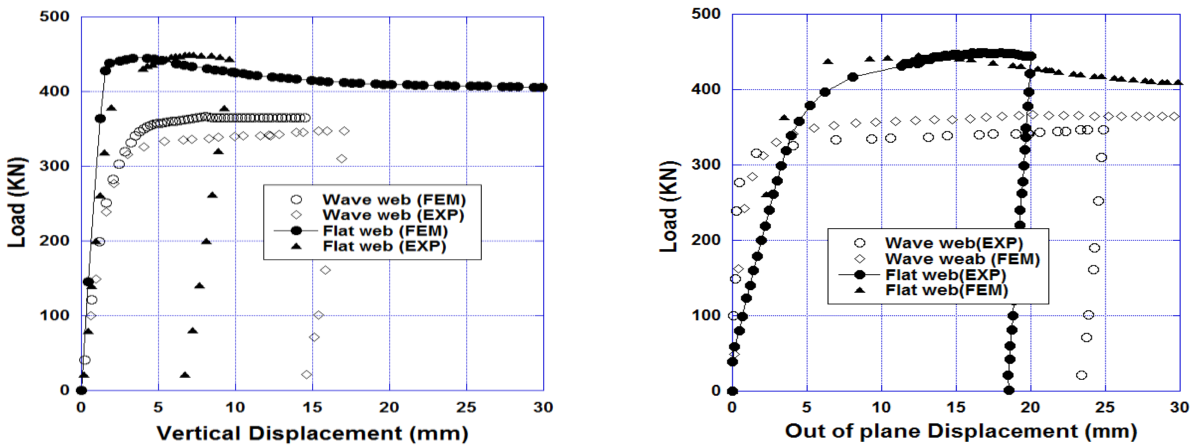

Fig 7: Load- Displacement Curves (wave & Flat web)

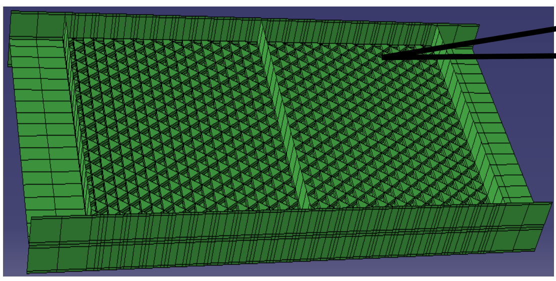

Fig 8: Numerical model (Case30110)

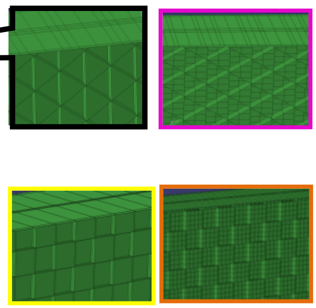

Fig 9: Case 40110

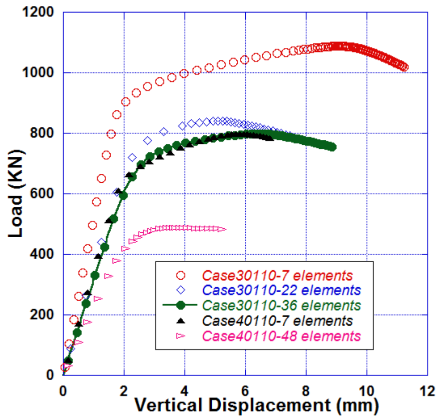

Fig 10: Load-Vertical Dis Curve
(40110&30110)

6. CONCLUSIONS

As compare to plane plate girder, the structured plate girder has lower stiffness and strength. For structured web, size of the mesh has significant effect on the numerical results. The new models have good results, but it has slightly higher weight corresponding to plane plate girder.