Summary of corrugated web H-shaped steel beam joints

Cheng Jin

Southwest Petroleum University School of Civil Engineering and Architecture, Chengdu China

Abstract

With the development of building industrialization process in recent years, advances in the steel industry, the steel is used to build a broader variety of landmarks. Steel structure design, designers are increasingly focused on high efficiency design bearing structures and components. Past the traditional H-beam flange and ends by the middle of the web structure, but in practical engineering applications, we can not break through the web thickness ratio requirements. So, before yielding committed to avoid the occurrence of local buckling of corrugated web came into being. Consider corrugated web via its waveform, capable of small thickness to provide sufficient shear buckling strength and rigidity out of the plane, thus reducing cost. In recent years, as the corrugated web steel beams in the project more widely, the beam end joint of stable performance affects the performance of the structure, the paper summarizes the analysis of domestic and foreign scholars on the beam end nodes force performance.

Keywords

H-shaped steel beam joints,Abaqus,node

1. Introduction

With the development of technology, the process of industrialization intensified construction industry, steel industry in the application of engineering practice more and more.1980s,Sumitomo Corporation of Japan for the first time by welding method to produce corrugated web H-beam. Corrugated web production, breaking the traditional H-beam thickness ratio limits, reaching 500 to 600, which not only makes the steel beam to obtain a larger web thickness ratio also increases the moment of inertia of the cross section of the web , from the resistance and warping moment of inertia.

Corrugated web H-shaped steel is mainly characterized in that instead of the flat web with corrugated webs, which can make a small web thickness, it can produce high shear buckling load capacity and greater rigidity plane, so this types of H-beam has a larger carrying capacity and economic benefits. Now consider the corrugated web H-beam applications in engineering, more and more corrugated web H-shaped steel beams and columns are connected at node checking the strength of the design meets the requirements for each type of node now reviewed research.

2. Beam end nodes just pick Stress Analysis

Corrugated web steel node connections, can be high-strength bolts, welding and bolted and welded connection mixed connection. Anami K and Sause R traditional fatigue test of H-beams and corrugated web, indicate tectonic way traditional flat web steel beam pile rigid connection node is commonly used in the column with full penetration welds connecting flange, web and column using high strength bolts. Since the corrugated web is corrugated web, the traditional process can not be connected to the trial.

Moment end plate bolt nodes usually T-connectors or rigid end plate connections. Assumed bolt force distribution line and the neutral axis of the bolt group centroid axis, under bending moment, shown in Figure 1, the end plate deemed no bending of the rigid body, the maximum bolt force following formula calculated:

$$N_t^1 = My_1 / (m\sum y_i^2) \quad (1)$$

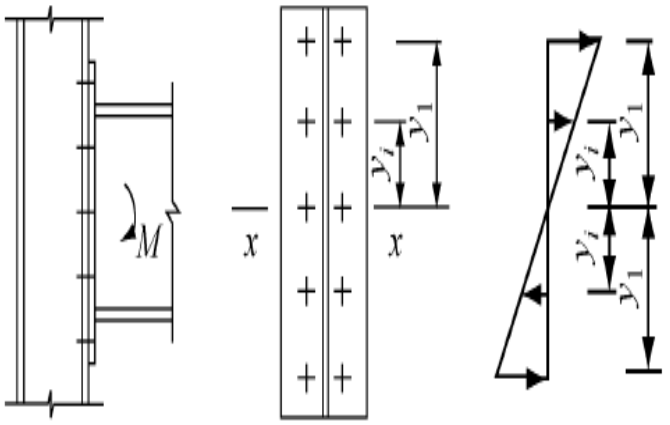

Fig. 1 rigid end plate model

In order to solve the connection problem, Tong ji University, Li Guoqiang, Fan Xin and other scholars have designed two ways of connection. As shown in Figure two, the connections of the 2 nodes are connected through the full penetration butt weld.As shown in Technical specification for steel structures with Corrugated Webs,for the ordinary beam - column joints with the rigid connection, calculation of beam to column connection under bending and shear bearing capacity, so the specimen is loaded by hydraulic jacks, until the trial failure.As shown in the table1:

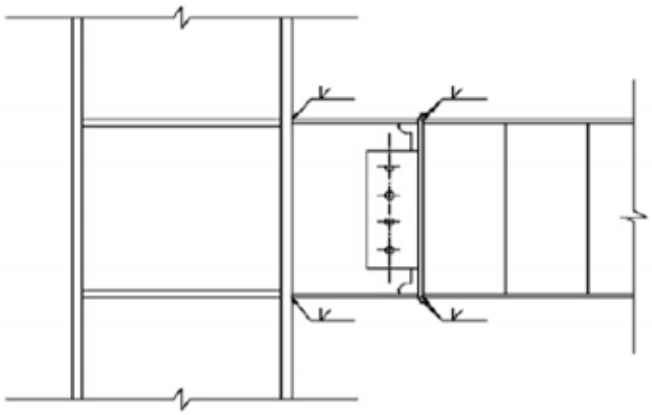

Figure 2 corrugated web H steel rigid node approach

Table 1 results of tests

batch	Thickness /mm	Elasticity $/10^5$ *Mpa*	yield strength $/$ *Mpa*	tensile strength *Mpa*	Tensile strain /%	Elongation /%
1	2	2.061	244.0	394.0	25.1	38.5
1	10	2.066	296.7	413.3	25.1	35.7
1	12	2.060	318.3	443.3	24.8	28.3
1	18	2.059	303.3	435.0	24.6	34.7
2	2	2.061	320.0	456.7	25.1	34.7
2	6	2.058	292.0	426.0	25.2	40.5
2	10	2.066	278.0	428.0	24.9	40.5
2	12	2.060	328.0	461.0	24.6	34.0

Formula for the shear stress of material test:

$$\tau = \frac{VS}{It_w} \tag{2}$$

The following conclusions can be drawn:(1) In the elastic deformation stage, the shear stress at the weld is basically the same as that of the section of the beam;(2) In the elastic deformation stage, the shear strain at the midpoint is far greater than half of the shear strain;(3)Can be found through the ABAQUS finite element simulation, the existing H-shaped steel beam Duangang connected node design formula for H-beam with corrugated webs beam Duangang joints can also be used.

3. Performance analysis of beam end joints

Because of the technical innovation of corrugated web, the original flat web is made into corrugated web, thus reducing the thickness of the web and increasing its bending resistance.In Technical specification for steel structures with Corrugated Webs The hinge between the beam column main shaft can be arranged in the beam height range, and the vertical connecting plate of the column is connected with the high strength bolt, as shown in Figure 3.

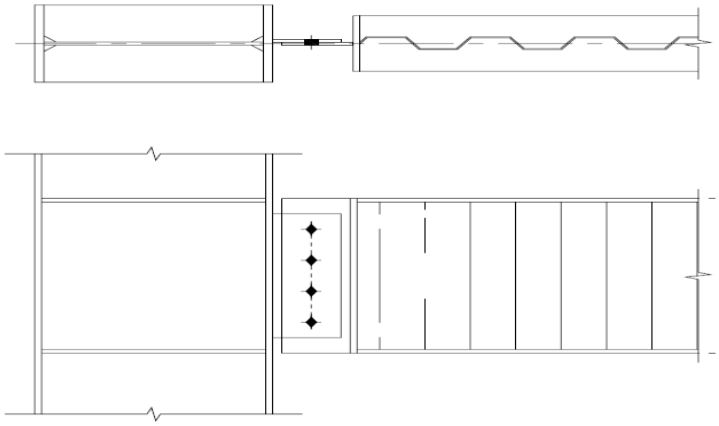

Figure 3 beam column hinge (strong axis direction)

Corrugated web H type steel peace web H-shaped steel in theory to study the stress direction has significant difference, mainly reflected in three aspects: (1) vertical shear almost by the webs bear, and even stress; (2) moment is mainly undertaken by the flange web almost does not bear bending moment; (3) flange exist near stress. We to trapezoid web, for example, geometric size as shown in Figure 4, in accordance with around shear analysis is derived out.

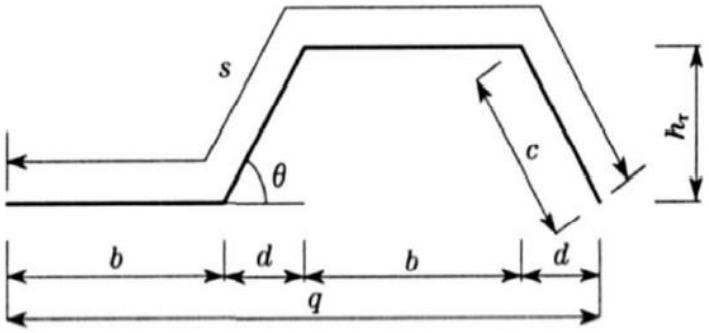

Figure 4 geometric dimensions of trapezoidal Web

The elastic local buckling strength formula:

$$\tau_{cr,1} = k_s \pi^2 E / \left[12\left(1-\mu^2\right)(\omega / t_w)^2\right] \tag{3}$$

The elastic modulus of the E is the Poisson's ratio;the μ of the corrugated plate; the h_w local buckling elastic ultimate bearing capacity of corrugated web, $\omega = \max\{b, c\}$

According to the anisotropic plate theory, the overall buckling elastic ultimate strength:

$$\tau_{cr,g} = k_s D_x^{0.25} D_y^{0.25} / (t_w / h_w^2) \quad (4)$$

Corrugated uniform distribution under the action of ABUQUS strength according to the elastic theory, Chang and other scholars in the traditional H type steel beam node connecting method, through a bolt, beam connecting plate and column connecting plate, the beam column is hinged. Through experiments and the finite element static analysis, it is concluded that a beam Hinged joint in the static performance of the conclusions: (1) with corrugated webs and the end plate of fillet welds along the section; (2) steel beam column welding position of mechanical performance and no obvious relationship; (3) connecting plate is shorter, thicker, and the shear strain distribution is more uniform; (4) the existing H type steel design formulas are also suitable for corrugated web H type steel hinged joint design; (5) of the web and the end plate connection weld breakpoints, does not affect the hinged joint mechanical properties.

Induction and Li Guoqiang design a beam end nodes to validate the reliability formula design, using the corrugated web H type steel CWA500-200 x 10, the girder web height of 500 mm, 2mm thick, beam flange width 200mm, 10mm thick, the bolt by 10.9 M20 friction type high strength bolt,In Technical specification for high strength bolt connection of steel structure The design formula for the shear strength of high strength bolts is as follows:

$$N_v^b = k_1 k_2 n_f \mu P \quad (4)$$

The experiment mainly considers two factors: the position of the breakpoint, symmetry, and the conclusion that the finite element analysis can verify the shear strength of the welded joints.

According to the beam shear to design a two node control. Due to the thinner the webs of H-beam with corrugated webs, it should not be used in traditional welding method connection. Therefore, according to the traditional welding connection method at the same time, through the high strength bolt are fixedly connected, and through experiments, and a large number of finite element analysis, the loading measures such as the device shown in Figure 5.

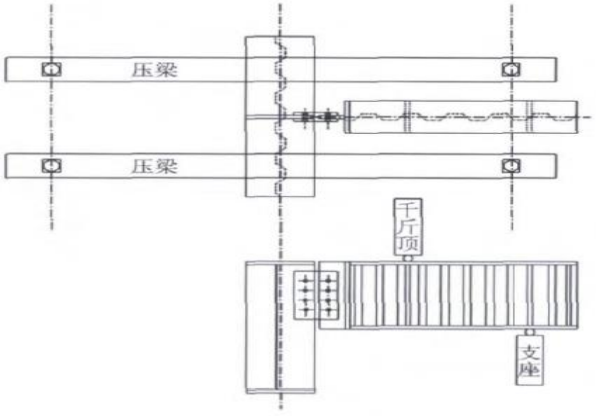

Fig. 5 Schematic diagram of test loading device

According to the displacement curve shown in figure 6:

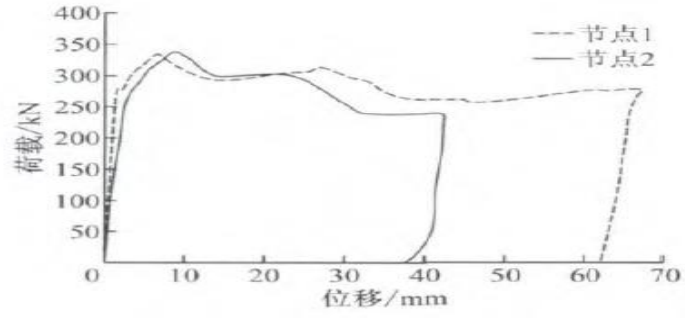

Fig. 6 nodal load displacement

It is found that the secondary beam connecting plate of the secondary beam is assumed to bear the shear force of the secondary beam, and the load is transferred to the main beam through the high strength bolt and the plate:

4. Illustrations

With the development of economy, intensified construction industrial process, corrugated web as a kind of new structure, is becoming more and more in the steel structure factory building, the research in our country is more and more thorough, but as the node structure stabilizing effect on the junction, research will more due to the corrugated webs in reducing the web thickness at the same time, and an increase of the partial shear bearing capacity, so more and more recognition of the majority of experts and scholars, in our country is still in the stage of economic development. So the author thinks that the application prospect of more extensive

References

[1]Anami K,Sause R,Abbias H H.Fatigue of web-flange weld of corrugated web girders:1.influence of web corrugateion geometry and flange geometry on web flange weld toe stresser[J].international journal of Fatigue,2005,27(4):373-583

[2] Hamilton R . Behavior of welded girders with corrugated webs[D]. Dept. of Cir. Engrg,Univ. of Maine, Orono, Maine, 1 993.

[3] Luo, R., & Edlund, B. Ultimate Strength of Girders With Trapezoidally Corrugated Webs Under Patch Loading[J]. Thin-Walled Structures, Dec.1996,24,135-156

[4] Luo, R., & Edlund, B. Shear Capacity of Plate Girders With Trapezoidally Corrugated Webs. Thin-Walled Structures, Jan.1996,26(1):16-44

[5] Krzysztof R. Kuchta . Design of corrugated webs under patch load[J]. Advanced Steel Construction, 2007, 3(4): 737-751.

[6] Harrison, J.D. Exploratory Fatigue Test of Two Girders With Corrugated Webs[J]. British Welding Journal. Report Partl, 1965, 12(3):121-125

[7] Troitsky, M.S., Zielinski, Z.A., Pinprikar, M.S. Analysis of Stress and Buckling for a Corrugated Steel Girder [J]. Annual Conference-Canadian Society for Civil Engineering, 1984(1):201-205

[8] Yu huanqing,Xu haiqin Characteristics and prospects of H beam with corrugated web Zhejiang Jinggong Polytron Technologies Inc

[9] Fan xin, Li guoqiang,Sun feifei, H type corrugated web steel beam column end plate bolted connection flexural performance