Bolted beam-to-column steel connections

Autor(en): **Yardimci, Nesrin / Yorgun, Cavidan / Arda, T. Seno**

Objekttyp: **Article**

Zeitschrift: **IABSE reports = Rapports AIPC = IVBH Berichte**

Band (Jahr): **75 (1996)**

PDF erstellt am: **11.08.2024**

Persistenter Link: https://doi.org/10.5169/seals-56895

Bolted Beam-to-Column Steel Connections

Nesrin YARDIMCI
Prof.Dr.
Istanbul Technical Univ.
Istanbul, Turkey

Cavidan YORGUN
Assist.Prof.Dr.
Istanbul Technical Univ.
Istanbul, Turkey

T.Seno ARDA
Prof.Dr.
Istanbul Technical Univ.
Istanbul, Turkey

Güliz BAYRAMOĞLU
Assist.Prof.Dr.
Istanbul Technical Univ.
Istanbul, Turkey

Oğuz EYREKCİ
Dr.Eng.
Istanbul Technical Univ.
Istanbul, Turkey

Summary

The "Parallel Beam" approach to steel framing makes use of composite and continuous construction to give a cost effective answer for industrial and commercial structures. In this study, the actual behaviour of parallel beams having double channel profiles as beam is investigated. The aim of the study is to provide moment-rotation characteristics and corresponding parameters of this kind of connections.

1. Introduction

The steel frame is ideally suited to satisfy the most stringent commercial, architectural and engineering demands for quality, speed, economy and flexibility. Several alternative systems for providing "Fast-Built" construction have been developed over the past few years. The Parallel Beam approach to steel framing makes use of composite and continuous construction to give a cost effective answer for industrial and commercial structures. It is especially beneficial for buildings with high service contents. The aims are to:

- -Reduce the number of members,
- -Reduce the weight of the beams by means of continuity,
- -Simplify connections,
- -Allow simple service integration,
- -Reduce cost.

A building profits from a steel frame designed in this way because it gives flexible service layouts and can be fabricated and erected quickly, at reduced cost.

The response of steel frames is also influenced by the mechanical properties of the joints (strength, stiffness, rotation capacity). In practice, the joints are usually considered as either rigid or pinned. Research has shown that frames with semi-rigid joints can be more economical than frames with rigid or pinned joints.

In recent years, many researchers have published papers discussing the influences of connection rigidity on steel frame structures for different types of connections. In this study, the actual behaviour of Parallel Beams having double channel profiles as beams is investigated. The aim of the study is to provide moment-rotation characteristics and corresponding parameters of the, this kind of connections. As known for the pre-design stage there is a need for simple rules to estimate the mechanical properties of the joints. Because of the shortage of the knowledge about the real behaviour of this kind of joints and the non-existance of the simple rules for pre-designed in the Codes, the moment-rotation curves of the tested joints are obtained to be the starting point of a general research protect aimed to extend for this type of connections. The test programme performed at the Structural Laboratories of Istanbul Technical University and consisted of six full-scale connections. Both strong and weak axis connections were tested.

2. Experimental Programme

In the programme six specimens were tested. In each specimen, the beam is composed with double [300 profiles and the column has HE 280 B profile as cross-section. A schematic view of the test set-up for the full-scale tests is shown in Fig.1. The testing frame was anchored on the testing floor of the laboratories and aimed to resist the applied load and the support reactions. Accessories clamped on the testing slab whose rigidity can be considered as infinite. A load-cell which has been stated at the end point of the cantilever was used to measure the vertical load.

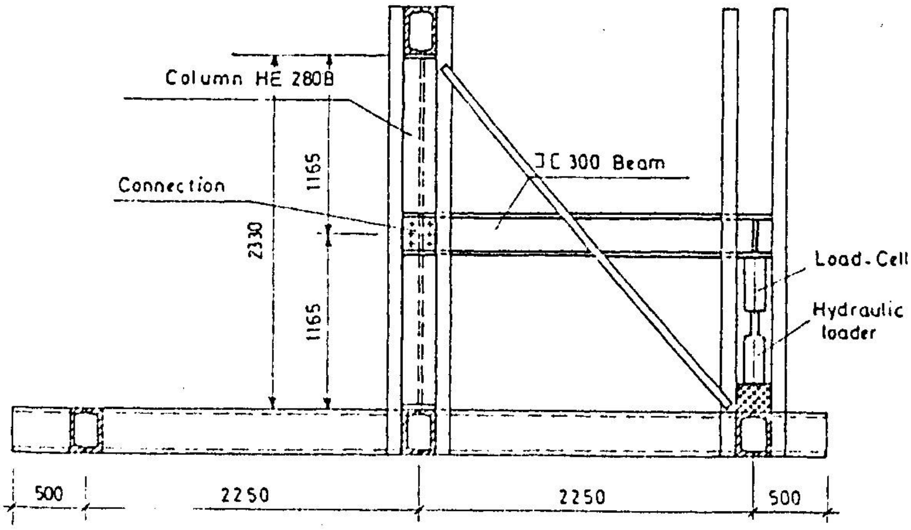

Fig. 1. The test set-up

The material of the specimens is Fe 360 (St 37) structural steel and the strength of the material is tested and proved at the laboratories. The bolts used in connections are in 10.9 quality. In strong axis connections eighteen and in weak axis connections twelve electronic strain-gages were mounted on the beam web to determine the vertical and horizontal variations of the strains. In each specimen eleven comparameters were used to measure the displacements. One of them was located under the load point and the rest at the connection.

Three of the samples are strong axis connections in which the webs of the twin channels are connected by nine bolts to the two plates welded to the column flanges by fillet welds. Other three samples are weak axis connections and in these the webs of the beams are directly connected by six bolts to the flanges of the column (Fig.2).

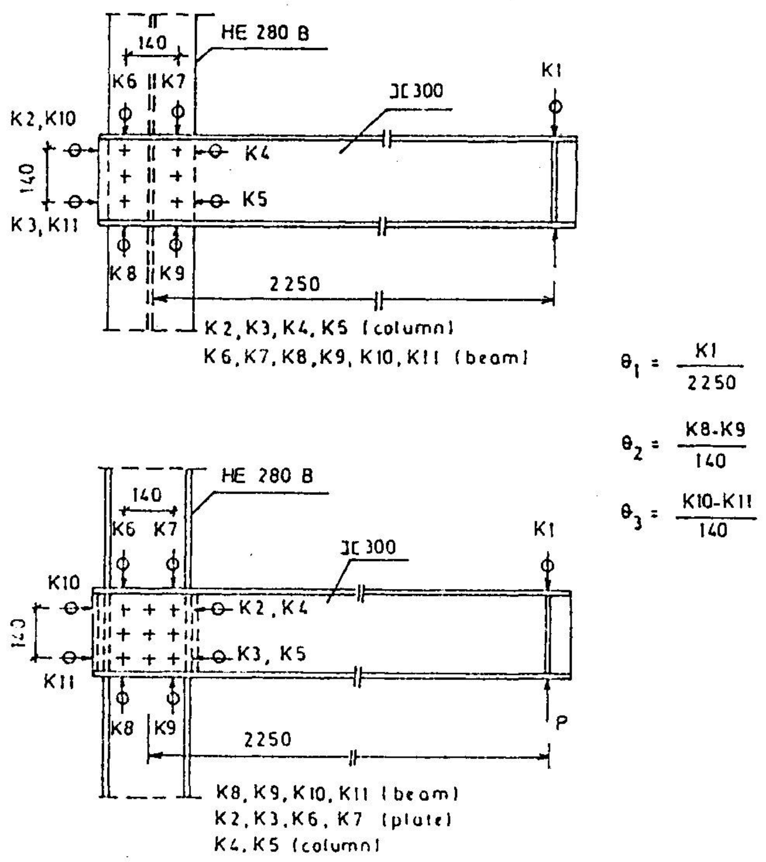

Fig.2. Test specimens

3. Test Procedure

Due to the acting load (V), (L) being the distance from the edge to the connection, a shearing force equal to the value of (V) and a bending moment equal to the value of (VL) occured at the connection. The load (V) was increased step by step and in each step of the loading, displacements were measured by comparameters. After each displacement, the load was allowed to stabilize until there was no further movement. First the load was increased progressively until the bending moment reaches sixty percent of the elastic moment resistance of the cross-section. Then the samples were unloaded. The specimens were loaded and unloaded in the same way for a second time. In the third loading case, the load was increased until the connection collapses. The strains were recorded during the tests for all levels of the load by strain-gages mounted at the edges of the bolts.

4. Behaviour and Failure of Connections

The study of the bolt holes after completion of each test indicated that all of the connections failed by bolt hole yielding. From the observation of the bolt holes, it is found that the centre of rotation of the connection is located nearly on the centre of gravity of the bolts. The design moment of the connection obtained from the test results is equal to the moment value obtained from the evaluation of the moment resistance using the method given in Ref [1]. The centre of rotation at the connection can approximately be determined from the strain distribution. As seen from the examination of the bolt holes, the most deformed bolt hole is the one which located at

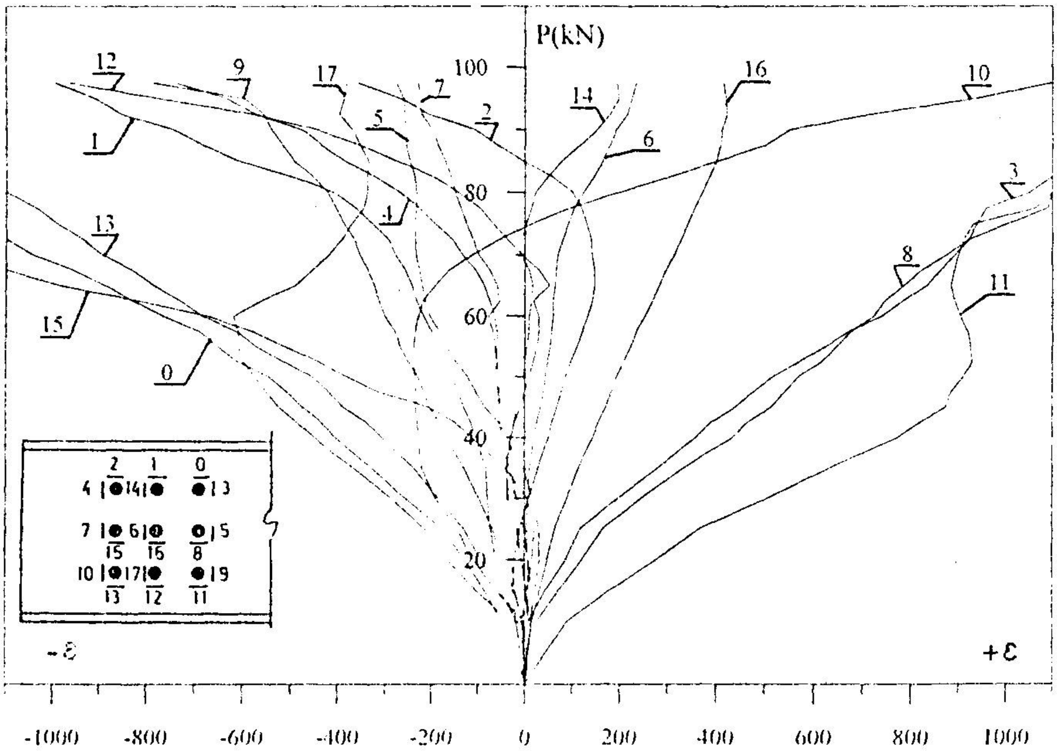

Fig.3. Strain-gages records

the farest distance from rotation centre of the connection. No deformation has been observed for the bolt hole located at the centre. The load-deformation relationships at the edges of the holes were obtained from the records of strain-gages during the tests. One of the records for strong axis connections is given in Fig.3.

In the strong axis connections, the fillet welds showed no sign of yielding during the tests.

An evaluation of the test datas showed that, in general, a plot of applied moment versus to the rotation of the beam gave the best quantative description of the connection behaviour. Location of the comparameters used in the tested samples is shown in Fig.2. The rotation (ϕ) of the beam is obtained from dividing the difference between the measured and calculated deflection of its vertical displacement by the length (L). The calculated deflection is occured due to the bending and shear of the beam. The moments and corresponding rotations of the connections obtained from three test specimens for strong and other three for weak axis connections are plotted on two separate (M-ϕ) diagrams. Then a continuous curve is plotted for each type of the connection using these tests prints (Figs.4a-4b). As seen from Figs.4a-4b, unlike the strong and weak axis connections designed by I profiles, there is not much difference between the diagrams of such the strong and weak axis connections, designed by double channel profiles, Ref [2].

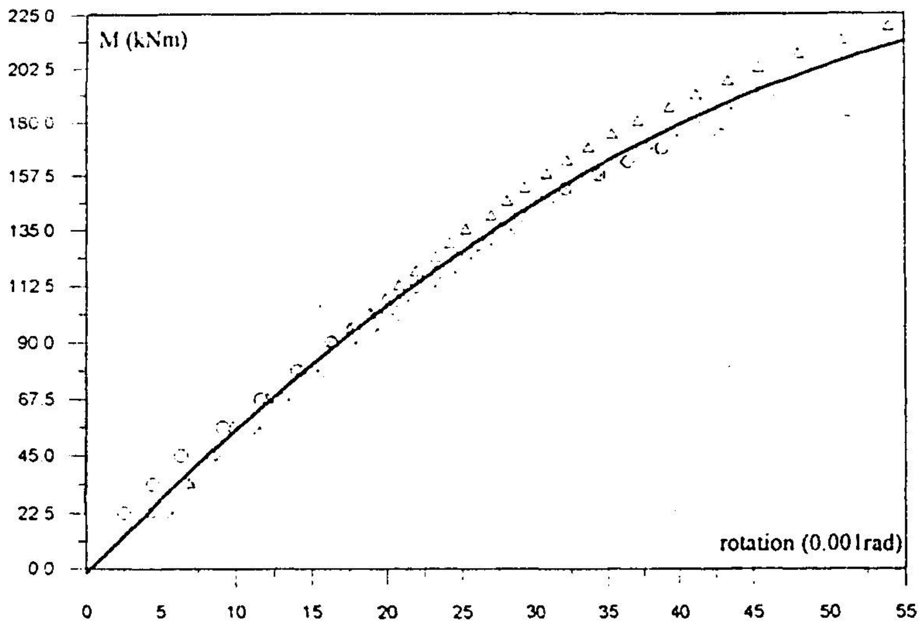

Fig.4a. (M-ϕ) *diagram of the strong axis connections*

The rotations of the joints evaluated using the corresponding comparemeters are seen in Figs.5a-5b. It is seen from these diagrams that the column is not effective on the behaviour of the tested connections. The bolt hole yielding is the most effective component on the moment resistance of all the connections so, there is not much difference between the diagrams of strong and weak axis connection types tested in this study.

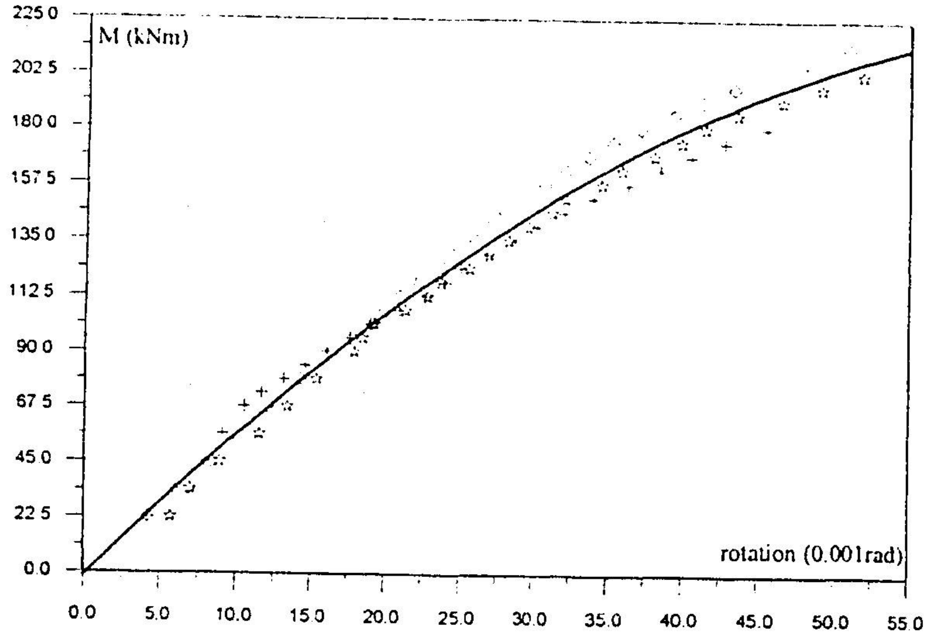

Fig.4b. (M-ϕ) *diagram of the weak axis connections*

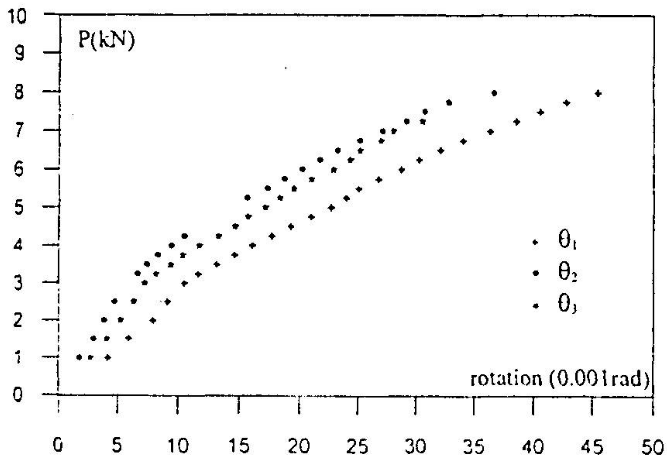

Fig.5a. Rotation of the strong axis joints

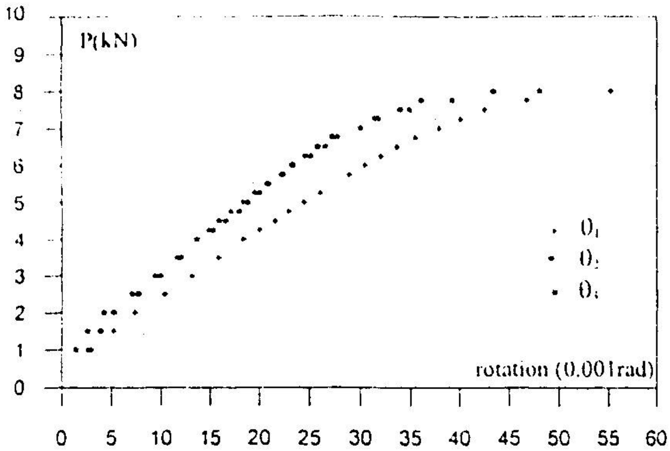

Fig.5b. Rotation of the weak axis joints

Fig.6 shows the moment-rotation behaviours of the typical steel connections. The classification boundary according to Eurocode 3 is included in the figure, Ref [3]. Using (M-ϕ) diagrams, $\overline{m}$ and $\overline{\phi}$ values are obtained for the two types of the tested connections and plotted on the same diagram. The behaviour of tested connections are situated somewhere between the pinned and semi-rigid boundary lines.

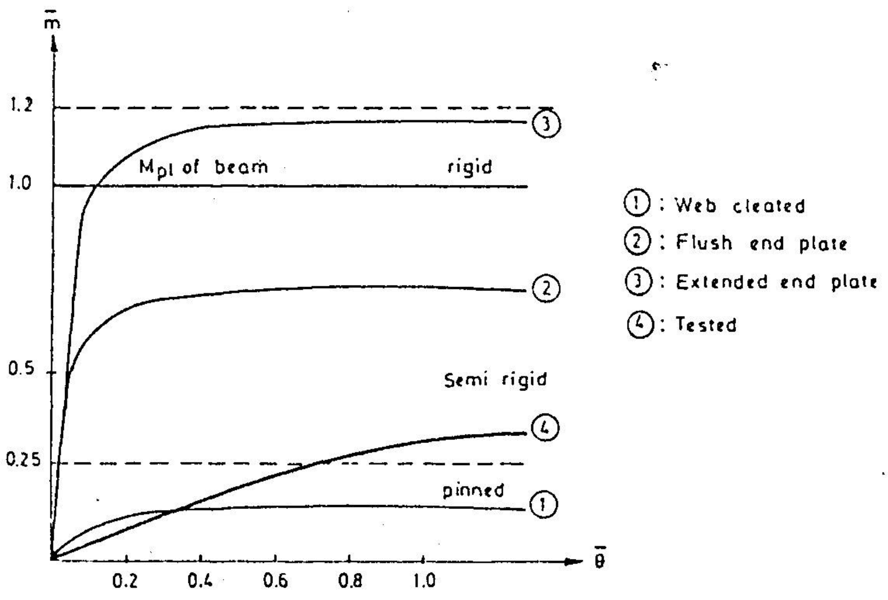

Fig.6. ($\overline{m}$-$\overline{\phi}$) diagram

The non-dimensional parameters used in this diagram are, Ref [4]

$$\bar{m} = \frac{M}{M_{pl\,Rd}} , \qquad \bar{\phi} = \frac{EI\phi}{LM_{pl\,Rd}}$$

Here,

$M_{pl\,Rd}$: the plastic moment capacity of the beam
E : the modulus of elasticity of steel
I : the moment of inertia of the cross-section of the beam

The higher values of $\frac{M}{M_{pl\,Rd}}$ ratios and connection stiffness can be achieved if the webs of the profiles are strengthened.

5. Conclusions

In the (M-ϕ) diagrams, the relations between the values of moments and rotations are increasing linearly up to the yield moment level and then tending to curve until the connection collapses.

There is not any given procedure in the literature to evaluate the moment resistance of this kind of connections to compare by test results. The most similar connection to the tested ones in the study is the web cleat connections composed by I profiles. So the tested connections compared by these kind of connections and the classification conditions given in Eurocode 3 for cleat connections are used to decide the type of the connections used in the study.

Column does not affect to the moment resistance of the connection; the bolt hole yielding is the most effective component on the behaviour of the joint. To obtain a greater moment resistance for the connection, the webs of the profiles should be strengthened.

As mentioned above, the tested connection has a very low strength and stiffness and connections are situated somewhere between the pinned and semi-rigid boundary lines. When a composite beam is used in the connection the strength and stiffness of the specimen is obviously enhanced.

In the practice, this kind of beams are mainly used as continuous beams. So, the values of the rotations encountered in the tests with cantilever samples show greater values compared by the beams used in practice.

This study is to be intended as the starting point of a general research project aimed to extend for the connections in which beams designed by double channels.

References

[1] Yardımcı, N., Yorgun, C., Arda, T.S., Eyrekci, O., Bayramoğlu, G., "Tests on Full-Scale Steel Bolted Beam-to- Column Connections", Structural Assessment the Role of Large Scale and Full Scale Testing, City University, London,England, July 1-3, 1996.

[2] Yardımcı, N., Yorgun, C., Arda, T.S., "An Experimental Investigation on the Behaviour of Semi-Rigid Welded Beam-to-Column Connections", Proc. of the Nineth National Congress of Mechanics, Ürgüp, Turkey 4-8 September, 1995, pp.748-757.

[3] Eurocode 3, Design of Steel Structures, Part 1.1, General Rules and Rules for Buildings, ENV, 1993-1-1.

[4] Yu, C.H., Liew, J.Y.R., "Design of Semi-Rigid Frames Using Second-Order Inelastic Analysis, Proc. of the Third International Conference on Steel and Aluminium Structures, ICSAS, Istanbul, Turkey, 1995, pp.351-358.

Leere Seite
Blank page
Page vide