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# Investigation of moment resistance characteristic of bolted semi-rigid connections: An experimental study

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***Abstract:*--** **Structural steel is commonly used as construction material. Therefore, it is needed to understand the structural behaviour of the connection. This study presents an experimental study on the behaviour of top and seat T connections with different stiffeners and different Dimensions. four full scale semi-rigid steel top and seat T connections were tested. The aim of this study was to analyze the influence of top and seat T connections based on the IPE 140 standard profile, stiffener thickness (t) of connections, and Width (X) of top and seat T connections on the behavior of steel connections, to provide the necessary data for improving Eurocode 3 and enable efficient use of residue IPE standard profiles and back to the consumption cycle.**

**Keyword:-- Experimental study, Stiffener, top and seat T connections, IPE 140 standard profile.**

## 1. INTRODUCTION

Steel is one of the most widely used construction materials in the world. Bridges, factories, airport terminals, office buildings, and apartments typically use structural steel. To ensure the safety of buildings constructed using structural steel, design codes have been issued by the regulators [1].In recent years, many research works were carried out to study the behaviour of steel joints include the work of Maali M et al [2], who studied experimental model for predicting the semi-rigid connections' behaviour with angles and stiffeners and Maali M et al. [3] Done, several test models on Bolted Angles Connections with Stiffeners. Also, Aydın A.C et al [4] analysed some experiments on the Semi-Rigid Connections Behavior with Angles and Stiffeners. Piluso and Rizzano [5] studied Experimental analysis and modelling of bolted T-stubs under cyclic loads. Coelho et al [6] studied Experimental assessment of the behaviour of bolted T-stub connections made up of welded plates. So, the aim of this study was to analyze the influence of top and seat T connections based on the IPE 140 standard profile, stiffener thickness (t) of connections, and Width (X) of top and seat T connections on the behavior of steel connections, to provide the necessary data for improving Eurocode 3 and enable efficient use of residue IPE standard profiles and back to the consumption cycle.

## 2. TEST DETAILS

This study presents the four test models that were improved to predict the behavior of bolted top and seat T connections under static loads. The test program is shown on Fig. 1, and the details are listed Table 1. The behaviors of the top and seat T connections were compared each other's. The different stiffeners with a thickness equal to 5, 8 and 12 mm were welded to the connections by means of a continuous 45° fillet weld. The fillet welding was performed from the upper side of the joint in the down-hand position in the workshop. The plate stiffener, top and seat T connections profile, and profile section was S235. HEB160 was used for the columns, and IPE140 was selected for the beams. Hand tightened full-threaded grade 8.8 M10 bolts in 12-mm drilled holes were used consistently for all the tested specimens. The goal this study was to analyze the influence of top and seat T connections with stiffener thickness (t) of connections, and Width (X) of top and seat T connections that used the IPE standard profile on the behaviour of steel structure joints, to provide the essential data for devoloping Eurocode 3 standard and efficiently using residue IPE standard profiles, rather than sending them back to the consumption cycle.

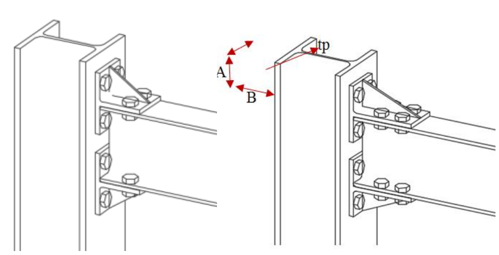


***Fig. 1. proposed three-dimensional top and seat T connections***

 

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*Table 1. Test details*

| Experiment | top and seat T connections | X (mm) | A(mm) | B(mm) | tp(mm) |
|---|---|---|---|---|---|
| X70-S60x60-$t_p$5-B1 | | 70 | 60 | 60 | 5 |
| X70-S60x60-$t_p$12-B1 | IPE 160 | 70 | | 60 | 12 |
| X125-S60x120-$t_p$8-B2 | | 125 | | 120 | 8 |
| X125-S60x120-$t_p$12-B2 | | 125 | | 120 | 12 |

The average actual properties are given the values for the Young's modulus, E= 210 MPa, the static yield fy=235 MPa, tensile stresses fu=360MPa, the yield ratio, ν=0.3.

## 3. PROCESS OF TESTS

The experimental models were set-up of Maali et al paper [2-3]. The illustration of the test arrangements and the mechanism is shown in Fig. 2.


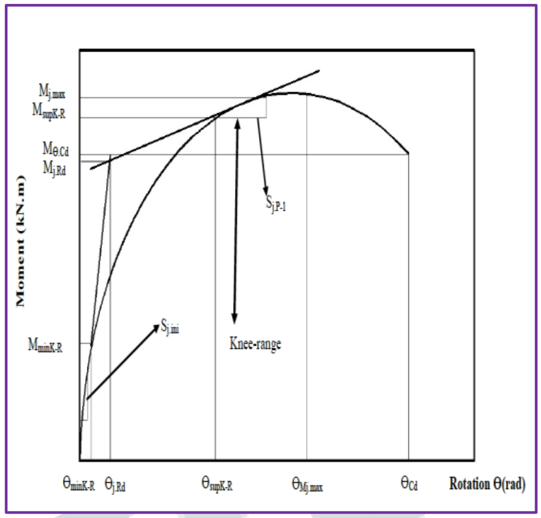


***Fig. 2. Location of the DT=LVDTs (displacement transducers tool) and Moment–rotation curve characteristics***

All measurements of test machines used by Aydın et al paper [4]. The test setup is shown in Fig. 2.

The designed connections form various moment-rotation curves that describe the relationship between the moment (M) and the rotation (Θ) [4]. The moment and the rotational deformation obtained from equations:

$$M = PL_{load} \text{ and } \frac{\arctan(\delta_{DT1}-\delta_{DT5}-((-\frac{P}{EI})(\frac{X_{DT1}^3}{6}-\frac{L_{load}X_{DT1}^2}{2})))}{L1}$$

where I is the moment of inertia and E is Young's modulus of beam steel.

The M–Θ curve of the connection may be characterized using the aforementioned relationships. The main features of this curve are the plastic flexural resistance, $M_{j.Rd}$; the maximum bending moment, $M_{j.max}$; and the bending moment capacity, $M_{\Theta.Cd}$. In particular, the following characteristics were assessed in the different experimental tests [7-8], as shown in Fig. 2.

## 4. TEST RESULTS

The moment resistance characteristic for the four full-scale specimens of steel-bolted, beam-to-column connections with top and seat T connections (T= IPE 140) with different stiffeners (tp =5, 8 and 12mm) under static loads are reported in Fig. 3 and listed in Table 2. This curve and table showed that: the Mj.Rd values for the tp12 groups decreased by about 14.13%, with an increase in X from 70mm to 125mm. the Mj.Rd values for the all models decreased , with an increase in tp from 5mm and 8mm to 12mm. so, the Mj.Rd values decreased, with an increase in X and tp. the Mj.max and the MΘ.Cd values decreased by about 83.33% and 80.89%, respectively , with an increase in X from 70mm to 125mm. the Mj.max and the MΘ.Cd values for the all models decreased , with an increase in tp from 5mm and 8mm to 12mm. so, the Mj.max and the MΘ.Cd values increased, with an increase in X and an decreased in tp. So, the X parameter is very important of the tp parameter in the top and seat T connections (T= IPE 140) with different stiffeners (tp =5, 8 and 12mm) under static loads. In the result in moment resistance values in all models with two rows bulon in bigger than one two row bulon. The failure modes were observed during the tests: the bolt being directly overloaded by the applied forces on the beam of the top and seat T connections (Fig. 4). The failure modes of the specimens appeared after necking positions on the beam of the top and seat T connection (Fig. 4).

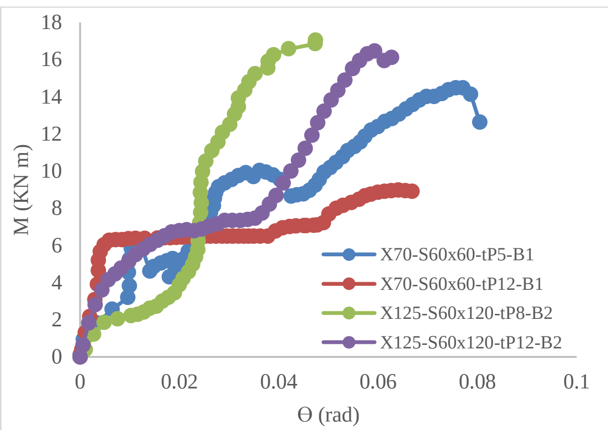


***Fig. 3. Moment–rotation curves***

| Experiment | Resistance (KN.m) | | |
|---|---|---|---|
| | $M_{j.Rd}$ | $M_{j.max}$ | $M_{\Theta Cd}$ |
| X70-S60x60-tp5-B1 | **8,13** | **14,48** | **12,63** |
| X70-S60x60-tp12-B1 | **6,77** | **8,98** | **8,90** |
| X125-S60x120-tp8-B2 | **13,45** | **17,04** | **16,61** |
| X125-S60x120-tp12-B2 | **5,80** | **16,46** | **16,10** |

***Table 2. Moment–rotation characteristics***


***Fig.4. Failure of models for all models***

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