Journal of Ferdowsi Civil Engineering, Vol.33, No.3, 2020.

Experimental Evaluation of the Effect of Contact Surfaces on The Friction Resistance of Bolt Connections

Mussa Mahmoudi[1] Milad Kosari[2] Mehran Lorestani[3]

1. Introduction

Many researchers have investigated the behavior of structural bolted connection so far. For example, Puthli and Fleischer considered such connections in the case of high-strength steel plates. They evaluated the effect of some structural factors such as bolt's spacing and edge distance for two M27 grade 10.9 bolts. In this study, the tested specimens were designed to prevent tensile failure of the plate or bolt shear failure, since the primary attention was devoted to the bearing resistance of these members. The obtained experimental results involving failure loads finally were compared to Eurocode 3 to interpret the design formula for high-strength steel grades. In another research, Shi et al. developed a finite element model for beam-column end-plate-type connections with pre-tensioned high-strength bolts in the software framework of ANSYS. Verification of the finite element model with experimental results has been done, and it was shown that numerical modeling with excellent accuracy can determine the actual behavior of these connections. In other words, the results of numerical simulations were able to obtain a precise momentum curve for such connections by considering the pre-stress effect of the bolts. Furthermore, Moze and Beg experimentally examined the ductility and resistance of 38 tension splices double-shear bolts where plates were made from steel grade S690. They compared their experimental data with Eurocode provisions and proposed a new formula for computing the bearing resistance in such connections.

This study intends to examine the effect of different surface conditions on the behavior of Slip-critical Bolted connections. In this regard, in order to the optimal design of these components, the influence of these factors on the strength of the Slip-critical Bolted connection must be considered correctly. In other words, this research intends to find how much the colored and sandblasted surface can affect the capacity of the Slip-critical Bolted connection.

2. Slip-critical Bolted Connections

There are two different mechanisms for tolerating external forces, including bearing and slip-critical types.

2.1. Bearing-type Connections. Bearing-type connection is one of the most convenient methods for transferring load between two steel members. This connection is only for gravity loading and should not be used in seismic design. In this type of connection, no pre-tension forces are generated in the bolts and, only tightening the bolt is sufficient by the ironworker; that is, the bolts are not tightened adequately so as to considerably squeeze the plates together.

2.2. Slip-resistant Connections. In the design of all moment-resisting and dual frames, as well as bracing joints and lateral-resisting columns in simple frames, this type of connection should be utilized. In a slip-critical or friction type connection, when a fastener is tightened the pre-tension force T_i is generated in the bolt.

3. Method

Regarding the single-shear type of components, in all samples, two A36 ASTM steel plates are used to make each connection. The length, width, and thickness of these plates respectively are 350, 200 and 20*mm*, which is constant in all cases (Figure 1).

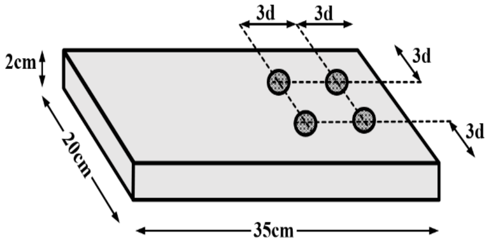

Figure . 5. Configuration of samples along with spacing and edge distances (d = bolt diameter)

In general, in this study, eight different contact conditions are considered in order to investigate the effect of slipping. These conditions involve ordinary, sandblasted, painted (with two different thicknesses) and grooved (with two types of shapes and different heights) steel plates.

4. Results and Discussion

4.1. The effect of sandblasting. Figure 2 shows that the utilization of sandblasted steel plates increases the frictional strength of the member. Indeed, by comparing the resistance values of the horizontal parts of the two graphs, it is observed that the average frictional resistance of the member has increased by about 20% using this procedure.

The amount of slipping of the samples is about 1.5mm to reach the start of the bearing resistance. After this initial

---

[1] Corresponding Author. Associate Professor, Structural Engineering Department, Faculty of Civil Engineering, Shahid Rajaie Teacher Training University.
Email: m.mahmoudi@sru.ac.ir.

[2] MSc. Student, Structural Engineering Department, Faculty of Civil Engineering, Shahid Rajaie Teacher Training University.

[3] MSc. Student, Structural Engineering Department, Faculty of Civil Engineering, Shahid Rajaie Teacher Training University.

slip, bolts are contacted with the connected plates and ultimately the connection reaches its final resistance at 600 *kN*. Moreover, the amount of slipping of samples with and without sandblasting is approximately equal.

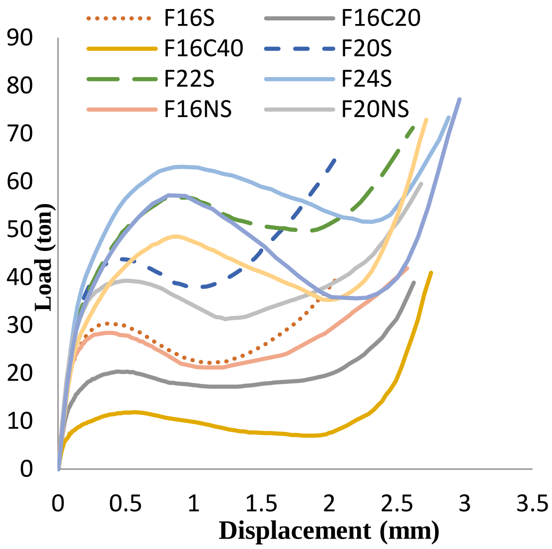

Figure 2. The load-displacement diagram of specimens

4.2. The Effect of Painting. A Figure 2 shows it is found that the thickness of the paint has a substantial effect on the frictional resistance of the connection. As the color thickness increases from 20 microns to 40 microns, the frictional resistance decreases by about 30 percent. Further, it can be observed that the amount of slippage in both cases is the same and is about 2 mm. The area under the curve with a thickness of 20 microns is also greater than the other one, which indicates more energy absorption in this case. Moreover, both specimens have reached their ultimate strength at 600 kN.

5. Conclusion

In the present study, the effects of different contact conditions (painted, sandblasted, and grooved) were investigated experimentally. Based on the interpretation of the results, the following findings can be expressed:

-Sandblasting the steel surfaces, by increasing the friction coefficient of plates in contact with each other, increased the slip resistance of the joints about 60 percent;

-If there is a color on the connecting steel surfaces, the resistance of the connection will be greatly reduced. This decrease was amplified by increasing the thickness of the color, as an instance, it was observed to be 36% for specimens that were painted with a thickness of 40 microns.

-For grooved steel plates, the absorbed strain energy (toughness) significantly increases compared to other cases, in which, with increasing the height of grooves this parameter is increased.