Study on applicability of high durability friction grip joints with high strength countersunk head bolts for steel bridge structures

Akiko TABATA
Assistant Manager
Hanshin Expressway Company Limited
Osaka, Japan
akiko-tabata@hanshin-exp.co.jp

Hidesada KANAJI
Manager
Hanshin Expressway Company Limited
Osaka, Japan
hidesada-kanaji@hanshin-exp.co.jp

Yoshihide Kurono
Graduate Student
Osaka City Univ.
Osaka, Japan
kurono@brdg.civil.eng.osaka-cu.ac.jp

Takashi YAMAGUCHI
Professor
Osaka City Univ.
Osaka, Japan
yamaguti@civil.eng.osaka-cu.ac.jp

Summary

The authors focused on the high strength bolted friction grip joints with countersunk head bolts which can finish the surface of the connection plate flat smoothly and prevent from functional depression due to corrosion. Firstly we carried out Finite Element Analysis in order to evaluate the contact pressure of double shear connected friction joints with countersunk heads varying the angle of countersunk head. Secondly, we have compared the slip strength of the joints which has the optimum countersunk head angle with that of the joint with the normal high strength bolt through the standard slippage test considering variation of plate thickness and the yield strength of the base and splice plates. As a result, it was concluded that the slip strength of the joints with countersunk heads exceeds the required design slip strength which has specified in JSHB and that its slip coefficients is about 10% lower than that with normal head bolts.

Pic.1 :High strength countersunk head bolt

Keywords: countersunk head bolt; contact pressure; slippage test; slip coefficient; slip to yield resistance ratio.

1. Mechanical Behavior from FEA

The axisymmetric FEA was conducted by ABAQUS Standard 6.9[1]. Double shear connected joint are dealt with in the analysis (See Fig.1). In order to evaluate the slip strength with countersunk head bolts, the angle of countersunk head is changed as 60, 70, 80, 90, and 110 degrees. As shown in Fig.2, the FEA results indicate that contact pressure of CD series is higher than that of HD and is distributed in smaller area, and high shear stress occurs near the bolt hole edge due to the friction force by the local deformation of the splice plate. It is found that the maximum stress of CD series is higher than that of HD, and that the case of the angle of countersunk head is 90 degrees shows lowest maximum stress.

https://doi.org/10.2749/222137813806474651

2. Slippage test

In order to clarify the behaviour of friction joints with high strength countersunk head bolts for steel bridge structures, we have carried out the standard slippage test taking into account for steel material grade, slip to yield resistance ratio β, and the number of contact surfaces. Geometrical configurations of the specimens for the slippage test are shown in Fig.3. In this experiment, the definition of slip occurrence is when the relative displacement at δ_3 becomes 0.2 mm. From the experiment results that the slip strength of the joints with countersunk head bolts exceeds the design slip strength specified in JSHB calculated by the slip coefficient 0.45. Fig.4 shows the relationship between slip coefficient μ_1 and slip to yield resistance ratio β_e. It is observed that slip coefficient μ_1 has a tendency to get lower by increasing of β_e regardless of the bolt type, steel material grade, and number of contact surfaces. It is summarized that slip coefficients μ_1 for the countersunk head specimens are approximately 10% lower than those for hexagon head specimens in spite of number of the contact surface. The reason is that the contact pressure of the joints with countersunk heads reduces due to local yielding around the countersunk bolt holes by increasing applied tensile load.

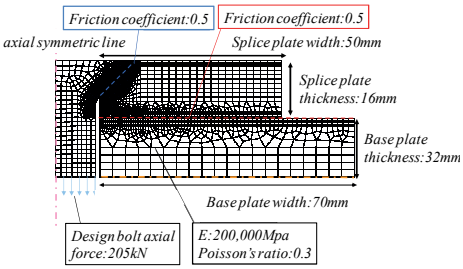

Fig.1: FEA model for CD-90

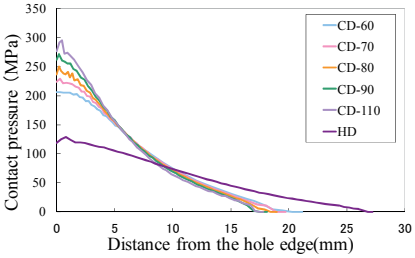

Fig.2: Contact pressure distribution of contact surface

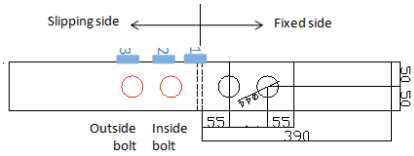

Fig.3: Dimensions of the specimen and measured location of relative displacements

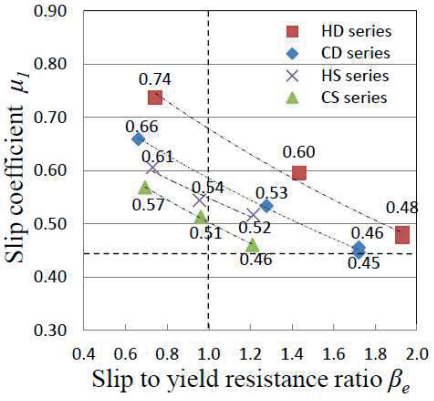

Fig.4: Relationship between μ_1 and β_e

3. Conclusions

(1) In order to clarify the distribution of the contact pressure on the contact surface of the joints with countersunk heads, the FEA was carried out varying the angle of the countersunk head. It was concluded that the most desirable angle of the countersunk head is 90 degrees from the viewpoint of distribution of the contact pressure and stress concentration of the bolt.

(2) In the cases of CD series, the FEA results indicate that high contact pressure over yield strength occurs around the countersunk edge of the bolt hole and the distributing area is small comparing with HD series.

(3) It was concluded from the standard slippage test results that the slip strength of the joints with countersunk head bolts exceeds the design slip strength specified in JSHB calculated by the slip coefficient 0.45 and that its slip strength is about only 10% lower than that with normal head bolts. It is caused by that the contact pressure of the joints with countersunk head reduces due to local yielding around the bolt holes as increasing applied tensile load.