Research on Design Method of Patch Plate Reinforcement Used High-strength Stud Bolts

高カスタッドボルトを用いた当て板補強工法の設計法に関する研究

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Establish the Design Method of Patch Plate Reinforcement Using High-strength Stud Bolts

BACKGROUND

In Japan, there are many bridges that have been in service for more than 40 years, which need to reinforce or repair. However, when reinforcing steel parts with closed sections, due to the limitation of construction space, the bolts(high strength blind bolts) can only be used from the outside to connect the main plate and patch plate(Fig.1). Meanwhile, punching holes on the main plate will reduce the strength. Here, we propose a reinforce method in which high strength bolts are welded to the main plate replacing the high strength blind bolts(Fig.2), to connect the main plate and the patch plate. However, the transmission mechanism of the patch plate reinforcement is different from friction joint design. When using the number of bolts calculated from the joint design, the load sharing ratio of patch plate is not equal to the cross-sectional ratio. This study aim at confirming the fatigue performance and reinforcement effect of Patch plate method used high strength stud bolt. Then, propose the design method.

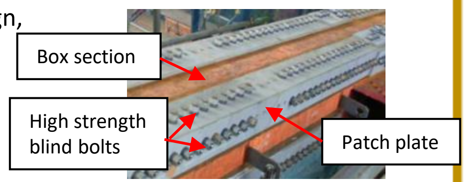

Fig.1 Reinforcement of Closed Section

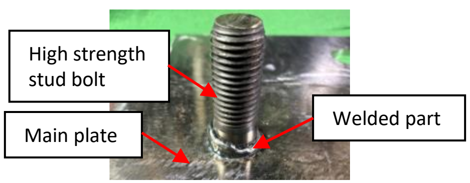

Fig.2 Welded Stud Bolt

keywords :
High Strength Stud Bolt, Patch Plate Reinforcement, Fatigue, Load sharing ratio

METHODS

1.Fatigue testing and tension testing

Fatigue testing: Main plate thickness: 12mm,9mm,
Nominal stress range:100MPa, 120MPa, 150MPa, 170Mpa
Tensile testing: box section, reinforced by 4-sides

2.FE analysis

Elastoplastic analysis (to confirm the reinforcement effect)
Confirm the effect of the number of bolts, tightening force, thickness of patch plate, bolting type to load sharing ratio of the patch plate

Fig.3 Fatigue testing

Fig.4 Tensile testing

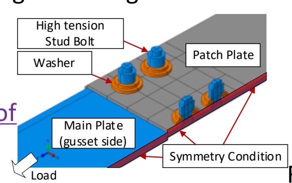

Fig.5 FE model

RESULTS

1.Fatigue testing and tension testing

Tension testing: Fig.6 shows the load sharing ratio of the main plate at each load stage. As the number of bolts is increased, the load sharing ratio of the main plate approaches the cross-sectional ratio. The composite effect of the main plate and patch plate of the case Stud-5-t6, is maintained up to a higher load level than the Case Stud-2-t6, which has the least number of bolts. For Stud-2-t6, as the load increased, slippage occurred and the load sharing ratio of the main plate decreased.

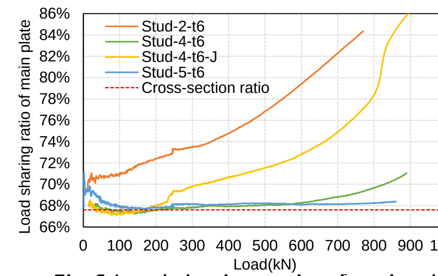

Fig.6 Load sharing ratio of main plate

2.FE analysis

Fig.7 shows the load transfer efficiency of each row of bolts.
The load transfer efficiency r_i is defined by follows.

$$r_i = F_i / F_d \times 100(\%)$$

Where, F_i :The actually load transmitted by the row i ;
F_d: The load transmitted by total plate (calculated by cross-section ratio)

When multiple rows of bolts are placed, the load transmitted by the first row of bolts is the largest. From the first row of bolts, the load transmitted by each row gradually decreases until the load is completely transmitted ($\sum r_i = 1$).

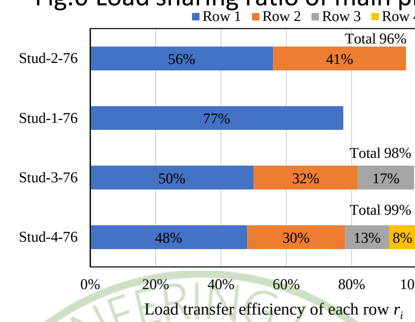

Fig.7 Load transfer efficiency of each row

SUMMARY

1. The load sharing ratio of the patch plate did not match the cross-sectional ratio when the bolts were placed according to the joint design. The load sharing ratio of the patch plate increased until reach the cross-section ratio when the number of bolts increased.
2. If the number of bolts is small, slippage will occur, which reduces the load sharing ratio of the patch plate.
3. When multiple rows of bolts are placed, the load transmitted by the first row of bolts is the largest. From the first row of bolts, the load transmitted by each row gradually decreases.