

Clarify the fatigue strength and reinforcement effect of patch plate reinforcement

BACKGROUND

In Japan, there are many bridges that have been in service for more than 40 years, which need to reinforce or repair. And the patch plate reinforcement method is commonly applied to repair the bridge. 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 fasten the main plate and patch plate (Fig.1). Here, we propose a reinforcement method in which high-strength bolts are welded to the main plate replacing the normal bolts (Fig.2). In this study, we will confirm the Fatigue performance and load sharing ratio of the patch plate method to clarify the reinforcement effect. And then, propose the design method of patch plate reinforcement.

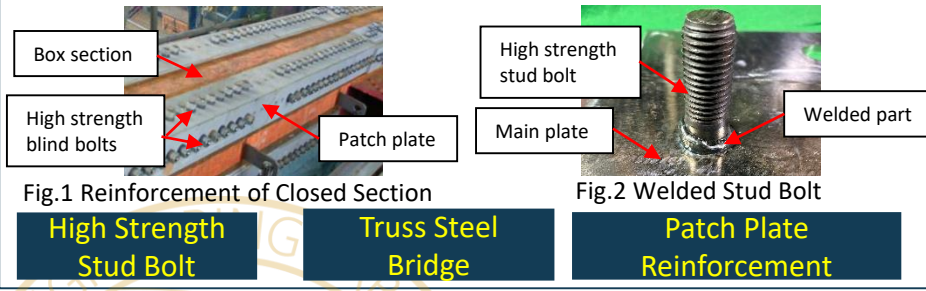


Fig.1 Reinforcement of Closed Section

Fig.2 Welded Stud Bolt

RESULTS

1. Fatigue testing

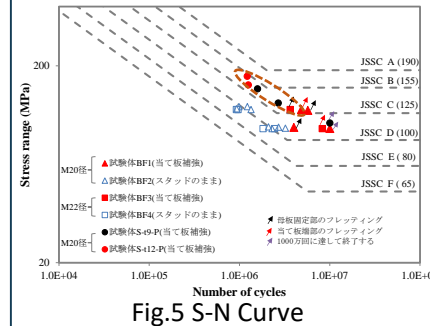


Fig.5 S-N Curve

As shown in the Fig.5, the fatigue strength of Specimen S-t9, S-t12 is class C, and 1 class higher than that of the test specimen only with the stud bolt (without patch plate and axial force). The location of the cracks is in the welded toe (shown in Fig.6).

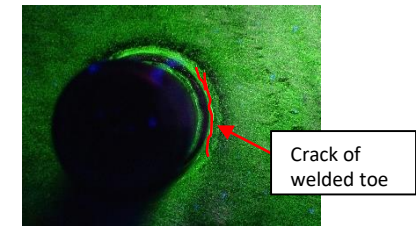


Fig.6 Magnetic-Particle Test

2. FE analysis

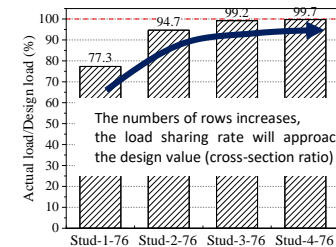


Fig.7 Load Sharing of patch plate

As shown in the Fig.7, the load sharing ratio of patch plate with 2 rows bolts (joint design method), is 94.7%, less than cross-section ratio. This is because the relative displacement between the main plate and the patch plate is small than bolted joint, so the load is not transferred effectively. The load sharing ratio will increase while the numbers of stud bolts increase, until reach the cross-section ratio.

METHODS

1. Fatigue testing

Main plate thickness: 12mm, 9mm
Patch plate thickness: 9mm
Nominal stress range: 100MPa, 120MPa, 150MPa, 170MPa

2. FE analysis

Elastoplastic analysis
(consider contact conditions)

Confirm the effect of the number of bolts, tightening force, thickness of patch plate, bolting type to load sharing ratio of the patch plate

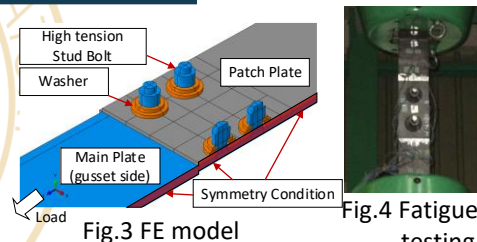


Fig.3 FE model

Fig.4 Fatigue testing

SUMMARY

- The fatigue strength of the main plate with welded stud bolts tightened ($t=9\text{mm}$, 12mm) is **class C**. It is considered that the **tightening of the bolts reduced the stress concentration effect**.
- The load sharing ratio of patch plate using the joint design method is less than cross-section ratio. It is due to the small relative displacement and the low load transferred. **The numbers of rows increases, the load sharing rate will approach the design value (cross-section ratio)**