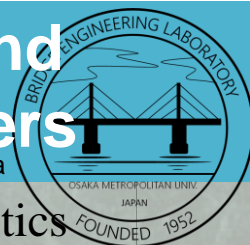


Development of Strengthening Method with a Patch Plate and High-Strength Stud Bolts for Composite I-section steel girders

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Validation of the effectiveness of continuous patch plates on load-carrying characteristics

BACKGROUND

- Recently, a strengthening method using patch plates and high-strength stud bolts has been gradually applied to some existing bridges and can be implemented from one side. (Fig.1)
 - Patch plate should be divided into several pieces due to construction and shipping restriction, such as the presence of intermediate transverse and bearing stiffeners. (Fig.2)
- ⇒ Patch plate strengthening method using divided plates with high-strength stud bolts

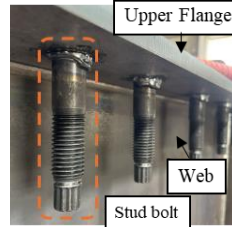


Fig. 1 Stud bolt

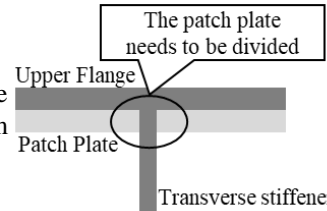


Fig. 2 Divided patch plate region

Previous studies presented two cases of divided patch plate methods. However, both results indicated that maximum stress exceeded its allowable stress specified on JSHB.

This study focuses on the difference in strengthening effects between divided and continuous patch plates.

METHOD

Patch plate strengthening of the upper flange at the maximum bending moment region of a steel I-girder

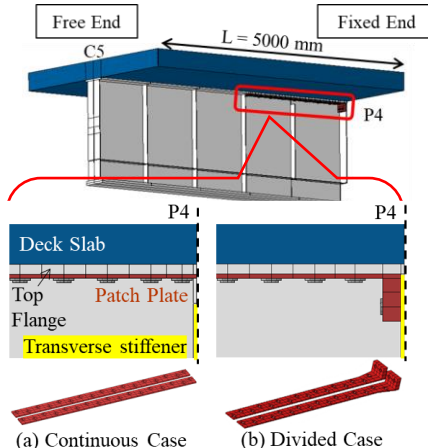


Fig. 3 Analysis model and patch plate cases

The model is based on an actual bridge, made as a half model considering symmetry. The difference in strengthening effects due to the patch plate connection details at P4 is investigated.

- Case 1: Continuous Case**
The transverse stiffener is cut, and the continuous patch plate is installed.
- Case 2: Divided Case**
The transverse stiffener is not cut, and the divided patch plates are installed. The segments are connected by a tension-type joint.

KEYWORDS

□ Patch plate connection, Stud bolts, Load distribution ratio

RESULTS

Load-displacement relationship

As shown in Fig. 4, the slope of the load-displacement curves does not vary between the two cases within the design load range but does vary beyond their proportional limit load. The slope of the case with continuous patch plates becomes larger than that of the case with divided patch plates.

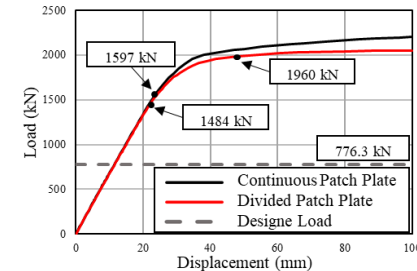


Fig. 4 Load-displacement relationship

Load distribution ratio

Figure 5 depicts the longitudinal load distribution ratio of the upper flange when the divided case exhibits a nonlinear behavior. Focused on the ratio in the one-end section "P4", the divided patch plate transmits axial force less than its cross-sectional area ratio to the upper flange. In addition, continuous plates provide greater strengthening effect.

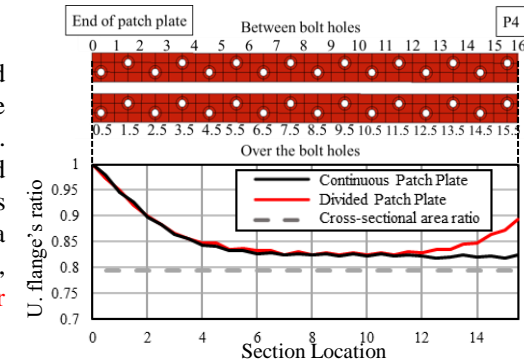


Fig. 5 Load distribution ratio

Elastoplastic behavior

Figure 6 shows the von Mises stress distribution at the 1960 kN where the upper flange strengthened with continuous plates is completely yielded. As shown in Figs. 4 and 5, continuous patch plates enhance the ultimate load by 5% compared to divided plates.

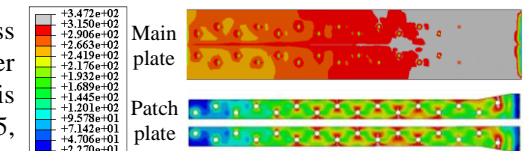


Fig. 6 Von Mises stress distribution in elastoplastic state (1960 kN)

SUMMARY

- Divided patch plates showed little difference in strengthening effect at the design load level compared with continuous patch plates.
- Different patch plates configurations showed differences in strengthening effect in load-displacement relationship at the proportional limit load and in the plastic range.
- Divided patch plates could not carry sufficient load because of the low composite action at the divided joint, which reduced the load-sharing ratio of the patch plates.