Research on transversal connection strengthening of T beam bridges

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Abstract. This paper presents a new type of brace system to strengthen transversal connection of T beam bridges. A nylon T beam bridge was made to study the strengthening effect. Braces were installed in the mid span and the load was symmetrical. The results show that the reduction of the maximum deflection of the bridge with the brace system was 14.9% in experiments and 19.1% in finite element analysis, which show that the transversal connection of T beam bridge can be improved efficiently by the proposed brace system.

1. Introduction
Concrete T beam bridges have been widely used in China. They are manufactured in the precast plant and erected in the construction site. Compared with rectangle beam, T beam makes full use of compression behavior of concrete and decreases the volume of concrete in pressure region, which make it appeal for the construction of short-to medium-span bridges. With long term overload and insufficient maintenance, many damages emerged, including concrete deterioration, reinforcement corrosion and so on. One serious problem is the damage of transversal connection between adjacent beams, which causes the “single slab bearing”[1] and decreases the structural stiffness.

A number of studies have been reported on strengthening the transversal connection of T beam bridge. Xie et al.[2] strengthened Liu Liang River Bridge by transversal prestressed tendons in Hubei, China. Field tests and finite element analysis showed that transversal prestressed tendons enhanced the transversal connection and improved the live load distribution between beams. Guo[3] strengthened the diaphragms of Guang Bei Overpass Bridge by bonding steel plates, which decreased the maximal deflection obviously and prevented crack growth. Niu et al.[4] used the finite element method to analyze the effect of diaphragm on integrity of precast T-shape girder bridge. The results showed that the live load distribution and the integrity of the bridge were improved with the increasing number of diaphragms. Li et al.[5] studied the effect of intermediate diaphragms on the deflection and strain of beams at mid span. It was found that the effect of diaphragms on the mid span deflection was more prominent in the short span bridge and the reduction in the maximum bending moment by the diaphragms was more significant in long span bridge.

In this paper, a new kind of brace system is proposed to strengthen the transversal connection of T beam bridges, which can be prefabricated in factory and installed in the field. Static experiments and finite element model shows that the newly proposed brace system can not only improve the load distribution between beams, but also enhance the integrity of T beam bridge.

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2. Newly proposed brace system
The newly proposed brace system consists of two diagonal braces and one horizontal brace. They are
connected by bolts with each other. The three braces connect with T beam bridge by a plate on the top
and two brackets at the bottom. The brackets are fixed on the original T beam bridge by bolts. In order
to study the strengthening effect of the proposed brace system, a T beam bridge was made by nylon
and the brace system was made by aluminum alloy. Figure 1 shows the brace system and figure 2 is the
nylon T beam bridge.

![Figure 1. Brace system.](image1)

![Figure 2. Nylon T beam bridge (unit:mm).](image2)

3. Experiments

3.1. Material performance tests
As the T beam bridge was made of nylon, elastic modulus and Poisson’s ratio of nylon were measured
by tension tests. Elastic modulus was tested as figure 3 shows and figure 4 illustrates Poisson’s ratio
tests.

![Figure 3. Elastic modulus tests.](image3)

![Figure 4. Poisson’s ratio tests.](image4)

As shown in figure 5 below, the average of Poisson’s ratio values is almost a constant around \( \nu = 0.386 \).
The average of elastic modulus is shown in figure 6 and is around $E=1436\text{Mpa}$. These values can be considered in numerical calculation.

3.2. Static deflection tests
To measure the effect of the proposed brace system, static tests of the T beam bridge with and without brace system were carried out respectively. In the static tests, load was at mid span and on the top of the middle beam, which is shown in figure 7.

Displacement meters were placed at the bottom of each beam to measure the mid span deflection, which is shown in figure 8. The mid span deflection of all beams before and after strengthening is shown in figure 9.

At a same load, the maximum static deflection was decreased 14.9% when the T beam bridge was strengthened with the proposed brace system.

4. Finite element analysis
The ANSYS finite element software was used in this study to create models of the nylon T beam bridge and brace system to study the strengthening effect of the proposed brace system on transversal connection of T beam bridges.

The model’s section is as given in figure 2(b) and the properties of nylon are as given in section 3.1. The elastic modulus and Poisson’s ratio of aluminum alloy is 70000Mpa and 0.3[6], respectively.
Solid45 was adopted to represent the T beam bridge and brackets, whereas the diagonal braces and horizontal brace were represented by using beam4. Figure 10 shows the modeled control and strengthened T beam bridge in ANSYS software. The brackets were connected to T beam bridge at common node points and assumed a complete connection in finite element model.

Figure 10. Control and strengthened T beam bridge simulation detail.

Figure 11 shows the computed result of mid span deflection of three beams. At symmetrical loading, the maximum displacement decreased 19.1%. As the slippage of bolts in the experiments, the computed strengthening effect is better than that in experiments.

Figure 11. Computed deflection.

5. Conclusion
This paper presents a new strengthening method for transversal connection of T beam bridges. The proposed brace system can be manufactured in plant, avoiding interrupting the transportation. Experiments and finite element analysis showed that the proposed brace system can strengthen the connection between the adjacent beams and can solve the problem of “single slab bearing”.

References
[1] Li H J, Zhao S C, Li W H, Yang Y and Zhang J Q 2014 Evaluation methods for transversal connection of precast beam bridges Journal of China & Foreign Highway 34 124–8
[2] Xie Z Y, Wu Y B, Ma H W and Jia W W 2014 Research on transversal connection strengthening of Simply-supported T beams by transversal prestress Highways & Automotive Applications 3 205–7
[3] Guo Z M 2009 Simply-supported T beams strengthening by bonded steel plates Science and Technology of West China 8 14–5
[4] Niu Y W, Zhao Y, Rong S and Huang P M 2014 Effect of diaphragm on integrity of precast T-shaped girder bridge based on inner force analysis Bridge maintenance, safety, management and life extension 1193–7
[5] Li L, John Ma Z 2010 Effect of intermediate diaphragms on decked bulb-tee bridge system for accelerated construction Journal of Bridge Engineering 15 715-722
[6] China Standard 2007 Code for Design of Aluminum Structures China p 17