The Damage Defecting and Reinforcement of a Post-fire Continuous Beam Bridge

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ABSTRACT: With the constantly construction of highways, highway bridges were suffered fire disasters increasingly. After suffering from fires, the load-bearing capacity, usability and operation safety of the bridge will be affected. In this paper, the detection method of concrete and damaged rebar of a post-fire highway flyover was introduced. According to the detection result, a situation analysis of the extent of the damaged performance of the box beam bridge structure is carried out, so as to work out a repair and reinforcement plan.
KEYWORD: Bridge; Highway; Fire disaster; Damage detecting; Reinforcement

1 INTRODUCTION OF THE PROJECT AND FIRE DISASTER

On the 5# pier of one bridge, the outer mold of the continuous beam with the just placed concrete was caught fire. The ignition point was on the beam web, 2 meters away from the beam-end of the 5# pier, 9 meters above earth, with an area of $0.5 \mathrm{m}^2$. The flame was big and expanded quickly. The bamboo plywood and square timber which were in contact with the concrete surface have burned above the door-like scaffold. Then, the fire fighting truck rushed to the scene and all the open fire was put out. The fire has burned the outer molding of bamboo plywood and supporting square timber of a side span and half of a middle span.

2 DAMAGE DETECTING

In order to evaluate the security status of the bridge correctly, on the basis of visual detect, the bridge deck slab was detected, including the core sample detection of concrete strength, the damage detection of the rebar and the characteristic test of the dynamic behavior of whole-bridge structure [1].

2.1 *The strength detection of concrete*

On the basis of the scene investigation, the concrete core which was badly damaged after fire and sample of the exposure base rebar were taken out. The test result shows that the concrete strength of the flange plate area which was not damaged after fire is $59.7 \sim$ 58.1MPa, the average strength is 61.8MPa; Except that the concrete strength of the 19# core sample in the flange plate area which was damaged after fire is 47.9MPa, other concrete strength in this area is $55.5 \sim 63.5$MPa, the average figure of which is 57.0MPa;The concrete strength of the web beam which was damaged after fire is $45.5 \sim 50.9$MPa, the average figure of which is 47.8MPa. The concrete strength of the base area which was damaged after fire is 48.1~58.1MPa，the average figure of which is 53.6MPa. Within the 18# beam web, the concrete strengths of the outer test pieces are basically the same. From the test results of the core sample strength of the concrete, the fire disaster only decreased the strength of part of the concrete at a certain extent.

2.2 *Damage detecting of the rebar*

The yield strength of the rebar in the area which was damaged after fire is $365 \sim 410$MPa, with the ultimate strength of $550 \sim 615$MPa and the elongation of $25 \sim 29\%$, which all meet the requirements from the code [2][3][4]. The average yield strength of the rebar in the area which is not damaged after fire is $370 \sim 400$MPa, with the ultimate strength of $560 \sim 565$MPa and the elongation of $29 \sim 32\%$；Therefore, the tensile strength and elongation of the rebar are in accordance with the criterion.

3 ANALYSIS OF THE DAMAGE OF THE BOX BEAM PERFORMANCE AFTER FIRE DISASTER

By making a detailed statistics of the fire-damaged location and area; evaluating, checking and calculating the whole continuous beam bridge; collecting the fallen broken concrete on the spot; taking the crystal phase analysis of the concrete damaged by the fire and the exposed rebar sample, combined with the test report, the prestress after fire, the temperature filed and thermal stress field of the continuous beam were analyzed. The results are as follows:

(1) After 40-minute fire, the surface temperature of the concrete can reach 818℃, the fire depth of the concrete over 100℃ is 6cm.

(2) The thickness of the protective layer of the concrete is about 6cm, after 40-min fire, the temperature around the rebar is about 166℃; After 30-min fire, the temperature around the rebar is about 118℃ and the mechanical property of the rebar is not damaged; After 40-min fire, the sub-layer temperature of the prestressed steel is 42℃ and the material is not qualitative changed.

(3)After 40-min fire, according to decayed intensity of the spray cooling of the concrete, the accumulating burned conversion depth of the concrete is about 2.23cm; according to the natural decayed intensity of the spray cooling, the accumulating burned conversion length of the concrete is about 0.8cm; according to the decayed elasticity modulus of the concrete, the accumulating burned conversion length of the concrete is about 2.38cm.

Based on the relevant information like the test report of the post-fire bridge, the calculation and analysis report of the temperature filed and thermal stress field, the conclusion that fire disaster has neglected effect on the material property of bridge was drawn, which infers that the load-bearing capacity of the bridge remained the same; the fire disaster leaded to the loss of the concrete section and influenced the integrity of the structure.

The damaged section was taken as the basis of stress analysis, the calculation analysis results of three kinds of damaged sections were offered. The first plan: the one that is in accordance with the calculated model of the original bridge; the result is normal. The second plan: the baseboard side span is 2cm decreased; the baseboard of the burning middle span is 5cm decreased and the middle span of the burning web and flange plate is 2cm decreased. When doing the crack resistance checking computations of the right section during the operation stage, under the load effect of the principal load and subsidiary load (the subsidiary load is the temperature gradient), the 5cm folding area of the middle span has the largest tensile stress, 0.277MPa. The third plan: the baseboard of the side span is 2cm decreased; the baseboard of the burning middle span is 5cm decreased and the middle span of the burning web and flange plate is 2cm decreased. All the concrete grades of the concrete are checked and calculated according to C45. When doing the crack resistance checking computations of the right section during the operation stage, under the load effect of the principal load and subsidiary load (the subsidiary load is the temperature gradient), the 5cm folding area of the middle span has the largest tensile stress, 0.34MPa. Combining the second plan and the third plan, under the load effect of the principal load and subsidiary load (the subsidiary load is the temperature gradient), the concrete in the 10cm burning area of the middle span has tensile stress, which exceeds the design specifications. Other burning areas are normal.

4 REPAIR AND REINFORCEMENT PLAN

In order to ensure that the tensile stress created by the dynamic load in the middle span can be eliminated and the surface of the concrete not be influenced, through comparing and selecting various reinforcing plans, and combining the field test, repair and reinforcement of the structure are completed from the following two aspects [1][5]:

(1)Repair of the damaged concrete: high-performance polymer mortar is used to repair the surface of the concrete. When the damaged depth is above 20mm, high-strength galvanized steel wire meshes are used, plaster them twice so as to mold them; clean the surface of the area which is blackened and shortly burned. Before plastering, deal with the base plane according to related technical standard.

(2)Reinforce the middle of the mid-span: damaged area of the middle span caused by the fire disaster is not the biggest but is relatively deep, and the 5cm area of the middle section of the mid-span has tensile stress under the working condition of the load effect and the thermal stress. Paste 8mm thick steel plate, whose width is 200mm, separation distance is 200mm and average length in longitudinal direction with the bridge is 9.0m, on the top surface of the middle-span baseboard, so as to reinforce the middle of the mid-span. Pasting steel plate can confine the strain of the concrete and control the risk of concrete cracking effectively in the most unfavorable condition.

5 CONCLUSION

This paper focuses on the main points of the field test of the post-fire steel reinforced concrete bridge and how to analyze the test result, evaluate the damage degree and load-bearing capacity of the bridge and

explain it with a living example of a post-fire bridge. The detection, evaluation and reinforcement methods introduced in this paper can provide a reference for the handling of the similar damaged bridges.

REFERENCES

[1] Guobiao TANG. The Inspection, Evaluation and Enforcement of the Damaged Bridge after Fire. *Shanxi Science & Technology of Communications,* 2009 (4):51-53

[2] *CECS 252: 2009, Assessment Standard of Existing Build Structures after Fire* Beijing: China Planning Press

[3] *JTG/TJ21-2011, Specification for Inspection and Evaluation of Load-bearing Capacity of Highway Bridges.* Beijing: China Communications Press

[4] *The Mechanical Property of the Reinforced Concrete Structure after Fire.* Beijing: Science Press, 2003.

[5] Hongxiu DU, et al. The Fire Hazard and the Detection and Evaluation of Damage of Concrete Structures. *Journal of Building Materials*, 1998,1 (2): 175-181