第 I 部門

Compressive Behavior of Steel Cruciform Column Subjected to Fire Damage

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1. Introduction

Bridge is one of the most important social infrastructures. When a fire happens around bridges, the transportation service on the bridge must be stopped until the bridge can continue to be used, which will take a lot of manpower and material resources. Understanding the changes in mechanical behavior of steel bridge members subjected to thermal history due to fire will be helpful to judge the steel bridge needs repair / reinforcement or not.

From the relevant fire reports about bridges in Japan [1], fires frequently happen on the bridge girder end. In this study, a series of experiments were conducted on cruciform columns modeling the bridge girder end structure. A heating experiment simulating a fire on the bridge girder end. Then, a compressive loading experiment was performed on the specimens with / without the thermal history. By heating and loading the specimens, the changes in compressive behavior of steel members in bridges was examined.

2. Heating Experiment

Fig. 1 shows the shape and dimension of specimen used in this study. The structure of steel bridge girder end was modeled by two flange plates, a web plate and two stiffeners, namely, a cruciform column. The material of these plates was SM400A. The thicknesses of flanges, web and stiffeners were 19 mm, 6 mm and 9 mm, respectively. These plates were joined by gas metal arc welding.

Because most of the fires happen on steel bridge girder end also close to the bridge bearing, so, the

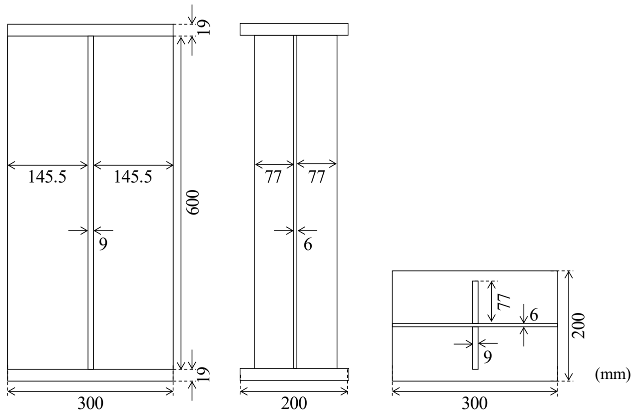

Fig. 1 Shape and dimension of specimen

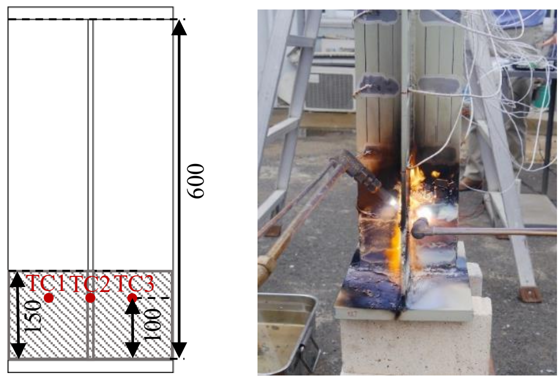

Fig. 2 Heating area and heating experiment

selected heating area was one fourth of the web height from the lower flange as shown in Fig. 2. The thermocouples were attached on each side of web and stiffeners. The target area was heated by a gas burner. The temperature monitored by the thermocouples was intended to be over 900 degrees Celsius. This temperature simulated a large fire [1]. Then, the heated area was cooled down by dipping the lower part of specimen into a tank filled with water. Fig. 3 shows the temperature histories.

For examining the degree of hardening due to the applied thermal history, impact-type hardness (Leeb Hardness) test [2] was performed on the panels of

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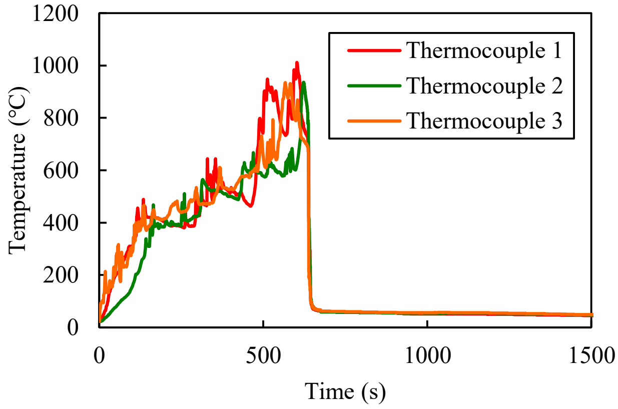

Fig. 3 Temperature histories of heating area

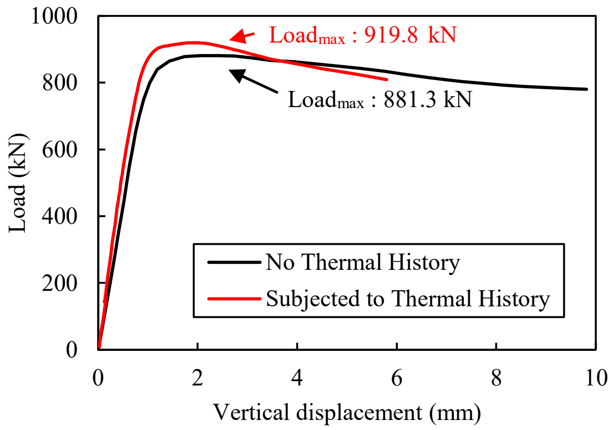

Fig. 4 Load-vertical displacement curve

heated specimens. It could be confirmed that the average value of hardness around the heated area increased by 16.1 % compared to that around the non-heated area.

3. Compressive Loading Experiment

After the heating experiment, a universal testing machine was used for the compressive loading experiment on the non-heated and heated specimens. Two displacement transducers were set between the upper and lower flanges for measuring the vertical displacement. By the loading machine, the monotonic compressive load in vertical direction was slowly applied on the specimen. The maximum load was confirmed and the vertical displacement reached to 5 mm, then the load was released.

Fig. 4 shows the relationship between load and vertical displacement. The stiffnesses of the non-heated and heated specimens were almost the same. The maximum compressive load of the heated specimen increased by 4.4% compared to the non-heated specimen. This might be that the yield stress and ultimate stress of material increased due to the quenching. No difference could be confirmed in the deformation modes of the non-heated and heated specimens.

4. Conclusions

For investigating the influence of thermal history assuming a fire on the compressive behavior of steel bridge girder end, a series of experiments were conducted. The following results were obtained.

(1) The heating of 900 degrees Celsius was applied to the lower part of cruciform column specimen modeling a steel bridge girder end. The heated part was cooled by dipping into a water tank. The hardeness of heated area increased by 16.1 % compared to that of non-heated area.

(2) The monotonic compressive loading experiments were performed on the non-heated and heated specimens. The maximum compressive load of the heated specimen increased by 4.4% compared to the non-heated specimen. This might be that the yield stress and ultimate stress of material increased due to the quenching. No difference could be confirmed in the deformation modes of the non-heated and heated specimens.

(3) The compressive load-carrying capacity of the heated members were not decreased compared to that of intact members when the thermal history induced hardening of material and the deformation by the thermal history was small sufficiently.

References

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