別紙４

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主　論　文　の　要　旨

論文題目

Studies on reusabilities of cold-formed steel square hollow section columns after fire

(冷間成形角形鋼管柱の火害後再利用性能に関する研究)

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論　文　内　容　の　要　旨

In this research, the reusabilities of the cold-formed steel square hollow section column, which is generally used in the steel structures, was investigated. The column is constituted by both the steel welded connections and the cold-formed steel square hollow section. Therefore, to comprehensively study the reuse ability of the steel-structure column after fire, both the welded connections and cold-formed steel square hollow section column is considered, based on a comprehensive experimental investigation of the column after fire. The reusability of the column after fire including the material properties of both welded connections and cold-formed steel square hollow section members after fire and the post-fire mechanical properties of the cold-formed steel square hollow section column. In the view of material properties, a Charpy impact test was employed to study the fracture performance, on the other hand, for mechanical properties, a coupon tensile test, an axially loaded compressive test and a stub-column test were employed. Furthermore, a prediction equation on the residual displacement of the cold-formed steel square hollow section column was proposed, considering the safety of fire damage diagnosis and repair work for reuse. The organization of thesis are summarized as following;

Chapter 1 introduces the research background.

In Chapter 2, the results of a Charpy impact test on steel welded connections at low- and ambient-temperature as well as high-temperature, including the blue brittleness temperature range (100-300) ºC, is reported. Then, the Charpy impact test result of steel welded connections after heating and cooling treatment (water-cooling and furnace-cooling) is also investigated at ambient temperature. Furthermore, the Vickers hardness and microstructure observation were conducted to confirm the microstructural change in steel members after the heating and cooling treatment temperature.

It is confirmed the Charpy impact energies decreased owing to the incomplete quenching that occurred during the water-cooling process from 700 and 800 ºC. However, the Charpy impact energies recovered, owing to the occurrence of martensitic transformation in the specimens quenching from 900 ºC.

In Chapter 3, results of cold-formed steel square hollow sections at low- and ambient-temperature as well as high-temperature, including the blue brittleness temperature range (100-300) ºC, is reported. Then, the Charpy impact test result of the above steel after the heating and cooling treatment (water-cooling, furnace-cooling, and air-cooling) is also investigated at ambient temperature. Furthermore, the Vickers hardness and microstructure observation were conducted to confirm the microstructural changes in the steel members after the heating and cooling treatment. It is also confirmed the Charpy impact energies decreased owing to the incomplete quenching that occurred during the water-cooling process from 700 and 800 ºC and the Charpy impact energies of the specimens quenching form recovered, owing to the occurrence of martensitic transformation. Furthermore, it is confirmed that the fracture Charpy impact energies of the specimens that air-cooled from 200-400 ºC decreased, because of the strain aging.

In Chapter 4, the mechanical properties as well as flexural and local buckling strength of cold-formed steel square hollow sections after heating and cooling treatment (water-cooling and furnace-cooling) were measured at ambient-temperature though three types of tests, which included coupon tensile tests, axially loaded compressive tests, and stub-column tests. Furthermore, the flexural and local buckling strength was examined and calculated based on the existing design equations, and the validity was examined based on the test results. It was confirmed that the yield point and tensile strength of the cold-formed steel square hollow section steel that were subjected to a slowly cooling rate after the low and medium temperature (200-400 °C) increased in comparison with the untreated specimens. However, when the specimens were subjected to heating at high-temperature (500–800 °C), the yield strength and tensile strength started decrease. According to the results of the axially loaded compressive test and stub-column tests, it was confirmed that both the residual flexural and local buckling strengths changed after the heating and cooling process.

In Chapter 5, a prediction equation of the residual displacement of cold-formed steel columns after fire is proposed. Three kinds of models, namely a basic model, a model subjected to axial load and a model considering the local buckling were used to simulate the whole proceeding for the buildings suffer to fire and then cooled by fire extinguishing, and the residual displacement of these three kinds of models was obtained through a FEM analysis. The FEM analysis result of these models was compared to the calculation results of the prediction equation. it is considered that the prediction equations could be used to evaluate the residual displacement of the column after fire without considering the effect of the beam.

Chapter 6 concludes the above test results and proposed that how to reuse a steel building after fire, based on this research.