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Residual stresses in welded flame-cut high strength steel H-sections

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ABSTRACT

The presence of residual stress in members can significantly compromise the stiffness and fatigue life of steel structural components. Researches in this area are well documented for structural members of mild carbon steels. Nevertheless, due to the difference of stress–strain relations and material properties under ambient and high temperatures, the residual stress distribution in a high strength steel member is physically different from those fabricated from mild carbon steel. It is imperative to study the residual stress distribution for structural members fabricated from high strength steel. In this paper, the residual stresses of three welded flame-cut H-section columns with a nominal yield strength of 460 MPa but different cross-section dimensions were investigated. Both sectioning and hole-drilling methods were used in the measurement and the obtained residual stresses were compared between the two methods. The magnitudes and distributions of the measured residual stresses are identical with those of carbon steel, however in relatively smaller residual stress ratios. Finally, based on the measurements, a simplified residual stress distribution for 460 MPa high strength steel members with welded flame-cut H-section is proposed.

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1. Introduction

Welded, hot-rolled, flame-cut or flame-straightened structural components are usually not initially stress free. Residual stresses exist in these structural steel members induced by the non-uniform temperature distributions during the manufacture, fabrication or refinement processes. Owing to the sufficiently high ductility of steel material, residual stresses are often not detrimental to the plastic strength of cross sections, but the presence of residual stress may significantly impair the stiffness of compression members and shorten the fatigue life of steel members under periodical load or dynamic load. In order to investigate the effect of residual stresses, the magnitudes and distributions of residual stresses in welded mild carbon steel sections have been extensively investigated [1,2]. Since the stress–strain curves and high-temperature material properties [3] of high strength steel (HSS, yield strength ≥ 460 MPa) are different from the regular strength steel, it is expected that the residual stresses in HSS sections are different from those in mild carbon steel sections. For this reason, the ultimate bearing capacities under compressive load and fatigue life under cyclic load of HSS members will be different from mild carbon steel members. However, the research on residual stresses in HSS welded sections is very limited. HSS members have been applied in many buildings, spatial structures and bridges [4] because of advantages such as reducing structural dead load and dimensions of members, and saving material and space. For the safe and efficient application of HSS members, especially beam-column members, it is important to evaluate the influence of residual stresses in HSS members.

1.1. Previous residual stress researches in HSS H-sections

In 1992, Rasmussen and Hancock [5] fabricated 6 welded H-section stub columns from nominal 6 mm guillotined plates with a yield strength of 670 MPa to study the plate slenderness limits for high strength steel sections. The residual stresses on each side of the component plates were measured for three H-section columns with various cross-sectional dimensions (flange widths from 96 mm to 136 mm) and the distributions were presented. In 1995, Rasmussen and Hancock [6] measured the residual stresses in the welded H-section (flange breadth 140 mm) fabricated from nominal 8 mm flame-cut plates with a yield strength of 660 MPa. The distribution of residual stresses was presented and taken into account for selecting the appropriate design curve for HSS column. In 1996, Beg and Hladnik [7] fabricated 10 beams from nominal 10 mm and 12 mm plates with a nominal yield strength of 700 MPa to investigate the slenderness limit of the class 3 H-section. The residual stresses in flanges of two different H-sections (flange widths of 270 mm and 220 mm) were measured and presented.

Previous research works on residual stress are mainly focused on the effect on local buckling of steel members, therefore the relatively higher width to thickness ratios of flanges are adopted, which are ranging from 7.5 to 10.8. Due to the capacity of the loading equipment, the thicknesses are limited to the range from 6 mm to 12 mm. Nevertheless,

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