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Fatigue Behaviour of Steel Reinforced Concrete Beams

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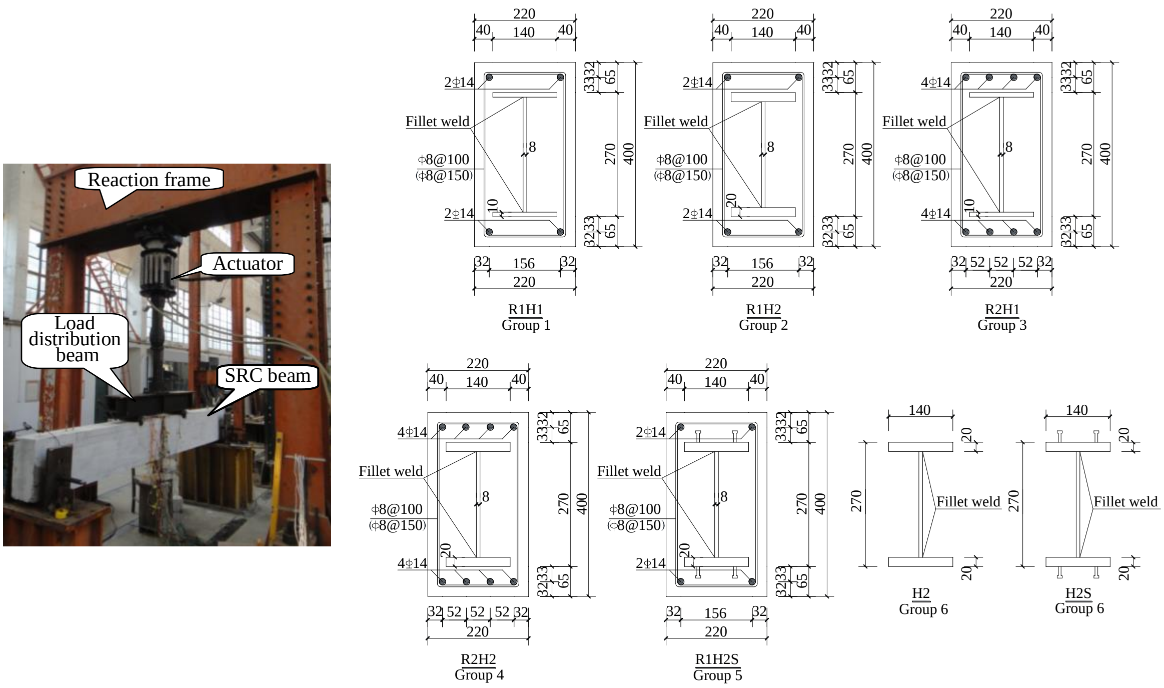
Extended Abstract

Steel reinforced concrete (SRC) structures have been widely applied in civil engineering. High speed railway is quickly developed all over China in recent years. SRC beams are often used in bridges as well as in floors of buildings for high speed railway stations. Fatigue design is essential for a structure subjected to high-cycle fatigue loading. The fatigue behaviour of steel beams, reinforced concrete beams and steel-concrete composite beams has been investigated quite well and relevant fatigue design specifications have come into use (Eurocode 2, 2005; Eurocode 3, 2005). However, fatigue of SRC beams is a new research topic. Tong *et al* (2012; 2013) carried out fatigue tests on SRC beams and their connections in order to meet needs of fatigue design of the engineering project for Shanghai Hongqiao Railway Station. A fundamental study on fatigue behaviour of SRC beams are reported in this paper. Both the experimental and numerical simulation results are presented.

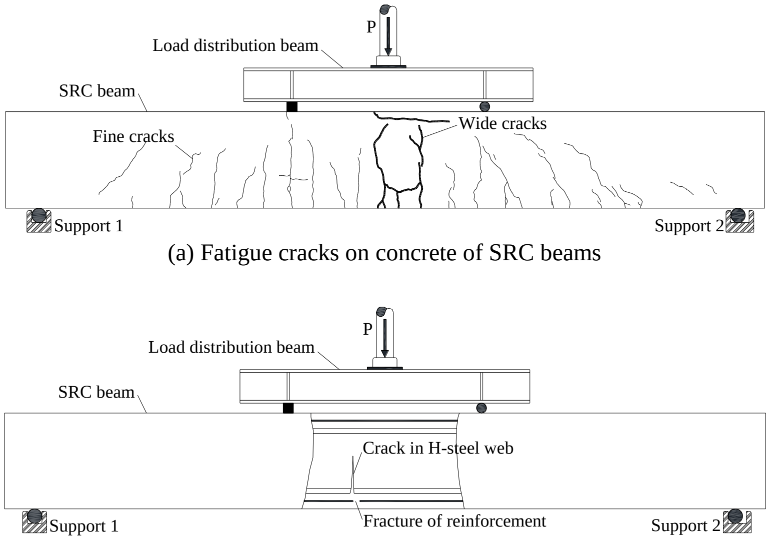
The fatigue test setup is shown in Fig.1. A total of twenty test specimens were organized, including eighteen SRC beams and two pure steel beams. All SRC beams were divided into five groups in such a way that the effects of different parameters could be revealed. The key parameters dealt with the steel ratio of longitudinal reinforcements, the steel ratio of H-steel beams and the situation with or without stud shear connectors.



Cross section of SRC beams and H-steel beams (unit: mm)

Figure 1. Fatigue test setup

Fatigue test results are described. Key issues are discussed on failure modes (Fig.2), failure sequences, crack initiation, crack propagation and stiffness of SRC beam. A comparison of fatigue behaviour between H-steel component inside SRC beams and pure H-steel beam has been made. The key parameters influencing the fatigue strength of SRC beams are identified. The regression analysis of S-N curves is conducted for fatigue assessment of welded H-steel components and reinforcement components inside SRC beams, respectively. ABAQUS software was utilized to perform numerical simulation which considers the crack propagation in the H-steel using fracture mechanics theory and the damage evolution of the reinforcement and concrete. The predicted fatigue life of SRC beams was in good agreement with experimental data.



(a) Fatigue cracks on concrete of SRC beams

(b) Fatigue fracture of reinforcement and H-steel inside SRC beam after removal of concrete

Figure 2. Schematic of typical fatigue failure of SRC beams

The following conclusions can be drawn: (1) For the H-steel with stud shear connectors, cracking started from the weld toe of connection between a stud shear connector and the bottom flange in tension. For the H-steel without stud shear connectors, cracking started from the weld toe of connection between the bottom flange and web in tension. The fatigue strength of SRC beams with stud shear connectors was much lower than for those without stud shear connectors. (2) The H-steel section inside SRC beams had significantly higher fatigue strength (or fatigue life) than the pure H-steel when H-steel in both cases was subjected to the same value of stress range in the tensile flange. (3) Increasing the steel ratio of the H-steel components or the steel ratio of reinforcement components could more or less benefited the increase of fatigue strength of SRC beams. (4) For fatigue design of SRC composite beams, S-N curves are recommended respectively for fatigue assessment of welded H-steel components without stud shear connectors on the flange, and for reinforcement components.

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