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A study on axial compressive behaviors of reinforced concrete filled tubular steel columns

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ABSTRACT

It is clear from former researches on reinforced concrete filled tubular steel (RCFT) columns that RCFT columns have better performance than concrete filled steel tubular (CFT) columns. The enhancements may be mainly due to the improvements in performance of the concrete core because of the confinement pressure imposed by both steel tube and reinforcement. To clarify the effect of confinement on concrete core and propose evaluation equation for axial compressive strength of RCFT columns, numerical analyses of RCFT columns are conducted by matching the numerical results with experimental results via parametric study. According to the results of the analyses, effect of confinement on concrete and effect of stress state on steel tube of RCFT columns are discussed, as a result, a non-conventional method for evaluating the confinement effect which is concerned with load-sharing ratio of RCFT columns is proposed, and the evaluation equation for axial compressive strength of RCFT columns is obtained and validated through the experimental data.

1. Introduction

Concrete filled tubular steel (CFT) structures have gained popularity in supporting heavy loads in high rise buildings, bridges and offshore structures. Various experimental and analytical studies have been performed on CFT structures [1–7]. According to the results of those studies, the in-filled concrete controls the local buckling of steel tube, and the steel tube imposes lateral pressure to the concrete helping it to improve compression, bending moment, and shear capacity and helping to prevent the concrete from spalling. Due to the benefit of composite action of the two materials, the CFT provides excellent seismic event resistant structural properties such as high strength, high ductility and large energy absorption capacity.

In the Hansin–Awaji earthquake of Japan in 1995, the CFT structures were avoided from collapse while most of reinforced concrete (RC) and steel structures were heavily damaged due to shear failure and local buckling. As a reinforcement method, steel plates were wrapped around the RC columns and RC was filled into the steel tubes. These reinforced structures can be considered as the embryonic form of reinforced concrete filled tubular steel (RCFT) structures. Fig. 1 shows the model of CFT and RCFT.

RCFT structures are developed mainly on the purpose of combining the merits of RC and CFT structures. Known research results and application examples until now [8–10] proved that the bearing capacity, toughness, ductility and anti-seismic performance of RCFT structures are increased compared with those of CFT. In other words, because of the existence of reinforcement, the performance of RCFT differed from that of CFT.

Therefore, the main purpose of this investigation is to study the effect of confinement on concrete core and propose evaluation equation for axial compressive strength of RCFT columns. To achieve this goal, based on the results of experimental studies, numerical analyses on RCFT columns are conducted using nonlinear finite element method (FEM) software – ADINA – by matching the numerical results with experimental results via parametric study. According to the results of the analyses, effect of confinement on concrete and effect of stress state on steel tube of RCFT columns are discussed, and the axial compressive strength evaluation equation of RCFT columns are obtained and validated through experimental data.

2. Expressions for bearing capacity of RCFT columns

Based on the results of experimental studies on RCFT columns [8–10], the following assumptions are supposed:

(1) There is no gap between the steel tube and in-filled concrete until the maximum load.
(2) In-filled concrete is in a multiaxial stress state since it is subjected to the confinement pressure from both steel tube and reinforcement, the strength of concrete increases compared with its uniaxial stress state.
(3) Steel tube is in a multiaxial elastic–perfectly-plastic stress state, the effect of shrinkage and creep of concrete and local

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