Elastic-plastic Behavior of Steel and Concrete Composite Columns Using Cruciform Steel

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Summary

The authors have designed to develop two types of steel and concrete (hereinafter referred to as SC, and the other OSC) composite members not used reinforced bars. The details of SC cross section are composed of steel and concrete composite section encased cruciform steel and covered by thin steel tube. On the other hand, OSC sections are composed of only cruciform steel and concrete, and the cross section shape forms an Octagon. In order to study the elastic-plastic behavior of steel and concrete composite columns under earthquake loading, 14 specimens were tested. From the experimental results, SC columns and OSC columns showed good seismic performance up to large deformation. By comparing the elastic-plastic behavior of SC columns with that of OSC columns, when used high strength concrete, SC columns have advantage due to strong confinement effect to the column confined by encased cruciform steel and steel tube.

Keywords: steel and concrete composite column; elastic-plastic behavior; high axial load; high strength concrete; cruciform steel; steel tube.

1. Introduction

Steel reinforced concrete (SRC) structures in high-rise building have been widely used in Japan, and SRC columns show large ductility and large energy dissipation capacity under seismic attacks. However, SRC structures are apt to be avoided to construct for the following two reasons; 1) High cost and complexity of construction, 2) Shortage of successors to artisan due to aged society. In order to resolve the problems of SRC structures, the authors have designed to develop two types of steel and concrete (hereinafter referred to as SC, and the other OSC) composite members not used reinforced bars.

The details of SC cross sections are composed of steel and concrete composite section encased cruciform steel and covered by thin steel tube (available value of width-to-thickness of the steel tube is thought almost 100). On the other hand, OSC sections are composed of only cruciform steel and concrete, and the cross section shape forms an Octagon. As compared with SRC structures, SC and OSC structures have several advantages; 1) to be able to construct simply and to reduce of construction cost due to needlessness of arrangement of reinforcement bars, 2) Using cruciform steel on SC and OSC columns, to enhance strength and ductility of concrete owing to confined effect by cruciform steel.

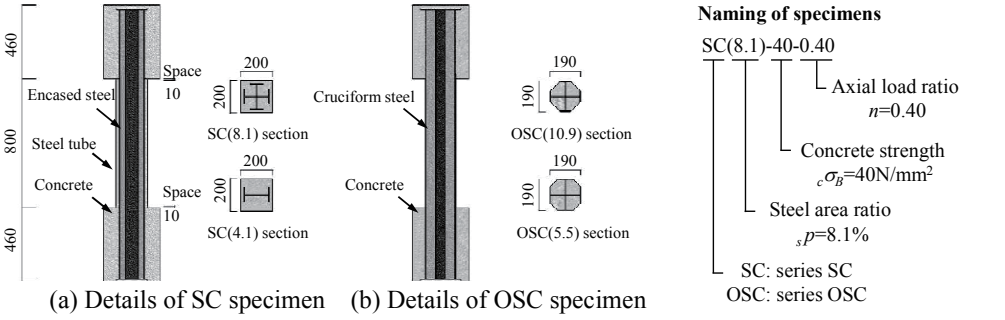
This paper presents experimental results conducted to study structural performance of SC and OSC columns under cyclic horizontal load and constant axial load. The experimental parameters were cruciform steel section ratio, compressive strength of concrete, width-to-thickness of thin steel tube, and axial load ratio. Effects of the above mentioned parameters on the elastic-plastic behavior of these columns being based on the experimental results are discussed.

2. Experimental work

In order to study the elastic-plastic behavior of steel and concrete composite columns under earthquake loading, 14 specimens were tested. All specimens were divided into two series according to the shapes of the cross section.

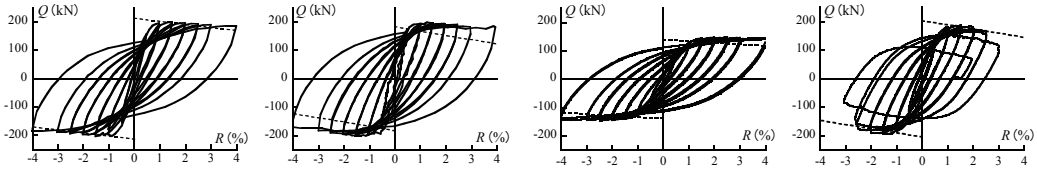
SC cross sections are composed of steel and concrete composite section encased cruciform steel and covered by thin steel tube. Specific cross-section details are shown in Fig. 1(a). The details of OSC sections are composed of only cruciform steel and concrete, and the cross section shape forms an Octagon shown in Fig. 1(b).

The experimental relations of horizontal load Q and the rotation angle of the column R are shown in Fig. 2. All of the specimens exhibited very stable behavior up to large deformation. Abrupt flexural strength degradation was observed in the specimens OSC(10.9)-75-0.50 after rotation angle R=3.0% because of spalling of cover concrete and local buckling of steel. On the contrary, the series SC specimens did show good performance until the end of tests. SC series, when used high strength concrete, has advantage compared with OSC columns due to strong confinement effect to the column confined by encased cruciform steel and steel tube.



(a) Details of SC specimen (b) Details of OSC specimen

Fig. 1: Test specimen



(a) SC(8.1)-40-0.40 (b) SC(8.1)-60-0.60 (c) OSC(10.9)-30-0.30 (d) OSC(10.9)-75-0.50

Fig. 2: Relations of horizontal load and rotation angle of SC and OSC columns

3. Conclusions

Based on the results of this study, the concluding remarks are drawn as follows:

1) Series SC and OSC specimens showed good seismic performance up to large deformation under cyclic horizontal load and constant axial load.

2) Effects of axial load ratio, concrete strength and cruciform steel ratio on structural performance of these columns were very significant. On the basis of these test results, to make the SC and OSC columns ductile enough, use of cruciform steel ratio $_sp$=8.1% is necessary.

3) SC series, when used high strength concrete, has advantage compared with OSC columns due to strong confinement effect to the column confined by encased cruciform steel and steel tube.