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Theoretical study on mechanical behavior of steel confined recycled aggregate concrete

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ABSTRACT

A theoretical study of the mechanical response of recycled aggregate concrete (RAC) confined by steel tubes under axial compression is conducted to examine the sensitivity of the confining pressure on the strength and deformation of RAC. The main parameter in this analysis is the recycled coarse aggregate (RCA) replacement percentage. The axial stress–strain relationship of confined RAC is obtained based on the elastoplasticity and verified by experimental results. It is found that the development of the confining pressure can be divided into three sections: linear increase, nonlinear increase and relatively smooth increase. The mechanical proprieties of confined RAC are dependent on the variation of the confining pressure. The analysis results indicate that the assumption of constant confinement or elastic–plastic confinement is not appropriate for concrete confined by steel tubes and the RCA replacement percentage has a moderate effect on the mechanical response of the confined concrete. Finally, a simple model for the constitutive relationship of RAC under varying pressures and different RCA replacement percentages is proposed.

1. Introduction

Concretes are characterized by high compressive strength but low deformability. Confined concrete is an effective way to improve the properties of plain concrete. Some investigations have shown that due to the presence of lateral confinement, the axial response of confined concrete is enhanced with respect to the deformation and compressive strength. At present, confined concrete members are widely applied because of their excellent properties. For example, the concrete filled steel tube (CFST) members have been already widely used in civil and military engineering. The design and detailed analyses of these elements can be performed in safe and economic ways by a thorough understanding of the confining reinforcement-concrete interactions and the confined concrete behavior.

Since the performance of concrete is significantly affected by the lateral pressure, there have been many researches to investigate the steel tube confined concrete behavior and some constitutive relationships have been suggested for the confined concrete in the CFST. For example, Tang et al. [1] proposed a model for the confined concrete in circular CFST columns, which took into account of the effects of the material and geometrical properties of the column on the strength enhancement and the post-peak behavior. It is found that their model generally overestimates the effect of the lateral confining pressure in circular CFST columns [2]. Based on the confining pressure model proposed by Tang et al. [1], Susantha et al. [3] developed a uniaxial stress–strain relationship for concrete confined by steel tubes with various shapes. Tomii et al. [4] and Hajjar's model [5] was applicable to square CFST, but the strength improvement due to the confinement was neglected. Considering the effects of the confining pressure, Liang and Fragomeni [6] developed a model for the confined concrete in circular CFST. Hu et al. [7] proposed a stress–strain relationship for the core concrete in CFST, which was based on the model of Saenz [8] and Richart et al. [9]. Ellobody et al. [10] presented an axial stress–strain relationship for the confined concrete in circular CFST. Both of these models were divided into three parts and took into account of the confinement effects. Sheikh et al. [11] suggested a constitutive model for concrete under triaxial compression, which was divided into two stages and was applicable to the steel- and FRP-confined concrete elements. Binici [12] presented a theoretical confined concrete model for the mechanical behavior of CFST under different loading conditions. This model was capable of simulating both axial and lateral deformations of confined concrete. However, among the above mentioned models, most of them were based on the following assumptions: (1) during the loading history the confining pressure nearly remains constant or ideal elastic–plastic; (2) the outer steel tube carries negligible axial load or does not bear any axial load. The first assumption may be appropriate when the outer tube is a perfectly plastic material and the outer tube does not carry any axial load. However, the steel is an elastic–plastic material with a strain hardening. So the confining pressure will not remain as a constant. The second assumption may be right for the fiber reinforced plastic (FRP) members because their axial elastic modulus is negligible. In

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