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Study on Recycled-Concrete-Filled Steel Tube and recycled concrete based on damage mechanics

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ABSTRACT

The damage mechanics is for the first time applied to the research on the Recycled-Concrete-Filled Steel Tube (RCFST) and Concrete-Filled Steel Tube (CFST). A new damage model is provided and the recycled concrete and ordinary concrete are idealized to be shunt-wound and series-wound spring in this paper. The energy-absorbing capacity of recycled concrete is worse than that of ordinary concrete, because the initial damage of recycled concrete is more than that of the latter, which is verified by experiments. For RCFST and CFST, the initial damage of recycled concrete and ordinary concrete does not continue to grow, attributing to the tightening-ring force of steel tube. The energy-absorbing capacity of RCFST in the elastic range is much more than that of recycled concrete in the elastic range, and their ratio calculated based on the damage mechanics model in this paper is in agreement with the experimental results. Also, the difference of released strain energy between RCFST and CFST due to the initial damage based on the damage model is close to that based on experimental load–displacement curves of RCFST and CFST, which shows further feasibility of applying damage theory to studying RCFST.

1. Introduction

Concrete-Filled Steel Tube (CFST) consists of steel tube and concrete. CFST not only takes advantage of steel tube and concrete but also makes up for their respective shortcomings. CFST have good properties such as high compressive strength, high yield strength and good seismic resistance [1,4]. According to the existing research [2], the recycled aggregate could reduce strength and durability of the concrete. For this reason, the recycled aggregate has not been used for civil engineering on a large scale. But recycled aggregate used for CFST is better condition due to the contribution of the confining steel tube, which will improve strength and durability of recycled concrete [2,17]. The recycled aggregate can be potentially massively used for civil engineering by means of Recycled-Concrete-Filled Steel Tube (RCFST). The study on RCFST only started recently [2,17,21].

Since 1982, the damage mechanics has been used in the research on concrete [5,6,12]. Currently, the model of the damage mechanics can be divided into two parts: macroscopical phenomenology model and microscopic damage model [12].

The damage of concrete under compression stress can be divided into elastic and plastic damage [5]. The damage degree of concrete (D) can be described by the definition [5,6,7,8,12] as follows:

$$D = 1 - \frac{\tilde{A}}{A} \tag{1}$$

where $\tilde{A}$ is the actual area of the section and A is the initial area of the undamaged section. It is generally believed that concrete is destroyed under tension and shearing [12]. The tension is dominant [12], so the shearing is ignored in this paper.

Li [12] has done some research on constitutive model of concrete and provided stochastic damage constitutional law of concrete under uniaxial compression.

$$\int_0^{\varepsilon_2} \sigma_2(x)\,dx = w_e(\varepsilon_2) - 2w_D(\beta\varepsilon_2) \tag{2}$$

$$w_e(\varepsilon_2) = \frac{1}{2}E_2\varepsilon_2^2 \tag{3}$$

$$w_D(\beta\varepsilon_2) = \alpha\int_0^{\beta\varepsilon 2} E_1 x D(x)\,dx \tag{4}$$

where ε_2 is uniaxial compression strain of concrete, $w_e(\varepsilon_2)$ is strain energy density when uniaxial compression strain of concrete reaches ε_2 and $w_D(\beta\varepsilon_2)$ is the released energy density after transverse small springs break. In addition, E_2 is vertical compressive modulus of

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