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Experimental study on the failure mechanism of recycled concrete

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ABSTRACT

In this study, Young's modulus, strength, and peak strain of recycled concrete under both compressive and tensile loading were experimentally studied to understand its failure mechanism. Due to the different colors of natural aggregates, old hardened mortar, new hardened mortar, and interfacial transition zone (ITZ), the quantity and the distribution of each phase were analyzed by images processing and analysis of cut sections. With the tests, the failure processes and crack situation of the recycled concrete under tensile and compressive loadings were illustrated. It was found that some mechanical properties of recycled concrete are similar to those of mortar, for instance, lower Young's modulus, higher peak strain and more brittleness, due to a larger volume content of both new and old hardened mortar. When compared with old hardened mortar, new hardened mortar has more significant influence on both the strength and the Young's modulus of recycled concrete.

1. Introduction

Recycled concrete is an environmental green construction material, which uses processed or rather crushed waste concrete as coarse aggregates. Compared with conventional concrete, recycled concrete normally has a lower strength, lower elastic modulus, and a higher peak strain [1–4]. Although many investigations have been carried out to study its strength, modulus, durability, etc., the fundamental failure mechanism of recycled concrete is still not clear.

The waste concrete that is used in the production of recycled aggregates is called parent concrete in this paper. Researchers found that the properties of recycled concrete were greatly affected by the properties of the parent concrete used. Padmini [5], Xiao and Du [6] have pre-tested the elastic modulus and strength of the parent concrete before using it to make recycled concrete. Their experiments showed that for a given water-to-cement ratio, the recycled concrete containing parent concrete with better quality had a higher compressive strength and a higher Young's modulus.

From the material point of view, recycled concrete can be regarded as a four-phase composite that includes natural aggregates (NA), old hardened mortar (OM), new hardened mortar (NM) and interfacial transition zone (ITZ). The differences in quality and quantity of each phase will cause the distinctness of the mechanical properties of recycled concrete.

ITZ is regarded as the weakest link in concrete by most researchers [7]. For recycled concrete, there are three types of ITZ: between NA and OM, between NA and NM and between OM and NM. To what degree do ITZs, NM and OM influence the mechanical properties of recycled concrete? Answers to these questions are still not clear. This leads to the objective of this study, which is to study the failure mechanism of recycled concrete by investigating the influences of NM and its parent concrete.

In this study, intensive laboratory tests were conducted to obtain the compressive and tensile behaviors and to analyze influences of each phase on mechanical properties of recycled concrete, such as strength and Young's modulus. Two types of recycled aggregates were produced from two different strength grades of parent concrete.

2. Experimental descriptions

2.1. Design of experiments

In order to control the properties of parent concrete, concrete was first mixed with white cement, black natural aggregates, river sand and water. Two strength grades (i.e., C20 and C30) were prepared by using different mix proportions as listed in Table 1. Specimens were made to conduct both the tensile and compressive strength tests for the parent concrete. In addition, six cube specimens (150×150×150 mm) were prepared for crushing and sieving to be used as recycled coarse aggregates. The recycled coarse aggregates made from C20 and C30 concrete were named as RA20 and RA30, respectively. Because it is necessary to know the mechanical properties of mortars (the OM phase in recycled concrete) for the analysis purposes, mortars with the same mix proportions as concrete without coarse aggregates were also made to conduct compressive and tensile strength tests.

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