Research on Construction of Sponge City Based on Mechanical Analysis of Permeable Recycled Concrete

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Abstract: With the rapid development of the construction process of sponge cities, the amount of waste old concrete is getting higher and higher, which not only occupies a certain amount of placement space, but also causes greater pollution to the environment. Therefore, it is of great significance to use waste concrete reasonably. Five different replacement rates are used in the paper to carry out a systematic experimental research on the mechanical properties of recycled concrete under compression, in which hydraulic servos and material shears are adopted to obtain the stress-deformation curves and failure modes of recycled concrete with different replacement rates.

Introduction

To meet the requirements of sponge city construction, the research on permeable concrete in buildings is becoming increasingly important. Moreover, waste concrete is re-broken and classified according to different particle sizes, replacing the new material crushed stone as the coarse aggregate of the poured concrete. The formation of recycled concrete can not only achieve the secondary application of waste materials, but also have great significance for social environmental protection[1-2].

In the paper, by analyzing the characteristic values of stress-deformation curve, the influence of the replacement rate of recycled aggregate on the strength and deformation of concrete under compression is analyzed, which provides theoretical basis for the engineering application of recycled concrete.

1. Test Overview

1.1 Test Materials

The test mainly focuses on the mechanical properties of recycled concrete with different replacement rates. It is proposed to use 5 different recycled aggregate replacement rates, which are 0, that is, ordinary concrete, 25%, 50%, 75%, and 100% of the cement used. What's more, both the fine aggregate and the water are from the same source, and the recycled concrete required to contain new material and crushed stone is the same as ordinary concrete. Besides, the cement is P.O42.5 and the fine aggregate is natural river sand. In addition, the particle size range of recycled material and new material crushed stone is 4 ~ 16mm, and water is from urban tap water without adding any admixture ingredients. The mix of recycled concrete with different substitution rates is shown in Table 1[3-4].

Table 1. Proportion of recycled concrete with different substitution rates

kg / m3

Replacement rate of recycled materials /%	Water	Cement	Sand	Coarse Aggregate	
				Gravel	Recycled material
0	175	461	512	1358	0
25	175	461	512	883	387
50	175	461	512	567	567
75	175	461	512	387	883
100	175	461	512	0	1358

The cement concrete and fine aggregate are poured into the mixer in turn. After mixing well, the weighed new material crushed stone and recycled aggregate are poured. Then stir it again until it is mixed well. Moreover, water is slowly added to the mix, then stir it until it is fully contacted, and pour it into the mold. After 1 day, it is de- molded and placed in a standard curing room in which the temperature is (200 ± 30) ℃, and the humidity is above 95% for 28 days, and then the test will be started.

1.2 Loading Device and Method

The test is completed with a hydraulic servo device, and the loading rate under pressure is the same. Moreover, the displacement control loading method is adopted, and the loading rate is 1mm / min. What's more, the load and deformation collection in the test are automatically collected by computer through the load displacement sensor equipped by loading device, and the test sample is pre- loaded three times in the early stage of loading to eliminate the gap between the device and the test sample, and then the test is officially collected[5-6].

2 Test Results Analysis

2.1 Specimen Failure Mode

The research on the compressive form of recycled concrete with different substitution rates is very important, which belongs to the most intuitive form of expression. According to the test loading device and loading scheme, the failure modes of recycled concrete with different replacement rates under compression are shown in Figure 1.

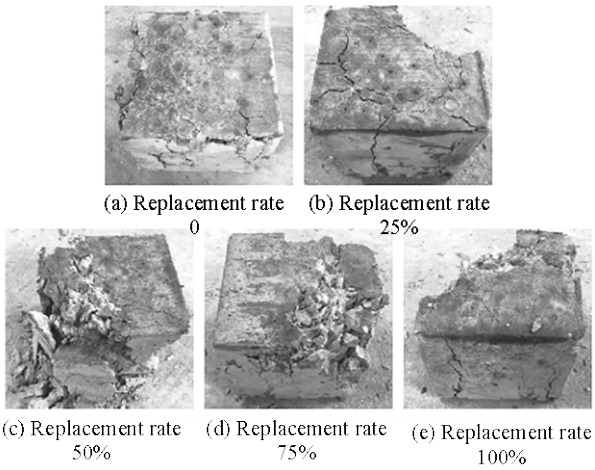

Figure 1. Compression of recycled concrete

Figure 1 shows the failure mode of the recycled concrete under pressure. The failure mode of the recycled concrete is basically the same as that of ordinary concrete. Both are due to Poisson's ratio, tensile strain is generated on the unloaded surface, and more cracks are formed on the unloaded surface in the end time. However, the difference is that the fine cracks formed on the non-loaded surface of recycled concrete are significantly less than that of ordinary concrete. Meanwhile, the test sample is prone to the test phenomenon that recycled aggregate falls off[7-8].

2.2 Stress-deformation Curve

The compressive stress-strain curve of recycled concrete with different replacement rates obtained by applying concrete hydraulic servo is shown in Figure 2.

Figure 2. Stress-strain curve analysis of recycled concrete with different substitution rates

According to the analysis of the stress-strain curve of recycled concrete with different replacement rates in Figure 2, the stress-strain curve development trend of recycled concrete is basically the same as that of ordinary concrete, which consists of three phases, namely the linear elastic phase, the elasto-plastic phase and the descending phase. However, there are also differences. The compressive strength of recycled concrete is significantly lower than that of ordinary concrete, and the linear elastic modulus of ordinary concrete is higher than that of recycled concrete. Meanwhile, the descending section of ordinary concrete is above the recycled concrete, indicating that the recycled concrete is more brittle than ordinary concrete. Therefore, preliminary analysis indicates that the higher the content of recycled material is, the stronger the brittleness of recycled concrete will be.

2.3 Stress Effect Analysis

According to the compression deformation curve of recycled concrete with different substitution rates in Figure 2, as shown in Table 2, the peak stress point is extracted to analyze the impact of different substitution rates on the compression of recycled concrete for the point.

Table 2. Analysis of the influence of different substitution rates on the compression of recycled concrete

Replacement rate of recycled materials /%	Under pressure /MPa
0	28.64
25	27.55
50	26.65
75	25.13
100	24.45

According to Table 2, the higher the replacement rate of recycled concrete is, the lower the peak pressure stress will be. What’s more, affected by the replacement rate, the change trend of the compressive stress has a linear relationship, which is mainly decided by the physical characteristics of the recycled aggregate used in recycled concrete. Meanwhile, since the surface of the recycled aggregate itself has many micro-damaged parts, during compression process, the specimen has a certain reduction effect on its stress, resulting in a reduction in its compression stress. The main reason is that the failure mechanism under compressive loading is different. When the specimen reaches the peak pressure stress point, the reaction force is mainly supported by three parts, namely the chemical adhesion force of the concrete without failure, Van der Waals force, and the mechanical occlusion force of the failure part. Moreover, due to the damage, unlike ordinary concrete in which only cement colloid damage exists, there is some aggregate damage in recycled concrete. Recycled concrete has some

aggregate damage, where mechanical occlusion force between aggregate and aggregate is stronger than that between aggregate and cement colloid.

Conclusion

Experimental research is carried on the basic mechanical properties of 5 kinds of recycled concrete with different replacement rates from compression in the paper. Then based on the comparative analysis of failure morphology and stress-deformation curve, the relevant data based on the mechanical experiments of recycled concrete are obtained, which has made due contributions to the goals of the sponge city proposed for future construction.

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