Research on Mechanical Properties of Waste Aggregate Concrete Beams in Laboratory

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ABSTRACT. With the proposal of the "dual carbon" goal, various industries have launched research on energy conservation and carbon reduction. Realizing the resource utilization of construction waste can contribute to energy conservation and carbon reduction in the construction industry. This article takes the construction waste from university laboratories as the research object, and adds it as recycled aggregate to the new concrete test. The workability, cube compressive strength, and flexural performance of concrete simple supported beams are measured for the waste concrete at each dosage. Exploring a reasonable amount of waste aggregate through experiments can provide reference for other university laboratories and also contribute to the waste recycling in China's construction industry.

Keywords: Garbage aggregate; Resource utilization; Concrete beams; mechanical property

1 INTRODUCTION

In recent decades, with the rapid development of the economy and the continuous acceleration of urbanization, urban public and civil buildings, as well as municipal engineering, have undergone a large number of updates and renovations, and construction waste is also increasing. Especially in recent years, the country has vigorously promoted the construction of new rural areas, and a large number of old buildings have been demolished, making the impact of construction waste on the environment increasingly severe. [8]According to statistics, China generates over 300 million tons of new construction waste every year, accounting for 30% -40% of the total urban waste. However, with such a large amount of waste, its recycling rate is less than 5%. [7,9]Most of the untreated garbage is transported to the suburbs for burial or outdoor stacking, damaging the ecological environment, wasting land resources, and causing serious impacts. In other countries such as Japan, the United States, and the European Union, the resource utilization rate of construction waste has reached over 80%, or even close to 100%.[2] This data reminds us that we still have a long way to catch up in the process of recycling construction waste.

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2 PROBLEMS IN THE TRADITIONAL TREATMENT OF CONSTRUCTION WASTE IN THE LABORATORY

In recent years, the country has increasingly attached importance to the cultivation of applied talents. In order to cultivate high-quality and competitive applied talents, many schools are increasingly emphasizing the cultivation of students' experimental and practical abilities. Therefore, the construction of laboratories is becoming increasingly important and the number is also increasing. As a result, a large amount of laboratory waste has also been generated, and the resource utilization of laboratory waste has become a new trend in laboratory management. [1] The construction waste in the laboratory mainly targets abandoned cement, mortar, and concrete test blocks, as well as various damaged structural components. These construction waste, as a part of the laboratory waste, account for a large proportion and are difficult to handle. The main problems are as follows:

(1) Occupying land resources and reducing soil quality. Abandoned various types of test blocks and components, after being transported to the stacking site, directly stacking will occupy a large amount of ground space and waste land resources; Burying will directly affect soil quality and create unsafe hazards.

(2) Causing environmental pollution. During the transportation of laboratory waste, a large amount of dust is generated, which reduces air quality. During the incineration process, a large amount of harmful gases are also generated, causing serious air pollution; The buried garbage may decompose into harmful substances, directly polluting soil and groundwater, causing irreversible damage to the environment.

(3) Affects the image of the city. The establishment of a city's image has always been a top priority in urban development. Like ordinary construction waste, laboratory construction waste, whether transported or stacked, can damage the city's appearance and image, thereby affecting the long-term development of the city.

(4) Waste of manpower and resources. During the treatment of construction waste in the laboratory, it is necessary to find a dedicated vehicle from outside the school to handle it, which is a heavy workload and expensive. In the face of high laboratory waste treatment costs, the best choice is undoubtedly to recycle and utilize laboratory construction waste as a resource.

The resource utilization of laboratory construction waste is currently a major research direction for laboratory construction waste treatment. Firstly, it solves the problems of resource waste, environmental pollution, image destruction, and high processing costs that exist in traditional processing methods; Secondly, by participating in experiments, students can strengthen their environmental awareness, enhance their understanding and understanding of the recycling of construction waste, and gradually attract social attention and attention; In addition, the resource utilization of construction waste in the laboratory provides effective experimental data and theoretical support for future construction waste recycling, and also contributes to the promotion of construction waste recycling.

3 MECHANICAL PERFORMANCE TESTING OF LABORATORY WASTE CONCRETE

At present, the main resource utilization method for laboratory construction waste is to replace some aggregates with it and reuse it for the production of various test blocks and components. Firstly, the discarded test blocks and components are crushed with a crusher to a particle size similar to the aggregate. Then, during the process of mixing concrete or mortar, a portion of the aggregate is replaced with screened waste to achieve recycling of the waste.[5]

3.1 Performance testing of freshly mixed concrete

The slump method is selected for testing the workability of concrete, and its flowability is evaluated by measuring the magnitude of slump, supplemented by observing its cohesion and water retention. The workability of concrete at various dosages obtained from the experiment is shown in Table 1. Through experiments, it can be seen that compared to concrete without adding garbage aggregate under the same mix ratio, when the amount of garbage aggregate added in the laboratory is within 30%, it has little impact on the working performance of the fresh concrete mixture, and the slump, cohesiveness, and water retention can basically meet the requirements. When the amount of waste aggregate in the laboratory reaches over 30%, the slump remains basically unchanged, that is, the flowability of the newly mixed concrete mixture remains basically unchanged, but the cohesiveness and water retention become worse. The mixture will have slight segregation and bleeding, especially when the amount of waste aggregate in the laboratory reaches 50%, the segregation phenomenon is more obvious, which will seriously affect construction.

Table 1. Working Performance of Concrete with different mixing amount

Group	Mixing amount	Slumps (mm)	Cohesiveness	Water retention
1	0%	15	good	good
2	10%	13	good	good
3	20%	13	good	good
4	30%	13	slight segregate	slight bleeding water
5	40%	15	slight segregate	slight bleeding water
6	50%	13	segregate	slight bleeding water

3.2 Testing the compressive strength of concrete cubes

Table 2. Cube compressive strength of concrete with different mixing amount

Group	Mixing Amount	Cube compressive strength of concrete	
		7d	28d
1	0%	29.87	37.78
2	10%	22.57	33.45

3	20%	21.99	35.10
4	30%	23.96	37.74
5	40%	21.16	32.46
6	50%	18.81	31.24

In this experiment, a cube with a side length of 150mm was selected for concrete compressive strength testing, and its strength after 7 and 28 days of curing was measured. The cube compressive strength of concrete obtained from the experiment at each dosage is shown in Table 2. Through experiments and Figure 1, it can be seen that compared to concrete without laboratory waste aggregate under the same mix ratio, the strength of concrete after adding waste aggregate has decreased, especially in the early stage. The maximum decrease in strength within 7 days was 37% (with a 50% dosage), while the minimum decrease was also 20% (with a 30% dosage). Although the intensity decreased slightly after 28 days, the decrease was not significant, ranging from 1% to 18%. From this, it can be seen that within a certain dosage range, the addition of laboratory waste aggregate concrete has a more significant impact on the early strength of the concrete, and a smaller impact on the later strength.

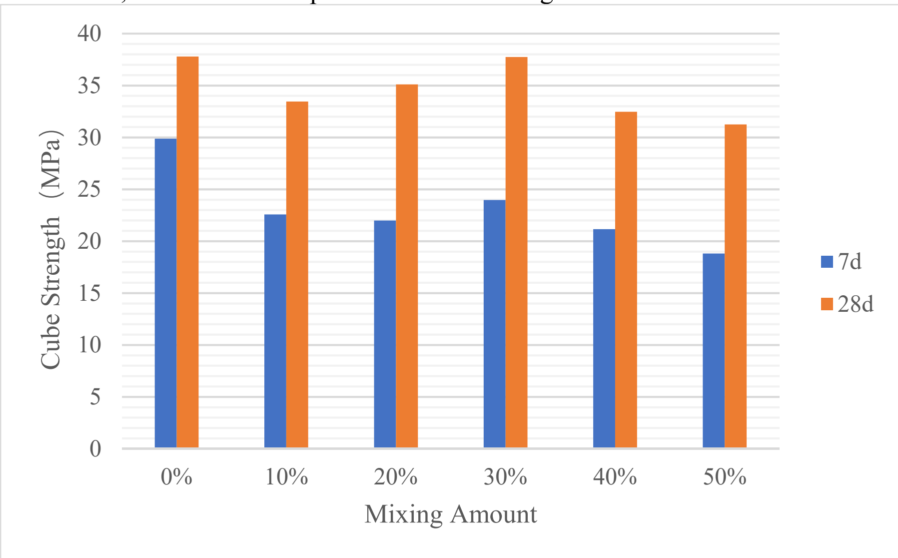

Fig. 1. Cube compressive strength of concrete with different mixing amount

3.3 Performance Testing of Concrete Simply Supported Beams

The reinforced concrete test beam used in the experiment is a rectangular cross-section beam, with specific dimensions as follows: the concrete strength grade is C30, the longitudinal tensile reinforcement and stirrup are both HRB335, the lower longitudinal reinforcement is 2Φ14, the upper longitudinal reinforcement is 2Φ6, and the stirrup is selected Φ8@50 (2) The thickness of the longitudinal reinforced concrete protective layer is 15mm. [4,6] As shown in Figure 2,the experiment adopts a three-point loading method for loading, and the distance between the two loading points of the distribution beam is 500mm.[3,10]

Fig. 2. Bending Performance Test of Concrete Simply Supported Beams

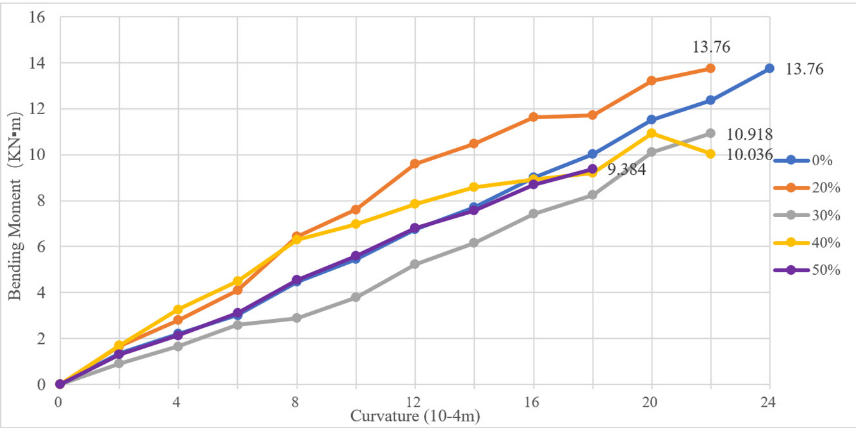

Fig. 3. Bending Moment (M) and Curvature (φ) Relationship curve

After data compilation, the bending moment and curvature curves of the beam under various admixtures are shown in Figure 3, and are determined by M- φ The curve shows that after adding laboratory waste aggregate concrete, the overall M- φ The influence of the curve is not significant, and there are no obvious turning points or significant fluctuations in the curves at each dosage, indicating that the addition of laboratory waste aggregate has no significant impact on the ductility and brittleness of the beam.

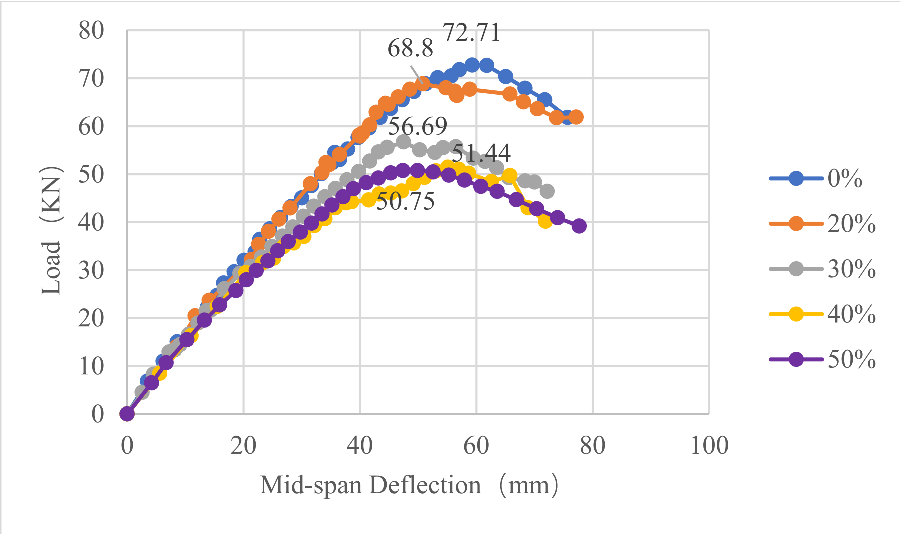

Fig. 4. Relationship Curve between Load (P) and Deflection (f)

After data sorting, the load and deflection curves of the beam under each dosage are shown in Figure 4. From the P-f curve, it can be seen that the load and deflection initial stage are basically linear under each dosage. The ultimate load of ordinary concrete beams can reach 72.71 KN, and the ultimate load decreases after adding laboratory waste aggregate, especially after the dosage exceeds 30%, the impact on the ultimate load is more obvious. When the content of garbage aggregate is 50%, the ultimate strength of ordinary concrete beams is reduced by 30%.

4 CONCLUSION

Through the above experimental analysis, it can be concluded that:

(1) When the content of waste aggregate concrete in the laboratory is within 30%, it will not have a significant impact on the workability, 28 day strength, and deflection, ductility, and brittleness of the concrete beam, but only on the early (7 day) strength.

(2) After the amount of garbage aggregate concrete added in the laboratory exceeds 30%, the workability of the fresh concrete mixture is significantly affected, mainly reflected in the deterioration of cohesion and water retention, and the phenomenon of segregation and bleeding. At the same time, it will also reduce the ultimate load of concrete beams and affect their bearing capacity.

(3) For the laboratory, garbage aggregate concrete with a content of less than 30% can be used for relevant tests, which can achieve the test purpose. For practical engineering, it is not suitable to use garbage aggregate concrete for concrete projects with high early strength requirements.

The recycling and utilization of construction waste has a great impact on urban construction, social development, and environmental protection. Realizing the resource utilization of construction waste is the most effective way to solve a series of problems such as resource scarcity, environmental pollution, and land scarcity, and is also an important way to achieve ecological development. Through the study of various mechanical properties of laboratory waste aggregate concrete beams, it has been confirmed that university laboratories can solve some of the construction waste problems through the resource utilization of laboratory construction waste. At the same time, it also provides experience for the research and use of waste aggregate concrete in engineering, and makes a contribution to achieving the national resource utilization of construction waste in the future.

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