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Experimental study on compressive strength factors of ecological concrete

Wei Chen^{1, a}, Siguang Lu^{1, b}, Zhanyuan Zhu^{1, c*}, Sijia Mu^{1, d} and Zonghang He^{1, e}

¹College of Civil Engineering, Sichuan Agricultural University, Dujiangyan, Sichuan, 611830, China

^aEmail: chenwei@sicau.edu.cn,

^bEmail: siguangsiguang@qq.com,

^cEmail: 496408292@qq.com,

^dEmail: 2116958140@qq.com,

^eEmail: 1034091937@qq.com,

Abstract: In order to deeply research the influencing factors of the compressive strength of ecological concrete, using the orthogonal experiment, it studies on water-cement ratio, cement content and aggregate particle size as influence factors. The results showed, with the increase of water-cement ratio, the strength of ecological concrete decreased. With the increase of cement content, the strength of ecological concrete increases. Under the premise of ensuring strength, the use of a single grade of aggregate is more beneficial to the overall performance of ecological concrete.

1. Introduction

After 40 years of urbanization and development in China after its new reform process, China has achieved remarkable results in the world. However, there are still certain problems in the construction of infrastructure due to unreasonable planning modes such as excessive urban development and construction, in terms of river drainage, the drainage mode of the traditional water conservancy project only considers how to make the flood discharge faster and smoother. The original ecological river channel was cut and straightened and the use of bare and hard masonry, dry masonry and other cement river revetment, so that the river's ability to store water and seepage is weakened, blocking the water cycle of rivers and ecological land. Moreover, in terms of appearance, this kind of dense and hard material slope protection gives people a feeling of cool and hard, which is extremely inconsistent with the surrounding natural landscape, and is not in line with the national proposal in recent years. "Green mountains and clear water are equal to mountains of gold and silver" The correct ecological governance concept. Therefore, the development of sponge city is an inevitable trend of the new era. At the same time, the study of ecological concrete materials is also a necessary means to develop sponge cities^[1-8].

Eco-concrete has a continuous pore structure, good ventilation and water permeability, and continuous pores can provide nutrient space necessary for plant roots or aquatic growth, reduce environmental load, and is a new type of environmentally friendly material. This paper will study the compressive strength of ecological concrete, and study its influencing factors, and provide theoretical



basis for engineering practice.

2. Test materials and methods

2.1 Test raw material

The test cement is Lafarge Du jiangyan P•O42.5R cement, initial setting time is 200min, final setting time is 260min, 3d intensity is 27MPa, and 28d intensity is 51MPa. The crushed stone is a single-grained particle crushed stone of 10-15 mm and 15-20 mm in Dujiangyan, Sichuan, with a compact bulk density of 1565 kg/m³ and 1545 kg/m³. Mixing and curing water for Dujiangyan municipal water supply.

2.2 Experiment method

Since ecological concrete belongs to a new type of concrete, there are no formal test procedures and test methods in China. Here, the experimental design of the "Pore Test Method for Porous Concrete Performance" proposed by the Japan Concrete Association in 1998 and JGJ55-2011 "General Concrete Mix Design Specification" are used^[9]. The preparation of concrete specimens is carried out in accordance with GB/T50080-2016 "Standards for Testing Performance of Common Concrete Mixtures". The test method of concrete compressive strength is in accordance with GB/50081-2016 "Standards for Testing Methods of Mechanical Properties of Ordinary Concrete". The volumetric method was used to determine the reference mix ratio. Each aggregate particle size was molded into 5 sets of 150×150×150mm³ specimens under various water-cement ratios and cement dosages. The standard curing method was adopted, and the test specimens and fitting ratios are shown in the table. 1.

Table. 1. 42.5 cement gravel concrete mix ratio and mixture performance

Matching number	Mix ratio				
	Aggregate grading (mm)	Aggregate dosage (kg/m ³)	Cement consumption (kg/m ³)	Water cement ratio	Water consumption (kg/m ³)
S1	10~15	1565.00	150.00	0.30	45.00
S2				0.35	52.50
S3				0.40	60.00
S4				0.45	67.50
S5				0.50	75.00
S6			200.00	0.30	60.00
S7				0.35	70.00
S8				0.40	80.00
S9				0.45	90.00
S10				0.50	100.00
S11	15~20	1545.00	150.00	0.30	45.00
S12				0.35	52.50
S13				0.40	60.00
S14				0.45	67.50
S15				0.50	75.00

S16		0.30	60.00
S17		0.35	70.00
S18	200.00	0.40	80.00
S19		0.45	90.00
S20		0.50	100.00

3. Test results and analysis

3.1 Test results

After 28 days of standard curing of the test piece, the thickness of the slurry, the Subsidence area, the compressive strength and the porosity were measured. The test results are shown in Table 2.

3.2 Influence of water cement ratio on concrete strength

According to the experimental data of Table 2, the 28d compressive strength relationship diagram of cement mixed gravel concrete with the reference of 42.5 is shown in Fig. 1.

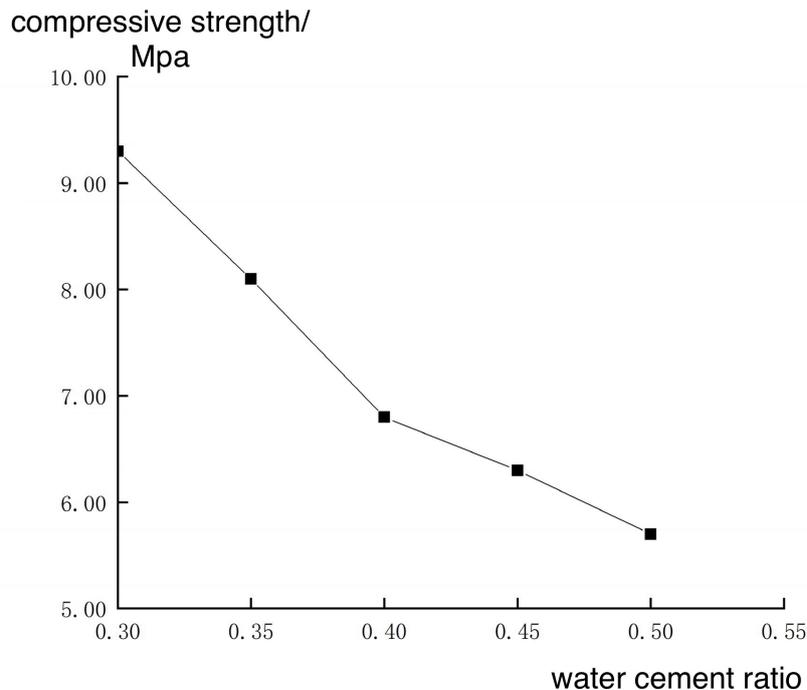


Fig.1 Relationship between compressive strength and water-cement ratio of 42.5 cement gravel concrete specimens (Dm=10~15, C=200)

It can be seen from Fig. 1 that the general trend is that as the water-cement ratio increases, the strength of the ecological concrete decreases. As the amount of cement increases, the strength of the ecological concrete increases, conforming to the general rule of ordinary concrete. Because the ecological concrete has no fine aggregate, its performance is far less than ordinary concrete. The problem of difficulty in mixing is more prominent in the case of low water ash; and the high water-cement ratio is not conducive to the development of the strength of ecological concrete. Therefore, from the perspective of ensuring strength and ease of construction, it is recommended to adopt a water-cement ratio of 0.35.

3.3 Effect of Aggregate Size on Concrete Strength

From the strength data of Table 2 and the relationship between the aggregate size and the concrete strength given in Figure 2, it can be seen that with the certain water-cement ratio, the strength of the ecological concrete increases with the increase of the amount of cementitious material; In the same amount, the smaller the aggregate particle size is, the denser the bulk density is, the denser the molded concrete specimen is, the more fully encapsulated cement material on the aggregate surface is, and the more stable the aggregate structure is, so the intensity of the ecological concrete will increase. In addition, if the aggregate gradation of the aggregate is more reasonable, the support contact surface between the aggregates increases, and the formed aggregate structure becomes more stable, which is beneficial to improve the strength of the permeable concrete, but it will also bring certain permeable properties. Negative Effects. Therefore, if the strength can be guaranteed, a single grade of aggregate should be used whenever possible. Figure 3 shows the appearance of concrete prepared with two kinds of crushed stone. As can be seen from the figure, the concrete made of crushed stone with smaller particle size is denser.

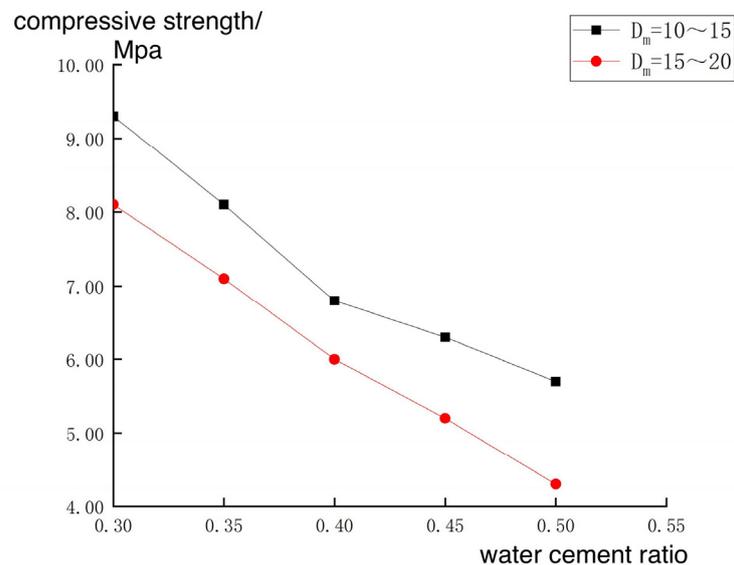


Fig. 2 Relationship between aggregate size and compressive strength under 200 cement dosage

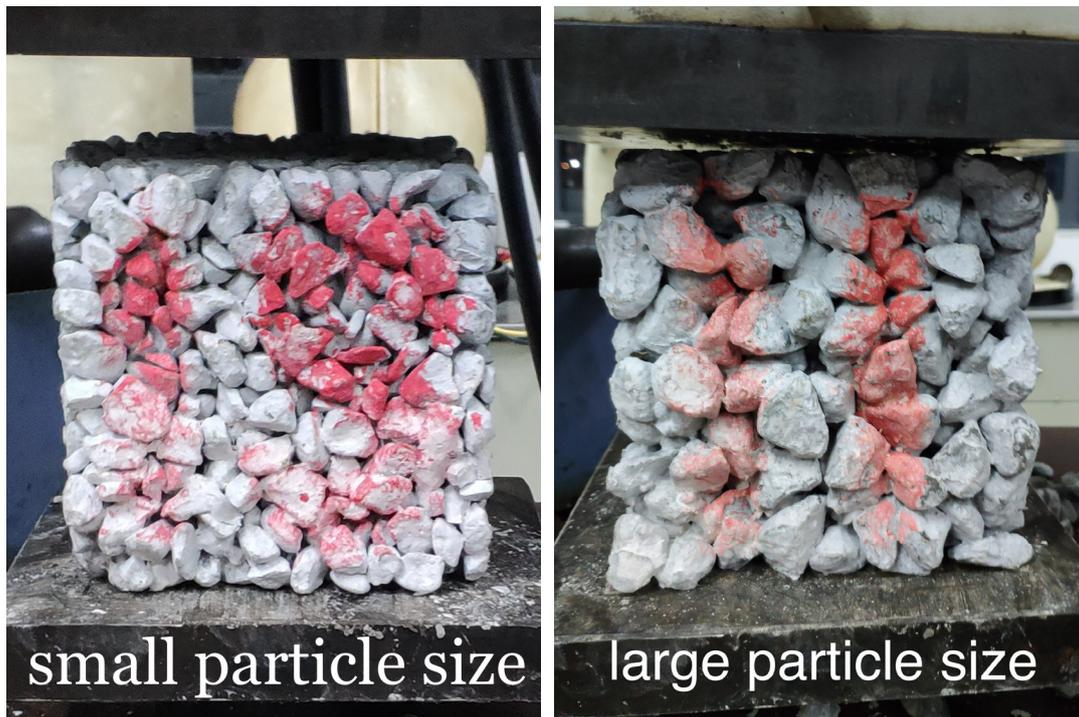


Figure 3 Appearance of two kinds of gravel-prepared concrete

3.4 Influence of construction process control on quality of ecological concrete and precautions

Due to the small slump of the ecological concrete, it is relatively dry and hard, and the thickness required for the design is laid, and the artificial flattening can be achieved. The loosening factor requirement is 1.1. When paving, attention should be paid to the position of the comparative details such as the corners. Material missing should be found in time to fill and artificial compaction to avoid secondary paving. In order to avoid the influence of the bottom sediment on the water permeability and the unevenness of the cement slurry in the upper and lower layers of the carcass, it is not possible to use a high-frequency vibrator or strong vibrating or compacting. Before using the low-frequency vibrating compactor, manually scrape flat with a ruler and find the flatness; when the low frequency flat vibrator vibrates, it is not advisable to vibrate for too long in the same place. When the time is too long, the cemented slurry will sink down, sealing the bottom, increasing the compactness, reducing the porosity of the permeable concrete, not permeable to water, affecting the water permeable effect; in the process of compaction in order to ensure the proper drainage gradient according to the design requirements. After pouring, when the concrete strength reaches 5 MPa or more, the cutting is performed, and the cutting depth is preferably $1/2H$ to $1/3H$, and the control is not less than 30 mm. The caulking material is made of oak plastic material. After the surface layer is dry, the masking agent can be applied. After the completion of the construction, the plastic film is covered for curing, and the curing time is not less than 14d. The permeability of the permeable concrete is large, and it is easy to quickly lose water, which affects the early strength of the concrete, so it must be covered and cured. If the outdoor average daily temperature is lower than $5\text{ }^{\circ}\text{C}$ for 5 consecutive days, the permeable concrete road surface shall not be constructed; when the outdoor maximum temperature reaches $32\text{ }^{\circ}\text{C}$, unfavorable construction.

4. In conclusion

(1) Water-cement ratio and aggregate particle size are the most critical factors affecting the strength of permeable concrete. As the water-cement ratio increases, the strength of the ecological concrete decreases. As the amount of cement increases, the strength of the ecological concrete increases. Under

the premise that the strength can be guaranteed, a single grade of aggregate should be used as much as possible. The overall performance of the ecological concrete is better.

(2) The requirements of ecological concrete raw materials and construction process requirements and climatic conditions are also factors directly affecting the quality of permeable concrete. To ensure the construction quality, the construction process requirements should be strictly observed.

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