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Study on Strength Change of Recycled Concrete with Age in a Natural Jungle Covered Buildings

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Abstract:

In order to lay a solid experimental and theoretical foundation for the application of recycled concrete and structural engineering, it is necessary to strengthen the research on the performance of recycled concrete. Forest evaporation and turbulent exchange intensity affect the characteristics of soil and stone. The accelerated demolition and construction speed of various projects leads to the accumulation of waste concrete. In this paper, the mix design and basic mechanical properties of recycled concrete are studied. Based on the mix proportion design method of ordinary concrete, this paper applies the calculation formula of additional water consumption and replacement regression coefficient αa, αB, the mix proportion of recycled concrete is designed. Based on the mix proportion of recycled concrete, the mix proportion design of water reducer recycled concrete, fly ash recycled concrete, silica fume recycled concrete and composite recycled concrete is discussed by adding admixtures and admixtures, which provides a theoretical basis for the high performance of recycled concrete. Based on the compressive strength test of 288 standard cubes, this paper discusses the failure mode and process of recycled concrete. The compressive properties of high performance recycled concrete and ordinary concrete are compared, and the influence of admixtures and admixtures on the compressive strength of recycled concrete is discussed. In this paper, the splitting tensile strength test, flexural strength test and elastic modulus test of recycled concrete are also carried out. It is found that the above three properties of recycled concrete are decreased..

***Keywords**: Recycled Concrete, Structural Engineering, Natural Jungle Covered Buildings, Mechanical Properties.*

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I. INTRODUCTION

The performance of recycled concrete is closely related to the performance of recycled aggregate and the microstructure of recycled concrete [1-2]. The quality variability of recycled concrete is large because of the internal transverse cracks, the porosity and poor particle gradation of recycled concrete aggregate, the impurities mixed in recycled concrete aggregate, sulfate and chloride, and the weak bonding area between the old mortar and recycled aggregate. Compared with the natural aggregate concrete with the same mix proportion, the strength, workability and durability of recycled concrete are inferior to those of natural aggregate concrete. The surface treatment of recycled aggregate and the addition of superplasticizer and ground fly ash in recycled concrete system can effectively improve the performance of recycled concrete [3]. The research shows that adding superplasticizer and ground fly ash into recycled concrete can significantly improve the fluidity of fresh recycled concrete [4-6]. The reason is that the "ball effect" and "micro aggregate effect" of fly ash can help to improve the fluidity of concrete.

II. DESIGN OF RECYCLED CONCRETE MIX RATIO

2.1 Mix proportion of recycled concrete

A considerable part of cement mortar is attached to the surface of recycled aggregate, and its porosity is large, which leads to the water absorption of recycled aggregate far greater than that of natural aggregate. Therefore, in order to maintain the workability, fluidity and workability of recycled concrete mixture, it is necessary to increase the adsorption water of recycled aggregate more than natural aggregate on the basis of the design water consumption (W) of ordinary concrete. This part of absorbed water is called the additional water consumption (△ w) of recycled concrete. Its function is to keep the slump of recycled concrete consistent with that of ordinary concrete under the condition of constant design strength.

According to the new concept of additional water consumption for mix proportion design of recycled concrete, this paper puts forward the calculation principle of water consumption for mix proportion design of recycled concrete, namely "water consumption for recycled concrete, water consumption for ordinary concrete, additional water consumption for recycled concrete aggregate", and its quantitative mathematical expression is [7-8]:

$$m_{wr} = m_w + m_{\Delta w} \quad (1)$$

Where: m_w - design water consumption per unit volume of concrete (kg / m^3);

$m_{\triangle w}$ - design additional water consumption per unit volume of recycled concrete (kg / m^3);

m_{wr} - design water consumption per unit volume of recycled concrete (kg / m^3).

The hygroscopicity of recycled fine aggregate can be calculated by the following formula,

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i.e [9]:

$$r_s' = \frac{m_{ds}' - m_s'}{m_s'} \times 100\% \quad (2)$$

Where: m'_{ds} - mass of recycled concrete fine aggregate after moisture absorption (moisture content) (kg);

r'_s - moisture absorption rate (%) of recycled concrete fine aggregate.

2.2 Mix proportion of recycled concrete with water reducing agent

Concrete admixtures refer to the substances added in the process of mixing concrete to improve the performance of concrete. The amount of admixture in concrete is not much (generally not more than 5% of the mass of cement), but it can significantly improve the workability of concrete mixture, and significantly improve the physical and mechanical properties and durability of concrete [10]. At present, the application of admixtures in concrete is very common, which has become a necessary condition for the preparation of excellent performance concrete, known as the fifth component of concrete. Among them, the most widely used one is water reducing agent.

Superplasticizer is an additive that can reduce the amount of water when the slump of the mixture is basically the same. The reason why superplasticizer can reduce water is that it is a kind of surfactant. Concrete has the adsorption and dispersion of superplasticizer, and the superplasticizer also has the function of wetting and lubrication. The fluidity of concrete mixture will be improved by adding superplasticizer into the concrete with the same type and amount of concrete materials. In order to keep the fluidity of concrete mixture unchanged, the amount of water added to concrete can be reduced.

Taking recycled concrete with strength grade of C25 as an example, the mix proportion of recycled concrete with water reducing agent is designed.

It is known that the design strength grade of recycled concrete is C25, the required strength guarantee rate is 95%, and the slump is required to be 10-30mm in construction, and mechanical mixing machine is used for vibration. In order to improve the strength of recycled concrete, the material specifications are as follows: 1

Cement: Ordinary portland cement, strength grade 42.5, cement density 3.10g/cm^3;

Sand: sand in the river, qualified in gradation, apparent density of 2640kg/m3, water content 1%;

Coarse aggregate: recycled coarse aggregate, with particle size of 5mm-40mm, qualified grading, apparent density of 2410kg/m^3;

Water: tap water.

Water reducing agent: WS PC type poly (shuttle acid) superplasticizer produced by Shenzhen Wushan Building Materials Industry Co., Ltd. with a density of 1.08 g/cm3 （ Recommended dosage: the dosage is 1.0 of the cementitious material and 28% water

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reduction. During the test, the required amount of water reducing agent is mixed in the weighed water, and then poured into the mixer for mixing), which has the function of micro air entrainment, as shown in Figure 1.

(a) Original water reducer

(b) Dosage of water reducing agent in test

Fig 1: Water reducing agent

III. EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF RECYCLED CONCRETE

3.1 Specimen making and maintenance

Due to the large number of test blocks, the mixer is used for mixing. In order to make the mixing uniform, first pour the cement, sand and coarse aggregate (and fly ash or silica fume) into the mixer for pre mixing for 1min, and then add water (and water reducer) for mixing for 2min. Then, the concrete mixture is inverted on the wet iron sheet to facilitate the test

1. Apparent density. Shovel the concrete mixture into the measuring bucket with the volume of 2l, and then place the measuring bucket full of concrete mixture on the vibrator to vibrate tightly, and make the concrete mixture just level with the measuring bucket mouth. Finally, put the vibrating measuring bucket on the balance to test and calculate the apparent density of the concrete mixture.

2. Slump. The workability of concrete mixture was tested by slump tube method. The concrete mixture is divided into three layers (each layer is about 1 / 3 of the height of the cylinder) into the slump cylinder, and each layer is tamped 25 times with Φ16 round iron rod. After being filled and leveled, lift up the slump cylinder vertically and smoothly. Measure the height difference (mm) between the height of cylinder and the highest point of concrete mixture after slump with ruler, which is the slump value of concrete mixture. Observe the cohesiveness and water retention of the mixture.

3. Test block production and maintenance

Shovel the concrete mixture into the corresponding test forms (150 mm x 150 mm x 150

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mm cube test form, 100 mm x 100 mm x 300 mm prism test form, 150 mm x 150 mm x 550 mm cuboid test form). It is estimated that the amount of each addition is the same. Use the mixing rod to insert and tamp in three layers, especially four corners. Then place it on the shaking table to vibrate until the concrete mixture is flush with the test mold opening, and a small amount of cement slurry overflows. Take down the test mold from the shaking table and complete the production of the test mold.

4. Maintenance

Put the test mold at 20 ℃ ± 2 ℃, and the relative humidity is more than 95% in the standard curing room. After one day, the formwork is removed and kept in the standard curing room until it needs to be taken out.

3.2 Compressive strength of recycled concrete

The cube compressive strength of recycled concrete was measured according to the Test Method for Mechanical Properties of Ordinary Concrete (GB/T 50081-2019). The size of test concrete specimen is 150mm×150mm×150mm, which is cured under standard conditions (temperature 20±2℃, relative humidity ≥95%). Cubic compressive strength test steps should be carried out according to the following methods:

1. After the specified time, take it out from the maintenance site and test it in time, and clean the surface of the specimen and the upper and lower pressure-bearing plates;

2. Place the specimen on the lower platen or base plate of the testing machine, and the bearing surface of the specimen shall be perpendicular to the top surface during molding. The center of the specimen should be aligned with the center of the lower platen of the testing machine. Start the testing machine. When the upper platen is close to the specimen or steel base plate, adjust the ball seat to make the contact balanced;

3. During the test, load should be applied continuously and evenly, and the loading speed should be 0.3-0.5MPa per second;

4. When the specimen starts to deform sharply when it is close to failure, stop adjusting the throttle of the testing machine until it fails, and then record the failure load.

Compressive strength of recycled concrete cube is calculated according to Formula 3:

$$f_{cc} = \frac{F}{A} \quad (3)$$

Where: f_{cc}— compressive strength of concrete cube specimen (MPa);

F— failure load of specimen (N);

A— pressure bearing area of specimen (mm^2).

Compressive strength calculation of concrete cube shall be accurate to 0.1MPa.

288 cube test blocks were made in the experiment. The compressive strength of ordinary concrete, recycled concrete, recycled concrete with admixtures and admixtures at different ages was measured, and the change law of recycled concrete strength with age was discussed.

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Compared with ordinary concrete, the characteristics of strength growth of recycled concrete are discussed, and the influence of different admixtures and admixtures on the strength of recycled concrete is discussed.

The failure characteristics of recycled concrete specimens are similar to that of ordinary concrete. No cracks are found on the surface of recycled concrete specimens at the beginning of loading. With the increase of load, the stress in recycled concrete block increases continuously, and cracks begin to appear in the test block. At first, the crack is near the surface of the test block side, and it is vertical in the center of the test block, and it is inclined to develop up and down. Turn to the corner of the test block at the loading surface to form a positive and inverted "eight" type. With the increase of load, the new cracks gradually develop inward. The surface concrete starts to bulge and peel off. The final failure form of recycled concrete cube is a four corner cone connected with the positive and negative, as shown in Figure 2. From the failure mode, the failure of recycled concrete is basically the bond failure between coarse aggregate and cement gel surface, and no coarse aggregate is split.

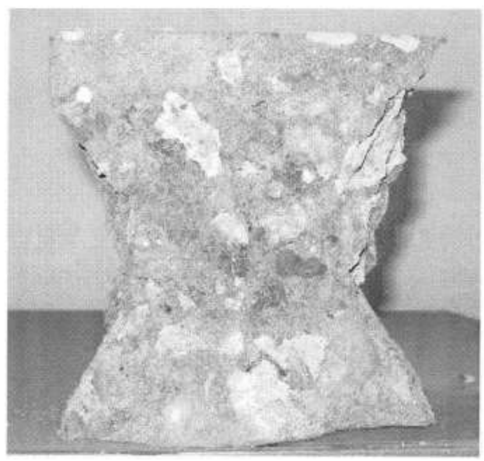

Fig 2: Failure mode of recycled concrete under compression

The compressive failure process of recycled concrete can be divided into four stages: elastic stage, microcrack generation stage, crack development stage and failure stage.

1. Elastic stage. Recycled concrete is basically in the elastic working stage. Under the action of external force, the concrete mainly resists the change of external force by the change of internal intermolecular force, and there is no damage evolution or new damage. Therefore, when the external force is cancelled, the concrete can recover the deformation.

2. The generation stage of microcracks. At this stage, although the stress on the recycled concrete continues to increase, it is no longer a linear increase, and microcracks begin to appear, so when the external force is withdrawn, the deformation can not be completely restored, that is, the plastic working stage.

3. Fracture development stage. The interface cracks continue to develop, cracks appear in the mortar, and the adjacent interface cracks are connected into continuous cracks, and the

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speed of deformation increase is further accelerated.

4. Destruction stage. When the load exceeds the ultimate load of recycled concrete, the continuous cracks develop rapidly, the bearing capacity of recycled concrete decreases, the load decreases, and the deformation increases rapidly, even completely destroyed.

3.3 Flexural strength of recycled concrete

In the structural design, quality control and acceptance of concrete road engineering and bridge engineering, it is necessary to detect the flexural strength of concrete.

According to GB/T 50081-2019, the flexural strength of concrete refers to the flexural strength value measured by the standard test method for the rectangular specimen with the standard size of 150 mm × 150 mm × 600 mm (or 550 mm), which is cured to 28 days under the standard curing conditions. The loading diagram is shown in figure 4.

The flexural strength of concrete is calculated according to formula 3:

$$f_{cf} = \frac{PL}{bh^2} \quad (4)$$

Where: f_{cf} - flexural strength of concrete (MPa);

P-failure load of specimen (N);

L-distance between supports (mm);

b. h-the width and height of the specimen section (mm).

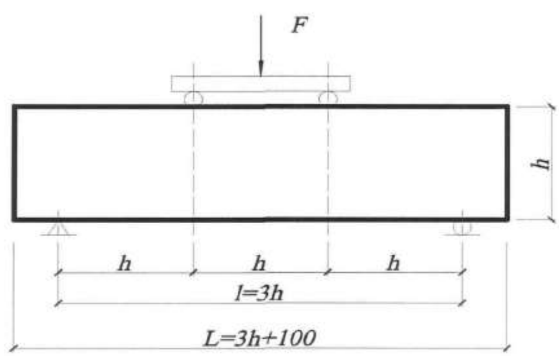

Fig 3: Loading diagram

The non-standard specimen of 100 mm × 100 mm × 400 mm is used in the test, which is multiplied by the conversion factor of 0.85.

IV. CONCLUSION

This paper discusses the characteristics of basic mechanical properties of recycled concrete in mix design of recycled concrete. It provides sufficient and reliable theoretical basis for recycled concrete and high performance mix design. Due to the absorption, dispersion, wetting and lubrication of water reducing agent, it is easy to mix the concrete evenly with a small amount of water, so as to improve the workability of recycled concrete mixture. The

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development law of recycled concrete compressive strength with age is basically consistent with that of ordinary concrete. The factors that affect the compressive strength of recycled concrete include the performance of recycled aggregate, water cement ratio and the use of admixtures and admixtures. The tensile strength, flexural strength, elastic modulus and other mechanical properties of recycled concrete are reduced, but through the use of admixtures and admixtures, these properties can be improved.

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