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Study on Influence of Mechanical Properties of Concrete based on Microbe Supported in Slag

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Abstract

Concrete material with its own excellent properties, plays a vital role in the construction industry, the annual production of about 10 billion tons, which makes concrete become second only to water, the world's second largest amount of material. However, in the actual service process, all kinds of buildings will be affected by their own and environmental factors, concrete is easy to crack, which affects the mechanical properties of concrete decline, this paper in slag as a carrier of microorganisms on the basis of adding nano-SiO_2 in ready-mixed concrete, studied its 3d, 7d, 14d, 28d compressive strength changes. The results show that the strength of concrete can be improved by adding the right amount of nano-SiO_2. The addition of nano SiO_2 can promote the hydration reaction of cement, resulting in more hydration gelling products of concrete, thus reducing the porosity of concrete and improving the compressive strength of concrete. The results of this study provide an important reference value for the practical application of microbial concrete self-healing.

Keywords

Concrete; Crack Self-healing; Nano-Sio_2; Compressive Strength.

1. Introduction

As a commonly used building material, concrete has excellent compressive resistance and durability,[1] but with the growth of the service life of concrete buildings, with the effect of external erosion, the quality of concrete may be reduced, resulting in the generation of micro-cracks. These cracks speed up moisture and erosive ion transport, resulting in damage to the concrete specimen structure, reducing the durability of the concrete structure, and ultimately mayaffect the safety and service life of the overall building.[2]The concrete crack repair methods[3]The self-healing methods include built-in[4]loaded adhesive in the hollow glass tube[5][6][7]With the self-healing technology of concrete with microbially induced mineralization deposit has made great progress. It can repair cracks quickly and accurately without any cumbersome procedures, and is also a new material that saves resources and achieves sustainable development [8].

In his experiment, Jonkers conducted a deep test on the mixed material containing calcium lactate by adding spo[10]Using the expanded clay particles and nanographene-supported microbiome technology developed by Khaliq et al., we found that this self-healing concrete performed[9]Qian Chunxiang used ceramic particles and Bacillus coiformis to construct a concrete sample in which cracks have been effectively removed after 28 days of maintenance, with the largest crack shrinking to 0.79mm[10] And with the help of Li Zhu, these cracks have been effectively[11]. OzkanSengul et al. have shown that microcracks in concrete can be repaired to a certain extent by microbial mineralization deposition[12], but if expanded perlite is added to the concrete, this improvement will have a significant impact on the physical and mechanical properties of the concrete[13].

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In this experiment, the slag was used as the carrier of microbial repair agent particles due to its strong porous structure load capacity, so as to solve the problem of decreasing compressive strength of self-repairing concrete with large dosage of microbial repair agent particles. At the same time, based on the selection of slag as the repairing agent particles, the influence of nano-SiO_2content on the mechanical properties of microbial self-repairing concrete was studied. The purpose of this study was to explore the amount of microbial repair agent, aggregate particle size and their influence on the mechanical properties and working performance of microbial concrete, in order to improve the performance of microbial concrete by optimizing the ratio.

2. Test Material and Test Method

2.1. Test Materials

In this experiment, the material used is common silicate, which is manufactured by Fushun Concrete Co., LTD. Its quality and technical indicators can be seen in Table 1 and Table 2. The microorganism is Bacillus bussii (produced by Beijing Conservation Biological Center), the concentration of microbial liquid is not less than 3.6×109 /cm3 , and the fine aggregate is natural river sand; Coarse aggregate refers to crushed gravel with a particle size greater than 4.75mm. In this paper, natural pebbles with a particle size of 5~31.5mm are selected as coarse aggregate; The slag of blast furnace is used as the slag, the particle size is less than 3mm, the mixing water is tap water, and the water reducing agent is produced by Shanxi Feike New Material Technology Co., LTD.

Table 1. Technical properties of cement

Technical Performance	Safety	MgO (%)	SO_2 (%)	Na_2O+K_2O(%)
Indicator requirements	≤5.0	≤5.0	≤3.5	≤0.6
Test result	4.6	4.3	2.9	good
Evaluation of results	good	good	good	good

Table 2. Cement strength index

Technical Performance	Safety	MgO (%)	SO_2 (%)	Na_2O+K_2O(%)
Specification requirements	≥3.5	≥16	≥6.5	≥32.5
Test results	5.6	22	7.2	36.5
Evaluation of Results	good	good	good	good

2.2. Preparation of Slag Fixative Particles

First of all, the qualified microbial bacteria solution is adsorbed on the surface of the slag and the void by natural impregnation method. Secondly, after the adsorption is completed, the slag is put into an environment of 40±2 ° C, after 24 hours of drying treatment, and then use the watering can to evenly spraythe yeast extract solution on the slag surface, each 1kg of slag spraying amount of 150g. Once again, the slag particles are placed in 40±2°C environment and dried for 1d. The coating is treated by spraying technology, the carrier is evenly placed in the container, then the cement slurry is evenly sprayed on the carrier using the spray gun, the repair agent particles are turned over on the ground, and the same spray is done on the other side, the process is repeated 2 times. After completion, the microbe restorant particles are dried in an oven at 40 ° C for 24 hours for use.

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2.3. Mix Ratio of Concrete and Specimen Making

We redesigned the mix ratio of concrete by using slag immobilized microorganism technology. The concrete mix ratio is 1257kg/$m^3$for stone, 619kg/$m^3$for sand, 344kg/$m^3$for cement and 152kg/$m^3$for water. Because if the proper measures are not taken to control the water content of the slag, even if the total water consumption is kept stable, it may greatly increase the humidity of the concrete, resulting in serious damage to the structure. In order to ensure that the quality of the concrete is not affected, it is necessary to advance the humidification treatment of the repair agent particles. In the pre-wet treatment project, it is necessary to ensure that the net water consumption of each group is not affected, and it is necessary to consider the use of pre-wet water in the concrete mix design. The concrete mix design is shown in Table 3.

Table 3. C30 concrete mix ratio (kg/m3)

Specimen Number	Cement	water	Pebbles	Sand	Water reducer	Water reducer	Anchor type restorers	Nonimmobilized restorers	Nano SiO_2
PC	344	152	1257	619	3.44	0.17	0	0	0
BC10	344	152	1257	557.1	3.44	0.17	0	61.9	0
BC20	344	152	1257	495.2	3.44	0.17	0	123.8	0
BC30	344	152	1257	433.3	3.44	0.17	0	185.7	0
BBC10	344	152	1257	557.1	3.44	0.17	61.9	0	0
BBC20	344	152	1257	495.2	3.44	0.17	123.8	0	0
BBC30	344	152	1257	433.3	3.44	0.17	185.7	0	0
NBBC5	342.28	152	1257	495.2	3.44	0.17	123.8	0	1.72
NBBC10	340.56	152	1257	495.2	3.44	0.17	123.8	0	3.44
NBBC15	338.84	152	1257	495.2	3.44	0.17	123.8	0	5.16

The content of slag containing microorganisms shall be 0, 10%, 20% and 30% of the initial concrete volume respectively. The dosage of nano-SiO_2 was taken as 1.72, 3.44 and 5.16kg/m^3. Before mixing the concrete, the wrapped slag should be immersed in water for 1h to ensure that it fully absorbs water. The 10 groups of size are set in the standard concrete cube of 100mm×100mm×100mm, and put them into 12 pieces respectively, to be completed in the room within 24 hours, and then take it out, and move it to the ambient temperature and humidity at 28°C, and the corresponding temperature and humidity are not less than 90% of the conditions to be standardized maintenance.

2.4. Test Method

In order to ensure that the mechanical properties of concrete meet the national standards, we must carry out a strict inspection of its compressive strength. We used YAW-2000 automatic test press and followed the provisions of Standard for Mechanical Test Methods of Ordinary Concrete. The data of loading process were recorded, and the strength of 3d, 7d, 14d and 28d were measured respectively.

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3. Test Results and Analysis

3.1. Study on the Performance of Microbe Repair Agent Particles Contained in Cement Slag Or Not

Table 4: Test results of physical properties of particles of encapsulated and unencapsulated slag supported microbial restorers

Categories	Cylinder Pressure Strength (kPa)	24h water absorption (%)	Packing density (kg\m^3)
NC	624	149	1235
NEC	757	105	1336

Table 4 shows the results of common physical properties tests for unwrapped and cement coated microbiological restorant particles. When the particles arecoated with cement, the packing density of NEC particles is 1.15 times higher than that of NC particles, and the particle distribution of NEC particles is more uniform, which greatly improves the performance of concrete. The compressive strength of NEC particles is 1.23 times higher than that of EP particles. This improved result can significantly improve the mechanical properties of concrete.In addition, the 24h water absorption of NEC particles is reduced by 36.7% compared with NC particles.

3.2. Study on the Influence of Microbiome Free Slag Repair Agent Particle Content on the Compressive Strength of Self-healing Concrete

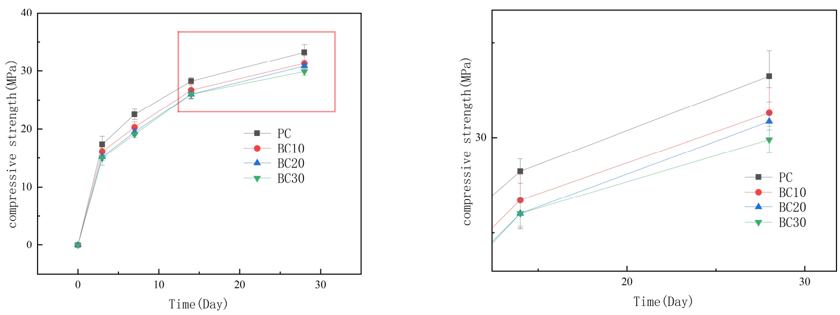

Figure 1. Effect of coal slag content on compressive strength of concret

As can be seen from Figure 1, when the particle content of non-microbial slag repair agent is 10%, 20% and 30%, the compressive strength of the seventh day is reduced by 7.1%, 12.45% and 13.6% compared with the standard concrete specimen, respectively. After 28 days of maintenance, the compressive strength is reduced by 8.5%, 9.84% and 12.65%, respectively. It can be seen that the compressive strength of concrete decreases with the increase of the content of non-microbial slag repair agent particles, which is due to the addition of nonmicrobial slag repair agent particles and other mass to replace coarse aggregate. The particle size of non-microbial slag repair agent particles is smaller than that of coarse aggregate, resulting in changes in the internal structure of concrete and the failure to form a good aggregate skeleton. Resulting in a reduction in the compressive strength of concrete.

3.3. Study on the Influence of Microbial Slag Repair Agent Particle Content on the Compressive Strength of Microbial Concrete

As can be seen from Figure 2, the compressive strength of slag concrete basically remains unchanged with a small amount of microorganisms. When the particle content of microbial slag repair agent was 10%, 20% and 30%, the compressive strength of the specimen was

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significantly reduced by 2.89%, 0.6% and 8.47% compared with the benchmark concrete on the seventh day. After 28 days of maintenance, the compressive strength decreased by 5.5%, 6.95% and 12.6%, respectively. This is because the microbe particle size is small enough to enter the void of the slag without changing the pore structure in the concrete. Therefore, the compressive strength of the bacteria-doped slag concrete does not change significantly.

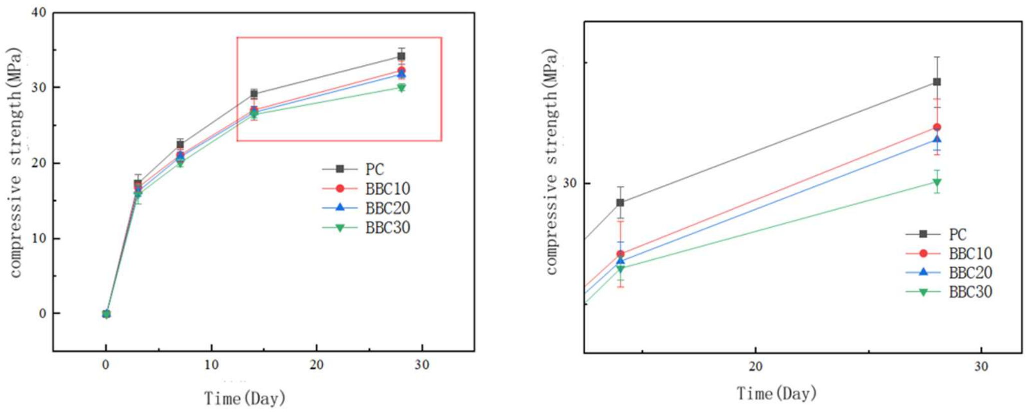

Figure 2. Influence of microbial slag content on compressive strength of concrete

3.4. Study on the Influence of Nano-SiO_2 Content on the Compressive Strength of Microbial Concrete

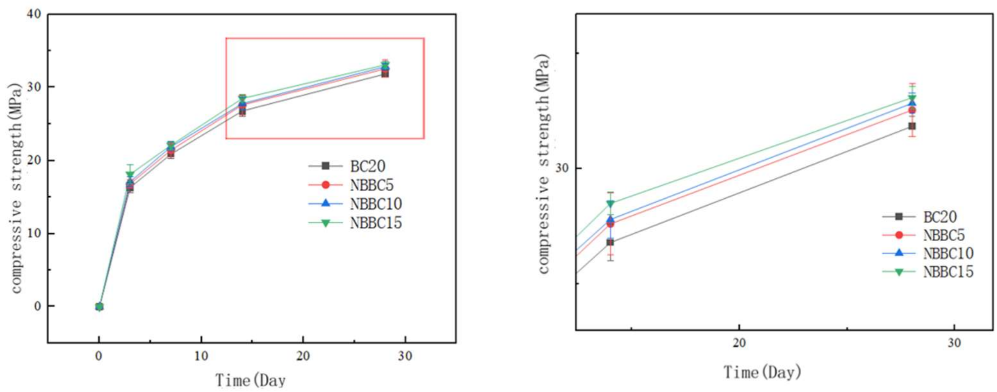

Figure 3. Influence of nano-SiO_2 slag supporting microbial content on compressive strength of microbial concret

As can be seen from Figure 3, when the nano- SiO_2 content increases from 0% to 1.5%, the compressive strength of concrete supported by microorganisms in slag increases by 3.92%. Especially in the early strength of concrete, the addition2 of nano- SiO_2 causes the strength of microbial concrete to increase more than that in the later strength, which meets the requirements of compressive strength of standard concrete. The reason for this phenomenon may be that nano SiO_2 can be better combined with the fine aggregate of concrete, so that the micro cracks in the concrete are reduced, and the porosity is also reduced. On the other hand, the appropriate amount of nano- SiO_2 and cement has not produced the hydration2 product Ca(OH) to produce C-S-H_2 gel, which improves the compressive strength of concrete due to the generation of gel.

4. Conclusion

Based on the premise that slag is used as the carrier of microorganisms, nano SiO2 is used as an external additive in this study to enhance the compressive strength of microbial concrete.

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Through the controlled test method, the main factors affecting the compressive strength of concrete are analyzed, and the following conclusions are drawn:

With the increase of the content of microbe restorant particles in the slag, the compressive strength of concrete gradually decreases, especially in the 7-day period, the early strength decreases, and the lowest compressive strength only reaches 86.4% of the standard concrete in the same period. After 28 days of maintenance, the compressive strength of concrete with 30% slag repair agent particles reached 30.1Mpa, which is equivalent to 87.9% of the compressive strength of standard concrete in the same period.

Through the first two groups of control tests, with the addition of microorganisms as a single variable, it is found that the impact of microbial content in line with the standard on the compressive strength of concrete is less than 1Mpa. However, the reduction of the compressive strength of concrete by adding a small amount of microorganisms is very weak, and the compressive strength is only reduced by less than 5%.

Based on the condition that the content of microbial restorant particles supported by slag is 20%, when the content of nano-SIO2 is increased from 0% to 1.5%, its compressive strength is increased to 3.92%. This coupling strategy can not only ensure the uniform dispersion of microbial restorant particles in the concrete, but also improve the strength of the concrete. The results of this study provide an important reference value for the practical application of microbial concrete self-healing.

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