Influence of charging mixing order on concrete performance

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Influence of charging mixing order on concrete performance

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Abstract. To know whether or not the concrete performance will be effected by the charging mixing order of three materials including the fine materials, the hydrophobic materials and the poriferous internal curing materials, three kinds of charging mixing order were designed. The slump of fresh mix concrete was tested. The compressive strength of harden concrete was tested. The pore structure was also detected. The test results show that charging mixing order can effect on the slump of concrete. While, it has no effect on compressive strength and pore size distribution. About the pore parameters, charging mixing order can effect on the average pore diameter and the critical pore diameter. It has no effect on the porosity of the concrete.

1. Introduction

By optimize the composition and mix proportion, high performance concrete can be obtained [1]. In order to produce concrete with high performance of anti-acid corrosion, super fine materials can be used [2]. Hydrophobic materials are also often used for improving the permeability performance of concrete [3]. Internal curing materials can be used for decreasing the probability of early age cracking in concrete [4]. All of these methods can enhance the concrete anti-acid corrosion durability because the concrete microstructure can be optimized by these methods.

While, if these three methods are used in concrete at the same time, there is an opportunity that the super fine materials block off the hole on the surface of internal curing materials so that the inner water in the curing materials can’t be released smoothly [5]. There is also an opportunity that the hydrophobic materials will be adsorbed by the super fine materials and failure to give play to the permeability performance [6]. So it is necessary to test whether or not that these three method used at the same time will be mutual interference.

At the same time, we can find a method to resolve this interference problem by charging these materials at different time or different groups. So it is necessary to design a test to study which kind of charging mixing order is the most effective one.

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2. Raw materials and mix proportion

2.1. Raw materials
Silica fume whose diameter is 200nm and silicon nitride whose diameter is 20nm are used as Fine materials. Organic silicone emulsion is used as water-proofing material to resistance the permeating of harmful ions. Fly ash ceramsite is used for inner curing for concrete.

The main binding material is P.O 42.5 Portland cement which is produced by Hua Xin cement plant. The fine aggregate is nature sand whose fineness modulus is 2.8. The coarse aggregate is crushed stone whose diameter is 5-20mm. Polycarboxylic acid water reducer whose water-reducing rate is 20% has been used.

Silica fume is necessary. It is used for filling the micro pores in concrete which is produced by Shang Hai Yao Qian Construction Coating and Decorate Co., LTD.. The properties of silica fume are listed in table 1.

Table 1. The properties of silica fume.

Diameter μm	Density kg/m^3	Specific surface area m^2/kg
0.2	3200	15000

The other silica material is nano silicon nitride which is produced by Qin Huang Dao Yi Nuo New Materials Development Co., LTD. It is used for filling the nano pores in concrete. The properties of silicon nitride are listed in table 2.

Table 2. The properties of silica nitride.

Diameter nm	Density kg/m^3	Specific surface area m^2/kg
20	90	50000

The water-proofing agent of organic silicone emulsion is used in concrete which is produced by Nan Xiong Ding Cheng new material technology Co.,LTD. It is used to resistance the permeating of harmful ions. The properties are listed in table 3.

Table 3. Properties of organic silicone emulsion.

Style	PH	Effective Ingredient
FS-170	7.0	>95%

Fly ash ceramsite is used for inner curing for concrete. The properties are listed in table 4.

Table 4. Properties of silica nitride fly ash ceramsite.

Apparent density kg/m^3	Diameter mm	Saturated percent sorption %
1950	2-5	42.3

2.2. mix proportion
The mix proportion of concrete is shown as table 5.

Table 5. Mix proportions of concrete Unit: kg/m^3

Cement	Water	Nature sand	5mm-10mm crushed stone	10mm-20mm crushed stone	Silicon nitride	Silica fume	Ceramsite	Organic silicone emulsion agent	Water reducer
360	170	721	308	720	2	20	54.5	3.82	2.05

The slumps are designed as 180mm±10mm.

3. Test methods

3.1. Charging mixing order

Three kinds of charging mixing order were designed. Table 6 shows us the different charging mixing order. For example, for charging mixing order 1, firstly, we put cement, sand, stone, silicon fume and ceramsite into the mixing machine. And then, mix them homogeneously. After that, we mix organic silicone emulsion agent and water reducer into water for mixture and then put the mixed liquid into the mix machine. And make the slurry mixing homogeneously. Charging mixing order 2 and 3 are in a similar way.

Table 6. Charging mixing order

Order ID	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
1	cement, sand, stone, silicon nitride, silica fume, ceramsite	mix	organic silicone emulsion agent, water, water reducer	mix	/	/
2	cement, sand, stone, silicon nitride, silica fume	mix	organic silicone emulsion agent, water, water reducer	mix	ceramsite	mix
3	cement, sand, stone, ceramsite	mix	organic silicone emulsion agent, water, water reducer	mix	silicon nitride, silica fume	mix

3.2. Microstructure test

After testing the 28d compressive strength, the specimens will be crushed by a machine. The round shaped mortar particles about 10g will be selected. After washing these particles with ultrasonic cleaner, put them into the air dry oven and dry under the temperature of 105 ℃±5 ℃ for 24h. Then put these particles into dryer and cool under nature environment. Test the pore structure by Mercury Injection Apparatus.

4. Test results and analysis

To evaluate the effects of charging mixing orders, the slumps of the fresh mixed concrete are tested. After 28d curing, the compressive strength of the concretes are tested. The pore structure of the concretes are also tested by Mercury Injection Apparatus.

4.1. Slumps of concrete

Test result has been tested as shown as table 7.

Table 7. Slumps for different charging mixing orders

Charging mixing order	Slump /mm
1	178
2	145
3	95

From table 7, only charging mixing order 1 can reach the designed slump range standard.

4.2. Compressive strength

The compressive strength of 7d, 28d and 56d have been tested among concretes made by different charging mixing order. Figure 1 shows the difference.

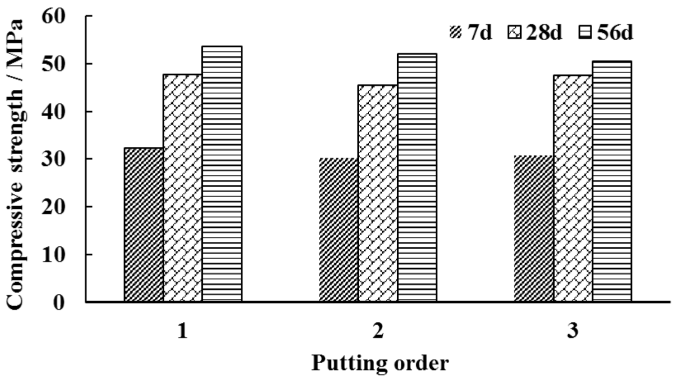

Figure 1. Compressive strength VS charging mixing order.

From Figure 1, the compressive strength of concretes with different charging mixing orders have the similar value in different curing date. The 7d compressive strength of order 1 concrete is 32.23 MPa. It is higher than order 2 and order 3. When the curing date goes up to 56d, the compressive strength of these three concrete are all above 50MPa and the order 3 is the highest one.

4.3. Micro pore structure

Figure 2 is about the pore distribution situation.

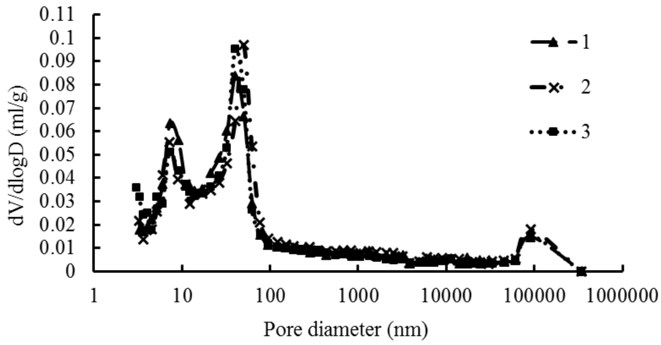

Figure 2. Pore size distribution situation.

As shown as Figure 2, although the charging mixing orders are different, the pore size distributions are very similar. Table 8 shows the pore structure parameters.

Table 8. Pore structure parameters.

Charging mixing order	Porosity /%	Average pore diameter/nm	Critical pore diameter
1	18.7281	20.3	227
2	18.9915	22.5	283
3	18.4788	18.4	284

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Porosity is the specific value from pore volume to whole volume. Generally, the less the porosity, the better the concrete strength. These three charging mixing orders are all around 18%. That means the porosity can't be effected by charging mixing orders. That's why the compressive strength of concretes are all similar in different curing date.

Average pore diameter can reflect pore size average value. When the porosities are similar, the larger the average pore diameter, the more the max pores. The average pore diameter of concrete of charging mixing order 3 is better than the other two.

Critical pore diameter is the pore which can combine all grades of pores. This index can reflect the connectivity of pores in concrete and can reflect the permeability of concrete. The smaller the critical pore diameter, the better the permeability of concrete. Therefore, the charging mixing order 3 is the best of all.

In conclusion, the compressive strength of charging mixing order 1 concrete is the best. Porosity are similar. Critical pore diameter of charging mixing order 1 concrete is the best. Average pore size of charging mixing order 3 concrete is the best but 1 and 3 have only a small difference value. Therefore, the charging mixing order 1 is selected as the best one.

5. Conclusions

To know whether or not the concrete performance will be effected by the charging mixing order of three materials including fine materials, hydrophobic materials and poriferous internal curing materials, three kinds of charging mixing order were designed. The slump of fresh mix concrete was tested. The compressive strength of harden concrete was tested. The pore structure was also detected. The test result show that charging mixing order can effect on the slump. It has no effect on compressive strength and pore size distribution. About the pore parameters, charging mixing order can effect on the average pore diameter and critical pore diameter. It has no effect on porosity of concrete.

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