Effect of Silica Powder to Frost Resistance of Concrete

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Abstract: The improving strength of concrete is the hot issue. The concrete with silica powder was studied. This experimental study comprises 3 groups concrete specimens with a fixed water/cement ratio. The concrete using various silica powder had improved the concrete relative dynamic elastic modulus and weight loss rate. The experiments showed that the concretes with mixture of silica powder showed good performance , and the concrete frost resistance increased significantly. The silica powder improved its structure of concrete. The tests proposed that silicon powder has great impact.

1. Introduction

The concrete often can be damaged by the environments , sometimes even made structure completely destroyed. Concrete engineering projects are used in many area, so the durability of indexes for concrete is one of the most important factor. The frost resistance of concrete is especially important in the cold area buildings. To improve the frost resistance of concrete that using silica powder was studied in the paper. The result showed that the silica powers greatly improves the concrete freezing andsilica powderproperties.

2. The concrete damage by freezing and thawing in cold area

The damage of concretes are related to the volume change of water turn into ice which the volume increased 9%，it cause the structure of concrete deformed. When water in the concrete rate have great effected by the freezing and silica powder. The destructive function mainly includes ice expansion pressure, water pressure and microscopic analysis of water [1-2].

2.1. Effects of ice expansion pressure in the concrete

When water is freezing because the temperature is below zero , its ice occurs in pores which the full of water in concretes. When the water that filled with pores in concrete changed into ice, ice will occur very big ice expansion pressure. The capillary wall changed into tensile stress, resulting in concrete of buildings were destructed. The size of the ice expansion pressure and damage degree, they depending on the material pore water saturation degree and the material deformation ability [3].

2.2. water pressure in the concrete

The concretes have various types pores that cause by the materials and curing conditions etc.The water filling degree which are based on the internal structure and its environments. When water in concretes freezes in various gradually, and the ice volume of concretes increased, resulting in that excess water which has not frozen will move to the ice specimen edges [4]. In the process, water pressure

generated, also the pore wall is subjected to tensile stress, material volume expansion were happened. When ice melt into water, material volume will be shrinkage, residual stress and deformation were released. With many times of freezing and thawing cycles, concretes were destroyed.

2.3. Microscopic Analysis of Water in the concretes

Pore water in the concretes usually is dilute solution of salts. When water was frozen, pure ice was precipitation, and the concentration of solution was changed. During this period, if adjacent pores of concretes in freeze and there are still the original concentration of the solution, made the concentration difference, water in the concretes have migration to frozen regional and quickly frozen [5]

To the pure water in concrete, when the temperature decreases, water surface tension will be increased, cause water transfer to larger pore, and the ice in the concrete will be increased, causing the ice expansion pressure and water pressure are increased quickly. The phenomenon of microscopic analysis of water in the concrete, so that freeze-thaw damage intensifies [6].

3. Mechanism of silica powder worked in the concretes

Silica powder is one kind of fine blend materials. The particles size is 0. 1~ 1.0 μ m , and the activity is very high because its specific surface area is very high. The main composition is amorphous silica. While the silica powder and water reducer were used in concrete, silica powder and Ca $(OH)_2$ have the reaction each other and hydrated calcium silicate gel, it filling the gap between the cement particles, so it improved the interface structure and increased bonding force, so as to improve the concrete strength.

Judging from its structure, silica powder were mixed in concrete, although the crevice rate of cement stones were basically the same with no the content, but the coarse pores and capillary pores in the concretes reduced, and ultrafine pore increase. Ultrafine pore have larger adsorption to the water, it cause the water's freezing point decreased.Delaying the process of freezing and thawing, and it will reduce the failure stress. The increase of strength and structure were improved, en-strength the frost resistance of concrete [7].

4. Contrast test

*4.1. Experiment**al** Raw Materials of the concretes*

The raw materials of experimental are shown in Table 1.

4.2. Design of the Concrete Proportioning

The comparative tests of different silica powder volumes concretes , for determine the effect of silica powder in concretes to the frost resistance . The experimental conditions were water cement ratio was constant, control collapse depth were 3 ~4 cm, and change the amount of silicon powder in the concretes. The test samples were cuboid , its size was10 cm× 10 cm× 40 cm. Curing time is 28 d, water cement ratio was 0.5, sand rate was 44%, high efficiency water reducing agent (UNF) used 9%, the packet is shown in table 2.

Table 1. The experimental materials

Materials	Standards
Cement	42.5 Portland cement
Sand	Medium sand FM= 2.7
Breakstone	D max= 20 mm
Admixtures	water reducing agent
Silica powder	10%和 15%

Table 2. Mixture ratio of 3 groupes .

Group	1 m^3 / kg			
	42.5 Cement	Break stone	Silica powder	Sand
1	400	1000	40	550
2	400	1000	60	550
3	400	1000	---	550

The experimental study used freeze-thaw test machine. The specimen in the freezing and thawing process were in a saturated state. The specimen in the frozen thaw process, the center temperature respectively control in between -17~ 18℃. Once freeze-thaw cycle took about 6 h. The test results are shown in Table 3.

Table 3.The test results of the concretes with different freezing and thawing cycles.

The times of freezing and thawing	Weight loss ratio/ %			The relative dynamic elastic modulus/ MPa		
	1 (with silica powder 40 kg)	2 (with silica powder 60 kg)	3 (with silica powder 0 kg)	1	2	3
0	0	0	0	100	100	100
50	0.1	0.1	0.7	95.2	95.4	91.0
100	0.2	0.2	1.6	93	94.9	85.7
150	0.3	0.3	2.1	89.3	92.6	72.2
200	0.4	0.4	2.8	85.9	92.6	61.0
250	0.5	0.5	3.2	83	88.8	45.2
300	0.6	0.5	3.5	81.5	88.8	24.8

5. Analysis and discussion

Based on the experiments of the concrete with freezing and thawing cycles tests results ,the relative dynamic elastic modulus were decreased, the concrete micro crack propagation path and toughening was put forward . the structure deformation stored energy release. The crack tip stress concentration started to spread in the vicinity of cement gel block. The study is developed by the effects of composition silica fume replacement ratio, Results indicate that dynamic elastic modulus decreased to 88after 300 freezing and thawing cycles, compare to no silica fume concrete, the elastic modulus decreased 24.

The concrete weight rate were 0.6%, 0.5%, 3.5%, and indicate that the surface of silica powder concrete control cracking occur after freezing and thawing, while the ordinary concrete cracking is generated actual state of cracking from peeling .

6. Conclusions

The effect of silica powder in concrete was not only have the excellent mechanical properties, it was also the freezing-thawing cycle number is bigger than 500, but also have nice durability .

The result showed that silica powder improves the internal structure、density and strength which leads to 300 freezing-thawing cycles, and the decrease of relative dynamic modulus of elasticity is

small. The silica powder mix design by optimizing resistance of freezing-thawing improved the properties of concretes..

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