Study on the Effect of XYPEX Admixture on the Performance of Panel Concrete and Microscopic Mechanism

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Abstract: The influence of different XYPEX content on the performance of dam panel concrete was studied through laboratory tests. The test results show that a certain amount of XYPEX can improve the compressive strength and impermeability of panel concrete. According to the scanning electron microscope photos, XYPEX admixture has a good filling effect on the internal pores of concrete in the microstructure, and the macro performance is improved for impermeability, but the effect on the visible cracks on the surface of concrete is small. The research results fill the gap in the research field of XYPEX admixture in dam panel concrete, provide a new idea for improving the durability of panel concrete, and provide technical support and data support for the future application of XYPEX admixture in water conservancy and hydropower projects.

Keywords: XYPEX admixture; Panel concrete; Scanning electron microscopy; Microstructure; durability.

1. Introduction

As an anti-seepage structure of water-retaining buildings, concrete panels have been widely used in water conservancy and hydropower projects in recent years [1~2]. The durability of panel concrete is the most important technical index and an important factor determining the service life of concrete panel and the safe operation of dam [3~4]. The concrete panel has the characteristics of large area and relatively thin thickness. Compared with other structures, cracks are more likely to occur, which will reduce the impermeability of the concrete panel, and even lead to the failure of the panel structure, affecting the dam safety. Therefore, improving the durability of panel concrete has always been the focus of water conservancy and hydropower engineering research.

At present, the research on the durability of panel concrete mainly improves and enhances the performance of panel concrete by adding various additives and anti-cracking materials [5~6]. XYPEX admixture is a kind of cement impermeable material, consisting of Portland cement, silica sand and many active chemical substances. After being mixed into concrete, it can improve the impermeability of concrete, and for cracks below 0.4mm that appear on the surface of concrete structure, it has the ability to self-repair after being exposed to water. It is applied well in construction projects. It can improve the waterproof performance of concrete [7~10], but there are few research results on its impact on the durability of panel concrete. Therefore, aiming at this characteristic of XYPEX blend, it is planned to study the impact of XYPEX blend on the durability of panel concrete and the self-healing ability of concrete micro-cracks through experiments. The microcosmic mechanism of XYPEX admixture affecting concrete performance was studied to provide technical support and data support for the future application of XYPEX admixture in dam concrete panels.

2. Research Overview

According to the engineering application of XYPEX admixture, 0.8%, 1.0%, 1.2% were selected for the test, and the mixture ratio specimen without XYPEX admixture was used as the benchmark specimen. Among them, the design index of the panel concrete is C30W12F300, two-stage mix,

slump 120-140mm, P.O42.5 cement, grade fly ash content 20%, water-binder ratio 0.38, sand rate 36%, water reducing agent, air entraining agent and polypropylene fiber are added. After standard curing, the effect of XYPEX mixture on the durability of panel concrete was studied.

3. Study on the Influence of XYPEX Admixture on Compressive Strength of Panel Concrete

Compressive strength is an important index to measure the quality of concrete. In this study, four sets of 150mm × 150mm × 150mm concrete standard cubic compressive specimens were formed, and the content of Cybers admixture was 0%, 0.8%, 1.0% and 1.2%, respectively. After 28 days of standard maintenance, compressive strength tests were carried out. During the test, pay attention to the side of the specimen when forming as the upper and lower pressure surface, and the center of the specimen is aligned with the center of the lower pressure plate of the testing machine. Start the testing machine, when the upper cushion plate and the upper pressure plate are about to contact if there is a significant deviation, immediately adjust the ball seat, so that the specimen pressure uniform. Load continuously and uniformly at the speed of 0.3MPa/s~0.5MPa/s. When the specimen is close to failure and begins to rapidly deform, stop adjusting the throttle until the specimen is broken, and record the failure load. The test results are shown in Table 1, Fig. 1 is the column diagram of compressive strength of the concrete with different mixtures, and the specimens after breaking are shown in Fig. 2.

Table 1. Compressive strength test results

Serial number	Dosage (%)	Sample number	Design index	Compressive strength (MPa)
1	0	KY0	C30W12F300	36.6
2	0.8	KY0.8	C30W12F300	38.3
3	1.0	KY1.0	C30W12F300	40.2
4	1.2	KY1.2	C30W12F300	39.7

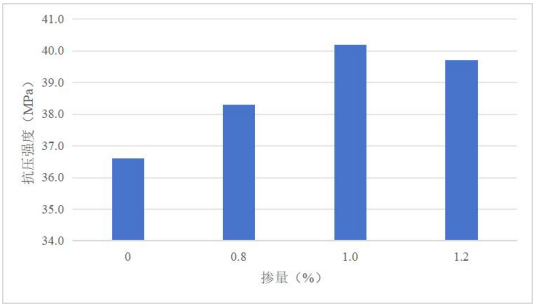


Fig. 1 Column diagram of compressive strength of face concrete

a.dosage 0%　　b. dosage 0.8%

c. dosage 1.0% d. dosage 1.2%

Fig. 2 Photo of specimen after breaking

4. Study on the influence of XYPEX admixture on the impermeability of panel concrete

As a waterproof material, the main function of XYPEX admixture is to improve the impermeability of concrete, which is better for the concrete under the condition of moisture and saturated water for a long time, and has the function of filling the pores inside the concrete. Therefore, in this study, 4 groups of concrete anti-seepage specimens were prepared, and a < 0.3mm through channel was artificially created in the direction of the height of the specimens. Under the conditions of standard curing for 28 days and 56 days, the anti-seepage specimens were continuously pressurized by step pressure test method until water permeated the specimens, or pressurized to the maximum pressure limit of instruments and equipment (4.0MPa). The water seepage of each specimen was recorded. The impermeability test results are shown in Table 2, and the test process is shown in Fit. 3 and Fig. 4.

Table 2. Test results of impermeability

Serial number	Dosage (%)	Age (days)	Sample number	Compressive strength (MPa)					
				1	2	3	4	5	6
1	0	28	HW0	2.4	0.3	1.9	2.4	1.2	2.4
2	0.8	28	HW0.8	0.8	1.7	0.8	0.8	0.1	0.1
3	1.0	28	HW1.0	0.9	1.3	2.4	0.2	0.3	1.2
4	1.2	28	HW1.2	2.7	1.8	1.2	1.2	1.1	2.1
5	0	56	HW0	2.6	0.6	2.2	2.7	1.3	2.5
6	0.8	56	HW0.8	1.8	4.0	4.0	Intact	Intact	Intact
7	1.0	56	HW1.0	4.0	1.6	2.7	3.3	2.4	3.3
8	1.2	56	HW1.2	Intact	Intact	1.8	1.3	1.4	Intact

a.dosage 0% b. dosage 0.8%

c. dosage 1.0% d. dosage 1.2%

Fig. 3 Photo of 28-day age impermeable specimen

a.dosage 0% b. dosage 0.8%

c. dosage 1.0% d. dosage 1.2%

Fig. 4 Photo of 56-day age impermeable specimen

It can be seen from Table 2 that after 28 days of standard curing, No. 2 of the blank concrete impermeability test specimen experienced water seepage at 0.3MPa, and all of the 6 test specimens experienced water seepage at 2.4MPa pressure. Under the pressure of 0.1MPa, No. 5 and No. 6 concrete impermeable specimens with a content of 0.8% XYPEX have water seepage, and the maximum seepage pressure is 1.7MPa. Under 0.2 pressure, specimen No.4 began to permeate water, and specimen No. 3 permeated water under the maximum pressure of 2.4MPa. Under the minimum pressure of 1.1MPa, specimen No. 5 began to permeate water, the maximum pressure was 2.7MPa, and specimen No.1 began to permeate water. After continuous curing for 28 days, that is, after the age reaches 56 days, the impermeability test is carried out again. Under the pressure of 0.6MPa, the blank concrete impermeability test specimen No. 2 begins to permeate water, and the maximum seepage pressure reaches 2.6MPa. Among the 0.8% anti-seepage specimens of Cybers, No. 1 showed water seepage under the minimum pressure of 1.8MPa, while No. 4, No. 5 and No. 6 showed no water seepage under the maximum pressure of 4.0MPa (measuring range of test instrument). In the test specimen with a content of 1.0%, specimen No. 2 had water seepage under the lowest pressure of 1.6MPa, and specimen No. 1 had water seepage under the maximum pressure of 4MPa. Among the anti-seepage specimens with a content of 1.2%, specimen No. 4 began to permeate at a pressure of 1.3MPa, and three specimens did not permeate at a maximum pressure of 4.0MPa (measuring range of the test instrument).

The comparison of impermeability test results between the 28-day and 56-day specimens shows that the impermeability of the four specimens is improved after curing for 56 days. In the impermeability test of blank concrete, the maximum seepage pressure of a single specimen can be increased by 0.3MPa, and the minimum seepage pressure can be increased from 0.3MPa to 0.6MPa. In the 0.8% XYPEX anti-seepage test, the maximum seepage pressure of a single specimen can be increased by > 3.9MPa, and the minimum seepage pressure can be increased from 0.1MPa to > 4.0MPa. The maximum seepage pressure of a single specimen was increased by 3.1MPa, and the

minimum seepage pressure was increased from 0.2MPa to 3.3MPa. The maximum seepage pressure of a single specimen was increased by more than 2.2MPa, and the minimum seepage pressure was increased from 1.1MPa to 1.4MPa. It can be seen from the comparative test results that the concrete impermeability of the 4 specimens at 56 days of age has improved compared with that of 28 days of age. The 28-day impermeability specimens were broken down under certain water pressure and formed a certain seepage channel in the interior. After 56 days of age, the impermeability of the specimens was significantly improved compared with that of 28 days of age. The test results show that XYPEX has a good filling effect on the internal impermeable channel of concrete, and the improvement of the impermeable property of concrete is more obvious.

5. Effect of XYPEX admixture on microstructure of concrete

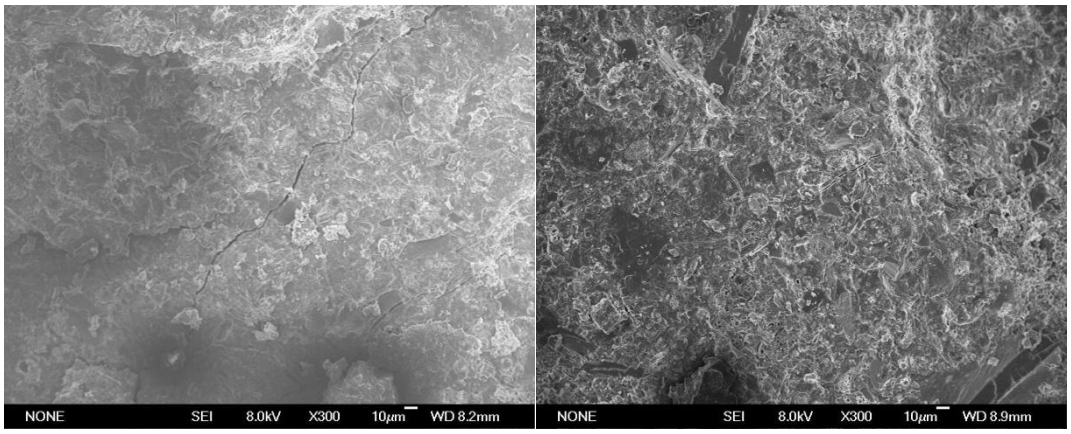
With the continuous development of modern science and technology, a large number of cutting-edge scientific work has turned the research direction to the exploration and research of the material microcosmic world, and the resolution of the human eye is only about 0.2m, which cannot meet the requirements of scientific research. In the late 16th century, the optical microscope was invented by Dutch scientists, with the continuous development of the optical microscope, but the limit resolution of the optical microscope is 200nm. With the continuous development of theoretical research, scientists use the principle of wave-particle duality to accelerate electrons as a new light source to make higher resolution electron microscopy, which is the principle of SEM scanning electron microscopy. At present, scanning electron microscope SEM has been applied to many fields such as scientific research and production.

By observing the SEM images of concrete with 0%, 0.8%, 1.0% and 1.2% at different magnification times (300 times, 500 times, 1000 times and 2000 times), the mechanism of action of XYPEX admixture on concrete was directly observed and analyzed from the perspective of microstructure. The above concrete was destroyed and fragments with a particle size of about 1cm were selected as samples. 1-3 pieces of each mixture were selected. After the surface was cleaned, the fragments were put into sealed bags and marked for scanning electron microscope test, the prepared sample is shown in Fig. 5.

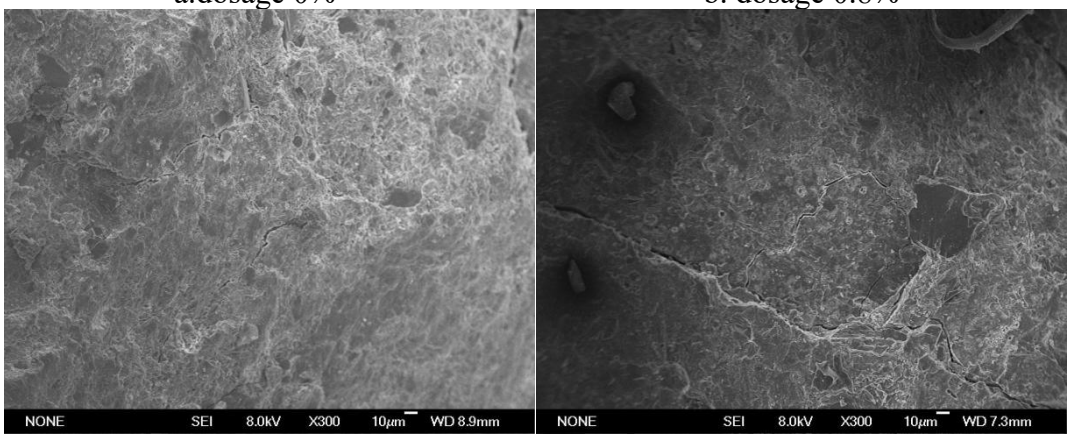
Fig. 5 SEM sample

Fig. 6 to Fig. 9 are the electron microscope photos of XYPEX concrete with different dosage under different magnification. It can be seen from the figure that an obvious crack can be seen on the surface of the sample with the dosage of 0%, while the surface crack with the dosage of 0.8% is not obvious and small in size. The surface cracks of the sample with content of 0% are relatively flat, while those with other content are relatively tortuous, and there are more forks in the cracks. According to the knowledge of fracture mechanics, if the path is tortuous and the direction of the expansion surface changes more during the fracture process, the fracture will absorb more energy. Therefore, this difference in microstructure is consistent with the high compressive strength of

XYPEX concrete at the macro level. With the increase of magnification, it can be seen that there is no filling in the cracks of concrete with a content of 0%, while crystal filling is clearly visible in the cracks of concrete doped with XYPEX. Therefore, the better the crystal development, the more difficult it is for water to penetrate, which can also prove that XYPEX concrete shows high impermeability in the macro level.

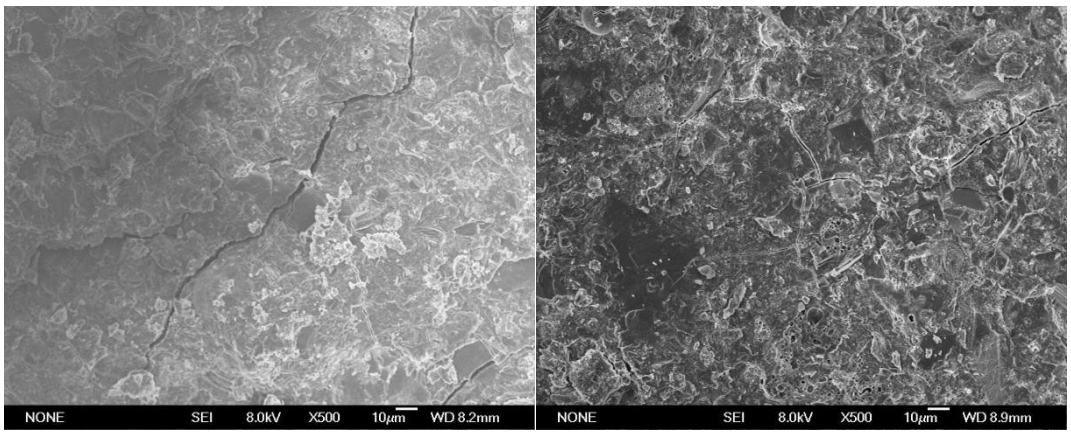


a.dosage 0% b. dosage 0.8%

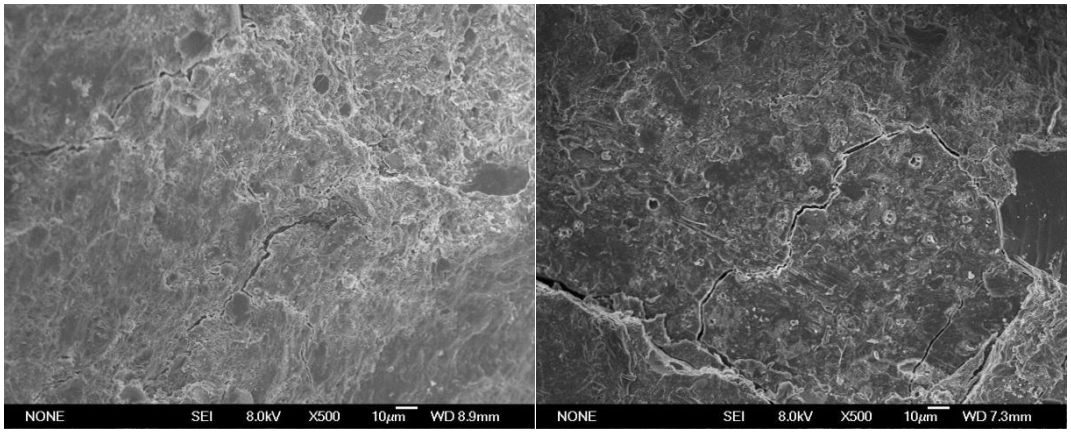


c. dosage 1.0% d. dosage 1.2%

Fig. 6 Sem image after 300 times magnification

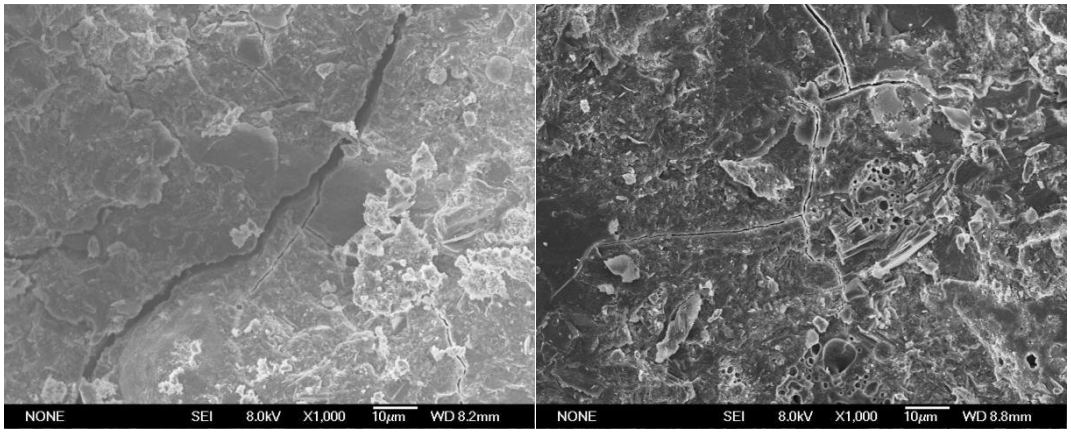


a.dosage 0% b. dosage 0.8%

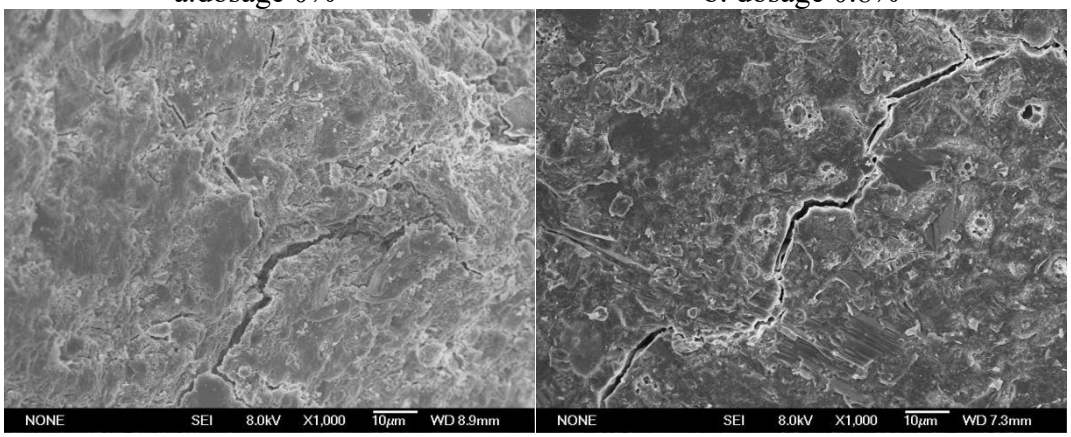


c. dosage 1.0% d. dosage 1.2%

Fig. 7 Sem image after 500 times magnification

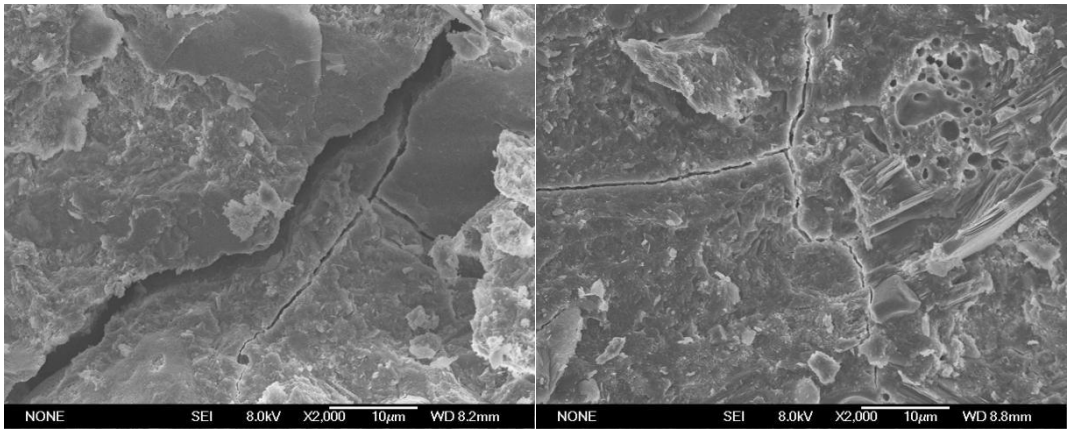


a.dosage 0% b. dosage 0.8%

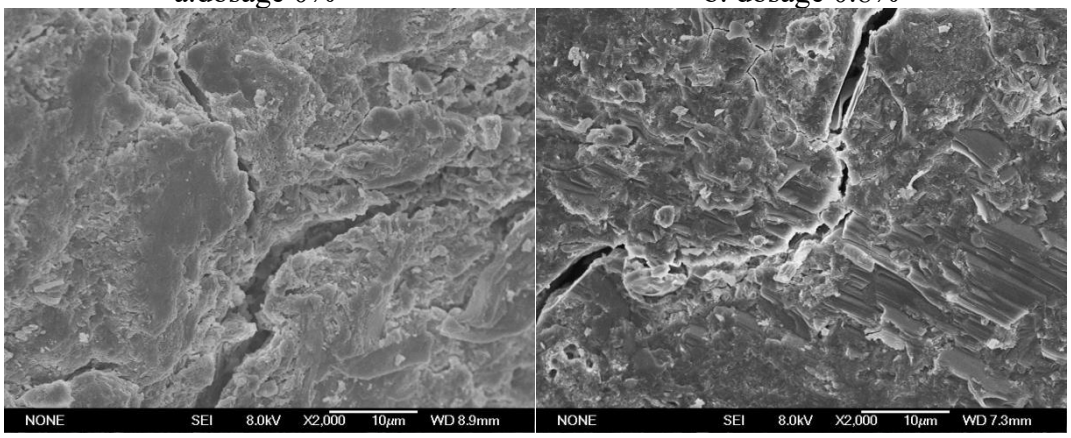


c. dosage 1.0% d. dosage 1.2%

Fig. 8 Sem image after 1000 times magnification



a.dosage 0% b. dosage 0.8%



c. dosage 1.0% d. dosage 1.2%

Fig. 9 Sem image after 2000 times magnification

6. Conclusion and Prospect

6.1 Conclusion

(1) The compressive strength test results show that a certain amount of XYPEX admixture can improve the compressive strength of concrete to a certain extent, compared with the benchmark sample, the maximum increase is 9.8%, and when the XYPEX admixture exceeds 1.0%, the concrete strength begins to decrease, indicating that the compressive strength of concrete decreases with the increase of the addition of XYPEX admixture, and the two show a parabolic relationship. The maximum compressive strength was obtained when the content of XYPEX was 1.0%.

(2) The comparison of impermeability test results shows that the impermeability of shotcrete with various mixtures is higher than that of blank specimens without XYPEX blend. The impermeability of the four types of panel concrete impermeability specimens at 56 days of age under standard curing conditions is improved compared with 28 days, but the impermeability improvement is more obvious after the addition of XYPEX blend. In particular, the permeability resistance of 0.8% and the seepage pressure increased by more than 3.9MPa, indicating that XYPEX additive has a better self-healing filling effect on the internal permeation channels of concrete, and the macro performance is the improvement of the permeability resistance of concrete.

(3) According to the SEM results, there are cracks on the surface of XYPEX concrete with different content, and the cracks of XYPEX concrete with 0.8% content are small and not obvious at small multiratios. Crystalline fillers develop in the cracks of XYPEX concrete, and the more developed the fillers are, the more difficult water penetration is. It is proved that XYPEX concrete exhibits high impermeability in macroscopic

(4) Comprehensive test results, from the perspective of saving engineering costs, 0.8% XYPEX content is recommended as the optimal content, which can not only improve the compressive strength of panel concrete, but also improve the impermeability of panel concrete.

6.2 Prospect

In this test, the influence of XYPEX additives on the compressive strength and permeability resistance of panel concrete was studied without involving other durability indexes. The next step will be to study the frost resistance and crack resistance of the panel concrete after incorporation of XYPEX, so that the research results will be richer and more convincing, and can better serve to ensure the quality of the project.

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