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Chemical Durability of Cement Crystal Increasing Agent Applied Concrete

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1. Introduction

It is unavoidable that structural concrete suffers from erosion by chemical reaction with cement hydrate under such acidic environment condition as acid rain, polluted water, industrial sewage, acidic river water, and so on. The damage of such chemical erosion is increasing year by year. As a countermeasure to the problem of deterioration from acid in structural concrete, the usefulness of a cement crystal multiplicative agent has received a great deal of attention. This inorganic cement crystal, multiplicative agent is called "Xypex" and is manufactured by Xypex Chemical Corporation. Although the use of Xypex is increasing, more detailed experimental and quantitative data is required to support its usefulness and effectiveness. Based on this background, we have performed some experiments to obtain quantitative data on the effectiveness of XYPEX on chemical durability against acid using cement paste samples applied with and without XYPEX.

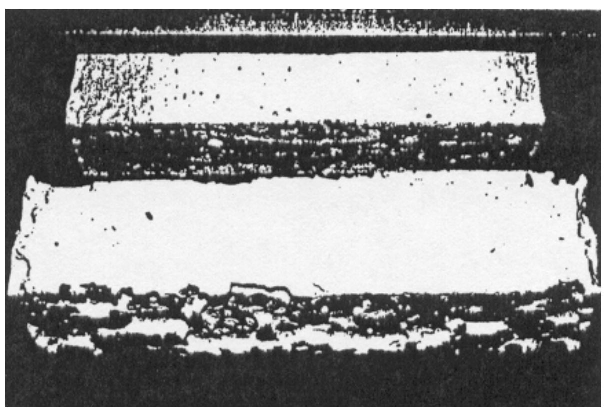
2. Samples and Measurement

We used conventional Portland cement to prepare the samples. The samples were made by mixing the cement and calcium carbonate in a 1:1 ratio, and by adding water so that the water to cement ratio was 60%.

Two shapes of samples were designed. One was a 10x10x40 cm^3 square pillar type for measuring changes in mass and the dynamic elasticity coefficient. The other was a cylinder type for press-testing with a diameter of 5 cm and a length of 10 cm. These samples were made in the following way. The samples were removed from a mold 24 hours after mixing, and then cured for 14 days in water. After curing, the samples were divided into two groups. One group of samples, with XYPEX Concentrate applied to the entire surface, was cured under dry air conditions and the additional curing process was applied for 14 days during which the accelerative curing agent XYPEX Gamma Cure was scattered on the samples surface 3 times a day. The curing time for the other group of samples, without XYPEX applied (hereafter it is called a "reference" sample), was the same as the one for the XYPEX applied group. In a soaking test, the samples were soaked completely in a 5% sulfuric acid solution (still water solution) for 10 weeks. We observed changes in mass, the dynamic elasticity coefficient, and the resisting pressure weight of the samples of both groups at the end of each week.

3. Experimental Results and Discussion

Figure-1 shows the comparison of the changes in mass, with respect to time, between samples to which XYPEX was applied and soaked in 5% sulfuric acid solution, and ones to which no XYPEX was applied and were also soaked in 5% sulfuric acid solution. As seen from this figure, in the XYPEX applied samples the mass decreasing ratio was very small during the first three weeks, however, increased and reached 20% by the end of the 10th week. On the other hand, in the standard samples, change of mass began right after soaking and reached 60% by the end of the 10th week. Photograph 1 illustrates the samples showing the status of chemical erosion at the end of the 10th week. Remarkable differences in erosion can be observed in these two samples.



Photograph 1 Comparison in the status of chemical erosion in two samples after soaking for 10 weeks.
Top: Standard Samples
Bottom: XYPEX Applied Samples

Figure-2 shows the change in the standing of the dynamic elasticity coefficients. Changes in the dynamic elasticity coefficient showed the same tendencies as the changes in mass. That is, in the XYPEX applied samples, although the decrease of the dynamic elasticity coefficient was small during the first 3 weeks, increases in the decreasing ratio were observed after that. On the other hand, in the reference samples, a remarkable decrease of dynamic elasticity coefficient was observed from the beginning of the soaking test.

Figure-3 shows the changes in the resisting pressure weight in both samples with respect to soaking time. However, a remarkable difference was observed in the nature of the decrease between the two kinds of samples.

As described above, we performed experiments to confirm the effectiveness of XYPEX, observing the changes in mass, the dynamic elasticity coefficient, and the resisting pressure weight (the XYPEX applied samples and the reference samples), in a 5% sulfuric acid solution environment. The reason for the large decrease in mass, the dynamic elasticity coefficient, and the resisting pressure weight in the standard samples is that corrosion by acid proceeds rapidly on the surface of the ordinary concrete without XYPEX application. On the other hand, the reason that decrease in those parameters is suppressed in XYPEX applied samples is that the catalytic crystal increasing agent XYPEX reacts to the active silica included in the unhydrated cement and produces the silicate crystals which have high durability against acid. In conclusion, corrosion of the concrete surface by acid is suppressed and durability against acid is greatly improved by applying XYPEX.

4. Summary

In this report, we have described the results of experimental investigation on the effectiveness of the cement crystal increasing agent as one of the countermeasures for suppressing chemical erosion by acid in concrete structures. It was confirmed that in a 5% sulfuric acid solution environment it is possible to suppress chemical erosion to 1/8 of standard samples by applying XYPEX on the surface of concrete.

From this investigation, it is concluded that the utilization of the cement crystal increasing agent is very effective for suppressing chemical erosion of concrete structures and improving durability of structural concrete.

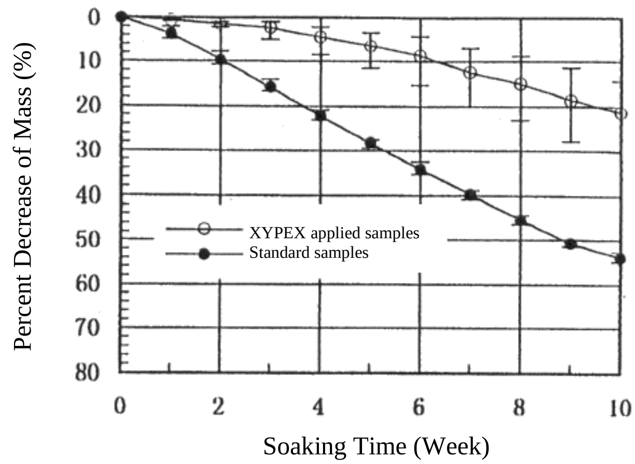


Figure-1 Change in mass of the samples in a 5% sulfuric acid solution environment.

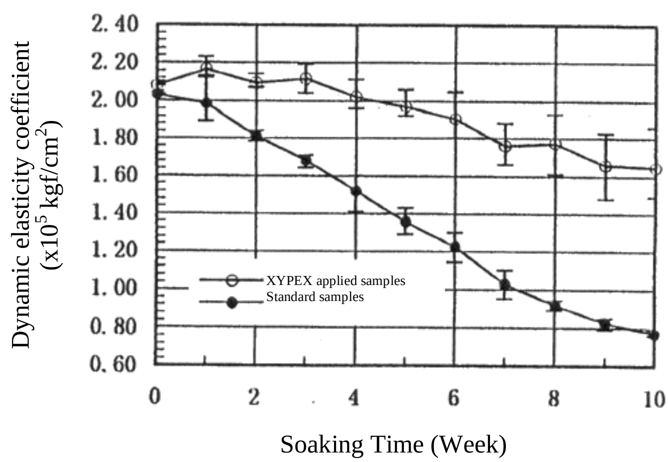


Figure-2 Change in the dynamic elasticity coefficient of the samples in a 5% sulfuric acid solution environment.

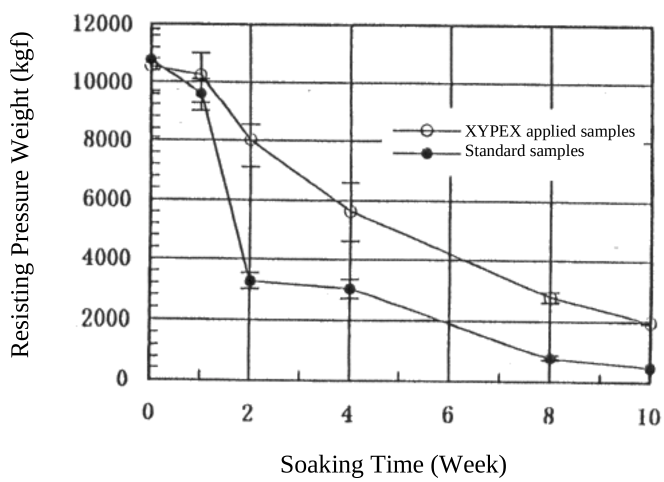
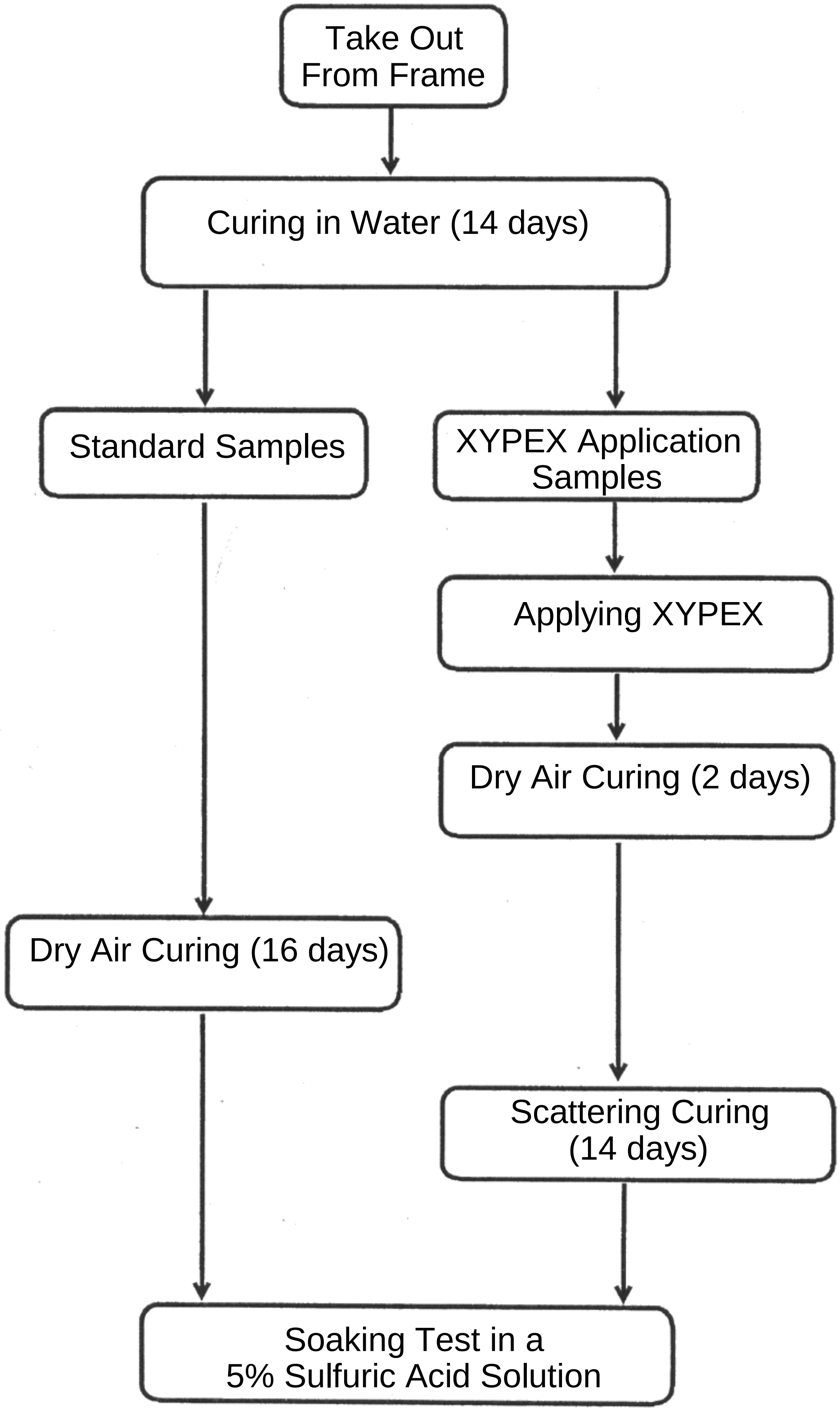


Figure-3 Change in the resisting pressure weight of the samples in a 5% sulfuric acid solution environment.

References
1) Koichi Kishitani, Noriaki Nishizawa and Kunio Minakami, “Chemical Erosion” in the series of “Durability of Structural Concrete”, Hakuhodo Publication Inc.

Flow Diagram of Curing



Photograph-2 Experimental Samples
Top: square pillar type sample (10x10x40cm^3)
Bottom: Cylinder type sample (Ø5 x 10 cm)

Photograph-3 Soaking test in a 5% sulfuric acid solution
Cylinder type sample (Ø5 x 10 cm)

Before Soaking

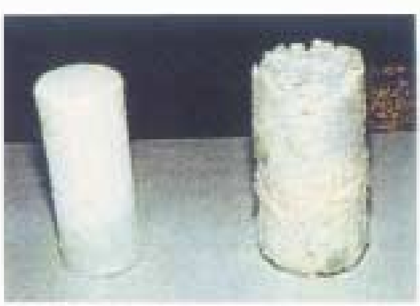
5th Week

1st Week

6th Week

2nd Week

7th Week



4th Week

10th Week

Photograph-4: Status of chemical erosion after various soaking times
Right: XYPEX applied sample
Left: Standard sample