Acid Resistance of Mortar With Xypex Concentrate and Xypex Admix C-1000NF

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The main objective of this research was to determine the acid resistance of mortars which were designed to have different water to binder ratios and fly ash contents. Xypex Concentrate and Xypex Admix C-1000NF were applied.

CONCLUSION

It was observed that weight loss of coated mortars were lower than that of the uncoated mortars for the same mix proportion.

Keywords: Acid Resistance.

Key Points:

"weight loss of coated mortars were lower than that of the uncoated mortars"

ACID RESISTANCE OF MORTAR WITH XYPEX CONCENTRATE AND XYPEX ADMIX C-1000NF

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1. INTRODUCTION

This research program was undertaken at Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) of the Thammasat University with research fund from Xypex Marketing Service (Thailand). The main objective of this research was to determine the acid resistance of mortars which were designed to have different water to binder ratios (0.4, 0.5) and fly ash contents (0, 30%). Two types of crystalline materials i.e. Xypex Concentrate and Xypex Admix C-1000NF were applied. Both Xypex Concentrate and Xypex Admix C-1000NF improved the acid resistance of mortar.

2. MATERIALS AND MIX PROPORTIONS

Cement type 1 (OPC1) and fly ash class F (FA) were used as binders. Xypex Admix C-1000NF (CA) was used as an admixture (1% by weight of cementitious materials) and Xypex Concentrate (CCM) was used as a coating material in the case of coated sample. Cement paste (C100) and cement-fly ash paste with 30% fly ash replacement (FA30) with different water-to-binder ratios (0.4, 0.5) were used. River sand with specific gravity of 2.60 and F.M. of 2.13 was used as fine aggregate. The fine aggregate used in the experiments complies with ASTM C33 [1].

2.1 Uncoated mortars and mortars coated with Xypex Concentrate

Mortar specimens with the size of 50x50x50 mm^3 were cast and demolded after 24 hr. Cement-only mortars (C100) and mortars with 30% fly ash replacement (FA30) with different water-to-binder ratios (0.4, 0.5) were used. Amount of cement paste in all mortars was controlled to be the same (43.2 % by total volume). Details of mix proportions of mortars coated with crystalline material are given in Table 1 (the first 4 mixtures). These specimens were separated into 5 sets. The first set was uncoated specimen and seal-cured for 7 days (S7) before being submerged in 5% H_2SO_4 solution. The second, third, and fourth sets were specimens coated at the ages of 1, 3 and 7 days, respectively, and were seal-cured for 3 days (C1S3, C3S3, C7S3) before being submerged in 5% H_2SO_4 solution. The fifth set was specimens coated at the ages of 3 days and seal-cured for 7 days (C3S7) before being submerged in 5% H_2SO_4 solution. Figure 1 illustrates the period of curing and coating time for each group of specimens.

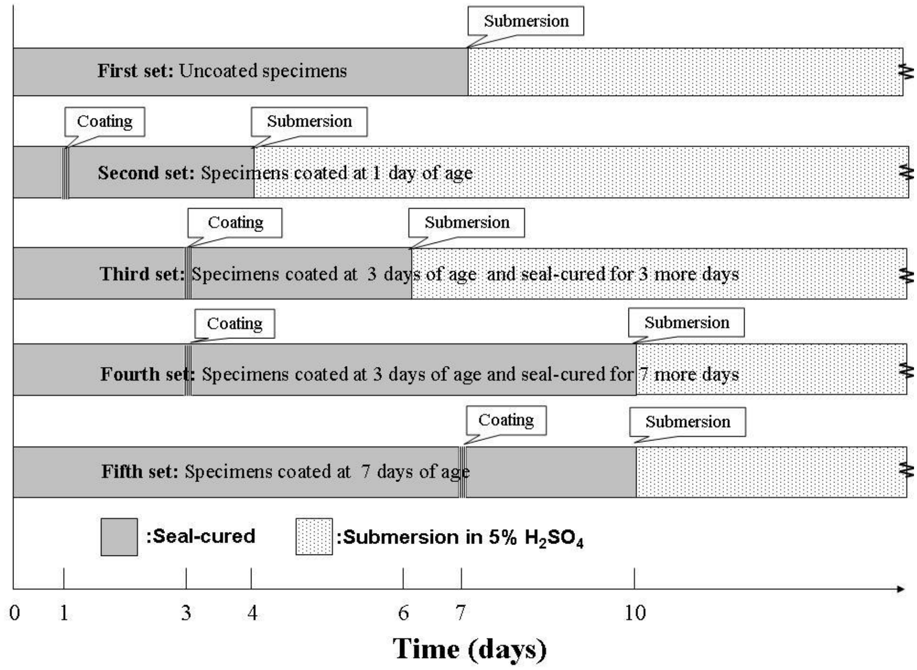

Figure 1: Illustration of curing periods and time of coating of uncoated and coated specimens

2.2 Mortars with 1% Xypex Admix C-1000NF

Cement-only mortars with 1% CA (A1) and 30% fly ash mortars with 1% CA (FA30A1) containing water-to-binder 0.5 were prepared. These specimens were seal-cured for 3, 7, 28 days (-S3, -S7 and -S28), respectively, before being submerged in 5% H_2SO_4 solution. The details of mix proportions of mortars with Xypex Admix C-1000NF are given in Table 1 (the last 2 mixtures).

Table 1: Mix proportions of mortars

Mix	C	FA	W	S	CA
0.4	588.2	0	235	1505	-
0.5	516.2	0	258	1505	-
0.4FA30	386.1	165.5	221	1505	-
0.5FA30	341.5	146.3	244	1505	-
0.5C100A1	511.8	0	258	1505	5.2
0.5FA30A1	337.0	146.3	244	1505	4.9

Where C, FA, W, S, and CA are weight of cement, fly ash, water, sand, and crystalline admixture (kg/m^3)

3. TESTING METHOD

3.1 Hydro sulfuric acid solution for submersion test

The mortar specimens were submerged in 5% H_2SO_4 solution. 5% which was chosen o simulate the aggressive environment in sewer system. The ratio of acid volume to the surface area of specimens was fixed at 5:1. 5% H_2SO_4 was prepared 1 day before the submersion and renewed every 2 weeks. The pH value of the 5% H_2SO_4 solution was monitored with a digital pH meter. The pH value of the H_2SO_4 solution before the submersion of mortar specimens was 0.25 and not greater than 0.54 during submersion period [2].

Table 1: Mix proportions of cement pastes

MIX	C	FA	W	CA
0.4	1380	0	552	-
0.5	1211	0	606	-
0.4FA30	922	395	527	-
0.5FA30	814	349	581	-
0.4C100A1	1366	0	552	14
0.5C100A1	1199	0	605	12
0.4FA30A1	909	395	527	13
0.5FA30A1	797	347	577	12

Where C, FA, W, and CA are weight of cement, fly ash, water, and Xypex Admix C-1000NF (kg/m^3)

3.2 Weight loss and visual observation of samples

Initial weight of each specimen was measured in the SSD condition before being submerged in 5% H_2SO_4 solution. During this submersion, mortar specimens were periodically retrieved from the acid solution for visual inspection of the surface appearance. Photographs of the mortar specimens were also taken after different period of submersion to record changes of the surface appearance.

Weight loss of each specimen was monitored by measuring weight change of each specimen in the SSD condition until 12 weeks of submersion. At each time of weight measurement, the specimens were washed to remove loose particles and then weighted for their SSD weight. The weight change of a mortar specimen in percentage relative to its initial weight was used as an indicator of the deterioration of the mortar specimen [3].

4. RESULTS AND DISCUSSIONS

4.1 Weight loss of mortar with Xypex Admix C-1000NF over submersion time

Figure 1 and Figure 2 show the effect of Xypex Admix C-1000NF on the weight loss of mortars. The results show that the mortars with Xypex Admix C-1000NF have lower weight loss than the control mortars (0.5-S7) and 30% fly ash mortars (0.5FA30-S7). At 12 weeks of exposure, one percent of CA can reduce the weight loss up to 48% and 53% in the case of cement-only mortar (compare 0.5A1-S7 with 0.5-S7) and fly ash concrete (compare 0.5FA30A1-S7 with 0.5FA30-S7), respectively.

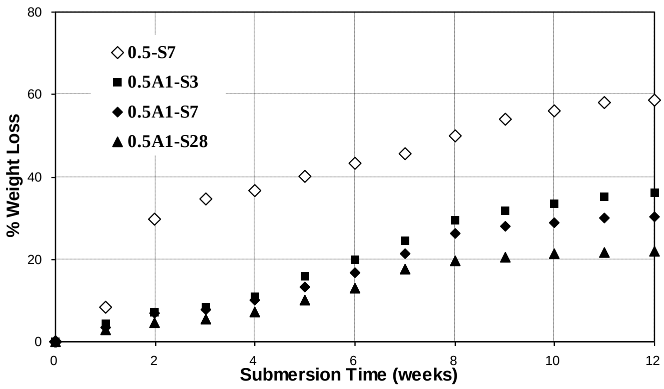

Figure 1: Weight loss of mortar with 1% CA

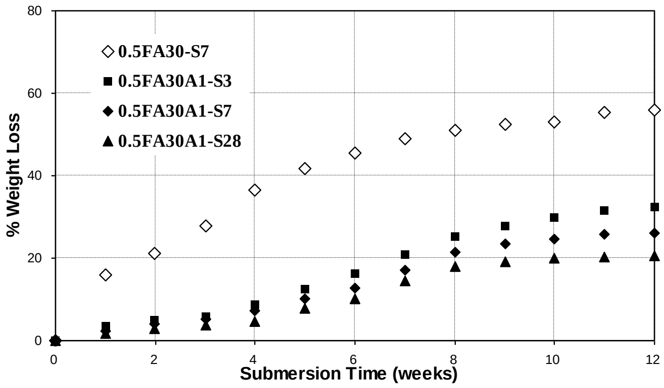

Figure 2: Weight loss of fly ash mortar with 1% CA

The results also show that, when compare with exposure at 7 days, acid resistance of mortar with 1%CA becomes better if the start of exposure to acid is delayed to 28 days and worse if the sample is exposed to acid at 3 days. However, it was found that mortar with 1% CA exposed at 3 days still give substantially better performance in comparison with ordinary mortars (without CA) exposed at 7 days [3].

4.2 Weight loss of mortar coated with Xypex Concentrate over submersion time

The weight loss percentage of the coated mortar is plotted against the adjusted exposure time (t_{adj}) in Figure 3 to Figure 6. In all cases, all uncoated specimens have higher weight loss than the coated specimens of the same mix proportion. This means that the base mortar show better acid resistance even after the contribution of the coating and modified layers is excluded, however, the effect is not as large as the case of mortar with CA.

CCM Coating at age of 1 day provides the best acid resistance (lowest weight loss) than the coating at other ages except for the case of 0.4FA30 specimens which show similar weight loss for all coating times. And, by comparing C3S3 and C3S7 cases in Figure 3 to Figure 6, it may be concluded that the length of curing period provided after coating hardly affects the performance of CCM. From these results, it is suggested for the practical application that the CCM coating is applied at one day and curing of three after coating is sufficient.

Figure 7 and Figure 8 compare the effect of CCM coating on the reduction of weight loss after the 12 weeks of submersion. In the case of mortar without CCM coating, low w/b specimen has higher resistance (less weight loss) because higher w/b mortar is more porous and this is true for both the cases of cement-only (Figure 7) and fly ash mortars (Figure 8). In the case of coated mortars, CCM seems to be more effective to improve acid resistance (more reduction of weight loss) of the cement-only mortars than fly ash mortars (see Figure 7 and Figure 8) [3].

The reduction of weight loss by CCM coating is also larger for the fly ash mortar with higher w/b (w/b= 0.5). The reduction of weight loss was only 5.98% for 0.4FA30 but was 21.30% for 0.5FA30 (see Figure 8). As the results, 0.5FA30C1S3 has better acid resistance than 0.4FA30C1S3 [3].

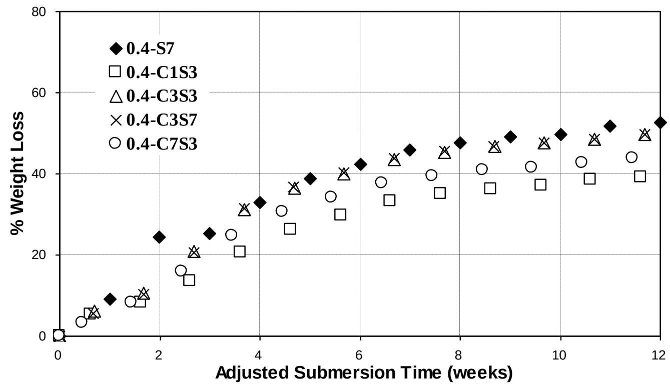

Figure 3: Weight loss of coated mortar w/b 0.4

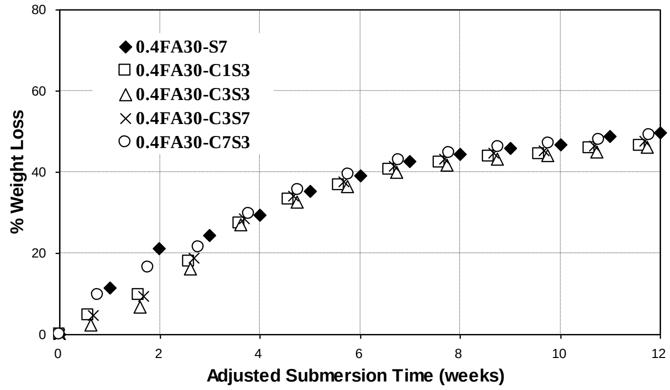

Figure 4: Weight loss of coated fly ash mortar w/b 0.4

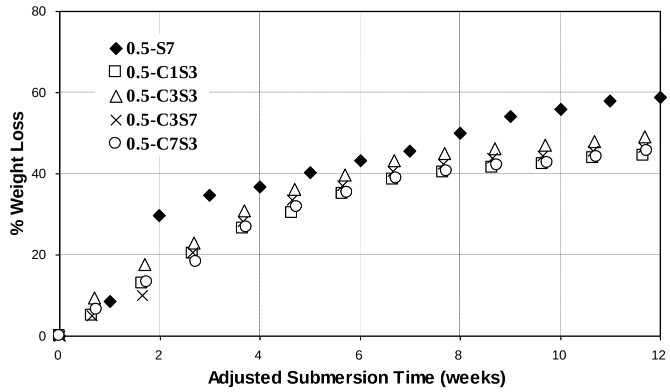

Figure 5: Weight loss of coated mortar w/b 0.5

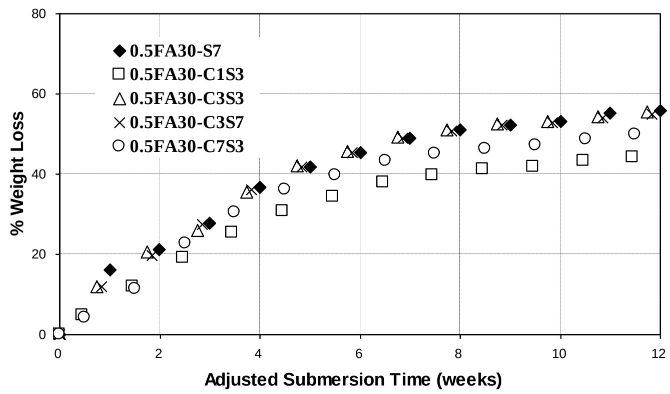

Figure 6: Weight of coated fly ash mortar w/b 0.5

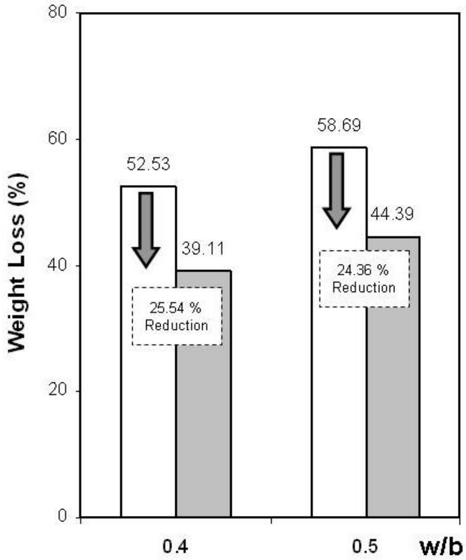

Figure 7: Reduction of weight loss of cement-only mortar after 12 weeks of exposure by the effect of CCM coating (C1S3)

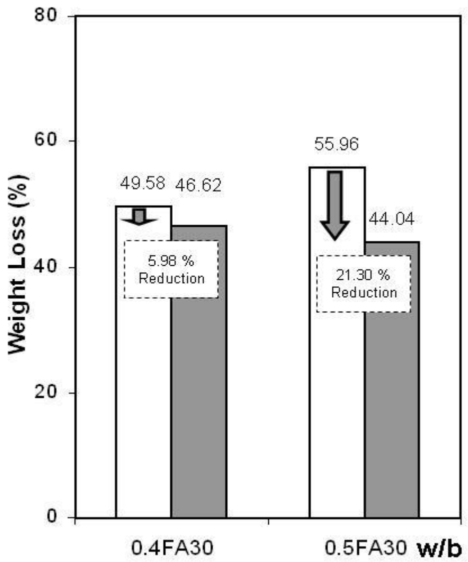

Figure 8: Reduction of weight loss of fly ash mortar after 12 weeks exposure by the effect of CCM coating (C1S3)

4.3 Visual observation of mortar specimens

The appearances of the uncoated mortar specimens (0.5-S7) and ones coated at 1 day (0.5-S1C3) after different period of 5% H_2SO_4 exposure are shown in Figure 9. It is clear that the reference mortar, uncoated mortar with w/b 0.5 (0.5S7), shows severer damage with significant loss of paste near the surface of the specimen. This observation indicates that surface of the uncoated specimens are more vulnerable to acid attack.

Figure 9: The deterioration of uncoated specimen (Top) and specimen coated at the age of 1 day (Bottom) with cement-only w/b 0.5 during submersion period

5. CONCLUSION

From the tested results, weight loss of coated mortars was lower than that of the uncoated mortars for the same mix proportion. The mortar coated with crystalline coating material at the age of 1 day had lower weight loss than mortar coated at 3, and 7 days. After 12 weeks of submersion, mortars with 1% crystalline admixture by weight of binder have lower weight loss than uncoated and coated mortars at the same water to binder ratio and fly ash content**.**

6. REFERENCES

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