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ADHESION MECHANISM OF PRIMER APPLIED FOR FINISH COAT MORTAR

Hiroshi ABE*, Takayuki HIRAI**, Kenji MOTOHASHI***

Ethylene-vinyl acetate or polyacrylic ester emulsion have been used as primers to improve the adhesion strength of finish coat mortar. In this study, the adhesion mechanism of primer was investigated by adhesion test, water absorption test and analysis of calcium hydroxide by thermogravimetry. The primer layer that was coated on the substrate concrete reduced the absorption of water from finish coat mortar to substrate concrete. Regardless of the water content of the substrate concrete, an improvement in the adhesion strength between the finish coat mortar and substrate concrete was gained by the application of the primer. Sufficient hydration of cement in the finish coat mortar occureed around the bonded interface when the primer was applied on the surface of the substrate concrete.

KEY WORDS : Primer, Adhesion Strength, Cement mortar, Water Absorption, Calcium Hydroxide

1. INTRODUCTION

Concerning on primer, the study of early adhesion centering on the mortar adhesion test, durability and deformation attendantness are given, but there are still many unelucidated parts, including adhesion mechanism. On this study, in order to confirm the effects of primer, we executed the adhesion tests, the water absorption tests and the quantitative analysis tests of calcium hydroxide, and examined the adhesion mechanism of primer.

2. EXPERIMENTAL METHOD

On the Table 1, as the factors of experiments, we show the state of water content of substrata, the method of substrata treatment and the curing conditions. We used the ethylene-vinyl-acetate polymer dispersion system as primer, and applied the same concentration as shown on Table 1. The mix proportion of finish coat mortar is shown on the Table 2.

2.1 ADHESION TEST

By polishing papers polishing mortar substrata for tests (70 × 70 × 20 mm) provided in JIS 6909, and cleaning them, applying the primer shown on Table 1 by rate of 15 g/m2, we dried them during 24 hours. Fitting the mold of inside measure of 40 × 40 × 10 mm to substrata we trowelled finish coat mortar shown on the Table 2 inside the mould. After curing them under curing condition shown on the Table 1, equipping the steel jigs measuring the largest tensile load, we calculated the adhesion strength.

2.2 WATER ABSORPTION TEST

As same as 2.1, applying the primer to mortar substrata, drying during 24 hours, sealing the four sides with epoxy resin in accordance with JISA 6916, lowering the face applied the primer, soaking them in the water until depth of 10 mm, we measured the absorption after 1, 3, 6, 12, 24 and 48 hours.

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* Graduate School of Engineering, Doctor's Courses, Oita University
** Department of Wellfare Enginering, Faculty of Engineering, Oita University
***Building Research Institute, the Ministry of Construction

2.3 QUANTITATIVE ANALYSIS OF CALCIUM HYDROXIDE

As same as 2.1, we made the specimens for measuring thermogravimetry (TG). Scraping mortar substrata under 1 mm by diamond cutters, we scraped the parts, where remained mortar substrata, and the films of primer by cutter-knife. Dehydrating the taken out finish coat mortar by acetone, after drying them by vacuums, scraping the neighborhood of adhesion surfaces by steel files, we got assay samples. With the same way we got assay samples from the parts of mortar of the depth of 1, 3 and 5 mm from the neighborhood of adhesion surfaces. Holding them during 15 minutes in 105 ℃, standardizing the weight of this time, we calculated the amount of Ca(OH)2, include the parts of carbonation, from the width of decrease of weight from 380 ℃ to 650 ℃ of the chart. Moreover, as comparison, executing sealed curing of mortar of the same mix proportion with the finish coat mortar, we analyzed the amount of Ca(OH)2.

3. RESULTS AND DISCUSSIONS

3.1 ADHESION TEST

1) Percentage of water content of substrata: in normal cases

We show the results of mortar adhesion tests in the Fig. 1. Comparing with applying primer, moisture and intactness of mortar, adhesive strength by applying primer remarkably improved as over1.5 N/mm2. As to the state of break as shown in the Fig. 2, in applying primer the break from inside of mortar was dominant, but in the state of moisture and intactness the break from the boundary faces of substrate and finish coat mortar was dominant.

2) Percentage of water content of substrata: in dry cases

From the Fig. 1 adhesive strength shows almost the same tendency in normal cases, and has little influence in the percentage of water content of substrata. But on the state of break, in the case of applying primer as same as 1) cohesive break occurred from inside of mortar and in the cases of moisture and intactness also break occurred from inside of mortar, and adhesive strength was under 1 N/mm2 and the break face was fragile. It is thought that the appearance of mortar strength is insufficient because water content in mortar is absorbed into the substrata and the hydration of cement is inhibited.

3.2 WATER ABSORPTION TEST

1) Percentage of water content of substrata: in normal cases

In the Fig. 3, we show aging variation of amount of water absorption against the substrata of primer with each concentration in the normal cases of the percentage of water content of substrata.

On the cases of applying each concentration, water absorption slowly continues for a long time, and the higher the concentration of primer is, the less the amount of water absorption is. In the cases of intactness, the amount of water absorption is about 5 g/49 cm2 for 24 hours, converting each m2 that is 1.0 kg/m2. As the amount of water included in the finish coat mortar of the depth of 10 mm is 3.5 kg per m2, even in the normal state of water content, if the absorption of water continues for a long time, there is possibility of dry and of mortar specially at the neighborhood of adhesive interface.

2) Percentage of water content of substrata: in dry cases

In the Fig. 4, we show the results of water absorption tests in the case where percentage of water content of substrata is dry. Comparing with the normal cases of substrata, as absorption is rapid in shorter time, in the unsuitable area of primer concentration, capability of preventing strength appearance of finish coat mortar is more higher because of dry out. In the cases of intactness, there are amount of water absorption of 18 g/49 cm2 (3.7 kg/m2) for 24 hours, and in the substrata, where are dry and have large absorption, the lower the concentration is, the smaller the effect of prevention of water absorption is.

3.3 QUANTITATIVE ANALYSIS OF CALCIUM HYDROXIDE

1) Amount of Ca(OH)2 in sealed curing mortar

As TG can accurately is analyzed by minor specimens of some 10 mg, if both heat decomposition reaction and decomposition temperature of aimed material are known, it is suitable for quantitative analysis of $Ca(OH)_2$ produced by hydration of cement. In the Fig. 6 we show the change of weight standardized at 105 ℃ about each material measured by TG. The loss of weight occurred by hydration of cement in the mortar of standard sand was observed in the range of temperature of 400-500 ℃.

In the Fig. 7, we show the measured results at each age of the amounts of $Ca(OH)_2$ in the sealed curing mortar, passing about 6 hours after the hydration, amounts of $Ca(OH)_2$ in the mortar rapidly increased and became definite after 7 days of age. Perfect hydration of normal portland cement produced about 25-33% of $Ca(OH)_2$, but amounts of $Ca(OH)_2$ included in the mortar was 7-8% as they included aggregate.

2) Amounts of $Ca(OH)_2$ included in finish coat mortar

In the Fig.8, we show the distribution of depth direction from adhesive interfaces as to the amounts of $Ca(OH)_2$ included in the finish coat mortar. From the Fig. 8 in the normal cases of percentage of water content of substrata, the influence for hydration of cement in the mortar by the concentration of primer is small, but the amounts of $Ca(OH)_2$ in the neighborhood of adhesive interfaces are higher by about 2% than those inside of the mortar. This is because the layers, where hold much amounts of cement, exist in the neighborhood of interfaces of mortar. Because of the mortar of air-dried curing, compared with the mortar of sealed curing, the amounts of $Ca(OH)_2$ in the finish coat mortar are about 4% little in spite of the concentration of primer. This is because water was evaporated except absorption of the substrate. Moreover, in the Fig.9 we show the distribution of the amounts of $Ca(OH)_2$ in dry cases of substrata. The amounts of $Ca(OH)_2$ inside of mortar, where primer of high concentration was applied, are almost about 4% as same as in normal cases. While the amounts of $Ca(OH)_2$, in the cases of applying low concentration, moisture and intactness, are 2% little. From this analysis, we understand as follows. That is, from the Fig. 6 the 2% amounts of $Ca(OH)_2$ in mortar of sealed curing are equivalent to the amounts of 12 hours after adding water, and the water in mortar is absorbed into the substrata and mortar is under the state of dry out.

In the Fig. 10, by percentage of water content of substrata, we compare the amounts of $Ca(OH)_2$ in mortar in the neighborhood of interfaces. The percentage of water content of substrata greatly influenced the amounts of $Ca(OH)_2$ in mortar in the neighborhood of adhesive interfaces, and at the dry substrata the amounts of $Ca(OH)_2$ were little and hydration of cement was insufficient. As to the influence of the percentage of water content of substrata, the difference of adhesive strength was not seen in the adhesion tests, but the influence of the percentage of water content of substrata for hydration of cement in the mortar was clearly caught from results of analysis of the amounts of $Ca(OH)_2$ of the finish coat mortar. As the effect of primer, we confirmed the advancing of hydration of cement in the finish coat mortar in the neighborhood of adhesive interfaces.

4. CONCLUSION

From the effect of adhesion tests, by applying primers with proper concentration, the adhesive property of the finish coat mortar was improved without receiving the influence of percentage of water content of substrata.

From both the absorption tests and the results of analysis of $Ca(OH)_2$ in the finish coat mortar, it was observed that the primer properly regulated the migration of water in the finish coat mortar and had the protective effect of dry out without obstructing the hydration of cement.

By applying primer with proper ranged concentration on the substrata, the influence of percentage of water content of substrata becomes less, and both adhesive strength and the hydration of cement in finish coat mortar are kept. It is thought that by forming precise mortar layers at the neighborhood of adhesive interfaces as adhesion mechanism of primer, adhesiveness is improved.

We could inspect both the grade of hydration of cement in mortar gained from results of analysis of $Ca(OH)_2$ in finish coat mortar by TG, and the effects of primer from the results of adhesion tests and water absorption tests etc..

Table 1 Factors and levels in experiment

Factor	Level	
Water content of substrate	Ordinary : Water content 7 wt%	
	Dry : Dring to constant weight at 105℃	
Application of primer on substrate	Mortar primer	Ingredient : Ethylene-vinyl acetate
		Concentration : 22.3,14.8, 11.4, 7.5 and 5.0%
	Water : Application of water 300g/m²	
	Non primer	
Curing methed	Primer : 20℃ ,65%(RH) 24h	
	After bonding : 20℃ ,80%over(RH) 2d and	
	mortar 20℃ ,65%(RH) 26d	

Table 2 Mix proportion of finish coat mortar (wt.%)

Ordinary portland cement	Toyoura standerd sand	Water
27.4	54.8	17.8

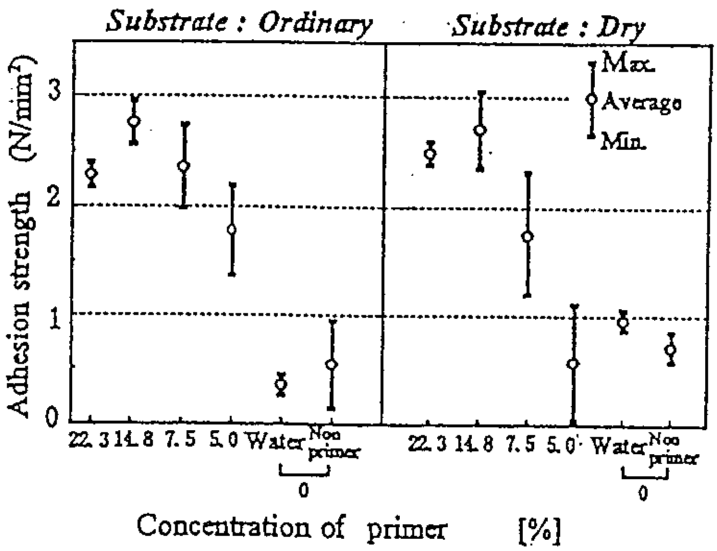

Fig. 1 Relationship between concentration of primer and adhesion strength

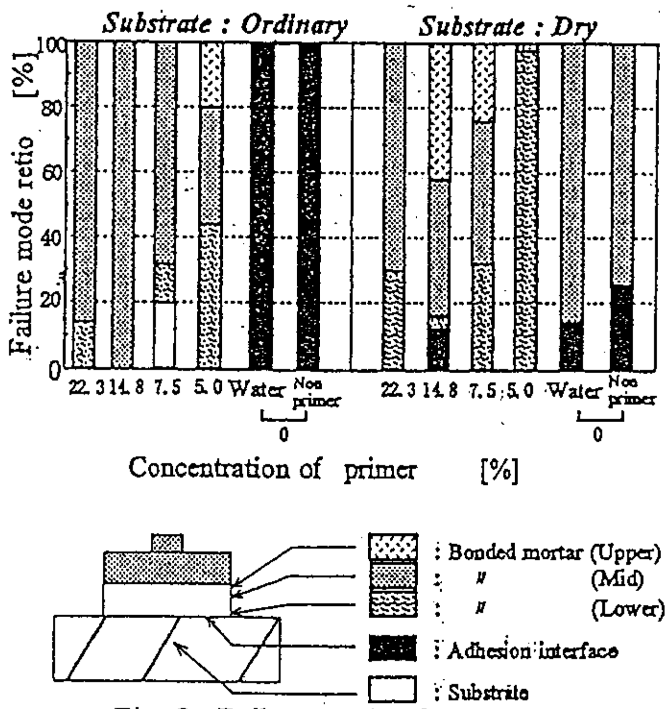

Fig. 2 Failure mode of adhesion test

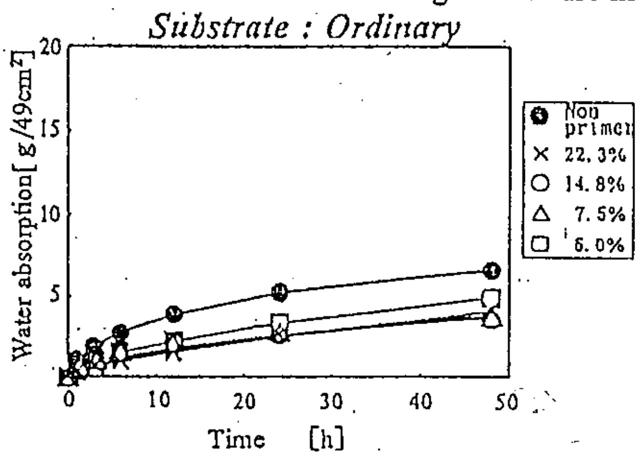

Fig. 3 Relationship between time and water absorption under different concentrations of primer on ordinary substrate

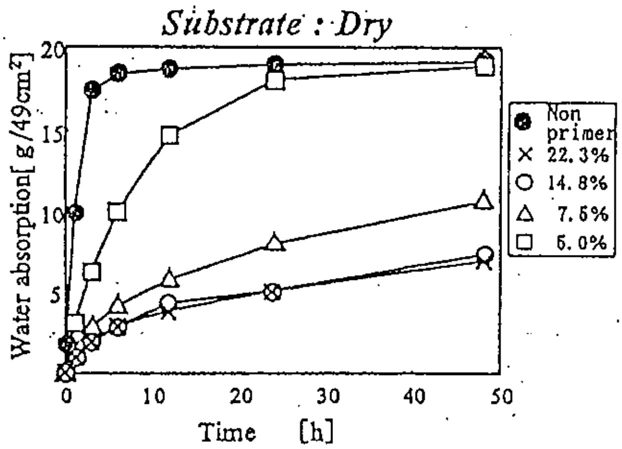

Fig. 4 Relationship between time and water absorption under different concentrations of primer on dry substrate

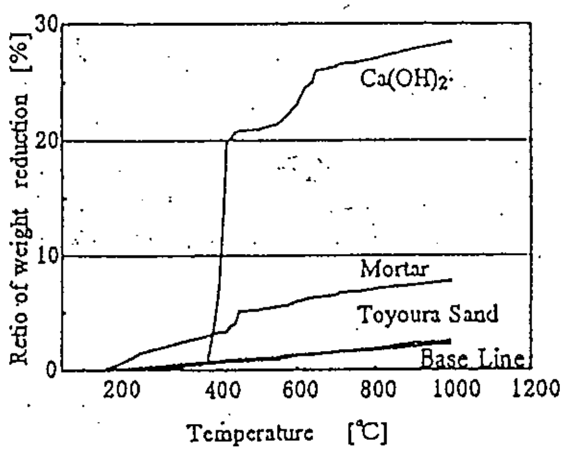

Fig. 5 Relationship between temperature and weight reduction

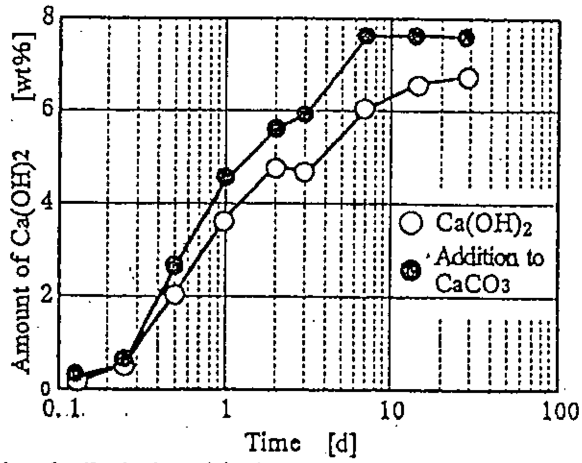

Fig. 6 Relationship between age and amount of $Ca(OH)_2$ in seal suring mortar

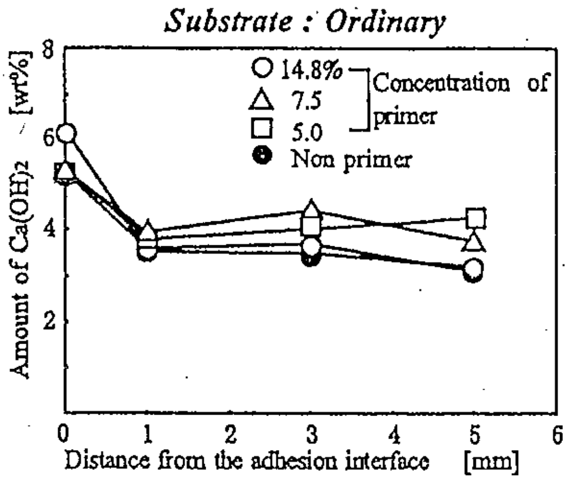

Fig. 7 Relationship between distance from adhesion interface and amount of $Ca(OH)_2$ on ordinary condition substrate

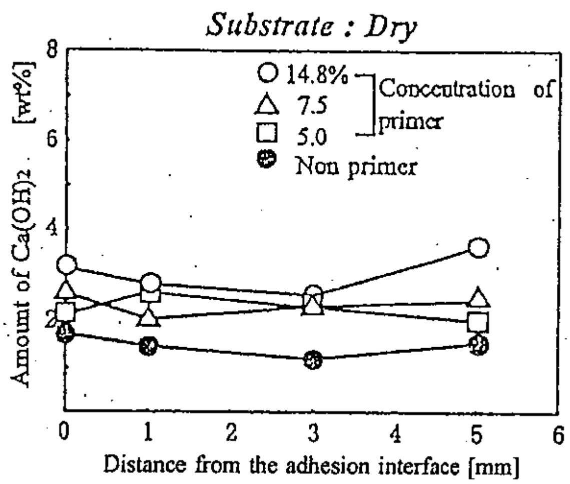

Fig. 8 Relationship between distance from adhesion interface and amount of $Ca(OH)_2$ on dry condition substrate

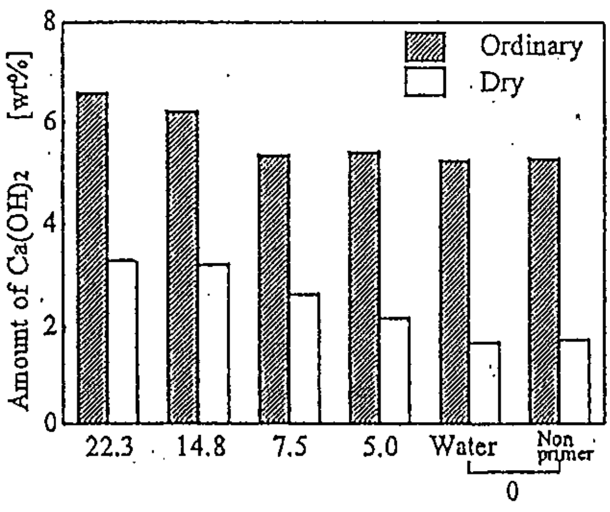

Fig. 9 Amount of $Ca(OH)_2$ in bonded mortar in the adhesion interface