論 文

[2117] Application of Polymer Dispersions as Primers for Troweling Works

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1. INTRODUCTION

Ordinary cement mortar, one of the most common construction materials has widely been used as a finishing or repairing material. Thus it is extremely important to maintain the certain adhesion or bond of fresh mortar to concrete or mortar surfaces in the construction industry. For the purpose of obtaining the certain adhesion, polymer dispersions (latexes or emulsions) have been employed as primers or bonding agents for the concrete or mortar surfaces for the past 20 years [1,2,3,4]. In the United States, an ASTM Standard for the quality requirements of such polymer dispersions has already been published [5]. However, the effectiveness of the polymer dispersions as adhesion aids has differently been evaluated by their manufacturers and users till now [2].

The mechanism of improving the adhesion between fresh mortar and concrete or mortar substrates by polymer dispersion coatings is generally considered as follows [6]:

(1) The prevention of dry-out due to the inhibition of water absorption into the concrete or mortar substrates and of air bubbles releasing with water absorption from the substrates by the effects of the formed polymer films.
(2) The reinforcement of the bonding surfaces due to the penetration of the polymer dispersions into the surface layers of the concrete or mortar substrates.
(3) The formation of chemical bonds and micromechanical interlocking mechanisms through the formed polymer films at the adhesive interfaces.
(4) Relaxation of stresses occurring at the adhesive interfaces by the formed polymer films.

The paper deals with a basic study on an improvement in the adhesion of fresh mortar to mortar substrates with polymer dispersion coatings. Mortar substrates are coated with three types of polymer dispersions as primers with various polymer solid contents at various coverage rates. After various open times, the polymer dispersion coated mortar substrates were bonded or placed with fresh mortar, and the coated mortar substrates bonded with the fresh mortar were tested for adhesion in tension. The effects of the open time, polymer solid content and coverage rate on the adhesion in tension are discussed.

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2. MATERIALS

2.1 CEMENT AND AGGREGATE

Ordinary portland cement and Toyoura standard sand were used for mortar substrates and fresh mortar bonded to or placed on them.

2.2 POLYMER DISPERSIONS FOR PRIMERS OR BONDING AGENTS

Commercially available polymer dispersions used as primers or bonding agents were a styrene-butadiene rubber (SBR) latex, an ethylene-vinyl acetate (EVA) emulsion and a polyacrylic ester (PAE) emulsion. Their properties are listed in Table 1. The polymer solid content of the polymer dispersions was adjusted to be 10, 15 and 20% by diluting with tap water.

Table 1. Properties of Polymer Dispersions.

Type of Polymer Dispersion	Specific Gravity (20°C)	pH (20°C)	Viscosity (20°C, cP)	Total Solids (%)
EVA	1.06	4.99	1000	44.49
PAE	1.08	9.27	42.5	44.65
SBR	1.02	9.13	135	45.11

3. TESTING PROCEDURES

3.1 PREPARATION OF MORTAR SUBSTRATES

Ordinary cement mortar was mixed according to JIS R 5201(Physical Testing Methods for Cement) with a weight ratio of cement to standard sand 1:2 and a water-cement ratio of 65%. Mortar substrates 70X70X20 mm were molded, and given a 1-day-20°C-80% R.H.-moist, 1-day-70°C-water and 5-day-20°C-50% R.H.-dry cure. Then the bonding surfaces of the mortar substrates were treated with the AA-150 abrasive papers specified in JIS R 6252 (Abrasive Papers), and blown with compressed air to remove free dust particles before coating polymer dispersions.

3.2 PREPARATION OF SPECIMENS

Mortar substrates were coated with polymer dispersions with polymer solid contents of 10, 15 and 20% at coverage rates of 20, 25 and 30 g/m^2 , and the coated mortar substrates were stored at 20°C and 50% R.H. for the respective open times before placing fresh mortar. The fresh mortar was mixed with a weight ratio of cement to standard sand 1:3 and a water-cement ratio of 72%. Specimens were made by placing the fresh mortar on the polymer dispersion coated surfaces of the mortar substrates as shown in Fig. 1, and subjected to a 1-day-20°C-80% R.H.-moist, 6-day-20°C-water and 21-day-20°C-50% R.H.-dry cure.

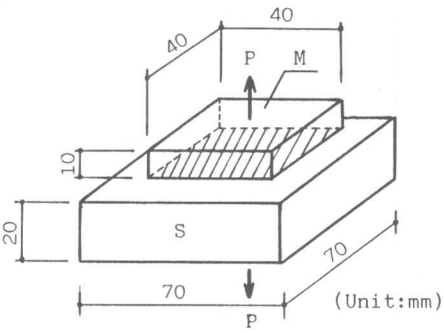


Fig.1 Specimen for Adhesion Test

3.3 ADHESION TEST

After curing, specimens were tested for adhesion in tension by using a manually operated pull-gage in accordance with JIS A 6915 (Wall Coatings for Thick Textured Finishes). The adhesion in tension was calculated as follows:

$$\text{Adhesion in tension } (kgf/cm^2) = P/A$$

where P is the maximum load (kgf), and A is the area (cm^2) of the bonded surfaces.

After adhesion test, the failed cross-sections of the specimens were observed for failure modes, which were classified into the following three types:

A: Adhesive failure (failure in the interface)
M: Cohesive failure in the bonded mortar
S: Cohesive failure in the mortar substrate

The total area of the bonded surfaces was supposed to be 10, and the respective approximate rates of A, M and S areas on the failed cross-sections were expressed as suffixes for A, M and S. The adhesive interfaces between bonded mortar and polymer dispersion coated mortar substrates were observed by a scanning electron microscope on the samples prepared from the specimens after adhesion test.

4. TEST RESULTS AND DISCUSSION

Figs.2 to 4 show the adhesion in tension of bonded mortar to polymer dispersion coated mortar substrates with various coverage rates and open times. In general, the adhesion in tension of the bonded mortar to the polymer dispersion coated mortar substrates increases with additional open time, and becomes nearly constant at open times of 1 to 7 days. The adhesion in tension of the bonded mortar to the coated mortar substrates is larger than that to uncoated mortar substrate. A remarkable improvement in the adhesion in tension is achieved by polymer dispersion coatings to the mortar substrates, except for the coated mortar substrates with an open time of 30 minutes. The improved adhesion in tension to the coated mortar substrates is about 2 to 3 times that to the uncoated mortar substrate irrespective of the types,

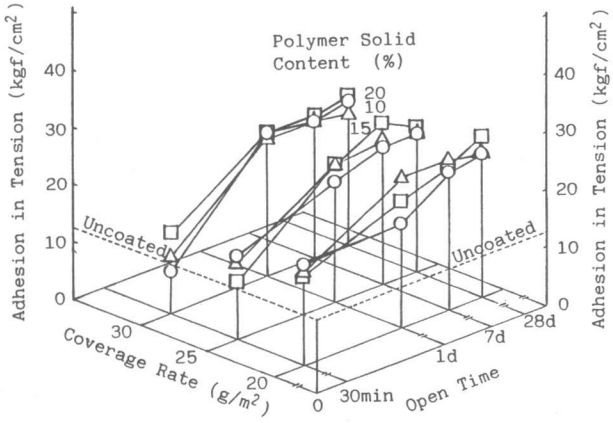


Fig. 2 Adhesion in Tension of Bonded Mortar to SBR-Coated Mortar Substrates.

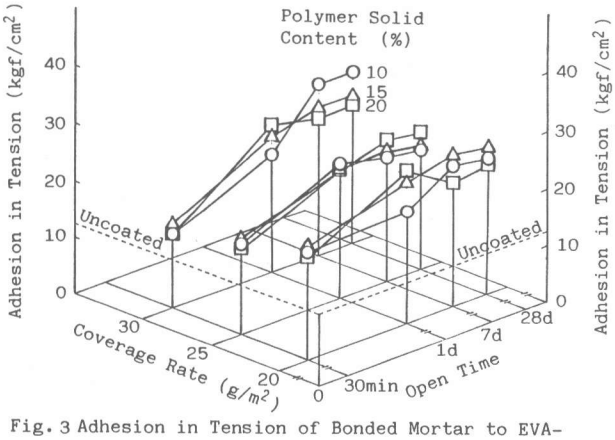


Fig. 3 Adhesion in Tension of Bonded Mortar to EVA-Coated Mortar Substrates.

polymer solid content and coverage rate of the polymer dispersions. The inferior adhesion in tension of the bonded mortar to the coated mortar substrates with an open time of 30 minutes may be explained in terms of the insufficient polymer film formation due to the diffusion of the polymer dispersions in the bonded mortar.

Figs. 5 and 6 represent the effects of the polymer solid content and coverage rate of polymer dispersions on the adhesion in tension of bonded mortar to polymer dispersion coated mortar substrates with an open time of 7 days. With increasing polymer solid content or coverage rate, the adhesion in tension of the bonded mortar to the coated mortar substrates tends to increase, decrease, reach the maximum or minimum. It is generally considered that the adhesion of the bonded mortar to the coated mortar substrates provides the maximum at an appropriate polymer solid content or coverage rate [1, 2]. As mentioned above, such an obvious trend is not necessarily recognized in this study. This fact is attributed to the limited narrow ranges of the polymer solid content and coverage rate, which are found to be suitable from the viewpoint of practical use [1]. In addition, the effects of the polymer solid content and coverage rate on the adhesion in tension of the bonded mortar appear to depend on the types of

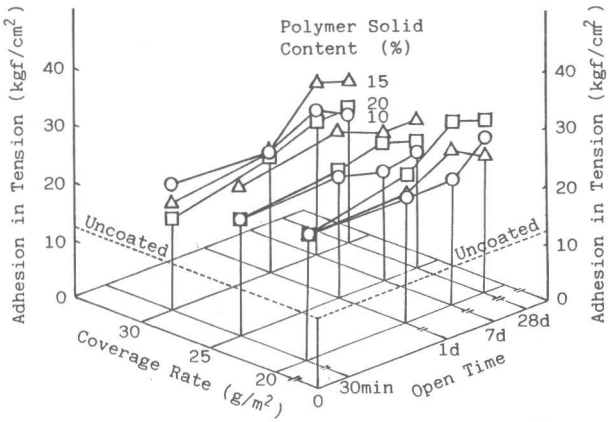


Fig.4 Adhesion in Tension of Bonded Mortar to PAE-Coated Mortar Substrates.

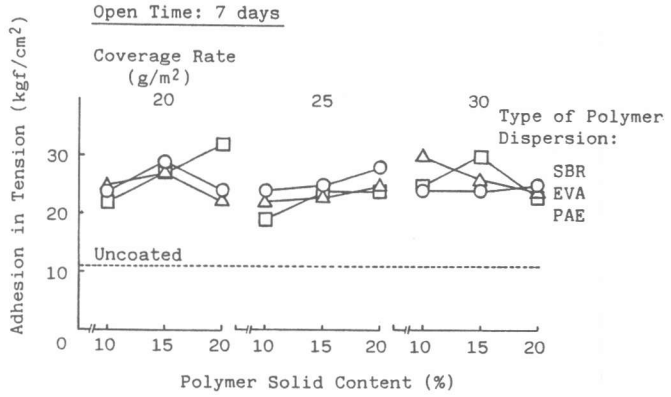


Fig.5 Adhesion in Tension of Bonded Mortar to Polymer Dispersion Coated Mortar Substrates vs. Polymer Solid Content of Polymer Dispersions Used as Primers.

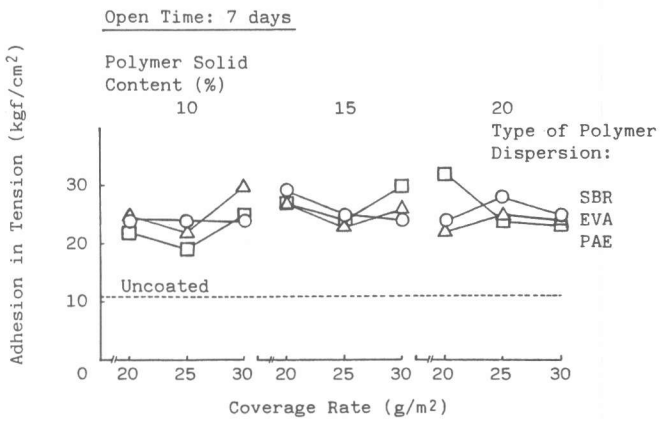


Fig. 6 Adhesion in Tension of Bonded Mortar to Polymer Dispersion Coated Mortar Substrates vs. Coverage Rate of Polymer Dispersions Used as Primers.

and properties of the polymer dispersions to some extent.

Fig. 7 illustrates the failure mode distribution and adhesion in tension of bonded mortar to polymer dispersion coated mortar substrates with an open time of 7 days. Except for a few cases, the failure modes in the adhesion test in tension of the bonded mortar to the polymer dispersion coated mortar substrates are almost cohesive failure in the bonded mortar, and the ratio of the cohesive failure in the bonded mortar is 6/10 or more. The reason for the occurrence of the cohesive failure in the bonded mortar rather than in the coated mortar substrates is found to be based on a difference in strength between the bonded mortar and the mortar substrates due to their different mix proportions, i. e., cement: sand ratio 1:3 for the bonded mortar and cement :sand ratio 1:2 for the mortar substrates. As described above, the occurrence of the cohesive failure in the bonded mortar at ratios of 6/10 or more means a good adhesion through the polymer films formed by the polymer dispersion coatings, at the interface between the bonded mortar and the mortar substrates.

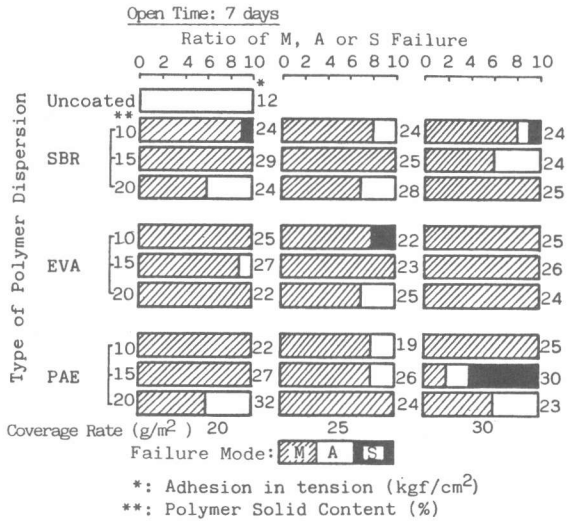
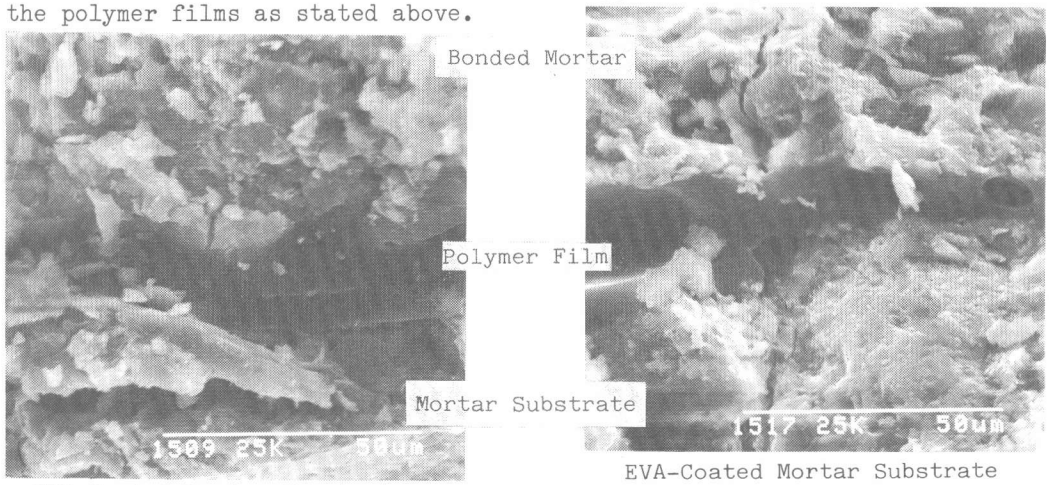


Fig. 7 Failure Mode Distribution and Adhesion in Tension of Bonded Mortar to Polymer Dispersion Coated Mortar Substrates.

Fig. 8 shows the microstructures of the adhesive interfaces between bonded mortar and polymer dispersion coated mortar substrates with a polymer solid content of 10%, a coverage rate of 30 g/m^2 and an open time of 7 days. The presence of the polymer films formed at the adhesive interfaces between the bonded mortar and the coated mortar substrates is clearly observed. This fact is found to support the good adhesion through the polymer films as stated above.



SBR-Coated Mortar Substrate

EVA-Coated Mortar Substrate

(Magnification, x1000)

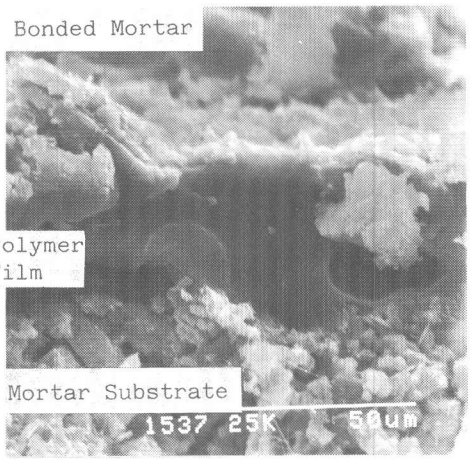
Fig. 8 Microstructures of Adhesive Interfaces between Bonded Mortar and Polymer Dispersion Coated Mortar Substrates (Part 1).

5. CONCLUSIONS

(1) The adhesion in tension of fresh mortar to polymer dispersion coated mortar substrates is increased to about 2 to 3 times that to uncoated mortar substrates.

(2) A suitable open time is necessary for the good adhesion of fresh mortar to polymer dispersion coated mortar substrates.

(3) The effects of the polymer solid content and coverage rate of polymer dispersions on the adhesion in tension of fresh mortar to polymer dispersion coated mortar substrates are not clarified in this study.



PAE-Coated Mortar Substrate

Magnification, x1000)

Fig. 8 Microstructures of Adhesive Intrefaces between Bonded Mortar and Polymer Dispersion Coated Mortar Substrates (Part 2).

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