Properties of Polymer-Modified Mortars Using VAE Redispersible Powders

아론 조셉 앙고* 김완기** 소양섭***
Aaron Joseph Ango Kim, Wan-Ki Soh, Yang-Seob

Abstract

Recently, there is a growing trend in the United States toward replacing latex additives in polymer-modified cement mortars with redispersible polymer powders. This movement is relatively new in the U.S. but is further advanced in Europe due to the more extensive use of cement and concrete in residential construction. Hitherto, in Korea - there is a very diminutive movement towards this growing trend. Thus, there is limited availability of data on redispersible polymer powders. This study investigates the effectiveness of redispersible polymer powder on improvement of the mechanical properties of modified mortar. It was concluded from the results of the experiments that the size of the dispersed polymer particles, variations in glass transition points (Tg), and variations in minimum film formation temperature (MFT) influenced the strength development of the modified mortars, and optimum strength in modified mortars using redispersible powders can be achieved when the Tg which accounts for the degree of powder flexibility is considered.

1. INTRODUCTION

Due to the versatility of redispersible powders, they are able to replace liquid latexes in most cement applications. The benefits of polymer addition using redispersible powders are similar to addition a latex system. In the past, the method of producing polymer-modified mortars involved mostly latex polymer dispersions added to ordinary cement mortar during mixing. However, problems arise when preparing mixes from the aqueous cement modifiers because of the complex mix calculations. These problems led to a recent advancement in the use of redispersible powder with improved qualities. Irrespective of the growing trend in redispersible polymers, Korea has little data available on various mechanical properties of mortars modified by redispersible polymer powders in Korea. The effects of various redispersible powders on the mechanical properties of polymer-modified mortar have already been reported [1]. But the effects of polymer particle flexibility have not been investigated. This study aims at investigating the effectiveness of redispersible polymer powder on improvement of the mechanical properties of modified mortar, evaluate and compare the mechanical properties of various powder polymer types and to obtain basic data necessary for selecting and using redispersible polymer types. 3 polymer types supplied by Wacker polymer systems GmbH, Germany were used in this study (as shown in table 1).

* 정회원, 전북대학교 대학원 박사과정
** 정회원, 협성대학교 건축공학과 교수
*** 정회원, 전북대학교 건축·도시공학부 교수

Table 1. Properties of Redispersible Polymers

Polymer Type	Flexibility	Particle size	Tg (DSC, onset)
VAE - 1	Flexible	0.8 – 8 μm	-7^0C
VAE – 2	Medium Hard	0.3 – 9 μm	$+10^0$C
VAE 2	Hard	0.5 – 8 μm	$+16^0$C

3. EXPERIMENTAL PROCEDURE

3.1 Materials

(1) Cement

Ordinary Portland cement I as specified by KS (Korean Standards) L 5201 (Portland cement) was used.

(2) Fine Aggregate

Fine Aggregate of size 0.25~0.6mm was used as silica sand.

(3) Cement Modifiers

Three (3) Vinnapas redispersible powders were used as cement modifiers.

(4) Antifoamer

1 % of Silicone redispersible antifoaming agent was used for reducing air content in the mix proportions.

3.2 Experimental Method

(1) Preparation of Specimens/Samples

Polymer–modified mortars were prepared in accordance with KS F 2476 (Method of Making Test Sample for Polymer–Modified Mortar in the Laboratory). For the flexural strength test, mortar specimens of 40x40x160 mm were molded. For the compressive strength test, mortar specimens of 40x40 mm were molded according to KS F 2477 (Method of Test for Strength of Polymer - modified Mortar), a small percentage of powdered antifoamer was utilized in the mix proportioning of all the samples. The samples were subjected to a 2–days–200C–80 R.H. - moist plus 1 to 5 days curing in water and 0, 3, 14, and 28 days of dry curing periods. After the curing periods, samples were then tested for mechanical properties such as flexural strength, compressive strength, and water absorption ratio. SEM morphology was analyzed.

Table 2. Mix Proportions of Redispersible powders

Type of Mortar	Cement:Sand	P/C (%)	W/C (%)	Air Content (%)	Flow (mm)
Unmodified	1 : 2.45	0	60.1	3.1	168
VAE –1-Modified		5	49.6	3.4	166
		10	55.8	3.7	168
		15	54.8	4.1	171
		20	52.0	4.7	171
VAE – 2-Modified		0	60.1	3.1	168
		5	56.1	3.8	169
		10	54.6	4.1	167
		15	52.5	4.1	166
		20	54.0	4.6	166
VAE-3-Modified		0	60.1	3.1	168
		5	65.2	4.4	172
		10	61.0	4.6	172
		15	60.9	5.3	169
		20	60.9	5.3	168

4. TEST RESULTS AND DISCUSSION

4.1 Effects of flexibility and particle size on the properties of fresh polymer- modified mortar

The properties of fresh mortar with various mix proportions are presented in table 2. There was increase in water cement ratio of all the modified mortars compared to conventional mortar. This can be attributed to the improved consistency which occurs as a result of the ball bearing action of polymer particles among cement particles, entrained air, and the dispersing effects of the redispersible powders when mixed in water. A PS 508 redispersible powder was used to stabilize excessive air entrainment in the polymer-modified mortars.

4.2 Effects of flexibility and particle size on properties of hardened polymer- modified mortar

Fig. 1 shows the flexural strength of polymer-modified mortars using VAE redispersible powders. Generally all the redispersible polymers showed improved flexural strength compared to unmodified mortar. However, VAE 1 and VAE 3 showed improved flexural strength over VAE 2. This could be attributed to the film formation capability of the powders which is also related to the nature of the particle size and state of cohesiveness (flexibility). The addition of a low minimum film formation temperature (MFT), high molecular-weight polymer to mortar should improve flexibility and, indeed is observed [2]. The decrease in flexural strength of VAE 2 can be attributed to the partial deflocculation of the dispersed polymer particles.

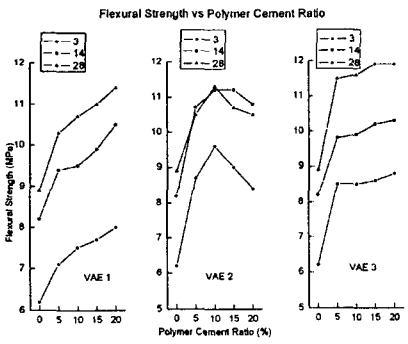

Fig.1 Flexural Strength

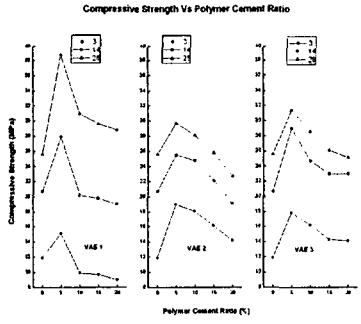

Fig.2 Compressive Strength

Fig. 2 shows the compressive strength of polymer-modified mortars. As the polymer-cement ratio increases, cement to cement bonding is decreased considerably. However since the compressive strength between cement particles is stronger than cement to polymer bonds, the compressive strength decreases as polymer-cement ratio is increased [3]. The Tg accounts for optimum strength in the modified mortars. The size of the dispersed polymer particles affected the strength development of the modified mortar [4].

Fig. 3 shows the water absorption of polymer-modified mortars using VAE redispersible powders. All modified mortars showed improved and remarkable water absorption ratios. This property is attributed to the function of water-cement ratio and cement content in the mix. The modified mortars maintained a consistent water absorption ratio. Other redispersible powders used in the study showed a similar result.

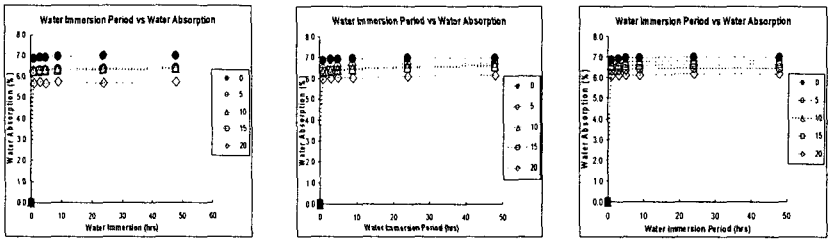

Fig. 3 Water Absorption rate of VAE Polymer Modified Mortars Using VAE Redispersible Powders

4.3 Observation of microstructure by SEM

SEM morphology was observed and was concluded that redispersible polymers form very good matrix network similar to latex polymer. Other redispersible powders used in this study showed similar results.

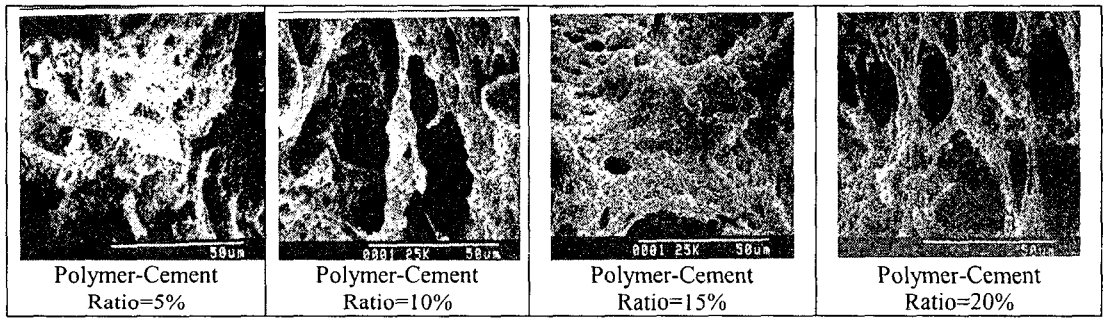

Photo.1 Microstructure of Polymer-Modified Mortars with VAE-2 Redispersible Powders (Age; 28days, Magnification; x1000)

5. CONCLUSIONS

(1) Compressive strength is decreased with increasing water cement ratio.
(2) Size of dispersed polymer powder determines the strength of the development of the mortar.
(3) The Tg accounts for optimum strength in modified mortars.

REFERENCES

1. Y. Ohama, Katsunori Demura, and Wanki Kim, Properties of polymer-modified mortars using redispersible polymer powders. Proceedings of the first east symposium on polymersin concrete Chuncheon, Korea, May 2-3, 1994]
2. Joseph A. Lavelle, Acrylic Latex-modified Portland Cement, ACI materials journal Aug. 1, 1988
3. Steven I Schneider, Dennis R. DeWacker, and Joseph G. Palmer, Redispersible powders for tough, flexible cement mortars. Polymer-Modified Hydraulic- Cement Mixtures, STP 1179, American Society for Testing and Materials, bridgewater, NJ 08807.
4. Kunio Esumi, Polymer interfaces and Emulsins Marcel and Dekker, Inc. New York pp. 129-132