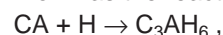


# Industrial Applications

## MECHANISM OF CURING REACTION FOR POLYMER-MODIFIED CEMENT WATERPROOFING MEMBRANE

Recently, with the demands for material properties becoming more complex and severe for waterproofing applications, polymer-modified cement materials which consist of a polymer emulsion and cement materials, have been widely developed for building materials fields for roofs, balconies and underground outer walls, for example. Figure 1 shows photographs of polymer-modified cement materials. After mixing polymer emulsion and cement powder, the viscous polymer-modified cement paste was applied to a thickness of 1-2 mm onto the concrete, followed by drying and curing. By this process, a polymer-modified cement-waterproofing membrane was obtained. This organic/inorganic composite product possesses the characteristics of both toughness from the cement materials and flexibility and adhesiveness from the polymer emulsion. Therefore, the material properties can be controlled by changing the polymer/cement mixing ratio. Furthermore, in order to satisfy the demand for high-performance materials, not only the material properties but also workability, such as shortening of the construction period, is increasingly required.

The formation process of the polymer-modified cement membrane at ambient temperature involves simultaneous evaporation of water within the polymer emulsion and curing of the cement. The curing process is the hydration reaction of alumina cement, which is already known as the reaction formula [1,2]



where  $C = CaO$ ,  $A = Al_2O_3$  and  $H = H_2O$ . To successfully obtain the polymer-modified cement material it is important that the hydrate crystal of cement is generated by the hydration reaction during the curing process with the existence of the polymer emulsion. In this study, the mechanism of the curing reaction of the polymer-modified cement paste was investigated by X-ray diffraction (beam size of 0.3 mm (V)  $\times$  3 mm (H), wavelength 1 Å, X-ray exposure time 900 s) at beamline **BL19B2** using the Debye-Scherrer camera.

In order to obtain good mechanical properties, excellent thermal resistance and high chemical resistance, alumina cement was used as the cement material. The sample was alumina cement and polymer emulsion mixed in the polymer/cement ratio

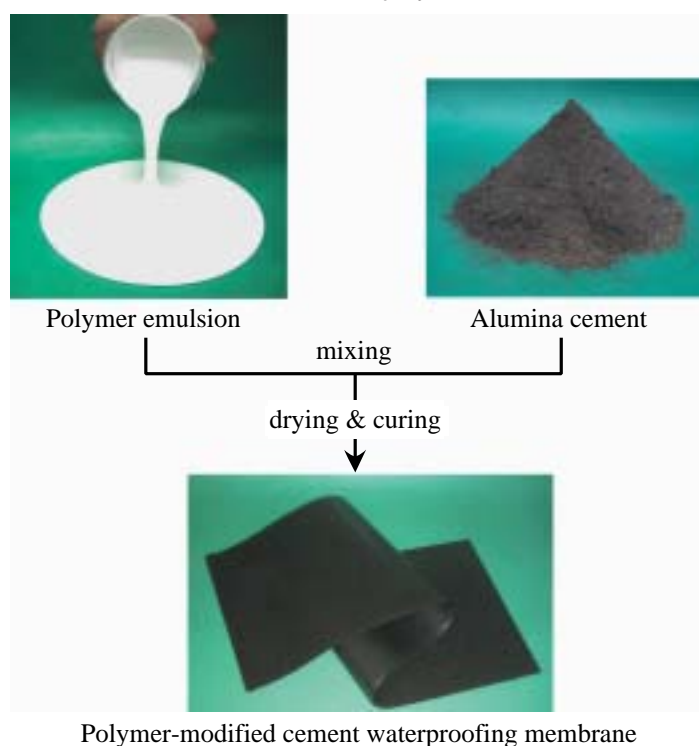


Fig. 1. Photographs of polymer-modified cement materials.

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of 100%. After mixing, the sample was wrapped with Mylar film in order to prevent drying. Figure 2 shows the X-ray diffraction profiles of the polymer-modified cement membrane before and after curing at ambient temperature. The diffraction peaks of calcium aluminate (CA) almost disappeared after curing. On the other hand, the peaks of hydrate crystals of alumina cement, such as  $C_2AH_8$  and  $C_3AH_6$ , could be observed at diffraction angles  $2\theta=5.3$  and  $11^\circ$ , respectively. After curing, a tough and flexible polymer-modified cement membrane was obtained in spite of preventing water evaporation. This polymer-modified alumina cement paste underwent a hydration reaction during the formation of the membrane. This implies that the water within the polymer emulsion participates in the hydration reaction of the cement during the curing process.

Figure 3 shows the temporal changes of the conversion to hydrate crystals of alumina cement. With curing time, the amount of CA ( ) decreased, and the amount of the alumina hydrate ( $C_2AH_8$  ( ) and  $C_3AH_6$  ( )) increased. This means that the hydration reaction of CA occurred during the forming process of the polymer-modified cement membrane. The hydration reaction to form  $C_2AH_8$  from CA began at around 300 min and was almost completed at 700 min. Thereafter, the amount of  $C_2AH_8$  hydrate exceeded 100% once and then decreased gradually, and the amount of  $C_3AH_6$  hydrate increased. The  $C_2AH_8$  hydrate is in the form of unstable hexagonal crystals. This implies that the crystal transition from  $C_2AH_8$  to  $C_3AH_6$  occurred to form the more stable phase.

Accordingly, stable hydrate crystals of  $C_3AH_6$  were obtained by the hydration reaction of calcium aluminate through the crystal transition of the unstable  $C_2AH_8$  even with the coexistence of the polymer emulsion. That is, it is thought that the alumina cement was cured via the consumption of the water within the polymer emulsion, and the polymer-modified cement materials formed a thick film.

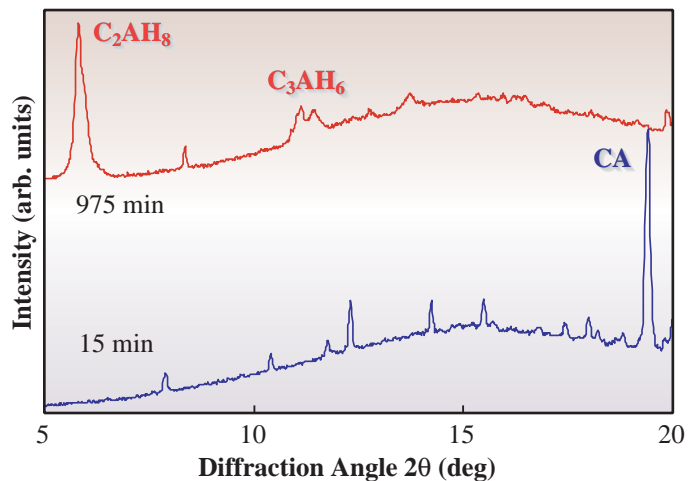


Fig. 2. X-ray diffraction profiles of polymer-modified cement membrane before and after curing.

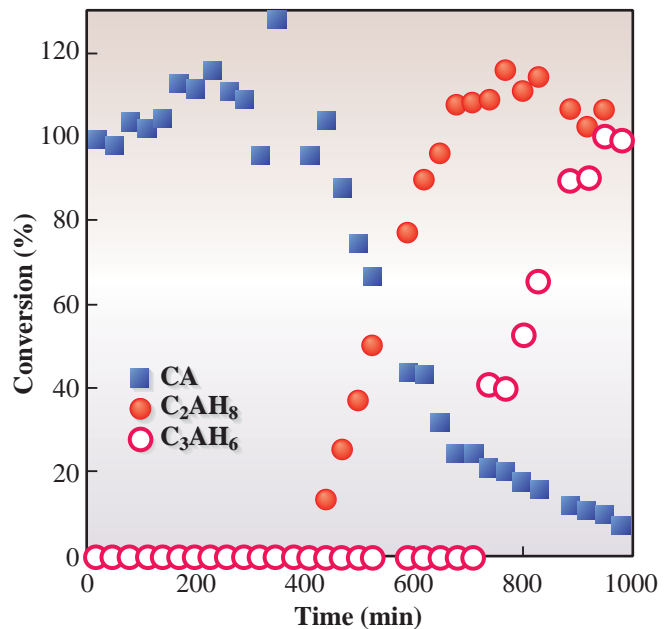


Fig. 3. Relationship between the conversion of hydrate crystals and the curing time.

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