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MORPHOLOGICAL CHARACTERIZATION OF LOW SULPHOALUMINATE - TYPE (AFm) CRYSTALS, HOLLOW TUBULES AND HOLLOW CRYSTALS IN POLYMER - MODIFIED MORTARS

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In order to understand the structure - property relationships of cementitious systems comprehensively, studies concerning the formation of cement hydration products have been a favourite topic of the researchers. Despite this research activity, lesser attention has been paid towards the understanding of the hydration products formed in polymer-modified mortars (PMMs). PMMs are being popularly used in the world as high performance, low - cost construction materials, particularly for finishing and repairing works. To fill the gap, authors have already reported their detailed observations on the morphological characterization of calcium hydroxide and high sulphoaluminate or ettringite-type (AFt) crystals in PMMs (1,2,3,4). Apart from this, there is much to be unveiled with regard to morphological characterization of PMMs.

The purpose of this paper is to establish morphologically the formation of AFm crystals, hollow tubules and hollow crystals in PMMs. It is better to study them together because of a possible common ancestral base. The study of calcium aluminate hydration products in cementitious systems is particularly important in the development of microstructure in certain types of cement like expansive cement. Morever, they are of major concern in the sulphate attack and perhaps in other secondary degradation processes (5). Further, AFm crystals can contribute to early strength of cement and may also affect the creep and shrinkage of the paste (6). In addition, the hydration of aluminate and alumino ferrite (C_3A, C_4AF) phases may also give rise to hollow tubes (7). Actually, existence of hollow tubules in hydrating cement systems has been a matter of controversial arguments

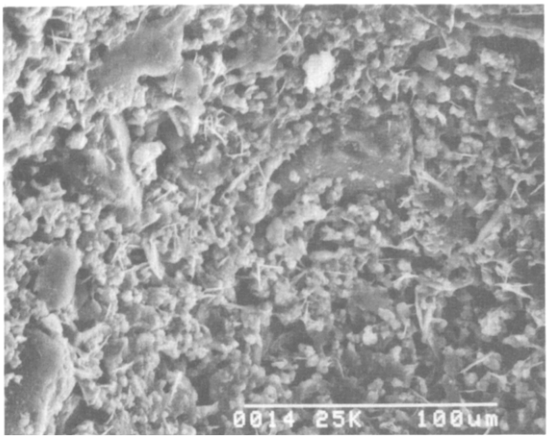
among the researchers. In this context, Double and Hellawell (8) linked their origin with silicate(C_2S, C_3S) phases in opposition to Barnes et al (7) as mentioned earlier.

For the morphological characterization of AFm crystals, hollow tubules and hollow crystals, PMMs with twenty five mix proportions, using six commercial cement modifiers, including redispersible polymer powders and aqueous polymer dispersions, were prepared with various polymer-cement ratios (P/C) and subjected to a combined water and dry cure for 28 days. After curing, they were observed by a scanning electron microscope (SEM). The details regarding materials, mix proportions and testing procedures are given in reference (2).

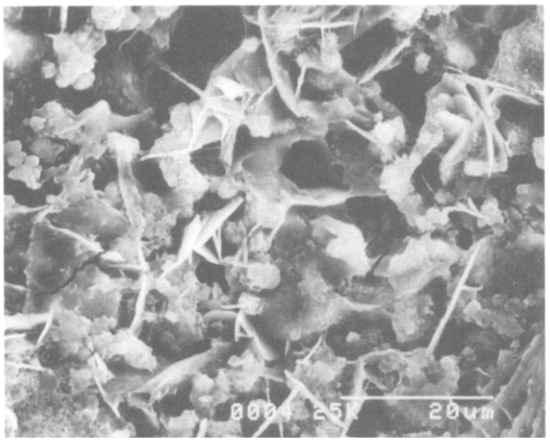
According to present studies, AFm crystals are mostly observed in the voids of EVA-modified mortars as shown in Figs. 1(a)-1(c). At low magnification, Fig. 1(a), AFm crystals appear to be small needle-like structures scattered throughout the mass. However, on high magnification, these crystals are plate-like in nature with the "edge-to-face" contact between adjacent plates, which is a characteristic feature of AFm crystals (5). The plate-like nature of AFm crystals is clearly evident at higher magnifications from Figs.1(b) and 1(c). It is therefore, obvious that formation of AFm crystals in PMMs depends upon the type of cement modifier used and varies with variation in this factor. This happens because microstructure - forming processes respond to all aspects of internal environment during hydration (5). Since each cement modifier has different characteristics so it can enter in to chemical responses with the developing hydration system in a different way, hence affecting the formation of AFm crystals upto different extent.

These studies sometimes reveal the presence of hollow tubules and hollow crystals in PMMs as shown in Figs. 2 and 3. Fig.2 depicts single hollow crystal, with a broken posterior end, in a void of powdered EVA-1-modified mortar with a P/C of 5%. The broken posterior end of this hollow crystal indicates its past link with a tube like structure, which is perhaps broken after the hollow crystal has completely formed. Whereas, Fig. 3 clearly shows the growth of a hollow tubule and hollow crystal in a void of EVA-modified mortar with a P/C of 15%. From the Fig. 3, it is apparent that the growth of the hollow crystal probably has not yet been completed, and hence it is still connected by a hollow tubule to the "source" producing it. On close observation through SEM, this "source" appears to be a heap of small plate-like low sulphoaluminate-type (AFm) crystals, as those discussed abov, and surely not that of the silicate hydrates. This leads to infer that under favourable conditions AFm crystals can produce hollow tubules, in conformity with the findings of Barnes et al (7), through which liquid material flows and accumulates at a particular distance to form the hollow crystals in PMMs. The tubular link is then broken somehow or the other when the growth of the hollow crystals is completed.

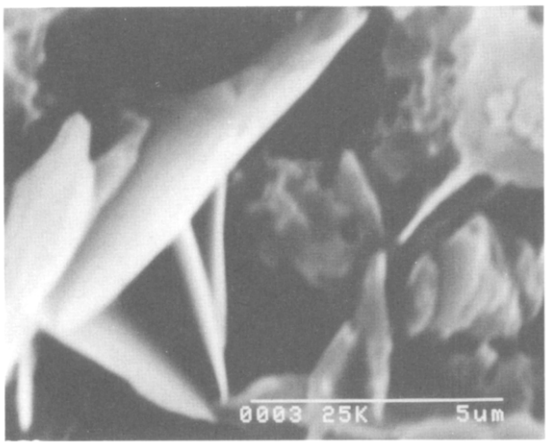
In conclusion, AFm crystals are observed in PMMs. However, their formation depends upon the type of cement modifier used. Such crystals sometimes give rise to hollow tubules and hollow crystals in PMMs as well.



(a)

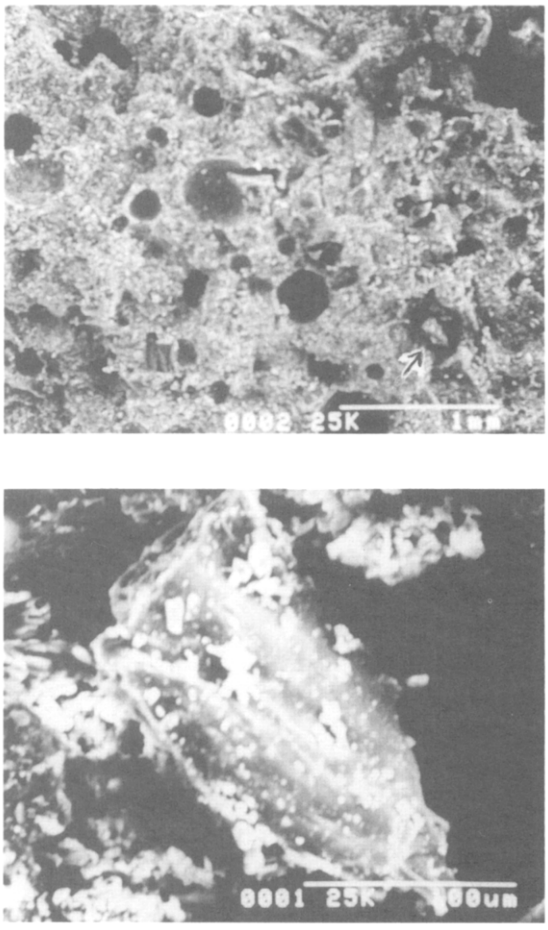


(b)



(c)

Fig. 1. Low Sulphoaluminate-Type (AFm) Crystals at Various Magnifications in a Void of EVA-Modified Mortar with a P/C of 15%. (a) Low Magnification Micrograph, (b) Higher Magnification Micrograph, (c) More Higher Magnification Micrograph.



(a)

(b)

Fig. 2. Hollow Crystal in a Void of Powdered EVA-1-Modified Mortar with a P/C of 5% at (a) Low Magnification, (b) Higher Magnification.

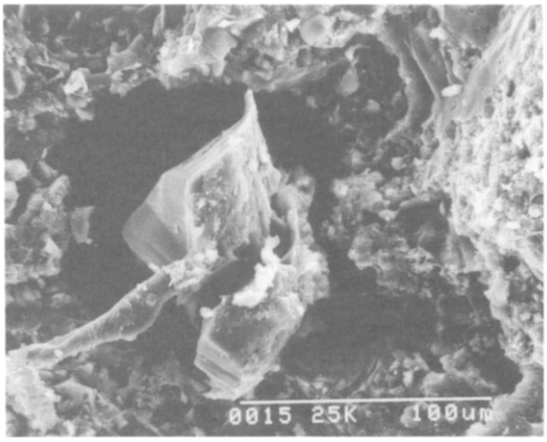


Fig. 3. Growth of a Hollow Tubule and Hollow Crystal from the Heap of AFm Crystals in a Void of EVA-Modified Mortar with a P/C of 15%.

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