工学論文

[1204] A Simple Model for Predicting Expansion in Mortar Bars Due to Alkali-Silica Reaction

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1.INTRODUCTION

Alkali-Silica reaction (ASR) has been identified as one of main causes for premature deterioration of concrete structures, and many papers have been published dealing with various aspects of the mechanism and its effect. However, a comprehensive method to predict the extent of reaction and the ensuing damage has not yet been established. In this paper, an attempt has been made to present a new model based on kinetics to predict the extent of reaction between reactive aggregate and the surrounding cement matrix. The model also incorporates the affect of diverse factors such as size and reactivity of aggregate, alkalinity of cement matrix, etc.,

2.PREDICTING THE EXTENT OF ASR AND EXPANSION IN MORTAR PRISMS

ASR is considered as occurring in stages. Assuming that the rate-determining stage of ASR is the diffusion of alkali ions from the surface into the reactive aggregate, the following equation can be derived from Fick's first law to approximate the extent of ASR as shown in fig.1.

$$dx/dt=kC/x \qquad (1)$$

Where, t ,x ,k and C represent time after ASR starts(hr), thickness of reacted layer(cm), diffusion coefficient of alkali in reactive aggregate(cm^2/hr) and alkali concentration in pore water(mol/l), respectively.

Assuming a spherical aggregate of radius R(cm), the reaction ratio (α) can be written as

$$\alpha=1-(1-\sqrt{kCt}/R)^3 \qquad (2)$$

The model further assumes that the reaction products of ASR are absorbed in the pore of the cement matrix, that the volume of such pores is proportional to the surface area of the aggregate size, the following equation is obtained to predict expansion ratio(ε;%) of mortar prisms.

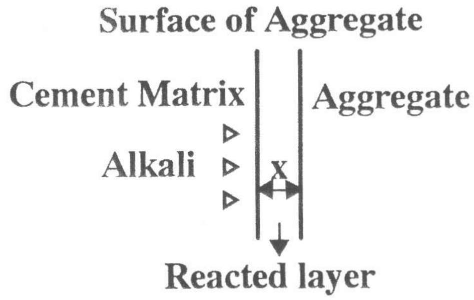

Fig.1 Reaction at Surface of Aggr.

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$$\varepsilon = A^* \Sigma \beta_i (k_1 \alpha_i - (k_2 / R_i)) \qquad (3)$$

A, k_1 and k_2 are experimental constants, and β_i is the volume fraction of aggregate with equivalent radius R_i.

3.CALCULATED AND OBSERVED EXPANSION BEHAVIOR

The model presented above has been used to predict the expansion of mortar prisms with different conditions. Fig.2 and 3 show the experimental and analytical results for different content of reactive aggregate. Further, Fig4. and 5 show the experimental and calculated values when different sizes of reactive aggregate are used. Under both these conditions, we find that the model satisfactorily predicts the pessimum behavior. This model can also be used to explain other phenomenon like the incubation period observed before measurable expansion, and the mechanism of reduced expansion by adding of mineral admixtures (like fly ash etc,.).

It was also found that the results obtained from the simple chemical test (ASTM C 289) can be explained on the basis of the model proposed here.

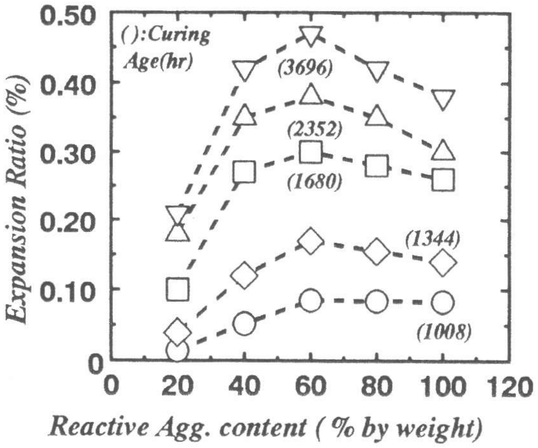


Fig.2 Observed Expansion Ratio

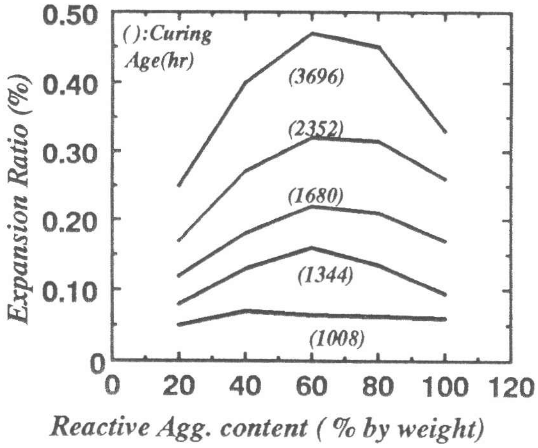
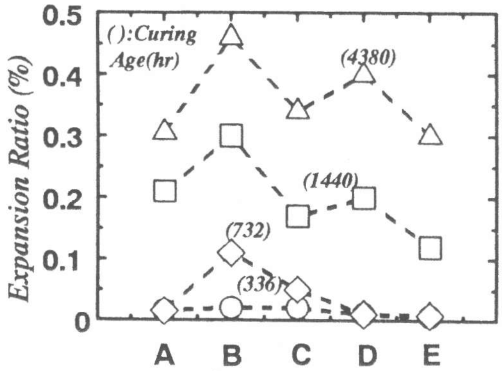
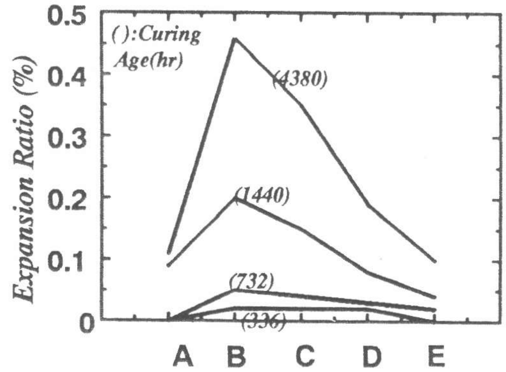


Fig.3 Calculated Exp. Ratio





Diameter of Agg. (μm) A:150-300,B:150-300,C:600-1880,D:1180-2360,E:2360-4750

Fig.4 Observed Expansion Ratio

Fig.5 Calculated Exp. Ratio