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An improved model to predict the ultimate drying shrinkage of concrete

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Contribution by D. McDonald

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Professor Almudaiheem extends the work originally presented by Pickett. The object of this research is to predict the drying shrinkage of concrete based on the shrinkage of the paste, the amount of hydration of the paste and the ratio of paste to aggregate volumes. Almudaiheem considers the added restraint from unhydrated cement (or, more precisely, clinker) in the mortar system, which would reduce the obtained shrinkage strains. This type of research may lead to a greater understanding of the mechanism of shrinkage of concrete.

Although this paper leads the reader to believe that work was conducted on concrete, only mortars are considered. The specimens used to measure shrinkage were 2.5 mm × 10 mm × 75 mm, which would retain relatively uniform humidity gradients through their cross-sections as they dry. The correlation between measured and predicted shrinkage values is satisfactory; however, such specimens are not representative of larger concrete sections. The effects of creep and non-uniform humidity distributions are not considered.

It is not immediately apparent which equations or parameters were used in the construction of Table 1 of the Paper. The relative amount of hydration α for each specimen needs to be determined. It would be useful to others if representative data from the Taplin Paper (ref. 19), used to predict the parameter α , were presented. Assumed values of ν_p (0.28), ν_r (0.10), E_H (4.55×10^6 psi) and E_R (11×10^6 psi) are given in the Paper. It is also necessary to assume a specific gravity of cement (3.15 or 3.20), which is referred to in the Paper as the density of cement.

Once these values are known it is then necessary to calculate the values of ϵ_c/ϵ_p for both the mortar and paste; the calculations proceed as follows. Equation (12) is used to determine P_{capl} ; equation (11) to determine E_p ; equation (8) to determine the value of V_R ; equation

(14) to determine ν_c ; and equation (13) to determine E_c . Equation (2) is used to determine β , and finally equation (1) to determine ϵ_c/ϵ_p for both the mortar and paste. From the measured ultimate shrinkage (if such a value can be measured) the value of mortar shrinkage is then determined.

It is stated in the Paper that a wide range of uncertainty in shrinkage and creep predictions would be unacceptable in the design of reactor vessels. I agree with this statement; however, testing should be conducted on concrete containing the materials with the proportions to be used in the construction of the shrinkage- and creep-sensitive structure.

Reply by the Author

The Author appreciates the contribution made by Dr McDonald. His argument concerning concrete versus mortar is very well documented and published elsewhere.^{1,2}

Dr McDonald wants to include representative data from the Taplin work. Since the data are very well documented in the Taplin Paper (ref. 19), there is no reason for duplication.

I totally agree with the last paragraph of the discussion. The model presented in the Paper holds for any type of concrete since it was derived from the theory of elasticity, composite theory and microstructural considerations.

References

1. ALMUDAIHEEM J. A. *Drying shrinkage of Portland cement paste and concrete*. PhD thesis, University of Michigan, 1986.
2. ALMUDAIHEEM J. A. and HANSEN W. Effect of specimen size and shape on drying shrinkage of concrete, *ACI Mater. J.*, 1987, 84, 130–135.