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A Discussion of the Paper "THE FRACTAL ARRANGEMENT OF HYDRATED CEMENT PASTE" by D. Winslow, J.M. Bukowski and J.F. Young*

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Experimentally the authors have collected x-ray scattering data, from different cement pastes, relevant to the scatter features in the size range of 30 to 1500 Å. The authors then analyzed the data on the assumption that the cement paste has a fractal structure; although there is no apriori reason to think that a cement paste has a fractal structure. From these analyses the authors have drawn a number of inferences on the structure of cement pastes and its variation with drying and resaturation. These inferences have a number of theoretical and practical implications. I would much appreciate if the authors' would comment on following two of these implications.

In the section 'Effects of Adsorption vs Desorption' the authors wrote that if one compares samples having similar degrees of saturation then one cannot distinguish between adsorption and desorption. From this one would gather that a sample which has been oven dried and then resaturated under water would have the same surface area as that of its companion virgin sample; though in the dried state the oven dried sample had a lower surface area.(This recovery has happened even though it is known that some of the cement hydration products e.g. ettringite decompose at the drying condition used.) The authors have buttressed this point by referring to Winslow and Diamond' earlier work (1). This essentially complete surface recovery indicates that during drying the scattering features have not formed any chemical bond among themselves which would have reduced their surface area irreversibly. Or if any chemical bond formation and accompanying surface loss had occurred during drying then a corresponding amount of bond breakage and surface recovery occurred during resaturation. As the second alternative is very unlikely then one would infer that subsequent to their formation the scattering features i.e. cement hydration products don't form much chemical bonds among themselves. In the absence of extensive chemical bonding the scattering features are free to come together or separate from each other depending on the state of saturation. This inference has an implication on the stability of cement paste.

Coming to the fractal dimensions of the samples, Figs. 4 and 5 show that resaturated oven dried and virgin samples have similar larger and smaller-scale fractal dimensions. Thus fractal dimensions could not distinguish between a resaturated oven dried and its virgin companion. This has to be contrasted against some macroscopic properties of cement pastes. Drying of a cement paste sample cause visible

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crack formation which is not known to heal fully even after prolonged storage under water. The degree of cracking increases with the degree of drying unless special precautions are taken to avoid the crack formation. This persistence of cracks indicates an irreversible change in the paste structure. Powers' showed that water transport through a cement paste dried to 79% RH is 70 times higher than its virgin companion (2). Water transport experiment is itself a resaturation process. Thus this increased rate of water transport through the dried and resaturated sample indicates an irreversible change in its structure. A similar irreversible change in paste structure with drying could be inferred from the chloride ion diffusion data of Uchikawa (3). Uchikawa showed that chloride ion diffusivity through a paste, self-desiccated at 45°C, is about 20 times higher than that through its water stored companion. In each of the above cases the experimental determination takes a long time to perform i.e there should be ample time for the complete resaturation of the samples. A similar inference of irreversible change could be drawn from the increased freezable water contents in dried and resaturated cement paste and concrete samples. All the above experimental results indicate that during drying some volume of the paste are getting denser and other parts are getting less dense and through the less dense parts water, ions etc could move easily.

From the above it appears that the fractal dimension is not sensitive enough a tool to explore the changes in paste structure with drying and rewetting. To determine the fractal dimension of a sample one has to plot log Intensity against log Q. It is of course known that a log-log plotting always compresses the data spread. This compression could have obliterated the difference between the dried and resaturated sample and its virgin companion.

References.

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2) T. C. Powers, L. E. Copeland, J. C. Hayes and H. M. Mann, Bull. No. 53, Portland Cement Association, Chicago. 1955.
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