A study of the relationship between permeability and tortuosity of concrete

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Abstract:

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Permeability of concrete is commonly used as a key index for assessing the durability of concrete, especially when concrete is to be exposed to the aggressive environment like that of the Arabian Gulf. There are several tests developed for measuring permeability of concrete, but most of these tests are complicated, time-taking, and are non-standardized.

For a porous material, a relationship exists between permeability and tortuosity, both of which depend upon the pore formation and the connectivity of the pores. As concrete can be assumed as a porous material (although the pore size is very small), it is of interest to see if a relationship exists between permeability and tortuosity of cementitious material.

In the present study, an attempt has been made to correlate permeability of concrete with its tortuosity. For this purpose, a total of 18 different concrete mixes were prepared taking three levels of water to cement ratio, three levels of cement content, and two levels of coarse to fine aggregate ratio. The specimens were tested to develop data pertaining to: (i) *permeability*, measured using the test setup which was developed under this study in the Department of Civil Engineering, KFUPM; (ii) *tortuosity*, measured through gas diffusion test using the available laboratory facility in the Department of Chemical Engineering, KFUPM; (iii) *porosity*, measured using the testing facility available in the Department of Petroleum Engineering, KFUPM; (iv) *pore size distribution*, measured using the mercury intrusion porosimetry (MIP) available at the Research Institute, KFUPM; and (iv) *compressive strength*, measured using the compression test machine available in the Department of Civil Engineering, KFUPM.

The experimental data under this study were used to fit into Kozeney's theoretical equation that relates permeability to tortuosity and porosity for a porous material. The study has found that a value of c_0 = 8788 (Kozeney's constant) appears to yield satisfactory results for all mixes in consideration. An empirical relationship between permeability and tortuosity has been proposed based on the experimental data. As tortuosity can be determined more rapidly, the proposed method of determining permeability through tortuosity appears to be very appealing and needs a more rigorous exploration.