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Permeability to gas of partially saturated concrete

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The author highlighted the need for a method of drying specimens prior to permeability testing. A simple method for rapidly achieving uniform moisture contents in permeability test specimens was reported in 1994.[1] Initial drying at 50°C to the desired moisture state was followed by a short period under sealed conditions, with the samples held at 50°C. Redistribution of moisture at this moderately elevated temperature was much more rapid than at 20°C, and specimens could be equilibrated to relative humidities of 60–90% in 7 days. It was observed that the air permeability increased markedly as the capillary pore system was emptied down to a equilibrium relative humidity of 70%; however, the effect of further drying from equilibrium relative humidities of 70% down to 20% was small. The author's results appear to be broadly consistent with these observations.

Reply by the author

The aim of the author was to stimulate the discussion on the advantages and disadvantages of drying procedures. Dr Parrott took this opportunity, and therefore I have to thank him very much. Dr Parrott cites a drying method at 50°C.[1] With the proposed drying regime an intermediate moisture content is achieved. The aim of a test should be ideally to determine a material property such as intrinsic permeability. In the case of determining permeability, a strong influence of sample humidity can be seen.[1,2] Hence the measurement of the permeability to gas should be carried out at very low water contents of the samples. A conflict arises from this requirement, as pointed out by Jacobs,[2] between a low enough moisture content and as little possible damage due to the drying.

For convenience one can consider determination of permeability to gas at higher moisture contents, for example equal to relative humidities between 20 and 60% relative humidity. Within this range, permeability to gas changes little (about a factor of 2[1,2]). As shown by Dr Parrott,[1] this moisture content can be achieved by drying specimens between approximately 4 and 8 days at 50°C. The duration depends on the moisture content and tightness of the sample. A too long drying period results in lower moisture contents and hence higher permeabilities. For well-known (so-called) laboratory concretes, experience will tell us for how long a particular type of concrete must be dried. But for normal concretes on site, or concretes of unknown composition and/or moisture content, it is not possible to select the appropriate drying time easily. Therefore, the drying regime cited[1] would appear to be unsuitable for general laboratory work with the permeability test according to the CEMBUREAU method, which was used by Jacobs.[2] With the CEMBUREAU method a concrete disc of 5–6 cm height and 15 cm dia. should have a suitably low and uniform moisture content. Dr Parrott studied the drying at 50°C for permeability measurements with a different method and sample geometry.[1] Further studies must be carried out to check if this drying regime or a modified one is applicable to samples prepared according to the CEMBUREAU method.

In the author's opinion, measurement of permeability to gas at low moisture contents has—besides determining a material property—an additional advantage. At low moisture contents the Klinkenberg effect can be observed and serve as a quality criterion of the measurement. Klinkenberg[3] showed that the permeability decreases with increasing inlet pressure of the gas. The decrease is proportional to the reciprocal mean pressure between the inlet and outlet pressures. The decrease tends to increase with decreasing intrinsic permeability.[4] If this proportionality cannot be observed either the moisture content in the sample has changed during the measurements or something else has gone wrong.[4]

References

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