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Cost-viable improvements to concrete durability

A.J. Houston

Adoption of research outputs, supporting advances in structural concrete performance, implies satisfaction about technical and economic concerns. By their adoption, financial institutions, specifiers and property owners acknowledge their benefits. Concrete research has been driven by many forces; for example, the advances needed for long-term durability in ocean environments satisfy many and complex concerns. But other research has been reductionist in nature, pedantic in style and of less immediate commercial value. Although concretes in general, over the past one hundred years have exhibited good physical performances, continuing improvements in many physical properties and reductions in permeability are now possible using available current science and technology — all based on previous research.

Missing from the published research, however, is a discussion on just how to achieve, at low cost, concretes that are sustainable and durable, more impermeable, that satisfy many applications when using a wide range of labour skills and are achieved without dramatically changing mix ratios or concreting practices.

Future concrete-related research must be directed to the likely increasing take-up of "green" concretes. Research approaches to be explored will include a need to build holistically on the work of others who, for instance, have successfully incorporated waste materials such as fly ash . The creation of impermeable "skins", irrespective of core materials will be important. Over a recent 15 year period, evidence has shown that despite improvements in structural strengths with existing concretes, one cause of ongoing failure has been the high porosity of the concrete skin. This allows the ingress of harmful liquids and gases — wherever present — into concrete, thus affecting the cement pastes, aggregates and reinforcing steel. Beneath a code-specified depth of concrete cover, the initiation and rate of degradation is accelerated.

Recent laboratory investigations in Canada indicate that a workable approach to assessing future concrete durability is possible through field measurements of the rheology

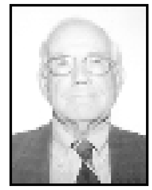
The world-wide need for long-term durable concrete is well explained in the literature. Distinctions are made between the needs and the extensive technology base of the industrialized world and in developing countries. The literature suggests that, to satisfy ongoing world needs, the leisurely technical developments of the past are no longer practical and that the reductionist approach to research will not provide timely and cost-effective answers. Therefore, the holistic approach is imperative.

Clients, such as some Provincial Highway or Federal Bridge Authorities now stipulate certain field performances that are based on previous research findings. Thus, they ensure for themselves, the beneficial transfer of relevant research findings to their field practice, accepting any higher costs. There is no obligation, however on the part of any participant to further transfer this new complete knowledge base. No single product supplier nor user engages in holistic research which will financially benefit other suppliers or other users. Full technical benefits have not yet been obtained from regular concrete mixes, as no holistic study is available.

Water permeability of concrete is considered the single most important property that can be directly related to long-term durability. The production of impermeable concrete for more general use has been difficult to achieve due to the fragmentation of the construction processes, costs and to production considerations; introducing "green concrete" issues, on a world basis, poses a complication to on-site quality control routines. More recently, however, laboratory investigations in Canada indicate a workable approach, to assessing that future durability, through field measurements of the concrete workability (rheology). The study provided a view of the interrelated factors that are brought to bear (holistic) in the construction of concrete structures.

The complex interplay between concrete mix parameters, forming materials (form-face stiffness, and absorbency characteristics) and vibration (frequency, amplitude and duration) in the production of low-porosity fair-faced concrete surfaces has been demonstrated. Uniform aggregate distribution from core to cover has been achieved. Uniform colour of that cover and a reduction in surface blemishes has been shown. Building on the work of others, mathematical models have been developed to assist in the theoretical evaluation and selection of concrete mixes having certain rheological properties. The result is a regular concrete mix which will, through an interplay of mix design/vibratory amplitude/dampening and moisture imperviousness and energy absorbency characteristics of the form liner concentrate the hydrophobic molecules at the concrete/form interface and; will more likely and consistently provide the required quality in the code-specified depth of cover over the reinforcing steel.

The advent of performance specifications and a push to full life cycle costing and field quality control prior to acceptance is driving the durability emphasis. A full scale demonstration of the new and holistic approach can be planned with industry, code writing authorities and others being receptive to the findings and field control techniques. It is expected that agreement could be reached, by all participants, on the significance of the findings.



Mr Alvin J. Houston was involved in research into building products and systems — and the causes of their failure in buildings — both in industry and public service for a period of 37 years He was a Research Manager at Canada's Housing Corporation for 15 years prior to retirement. During his tenure as Research Manager he used private sector business criteria, to initiate and manage a series of federally funded studies to determine causes of failure of structural concrete in high and low-rise housing. He led the search for durable remedial measures and assisted in the writing of restoration advisory documents and standards.

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