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# Editorial

There is always considerable argument and debate as to whether concrete structures that are exposed continually to high chloride contamination and harsh environments at the same time should be protected from the ambient conditions or not. "Should we, or should we not?"—is a question that haunts many engineers, and that has not been resolved with any degree of firmness or conviction. Obviously, not all structures exposed to the elements would, or should, need protection from the environment. But the fact remains that when the exposure conditions are heavily salt-laden and the climatic conditions are extremely severe and unpredictable protecting the concrete structure and the embedded steel seems to be sensible, rational and cost-effective in the long-term.

Exposure to ambient environment is the one single predominant external factor that is beyond human control, and that which can create an alarming degree of degradation in a short time, and critically determine the stability and serviceability of concrete structures. Engineers tend to underestimate the durability effects of aggressive environments on concrete, and the time-dependent and interactive effects of exposure and climatic conditions which ultimately decide the stability and durability of materials and structures. Current design specifications embodied in national building codes grossly underestimate the material and structural implications of exposure to aggressive environments. There is now incontrovertible evidence that even when design specifications such as those related to concrete grade, cement content, water/cement ratio and concrete cover are correctly implemented, they do not provide adequate resistance to chloride penetration for concrete structures exposed to severe marine environments and the effects of de-icing salts. Such designs will only lead to insufficient margins of safety against durable service life and structures would continue to deteriorate and fail to provide the designed service life at an unacceptably high level.

So the question arises as to why we should consider protecting concrete structures that are continually exposed, during their entire period of existence, to aggressive, unforgiving, and hostile external conditions. There are four basic reasons as to why we should design for protection of concrete structures under such conditions as part and parcel of the construction process. Firstly, modern Portland cement concretes do not have the capability to provide the same degree of impermeability and resistance to aggressive salt-laden exposure conditions as concretes made with Portland cements of four/five decades ago, or concretes with mineral admixtures. Significant changes have occurred in the chemical composition of modern Portland cements compared to those produced in the early fifties. The ratio of $C_3S$ to $C_2S$ has significantly increased during this period—from about 1·2 to 3·0 implying that structural design strengths can be achieved with lower cement and higher water contents. Further, a direct result of the change in this chemical composition of Portland cement is an increase in the heat of hydration evolved, but more importantly, in the evolution of heat at early ages. An increase in peak temperature, reached in much less time than before, would result in thermal gradients and microcracking which are slow to heal.

Secondly, the hydration/pozzolanic reactions, and hence, the development of a highly impermeable pore structure are themselves time-dependent operations, and they require favourable ambient conditions if the concrete is to mature and develop the full potential of chemical bonding and synergic interactions of its constituents. A refined pore structure—and the ability to retain this for a long period of time—is the key to durable service life.

Thirdly, the degradation process of concrete is also time-dependent—but above all, it is not the result of one factor, one mechanism or one set of aggressive agents. With a complex composite system such as concrete, an aggressive environment becomes a major factor in initiating a progressively cumulative damage activity—indeed, the systematic advancement of deterioration then becomes an overall synergistic process, a complex combination of many individual mechanisms, the exact role, effect and contribution of each of which to the totality of damage is inconceivable and unpredictable.

Finally, it is the ubiquitous nature of exposure that determines the strength, stability and durable service life. Adverse climatic conditions combined with equally adverse geomorphologic states such as severe ground contamination, low water tables, high ambient salinity, high temperature and high humidity and large variations of temperature and humidity generate the most insidious but imperceptible forces that irreparably damage the long term ability of concrete to give durable performance. In such circumstances protection of the young concrete, and prevention of its drying to develope a dense microstructure, and a high degree of impermeability to ionic diffusion become a paramount necessity. This is not necessarily the only step—but it is the first reliable and positive step—if concrete structures are to give durable service life when exposed to chloride environments and rapidly drying ambient conditions.