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Editorial

Experience world-wide on the performance of concrete structures exposed to real environments tells us that the assessment and rehabilitation of deteriorating structures should be considered as an essential part of an overall structural design management strategy. Indeed, there is no alternative to sustainable development of the cement and concrete industry but to ensure that steps are taken to preserve and maintain the durable service life of a country's infrastructure system. This was discussed and illustrated in the last two Editorials by references to Alkali-Aggregate Reactivity (AAR)—a chemically induced deteriorating process of concrete often deemed as "incurable", and invariably cursed as a "cancerous" disease. But the science and engineering of construction materials tells us that AAR need neither be incurable nor a process of continuing debilitation leading to eventual self-destruction.

Experience of AAR damage to concrete and concrete structures confirms that the key to enhance the durable service life of structures undergoing AAR is to protect them from the environment. But the chequered history of protective coatings is not likely to inspire much confidence in engineers because of their varied performance in the field. The basic reason for this poor performance is that many of these products fall short of certain basic requirements in terms of chemical and engineering performance that are essential for long-term, durable service life. For example, exposure to solar radiation, ultraviolet rays, ozone, wetting and drying, and structural movements of the substrate concrete will slowly but surely erode many of the chemical and diffusion characteristics of barrier coatings. Whilst coating thicknesses of 250–500 μm may show good performance characteristics under laboratory/sheltered conditions, real environments are far more aggressive, and demand thicknesses of the order of 1000 μm for durable service performance.

Similarly, apart from adequate elasticity and strain capacity, coatings should also possess sufficient thermal stability to withstand high ambient temperatures and temperature fluctuations, and still retain their properties of elasticity and elongation. Thermal stability in the range of −50 °C to +70 °C should cover almost all normal and severe exposure conditions, and coatings should be able to preserve both elasticity and strength throughout this range.

Another important engineering requirement of surface coatings is their crack-bridging ability. It is this property that will enable the coating to maintain its integrity without debonding and rupture, particularly when applied to deteriorating structures, as cracks open and close with variations in the applied load, and changes in exposure conditions. In addition, a coating should be able to retain this crack-bridging ability under both static and dynamic load conditions.

So the question arises as to whether surface or barrier coatings can significantly slow down alkali–silica reactivity, even when the concrete is exposed to conditions favourable to AAR? And the resounding answer is YES. Tests show that when applied to concrete surfaces before any expansion occurs, significant reductions in expansion of the order of 50–90%, depending on the environment and exposure mode, can be achieved. In wet, chloride environments at 30 °C, coated specimens have shown substantially reduced expansions of 0.2–0.32% compared to 1.4–1.8% of uncoated concrete exposed to similar environments. Even when the coating is applied after concrete expansions of 0.15% and 0.35%, significant reductions in expansion have been reported. Tests on reinforced concrete beams also show that an efficient surface coating, protective against AAR expansion, can significantly enhance the structural performance of AAR affected beams undergoing sustained loading. The protective coating applied early in its life can reduce loss of elastic modulus of the concrete and its compressive strength. The coating can also significantly reduce the effects of creep by a substantial reduction in the creep coefficient—and it can also provide protective effects against chloride attack. All these tests show that surface coatings of the right quality and

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applied at the right time can significantly contribute to increase the durable service life of concrete structures.

It should, however, be borne in mind that in real structures, already cracked due to AAR and undergoing further expansion, and exposed to hot, highly humid and chloride-laden environments, where the chlorides and moisture can penetrate the concrete through the cracks, surface coatings cannot be expected to totally counteract the influences of the alkalies and water already trapped inside the concrete, although they can substantially reduce the expansion. In such situations, relying on a single protective system alone is not reasonable, and can only be partly productive. A total protective strategy needs then to be developed if the material degradation and structural instability arising from such internal distress mechanisms are to be avoided, and further useful service life is to be derived. Such a strategy involving an efficient protective coating system can make major contributions to extend the durable service life of AAR—affected structures.