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Editorial

There is now massive evidence, growing all the time from all over the world, that the major problem facing the concrete and construction industry is the lack of a specified and durable service life for concrete structures. Structures seldom fail due to lack of intrinsic strength, *per se*. There are very few examples where structures have collapsed due to lack of adequate strength, unless of course, some fundamental mistakes have been made in design or construction, or some unexpected dynamic forces have occurred. Ultimate strength failures are thus, in general, very rare. Serviceability failures on the other hand, appear to be the constant and unending problem affecting concrete structures. Lack of serviceability—failing to maintain the Serviceability Limit State—leading to lack of safety, loss of strength, loss of ductility and loss of structural integrity—is, without a shadow of doubt, the perennial disease afflicting concrete structures. Lack of serviceability can arise from a number of sources—lack of adequate impermeability of the concrete, steel corrosion, internal material reactions such as delayed ettringite formation, sulfate attack, and alkali-aggregate reaction or freeze–thaw expansion.

The ASCE Reports on America's Infrastructure and the ICE State of the Nation Reports in the UK, all confirm the one undeniable fact that we face a horrendous, and an almost unstoppable, situation in being unable to ensure that the materials we manufacture and use, and the structures we design and build can meet up with the Limit State of Serviceability during the specified design service life of a structure. This inevitably leads to the conclusion that the present approach to structural design—Design for Ultimate Limit State and checking for Serviceability Limit State—is no longer valid or relevant—indeed fundamentally flawed—to the construction industry of the 21st century. All the evidence that stares at our face confirms that we need to adopt a totally different DESIGN philosophy—a HOLISTIC approach—where structures should be designed for Serviceability Limit State and checked for the Ultimate Limit State. The Holistic approach implies a Management Strategy of Structural Health Monitoring during the service life of all concrete structures that have an impact on Society and the Quality of Life.

There is now incontrovertible, unchallengeable and unquestionable evidence that our infrastructure systems all over the world are deteriorating at an alarming and unacceptable rate. If we allow this situation to continue, it will be impossible for us to achieve an environmentally friendly, energy efficient and sustainable development of the construction industry for the 21st century—and this will be a great tragedy if we bear in mind that it is the construction industry that can enhance the Quality of Life for all peoples of the world. A critical analysis and appraisal of all the different types and modes of serviceability failures all over the world teaches us two fundamental lessons. Firstly, the damage mechanics and the deterioration processes of concrete materials is a time-dependent, and interdependent interactivity of load, ageing, cracking, immediate environmental conditions and climatic changes. The progress of degradation in concrete is then not the result of one factor, one process, or one set of aggressive agents. Indeed it is a progressively cumulative damage activity, an overall synergistic process, a complex combination of several individual mechanisms, the exact role, effect and contribution of each of which to the totality of damage cannot be clearly and fully evaluated or even estimated.

Secondly, engineers invariably 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 serviceability of materials and structures. Continual exposure to ambient environment is thus the one single predominate external factor that is beyond human control, and that can create an alarming degree of degradation in a short time immediately on exposure, particularly at early ages.

Alkali-aggregate reactivity (AAR), is a particular and appropriate example of the case in point as in practice there is virtually no country in the world which is totally free or immune from this type of concrete deterioration. The very mention of AAR often conjures up visions of

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an intolerable, untreatable and unremediable disease—a "concrete cancer"—to which all concrete is subjected. It generates a lack of precise and thorough understanding of the phenomenon, and strikes fear in the minds of engineers, concrete technologists and those of the public alike. The diagnosis, assessment and rectification of concrete structures affected by AAR are complex, difficult and time-consuming. To identify, evaluate and counteract the effects of AAR, as well as the prescription of remedial measures, require a clear and thorough understanding of the enemy, the resources and friends it can muster in initiating and continuing the reactivity, and the ways and means of how it operates and attacks an apparently normal concrete structure.

A major problem facing those involved in identifying and evaluating material and structural damage due to AAR is the many stages where confusions, contradictions and uncertainties challenge the assessment. Further, Assessment of AAR is closely and intimately involved with testing, and test results depend entirely on test methodologies. Environment, or more precisely, the changes in climate and exposure conditions, is probably the most critical factor influencing and modifying accepted concepts of behaviour of AAR-affected concrete. Because of the many complex interactive and interdependent parameters involved in controlling the rate of expansion and total expansion, each structure will have to be assessed and treated individually and independently, while appreciating the known commonalities of the damage process and similar patterns of behaviour exhibited by affected structures.

All these go to show that there is no alternative to an integrated material and structural design strategy—a HOLISTIC approach—for the assessment and retrofitting of concrete elements and structures undergoing and/or damaged by AAR. There is now conclusive proof that a total protective strategy system can avoid continued material degradation and structural instability arising from the internal distress mechanisms of AAR. Indeed, such a strategy can make major contributions to extend the durable service life of AAR-affected concrete structures.