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Editorial

The incorporation of polymers, in whatever form, within the body of concrete, or the use of resin systems as the binder to replace the cement matrix has not always found favour with concrete traditionalists and purists who throw their arms up at this supposedly wanton desecration of their beloved construction material. It is considered to be an unforgivable sin to contaminate the purity and sanctity of portland cement-based concretes with unknown and unreliable foreign matter, and polymers, in whatever form, were always though of as undesirable agents that did nothing to modify the properties of concrete either in the fresh state or in its hardened form. A survey of many historical structures in Babylon, India, China, Turkey and Italy, to name a few, shows that this perception of polymers is not only misguided and erroneous, but it also shuts off the useful and beneficial modifications that one can derive by the skilful combination of these materials.

Portland cement concrete is in many respects a wonder material and can be made durable through proper design and construction. However, concrete is not immune to damage and deterioration when it is exposed to aggressive environmental conditions or when it comes into contact with hostile liquids, gases and ions which permeate and diffuse into it. Organic polymers which exist in nature often do so in a balanced form, and are therefore able to remain stable and maintain their integrity when combined with cementitious materials. Synthetic polymers, on the other hand, are designed and made to remain stable in certain environments, and may therefore become destabilized when exposed to conditions that they are unable to cope with. It will readily be seen that durability of concrete–polymer systems is a property that cannot be assumed or taken for granted, but has to be designed for.

By their very nature, all polymers, when added to fresh concrete, exhibit water-reducing qualities and tendencies for retardation in setting time. These effects are a function of the type of polymer and the level of polymer loading. High polymer loadings are therefore likely to result in lower water demand and a high degree of set retardation. Both liquid latex and redispersible powder modifiers are likely to show these effects, but setting time is very much governed by the water–binder ratio and, therefore, much of the retardation tendencies can be overcome by careful design in which the water–binder ratio is controlled, and adequate workability of the polymer modified composite system is obtained through the use of plasticizing admixtures.

The retardation of the set time will have a significant effect on the early age, (e.g. one day) strength of the polymer modified mortar/concrete (PMC). However, increases in strength obtained with PMC composites compared to the unmodified material are not due to their water-reducing characteristics. Dry curing enables the polymers to achieve their full and complete film formation, and this therefore shows substantial increases, particularly in flexural strength and tensile strength compared to the control unmodified material. Subsequent wetting, unfortunately, also has a significant adverse effect on the strength properties, and tests show that the loss in strength increases with increased exposure to a wet environment. Durability of PMC formulations thus depends on their formulation, i.e. the polymer type, the level of polymer loading, and water–binder ratio — and, of course, the subsequent exposure conditions.

PMC systems show much less mass change compared to unmodified mortar and concrete when subjected to repeated wetting/drying cycles, the polymer modification enabling much lower moisture movement from and into the cement matrix. Thus, both water absorption and evaporation/expansion are restrained by polymer modifications. The presence of the polymer films inhibits water absorption and the repeated drying leads to more stiff, cohesive polymer films which lead to improved water resistance.

Many factors, however, influence the permeability characteristics of PMC systems. Apart from polymer–cement ratio, and wetting after drying, the size of the polymer latex particle, the glass transition temperature and the presence/amount of carboxylic acid also influence permeability properties. For long term durable service life, PMC systems have to be carefully designed and tailored to the requirements of a particular situation. The polymer type, polymer-loading, the water–binder ratio and the curing regime, all have a major influence on the performance of PMC systems in practice. The curing regime must reflect the ability of the cement system to achieve its optimum properties and the polymer to form effective films which will then resist better the effects of external aggressive agents. Formulations of PMC systems must, thus, go hand in hand with clearly defined specifications for their application and curing. There are many PMC bonded overlays on bridge and parking garage decks which have shown excellent performance against chloride penetration and corrosion of embedded steel, and have maintained their material stability and structural integrity for over 20 years. This is clear evidence of the benefits which could be derived from the PMC systems in an area which has been rather notorious for structural degradations.