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Editorial

Structural and patch repair in concrete structures

Maintaining and repairing building stock has been a recurring need owing to the natural degradation of materials and structures under the combined effects of loads and environmental factors. The urgent need to repair structures that have failed – because they either were not designed to withstand service conditions or were not properly constructed – has made durability the most pressing construction problem of the day.

Concrete structures are an assembly of operating systems that experience temperature, air pressure and vapour pressure gradients. Seasonal and diurnal fluctuations in outdoor conditions provide variability and direction of the gradients. These operating conditions can aggravate or accelerate premature failure of the components in a repair. The relative severity of these factors will vary depending on the use and location of the structure; and the type of repair material used will, of course, determine if deterioration will occur. Predicting these fluctuations and accommodating them at the design stage is important. However it is often overlooked probably due to a lack of awareness or understanding. The result is that all too often the repairs have to be re-done within a short period.

Deterioration of a material is a complex phenomenon that requires appreciation at the micro-structural level for diffusion of chemical species and at the macro-structural level for cracks and damage. The heterogeneity of the materials combined in an assembly requires an understanding of the interaction of the materials. In addition it is also important to understand that the durability of the repair is a function not only of the nature of its basic components but is also dependent on how such components and the system as a whole respond to the exposure conditions of the structure.

Current rehabilitation techniques and practices have been derived largely from those of new construction. New construction and rehabilitation however, differ in several important respects, including project scale and technology. The use of proper procedures in repair and rehabilitation is critical to success, yet these procedures were not – until three years ago – nearly as well defined by codes and standards as those for new construction.

Concrete repair requires a range of materials with different physical and chemical properties and application techniques. Compatibility with the original construction material (called the substrate), structural considerations and ease of use in a wide variety of situations are all crucial. Despite these accepted principles, many architects and engineers design rehabilitation projects without sufficient knowledge of the materials they specify. They often do not appreciate the meaning and importance of compatibility between repair materials and the substrate.

It is unclear whether most standards tests are representative of field conditions, yet they are often used to determine durability criteria for field use. The development of performance standards has not kept pace with the development of materials, primarily because of a lack of supporting scientific and field data. Thus, it is no surprise that there is a high failure rate with new technologies and materials. A more direct means is required for linking the properties of repair materials with quality and performance of what is actually produced in the field.

The challenge for the future involves gaining a better understanding of the mechanisms involved in concrete deterioration as they relate to the environmental conditions in which structures perform; of the effects of material modifications, and of the controlling parameters of new composites. What is needed, is a correlation of the research on material degradation in controlled laboratory conditions with the environmental conditions in which the structures perform. This will enable us to obtain quantitative data for determining critical properties and to develop predictive procedures for assessing the effects of changes in materials.

The purpose of this Special Issue – which discusses the scope function, mechanism and attributes of the different types of repair materials and techniques used in patch repair – was to provide a practical and readable guide that presents the broad underlying concepts for the architect, consulting engineer, contractor and technician. Effects of a repair on the corrosion activity and structural capability of the repaired structure are addressed.

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Because of the electrochemical and mechanical incompatibility of some of the repair materials with the existing concrete substrate many researchers and practitioners have advocated a holistic approach to repair. The paper on the holistic approach to repair stresses the requirement of compatibility and a matching of the material properties to the performance necessary for a given set of in service conditions. Papers 2 and 3 augment the compatibility issue through a discussion on electrochemical factors involved in patch repair.

An appreciation of the mechanisms of corrosion involved – after the installation of a patch – can be obtained from papers 4 and 5 that address micro and macrocell corrosion by a micro-structural approach. Paper 6 indicates that chemical, physical and mechanical characterizations are insufficient to guarantee protection against aggressive agents. It provides a methodology to evaluate the performance of various repair materials in situ.

The techniques to evaluate structural performance and the effects of corrosion on structural performance are discussed in two papers. Paper 7 examines the effectiveness and structural implications of electrochemical chloride extraction when applied to reinforced concrete beams containing chlorides and reactive aggregates. Paper 8 investigates the structural behavior of columns with patch repair under both loaded state and unloaded states. The last paper presents the retrofitting of deteriorated structures using FRP plates. The study invalidates three basic but important concepts in terms of debonding.

The detailed discussions of specific subjects by the authors have been drawn from their many years of laboratory and field experience. Their support in the drawing up of the theme of the issue and the contribution of important articles and the painstaking reviews provided by the reviewers are gratefully acknowledged.

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