aggregates, and admixtures. Many designers do not appreciate the complexity of the concrete repair system; they merely choose a material according to its compressive strength, as measured in the field or some laboratory. Design codes seem to encourage this material selection method, by relating most material performance indicators to the concrete’s compressive strength.

Almost all concrete repair design problems are open-ended; they do not have a unique or “correct” solution, though some solutions are clearly better than others. These field problems differ from those used in mechanics and structures classes that generally have single correct answers. The designer needs a better understanding of concrete repair as a unique composite system of materials exposed to a combination of interior and exterior environments. The durability of a concrete repair, however, is not based on the repair material alone—design, detailing, workmanship, and quality control are all important factors. Understanding concrete repair requires an open mind, a willingness to consider all facts, and, of course, knowledge about concrete.

In “new” structures, there is often a well-defined structural system that has been designed and its capacity documented with calculations. In repair and rehabilitation, one has only problems, symptoms, and sometimes causes, often without any information about the structural system. The following are some of these problems:

- What caused the failure or deterioration?
- What is the remaining service life of the structure (durability capacity)?
- What is the present load-carrying capacity of the structure?
- How will the repair treatment affect the overall structure (“side effects?”); and
- Which materials and methods will offer the best (technically and economically) solution?

There is an increased need for designers to pay more attention to “constructibility” issues during the development of specifications and to gain a higher level of knowledge in concrete technology, including field experience. The repair design must contribute to the solution and not be the major problem. Geometry, access, amount and spacing of reinforcement, climatic conditions, available equipment, local engineering and labor skills, quality control, and economical considerations have to be analyzed. Repair specifications are often a mixture of referenced standards and “cut and paste” clauses from previous projects. In the best cases, they tend to be based on borrowed wisdom as opposed to documented performance.

The analysis of premature deterioration of concrete repairs highlights the very essential role played by the construction process in providing the quality needed for a concrete structure to resist its environment. On-site workmanship is a crucial element of the repair success or failure. Poor workmanship results in unacceptable variability in concrete. Variability leads to premature failures due to various destructive processes. All good intentions in a rational design and material selection will fail if not supported by quality workmanship and quality control during construction.

**RESEARCH AND TESTING**

Existing research and testing methods used for evaluating the performance of a concrete repair are clearly unsatisfactory. Many of the laboratory test results are inconsistent. One of the reasons for this is that most of the tests are related to concrete produced and cured in the laboratory—labcrete. This does not allow the researcher or practitioner a complete understanding of the material’s in-place behavior and its effects on repaired structures.

Laboratory and experimental testing should study repair-related issues of realcrete—concrete under field conditions. Researchers should consider the environment, repair location in the existing structure, its geometry, restraint, and nonuniformity. Various loading conditions need to be included in such testing programs. To give designers confidence in new technology, research should provide the credible basis on which prognosis of performance and longevity can be made.

For example, cracking in the repair, caused by restrained volume changes, is one of the truly insidious phenomena of repair pathology.