New Code Sets Standards for Concrete Repair

A new era has begun for concrete repair, in which specifiers and contractors are rethinking their approach to existing structures. The shift is reflected through the publication of ACI 562,[1] the first code by the American Concrete Institute (ACI) that focuses specifically on evaluating, repairing, and rehabilitating reinforced concrete. The material-specific code was conceived as a way to raise the bar for concrete repair by providing clearly defined, uniform requirements, and will help concrete professionals devise more effective rehabilitation solutions that ultimately will extend the service life of concrete structures.

Without specific provisions to ensure quality, safety, and efficiency, concrete repair practices and inspections had been inconsistent. Design professionals evaluated repairs according to standards for new construction, which often resulted in overly extensive or costly repair solutions. In many cases, viable concrete structures were neglected or demolished instead of being rehabilitated. Rather than provide a prescriptive set of rules, the code is designed to give concrete designers significant latitude in developing repair strategies that account for the variables and unique considerations of each project (age of the structure, properties and condition of the original materials used, environmental conditions, etc.), while following a minimum baseline of requirements.

The accompanying guide to ACI 562 provides examples of actual concrete repair projects. In one example of a façade repair, the extent of concrete and steel deterioration was relatively minor. Spalling and delamination occurred mostly where reinforcing bars were placed too close to the surface and located in carbonated concrete. Photo courtesy of ACI.

The code directs the concrete professional to evaluate the particular conditions of each project to specify the most effective solution. To support this task, chapters of the code cover all aspects of concrete repair, from conception to completion, including the basis for compliance, evaluation and analysis, design of structural repairs, durability, and construction. For example, Chapter 8: "Durability" encompasses considerations such as the properties and characteristics of existing concrete and repair materials (reinforcing steel cover, cracks, protective coatings, corrosion potential, etc.), environmental effects (moisture, freeze/thaw cycles, chlorides, etc.), and design service life.

The concrete professional is responsible for evaluating the level of damage to existing reinforcement and determining its effects on the strength of steel and concrete; and Section 8.4 requires corrosion of embedded reinforcement to be considered when developing a durable repair strategy. The code also describes various methods for creating a cost-effective repair solution.

Provisions for using surface treatments and coatings to limit the effects of concrete deterioration are included, with Section 8.5 detailing options such as elastomeric coatings, penetrating epoxy, sealant joints, and flashings for limiting moisture and chemical penetration. For instance, surface membranes can limit the penetration of moisture and chemicals that deteriorate reinforcement, but they can accelerate deterioration in concrete that is already saturated. Similarly, different types of surface treatments should be used on moving cracks vs. non-moving cracks.

The code also assists designers in selecting durable strategies for repairing reinforced concrete structures that exhibit corrosion. In locations where embedded reinforcement extends into concrete added for repair, the resulting difference in electrical potential can accelerate reinforcement corrosion. This corrosion can be addressed by methods such as corrosion-resistant reinforcement coatings, galvanic anodes, and replacement concrete materials with enhanced properties (i.e., corrosion-inhibiting admixtures, additional concrete cover, surface treatments, or coatings). In locations where reinforcement will remain embedded in existing concrete, designers may consider crack treatments, surface treatments or coatings, surface-applied penetrating corrosion inhibitors, active cathodic protection, galvanic protection, chloride extraction, and realkalinization.

To ease the transition to using the new code and its provisions, ACI and the International Concrete Repair Institute (ICRI) have published a user-friendly reference to help designers and contractors interpret ACI 562 requirements and apply them to specific situations.[2] The guide explains the repair evaluation process, repair requirements, and durability considerations required by ACI 562. This helps concrete designers achieve a structure's targeted service life by addressing causes of deterioration, ensuring compatibility between repair materials and the existing structure, evaluating the durability of repair materials, and devising a routine maintenance plan. The first 11 chapters of the guide mirror each chapter of ACI 562, with an overview of each topic that includes in-depth analysis, commentary, and references not explicitly

included in the code. The guide also includes flowcharts and call-out boxes with additional resources, such as useful references on the causes, evaluation, and repair of reinforcement corrosion in concrete structures.

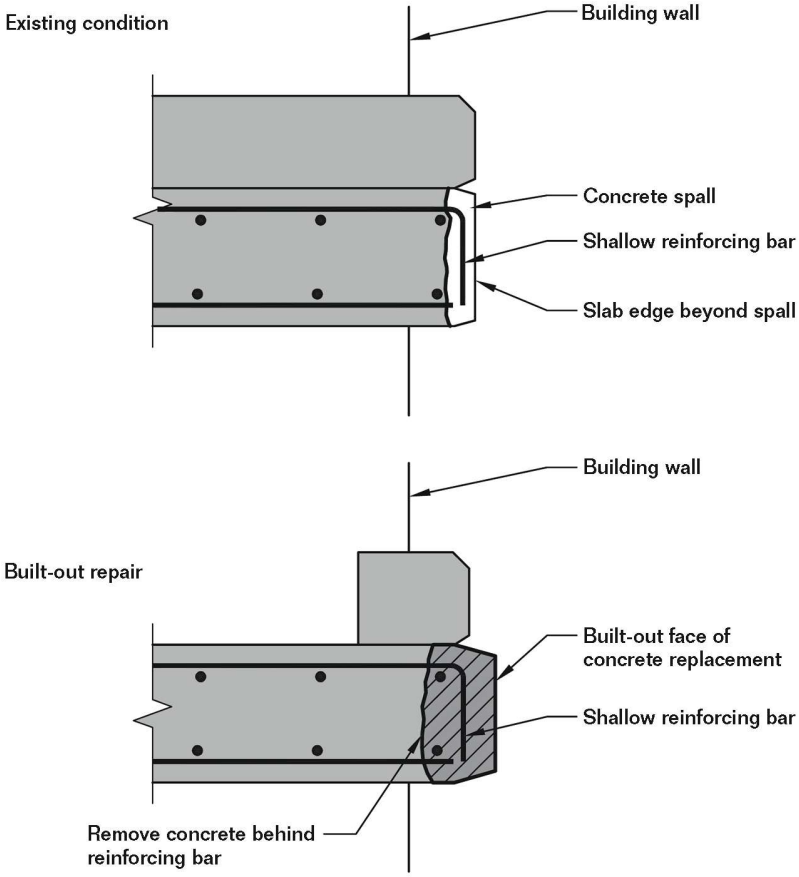
The guide also provides detailed examples of concrete repair projects to illustrate how ACI 562 requirements apply to common repair scenarios. Project examples in the guide include typical parking garage repairs, typical façade repairs, repair of a historic structure for adaptive reuse, strengthening of a two-way flat slab, and strengthening of double-tee stems for shear. Alongside each project description are references to ACI 562 requirements for each phase, such as identifying the design basis code, evaluating concrete and reinforcement strength, and meeting durability requirements.

In one example, the owner of a 1970s residential tower noticed spalling in the concrete façade and corrosion on exposed reinforcing bars. A licensed design professional was hired to determine the condition of the concrete, identify unsafe conditions, and develop a maintenance plan. The guide lists ACI 562 provisions a concrete professional would apply during each step of this process, including testing deteriorated concrete for chlorides, carbonation, and concrete quality; restoring affected concrete and reinforcement; remediating unsafe conditions (falling hazards); and providing the owner with a maintenance plan to limit future damage.

In this case, the licensed design professional determined there was no reason to question the design strength of affected members or the structure; therefore, a structural analysis and evaluation was not required. The primary purpose of the repair was to eliminate unsafe conditions and to restore the concrete façade for durability and aesthetic purposes.

As concrete professionals apply ACI 562 to their work, the guide helps them navigate the new code by pinpointing the provisions that address their most fundamental concerns. By understanding the code, engineers and architects can elevate the overall quality of concrete repair while educating project owners and municipalities about the new requirements that are becoming standard practice. Building officials have adopted ACI 562 on a case-by-case basis, and local jurisdictions can also adopt the code. ACI 562 is compatible with the International Existing Building Code (IEBC), and is being considered for adoption in 2018.

ACI 562 was developed as a result of the *Vision 2020* plan, put forth in 2006 by the ACI Foundation's Strategic Development Council and supported by the ICRI and other industry leaders.



To repair damaged concrete balconies on a 1970s apartment building, the owner elected to build out the concrete replacement with a minimum concrete cover of 1 in (25 mm). Unsound concrete was removed to provide minimum patch depths and minimum gaps behind the reinforcing bars. The concrete and steel surfaces were cleaned by wire brushing and reinforcing steel was coated with a corrosion-inhibiting material for improved corrosion resistance, which is a requirement of ACI 562. Image courtesy of ACI.

Source: American Concrete Institute (ACI), concrete.org. This article was submitted by Jay H. Paul with Klein and Hoffman, Inc. (Chicago, Illinois)—e-mail: jayhpaul@comcast.net. Paul is past chair of ACI Committee 546—Concrete Repair.

References

1 ACI 562-13, "Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings" (Farmington Hills, MI: ACI, 2013).

2 "Guide to the Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings," ACI and ICRI, 2015. MP