Guide to Materials Selection for Concrete Repair

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This document provides guidance on the selection of materials for concrete repair. An overview of the important properties of repair materials is presented as a guide for making an informed selection of the appropriate repair materials for specific applications and service conditions.

Keywords: cementitious; cracks; epoxy; materials; methacrylate; polymer; polyurethane; repair; surface sealer; silica fume; test methods; waterproofing.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Concrete is inherently a durable material, but its durability under any given set of exposure conditions varies with concrete mixture proportions; the presence and positioning of reinforcement; and the detailing, placing, finishing, curing, and protection it receives. In service, it may be exposed to conditions of abrasion, moisture cycles, cycles of freezing and thawing, temperature fluctuations, reinforcement corrosion, and chemical attack, resulting in deterioration and potential reduction of its service life.

As the concrete industry develops and grows, concrete repair is frequently required; however, with the increasing number and age of concrete structures, frequent deferral of maintenance, and increased public awareness of deterioration and maintenance needs, repair is becoming a major focus of design and construction activities. Although concrete repair is traditionally as much an art as a science, engineers and contractors typically do not receive much formal training in techniques for repair and the performance of repair materials applied to concrete. Personal experience is beneficial, but takes time to accumulate and can be costly in terms of failed repairs. Although this is changing, there is still too little information available to reliably predict the serviceability and durability of repairs. Concrete repairs that fail prematurely result in economic loss and usually require additional repairs.

Due to a greatly expanded repair market, new materials and repair methods are being introduced at an increasing rate to the construction market. At the same time, due to changing environmental and building codes and other regu-

lations, many existing, well-proven products are being reformulated into essentially new products that have limited track records. The user might not be informed of these changes.

It is often difficult for a specifier to find the appropriate data to systematically evaluate a product for a given repair situation. Often, test data are unavailable or, if available, are either not presented in useful or appropriate terms or presented in a manner that makes comparison with other competing materials difficult. One example is the use of nonstandard or modified test methods.

Although there are many competent repair materials available commercially, there are also unsubstantiated claims of suitability and success. Even the highest-quality materials do not perform as expected if they are used inappropriately.

ACI 546R is the first ACI publication devoted entirely to the subject of concrete repair. Its principle emphasis is on techniques for concrete repair with limited information on selecting repair materials. The physical properties of repair materials govern their performance in service and, as a result, the appropriate selection of these materials for a given repair is at least as important to a successful, long-lasting repair as is using the proper procedures and workmanship. This guide is the second in a series of documents prepared by Committee 546 to aid the user in specifying and executing typical concrete repairs.

1.2—Essential steps of concrete repair

The success of concrete repairs depends on determining the cause and extent of concrete distress or deterioration and developing a repair strategy to address the problem. Typical steps in a systematic repair are to:

a) Conduct a condition survey with a scope consistent with the perceived condition of the structure and the owner's repair objectives, performed by qualified individuals, to document and evaluate visible and concealed deterioration, distress, defects, and damage, as well as potential future deterioration and distress;

b) Determine the cause of the damage or deterioration necessitating the repair—for example, mechanical damage such as impact or abrasion; design, detailing, or construction deficiencies; chemical damage such as alkali-aggregate reaction; physical damage related to cycles of freezing and thawing or thermal movements; corrosion of the steel reinforcement caused by improper placement; carbonation of the concrete; or chloride ingress into the concrete to the reinforcing steel;

c) Assess the application and service conditions to which the concrete repair material is, or will be, exposed;

d) Determine the repair objectives, including desired service life;

e) Select a repair strategy, including consideration of an appropriate protection system in conjunction with future maintenance, in terms of what is required to preserve or protect the structure and repairs, and what actual maintenance is likely to be available.

Once the concrete to be repaired is evaluated and the cause of distress established, details of the proposed repair are developed. This includes evaluating and determining the required physical properties of repair materials, followed by the appropriate selection of available repair materials. Selection is usually based on the ability of the material to conform to repair constraints and objectives as defined in this guide, including consideration of cost and availability.

The repair is then implemented, including protective systems if designed as part of the repair. Refer to ACI 546R, where these steps are discussed in further detail.

1.3—Objective

The objective of this guide is to provide guidance for the materials selection for concrete repair, including:

a) Identification of common repair materials;

b) Discussion of relevant material properties;

c) Lists and discussion of test procedures for measuring these properties;

d) Recommendations of minimum test values or performance levels;

e) Discussion of the importance of specific material properties for various repair applications and service environments.

1.4—Scope

This guide discusses material selection for several types of repairs and materials used in their repair:

a) Concrete replacements, categorized on the basis of the depth and orientation of repair;

b) Overlays, categorized on the basis of their thickness;

c) Crack repairs, categorized on the basis of crack stability, crack width, and other service conditions;

d) Surface sealers and traffic-bearing elastomeric coatings, categorized on the basis of their water and chloride ion permeability;

e) Anti-carbonation coatings, categorized on the basis of their carbon dioxide diffusion;

f) Reinforcing steel coatings, embedded galvanic anodes, concrete bonding agents and procedures, crystalline pore blockers, and surface-applied, penetrating corrosion inhibitors, categorized on their ability to alter and improve various concrete properties.

1.4.1 *Concrete replacement and overlay materials discussed in this guide include:*

a) Portland or blended cement-based mortar and concrete;

b) Portland or blended cement-based silica-fume mortar and concrete;

c) Portland or blended cement-based polymer-cement mortar and concrete;

d) Magnesium-ammonium-phosphate-cement mortar and concrete;

e) Polymer-based mortar and concrete.

1.4.2 *Crack repair materials discussed in this guide include:*

a) Epoxy resin;

b) Methacrylate resin;

c) Polyurethane chemical grout;

d) Polyurethane sealant;

e) Silicone sealant;

f) Silyl-terminated polyether sealant;

g) Polysulfide sealant;