Guide for Polymer Concrete Overlays

Reported by ACI Committee 548

ACI 548.5R-16

American Concrete Institute
Always advancing

First Printing
January 2016
ISBN: 978-1-942727-39-2

Guide for Polymer Concrete Overlays

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at http://concrete.org/Publications/DocumentErrata.aspx. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided "as is" without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

ACI 548.5R-16

Guide for Polymer Concrete Overlays

Reported by ACI Committee 548

Brad Nemunaitis, Chair

Mahmoud M. Reda Taha, Secretary

Ashraf I. Ahmed
Mohammad A. Alhassan
Jacques A. Bertrand
Constantin Bodea
Chris Davis
David W. Fowler
Quentin L. Hibben
Albert O. Kaeding
John R. Milliron
Myles A. Murry
Joseph A. Nuciforo Jr
John R. Robinson

Michael L. Schmidt
Joe Solomon
Michael M. Sprinkel
Michael S. Stenko
Donald P. Tragianese
Wafeek S. Wahby
David White
Richard E. Wollmershauser

Consulting Members
Milton D. Anderson
Lu Anqi

Craig A. Ballinger
John J. Bartholomew
Shashi P. Bhatnager
Zhi-Yuan Chen
Lech Czarnecki
Harold (Dan) R. Edwards
Larry J. Farrell
Jack J. Fontana
George Horeczko
David P. Hu
Bert Paul Kriekemans
Deon Kruger

William Lee
Troy D. Madeley
Henry N. Marsh Jr
Peter Mendis
Peter J. Moss
Yoshihiko Ohama
Kelly M. Page
Hamid Saadatmanesh
Donald A. Schmidt
Meyer Steinberg
Harold H. Weber Jr

This guide provides an overview of thin (less than 1 in. [25 mm] thick) polymer concrete overlays for concrete and steel substrates. Emphasis is placed on their use in the transportation sector, specifically for bridge decks and parking garages. Surface preparation, application, quality control, and safety aspects are included.

Keywords: aggregate; bridge deck; epoxy; high friction surface; methyl methacrylate; mortar; overlay; parking garage decks; polyester; polymer concrete; premixed; resin; skid resistance; slurry.

CONTENTS

ACI 548.5R-16 supersedes ACI 548.5R-94(98) and was adopted and published January 2016..

CHAPTER 1—INTRODUCTION

1.1—General

Reinforced concrete, steel grid, and steel orthotropic decks are constantly exposed to deicing salts and other environmental factors such as acid rain and pollution chemicals. Escalating costs of preservation and replacement of bridges and parking garage decks have promoted construction and maintenance options such as high-density concrete overlays, latex-modified concrete overlays, membrane/asphalt overlays, cathodic-protection systems, epoxy-coated reinforcing bars, and thin polymer concrete (PC) overlays (Mo et al. 2012).

Each option has advantages and disadvantages that should be analyzed before a choice is made. Costs vary by region with the availability of materials and experienced contractors. In addition, the life expectancies of these options are different.

Bridges and parking garage decks contain structural elements that are susceptible to premature failures due to moisture, chlorides, freezing and thawing, and wear from high traffic volumes.

1.1.1 *Advantages*—Compared with other overlay systems, PC overlays are cost effective on a life cycle cost basis (Kim and Lee 2013). Rapid-cure characteristics of PC overlays minimize disruptions, reduce traffic-control costs, and ease the inconvenience of scheduling repairs. With dead load of only 2 to 6 lb/ft^2 (9.8 to 29.3 kg/m^2), PC overlays result in greater live-load capacity than heavier conventional systems. This is a critical factor to be considered for aging structures. At application thicknesses of 3/8 to 1 in. (10 to 25 mm), PC overlays do not require modification of expansion joints or drainage structures. They are highly resistant to the penetration of water and exhibit better chloride-intrusion resistance than other types of concrete overlays. In addition, they offer a high skid resistance and wearing resistance for both concrete and steel deck protection (Lopez-Anido et al. 1998; Wang et al. 2012). PC overlays can be installed without specialized equipment; however, technical expertise is required. Maintaining quality control is important, and proper surface preparation requires close attention.

1.1.2 *Disadvantages*—A disadvantage associated with PC overlays is that they must be applied to dry surfaces. The workability and curing rate of PC overlays are dependent on the substrate, material, and ambient temperatures. Polymer overlays are not intended to provide resistance to reflective cracking.

1.2—History of polymer concrete overlays

Polymer concrete (PC) overlays date back to the 1950s, with original systems consisting of a single layer of coal-tar epoxy evenly spread over the substrate and broadcast with aggregate. These overlays were relatively porous and did not stand up well to heavy traffic. In the early 1960s, oil-extended epoxy came into use in an attempt to improve resistance to water penetration. By the mid-1970s, low- and medium-modulus 100 percent solids epoxy formulas were introduced, and many of these systems continue to be used successfully today.

By the mid-1960s, single- and double-layer polymer broadcast systems and polyester resins, and methyl methacrylate overlays were introduced. The first premixed and screeded polymer and aggregate systems also appeared at this time. Thicker PC overlays and brittle materials were used, frequently exhibiting cohesive failure in the concrete. Through trial and error, resin formulations were modified to provide better thermal compatibility and improved physical properties. Resistance to chemical and mechanical attack, corrosion resistance, and performance under adverse installation conditions have also been the subject of extensive development. For instance, Whiting (1991) showed, using field measurements that corrosion current in reinforced concrete bridge deck substrates is decreased when a low-permeability overlay (for example, latex-modified concrete overlay) was installed. Virmani (1992) showed that electrically conductive PC overlays can be used as secondary anodes to distribute cathodic protection current across the concrete surface and provide a skid- and water-resistant surface. PC overlays have been shown to be successful, though some problems still exist. Many of these problems are the result of inadequate surface preparation, improper application techniques, or inappropriate selection of polymer materials.

There have been many improvements in PC materials and technology. PC overlays are now generally specified with flexible resins and high-friction wear-resistant aggregates. Workmanship and inspection techniques have also improved as designers, inspectors, and applicators have gained experience related to the causes and prevention of PC overlay defects continues to improve. Some of the best practices on PC overlays have been reported by Fowler and Whitney (2011).

1.3—Scope

This guide is intended to aid in the proper selection and application of PC overlays for structures in the transportation industry, focusing primarily on bridge and parking garage decks. Materials discussed are epoxies, polyesters, and methacrylates for application on either concrete or steel surfaces.

In general, these overlays are used for the protection of the substrate and are designed to be compatible without causing stress. The low permeability of PC overlays makes them resistant to the penetration of water and provides protection against chloride penetration. Overlays are designed to minimize deterioration from repeated thermal expansion and contraction (Fowler et al. 2001). In addition to describing the characteristics of PC overlays, this guide includes chapters on surface preparation, application, quality control, and handling and safety. The information should allow the reader to select materials for a given application and may serve as the basis for the preparation of overlay specifications.

CHAPTER 2—DEFINITIONS

Please refer to the latest version of ACI Concrete Terminology (https://www.concrete.org/store/productdetail.aspx?ItemID=CT13) for a comprehensive list of definitions. Definitions provided herein complement that resource.

A/B component—individual parts of a polymer binder system; components typically consist of resin and curing agent (also known as a hardener).

broadcast—to scatter over a wide area by hand or mechanical method.

catalyst—substance that markedly speeds up the curing of a binder when added in minor quantity.

compressive strength—measured maximum resistance of a concrete or mortar specimen to axial loading; expressed as force per unit cross-sectional area.

crosslinking—joining of preformed linear polymer chains to each other to form three-dimensional networks.

cure time—interval after mixing in which a polymer concrete system develops the required strength

flexibilizer—additive that gives a rigid plastic flexability.

gel time—time interval after mixing that a liquid material exhibits a significant viscosity increase.

high-molecular-weight methacrylate—low-viscosity substituted methacrylate monomer that is characterized by low volatility.

initiator—substance capable of causing the polymerization of a monomer by a chain reaction mechanism.

methyl methacrylate—low-viscosity methacrylate monomer that is characterized by high volatility.

monomer—organic liquid of relatively low molecular weight that creates a solid polymer by reacting with itself, other compounds of low molecular weight, or both.

organic peroxides—sources of free radicals used in polymerization and crosslinking.

polyester—group of resins mainly produced by reaction of unsaturated dibasic acids with dihydroxy alcohols; commonly dissolved in a vinyl group monomer such as styrene.

promoters—reducing agent compounds added to the monomer system to cause the decomposition of the peroxide initiators in the system (often called accelerators).

reflective cracking—phenomenon where cracks form in the overlay directly over existing cracks in the substrate.

rutting—formation of a depression in the overlay.

scarification—process of scratching, cutting, or chipping the existing concrete surface for the purpose of cleaning and texturing it.

sensitization—act, process, or result of sensitizing or making sensitive.

skinning—in polymer concrete, the loss of patches of material from the top surface of the overlay, usually associated with overworking it.

surface failure—loss of top surface aggregates from the polymer binder in polymer concrete.

surface broadcasting—application of aggregate to the freshly applied polymer concrete resin or premix matrix overlay to provide intercoat adhesion or to act as the wearing course.

surface tining—scoring or grooving of the polymer concrete overlay to provide for drainage, additional skid resistance, or both.

wear—deterioration of a surface due to traffic, use, the environment, or a combination of these.

near white metal surface—metal substrate that has been abrasively blast-cleaned.

working life—time period between the mixing of polymer concrete and the point at which its viscosity has become too high to be workable or too high to bond properly to the substrate.

CHAPTER 3—POLYMER BINDERS

3.1—General

Polymer concrete (PC) is a class of composite materials that includes a broad group of organically bound mortar, each with its own distinctive properties. Familiarity with the properties of each group is essential to understanding PC.

The resins used as binders for the formulation of PC are monomers or polymer/monomer solutions that are mixed at the time of application with their respective curing agents. The cured polymer serves as the binder for aggregate and fillers in the same manner that portland cement acts to bind conventional concrete.

The polymer families most commonly used for the preparation of PC overlays are epoxies, polyesters, and methacrylates. The chemical compositions of each of these polymer binders are distinctly different, and the PC they form have varying properties.

3.2—Properties of polymer binders

Polymer binders are classified by both uncured and cured properties that are measured in the laboratory according to industry standards. The nature of these properties and their relationship to the performance of the PC are described in the following.

3.2.1 *Uncured properties*—The uncured properties of polymer binders are related to their handling characteristics. In addition to methods of application, environmental conditions may dictate the use of selected systems.

Polymer binders may be distinguished by the viscosities of the individual or mixed components. These values may range from 100 to 2500 centipoise (cps). For applications with deck surface slopes of greater than 3 percent, higher viscosities may be required for neat applications of the polymer with aggregate broadcast into the surface to maintain uniform thickness. Binder resins with a low initial viscosity are suitable for highly filled PCs prepared by the premix or slurry method, with or without broadcasting on the surface.

The working life of the binder is dependent on the amount mixed, material temperature, substrate temperature, and the ambient temperature. As more material is mixed in bulk or as