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Report on Polymer-Modified Concrete

Reported by ACI Committee 548

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This report addresses concrete made with organic polymers combined with hydraulic cement and discusses the polymer systems used to produce polymer-modified concrete, including their composition and physical properties. It explains the principle of polymer modification and reviews the factors involved in selecting appropriate polymer systems. The report also discusses mixture proportioning and construction techniques for different polymer systems and summarizes the properties of fresh and hardened polymer-modified concrete and common applications.

Keywords: abrasion; acrylic resins; admixtures; bridge deck; construction; corrosion; curing; durability; epoxy resins; latex; mixture proportioning; mortar; pavements (concrete); plastic; polymer; polymer-cement concrete; repair; resin; resistance to chemical attack; resistance to freezing and thawing; test.

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PREFACE

Polymer-modified concrete (PMC) is developed by mixing a polymer material to portland-cement concrete with the interest of enhancing the concrete durability and bond strength. PMC, also known as polymer portland-cement concrete (PPCC) or latex-modified concrete (LMC), was originally developed during the 1950 and 1960s. The material quickly found its way to awaiting industry to make use of its unique properties and became a common material in bridge deck slab overlays, industrial floors and as repair material with enhanced tensile and bond strength. Extensive research and numerous publications on the behavior of PMC were produced from the late 1970s up to the early 1990s. These publications constitute most of our current knowledge on PMC and polymer-modified mortars (PMM). While the development of PMC has significantly slowed down in the last decade, this document is designed to provide a major source of collective information for the public about PMC. The intent is to provide insight on most up-to-date standards, current practices, and the state of the art on research developments on PMC.

The International Congress on Polymers in Concrete (ICPIC) served during the last four decades as the international forum for research and development (R&D) on all types of polymer concrete including PMC. Proceedings of the ICPIC reflected the state of R&D on PMC and the issues of current interest for both academia and industry. The first ICPIC was held in London (UK) in 1975, and the most recent ICPIC was held in Chuncheon (South Korea) in 2007. For the last three decades, the ICPIC forum has served to connect interested specialists in PMC while providing insight on new technologies and future development trends.

Research on PMC continues to date with little addition to the main body of knowledge that was generated in the last 20 years of the twentieth century. Research developments in the 1980s and 1990s explained the principles of polymer modification of cement hydration (Ohama 1987) and provided the basis for selecting the suitable polymer type for PMC. Today, styrene butadiene rubber (SBR) and styrene-acrylic (S-A) copolymer represent the most usable polymers in PMC. It is therefore evident that PMC production and use has reached a high level of maturity and most research investigations in the last two decades were applications directed to further establish the procedures and standards for the material's use in the field.

Within the past few years, the most interesting developments in PMC are the development of new very-early-strength LMC (Sprinkel 2005) and the use of chopped glass and carbon fibers as additives to reduce LMC plastic shrinkage cracking (Issa et al. 2007). Both developments have found their way to bridge deck slab overlays for their ability to provide fast construction and reduce plastic shrinkage cracking. The recent work by Ohama and Demura (2001) and Ohama (2007a) on self-repair epoxy-modified mortars is definitely worth noting.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Polymer-modified cementitious mixtures (PMCs), also called polymer portland-cement concrete (PPCC) and latex-modified concrete (LMC), are defined as hydraulic cement combined at the time of mixing with organic polymers that are dispersed or redispersed in water, with or without aggregates. An organic polymer is a substance composed of thousands of simple molecules combined into large molecules. The simple molecules are known as monomers, and the reaction that combines them is called polymerization. The polymer may be a homopolymer if it is made by the polymerization of one monomer, or a copolymer when two or more monomers are polymerized. The organic polymer is supplied in three forms: as a dispersion in water that is called latex; as a redispersible powder; or as a liquid that is dispersible or soluble in water. Dispersions of polymers in water and redispersible polymer powders have been in use for many years as admixtures to hydraulic-cement mixtures. These admixtures are called polymer modifiers. The dispersions of these polymer modifiers are called latexes, sometimes incorrectly referred to as emulsions.

In this report, the use of the general term "polymer-modified cementitious mixture" includes polymer-modified cementitious slurry, mortar, and concrete. Where specific slurry, mortar, or concrete mixtures are referenced, specific terms are used, such as LMC and latex-modified mortar (LMM). Several other terms used in this report are defined in ACI 548.1R.

The improvements from adding polymer modifiers to concrete include increased bond strength, flexural and tensile strengths, split strength, and reduced elastic modulus. These lead to improved physical resistance such as impact resistance and abrasion resistance (Shaker et al. 1997; Wong et al. 2003; Colak 2005). A reduced elastic modulus might be particularly helpful when LMC is applied as a bridge deck overlay or repair surface. The reduced elastic modulus results in a reduction of the stresses developed due to differential shrinkage and thermal strains that would reduce the tendency of the material to crack. PMC can also improve corrosion resistance, resistance to chemical attack and severe environment (such as sulfuric acid attack, penetration by water and dissolved salts, and freezing-and-thawing resistance), and it reduces need for sustained moist curing. These improvements are largely due to reduced water permeability in PMC (Shaker et al. 1997; Ohama 1995b). The improvements are measurably reduced when PMC is tested in the wet state (Popovics 1987; Soroushian et al. 1993). The specific property