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Polymer Concrete: Guidelines for Structural Applications

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Polymer Concrete: Guidelines for Structural Applications

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

www.concrete.org

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Reported by ACI Committee 548

Mahmoud M. Reda Taha, Chair

Ashraf I. Ahmed
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Subcommittee 548B

Aly Said

Polymer concrete (PC) can be used in the construction of structural elements with applications, including wall panels withstanding wind and seismic loads, underground vaults resisting lateral earth pressure, vault and utility box covers resisting vehicle loads, and railroad ties resisting static and dynamic rail loads. PC structural elements are used to resist bending moments and axial and shear loads. Creep, fatigue, and service temperature are important aspects for PC structural elements. These guidelines help the defining and understanding of mechanical properties and structural behavior of PC. Industrial standards and design guidelines governing design with PC have been developed and used by the PC industry for the last five decades. These guidelines highlight some of those standards.

Keywords: beam; creep; equipment foundation; fatigue; fire resistance; fracture; manholes; polymer; polymer concrete; reinforced polymer concrete; utility structures; walls.

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CHAPTER 1—INTRODUCTION

Polymer concrete (PC) has been used in structural applications where strength, stiffness, durability, and ease in molding provide an advantage over other materials. Many types of reinforcement can be used with PC. This guide presents the structural uses of PC.

Polymer concrete is a mixture of aggregates and resins or monomers without portland cement that hardens by polymerization after it is placed. PC was first used commercially in the 1950s in the United States in the production of synthetic marble, followed by the manufacture of architectural facing panels in the late 1950s. Beginning in the 1970s, other structural products began to appear in the market, including floor drains, utility trenches, underground utility vaults and covers, high-voltage insulators, and highway median barrier shells. These products were followed by the introduction of manhole structures and machine tool bases. By the mid-1970s, PC was used as a repair material for portland-cement concrete structures, mainly on highways and bridges. In the United States in the 1980s, chemical companies developed an increasing interest in specific materials and material properties required to produce PC. As a result, many enhancements in the polymers used for PC were developed, and resins tailor-made for PC production became available. This development continues, and important material improvements are often achieved by manufacturers.

Research into the behavior of PC structural elements has been conducted at numerous research labs. Structural research has been conducted on such uses as steel-reinforced beams and panels, ballistic panels (barriers to armed assault on embassies, for instance), electric transmission poles, structural sandwich elements, building blocks, utility trenches, utility covers, and insulation panels (Fowler 1988).

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

A_1 = amplitude of first cycle
A_n = amplitude of the n-th cycle
E = dynamic modulus, psi (MPa)
f_1 = frequency of the first mode, Hz
I = section moment of inertia, in.^{4} (mm^4)
l = specimen length, in. (mm)
n = number of amplitude cycles
T_g = glass-transition temperature, °F (°C)
W = weight of the specimen, lbf (lbf/N)
β = l^3/I, in.$^{-1}$ (m^{-1})
ζ = specific damping factor

2.2—Definitions

A/B components—individual parts of a polymer binder system; in epoxy PC, the components typically consist of resin (A) and curing agent/hardener (B); in free radical PC, the components typically consist of resin (A) and initiator (B).

accelerator—chemical used to increase the rate of cure in a free radical system by reacting with the initiator.

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

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

cross-linking agent—chemical used to increase the cross-link density of the polymer network.

cure time—the interval after mixing in which a PC system gains adequate strength to support loads, such as foot traffic, vehicular traffic, or both.

curing—the change in properties of a chemical by an increase in molecular weight via polymerization or cross-linking, usually accomplished by the action of heat, catalyst, cross-linking agent, curing agent, or any combination, with or without pressure.

fiberglass—a composite material consisting of glass fibers in resin.

flammable liquid—any liquid having a flash point below 38°C (100°F).

flash point—minimum temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

flexibilizer—additive that gives a rigid plastic flexibility.

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

heat deflection temperature—temperature at which a polymer or plastic sample deforms under a specified load.

inhibitor—substance that slows or stops a chemical reaction.

initiator—substance capable of causing the polymerization of a monomer by a chain reaction mechanism; often incorrectly called a catalyst.