

# **Report on Glass Fiber-Reinforced Concrete Premix**

Reported by ACI Committee 549



**American Concrete Institute®**



First Printing  
December 2009

American Concrete Institute®  
*Advancing concrete knowledge*

## Report on Glass Fiber-Reinforced Concrete Premix

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

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. Proper use of this document includes periodically checking for errata at [www.concrete.org/committees/errata.asp](http://www.concrete.org/committees/errata.asp) 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.

**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**  
**U.S.A.**

**Phone: 248-848-3700**  
**Fax: 248-848-3701**

**[www.concrete.org](http://www.concrete.org)**

ISBN 978-0-87031-354-7

# Report on Glass Fiber-Reinforced Concrete Premix

Reported by ACI Committee 549

Ashish Dubey<sup>\*†</sup>  
Chair

Corina-Maria Aldea <sup>†</sup>	David M. Gale	John L. Mulder	Surendra P. Shah
P. N. Balaguru	Graham T. Gilbert	Antoine E. Naaman	Yixin Shao
Hiram Price Ball, Jr. <sup>†</sup>	Antonio J. Guerra	Antonio Nanni	A. Kumar Sharma
Nemkumar Banthia	John Jones <sup>*†</sup>	Nandakumar Natarajan	Parviz Soroushian
Gordon B. Batson	Katherine G. Kuder	Omar A. Omar <sup>†</sup>	R. Narayan Swamy
Neeraj J. Buch	James R. McConaghy	P. Paramasivam	George J. Venta
James I. Daniel	Barzin Mobasher <sup>†</sup>	D. V. Reddy	Robert C. Zellers
Sidney Freedman <sup>†</sup>	Henry J. Molloy <sup>‡</sup>	Paul T. Sarnstrom	

\*Co-chairs of subcommittee responsible for preparing report.

†Members of subcommittee responsible for preparing report.

‡Chair of subcommittee responsible for preparing report.

*Glass fiber-reinforced concrete premix technology is becoming increasingly popular worldwide for manufacture of precast concrete products used in industrial, architectural, civil engineering, and construction applications. Glass fiber-reinforced concrete premix products provide a useful balance of properties such as strength, toughness, durability, moisture resistance, dimensional stability, fire resistance, and aesthetics. This report summarizes the current knowledge of materials, manufacturing methods, engineering properties, and applications of glass fiber-reinforced concrete premix.*

**Keywords:** cement-based composites; cement boards; cement panels; composite materials; concrete panels; ductility; durability; engineering properties; fiber-reinforced cement-based materials; ferrocement; fibers; flexural strength; glass fiber-reinforced concrete; glass fibers; manufacturing methods; mesh reinforcement; premix; toughness.

ACI Committee Reports, Guides, Manuals, and Commentaries are intended for guidance in planning, designing, executing, and inspecting construction. This document is 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. The American Concrete Institute disclaims any and all responsibility for the stated principles. The Institute shall not be liable for any loss or damage arising therefrom.

Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

## CONTENTS

### Chapter 1—Introduction and scope, p. 549.3R-2

- 1.1—Introduction
- 1.2—Scope

### Chapter 2—Notation, definitions, and acronyms p. 549.3R-2

- 2.1—Notation
- 2.2—Definitions
- 2.3—Acronyms

### Chapter 3—Materials and mixture proportions of glass fiber-reinforced concrete premix, p. 549.3R-3

- 3.1—Types of premix
- 3.2—Typical mixture ingredients
- 3.3—Typical mixture proportions

### Chapter 4—Properties of glass fiber-reinforced concrete premix, p. 549.3R-6

- 4.1—Influence of fiber content
- 4.2—Influence of fiber length
- 4.3—Influence of fiber orientation
- 4.4—Influence of fiber geometry
- 4.5—Influence of chopped fibers with reinforcing scrim

ACI 549.3R-09 was adopted and published December 2009.

Copyright © 2009, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

- 4.6—Influence of mixture proportions and mixture ingredients
- 4.7—Durability of glass fiber-reinforced concrete premix

### **Chapter 5—Manufacturing processes for glass fiber-reinforced concrete premix, p. 549.3R-9**

- 5.1—Cast premix process
- 5.2—Spray premix process
- 5.3—Press-molded premix process
- 5.4—Pultruded premix process
- 5.5—Extruded premix process
- 5.6—Types of equipment
- 5.7—Quality control considerations

### **Chapter 6—Applications of glass fiber-reinforced concrete premix, p. 549.3R-16**

- 6.1—Architectural products
- 6.2—Industrial products
- 6.3—Civil engineering products
- 6.4—Landscaping products
- 6.5—Surface bonding
- 6.6—Stucco
- 6.7—Shotcrete
- 6.8—Glass fiber-reinforced concrete bagged products

### **Chapter 7—Summary, p. 549.3R-22**

### **Chapter 8—References, p. 549.3R-22**

- 8.1—Referenced standards and reports
- 8.2—Cited references

## **CHAPTER 1—INTRODUCTION AND SCOPE**

### **1.1—Introduction**

The use of glass fiber-reinforced concrete started in the late 1960s with the development and commercialization of alkali-resistant (AR) glass fiber. The technology spread rapidly throughout the world because of desirable physical properties and durability performance of products reinforced with AR glass fibers. Glass fiber-reinforced concrete premix, as known in the industry and presented in this report, is a material that incorporates AR glass fibers into the slurry during mixing and slurry preparation. In glass fiber-reinforced concrete premix, fibers of various lengths from 0.25 to 1.5 in. (6 to 38 mm) and in concentrations of 0.25 to 4.0% by weight of the mixture are typically used and mixed together with the cementitious mixture while preparing the slurry. This fiber-reinforced slurry is then used to produce glass fiber-reinforced concrete premix products by selecting an appropriate manufacturing process. Glass fiber-reinforced concrete premix products are now manufactured in more than 100 countries.

Specific property improvements obtained with glass fiber-reinforced concrete premix include superior crack resistance and enhanced mechanical performance that includes improved tensile, flexural, and impact strength behavior. Note that glass fiber-reinforced concrete premix differs from another class of material, herein called conventional GFRC, primarily in the method of delivering fibers into the slurry and the amount of fiber reinforcement in the composite. Conventional GFRC typically incorporates greater than 4% AR glass fibers by weight and, during production, keeps the

glass fibers and slurry separate until delivering both simultaneously to the mold surface through a special spraying apparatus (ACI 544.1R and ACI 549.2R).

Glass fiber-reinforced concrete premix is a mixture of AR glass fiber, sand, cement, water, chemical and mineral admixtures, and aggregate if required. Mixture proportions are determined by the physical property requirements of the end product. Physical properties of glass fiber-reinforced concrete premix, such as tensile and flexural strength, are influenced by the fiber content, geometry, length, orientation, and the water-cementitious material ratio ( $w/cm$ ) of the mixture. The maximum amount of fiber successfully incorporated in the mixture is influenced by the fiber length, strand structure and integrity, and the ability of the mixer to efficiently disperse the fibers evenly throughout the matrix. Introducing over 4% of glass fibers by weight of the mixture does not significantly improve the mechanical strength of glass fiber-reinforced concrete premix composites. Conventional GFRC generally provides higher mechanical strength and ductility from its ability to incorporate higher fiber content, longer fiber lengths, superior two-dimensional fiber orientation, and lower water content. Both types of manufacturing methods are widely used commercially, and the choice between the two is primarily dictated by the required performance and aesthetical characteristics of the end product and application. The economics of manufacturing glass fiber-reinforced concrete premix are generally superior to that of conventional GFRC, mainly due to the lower labor costs per unit area of manufactured premix product.

Several manufacturing processes for producing glass fiber-reinforced concrete premix products have been developed, such as casting, spray premix, press molding, extrusion, and pultrusion. Many new products have been designed and produced to capitalize on the good performance of glass fiber-reinforced concrete premix. Glass fiber-reinforced concrete premix material and process technologies are commonly used for manufacturing precast concrete products for industrial, architectural, and ornamental applications. Examples include: trench lid covers for underground electrical distribution lines, modular building panels, decorative architectural products, terra cotta replacement products, and many other industrial products.

### **1.2—Scope**

This report introduces glass fiber-reinforced concrete premix and reviews the state of knowledge regarding selection of materials, mixture proportions, and manufacturing methods for producing premix products. Also highlighted is a diverse range of glass fiber-reinforced concrete premix applications from around the world and dry-bagged premix materials that are used in surface bonding, stucco, and certain shotcrete applications. The terms “glass fiber-reinforced concrete premix” and “premix” are used interchangeably throughout this report.

## **CHAPTER 2—NOTATION, DEFINITIONS, AND ACRONYMS**

### **2.1—Notation**

$V_f$  = volume fraction of fibers

$w/cm$  = water-cementitious material ratio