ACI 549.5R-16

Report on Spray-Up and Continuous Strand Glass Fiber-Reinforced Concrete (GFRC)

Reported by ACI Committee 549

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First Printing
March 2016
ISBN: 978-1-942727-73-6

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The committee thanks P. H. Mokhiber for his contributions.

Glass fiber-reinforced concrete (GFRC) is a popular construction material used to manufacture precast concrete products in architectural and civil engineering applications. GFRC products have desirable aesthetics and physical properties, including durability, strength, toughness, moisture resistance, dimensional stability, and fire resistance. This report summarizes the processes, properties, and applications of GFRC made by the spray-up process, and processes that use continuous strands and woven, knitted, or bonded textiles.

Keywords: alkali-resistant glass fiber; architectural panels; cement boards; composites; concrete panels; ductility; durability; fiber-reinforced concrete; filament winding; formwork; glass fiber-reinforced concrete; glass-reinforced concrete; mesh reinforcement; permanent formwork; premix; precast concrete; spray-up process; textile-reinforced concrete; toughness.

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ACI 549.5R-16 was adopted and published March 2016.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Glass fiber-reinforced concrete (GFRC) is a composite of alkali-resistant (AR) glass fibers embedded in a cementitious mixture, which could be a paste, mortar, or concrete, possibly with additives and admixtures added for improved processability, properties, or both. The fibers could be short individual fibers or monofilaments; bundles of fibers, which are often referred to as chopped strands; continuous strands or roving, or textiles (Fig. 1.1). Textiles are also synonymously called scrims, fabrics, or meshes.

Only AR glass fibers should be used in GFRC composites, to which this report is confined. There are four processes used to manufacture GFRC:

1) Premix
2) Spray-up, which usually contains a minimum of 4 percent chopped AR glass fiber roving strands by mass of the composite traditionally referred to as GFRC
3) Textile-reinforced concrete (TRC), which uses continuous structured AR glass fibers in woven (typically leno weave), knitted, and bonded constructions such as fabrics, scrims, or meshes
4) Continuous strands in oriented patterns such as filament winding

This report covers Items 2 through 4 and is a companion to ACI 549.3R, which covers Item 1.

GFRC is not just a single material, but rather a variety of materials with different properties and performance characteristics. Because GFRC in any of its forms does not contain steel reinforcing bars, there is no need of extra concrete cover to protect steel against corrosion. This allows it to be produced in thin sections, typically 0.5 to 1.0 in. (13 to 25 mm), which makes GFRC products much lighter in weight compared to conventional concrete products, which are usually 2 in. (50 mm) or thicker, although both are similar in density.

GFRC products have several significant advantages over conventional precast concrete products. They are lightweight, easy to handle and install, and have high toughness. Being lightweight offers cost-effective concrete-based alternatives in applications where the heavy weight of conventional precast concrete would make it unsuitable.

Research on GFRC composites began in the 1960s and has been in successful commercial use for over 40 years. This is proof that, if designed and manufactured to accepted, recommended practices, GFRC has a durability and longevity to be an acceptable building material. Its properties have been thoroughly researched, probably as much as, if not more than, any other material. Further research and development of new applications and mass production processes will move GFRC into the next phase of large-scale use.

Fig. 1.1—Alkali-resistant glass fiber roving, chopped strands, and textile (bonded scrim).

Table 1.2a—Chemical composition of selected glasses, percent of total by mass

Component	A-glass	E-glass	AR glass #1	AR glass #2
SiO_2	73.0	54.0	62.0	61.0
Na_2O	13.0	—	14.8	15.0
CaO	8.0	22.0	—	—
MgO	4.0	0.5	—	—
K_2O	0.5	0.8	—	2.0
Al_2O_3	1.0	15.0	0.8	—
Fe_2O_3	7.0	0.3	—	—
B_2O_3	—	7.0	—	—
ZrO_2	—	—	16.7	17.5
TiO_2	—	—	1.0	—
Li_2O	—	—	—	1.0

1.2—History

Much of the original research performed on glass fiber-reinforced cement paste took place in the early 1960s. This work used conventional borosilicate glass fibers (E-glass) and soda-lime-silica glass fibers (A-glass). The chemical compositions, densities, and mechanical properties of E- and A-glass are listed in Tables 1.2a and 1.2b. Glass compositions of E- and A-glass were found to lose strength quickly because of the high alkalinity (pH ≥ 12.5) of portland cement-based materials. Consequently, early A- and E-glass cementitious composites were unsuitable for long-term use (Larner et al. 1976). Some E-glass products have been developed with alkali-resistant (AR) coatings, but