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Report on Thin Reinforced Cementitious Products

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Thin reinforced cementitious products offer a useful balance of properties such as strength, toughness, environmental durability, moisture resistance, dimensional stability, fire resistance, esthetics, and ease of handling and installation. The growing emphasis on environmental durability and fire resistance of cementitious products has led to their increased use worldwide. This report summarizes the current knowledge of reinforcements, manufacturing methods, engineering properties, and applications of thin reinforced cementitious products.

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

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CHAPTER 1—INTRODUCTION

Thin reinforced cementitious products are used widely today in a variety of applications worldwide. Thin reinforced cementitious products are strong, possess superior deformability characteristics and enhanced impact and fatigue resistance—properties that are of great value in many practical applications. The aforementioned performance characteristics result primarily due to the inclusion of reinforcement in the cementitious matrixes of these products. In the past, asbestos fibers were the popular form of reinforcement in manufacturing thin cementitious products because asbestos fibers were widely available, inexpensive, possessed favorable processing characteristics, and provided significant improvements in strength and toughness characteristics of cements and mortars (Table 1.1). The use of asbestos fibers, however, continues to decline rapidly due to the serious health hazard risk to people involved in handling asbestos fibers and products. Consequently, other reinforcement materials have been developed to replace asbestos fibers in thin cementitious composites. These reinforcements are available in different geometric configurations such as discrete fibers, continuous fibers, and meshes. The former can be classified as a discontinuous reinforcement and the latter two as continuous reinforcement. The choice of reinforcement in terms of material type and geometric configuration has a significant influence on the engineering properties of the resulting thin cementitious products. Thin cementitious products that incorporate metal meshes as reinforcement are commonly referred to as ferrocement. A detailed description of metal mats and meshes and products made thereof is covered in ACI 549R and not covered in this report. Readers are referred to that document for further information. Thin cementitious products may contain both discontinuous and continuous reinforcements to produce products possessing tailored performance characteristics.

Table 1.1—Mechanical properties of cement paste, cement mortar, and asbestos cement (Studinka 1989; Hannant 1978)

	Property			
Material type	Flexural strength, MPa	Tensile strength, MPa	Elastic modulus, GPa	Tensile strain at failure, %
Cement paste	7 to 8	3 to 6	15	0.01 to 0.05
Cement mortar	—	2 to 4	25 to 35	0.005 to 0.015
Asbestos cement	30 to 40	17 to 20	28 to 35	0.40 to 0.50

Typical applications of thin reinforced cementitious products include exterior façade claddings, architectural elements, roofing panels and tiles, substrate panels for installation of tiles and other finishes, tunnel and sewer linings, cable ducts, permanent formwork, and pipes. Thin reinforced cementitious products have the ability to satisfy diverse requirements in these applications, such as strength, deformability, environmental durability, moisture resistance, dimensional stability, fire resistance, and rapid and economic construction.

As diverse are the reinforcement and the applications of thin reinforced cementitious products, so are the manufacturing methods to produce these products. A variety of cost-effective and rapid manufacturing methods have been developed to produce thin reinforced cementitious products having diverse performance characteristics and a range of geometric and aesthetic features. Popular manufacturing methods of thin reinforced cementitious products are described in this report.

Chapter 2 describes different types of reinforcements used to produce thin reinforced cementitious products. Known and popular manufacturing methods of thin reinforced cementitious products are described in Chapter 3. Chapter 4 describes the engineering properties of thin reinforced cementitious products. Finally, different applications of thin reinforced cementitious products are highlighted in Chapter 5.

CHAPTER 2—REINFORCEMENT TYPES AND REINFORCING MECHANISMS

A variety of reinforcement types are used to manufacture thin reinforced cementitious products today. These reinforcements can be broadly classified into three categories:

- Discontinuous or discrete reinforcing fibers;
- Continuous reinforcing fibers; and
- Reinforcing meshes.

Discrete (discontinuous) fibers are the most popular form of reinforcement used in thin cementitious products. Discrete fibers are made from a variety of materials and are available in different lengths and diameters. Examples of discrete fiber reinforcements include natural/cellulose fibers, glass fibers, polymer (polyvinyl alcohol and polypropylene) fibers, and carbon fibers. Continuous reinforcing fibers made from materials such as glass and polymers have also been used to manufacture thin cementitious products.