Alexandria Engineering Journal (2014) 53, 795–801

HOSTED BY

ELSEVIER

Alexandria University

Alexandria Engineering Journal

www.elsevier.com/locate/aej
www.sciencedirect.com

ORIGINAL ARTICLE

Effect of fabric material and tightness on the mechanical properties of fabric–cement composites

Magdi El Messiry *, Abou-Bakr Mito, Affaf Al-Oufy, Eman El-Tahan

Textile Engineering Department, Faculty of Engineering, Alexandria University, Egypt

Received 1 January 2012; revised 1 September 2014; accepted 8 September 2014
Available online 27 September 2014

KEYWORDS

Composite;
Fabrics;
Fabric tightness;
Fabric–cement;
Composite materials;
Warp float

Abstract This study shows the effect of fabric tightness and fabric material on the mechanical properties of fabric–cement composites. Six fabric designs from the same fabric material were used. These fabric designs are vary in the specific tightness. Also, three fabric materials with the same fabric design were used in this work. Different sets of specimens were made, after that these specimens were tested on tensile and bending testing machines. It was found that the mechanical properties of the composite materials were influenced by the length of the warp thread float, i.e. the longer is the yarns float in the fabric, the greater is the tensile strength properties of the reinforced fabric, its construction and the material of the reinforced fabric. Therefore, it is recommended to use fabric with yarns with higher tenacity in the direction of the application of load and with either long float or minimum number of intersections.

1. Introduction

The composite structures have been used by the ancient civilizations. However, over the past two decades advanced composites have been developed to the state where they are now routinely used alongside with the engineering materials in a wide variety of applications [1], [2] due to their high specific strength, high specific modules and low thermal expansion coefficient among others. The use of textile fabrics as reinforcement for cement and concrete elements is gaining increase interest in recent years for various applications such as thin elements, lightweight products, repair, strengthening, and pre-stressed concrete components [3], [4]. Civil engineers and the construction industry have begun to realize the potential of textile composites as strengthening material for many problems associated with the deterioration of infra-structures. These types of fabrics have been produced on different conventional and developed textile machines such as weaving machines, knitting machines, and sewing machines [5]. Unreinforced cement-based products are brittle, having high compressive strength but low tensile strength and low toughness. One of the method to improve the tensile strength, flexural strength, and toughness of thin cement-based elements is by adding fiber reinforcement, and a wide range of fiber types can be used for reinforcement in cement-based materials that was stated by Peled et al. [4]. Recently, several researchers reported very promising results of cement-based products reinforced with fabrics. In addition

* Corresponding author.
E-mail addresses: mmessiry@yahoo.com (M. El Messiry), bakrmito@yahoo.com (A.-B. Mito), affafaloufy@yahoo.com (A. Al-Oufy), eman_eltahan@yahoo.com (E. El-Tahan).

Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2014.09.002
1110-0168

to ease of manufacturing, fabrics provide benefits such as excellent anchorage and bond development [6]. Peled and Mobasher [6] found that the flexural strength of cement-based composite products with low-modulus polyethylene (PE) fabrics is almost two times higher than the strength of composites reinforced with straight continuous polyethylene yarns. In addition to the improved strength, these fabric-reinforced composites exhibited strain-hardening behavior even though the reinforcing yarns had low modulus of elasticity [6]. Several investigators [7–10] indicate the effect of the type of fabric as well as the material on the mechanical properties.

The objective of this work was to study the reflection of the fabric structure and their mechanical properties on the fabric–cement composite.

2. Materials and methods

The properties of the final product as fabric–cemented composites depend mainly on fabric material and fabric design, therefore six fabric designs of the same fabric material were woven. These fabric designs vary in their specific tightness. Three fabric materials (cotton fabric, high tenacity polyester HTPET fabric and Polypropylene PP fabric) with the same fabric design were also used in this work to show the effect of the fabric material on the mechanical properties of the fabric–cement composites and the final mechanical properties will be measured to show if influenced by the fabric structure.

2.1. Specification of the fabric samples

To investigate the effect of the fabric tightness, cotton woven fabrics with different six fabric designs were used in this work as given in Table 1.

The above mentioned fabrics have the following specifications

$$62'', \frac{\cdots 56 * 56}{24/2 * 24/2}$$

With total number of ends 3473, reed number 14 and 4 ends/dent.

The fabrics are produced with constant weight per unit area; however, the fabric design is different. This will lead to different values of fabric specific tightness.

To calculate the specific tightness for these fabrics in warp direction the following equation [11] was used.

Table 1 Fabric structure specifications.

Fabric design	Length of float/repeat in warp direction	No. of intersections/u. area in warp direction	Specific tightness
Plain weave	One pick	64	1
Warp rib weave 2 * 2	Two picks	32	0.50
Weft rib weave 2 * 2	One pick	64	1
Twill 2/2	Two picks	32	0.50
8H-satin	Seven picks	16	0.25
Honey comb	Five picks	34	0.6
Crepe	Scattered	46	0.72

$$\text{Specific tightness} = \frac{\text{specific intersections/inch}^2}{(\text{Max. specific intersections/inch}^2)_{\text{plain weave}}} = \frac{\text{specific intersections/inch}^2}{522}$$

To compare the effect of the fabric material properties on the fabric–cement composite, three different fabrics were used with the following properties given in Table 2.

2.2. Matrix material

Portland cement, type "Ordinary", CIM.I (42.5 N) produced by Alex. Portland Cement Company is used with all specimens.

2.3. Preparations of fabric cement composites

Different types of composite specimens from cement and fabrics with different types of structure and materials were prepared. These composite specimens were made by hand lay-up of the fabrics in 4:10 water to cement ratio paste matrix. Three specimens were made for each type of test according to ASTM [12] with different dimensions according to the standard test. These specimens were molded and cured under water at 20 °C for up to seven days; the tensile and bending properties were evaluated.

2.3.1. Dimensions of specimens for tensile test

All specimens for tensile test were 5 mm thickness, with lengths and widths of 150 and 25 mm, respectively.

2.3.2. Dimensions of specimens for bending test

All specimens for bending test were 40 mm thickness, with lengths and widths of 163 and 40 mm, respectively.

2.4. Measurement of mechanical properties

2.4.1. Tensile test of composites

The tensile properties of the fabric–cement composites were determined; test was carried out on a fabric tensile testing machine at rate of extension 1 mm/s.

2.4.2. Tensile strength of fabrics

The tensile strength of the used fabrics for cement composites was measured. Tests were carried out on a fabric tensile testing

Table 2 Fabrics properties.

Fabrics specifications	Cotton fabric	HTPET fabric	PP fabric
Fabric breaking force (N)	615	2950	850
Fabric tenacity (gm/Tex)	23.1	113.5	49
Fabric thickness (cm)	0.023	0.061	0.029
Areal density (gm/m^2)	133.33	130	86.66
Warp count (Ne)	47/2	2.4	6.8
Weft count (Ne)	50/2	24/1	6.8
Ends/cm	68	8.2	5
Picks/cm	43	0.8	5
Fabric design	Plain weave	Plain weave	Plain weave