Construction and Building Materials 158 (2018) 243–256

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Study of the microstructure and flexural behavior of cementitious composites reinforced by surface modified carbon textiles

Mana Halvaei [a], Masoud Latifi [a,*], Masoud Jamshidi [b,**]

[a] Textile Engineering Department, Textile Excellence & Research Centers, Amirkabir University of Technology, Tehran, Iran
[b] Polymer Research Lab., Chemical Engineering Department, Iran University of Science and Technology (IUST), Tehran, Iran

HIGHLIGHTS

- The microstructure of carbon textile reinforced concretes (TRCs) was studied.
- Strain hardening behavior and multiple cracking was obtained for modified samples.
- The textile surface modification improved the flexural behavior of the TRCs.
- Epoxy resin was a suitable modifying agent for increasing the strength of the TRCs.
- SBR latex & Castor oil coated textiles increased the flexural toughness of the TRCs.

ARTICLE INFO

Article history:
Received 7 June 2017
Received in revised form 3 October 2017
Accepted 6 October 2017

Keywords:
Textile reinforced concrete (TRC)
Surface modification
Flexural properties
Epoxy resin
Carbon textile
SBR latex

ABSTRACT

In this paper, the effect of surface modification of a carbon textile on the flexural behavior of the textile reinforced fine aggregate concretes was investigated. Three different surface modifying agents (i.e. styrene butadiene latex, hydrophilic oil and epoxy resin) were applied as coating on the carbon textiles at different weight ratios (i.e. 35, 70, and 100% by weight of the textile). The four point bending test was carried out on the samples. It was found that the textile surface modification led to an increase in the ductility of the textile reinforced concretes (TRCs). Utilizing the latex and oil coated textile reduced the post cracking strengths of the TRC samples while the epoxy coated textile led to a considerable increase in the post cracking strength (i.e. in the range of 72–190%). It was also found that the flexural toughness of the epoxy coated textile reinforced concrete improved in the range of 250–780% compared to the uncoated textile reinforced concrete. Meanwhile, it was found that in order to improve the flexural strength and toughness of the TRCs, it is more effective to apply surface modification to the textiles instead of using higher contents of reinforcing textiles. Finally, the interfacial transition zone (ITZ) of the textile and cement based matrix in all the samples was characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray (EDX) spectroscopy.

1. Introduction

The addition of fibers to concrete is one of the most popular methods to overcome the weakness of the concrete under tensile and flexural loadings [1–3]. However, the placement of the long fibers at the main direction of the tension is a much more effective method than utilizing the short fibers for improving the mechanical behavior of the cementitious composites [4–6]. The high modulus and strength textiles have been added to the concretes to produce high performance materials as replacement of the traditional building materials [7]. The tensile strength, ductility and energy absorption significantly improved in the textile reinforced concretes (TRCs) in comparison to the ordinary Portland cement concretes (OPCs) [8–10]. Generally, the textiles cause strain hardening and multiple cracking in the TRCs and so improve their flexural strength and toughness [11].

The TRCs showed both the advantages of the fiber reinforced concretes (FRCs) and the steel rebar reinforced concretes such as; high bearing capacity, excellent ductility and corrosion resistance [12].

The multiple micro cracking in the TRCs instead of the macro cracking in the fiber reinforced polymers (FRPs) along with doubling the stiffness of the TRCs are some of the advantages of the TRCs on the FRPs [13].

* Corresponding author.
** Co-corresponding author.
E-mail addresses: latifi@aut.ac.ir (M. Latifi), mjamshidi@iust.ac.ir (M. Jamshidi).

https://doi.org/10.1016/j.conbuildmat.2017.10.044
0950-0618/

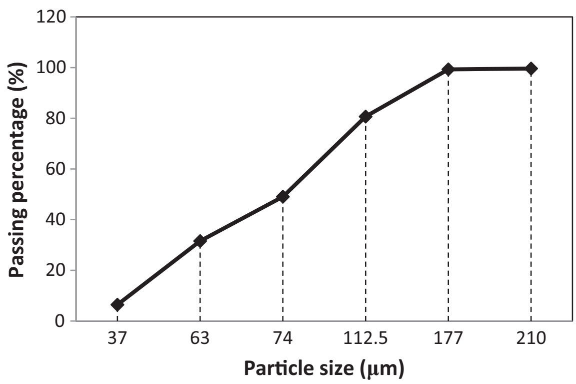

Fig. 1. Particle size distribution of the used silica sands.

Table 1
Physical properties of the used fly ash.

Characteristics	Results
Lime reactivity (N/mm^2)	8 min
Retention on 25 m sieve	>5%
Respirable fraction	Approximately 20–40% of particles are below 7 m in diameter
Drying shrinkage (%)	0.06

Table 2
Properties of the used epoxy resin.

Appearance	Liquid
Color	Yellowish
Odor	Mild
Relative density	(20 °C) 1.16 g/cm^3
Solubility	(20 °C) practically insolube in water
Viscosity	(25 °C) 12,000–15,000 cPs

However, the weakness of the TRCs is usually related to the bonding of the textiles to the cement based matrix which causes delamination of the TRC layers under loading. The textile surface treatment is an effective method to improve the fiber to cement bonding. The surface treatment of the reinforcing yarns by Silane as well as utilizing matrix containing micro silica or high values of polymer additives have been previously investigated [14]. Appropriate and consistent wetting of the carbon yarns with the cement matrix is an important factor to achieve the highest composite performance. Meanwhile, surface treatment of the carbon yarns using Nano clay particles provided an appropriate morphology of the textile-matrix interface [15]. Using Nano clay particles led to a decrease in crack tip opening at the post cracking loads by producing the hydrated cement products at the carbon yarn surface. They also improved the stiffness of the yarn-matrix interface. The impregnation of the carbon textiles with an epoxy resin is another method which used to improve the fiber to matrix bonding [16,17].

It has been found that the epoxy modified carbon filaments increased the tensile strength, extension and energy absorption capacity of the composite by 43, 220, and 140%, respectively. Moreover, the epoxy polymer decreased the free spaces between the filaments of a strand. This enhanced the stress transfer capacity of the composites components [17,18]. The partial modification of the carbon filaments at distinct distances led to an improvement in flexural strength and ductility of the composite as well [19]. Utilizing sand particles on the epoxy surface modified textiles increased the flexural strength and toughness of the concrete as well as fine crack creation in the matrix [12]. The dispersion of the short fibers on the epoxy coated carbon textiles led to the formation of a fluffy surface. Considerable improvement in the textile-matrix bonding and load bearing capacity of the composite was obtained by this method. However, this did not enhance the flexural strength of the TRCs [20].

In this paper, the effect of some surface modifying agents on the flexural properties of the carbon textile reinforced fine aggregate concretes was investigated. Three different materials including styrene butadiene latex (SBR), Castor oil and epoxy resin were used at different weight ratios for this purpose. The four point bending test was carried out on the samples and the results were compared to the unmodified textile reinforced concrete specimens.

2. Experimental

2.1. Materials

2.1.1. Matrix

Portland cement type I, manufactured by Tehran cement Co., and silica sand from a local company by a maximum aggregate size of 210 µm were used in this study. Fig. 1, shows the particle size distribution of the sands. Ultra-fine fly ash class F, was used as pozzolanic material. The physical properties of the used fly ash are listed in the Table 1. The poly-carboxylate ether based super

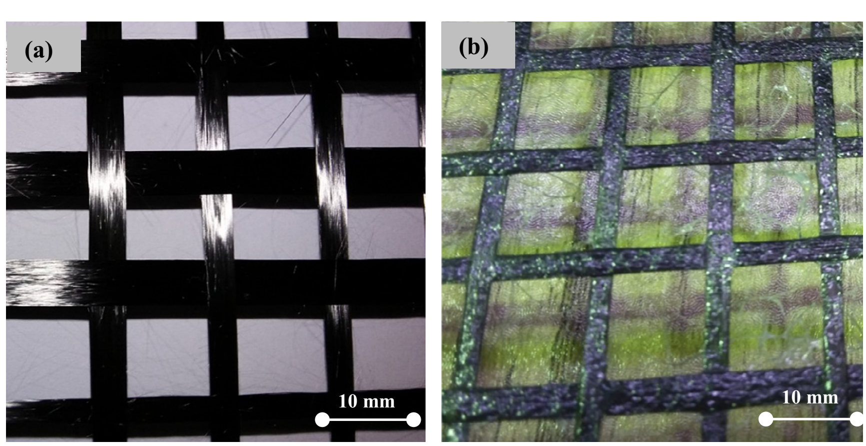

Fig. 2. Image of carbon textile; (a) before and (b) after coating by epoxy resin.