Materials and Design 89 (2016) 146–155

Contents lists available at ScienceDirect

Materials and Design

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

Property improvements of alkali resistant glass fibres/epoxy composite with nanosilica for textile reinforced concrete applications

Alexandru Chira [a,b,1], Anuj Kumar [a,*,1], Tomáš Vlach [a], Lenka Laiblová [a], Andrijana Sever Škapin [c], Petr Hájek [a]

[a] Department of Building Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Thákurova 7, 166 29 Praha 6, Czech Republic
[b] Department of Structural Mechanics, Faculty of Civil Engineering, Technical University of Cluj-Napoca, 15 C. Daicoviciu Str., RO-400020 Cluj-Napoca, Romania
[c] Slovenian National Building and Civil Engineering Institute, Dimičeva 12, SI-1000 Ljubljana, Slovenia

ARTICLE INFO

Article history:
Received 23 December 2014
Received in revised form 31 August 2015
Accepted 21 September 2015
Available online 25 September 2015

Keywords:
Alkali resistant glass fibres
Epoxy resin
Nanosilica particles
Textile reinforced concrete
Fracture surface morphology
Nanoindentation

ABSTRACT

The aim of this work is to study the tensile, compressive and shear properties of textile rovings and also their matrix. This paper describes the sample preparations to obtain the tensile, compression and shear testing results for alkali resistant glass fibres (ARG)/epoxy composite. Furthermore, the effect of nanosilica particles on the mechanical properties of ARG/epoxy composite was studied. The results obtained for the rovings with nanosilica showed mechanical improvements for all tested properties. A numerical model was developed with the new obtained textile properties for a TRC facade panel to investigate the flexural behaviour.

1. Introduction

Epoxy resins have been used successfully as a matrix for all types of fibres in order to achieve the necessary strength of textile rovings. An innovative idea is to improve the mechanical properties of textile rovings by adding nanoparticles to their epoxy matrix [1]. Applications of textile rovings have been widely used for textile reinforced concrete (TRC) because of their excellent mechanical properties. TRC is a relatively new composite material, which has been extensively studied at collaborative research centres: RWTH Aachen University and Dresden University of Technology in Germany [2–7].

There are some problems that occur with the use of glass fibres in concrete applications: the first being that the alkali nature of the concrete recipe has a corrosive effect on the glass fibres, which reduces the service life of TRC. Further, alkali resistant glass fibres (ARG) replaced the untreated ones in TRC applications, but the alkali treatment created nanoscale defects on the glass fibre surface. These nanoscale surface defects are providing extra stress at the tip of the cracks that can lead to cracking at low stress level [8]. The second problem is the improper interfacial bonding between each filament of ARG rovings, which leads to the pull-out of fibres from the epoxy or adhesive matrix and reduces the load bearing capacities of TRC or ARG/epoxy composites [9].

The interest of scientists in applying nanomaterial into polymer matrices is the attainment of potentially unique properties, as a result of nanometric dimensions. Numerous studies have been done regarding the interface regions in fibres-epoxy resin composites and also nanocomposites. Thomason [10–12] studied the interface region in glass fibre composites from sample preparation, void content and interfacial strength to fibre surface coatings, water absorption, and voids. Yazhou Guo et al. [13] investigated the quasi-static/dynamic response of SiO_2-epoxy nanocomposites with 0, 3 and 7% under uniaxial compression at different loading rates. The use of nanosilica with a high weight percentage up to 40% of epoxy resin matrix has been reported to give enhanced strength, stiffness and fracture toughness properties [14,15] for the glass fibres epoxy applications. An increase in tensile strength was obtained for the basalt fibres which were modified with epoxy resin that contained 2.5, 5.0, and 7.5 SiO_2 percentage of the weight content [16]. By filling the micro size gaps between the matrix and fibres, the nanoparticles are playing a big role in the mechanics of textile rovings, causing an improved activation of the fibres area when subjected to any kind of load [13].

The aim of this article is to investigate the properties of the nanosilica-epoxy resin matrix at tensile, compressive and shear loads. ARG fibres added for this matrix have also been tested under the same type of loads for comparison and to observe the mechanics of the 3 elements working together i.e. epoxy resin, nanosilica, and fibres. Further, a finite element model was developed to predict the effects of nanosilica on TRC facade panels.

* Corresponding author.
E-mail addresses: anuj.saroha@gmail.com, anuj.kumar@fsv.cvut.cz (A. Kumar).
[1] Both authors are equally contributed to this paper.

http://dx.doi.org/10.1016/j.matdes.2015.09.122

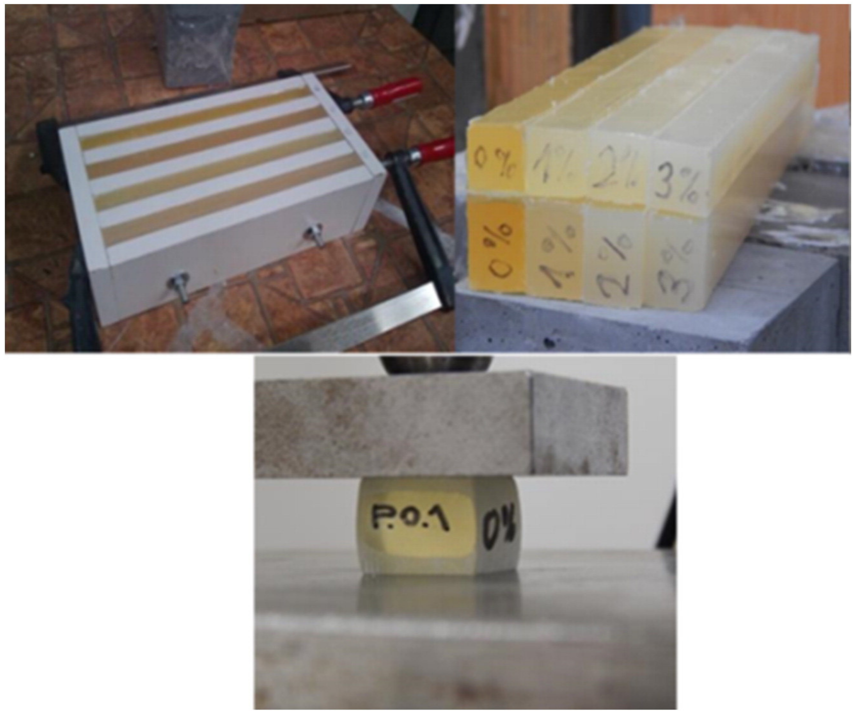

Fig. 1. Compression test sample preparation and testing process.

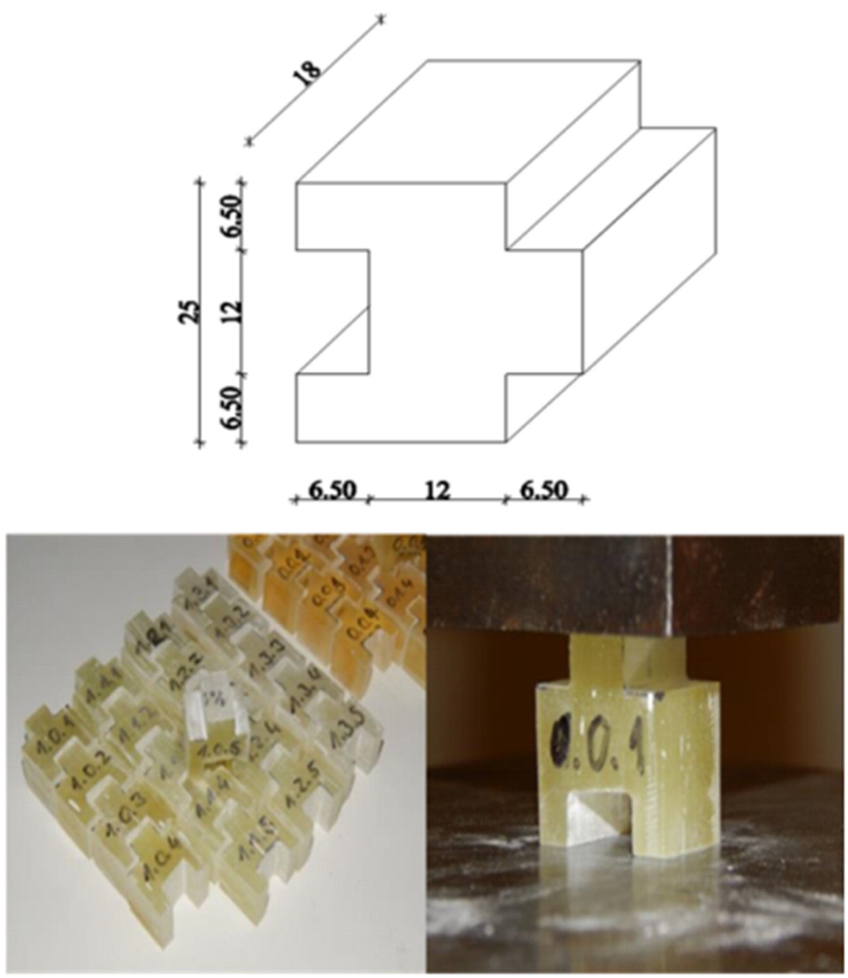

Fig. 2. Shear test sample preparation and testing process.