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Effect of waste tire textile Fibers on strength and deformability of shotcrete

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Abstract

As part of the stabilization systems for excavations and slopes, shotcrete today plays an extensive role in civil and mining engineering practices. A great number of efforts have been made during recent years to improve the strength and ductility of shotcretes. Fiber incorporation can be named as one of these efforts. Based on the type and characteristics of fibers, reinforced shotcretes display different properties. As a result, advantages and disadvantages of each type of fiber are being studied. This study presents the results obtained from experimental investigations of the influence of waste tire textile fiber addition on strength, ductility, and energy absorption capacity of shotcretes. After preparing specimens reinforced at fiber contents of 0.5%, 1%, 1.5%, and 2%, unconfined compressive strength, Brazilian tensile strength, and three-point bending strength were conducted on all samples. The results show that using the fibers inhibits the brittle behavior of specimens and increases energy absorption capacity. Several advantages of using this fiber can be named such as high entanglement in the matrix, low specific weight of the fibers as compared with mesh and steel fibers, easy pumping, and high durability in damp and acidic environments. Moreover, due to the fact of being waste materials, using these fibers leads to lowering the costs of projects as well as tackling the environmental hazards ensued by burying or burning them.

***Key words**: Fiber-Reinforced Shotcrete, Waste Tire textile Fibers, Strength Properties, Ductility, Energy Absorption*

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Extended Abstract:

1. Introduction

Shotcrete can be defined as ‘‘Mortar or concrete pneumatically projected at high velocities on to a surface’’ (Cengiz and Turanli, 2003). The early invented shotcrete was not a high-quality product. Therefore, since the 1970s, investigation and improvement have focused primarily on accelerators and admixtures (to reduce rebound and dust and to achieve higher early strengths with lower amounts of these expensive additives, without affecting the long term strength) and spraying equipment (to improve the quality and automation). Research into the mechanical properties of shotcrete followed later as the early challenges were overcome and the design approaches developed (Thomas, 2008). Of the many developments in shotcrete knowledge in recent years one of the most important was the introduction of steel fiber reinforcement. Steel fiber reinforced shotcrete was introduced in the 1970s and has since gained worldwide acceptance as a replacement for traditional plain shotcrete reinforced by wire mesh. The main role of fiber in shotcrete, which is a brittle material, is to impart ductility (Hoek, Kaiser, and Bawden, 2000). Nowadays, the industrial fibers are commonly used as a reinforcement of shotcrete. Based on the type and characteristics of fibers, reinforced shotcretes display different properties. The present investigation deals with textile fibers coming from the waste tires. More than 200000 tons of tires are produced per annum in the country. Considering the environmental problem of the disposal of waste tires, every opportunity to reuse tire components is valuable. One of the sub-products that is generated during the recycling process of End of Life Tires (ELT) is Waste Tire Textile Fibers (WTTF). Reuse of this fibers in shotcrete, in addition to reducing the environmental problems related to ELT, solves the problem of corrosion of steel fibers in the shotcrete.
The present paper deals with the use of Waste Tire Textile Fibers to reinforce shotcrete for mining and civil engineering practices. Experimental investigations were performed on WTTF reinforced shotcrete in order to compare mechanical behavior of this type fiber reinforced shotcrete with respect to plain shotcrete (without fibers).

2. Materials and methods

Investigations which covers the uniaxial compression, Brezilian tensile, and flexural tests were performed to evaluate the mechanical behaviour of WTTF reinforcet shotcrete. The Portland cement, fine and coarse aggregate, and wast tire textile fiber were used to create the shotcrete samples. The waste tire fibers were distributed homogeneously in the shotcrete matrix during the mixing process. Sieve analysis of the used fine and coarse aggregates is presented in Table 1.

Table 1. Sieve analysis of the used aggregates

Sieve Size	Passing percentage range in ACI 506 standard	Passing percentage used in this study
1/2 in. (12 mm)	100	100
3/8 in. (10 mm)	90-100	100
No.4 (4.75 mm)	70-85	72
No.8 (2.4 mm)	50-70	52
No.16 (1.2 mm)	35-55	34
No.30 (600 µm)	20-35	20
No.50 (300 µm)	8-20	11
No.100 (150 µm)	2-10	5

After preparing specimens reinforced at fiber contents of 0.5%, 1%, 1.5%, and 2%, uniaxial compression, Brazilian tensile, and three-point flexural tests were conducted on all specimens. The uniaxial compressive strength of WTTF-RS was assigned on the cylinderial spesiments with the dimension of 100 × 200 mm. The prepared shotcrete specimens were tested under static uniaxial compression with the constant loading rate equal to 1mm/min. Given this loading rate, each experiment lasted about 20 minutes. All tests were performed using a 2000 kN hydraulic compression testing machine. The three-point flexural tests were carried out on the specimens with the dimension of 50 × 50 × 160 mm. The span of the specimen was equal to 100 mm. The tests were carried out using a servo system with the rate of mid-span deflection equal to 0.2 mm/min. The tests were continued until the deflection reached 5 mm. The Brazilian tensile tests were performed on specimens with a diameter of 5 mm. All the experiments were carried out after 28 days of curing of plain and WTTF reinforced shotcrete specimens. The general view of the all prepared specimense is shown in Fig. 1.

Fig. 1. Prepared specimens for uniaxial compression, Brazilian tensile, and three-point flexural tests

3. Results and discussion

In the present paper, the effect of Waste Tire Textile Fibers on flexural strength, ductility and energy absorption of shotcrete is investigated. Uniaxial compresion, three-point flexural, and Brazilian tensile tests were performed on shotcrete specimens reinforced by 0.5, 1, 1.5 and 2% WTTF. The pronounced influence of WTTF was observed on post-peak parameters of shotcrete. The results show that using the WTTF inhibits the brittle behavior of shotcrete specimens and increases energy absorption capacity (Fig. 2). Also, the waste tire textile fibers delay the appearance of the micro-cracks on specimens and bridge the macro-cracks. Several advantages of using this fiber can be named such as high entanglement in the matrix, low specific weight of the fibers as compared with mesh and steel fibers, easy pumping, and high durability in damp and acidic environments. Moreover, due to the fact of being waste materials, using these fibers leads to lowering the costs of projects as well as tackling the environmental hazards ensued by burying or burning them.

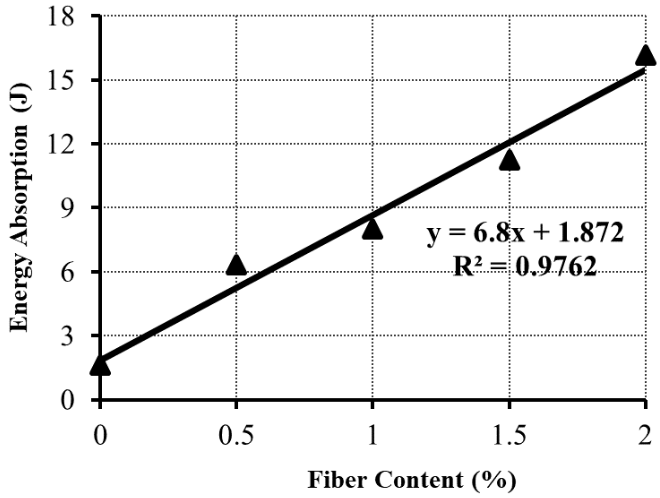

Fig. 2. The effect of waste tire textile fiber on energy absorption capacity of reinforced shotcrete

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