BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 63 (67), Numărul 3, 2017
Secția
CONSTRUCȚII. ARHITECTURĂ

PRACTICAL ISSUES IN PROCESSING OF CONCRETE WITH RECYCLED PET FIBERS

BY

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Received: August 18, 2017
Accepted for publication: September 21, 2017

Abstract. Major problem of wastes is preoccupying researchers from the entire world. Building materials industry is a domain in which a lot of types of wastes can be used. Wastes type fibers can be used in preparing concrete or mortars. The paper deals with an analyze of concrete production when fibers are introduced in fresh concrete and at pouring in formworks. Some problems such as floating, clogging or distribution of fibers in the concrete mass are analyzed and discussed to find best solutions for production of concrete with disperse fibers.

Keywords: PET fibers; fly ash; cement concrete; mechanical behaviour; fiber length.

1. Introduction

In the last decades the problem of consuming wastes has preoccupied the researchers because their environment pollution (Gökçe, 2013; Bolden, 2013; Bărbuță, 2015). Wastes such as powder, aggregate, fiber, etc. were tested for obtaining new building materials with improved properties or for finding a way

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to consume the wastes (Măgureanu, 2009; Frias, 2011; Bărbuță, 2017). Fibers wastes of any type such as: glass, metallic, polyester, etc. are used for improving the concrete characteristics, for all types of concrete: high and ultra-high performance concrete, self compacting concrete, lightweight concrete, polymer concrete, etc. (Doo-Yeol, 2016; Rafat, 2016; Iqbal, 2015; Bărbuță, 2008). The use of agricultural wastes in concretes had developed in the last years and fibers like: hemp, coconut, rice husk, etc. were tested as disperse reinforcement (Awwad, 2011; Awwad, 2012; Bilba, 2007). The effects of fibers in concretes depend on a lot of factors, such as shape, length, dosage, orientation, diameter, nature, etc. (Yoo, 2014; Kang, 2011; Corinaldesi, 2011; Marin, 2014; Șerbănoiu, 2017). Metallic or synthetic fibers present a more important influence on the characteristics of concrete than the natural fibers. By using fibers an improvement of mechanical strengths can be obtained, especially the tensile strengths, the values increasing generally with the increase of fiber dosage. Other benefit of using fibers is observed in the behavior of members under loading, at occurrence and developing of cracks by limiting the cracks width, and at failure, when a more ductile breaking was obtained (Chan, 2004). In the case of concretes with different additions such as: silica fume, fly ash, slag, rubber, polystyrene, etc. the fibers are also used for improving the mechanical characteristics and for obtaining a better behaviour under loading (Abaza, 2015; Bărbuță, 2017; Ciocan, 2017).

The article presents the production process of concrete with wastes type PET fibers and the problems that this fiber can generate when they are used as disperse reinforcement. The possible solutions for obtaining concrete with homogeneous mix are also discussed.

2. Experimental Program

2.1. Materials and Methods

The studied concrete with fly ash and PET fibers was prepared with cement type CEM II 42.5 (Șerbănoiu *et al.*, 2017), river aggregates in three sorts (sand 0,…,4 mm, sort 4,…,8 mm and sort 8,…,16 mm), water and additive. Fly ash was used in a dosage of 10% as replacement of cement. The PET fibers are sub-product of PET bottles which in the process of recycling are an intermediate product, Fig. 1. The fibers can be smooth, (Fig. 1 *a* and 1 *d*), or rigid, (Fig. 1 *b* and 1 *c*) and of different colors. They were cut with a length of 30 mm and 50 mm and were introduced in concrete in a dosage of 0.25% from the mix volume.

During preparation of fresh concrete the methodology was analyzed because of the problems that occurred. The fiber reinforced concrete is produced in the same manner as ordinary concrete: firstly were introduced the

dry components: aggregates, cement, fly ash and PET fibers and were mixed together. Then were introduced the wet components: water and super plasticizer. After mixing, the concrete was poured in moulds. After 24 hours the samples were demoulded and were introduced in water. Before testing at 28 days the samples were dried. The samples for determining mechanical characteristics were analyzed after testing for establishing fiber distribution and homogeneity of concrete structure and the type of failure.

Fig. 1 – PET fibers.

3. Results and Discussion

During preparing of concrete some problems occurred, firstly when the fibers were introduced in the mix: because their lightweight, the fibers were floating out the mix and they were agglomerated. For solving the problem, the fibers were introduced in the wet mix during mechanical mixing. The process of including fibers was done by introducing a small quantity in stages and the fibers were spread on the entire surface of the concrete for a better mixing. During mixing a uniform spreading of fibers must be realized to avoid agglomeration. This can be better obtained by using horizontal mixing. During vibration of the concrete a tendency of fibers to stand up at the bottom surface was observed, Fig. 2.

Fig. 2 – Aspects of the surface of the sample after hardening.

After the testing of samples, the concrete structure was analyzed, Fig. 3. It was observed fibers clogging in the concrete mass, Fig. 3. This happened because during mixing the fibers agglomerated and remained as a clog in the matrix, Fig. 4. The problem is of bigger importance in the case of long fibers. Some solutions can be applied, such as: the increase of fluidity of the concrete, the treat of fibers for easy separation in the mix, the use of special additives for a better dispersion of fibers, etc. The agglomeration of fibers is hard to control in the case of mixing with vertical rotation and probably a homogeneous mix can be obtained by using a horizontal mixer with palettes.

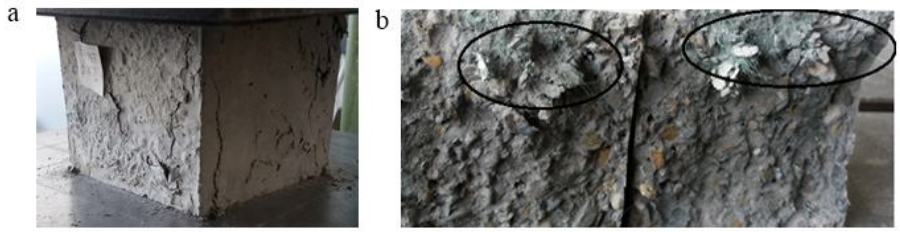

Fig. 3 – Aspects of concrete after testing: a – cracks; b – fiber agglomeration.

Fig. 4 – Fiber distribution in concrete.

The PET fibers presented another problem during testing in flexure and splitting when the fibers had a very long elongation, the two parts of the prisms were hardly separated, Fig. 5. The elongation of fiber is beneficial at failure, increasing the ductility of concrete. A uniform distribution of fibers can offer a better capacity of the concrete at failure and probably will not allow concrete to break instantly.

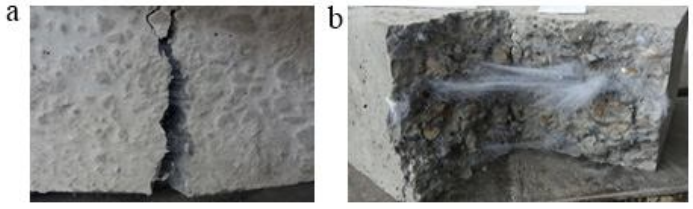

Fig. 5 – PET fiber elongation in flexural test.

For preparing concrete with PET fibers other problems related to obtaining a homogeneous distribution in the concrete structure are due to the fiber percentages and fiber length. For high dosages and high length of fiber is more difficult to obtain a uniform dispersion in the mix. In the study the dosage of fiber was reduce, about 0.25%, and there was a problem for spreading them into the mix. Also, a higher agglomeration was observed in the case of bigger length of fibers. A mechanical scattering under pressure looks to be more suitable during mixing, but this technology was not applied in the experiment.

4. Conclusion

The article analyses some aspects regarding the production of concrete with PET fibers as disperse reinforcement. Some problems were identified during preparing and pouring concrete and authors had tried different solutions to solve them. The wastes of PET fiber were used in a concrete prepared with 10% fly ash as replacement of cement, for improving the workability of the mix. The major problems were: the floating of the fibers when were introduced in dry mix, the clogging of fibers in the mix and the continuous elongation without failure of fibers during testing in tension. The floating and the clogging of fibers have a negative role on the dispersion in the concrete mass, but there are possibilities to reduced them, firstly the fibers are introduced in the wet mix, and is recommended a more fluid mix; then the fibers can be sprayed or can be firstly treated with different solutions (NaOH, cement paste, etc). The elongation of the fiber during sample failure is beneficial, increasing the ductility of the concrete.

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PROBLME PRACTICE ÎN PREPARAREA BETONULUI CU FIBRE RECICLATE DIN PET

(Rezumat)

Marea problemă a deşeurilor îi preocupă pe cercetătorii din întreaga lume. Industria materialelor pentru construcții este un domeniu în care pot fi utilizate multe tipuri de deşeuri. Deşeurile de tip fibră se folosesc la prepararea betonului sau a mortarelor. Lucrarea are ca scop analiza preparării şi turnării betonului proaspăt atunci când sunt introduse fibre în compoziție. Unele probleme cum ar fi separarea la suprafața amestecului proaspăt, formarea de aglomerări de fibre sau distribuirea neomogenă a fibrelor în masa betonului sunt analizate şi discutate pentru a găsi tehnologia eficientă a preparării betonului cu fibre.