Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(3) (2021) 255-258
DOI: 10.22060/ceej.2020.16789.6346

Presentation of a New Method for Production of Environment-Friendly Concrete using PET Waste/Silica Fume and Its Mechanical/Durability Properties Investigation in Concrete Pavement

M. Akhondi, M. H. Ramesht*, T. Pourostam, A. Golsoorat Pahlaviani

Department of Civil Engineering, Islamic Azad University (Central Tehran Branch), Tehran, Iran.

ABSTRACT: In this paper, we examine the simultaneous effect of polyethylene terephthalate and silica fume on the rheological and mechanical properties of concrete pavements and looking to present a new mix of green concrete (environmentally friendly concrete) with the use of PET waste materials and silica fume. Due to problems with asphalt pavement, such as endangering the environment, bitumen is expensive and considering that Iran is currently the third-largest producer of cement worldwide. Therefore, concrete pavements have been given special attention today. It also increases the consumption of pet food bottles and, consequently, increases waste production, and increasing the waste disposal site adds to the importance of reuse of these wastes. One of the uses of these lesions, without having a destructive effect on the environment, reusing them is to enclose them in concrete rigid pavements. On the other hand, research shows that another piece of waste products in the glass industry which is known as micro silica or silica fume which can be used in concrete pavement. The results from this study indicate the use of pet particles in concrete pavement did not have much impact on compressive strength But in contrast, it increases the tensile strength, bending. In contrast to the use of micro silica, it has increased compressive strength, reduced water absorption, and reduced permeability in concrete pavements.

Review History:

Received: Jul. 18, 2019
Revised: Nov. 04, 2019
Accepted: Dec. 10, 2019
Available Online: Jan. 02, 2020

Keywords:

Roller compacting concrete
Fresh properties
Mechanical properties of concrete
Recycled polyethylene terephthalate (PET)

1. Introduction

The reuse of plastic wastes has an important role in sustainable solid waste management. From

different points of view, it helps to save natural resources that are not replenished, Landfill space is limited, and the conditions in landfills make it impossible for plastic that can be converted to biodegrade. It decreases the pollution of the environment and it also helps to save and recycle energy production processes. One of the alternatives for the reduction of their negative effects is the application of these materials in other industries. The construction industry can consume a large amount of PET wastes without any environmental problem. The current applications of recycled PET in the construction industry include their use as an admixture for fiber concretes.

2. Methodology

Increasing the cementations materials and fillers in RCC will increase the brittleness of concrete matrix and more early-age cracking of RCC (due to plastic shrinkage, as well as thermal stress) and more drying shrinkage, comparing to normal concrete. Considering the successful experience of using particles in concretes during the past years to improve these shortcomings of concretes, the use of particles is a good idea to promote ductility and to reduce early-age cracking of RCC [1]. Besides due to the presence of particles that reduces the workability parameters of fresh concrete, maintaining the fresh properties of RCC within the desired range, limit the content of particles used in RCC [2]. The use of fiber-reinforced concrete (FRC) has been increased in building structures because the majority of using particles in concrete show improvement in toughness, compressive strength, flexural strength, tensile strength, impact strength as well as the failure mode of the concrete [3]. Based on experiments of other authors, limited works have been done on RCCs containing PET particles. Therefore, the effects of PET fiber on characteristics of fresh and hardened RCC were considered and were compared with RCC without fiber. In this study, the used coarse and fine aggregates-combination of natural and crushed-meet the requirements of ASTM C33. The normal Portland cement in RCC mixes was replaced with 10% of silica fume and water to a total cementations materials ratio (w/cm) of 0.40 was constant for all mixes. RCC mixes were prepared with total powder content of 450 kg/m3 (cement and silica fume) and coarse and fine aggregate contents of 660 kg/m3 and 860 kg/m3 respectively. The use of steel particles has become popular in FRC, especially their structural application is considered. In some cases, using steel particles could be more effective than the classic method of reinforcing the concrete with bars, such as below [4]. In thin sections, due to a small cover of concrete and geometric complications, the use of bars is not possible and the use of particles with a high volume percentage could be considered as a good replacement. Elements which are under severe loading, heavy

*Corresponding author's email:Mhramesht@yahoo.com

Copyrights for this article are retained by the author(s) with publishing rights granted to Amirkabir University Press. The content of this article is subject to the terms and conditions of the Creative Commons Attribution 4.0 International (CC-BY-NC 4.0) License. For more information, please visit https://www.creativecommons.org/licenses/by-nc/4.0/legalcode.

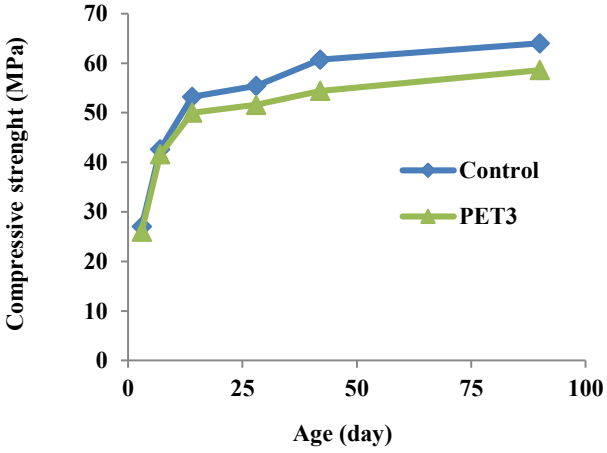

Fig. 1. Compressive strength specimen and test machine

Fig. 2. Compressive strength of control and PET.

loads, and large displacements (such as the interior cover of tunnels and explosion resistant structures) In such structures, particles act as additional reinforcements PET has been used increasingly in recent years especially use as PET bottles [5]. Burying or burning a great amount of these disposable materials does a lot of harm to the environment. Nowadays, researchers have investigated many effects of plastic waste on mortar and concrete, especially as mortar and concrete fiber reinforcement. Pereira and Castro investigated the effect of PET fiber on cement-lime mortar. The results indicated that the PET fiber incorporation did not significantly change the magnitude of the mortar compressive strength. Whereas, significantly improved the flexural strength of mortar with a major improvement in mortar toughness. A study by exploring the effect of PET particles on the ordinary concrete [6]. The test results showed that the addition of PET particles decreased the compressive strength of plain concrete [7].

3. Results and Discussion

Based on fresh concrete test results, the maximum permitted amounts of PET particles were 3 kg/m3 to preserve the workability of RCCs. Hence, for hardened concrete tests, PET3 mixtures along with the control mixture were considered. The test is conducted on a compression testing machine of capacity 3000 KN as shown in Fig. 1.

The results of the compressive strength test were graphically shown in Fig. 2.

As a first result, it can be observed that the splitting tensile strength of all reinforced PET particles concrete mixtures is higher than that of the control concrete. This improvement varies from 5% to 25% in the age of 3 to 90 days respectively. Moreover, the results showed that the mixes containing PET particles were more flexible and less brittle. With increasing PET replacement ratio, flexibility was increased in all mixes. In other words, the addition of PET to RCC mixes increased their plasticity. The relationship between splitting tensile strength of RCC mixtures versus cylindrical compressive strength was presented in Fig. 7. Accordingly, it can be seen that splitting tensile strength values of all RCC mixture containing PET particles lie in the range of bound value suggested [7].

4. Conclusions

The main conclusions of the paper must be put here. This experimental investigation focuses on the effect of reused plastic bottle waste particles (PET) on the fresh and hardened properties of RCC. The ecological benefit of effectively utilizing this waste material and sustainable development approaches are the main motivation for this work. From the obtained results of this study, the following conclusions can be drawn:

* The construction industry can consume a large amount of PET wastes without any environmental problem. The current applications of recycled PET in the construction industry include their use as resin for polymer concrete, as the results of this research showed, Pet particles even in the new generation of concrete-like roller-compacting concrete (RCC) can also be used, for example, to produce 3 to 5 kilograms PET particles, more than 100 waste bottles must be pulverized, that it could contribute to the solid waste management and sustainable development.

* Considering fresh concrete tests, the amounts of 3 kg/m3 PET particles can be regarded as the most optimized amounts of particles added to RCC mixtures.

* Amount of more than 5 kg/m3 not recommended, because the test results show that the addition of 5 kg/m3 PET particles decreased the flowability in the Vibe consistency time test, increased the flow time in the Vibe consistency time test.

References

[1] C. Albano, N. Camacho, M. Hernandez, A. Matheus, A. Gutierrez, Influence of content and particle size of waste pet bottles on concrete behavior at different w/c ratios, Waste Management, 29(10) (2009) 2707-2716.

[2] A.I. Al-Hadithi, Improving impact and mechanical properties of gap-graded concrete by adding waste plastic fibers, International Journal of Civil Engineering and Technology (IJCIET), 4(2) (2013) 118-131.

[3] C. ASTM, 1202: Standard test method for electrical indication of concrete's ability to resist chloride ion penetration, Annual Book of ASTM Standards, 4 (2012)

[4] A.F. Avila, M.V. Duarte, A mechanical analysis on recycled PET/HDPE composites, Polymer Degradation and Stability, 80(2) (2003) 373-382.
[5] M. Batayneh, I. Marie, I. Asi, Use of selected waste materials in concrete mixes, Waste management, 27(12) (2007) 1870-1876.
[6] S. Chidiac, S. Mihaljevic, Performance of dry cast concrete blocks containing waste glass powder or polyethylene aggregates, Cement and concrete composites, 33(8) (2011) 855-863.
[7] M. Dadsetan, H. Mirzadeh, N. Sharifi-Sanjani, M. Daliri, Cell behavior on laser surface-modified polyethylene terephthalate in vitro, Journal of Biomedical Materials Research: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials, 57(2) (2001) 183-189.
[8] P. Domone, A review of the hardened mechanical properties of self-compacting concrete, Cement and concrete composites, 29(1) (2007) 1-12.

HOW TO CITE THIS ARTICLE
M., Akhondi, M. H., Ramesht, T., Pourostam, A., Golsoorat Pahlaviani, Presentation of a New Method for Production of Environment-Friendly Concrete using PET Waste/ Silica Fume and Its Mechanical/Durability Properties Investigation in Concrete Pavement, Amirkabir J. Civil Eng., 53(3) (2021): 255-258.

DOI: 10.22060/ceej.2020.16789.6346

This page intentionally left blank