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Research Paper

Experimental Study of the Effect of Glass and Polypropylene Composite Fibers on Physical and Mechanical Properties of Concrete and Cement Mortar

Hosseini M.[1*], Fakhri D.[2]

1- Associate Professor, Dept. of Mmining Engineering, Imam Khomeini International university, Qazvin, Iran
2- M.Sc Student, Dept. of Mmining Engineering, Imam Khomeini International university, Qazvin, Iran

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Abstract: Concrete is the most widely used material in mining and civil projects and its mix design must be based on application, type of material and environmental conditions. In this study the effect of combined glass and polypropylene fibers on physical and mechanical properties of concrete and cement mortar was investigated. Nowadays, artificial fibers are used to improve the mechanical properties of concrete. Particularly, glass, polypropylene, carbon and steel fibers used in concrete lead to good results in improving its several properties. To this purpose, the concrete and cement mortar samples were made without fiber, with individual glass fibers (0.2, 0.35 and 0.5 volume percent of concrete or cement mortar), with individual polypropylene fibers (0.2, 0.35 and 0.5 volume polypropylene fibers 0.17 volume percent and glass fibers 0.18 volume percent of concrete or cement mortarpercent of concrete or cement mortar), and with combined glass and polypropylene fibers (). The physical properties including effective porosity, longitudinal waves velocity and the mechanical properties including Brazilian tensile strength and uniaxial compressive strength of the samples were analyzed. The results indicated that the effective porosity of concrete and cement mortar with combined glass and polypropylene fibers was less compared to the concrete and the cement mortar without fiber, with individual glass fibers and with individual polypropylene fibers. The velocity of longitudinal waves, tensile strength and uniaxial compressive strength of the concrete and the cement mortar samples with combined glass and polypropylene fibers were higher than the other samples. Compared to the concrete and the cement mortar samples without fibers, the tensile strength of the concrete and the cement mortar with combined glass and polypropylene fibers were increased by 15.22% and 16.44%, respectively, and their uniaxial compressive strength showed the increase of 27.3% and 20.56%, respectively.

Keywords: Concrete, Cement mortar, Combined fibers, Glass fibers, Polypropylene fibers, Physical-mechanical properties.

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*Corresponding Author Email: *ma.hosseini@eng.ikiu.ac.ir*

INTRODUCTION

Concrete is the most widely used material in mining and civil projects and its mix design must be based on application, type of material and environmental conditions. Except for gravity structures, application of unreinforced concrete is not so widespread due to its brittleness. In practice, this major defect of concrete is eliminated through its reinforcement by steel rebars; but since the reinforcement comprises only a small portion of the section, it is not so accurate to consider the concrete section as a homogenous and isotropic one. Moreover, corrosion of the reinforcement in reinforced concrete is one reason of damage to such structures and is the most common type of damage to concrete in shores. Nowadays, artificial fibers are used to improve mechanical properties of concrete. Generally, using fibers in concrete mixture considerably improves tensile, flexural, impact and yield strengths, abrasive resistance, bearing capacity after cracking and toughness of concrete [1]. In this research, polypropylene and glass fibers were used to make fiber-reinforced concrete and cement mortar.The advantage of the present study compared to previous studies is that, in addition to the study of the effect of combined glass and polypropylene fibers on the concrete's properties, the effect of these fibers on the properties of cement mortar was also explored. In this research, in addition to the study of uniaxial compressive strength and tensile strength of the concrete with combined fibers, the effective porosity and the velocity of longitudinal waves were also examined which rarely analyzed in previous studies.

MATERIALS AND METHODS

The concrete and cement mortar samples were made without fiber, with individual glass fibers (0.2, 0.35 and 0.5 percent volume of concrete or cement mortar), with individual polypropylene fibers (0.2, 0.35 and 0.5 percent volume of concrete or cement mortar), and with combined glass and polypropylene fibers (polypropylene fibers 0.17 percent and glass fibers 0.18 percent volume of concrete or cement mortar).

In the present research, the physical properties including effective porosity, dry unit weight and longitudinal waves velocity and the mechanical properties including Brazilian tensile strength and uniaxial compressive strength of the samples were determined according to ISRM standard.

RESULTS

Figures 1 and 2 show that the concrete and the cement mortar with combined glass (gl) and polypropylene (pp) fibers had higher tensile strength than the ones with individual fiber and without fiber. The tensile strength of the cement mortar was less than that of the concrete because it had more cement and less effective porosity. These variations were consistent with the variations of effective porosity so that the concrete and the cement mortar with combined glass and polypropylene fibers which had the least effective porosity, had the highest tensile strength. The results indicated that the tensile strength of the concrete and the cement mortar with combined glass and polypropylene fibers were increased by 15.22% and 16.44%, respectively, compared to those of the concrete and the cement mortar samples without fibers. They were also increased by 1.78% and 2.88%, respectively, compared to those of the concrete and the cement mortar samples with 0.35% volume glass fibers, and increased by 6.08% and 4.99%, respectively, compared to those of the concrete and the cement mortar samples with 0.35% volume polypropylene fibers. The studies by Hills and Zyara [2] and Ahmad and Jia [3] also showed that if the combined glass and polypropylene fibers were used with appropriate volume percent, the tensile strength of the concrete with double combined fibers (glass and polypropylene) would increase compared to the concrete without fiber and the one with individual fiber. The reason might be that by the reduction of the fibers percentages in double combinations, potential of balling and reduction of the fibers' effectiveness decreased and the fibers showed better performance.

CONCLUSION

The results of the present paper are as follow:

- The concrete and the cement mortar with combined glass and polypropylene fibers had less effective porosity than the concrete and the cement mortar with individual fibers and the concrete without fiber.
- The concrete and the cement mortar with combined glass and polypropylene fibers had higher velocity of longitudinal waves than the concrete and the cement mortar with individual fibers and the concrete without fiber. This variation was consistent with the variation of effective porosity.

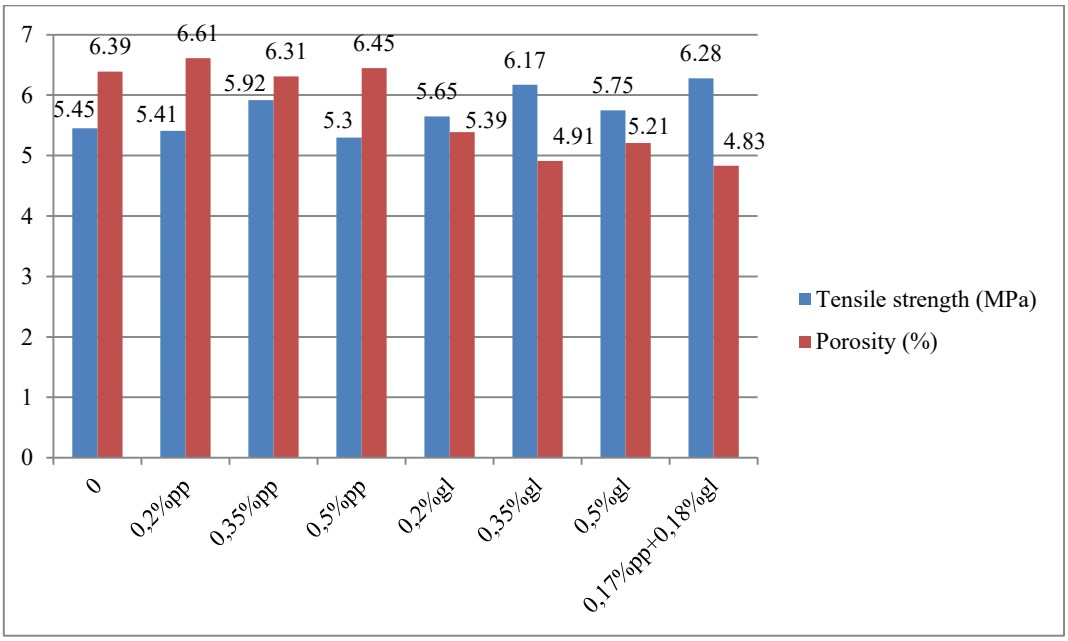

Figure 1. Changes in tensile strength and effective porosity in concrete by changing the volume percentage of fibers and the type of fibers

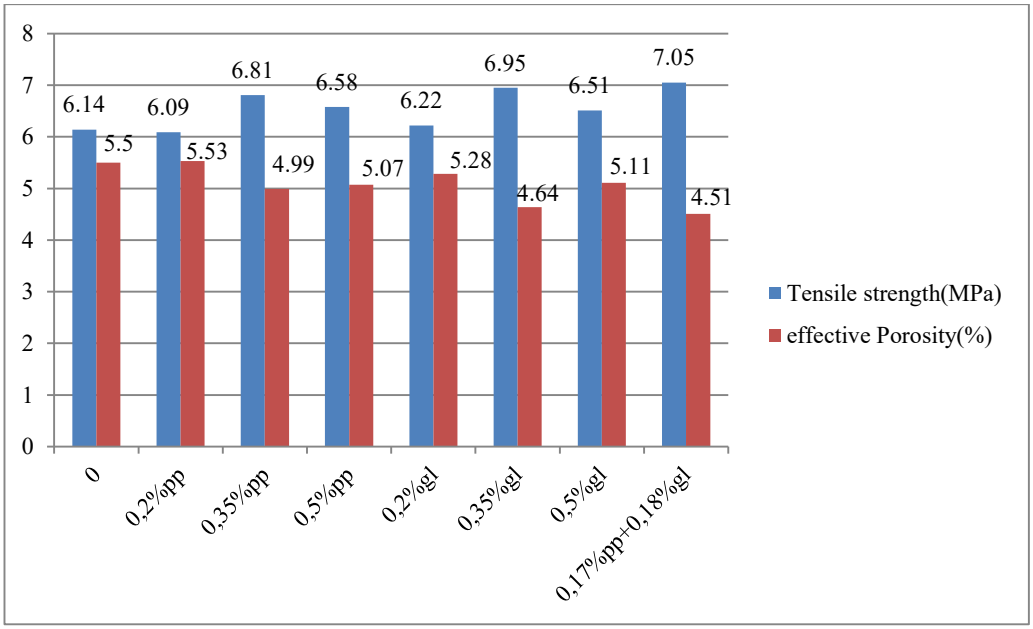

Figure 2. Changes in tensile strength and effective porosity in cement mortar by changing the volume percentage of fibers and the type of fibers

- The concrete and the cement mortar with combined glass and polypropylene fibers which had the least effective porosity, had the highest tensile strength. The results indicated that the tensile strength of the concrete and the cement mortar with combined glass and polypropylene fibers were increased by 15.22% and 16.44%, respectively, compared to those of the concrete and the cement mortar samples without fibers.
- The concrete and the cement mortar with combined glass and polypropylene fibers had higher uniaxial compressive strength than the concrete and the cement mortar with individual fibers and the concrete

without fiber.

- The uniaxial compressive strength of the concrete and the cement mortar with combined glass and polypropylene fibers were increased by 27.3% and 20.56%, respectively, compared to those of the concrete and the cement mortar samples without fibers.

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