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EXTENDED ABSTRACT

Laboratory investigation of the effect of replacing pumice and scoria lightweight aggregates with natural sand on the properties of cement-slag mortars

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1. Introduction

Mortar should be considered one of the oldest building materials, which is used to bond stone pieces with other masonry and plastering pieces. Pumice and scoria aggregates, each cell is separated from the other by thin walls and have a low permeability, and the silica content of the lavas that make up pumice is 70 to 75%, which is higher compared to scoria, which is 50 to 60%. The dry weight of scoria is higher compared to pumice (almost twice), but its average porosity percentage is lower (about 15 to 30% in different grain sizes). The use of scoria pumice for the construction of structural members and pumice pumice in the production of non-structural members or as filling materials is preferred. Properties of pumice mortars that show lower values compared to limestone mortars include: workability life, setting time, fresh mortar unit weight, hardened mortar unit weight, and ultrasonic pulse velocity. Properties of pumice mortars that show higher values compared to limestone mortars include water absorption percentage, capillary water absorption coefficient, drying shrinkage percentage, flexural strength and compressive strength, and the heat transfer coefficient of the wall system made with pumice mortar is lower compared to the wall system made with limestone mortar..

2. Methodology

2.1. Experimental study

Before making the samples, the flow table test was used to determine the flowability of the mortar (ASTM C230, 2008). The compressive strength of cement-sand mortar at the ages of 7, 28, 56 and 91 days was measured using 5 cm cube molds according to ASTM C109. Each mold was filled with mortar in three layers and each layer was filled with 25 strokes of a special compaction rod. The lateral surface of each sample was dried with a jute cloth after being removed from the water tank (saturated state with a dry surface) and then placed under a jack (ASTM C109, 2013). Given the importance of this research on long-term water absorption, the samples were removed from the curing tank after 7, 28, 56 and 91 days of age according to ASTM C642 standard and placed in an oven at a temperature of 110 °C for 72 hours and their water absorption was measured (ASTM C642, 2000). The flexural strength test was performed at 7, 28, 56 and 91 days of age according to ASTM C348 standard in 4 × 4 × 16 cm molds (ASTM C348, 2008). The four-electrode method or Wenner method was used to measure the electrical resistance. In this method, four electrodes were placed on the surface of the sample in the same way and a small alternating current was established between the outer electrodes and the potential between the middle electrodes was measured.

2.2. Research Mixture Design

To make the samples, first, fresh mortar tests were carried out on them and finally, with the help of ASTM C109 standard, a reference mortar mixing design was selected (ASTM C109, 2008), and then, according to the

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reference mixing design, the rest of the designs were made and the samples obtained from them were tested. In this study, the effects of replacing pumice and scoria sand with natural sand with 30% slag powder from Khuzestan Steel Company were investigated. Pumice and scoria sands were replaced with natural sand separately with percentages of 30%, 40%, 50%, 60% and 70%, and 10 mixing designs were made and the samples were treated in two drinking water environments and a laboratory environment. The naming method of the mixing designs is as follows: MC indicates the reference cement mortar, MCS indicates cement-slag mortar and 30 after the Latin letter of the name indicates 30% use of slag as a cement substitute. Sc indicates scoria sand and the number after the Latin letter indicates the percentage of using scoria sand as a substitute for natural sand; P indicates pumice sand and the number after the Latin letter of the name indicates the percentage of using pumice sand as a substitute for natural sand; for example, MCS30Sc30 means that the mortar contains 30% Ahvaz steel slag replacing cement with 30% scoria sand. In all mixing designs, the water-cement ratio was 0.41. The mixing process of the materials was carried out in a 5-liter laboratory mixer. The details of the mixing design of the research mortars are presented in Table 4. The samples were cured in Khuzestan drinking water (W) and laboratory ambient temperature (A).

3. Results and discussion

3.1. Analysis of compressive strength results

Based on the results presented regarding the use of the percentage of samples made with pumice sand and scoria instead of a part of natural sand in mortar making, it can be viewed from two perspectives. One view is that the compressive strength of cement-slag mortar should not be less than the same strength of the reference mortar even at the age of 91 days. In this view, 50% replacement of pumice sand and 30% replacement of scoria sand with 30% slag of Ahvaz Steel Plant in the curing environment in drinking water and 40% scoria sand with 30% pumice sand in the curing conditions of the laboratory temperature can be considered optimal. The second view is that at the age of 91 days, the goal is to have a cement-slag mortar with porous materials with a minimum strength of 30 MPa and that the strength of this type of mortar is not compared to the strength of the reference mortar, because its lower strength than the strength of the reference mortar at the same age will not cause a problem in the implementation of structures and this level of resistance is acceptable in the construction of structures. From this perspective and considering the economic perspective, along with it, the issue of 70% pumice sand and scoria sand with 30% slag from the Ahvaz Steel Company can be considered as the optimal percentage; but this combination does not meet our goal of having a higher compressive strength than the reference sample. By comparing the results of this study with the results of the compressive strength of the article by Ghanbari-Kanjin and Rezaei, who used two types of weakened slag and active slag from the Isfahan blast furnace, it can be noted that the compressive strength of the slag samples with different replacement values of 5% to 20% is higher than the reference design at the age of 56 days. It can be said that the use of activated slag up to 20% of the weight of cement, in addition to reducing cement consumption, has not led to a decrease in compressive strength at ages 28 and above, which is very significant from an environmental perspective (Ghanbari-Kenjin, Rezaei, 2015).

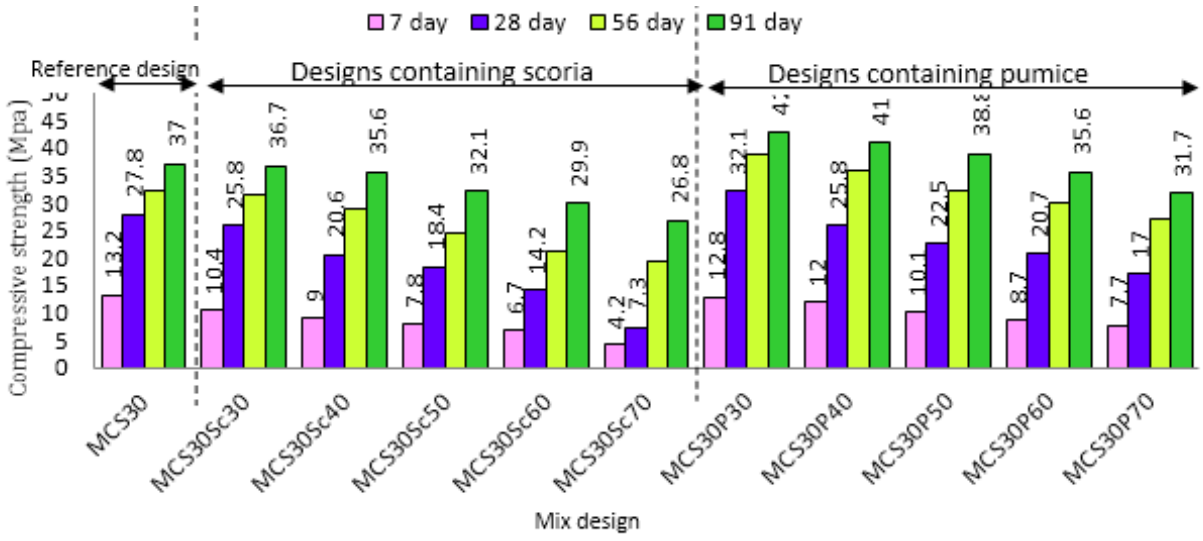

Fig. 1. Compressive strength results of samples in drinking water treated environment

3.2. Analysis of water absorption results

In the study of samples cured at laboratory temperature, the effect of samples made with pumice sand has less water absorption than samples made with scoria sand. The results of samples cured at laboratory temperature showed that no water was added to the samples, and the samples made with pumice sand and samples made with scoria sand retained an appropriate percentage of water, which was 91 days old in a sample with 70% scoria sand replacing 13% natural sand by weight, which shows a 90% increase in water absorption compared to the reference sample. Comparing the water absorption results of this study with the results of Esmaili and Kasaei's research on using pre-saturated scoria sand in cement mortar as an internal curing agent, it can be stated that it successfully led to the control of spontaneous shrinkage; although it affects the compressive and flexural strengths to a significant extent (Ismail ,Kasaei ,2012).

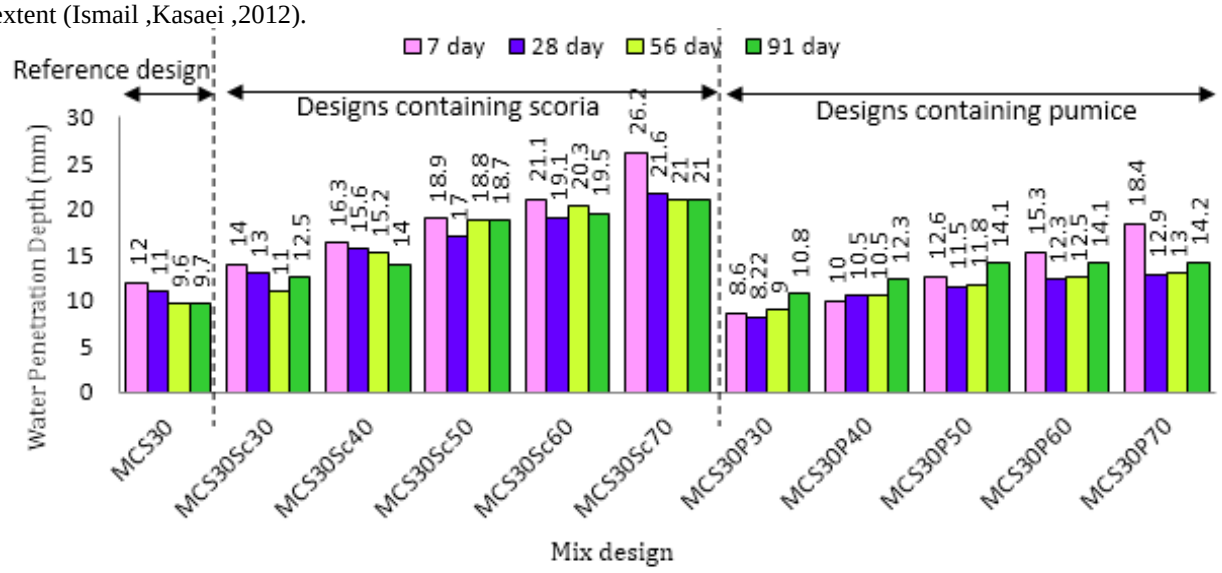

Fig. 2. Results of water absorption of samples in the environment treated with drinking water

4. Conclusions

•The compressive strength in a drinking water environment at the age of 91 days of samples made with 30%, 40% and 50% pumice sand increased by 15%, 11% and 4% compared to the reference sample.

•The samples made with pumice sand had lower water absorption than the samples made with scoria sand. With increasing percentage of scoria sand and pumice sand replacement compared to natural sand, the amount of water absorption increases.

• The optimal amount of 50% pumice sand replacing natural sand in mortar and the optimal amount of 30% scoria sand replacing natural sand in mortar with 30% overhead had the best performance in mortar

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