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Resistance of geopolymer mortar to acid and chloride attacks

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Abstract

This paper presents an experimental study on the chemical erosion resistance of geopolymer mortar (GM) to sulphuric acid and sodium chloride attacks. The variations of mechanical properties and mass of geopolymer mortar after soaked in water, sodium chloride and sulphuric acid solutions for different durations (30, 60, 90, 180, 270 and 360 days) were investigated. The test results showed that geopolymer mortar had good resistance to sodium chloride and sulfuric acid erosion solutions. The maximum degradation in flexural, compressive and tensile strength of geopolymer mortar soaked in sodium chloride and sulphuric acid solutions, during the whole soaking duration (360 days) was 6%, 11% and 15% respectively, compared to that in tap water. The strength fluctuation of geopolymer mortar in sulphuric acid solutions was higher than that in sodium chloride solutions. At the first 60 days of immersion, the compressive and tensile strength of geopolymer mortar in tap water, sodium chloride solutions and sulphuric acid solutions decreased, but its strength restored again after 60 days.

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Keywords: durability; geopolymer mortar; chemical erosion resistance

1. Introduction

In the past decades, rapid development of urban construction in China generates a great demand for cement. However, the production of cement is regarded as an important factor contributing to the greenhouse effect, due to a great amount of CO_2 emission during its production. Geopolymer is a kind of inorganic material derived by alkali

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activating silicon-aluminum material, which has comparable mechanical properties, high temperature resistance and durability as ordinary Portland cement [1-2], but less energy consumption and CO_2 emission for production [3-4]. Therefore, geopolymer can be used as a potential substitute of ordinary Portland cement in some fields. For instance, geopolymer mortar (GM) was utilized to strength concrete members by bonding textile or steel mesh [5-6]. Durability is an important concern for construction materials, but there are few researches on the durability of GM. This paper focuses on the durability of GM in the environment of tap water, sodium chloride and sulphuric acid solutions.

2. Experimental program

The durability of GM was investigated by accelerated erosion tests on GM specimens. Three solutions, including tap water, sodium chloride and sulphuric acid, were used to provide the chemical environment for geopolymer mortar. The variation of PH values of tap water and erosion solutions with time was monitored. Based on the tested PH values, the frequency of updating the solutions was determined. The flexural, compressive and tensile strength and mass of geopolymer mortar after soaked in the three types of solutions for different durations (0、30、60、90、180、270、360 days) were tested. Also the compressive strength of geopolymer mortar in air was tested for comparison.

2.1. Materials

The raw materials for preparing geopolymer mortar included fly ash, metakaolin, alkali activator, short polypropylene fibers, fine aggregate and tap water. The chemical composition of fly ash and metakaolin can be referred to [5]; Potassium silicate solutions, with concentration of 40% and modulus of 1.0, were used as alkali activator. The sodium chloride solution was prepared through adding sodium chloride crystals into tap water, with concentration of 5%. And the sulphuric acid was prepared from pouring concentrated sulfuric acid solutions into tap water, with PH values of 4.0.

2.2. Preparation of specimens

Prism specimens, with dimensions of 40mm × 40mm × 160mm, were used for testing flexural strength and compressive strength of GM. Tensile strength was tested on "8"-shaped specimens. The detailed dimensions of "8"-shaped specimens can be referred to [7].

To prepare GM specimens, potassium silicate solutions was firstly poured with the blend of fly ash and metakaolin powers (with the mass ratio of 1:1), and then fine aggregates together with dispersed short polypropylene fibers were added. After stirring for 5 mins in a mixer, the mixture was placed into the prismatic moulds and “8”-shaped moulds, and then vibrated.

After one day curing at a constant temperature of 20^{o}C and a constant humidity of 95%, these specimens were demoulded. And then, a 6-day curing at the same conditions was performed. Prior to soaking in the solutions, these specimens experienced another 35 days of natural room curing, to attain stable strength in air.

A total of 84 prism specimens, classified into 4 groups, were prepared to undertake the tests on compressive and flexural strength of GM in air and after soaked in tap water, sodium chloride and sulphuric acid for 7 different durations (0, 30, 60, 90, 180, 270 and 360 days). For each type of environment (air, water, sodium chloride and sulphuric acid) and each duration, 3 specimens were tested. The tests on compressive strength of GM in air at different ages was aimed to confirm the stability of strength development of GM. As for the tensile strength tests, a total of 63 specimens with “8”-shaped, classified into 3 groups, was cast. These “8”-shaped specimens were soaked in the same solutions (water, sodium chloride and sulphuric acid) for same durations as prism specimens.

2.3. Updating regime of erosion solutions

Three plastic containers, with sizes of 60 mm×35 mm×40 mm, were used to contain specimens and three types of solutions (tap water, sodium chloride and sulphuric acid) respectively. As the alkaline of GM was slightly