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Effect of mineral admixtures on resistance to sulfuric acid solution of mortars with quaternary binders

Zoubir Makhloufi[a*], Madani Bederina[a], Mohamed Bouhicha[a], El-Hadj Kadri[b]

[a] Laboratory of Materials and Structure Rehabilitation (SREML), University of Laghouat, Algeria
[b] Laboratory L2MGC, University of Cergy Pontoise, F9500 Cergy Pontoise, France

Abstract

This research consists to study the synergistic action of three mineral additions simultaneously added to the cement. This synergistic effect has a positive effect on the sustainability of limestone mortars. Tests were performed on mortars based on crushed limestone sand and manufactured by five quaternary binders (ordinary Portland cement and CPO mixed simultaneously with filler limestone, blast-furnace and natural pozzolan). The purpose of this research was to identify the resistance of five different mortars to the solution of sulfuric acid. Changes in weight loss and compressive strength measured at 30, 60, 90, 120 and 180 days for each acid solution were studied. We followed up on the change in pH of the sulfuric acid solution at the end of each month up to 180 days.

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Keywords. crushed limestone Sand, mineral admixtures, quaternary binders, sulfuric acid, changes in weight, compressive strength, pH.

1. Introduction

Concrete structures can be exposed to various acids because of to environmental pollution. Therefore, changes in physical and chemical properties as well as changes in weight, strength and microstructure of mortars and cements caused by interaction with various acids must be considered [1-3].

The reaction of sulfuric acid with calcium carbonate leads to the deposition of gypsum ($CaSO_4.2H_2O$). These gypsum coverings were studied in natural rocks such as limestone and marble [4,5]. The H^+ ions of the sulfuric acid dissolve $CaCO_3$ and $Ca(OH)_2$, while the simultaneous reaction of SO42-with Ca^{2+} causes deterioration due to the deposition of gypsum on the surface of cementitious material [6]. The capacity of the acid to separate the components of the cementitious material and the solubility of calcium salts also play an important role in the degradation of these materials.

It has been shown that the use of binary and ternary cements compound of 10% silica fume and 60% fly ash in concrete has better performance than other concrete incorporating mineral admixtures. The loss weight of concrete samples is 25% after 56 days of immersion in a solution of 1% sulfuric acid [7-9].

Corresponding author email: z_makhloufi@yahoo.fr

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Other research works [10-12] have shown a significant improvement in the resistance of fly ash concrete to the acid.

The greater resistance to a solution of 0.5% sulfuric acid was achieved by a binary binder mixture comprising over 60% of granulated blast furnace slag [13]. Conversely, Chang et al. [14] have recently reported that the binary binders of concrete prepared with 60% slag and the ternary binders with 56% slag and 7% of fumed silica had a lower yield compared to that of a mixture of 100% CPO when immersed in a solution of 1% sulfuric acid at pH 1.27.

In this research, crushed limestone sand was used with a quaternary binder to study the resistance of mortar to sulfuric acid attack.

2. Materials

The chemical and physical properties of the four components used in this research are presented in Table 1. Five mortars based on limestone aggregates were made. The compositions of different mortars are given in Table 2.

Clinker and mineral additions were ground separately in a laboratory ball mill to a fineness of Blaine 3500 ± 100 cm^2/g for clinker and 3800 ± 100 cm^2/g for mineral additions. The mortars were prepared from these binders according to European standard EN196-1. Crushed limestone sand which the diameter of the larger grain is 2.5 mm, the particle size thereof is continuous. The sand/cement ratio is equal to 3 and the water/cement ratio is 0.50. The specimens 4x4x16 cm^3 were molded and maintained for 24 hours in the molds for 28 days after demolding, in lime-saturated water.

Tables 1. Chemical composition and mineralogy of the different compounds.

Composition	Binder			
	Clinker	Limestone	Slag	Pozzolana
SiO_2	21,38	0,76	39,38	57,10
Al_2O_3	5,59	0,41	5,64	15,82
Fe_2O_3	3,21	0,23	2,3	6,16
CaO	65,26	54,9	40,3	5,95
MgO	1,72	0,61	4,50	2,09
K_2O	0,47	0,24	0,46	2,0
Na_2O	0,19	0,04	0,13	1,1
SO_3	0,56	0,61	0,90	0,28
Cl^-	0,02	0,005	-	1,40
PAF	0,58	36,3	0,8	1,2
Mineralogy of clinker (%)	C_2S	C_3S	C_3A	C_4AF
	15,64	60,97	9,39	9,76

Tables 2. Composition of cements

Composition (%)	0	1	2	3	4
Clinker	95	47,5	47,5	47,5	47,5
Gypsum	5	2,5	2,5	2,5	2,5
Limestone	0	30	10	10	16,67
Slag	0	10	30	10	16,67
Pozzolana	0	10	10	30	16,67