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Sulphate attack resistance of cement with zeolite additive

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Abstract

Concrete as one of the most common building material, exposed to groundwater, soil and seawater is often object to sulphate attack. Partial replacement of Portland cement by natural zeolite has been proven to be effective in reducing sulphate attack. The results of cement sulphate resistance after 52 weeks in Na_2SO_4 solution are presented. The sulphate resistance of mortars was examined by determination of linear changes of specimens immersed in Na_2SO_4 solution. The studies of microstructure of cement mortars were carried out by scanning electron microscope equipped with energy dispersive spectrometer (EDS). Investigation includes also pictures of samples after 32 weeks exposition in corrosion solution.

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Keywords: clinoptilolite; sulphate attack; corrosion resistance of Portland cement

Nomenclature

Notification for oxides compounds:

A	Al_2O_3
C	CaO
S	SiO_2
H	H_2O

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1. Introduction

Among the currently known engineering materials, concrete belongs to a group of the most common applications. Due to the different corrosive environments, which it is exposed to, including marine construction or hydraulic engineering, the precedent characteristic, that determines the use of concrete, has become its durability [1], [2], [3], [4]. One of the factors characterizing this feature of the concrete, is type of cement. For decades, a special role in shaping the physicochemical properties of concrete, play also mineral additives [6], [7], [8], [9], [10], [11]. It has been proven, that the use of the pozzolanic additives for cements increases their resistance to corrosion, due to the highly waterproof, decrease in the content of $Ca(OH)_2$ and reducing the presence of capillary pores in the matrix. In fact, it hinders the penetration of aggressive media [12]. Due to economic and technological benefits, new functional mineral additives in construction sector were required. In this group of materials, having unique properties, are zeolites [13], [14], [15], [16], [17], [18]. Natural zeolites are a group of hydrated tektoaluminosilicates, with a specific hierarchical structure. A characteristic feature of their framework is system of tetrahedra TO_4 [†], linked together via shared oxygen atoms, and the presence of voids filled ions and water molecules, having great freedom of movement [19], [20], [21]. Clinoptilolite is the most abundant and economically important natural zeolites. Based on literature data [14], [22], [23], [24] it can be concluded, that this mineral in the presence of water, has pozzolanic properties, reacts with the calcium hydroxide to form a product having binding properties (C-S-H). Determinant of pozzolanic activity is the quantity and the rate of binding of $Ca(OH)_2$ by active ingradients of pozzolans (SiO_2+Al_2O_3). Clinoptilolite similarly as diatomite or volcanic tuffs, belongs to the group of pozzolans of moderate activity relative to the $Ca(OH)_2$, compared to the less active siliceous or calcareous fly ash, gaize and highly active metakaolinite or silica fume [14], [25].

So far, little publications on the influence of zeolite on the process of binding sulphate ions and corrosion resistance of cements with this addition have been noted [26], [27], [28], [29], [30], [31], [32], [33]. Therefore, it seems necessary addition to the data on the effect of zeolite on the mechanism of sulphate attack on cements, that are exposed to aggressive environment. In the paper results of investigation of sulphate resistance of cement mortars exposed 52 weeks in Na_2SO_4 solution were presented. The mortars made of Portland cement (CEM I) and cement with mineral addition of zeolite (CEM II/A-P, CEM IV/A, CEM II/B-P, CEM IV/B [‡]) were tasted. Investigation of linear changes of mortars have been supplemented with visual assessment in the form of photographs of samples and SEM/EDS analysis.

2. Materials and experimental methods

2.1. Materials

In investigations Portland cement CEM I 42.5 R, natural clinoptilolite and anhydrous sodium sulfate (chemical pure) were used. Chemical and mineralogical composition of raw materials has been shown in Table 1 and 2. Authors have divided the research focus on the following steps:

- Stage I - study of measurement of linear changes of cement mortars with zeolite additive according to the Polish standard PN-B-19707:2003 and estimating the expansion of those mortars, immersed in Na_2SO_4 solution by 52 weeks,
- Stage II - assessment of the impact of zeolite on resistance of cement to sulphate attack, by visual and microscopic observation of specimens, the condition of their surface, exposed to aggressive Na_2SO_4 solution

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[†] Where: T – Si^{4+} or Al^{3+} ions, and also Na^+, K^+, Mg^{2+}, Ca^{2}+, Sr^{2+}, Ba^{2+} cations

[‡] Cements according to EN 197-1: CEM II – Pozzolan Portland Cement (where P – natural pozzolan and A - 6÷20% additive in cement, B - 21÷35% additive in cement), CEM IV – Pozzolanic Cement (where symbol means: A - 11÷35% or B - 36÷55% additive in cement)