ENVIRONMENTAL INFLUENCE ON SERVICE LIFE EXPECTANCY OF CERAMIC STRUCTURES

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During the service life, materials are exposed to environmental influences. The aim of this research is to analyze behavior of sulfur concrete compared to Portland cement concrete in acid environment. It has been shown that sulfur concrete has satisfying mechanical strength and good resistance to aggressive environment compared to conventional Portland cement concrete. These results can be used for finding new possibilities for sulfur concrete applying.

Keywords: ceramics, electron microscopy, sulfur concrete, Portland cement concrete, acid environment.

1. Introduction

While in service use, all materials are exposed to diverse external stresses and environmental influences (chemical, physical and mechanical interferences) that provoke some type of material response. The idea in this research was to analyze the degradation of concrete structures caused by imposed chemical influence. In the case of chemical deterioration, various ions penetrate from the surface and then permeate into the concrete. Concrete structures are more or less porous materials, which have a detrimental influence on the strength of concrete and on the durability because they become permeation paths for other deterioration factors.

Modern trends of obtaining materials with desired properties are based on combining ingredients with different properties in different proportions, as well as on the application of various manufacturing procedures and additional material processing. Sulfur concrete and mortar are high performance thermoplastic materials made of mineral aggregate, filler, and modified sulfur binder, instead of cement and water as in ordinary Portland cement concrete and mortar at temperatures above the hardening point of sulfur (120ºC). Contemporary experience all over the world shows that concrete with modified sulfur binder instead of cement and water have significant chemical and physical-mechanical advantages comparing with Portland cement concrete [1, 2]. Construction materials such as sulfur concrete and sulfur modified asphalt continue to receive more attention since they are environmentally friendly and cost-effective.

2. Experimental

2.1. Samples preparation

Sulfur concrete was prepared according to the manufacturing technological procedure [3]. Preheated aggregate and filler (up to 160ºC) were stirred for about 15 min in a mixer, then melted sulfur and modified sulfur were mixed into homogenized dry mixture of aggregate and filler at sulfur melting temperature, 132—141°C. The heated aggregate and filler were then properly mixed with the molten modified sulfur until a homogenous viscous mixture was obtained. After homogenization and mixing that lasted for 2 minutes, the sulfur concrete mixture was cast into molds preheated at 120ºC and vibrated for 10 seconds. The mixture was left inside the molds at room temperature for hardening. After 3 h of hardening at room temperature, samples were demolded and kept at room temperature of 20ºC for 24 h. Mechanical properties measurements were made after 75 h.

The Portland cement concrete mixtures, made with aggregate, Portland cement and water, were mixed in Hobart mixer. The overall mixing time was about 6 min. The concrete mixture was poured into molds and compacted by a vibration table. The specimens were demolded 24 h after casting and then cured in a moist room at a temperature of 20±2°C with 95—98% relative humidity for 27 additional days, before being subjected to the tests.

The prism-shaped concrete samples with dimensions (4×4×16 cm) were prepared.

2.2. Testing methods

For sulfur concrete and Portland cement concrete acid resistance testing, the samples were immersed in 10% hydrochloric acid for different intervals throughout six months' time frame.

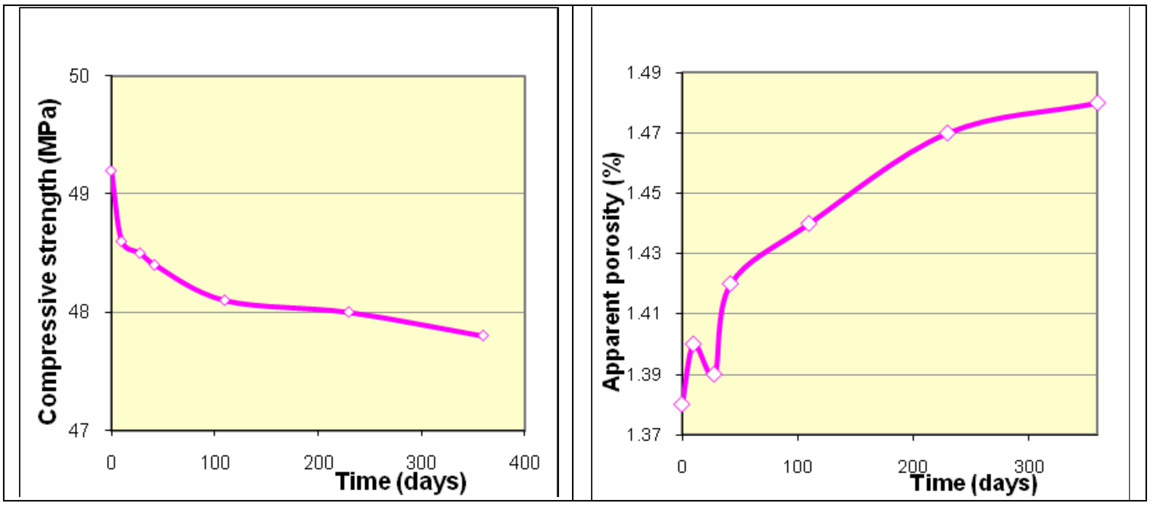
Mechanical strength of the concrete samples was conducted using the "Amsler" press with maximum load of 200 kN, and method for testing the strength of concrete according to the standard [4].

Apparent porosity of the samples was determined using boiling water saturation technique [5]. The samples were boiled for 5 h and then cooled for 19 h to a final temperature of 20—25ºC.

Morphological structure of the concrete samples was determined using scanning electron microscope JEOL JSM 5800.

3. Results and discussion

The compressive strength and apparent porosity changes of sulfur concrete samples in medium concentrated solution of hydrochloric acid are presented in Fig. 1.



a) b)

Fig. 1. Compressive strength (*a*) and apparent porosity of sulfur concrete treated in 10% HCl (*b*)

It can be noticed that compressive strength changes were limited. As it was expected, sulfur concrete samples exhibited increase of apparent porosity after a year of treatment in the aggressive environment.

Compressive strength loss of the treated sulfur concrete samples can be explained by increased porosity because mechanical strength is dependent on the defects in concrete microstructure. Porosity is related to the movement of chemical substances into and out of the concrete and consequently affects durability of concrete, as porosity is connected to many deterioration processes driven by the transport properties of concrete. In sulfur concrete, the majority of the matrix is composed of sulfur coated materials (aggregate and filler) and sulfur accumulated in the voids between particles.

Acid penetration and therefore corrosion was limited to the surface and open pores that were not coated by sulfur, which in turn resulted in slight porosity increase and slight compressive strength reduction [6].

It can be concluded that apparent porosity increase tendency of sulfur concrete samples is in accordance with compressive strength loss due to contact with the aggressive agent.

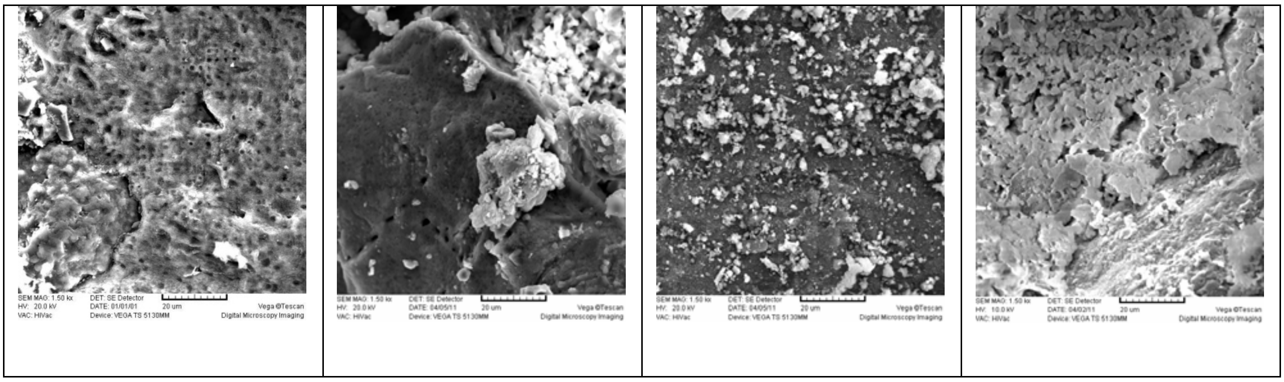
All samples of Portland cement concrete in acid environment after 2 months exhibited a strong damage followed by complete degradation of physical and mechanical properties, so further investigation was stopped.

The results of compressive strength for Portland cement concrete samples during the immersion period of 2 months in the aggressive environment are summarized in Table 1. Because of severe degradation, determination of apparent porosity was not possible.

Table 2. Compressive strength of Portland cement concrete during 2 months of immersion in 10% HCl.

Immersion time (days)	Compressive strength (MPa)	Apparent porosity (%)
0	46.3	16.3
7	6.49	n.d.
14	6.21	n.d.
21	1.84	n.d.
60	n.d.	n.d.

Structural differences between sulfur concrete and Portland cement concrete samples, both treated for 21 days, are given in Fig. 2.



(a) (b) (c) (d)

Fig. 2. SE images of sulfur concrete untreated (a) and treated for 21 days (b) and of Portland cement concrete untreated (c) and treated for 21 days (d)

The presented SEM microphotographs prove that for both materials changes in the structure on micro scale exist and they are result of interactions with the acid, which lead to different scenarios of sulfur concrete and Portland cement concrete life circles [1].

4. Conclusion

By adequate technological procedure and selection of the initial components, sulfur concrete with satisfying mechanical strength and good resistance to aggressive solution compared to conventional Portland cement concrete was produced.

The obtained results can be used for finding new possibilities of sulfur concrete applying when high resistance to corrosive effect of the environment is required.

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Влияние окружающей среды на срок службы керамических конструкций.

Во время всего срока службы материалы подвергаются воздействию окружающей среды. Целью данного исследования является анализ поведения серного бетона в кислой среде по сравнению с бетоном на портландцементе. Результаты показали, что бетон с содержанием серы, имеет удовлетворительную механическую прочность и хорошую стойкость к агрессивным средам по сравнению с обычным бетоном из портландцемента. Данные результаты исследования могут быть использованы для поиска новых возможностей применения серного бетона.

Ключевые слова: *керамика, электронная микроскопия, серный бетон, бетон на портландцементе, кислотная среда.*
