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Landfill Leachate as an Additive in Sand-Lime Products

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Abstract

Sand-lime blocks are ecological products. They are produced from natural raw materials: lime, sand and water. Sand-lime elements (also known as silicates) meet ecological requirements both at the production and operation stage. In the process of autoclaving, lime is combined with silica and produces insoluble calcium silicates. Thanks to this process, silicate bricks and blocks are characterized by their high strength and durability. Environmental aspects are of great importance in modern construction. Therefore, attention should be paid to the possibility of the production of silicates from waste materials. This article aims to investigate the possibility of using the leachate from environmental landfills (inert waste, which is not subject to specific physical, chemical or biological alternations) as a modifier of properties of sand-lime products.

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Keywords: sand-lime products; leachate; microstructure;

1. Introduction

In order to carry out laboratory tests of modified sand-lime products, rectangular samples with dimensions of 40x40x160 mm were prepared. Samples were manufactured in the Silicates Production Plant. The sand is mixed with quick lime and water in appropriate proportions. Approximately 90% of the weight of the product is sand, limestone is about 7% and about 3% constitutes water. In the reactors, a process of lime slaking takes place. When exposed to water, quick lime is converted to slaked lime as a result of the elevated temperature derived from the reaction of lime slaking and alkaline environment, the surface of sand grains loses its crystalline structure. Grains obtained in this way have the proper form for the further conversion. The essence of the research was to replace the water by leachate.

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Placed in trigeminal molds, silicate mass was pressed under a pressure of 20 MPa and then moved to the autoclave and cured at a temperature of 203 °C and under a pressure of 1.6 MPa. The article presents the effect of the addition of leachate and water resisting admixture on the properties of modified sand-lime products and their microstructure. In order to verify the effect of the various modifiers, a sample of a traditional sand-lime product was also prepared. By analyzing the results of the compressive strength of the modified sand-lime products, a certain impact of used modifiers was observed. The compressive strength of the sample with environmental leachate was slightly increased. Leachate in combination with an admixture showed a compressive strength of silicate similar to a conventional product. In contrast, using only admixture increased the compressive strength of the product. Microstructure analysis of the modified sand-lime products under a scanning electron microscope showed the presence of C-S-H phase, tobermorite and xonotlite, in samples with the addition of leachate and admixture. XRD study of the traditional silicate sample revealed the presence of quartz and tobermorite or other calcium silicate. Summing up studies it can be concluded that the addition of the environmental leachate even in small quantities results in an improvement of the performance of sand-lime products.

Sand-lime products enjoy a growing popularity among producers and consumers. Searching for new material solutions has become a widespread phenomenon. An important factor that promotes the development of material engineering in the construction sector is ecology, and thus the protection of man against harmful and often chronic effects of the environment and building materials, which contain harmful chemical compounds or elements. Further aspects are the economy and energy efficiency. The latter is related to the still rising fuel prices, as well as environmental protection and thereby limiting emissivity of compounds, such as sulfur dioxide nitrogen oxide and carbon monoxide, about which inform the new EU directives [1].

Therefore, attention should be paid to the possibility of the production of silicate products with waste materials. Research objects are thus silicate wall products, both traditional and modified with leachate. Performed tests were aimed to improve the standard silicates characteristics and analyze their microstructure and further to determine the impact of silicate mass modifiers on the functional properties and microstructure of the examined products.

The goal of the article is to investigate the possibility of using landfill leachate (i.e. neutral waste, which are not subject to specific physical, chemical or biological transformations) as modifiers of sand-lime products properties. According to [2], leachate is "any liquid percolating through the deposited waste or emitted from a landfill or contained within it".

Landfill leachate arises from the migration of rainwater through the landfill and as a result of biochemical changes in the deposited mass of waste. They are characterized by great diversity, both quantitative and qualitative, dependent on many factors, such as the size of the landfill, the amount and the type of deposited waste, as well as climatic conditions (in particular the amount and frequency of atmospheric precipitation), the age of the landfill and storage technology (the degree of waste compaction and the use of insulating layers). [3] Heavy metals are one of the most troublesome contaminants present in the leachate. However, the level of heavy metals in the used leachate is below the permissible limits of Polish laws. The low content of heavy metals may be due to many factors, and in this particular case, due to a pH of from 7.42 to 8.23 (increase in pH reduces the solubility of the metals). Moreover, the adsorption and precipitation reactions (through co-anions sulfides, carbonates, hydroxides) have a significant influence on the concentration of heavy metals in the stabilized landfill [4]. The leachate used in the experiment came from the municipal landfill Barcza near Kielce (Poland). The content of heavy metals in the used leachate is presented in the Table 1.

2. Methodology

There were prepared rectangular samples with dimensions of 40x40x160 mm, in order to carry out the laboratory tests of modified sand-lime products. The samples were performed in Silicate Production Plant in Ludynia (Poland). The sand for the production of sand-lime elements must meet the relevant requirements concerning the minimum SiO2 content of 80%, chemical composition and grain size distribution. The sand used in a technological process has a grain size of 0-2 mm. Grain size distribution of sand influences the mechanical properties of silicates. The sand is mixed with quick lime and water in appropriate proportions. Sand constitutes approximately 90% of the weight of the product, lime is about 7% and water – 3 %. In a reactor, a process of lime slaking takes place. When exposed to water the quick lime is converted to slaked lime. As a result of elevated temperature coming from the reaction of lime slaking