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POSSIBILITY OF THE STEEL SLAG USAGE IN THE CIVIL CONSTRUCTION

Jelena Đorđević[1a], Sandra Guševac[1b], Jelena Stefanović[1c], Ivan Jelić[1d], Miloš Živanović[1e]

[1]Mining and Metallurgy Institute Bor, Alberta Ajnštajna 1, 19210 Bor, Serbia
[1a] jelena.djordjevic@irmbor.co.rs, https://orcid.org/0000-0001-5406-0074;
[1b] sandra.filipovic@irmbor.co.rs, https://orcid.org/0000-0002-6776-9899;
[1c] jelena.stankovic@irmbor.co.rs, https://orcid.org/0000-0001-6418-1814;
[1d] ivan.jelic@irmbor.co.rs, https://orcid.org/0000-0003-4534-0706;
[1e] milos.zivanovic @irmbor.co.rs, https://orcid.org/0009-0006-3331-4294

Abstract

Industrial development during the last decades has led to creation a large amount of by-products that are stored on the landfills and create the major environmental problem. Many researchers deal with the topic of possibility of usage the alternative materials in various industrial areas, in order to solve the problem of deposition and enable saving the natural raw materials. Steel slag is a by-product of steel production and is one of the industrial waste materials in our country that is deposited in large quantities. This alternative material is very useful, especially in the road construction, which is described in this paper.

***Keywords**: steel slag, environmental protection, civil construction*

1. INTRODUCTION

Production of steel involves obtaining an alloy of iron and carbon with the desired chemical composition and mechanical properties. Achieving the certain mechanical characteristics depends on three interrelated factors: chemical composition, plastic processing and heat treatment. Steel production takes place in the steel mills, which are a part of a wider plant - ironworks.

The most common way of steel production is through an integrated blast furnace process – the basic oxygen blast furnaces, in which iron ore is combined with various amounts of steel scrap and small amounts of lime or dolomite.

Figure 1. *Steel rozonda in blast furnaces (5)*

Another method of steel production is the production process in the electric arc furnaces or mini mills, which does not involve the iron production. The existing steel is processed in these furnaces, thus avoiding the need for raw materials and their further processing. The furnace is filled with steel scrap, and porous iron or pig iron can also be used for chemical balance. An electric arc furnace works on the basis of an electric charge that occurs between two electrodes that produce heat for the needs of the process itself.

Figure 2. *Steel production in an electric arc furnace (5)*

After steel refining in the basic oxygen blast furnaces or electric arc furnaces, the steel can be re-refined through the secondary steelmaking operation in the casting furnaces. The goal of this additional operation in the steel production process is to achieve a specific chemical composition.

The by-product, obtained in the steel production process, is steel slag. The annual production of this waste industrial material in the world is about 130 million tons. [2] Many researchers study the possibility of using the steel slag as an alternative material in various spheres, in order to solve the problem of depositing this by-product and contribute to the environment preservation.

2. STEEL SLAG USAGE

One of the important applications of steel slag in the world is its use in the production of cement. Also, the high density of slag from the blast furnaces makes this material very suitable for hydrotechnical facilities. In Germany and the Netherlands, about 400,000 t of slag from the blast furnaces are used as material for lining the slopes. A significant application of this material is its use for rehabilitation the eroded watercourses. One of the newer areas of application the steel slag is its use as an aggregate in concrete. Certain countries in the world, such as Japan, have introduced a norm for the use of steel slag as an aggregate in concrete. [4]

A very important application of this material is its use in the road construction, where the steel slag is often used as a soil stabilization material. In addition to the surface layers of the soil, the granulated slag from the blast furnaces is also successfully used as a binder in the stabilization of deeper soil layers, in case of the weak bearing capacity of the soil on which the construction of engineering buildings is planned. According to the statistical data,

one of the most frequent applications is in unbound mixes for the road subgrades or as an aggregate in the asphalt mixes. [4]

In addition to the use for construction purposes, this material is increasingly used as a fertilizer in the soil. This refers to slag from the blast furnaces, which contains a high percentage of calcium and magnesium oxides, which is used as a substitute for lime. The steel slag can also be used in the other areas, such as the water treatment, cement clinker production, or returned to the blast furnace to reprocess the crude steel. [4]

3. STABILIZATION OF STEEL SLAG

The main problem with the use of steel slag from the blast furnaces in construction is its volumetric instability in the presence of water. This is the result of a high percentage of free lime and magnesium oxide that do not react with the silicate structures. Hydration of steel slag leads to expansion of this material, which limits its engineering applications. Several authors have investigated the steel slag stabilization methods in order to solve the volume instability problem. [1]

One of the methods is the aging treatment, which is passive, cheap, simple and effective. This way involves the natural storage of material until it stabilizes over time. However, this process takes a long time, usually more than a year, which creates the environmental problems of disposal. Due to this reason, this method is sometimes accelerated by the steam, pressurized water jets, or tumbling and vibrating the slag. [1]

Another stabilization process is the use of acidic compounds that react with the steel slag and remove free lime. [1]

Another treatment that can be applied is the immersion of fully hydrated slag in silicon resin for 1 hour. After that, the slag should be dried for 24 hours in a drying oven at temperature of 60℃ and the whole procedure should be repeated three times. [1]

All these methods of stabilization reduce the content of free lime in steel slag and enable its reuse, but these processes are the time-consuming and economically inefficient. If steel slag needs to be pretreated before being used as an alternative material, it is very difficult for it to be competitive with the natural aggregates for the road construction from an economic point of view. In addition, these pretreatments involve the consumption of other raw materials (energy, fuel, etc.), which includes the environmental impacts. This is the reason why many researchers are making great efforts to find a way to use the raw steel slag.

4. CONCLUSION

Many researchers deal with the topic of using the steel slag, as a by-product from the steel production process, for commercial purposes, in order to solve the problem of depositing this material on the one hand, while on the other hand it would save the natural raw materials. The results of studies show that steel slag can be widely used in industry, especially in construction, i.e., road construction.

A large number of laboratory analyzes have shown that the content of steel slag in the asphalt mixtures can improve the slip resistance, mechanical properties and resistance to rutting. Some studies show that mixing the limestone and steel slag, as a coarse aggregate, in the asphalt mixture provides a high resistance to the plastic deformation, fatigue resistance and durability.

All the mentioned facts are encouraging and leave a space for further tests and proving the possibility of using this alternative material.

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