# PRODUCTION AND VALORIZATION OF THE INDUSTRIAL MINING WASTE IN CIVIL ENGINEERING A LITERATURE REVIEW

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**ABSTRACT**

Billions of tons of waste are generated around the world every year. In fact, humanity rejects 12 billion tons of industrial and household waste annually. The production of this waste has increased incredibly over time due to rapid urbanization, population growth and industrial development. According to global statistics, industrial mining waste generation is not balanced across the world. The countries that produce the most waste are the developed industrialized countries. The management of these waste presents a challenge to producing countries because of the heavy metals they contain. The landfilling of these wastes directly threatens the environment and represents an additional burden in terms of occupation of the public domain. To get rid of this industrial mining waste, several researches have affirmed that valorization is the most suitable solution.

**Keywords:** Industrial mining waste, Environment, Management, Valorization.

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## 1. INTRODUCTION

Industrial waste is the waste produced by industrial activity. They include mining waste, chemical waste, radioactive waste, etc. The main mining wastes in the world are smelter wastes like slag, thermal power station wastes like fly ash and incineration wastes like bottom ash. Concerning chemical waste, they include acids, bases and chemical solutions. Radioactive waste comes from the production of energy in nuclear power stations. The most industrial waste producing countries worldwide are by continent as follows [1]:

- Europe: Germany, United Kingdom, France, Russia, and Bulgaria;
- America: United States, Brazil, Canada, Chile, and Colombia;
- Asia: China, Japan, India, South Korea, Saudi Arabia, United Arab Emirates;
- Australia: Australia;
- Africa: South Africa, Egypt and Tunisia.

Asian Pacific countries and especially China, Japan, India, South Korea, and Australia present the world's largest producer of industrial waste with 5357 million tons (58.4% of global production) [1]. In fact, the annual production of slag in China exceeds 100 million tons [2]. In Japan, about 40 million tons of slag are generated annually from iron and steel manufacturing processes [3]. On the other hand, India produces about 10 million tons of steel slag and 25 million tons of coal ash annually [4]. The annual production rate of fly ash is about 1.7 million tons in Malaysia, 14 million tons in the United States, and 4 million tons in Europe [5].

The main ways of valorization of industrial mining waste in the field of civil engineering approved in practice, we can cite the valorization in the formulation of concrete, in mortar and in the road sector.

## 2. VALORIZATION OF SLAG

Due to their chemical composition and mechanical properties, slag can be reused as a raw or secondary material for natural aggregates. The industrialized countries have been the precursors in innovating processes for the valorization of these residues. More than 20 countries in the world started early the recycling of slag. Among them are: the United States, Japan, Russia, Germany and France [6]. As an example, the utilization rate of steel slag is about: 98.4% in Japan; 87.0% in Europe; 84.4% in the United States; and 29.5% in China [2].

The use of slag in civil engineering applications can reduce the need for its disposal and decrease the use of natural resources [7]. In particular, slag can be used as: a ballast for railroads and untreated aggregates for pavement bodies and highways [8]–[10]. Indeed, coarse slag aggregates are used as ballast for the purpose of maintaining the stability of railroad tracks [11]. Given that the use of slag in road construction has multiple advantages. Among them are: solving the challenge of waste disposal and preserving non-renewable natural aggregate resources [12]. It has been stated in most developed countries that slag represents a useful construction material [13].

In addition, slag can also be used in concrete and mortar as a substitute for aggregates and sands. Indeed, partial replacement of fine and coarse aggregates with steel slag has been shown to improve the compressive, tensile and flexural strength of concrete [14]. Thus, they also proved that the use of slag in concrete confers good mechanical properties and increases its durability more via decreasing its absorption and reducing its porosity [15]. In addition, it has been affirmed that slag can be used in unreinforced concrete as a substitute partially replacing natural aggregates [16].

The feasibility of using slag in mortars was also studied. In fact, it was observed that partial replacement of natural sand up to 75% of blast furnace slag, using appropriate dosage of superplasticizer, results in an acceptable mortar in terms of strength and workability [17]. A new type of mortar composed of granulated blast furnace slag, gypsum, clinker and steel slag was developed by improving the mechanical performance and microstructure [18]. Thus, it has been proved that the fineness of slag is the determining factor affecting the strength of mortar [19].

## 3. VALORIZATION OF FLY ASH

Fly ash presents a very successful example of industrial by-products valorization because of its current use in several types of cement. In China, the largest producer of cement in the world, cement production reached 1200 million tons in 2006. The Chinese cement standard set the addition rate of fly ash in fly ash cement between 20-40% [20]. In Taiwan, a research confirmed that the cement produced with fly ash addition meets the requirements of China's national standard of Type II portland cement in terms of compressive strength [21]. This can be explained by the particle size distribution of fly ash and its calcium content which are the most important parameters reacting on the strength development rate of portland cement mixtures [22]. In addition, Turkish researchers have added that fly ash fineness is an effective parameter for the improvement of compressive strength of portland cement [23].

In the cement industry, fly ash is used as a pozzolanic material for the manufacture of portland pozzolanic cement taking into account the $SiO_2$ and $Al_2SiO_3$ content is very similar to that of portland cement [24]. In addition, they are used to promote the hydration of cement [25]. Also, Moroccan researchers have demonstrated that the addition of fly ash to Moroccan portland cement leads to a significant increase in setting time compared to standard portland cement [26].

In addition, concrete and mortar have also been avenues for fly ash valorization in civil engineering. In fact, a study demonstrated the feasibility of producing geopolymer mortar based on fly ash [27]. Thus, it has been approved that the addition of fly ash in mortar and concrete has a significant influence in improving their properties such as water requirement, workability, setting time, compressive strength and durability [28].

## 4. CONCLUSION

This literature review has shown that slag and fly ash, as industrial wastes, have very interesting properties that encourage their valorization in civil engineering. Furthermore, from several researches, it is evident that industrial waste is an interesting source of valorization.

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