COMPARATIVE ANALYSIS OF FLY ASH MANAGEMENT IN EUROPE AND SERBIA: ASPECTS AND REGULATIONS

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ABSTRACT

This paper presents a comparative analysis of the fly ash management in Europe and Serbia, as well as its application the building materials production, with special reference to the existing legislation. The draft development remediation plan is also given, with regard to non conformity with generated and used amount of fly ash and slag.

Aim of this paper is to point out the importance of ash used as a replacement for the traditionally building materials, without compromising product quality, while keeping in mind the economic aspect (reducing the amounts of waste ash in landfills), and the aspect of environmental protection.

IZVOD

U radu je prikazana komparativna analiza upravljanja letećim pepelom u Evropi i Srbiji, kao i mogućnost primene u proizvodnji građevinskih materijala, sa posebnim osvrtom na zakonsku regulativu. Dat je i nacrt izrade plana za remedijaciju deponija pepela i šljake, s obzirom na neusaglašenost generisanih i upotrebljenih količina. Cilj rada je da se ukaže na značaj upotrebe pepela kao zamene za tradicionalno građevinske materijale, bez narušavanja kvaliteta proizvoda, imajući u vidu kako ekonomski aspekt (smanjenje količina otpadnog pepela na deponijama), tako i aspekt zaštite životne sredine.

1. INTRODUCTION

During the past 50 years, the use of coal to generate electricity has increased substantially, as has the generation of fly ashes. The world-wide production of coal ash is estimated to exceed $550x10^6$ t/year. The disposal of FA is becoming more expensive each year due to the large lands need for its disposal [1-3]. Fly ash landfills in Serbia are getting expanded (currently estimated at 1800 ha), and the quantity of released ash is 6-7 million tons per year [4]. Due to the impossibility of covering these landfills, it comes to pollution of soil, air and groundwater. Most of approaches for finding a solution to this problem are either geared to utilize the ash beneficially in order to reduce the cost of disposal, or to minimize their environmental impact.

Fly ash particles are considered to be highly contaminating, due to their enrichment in potentially toxic trace elements which condense from the flue gas. Research on the potential applications of these wastes has environmental relevance, in addition to industrial interest [5]. Fly ash can contain metals such as cadmium, iron, lead, aluminum and zinc in its structure in appreciable amounts.

These metals can leach out into surface and ground waters if fly ash is not properly disposed of. The presence of heavy metals in the environment even in moderate concentrations is responsible for illnesses related to respiratory or dermal damage and even several kinds of cancers. It is therefore important to remove toxic metal contaminants from waste water prior to discharge as they are considered persistent and bioaccumulative [6].

2. UTILIZATION OF FLY ASH IN EUROPE

Coal Combustion Products (CCPs) are mainly utilized in the building material industry, in civil engineering road construction, for construction work in underground coal mining, as well as for recultivation and restoration purposes in open cast mines. CCPs are produced to meet the requirements of standards or other specifications with respect to utilisation in the construction industry. Fly ash is the most important CCP with nearly 68% of the total amount. Most of the fly ash produced in 2004 was used as concrete addition, in road construction and as a raw material for cement clinker production. Fly ash was also utilised in blended cements, in concrete blocks and for infill (that means filling of voids, mine shafts and subsurface mine workings) (Figure 1). From about 64 million tons of fly ash produced in Europe, total utilization is estimated to 22 million tones, which is only 14.1% [7, 8].

Sufficiently large amounts of fly ash can be used only in the building industry. Construction materials which can be produced with addition of fly ash are: light aerated concrete, masonry blocks, lime-silicate elements (gas concrete), ceramic products (bricks, tiles, pipes) [9-11], and glass-ceramics [12].

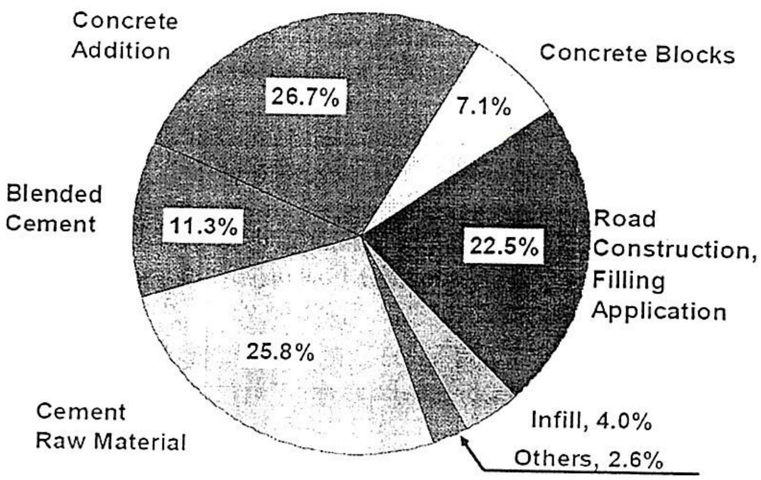

Figure 1. Utilisation of Fly Ash in the Construction Industry and Underground Mining in Europe [8]

The requirements for siliceous and calcareous fly ash for the production of blended cement are defined in EN 197, where over the last years about 2 million tonnes of fly ash has been used every year. Due to the necessary reduction in CO_2 emission of the cement industry this amount is expected to increase.

The cement industry currently emits 0.7 to 1.2 kg of CO_2 for every kilogram of cement produced, depending upon the type of fuel used. The use of fly ash in cement and concrete helps to reduce this greenhouse gas emission by e.g. reducing the production of cement clinker.

3. RESEARCH RELATED TO THE QUALITY OF FLY ASH IN EUROPE

The properties of the coal fly ash are strongly dependent on its geological origin and the combustion process of the coal. In the fully controlled combustion process flay ash is produced to meet the requirement of standard. The most important parameters for the process control are the fineness and loss on ignition, which represents the unburned carbon [7].

According to EN 450, which introduces the demands for fly ash used in concrete, the desire is to have lower content of residual particles on 45μm sieve and the lower carbon content. Only certified fly ash meeting the requirements of EN 450 may be used in concrete. Fly ash which is not certified can only be used in other applications or, alternatively, has to be sent to disposal. The processing of fly ashes to improve certain properties, e.g. reduction of loss on ignition (LOI) or increase of fineness was not covered by the former EN 450 published in 1994. On 1 January 2007 the revised EN-450 entered the incrased demands. The new standard covers also fly ash from processing plants, which is produced by e.g. classification, selection, sieving, drying, blending, grinding or carbon reduction. This is because in some countries fly ash has been processed according to national regulations for years or, in some cases, decades [13-16].

In the brick industry the only limit is the amount of heat released in relation to the mass, where less than 400 KJ/kg is aloud, so that gives a potential energy saving. Larger amounts of released energy can cause deformation of firing curve and high heating rate can cause the cracking of product, where there is always a risk that the energy released in the furnace will be impossible to control. In addition, fired products must meet the quality requirements according to EN 772 [17, 18].

4. CHEMICAL CHARACTERISTICS OF FLY ASH

The chemical composition of Serbian (SFA) [19] and European fly ash (EFA) [20] is compared and given in Table 1. In the case of European fly ash, SFA consisted mainly of silica (53.49-58.32 %), alumina (17.72-21.28%) and iron oxides (6.20-10.48%) depending on the origin of a fly ash. Relatively low loss on ignition (LOI) of SFA (1.84-4.91%) was attributed to the fact that organic matter is not present in the investigated fly ash samples. SiO_2 content was higher than 50%, while content of Al_2O_3 was in range 17-25% in all investigated SFA samples.

Trace element concentrations of SFA are shown in Table 1 [19]. It was noted that SFA had lower concentrations of a number of trace elements, namely Pb, Cd, Zn, Hg, Ba and Se. Relatively low level of mentioned trace elements, present in the investigated SFA, results in low leachability.

Thus, there is equally low environmental risk posed by the presence of contaminant trace elements in the SFA if it is used in a construction element and exposed to the force of rain and air. Also, such fly ash can be used as adsorber (e.g.: used in synthesis of artificial zeolite).

Table 1. Chemical composition of fly ashes in Serbia and EU

Oxide, wt %	SFA	EFA
SiO2	53.49-58.32	41.10–59.60
Al2O3	17.72-21.28	17.60–35.60
Fe2O3	10.48-6.85	2.60–16.00
TiO2	0.52-0.57	0.50–2.60
CaO	6.96-8.71	0.50–11.80
MgO	1.98-2.74	0.80–3.80
P2O5	0.02-0.03	0.10–1.70
SO3	0.78-1.29	0.10–8.60
Na2O	0.36-0.50	0.10–1.20
K2O	0.59-1.16	0.40–4.00
CO2	0.09-0.25	0.60–7.60
LOI	1.84-4.91	1.10–8.10

All of the SFA chemical analysis parameters were between the ranges reported for EFA. Also, it should be stated that EFA were directly collected in electrostatic precipitators, unlike SFA which were landfilled, which highlights positive characteristics of SFA and, thus, influences and widens utilization possibilities of the investigated fly ashes.

5. DISPOSAL OF FLY ASH

Due to the fact that fly ash and slag may contain a variety of potentially toxic elements - such as Ni, Cr, As and B, it must be assumed that the landfill of waste such magnitude could encourage a major environmental problem [21]. The main problems are related to:

- Soil contamination;
- Contamination of water / groundwater from leaking toxins (waste and processed water);
- Particle dispersion;
- The entry of toxins into the food chain.

The process of remediation of fly ash disposal and vulnerable water resources is a necessary measure to be implemented together with a series of legal measures to protect and improve environmental quality.

After numerous analyses the right strategy of Remediation Plan should contain [21]:

- Defining the problem;
- Defining the objectives of the strategy that can be relied on local concerns and requirements and must meet the legal, social and environmental needs;
- The list of options-List of Potential Development Options - range of remediation strategies for providing effective and secure solutions with a number of "backup" plans and alternative actions;
- Development of a complete and comprehensive strategy on the basis of predefined options;
- Monitoring and evaluation;
- Establishing measures to ensure and assess the long-term sustainability strategy.

To overcome the problem with degraded areas, fly ash dumping sites have been started as a potential resource for biomass production of tree species. Phytoremediation is a strategy that uses plants to degrade, stabilize, and remove contaminants from soils, water and waste FA. Phytomanagement of FA is based on the plants' root systems, high biomass, woody nature, native nature, and resistance to pH, salinity, and toxic metals.

6. ENVIRONMENTAL CONSIDERATIONS AND LEGISLATION

The utilisation of CCPs in Europe is being influenced by standardisation and environmental legislation. In December 2010, the Waste Directive defined which CCP is a „by-product" and when a material will leave the waste status. From December 1, 2010 the producers of CCPs had registered their product according to the European Community Regulation on chemicals and their safe use (EC 1907/2006). It deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH). This is the precondition to place a product on the market based on a new regulation.

When fly ash is used in concrete, the potential for leaching of trace elements is very low. This is due to the constituents of fly ash being encapsulated in the matrix of the concrete [22].

Unencapsulated use, however, has the potential for trace element leaching. Use of fly ash in stabilized base or embankments requires good management to ensure the environment is not impacted negatively. Although studies have shown that coal fly ash is typically safe to use in unencapsulated applications, precautions must still be taken to ensure environmental impacts are acceptable [23].

An evaluation of groundwater conditions, applicable state test procedures, water quality standards, and proper construction are all necessary considerations in ensuring a safe final product [24].

7. CONCLUSION

The utilisation of fly ash across Europen countries is differs. A precondition for the use as construction material is meeting of the requirements in standards and specifications. In the majority of cases CCPs are used as a replacement for natural materials and therefore they contribute to sustainable development, because they offer environmental benefits by avoiding the need to quarry or mine natural resources.

Therefore, safe utilization of fly ash is a major concern around the world and regulatory bodies are enforcing stringent rules for its proper management.

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