# Possible uses of fossil fuel combustion waste in building materials industry

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*Abstract:* - The amount of natural materials used to manufacture building materials is limited and the costs of obtaining them are increasing. Regarding this, it was a continuous concern to find alternative materials for building, and industrial waste is one of such category.

In the south of Romania there are many areas where were deposited large amounts of industrial waste coming from coal, oil and natural gas extraction, metallurgical companies and energy industry. These landfills are sources of environmental pollution and they are also danger to population health and a threat to flora and fauna from surroundings areas.

The paper presents the properties of the ash and slag evacuated by Turceni power plant in order to use them for building materials manufacturing.

Key-Words: - ash and slag properties, building materials industry

## **1** Introduction

The fly ash comes primarily from coal-fired electricity generating power plants. These power plants grind coal to a powder fineness before it is burned. Fly ash is the mineral residue produced by burning coal and it is captured from the power plant's exhaust gases, collected and dumped.

Over the past several decades, the use of fly ash had a successful track record. The various segments of ash utilization currently include concrete manufacturing industries, land development, road embankment construction, building products such as bricks/ blocks/tiles, reclamation of coal mines and as a soil amender and source of micro and macronutrients in agriculture.

It is well known that fly ash produces more cementitious paste. The greater the percentage of fly ash "ball bearings" in the paste, the better lubricated the aggregates are and the better concrete flows. Concrete mixed with fly ash needs less water. This means that there is less shrinkage and cracking. Since fly ash costs less than cement, using fly ash in the mixture lowers the cost of concrete.

For concrete exposed to chlorides, fly ash, silica fume and slag can increase resistance to deterioration related to the corrosion of reinforcing steel by reducing chloride ion penetrability of concrete, with increasing levels typically leading to improved performance. Ash bricks are usually made of fly ash, lime, gypsum and sand and they are comparatively lighter in weight and stronger than common clay bricks.

Fly ash is a non-plastic material and it is used for roads and embankment works due to its very good compaction characteristics, shear strength, compressibility and permeability properties.

# **2** Problem Formulation

University "Constantin Brancusi" from Targu-Jiu is the coordinator of the ECOWASTES LIFE+ project, whose aim is to demonstrate that the recycling of waste from energy industry (coal combustion waste), petroleum extraction (drilling mud) and metallurgy (steelmaking slag) is a technically feasible alternative, taking into account that:

- Coal combustion waste (ash and slag) can replace up to 30-50% of natural quartz sand used in the ceramics manufacturing
- Drilling fluids waste (sintered material) can replace about 25% of clay used for classical bricks
- Metallurgical slag can replace about 50% of necessary calcium oxide.

By using the different types of industrial waste mentioned above, the following results are expected: fabrication of new building materials, reducing landfills and preserving important material resources.

The partners in ECOWASTES LIFE+ project are: University "Constantin Brâncuşi" of Târgu Jiu (UCB), Metallurgical Research Institute (ICEM), Energy Complex Turceni (ECT), Environmental Protection Agency Gorj (EPA).

One of the first project's objectives is selection and fully characterization of the three types of wastes (ashes, drilled solid wastes, metallurgical slag) identified as potential raw materials for the replacement of mainly three natural resources (clay, quartz sand, feldspar) used for building materials.

## **3** Problem Solution

First, there were identified the supply sites (fig.1) and then there were collected the necessary information.





Fig. 1. Landfills and supply sites location
coal burning waste;
drilling waste;
metallurgical slag

Different procedures for data evaluation and conversion, including digitization were developed and applied. The database of ECT containing the necessary information was consulted. The inventory of the topographical points in STEREO 70 system has been carried out, STEREO 70 system being the official Romanian cartographic projection.

Aerial and satellite photographs of areas taken by time to time may be used to estimate the waste quantities stored in that period.

a. <u>Thermal power plant wastes.</u> In Romania, the energy industry generates yearly great amounts of slag and ash which claims a lot of work for transport and storage by landfill. Ash and slag

resulting from steam power plants require approximately 1.2 ha storage space for every million tonnes. Currently, a great number of ash and slag dumps exist (108) which cover about 2800 ha, the greatest amount (about 800 ha) being in Gorj County (main geographical area for EcoWASTES wastes supply) and Dolj (neighbouring county with about 400 ha)

There were mapped three landfills located in Oltenia region, belonging to Craiova, Rovinari and Turceni power plants.

The fly ash supplier is the Energy Complex Turceni, associated beneficiary within the project. With a total installed capacity of 1980

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MW the plant produces about 7400  $\text{m}^3$  of flyashes per day using lignite as main fuel. The ash is recovered after the 2-nd gas flow (rotary air preheater) and from the electrofilters. Slag and ash from the combustion process are transported hydraulically (1:10 dillution with water) using centrifugal pumps, in series, in deposits designated for this purpose (a natural area with waterproof closure dumps)

Turceni Power Plant has two deposits: 1-st deposit (on 240 ha, 3 compartments and a total

capacity of 36 million m<sup>3</sup>) and 2-nd reserve deposit (on 175 hectares, 5 compartments and a total capacity of 20 million m<sup>3</sup>). Currently, exists a free capacity of approx. 4 million m<sup>3</sup> (main dump) and approx. 8 million m<sup>3</sup> (reserve dump)

The coal combustion waste samples were collected from these landfills. About 500 samples were collected by drilling in 120 different locations on four levels 5,10,15,20 m depth – fig. 2.



Fig. 2. Map of Turceni landfill. Locations of collected samples in STEREO 70.

Qualitative evaluation of the wastes was carried out. A representative sample bank has been created for the preliminary experiments: about one hundred samples have been investigated for physical & chemical tests and tens for mineralogical tests. The following tests were performed:

- (i) determination of compositional features included chemical analysis on average samples and the elementary;
- (ii) structural properties (mineralogical analysis) of the waste of interest were investigated by X-ray diffraction method, following the nature and type of crystalline compounds in which are present formations of oxides components.
- (iv) wastes behavior having relatively low melting point (ash and sludge) under thermal treatment was studied using high temperature microscopy, in which were determined: sintering, melting and

flowability points, important characteristics for evaluating the maximum burning temperature of the obtained waste products (eg, bricks and burned pellets).

- (v) general physical characterization was focused to establish the limits variation of one of the basic parameters, as are: dimensional distribution of particles (grain size composition), moisture content, bulk density (charged and stamped). In case of metallurgical slag, these parameters were determined after primary processing of elementary samples by crushing, granulation and/or advanced grinding.
- (vi) of all the elementary samples of waste were established minimum control samples of 500 g weight, which are kept in a bank of samples at the ICEM, for any further investigation.
- b. <u>Drilling sludge (detritus).</u> There were identified three sites for recovery the necessary samples from: Oprisenesti, Braila County, Filipestii de Padure, Prahova County and Valcele of Arges County.
- c. <u>Metallurgical slag</u>. There were identified three sites for recovery the necessary samples of metallurgical slag, at: SMR Balş, Olt County, Doosan IMGB, Ilfov County, Mechel

Târgoviște, Dimbovita County. Each of the three locations have their own methods of selection, storage and utilization of slags: in the location of SMR Balş exists separate collection and storage places for the two types of slag in Brăneț deposit, with a modest recovery of these slags by other companies; in the location of Doosan IMGB exists separate collection and storage places for the two types of slag, all of the slag being taken by the waste recovery company Ecorec; in the Mechel Targoviste location the resulting slag is now temporarily stored in the steel hall, and then taken over by recovery company AMSI Romania, without selecting the two categories.

The clay is a major constituent of porous building products and it is expected to have almost the same composition as the burnt clay from which it is derived. Fig. 3 shows the areas of usage of various types of clay, depending on their chemical composition: refractory clays for china clay and chamotte, refractory clays for antacids, clays for tiles and pottery, clays for clinker paving, clays for tiles and kaolin that is the most pure variety.



Fig. 3. Areas of clays usage depending on their chemical composition

The average chemical oxides composition of the ash is shown in table 1.

Taking into account the major oxide components in the oxide composition of the Turceni power plant ash, the medium samples denoted A, B, C, D were positioned in the ternary system CaO-Al2O3-SiO2 as shown in fig. 4.

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Probe	SiO2	TiO2	Al2O3	Fe2O3	MgO	CaO	MnO	Na2O	K2O	P2O5	SO3
А	49.7	0.77	20.95	8.96	2.48	9.25	0.08	0.21	1.55	0.2	0.59
В	40.8	0.67	15.7	8.4	2.36	13.75	0.08	0.19	1.35	0.21	4.6
С	45.24	0.76	19.15	8.65	2.35	9.45	0.07	0.2	1.44	0.24	1.52
D	46.8	0.68	19.4	8.9	2.42	9.35	0.08	0.25	1.42	0.24	1.38



Fig.4. Positioning in the ternary system CaO-Al2O3-SiO2 oxide composition of the ashes

The oxide composition of the ash was positioned in thermal equilibrium diagram of CaO-Al2O3-SiO2 as shown in fig. 5

All compositions of ash samples are in the range of paragenesis of anorthite CaO.Al2O3. 2SiO2. This was confirmed by X-ray diffractometer analysis. Because CaO and Fe2O3 oxides share amount is approximately equal to the weight of Al2O3 content, it is expected that mineralogical phases prediction to be not relevant according to ternary diagram CaO-SiO2-Fe2O3, all compositions laying in liquidus field of quartz.

### **4** Conclusion

In terms of chemical composition, the ash and slag Ceplea Valley landfill fall within the calcium aluminum silicate class materials with high-Fe2O3. The ash and slag resulting from lignite burning are comparable in composition to sandy clay derived from natural deposits situated in mountainous areas surrounding limestone massifs.

Having a widely oxides composition such as SiO2, Al2O3, CaO, Fe2O3, the lignite combustion waste could replace up to 30-50% from the natural sand used in the process of ceramic products manufacturing

With an average price of 40  $\notin$ /tone of raw materials used for building bricks manufacturing (clays + clay sands), the valorisation of about 500.000 t/year lignite combustion waste could involve a significant decrease of the production costs, considering that the transport of the waste to the utilization place will be done by the waste suppliers.

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Fig. 5. Oxides ash composition positioning in thermal equilibrium diagram of CaO-Al2O3-SiO2

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