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CHARACTERIZATION OF POWER PLANT "NIKOLA TESLA" WASTES

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ABSTRACT

The power plant "Nikola Tesla" B (Obrenovac, Serbia) is the largest power plant in Serbia and it produces 5-6 millions tones of fly and bottom ashes per a year. These ashes are disposed in a large areas near the plant and make the serious environmental problem. For this reason attempts are made to utilize them rather than to dump them.

Their application for the road construction consume the larges quantities of these wastes. In this work the wastes characteristics, density, bulk density, dry density, chemical and mineralogical compositions as so as the composition of their mixtures with the highest dry density, were determined.

INTRODUCTIOON

The materials remaining from burning of coal in electric power plants are known as the coal combustion products (CCPs). These are: fly ash, bottom ash, FGD material and the bottom slug (1, 2).

Fly ash is very small particle mineral residue that result from the burning of powdered coal in utility boilers. The individual particles are very small like talcum powder and are carried of the boiler in the flow of air used in the boiler for burning coal. Hence the term fly ash. The fly ash particles are removed from the stack gasses using electrostatic precipitators or other gas scrubbing systems.

According to ASTM classification fly ash can belong to class F (low calcium fly ash) and to class C (high calcium fly ash). The both these classes of fly ash can be used as the component of the base and subbase of road construction. The application for road construction is based on their pozzolanic properties. For class C, high calcium fly ash, pozzolanic reactions take place in the presence of moisture. For class F, low calcium fly ash, they take place in the presence of moisture and activator (lime, cement). The product of the pozzolanic reactions are: monosylphaoluminate hydrate, calcium silicate hydrate, calcium aluminate hydrate and ettringite. These compounds connect the particles of aggregates in the mixtures for road base and subbase constructions(2, 3).

Bottom ash is the coarse, solid material residue that result from the burning of coal in utility boilers. The individual particles are much larger than fly ash particles and fall down through the air flow to the bottom of the boiler and are called bottom ash. The material is removed from the bottom of the boiler in a wet state and is transported to a handling areas by conveyor or pipe. Bottom ash has a similar chemical composition to fly ash, but is produced in size grades ranging from fine sand to large gravel. Because of larger sizes, it does not have any cementitous properties. It is utilized in a variety of markets as an aggregate or fliller material in construction projects and building products. Unfortunately, the particles of the bottom ash are more brittle than the particles of nautral aggregates what limit their application for less loaded roads (4).

FGD material is the solid material resulting from the removal of sulfur dioxide gas from the utility boiler stack gases in the flue gas desulphurization process. The materials produced in the flue gas scrubbers by reacting slurried limestone or lime with the gaseous sulfur dioxide to produce calcium sulfate. FGD gypsum is 90-95 % pure calcium sulfate and has many uses: replacing natural gypsum, wallboard production, agricultural fertilizer, soil amendment, Portland cement production and so on.

Boiler slug is the molten inorganic material that is collected at the bottom of the boiler and is discharged into a water - filled pit where it is quenched and removed as a glassy particles resembling sand.

The major components of CCPs are: fly ash (58% mass.), than FGD material (24 % mass.), bottom ash (15,5% mass.) and finally boiler slug (2,5% mass.).

It is the fact that CCPs are not only abundant, they are not hazardous and are not considered to be waste material when used in beneficial applications (5, 6).

Unfortunately, to day in Serbia CCPs are the mostly disposed near the plants. Thermo power plant “Nikola Tesla”B do not yet have installed FGD system so the FGD material as the waste is not actual in this moment for us. The problem of the other two, the most abundant, wastes is very actuall. The largest quantities of them is possible to consume for road construction. So the aim of this work is to characterize fly and bottom ash from for application in road construction.

EXPERIMENTAL WORK

Physical characteristics of fly and bottom ash were determined by Yugoslav standards (7).

Particle size distribution was determined by sieving through sieves of Tylor series.

The compaction test was performed by standard Proctor method.

Chemical composition was determined by classical chemical analyze.

Mineralogical composition of the ashes was determined by X ray difractometar Philips PW 1710

RESULTS AND DISCUSSION

The values for the density and bulk density for fly and bottom ash is presented in Table 1.

Table 1. Density and bulk density of ashes

	Fly ash	Bottom ash
Density (g/cm^3)	2,088	1,967
Bulk density (g/cm^3)	0,797	0,5377

They shows the significant lover values of these characteristics for the bottom ash.
The results of sieving of fly and bottom ashes through sieves of Tyler series are presented in Fig 1 and Fig 2.

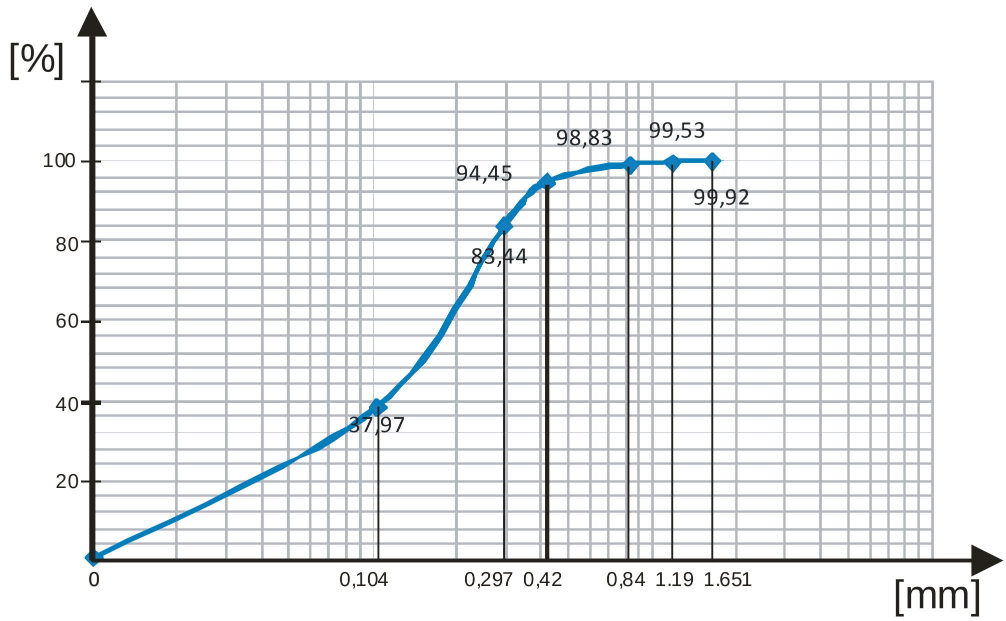

Fig 1. The result of sieving the fly ash

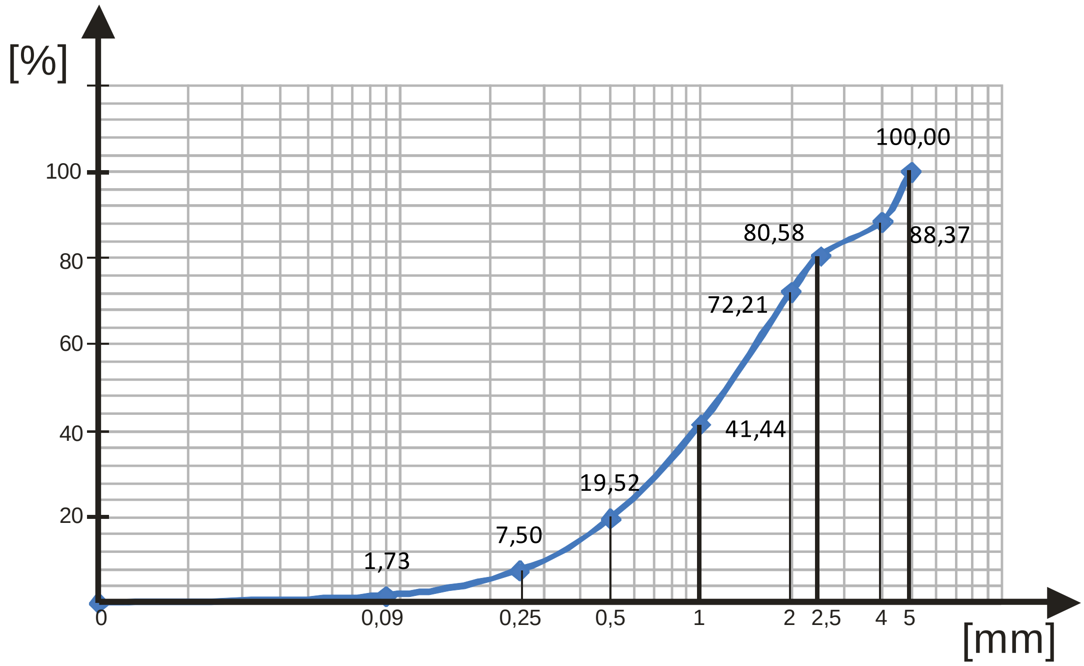

Fig 2. The result of sieving the bottom ash

They shows that the both ashes satisfies the recommendations given by ASTM specifications for the application of these ashes for road construction: 98,83% of particles finer than 0,42 mm (fly ash) and 100% smaller than 5mm (bottom ash).

The compaction test, with the aim to give the compactibility of these materials, were performed on the fly ash-water, bottom ash-water and and fly ash, bottom ash and water mixtures with different compositions. On the basis of them the plots of dry density with moisture content were drawn (Fig 3 and 4) for each ashe.

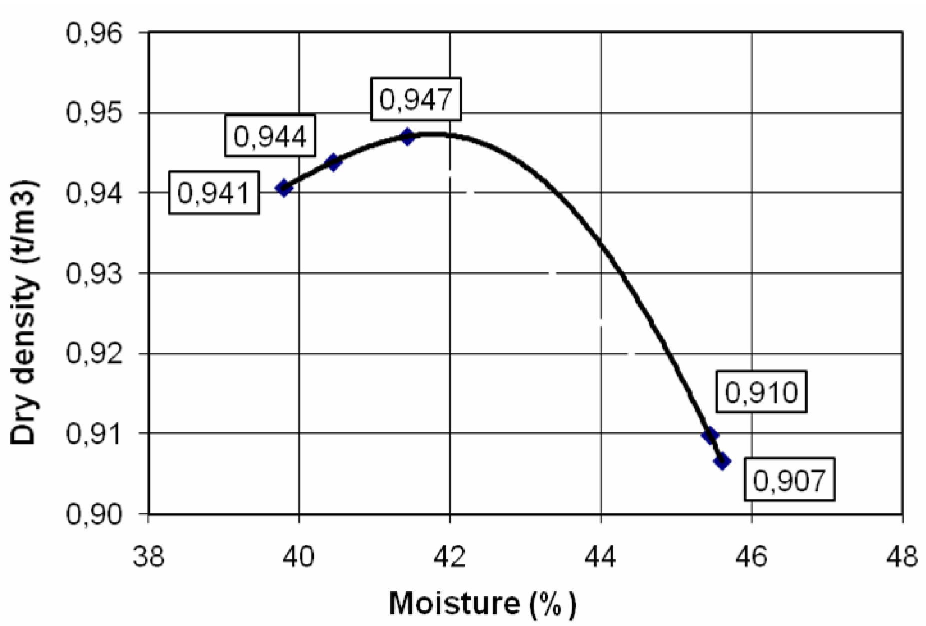

Fig 3. The plot of dry density and moisture for fly ash

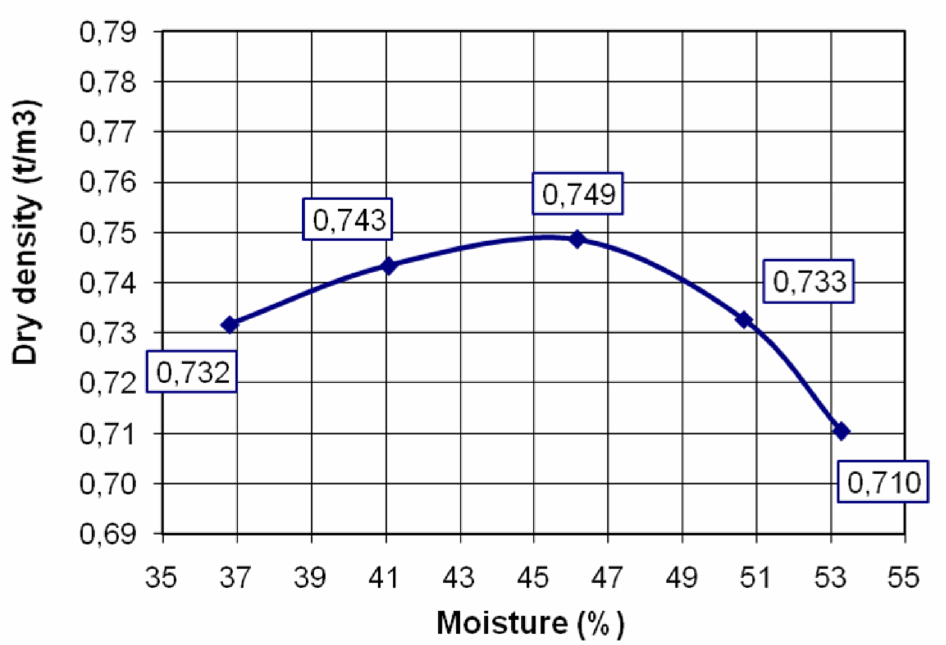

Fig 4. The plot of dry density and moisture for bottom ash

The dry density for fly ash has the higher value (0,947 t/m^3) than for the bottom ash (0,749 t/m^3) and their optimal moistures are 41,433 % and. 46,176 %. Obtained results for the mixtures of the both ashes determined that the highest dry density(0,848 t/m^3) has the mixture of fly and bottom ash with the composition of 50% of fly and 50% of bottom ashes.

The chemical composition of fly and bottom ash is presented in Table 2.

Table 2. Chemical composition of fly and bottom ash

Constituents	fy ash	bottom ash
SiO_2	52,25	42,09
Al_2O_3	22,34	14,72
Fe_2O_3	6,05	5,56
CaO	6,64	2,64

MgO	4,41	2,69
SO_3	2,74	1,98
P_2O_5	0,09	0,078
TiO_2	1,07	0,70
Na_2O	0,41	0,33
K_2O	1,36	0,90
L.O.I.	2,34	28,39

On the basis on it it can be concluded that this fly ash belongs to low calcium ashes (class F). It contains 80,64% of oxides (SiO_2+Al_2O_3+Fe_2O_3). It means that this ash satisfies the requirement for use as the pozzolan. The pozzolan reaction in this ash will take place in the presence of water and activator. Also the content of the other components in this ash satisfies the requirement for use as the pozzolan.

The chemical composition of the bottom ash shows significantly higher content of unburned coal X-ray diffraction investigation for fly ash was presented in Fig 4.

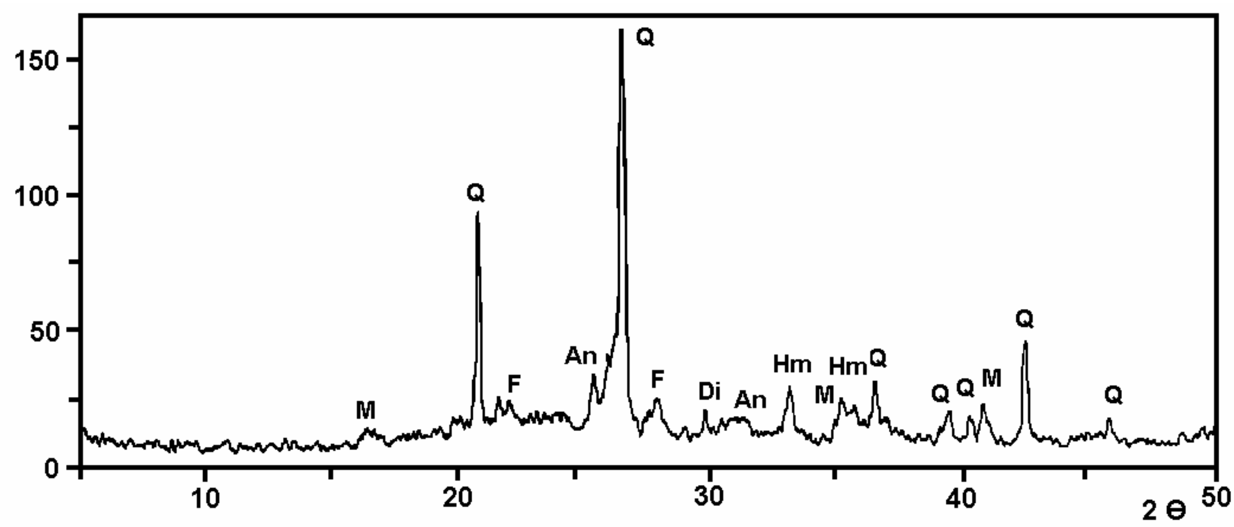

Fig 5. X-ray difractogram for fly ash: M-mullite, Q-quartz, F-feldspar, An-anhydrite, D-diopside, Hm-hematite

They shows that the dominant crystalline phase in fly ash is quartz (SiO_2). Also and the other crystalline phases, in smaller quantities, are present: mulite - $Al_2Si_2O_3$, feldspar - $NaAlSi_3O_8$, anhydrite - $CaSO_4$, diopsid - $CaMg(SiO_3)_2$ and hematite - Fe_2O_3.

In the bottom ash X-ray difractogram (Fig 6), the quartz is also the dominant crystalline phase, together with the calcite. Beside these compounds in a crystalline phase and the small amounts of anhydrite, diopside, feldspar and hematite are present.

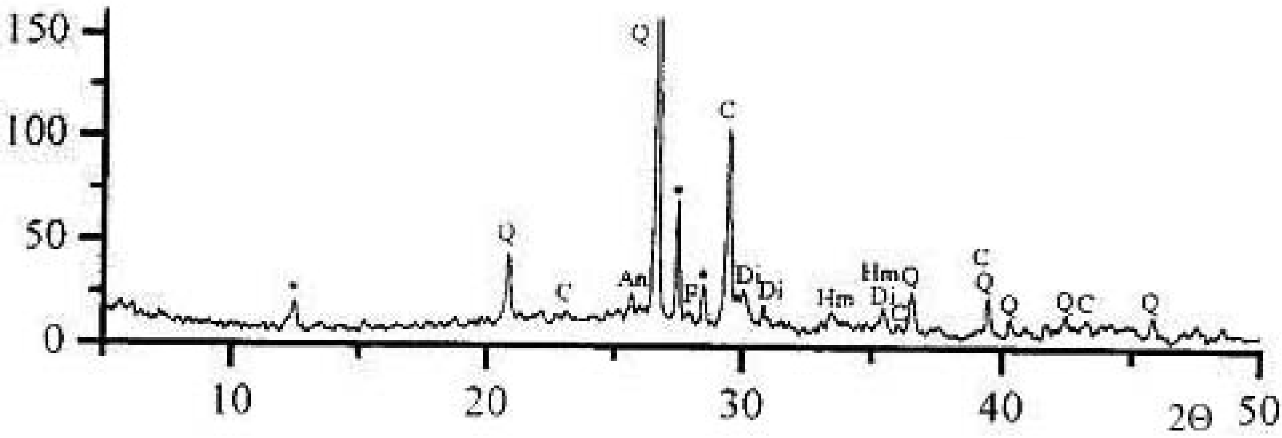

Fig 6. X-ray difractogram of bottom ash: Q-quartz, C-calcite, An-anhydrite, Di-diopside, F-feldspar and Hm-hematite

Beside crystalline phases the presence of amorphous phase, composed of alumosilicates is detected on the base on a broad hump in difractogram of the both ashes. On the basis of it, it was concluded, that the amount of amorphous alumosilicates in the bottom ash are smaller than in the fly ash. It means that the fly ash, with the higher quantity of reactive amorphous phase and the significantly finner particles, is more reactive than the bottom ash.

CONCLUSIONS

The result of investigation of the characteristics of fly and bottom ash from thermo power plant “Nikola Tesla” B (Obrenovac) Serbia are the next:

- fly ash satisfies the ASTM recommendation about particle size distribution for the application in mixtures for road base and sub base constructions. It contains 98,83% of particles finner than 0,42 mm;
- bottom ash also satisfies the ASTM recommendation about particle size distribution for the application as the aggregate in the road construction. It contain 100% of particles smaller than 5 mm;
- the mixture of fly and bottom ash with the highest dry density (0,848 t/m^3)has the composition of 50% of fly ash and 50% of bottom ash;
- fly ash posses appropriate pozzolonic activity. It contains 80,64 % of oxides what means that it can, in the presence of activator and moisture, be applied as the component in the mixture for road construction. Also it contains high quantity of reactive amorphous alumosilicates;
- bottom ash have the shortage for the application as the aggregate for road construction. It contains high lost of inignation and also high comtent of unburned coal carbon. The presence of light, soft and porous particles of unburned coal carbon in the bottom ash causes small densitiy, bulk and dry density. Solution of this problem can be in carbon elimination by standard methods.

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