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NEW TYPES OF COMPOSITE

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Abstract: *The polymer concrete properties are influenced by the components and also by the type of additions. The experimental studies realized on polymer concrete obtained of epoxy resin and aggregates have shown that components dosages, especially resin dosage, have an important contribution in obtaining high performance concretes. Different types of materials (waste, by-products, natural powders, etc.) can be introduced in the polymer concrete mixture for improving the properties or for obtaining new materials. The experimental results presented in the paper analyzed new composite polymers obtained by introducing in the mix different additions such as: silica fume, fly ash and tire powder. The resin dosage and addition quantity were maintained the same for all compositions (12.4% epoxy resin and 12.8% addition). The polymer concrete with fly ash shown good workability, a good microstructural compactity, the density of about 2,300kg/m^3 and the highest value of compressive strength.*
Keywords: *composite, polymer concrete, compressive strength, fly ash, silica fume*

1. INTRODUCTION

The construction material industry had developed in the last decades new materials on the base of different types of polymer. Polymer composites are competitive in the competition with cement concrete because they offer some advantages such as: great resistance to the chemical aggressions, fast hardening, good adhesion to other types of materials, high mechanical strengths, resistance to frost thaw cycles, etc. [1, 2, 3].
The use of polymer in concrete is a new possibility of obtaining construction performance materials [4. 5. 6], considering the strengths and/or durability properties. In the same time, as in the case of cement concrete, in the polymer concrete composition a lot of types of addition can be used, especially for improving the properties or just for consuming some wastes [7. 8, 9, 10].
Very large quantities of waste are produced in the world. The usual method of managing wastes is through their disposal in landfills. The most important wastes are: fly ash, silica fume, steel slag, tires etc. which occupy great area of land and in time they create a severe social and environmental problem [11, 12, 13]. In this situation, waste recycling alternatives are gaining increasing importance.
The purpose of the study was to analyze new types of polymer composite concretes obtained by introducing some additions in the mixture.

2. EXPERIMENTAL PROGRAM

The materials used were: epoxy resin and crushed aggregates of two grades 0-4 mm (Sort I) and 4-8 mm (Sort II). Epoxy resin used was type ROPOXID, made in Romania [14]. The hardener was type ROMANID 407 [14]. The epoxy resin in combination with the hardener forms the binder of the polymer concrete. A minimum resin content of 12.4% was adopted from the workability condition [15].
The additions used in the study was type powder, silica fume (SUF) and fly ash (FA) were used as they resulted as wastes. The powder of used tires was mechanically obtained firstly, by cutting the tires in small pieces, after that the steel insertions were eliminated and the cut pieces were transformed in balls and finally in powder.
For the study of polymer concrete properties all compositions were prepared with the same dosages of components: 12.4% epoxy resin, 12.8% filler, 37.4% sort I and 37.4% sort II. In the case of polymer concrete used as witness (PCW) the resin dosage was maintained at 12.4% and the aggregates were 43.8% for both sorts.

In function of additions the samples was named: PCS (with SUF), PCFA (with fly ash) and PCTP (with tire powder). The test samples (cubes of 70 mm sizes) for determining the compressive strength were poured according to Romanian standards [16].

3. RESULTS AND DISCUSSION

3.1. Additions characterization

The **SUF** is a by-product that results from ferrosilicon production having the following characteristics: Particle sizes of 0.01…0.5 µm; Shape of particles is spherical and angular, Figure 1

Specific surface is 130,000 m^2/kg; Density is 2.250 kg/m^3 [17]. For chemical analysis it was used the non-destructive method (EDX). Experimental results obtained for elementary composition are presented in Figure 1 and Table 1.

The principal elements contained by the SUF are: Si, O, Al, K, and Na. These elements appear in crystalline form, Figure 1.

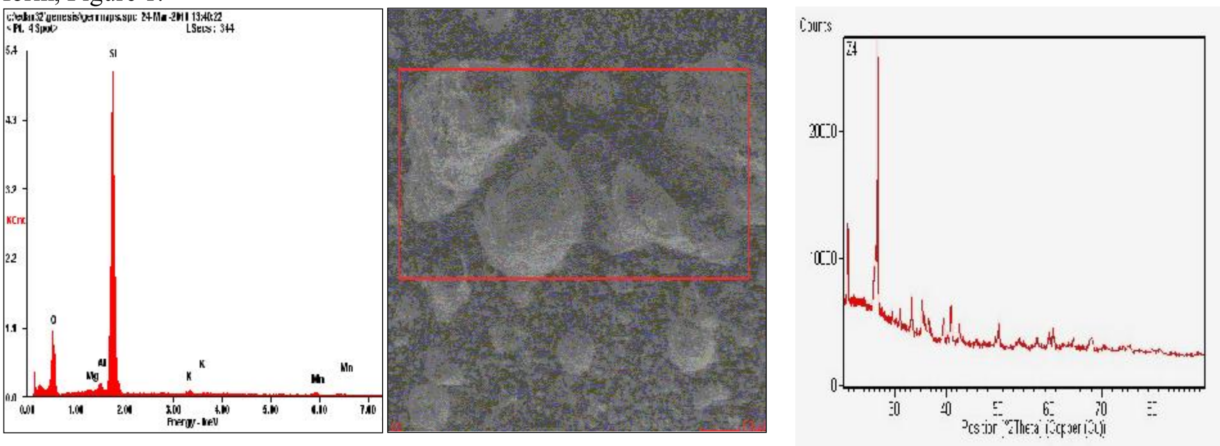

Figure 1: SEM, EDAX and XRD characterization of SUF

XRD as seen in Figure 2 shows that the SUF contains principal crystalline phase quartz and small quantities of kaolinite, mullite, muscovite and rutile.

Table 1: Chemical composition of additions

Element	SUF	Fly Ash
O	36.62	26.61
Mg	0.4	1.49
Al	1.64	17.54
Si	60.75	36.19
K	0.78	3.38
Ca	0.89	4.86
Fe	0.52	6.73

The **fly ash** is a by-product of power plants and it has particles with spherical shape and elementary composition contains [18]: Si, O, Al, Mg, C, K, Fe, and Ca (Figure 2 and Table 1).

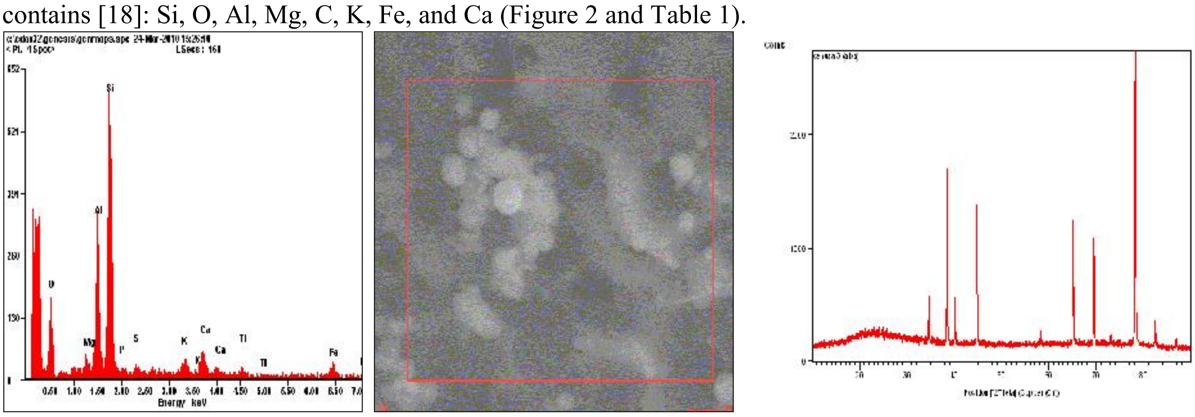

Figure 2: SEM, EDAX and XRD characterization of power plant ash

The elements from fly ash appear in crystalline form, XRD diagram is presented in Figure 2.
XRD as seen in Figure 2 shows that the ash contains crystalline phases: quartz, illite, kaolinite, mullite, hematite, muscovite, rutile and a glassy phase.
The SEM imagine for tire powder is presented in Figure 3.

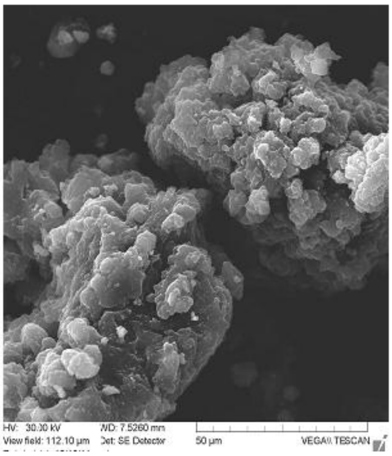

Figure 3: SEM of tire powder

3.2. Properties of polymer concretes

Workability of fresh concrete

The workability was one of the important conditions in preparing polymer concrete [19], because it imposed the maximum dosage of addition and the minimum dosage of resin (which is the most expensive component). Each type of polymer concrete was prepared with the same dosage of resin and addition.

- Polymer concrete with silica fume was a robust concrete, the silica fume made to decrease the workability.
- In the case of tire powder the workability of the concrete was the lowest in comparison with the other types of polymer concrete;
- The polymer concrete with fly ash had a good workability compared with the other compositions, approximately the same with that of the witness.

Density of polymer concretes was determined for each type of addition, Table 2

Table 2: Density of polymer concrete

Mixture	Density, kg/m^3	
	Fresh	Hardened
PCW	2086	2128
PCS	2255	2098
PCFA	2352	2120
PCTP	1692	1678

The experimental results obtained for density on polymer concrete with different types of additions are presented in Table 2. For comparison in the table are presented also the experimental results for polymer concrete without addition (PCW).

- The density of polymer concrete with tire powder indicated that this type of concrete is a lightweight composite;
- The highest density was obtained for polymer concrete with fly ash.

By introducing addition such as silica fume and fly ash the density of polymer concrete increase, compared with that of a polymer concrete without additions.

Microstructure of polymer composite concrete

For analyzing the microstructure of polymer concrete morphological [18, 19] studies were done. Scanning electron microscope (SEM) images were realized with Vega Tescan, for composite without filler the image is presented in Figure 4.

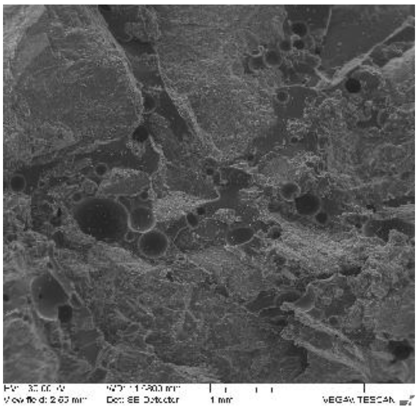

Figure 4: Polymer concrete with 12.4% epoxy resin (EP) and aggregates without filler

From the figures it can observe the microstructure of witness, Figure 4, the presence of voids and also microcracks to the interface between resin and aggregates. In the case of polymer concrete with silica fume, Figure 5, the number of voids is reduced, but a lot of resin sinterings are among aggregates.

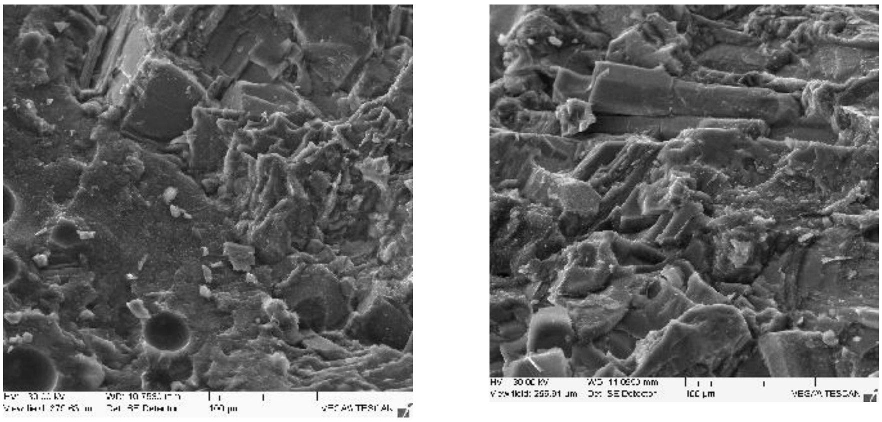

Figure 5: Polymer concrete with 12.4% epoxy resin (EP) and SUF

In the case of polymer concrete with fly ash, Figure 6 the presence of additions produced a more compact structure, also with small voids, but without resin sinterings.

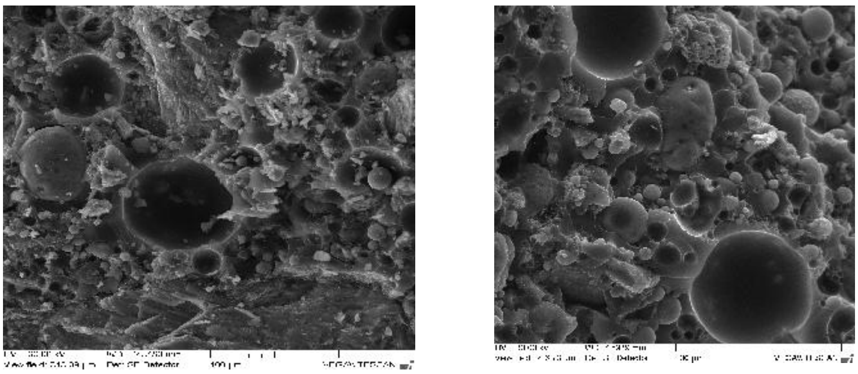

Figure 6: Polymeric concrete BPF2 with 12.8% fly ash and 12.4 % resin

In the case of polymer concrete with tire powder, Figure 7, it can observe that there are much more voids and microcracks.

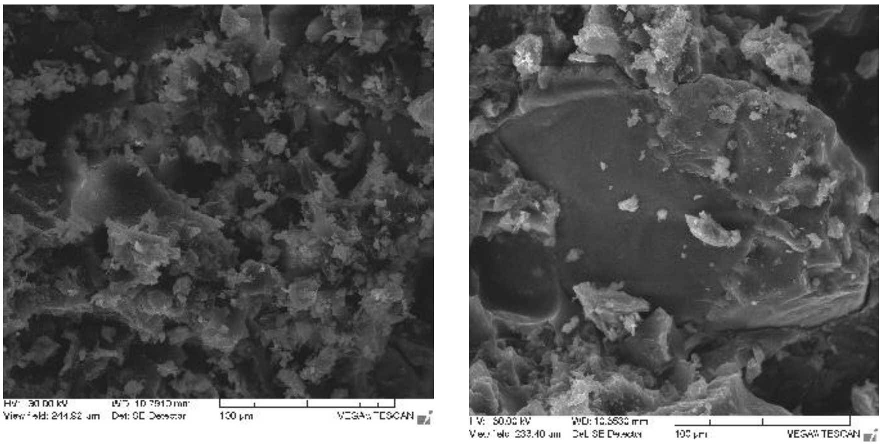

Figure 7: Polymer concrete with tire powder

Compressive strength

The experimental results, presented in Figure 8 have shown that the polymer concrete with fly ash presented the highest value, 69. 82 MPa, very closed to that of the witness, 69.92 MPa. The smallest value was obtained for PCTP, of about 25.75 MPa (with about 60% smaller than the strength of witness). In the case of polymer concrete with silica fume the compressive strength was only with 10% smaller than the strength of the witness [20, 21, 22].

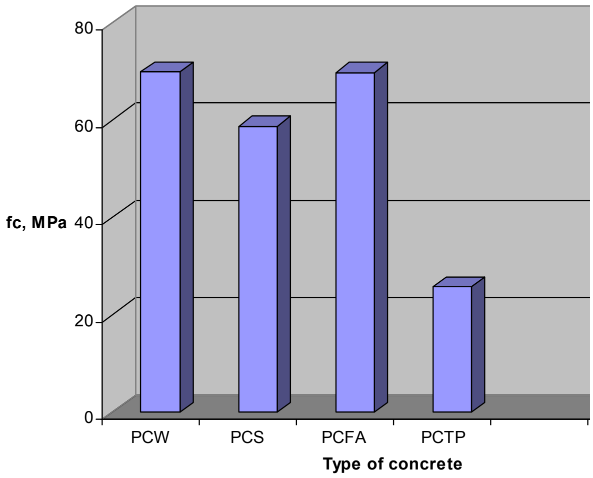

Figure 8: Compressive strength of polymer concrete

3. CONCLUSION

In the paper are presented new composite polymer concretes obtained with different additions such as silica fume, fly ash and tire powder. The purpose was to study the influence of additions type on physical-mechanical characteristics of polymer concrete. A good workability is obtained if in the polymer concrete is introduced fly ash. In the case of tire powder the polymer concrete is very robust, compared with all other types of polymer concretes. The densities have shown that by introducing the additions the densities increase in the case of silica fume and fly ash and it decreases in the case of tire powder. The microstructure of analyzed polymer concretes had shown a more compact structure in the case of addition of fly ash.

The compressive strength was near the value of the witness in the case of addition type fly ash, with about 10% smaller in the case of silica fume and lower in the case of tire powder (with about 60%).

In conclusion, even these additions are not improving the characteristics of fresh concrete and the compressive strength, it is possible that they can improve other mechanical or durability properties, which were not studied yet. Also, the use of these wastes as components in the composition of composite polymer concrete contributes to the superior capitalization, on the one hand, and on the other hand storage pollution is reduced.

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