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Characterization of Polymer Concrete with Different Wastes Additions

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Abstract

A lot of types of wastes pollute today the environment and occupy great soil surfaces. One way for consuming wastes is to obtain green materials. Polymer concrete is a new advanced composite material which is used in construction industry due to its superior properties in comparison with ordinary Portland cement concrete such as: higher mechanical strengths and chemical resistance.

The paper characterizes the polymer concrete obtained by adding different types of wastes, such as: argillaceous powder, calcareous powder, marble powder and fly ash to a witness mix obtained by mixing epoxy resin and aggregates in two sorts (0-4 mm and 4-8 mm). The microstructure of polymer concrete was analyzed by electronic scanning. The mechanical properties (compressive strength, flexural strength and split tensile strength) were experimentally determined. The calcareous and fly ash addition in polymer concrete mix improved the mechanical properties. The argillaceous powder addition decreased the values of mechanical strengths in comparison with the witness.

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Keywords: epoxy resin; wastes; compressive strength; flexural strength; split strength.

1. Introduction

Significant amounts of different types of wastes are disposed worldwide and they are polluting the environmental. For their elimination, a lot of studies and technologies were elaborated especially for using them as resources for different industries. In building materials industry there are used different types of wastes for obtaining new materials, for improving the mechanical and durability characteristics of ordinary materials, for obtaining

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materials with specific properties, etc. By using the silica fume, slag, fly ash or ferrochromium, new materials such as high strength or high performance concretes are prepared [1,2,3,4], or if they are used as filler, the wastes can improve the properties of polymer concrete [5, 6, 7,8]. Silica fume and fly ash can be used for entire replacement of cement in geopolymer concrete [9,10], or as partial replacement of cement for obtaining green concrete [11].Wastes like tire powder, PETs fiber are used as replacement of aggregates in mortars or concretes or as fine additions in cement concrete [12,13,14]. Other types of wastes, for example mineral powder of marble, or calcareous or rocks are used for replacing different sorts of natural aggregates or for obtaining concrete bricks [15, 16].

The paper presents the experimental researches on polymer concrete obtained with different wastes used as powder additions: argillaceous, calcareous, marble and fly ash. The mechanical properties are analyzed in order to determine the use domain of each new concrete.

2. Experimental program

2.1. Materials

For preparing polymer concrete as binder is used a polymeric material, i.e. thermoset resin which binds the aggregates. In the experimental program was used an epoxy resin type ROPOXID produced in Romania by Policolor SA Bucuresti which was combined with hardener type ROMAMID 700, from the same producer. The aggregates were in two sorts: sort I (0-4 mm) and sort II (4-8 mm) from river gravel.

Near the witness (BP), which was prepared with 12.4% epoxy resin and the two sorts in equal dosages of 43.8% , the additions type argillaceous (BPA and BPNA), calcareous (BPCa), marble (BPM) and fly ash (BPFA) were added in the mix in a dosage of 12.8%, by reducing the aggregates dosage to 37.4 % for each sort. The aggregates and the filler were mixed together, after that the epoxy resin with hardener were combined with dry components. All mixes of fresh concrete had a good workability. For each mix the test samples were poured: cubes of 70 mm sizes and prisms of 210x70x70 mm sizes for determining mechanical characteristics such as: compressive strength (f_c), flexural strength (f_{ti}) and split tensile strength (f_{td}). The mechanical tests were done according to Romanian standards [17-19] after 14 days.

The mixes for polymer concrete with additions were established from the condition of using the lowest quantity of epoxy resin, but enough for a good concrete workability, Table 1.

Table 1. Composition and density of polymer concrete with additions.

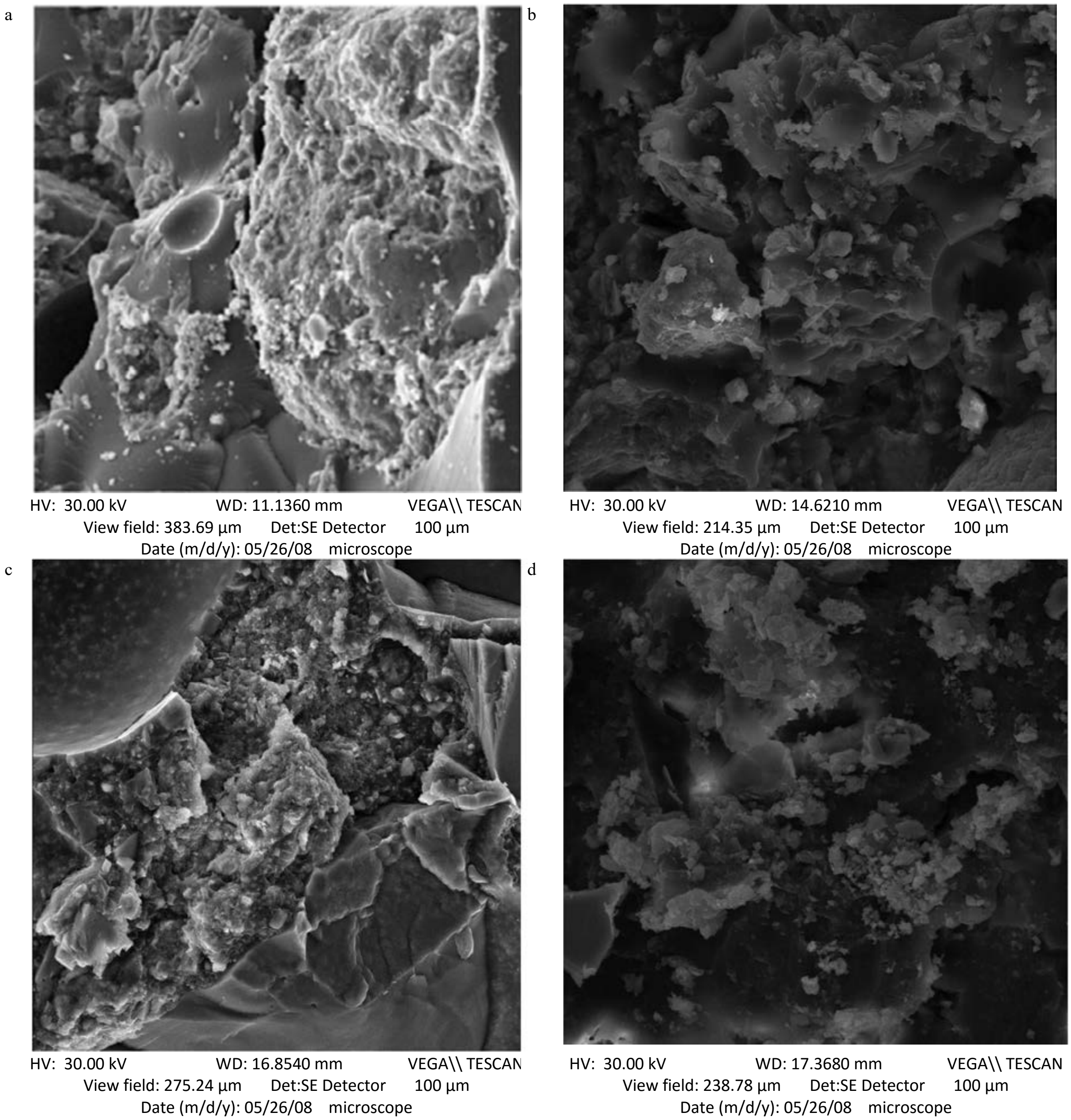
Mixes	Epoxy resin Dosage (%)	Addition Powder (%)	Sort I (%)	Sort II (%)	Density of hardened concrete (kg/m^3)
Witness BP	12.4	-	43.8	43.8	1876.0
BPA	12.4	12.8	37.4	37.4	2062.3
BPNA	12.4	12.8	37.4	37.4	2257.4
BPCa	12.4	12.8	37.4	37.4	2062.3
BPM	12.4	12.8	37.4	37.4	2104.1
BPFA	12.4	12.8	37.4	37.4	2120.1

3. Results and discussions

The results of experimental tests on hardened polymer concrete with additions are given in Table 2. The densities of hardened epoxy polymer concrete with additions are given in Table 1. All mixes with additions powder had densities bigger than witness and bigger than 2000 Kg/m^3.

3.1. Microstructure of Polymer Concrete

Scanning electron microscope (SEM) Vega Tescan analysis running at 30 kV and selenium detectors were used to study the polymer concrete morphology. An Ag sputter coating was applied on the surface of the specimens to provide greater depth of image. Fig. 2 shows the surface of polymer concrete made with different additions at a magnification of 100 times. In the case of witness (a), calcareous powder (c) and fly ash (e), the resin is homogeneous. In the case of argillaceous (b) and marble powder (d) the addition is not homogeneous forming particles agglomerations which are not coated with resin.



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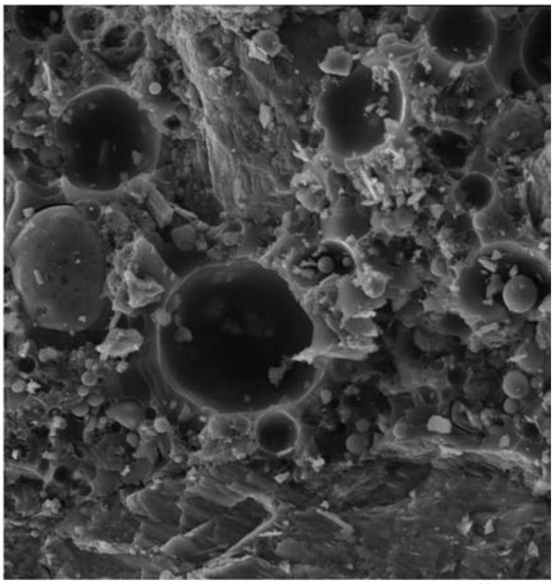

Fig. 1. Scanning electronic microscopy for polymer concrete samples with epoxy resin: a) witness; b) argillaceous powder addition; c) calcareous powder addition; d) marble powder addition; e) fly ash addition

3.2. Mechanical properties

The experimental results for all polymer concretes are given in Table 2 and are graphically represented in Fig. 2.

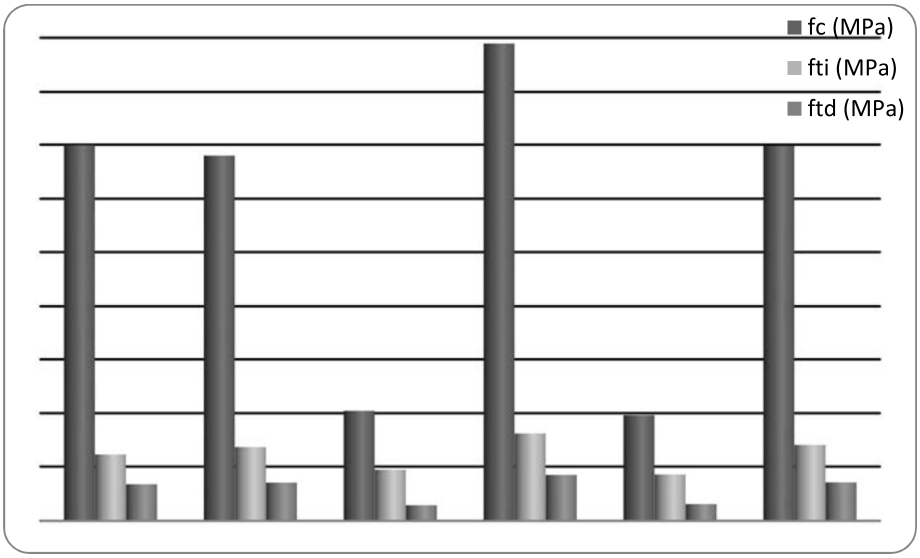

Fig. 2. Variation of mechanical strengths of polymer concrete with addition powders

Table 2. Experimental tests results of polymer concrete with additions powders.

Polymer concrete	fc (MPa)	fti (MPa)	ftd MPa
Witness BP	69.92	12.26	6.82
BPA	67.96	13.64	7.14
BPNA	20.45	9.42	2.92
BPCa	88.93	16.16	8.46
BPM	19.63	8.52	3.13
BPFA	69.82	14.03	7.18

3.2.1. Compressive strength

Analyzing the experimental results in the case of compressive strength it can observe the followings:

- The highest value of compressive strength 88.93 MPa was obtained for mix BPCa, higher than that of the witness and the minimum value of compressive strength 19.63 MPa was obtained for BPM.
- The compressive strengths for the other types of additions were smaller than that of witness, very closed to the witness were the values of BPA and BPFA.
- In the case of nano-argillaceous addition (dmax<0.40 mm) the value of compressive strength was smaller than that of polymer concrete with ordinary argillaceous powder.

3.2.2. Flexural strength

Analyzing the experimental results in the case of flexural strength it can observe the followings:

- The highest value of flexural strength of 16.16 MPa was obtained for mix BPCa, higher than that of the witness and the minimum value of compressive strength 8.52 MPa was obtained for BPM.
- The flexural strengths for BPA and BPFA were bigger than that of witness, and the values for BPNA and BPM were smaller than witness.
- In the case of nano-argillaceous addition (dmax<0.40 mm) the value of flexural strength was smaller than that of polymer concrete with ordinary argillaceous powder.

3.2.3. Split tensile strength

Analyzing the experimental results in the case of split tensile strength it can observe the followings:

- The highest value of split tensile strength 8.46 MPa was obtained for mix BPCa, higher than that of the witness and the minimum value of split tensile strength 2.92 MPa was obtained for BPNA.
- The split tensile strengths for the other types of additions were smaller than that of witness, very closed to the witness were the values of BPA and BPFA.
- In the case of nano-argillaceous addition (d_{max}<0.40 mm) the value of split tensile strength was smaller than that of polymer concrete with ordinary argillaceous powder.

4. Conclusions

Polymer concrete was obtained from epoxy resin with two sorts of aggregate 0-4 mm and 4-8 mm and different waste powders as addition (filler). From the experimental tests it resulted that polymer concrete had higher values of all mechanical strengths, bigger than that of witness only in the case of calcareous powder. In the case of argillaceous, nano-argilaceous and marble powder the compressive strength is smaller than that of witness. In the case of flexural strength and split tensile strength the calcareous, argillaceous and fly ash additions increased the strengths in comparison with that of witness.

The powder wastes used in polymer concrete produce a composite material with reduced content of resin. The study showed which additions improved the mechanical characteristics. The durability characteristics must also be studied to find the proper use of polymer concrete with waste additions. The use of wastes in concrete is favourable for the environment and also new materials with improved properties can be obtained.

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