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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

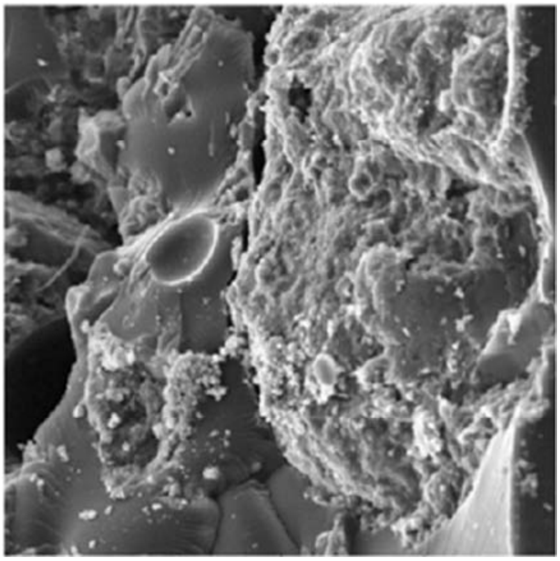
3. Results and discussions

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

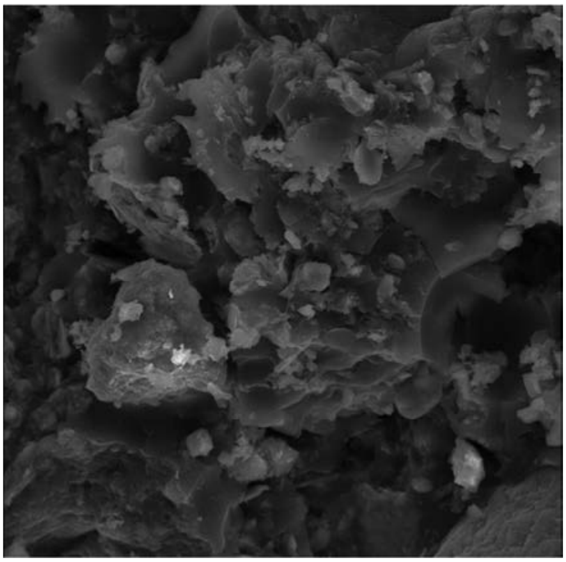
Scanning electron microscope (SEM) Vega Tescan analysis running at 30 kV and selenium detectors were used to study the polymer concrete morphology. An Ag sputter coating was applied on the surface of the specimens to provide greater depth of image. Fig. 2 shows the surface of polymer concrete made with 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.

a



HV: 30.00 kV WD: 11.1360 mm VEGA\\ TESCAN
View field: 383.69 µm Det:SE Detector 100 µm
Date (m/d/y): 05/26/08 microscope

b



HV: 30.00 kV WD: 14.6210 mm VEGA\\ TESCAN
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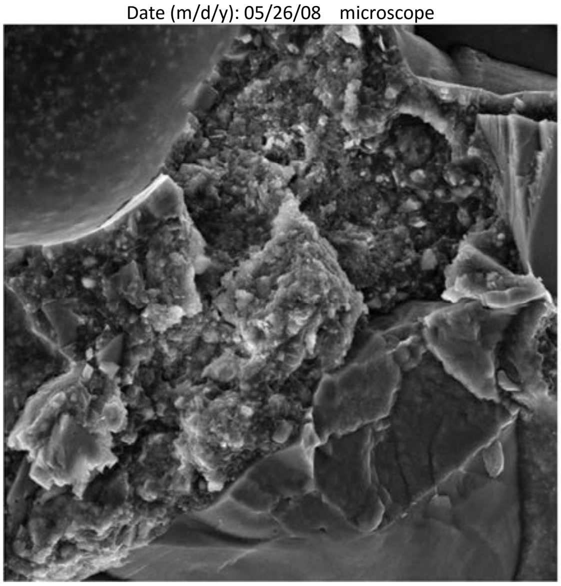
Date (m/d/y): 05/26/08 microscope

c



HV: 30.00 kV WD: 16.8540 mm VEGA\\ TESCAN
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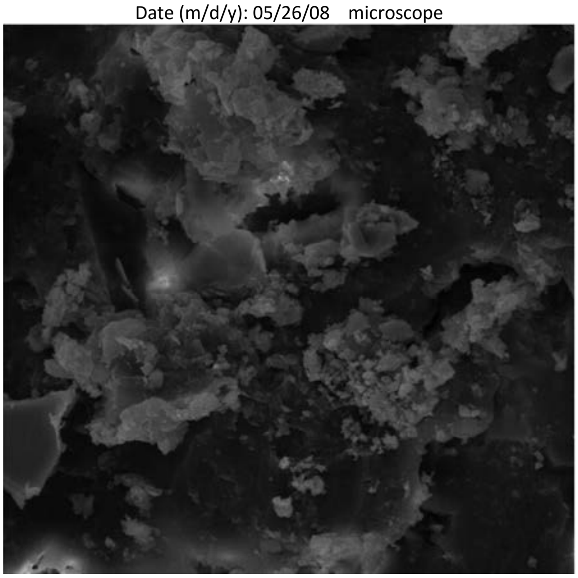
Date (m/d/y): 05/26/08 microscope

d



HV: 30.00 kV WD: 17.3680 mm VEGA\\ TESCAN
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Date (m/d/y): 05/26/08 microscope

e

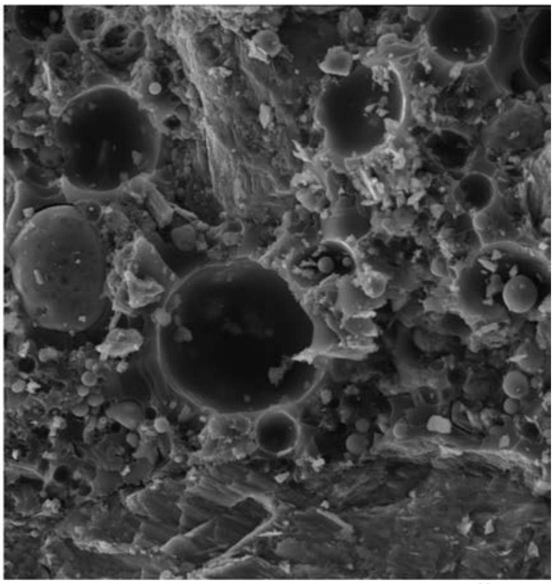

Fig. 1. Scanning electronic microscopy for polymer concrete samples with epoxy resin: a) witness; b) argillaceous powder addition; c) calcareous powder addition; d) marble powder addition; e) fly ash addition

3.2. Mechanical properties

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

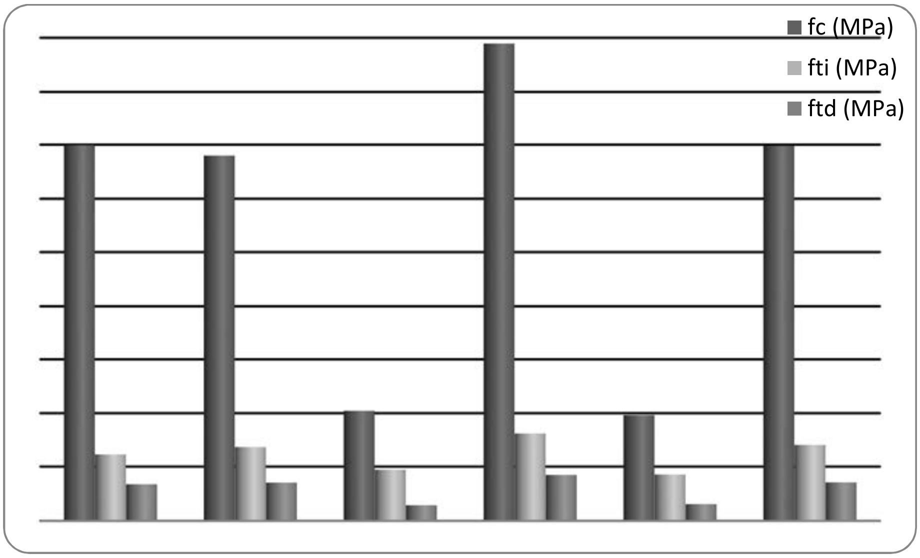

Fig. 2. Variation of mechanical strengths of polymer concrete with addition powders

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.

References

[1] Hunchate SR, Chandupalle S, Ghorpode VG, Reddy TCV. Mix Design of High Performance Concrete Using Silica Fume and Superplasticizer, International Journal of Innovative Research in Science, Engineering and Technology Vol. 3, Issue 3, March, 10735-10743,2014.

[2] Bharatkumar BH, Raghuprasad BK, Ramachandramurthy DS, Narayanan R, Gopalakrishnan S. Effect of fly ash and slag on the fracture characteristics of high performance concrete, Materials and Structures, January–February, Volume 38, Issue 1, pp 63-72,2005

[3] Kayali O. Fly ash lightweight aggregates in high performance concrete Constr Build Mater, vol. 22, 2393-2399, 2008.

[4] Parmar A, Patel DM. Experimental Study on High Performance Concrete by Using Alccofine and Fly Ash - Hard Concrete Properties International Journal of Engineering Research & TechnologyVol.2 - Issue 12,3363-3366,2013

[5] Gencel O, Koksal F, Ozel C, Brostow W. Combined effect of fly ash and waste ferrochromium on properties of concrete, Constr Build Mater., vol. 29, 633-640, 2012.

[6] Nadeem M, Pofale AD. Utilization of Industrial Waste Slag as Aggregate in Concrete Applications by Adopting Taguchi’s Approach for Optimization, Open Journal of Civil Engineering, 2, 96-105,2012

[7] Barbuta M, Diaconescu RM, Harja M. Using Neural Networks for Prediction of Properties of Polymer Concrete with Fly Ash. J Mater Civil Eng, vol. 24/issue 5, 2012.

[8] Lokuge W, Aravinthan T. Effect of fly ash on the behaviour of polymer concrete with different types of resin, Materials & DesignVolume 51, 175–181, 2013.

[9] Joseph B, Mathew G. Influence of aggregate content on the behavior of fly ash based geopolymer concrete Scientia Iranica Volume 19, Issue 5, 1188–1194, 2012.

[10] Abdullah MMAB, Hussin K, Bnhussain M, Ismail KN, Yahya Z, Razak RA. Fly Ash-based Geopolymer Lightweight Concrete Using Foaming Agent Int J Mol Sci. 13(6): 7186–7198, 2012;

[11] Magureanu C, Negrutiu C. Performance of concrete containing high volume coal fly ash - green concrete. In Wit Press, Ashurst Lodge Southampton SO40 7AA, Ashurst, England, editor. Proceedings 4th Int Conf on Computation Methods and Experiments in Mater Charact, vol. 64, 373-379, 2009.

[12] Benazzouk A, Douzane O, Mezreb K, Laidoudi B, Queneudec M. Thermal conductivity of cement composites containing rubber waste particles: Experimental study and modelling. Constr Build Mater vol. 22/issue 4, 573-579, 2008.

[13] Pacheco-Torgal F,Ding Y, Jalali S. Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): An overview Constr. Build. Mater., 30, 714-724, 2012

[14] Barbuta M, Harja M, Ciobanu G. Mechanical properties of polymer concrete containing tire waste powder Journal of Food, Agricultural and Environment, Volume 12, Issue 1, 1185-1190, 2014

[15] Barbuta M, Lepădatu D, Nicuta AM, Judele L, Mitroi R. Caracterization of polymer concrete with calcareous powder, 14TH International multidisciplinary scientific geoconference SGEM 2014, Nano, Bio, and green technologies for a sustainable future, vol. II, ISBN 978-619-7105-21-6, ISSN 1314-2704, DOI:10.5593/sgem 2014B62, 57-64,2014

[16] Rania A. Hamza, Salah El-Haggar, and Safwan Khedr Marble and Granite Waste: Characterization and Utilization in Concrete Bricks International Journal of Bioscience, Biochemistry and Bioinformatics, Vol. 1, No. 4,286-291, 2011

[17] Romanian Standard Association, SR EN 12390-3:2005, Testing hardened concrete. Part 3: Compressive strength of test specimens, 2011.

[18] Romanian Standard Association, SR EN 12390-5:2005 - Testing hardened concrete. Part 5: Flexural strength of test specimens, 2009.

[19] Romanian Standard Association, SR EN 12390-6:2010, Testing hardened concrete. Part 6: Split tensile strength of test specimens, 2005.