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INVESTIGATION OF THE EFFECTS OF FLY ASH ON MECHANICAL PROPRIETIES OF POLYMER CONCRETE

BY

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Abstract. Polymer concrete with epoxy resin, fly ash and river aggregate has been prepared in the study. All components had varied dosages in the mix. Fly ash was used as filler in different dosages (from 6.4 to 25%). The resin dosage was between 12.4% and 23%. Aggregates varied between 30% and 43%. The mechanical properties such as: compressive strength, flexural strength and split tensile strength were determined. The dosages of components influenced the mechanical properties. A high epoxy resin dosage improved the compressive strength. The increase of fly ash dosage generally improved all mechanical properties, but the results were related to the dosages of epoxy resin and aggregates. The maximum values of mechanical strength were obtained for a medium fly ash dosage, but in strong relation with epoxy resin dosage.

Keywords: fly ash; polymer concrete; epoxy resin; mechanical strength.

1. Introduction

Polymer concrete is an important composite in the building material industry because it shows increased strength and durability compared to

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conventional materials. In different domain such as precast production or application of coatings or repair, polymer concrete is more advantageous than traditional concrete (Heidari-Rarani *et al*., 2014; Elalaoui *et al*., 2012; Mutukumar & Mohan, 2005; Aggarwal *et al*., 2007).

Polymer concrete is produced by using fine and coarse aggregates and natural or synthetic polymers. Polymer concrete contains no cement or water. The performances of polymeric concrete depend on the polymer properties, type of filler and aggregates, reinforcing fiber type, curing temperature, components dosage, etc., (Garbacz & Sokolovska, 2013; Reis & Ferreira, 2005). It can be prepared of a lot types of components: raw materials or by-products. Different type of fine materials can be used such as: fly ash, silica fume, phosphogyps, cinder, etc. that can improve the properties of polymer concrete (Golestaneh *et al*., 2010; Agavriloaia *et al*., 2012; Bărbuță *et al*., 2016, Bărbuță *et al*., 2014; Bedi *et al*., 2013).

In the article the experimental results of studies on polymer concrete with different dosages of components are presented. The influence of epoxy resin and fly ash amount on mechanical characteristics such as compressive strength, flexural strength and split tensile strength was investigated.

2. Experimental Program

2.1. Materials

In the study the polymer concrete was prepared by using the following materials: epoxy resin, fly ash as filler, and two sorts of river aggregates.

The epoxy resin, called ROPOXID is a thermoplastic resin and the hardener was type ROMANID 407, both are produced by POLICOLOR S.A. Bucureşti (Bărbuță *et al*., 2016).

The fly ash (FA) from the power plant CET Holboca Iasi was used in addition to fine aggregates (Bărbuță & Lepădatu, 2008). The fly ash is an inorganic waste resulted from burning pulverized coal in electric power stations and consists of many small spherical particles with sizes from 0.01 to 100 μm.

The principal properties of FA are: colour gray to black function of carbon unburned, specific surface is between 4,800,...,5,200 m^2/kg, the density is between 2400 and 2550 kg/m^3, with components such as Si, C, Al, etc. (Bărbuță & Lepădatu, 2008; Bărbuță *et al*., 2018).

The aggregates were used in two sorts: sort I: 0,...,4 mm and sort II: 4-8 mm, with continuous granulosity. Type the second section of your paper in here. Use as much space as necessary.

2.2. Experimental Samples

For analyzing the influence of filler dosage on the polymer concrete properties ten mixes (M) were prepared in the experimental program, Table 1.

Table 1
Polymer concrete mixes, (%)

Mixtures	Epoxy resin	flyash	Aggregate sort I	Aggregate sort II
M1	12.4	6.4	43.8	37.4
M2	12.4	9.6	40.6	37.4
M3	12.4	12.8	37.4	37.4
M4	15.0	25.0	30.0	30.0
M5	15.0	21.0	40.6	37.4
M6	16.0	18.0	31.0	35.0
M7	17.0	19.0	32.0	32.0
M8	19.0	21.0	30.0	30.0
M9	20.0	18.0	31.0	31.0
M10	23.0	17.0	30.0	30.0

The polymer concrete mixtures were prepared by mixing firstly the dry components: sand, gravel and fly ash. The resin was combined with hardener, then was poured in the dry mix. A mechanical mixer was used for obtaining a homogeneous mix.

For experimental tests the following samples were poured: cubes of 70 mm sizes and prisms of 210 × 70 × 70 mm sizes. The samples were kept for 14 days in laboratory conditions according to Romanian standard (SR EN 12390-1: 2011).

The mechanical characteristics experimentally determined were: compressive strength (f_c), on cube sample, flexural strength (f_{ti}) and split tensile strength (f_{td}) on prismatic samples according to standard prescriptions (SR EN 12390-3: 2011; SR EN 12390-5:2005; SR EN 12390-4:2010).

3. Results and Discussions

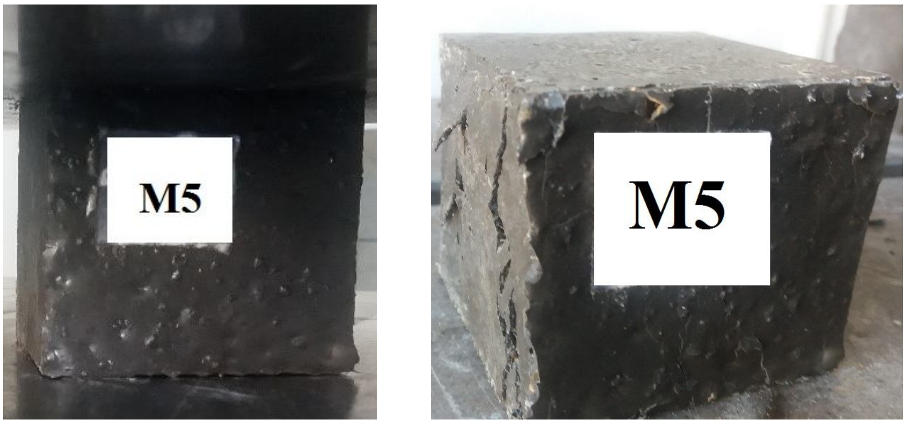
In Table 2 are presented the results obtained from experimental tests.

Table 2
Mechanical Characteristics of Polymer Concrete

Mixture	f_c (MPa)	f_{ti} (MPa)	f_{td} (MPa)
M1	57.96	16.67	5.77
M2	64.89	16.85	7.15
M3	69.82	14.03	7.18
M4	80.19	21.13	6.46
M5	86.37	19.25	9.44
M6	75.6	20.03	7.55
M7	75.87	18.49	8.59
M8	74.68	18.02	8.38
M9	80.3	15.17	7.59
M10	80.19	12.60	6.40

3.1. Compressive Strength

In Fig. 1 the test and the failure in compression are presented:



a *b*

Fig. 1 – Compressive strength test.

From the experimental tests the following observations resulted:

• The maximum values of compressive strengths were obtained for mix M5 a fly ash dosage of 21%, Fig. 2.

• The minimum value of compressive strength was obtained for mix M1 with a fly ash dosage of 6.4%. From M1 to M5 the compressive strength increased with the increase of the fly ash dosage, Fig. 2.

For mixes M6 to M8 a decrease of compressive strength is observed (also the fly ash dosage was reduced) and for the last mixes, M9 and M10 an increase of compressive strength was obtained, Fig. 2.

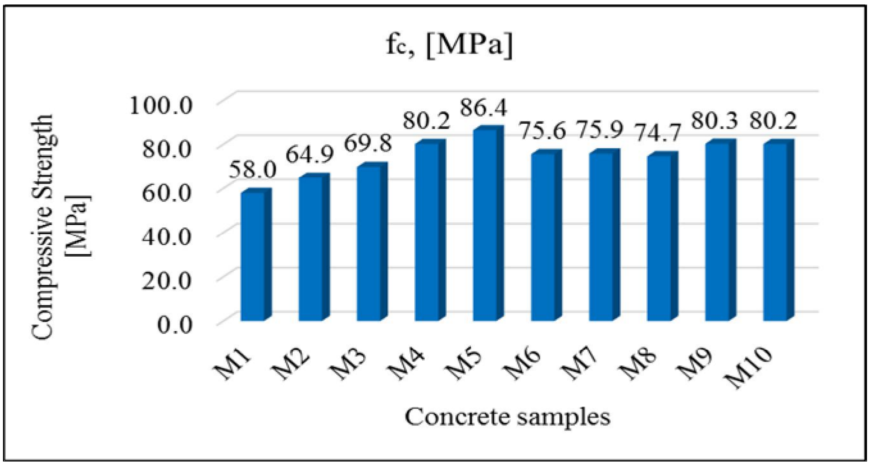


Fig. 2 – Variation of compressive strength of polymer concrete.

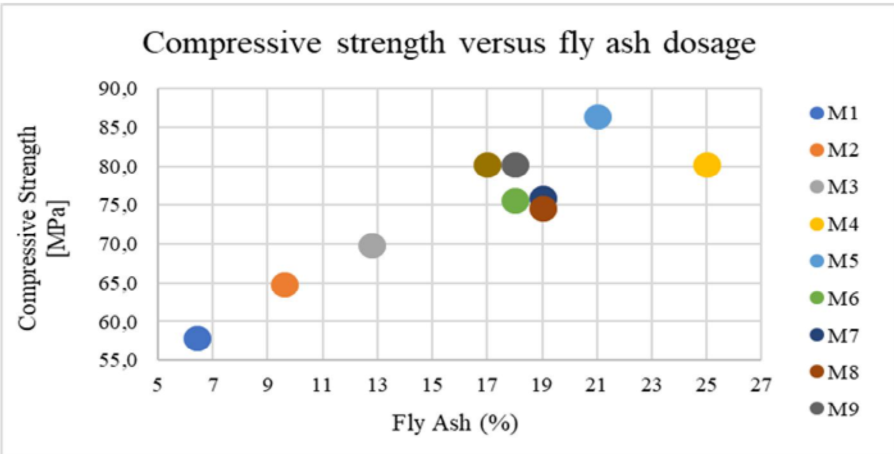


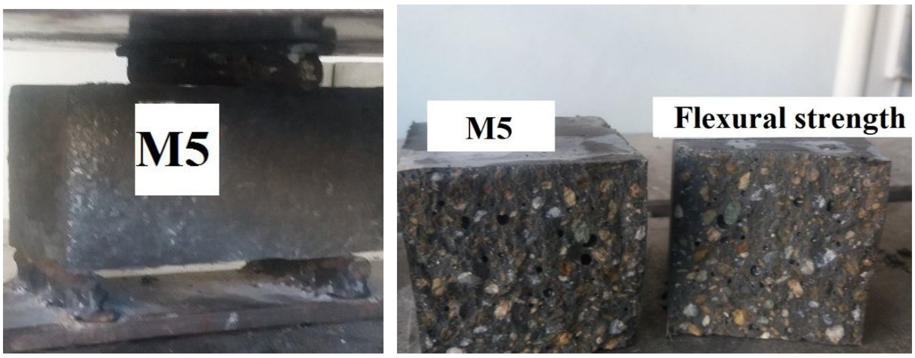
Fig. 3 –Compressive strength versus fly ash dosage.

• The fly ash improved the compressive strength until a dosage of 21%, after that the compressive strength had not increased, Fig. 3.

• High dosages of fly ash near high dosages of resin improve the compressive strength. High amounts of filler maintain a good compressive strength of polymer concrete.

3.2. Flexural Strength

In Fig. 4 the test of determining the flexural strength and the failure surfaces are presented



a

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Fig. 4 – Flexural strength test.

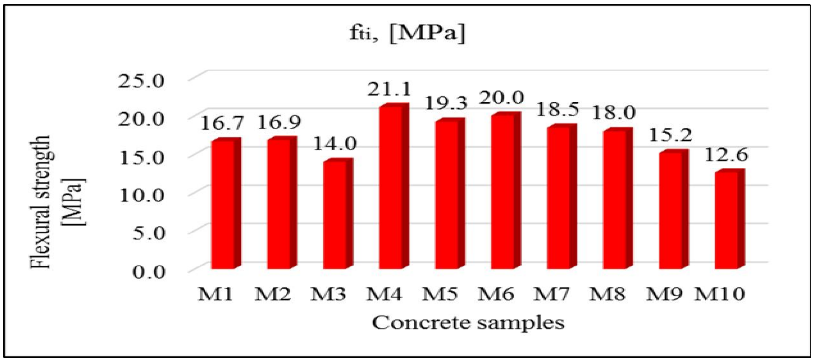


Fig. 5 – Variation of flexural strength of polymer concrete.

• The maximum value of flexural strength was obtained for mix M4 with a fly ash dosage of 25%, Fig. 5.

• The minimum value of flexural strength was obtained for mix M3 with a fly ash dosage of 12.8%, Fig. 5.

• The fly ash improved the compressive strength with the increase of the dosage, Fig. 6.

The high content of fly ash near a high dosage of epoxy resin improve the flexural strength.

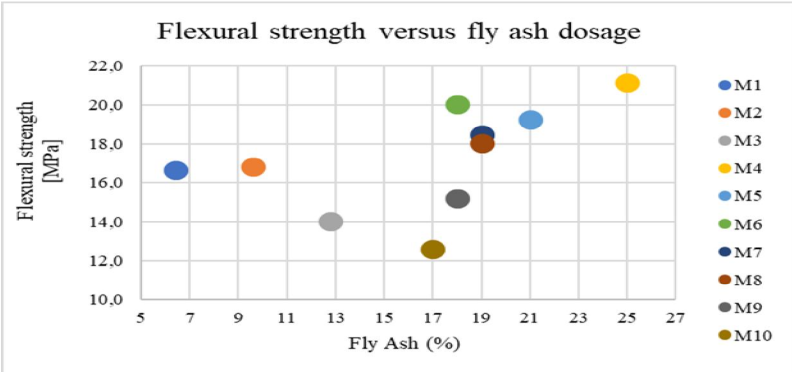
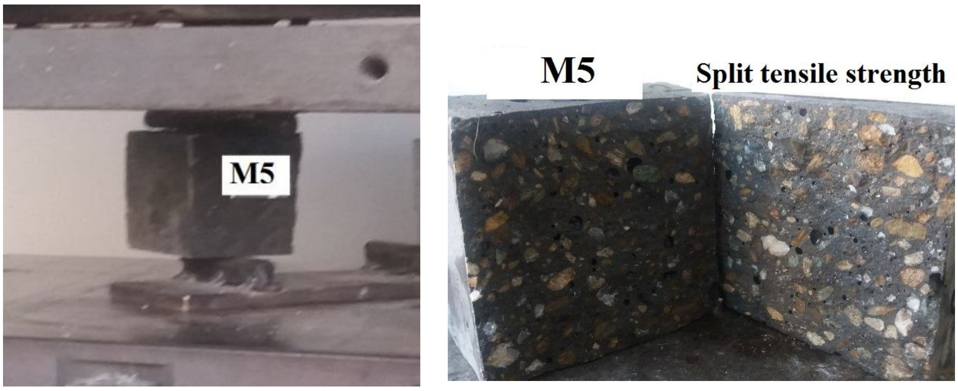


Fig. 6 – Flexural strength versus fly ash dosage.

3.3. Split Tensile Strength

In Fig. 7 the split tensile test and the failure surfaces are presented.



a *b*

Fig. 7 – Split tensile strength test.

The maximum value of split tensile strength was obtained for the mix M5 with a fly ash dosage of 21%, Fig. 8.

• The minimum value of split tensile strength was obtained for mix M1 with a fly ash dosage of 6.4%.

• The high content of fly ash related to high content of epoxy resin increased the split tensile strength, Fig. 9.

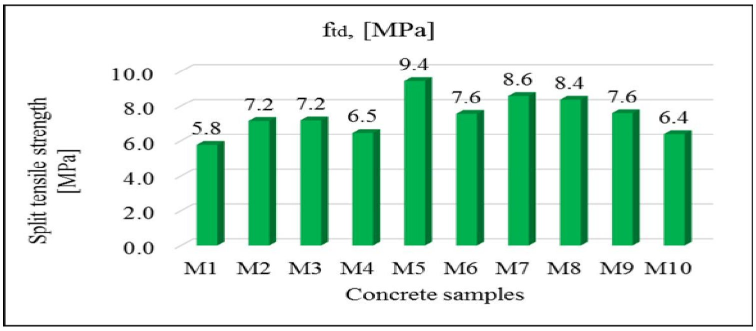


Fig. 8 – Variation of split tensile strength of polymer concrete.

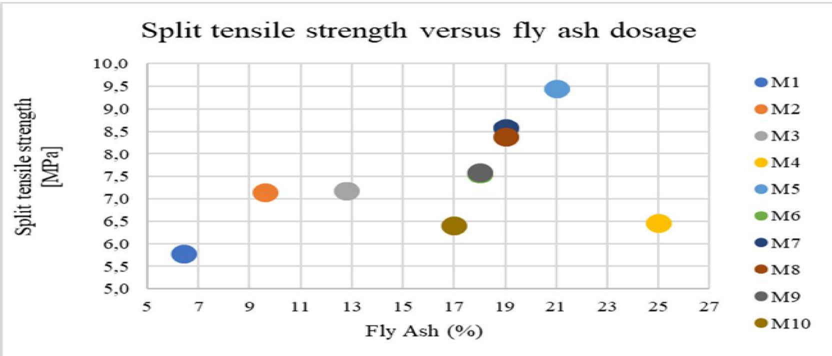


Fig. 9 – Split tensile strength versus fly ash dosage.

In Fig. 10 the relation between f_c and f_{ti} is represented. The values of f_{ti} are not directly proportional to f_c. For small values of f_c the ratio f_c/f_{ti} is between 3.5,...5 and for high values of f_c the ratio f_c/f_{ti} varied between 3.8 and 6.5. All components influenced variation of f_{ti}.

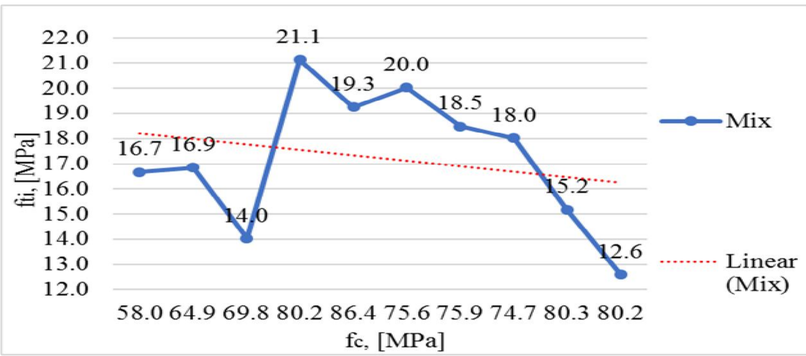


Fig. 10 – Relation between $f_c - f_{ti}$.

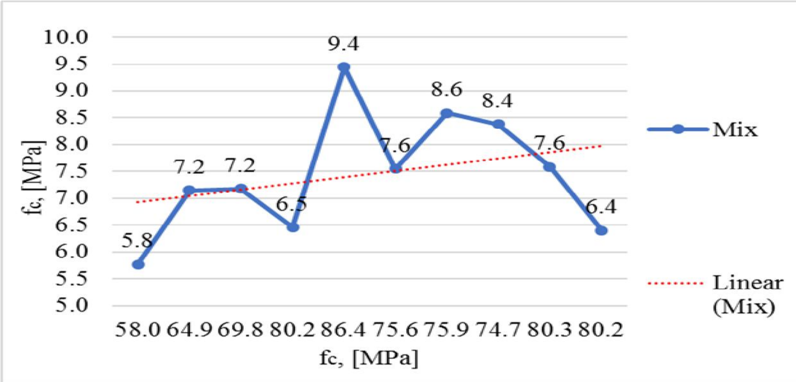


Fig. 11 – Relation between $f_c - f_{td}$.

The highest values of compressive strength and split tensile strength were obtained for mix M5 that had a medium content of epoxy resin, a high dosage of fly ash and aggregate sort 0,...,4 mm. The highest value of flexural strength was obtained for mix M4, that has a medium content of epoxy resin, the highest dosage of fly ash and the minimum dosage of aggregates.

The values of all mechanical strengths were influenced by the variation of components dosage. Fly ash clearly improved the mechanical strengths. An increase in epoxy resin dosage improved the compressive strength.

4. Conclusions

The experimental researches on polymer concrete had investigated the mechanical characteristics of epoxy polymer concrete prepared with different dosages of epoxy resin, fly ash and aggregates. The mechanical properties were influenced by the dosage of epoxy resin and fly ash. A high epoxy resin dosage improved the compressive strength. The increase of fly ash dosage improved all mechanical properties, but the results were related to the dosages of epoxy resin and aggregates.

REFERENCES

Agavriloaia L., Oprea Şt., Bărbuță M., Luca C., *Characterization of Polymer Concrete with Epoxy Polyurethane Acryl Matrix*, Constr. Build. Mater., 2012; 12:190-196.

Bărbuță M., Harja M., Ciobanu G., *Mechanical Properties of Polymer Concrete Containing Tire Waste Powder*, J. Food Agr. Env, **12**, *2*, 1186-1190 (2014).

Bărbuță M., Lepădatu D., *Mechanical Characteristics Investigation of Polymer Concrete using Mixture Design of Experiments and Response Surface Method*, Journal of Applied Science, **8**, 2242-2249 (2008).
Bărbuță M., Rujanu M., Nicuta A., *Characterrization of Polymer Concrete with Different Wastes Additions*, Procedia Technology, **22**, 407-412 (2016).
Bărbuță M., Timu A., Bejan L., Bucur R. D., *Mechanical Properties of Fly Ash Polymer Concrete with Different Fibers*, Rev. Rom. Mat. Plast., 2018.
Bedi R., Chandra R., Singh S. P., *Mechanical Properties of Polymer Concrete*, Journal of Composites, **2013**, Article ID 948745, 12, 2013, doi:10.1155/2013/948745.
Elalaoui O., Ghorbel E., Mignot V., Ben Ouezdou M., *Mechanical and Physical Properties of Epoxy Polymer Concrete After Exposure to Temperatures Up to 250 C*, Constr. Build. Mater., 2012; 27:415-24.
Garbacz A., Sokolovska, J.J., *Concrete Like Polymer Composite with Fly Ash-Comparative Study*, Construction and Building Materials 2013; 38: 689-699.
Golestaneh M., Amini G., Najafpour D., Beygi M.A., *Evaluation of Mechanical Strength of Epoxy Polymer Concrete with Silica Powder as Filler*, World Appl Sci. J., **9**, 216-220 (2010).
Heidari-Rarani M., Aliha M.R.M., Shokrieh M.M., Ayatollahi M.R., *Mechanical Durability of an Optimized Polymer Concrete under Various Thermal Cyclic Loadings – An Experimental Study*, Construction and Building Materials, **64**, 308-315 (2014).
Mutukumar M., Mohan D., *Studies on Furan Polymer Concrete*, Journal of Polymer Research, **12**, 231-241 (2005).
Reis J.M.L., Ferreira A.J.M., *Effect of Marine Exposure on Fracture Properties of Epoxy Concretes*, Polym Test, 2005; 24(1):121-5.
* * * *Testing hardened concrete, Part 5: Flexural strength of test specimens 2009*, SR EN 12390-5:2005, Romanian Standard Association, Bucharest, Romania.
* * * *Testing hardened concrete. Part 1: Shape, dimensions and other requirements for specimens and moulds*, SR EN 12390-1: 2011, Romanian Standard Association, Bucharest, Romania.
* * * *Testing hardened concrete. Part 3: Compressive strength of test specimens*, SR EN 12390-3: 2011, Romanian Standard Association, Bucharest, Romania.
* * * *Testing hardened concrete. Part 7: Split tensile strength of test specimens*, SR EN 12390-4:2010, Romanian Standard Association, Bucharest, Romania.

CARACTERISTICI MECANICE ALE BETOANELOR DE ÎNALTĂ REZISTENȚĂ CU DEȘEURI

(Rezumat)

În cadrul studiului a fost preparat beton polimeric din rășină epoxidică, cenușă de termocentrală și agregate de râu. Toți componenții au avut dozaje variabile. Cenușa de termocentrală a fost utilizată ca filer, în dozaje cuprinse între 6,4% și 25%. Dozajul de răşină a variat între 12,4% şi 23%. Agregatele au variat între 30% şi 43%. Au fost determinate următoarele proprietăți mecanice: rezistența la compresiune, rezistența la întindere prin încovoiere şi rezistența la întindere prin despicare. Dozajele componenților au influențat proprietățile mecanice. Un dozaj ridicat de răşină epoxidică a îmbunătățit rezistența la compresiune. În general, creşterea dozajului de cenuşă de termocentrală a îmbunătățit toate proprietățile mecanice, dar rezultatele sunt influențate şi de dozajele de răşină epoxidică şi agregate. Valorile maxime ale rezistențelor mecanice au fost obținute pentru un dozaj mediu de cenuşă de termocentrală, dar în strânsă relație cu dozajul de răşină epoxidică.