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# EXPERIMENTAL STUDY ON THE CHARACTERISTICS OF POLYMER CONCRETE WITH EPOXY RESIN

BY

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**Abstract.** In the paper are presented the results of some experimental researches concerning polymer mortars and concretes realized of epoxy resin, silica fume and crushed aggregates. The mechanical characteristics of hardened concrete were determined. The silica fume content varied between 6.5% and 30% to polymer mortar and 6.4% and 9.6% to polymer concrete.

The obtained results show maximum characteristics for a dosage of 24% resin and maximum dosage of silica fume to the polymer mortar, and for the polymer concrete the mechanical characteristics are influenced by all mixture factors: the compressive strength increases with the increase of silica fume dosage, and the flexure strength and split strength increase with the decreasing of silica fume dosage.

**Key words:** epoxy resin, silica fume, polymer mortar, polymer concrete.

## 1. Introduction

In the constructions industry new building materials with improved properties are required for satisfying the new utilization domains for modern construction or for repair works. The application of polymer on concrete has significantly progressed in the last 30 years. Polymers are either incorporated in a cement-aggregate mix or used as single binder. The composites made by using polymer along with cement and aggregates are called *polymer-modified mortar* or *polymer-modified concrete*, while composites made with polymer and aggregates are called *polymer mortar* or *polymer concrete*, depending on the maximum size of aggregate granule [1].

In the composition of polymer concrete there is not cement: the aggregates are bonded by the resin. Function of the type of polymer it can obtain concretes with synthetic resin, concretes with plastic resin or simple concrete with resin [2]. The composite does not contain hydrated cement paste.

Polymer concrete presents some advantages compared to the cement Portland concrete such as: rapid hardening, high mechanical strengths, improved resistance to chemical attack, durability, etc. [3] [4]. One of the most

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important disadvantages is the high cost of resin that limited the use domains of polymer concrete.

The performances of polymeric concrete depend on the polymer properties, type of filler and aggregates, curing temperature, components dosage, etc. The aggregates can be silicates, quartz, crushed stone, gravel, limestone, calcareous, granite, clay, etc. Near the aggregate, the filler is very important. Different types of fine materials can be used such as fly ash, silica fume, phosphor-gypsum, cinder, etc. [5], [6].

In this paper, the experimental results made for polymer concrete are presented. The properties of polymer mortar and polymer concrete were studied.

## 2. Experiment

### 2.1. Materials

For the experimental researches of polymer mortar and concrete properties, the following materials were used: polymer, silica fume (SUF) as filler and crushed aggregates.

The polymer was type epoxy resin, called ROPOXID, made in Romania by POLICOLOR, Bucureşti [7]. The hardener was type ROMANID 407, also made by POLICOLOR, Bucureşti [7].

The filler was type silica fume and was added to the composition without replacing the fine part of aggregate. The principal characteristics of SUF are: gray color, particles sizes between 0.01…0.03 and 0.3...0.5 μm; the shape of particles is spherical, specific surface is between 13,000 and 23,000 $m^2/kg$, the density is between 2,100 and 2,250 $kg/m^3$ [8].

The aggregates were used in two sorts: 0…4 mm and 4…8 mm, with continuous granulosity, obtained from crushed river gravel by S.C. EMBERON SRL, Iaşi.

### 2.1. Experimental Samples

Two types of compositions were studied in the experimental program:

a) *Type I* (noted MP) - polymer mortar (or micro-concrete), for which the maximum size of aggregate was 4 mm,

b) *Type II* (noted BPS) - polymer concrete for which the maximum size of aggregate was 8 mm.

There were studied six mixtures for concrete type I and seven mixtures for concrete type II. The mixtures are given in Table 1.

For mixtures type MP with one sort of aggregate 0…4 mm the polymer was reduced from maximum 58.87% (composition MP1) to a minimum of 24.2% (composition MP5). The aggregate percentage varied from minimum 29.4% to maximum 59.8%.

Table 1 – Composition of Polymer Concrete, [%]

| Types | Resin | SUF | Aggregate, sort I | Aggregate, sort II |
|---|---|---|---|---|
| MP1 | 58.8 | 11.8 | 29.4 | - |
| MP2 | 40 | 30 | 30.0 | - |
| MP3 | 34.8 | 6.5 | 58.7 | - |
| MP4 | 44.5 | 6.6 | 48.9 | - |
| MP5 | 24.2 | 17.5 | 58.3 | - |
| MP6 | 25.6 | 14.6 | 59.8 | - |
| BPS1 | 18.8 | 6.4 | 37.4 | 37.4 |
| BPS2 | 12.4 | 6.4 | 43.8 | 37.4 |
| BPS3 | 15.6 | 9.6 | 37.4 | 37.4 |
| BPS4 | 15.6 | 6.4 | 40.6 | 37.4 |
| BPS5 | 16.4 | 7.2 | 38.2 | 38.2 |
| BPS6 | 13.2 | 7.2 | 41.4 | 38.2 |
| BPS7 | 14.0 | 8.0 | 39.0 | 39.0 |


Fig. 1. – Samples of polymer concrete

For mixtures type BPS with two sorts of aggregates 0…4 mm and 4…8 mm the polymer was reduced from maximum 18.8% (composition BPS1) to a minimum of 12.4% (composition BPS2). The aggregate percentage varied from minimum 37.4% to maximum 43.8%.

For all MP and BPS compositions types, the mechanical characteristics were experimentally determined: compressive strength on cube samples of 70.7 mm sizes, flexural strength and split tensile strength on prismatic samples of sizes 210×70×70 mm, (Fig. 1) according to standard prescriptions [9].

## 3. Results and Discussions

The following mechanical characteristics of polymer mortar and polymer concrete were experimentally determined: compressive strength ($f_c$), flexural strength ($f_{ti}$) and split tensile strength ($f_{td}$). The results are given in Table 2.

Table 2 – Mechanical Characteristics of Experimental Composition

| Composition | $f_c$, [Mpa] | $f_{ti}$, [Mpa] | $f_{td}$, [MPa] |
|---|---|---|---|
| MP1 | 63.2 | 10.6 | 8.78 |
| MP2 | 62.1 | 9.32 | 5.80 |
| MP3 | 45.3 | 11.4 | 5.20 |
| MP4 | 50.4 | 9.96 | 4.72 |
| MP5 | 69.1 | 12.7 | 12.1 |
| MP6 | 51.1 | 10.3 | 4.90 |
| BPS1 | 59.2 | 15.9 | 6.76 |
| BPS2 | 59.6 | 16.8 | 7.67 |
| BPS3 | 64.1 | 15.8 | 7.62 |
| BPS4 | 58.6 | 17.6 | 6.27 |
| BPS5 | 58.8 | 15.6 | 7.28 |
| BPS6 | 65.3 | 14.8 | 7.02 |
| BPS7 | 57.8 | 14.9 | 6.49 |

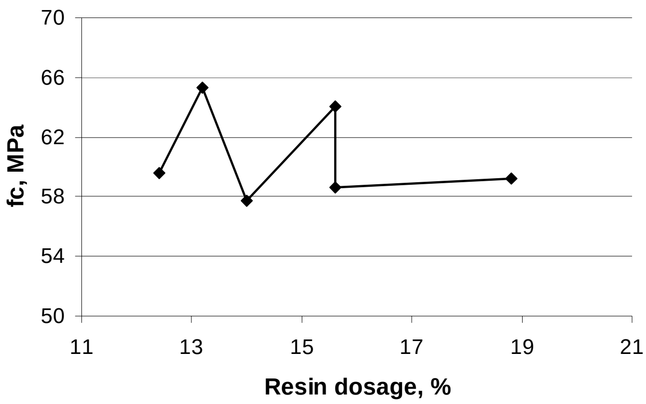


Fig. 2. – Variation of the compressive strength for BPS

The experimental results concerning polymer concrete lead to the following conclusions:

a) The values of compressive strengths for mortar MP vary between 51.1 MPa (for MP6) and 69.1 MPa (for MP5) that means: until 25.1% resin dosage the compressive strength decreases and up to this value, compressive strength increases. Mortar MP5 (with 24% polymer) shows the biggest values for all mechanical strengths.

b) The values of compressive strengths for concrete BPS (Fig. 2) vary between 65.32 MPa (for BPS6) and 57.75 MPa (for BPS7); in this case it cannot specify how much the resin dosage or silica fume dosage influence the compressive strength;

c) The values of flexure strengths for mortar MP vary between 12.7 MPa (for MP5) and 9.32 MPa(for MP2) that signifies a value of about 24% resin to increase the flexure strength;

d) The values of flexure strengths for concrete BPS (Fig. 3) vary between 17.57 MPa (for BPS4) and 14.81 MPa (for BPS6), so, the decrease of resin dosage results in the increase of flexure strength;

e) The values of split tensile strengths for mortar MP vary between 12.1 MPa (for MP5) and MPa (for MP4), that signifies a value of about 24% resin to increase the split tensile strength, but for this mechanical characteristic the values are varying from a percentage to the other;

f) The values of split tensile strengths for concrete BPS (Fig. 4) vary between 7.67 MPa (for MP5) and 4.72 N/mm$^2$ (for MP4) so, the decrease of resin dosage results in the increase of split tensile strength.

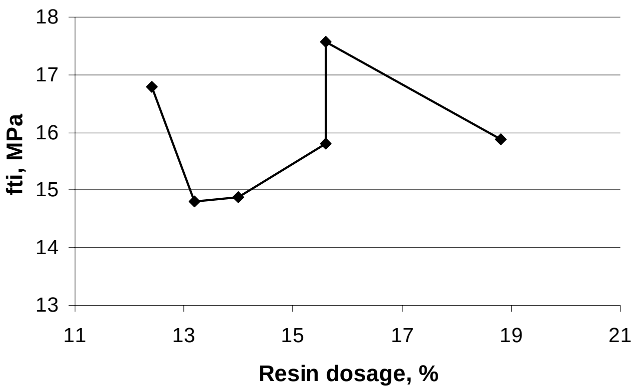


Fig. 3. – Variation of flexural strength for BPS

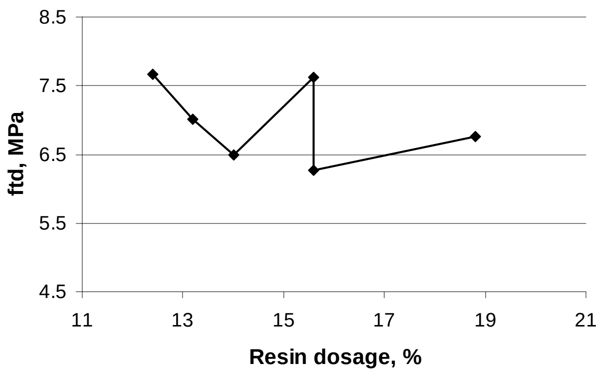


Fig. 4. – Variation of split tensile strength for BPS

The compressive strengths and split tensile strengths resulted bigger in the case of mortar MP (with aggregate sort 0…4 mm and SUF dosage between 6.5% and 30%); the flexure strengths resulted with bigger values in the case of BPS (with aggregates of two sorts, 0…4 mm and 4…8 mm, and SUF dosage between 6.4% and 9.6%).

The experimental researches showed the following:

a) The use of one sort of aggregate (0…4 mm) results in high values of compressive strengths for a resin dosage of about 24%,

b) The use of two sorts of aggregates (0…4 mm and 4…8 mm) results in smaller values of compressive strengths compared to polymer mortar, but the flexure strengths are bigger,

c) Epoxy resin was used as binder, the principal objective being the reduction of its dosage for obtaining an optimum cost.

d) Silica fume had improved the mechanical characteristics of the polymer concrete.

The high values of mechanical strengths obtained from experimental researches showed that the polymer concretes are concretes of high strength.

## 4. Conclusions

The experimental researches concerning the polymer concrete had as principal objectives the decreasing the epoxy resin dosage and improving the mechanical characteristics by using the silica fume as fine filler.

The polymer mortar obtained showed good mechanical properties that are necessary for repair works. The high silica fume dosage in the mortar improved the strengths and reduced the cost of the composite.

The values for mechanical strengths showed that polymer concrete with silica fume is a high strength concrete. This concrete can be used for realizing the rehabilitation of structures by coating or for realizing structural elements such as beams, columns, foundation beams, etc.

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## STUDIU EXPERIMENTAL PRIVIND CARACTERISTICILE BETOANELOR POLIMERICE CU RĂŞINĂ EPOXIDICĂ

(Rezumat)

Se prezintă rezultatele unor studii experimentale efectuate pe mortare şi betoane polimerice obținute din răşină epoxidică, silice ultrafină şi agregate concasate. Au fost studiate proprietăților mecanice ale betonului întărit. Conținutul de silice ultrafină a variat, la mortarele polimerice, între 6,5% şi 30%, iar la betoanele polimerice, între 6,4% şi 9,6%. Rezultatele indică caracteristici maxime la mortarele polimerice pentru un dozaj de 24% răşină epoxidică şi dozaj maxim de silice ultrafină (17%), iar la betoanele polimerice caracteristicile mecanice sunt influențate de toți factorii de compoziție; rezistențele la compresiune cresc cu creşterea dozajului de silice ultrafină iar rezistențele la întindere din încovoiere şi prin despicare cresc cu scăderea dozajului de silice ultrafină.