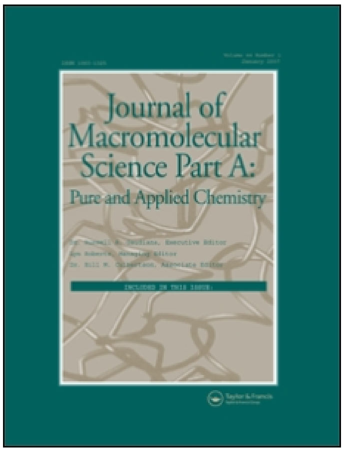

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Investigations of New Lightweight Polymer Composites

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Investigations of New Lightweight Polymer Composites

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ABSTRACT

Two new lightweight polymerized composites derived from perlite or fly ash were investigated. The properties of these materials were found to be superior to those of conventional concrete. These materials may find use in sculptural and architectural work where superfine and noncracking properties are required.

INTRODUCTION

Polymer composites with enhanced properties have been under active investigation since the pioneering work of Kukacka and coworkers at Brookhaven National Laboratory in the late sixties and early seventies [1-6]. In an earlier study, several waste materials were employed for making polymer composites [7-9]. The mechanical properties of some of these materials were found to be better than control concrete. In this investigation, as a part of an ongoing research program, the results on two new lightweight polymerized composites containing either fly ash or perlite are reported. The materials are discussed in relation to their unit weight, strength, and finishability. Sculptural and architectural applications of these materials are indicated.

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EXPERIMENTAL

Silica, perlite, and fly ash were finely ground so as to pass through a filter of 400 mesh size. Exact amounts of these materials were weighed in a dry atmosphere. The mechanical mixing of these materials was done either by dry mixing or by wet mixing. In the wet mixing process, the polymer mixture was prepared by combining the epoxy with the hardner, metaphenylene diamine. This resinous mixture was then added to the batch of materials and was stirred mechanically in a mixer until a uniform wet mix was obtained. In the dry mixing process, the previously weighed powdered materials were placed for about 20 min in an electrically operated mixer to produce a homogeneous mix. In both mixing processes, extreme care was taken to minimize the number of air voids. From the sculptural and architectural viewpoint, smoothness and workability were considered, and it was found possible to optimize these properties by suitable mix proportioning. Several other factors, such as types of aggregate, strength, unit weight, and resin content, were also taken into consideration. Variations in aggregate unit weight were achieved by adding fillers such as silica.

In the present research, perlite and fly ash were used in varying proportions of ingredients. To have uniform bonding, pressures of up to 600 kg/cm^2 were applied. The curing of the samples was done at about 60°C in an electrically heated oven for nearly 8-10 h.

For testing, cubes of size 2.54 cm × 2.54 cm × 2.54 cm were used; three specimens tested in each case. Six series each of polymerized fly ash and perlite composites were prepared according to the compositions given in Tables 1 and 2. Various physicomechanical tests were performed according to procedures published earlier [7-9]. The acid tests were carried out by immersing the samples in 30% sulfuric acid. Each cycle consisted of 4 d immersion with subsequent heat treatment at a constant temperature (80°C) after which the specimens were weighed. The average weight loss for each specimen was calculated. Properties of the composites are also presented in Table 3.

RESULTS AND DISCUSSION

Details of mixture composition of fly ash series (A-1 to A-6) are given in Table 1. Similar sets of data (B-1 to B-6) for perlite aggregates are presented in Table 2. From these tables it is seen that with the increase of sand and epoxy in a mixture, an increase in water-cement ratio was required, thus suggesting the formation of silicates in the mix. Formation of such silicates might have improved the strength of the finished product due to multiple bond formation.

Results in Table 3 indicate that for the fly ash series (A-1 to A-6) an increase in compressive strength from 552 to 845 kg/cm^2 was observed. A similar increase in Young's modulus and unit weight was

TABLE 1. Mixture Composition Data for Fly Ash Aggregates

Series	Sand (% wt)	Cement (% wt)	Fly ash (% wt)	Epoxy resin (% wt)	Water-to-cement ratio
A-1	0	50	30	20	0.53
A-2	5	45	25	25	0.63
A-3	10	40	20	30	0.66
A-4	15	35	15	35	0.72
A-5	20	30	10	40	0.78
A-6	25	25	5	45	0.85

TABLE 2. Mixture Composition Data for Perlite Aggregates

Series	Sand (% wt)	Cement (% wt)	Perlite (% wt)	Epoxy resin (% wt)	Water-to-cement ratio
B-1	0	55	30	15	0.53
B-2	5	45	25	25	0.63
B-3	10	40	20	30	0.66
B-4	15	35	15	35	0.72
B-5	20	30	10	40	0.78
B-6	25	25	5	45	0.84

also observed. The maximum strength was achieved when about 25% sand and 25% cement were added at a water-cement ratio of 0.85. A further increase in the amount of sand did not seem to improve the properties (data not presented in tables). This may be due to the fact that the porosity of the composite increases as the percentage of sand is increased or there is inadequate polymer to bind the aggregates.

Perlite composites exhibited a similar trend in properties, maximum strength and stiffness being achieved for a mixture of 25% sand and 25% cement. Other properties, such as percentage of water absorption, fire resistance, and acid resistivity, were found to be better

TABLE 3. Physicomechanical Properties of Composites of Fly Ash and Perlite

Series	Unit weight × 10^{-2} kg/m^3	Compressive strength × 10^{-2} kg/cm^2	Modulus of elasticity × 10^{-3} kg/cm^2	Water absorption (%)	Acid attack weight loss (%)	Fire resistance (sec)
A-1	15.90	5.52	4.77	5.32	10.22	25
A-2	16.08	5.89	5.34	6.00	10.88	24
A-3	17.12	6.39	6.11	6.88	11.42	22
A-4	19.00	7.88	6.76	6.99	12.33	21
A-5	21.09	8.01	7.31	7.98	13.02	19.5
A-6	22.11	8.45	7.96	8.68	13.80	19.5
B-1	14.82	6.31	7.12	4.38	6.70	22
B-2	15.12	7.10	7.56	5.83	7.98	20.5
B-3	16.10	7.33	7.98	6.34	9.21	20.0
B-4	16.86	7.89	8.31	7.58	9.75	19.0
B-5	17.54	8.44	8.68	8.11	10.22	19.5
B-6	18.00	8.99	9.01	8.54	11.45	18.0

as compared to fly ash aggregates. The unit weights of perlite composites are in the range of 1482 to 1800 kg/m^3 and are much lighter than fly ash aggregates. In a study by Kukacka [10] on perlite composites, compressive strengths up to 548 kg/cm^2 were obtained. In the present research it is shown that compressive strength varied from 631 to 899 kg/cm^2. This increase may have been due to the use of additives in the mix. Significant improvement in the mechanical properties of the composites by the addition of sand, cement, and polymer in the mix has been attributed to the effect of interaction between cement grains, polymer, and silica [11, 12]. Resistance to water absorption, acids and alkalies, and fire for perlite composites was better than for fly ash aggregates.

CONCLUSIONS

Epoxy binders containing perlite may be readily modified with other fillers such as sand and cement to give an extremely wide range of useful materials for artists and craftsmen. Fly ash aggregates with improved properties may find applications in the construction industry where high strength and light weight are required. Improvements in chemical resistivity and aging have been observed in all these composites.

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