Review of Polyester Polymer Concrete Properties

Victor Y. Garas and C. Vipulanandan

Center for Innovative Grouting Materials and Technology (CIGMAT)
Department of Civil and Environmental Engineering
University of Houston, Houston, TX 77204-4003
Phone: 713-743-4291 e-mail: vgaras@mail.uh.edu

ABSTRACT

Polymer Concrete (PC) composites posses a unique combination of properties that depend upon the formulation. This study reviewed the variations in polyester polymer concrete mixture components that affected the properties. The effect of resin content, aggregates, fibers and coupling agents were critically reviewed. It was found that the optimum polymer content varied from 12% to 14% (w/w). Using fibers and coupling agents showed further enhancement of the mechanical properties of PC. Also, a new database was designed to document different properties of PC.

1. Introduction

Polymer concrete (PC) is a composite material formed by combining mineral aggregates such as sand or gravel with a monomer. Due to its rapid setting, high strength properties and ability to withstand a corrosive environment, PC is increasingly being used as an alternate to cement concrete in many applications, construction and repair of structures, highway pavements, bridge decks, waste water pipes and even structural and decorative construction panels. These widely divergent uses clearly indicate that no commercially available product could be compounded to perform all these tasks well; therefore, the term PC should never suggest only one product, but rather a family of products. Advances in coupling agents and material science in general further optimize the PC mixtures. Information collected will be used in developing a database for polymer concrete and their corresponding properties and applications.

2. Objectives

The overall objective is to determine the effects of different components in the PC mixtures on their properties and building an informative database for documenting different properties of polymer concrete.

3. Review of Literature

(a) Polyester Resins:

There are three classes of polyester used in polymer concrete mixtures Class I resins, resist mild corrodents and non oxidizing mineral acids. Class II resins, isophthalic type, are more resistant as compared to class I. Class III resins are based on bisphenol-A and have the best overall resistance to corrosive solutions.

Increasing polymer content, resulted in increasing flexural strength and flexural modulus while the compressive strength decreased. In general, the lowest polymer content at which compressive strength/modulus was maximum represented the optimum polymer content for polymer concrete. Reviewed literature indicated a (60 – 70 MPa) range for PC compressive strength and a (6.5 – 8.0 MPa) range for tensile strength it also indicated that the optimum polymer content to get a workable with the best mechanical properties mixture should be in the range of 12% to 14% (w/w).

(b) Aggregates:

Aggregates composed primarily of silica; quartz, granite, good limestone and other high-quality material have been used successfully in the production of PC. Aggregates used must be usually dry and free of dirt to get the best bond between aggregates and resin. Figure 1 shows some aggregate systems used in PC mixtures.

Blasting sand aggregate systems showed an increase in the flexural modulus with the increase in the polymer content. With 18% polymer content, crushed sand had a relatively high flexural strength of 32 MPa and a Modulus of 31 GPa but the lowest fracture toughness, 1.2 MPa m^0.5. Polyester polymer concrete with well graded blasting sand has better fracture properties than uniform Ottawa sand systems.

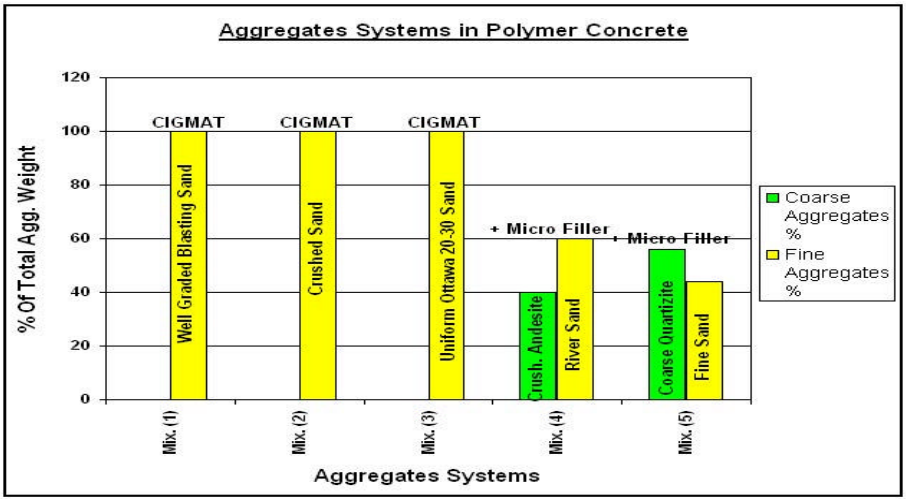

Figure 1 Most common aggregate systems used in PC

(c) Fibers:

- Carbon Fibers: PAN based carbon fibers up to 6% (w/w) were used to reinforce PC. In compression, it increased the failure strain, but the strength and modulus decreased. In tension, the addition of carbon fibers increased failure strain, strength and modulus.
- Glass Fibers: the addition of glass fibers enhanced flexural strength and toughness fracture properties; treatment glass fibers further enhanced flexural properties of PC. (Vipulanandan et al in 1990).
- Steel Fibers: Different steel fibers of sizes varied from (0.5x0.5x30mm.) to (*F*0.35x25) were used, the effect of steel fibers in a PC system and noted an increase in compressive, flexural and impact strengths. (Ohama & Nashimura in 1979).

(d) Coupling:

The coupling process is a chemical bond at the interface between the organic polymer and the inorganic substrate. The most common used coupling agent is "?-Methacryloxypropyltrimethoxysilane, ?-MPS". Also, an effective coupling method is to treat aggregates and fibers by wetting them with an aqueous solution of the coupling agent and then drying prior to mixing with the polyester polymer (Fig.2).

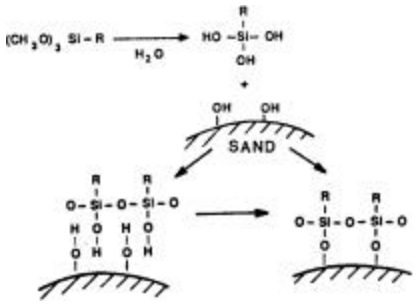

Fig.2. Coupling Process

Silane treatment resulted in more than 35% increase in the flexural strength. (Mebarkia & Vipulanandan; 1990). Desai in 1987 reported an improvement in compressive strength of about 4 to 6% due to silane treatment. Also, silane treatment reduced water uptake into PC specimens, so it showed the least decrease in compressive strength (7%) after emersion in water for a month. (Mebarkia & Vipulanandan; 1995).

4. Conclusions

Based on the reviewed literature, it is concluded that using certain polymer content, well graded aggregates, fibers and coupling agents strongly improve different properties of polyester polymer concrete.

5. Acknowledgement

This work was supported by the Center for Innovative Grouting Materials and Technology (CIGMAT), University of Houston.

6. References

1) Sopory; Jaiswal, Sanjeev; Nautiyal, “Smart Materials and Structures – A review”, Journal of Structural Engineering, Vol. 29, No. 3, December 2002.
2) Mebarkia, S.; Vipulanandan, C. “Mechanical Properties and Water Diffusion in Polyester Polymer Concrete”, Journal of Engineering Mechanics, Vol. 121, No. 12, December 1995.
3) Vipulanandan, C., “Characterization of Polyester Polymer and Polymer Concrete”, Journal Materials in Civil Engineering, Vol. 5, No. 1, February, 1993.
4) Mebarkia, S.; Vipulanandan, C. “Aggregates, Fibers and Coupling Agent in Polyester PC”, Materials Engineering Congress, ASCE Denver, Colorado, Vol. 2, 1990.
5) Vipulanandan, C.; Dharmarajan, N., "Influence of Aggregate on the Fracture Properties of Polyester Polymer Concrete", American Concrete Institute, pp. 83-94, October 1989.
6) Desai, S.V.; Nair, N. G., “Development of Polymer Concrete”, The Indian Concrete Journal, Vol. 61, No. 12, (1987).
7) Ohama,Y.; Nishimura, T., “Properties of Steel Fiber Reinforced Polyester Resin Concrete”, In Proceedings 22nd. Congress on Material Research, Society of Material Sciences, Kyoto, Japan, 1979.

Ohama, Y.; Terata, O., “Determination Methods for Consistency of Polyester Resin Concrete”, In Proceedings 22nd Congress on Material Research, Society of Material Sciences, Kyoto, Japan, 1979.