POLYMER CONCRETE FOR A NEW SANDWICH PIPE

H. Jia and C. Vipulanandan

Department of Civil and Environmental Engineering

University of Houston

Houston, Texas 77204-4791

Phone: 713-743-4291; e-mail: hjia@bayou.uh.edu

Abstract

Polymer concrete (PC) with and without fibers were characterized using both nondestructive and destructive testing techniques. Performance of polymer concrete containing PVC, polypropylene, glass, carbon and steel fibers at the same weight content were compared in term's of compressive strength, tensile strength, static modulus, dynamic modulus and elongation at peak load. PVC and polypropylene fibers improved the ductility and tensile strength, but did not improve the compressive strength, Steel fibers gave the highest compressive and tensile strength. Bonding strength of polymer concrete in tension and shear has been quantified.

1. Introduction

Polymer concrete (PC) is being increasingly used in construction and rehabilitation of civil infrastructure. It is known that the tensile strength and ductility of concrete can be greatly increased by addition of short fibers. Only glass fibers have been used with PC. There have been recent studies on other fibers such as PVC, polypropylene, carbon or steel fibers in concrete. Thus an objective of this study is to compare the behaviors of PC reinforced with PVC, Polypropylene, glass, carbon and steel fibers (FRPC) systematically by using destructive test and nondestructive tests. New PVC-PC-PVC sandwich pipes were designed and tested under parallel plate external loading.

2. Materials and Experimental procedure

The basic constituents of the polymer concrete (PC) were polyester resin (14%) and blasting sand(86%). PC was reinforced with steel fibers (6%) or non-metal fibers(1%, 3% or 6%). Compression tests were performed using a 400 kip capacity Tinius Olsen universal testing machine in strain control mode. Specially designed specimens(CIGMAT standards) were used for tensile testing by using a screw type mechanical testing system. Pulse velocity and impact resonance test was performed according to ASTM C 597-83 and C 215-91. The behavior of sandwich pipes was investigated experimentally under parallel plate external loading according to ASTM D 2412-87.

3. Results and Discussion

3.1 Nondestructive Tests

3.1.1 Pulse velocity test

Among the five types of fibers tested steel fibers gave the highest pulse velocity and highest dynamic modulus of elasticity (Ed). PVC and polypropylene fibers gave the lowest velocities and Ed. Comparison of results from the large cylinders shows that the values of Ed for PVC fibers and polypropylene fibers were about 10% and 19% lower respectively than those for PC. The data obtained from small cylinders and from large cylinders show the similar tendency.

3.1.2 Impact resonance test

From the impact resonance test, it also can be seen that steel fibers gave the highest dynamic modulus and the PVC and polypropylene fibers gave the lowest dynamic modulus. The dynamic modulus obtained from longitudinal and transverse vibration were no more than 10% than the corresponding static modulus from compression test and pulse velocity modulus. So the dynamic data agreed well with the static modulus.

3.2 Destructive Tests

3.2.1 Uniaxial compressive and tensile tests

The results of compressive and tensile testing show that PVC and polypropylene fibers did not significantly influence the compressive strength of the PC but they gave much higher tensile strength than plain PC. Steel fibers gave the highest compressive and tensile strength which were 17% and 150% higher than PC. For fiberglass the compressive strength was 15% higher than that of PC. It was found that the elongation of specimens at peak load greatly increased due to the addition of fibers. This change in mode of failure from a brittle failure to a ductile failure was observed in all cases of fibers.

3.2.2 Shear Strength

All the pushoff specimens were tested in a grip machine with a displacement rate of about 0.06/min. loading along the shear plane for the direct type of shear loading. The shear stress was then obtained by dividing the applied shear load by the area of the shear plane. Test results reveals that the addition of fibers increased the shear strength and ductility of PC.

3.3 Bonding between PVC and Polymer Concrete

Bond between the PVC and the core materials was found to be an important factor that affected the performance of the sandwich pipe. The strong bond between PVC and PC made sandwich pipe far superior to weak bond sandwich pipe. It is of interest to investigate the bond stress between PVC and PC. In this study, the bond stress between PVC and PC was characterized using both direct tension method and shear method. It was found that direct tensile bonding between PVC and PC was 21% higher than that of PVC-Epoxy Glue-PC. Hence, polymer concrete itself can bond better PVC than that with epoxy glue.

3.4 Test on Sandwich Pipe

Sandwich pipe specimen design, casting procedure, quality control and parallel plate external

loading test were investigated in this study. The quality of PC core of sandwich pipe can be evaluated by non destructive test. From parallel plate external loading test, it can be seen sandwiching polymer concrete pipe in-between two PVC pipes dramatically improved its performance.

4. CIGMAT Standards

CIGMAT standards for making and testing PC are being developed.

5. Conclusions

Adding PVC, polypropylene and glass fibers, fiber additions decreased the unit weight of polymer concrete while steel fibers increased it. PVC and polypropylene fibers did not significantly influence the compressive strength, but they provided PC much higher tensile strength and ductility. Among the four types of fibers, steel fibers gave the highest compressive and tensile strength. Fiber addition decreased the compressive elasticity modulus with all fibers expect for steel fibers. The dynamic modulus of elasticity of PC and FRPC from pulse velocity and Impact resonance test agreed well with the static modulus. Shear and tensile bond strength between the PVC and PC was quantified.

6. Acknowledgment

This research is being supported by the National Science Foundations(CMS-9634685).

7. References

1. Vipulanandan, C. and Paul, E. Performance of Epoxy and Polyester Polymer and Polymer Concrete, Journal of Materials in Civil Engineering, V5, No.1, 1993, pp. 62-82

2. S.A. Mebarkia, Mechanical and Fracture Properties of High Strength Polymer Concrete under Various Loading and Corrosive Environments, Ph.D. dissertation, 1992

If you have any questions, please contact Dr. C.Vipulanandan