TABLE 3--SLUMP AND COMPRESSIVE STRENGTH AS A FUNCTION OF FA CONCENTRATION IN FA-PC

FA monomer by weight of total PC mass, %	Slump, cm	Compressive strength at 24 hr age, MPa
12	29.0	77.5
10	26.3	83.2
9	13.0	86.1
8	5.6	80.7
6	2.8	71.9

[a] 1 MPa = 145 psi

TABLE 4--PROPERTIES OF PACKAGED FA-PC SYSTEMS AS A FUNCTION OF STORAGE LIFE

System	Time	Viscosity, cP	pH	Gel time, min:sec	1-hr compressive strength, MPa
FA-1.0% pyridine	30 min	6.4	6.15	8:50	37.2
	1 week	6.4	5.90	8:30	37.1
	2 weeks	6.4	5.81	8:00	37.6
	5 weeks	6.5	5.50	7:50	37.4
	3 mo	6.4	5.51	7:55	38.1
	6 mo	6.4	4.71	6:40	41.2
	12 mo	6.4	4.60	6:10	36.9
	15 mo	6.4	4.30	5:40	38.5
50% TCT-50% silane	1 week	---	9.0	7:10	42.7
	1 mo	---	9.0	7:20	42.4
	2 mo	---	9.0	7:05	44.5
	6 mo	---	8.5	6:25	49.2
	12 mo	---	8.0	6:10	50.8
	15 mo	---	7.7	6:05	51.0
22% $ZnCl_2$-78% silica flour	1 week	---	---	6:20	49.7
	1 mo	---	---	6:30	50.2
	3 mo	---	---	6:20	49.0
	9 mo	---	---	6:20	50.7
	12 mo	---	---	6:35	49.7

[a]1 MPa = 145 psi

TABLE 5--COST OF FA-PC PATCHING MATERIALS

Ambient temperature °C	Materials	Quantity kg/m^3	Unit cost, $/kg	Cost, $\$/m^3$
52 to -20	FA	219.68	1.7	373.46
	TCT (6%/FA)	13.28	6.61	87.78
	Pyridine	2.71	13.89	37.64
	$ZnCl_2$	142.68	0.93	132.69
	Silica aggregate	1559.64	0.02	31.19
	Silica flour	519.06	0.20	103.81
	Silane A-1120	2.21	19.84	43.85
			Total $\$/m^3$	810.42
			$\$/yd^3$,	619.65
-20 to -32	FA	268.14	1.7	455.24
	TCT (5.5%/FA)	14.74	6.61	97.43
	Pyridine	3.37	13.89	46.81
	$ZnCl_2$	231.49	0.93	215.29
	Silica aggregate	1454.60	0.02	29.09
	Silica flour	484.87	0.20	96.97
	Silane A-1120	2.68	19.84	53.17
			Total $\$/m^3$	994.60
			$\$/yd^3$,	760.47

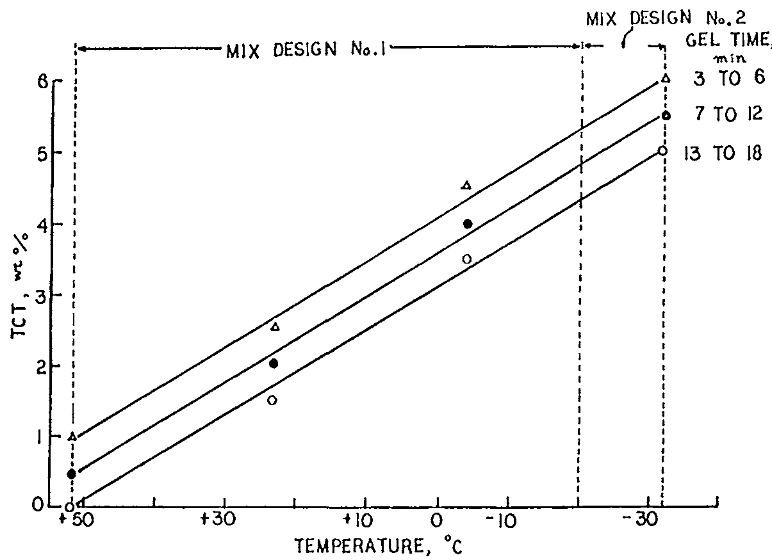

Fig. 1--Required TCT concentration as a function of temperature and gel time for premixed FA-PC containing water-saturated aggregate

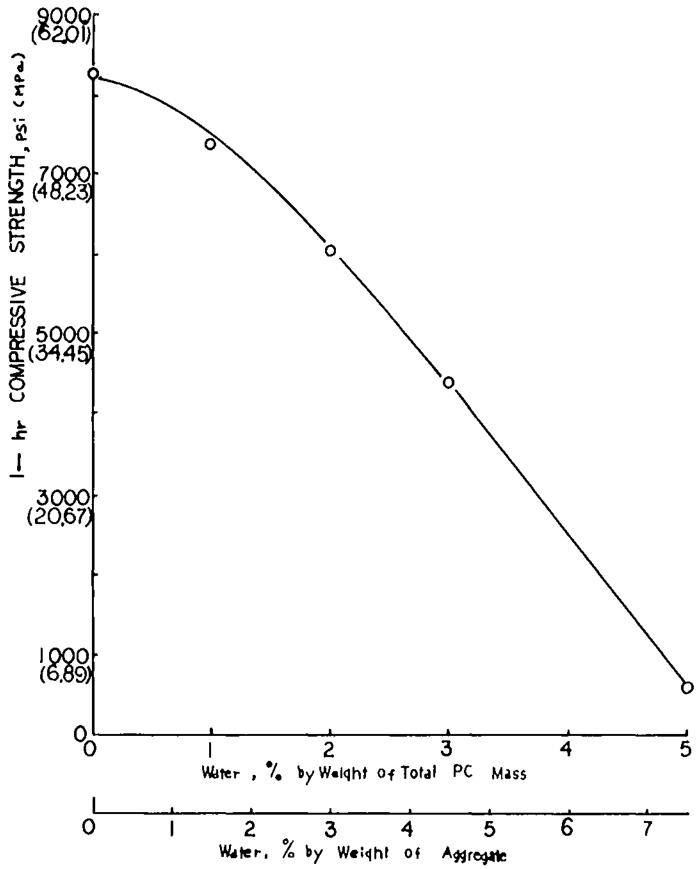

Fig. 2--One hour compressive strength of FA-PC as a function of water concentration

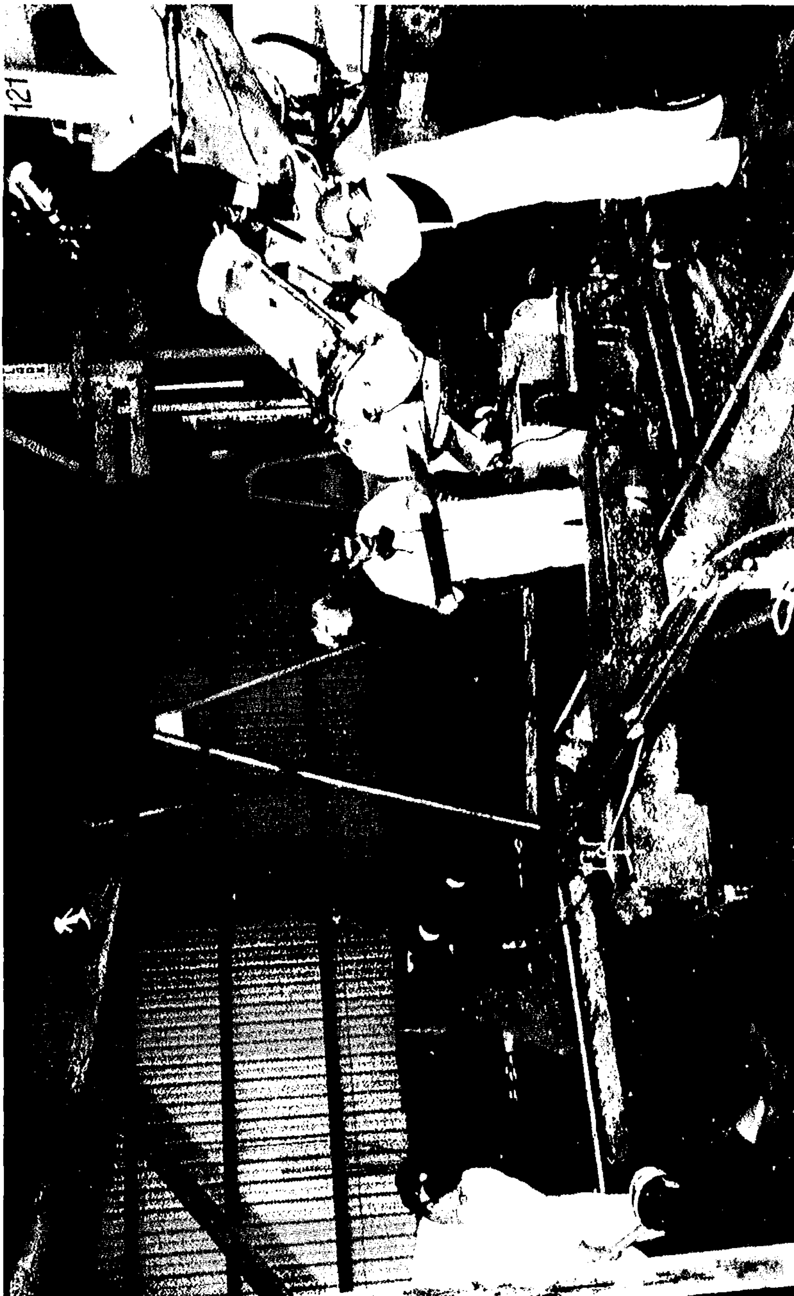

Fig. 3--Placement of FA-PC in hot-weather wet, small crater test

Fig. 4--F-4 load cart

SP 99-7

Mechanical and Durability Properties of a High Molecular Weight Methacrylate Polymer Concrete

By R.G. Kushner, D.W. Fowler, and D.L. Wheat

Synopsis: Polymer concrete is a composite material which is often times a viable alternative to Portland Cement Concrete. The mechanical and durability properties of three high molecular weight methacrylate polymer concrete systems using different monomers are discussed. Properties discussed include compressive strength, flexural bond testing, modulus of elasticity, coefficient of thermal expansion, shrinkage, freeze-thaw, freeze-thaw shear bond, water absorption, chemical resistance, and crack repair. The monomers themselves were shown to be very effective in sealing cracks with widths as narrow as 0.5 mm. while restoring flexural strength.

Keywords: compressive strength; durability; flexural strength; freeze-thaw durability; mechanical properties; methacrylates; modulus of elasticity; monomers; polymer concrete; shrinkage; thermal expansion

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INTRODUCTION

Polymer concretes have been the subject of much discussion and research over the past ten years. Polymer concrete is a composite material formed by polymerization of a monomer and aggregate mixture in which the polymerized monomer acts as the binder for the aggregate (4). The construction and machining industries are beginning to accept polymer concrete (PC) as a viable alternative to Portland Cement Concrete (PCC) where PCC proves to be inefficient. Polymer concrete have higher compressive strengths, greater tensile strengths, and often exhibit greater corrosion resistance, a higher impact resistance, greater freeze-thaw resistance, and exhibit a much faster cure time (one hour or less) than Portland Cement Concrete.

EXPERIMENTAL PROGRAM

A brief discussion of materials and preparation, the experimental test program for the properties studied, and the variables considered, follow for the benefit of the reader.

MATERIALS AND PREPARATION

The chemicals used in the production of the two acrylic polymer concretes included three polymer concrete monomers, cumene hydroperoxide or benzoyl proxide (BSF-50) as initiators, and catalyst 4142 or cobalt napthenate as catalysts. The PC I system was initiated by cumene hydroperoxide while the PC II and PC III systems were initiated by 50 percent benzoyl peroxide. The benzoyl peroxide can also be added by the supplier to the dry mix as a powder.

The system tested was a mortar system only, thus it included no aggregate. The dry mix was prepackaged by the manufacturer. The dry mix consisted of 60 parts of a 45 mesh sand, 40 parts of a 120 mesh silica flour, 0.05 parts Meyer oxide and 0.45 parts titanium dioxide, a colorant used to produce a gray color, and 0.17 parts catalyst 4142 (11.2 percent cobalt).

The PC I system mixing procedure is to add monomer to a dry mix and then to mix cumene hydroperoxide to the previous components. The mixing procedure for the PC II and PC III systems is to add BSF-50 powder to a dry mix (unless already premixed in the dry mix) and then to add the monomer. A conventional concrete mixer was used to mix all specimens. ASTM rodding and vibration procedures then followed.

Due to excessive monomer bleeding during the casting of the small test samples, monomer content was reduced by 10 percent from that suggested by the manufacturer. The components of the PC I system utilized

100 parts dry mix,
16.0 parts PC I, and
0.648 parts cumene hydroperoxide.

The components of the PC II or PC III system utilized

100 parts dry mix,
16.0 parts PC II or PC III, and
0.540 parts BSF-50 powder (if premixed in dry mix then 0.60 parts were used).

Specimens were cast in various types of molds. Steel, polyvinyl chloride, plastic coated wood, wax coated cardboard, and Teflon(R) formwork were all used.

All Portland Cement Concrete (PCC) specimens consisted of 3/4 in. graded coarse aggregate and a fine aggregate. The water to cement ratio of the PCC was 0.50.

EXPERIMENTAL TEST PROGRAM

The test procedures used to evaluate the mechanical properties, durability, and applications of the two polymer concrete systems are discussed below. ASTM standard testing procedures were followed when possible and were used as guidelines in those instances where such tests were not directly applicable to polymer concrete.

The tests for COMPRESSIVE STRENGTH was adapted from ASTM while using 3-in. by 6-in. cylinders. This size is used due to the very high compressive strength of PC. Compressive strength was studied as a function of time and as a function of time and as a function of the temperature.