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DEVELOPMENT OF A GLASS POLYMER COMPOSITE SEWER PIPE FROM WASTE GLASS

PROGRESS REPORT NO. 2
OCTOBER-DECEMBER 1976

PROCESS TECHNOLOGY DIVISION
DEPARTMENT OF APPLIED SCIENCE

MASTER

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Abstract

Large quantities of energy and money can be conserved by recycling solid urban waste. While uses for recycled ferrous and non-ferrous metals are apparent, uses for the glass fraction have not been identified. As a result, a program to develop methods for incorporating waste glass into composites which can be used for construction materials was started in July 1976. Since that time tests have been started to measure the properties of glass-polymer sewer pipe. Field testing of full-scale specimens is also in progress. Work accomplished during the period October 1- December 31, 1976 is described in the current report.

Summary

Tests have been started to determine the properties of glass-polymer sewer pipe to a degree that they are statistically acceptable with respect to relevant ASTM methods and standards. To date the results from compressive strength and three-edge bearing strength measurements indicate that the properties are reproducible. The coefficient of variation is generally <10%. Hydrostatic test requirements can also be attained.

Field testing of full-scale pipe sections has been in progress since 1972. To date no deterioration is apparent.

Calculations to determine energy budgets and costs will commence during the third quarter of FY 1977.

Development of a Glass Polymer Composite Sewer
Pipe From Waste Glass

Progress Report No. 2
October-December 1976

Introduction

Large quantities of energy can be conserved by recycling solid urban waste. Governmental groups also have great interest in developing waste management systems due to the rapidly increasing costs associated with the landfilling of wastes. While uses for recycled ferrous and non-ferrous metals are apparent, efficient methods for utilizing other components of urban waste such as glass and paper are needed. Glass constitutes ~10 wt% of the urban waste in the U.S. and the potential amount of recoverable glass was estimated in 1973 to be $\sim 12 \times 10^6$ ton/yr.¹

The Brookhaven National Laboratory (BNL) program for the utilization of waste glass in construction materials is an outgrowth of previous work on concrete-polymer materials.² One of the materials developed in that program is polymer concrete (PC) which consists of a mixture of fine and coarse aggregate and a polymeric binder. The material can be mixed and placed using conventional equipment, cures rapidly at ambient temperature, and has strength and durability properties that exceed those of portland cement concrete.

In 1973 experiments were performed at BNL which indicated that glass and paper could be used as aggregate in PC formulations.³ Potential applications as construction materials for sewer pipe, building block, chemical storage tanks, and insulating panels for use in energy storage systems were identified. Several pieces of glass polymer composite (GPC) sewer pipe were produced and installed in the Town of Huntington, on Long Island and in Newark, New Jersey.

Based upon the above work, a preliminary cost analysis was performed¹ and a technology transfer program was initiated.⁴ The latter resulted in the establishment of a cooperative program with an industrial company (Teledyne National) to utilize the glass fraction from a large urban waste plant in operation in Maryland.

In June 1976 the Office of Conservation of ERDA initiated support of the program. The goals for the program are as follows:

1. To provide the technical basis for energy conservation by the development, testing and practical demonstration of products made from industrial waste materials.
2. Rapid transfer and implementation of the technology in the private sector.

The program goals will be achieved by performing the following tasks:

1. Determine the properties of GPC sewer pipe to a degree that they are statistically acceptable with respect to relevant ASTM methods and standards.

2. Perform field testing of prototype and full-scale specimens.

3. Prepare energy budgets and cost analyses.

4. Involve the solid waste utilization industry in all phases of the program in order to provide a technical basis for the rapid implementation of the technology.

To date one progress report on the program has been issued.⁵ Accomplishments during the period October-December 1976 are summarized in this report.

Task 1. GPC Property Measurements

Work to determine the minimum wall thickness of 8-in.-i.d. GPC sewer pipe required to meet the ASTM standard C-76 was continued.

During the previous report period 7000 lb. of ground glass was received from the Cockeysville, Maryland solid waste separation plant. Included with the glass were small amounts of ceramics, metals and organic materials. A considerable amount of stone was also present. The concentrations of these materials in the glass are given in Table 1.

TABLE 1

Composition of Glass Fraction
Separated from Municipal Waste

Source: Cockeysville, Maryland

<u>Material</u>	<u>Amount, %</u>
Glass	95.62
Ceramics	1.03
Metals	0.21
Organics	0.21
Plastics	0.06
Stones	2.87

The as received glass was screened to remove all pieces that would not pass through a size No. 6 U.S. Sieve. This is necessary to assure high strength and leak-tightness when thin-wall sections of GPC are produced. The particle size distribution of the screened material is listed in Table 2.

As noted in the table, ~95% of the Cockeysville glass was of sieve size >No. 48. Previous work had indicated that a broader particle size distribution was needed to obtain high strengths with a minimum monomer loading.

Since equipment to regrind the glass was not available, it was decided to blend the glass with finer material obtained earlier from the Bureau of Mines Facility in College Park, Maryland. The particle size distribution of this material is also given in Table 2. Calculations indicated that a mixture consisting of 61 wt.% of the Bureau of Mines glass and 39 wt% of the Cockeysville glass would give a particle size distribution approximating the mix used with success in earlier work. The particle size of the mixture is given in Table 3. All GPC specimens produced in the program will be fabricated using glass from this mix.

TABLE 2

Particle Size Distribution of Glass
From Cockeysville and Bureau of Mines

<u>U. S. Sieve Size</u>	<u>Amount retained %</u>	
	<u>Cockeysville</u>	<u>Bureau of Mines</u>
No. 8	18.29	0.02
No. 10	17.44	--
No. 14	17.69	--
No. 20	13.26	0.10
No. 28	12.19	--
No. 35	9.44	--
No. 40	--	38.52
No. 48	6.33	--
No. 60	--	27.29
No. 65	2.74	--
No. 100	--	14.58
Pan	2.62	19.49

TABLE 3

Particle Size Distribution of Glass
Used to Produce GPC Pipe

Mixture: 61 wt% Bureau of Mines
 39 wt% Cockeysville

<u>U. S. Sieve Size</u>	<u>Experimental quantity retained, %</u>
No. 8	3.64
No. 20	19.33
No. 40	32.95
No. 60	20.16
No. 80	8.69
No. 100	2.57
Pan	12.66

Four test batches, each consisting of three 12-in.-long sections of 8-in.-i.d. x 1.5-in. wall GPC pipe, were prepared during the report period. Two additional batches will be prepared to complete the series. Test cylinders for use in compressive strength measurements were also made.

The GPC formulation used to fabricate the test specimens consisted of 88.25 wt% glass and 11.75 wt% of a polyester-styrene mixture. The composition of the monomer was 9.5 wt% styrene from which the tert butyl pyrocatechol inhibitor had been removed, 1.75 wt% of a low viscosity polyester resin (Selectron 50293)^a and 0.5wt% of a low shrinkage polyester resin (Grace 13024)^b. A silane coupling agent, an internal release agent, and benzoyl peroxide-98, each at a concentration of 1% by weight of monomer were also included in the mix.

All of the samples for a batch were fabricated from a single GPC mix. After mixing in a conventional cement mixer until all of the aggregate was wetted with monomer (~3 min), the GPC was placed in the forms and compacted using an air-

^a Supplier, PPG Industries, Inc.

^b Supplier, W.R. Grace Company

operated vibrator. Disassembled and assembled forms for the pipe are shown in Figure 1. The samples were then cured by heating in an oven at a temperature of 82°C (180°F) for a minimum of 4 hr.

After curing, the compressive strength of the cylinders was measured in accordance with the procedure specified in ASTM C-39.

The effectiveness of the release agents is determined when the pipe sections are removed from the forms. In these tests the force required to remove the inner and outer form from the pipe is measured. These data will be needed for the design of equipment for the removal of full-size pipes. A pipe section after removal of the forms is shown in Figure 1.

Data required to determine if the pipe meets the standards specified in ASTM C-76 are being obtained by performing hydrostatic and three-edge bearing strength tests. Conditions for the former are a pressure of 10 psig for 10 minutes. The three-edge bearing test is performed in accordance with ASTM C-497.

Data obtained to date are summarized in Tables 4-6. The mean, standard deviation, and the coefficient of variation for each test batch are given. Good reproducibility of properties within any given batch of samples is indicated.

Figure 1. Forms used to produce 12-in.-long test pieces of GPC pipe and completed specimen.

TABLE 4

Compressive Strengths of GPC

Specimen size, 3-in.-diam x 6-in.-long

Test procedure, ASTM C-39

<u>Batch No.</u>	<u>Compressive strength, psi</u>	<u>Mean</u>	<u>Standard deviation</u>	<u>Coefficient of variation</u>
258	6930	6394	1052	0.164
	6620			
	6803			
	5254			
	6634			
	6120			
259	5888	6387	451	0.071
	6610			
	6663			
260	8343	8522	433	0.051
	8473			
	8260			
	9012			
261	7680	7692	66	0.009
	7633			
	7763			

TABLE 5

Three-Edge Bearing Strength of GPC Pipe

Specimen size, 12-in.-long x 8-in.-i.d. x 1.5-in.-wall

Test procedure, ASTM C-497

Batch No.	Three-edge bearing strength, lb/ft _L -ft _{i.d.}	Mean	Standard deviation	Coefficient of variation
258	10500 10039 9139	9893	692	0.070
259	10044 9591 9457	9697	308	0.032
260	10725 10800 11850	11125	628	0.056
261	9750 8325 9495	9190	760	0.083

TABLE 6

Bonding Stress of GPC Pipe to Forms

Specimen size, 12-in.-long x 8-in.-i.d. x 11-in.-o.d.

Batch No.	External release agent	Bond stress to inner form, psi		Bond stress to outer form, psi	
			Mean		Mean
258	A	11.57		2.36	
		2.14		3.83	
		4.41	6.04	1.67	2.62
259	B	3.26		7.11	
		2.55		4.53	
		2.69	2.83	0.41	4.01
260	C	2.84		2.48	
		2.84		1.76	
		1.85	2.51	2.48	2.24
261	D	10.52		2.27	
		5.69		14.48	
		4.83	7.01	1.76	6.17

A, Kantstik. 78 cured at 120°C for 15 min.

B, Kantstik 78 cured at 204°C for 15 min.

C, Koray 2071 cured at 120°C for 15 min.

D, Koray 2071 cured at 20°C.

With only one exception the coefficients of variation are <9%. All samples passed the hydrostatic test requirements.

Two additional batches of samples are being prepared to complete the 1.5-in.-wall thickness test series. The variation in properties between batches will then be determined.

During the next report period the work will be extended to 8-in. pipe with a wall thickness of 1.0 and 0.625-in. It is anticipated that both series will be completed during the period.

Task 2. Field Test and Inspection

Monitoring of the performance of GPC pipe currently in test in Huntington, N.Y. and Newark, N.J. is being continued. At Huntington, a total of 35 ft of 8-in.-diam. pipe was installed during October 1972. Two pieces of pipe contained methyl methacrylate and 8 contained polyester-styrene. To date no problems with the pipe have been reported. A visual inspection was made in 1974 and another will be made during the latter half of FY 1977.

In November 1975 ~ 12 ft of 12-in.-diam. pipe was installed in a sewer line in Newark, N.J. The pipe is in an industrial part of the city and is exposed to acid-type waste from several chemical plants. Prior to installation the pipe was shown to conform to the ASTM strength and hydrostatic test

specifications. The leakage rate at the joints was also measured as well below that specified by the City of Newark.

A T.V. inspection of the pipe was made during September 1976. No deterioration was apparent. Another inspection will be made in September 1977.

Task 3. Materials and Energy Estimate

Estimates of the materials and energy trade-offs of GPC pipe vis-a-vis replacing vitrified clay pipe or other suitable sewer pipe will be made upon completion of the property measurement phase (Task 1) of the program. Production and energy cost estimates will also be made. It is anticipated that work in this task will be started in the third quarter of FY 1977.

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