DEVELOPMENT OF A GLASS POLYMER COMPOSITE SEWER PIPE FROM WASTE GLASS

PROGRESS REPORT NO. 6
OCTOBER - DECEMBER 1977

MASTER

PROCESS SCIENCES DIVISION
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
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Abstract

Large quantities of energy can be conserved by recycling municipal solid waste. Reductions in the costs associated with waste disposal such as by landfilling can also be accrued. While uses for recycled ferrous and non-ferrous metals are apparent, uses for the glass fraction which constitutes ~ 10% of municipal solid waste, have not been developed. 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 the properties of as-produced glass polymer composite (GPC) sewer pipe have been measured, durability tests started, field testing of full-scale specimens initiated, and calculations made to determine the energy requirements and costs. Work accomplished during the period October 1-December 31, 1977 is described in the current report.

Summary

Tests have been started to determine the long-term durability of glass polymer composite (GPC) pipe in hot water and 5% H_2SO_4 . Experiments to optimize the particle size distribution of the glass fraction in GPC are also being performed. These data will be utilized in calculations to determine the energy requirements and cost to produce GPC pipe as a replacement for vitrified clay, asbestos cement, and concrete pipe in sewage systems. Earlier calculations based upon as-produced properties indicated the use of GPC could result in energy savings of up to 16% and reductions in cost compared to vitrified clay from 11 to 44%.

Field testing of full-size pipe is continuing at two locations. A test in a line containing pH 2.4 waste is scheduled. The pipe has been fabricated and hopefully will be installed during the next report period.

Development of a Glass Polymer Composite Sewer Pipe from Waste Glass

Progress Report No. 6
October-December 1977

Introduction

The utilization of solid urban waste could result in many benefits. In addition to the production of substantial quantities of energy and the recovery of valuable materials, the costs associated with landfilling wastes would be lowered considerably. At the present time uses for recycled ferrous and non-ferrous metals are apparent. Efficient uses for recycled glass which constitutes ~ 10 wt% of urban waste in the US, need to be developed.

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.¹ 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.² Potential applications as construction materials for sewer pipe, building block, chemical storage tanks, and insulating panels for use in energy storage systems were identified.

The particular application of GPC sewer pipe appeared quite attractive because of its high strength and durability to acids which exist in municipal sewage. GPC is far superior to concrete in these properties and potentially less energy intensive and less costly than vitrified clay and asbestos cement which are presently specified for sewage systems. Furthermore, this application takes a waste material generated by a municipality and converts it to a product which can readily be used by that same municipality.

Based upon the above work, a preliminary cost analysis was performed³ 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 DOE (formally 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 are being achieved by performance of 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 five progress reports on the program have been issued.⁵⁻⁹ Accomplishments during the period October-December 1977 are summarized in the current report.

Summary of Accomplishments during FY 1977

Tests were started to determine if the use of glass polymer composite (GPC) pipe as a replacement for vitrified clay, asbestos cement, and concrete pipe in sewage systems can result in energy conservation and economic benefit. As the initial phase of this work, the properties of as-produced GPC were measured to a degree that they are statistically acceptable with respect to relevant ASTM methods and standards. The results from compressive strength, three-edge bearing strength, and hydrostatic tests indicated that when compared to several ASTM classes of steel reinforced concrete pipe, the use of GPC reduces the wall thickness from 30 to 50%.

Calculations were made to determine the energy requirements to produce GPC and vitrified clay pipe. Conservative estimates indicate that the use of GPC can result in energy savings of up to 16%.

The cost of producing GPC utilizing glass from a 1,200 ton/day waste separation plant was estimated. These calculations indicate that 6 to 48-in. GPC pipe can be produced at a cost from 11 to 44% less than the 1974 selling price of vitrified clay when a value of

\$20/ton is assumed for the waste glass fraction. Substitution of GPC for reinforced concrete pipe up to a diameter of 36-in. will result in similar cost reductions.

Task 1 GPC Property Measurements

During FY 1977 tests to determine the minimum wall thickness of as-produced 8-in.-i.d. GPC sewer pipe required to meet the ASTM Standard C-76 were completed. These results were summarized in Progress Report No. 5.⁹ During the current report period durability tests were initiated to determine the properties of the material after long-term exposures to water at 65°C and 5% H₂SO₄.

As the initial part of this work, control samples of 8-in.-i.d. x 1.5-in.-wall GPC pipe were fabricated. The GPC formulation consisted of 88.25 wt% glass from the Cockeysville, Maryland solid waste separation plant and 11.75 wt% of a polyester-styrene mixture. The monomer mixture consisted of 81 wt% styrene, 14.9 wt% of low viscosity polyester resin, and 4.1 wt% of a low shrinkage polyester. Prior to mixing with the glass fraction, a silane coupling agent, an internal release agent, and a polymerization initiator, each at a concentration of 1% by weight of monomer, were added to the monomer.

The GPC formulation was mixed in a conventional concrete mixer until all of the glass aggregate was wetted with monomer. It was then placed in the pipe forms and compacted using air-operated vibrators. A description of the forms is given in Ref. 6. The pipes were then cured in an oven at a temperature of 82°C for 4 hr.

Three-edge bearing strength measurements were performed on four 8-in.-long pieces of pipe. An average strength of $14,379 \pm 764 \text{ lb/ft}_L\text{-ft}_{id}$ was measured (see Table 1). This value is in excellent agreement with a predicted value from previous work⁹ of $14,492 \pm 410 \text{ lb/ft}_L\text{-ft}_{id}$ and will be used as the initial strength in determining the effects of exposure to fluids on the strength properties. Similar tests will be performed on 1-in.-wall pipe sections.

Samples have been prepared and durability testing in water at 65°C and in 5% H_2SO_4 will be started during the next report period. These test conditions were selected so that the results can be compared with Australian work¹⁰ on PC pipe which utilized 10,000 hr exposure data to predict strength characteristics over a 100 yr period in sewage systems.

The tests in hot water will be performed in a 5-ft-diam x 15-ft-long stainless steel autoclave previously used for the impregnation of concrete pipe. Eight-in.-diam sections of 1.5-in.-wall GPC pipe, 1-in.-wall GPC pipe, and sections of vitrified clay, concrete, and asbestos cement pipe will be placed in test. The samples will be tested in triplicate at ~ 4 month intervals. The tests in 5% H_2SO_4 will be performed in a similar manner except that the sections will be contained in closed glass battery jars.

In an earlier report,⁷ increases in the strength properties of GPC with increased concentrations of glass fines in the mix were discussed. This is important since it can result in reductions in energy consumption and cost. Experiments are currently in progress to optimize the particle size distribution with respect to monomer concentration and

Table 1

Three-Edge Bearing Strengths of GPC Pipe
Prior to Long-Term Durability Tests

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

Test procedure, ASTM C-497

Batch No.	Wall thickness, in.	Three-edge bearing strength, lb/ft _L -ft _{i.d.}	Mean	Standard deviation	Coefficient of variation
302-1	1.5	12828			
302-2		13900			
302-3		15922			
302-4		14868			
Entire series			14379	764	0.05

properties. The effect of various concentrations of organic materials in the waste glass fraction on the properties will also be determined. The goal of this work is to develop specifications for the particle size and purity of the glass fraction in GPC.

Task 2. Field Test and Inspection

Monitoring of the performance of GPC currently in test at Huntington, New York and Newark, New Jersey is continuing. At Huntington, a total of 35 ft of 8-in.-diam sewer pipe has been in test since October 1972. Two sections of pipe contain methyl methacrylate and eight others contain polyester-styrene. To date no problems with the pipe have been reported. A visual inspection of the pipe was made in 1974. A second inspection, originally scheduled for the previous report period, has been rescheduled to FY 1978.

Twelve feet of 12-in.-diam pipe has been in test in Newark since November 1975. 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.

A TV inspection of the pipe was made during September 1976. No deterioration was apparent. A second inspection, originally scheduled for the previous report period, has been rescheduled to FY 1978.

Arrangements have been made to initiate a second test at Newark. In this test, two 5 ft lengths of 12-in.-diam pipe will be installed at a location where the pH in steady operation is 2.4. The fabrication

of the pipe was completed during the report period. Adaptors to connect the GPC to the existing vitrified clay pipe in the sewage line are being fabricated. Hopefully installation of the specimens will take place during the next report period.

Task 3. Materials, Costs, and Energy Estimates

Estimates of the energy requirements and costs to produce GPC pipe based upon as-produced properties, were given in the previous progress report.⁹ These calculations indicated energy savings of up to 16% and reductions in cost compared to vitrified clay from 11 to 44%. No additional work in this task was performed during the current report period. Revised estimates will be made when results from particle size distribution and durability tests are available.

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