DEVELOPMENT OF A GLASS POLYMER COMPOSITE SEWER PIPE FROM WASTE GLASS

PROGRESS REPORT NO. 4
APRIL - JUNE 1977

PROCESS TECHNOLOGY DIVISION
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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 glass polymer sewer pipe have been measured and field testing of full-scale specimens has been initiated. To date, the results indicate that high-strength durable materials can be produced. Conservative estimates indicate that the energy value for glass polymer pipe is up to 16% less than that for vitrified clay pipe. Work accomplished during the period April 1 - June 30, 1977 is described in the current report.

Summary

Tests are in progress 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. As the initial phase of this work, the properties of GPC are being measured to a degree that they are statistically acceptable with respect to relevant ASTM methods and standards. To date the results from compressive strength, three-edge bearing strength, and hydrostatic tests indicate that when compared to several ASTM classes of steel reinforced concrete pipe, the use of GPC reduces the wall thickness from 30 to 50%.

Preliminary calculations have been 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%. Additional savings will be accrued as work to optimize the glass particle size distribution and resin content is performed.

Development of a Glass Polymer Composite
Sewer Pipe from Waste Glass

Progress Report No. 4
April-June 1977

Introduction

Large quantities of energy can be conserved by recycling and utilization of municipal solid waste (MSW). In addition to the production of substantial quantities of energy and the recovery of valuable materials, the costs associated with landfilling wastes are lowered considerably.

At the present time recycled ferrous and non-ferrous metals have the highest market value. Paper and other combustibles which constitute as much as 50% of MSW have value as fuel or recycled paper. However, the remaining glass fraction which constitutes up to 10% of MSW, currently does not have a suitable market value. The development of the use of this fraction in the production of sewer pipe is directed toward providing that needed market.

The Brookhaven National Laboratory (BNL) program for the utilization of waste glass in construction materials is an outgrowth of concrete polymer technology.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 could be used as aggregate in PC formulations.² Potential

applications of glass polymer composite (GPC) as a material of construction 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 durability to acids which exist in municipal sewage and because of its high strength. 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.

Approximately 35 ft of 8-in.-diam pipe was installed for a field test in the Town of Huntington on Long Island, New York and 12 ft of 12-in.-diam pipe was installed in Newark, New Jersey. To date the GPC pipe has performed very satisfactorily with no apparent problems.

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 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 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 three progress reports have been issued.⁵⁻⁷ Accomplishments during the period April- June 1977 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.

The formulation used to produce GPC consists of 88.25 wt% glass and 11.75 wt% of a polyester styrene mixture. The glass fraction is obtained from the Cockeysville, Maryland solid waste separation plant and contains small quantities of organics, metals, and stones. A typical analysis is given in Ref. 6. The glass is then oven dried and ground to the required particle size distribution (see Ref. 7).

A monomer mixture consisting of 9.5 wt% styrene from which the inhibitor has been removed, 1.75 wt% of a low viscosity polyester resin,

and 0.5 wt% of a low shrinkage polyester is then mixed with the glass fraction. Prior to mixing, a silane coupling agent, an internal release agent, and a polymerization initiator, each at a concentration of 1% by weight of monomer, are added to the monomer.

The PC formulation is mixed in a conventional concrete mixer until all of the glass aggregate is wetted with monomer. It is then placed in the pipe forms and compacted using air-operated vibrators. Rotational casting methods may also be utilized. The pipe is cured by heating in an oven or with heated water at a temperature of 82°C for 4 hrs.

In the previous report period,⁷ increases in compressive and three-edge bearing strength of the GPC were noted as the percentage of fines in the mix was increased. Reductions in the amount of monomer needed to produce the GPC were also obtained. Since both effects will significantly reduce the energy input requirements and cost of GPC pipe, it was decided to repeat some of the earlier work using the improved glass mixture. This work is in progress and some of the results are summarized in Table 1. Additional specimens will be produced at each of the three wall thicknesses. To date, compared with earlier data,⁷ the use of the improved glass mixture has resulted in increases in the three-edge bearing strength of 30 and 42% for the 0.625 and 1.5-in. wall thickness pipe, respectively. These data have been utilized in preliminary materials and energy estimates which are summarized in Task 3.

Task 2. Field Test and Inspection

Monitoring of the performance of GPC pipe currently in test at Huntington, New York and Newark, New Jersey is being continued.

Table 1

Three-Edge Bearing Strength of GPC Pipe
Summary of Results, Series No. 2

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
276	0.625	3582 3510	3544	51	0.014
278	0.625	3009 2868 2769	2882	121	0.042
Entire Series			3213	381	0.118
279	1.50	14696 14580 14332	14536	186	0.013
282	1.50	14706 13908 14362	14325	400	0.028
Entire Series			14430	279	0.019
283	1.0	4654 4805 5346	4935	364	0.074
286	1.0	6156 6033 6606	6265	302	0.048
292	1.0	6806 7007	6907	142	0.021
296	1.0	5724 5600 6352	5892	403	0.068
Entire Series			6000	780	0.130

At Huntington, a total of 35 ft of 8-in.-diam pipe was installed during October 1972. Two pieces 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 late in FY 1977.

In November 1975 ~ 12 ft of 12-in.-diam pipe was installed in a sewer line in Newark, New Jersey. 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. Another inspection will be made in September 1977.

Task 3. Materials and Energy Estimate

During the report period preliminary estimates were made of the energy requirements to produce GPC and vitrified clay sewer pipe.

In the previous report⁷ a summary of the wall thicknesses of GPC pipe meeting various ASTM specifications was listed. During the current period these calculations were revised using three-edge bearing strength data obtained from samples prepared with finer-ground glass. Data from Batches 276, 278, and 279 (see Table 1) were utilized. The method of calculation was described in Progress Report No. 3.⁷

Energy requirements to produce GPC and vitrified clay pipe were calculated using the assumptions listed below.

a. The ultimate energy consumption for polystyrene resin is 116×10^6 BTU/ton.⁸

b. The ultimate energy consumption for vitrified clay is 9×10^6 BTU/ton.

c. All of the organic components of GPC (styrene, polyester, initiator, etc.) were combined and assumed to have the energy consumption of polystyrene resin. The assumed overall resin content of the GPC was 12.51% wt.

d. The energy consumption for fabricating both types of pipe (mixing and forming or casting) was neglected in these preliminary estimates based upon an assumption that it was small in comparison with the energy requirements for the finished polymer and clay.

e. Both types of pipe must meet the requirements of ASTM Specification C700-75 for Extra Strength Pipe since Standard Strength Pipe is not specified in the Baltimore County (the source of the glass aggregate) area.

The results from these calculations are summarized in Table 2. In general, the use of GPC results in a savings in energy ranging up to 16%. These savings will probably increase as additional work to optimize the glass particle size distribution and resin content is performed.

Uncertainties in the assumed value for the ultimate energy consumption for styrene also could result in the savings indicated in

Table 2

Comparison of Energy Requirements for Glass Polymer
Composite and Vitrified Clay Pipe

<u>Nominal Size^a</u>	<u>Energy Requirements, Million BTU/Mile</u>		<u>Energy Saving, %</u>
	<u>Extra Strength Vitrified Clay</u>	<u>Glass-Polymer Composite</u>	
4	235.4	235.0	+0.2
6	371.4	432.4	-16.4
8	626.4	685.3	-9.4
10	885.7	993.7	-12.2
12	1260.3	1357.6	-7.7
15	1992.2	2121.2	-6.5
18	3003.0	2512.8	+16.3
21	4218.9	3839.4	+9.0
24	5340.0	5066.4	+5.1
27	6589.4	6056.8	+8.1
30	7971.0	7129.0	+10.6
33	9403.2	8773.6	+7.5
36	11123.1	10588.1	+4.8
39	12896.0	12572.2	+2.5
42	14799.4	14097.8	+4.7

a, ASTM Specification C700-75

Table 2 being considered as a lower limit. As noted above, a value of 116×10^6 BTU/ton was used in the calculations. Other published data⁹ indicate values as low as $\sim 50 \times 10^6$ BTU/ton. If the latter are correct, the energy savings listed in Table 2 would be increased by a factor of 2.3.

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