STABILIZED FLY ASH AS LIGHTWEIGHT FILL

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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Stabilized fly ash as
lightweight fill

STABILIZED FLY ASH AS LIGHTWEIGHT FILL

Research Laboratory Section
Testing and Research Division
Research Project 81 TI-785
Research Report No. R-1226

Lansing, June 1983

This project was initiated as a result of a memorandum from D. F. Malott to K. A. Allemeier (December 15, 1981) in which it was requested that the Research Laboratory investigate the properties of cement-stabilized fly ash to determine its suitability as a relatively lightweight fill material and specifically to determine:

1) Ultimate unit weight of in-place stabilized fly ash where placed as an embankment near or below water level,

2) Susceptibility of the material to breakdown under repeated freeze-thaw cycles.

Two fly ash samples, from different sources, were furnished by the Michigan Foundation Co., Inc. for use in this study.

Testing Program

Three levels of cement treatment, 0, 5, and 10 percent by weight of the fly ash, were used with each of the two types of fly ash. Maximum AASHTO T-99 density and optimum moisture content were determined for each combination, results of which are shown in Figure 1.

Percent saturation at various heights above a water table were determined for each sample condition, using a membrane apparatus and desorption test procedure. Figure 2 shows the relationships between wet density and height of the material above a water table.

Cement-stabilized samples were tested for freeze-thaw durability in accordance with AASHTO T-136 test procedures. Unstabilized samples (fly ash alone) were unable to withstand the preliminary saturation required for the test. The deterioration of the cement-stabilized samples due to the freeze-thaw cycles is shown in Figure 3.

A limited study was also conducted to determine certain engineering characteristics of the fly ash used. These tests included determination of gradation, permeability, apparent cohesion and angle of internal friction, Ø, (by the triaxial test method), and frost susceptibility. These data are included in Tables 1 and 2. Figure 4 shows typical frost heave experienced by a fly ash sample.

Discussion of Results

As shown in Figures 3 and 4, our laboratory tests indicate cement-stabilized fly ash, when compacted to T-99 density, deteriorated as a result of freeze-thaw action, and fly ash alone was highly susceptible to frost heaving. Our results are in conflict with those obtained by a commercial testing laboratory for a contractor using cement-stabilized fly ash as a

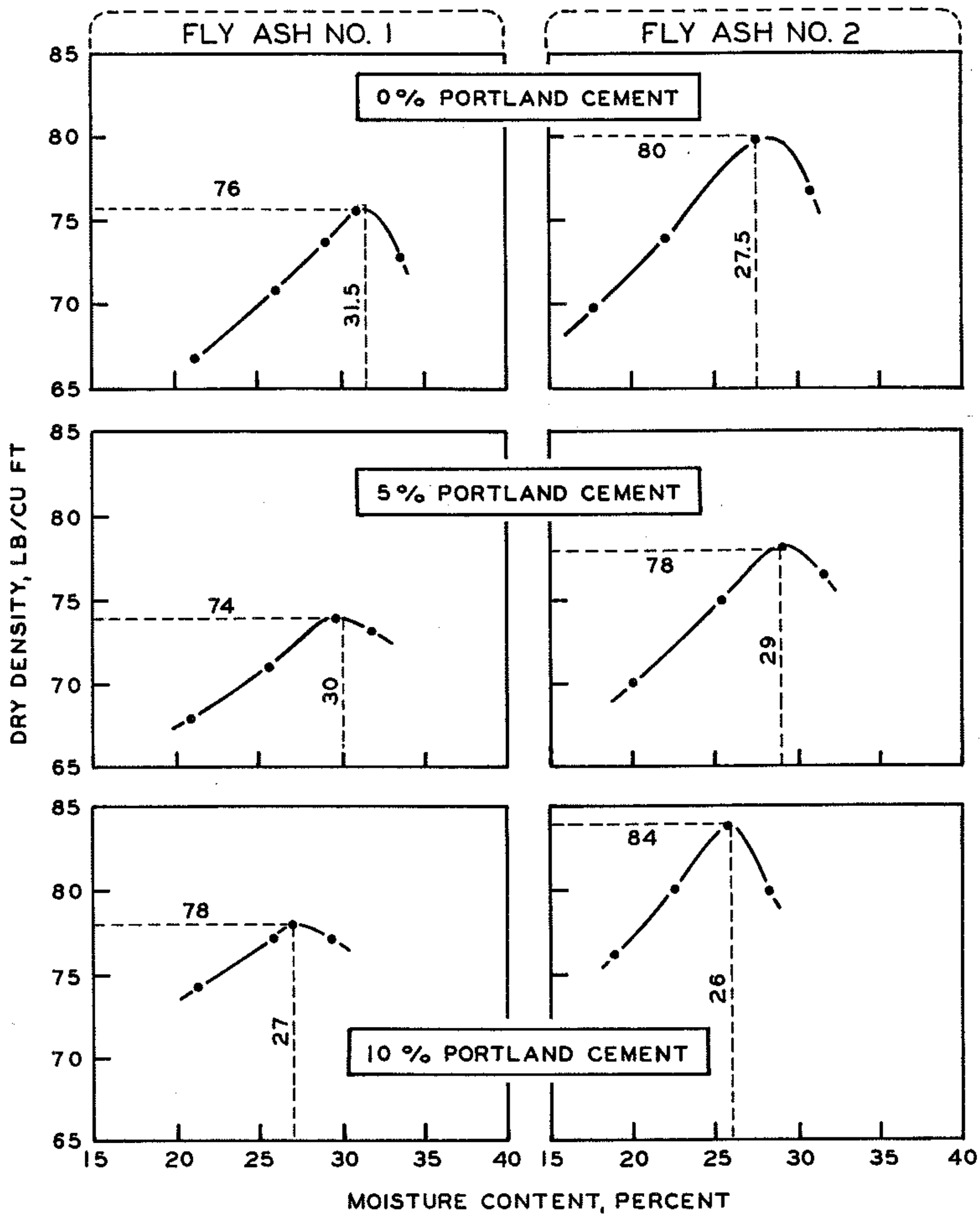

Figure 1. AASHTO T-99 moisture density relationships of portland cement fly ash mixtures.

base mixture (Appendix). These data were furnished to us by the Michigan Foundation Co., Inc.

TABLE 1
SUMMARY OF DENSITY, FREEZE-THAW DURABILITY, FROST SUSCEPTIBILITY, AND GRADATION TEST RESULTS

Fly Ash	Portland Cement, percent	T-99 Density		Freeze-Thaw Durability T-136				Frost Suscep-tibility,	Gradation		
		Dry, lb/cu ft	Opt., H_2O	Water Content, percent	Dry Density, lb/cu ft	No. of Cycles to Failure	Fly Ash Cement Loss, percent		Clay, percent	Silt, percent	Sand, percent
	0	76	32	--	--	--	--	High	22	68	10
1	5	74	30	31	74	8	45	--	--	--	--
	10	78	27	28	78	11	48	--	--	--	--
	0	80	28	--	--	--	--	High	10	78	12
2	5	78	29	29	77	9	50	--	--	--	--
	10	84	26	22	79	8	47	--	--	--	--

The difference in results might be due to differences in the compacted densities used. Our tests were conducted in accordance with the AASHTO T-136 specification procedure, which calls for the T-99 compaction effort. The results shown in the Appendix were obtained using modified T-136 procedures in which the compactive effort was equivalent to that obtained in the T-180 test.

For design purposes, the wet density of fly ash and portland cement-stabilized fly ash can be obtained from Figure 2. This figure indicates that the design weight of fly ash fills will depend on the type of fly ash used, the amount of treatment with cement, and the height of the fill above a water table. The detrimental influence of the high capillary sorption characteristics of fly ash could be diminished by placing a layer of granular material between the fill and the free water table. For the materials tested, saturated density varied from about 103 to 110 lb/cu ft.

The engineering properties of the fly ash samples tested (Table 2) indicate that its shearing resistance, as expressed by the angle of internal friction, ϕ, may be dependent on density. When the dry density is equal to or greater than maximum T-99 density, the angle of internal friction, ϕ, varies from 40 to 45 degrees. At slightly reduced density (73 lb/cu ft for sample 1), even when the water content was lower (64 percent saturation), the angle of internal friction was reduced from 45 to 29 degrees, as indicated in Table 2. Most permeability tests conducted on fly ash indicate it has a low permeability, generally less than 0.5 ft/day. One sample, how-

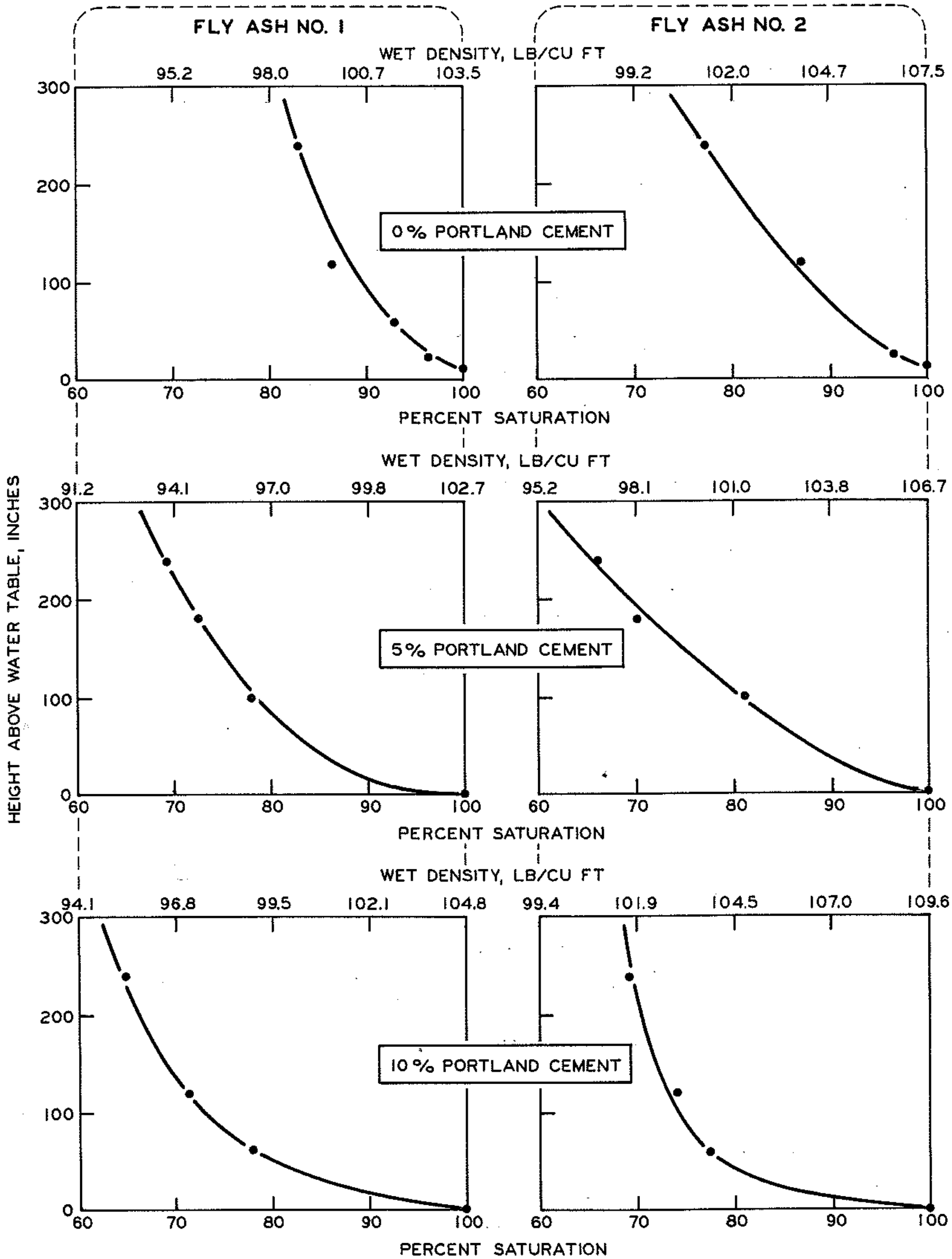

Figure 2. Percent saturation and wet density at various distances above the water table.

ever, as shown in Table 2, had a high permeability of 8.0 ft/day. The reason for such a high permeability value could not be determined.

TABLE 2
SUMMARY OF TRIAXIAL AND PERMEABILITY TEST RESULTS

Fly Ash	Percent Saturation	Dry Density, lb/cu ft	Apparent Cohesion, psi	Angle, ø	Permeability, ft/day
1	100	76	0	45	0.4
	64	73	12	29	---
2	100	80	6	40	0.1
	100	81	1	43	8.0

Conclusions

The following properties of fly ash and portland cement-stabilized fly ash are indicated as a result of this study.

1) The design unit weight of fly ash and fly ash cement mixtures will vary with the height of the proposed fill above a water table or a capillary cut-off layer and on the percent cement added. Design unit weight, wet density, may be estimated directly from Figure 2.

2) The fly ash and fly ash cement mixtures are detrimentally affected by frost action when compacted to T-99 density so care should be taken to provide a proposed fill with sufficient cover to prevent freezing. Greater resistance to frost action at T-180 density is indicated by data provided by the Michigan Foundation Co., Inc., but freeze-thaw durability at higher density was not investigated in this study.

3) Fly ash has a design angle of internal friction, ø, of approximately 40 degrees when compacted to 100 percent of T-99 density. A reduction of angle ø may occur at densities slightly lower than 100 percent of T-99 density. In other respects, fly ash properties are similar to those of a fine silt.

Where readily and economically available, and if protected from freeze-thaw cycles, cement-stabilized fly ash could be used as a relatively lightweight fill material.

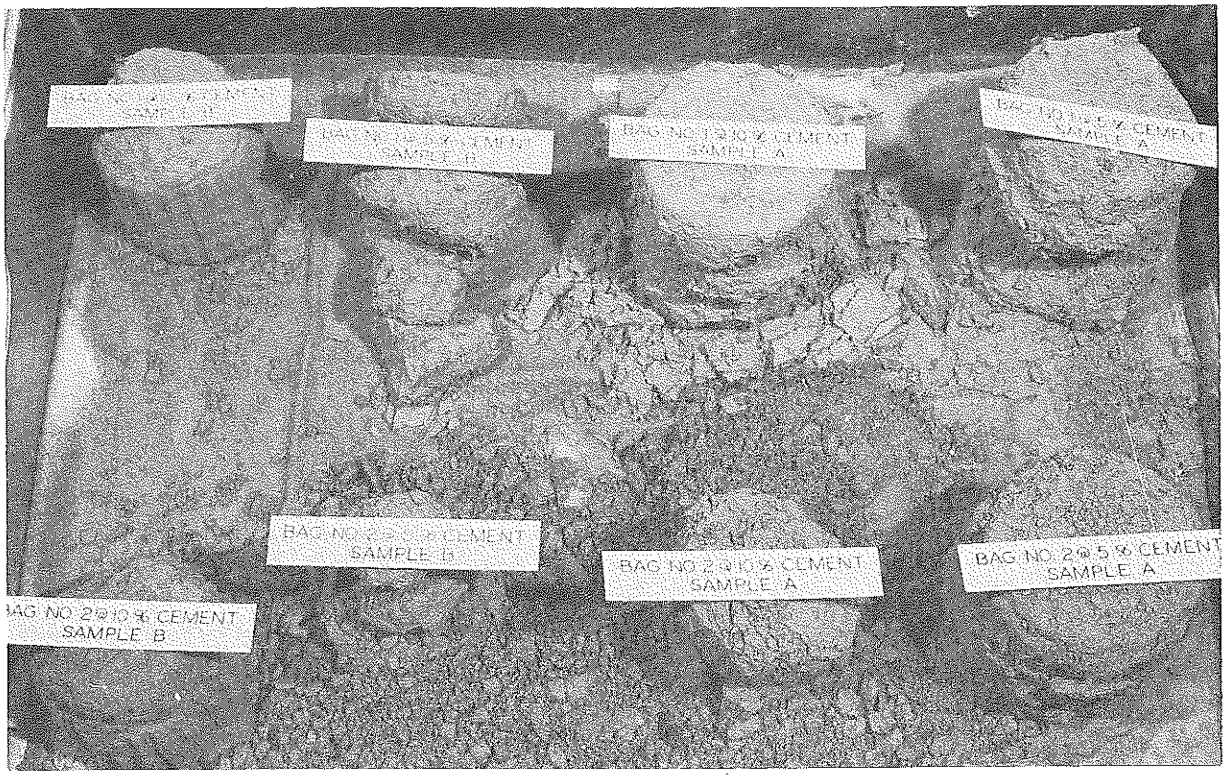

Figure 3. Effect of freeze-thaw cycles on cement-stabilized fly ash samples.

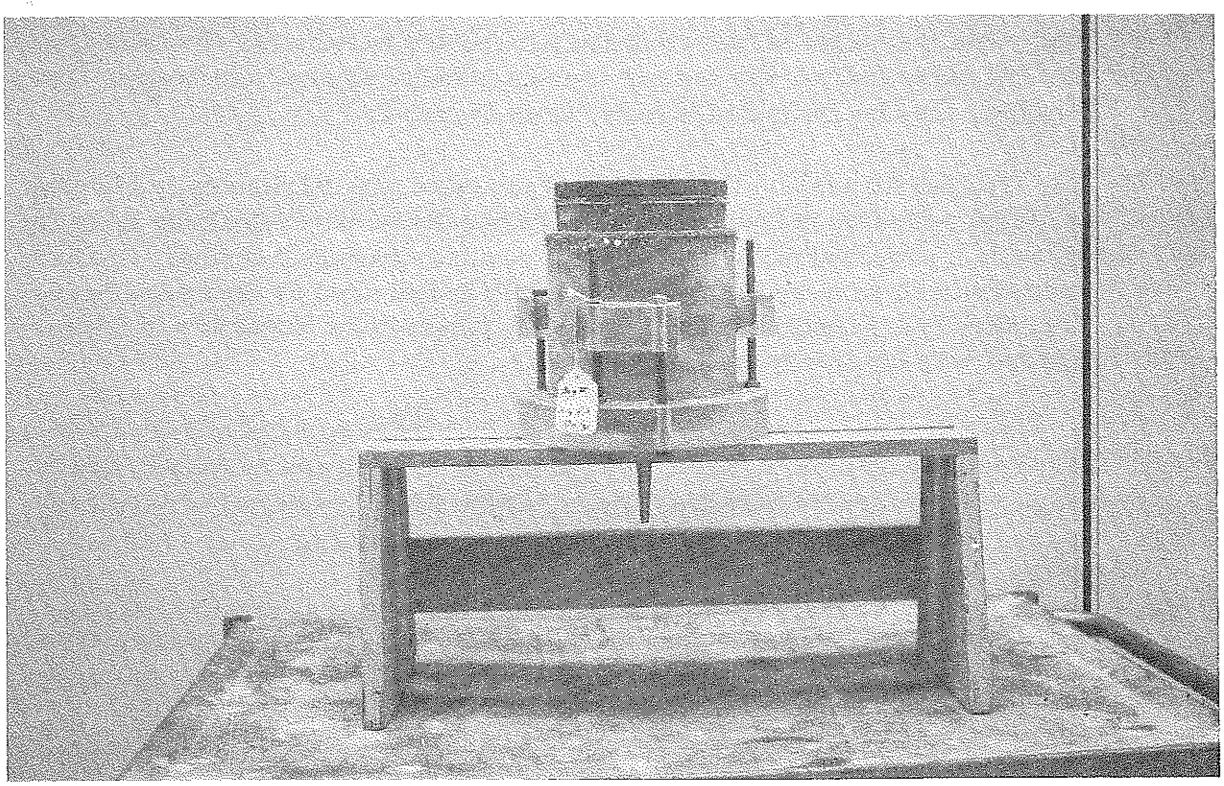

Figure 4. Frost heave of fly ash sample.

APPENDIX

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FRANK A. HENDERSON
EDWARD S. LINDOW, JR., P.E.

April 23, 1981

Michigan Foundation Company, Inc.
110 West Jefferson
Trenton, Michigan 48183

Attention: Mr. Wayne Hatchett

RE: Freeze-Thaw Test
Fly Ash/Cement Base Mix
SME Job No. 6497

Gentlemen:

A freeze-thaw test has been performed on one specimen of a fly ash/ cement base mixture. The specimen was molded using a 90/10 ratio of fly ash to cement (dry weights) with 23% water added during mixing. This water content was selected as the optimum based on the mixture's modified proctor curve. The specimen was compacted using the modified proctor compactive effort providing a dry density of 81.6 pcf.

The freeze-thaw testing generally followed the standard method of AASHTo T-136. Twelve cycles of freezing and thawing were conducted. At the conclusion of the 12th cycle, the specimen was oven dried to a constant mass. The specimen loss during the freeze-thaw testing was calculated to be 1%. Based on this loss and the general appearance of the specimen after testing, the frost susceptibility of the subject mixture is judged to be not significant.

If you have any questions concerning this information, please contact us.

Very truly yours,

SOIL AND MATERIALS ENGINEERS, INC.

Edward S. Lindow, Jr., P.E.
Project Manager

ESL/sw

5pc: Enclosed

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May 14, 1981

Michigan Foundation Company, Inc.
110 West Jefferson
Trenton,Michigan 48183

Attention: Mr. Wayne Hatchett

RE: Freeze-Thaw Test
Fly Ash/Cement Base - 92/8 Mix
SME Job No. 6497

Gentlemen:

A freeze-thaw test has been performed on one specimen of a fly ash/cement base mixture. The specimen was molded using a 92/8 ratio of fly ash to cement (dry weights) with 23% water added during mixing. This water content was selected as the optimum based on the mixture's modified proctor curve. The specimen was compacted using the modified proctor compactive effort providing a dry density of 81.6 pcf.

The freeze-thaw testing generally followed the standard method of AASHTO T-136. Twelve cycles of freezing and thawing were conducted. At the conclusion of the 12th cycle, the specimen was oven dried to a constant mass. The specimen loss during the freeze-thaw testing was calculated to be 4%. Based on this loss and the general appearance of the specimen after testing, the frost susceptibility of the subject mixture is judged to be not significant.

If you have any questions concerning this information, please contact us.

Very truly yours,

SOIL AND MATERIALS ENGINEERS, INC.

Edward S. Lindow, Jr., P.E.
Project Manager

ESL/sw

5pc: Enclosed