Technical Report Documentation Page

1. Report No.	**2. Government Accession No.**	**3. MDOT Project Manager**
R-1494		

4. Title and Subtitle Graphical Analysis of Iowa Pore Index Test Results	**5. Report Date** May 2007 **6. Performing Organization Code**
7. Author(s) Robert W. Muethel	**8. Performing Org. Report No.**
9. Performing Organization Name and Address Michigan Department of Transportation Construction and Technology Division P.O. Box 30049 Lansing, MI 48909	**10. Work Unit No. (TRAIS)** **11. Contract No.** **11(a). Authorization No.**
12. Sponsoring Agency Name and Address Michigan Department of Transportation Construction and Technology Division P.O. Box 30049 Lansing, MI 48909	**13. Type of Report & Period Covered** **14. Sponsoring Agency Code**

15. Supplementary Notes

16. Abstract

Aggregates that record high water uptake during the Iowa Pore Index test, Michigan Test Method MTM 128, typically produce high expansions in concrete when tested for freezing and thawing according to Michigan Test Method MTM 115, using vacuum-saturation pre-treatment. Absorption values obtained during Iowa Pore Index tests conducted on absorbent and dense aggregates were used to generate graphical plots. Highly absorbent aggregates that produce high expansions in concrete when subjected to freeze-thaw tests were shown to produce curves that followed power correlations, whereas dense aggregates that produce low expansions in the freeze-thaw test were shown to produce curves that followed linear correlations.

17. Key Words	**18. Distribution Statement**
water uptake, freeze-thaw expansions, aggregates, graphical analysis	No restrictions. This document is available to the public through the Michigan Department of Transportation.

19. Security Classification - report	**20. Security Classification - page**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified		

MICHIGAN DEPARTMENT OF TRANSPORTATION
MDOT

Graphical Analysis of Iowa Pore Index Test Results

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Research Report R-1494

Lansing, Michigan
May 2007

ACKNOWLEDGEMENTS

The author wishes to thank Thomas Woodhouse for providing the expansion data necessary for this analysis. Also thanks to Robert Miller for the graphics and technical review of the correlations.

SUMMARY

A graphical analysis procedure was used to investigate the rates and amounts of water up-take in selected aggregates when tested according to the Iowa Pore Index Test procedure, Michigan Test Method MTM 128. The graphical analysis procedure produced curves that followed power and linear correlations. Aggregates that record high water up-take during the Iowa Pore Index test typically produce high freeze-thaw expansions in concrete beams when tested according to Michigan Test Method MTM 115 for freeze-thaw durability when following the standard vacuum-saturation aggregate pre-treatment procedure.

OBJECTIVES

The objective of the graphical analysis was to investigate the types of correlations shown by the water up-take in selected aggregates during the Iowa Pore Index test. The analysis includes typical examples of the major aggregate types used in concrete.

SAMPLES

Six aggregates were selected to represent both synthetic and natural types that record high to low freeze-thaw expansions in the freeze-thaw test conducted according to the Michigan Test Method MTM 115 (1).

Synthetic, absorbent aggregates are represented by expanded shale, blast furnace slag, and recycled Portland cement concrete.

Heterogeneous gravel, containing many differing rock type categories including varying percentages of deleterious aggregate, was included to represent similar Michigan glacial gravels.

Heterogeneous quarried stone containing both dense and absorbent rock subtypes was included as an example of similar sources.

Homogeneous quarried stone containing only dense particles with low absorbency was included as an example of similar regional sources.

Table 1 lists the aggregates by source name and Aggregate Source Index (ASI) numbers. The reference numbers in the table indicate the corresponding MDOT freeze-thaw test reports noted in the References section of this report. The table also includes the aggregate types in the samples.

TABLE 1 **Samples**				
Sample No.	Source	ASI No.	Ref. No.	Aggregate Type
1	Carolina Solite	99-004	3	Expanded Shale
2	Levy (Dix)	82-019	4	Blast Furnace Slag
3	I-94 PCC	99-003	5	Recycled Concrete
4	Round Lake	46-047	6	Heterogeneous Gravel
5	Rockwood	58-008	7	Heterogeneous Quarried Stone
6	Cedarville	49-065	8	Homogeneous Quarried Stone

RESULTS OF IOWA PORE INDEX ABSORPTION GRAPHICAL ANALYSIS

The Iowa Pore Index measurements, recorded at one-minute intervals for a total of fifteen minutes during the MTM 128 Iowa Pore Index test (2), were graphed on worksheets. From the data plots, appropriate correlations were identified.

Water uptake rates of the absorbent aggregates produced power correlation curves resulting from the rapid initial absorption by large, open pores, followed by slower absorption as the smaller pores became filled. The absorbent aggregates included expanded shale, blast furnace slag, recycled Portland cement concrete (PCC), the absorbent subtype in the heterogeneous quarried stone, and the deleterious rock constituents (soft particles and chert) of the heterogeneous gravel.

The least absorbent aggregates were the igneous/metamorphic and dense carbonate subtypes in heterogeneous gravel and the dense homogeneous quarried stone.

Absorption curve plots generated from the absorption data are shown in Figures A1 through A4 of the Appendix.

Table 2 includes a list of corresponding freeze-thaw expansions that were recorded for concrete specimens containing the selected aggregates.

TABLE 2 **Freeze-Thaw Expansions**				
Sample No.	Source	ASI No.	Expansion per 100 Cycles, % MTM-115 Report	Ref. No.
1	Carolina Solite	99-004	0.525	3
2	Levy (Dix)	82-022	0.100	4
3	I-94 PCC	99-003	0.067	5
4	Round Lake	46-047	0.160	6
5	Rockwood	58-008	0.044	7
6	Cedarville	49-065	0.003	8

CONCLUSIONS

The plots of water up-take during the Iowa Pore Index test show that absorption occurs at rates that result in power and linear correlation curves, dependent upon the pore characteristics of the aggregate.

The absorbent aggregates that show power correlation curves can produce high freeze-thaw dilations in concrete tested according to the Michigan Test Method MTM 115 procedure. Aggregate with low water uptake, showing a linear correlation, typically produces low freeze-thaw dilation in the freeze-thaw test.

REFERENCES

1. Michigan Test Method for Testing Concrete for Durability by Rapid Freezing in Air and Thawing in Water, MTM 115.

2. Michigan Test Method for Determination of Iowa Pore Index of Coarse Aggregates, MTM 128.

3. MDOT Report of Test, Freeze-Thaw No. 03FT-10
   Carolina Solite, ASI# 99-004, Lab. No. 03A-3134 (Sample 1)

4. MDOT Report of Test, Freeze-Thaw No. 89FT-31
   Levy (Dix), ASI# 82-019, Lab. No. 89A-3972 (Sample 2)

5. Tested for information, no report issued.
   I-94 Recycled PCC, ASI# 99-003, 83A-2527 (Sample 3)

6. MDOT Report of Test, Freeze-Thaw No. 99FT-25
   Round Lake, ASI#46-047, Lab. No. 99A-3204 (Sample 4)

7. MDOT Report of Test, Freeze-Thaw No. 03FT-06
   Rockwood, ASI# 58-008, Lab. No. 03A-3026 (Sample 5)

8. MDOT Report of Test, Freeze-Thaw No. 01FT-19
   Cedarville, ASI# 49-065, Lab. No. 01A-3176 (Sample 6)

APPENDIX A

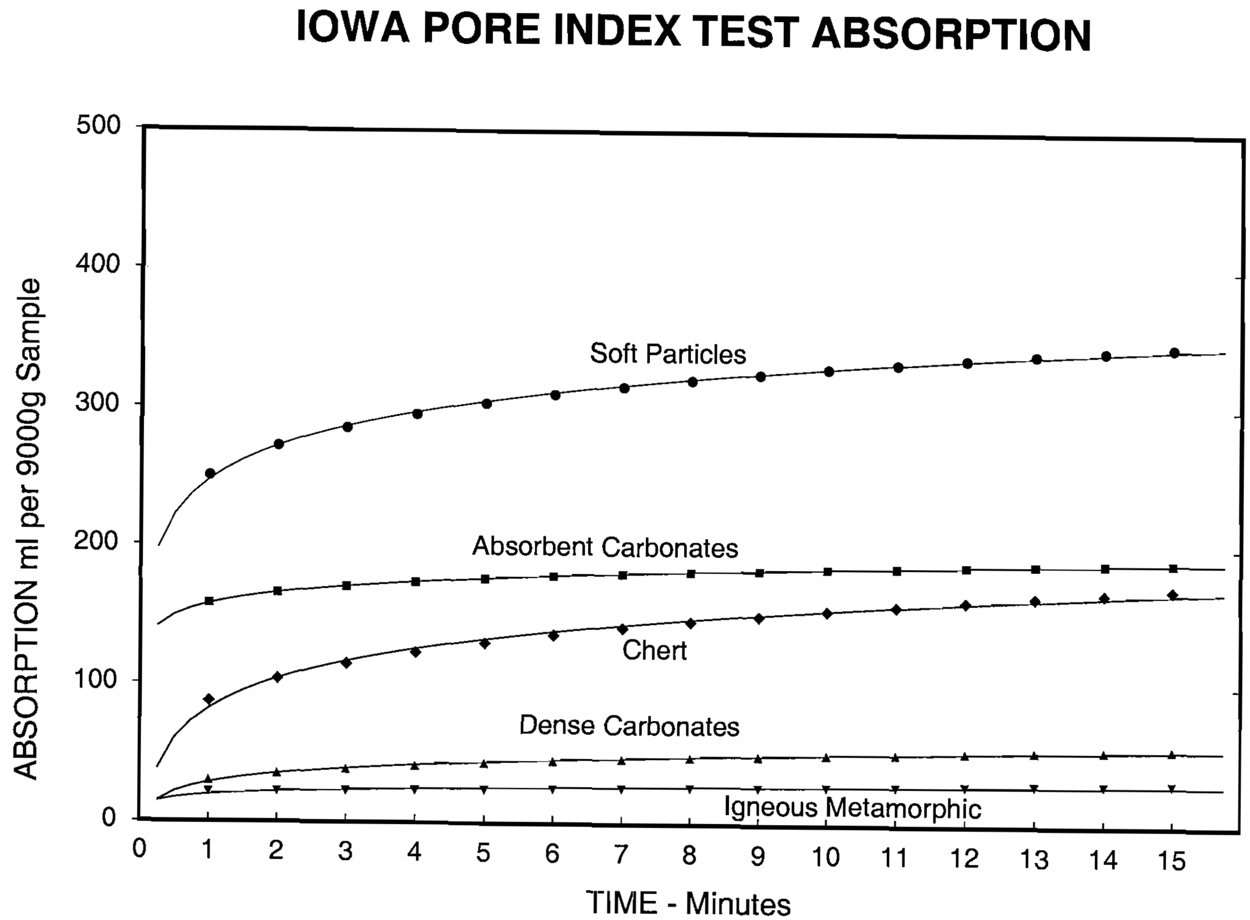

Figure A1. Heterogeneous Gravel

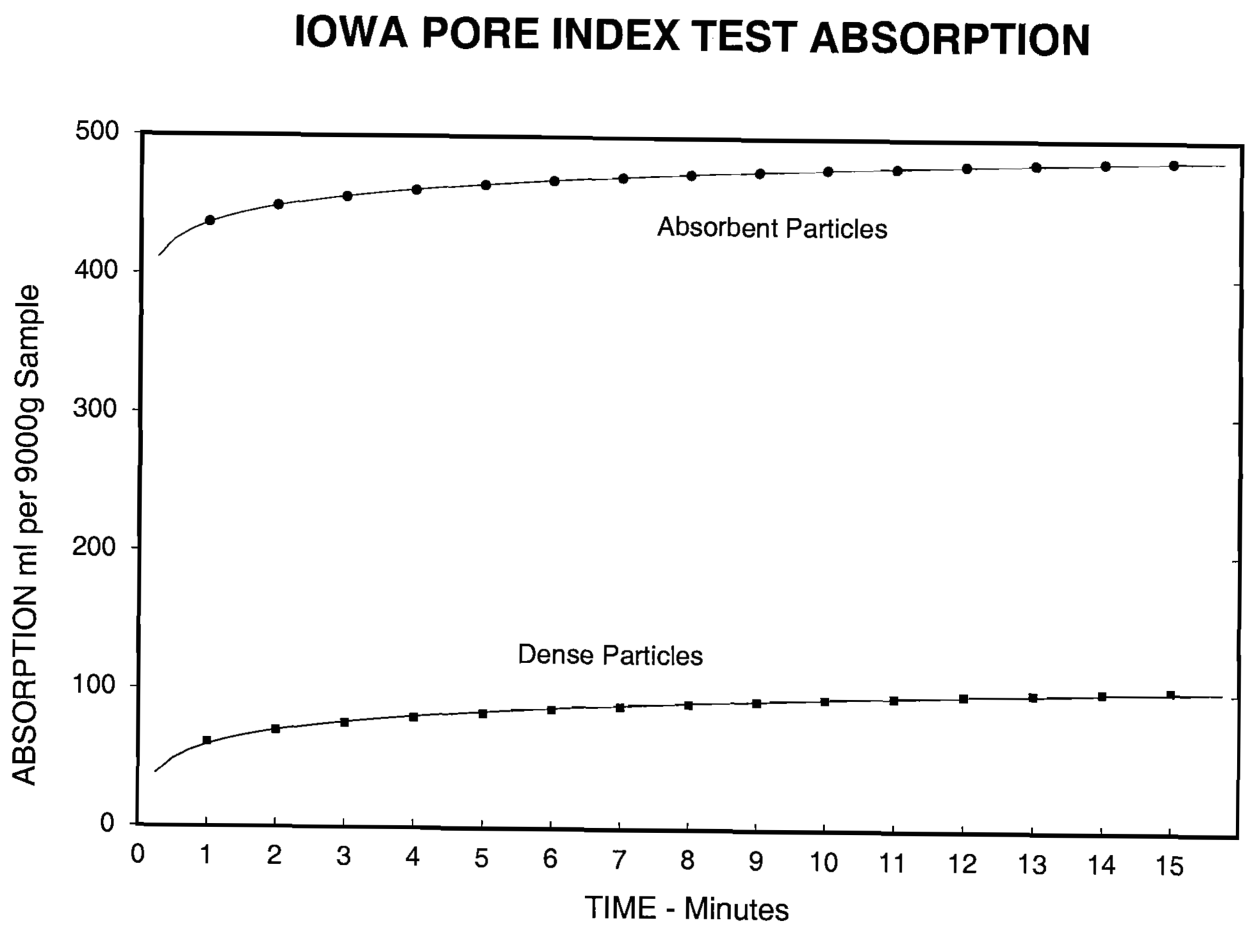

Figure A2. Heterogeneous Quarried Stone

FREEZE - THAW EXPANSION

Beam 99A - 3204-1-3

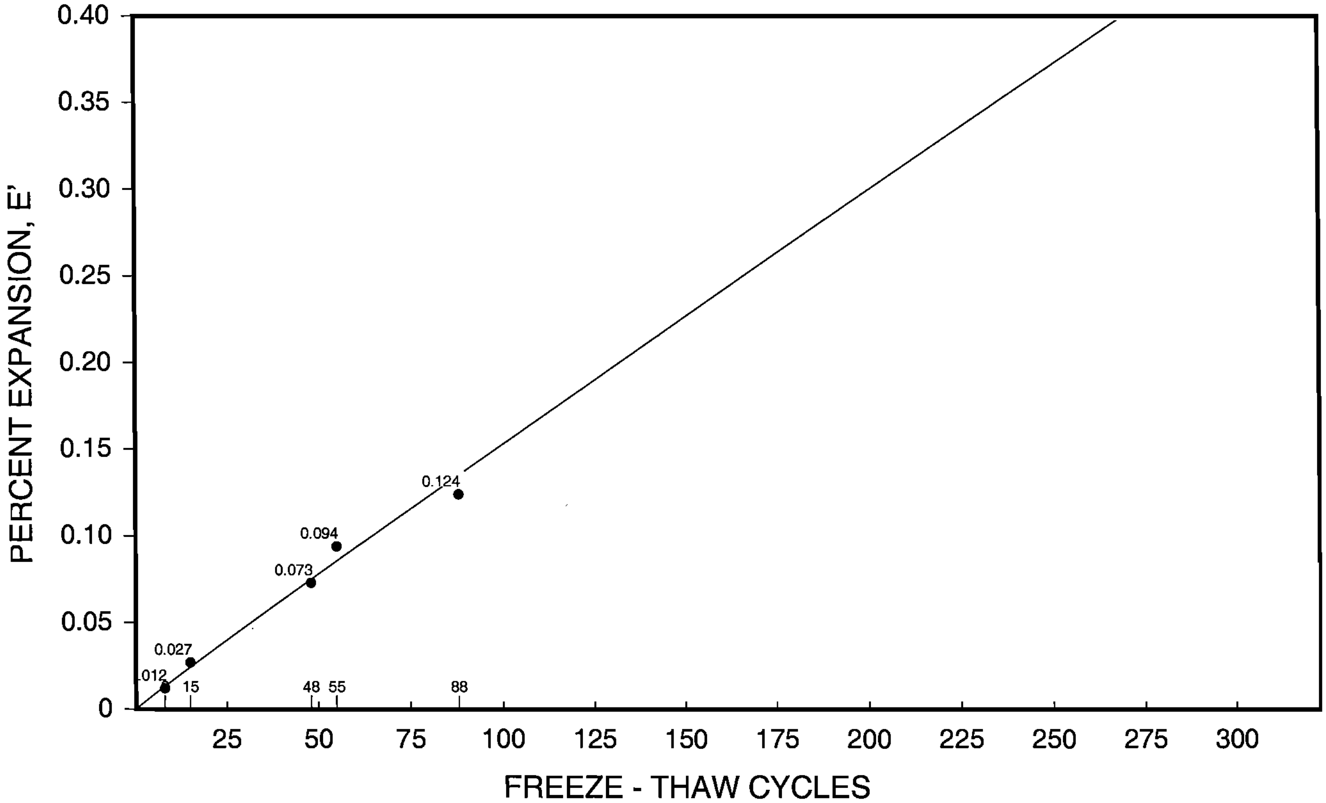

Figure A3. Heterogeneous Gravel

FREEZE - THAW EXPANSION

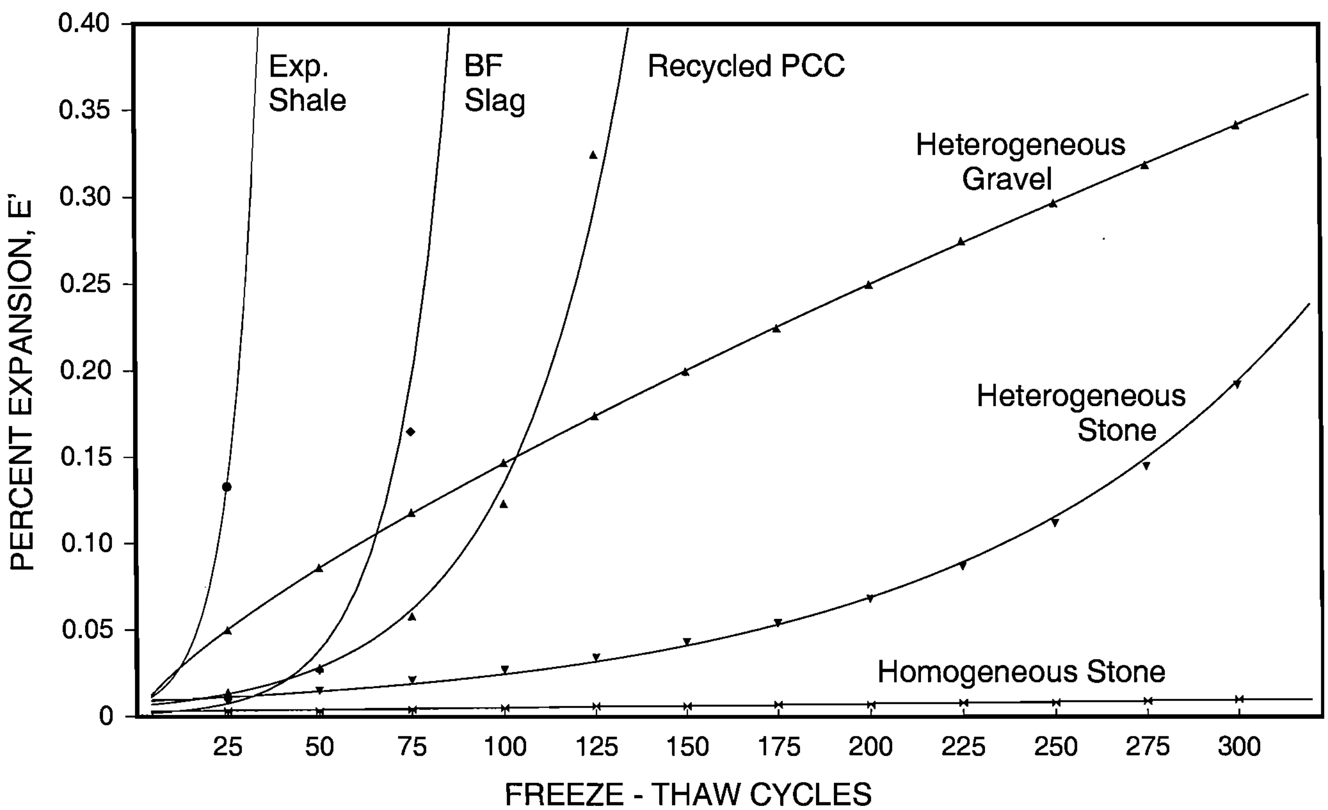

Figure A4. Plots of F-T Correlation Curves