

**LABORATORY STUDY OF THE
LEACHATE FROM CRUSHED
PORTLAND CEMENT
CONCRETE
BASE MATERIAL**

**Final Report
For
MLR-96-4**

September 1999

Project Development Division



**Iowa Department
of Transportation**

Laboratory Study of the Leachate
From Crushed Portland Cement Concrete
Base Material

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8. ABSTRACT

Since the 1980's, the Iowa Department of Transportation has increased its use of recycled Portland Cement Concrete (PCC) as drainable base material below some new pavements. Water flowing out of the longitudinal drains on projects having recycled PCC drainable bases was found to have a high pH value. The high pH water impedes vegetation growth and becomes a contributing factor to soil erosion at the drain outlet. In addition, the high pH water contributes to the growth of crystalline deposits on the drain outlet wire mesh rodent guard and in some cases caused it to become completely blocked. This research determined which of three choices of recycled PCC drainable base material, gradation, and design would give the lowest pH value in the drain discharge water.

The drainable base material having its fines separated out and placed as a 2" bottom layer, below the remaining coarse material, generally gave pH values around 11.2 while other designs tested gave pH values around 11.5

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DISCLAIMER

The contents of this report reflect the views of the author and do not necessarily reflect the official views of the Iowa Department of Transportation. This report does not constitute any standard, specification or regulation.

INTRODUCTION

Since the mid 1980's the Iowa Department of Transportation has been applying more efforts toward new techniques and applications of conserving and recycling highway materials. One of these efforts is in the area of using recycled, crushed, or rubblized Portland Cement Concrete (PCC) as drainable base material below new or reconstructed pavements. The basic idea is definitely in line with the philosophy of reuse and conservation of material resources, however, this application does also generate several new concerns. Three of the primary concerns are:

1. High values of pH in the drainage water which has filtered through the drainable base and is being discharged at the edge drain outlet.
2. Precipitation of calcium carbonate across the rodent guard screens at the edge drain outlets.
3. Drainage water erosion channels from loss of vegetation, due to high pH water.

This report investigates the problems concerning drainage water pH values. The drainage water pH is raised as it filters through the recycled drainable base material. The pH is lowered as the discharged water encounters soil in the right-of-way.

The high pH water can be detrimental to growth of grass or other vegetation near the drain outlets. The lack of the grass root structure, in turn, allows soil erosion to occur below and beyond the drain outlet. Severe erosion may cause the drain outlet headwall to be displaced. This erosion is also hazardous for right-of-way mowing operations.

OBJECTIVE

The objective of this research was to simulate drainage of water through recycled crushed PCC base material and record the resultant change of pH in the water. The test was scheduled to be done weekly throughout one year to be able to observe any trends overtime in pH value. A Materials Laboratory Research (MLR) proposal was prepared (see Appendix A).

DISCUSSION

Problems of soil erosion were being noted at drain outlets, specifically in western Iowa, in the area of loess soils. Of course, the erosion is detrimental to efficient and safe grass mowing operations. Field trip observations tied the erosion to lack of vegetation growth as a result of high pH water from drain outlets. Field trip observations also turned up several cases where the wire mesh rodent guards had been clogged with calcium carbonate precipitation. See Appendix B, photos 1, 2, 3, and 4 showing drain rodent guard blockage and soil erosion.

MATERIALS

CAggregates

Drainable base materials were obtained from a 1995 project on US 151 in Linn County. The material had been stockpiled for about 1 year at the time the sample was collected.

CWater

Distilled water was used as entrance water for the tests.

EQUIPMENT

Three narrow and long boxes were constructed to contain the aggregate and water for the test (see Appendix C). The boxes were made of Plexiglas to allow visibility through the walls. Box dimensions were 6 inches wide, by 6 inches high, by 48 inches long. The top was a sliding removable cover. A compartment to pour water into the box was at the top of one end and a cork-plugged outlet was at the bottom of the opposite end. The compartment regulated the actual water flow into the box to a low level. The boxes were set at a slight angle so that any water that was poured in at the top end would flow toward the lower corked outlet. The boxes were kept in the Cement and Concrete laboratory wet room during the test period.

A 500 ml beaker was used to pour distilled water into the top end of the boxes and to catch the outflow water. A Cole-Parmer pH tester with Automatic Temperature Control (ATC) was used to determine the pH of the water flowing out of the boxes.

TEST PROCEDURE

The materials were uniformly placed in three lifts in each box and were hand compacted. The contents of each box were as follows:

CBox A

32 lbs. fines (bottom 2")
60 lbs. #12 gradation (top 4")
92 lbs. TOTAL

CBox B

10 lbs. fines
96 lbs. #12 gradation
106 lbs. uniformly mixed together (full 6") TOTAL

CBox C

95 lbs. # 12 gradation (full 6") TOTAL

NOTES:

#12 gradation aggregate is granular subbase of 1.5 inches or smaller size.

Current practice in Iowa, with some limitations, is to allow a 2" layer of produced fines at the bottom of a recycled PCC drainable base.

For the duration of the test, the 3 boxes were placed in the PCC laboratory moisture room. Distilled water was poured in with the aggregate until each box was full. The water was left in the boxes for an initial 24 hour soaking period. Readings for pH were taken at the beginning and end of the 24-hour period. After the soaking period, the boxes were drained from their lower end outlets.

After seven days, 500 ml of distilled water was poured into the upper end of the box. The filtrate water which later arrived at the lower end of the box, after two to five minutes, was collected and analyzed for its pH value. The seven day waiting and testing cycle was repeated for one year.

TEST RESULTS

Upon the initial combining of distilled water with the recycled crushed PCC drainable base material, the water pH soon rose to the range of 12.5. Over the first 10 weeks of testing the pH gradually came down to around 11.5. It leveled off and stayed around that value for the next 20 weeks. Within the last 20 weeks of testing there was a dip in the pH down to around 11.0. However, this dip is believed to be due to problems with the pH meter. After the meter was repaired, the pH readings were again around 11.5.

From comparison of pH values between the 3 boxes, it was clearly evident that Box A consistently had a pH value of about 0.3 lower than Box B or Box C (see Appendix D for a graph of the results). As testing progressed, considerable amounts of calcium carbonate precipitated around the outlet holes.

CONCLUSIONS

The design of the drainable base material in Box A produced a slightly (but significantly) lower pH drainage water than the mixtures in Boxes B and C. The cause for this is not totally known. A plausible scenario is as follows: Box A had a two-inch layer of fine particles in the bottom. These fine particles offered a large surface area and a small mass per particle. The active lime would be easily leached from these fines initially and removed or reacted with atmospheric CO₂. Additionally, during stockpiling, the active lime would be subject to reaction with the

atmospheric CO₂. The small mass means that there would be no additional free lime to continue contact with the wash water. In boxes B and C, the water would only leach a small percentage of the available lime in each relatively large piece of aggregate. Thus there would be a more continuous supply of lime to cause the higher pH values in the wash water.

Although the initial three months of testing showed some decline in pH value, the following nine months showed the pH value to decline very little.

From field observations related to this test:

1. High pH levels of drainage water will continue high for many years following construction.
2. The high pH drainage water will leave precipitates at the edge drain outlets. The precipitate growth can completely block the wire mesh rodent guards at the end of a drain outlet and cause drainage water to be backed up inside the drain. This is not a problem with the 'finger' type rodent guards.
3. The high pH of the drainage water can kill or impede grass growth at the drain outlet.
4. Soil erosion may occur from a loss of vegetation growth at drain outlets which have high pH water discharge. The erosion can become a hazard for the maintenance mowing equipment and personnel. It can also cause the headwall slabs to fall away.

IMPLEMENTATION

The results of this research will be provided to the Iowa DOT Design, Methods, Soils, Roadside Development, and Maintenance sections for their use in decisions for improvements or design changes in the future.

FUTURE RESEARCH NEEDS

A listing of all paving projects using recycled PCC as drainable base material should be tabulated. A survey of longitudinal drain outlet water pH values should be made, covering those projects. The data should be evaluated for pH value, project design, material used and project age.

ACKNOWLEDGMENT

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APPENDIX A
MATERIALS LABORATORY RESEARCH PROPOSAL

DATE: November 18, 1996

PROJECT: MLR-96-4

PROJECT TITLE: Laboratory Study of the Leachate From Crushed PCC
Base Material

PRINCIPAL INVESTIGATOR: Bob Steffes

OBJECTIVES: 1) To produce leachate from crushed Portland cement concrete (PCC) pavement; 2) to analyze the leachate chemical properties; and 3) to determine which design of drainable base from crushed PCC is the most environmentally compatible for below new pavements.

PURPOSE: The purpose of the research is to evaluate three design of drainable base materials, from crushed PCC, and determine which design is the most environmentally compatible.

EQUIPMENT: 3 - troughs, (A, B and C) each 6" high, 6" wide and 48" long with a removable top cover and a fill port on one end and a lower drain port on the opposite end.

1 - compactor for aggregate.

1 - pH meter

MATERIALS: 4 - ft³ crushed PCC pavement as used in the field as drainable base material.

PROCEDURES: Fill A, B and C with crushed PCC as follows:

A) Fill with 2" of fines (fluff) + 4" of gradation 12, Section 4121.

B) Fill with 6" of non-screened total production.

C) Fill with 6" of gradation 12, Section 4121.

Compact each in 3 lifts

1 - Fill with distilled water and measure pH of water going in, cover.

2 - Hold full 24 hours.

3 - Drain and measure pH of water outflow.

4 - Tilt 1.5%, cover and hold in 100% humidity.

5 - Wait 7 days, pour in, at upper end, slowly, ±0.25 L distilled water to generate outflow/seepage at the lower end. Measure pH of outflow.

6 - Repeat step 6 weekly for 52 weeks.

7 - Evaluate trend of pH values and determine date to end testing.

APPENDIX B

**PHOTOS OF SOIL EROSION
AND DRAIN RODENT GUARD BLOCKAGE**



Fig B-1
Drain outlet with wire mesh rodent guard completely plugged by calcium deposits.



Fig B-2
Plugged drain outlet discharging backed-up water after being punctured with a screwdriver.



Fig B-3
Wire mesh rodent guard plugged by deposits.



Fig B-4
High pH drainage water impedes vegetation growth and contributes to soil erosion and loss of drain outlet headwalls.

APPENDIX C

**THREE BOXES BUILT TO HOLD RECYCLED PCC
DRAINABLE BASE SAMPLES FOR LEACHATE EVALUATIONS**



Fig C-1
Three boxes built to hold recycled PCC drainable base samples for leachate evaluation.

APPENDIX D

pH TEST RESULTS VERSUS TIME

pH Test Results

