Construction and Performance Evaluation of Geocomposite Pavement Edge Drains Hydraway and Akwadrain

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Research Report
KTC-89-51

CONSTRUCTION AND PERFORMANCE EVALUATION OF GEOCOMPOSITE PAVEMENT EDGE DRAINS HYDRAWAY AND AKWADRAIN

by

John Fleckenstein
Engineering Geologist

and

David L. Allen
Chief Research Engineer

Kentucky Transportation Research Program
College of Engineering
University of Kentucky

in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U. S. Department of Transportation

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<td>Construction and performance evaluations of Hydraway and Akwadrain edge drains are presented. Construction procedures, laboratory tests, and discharge data, are included.</td>
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During installation of the Akwadrain, several deformed sections in the core had to be cut out and a splice was made at those points.
EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT NO. 11
STATE YEAR NUMBER SUF.
K Y 8 9 0 6 8
CONSTRUCTION PROJ. NO.
IR 64-5(44)
LOCATION
Mile Post 82.25-89.5, Fayette Co.

EVALUATION FUNDING
1 □ HP&R 2 □ DEMONSTRATION
3 □ CONSTRUCTION 4 □ IMPLEMENTATION
NEEP NO.
49
PROPRIETARY FEATURE?
51 □ YES □ NO

TITLE
Construction and Performance Evaluation of Geocomposite Pavement Edge Drains Hydraway and Akwadrain.

DATE MO. YR.
12-8-91
REPORTING
1 □ INITIAL 2 □ ANNUAL 3 □ FINAL

KEY WORDS
Drainage Pipes
Plastic

QUANTITY AND COST
1 LIN. FT. 2 TON
3 S.Y. 4 LBS.
5 S.Y.-IN. 6 EACH
7 C.Y. 8 LUMP SUM

AVAILALBE EVALUATION REPORTS
□ CONSTRUCTION □ PERFORMANCE □ FINAL

EVALUATION
CONSTRUCTION PROBLEMS
1 □ NONE
2 □ SLIGHT
3 □ MODERATE
4 □ SIGNIFICANT
5 □ SEVERE

PERFORMANCE
1 □ EXCELLENT
2 □ GOOD
3 □ SATISFACTORY
4 □ MARGINAL
5 □ UNSATISFACTORY

APPLICATION
1 □ ADOPTED AS PRIMARY STD.
2 □ PERMITTED ALTERNATIVE
3 □ ADOPTED CONDITIONALLY
4 □ PENDING
5 □ REJECTED
6 □ NOT CONSTRUCTED

REMARKS
It appears that the original Hydraway Edge Drain inner core does not have sufficient rigidity in the vertical axis to resist folding in the top and bottom portions of the core during installation.
EXECUTIVE SUMMARY

In 1987, geocomposite, longitudinal edge drains were installed along Interstate 64 in Fayette County. Two types of panel drains were installed. Hydraway brand (developed by the Monsanto Company) was placed on the eastbound side of Interstate 64 from milepost 82.25 to milepost 88.5, and on the westbound side of Interstate 64 from milepost 82.25 to milepost 89.5. Akwadrain brand developed by International Construction Equipment was placed on the eastbound side of Interstate 64 from milepost 88.5 to milepost 89.5, at the Clark County line.

The purposes of this study were to evaluate the engineering properties of the Hydraway Drain and Akwadrain before, during, and after placement, to observe and compare construction procedures of the two edge drains, and to evaluate the hydraulic effectiveness of the two drainage systems.

Laboratory test results indicate that the Akwadrain fabric had the highest coefficient of permeability. The Hydraway fabric was 19.86 percent less permeable. Puncture tests indicated the Hydraway had over 40 percent greater capacity for resisting puncture than the Akwadrain fabric.

The slurry filtration tests indicated the Hydraway fabric was less susceptible to clogging and discharged a greater volume of water. Flow test through the core indicated the Hydraway core drained a 60-gallon container more rapidly than the Akwadrain core.

Field data indicates that the Hydraway panel has a greater discharge capacity than the Akwadrain panel. The response time of the two drainage systems to rainfall appears to be approximately the same. Akwadrain is less likely to become damaged during field compaction. It should be noted that five different projects containing Hydraway were borescoped and each site showed damage from over compaction. It appears Hydraway does not have sufficient rigidity in the vertical axis to resist folding in the top and bottom portions of the core.
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INTRODUCTION

In 1987, geocomposite, longitudinal edge drains were installed along Interstate 64 in Fayette County (Figures 1 and 2). Two types of panel drains were installed. Hydraway brand (developed by the Monsanto Company) was placed on the eastbound side of Interstate 64 from milepost 82.25 to milepost 88.5, and on the westbound side of Interstate 64 from milepost 82.25 to milepost 89.5. Akwadrain brand developed by International Construction Equipment was placed on the eastbound side of Interstate 64 from milepost 88.5 to milepost 89.5, at the Clark County line.

The purposes of this study were to evaluate the engineering properties of the Hydraway Drain and Akwadrain before, during, and after placement, to observe and compare construction procedures of the two edge drains, and to evaluate the hydraulic effectiveness of the two drainage systems.

CONSTRUCTION

Both the Hydraway and Akwadrain installations followed similar construction procedures. A 4-inch wide trench, approximately 22 inches deep was cut in the shoulder (Figure 3). Both materials were unrolled in 400-foot sections and were spliced together (Figures 4 and 5). The 18-inch Hydraway Drain and Akwadrain were then mechanically placed into the trench (Figures 6 and 7). The excavated trench material (mixture of DGA, asphalt, and soil) was then placed back into the trench and mechanically compacted (Figures 8 and 9)(1). During installation of the Akwadrain, several deformed sections in the core had to be cut out and a splice was made at those points. International Construction Equipment indicated the problem was a result of the method of manufacturing (Figure 10).

INSTRUMENTATION

To evaluate the effectiveness of both the Hydraway Drain and the Akwadrain, outflow volumes were measured with calibrated tipping buckets. The essential parts of the system included the acrylic plastic case, calibrated tipping bucket, and the superstructure that connects to the edge drain outlet pipe. Also included was a microswitch mounted on the case that permitted a striker rod on the tipping bucket to trip the switch each time the bucket tips. The microswitch, which is connected to a conventional traffic counter, records each time the microswitch is activated. A schematic of the tipping bucket system is shown in Figure 11.

On September 22, 1987, installation of the tipping-bucket monitoring systems were completed. The tipping buckets for the Hydraway Drain were installed on the westbound lanes at Milepost 89.25 and Milepost 88.95. The tipping buckets for the Akwadrain were installed on the eastbound lanes at Milepost 88.85 and Milepost 89.15 (Figures 12 through 15).

LABORATORY TEST

The following laboratory tests which were performed are not ASTM standard test
procedures.

Fabric Permeability

In each case, the fabrics were removed from the cores and cut into 4-inch squares. The fabric was then clamped over the end of a plastic funnel that was attached to a 4,000-ml graduated cylinder. A falling-head permeability test was performed. The cylinder was filled with water and the time required for the water to fall from one elevation (h1) to a second elevation (h2) was recorded. The following equation was used to calculate the coefficient of permeability (K).

\[ K = \frac{\Delta aL}{\Delta t} \ln \left( \frac{h_1}{h_2} \right) \]

where
- a = area of plastic cylinder (cm²);
- A = area of fabric sample (cm²);
- L = thickness of fabric sample (cm);
- t = elapsed time of test (sec);
- ln = natural logarithm;
- h1 = beginning elevation (cm);
- h2 = ending elevation (cm);

Fabric Puncture Test

The fabric was removed from the core and clamped over a hollow cylinder having an inside diameter 2.0 inches. The fabric was then punctured with a steel ram having a cross-sectional area of approximately 0.25 square inch. Tests were performed on dry material and the maximum loads were recorded.

Slurry Filtration Test

A falling-head permeability test was performed to determine the possibility of the fabric clogging. The same procedure used in the fabric permeability test was used for this test except the water was replaced with a slurry solution. The solution consisted of 20 grams of minus 200-size particles per 4,000 milliliters of water. The slurry solution was placed in the cylinder and allowed to flow through the fabric. Permeabilities were not calculated from this test. Rate of flow and time to clogging were recorded.

Core Compression Test

Compression tests were conducted on core material that was 11.5-inches square. The specimens were loaded at a uniformly increasing rate of 35.7 pounds per second. Tests continued until the maximum load was reached.

A second series of compression tests were conducted at a machine head speed of 0.5 inch per minute. Tests continued for 18 seconds and the maximum load was recorded.
Flow Through Core

A specimen of each material (2 feet x 11.5 inches) was placed in a rectangular acrylic box (2 feet x 11.37 inches x 1.75 inches). The box was attached to the bottom of a 60-gallon, steel barrel that was fitted with a stopper valve and held in an upright position. The barrel was filled with water, and the water was allowed to flow through the core. The time necessary for the barrel to empty was recorded.

SUMMARY OF TEST RESULTS

Results of the fabric permeability test indicate Akwadrain had the highest average coefficient of permeability (0.070 cm/sec). The coefficient of permeability for the Akwadrain was 19.9 percent greater than Hydraway. Fabric permeabilities are listed in Figure 16 and in Table 1. Flow rates are shown in Figures 17 through 19.

Results of the fabric puncture test indicate Hydraway fabric had the highest average puncture strength (479.9 psi). Puncture strength of the Hydraway was 46.7 percent greater than Akwadrain. Puncture test data are contained in Figures 20 through 22 and in Table 2.

Results of the slurry filtration test indicate the Hydraway fabric was less susceptible to clogging than was the Akwadrain fabric. The Hydraway fabric discharged 716.7 milliliters of slurry solution before clogging in 90 seconds. The Akwadrain discharged 155.0 milliliters in 37.5 seconds. Data indicated there are variations in permeabilities of the fabrics as shown by the wide scatter in test data for each fabric. Slurry filtration test data are shown in Figures 23 through 25 and are listed in Table 3.

Compression tests conducted at a compression rate of 35.7 pounds per second indicate that Akwadrain had the highest compressive strength of 54.72 pounds per square inch. The compressive strength of the Akwadrain was 6.0 percent higher than Hydraway. Compression test data are shown in Figures 26 through 28 and are listed in Table 4.

Compression tests performed at a machine head rate of .028 inch per second indicate Hydraway had the highest compressive strength of 64.91 pounds per square inch. The compressive strength the Hydraway was 10.8 percent greater than Akwadrain. Compression test data are listed in Table 5.

The results of flow through the core indicate the Hydraway core emptied the 60-gallon barrel of water in 24.9 seconds. The Akwadrain core emptied the barrel in 44.0 seconds. Flow data are shown in Figure 29 and are listed in Table 6.

CONCLUSIONS OF LABORATORY TESTING

Test results indicate that the Akwadrain fabric had the highest coefficient of permeability. The Hydraway fabric was 19.86 percent less permeable. Puncture tests indicated the Hydraway had over 40 percent greater capacity for
resisting puncture than the Akwadrain fabric.

The slurry filtration tests indicated the Hydraway fabric was less susceptible to clogging and discharged a greater volume of water. Flow test through the core indicated the Hydraway core drained a 60-gallon container more rapidly than the Akwadrain core.

FIELD DATA

Flow Rates

Box No. 3 (Hydraway) discharged 38.9 gallons per linear foot of drain over a ten-month period. Box No. 3 (Hydraway) discharged 34.4 percent more water than Box No. 2 (Akwadrain), and 67.7 percent more than Box No. 1 (Akwadrain). Box No. 4 (Hydraway) discharged 4.0 percent more than Box No. 2 (Akwadrain), and 52.7 percent more than Box No. 1 (Akwadrain). Discharge rates are listed in Table 7, and in Appendix A.

Flow Rates versus Grade

Elevations were obtained at 100-foot intervals in the study area to determine the influence of grade on the amount of water discharged (Figures 30 and 31). Box No. 1 discharged an average 0.138 gallon per foot on a 0.67 percent grade and Box No. 2 discharged an average 0.245 gallon per foot on a .87 percent grade. The 0.20-percent increase in grade increased the discharge by 43.7 percent. Box No. 4 discharged 0.409 gallon per foot on an average 0.59-percent grade and Box No. 3 discharged an average 0.295 gallon per foot on a 1.31-percent grade. In this case, the higher grade produced 27.8 percent less discharge (Figure 32).

BORESCOPE INSPECTION

On August 16, 1988, borescope inspections were performed on both edge drains. Both panels were visually inspected and photographed with the borescope. The Akwadrain site was open, and showed no signs of damage from installation. The fabric surrounding the Akwadrain core appeared to be clean and permeable (Figures 33 and 34). The Hydraway fabric was open and showed signs of core compression during installation. The Hydraway fabric and core showed little to no signs of siltation (Figures 35 and 36).

On August 29, 1988 two more locations were borescoped in the Hydraway section. Borescope information is contained in Appendix B.

The compressive strengths of the Hydraway and Akwadrain cores were similar. The Hydraway core tends to test well in compression if the applied force is perpendicular to the support columns. However, if a row of columns start to bend, this tends to create a domino effect causing adjacent rows of columns to collapse. Both laboratory compression tests and visual inspection in the field indicated that the columns and the backing have a tendency to fold over when compression and shearing forces are placed on the Hydraway during backfilling.
CONCLUSIONS

The Hydraway panel has a greater discharge capacity than the Akwadrain panel. The response time of the two drainage systems to rainfall appears to be approximately the same. Akwadrain is less likely to become damaged during field compaction. It should be noted that five different projects containing Hydraway were borescoped and each site showed damage from over compaction. It appears Hydraway does not have sufficient rigidity in the vertical axis to resist folding in the top and bottom portions of the core.

REFERENCE

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Figure 10. Deformed Akwadrain Section.
Tipping Buckel (Only One Baffle Shown)

Rubber Pod to Cushion Bucket Impact

Inlet Pipe

Acrylic Superstructure

Acrylic Cas.

Micro Switch

Bucket Pivot

Opening for Water Outlet

Rubber Pad to Cushion Bucket Impact

Figure 11. Schematic of Tipping-Bucket System.
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Figure 33. Horizontal view of Akwadrain inner core photographed through the borescope.

Figure 34. The Akwadrain core appears to be open and shows no signs of over compaction.
Figure 35. The columns in the Hydraway inner core are tilted due to over compression during backfilling.

Figure 36. The Hydraway core appears to be open and undamaged.
**TABLE 1. FABRIC PERMEABILITY**

(Coefficient of Permeability) (cm/sec)

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<th>Sample #1</th>
<th>HYDRAWAY</th>
<th>AKWADRAIN</th>
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<tbody>
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<td>.0549736</td>
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<td>Sample #4</td>
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<td>.0525572</td>
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Average:  
HYDRAWAY: .0561450  
AKWADRAIN: .0700665

**TABLE 2. PUNCTURE STRENGTH OF FABRIC (psi)**

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<th>Sample #1</th>
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<td>512.00</td>
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<td>Sample #2</td>
<td>517.60</td>
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<td>Sample #3</td>
<td>410.00</td>
<td>257.60</td>
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Average:  
HYDRAWAY: 479.88  
AKWADRAIN: 258.40
### TABLE 3. SLURRY FILTRATION TEST

(Amount Discharged/Time to Clog)  
(ml/sec)

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### TABLE 4. COMPRESSION STRENGTH OF CORE

(At First Peak)  
(psi)

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<td>#2</td>
<td>50.76</td>
<td>51.25</td>
</tr>
<tr>
<td>#3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>51.39</td>
<td>54.72</td>
</tr>
</tbody>
</table>

* Load Increased at 35.7 lbs/sec
### TABLE 5. COMPRESSION STRENGTH OF CORE

<table>
<thead>
<tr>
<th></th>
<th>HYDRAWAY</th>
<th>AKWADRAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample #1</td>
<td>65.28</td>
<td>55.49</td>
</tr>
<tr>
<td>Sample #2</td>
<td>67.64</td>
<td>58.35</td>
</tr>
<tr>
<td>Sample #3</td>
<td>61.81</td>
<td>59.72</td>
</tr>
<tr>
<td>Average:</td>
<td>64.91</td>
<td>57.85</td>
</tr>
</tbody>
</table>

* Machine Head Rate of .5 in/min

### TABLE 6. FLOW THROUGH THE CORE

<table>
<thead>
<tr>
<th></th>
<th>HYDRAWAY</th>
<th>AKWADRAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample #1</td>
<td>25.2</td>
<td>44.4</td>
</tr>
<tr>
<td>Sample #2</td>
<td>24.6</td>
<td>43.8</td>
</tr>
<tr>
<td>Sample #3</td>
<td>24.9</td>
<td>43.8</td>
</tr>
<tr>
<td>Average:</td>
<td>24.9</td>
<td>44.0</td>
</tr>
</tbody>
</table>
TABLE 7.

DISCHARGE RATES

(Ten Month Period)

<table>
<thead>
<tr>
<th>Gallons</th>
<th>Drain Length (ft.)</th>
<th>Gallons/Drain Length (g/ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box No. 1</td>
<td>12,765</td>
<td>1017.0</td>
</tr>
<tr>
<td>Akwadrain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box No. 2</td>
<td>14,982</td>
<td>587.5</td>
</tr>
<tr>
<td>Box No. 3</td>
<td>49,889</td>
<td>1292.7</td>
</tr>
<tr>
<td>Hydraway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box No. 4</td>
<td>22,026</td>
<td>828.7</td>
</tr>
</tbody>
</table>
APPENDIX A
FLOW BOX DISCHARGE DATA
EDGE DRAIN DATA

△ RAINFALL

[] EASTBOUND - ARMADRAIN BOX 1

○ WESTBOUND - HYDRAWAY BOX 4

RAINFALL (INCHES)

DISCHARGE (GALLONS/LINEAR FOOT DRAIN)

SEPTEMBER 87 (days)
EDGE DRAIN DATA

△ RAINFALL

☐ EASTBOUND - AKWADRAIN BOX 2

○ WESTBOUND - HYDRAWAY BOX 3

RAINFALL (inches)

DISCHARGE (GALLONS/LINEAR FOOT OF DRAIN)

0 1 2 3 4 5

0 10 20 30 40 50

22 23 24 25 26 27 28 29 30

SEPTEMBER 87 (days)
EDGE DRAIN DATA

△ RAINFALL

□ EASTBOUND - AKWADRAIN BOX 1

○ WESTBOUND - HDRAWAY BOX 4

RAINFALL (inches)

DISCHARGE (GALLONS/LINEAR FOOT OF DRAIN)

OCTOBER 87 (days)
EDGE DRAIN DATA

- RAINFALL
- EASBOUND - ARAHADARIN BOX 2
- WESTBOUND - HYDRAWAY BOX 3

OCTOBER 87 (days)
EDGE DRAIN DATA

△ RAINFALL

□ EASTBOUND - ANGULAR DRAIN BOX 2

○ WESTBOUND - HYDRAWAY BOX 3

NOVEMBER 87 (days)
EDGE DRAIN DATA

- RAINFALL
- EASTBOUND - AKWADRAIN BOX 2
- WESTBOUND - HYDRAWAY BOX 3

DECISION 87 (days)
EDGE DRAIN DATA

△ RAINFALL

□ EASTBOUND - AXWADRAIN BOX 1

○ WESTBOUND - HYDRAWAY BOX 4

JANUARY 88 (days)
EDGE DRAIN DATA

- △ RAINFALL
- □ EASTBOUND - AKHADRRAIN BOX 2
- ○ WESTBOUND - HYDRAWAY BOX 3

RAINFALL (inches)

JANUARY 88 (days)

DISCHARGE (GALLONS/LINEAR FOOT OF DRAIN)

1.75 - 2.5

1.4 - 1.05

0.7 - 0.35

0.0 - 0.5

0 - 2.5
EDGE DRAIN DATA

△ RAINFALL

□ EASTBOUND - AKWADRAIN BOX 1

○ WESTBOUND - HYDRAWAY BOX 4

RAINFALL (INCHES)

DISCHARGE (GALLONS/LINEAR FOOT OF DRAIN)

FEBRUARY 88 (days)
EDGE DRAIN DATA

△ RAINFALL

□ EASTBOUND - AKWADRAIN BOX 2

○ WESTBOUND - HYDRAWAY BOX 3

RAINFALL (Inches)

DISCHARGE (GALLONS/LINEAR FOOT OF DRAIN)

FEBRUARY 88 (days)
EDGE DRAIN DATA

- RAINFALL
- EASTBOUND - AXWADRAIN BOX 2
- WESTBOUND - HYDRAWAY BOX 3

MARCH 88 (days)
EDGE DRAIN DATA

RAINFALL

EASTBOUND - AXWADRAIN BOX 1
WESTBOUND - HYDRAWAY BOX 4

APRIL 88 (days)
EDGE DRAIN DATA

△ RAINFALL

☐ EASTBOUND - AKWADRAIN BOX 2

○ WESTBOUND - HYDRAWAY BOX 3

RAINFALL (inches)

APRIL 88 (days)

DISCHARGE (GALLONS LINEAR FOOT OF DRAIN)
APPENDIX B
BORESCOPE INSPECTION DATA
BORESCOPE INSPECTION DATA

Date: 8-29-88

Location No. 1: Approximately 30 feet east of Box No. 3.

All 14 rows are visible in the Hydraway core. The bottom two rows are curved forming a J-type pattern in the fabric. The support columns are slightly tilted downward between rows 1 and 12. The material appears to be approximately 95 percent open.

Location No. 2: Approximately 20 feet east of Box No. 4.

Thirteen out of the 14 rows are visible. The top row of the Hydraway fabric is bent over. The eleventh row from the top, the backing has been completely folded into. The columns appear to bent slightly downward. The bottom two rows are open but the backing has been slightly rounded due to over compression. The inner core has probably been decreased by 10 to 14 percent.