Construction and Performance Evaluation of a Geocomposite Pavement Edge Drain Including Comparison with a 4-Inch Pipe Drain

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CONSTRUCTION AND PERFORMANCE EVALUATION OF A GEOCOMPOSITE PAVEMENT EDGE DRAIN INCLUDING COMPARISON WITH A 4-INCH PIPE DRAIN

by

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and

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in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U. S. Department of Transportation

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July 1987
Construction and performance evaluations of a Geocomposite Pavement Edge Drain including comparison with a 4-Inch Pipe Drain are presented. Construction procedures, laboratory tests, and discharge data, are included.
INTRODUCTION

This report documents two types of pavement edge drain installations. Both drainage systems were installed along I 64 in Franklin County and in similar hydrologic settings (Figures 1 through 3). Hydraway Drain developed by the Monsanto Company and the University of Illinois was placed on the eastbound side of I 64, and the standard pavement edge drain was installed on the westbound side of I 64.

The purposes of this study were to evaluate the engineering properties of the Hydraway Drain 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

The Hydraway Drain was installed on the shoulder directly adjacent to the pavement on the eastbound side of I 64. A 4-inch wide trench, approximately 22 inches deep was cut in the shoulder (Figures 4 and 5). The material was unrolled from a small trailer in 400-foot sections and spliced together (Figures 6, 7, 8, and 9). The 18-inch Hydraway Drain was then mechanically placed into the trench by the trencher (Figure 10).

Following trenching and placement, the trench was backfilled. The first lift consisted of a coarse, clean sand placed in the trench from a sand cart (Figures 11 and 12). The material was then compacted and a second lift of a 4-inch layer of asphaltic concrete was added to bring the shoulder surface to its final (original) grade (Figure 13 and 14). Special note for pavement edge drains are contained in Appendix A. MDM drainage mat and highway edge drain product specifications are contained in Appendix B.

The conventional perforated pipe edge drain was installed on the shoulder directly adjacent to the pavement on the westbound side of I 64 (Figure 15). A 1-foot wide trench 20 inches deep was cut for the 4-inch perforated pipe. This trench also was backfilled with coarse, clean
sand (compacted) and a 2-inch layer of asphaltic concrete was used to fill to final grade.

Construction prices for the Hydraway Drain and 4-inch pipe base drain installations follow:

<table>
<thead>
<tr>
<th>Drain Type</th>
<th>Cost Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraway Drain</td>
<td>$110,332.50 for 29,422 ft ($3.75 per ft)</td>
<td>$110,332.50</td>
</tr>
<tr>
<td>Typical Base Drain</td>
<td>$92,002.50 for 34,075 ft ($2.70 per ft)</td>
<td>$92,002.50</td>
</tr>
</tbody>
</table>

INSTRUMENTATION

To evaluate the effectiveness of both the Hydraway Drain and the conventional pavement edge drain, outflow water volumes were measured with calibrated tipping buckets (Figure 16). A tipping bucket was placed at a discharge pipe on both systems which were located in similar hydrologic locations. A schematic of the tipping bucket system is shown in Figure 17.

The essential parts of the system included the acrylic plastic case, calibrated tipping bucket, and the superstructure that connects to the subdrainage outlet pipe. Also included was a microswitch mounted on the case so the striker rod on the tipping bucket strikes the switch each time the bucket tips. The microswitch, which is connected to a conventional traffic counter, records a count each time the microswitch is activated.

FIELD DATA

During early September 1985, installation of the tipping-bucket monitoring systems were completed. The tipping bucket for the Hydraway Drain was installed on the eastbound lane of I 64 approximately 1/2 mile west of the Kentucky River. The tipping bucket for the pipe edge drain was installed adjacent to the Hydraway system in the westbound lane.

The pipe edge drain stopped functioning in late October 1985.
During the winter of 1985, a 4-inch hole was drilled through the pavement and down into the pipe edge drain. Approximately three hundred gallons of water were pumped into the 4-inch pipe. No water discharged at the outlet in the headwall was detected. It appeared that water seeped into the sand surrounding the 4-inch pipe.

The tipping bucket system for the pipe edge drain was moved in early August 1986 to a similar site approximately 1 mile east of the original site also located in the westbound lane.

Data were obtained immediately after construction and at approximately 30-day intervals thereafter. Field data consisted of tipping-bucket discharges on an hourly basis and daily climatological data collected at a weather station at the Frankfort Lock No. 4, located on the Kentucky River. After retrieval, the discharge and daily precipitation data were plotted as a function of time (Figures 18 through 26).

LABORATORY TESTS

The following is a description of laboratory tests and procedures performed on the Hydraway Drain. None of the procedures were ASTM standard test methods.

FABRIC PERMEABILITY

The fabric on the Hydraway Drain was removed from the core and placed over the end of a small plastic cylinder. A falling-head permeability test was used. The cylinder was filled with water and the time required for the water to fall from one elevation ($h_1$) to a second elevation ($h_2$) was recorded. The following equation was used to calculate the coefficient of permeability:

\[ k = \left( \frac{aL}{At} \right) \ln\left( \frac{h_1}{h_2} \right) \]

in which $a$ = area of plastic cylinder (cm$^2$),
A = area of fabric sample (cm²),
L = thickness of fabric sample (cm),
\( t \) = elapsed time of test (sec),
ln = natural logarithm,
h₁ = first elevation (cm), and
\( h₂ \) = second elevation (cm).

FABRIC PUNCTURE TEST

The fabric was removed from the core and clamped over a hollow cylinder having an inside diameter of 2.0 inches. The fabric was then punctured with a steel ram having a cross-sectional area of approximately 0.25 square inch. The force required to cause the fabric to puncture was recorded. The test was performed with the material dry and with it saturated.

SLURRY FILTRATION TEST

To measure the retention efficiency of the fabric (ability to filter fine soil particles out of suspension), a device similar to that reported by R. G. Carroll, Jr., in Transportation Research Record 916 was constructed. This consisted of a vertical, hollow, plastic cylinder 1.0 inch inside diameter and approximately 20.5 inches in length. The filter fabric was clamped over the bottom end of the cylinder. A slurry of soil and water was placed in the cylinder and allowed to flow through the fabric. Three concentrations were used. The first was 1.0 pound of minus-200-sized particles per gallon of water. The second was 0.10 pound of minus-200 material per gallon of water, and the third was 0.05 pound of minus-200 material per gallon.

COMPRESSION TEST ON CORE

Samples of the drain core material 6 inches by 6 inches were tested in compression at a uniform loading rate. The load and deflection were recorded.
FLOW THROUGH CORE

A sample of Hydraway material (2 feet in length by 12 inches in width) was clamped between two sheets of plexiglass. The side of the sample was sealed to prevent water from flowing around the sides. The sample was held in an upright position and a gating mechanism was fitted to the bottom of the specimen. The gate was closed and the core sample was filled with water. The gate was then opened and the time for the core to empty was recorded.

RESULTS OF LABORATORY TESTS

Results of the laboratory tests are summarized in Table 1. The average measured permeability of the Hydraway fabric was 0.146 cm/sec. The published permeability of that fabric is 0.2 cm/sec.

The average load on the core of the Hydraway specimens compression tests was 2,635 pounds (73 psi). Load-deflection curves for the specimens are illustrated in Figures 27 through 32.

The average dry puncture strengths for Hydraway were 480 psi and 460 psi, respectively. The average wet puncture strength for Hydraway was 496 psi. The material appeared to be slightly more resistant to puncture when wet.

Flow through the inundated core of the Hydraway drain emptied in an average of 0.506 sec (with a standard deviation of 0.11 sec).

No exact numbers (such as time to clogging or amount of filter cake) could be obtained from the slurry filtration tests. The fabric clogged within 2 to 3 seconds when using the two higher concentrations of slurry. With the lowest slurry concentration (0.05 pound of soil per gallon of water), the fabric never completely clogged during the test. However, a filter cake approximately 1/16 inch thick accumulated on the fabric.

During March 1987 along I 64 in Franklin County, a small section of the Hydraway Drain was excavated and inspected. The Hydraway Drain showed no signs of wear or clogging after 2 years of service. (Figures 33 through 36).
DISCHARGE FLOWS

Initial tests on the Hydraway Drain and the conventional perforated pipe edge drain indicated higher flow rates and quicker response by the Hydraway drainage system (Figures 18 and 19). These readings were taken in September and October of 1985. Testing was suspended due to equipment problems until August 24, 1986. Readings taken from August 24, 1986, to the end of the month indicated a slow response with steady flow rates by the pipe edge drain and no response from the Hydraway system (Figure 20).

Readings taken in September 1986 indicated a quicker response by the Hydraway system, although volumes were less (Figure 21). Test results for October 1986 through November 1986 indicated higher flow rates and quicker response by the Hydraway system (Figure 22 and 23). Results for December 1986 through January 29, 1987, indicated that both systems proved ineffective during freezing temperatures. A notable temperature increase occurred during the last few days of January. The Hydraway system responded quickly with a strong discharge; there was no response by the pipe edge drain (Figures 24 and 25). Readings taken during February 1987 indicated higher flow rates and quicker response by the Hydraway system during warmer days of the month (Figure 26). Throughout the 9-month testing period, neither drainage system proved effective during freezing temperatures.

During October 1986, after a brief rainy period, a visual survey indicated that only two of 14 headwalls on the westbound lanes (pipe drain) were discharging water. However, on the eastbound lanes, over 50 percent were discharging water.

CONCLUSIONS

Test results on the Hydraway Drain and the conventional perforated pipe edge drain indicate the Hydraway Drain responds more quickly to precipitation and discharges a greater volume of water. After a 2-year installation period in a sand backfill, Hydraway Drain showed no signs
of clogging. Although there is no data to confirm this, it appears the conventional perforated pipe edge drain backfill medium may have to be saturated before it discharges.
TABLE 1. SUMMARY OF TEST RESULTS

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>FABRIC PERMEABILITY (cm/sec)</th>
<th>COMPRESSION STRENGTH (at first peak) (lb)</th>
<th>PUNCTURE STRENGTH OF FABRIC (psi)</th>
<th>TIME FOR INUNDATED CORE TO DRAIN (MEASURE OF FLOW RATE) (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monsanto #1</td>
<td>0.118</td>
<td>2480</td>
<td>492</td>
<td>476</td>
</tr>
<tr>
<td>Monsanto #2</td>
<td>0.180</td>
<td>2789</td>
<td>434</td>
<td>619</td>
</tr>
<tr>
<td>Monsanto #3</td>
<td>0.154</td>
<td>2823</td>
<td>454</td>
<td>456</td>
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<tr>
<td>Monsanto #4</td>
<td>0.126</td>
<td>2279</td>
<td></td>
<td>434</td>
</tr>
<tr>
<td>Monsanto #5</td>
<td></td>
<td>3268</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsanto #6</td>
<td></td>
<td>2172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.146</td>
<td>2635</td>
<td>460</td>
<td>496</td>
</tr>
</tbody>
</table>
Figure 1. Location of Franklin County, Kentucky.
Figure 2. Location of Study Area in Franklin County.
Figure 3. Location of Study Area in Franklin County.
Figure 4. Typical Cross-Section of Installed MDM.
Figure 5. Trencher and MDM Placing Mechanism.

Figure 6. Unrolling MDM.
Figure 7. Trencher Installing MDM.
Figure 8A. Field Splice.

Figure 8B. MDM End Cap.
Figure 9A. MDM T-Outlet Fitting.

Figure 9B. MDM Standard Outlet Fitting.
Figure 10. Trencher Installing MDM.
Figure 11. Placement of Coarse Sand Backfill.

Figure 12. Coarse Sand in Sand Cart.
Figure 13. Backfill after Compaction.

Figure 14. Finished MDM Installation.
Figure 15. Typical Cross-Sectional View of Installed Pipe Edge Drain.
Figure 16. Tipping Bucket System, I 64, Franklin County.
Figure shows an isometric drawing of the tipping bucket system. Some details are eliminated for sake of clarity.

The essential parts of the system include the case, tipping bucket, and superstructure which connects to the subdrainage outlet pipe.
Figure 18. Edge-Drain Data for September 1985.
Figure 19. Edge-Drain Data for October 1985.
Figure 20. Edge-Drain Data for August 1986.
Figure 21. Edge-Drain Data for September 1986.
Figure 22. Edge-Drain Data for October 1986.
Figure 23. Edge-Drain Data for November 1986.
Figure 24. Edge-Drain Data for December 1986.
Figure 25. Edge-Drain Data for January 1987.
Figure 26. Edge-Drain Data for February 1987.
Figure 27. Monsanto No. 1, Compression Test.
Figure 28. Monsanto No. 2, Compression Test.
Figure 29. Monsanto No. 3, Compression Test.
Figure 30. Monsanto No. 4, Compression Test.
Figure 31. Monsanto No. 5, Compression Test.
Figure 32. Monsanto No. 6, Compression Test.
Figure 33. Excavation of Shoulder, Showing MDM.

Figure 34. View of Excavated MDM.
Figure 35. View of Excavated MDM.

Figure 36. View of Excavated MDM.
BIBLIOGRAPHY


APPENDIX A

SPECIAL NOTE FOR
PAVMENT EDGE DRAIN
SPECIAL NOTE FOR
PAVEMENT EDGE DRAINS

I. DESCRIPTION

This item shall consist of furnishing and installing an experimental prefabricated underdrain in accordance with this Special Note, and as directed by the Engineer.

II. MATERIALS

A. Prefabricated Underdrain. The prefabricated underdrain shall be the latest design of the Monsanto Drainage Mat (MDM) as developed and produced by the Monsanto Company, 800 N. Lindbergh Boulevard, St. Louis, Missouri 63167, Telephone (800) 325-4330. All auxiliary materials (splice kits, outlet connections, etc.) shall be as produced by Monsanto Company.

B. Acceptance. Acceptance of the prefabricated underdrain and fittings will be by visual inspection on the project. However, the Engineer may take samples for testing or research purposes. No separate measurement or payment will be made for material taken as samples.

III. CONSTRUCTION REQUIREMENTS

A. General. Before beginning installation, the Contractor shall furnish to the Engineer on the project copies of the manufacturer's literature and specifications showing details of the product and methods of installation. The manufacturer's literature shall include complete instructions for placing and splicing the underdrain, and for connecting standard 4 inch diameter outlet pipe.

A representative of the manufacturer shall be on the project to advise the Engineer when work begins, and at other times when requested by the Engineer. Any costs for the manufacturer's representative visiting the project will be considered incidental to the MDM.

B. Installation. The MDM shall be installed in a trench as shown on the drawings and in accordance with the manufacturer's instructions.

At the Contractor's option, the trench may be backfilled with the excavated material, No. 9M coarse aggregate, pea gravel, or natural sand. When excavated material is used, the trench shall be backfilled to the limits shown with the excavated trench material (excluding fragments of existing bituminous material larger than one inch) placed in 2 layers, and compacted to at least 90% of the maximum density as determined by KM 64-511. Acceptability of compaction will be determined by KM 64-512 or by using nuclear gages, except when the trench is too narrow to perform tests acceptability will be determined by visual inspection.
SPECIAL NOTE FOR PAVEMENT EDGE DRAINS

When either No. 9M coarse aggregate or pea gravel is used, the trench shall be backfilled in 2 lifts and each lift compacted to the satisfaction of the Engineer. Gradation of pea gravel shall be as approved by the Engineer.

When natural sand is used, the sand shall be dried in a hot-mix bituminous plant drier or similar means so that no moisture is apparent in the sand, and the sand is free flowing. The trench shall be backfilled in 2 lifts, and each lift shall be thoroughly flooded with water to compact the sand backfill.

Means shall be provided to hold the mat flush against the trench wall during backfilling.

Splices shall be made as needed prior to placing the MOM in the trench. Splices shall be made using splice kits furnished by the manufacturer, and in accordance with the manufacturer's written instructions. All splice material will be supplied in the kit but any equipment required shall be furnished by the Contractor.

Outlets shall be constructed at the locations shown on the plans or as directed by the Engineer. Outlet fittings to transition from the MOM to standard 4 inch diameter pipe shall be furnished by Monsanto Company, and shall be installed in accordance with the company's written instructions.

All removed material not used for backfilling, or other purposes required by the contract or other uses as specified or permitted by the Engineer, shall be wasted off the right-of-way at no additional cost to the Department.

C. Adjustment of Quantities. The Engineer reserves the right to make increases or decreases in the quantity of MOM constructed as may be deemed necessary or desirable, in accordance with Section 104.02 of the Standard Specifications.

IV. METHOD OF MEASUREMENT AND BASIS OF PAYMENT

MOM Underdrain will be measured in linear feet complete and accepted in the final work. Payment for the accepted quantity at the contract unit price for "MOM Underdrain" shall be full compensation for excavation; backfill, including dried natural sand and water when used; furnishing and installing all materials, including splices and fittings; and all equipment, labor, and incidentals necessary to complete the work.

Outlet pipe, headwalls, bituminous mixtures, and other work required by the contract will be measured and paid for as specified elsewhere in the contract.

July 16, 1986
DETAIL FOR INSTALLATION OF MONSANTO DRAINAGE MAT UNDERDRAIN

1. The existing 2"± Bituminous Shoulder over the trench shall be saw-cut to a neat line before removing. Other approved methods may be used provided a neat edge is obtained.

2. Compacted backfill.

3. Depth to be shown on plans or proposal.
4" Dia. Standard Pipe Nipple

Fabric Seal or Fitting

MDM T-OUTLET FITTING (SAG COND.)

MDM Drainage Core

Standard Outlet Fitting

Fabric Seal or Fitting

4" Dia. Standard Pipe Nipple

MDM STANDARD OUTLET FITTING
3" Wide Polyethylene Underground Tape

Butt Joint

Polyethylene Stiffener

MDM Drainage Core

Pavement Side

2 Cross Butt Staples

FIELD SPLICE

3 Equally Spaced Staples (each side)

MDM Drainage Core

This end Closed

MDM END CAP
SPECIAL NOTE FOR PERFORATED PIPE UNDERDRAINS AND ROCK OR SAND DRAINAGE BLANKETS

I. PERFORATED PIPE UNDERDRAINS

Contrary to Section 705 of the Standard Specifications, the following aggregates will be permitted for backfilling pipe underdrains. The use of coarse aggregate or natural sand will be at the Contractor’s option.

A. Coarse Aggregate

Coarse aggregate, crushed or uncrushed (including pea gravel), shall meet the quality requirements of Section 805.03 of the Standard Specifications except the shale content may be 5 percent providing the combined shale, friable particles, and minus No. 100 content does not exceed 8 percent. Gradation shall be uniform and shall meet the following requirements when tested by KM 64-602.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/2 inch</td>
<td>100</td>
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<tr>
<td>No. 4</td>
<td>0-30</td>
</tr>
<tr>
<td>No. 100</td>
<td>0-5</td>
</tr>
</tbody>
</table>

B. Natural Sand

Gradation shall be uniform and shall meet the following requirements when tested in accordance with KM 64-602. In addition, the natural sand shall have a sand equivalent value of no less than 70.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>75-100</td>
</tr>
<tr>
<td>No. 100</td>
<td>0-8</td>
</tr>
</tbody>
</table>

C. Construction Requirements

When natural sand is used for backfilling perforated pipe underdrains, the perforated pipe shall be wrapped in geotextile fabric; however, when coarse aggregate is used for backfilling perforated pipe underdrains, the aggregate shall be completely wrapped in geotextile fabric.

Backfill for pipe underdrains shall be placed in 6-inch layers in accordance with Section 705.

Fabric shall meet the requirements of Table II of the Department's Special Provision No. 39, current edition, except that fabric for wrapping perforated pipe, when required, may be polyester material (sock) as recommended by the pipe manufacturer. Fabric used for wrapping coarse aggregate backfill for pipe underdrains or for wrapping perforated pipe in underdrains shall be considered incidental to the unit price bid per linear foot for perforated pipe.
SPECIAL NOTE FOR PERFORATED PIPE UNDERDRAINS AND ROCK OR SAND DRAINAGE BLANKETS

II. ROCK OR SAND DRAINAGE BLANKETS

The following aggregates will be permitted for drainage blanket construction for embankment stabilization. The use of coarse aggregate or natural sand will be at the Contractor's option unless otherwise specified.

A. Coarse Aggregate (Rock Drainage Blanket)

Coarse aggregate, crushed or uncrushed (including pea gravel), shall meet the quality requirements of Section 805.03 of the Standard Specifications except the shale content may be 5 percent providing the combined shale, friable particles, and minus No. 100 content does not exceed 8 percent. Gradation shall be uniform and shall meet the following requirements when tested by KM 64-602.

<table>
<thead>
<tr>
<th>Sieve Size</th>
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</tr>
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<tr>
<td>4 inch</td>
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<tr>
<td>No. 4</td>
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<tr>
<td>No. 100</td>
<td>0-5</td>
</tr>
</tbody>
</table>

B. NATURAL SAND (Sand Drainage Blanket)

Gradation shall be uniform and shall meet the following requirements when tested in accordance with KM 64-602. In addition, the natural sand shall have a sand equivalent value of no less than 70.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>75-100</td>
</tr>
<tr>
<td>No. 100</td>
<td>0-8</td>
</tr>
</tbody>
</table>

C. Construction Requirements

Drainage blankets shall be constructed in one foot layers. Drainage blankets for embankment stabilization shall be wrapped entirely with geotextile fabric, regardless of whether coarse aggregate or natural sand is used. In addition, if the drainage blanket is constructed of natural sand, any perforated pipe enclosed by the drainage blanket shall be wrapped with geotextile fabric.

Fabric shall meet the requirements of Table II of the Department's Special Provision No. 39, current edition, except that fabric for wrapping perforated pipe, when required, may be polyester material (sock) as recommended by the pipe manufacturer. Fabric used for wrapping drainage blankets will be paid for at the unit price bid per square yard. However, fabric used for wrapping perforated pipe enclosed by drainage blankets shall be considered incidental to the unit price bid per linear foot for perforated pipe.

May 29, 1985
SPECIAL NOTES
FOR
PAVEMENT UNDERDRAIN SYSTEM

PURPOSE: The purpose of this system is to remove damaging water from the pavement structure through the use of combinations of aggregate encased with filter fabric, and with perforated underdrain pipe included when specified.

DESCRIPTION: The aggregate encased with filter fabric shall be constructed at each edge of the pavement. When the grade of the roadway is 1% or less, perforated underdrain pipe shall be a part of the system. When an outlet through the shoulder is required, and no perforated pipe is included in the run, a 10 foot length of perforated pipe shall be installed prior to joining with the non-perforated outlet pipe. Non-perforated outlet pipe shall be used through the shoulder.

MATERIALS:
1. Perforated & Non-Perforated Underdrain Pipe shall be one of the alternates as shown on Standard Drawing No. RDP 001-02.

2. Porous Aggregate for Underdrains shall be Size No. 57, and meet the requirements of Section 805 of the 1976 Standard Specifications.

3. Filter Fabric – The filter fabric shall be formed in widths of not less than six (6) feet. Sheets of fabric may be sewn together to form cloth widths as required. The sheets of filter fabric shall
be sewn together at the point of manufacture or other approved locations. A competent laboratory must be maintained by the producer of the fabric at the point of manufacture to maintain and insure quality material. During all periods of shipment and storage, the fabric shall be maintained in a manner to reduce damage and protect the product. A sample of five (5) square yards shall be furnished the Bureau of Highways for each shipment for verification testing. The vendor is to furnish certified test reports with each shipment of material attesting that the fabric meets the requirements of these special notes.

The fabric shall be either woven or non-woven meeting the requirements of these special notes.

A. Woven Fabric - The plastic woven fabric shall be a pervious polymer composed of at least 85% by weight of propylene, ethylene, amide, ester, or vinlyledenechloride, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultraviolet rays and heat exposure. After forming, the fabric shall be processed so that the filaments retain their relative positions with respect to each other. The fabric shall be free of defects or flaws which significantly affect its physical and/or filtering properties. During shipment and storage the fabric shall be wrapped in a heavy duty protective covering to protect it from direct sunlight, ultraviolet rays, temperatures greater than 140° F, mud, dirt, dust, and other debris.
The woven filter fabric shall meet all the requirements listed in Table I of these notes.

B. Non-Woven Filter Fabric - In addition to the general requirements listed previously, the non-woven filter fabric shall meet the requirements shown in Table II of these notes.

4. Fastener Pins shall be formed of No. 9 steel wire or heavier and shall be at least 12" long with a 4" right angle bend on one end. They shall be used at a spacing of 2'-6".

CONSTRUCTION: The trench shall be excavated to the dimensions shown on the plans with a suitable trenching or excavating machine. The resulting trench shall have neat lines with no sharp objects to puncture cloth.

The filter fabric shall be placed and shaped to the sides and bottom of the trench with suitable equipment without stretching. Care shall be taken so that an equal amount of fabric shall be available for top lap. The filter aggregate shall be placed so as not to damage, displace, or dislodge the fabric. Backfill shall be placed in accordance with Section 704.03 of the Standard Specifications.

The filter fabric shall then be folded over the backfilled trench and secured with steel pins at 2'-6" centers which produces a double thickness of the filter fabric over the top of the trench.

The filter fabric shall be ordered in lengths to minimize the number of splices necessary. When splices between rolls are necessary, the cloth shall be lapped a minimum of 3 feet and secured with fastener pins as directed by the Engineer.
The remaining Dense Graded Aggregate Base, Pavement, and other shoulder work shall then be constructed.

Materials excavated from trench shall be disposed of as directed by the Engineer.

Porous underdrain will be measured in linear feet along the center line of the trench. Woven filter fabric will be measured in square yards, and will be calculated as the product of the length of porous underdrain and the specified cloth width.

The accepted quantity of "Porous Underdrain" will be paid for at the contract unit price per linear foot, and the accepted quantity of "Woven Filter Fabric" will be paid for at the contract unit price per square yard. Such payment shall be full compensation for all labor, materials, equipment, and incidentals necessary to excavate the trench, furnish and place the filter fabric and aggregate, and satisfactorily dispose of the materials excavated from the trench.

The accepted quantity of Perforated and Non-Perforated Pipe for underdrain and outlets will be measured and paid for as specified in Section 705 of the 1976 Standard Specifications.

The accepted quantity of Class A concrete used in headwalls will be measured and paid for as specified on Standard Drawing No. RDP 010-02.
APPENDIX B

MDM DRAINAGE MAT
HIGHWAY EDGE DRAIN PRODUCT SPECIFICATION
### TABLE 1

**REQUIREMENTS FOR WOVEN FILTER FABRIC**

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength * (unaged cloth)</td>
<td>ASTM D-1682 Grab Test Method using 1 square inch jaws and a travel rate of 12 inches per minute.</td>
<td>200 lbs. Min. in any principle direction.</td>
</tr>
<tr>
<td>Bursting Strength * (unaged cloth)</td>
<td>ASTM D-751 Diaphragm Bursting Tester.</td>
<td>500 psi Min.</td>
</tr>
<tr>
<td>Puncture Strength * (unaged cloth)</td>
<td>ASTM D-751 Tension Testing Machine with Ring Clamp; steel ball replaced with a 5/16&quot; diameter solid steel cylinder centered within the ring clamp.</td>
<td>120 lbs. Min.</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>ASTM D-1682 as above, after abraded as in ASTM D-1175 Rotary Platform, Double Head Method; rubber-base abrasive wheels equal to CS-17 &quot;Calibrase&quot; by Taber Instruments Co., 1 kilogram load per wheel; 1000 revolutions.</td>
<td>55 lbs. principle direction.</td>
</tr>
<tr>
<td>Seam Breaking Strength</td>
<td>ASTM D-1683, 1&quot; square jaws, constant rate of traverse 12&quot; per minute.</td>
<td>180 lbs. Min.</td>
</tr>
<tr>
<td>Permeability</td>
<td>AHD Permeability for Filter Fabric</td>
<td>$2 \times 10^{-2}$ cm/sec. Min. $3 \times 10^{-1}$ cm/sec. Max.</td>
</tr>
</tbody>
</table>

*Unaged cloth is defined as cloth in the condition received from the manufacturer or distributor.*
<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Strength*</td>
<td>ASTM D-1682**</td>
<td>Minimum 90 lbs.</td>
</tr>
<tr>
<td>Grab Elongation*</td>
<td>ASTM D-1682**</td>
<td>Minimum 50%</td>
</tr>
<tr>
<td>Permeability*</td>
<td>Kentucky Method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>64-519-78 Permeability for Engineering Fabric</td>
<td>2 x 10^{-2} cm/sec. Min.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 x 10^{-1} cm/sec. Max.</td>
</tr>
<tr>
<td>Fabric Toughness (Grab Strength x Grab Elongation)</td>
<td></td>
<td>Minimum 8000</td>
</tr>
</tbody>
</table>

* Tests shall be run on wet samples soaked twenty-four (24) hours at ambient room temperatures.

** Tensile strength determined by the method stated in Table 1.
HIGHWAY EDGE DRAIN PRODUCT SPECIFICATION

I. GENERAL DESCRIPTION

MDM Highway Edge Drain is designed for effective dewatering of highway pavement systems. It is a flexible, rectangular shaped product consisting of a filter fabric permanently bonded with a suitable adhesive to an internal supporting core. The filter fabric is supported on three sides by cylindrical projections extending from the base of the core and on the fourth side by the base of the core. The product is designed to be machine installed using commercial trenching equipment.

II. PRODUCT SPECIFICATION

MDM Highway Edge Drain is approximately 1 inch wide. It is available in nominal 5\(\frac{1}{2}\) or 17\(\frac{1}{2}\) inch depths in rolls up to 400 feet in length. It has a minimum weight of 0.35 pounds per square foot, and is resistant to deterioration from salts, road oils, fuels and other materials commonly encountered in this application. There is no MDM core deflection and less than 0.07 inch fabric deflection under a 60 psi load (University of Illinois Test Method).

A. CORE MATERIAL SPECIFICATION:

The MDM core is continuously injection molded of a Low Density Polyethylene having the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ASTM D792</td>
<td>0.918</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM D570</td>
<td>Less than 0.01% at 24 hours</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D638</td>
<td>1200 psi</td>
</tr>
<tr>
<td>Fungus Resistance</td>
<td>ASTM 2170</td>
<td>No Growth</td>
</tr>
</tbody>
</table>

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B. FILTER FABRIC MATERIAL SPECIFICATION:

The MDM filter fabric is a nonwoven Polypropylene having the following properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric Weight</td>
<td>ASTM D1910</td>
<td>4.5 oz/yd²</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D1682</td>
<td>90 lbs.</td>
</tr>
<tr>
<td>Elongation</td>
<td>ASTM D1682</td>
<td>60 %</td>
</tr>
<tr>
<td>Burst Strength</td>
<td>Mullen Burst Test</td>
<td>230 psi</td>
</tr>
<tr>
<td>Accelerated Weathering</td>
<td>Federal Test Method</td>
<td>70 %</td>
</tr>
<tr>
<td>(Strength Retained)</td>
<td>CCCT-T-191 Method</td>
<td>5804 (500 Hour Exposure)</td>
</tr>
<tr>
<td>Permeability Coefficient</td>
<td>Falling Head</td>
<td>0.2 cm/sec.</td>
</tr>
<tr>
<td>(75MM to 25MM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permittivity per</td>
<td>Falling Head</td>
<td>0.75 cm/sec.</td>
</tr>
<tr>
<td>Fabric Layer</td>
<td>CW-02215, U.S. Sieve</td>
<td>70</td>
</tr>
<tr>
<td>Equivalent Opening Size</td>
<td>No. Equivalent</td>
<td></td>
</tr>
<tr>
<td>Resistance to Blinding/Clogging</td>
<td>University of Illinois Test Method</td>
<td>No significant change in saturated hydraulic conductivity after 1,000,000 load applications.</td>
</tr>
<tr>
<td>Fungus Resistance</td>
<td>ASTM 2170</td>
<td>No Growth</td>
</tr>
</tbody>
</table>

III. SPECIFICATION EXPIRATION

Monsanto may change the specifications at any time without notice to the potential purchaser. The Purchaser should verify that he has the current specification prior to the establishment of bid or contractual specifications.

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