Evaluation and Performance of Geocomposite Edge Drains in Kentucky

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Longitudinal edge drains have been used in Kentucky for approximately two decades. Most were installed on the Interstate and parkway systems. Currently there are hundreds of lane-miles in place. The first edge drains consisted of 4-in., perforated, polyethylene pipe installed in a 12-in.-wide trench. Various types of backfill were used. Some trenches were fabric wrapped and backfilled with crushed limestone aggregate of uniform size (approximately ¾ in.). Other trenches were not wrapped and were backfilled with a natural sand. In these cases, the pipe was covered with a fabric sock. This paper deals mostly with geocomposite (panel) edge drains, because most of the research and performance monitoring in Kentucky in the past 6 years has been on that type of drain. Much attention should be given to details during installation and construction of the panel drains. Many problems encountered were the result of improper construction practices. Problems included compression of the inner core of the panel drain during compaction of the backfill, damage to flexible outlet pipes during construction, and improper drainage at the outlet. Outlet pipes should be installed at the proper grade. This helps maintain the velocity of the water in the drains, which helps to flush out silt and clay-size particles that enter the drain. The drains and outlet pipes should be well protected during the remainder of construction. Headwall distances should be designed on a project-by-project basis. This prevents exceeding the capacity of the drains. Breaking and seating the rigid concrete slab produces unstable situations in which silt-size particles are set in motion by cyclic loading and by the flow of water. If this silt source is sufficiently great, clogging may occur. Geocomposite fin drains are good alternatives to pipe edge drains because of their ease of construction, narrow trench widths, and more rapid response times. Care should be exercised in the design and construction of the drains to ensure that they perform properly. The core should be inspected after installation to ensure that the integrity of the core has been maintained throughout construction.

Longitudinal edge drains have been used in Kentucky for approximately two decades. Most were installed on the Interstate and parkway systems. Currently there are hundreds of lane-miles in place. The first edge drains consisted of 4-in. perforated polyethylene pipe installed in a 12-in.-wide trench. Various types of backfill were used. Some trenches were fabric wrapped and backfilled with crushed limestone aggregate of uniform size (approximately ¾ in.). Other trenches were not wrapped and were backfilled with a natural sand. In these cases, the pipe was covered with a fabric sock.

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INTERSTATE 64, FRANKLIN COUNTY (1985)

The first panel drains installed in Kentucky were on a 5-mi section of Interstate 64 in Franklin County. The pavement was a 10-in. nonreinforced portland cement concrete (PCC) slab. The pavement was being rehabilitated by joint replacement and full-depth and partial-depth patching. The panel drain installed was the Hydraway brand (original design) (Figure 1, Type A). It was placed in a 4-in.-wide trench on the outside shoulder of the eastbound lanes. The westbound lanes were retrofitted with a longitudinal edge drain that was a 4-in. perforated pipe in a 12-in.-wide trench. The trenches for both types of drains were backfilled with a clean coarse sand (Figures 2 and 3). The sand was placed in two lifts in the trench for the panel drain, and each lift was compacted with a vibrating compacting shoe. A single device that automatically records the volume of outflow from the drain outlet was installed on the eastbound and westbound lanes. The sites chosen for the recording devices had the same length of drain and were on the same grade. Results of measurements indicated that, after a rain, the panel drain began flowing much more quickly than did the pipe drain. The panel drains responded within a few minutes after a rain, whereas the pipe drain usually did not respond for approximately 24 to 48 hr (*1*). Because the pipe is located approximately 4 in. above the base of the trench, this area must first become saturated before the pipe begins to drain. The extra storage capacity means that more water is retained before the drain begins to function, which could be detrimental to the life of the pavement.

After the panel drain had been in service for 2 years, approximately 15 ft of the material was dug up and examined. The drain appeared to be in good condition. The fabric was clean and there was no evidence of clogging (Figure 4). The core also was in good condition. The drain was borescoped approximately 2 years later at several locations. Some minor distress was observed in the core because of compaction of the sand backfill. Observations at other sites that used the excavated trench material as backfill showed considerably more damage. It is apparent that the first installation in Kentucky was one of the best. Less effort had to be used to compact the sand backfill, which minimized the potential for damage to the panel drain.

INTERSTATE 64, FAYETTE COUNTY (1987)

The second installation of experimental panel drains was on Interstate 64 in Fayette County. The section was approxi-

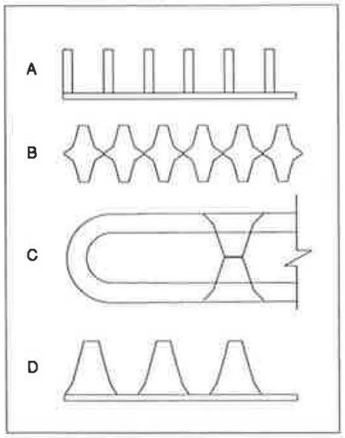

FIGURE 1 Profile of panel drain core types.

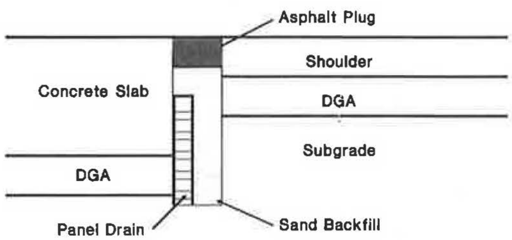

FIGURE 2 Cross section of Type-A drain installation on I-64, Franklin County.

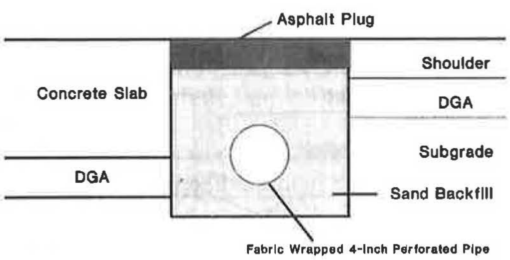

FIGURE 3 Cross section of 4-in. perforated pipe drain on I-64, Franklin County.

mately 5 mi long. The pavement on this section was a 10-in. nonreinforced PCC slab. The pavement was in good condition, and no rehabilitation was being performed. Core Type-A panel drains were installed in the westbound lanes. The eastbound lanes had approximately 4 mi of Core Type-A drains and approximately 1 mi of Akwadrain (original design) (Figure 1, Type B). Outflow-volume monitoring devices were also installed on this project, placed so that each brand of fin drain could be monitored. The devices were placed on equal lengths of drain for each brand and on equal grades. Both brands of panel drains were installed in 4-in. trenches and backfilled with the trench cuttings (Figure 5). The backfill material was compacted by using a vibrating shoe in two lifts (Figure 6).

Outflow-volume data from the drains indicated that Type-A brands drained from two to three times the volume of Type-B brands in equal periods of time. However, the response time appeared to be approximately the same for both brands. One 1,200-ft section of Type A had an outflow volume of more than 50,000 gal in 6 months. Laboratory flow studies conducted at the University of Kentucky indicated that it took Type B on the average of 1.7 times longer to discharge a given volume of water than it took Type A (*2*).

After the drains had been in service for approximately 2 years, a borescope was used to examine and photograph the condition of the core of both brands. The interior of the cores of both brands appeared to be relatively clean, with only trace amounts of silt present. The Type-B core was in good condition (Figure 7). However, the Type-A core appeared to

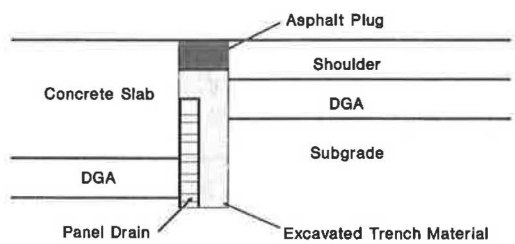

FIGURE 5 Cross section of edge drain installation on I-64, Fayette County.

FIGURE 4 Excavated Type-A drain on I-64, Franklin County.

FIGURE 6 Installation of edge drain on I-64, Fayette County.

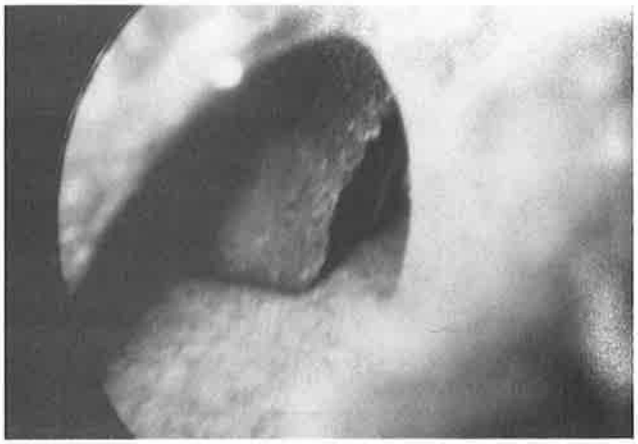

FIGURE 7 Open Type-B core showing no signs of overcompaction.

have been damaged somewhat during compaction. The top three or four rows of columns of the fin drain core were partly crushed. Also, there was evidence that the back part of the core (the shoulder side of the drain) was partly misshapen (Figure 8). It appeared that the compaction process had partly compressed the core vertically. Although the drain was still working, the capacity had been reduced.

Laboratory compression tests conducted on both Type-A and Type-B cores showed that the compressive strengths were similar. The Type-A core tends to test well in compression if the applied force is perpendicular to the support columns. However, if a row of columns starts to bend, this causes 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 Type-A core during backfilling in the field (*3*). Specifications were rewritten to help prevent core damage during installation. The new specification is discussed in a later section.

FIGURE 8 Partially misshapen inner core of Type-A edge drain.

PENNYRILE PARKWAY (1987)

The Pennyrile Parkway is a 4-lane, limited-access route in western Kentucky. The original pavement was a 9-in. unreinforced PCC slab. An 8-mi section of the pavement was rehabilitated in 1987 by breaking and seating the old slab and overlaying it with 5 in. of asphaltic concrete. Longitudinal panel drains were installed at selected locations throughout the project as part of the rehabilitation work. Type-A drains were used; they were installed in 4-in.-wide trenches, which were backfilled with the trench cuttings. A heavy compaction wheel was used to compact the backfill in two lifts. The edge drain was installed before the breaking and seating operation.

In April 1988, approximately 8 months after the project was completed, an average of five sites per mile showed signs of severe distress. Water and white, silty fines were pumping up through the new asphalt overlay, severe potholes were beginning to form in the overlay, and many of the sites required patches (Figure 9). In addition, water was pumping up through the asphalt overlay at the old joint between the shoulder and the broken slab (Figure 10).

Two of the sites at which severe distress was evident were excavated to determine if the panel drains were working properly. When the 4-in. asphalt overlay was removed, the old broken slab was found to be full of water (Figure 11). After the newly installed panel drain was excavated and pulled away from the side of the old slab, water drained freely from the old slab for almost an hour. It appeared that the drain had actually been acting as a dam (Figure 12). The panel drain was cut and a piece removed for examination. The core had

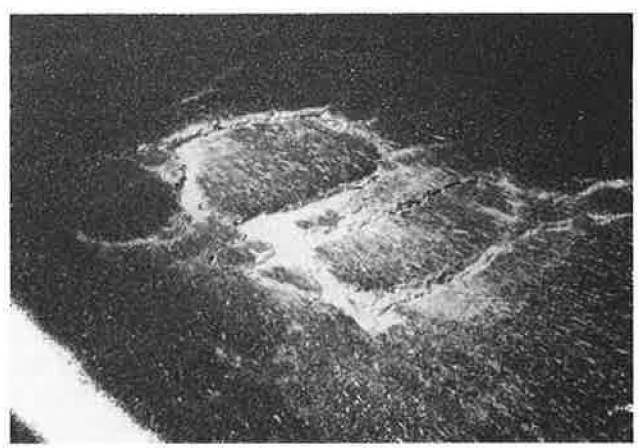

FIGURE 9 Water and silty fines pumping up through pavement on Pennyrile Parkway.

FIGURE 10 **Water pumping up through asphalt overlay directly above edge drain.**

FIGURE 11 **Water ponding in old broken slab.**

been badly crushed during compaction. The rigid backing had been folded at approximately a 90-degree angle (Figure 13). Several rows of the core of the drain had been compressed, and the drain had been deformed into an approximate J-shape, its capacity severely reduced (Figure 14). In addition, the core was almost completely clogged with silt (Figures 15 and 16). Samples of the silt in the core were collected and tested for composition in the laboratory. A high silica content indicated that most of the material was probably concrete debris created by the breaking of the old slab.

FIGURE 12 **Water ponding behind Type-A edge drain.**

FIGURE 13 **Rigid backing of Type-A core folded to approximately 90 degrees.**

FIGURE 14 **Severely compressed Type-A drain.**

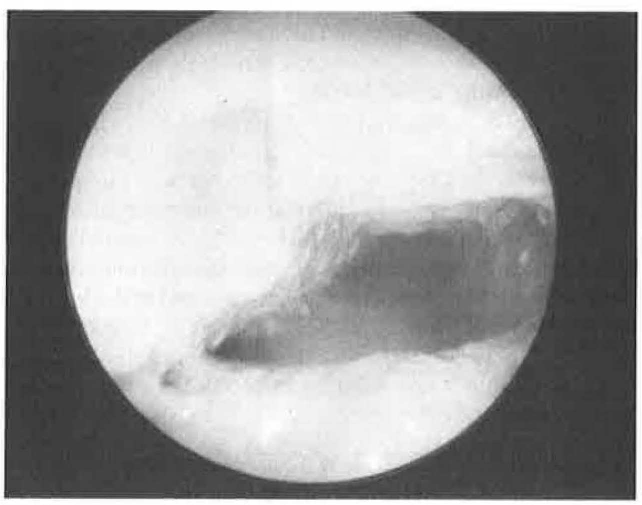

FIGURE 15 **Severely silted inner core of Type-A drain.**

Improper installation of the outlet pipes and overcompaction of the backfill material in the trench, which caused crushing of the core, appeared to be the principal causes of the failure of the panel drains on this project (*4*). The outlet pipes were made of flexible polyethylene. At both of the sites excavated, the outlet pipes were partly crushed, and one appeared to have a 4-in. hump, which decreased the water velocity and allowed silt to be deposited. The panel drains were completely removed from this project and were replaced by 4-in. pipes in 12-in.-wide trenches, for fear that similar panel edge drains would fail. It was apparent that panel drain and installation techniques needed to be revised.

FIGURE 16 **Exposed inner core showing siltation.**

In 1988 Type-A drains were being installed on a number of other projects throughout Kentucky. Because of the apparent flexibility of the Type-A drain in the vertical direction and its susceptibility to deformation under compaction, contractors were instructed to use less compactive effort during the backfilling procedure to reduce damage to the panel drain. Several of these projects were examined after installation by using the borescope. It appeared that considerable damage was still occurring to the core, even when less compactive effort was used.

MOUNTAIN PARKWAY (1988)

The Mountain Parkway is a four-lane, limited-access highway in eastern Kentucky. The original pavement was a 9-in. unreinforced PCC slab, which was rehabilitated in June 1988 by breaking (6-in. blocks) and seating and overlaying with 8-in. of asphaltic concrete. Type-A longitudinal panel drains were also installed on most of the project; approximately 5,000 ft of a new drain, manufactured by Advanced Drainage Systems and identified by the brand name Advanedge (Figure 1, Type C), was installed on an experimental basis. Both products were installed in a 4-in.-wide trench, which was backfilled with the cuttings. Lighter compaction was attempted in two lifts using the vibrating shoe. As in all other break-and-seat projects, the panel drains were installed before the breaking and seating of the old slab. To address the question whether the breaking and seating operation may have been the major cause of damage to the drains rather than the compaction procedure, the drains were examined with the borescope immediately after installation and before the breaking and seating operation. Type-A core still showed considerable compression and damage in the vertical direction, leading to the conclusion that compaction was still the major cause of damage (Figure 17). Although Type-C drain is considerably stiffer vertically and showed little or no vertical damage, it showed some horizontal compression (Figure 18). Never-

FIGURE 17 Compressed interior support columns.

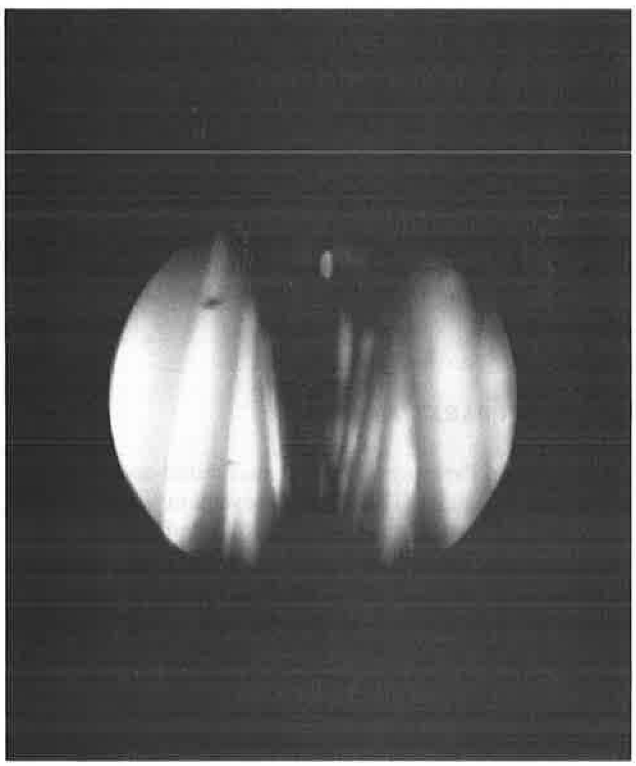

FIGURE 18 Signs of horizontal compression in core of Type-D edge drain.

theless, Type C appeared to be in better condition than Type A (*5*).

Sections of Type A and Type C were excavated in 1989 after being in service for approximately 1 year. Both products appeared to have some silt in the core, but water was flowing freely through them. The Type-A core was reduced from its original height of 12 in. to approximately 10 in. and many rows of columns were compressed (Figure 19). The Type-C core appeared to be in good condition, although a small amount

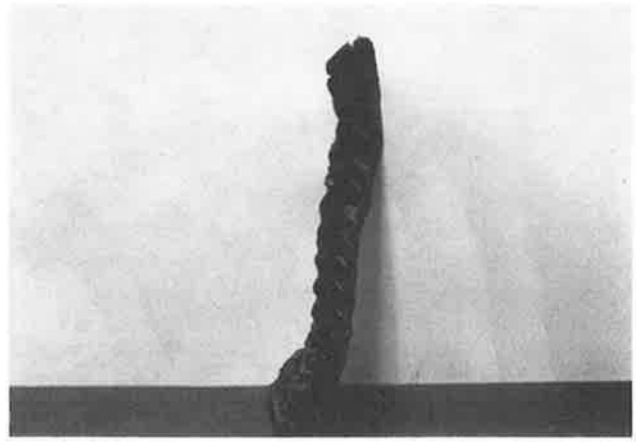

FIGURE 19 Excavated Type-A drain showing compression.

of silting was occurring between the fabric and the core and one of the slits in the core was partly clogged with silt.

Because of the known compaction problem and the possibility of a silting problem, the Kentucky specifications on installation of panel drains were changed in 1989. The new specifications require the panel drain to be installed on the shoulder side of the trench instead of on the pavement side. Backfilling with the trench cuttings is no longer permitted; a clean, coarse sand is specified for backfill material (Figure 20). The sand must also be compacted by flushing the trench with water, thus avoiding the use of heavy compaction over the panel drains. The sand backfill should prevent much of the silt from the broken concrete slab and possibly the dense-graded aggregate from reaching the fabric on the drain core. All projects constructed since the latter part of 1989 have used the new specifications. Later borescope inspections of these projects, after they were completed, showed no damage to the core of the panel drains.

However, in 1989 some spot distresses were beginning to appear in the rehabilitation projects completed on the Mountain Parkway in 1988. At some sites, silt was pumping up through the 8-in. asphalt overlay at the shoulder joint and in the middle of the passing lane (Figure 21). Excavation of two of these sites showed evidence of poor construction practices. At one the outlet pipe had not been connected to the headwall and consequently it was completely blocked. At another the outlet pipe was crushed just before it entered the headwall. Of 14 outlet pipes inspected by using the borescope, 11 had

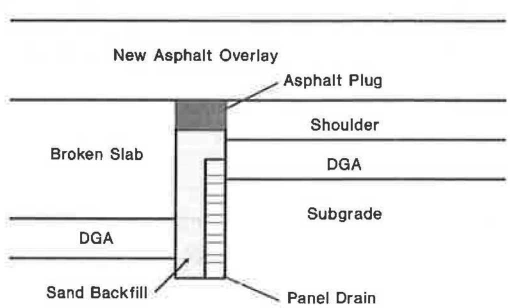

FIGURE 20 Cross section of new installation procedure for panel drains.

FIGURE 21 Silt being pumped up at centerline of Mountain Parkway.

guardrail posts driven through them. All the edge-drain outlet pipes on the inside shoulder were connected to the bottom of the drop inlet boxes located in the median. This allowed silt and trash in the bottom of the box to block the outlet pipe.

A later rehabilitation project, constructed on the Mountain Parkway in 1989, was inspected after the edge-drain installation and the paving operation were completed. The inspection was made during the operation to shape the median. It was noted that many drain outlet pipes were cut by the grading operation, some were simply buried by the grader, and other pipes were crushed (*6*).

WESTERN KENTUCKY PARKWAY (1988)

The Western Kentucky Parkway is a four-lane, limited-access highway. The original pavement was a 9-in. unreinforced PCC slab. Type-A longitudinal panel drains were installed in 1988. The pavement was rehabilitated in July 1989. The old slab was broken (6-in. blocks) and seated.

In July 2 in. of asphaltic concrete base was placed over the old broken pavement and used as a driving surface for a while. During that time, several heavy rains occurred. After the rain it was evident that a large amount of silt had been pumped up through the 2 in. of new base and deposited on the shoulder, but the source of water and silt was not immediately evident. On August 15, 1989, personnel from the Kentucky Transportation Center drilled into the drains and photographed the interior of the drain panel with a borescope. The photographs revealed that the drain panel had been partly crushed from the backfilling operation used during construction. It was estimated that the internal volume of the drain had been reduced by approximately 30 to 40 percent because of crushing (*7*), but the drains were still functioning at this reduced capacity. Although a large quantity of grayish-white silt was present at the headwalls, the drains appeared to be relatively free of silt deposits.

On August 18, the pavement was trenched and sampled at two locations. A trench approximately 8 in. wide was cut from the centerline of the westbound lanes through the outside shoulder and approximately 3 in. into the subgrade. The edge-drain panel was also severed when the trench was cut. There was no free-flowing water in any portion of the pavement, although droplets of water were trapped throughout the newly placed asphaltic concrete base and cracks in the broken PCC slab were damp. The dense-graded aggregate was damp but not excessively wet, and the subgrade was relatively dry.

During the approximately 3 hr the trench remained open, the uphill end of the severed panel drain emitted a stream of water approximately 2 in. in diameter. A water truck was positioned about 100 ft uphill from the open trench, and approximately 500 gal of water was allowed to run onto the asphaltic concrete surface from the spray bar on the back of the truck. Some of the water ran downhill over the surface and into the trench. However, the uphill end of the severed panel drain begin to flow less than 5 min after the water was released. This showed that the newly placed asphaltic concrete base and the old broken slab were very porous and drained freely.

Permeability tests were performed in the laboratory on samples of the newly placed asphaltic base course. A hydraulic and hydrologic analysis of the pavement and drainage system showed that the capacities of the drains were being exceeded by as much as 600 percent, allowing them to overflow. This excess water in the drains was forced upward through the asphalt plug covering the drain and through the 2-in. overlay, depositing concrete debris and limestone fines onto the surface of the shoulder. It was concluded that the distance between headwalls was much too long, in some cases, as much as 2,200 ft. The average was approximately 700 ft. Analysis showed that the maximum distance on grades of over 2 percent should be no more than 450 ft and on grades of less than 2 percent, 200 ft. Additional headwalls were added on this project. As a result of this study, the Kentucky specifications on headwall distances has been changed.

INTERSTATE 75, FAYETTE COUNTY (1989)

The original pavement on this project was a 10-in. unreinforced PCC slab. Longitudinal edge drains were installed in fall 1989. Two panel drain products and a 4-in. perforated pipe edge drain were installed. The panel drains were Type C (the latest design, which was stiffened in the horizontal direction) and Contech (Type D). Both panel drains were installed using the latest specifications on backfilling and headwall distances. The 4-in. perforated pipe was installed in a 1-ft-wide trench. Both the trench and the pipe were wrapped with fabric, and the trench was backfilled with size 57 stone (Figure 22). There were no construction problems during the installation of these products. Borescope inspections after installation showed that all the products were in good condition with no apparent damage to the cores. At present, the pavement has not been broken and seated.

CONCLUSIONS

The conclusion of this study is that greater attention should be given to details during installation and construction of

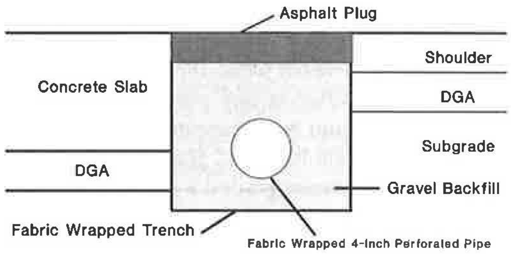

FIGURE 22 Cross section of new installation procedure used on part of I-75.

panel drains. Many of the problems encountered were the result of improper construction practices. Outlet pipes should be installed with the proper grade, which helps maintain the velocity of the water in the drains, flushing out silt and clay-size particles that enter. The drains and outlet pipes must be well protected during the construction operations.

Headwall distances should be designed on a project-by-project basis to prevent exceeding the capacity of the drains.

Breaking and seating of the rigid concrete slab produces the unstable situation in which silt-size particles are set in motion by cyclic loading and by the flow of water. If this silt source is sufficiently great, clogging may occur. At this time, clogging is not a factor under the new specification. The only notable effect of breaking and seating still occurring under the new specification is formation of thin layers of calcium carbonate at the surface of the water inside the core of the drain and at the headwall.

It was concluded that geocomposite fin drains are viable alternatives to pipe edge drains because of their ease of construction, narrow trench widths, and more rapid response times. However, it was also concluded that greater care must be taken in the design and construction of the drains to ensure that they perform properly. To ensure that the integrity of the core has been maintained throughout construction, the authors recommend a specification for inspection of the core after installation is finished.

ACKNOWLEDGMENTS

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