Evaluation of Pumping Pavement on Interstate 77

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Prefabricated pavement edge drains have rapidly gained widespread acceptance as a workable means of preventing intrusive water accumulation on traditionally designed pavement structures. As found in West Virginia, however, the components of some pavement systems are so dense that effective rapid drainage is not possible without special consideration. This paper documents West Virginia's experience with pumping on a rehabilitated section of Interstate in which prefabricated pavement edge drains had been installed. The investigation of the problem is detailed, and recommendations from the study are outlined.

In an effort to increase the service life of West Virginia pavements, the Department of Transportation has elected to increase attention toward pavement drainage, partly by the use of prefabricated pavement edge drains in conjunction with major primary pavement rehabilitation work.

Although West Virginia has had only 5 years' experience with prefabricated edge drains, all installations until recently appeared to be working satisfactorily.

In March 1989 unusual sporadic staining of the paved shoulders of a rehabilitated section of Interstate 77 just north of Charleston was observed (Figure 1). Closer examination indicated that the staining appeared to emanate from the pavement-shoulder interface and to consist of fine soil particles that had pumped from the pavement substructure. A cursory inspection of the associated outlets indicated relatively good outflow, although similar staining was evident in the outwash.

INTERSTATE 77 REHABILITATION HISTORY

Rehabilitation of portions of Interstate 77 between Charleston and the Ohio River (approximately 80 mi to the north) was begun in 1984. Most of the rehabilitation involved the repair of the badly deteriorated portions of the original portland cement concrete (PCC) pavement, installation of underdrains, breaking and seating of the original pavement slabs, and rcpavment with 4 in. of new bituminous pavement.

Prefabricated edge drains were first used on this section of roadway in 1987. The rapid installation (Figure 2), relative low cost, and alleged superior performance made prefabricated pavement edge drains an attractive product to both the state and the contractors.

By the start of the 1989 construction season, nine separate rehabilitation projects on Interstate 77 had been completed in which prefabricated pavement edge drains were installed. Records indicate that only two brands of prefabricated pavement edge drains were used, namely, Hydraway (Monsanto) and AdvanEdge (Advanced Drainage Systems). Although similar in concept, both products exhibit radically different core designs. The Hydraway core (Figure 3) is basically composed of numerous flexible cylindrical projections or posts from a single flexible base. The AdvanEdge core (Figure 4) resembles a flattened corrugated plastic pipe with slit-type openings in the corrugations on both sides of the panel.

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FIELD REVIEW

A field review of all rehabilitated Interstate 77 projects north of Charleston revealed that the more obvious pumping was occurring on projects where AdvanEdge was used. Although the pavement sections drained by Hydraway and by aggregated-filled, fabric-wrapped trenches were found later not to be totally free from problem areas, the evidence of pumping was less frequent on those sections and was considerably less severe.

All prefabricated edge drains on Interstate 77, regardless of brand used, were installed 1 ft away from the edge of the pavement in the shoulder, as shown in Figure 5. The edge drain was placed at such a depth that its top 2 in. was on the same plane horizontally as the bottom 2 in. of the pavement slab. With a base course 6 in. deep, the bottom 4 in. (vertically) of edge drain was in the native soil. Consequently, because the material excavated from the trench was used as backfill, one-third of the backfill consisted of soil.

With FHWA an inspection was planned to determine the cause of the pumping problem. The work plan included borescoping of typical problem areas, the excavation of several test pits for a close look at the material involved, and an outlet evaluation.

BORESCOPE INVESTIGATION

Borescoping is essentially a nondestructive test that involves the insertion of a small camera lens and light source on the end of a probe into a small-diameter hole. The use of such an instrument allows a close examination of the flow channel of a pavement edge drain without a major excavation. A total of three problem sites drained by AdvanEdge were chosen for borescope investigation. All borescope observations revealed similar findings:

- The inner flow channel was open and did not appear to have been crushed.

FIGURE 1 Soil-stained shoulders.

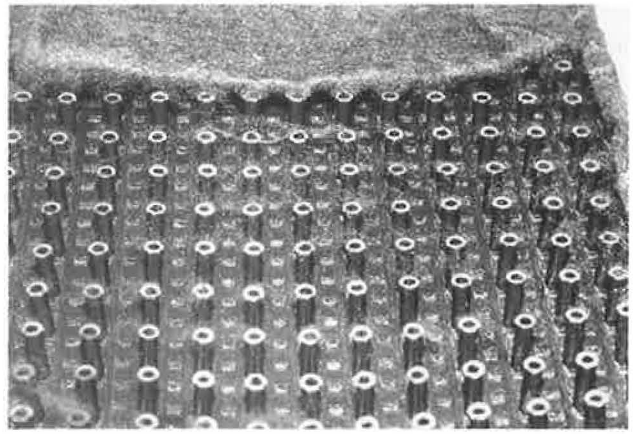

FIGURE 3 Monsanto Hydraway core.

FIGURE 2 Edge-drain installation.

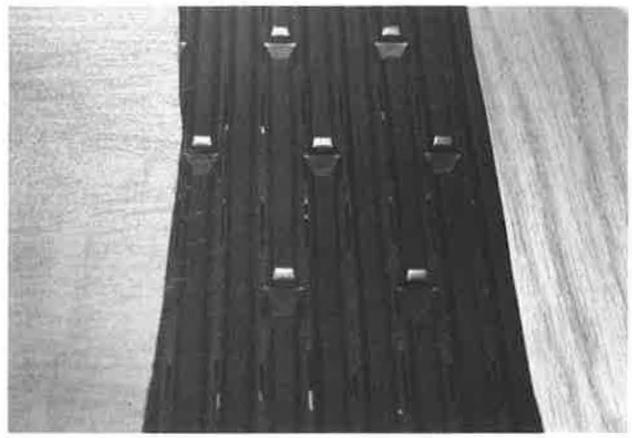

FIGURE 4 Advanced Drainage Systems AdvanEdge core.

- Up to 3 in. of sediment and standing or slowly flowing water was found in the bottom of the flow channel.
- Many of the slit openings, especially in the bottom two rows (of four rows), had been blinded with sediment.

TEST PIT EXCAVATION

Test pits were excavated in the shoulder adjacent to the pavement in three separate sections of Interstate 77:

1. Pumping AdvanEdge pavement,
2. Pumping Hydraway pavement, and
3. Functional (nonpumping) AdvanEdge pavement.

All test pits were excavated in the same manner, using a jackhammer and backhoe as well as manual labor. A trench 3 ft wide was excavated into the shoulder with the power equipment to a depth certain to be below the bottom of the edge drain. The power trenching was not allowed to come closer than 6 horizontal in. to the edge drain itself. Excavation

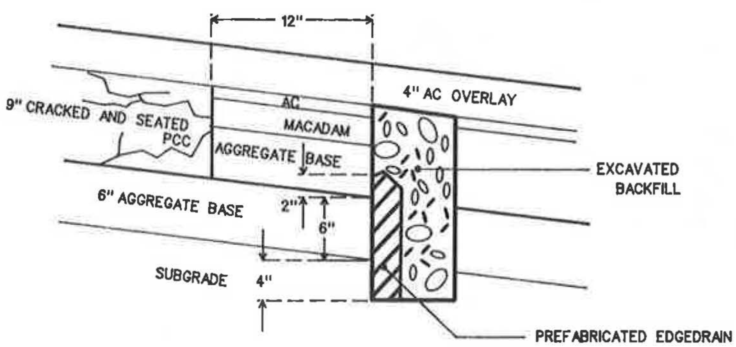

FIGURE 5 Original edge-drain installation design.

by hand was then utilized to expose the edge drain as well as the material between the edge drain and the pavement. Detailed observations, measurements, and samples of the base course, subgrade, backfill, and edge drain were collected from each test pit.

Test Pit 1 (Pumping AdvanEdge)

As shown in Figure 6, Test Pit 1 was excavated in an area that not only showed the most severe signs of pumping, but was still moist from pumping as the excavation was begun, even though it had not rained in several days. Although considerable information was collected, the most significant had to do with the base course and the soil contamination of the edge drain.

The limestone base course used on this project was extremely dense, so much so that it had to be chiseled out of the test pit with a rock hammer (Figure 7). Although the area was moist, no free water was found in the base course on either side of the edge drain. When the base course was removed from the side of the original pavement slab, however, the crack-and-seat operation caused water to begin flowing from the fractures in the pavement (Figure 8). The base course essentially acted as a dam that kept water from reaching the edge drain. Although the original gradation of the base course was not conducive to good permeability, what permeability it had may have been lessened by the addition of pulverized concrete matrix fines from the crack-and-seat operation.

Soil contamination of the edge drain appeared to have a substantial effect on the ability of water to reach the internal flow channel of the AdvanEdge core (Figure 9). It is believed that most of this soil came from the backfill placed during the installation of the edge drain. Examination of the excavated sample revealed that less than 50 percent of the core wall slits remained open. The remainder of the slits were either partially blinded or totally plugged with soil sediment.

Test Pit 2 (Pumping Hydraway)

Earlier field reviews revealed only one small section of pavement (100 to 150 ft) drained by Hydraway that was showing signs of pumping. Although a test pit was excavated in the approximate center of the pumping area, it appeared that the area was located on a slight vertical curve that had not been provided with an outlet. Confirmation of this suspected cause of pumping was made when the test pit was opened. As the

FIGURE 6 Site of Test Pit 1: severe staining of shoulder.

FIGURE 8 Free water from cracked pavement slab, Test Pit 1.

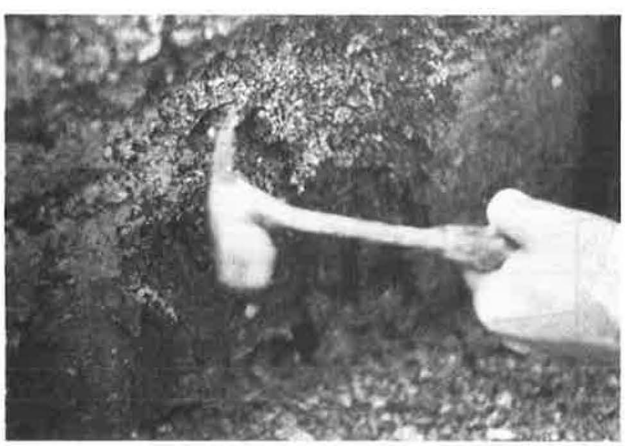

FIGURE 7 Hand excavation of base course, Test Pit 1.

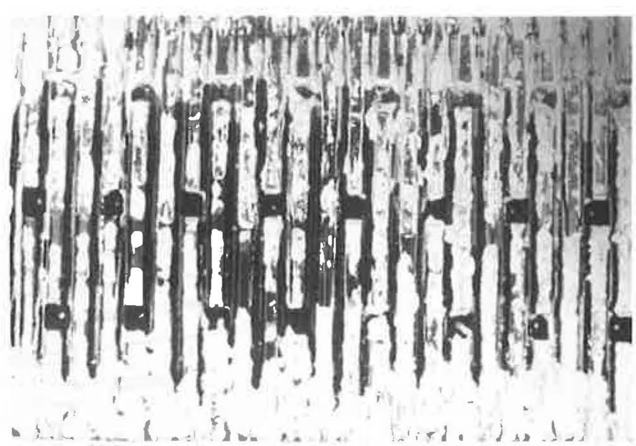

FIGURE 9 Soil-contaminated AdvanEdge core, Test Pit 1.

hand digging got close to the edge drain, water began to flow rapidly from it, washing much of the backfill away from the shoulder side of the drain (Figure 10).

The base course in this section was a mixture of sand and gravel. The gradation appeared to be more conducive to drainage than that encountered in excavation of the pumping AdvanEdge section.

Deformation of the Hydraway core was apparent and is shown in Figure 11. The top row of the support columns was bent downward about 30 degrees and the bottom two rows were bent upward about 45 degrees. In addition, where the edge drain had intersected the base-subgrade interface, there was distortion along a horizontal plane that caused an offset of as much as ½ in. between the top and bottom of the product. Although deformed, it appeared that the edge drain would perform satisfactorily if given a proper outlet. Consequently, before the test pit was closed, a trench was cut into the shoulder that linked the test pit with the side of the embankment. The trench was lined with engineering fabric and backfilled with pea gravel. Recent observations indicate that pumping of the shoulder has subsided.

Test Pit 3 (Functional AdvanEdge)

Excavation of this section revealed a sand-and-gravel base that appeared to be relatively permeable. Although the backfill contained appreciable amounts of soil, there apparently was enough water flow to flush the soil fines from the slit openings into the core's internal flow channel. Evaluation of the core indicated that as much as 93 percent of the slits was completely open.

Outlet Examination

All outlets examined were constructed of 4-in. corrugated plastic pipe. The outlet openings were encased in a concrete headwall as shown in Figure 12. All outlets associated with pumping pavement appeared to be functioning, although soil staining of the outwash was apparent. Occasionally, an outlet was encountered that appeared to have a slight reverse grade, which may have slowed the drainage process. In addition, a

FIGURE 10 Water flow from hydraway, Test Pit 2.

FIGURE 11 Hydraway deformation, Test Pit 2.

calcium carbonate crystalline growth was observed on several of the rodent screens and in the corrugations on the bottom of the outlet pipes.

CONCLUSIONS

As shown in Figure 13, the staining of the shoulder is the result of water infiltrating the asphalt overlay into the cracked and seated PCC pavement slab. There it travels through the fractures in the slab to the pavement-shoulder interface. At that point, if anything impedes the flow of water to the surface drainage, it is essentially trapped in the fractures of the pavement. The main flow problem appears to be the very dense base course that surrounds the pavement and the location of the edge drain.

As shown in Figure 14, much of the base course used on Interstate 77 is very dense, almost to the point that it is impermeable. Because the edge drain was placed 1 ft out into this base course, free flow of water to the surface drainage in many locations is not possible. Under the circumstances, free water and suspended fine particles have only one way to go under traffic loadings—up through the asphalt and onto the pavement surface. In an effort to reduce, if not eliminate, the same problem on future rehabilitation projects, the following recommendations have been made:

FIGURE 12 Typical outlet opening.

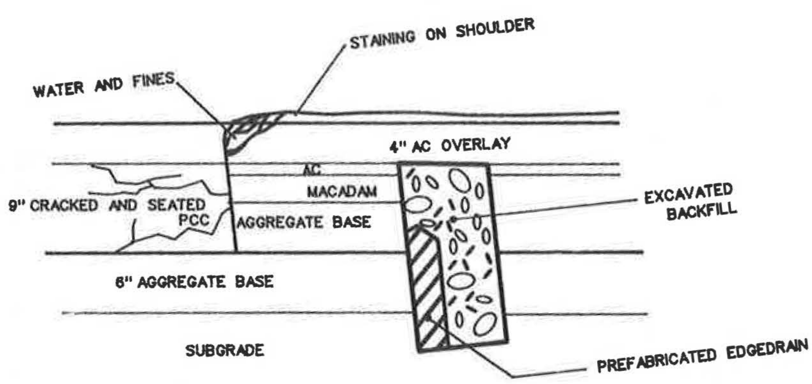

FIGURE 13 Origin of Interstate 77 shoulder staining.

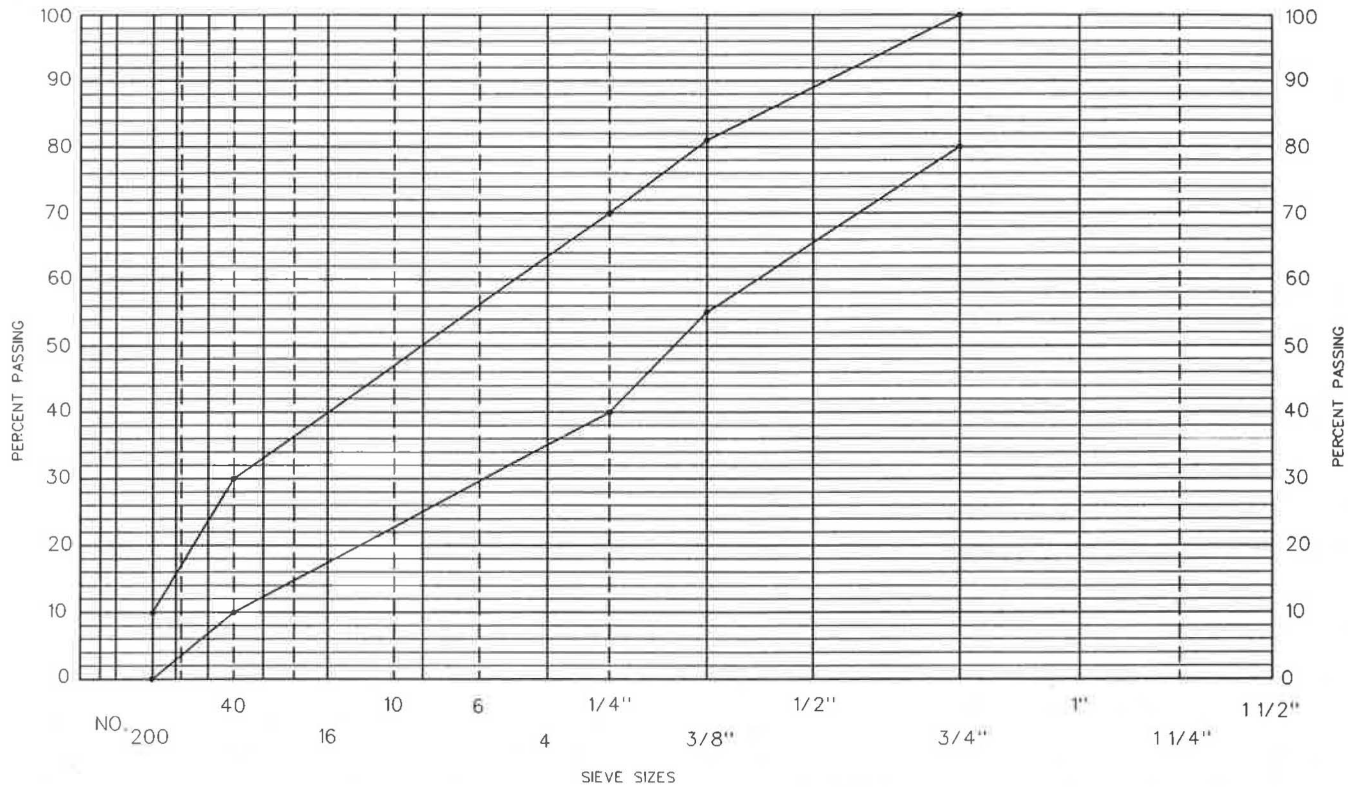

FIGURE 14 Gradation range used for original base course (sieve sizes raised to 0.45 power).

1. Placement of the edge drain should be done in such a way that a large portion of it is in direct contact with the cracked and seated pavement. This can be accomplished by installing the edge drain immediately adjacent to the pavement slab at a depth not to exceed 1 in. into the soil subgrade, as is shown in Figure 15. Elevating the edge drain will also reduce the amount of soil particles available to clog the drain.

2. Outlets should be constructed with smooth-walled rigid pipe to help ensure that the proper outlet grade is maintained.

3. Asphaltic concrete compaction requirements should be tightened to reduce the amount of moisture available to the pavement structure.

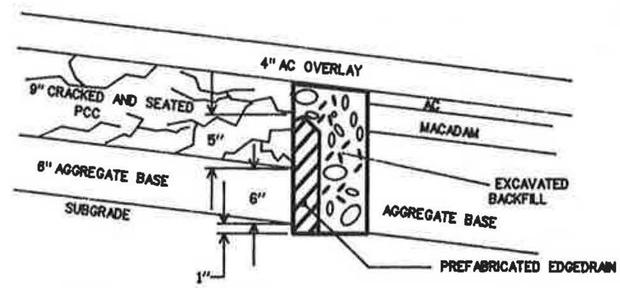

FIGURE 15 Recommended prefabricated edge-drain placement.