Status Report for Selected Projects Containing Experimental Features

Kentucky Transportation Research Program
Research Report  
UKTRP-86-29

STATUS REPORT  
FOR  
SELECTED PROJECTS CONTAINING  
EXPERIMENTAL FEATURES

by

Staff

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Lexington, Kentucky

in cooperation with  
Transportation Cabinet  
Commonwealth of Kentucky

and

Federal Highway Administration  
US Department of Transportation

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December 1986
Projects containing experimental features or innovative concepts were selected for long-term monitoring and are reported herein. Certain projects are recommended for more intensive investigation under other appropriate ongoing studies.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Collection and Analyses of Base Course Rutting and Deflection Data</td>
<td>3</td>
</tr>
<tr>
<td>Performance of Pavement Joints and Seals</td>
<td>5</td>
</tr>
<tr>
<td>Evaluation of Subdrainage and Edgedrain Systems</td>
<td>10</td>
</tr>
<tr>
<td>Cracking and Reflective Cracking in Overlays on Portland Cement Concrete Pavements</td>
<td>42</td>
</tr>
<tr>
<td>Performance of Full-Depth Asphalitic Concrete Pavement</td>
<td>43</td>
</tr>
<tr>
<td>Performance of and Loads on Culverts</td>
<td>44</td>
</tr>
<tr>
<td>Performance of Metal Long-Span Structures, Metal Box Culverts, and Precast Reinforced Concrete Box Culverts</td>
<td>46</td>
</tr>
<tr>
<td>Evaluation of Bridge Expansion Dams and Deck Drains</td>
<td>56</td>
</tr>
<tr>
<td>Evaluation of Structural Paint Systems</td>
<td>62</td>
</tr>
<tr>
<td>Effectiveness of Direct Tension Indicators</td>
<td>66</td>
</tr>
<tr>
<td>Performance Evaluation of Corrugated Polyethylene Entrance Pipe</td>
<td>67</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Projects containing experimental features or innovative concepts are reported herein.

Altered gradations of DGA subbase courses employed on KY 627 in Clark County did not prove suitable for further evaluation due to difficulties encountered during placement, compaction, and trimming. No variations in performances were observed.

Silicone pavement joint seals appear to be performing well and continued use is recommended.

The Cedegren subdrainage system on KY 55 in Taylor County functioned satisfactorily. Long-term variations in performances between sections with and without the underdrainage system were not detected. Low to moderate traffic volumes may be a primary reason for the excellent performance of all sections. Use of the subdrainage system on future construction is recommended. Further study of edgedrain installations is recommended. Efforts should be made to determine whether edgedrains clog soon after installation.

A report documenting breaking and seating projects is to be distributed in the near future and will discuss cracking and reflective cracking in overlays on portland cement concrete pavements.

Data obtained from full-depth asphaltic concrete projects have been used to develop recommendations for pavements requiring rehabilitation.

Information gained from a previous study concerning loads on culverts was used to develop guidelines for design of those types of structures. Load measurements have continued to determine whether loads remain constant over an extended time.

Performances of metal long-span structures, metal box culverts, and precast reinforced concrete box culverts have been excellent except for a long-span structure in Floyd County. Research Report UKTRP-86-27 contains information relative to the Floyd County structure.

Problems associated with bridge expansion dams warrant correction. Continued use of modular expansion joints is not recommended. Performance of deck drains has been generally satisfactory. Periodic inspections, cleaning, and flushing are recommended.

Inspections of bridge paint systems have verified the importance of cleaning the steel prior to painting. Observations of paint systems on
new structures and repainted structures prove that proper cleaning prior to painting greatly enhances durability.

Evaluation of direct tension indicators is pending completion of the bridge.

Performances of corrugated polyethylene entrance pipe varied widely. Proper installation is important to maintain the structural integrity of the pipe. Siltation was noted as a frequent problem. Protective devices are recommended for situations where crushed ends are anticipated or observed.
INTRODUCTION

Over the years, numerous experimental features and innovative concepts have been used in the construction, maintenance, or rehabilitation of transportation facilities. The majority of the formal studies involving experimental features or unconventional procedures normally provide for 1) surveillance during construction or installation and 2) periodic performance surveys for one to three years after completion of the installation. In certain instances, non-specification materials or methods may be employed by use of a Special Note or Special Provision designated EXPERIMENTAL. Provisions are normally made for monitoring installations during construction and periodic inspections thereafter until the time of project acceptance and final payment. Very rarely were provisions made for long-term monitoring.

Recognizing that valuable information could be gained at relatively nominal costs, Study KYHPR-85-107, Long-Term Monitoring of Experimental Features, was initiated early in Fiscal Year 1985. A Study Advisory Committee was established and the Director of the Division of Materials was appointed as the committee Chairman. Proposals for items for inclusion in the long-term monitoring program were solicited from Transportation Cabinet engineering personnel and Transportation Research Program principal investigators. A compilation of suggestions received included approximately 60 items for consideration by the Study Advisory Committee. The following items were selected and identified as subtasks:

KYHPR-85-107-1 Collection and Analyses of Base Course Rutting and Deflection Data
KYHPR-85-107-2 Performance of Pavement Joints and Seals
KYHPR-85-107-3 Evaluation of Subdrainage and Edgedrain Systems
KYHPR-85-107-4 Cracking and Reflective Cracking in Overlays on Portland Cement Concrete Pavements
KYHPR-85-107-5 Performance of Full-Depth Asphaltic Concrete Pavements
KYHPR-85-107-6 Performance of and Loads on Culverts
KYHPR-85-107-7 Performance of Metal Long-Span Structures, Metal Box Culverts, and Precast Reinforced
Concrete Box Culverts

KYHPR-85-107-8 Evaluation of Bridge Expansion Dams and Deck Drains

KYHPR-85-107-9 Evaluation of Structural Paint Systems

KYHPR-85-107-10 Effectiveness of Direct Tension Indicators

KYHPR-85-107-11 Performance Evaluation of Corrugated Polyethylene Entrance Pipe

Information obtained under each subtask through October 1986 follows.
Dense-graded aggregate (DGA) was first used for bases in Kentucky in the mid 1950's. DGA could be planed easily with a grader, or spread and shaped with other equipment. In the early 1970's, field investigations of DGA bases indicated gradations might contain too many fines, causing them to become saturated and weak. Several aggregate gradations were chosen for preliminary laboratory evaluations. Two aggregate gradations were selected for a field trial. The Kentucky Crushed Stone Association cooperated with the Department of Highways in the study.

KY 627 in Clark County, Boonesboro-Winchester Road, was chosen for trial installations. Construction and performance data were reported in Report UKTRP-83-15, Crushed Rock Base. Ten sections of varying subbase and base thicknesses were chosen for study between Stations 58+62 and 364+65.3. The prevailing DGA gradation and two modifications were used as subbase material for various sections. Aggregate gradations used are listed in Table 1-1, with No. 1 being the prevailing DGA gradation at the time of project construction in 1975-76.

<table>
<thead>
<tr>
<th>Sieve</th>
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<tr>
<td>1 1/2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>1 1/4&quot;</td>
<td>92-98</td>
</tr>
<tr>
<td>1&quot;</td>
<td>100</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>70-100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>50-80</td>
</tr>
<tr>
<td>No. 4</td>
<td>35-65</td>
</tr>
<tr>
<td>No. 10</td>
<td>25-50</td>
</tr>
<tr>
<td>No. 40</td>
<td>15-30</td>
</tr>
<tr>
<td>No. 200</td>
<td>5-12</td>
</tr>
</tbody>
</table>

3
An attempt was made to decrease fines in Gradations No. 2 and No. 3 to enhance drainage. A slight increase in larger particles for Gradation No. 2 was an attempt to determine the effect, if any, on stability.

Four sections utilizing the conventional DGA (Gradation No. 1) were placed without any problems. Four sections utilizing Gradation No. 2 were placed with difficulty. Density was difficult or impossible to obtain. The Resident Engineer was of the opinion segregation was more apparent than with the trial gradations. Two sections utilizing Gradation No. 3 were placed and density was difficult to obtain. In some instances, the aggregate was crushed during rolling and the subbase cracked during rolling before densities could be obtained. The rolling pattern was varied and moisture contents were adjusted to no avail.

No variations in performances of the various sections attributable to aggregate gradation have been detected. Road Rater deflection measurements were obtained during various stages of construction and periodically (May 1986, most recent) thereafter. Deflection data did not indicate variations in behaviors for any of the sections. The magnitudes of recent deflections increased relative to earlier deflections, indicating a weakening of the pavement structure. No discernable differences were noted for the various sections. Such observations are expected as the fatigue life of the pavement structure is consumed. Specific calculations associated with the determination of the remaining life are not planned for this most recent series of measurements. This section will be included in the series of pavements selected for study under Study KYHPR-86-115. Analyses under that study will utilize all prior data for a description of historical deterioration and also will involve detailed laboratory materials characterizations.
PERFORMANCE OF PAVEMENT JOINTS AND SEALS

The current Standard Specifications provide for use of either hot-poured elastic or preformed compression joint sealers for longitudinal and transverse portland cement concrete pavement joints. Most hot-poured seals deteriorate relatively soon after installation and resealing is necessary at frequent intervals. Preformed compression seals are rather expensive and sometimes difficult to install. Early in 1978 a one-part silicone rubber was demonstrated and proposed for use as a joint sealer. A Special Note dated December 27, 1978, provided for use of silicone rubber sealants. Special Provision No. 63, Silicone Rubber Sealant for Concrete Pavement, was approved January 13, 1982. Silicone rubber sealants are currently permitted under Special Provision No. 63E(85) approved May 30, 1986.

Seven projects having silicone rubber sealants were selected for long-term monitoring. Table 2-1 is a listing of those projects and pertinent data. All silicone rubber employed in the seals was produced by Dow Corning Corporation.

TABLE 2-1. SILICONE RUBBER SEALANT PROJECTS

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>ROUTE</th>
<th>PROJECT</th>
<th>DATE AWARDED</th>
<th>LENGTH</th>
<th>INSPECTION LENGTH</th>
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<tr>
<td>McCracken</td>
<td>US 60</td>
<td>CF 60-1(6)</td>
<td>6/20/80</td>
<td>2.31</td>
<td>2.3</td>
</tr>
<tr>
<td>Franklin</td>
<td>US 60</td>
<td>HE S7320(1)</td>
<td>6/22/79</td>
<td>1.01</td>
<td>1.0</td>
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<tr>
<td>Rowan/Bath</td>
<td>I 64</td>
<td>EACIR 64-6(31)113</td>
<td>3/01/84</td>
<td>33.38</td>
<td>5.0</td>
</tr>
<tr>
<td>Franklin</td>
<td>I 64</td>
<td>ACIR 64-4(62)53</td>
<td>9/12/84</td>
<td>4.71</td>
<td>3.0</td>
</tr>
<tr>
<td>Owen</td>
<td>US 127</td>
<td>SR 5170(1)</td>
<td>3/08/82</td>
<td>9.21</td>
<td>5.2</td>
</tr>
<tr>
<td>Boone</td>
<td>KY 18</td>
<td>SR 5228(5)</td>
<td>3/08/82</td>
<td>3.26</td>
<td>2.0</td>
</tr>
<tr>
<td>Campbell</td>
<td>I 471</td>
<td>I 471-4(17)2</td>
<td>3/04/80</td>
<td>1.39</td>
<td>1.3</td>
</tr>
<tr>
<td>Trigg/Christian</td>
<td>I 24</td>
<td>ACIR 00243(27)65</td>
<td>6/26/85</td>
<td>45.00</td>
<td>22.0</td>
</tr>
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The majority of the seals on US 60 in McCracken County appeared to be in good condition in mid August 1985. Most seals were covered by
sand and small aggregate, which was removed for inspections. Joint
widths varied from 3/8 to 1 inch due to irregular saw cuts. Seal
surfaces varied from flush to 1 inch below the pavement surface. In a
few instances, the seal had separated from the joint face and in some
cases the sealant was missing. Complete sealant failure was observed in
one area where water ponded over extended periods.

A paved median was constructed between the eastbound and westbound
lanes for approximately 1 mile. Silicone seals were placed
longitudinally between the pavements and median and transversely at
regular intervals in the median. Longitudinal joints averaged 1/4 inch
in width and seal surfaces were flush to 1/4 inch below the pavement
surface in October 1985. Transverse joints averaged 3/4 inch wide and
seal surfaces were uniformly 5/16 inch below the median surface. Debris
had collected above some seals. Debonding of the sealant and joint face
was noted in a few instances.

A few seals were twisted and disfigured. The median surface was
above or below the pavement surface in many locations and may have
created problems during longitudinal seal installation. The
longitudinal seals were generally in poor condition. Pavement breakage
near the longitudinal joint led to failure in some locations. Complete
failure of the longitudinal seal was observed along the north edge of
the median near the entrance to Juniper Hills Park and extending
approximately 800 feet. One transverse joint failure was observed near
Station 1578+00. The majority of transverse seals were in good
condition.

Seals on I 64 in Rowan and Bath counties were last inspected in
March 1986. Most seals were in excellent condition and only nominal
debris was noted near the pavement edges. The average width of
longitudinal joints was 7/16 inch and their seal surfaces were
approximately 7/16 inch below pavement surfaces. All sealants had very
smooth surfaces and appeared to have been installed in an excellent
manner. The only problem observed was in an area where the shoulder
surface was slightly above the pavement surface. Debris accumulated at
the interface and was pushed into the sealant.

An inspection of the sealants on I 64 in Franklin County between MP
54.0 and MP 57.0 was made in April 1986. Pavement joints had been
reconstructed and sealed with silicone. The average longitudinal and transverse joint widths were 3/8 and 7/8 inch, respectively, and the tops of most sealants were 3/8 inch below the pavement surface in the westbound lanes. In the eastbound lanes, the average width of the longitudinal joint was 7/16 inch and the depth to the top of the sealant averaged 3/8 inch. Transverse joint widths and depths to the top of the sealant averaged 7/8 and 7/16 inch, respectively.

The majority of seals were in very good condition. Only one minor failure was observed where the seal had dislodged approximately 1 foot near the median shoulder.

An inspection of US 127 in Owen County between MP 20.0 to the Owenton city limit was made in April 1986. Old seals had been removed, joint faces were sawed, and cleaning was in accordance with the Special Provision. Saw cuts were rather irregular. The average longitudinal and transverse joint widths were 3/8 and 3/4 inch, respectively. Depths to the tops of seals ranged from 3/8 to 1 inch. Debris had accumulated above some seals. A 3-inch puncture was noted in one seal and the seal had debonded at a portion of one transverse joint. A portion of the longitudinal joint had failed near the KY-845 intersection. That failure was attributed to deterioration of the concrete and not necessarily the silicone.

The seals were in generally fair condition. The seals were not smoothly finished and variations in depths to the seal surfaces indicated poor installation procedures.

A 2-mile section of KY 18 in Boone County was last inspected in April 1986. The seals were in excellent condition. Longitudinal and transverse joint widths averaged 3/8 and 1/2 inch, respectively. Seal surfaces were 1/4 to 1/2 inch below the pavement surface in all installations. A 1-inch and a 7-inch seal puncture were observed in the westbound lanes. Only nominal debris was observed above sealants. The pavement is quite old and many joints exhibited deterioration. The project is an excellent example of quality workmanship in resealing pavement joints.

A 1.3-mile section of I 471 from MP 4.0 to the end of the project in Campbell County was inspected in April 1986. The longitudinal joints had been resealed with hot-poured elastic sealant. Transverse joint
widths averaged 1/2 inch and the distances from the pavement surface to the tops of the silicone seals were 1/4 to 1/2 inch. A portion of the sealant was missing from approximately 85 percent of the transverse joints. Many joints had 25 percent or more of the sealant missing. It is suspected that joints were not adequately cleaned prior to installation of the silicone seals.

Overall the seals observed on I-24 in Christian and Trigg Counties were in excellent condition. No failed seals were observed. The worst conditions were crooked saw cuts and several wide joints. Although several saw cuts as wide as 2 to 3 inches were observed, the seals were performing as expected (Figure 2-1). There were no loose seals in those wide saw cuts. The average width of the transverse saw cuts was 1 inch. Most cuts were fairly uniform. However, some of the cuts were bottle shaped with wide and narrow areas (Figure 2-2). Transverse saw cuts in the section from US 41-A to the Tennessee line were slightly wider, averaging approximately 1-1/8 inches. The longitudinal saw cuts were noticeably wider on the western end compared to the eastern end. Longitudinal saw cuts on the west end, from US 68 to KY 117, averaged 1/2 inch or larger, with many measuring nearly 3/4 inch. On the east end, US 41-A to the Tennessee line, longitudinal saw cuts averaged 1/2 inch or less, with many measuring 3/8 to 1/4 inch. The depth of the transverse seals in both sections surveyed averaged 1/2 inch. Many places were higher and a few were deeper. Even where the seal was flush with the surface, it appeared to be well sealed. Longitudinal seals varied in depth. Generally, the depth of the seals averaged less than 1/2 inch. The depth of the seal was more uniform for the wider saw cuts.
Figure 2-1. Some Transverse Joints Were 2 to 3 Inches in Width.

Figure 2-2. Saw Cuts Were not Uniform.
EVALUATION OF SUBDRAINAGE AND EDGEDRAIN SYSTEMS

Subdrainage

A 5.2-mile section of KY 55, Columbia-Campbellsville Road, in Taylor County was selected early in 1976 for design and construction under NEEP 14, Drainage Blanket in Highway Pavement Systems. The objective was to design a cost effective, two-layer drainage system that could be constructed using locally available materials and conventional equipment. The project included ten sections of equal lengths. Section designs are shown in Figure 3-1. Section 1 was of conventional design and served as a control section. Four experimental designs were employed in Sections 2 through 5. Each of the five designs was repeated in Sections 6 through 10 to provide a broader base for evaluation.

A portion of the DGA was replaced with either No. 4, No. 5, or No. 57 crushed limestone, which was to serve as the drainage blankets in the experimental sections. A pipe system consisted of 4-inch perforated, corrugated polyethylene conduit was placed longitudinally in a V-shaped trench near each pavement edge as well as transversely between pavement sections. Underdrains were not installed in control sections 1 and 6.

Soon after completion of construction, attempts were made to measure the in situ permeability of the drainage blankets and conventional DGA subbases. The DGA did not generate sufficient flow to enable measurement. The capacities of the experimental drainage blankets exceeded the capacity of the instrument used for measurements.

Road Rater deflection measurements have been obtained at various times over the years and analyses indicate the remaining life of sections as being fairly equal, except for Sections 4 and 9. Sections 4 and 9 were of weaker design and tests indicated the remaining life for those sections as being less than for other sections.

Edgedrains

In recent years, many miles of pavement edgedrains have been installed along interstate highways and other high-type facilities. The purpose of these installations is to drain any water that might intrude under the pavement slab or under the asphaltic concrete layers. Water may enter the pavement structure from a number of sources. These may include cracks in the pavement surface, construction joints, edge joints
between the shoulder and driving lane, raised grass medians, and groundwater. It is intended that the drains will intercept water and drain it away from the structure, thereby helping to prevent saturation of the subgrade and dense-graded aggregate.

The drains are usually installed at the interface between the driving lane and the shoulder. The depth of installation varies from project to project. The drains are normally installed in a trench 12 inches wide. The 4-inch perforated, polyethylene pipe is covered with a fabric, and the trench is backfilled with a granular material. In some cases, the trench is lined with a filter fabric before backfilling, in which case the fabric on the pipe is omitted. The edgedrain pipe is daylighted to the edge of the shoulder at various intervals, and the pipe is anchored with a small precast headwall.

These edgedrains have been installed at a number of sites throughout Kentucky. During the week of October 20–24, 1986, the following sites were inspected and evaluated:

1. I 64 and I 75, Fayette County, MP 111.8 to 116.3;
2. US 60, Fayette County, Keeneland Race Track Entrance to KY 4;
3. I 275, Boone County, US 25 to KY 16;
4. I 75, Boone County;
5. I 71, Gallatin County, MP 56 to 70;
6. I 75, Whitley-Laurel Counties;
7. I 64, Franklin County, US 127 to US 60; and
8. KY 55, Taylor County, Stations 276+17.8 to 533+20, Cedergren Underdrain System.

It should be noted that the inspections were made during a relatively dry period.

I 64 AND I 75, FAYETTE COUNTY -- It was difficult to determine whether all of the pipes had drained previously. However, many of the pipes had silt deposits at the end, indicating some flow. No headwall had water flowing on the date of inspection. Nearly all headwalls had debris in the flowline (Figure 3–2). Much of the debris appeared to be erosion from the shoulder and from around the headwall. Erosion appeared to be a problem on approximately one-third of the headwalls. Figure 3–3 shows longitudinal cracks along the edge of the driving lane.
These have occurred as a result of settlement of the trench. These cracks occurred intermittently over approximately 50 percent of the project.

The pavement appeared to be performing well. However, because there is no control section on this project that has no edgedrains, the effect of the edgedrains on pavement performance could not be fully evaluated.

US 60, FAYETTE COUNTY -- All headwalls on this project were partially clogged with organic debris or silt (Figures 3-4 through 3-6). Because of the heavy growth of grass on the embankment shoulders, erosion did not appear to be a problem. Figure 3-7 shows that settlement has occurred over the trench, although no longitudinal cracks were visible at the time of the survey.

The portion of the pavement that had edgedrains appeared to be performing well; however, there appeared to be no significant difference in performance between the edgedrain portion of the project and those portions that have no edgedrains.

I 275, BOONE COUNTY -- Most headwalls were partially clogged with organic debris and trash (Figure 3-8). Also, settlement was present over the trench in some isolated locations (Figure 3-9). The performance of the pavement did not appear to be significantly better than other sections of I 275 that have no edgedrains.

I 75, BOONE COUNTY -- A small number of headwalls were relatively free of debris, however, it appeared as if most of those had drained little or no water (Figure 3-10). As in the case of the other projects, most of the headwalls were filled with debris and silt, and in two cases they were completely blocked (Figures 3-11 and 3-12). The headwalls that were located in the median were mostly obscured by a heavy growth of grass, and nearly all were choked with organic debris (Figure 3-13). Erosion was a severe problem for a number of headwalls located on the embankment slope. Figures 3-14 and 3-15 illustrate two cases of severe erosion. One pipe was draining water at the time of inspection (Figure 3-16). It appeared that this particular drain may have been intercepting groundwater because it was in a low, swampy area that had a
high water table. At the time of inspection, there was no noticeable settlement over the trench. The pavement appeared to be performing well.

I 71, GALLATIN COUNTY -- Erosion and debris appeared to be the major problems with the headwalls on this project (Figure 3-17 and 3-18). Settlement over the trench was not immediately evident. The pavement appeared to be performing well. Again, no significant difference in performance could be noted between the drained and undrained portions of the pavement.

I 75, LAUREL-WHITLEY COUNTIES -- The Whitley County portion of the project was still under construction, and no inspection was made in that county. Some of the drains in Laurel County showed evidence that no water had ever flowed through them (Figures 3-19 and 3-20). Although none of the headwalls were completely clogged on this project, debris was present in nearly all of them. Erosion did not appear to be as severe on this project as on some of the other projects. Figure 3-21 shows fairly large aggregate trapped behind the grating. This apparently has flowed through the pipe; however, it is not clear how such large aggregate got into the drainage system. The trench along the edge of the pavement does not appear to have settled yet; however, the exit trenches that cross the shoulder have settled, as shown in Figure 3-22.

I 64, FRANKLIN COUNTY -- The westbound lanes on this project have the 4-inch perforated pipe. The eastbound lanes have the Monsanto edgedrain. Most headwalls showed evidence of water having drained from the pipe on both lane directions as illustrated in Figure 3-23. The soil collected at the end of the pipe should be noted in that figure. Also, particles as large as 3/4 inch are visible in the photograph. A survey was made on the project on November 11, 1986, after several days of rain. Approximately 50 percent of the pipes of the Monsanto edgedrain were draining water. Only two pipes were draining water on the side that had 4-inch perforated pipe. Debris and trash collecting in the headwalls is also a problem on this project (Figure 3-24).
Settlement over the trenches was particularly severe on this project. Longitudinal cracks had formed over both sides of the trench, on the eastbound and westbound lanes (Figures 3-25 and 3-26). Also, most trenches for the exit pipes have settled (Figure 3-27). Figure 3-28 shows severe erosion around one headwall that has been caused by surface water. At present, pavement performance appears to be good.

KY 55, TAYLOR COUNTY -- This project has longitudinal edgedrains (4-inch perforated pipe) connected to an open-graded drainage blanket (No. 4, No. 5, or No. 57 stone) on top of a dense-graded aggregate layer. This system has been in service for approximately 10 years. The longitudinal drains are continuing to drain water. The undrained control section appears to be performing as well as the drained sections. However, traffic volumes on this highway are relatively low.

CONCLUSIONS AND RECOMMENDATIONS

1. Trash and debris clogging or partially clogging the headwalls is a problem on all locations. It is recommended that greater attention be given to keeping them cleaned.

2. Settlement over the trenches is also a problem and will continue to be a source of water to the base and subgrade. It is recommended that greater effort be expended in compacting the backfill during construction.

3. Erosion around many of the headwalls (from surface water) will continue to be a problem.

4. It appears that many pipes are not draining water or have never drained water. This would appear to seriously reduce the effectiveness of the edgedrains.

5. Visually, no significant difference could be observed in pavement performance between drained and undrained sections of pavement. However, it is realized that a number of years may be necessary before any visual difference may be noticed. It is recommended that the Road Rater be used on these projects in an attempt to determine if any differences could be detected in deflection behavior for the drained and undrained sections.
Figure 3-1. Experimental Sections; KY 55, Taylor County; Pavement Designs.
Figure 3-2. I 64 and I 75, Fayette County -- Debris in Flowline of Headwalls.
Figure 3-3. Settlement within Trench Caused Cracking in Pavement.
Figure 3-4. Headwalls Filled with Hay and Grass; US 60, Fayette County.
Figure 3-5. Soil and Grass Collect in Flowline; US 60, Fayette County.
Figure 3-6. Early Stage of Siltation; US 60, Fayette County.
Figure 3-7. Settlement within Trench Creates Hazard to Motorists; US 60, Fayette County.
Figure 3-8. Trash and Debris Collect at the Inlets; I 275, Boone County.
Figure 3-9. Settlement within Trench Creates Drop Off; I 275, Boone County.
Figure 3-10. Previous Flow Was not Evident for Some Outlets; I 75, Boone County.
Figure 3-11. A Few Headwalls Were Completely Blocked; I 75, Boone County.
Figure 3-12. Aggregate from Shoulder Blocked Outlet; I 75, Boone County.
Figure 3-13. Heavy Growths in Medians Obscured Some Outlets; I 75, Boone County.
Figure 3-14. Severe Erosion Exposed Several Headwalls; I 75, Boone County.
Figure 3-15. Erosion Evident on I 75 in Boone County.
Figure 3-16. Pipe Transmitting Water at Time of Inspection; I 75, Boone County.
Figure 3-17. Erosion and Debris in Flowlines Were Major Problems; I 71, Gallatin County.
Figure 3-18. Trash and Aggregate Collect in Flowlines; I 71, Gallatin County.
Figure 3-19. No Evidence of Flow for Some Locations; I 75, Laurel-Whitley Counties.
Figure 3-20. Evidence of Prior Flow Was not Apparent; I 75, Laurel-Whitley Counties.
Figure 3-21. Large Aggregate within Pipe; I 75, Laurel-Whitley Counties.
Figure 3-22. Exit Trenches Crossing Shoulders Settled; I 75, Laurel-Whitley Counties.

Figure 3-23. Exit Conduit for Monsanto Edgedrain; I 64, Franklin County.
Figure 3-24. Debris and Trash at Outlets Was Problem; I 64, Franklin County.
Figure 3-25. Settlement within Trenches Was Most Evident; I 64, Franklin County.
Figure 3-26. Drop Off due to Settlement in Trench; I 64, Franklin County.
Figure 3-27. Trenches for Exit Conduit Settled Appreciably; I 64, Franklin County.
Figure 3-28. Erosion Undermining Outlet Structure; I 64, Franklin County.
CRACKING AND REFLECTIVE CRACKING IN OVERLAYS ON PORTLAND CEMENT CONCRETE PAVEMENTS

A report documenting observed performance of crack and seat sections throughout Kentucky is in the final stages of completion. All sections are performing adequately, with the exception of one section (171, Oldham-Henry Counties, IR71-1(64)22) wherein reflective cracking was observed during the first year after reconstruction. It has been theorized that insufficient or improper breaking procedures were the cause of the reflective cracks.

It is planned to continue deflection testing of these pavements under Research Study KYHPR-86-109. Visual distress surveys and monitoring of performance of these sections will continue under this research study.
PERFORMANCE OF FULL-DEPTH ASPHALTIC CONCRETE PAVEMENT

A series of deflection measurements has been obtained for full-depth asphaltic concrete sections on the Daniel Boone Parkway, the Cumberland Parkway, and US 60 in Boyd County. Measurements obtained for the Daniel Boone Parkway and the Cumberland Parkway also were utilized to develop recommendations for rehabilitation needs. Deflections from all sections were obtained to update the family of curves describing pavement deterioration and the accumulation of fatigue as presented in Research Report UKTRP-84-21. These analyses have not been completed.

Evaluations of these sections will be made under Research Studies KYHPR-86-109 and KYHPR-86-115 wherein more detailed analyses are planned. Data from these and many other sections will be incorporated into a statewide deflection data base being developed under Research Study KYHPR-86-109.
PERFORMANCE OF AND LOADS ON CULVERTS

Study KYHPR-72-68, Loads on Reinforced Concrete Culverts under High Embankments, was initiated in January 1972 specifically for the purpose of determining loads imposed upon culverts. Data were obtained at sites selected for study through the use of Carlson earth stress cells, strain gages, settlement plates, multipoint settlement gages, and pneumatic piezometers. Models representing the various culvert sites were analyzed using a finite element program. Theoretical and actual data were compared. Details of the study are presented in Report UKTRP-84-22, Analysis of Loads and Settlements for Reinforced Culverts. Specific recommendations included in the report were implemented by their inclusion in the Division of Bridges Guidance Manual. The following tabulation includes site locations and features for instrumented installations.

BLE 6-1. SITE INFORMATION FOR INSTRUMENTED CULVERTS

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>LOCATION</th>
<th>SIZE</th>
<th>FILL</th>
<th>FOUNDATION</th>
<th>BEDDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creary</td>
<td>US 27 89+20 5/72-9/72 8x8 48</td>
<td>unyielding</td>
<td>high fill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creary</td>
<td>US 27 203+20 5/72-9/72 5x5 72</td>
<td>unyielding</td>
<td>high fill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creary</td>
<td>US 27 210+50 5/72-9/72 5x6 96</td>
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<td>high fill</td>
<td></td>
<td></td>
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<td>Lark</td>
<td>KY 627 123+95 3/74-10/74 4x4 77</td>
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<td>high fill</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>high fill</td>
<td></td>
<td></td>
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<tr>
<td>Lark</td>
<td>KY 55 448+90 9/80-5/81 5x5 69</td>
<td>yielding</td>
<td>high fill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>KY 55 459+50 7/80-7/81 6x6 50</td>
<td>yielding</td>
<td>standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More</td>
<td>KY 80 1202+12 8/80-9/81 twin 180</td>
<td>yielding</td>
<td>standard</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8"-diam.

Second date notes embankment at subgrade elevation

Sites were monitored through early 1984 under Study KYHPR-72-68 and have been monitored under Study KYHPR-85-107 since August 1984. Stress readings at the McCreary County sites have become erratic and monitoring there will be discontinued. Pressure on the south barrel at the Laurel
County installation exceeded the capacity of the pressure cells. No cracking or any other forms of distress were observed during the most recent inspection in August 1986. Pressures have remained nearly constant at the Clark County and Marion County sites and monitoring will continue. At this time, it appears that significantly valuable information has been gained and report recommendations implemented by the Division of Bridges are justified.
PERFORMANCE OF METAL LONG-SPAN STRUCTURES, METAL BOX CULVERTS, AND PRECAST REINFORCED CONCRETE BOX CULVERTS

Metal Long-Span Structures

Metal long-span structures are permitted under Special Provision 47D, Steel Long Span Structural Plate Structures, or Special Provision 57B, Aluminum Long Span Structural Plate Structures (Experimental). No structures have been installed under 57B or prior versions of that special provision. Three structures installed in accordance with the requirements of preceding versions of 47D were selected for long-term monitoring.

A 28-foot 10-inch by 17-foot 5-inch by 64-foot long-span structure manufactured by Republic Steel Corporation was installed in 1978 at Station 102+62 on KY 979 at Toler Creek in Floyd County. The fill above the top of the structure is approximately 5 feet. No obvious defects were noted during an inspection in March 1986 and the structure was reported as being in excellent condition. Figure 7-1 is an overall view of the structure and Figure 7-2 is a close-up of the structural plate showing it to be in excellent condition.

A 34-foot 5-inch by 13-foot 3-inch by 125-foot long-span structure manufactured by Republic Steel Corporation was installed at Station 176+40.26 on KY 1009 at Gap Creek in Wayne County in 1979. The fill height above the top of the conduit is approximately 8 feet at centerline. Figure 7-3 is an overall view of the installation taken during a September 1985 inspection. No signs of distress were noted and the structure was judged as being in excellent condition.

A 28-foot 5-inch by 27-foot 10-inch by 125-foot long-span structure manufactured by Armco Steel Inc. was installed under KY 80, Hazard-Watergap Road, between April and June 1980. The height of fill varied from 10 feet in the eastbound lanes to 2.5 feet in the westbound lanes. Early in November 1980 measurements obtained throughout the structure indicated the cross-sectional shape was outside of the specified tolerances. A Change Order was issued in July 1981 to provide for installation of tension ties in a portion of the top of the super span. Relatively close surveillance was maintained thereafter. Figure 7-4 is a view of the structure in June 1981.

In April and May 1985, settlement was detected and wedging of the
overlying pavement was necessary. On March 5, 1986, a dimple was discovered in the top portion of the structure under the eastbound lanes. A 24-hour watch was established, the eastbound lanes were later closed, and work commenced on removal of earth above the structure.

Two-directional traffic was established in the westbound lanes. Remedial plans were prepared and approved September 12, 1986, with a scheduled letting date of November 14, 1986. At approximately 2:00 am, on October 26, the structure collapsed and two vehicles plunged into the resultant cavern prior to closure of the roadway. Research Report UKTRP-86-27 contains results of an investigation of the collapse.

Photographs in Figures 7-5, 7-6, and 7-7 were made October 21, 1986, showing an overall view; one-lane, two-directional traffic; and the dimple, respectively. Figures 7-8 and 7-9 were made October 29 and are views of the collapsed structure.

**Metal Box Culverts**

Metal box culverts are permitted by Special Provision No. 71, Aluminum Structural Plate Box Culvert (Experimental), and Special Provision No. 72, Steel Structural Plate Box Culvert (Experimental). An aluminum box culvert manufactured by Kaiser Aluminum and Chemical Sales, Inc. was installed at Station 230+05 under Ky 90 in Metcalfe County. The structure was installed in April 1984 and the roadway was opened to traffic in September 1984. The structure is 17 feet 5 inches by 5 feet 4 inches by 32 feet. Figure 7-10 shows the erected structure being placed and Figure 7-11 is a view of that structure in service. Upon the most recent inspection in October 1986, the performance was reportedly excellent.

**Precast Reinforced Concrete Box Culverts**

Precast reinforced concrete box culverts are permitted in accordance with the requirements of Section 616 of the Standard Specifications. A double 6-foot by 4-foot by 160-foot precast reinforced concrete box culvert was installed in 1981 at Station 320+70 on KY 1934, Greenbelt Highway, in Jefferson County. The maximum fill height is approximately 10 to 12 feet. Precast sections are 8 feet in length.

The structure was inspected in October 1986. No signs of distress
were noted and both alignment and grade of each barrel did not indicate undue differential settlement or horizontal displacement. The majority of joints were snug and appeared well sealed. A 3-inch separation was noted in the bottom slab at joint 15 (from outlet) in the north barrel. A 2 1/2-inch separation was noted in the top slab at joint 4 (from outlet) in the south barrel. Those separations were not considered significant and no signs of leakage (water or soils) were observed. Figure 7-12 is an overall view of the installation.
Figure 7-1. Overall View of Long-Span Structure; Station 102+62, KY 979, Floyd County.

Figure 7-2. Structural Plates Were Excellent; Station 102+62, KY 979, Floyd County.
Figure 7-3. Overall View of Long-Span Structure; Station 176+40.26, KY 1009, Wayne County.

Figure 7-4. Pear Shaped, Long-Span Structure; Station 1001+31.3, KY 80, Floyd County (June 1981).
Figure 7-5. Close-up View of Structure under KY 80 (October 1986).

Figure 7-6. Traffic Diverted to Westbound Lanes and Fill Removed at Eastbound Lanes; KY 80.
Figure 7-7. View of Dimple in Top of Long-Span Structure under KY 80.

Figure 7-8. View of KY-80 Structure Collapsed onto Railway Cars.
Figure 7-9. Longitudinal Seam Separated upon Collapse; KY 80.
Figure 7-10. Corrugated Aluminum Structural Plate Box Culvert Assembled; Station 230+05, KY 90, Metcalfe County.
Figure 7-11. Performance of Aluminum Box Culvert Has Been Excellent.

Figure 7-12. Overall View of Precast Reinforced Box Culvert; Station 320+70; KY 1934, Jefferson County.
EVALUATION OF BRIDGE EXPANSION DAMS AND DECK DRAINS

Modular expansion joints were first used in Kentucky in the 1960's. Study of their performance was initiated in 1971 (Research Study KYHPR-71-25). An interim report of the performance of 100 joints including Transflex, Wabo-Maurer, Acme, and Fel-Span was issued in July 1981 (UKTRP-81-12).

During that period, the performance of the modular joints varied from acceptable to poor. A typical example was the General Tire Company (Transflex 200-A) joints employed on the Clark Memorial Bridge in Louisville in 1967. Initially, the ride quality of the Transflex joints was very good. With additional service, the Transflex 200-A joints became loose. This resulted in poor ride quality and increased impact noise as vehicles passed over the joints. The joint free play was caused by inadequate tightening of bolts used to hold the individual expansion joints (modules) together in a singular unit. As a result, traffic further distorted and damaged the Transflex assemblies, allowing them to leak. Other brands exhibited similar problems in varying degrees.

Recent inspections conducted from March to September 1986 on selected bridges have revealed several defects. Debris accumulates on tops of the joints and may act to clog and hinder joint movement (Figure 8-1). Examples are the ACME 3M600 joints on the I 275 bridge over the Licking River in Campbell County. The floating ribs and accordion membranes shift. This creates an uneven surface. Examples of that problem are the Wabo Maurer D1040 joints on the US 27 bridge over the Kentucky River at the Jessamine-Garrard County line. Vehicle tires passing over those defective joints dip and impact the far deck slab. This action is both harmful to the slab and vehicle tires (which have been observed to completely bottom out). This may be due to inadequate initial design in some instances rather than service deterioration. The Poplar Level Road bridge over the Southern RR in Louisville is a good example of this type deterioration.

The modular joints on the I-471 bridge at Newport were inspected in June 1986. One Wabo Maurer 1560 (south end of SB bridge) joint exhibited movement of about 1/2 inch due to a single large truck. The joint closed slowly. This closure compressed the bag formed by the
rubber membranes between the floating ribs. Water was observed pulsing from the end of the membrane (outside the plinth), indicating water was trapped in the membrane. Water was probably retained by debris that had entered the joint during expansion and acted as a dam.

Also, the spacing mechanisms employed to maintain position of the joint ribs were observed as not always working properly (Figure 8-2). This allowed the ribs to shift to one side of the joint, creating an uneven surface. The Wabo Maurer DI040 joints on the US 25 bridge over the Kentucky River at the Fayette-Madison County line are examples.

Performance of existing modular joints does not justify their continued use.

Inspections of deck drains have revealed they are generally functioning satisfactorily. Figures 8-3 and 8-4 show grate-covered floor drains. Figure 8-3 shows the grate has rejected a can that could clog the drain. Generally, drainage problems appear more related to deck imperfections. Ponding is often evident. Note the sedimentation build-up caused by the modular expansion joint in Figure 8-4. Ponding may lead to freeze-thaw problems on the bridge at or near the curb line.

Other problems are lack of drains and the undersizing of troughs at finger-type expansion joints. Some bridges lack deck drains and rely on grade and/or cross slope for drainage. In one instance, a heavy accumulation of sediment was visible in the gutter areas. This could eventually lead to hydroplaning problems on the bridge deck (i.e. lack of proper maintenance). That design approach should definitely be limited to short-span bridges. One problem that has been noticed in several inspections are drain pipes that do not prevent the exiting water from contacting the bridge. Stub-type drains are a good example of this. Those should be located and retrofitted with extended drain pipes.

Figure 8-5 shows a typical under-curb slot-type drain. Those type drains were performing satisfactorily.
Figure 8-1. Debris Accumulates in Modular Expansion Joints.
Figure 8-2. Modular Expansion Joint Ribs Were not Spaced Evenly.
Figure 8-3. Grate on Deck Drain; KY 770 over Laurel River.

Figure 8-4. Grate on Deck Drain; I 275 over Licking River.
Figure 8-5. Under Curb Slot Drains; KY 227 over White's Run, Carroll County.
EVALUATION OF STRUCTURAL PAINT SYSTEMS

Bridge paints should last 15 to 20 years. Normally, they last about one-half that time. To facilitate understanding, a nutshell history follows.

Raw linseed oil with some bodied oil and red lead pigment served more or less as the standard paint (primer) for steel until well after World War II. Alkyd resin vehicles supplanted straight linseed oils and basic lead silico chromates supplanted red lead. AASHO tung oil and leafing aluminum were superseded by Foliage Green. Vinlys and organic and inorganic zinxs have come to the forefront. Inorganic zinc primers or base coats covered with vinyl topcoats are the preferred system presently.

All of the newer paints required better cleaning of the steel and removal of mill scale (see Figure 9-1). The Kentucky Department of Highways moved deliberately in 1966 to require shot-blasting and shop priming of all new steel. Field blasting was instituted for some repainting and brush-off blasting was adopted for some spot cleaning. Removal of rust and mill scale was the principal objective.

Thirty-two bridges painted since 1979 are in an experimental group. Eight of those are new bridges or involve new steel. Five additional bridges have been included for observation. Only a few are old enough to yield significant observations. Eleven bridges have been inspected. The paint on those bridges has been in place at least four years. Four of the inorganic-zinc/vinyl painted bridges have been subjected to baseline inspections.

The I-64 twin bridges over the Kentucky River are showing significantly better performance in areas blast-cleaned and primed with two-component zinc and areas primed with Federal Specification TT-P-615, Primer Coating: Basic Lead Silica Chromate, Ready-Mixed. It appears that paint has peeled from some spots in areas not blast cleaned (see Figure 9-2). Similar deterioration was noted on the I-65 (Kennedy) bridge over the Ohio River at Louisville.

The paint systems, themselves, have shown little atmospheric deterioration. Adhesion to the steel appears to be a major factor in paint durability. Field evidence indicates that steel preparation, especially on repainted bridges, is a major factor in paint durability.
Of the paint systems inspected to date, the two-component zinc has performed the best. However, that system benefitted from superior surface cleaning. The importance of thorough cleaning and good surface preparation practices prior to painting was evident during the inspections.

Some newer paint systems may last 20 years. Some of the older ones could have served far longer if maintenance spot painting had been performed.
Figure 9-1. Paint Has Peeled in Spots; I 65 over Ohio River, Jefferson County.
Figure 9-2. Paint Peeled from Spots not Sandblasted; I 64 over Kentucky River, Franklin County.
EFFECTIVENESS OF DIRECT TENSION INDICATORS

In May 1986, several on-site inspections of load-indicating washers on the Catlettsburg–Kenora (US 60) bridge in Boyd County were made. The load-indicating washers were being employed on bolted field splices on the new girder bridge being erected.

The first inspection revealed the washers were sometimes not being installed in accordance with manufacturer’s recommendations. That allowed the nut to spin on the load-indicating bumps stamped in the washers. That action abraded the bumps and did not provide a proper indication of the bolt’s tension.

That problem was corrected by the inspectors. Several follow-up inspections revealed bolt installations to be progressing satisfactorily.

Torque tests will be performed upon resumption of work on the structure. Completion of this work and a report on the load-indicating washers is pending completion of the bridge.
PERFORMANCE EVALUATION OF CORRUGATED POLYETHYLENE ENTRANCE PIPE

Early in 1984, the State Highway Engineer requested that the feasibility of using corrugated polyethylene (PE) pipe as entrance and/or cross-drain conduit be investigated. Transportation officials in 15 states were contacted to determine their position in regard to utilizing corrugated PE pipe under roadways and entrances. Three states indicated the conduit was permitted for use as entrance pipe as well as for cross drains. Another state reported that the material was permitted experimentally for entrances or cross drains. None of those respondents reported knowledge of long-term performance for any installations. One state, indicating the conduit was not currently permitted for use, reported one cross-drain installation in good condition after two years in service. A second state that did not permit use of the conduit reported failures of prior installations due to lack of cover.

AASHTO M 252 contains requirements for corrugated polyethylene drainage tubing in nominal sizes 3 to 15 inches and AASHTO M 294 contains requirements for pipe 12 to 24 inches nominal sizes. Each of those standards references pipe stiffness requirements as described in ASTM D 2412. Based upon information presented in ASTM D 2412 and requirements designated in the AASHTO standards, it was determined the conduit should be adequate under fill heights from 1 to 38 feet. It was recommended that polyethylene pipe be permitted as an alternate for entrance pipe. It was recommended that its use as cross drains be determined at a later date and decided upon the basis of its performance as entrance pipe.

Special Note for Corrugated Polyethylene Entrance Pipe was issued May 30, 1985. That note permits the tubing for use as 15- , 18- , or 24-inch entrance pipe, at the Contractor's option. Transportation Cabinet maintenance personnel could also use the tubing for replacements or new installations. The special note specifies that tubing and fittings shall meet the requirements of AASHTO M 294. Bedding and backfill are specified to be in accordance with requirements for culverts as contained in Section 611 of the Standard Specifications and on Standard Drawing RDI-020, current edition.
Heavily loaded vehicles may crush the exposed ends of corrugated, steel, and polyethylene entrance pipe. When crushing is anticipated or becomes apparent, precast concrete protective devices should be employed. Silting was observed in numerous instances for rigid and flexible entrance installations. Silting was not attributable to the type material used in manufacture of the conduit.

Division of Maintenance personnel compiled a listing of PE entrance installations made in Districts 2 and 7 (Table 11-1). Four installations were in District 7 and 53 installations were in District 2. Sites in District 7 were inspected in April 1986 and sites in District 2 were inspected in June 1986. Observations made during those inspections follow.

Figure 11-1 shows the installation at MP 10-11 on KY 130 in Union County. The channel lining is a good cover of grass and no silting was noted. Figure 11-2 is located at MP 10-11 on US 41-A in Henderson County. Large-sized stone placed at the entrance and outlet of the conduit have prevented silting even through the channel has only a nominal stand of grass in the invert. Figures 11-3 and 11-4 are evidence of the disadvantage of using small-sized aggregate at entrances. Figures 11-5 and 11-6 are views of the inlet and outlet of the conduit located under the entrance to the Utica Truck Garage at MP 1-2 on US 431 in Daviess County.

Attempts to evaluate the cost effectiveness of polyethylene entrance pipe were not productive. Unit costs of various size corrugated steel and corrugated polyethylene conduit purchased for Districts 2 and 7 were not available within the Division of Purchases. Tabulations for average unit bid prices for projects let to contract do not include information regarding conduit material and cost comparisons may not be obtained from those tabulations. Corrugated steel installations are made by shaping the ditch to fit 1/3 the outside height of the pipe. Polyethylene conduit must be installed in a manner comparable to culvert installations. It is reasonable to assume that any savings realized in materials cost would probably be offset by additional costs of installation. Costs for steel and polyethylene installations are probably very nearly equal.

There were no significant observations made during the inspections.
that would support revisions to the current specifications or policies. One Resident Engineer has recommended that use of polyethylene pipe for entrances be discontinued. That Resident Engineer stated the conduit was difficult to install and would drift of grade and alignment when side fill was tamped. In addition, some of the conduit delivered to the project was defective (according to the manufacturer) and two installations were damaged by the weight of a backhoe after 6 to 12 inches of backfill had been placed above the pipe.
<table>
<thead>
<tr>
<th>DATE</th>
<th>DISTRICT</th>
<th>LOCATION</th>
<th>INSPECTED</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/3/86</td>
<td>District 7</td>
<td>BOURBON COUNTY</td>
<td>KY 1939</td>
<td>Pipe #1, MP 3-4 Small entrance to house and paddocks appears to be rarely used. Sight through pipe and noted slight bulge in top middle. Otherwise in good condition. 15&quot; dia.</td>
</tr>
<tr>
<td>4/3/86</td>
<td>District 7</td>
<td>BOURBON COUNTY</td>
<td>KY 1939</td>
<td>Pipe #4, MP 0-1 Entrance to yard and paddocks. End crushed by tractor or truck. Slight bulge in center. Fair condition. 18&quot; dia.</td>
</tr>
<tr>
<td>4/4/86</td>
<td>CLARK COUNTY</td>
<td>US 60, Pipe #3</td>
<td>MP 0-1</td>
<td>Entrance to house. Slight bulge in center, mower cut at one end. Fair condition.</td>
</tr>
<tr>
<td>4/4/86</td>
<td>CLARK COUNTY</td>
<td>US 60, Pipe #5</td>
<td>MP 2-3</td>
<td>Pipe under entrance to house/farm. Slight bulge in center. Owner stated that heavily loaded trucks had traveled over it during construction. Good condition.</td>
</tr>
<tr>
<td>6/3/86</td>
<td>District 2</td>
<td>HANCOCK COUNTY</td>
<td>US 60, MP 14-15</td>
<td>18&quot; pipe in front of Willamette Industries. Pipe appears to be in good condition. Was able to sight through pipe to other end. Cover was eroded, exposing nylon fabric.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>KY 144</td>
<td>MP 0-1 18&quot; pipe under farm entrance. Excellent shape. 20&quot; cover in good condition.</td>
</tr>
<tr>
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<td></td>
<td>KY 1700</td>
<td>MP 0-1 18&quot; pipe under small pasture entrance. Water standing in pipe, but in excellent condition. Thick brush at both ends.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>KY 271</td>
<td>MP 0-1 18&quot; pipe under entrance to house. Semi-clogged with mud at inlet. Small bulge at left end. Fair condition.</td>
</tr>
<tr>
<td>6/3/86</td>
<td>MCLEAN COUNTY</td>
<td>KY 1080, MP 3-4</td>
<td>18&quot; pipe under heavily traveled driveway. One end badly clogged; could not sight through pipe. Possibly crushed in middle. Fair condition.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>KY 1080</td>
<td>MP 4-5 18&quot; pipe under driveway is almost completely clogged. Concrete driveway above pipe. Clogged totally one side. Bad condition.</td>
</tr>
<tr>
<td>6/6/86</td>
<td></td>
<td></td>
<td>KY 1233</td>
<td>MP 2-3 15&quot; pipe under home driveway. Clogged right side. Bulged</td>
</tr>
</tbody>
</table>
KY 136, MP 11-12
18" pipe under driveway to farm and house. Draining well, good condition.

KY 1046, MP 5-6 (A)
15" pipe under field entrance. Some silt clogging. Draining fair, good condition.

KY 1046, MP 5-6 (B & C)
18" and 15" pipes side by side (field entrances) 18" pipe is nearly buried at one end; bad condition. 15" pipe is partially clogged but still draining. Both covers eroding.

KY 798, MP 0-1
15" pipe under field entrance. Slightly clogged one end. Heavy undergrowth. Good condition.

US 431, MP 6-7
18" pipe under driveway to woods. Cover eroding slightly. Pipe in good condition.

KY 254, MP 2-4
18" pipe under field entrance. Clogged on right side, but still draining. Fair condition.

KY 81, MP 14-15
15" pipe in front of house. Bulge in center, still draining. Fair condition.

KY 85, MP 1-2
18" field entrance. Bulged in top, draining well. Fair condition.

OHIO COUNTY
6/3/86

KY 54, MP 6-7
Entrance to mobile home. 18" pipe in excellent condition. Owner dug and cleared inlet and outlet channels recently. Cover 20"-30".

KY 54, MP 7-8
18" pipe east of Fordville. Small entrance to yard and barn. Cover eroding. Both ends clogged with silt. May be bulged in center. Little or no traffic on entrance. Fair condition.

KY 695, MP 16-17
18" pipe slightly crushed on one end. Otherwise, good condition. Entrance to field.

KY 136, MP 8-9
18" pipe across from road having stop sign. Pipe is bulged on top. Fair condition. Cover in good condition.

KY 136, MP 0-1
24" pipe near McLean and Ohio County line under driveway to farm and house. Heavy brush at each end. Pipe dented in
KY 764, MP 2-3
18" pipe under driveway to home. Slight bulge in top, unclogged. Good condition.

KY 762, MP 0-1
18" pipe in home driveway. Pipe in good condition, but erosion has caused it to clog with silt and gravel almost 70 percent.

DAVIESS COUNTY
6/3/86 US 43, MP 1-2
18" pipe under entrance to Utica Truck garage. Ends are severely crushed; could not sight through pipe. Bad condition due to heavy truck traffic.

Caldwell County
6/4/86 KY 91, MP 5-6
18" pipe under driveway to field. Pipe free of debris. Small bulges on top; otherwise good condition.

KY 139, MP 12-13
18" pipe under entrance to wooded area. Cover is slightly eroded. Excellent condition due to little or no traffic.

KY 293, MP 14
18" pipe under driveway to home. Right end badly clogged with silt. Small bulges on top. Fair condition.

WEBSTER COUNTY
KY 132, MP 4-5
24" pipe along right-of-way ditch leading into creek. Leaves and debris clogged inlet. Good condition.

US 41-A, MP 19-20
15" pipe and 18" pipe coming out of underground box. Both in good condition.

UNION COUNTY
6/4/86 US 60, MP 3-4
15" pipe in front of grain elevator. Pipe has gravel in it, but draining well and in good condition.

KY 270, MP 4-5
15" pipe leading to field. Curved in middle, otherwise good condition.

US 60, MP 12-13
15" pipe under driveway to home. Left side almost completely clogged by silt. Right end clogged also, was not able to sight through pipe. Bad condition.

6/5/86 KY 56, MP 13-14

KY 141, MP 20-21
15" pipe under cemetery drive. Clogged with silt on right side. Pipe in good condition.

KY 130, MP 7-8 (A)
15" pipe under driveway to mobile home. Slightly clogged with leaves at both ends. Pipe in good condition.

KY 130, MP 7-8 (B)
15" pipe under driveway to oil pump. Heavy undergrowth at both ends. Pipe in good condition.

KY 950, MP 1
18" pipe under driveway to home. Good condition.

KY 1594, MP 0-1
15" pipe under driveway to home. Clogged throughout, but still able to sight through. Gouged by mower on left side. Bad condition.

KY 130, MP 10-11
18" pipe under driveway to home. Good condition.

KY 130, MP 0-1 (A)
15" pipe under farm driveway. Heavy undergrowth, pipe nearly buried. Possibly crushed in center. Fair condition.

KY 130, MP 0-1 (B)
15" pipe under entrance to field. Pipe almost completely clogged by silt. Bad condition.

KY 109, MP 2-4
15" pipe under driveway to house. Good condition.

KY 130, MP 8-9
15" pipe under driveway to field and oil tanks. Heavy undergrowth. Fair condition.

CHRISTIAN COUNTY
6/5/86  KY 91, MP 1-2
15" pipe under driveway to home. Small bulge in top center. Good condition.

MUHLENBERG COUNTY
6/6/86  KY 277, MP 0-1
15" entrance pipe to homes. Draining well, good condition.

HENDERSON COUNTY
6/5/86  US 41-A, MP 4-5
15" pipe under home driveway. Crushed slightly on left side. Free of debris. Fair condition.

US 41-A, MP 6-7
18" pipe under home driveway. Bulged in center. Good condition.

US 41-A, MP 10-11
18" pipe under home driveway. Excellent condition.
KY 1078, MP 3-4
15" pipe under field entrance. Bulged in center. Good condition.

KY 351, MP 11-12
15" pipe under home driveway. Appears in good condition.

KY 136, MP 11-12
15" pipe under driveway to home. Owner cleaned ditches at both ends. Good condition.

HOPKINS COUNTY
6/5/86 KY 1294, MP 3-4
18" pipe under home driveway. Left side eroded and half clogged with silt and gravel. Otherwise good condition.
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in center. Fair condition.

KY 136, MP 11-12
18" pipe under driveway to farm and house. Draining well, good condition.

KY 1046, MP 5-6 (A)
15" pipe under field entrance. Some silt clogging. Draining fair, good condition.

KY 1046, MP 5-6 (B & C)
18" and 15" pipes side by side (field entrances) 18" pipe is nearly buried at one end; bad condition. 15" pipe is partially clogged but still draining. Both covers eroding.

KY 798, MP 0-1
15" pipe under field entrance. Slightly clogged one end. Heavy undergrowth. Good condition.

US 431, MP 6-7
18" pipe under driveway to woods. Cover eroding slightly. Pipe in good condition.

KY 254, MP 2-4
18" pipe under field entrance. Clogged on right side, but still draining. Fair condition.

KY 81, MP 14-15
15" pipe in front of house. Bulge in center, still draining. Fair condition.

KY 85, MP 1-2
18" field entrance. Bulged in top, draining well. Fair condition.

OHIO COUNTY
6/3/86

KY 54, MP 6-7
Entrance to mobile home. 18" pipe in excellent condition. Owner dug and cleared inlet and outlet channels recently. Cover 20"-30".

KY 54, MP 7-8
18" pipe east of Fordville. Small entrance to yard and barn. Cover eroding. Both ends clogged with silt. May be bulged in center. Little or no traffic on entrance. Fair condition.

KY 695, MP 16-17
18" pipe slightly crushed on one end. Otherwise, good condition. Entrance to field.

KY 136, MP 8-9
18" pipe across from road having stop sign. Pipe is bulged on top. Fair condition. Cover in good condition.

KY 136, MP 0-1
24" pipe near McLean and Ohio County line under driveway to farm and house. Heavy brush at each end. Pipe dented in
center, but still draining. Fair condition.

KY 764, MP 2-3
18" pipe under driveway to home. Slight bulge in top, unclogged. Good condition.

KY 762, MP 0-1
18" pipe in home driveway. Pipe in good condition, but erosion has caused it to clog with silt and gravel almost 70 percent.

DAVIESS COUNTY
6/3/86 US 43, MP 1-2
18" pipe under entrance to Utica Truck garage. Ends are severely crushed; could not sight through pipe. Bad condition due to heavy truck traffic.

Caldwell County
6/4/86 KY 91, MP 5-6
18" pipe under driveway to field. Pipe free of debris. Small bulges on top; otherwise good condition.

KY 139, MP 12-13
18" pipe under entrance to wooded area. Cover is slightly eroded. Excellent condition due to little or no traffic.

KY 293, MP 14
18" pipe under driveway to home. Right end badly clogged with silt. Small bulges on top. Fair condition.

WEBSTER COUNTY
KY 132, MP 4-5
24" pipe along right-of-way ditch leading into creek. Leaves and debris clogged inlet. Good condition.

US 41-A, MP 19-20
15" pipe and 18" pipe coming out of underground box. Both in good condition.

UNION COUNTY
6/4/86 US 60, MP 3-4
15" pipe in front of grain elevator. Pipe has gravel in it, but draining well and in good condition.

KY 279, MP 4-5
15" pipe leading to field. Curved in middle, otherwise good condition.

US 60, MP 12-13
15" pipe under driveway to home. Left side almost completely clogged by silt. Right end clogged also, was not able to sight through pipe. Bad condition.

6/5/86 KY 56, MP 13-14

KY 141, MP 20-21
15" pipe under cemetery drive. Clogged with silt on right side. Pipe in good condition.

KY 130, MP 7-8 (A)
15" pipe under driveway to mobile home. Slightly clogged with leaves at both ends. Pipe in good condition.

KY 130, MP 7-8 (B)
15" pipe under driveway to oil pump. Heavy undergrowth at both ends. Pipe in good condition.

KY 950, MF 1
18" pipe under driveway to home. Good condition.

KY 1594, MP 0-1
15" pipe under driveway to home. Clogged throughout, but still able to sight through. Gouged by mower on left side. Bad condition.

KY 130, MP 10-11
18" pipe under driveway to home. Good condition.

KY 130, MP 0-1 (A)
15" pipe under farm driveway. Heavy undergrowth, pipe nearly buried. Possibly crushed in center. Fair condition.

KY 130, MP 0-1 (B)
15" pipe under entrance to field. Pipe almost completely clogged by silt. Bad condition.

KY 109, MP 2-4
15" pipe under driveway to house. Good condition.

KY 130, MP 8-9
15" pipe under driveway to field and oil tanks. Heavy undergrowth. Fair condition.

CHRISTIAN COUNTY

6/5/86 KY 91, MP 1-2
15" pipe under driveway to home. Small bulge in top center. Good condition.

MUEHLENBERG COUNTY

6/6/86 KY 277, MP 0-1
15" entrance pipe to homes. Draining well, good condition.

HENDERSON COUNTY

6/5/86 US 41-A, MP 4-5
15" pipe under home driveway. Crushed slightly on left side. Free of debris. Fair condition.

US 41-A, MP 6-7
18" pipe under home driveway. Bulged in center. Good condition.

US 41-A, MP 10-11
18" pipe under home driveway. Excellent condition.
KY 1078, MP 3-4
15" pipe under field entrance. Bulged in center. Good condition.

KY 351, MP 11-12
15" pipe under home driveway. Appears in good condition.

KY 136, MP 11-12
15" pipe under driveway to home. Owner cleaned ditches at both ends. Good condition.

HOPKINS COUNTY
6/5/86  KY 1294, MP 3-4
18" pipe under home driveway. Left side eroded and half clogged with silt and gravel. Otherwise good condition.
Figure 11-1. Grass Lined Channel Prevented Erosion; KY 130, Union County.

Figure 11-2. Large Stone Protects Inlet and Outlet; US 41A, Henderson County.
Figure 11-3. Small Aggregate Erodes Readily and Clogs Outlet.

Figure 11-4. Aggregate Washed from Shoulder and Blocked Exit.
Figure 11-5. Heavy Vehicles Damaged Unprotected Outlet.

Figure 11-6. Truck Damage to Inlet.