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RESEARCH PROJECT TITLE

[Evaluating Roadway Subsurface Drainage Practices – Phase II](#)

SPONSORS

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Evaluating Roadway Subsurface Drainage Practices – Phase II

tech transfer summary

Adequate subsurface drainage systems are generally believed to be beneficial to the performance of various pavement types.

Background and Problem Statement

The presence of subsurface drainage systems (e.g., granular bases or outlets) is generally believed to be beneficial to the performance of various pavement types. Well-performing subsurface drainage systems form an important aspect of pavement design for the Iowa Department of Transportation (DOT).

Iowa Highway Research Board (IHRB) Project TR-643 provided extensive insights into Iowa subsurface drainage practices and pavement subdrain outlet performance. However, that project's forensic testing and evaluation were carried out in a drought year and during October and November of 2012, when relatively little rainfall was recorded.

Based on the findings of IHRB Project TR-643, the Iowa DOT requested an expanded Phase II study to address several additional research needs, such as the effects of seasonal variation on subdrain outlet performance, condition of composite (HMA over JPCP) pavement subdrain outlets, and the characteristics of tufa formation.

Project Objectives

- Evaluate the effects of seasonal variation on subdrain outlet condition and performance
- Investigate the condition of composite pavement subdrain outlets
- Examine the effect of resurfacing/widening/rehabilitation on subdrain outlets
- Investigate the characteristics of tufa formation in Iowa subdrain outlets
- Identify a suitable drain outlet protection mechanism (such as a headwall) for Iowa based on a review of practices adopted by nearby states



About ProSPER

Mission of the Program for Sustainable Pavement Engineering and Research (ProSPER):

- Advance research, development, and implementation of next-generation sustainable roadway systems
- Integrate cutting-edge technologies from various disciplines to tackle real-world highway and airport pavement infrastructure problems
- Investigate sustainable paving materials and construction technologies, pavement non-destructive testing and evaluation, performance monitoring, maintenance, repair, and rehabilitation

Research Description

A detailed forensic test plan was developed for inspecting and evaluating Iowa pavement subdrains. The plan included site selection for inspection of drain outlets, identification of drainage components for evaluation, and inspection and evaluation methods.

The following sites were selected for forensic testing and inspection of subdrain outlets:

- 51 newly constructed jointed plain concrete pavement (JPCP) sites (231 outlet locations)
- 8 newly constructed hot-mix asphalt (HMA) sites (47 outlet locations)
- 23 HMA over JPCP sites (120 outlet locations)
- 52 outlet locations near pavement sections exhibiting high-severity moisture-related surface distress or patching, including 34 locations from 25 of the new JPCP sites and 18 locations from 11 of the HMA over JPCP sites

The rigid and flexible pavement sites constructed after 1990 were investigated during spring and summer of 2013, when about 5 inches of precipitation was recorded. Most of the composite pavement sites were investigated during late spring 2014, when the maximum recorded precipitation was 9.9 inches. The JPCP and HMA sites had been investigated in late fall 2012 during the Phase I study, when the recorded precipitation was about 3 inches.

In addition, headwall design plans and specifications adopted by other states were investigated.



Moisture-related distresses on JPCP where no drainage outlets located at site



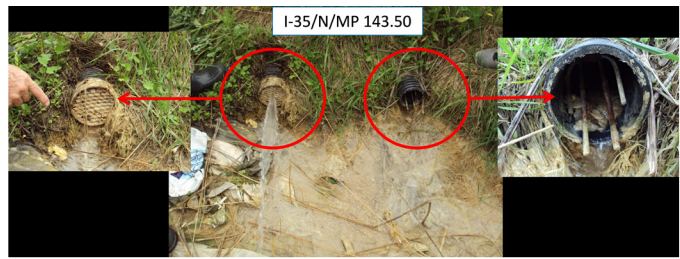
Moisture-related distresses on HMA over JPCP-type composite pavement system where no drainage outlets located in the field

Key Findings

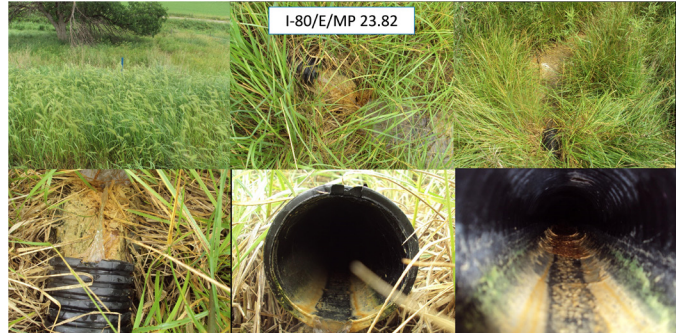
- Moisture-related pavement surface distresses were observed in sections where no drainage outlet could be located.
- At the JPCP sites, slightly more outlets were observed with blockage and associated surface distresses in summer 2013 than in fall 2012. However, these differences are not significant.
- Tufa formation resulting from the use of recycled PCC base was observed to be lesser in quantity at locations where a plastic outlet pipe was used without a gate screen rodent guard and where blended recycled PCC and virgin aggregate materials were used.
- Shoulder distresses in JPCP were observed near blocked drainage outlet locations.
- Cracking/patching was observed near culvert-only or culvert-with-drainage outlet locations.
- More than 50 percent of HMA over JPCP outlets were blocked by sediment and soil deposits.
- Surface distresses were observed near blocked drainage outlet locations at HMA over JPCP sites.
- At HMA over JPCP sites, moisture-related distresses were observed more frequently near blocked than clear drainage outlet locations. Compromised drainage outlet performance may therefore accelerate the development of moisture-related distresses in HMA over JPCP.

Recommendations and Future Research

- Use of a gate or mesh screen rodent guard may cause outlet blockage. Because very little rodent evidence was observed during field investigations, it is highly recommended that rodent guards not be used to cover drainage outlets.
- Use of recycled PCC as base/subbase material results in tufa formation, which is the primary cause of drainage outlet blockage in JPCP. Using blended recycled PCC and virgin aggregate subbase materials seems to mitigate this problem at least partially.
- Less tufa formation due to the recycled PCC base is observed with the use of plastic outlet pipe without a gate screen rodent guard.
- Screening recycled PCC before using it in foundation layers can reduce the potential for fine material deposits to accumulate in pavement drainage systems. Studies have shown that selective grading or blending with virgin aggregates significantly reduces precipitation potential. Further research is recommended on this issue.
- Strategies to mitigate the occurrence of transverse cracking on pavements over culvert structures are needed. Further research is recommended on this topic.
- Blocked drainage outlets seem to contribute more to shoulder distresses than to pavement surface distresses. Further research is recommended for this issue.
- Rigid, slotted plastic drain pipe is more durable, offers better performance, and is better at resisting loads from construction and maintenance than other types of pipe. Flexible, lightweight subdrain pipe has been known to collapse during construction or maintenance.
- Retrofitted edgedrains are generally recommended on relatively young (<10 years old) concrete pavements that have begun to exhibit signs of early moisture-related distresses such as pumping and joint faulting but that only exhibit minimal cracking (less than 5 percent cracked slabs). However, because of the mixed historical field performance of retrofitted edgedrains as reported in the literature, the decision to install retrofitted edgedrains should be made in light of the local experience.
- Compromised drainage outlet performance may accelerate the development of moisture-related distresses in HMA over JPCP. Further research is recommended for this issue.
- Precast concrete headwalls are recommended for Iowa subdrain outlets to prevent clogging and damage from grass mowing operations. Additional research is needed to investigate the economic feasibility and field performance.



Mesh screen type rodent guards (left) exacerbated outlet clogging by blocking free flow of draining water while fork-shaped rodent guards (right) did not



Removal of rodent guards from plastic outlet pipe often mitigated tufa blockage problem

Implementation Readiness and Benefits

The recommendations and subdrain best management practices summarized above have the potential to help maintain adequate drainage systems and minimize moisture-related distresses.

Additional research is required into prevention of tufa formation while using recycled PCC as base/subbase materials, strategies to mitigate the occurrence of transverse cracking on pavements over culvert structures, the effects of blocked drainage outlets on shoulder distresses and the effects of compromised drainage outlet performance on moisture-related distresses.