IOWA STATE UNIVERSITY
Institute for Transportation

Evaluating Roadway Subsurface Drainage Practices

tech transfer summary

Based on the results of this study, the researchers recommend discontinuing the use of rodent guards to cover drainage outlets in Iowa.

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RESEARCH PROJECT TITLE
Evaluating Roadway Subsurface Drainage Practices

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Problem Statement

The bearing capacity and service life of a pavement is adversely affected by the presence of undrained water in the pavement layers. In cold climates like in Iowa, this problem is magnified further by the risk of frost damage when water is present. Therefore, well-performing subsurface drainage systems form an important aspect of pavement design by the Iowa Department of Transportation (DOT).

Previous studies have reported that properly-designed, constructed, and maintained pavements that incorporate positive subsurface drainage features can extend the life of a pavement greatly. However, controversial findings are also reported in the literature regarding the benefits of subsurface drainage.

In addition, the use of recycled portland cement concrete (PCC) as a granular subbase is a prevalent pavement construction practice by the Iowa DOT. A previous study showed that excessive fines in recycled PCC can cause deposits to form on the subdrain rodent guards, blocking the outlet.

In light of the recent Iowa DOT field maintenance staff reductions, budget cuts, and their implications on subdrain outlet maintenance, there is a need to determine the impacts of not maintaining the subdrain outlets on pavement performance in Iowa.

Objectives

The specific objectives of this project were as follows:

- Conduct an extensive performance review of primary interstate pavement subdrains in Iowa
- Include the condition of the drains and a determination of whether they are functioning as designed
- Evaluate a corresponding pavement to determine if pavement deterioration is occurring at the drain locations
- Determine the cause of the problem if there are drains that are not functioning properly
- Make recommendations for improvements to the pavement drainage system, when appropriate

It is important to note that this research project was not intended to investigate whether or not Iowa pavements need subdrains, but to evaluate roadway subsurface drainage practices in Iowa.

Research Methodology

An extensive literature review was performed covering national-level and state-level research studies mainly focusing on the effects of subsurface drainage on performance of asphalt and concrete pavements. Several studies concerning the effects of a recycled concrete aggregate (RCA) or recycled PCC (RPCC) subbase on PCC pavement drainage systems were also reviewed. A detailed forensic test plan was developed in consultation with the project technical advisory committee (TAC) for inspecting and evaluating the Iowa pavement subdrains.

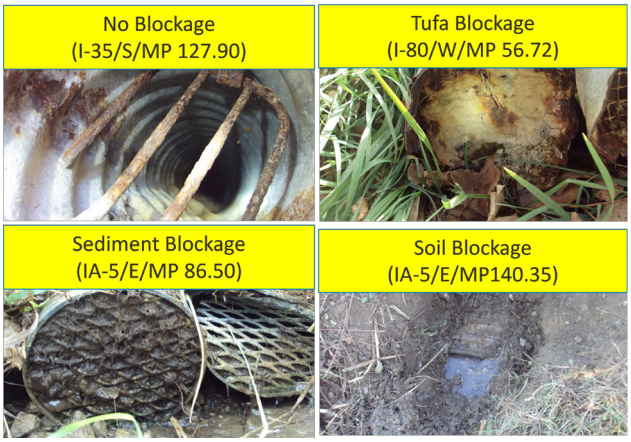
Field investigations were conducted on 64 selected (jointed plain concrete pavement/JPCP and hot-mix asphalt/HMA) pavement sites during the fall season of 2012. Field investigations were focused mainly on the drainage outlet conditions. Many JPCP sites using RPCC base materials were included in the forensic test plan to investigate the issue of tufa formation leading to poor drainage performance.

At least three drainage outlet spots per selected site, representing start, middle, and end were investigated. A drainage inspection report template was prepared and used during field inspections to document mainly the condition of outlet openings in terms of percentage of blockage caused by coarse/fine material accumulation. Any pavement distresses observed near inspected drainage spots were also recorded (pictures and videos).

Pavement distress records for the selected sites were also extracted from Iowa the DOT Pavement Management Information System (PMIS) and organized with field inspection results. Statistical analysis was conducted on the compiled data from field investigations to investigate the effect of drainage on pavement performance further.

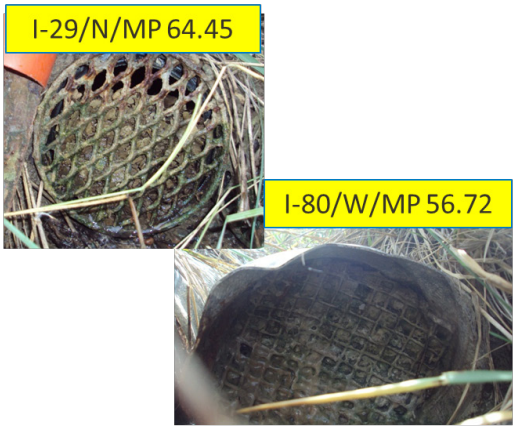
Key Findings

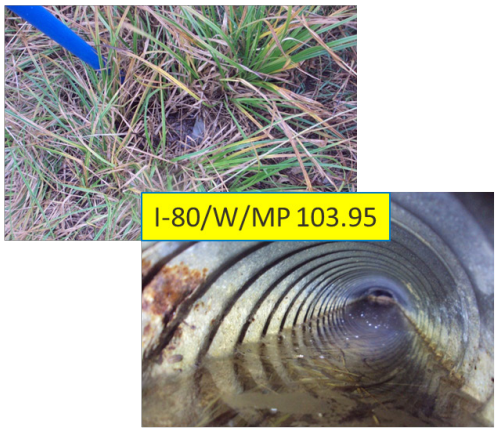
- Most Iowa subsurface drainage outlet blockage is due to tufa, sediment, and soil.
- Among the ones investigated, over 80 percent of drainage outlets in JPCP were not damaged while less than 20 percent were damaged. For HMA pavements, less than only 10 percent of drainage outlets were broken.



Typical roadway subsurface drainage outlet conditions in Iowa

- About 35 percent of investigated outlets in JPCP and 60 percent in HMA pavements were not blocked by any materials. About 35 percent of outlets in JPCP were blocked by tufa, about 17 percent were blocked by sediment, and about 14 percent were blocked by soil deposits. However, most of the blocked outlets in HMA pavements were blocked by soil deposits. Only 2 percent of outlets in HMA pavements were blocked by sediment.
- Both field observations and performance analysis indicate that drainage outlet conditions do not have a significant effect on pavement performance.
- Rather than surface distresses, more shoulder distresses (shoulder drop or cracking) were observed near blocked drainage outlet spots. Over 10 percent of the blocked drainage outlet spots have shoulder distresses while only 2 percent of the opened drainage outlet spots have shoulder distresses.
- The use of RPCC as subbase material results in tufa formation, which is the primary cause of drainage outlet blockage in JPCP. However, those JPCP spots that utilized blended RPCC and virgin aggregate materials as subbase materials experienced fewer outlet blockages due to tufa formation.
- The use of a gate/mesh screen-type rodent guard has the potential to cause outlet blockage. Considering that very little rodent evidence was observed in subdrainage outlets during field investigations, it is highly recommended that these rodent guards not be used to cover the drainage outlets in Iowa.





Blocked Outlet with Mesh Gate Screen **Opened Outlet without Mesh Gate Screen**

Rodent guards contribute to subsurface drain outlet blockage

Future Research

Based on current research findings, the project TAC recommended an expanded Phase II research study to address the following research needs:

- Evaluate the seasonal variation effects (dry Fall 2012 versus wet Spring/Summer 2013, etc.) on subdrain outlet condition and performance
- Investigate the condition of composite pavement subdrain outlets
- Examine the effect of resurfacing/widening/rehabilitation on subdrain outlets (e.g., the effects of patching on subdrain outlet performance)
- Investigate the characteristics of tufa formation in Iowa subdrain outlets (i.e., identify the factors influencing the tufa formation and prevention, at what stage does tufa formation start influencing subdrain outlet performance, etc.)
- Identify a suitable drain outlet protection mechanism (like a headwall) and design for Iowa subdrain outlets based on a survey of nearby states

Implementation Readiness and Benefits

The research findings will be used directly by city, county, and Iowa DOT engineers to assess the performance of their pavement subdrains and improve their drainage practices.

The findings and recommendations will help refine Iowa DOT pavement/subdrain design, construction, and maintenance practices and policies to achieve long-lasting drainage performance.