



TECHNICAL SUMMARY

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PROJECT COST:

\$186,735



The handheld electromagnetic gauge is a promising tool for non-destructive testing of moisture levels in and beneath pavement layers.



RESEARCH
SERVICES SECTION

Evaluating Roadway Subsurface Drainage Practices

What Was the Need?

Effectively managing water in road systems is critical to the long-term effectiveness of highways. Few things challenge road structures the way moisture does. Water softens subgrades, erodes shoulders and contributes to pavement cracking and deterioration. Freeze-thaw cycles intensify the impact of moisture contained within the pavement structure.

Edge drains—systems that allow water to filter down through shoulder gravel into trenches and pipes that carry the water away—have long been a preferred method for managing subsurface drainage. Edge drains effectively manage runoff, the water shed by the roadway surface. These systems keep moisture from softening subgrades and reducing the structural strength of pavement. Effective drainage systems also keep water from gathering in lanes and challenging driver safety.

Water occasionally rises up from beneath a subgrade into the base and even into the bound pavement layers; edge drains offer little protection against this condition. Engineers have proposed centerline drains—systems that drain water from beneath the center of a road rather than from its edges—as an alternative to edge drains. If centerline drains can handle surface runoff, prevent water from gathering on lane surfaces and redirect water rising from beneath, then drainage systems would require only one line of drains in the center rather than lines at both edges. Such a system would save money spent on construction and materials as well as on maintenance.

What Was Our Goal?

This project aimed to determine if centerline drainage systems are an effective alternative to edge drains. By testing edge drains against centerline drains at various depths, investigators hoped to identify effective configurations of centerline drains.

What Did We Do?

Researchers tested drainage system configurations on an eight-mile stretch of highway in Nobles County. In 80 sections of 500 feet each, crews installed various combinations of edge drains at the shoulders, centerline drains at two-foot depths and centerline drains at depths of four feet beneath the pavement surface. On these highway segments, researchers gathered three kinds of data:

- To read drainage volume, they installed tipping buckets inside locked barrels fixed with instruments at drainage system outlets.
- To gather on-site moisture data for pavement, base and subgrade, researchers used a handheld electromagnetic gauge at each segment.
- To determine the extent to which material leaching through recycled concrete aggregate calcifies, obstructing the flow into the drain, they inspected select draining sections for calcification deposits.

The researchers also considered a fourth set of data: They collected electromagnetic induction instrument readings from four sections of roads with various drainage configurations in the city of Worthington, Minnesota.

What Did We Learn?

Investigators gathered data during a two-year period over 2006 and 2007, and found that:

“The quantity of water that the edge drains redirected surprised me. It was significantly higher than the volume drained from centerline systems.”

—Stephen Schnieder,
Director, Nobles County
Public Works

“We essentially found that edge drain systems should remain the recommended design for roadway drainage. In cases in which the subgrade is permeable, deep centerline drains may be a good alternative.”

—John Nieber,
Professor, University of
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Researchers cut out sections of edge drain pipes to evaluate sediment composition.

- Edge drains redirected by far the greatest volume of water of the three configurations sampled, with no significant difference measured between volumes redirected by edge drains on one side of the roadway or the other.
- Data showed no significant difference in drainage volume between two-foot and four-foot centerline depths. Over impermeable subgrades, the four-foot depths redirected somewhat higher volumes.
- Electromagnetic gauge readings showed more moisture present within edge drain lines than within centerline drains, but less in pavement structures and bases with edge drains than with centerline drain sections.
- Drainage lines that showed high levels of carbonate deposits were not in sections with recycled concrete aggregates, an unexpected finding. Researchers believe the deposits may have come from carbonate sands in those locations.
- Data did not match expectations that the older roads in Worthington would show higher moisture levels than the newer roads. Instead, one of the new roads produced higher retained moisture in bases than the others. Researchers found a loose but not compelling correspondence between moisture readings and pavement distress on old and new roads.

Researchers concluded that edge drains should remain the recommended drainage system design for highways and urban roadways. In cases of permeable subgrade in areas in which water sources could force moisture up into a structure, centerline drainage may yet be useful. If centerline drainage systems are to be used, the deeper configuration should be favored.

Investigators also concluded that the height of a roadway surface with respect to surrounding ground was not a significant factor in drainage performance.

What's Next?

No changes to pavement standards were recommended as a result of this study. The specific electromagnetic gauge used in this study, the Geonics EM38, shows promise as an in situ, point-by-point, nondestructive device for measuring moisture in and underneath pavement structures. The EM38 could have applications in roadway evaluation and in assessments for retrofitting or other maintenance, and its use and calibration warrants further investigation.

This Technical Summary pertains to the LRRB-produced Report 2009-08, “Evaluating Roadway Sub-surface Drainage Practices,” published January 2009. The full report can be accessed at <http://www.lrrb.org/PDF/200908.pdf>.