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LRRB
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LRRB PROJECT COST:
$118,941

The Hamburg wheel track test reveals weaknesses in asphalt mixes, such as loss of adhesion between binder and aggregate.

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Examining Possible Causes of Stripping in Asphalt Pavement Under Chip Seals

Researchers studied the stripping of binder from aggregate under chip seals in asphalt pavements through extensive field and laboratory tests. Study results suggest that air voids, asphalt mix and construction practices don't cause stripping. Further research into the causes is planned.

What Was the Need?

Chip sealing—the application of an asphalt emulsion with a layer of aggregate—has been used for decades on asphalt roads as preventive maintenance to extend their effective lives.

Despite this intention, some chip sealed roads laid in the last two decades have shown premature aging, displaying asphalt stripping—the loss of bond between bituminous cement and aggregate beneath the chip seal—at a rate high enough to generate concern among Minnesota's city engineers. Hundreds of miles of Minnesota roadways are showing signs of early failure. The chip sealing seems to have decreased rather than increased the effective life of some pavements.

MnDOT funded a comprehensive research study to determine the cause of stripping under chip seals and possible means of mitigating it. The project also tested an earlier study's conclusion that construction methods could contribute to stripping.

What Was Our Goal?

This research project had four objectives:

- Explore the indications that construction methods resulting in a high percentage of air voids might be the cause of stripping under chip seals.
- Investigate why high air voids occurred where they were observed.
- Identify asphalt mix design or construction practices that may have led to stripping.
- Upon verification of cause, develop or suggest means to avoid or mitigate stripping, including mix design, construction guidelines and maintenance techniques.

What Did We Do?

Researchers examined roads at 18 sites located in seven municipalities and one county. They collected at least 12 samples from each site and used the samples in field and laboratory testing. (The previous study examined 16 samples from three locations—a sample size too small to support a generalizable conclusion.) Researchers also surveyed 129 city and county engineers to gather information about chip seal practices.

In the field, researchers compiled condition surveys of the extent of each site's pavement distress. At least 12 6-inch-diameter asphalt cores were obtained from each of the 18 sites for laboratory testing. A total of 280 cores were obtained. Ground penetrating radar coupled with precise GPS location data were collected at 13 locations to determine pavement thickness and evaluate base layers. A nuclear density gauge measured the density of on-site pavements through the detection of deflected gamma radiation.

In the lab, researchers performed:

- **Volumetric tests.** Six samples per site were tested to determine the percent of air voids, specific gravity and average asphalt film thickness.

continued

"This study suggests that there may be a systematic problem in road maintenance practice. We will have to look very closely and clearly in future studies and examine what works rather than why something doesn't work."

—Klayton Eckles,
Engineering and Public Works Director, City of Woodbury

"Pavement distress is a complex phenomenon that may be caused by the presence of the chip seal as much as it is by the composition of the underlying asphalt. The data collected in this study will be valuable for future work examining this problem in detail."

—David Rettner,
PE, American Engineering Testing, Inc.

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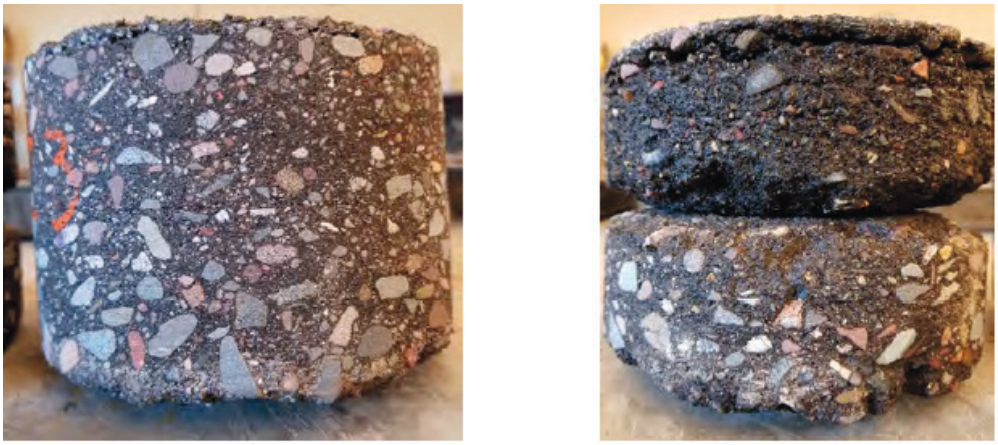

The samples above show an intact asphalt core (left) and a stripped core (right) under chip seal and between asphalt lifts that were collected from a site in Shoreview, Minnesota.

- **Hamburg wheel tracker tests.** Weaknesses in bituminous mixtures, such as a weak bond between binder and aggregate, can be revealed when a heavy steel wheel repeatedly passes over a specimen. Researchers tested paired specimens—one with a chip seal and one without—from 18 locations.
- **Disk-shaped compact tension tests.** Researchers evaluated the fracture energy of seven specimens.
- **Falling head permeability tests.** The speed of water passing through low-permeable material allows the calculation of coefficients of permeability. Investigators tested the permeability of 68 samples from 18 locations.
- **Tensile strength ratio tests.** Tensile strength loss due to damage under accelerated water conditioning was measured in 18 specimens.
- **Asphalt mix evaluation.** Researchers examined the properties of asphalt mix samples from the 1990s and later.

What Did We Learn?

The project's field and laboratory testing represents an extensive study of chip sealed pavement performance in Minnesota. In spite of this effort, however, many concerns remain unresolved. This study did not verify the conclusion of the earlier study that air voids are the cause of stripping. None of the samples from any location used in this study exhibited high air voids.

The results of field and laboratory tests revealed that there does not appear to be a direct relationship between pavement density and stripping under chip seals. In addition, there does not appear to be a direct relationship between specific mixture, contractor, geographic location or year of construction and this distress.

The survey of 129 engineers revealed that 64 percent regularly used chip seals. Of that portion, 39 percent observed some stripping, and 26 percent reported it as a major issue for their chip sealed pavements. Thus, the majority of engineers who used chip seals saw signs of moderate to severe stripping on their roadways.

What's Next?

Stripping under chip seals cannot be addressed with a simple mix design or paving practice. It is a complex phenomenon that may be caused by the chip seal itself as much as by some aspect of the underlying asphalt. This study's extensive field and laboratory data will be valuable in future investigations. Researchers are planning a new study to examine whether chip sealing is counterproductive as a maintenance practice.

This Technical Summary pertains to the LRRB-produced Report 2017-35, "Prevention of Stripping Under Chip Seals," published October 2017. The full report can be accessed at mndot.gov/research/reports/2017/201735.pdf.