Investigation of Winter Pavement Tenting

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The term “pavement tenting” refers to a condition of localized heave that develops at pavement cracks or joints during winter weather. Severe winter pavement tenting of transverse cracks impacts ride quality. Results from other research studies support the hypothesis that road deicing chemicals can contribute to tenting. The Minnesota Local Road Research Board sponsored this investigation of perceived causes and winter maintenance strategies for pavement tenting. The study included a survey of engineers and a variety of winter field tests and pavement performance monitoring methods.

SURVEY FINDINGS

37 percent of respondents identified winter pavement tenting occurring in their local road network. They estimated that the percentage of low, moderate, and high severity tented cracks were respectively 44, 30, and 26 percent. Over 60 percent of respondents used route and seal and 45 percent used crack filling to maintain their road network. Route and seal techniques were considered the most effective treatment with respect to pavement tenting. Respondent agencies used a variety of sand and salt deicing products, applying treatments at rates between 0.2 and 1.0 tons per lane mile.

TESTING AND EVALUATION PROGRAM

Field testing was performed based on theory that the presence of deicing chemicals, sands, and crack sealing all influence pavement tenting. Methods were chosen mainly to gain information on conditions that exist during time that the test sites would likely show tenting. Test pits excavations, surface sampling, and longitudinal profile measurements were used in the study. 

Seasonal Effects: Analysis included examining statistical relationships for tenting severity based on temperature conditions and the presence of deicing chemicals, as well as the effect of various maintenance activities on tenting severity. Crack openings ranged from 0 – 1.0 in. between summer and winter. Likewise, tenting ranged from 0 – 0.4 in. between summer and winter. As expected, analysis showed a positive relationship existed between tenting and transverse crack opening. A subset of subject roads in northern Minnesota showed a higher correlation between vertical tenting and longitudinal opening of transverse cracks. The magnitude of the correlations was approximately the same between temperature, longitudinal movement, and vertical movement for the general data set.

Test Pits: Three test pits were excavated during February 2005 with the help of local agencies. A complete history of the aggregate base material was unavailable for pits 1 and 2, but upon examination they were found to contain both sound and degraded recycled concrete and natural aggregates. Pits 1 and 2 were cut through one and two 4-in. layers of bituminous pavement without using water lubrication, enabling observation and sampling of
undisturbed base material. A ridge of silt like material was found just below the location of the tented cracks in the first two pits. In one case the ridge rested directly on the base, and was less pronounced than the ridge found between HMA layers in the next pit. It is hypothesized that in these cases the fines originated from degraded crack seal. Part of the ridge in the first case may have been assimilated into the aggregate base. The third test pit was located in 6.5-in. of sawed and unsealed HMA over a class 6 aggregate base, all above a rubblized concrete pavement. This pit was sawed using water lubrication. After water removal the base was sampled at various locations. Uneven expansion of the HMA was not evident. A string line check of the bottom of the HMA layer showed that the tented saw cut deviated 0.4 in. from the straight line. Although inspection of the third pit did not reveal ice lenses that were comparable to those found in the first two cases, thermal images of the aggregate base indicated that non-homogeneous thermal properties existed in the region near the saw cut.

Conductivity and Tube Suction Measurements: The concentration of deicing chemicals was studied at the by using conductivity measurements. A proportional relationship exists between ion concentration and conductivity value. In this report conductivity is shown in units of mS/cm. Conductivity values from materials sampled from test pit excavations ranged between 0.48 to 20 mS/cm. These values are approximately 10 and 400 times the conductivity of tap water. Analysis showed that measurable differences in deicing chemical concentration occurred in the base structure near cracks. Gradation analysis and tube suction testing was performed on material from the third test pit excavation (TS39**). The gradation conformed to the Mn/DOT class 6 standard specification, and contained approximately 5 percent fines. Tube suction tests for conductivity and dielectric values over time and various moisture contents showed the gravimetric moisture content increased to over six percent, but did not coincide with peak conductivity. Volumetric water content, indicated by dielectric value, showed that material from the third pit reached a plateau at approximately 50 hours and approximately 5.5 percent moisture.

Other subject roadways: The presence of salt was also tested by measuring the conductivity values for samples obtained from the subject roadways at the surface, open transverse cracks, or from the aggregate base. It was found that a log-normal distribution best described the data set, with an average value of 7.6 mS/cm.

Profile and Characterization of Tented Condition: Prior work at the Mn/DOT Pavement Management unit established a threshold of 0.1-in. to classify a measurement as tented. This criterion was applied to the data set of dipstick and high-speed profile measurements. The results showed that during the investigation most of the subject roads met or exceeded the minimum classification value.
MAINTENANCE CASE STUDIES

The tube suction data suggest that base materials may accumulate large amounts of road salt, even in relatively new pavement construction. The accumulation presents a potential problem since salts have the ability to attract moisture, and are known for their hygroscopic properties.

Case study: Mill and bituminous overlay.

A mill and overlay treatment was performed over the area including test pit 2. Adjacent sections were also crack sealed, along with the area including test pit 1 (control). Dipstick and hand measurements were obtained over the transverse cracks at these sites over two winters. Measurements obtained after one year of service showed there was no difference in between the treatment and control sections.

Case study: Route and seal of sawed bituminous pavement.

A route and seal treatment was performed on previously unsealed-sawn highway sections in northern Minnesota. An unsealed section on another road of similar age and design was used as a control section. In the winter after treatment International Ride Index (IRI) measurements dropped an average of 98 in./mile, an improvement of 25 percent.

Case study: Crack seal and seal coat on bituminous pavement.

Crack sealing and a seal coat was installed on a northern Minnesota highway having random transverse cracks. The untreated sawn-unsealed was selected as a control section. In the winter following treatment, IRI measurements dropped to an average of 194 in./mile, an improvement of 18 percent.

CONCLUSIONS

Measurement of base materials below tented cracks showed that the concentration of deicing salts was highest near crack openings and decreased with depth and distance from the crack. The presence of salt in the base, combined with an open crack, can promote the retention and accumulation of moisture in the pavement structure near the crack.

Measurements showed that crack sealing can reduce roughness and height of tented cracks. The data suggests that by crack sealing a tented road there may be a benefit of reducing tenting roughness from 20 to 35 percent during the first year.

Field observations showed the extreme vertical heave at tented cracks was approximately 50 percent of the longitudinal displacement. Longitudinal profiles of tented cracks show that heave may occur several feet from the crack opening. Therefore, when maintenance crack sealing is performed on roads having wide cracks that are prone to tenting, every effort should be made to install the most elastic and durable sealant material available. It is also recommended that agencies perform cold weather inspections of sealant performance to become aware of adhesive or cohesive failures that may not be apparent during warm weather.

Mill and overlay treatment was successful in eliminating tenting during the first year. However, it was observed that reflective cracking occurred during the first winter on a mill and overlay pavement structure that was prone to tenting. In order to reduce the likelihood of tenting recurrence it is recommended that agencies investigate the moisture sensitivity as well as the level of salt contamination of the base material prior to overlay. It is also recommended that full depth reclamation or contaminated base removal is considered as a treatment alternative.
NEED MORE INFORMATION ON THE WINTER PAVEMENT TENTING STUDY OR THE MINNESOTA ROAD RESEARCH PROJECT (MN/ROAD)?

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