Research in Progress: Increasing the Gradation of Limestone Aggregate Bases to Increase Road Performance

What Was the Need?

To perform well, pavements must be constructed over good quality aggregate base layers. MnDOT sets specifications governing the allowable sizes, or gradation, of particles within these aggregates. Aggregates with excessive fine particles will tend to absorb and hold water, which can then damage the road by expanding and contracting during seasonal freezing and thawing, and provide insufficient support during wet periods.

However, MnDOT’s current aggregate base specifications are geared toward granular materials obtained from gravel pits. In southern Minnesota, the most prevalent aggregate base material is quarry limestone, consisting of larger rocks that have to be crushed to meet current Class 5 specifications. The crushing effort needed to produce a Class 5 typically results in excessive fines, and this material is susceptible to further fragmentation during the compaction process and degradation beneath the pavement over time. Research was needed to see if the gradation of limestone aggregate bases should be increased to offset degradation during compaction. Using larger particles might not only improve the performance of roads but would require less initial crushing effort, potentially reducing production costs.

To evaluate the use of larger particle sizes in aggregates and other factors in road performance, in 2000 the Local Road Research Board and MnDOT jointly funded INV 767, Investigation of Flexible Pavement Performance in Relation to Aggregate Base and Asphalt Mixture Low-Temp Characteristics. Researchers built test sections for this project using different crushed limestone aggregate base gradations. Because these sections did not develop cracking or other distresses before the project’s end in 2005, further study was required for continued monitoring from 2005 to 2010.

What Is Our Goal?

The objective of this project was to perform follow-up performance monitoring of Olmsted County Roads 104 and 117 to evaluate the effect on pavement performance of limestone aggregate base particle size, asphalt binder type and the use of saw-and-seal construction.

What Have We Done?

As part of INV 767, in 2000 researchers constructed six test sections on Olmsted County Roads 104 and 117 near Rochester, Minnesota, using three base materials:

- Standard Class 5, which consists primarily of ¾-inch rocks and smaller particles.
- Class 5 Modified, in which crushing was reduced to yield 2-inch top size.
- Permeable Aggregate Base, or PAB, with 3-inch top size particles.

Researchers also tested the effects on cold temperature cracking of two asphalt binders (PG 5-28 and PG 58-34) and saw-and-seal construction, in which joints are sawed into...
the pavement at regular intervals to allow expansion and contraction as temperatures fluctuate. Researchers have monitored the test sections regularly since construction and used a variety of methods to measure:

- Layer stiffness, using the falling weight deflectometer.
- Ride quality, rutting, cracking and other forms of distress, using automated and visual pavement distress surveys.
- The effects of traffic loads, by recording traffic volumes and vehicle types.
- The properties of materials used, via laboratory testing.

What Have We Learned?

Performance of test sections has not yet differed significantly enough to form definitive conclusions about the relative quality of the asphalt binders or saw-and-seal construction techniques. However, despite its higher traffic loading than other sections, the non-sawed test section using a Class 5 Modified aggregate base and PG 58-34 binder is performing somewhat better than others.

Postcompaction gradation testing of the Class 5 Modified aggregates showed a material that approximates the desired Class 5 gradation specification. After winter freezing, the Class 5 Modified aggregate base also retained more stiffness during the spring thaw and recovered it more quickly than those with the standard Class 5 aggregate. The use of a larger gradation may maximize the effectiveness of load restrictions typically imposed during the spring to prevent heavier vehicles from damaging weaker roads.

These initial results suggest that reduced crushing is a better design procedure for the crushed limestone aggregate bases commonly used in counties in southeastern Minnesota.

Table: Recommended Class 5 Modified Gradation Specification

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<tr>
<th>Sieve Size</th>
<th>Total % Passing</th>
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<tbody>
<tr>
<td>2 inch</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2 inch</td>
<td>95-100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>65-95</td>
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<tr>
<td>3/8 inch</td>
<td>35-70</td>
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What’s Next?

Researchers will continue to monitor the test sections as part of a follow-up study (INV 899) expected to conclude in 2015. The tests used in this study will continue, including distress surveys, traffic counts and falling weight deflectometer measurements. Researchers will also add new tests for a more detailed local traffic analysis and the investigation of subgrade soils, allowing for forensic pavement and base material analysis if significant pavement distresses develop during the follow-up study period.

“This project suggests that by using larger particle sizes in limestone aggregates, we can both save money on production costs and produce a better quality road base.”

—Matthew Lebens,
Research Project Engineer, MnDOT Office of Materials and Road Research

“For very little cost to the LRRB, this project resulted in a successful change in the specification for Class 5 limestone aggregates used in road construction in Olmsted County and southeastern Minnesota.”

—Alan Rindels,
Research Development Engineer, MnDOT Research Services

Recommended Class 5 Modified Gradation Specification

This Innovation Update pertains to LRRB projects INV 767, INV 825 and INV 899. For more information, including the Class 5 Modified crushed limestone base gradation specification developed from this project, contact Michael Sheehan at Sheehan.Michael@co.olmsted.mn.us or Matthew Lebens at Matthew.Lebens@state.mn.us.