

TECHNICAL SUMMARY

Questions?

Contact research.dot@state.mn.us.

Technical Liaison:

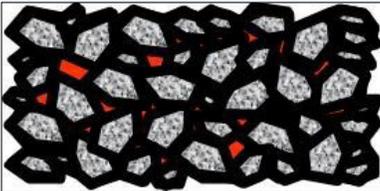
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Investigator:

Mihai Marasteanu, University of Minnesota

PROJECT COST:

\$144,405



Asphalt compactability depends on the level of air void (depicted in red) in addition to the sizes and shapes of aggregate.

Improving Asphalt Performance and Durability With Superpave 5

What Was the Need?

Denser asphalt pavements with a lower air void content are generally better able to provide long-term durability and withstand Minnesota's cold temperatures, precipitation and freeze-thaw cycles. Higher air voids can lead to pavement cracking and rutting. While asphalt pavements need air void space to allow for some compaction under traffic or expansion in hot weather, an air void ratio that is too high can result in excess compaction in the wheel tracks. Simply adding more asphalt binder to the mix helps the initial pavement compaction but it is costly and may actually decrease asphalt stability.

Superpave is a performance-based asphalt mixture specification developed in the 1990s by the Strategic Highway Research Program. While the traditional Superpave mixture is designed at a 4% air void content, the pavement, after compaction, may have up to 10% air content in the field. Superpave 5, a new mix design method developed by Indiana Department of Transportation and Purdue University, results in a 5% mixture air void design requirement and a 5% after compaction pavement density requirement.

Previous research developed a model simulating high-density asphalt compaction to understand how a new, more durable mix could be produced. To benefit roads across the state, MnDOT wanted to take further efforts to create Superpave 5 for denser and more durable pavements.

What Was Our Goal?

The goal of this project was to design a range of Superpave 5 mixes using local materials to withstand Minnesota's harsh climatic conditions and lower life cycle costs.

What Did We Do?

Researchers first reviewed previous investigations into compaction and field density of asphalt mixtures. To understand the correlations between material properties and field density, they performed comprehensive gradation analyses on mixes used in various past projects to assess the distribution of aggregate particle sizes. A dense mix requires a specific air void ratio achieved by smaller particles filling in between larger ones.

They collected mix design information and investigated the field density of 25 previous projects constructed in Minnesota between 2018 and 2020, including four projects in which the contractor developed Superpave 5 mixtures. Testing the mixes through a variety of methods, researchers identified aggregate gradation and angularity. They cut cores from the pavement project sites to determine the in-place density and performed statistical analyses to examine the field density distribution.

Using a gyratory compactor on the original loose mixtures from three of the projects, researchers simulated compaction behavior under road paving operations for a defined traffic level to compare to actual pavement densities. They determined the number of gyrations necessary to represent the field compaction levels of those projects at the design air void value. Generally, a higher-traffic road would require higher compaction and, thus, more gyrations.

Minnesota's harsh climate requires dense, durable asphalt to avoid frequent maintenance and replacement. Asphalt mixes as designed in the laboratory, however, don't always perform consistently in the field. A new Superpave mix shows promise for providing cost-effective, high-performing pavements for state roadways.

“A key finding here is that our regular Superpave mix can be modified by changing the aggregate gradation of the mixture with the potential of adding little to no additional binder. This is positive from a cost perspective and will result in more durable pavement.”

—**Chelsea Bennett**,
Assistant Bituminous
Engineer, MnDOT Office
of Materials and Road
Research

“This research demonstrated a feasible approach for designing Superpave 5 mixtures using local materials by making small changes in the gradation of the aggregates currently used in the traditional Superpave design.”

—**Mihai Marasteanu**,
Professor, University of
Minnesota Department of
Civil, Environmental and
Geo-Engineering

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Full compaction was thought to be achieved only under traffic loadings. But a Superpave 5 asphalt mix will be compacted to the design level air voids with regular paving equipment during construction.

Finally, four traditional asphalt mixtures were modified to create Superpave 5 mixes using the same raw materials and binder content but changing the aggregate gradation. Researchers examined the mechanical properties of the mixes and conducted performance tests at two different laboratories.

What Did We Learn?

Building on previous work, researchers gained an understanding of the appropriate material properties and compaction level to ensure sufficient field density for Superpave 5 mixes.

Field densities of the asphalt material from previous projects were shown to have considerable randomness. Factors correlating to lower field densities included mixtures designed for higher traffic levels, larger aggregate size and higher fine aggregate angularity. The Superpave 5 projects that were analyzed illustrated those pavements had a significantly higher field density than traditional mixes, though it was not clear what changes in material properties caused the increase.

Contrary to the traditional practice of higher compaction for more heavily traveled roads, researchers found the number of gyrations required to reach the air void design level of 5% and the corresponding field density—30 gyrations—was consistent regardless of the intended traffic level. This finding illustrated the level of compaction for which the Superpave 5 mix should be designed.

Lastly, by creating Superpave 5 mixtures, researchers found that aggregate gradation can significantly impact the asphalt's compactability by lowering the air voids. Using local materials without changing the binder content, researchers demonstrated the feasibility of designing Superpave 5 asphalt by increasing the proportion of coarse aggregates, which improved compactability. In addition to improvements in density, the refined mixes were more rut- and crack-resistant.

What's Next?

MnDOT will use the new Superpave 5 mix design in pilot projects to ensure contractors can successfully work with it and to monitor the pavement densities in the field. If the agency decides to fully adopt the Superpave 5 mixture, a slightly modified standard specification for asphalt mixtures would be needed.

This Technical Summary pertains to Report 2022-18, “Development of Superpave 5 Asphalt Mix Designs for Minnesota Pavements,” published June 2022. The full report can be accessed at mndot.gov/research/reports/2022/202218.pdf.