WISCONSIN DEPARTMENT OF TRANSPORTATION

PUTTING RESEARCH TO WORK

BRIEF

Identifying Effective Lower Compaction Temperatures for HMA

Hot-mix asphalt pavement layers must be compacted to the correct density. HMA pavements that are not sufficiently compacted will tend to rut rather than rebound under vehicle loading while pavements that are compacted too much will tend to crack. Proper compaction also makes HMA pavements less permeable to air and water, protecting them from rapid oxidation of binder materials and excessive moisture damage to their layers, both of which shorten pavement life.

To achieve optimum compaction, engineers measure HMA density and permeability as it is compacted by drum rollers. Density is measured by detecting the percentage of air voids within the asphalt pavement. Permeability is measured by the rate of the flow of water and air through the asphalt pavement.

What's the Problem?

National studies have shown that the desired air void content of in-place HMA pavements is below 8 percent Gmm (maximum specific gravity) and that the desired permeability is below 150 x 10^{-5} cm/second. However, these values are empirically derived, and their relationship to performance is not clearly defined. To better understand this relationship and achieve the target density and permeability values, it is necessary to better understand factors that affect them, including degree of compaction and variations in temperatures during the process of laying down asphalt layers, or mats. A lower temperature limit for compaction is missing in current specifications and construction manuals, and these may also specify compaction temperatures that are too high.

Research Objectives

The objectives of this study were to investigate the lowest temperatures at which the required density of HMA can be achieved with typical compaction effort; quantify the effects of warm-mix additives on these temperatures; and create a model relating density, permeability and asphalt pavement performance in Wisconsin.

Methodology

Investigators collected data at 22 HMA construction projects during the 2007 paving season and at a single warm-mix project during the 2008 paving season. During compaction, investigators took measurements between roller passes to assess the density increase with each pass as mat temperature decreased. Immediately after compaction had been completed and as the mat cooled, investigators measured water and air permeability at five of these sites.

Finally, investigators collected uncompacted loose-mix samples at these sites and tested them in the laboratory to determine whether field compaction measurements could be correlated with laboratory compaction data collected at varying temperatures and compaction pressures.

Results

In the field, investigators did not encounter a compaction temperature lower than 150 degrees F. The target density of 92 percent Gmm could always be achieved at any of the temperatures encountered, although lower temperatures required more roller passes. As a result, investigators were unable to specify a lowest limiting temperature for compaction. However, they did find that factors affecting field density include (in order of importance) mat temperature, number of roller passes, roller type, vibratory setting and PG binder grade.

In the laboratory, a compaction pressure of 300 kPa produced a density about 1.8 percent less than 600 kPa at a baseline temperature of 248 degrees F. Dropping the compaction temperature from 248 degrees F to 194 degrees F decreased the average density only by 0.4 percent Gmm, indicating relatively little benefit in compacting at higher temperatures over that specific range. On the other

Investigator

"This approach will allow the state to move toward true performance-based criteria for HMA pavement research and development."

–Robert Schmitt
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Investigators measured pavement density and air and water permeability between roller passes to compare these properties at different pavement temperatures.

hand, dropping the compaction temperature to 140 degrees F from the baseline reduced density by 2.4 percent. There was a moderate correlation between the temperatures required to produce the same density in the laboratory as in the field, and the type of aggregate had little effect on the compactive effort required.

Finally, a lab and field evaluation of a single warm-mix asphalt mixture showed that the average final density for WMA and traditional HMA were nearly identical.

Benefits

Defining the target minimum temperatures needed to achieve the right permeability and density of HMA pavements will allow Wisconsin to more consistently control the quality of asphalt pavements. The project results include a database model correlating the performance of HMA pavements in Wisconsin with permeability, density and mixture characteristics. As this model is developed, it will allow WisDOT and partners to establish accurate criteria across a broad range of HMA paving projects.

Implementation and Further Research

This study provides preparatory work and background information useful to the study of warm-mix technologies, which is the focus of a project by the Asphalt Research Consortium at the University of Wisconsin–Madison as well as various other studies. WMA will allow contractors to save energy and haul mixes farther. Investigators recommend continuing rigorous evaluation of the impacts of a variety of warm-mix additives and processes on the workability of WMA and HMA.

Project Manager

"As long as the mix quality is good and aggregates meet Superpave specifications, there's no reason contractors can't get the right density in the field at lower temperatures."

–Judie Ryan
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Brief prepared by
CTC & Associates LLC
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This brief summarizes Project 0092-07-17, "Development of Recommendations for Compaction Temperatures in the Field to Achieve Density and Limit As-Built Permeability of HMA in Wisconsin," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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