TECHSUMMARY May 2019

State Project No. DOTLT1000008 / LTRC Project No. 14-1B

Effects of Temperature Segregation on the Volumetric and Mechanistic Properties of Asphalt Mixtures

INTRODUCTION

Segregation in asphalt mixtures can be described as a concentration of coarse materials in some areas and fine materials in others, which results in non-uniform mixes that do not duplicate the original design, grading, or asphalt cement. Temperature segregation (TS) is a recently found phenomenon of non-uniform distribution of temperatures across the uncompacted asphalt mat during the construction thanks to the popular use of high-precision portable infrared thermal cameras in the paving sites. While many researchers have reported correlations between the TS and the performance of pavements, many others did not. The lack of agreement on the influence of TS to pavement quality and performance could have resulted from inconsistent definition of temperature segregation and dissimilar ranges of asphalt mat temperatures investigated by different researchers.

Actual occurrence of TS in Louisiana asphalt pavements has not been investigated until recently and under which circumstances, how often, how long, and how severe the TS occurs in the state have been mostly unknown. Better understanding the ultimate link between temperature segregation and asphalt pavement performance via mechanical properties of asphalt mixtures will enable Louisiana pavement engineers to find the solutions to mitigate the problem.

OBJECTIVE

The objective of this study was to determine the impact of temperature segregation on the quality and mechanical properties of asphalt mixtures as defined by density, fracture resistance, stiffness, and rutting performance of asphalt mixtures. Specific objectives of the study included were to:

- Ascertain and establish temperature segregation range during paving operations;
- Measure the density of roadway cores at uniform- and non-uniform temperature zones;
- Measure mechanical properties (Loaded Wheel Tracking test, Semi Circular Bend test, and Indirect Tensile Dynamic Modulus test) of roadway cores at uniform- and non-uniform temperature zones; and
- Establish an acceptable temperature segregation range during paving.

METHODOLOGY

To achieve the aforementioned objectives of the study, the following research tasks were planned and conducted:

Task 1: Conduct Literature Review
Task 2: Develop Experimental Design and Select Field Projects
Task 3: Install and Calibrate of Temperature Measuring Device
Task 4: Preform Thermal Profile Measurement
Task 5: Identify Project Locations with Thermal Segregation
Task 6: Perform Field Sampling and Laboratory Testing
Task 7: Perform Data Analysis
Task 8: Benefits of Implementation
Task 9: Prepare Draft Final Report

CONCLUSIONS

- Analyses on the thermal profiles obtained from all seven field projects showed two distinctive temperature patterns, i.e., a cyclic temperature segregation (CTS) and an irregular temperature segregation (ITS). While the CTS occurs due to the natural cooling of asphalt mixtures during the normal operation and may be at low risk severity levels of TD, the ITS occurs at work stoppages with the severity ranging widely from low to extremely high depending on the work stoppage time and ambient temperatures.

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- According to the temperature uniformity analysis, use of MTV significantly improved the uniformity of asphalt mixture temperature across the uncompacted mat. Pavement sections where full-size MTV with 20-ton storage capacity was utilized showed significantly better consistency than the sections where no MTV and light MTV were utilized. Aggregate mixtures with 19-mm nominal maximum aggregate size (NMAS) appeared to have higher temperature variability across the mat than the 12.5-mm NMAS mixtures. Other factors, i.e., ambient temperature, contractors, and target laydown temperature did not appear to influence the temperature uniformity significantly.
- Laboratory test results showed mixed trends in relationships to the temperature differentials:
  1. For the density, a fair correlation (R^2 = 0.49) between the density and temperature differential was found in Phase II projects where the temperature differential was measured right before compaction at work stoppage locations. Density differential comparisons between random samples and targeted samples showed that the thermal imaging technique would be helpful to guide decisions on QA sampling locations for better quality assessments.
  2. In Phase I, only one project showed the effect of TD on the fracture resistance measured by the SCB J_c values, while in Phase II, the effects were clearly observed in all three field projects with high and more TD severity levels.
  3. IDT |E*| values of high severity TD samples at 30°C showed significant stiffness reductions around 35 to 40%, while the reductions were not significant at lower temperatures (e.g., -10 and 10°C)
  4. Rut depths measured by LWT and the Pavement-ME predicted rutting values both showed significantly higher ruttings in the high severity TD areas, although the values still satisfy the Louisiana DOTD's specification limit.

Based upon the analysis and findings presented, the following conclusions can be drawn:
- Temperature differential, as measured at the time of compaction, affects mixture properties depending on its level of severity.
  1. TD of 25°F or 50°F does not cause severe effect on mixture properties
  2. TD of 75°F shows inconclusive effect, i.e., it affects severely in a few cases.
  3. TD of 100°F or higher causes severe effect on mixture properties

- TD measured right before compaction in Phase II projects correlated well with decrease in density, fracture resistance, dynamic modulus, and increase in rut depth.

RECOMMENDATIONS

The use of thermal scanning device such as the Pave-IR system or handheld portable thermal camera in Louisiana asphalt paving projects is recommended as the technology provides real-time thermal images of the uncompacted asphalt mats that can help making guided decisions by both contractors and DOTD project engineers for the quality control (QC) and quality acceptance (QA). It is strongly recommended that the thermal scanning is to be performed just prior to the compaction.
- When using the Pave-IR system, the full-length thermal profile of a day work can be obtained and submitted to the project engineer for review.
- When using the portable thermal camera, a minimum of one thermal image per each 150-ft. long segment may be obtained and submitted to the project engineer.

The thermal profile information can be used by the contractors to identify significantly colder than desirable spots on the mat, and adjust the compaction efforts as needed to achieve adequate field densities for a better guided QC. Also, the information collected and submitted by the contractors can be used by the project engineers or inspectors to determine targeted QA sampling spots for the better assessment of the construction quality. Table 1 suggests the range of temperature differentials and corresponding actions that can be required by the project engineers (inspectors).

When the paving process is interrupted by the shortage of mix supply or field troubleshooting of any equipment in the paving train, both contractors and project engineers need to monitor the temperature of uncompacted mat closely until the process resumes. Contractors should practice preventive actions to avoid an excessive cooling, 100°F or more below the target laydown temperature, in the area. Project engineers may require contractors to remove the area, if the temperature differential of 100°F or more is detected.

Table 1
Range of temperature differentials and suggested actions by the project engineer

TD (°F)	Actions
0 to 50	• No actions may be required.
50 to 75	• Require contractors to reduce TD below 50 °F. • Require contractors to stop operation if TD is not reduced. • Measure field densities in the affected area. • QA cores may be taken from the area.
Above 75	• Require contractors to reduce TD below 50 °F. • Require contractors to stop operation if TD is not reduced. • Obtain QA cores from the affected area. • Require contractors to remove the affected area if the density fails to meet the requirement.