Laboratory and Field Investigation of Temperature Differential in HMA Mixtures Using an Infrared Camera

Report No. FHWA-SC-06-06

Introduction

Segregation, in general, of hot mix asphalt (HMA) has been one of the most common and costly problems in the highway industry for many years. Several years of research have been spent to determine the causes and effects of segregation in HMA, but the problem still lingers in many pavements.

Segregation can occur for many reasons and at several locations in the construction process. Any time HMA is manipulated, moved or transferred in anyway, the risk of segregation is present. Some of the most common causes of segregation during construction are improper truck loading, improper truck dumping, and poor paver operation. One of the most important concepts concerning segregation that has surfaced in recent years is that of temperature segregation.

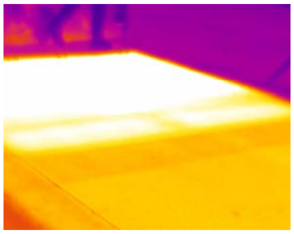
Because of the problems associated with temperature segregation, it was necessary to find a tool that would identify temperature segregation immediately during the construction process, so that the problem could be rectified. One of the tools that have been recognized to be effective in identifying temperature segregation is an infrared camera. By using an infrared camera, pictures of HMA can be taken throughout the construction process, including the HMA at load out, in the truck during transport, in the truck prior to dumping, in the paver hopper, behind the screed prior to compaction, and during compaction. The use of an infrared camera could identify areas of differential temperature during the construction process, and identify which processes work best to avoid or rectify temperature segregation.

This research study was divided into two phases. In the first phase, an extensive literature review was conducted to identify causes and cures of traditional segregation as well as what was known about temperature segregation. Also, at this time, infrared cameras were investigated to determine which type should be used for this particular application. The second phase of the study included an in-depth field study of temperature segregation as well as its causes and potential cures.

By studying temperature variability and segregation, common HMA production and construction practices could be modified so as to avoid or minimize this problem. The South Carolina Department of Transportation (SCDOT) should benefit from this study by using the information gathered to either modify current specifications, if necessary, or develop a manual of best practices to prevent TDD. This could potentially result in major cost savings due to an improvement in the quality of HMA pavements (e.g., more consistent physical characteristics, longer service life, lower maintenance costs, and increased safety to the traveling public).

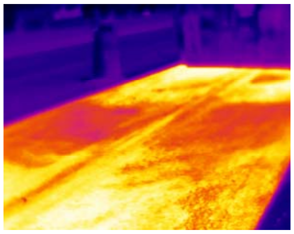
Results

From this field study, five major categories of thermal segregation were consistently reported: cold joints, truck end segregation, wing dumps, cold streaks, and cold spots. For each category, potential causes and cures were identified as well as levels of severity. These were compiled in a field guide to be referenced by contractors and inspectors in the field to aid in the identification of temperature differentials.



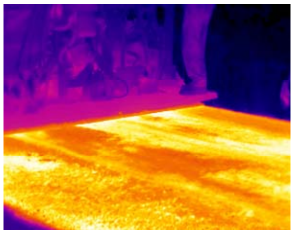
Cold Joint

Cold joints in asphalt pavements form when hot asphalt is placed adjacent to cool asphalt. During asphalt roadway construction, cold joints are the result of delays in the paving operation such as haul truck delays and equipment breakdown, or temperature differentials between truckloads of asphalt, for example. At the location of such cold joints there is a decrease in the bond between the sections of asphalt, which can potentially lead to transverse cracking in the pavement. The occurrence of cold joints can be minimized by ensuring proper equipment function (e.g., asphalt plant, paver, material transfer vehicle, etc.), maintaining a steady pace of asphalt paving, and monitoring the delivery of asphalt by haul trucks to avoid delays.



Truck End Segregation

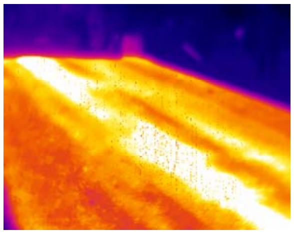
Thermal segregation in asphalt pavements can also occur as the result of temperature differentials at the end of a truckload of asphalt. This is called “end of load” or “truck end” segregation. Truck end segregation can result from the improper loading of the haul truck, too long of a haul time, or lack of proper use of the tarps on the haul truck. The locations where this type of segregation is present typically exhibit a localized decrease in pavement density, which can lead to future distresses such as raveling, rutting, moisture damage, potholes, etc. Truck end segregation can be minimized through proper loading of haul trucks, decreasing the duration between truck loading and unloading into the paver, or employing a material transfer vehicle in the paving operation to remix the asphalt in the truck prior to introduction to the paver.



Paver Wing Dump

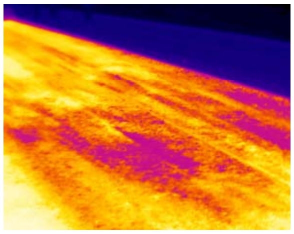
The operation of a paver can also contribute to temperature differentials in an asphalt pavement. Such practices include dumping the wings in the paver hopper after each truckload of asphalt. When asphalt is dumped from the haul truck to the paver hopper, the mix collects in the wings located at the sides of the hopper. The mix that collects in these locations is exposed to ambient temperatures longer than the rest of the load, so if the wings are dumped at the end of the load, this cooler asphalt results in areas of temperature differential in the pavement mat. Such locations are typically localized having lower density than the bulk of the pavement which can lead to future distresses including raveling, rutting, potholes, moisture damage, etc. Thermal segregation resulting from wing dumps can be eliminated by not dumping the paver wings between truckloads or using a MTV with a box in the paver hopper to avoid collecting asphalt in the wings.

Areas of temperature segregation can occur in several shapes. One typical shape is a streak, which can be identified as a long, narrow band of cooler material that runs parallel to the direction of paving. Causes for this type of segregation generally stem from the functioning of the paving equipment, namely the paver screed. The screed is a portion of the paver that is heated and controls the thickness of the pavement mat as the paver extrudes a smooth layer of asphalt. These cold streaks are typically areas of lower density than the rest of the pavement mat, which can lead to future distress in the form of raveling, rutting, moisture damage, potholes, etc. To minimize the occurrence of cold streaks in an asphalt pavement, it is important to ensure that the screed is functioning properly, especially with respect to maintaining a uniform temperature across the entire screed.



Cold Streaks

Another typical shape of temperature segregation is a cold spot, which is localized area of low temperature material. There are several causes for cold spots such as "crust" material from the haul truck being introduced to the paver without being thoroughly remixed with warmer material. Another potential cause is asphalt material caught in the paver (an obstruction) eventually breaking loose and being compacted into the pavement mat. Another typical cause is when asphalt mix that had built up on the paver tracks comes loose and becomes part of the mat. As with other areas of temperature segregation, cold spots are typically lower in density than the rest of the pavement, which can potentially lead to future distresses including raveling, rutting, potholes, moisture damage, etc. Cold spots can typically be minimized by properly using the tarps covering the material in the haul trucks, ensuring proper functioning of the paver (e.g., no obstructions), and maintaining a clean road surface in front of the paver tracks to prevent material build-up on the tracks.



Cold Spots

Conclusions

Based on the results of this limited study, the following conclusions can be made:

- ✓ The thermal camera is an effective tool in identifying temperature segregation in the field during the paving operation. Additionally, the capabilities of the software enable the user to quantitatively determine the severity of such differentials.
- ✓ Based on the information collected during this study, there is no evidence indicating that one particular type of asphalt mix is more susceptible to TDD than another.
- ✓ The thermal camera was not able to accurately detect temperature differentials in open-graded friction course (OGFC) mixtures. This was likely due to either the thin lift thickness, high void content, or clumps of fiber and binder.
- ✓ Based on the asphalt pavers evaluated in this study, there was no discernable difference in the occurrence of temperature segregation between either different paver manufacturers or paver types (i.e., auger-fed or slat-fed).
- ✓ The most identifiable cause of temperature segregation within a pavement appeared to be due to either material segregation at the end of a truck load, or the introduction of cooler material as the result of dumping the paver wings. Because the wings were typically dumped at the end of a truck load, it was difficult to identify which was the primary cause.
- ✓ The proper utilization of a material transfer vehicle (MTV) (e.g., with a hopper box) appears to be the most effective means to minimize temperature differentials in the pavement mat for many mixtures.
- ✓ Based on the projects evaluated, there is no evidence that suggests that the time of day in which paving takes place has an effect on TDD. It is, however, important to mention that the ambient temperature of most of the observed nighttime projects was greater than 70°F. Even though the findings indicate that there is no evidence that TDD increases with nighttime paving, it is believed that this variable does have an effect on the finished asphalt pavement.
- ✓ Haul time appeared to be one of the largest factors contributing to TDD. With haul times greater than 70 minutes, the occurrence of temperature segregation increased. For durations less than 70 minutes, there was no major difference observed.
- ✓ The analysis of the data did not indicate that one contractor was more effective than another in preventing temperature segregation. It was determined that some practices of a paving crew do lend themselves to either causing, or minimizing the occurrence of temperature differentials (e.g., paver speed, haul truck spacing, wing dumping, and MTV utilization methods).
- ✓ There is a correlation with the mat temperature and the ability to achieve pavement compaction. The pavement density in the locations of cold spots was typically less than the areas of the pavement not affected by temperature differentials. Such a reduction in pavement density can lead to future pavement distress such as raveling, rutting, moisture susceptibility, potholes, etc.

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