Washington State Department of Transportation

Materials Laboratory
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technotes

"tech notes" are a product of the State Materials Laboratory to share design and construction technology gained from projects done through WSDOT. This issue is from the Pavements Branch discussing Infrared Camera Detection of Thermal Differentials..

Infrared Camera Detection of Thermal Differentials

One of the nagging problems that has plagued WSDOT for many years is the occurrence of localized "spots" of coarse surface texture in asphalt pavements. These spots show up only on certain projects and occur in a cyclic pattern that seems to coincide with the dumping of each new load of asphalt into the paving machine. The term cyclic segregation and truck fans have been used in the past to describe this phenomenon. The unsightly appearance of these spots is only one of the negative aspects of this phenomenon. The spots are also prone to premature failure due to fatigue, ravelling, and moisture related damage.

Image 1 - Segregated areas in pavement

WSDOT Materials Laboratory, Construction Office, Research Office, and the University of Washington are working jointly on a solution.

In 1997, a research study was initiated to study this problem of cyclic segregation. This study determined that one cause was the occurrence of areas of cooler than desirable asphalt mix that were incorporated into the final mat behind the paver. These cooler areas of mix could not be compacted to the same density as the surrounding hotter mix. The result was areas of pavement that had the classic coarse surface texture, termed thermal or temperature differentials.

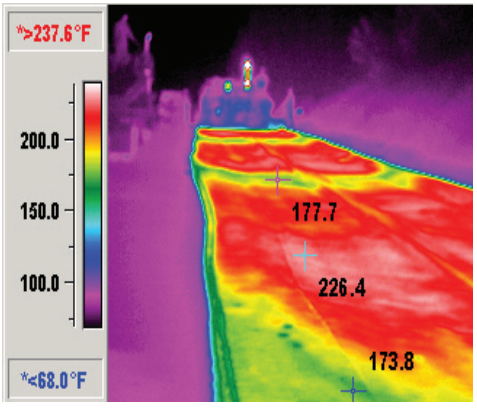

Image 2 - Cyclic segregation (infrared image)

The other common cause is true aggregate segregation of the asphalt mix that is frequently associated with large stone asphalt mixes (such as WSDOT Class E).

During the 1998 construction season, WSDOT, along with Astec Industries, visited four of WSDOT's paving projects. Astec Industries provided an infrared camera to view the paving operation and the WSDOT personnel took mix samples from the cooler and surrounding warmer areas of the mat to check for aggregate segregation. They observed from these four projects:

- All four projects experienced significant temperature differentials.
- No significant aggregate segregation was observed for the four projects sampled.
- Concentrated areas of significantly cooler HMA generally resulted in inadequate compaction of these areas (an average increase in air voids of about 3 to 4%).
- Concentrated areas of cooler HMA commonly occur during construction (based on this study and others).
- Good rolling practices can partially offset temperature differential related compaction problems.
- Temperature differentials are easily identified by infrared imaging.

Image 3 - Dumping asphalt mix into the paver

In February of 1999, the WSDOT Materials Laboratory purchased an infrared camera to observe as many paving projects as possible. The objective of the 1999 study was to:

- Investigate the effectiveness of different MTV (material transfer vehicle)/MTD's (material transfer device) and remixing devices/ methods.
- Investigate other possible mitigation techniques (aggressive rolling, tarps, insulated trucks, etc.).
- Reexamine the criteria for when and where to use MTV's.

(The difference between the material transfer vehicle and device is that the vehicle is self-propelled and the device is pushed along by the paver.)

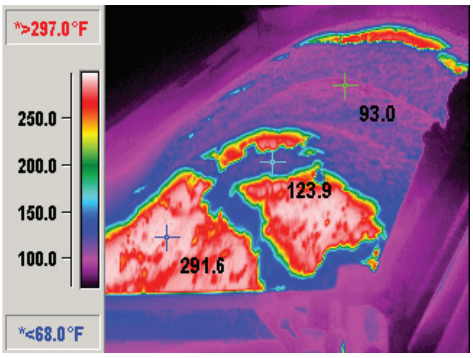

Image 4 - Infrared image of truck dumping mix

During the 1999 paving season, a total of 35 projects were visited. Collected data included mat temperatures using the infrared camera, a handheld infrared thermometer, and temperature probes; mat densities associated with the cooler and warmer portions of the mat; and construction equipment (MTV/MTD, paver, roller, trucks) used. From this data, it was determined that a temperature differential of 25°F was a breakpoint between achieving fairly uniform densities and non-uniform densities. The following table lists the use of MTV/MTD by number of projects.

Equipment	**# Projects**
Blaw-Knox MC-30	7
Roadtec Shuttle Buggy	5
Cedarapids MS-2	8
Cedarapids MS-3	3
Barber Greene MTV 650	2
Lincoln 660 H	1
Ko-Cal	2
No MTV/MTD	7

Some of the findings from this study include:

- Large temperature differentials were observed under a variety of paving conditions including pavement surface temperatures.
- The higher the temperature differentials, generally the higher the as-compacted air voids associated with the cooler portions of the mat.
- Temperature differentials generally decreased when ambient air temperatures were ≥ 85°F (limited data).
- Mat temperature differentials decreased when remixing occurred.
- Mat temperature differentials decreased when thick, tight tarps (tied down on sides and back of truck) were used (limited data).
- As-compacted air voids increased with longer haul times.
- As-compacted air voids increased when no transfer device was used.
- As-compacted air voids increased when the temperature differentials were above 25°F (generally saw a 2% increase).
- As-compacted air voids decreased with higher mat temperatures (>265°F).

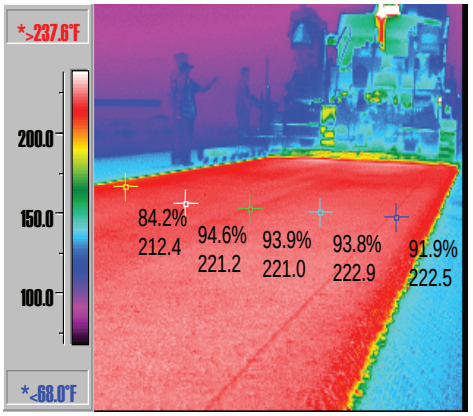

Image 5 - Mat with uniform temperatures and densities

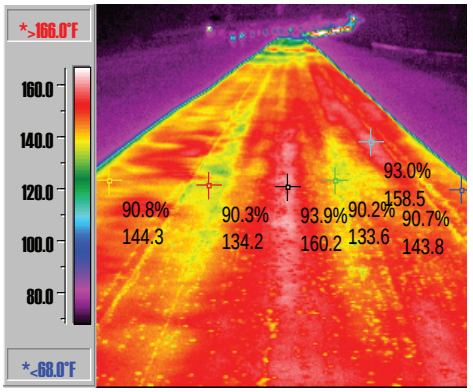

Image 6 - Mat with non-uniform temperatures and densities

Images 5 and 6 show the mat temperatures and the associated densities. The uniform mat has temperatures that are within 10°F transversely and the densities are fairly uniform (excluding the edges). The non-uniform mat has lower densities associated with the cooler portions of the mat. In both of these images, the densities at the edges of the mat are lower than what would be expected for the corresponding temperatures.

In summary, the 1999 data showed that:

- Long hauls can effect the degree to which the temperature differentials occur on the mat, but can be offset by remixing.
- End dumping directly into the paver produced the largest temperature differentials (up to 80°F).
- There are definite benefits to using a material transfer device/vehicle (even on low volume roads) because of the remixing capabilities and continuous paving operations.
- The contractor can correct for some surface defects that occur on a freshly laid mat with adjustments to the paving machine.

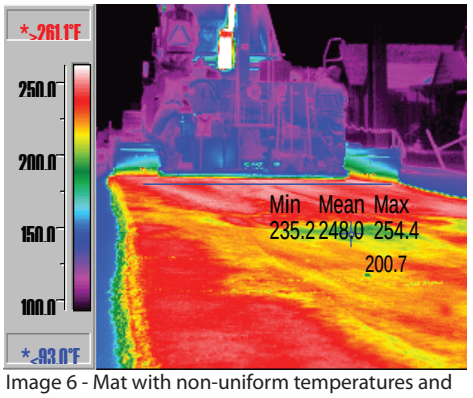

Image 6 - Mat with non-uniform temperatures and densities

Image 7 is from a truck that has a tight, thick tarp that was tied down on the sides and back of the truck. The mix right behind the paver is from this truck and the mix at 200°F is from

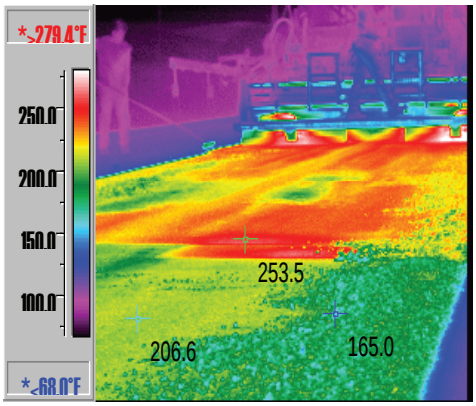

Image 8 - Mat from a start and stop operation

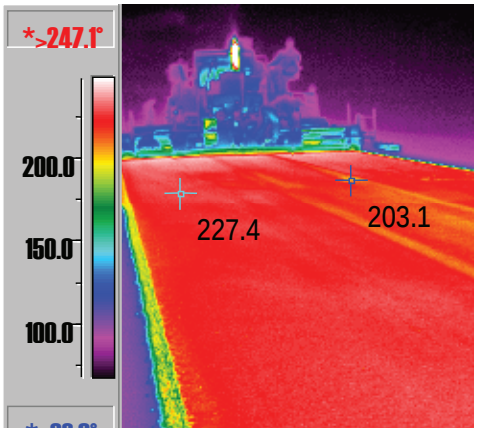

Image 9 - Streaks caused by the paver

the previous truck that had no tarp. This job had temperature differentials of over 50°F, but decreased the temperature differential to only 20°F by tight tarping.

Image 8 is from a discontinuous paving operation. Due to the delay in mix delivery, the mat temperature cools towards the cessation temperature (175°F), below which significant compaction can not be achieved.

The operation of the paving machine can cause the streaks seen in image 9. These streaks are typically visible to the naked eye and appear as an open or coarse surface texture. By making adjustments to the paving machine, these streaks can diminish or disappear completely. Some of these corrections include adjusting the flow gates to control the amount of mix to the auger, changing the height of the pre-strike off edge, or altering the height of the auger itself.

These streaks could be associated with the longitudinal cracking seen on some of WSDOT's roadways towards the center of the traveled lane. Eliminating these streaks during construction can reduce the possibility of longitudinal cracks and increase the life of the pavement.

Team members for the 1999 study include Linda Pierce, Jeff Uhlmeyer, and Kim Willoughby from the WSDOT Materials Laboratory, Keith Anderson from the WSDOT Research Office and Professor Joe Mahoney and graduate student Travis Thompson from the University of Washington.

The final report covering the 1999 study will be available after April 30, 2000.

During the 2000 construction season, there will be research conducted in California, Minnesota, Texas, and Washington to further investigate the causes and effects of temperature differentials. A test procedure to determine the amount of temperature segregation and the related effects of the cooler temperatures will also be evaluated.

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