RUTGERS Asphalt Paving Conference
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PAVE IR UPDATE

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New QC/QA Technology for Asphalt Contractors/DOTs

Thermal Segregation (unseen enemy)
Topics

The Problem

Time line: A ten year journey on identifying the problem and how to fix it

- 1995-1996
- 1998
- 1999
- 2000
- 2001-2006

Washington DOT study

64 Projects
The Problem

- Localized “spots” of coarse surface texture
- Premature failure due to fatigue cracking, raveling, and moisture damage
- Increased roughness
The Problem

- Cooling of mix during transport is not remixed during the laydown process.
- Paver Set-up
- Results in erratic mat temperatures that are not apparent to the laydown crew.
Data Collected

- Haul distance and time
- Weather conditions
- Equipment
  - Type of truck
  - MTV/MTD
  - Paver
  - Roller
- Nuclear density data

- Temperature data
  - Infrared camera
  - Probes
  - Hand held infrared thermometer
- Plant information
  - Temperature of mix
  - Loading operations
- Mat Placement
1998 Conclusions

None of the 4 projects experienced significant aggregate segregation.

All 4 projects experienced significant temperature differentials.

Concentrated areas of significantly cooler HMA generally resulted in lower than desirable compaction of those areas.
1998 Conclusions (cont.)

- 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.
- MTVs not specifically examined.
- Temperature differentials are easily identified by infrared imaging.
End Dump/No MTV

* > 252.7°F

* < 68.0°F

94.2%  89.0%  94.5%  90.0%
223.7  186.7  218.6  195.5
85.4%  196.9
1999 Study Objectives

- Investigate the effectiveness of different MTVs and remixing devices/methods
- Investigate other possible mitigation techniques
- Reexamine criteria for when and where to use MTV’s
- 64 Projects Studies
End Dump/ MTV

* > 252.7°F

* < 68.0°F

91.8% 237.6
93.8% 237.0
92.4% 234.8
91.8% 231.3
91.8% 227.6
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
Effects on Pavement

- Same as insufficient compaction
  - Increased raveling and moisture damage
  - Reduced fatigue life
  - Increased roughness

- One percent increase in air voids results in a minimum of 10% reduction in pavement life (a rule of thumb)

- 25°F Differential=1 to 2% more air voids
3/8" HMA APA Fatigue Results

Compaction Temperature (°F)

APA Cycles to Failure

Air Voids 6.8

9.3
8.4
8.4
7.8
7.3
6.8

Courtesy of PTI and Ron Collins
A number of State DOTs have developed and implemented specifications to address this issue.

**WSDOT’s current specification**
- Cyclic density areas are defined as less than 89.0 percent of maximum density.
- If *four or more* low cyclic density areas are identified in a lot, a price adjustment will be assessed for that lot (a lot is 400 tons).
- The price adjustment will be calculated as 15% of the unit bid price of HMA represented by that lot.
- This assessment starts with examining the mat for temperature differences of 25°F or greater. If these do not exist, then no further special density testing is performed.
50% Increase in HMA Pavement Life
Washington State

US Highway 12 (MP 102 – 118)

Approximately 32 lane miles

Thermal segregation resulted in failure five years prior to anticipated 20 year life

**ESTIMATED EXTRA COST: $2.4 MILLION**
Calculations:

• If this trend continues, over a 60 year period, an entire additional overlay will be needed.

• Mill and Overlay of 1.8” on average cost of about $200,000 per lane mile.

• For this stretch of highway, thermal segregation risks a cost increase of:
  
  • $2.4 million in present dollars
  
  - or -
  
  • $24.9 million in year 60 dollars.
NCAT (2000) and TTI (2002) similarly found thermal uniformity suitable for detecting segregation

- **NCAT** – low severity segregation/density when \( \Delta t > 18 \) °F
- **TTI** – when \( \Delta t > 25 \) °F, TxDOT density uniformity requirements not met

\[
y = 0.2415x
\]

\[
R^2 = 0.9027
\]

Spec max density differential = 6 pcf

6 pcf density differential at ~ 25 F temp differential
TxDOT funded research conducted by Texas Transportation Institute (TTI) to study the relationship between thermal segregation and density, in addition to developing a method for practical data collection.

Initial research included the use of a thermal camera operated by a researcher in the back of a pickup truck. In addition to obvious safety considerations, this initial method was found not to be practical. A series of infrared images had to be manually combined to produce a complete profile. Distance and position data were also difficult to incorporate.
First generation Pave-IR system was first used in October 2003.

- Propelled manually
- Long setup time
- Loose connection wires
- Unstable wheel design
- Battery powered
- Required two operators
Third generation Pave-IR system was first used in January 2005.

**IMPROVEMENTS**
- Paver mounted
- Rapid setup time
- Central master control
- No dedicated operator

**CHALLENGES**
- Battery powered
- Distance measuring wheel
- Components not suitable for everyday use on heavy equipment.
• In 2005 TTI published research reports outlining the relationship between thermal segregation and density. These reports also outline the methods used for thermal data collection supporting Pave-IR as the preferred tool for thermal data collection.

Reports available online at:
http://tti.tamu.edu/documents/5-4577-01-1.pdf

• Following the completion of this research, TTI & TxDOT were interested in finding a commercial partner for development and production of Pave-IR systems for future implementation into TxDOT specifications.
MOBA PAVE-IR SYSTEM COMPONENTS

- 12 – Infrared sensors (standard)
- Absolute encoder used for distance measurement
- MOBA OPERAND™ computer
- GPS antenna
- Includes PAVE PROJECT MANAGER™ software for post analysis and reports
- Kit includes system cabling and all necessary screed mounting hardware.
WHAT IS PAVE-IR?

• Paver mounted system used to identify thermal segregation in newly placed asphalt surfaces.

• Uses a series of infrared, GPS, and distance measuring sensors.

• Sensors are networked together and connected to a mobile computer with color display.

• Computer processes and displays data from all sensors.

• Areas where thermal segregation is present are displayed in real-time.

• Data stored on flash drive for post processing on PC
The MOBA Operand™ computer attaches to sensor beam.

GPS antenna mounts above the Operand™ computer.

Memory drive connects directly to Operand™ computer

System is powered by machine voltage (10-28 VDC).

Sensor beam is hinged in center for easy setup and storage.
The PAVE-IR™ system mounts to the screed walkway by bolting or welding.

The distance encoder mounts to the wheel or torque hub using a magnet.
BENEFITS OF PAVE-IR

- Provides full coverage of entire paved surface.
- Ensures compliance with most existing DOT temperature specification requirements.
- Data is logged automatically and can be stored permanently.
- More cost effective versus infrared cameras.
- System also records paving speed and paver stops.
- System can be moved from one machine to another.
- System is scaleable from 2-8 meters depending on paving width.
• Next Generation PAVE-IR(I)
  • Real-time (pre-compacted) IRI smoothness measurement.
  • Network (wireless) to onboard compaction systems.
  • Wireless transmission of job data to QC office or plant.
  • Grade and slope control monitoring.
  • Material control (auger/conveyor) system monitoring.
  • Infrared scanner mounted above paver deck.
CREATE NEW PROJECT SCREEN

Operator: AUSTIN BRIDGE
Roadway ID: SH-114
Start location: WALNUT HILL LN
Comment: PAVE-IR DEMO
DATA COLLECTION SCREEN

- Sensor Bar Online State
- Odometer Online State
- GPS Quality
- Stop Data Acquisition (Return to project... dialog)
- Activate Full Screen View
- Change Color Scale
- Current Time

Collected Data coded with actual Color Scale

Actual Color Scale

Not available

Current GPS Position

Driven Distance

Current Speed

51.0472°N 013.7151°E 109.76 ft 0.00 ft/min 09:56
FULL SCREEN MODE
### Thermal Profile Results Summary

<table>
<thead>
<tr>
<th>Number of Profiles</th>
<th>Moderate [25°F;50°F]</th>
<th>Severe &gt;50°F</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
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<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>17</td>
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</table>

### Recent Test Result

<table>
<thead>
<tr>
<th>Beginning Location</th>
<th>Ending Location</th>
<th>Temp Differential</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150</td>
<td>20.3</td>
<td></td>
</tr>
</tbody>
</table>

[Image of thermal analysis screen]
After data collection, the project file is transferred to PC via USB cable.

PPM allows contractor to evaluate the project in detail.

PPM displays thermal data, stations, paving speed, paver stops, and GPS location for any position in the project.

QC/QA reports are generated by PPM.
PROJECT PROPERTIES WINDOW (Meta Information)
TIME DIAGRAM DISPLAYS PAVER STOPS
PAVE PROJECT MANAGER (PPM)

SPEED DIAGRAM DISPLAYS PAVING SPEED
TEMPERATURE DIAGRAM DISPLAYS TEMPERATURE GRAPH
Reports specific to various DOT specifications can be generated in PPM.

This report is based on TxDOT thermal specification Tex-244-F.

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**Tex-244-F Part II**

**Thermal Profile Summary Report**

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<tr>
<th>Profile ID:</th>
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<th>Profile Date:</th>
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<td>Status:</td>
<td>Controlling</td>
<td>CSJ:</td>
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<tr>
<td>County:</td>
<td>Dallas</td>
<td>Spec Year:</td>
<td>2009</td>
</tr>
<tr>
<td>Tested By:</td>
<td>J. Lano (MOBA)</td>
<td>Spec Item:</td>
<td></td>
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<tr>
<td>Test Location:</td>
<td>WALNUT HILL LN</td>
<td>Special Provision:</td>
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<td>Material Code:</td>
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<td>Producer:</td>
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<tr>
<td>Area Engineer:</td>
<td>Project Manager:</td>
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<td></td>
</tr>
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</table>

| Course/Lift: | 2 | Temperature Differential Threshold: | 25.0 |
| Segment Length (ft): | 150 | Sensors Ignored: | - |

**Thermal Profile Results Summary**

<table>
<thead>
<tr>
<th>Number of Profiles</th>
<th>Moderate 25.0°F &lt; differential &lt;= 50.0°F</th>
<th>Severe differential &gt; 50.0°F</th>
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<tr>
<td>55</td>
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<td>Percent</td>
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</table>
### Summary of Locations with Thermal Segregation

<table>
<thead>
<tr>
<th>Profile Nr</th>
<th>Beginning Location</th>
<th>Ending Location</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Temperature Differential</th>
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<tr>
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<td>Distance (ft)</td>
<td>GPS in °</td>
<td>Distance (ft)</td>
<td>GPS in °</td>
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### Summary of Locations Without Thermal Segregation

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<tr>
<th>Profile Nr</th>
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<th>Max Temp</th>
<th>Min Temp</th>
<th>Temperature Differential</th>
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<tr>
<td></td>
<td>Distance (ft)</td>
<td>GPS in °</td>
<td>Distance (ft)</td>
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</tr>
</tbody>
</table>
Specified in Texas, Ohio, Louisiana, Minnesota, Washington
SHRP 2 Study completed (Recommend Implementation)
SHRP 2 Research extension of 18 month to help states implement
EveryDayCounts/IC
NCAT Alabama Study
AASHTO Spec Draft
Thank You!

Questions?

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