Detection of Thermal Segregation During Paving by Using Infrared Thermography

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Segregation in asphalt pavements is one of the most common and costly problems in the paving industry. This paper deals with the thermal segregation of hot mix asphalt (HMA) pavement. HMA is produced and placed at high temperatures (e.g. 155 – 163°C and 140 – 155°C, respectively.) Cold spots in the asphalt layer can cause temperature differential damage (TDD) and reduce the pavement life. If temperature is not consistent the pavement will eventually show signs of distress in the locations of the cold spots, figure 1.

Figure 1: Pavement raveling and alligator (fatigue) cracking of pavement

The objective of this study was to utilize an infrared camera to identify thermal segregation in asphalt pavements during construction and possible causes of the temperature differentials which affect compaction and lead to premature distress of the pavement. Temperature data was obtained using an infrared camera (thermal sensitivity 60 mK, geometric resolution 640x480 pixels, FOV 24°) at the paving site.

Construction-related temperature differentials are large material temperature differences resulting from placement of a significantly cooler portion of HMA mass into the new pavement. This cooler mass comes typically from the surface layer (or crust) developed during HMA transport from the mixing plant to the job site, figure 2.

When placed, these cooler areas will cool down to cessation temperature (commonly taken as 80°C) more quickly than the surrounding material. Generally, temperature differentials greater than about 15°C can potentially cause compaction problems (Willoughby et al., 2001). Developed roller patterns may not be adequate to compact these cooler areas before they cool to cessation temperature due to reduced viscosity of bitumen thus resulting in isolated spots of inadequate compaction, figure 3.

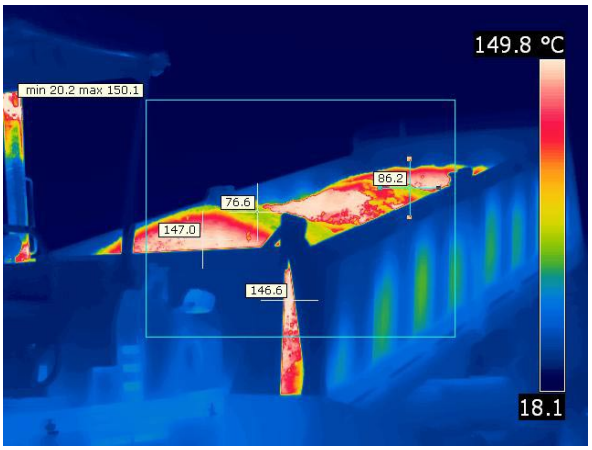

Figure 2: Thermogram shows placement of cooler HMA, which creates pavement temperatures near cessation temperature

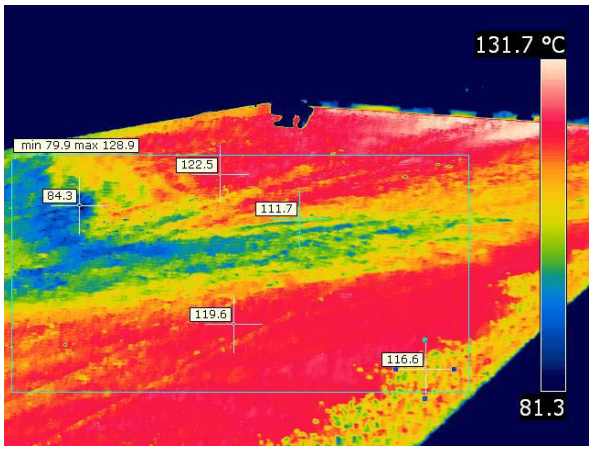

Figure 3: Thermogram showing V-shaped thermal segregation

One of the most important factors that affect the durability of hot mix asphalt concrete is the density achieved at the time of construction. If compacted HMA has air-void content less than 3% pavement will be susceptible to permanent deformations. Air void content higher than 6% reduces pavement fatigue life as well as durability and increases its susceptibility to moisture damage, figures 4, 5.

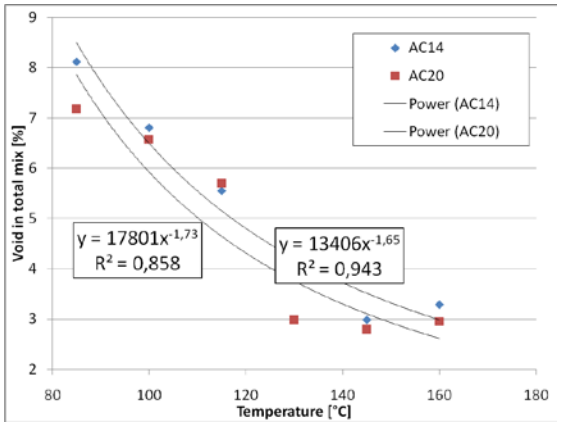

Figure 4: Temperature vs Density for asphalt concrete mixtures AC14 and AC20 [Silas, 2005]

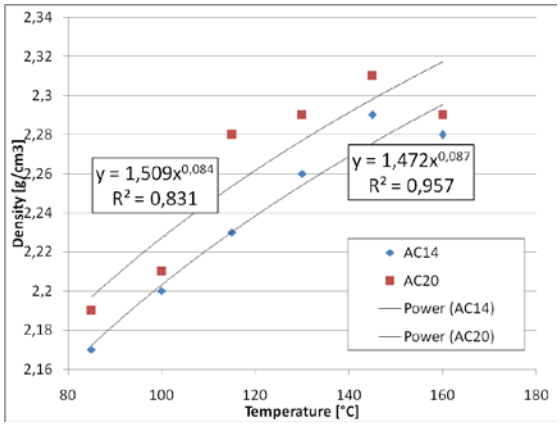

Figure 5: Temperature vs Void in total mix (VTM) for asphalt concrete mixtures AC14 and AC20 [Silas, 2005]

As shown in figures 2 and 3, the infrared camera was able to clearly discern cool areas in uncompacted and compacted layer, as well as to determine the temperatures of loose mix in trucks and pavers. The results of the investigation were compared to the literature data of the in-place density testing that was performed on finished pavement in areas identified as “normal” and “cool”, and tested for density differentials. The relatively cooler areas were found to have lower densities than the hotter areas, with an overall air void range of 3.0 to 8.0 % thus being submissive to TDD.

REFERENCES:

Phillips, Leonard; Willoughby, Kim; Mahoney, Joe: Infrared Thermography Revolutionizes Hot-Mix Asphalt Paving; Inframation 2003 Proceedings ITC, ITC 092 A 2003-08-15

Silas Tirau, Larry AK: "Evaluation of Hot Mix Asphalt Properties Compacted at Various Temperatures", Faculty of Civil Engineering, Universiti Teknologi Malaysia, 2005

A.: Construction-Related Asphalt Concrete Pavement Temperature Differentials And The Corresponding Density Differentials; Research Report, Research Project Agreement T9903, Task A3, Cyclic Segregation