SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Thermal Profiling to Increase Pavement Life

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U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

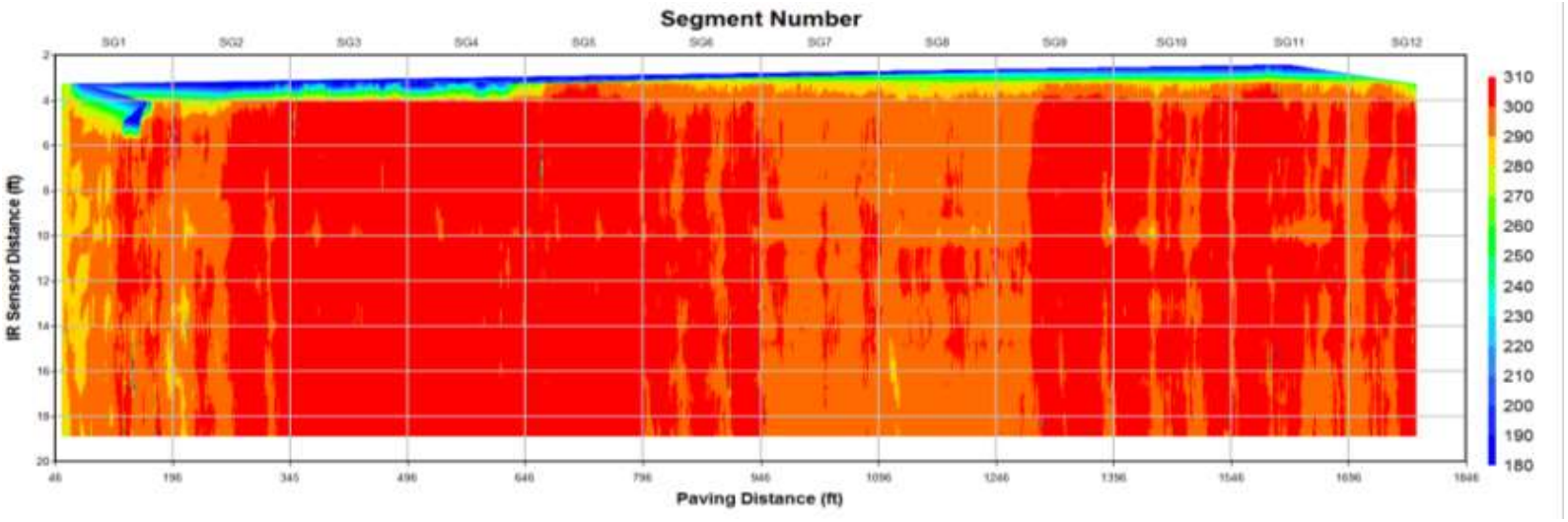
Thermal Profiling to Increase Pavement Life

1. IR Defined.
2. Why is it important?
3. How is it measured?
4. Data Analysis
5. Data Summary

IR Defined

Infrared Thermography:

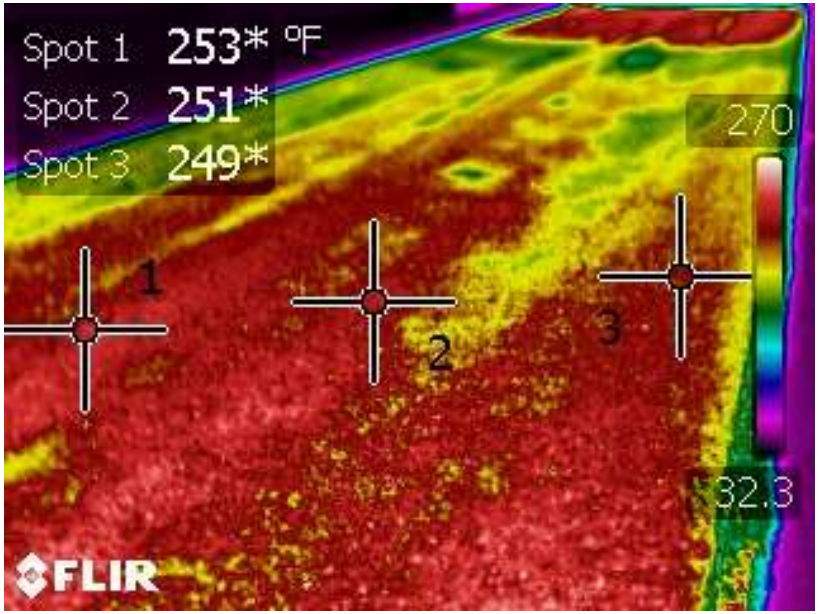
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.

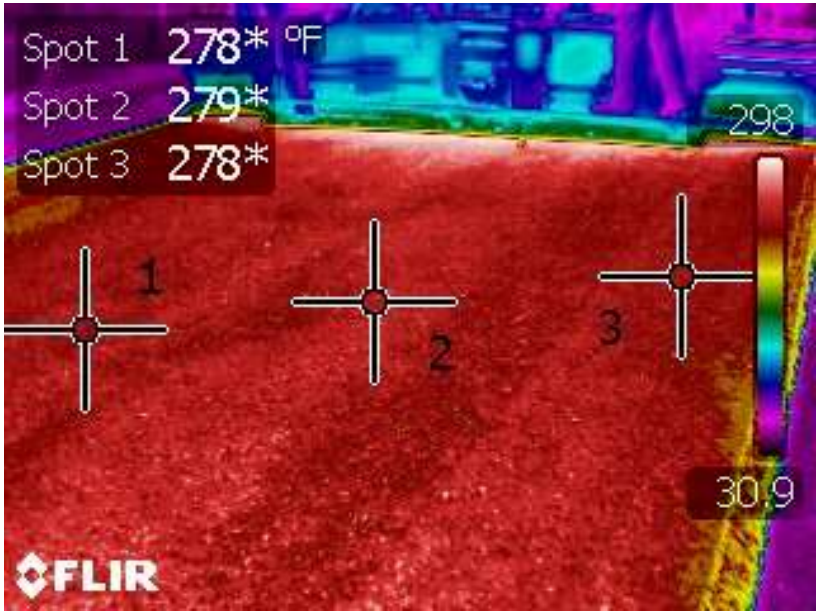


IR – Defined

Temperature segregation:

- More than 25 ºF difference in mat temperature behind screed.

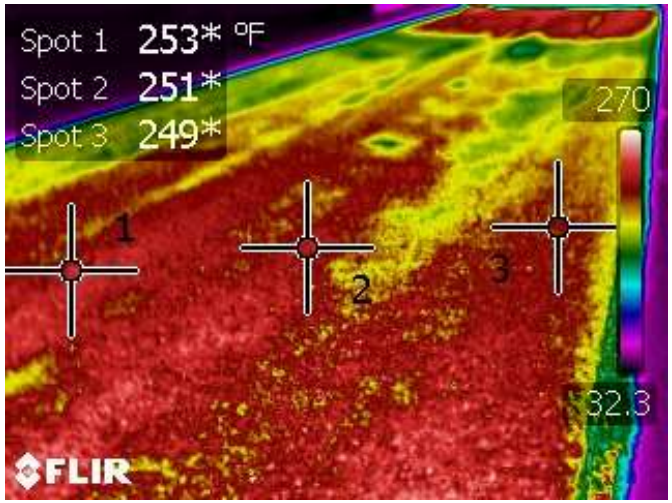


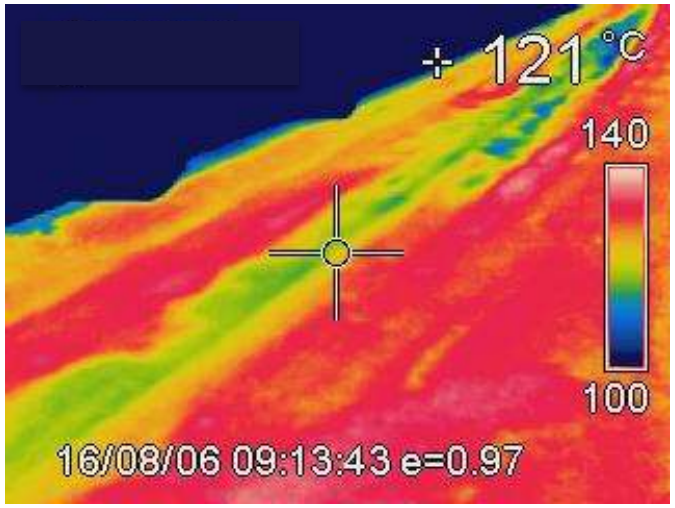


IR – Defined

Types of Temperature Differences:

1. Cold spots
   - Truck to truck temperature differences
   - Improper loading and unloading of trucks
2. Thermal streaks
   - Longitudinal segregation
   - Inadequate or non-uniform amount of material across the mat

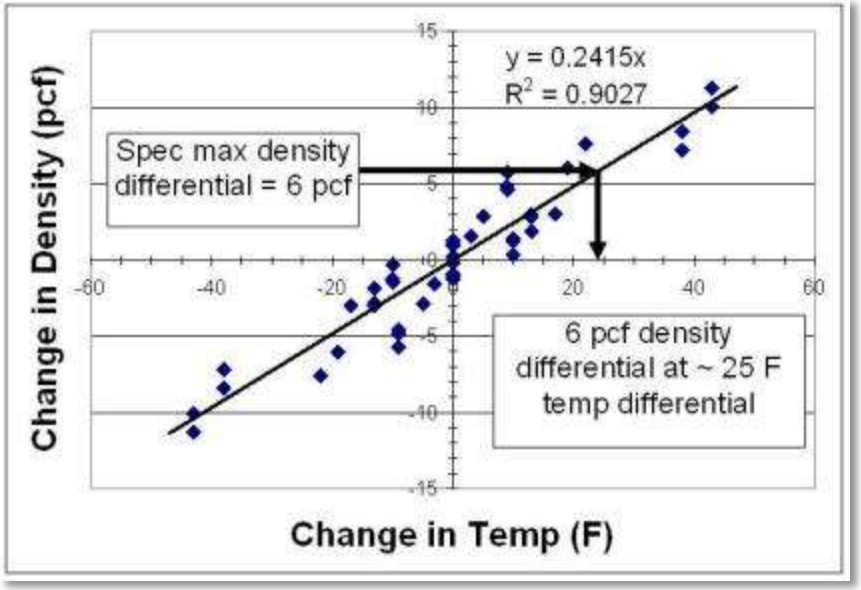




IR – Defined

Background

- 1996 through 2000s – field work concluded temperature differences could be accurately detected and quantified:
  - Low temperatures result in low density zones in mat
  - A few States adopt temperature uniformity specification



Temperature profile criteria based on desired density uniformity.

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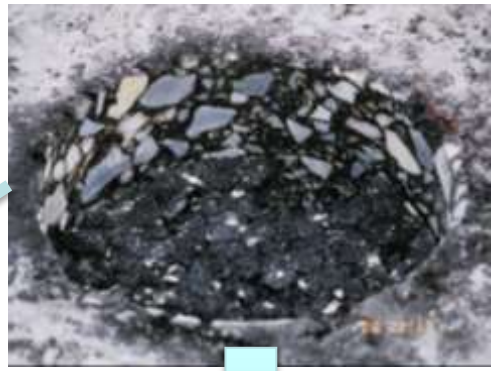
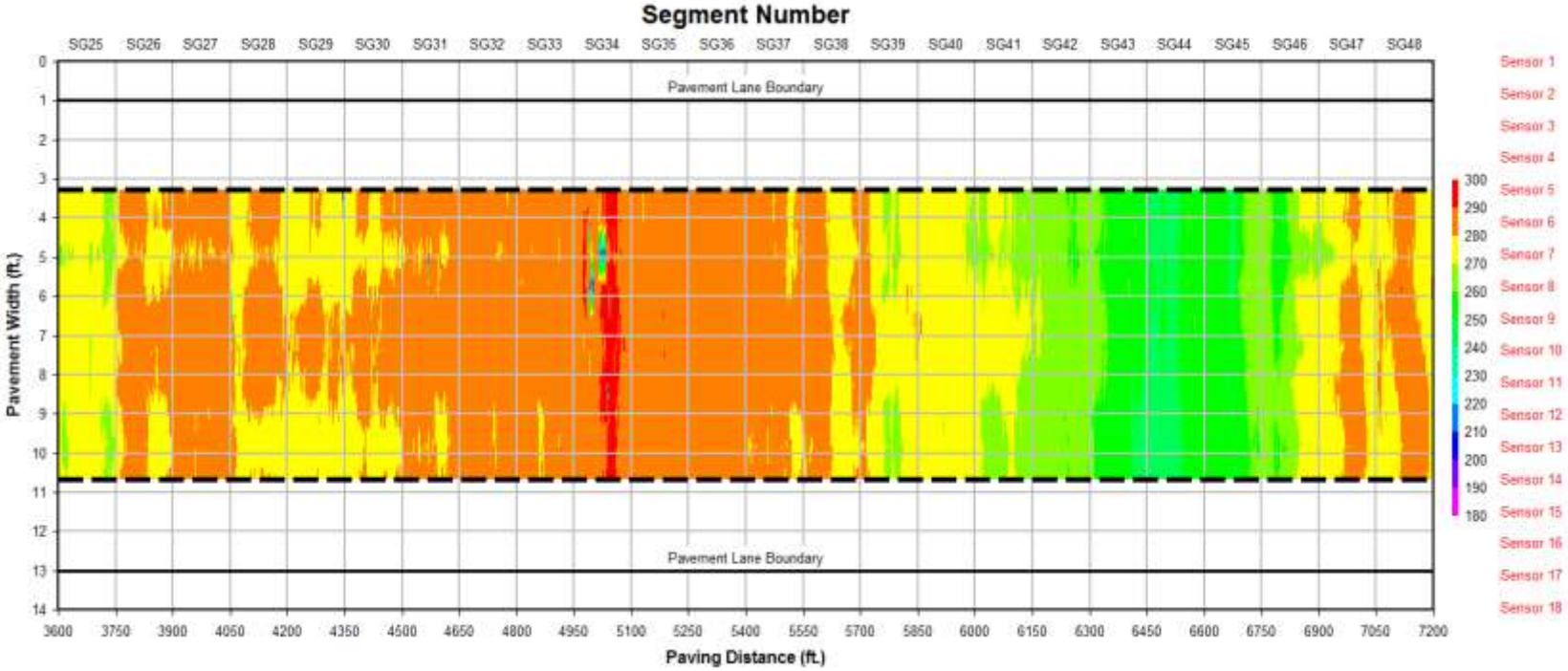
IR – Why use it?

Segregation – A difficult issue to resolve, when it is difficult to identify or confirm.



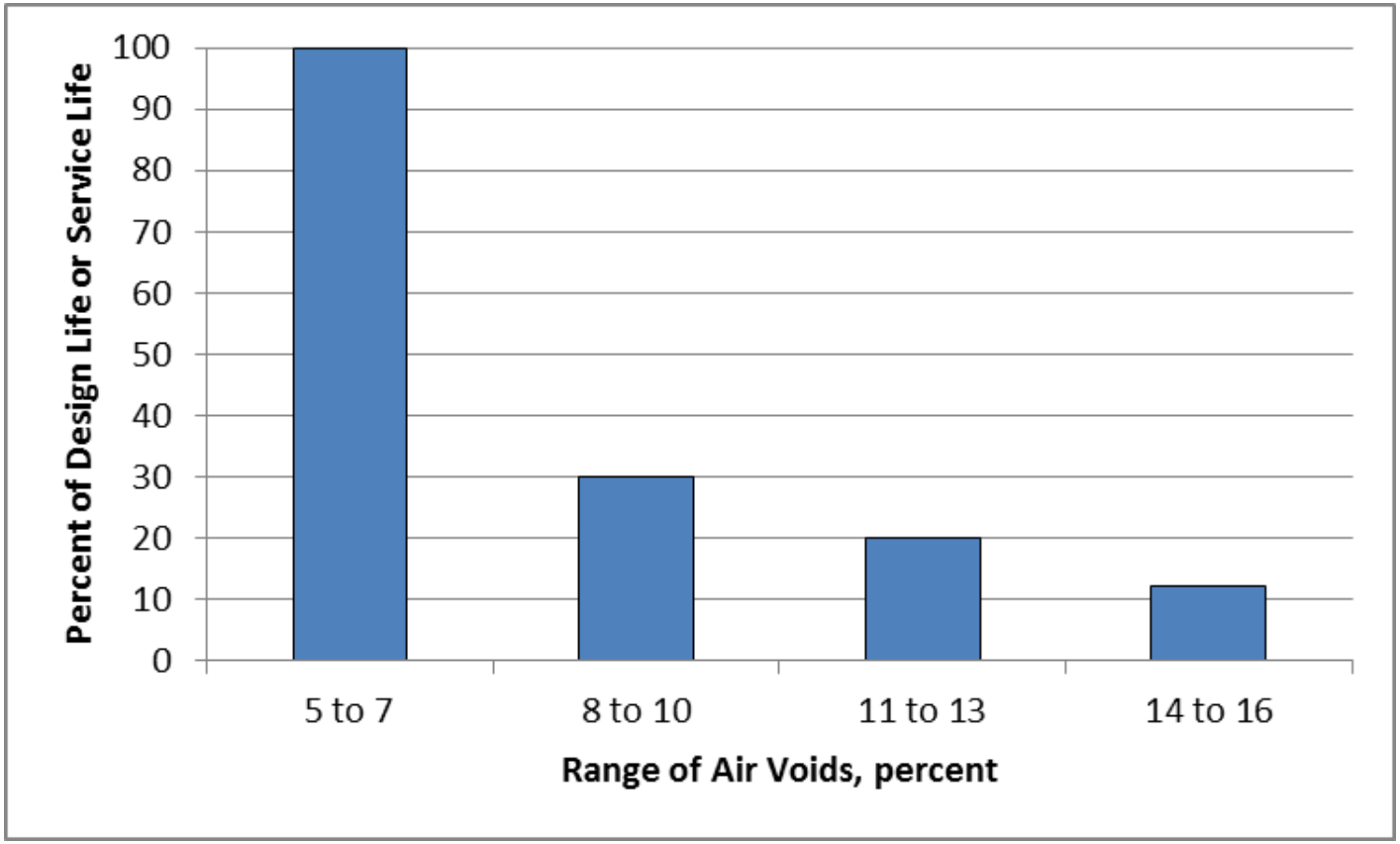
IR – Why use it?

- Aggregate segregation in mat = temperature segregation
- Non-uniform temperatures usually result in non-uniform densities



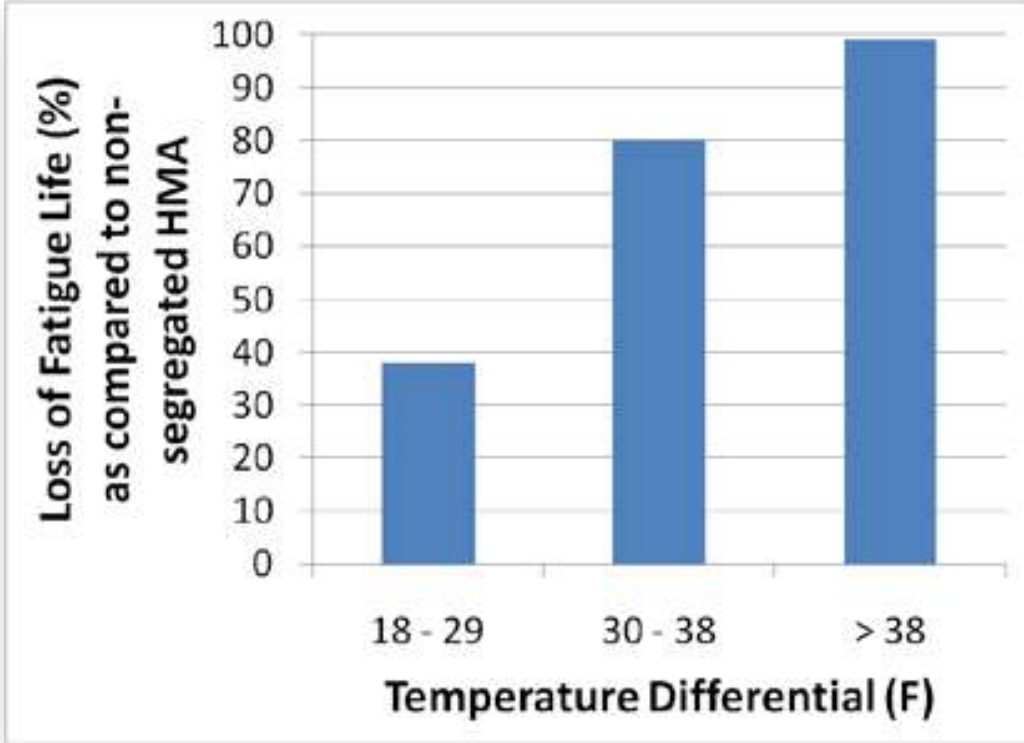
IR – Why use it?

- Effect of cold spots, low mat temperatures on percent compaction; densities are lower:



IR – Why use it?

- Fatigue life can be substantially reduced, as a result of lower densities because of lower mat temperatures.



Source: NCAT (2000)

IR – Why use it?

Impact of temperature differences or areas with low temperatures.

IR – Why use it?

Cold spots; areas with increased potential for:

- Fatigue cracks
- Raveling
- Pot holes

IR – Why use it?

Thermal streaks; longitudinal areas with increased potential for:

- Longitudinal cracking

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IR – Measurements

Mat Temperature Measurements

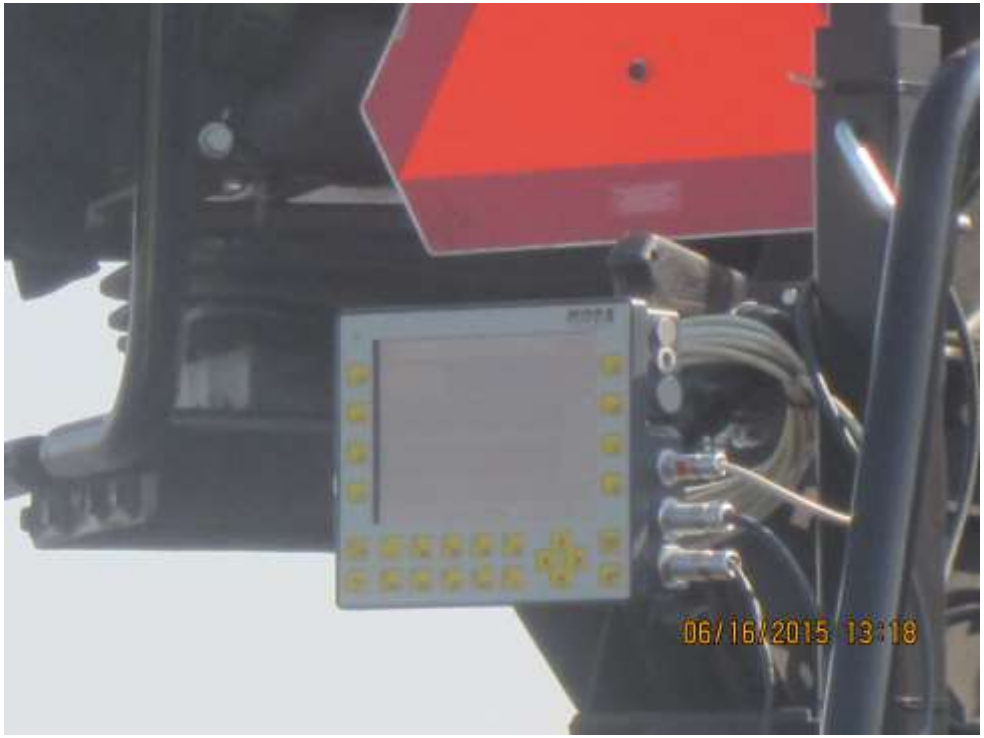
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings

IR – Measurements

- IR Scanner attached to paver and scans mat behind screed in one direction.
- GPS attached to the scanner arm.

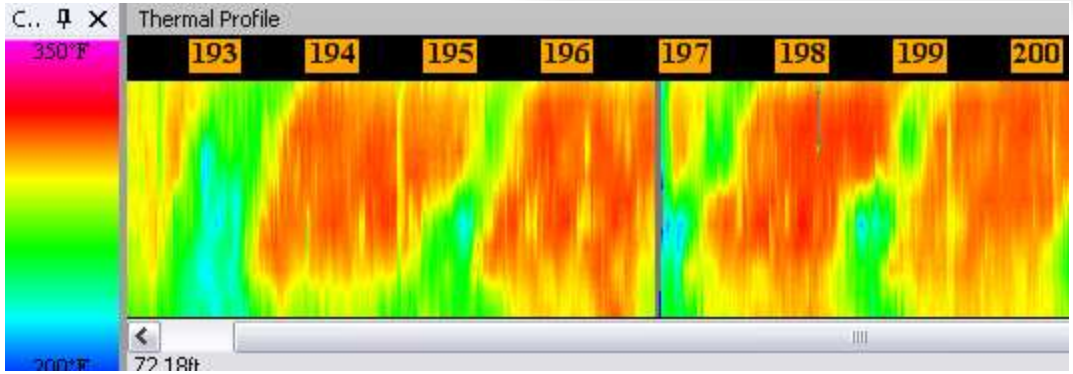
IR – Measurements

IR scan screen to monitor mat temperatures on real time basis; attached to the scanner post.



IR – Measurements

- Continuous readings to evaluate mat uniformity through temperature uniformity.
- Non-uniform temperatures usually mean, non-uniform densities.



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Data Analyses

Specification Guide; AASHTO PP 80-14

Standard Practice for

Continuous Thermal Profile of Asphalt Mixture Construction

AASHTO Designation: PP 80-14[1]

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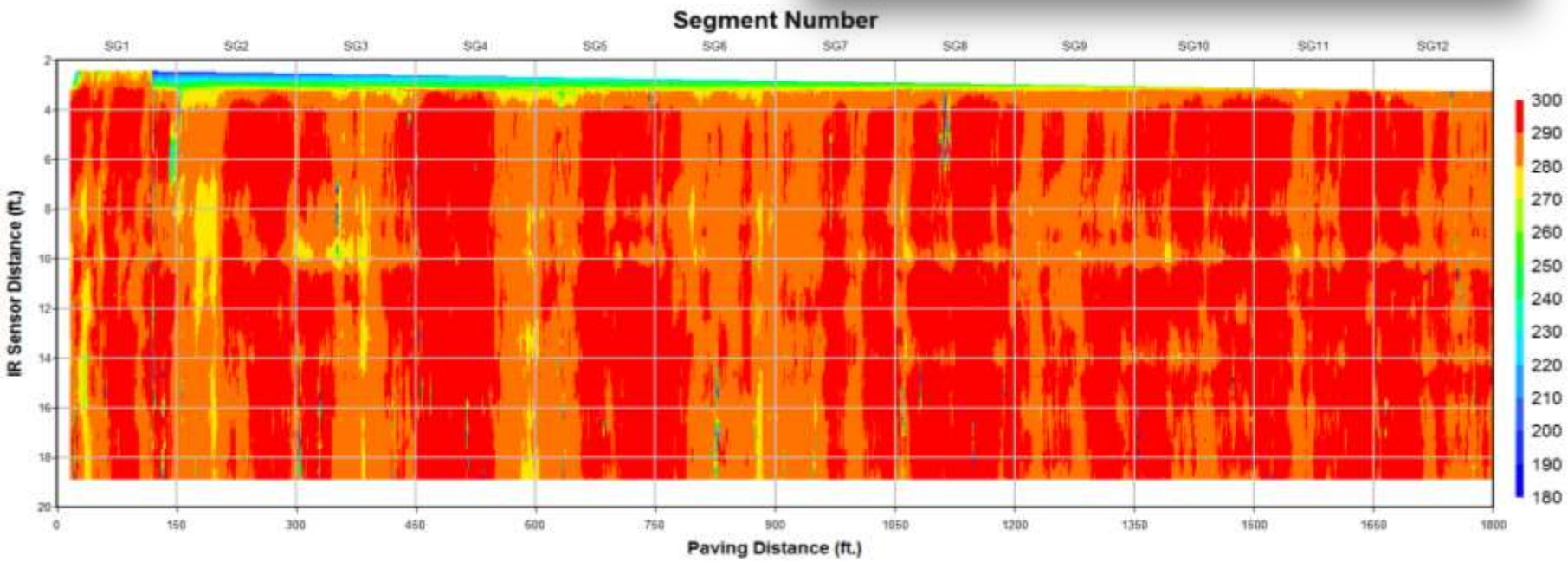
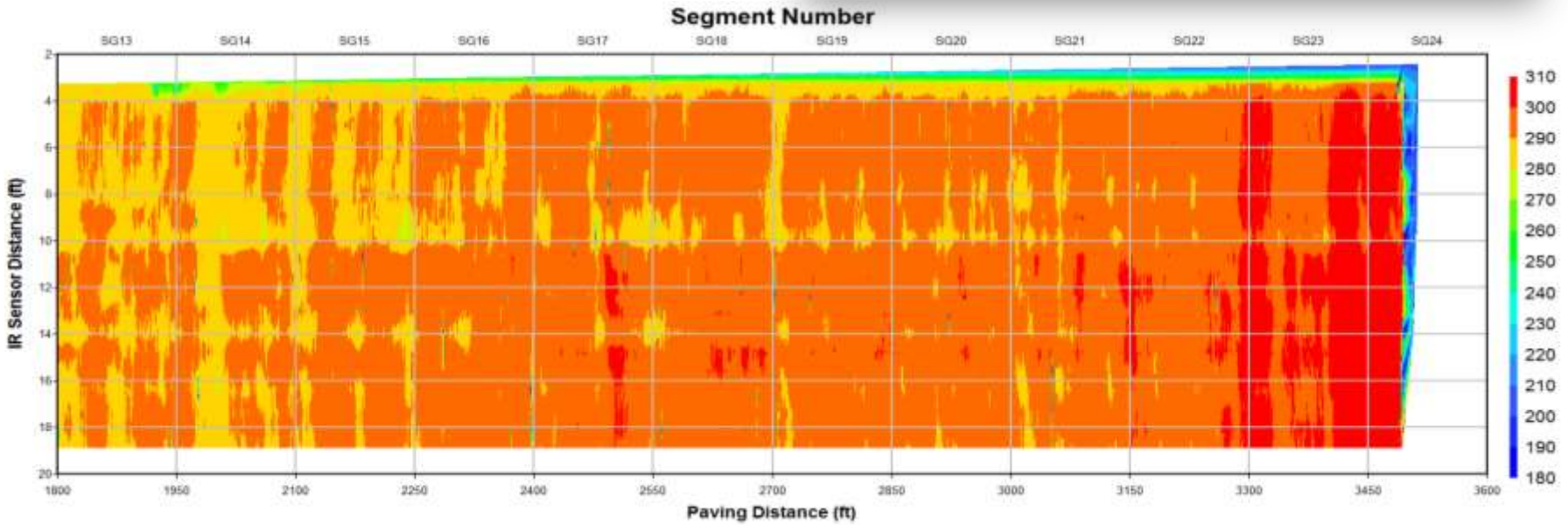
Data Analyses

Raw Temperature Profile for first part of the first path.

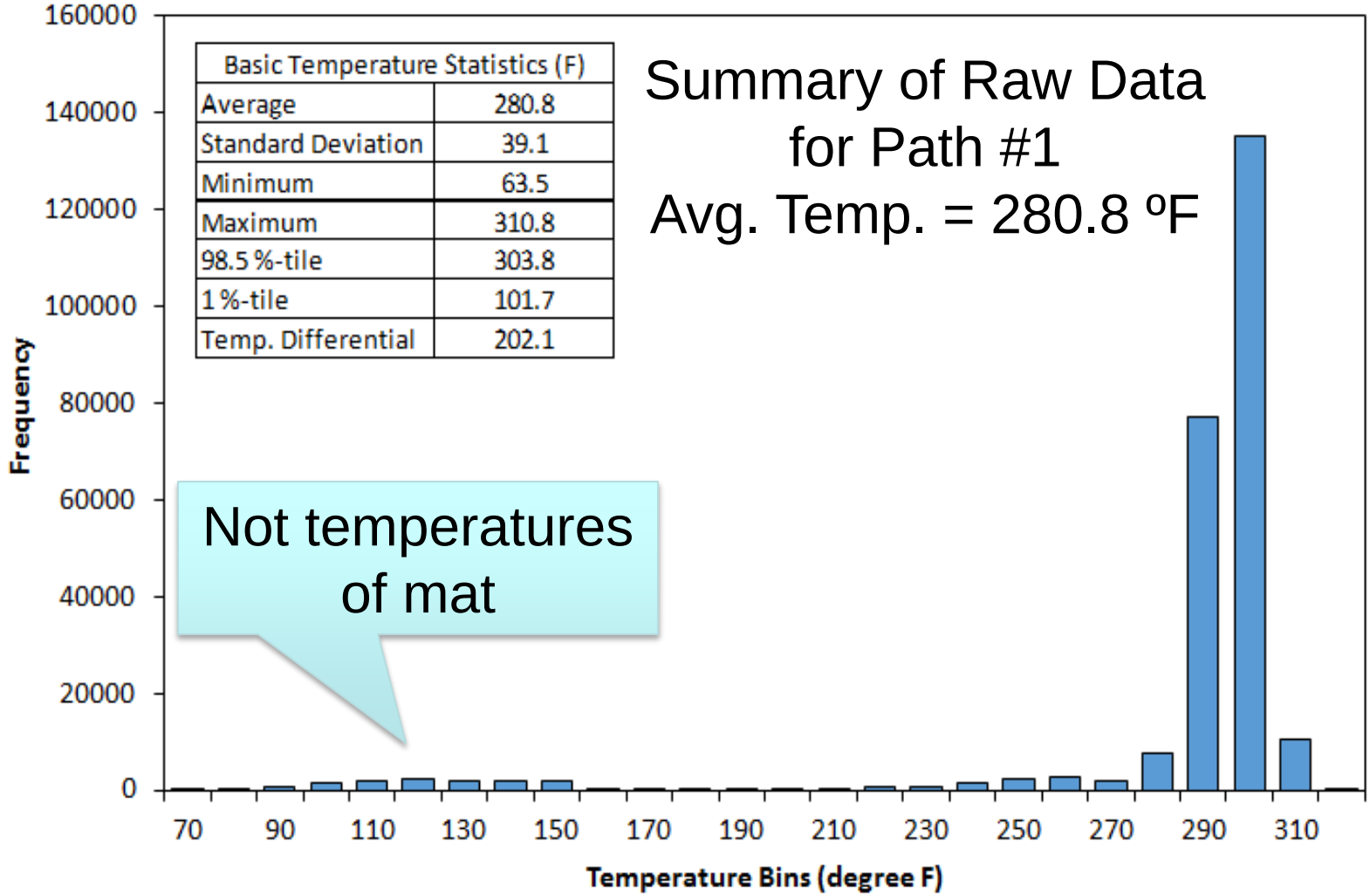


Data Analyses

Raw Temperature Profile for second part of the first path.



Data Analyses

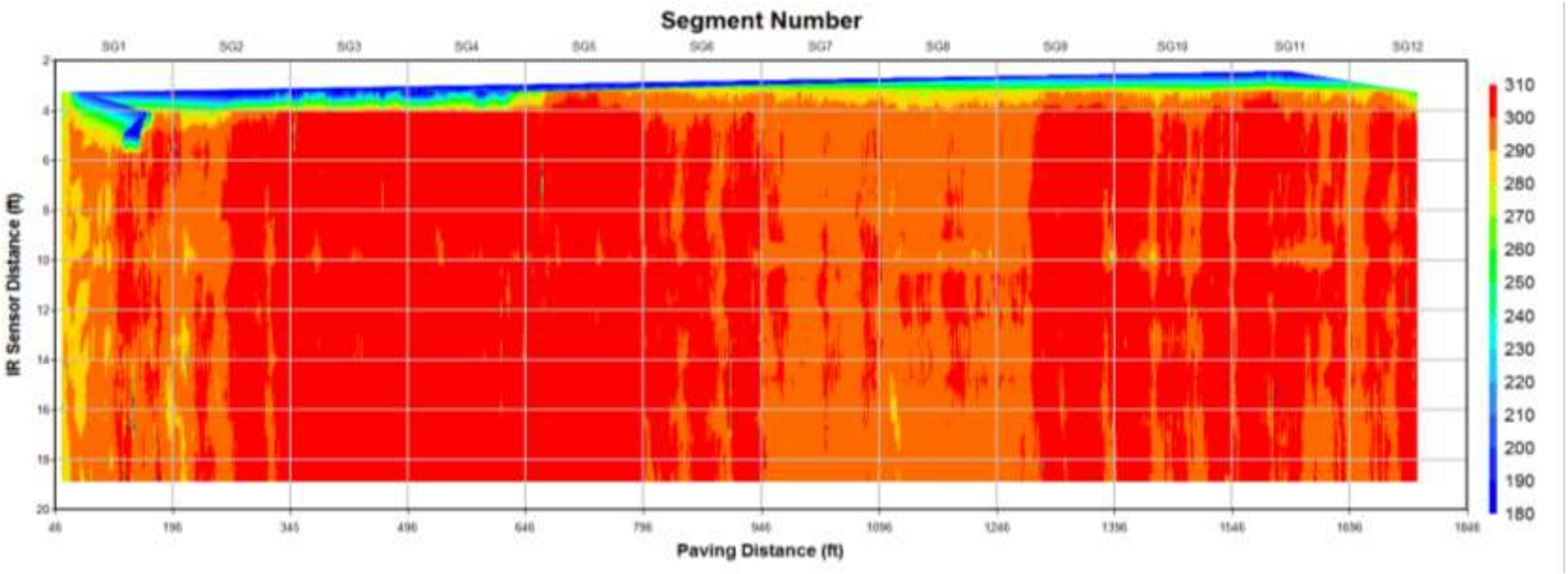


Basic Temperature Statistics (F)	
Average	280.8
Standard Deviation	39.1
Minimum	63.5
Maximum	310.8
98.5 %-tile	303.8
1 %-tile	101.7
Temp. Differential	202.1

Data Analyses

Data Processing—eliminate invalid temperature measurements:

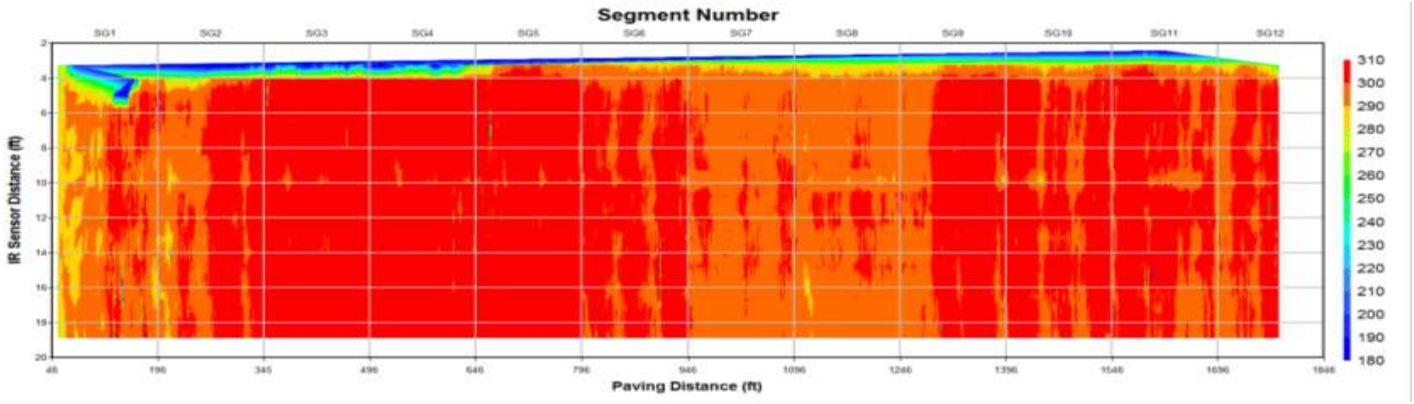
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses

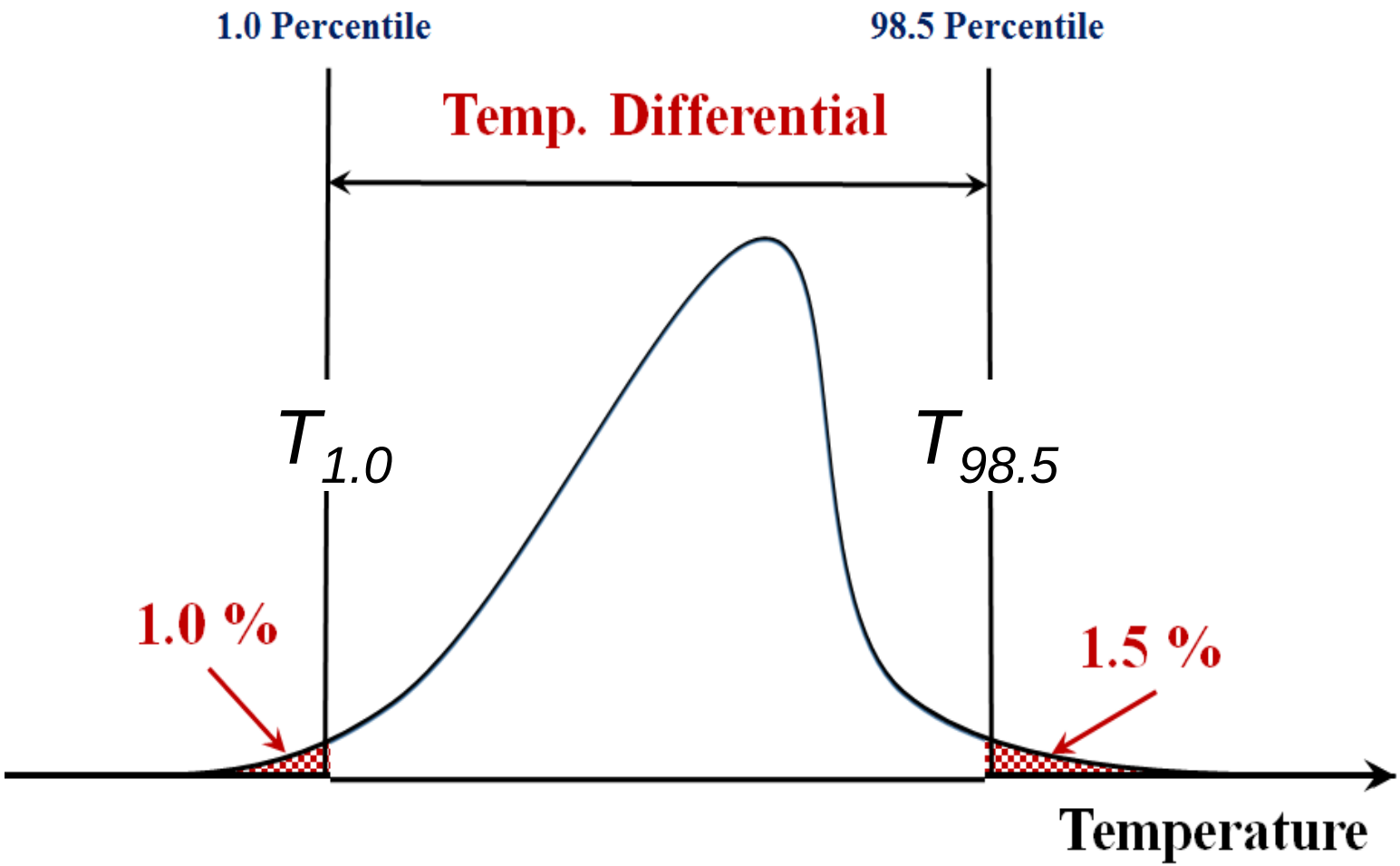
Data Processing—eliminate invalid temperature measurements:

2. Eliminate data with paver stops greater than 10 seconds, between locations:
   - 2 feet behind measurement location of stop
   - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 ºF and > 400 ºF.



Data Analyses

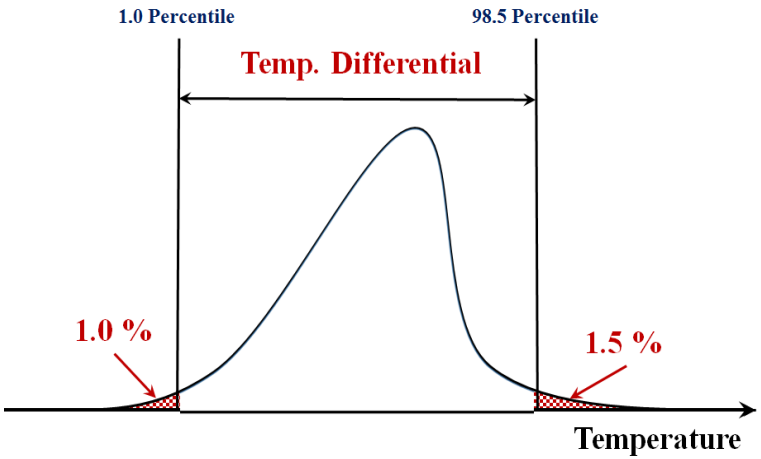
- Temperature Differential, each 150 foot segment



Data Analyses

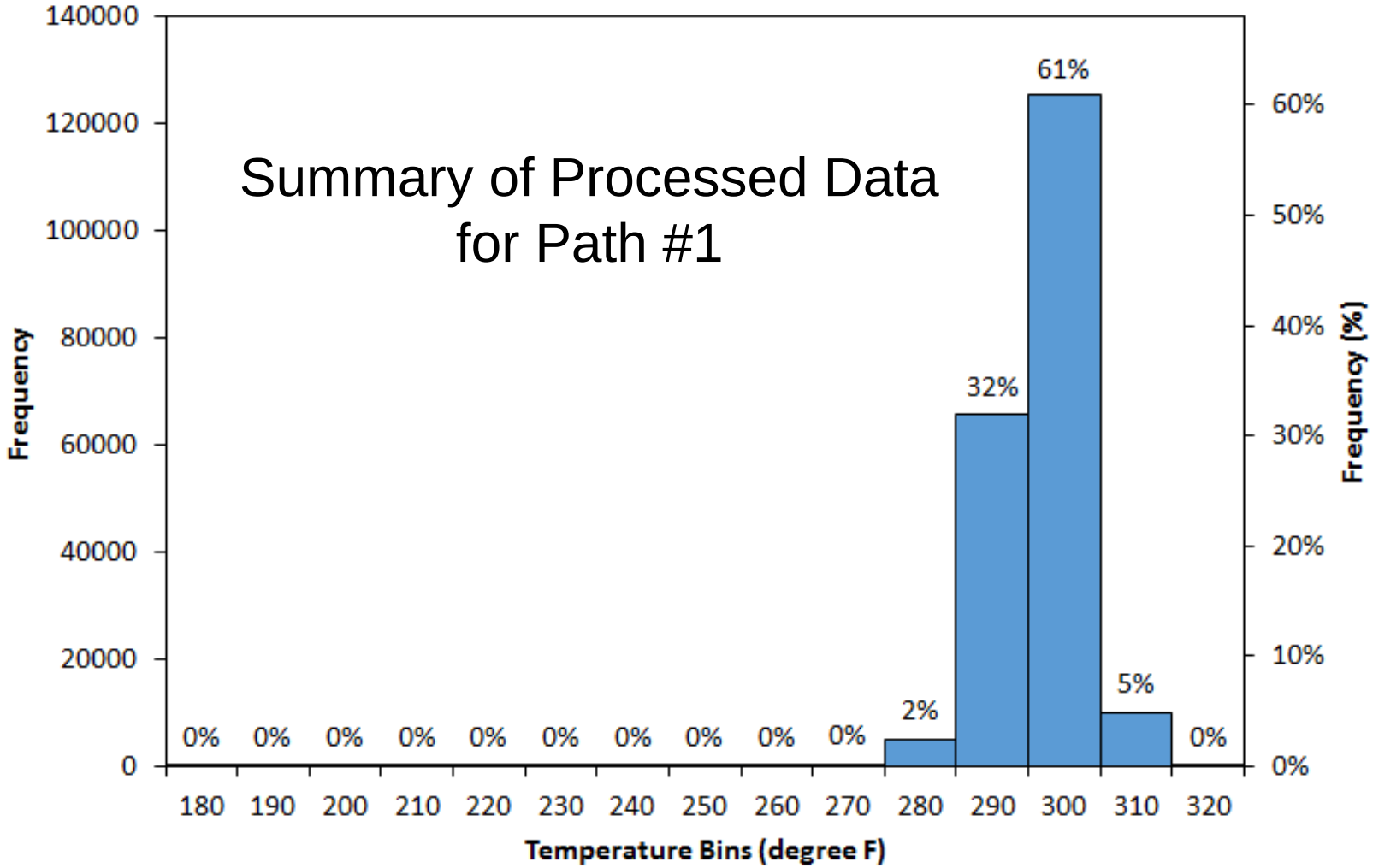
- Temperature Differential Criteria, each 150 foot segment:

$$T_{Diff} = T_{98.5} - T_{1.0}$$



- **$T_{diff} \leq 25$ ºF** — **No temperature difference**
- 25 ºF < $T_{diff} \leq 50$ ºF — Moderate temperature difference
- **$T_{diff} > 50$ ºF** — **Severe temperature difference**

Data Analyses



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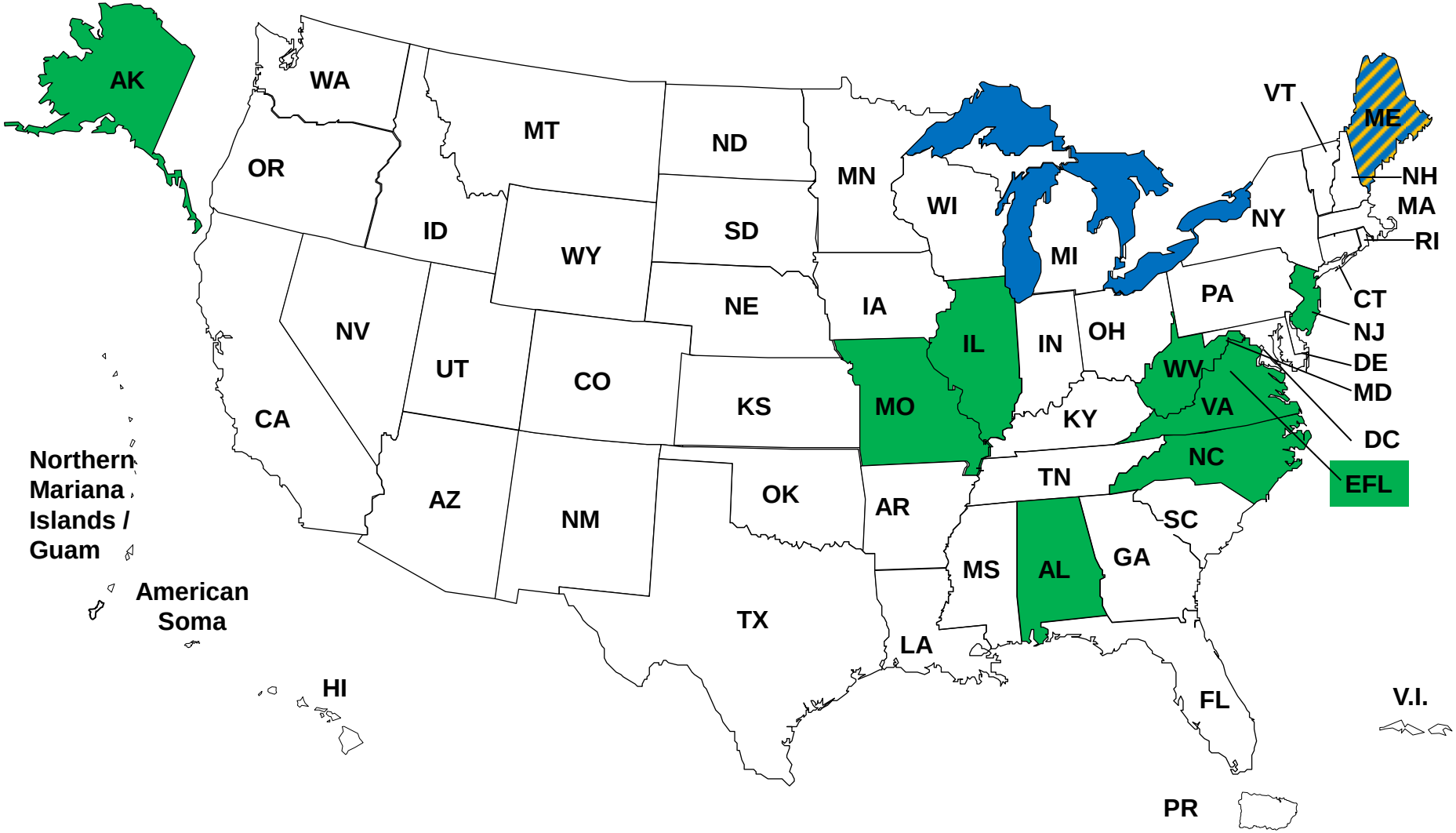
Demonstration Projects



Data Summary – One Project

Processed Data, **excluding** paver stop locations.

Lot or Paver Path ID	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
1	24	17	7	0	None
2	12	10	2	0	None

Minnesota DOT's specification:

- Minor Temperature Difference: +$20 per Increment
- Moderate Temperature Difference: $0 per Increment
- Severe Temperature Difference: -$20 per Increment

Total Incentive to Contractor: $540 for the two Path IDs.

Data Summary – One Project

Processed Data, **including** paver stop locations.

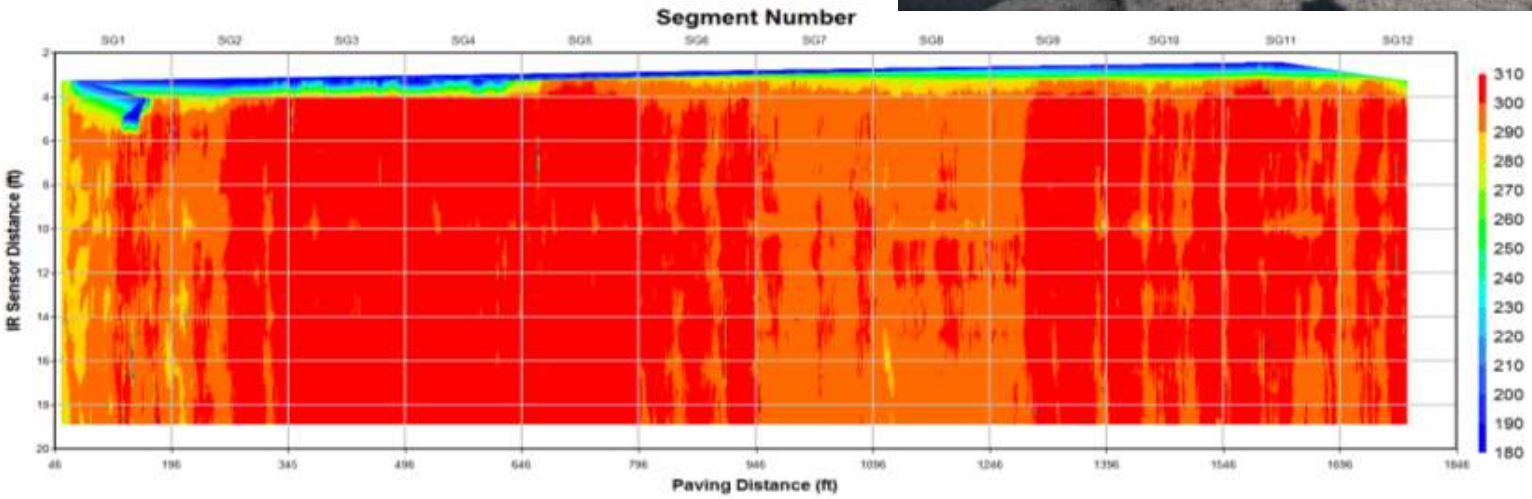
Lot or Paver ID	Total Number of Increments	Number of Increments within Temperature Regimes		
		Minor	Moderate	Severe
Path 1	24	17	5	2
Path 5	12	5	3	4

Total Incentive to Contractor: $320 for the two Path IDs.

Thermal Profiling to Increase Pavement Life

Conclusion from demonstration projects, to-date:

- Pave-IR scanner is one tool to confirm a uniform, high-quality mat.



Thermal Profiling to Increase Pavement Life

Role of IR in Quality Assurance Programs

1. Quality control plan; contractor
   - Monitor production/placement operations to minimize temperature differentials of mat.
   - Trouble shooting
2. Acceptance plan; agency
   - Reduce future distress and maintenance costs
   - Dispute resolution

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QUESTIONS