Alaska Department of Transportation & Public Facilities

Use of Advanced Technology for Quality Assurance in Alaska
Rich Giessel

Idaho Asphalt Conference: October 25, 2018
Outline

1. Failure Modes Drive Testing Philosophy Shift
2. Implementation History of ICTs in Alaska
3. Surprising things we have discovered with Dielectric Profiling System (DPS) GPR
4. Main Features of Continuous-Full-Coverage Specifications for Compaction Acceptance
5. Compaction Defect Mapping and Remediation
1. Failure Modes of Asphalt Paving

Major Failure Modes:

1. Studded Tires (a political problem)
2. Poor Compaction (a construction problem)
3. Poor Tack Bond Between Layers (a Specification and pay item problem)

Minor Failure Modes:

- Stripping (a surface chemistry problem)
- Rutting & Shoving (a mix design problem)
Avoidable Major Failure Modes:

2. Poor Compaction
3. Poor Tack Bond Between Layers

Our focus will be on Enhancing Compaction
Required Shift in Philosophy-1

- We Must Abandon Random Testing

“The primary problem is not so much to determine the average conditions, as it is to make reasonably certain that possibly the most unfavorable conditions are known over a given area that may give rise to soft spots.”

Donald M. Burmister (1948)
OPTIMAL SAMPLE SIZE

Variability of Est. PWLs vs Number of Samples

- n=3
- n=4
- n=15

PWL = 90
Required Shift in Philosophy-2

- Adopt current state-of-practice technology to achieve 100% testing & inspection coverage
  - Intelligent Compaction (IC) Rollers provide 100% pass coverage, temperature, ICMVs
  - Paver Mounted Thermal Profilers (PMTP) provide 100% thermal mapping of mat
  - Asphalt Surface Dielectric Profiling Systems (DPS) using Ground Penetrating Radar (GPR) provide 100% Mapping of compaction
Expected Outcomes

- No potholes or raveling joints
- Longer-life pavements
- Much less maintenance
- Lower life-cycle cost
2. Implementation History of ICTs in Alaska
Intelligent Compaction Rollers

- Intelligent Compaction Rollers required at Sitka Airport for Night Paving. (Bruce Brunette 2013)
- Echelon Paving also employed to reduce longitudinal joints from 11 to 5.
Pave IR Benefits

- Real-time thermal mapping, color display on paver provides immediate feedback to DOT and paving crew
Example Pave-IR Display

Figure 3.2. Thermal profile from US-29 (continued).
Birth of a Pothole

Research Report – July 1, 2001
Research Project Agreement T9903, Task A3
Cyclic Segregation

CONSTRUCTION-RELATED ASPHALT CONCRETE
PAVEMENT TEMPERATURE DIFFERENTIALS
AND THE CORRESPONDING DENSITY
DIFFERENTIALS – Report No: WA-RD 476.1

Washington State Transportation Center (TRAC)
University of Washington, Box 354802
University District Building
1107 NE 45th Street, Suite 535
Seattle, Washington 98105-4631
Cold Spots - Infrared vs B&W Photo
Glenn Hwy Incentive (2016)

- Pay a $75 Bonus for each 150’ segment with No Thermal Segregation (0-250°F variation)
- 2140 each 150’ segments = $160,500 potential bonus on 15 miles of 4 lane highway
No Incentive

- No bonus for 150’ segments with Moderate Thermal Segregation (25-50°F)
Penalty or Disincentive

- $75 Penalty (not used on Glenn Hwy) for each 150’ segment with Severe Thermal Segregation (>50° F)
- Only used the Carrot 😊
• PMTP is an objective tool for rewarding best practices such as:

1. Tarping all loads
2. Steady delivery of material to project with a minimum number of paver stops
3. Tying loads together when dumping
4. Use of Material transfer vehicle to homogenize temperature and smooth material flow to paver

PMTP Use Rewards Good QC
Dielectric Profiling System (DPS) using Ground Penetrating Radar (GPR) gives:

1. Dielectric Mapping
2. Readout as % Voids, % Compaction, or Density in asphalt mat in real-time once calibration data from drilled cores has been entered.

(Note: Testing equipment became commercially available in May 2016 with FCC approval. Alaska purchased the 10th machine made in October 2016)
Fritz Cove Dielectric (July 2018)
Mainline Dielectric vs % Compaction

\[ y = 0.1264x + 0.3013 \]

\[ R^2 = 0.9551 \]
Fritz Cove % Compaction
PaveScan RDM

- PaveScan Rolling Density Meter Provides:
  - Geo-located Data
  - 400,000 pulses per second processed with equivalent time sampling to produce 60 scans/sec
  - 60 scans (dielectric readings) per second recorded to Raw Data File
  - =10 Dielectric readings per foot of travel at 6 ft/sec (~ 4 mph walking speed) per antenna
What is Dielectric?

- Related to Speed of RADAR through a Material

\[ e = \frac{C^2}{V^2} \] or \[ (V = \frac{C}{\sqrt{e}}) \]

Where:
- \( e \) = Dielectric
- \( C \) = Speed of light in a vacuum
- \( V \) = Speed of RADAR in material
Relative Speeds of RADAR

RADAR is fastest in Air $e = 1$ $(V=C)$
RADAR is slowest in Water $e = 81$ $(V=1/9C)$
Asphalt Concrete $e = 4-7$ $(V=0.5-0.35C)$

(note more air gives lower dielectric, i.e. RADAR passes through porous asphalt faster)

LOW DIELECTRIC = LOW DENSITY
3. Surprising things we have discovered with DPS GPR
What can we “SEE” with GPR?

- Answer: Defects we have never “SEEN” before
- For example, density variation across a longitudinal joint
Core 70J (91.7%) – Resolution 0.25 ft
Core 69J (92.9%) – Resolution 0.25 ft
Core 87J (94.9%) – Resolution 0.10 ft
## Core 87J – Distance Statistics

<table>
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<tr>
<th>Sensor Position</th>
<th>Total Dist</th>
<th>Median</th>
<th>Average</th>
<th>Min</th>
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<th>Standard Dev</th>
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## Core 87J – Time Statistics

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Core 85J (92.4%) – Resolution 0.25 ft
Calibration Core 19J (96.2%) 0.25 ft
Longitudinal Joint at Core 19J
### 165 Core Densities: 90.9 to 97.8%

<table>
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<tr>
<th>Compaction Summary - 2017 Data</th>
<th>% Compaction</th>
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<tr>
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<td>SB-L1 Average Panel Density (20 Cores)</td>
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<td>NB-L1 Average Panel Density (17 Cores)</td>
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<td>SB-L2 Average Panel and Joint Densities (33 Cores)</td>
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<td>SB-L3 Average Panel and Joint Densities (3 Cores)</td>
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<td>Min</td>
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**Note:**

- 50 of 101 (50%) of Panel Cores 95.0% or Higher
- 26 of 64 (41%) of Joint Cores 95.0% or Higher
SB(Joint CL) Density Histogram
SB Joint Cumulative Densities - 24.5% below 91%
Low Density is Typical at Bridges
S. Birchwood Bridge,
SB Lane 2, 18-24’ LT
Low Density Adjacent Rumble Strip
We don’t want a “Pretty” edge joint

ROLLER DRUM POSITION – PASS 1

6” OVERHANG ON PAVED SHOULDER

NEW HMA

2” MILL

6” ASPHALT PAVING

PAVED SHOULDER W/ RUMBLE STRIP

ROADWAY
We Want a “Compacted” edge joint

ROLLER DRUM POSITION – PASS 2

ROLLER JUST INSIDE VERTICAL FACE

NEW HMA

-2” MILL

6” ASPHALT PAVING

ROADWAY
4. Main Features of CFC Specs for Compaction Acceptance
What Changes?

The main specification change for implementation of GPR technology is substituting Percent Conforming (PC) for Percent Within Limits (PWL) in the Density Pay Factor.

For a lot (5000 tons) of asphalt, placed in a 2” thick lift, PC will be based on approximately 400,000 density readings (one per square foot, assuming an asphalt density of 150 pcf). PWL for that same lot of asphalt would be based on 10 density readings (one per sublot).
What % Conforming thresholds should trigger repair, R&R?

Mat Density Pay Factor = 0.55 + PC/200, allowing up to 5% bonus at PC = 100%. (Lower limit of PC = 50%, PF = .80)

• Remove and Replace is triggered if PF is below 0.80

What PC should trigger repair with Sand Seal?
• Perhaps from PC = 50% to 70%, PF = 0.80 to 0.90?
Or
• Perhaps from PC = 50% to 80%, PF = 0.80 to 0.95?
Cost of Potholes

American drivers pay an estimated $3 billion a year to repair damage caused by potholes, according to AAA. Over a five-year period, 16 million drivers reported their vehicles were damaged by potholes, from tire punctures and bent wheels to suspension damage.
Instead of Percent Conforming should we use defect size and low compaction threshold for repair criteria?
What size low-compaction area should trigger mat repair?

Current programming allows PaveScan Operator to Select defect size and compaction threshold for identification and mapping of both linear and area defects.

What size area should trigger repair?
  (Currently using 8 ft\(^2\))

What % compaction should trigger repair?
  (Currently using <92%)
What length of low-compaction Longitudinal Joint should trigger repair?

What length should trigger joint repair?
(Currently using 5 ft)

What % Compaction should trigger repair?
(Currently using <91%)
What equipment might one see when incentives are given for superior mat & joint compaction?
What you don’t want to see
5. Compaction Defect Mapping & Remediation
Portage Glacier Road
Sta. 191-181, 11'-17' Right
Area defects
## Number and % Defective – File 001

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<th>Segment (ft)</th>
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Station 184, 0.17% Defective
Station 188, 62% Defective
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Portage Glacier Rd - Sta 139-144
Glenn Hwy at Eagle River Bridge
Lane 1 Compaction Coverage
Glenn Hwy at Eagle River Bridge
Lane 1 Area Defects
Glenn Hwy at Eagle River Bridge
Lane 1 Linear Defects

[Image of a bridge with linear defects highlighted in red on a Google Earth map]