Real-Time Smoothness Technology for Improving Concrete Pavement Smoothness

RPUG 2016 Annual Meeting
2 November 2016
David K. Merritt, PE(TX)
Real-Time Smoothness for Concrete Paving

- Overview of Real-Time Smoothness Technology
- SHRP2 RTS Implementation Support Program
- Using RTS Systems to Achieve Smoothness Requirements
- Observations from RTS Equipment Loan Projects
Real-Time Smoothness for Concrete Paving

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What is Real-Time Smoothness?

Real-time Smoothness (RTS) refers to measuring and evaluating the concrete pavement surface profile during construction, somewhere along the paving train while the concrete surface is still wet (plastic).
RTS Profilers

Paver-Mounted GOMACO Smoothness Indicator (GSI)
RTS Profilers

Ames Engineering Paver-Mounted Real Time Profiler (RTP)
RTS Profilers

Stand-Alone GOMACO GSI Machine
### Real-Time Tracking of “Events”

#### Event Log

<table>
<thead>
<tr>
<th>Station</th>
<th>Start Time</th>
<th>Description</th>
<th>Date/Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>91+10 st</td>
<td>0:00 st</td>
<td>PAVER STOP</td>
<td>10:58a 10/01</td>
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<tr>
<td>91+71 st</td>
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<tr>
<td>97+14 st</td>
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<td>01:02p 10/01</td>
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<td>97+41 st</td>
<td>0:00 st</td>
<td>PAVER STOP</td>
<td>01:08p 10/01</td>
</tr>
</tbody>
</table>

- **Add**
- **Edit**
- **Delete**
- **Default Events**

**Ok**
Reasons for Using RTS Equipment

• Reduce Disincentives and Increase Incentives
• Increase Production(?)
• Anticipated change in smoothness acceptance requirements
  ▪ PI to IRI
  ▪ Change in localized roughness specification limits
Benefits of Real-Time Smoothness

• Opportunity to identify real-time and correct objectionable profile features caused by:
  - Stringline/stringless system disturbance
  - Padline variability
  - Non-uniformity of concrete
Benefits of Real-Time Smoothness

• Validation of adjustments in 1 hour vs. 12 to 24 hours:
  ▪ Hydraulic sensitivity relative to machine control input (stringline and stringless)
  ▪ Vibrator frequencies
  ▪ Paving speed
  ▪ Concrete head
  ▪ Concrete mixture proportions
  ▪ Others
Limitations of Real-Time Smoothness

- Not a replacement for conventional profiling for acceptance.
- Not a replacement for better practices to construct smoother pavements.
Real-Time Smoothness for Concrete Paving

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RTS Implementation Support Activities

- Full use of an RTS system for two weeks
- On-site technical support and training
- 11 equipment loans nationwide (ID, NE, MI, TX, PA, IA, IL, UT[2], CA to date)

Task 2: Regional Showcase (Open House)
- One day classroom presentations with an on-site RTS demonstration
- In conjunction with an equipment loan project
- Aug. 9 2016 (Salt Lake City, Utah)
RTS Implementation Support Activities

Task 3: Workshops
- Four hour workshops (UT, CA to date)

Task 4: Documentation of Results/Case Studies
- Synthesis of contractors’ experience
- Case study – Comparing real-time measurements to QA results
- Case study – Long-term performance of RTS
- Documentation of equipment loans and lessons learned
RTS Implementation Support Activities

Task 5: Specification Refinement
- QC approach
- Process improvement

Task 6: Outreach Materials
- Quick field reference guide
- Brochures
- Project updates (30 minute briefings)
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Using RTS Systems

• **Step 1 – Establish a baseline**
  - Monitor results for 1 to 2 days.
  - Keep processes static, but make ordinary adjustments.
  - Observe typical responses to the ordinary adjustments and make notes or add event markers in the RTS.
    - Mixture
    - Vibrators
    - Speed
    - Head
    - Paver stops
    - Etc.
Using RTS Systems

- The RTS results are higher than the QC hardened profiles – what’s up with that?
  - Don’t panic
  - Just focus on making the RTS results better (lower IRI)
  - QC profiles will improve as well
Using RTS Systems

• Step 2 – Pick the low hanging fruit

• Eliminate large events that cause excessive localized roughness.
  ▪ Stringline/stringless interference
  ▪ Paver stops
  ▪ Padline issues
  ▪ Etc.
Localized Roughness Events

- Stringless system interference
Localized Roughness Events

- Running the paver out of concrete
Localized Roughness Events

- Stopping the paver

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Using RTS Systems

• Step 3 – Adjust the paving process to improve overall smoothness
  - Maintain a consistent head
  - Lead/draft to get the paver as flat as possible
  - Sensitivities
  - Vibrators (height and frequency)
  - Mixture
  - Paver operation
  - Paving speed
• Eliminating big events gives you a new “baseline” to adjust from.
  - Systematically make changes in small increments.
  - Get a minimum of 0.1 mile with consistent paving (no big events) and then evaluate if the adjustment made things smoother.
  - Continue adjusting in small increments and evaluating every 0.1 mile.
Overall Smoothness

- Stay focused and incredible things can happen

Over a mile paved per day – average IRI = 28 in/mi:
Using RTS Systems

• Step 4 – Identify repeating features using a ProVAL PSD plot and adjust processes when possible.
  - Joints
  - Dumping/Spreading loads
  - CRCP bar supports
Repeating Features

- What repeating feature shows up here?
- What can you do to mitigate this feature?

![Graph showing wavelength and slope spectral density](image-url)
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Equipment Loans to Date

- Idaho, I-84
- Nebraska, I-80
- Michigan, I-69
- Texas, SH99
- Pennsylvania, I-81
- Iowa, Lyon Co. L-26
- Illinois, I-90 Tollway
- Utah, I-15
- Utah, I-215
- California, SR46

- 7 JPCP, 2 CRCP, 1 Thin Overlay
- Varying slab thickness and base/subbase types
- Daytime and nighttime paving
- Varying paver types and setup (paver width, concrete delivery, finishing operations)
- Varying mix designs
- Dowel baskets and DBI
- All but one project stringless
• Real-time and hardened profiles parallel each other
• Short wavelength features in RTS that are not in hardened.
Equipment Loan Observations

- RTP consistently measured higher roughness than hardened (20-80 percent higher).
Equipment Loan Observations

- Joint spacing (with dowel baskets) generally dominant content in hardened and RTP PSD, but less dominant in hardened.
• PSD content sporadic on days with poor smoothness results.
Equipment Loan Observations

- Paver stops appear to have some effect on RTP measurements, but it is not consistent.
Equipment Loan Observations

- Paver stops appear to have some effect on RTP measurements, but it is not consistent.
Equipment Loan Observations

- Benefits of good finishing processes
Equipment Loan Observations

- Benefits of good finishing processes are apparent
Equipment Loan Observations

- Dominant features in RTS PSD plot
- What happening at 10.5-’11’?
Equipment Loan Observations

- Hardened profile data
- What happening at 10.5-'11'?
Equipment Loan Observations

- Roughness “spikes” every 350-450 ft
- What is it?
Equipment Loan Observations

- RTS is a valuable tool for contractor QC during paving.
  - Identification of effects of paving process adjustments.
  - Identification of effects of construction artifacts.
  - Achieving better hardened profile results.

- RTS cannot be used in a vacuum – correlation to hardened profile data is essential.

- Several contractors have seen the value of this tool and purchased systems.
Real-Time Smoothness for Concrete Paving

Questions and Discussion