EL01-2015 Implementation Assistance Program

Tools to Improve PCC Pavement Smoothness During Construction (R06E)

Seeking widespread adoption of the real-time smoothness (RTS) technology by contractors and agencies who routinely construct PCC pavements will be achieved through:

1. Equipment Loan Program
2. Showcases
3. Workshops
4. Case studies/results Documentation
5. Specification Refinement
6. Marketing & Outreach

SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

National Concrete Pavement Technology Center

FIELD REPORT: IDAHO EQUIPMENT LOAN

U.S. Department of Transportation Federal Highway Administration

American Association of State Highway and Transportation Officials AASHTO The Voice of Transportation

TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

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INTRODUCTION

The Federal Highway Administration (FHWA) has contracted with the National Center for Concrete Pavement Technology (CP Tech Center) for *Implementation Support for Strategic Highway Research Program II (SHRP2) Renewal R06E Real-time Smoothness Measurements on Portland Cement Concrete Pavements During Construction*. One of the tasks included in this contract is equipment loans to contractors. This task involves facilitating the loan of real-time smoothness equipment for field trial use on 11 designated PCC pavement construction projects. The scope of this task includes the following activities:

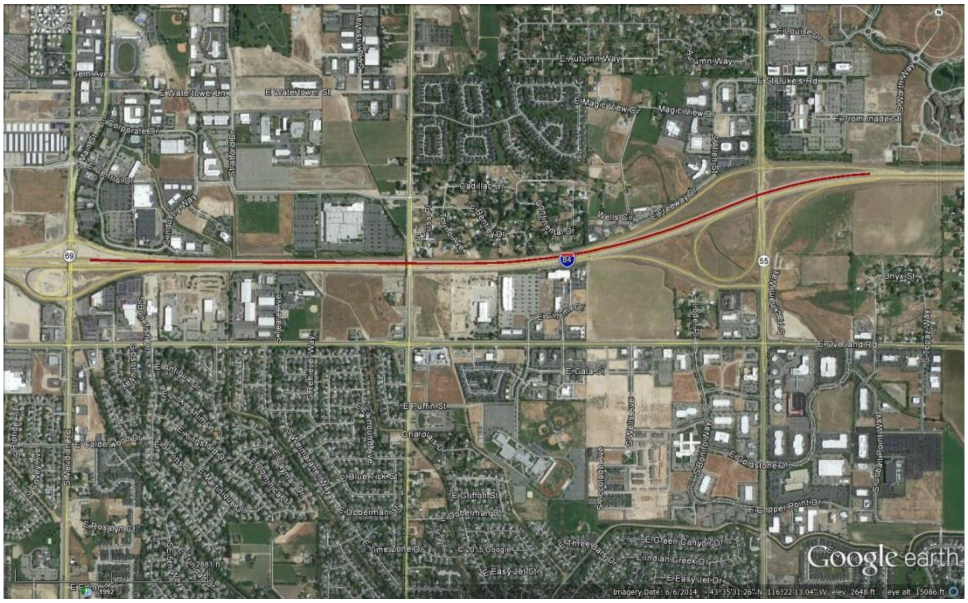
- Provide equipment (GOMACO GSI or Ames RTP) and labor for a field trial of 10 to 30 paving days
- Provide technical assistance for equipment installation start-up and operation
- On-call technical support throughout the duration of the field trial
- Planning, coordination and execution of the field trials
- Contact the recipient within 5 days of notice to proceed from the COR
- On-site support for at least 2 weeks
- Maintain a master list of field trial participants and update the list quarterly

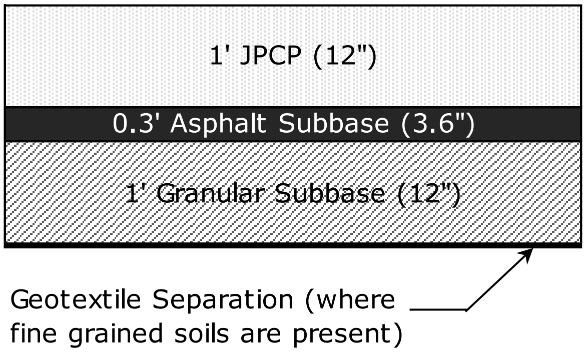
This report summarizes the activities and findings of the equipment loan conducted in Idaho.

PROJECT DETAILS

The equipment loan was performed in April 2015 on a project in Boise, Idaho. Table 1 summarizes the pertinent project details.

Table 1. Boise, Idaho I-84 Project Information

Item	Details
Project Location	Mainline paving with gaps for entrance and exit ramps was located on westbound I-84 from just east of the Eagle Road interchange to the vicinity of the Meridian Road interchange. 

Item	Details
Route	I-84
Agency	Idaho Transportation Department (ITD)
Paving Contractor	Concrete Placing Corporation (CPC)
Paving Equipment	Guntert-Zimmerman S-850 paver, Leica stringless machine control and Gomaco 9500 Placer
Real-Time System	Ames RTP
Typical Section	12” dowel jointed portland cement concrete pavement  Note: There was a section of mainline pavement near the Meridian Road interchange which did not have any asphalt subbase and was placed directly on the granular subbase.
Joint Spacing	Transverse: 15’ c/c with dowel baskets Longitudinal spaced at 12’: • Construction – inserted tie bars • Contraction – inserted FRP dowels
Ames RTP Setup	Paver width = 24’ April 21 & 22: Sensors approximately 9’-4” from each edge of pavement. The contractor requested that we concentrate on profiles near the middle of the paver because in their experience, these are typically rougher than the profiles nearer the pavement edges. April 23 & 24: Sensors approximately 4’-6” from the pavement edges.
Miscellaneous Details	A vibrator monitor was in use, vibrators were consistently operated in the range of 5,500 to 6,500 vpm. Burlap drag behind the trailing finishing pan. Hand finishing consisted of a 14’ straightedge and 12’ float advanced with approximately 3’ overlaps. An artificial turf drag was used prior to longitudinal tining.

IMPLEMENTATION ACTIVITIES

As a lead adopt agency, coordination and planning with ITD and the contractor (CPC) began in December of 2014. On-site coordination with the contractor began on April 7, 2015. Initial install of the Ames Real-Time Profiler (RTP) was delayed until April 13, 2015 due to inclement weather and project schedule conflicts. The R06E team returned to Boise and reinstalled the RTP on April 20, 2015, to accommodate the addition of a float pan to the paver. Ames Engineering provided on-site support for both install procedures.

Collection of real-time profile data on the I-84 Meridian project began on Tuesday, April 21, 2015 and continued through Friday, April 24, 2015. Although the nature of this project and scheduling difficulties limited the contractor's use of the RTP to four days of paving, it was beneficial to all parties involved.

Being the first equipment loan, the R06E team was focused on becoming proficient with initial install procedures and RTP software operations. The team also made it a priority to train CPC's personnel on use of the RTP and take notes regarding potential profile roughness impacts (construction artifacts). Perhaps the most beneficial aspect of the on-site technical support was the opportunity to exchange ideas with the contractor and agency regarding best practices for improving initial smoothness and the applicability of real-time smoothness equipment to implement these perceived best practices. Table 2 provides a summary of the R06E team's on-site technical support activities.

Table 2. Summary of R06E On-Site Activities

Date	On-Site Implementation Activites
07APR2015	Meeting with the contractor to review the paving equipment, I-84 project details and coordinate the RTP install.
09APR2015	Inspection and measurements of the paver to collect additional measurements necessary for installation of the RTP on a paver without a float pan.
13APR2015	Install the RTP on CPC's paver.
20APR2015	Reinstall the RTP after the float pan was attached to CPC's paver.
21APR2015	Real-time profile data collection, 4:30 am to 3:30 pm. from approximately 2446+00 to 2420+00. The RTP system was restarted at approximately 2438+16.
22APR2015	Real-time profile data collection, 4:30 am to 2:30 pm. from approximately 2420+00 to 2403+00.
23APR2015	Real-time profile data collection, 4:30 am to 3:30 pm. from approximately 2386+00 to 2363+00. ITD project management personnel visited the site to observe the RTP in use.
24APR2015	Real-time profile data collection, 6:00 am to 1:00 pm. from approximately 2361+00 to 2350+00. ITD central office personnel visited the site to observe the RTP in use. The RTP was removed from CPC's paver.

OBSERVATIONS, DATA and ANALYSES

CPC's paving operation was highly organized and proficient. The concrete mixture was batched at a central plant approximately 8 miles from paving location and delivered in dump trucks. Figures 1 through 6 illustrate the installation of the RTP and different aspects of the paving equipment and processes used by CPC.

Figure 1. Ames RTP Mounted to G-Z S-850 Paver With a Float Pan

Figure 2. Trucks Dumping Concrete at Gomaco 9500 Placer, Installation of Dowel Baskets and Concrete Deposited Ahead of the Paver

Figure 3. Concrete Deposited on Dowel Baskets Ahead of the Paver

Figure 4. Use of a Final Finisher (auto-float) and Hand Finishing Behind the Paver

Figure 5. Artificial Turf Drag and Longitudinal Tining

Figure 6. Application of Curing Compound

CONCRETE MIXTURE

Initial smoothness is sensitive to the workability and uniformity of the concrete mixture. The mixture proportions used by CPC are shown in Table 3.

Table 3. I-84 Meridian Concrete Mixture Proportions

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REAL-TIME SMOOTHNESS IMPLEMENTATION

Mix Design & Proect Info.

General Information

Project:	IDAHO I-84 MERIDIAN
Contractor:	CPC
Mix Description:	SLIPFORM MAINLINE
Mix ID:	N/A
Date(s) of Placement:	

Cementitious Materials	Source	Type	Spec. Gravity	lb/yd^3	% Replacement by Mass
Portland Cement:	ASH GROVE	I/II	3.150	500	
GGBFS:					
Fly Ash:	HEADWATERS	F	2.360	125	20.00%
Silica Fume:					
Other Pozzolan:					
				625	**lb/yd^3**
				6.6	**sacks/yd^3**

Aggregate Information	Source	Type	Spec. Gravity SSD	Absorption (%)	% Passing #4
Coarse Aggregate:	1 1/2"	CRUSHED ROCK	2.600	N/A	1%
Intermediate Aggregate:	3/4"	CRUSHED ROCK	2.600	N/A	15%
Fine Aggregate #1:	SAND	NATURAL	2.560	N/A	98%
Fine Aggregate #2:					

Coarse Aggregate %:	15.6%
Intermediate Aggregate %:	41.8%
Fine Aggregate #1 % of Total Fine Agg.:	100.0%
Fine Aggregate #2 % of Total Fine Agg.:	
Fine Aggregate #1 %:	42.7%
Fine Aggregate #2 %:	

Mix Proportion Calculations

Water/Cementitious Materials Ratio:	0.397
Air Content:	6.00%

	Volume (ft3)	Batch Weights SSD (lb/yd3)	Spec. Gravity	Absolute Volume (%)
Portland Cement:	2.544	500	3.150	9.421%
GGBFS:				
Fly Ash:	0.849	125	2.360	3.144%
Silica Fume:				
Other Pozzolan:				
Coarse Aggregate:	2.780	451	2.600	10.296%
Intermediate Aggregate:	7.452	1,209	2.600	27.600%
Fine Aggregate #1:	7.737	1,236	2.560	28.657%
Fine Aggregate #2:				
Water (*forced to include admix*):	4.018	248	1.000	14.883%
Air:	1.620			6.000%
	27.000	**3769**		**100.000%**
	Unit Weight (lb/ft^3)	**139.6**	**Paste**	**33.448%**
			Mortar	**65.774%**

Admixture Information	Source/Description	oz/yd3	oz/cwt
Air Entraining Admix.:	BASF AE90	10.00	1.60
Admix. #1:	BASF POZZ 80	30.00	4.80
Admix. #2:			
Admix. #3:			

Combined gradation data is provided in Tables 4 and 5 and Figures 7 and 8.

Table 4. Mix Design Submittal Sieve Analysis Data

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REAL-TIME SMOOTHNESS IMPLEMENTATION

Combined Gradation Test Data

Project: IDAHO I-84 MERIDIAN
Mix ID: MAINLINE SLIPFORM
Sample Comments: MIX DESIGN VALUES FROM CPC
Test Date: MIX DESGN SUBMITTAL

Total Cementitious Material: 625 lb/yd^3

Agg. Ratios: 15.60% 41.70% 42.70% 100.00%

Sieve	Coarse	Intermediate	Fine #1	Fine #2	Combined % Retained	Combined % Retained On Each Sieve	Combined % Passing
2 ½"	100.0%	100.0%	100.0%		0%	0%	100%
2"	100.0%	100.0%	100.0%		0%	0%	100%
1 ½"	100.0%	100.0%	100.0%		0%	0%	100%
1"	59.8%	100.0%	100.0%		6%	6%	94%
¾"	13.6%	94.5%	100.0%		16%	10%	84%
½"	2.1%	57.8%	100.0%		33%	17%	67%
⅜"	1.5%	41.0%	100.0%		40%	7%	60%
#4	1.1%	14.6%	97.7%		52%	12%	48%
#8	1.1%	8.7%	84.4%		60%	8%	40%
#16	1.0%	6.4%	71.1%		67%	7%	33%
#30	1.0%	4.3%	46.2%		78%	12%	22%
#50	0.8%	2.2%	16.3%		92%	14%	8%
#100	0.8%	1.1%	5.0%		97%	5%	3%
#200	0.5%	0.8%	2.0%		98.7%	1.5%	1.3%

Workability Factor: **41.5** — 26% Coarse Sand

Coarseness Factor: **66.4** — 32% Fine Sand

Table 5. QA Sieve Analysis Data from ITD

SHRP2 SOLUTIONS — TOOLS FOR THE ROAD AHEAD

REAL-TIME SMOOTHNESS IMPLEMENTATION

Combined Gradation Test Data

Project: IDAHO I-84 MERIDIAN
Mix ID: MAINLINE SLIPFORM
Sample Comments: QA RESULTS FROM ITD
Test Date: 10APR2015 #40

Total Cementitious Material: 625 lb/yd^3

Agg. Ratios: 15.60% 41.70% 42.70% 100.00%

Sieve	Coarse	Intermediate	Fine #1	Fine #2	Combined % Retained	Combined % Retained On Each Sieve	Combined % Passing
2 ½"	100.0%	100.0%	100.0%		0%	0%	100%
2"	100.0%	100.0%	100.0%		0%	0%	100%
1 ½"	98.0%	100.0%	100.0%		0%	0%	100%
1"	55.0%	100.0%	100.0%		7%	7%	93%
¾"	12.0%	98.0%	100.0%		15%	8%	85%
½"	3.0%	67.0%	100.0%		29%	14%	71%
⅜"	2.0%	49.0%	100.0%		37%	8%	63%
#4	1.0%	20.0%	98.0%		50%	13%	50%
#8	1.0%	12.0%	83.0%		59%	10%	41%
#16	1.0%	8.0%	67.0%		68%	9%	32%
#30	1.0%	6.0%	41.0%		80%	12%	20%
#50	1.0%	3.0%	16.0%		92%	12%	8%
#100	1.0%	2.0%	5.0%		97%	5%	3%
#200	0.4%	1.0%	2.4%		98.5%	1.6%	1.5%

Workability Factor: **42.2** — 30% Coarse Sand

Coarseness Factor: **61.5** — 31% Fine Sand

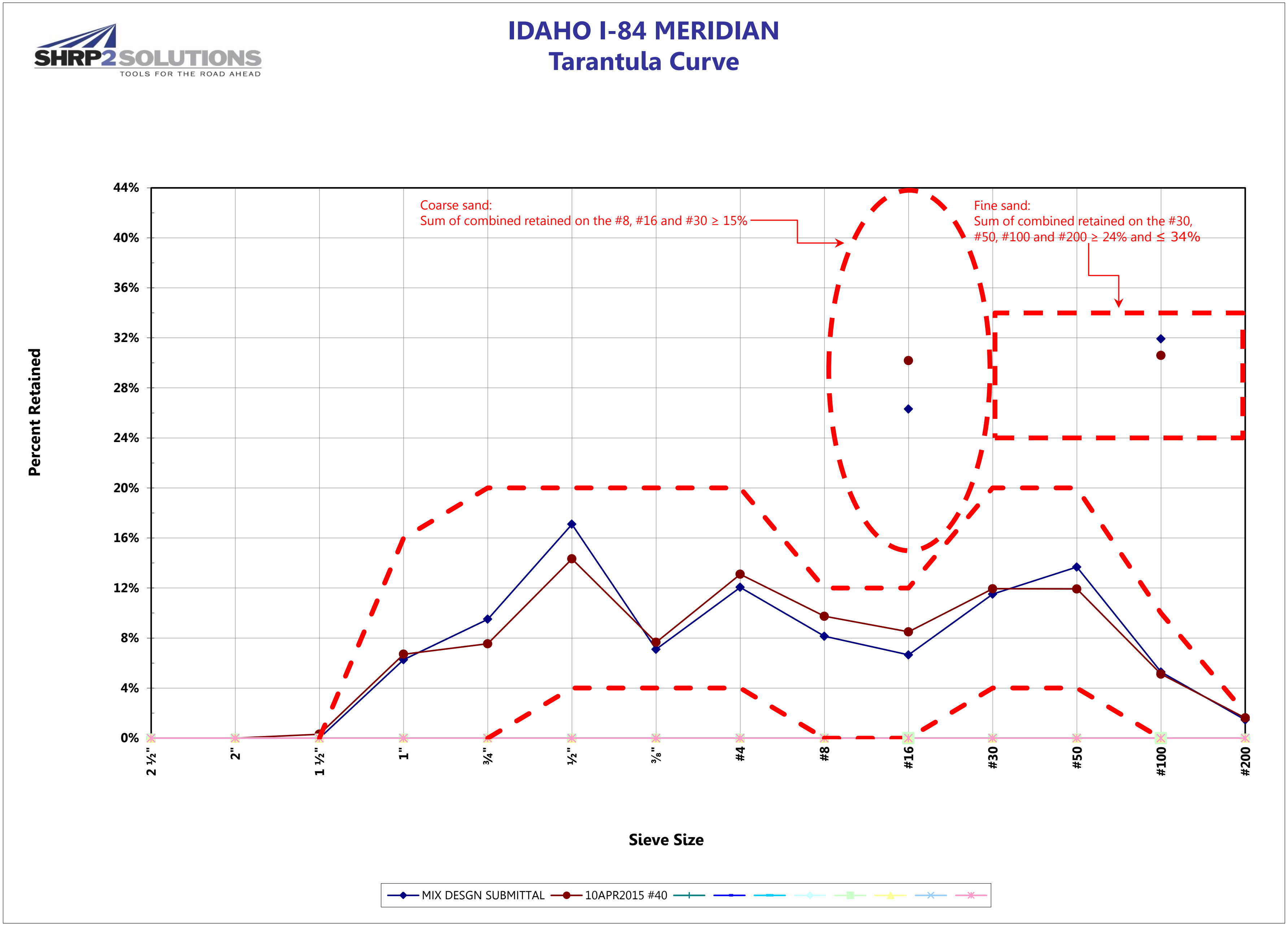

Figure 7. I-84 Combined Percent Retained (Tarantula Curve)

IDAHO I-84 MERIDIAN

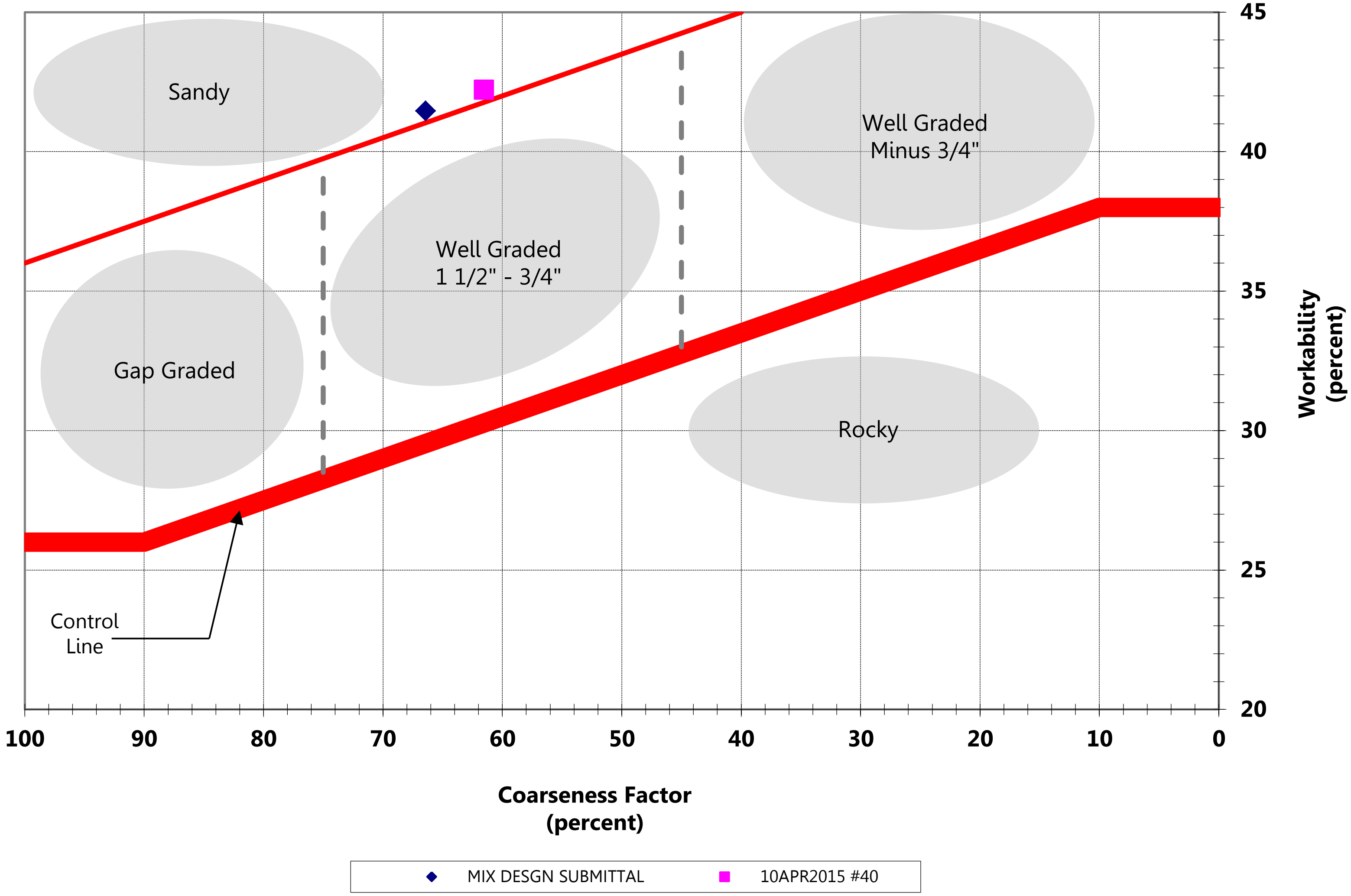

Figure 8. I-84 Combined Gradation Coarseness and Workability Factors

The mixture produced and delivered to the project by CPC was observed to be uniform and workable: consolidation was achieved with relatively low vibrator frequencies (approximately 5,000 vpm) and edges were stable (Figure 9).

Figure 9. Nearly Vertical, Stable Slipformed Edge With Minimal Hand Finishing Required to Seal the Slab Surface

PROFILE CHARCTERISTICS

The nature of this project provided limited opportunity for extensive data collection. Therefore, it is difficult to make any statistically valid conclusions. The following information is provided to convey how real-time smoothness systems can be used as a tool to improve the initial smoothness of concrete pavements.

Real-Time Smoothness (RTS) vs. Hardened QC Profile

The Ames RTP consistently measured higher roughness (localized and overall) than the hardened QC profile. This is not unexpected as finishing operations (mechanical and hand) will help remove much of the localized roughness measured behind the pan. An example from April 22nd is provided in Figure 10 (blue and yellow are hardened profile traces, green and pink are RTP traces).

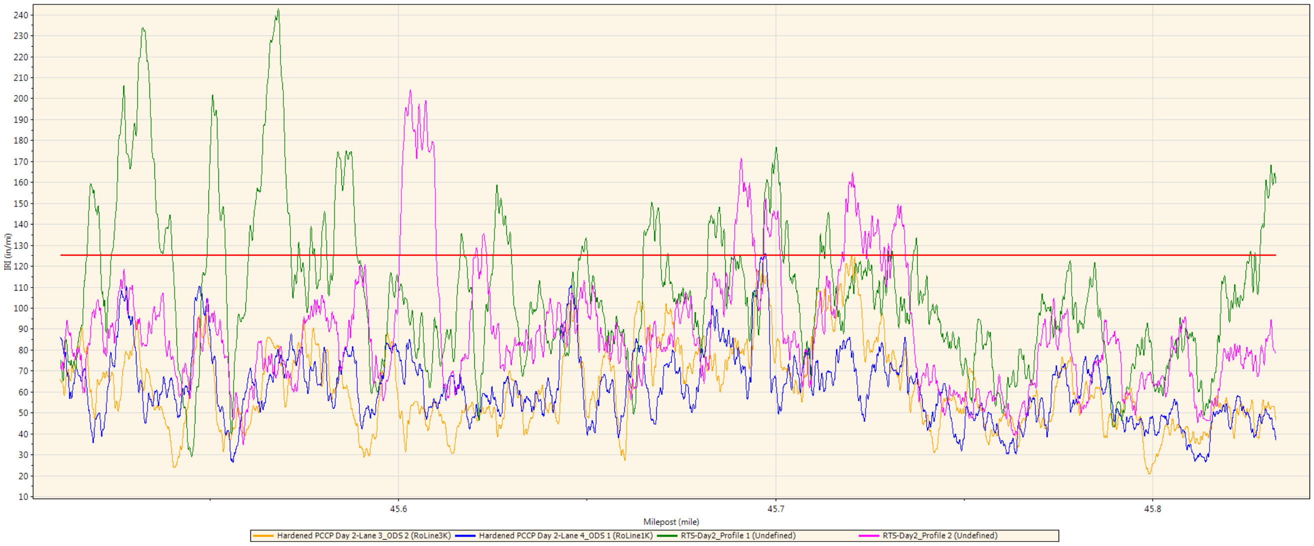

Figure 10. Comparison of Real-Time and Hardened QC IRI Results

Effect of Transverse Contraction Joints

Joints (dowel baskets) were the dominant power spectral density (PSD) content in both the RTP traces and hardened profile traces, but were generally more significant in the RTP traces, indicating that finishing operations helped to reduce the effects of the joints on roughness. PSD plots all showed harmonics of the joint spacing effect, typically at 7.5', 5', 3.75' and 3'. Figure 11 shows the PSD plot from April 23rd illustrating the difference in the effects of joints on the RTP trace and hardened concrete trace.

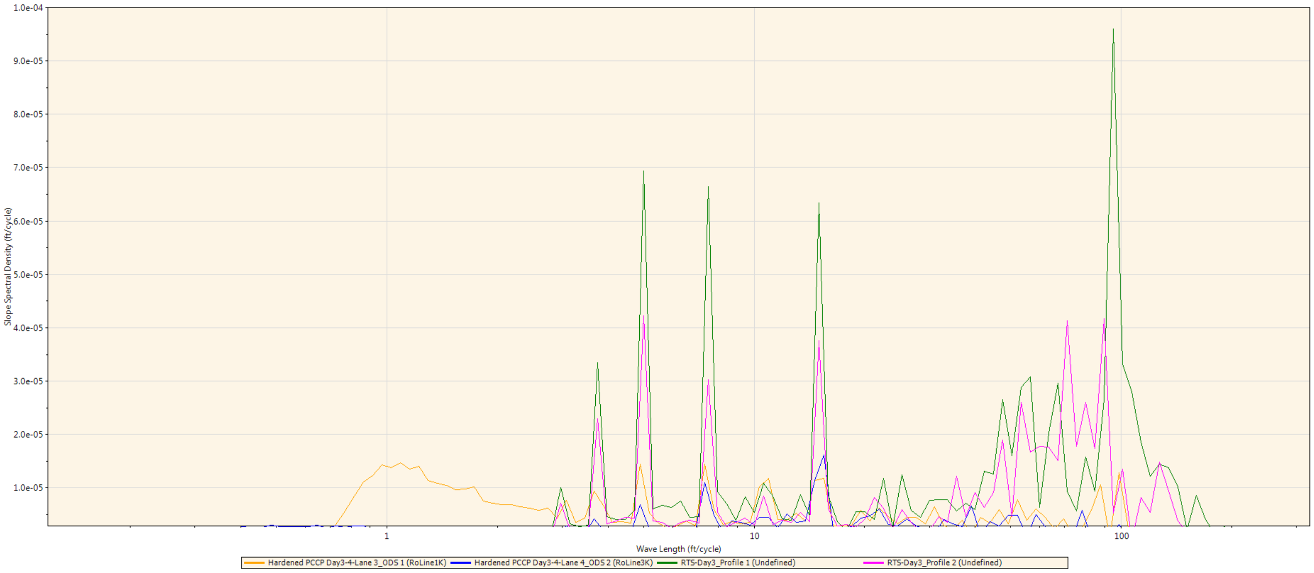

Figure 11. Power Spectral Density Analysis from April 23, 2015

Truck Load Influence

On April 21st, the RTP picked up a ~10.5' feature that was determined to be related to concrete load spacing which averaged 10.6' (with a standard deviation of 2'). This feature was also reflected in the hardened profile, and was more dominant than the joint spacing in the PSD plot. This content was not noticeable for any of the other days of paving. A PSD analysis from first part of April 21st is provided in Figure 12.

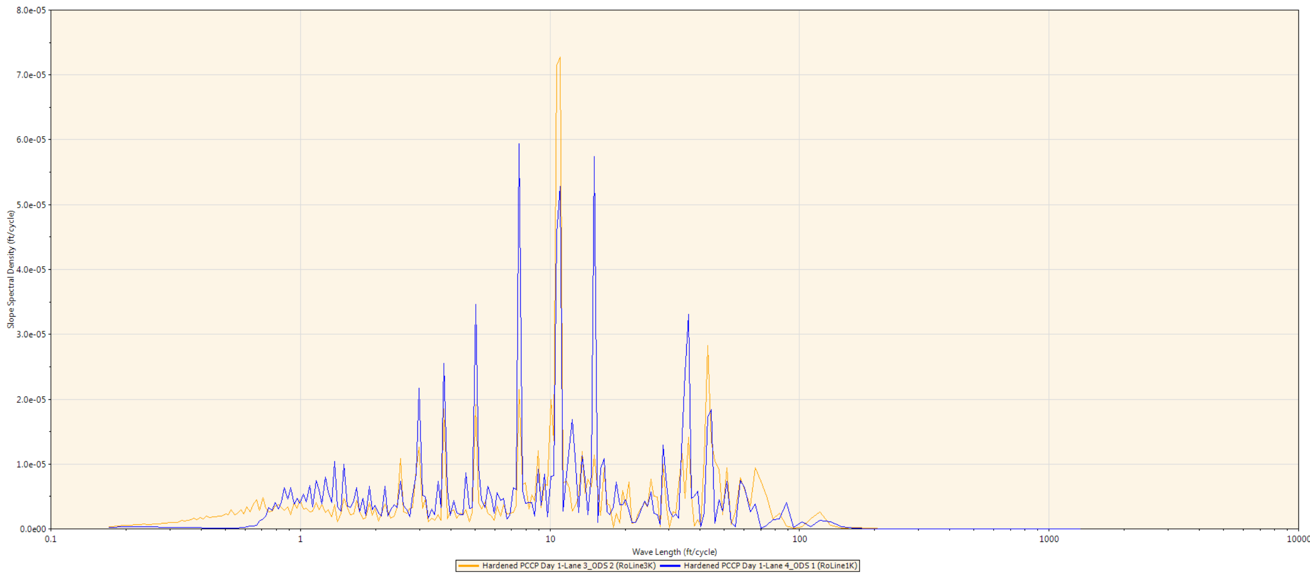

Figure 12. Hardened QC Profile PSD Plot from April 21, 2015 Showing Wavelength Attributable to Truck Load Spacing

A PSD plot from the second part of April 21st (blue and yellow are hardened profile traces, green and pink are RTP traces) shows the ~10.5' feature in the hardened QC profile as well as RTP profile data (Figure 13).

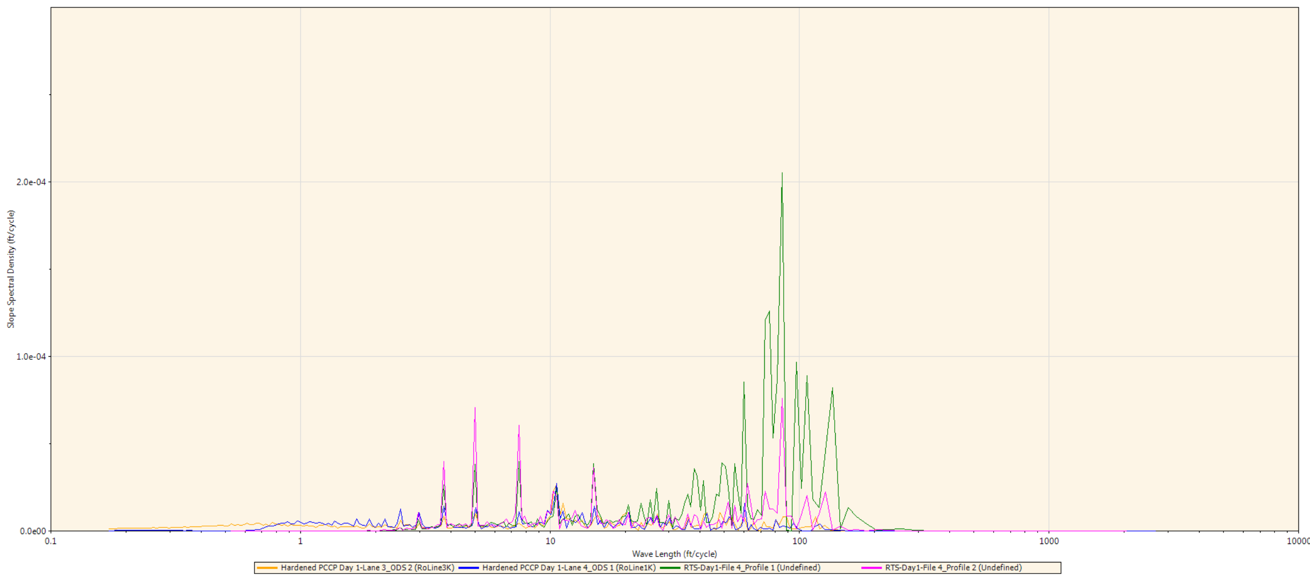

Figure 13. RTP and Hardened QC Profile from April 21, 2015 Showing Wavelength Attributable to Truck Load Spacing

Observation of Long Wavelength Roughness in RTP Profiles

RTP traces picked up significant longer wavelength (~40’-100’) content that did not show up in the hardened QC profiles, it is our hypothesis that this is likely an artifact of the RTP measurement system. Further analysis of data from future equipment loans is needed to confirm this hypothesis or determine the source these wavelengths and the reason(s) that they were not reflected in the hardened QC data. An example of this from April 24th (blue and yellow are hardened profile traces, green and pink are RTP traces) is shown in Figure 14.

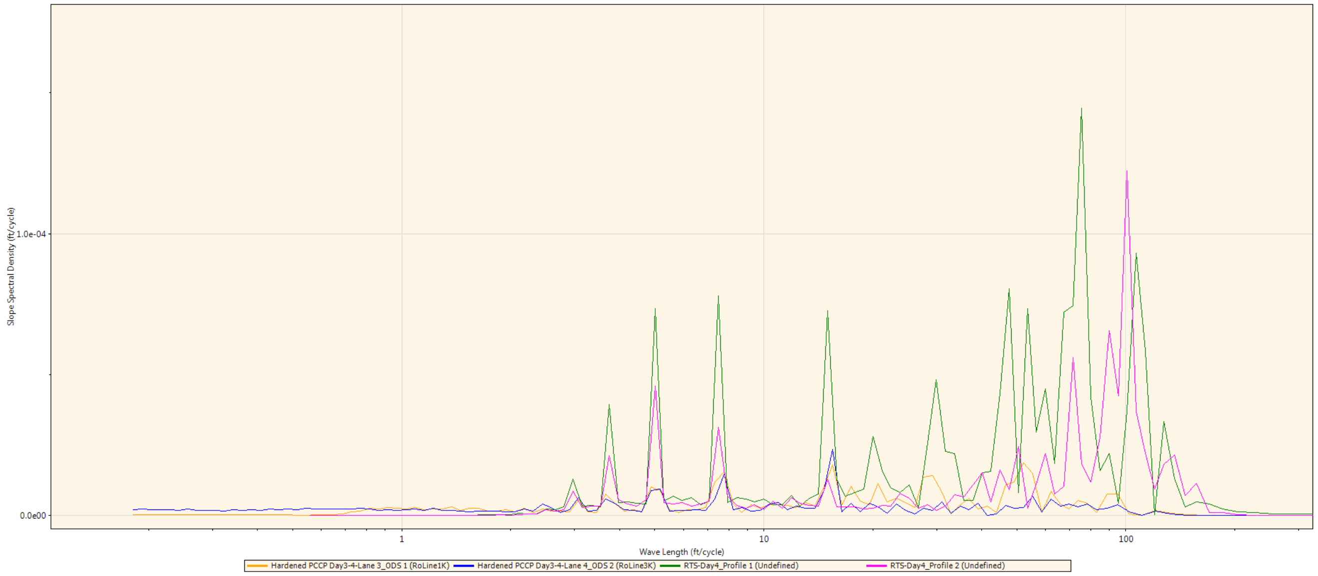

Figure 14. Contrast of Longer Wavelengths Between RTP and Hardened QC Profiles

Localized Roughness Introduced After Real-Time Measurement

A localized roughness feature was picked up in one trace of the hardened profile for April 23rd that was not in the RTP traces, indicating something was introduced in the finishing operation (blue and yellow are hardened profile traces, green and pink are RTP traces)(Figure 15).

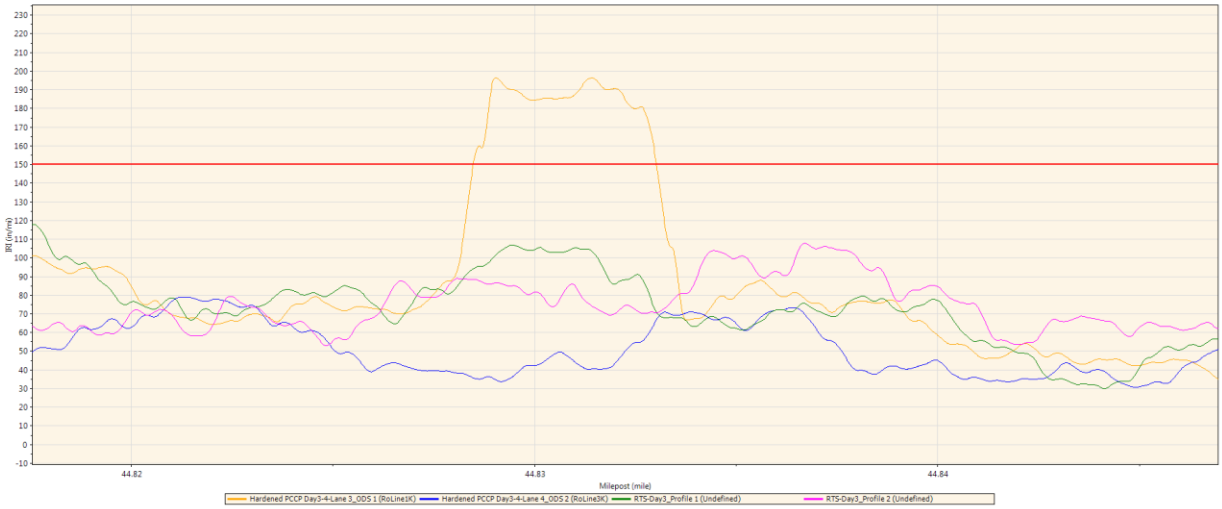

Figure 15. Localized Roughness Apparent in the Hardened QC Profile that Is Not Reflected in the RTP Data

Paver Stops

There appeared to be some effect of paver stops on localized roughness (as measured by the RTP), but these localized profile features were not apparent in the hardened QC profiles (Figures 16 [blue and yellow are hardened profile traces, green and pink are RTP traces] and 17). Our preliminary conclusion for this is that hand finishing efforts were effective at mitigating the roughness caused by paver stops.

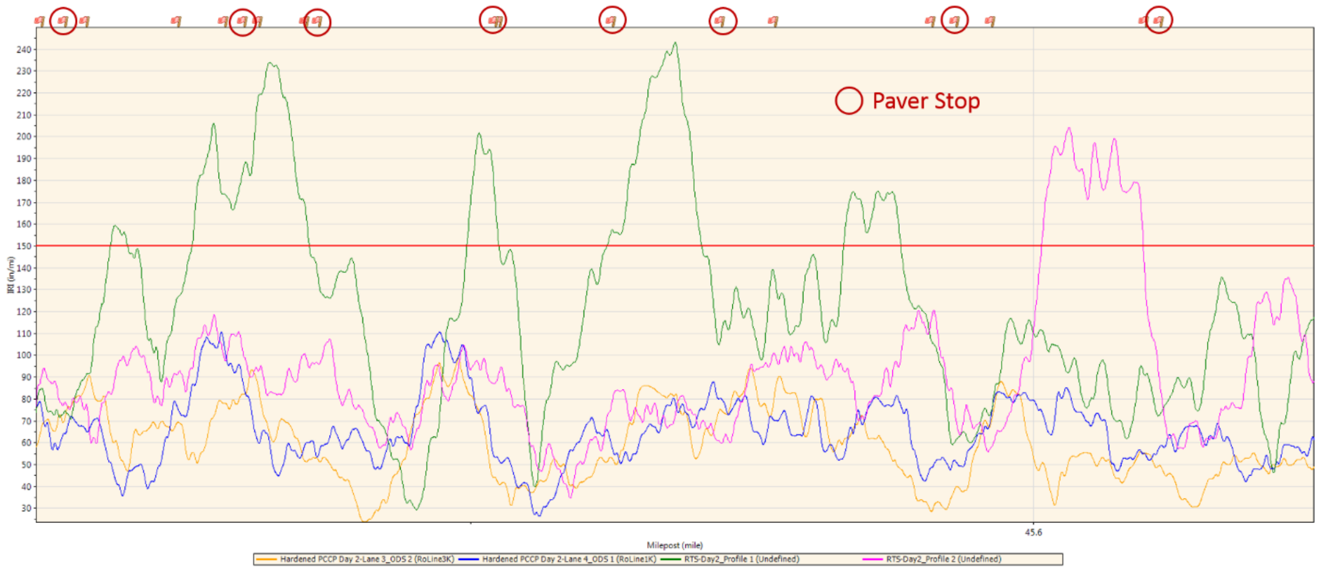

Figure 16. Localized Roughness and Paver Stops

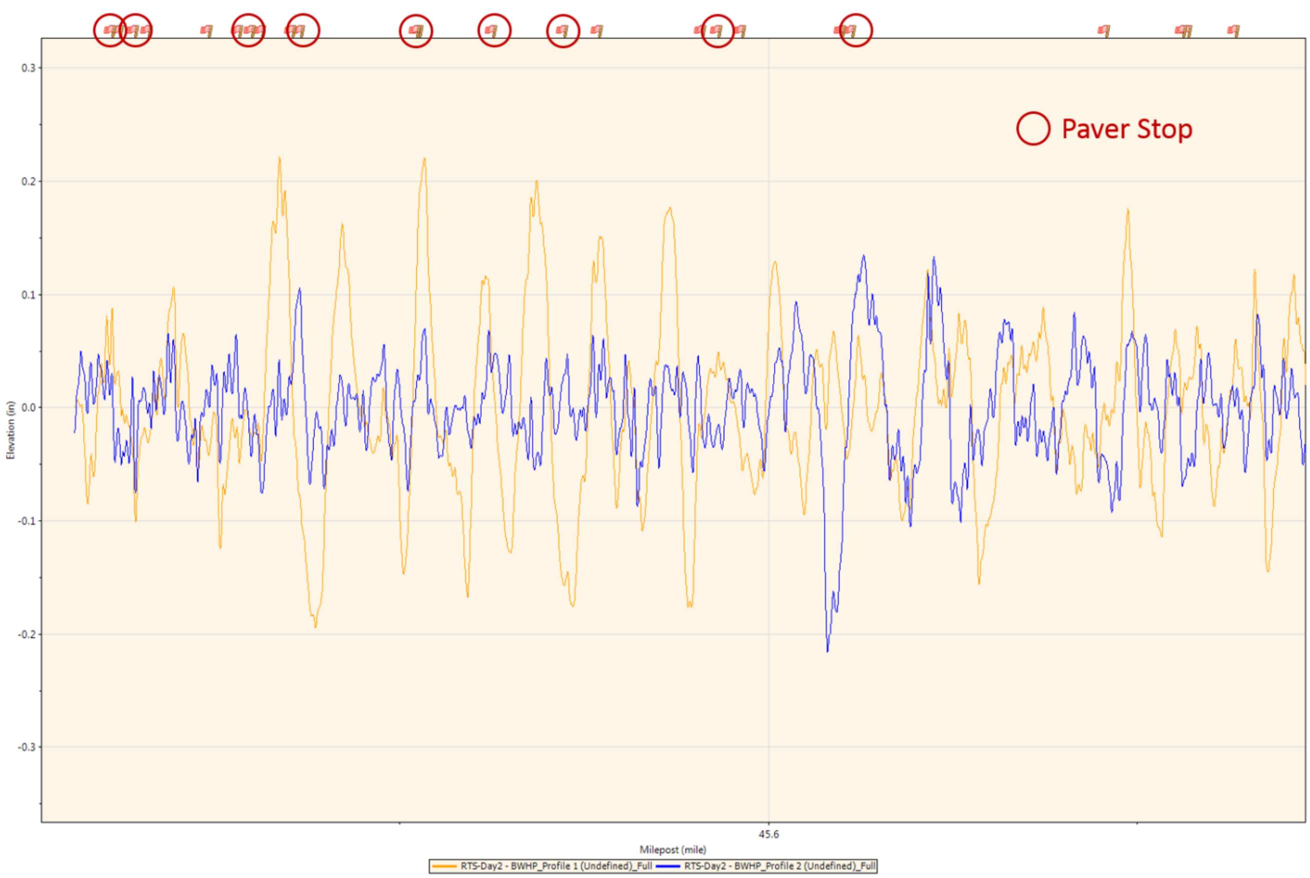

Figure 17. High-Pass Filtered RTP profiles from April 22, 2015 Showing Paver Stops

CONCLUSIONS and LESSONS LEARNED

The following points summarize the preliminary conclusions made from profile analyses and on-site documentation as well lessons learned from the equipment loan.

Profile Analyses:

- Paver stops and a qualitative assessment of concrete head height within the paving box was tracked for most of April 22nd - there was no clear correlation between material head height and the RTP profiles or localized roughness.
- There was not a noticeable difference in smoothness (hardened profile) between the areas where the auto float was and was not used. The RTP was in front of the auto float, so there would not be any effects on the RTP measurements.
- April 22nd side-by-side analysis – the RTP picked up a lot of the longer wavelength content, but this content is not associated with the asphalt base and is not present in the hardened profiles.
- The RTP picked up load spacing for April 21st, which was also reflected in the hardened profile. This wavelength was not as dominant during the second part of the day as the first, possibly due to changes in the concrete mixture.
- The RTP picked up joints and harmonics much more than hardened profile for both days. Finishing likely removed the effects picked up by the RTP.
- Changes to the paver operation and/or the concrete mixture after the first part of April 21st seem to have significantly improved smoothness for the remainder of April 21st and all of April 22nd.
- There appeared to be some effect of paver stops on roughness (from the RTP), but the correlation was not always apparent.

SHRP2 Implementation Team and Contractor Observations

- Project constraints (staged construction phases) limited the opportunities for data collection to 4 days.
- Installation of the Ames RTP is relatively simple, requiring approximately 4 hours. With multiple wiring harnesses, the RTP could be moved to other paving machines with minimal effort.
- Care must be taken to mount the RTP sensors at the correct height and assure that they are tracking parallel to the edge of the pavement.
- Someone should be assigned to be the primary caretaker of the real-time smoothness data:
    - Analysis should be done soon after paving is completed for the day (IRI and PSD).
    - Files should be named and organized in a manner that makes it easy to perform comparative analyses between real-time and hardened QC profile data.
    - Comparative analyses should be done every day.
- Software improvements would add greater benefit to using the RTP:
    - Capability to store event markers.
    - Enhanced real-time identification of must grind locations.
    - Improved vertical scale adjustment of the real-time display.
- An exit interview was conducted with the paving superintendent, his observations regarding real-time smoothness measurements included:

    - Vibrator frequency is often adjusted out of convenience to improve the finishing characteristics of a slab, using real-time smoothness measurements allows the crew to see if those adjustments are adversely affecting the smoothness.
    - Large profile events (e.g. must grinds) can be seen on the real-time display and assist the concrete finishers in mitigating the bump and/or dip.
    - Stringless paver controls and IRI smoothness specifications are changing the slipform paving process; real-time smoothness equipment is one tool to help the contractors better understand their processes and improve them.
- The contractor purchased an Ames RTP soon after the conclusion of the SHRP2 equipment loan.

SHRP2 PERFORMANCE MEASURES

FHWA has developed performance measurements to assist in assessing the effectiveness of this implementation effort. A summary of the measurements applicable to this equipment loan is shown in Tables 5 and 6.

OUPUT

None applicable

OUTCOME

Table 5. Outcome Performance Measures

Outcome Measures	Commentary	Supporting Data
Number of successful field trials performed by Dec 2016.	1	*Field report*
Number of equipment purchases.	2	*Invoice*
Documentation of field trials and lessons learned.	1	Field report
Adoption of technology by contractors	1	*Vendor phone call*
Sustainability and ability for long-term use of technology	The contractor recognized the need for and benefit of real-time smoothness measurement	Exit interview and purchase of a system
Reduced construction zone exposure	Not quantifiable for this project	
Improved IRI using this technology over existing methods	Improvements were made during the equipment loan	Data analyses included in the field report
Reduction of bump grinds to achieve IRI compared to existing methods	Not quantifiable for this project	
Real time identification of objectionable profile characteristics, their root causes, and appropriate corrective measures, minimizing more costly corrections later	Yes – localized roughness was observed and corrected in real-time	Data analyses included in the field report
Fewer penalties associated with pavement smoothness imposed on contractor	Not quantifiable for this project	

IMPACT

Table 6. Impact Performance Measures

Impact Measures	Commentary	Supporting Data
Save Time- Reduced average construction duration across all PCC projects	Not quantifiable for this project	
Save Time- Less road user delay associated with shorter construction duration	Not quantifiable for this project	
Save Time- Refined specification for materials, equipment, and process needed to produce desired quality and smoothness helps reduce time needed for putting together job special provisions for future contracts	Not quantifiable for this project	
Save Money- Better adherence to quality specifications	Not quantifiable for this project	
Save Money- Longer PCC pavement life leads to fewer repairs and reconstruction cycles	Not quantifiable for this project	
Save Money- Fewer re-couping of penalties by passing costs on through future pavement projects, driving down costs associated with transportation improvement program	Contractor purchase of the equipment validates that the capital investment for this equipment should provide a return on investment that is typically passed on through future bids.	Equipment purchase by the contractor
Save Money – Reduced instances of hand finishing (need to determine how real time smoothness values correlate to the hardened IRI values)	Not quantifiable for this project	

Appendix: Notes

Daily Observations

The following summarizes field notes and general observations made during the equipment loan and analysis of the profile data.

April 21, 2015:

PSD Content:

- RTP
  - 15′ content (joint spacing) and associated harmonics (7.5′, 5′, 3.75′, 3′) were more dominant during the first part of the day (File 3) than second part (File 4).
  - ~10.6′ content (determined to be load spacing) was also more dominant during the first part of the day (File 3) than second part (File 4).
  - Longer wavelength content (~35′-90′) was much more prevalent in the left RTP trace (RWP of Lane 3) for whole day.
  - Joint content more dominant in right RTP trace; 10.6-11′ content more dominant in left RTP trace.
- Hardened QC Profiles (only right trace from Lane 3 and left trace from Lane 4, corresponding to locations of RTP sensors were analyzed)
  - Dominant content at 10.6′-11′; much more dominant for first part of day (File 3) than second part of the day (File 4).
  - Dominant content at 15′ (joint spacing), harmonics at 7.5′, 5′, 3.75′, 3′, 2.5′ – more dominant first part of the day than second.
- Asphalt Base (only left trace from Day 5, corresponding to right padline was analyzed)
  - First part (File 3): Longer wavelength content (~40-100′) is dominant. Spike at 41.5′ after high-pass filtering at 50′.
  - Second part (File 4): Longer wavelength content (~20-100′) is dominant. Spike at ~90′.

IRI:

- RTP: First part of the day (File 3) was significantly rougher than second part of the day.
  - MRI = 112-124 in/mi (0.1 mile lots) for first part of the day
  - MRI = 78-101 in/mi (0.1 mile lots) for second part of the day
- Hardened profile was significantly lower than RTP:
  - MRI = 68-98 in/mi (0.1 mile lots) for first part of the day
  - MRI = 57-63 in/mi (0.1 mile lots) for second part of the day

Localized Roughness:

- RTP: Significantly more localized roughness the first part of the day and at the very beginning of the second part of the day.
- Left profile (RWP of Lane 3) was consistently rougher than right profile (LWP of Lane 4).
- Most localized roughness, with the exception of some of the first part of the day, was not present in the hardened profile.

April 22, 2015:

PSD Content:

- RTP
  - 15′ (joint spacing) content and associated harmonics (7.5′, 5′, 3.75′) were still present, but less dominant than Day 1.
  - Longer wavelength content (~40′-100′) still primarily dominant in left RTP trace.

  - Significant peaks at 45′, 60′, 90′ – likely subharmonics.
  - Only minor content at 10.6′, primarily in left RTP trace.
- Hardened Content
  - Dominant content is 15′ (joint spacing) and harmonics at 7.5′, 5′, 3.75′, 3′
  - Some longer wavelength content at ~25′-80′
- Asphalt Base (only left trace from Day 5, corresponding to right padline was analyzed)
  - Longer wavelength content (~25-100′) is dominant. Spike near 100′.
  - Spikes at 28′, 37′, 41.5′ after 50′ HP filtering.

IRI:

- RTP: Significant roughness through most of the day, MRI = 79-112 in/mi (0.1 mile lots).
- Hardened: Significantly lower roughness than RTP, MRI = 49-75 in/mi (0.1 mile lots)

Localized Roughness:

- RTP: Significantly more localized roughness toward the end of the day.
- Most localized roughness was not present in hardened profile.

April 23, 2015:

- RTP Located ~4-5 ft from outside edges of paver (Lane 3 LWP, Lane 4 RWP)

PSD Content:

- RTP
  - Joint spacing and associated harmonics are most dominant content. More dominant on left side of paver (padline on existing pavement) than right side.
  - Some content at 10.5′-11′
- Hardened Profile
  - Joints are the predominant content, but a 10.5-11′ feature also shows in the hardened profile, more so in Lane 3 than Lane 4.
- RTP vs Hardened
  - Joint content is much more dominant in RTP than hardened. Longer wavelength content (50′-100′) as well.

IRI:

- RTP: Moderate roughness throughout the day (MRI = 84-105 in/mi), improving during the day
- Hardened:
  - MRI = 61-71 in/mi
  - MRI = 53-62 in/mi
  - Both improving over the course of the day (Lane 4 more than Lane 3)

Localized Roughness:

- Hardened vs RTP: no trend for either throughout the day; hardened significantly smoother than RTP
- Potentially some localized roughness introduced by finishers at MP 44.83 (2367+08)
- No noticeable difference in area where autofloat was not used

April 24, 2015:

PSD Content:

- RTP

- Joint spacing and associated harmonics are most dominant content. More dominant on left side of paver (padline on existing pavement) than right side.
- Longer wavelength content (30’-80’) also present, more so on left side of paver.

- Hardened Profile
  - Joint spacing and associated harmonics are most dominant content.
  - No content at 10.5’-11’
- RTP vs Hardened
  - Joint content is much more dominant in RTP than hardened. Longer wavelength content (30’-100’) as well.

IRI:

- RTP: Moderate roughness throughout the day (MRI = 98-106 in/mi), very slight improvement during the day
- Hardened:
  - MRI = 62-65 in/mi (Lane 3)
  - MRI = 59-64 in/mi (Lane 4)

Localized Roughness:

- Hardened vs RTP: no trend for either throughout the day; hardened significantly smoother than RTP
- No noticeable localized roughness where base transitioned from asphalt to granular.