EL06-2016 **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**

FIELD REPORT: IOWA EQUIPMENT LOAN

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:

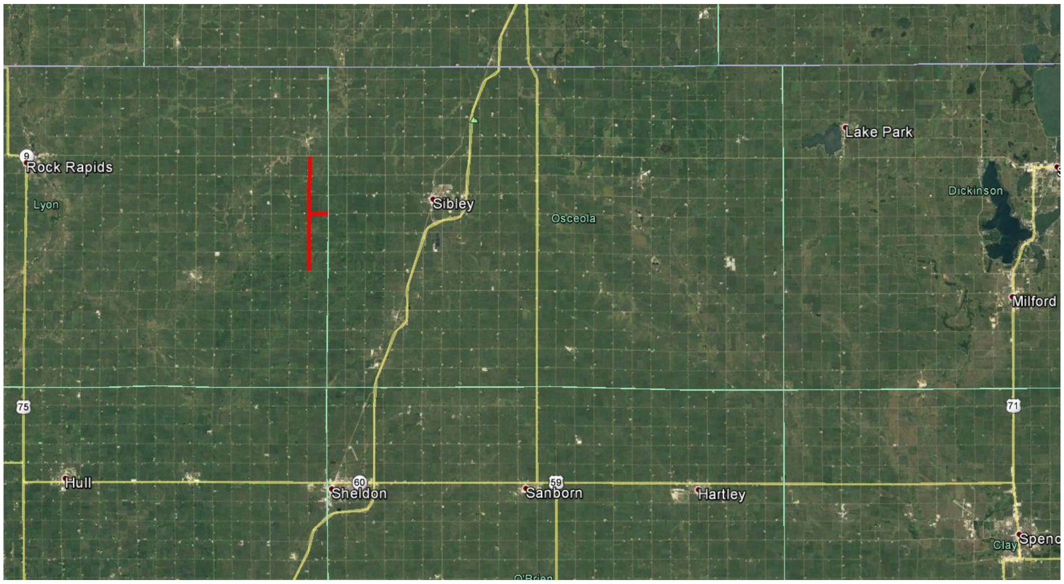
- Provide equipment (GOMACO GSI or Ames RTP) and labor for a field trial of 10 to 30 paving days
- Provide technical assistance for equipment installation start-up and operation
- On-call technical support throughout the duration of the field trial
- Planning, coordination and execution of the field 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

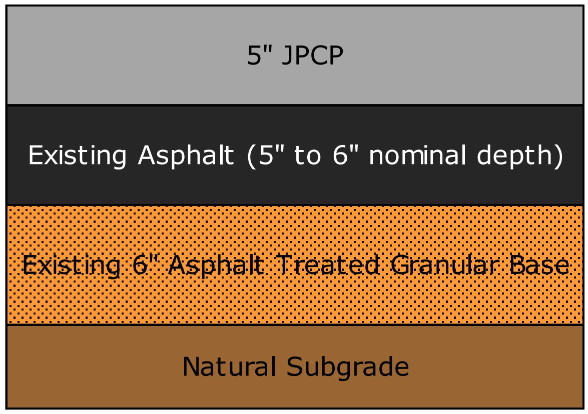
This report summarizes the activities and findings of the equipment loan conducted in Iowa.

PROJECT DETAILS

The equipment loan was performed in April 2016 on a project in Lyon County, Iowa. Table 1 summarizes the pertinent project details.

Table 1. Lyon County, IA, L-26 Project Information

Item	Details
Project Location	Mainline paving of an unbonded overlay of Lyon County, L-26. 
Route	L-26 & A-22
Agency	Iowa Department of Transportation (IADOT) and Lyon County

Item	Details
Paving Contractor	Flynn Company, Inc.
Paving Equipment	Guntert-Zimmerman S-850 paver and Leica stringless machine control
Real-Time System	Ames RTP
Typical Section	5” jointed plain concrete pavement (JPCP) on existing asphalt pavement.  Transition sections consisted of 8” dowel jointed plain concrete pavement (DJPCP) on subgrade.
Joint Spacing	Transverse: 6’ c/c Longitudinal: 6’ c/c (no tie bars in the overlay section)
Ames RTP Setup	Paver width = 24’ Sensor #1: approximate center of northbound lane Sensor #2: approximate center of southbound lane
Miscellaneous Details	A vibrator monitor was in use; vibrators were consistently operated in the range of 6,700 to 7,300 vpm. Burlap drag behind the trailing finishing pan. Hand finishing consisted of a 16’ straightedge with an approximate 3’ overlap. A 12’ float was used intermittently to seal the surface.

IMPLEMENTATION ACTIVITIES

Installation of the RTP took place on the morning of April 12, 2016. Collection of real-time profile data began that afternoon and continued through the night of April 21, 2016.

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 Activities
12APR2016	Install RTP and begin collecting data. Troubleshooting RTP software issues resulted in incomplete profile data files.
13APR2016	Real-time profile data collection, 7:30 am to 5:00 pm from approximately 100+50 to 69+00.
14APR2016	Real-time profile data collection, 7:00 am to 5:00 pm from approximately 68+20 to 32+50.
15APR2016	Real-time profile data collection, 7:00 am to 3:00 pm from approximately 32+30 to 12+50. IADOT representative on-site to observe real-time smoothness equipment.
18APR2016	No work (rain).
19APR2016	Real-time profile data collection, 8:00 am to 4:30 pm from approximately 12+35 to 0+00 and 0+00 to 12+75.
20APR2016	No work (rain).
21APR2016	Real-time profile data collection, 7:00 am to 5:00 pm from approximately 16+25 to 44+50.

OBSERVATIONS, DATA and ANALYSES

This equipment loan was initiated through a real-time smoothness briefing that was presented at the Iowa concrete paving conference in January of 2016. Representatives from the Flynn Company requested the equipment loan. Their interest was for multiple reasons:

1. the hydraulic system on the paver had been rebuilt over the winter,
2. IADOT has a draft specification for IRI that will be implemented in the future,
3. smoothness results from 2015 paving did not meet Flynn's standards of excellence.

Having the opportunity to try real-time smoothness equipment allowed Flynn to evaluate the performance of the paver's hydraulic system on the first project of 2016 and to familiarize themselves with IRI measurement in real-time before adoption of the specification by IADOT.

The paving observed by the SHRP2 team was typical mainline paving, Flynn's crews demonstrated quality workmanship and a clear understanding of slipform paving. No major issues were observed. However, as expected, the full depth 8" JPCP sections did have slightly higher real-time IRI values primarily due to the stop-and-start nature of setting load transfer baskets directly ahead of the paver. Figures 1 through 6 illustrate different aspects of the project and Flynn's paving processes.

Figure 1. RTP Installed Directly at the Rear of the Paver

Figure 2. Typical Finishing With a Straightedge

Figure 3. Concrete Dumped Directly in Front of the Paver

Figure 4. Lyon Co. L-26, Looking South Behind the Paver

Figure 5. Flynn Crew Member Observing Real-Time Smoothness Results on the RTP Display

Figure 6. Relatively High Level of Concrete at the Front of the Paver

CONCRETE MIXTURE

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

Table 3. L-26 Concrete Mixture Proportions

SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

REAL-TIME SMOOTHNESS IMPLEMENTATION

Mix Design & Project Info.

General Information	
Project:	LYON CO., IOWA L-26
Contractor:	FLYNN
Mix Description:	SLIPFORM MAINLINE
Mix ID:	C4WRC20
Date(s) of Placement:	

Cementitious Materials	Source	Type	Spec. Gravity	lb/yd^3	% Replacement by Mass
Portland Cement:	GCC	I/II	3.140	476	
GGBFS:					
Fly Ash:	HEADWATERS PN #3	C	2.700	118	19.87%
Silica Fume:					
Other Pozzolan:					
				594	**lb/yd^3**
				6.3	**sacks/yd^3**

Aggregate Information	Source	Type	Spec. Gravity SSD	Absorption (%)	% Passing #4
Coarse Aggregate:	CMT	QUARTZITE	2.640	n/a	n/a
Intermediate Aggregate:				n/a	n/a
Fine Aggregate #1:	HALLET ASHTON	NATURAL	2.690	n/a	n/a
Fine Aggregate #2:					

Coarse Aggregate %:	50.0%
Intermediate Aggregate %:	
Fine Aggregate #1 % of Total Fine Agg.:	100.0%
Fine Aggregate #2 % of Total Fine Agg.:	
Fine Aggregate #1 %:	50.0%
Fine Aggregate #2 %:	

Mix Proportion Calculations	
Water/Cementitious Materials Ratio:	0.430
Air Content:	6.00%

	Volume (ft3)	Batch Weights SSD (lb/yd3)	Spec. Gravity	Absolute Volume (%)
Portland Cement:	2.429	476	3.140	8.998%
GGBFS:				
Fly Ash:	0.700	118	2.700	2.594%
Silica Fume:				
Other Pozzolan:				
Coarse Aggregate:	9.078	1,496	2.640	33.624%
Intermediate Aggregate:				
Fine Aggregate #1:	9.078	1,524	2.690	33.624%
Fine Aggregate #2:				
Water:	4.093	255	1.000	15.160%
Air:	1.620			6.000%
	27.000	**3869**		**100.000%**
	Unit Weight (lb/ft^3)	**143.3**		

Admixture Information	Source/Description	oz/yd3	oz/cwt
Air Entraining Admix.:	BRETT AEA 92	5.94	1.00
Admix. #1:	BRETT EUCHON WR	23.76	4.00
Admix. #2:			
Admix. #3:			

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

Table 4. Tabular Sieve Analysis Data

REAL-TIME SMOOTHNESS IMPLEMENTATION

Combined Gradation Test Data

Project: LYON CO., IOWA L-26

Mix ID: C4WRC20

Sample Comments: MIX DESIGN FROM FLYNN

Test Date: MIX DESIGN SUBMITTAL

Total Cementitious Material:		594 lb/yd^3		
Agg. Ratios:	50.00%		50.00%	100.00%

Sieve	Coarse	Intermediate	Fine #1	Fine #2	Combined % Retained	Combined % Retained On Each Sieve	Combined % Passing
2 ½"	100%		100%		0%	0%	100%
2"	100%		100%		0%	0%	100%
1 ½"	100%		100%		0%	0%	100%
1"	100%		100%		0%	0%	100%
¾"	79%		100%		11%	11%	90%
½"	26%		100%		37%	27%	63%
⅜"	9%		100%		46%	9%	55%
#4	2%		100%		49%	4%	51%
#8	1%		83%		58%	9%	42%
#16	1%		60%		70%	12%	31%
#30	1%		33%		83%	14%	17%
#50	1%		8%		96%	13%	4%
#100	1%		2%		99%	3%	2%
#200	0.7%		1.6%		98.9%	0.3%	1.2%

Workability Factor:	**42.8**	34%	Coarse Sand
Coarseness Factor:	**78.4**	29%	Fine Sand

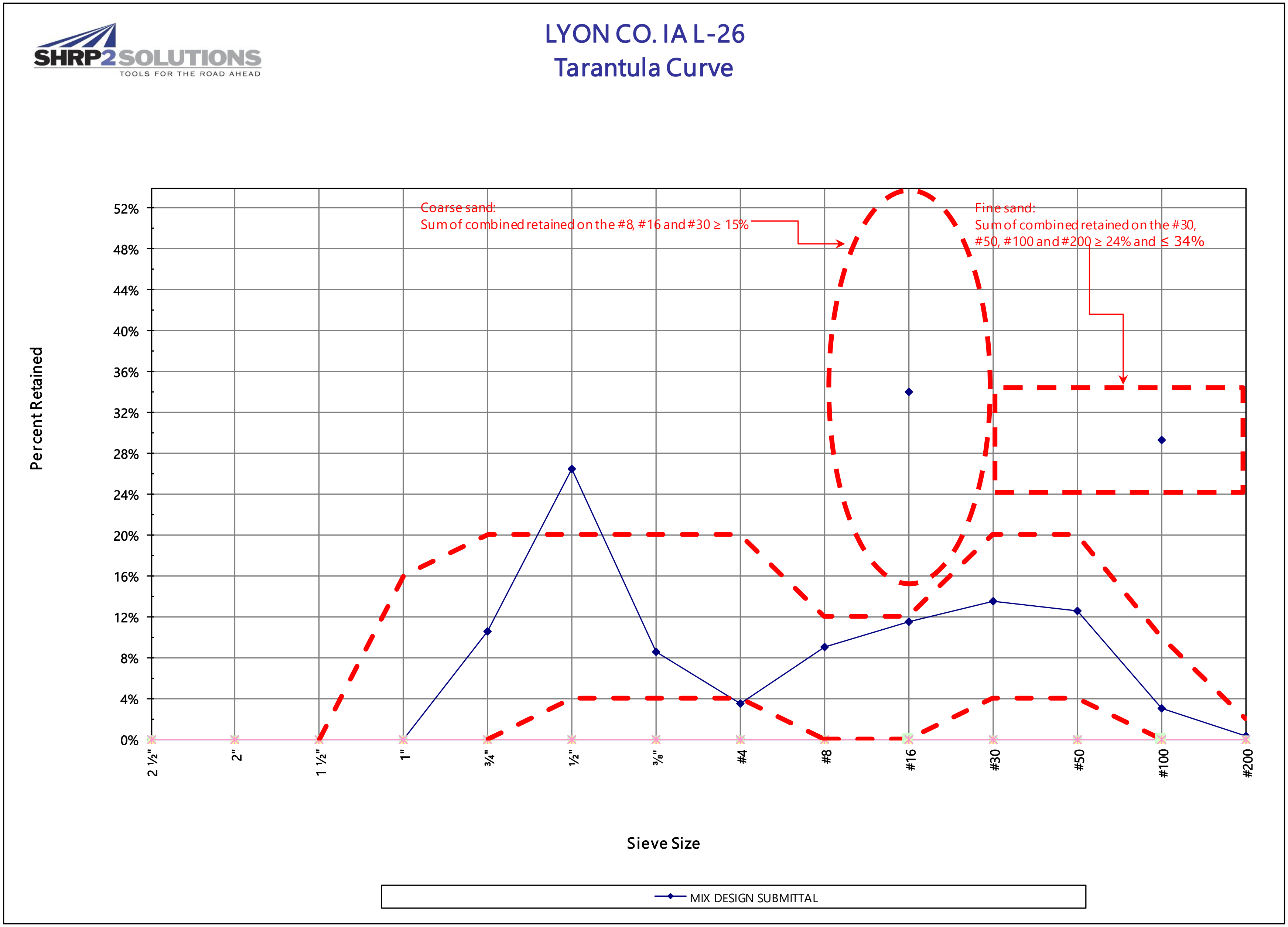


Figure 7. Lyon Co. L-26 Combined Percent Retained (Tarantula Curve)

LYON CO. IA L-26

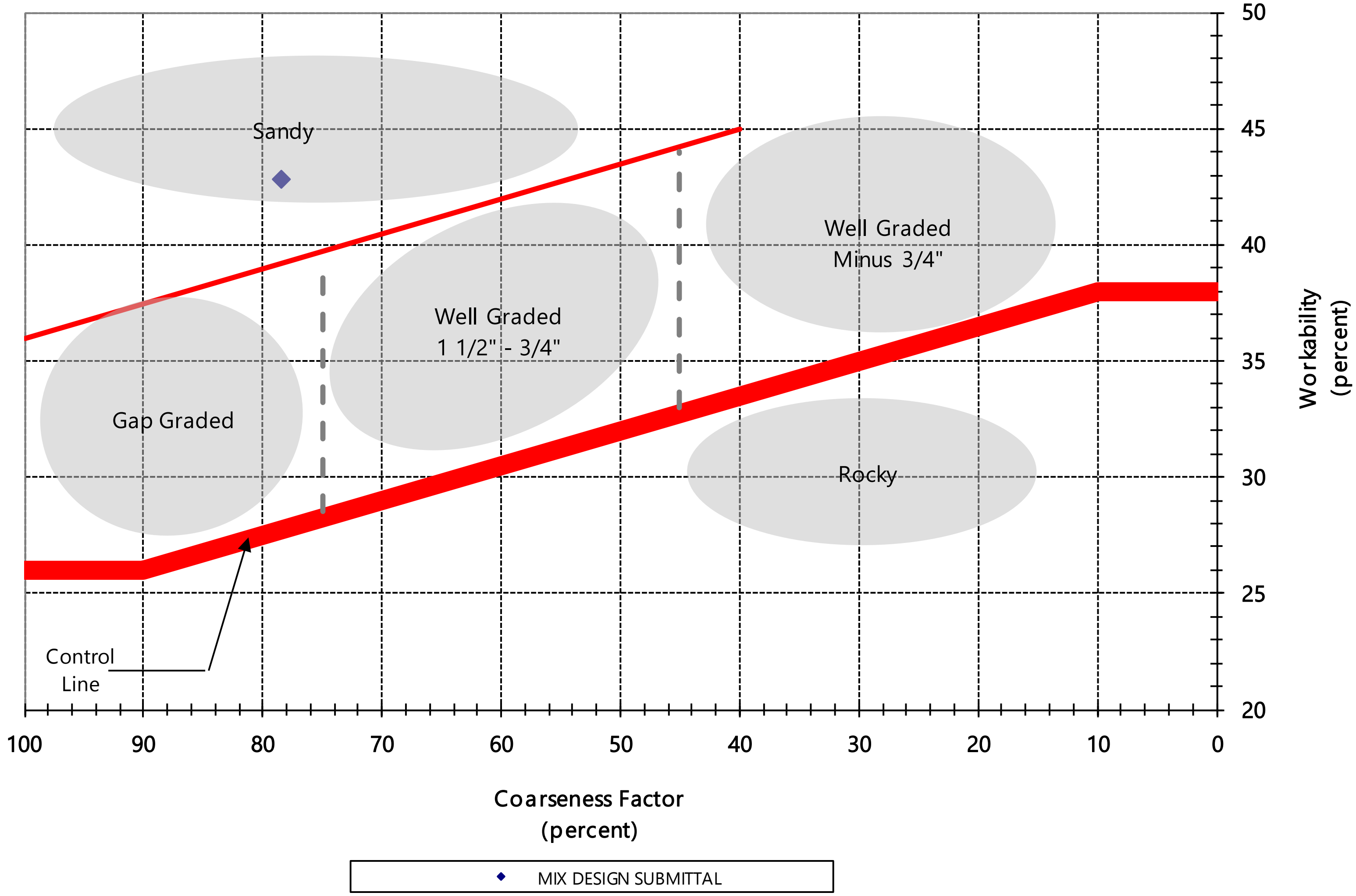


Figure 8. Lyon Co. L-26 Combined Gradation Coarseness and Workability Factors

PROFILE CHARCTERISTICS

The following information is provided to illustrate 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

Real-time smoothness measurements tracked closer than normal with hardened profile results. This is likely due to the fact that there is no embedded steel in any of the joints. A comparison of the first three days of profile results is shown in Table 5 and Figure 9.

Table 5. Tabular Results Comparing Real-Time and Hardened Profile Results

			RIGHT SIDE OF PAVER		LEFT SIDE OF PAVER			
HARDENED PROFILE SEGMENTS	LENGTH (ft)	MATCHED 0.10 mi SEGMENT #	HRD IRI LT (SB) (in/mi)	RTP IRI LT (SB) (in/mi)	HRD IRI RT (NB) (in/mi)	RTP IRI RT (NB) (in/mi)	Δ RTP-HRD (in/mi) SB	NB
-106+52.00								
-101+24.00	528		88		79			
-95+96.00	528		64		69			
-90+68.00	528	1	50	49	48	55	-1	7
-85+40.00	528	2	69	76	55	90	7	35
-80+12.00	528	3	56	60	46	61	4	15
-74+84.00	528	4	52	54	53	62	2	9
-73+45.00	139		78	78	61	85	0	24
-68+17.00	528		63		67			
-62+89.00	528	5	48	64	48	63	16	15
-57+61.00	528		51		52			
-52+33.00	528	6	57	54	54	71	-3	17
-50+91.00	142		43	58	48	54	15	6
-45+63.00	528	7	53	46	52	62	-7	10
-40+35.00	528	8	59	58	58	67	-1	9
-35+07.00	528	9	51	50	58	60	-1	2
-29+79.00	528		54		51			
-24+51.00	528	10	49	45	57	64	-4	7
-19+23.00	528	11	60	66	65	64	6	-1
-17+38.00	185		52	55	47	45	3	-2
AVERAGE			57.7	58.1	56.2	64.5	2.6	10.9

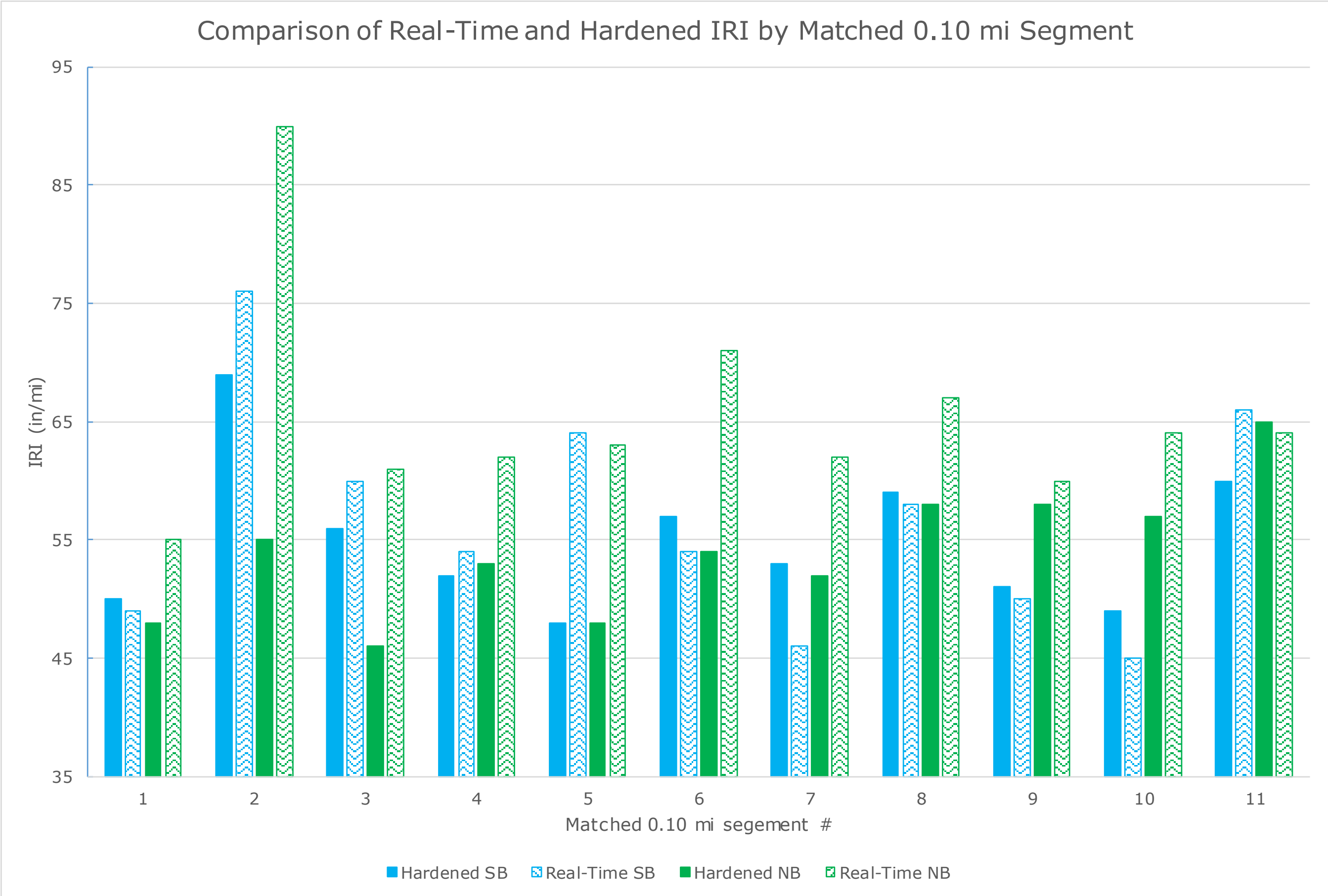


Figure 9. Real-Time and Hardened IRI for Matched Profile Sections

Repeating Profile Features

The power spectral density analysis (PSD) from ProVAL shows no shorter wavelength repeating features in either the real-time or hardened profiles (Figure 10). This again is likely due to the fact that there is no embedded steel in any of the joints and minimal curling and warping as a result of the small slab dimensions (6' x 6'). There is a repeating feature with a wavelength of approximately 55' which is more pronounced in the real-time profile than the hardened profile. The root cause(s) of this roughness was not identified during the equipment loan, one possible source that deserves further investigation is the 3D model,

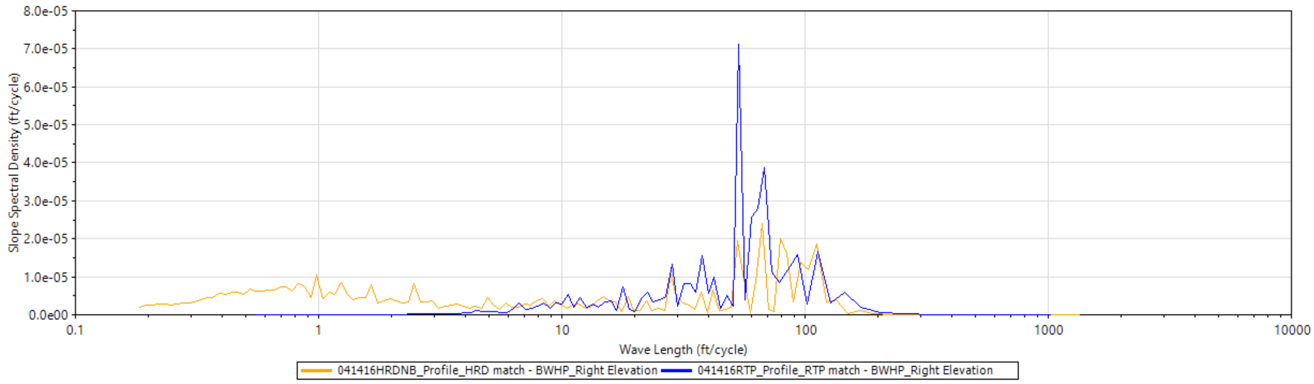


Figure 10. PSD Analysis Showing No Shorter Wavelength Repeating Features Contributing to Pavement Roughness

Paver Adjustments

Flynn’s years of experience with this paver and reviews of their hardened profile data had taught them that the right side of the paver was consistently rougher than the left side. A slight adjustment was made to the hydraulic sensitivity of the paver on 13APR2016. This adjustment improved the real-time smoothness of the right side and the effect was observable in real-time watching the localized roughness screen of the RTP display. The impact on hardened IRI is not discernable (Figure 11), perhaps due to hand finishing or other interfering factors that affect smoothness. Regardless, we know from experience that improving real-time IRI translates to overall lower hardened IRI.

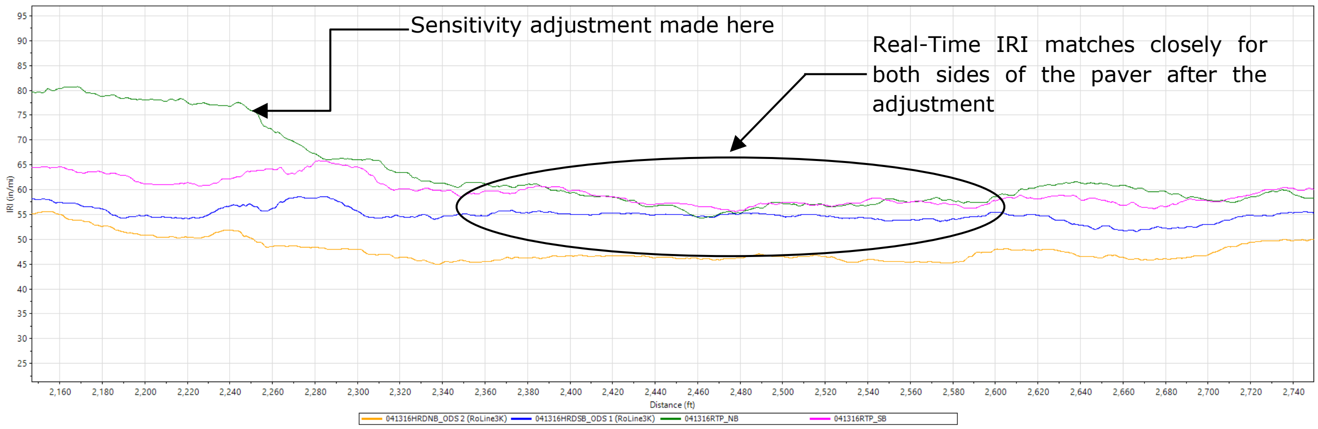


Figure 11. Continuous IRI (528’ segment length), Showing Improved Real-Time IRI After an Adjustment to Hydraulic Sensitivity

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:

- Real-Time and hardened profile results tracked closer than what is typically observed, averaging 2.6 in/mi and 10.9 in/mi higher for the southbound and northbound respectively.
- Due to the absence of any embedded steel and the small slab dimensions, there were no shorter wavelength repeating features contributing to roughness in either the real-time or hardened profiles.
- The RTP was beneficial in observing the positive effects of an adjustment to the hydraulic sensitivity of the paver.

SHRP2 Implementation Team and Contractor Observations

- An exit interview was conducted with the paving superintendent. His observations regarding real-time smoothness measurements included:
    - Sees a need for an RTP on days when project constraints and concrete mixture issues adversely impact IRI.
    - The impacts of process adjustments are seen much sooner using the RTP, which provides them the confidence to make adjustments sooner.
- Soon after the SHRP2 equipment loan, the contractor purchased an Ames RTP.