EL08-2016 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

SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

National Concrete Pavement Technology Center
CP Tech Center

FIELD REPORT: UTAH EQUIPMENT LOAN #8

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

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:

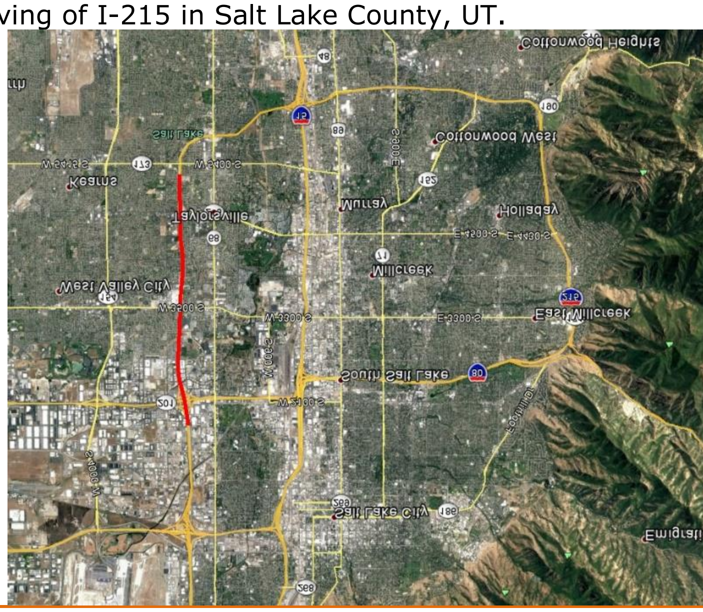
- Provide equipment (GOMACO GSI or Ames RTP) and labor for a field trial of 10 to 30 paving days
- Provide technical assistance for equipment installation start-up and operation
- On-call technical support throughout the duration of the field trial
- Planning, coordination and execution of the field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

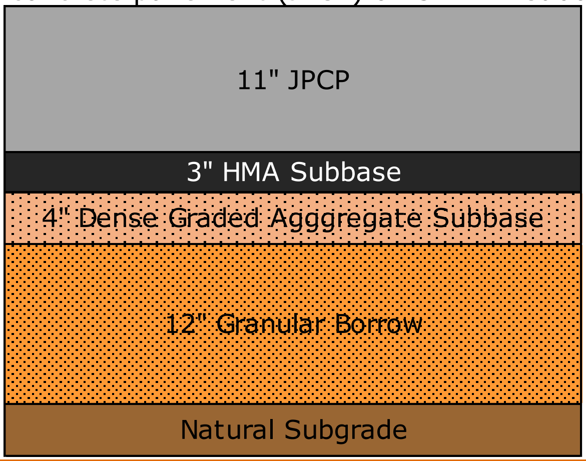
This report summarizes the activities and findings of an equipment loan conducted in Utah.

PROJECT DETAILS

The equipment loan was performed in July and August of 2016 on a project in Salt Lake County, Utah. Table 1 summarizes the pertinent project details.

Table 1. Salt Lake County, UT, I-215 Project Information

Item	Details
Project Location	Mainline paving of I-215 in Salt Lake County, UT. 
Route	I-215
Agency	Utah Department of Transportation (UDOT)
Paving Contractor	Ralph L. Wadsworth Construction Company (RLW)
Paving Equipment	Gomaco 2800 paver with DBI and Leica stringless machine control

Item	Details
Real-Time System	Gomaco GSI
Typical Section	11″ jointed plain concrete pavement (JPCP) on 3″ HMA subbase. 
Joint Spacing	Transverse: 15′ c/c Longitudinal: 12′ c/c
Gomaco GSI Setup	Paver width = 25′ Sensor #1: approximate 7′ off median edge. Sensor #2: approximate 6′ off edge nearest existing pavement.
Miscellaneous Details	A vibrator monitor was in use; vibrators were consistently operated in the range of ±8,500 vpm. Turf drag behind the paver and auto-float. Hand finishing consisted of a 16′ straightedge with an approximate 3′ overlap and a 6′ channel float.

IMPLEMENTATION ACTIVITIES

Installation of the GSI 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
13JUL2016	Install GSI.
14JUL2016	Project coordination and mix proportion analyses.
15JUL2016	GSI calibration and project coordination.
16JUL2016	Real-time profile data collection, 5:30 pm to 8:30 am.
17JUL2016	Real-time profile data collection, 5:30 pm to 4:30 am.
18JUL2016	Real-time profile data collection, 6:30 pm to 2:30 am.
19JUL2016	Real-time profile data collection, 6:30 pm to 12:00 am.
20JUL2016 through 08AUG2016	GSI was left with the contractor for continued unsupervised use.
09AUG2017	Uninstall the GSI

OBSERVATIONS, DATA and ANALYSES

This equipment loan was initiated through discussions with the local concrete pavement association representative. It was planned to coincide with the *Real-Time Smoothness Technology National Showcase* held in Salt Lake City, UT on August 9th, 2016. Both the contractor and UDOT were interested in utilizing the RTS equipment because UDOT had just recently transitioned from a profilograph index (PI) to an international roughness index (IRI) for pavement smoothness acceptance.

The paving observed by the SHRP2 team was urban mainline paving, and presented challenges typical to that type of work. Drainage inlets, paving adjacent to temporary barrier wall, and night paving were just some of the factors which complicate this type of paving. RLW's crews demonstrated quality workmanship and a clear understanding of slipform paving materials and processes. No major issues were observed during our tenure on the project.

Figures 1 through 4 illustrate different aspects of the project and RLW's paving processes.

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

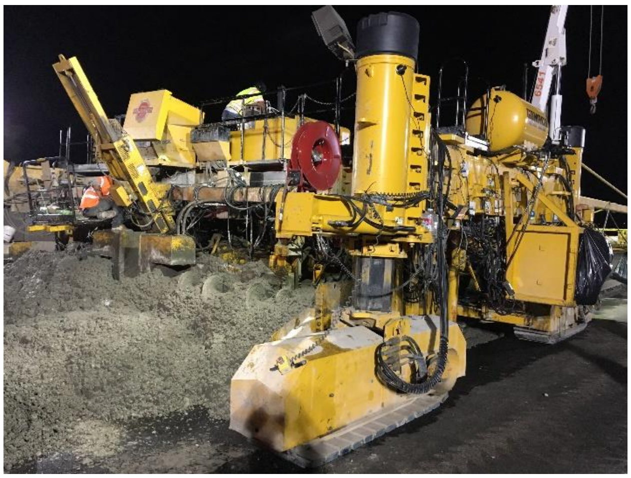


Figure 2. Concrete Dumped Directly in Front of the Paver

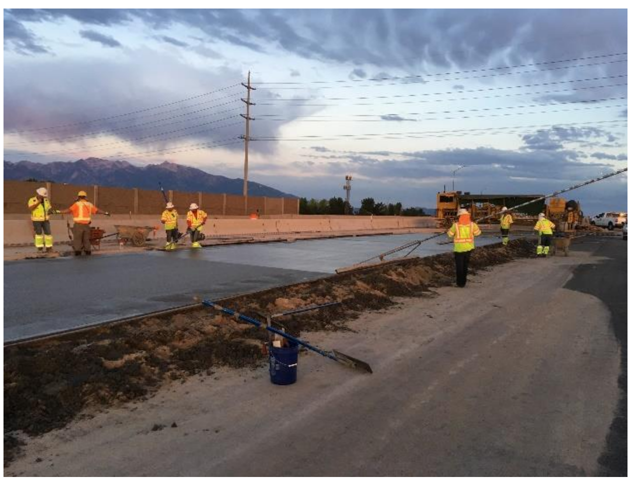


Figure 3. Typical Finishing Hand Finishing Behind the Paver

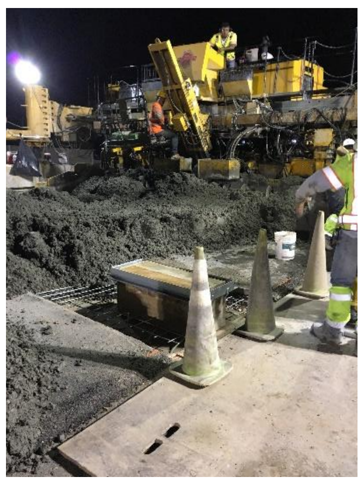


Figure 4. Paving at a Drainage Structure

CONCRETE MIXTURE

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

Table 3. I-215 Concrete Mixture Proportions

SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

REAL-TIME SMOOTHNESS IMPLEMENTATION

Mix Design & Proect Info.

General Information

Project:	SALT LAKE COUNTY, I-215, 300 EAST TO SR-201
Contractor:	RLW
Mix Description:	SLIPFORM MAINLINE #2
Mix ID:	
Date(s) of Placement:	

Cementitious Materials	Source	Type	Spec. Gravity	lb/yd^3	% Replacement by Mass
Portland Cement:	ASH GROVE		n/a	459	
GGBFS:					
Fly Ash:	NAVAJO	F	n/a	152	24.88%
Silica Fume:					
Other Pozzolan:					
				611	**lb/yd^3**
				6.5	**sacks/yd^3**

Aggregate Information	Source	Type	Spec. Gravity SSD	Absorption (%)	% Passing #4
Coarse Aggregate #1:	STAKER - PT WEST #4		n/a	n/a	n/a
Intermediate Aggregate:	STAKER - PT EAST #8		n/a	n/a	n/a
Fine Aggregate #1:	STAKER - EAST		n/a	n/a	n/a
Coarse Aggregate #2:	STAKER - PT EAST #57				

Coarse Aggregate %:	n/a
Intermediate Aggregate %:	n/a
Fine Aggregate #1 % of Total Fine Agg.:	n/a
Fine Aggregate #2 % of Total Fine Agg.:	n/a
Fine Aggregate #1 %:	n/a
Fine Aggregate #2 %:	n/a

Mix Proportion Calculations

Water/Cementitious Materials Ratio:	0.400
Air Content:	6.00%

	Volume (ft3)	Batch Weights SSD (lb/yd3)	Spec. Gravity	Absolute Volume (%)
Portland Cement:	n/a	459	n/a	n/a
GGBFS:				
Fly Ash:	n/a	152	n/a	n/a
Silica Fume:				
Other Pozzolan:				
Coarse Aggregate #1:	n/a	548	n/a	n/a
Intermediate Aggregate:	n/a	300	n/a	n/a
Fine Aggregate #1:	n/a	1,192	n/a	
Coarse Aggregate #2:	n/a	921		n/a
Water:	n/a	244	1.000	n/a
Air:	n/a			n/a
		3816		
	Unit Weight (lb/ft^3)	**141.3**		

Admixture Information	Source/Description	oz/yd3	oz/cwt
Air Entraining Admix.:	BASF MASTERAIR 200	15.30	2.50
Admix. #1:	BASF POZZ 80	24.45	4.00
Admix. #2:			
Admix. #3:			

Combined gradation data is provided in Table 4 and Figures 5 and 6.

Table 4. Tabular Sieve Analysis Data

SHRP2 SOLUTIONS TOOLS FOR THE ROAD AHEAD

REAL-TIME SMOOTHNESS IMPLEMENTATION

Combined Gradation Test Data

Project: SALT LAKE COUNTY, I-215, 300 EAST TO SR-201

Mix ID: n/a

Sample Comments: MIX DESIGN FROM RLW

Test Date: SUPPLIER AVERAGES FROM VARIOUS DATES

Total Cementitious Material: 611 lb/yd^3

Agg. Ratios: 18.50% 10.10% 40.30% 31.10% 100.00%

Sieve	Coarse #1 (#4)	Intermediate (#8)	Fine #1	Coarse #2 (#57)	Combined % Retained	Combined % Retained On Each Sieve	Combined % Passing
2 ½"	100%	100%	100%	100%	0%	0%	100%
2"	100%	100%	100%	100%	0%	0%	100%
1 ½"	99%	100%	100%	100%	0%	0%	100%
1"	35%	100%	100%	100%	12%	12%	88%
¾"	3%	100%	100%	93%	20%	8%	80%
½"	1%	100%	100%	45%	35%	15%	65%
⅜"	1%	94%	100%	15%	45%	10%	55%
#4	*1%*	13%	98%	2%	58%	13%	42%
#8	*1%*	3%	88%	1%	64%	5%	36%
#16	*1%*	1%	57%	1%	76%	13%	24%
#30	*1%*	1%	38%	*1%*	84%	8%	16%
#50	*1%*	1%	24%	1%	90%	6%	10%
#100	*1%*	*1%*	10%	*1%*	95%	6%	5%
#200	0.4%	0.5%	2.6%	0.3%	98.7%	3.4%	1.3%

Workability Factor: 37.5

Coarseness Factor: 71.2

26% Coarse Sand

22% Fine Sand

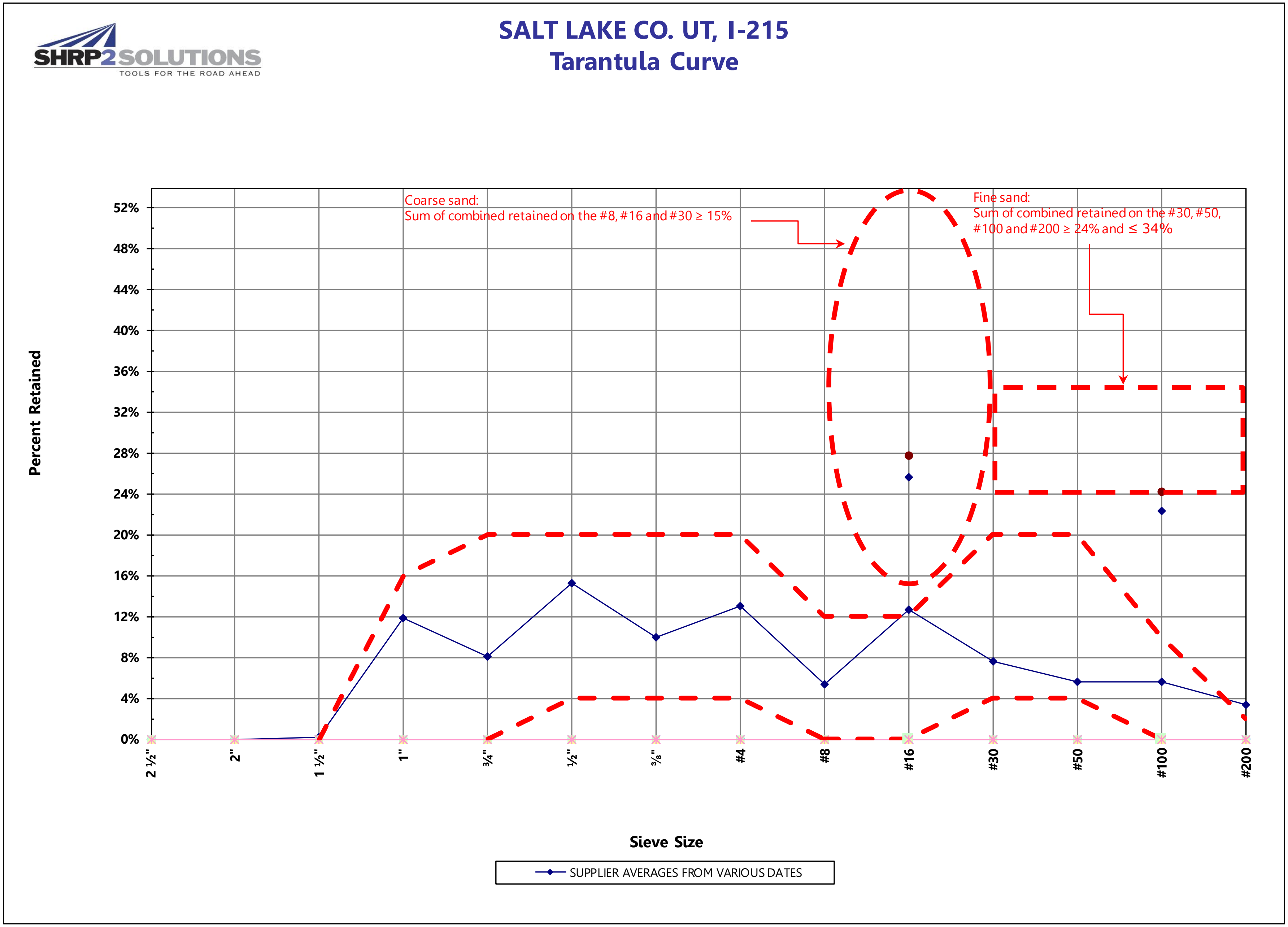


Figure 5. I-215 Combined Percent Retained (Tarantula Curve)

SALT LAKE CO. UT, I-215

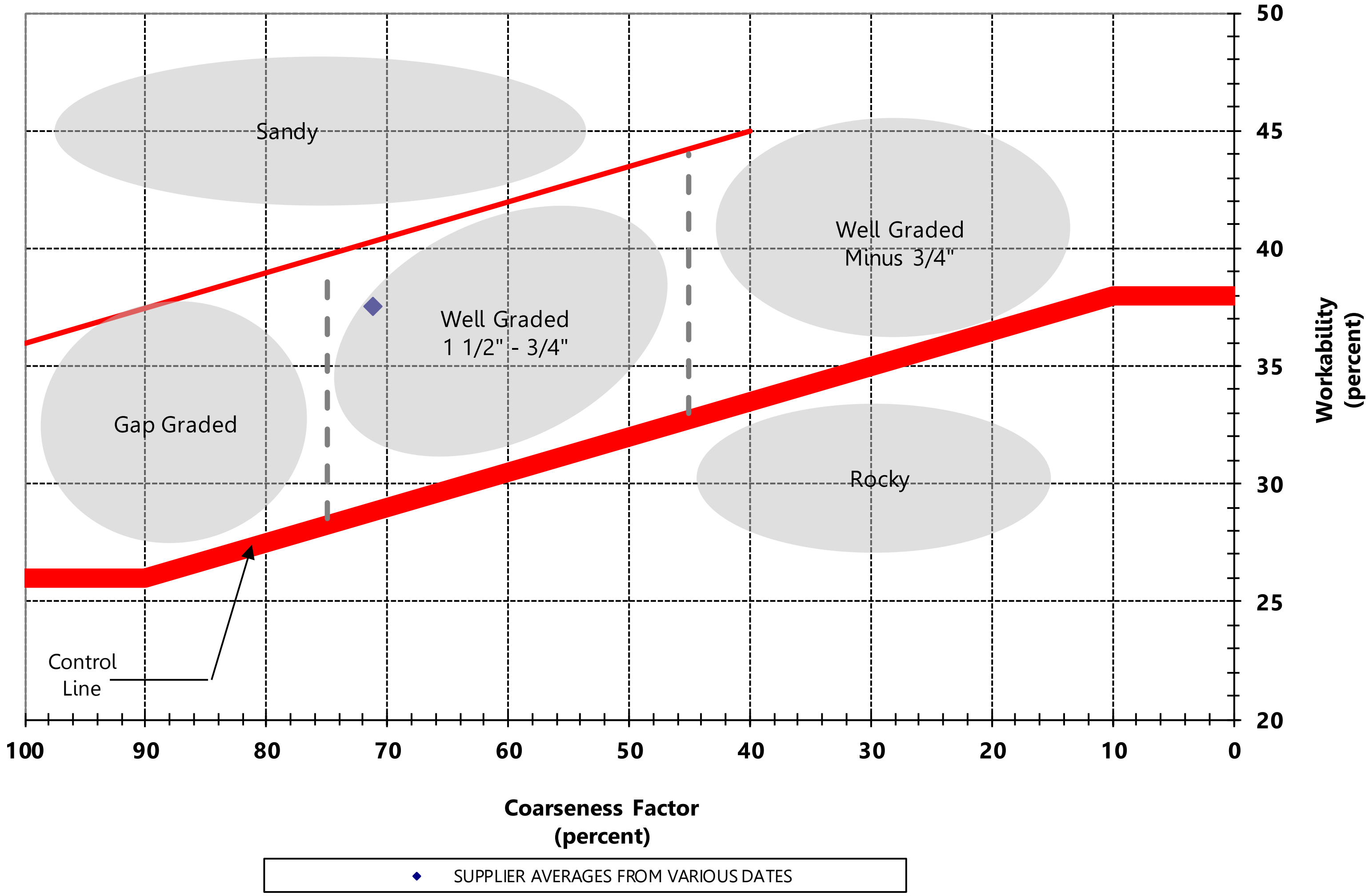


Figure 6. I-215 Combined Gradation Coarseness and Workability Factors

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

The real-time smoothness results for the first night of paving had lower IRI values than the hardened profiles (Table 5). It was apparent that the auto-float was not adjusted properly, introducing roughness behind the GSI sensors that was not fully removed by the hand finishers.

Table 5. Real-Time and Hardened IRI for 500' Section of Matched Profiles with Auto-Float Operating on July 16, 2016.

		IRI (in/mi)		
Location	Description	Real-Time	Hardened	Difference
1026+47 to 1031+47	Shoulder	76	88	12
	Lane	66	96	30

This relationship between real-time and hardened IRI values is not the norm, and RLW subsequently removed the auto-float from use on the second night's paving which resulted in lower IRI values for the hardened profiles (Table 6).

Table 6. Real-Time and Hardened IRI for 800' Section of Matched Profiles with No Auto-Float Operating on July 20, 2016.

		IRI (in/mi)		
Location	Description	Real-Time	Hardened	Difference
1072+00 to 1080+00	Shoulder	49	46	-3
	Lane	56	50	-6

The difference between real-time and hardened IRI as shown in Table 6 is typical for initial smoothness values in the ±50 in/mi range.

Repeating Profile Features

The power spectral density analysis (PSD) from ProVAL shows the 15' joint spacing and 5' harmonic as the dominant wavelengths contributing to roughness. These wavelengths are present in the real-time and hardened profiles (Figure 7). This is typical for JPCP with initial smoothness in the ±50 in/mile range.

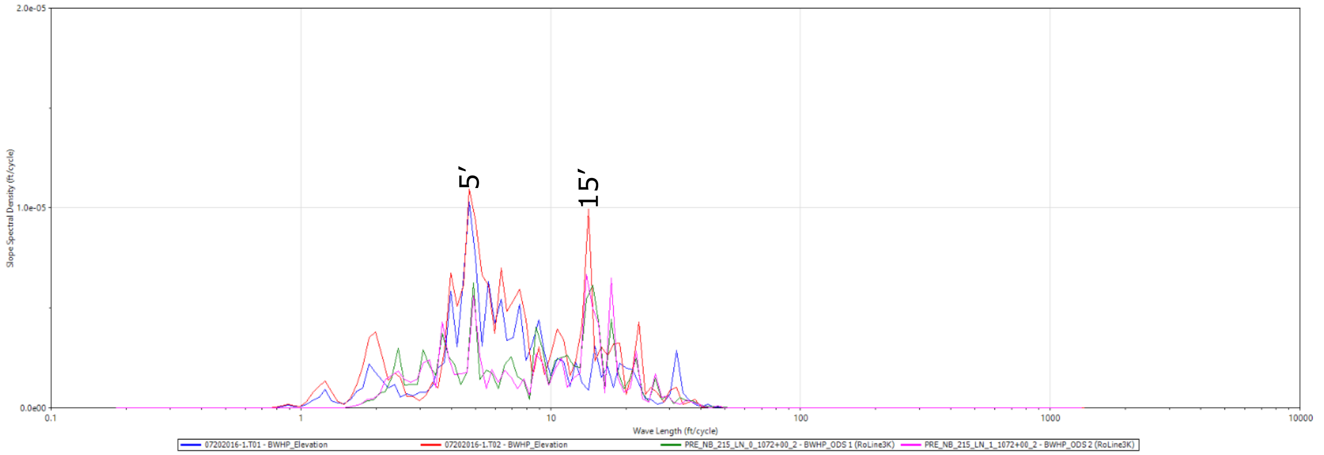


Figure 7. PSD Analysis Showing Joint Spacing at 15′ and 5′ Harmonic Wavelengths Contributing to Pavement Roughness

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:

- Removal of the auto-float improved the hardened profile substantially.
- Initial smoothness (real-time and hardened) improved after the first night of paving and remained consistently below 70 in/mile,
- The influence of dowel bars at the transverse joints is the largest impact on initial smoothness in sections where paving is consistent and other factors are not influencing the paving process.

SHRP2 Implementation Team and Contractor Observations

- An exit interview was conducted with the paving superintendent. His observations regarding real-time smoothness measurements included:
  - The GSI provides valuable real-time feedback regarding initial smoothness.
  - The ability to see the impacts of process adjustments in an hour or two provides confidence to make changes in the processes.
- Soon after the SHRP2 equipment loan, the contractor purchased an Gomaco GSI.