EL10-2016 **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
Tech Center

FIELD REPORT: CALIFORNIA 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

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:

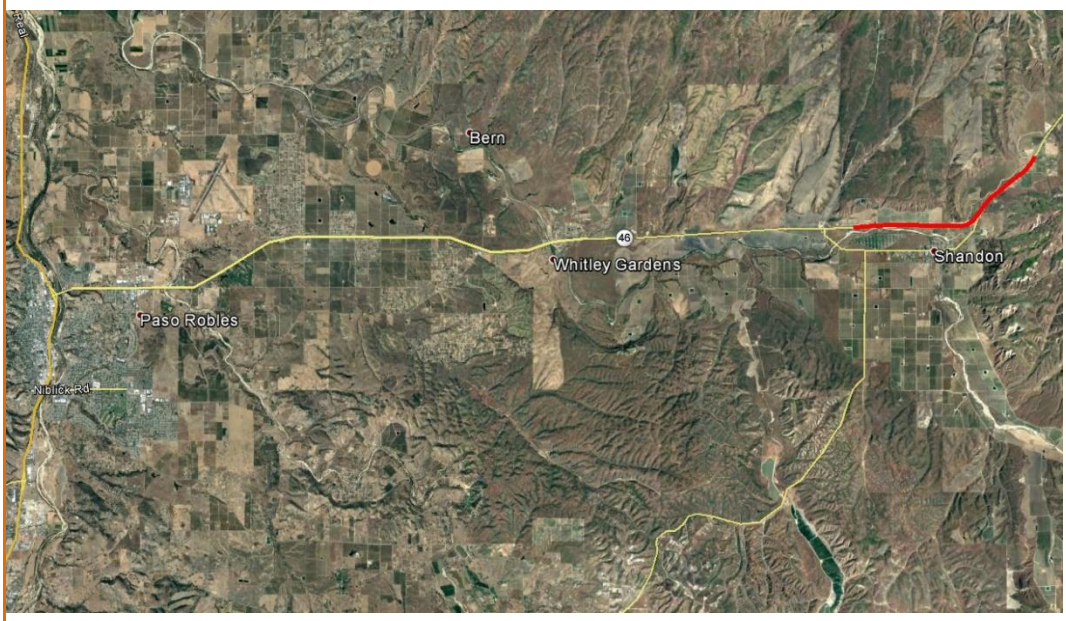
- Provide equipment (GOMACO GSI or Ames RTP) and labor for a field trial of 10 to 30 paving days
- Provide technical assistance for equipment installation start-up and operation
- On-call technical support throughout the duration of the field trial
- Planning, coordination and execution of the field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

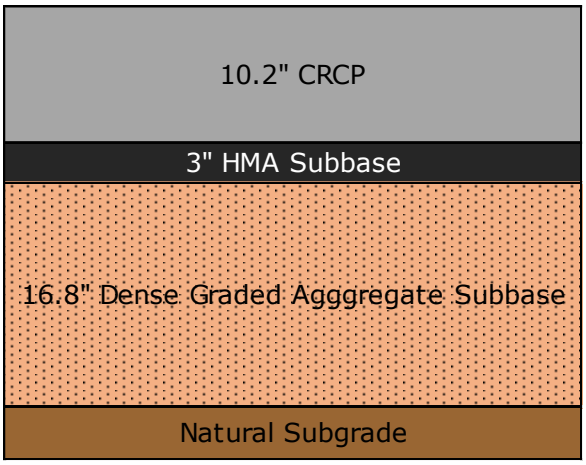
This report summarizes the activities and findings of the equipment loan conducted in Iowa.

PROJECT DETAILS

The equipment loan was performed in October 2016 on a project in San Luis Obispo County, California. Table 1 summarizes the pertinent project details.

Table 1. San Luis Obispo County, CA, SR-46 Project Information

Item	Details
Project Location	Mainline paving of a new CRCP on SR-46. 
Route	SR-46

Item	Details
Agency	Caltrans
Paving Contractor	Brosamer and Wall, Inc,
Paving Equipment	Guntert-Zimmerman S-850 paver
Real-Time System	Ames RTP
Typical Section	0.85’ (10.2”) continuously reinforced concrete pavement (CRCP) over 0.25’ (3”) asphalt base over 1.4’ (16.8”) aggregate base. 
Joint Spacing	Transverse: none Longitudinal: 12’ c/c
Ames RTP Setup	Paver width = 22’ Sensor #1: approximately 3’ off centerline longitudinal construction joint Sensor #2: approximately 9’ off centerline longitudinal construction joint
Miscellaneous Details	Burlap drag behind the trailing finishing pan. Hand finishing consisted of a 16’ straightedge and a 6’ float.

IMPLEMENTATION ACTIVITIES

Installation of the RTP took place on October 10, 2016. Collection of real-time profile data began on October 11, 2016 and continued through October 19, 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
10OCT2016	Install RTP.
11OCT2016	Real-time profile data collection, EB lane near the rest area start at approx. 1056+80.
13OCT2016	Real-time profile data collection, WB lane start at approx.. 883+50.
16OCT2016	Adjust RTP installation.
17OCT2016	Real-time profile data collection, WB lane start at approx.. 896+00.
18OCT2016	Real-time profile data collection, WB lane start at approx.. 911+00.
19OCT2016	Real-time profile data collection, WB lane start at approx.. 927+50.

OBSERVATIONS, DATA and ANALYSES

This equipment loan was initiated through a real-time smoothness workshop conducted on May 18, 2016 in Fontana, CA. Representatives from the Brosamer and Wall, Inc. were in attendance and later requested the equipment loan. Their interest in the equipment loan was driven by two primary reasons:

1. Caltrans' adoption of IRI for pavement smoothness acceptance.
2. Brosamer and Wall's, re-entry in to the concrete paving market.

Having the opportunity to try real-time smoothness equipment allowed Brosamer and Wall to have an early indication of the IRI results.

The paving observed by the SHRP2 team was typical mainline paving, Brosamer and Wall's crews demonstrated adequate workmanship, no major issues were observed. Figures 1 through 4 illustrate different aspects of the project and Brosamer and Wall's paving processes.

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

Figure 2. Concrete Dumped Directly in Front of the Paver Using Belt Placer

Figure 3. Typical Hand Finishing Procedures

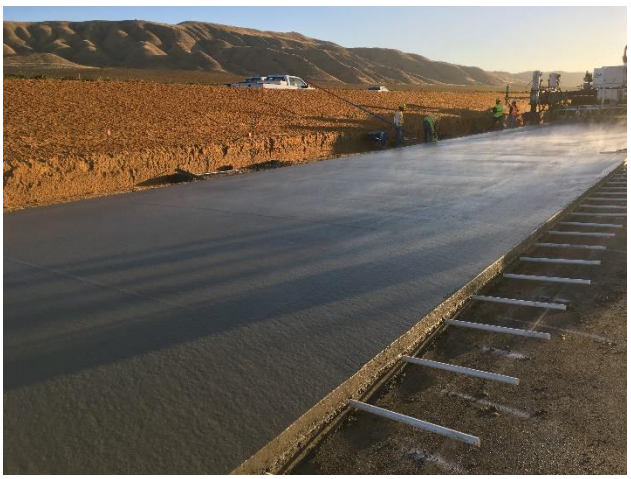


Figure 4. SR-46 Behind the Paver Looking East

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. SR-46 Concrete Mixture Proportions

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REAL-TIME SMOOTHNESS IMPLEMENTATION

Mix Design & Proect Info.

General Information

Project:	CALIFORNIA SR-46
Contractor:	BROSAMER & WALL, INC.
Mix Description:	SLIPFORM MAINLINE 564
Mix ID:	N/A
Date(s) of Placement:	N/A

Cementitious Materials	Source	Type	Spec. Gravity	lb/yd³	% Replacement by Mass
Portland Cement:	CAL PORTLAND - MOJAVE	II/V	3.150	479	
GGBFS:					
Fly Ash:	SRMG - TBD	F	2.390	85	15.07%
Silica Fume:					
Other Pozzolan:					
				564	**lb/yd³**
				6.0	**sacks/yd³**

Aggregate Information	Source	Type	Spec. Gravity SSD	Absorption (%)	% Passing #4
Coarse Aggregate:	GRANITE COALINGA	1" X #4	2.620	0.9%	1%
Intermediate Aggregate:	GRANITE COALINGA	3/8" X #8	2.605	1.1%	11%
Fine Aggregate #1:	GRANITE COALINGA		2.634	1.3%	99%
Fine Aggregate #2:					

Coarse Aggregate %:	49.0%
Intermediate Aggregate %:	10.0%
Fine Aggregate #1 % of Total Fine Agg.:	100.0%
Fine Aggregate #2 % of Total Fine Agg.:	
Fine Aggregate #1 %:	41.0%
Fine Aggregate #2 %:	

Mix Proportion Calculations

Water/Cementitious Materials Ratio:	0.428
Air Content:	3.00%

	Volume (ft³)	Batch Weights SSD (lb/yd³)	Spec. Gravity	Absolute Volume (%)
Portland Cement:	2.437	479	3.150	9.026%
GGBFS:				
Fly Ash:	0.570	85	2.390	2.111%
Silica Fume:				
Other Pozzolan:				
Coarse Aggregate:	9.464	1,547	2.620	35.053%
Intermediate Aggregate:	1.931	314	2.605	7.154%
Fine Aggregate #1:	7.919	1,302	2.634	29.330%
Fine Aggregate #2:				
Water:	3.868	241	1.000	14.328%
Air:	0.810			3.000%
	27.000	**3,968**		**100.000%**
	Unit Weight (lb/ft³)	**147.0**	**Paste**	**28.464%**
			Mortar	**58.638%**

Admixture Information	Source/Description	oz/yd³	oz/cwt
Air Entraining Admix.:	MB AE 90	1.70	0.30
Admix. #1:	POZZOLITH 322 N	22.60	4.01
Admix. #2:			
Admix. #3:			

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

Table 4. Tabular Sieve Analysis Data

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REAL-TIME SMOOTHNESS IMPLEMENTATION

Combined Gradation Test Data

Project: CALIFORNIA SR-46
Mix ID: MAINLINE SLIPFORM 564
Sample Comments: MIX DESIGN VALUES FROM BROSAMER & WALL
Test Date: MIX DESGN SUBMITTAL 564

Total Cementitious Material: 564 lb/yd^3

Agg. Ratios: 49.00% 10.00% 41.00% 100.00%

Sieve	Coarse	Intermediate	Fine #1	Fine #2	Combined % Retained	Combined % Retained On Each Sieve	Combined % Passing
2 ½"	100%	100%	100%		0%	0%	100%
2"	100%	100%	100%		0%	0%	100%
1 ½"	100%	100%	100%		0%	0%	100%
1"	100%	100%	100%		0%	0%	100%
¾"	77%	100%	100%		11%	11%	89%
½"	25%	100%	100%		37%	25%	63%
⅜"	5%	97%	100%		47%	10%	53%
#4	2%	11%	99%		57%	10%	43%
#8	2%	9%	81%		65%	8%	35%
#16	1%	7%	62%		73%	8%	27%
#30	1%	5%	41%		82%	9%	18%
#50	1%	3%	16%		93%	10%	7%
#100	1%	1%	5%		97%	5%	3%
#200	0.1%	0.1%	1.0%		99.5%	2.2%	0.5%

Workability Factor: **35.1**

Coarseness Factor: **72.2**

25% Coarse Sand

26% Fine Sand

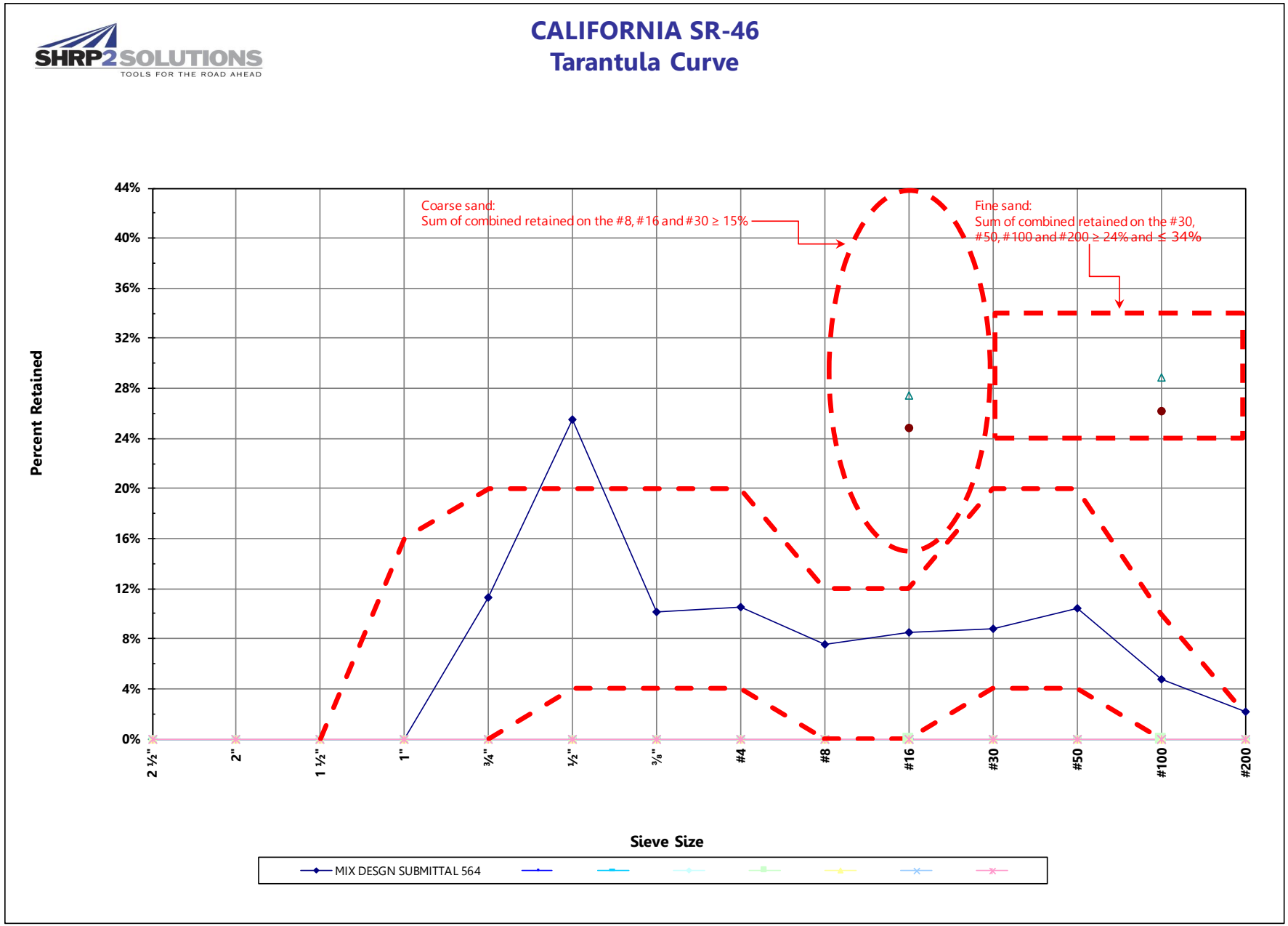

Figure 5. SR-46 Combined Percent Retained (Tarantula Curve)

CALIFORNIA SR-46

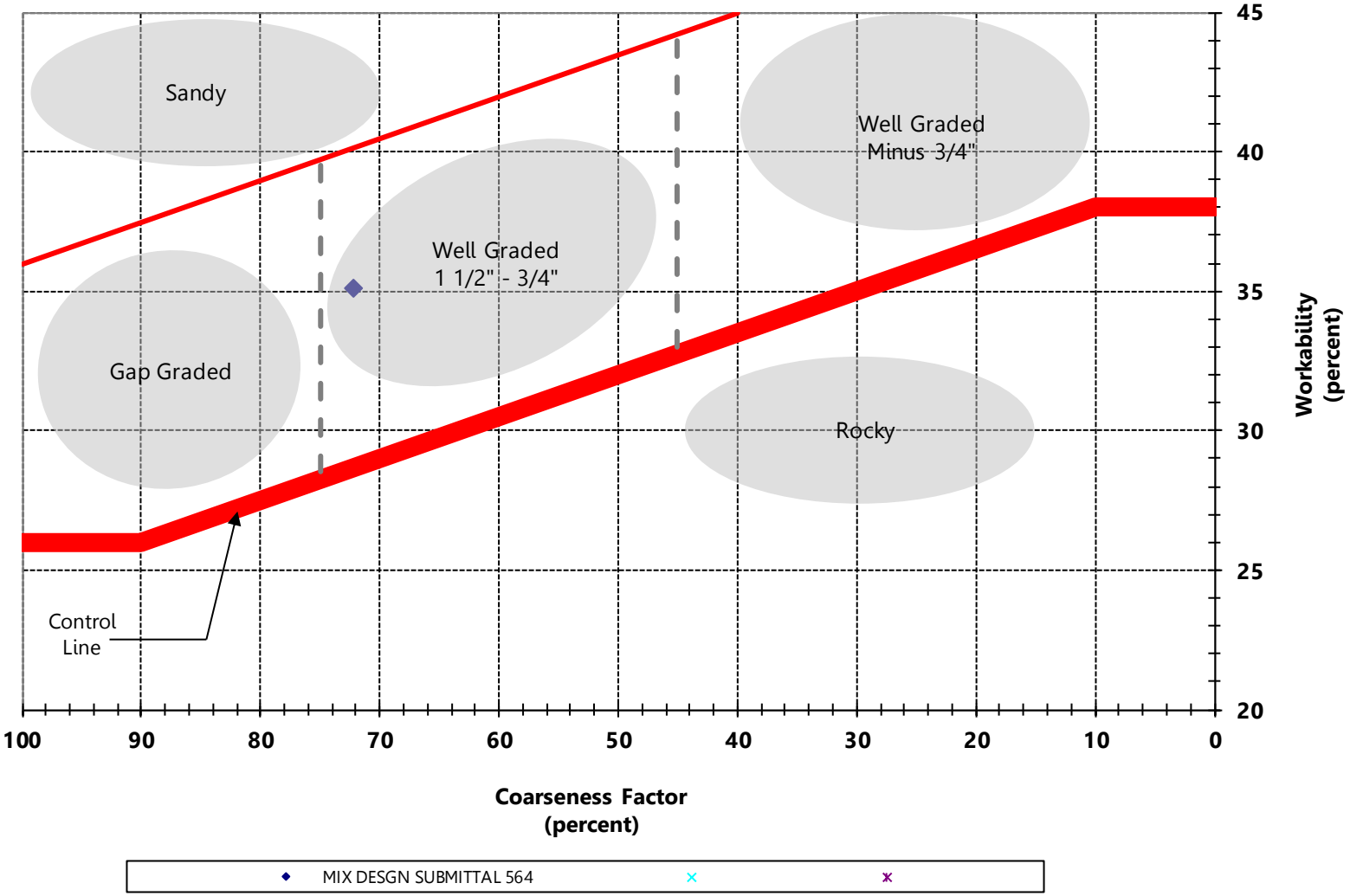

Figure 6. SR-46 Combined Gradation Coarseness and Workability Factors

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.

Several factors impaired the ability to realize the full potential of real-time smoothness systems during this equipment loan, these include:

- Frequent adjustment by the paving crew of the trailing finishing pan, which necessitated on-the-fly adjustments to the RTP installation and restart of real-time profile data collection.
- RTP sensor #2 malfunctioned during the second paving day, limiting real-time profile collection to sensor #1 for the remainder of the equipment loan.
- Project sequence and scheduling limited the paving days to five over a 10 calendar day period.
- Outsourcing of the hardened QC profiling by the contractor also led to additional delays in obtaining hardened IRI data. As a cost savings measure, contractors who outsource their hardened profiling tend to wait until multiple days of paving can be profiled to schedule their profiling sub.
- Caltrans' specifications prohibit the use of a lightweight inertial profiler to collect hardened profile data until opening strength has been achieved. This delays any comparison between real-time and hardened profiles. While not affecting real-time smoothness data collection this delay does impair the effectiveness of using real-time smoothness feedback to make timely process adjustments. Based on our experience, the difference between real-time IRI and hardened IRI is variable due to project specific factors related to mixture materials, mixture workability, paving equipment setup, hand finishing techniques and early age curling/warping of the slab. It is important to acquire hardened profiles as soon as possible to gain confidence in the IRI offset for each project and/or equipment setup to fully realize the benefits of using a real-time smoothness system.

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

Because of the limitations listed previously, there is limited profile data from 13OCT2016 which we can use with any confidence. Table 5 provides a summary of real-time and hardened IRI values for sections of paving from 13OCT2016, these are not matched by station, but are representative of the overall IRI results.

Table 5. Tabular Results Comparing Real-Time and Hardened Profile Results from 13OCT2016

Description	IRI (in/mi)
Real-Time RTP Measurements (approx. 0.15 mi)	166
Hardened Profile Measurements (approx. 0.17 mi)	122

Repeating Profile Features

The power spectral density analysis (PSD) from ProVAL (Figure 7), shows a spike at the 4' wavelength and subharmonics at 2' and 1.33'. This is typical for CRC pavements due to the spacing of transverse bar supports.

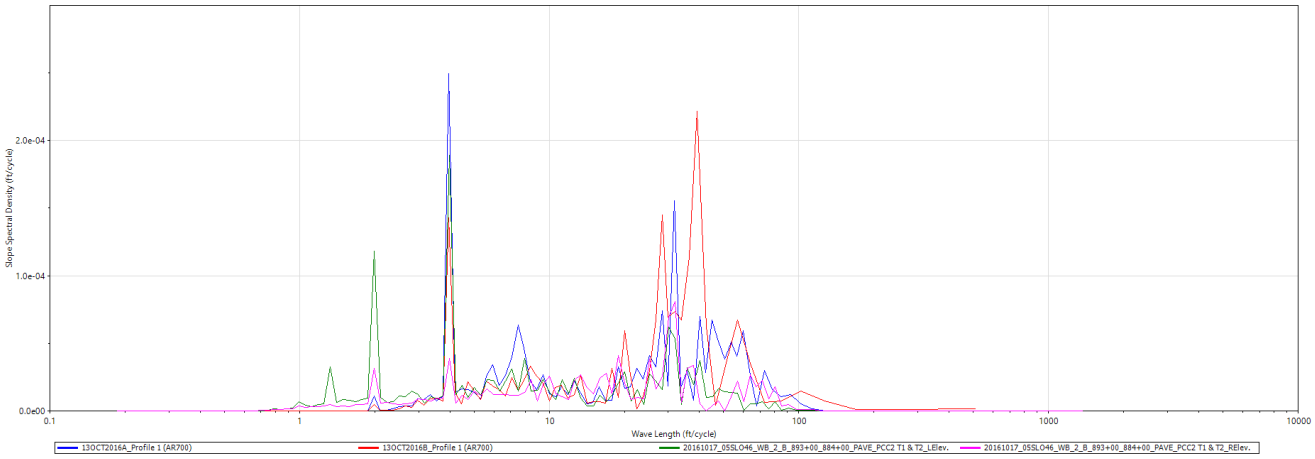

Figure 7. PSD Analysis Showing the Influence of Transverse Bar Supports Spaced at 4' c/c

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:

- The full benefit of RTS systems is unrealized when the collection of hardened profile data for comparison is delayed.

SHRP2 Implementation Team and Contractor Observations

- An exit interview was conducted with the paving superintendent. His observations regarding real-time smoothness measurements were limited due to a lack of interaction with the system during the equipment loan.