EL04-2015 **Implementation Assistance Program**

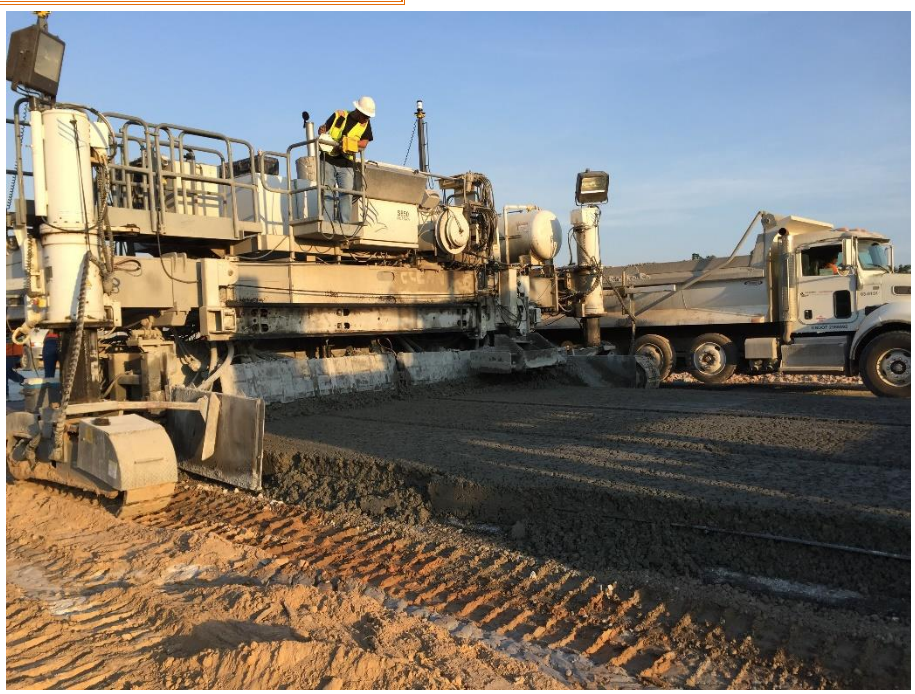
Tools to Improve PCC Pavement Smoothness During Construction (R06E)

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: TEXAS 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:

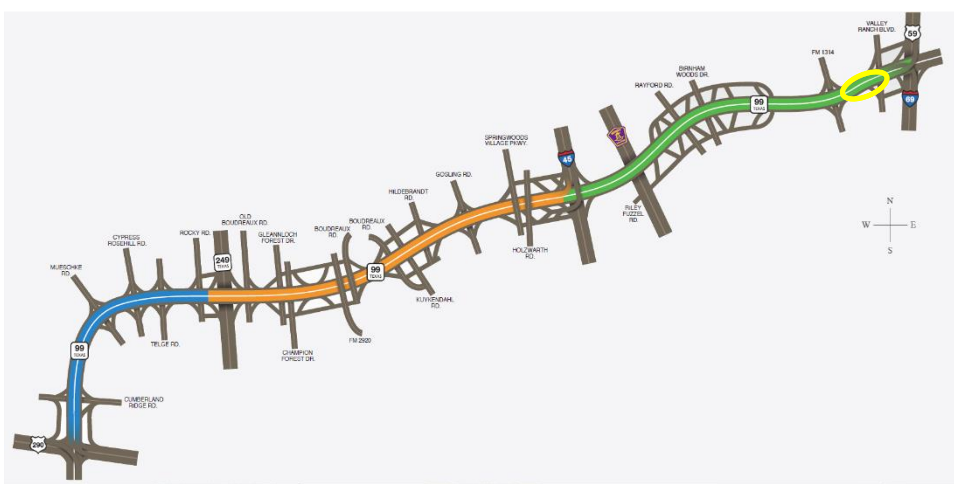
- Provide equipment (GOMACO GSI or Ames RTP) and labor for a field trial of 10 to 30 paving days
- Provide technical assistance for equipment installation start-up and operation
- On-call technical support throughout the duration of the field trial
- Planning, coordination and execution of the field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

PROJECT DETAILS

The equipment loan was performed in August 2015 on a project in Houston, TX. Table 1 summarizes the pertinent project details.

Table 1. Houston, TX SH-99 Project Information

<table>
<tr><th>Item</th><th>Details</th></tr>
<tr><td>Project Location</td><td>Mainline paving located in the eastbound lanes of Segment G of the Grand Parkway (SH-99) east of the FM 1314 interchange (yellow oval on schematic).

</td></tr>
<tr><td>Route</td><td>SH-99</td></tr>
<tr><td>Agency</td><td>Texas Department of Transportation (TXDOT)</td></tr>
<tr><td>Paving Contractor</td><td>Zachry-Odebrecht Parkway Builders (ZOPB)</td></tr>
<tr><td>Paving Equipment</td><td>Guntert-Zimmerman S-850 paver, Trimble stringless machine control and Gomaco 2600 Placer</td></tr>
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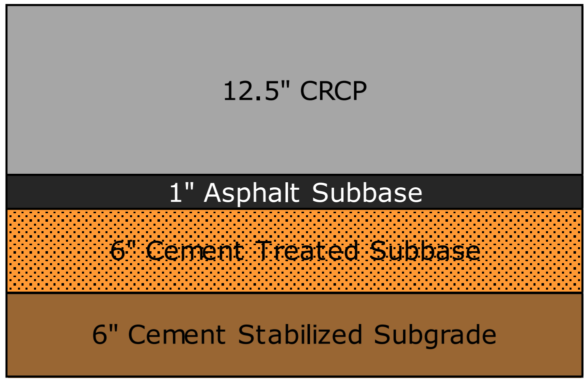
Item	Details
Real-Time System	Gomaco GSI
Typical Section	12.5″ continuously reinforced portland cement concrete pavement (CRCP) on 1″ asphalt subbase, 6″ cement treated subbase and 6″ cement stabilized subgrade. 
Joint Spacing	Transverse: N/A Longitudinal spaced at 10′ and 12′: • Construction – inserted tie bars • Contraction – tied to reinforcing mat
Gomaco GSI Setup	Paver width = 22′ Sensor #1: left wheel path of driving lane (37.5″ off of mainline longitudinal joint) Sensor #2: right wheel path of driving lane (37.5″ off of 10′ shoulder longitudinal joint)
Miscellaneous Details	A vibrator monitor was in use, vibrators were consistently operated in the range of 8,000 to 9,000 vpm. Burlap drag behind the trailing finishing pan. Hand finishing consisted of a 16′ straightedge and 10′ float advanced at approximately a 45 degree angle to the edge of pavement. Final surface texture consisted of an artificial turf drag followed by longitudinal tining. Corrective action required for any 0.10 mile extent with an IRI exceeding 75 in/mi.

IMPLEMENTATION ACTIVITIES

On-site coordination with the contractor began on August 4, 2015 with installation of the Gomaco GSI on August 5 and 6, 2015. Collection of real-time profile data began the night of August 6, 2015 and continued through the night of August 14, 2015.

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
04AUG2015	Contractor coordination 8:30 am to 11:30 am and observation of paving operations 6:00 pm to 12:00 am.
05AUG2015	GSI Installation 4:30 am to 2:00 pm and observation of paving operations 4:00 pm to 9:00 pm.
06AUG2015	Complete installation of the GSI 7:00 am to 12:00 pm and real-time profile data collection, 6:00 pm to 7:30 am from approximately 4289+25 to 4266+20.
07AUG2015	Real-time profile data collection, 5:30 pm to 5:00 am from approximately 4266+20 to bridge approach at Timber Lane.
08AUG2015	No data collection due to rain and contractor equipment issues.
09AUG2015	No work.
10AUG2015	Real-time profile data collection, 4:30 pm to 1:30 am from approximately 4250+10 to 4245+60 (plant breakdown).
11AUG2015	Real-time profile data collection, 4:00 pm to 10:30 pm from approximately 4245+60 to 4241+25 (rain shortened).
12AUG2015	Real-time profile data collection, 3:00 pm to 11:00 pm from approximately 4241+25 to 4238+50 (rain shortened).
13AUG2015	Real-time profile data collection, 4:00 pm to 6:00 am from approximately 4238+50 to 4215+95; TXDOT representatives visited the project to observe the real-time profiler in use.
14AUG2015	Real-time profile data collection, 4:00 pm to 11:00 pm from approximately 4215+95 to bridge approach at FM 1314.
15AUG2015	Uninstall GSI, 7:30 am to 11:00 am.

OBSERVATIONS, DATA and ANALYSES

This equipment loan was initiated through a joint effort of the SHRP2 project team, ZOPB, Transtec and Guntert-Zimmerman. Although large quantities of paving had been completed on this project prior to August 2015, the bulk of the work had been short runs, ramps and similar low production machine paving. The August 2015 timeframe offered the first opportunity for the ZOPB team to truly gauge their pavement smoothness results on mainline paving.

ZOPB's paving operation was at night due to high daytime temperatures. During the first two nights of observation (before collection of real-time profile data by the SHRP2 project team) multiple negative factors related to localized roughness were noted and discussed with ZOPB's paving personnel, these included:

- Non-uniformity of concrete delivered to the paver
- Consistent delivery of concrete to the paver
- Concrete workability
- Highly variable concrete head
- Lack of timely quality control profiling following each day's paving
- Rough and unstable paver trackline

During the equipment loan, ZOPB made efforts to address many of these factors with varying degrees of success. Figures 1 through 6 illustrate the installation of the GSI and different aspects of the paving equipment and processes used by ZOPB.

Figure 1. Gomaco GSI Mounted to G-Z S-850 Paver With a Float Pan

Figure 2. Concrete Spreading by Gomaco 2600 Ahead of the Slipform Paver

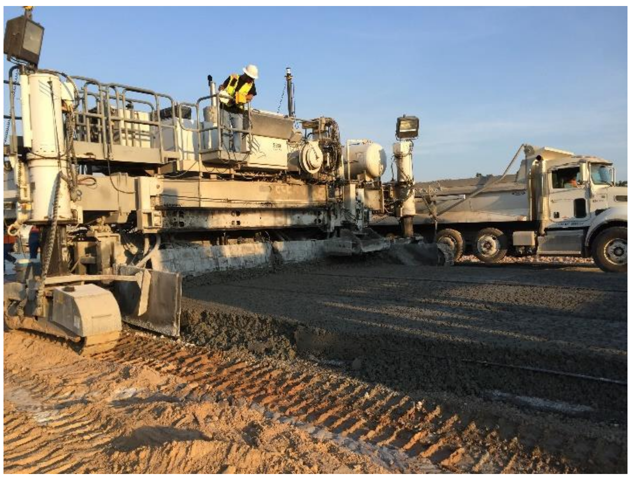


Figure 3. Concrete Deposited on Reinforcing Steel Ahead of the Paver

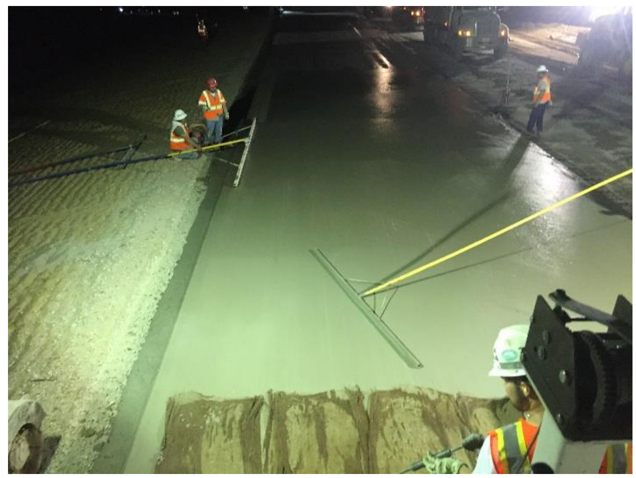


Figure 4. Typical Hand Finishing Behind the Paver

Figure 5. Unstable Paver Trackline

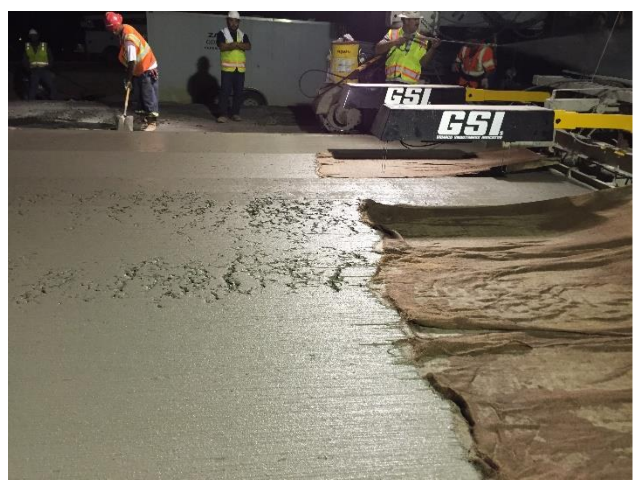


Figure 6. Non-Uniformity of Concrete

CONCRETE MIXTURE

Initial smoothness is sensitive to the workability and uniformity of the concrete mixture. Multiple requests were made for copies of aggregate gradations, but none were obtained. The mixture proportions used by ZOPB as reflected in a batch ticket from 14AUG2015 are shown in Table 3.

Table 3. SH-99 Concrete Mixture Proportions

Material	Quantity per Cubic Yard	Unit
Portland Cement	293	lb
Fly Ash (Type F)	158	lb
Coarse Aggregate (#467)	1,819	lb
Fine Aggregate	1,349	lb
Water	12.6	gal
Air Entraining Admixture	0.5	oz
Water Reducer/Retarder (ASTM C 494 Type B and D)	13.5	oz
High Range Water Reducer (ASTM C 494 Type A and F)	45	oz

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 vs. hardened analyses were not possible on this project as ZOPB did not provide any hardened profile data to the SHRP2 project team.

Repeating Profile Features

Two wavelengths show up as predominant in the power spectral density analysis (Figure 7). The peak at 4’ (red circle) is related to the transverse bar supports which are spaced at 4’ c/c. The cause of the peak at 50’ (green circle) is not certain, but may be attributable to the 3D model used for machine control. The polylines used in the model were based on points at 50’ intervals in the tangent sections of roadway.

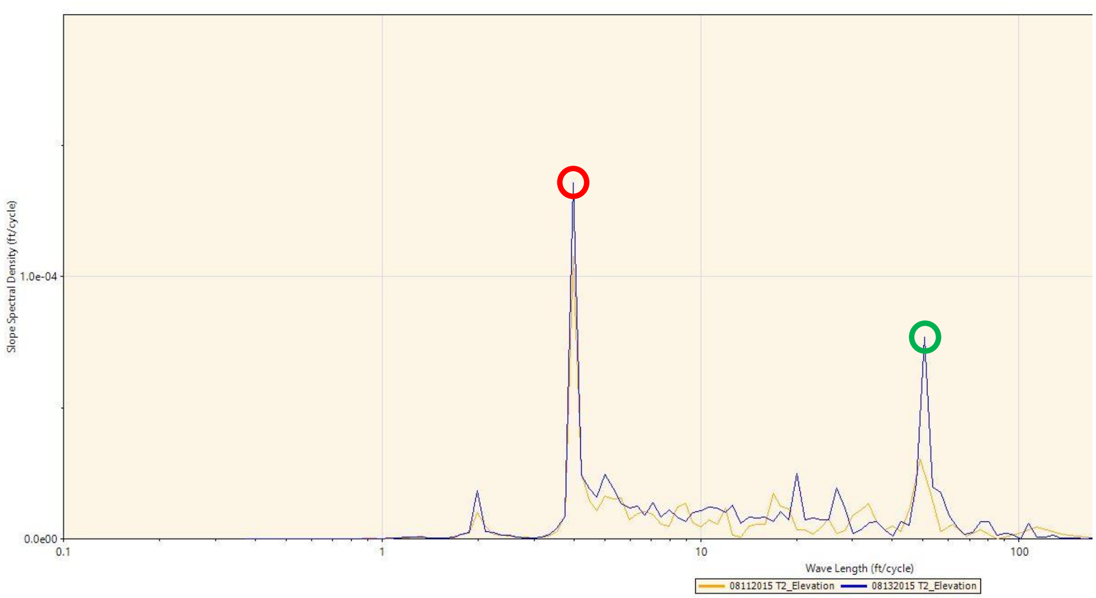


Figure 7. Power Spectral Density Analysis from August 11 and 13, 2015 for Trace 2 (right wheel path of the driving lane)

Estimating a Baseline IRI

As noted during the initial observations of ZOPB's paving operation, there were numerous factors that were adversely affecting the pavement smoothness. These were showing up as "events" (e.g. paver stops, coming off the 3D model, variable concrete head, etc.) in the real-time profile data. It was desirable to estimate what the IRI would be if these "events" could be eliminated (baseline IRI). This could help ZOPB determine what other process changes may be necessary to meet the specified IRI of 75 in/mi. An analysis was performed on the profile data from 06AUG2015 by subjectively creating 12 "leave-out" sections where the localized roughness was attributable to an "event" and comparing it to the full profile sections. The difference between these two data sets was approximately 23 in/mi (Table 4).

Table 4. Ride Quality Analysis for 06AUG2015

Profile	IRI (in/mi)
Driving Lane Left Wheel Path	
Full Data Set	104
Events Removed	80
Driving Lane Right Wheel Path	
Full Data Set	106
Events Removed	84

Localized Roughness

As shown from the estimated baseline IRI analysis above, the adverse effect of events that were causing localized roughness was significant. When these events occur, it is obvious even to inexperienced crews that the initial pavement smoothness is not as good as it could be. So, when these events happen, a real-time profiler isn't necessarily needed to signal the crew that bumps and dips need to be corrected by hand finishing. However, the real-time system can be very useful in identifying the location and magnitude of the bumps and dips and perhaps more importantly gauging whether actions taken to eliminate or mitigate these events from reoccurring have been effective (Figures 8 and 9).

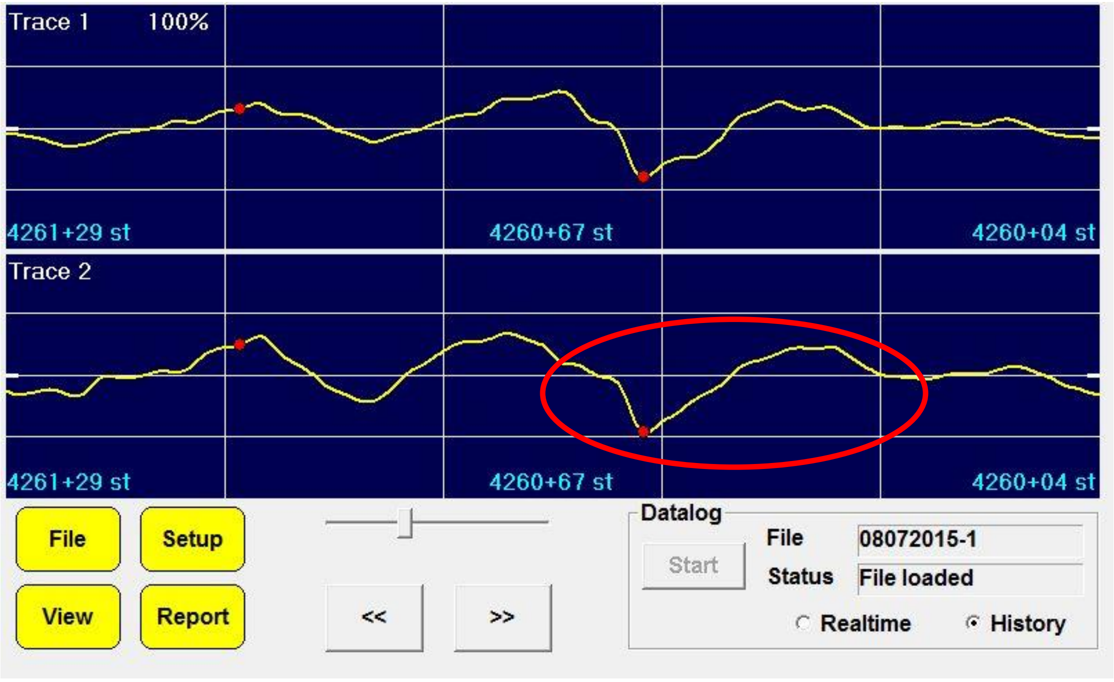


Figure 8. GSI Screen Showing a Dip and Bump (red oval) Where the Stringless System Malfunctioned

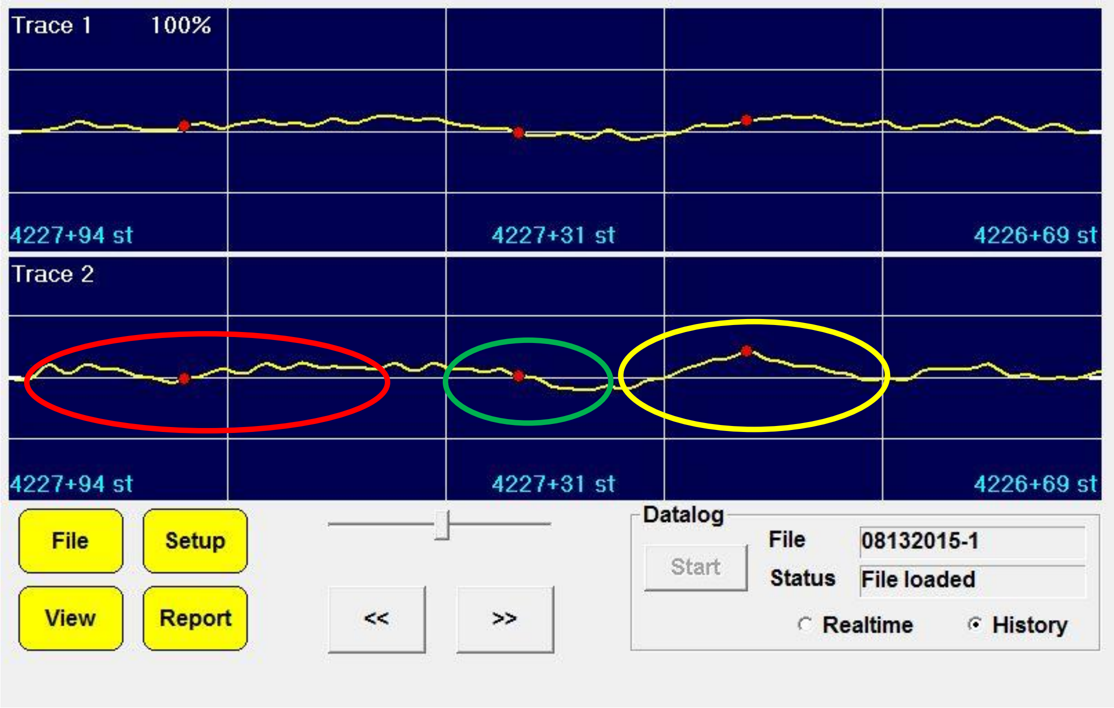


Figure 9. GSI Screen Showing Event Markers for Rough and Unstable Paver Trackline (red oval), Paver Stop (green oval) and Overloaded Paver (yellow oval).

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:

- Similar to other continuously reinforced projects where we have collected real-time profile data, the transverse bar spacing is the primary repeating wavelength contributing to pavement roughness. Unfortunately, it was not possible to verify whether this roughness wavelength was also present in the hardened profile.
- The influence of 3D model point spacing and stringless paver systems (gun tracking) on profile features needs further investigation.
- Post-paving analysis of the real-time data using ProVAL, can provide insight into what the baseline IRI could be if localized roughness events were eliminated.
- Real-time smoothness systems complement a crew's experience and intuition regarding localized roughness. They can verify the location of bumps and dips as well as confirm the cause(s) of these features.

SHRP2 Implementation Team and Contractor Observations

- Installation of the Gomaco GSI is relatively simple, requiring approximately 4 hours. With multiple wiring harnesses, the GSI could be moved to other paving machines with minimal effort.
- Care must be taken to mount the GSI sensors at the correct height and assure that they are tracking parallel to the edge of the pavement.

- An exit interview was conducted with the paving superintendent. His observations regarding real-time smoothness measurements included:
    - The GSI system proved to be beneficial in identifying factors which were causing the IRI to be higher than expected.
    - Process improvements were not easily implemented due to material and labor issues.
    - A lightweight profiler is a higher priority than a real-time system at this time.
- Soon after the SHRP2 equipment loan, the contractor purchased an Ames lightweight profiler and conducted an extended trial of the Ames RTP.