Accelerated Innovation Deployment (AID) Demonstration Project:

Warm-Mix Asphalt Additive & Intelligent Compaction AID Project

Final Report
November 30, 2016

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INTRODUCTION

ACCELERATED INNOVATION DEPLOYMENT (AID) DEMONSTRATION GRANTS

The Accelerated Innovation Deployment (AID) program is one aspect of the multi-faceted Technology and Innovation Deployment Program (TIDP) approach, which provides funding and other resources to offset the risk of trying an innovation. The AID Demonstration funds are available for any project eligible for assistance under title 23, United States Code. Projects eligible for funding shall include proven innovative practices or technologies such as those included in the EDC initiative. Innovations may include infrastructure and non-infrastructure strategies or activities, which the award recipient intends to implement and adopt as a significant improvement from their conventional practice.

The Federal Highway Administration (FHWA) Accelerated Innovation Deployment (AID) Demonstration grant program, which is administered through the FHWA Center for Accelerating Innovation (CAI), provides incentive funding and other resources for eligible entities to offset the risk of trying an innovation and to accelerate the implementation and adoption of that innovation in highway transportation.

Projects deemed eligible for funding included proven innovative practices or technologies, including infrastructure and non-infrastructure strategies or activities, which the applicant or subrecipient intends to implement and adopt as a significant improvement from their conventional practice. The AID Demonstration funds were available for any project eligible for assistance under title 23, United States Code.

Entities eligible to apply included State departments of transportation (DOT), Federal Land Management Agencies, and tribal governments as well as metropolitan planning organizations (MPOs) and local governments which applied through the State DOT as subrecipients.

REPORT SCOPE AND ORGANIZATION

This report documents the Rhode Island Department of Transportation’s (RIDOT) demonstration grant award for 1R Improvements to Route 102 using Warm Mix Asphalt Additive and Intelligent Compaction (WMA & IC). The report presents details relevant to the employed project innovation(s), the overarching TIDP goals, performance metrics measurement and analysis, lessons learned, and the status of activities related to adoption of Warm Mix Asphalt & Intelligent Compaction as conventional practice by RIDOT.

PROJECT OVERVIEW

PROJECT OVERVIEW

This Warm-Mix Asphalt Additive & Intelligent Compaction (WMA & IC) project meets the program goals of the Accelerated Innovation Deployment (AID) Demonstration Grant offered by U.S. DOT Federal Highway Administration (CFDA Number 20.200), as both innovations are included in Every Day Counts (EDC) initiatives. This complete project will be implemented by the Rhode Island Department of Transportation (RIDOT) as a means of documenting two important benefits WMA and IC technologies help achieve; proper pavement density; and improved pavement performance with the goal of encouraging greater acceptance of these innovations within the Rhode Island highway construction community. The work consisted of applying WMA Additive to the pavement mixture for approximately one half of 22,400 feet of RI Route 102 within the Towns of Coventry and Foster, Rhode Island and applying HMA on the remaining half of the roadway. IC was applied over the entire paving limits for both the WMA and the HMA. The work also included conducting a comparative analysis of the pavement performance for the HMA and WMA sections. This analysis will continue to be conducted over a three-year period with supplements to this Final Report issued accordingly.

The AID goal of this project was to document the achievement of equal or better pavement performance for the road segment paved with WMA additive as compared to the traditional HMA pavement segment over a three-year period. Our target of achieving a 0.5% improvement in the HMA control group and the WMA pavement was not achieved in the first set (three sets in total) of data analysis sessions. As this innovation is expected to improve the life of the pavement, the Department expects to see long term improvements, for example superior fatigue and rutting performance and a decrease in the permeability of the asphalt mixtures. This improvement is expected to decrease the speed at which the pavement ages. Because of the characteristics of the innovations, the use of WMA and the use of IC had no effect on the project completion time.

LESSONS LEARNED

Through this project, RIDOT gained valuable insights with regard to the innovative Intelligent Compaction & Warm Mix Asphalt Additive used. The following were some of the lessons learned to date:

- The average core densities of HMA vs WMA during the first round of testing concluded that each set of cores performed nearly identically to the other, not achieving the anticipated 0.5% improvement by using WMA.
- The use of Intelligent Compaction was beneficial to the process. It allowed precise knowledge of areas compacted using GPS location.

PROJECT DETAILS

BACKGROUND

The project involved implementing the WMA Additive & IC demonstration project along a 4.2-mile portion of Route 102, a rural principal arterial state road, as part of a highway improvement project. The work on the project included reclamation of an existing pavement structure and placement of 3-inches of Class 19.0 HMA (a 19.0mm Superpave mix) with Warm-Mix Additive as the base course and 2-inches of Modified 12.5 HMA (a 12.5mm Superpave mix using Grade E binder) with Warm-Mix Additive surface course in both pavement layers between the limits of Old Plainfield Pikes and Sisson Road (11,500 feet) and then placement of 3-inches of Class 19.0 HMA base course and 2-inches of Modified Class 12.5 HMA surface course for the remaining segment, from Sisson Road to Harkney Hill Road (10,000 feet). The project also included installation of new portland cement concrete curbing and sidewalk, new guardrail installation pavement markings, new signs and other improvements.

Because the Department has had limited experience with both the WMA Additives and IC technology, the design of this demo project enabled the Department to better understand the comparative benefits of using WMA additive when compared to HMA as well as the benefits of using intelligent compaction (IC) vibratory rollers equipped with Global Positioning System (GPS) technology systems to measure and assess the properties of the compacted asphalt to ensure achievement of optimum compaction. The Department will continue monitoring this project over the three-year period, which will allow even more insights to be made regarding the comparative benefits of WMA & IC. The requested AID grant funding was used to cover the cost of the two innovations used during this highway improvement project and for evaluation of their performance during construction and over a three-year review period.

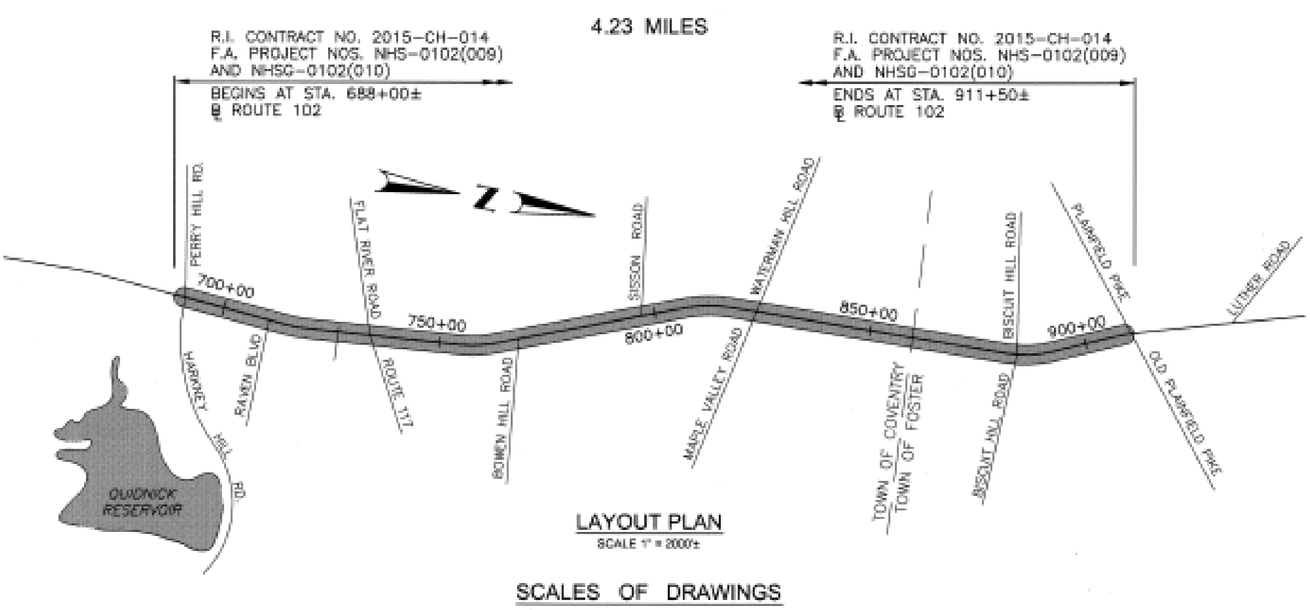

Figure 1. Map containing the two segments. Project location

PROJECT DESCRIPTION

The Department's performance goal for this AID project was to document the achievement of equal or better pavement performance for the road segment paved with WMA additive & IC as compared to the traditional HMA pavement & IC segment over a three-year period. This expectation is based on numerous technical studies which have identified benefits using this innovative technology. Four performance measures were proposed.

The first measurement compared the post-compaction density rating between the WMA test segment and the control HMA segment to determine whether there is an anticipated improvement of at least 0.5% of the theoretical maximum density for the WMA segment. The deployment of IC enabled compaction to be monitored and measured to ensure density is consistently being achieved during construction. The Contractor used BOMAG equipment. BOMAG uses an Intelligent Compaction Measurement Value (ICMV) called E_{vib} (vibration modulus) in units of MN/m^2 (Mega-Newtons per Square Meter).

Rutting and top-down cracking pavement performance was observed and will be evaluated annually over the three-year period as part of the Department's annual measurement program conducted by DTS for inclusion in RIDOT's Pavement Management System (PMS) and Highway Performance Management System (HPMS) submission. The length of each section was identified through the Department's linear referencing system (LRS). Pavement performance comparisons were made between the WMA section and HMA section based on the annual HPMS submission. The WMA pavement segment is expected to perform as well as that of the HMA segment in terms of rutting and possibly better in terms of top-down cracking at the conclusion of the three-year period.

Pavement rideability was measured for each segment using a profiler that met all equipment requirements of ASTM E 950 for a Class 1 profiler. The surface course ride quality measurement was based on the average International Roughness Index (IRI). Falling Weight Deflectometer (FWD) data was collected to analyze and compare the structural adequacy of each section.

In addition, RIDOT's inspectors recorded their observations during the construction phase as to comparative differences in the workability and ease of manipulation between the two types of asphalt mixes.

For this project, the only interactions were with a local FHWA representative who had been consulted, as well as general updates. A notable technology transfer occurred with the contractor and their roller operators who learned the benefits of Intelligent Compaction. The innovation was an improvement over standard compaction practice because of the use of more sophisticated technology to improve knowledge of compaction in the current area as well as the use of the pinpoint location to guarantee even compaction.

The process of implementing the innovations of WMA & IC was, for the most part, the same as conventional practice. Because this project was quality based, the implementation of the product was the same as if a different product (HMA) was used. The only difference was the type of material (WMA compared to HMA) and the use of intelligent compaction instead of conventional rollers.

DATA COLLECTION AND ANALYSIS

Performance measures consistent with the project goals were jointly established for this project by RIDOT and FHWA to qualify, not to quantify, the effectiveness of the innovation to inform the AID Demonstration program in working toward best practices, programmatic performance measures, and future decision making guidelines.

The data was collected to determine the impact of using WMA & IC on quality, schedule, cost, and demonstrate the ability to:

- Reduce life cycle costs through producing a high-quality project

This section discusses how the Rhode Island Department of Transportation established baseline criteria, monitored and recorded data during the implementation of the innovation, and analyzed and assessed the results for each of the performance measures related to these focus areas.

The Department's performance goal for this AID project is to document the achievement of equal or better pavement performance for the road segment paved with WMA additive as compared to the traditional HMA pavement segment over a three-year period. Four performance measures were proposed.

The first performance measure taken was the post compaction densities. This measure was to compare the post-compaction density rating between the WMA test segment and the control HMA segment to determine whether there is an anticipated improvement of a least 0.5% of the theoretical maximum density for the WMA segment.   The data concluded that the average core densities for HMA and WMA samples were statistically equivalent.

When 20 cores of Class 19.0 without WMA had been measured, the average core density was 155.80 lbs/ft^3. Compared to 38 cores of Class 19.0 with WMA equaling 155.88 lbs/ft^3, there was a 0.08 lbs/ft^3 difference. This indicates a very small, statistically insignificant, sample comparison. When 18 cores of Modified Class 12.5 without WMA were compared to 16 cores of Modified Class 12.5 sample with WMA, both equaled an average core density of 158.2 lbs/ft^3.

The second performance measure was rutting and top-down cracking of the pavement performance. The distress data below was collected on July 23, 2015, prior to the project starting, and was included with the 2015 HPMS Submission. It serves as the baseline data. The length of each section was identified through the Department's linear referencing system (LRS). Pavement performance comparisons between the HMA and WMA section will be done based on the HPMS submissions for each year of three-year period.

2015 Rutting and Top-Down Cracking

	HPMS LRS ID	Begin Point – End Point	Average Rutting (Inch)	Average Cracking (%)
HMA & IC Section	2900	18.033 – 20.046	0.26	31.4
WMA & IC Section	2900	20.046 – 22.196	0.28	31.0

Table 1; Rutting and Top-Down Cracking, From 'RI102PaveDistress - HPMS Data 2015.xlsx' – Excel File

The third performance measure was the pavement's rideability. The surface course ride quality measurement was based on the average International Roughness Index (IRI). The data concluded that the average IRI for the HMA and WMA portions of the project were statistically equivalent.

Average IRI Combining Wheel Paths

	November 2015	September 2016	Δ IRI (2016 - 2015)	Δ IRI (% of 2015)
HMA & IC Section	57.56	58.07	0.51	0.89%
WMA & IC Section	48.87	49.26	0.39	0.79%

Table 2; Average IRI Combining Wheel Paths; From 'Route 102 IRI Comparision 2016 to 2015.xlsx' – Excel File

Falling Weight Deflectometer (FWD) data was also collected to compare the structural adequacy of each section. Again, the data concluded that both the Subgrade Stiffness and the AC Stiffness were statistically equivalent.

Falling Weight Deflectometer (FWD) Data

	Subgrade Stiffness (psi)	Asphalt Concrete Stiffness (psi)
	Section Average (Hogg subgrade model)	Section Average (bound layers)
HMA & IC Section	**22,377**	**2,724,676**
WMA & IC Section	**23,094**	**2,930,180**

Table 3: Falling Weight Deflectometer Data; From 'Rt. 102 Forwardcalculation FWD Data.xlsx' – Excel File

During the construction phase of the asphalt placement, RIDOT's inspectors noted they did not observe any comparative differences in the workability and ease of manipulation between the two types of asphalt mixes.

SCHEDULE

The method traditionally employed by RIDOT to deliver a comparable project would usually take about one season to accomplish. Due to the nature of the innovations (a quality change), the project's schedule was not affected. The only difference being the use of the warm mix additive in the mix design and the use of advanced rollers.

COST

A traditional project of similar scope and scale delivered using our traditional methods was estimated to cost approximately $79,000 less than the WMA & IC project. The Rhode Island Department of Transportation estimated that the use of WMA & IC would result in a cost of $1,188,800.00 based on estimates using RIDOT's Weighted Average Unit Price (WAUP) for WMA Materials and Labor, IC Equipment Rental, and Testing & Evaluation.

There were no complications experienced during construction, there was however, a change order that adjusted the quantities as the road was found to be wider than anticipated through the design phase. The project was still completed on time.

The actual direct financial cost associated with delivery of this project using WMA & IC resulted in a cost of $1,360,875.84. The final cost was based on those items paid resulting from the work are listed as follows:

- Item 020.0001: 19 mm HMA with Warm Mix Additive; 8,605.41 Tons @ $84.00/Ton = $722,854.44
- Item 028.0001: Intelligent Compaction of HMA; 1.00 Lump Sum @ $50,000.00 = $50,000.00
- Item 104.0001: 12.5 mm HMA with Warm Mix Additive; 5,069.15 Tons @ $116.00/Ton=$588,021.40

QUALITY

As previously discussed, using traditional construction techniques the Rhode Island Department of Transportation would have used a standard HMA and regular compaction approach to the paving of a roadway and compaction. However, through the use of this innovation we expect to see long term improvements, for example, superior fatigue and rutting performance and a decrease in the permeability of the asphalt mixtures. This improvement is expected to decrease the speed at which the pavement ages. It is to be noted that a final quality summary of the project will not be available until the completion of the three-year lifetime of the project.

USER SATISFACTION

The Rhode Island Department of Transportation has not received feedback (positive or negative) from users of the treated facilities, but will continue to monitor Customer Service messages over the next three years as we conduct a comparative analysis of the pavement performance for the HMA and WMA sections.

RECOMMENDATIONS AND IMPLEMENTATION

RECOMMENDATIONS

The Rhode Island Department of Transportation determined from the results of our first set (three in total) of data analysis sessions that the two different segments performed nearly identically in terms of average core densities, therefore not achieving the anticipated 0.5% improvement by using WMA. RIDOT's procedure for use of WMA is to either explicitly require it in the bid documents or, if it is not explicitly required, leave it available as an option for a contractor to elect to use in order to increase their temperature based paving windows. The use of Intelligent Compaction was beneficial to the process. It allowed precise knowledge of areas compacted using GPS location. RIDOT proposes adopting Intelligent Compaction into our standard operating procedures.

However, we also identified the following areas that could be improved upon in future applications of this innovation:

- A test method to determine the efficacy of the various categories and manufacturers of WMA should be developed[1]. At this time, state agencies rely upon anecdotal evidence to approve WMA suppliers.

STATUS OF IMPLEMENTATION AND ADOPTION

Since the completion of the 1R Reconstruction to Route 102 project, the Rhode Island Department of Transportation has recommended that Intelligent Compaction be brought into our standard operating procedures as a significant improvement from our traditional practice for similar types of pavement projects.

Our plan for full adoption of WMA & IC is as follows:

- Finish the three-year lifecycle evaluation of WMA & IC, and conducting a comparative analysis of the pavement performance for the HMA and WMA sections over a three-year period. Supplements to this Final Report issued accordingly.
- Make a decision regarding the success of each portion of the innovation, as well as the combination of the innovations.
- Send an Intelligent Compaction Specification to the Department's Specification Committee for inclusion in a future compilation to the RI Standard Specifications for Road and Bridge Construction.

[1] The brand of WMA used in the mix for this project was Evotherm, which is chemical based.

APPENDIX A:
WMA & IC PROJECT NARRATIVE

May 15, 2015

Rhode Island Department of Transportation

Warm-Mix Asphalt Additive & Intelligent Compaction AID Project

Project Narrative

I. Project Abstract

This Warm-Mix Asphalt Additive & Intelligent Compaction (WMA & IC) project meets the program goals of the Accelerated Innovation Deployment (AID) Demonstration Grant offered by U.S. DOT Federal Highway Administration (CFDA Number 20.200), as both innovations are included in Every Day Counts (EDC) initiatives. This complete project will be implemented by the Rhode Island Department of Transportation (RIDOT) as a means of documenting two important benefits WMA and IC technologies help achieve; proper pavement density; and improved pavement performance with the goal of encouraging greater acceptance of these innovations within the Rhode Island highway construction community. The work will consist of applying WMA Additive to the pavement mixture for approximately one half of 22,400 feet of RI Route 102 within the Towns of Coventry and Foster, Rhode Island and applying HMA on the remaining half of the roadway. The IC will be applied over the entire paving limits for both the WMA and HMA. The work will also include conducting a comparative analysis of the pavement performance for the HMA and WMA sections over a three year period.

II. Project Description

RIDOT will implement the WMA Additive & IC demonstration project along a 4.2 mile portion of Route 102, a rural principal arterial state road, as part of a highway improvement project. The work on the project will include reclamation of existing pavement structure and placement of 3-inches of Class 19.0 HMA with Warm-Mix Additive as the base course and 2-inches of Modified 12.5 HMA with Warm-Mix Additive surface course in both pavement layers between the limits of Old Plainfield Pike and Sisson Road (11,500 feet) and then placement of 3-inches of Class 19.0 HMA base course and 2-inches of Modified Class 12.5 HMA surface course for the remaining segment, from Sisson Road to Harkney Road (10,900 feet). The project also includes installation of new cement concrete curbing and sidewalk, new guardrail installation pavement markings, new signs and other improvements. Because the Department has had limited experience with both the WMA Additives and IC technology the design of this demo project will enable the Department to better understand the comparative benefits of using WMA additive when compared to HMA as well as the benefits of using intelligent compaction (IC) vibratory rollers equipped with Global Positioning System (GPS) technology systems to measure and assess the properties of the compacted asphalt to ensure achievement of optimum compaction. The requested AID grant funding will be used to cover the cost of the two innovations being used during this highway improvement project and for evaluation of their performance during construction and over a three year review period. Each innovation is described below.

A. Intelligent Compaction (IC)

Intelligent compaction technologies have been found to improve the uniformity and compaction of road-building materials.[1] It is defined as the process of mechanically tamping road materials (e.g., soils, aggregate bases or asphalt surfacing materials) and using modern vibratory rollers equipped with an integrated measurement system, an onboard computer reporting system, Global Positioning System (GPS) based mapping and optional feedback control. Intelligent Compaction rollers facilitate real-time compaction monitoring and timely adjustments to the compaction process by integrating measurement, documentation and control systems. The primary benefits of IC technologies are:
(1) Improved in-place density of pavement materials as well as reduced variability of measured density.
(2) Improved efficiency of compaction resulting in fewer roller passes than typically required and minimization of spot failures.
(3) Longer pavement service life and reduced highway repair and maintenance costs.

B. Warm Mix Asphalt (WMA) Additive

This project will consist of incorporating a WMA Additive into the HMA and applying this mixture on 11,500 feet of roadway as part of a larger highway improvement project. The remaining 10,900 feet of roadway will be paved with HMA. The type of WMA additive to be used in this AID project may be any one of the approved wax or chemical based WMA's that are listed on North East Asphalt User Producer Group's approved list. WMA technologies have been found to provide more consistent pavement density across an entire pavement. A less variable, better compacted asphalt should result in improved pavement performance overall. Better compacted asphalt pavements often have superior fatigue and rutting performance, decrease the permeability of asphalt mixtures, which would decrease the amount of field aging of the mixture and improve performance in terms of cracking and moisture susceptibility.

C. Performance Expectations:

The Department's performance goal for this AID project is to document the achievement of equal or better pavement performance for the road segment paved with WMA additive as compared to the traditional HMA pavement segment over a three year period. This expectation is based on numerous technical studies which have identified benefits using this innovative technology. Four performance measurements are proposed for this project. The first measurement will compare the post-compaction density rating between the WMA test segment and the control HMA segment to determine whether there is an anticipated

[1] Intelligent Compaction, Case Study, Spring 2014 Summary of Intelligent Compaction for HMA/WMA paving, TECHBRIEF, U.S. DOT/FHWA, FHWA-HIF-13-053

improvement of a least .5% of the theoretical maximum density for the WMA segment. The deployment of IC will enable compaction to be monitored and measured to ensure density is consistently being achieved during construction. The IC industry has not agreed upon a standard measure for reporting the compaction results of IC rollers for HMA/WMA paving. A target Intelligent Compaction Measurement Value (IC-MV) will be identified upon selection of IC equipment by the bid awarded contactor.

Rutting and top-down cracking pavement performance will be observed and evaluated annually over the three year period as part of the Department's annual measurement program conducted by DTS for inclusion in RIDOT's Pavement Management System (PMS) and HPMS submission. Pavement performance comparisons will be made between the WMA section and the HMA section of the roadway. The length of each section will be identified through the Department's linear referencing system (LRS). The WMA pavement segment is expected to perform as well as that of the HMA segment in terms of rutting and possibly better in terms of top-down cracking.

Pavement rideability will also be measured for each segment using a profiler which meets all equipment requirements of ASTM E 950 for a Class 1 profiler. The surface course ride quality measurement will be based on the average International Roughness Index (IRI). Falling Weight Deflectometer (FWD) data will be collected to analyze and compare the structural adequacy of each section.

RIDOT's inspectors will also record their observations during the construction phase as to comparative differences in the workability and ease of manipulation between the two types of asphalt mixes.

III. Innovation Performance

The Department is committed to monitoring this project over a three year period. Monitoring will begin at the time of the production of the HMA and WMA with the addition of the selected chemical additive. The asphalt material mix designs will be verified to meet the Department's standards. Test samples will be produced to compare the volumetric properties of both the HMA and WMA. Cores will be extracted to compare the in-place densities statistically. All material testing to be conducted will be based on RIDOT Standard Specifications. A comparative analysis of the test and control asphalt mixes will be conducted by RIDOT Materials engineering staff.

During construction, the proposed IC process will measure and record compaction parameters during the compaction process, assess the properties of the asphalt applied to the two segments of the project.

Post-Construction evaluation will consist of collecting data for rideability, structural adequacy (FWD), rutting, and cracking. This data will be analyzed statistically to determine how each section decays relative to the other and if the additional cost of the WMA additive warrants its use in all projects.

Table 1. Project Schedule

Planned Tasks	Planned Date
Bid Advertise Date	May 6, 2015
Bid Award Date	July 10, 2015
Construction Notice to Proceed	July 29, 2015
Pre-Paving Project Kick-Off Planning Meeting	August 2015
Construction Planned Completion Date	November 3, 2015
Initial Laydown Evaluation /Assessment Report	November 2015
Year-1 Project Testing and Evaluation Report	November 2016
Year-2 Project Testing and Evaluation Report	November 2017
Year-3 Final Project Testing, Evaluation Findings Report	January 2019

IV. Application Information and Coordination with Other Entities

RIDOT will implement the WMA Additive & IC demonstration project as part of a 1R highway improvement project which is listed in the current approved Statewide Transportation Improvement Program (STIP) for 2013-2016. The work will be performed by a low bid awarded contract. The RIDOT Materials Unit will be responsible for the monitoring of the pavement during the construction phase and throughout the three year demonstration phase. No other entities will be involved in this project.

RIDOT Contact Person:

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V. Funding Request

The total estimated cost for this highway improvement project is $5,616,434 (with E & C). To implement the Warm Mix Asphalt & Intelligent Compaction AID Project, the RIDOT is requesting $951,040.00 dollars from the AID program. RIDOT will provide the $237,760 in state funds to meet the required 20% federal funding match requirement. The cost covers asphalt materials, and labor required for the application of WMA Additive portion of the project and for the use of IC equipment during the construction phase of the project. The costs were determined on the basis of the final design estimated quantities and recent pricing for asphalt. The estimated rental cost per month for IC technology is about $12,500 for an IC roller (about $4,500 for the roller and $8,000 for the IC equipment) and the minimum unit price as listed in the contract's specification is $50,000.

Table 2. Project Budget

WMA Additive & IC Project Budget	AID Funds 80%	State Match 20%	Total AID Funding Requested
WMA Materials and Labor* (Based on 11,900 tons of HMA w/ WMA Additive @$92 per ton)	$875,840	$218,960	$1,094,800
IC Equipment Rental** (Based on minimum unit price per contract specification)	$40,000	$10,000	$50,000
Testing and Evaluation • Construction Phase Testing & Evaluation • Post-Construction Testing, including cost of Uniformed Traffic Control, Evaluation and Reporting	$35,200	$8,800	$44,000
Total	**$ 951,040**	**$ 237,760**	**$ 1,188,800**

* Price estimated based on RI's weighted average unit price (WAUP) data for the quantity of specified AC surface course and base courses in the contract documents. ** Specified as the only acceptable bid price in the contract documents.

VI. Eligibility and Selection Criteria

The Rhode Island Department of Transportation (RIDOT) is an eligible entity as defined in Section III of the Notice of Funding Availability (NOFA) for Accelerated Innovation Deployment Demonstration. This is the first AID project application to be submitted for fiscal year 2015 for implementation by the RIDOT.

This project meets the selection criteria of the NOFA in that the Warm Mix Asphalt innovation is included in Every Day Counts Round-1 and the Intelligent Compaction innovation was introduced though Every Day Counts Round -2. This Project is ready to be initiated within the next three months as indicated above in Table #1 Project Schedule.

WMA additive technologies have been proven in real-world applications through many states, including California, Colorado, Minnesota, Missouri, New York, North Carolina, Ohio, Texas, Virginia, and Wisconsin. As for IC technology, 10 states participated in an FHWA-sponsored study, designed to evaluate and document the benefits of IC through field projects.[2] The use of IC was demonstrated to be a success in all 10 states. The utilization of these new technologies has been very infrequent in Rhode Island. The performance results, and real-world, hands-on experience obtained during this demonstration project, will be used to promote the use of these innovations throughout the state and thus increase the life of asphalt pavements.

Additional Attachments ☐ **No** ☒ **Yes**

(1) Route 102 Contract 3 Project Map Identifying the WMA and HMA Sections.
(2) Project Location within Rhode Island.
Contract (RIC 2015-CH-014) documents are available upon request.

[2] Intelligent Compaction, Case Study, Spring 2014 Summary of Intelligent Compaction for HMA/WMA paving, TECHBRIEF, U.S. DOT/FHWA, FHWA-HIF-13-053

APPENDIX B:
WARM MIX ADDITIVE SPECIFIATION

Add the following new **Section 414; Warm Mix Additive** to the RI Standard Specifications for Road and Bridge Construction.

SECTION 414

WARM MIX ADDITIVE

414.01 DESCRIPTION. This work consists of incorporating a WMA (Warm Mix Additive) in HMA (Hot Mix Asphalt).

414.02 MATERIALS. One unit of WMA shall be added to each ton of HMA. All WMA shall be selected from the RIDOT Approved Materials List and shall be added at a dosage rate recommended by the manufacturer.

414.03 CONSTRUCTION METHODS. If HMA is designated as "with WMA", the Contractor shall use a WMA. If HMA is not designated as "with WMA", the Contractor may request to use a WMA at his own discretion and expense. Additionally, the Engineer may direct the Contractor to use a WMA. If a WMA is used it shall be for an entire day's production for that class of HMA.

414.04 METHOD OF MEASUREMENT. WMA will be measured by the number of units actually used in accordance with the specifications and/or as directed by the Engineer.

414.05 BASIS OF PAYMENT The accepted quantity of the WMA will be paid for at its respective contract unit price per each as listed in the Proposal.

APPENDIX C:
INTELLIGENT COMPACTION FOR HMA
JOB SPECIFIC SPECIFICATION

Code 415.9901
Intelligent Compaction for HMA

DESCRIPTION

This work shall consist of the compaction of the HMA utilizing intelligent compaction (IC) rollers within the limits of the work as described in the plans. IC is defined as a process that uses vibratory rollers equipped with a measurement and documentation system that automatically records various critical compaction parameters in real time during the compaction process. IC uses roller vibration measurements to assess the mechanistic properties of the compacted materials to ensure optimum compaction is achieved through continuous monitoring of the operations.

The Contractor shall supply sufficient numbers of rollers and other associated equipment necessary to complete the compaction requirements for the specific materials. At least one IC roller shall be used. The required position for an IC roller is in the initial phase (breakdown) in the paving sequence. Any additional IC rollers shall be used in the intermediate phase.

EQUIPMENT

IC Roller - The IC roller(s) shall meet the following specific requirements:

1. IC rollers shall be self-propelled double-drum vibratory rollers equipped with accelerometers mounted in or about the drum to measure the interactions between the rollers and compacted materials in order to evaluate the applied compaction effort. IC rollers shall be equipped with non-contact temperature sensors for measuring pavement surface temperatures.

2. The output from the roller is designated as the Intelligent Compaction Measurement Value (IC-MV) which represents the stiffness of the material being rolled based on the vibration of the roller drums and the resulting response from the underlying materials.

3. GPS radio and receiver units shall be mounted on each IC roller to monitor the drum locations and track the number of passes of the rollers.

4. IC rollers shall include an integrated on-board documentation system that is capable of displaying real-time color-coded maps of IC measurement values including the stiffness response values, location of the roller, number of roller passes, pavement surface temperatures, roller speeds, vibration frequencies and amplitudes of roller drums.

5. The display unit shall be capable of transferring the data by means of a USB port.

6. An on-board printer capable of printing the identity of the roller, the date of measurements, construction area being mapped, percentage of the construction area mapped, target IC-MV, and areas not meeting the IC-MV target values shall be provided.

The following contact information is provided for three pre-approved vendors. Others may be submitted for approval.

Vendor	Bomag	Sakai	Wirtgen/Hamm
Model	Asphalt Manager	CIS	HCQ
Model No.	BW190AD-4AM	SW880/SW890	HD+ 90 / HD+ 110 HD+ 120 / HD+ 140
Documentation	BCM 05 Office	AithonMT-A	HMV
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Global Positioning System (GPS). The Contractor shall provide GPS technology to achieve accurate and consistent GPS measurements among all GPS equipped devices on the project.

GPS-Related Definitions

• GPS: A space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth to determine the location in geodetic coordinates. In this specification, GPS refers to all GPS-related signals including US GPS, and other Global Navigation Satellite Systems (GNSS).

• Hand-Held GPS rover: A portable GPS radio/receiver for in-situ point measurements.

• GPS Base Station: A single ground-based system that consists of a GPS receiver, GPS antenna, radio and radio antenna to provide L1/L2 differential GPS correction signals to other GPS receivers within a range limited by radio, typically 3 miles (4.8 Km) in radius without repeaters.

• Network RTK: Network RTK is a system that use multiple bases in real-time to provide high-accuracy GPS positioning within the coverage area that is generally larger than that covered by a ground-based GPS base station; e.g.., VRSTM.

• GPS Correction Service Subscription: A service that can be subscribed to receive VRS signals in order to achieve higher accuracy GPS positioning normally via cellular wireless data services; i.e., without the need for a ground-based base station. Examples of GPS Correction Service subscriptions are: Trimble VRSTM, Trimble VRS NOWTM, OmniSTAR, etc.

• RTK-GPS: Real Time Kinematic Global Positioning Systems based on the use of carrier phase measurements of the available GPS signals where a single reference station or a reference station network provides the real-time corrections in order to achieve centimeter-level accuracy.

• UTM Coordinates: Universal Transverse Mercator (UTM) is a 2-dimensional Cartesian coordinates system that divides the surface of Earth between 80°S and 84°N latitude into 60 zones, each 6° of longitude in width and centered over a meridian of longitude. Zone 1 is bounded by longitude 180° to 174° W and is centered on the 177th West meridian. The UTM system uses projection techniques to transform an ellipsoidal surface to a flat map the can be printed on paper or displayed on a computer screen. Note that UTM is metric-based.

• Geodetic Coordinates: A non-earth-centric coordinate system to describe a position in longitude, latitude, and altitude above the imaginary ellipsoid surface based on a specific geodetic datum. WGS-84 and NAD83 datum are required for use with UTM and State Plans, respectively.

• ECEF XYZ: Earth-Centered, Earth-Fixed Cartesian X, Y, Z coordinates.

• Grid: Referred to ECEF XYZ in this specification.

• GUI Display: Graphical User Interface Display

• State Plane Coordinate: A set of 124 geographic zones or coordinate systems designed for specific regions of the United States. Each state contains one or more state plane zones, the boundaries of which usually follow county lines. The current State Plane coordinate is based on NAD83.

• UTC: Coordinated Universal Time (UTC) is commonly referred to as Greenwich Mean Time (GMT) and is based on a 24 hours' time scale from the mean solar time at the Earth's prime meridian (zero degrees longitude) located near Greenwich, England.

All GPS devices for this project shall be set to the same consistent coordinate datum/system no matter whether GPS or Grid data are originally recorded. The Rhode Island State Plane Coordinate shall be used. The records shall be in meters.

Ad-hoc local coordinate systems will not be allowed.

Construction Requirements. The Contractor shall provide the GPS system (including GPS receivers on equipment and hand-held GPS receivers (Rovers)) that makes use of the same reference system that can be a ground-based base station or network-RTK, to achieve RTK-GPS accuracy. Examples of combinations are:

1. GPS receivers on equipment and hand-held GPS rovers referenced to the same on-ground base station.

2. GPS receiver on equipment and hand-held GPS receivers referenced to the same network RTK.

GPS Data Records and Formats. The recorded GPS data from the equipment and hand-held

GPS rovers shall be in the following formats:

1. Time: The time stamp shall be in military format, hhmmss.ss in either UTC or local time zone. 0.01 second is required to differentiate sequence of data points during post process.

2. GPS: Latitudes and longitude shall in ddmm.mmmmmmmm or decimal degrees, dd.dddddddd. Longitudes are negative values when measuring westward from the Prime Meridian.

3. Grid: Coordinates shall be in meters with at least 3 digits of significance (0.001 m or 1 mm).

When importing data into the data analysis management program, the GPS data and associated measurements shall be stored with minimum data conversions and minimum loss of precisions. Users can then select unit of preference to allow real time unit conversion for the GUI display.

Post-Process GPS Check. Follow the vendor-specific instructions to export data to Veda-compatible formats. The Contractor shall import the equipment data into Veda and enter GPS point measurements from the rover and visually inspect the map and point measurements on the Veda display screen for consistency.

Data Analysis Software. Standardized data analysis software (Veda) is available on the website www.intelligentcompaction.com. As a minimum, the following Essential Data Information and Data Elements shall be included in each data file or section.

Item	Description
1	Section Title
2	Machine Manufacture
3	Machine Type
4	Machine Model
5	Drum/Screed Width (m)
6	Drum Diameter (m) (roller only)
7	Machine Weight (metric ton)
8	CSPC Zone
9	Offset to UTC (hrs)
10	Number of data points

- Essential Data Elements for Each Data Point:

Item	Date Field Name	Example of Data
1	Date Stamp (YYYYMMDD)	e.g. 20080701
2	Time Stamp (HHMMSS.SS -military format)	e.g. 090504.00 (9 hr 5 min. 4.00 s.)
3	Longitude (decimal degrees)	e.g. 94.85920403

4	Latitude (decimal degrees)	e.g. 45.22777335
5	Easting (m)	e.g. 354048.300
6	Northing (m)	e.g. 5009934.900
7	Height (m)	e.g. 339.9450
8	Pass number (rollers only)	e.g. 2
9	Direction index	e.g., 1 forward, 2 reverse
10	Speed (kph) (rollers and pavers)	e.g. 4.0
11	Vibration on	e.g., 1 for yes, 2 for no
12	Frequency (vpm)	e.g. 3500.0
13	Amplitude (mm)	e.g. 0.6
14	Surface temperature (°C) (rollers only)	e.g. 120

Longitude and latitude can be exclusive with easting and northing, and vice versa. The size of data mesh after post-processing shall be less than 18 inches (450 mm) by 18 inches (450 mm) in the X and Y directions.

Equipment. The supplier, make, model, unique identifier, and the GPS system supplier to be utilized.

Process Control During Rolling: In addition to any other QC responsibilities, the Contractor shall be responsible for the following:

1. Daily GPS check testing for the equipment and rover(s).

2. Establishing target number of passes using data from standard testing devices; i.e., Nondestructive density gauges, pavement cores, and roller(s).

3. Monitoring the equipment location during paving operations and the operation of the entire GPS system on the project site.

4. Quality control testing to monitor the pavement temperature.

5. Daily download and analysis of the data from the roller(s).

6. Daily set-up, take down and secure storage of GPS and equipment components

Materials Sampling and Testing.

A minimum of 95% of the mat must be rolled at least three times when analyzed using Veda software. Three 500 foot test sections shall be constructed at the beginning of three different locations determined by the Engineer. The test sections shall be rolled six times at 100% coverage to determine the IC-MV values and temperatures. The minimum frequency of obtaining the data from the equipment shall be two (2) times per day of asphalt compaction operations. The data shall be date and time stamped permitting external evaluation at a later time. Data from the on-board printer shall be submitted to the Engineer upon request.

The raw data and results from the analysis software shall be made available to the Engineer within 24 hours of obtaining the data.

GPS Setup. Prior to the start of production, the Contractor and representatives of the GPS and equipment manufacturer shall conduct the following to check the proper setup of the GPS equipment and the rover(s) using the same datum:

1. On a location nearby or within the project limits, the GPS base station (if required by the GPS) shall be established and the equipment and the GPS rover tied into the same base station.

2. Verification that the equipment and rover are working properly and that there is a connection with the base station.

3. There are two options for comparing the equipment and rover coordinates. Production shall not begin until proper GPS verification has been obtained. The vendor's recommended verification process can be used to augment either of the following options:

a. GPS verification measurements shall be conducted while the equipment is stationary. The GPS coordinates from the equipment on-board display shall be recorded ensuring that the distance offsets are applied correctly to the center of the front drum (e.g., the measurement is at the equipment GPS receiver position). Place the hand-held GPS receiver on top of the GPS receiver mounted on the equipment and record the coordinates from the hand-held receiver display. The differences of the coordinates between the equipment GPS receiver and hand-held GPS receiver shall be within 2 inches (50 mm) in both the horizontal axes (X and Y). The check for the vertical axis is not required.

b. A reference location on the project site shall be selected and marked by the Contractor. The equipment shall be placed so that the center of the front drum is on top of the reference location and the location measurement shall be recorded. After moving the equipment from the marked location, a hand-held rover must be used to locate the reference location. The differences of the coordinates in grid shall be within 6 inches (150 mm) in both the horizontal axes (X and Y). The GPS location measurements from the equipment must be used to determine any offsets that are required so that the GPS coordinate of the equipment is at the center of the front drum or hopper. On some systems, distance offsets are applied to the roller GPS measurements from the on-board display and the coordinates may be on the left or right side of the drum. In those cases the equipment must be moved so that the left or right side of the front drum axle is flush with the reference location. The hand-held rover must be placed on the marked location and the difference of both coordinate records checked. The final GPS coordinate for each data point recorded in data files must be at the center of the front drum or hopper.

4. GPS setup shall be conducted daily during production operations to ensure consistency and accuracy of GPS measurements for all GPS devices prior to the compaction operation.

Documentation. The documentation shall include the following.

1. Equipment. Documentation of the manufacturer and model of the IC rollers used each day of paving. The relative positioning of the equipment in the paving operations shall be noted.

2. Initial Data. At a minimum, the electronic data from equipment and the data analysis software shall be provided to the Engineer upon the completion of the first day's paving.

3. Production Roller Data. The Contractor shall export from the vendor's software all data on a daily basis. The Contractor shall analyze the equipment data for coverage area and uniformity and shall submit the results to the Engineer within 24 hours of the completion of the each day's paving operation.

A summary of all equipment data shall be given to the Department at the completion of the contract.

Assistance and Training

Technical Assistance. The Contractor shall coordinate for on-site technical assistance from the equipment representatives during the initial seven (7) days of production and then as needed during the remaining operations. As a minimum, the equipment representative shall be present during the initial setup and verification testing of the equipment. The equipment representative shall also assist the Contractor with data management using the data analysis software including data input and processing.

On-Site Training. The Contractor shall provide and coordinate on-site training for Contractor and Agency project personnel. Contractor's personnel shall include the paving superintendent, QC technicians (if applicable), and equipment operators. At a minimum, training topics shall include:

1. Background information for the specific system(s) to be used

2. Setup and checks for system(s), GPS receiver, base-station and hand held rovers

3. Operation of the system(s) on the equipment; i.e., setup data collection, start/stop of data recording, and on-board display options

4. Transferring raw data from the equipment; i.e., via USB connections

5. Operation of vendor's software to open and view raw data files and exporting all-passes and proofing data files in Veda-compatible format

6. Operation of Veda software to import the above exported all-passes and proofing data files, inspection of maps, input point test data, perform statistics analysis, and produce reports for project requirements

7. Coverage and uniformity requirements of the HMA specification

METHOD OF MEASUREMENT

Intelligent Compaction for HMA will be measured for payment according to the following method. The total number of days IC is used will be counted and compared to the total number of days paving, and a ratio will be calculated as total-days-IC/total-days-paving which will be used in determining the Basis of Payment.

BASIS OF PAYMENT

The Lump Sum bid price constitutes full and complete compensation for all labor, materials, equipment and incidentals required to finish the work complete and accepted by the Engineer. The accepted quantity for Intelligent Compaction for HMA will be paid for using the contract Lump Sum bid price adjusted as follows. The Lump Sum bid price will be multiplied by the ratio calculated in the Method of Measurement and the resultant amount will constitute the total payment for IC. For example, if total days paving is 8 and total days IC is 6, then the ratio will be 6/8 or 75%, and the total payment for IC will be 0.75xLumpSumBidPrice. The full contract Lump Sum bid price will be paid when IC was used for all days paving.

** -The intent of adjusting the Lump Sum amount is to encourage the Contractor to use the Intelligent Compaction and allows the Department to pro-rate the Lump Sum amount if Intelligent Compaction is not being used. On this project IC was used on all days paving and therefore the full lump sum was paid.*