Vermont Demonstration Project:

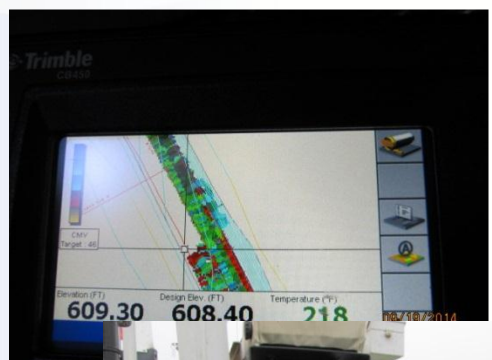
Stockbridge-Bethel Roadway Reclamation Project

Final Technical Brief

August 2015

HIGHWAYS FOR LIFE

Accelerating Innovation for the American Driving Experience.



U.S.Department of Transportation
Federal Highway Administration

FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. Such "innovations" encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community's culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decision makers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

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As a part of the HfL initiative, the FHWA provided a $1,900,000 grant to the Vermont Agency of Transportation for the Stockbridge-Bethel roadway reclamation project. The Stockbridge-Bethel project involved reclaiming the roadway that spanned 9.7 miles over VT RT-107 from the new through-truss bridge in the town of Bethel to Stockbridge, where RT-107 intersects VT Route 100. The work performed on this project included cold planing, reclamation of the existing roadway, base stabilization, superelevation and other minor geometric improvements, resurfacing with new base, intermediate, and wearing surfaces, new pavement markings, guardrail improvements, drainage improvements, and other incidental items. The project scope also included the construction of a new park and ride facility.

The Stockbridge-Bethel roadway reclamation project included the use of the following technologies:

• Global positioning system (GPS) surveying equipment.
• GPS-equipped machine graders.
• Intelligent compaction (IC) equipment mounted on both dirt and pavement rollers.
• Infrared thermal imaging equipment mounted on the back of the paver.

These technologies helped with the real-time monitoring of roadway construction and served as important quality assurance tools to both the contractor and the resident engineer over the duration of the project.</td></tr>
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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
(none)	mil	25.4	micrometers	μm
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	Newtons	N
lbf/in^2 (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in^2 (ksi)	kips per square inch	6.89	megaPascals	MPa
		DENSITY		
lb/ft^3 (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
μm	micrometers	0.039	mil	(none)
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	poundforce	lbf
kPA	kiloPascals	0.145	poundforce per square inch	lbf/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ABBREVIATIONS AND SYMBOLS

CMV	Compaction Measurement Value
DCP	dynamic cone penetrometer
FHWA	Federal Highway Administration
GPS	global positioning system
HfL	Highways for LIFE
IC	intelligent compaction
IRI	International Roughness Index
OBSI	on-board sound intensity
OSHA	Occupational Safety and Health Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

Highways for LIFE (HfL) is the Federal Highway Administration's (FHWA) initiative to advance longer-lasting and promote efficient and safe construction of highways and bridges using innovative technologies and practices. The HfL program provides incentive funding to highway agencies to try proven but little-used innovations on eligible Federal-aid construction projects. The HfL team prioritizes projects that use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the Applicant State has never or rarely used, even if it is standard practice in other States. Recognizing the challenges associated with deployment of innovations, the HfL program provides incentive funding for up to 15 demonstration construction projects a year. The funding amount typically totals up to 20 percent of the project cost, but not more than $5 million.

The HfL program promotes project performance goals that focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. The goals are categorized into the following categories:

1. **Safety**

    a. Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.

    b. Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.

    c. Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

2. **Construction Congestion**

    a. Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.

    b. Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.

    c. Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).

3. **Quality**

    a. Smoothness—International Roughness Index (IRI) measurement of less than 48 inches/mile.

    b. Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the on-board sound intensity (OBSI) test method.

4. **User Satisfaction**

    a. User satisfaction—An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

PROJECT OVERVIEW

As a part of the HfL initiative, the FHWA provided a $1,900,000 grant to the Vermont Agency of Transportation for the Stockbridge-Bethel roadway reclamation project. The Stockbridge-Bethel project involved reclaiming the roadway that spanned 9.7 miles over VT RT-107 from the new through-truss bridge in the town of Bethel to Stockbridge, where RT-107 intersects VT Route 100. The work performed on this project included cold planing, reclamation of the existing roadway, base stabilization, superelevation and other minor geometric improvements, resurfacing with new base (cold mix made from RAP from the project), intermediate, and wearing surfaces, new pavement markings, guardrail improvements, drainage improvements (including underdrain), centerline rumble strip, and other incidental items. The project scope also included the construction of a new park and ride facility.

PROJECT DETAILS

PROJECT BACKGROUND AND LOCATION

The Stockbridge-Bethel project involved reclaiming the roadway that spanned 9.7 miles over VT RT-107 from the new through-truss bridge in the town of Bethel to Stockbridge, where RT-107 intersects VT Route 100.

PROJECT DESCRIPTION

The work performed on this project included cold planing, reclamation of the existing roadway, base stabilization, superelevation and other minor geometric improvements, resurfacing with new base (cold mix made from RAP from the project), intermediate, and wearing surfaces, new pavement markings, guardrail improvements, drainage improvements (including underdrain), centerline rumble strip, and other incidental items. The project scope also included the construction of a new park and ride facility.

Project Innovations

The Stockbridge-Bethel roadway reclamation project included the use of the following technologies:

1. Global positioning system (GPS) surveying equipment.
2. GPS-equipped machine graders.
3. Intelligent compaction (IC) equipment mounted on both dirt and pavement rollers.
4. Infrared thermal imaging equipment mounted on the back of the paver.

These technologies helped with the real-time monitoring of roadway construction and served as important quality assurance tools to both the contractor and the resident engineer over the duration of the project.

Bidding Information

Three bids were received for this project. The winning bid was $11,155,452.75. The contractor was responsible for reclaiming and/or cold planing segments of the existing highway and overlaying with an intermediate course and a wearing course, with pavement markings, guardrail, drainage improvements, and other related items. Table 1 presents a bid comparison summary.

Table 1. Bid comparison summary.

Bidder	Construction Bid	% Over Low Bid
Pike Industries, Inc.	$3,062,056.10	100%
Frank W. Whitcomb Construction Corporation	$3,167,510.07	113%
Kubricky Construction Corporation	$3,999,949.37	115%

Project Schedule Information

The Stockbridge-Bethel roadway reclamation project was let on May 16, 2014, and the contract completion date was set as July 31, 2015.

Construction

The construction work on this project began in July 2014. The initial stage of the project involved milling and installing underdrain along Route 107 in Stockbridge. New catch basins and pipe extensions were installed, and guardrails in Bethel and Stockbridge were temporarily reset. Stone slope stabilization operations were also carried out.

The aforementioned operations were followed by roadway reclamation from the truss bridge in Bethel and westward towards Stockbridge along Route 107. The existing milled pavement was rototilled, leaving a gravel surface on the roadway. This was followed by paving four layers of the new pavement on Route 107. During this work, there were several active work zones on the project due to no practical detour and the traffic pattern for the Route 100/107 Intersection was changed. The Route 100/107 intersection was converted to a “T” intersection in place of a “Y” intersection, and new traffic signs were installed. During the final stage of paving, granite curbing was provided in the new park and ride facility near the intersection of Routes 100/107.

Once the roadwork was completed, the construction signs were removed and the project was shut down for the winter. The work restarted in spring 2015, with installation of lighting and pavement markings in the new park and ride facility. The work that followed included excavation on the shoulder near the intersection of VT 100/107 to install electrical conduit for lighting in the park and ride facility.

Milling, drain installation, paving, guardrail work, and shoulder excavation work required alternating one-way traffic within the construction zones, and traffic control was made available to maintain traffic flow. The 50 mph speed limit zones within the project were reduced to 40 mph, and the reduced speed limit was in effect at all times for the duration of the project. Law enforcement officials were also present at the project location to enforce the reduced speed limit.

The innovative technologies employed on this project are described in further detail on the following pages. [(1)]

Intelligent Compaction

The contractor was required to install IC technology on a dirt roller to be used for the two reclaimed stabilized base passes. The IC technology was installed on a double drum vibratory paving roller to measure the interactions between the roller and the compacted materials beneath. The Compaction Measurement Value (ICMV or CMV) was the real-time rating used to analyze the applied compaction effort, and it represented the stiffness of the materials based off the vibration from the roller drums and the resulting response that is returned from the underlying materials. Two temperature sensors, one mounted on the front of the roller and one mounted on the back of the roller, were used with the IC technology. The CMV, frequency, amplitude, pass count, roller speed, and temperature data were recorded continuously (see figure 1) enabling the engineer to review the daily work-related data and identify any areas for quality improvement.

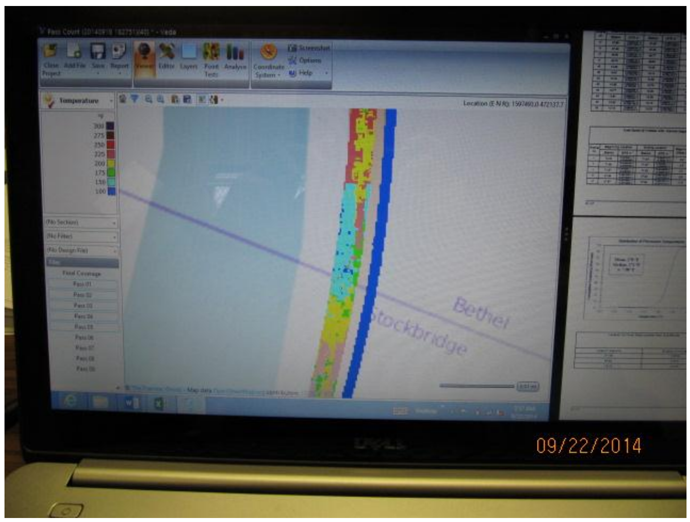

Figure 1. Photo. Example screen showing the CMV map. (courtesy: Vermont Agency of Transportation)

During the dirt work process, an IC technology-enabled Cat CS 54B single drum vibratory roller (see figure 2) was used for compaction of the dirt subbase on both the first and second reclaim operations. Dynamic cone penetrometer (DCP) tests were also conducted to correlate the material densities with the correct target CMV. For three lifts of hot mix, GPS-equipped IC equipment mounted onto a double drum Cat CB54 XW vibratory roller was used. A close-up of the on-board data monitor is shown in figures 3 and 4, and a close-up of the GPS radio receiver is shown in figure 5.

At the end of each day, the data from the IC data collector were downloaded and given to the engineering office for analysis and review with the accompanying Veda IC software.

Figure 2. Photo. Paving roller mounted with IC equipment. (courtesy: Vermont Agency of Transportation)

Figure 3. Photo. Temperature map from on-board IC data collector. (courtesy: Vermont Agency of Transportation)

Figure 4. Photo. CMV data screen from on-board data collector. (courtesy: Vermont Agency of Transportation)

Figure 5. Photo. IC GPS and radio receiver mounted to paving roller Cat CB54 XW. (courtesy: Vermont Agency of Transportation)

Thermal Imaging

Another technology used on the Stockbridge-Bethel project was the MOBA PAVE-IR thermal scanner, which uses an infrared temperature scanner mounted on the back of the paver for scanning and recording temperature data for the full width of the mat over the length of the paving operation. The infrared scanner mounted to the rear of the paver is presented in figures 6 and 7.

The thermal scanner provided data on the recording paver speed, paver location, stoppage times and locations, date, time stamp, and project information as well (see figures 8 and 9 for interface controller). The data are stored automatically by the interface controller and can be imported and reviewed in MOBA’s software, called Pave Project Manager.

Figure 6. Photo. Infrared thermal scanner attached to rear of paver with interface controller mounted below. (courtesy: Vermont Agency of Transportation)

Figure 7. Photo. Infrared thermal scanner attached to rear of paver with GPS receiver behind it.
(courtesy: Vermont Agency of Transportation)

Figure 8. Photo. Interface controller attached to the rear of the paver for real-time monitoring.
(courtesy: Vermont Agency of Transportation)

Figure 9. Photo. Interface controller monitor showing number and percentage of moderate and severe thermal profiles in yellow and red boxes. (courtesy: Vermont Agency of Transportation)

GPS Rover and Base Station

This project required the use of the innovative GPS rover and base station technology. The GPS rover consisted of a GPS receiver on top of a survey pole with a wireless data collector attached lower on the pole (see figure 11). The rover communicated with a GPS-enabled base station (see figure 12). The rover and base station setup was used for checking subbase cut and fill levels, laying out pipes, setting pipe grades, taking solid rock sections, verifying and laying out grade stakes, and laying out centerline and edge line alignment for roadway line painting. This innovative technology allowed one inspection engineer to perform the work normally done by two operators on land surveying.

Figure 10. Photo. GPS rover and data collector used to check cut/fill levels for subbase. (courtesy: Vermont Agency of Transportation)

Figure 11. Photo. GPS base station set up over control point. (courtesy: Vermont Agency of Transportation)

In addition to the GPS rover and base station, the project involved the use of a grader equipped with a GPS rover to enable complete automation of the cutting blade. The use of the GPS-enabled grader allowed fine and quicker grading operation at most times; however, there was some backtracking at times because of loss of GPS signal in some locations. The loss of GPS signal was primarily due the curvy road in the narrow steep valley.

HIGHWAYS FOR LIFE PERFORMANCE GOALS

The primary objective of acquiring data on HfL performance goals such as safety, construction congestion, and quality is to quantify project performance and provide an objective basis from which to determine the feasibility of the project innovations and to demonstrate that the innovations can be used to do the following:

1. Achieve a safer work environment for the traveling public and workers.

2. Reduce construction time and minimize traffic interruptions.

3. Produce a high-quality project and gain user satisfaction.

Data were not available to evaluate whether this project met HfL performance goals.

However, this project has resulted in the use of GPS on Vermont reclaim project providing the following unquantifiable benefits:

1. Less staking and layout (reduce worker exposure to traffic – improve workers safety)

2. Less staking and layout (reduce the amount of time in roadway – less traffic delays during construction)

3. Machine grading of roadway (higher quality of roadway alignment)

REFERENCES

1. Michaud, C. Roadway Technology Implementation Report, Project: Stockbridge-Bethel STP2910(1). Vermont Agency of Transportation, Montpelier, VT. 2014.

ACKNOWLEDGMENTS

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