Rhode Island Demonstration Project:

Replacement of East Shore Expressway Bridge No. 475 over Warren Ave.

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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16. Abstract

As a part of the HfL initiative, the FHWA provided a waiver to the State match requirement to the Rhode Island Department of Transportation (RIDOT) to replace Bridge No. 475, East Shore Expressway over Warren Avenue, East Providence. The project's innovative aspects include the use of a self-propelled modular transporter (SPMT), which is a computer-controlled platform vehicle capable of moving objects weighing up to several thousand tons. Other innovations on the project include geosynthetic reinforced soil (GRS) and precast bridge elements. Using these innovations will accelerate construction, minimize traffic impacts, reduce congestion, and improve quality. The project will provide RIDOT personnel with valuable experience in these technologies.

The project is anticipated to be advertised for construction in fall 2015.

17. Key Words	18. Distribution Statement
Highways for LIFE, self-propelled modular transporter, SPMT, precast bridge elements, GRS, geosynthetic reinforced soil	No restriction. This document is available to the public through the Highways for LIFE website: http://www.fhwa.dot.gov/hfl/

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Unclassified	Unclassified	15	

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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

ABC	accelerated bridge construction
FHWA	Federal Highway Administration
GRS	geosynthetic reinforced soil
HfL	Highways for LIFE
IRI	International Roughness Index
OBSI	onboard sound intensity
RIDOT	Rhode Island Department of Transportation
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SPMT	self-propelled modular transporter

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 onboard sound intensity (OBSI) test method.

4. **User Satisfaction**

    a. 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 waiver to the State match requirement to the Rhode Island Department of Transportation (RIDOT) to replace Bridge No. 475, East Shore Expressway over Warren Avenue, East Providence. The project's innovative aspects include the use of a self-propelled modular transporter (SPMT), which is a computer-controlled platform vehicle capable of moving objects weighing up to several thousand tons. Other innovations on the project include geosynthetic reinforced soil (GRS) and precast bridge elements. Using these innovations will accelerate construction, minimize traffic impacts, reduce congestion, and improve quality. The project will provide RIDOT personnel with valuable experience in these technologies.

The project is anticipated to be advertised for construction in fall 2015.

PROJECT DETAILS

PROJECT BACKGROUND AND LOCATION

The East Shore Expressway Bridge No. 475 carries two eastbound exit lanes of Interstate Route 195 before becoming the East Shore Expressway (State Route 114). The bridge traverses over four lanes of Warren Avenue (State Route 6) in East Providence. Figure 1 shows a map of the project location.

The existing bridge is a three-span continuous concrete "T" beam stringer bridge. The "T" beam stringers are haunched over the two interior piers. The bridge has a span arrangement of 55 feet–110 feet–55 feet, with a skew angle of 60 degrees and a curb-to-curb width of 38 feet. The bridge was built in 1959, and a minor rehabilitation was performed in 1993. Figures 2 through 5 show the condition of the bridge. The bridge carries approximately 23,000 vehicles per day and is the major route connecting the east bay section of the State to points north.

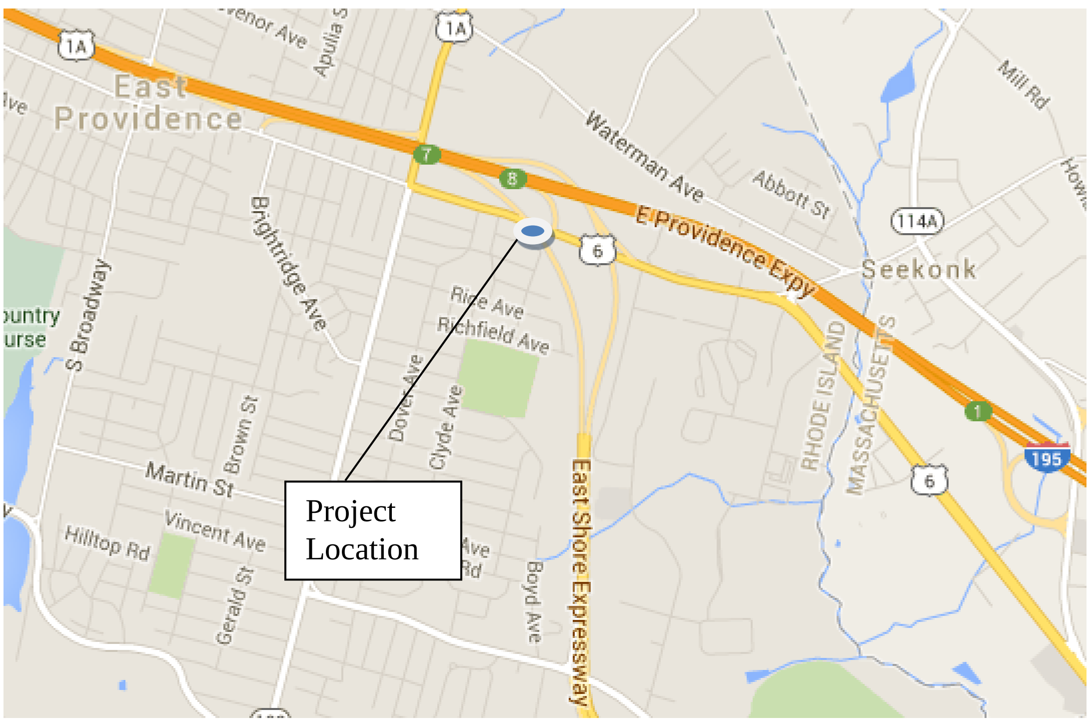

Figure 1. Map. Project location.

In their HfL application, RIDOT stated:

> The proposed superstructure will be a single span structure supported on precast concrete stub abutments that are founded on a geosynthetic reinforced soil mat. The substructure units will be constructed behind the existing interior piers, resulting in a span length of approximately 122 feet, which will allow Warren Avenue traffic to remain uninterrupted with the exception of minor closures for erection purposes.

Figure 2. Photo. North view of existing bridge deck (Courtesy Google Maps).

Figure 3. Photo. South view of existing bridge deck (Courtesy Google Maps).

Figure 4. Photo. West face of existing bridge (Courtesy Google Maps).

Figure 5. Photo. Close-up of west face of existing bridge (Courtesy Google Maps).

The draft elevation of the new structure is shown in figure 6.

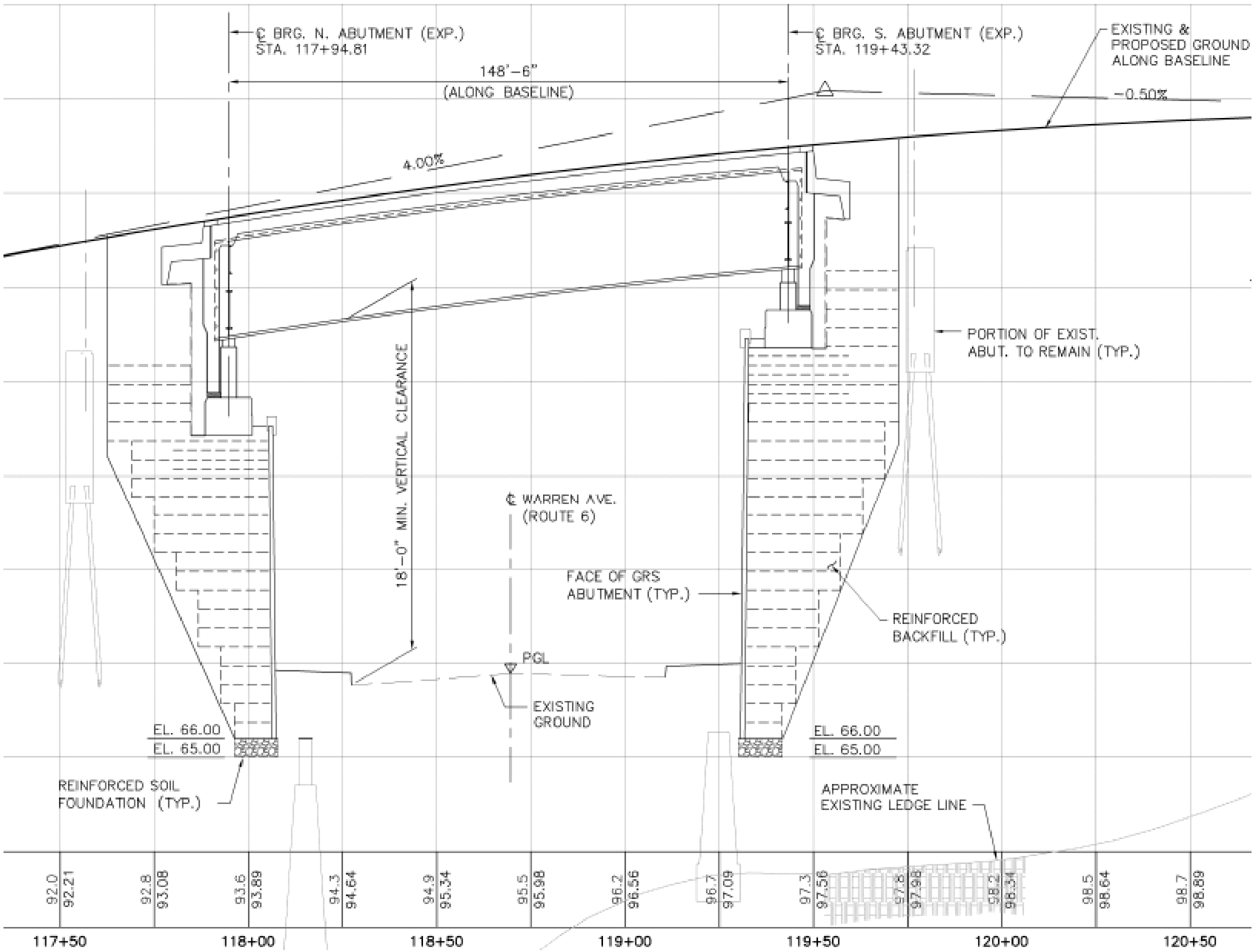

Figure 6. Drawing. Draft elevation of new bridge.

INNOVATIONS

Using conventional construction methods, the bridge structure would have been built in phases. The bridge would have been narrowed to one lane of travel, causing major traffic disruptions, while the other half of the structure was being demolished and rebuilt. Conventional footings would have been cast in place and would have required an elaborate support of excavation. This would have been followed by the construction of substructure, erection of girders, forming, casting and waterproofing of the concrete deck, and placement of approach slabs and an asphalt wearing surface. The traffic would then have been transferred to the newly constructed portion of the structure and the whole process would have been repeated to complete the remainder of the bridge. At each step during construction, freshly placed concrete would have required anywhere from 7 to 21 days to cure and reach strength suitable for the continuation of construction activities. It is estimated that the phasing, sequential construction, and curing for concrete would have caused major traffic disruptions and would have required two construction seasons and a winter shutdown.

In contrast, RIDOT anticipates completing the project in only 12 months with traffic impacts limited to 48 hours using accelerated bridge construction (ABC) and innovative technologies.

The majority of elements for the new bridge will be precast to accelerate construction. RIDOT plans to use precast concrete wall panels and footings, precast concrete stub abutments and footings, and precast concrete approach slabs. The wing walls will consist of precast concrete panels and will serve as a facing to the GRS mat or as part of a mechanically stabilized earth retaining wall system. The approach slabs will be dropped into place at the appropriate time.

The superstructure will be built offsite while substructure work is being performed. The steel girders will be shored prior to placement of the concrete deck to utilize the full benefit of a composite structure. Once the existing structure is demolished and the area cleared of debris during a weekend closure of the site, the superstructure will be transported from the bridge staging area using an SPMT and dropped into place.

Besides compressing project construction time, the innovative features of the project will provide advantages related to safety, construction congestion, and quality.

Safety

With the reduction in construction duration, the likelihood of worksite accidents will be reduced. Constructing the superstructure offsite means that workers will not be exposed to vehicular traffic during superstructure construction. By avoiding phased construction, there will be no reduction in the number of traffic lanes through the work zone; therefore, crashes that would result from merging activities will be avoided. Also by constructing the GRS abutments outside the roadway, both workers and travelers will have reduced exposure to worksite accidents. It is therefore believed that the innovative approach will meet or exceed the HfL performance goal of achieving incident rate for worker injuries to be less than 4.0 based on the OSHA 300 rate.

Construction Congestion

Thanks to the innovative aspects of the project, the construction duration that will impact traffic will be reduced from two construction seasons to only one weekend, virtually eliminating the impact of detour length, queuing, and increased trip time and easily exceeding the HfL goals for reducing congestion.

Quality

Building the bridge superstructure away from traffic will enable easy construction access and improved quality due to avoidance of damage that could be caused by traffic-induced vibrations. Furthermore, the more controlled conditions will allow for longer concrete cure times, better material staging areas, and smoother assembly. The casting of the deck in one piece will also avoid longitudinal joints that are caused by phased construction.

The quality of precast elements is also apt to be superior to cast-in-place construction. For instance, in precast construction, a single team typically ensures quality control at a plant, whereas for cast-in-place construction responsibility for quality control is divided and dispersed among multiple teams. Teams range from those responsible for proportioning aggregates, cement, and water in batch plants to contractor teams exercising quality control procedures to the owner’s inspection personnel on site responsible for proper placement, curing, and testing of concrete. It is important to ensure that precast elements are fabricated accurately, as correcting any misalignment of connecting pieces can cause significant project delays. Therefore, it will be important for the project team to be proactive and spend extra effort to ensure that precast elements are built correctly.

Finally, the new riding surfaces of the approaches and the new bridge deck covered with new asphalt are likely to be a great improvement over the surfaces of the old bridge.

SPMT

RIDOT has used SPMTs in its bridge program in the past but not to remove or replace a bridge on a roadway that is in use. The project team will need to ensure coordination and collaboration among the subcontractor specializing in SPMT, the prime contractor for the project, and the designer to refine the design of the moving equipment and the design of the lifting diaphragms. The vertical stroke of the SPMT will need to be such that it is adequate to lift the superstructure off the supports at the bridge staging area and set it on the abutments of the new bridge.

The completed superstructure will also need to be monitored for deflections and twist during lifting, transfer, of support to lifting diaphragms, transport from the bridge staging area to the bridge abutments, and transfer to its final position. The number of SPMT axles will depend on the weight of the superstructure.

The project team will need to be thoroughly familiar with the travel path and its grade changes and ensure that it does not exceed the 3 percent maximum grade that is typical for the stability of equipment. The team will also need to assess the need for steel plates along the travel path to avoid damage to the roadway due to the high stresses.

The SPMT specialty subcontractor and the prime contractor will need to work closely together on the schedule, as the former's availability will have significant impact on the latter's work activities and schedule.

Experience in other regions of the country has shown that use of SPMT on bridge projects typically generates considerable public interest. It is not known at this time whether RIDOT will be setting up a viewing area and/or provide live streaming of the bridge rollout and/or provide a time-lapse video online, following the bridge move.

RIDOT plans to conduct a media blitz encouraging motorists to plan ahead for full roadway closure during a weekend when the existing bridge will be demolished and the new one moved into place using the SPMT. Should the prime contractor wish to opt out of using the SPMT, he will need to present alternatives that are acceptable to RIDOT.

In summary, RIDOT views this project as a model for future projects in the short to medium span range. Success on this project is likely to further enhance the State's enthusiasm about utilizing ABC and making it a standard practice on future projects.

ACKNOWLEDGMENTS

The project team acknowledges the invaluable insights and guidance of Highways for LIFE Team Leader Byron Lord and Program Coordinator Ewa Flom, who served as the technical panel on this demonstration project. Their vast knowledge and experience with the various aspects of construction, technology deployment, and technology transfer helped immensely in developing both the approach and the technical matter for this document. The team also is indebted to RIDOT Engineers John Preiss and Brad Owens and FHWA Engineer Anthony Rotondo, for their advice and assistance during this project.