Louisiana Demonstration Project: A Project to Improve Safety and Speed Construction on LA 511 (70th Street) in Shreveport

Final Report
April 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. "Innovations" is an inclusive term used to 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 decisionmakers 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 available at www.fhwa.dot.gov/hfl.

NOTICE

<table>
<tr><td>1. Report No.</td><td>2. Government Accession No</td><td>3. Recipient's Catalog No</td></tr>
<tr><td colspan="2" rowspan="2">3. Title and Subtitle
Louisiana Demonstration Project: A Project to Improve Safety and Speed Construction on LA 511 (70th Street) in Shreveport</td><td>5. Report Date
April 2015</td></tr>
<tr><td>6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Authors
Jay Bledsoe</td><td>8. Performing Organization Report No.</td></tr>
<tr><td colspan="2">9. Performing Organization Name and Address
Applied Research Associates, Inc.
100 Trade Centre Drive, Suite 200
Champaign, IL 61820</td><td>10. Work Unit No. (TRAIS) C6B

11. Contract or Grant No.</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address
Office of Infrastructure
Federal Highway Administration
1200 New Jersey Avenue, SE
Washington, DC 20590</td><td>12. Type of Report and Period Covered
Final Report</td></tr>
<tr><td>14. Sponsoring Agency Code</td></tr>
<tr><td colspan="3">15. Supplementary Notes
Contracting Officer's Representative: Julie Zirlin
Contracting Officer's Task Manager: Ewa Flom</td></tr>
</table>

16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE program, the Louisiana Department of Transportation and Development (DOTD) was awarded a $1 million grant to demonstrate the use of proven, innovative technologies for A + B bidding and the use of open-graded friction course (OGFC) for improving facility safety. This report documents the background of the project, the construction activities, and the economic analysis.

The project undertaken by the DOTD involved the following innovative technologies: (1) the use of asphalt treated base (ATB) material to speed construction and improve stability of the paving platform, (2) the use of an OGFC to enhance safety by way of improved friction and reduction of spray while providing a smooth, quiet riding surface, (3) the use of precast gravity retaining walls to speed construction and minimize impact on adjoining right-of-way, (4) the use of a pan/tilt/zoom camera to monitor traffic during construction, and (5) contractor incentives for smoothness of the riding surface and early project completion.

The experience gained on this project was extremely valuable to the DOTD. The use of innovative technologies provided several insights in the areas traffic management and construction techniques that will be useful in future implementations.

Construction costs for the project totaled about $5.3 million. The DOTD realized an initial capital cost increase of about $350,254 from the use of ATB (+$126,344), OGFC (+$273,030), and gravity retaining walls (-$49,120). While not direct savings to the agency, there were significant short-term and long-term savings to the public. The savings in construction time was estimated to save about $150,000 in user costs. The savings assumed from reduced work zone crashes accounts for an additional $85,000. If these are included in the analysis, the initial cost differential is reduced to about $115,000. If the safety benefit associated with the OGFC is realized for a 3-year period, an additional savings of about $680,000 could be realized, far offsetting the initial construction cost differential.

<table>
<tr><td colspan="2">17. Key Words
Highways for LIFE, asphalt treated base, paving platform, open graded friction course, precast gravity retaining wall, smoothness incentives</td><td colspan="2">18. Distribution Statement
No restriction. This document is available to the public through http://www.fhwa.dot.gov/hfl/.</td></tr>
<tr><td>Security Classif.(of this report)
Unclassified</td><td>19. Security Classif. (of this page)
Unclassified</td><td>20. No. of Pages
37</td><td>21. Price</td></tr>
</table>

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND SYMBOLS

ATB	Asphalt treated base
dB(A)	A-weighted decibel
DOTD	Department of Transportation and Development
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
ITS	Intelligent transportation systems
OBSI	Onboard sound intensity
OGFC	Open-graded friction course
OSHA	Occupational Safety and Health Administration
PDO	Property damage only
RAP	Recycled asphalt pavement
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SRTT	Standard reference test tire
VOC	Vehicle operating costs

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration (FHWA) initiative to accelerate innovation in the highway community, provides incentive funding for demonstration construction projects. Through these projects, the HfL program promotes and documents improvements in safety, construction-related congestion, and quality that can be achieved by setting performance goals and adopting innovations.

The HfL program—described in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—may provide incentives to a maximum of 15 demonstration projects a year. The funding amount may total up to 20 percent of the project cost, but not more than $5 million. Also, the Federal share for an HfL project may be up to 100 percent, thus waiving the typical State-match portion. At the State's request, a combination of funding and waived match may be applied to a project.

To be considered for HfL funding, a project must involve constructing, reconstructing, or rehabilitating a route or connection on an eligible Federal-aid highway. It must use innovative technologies, manufacturing processes, financing, or contracting methods that improve safety, reduce construction congestion, and enhance quality and user satisfaction. To provide a target for each of these areas, HfL has established demonstration project performance goals.

The performance goals emphasize the needs of highway users and reinforce the importance of addressing safety, congestion, user satisfaction, and quality in every project. The goals define the desired result while encouraging innovative solutions, raising the bar in highway transportation service and safety. User-based performance goals also serve as a new business model for how agencies can manage the highway project delivery process.

HfL project promotion involves showing the highway community and the public how demonstration projects are designed and built and how they perform. Broadly promoting successes encourages more widespread application of performance goals and innovations in the future.

Project Solicitation, Evaluation, and Selection

FHWA has issued open solicitations for HfL project applications annually since fiscal year 2006. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, and contacted applicants to discuss technical issues and obtain commitments on project issues. Documentation of these questions and comments was sent to applicants, who responded in writing.

The project selection panel consisted of representatives of the FHWA offices of Infrastructure, Safety, and Operations; the Resource Center Construction and Project Management team; the Division offices; and the HfL team. After evaluating and rating the applications and supplemental information, panel members convened to reach a consensus on the projects to recommend for approval. The panel gave priority to projects that accomplish the following:

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- 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.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1 year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the applicant department of transportation to participate in technology transfer and information dissemination activities associated with the project.

HfL Project Performance Goals

The HfL performance goals 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. States are encouraged to use all applicable goals on a project:

- **Safety**
  - Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
  - Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported via Occupational Safety and Health Administration (OSHA) Form 300.
  - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

- **Construction Congestion**
  - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
  - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
  - 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).

- **Quality**
  - Smoothness—International Roughness Index (IRI) measurement of less than 48 inches per mile.
  - Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

- **User Satisfaction**
    - 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 rating of 4 or more points on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report documents the Louisiana Department of Transportation and Development (DOTD) HfL demonstration project, which involved the use innovative construction techniques and intelligent transportation systems (ITS) components during the reconstruction of a section of LA 511 (70th Street) form Line Avenue to Fern Avenue in Shreveport. The report presents project details relevant to the HfL program, including safety, construction congestion, and user satisfaction. HFL performance metrics and economic analysis lessons learned are also discussed, along with innovative methods of public involvement and technology transfer.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

The project is located along a section of LA 511 (70th Street) between Line Avenue and Fern Avenue in Shreveport. It is part of a corridor that runs from I-49 to US 71 in Bossier City and is one of the busiest and congested in the Shreveport area.

Prior to construction, the facility consisted of a four-lane urban section with no shoulders and extensive entrances along both sides of the roadway. At the time of construction, the facility carried more than 23,000 vehicles per day.

Construction included the expansion of the facility to four through lanes with a 14-foot continuous center turn lane, precast gravity retaining walls, an open-graded friction course (OGFC) surface, and ITS monitoring for traffic management throughout construction. The widening of a bridge over Bayou Pierre near Fern Avenue was also included in the construction contract.

PROJECT INNOVATIONS

Originally, the HfL proposal included seven innovations as part of this project; however, only five were actually undertaken. Roller compacted concrete was included as an alternate bid in the contract, proposed for use in the paving of lane widening sections, but it received no bids. Also, the use of plastic catch basins was included in the application, but existing DOTD specifications excluded their use in the sizes required.

The HfL project undertaken by the DOTD involved the following innovative technologies:

- Asphalt treated base (ATB) material to speed construction and improve stability of the paving platform.
- OGFC to enhance safety by way of improved friction and reduction of spray while providing a smooth, quiet riding surface.
- Precast gravity retaining walls to speed construction and minimize the impact on adjoining right-of-way.
- A pan/tilt/zoom camera to monitor traffic during construction.
- Contractor incentives for smoothness of the riding surface and early project completion.

Using the experience gained through this project, the DOTD will be better able to provide a safe, smooth, and long-term solution to the challenges related to maintaining the serviceability of their highway facilities.

HFL PERFORMANCE GOALS

The successful implementation of an HfL project is assessed with respect to how safety, construction congestion, quality, and user satisfaction were addressed during the construction of the project. On most HfL projects, data are collected before, during, and after construction, as appropriate, to demonstrate that the featured innovations can be deployed while simultaneously meeting the HfL performance goals in these areas.

- **Safety**

    - Work zone safety during construction—While no data were available from the DOTD at the time of this report concerning work zone crashes, the reduction in construction time for the project could certainly be expected to result in fewer work zone crashes. Based on national averages and site-specific crash rates, it can be assumed that approximately three fewer crashes would be expected using the accelerated construction practices employed in this project.
    - Worker safety during construction—No worker injuries occurred during construction, which exceeded the goal of less than a 4.0 rating on the OSHA 300 form.
    - Facility safety after construction—The installation of the continuous left turn lane is expected to have an immediate and continuing improvement in safety, especially in the area of rear end collisions, which are a major issue for turning traffic at this location. In addition, the application of an OGFC is expected to greatly improve safety through increased friction and increased visibility due to reduced spray.
- **Construction Congestion**
    - Faster construction—The project was completed in 275 days instead of the 325 days originally estimated.
    - Trip time during construction—Trip time data were inconclusive, due to the wide variation in construction activities and the inability to collect data multiple times throughout the construction.
    - Queue length during construction—No changes in traffic control would have been made as a result of the innovations; therefore, the queue length could be expected to be the same as for the traditional option.
- **Quality**
    - Smoothness—The average post-grinding IRI was measured to be 132 inches/mile. The HfL goal of IRI less than 48 inches/mile was not met on this project. However, the OGFC resulted in more than a 50 percent reduction in roughness from the original surface. In accordance with the contract, the contractor received a bonus of $95,000 for the smoothness improvement.
    - Noise—The initial measurements of noise before construction averaged 98.3 dB(A) in both directions of travel. The post-construction measurement averaged 99.7 dB(A), an increase of 1.4 dB(A)—slightly above the HfL goal of 96 dB(A). In an urban setting with a relatively low operating speed of around 40 mph, the pavement noise component is considered acceptable.
    - The ATB is expected to contribute to pavement performance well in the future, reducing the need for routine maintenance. The ATB supplies a higher stiffness layer with reduced erodability, resulting in a more even transfer of loading from the surface layers. In this case, it also allowed the use of recycled materials to reduce cost. Using the ATB also greatly reduced construction time for this project, allowing work to proceed faster during periods of wet weather common in this area.
- **User satisfaction**
    - User satisfaction—A user satisfaction survey was conducted by Louisiana Tech University. The results of this survey were not available at the time of this report.

Economic Analysis

An economic analysis showed that the implementation of the technological innovations discussed previously, as compared to the most likely alternative, resulted in an initial capital cost increase of about $115,000. The majority of this cost was associated with the ATB (+$126,344) and the OGFC (+$273,030). The total cost was offset slightly by a savings of about $49,120 associated with the use of precast gravity retaining walls.

Much of the cost increase was offset by decreased construction time and future savings in the areas of safety. This subject is discussed in greater detail later in the report.

Lessons Learned

The experience gained on this project was extremely valuable to the DOTD. The use of innovative technologies provided several insights in the areas traffic management and construction techniques that will be useful in future implementations.

The DOTD contacts indicated no real issues with any of the innovations. The gravity precast retaining wall system was seen as having some of the greatest benefits. Not only was the system easy and fast to install, it greatly minimized the impact to property owners along the route. As with anything new, the agency believes that some of the costs associated with the innovations were due to contractor unfamiliarity with the new techniques and that, as these items become more common practice, the initial cost will come down. In this case, some of the increased cost could have been due to the way the construction was staged. To minimize the impact to residents along the route, work was completed in small sections between entrances, and then the gaps were filled in later. This prevented a consistent flow of work, adding to costs. However, this would have been the method employed even if conventional treatments were used.

The uncertainty of the contractor that they would be able to meet the density requirements on the single 8-inch lift of this material and the asphalt plant not being familiar with the mix design was partially responsible for the high cost of this product. The DOTD expects the price to decrease when the market become more comfortable with the product.

The DOTD also noted that the OGFC resulted in a very aesthetically pleasing project. Due to the widening and patching, this project look rugged prior to the placement of the OGFC. With the improved ride and aesthetics of the OGFC, according to the DOTD, this road could be mistaken for new contruction. Many complements were received after the placement of the OGFC from those that were previously critical of the project.

Conclusions

The DOTD gained valuable experience from the use of HfL innovations on the Shreveport LA 511 project. The addition of a dedicated center turn lane should improve traffic flow and reduce rear end crashes along the improved corridor. The OGFC should improve friction along the roadway, also contributing to a safer, quieter facility. The use of innovative solutions such at ATB and precast retaining walls proved valuable in reducing the overall construction time, and thus the inconvenience to the user.

PROJECT DETAILS

BACKGROUND

The project is located along a section of LA 511 (70th Street) between Line Avenue and Fern Avenue in Shreveport. It is part of a corridor that runs from I-49 to US 71 in Bossier City. This corridor is one of the busiest locations in Shreveport and has an associated high incidence of crashes. Recently, the City has made major improvements to Fern Avenue, allowing it to function as an alternate north/south route to LA 1. This, coupled with the planned improvement to LA 511 from I-49 to Line Avenue, is expected to prompt significant traffic growth through this corridor in the near future. Figure 1 indicates both the corridor and project limits.

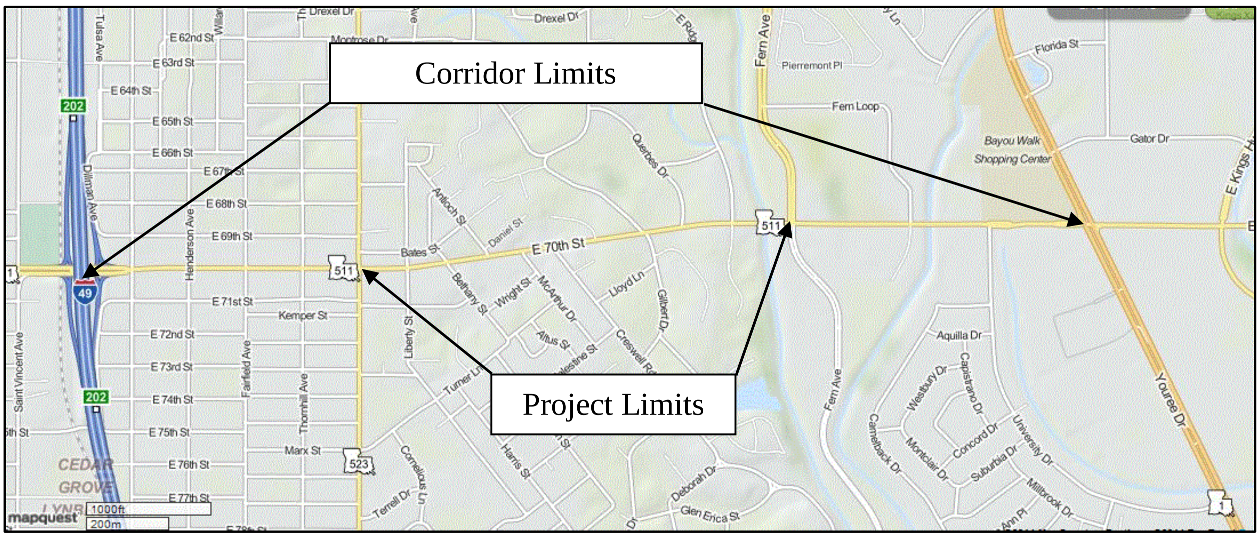

Figure 1. Map. General location.

Prior to construction, the facility consisted of a four-lane urban section with no shoulders and extensive entrances along both sides of the roadway. At the time of construction, the facility carried more than 23,000 vehicles per day. Figure 2 shows a typical roadway view prior to construction.

Construction included the expansion of the facility to four through lanes with a 14-foot continuous center turn lane, extensive utility work, gravity retaining walls, an OGFC, and the widening of a bridge over Bayou Pierre, near Fern Avenue.

Figure 3 shows the backup resulting from traffic entering or leaving LA 511 from side streets.

Figure 2. Photo. Typical view of LA 511 prior to construction with utility work on north right-of-way.

Figure 3. Photo. Congestion resulting from traffic entering from or exiting to side streets.

PROJECT DESCRIPTION

The resulting template of the completed project is conventional in appearance. The innovations are not generally noticeable to the traveling public. ATB material was used to speed up construction. The gravity retaining walls likewise were used to speed construction and minimize intrusion onto the surrounding right-of-way. The application of an OGFC is expected to improve safety along the corridor and provide a smooth, quiet ride for the public. In addition to traditional signing placed along the roadway, a video feed was supplied to the DOTD local office to aid in the early detection of incidents and to monitor queue lengths and traffic flow.

Asphalt Treated Base

ATB was used on this project for two main reasons: to speed construction and to reduce cost. Recycled asphalt pavement (RAP) was also included in the mix to decrease cost. Construction time is reduced because of the ease of achieving compaction and by the ability to apply subsequent surface treatments under less-than-ideal moisture conditions.

In this case, the base was constructed in short segments, due to the numerous driveways, cross streets, and commercial enterances along both sides of the roadway. Figure 4 shows a typical example of base widening using the ATB technique.

The ATB was placed without the use of typical asphalt equipment. The contractor was able to place the material in small sections with a small track hoe and dozer. Then it was rolled into place with a light weight roller. With these methods density was easily met. In a widening type project the ability to place the material with the speed as you would a typical stone base, but have the benefit of a material that would not become saturated and unstable, causing rework, was the greatest benefit that was observed by the project staff.

The mix deisgn for the base material is shown in table 1.

Table 1. Mix design for base material.

Material	Aggregate Type	Percentage	Bulk Specific Gravity
Coarse aggergate	1 ½-inch stone	20.0	2.670
Coarse aggergate	5/8-inch stone	20.0	2.640
Coarse aggergate	½-inch stone	25.0	2.640
Fine aggregatge	Coarse sand	8.0	2.610
Fine aggregatge	Fine sand	7.0	2.610
RAP	RAP	20.0	2.690

The asphalt used for this mix consisted of 3.2 percent PG 64-22 with an additional 1 percent provided by the RAP.

Figure 4. Photo. Short section of ATB next to existing pavement.

Gravity Retaining Wall

Precast gravity retaining walls were used at several locations along this project to decrease construction time and reduce costs. Estimates provided by the DOTD indicate a reduction of about $15 per foot of wall using the precast innovation. The use of precast systems decreased the amount of overall excavation area by eliminating the need to construct forms. This minimizes both the excavation time and the backfill time for construction. It also minimizes the need for additional easements or right-of-way along the project. Figure 5 shows a typical cross section of the gravity wall, detailing the drainage and slope requirements.

Figure 6 shows the first layer of block placed on a 6-inch nonreinforced concrete leveling pad with granular backfill and filter fabric installed. Note the minimal excavation required for placement.

Figure 7 shows the wall nearing completion, after the addition of the third layer of precast block.

Figure 8 shows the completed wall in service.

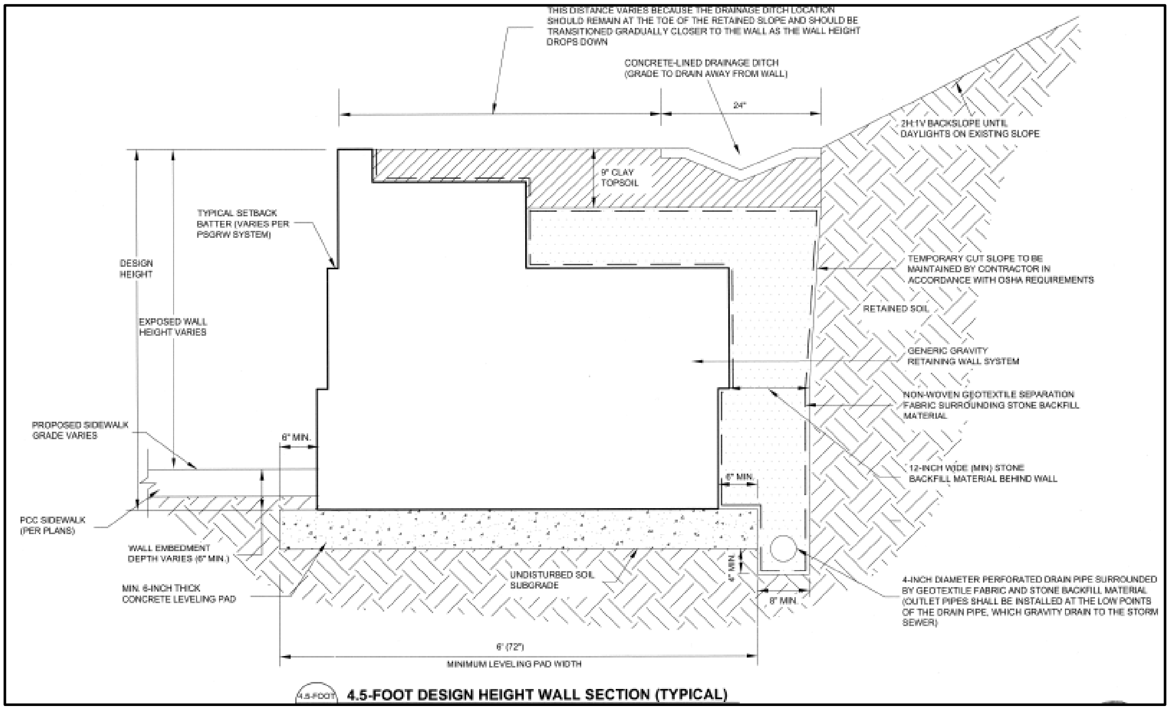

Figure 5. Diagram. Typical section of 4.5-foot precast retaining wall.

Figure 6. Photo. Unreinforced concrete leveling pad (not shown) with first course of block installed with the stone backfill material shown.

Figure 7. Photo. Wall with three courses of block installed.

Open-Graded Friction Course

The OGFC is a porous, gap-graded asphalt concrete mix with a high void content. It generally employs a predominately single size aggregate. The result is a mix that provides excellent drainage that reduces the effects of hydroplaning and increases visibility due to the reduced amount of splash and spray. While not a new concept, it has not been in general use in Louisiana. Where it has been used, the results have shown a great reduction in wet weather crashes—in some cases, as much as an 80 percent reduction. The mix design for the OGFC is shown in table 2. The asphalt used was a PG 76-22 at 6.5 percent of the mix with 0.6 percent antistrip agent also employed.

Figure 8. Photo. Completed gravity retaining wall system.

Table 2. OGFC mix design.

Material	Aggregate Type	Percentage	Bulk Specific Gravity
Coarse aggergate	5/8-inch stone	27.0	2.640
Coarse aggergate	½-inch stone	61.0	2.640
Fine aggregatge	Screens	12.0	2.620

Figure 9 shows the typical section of the pavement structure on this project.

Sawing and sealing joints in the OGFC to match the underlying pavement joints was originally considered on this project. However, the DOTD indicated that prior experience had shown this to be unnecessary due to the high polymer content of the asphalt.

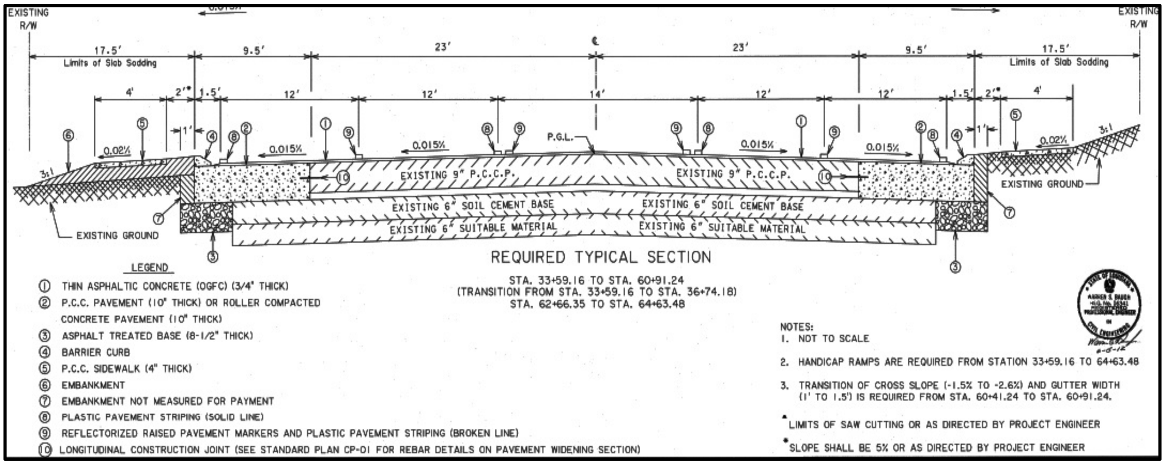

Figure 9. Diagram. Typical section of pavement structure.

PUBLIC OUTREACH

Extensive preconstruction public education was conducted to allow the public to make decisions about alternate routes. A public satisfaction survey was conducted by Louisiana Tech University to determine the public reaction to the manner in which the project was constructed. The results of this survey were not available at the time of this report.

DATA ACQUISITION AND ANALYSIS

As appropriate, safety, construction congestion, and quality data were collected before and after the project construction to determine if this project met the HfL performance goals. The primary objective of this data acquisition and analysis was to quantify the project performance, to provide an objective basis to determine the feasibility of the project innovations, and to demonstrate that the innovations can be used to do the following:

- Achieve a safer work environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Produce a high-quality project and gain user satisfaction.

This section discusses how well the DOTD project met the specific HfL performance goals related to these areas.

SAFETY

Safety goals for HfL projects are based on worker safety during construction and traveler safety during and after project completion. The worker safety goal is set at a 4.0 or less based on the OSHA 300 form available from the contractor. The public goal is a crash rate equal to or less than the preconstruction crash rate.

Table 3 shows the crash history at the project location from April 2010 through April 2013. Assuming an average traffic volume of 23,143 vehicles per day, the 3-year crash rate for the project location was calculated to be about 8.95 per million vehicle miles traveled, a rate nearly 7 times the statewide average of 1.23. Table 3 also shows the crash occurrences for the larger impact area of I-49 to LA 1. Given the approximately equal traffic volumes used above, the crash rate for the impact area is calculated to be 7.7 per million vehicle miles traveled, a rate more than 6 times the statewide average.

Table 3. Crash history.

Route	Location Reference	Length, miles	Time Frame	Crash Occurrences			
				Total	Fatal	Injury	PDO
LA 511	Line to Fern	0.93	4/1/2010 – 3/31/13	211	0	53	158
LA 511	I-49 to LA 1	2.08	4/1/2010 – 3/31/13	407	0	113	394

PDO = property damage only

Crash data during the construction period were not available at the time of this report, making it impossible to make a direct comparison to the preconstruction period. However, assuming that the crash rate in this construction zone "behaves" in a manner consistent with national norms, the crash rate during construction is expected to increase by approximately 30 percent.

Using a crash rate of 8.95 per million vehicles and a volume of 23,143, we could expect 0.193 crashes per day to occur within the project limits with no construction present, corresponding to 63 crashes for the estimated traditional construction duration of 325 days. Assuming a 30 percent increase for an active work zone, this corresponds to 82 crashes, 19 of which could be attributed to the work zone. The innovations employed here reduced the construction time to 275 days, or 50 days less than with traditional methods, resulting in an estimated 16 crashes attributed to the work zone. Given these assumptions, the reduction of construction time would have eliminated three crashes.

No worker injuries were reported on this project. The performance goal of achieving an incident rate for worker injuries of less than 4.0 (based on OSHA Form 300) was thus met for this project.

CONSTRUCTION CONGESTION AND TRAVEL TIME STUDY

One of the HfL performance goals was to achieve a 50 percent reduction in the time highway users are impacted during construction compared to traditional practices. The traditional alternative on a project of this nature would have been the use of traditional base construction with a thin (2-inch) hot mix asphalt overlay. The construction time for a traditional overlay as compared to the OGFC was estimated to be the same. The use of precast gravity retaining walls did not impact the overall project duration but did minimize the time and right-of-way required for this phase of construction. The use of ATB resulted in a significant time savings over traditional methods, as far less time was required for compaction and the treated base was available for use during wet periods when other construction would have been impossible.

While the HfL goal of a 50 percent reduction was not achieved on this project, future disruption of travel for additional treatments is expected to offset some of the difference between the as-built and traditional scenarios. Furthermore, the experience gained is expected to prove helpful in reducing the construction time and associated costs for future projects.

Traffic Study

Improvements along the LA 511 corridor were accomplished through typical partial-width construction techniques. Most of the utility work was completed without the need to restrict the lanes, but there was equipment working alongside the road much of the time. The impact of this work varied along the project based on several factors, many of which involved the movement of contractor equipment in and out of the work zone. During the widening operation, one lane was closed to allow for the base widening and paving operations. Only one direction of traffic was restricted at a time, to minimize the impact. Travel time studies were conducted prior to construction during July 2013. Additional studies were conducted during November 2013 to evaluate the impacts of the general construction and lane closure activities on mobility.

Note that the bridge replacement at the east end of the project had an impact on the operation of traffic through the remainder of the project. Numerous times, there were lane restrictions associated with the bridge work that affected the ability to move traffic efficiently through the project, even when no other restrictions or work were present.

The floating car methodology was used to collect travel times, attempting to mimic the typical driving speed of other vehicles along the corridor. Data were collected during daylight hours, as traffic demands were reduced significantly at night. Data were collected along LA 511 in both directions, starting outside the active project limits to include any backup that might be present as a result of the construction. Data were collected between I-49 and LA 1. Intermediate data points were recorded for the actual project limits of Fern Avenue and Line Avenue.

All data were collected during weekdays. Preconstruction data were collected on July 15 and July 26. However, data for the morning peak could not be collected on July 15 due to a storm that had cut off the electric to all traffic signals along the route. Discussion with the DOTD indicated that the peak traffic flow for the morning occurred between 8:00 and 9:30 AM, with the afternoon peak occurring between 2:30 and 4:30 PM.

Travel Time Comparison Results

Tables 4 and 5 show travel conditions before and during construction along LA 511. Table 4 shows data for the actual project limits only, from Fern Avenue to Line Avenue. Table 5 shows average travel time for a larger area (between I-49 and LA 1) to determine if there were any farther-reaching impacts due to construction activities.

As table 4 illustrates, there was minimal impact to traffic through the actual project limits during non-peak hours. In fact, the average travel times actually decreased during several of the analysis periods. The magnitude of these decreases is small enough to be considered irrelevant in the travel study.

Travel in the eastbound direction during the morning peak period showed no delay. In fact, the time was reduced by nearly 3.5 minutes. Westbound travel during the morning peak also showed a decrease in travel time of about 1 minute. Westbound travel in the afternoon peak showed the only increase in travel time, a delay of about 6 minutes.

The data show that the influence on travel time outside the actual construction limits was similar. All eastbound travel times were reduced during the construction period. The westbound travel was increased by about 6 minutes during the morning non-peak period, and the afternoon peak time increased by more than 8 minutes.

While the travel times observed do not seem reasonable at first inspection, discussion with the DOTD indicated several reasons for the observed patterns. First, there are many parallel routes available near the project site. Many local travelers may simply have diverted to an alternate route, thus reducing the volume of traffic using the facility. The DOTD used a public information campaign to alert travelers to the construction and advise them to take alternate routes.

Also, construction was not consistent along the project length. At some times, several locations may have been affected concurrently, while at other times, much of the work was taking place off the roadway for utility work, retaining walls, and other activities that did not significantly affect traffic. Work on the bridge replacement at the east end of the project sometimes restricted traffic flow, even though there were no restrictions within the remaining project limits. Thus, timing of the data collection may have resulted in data that were not representative of all construction activities.

Table 4. Comparison of LA 511 travel times from Line Avenue to Fern Avenue.

	Preconstruction Travel Time (Project)	During Construction Travel Time (Project)	Change (Project)
Eastbound LA 511			
AM peak	9:36	6:00	-3:36
off peak	2:35	2:33	-0:02
PM peak	8:32	2:09	-6:23
Westbound LA 511			
AM peak	3:18	2:28	-0:50
off peak	2:00	1:47	-0:03
PM peak	2:39	8:47	6:08

Table 5. Comparison of LA 511 travel times for I-49 to LA 1.

	Preconstruction Travel Time (Impact Area)	During Construction Travel Time (Impact Area)	Change (Impact Area)
Eastbound LA 511			
AM peak	14:03	10:55	-3:08
off peak	6:54	6:22	-0:32
PM peak	13:16	6:55	-6:21
Westbound LA 511			
AM peak	6:31	6:21	-0:10
off peak	5:06	11:03	5:57
PM peak	5:57	14:36	8:39

When comparing the total travel time changes in tables 4 and 5, it seems that there was little change in travel time outside the project limits, indicating that most of the delay was confined to this limited area. The collected data indicate that the travel patterns during construction of this project resulted in a wide variation of travel times at various stages of construction. Since no traffic counts were taken during construction to measure diversion, and because it was impractical to collect data multiple times during construction, a dollar cost to travel disruption on this project is not considered in the economic analysis.

QUALITY

Sound Intensity Testing

Sound intensity measurements were made using the current OBSI technique AASHTO TP 76-08, which uses dual vertical sound intensity probes and an ASTM-recommended standard reference test tire (SRTT). The sound measurements were recorded and analyzed using an onboard computer and data collection system. A minimum of five runs were made at highway speed in the right wheel path of the mainline lanes. The two microphone probes simultaneously captured noise data from the leading and trailing tire-pavement contact areas. Figure 10 shows the dual-probe instrumentation and the tread pattern of the SRTT.

The average of the front and rear sound intensity values was computed. Raw noise data were normalized for the ambient air temperature and barometric pressure at the time of testing. The resulting mean sound intensity levels were A-weighted to produce the noise-frequency spectra in one-third octave bands, shown in figure 11.

Sound levels were calculated by using logarithmic addition of the one-third octave band frequencies between 315 and 4,000 Hz. The initial measurements of noise before construction averaged 98.3 dB(A) in both directions of travel. The post-construction measurement averaged 99.7 dB(A), an increase of 1.4 dB(A), which is slightly above the HfL goal of 96 dB(A). In an urban setting with a relatively low operating speed of around 40 mph, the pavement noise component is considered acceptable.

Figure 10. Photo. OBSI dual-probe system and the SRTT.

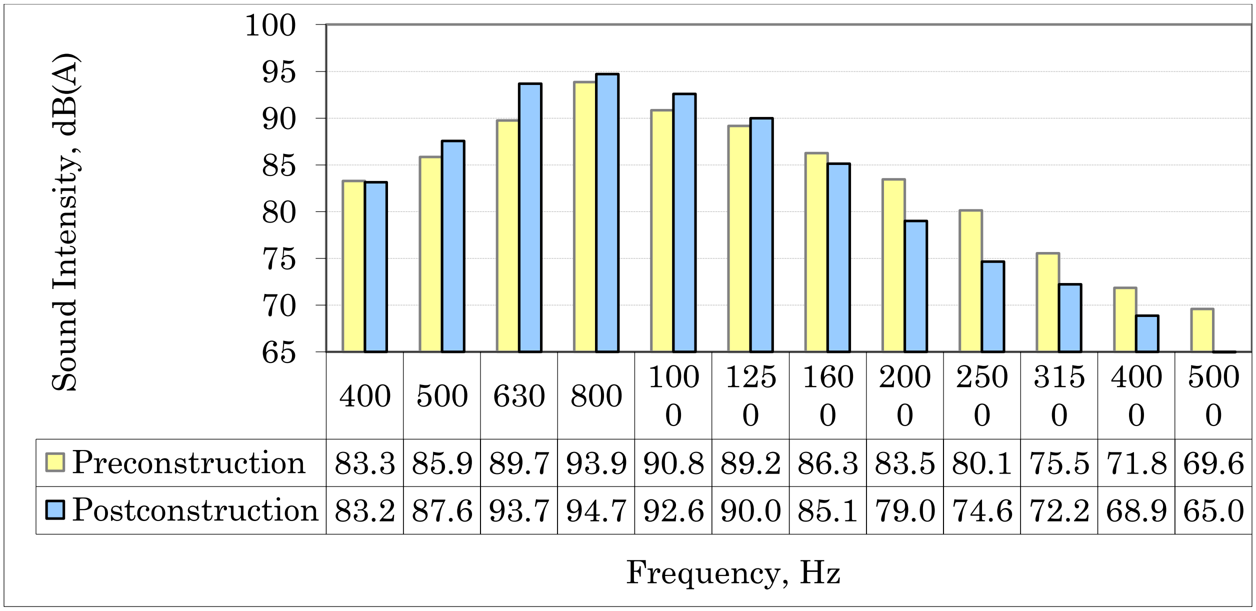

Figure 11. Chart. Mean A-weighted sound intensity frequency spectra.

Independent of the HfL measurements for sound intensity, the DOTD added a bid item to obtain before and after sound measurements. The contractor collected data on eleven 440-foot segments in both the driving and passing lanes. The results were higher across the board than those presented here, and the results indicated a drop in overall sound levels. The average for all directions and all lanes prior to construction measured 102.8 dB, while the post-construction levels dropped to 101.5 dB, a reduction of 1.2 dB.

The fact that the contractor measurements were collected using 440-foot samples rather than the continuous collection method could account for the difference in measured values.

Smoothness Measurement

Smoothness testing, required by HfL as a quality indicator, was performed following the ASTM E 950 method in conjunction with noise testing for the original and the newly constructed pavement using a high-speed inertial profiler built into the noise test vehicle. Figure 12 shows the test vehicle with the profiler positioned in line with the right rear wheel.

IRI prior to construction was measured at 289 inches per mile in the westbound direction and 275 inches per mile in the eastbound direction. Post-construction IRI measured 130 inches per mile in the westbound direction and 135 inches per miles in the eastbound direction, above the HfL goal of 48 inches per mile. Figures 13 and 14 provide a summary of the smoothness results.

Figure 12. Photo. High-speed inertial profiler mounted behind the test vehicle.

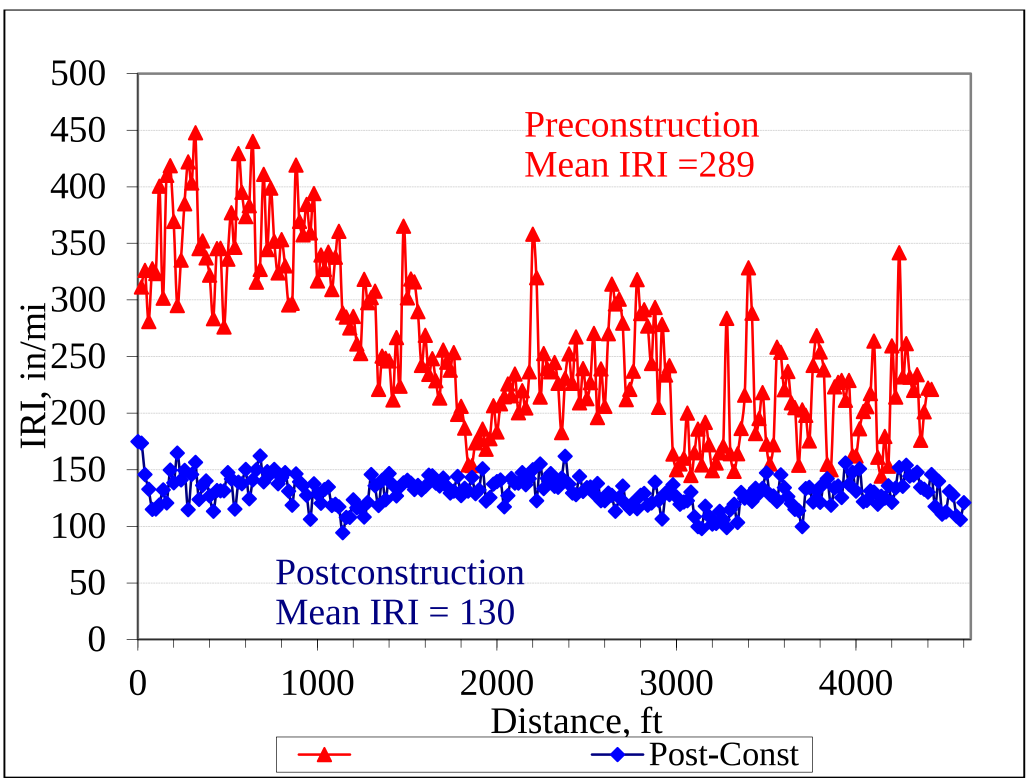

Figure 13. Chart. Summary of westbound IRI.

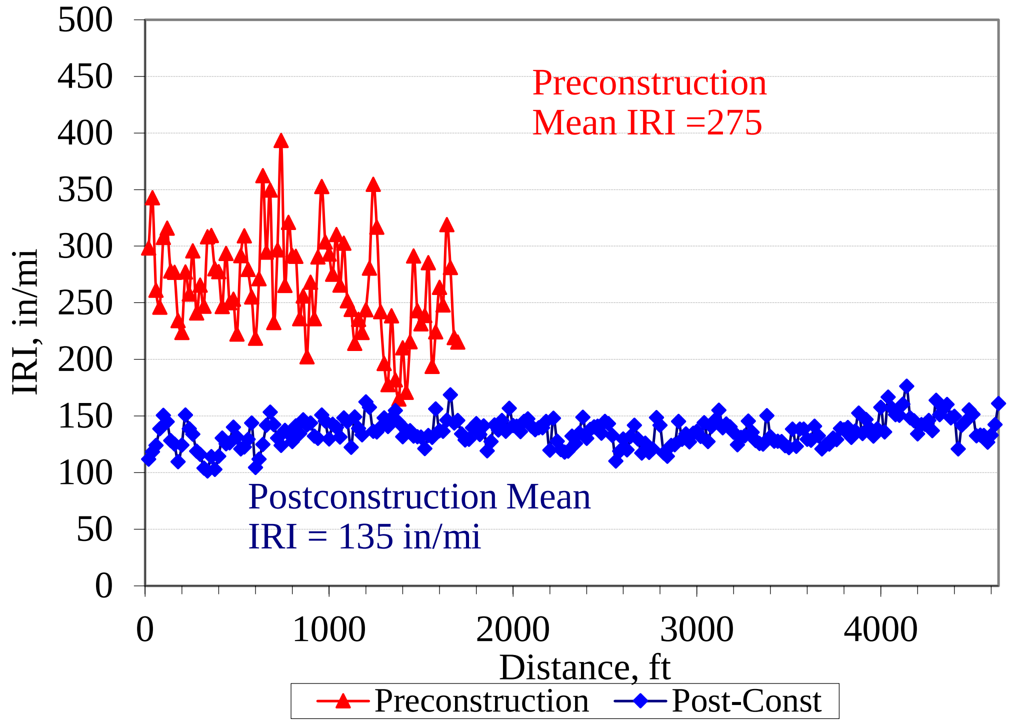

Figure 14. Chart. Summary of eastbound IRI (note: lane closure prevented collection for entire length).

The contractor was required to conduct his own evaluation of smoothness as part of the contract for use in determining the applicability of a paving bonus. The contractor's measurements are shown in table 6, along with the calculation for bonus.

While this reduction in IRI did not meet the HfL goal for smoothness, it still resulted in a reduction of more than 50 percent from the preconstruction measurements. In accordance with the contract, the contractor received a bonus of $95,000 for the smoothness achieved on the OGFC surface. Given the nature and relatively low speeds on this project, and the considerable IRI improvement from the preconstruction levels, the DOTD believes that the pavement surface will provide adequate smoothness to the traveling public.

Table 6. Contractor-supplied smoothness measurements and bonus calculations.

	Original Pavement		**OGFC**	
	Length of Lane	**IRI**	**Length of Lane**	**IRI**
Westbound outside lane	5,636	222.30	5388	114.55
Westbound inside lane	5,624	198.91	5379	95.17
Center turn lane			2739	97.78
Eastbound inside lane	5,622	212.19	5229	98.49
Eastbound outside lane	5,622	235.01	5314	103.97
Total length tested (feet)	22,504		24,049	
Weighted averages based on length of segment	***IRI(initial)***	**217.10**	***IRI(final)***	**102.48**
% improvement				52.80
Amount of incentive				$95,500.00

Durability of ATB Base

ATB was used in lieu of traditional granular base for outside widening to allow the addition of the continuous center turn lane. Research has shown that ATB has a greater stiffness and provides better resistance to permanent deformation than unbound granular base. Analysis performed by the DOTD showed that using ATB extends pavement life and reduces the necessary design thickness.

While the original construction estimate called for 325 working days, the contract was adjusted to 275 days based on the expected time savings of the innovations. The work was completed within the established timeframe, and there was no bonus for early completion.

USER SATISFACTION

The DOTD contracted with Louisiana Tech University to conduct a user satisfaction survey. At this time, that survey has not been completed and thus cannot be discussed in this report.

ECONOMIC ANALYSIS

A major component of the HfL program is to quantify the monetary value of the selected innovation when compared to the most likely traditional method in use by the agency. Several items are included in this analysis including the base construction/design costs, the user cost associated with delay and or detours and the safety value of reduced crashes associated with reduced construction time or other innovative safety features.

CONSTRUCTION COSTS

Of the five innovations included in the project, only four had a direct impact on the initial capital cost.

There were 1,858 tons of ATB included on the project for lane widening and full-depth pavement repair. The bid cost of the ATB was $110 per ton compared to the traditional granular base estimated at between $31 and $54 per ton. Assuming an average cost of $42 per ton for granular base, this resulted in an increased project cost of $126,344. Some of this cost was offset by the ability to reduce the overall construction time and in greater longevity of the final product.

An OGFC was employed to provide a safe, quiet riding surface for the public. Traditional construction techniques would have been to apply a standard Superpave surface course. The cost of the OGFC was bid at $275 per ton compared to an average Superpave cost of $85. The cost differential applied over the contracted quantity of 1,437 tons equates to an increased project cost of $273,030.

Gravity retaining walls were included for ease and speed of construction, as well as for the ability to limit the right-of-way needed for construction. The cost of the wall was bid at $60 per square foot, corresponding to a total cost of $147,360 for 2,456 square feet. Conventional construction was more difficult to estimate, as it is not generally bid as a single item. The DOTD estimates that the cost is about $80 per square foot, compared to the cost of the innovation. This results in a cost savings of $49,120 over the traditional approach. Additional savings are realized, although not quantified here, by a reduction in easements and right-of-way required and by a reduction in the excavation required to form traditional methods.

The final innovation employed on this project was the use of a video feed to observe traffic during construction, which allowed the DOTD or emergency response to react quickly to incidents that happened during the construction phase. The video was observed in real time, but no record of incidents was made and no recordings were retained. All costs associated with this portion of the project were borne by the agency, with the equipment removed and reused on other locations. There was no additional cost to the agency for this innovation.

USER COSTS

Three categories of user costs are normally used in an economic/life cycle cost analysis: vehicle operating costs (VOC), delay costs, and safety-related costs. VOC could not be calculated for this project because no continuous data were collected for the surrounding area that could be used to determine the length or nature of any traffic diversion that may have taken place.

Delay Costs
As discussed previously, there were essentially no delay costs associated with this project. It is believed that because of the large number of alternate routes available, once construction started, much of the local traffic diverted to these routes, reducing the volume to the point where little delay was evident.

However, one item that could be considered to influence the overall delay costs to the public was the use of A+B bidding on time of construction. Bidders were asked to bid the number of working days on the job at $3,000 per day, with a bonus paid for days below the bid amount and a penalty for days above. Bids from the three top bidders ranged from 250 to 480 days, with the low overall bidder at 275 days. The actual days used met the 275 limit, so there was no bonus or penalty associated with the project.

The DOTD had done calculations prior to construction for anticipated delay as part of the method used to establish the bid cost for working days. They had set the cost to the public per day at $3,000. If we assume that the original estimate for construction was 325 days and the bid was for 275 days, the agency achieved a savings of 50 days by the use of innovative technology. This would equate to a cost savings of $150,000 in user delay costs.

Safety Costs
The increased cost of the OGFC is expected to be justified to some extent by a reduction in crashes in the future. Using the limited data available in Louisiana, analysis has shown up to an 80 percent decrease in wet weather crashes on sections using OGFC. Of the 211 crashes reported in the 3-year period prior to construction, 30 were categorized as “wet weather” crashes. If we assume that the 80 percent reduction is valid for this location and the benefit derived from the OGFC is at least 3 years, we could expect to reduce the number of crashes by 24.

The National Safety Council gives the costs associated with crashes based on severity as shown in table 7.

The DOTD does not separate injury crashes into the three categories shown, listing only “injury” as the severity. If we assume that one-third of the crashes reported fall into each of the three listed in table 7 and use the 3-year crash history reported for this project location, the average crash cost is estimated to be about $28,400.

Table 7. Average comprehensive cost of injury by severity.[1]

Severity	Cost (dollars)
Fatal	4,538,000
Incapacitating injury	230,000
Injury	58,700
Possible injury	28,000
PDO	2,500

Given the assumptions discussed previously, it is assumed that three crashes could have been avoided due to the decreased time of construction from HfL innovations. The three crashes presumed avoided by implementation of the HfL technology reflect a savings of $85,200.

COST SUMMARY

Construction costs for the Louisiana HfL project totaled about $5.3 million. The agency realized an initial capital cost increase of about $350,254 from the use of ATB (+$126,344), OGFC (+$273,030), and gravity retaining walls (-$49,120).

While not direct savings to the agency, there were significant short-term and long-term savings to the public. The savings in construction time was estimated to save about $150,000 in user costs. The savings assumed from reduced work zone crashes accounts for an additional $85,000. If these are included in the analysis, the initial cost differential is reduced to about $115,000.

Finally, if the safety benefit associated with the OGFC is realized for a 3-year period, an additional savings of about $680,000 could be realized, far offsetting the initial construction cost differential.

[1] National Safety Council 2012. Accessed March 20, 2015.
http://www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of FHWA 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 Jerry Pits of the FHWA Louisiana Division for his effective coordination effort and to Louisiana Department of Transportation and Development Project Engineer Greg Wall, Construction Inspector Daniel Palmer, Project Manager Michael Rister, and Traffic Engineer Jim Hollier. The project team was instrumental in making this project a success and provided the information that helped shape this report.