District of Columbia Demonstration Project: Replacement of the 27th Street, NW Bridge over Broad Branch Stream

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 Highways for LIFE initiative, the Federal Highway Administration provided a grant of $104,000 in support of the District of Columbia Department of Transportation (DDOT) project to replace the 27th Street, NW Bridge over the Broad Branch Stream. The existing substructure was constructed before 1950 and is structurally deficient, as indicated by the current structural rating of 2 based on the National Bridge Inventory (NBI). In addition, the existing bridge does not meet the current standards for lane and shoulder widths.

The key innovation on the project was the use of a geosynthetic reinforced soil-integrated bridge system (GRS-IBS) for the construction of the bridge abutments. This is DDOT's first GRS-IBS project.

The construction for this project began on July 20, 2015, and the existing bridge is currently being demolished.

17. Key Words	18. Distribution Statement
Highways for LIFE, geosynthetic reinforced soil, integrated bridge system, GRS-IBS	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	19	

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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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LIST OF ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
DDOT	District of Columbia Department of Transportation
EDC	Every Day Counts
FHWA	Federal Highway Administration
GRS	geosynthetic reinforced soil
HfL	Highways for LIFE
IBS	integrated bridge system
IRI	International Roughness Index
NBI	National Bridge Inventory
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
SC	clayey sand
SM	silty sand

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:

- **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 on 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/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 measurement of 4 or more on a 7-point Likert scale.

PROJECT OVERVIEW

As a part of the HfL initiative, the FHWA provided a $104,000 grant to the District of Columbia Department of Transportation (DDOT) to cover partial construction costs for the replacement of the bridge carrying 27th Street NW over Broad Branch Stream in the District of Columbia. The innovation employed on this project is the use of a geosynthetic reinforced soil-integrated bridge system (GRS-IBS) for the construction of the bridge abutment. The project is currently under construction. This technical brief presents the available project information.

PROJECT DETAILS

PROJECT BACKGROUND AND LOCATION

This DDOT project involved reconstructing 27th Street, NW Bridge over Broad Branch Stream. As shown in Figure 1, the project is located to the north of downtown Washington, D.C., in the urban northwest quadrant. A zoomed-in version of the project map is shown in Figure 2. The project is located just to the east of the Broad Branch Road intersection and borders the Rock Creek Park, which is under the jurisdiction of the National Park Service.

The 2012 average daily traffic (ADT) for this portion of 27th Street, NW was 3,350 vehicles with 2 percent truck traffic. The projected ADT for the year 2032 is 4,100 vehicles. This section of roadway has a posted speed limit of 20 mph and a design speed of 25 mph.

PROJECT DESCRIPTION

Existing Bridge Information

The existing bridge is a single-span reinforced concrete beam structure supported on stone masonry abutments. Figure 3 shows the typical section of the existing bridge. As shown in the figure, the bridge carries two 9.5-ft-wide lanes of traffic along 27th Street, NW (one lane in each direction, eastbound and westbound) over Broad Branch Stream. The existing structure has an overall length of 20 feet, 6 inches, with an out-to-out width of 21 feet, 2 inches, and a curb-to-curb width of 18 feet, 11 inches. The existing superstructure was constructed in 1950; however, the stone masonry substructure predates this construction.

With a structural rating of 32.6 and a substructure condition rating of 2 based on the National Bridge Inventory (NBI), this bridge was determined to be structurally deficient. Additionally, the roadway geometry on the bridge does not meet current standards for lane and shoulder widths. Figures 4 and 5 show the north and south faces of the existing bridge, respectively.

Project Innovations

The key innovation used on this project is GRS-IBS for reconstruction of the bridge abutments. GRS-IBS is an accelerated bridge construction technique that was also selected as one of FHWA’s Every Day Counts (EDC) initiative. The GRS-IBS technology provides support to the bridge through the use of alternating layers of compacted granular fill and sheets of geosynthetic fabric reinforcement. Compared to traditional construction techniques, GRS-IBS technology results in reduction of the environmental footprint, as it eliminates the need for deep/pile foundations that are abrasive to the environment.

DDOT decided to use the GRS-IBS technology for the current project for the following reasons:

- Reduced construction duration: DDOT anticipates that the GRS-IBS technology will shorten the construction duration by several weeks, thereby reducing the duration of the full detour necessary for the reconstruction of the bridge.

- Reduced cost: DDOT anticipates approximately a 25 percent reduction in the bridge construction cost through the use of GRS-IBS.
- Reduced differential settlement: Since the GRS-IBS allows for the abutment foundation to settle at the same rate as the approach roadway, it is capable of reducing the differential settlement, or "bump," typically seen in the approach joint of a bridge.

Although the GRS-IBS technology has been used in other States, this is DDOT's first project utilizing this technology.

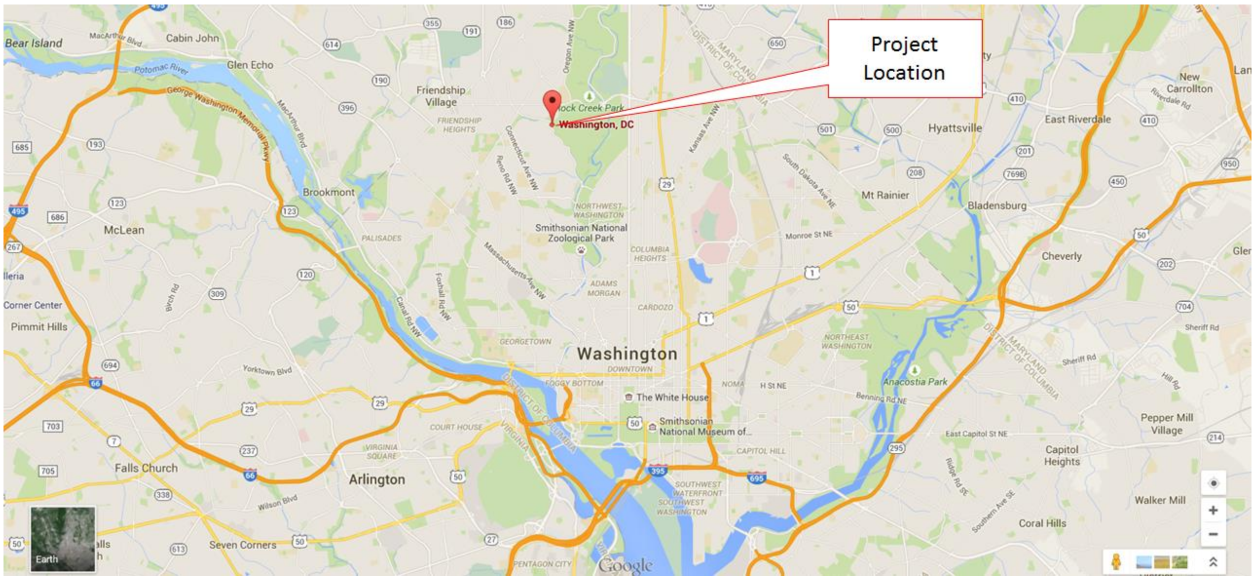


Figure 1. Map. Approximate location of the 27th Street, NW Bridge over Broad Branch Stream.

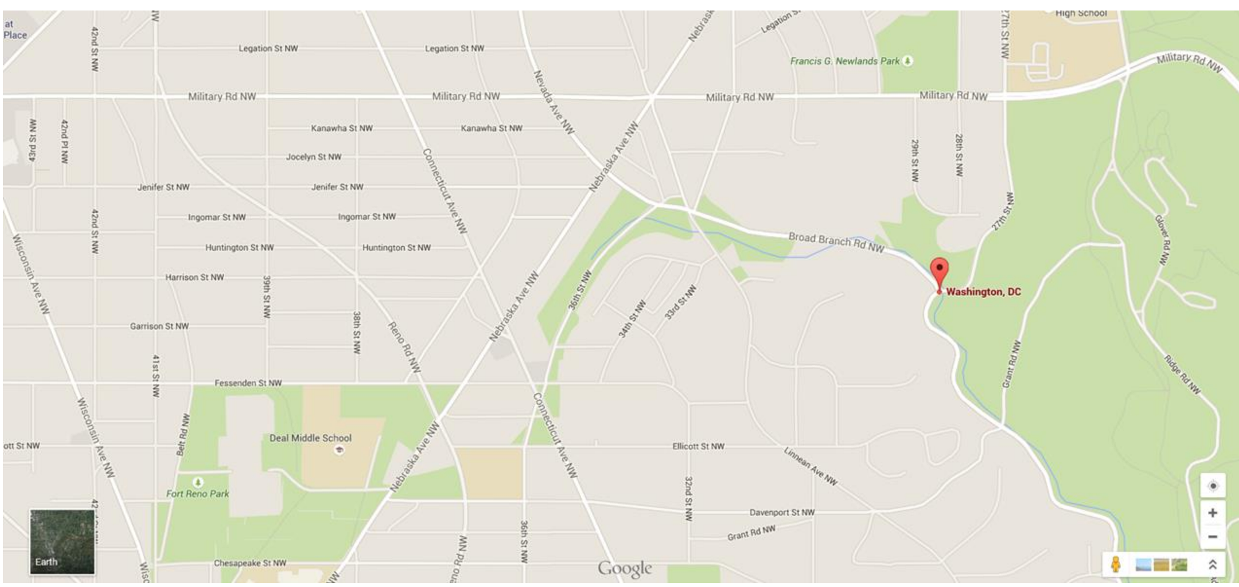
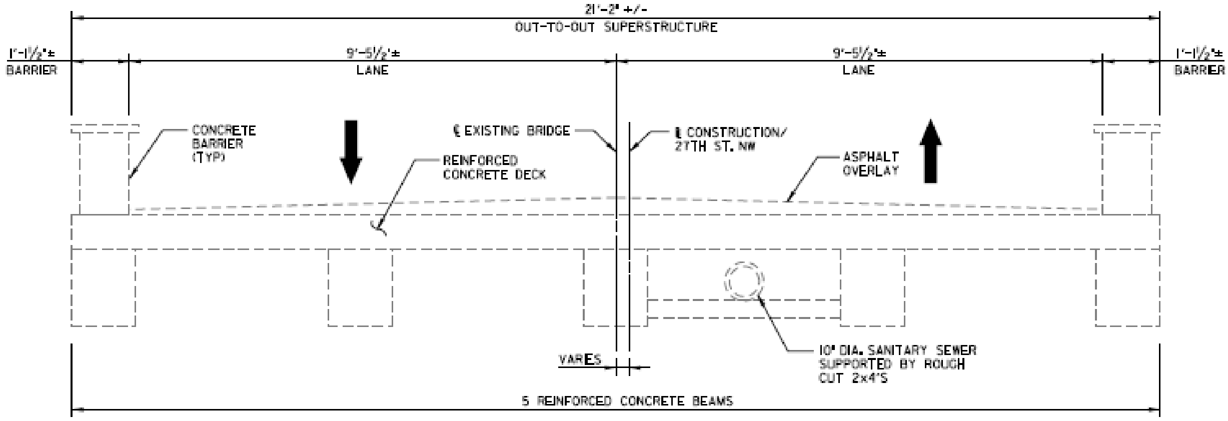


Figure 2. Map. Detailed map of project location.



EXISTING BRIDGE TYPICAL SECTION

Figure 3. Diagram. Typical section of existing bridge.

Figure 4. Photo. North face of existing bridge (courtesy: DDOT).


Figure 5. Photo. South face of existing bridge (courtesy: DDOT).

NEW BRIDGE SPECIFICATION

Figures 6, 7, and 8 show the proposed plan view, elevation view, and typical section of the new bridge, respectively. The new bridge is expected to have a 42.3-foot-long single span and will consist of two 10-foot lanes, two 2-foot shoulders, and a 6-foot sidewalk for a total out-to-out width of 33 feet including the barriers.

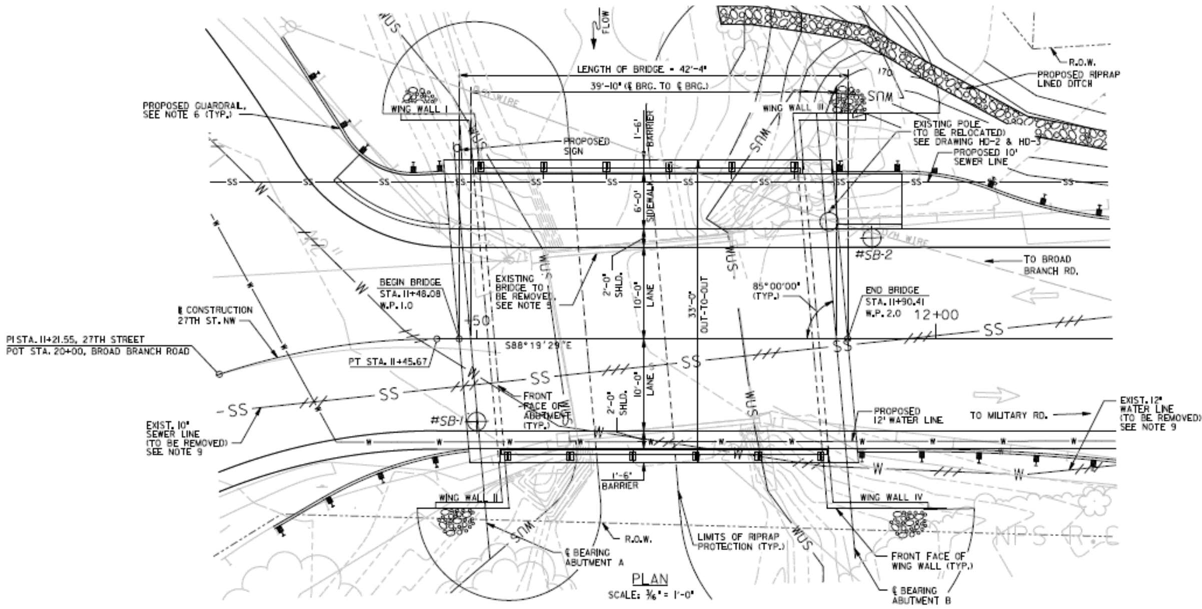


Figure 6. Diagram. Plan view diagram of the proposed bridge.

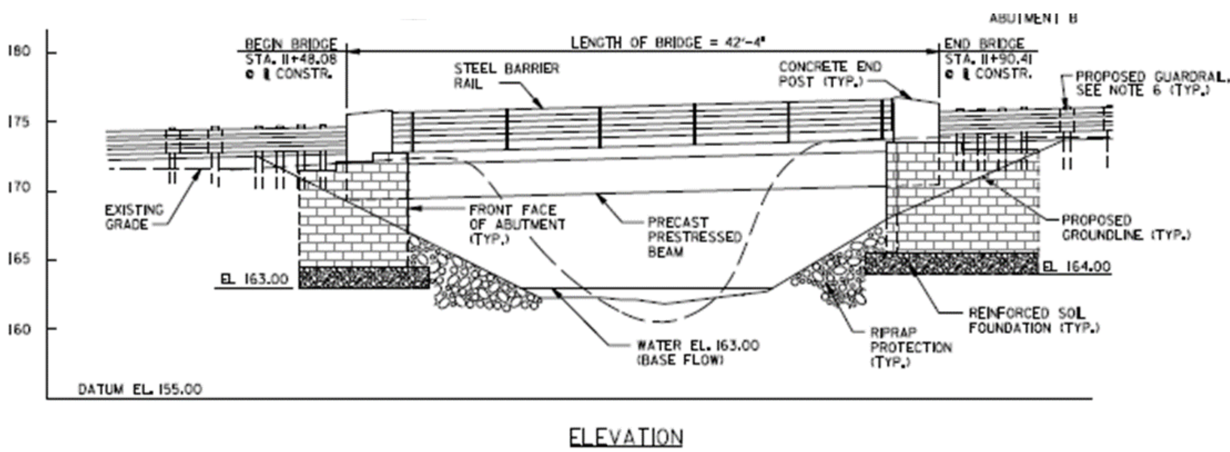


Figure 7. Diagram. Elevation view diagram of the proposed bridge.

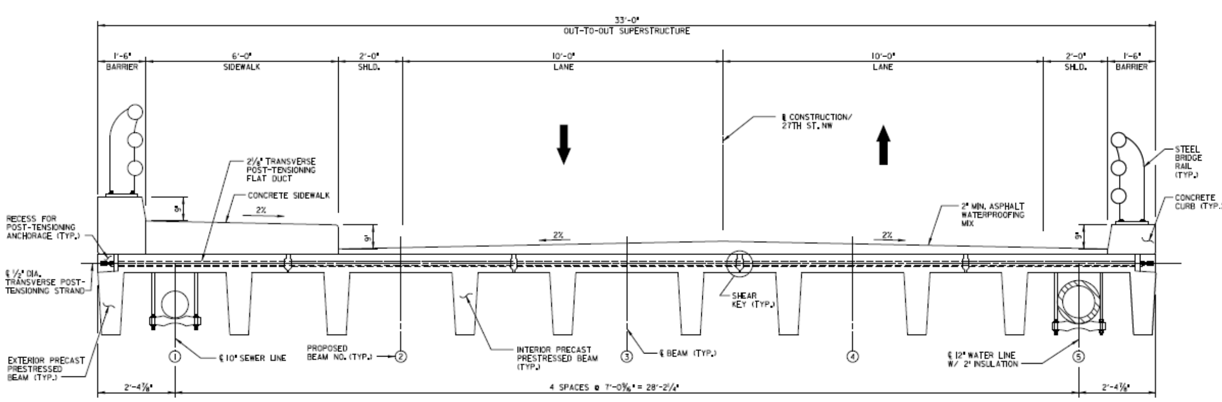


Figure 8. Diagram. Typical section of the proposed bridge.

PROJECT SCHEDULE INFORMATION

The project was awarded to Fort Myer Construction Corporation, and the construction began on July 20, 2015. Currently, the stream diversion is being installed and the existing bridge is being demolished (Figure 9).

Figure 9. Photo. Demolition of existing bridge.

GEOTECHNICAL DESIGN AND GRS-IBS CONSTRUCTION

Two boring were taken near the bridge construction area. The subgrade layer of the project area consisted of clayey sand (SC) and silty sand (SM). The design load of the bridge was American Association of State Highway and Transportation Officials (AASHTO) HL-93 for the live load and a constant dead load of 75 psf for the proposed sidewalk.

Figures 10 and 11 provide plan and elevation views for abutments A (west end of bridge) and B (east end of bridge), respectively, and Figure 12 shows the typical section of the abutment.

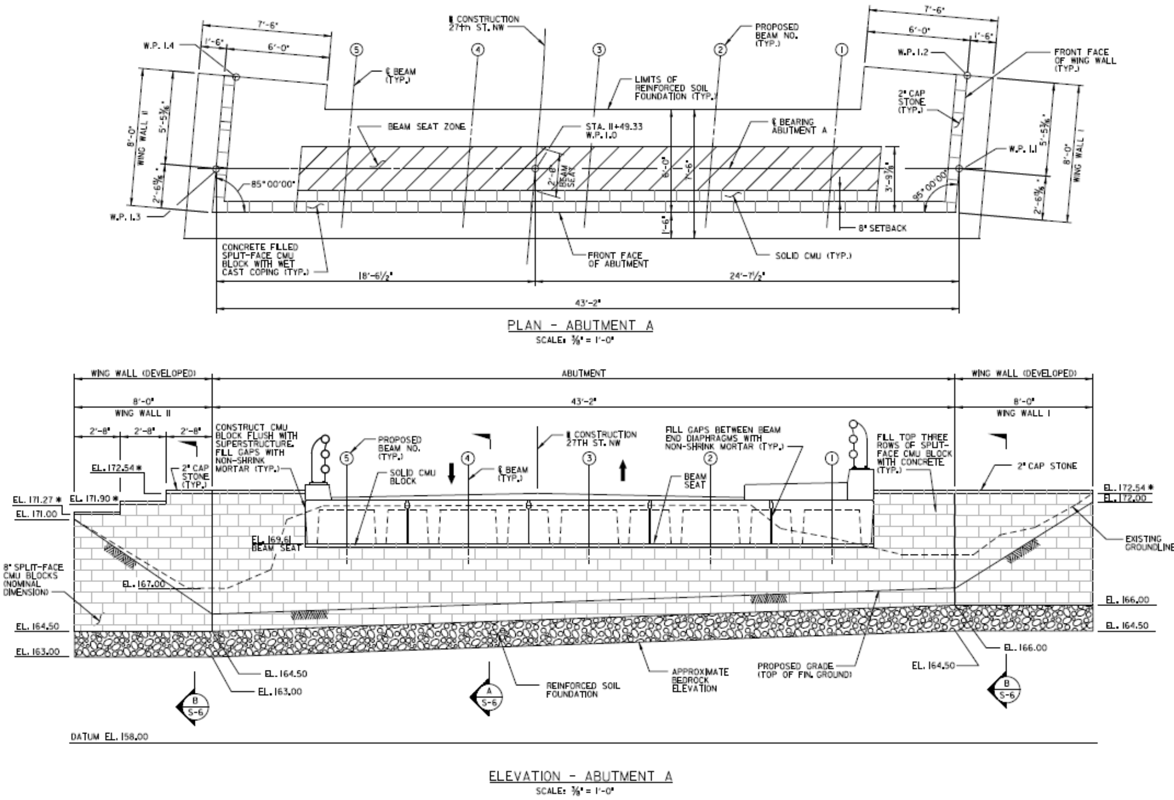


Figure 10. Diagram. Plan and elevation views of GRS abutment A.

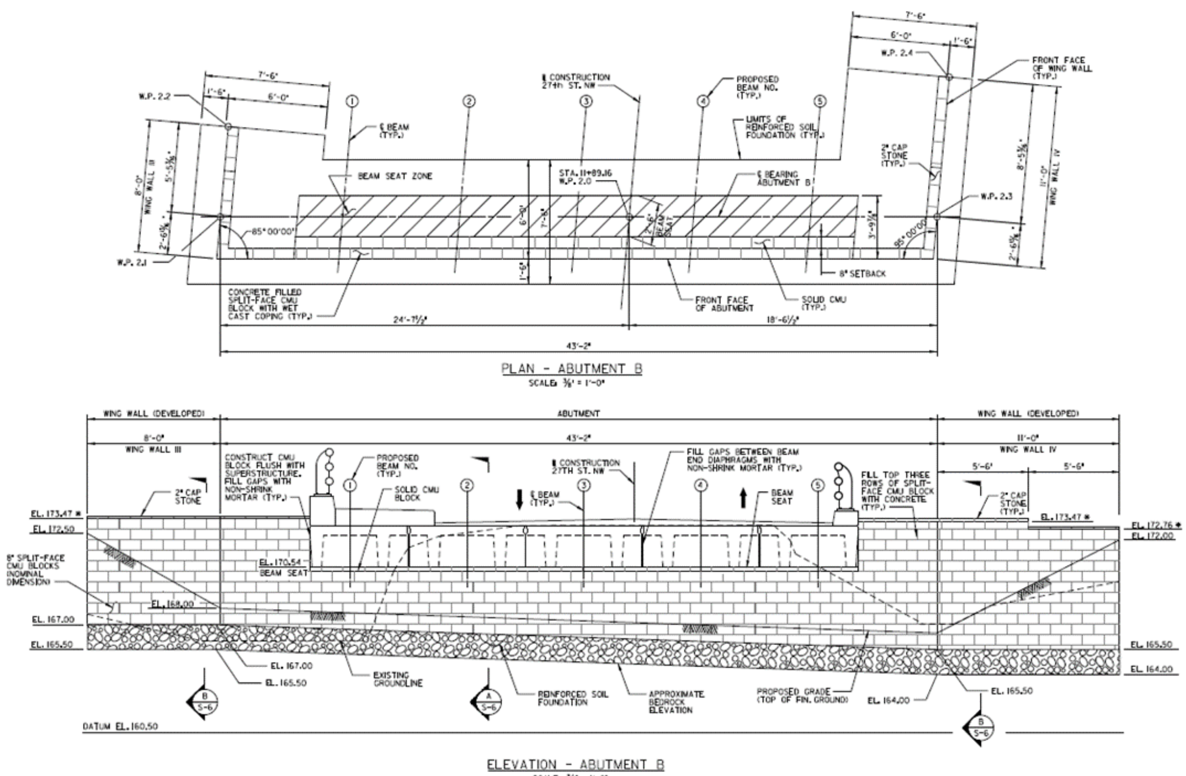


Figure 11. Diagram. Plan and elevation views of GRS abutment B.

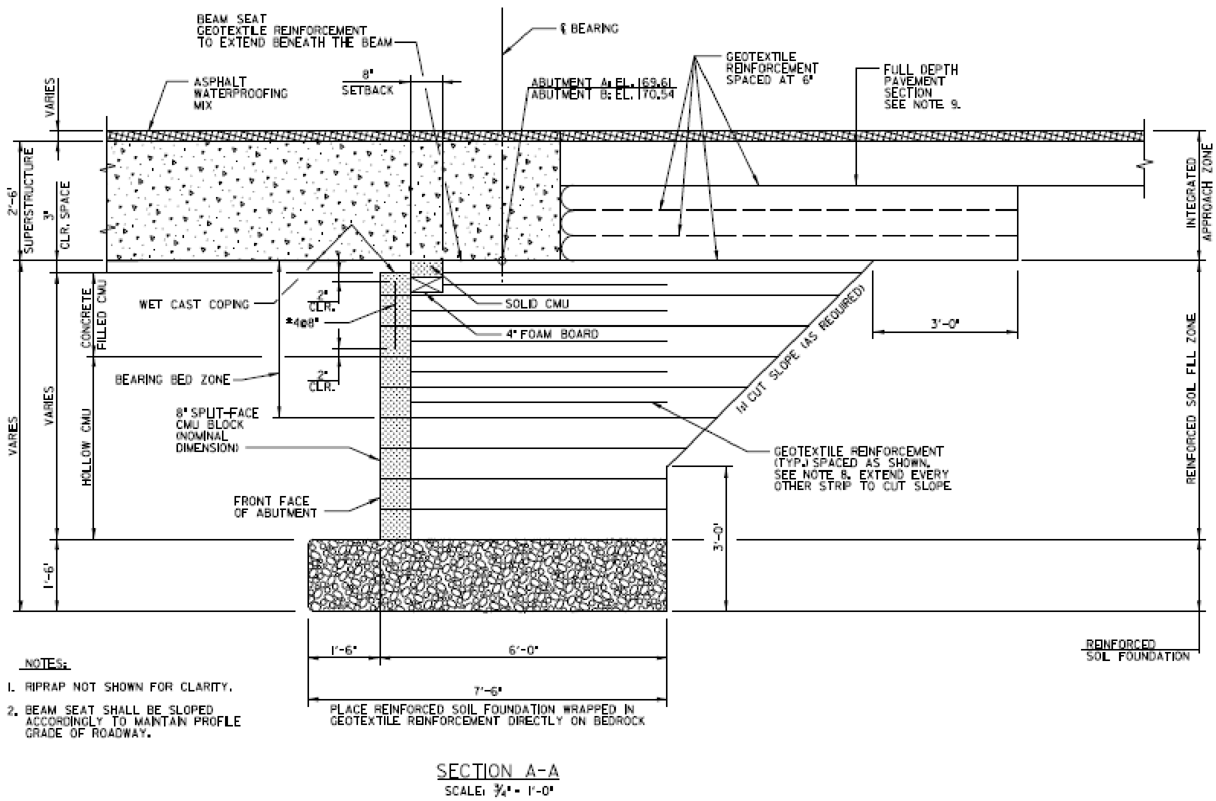


Figure 12. Diagram. GRS abutment section view of 27th Street, NW bridge.

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:

- 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.

Since this project is still ongoing, the HfL performance goals are yet to be measured. The following subsections provide additional information on the some of the significant factors that influence the HfL performance goals.

TRAVEL TIME

The overall length of the project, including the reconstruction of the bridge and the bridge approaches, was 182 feet, but 27th Street was closed to traffic from Military Road to Broad Branch Road, for a total length of approximately 0.4 miles. The traffic was detoured through Military Road, 32nd Street, NW, and Broad Branch Road, as shown in Figure 13. Roughly speaking, this would result in an increased travel time of 2 minutes. However, through the use of the GRS-IBS technology, DDOT anticipates that the construction duration (and, hence, the time needed for the disruption in the normal traffic flow) will be vastly reduced.

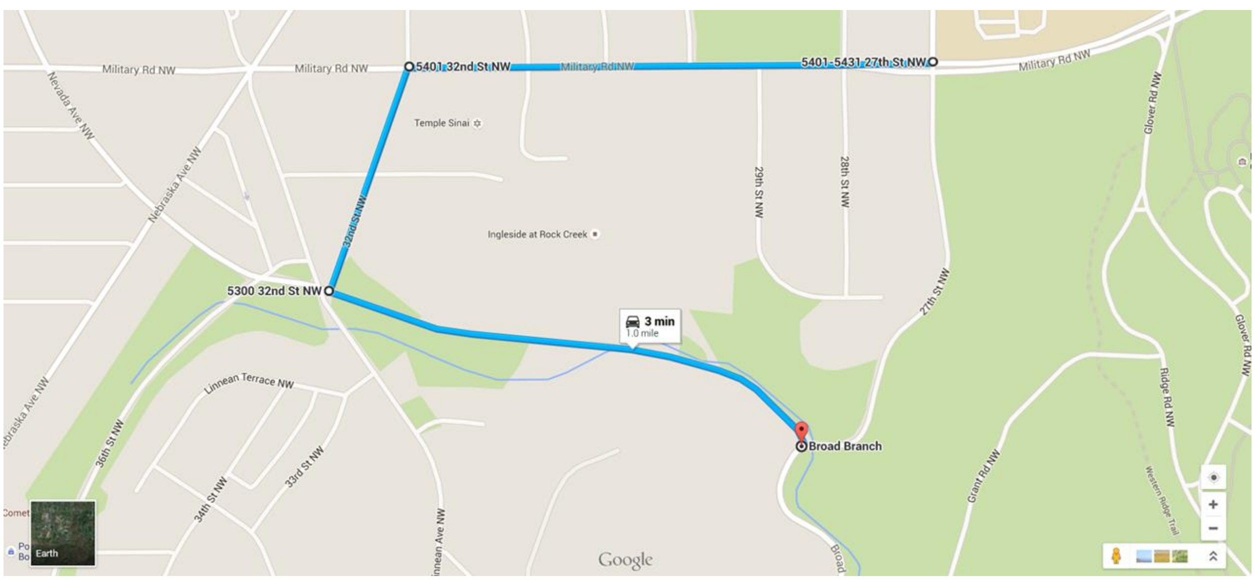


Figure 13. Map. Detour route for 27th Street, NW bridge replacement project.

CONSTRUCTION CONGESTION

Because of the full detour described above and the low traffic volumes across the project location, DDOT anticipates no queuing on this project. In addition, the accelerated construction techniques used on this project are expected to reduce the time roadway users are affected.

SOUND AND SMOOTHNESS

Due to the short length of the project, DDOT does not plan to collect smoothness and noise data after construction is completed. However, DDOT anticipates that the GRS-IBS technology will reduce the differential settlement typically observed at the bridge joints, which will improve the ride quality, pavement noise, and user satisfaction.

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 DDOT Engineer Dorriz Zahra and FHWA Engineer Robert Mihalek, for their advice and assistance during this project.