New York Demonstration Project:

I-84 Bridge Over Dingle Ridge Road Replacement Using Superstructure Slide-In Technology

Final Report
October 2014

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 by HfL 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 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 part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE program, the New York State Department of Transportation (NYSDOT) was awarded a $2.1 million grant to demonstrate the use of proven, innovative technologies for accelerated bridge removal and replacement. This report documents accelerated bridge construction techniques using prefabricated superstructure slide-in technology to replace two Interstate 84 bridges over Dingle Ridge Road in Putnam County. Each new superstructure was installed during a 20-hour time period over a weekend. This report includes project/site challenges, construction details, deployment of the lateral slide-in technology, and NYSDOT's public outreach efforts to minimize impact to traffic.

Under conventional construction methods, the project would have taken 2 years to build and would have required the construction of a temporary roadway and bridge to channel traffic during construction. This would have increased delays during peak hours of travel. Using precast elements and lateral slide-in technology, the project was built in 1 year, and the impact to travelers in each direction on I-84 was reduced to a detour for 20 hours. Furthermore, by reducing traffic impacts substantially, it is estimated that NYSDOT avoided six crashes, one of which could have potentially resulted in injury/fatality.

The innovative technology resulted in savings of $0.9 million in construction costs and $1.37 million in user delay costs. Together, the savings represent 22 percent of the $10.2 million construction cost of the project. Because of the success of this project, the NYSDOT plans to use the lateral slide-in technology on future projects where this innovative technology is feasible and appropriate for conditions.

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Unclassified	Unclassified	80	

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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)

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ABBREVIATIONS AND SYMBOLS

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ABC	accelerated bridge construction
ADT	average daily traffic
EB	eastbound
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
NYSDOT	New York State Department of Transportation
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
PTFE	polytetrafluorethylene
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SHRP2	Strategic Highway Research Program 2
SI	sound intensity
SPMT	self-propelled modular transporter
SRTT	standard reference test tire
UHPC	ultra high performance concrete
V/C	volume to capacity ratio
WB	westbound

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration's (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 highway 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 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 State 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 mile (mi) in a rural area or less than 1.5 mi 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, using the onboard sound intensity test method.

- **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-plus on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report documents accelerated bridge construction (ABC) techniques used to replace the I-84 eastbound and westbound bridges over Dingle Ridge Road in a rural area of Putnam County over two separate weekends. The report presents project details relevant to the HfL program, including innovative construction highlights, rapid superstructure demolition and replacement using lateral slide-in technology, HfL performance metrics measurement, and economic analysis. Technology transfer activities that took place during the project and lessons learned are also discussed.

This report includes construction details of the precast bridge superstructures supported on temporary structures built adjacent to abutments for the new bridges. It also discusses the details of the lateral slide setup. Under conventional construction methods, the project would have taken 2 years to build and would have required the construction of a temporary roadway and bridge to channel traffic during construction. This would have increased delays during peak hours of travel. However, using precast elements and lateral slide-in technology, the project was built in 1 year, and the impact to travelers in each direction on I-84 was reduced to a detour onto a parallel four-lane roadway from 5 p.m. Saturday to 1 p.m. Sunday—a period of only 20 hours for each bridge replacement.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

This project is located in the town of Southeast, New York. The project is on a heavily traveled section of I-84 between I-684 and the New York/Connecticut border. The average daily traffic (ADT) on I-84 at this location is near 75,000. The scope of the project includes replacement of the twin bridges that carry I-84 over Dingle Ridge Road, a typical two-lane local road with ADT of 3,000.

The replaced twin steel girder three-span bridges built in 1967 were 140 feet long with an out-to-out width of 33.3 feet. The eastbound (EB) bridge had a sufficiency rating of 62.0, and the westbound (WB) bridge had a sufficiency rating of 60.2. Each bridge had structural deficiencies and carried two lanes of traffic.

Dingle Ridge Road at the project location has a steep grade with a slope of 15.7 percent. Additionally, the elevation difference between the EB and WB bridges is 15 feet. Under the original conventional approach, NYSDOT planned to build a temporary bridge and cross-over roadway system in the median between the bridges to channel traffic. This approach would have required substantial roadway construction to overcome the large elevation differential between the roadways at this location and would have impacted 7 acres of the highly sensitive New York City watershed area in which the project is located. NYSDOT estimated that the temporary bridge and roadway system would have cost the agency approximately $2.0 million, and user delay costs for channeling the traffic during construction would have cost another $1.4 million. Furthermore, the project would have taken 2 years to build.

NYSDOT decided to use innovative ABC technology to compress construction time, reduce impact to the watershed area, and minimize traffic impacts. They initially considered using the self-propelled modular transporter (SPMT) technology that has been successfully deployed in some States to remove and replace each superstructure. However, this approach was ruled out primarily because of the steep grade of Dingle Ridge Road. Instead, NYSDOT opted for overnight lateral slide. In this approach, the contractor would construct the replacement superstructures adjacent to the existing structures and slide each superstructure overnight after demolishing the old structure. This approach would:

- Eliminate the need for a temporary bridge and cross-overs.
- Reduce impact to the watershed from 7 acres to 2 acres.
- Reduce traffic disruption on I-84 from 2 years to about 20 hours during each of two separate weekends.

NYSDOT applied for and successfully obtained $2.1 million in HfL funding and a grant of $0.3 million and engineering support (design) from the Transportation Research Board's second Strategic Highway Research Program (SHRP2).

The replacement structures were to be wider to accommodate three lanes of traffic, a 6-foot left shoulder, and a 12-foot right shoulder to provide for future lane addition and traffic control. The replacement structures also were to be raised by about 2 feet to provide 14.5-foot under-clearance. Additionally, substructure construction of the replacement structures needed to minimize any impact on existing abutments supported on spread footings on fill.

To accelerate construction, NYSDOT used prefabricated elements for both the superstructure and wall elements and, to the extent practicable, readily available innovative bridge designs for rapid renewal that are included in SHRP2 Report S2-R04-RR-2 (1). Each superstructure consisted of Double Tee NEXT beams precast elements. The longitudinal joints between the superstructure elements were closed at the job site using ultra high performance concrete (UHPC).

Because NYSDOT planned to close I-84 to the minimal extent possible, the approach slabs were precast and connected to the superstructure as one unit ahead of the ABC closure period. The gap between the slab and the ground of the end spans was filled with flowable fill so that each slab was fully supported, resulting in each structure being single span.

The notice to proceed was issued to the contractor just prior to the beginning of 2013, with the expectation the new structures would be in place during the fall of 2013 and that traffic would not be disrupted for more than 20 hours during each weekend. An incentive/disincentive of $10,000 per hour with a maximum incentive of $30,000 was included in the contract.

The overnight slide of the I-84 WB bridge was successfully completed September 21-22, 2013, and the overnight slide for the I-84 EB bridge was successfully completed October 19-20, 2013. This innovative technique was determined to be safer, significantly faster, and more economical while having reduced environmental impact, and as being less obtrusive to the traveling public than traditional construction methods. Through public outreach and tools such as shareholder meetings, website, emails, Twitter, Facebook, media and press, postcards, and variable message sign displays, every effort was made to reduce traffic and minimize delays during the slide-in period.

On the weekends of the bridge closures, I-84 was closed to traffic at 5 p.m. on Saturday and was reopened to traffic at about approximately 1 p.m. on Sunday. During the WB closure on September 22, backups started as soon as the detours were put into effect, but by 9 p.m. the traffic was free flowing. The queue at its peak was about 0.75 miles long with an estimated delay of 15 minutes. There was a similar experience on October 19, when the EB bridge was demolished and replaced. Backups occurred on both I-84 and I-684 with queues being longer on I-684. Again, traffic was free flowing by 11 p.m. on both roadways. Backups resumed at about 9 a.m. on October 20 and continued to increase with time. The queue length on I-684 just prior to opening the roadway was estimated at 1.5 miles with a delay time of 30 minutes.

Dingle Ridge Road was closed to traffic during the weekend and until the demolition debris was removed. The traffic on Dingle Ridge Road was comparatively low, and the local users presumably were able to find alternative routes with minimal impact to their travel time.

The slide-in technology on this project is a first for NYSDOT. The two bridges replaced are similar to more than 95 structures that carry I-84 over other highways in New York. Many of these structures are of the same age and era as the ones replaced. With successfully removing and replacing each structure during a 20-hour window, NYSDOT undoubtedly has raised customers' expectations on project delivery in the future. The agency plans to develop a process to screen locations where this technology will be applicable and use this innovative tool in its toolkit.

HfL Performance Goals

Safety, construction congestion, quality, and user satisfaction data were collected before, during, and after construction to demonstrate that ABC technologies can be used to achieve the HfL performance goals in these areas.

- **Safety**
    - Work zone safety during construction—No motorist incidents were reported during construction, which meets the HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate.
    - Worker safety during construction— No worker injuries were reported during construction, so the contractor achieved a score of 0.0 on the OSHA Form 300, meeting the HfL goal of less than 4.0.
    - Facility safety after construction— There were no safety features implemented on this project. The HfL goal of 20 percent reduction in fatalities and injuries in 3-year crash rates after construction is yet to be determined.
- **Construction Congestion**
    - Faster construction—If a traditional approach had been used to remove and replace a bridge in each direction, NYSDOT estimated that it would have taken 550 days, or two construction seasons, to complete the project. In contrast, under the innovative slide-in option, the construction season was reduced to one season, and traffic impacts were limited to 20 hours over each of two weekends. Compressing the time for bridge replacement from 550 days to 20 hours under the ABC approach drastically reduced the impact to motorists and went beyond the HfL goal of a 50 percent reduction in the time traffic is impacted compared to traditional construction methods.
    - Trip time—Considering the cumulative trip time over the 20-hour full closure and detour compared to 550 months of maintaining traffic on a temporary bridge for traditional construction, motorists experienced a reduction in trip time, meeting the HfL goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions.
    - Queue length during construction—The observed queue lengths were less than 1.5 miles on both closure events, thus meeting the HfL goal of less than a 1.5-mile queue length in an urban area.
- **Quality**
    - Smoothness—Smoothness increased across the bridges. The IRI decreased from 474 inches/mile before construction to 127 inches/mile after construction for the westbound bridge and from 358 inches/mile to 155 inches/mile for the eastbound

bridge. Motorists will notice a smoother ride, although the HfL goal for IRI of 48 inches/mile—typically expected to be attainable on long, open stretches of pavement—was not met on this project.
  - Noise—The sound intensity (SI) data showed a noticeable 1.4 dB(A) increase in noise for both bridges after construction, which does not meet the HfL requirement of 96.0 dB(A) or less.
  - Durability—The superstructure and some elements of the substructure were precast and fabricated in a controlled environment with tight fabrication tolerances. The precast units therefore benefitted from not being subjected to weather conditions and adjacent traffic vibrations throughout placement and cure times. Additionally, the use of stainless steel reinforcement in the deck elements should contribute to extending the service life of the structure.
  - User satisfaction—NYSDOT routinely provides the public access to the website of every significant project for information on project progress and comments. The user satisfaction survey results on this project will be included later upon receipt from NYSDOT.

ECONOMIC ANALYSIS

The benefits and costs of this innovative project approach were compared with costs using the traditional approach. NYSDOT provided the cost figures for the as-built project. The traditional approach would have required a temporary two-lane bridge and substantial temporary roadway work, which NYSDOT estimated at $2.0 million. The innovative option required temporary support structures as well as the horizontal slide system for both the EB and WB structures. This was bid as a lump sum item by the contractor for $1.1 million, resulting in net savings of $0.9 million in construction costs.

The reduction in user delay costs with the innovative option was calculated to be $1.37 million. Therefore, construction and user delay costs together resulted in savings of $2.37 million, which is more than 22 percent of the $10.2 million construction cost for the project.

LESSONS LEARNED

Through this project, NYSDOT gained valuable insights on the innovative processes deployed—both those that were successful and those that need improvement in future project delivery:

- The use of the SHRP2 R04 ABC Toolkit for Innovative Bridge Designs for Rapid Renewal was effectively demonstrated through this project.
- The closure period for the demolition of the old structure and sliding in of the new superstructure was adequate.
- The incentive/disincentive concept used on this project was effective in deliverying the project.
- Public outreach efforts, including pre-event and during event communications with stakeholders, were effective in reducing traffic by an estimated 40 percent during the closure periods.

- It is important that key decision makers be available on site, as they were on this project, to deal with any challenges that are encountered during the bridge demolition and slide-in of the new superstructure.
- Adequate time must be allowed for submittal and review of documents that are required to be completed prior to construction. Despite the excellent cooperation and coordination of all parties in this project, and the extra effort by the NYSDOT and the designer to maintain the aggressive schedule set by the contractor, this was a challenge.
- On any project, contract documents need to be complete and accurate to minimize extra costs and schedule impacts. These impacts are amplified when the schedule is compressed.
- A conservative value for friction should be used when designing the slide-in mechanism, as inclement weather such as rain may adversely affect slide mechanisms.
- Take exceptional care in monitoring the slide. Displacements at all slide points should be the same, with a maximum tolerance of 2 inches. Do not rely on hydraulic pressure readings alone. Assign the task of measuring displacements to someone whose sole responsibility is to make measurements so s/he is focused on this task.
- Ensure that the specialty contractors, especially for bridge slide-in, are experienced, as it was specified in this project.
- Excellent communications among the contractor, specialty slide contractor, precast subcontractor, and support steel subcontractor is paramount to ensuring that the support elevation is proper and that the dimensions of the slide shoes match the specialty contractor's push mechanism and equipment.

Public Involvement

NYSDOT's comprehensive public outreach efforts and coordination with Connecticut DOT were very effective in reducing the traffic during the compressed ABC closure period. Traffic management with numerous variable message signs and substantial police presence during the closure went as well as can be expected. The approach to educate—and not just inform—worked well and is likely to be used at other locations when innovative technology is deployed.

CONCLUSIONS

From the standpoint of construction speed, motorist and user safety, cost, and quality, this project was a success and embodied the ideals of the HfL program. NYSDOT learned that careful planning, coupled with aggressive public outreach and the use of ABC technologies, can result in projects that serve as watershed events in the way they are delivered to the public.

Because of the success of this project, NYSDOT plans to consider bridge slide technology as a viable tool in its ABC toolkit on all future projects.

PROJECT DETAILS

BACKGROUND

This project is located in the Hudson Valley Region of New York in the town of Southeast, Putnam County, on a heavily traveled section between the I-84 and I-684 intersection and the New York–Connecticut border (see figure 1). The scope of the project was to replace the two-lane, three-span twin bridges that carry I-84 over Dingle Ridge Road with new three-lane, single-span bridges.

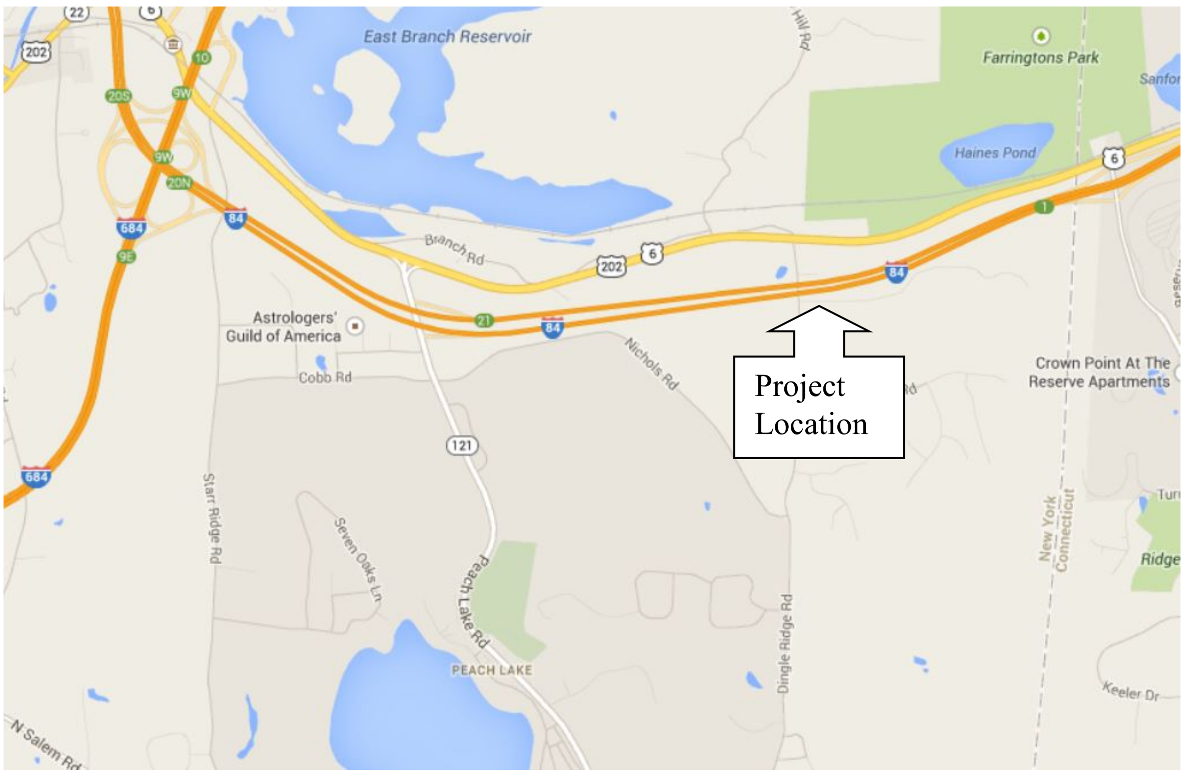

Figure 1. Map. Project location.

Route I-84 is an urban principal arterial interstate on the Federal-Aid National Highway System. Dingle Ridge Road is a local road with an ADT of 3,000 and a grade of 15.7 percent in the area of the bridges. The distance between the centerline of the bridges over Dingle Ridge Road is about 140 feet, resulting in an elevation differential of about 15 feet between the bridges. Figure 2 shows the spacing between the twin bridges, and it shows Route 6/202 that runs north of and parallel to I-84. This road served as the detour route during the accelerated bridge replacements.

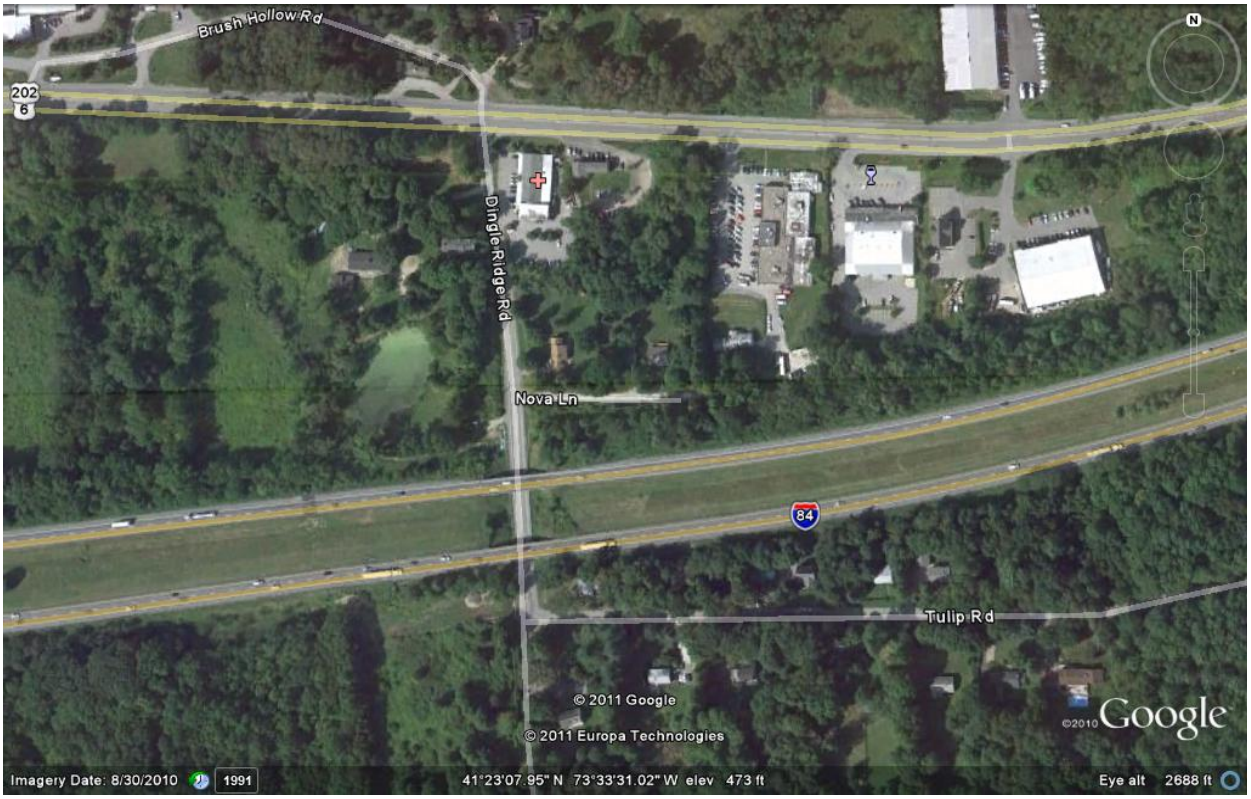

Figure 2. Photo. Site overview showing twin bridges in relation to Route 6/202.

The original bridges were constructed in 1967. Each of the twin bridges consisted of three simple spans of 37 feet, 41 feet, and 56 feet, with five steel beams per span. The bridges were supported on spread footings over soil. The last available inspection report showed paint in generally poor condition and random rust on approximately 25 percent on all girders. A temporary steel support supported the end of girder 1, span 2 for the I-84 EB bridge and the end of girder 5, span 2 for the I-84 WB bridge. The temporary supports were installed as a result of lower web crippling. Both bridges showed characteristic deterioration due to leakage at joints. Furthermore, the wearing surface of the deck had worn asphalt pavement with wheel rutting on all spans. Figure 3 shows the twin bridges over Dingle Ridge Road highlighting the differential in their elevations. Figure 4 shows the condition of the fascia girders.

The EB bridge had a sufficiency rating of 62.0, and the WB bridge had a sufficiency rating of 60.2.

NYSDOT considered four alternatives: a null alternative (i.e., doing nothing), a rehabilitation alternative, and two replacement options—one with two lanes and the other with three lanes. Since the I-84 corridor in this area will be widened in the future because of the need for increased capacity, the agency selected the replacement with a three-lane bridge.

Figure 3. Photo. Original bridges over Dingle Ridge Road, showing elevation differential.

Figure 4. Photo. General deterioration of the girders.

The high volume of traffic on I-84 requires two travel lanes in each direction to be maintained at all times. Various alternatives were investigated, and the best method for maintaining traffic was determined to be shifting EB and WB traffic on I-84 to the median and carrying the traffic over a two-lane temporary bridge over Dingle Ridge Road for each direction. This approach would have required substantial roadway construction to overcome the large elevation differential between the roadways at this location and would have impacted 7 acres of the highly sensitive New York City watershed area in which the project is located. NYSDOT estimated the temporary bridge and roadway system to cost $2 million. Furthermore, the project would have taken 2 years to build (one construction season for each bridge), which would have had a substantial impact on traffic. The temporary bridge and approaches would have been removed once the new bridges were completed. Figure 5 shows a drawing of how the project would have been staged.

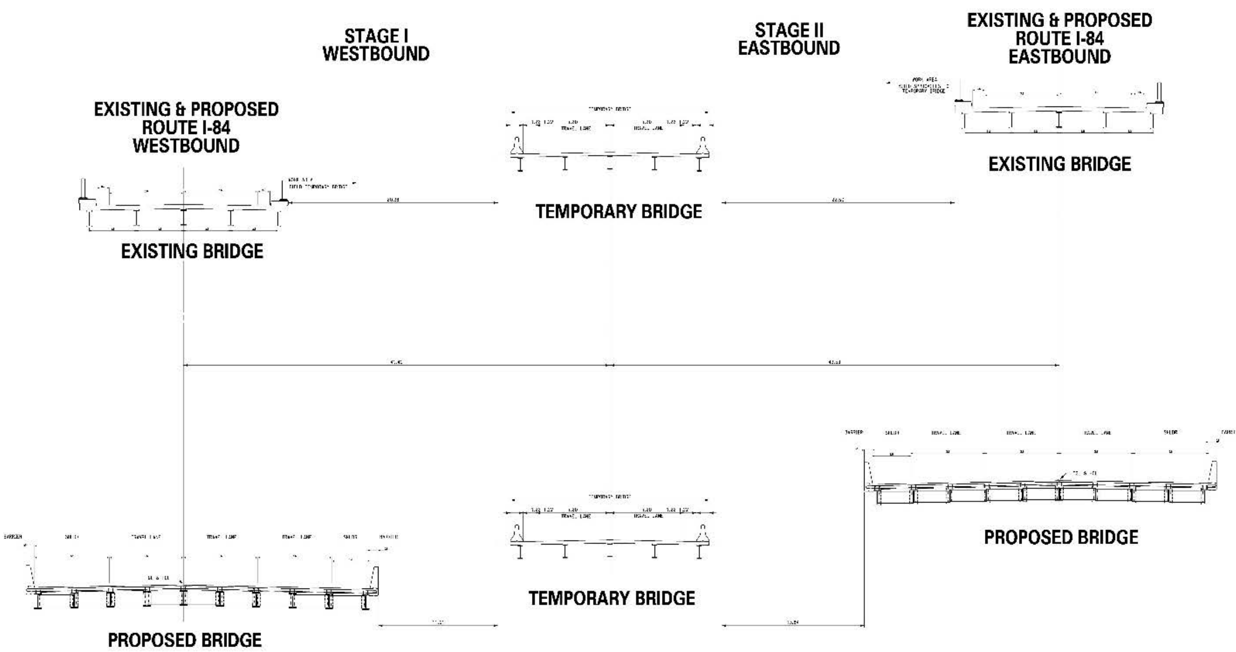

Figure 5. Diagram. Project staging as envisioned under traditional construction.

The traditional construction user cost was calculated to be $7.5 million based on a daily user cost of $13, 611 for the estimated construction duration of 550 days. The estimated user cost for no construction was calculated to be $6.0 million based on a daily user cost of $10, 981 for the same 550-day duration, resulting in a differential of $1.5 million.

At this juncture, NYSDOT explored faster ways to build the project using precast elements and ABC methods of rolling in or sliding in replacement superstructures. ABC methods are known to have the following advantage:

- Reduce onsite construction time.
- Reduce disruption to traffic.
- Improve construction-related safety.

- Improve quality because of construction of some of the elements in a controlled environment.
- Reduce user costs.

This project received a National Environmental Protection Agency process waiver for conducting environmental assessment and preparing an impact statement under the NYSDOT's programmatic categorical exclusion agreement with the FHWA New York Division.

In July 2011, the agency applied for HfL funding, highlighting the feasibility of using innovative technology at this site and reducing the influence to traffic by more than 90 percent on this project. Funding was approved in the amount of $2.1 million. Earlier, the agency applied for and was approved for a grant of $0.3 million in engineering design support from SHRP2. The grant would be used to demonstrate the use of the SHRP2 ABC toolkit for designing and constructing complete bridge systems that address rapid renewal needs.

Project Engineering

The project team decided to use Route 6/202 that runs north of and parallel to I-84 as the detour route. Traffic count data at this location indicated that there was about a 20-hour window during which the impact would be minimal—between 5 p.m. on Saturday and 1 p.m. on Sunday. During this window, the team needed to demolish the old structure and replace it with a new structure. The team addressed this challenge by using precast elements to the extent practicable and assembling the superstructure nearby so that it could be slid into place after the old structure was demolished. The elements would be connected together with UHPC to minimize the gap between connecting elements, provide impermeability, and provide high durability, all consistent with the HfL goal of a long-lasting project. Also consistent with this goal would be the use of stainless steel for the top mat of the deck that NYSDOT uses as standard practice in this region, as the agency has found this to be cost-effective.

Figure 6 shows the superstructure sections of both old and new structures. The new structure is 57 feet wide to accommodate three lanes of traffic, a 6-foot left shoulder, and a 12-foot right shoulder to provide for future lane addition and traffic control. This is about double the width of the replaced bridges. The extra width reduces the under-clearance over the steep Dingle Ridge Road to the point where, despite the project team’s decision to use a shallow superstructure to minimize depth, it still needed to be raised by 2 feet to fulfill the 14.5-foot under-clearance requirement.

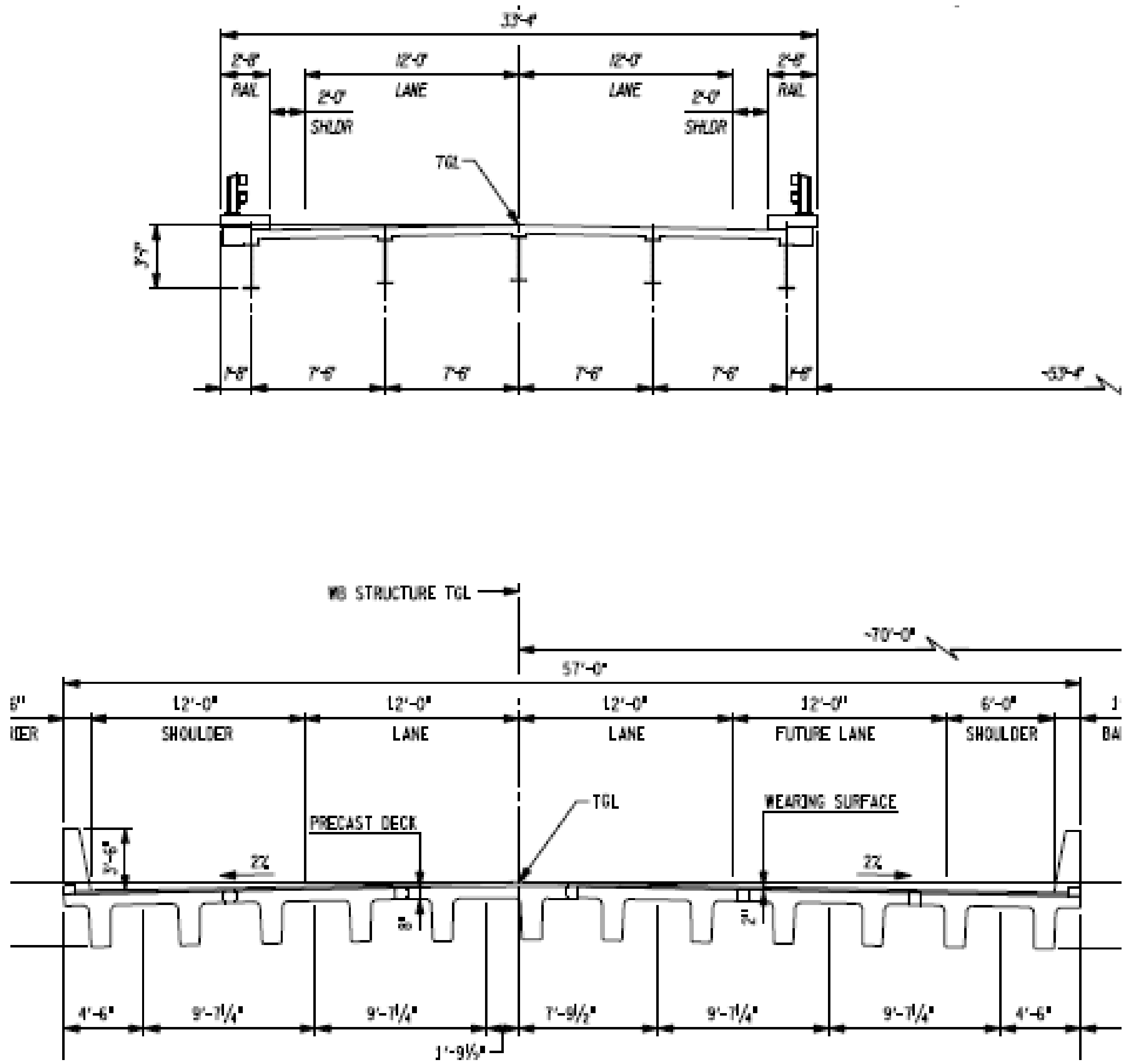

Figure 6. Diagram. Superstructure sections of replaced and new bridges.

The shallow superstructure consists of Double Tee NEXT beam precast elements. Details are available in SHRP2 Report S2-R04-RR-2, Innovative Bridge Designs for Rapid Renewal. This report is intended to serve as a toolkit for ABC, and the use of standard details from the report on this project demonstrates an application of the toolkit.

To accelerate construction, the project team considered the SPMT and bridge roll-in and slide-in options. The SPMT option was not viable because of the steep grade of Dingle Ridge Road. The roll-in option was also dropped from consideration because it entails the additional time-consuming step of changing out the rollers by jacking. The team therefore zeroed in on the slide-in option, pushing the superstructure with hydraulic jacks as opposed to pulling.

To complete removal and replacement during the allotted 20-hour timeframe, the project team decided to slide the bridges and approaches together as one unit, as this reduces closure time. This required the two approach slabs to serve as temporary end spans. They were designed to carry traffic on a temporary basis. These end spans were subsequently filled with flowable fill, and the three-span structure was converted to a single-span structure with ground-supported slab on either side. Figure 7 shows a sketch of the bridge and approaches as one jointless bridge with provision for expansion at the approach slab ends. The figure also shows the four sliding surfaces, two at the abutments and two at the end of the approach slabs. Figure 8 is a drawing of the precast approach slab, which slides on the sleeper slab shown in figure 9 and figure 10. The sleeper slab also acts like a retaining wall against which asphalt pavement was placed during the slide.

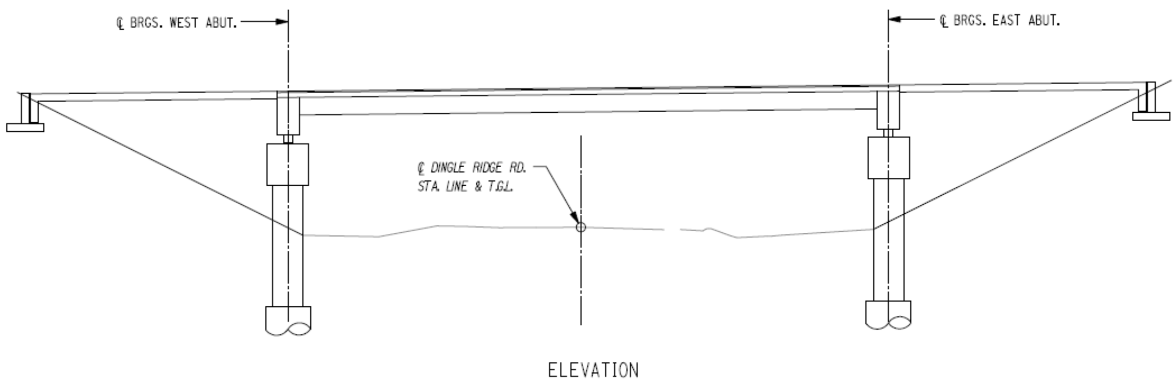

Figure 7. Diagram. Drawing showing approach slabs as temporary end spans.

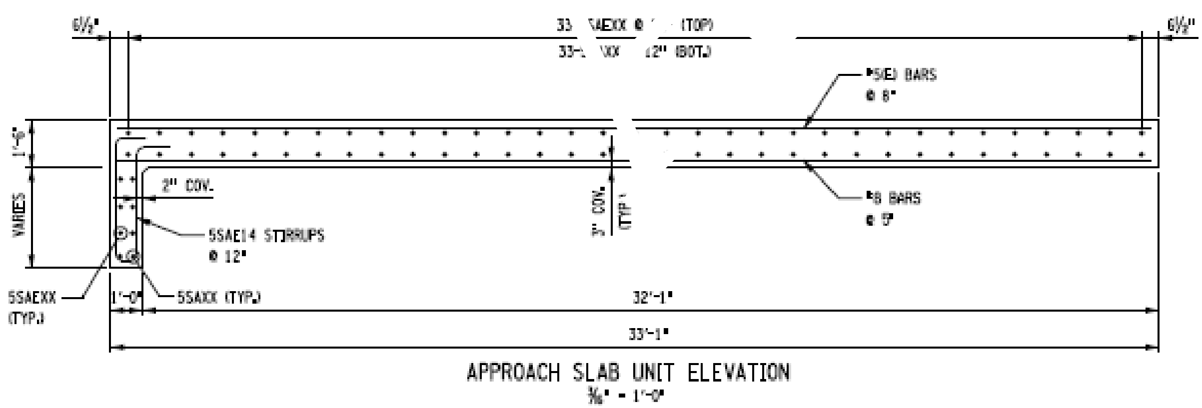

Figure 8. Diagram. Typical precast approach slab section.

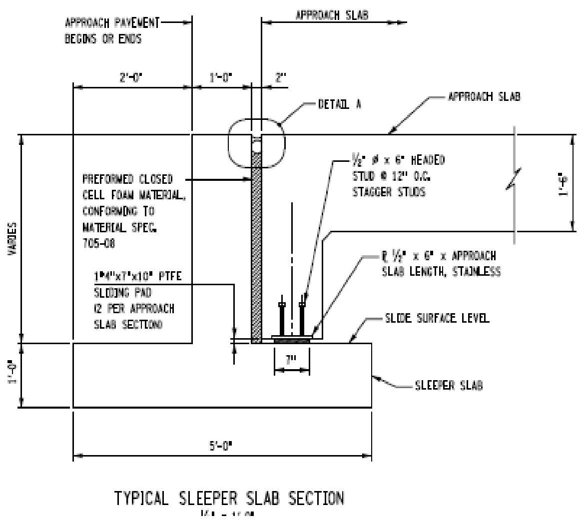

Figure 9. Diagram. Typical precast sleeper slab section.

Figure 10. Photo. Typical precast sleeper slab element.

Another challenge related to rapid renewal and replacement is the need to minimize disturbance to the existing structure while constructing the replacement structure. The project team determined that, with the availability of bedrock at 15 to 20 feet below ground level, drilled shafts outside the existing bridge footing were both viable and cost-effective. The team also considered the micropile option, which was determined to be costly, and the shallow foundation option, which required risky extensive excavation of existing slopes. Additionally, the shallow foundation option raised concerns about the abutments deflecting when the weight of the superstructure is placed all at the same time, as opposed to incrementally as in traditional construction.

The contractor chose steel piling as the foundation for the temporary structure to support the bridge in its temporary position. The support structure on this project consisted of primary bents to support slide tracks at the abutments and secondary bents to support slide tracks at the approach ends, as shown in figure 11.

Figure 11. Photo. Primary bent in the foreground and secondary bent in the background.

Project Construction

The key construction elements on this project are drilled shafts, concrete substructures, temporary shoring, bridge superstructure, retaining walls, and horizontal slide and approach roadway work. The notice to proceed was issued to the contractor near the end of 2012, with the expectation that the new structures would be in place by fall 2013. The project team broke the project down to three stages:

1. Pre-ABC Period—Abutments supported on drilled shafts and superstructure constructed.
2. ABC Period—One direction of I-84 was closed, traffic was detoured to a parallel roadway, the existing bridge was demolished, the new superstructure was slid in with approach slabs connected to it, and the approach roadways were raised by 2 feet.
3. Post-ABC Period—Openings under the approach slabs were filled using flowable fill material, temporary supports for the superstructures were removed, modular wing walls were completed, and approach work was finished.

A substantial amount of work needed to be completed up front before the contractor could go into construction. This included submittals for constructing drill shafts and the temporary structures along with the approval of shop drawings for the precast elements.

The first construction activity started in February 2013, with construction of the drill shafts outside the footprint of the structure. There were a total of eight drill shafts, two for each abutment. Figure 12 shows a drawing of the complete straddle bent abutment with a drilled shaft at each end. Figure 13 is a photograph of one of the 6-foot-diameter casings of the drilled shaft in place.

The drawing shows a modular wall, which is like a breast wall and does not support the structure. The cap beam supported by the drilled shafts shown in the figure was cast in place, and the top of the cap beam served as a sliding surface. The drawing also shows an end diaphragm with four sliding shoes. One might expect the sliding shoes to be at the bottom of the beams, but because of site constraints, the sliding shoes in this instance are at the bottom of the diaphragm.

The construction of the temporary shoring was on the critical path, and the contractor worked around the clock to construct the primary and secondary bents. Figure 14 shows construction of the bents in the initial stage, and figure 15 shows construction nearing completion. A plan view of the primary and secondary bents and their alignment with the abutments and sleeper slabs of the new structure is shown in figure 16.

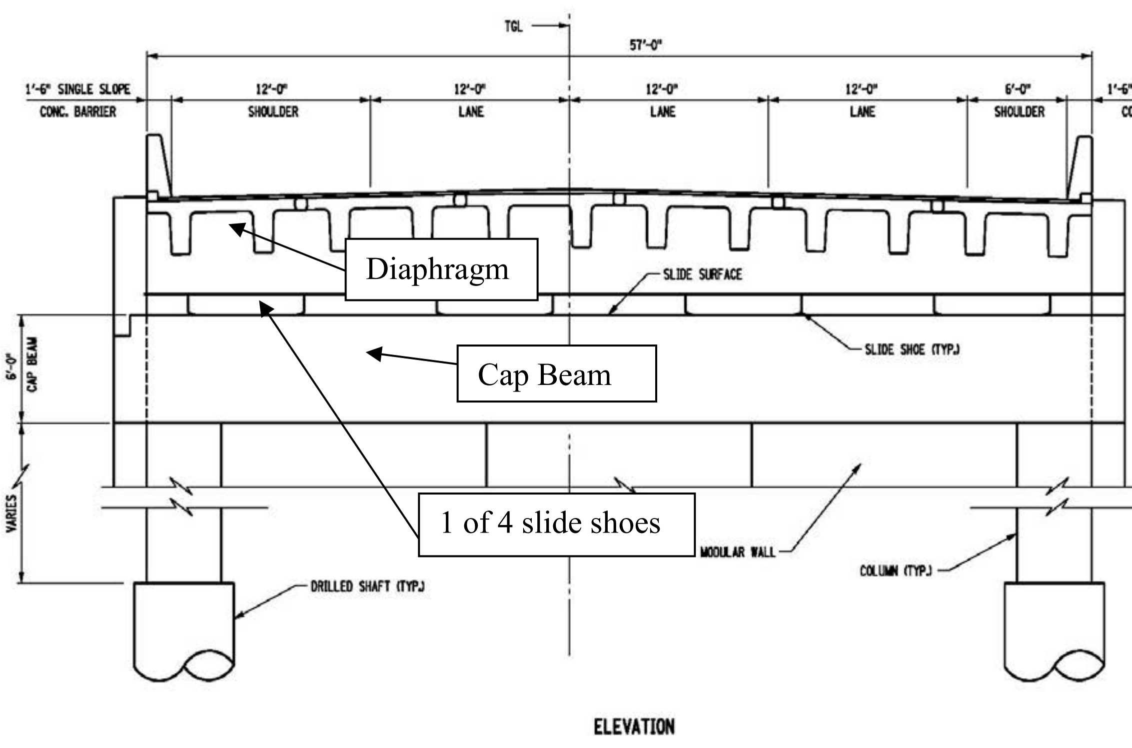

Figure 12. Diagram. Straddle bent abutment.

Figure 13. Photo. Drill shaft casing with reinforcement.

Figure 14. Photo. Construction of temporary bents, initial stage.

Figure 15. Photo. Construction of temporary bent nearing completion.

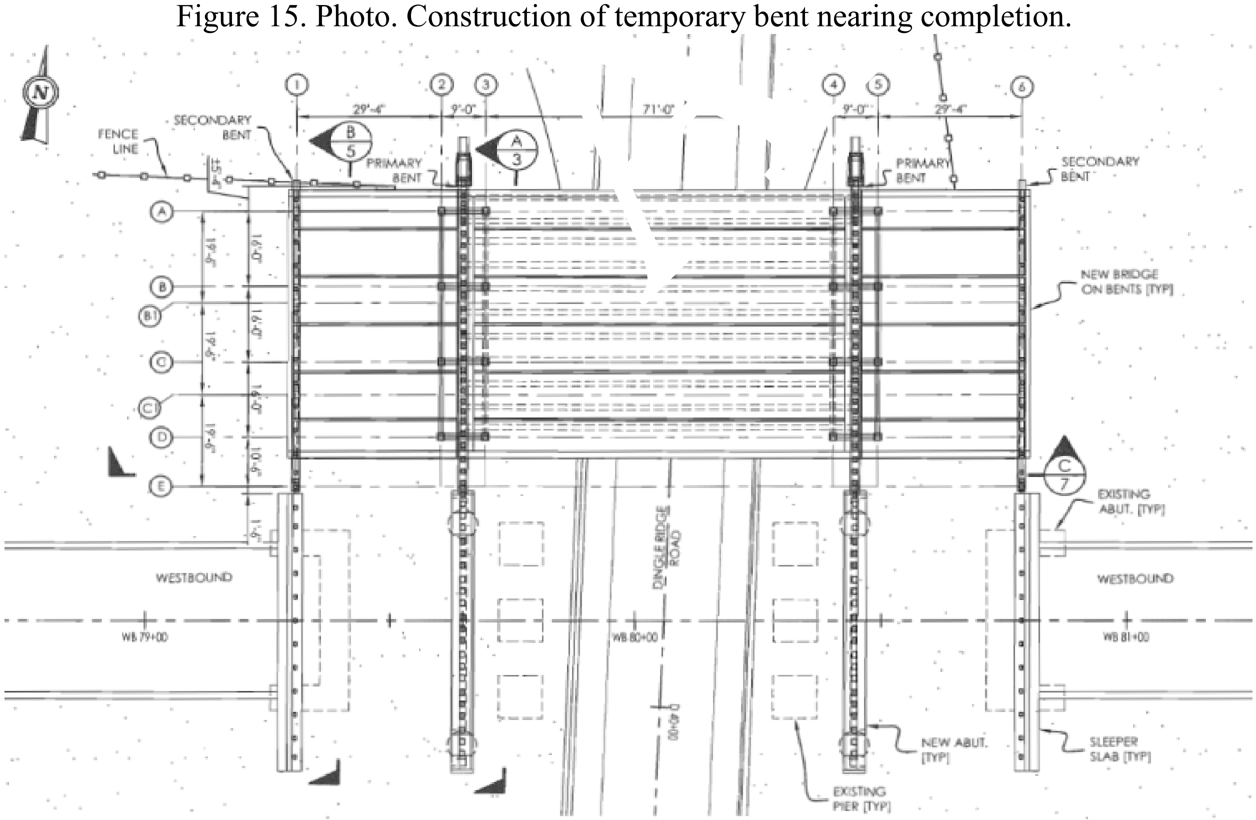

Figure 16. Diagram. Plan showing new bridge on bents aligned with new abutments and sleeper slabs.

Figure 17 shows the reinforcement for the abutment while it is being built, and figure 18 shows the installation of T-wall which served as wings for the abutments of the new structures.

Figure 17. Photo. Abutment construction.

Figure 18. Photo. Installation of the T-wall used for abutment wings.

The end diaphragm with the slide shoes enabled lowering the slide elevation to clear existing structures and includes beam bearings and slide shoes. The precast portion of the end diaphragm being maneuvered into the slide rail is shown in figure 19. The diaphragm's cast-in-place portion connects it to the approach slab, enabling a jointless bridge. Figure 20 is a drawing that shows the end diaphragm supporting the NEXT beams on the left, with the precast portion and the cast-in-place connection with the approach slab on the right. It also shows the polytetrafluorethylene (PTFE) sliding bearing pads on top of the cap beam and the end view of the sliding shoes at the bottom of the diaphragm.

Figure 21 shows two cranes guiding the NEXT beams to be placed on the end diaphragms, and figure 22 shows near completion of the placement of the NEXT beam elements. Note the existing and replacement WB structures in the background. Figure 23 shows the underside of the superstructure, with daylight showing through the gap between the elements. Figure 24 is a close-up of the joint and shows the staggering of the reinforcement. The bottom layer of the deck reinforcement is epoxy coated and the top layer is stainless steel. Figure 25 provides a close-up of the reinforcement between the NEXT beam superstructure and the approach slab. UHPC with steel fibers was used for the closure pours and required a waiver of the Buy America clause, as the only known source of supply is outside the country and the quantities used were small. The closure operation is shown in figure 26. An underside close-up of the NEXT beam element after the closure pour is shown in figure 27

Figure 19. Photo. End diaphragm being maneuvered into the slide rail.

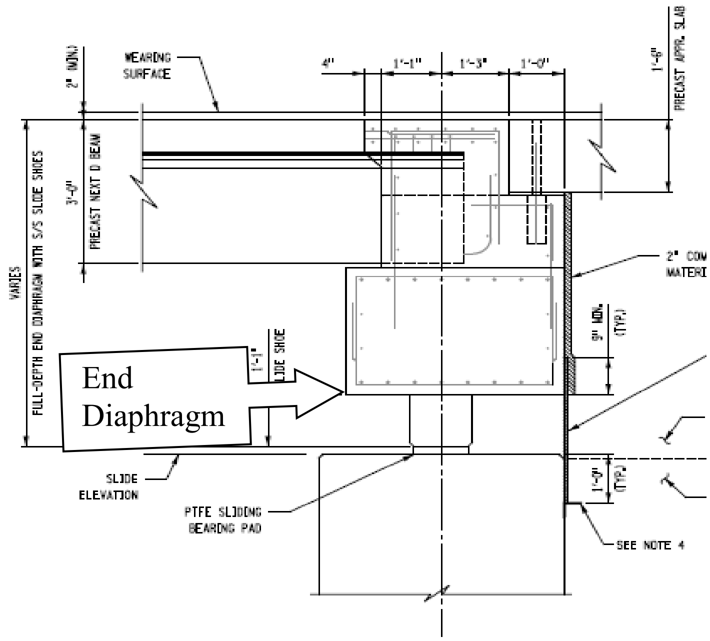

Figure 20. Diagram. End diaphragm.

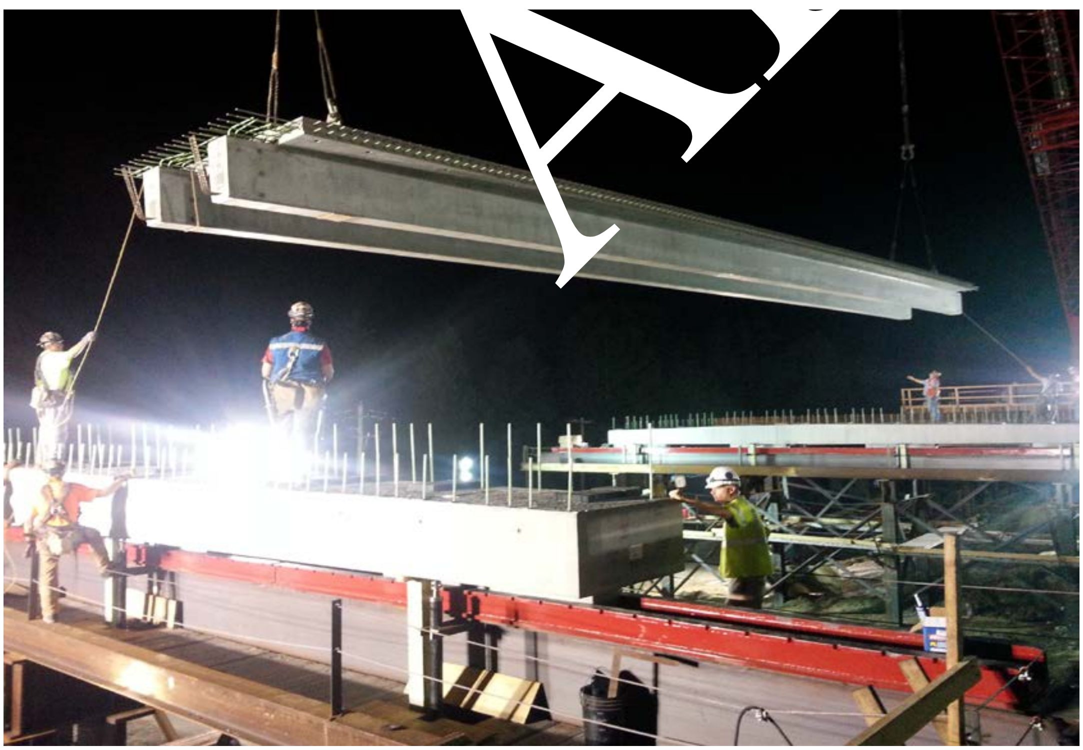

Figure 21. Photo. Placement of NEXT beams on end diaphragms.

Figure 22. Photo. Near completion of NEXT beam placement.

Figure 23. Photo. View of the superstructure from under the bridge.

Figure 24. Photo. Close-up of reinforcement of adjacent NEXT beam elements.

Figure 25. Photo. Close-up of reinforcement connecting beams and approach slab.

Figure 26. Photo. UHPC closure pours in progress.

Figure 27. Photo. Close-up of NEXT beam from underneath after UHPC pour.

The project team originally intended moving traffic on the concrete deck surface but subsequently decided to place an asphalt surface over it before opening the bridge to traffic after the ABC period. Figure 28 shows blast cleaning of the deck prior to placement of the primer. The waterproofing was performed with two layers. Spraying of the first layer of rubberized plastic material is shown in figure 29. This was followed by spraying of the second layer and fine aggregate material, as shown in figure 30. After curing of the waterproofing membrane the structures were ready to be moved. Figure 31 shows the two new superstructures just to the north of the old structures. The WB bridge was the first to be moved, during the weekend of September 21-22, 2013.

Figure 28. Photo. Blast cleaning deck surface.

Figure 29. Photo. Placing the first layer of waterproofing membrane after priming the deck.

Figure 30. Photo. Placing the second layer of waterproofing membrane and fine aggregate.

Figure 31. Photo. Westbound structure ready for move.

A prequalified specialty contractor is usually responsible for heavy structural moves, whether of the SPMT type or the sliding/rolling type, and selects the means and methods based upon experience. For the project team to be successful, it must closely coordinate the schedule, particularly in a compressed timeframe, and must think through every step—from designing temporary support structures to handling movement and transfer loads to stresses during moving, lifting, and transfer of loads.

The specialty contractor on this project used the Push Gripper assembly shown in figure 32 and figure 33. The pushing of the structure and approach slabs could conceivably have been done at four points, two at the diaphragms and two at the end of the approach slabs. In this instance, the specialty contractor chose to go only with two at the diaphragms, as shown in figure 34, because the equipment's hydraulic capacity was sufficient and the monitoring of movement and coordination among the monitors to ensure movement at the same rate would be less complicated and would require fewer resources.

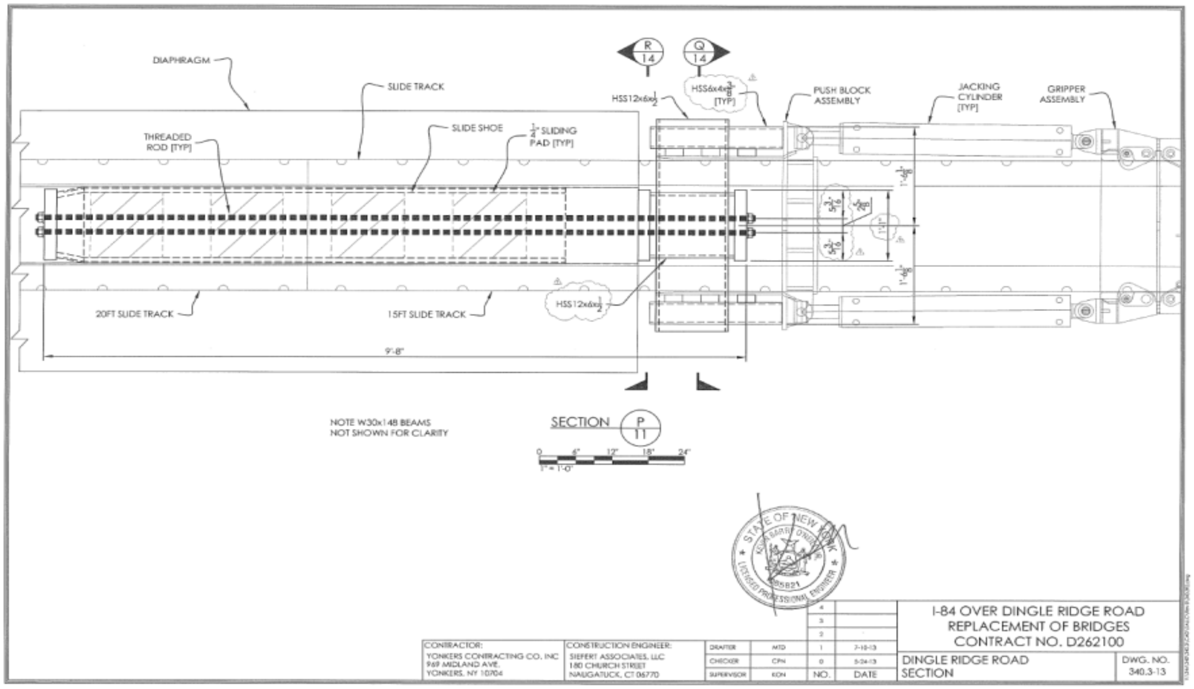

Figure 32. Diagram. Push Gripper assembly drawing.

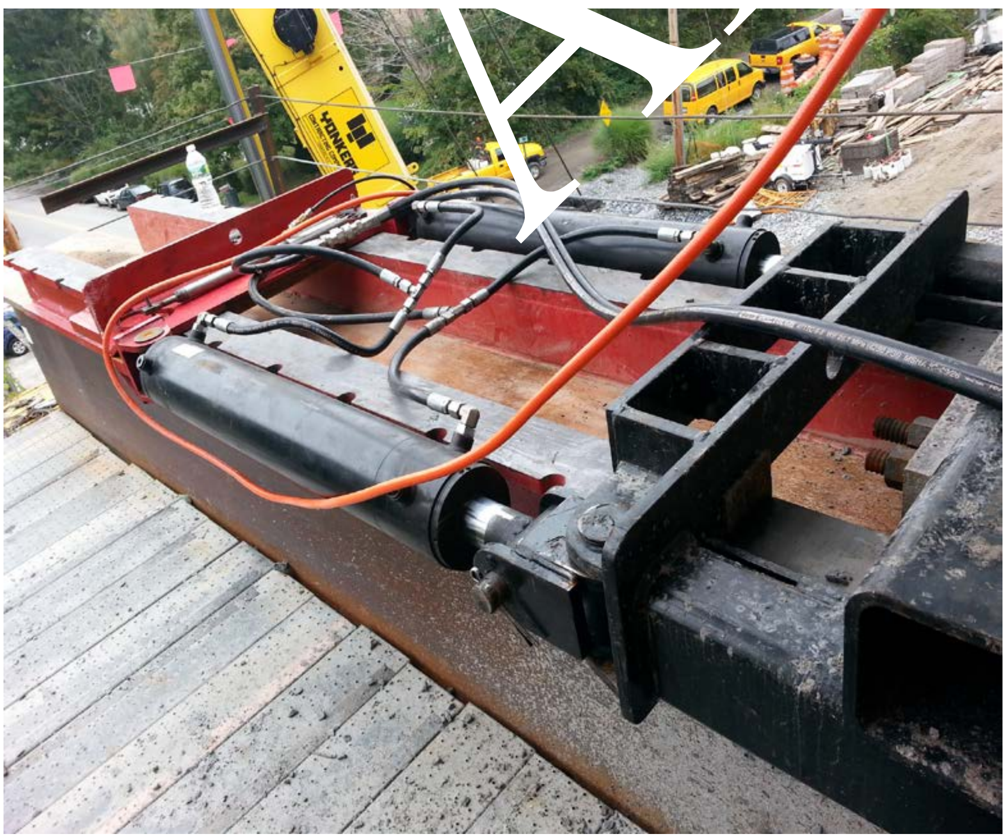

Figure 33. Photo. Close-up of Push Gripper assembly.

Figure 34. Photo. Push Gripper assembly pushing the end diaphragm.

During the first slide, one end advanced faster than the other, causing "fishtailing" and binding. The contractor attributed this situation to poor communications due to heavy rain at the time of the move. Once the rain stopped and personnel were assigned singular responsibility of monitoring and communicating movement only, the slide proceeded without incident. The slide-in for the EB structure on October 19-20 was accomplished without incident in less than 3 hours, less than half the time it took to slide in the WB structure.

The sliding mechanism on this project was stainless steel over PTFE bonded to elastomeric pads, for which the static coefficient of friction was estimated to be 7 to 8 percent.

Figure 35 shows a close-up of the stainless steel shoe sliding over PTFE bonded elastomeric pads. Figure 36 provides elevation view and details, and figure 37 provides end view and details of the shoe. Figure 38 and figure 39 show the slide track and setup of PTFE pads at the secondary sliding surfaces.

Project specifications called for a trial slide in which the movement was monitored as shown in figure 40. The trial was conducted on September 13, and no problems were encountered, confirming that despite their heavy weight, the concrete superstructures can be moved by readily available jacks. The successful trial slide also reinforced the plan to move ahead with the first slide on September 21-22.

Extensive public outreach helped reduce traffic by an estimated 40 percent during the closure period, and the demolition shown in figure 41 started soon after the closure of the roadway to traffic. Simultaneously, construction began to raise the approach roadway by 2 feet. The sleeper slab design enabled the bridge move and the placement of asphalt as shown in figure 42 to occur simultaneously. The bridge deck was overlaid with asphalt, and the entire bridge and approaches were striped and opened to traffic (figure 43) as planned.

Figure 35. Photo. Close-up of stainless steel shoes sliding over PTFE bonded to elastomer pads.

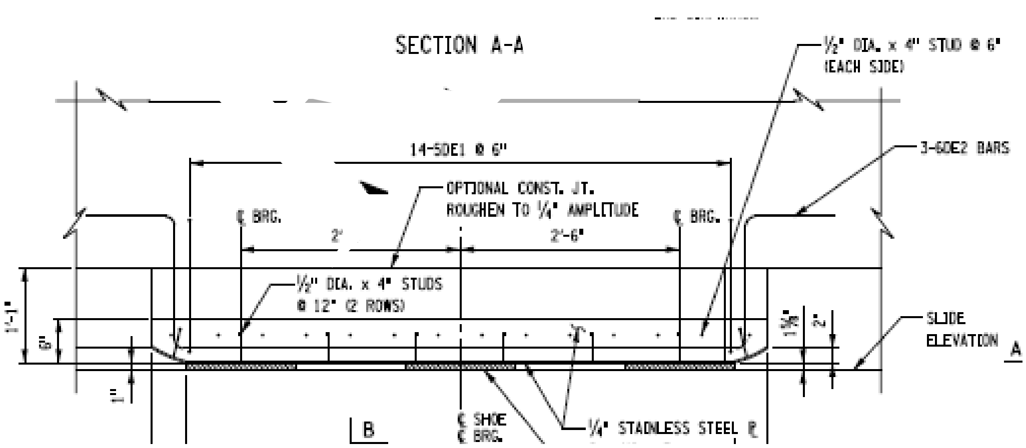

Figure 36. Diagram. Shoe detail.

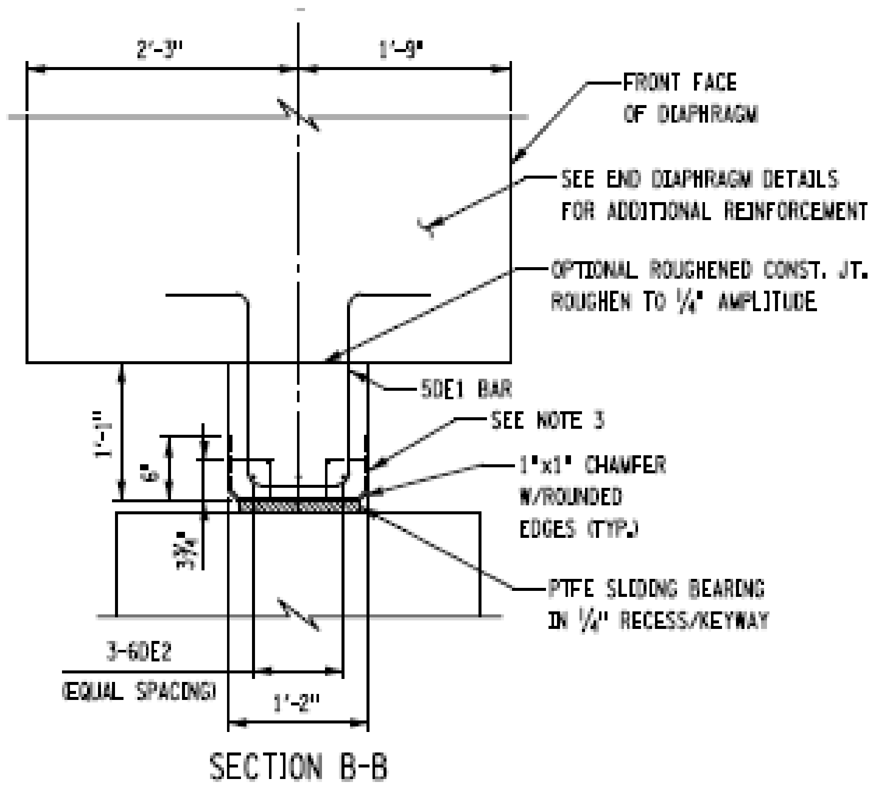

Figure 37. Diagram. End view of shoe detail.

Figure 38. Photo. PTFE pads on sleeper slab to facilitate sliding at end of approach slab.

Figure 39. Photo. Close-up at approach slab end.

Figure 40. Photo. Monitoring of movement during trial slide.

Figure 41. Photo. Demolition of the old structure.

Figure 42. Photo. Approach roadway work being performed simultaneously during bridge move.

Figure 43. Photo. Bridge opened to traffic after line painting.

Timeline and Traffic Conditions during ABC

Throughout the construction process, NYSDOT kept the public informed on progress being made at the site through the agency's website. A very detailed timeline was provided regarding project construction progress, including photographs and traffic conditions monitored by police and construction personnel.

I-84 WB Bridge Removal and Replacement – September 20, 21, and 22, 2013

The I-84 WB bridge over Dingle Ridge Road was removed and replaced on the weekend of September 21-22, 2013. The closure of WB lanes began at 5:30 p.m. on Saturday at I-84 Exit 1 in Connecticut. The traffic was detoured onto Route 6 before re-entering I-84 at Exit 20 in New York (see figure 44). There was no change to traffic in the EB direction. The existing bridge was demolished, the new bridge was slid into place, the road approaches were raised almost 2 feet and the pavement completed at 1 p.m. on Sunday, and the I-84 WB lanes were re-opened. Dingle Ridge Road remained closed to traffic until September 25, 2013. The queue length for I-84 WB traffic was 0.75 mile long east of I-84 Exit 1.

The following is a summary of the construction timeline that was presented on the NYSDOT website.

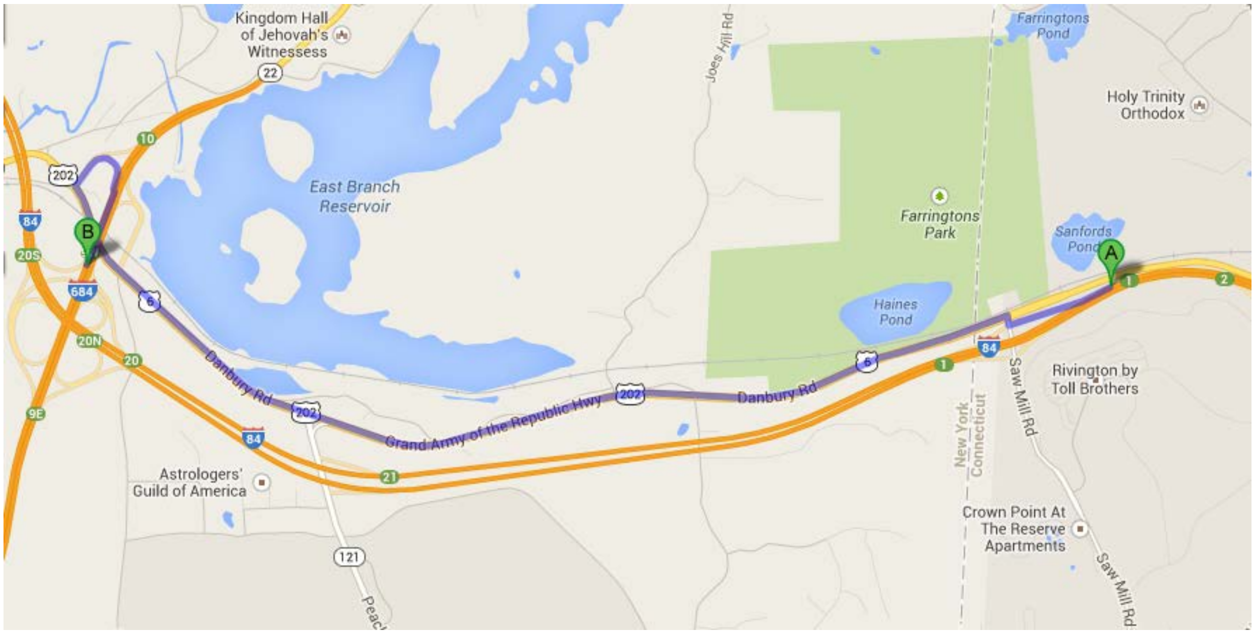

Figure 44. Map. Detour for I-84 WB through traffic during I-84 WB bridge replacement.

UPDATE: Friday, 09/20/13, 11:30 a.m.

All activities on schedule for a Saturday 5 p.m. road closure.

UPDATE: Friday, 09/20/13, 5:45 p.m.

Preparation for closure, including sign and signal work, to begin at approximately 1 p.m. Saturday. Activities on track for I-84 WB closure at 5 p.m. Saturday.

UPDATE: Saturday, 09/21/13, 3:45 p.m.

I-84 WB left lane closed. Complete WB closure still on schedule for 5 p.m.

UPDATE: Saturday, 09/21/13, 5:30 p.m.

I-84 WB closed. All traffic detoured onto Route 6 at Exit 1 in Connecticut.

UPDATE: Saturday, 09/21/13, 6:30 p.m.

I-84 WB closed. Traffic detoured onto Route 6 at Exit 1 in Connecticut. Demolition of I-84 WB bridge over Dingle Ridge Road underway.

UPDATE: Saturday, 09/21/13, 9:40 p.m.

Demolition complete. Traffic queue on Route 6 and I-84 is diminishing.

UPDATE: Sunday, 09/22/13, 12:20 a.m.

New bridge is being slid into place. Paving on east and west approaches to bridge. No traffic queue on Route 6 or I-84.

UPDATE: Sunday, 09/22/13, 6:00 a.m.

New bridge is being slid into place (slide is more than 50 percent completed). Paving on east and west approach to bridge is ahead of schedule. No traffic queue on Route 6 or I-84.

UPDATE: Sunday, 09/22/13, 9:15 a.m.

Bridge slide is complete. Paving on bridge has begun. No backups on I-84 or Route 6 detour.

UPDATE: Sunday, 09/22/13, 12:05 p.m.

Finishing final paving of bridge. Striping of pavement is starting. Traffic moving slowly on I-84, ramps, and detour. WB traffic on I-84 queuing to approximately 3/4 mile east of Exit 1.

MILESTONE: Sunday, 09/22/13, 1:00 p.m.

The WB bridge was open to traffic.

I-84 EB Bridge Removal and Replacement – October 18, 19 and 20, 2013

The I-84 EB bridge over Dingle Ridge Road was removed and replaced on the weekend of October 19-20, 2013. The closure of EB lanes began at 5:00 p.m. on Saturday, and these lanes were re-opened at 12:40 p.m. on Sunday. The following detours were in place:

- I-84 EB traffic reduced to one lane and diverted onto Route 6 from Exit 20 to Exit 1 (see figure 45).
- Traffic exiting I-684 northbound entered Route 6 WB at the normal exit. Detour signs were in place directing traffic to continue onto Route 22 northbound. A temporary signal was in place to allow a left turn from Route 22 onto Sodom Lane and back onto Route 6 to the west of the detour area (see figure 46).
- During the I-84 EB detour onto Route 6, I-84 traffic entered Route 6 on a continuous green. Traffic traveling west on Route 6 was not able to cross the I-84 traffic entering at Exit 20. Detour signs were in place directing traffic to continue onto the Route 22 northbound ramp. A temporary signal was in place to allow a left turn from Route 22 onto Sodom Lane and back onto Route 6 to the west of the detour area (see figure 47).
- During the I-84 EB detour onto Route 6, I-84 traffic entered Route 6 on a continuous green. Traffic traveling east along Route 6 was not able to cross/merge with the I-84

traffic entering at Exit 20. Detour signs were in place directing traffic to continue onto the I-684 southbound ramp and onto I-84 EB to join the detour traffic (see figure 48).

- Dingle Ridge Road remained closed to traffic from 1:00 p.m. Friday, October 18, to October 25, 2013.

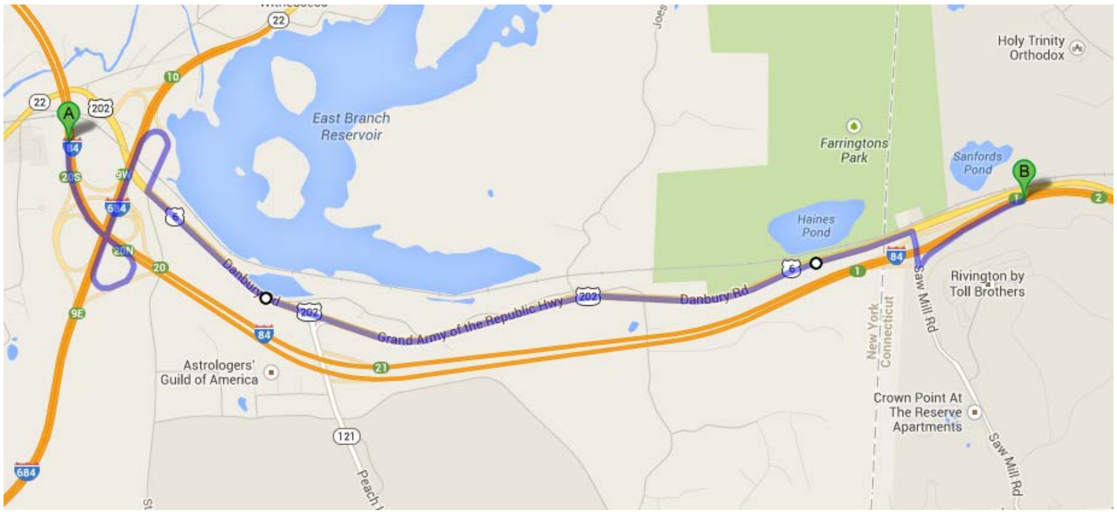

Figure 45. Map. Detour for I-84 EB through traffic during I-84 EB bridge replacement.

Figure 46. Map. Detour for traffic exiting I-684 northbound detour during I-84 EB bridge replacement.

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Figure 47. Map. Detour for Route 6 WB traffic during I-84 EB bridge replacement.

Figure 48. Map. Detour for Route 6 EB traffic during I-84 EB bridge replacement.

Traffic conditions during EB bridge replacement were more challenging because of the I-84 and I-684 intersection just westbound of the bridge, and the queue length at the traffic's peak was about 1.5 miles with an estimated delay time of 30 minutes. The queue length at the traffic's peak was 0.75 miles long with an estimated delay time of 15 minutes.

The following is a summary of the construction timeline that was presented on the NYSDOT website.

> **UPDATE: Friday, 10/18/13, 1:00 p.m.**
>
> Dingle Ridge Road is now closed to traffic. Expected to re-open on 10/25/13. Follow marked detour signs.
>
> **UPDATE: Saturday, 10/19/13, 5:00 p.m.**
>
> All local detours and closures are in place. I-84 EB is closed and detoured. Traffic is moving slowly on I-84 and I-684.
>
> **UPDATE: Saturday, 10/19/13, 5:40 p.m.**
>
> Construction is on schedule. Demolition has begun.
>
> **UPDATE: Saturday, 10/19/13, 9 p.m.**
>
> Demolition is now complete. The contactor is preparing for the bridge slide. There are minimal delays on I-84, and I-684 has about a mile delay.
>
> **UPDATE: Saturday, 10/19/13, 11 p.m.**
>
> Paving has started. The bridge slide has also begun. No traffic delays on I-84 or I-684.
>
> **UPDATE: Sunday, 10/20/13, 12 a.m.**
>
> Paving continues. The bridge slide is approximately 50 percent complete. No traffic delays on I-84 or I-684.
>
> **MILESTONE: Sunday, 10/20/13, 1:15 a.m.**
>
> The bridge slide is complete.
>
> Paving continues. No traffic delays on I-84 or I-684.
>
> **UPDATE: Sunday, 10/20/13, 3a.m.**
>
> The bridge slide is complete. Placement of the permanent bearings is occurring. Paving continues steadily. No traffic delays on I-84 or I-684.
>
> **UPDATE: Sunday, 10/20/13, 5:45 a.m.**

Paving continues. I-84, I-684, and detour routes are flowing smoothly with light traffic.

UPDATE: Sunday, 10/20/13, 9a.m.

Paving continues steadily. No traffic delays on I-84 or I-684.

UPDATE: Sunday, 10/20/13, 9:50a.m.

I-84 westbound experiencing backups between the Dingle Ridge Bridge and Exit 1 due to a disabled vehicle. I-684 North has a ¼-mile backup. The I-84 EB detour on Route 6 is moving slowly but steadily.

UPDATE: Sunday, 10/20/13, 10:30a.m.

I-84 WB disabled vehicle cleared. No backups on I-84 WB. I-684 North is continuing to back up at Exit 20. I-84 EB detour on Route 6 is moving steadily.

UPDATE: Sunday, 10/20/13, 12:20 p.m.

Contractor has completed construction operations. I-84 EB and ramps are in the process of opening.

Traffic volumes are picking up on both I-684 northbound and I-84 EB. There is an approximately 1.5-mile backup on I-684 northbound from Exit 9. The I-84 detour on Route 6 EB is backed up for approximately 0.5 miles west of the on-ramp onto I-84 at Exit 1. I-84 EB is backed up approximately 1 mile to the west of the detour at Exit 20.

MILESTONE: Sunday, 10/20/13, 12:40 p.m.

I-84 EB is now open. Backups on all affected roads are in the process of clearing.

The project is estimated to be substantially completed by the end of January 2014, by which time the contractor is required to complete placement of flowable fill, remove temporary supports, and complete modular wall construction and approach roadway work.

Public Information and Outreach

A public information and outreach plan is a key component of traffic management. Key goals of the plan include making stakeholders aware of the project, alerting them about potential impacts, modifying travel to reduce traffic congestion during project construction, and promoting project support.

Even with the availability of a four-lane roadway that runs parallel to I-84, NYSDOT personnel recognized that the volume of traffic needed to be reduced substantially to avoid major queuing and delays during the ABC period. NYSDOT personnel made an aggressive effort to identify key stakeholders, educated and informed the public, built and fostered relationships, set expectations, and worked hard to build consensus and support. The stakeholders included local government and residents, Connecticut DOT (since the project is close to the Connecticut border), emergency services, media, commuter traffic, the trucking industry, and other agencies.

The tools of outreach included stakeholder meetings, website, emails, Twitter, Facebook, media and press, postcards, and variable message sign displays. Figure 49 shows a postcard designed to reach out to both English-speaking and Spanish-speaking members of the public.

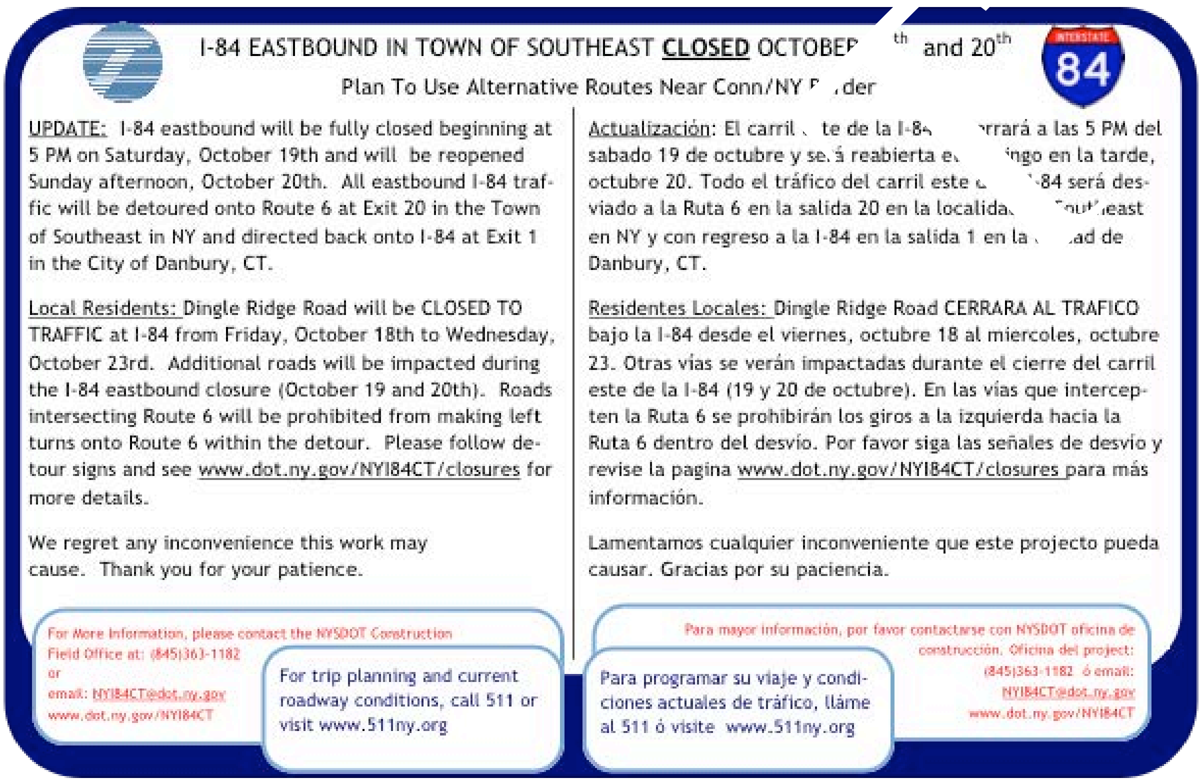


Figure 49. Illustration. Postcard suggesting use of alternate routes.

The outreach efforts were quite effective during the ABC period. NYSDOT estimated from the traffic data that about 40 percent of travelers avoided the closed segment of I-84.

DATA ACQUISITION AND ANALYSIS

Data collection on the NYSDOT HfL project consisted of acquiring and comparing data on safety, construction congestion, quality, and user satisfaction before, during, and after construction. The primary objective of acquiring these types of data was to provide HfL with sufficient performance information to evaluate the feasibility of the proposed innovations and to demonstrate that ABC technologies 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 greater user satisfaction.

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

SAFETY

The use of slide-in technology for the construction of the I-84 project provided several safety benefits. The technology enabled the superstructures to be fabricated offsite and assembled in the staging area adjacent to the existing bridges, yet away from the high volumes of traffic on the Interstate. This improved the safety of the workers in the work zone as well as that of motorists, who were not exposed to typical work zone hazards. Also, work could be performed without interruptions throughout the construction process.

The HfL performance goals for safety include worker and motorist safety goals during construction. NYSDOT's traffic data indicated a total of 37 crashes during the 3-year period from January 1, 2008, to December 31, 2010, within the project limits, of which 31 involved property damage only and 6 involved injuries and fatalities. This amounts to an average of 1.03 crashes per month. With restrictions to travel on I-84 limited to just 4 days under the innovative slide-in option deployed, no motorist incidents were reported during construction, thus satisfying the HfL goal. Similarly, no worker injuries were reported during construction, which means NYSDOT exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the rate reported on OSHA Form 300).

The wider replacement bridge with desirable shoulder width of 12 feet should further reduce the low crash rate of 0.77 million vehicle miles crash rate at this location, which is about half the statewide rate for similar facilities. This will be validated by tracking crash rate in the long term.

Construction Congestion

Faster Congestion

The HfL performance goal for construction congestion is a 50 percent reduction in the time highway users are impacted, compared to traditional construction. If a traditional approach had been used to remove and replace a bridge in each direction, while maintaining traffic on a temporary bridge, NYSDOT estimated that it would have taken 550 days—or 2 construction seasons—to complete the project. Using the innovative slide-in option, the construction was reduced to one season, and traffic impacts were limited to 20 hours over each of two weekends.

Trip Time and Queue Length

NYSDOT estimated the travel time delay and queuing using traffic demand – capacity analysis. The results of NYSDOT's study are presented in appendix B.

During the replacement of the WB bridge on the weekend of September 21-22, the WB lanes were closed at 5:00 p.m. on Saturday at I-84 Exit 1, and the traffic was detoured onto Route 6 before re-entering I-84 at Exit 20. No backups were observed until Sunday noon; however, around Sunday noon, the traffic was moving slowly on I-84, ramps, and detour routes, while the queuing was building up in the WB direction for approximately 0.75 miles east of I-84 Exit 1. Traffic backups cleared when the I-84 WB bridge was reopened Sunday at 1:05 p.m.

Similarly, during the replacement of the EB bridge on the weekend of October 19-20, no traffic delay or backup was observed until Saturday evening. There were some noticeable traffic delays around 5:00 pm Saturday, and the traffic flow eased thereafter. On Sunday around 10:00 a.m., there were traffic delays and backups due to a disabled vehicle on the road; however, the incident was cleared in 30 minutes, and the traffic started to ease. During this weekend closure, traffic backups were reported for approximately 1.5 miles on I-684 northbound from Exit 9. The I-84 EB was backed up approximately 1 miles to the west of the detour at Exit 20. The I-84 detour on Route 6 EB was backed up for approximately 0.5 miles west of the on-ramp onto I-84 at Exit 1.

Dingle Ridge Road was closed to traffic during the weekend and until the demolition debris was removed. Travelers on this low volume road were able find local alternate routes with minimal impact to their travel time. When compared to the high volume of travel on I-84, the impact on local residents was negligible and was therefore not considered in the analysis.

Quality

Pavement Test Site

Researchers collected sound intensity and smoothness test data from both eastbound and westbound directions of I-84 across the bridge before and after construction. Comparing these data to the test results after construction provides a measure of the quality of the finished bridge.

Sound Intensity Testing

Researchers recorded SI measurements using the current accepted onboard sound intensity (OBSI) technique described in American Association of State Highway and Transportation Officials (AASHTO) TP 76-10, which includes dual vertical sound intensity probes and an ASTM-recommended standard reference test tire (SRTT). SI data collection occurred prior to construction and on the new bridge surfaces shortly after opening to traffic. The SI measurements were recorded and analyzed using an onboard computer and data collection system. Researchers made a minimum of three runs in the right wheelpath of the project. The two microphone probes simultaneously captured noise data from the leading and trailing tire/pavement contact areas. Figure 50 shows the dual probe instrumentation and the tread pattern of the SRTT.

Figure 50. Photos. OBSI dual probe system and the SRTT.

The average of the front and rear OBSI values from both lane directions was computed to produce the global SI level. Raw noise data were normalized for the ambient air temperature and barometric pressure at the time of testing.

The mean SI levels of the WB bridge, approach and leave sections are presented in figure 51. The resulting mean SI level was A-weighted to produce the SI frequency spectra in one-third octave bands, as shown in figure 52. Similarly, the mean SI levels of the EB bridge, approach and leave sections are presented in figure 53. The resulting mean SI level was A-weighted to produce the SI frequency spectra in one-third octave bands, as shown in figure 54.

SI levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. For the WB bridge, the SI level increased 1.4 dB(A) from 100.6 DB(A) before construction to 102.0 dB(A) after construction, while for the EB bridge, the SI level increased by the same quantity from 100.5 DB(A) before construction to 101.9 dB(A) after construction. The new bridges did not meet the HfL goal of 96.0 dB(A) or less.

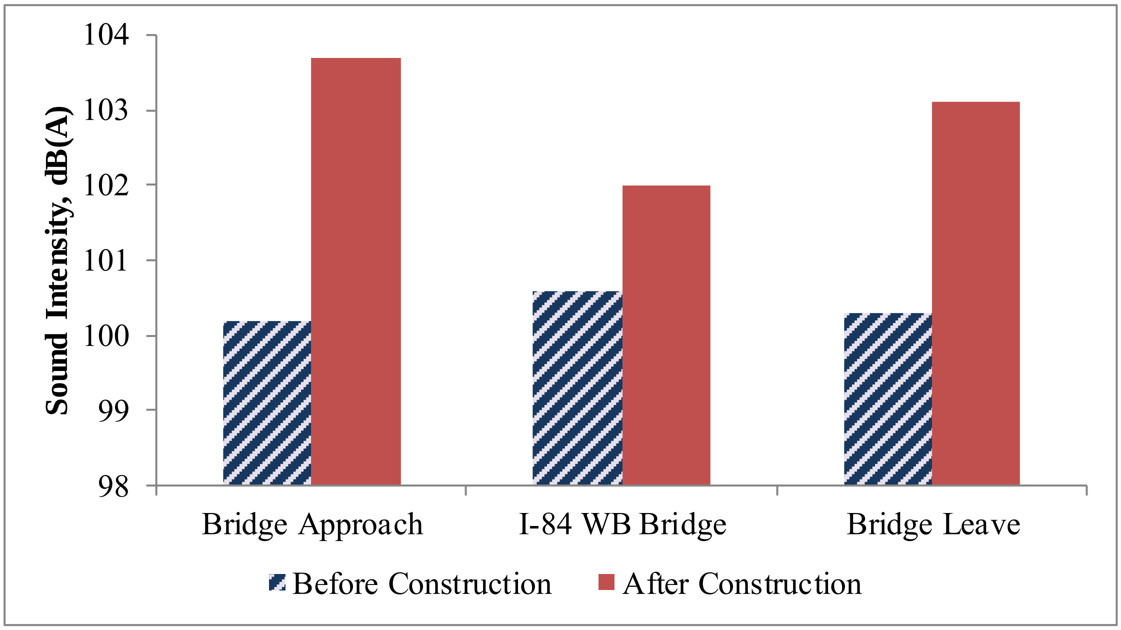
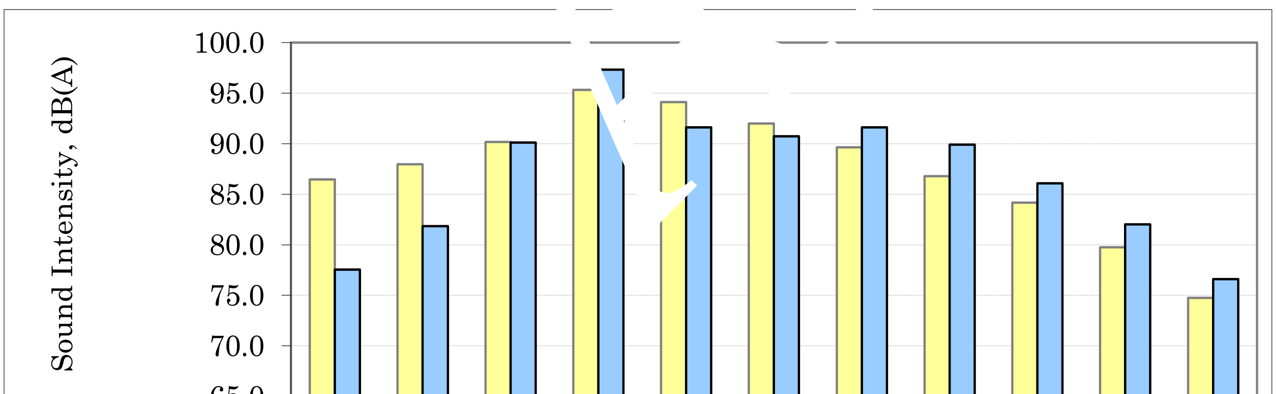


Figure 51. Chart. Mean SI levels of the I-84 WB bridge, approach and leave sections before and after construction.



	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
Preconstruction	86.5	88.0	90.2	95.3	94.1	92.0	89.6	86.8	84.2	79.8	74.8
Postconstruction	77.6	81.8	90.1	97.3	91.6	90.7	91.6	89.9	86.1	82.0	76.6

Figure 52. Chart. Mean A-weighted SI frequency spectra of the I-84 WB bridge before and after construction.

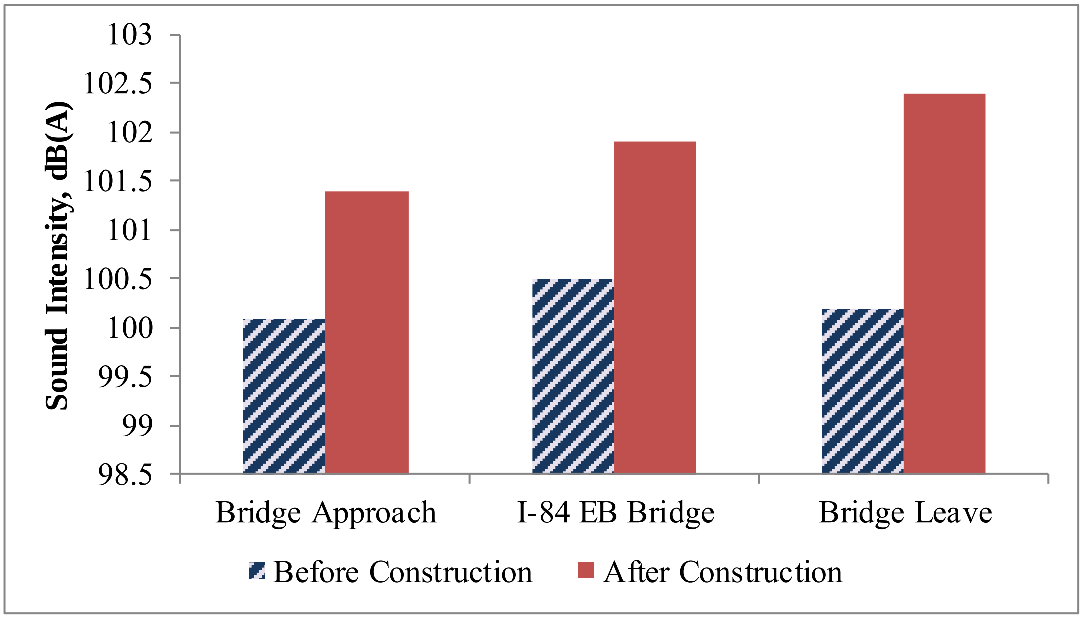
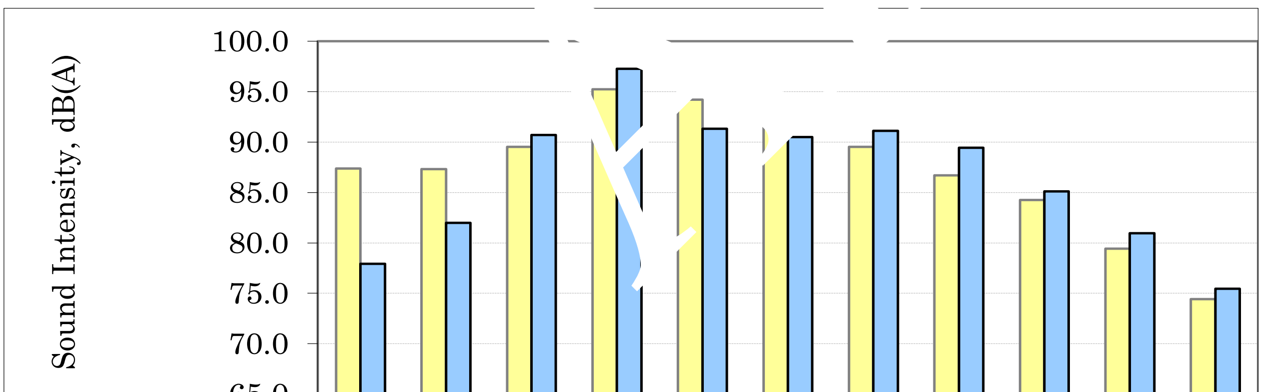


Figure 53. Chart. Mean SI levels of the I-84 EB bridge, approach and leave sections before and after construction.



	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
Preconstruction	87.4	87.3	89.5	95.2	94.2	92.1	89.5	86.7	84.3	79.4	74.4
Postconstruction	77.9	82.0	90.7	97.3	91.3	90.5	91.1	89.4	85.1	80.9	75.5

Frequency, Hz

Figure 54. Chart. Mean A-weighted SI frequency spectra of the I-84 EB bridge before and after construction.

Smoothness Measurement

This project involved bridge replacement that matched the existing roadway grades. The only roadway work was to tie the new construction to the existing approach roadways. The new riding surfaces of the approaches and the asphalt covered bridge decks, however, are a great improvement over the surfaces of the deficient bridges.

Smoothness data collection occurred in conjunction with the SI runs utilizing a high-speed inertial profiler integrated into the noise test vehicle. The profile data collected with this equipment provide IRI values, with lower values indicating a higher quality ride. Figure 55 is an image of the test vehicle showing the profiler positioned in-line with the right rear wheel. Figure 56 and 57 graphically present the IRI values of WB and EB bridges, respectively, before and after construction. Testing was done at a speed of 45 mph with three runs per section.

Figure 55. Photo. High-speed inertial profiler mounted behind the test vehicle.

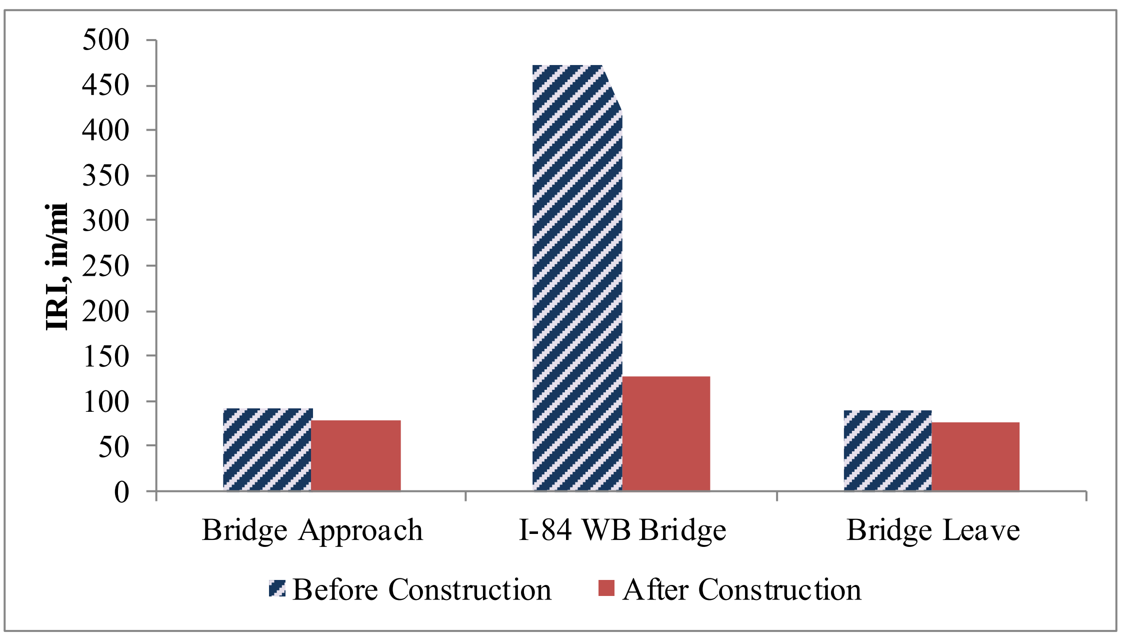


Figure 56. Graph. Mean IRI values of I-84 WB bridge before and after construction.

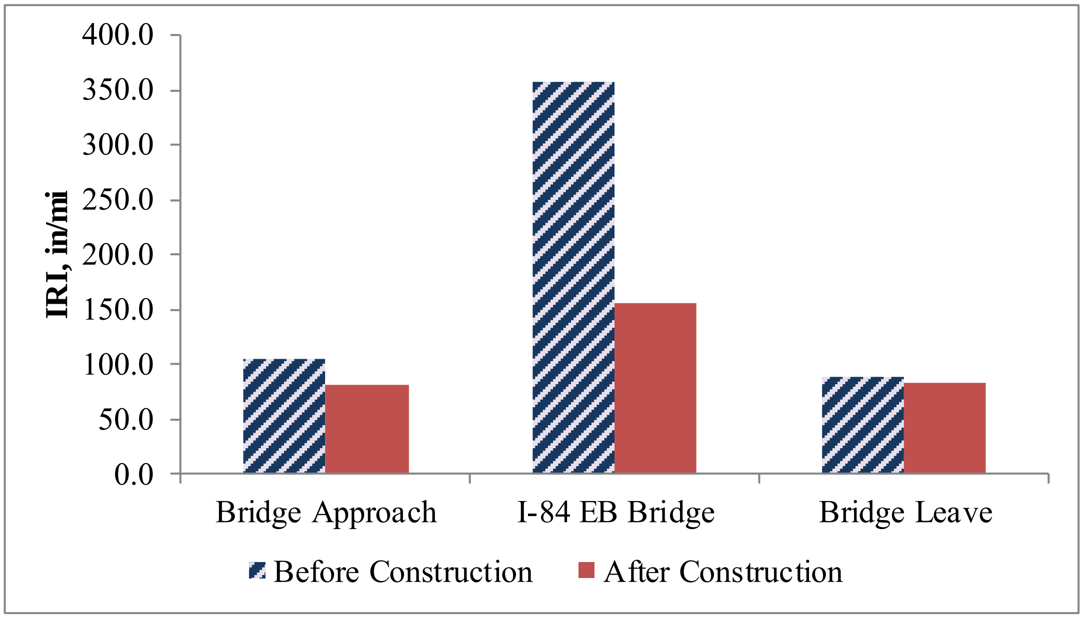


Figure 57. Graph. Mean IRI values of I-84 EB bridge before and after construction.

Figure 56 indicates that the smoothness of the newly constructed WB bridge resulted in a reduction in IRI value from 474 inches/mile to 127 inches/mile. The average smoothness of the WB roadway approaches increased from 92.6 inches/mile to 77.4 inches/mile. Similarly, figure 57 indicates the smoothness of the newly constructed EB bridge resulted in a reduction in IRI value from 358 inches/mile to 155 inches/mile. The average smoothness of the roadway approaches increased from 97.5 inches/mile to 81.9 inches/mile. While not meeting the HfL goal of less than 48 inches/mile after construction, the new bridge surface is an improvement.

Durability

This was a hybrid concrete construction project, with only the foundation items (excluding modular wingwalls and portions of end diapragms and parapets) being cast in place. The remaining elements were fabricated under controlled conditions and tight tolerances in a plant. These precast units were not subjected to adjacent traffic vibrations and adverse weather conditions. Performing work offsite and assembling elements adjacent to the existing bridge also avoided any delays due to corrections or assembly at the site.

Using UHPC along with stainless steel reinforcement in the top layer of the deck should increase the deck's durability significantly.

USER SATISFACTION

NYSDOT had a dedicated website to provide project information to stakeholders on substantial projects. A webcam at the project site enabled viewers to follow construction progress as it was occurring. The agency's web page for this project was continuously updated. The information provided included the following:

- Project schedule, including special traffic messages.
- Project documents, including news releases and information on detours.
- Project contacts.
- Maps.
- Media information showing project progress with photographs.
- Opportunity for website visitors to provide feedback.

The HfL requirement for user satisfaction includes a performance goal of 4-plus on a Likert scale of 1 to 7 for the following two questions:

- How satisfied are you with the results of the new bridge compared to the condition of the previous bridge?
- How satisfied are you with the approach NYSDOT used (accelerated bridge construction) to construct the new bridge in terms of minimizing disruption?

The user satisfaction survey results on this project will be included later upon receipt from NYSDOT.

TECHNOLOGY TRANSFER

To promote the innovations used on this project—prefabricated bridge elements, high-performance materials, and accelerated construction methods—NYSDOT, in conjunction with the FHWA, Transportation Research Board, and SHRP2 sponsored a 1-day showcase. The showcase was held September 24, 2013, at the West Chester Marriott Hotel in Tarrytown, New York. The event was moderated by Jerry DiMaggio, the Transportation Research Board's SHRP2 Implementation Coordinator, and featured presentations by representatives of the FHWA, NYSDOT, HNTB Corporation, and the contractor. It included a visit to the project site to observe conditions and details up close.

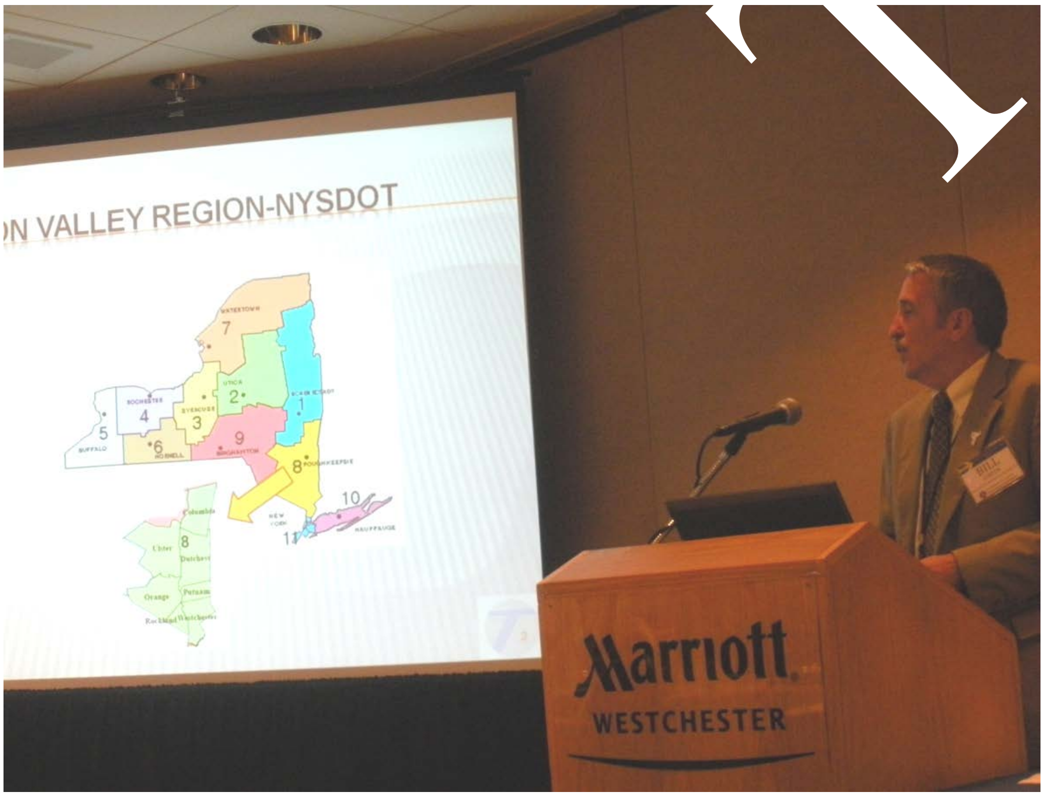


Figure 58. Photo. Bill Gorton providing project overview.

The showcase attracted approximately 80 attendees from Federal and State DOTs, transportation authorities, consultants, contractors, and suppliers. The showcase agenda is shown in appendix A.

Speaking on behalf of Phillip Eng, Executive Deputy Commissioner/Chief Engineer of NYSDOT, Nick Choubah, Acting Regional Design Engineer of NYSDOT Hudson Valley Region 8, and Jonathan McDade, Administrator for FHWA's New York Division, welcomed the audience and provided introductory remarks. The I-84 corridor has 95 structures of the same age, and with success on this project, NYSDOT plans on using this technology in the corridor and the rest of the system, where applicable.

Ewa Flom, Program Manager for FHWA's Center for Accelerating Innovation, provided an overview of national innovation deployment. She highlighted that initiatives like HfL, Every Day Counts, and SHRP2 are all about deploying innovation. HfL is a legacy program from SAFETEA-LU that provided innovation demonstration grants. SHRP2 is a source of innovation, and Every Day Counts is a rapid innovation deployment model. As more SHRP innovations are tried and tested, they will be ready for rapid deployment through the Every Day Counts initiative. Visit www.fhwa.dot.gov/everydaycounts and www.fhwa.dot.gov/goSHRP2 for more details.

Bill Gorton, Acting Director for the Hudson Valley Region, and Nick Choubah, Acting Regional Design Engineer of NYSDOT Hudson Valley Region 8, gave a project overview from NYSDOT perspective (see figure 58). In terms of construction impacts, the conventional process would have adversely affected 75,000 daily users of this roadway for a period of 2 years. Instead, with deployment of innovative technology, the impact was reduced to a period of only 20 hours on the weekend of September 21-22 to replace the structure in the WB direction. Similar replacement time was anticipated for the structure in the EB direction. (Note that the showcase was held prior to the replacement of the EB bridge.) Innovative slide technology avoided $2 million in temporary construction costs and over $1 million in user delay costs. Additionally, it substantially reduced impacts to the sensitive New York City watershed from 7 acres to 2 acres.

Bala Sivakumar of the HNTB Corporation reiterated the SHRP2 project goal of developing standardized approaches to designing and constructing complete bridge systems that address rapid renewal needs. Challenges at this site included the 15.7 percent grade of the Dingle Ridge Road passing under the structure, the need to raise I-84 approaches as much as 2 feet during the removal/replacement window, and the need to minimize disturbance to existing abutments on spread footings during construction of the new abutment. Construction was completed in three stages. In stage 1, substructures were completed to the slide elevation, and new superstructure and approach slabs were prefabricated and placed on temporary supports. In stage 2, the old bridge was demolished, new bridge and approach slabs were slid in, and the approach roadways were raised. The superstructure with stainless steel shoes slid over PTFE bearings bonded to elastomeric bearing pads using a slide rail system designed by the specialty subcontractor. Finally, in stage 3, the flowable fill will be placed under the approach slabs, temporary structures will be removed, and approach roadwork will be completed.

Scott Geiger, Design Project Manager, discussed public outreach using stakeholder meetings, website, email, Twitter, Facebook, media and press, postcards and displays, and variable message signs—all to change driver behavior to reduce the amount of traffic onto the detour route. The outreach efforts were quite successful, as an estimated 40 percent of the traffic avoided travel on I-84 WB during the closure period.

Yonkers Contracting, Inc. personnel along with the Resident Engineer for the project provided an overview of the construction process. The biggest challenge was the schedule; however, with excellent cooperation of all parties involved, they were able to slide the first bridge in approximately 9 months after the Notice to Proceed was issued.

Wahid Albert, Acting Director, Structures Design Bureau, presented NYSDOT ABC applications before the attendees proceeded to the job site, where they observed construction details and highlights in small groups led by project personnel (see figure 59).

Figure 59. Photo. Showcase participants at job site.

The site visit was followed by a session on lessons learned by this experience. During the panel discussion that followed, over a dozen questions were asked and insightful comments were made, clearly demonstrating considerable interest in this innovative technology.

KEY QUOTES FROM THE SHOWCASE

"We have 95 similar structures on Interstate 84 that have pretty much same age as the bridges we are replacing, and as a first move we have shown success. We are planning on using this technology for the rest of the corridor, hopefully the rest of the system we have." *Nick Choubah, Acting Regional Design Engineer, NYSDOT*

"Featured in this showcase also is the SHRP2 R04 project: Innovative Bridge Designs for Rapid Renewal. The SHRP2 implementation assistance program provides support, either in the form of funding or technical assistance, to support organizations in the deployment of SHRP2 products." *Ewa Flom, Program Manager, Center for Accelerating Innovation, FHWA*

‘Everybody had critical players in the field to make decisions….I don’t think anybody had to make a phone call to anyone off site to resolve any issues.” *Bill Gorton, Acting Regional Director, NYSDOT*

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This entails comparing the benefits and costs associated with the innovative project delivery approach adopted on an HfL project with those from a more traditional delivery approach. The latter type of project is referred to as a baseline case and is an important component of the economic analysis.

For this economic analysis, NYSDOT supplied the cost figures for the as-built project as well as the baseline case.

CONSTRUCTION TIME

NYSDOT, through the use of innovative construction technology, was able to dramatically reduce the impact of this project's construction on roadway users. A two-construction season project that would have taken an estimated 550 days to build was reduced to a one-construction season project with virtually no impact on travel until the I-84 bridges were ready to be demolished and replaced. The demolition and replacement of each bridge took only 20 hours. The impact on users under the innovation option was less than 1 percent of what it would have been under the baseline case.

CONSTRUCTION COSTS

The traditional approach would have required a temporary two-lane bridge and substantial temporary roadway work, which NYSDOT estimated at $2.0 million. The innovative option required temporary support structures as well as the horizontal slide system for both EB and WB structures. This was bid as a lump sum item by the contractor for $1.1 million, resulting in net savings of $0.9 million in construction costs with the innovative option, which is approximately 9 percent of the construction cost of $10.2 million for the project.

USER COSTS

Generally, three categories of user costs are used in an economic analysis: vehicle operating costs, delay costs, and safety-related costs. The cost differentials in delay costs and safety costs were considered for comparative analysis of cost differences between the baseline and as-built alternatives.

Safety Costs

There were no work zone related crashes during construction, and hence, the safety cost is considered as zero for the as-built case. However, for the traditional alternative, the safety costs are estimated based on the expected increase in crashes due to construction.

Based on national crash statistics, NYSDOT estimated that the crash rate would increase by 30 percent due to construction and for the 18-month construction period under conventional construction. The increase in number of crashes due to construction would have been:

30% x 1.03 x 18 = 5.56 crashes.

Therefore, with no crashes during the abbreviated construction period when traffic restrictions applied to interstate traffic, it is estimated that NYSDOT avoided six crashes, one of which could have potentially resulted in injury/fatality, while the remaining five could have resulted in property damage only.

The safety costs that NYSDOT avoided with ABC slide-in construction are included in the computations presented in Appendix B and Table 1.

Delay and Vehicle Operating Costs

These costs are incurred because of extra travel distance using detours and when motorists are delayed by congestion in the work zone, slowing down due to reduced lane width and channeling of traffic. No vehicle operating costs were calculated since the traffic control strategies for both as-built and traditional scenarios did not result in significant increases in travel distance. For user delay costs, NYSDOT conducted a detailed study on expected user delay for both accelerated and traditional construction scenarios.

Total User Costs

NYSDOT calculation of user cost is summarized in table 1, and details are provided in appendix B.

The table shows that traditional construction would have increased user costs by:

$7,486,076 – $6,039,482 = $1,448,594

Innovative construction increased user costs by:

$100,000 – (2 x $10,981) = $78,038

Savings in user costs using innovative construction equals:

$1,448,594 – $78,038, or $1,370,556.

Therefore, total savings in user costs using innovative construction equals $1,370,556.

Table 1. User cost analysis.

	Peak Hour Speed (mph)	Daily User Cost	Construction Duration (days)	User Costs
Existing Condition	27	$10,981	550	$6,039,4682
Traditional Construction (18 Months)	15	$13,611	550	$7,486,076
Accelerated Construction (2 days)	2	$50,000	2	$100,000

COST SUMMARY

For traditional project delivery, both construction costs and user costs would have been higher than the costs for the innovative method used. The construction cost would have been 0.9 million higher, and the user delay cost would have been $1.37 million higher. The innovative option saved $2.27 million, which is more than 22 percent of the construction cost of $10.2 million for the project.

REFERENCES

1. SHRP 2, Innovative Bridge Designs for Rapid Renewal: ABC Toolkit, Report S2-R04-RR-2, Submitted by HNTB Corporation et al, Strategic Highway Rearch Program 2, Transportation Research Board, Washington, D.C., 2013. http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_S2-R04-RR-2.pdf

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of FHWA Highways for LIFE Team Leader Byron Lord, Program Coordinators Mary Huie and Kathleen Bergeron, and Ewa Flom, Program Manager for FHWA's Center for Accelerating Innovation. 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 New York State Department of Transportation Engineers Bill Gorton, Nick Choubah, Oscar Pinheiro, Scott Geiger, and Paul Tirums, as well as FHWA Engineers Richard Beers, Benjamin Beerman, and Tim Cupples for their advice, assistance, and coordination during this project.

APPENDIX A—SHOWCASE AGENDA

U.S. Department of Transportation
Federal Highway Administration

NYSDOT I-84 Bridge Replacement Showcase

A SHRP2 R04 Accelerated Bridge Construction Project

AGENDA

Tuesday, September 24, 2013
Westchester Marriott Hotel
Salons III-IV

Moderator: Jerry DiMaggio, SHRP2 Implementation Coordinator – Transportation Research Board

7:00am	**Registration/Check-in**
8:00am - 8:30am	**Welcome Remarks** Phillip Eng, Executive Deputy Commissioner/Chief Engineer – NYSDOT Jonathan McDade, Division Administrator – FHWA, NY Division
8:30am - 9:00am	**National Innovation Deployment Overview** Ewa Flom, Program Manager – FHWA, Center for Accelerating Innovation
9:00am - 9:30am	**Project Overview, NYSDOT Perspective** Nick Choubah, Acting Regional Design Engineer – NYSDOT, Hudson Valley Region 8 Bill Gorton, Acting Regional Director – NYSDOT, Hudson Valley Region 8
9:30am - 10:00am	**Project Overview, Designer Perspective** Bala Sivakumar, Vice President – HNTB Corp.
10:00am - 10:15am	**Break**
10:15am - 10:30am	**Public Outreach** Scott Geiger, Design Project Manager – NYSDOT, Hudson Valley Region 8
10:30am - 10:45am	**Construction Overview, Contractor Perspective** Paul Hubert, Vice President of Construction – Yonkers Contracting Company, Inc. Tom Whelahan, Project Manager – Yonkers Contracting Company, Inc.
10:45am - 11:15am	**Construction Overview - Video of 1st Bridge Slide** Charlie LaBarbera, Resident Engineer – Parsons Brinckerhoff, Inc. Paul Hubert, Vice President of Construction – Yonkers Contracting Company, Inc. Paul Tirums, Engineer in Charge – NYSDOT Region 8 Tom Whelahan, Project Manager – Yonkers Contracting Company, Inc.
11:15am - 12:15pm	**Lunch** ***Presentation on NYSDOT ABC Applications*** Wahid Albert, Acting Director, Structures Design Bureau – NYSDOT
12:15pm - 12:30pm	**Break**
12:30pm	**Load Buses for Site Visit**
12:45pm	**Buses Depart for Site Visit**
12:45pm - 3:00pm	**Site Visit**

3:00pm - 3:30pm	**Lessons Learned** Charlie LaBarbera, Resident Engineer – Parsons Brinckerhoff, Inc. Paul Hubert, Vice President of Construction – Yonkers Contracting Company, Inc. Kevin O'Neill, Project Engineer – Siefert Associates, LLC Vincent Siefert, President – Siefert Associates, LLC Paul Tirums, Engineer in Charge – NYSDOT, Hudson Valley Region 8 Tom Whelahan, Project Manager – Yonkers Contracting Company, Inc.
3:30pm - 4:00pm	**Panel Discussion/Open Q&A** Charlie LaBarbera, Resident Engineer – Parsons Brinckerhoff, Inc. Paul Hubert, Vice President of Construction – Yonkers Contracting Company, Inc. Bala Sivakumar, Vice President – HNTB Corp. Paul Tirums, Engineer in Charge – NYSDOT, Hudson Valley Region 8 Tom Whelahan, Project Manager – Yonkers Contracting Company, Inc.
4:00pm	**Adjourn**

Special Thanks to:

U.S. Department of Transportation
Federal Highway Administration

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

SHRP2 SOLUTIONS

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

HNTB

Figure 60. Project showcase agenda.

APPENDIX B—USER COST SUMMARY

PIN 8062.10
I-84 OVER DINGLE RIDGE ROAD
USER COST ANALYSIS

1. The analysis was based on annual average daily traffic (AADT) of 75,000 for the four-lane section of I-84 (two lanes EB and two lanes WB).
2. Existing, traditional, and accelerated construction methods were analyzed (tables 3 to 5),
3. Existing condition (table 3).
4. Under a traditional construction method, both EB and WB I-84 would be temporarily realigned to the median and cross over Dingle Ridge Road via a temporary bridge. This would entail a reduced lane width and barrier separation. A lane width factor of 0.85 was used for this case (tables 2 and 4).
5. Under the accelerated construction method, a single lane detour in one direction was utilized to evaluate the condition.
    a. Due to the restriction of capacity, the volume to capacity (V /C) ratio is greater than 1.2 for the a.m. and p.m. peak 7 hours (table 5).
    b. The daily user cost was estimated to be approximately $50,000 based on taking the highest user cost before the V /C ratio was exceeded, using this value for the 7 peak hours, and then multiplying by a factor of 5.
6. Conclusions.
    a. The user costs differences are shown in table 6 and figures 61 and 62.
        i. Traditional vs. existing condition
            1. The traditional construction user cost was calculated to be $7,486,076 based on the daily user cost of $13,611 for the estimated construction duration of 550 days.
            2. The existing user cost with no construction was calculated to be $6,039,486 based on a daily user cost of $10,981 for the same 550-day duration.
            3. The difference is calculated to be $1,446,593.
        ii. Accelerated vs. existing condition
            1. The accelerated construction user cost was calculated to be $300,000 using the method in step 5a above for an estimated duration of 6 days.
            2. The existing user cost was calculated to be $65,886 based on the same daily user cost as above, $10,981 for the same 6-day duration.
            3. The difference is calculated to be $234,115.

Table 2. Inputs for user cost accounting for the existing and traditional construction alternative cases (source: NYSDOT).

USER COST ACCOUNTING FOR FREEWAYS (JULY, 1991)					
Input		**User Summary**	**Traditional**	**Existing**	**Delta**
Facility: I-84 Dingle Ridge		(w/o breakdowns)			
Location: **I**		Daily Time Cost :	$7,487	$5,666	$1,820
Year of Analysis :	2011	Daily Oper. Cost :	$5,753	$4,943	$810
AADT (mixed veh) :	75000	Daily Accid. Cost:	$372	$372	$0
Freeway Length	0.4	Daily User Cost :	$13,611	$10,981	$2,630
Truck Factor	0.85	Ann.User Cost($M):	$4.968	$4.008	$0.960
Peak Hour Factor:	0.95	Avg.Daily Speed	30.1	39.7	9.7
Truck Group (1-3):	2	DailyVMT	30000	30000	0
Incident Duration:	10	DailyVHT	998	755	243
Yrly.PH Incidents:	0	User Cost per VMT:	$0.45	$0.37	$0.09
No. Lanes (trad.) :	4	User Cost per VHT:	$13.64	$14.53	($0.90)
Width Fac. (trad.):	0.85	EstPH LOS(A=1F=6):	6	6	
Accid.Rate (trad.):	1	For Use in Economic Analysis Program (b:BC)in $M:			
No. Lanes (exist.) :	4		w/o incidents	w incidents	
Width Fac. (exist.):	1	Null UC	$4.968	$4.968	
Accid.Rate (exist.):	1	Imp. UC	$4.008	$4.008	

Table 3. User cost calculations for the existing case (source: NYSDOT).

Freeway User Cost Accounting: Existing Case															
Hour	Hourly Volume	Lane Volume	Capacity	V/C ratio	Steady State Speed	Steady State VHT	Steady State VMT	Steady State Time Cost	Steady State Oper Cost	Accident Cost	Total User Cost	To Estimate LOS Only			
												Adjusted Houly Volume	Adj V/C ratio	Adj. Steady State Speed	Adj. Steady State LOS based on vol
1	6150	1538	6131	1.00	27.5	89	2460	$671	$504	$31	$1,206	6474	1.06	24.0	6
2	5850	1463	6131	0.95	32.7	72	2340	$536	$428	$29	$994	6158	1.00	27.5	5
3	5700	1425	6131	0.93	34.5	66	2280	$496	$397	$28	$921	6000	0.98	31.0	5
4	5325	1331	6131	0.87	37.6	57	2130	$424	$354	$26	$804	5605	0.91	36.2	5
5	5100	1275	6131	0.83	39.1	52	2040	$392	$333	$25	$770	5368	0.88	37.6	4
6	4950	1238	6131	0.81	39.8	50	1980	$373	$323	$25	$720	5211	0.85	38.4	4
7	4725	1181	6131	0.77	40.9	46	1890	$346	$304	$23	$674	4974	0.81	39.8	4
8	4425	1106	6131	0.72	42.0	42	1770	$316	$280	$22	$617	4658	0.76	41.5	4
9	4425	1106	6131	0.72	42.0	42	1770	$316	$280	$22	$617	4658	0.76	41.5	4
10	4125	1031	6131	0.67	43.5	38	1650	$284	$259	$20	$564	4342	0.71	42.6	3
11	3900	975	6131	0.64	44.4	35	1560	$262	$242	$19	$524	4105	0.67	43.5	3
12	3600	900	6131	0.59	45.3	32	1440	$238	$222	$18	$478	3789	0.62	44.9	3
13	3225	806	6131	0.53	46.4	28	1290	$208	$197	$16	$421	3395	0.55	46.2	3
14	2850	713	6131	0.46	47.4	24	1140	$179	$174	$14	$368	3000	0.49	47.4	2
15	2400	600	6131	0.39	49.1	20	960	$147	$147	$12	$305	2526	0.41	48.8	2
16	1950	488	6131	0.32	50.5	15	780	$116	$119	$10	$244	2053	0.33	50.2	1
17	1725	431	6131	0.28	50.8	14	690	$102	$105	$9	$215	1816	0.30	50.8	1
18	1350	338	6131	0.22	51.8	10	540	$78	$82	$7	$166	1421	0.23	51.8	1
19	975	244	6131	0.16	53.0	7	390	$55	$59	$5	$119	1026	0.17	52.7	1
20	750	188	6131	0.12	53.3	6	300	$42	$45	$4	$91	789	0.13	53.3	1
21	525	131	6131	0.09	53.9	4	210	$29	$32	$3	$64	553	0.09	53.9	1
22	450	113	6131	0.07	54.2	3	180	$25	$27	$2	$54	474	0.08	54.2	1
23	300	75	6131	0.05	54.4	2	120	$17	$18	$1	$36	316	0.05	54.4	1
24	225	56	6131	0.04	54.7	2	90	$12	$14	$1	$27	237	0.04	54.7	1
SUM	**75000**	**18750**			**39.7**	**755**	**30000**	**$5,666**	**$4,943**	**$372**	**$10,981**	**78947**			

Table 4. User cost calculations for the traditional construction alternative case (source: NYSDOT).

Freeway User Cost Accounting: Traditional Case															
Hour	Hourly Volume	Lane Volume	Capacity	V/C ratio	Steady State Speed	Steady State VHT	Steady State VMT	Steady State Time Cost	Steady State Oper Cost	Accident Cost	Total User Cost	To Estimate LOS Only			
												Adjusted Houly Volume	Adj V/C ratio	Adj. Steady State Speed	Adj. Steady State LOS based on vol
1	6150	1538	5211	1.18	15.9	155	2460	$1,159	$706	$31	$1,895	6474	1.24	#VALUE!	6
2	5850	1463	5211	1.12	18.1	129	2340	$971	$613	$29	$1,613	6158	1.18	15.9	6
3	5700	1425	5211	1.09	20.5	111	2280	$833	$561	$28	$1,422	6000	1.15	17.4	6
4	5325	1331	5211	1.02	25.8	83	2130	$620	$456	$26	$1,102	5605	1.08	22.3	6
5	5100	1275	5211	0.98	31.0	66	2040	$494	$390	$25	$909	5368	1.03	25.8	6
6	4950	1238	5211	0.95	32.7	61	1980	$454	$362	$25	$841	5211	1.00	29.2	5
7	4725	1181	5211	0.91	36.2	52	1890	$392	$318	$23	$733	4974	0.95	32.7	5
8	4425	1106	5211	0.85	38.4	46	1770	$346	$292	$22	$660	4658	0.89	36.9	5
9	4425	1106	5211	0.85	38.4	46	1770	$346	$292	$22	$660	4658	0.89	36.9	5
10	4125	1031	5211	0.79	40.4	41	1650	$307	$266	$20	$593	4342	0.83	39.1	4
11	3900	975	5211	0.75	41.5	38	1560	$282	$250	$19	$551	4105	0.79	40.4	4
12	3600	900	5211	0.69	43.1	33	1440	$251	$226	$18	$495	3789	0.73	42.0	4
13	3225	806	5211	0.62	44.9	29	1290	$215	$200	$16	$431	3395	0.65	44.0	3
14	2850	713	5211	0.55	46.2	25	1140	$185	$174	$14	$374	3000	0.58	45.7	3
15	2400	600	5211	0.46	47.7	20	960	$151	$147	$12	$310	2526	0.48	47.4	2
16	1950	488	5211	0.37	49.5	16	780	$118	$119	$10	$247	2053	0.39	49.1	2
17	1725	431	5211	0.33	50.2	14	690	$103	$105	$9	$217	1816	0.35	49.8	2
18	1350	338	5211	0.26	51.5	10	540	$79	$82	$7	$167	1421	0.27	51.1	1
19	975	244	5211	0.19	52.4	7	390	$56	$59	$5	$120	1026	0.20	52.4	1
20	750	188	5211	0.14	53.0	6	300	$42	$45	$4	$91	789	0.15	53.0	1
21	525	131	5211	0.1	53.6	4	210	$29	$32	$3	$64	553	0.11	53.6	1
22	450	113	5211	0.09	53.9	3	180	$25	$27	$2	$54	474	0.09	53.9	1
23	300	75	5211	0.06	54.4	2	120	$17	$18	$1	$36	316	0.06	54.2	1
24	225	56	5211	0.04	54.4	2	90	$12	$14	$1	$27	237	0.05	54.4	1
SUM	**75000**	**18750**			**30.1**	**998**	**30000**	**$7,487**	**$5,753**	**$372**	**$13,611**				

Table 5. User cost calculations for the accelerated construction alternative case (source: NYSDOT).

Freeway User Cost Accounting: Accelerated Case															
Hour	Hourly Volume	Lane Volume	Capacity	V/C ratio	Steady State Speed	Steady State VHT	Steady State VMT	Steady State Time Cost	Steady State Oper Cost	Accident Cost	Total User Cost	To Estimate LOS Only			
												Adjusted Houly Volume	Adj V/C ratio	Adj. Steady State Speed	Adj. Steady State LOS based on vol
1	6150	2050	3908	1.57	#VAL	#VAL	2460	#VAL	#VAL	31	#VAL	6474	1.66	#VAL	6
2	5850	1950	3908	1.50	#VAL	#VAL	2340	#VAL	#VAL	$29	#VAL	6158	1.58	#VAL	6
3	5700	1900	3908	1.46	#VAL	#VAL	2280	#VAL	#VAL	$28	#VAL	6000	1.54	#VAL	6
4	5325	1775	3908	1.36	#VAL	#VAL	2130	#VAL	#VAL	$26	#VAL	5605	1.43	#VAL	6
5	5100	1700	3908	1.31	#VAL	#VAL	2040	#VAL	#VAL	$25	#VAL	5368	1.37	#VAL	6
6	4950	1650	3908	1.27	#VAL	#VAL	1980	#VAL	#VAL	$25	#VAL	5211	1.33	#VAL	6
7	4725	1575	3908	1.21	15.2	124	1890	$933	$542	$23	$1,498	4974	1.27	#VAL	6
8	4425	1475	3908	1.13	18.1	98	1770	$734	$464	$22	$1,220	4658	1.19	15.9	6
9	4425	1475	3908	1.13	18.1	98	1770	$734	$464	$22	$1,220	4658	1.19	15.9	6
10	4125	1375	3908	1.06	24	69	1650	$515	$363	$20	$899	4342	1.11	18.8	6
11	3900	1300	3908	1.00	29.2	53	1560	$400	$306	$19	$725	4105	1.05	24.0	6
12	3600	1200	3908	0.92	34.5	42	1440	$313	$251	$18	$582	3789	0.97	31.0	5
13	3225	1075	3908	0.83	39.1	33	1290	$248	$210	$16	$474	3395	0.87	37.6	4
14	2850	950	3908	0.73	42	27	1140	$203	$180	$14	$398	3000	0.77	40.9	4
15	2400	800	3908	0.61	44.9	21	960	$160	$149	$12	$321	2526	0.65	44.0	3
16	1950	650	3908	0.50	47.4	16	780	$124	$119	$10	$253	2053	0.53	46.6	3
17	1725	575	3908	0.44	48.1	14	690	$108	$106	$9	$222	1816	0.46	47.7	2
18	1350	450	3908	0.35	49.8	11	540	$81	$83	$7	$171	1421	0.36	49.5	2
19	975	325	3908	0.25	51.5	8	390	$57	$59	$5	$121	1026	0.26	51.1	1
20	750	250	3908	0.19	52.5	6	300	$43	$45	$4	$92	789	0.20	52.1	1
21	525	175	3908	0.13	53.3	4	210	$30	$32	$3	$64	553	0.14	53.0	1
22	450	150	3908	0.12	53.6	3	180	$25	$27	$2	$55	474	0.12	53.3	1
23	300	100	3908	0.08	54.2	2	120	$17	$18	$1	$36	316	0.08	53.9	1
24	225	75	3908	0.06	54.4	2	90	$12	$14	$1	$27	237	0.06	54.2	1
SUM	**75000**	**25000**			**#VAL**	**#VAL**	**30000**	**#VAL**	**#VAL**	**$372**	**#VAL**				
Total User Cost = 1498 * 7 * 5 ~ $ 50,0000															

Table 6. User cost summary (source: NYSDOT).

Case	Peak Hour Speed (mph)	Daily User Cost	Construction Duration (days)	Total User Cost	Difference in Construction User Costs
Existing Condition	27	$10,981	550	$6,039,550	
Traditional Construction (18 months)	15	$13,611	550	$7,486,050	$1,446,500
Accelerated Construction (6 days)	*	$50,000	6	$300,000	$234,115

*V/C ratio is greater than 1.2 for a.m. and p.m. peak hours. A factor of 5 was used for the 7 peak hours to approximate a daily user cost of $50,000.

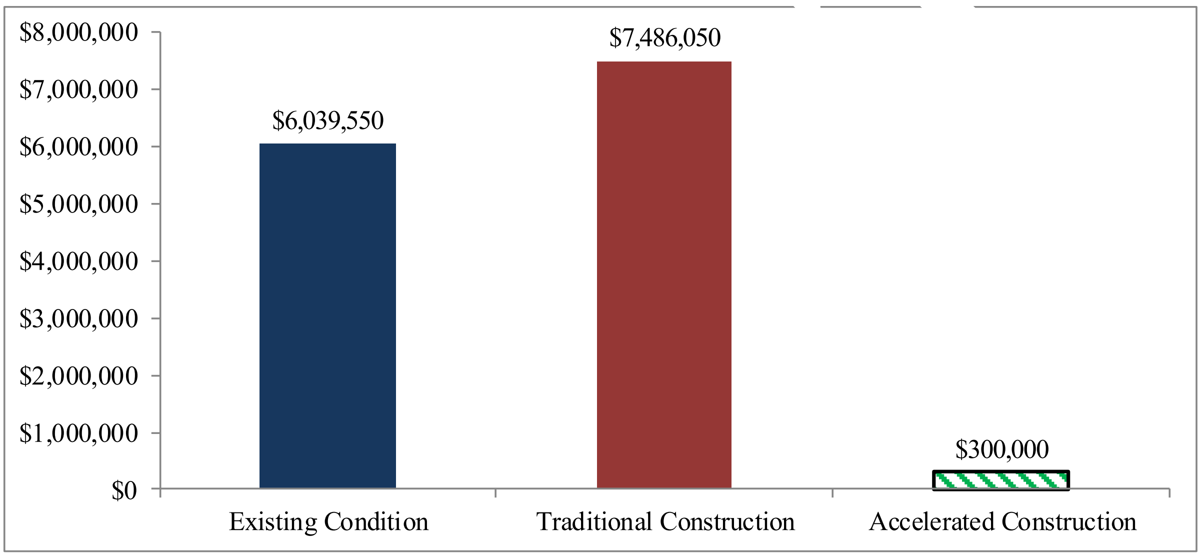


Figure 61. Graph. User cost summary – comparison of total user cost.

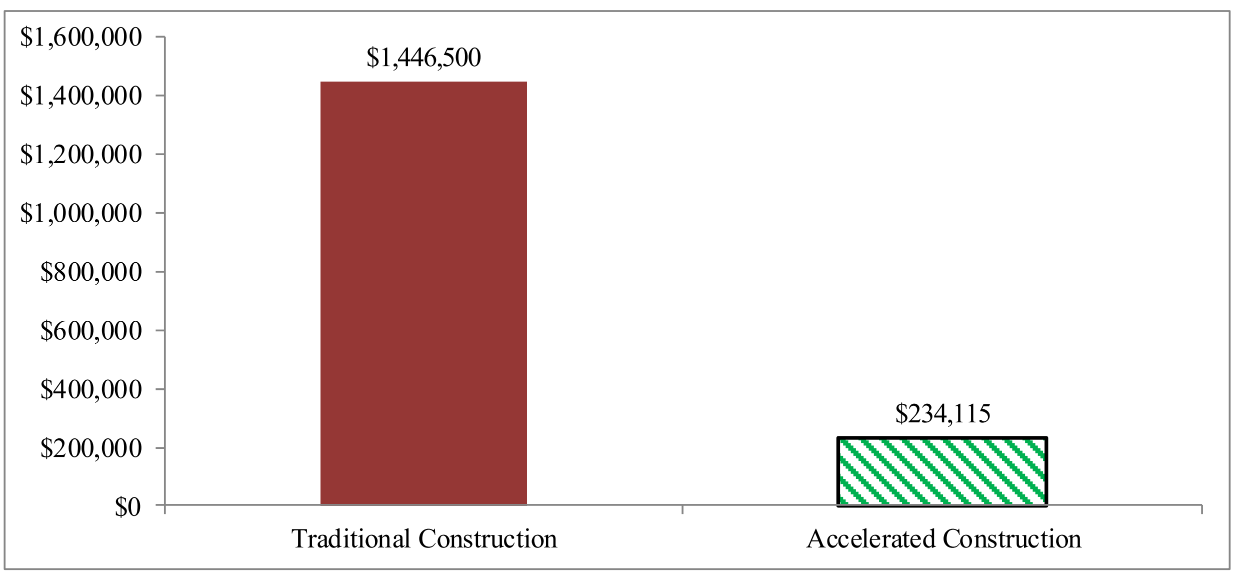


Figure 62. Graph. User cost summary – comparison of the difference in construction user cost.