Rhode Island Demonstration Project:

Replacement of Frenchtown Brook Bridge No. 435

Final Report
January 2013

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S. Department of Transportation
Federal Highway Administration

FOREWORD

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

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

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

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

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

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16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration (FHWA) under the Highways for LIFE program, the Rhode Island Department of Transportation (RIDOT) was awarded a $620,000 grant to demonstrate the use of proven, innovative accelerated bridge construction technologies to deliver this $1.9 million project in substantially less time than conventional construction.

This report details the replacement of the 57-year old Frenchtown Brook Bridge featuring prefabricated superstructure, substructure, and foundation systems. The new bridge was completely prefabricated offsite and installed in place—a first in Rhode Island. The accelerated construction approach and innovations in this project increased safety, enhanced quality, and allowed the contractor to replace the bridge during a 33-day road closure instead of the 6 months required under traditional construction methods.

Use of prefabricated bridge systems and innovative materials increased the initial bridge construction cost compared to traditional construction by $47,000. However, a comprehensive economic analysis including user costs shows that the project saved road users about $2 million (or about 45 percent of the total project costs for conventional construction). The experience gained on this successful project will help RIDOT implement these innovations more routinely on future projects.

Encouraged by the success of this project, RIDOT announced that it will evaluate all future bridge projects to determine if they can be built using accelerated bridge construction techniques.

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Unclassified	Unclassified	54	

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SI* (MODERN METRIC) CONVERSION FACTORS

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

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
µm	micrometers	0.039	mil	(none)
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3 m^3
	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	poundforce	lbf
kPA	kiloPascals	0.145	poundforce per square inch	lbf/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)

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

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration (FHWA) Highways for LIFE Team Leader Byron Lord and Program Coordinators Mary Huie and Kathleen Bergeron. 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 Rhode Island Department of Transportation Engineers Rahmat Noorparvar and John Capelli and FHWA Engineer Anthony Rotondo for their tireless advice and assistance during this project. The team also thanks Wayne Singleton and John Wayland of Gordon R. Archibald Engineers for sharing project-related information, photographs, and valuable insights on lessons learned from the design and the Turino Group for the weekly updates on construction.

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ABBREVIATIONS AND SYMBOLS

AADT	average annual daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ABC	accelerated bridge construction
dB(A)	A-weighted decibel
DOT	department of transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
PCI	Precast/Prestressed Concrete Institute
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SI	sound intensity
VOC	vehicle operating cost
VPD	vehicles per day

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

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

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

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

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

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

Project Solicitation, Evaluation, and Selection

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

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

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- Use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1 year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the applicant department of transportation (DOT) 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 on Occupational Safety and Health Administration (OSHA) Form 300.
  - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.
- **Construction Congestion**
  - Faster construction—Fifty percent reductions in the time highway users are impacted, compared to traditional methods.
  - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
  - Queue length during construction—A moving queue length of less than 0.5 miles (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 (dB(A)), using the onboard sound intensity (OBSI) 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 or more on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report details the replacement of the 57-year old Frenchtown Brook Bridge featuring prefabricated superstructure, substructure, and foundation systems. The new bridge was completely prefabricated offsite and installed in place—a first in Rhode Island. The accelerated construction approach and innovations used on this project increased safety, enhanced quality, and allowed the contractor to replace the bridge during a 33-day road closure instead of the 6 months required under traditional construction methods. The report presents project details relevant to the HfL program, including bridge replacement and construction highlights, accelerated bridge construction (ABC) methods and materials, HfL performance metrics measurement, and economic analysis.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

The project consisted of replacing a bridge on Davisville Road over Frenchtown Brook in East Greenwich, RI, just north of the East Greenwich–North Kingston boundary. The existing bridge suffered from constant weight reductions. The replacement structure was designed to increase the structural capacity of the bridge, improve roadway conditions, minimize disturbance to the Frenchtown Brook, and minimize inconvenience to users by limiting road closure to less than a third of the period required for conventional construction.

The focus of this demonstration project was the innovation of combining precast bridge elements and incentives to reduce road closure and construction periods. Lessons learned on this project can help guide similar projects in the future. Featured in the project are prefabricated culvert-like three-sided bridge elements (two legs and roof) that span 28 feet (ft) over Frenchtown Brook and are placed on precast concrete footings. Each element is 6 ft wide and 7 ft high at its centerline. The four prefabricated wingwalls consist of wall stems that are also placed on precast concrete footings.

The technologies incorporated into this bridge project have been used successfully around the United States on a limited basis, such as a HfL demonstration project in Washington, DC, featuring a prefabricated substructure and steel and concrete modular superstructure system.[1] Furthermore, the New Hampshire Department of Transportation presented a project that used techniques similar to this project, and its success set the stage for the all-precast method for the Rhode Island Department of Transportation (RIDOT). The fact that several diverse structural systems have been assembled and incorporated into a single project reinforces the concept that innovation does not necessarily mean creating something completely new, but rather facilitating incremental improvements in a number of specific bridge details to fully leverage previously successful work.

Under traditional construction methods, RIDOT estimated the bridge would have been closed for 6 months to accommodate cast-in-place construction. Central to the ABC approach adopted on this project was condensing the bridge closure to only 65 days, which was eventually reduced to 33 days by a $3,000-per-day contractor incentive capped at $90,000. This was enough time to facilitate both removal of the old bridge and construction of the new bridge.

Preliminary analysis of alternatives for the replacement bridge showed that the bridge with precast elements would be competitive with a conventional bridge at the site. The conventional bridge would have been a butted prestressed beam superstructure on cast-in-place abutments.

Construction on the project was completed without delays because of offsite fabrication and no handling, transportation, or erection difficulties. Also, user delay costs from roadway closure were reduced by more than 80 percent.

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[1] *Reconstruction of Eastern Avenue Bridge Over Kenilworth Avenue in Washington, DC,* August 2011, Federal Highway Administration, www.fhwa.dot.gov/hfl/summary/projects_summary.cfm.

Encouraged by the success of this project, RIDOT announced that it will evaluate all future bridge projects to determine if they can be built using ABC techniques, taking into account factors such as the impact of total road closures that projects of this type normally require and the complexity of utility relocations.

HfL Performance Goals

Safety, construction congestion, quality, and user satisfaction data were collected before, during, and after construction to demonstrate that innovations can be an integral part of a project while simultaneously meeting the HfL performance goals in these areas.

- **Safety**
  - Work zone safety during construction—As expected, no incidents occurred during the entire construction period including the full closure period, 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 workers were injured on the project, so the contractor achieved a score of 0 on the OSHA Form 300, meeting the HfL goal of less than 4.0.
  - Facility safety after construction—Normally, 3-year crash rates after construction are determined and compared to the preconstruction crash rates. With no change in roadway width (44 ft) before and after construction, the crash rate attributable to roadway width should be the same. However, traffic volume and flow are likely to affect facility safety after construction. The pre-construction Davisville Road consisted of two lanes and two shoulders carrying one-way traffic north toward Frenchtown Road and the on-ramp to Route 4 North. Post-construction, Davisville Road will no longer be part of Route 403 under the relocated Route 403 project and will serve as a two-way local road with less than 75 percent of its preconstruction traffic volume.

- **Construction Congestion**
  - Faster construction — Compressing the time it took to replace the bridge from an estimated 6 months to only 33 days under the ABC approach drastically reduced the impact on 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 33-day detour compared to 6 months of detour estimated for traditional construction, motorists experienced a substantial reduction in trip time, meeting the HfL goal of no more than a 10 percent increase in trip time.
  - Queue length during construction — There were no traffic backups observed along the detour routes. The project, therefore, met the HfL goal of less than a 0.5-mi queue length in a rural area.

- **Quality**
  - Smoothness—Because of the new asphalt surface on the bridge, motorists will notice a smoother ride.

- The quality of the products used was superior because the contract required that the manufacturing plant furnishing precast bridge members be certified by the Precast/Prestressed Concrete Institute (PCI) Certification program at a minimum of B3 category. Furthermore, it required that dimensional tolerances not exceed those recommended in the latest edition of the PCI manual for quality control for plants and production of precast and prestressed concrete products. This assessment is based on the products meeting all specifications and the belief that disciplined procedures enforced at certified plants audited by external personnel are likely to yield better quality control than those at a construction site where quality control of concrete cast in place is dispersed among several entities and individuals. These personnel range from those at batch plants proportioning aggregates, cement, and water to drivers transporting the mixes in concrete trucks to inspectors responsible for ensuring that placing, compacting, and curing of concrete conforms to specifications.
- User satisfaction—A formal user satisfaction survey was not conducted on this project. It is, however, evident to the project team that with reduction in roadway closure time by more than 80 percent compared to conventional construction, users are likely to be very satisfied and their responses would easily meet the goal of 4 or more points on a 7-point Likert scale.

  In a similar study on the use of ABC on U.S. 6 over Keg Creek[2] in Iowa, where the roadway closure was reduced from 6 months to 2 weeks through the use of prefabricated bridge elements, user satisfaction was quite positive. 92 percent of respondents to the survey considered using prefabricated components to speed construction as important or somewhat important and 100 percent of the respondents found condensing closure to 2 weeks to be important.

ECONOMIC ANALYSIS

The costs and benefits of this innovative project approach were compared with those of a project of similar size and scope delivered using a more traditional approach. A comprehensive economic analysis that accounted for construction and road user costs revealed that RIDOT's innovative approach realized a cost savings of about $1.5 million, or 38 percent of the total project cost, over conventional construction practices. A significant amount of the cost savings stemmed from avoiding delay costs to road users through the use of ABC techniques.

LESSONS LEARNED

Through this project, RIDOT gained valuable insights on the innovative techniques and materials—both those that were successful and those that need improvement in future project deliveries. The following are some of the lessons learned on using prefabricated elements:

- The 65-day bridge closure allowed in the contract was adequate for demolition and construction of a bridge of this size. In fact, the contractor completed the work in 33

[2] *Iowa Demonstration Project: Accelerated Bridge Construction on U.S. 6 Over Keg Creek*, March 2012, Federal Highway Administration, www.fhwa.dot.gov/hfl/summary/projects_summary.cfm.

days, qualifying for the incentive of $3,000 per day capped at $90,000. This was enough time to completely remove the existing bridge and set the precast elements in place despite a significant rain event that disrupted operations. The contractor typically did not have to work past dusk during this period.

- A muddy job site would have made moving the heavy bridge elements difficult, but this did not occur.
- By reducing the construction time at the site with accelerated construction using prefabricated elements, the amount of time construction crews and motorists were exposed to the dangers of the work zone was also reduced.
- Onsite construction time is often limited by weather and environmental permitting requirements. Because of prefabrication and accelerated construction, limited available construction time was not a factor and the project was easily completed during the construction season.
- While precast concrete produced at a certified plant has the advantage of being constructed in a controlled environment with higher production and curing standards than normally found in the field, there is debate on the impact this has on costs and the need to evaluate this requirement for simple elements. The positive side of plant certification is that internal quality control is apt to be at least satisfactory, but the negative aspect is that all elements must be shipped from a certified facility that may be a long way from the construction site, increasing transportation cost. Transportation also involves restriction on the size and weight of individual elements. The option of allowing near-site fabrication versus fabrication at a certified facility should be considered on future projects that involve prefabricated elements.
- The incentives in the actual contract helped offset some of the risk in the contractor's bid decision making process.

CONCLUSIONS

RIDOT gained valuable insights on this project on the use of innovative ABC techniques. These innovations were key to successfully achieving the HfL performance goals of increasing safety, reducing traveler inconvenience from construction, and increasing quality at a lower cost.

PROJECT DETAILS

BACKGROUND

Frenchtown Brook Bridge No. 435 carries Davisville Road, an urban minor arterial that starts at Frenchtown Road in the town of East Greenwich and proceeds generally in the southeasterly direction to U.S. Route 1 (Post Road) in North Kingston (shown in Figure 1). RIDOT included replacement of this bridge as part of its relocated Route 403 project, a major undertaking.

The16-ft-wide rectangular slab bridge built in 1955 at a 60-degree skew resembles a culvert (Figure 2). It was functionally obsolete and structurally deficient with a load rating of only 12 tons for a HS-20 vehicle. The concrete abutments that supported the structure had substandard dimensions. RIDOT decided to leave a portion of the existing substructure in place to minimize the impact on Frenchtown Brook, an important tributary of Hunt River.

Under the relocated Route 403 project, Davisville Road is no longer part of Route 403. The two one-way lanes and two shoulders to the north toward Frenchtown Road and the on-ramp to Route 4 North before relocation will serve as lanes for two-way traffic, a lane in each direction. With relocation, traffic volume of 10,200 vehicles per day (vpd) is estimated to drop to 7,300.

The traffic analysis in conjunction with the project indicated that it was feasible to detour traffic because the detour was short and the impacted traffic was primarily local.

PROJECT DESCRIPTION

RIDOT considered six alternatives to replace the structure, the first two of which appeared the most promising:

- Alternative 1: Precast concrete arch with varying gravel over top and bituminous pavement. The bridge would have a span of 28 ft square with no skew.
- Alternative 2: Butted prestressed concrete box beams with 3-inch (in) minimum pavement. The bridge would have a span of 94 ft for a skew angle of 45 degrees.

It was estimated that alternative 2 would cost $360,000 more if piling was needed and about $40,000 more if no piling was needed. Alternative 1 would not require piling because the loads on the footings would be much less because of the shorter span and more uniform bearing pressures.

RIDOT decided to go with option 1 and use precast elements for all segments of the structure for the first time in its project delivery history. This included both the footings and three-sided (roof and two legs) bridge segments for the main structure and precast elements for the footings and the wall stems for the four wingwalls of the bridge. See Figure 3 and Figure 4.

To complete the bridge construction work as quickly as possible and to lessen the impact of the project, RIDOT concluded that it would have to close Davisville Road to traffic. RIDOT further estimated that by using precast elements for all components, the closure period would be reduced from 6 to 2 months.

RIDOT applied for an HfL grant designed to advance longer-lasting highway infrastructure using innovations to accomplish fast construction of efficient and safe highways and bridges. A grant of $620,000 was made to RIDOT under the program.

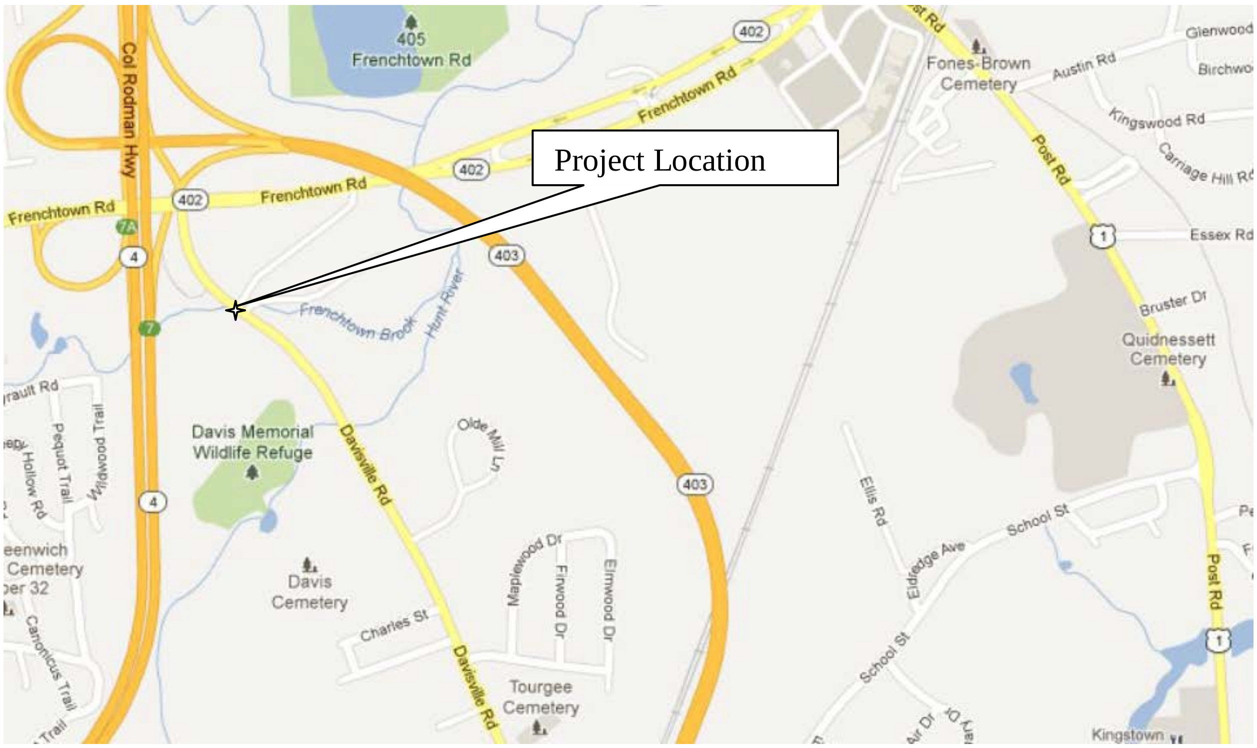

Figure 1. Project location.

Figure 2. Old Frenchtown Brook Bridge.

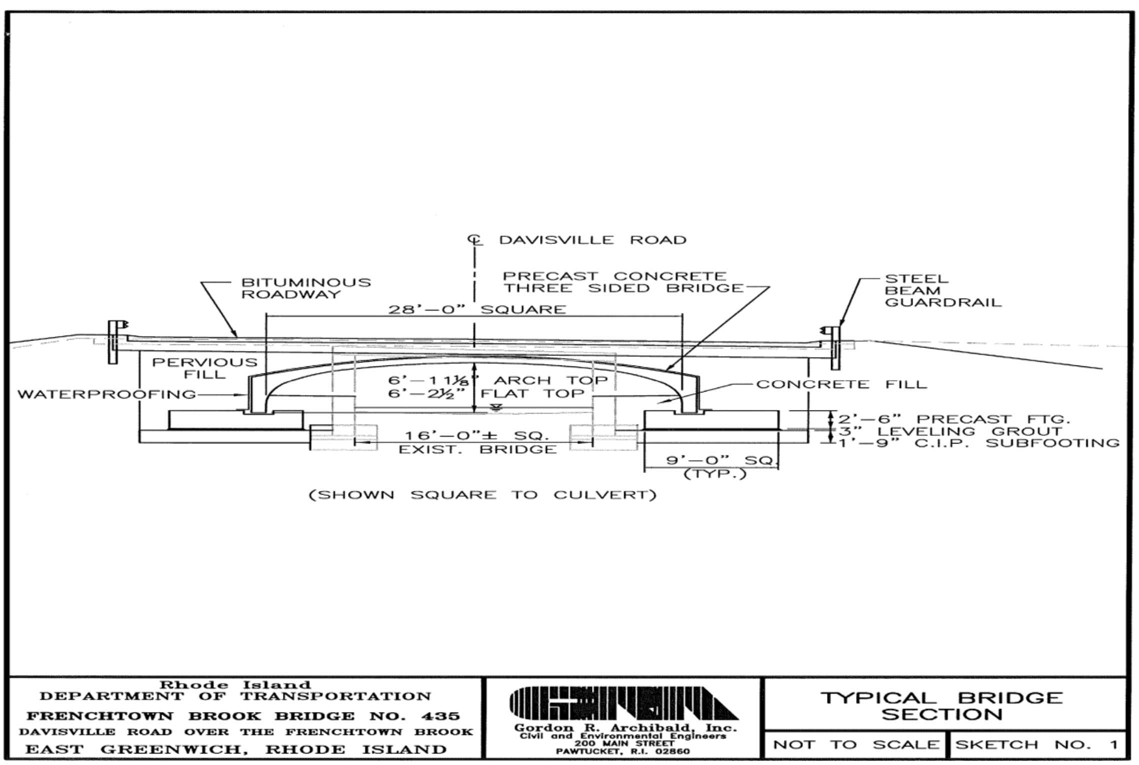

Figure 3. Typical bridge section.

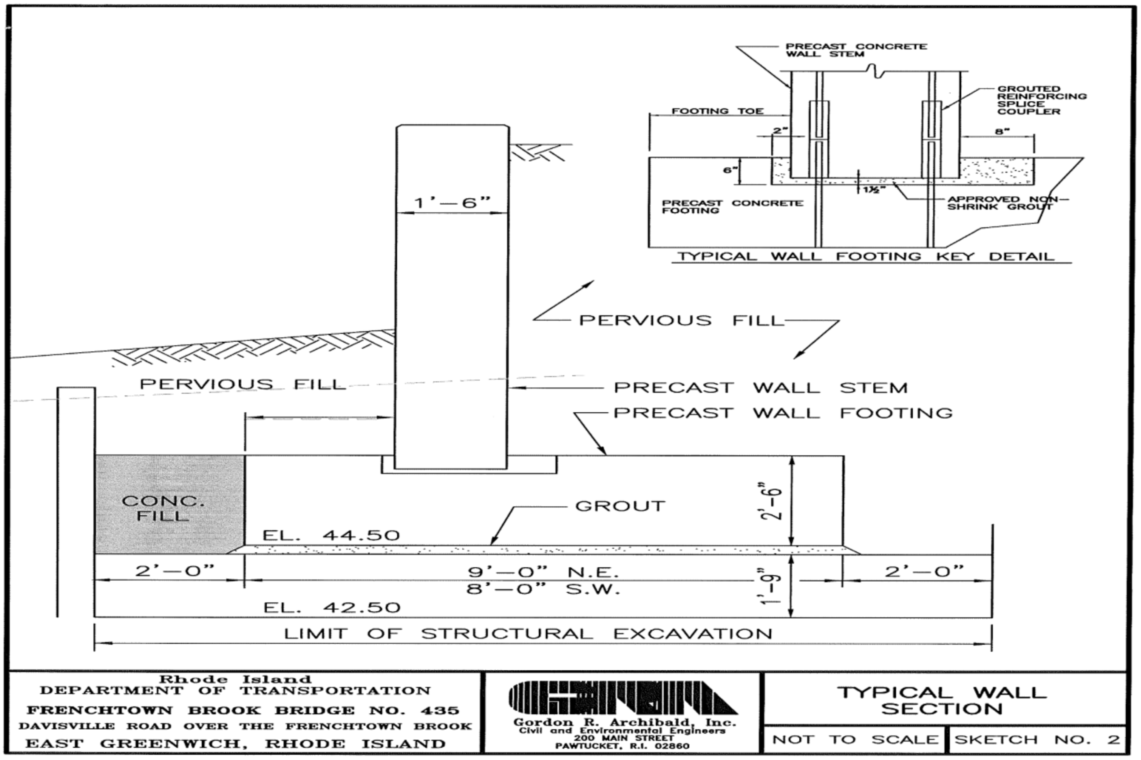

Figure 4. Conceptual typical wall element.

To ensure that the closure of Davisville Road would be for only a brief period, RIDOT included an incentive/disincentive clause in the contract specifications. For each calendar day that the bridge was fully open to traffic before the allowed 65-calendar day period, an incentive of $3,000 would be paid to the contractor. The incentive was capped at $90,000. A disincentive of $3,000 applied for each day the road was closed beyond the allowed 65-day period.

Other highlights relevant to precast concrete bridge elements included the following:

- Exposed portions of wingwalls and headwalls were to receive a form liner finish. Form liner was to be Pattern No. 1508 “Large Dry Stack Fieldstone” or an approved equivalent.
- Grout requirements included that the material be flowable nonshrink grout capable of achieving a 28-day compressive strength of 11,000 pounds per square inch (psi) from an approved RIDOT source.
- Inserts and hardware were to be of A304 stainless steel unless otherwise approved by the engineer.
- Precast sections were to be manufactured in a RIDOT/PCI-certified facility.
- Precast three-sided bridge sections were to be placed on steel shims about 0.5 in within the keyway.
- The headwall was to be continuous, without joints.
- Precast products were to be handled, moved, or transported only after the 28-day design strength had been attained.

- The butt joint made by two adjacent precast bridge units was to be covered with a piece of preformed bituminous joint sealant.
- The entire top and sides of the precast bridge units were to receive rubberized asphalt liquid membrane to the limits shown on the plans.

The contract was awarded to Aetna Bridge Co. of Pawtucket, RI, which had a low bid of $1.9 million. The contractor chose Contech Engineered Solutions of Palmer, MA, as its prefabricated elements subcontractor, located about 85 mi from the project site. The consultant designer on the project was Gordon R. Archibald, Inc. Professional Engineers of Pawtucket, RI.

The contractor started the roadway closure on July 30, 2012, for bridge construction. Approved shop drawings for the project are shown in the Appendix. The shop drawing package includes the bridge plan, foundation plan, upstream and downstream elevations, and a variety of connection details and specifications for manufacture and installation.

Construction of the project is highlighted in Figure 5 through Figure 31.

The contractor started with dewatering measures, installation of demolition shield, demolition of wingwalls, and excavation behind the abutments. To minimize impact on Frenchtown Brook, a portion of the existing abutment was left in place (see Figure 7 through Figure 9).

Figure 5. Bridge before closure.

Figure 6. Closure of Davisville Road.

Figure 7. Demolition of old structure in process with stream diversion in place.

Figure 8. Demolition showing slab removal with abutment walls left in place.

Figure 9. Abutment walls of old bridge left in place so work does not impact stream.

Figure 10 shows the plan view of the structure 150 ft long with 25 6-ft elements. The original plans called for concrete and grout subfooting under the precast foundation elements, but the contractor's value engineering proposal to use a crushed stone subfooting wrapped in geotextile was approved instead. The precast foundation units were lifted off a tractor-trailer and placed on the subfooting. See Figure 11 for the construction detail and Figure 12 through Figure 14 for the modular foundation element placement. The interior foundation elements are 23 ft, 11.5 in long, 6 ft wide and 2.5 ft high. The end units are of the same width and height and 26 ft, 11.75 in long. The units were hollow to facilitate transport and handling and were subsequently filled with concrete at the site. See the shop drawings in the Appendix for more details.

The three-sided 6-ft-wide bridge elements with an internal span of 28 ft shown in Figure 15 were lifted off the trucks and placed on the footings (see Figure 16). These elements came with a cable tie. The cables were removed after arch units had been erected and the concrete placed in the foundation units and at the arch unit had been allowed to cure to 2,000 psi. The headwall elements with their counterforts and wingwall elements with anchors were then placed. The butt joints between adjacent bridge elements were filled with preformed bituminous joint sealant and a 9-in-wide continuous joint wrap. A primer compatible with the joint wrap was applied for a minimum width of 9 in on each side of the joint. Other joints between the bridge elements and headwalls and bridge elements and wingwalls were similarly sealed (see Figure 17 through Figure 25).

See the Appendix for grouting requirements at the joints. Minimum 28-day strength of 11,000 psi was required. The specifications for manufacture and installation also required that the lifting and erection anchor recesses be filled with grout.

Approved backfill shown in Figure 26 was rolled into place (Figure 27) and covered by a 5-in modified base course in two 2.5-in lifts followed by a 2-in bituminous surface course (Figure 28).

The road, which once served one-way traffic, was striped for two-way traffic (Figure 29) and opened on Friday, August 31, 2012, in time for the Labor Day weekend, just 33 days after it was closed to traffic. Figure 30 shows the completed structure with guardrail and riprap in place, and Figure 31 shows a view of the bridge opening with riprap placed behind old structure abutment walls.

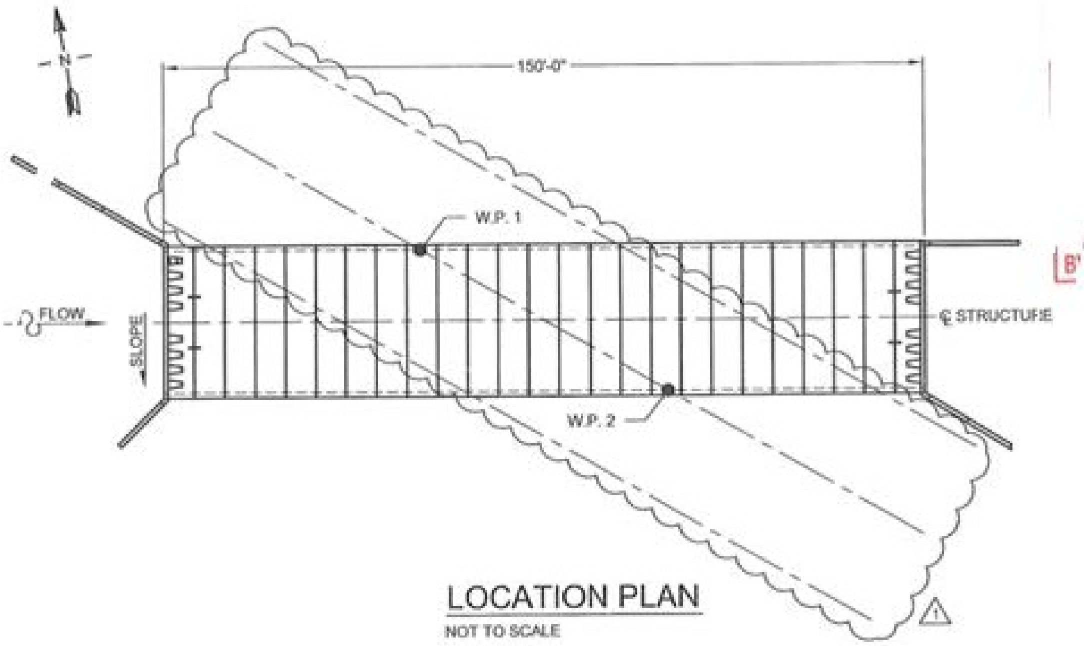

Figure 10. Plan view of structure.

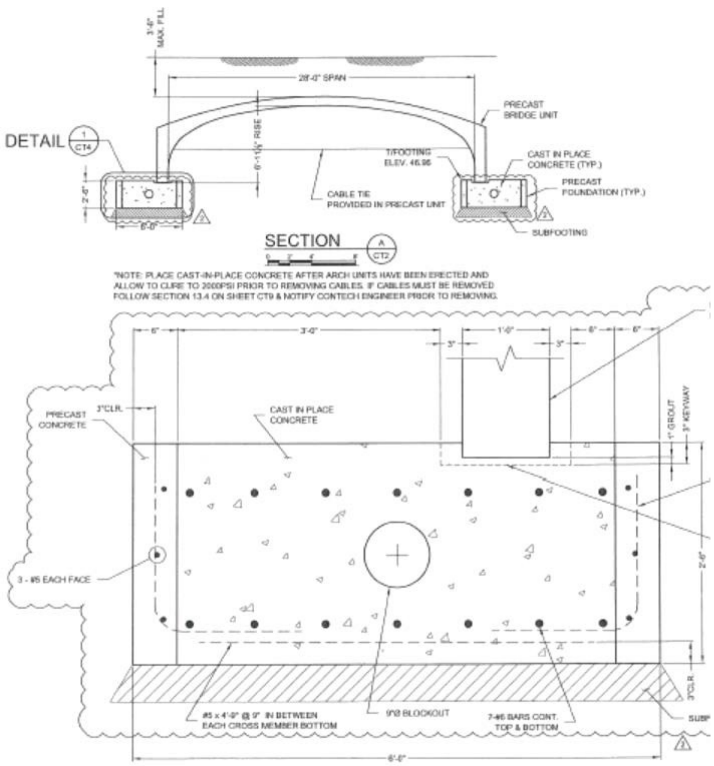

Figure 11. Bridge element support detail.

Figure 12. Precast foundation units being lifted off tractor-trailer.

Figure 13. Precast foundation unit being placed on subfooting.

Figure 14. Modular prefabricated footings in place.

Figure 15. Main bridge element with cable tie on flatbed.

Figure 16. Modular main bridge elements lowered into place.

Figure 17. All 25 main bridge elements lowered into place.

Figure 18. Modular headwall being lowered into place.

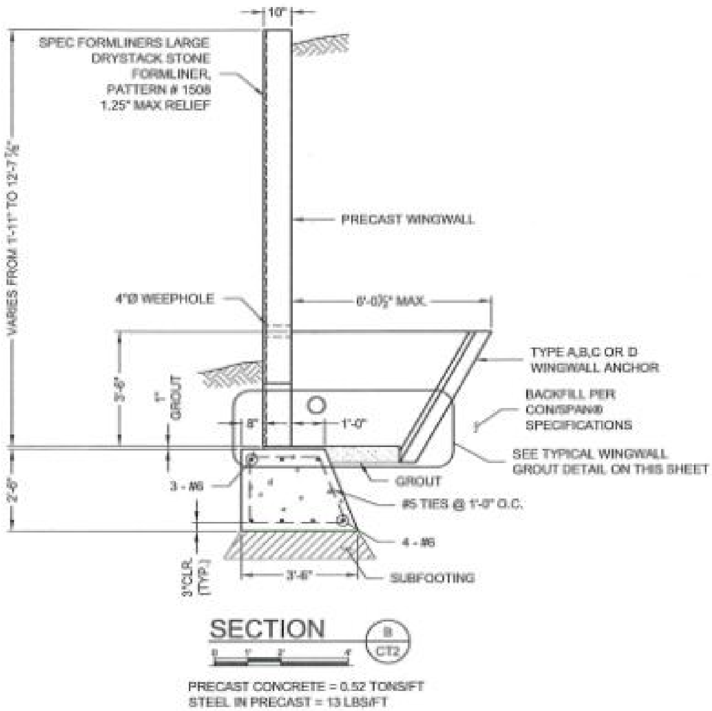

Figure 19. Wingwall support detail.

Figure 20. Modular wingwall being lowered into place.

Figure 21. Another wingwall being lowered into place.

Figure 22. Far end headwall being lowered into place.

Figure 23. Closeup of headwall anchors.

Figure 24. Closeup of wingwall anchors.

Figure 25. Prefabricated structure showing joints sealed and wrapped.

Figure 26. Stockpiled structure backfill.

Figure 27. Gravel backfill being rolled into place.

Figure 28. Bituminous material being rolled into place.

Figure 29. Davisville Road opened to traffic.

Figure 30. Completed structure with guardrail and riprap in place.

Figure 31. Bridge opening with riprap placed behind old structure abutment walls.

DATA ACQUISITION AND ANALYSIS

Data on safety, traffic flow, and quality before, during, and after construction were collected to determine if this project met the HfL performance goals. The primary objective of acquiring these types of data was to quantify project performance to provide an objective basis to determine the feasibility of the project innovations and demonstrate that the innovations can be used to do the following:

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

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

SAFETY

The project included the HfL performance goal of achieving a work zone crash rate equal to or less than the existing conditions. During this project, no crashes occurred, satisfying the HfL goal. Work zone safety was ensured by completely closing the bridge to traffic, accelerating construction, and using prefabricated bridge components. Accelerated construction methods, including the use of prefabricated bridge components, made the brief traffic detour feasible.

The project included the performance goal of achieving an incident rate for worker injuries of less than 4.0 based on the OSHA 300 rate. Not only did closing the bridge to traffic help achieve this goal, but precasting the bridge system at an approved facility eliminated the need for workers to spend most of their time exposed to falling hazards, which would have been required with traditional cast-in-place construction methods. No work-related injuries occurred during construction, resulting in an OSHA Form 300 score of 0.

It is difficult to compare crash data before and after construction at this site because both the traffic volume and flow have changed. Davisville Road under the relocated Route 403 project, a major undertaking of RIDOT of which this project was a part, is no longer part of Route 403. The two one-way lanes and two shoulders to the north toward Frenchtown Road and the on-ramp to Route 4 North before relocation now serve as two-way traffic with a lane and a shoulder in each direction. With relocation, traffic volume of 10,200 vpd was estimated to drop to 7,300 vpd.

CONSTRUCTION CONGESTION

Accelerated construction techniques reduced the time highway users were affected by more than 50 percent. The estimated roadway closure time for bridge construction would have been 6 months under non-accelerated construction. The actual impact on traffic lasted only 33 days, from July 30 to August 31, 2012.

The impact started when Davisville Road was closed to traffic on July 30, 2012, and the traffic was detoured. Figure 32 shows detours that were set in place. The primary detour route used

Route 402 (Frenchtown Road) in East Greenwich and Route 1 (Post Road) and School Street in North Kingston. Motorists on Devil's Foot Road (which turns into Davisville Road) could access the new Route 403 at West Davisville Road using the alternate route and take the exit for Route 4 North. They could also take the exit for Route 4 South to Route 402 (Frenchtown Road).

During the 33-day closure, detours eliminated traffic queuing and congestion at the construction site, allowing efficient installation of the modular bridge components.

The innovative accelerated bridge construction technique enabled reduction of the traffic detour duration by more than 80 percent, from an estimated 6 months for conventional construction to only 33 days.

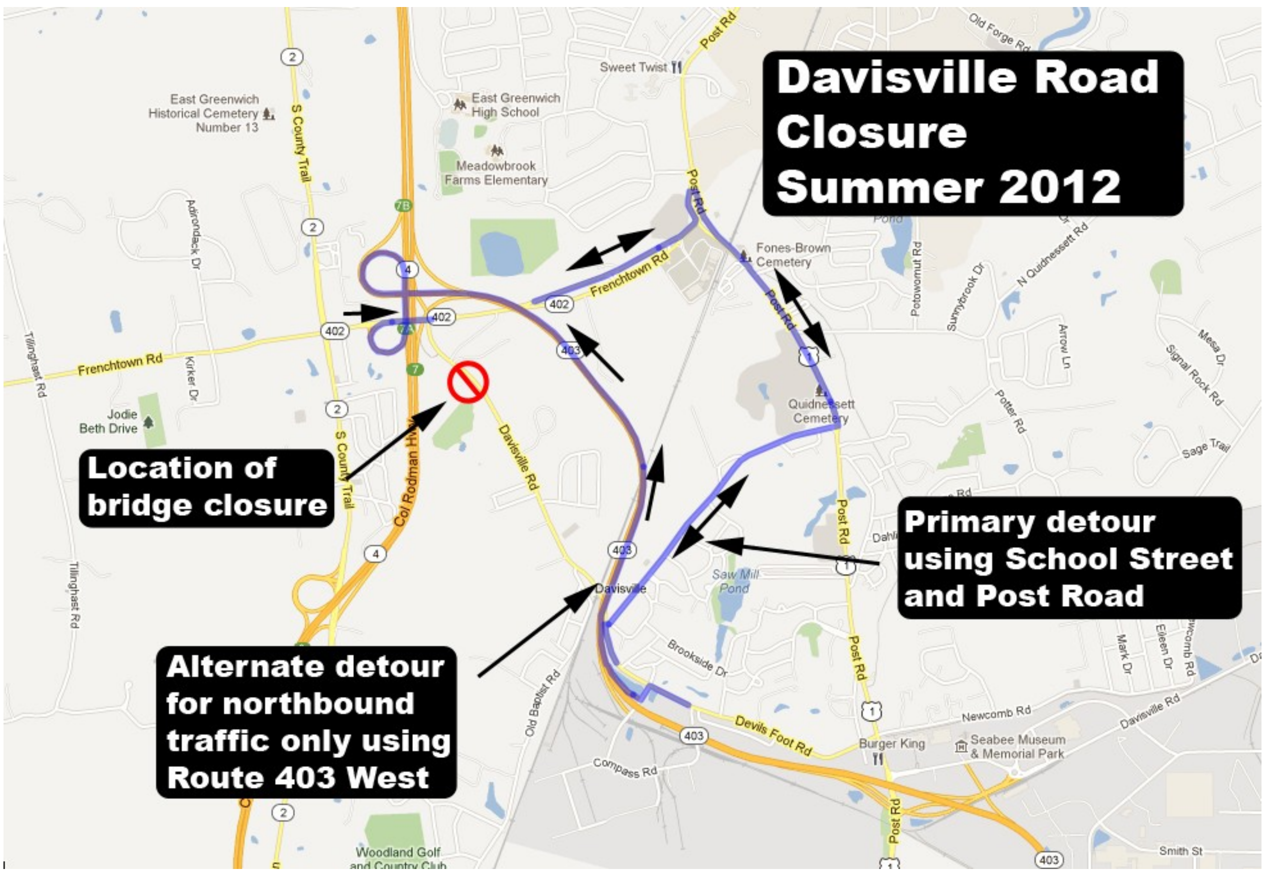

Figure 32. Traffic management plan.

Researchers collected trip time data before Davisville Road was closed to traffic and during the closure. No queuing was observed on the primary or alternate routes. In general, the traffic flow along the both detour routes was light and flowed freely without backups or congestion at or above the posted speed limits.

The following nodes were established for trip time data collection:

- Node 1—Intersection of Davisville Road and Frenchtown Road
- Node 2—Intersection of Frenchtown Road and Post Road (Route 1)
- Node 3—Intersection of Post Road (Route 1) and School Street
- Node 4—Intersection of School Street and Davisville Road

When Davisville Road was open, the average travel time from Node 1 to Node 4 was 2.59 minutes based on morning, midday, and afternoon runs. Travel along the primary detour from Node 1 to Node 4 increased this average time from 2.59 to 5.26 minutes, an increase of 2.67 minutes. Travel along the alternative route averaged 3.99 minutes, an increase of 1.40 minutes.

The cost associated with the additional time to traverse the detour route is presented later in this report.

QUALITY

The load restrictions on the bridge because of structural inadequacy will no longer be needed. The new bridge meets all current standards for structural adequacy and is open to all traffic. Furthermore, motorists will notice a smoother ride when traversing the bridge because of its new asphalt surface.

The quality of the products used was superior because the contract required that the manufacturing plant furnishing precast bridge members be PCI certified at a minimum of B3 category. Furthermore, it required that dimensional tolerances not exceed those recommended in the latest edition of the PCI manual for quality control for plants and production of precast and prestressed concrete products. This assessment is based on the products meeting all specifications and the belief that disciplined procedures enforced at certified plants audited by external personnel are likely to yield better quality control than those at a construction site where quality control of concrete cast in place is dispersed among several entities and individuals. These personnel range from those at batch plants proportioning aggregates, cement, and water to drivers transporting the mixes in concrete trucks to inspectors responsible for ensuring that placing, compacting, and curing of concrete conform to specifications.

USER SATISFACTION

The September 7, 2012, *AASHTO Journal Weekly Transportation Report*, published by the American Association of State Highway and Transportation Officials, featured the Frenchtown Brook Bridge. The article includes the following quote from RIDOT Director Michael Lewis:

"Going into this project, we knew it would take only a third of the time to replace this bridge compared with the time it would have taken if we used traditional construction methods. We are pleased to be able to take this approach with the Frenchtown Brook Bridge and reopen it as quickly as possible for drivers in East Greenwich and North Kingston who rely on this bridge on a daily basis."

The article goes on to state, "The project was so successful that RIDOT noted it will evaluate all future bridge projects to see if they could be built using the ABC method."

It is clear from these statements that RIDOT is pleased with the decisions made on this project. It is also evident to the project team that absent formal user satisfaction surveys, based on the data and chart shown in Figure 33 and Figure 34, users of Davisville Road would be quite satisfied with RIDOT's approach to minimizing the impact of construction on this project from 6 months for conventional construction to just 1 month using innovative ABC methods. Figure 33 and Figure 34 show results of a user satisfaction survey on a similar ABC project using precast components in Iowa. Clearly, the responses were positive (very important and important) on a number of decisions made on this project:

1. Closing a road or bridge to reduce cost and time (90 percent positive)
2. Creating alternative routes while project is underway (100 percent positive)
3. Reducing time to complete project through incentives (80 percent positive)

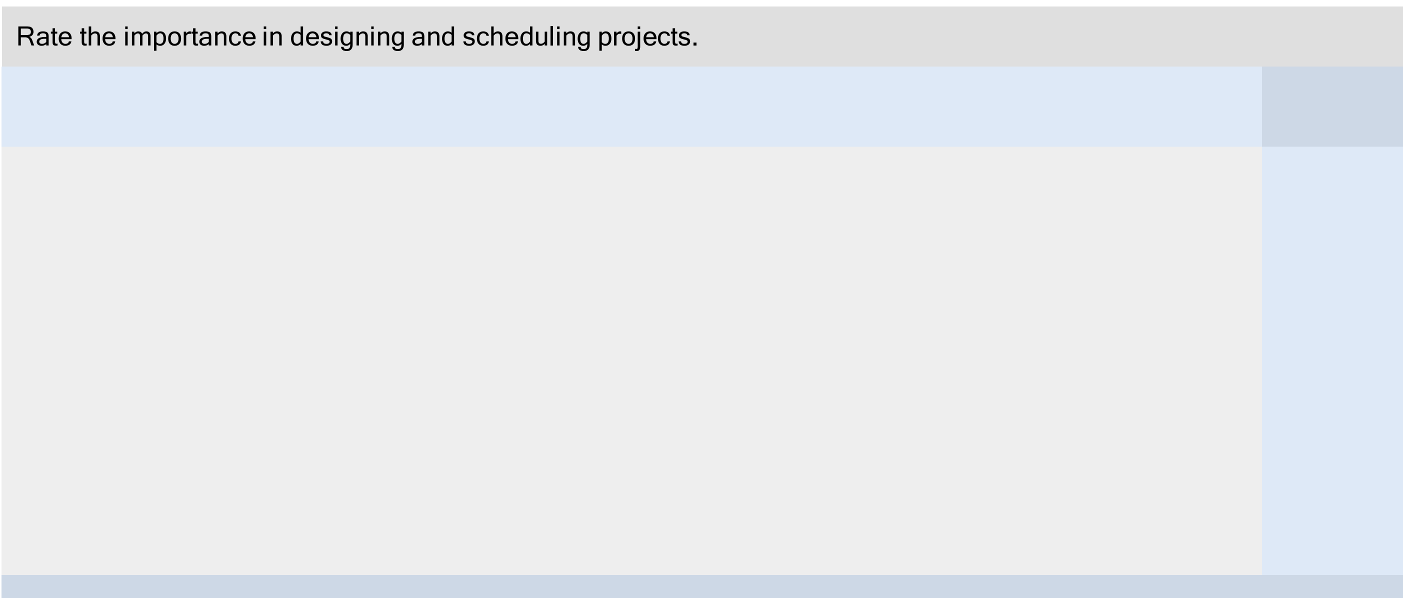

Figure 33. Rating of approaches to design, scheduling, and traffic management on projects.

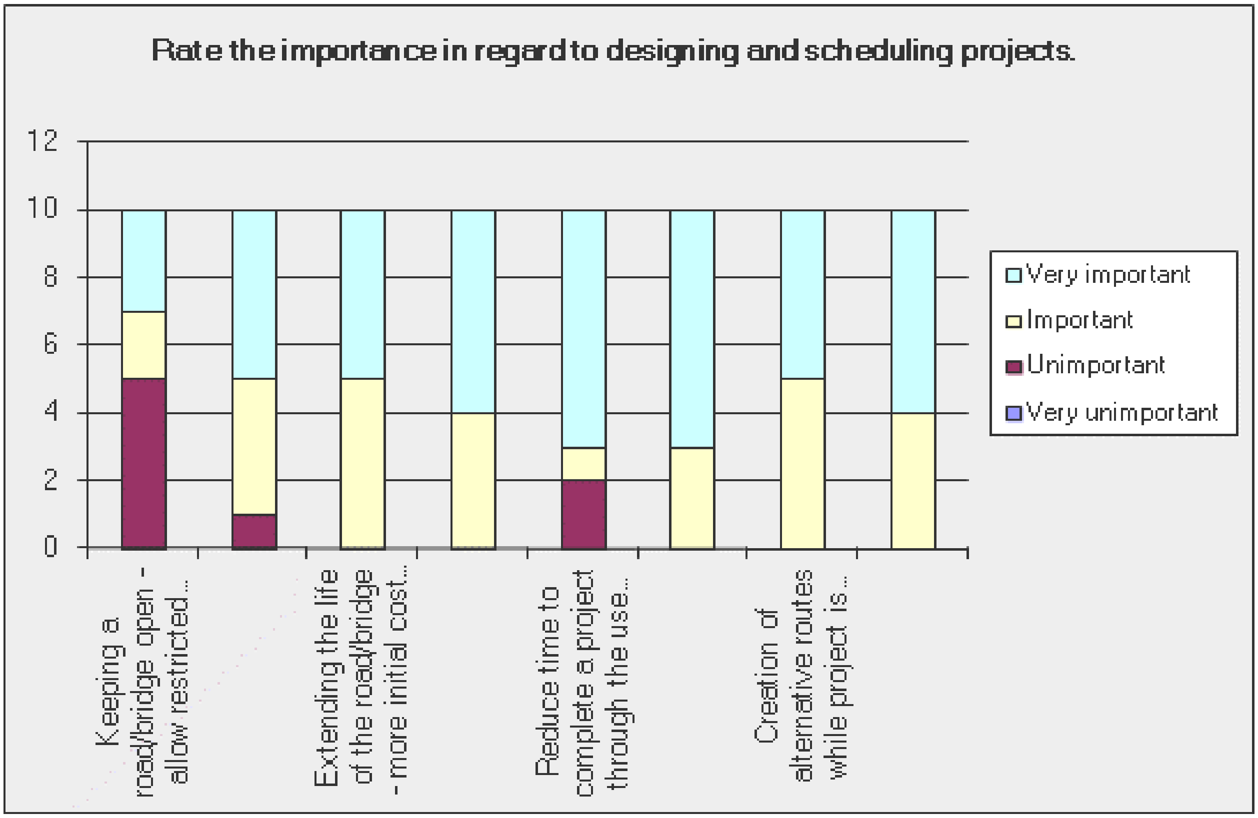

Figure 34. Chart showing results of user responses on approaches to design, scheduling, and traffic management.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This involves 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 on a project of similar size and scope. 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, RIDOT supplied the cost figures for the as-built project and baseline construction. Traditional methods would have involved the use of cast-in-place construction coupled with standard pretensioned precast concrete bridge beams.

CONSTRUCTION TIME

The baseline scenario would have closed the bridge for at least 6 months to accommodate traditional cast-in-place construction methods. The ABC approach allowed the contractor to fabricate the bridge components ahead of time and use a condensed 33-day closure to assemble the bridge.

CONSTRUCTION COSTS

The alternative analysis for the Frenchtown Brook bridge project itemized costs for six options, with the following three lowest cost options:

1. Precast arch option ($1,800,000)
2. Butted box beam option ($1,840,000 without piles, $2,160,000 if piling needed)
3. Spread box beam option ($1,880,000 without piles, $2,190,000 if piling needed)

Details of the analysis are shown in Table 1.

The precast arch option was estimated to cost $40,000 less than the conventional alternative of butted box beam and $360,000 less if piling was needed for the butted box beam structure.

The successful (lowest) bid on the project was $1,945,063.80.

Assuming that the conventional bridge would have been bid proportionately higher, the difference between the conventional option and the precast arch option is estimated as follows:

$1,945063.80 * 40,000/1,800,000 = $43,223.64 or about $43,000.

However, with the incentive of $90,000 for completing the project ahead of the time allotted, the innovative option cost **$47,000** more than the conventional option.

Table 1. Construction cost analysis.

Relocated Route 403

Rooonstrudion of Frenchtown Brook Bridge No.435

ITEM CODE	DESCRIPTION	UNIT	UNIT PRICE	AI.TERNATIVE I PRECAST ARCH		ALTERNATIVE 2 BUnEDBOXE$		AITERNATIVE 3 SPREAD BOXES	
2010409	R&DFIEXBLE PAVEMENT	SY	$15	1100	$16,600	1300	$19,600	1650	$24,750
203.DIOO	STRUCTURAL EXCAVATION EARTH	CY	$15	3500	$52,600	1700	$25,500	1700	$25,500
203,0650	CRUSHED STONE FILL UNDER STRUCTURES	CY	$50	170	$6,500	75	$3,750	75	$3,750
203.0700	PERVIOUS FILL	CY	$50	3200	$100,000	980	$49,000	960	$49000
301.0001	GRAVEL BORROW BASE COURSE	CY	$23	410	$9,430	300	$6,900	420	S9,G60
401.0200	BITUMINOUS PAVEMEI'T	TOI'I	$70	400	$28,000	440	$30,800	550	$38,500
803.9901	R & DPORTIONS OF EXISTING BRIDGE	CY	$200	370	$74,000	310	$62,000	310	$62,000
804.9901	H-PILES	LF	$100	0	S0	2(i00	$260,000	2(i00	$260,000
806.2000	TEMPORARY SHEET PIUNG STEEL FURNISH AND DRIVE	SF	$90	1400	$126,000	500	$45,000	500	$45,000
808.0322	CONCRETE SUBSTRUCTURE CLASS HP 3/4" ENOPOSTS	CY	$1,400	6	$6,400	6	$6,400	6	$8,400
808.0323	CONCRETE SUBSTRUCTURE CLASS HP 3/4" PARAPETS	CY	$1,400	26	$36,400	40	$84,400	50	$70,000
806.0504	CONCRETE SUBSTRUCTURE CLASS HP 3/4" WALL FOOTING	CY	$850	130	$84,600	66	$42,900	77	$50,050
806.0806	CONCRETE SUBSTRUCTURE CLASS ftP 3/4' WALL STEM	CY	$6$0	20	$13,000	80	$39,000	6$	$55,250
806.0806	CONCRETE SUBSTRUCTURE CLASS HP 3/4' ABUTI.tEHT STEMS	CY	$6$0	0	$0	175	$113.750	175	$113,750
808.0508	CONCRETE SUBSTRUCTURE CLASS HP 314" APPROACH SLABS	CY	$300	0	$0	55	$18,500	55	$18,500
808.0602	CONCRETE SUBSTRUCTURE CLASS HP 3/4" 81\CKWALLS	CY	$1,000	0	$0	16	$18,000	24	$24000
808.1501	CONCRETE SUPERSTRUCTURE CLASS HP 314" BRIDGE DECKS	CY	$1,000	0	$0	0	50	120	$120,000
809.0821	PRESmESSED CONCRETE AASHTO BEAMS TYPE 2 FF&E CLASS HP 314"	LF	$125	0	$0	0	50	O	S0
809.0924	PRE5mESSED CONCRETE BOXES 811-48 FF&E CIASS HP 314"	SF	S80	0	$0	4700	$376,000	O	S0
8011.0934	PRESTRESSED CotiCRETE BOXES 811-48 FF&E CLASS HP 314"	SF	$90	0	$0	0	S0	2330	$209,700
809.1012	PRESTRESSED CONCRETE BULB TEES NE1200 FF&E CLASS HP 314'	LF	$300	0	$0	0	$0	O	S0
809.1146	PRESTRESSED CotiCRETE SLABS 1.8 & FF&E CLASS HP 314"	SF	$75	0	S0	0	S0	O	S0
809.9901	PRECAST CONCRETE ARCH CLASS HP314'	LS	$400.000	1	$400,000	0	$0	O	S0
810.0300	EPOXY COATED BAAS GRADE 80	LBS	$1	60000	$60,000	8000	$85,000	114000	$114,000
813.0400	RUBBERIZED ASPHALT LIQUID MEMBRANE (WATERPROOFING MEMBRANE)	SY	S00	690	$34,500	515	$25,750	515	$25,750
828.0303	ELASTOMERIC BEARINGS LAMINATED	EA	$500	0	S0	24	$12,000	12	$6,000
833.0400	GRANITE IDENTIFICATION TABLETS	EA	$400	4	S1,600	4	$1.800	4	$1.800
834.91101	VERTICAL FACE GRANITE BRIDGE CURB	LF	$45	176	$7,920	200	$13,050	304	$13,880
801.0183	STEEL BEAM BRIDGE CONNECTIOtI APPROACH Ei'ID (W/0 NESTED RAIL}	EA	$2,000	2	$4,000	2	$4,000	2	$4,000
901.0184	STEEL BEAM BRIDGE CONNECTION TRAILING END rN/ NESTED RA!L)	EA	$3.000	2	S6,000	2	$8,000	2	$6.000
820.0086	DUI.I?EOSTOtiE RIP-RAP R-1, R-2 ST0.8.3.0	CY	$40	150	$6,000	120	$4,800	120	$4.800
838.0110	M08-.wlnoN	LS	$100,000	I	$100,000	I	$100,000	I	$100,000
937.D200	MAINTENANCE AND MOVEMENT mAFFIC PROTECTION	LS	$300,000	0.5	S150000	I	$300,000	I	$300000

	Alternative 1	Alternative 2	Alternative 3
	$1,798,583	$2,152,000	$2,189,550
Rounded Total C.ost PHes for AitematiVes 2, 3, 4 & 6 (Wilh 25% Msc.J =	**$1,800,000**	$2,180,000	$2190,000
	SI,706,563	$1,839,500	$1.877.050
Rounded Total Cosl without Plies for Allcmatlvcs 2,3, 4 & 6 (Wllh 25% Msc.) =	$1800,000	$1840000	$1880,000

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User Costs

Generally, three categories of user costs are used in an economic and life cycle cost analysis: vehicle operating costs (VOC), delay costs, and crash- and safety-related costs. Because the bridge would have been closed to traffic under both the baseline and as-built cases, the possible safety hazard to the traveling public from a work zone was eliminated, so safety-related costs were not evaluated. However, VOC and delay costs were compared and are discussed in the following subsections.

VOC

The savings in VOC from using ABC are essentially the difference between the mileage-related VOC applied to the 6 months (183 days) of detour time for the baseline case and the 33 days for the as-built case applied to an average extra detour distance of 2 mi.

Assuming an average unit cost of $0.81 per mile for commercial vehicles (light and heavy trucks) [2] and $0.32 per mile for an average sedan[3] for the variable operating costs (including costs for fuel, maintenance and repair, tires, and depreciation) and given the 2012 annual average daily traffic (AADT) of 7,300 with 6 percent trucks for this project, the following VOC is computed:

<u>Baseline Case</u>

VOC (Auto) = 7,300 (AADT) * 0.94 (percent autos) * 2 (mi) * $0.32 (per mi) * 183 (days)
= $803,677

$\text{VOC}_{\text{Truck}}$ = 7,300 (AADT) * 0.06 (percent trucks) * 2 (mi) * $0.81 (per mi) * 183(days)
= $129,849

VOC (Total) = $803,677+ $129,849
= **$933,527**

<u>As-Built Case</u>

The detour was in effect for 33 days, hence the VOC (total) for the as-built case is as follows:

= 33 * 933,527/183
= **$168,341**

$\text{VOC}_{\text{Differential}} = \$933{,}527_{\text{baseline}} - \$168{,}341_{\text{As-built}}$
= **$765,186**

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[2] Barnes and Langworthy, *The Per-Mile Costs of Operating Automobiles and Trucks*, 2003, Report No. MN/RC 2003-19, Minnesota Department of Transportation. Adjusted for fuel price increase and inflation in 2011.

[3] American Automobile Association, Your Driving Costs 2012, Both operating costs and per mile depreciation costs were considered. http://newsroom.aaa.com/wp-content/uploads/2012/04/YourDrivingCosts2012.pdf

Delay Costs

The delay time using the primary and alternate detour routes averaged 2.67 minutes (0.0445 hour) and 1.40 minutes (0.0233 hour), respectively, more than travel before closure. RIDOT estimated that traffic would be distributed about 50 percent on each detour route. The average delay time is calculated as follows:

Delay time per vehicle = 0.5 * 0.0445 hour + 0.5 * 0.0233 hour
= 0.0339 hour

The savings in delay cost can be determined by applying an hourly value to the extra time needed to traverse the detour and assuming a monetary hourly value of $19.68 and $23.57 an hour for autos and trucks, respectively[4]:

<u>Baseline Case</u>

Delay (Auto) = 7,300 (AADT) * 0.94 (percent autos) * 0.0339(hr/veh) * $19.68 (per hr) * 183 (days)
= $837,773

Delay (Truck) = 7,300 (AADT) * 0.06 (percent trucks) * 0.0339(hr/veh) * $23.57 (per hr) * 183(days)
= $64,045

Delay (Total) = $837,773 +$64,045
= **$901,818**

<u>As-Built Case</u>

Delay (Auto) = 7,300 (AADT) * 0.94 (percent autos) * 0.0339(hr/veh) * $19.68 (per hr) * 33 (days)
= $151,074

Delay (Truck) = 7,300 (AADT) * 0.06 (percent trucks) * 0.0339(hr/veh) * $23.57 (per hr) * 33(days)
= $11,549

Delay (Total) = $151,074+ $11,549
= $162,623

The total saving in delay costs between baseline and as-built scenarios is as follows:

$\text{Delay}_{\text{Differential}} = \$\mathbf{901{,}818}_{\text{Baseline}} - \mathbf{\$162{,}623}_{\text{As-built}}$
= $739,195

4 Mallela and Sadasivam, Work Zone Road User Costs and Applications, Report No. FHWA-HOP-12-005, Federal Highway Administration, 2011. Per hour travel delay cost for autos was adjusted for Rhode Island's 2011 median annual household income of $49,033.

COST SUMMARY

From a construction cost standpoint, the innovative ABC delivery approach cost RIDOT about $43,000 less than traditional construction. However, with $90,000 in incentive for early completion, the construction cost for the ABC delivery approach ended up costing **$47,000** more.

User costs, however, were substantially lower for the ABC delivery approach. Compared to the conventional (baseline) approach, VOC costs were $765,186 lower and delay costs were also lower by $739,195 (see Table 2).

In summary, in terms of total costs, the conventional (baseline) approach would have cost **3,823,409** or about **62 percent** more than the cost of **$2,366,028** for the innovative ABC delivery method implemented on this project.

This project saved users **$1,457,381** or about **38 percent** of the total project costs for conventional construction.

Table 2. Comparison of project costs.

Item	Innovative Method	Conventional Method	Difference
Construction Cost	$1,945,064	$1,988,064	$ 43,000
Vehicle Operating Cost (VOC)	$ 168,341	$ 933,527	$ 765,186
Delay Cost	$ 162,623	$ 901,818	$ 739,195
Incentive	$ 90,000	0	$ (90,000)
Total	**$2,366,028**	**$3,823,409**	**$1,457,381**

APPENDIX: SHOP DRAWINGS

NOTES

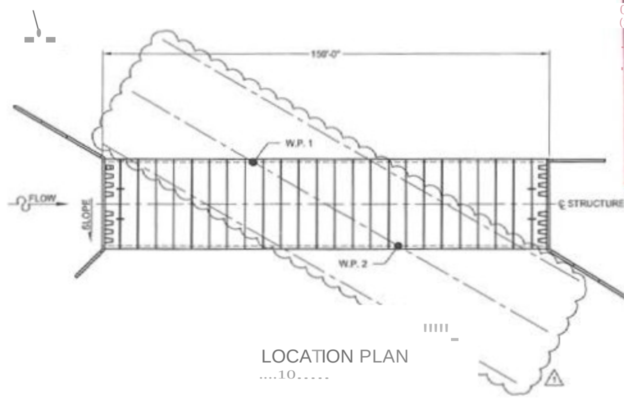
GENERAL NOTES:

REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435
RI CONTRACT NO 2011-CB-077, F.A. NO BR0-0435(001)
EAST GREENWICH, RHODE ISLAND

DESIGN DATA

"FOUNDATION EXCAVATION AND SUBGRADE PREPARATION SHALL BE IN ACCORDANCE WITH THE GEOTECHNICAL REPORT FOR THIS PROJECT PREPARED BY GZA GEOENVIROMENTAL, INC. DATED: 02/01/2012. CONTECH NOT RESPONSIBLE FOR CONFIRMATION OF SOIL CONDITIONS INCLUDING SCOUR ANALYSIS.

MATERIALS



LOCATION PLAN

☒ APPROVED ☐ REVISE & RESUBMIT
☐ APPROVED AS CORRECTED ☐ NOT APPROVED

NOTE FOR CONTACTOR - IMPORTANT

GORDON R. ARCHIBALD, INC.
CIVIL & ENVIRONMENTAL ENGINEERS
PAWTUCKET, R.I.

BY John Wayland DATE 5/7/1

MICHAEL G. CARFAGNO

No. 8105

REGISTERED PROFESSIONAL ENGINEER CIVIL

Michael G. Carfagno 5-4-12

RI CONTRACT NO 2011-CB-077, F.A. NO BRO-0435(001)

PROJECT No.	SEQ. No.	DATE
351166	001	1/17/2012
DESIGNED: JDR	DRAWN: KKB	
CHECKED: RKL	APPROVED: MGC	
SHEET NO.: CT1 OF CT9		

SPAN

REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435

CONSTRUCTION PRODUCTS INC.

EAST GREENWICH, RHODE ISLAND

2S-2tf.(f' SP ai'·H,..RSSEa S·11 "LONG
PRECAST CONCRETE BRIDGE LNTS
U S 24 JOINTS 0Y.'t PER JOINT

BRIDGE PL

4"0 PERFORATED BACKFI.I DRAIN
SUPPLIED WITH WINGWAU.
(4'0 SCHEDUIE 40 PIPE.
SEE PERFORATED DIWN
DETHL ON SHEt:.T &&.

MICHAEIG.CARFAGNO

No.

TOP OF PRECAST
BRIDGE UN1T

V SOUARE PECE OF
CON CS-212

UFTING INSERT

PRECAST 8RJDGE UNT.
HEADWALL OR WWGWAU

LIFTING INSERTS

TYPICAL LIFT POINT SEALING DETAIL

NOT TO SCALE

5/4/2012	NO CHNtGES TO THIS stEET	JOR	
5/31/2012	R:E\1SE OPERE HGaEERREVEW	JOR	CONSTRUCT10N PRODUCT
IIWIK	OAT£	R£V1510N OESCf WTION	

SPAN

BRIDGE SYSTEMS

8CJO.I3&.1122 $1 7000 13-64,5.1'183fAX

REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435
RI CONTRACT NO 2011-CB-077, F.A. NO BR0-0435(001)

EAST GREENWICH, RHODE ISLAND

CT2 CT9

PROJECT No.: 351166 | SEQ. No.: 001 | DATE: 1/17/2012
DESIGNED: JDR | DRAWN: KKB
APPROVED:

5-4-12

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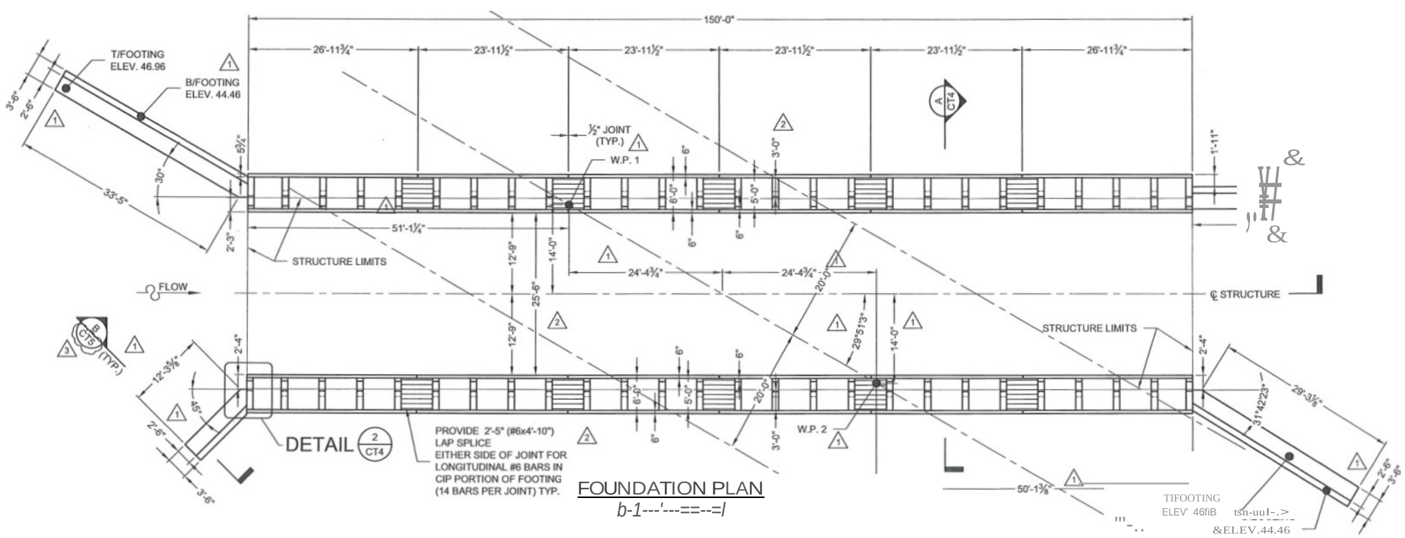


MICHAEL O. CARFAGNO

No. 8105

REGISTERED PROFESSIONAL ENGINEER CIVIL

CONSTRUCTION PRODUCTS INC.

CONSPAN BRIDGE SYSTEMS

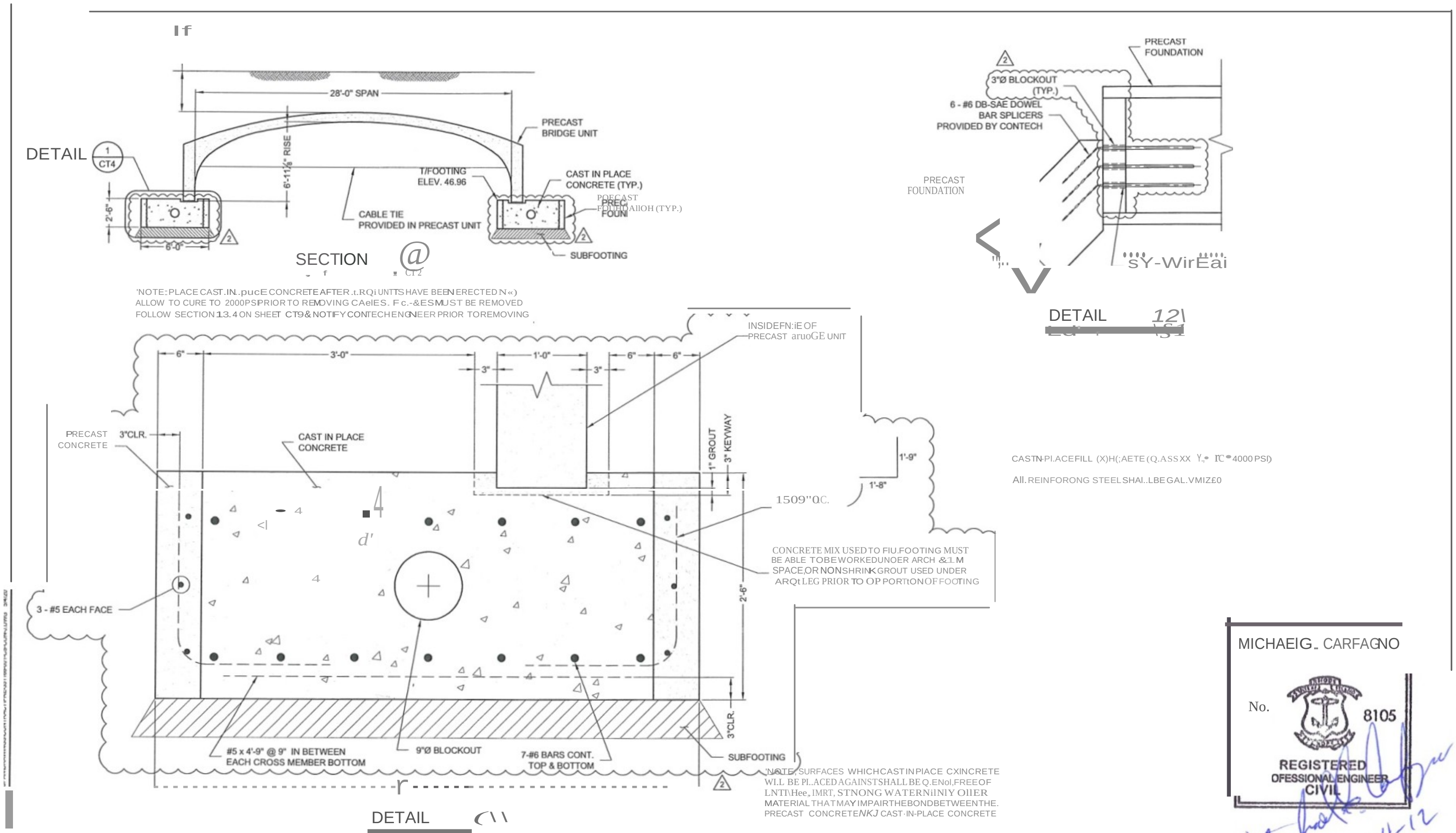
REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO.435

EAST GREENWICH, RHODE ISLAND

CONTRACT NO 2011-CB-077.F.A. NO BR0-0435(001)

351166	001	1/17/2012
DESIGNED: JDR	DRAWN: KKB	APPROVED:

CT3 CT9



NOTE: PLACE CAST-IN-PLACE CONCRETE AFTER BRIDGE UNITS HAVE BEEN ERECTED AND ALLOW TO CURE TO 2000PSI PRIOR TO REMOVING CABLES. CABLES MUST BE REMOVED. FOLLOW SECTION 13.4 ON SHEET CT9 & NOTIFY CONTECH ENGINEER PRIOR TO REMOVING.

CAST-IN-PLACE FILL CONCRETE (CLASS XX, f'c = 4000 PSI)

ALL REINFORCING STEEL SHALL BE GALVANIZED

CONCRETE MIX USED TO FILL FOOTING MUST BE ABLE TO BE WORKED UNDER ARCH & LM SPACE, OR NON-SHRINK GROUT USED UNDER ARCH LEG PRIOR TO OP PORTION OF FOOTING

NOTE: SURFACES WHICH CAST IN PLACE CONCRETE WILL BE PLACED AGAINST SHALL BE CLEAN, FREE OF LAITANCE, DIRT, STRONG WATER AND ANY OTHER MATERIAL THAT MAY IMPAIR THE BOND BETWEEN THE PRECAST CONCRETE AND CAST-IN-PLACE CONCRETE

MICHAEL G. CARFAGNO
No. 8105
REGISTERED PROFESSIONAL ENGINEER
CIVIL

5-4-12

REPLACEMENT OF

SPAN

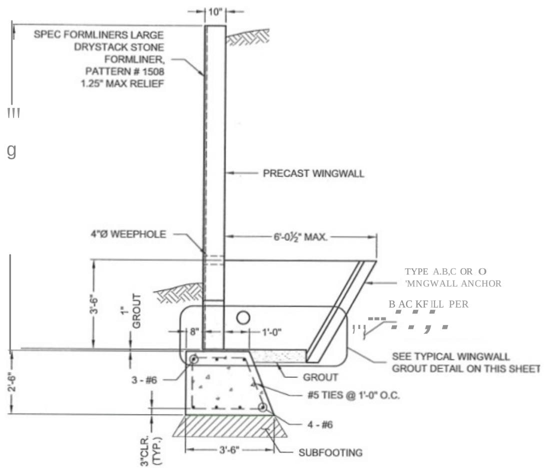
PROJECT No.:	SEQ. No.:	DATE:
351166	001	1/17/2012
DESIGNED: JDR		DRAWN: KKB
		APPROVED: MGC

CONSTRUCTION PRODUCTS INC.

BRIDGE SYSTEMS

FRENCHTOWN BROOK BRIDGE NO. 435
BR0-0435(001)
RI CONTRACT NO 2011-CB-077, FA NO
EAST GREENWICH, RHODE ISLAND

CT4 CT9



CT ON '@

PRECAST CCINaU:TE =0.52 1 0NSIFT
STEEL INPRECAST = 13I8SIFT

TrNNJ.
ELEV.59.70

30'-0"HE.ODWNJ.

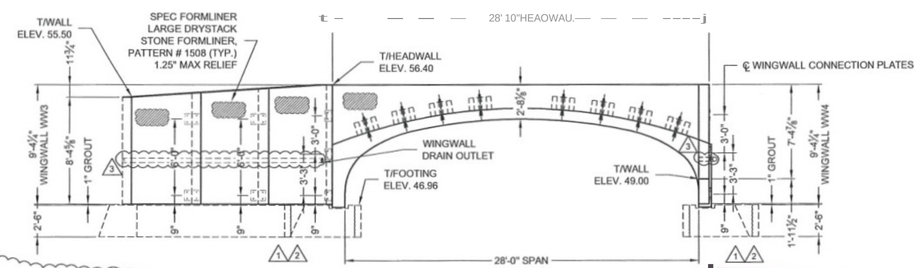
1/ ELEV 70

TIHEJDt\IAll
ELEVS7..

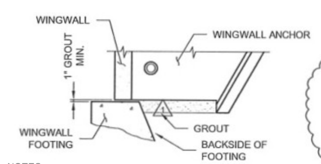
"ELEV ....

1--------28'-o"SPAN———— ---1

UPSTREAM END ELEVATION



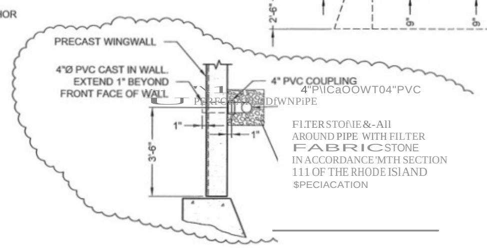
DOWNSTREAM END ELEVATION



NOTES:
MINIMUM 1" GROUT UNDER WINGWALL LEG & ANCHOR SID<
MEA BETWEEN WINGWALL FOOTING N#:I WIHGWALL ANCHOR S(W.L BE GROUTED SOLI) BEFORE BACKFILL
FORM BACKSIDE OF FOOTING TO DIMENSIONS SHOWN ON FOUNDATION

TYPICAL WINGWALL GROUT DETAIL

NOT TO SCALE



4"PVC OWT 04"PVC
PERFORATED DWN PIPE
FILTER STONE &-All AROUND PIPE WITH FILTER FABRIC STONE IN ACCORDANCE WITH SECTION 111 OF THE RHODE ISLAND SPECIFICATION

PERFORATED DRAIN PIPE DETAIL

NOT TO SCALE:

MICHAEL G. CARFAGNO
No. 8105
REGISTERED PROFESSIONAL ENGINEER CIVIL
5-4-12

S#U2012 HOCHNIGESTOIMSSHEET
5131'2012 REVIS(DPEREHGINEERRS'IEW
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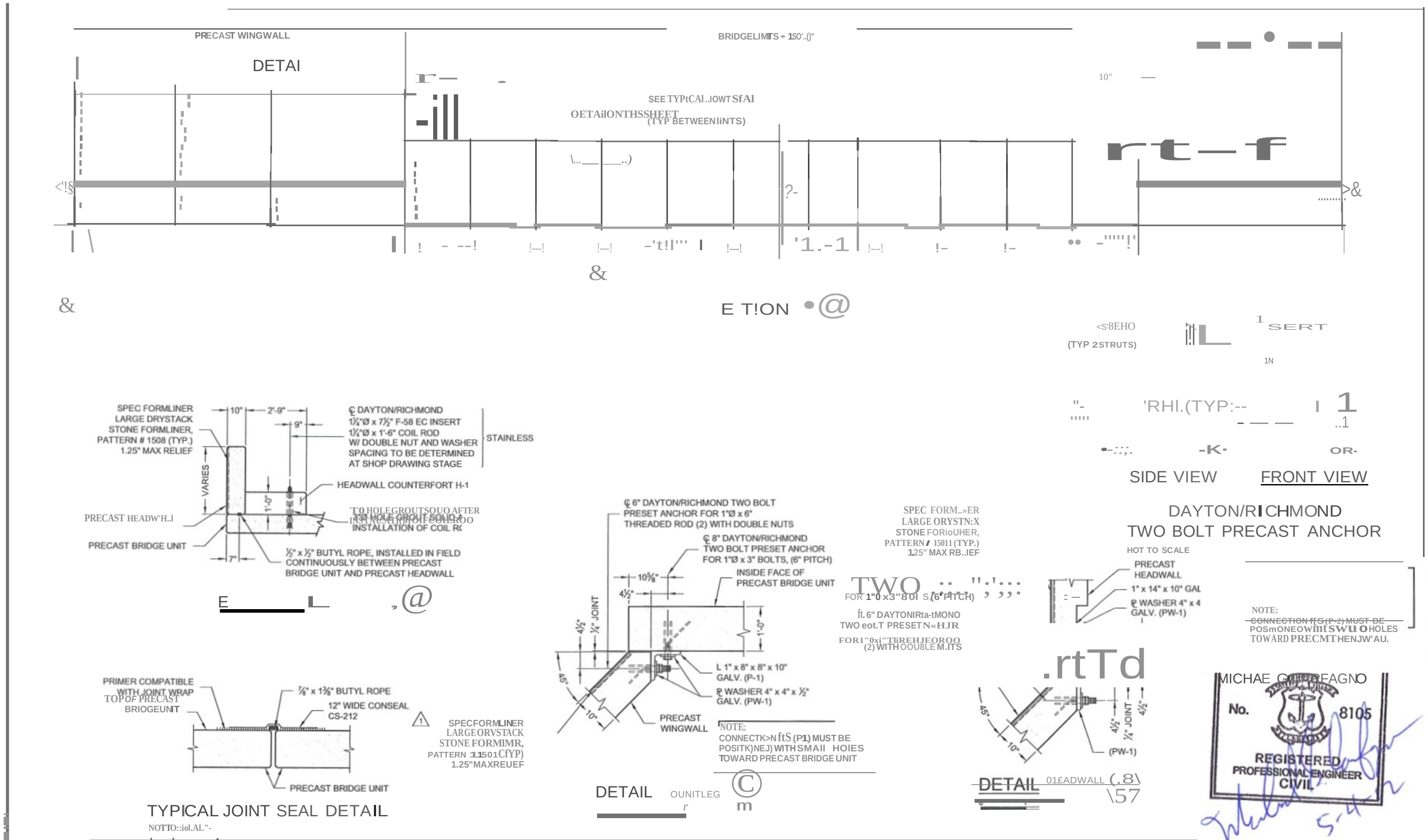
CONSPAN
BRIDGE SYSTEMS

CONTRACT

REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435
RI CONTRACT NO 2011-CB-077, FA NO BR0-0435(001)
EAST GREENWICH, RHODE ISLAND

351166	001	1/17/2012
DESIGNED: JDR	DRAWN: KKB	
	APPROVED: MGC	



PROJECT No.:	SEQ. No.:	DATE:
351166	001	1/17/2012
DESIGNED: JDR	DRAWN: KKB	
	APPROVED: MGC	

CONISPAN

BRIDGE SYSTEMS

CONSTRUCTION PRODUCTS INC.

CONTRACT

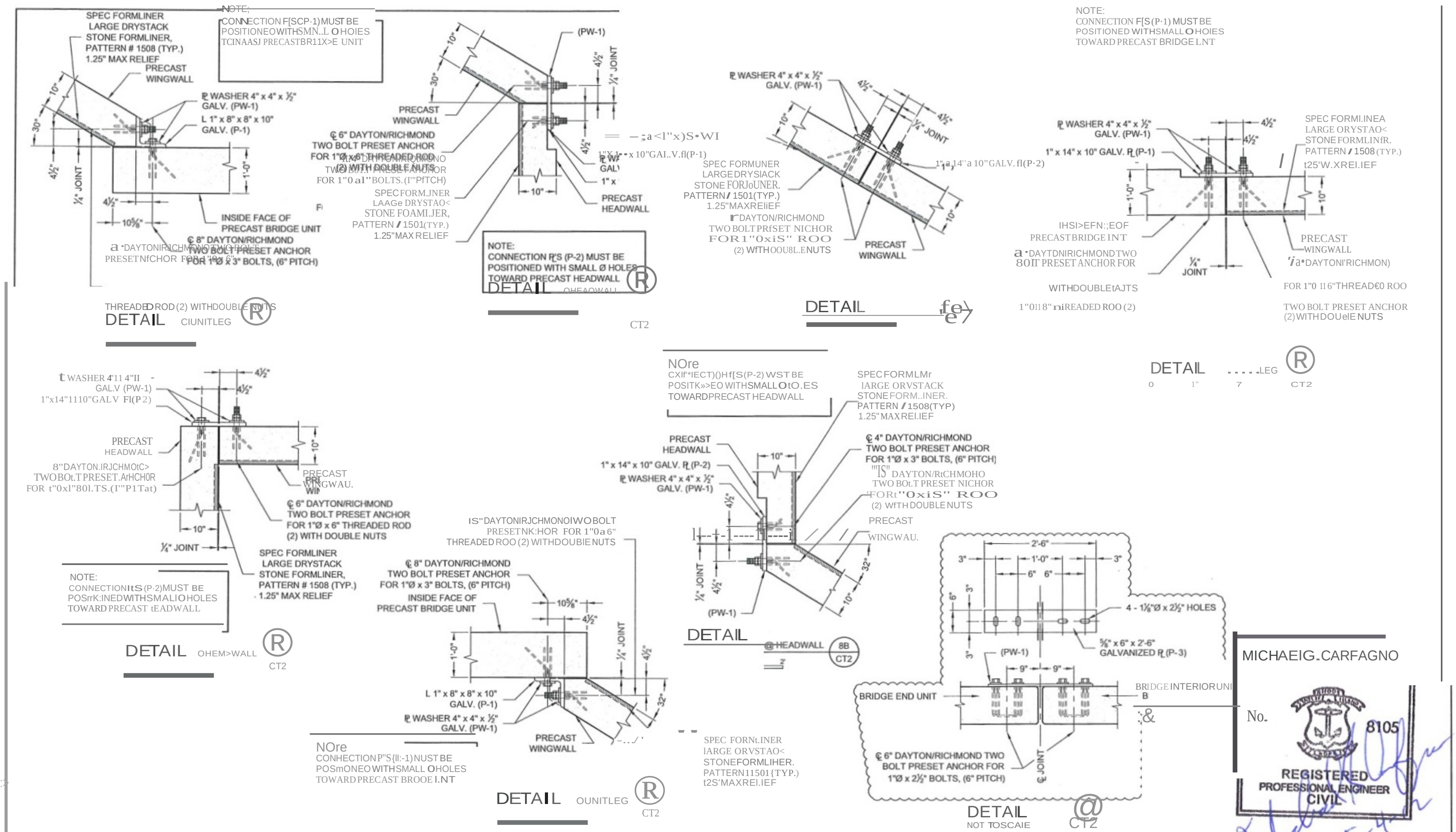
REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435

RI CONTRACT NO 2011-CB-077, FA NO BR0-0435(001)

EAST GREENWICH, RHODE ISLAND

REVISION DESCRIPTION

CT6 CT9



MICHAEL G. CARFAGNO
No. 8105
REGISTERED PROFESSIONAL ENGINEER CIVIL

SPAN BRIDGE SYSTEMS

CONSTRUCTION PRODUCTS INC.

PROJECT No.:	SEQ. No.:	DATE:
351166	001	1/17/2012
DESIGNED: JDR		DRAWN: KKB
		APPROVED: MGC

REPLACEMENT OF FRENCHTOWN BROOK BRIDGE NO. 435

RI CONTRACT NO 2011-CB-077, F.A. NO BR0-0435(001)

EAST GREENWICH, RHODE ISLAND

CT7 CT9

SPECIFICATIONS FOR MANUFACTURE AND INSTALLATION OF CON/SPAN® BRIDGE SYSTEMS

1. DESCRIPTION
   - 1.1. TYPE - THIS WORK SHALL CONSIST OF FURNISHING AND CONSTRUCTING A CON/SPAN® BRIDGE SYSTEM IN ACCORDANCE WITH THESE SPECIFICATIONS AND IN REASONABLY CLOSE CONFORMITY WITH THE LINES, GRADES, DESIGN AND DIMENSIONS SHOWN ON THE PLANS OR AS ESTABLISHED BY THE ENGINEER. IN SITUATIONS WHERE TWO OR MORE SPECIFICATIONS APPLY TO THIS WORK, THE MOST STRINGENT REQUIREMENTS SHALL GOVERN.
   - 1.2. DESIGNATION - PRECAST REINFORCED CONCRETE CON/SPAN® BRIDGE UNITS MANUFACTURED IN ACCORDANCE WITH THIS SPECIFICATION SHALL BE DESIGNATED BY SPAN AND RISE. PRECAST REINFORCED CONCRETE WINGWALLS AND HEADWALLS MANUFACTURED IN ACCORDANCE WITH THIS SPECIFICATION SHALL BE DESIGNATED BY LENGTH, HEIGHT, AND DEFLECTION ANGLE.

2. DESIGN
   - 2.1. SPECIFICATIONS - THE PRECAST ELEMENTS ARE DESIGNED IN ACCORDANCE WITH THE "AASHTO LRFD BRIDGE SPECIFICATION" 5TH EDITION, ADOPTED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS, 2010. A MINIMUM OF ONE FOOT OF COVER ABOVE THE CROWN OF THE BRIDGE UNITS IS REQUIRED IN THE INSTALLED CONDITION. (UNLESS NOTED OTHERWISE ON THE SHOP DRAWINGS AND DESIGNED ACCORDINGLY.)

3. MATERIALS
   - 3.1. CONCRETE SHALL CONFORM TO CONTRACT DOCUMENTS
   - 3.2. STEEL REINFORCEMENT SHALL CONFORM TO THE CONTRACT DOCUMENTS
   - 3.3. STEEL HARDWARE
     - 3.3.1. BOLTS AND THREADED RODS FOR WINGWALL CONNECTIONS SHALL CONFORM TO ASTM A 307. NUTS SHALL CONFORM TO AASHTO M292 (ASTM A194) GRADE 2H. ALL BOLTS, THREADED RODS AND NUTS USED IN WINGWALL CONNECTIONS SHALL BE GALVANIZED PER AASHTO M232.
     - 3.3.2. STRUCTURAL STEEL FOR WINGWALL CONNECTION PLATES AND PLATE WASHERS SHALL CONFORM TO AASHTO M 270 (ASTM A 709) GRADE 36 AND SHALL BE HOT DIP GALVANIZED AS PER AASHTO M111 (ASTM A123).
     - 3.3.3. INSERTS FOR WINGWALLS SHALL BE 1" DIAMETER TWO-BOLT PRESET WINGWALL ANCHORS AS MANUFACTURED BY DAYTON/RICHMOND CONCRETE ACCESSORIES, MIAMISBURG, OHIO, (800) 745-3700 AND BE GALVANIZE PER AASHTO M232
     - 3.3.4. FERRULE LOOP INSERTS SHALL BE F-64 FERRULE LOOP INSERTS AS MANUFACTURED BY DAYTON/RICHMOND CONCRETE ACCESSORIES, MIAMISBURG, OHIO, (800) 745-3700 AND BE GALVANIZE PER AASHTO M232
     - 3.3.5. HOOK BOLTS USED IN ATTACHED HEADWALL CONNECTIONS SHALL BE ASTM A307.
     - 3.3.6. INSERTS FOR DETACHED HEADWALL CONNECTIONS SHALL BE AISI TYPE 304 STAINLESS STEEL, F-58 EXPANDED COIL INSERTS AS MANUFACTURED BY DAYTON/RICHMOND CONCRETE ACCESSORIES, MIAMISBURG, OHIO, (800) 745-3700. COIL RODS AND NUTS USED IN HEADWALL CONNECTIONS SHALL BE AISI TYPE 304 STAINLESS STEEL. WASHERS USED IN HEADWALL CONNECTIONS SHALL BE EITHER AISI TYPE 304 STAINLESS STEEL PLATE WASHERS OR AASHTO M270 (ASTM A709) GRADE 36 PLATE WASHERS HOT DIP GALVANIZED AS PER AASHTO M111 (ASTM A123).
     - 3.3.7. REINFORCING BAR SPLICES SHALL BE MADE USING THE DOWEL BAR SPLICER SYSTEM AS MANUFACTURED BY DAYTON/RICHMOND CONCRETE ACCESSORIES, MIAMISBURG, OHIO, (800) 745-3700, AND SHALL CONSIST OF THE DOWEL BAR SPLICER (DB-SAE) AND DOWEL-IN (DI).

4. MANUFACTURE OF PRECAST ELEMENTS - SUBJECT TO THE PROVISIONS OF SECTION 5, BELOW, THE PRECAST ELEMENT DIMENSION AND REINFORCEMENT DETAILS SHALL BE AS PRESCRIBED IN THE PLAN AND SHOP DRAWINGS PROVIDED BY THE MANUFACTURER.
   - 4.1. FORMS - THE FORMS USED IN MANUFACTURE SHALL BE SUFFICIENTLY RIGID AND ACCURATE TO MAINTAIN THE REQUIRED PRECAST ELEMENT DIMENSIONS WITHIN THE PERMISSIBLE VARIATIONS GIVEN IN SECTION 5 OF THESE SPECIFICATIONS. ALL CASTING SURFACES SHALL BE OF A SMOOTH MATERIAL.
   - 4.2. PLACEMENT OF REINFORCEMENT
     - 4.2.1. PLACEMENT OF REINFORCEMENT IN PRECAST BRIDGE UNITS - THE COVER OF CONCRETE OVER THE OUTSIDE CIRCUMFERENTIAL REINFORCEMENT SHALL BE 2" MINIMUM. THE COVER OF CONCRETE OVER THE INSIDE CIRCUMFERENTIAL REINFORCEMENT SHALL BE 2" MINIMUM. THE CLEAR DISTANCE FROM THE END CIRCUMFERENTIAL WIRES SHALL NOT BE LESS THAN 2" FROM THE ENDS OF EACH SECTION. REINFORCEMENT SHALL BE ASSEMBLED UTILIZING SINGLE OR MULTIPLE LAYERS OF WELDED WIRE FABRIC (NOT TO EXCEED 3 LAYERS), SUPPLEMENTED WITH A SINGLE LAYER OF DEFORMED BILLET-STEEL BARS, WHEN NECESSARY. WELDED WIRE FABRIC SHALL BE COMPOSED OF CIRCUMFERENTIAL AND LONGITUDINAL WIRES MEETING THE SPACING REQUIREMENTS OF 4.3, BELOW, AND SHALL CONTAIN SUFFICIENT LONGITUDINAL WIRES EXTENDING THROUGH THE BRIDGE UNIT TO MAINTAIN THE SHAPE AND POSITION OF THE REINFORCEMENT. LONGITUDINAL DISTRIBUTION REINFORCEMENT MAY BE WELDED WIRE FABRIC OR DEFORMED BILLET-STEEL BARS AND SHALL [illegible] LESS THAN 1½" FROM THE ENDS OF THE BRIDGE UNIT. (4)
     - 4.2.2. BENDING OF REINFORCEMENT FOR PRECAST BRIDGE UNITS - THE OUTSIDE AND INSIDE CIRCUMFERENTIAL REINFORCING STEEL FOR THE CORNERS OF THE BRIDGE SHALL BE BENT TO SUCH AN ANGLE THAT IS APPROXIMATELY EQUAL TO THE CONFIGURATION OF THE BRIDGE'S OUTSIDE CORNER.
     - 4.2.3. PLACEMENT OF REINFORCEMENT FOR PRECAST WINGWALLS AND HEADWALLS - THE COVER OF CONCRETE OVER THE LONGITUDINAL AND TRANSVERSE REINFORCEMENT SHALL BE 3⁄4" MINIMUM FROM FORMLINER SURFACE OR 2" MINIMUM FROM THE DEEPEST FORMLINER RECESS. THE CLEAR DISTANCE FROM THE END OF EACH PRECAST ELEMENT TO THE END OF REINFORCING STEEL SHALL NOT BE LESS THAN 2" NOR MORE THAN 3". REINFORCEMENT SHALL BE ASSEMBLED UTILIZING A SINGLE LAYER OF WELDED WIRE FABRIC, OR A SINGLE LAYER OF DEFORMED BILLET-STEEL BARS. WELDED WIRE FABRIC SHALL BE COMPOSED OF TRANSVERSE AND LONGITUDINAL WIRES MEETING THE SPACING REQUIREMENTS OF 4.3, BELOW, AND SHALL CONTAIN SUFFICIENT LONGITUDINAL WIRES EXTENDING THROUGH THE ELEMENT TO MAINTAIN THE SHAPE AND POSITION OF THE REINFORCEMENT. LONGITUDINAL REINFORCEMENT MAY BE WELDED WIRE FABRIC OR DEFORMED BILLET-STEEL BARS AND SHALL MEET THE SPACING REQUIREMENTS OF 4.3, BELOW. (3) (2)
   - 4.3. LAPS, WELDS, SPACING
     - 4.3.1. LAPS, WELDS, AND SPACING FOR PRECAST BRIDGE UNITS - TENSION SPLICES IN THE CIRCUMFERENTIAL REINFORCEMENT SHALL BE MADE BY LAPPING. LAPS MAY BE TACK WELDED TOGETHER FOR ASSEMBLY PURPOSES. FOR SMOOTH WELDED WIRE FABRIC, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.5.2 AND 5.11.6.2. FOR DEFORMED WELDED WIRE FABRIC, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.5.1 AND 5.11.6.1. THE OVERLAP OF WELDED WIRE FABRIC SHALL BE MEASURED BETWEEN THE OUTER-MOST LONGITUDINAL WIRES OF EACH FABRIC SHEET. FOR DEFORMED BILLET-STEEL BARS, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.1 FOR SPLICES OTHER THAN TENSION SPLICES, THE OVERLAP SHALL BE A MINIMUM OF 1'-0" FOR WELDED WIRE FABRIC OR DEFORMED BILLET-STEEL BARS. THE SPACING CENTER TO CENTER OF THE CIRCUMFERENTIAL WIRES IN A WIRE FABRIC SHEET SHALL BE NOT LESS THAN 2" NOR MORE THAN 4". THE SPACING CENTER TO CENTER OF THE LONGITUDINAL WIRES SHALL NOT BE MORE THAN 8". THE SPACING CENTER TO CENTER OF THE LONGITUDINAL DISTRIBUTION STEEL FOR EITHER LINE OF REINFORCING IN THE TOP SLAB SHALL BE NOT MORE THAN 1'-4".
     - 4.3.2. LAPS, WELDS, AND SPACING FOR PRECAST WINGWALLS AND HEADWALLS - SPLICES IN THE REINFORCEMENT SHALL BE MADE BY LAPPING. LAPS MAY BE TACK WELDED TOGETHER FOR ASSEMBLY PURPOSES. FOR SMOOTH WELDED WIRE FABRIC, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.5.2 AND 5.11.6.2. FOR DEFORMED WELDED WIRE FABRIC, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.5.1 AND 5.11.6.1. FOR DEFORMED BILLET-STEEL BARS, THE OVERLAP SHALL MEET THE REQUIREMENTS OF AASHTO 5.11.2.1. THE SPACING CENTER-TO-CENTER OF THE WIRES IN A WIRE FABRIC SHEET SHALL BE NOT LESS THAN 2" NOR MORE ~~THAN 8"~~.
   - 4.4. CURING SHALL BE A MOIST CURE. (3)
   - 4.5. ~~STORAGE, HANDLING & DELIVERY~~ SHALL CONFORM TO THE CONTRACT DOCUMENTS EXCEPT AS AMENDED HERIN
     - 4.5.1. STORAGE - PRECAST CONCRETE BRIDGE ELEMENTS SHALL BE LIFTED AND STORED IN "AS-CAST" POSITION. PRECAST CONCRETE HEADWALL AND WINGWALL UNITS ARE CAST, STORED AND SHIPPED IN A FLAT POSITION. THE PRECAST ELEMENTS SHALL BE STORED IN SUCH A MANNER TO PREVENT CRACKING OR DAMAGE. STORE ELEMENTS USING TIMBER SUPPORTS AS APPROPRIATE. THE UNITS SHALL NOT BE MOVED UNTIL THE CONCRETE COMPRESSIVE STRENGTH HAS REACHED A MINIMUM OF 2500 PSI, AND THEY SHALL NOT BE STORED IN AN UPRIGHT POSITION.
     - 4.5.2. HANDLING - HANDLING DEVICES SHALL BE PERMITTED IN EACH PRECAST ELEMENT FOR THE PURPOSE OF HANDLING AND SETTING. SPREADER BEAMS MAY BE REQUIRED FOR THE LIFTING OF PRECAST CONCRETE BRIDGE ELEMENTS TO PRECLUDE DAMAGE FROM BENDING OR TORSION FORCES.
     - 4.5.3. DELIVERY - PRECAST CONCRETE ELEMENTS MUST NOT BE SHIPPED UNTIL THE CONCRETE HAS ATTAINED THE SPECIFIED DESIGN COMPRESSIVE STRENGTH, OR AS DIRECTED BY THE DESIGN ENGINEER. PRECAST CONCRETE ELEMENTS MAY BE UNLOADED AND PLACED ON THE GROUND AT THE SITE UNTIL INSTALLED. STORE ELEMENTS USING TIMBER SUPPORTS AS APPROPRIATE.
   - 4.6. QUALITY ASSURANCE - THE PRECASTER SHALL DEMONSTRATE ADHERENCE TO THE STANDARDS SET FORTH IN THE NPCA QUALITY CONTROL MANUAL. THE PRECASTER SHALL MEET EITHER SECTION 4.6.1 OR 4.6.2
     - 4.6.1. CERTIFICATION - THE PRECASTER SHALL BE CERTIFIED BY THE PRECAST/PRESTRESSED CONCRETE INSTITUTE PLANT CERTIFICATION PROGRAM OR THE NATIONAL PRECAST CONCRETE ASSOCIATION'S PLANT CERTIFICATION PROGRAM PRIOR TO AND DURING PRODUCTION OF THE PRODUCTS COVERED BY THIS SPECIFICATION.
     - 4.6.2. QUALIFICATIONS, TESTING AND INSPECTION
       - 4.6.2.1. THE PRECASTER SHALL HAVE BEEN IN THE [illegible]ETE PRODUCTS SIMILAR TO THOSE SPECIFIED FOR A MINIMUM OF THREE YEARS. HE SHALL MAINTAIN A PERMANENT QUALITY CONTROL DEPARTMENT OR RETAIN AN INDEPENDENT TESTING AGENCY ON A CONTINUING BASIS. THE AGENCY SHALL ISSUE A REPORT, CERTIFIED BY A LICENSED ENGINEER, DETAILING THE ABILITY OF THE PRECASTER TO PRODUCE QUALITY PRODUCTS CONSISTENT WITH INDUSTRY STANDARDS.
       - 4.6.2.2. THE PRECASTER SHALL SHOW THAT THE FOLLOWING TESTS ARE PERFORMED IN ACCORDANCE WITH THE ASTM STANDARDS INDICATED. TESTS SHALL BE PERFORMED AS INDICATED IN SECTION 6 OF THESE SPECIFICATIONS.
         - 4.6.2.2.1. AIR CONTENT: C231 OR C173
         - 4.6.2.2.2. COMPRESSIVE STRENGTH: C31,C39,C497
       - 4.6.2.3. THE PRECASTER SHALL PROVIDE DOCUMENTATION DEMONSTRATING COMPLIANCE WITH THIS SECTION TO CONTECH® BRIDGE SOLUTIONS AT REGULAR INTERVALS OR UPON REQUEST.
       - 4.6.2.4. THE OWNER MAY PLACE AN INSPECTOR IN THE PLANT WHEN THE PRODUCTS COVERED BY THIS SPECIFICATION ARE BEING MANUFACTURED.
     - 4.6.3. DOCUMENTATION - THE PRECASTER SHALL SUBMIT PRECAST PRODUCTION REPORTS TO CONTECH® BRIDGE SOLUTIONS AS REQUIRED.

5. PERMISSIBLE VARIATIONS - PERMISSIBLE VARIATIONS SHALL CONFORM TO PCI MNL 116 AND AS SPECIFIED HEREIN
   - 5.1. BRIDGE UNITS
     - 5.1.1. INTERNAL DIMENSIONS - THE INTERNAL DIMENSION SHALL VARY NOT MORE THAN 1% FROM THE DESIGN DIMENSIONS NOR MORE THAN 1½" WHICHEVER IS LESS.
     - 5.1.2. SLAB AND WALL THICKNESS - THE SLAB AND WALL THICKNESS SHALL NOT BE LESS THAN THAT SHOWN IN THE DESIGN BY MORE THAN ¼". A THICKNESS MORE THAN THAT REQUIRED IN THE DESIGN SHALL NOT BE CAUSE FOR REJECTION.
     - 5.1.3. LENGTH OF OPPOSITE SURFACES - VARIATIONS IN LAYING LENGTHS OF TWO OPPOSITE SURFACES OF THE BRIDGE UNIT SHALL NOT BE MORE THAN ½" IN ANY SECTION, EXCEPT WHERE BEVELED ENDS FOR LAYING OF CURVES ARE SPECIFIED BY THE PURCHASER.
     - 5.1.4. LENGTH OF SECTION - THE UNDERRUN IN LENGTH OF A SECTION SHALL NOT BE MORE THAN ½" IN ANY BRIDGE UNIT.
     - 5.1.5. POSITION OF REINFORCEMENT - THE MAXIMUM VARIATION IN POSITION OF THE REINFORCEMENT SHALL BE ± ½". IN NO CASE SHALL THE COVER OVER THE REINFORCEMENT BE LESS THAN 2" FOR THE OUTSIDE CIRCUMFERENTIAL STEEL OR BE LESS THAN 2" FOR THE INSIDE CIRCUMFERENTIAL STEEL AS MEASURED TO THE EXTERNAL OR INTERNAL SURFACE OF THE BRIDGE. THESE TOLERANCES OR COVER REQUIREMENTS DO NOT APPLY TO MATING SURFACES OF THE JOINTS.
     - 5.1.6. AREA OF REINFORCEMENT - THE AREAS OF STEEL REINFORCEMENT SHALL BE THE DESIGN STEEL AREAS AS SHOWN IN THE MANUFACTURER'S SHOP DRAWINGS. STEEL AREAS GREATER THAN THOSE REQUIRED SHALL NOT BE CAUSE FOR REJECTION. THE PERMISSIBLE VARIATION IN DIAMETER OF ANY REINFORCEMENT SHALL CONFORM TO THE TOLERANCES PRESCRIBED IN THE ASTM SPECIFICATION FOR THAT TYPE OF REINFORCEMENT.
   - 5.2. WINGWALLS & HEADWALLS
     - 5.2.1. WALL THICKNESS - THE WALL THICKNESS SHALL NOT VARY FROM THAT SHOWN IN THE DESIGN BY MORE THAN ½".
     - 5.2.2. LENGTH/HEIGHT OF WALL SECTIONS - THE LENGTH AND HEIGHT OF THE WALL SHALL NOT VARY FROM THAT SHOWN IN THE DESIGN BY MORE THAN ½".
     - 5.2.3. POSITION OF REINFORCEMENT - THE MAXIMUM VARIATION IN THE POSITION OF THE REINFORCEMENT SHALL BE ± ½". IN NO CASE SHALL THE COVER OVER THE REINFORCEMENT BE LESS THAN 3".
     - 5.2.4. SIZE OF REINFORCEMENT - THE PERMISSIBLE VARIATION IN DIAMETER OF ANY REINFORCING SHALL CONFORM TO THE TOLERANCES PRESCRIBED IN THE ASTM SPECIFICATION FOR THAT TYPE OF REINFORCING. STEEL AREA GREATER THAN THAT REQUIRED SHALL NOT BE CAUSE FOR REJECTION.

6. TESTING/ INSPECTION
   - 6.1. TESTING SHALL CONFORM TO THE CONTRACT DOCUMENTS AND THESE NOTES, WITH THE MORE STRINGENT GOVENING
     - 6.1.1. TYPE OF TEST SPECIMEN - CONCRETE COMPRESSIVE STRENGTH SHALL BE DETERMINED FROM COMPRESSION TESTS MADE ON CYLINDERS OR CORES. FOR CYLINDER TESTING, A MINIMUM OF 4 CYLINDERS SHALL BE TAKEN FOR EACH BRIDGE ELEMENT. EACH ELEMENT SHALL BE CONSIDERED SEPARATELY FOR THE PURPOSE OF TESTING AND ACCEPTANCE.
     - 6.1.2. COMPRESSION TESTING - CYLINDERS SHALL BE MADE AND TESTED AS PRESCRIBED BY THE ASTM C39 SPECIFICATION. CYLINDERS SHALL BE CURED IN THE SAME ENVIRONMENT AS THE BRIDGE ELEMENTS. CORES SHALL BE OBTAINED AND TESTED FOR COMPRESSIVE STRENGTH IN ACCORDANCE WITH THE PROVISIONS OF THE ASTM C42 SPECIFICATION.
     - 6.1.3. ACCEPTABILITY OF CYLINDER TESTS - WHEN THE AVERAGE COMPRESSIVE STRENGTH OF ALL CYLINDERS TESTED IS EQUAL TO OR GREATER THAN THE DESIGN COMPRESSIVE STRENGTH, AND NOT MORE THAN 10% OF THE CYLINDERS TESTED HAVE A COMPRESSIVE STRENGTH LESS THAN THE DESIGN CONCRETE STRENGTH, AND NO CYLINDER TESTED HAS A COMPRESSIVE STRENGTH LESS THAN 80% OF THE DESIGN COMPRESSIVE STRENGTH, THEN THE ELEMENT SHALL BE ACCEPTED. WHEN THE COMPRESSIVE STRENGTH OF THE CYLINDERS TESTED DOES NOT CONFORM TO THESE ACCEPTANCE CRITERIA, THE ACCEPTABILITY OF THE ELEMENT MAY BE DETERMINED AS DESCRIBED IN SECTION 6.1.4, BELOW.
     - 6.1.4. ACCEPTABILITY OF CORE TESTS - THE COMPRESSIVE STRENGTH OF THE CONCRETE IN A BRIDGE ELEMENT IS ACCEPTABLE WHEN THE AVERAGE CORE TEST STRENGTH IS EQUAL TO OR GREATER THAN THE DESIGN CONCRETE STRENGTH. WHEN THE COMPRESSIVE STRENGTH OF A CORE TESTED IS LESS THAN THE DESIGN CONCRETE STRENGTH, THE PRECAST ELEMENT FROM WHICH THAT CORE WAS TAKEN MAY BE RE-CORED. WHEN THE COMPRESSIVE STRENGTH OF THE RE-CORE IS EQUAL TO OR GREATER THAN THE DESIGN CONCRETE STRENGTH, THE COMPRESSIVE STRENGTH OF THE CONCRETE IN THAT BRIDGE ELEMENT IS ACCEPTABLE.
       - 6.1.4.1. WHEN THE COMPRESSIVE STRENGTH OF ANY RECORE IS LESS THAN THE DESIGN CONCRETE STRENGTH, THE PRECAST ELEMENT FROM WHICH THAT CORE WAS TAKEN SHALL BE REJECTED.
       - 6.1.4.2. PLUGGING CORE HOLES - THE CORE HOLES SHALL BE PLUGGED AND SEALED BY THE MANUFACTURER IN A MANNER SUCH THAT THE ELEMENTS WILL MEET ALL OF THE TEST REQUIREMENTS OF THIS SPECIFICATION. PRECAST ELEMENTS SO SEALED SHALL BE CONSIDERED SATISFACTORY FOR USE.
       - 6.1.4.3. TEST EQUIPMENT - EVERY MANUFACTURER FURNISHING PRECAST ELEMENTS UNDER THIS SPECIFICATION SHALL FURNISH ALL FACILITIES AND PERSONNEL NECESSARY TO CARRY OUT THE TEST REQUIRED.
   - 6.2. INSPECTION - THE QUALITY OF MATERIALS, THE PROCESS OF MANUFACTURE, AND THE FINISHED PRECAST ELEMENTS SHALL BE SUBJECT TO INSPECTION BY THE PURCHASER.

7. JOINTS

   THE BRIDGE UNITS SHALL BE PRODUCED WITH FLAT BUTT ENDS. THE ENDS OF THE BRIDGE UNITS SHALL BE SUCH THAT WHEN THE SECTIONS ARE LAID TOGETHER THEY WILL MAKE A CONTINUOUS LINE WITH A SMOOTH INTERIOR FREE OF APPRECIABLE IRREGULARITIES, ALL COMPATIBLE WITH THE PERMISSIBLE VARIATIONS IN SECTION 5, ABOVE. THE JOINT WIDTH BETWEEN ADJACENT PRECAST UNITS SHALL NOT EXCEED ¾".

8. WORKMANSHIP/ FINISH
   - 8.1. WORKMANSHIP SHALL CONFORM TO THE CONTRACT DOCUMENTS

9. REPAIRS

   PRECAST ELEMENTS MAY BE REPAIRED, IF NECESSARY, BECAUSE OF IMPERFECTIONS IN MANUFACTURE OR HANDLING DAMAGE AND WILL BE ACCEPTABLE IF, IN THE OPINION OF THE PURCHASER, THE REPAIRS ARE SOUND, PROPERLY FINISHED AND CURED, AND THE REPAIRED SECTION CONFORMS TO THE REQUIREMENTS OF THIS SPECIFICATION.

10. REJECTION
    - 10.1. REJECTION SHALL CONFORM TO THE CONTRACT DOCUMENTS

11. MARKING
    - 11.1. MARKING SHALL CONFORM TO THE CONTRACT DOCUMENTS

(2)

MICHAEL G. CARFAGNO
No. 8105
REGISTERED PROFESSIONAL ENGINEER CIVIL
5-4-12

MARK	DATE	REVISION DESCRIPTION	BY
4	5/4/2012	REVISED PER ENGINEER REVIEW	JDR
3	5/3/2012	REVISED PER ENGINEER REVIEW	JDR
2	4/26/2012	REVISED PER ENGINEER REVIEW	JDR
1	3/8/2012	REVISED PER ENGINEER REVIEW	JDR

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CON/SPAN® BRIDGE SYSTEMS

CONTECH CONTRACT DRAWING

REPLACEMENT OF
FRENCHTOWN BROOK BRIDGE NO. 435
RI CONTRACT NO 2011-CB-077, F.A. NO BRO-0435(001)
EAST GREENWICH, RHODE ISLAND

PROJECT No.: 351166	SEQ. No.: 001	DATE: 1/17/2012
DESIGNED: JDR		DRAWN: KKB
CHECKED: RKL		APPROVED: MGC
SHEET NO.: CT8 OF CT9		

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SPECIFICATIONS FOR MANUFACTURE AND INSTALLATION OF CON/SPAN® BRIDGE SYSTEMS (CONT'D)

12. INSTALLATION PREPARATION
TO ENSURE CORRECT INSTALLATION OF THE PRECAST CONCRETE BRIDGE SYSTEM, CARE AND CAUTION MUST BE EXERCISED IN FORMING THE SUPPORT AREAS FOR BRIDGE UNITS, HEADWALL, AND WINGWALL ELEMENTS. EXERCISING SPECIAL CARE WILL FACILITATE THE RAPID INSTALLATION OF THE PRECAST COMPONENTS.

12.1. FOOTINGS
DO NOT OVER EXCAVATE FOUNDATIONS UNLESS DIRECTED BY SITE SOIL ENGINEER TO REMOVE UNSUITABLE SOIL.

13. INSTALLATION

13.1. GENERAL - THE INSTALLATION OF THE PRECAST CONCRETE ELEMENTS SHALL CONFORM TO THE CONTRACT DOCUMENTS AND AS EXPLAINED IN THE PUBLICATION CON/SPAN BRIDGE SYSTEMS INSTALLATION HANDBOOK. THE MORE STRINGENT SHALL GOVEN.

13.1.1. LIFTING - IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO ENSURE THAT A CRANE OF THE CORRECT LIFTING CAPACITY IS AVAILABLE TO HANDLE THE PRECAST CONCRETE UNITS. THIS CAN BE ACCOMPLISHED BY USING THE WEIGHTS GIVEN FOR THE PRECAST CONCRETE COMPONENTS AND BY DETERMINING THE LIFTING REACH FOR EACH CRANE UNIT. SITE CONDITIONS MUST BE CHECKED WELL IN ADVANCE OF SHIPPING TO ENSURE PROPER CRANE LOCATION AND TO AVOID ANY LIFTING RESTRICTIONS. THE LIFT ANCHORS OR HOLES PROVIDED IN EACH UNIT ARE THE ONLY MEANS TO BE USED TO LIFT THE ELEMENTS. THE PRECAST CONCRETE ELEMENTS MUST NOT BE SUPPORTED OR RAISED BY OTHER MEANS THAN THOSE GIVEN IN THE MANUALS AND DRAWINGS WITHOUT WRITTEN APPROVAL FROM CONTECH® BRIDGE SOLUTIONS.

13.1.2. CONSTRUCTION EQUIPMENT WEIGHT RESTRICTIONS - IN NO CASE SHALL EQUIPMENT OPERATING IN EXCESS OF THE DESIGN LOAD (HL-93) BE PERMITTED OVER THE BRIDGE UNITS UNLESS APPROVED BY CONTECH® BRIDGE SOLUTIONS.

13.1.2.1. IN THE IMMEDIATE AREA OF THE BRIDGE UNITS, THE FOLLOWING RESTRICTIONS FOR THE USE OF HEAVY CONSTRUCTION MACHINERY DURING BACKFILLING OPERATIONS APPLY:
NO CONSTRUCTION EQUIPMENT SHALL CROSS THE BARE PRECAST CONCRETE BRIDGE UNIT.
AFTER THE COMPACTED FILL LEVEL HAS REACHED A MINIMUM OF 4" OVER THE CROWN OF THE BRIDGE, CONSTRUCTION EQUIPMENT WITH A WEIGHT OF LESS THAN 10 TONS MAY CROSS THE BRIDGE.
AFTER THE COMPACTED FILL LEVEL HAS REACHED A MINIMUM OF 1'-0" OVER THE CROWN OF THE BRIDGE, CONSTRUCTION EQUIPMENT WITH A WEIGHT OF LESS THAN 30 TONS MAY CROSS THE BRIDGE.
AFTER THE COMPACTED FILL LEVEL HAS REACHED THE DESIGN COVER, OR 2'-0" MINIMUM, OVER THE CROWN OF THE PRECAST CONCRETE BRIDGE, CONSTRUCTION EQUIPMENT WITHIN THE DESIGN LOAD LIMITS FOR THE ROAD MAY CROSS THE PRECAST CONCRETE BRIDGE.

13.2. LEVELING PAD/SHIMS - THE BRIDGE UNITS AND WINGWALLS SHALL BE SET ON MASONITE OR STEEL SHIMS MEASURING 5" x 5", MINIMUM, UNLESS SHOWN OTHERWISE ON THE PLANS. A MINIMUM GAP OF ½" SHALL BE PROVIDED BETWEEN THE FOOTING AND THE BOTTOM OF THE BRIDGE'S VERTICAL LEGS OR THE BOTTOM OF [illegible]

ON SITE.
PLACEMENT OF BRIDGE UNITS - THE BRIDGE UNITS SHALL BE PLACED AS SHOWN ON THE ENGINEER'S PLAN DRAWINGS. SPECIAL CARE SHALL BE TAKEN IN SETTING THE ELEMENTS TO THE TRUE LINE AND GRADE. THE JOINT WIDTH BETWEEN ADJACENT PRECAST UNITS SHALL NOT EXCEED ¾".

IT IS IMPERATIVE THAT ANY LATERAL SPREADING OF THE BRIDGE ELEMENTS BE AVOIDED DURING AND AFTER THEIR PLACEMENT. GENERALLY, HORIZONTAL CABLE TIES OR TIE RODS ARE SHIPPED IN THE LARGER BRIDGE ELEMENTS TO PREVENT THIS SPREADING. CABLE TIES/TIE RODS SHALL NOT BE REMOVED UNTIL BRIDGE UNITS ARE GROUTED AND GROUT HAS CURED. IF, HOWEVER, DUE TO SITE RESTRICTIONS, THESE CABLE TIES/TIE RODS MUST BE REMOVED PRIOR TO PLACEMENT OF THE BRIDGE ELEMENTS, THE CONTRACTOR MUST NOTIFY CONTECH (MANUFACTURER) AND

IN ADDITION, IF THE CABLE TIES/TIE RODS MUST BE REMOVED PRIOR TO SETTING ARCH UNITS, THE FOLLOWING QUALITY CONTROL PROCEDURE MUST BE FOLLOWED:
1) FIND "MEASURED SPAN" UPON ARCH UNIT'S DELIVERY TO SITE, PRIOR TO LIFTING FROM TRUCK AND REMOVING CABLE TIES/TIE RODS. "MEASURED SPAN" SHALL BE THE AVERAGE OF (3) SPAN MEASUREMENTS ALONG THE LAY LENGTH OF THE ARCH UNIT.

[illegible] OR APPROVED EQUAL. THE JOINT [illegible] NUOUSLY FROM THE BOTTOM OF ONE [illegible] OSS THE TOP OF THE BRIDGE AND TO [illegible] TION LEG. ANY LAPS THAT RESULT IN [illegible] BE A MINIMUM OF 6" LONG WITH THE DOWNHILL.

[illegible] ADDITION TO THE JOINTS BETWEEN BRIDGE UNITS, THE BETWEEN THE END BRIDGE UNIT AND THE HEADWALL SHALL BE SEALED AS DESCRIBED ABOVE. IF PRECAST WINGWALLS ARE USED, THE JOINT BETWEEN THE END BRIDGE UNIT AND THE WINGWALL SHALL BE SEALED WITH A 2'-0" STRIP OF FILTER FABRIC. ALSO, IF LIFT HOLES ARE FORMED IN THE BRIDGE UNITS, THEY SHALL BE PRIMED AND COVERED WITH A 9" x 9" SQUARE OF JOINT WRAP.

ARE EXPECTED TO GO BELOW 35° FOR A P[illegible] GROUT (PORTLAND CEMENT AND WATER [illegible] COMPOSED OF PORTLAND CEMENT, SAND [illegible] MINIMUM 28-DAY COMPRESSIVE STRENGTH [illegible]

WITH GROUT.

13.8. BACKFILL

13.8.1. BACKFILL SHALL CONFORM TO THE CONTRACT DOCUMENTS AND THE NOTES HEREIN. THE MORE STRINGENT SHALL GOVEN

13.8.2. DO NOT PERFORM BACKFILLING DURING WET OR FREEZING WEATHER.

13.8.3. NO BACKFILL SHALL BE PLACED AGAINST ANY STRUCTURAL ELEMENTS UNTIL THEY HAVE BEEN APPROVED BY THE ENGINEER.

13.8.4. BACKFILL SHALL BE CONSIDERED AS ALL REPLACED EXCAVATION AND NEW EMBANKMENT ADJACENT TO THE PRECAST CONCRETE ELEMENTS. THE PROJECT CONSTRUCTION AND MATERIAL SPECIFICATIONS, WHICH INCLUDE THE SPECIFICATIONS FOR EXCAVATION FOR STRUCTURES AND ROADWAY EXCAVATION AND EMBANKMENT CONSTRUCTION, SHALL APPLY EXCEPT AS MODIFIED IN THIS SECTION.

13.8.5. BACKFILL ZONES:
IN-SITU SOIL
ZONE A: CONSTRUCTED EMBANKMENT OR OVERFILL.
ZONE B: FILL THAT IS DIRECTLY ASSOCIATED WITH PRECAST CONCRETE BRIDGE INSTALLATION.
ZONE C: ROAD STRUCTURE.

13.8.6. REQUIRED BACKFILL PROPERTIES

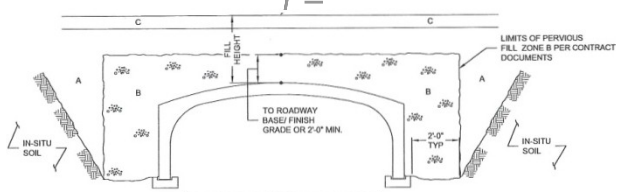
13.8.6.1. IN-SITU SOIL - NATURAL GROUND IS TO BE SUFFICIENTLY STABLE TO ALLOW EFFECTIVE SUPPORT TO THE PRECAST CONCRETE BRIDGE UNITS. AS A GUIDE, THE EXISTING NATURAL GROUND SHOULD BE OF SIMILAR QUALITY AND DENSITY TO ZONE B MATERIAL FOR MINIMUM LATERAL DIMENSION OF ONE BRIDGE SPAN OUTSIDE OF THE BRIDGE FOOTING.

13.8.6.2. ZONE A - ZONE A REQUIRES FILL MATERIAL WITH SPECIFICATIONS AND COMPACTING PROCEDURES EQUAL TO THAT FOR NORMAL ROAD EMBANKMENTS.

13.8.6.3. ZONE B - PERVIOUS FILL PER CONTRACT DOCUMENTS.

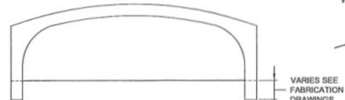
13.8.6.4. ZONE C - ZONE C IS THE ROAD SECTION OF GRAVEL, ASPHALT OR CONCRETE BUILT IN COMPLIANCE WITH LOCAL

THE FIRST MEASUREMENT ROW SHOULD TAKE PLACE AFTER THE ERECTION OF ALL PRECAST BRIDGE SYSTEM ELEMENTS, A SECOND AFTER COMPLETION OF BACKFILLING, AND A THIRD BEFORE OPENING OF THE BRIDGE TO TRAFFIC. FURTHER MEASUREMENTS MAY BE MADE ACCORDING TO LOCAL CONDITIONS.

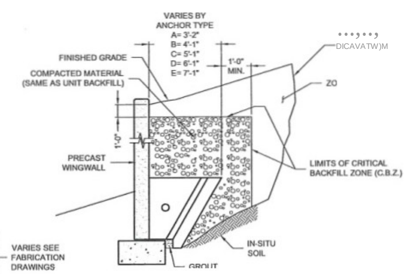


SPAN	FILL HEIGHT	ACCEPTABLE MATERIAL INSIDE ZONE B
≤ 24'-0"	≥ 12'-0"	A1, A3
≤ 24'-0"	< 12'-0"	A1, A2, A3, A4
> 24'-0"	ALL	A1, A3

BACKFILL REQUIREMENTS



CABLE TIES OR TIE RODS
(...24'-0" SPAN)



WALL BACKFILL REQUIREMENTS

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REVISE OPERATION DESCRIPTION

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