NEW YORK DEMONSTRATION PROJECT:

Replacement of I-190 Bridges over Buffalo Avenue, Niagara Falls, NY

Final Report
March 2015

HIGHWAYS FOR LIFE

Accelerating Innovation for the American Driving Experience.

U.S.Department of Transportation
Federal Highway Administration

FOREWORD

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

Specifically, HfL focuses on speeding up *the widespread adoption* of proven innovations in the highway community. “Innovations” is an inclusive term used 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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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 $1.407 million grant to replace two bridges on I-190 over Buffalo Avenue in Niagara Falls, NY, to demonstrate the use of proven, innovative technologies. This report documents Accelerated Bridge Construction (ABC) techniques using modular deck beam technology.

Under conventional construction methods, it would have taken three months to replace each bridge, impacting traffic on I-190, Buffalo Avenue, and the portion of Robert Moses State Parkway that connects Niagara Falls State Park to I-190. However, using precast modular deck beam technology, impact to travelers on I-190 was limited to only 72 hours for each bridge replacement. Travelers on the Parkway and Buffalo Avenue were impacted for five weeks, during which time Buffalo Avenue was reconstructed and lowered to correct an under-clearance deficiency. It was projected that by compressing the construction time using ABC, two crashes were avoided at the site.

Innovative iCone® technology was used to gather speed data and interpret queuing and incidents in the work zone.

The construction cost for the innovative bridge replacement was an estimated $0.276 million less than that for the conventional method, and user delay cost was also reduced by an estimated $2.279 million. When bundled together, there was an estimated total savings of $2.555 million. This represents about 33 percent of the $7.743 million successful bid on the project.

A post-construction user satisfaction survey indicated that, overall, more than 88 percent of the respondents were satisfied or very satisfied with the ABC techniques used to expedite construction.

Because of the success of this project, NYSDOT plans to accelerate bridge construction using modular deck beam technology on future projects where it is feasible and appropriate for conditions.</td></tr>
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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

ABC	Accelerated Bridge Construction
AADT	Average Annual Daily Traffic
ADT	Average Daily Traffic
CARP	Construction Accident Recording System
DOT	Department of Transportation
EB	Eastbound
EPS	Expanded Polystyrene
FHWA	Federal Highway Administration
HfL	Highways for LIFE
NB	Northbound
NYSDOT	New York State Department of Transportation
OSHA	Occupational Safety and Health Administration
PCI	Prestressed Concrete Institute
QC/QA	Quality Control/Quality Assurance
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SB	Southbound
SSD	Stopping Sight Distance
TOC	Traffic Operations Center
WB	Westbound

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration's (FHWA's) 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 per year. The funding amount may total up to 20 percent of the project cost, but not more than $5 million. 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 has 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.
- Be ready for construction within one 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 three-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 in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).
- **Quality**
  - Smoothness—International Roughness Index 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 tests method.
- **User Satisfaction**

- User satisfaction—An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4-plus on a 7-point Likert scale.

Report Scope and Organization

This report documents Accelerated Bridge Construction (ABC) techniques used to replace two I-190 bridges over Buffalo Avenue in Niagara Falls, NY. Each bridge was replaced over a 72-hour period. Innovative iCone technology used to detect traffic flow in the work zone indicated no significant backups or incidents during the replacement of the structures.

The report presents project details relevant to the HfL program, including innovative construction highlights, rapid superstructure demolition and replacement using precast modular deck beam technology, HfL performance metrics measurement, economic analysis, and lessons learned.

Under conventional construction methods, replacement of each structure would have taken three months and would have had considerable impacts to traffic. To reduce construction time, the project team built both substructure and superstructure concurrently. Modular deck beam units and precast approach slabs were cast at a nearby bridge staging area, while substructure work was being performed behind existing piers.

During the three-day closure period for removal and replacement, each bridge was demolished, precast units trucked to the jobsite, modular deck beam units installed, expanded polystyrene blocks placed as backfill behind abutments, approach slabs installed, precast units connected with closure pour concrete and parapets (barriers) cast and cured. Once each new bridge was in place, I-190 traffic that had been diverted onto the ramps was redirected to the mainline. Buffalo Avenue was closed for five weeks for the installation of the new bridges and for full-depth reconstruction to change its profile and correct the under-clearance deficiency at the bridges.

A user satisfaction survey, conducted once traffic was restored, showed that over 88 percent of the respondents were satisfied with the ABC techniques used on the project to expedite construction.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

This HfL project is located in the City of Niagara Falls on the Niagara Expressway section of the Interstate 190 (I-190) corridor connecting Grand Island and the Lewiston-Queenston border crossing to Canada. It is located immediately north of the Grand Island bridges and about six miles south of the border crossing. Figure 1 shows the Niagara Falls area in the vicinity of the border with Canada and the project's location on I-190. This segment of I-190 serves as an important and valuable trade corridor, carrying 45,000 vehicles per day with 17% trucks.

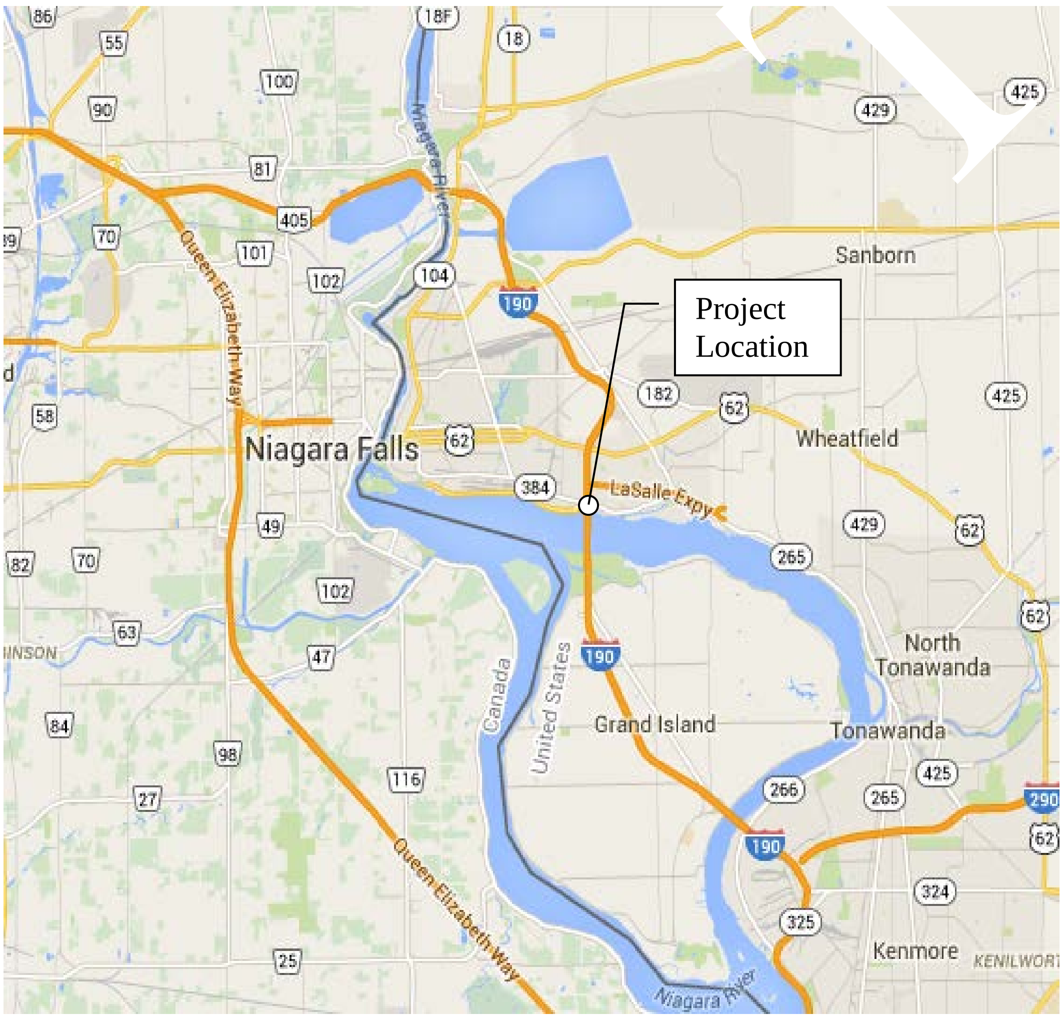

Figure 1. Map. Project location.

The scope of the project was to replace two bridges that carry I-190 in the northbound and southbound direction over Buffalo Avenue (Route 384). Each bridge carries two lanes of traffic, while the northbound structure also carries a deceleration lane for the exit to the LaSalle Expressway. Both bridges were originally three–span structures constructed in 1964 and had reached advanced stages of deterioration. The structures required full deck replacements and repairs to the bridge abutments, pier columns and pier caps. Additionally, the superstructures required repair of the ends of girders that had corroded, relocation of the diaphragms between the girders, and repainting of the entire superstructure.

NYSDOT considered alternatives for both rehabilitation and replacement. The rehabilitation alternatives were dismissed because, while they would have eliminated the structural deficiencies, they would have neither addressed the nonstandard vertical clearance over Buffalo Avenue nor the nonstandard stopping sight distance (SSD) on I-190. The alternatives would have also retained the fatigue-prone partial cover plate details and the potential for out-of-plane bending due to staggered configuration of the diaphragms.

Once the agency made the decision to replace the structures, the project team focused on how to reduce construction time because work zones impact travel time and cause delays, and their presence increases the potential for crashes and the attendant injuries/fatalities. NYSDOT estimated that conventional techniques would impact travelers on I-190 in each direction for about 90 days for each bridge replacement. However, the impact would be reduced to just three days, if ABC techniques using precast modular deck beam bridge elements were used.

NYSDOT decided to use ABC to compress construction time, minimize traffic impacts, improve worker/road user safety, and advance ABC knowledge in the State.

The innovative modular deck beam method would include the complete removal of the existing three-span, simply supported bridges and replace them with two single-span, prefabricated bridge systems. Abutments for the new bridges would be built directly behind existing piers, allowing for accelerated superstructure replacement with minimal delays to traffic. The vertical clearance would be increased to standard by lowering and reconstructing Buffalo Avenue in the vicinity of the bridge.

NYSDOT applied for, and successfully obtained, $1.407 million in HfL funding.

The project was constructed in three stages:

Stage A – Existing bridge remains in service.
Stage B – During weekend, bridge is closed and I-190 traffic is diverted.
Stage C – After new bridge is open to traffic.

During Stage A, after utility relocations, the substructure units were built behind the two existing piers and in front of the existing abutments, and the superstructure units and approach slabs were cast at a yard less than one-half mile away from the project site. Besides casting, the staging area allowed the contractor to fabricate the units in the yard on simulated abutments, ensure proper camber and fit of modular elements, and make adjustments as needed.

During Stage B, I-190 traffic was required to exit and re-enter at Exit 21 ramps using exiting and new temporary detour ramps. The northbound (NB) Bridge was closed to traffic and detoured onto the ramps from September 25-28, and the southbound (SB) Bridge from October 2-5, 2014. These closure periods, primarily weekends, were carefully chosen to minimize impacts to the travelers. Exit 21 was closed for exit and entry traffic, as was Buffalo Avenue between 63rd Street and 65th Street.

During the closure period, the contractor removed the existing superstructure, removed portions of existing pier cap beams that could infringe on installation of the new superstructure, and removed portions of existing abutments and existing approach slabs to allow for placement of new approach slabs. The contractor also loaded, transported, and installed fascia and interior modular deck beam units; placed expanded polystyrene blocks as backfill behind abutments; placed precast approach slabs; and connected the modular units with high early-strength concrete closure pours.

During the traffic diversion onto the ramps, NYSDOT used iCone technology to monitor traffic flow. Speed data obtained from the iCones were used to interpret queuing and/or incidents affecting mobility at the project location. The project team used existing traffic cameras in the project area and speed thresholds to adjust messages on the Variable Message Signs located upstream of the work zone on I-190.

Actual experience showed that project construction did not cause any significant backups on I-190, and it also validated traffic modeling used for traffic flow.

During Stage C, the contractor reconstructed and lowered Buffalo Avenue to correct the under-clearance deficiency.

Buffalo Avenue opened to traffic on October 31, 2014, five weeks after the roadway's closure on September 23, 2014.

Finally, all project-related work is expected to be completed by December 31, 2014.

DATA COLLECTION

Safety, construction congestion, quality, and user satisfaction data were collected to demonstrate how the use of innovative features at this interchange helped achieve the HfL performance goals in these areas.

The HfL performance goals for safety include worker and motorist safety during construction. During the construction of the I-190 over Buffalo Avenue project, there were two incidents (injuries) on the project. One involved a fall injury to a laborer which happened within the fabrication yard and one involved a burn injury to a construction inspector on the job site during the pier installation. There were no injuries during the 72-hour diversion period.

Also from a safety perspective, after analyzing crash experience at the site, it was projected that by reducing the construction time, approximately two crashes were avoided. Additionally, with the increase in overhead clearance on Buffalo Avenue to standard, there is less risk of the bridges being hit by vehicles in the future. The new structures, however, are not expected to reduce the fatalities/injuries rate on I-190 in the future, because both alignment and stopping sight distance post-project completion will be the same as they were before the start of the project.

NYSDOT estimated that traditional construction for the bridge portion of the project would have impacted traffic using I-190 for a three-month period for each bridge, and for Buffalo Avenue traffic, approximately six additional months due to the diversion of I-190 traffic down to and across it. However, using the innovative option, each existing bridge was replaced over a period of three days, or in about 3% of the time traditional construction would have taken. The agency easily surpassed the HfL goal of 50%.

Buffalo Avenue was closed to vehicular traffic for five weeks, from September 23 to October 31, 2014, to build both bridges and reconstruct the avenue from 63rd Street and 65th Street as well. This same scope of work would have taken well over seven months under traditional construction. Therefore, Buffalo Avenue users were inconvenienced for only a small fraction of the time, less than 25%, of traditional construction; again exceeding the HfL goal of 50 percent.

NYSDOT's analysis showed that the trip time through the work zones would increase from a preconstruction time of 55 seconds to 103 seconds, an increase of 48 seconds due to lowered speeds and diversion onto ramps. However, by implementing the innovative option, this increase was in effect for only three days versus 90 days for conventional construction. The increase in trip time over the 72-hour ABC period, through computations shown in this document, was limited to approximately 3% of the aggregate travel time for conventional construction methods, beating the HfL goal of no more than a 10% increase in trip time.

The project also exceeded the HfL queue-length goals for urban/rural areas, as there was no queuing on this project.

In addition to the safety-related benefits and reduced traffic impacts, building the bridge superstructure modules in a yard located away from traffic enabled easy construction access, improved quality and quality control, and avoided traffic-induced vibration effects on the structure. New deck surfaces on both bridges and Buffalo Avenue provide smoother ride to motorists as well.

The project team performed a post-construction survey on the project, which was completed by 34 people who provided favorable (very satisfied or satisfied) ratings to many aspects of the project. Overall, 88.2% of the respondents gave a favorable rating on how the project was built off site and erected over separate weekends in September and October to minimize disruption to traffic. 73.5% were satisfied with how traffic disruptions were minimized during construction for travel on I-190 and 41.2% on how disruptions were minimized on Buffalo Avenue. The lower satisfaction probably reflects the closure of Buffalo Avenue for five weeks to reconstruct it using conventional techniques.

ECONOMIC ANALYSIS

The benefits and costs of this innovative project approach were compared with the costs expected using the traditional approach. During project planning, NYSDOT estimated that the construction cost using traditional construction would be $8.025 million and the cost of building the bridge using the faster modular deck beam technology would be $7.749 million for the same scope of work, resulting in a savings of $0.276 million. NYSDOT also computed user delay costs for both options. Again, the costs were lower for the innovative option by $2.279 million. Therefore, when bundled together, there was an estimated total saving of 2.555 million using the innovative option, about 33 percent of the $7.743 million low bid on the project.

LESSONS LEARNED

- The closure period for the demolition and replacement of the structures was tight but adequate.
- Modular deck beam technology worked well. Construction of "simulated" abutments in the staging area avoided problems related to fitting at the jobsite.
- Use of expanded polystyrene material as backfill worked well. However, improved planning and coordination between the contractor and fabricator could have reduced the need to cut blocks at project site.
- Pouring of the concrete for the parapet at the jobsite worked well and avoided the need for transporting and installing these heavy items.
- Use of iCone technology for monitoring traffic flow was effective. However, consider acquisition, installation, data reporting and maintenance of units as a contract pay item. NYSDOT was disappointed in the battery longevity of the iCone units. This created a reliability issue during the 72-hour diversions. This may not be as significant an issue in warm weather climates.
- Public outreach efforts and pre-event and during-event communications with stakeholders were effective.
- There were several challenges that arose from precasting the deck beam units onsite. It was challenging at times to coordinate the drawing review, revisions, precaster, contractor and inspection staff resulting in need for additional resources. Some of these problems resulted in construction delays. NYSDOT believes that the success of onsite precasting would be very situational and contractor dependent.

PUBLIC INVOLVEMENT

NYSDOT's efforts to effectively communicate and minimize impacts on local businesses and neighborhoods due to construction were also rewarded. In a survey of stakeholders, 76.5% of the respondents were very satisfied or satisfied with the agency's public outreach and advisory notices and more than half, 57.6%, provided favorable responses on the agency's efforts to minimize disruptions in access to local businesses and neighborhoods.

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 with careful planning, use of ABC technologies during bridge construction can result in projects that serve as watershed events in the way they are delivered to the public. A post-construction stakeholder survey clearly indicated that local residents, businesses, and commuters did not experience major delays as a result of the bridge work and were satisfied with both the ABC approach to the project and the agency's efforts to minimize disruption.

Because of the success of this project, the New York State DOT plans to consider modular deck beam technology as a viable tool in its accelerated bridge replacement toolkit on all future projects.

PROJECT DETAILS

BACKGROUND

In the previous chapter, figure 1 showed the location of the project in reference to the U.S.-Canadian border and Grand Island, NY. Figure 2 is a close-up of the project area and shows the project's location over Buffalo Avenue.

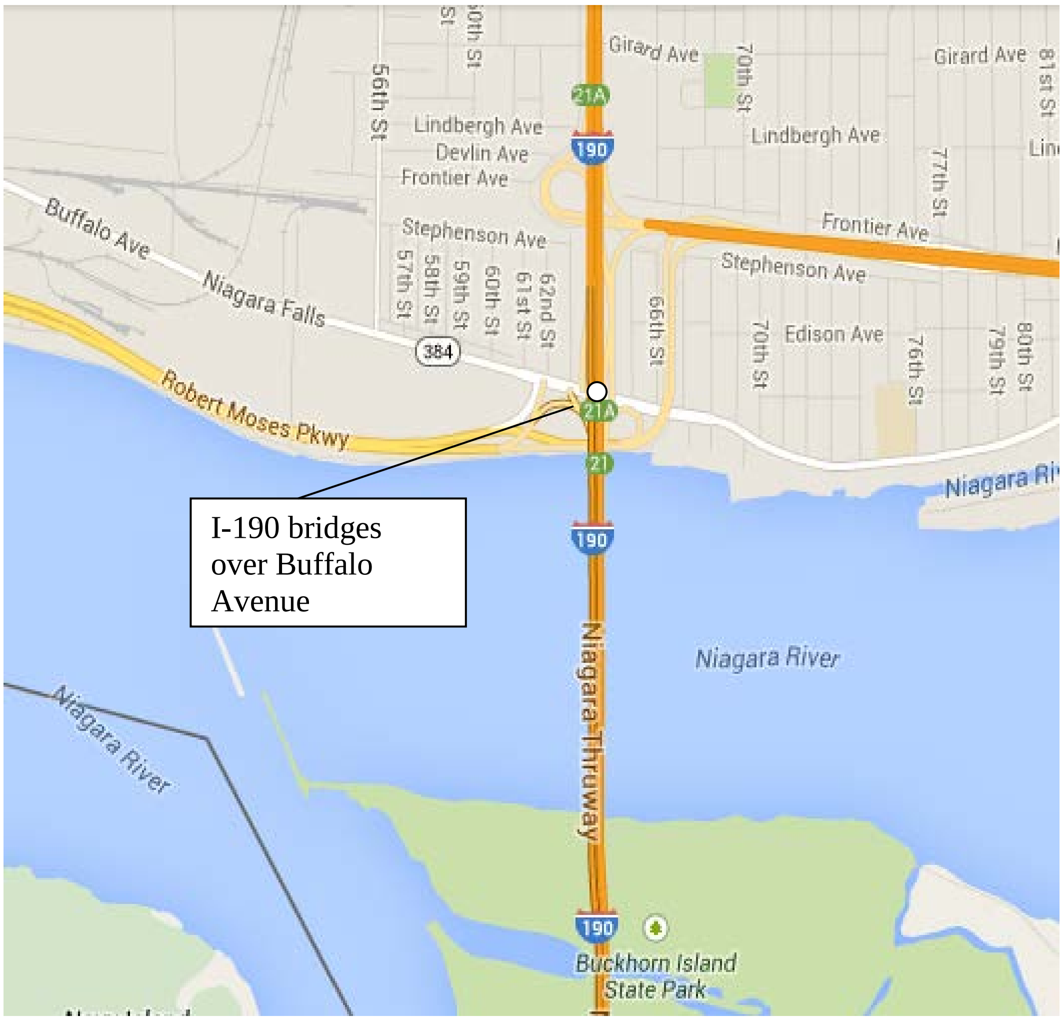

Figure 2. Map. Bridge project location over Buffalo Avenue.

The scope of the project was to replace two bridges that carry I-190 in the northbound and southbound direction over Buffalo Avenue. Each bridge carries two lanes of traffic, while the northbound structure also carries a deceleration lane for the exit to the LaSalle Expressway. Both bridges were originally three–span structures constructed in 1964 and had reached advanced stages of deterioration, as evidenced in figures 3-6. Figure 3 shows the condition of the deck surface with patched areas and spalls, and figure 4 provides an elevation view of the two bridges. Both bridges had substandard underclearance per current standards.

The abutments and piers on both bridges showed numerous cracks, spalled surfaces, and exposed rebars, as evidenced in figure 5, with substantial deterioration in bridge seat areas, as shown in figure 6. The superstructure also showed advanced deterioration, with girders under the joints showing substantial section loss due to corrosion, as shown in figure 7. In summary, deterioration of concrete pedestals, bridge bearing assemblies, and steel girder ends caused by leaking bridge joint systems required full deck replacement and repairs to substructure elements. Required superstructure work included repair of structure ends, relocation of diaphragms, and re-painting.

Figure 3. Photo. View of deck over end joint showing patched cracks and spalls.

Figure 4. Photo. Elevation view of bridges with substandard underclearance.

Figure 5. Photo. Delamination and spalling at pier columns and cap.

Figure 6. Photo. Cracked concrete under bridge seat.

Figure 7. Photo. Severe section loss at end of girders.

Two feasible replacement alternatives were considered. The first alternative would address all substandard features, and the second alternative would retain the nonstandard SSD feature. After considering the accident rate at the location, the fact that the SSD was not a factor in the crashes, and the cost of $2.19 million to mitigate the SSD deficiency, NYSDOT went with the second alternative.

NYSDOT estimated daily user cost at this location to be $12,831 for travelers on I-190 and $14,723 for travelers on Buffalo Avenue and Robert Moses State Parkway due to the detours. Therefore, any reduction in construction time would have a substantial payoff in reduced impact on travelers and user delay costs. These benefits, along with the reduced risk to both workers and travelers of an abbreviated work zone presence, were major contributing factors in the agency’s decision to use ABC technology for this project.

PROJECT ENGINEERING

NYSDOT considered the use of a pre-engineered, standard, precast deck system. The project team examined using precast concrete deck double tees, northeast extreme tee (NEXT) beams, that the agency had used in the accelerated replacement of I-84 bridges over Dingle Ridge Road in the eastern part of the state. However, this was determined impractical at this location because of the span length. Even with the 40-inch-deep beam, the deepest beam available, it would have required:

1. Lightweight concrete for the beam and concrete barrier. Lightweight concrete has a low modulus of elasticity. This results in camber in excess of 5 inches, making it difficult to control differential camber between units.
2. Seventy pre-stressing steel strands. Prestressed Concrete Institute (PCI) literature recommends using no more than 50 strands.
3. Conventional precast backwall, which would take time during a weekend installation time frame.
4. Larger cranes to ship and erect the heavier units.

NYSDOT chose a modular deck beam system consisting of decked steel beam modules. Prefabricated decked steel beam systems, such as "Inverset," have been used successfully by many States, and with the expiration of the patent for the Inverset system, variations of the system have also been used. A drawing of the modular deck beam system interior units is shown in figure 8. Each modular unit 2.214m (7'3") wide consists of two beams spaced 1.476m (4' 10") apart.

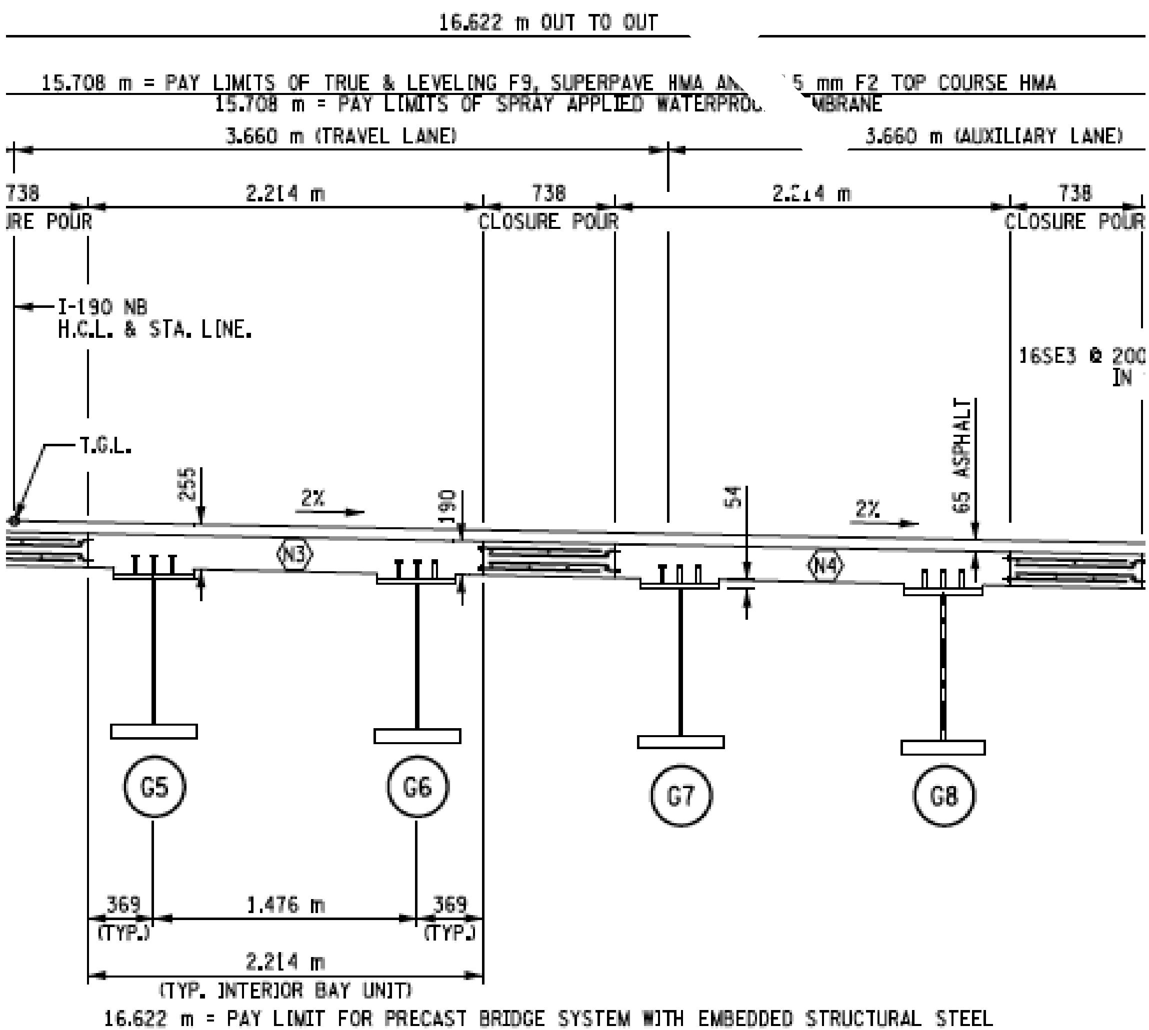

Figure 8. Diagram. Superstructure modular units.

The framing plan and the layout of the precast bridge system is shown in figure 9. The approach slab plan at one of the abutments is shown in figure 10, and closure pour reinforcement at abutment is shown in figure 11. The project designer's notes for the precast superstrucure are shown in figure 12.

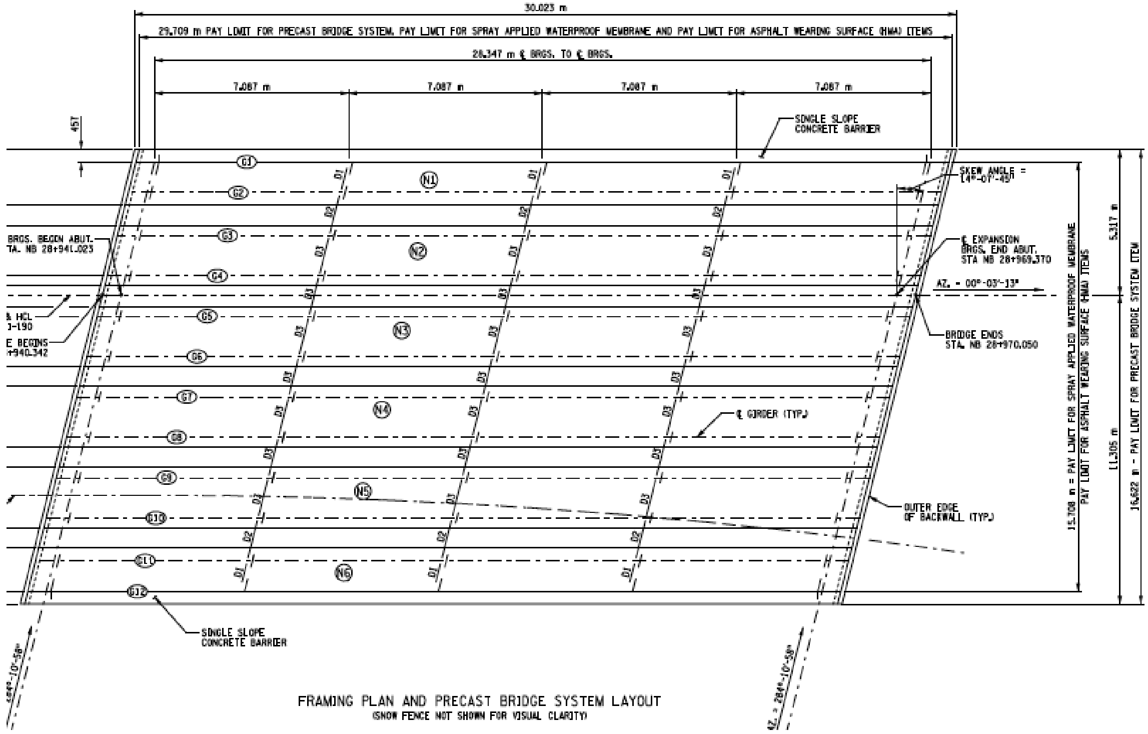

Figure 9. Drawing. Framing plan and precast bridge system layout.

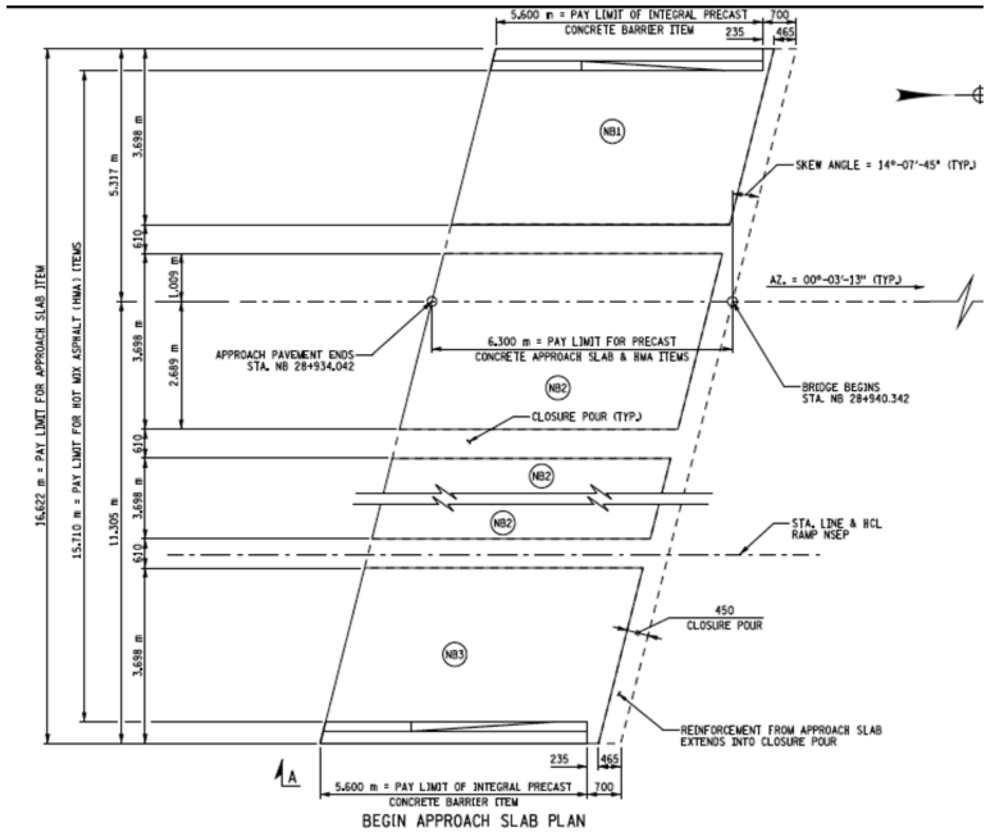

Figure 10. Drawing. Approach slab plan.

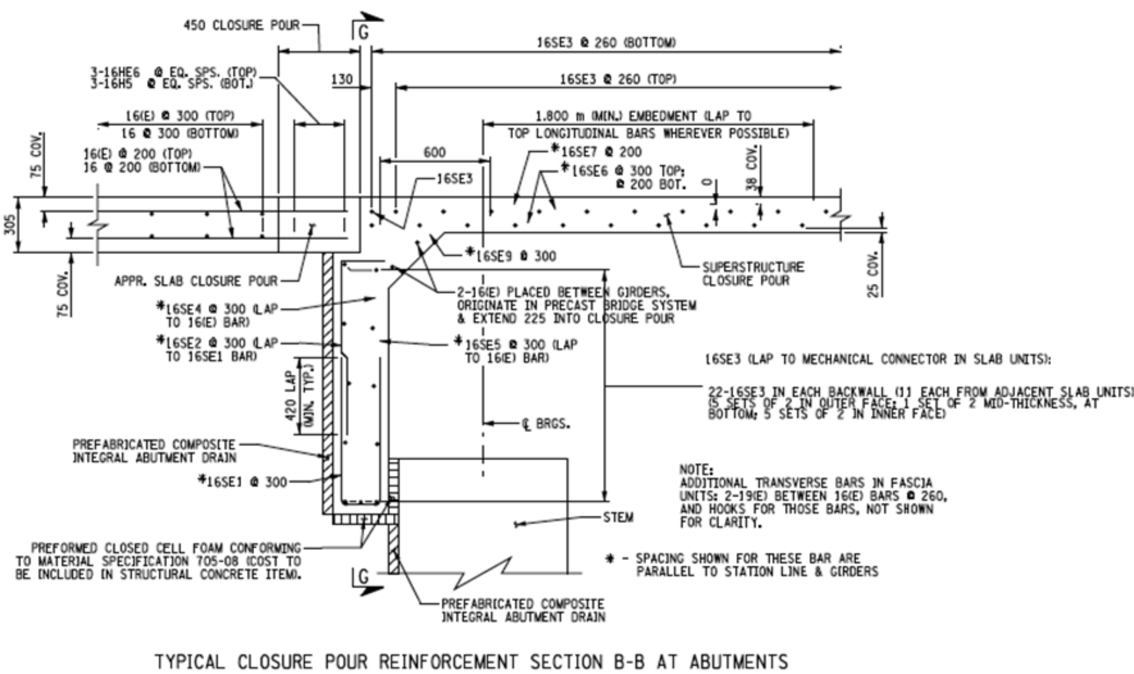

Figure 11. Drawing. Typical closure pour reinforcement at abutments.

A schematic of the foundation and abutment for the new bridge in relation to the existing bridge is shown in figure 13. Note that the abutment for the new bridge is between the abutment and pier of the existing bridge. Pertinent foundation notes are also shown.

Because piling for the new abutment was in close proximity to the piling for the existing structure, shown in figure 13, there was potential for interference between the micropiles and the old piling systems. The conflicts were, however, avoided because of the availability of drawings for the old structure.

The ABC method required that the abutment for the new bridge be constructed while the existing bridge remained in service and to backfill material behind the abutment as high as practicable to reduce the duration for the superstructure replacement. However, access for equipment to place normal granular backfill was a challenge because of the tight space, as shown in figure 13.

PRECAST BRIDGE SUPERSTRUCTURE NOTES:

CONCRETE IN THE DECK SLAB AND SEMI-INTEGRAL BACKWALLS SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH OF 35 MPa AT 28 DAYS. THE UNITS SHALL NOT BE HANDLED UNTIL CONCRETE STRENGTH REACHES A MINIMUM OF 21 MPa.

THE CONCRETE DECK SHALL BE POURED IN THE SHORED CONDITION ACCOUNTING FOR THE CAMBERS PROVIDED. THE SHORED CONDITION REQUIRES THAT THE STEEL DOES NOT DEFLECT UNTIL AFTER THE CONCRETE DECK REACHES A STRENGTH OF 21 MPa.

THE TOP SURFACE OF THE PRECAST BRIDGE SYSTEM UNITS, PRECAST APPROACH SLABS, AND CLOSURE POURS SHALL HAVE LONGITUDINAL TINE FINISH WITH A MAXIMUM SPACING OF 20 mm AND AMPLITUDE OF 5 mm.

ONCE THE BACKWALLS HAVE BEEN CAST, THE UNITS WILL NOT BE HANDLED AGAIN UNTIL THE BACKWALL CONCRETE HAS REACHED A MINIMUM STRENGTH OF 21 MPa.

SINGLE-SLOPE CONCRETE BARRIERS SHALL BE CAST ONTO THE FASCIA UNITS, UNDER SHORED CONDITIONS: EITHER AT THE FABRICATION PLANT OR AT THE PROJECT SITE, BUT PRIOR TO ERECTION OF THE FASCIA UNITS.

CLOSURE POUR CONCRETE BETWEEN PANELS SHALL REACH A MINIMUM COMPRESSIVE STRENGTH OF 17.5 MPa PRIOR TO THE APPLICATION OF: 1) THE WATERPROOF MEMBRANE AND 65 mm ASPHALT COURSE, AND; 2) LIVE LOAD.

ASTM A709M GRADE 345W STEEL SHALL BE USED AS STRUCTURAL STEEL.

HIGH STRENGTH BOLTS USED IN DIAPHRAGM CONNECTIONS SHALL BE ASTM A325M, TYPE 3.

ANY ADJUSTMENTS TO THE PRECAST BRIDGE UNIT LAYOUT OR CHANGES TO THE PRECAST UNIT GEOMETRY AS SHOWN ON THE PLANS SHALL BE SUBMITTED TO THE DCES FOR REVIEW.

STABILITY OF THE INDIVIDUAL PRECAST UNITS AND THE ENTIRE SUPERSTRUCTURE DURING INSTALLATION SHALL BE THE RESPONSIBILITY OF CONTRACTOR. THE INSTALLATION SEQUENCE SHALL BE SHOWN ON THE INSTALLATION DRAWINGS.

COST OF DIAPHRAGMS, CONNECTION PLATES, BEARING PLATES AND MISCELLANEOUS STEEL HARDWARE TO BE INCLUDED UNDER THE PRICE BID FOR ITEM 557.65010101.

TO ENSURE FULL AND EVEN BEARING BETWEEN BOTTOM OF BEAMS AND MASONRY PLATES, THE BOTTOM SURFACES OF BEAMS IN THE BEARING AREAS SHALL, WITHIN EACH PANEL, BE FABRICATED TO BE TRULY IN ONE PLANE.

ALL REINFORCEMENT SHALL HAVE A COVER OF 38 mm (TOP MAT) AND 25 mm (BOTTOM MAT) UNLESS SHOWN OTHERWISE. THE TOP BARS AND BOTTOM BARS IN THE DECK, AND TOP BARS IN THE APPROACH SLABS SHALL BE EPOXY COATED. NO CHAIRS, BOLSTERS OR OTHER SUPPORT DEVICES SHALL BE IN PLACE AGAINST THE BOTTOM SURFACE OF THE FORM (TOP OF DECK IN FIELD), IF CAST UPSIDE DOWN, DURING CASTING.

Figure 12. Drawing Notes. Precast bridge superstructure notes.

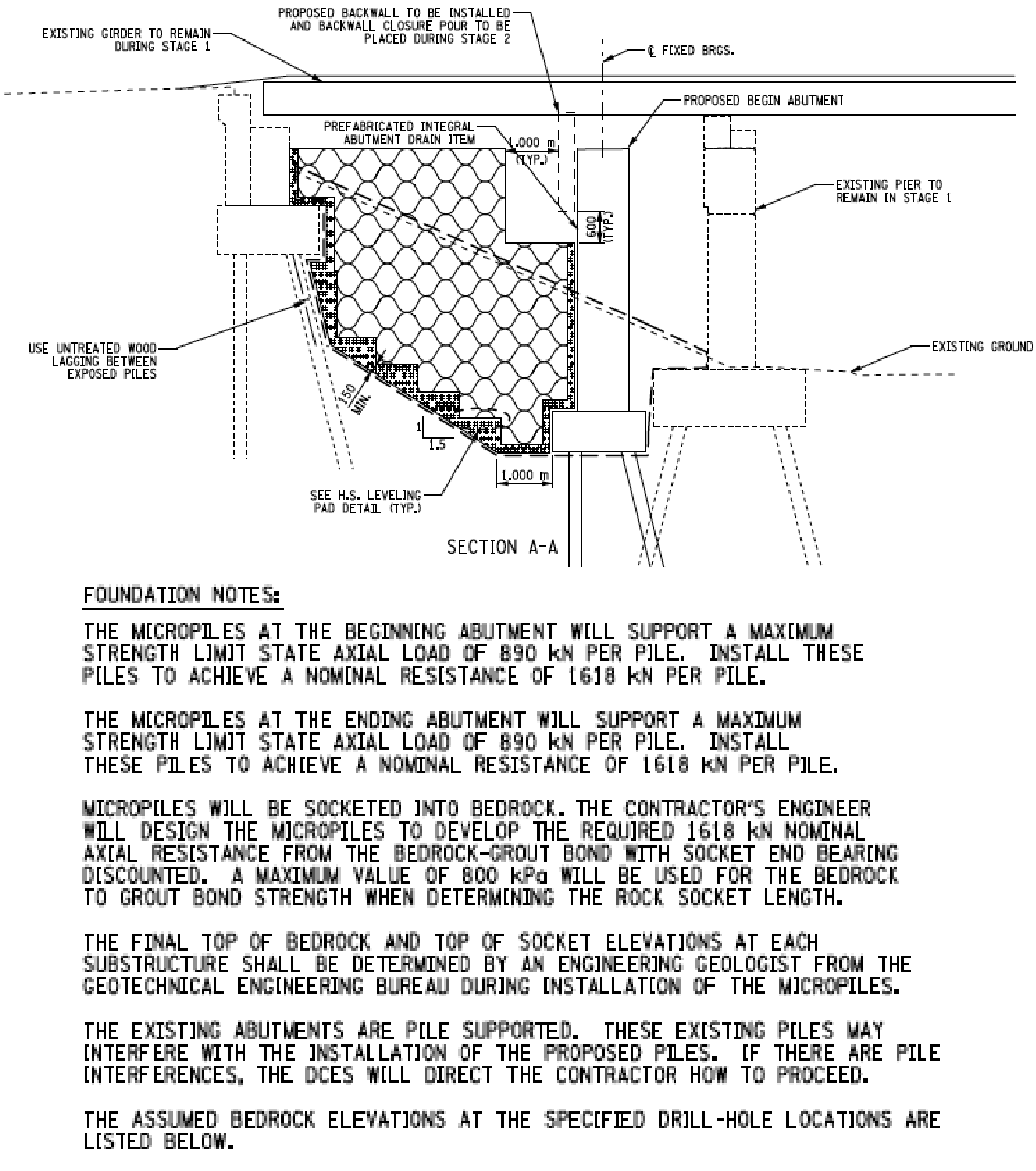

Figure 13. Drawing. Abutment location and foundation notes for new bridge.

The project designer opted to use expanded polystrene (EPS) blocks, or geofoam. EPS is durable, lightweight material, about one percent of the weight of usual backfill material. A typical block, 0.6m x 1.2m x 2.4m (2’ x 4’ x 8’), weighs about 36 kg (80 lbs) and can easily be handled and positioned into place by two workers; and the work can proceed quickly. The composition of the blocks allows for easy trimming or cutting into any shape with hot wire saws or power saws. Additionally, when properly designed as backfill, EPS blocks exert little or no lateral load on retaining structures, allowing for reduced sections. The special provision for EPS blocks is shown in Appendix A.

EPS blocks have been used successfully in locations with highly compressible soils and have shown little or no evidence of settlement or decay with time. NYSDOT is planning to use this technology on another project in the vicinity of this one.

PROJECT CONSTRUCTION

The project was constructed in three stages. Project details and construction progress were described with photographs that were made available to the public through the project's "I-190 Bridge over Buffalo Avenue" Facebook page.

Stage A – Existing bridge remains in service.
Stage B – During weekend, bridge is closed and I-190 traffic is diverted.
Stage C – After new bridge is open to traffic.

Stage A – Existing bridge remains in service.

During Stage A, while the existing bridge remained in service, the contractor excavated the area between the existing abutment and pier to make room for installation of micro-piles, new abutment footings, and the modular walls. The installation of micro-piles is shown in figure 14, the casting of footing and reinforcement for the stem of the abutment is shown in figure 15, and the completed abutment for the new structure without the backfill is shown in figure 16.

The size of the abutment is dependent on the backfill material, as some materials, such as expanded polystyrene blocks, exert little or no pressure on the stem. Note the tight working space between the footing of the existing pier and the abutment elements for the new structure in figure 17. Figure 18 shows modular T-walls in place and the space between the new and existing abutments filled with EPS blocks. This figure also shows cut portions of EPS blocks in the foreground. A photograph of a cut EPS block resting on standard size blocks already placed behind the new abutment is shown in figure 19.

The precast work for the superstructure was also performed during stage A. The contractor chose to precast superstructure elements and slabs at a yard less than one-half mile away from the project site. This allowed the contractor to fabricate the units in the yard on simulated abutments, ensure proper camber and fit of modular elements, and make adjustments as needed. Figure 20 shows beams being placed on "simulated" abutments cast in the yard. Figure 21 shows alignment adjustments being made in yard, figure 22 shows a worker correcting conflicts between rebars of adjacent modular units, and figure 23 shows a worker preparing barrier reinforcement for an end unit of a precast slab.

Figure 14. Photo. Installation of micropiles behind existing pier.

Figure 15. Photo. Construction of footings and reinforcement for abutment stems.

Figure 16. Photo. Completed abutment in place without backfill.


Figure 17. Photo. Tight space between existing and new units.

Figure 18. Photo. New abutment, modular walls, and space filled with EPS blocks.


Figure 19. Photo. Close-up of EPS block.

Figure 20. Photo. Steel beams being placed on simulated abutments in yard.


Figure 21. Photo. Making adjustments to cambers.

Figure 22. Photo. Correcting rebar conflicts between adjacent modular units.

Figure 23. Photo. Precast slab preparation in progress at yard.

Stage B – During I-190 closure.

During erection of the new bridges, I-190 traffic was required to exit and re-enter at Exit 21 ramps using exiting and new temporary detour ramps. Detours were in effect for I-190 NB travelers from September 25-28 and for SB travelers from October 2-5, 2014. These closure periods, which included weekends, were carefully chosen to minimize impacts to travelers. Exit 21 was closed for exit and entry traffic, as was Buffalo Avenue between 63rd Street and 65th Street. Detours were posted for the affected travelers. NYSDOT also prepared a toolkit with easy-to-read detour information to help businesses and communities navigate during the closures.

The contractor performed the following activities during the closure periods:

- Removed existing superstructure, removed portions of existing pier cap beams that would infringe on installation of the new superstructure, and removed portions of existing abutments and existing approach slabs to allow for placement of new approach slabs. Figure 24 shows demolition in progress.

- Loaded, transported, and installed fascia and interior modular deck beam units on bolsters and bearings on abutment stems. Figure 25 shows the fascia modular deck beam unit being loaded at the precast yard, figure 26 shows the interior modular unit being loaded, figure 27 shows units being placed on the new abutments, and figure 28 provides a close-up view of the units resting on the bearings.

- Erected the remaining portions of the modular T-walls using EPS blocks as fill material. Figure 29 shows modular T-wall construction, and figure 30 provides an elevation view of the in-place modular wingwall, the abutment stem, and the modular deck beam end fascia unit. The initial plan was to cast the parapet with the fascia unit at the yard and transport it to the project site. The contractor opted instead to pour the concrete for the fascia unit at the project site, as shown in figure 31, and use steam and blankets for curing. The plan was to use concrete barrier in the shoulder if the parapet concrete did not reach minimum strength at the time of opening I-190 to traffic.

- Installed diaphragms between units and formed the underside of closure pours for deck. At the same time, workers placed 30-mil-thick, PVC geo-membrane on top of the EPS fill to protect it from contamination (figure 32) and overlaid it with crushed stone.

- Poured closure pours on the bridge deck (including backwall) using high early strength, ready-mix concrete (figure 33) and installed precast approach slabs (figure 34), completing their installation with closure pours as well. The underside of the approach slabs were subsequently grouted to ensure full support.

- Placed asphalt in approaches to the approach slabs while the bridge-related work was being performed.

I-190 was opened to traffic after the closure pour concrete had gained a minimum strength of 17.5MPa (2.5 kips per square inch).

During the traffic diversion onto the ramps, NYSDOT used iCone® technology to monitor traffic flow. The iCone shown in figure 35 is a channelizing traffic barrel equipped with a radar gun, GPS antenna, cellular modem and a battery. The iCone relays data to a website (www.iconetraffic.com) where current traffic conditions can be viewed and monitored by the region's Traffic Operations Center (TOC).

Speed data obtained from the iCones can be used to interpret queuing and/or incidents affecting mobility at the project location. Traffic modeling during design of this project indicated that work zone travel speeds would operate at approximately 29 mph during construction. The project team used existing traffic cameras in the project area and speed thresholds to adjust the message on the Variable Message Signs located upstream of the work zone on I-190.

Actual experience during project construction showed no significant backups caused to I-190 traffic and validated the traffic modeling.

Figure 24. Photo. Demolition of existing structure.

Figure 25. Photo. Loading of modular deck beam fascia unit.

Figure 26. Photo. Loading of modular deck beam interior unit.

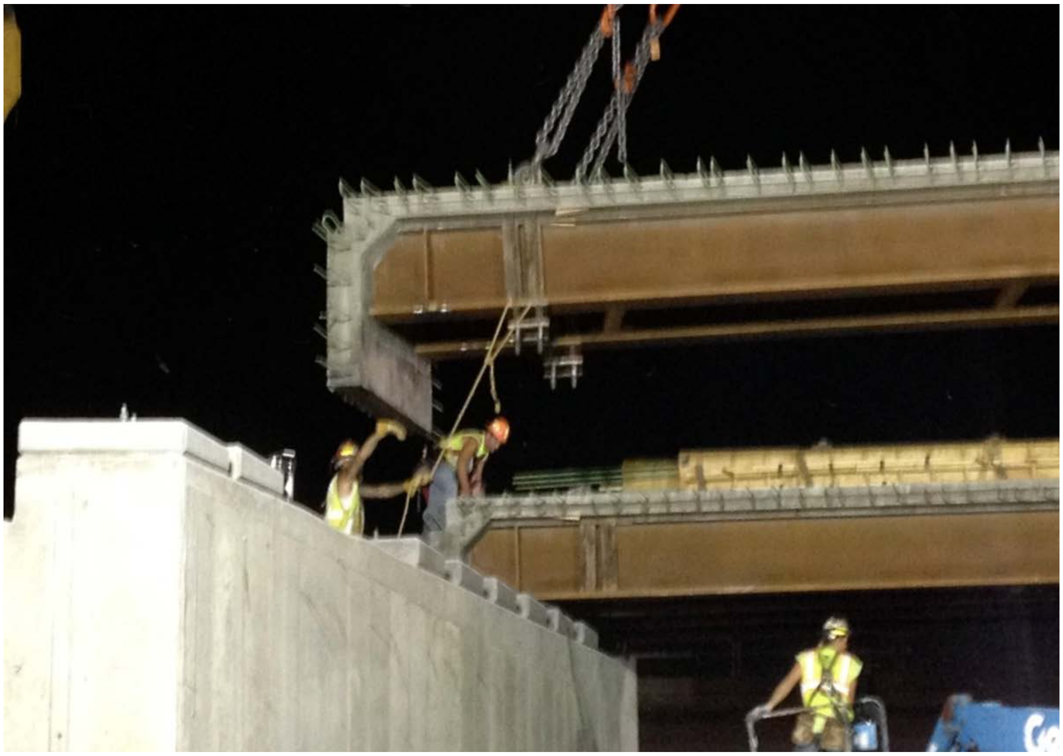
Figure 27. Photo. Modular deck units being installed.

Figure 28. Photo. Close-up of deck beams resting on bearings.

Figure 29. Photo. Modular T-wall construction and backfill installation.

Figure 30. Photo. View of modular deck units, abutment stem, and modular wall.

Figure 31. Photo. Concrete being poured in parapet.

Figure 32. Photo. View of geo-membrane placed on top of abutment fill.

Figure 33. Photo. Deck closure pour in progress.

Figure 34. Photo. End approach slab unit installation.

Figure 35. Photo. The iCone® traffic barrel measures speed of diverted traffic.

Stage C – After new bridge opens to traffic on I-190.

During Stage C, the contractor removed the remainder of the existing pier structure and concrete footings, finished the remainder of the miscellaneous bridge-related work, and concentrated on reconstruction and lowering of Buffalo Avenue from 63rd Street to 65th Street. Figure 36 shows subsurface reconstruction work in progress.

Buffalo Avenue opened to traffic on October 31, 2014, five weeks after its closure on September 23. All project-related work, including membrane and asphalt overlay placement over deck and approach slabs, is expected to be completed by December 31, 2014. Photographs of the virtually completed project are shown in figures 37 and 38. Figure 37 shows the completed bridges and Buffalo Avenue being used by motorists. Figure 38 is a view of I-190 with the Grand Island Bridges in the background showing all lanes in both NB and SB directions open to traffic.

Figure 36. Photo. Buffalo Avenue reconstruction under the new bridges.

Figure 37. Photo. Completed Buffalo Avenue open to traffic.

Figure 38. Photo. I-190 open to traffic

DATA ACQUISITION AND ANALYSIS

Data collection on the I-190 over Buffalo Avenue 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 support 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 modular deck beam technology used for this project provided several safety benefits. It enabled the superstructure and approach slab units to be fabricated off site, away from the high volumes of traffic on the interstate, and assembled at the project site. This improved the safety of the workers in the work zone as well as the safety of travelers using I-190 by not exposing them to typical work zone hazards. Also, work could be performed during the day and at night without interruptions throughout the construction process.

The HfL performance goals for safety include worker and motorist safety during construction. During the construction of the I-190 over Buffalo Avenue project, there were two incidents (injuries) on the project. One involved a fall injury to a laborer which happened within the fabrication yard and one involved a burn injury to a construction inspector on the job site during the pier installation. There were no injuries during the 72-hour diversion period.

NYSDOT uses a Construction Accident Recording System (CARP) to track work zone crashes. The most recent three years of historical data (2008-2010) for work zone crashes for the region was 2.1 crashes per year, per project, or 0.35 crashes per month, or 0.0117 crashes per day on a construction project. If conventional techniques had been used, replacing the superstructure for each bridge would have taken an estimated three months, resulting in a potential risk of:

- 0.35 (crashes/month) times 3 months = 1.05 crashes per bridge, or 2.10 crashes for both bridges.

Using the innovative approach, however, reduced potential risk to:

- 0.0117 (crashes/day) times 3 days = 0.035 crashes per bridge, or 0.07 crashes for both bridges.

Therefore: 2.10 minus 0.07 = an elimination of 2.03 potential crashes, or **2 crashes,** for both bridges using the innovative approach.

In summary, faster construction is calculated to have avoided two potential crashes. Furthermore, with the increase in overhead clearance on Buffalo Avenue to standard, there is less risk of the bridges being hit by vehicles in the future. The new structures, however, are not expected to impact safety on I-190 post completion, as both alignment and stopping sight distance will remain the same after the project is completed.

CONSTRUCTION CONGESTION

The HfL performance goal on construction congestion is a 50 percent reduction in the time highway users are impacted, compared to traditional construction.

NYSDOT estimated that traditional construction for the bridge portion of the project would have impacted traffic using I-190 for a period of three months for each bridge, and for Buffalo Avenue traffic, approximately six additional months due to the diversion of I-190 traffic down to and across it. However, using the innovative option, each existing bridge was replaced over a period of three days, or in about 3% of the time traditional construction would have taken. The agency easily surpassed the HfL goal of 50%.

Buffalo Avenue was closed to vehicular traffic for five weeks, from September 23 to October 31, 2014, to build both bridges and reconstruct Buffalo Avenue from 63rd Street and 65th Street. This same scope of work would have taken well over seven months under traditional construction. Therefore, users of Buffalo Avenue were inconvenienced for only a small fraction of the time, less than 25%, of traditional construction; again, exceeding the HfL goal of 50 percent.

There is also a trip time HfL goal: a less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling. The individual trip time data through the I-190 work zone for this project was as follows:

- Pre-construction (baseline) – 55 seconds
- During construction – 103 seconds (due to slower speeds and diversion)
- Increase in trip time due to construction: 48 seconds

The trip time data is summarized in Table 1. It shows that the total trip time increase of 144 seconds is only three percent of the total trip time of 4,950 seconds, beating the HfL goal of 10 percent.

Table 1. Trip time data comparison

Condition	Trip Time	Increase	Construction Duration	Total Travel Time	HfL 10% Goal	Total Increase in Trip Time
Pre-Construction	55 sec	-	90 days (conventional)	4,950 sec	495 sec	
Construction	103 sec	48 sec	3 days (innovative)	309 sec		144 sec

The HfL goal for queue length is a moving queue length of less than 1.5 miles in an urban area. Because there was no consistent queuing on the project due to construction, this goal was also positively exceeded.

QUALITY

Building the bridge superstructure in a yard, away from traffic, enabled easy construction access working at the ground level and avoided damage by traffic-induced vibrations. The controlled environment allowed longer concrete cure times, better material staging areas, and smoother assembly, all contributing to improved product quality.

This project involved bridge replacements that matched existing roadway grades on I-190. The only roadway work on I-190 was tying the new construction to the existing approach roadways. The new riding surfaces of the approaches and the new bridge deck, however, are a significant improvement over the surfaces of the old bridge. Also, the reconstructed Buffalo Avenue between 63rd and 65th Streets will provide a smoother riding surface to motorists.

USER SATISFACTION

(The following section reflects the User Satisfaction Survey Executive Summary provided by NYSDOT.)

After the I-190 over Buffalo Avenue bridge replacement project was complete, NYSDOT performed a public user's satisfaction survey. The purpose of the survey was to obtain feedback on the accelerated bridge construction techniques used to replace the I-190 structures. NYSDOT distributed the surveys door-to-door, via email, and via the project Facebook page.

Questions and Results

The survey was completed by 34 respondents. The results indicate that respondents were overwhelmingly satisfied or very satisfied with the project regarding the use of accelerated bridge construction techniques to minimize disruptions to the I-190 traffic. Respondents were less satisfied with overall disruptions on Buffalo Avenue (Questions 3, 4 and 5). However, more than 70% were not dissatisfied with the Buffalo Avenue disruptions. These responses are likely the result of the five-week closure of Buffalo Avenue and the I-190 ramps that access Buffalo Avenue. Below are the questions and summaries of the results:

1. How satisfied were you with the accelerated bridge construction technique used to replace the existing I-190 over Buffalo Avenue Bridge? The bridge was built off-site and moved into place over two separate weekends during September and October.

    a. 88.2 % Very Satisfied or Satisfied (67.6% Very Satisfied)

2. For traffic on I-190, how satisfied were you with the way traffic disruptions were minimized during the construction?

a. 73.5 % Very Satisfied or Satisfied (55.9% Very Satisfied)

3. As a motorist on Buffalo Avenue, how satisfied were you with the way traffic disruptions were minimized? Buffalo Avenue was closed for 5 weeks.

a. 41.2 % Very Satisfied or Satisfied (26.5% Very Satisfied); 70.6% including Neutrals

4. As a pedestrian on Buffalo Avenue, how satisfied were you with the way traffic disruptions were minimized? Buffalo Avenue was closed for 5 weeks.

a. 42.1 % Very Satisfied or Satisfied (42.1% Very Satisfied); 89.5% including Neutrals

5. For access to local businesses and neighborhoods, how satisfied were you with the way traffic disruptions were minimized during the construction?

a. 57.6 % Very Satisfied or Satisfied (33.3% Very Satisfied); 78.8% including Neutrals

6. How satisfied were you with NYSDOT's public outreach and advisory notices?

a. 76.5 % Very Satisfied or Satisfied (47.1% Very Satisfied)

The full survey with tables and charts is attached in Appendix B.

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 both the as-built project and the baseline case.

CONSTRUCTION TIME

Through the use of innovative construction technology, NYSDOT was able to dramatically reduce the impact of this project's construction on roadway users. Average Annual Daily Traffic (AADT) for this section of I-190 is 26,903 in the NB direction and 23,313 in the SB direction, with trucks accounting for 17% of the traffic in each direction.

The approach to managing traffic would have been the same for the conventional option as the innovative option. The principal difference is the amount of time to replace each bridge – 90 days for conventional construction versus three days for innovative construction.

In both construction techniques, the trip time through the work zones would have increased due to lowered speeds and diversion onto ramps from the preconstruction time of 55 seconds to 103 seconds, per NYSDOT's analysis. However, this increase was in effect for only three days for innovative construction, versus the 90 days that would have been needed for conventional construction.

The closure of Buffalo Avenue at I-190, Exit 21, also affected travel on Robert Moses State Parkway with AADT of 7,552, besides affecting travelers on Buffalo Avenue with AADT of 4,637 eastbound (EB) and 4,865 westbound (WB). As discussed in the Data Acquisition and Analysis section, the impact to travelers was for approximately five weeks using innovative construction compared to the more than seven months that conventional construction would have taken.

CONSTRUCTION COSTS

NYSDOT performed alternative analysis for two replacement and four rehabilitation alternatives. Costs for each feasible alternative were tabulated in the agency's Final Design Report. [1] These are shown in figure 39. Reviewing only the replacement options in this table, the traditional option (2B) and the innovative option (2C), the construction cost for the traditional option was projected to cost $10.215 million versus $7.576 million for the innovative option.

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[1] Final Design Report, Bridge Project P.I.N. 5051.10, BINS: 5039651 & 5039652, US Route I-190 over Buffalo Avenue, Niagara County, City of Niagara Falls, NY; USDOT FHWA and NYSDOT Report, April 2012.

However, the traditional option would have also included an amount of $2.190 million for correcting the SSD deficiency, which was retained in the innovative option.

April 2012 | Final Design Report | PIN 5051.10

		Exhibit 3.2.1.1-C Feasible Alternative Project Costs					
Activities		Alternate 2B (Million)	Alternate 2C (Million)	Alternate 3A (Million)	Alternate 3B (Million)	Alternate 3C (Million)	Alternate 3D (Million)
Construction Costs	Bridge[3]	$ 3.966	$ 4.145	$ 4.249	$ 5.605	$ 4.249	$ 5.582
	Highway	$ 0.515	$ 0.455	$ 0.635	$ 0.545	$ 0.635	$ 0.455
SSD Correction Cost[4]		$ 2.190	-	-	-	$ 2.190	-
VC Correction Cost[5]		$ 0.900	$ 0.820	-	-	-	$ 0.820
M&PT Cost		$ 1.183	$ 1.076	$ 1.049	$ 0.866	$ 1.137	$ 1.076
Wetland Mitigation		-	-	-	-	-	-
Storm Pollution Discharge Elimination System		$ 0.100	$ 0.100	$ 0.100	$ 0.100	$ 0.100	$ 0.100
Subtotal (2011)		$ 8.854	$ 6.596	$ 6.033	$ 7.116	$ 8.311	$ 8.033
Contingencies[1] (15% @ Design Approval)		$ 0.500	$ 0.500	$ 0.905	$ 1.067	$ 1.247	$ 1.205
Subtotal (2011)		$ 9.354	$ 7.046	$ 6.938	$ 8.183	$ 9.558	$ 9.238
Potential Field Change Order[2]		$ 0.468	$ 0.355	$ 0.347	$ 0.409	$ 0.478	$ 0.462
Subtotal (2011)		$ 9.822	$ 7.451	$ 7.285	$ 8.592	$ 10.036	$ 9.700
Mobilization (4%)		$ 0.393	$ 0.298	$ 0.291	$ 0.344	$ 0.401	$ 0.388
Construction Costs (2011)		**$ 10.215**	**$ 7.749**	**$ 7.576**	**$ 8.936**	**$ 10.437**	**$ 10.088**
Construction Inspection (2011)		$ 1.080	$ 0.540	$ 0.540	$ 0.540	$ 0.540	$ 0.540
ROW Costs (2011 Dollars)		-	-	-	-	-	-
Total Project Costs		**$ 11.295**	**$ 8.289**	**$ 8.116**	**$ 9.476**	**$ 10.977**	**$ 10.628**

1. NYSDOT recommends standard contingencies: 25% Scoping stage, 15% Design Approval stage, 5% Advanced Detail Plans stage. Contingency for the replacement alternatives – $0.500 M.
2. According to HDM Chapter 21 Section 21.3.9.4, EB 03-029 & EB 06-057.
3. Cost includes Pier Protection.
4. Cost for correction of non-standard Stopping Sight Distance on the I-190.
5. Cost for correction of non-standard vertical clearance over Buffalo Avenue.

Figure 39. Spreadsheet. Feasible alternative project costs.

Therefore, the cost savings due to the innovative option is estimated at:

$10.215 million – $7.749 million – $2.190 million, or $ 0.276 million

USER COSTS

User costs are defined as added vehicle operating costs and delay costs to highway users due to construction activity. These costs are incurred because of extra travel distance using detours and when motorists are delayed by congestion in the work zone, slowdown due to reduced lane width, and channeling of traffic. NYSDOT estimated that the total user delay costs for the conventional option would be $2.627 million and $0.348 million for the innovative option. Therefore the compressed construction timeframe for the innovative option would result in savings in user delay costs of $2.279 million.

Table 2 provides a summary of computed roadway user costs. Details of the user cost analysis are provided in Appendix C.

Table 2. Roadway user cost comparison

Condition	Location	Daily User Costs	Duration	Total User Costs
Conventional	I-190 Diversions	$12,831	90	$1,154,790
	Buffalo Avenue/Robert Moses Parkway Detours	$14,723	100	$1,472,330
			Total	**$2,627,120**
ABC	I-190 Diversions	$12,831	3	$38,493
	Buffalo Avenue/Robert Moses Parkway Detours	$14,723	21	$309,190
			Total	**$347,683**
User cost Savings through ABC Construction				**$2,279,437**

COST SUMMARY

The innovative option reduced construction cost by $0.276 million and it reduced user delay costs by $2.279 million. When bundled together, there was a total saving of 2.555 million. This represents about 33 percent of the $7.743 million low bid on the project.

REFERENCES

1. Final Design Report, Bridge Project P.I.N. 5051.10, BINS: 5039651 & 5039652, US Route I-190 over Buffalo Avenue, Niagara County, City of Niagara Falls, NY; USDOT FHWA and NYSDOT Report, April 2012.

ACKNOWLEDGMENTS

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ARA would like to also acknowledge the project team for successfully delivering this project and providing photographs and documentation:

- Owner: New York State Department of Transportation
- Designer: New York State Department of Transportation
- Contractor: Concrete Applied Technologies Corporation, CATCO.

APPENDIX A

ITEM 203.0395 17 - EXPANDED POLYSTYRENE FILL

Submit detailed manufacturing records for the tested blocks which clearly state, in part, the percentage, type (in-plant or post-consumer), and original density of any recycled EPS material (regrind) used in the molding process.

Basis of Acceptance

Each EPS block shall be labeled with the manufacturer's name, product type, lot number, date of manufacture and weight (as measured after seasoning and trimming). Unlabeled blocks will be rejected. The Contractor shall supply detailed manufacturing records of individual blocks if requested by the Engineer.

The Engineer will perform on-site density tests by weighing and measuring one block randomly chosen from each truckload or 75± cubic meters of EPS delivered to the project site. The Contractor shall provide a calibrated scale accurate to within 0.05 kg and with sufficient capacity for this purpose. Blocks shall be kept clean and dry prior to weighing. If any block does not meet the minimum density requirement, the sampled truckload or 75± cubic meter batch will be rejected by the Engineer.

EPS blocks that do not meet tolerances, or have side area surface damage of 20% or more or volume damage of 1% or more will be rejected.

The State reserves the right to take random samples from the project site (not to exceed 1 block per 285 cubic meters) for additional quality assurance testing. If testing yields unsatisfactory results the Contractor may be directed to remove and replace potentially defective EPS blocks at no additional cost to the State.

CONSTRUCTION DETAILS

General

Exercise care to prevent damage to the EPS during delivery, storage and construction. Protect the EPS blocks from (1) Organic solvents such as acetone, benzene, and paint thinner; (2) Petroleum based solvents such as gasoline and diesel fuel; (3) Open flames and (4) Prolonged exposure to sunlight (more than 30 days).

Provide a system of temporary weights or tie downs, approved by the Engineer, to anchor the EPS blocks if there is wind gust or flooding potential.

Do not drive or operate heavy machinery or place concentrated loads directly on the EPS blocks. EPS blocks damaged due to the Contractor's operations will be removed and replaced at no additional cost to the State.

Installation
Grade the leveling course within a tolerance of 13 mm in 3 meters. Place the EPS blocks as indicated on the plans. Fit blocks tight and flush against adjacent blocks on all sides. Avoid continuous vertical joints by laying blocks in a running bond pattern and orienting the long axis of the blocks in each successive layer perpendicular to the long axis of the blocks in the previous layer.

Trim the EPS blocks in the field where necessary with a portable hot wire device supplied by the manufacturer, or a handsaw, or an alternative cutting method approved by the Engineer.

METHOD OF MEASUREMENT

The quantity of Expanded Polystyrene fill is the number of cubic meters satisfactorily installed as measured in its final position.

BASIS OF PAYMENT

The unit price per cubic meter shall include the cost of labor, materials, incidentals, and equipment necessary to satisfactorily complete the work.

APPENDIX B

User Satisfaction Survey Results Summary

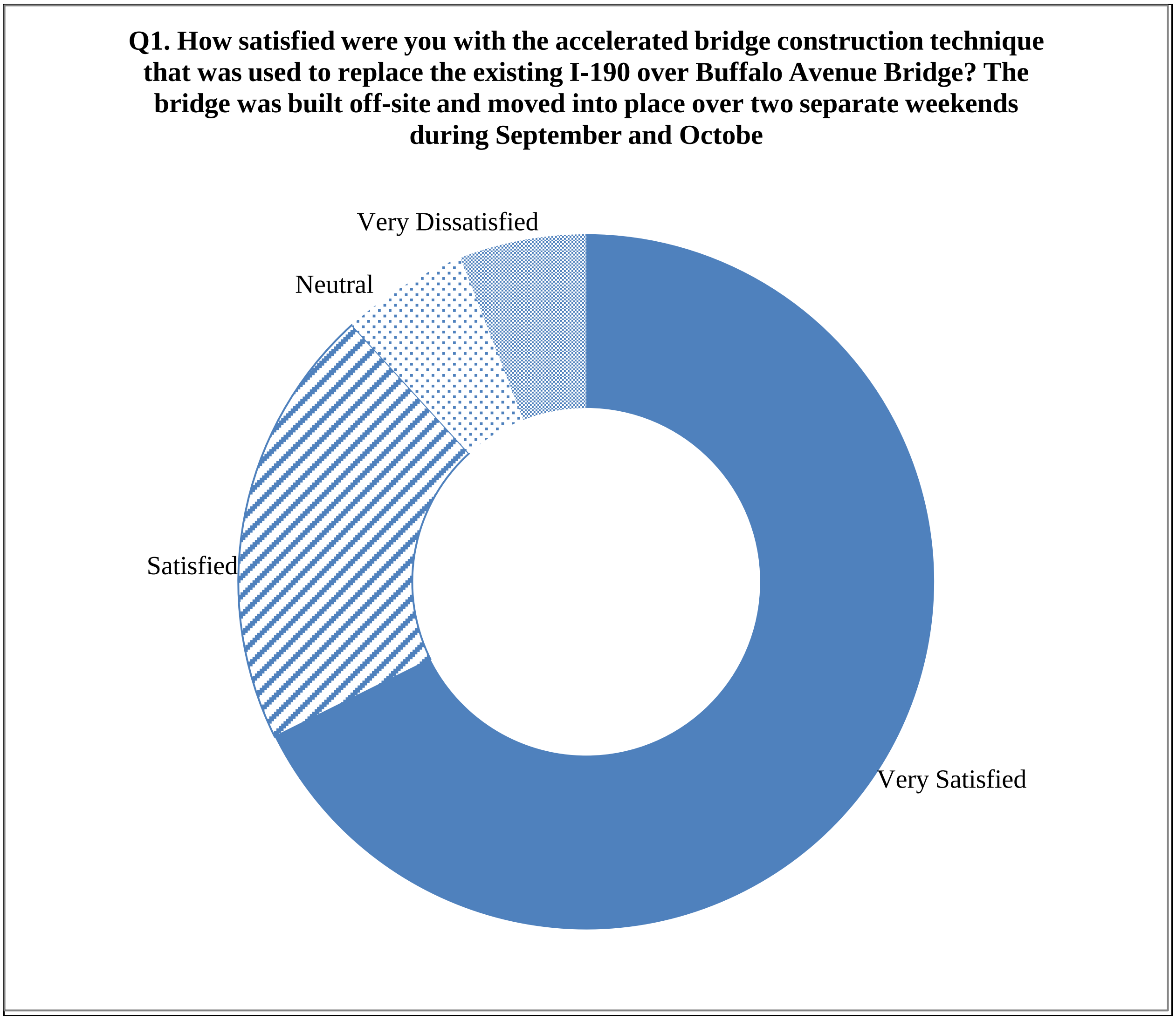

Figure 40. Chart. User satisfaction on the ABC technique.

Table 3. User satisfaction on the ABC technique.

Answer Choices	**Responses**	
	Number	Percent
Very Satisfied	23	67.65%
Satisfied	7	20.59%
Neutral	2	5.88%
Dissatisfied	0	0.00%
Very Dissatisfied	2	5.88%
Total	34	100%

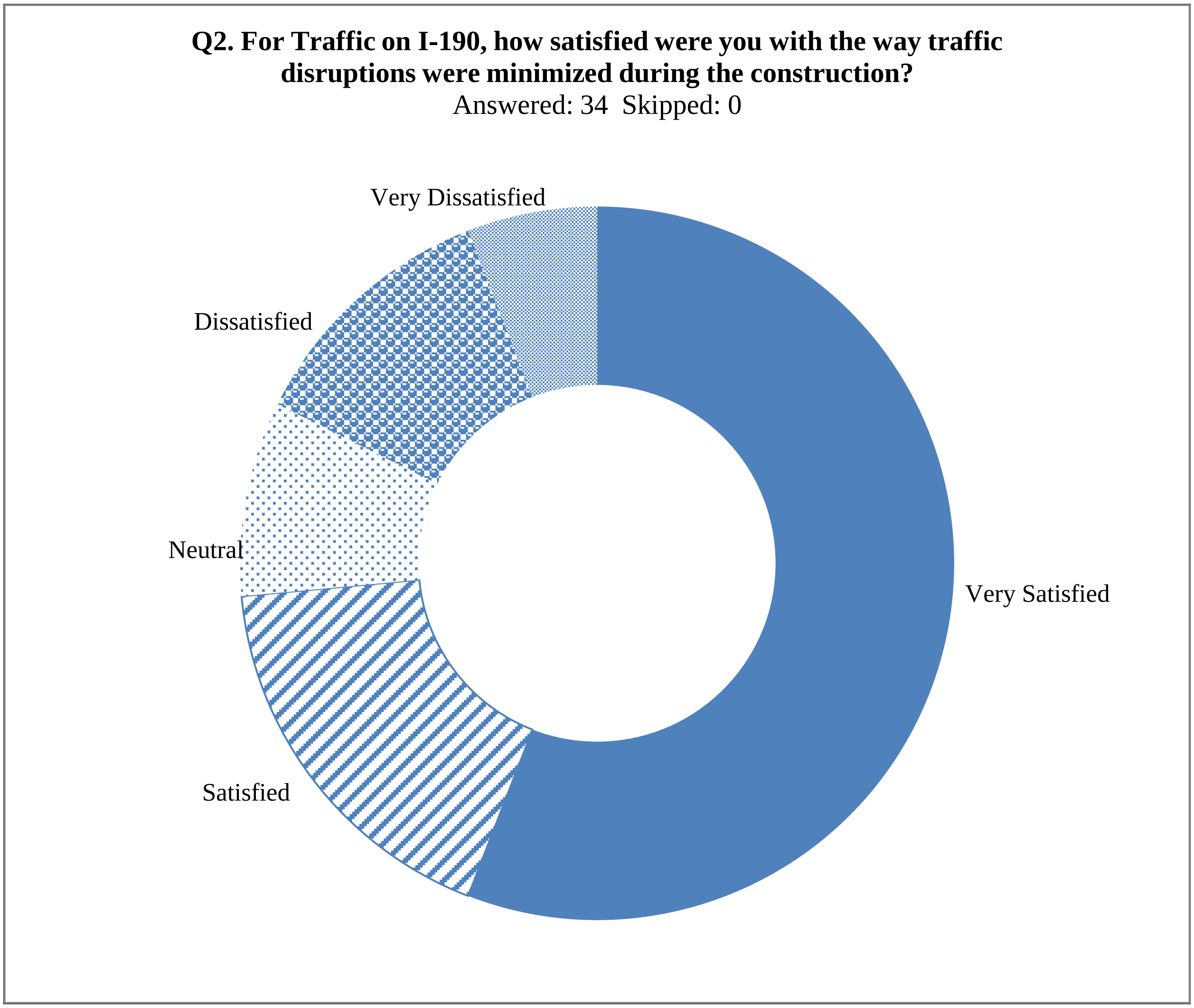

Figure 41. Chart. User satisfaction on minimization of traffic disruptions on I-190.

Table 4. User satisfaction on minimization of traffic disruptions on I-190.

Answer Choices	Responses	
	Number	Percent
Very Satisfied	19	55.88%
Satisfied	6	17.65%
Neutral	3	8.82%
Dissatisfied	4	11.76%
Very Dissatisfied	2	5.88%
Total	34	100%

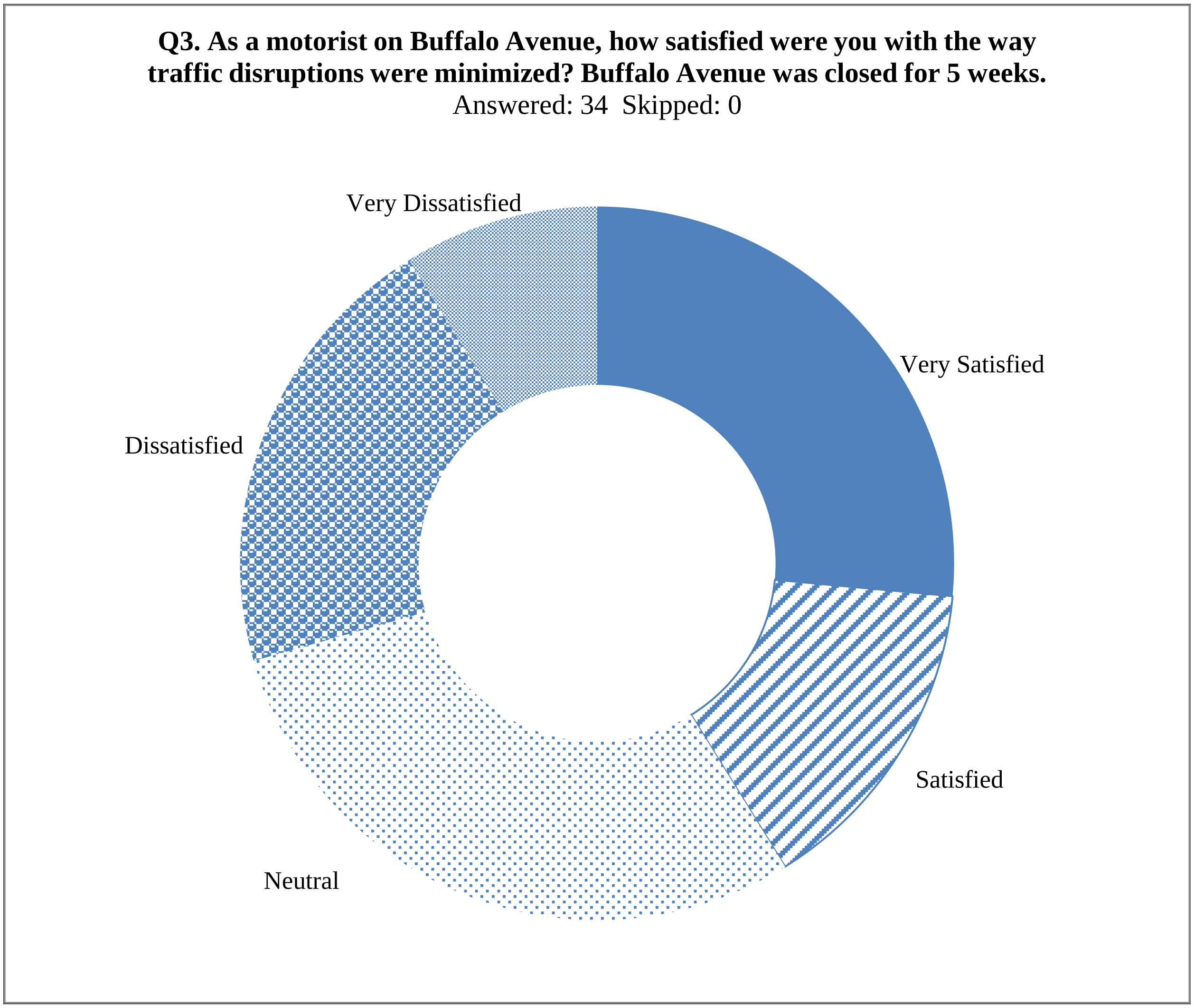

Figure 42. Chart. Motorist satisfaction on minimization of traffic disruptions on Buffalo Avenue.

Table 5. Motorist satisfaction on minimization of traffic disruptions on Buffalo Avenue.

Answer Choices	**Responses**	
	Number	Percent
Very Satisfied	9	26.47%
Satisfied	5	14.71%
Neutral	10	29.41%
Dissatisfied	7	20.59%
Very Dissatisfied	3	8.82%
Total	34	100%

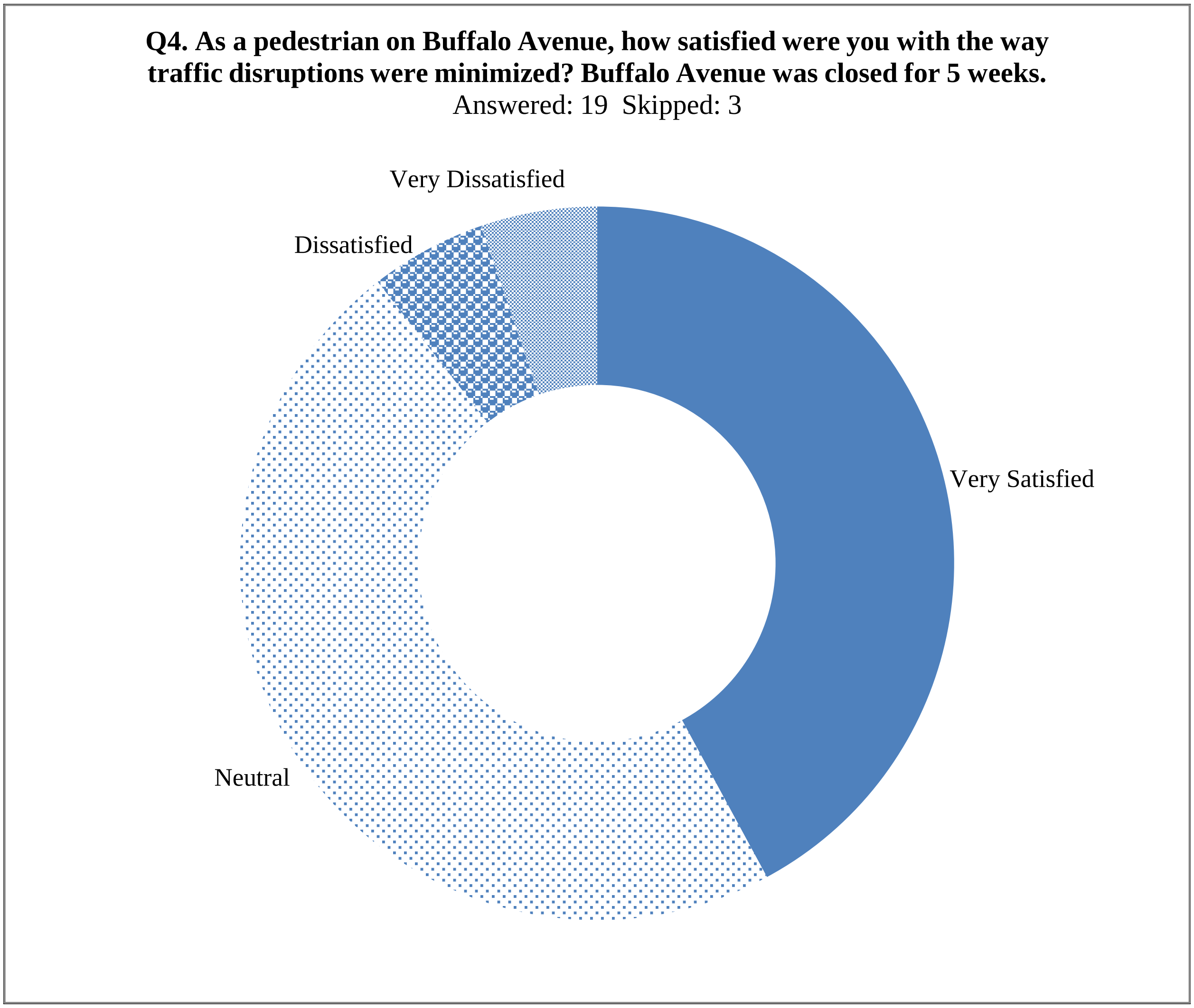

Figure 43. Chart. Pedestrian satisfaction on minimization of traffic disruptions on Buffalo Avenue.

Table 6. Pedestrian satisfaction on minimization of traffic disruptions on Buffalo Avenue.

Answer Choices	**Responses**	
	Number	Percent
Very Satisfied	8	42.11%
Satisfied	0	0.00%
Neutral	9	47.37%
Dissatisfied	1	5.26%
Very Dissatisfied	1	5.26%
Total	19	100%

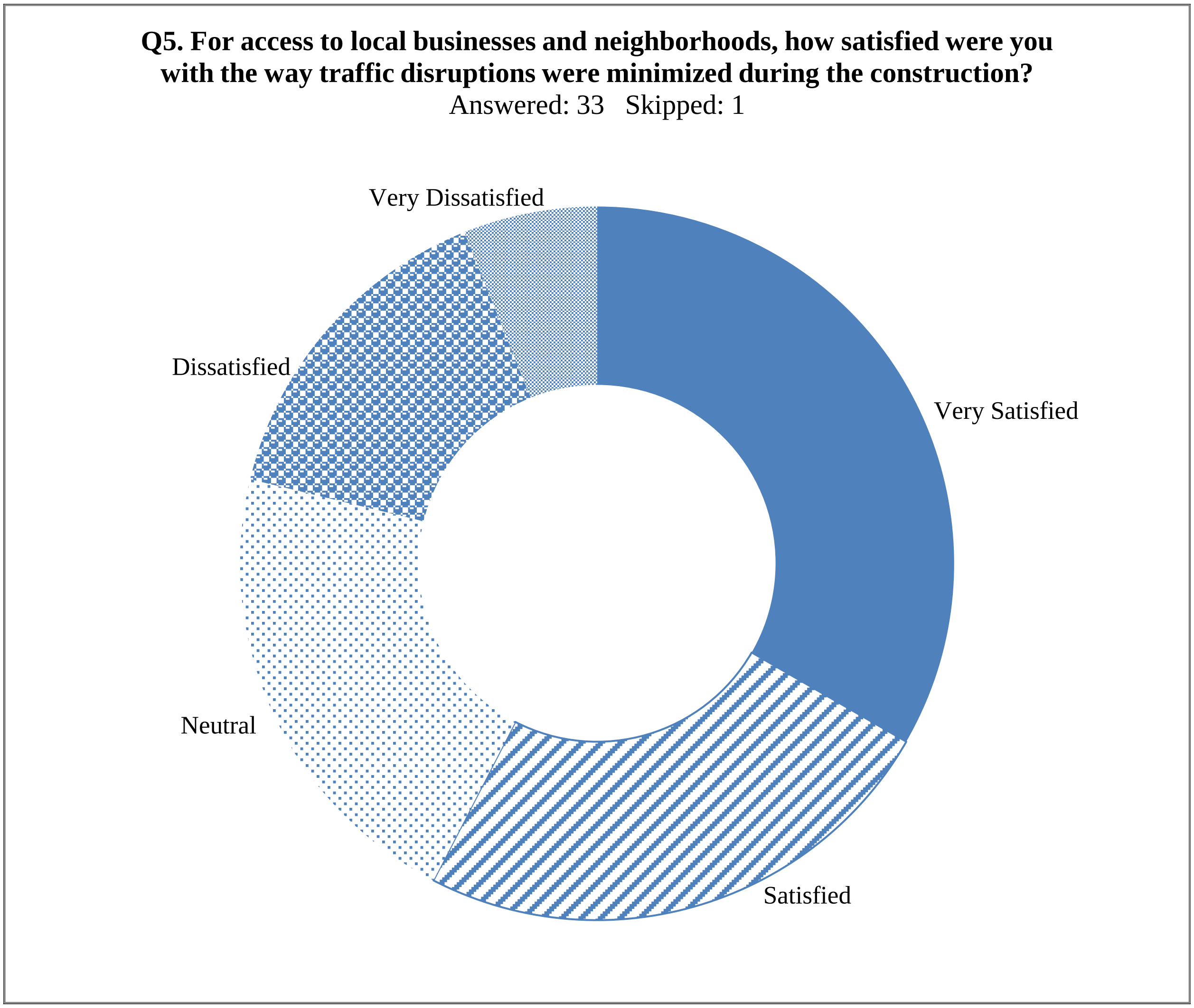

Figure 44. Chart. User satisfaction on access to local businesses and neighborhoods.

Table 7. User satisfaction on access to local businesses and neighborhoods.

Answer Choices	**Responses**	
	Number	Percent
Very Satisfied	11	33.33%
Satisfied	8	24.24%
Neutral	7	21.21%
Dissatisfied	5	15.15%
Very Dissatisfied	2	6.06%
Total	33	100%

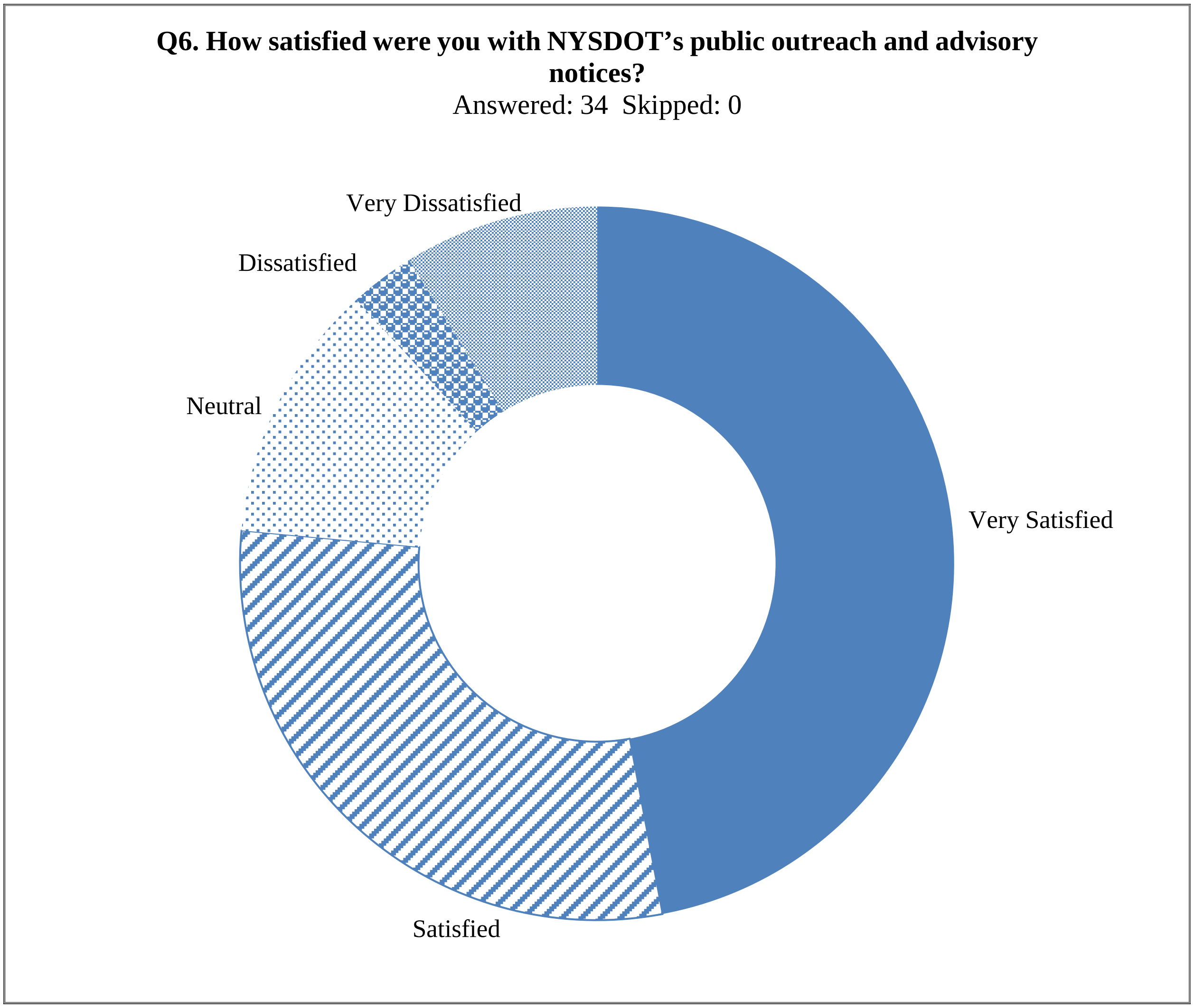

Figure 45. Chart. User satisfaction on NYSDOT's public outreach and advisory notices.

Table 8. User satisfaction on NYSDOT's public outreach and advisory notices.

Answer Choices	**Responses**	
	Number	Percent
Very Satisfied	16	47.06%
Satisfied	10	29.41%
Neutral	4	11.76%
Dissatisfied	1	2.94%
Very Dissatisfied	3	8.82%
Total	34	100%

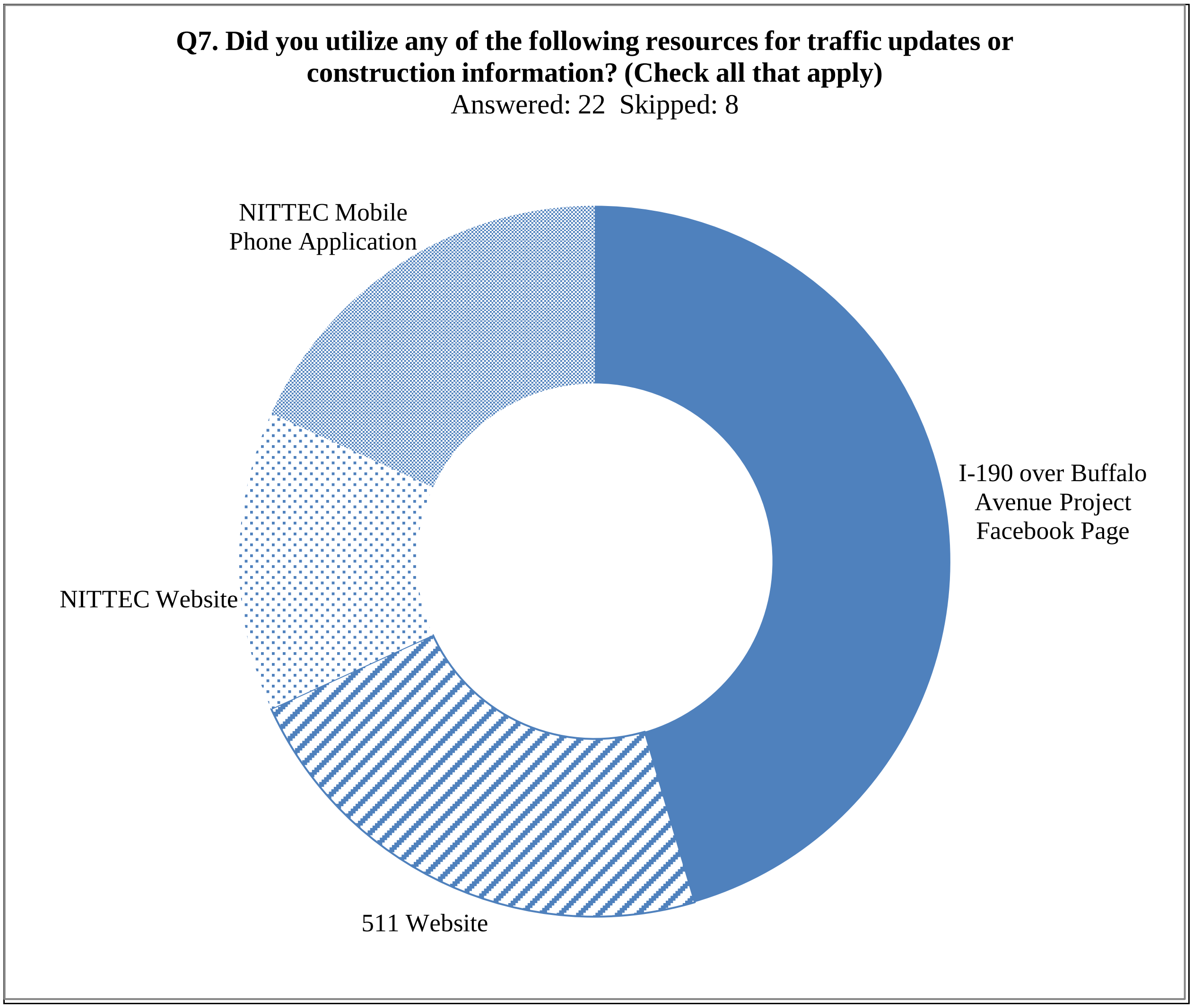

Figure 46. Chart. User utilization of resources for traffic and construction related information.

Table 9. User utilization of resources for traffic and construction related information.

Answer Choices	**Responses**	
	Number	Percent
I-190 over Buffalo Avenue Project Facebook Page	10	45.45%
511 Website	5	22.73%
NITTEC Website	3	13.64%
511 Mobile Phone Application	0	0.00%
NITTEC Mobile Phone Application	4	18.18%
Total	22	100%

APPENDIX C
User Delay Cost Analysis

PIN 5051.10 I-190 Over Buffalo Avenue User Costs Analysis

	Total AADT	Truck %	Trucks	Cars	User Costs	1999	2013	2.5%	Inflation Rate
Northbound	26,903	17%	4,574	22,329	Trucks	$ 21.25	$ 28.69		
Southbound	23,313	17%	3,963	19,350	Cars	$ 12.75	$ 17.21		

Conventional Bridge Construction

	Trucks	Δ Travel Time	Duration	Aggregate User Delay	Hourly User Cost	User Cost
Northbound	4,574	48 Sec	90 Days	5,489 Hours	$ 28.69	$ 157,459.85
Southbound	3,963	48 Sec	90 Days	4,756 Hours	$ 28.69	$ 136,426.28
	Pass. Cars	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Northbound	22,329	48 Sec	90 Days	26,795 Hours	$ 17.21	$ 461,205.50
Southbound	19,350	48 Sec	90 Days	23,220 Hours	$ 17.21	$ 399,674.25
						$ 1,154,765.97

$ 12,831.00 Cost per Day

Accelerated Bridge Construction

	Trucks	Δ Travel Time	Duration	Aggregate User Delay	Hourly User Cost	User Cost
Northbound	4,574	48 Sec	3 Days	183 Hours	$ 28.69	$ 5,248.67
Southbound	3,963	48 Sec	3 Days	159 Hours	$ 28.69	$ 4,547.54
	Pass. Cars	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Northbound	22,329	48 Sec	3 Days	893 Hours	$ 17.21	$ 15,373.52
Southbound	19,350	48 Sec	3 Days	774 Hours	$ 17.21	$ 13,322.48
						$ 38,492.20

$ 12,831.00 Cost per Day

Savings
$ 1,116,273.77

Conventional Bridge Construction

	Volume	Δ Travel Time	Duration	Aggregate User Delay	Hourly User Cost	User Cost
Buffalo Ave. EB to I-190 SB (2.0 Miles @ 35 mph)						
Cars	4,081	206 Sec	100 Days	23,320 Hours	$ 17.21	$ 401,395.50
Trucks	556	206 Sec	100 Days	3,177 Hours	$ 28.69	$ 91,144.29
Buffalo Ave. WB to I-190 SB (1.0 Miles @ 40 mph)	**Volume**	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Cars	4,277	90 Sec	100 Days	10,693 Hours	$ 17.21	$ 184,044.66
Trucks	583	90 Sec	100 Days	1,458 Hours	$ 28.69	$ 41,812.03
Robert Moses EB to I-190 SB (2.9 Miles @50 mph)	**Volume**	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Cars	7,552	209 Sec	100 Days	43,802 Hours	$ 17.21	$ 753,935.04
Trucks (No trucks allowed)	-	209 Sec	100 Days	Hours	$ 28.69	$ -
						$ 1,472,331.51

$ 14,723.00 Cost per Day

Accelerated Bridge Construction

	Volume	Δ Travel Time	Duration	Aggregate User Delay	Hourly User Cost	User Cost
Buffalo Ave. EB to I-190 SB (2.0 Miles @ 35 mph)						
Cars	4,081	206 Sec	21 Days	4,897 Hours	$ 17.21	$ 84,293.06
Trucks	556	206 Sec	21 Days	667 Hours	$ 28.69	$ 19,140.30
Buffalo Ave. WB to I-190 SB (1.0 Miles @ 40 mph)	**Volume**	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Cars	4,277	90 Sec	21 Days	2,245 Hours	$ 17.21	$ 38,649.38
Trucks	583	90 Sec	21 Days	306 Hours	$ 28.69	$ 8,780.53
Robert Moses EB to I-190 SB (2.9 Miles @50 mph)	**Volume**	**Δ Travel Time**	**Duration**	**Aggregate User Delay**		
Cars	7,552	209 Sec	21 Days	9,198 Hours	$ 17.21	$ 158,326.36
Trucks (No trucks allowed)	-	209 Sec	21 Days	Hours	$ 28.69	$ -
						$ 309,189.62

$ 14,723.00 Cost per Day

Savings
$ 1,163,141.90

Total User Cost Savings From ABC **$ 2,279,415.67**

Figure 47. Spreadsheet. User delay cost analysis.