Maine Demonstration Project:
Hotel Road (Littlefields Bridge) Replacement Using Superstructure Slide-In Technology

Final Report
April 2015

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S.Department of Transportation
Federal Highway Administration

FOREWORD

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

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

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

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

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

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16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE program, the Maine Department of Transportation was awarded a $580,000 grant to demonstrate the use of proven, innovative technologies for accelerated bridge removal and replacement. This report documents accelerated bridge construction techniques using prefabricated bridge elements and slide-in technology to replace Littlefields Bridge over Little Androscoggin River in Auburn. This report documents project/site challenges, construction details, use of glass fiber reinforced polymer rebars, use of precast elements for structural components, use of innovative incentive/disincentives to relocate utilities in an efficient and effective manner, and deployment of horizontal slide-in technology that did not require special equipment or specialty subcontractors.

Under conventional construction methods, the project would have taken 4 months to build and would have required the construction of a temporary roadway and two-lane temporary bridge to channel traffic during construction. This would have required acquisition of right-of-way and relocation of residents. However, using precast elements and horizontal slide-in technology, the impact of the project's construction was reduced to 33 days, during which the bridge was closed and traffic detoured. With its broader width, jointless construction, precast materials fabricated in a controlled environment, and high-performance deck reinforcement, the bridge is expected to demand less maintenance, last longer, and provide safer passage to the more than 10,000 daily users, including the many bicyclists who use this road.

The project cost was about the same as the expected cost if conventional methods were used, but the innovative option resulted in an additional user cost savings of $59,795. Nonetheless, this experience provides Maine Department of Transportation personnel with an additional tool to rapidly renew and replace bridges. Because of the success of this project, Maine plans to use the horizontal slide-in technology on future projects where it is feasible and appropriate for conditions.

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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)

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ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ABC	accelerated bridge construction
AADT	annual average daily traffic
DOT	department of transportation
FHWA	Federal Highway Administration
GFRP	glass fiber reinforced polymer
HfL	Highways for LIFE
IRI	International Roughness Index
LRFD	load and resistance factor design
OSHA	Occupational Safety and Health Administration
PBES	precast bridge elements and systems
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

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

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

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

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

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

Project Solicitation, Evaluation, and Selection

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

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

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- Use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the Applicant State has never or rarely used, even if it is standard practice in other States.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1 year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the State to participate in technology transfer and information dissemination activities associated with the project.

HfL Project Performance Goals

The HfL performance goals focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. States are encouraged to use all applicable goals on a project:

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

- **Construction Congestion**
    - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
    - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
    - Queue length during construction—A moving queue length of less than 0.5 mile 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 test method.

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

REPORT SCOPE AND ORGANIZATION

This report documents accelerated bridge construction (ABC) techniques in the form of horizontal superstructure slide-in technology used to replace Littlefields Bridge over Little Androscoggin River in Auburn, Maine. The report presents project details relevant to the HfL program, including innovative construction highlights, rapid superstructure demolition and replacement, HfL performance metrics measurement, and economic analysis.

The report includes construction details of the superstructure supported on temporary support structures built adjacent to the semi-integral abutments for the new bridge that were built behind the abutments of the old structure. It also discusses the details of the lateral slide set-up. Detailed specifications for the glass fiber reinforced polymer (GFRP) rebars—used for the first time in the State—are also discussed, and the special provisions are included in appendix A.

Under conventional construction methods, the project would have taken 4 months to build and would have required constructing a temporary roadway and bridge to channel traffic during construction. A two-lane temporary bridge would have required the acquisition of right-of-way, and a one-lane temporary bridge would have led to diversion of inbound or outbound traffic during the 4-month period. These situations were avoided and the project was successfully completed in 33 days with minimum disruption to highway users.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

The Littlefields Bridge project is located in Androscoggin County, Maine. Littlefields Bridge carries Hotel Road (State Aid #11), a two-lane urban collector, over Little Androscoggin River and carries current annual average daily traffic (AADT) of 10,300 vehicles a day with 10 percent trucks. The project is in the Lewistown-Auburn twin cities area along a major route that connects the cities to the interstate. The purpose of this project was to replace the single span bridge built in 1937, which had approached the end of its service life.

The bridge was functionally obsolete because of its narrow curb-to-curb width of 22 feet. Additionally, with no shoulders on the bridge, there was inadequate space for the significant volume of cyclist traffic traveling through the corridor. The bridge also severely constricted the approaches with 12-foot lanes and 8-foot shoulders, prompting safety concerns.

Hotel Road at this location is part of the Priority 3 Corridor, meaning that it is among a group of highways considered to be of statewide significance. The Maine Department of Transportation (DOT) determined that if the bridge was not replaced and allowed to fall into disrepair and ultimately closed, annual user costs would increase by approximately $1 million. The overall Sufficiency Rating for the bridge was 46.0, making it eligible for replacement.

The immediate vicinity of the bridge presented traffic management and property related challenges for construction of a replacement bridge. On the downstream side of Littlefields Bridge is a concrete arch bridge that formerly supported a trolley line and carries utilities, and on the northwest corner of the bridge is a residence with limited setback from the roadway.

With the old structure being a truss, staged construction was not feasible. Conventional construction would have required an 8-mile detour around the project for a period of 4 months, which Maine DOT considered too disruptive for the significant amount of private and commercial traffic using Hotel Road. Two-lane and single-lane temporary bridge options were also considered but later disregarded—the two-lane option because of right-of-way impacts and the single-lane option because of traffic disruption over a period of 4 months. Maine DOT concluded that ABC was the most prudent alternative, and it would provide agency personnel with valuable experience in the deployment of ABC technology.

For this project, Maine DOT obtained $580,000 in HfL funding.

To decrease construction time, initial innovative options considered the use of full-depth precast deck panels with stainless steel or composite reinforcement, offering the contractor the flexibility to use precast elements in a number of areas including abutments, approach slabs, and curbs. Maine DOT subsequently decided on a horizontal/lateral slide option because it was feasible at this location, would not have joints inherent in precast panels, and would not require post-tensioning.

The deck with GFRP reinforcement—a first for Maine DOT—was cast at the site. The entire superstructure, steel girders and deck, was then slid onto semi-integral abutments constructed behind the existing abutments, to its final position after removal of the old superstructure. The contractor had the overall responsibility for the design and construction of the temporary support structure and the design and deployment of the horizontal slide system.

The Water and Sewer District for the twin cities decided to take advantage of the construction to upgrade major water and sewer mains that are located on a nearby trolley bridge that was also nearing the end of its service life. Maine DOT addressed the challenge of coordinating utility work in the ABC environment with a unique incentive/disincentive approach. The agency divided the closure period into three phases:

1. Removal of old bridge, completion of pile supported abutment and wingwall construction, sliding of the new superstructure in its final position, installation of bridge rail and transition barriers, and clearance of site for use by utility companies.
2. Completion of utility work.
3. Completion of roadway work, including striping, until opening of roadway to two 11-foot-wide lanes of traffic.

Phase 1 was not to exceed 25 days, and phase 3 was not to exceed 4 days. The contractor was to be awarded $7,500 per day if phase 1 was completed early (e.g., if phase 1 was completed 3 days early, the award would be $7,500 x 3 = $22,500). Additionally, to encourage close positive coordination with the utility contractors, the contractor was to be awarded a single no-excuse bonus of $40,000 if phases 2 and 3 were completed within 15 consecutive days.

To discourage the contractor from completing the project late, a $7,500 disincentive would be applied for each day or portion of a day that he went beyond the 25-day period in phase 1 and the 4-day period in phase 3.

Hotel Road in the vicinity of the bridge was closed to traffic on July 29, 2013. It was reopened on August 30, 2013—12 days ahead of the anticipated closure period of 45 days.

DATA COLLECTION

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

A Maine DOT traffic study found that there were six crashes in the project area between 2008 and 2010. The arrow lanes and limited sight distance caused by through truss members were identified as contributing to the crashes. By replacing the 22-foot-wide truss bridge with a 34-foot-wide plate girder bridge, those contributing factors have been addressed. Furthermore, with improved alignment of approach roadways and upgraded traffic delineation and safety features, the crash rate at this location should decrease in the future. A 3-year study after construction is likely to validate a reduction in crash rate by at least 20 percent, which is the HfL goal.

In the absence of right-of-way takes, traditional construction methods would have required constructing a one-lane temporary bridge to provide uninterrupted service to inbound traffic to the Lewistown-Auburn area. Outbound traffic would have required alternate routes for 4 months during construction. With ABC, exposing travelers to bridge-related construction activities was completely avoided by the site's closure, and both inbound and outbound traffic were impacted for only 33 days. In terms of impact of construction duration on travelers, this equates to a reduction of over 72 percent, easily exceeding the HfL goal of 50 percent.

There were no work zone related crashes reported, easily meeting the HfL goal of a work zone crash rate equal to or less than the preconstruction rate at the project location. There also were no worker injuries reported on this project that were related to bridge construction. There was one incident of contusion reported 100 yards south of the bridge, when workers were filling a water tank using a fire hydrant as a source of supply.

Maine DOT uses alphabetical A-F levels of service to assess traffic conditions. Analysis of detour options on this project using Synchro/SimTraffic software and the regional Androscoggin Transportation Resource Center Metropolitan Planning Organization travel demand model indicated that the affected intersections could accommodate the detour traffic, maintaining a level of service of C or better (under 35 sec/veh). Therefore, queues were absent or minimal due to construction, easily exceeding the HfL goal of queue length of less than 1.5 mile in an urban area.

The rough surfaces of the old bridge and its approaches had an average International Roughness Index (IRI) in the range of 204 to 256 inches per mile as measured in 2011, detracting from the overall corridor IRI which was in the range of 120 to 240 inches per mile. Measurements following construction showed that the roughness of the section within the project limits was 143 inches per mile, making the smoothness within the project limits consistent with the rest of the corridor. Though the new bridge offered a much smoother and improved surface with a reduction in the IRI value from 204 to 256 in/mi to 143 in/mi, the HfL goal of less than 48 in/mi after construction was not met.

The post construction tire-pavement noise value was 99.2 dB(A). The new bridge, therefore, did not meet the HfL OBSI goal of 96.0 dB(A) or less. It can be safely assumed that the new texture of the bridge surface—while aiding traction and increasing safety—is prone to increasing noise.

Maine DOT applies significant amounts of salt to its roads during the winter months, which prompts concerns about corrosion and associated cracking of concrete and maintenance demands. The agency considered the use of stainless steel and GFRP on this project to address these concerns and selected the GFRP option to better understand use of this technology, which is new to the State. The advantages of GFRP reinforcement include imperviousness to chloride ion and chemical attack, greater tensile strength than steel, and lower weight—about 25 percent that of steel. Maine DOT believes that the higher initial cost of GFRP will be offset by lower maintenance costs during the bridge's life cycle.

Maine DOT performed a user satisfaction survey once the bridge was completed. The survey showed that 94 percent of the 54 respondents were satisfied with the new structure compared to the old one, which compares quite favorably with the HfL goal of 57 percent or more. The survey also found that 87 percent of the respondents were satisfied with the approach the agency used to minimize disruption during construction, again easily exceeding the HfL goal of 57 percent.

ECONOMIC ANALYSIS

Using data provided by Maine DOT, it is estimated that the cost of delivering the project using the traditional method, including the cost of right-of-way and the cost of the temporary bridge, would have been the same as the innovative method used on this project. The innovative method had an additional user cost savings of $59,795 due to traffic being detoured during the roadway closure period. However, the detour allowed the DOT to avoid relocating residents of a property located in the northwest corner of the bridge.

LESSONS LEARNED

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

- The closure period for the demolition of the old structure and sliding in of the new superstructure was adequate.
- The incentive/disincentive concept used on this project was effective.
- Involving personnel from the utilities early in the project development and construction processes led to success.
- The specification, availability, and handling of GFRP material by contractor personnel worked well.
- The horizontal slide-in of steel on steel with grease as the lubricant was slow but effective.
- Extreme care is required to ensure that the superstructure is advancing equally at both abutments to avoid binding. Excellent communications between personnel at either end monitoring the advancement is a must. Do not rely on hydraulic readings alone.
- Public outreach efforts and pre-event and during event communications with stakeholders were effective.
- Users were very satisfied with the new bridge and the approach used by the agency to minimize disruption to travel.

CONCLUSIONS

From the standpoint of construction speed, motorist and worker safety, quality, and cost, this project was a success and embodied the ideals of the HfL program. Maine DOT learned that careful planning and the use of ABC technologies 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 the project.

Because of the success of this project, Maine DOT plans to consider bridge slide technology, GFRP reinforcement, precast bridge elements and systems (PBES), and utility coordination incentives/disincentives as viable tools in its ABC toolkit on all future projects.

PROJECT DETAILS

BACKGROUND

Littlefields Bridge carries Hotel Road over Little Adroscoggin River. The site location is shown in figure 1. On the downstream side of the Littlefields Bridge are a railroad bridge about 250 feet away and a concrete arch bridge about 40 feet away, which formerly supported a trolley line and until recently carried gas, water, and sewer lines. The project area showing a plan view of the three bridges in a photograph taken prior to the bridge replacement is shown in figure 2.

The Auburn Sewer and Water District decided to take advantage of this project's construction to upgrade major water and sewer mains and relocate them on the new Littlefields Bridge. The District effectively worked with the contractor and Maine DOT, who successfully coordinated the relocation in a remarkably short time using a unique incentive/disincentive approach.

Other "firsts" for Maine DOT on this project included:

- Use of GFRP reinforcement.
- Use of superstructure horizontal/lateral slide-in technology to accelerate bridge construction and minimize disruption to travelers.
- Use of semi-integral abutments with shop fabricated elements assembled at site.
- Tying of bridge backwall and superstructure together for jointless construction.

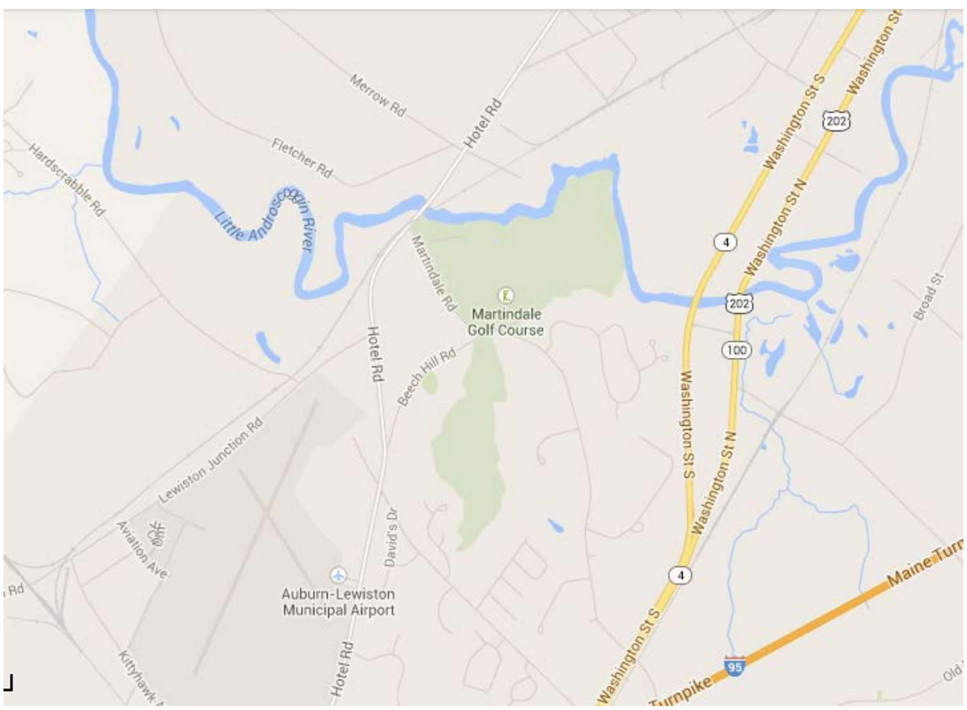


Figure 1. Map. Project location.

Figure 2. Map. Project area.

The original Littlefields Bridge was a single span simply supported steel through truss which was classified as being functionally obsolete due to its narrow width. The approaches that feature 12-foot lanes and 8-foot shoulders were severely constricted by the 22-foot curb-to-curb width. Additionally, with no shoulders, the bridge did not provide sufficient space for the significant volume of cyclist traffic through this corridor.

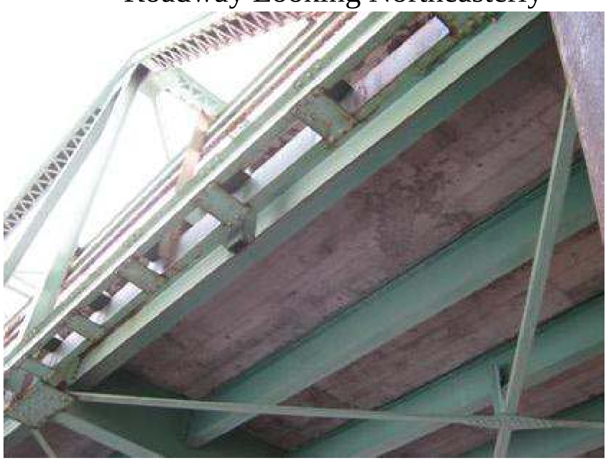
Per National Bridge Inspection Standards, the bridge’s superstructure was rated as being in fair condition and the substructure in satisfactory condition. It had an overall Sufficiency Rating of 46.0 out of 100, making it eligible for replacement, primarily because of its functional obsolescence.

Figure 3 shows photographs of the approach roadway, condition of north abutment, and typical condition of bearings and underside of the deck of the old bridge.

The immediate vicinity of the bridge presented challenges in terms of construction and maintenance of traffic. With the old structure being a truss, staged construction was not feasible, and the 8-mile detour around the project was considered too disruptive for the 4-month period that conventional construction would have taken.

Roadway Looking Northeasterly

North Abutment



Deck Underside, Typical

Bearing, Typical

Figure 3. Photos. Photographs of old structure.

Maine DOT considered the following options for traffic management:

1. Single-lane temporary bridge with alternating one-way traffic.
2. Single-lane temporary bridge with one-way traffic and a directional detour.
3. Two-lane temporary bridge with a truck detour.
4. Two-lane temporary bridge.
5. 30-day bridge closure with ABC.

Option 1 was ruled out because of excessive and unacceptable delay times, and option 2 was eliminated because of concern, based upon experience in the vicinity, regarding vehicles traveling the wrong way on a one-way temporary bridge, particularly at times of lower traffic volume. Options 3 and 4 would have involved substantial right-of-way impacts and temporary relocation of one property's residents. Additionally, option 3 would have had long-term user cost impacts on the significant truck traffic that uses Hotel Road. The cost of the temporary two-lane bridge was estimated at $350,000, and the right-of-way acquisition cost was estimated at $100,000. With these additions, the cost to deliver the project using either of these options was estimated to be the same as the ABC option. Maine DOT chose the ABC option.

ABC methods are known to have the following advantages:

- Reduce onsite construction time.
- Reduce disruption to traffic.
- Improve construction-related safety.
- Improve quality because of construction of some of the elements in a controlled environment.
- Reduce user costs.

The project was let on January 23, 2013 and was awarded to Wyman & Simpson, Inc. at a bid price of $ 2,134,271.50

PROJECT ENGINEERING

Borings at the site indicated bedrock at depths between 29 and 36 feet below the surface. A boring conducted for a possible pier at the center of the span indicated that bedrock was present at less than 12 feet below the streambed elevation. The project team considered the following structure alternatives:

1. Single-span steel welded girder.
2. Single-span New England bulb tee.
3. Two-span concrete box beams.

Option 2 was eliminated because of the long span length, as it would push the New England bulb tees to the limit. Option 3 was eliminated because of insufficient overburden for a pile-supported pier, and a traditional mass pier on bedrock would have increased the construction duration. Since construction speed was critical at this location and option 1 is the appropriate structure type for the span length needed at the site, the project team selected that option. The team also specified weathering steel, as the project site is not in a saltwater environment.

A challenge often encountered on rapid renewal and replacement projects is the need to minimize disturbance to the existing structure while constructing the replacement structure. The project team determined that, with the availability of bedrock at 29 to 35 feet below ground level and sufficient space to drive piles outside the existing bridge footing, integral abutments at this location were both viable and cost-effective.

Figure 4 shows the profile at the bridge location. To regain some of the free board lost due to the switch from a truss structure to a girder bridge, the profile of Hotel Road was raised 2 feet at the north abutment and 3 feet at the south abutment. The integral abutments behind the existing structure abutments were left in place. The distance from the existing abutment foundation was sufficient to not interfere with the pile driving operations.

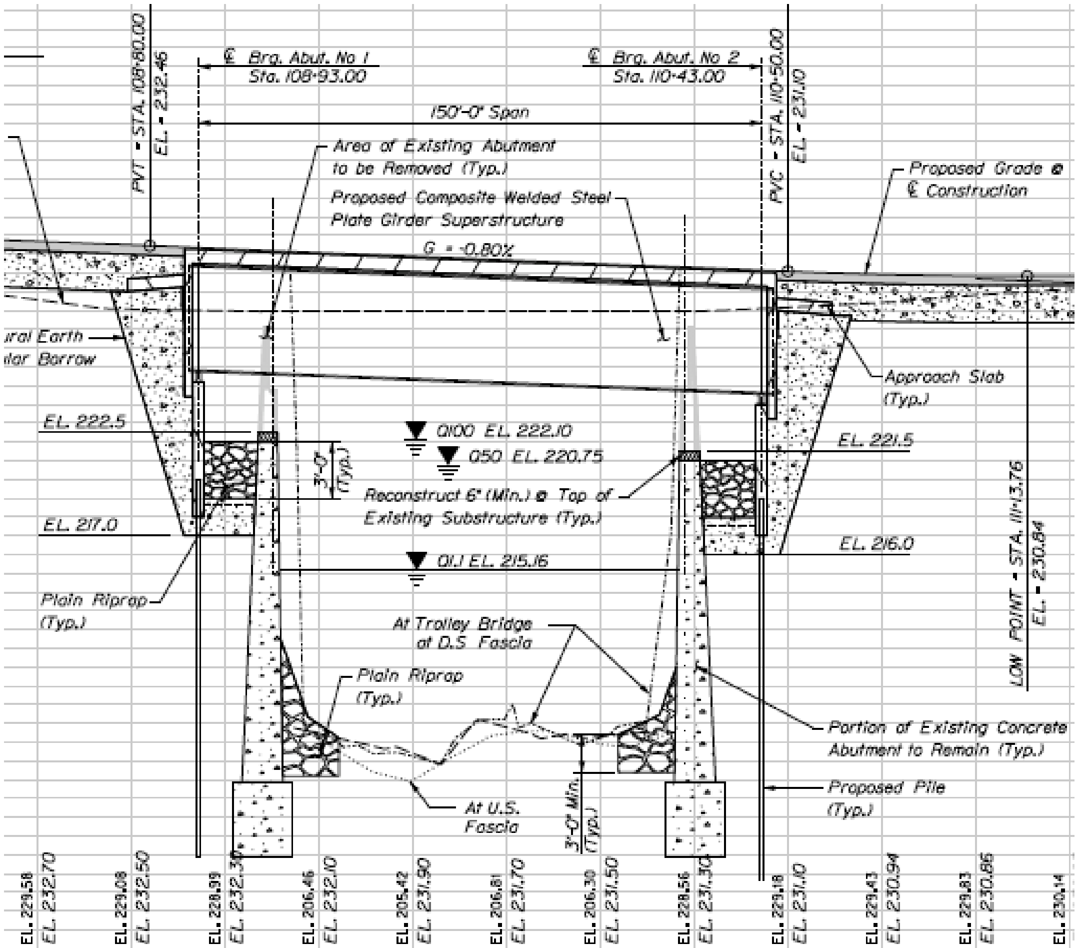


Figure 4. Diagram. Project profile.

The plan and elevation of an abutment are shown in figure 5. This was the first time Maine DOT used precast modules with blockouts for the piling. Each precast module weighed approximately 47 kips without the cast-in-place concrete (shown by the hatched areas) in the void. Each pile driven was capped with self-consolidating concrete, and an elastomeric bearing was placed on top of each cap. Pertinent abutment sectional details are shown in figure 6.

The bridge backwall and the superstructure were tied together (see figure 7).

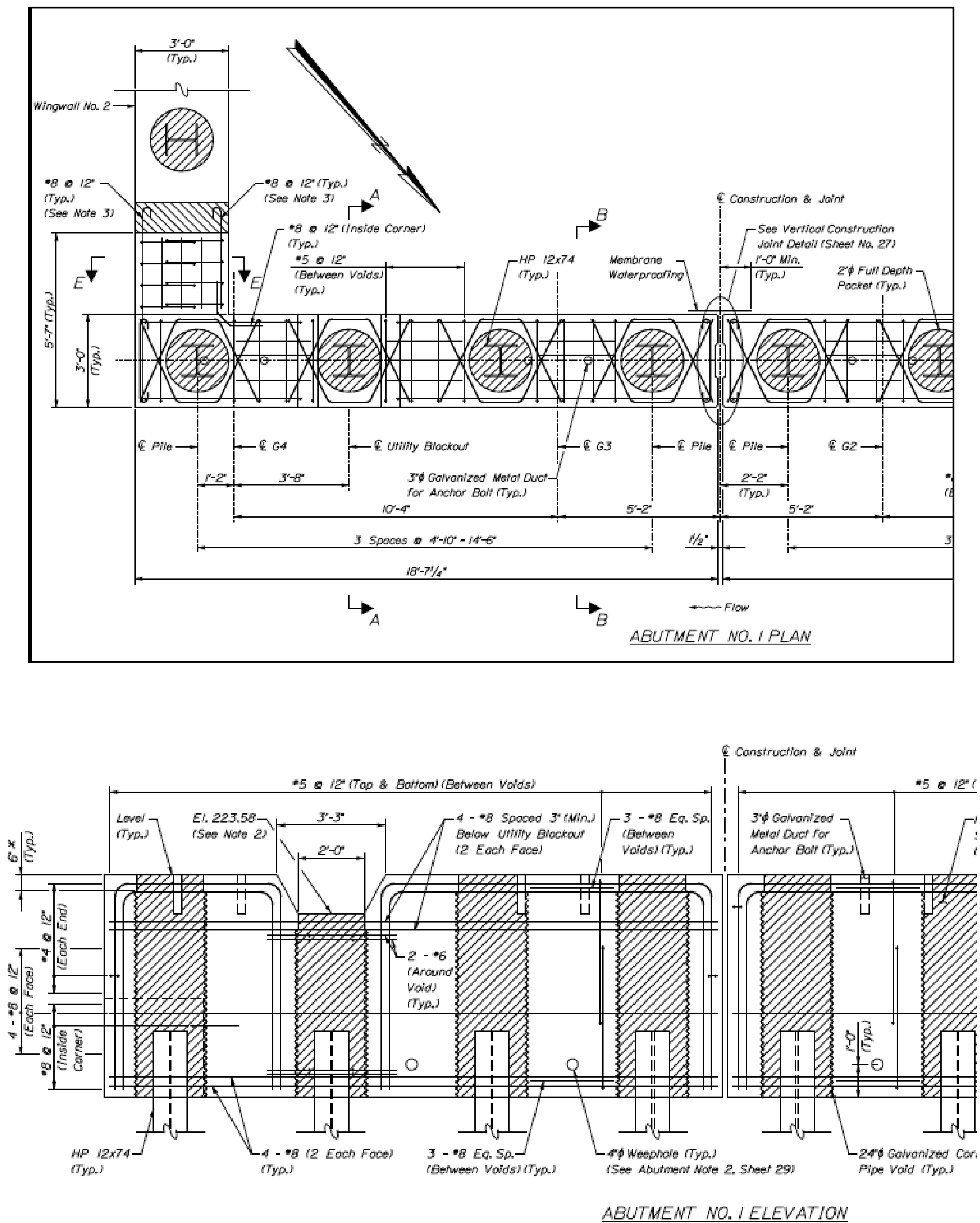


Figure 5. Diagram. Plan and elevation of integral abutment.

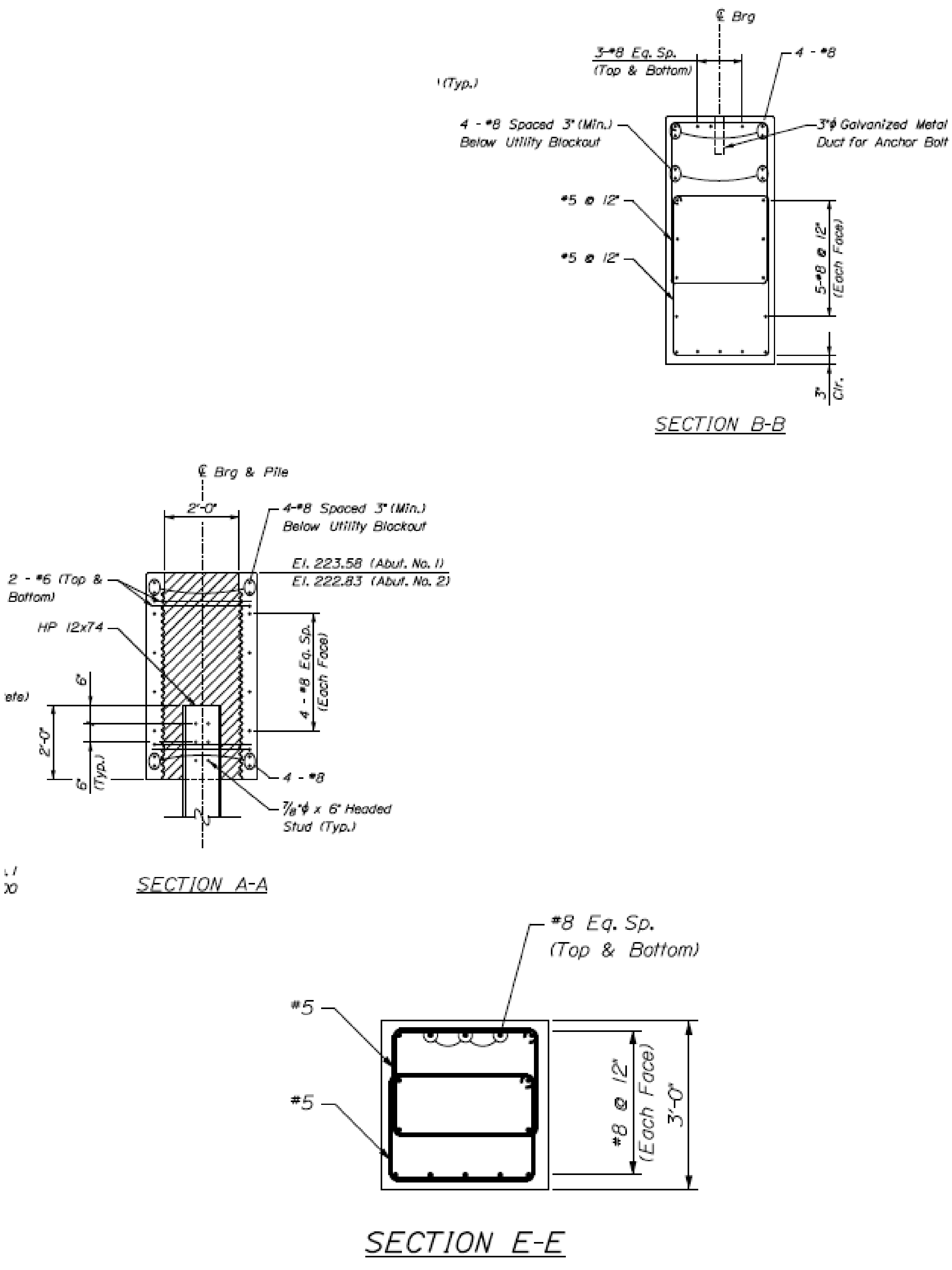


Figure 6. Diagram. Abutment sectional details.

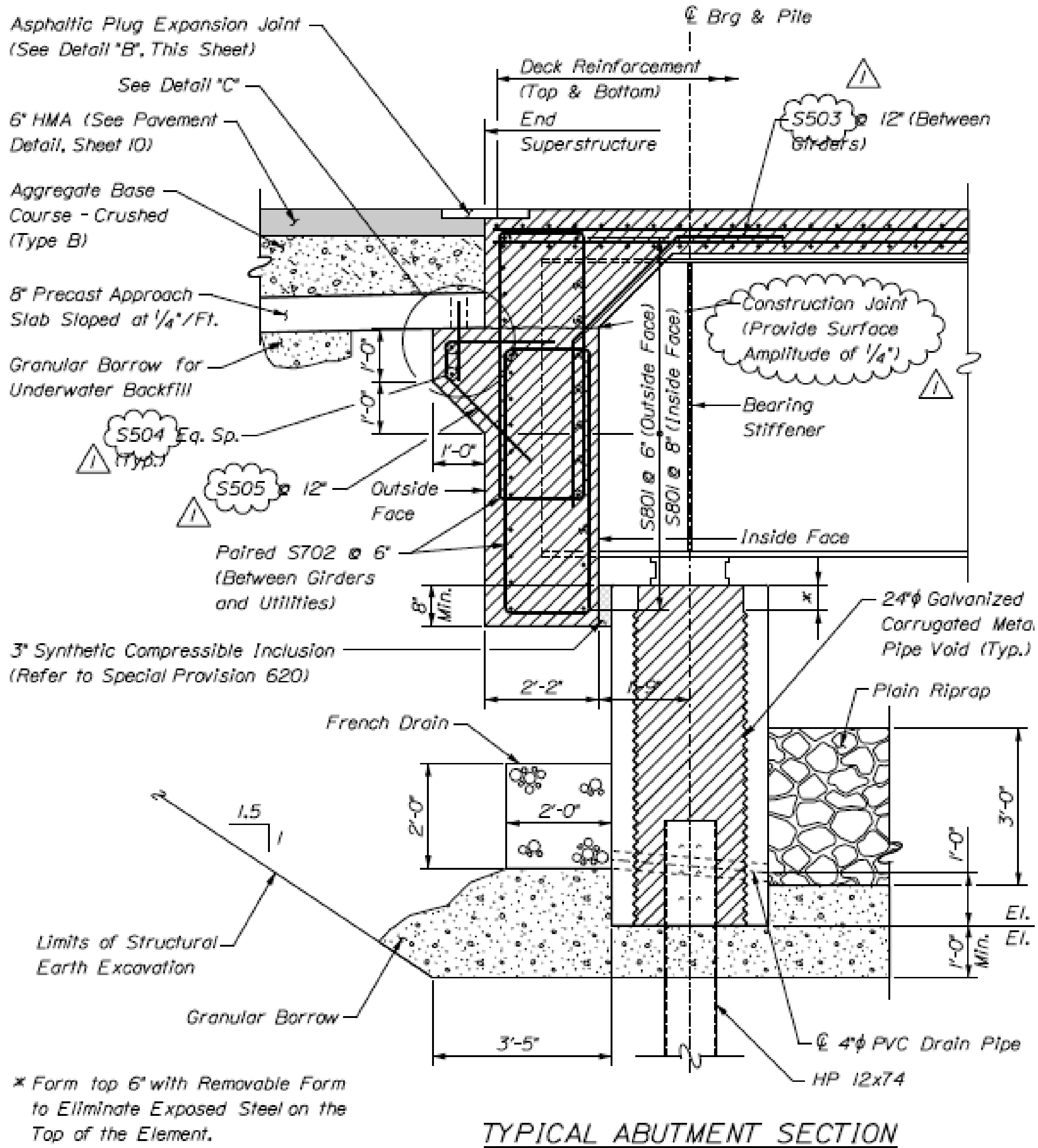


Figure 7. Diagram. Abutment end section details.

The cross section of the new superstructure is shown in figure 8; for reference purposes, a drawing of the old truss structure is provided in figure 9. The new structure is much wider, and it has 5-foot shoulders on each side as well. The wider bridge provides improved access likely leading to safer travel, including safer bicycle travel, which is significant at this location.

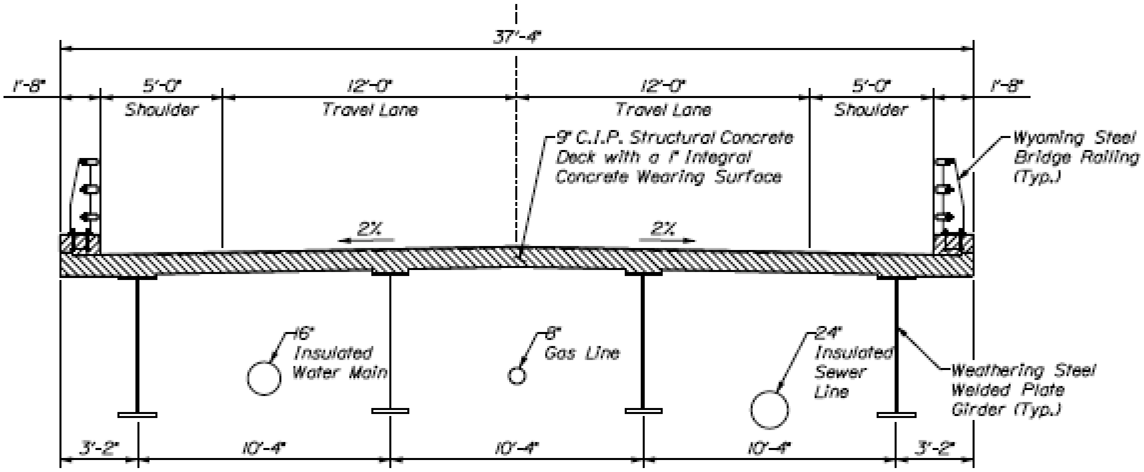


Figure 8. Diagram. Cross section of new girder structure.

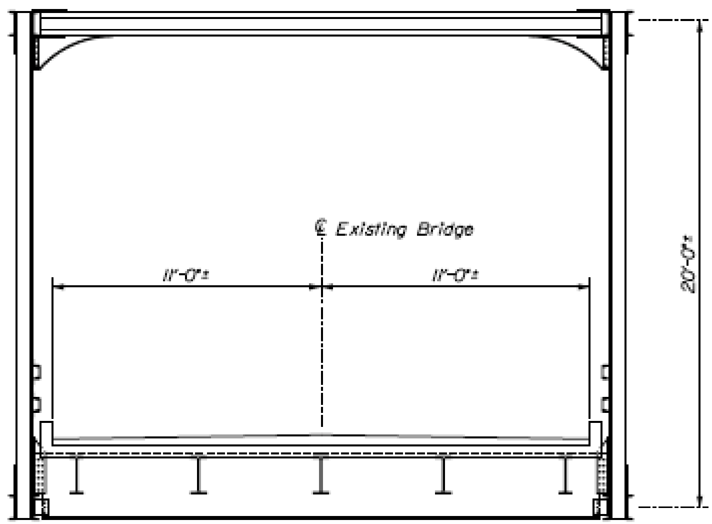


Figure 9. Diagram. Cross section of old truss structure.

To improve durability of the deck structure in the harsh winter environment, Maine DOT selected GFRP reinforcement bars because the material is impervious to chloride ion and chemical attack and has higher tensile strength than steel. Additionally, it weighs less than 25 percent of the weight of steel, reducing the structural requirements for the temporary support structure and sliding system.

Because the application of GFRP bars in the highway industry is in its early stages, there is no mature organization to represent the competing manufacturers, whose capabilities varied substantially. Therefore, when developing the GFRP rebar specification for the project, the project team needed to balance the capabilities of the manufacturers with the minimum needs of the project without being too restrictive. The team approved five sources of supply. The Special Provision, SP 530 included the following requirements (see appendix A for the entire special provision):

- All GFRP reinforcement shall conform to the requirements shown in the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Guide Specifications for GFRP Reinforced Concrete Bridge Decks and Traffic Railings (November 2009), unless otherwise specified.
- Material shall be from approved manufacturers. Furthermore, all GFRP bars in the same structural component shall be from the same manufacturer; there shall be no mixing of products from different manufacturers in a component, unless otherwise specified.
- Field bending of GFRP shall not be permitted.
- Concrete cover shall be a minimum of 2 inches, unless otherwise noted.
- Tensile modulus of elasticity shall be a minimum of 6,700 ksi.
- Minimum tensile strength for bent bars shall be 65 ksi.
- Minimum tensile strength for straight #5, #6, #7, and #8 bars shall be 105 ksi, 100 ksi, 95 ksi, and 90 ksi, respectively.
- Payment for fabrication and delivery shall be lump sum.
- Payment for placing shall be lump sum.

Figure 8 also shows approximate insertion points for the utilities that were relocated from the trolley bridge during the road closure period. To minimize the duration of detour around the project, encourage coordination between the contractor and utility owners, and minimize the time to relocate utilities, Maine DOT included Special Provision 107 in the contract. This Special Provision is included in its entirety in appendix B.

Table 1 summarizes the incentives and disincentives for various phases of activities. The no-excuse award bonus of $40,000 was included in the contract to incentivize the contractor to work closely with the utility owners and their subcontractors and complete the utility relocation and pavement activities within 15 days. The contractor took a “partnering” approach with the utilities by:

- Involving their representatives early in the process.
- Establishing and maintaining excellent communications throughout the project’s execution.
- Approaching each emerging issue with a spirit of collaboration.

The total road closure period was 33 days, making the contractor eligible for the no-excuse award bonus.

Table 1. Highlights of Special Provision 107.

	Phase1	Phase 2	Phase 3
Activity	• Removal of existing bridge • Installation of new pile supported abutments and wingwalls • Sliding of new superstructure on new abutments • Installation of bridge rail and and transition barriers • Clearance of site for use by utility contractors	Utility relocation	• Completion of roadway pavement • Completion of striping • Roadway opened to traffic
Duration	25 days		• 4 days for phase 3 • 15 days for phases 2 & 3 combined
Incentive for early completion	• $7,500 per day • Maximum for entire project, $100,000		No excuse award bonus of $40,000 if both phases 2 & 3 completed within 15 days or less
Disincentive for late completion	$7,500 per day (open ended)		•$7,500 for phase 3 (open ended)

PROJECT CONSTRUCTION

The project was completed in three stages. Figure 10 presents a schematic representation of the construction staging.

1. Stage I, construction prior to closure.
    a. Secure temporary work area.
    b. Construct temporary bents.
    c. Construct new superstructure on temporary bents.
2. Stage II, construction during closure.
    a. Close existing bridge and detour traffic.
    b. Remove existing superstructure.
    c. Cutoff existing abutments and wingwalls.
    d. Place precast stem and wingwalls.
    e. Construct precast modular retaining wall.
3. Stage III, construction during closure.
    a. Slide the bridge to final location.
    b. Place approach slabs.
    c. Complete utility relocation work.
    d. Complete roadway construction.

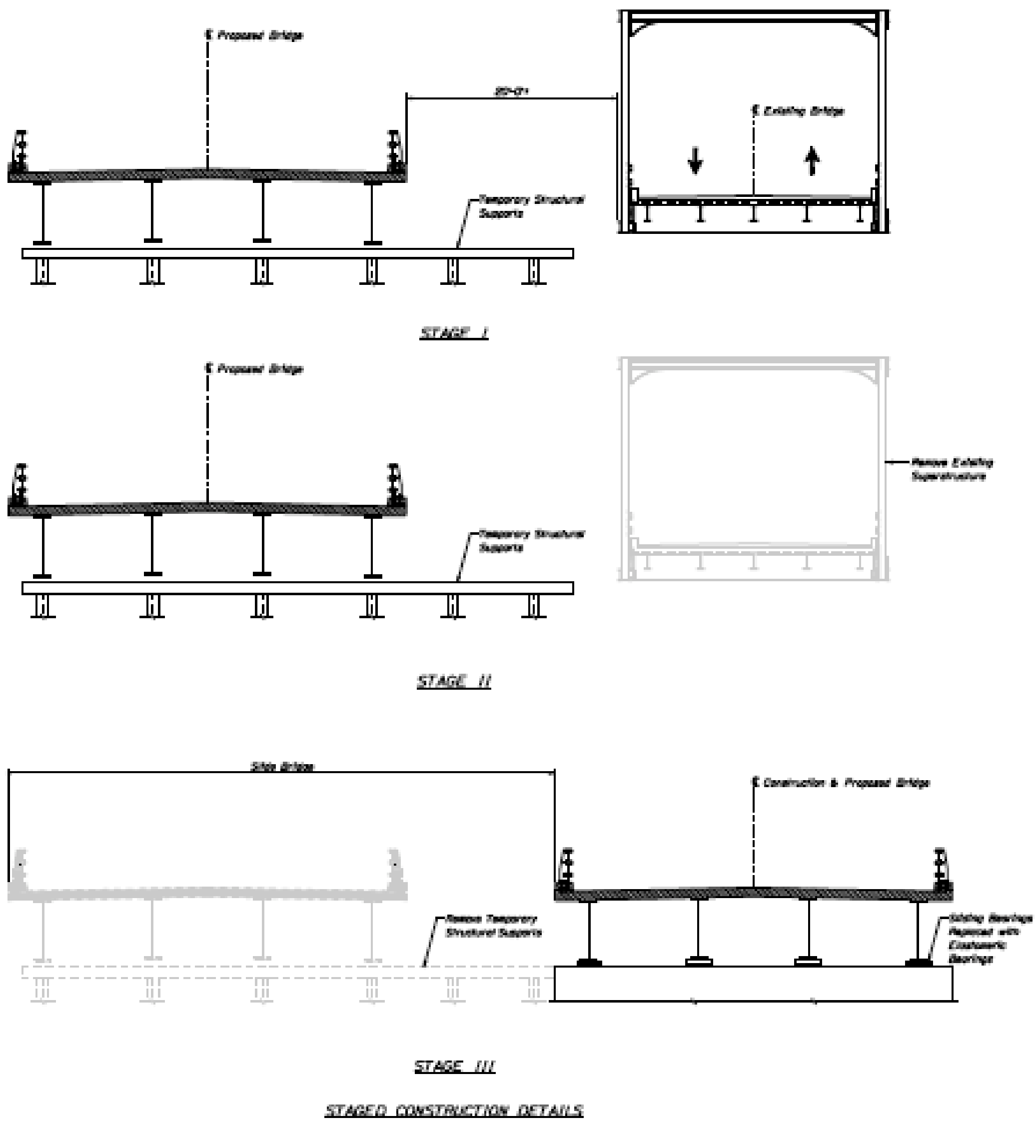


Figure 10. Diagram. Shematic representation of construction staging.

For slide-in type construction, a substantial amount of engineering and construction work needs to be completed ahead of the bridge closure period. Engineering items include submissions for foundation approval for both the permanent structure and the temporary structures on which the superstructure rests, submission and approval of shop drawings for the precast fabricated elements, and review and approval of the slide-in process that will be utilized. Some of this work may be done while the old structure is being dismantled, but much of the work needs to be completed prior to the road closure, and contractors typically find themselves pressed for time. This was not the case on this project, however, because there was adequate lead time and agency reviews were completed in a timely manner.

The contractor was responsible for designing, fabricating, erecting, maintaining, and dismantling the temporary structural supports. The temporary bents were required to be designed to support all vertical and horizontal loading, including but not limited to live load and impact, differential settlement forces, and horizontal and longitudinal forces, and were to account for any temporary unbalanced loading due to jacking forces and other loading during load transfer. The design was required to meet the current requirements of AASHTO Load and Resistance Factor Design (LRFD) Bridge Construction Specifications.

An important consideration in slide-in construction is the space needed to accommodate temporary bents and the large cranes needed to handle precast elements. On this project, two cranes were used, 100 tons and 80 tons. The contractor indicated that space was tight but manageable, although it would have been easier to operate if more space had been available. After installation of sheetpiling for erosion and sedimentation control, work began on piling for foundation of the temporary bents. See figure 11 showing sheetpiling in place and figure 12 for installation of H piling for the temporary structure. Piling for the integral abutments was also installed, behind the existing abutments. This required extra care because each pile had to align with the void in the precast element for subsequent placement of self-consolidating concrete.

Figure 11. Photo. Sheetpiling working platforms for existing substructure in place.

Figure 12. Photo. Pile driving for temporary support structure.

The next step was launching and placing the mainline girders and diaphragms on the temporary structure, shown in figure 13. The deck over the girders and diaphragms was cast at the site. The contractor had previous experience with GFRP reinforcement, although that experience had been with slabs on grade. The contractor stated that supply of material was not a problem, as a good number of sources were available, and ended up purchasing all material needed for the project from one manufacturer. Working with the GFRP material was easy as well, as rebars were easier to handle because of the light weight. Trucking costs were also lower, as fewer truckloads were needed.

Figure 13. Photo. Girder launching and installation

Both top and bottom mats of reinforcement, shown in figure 14, are GFRP. Figure 15 shows placement of the concrete, which is similar to conventional construction.

Figure 14. Photo. View of GFRP rebar prior to placement off concrete.

Figure 15. Photo. Concrete placement.

The contractor was also responsible for all utility-related work within the structure, which he completed in stage 1, to minimize the time required once the superstructure was in its final position. Figure 16 is a photograph taken by the webcam installed at the site. This photograph was taken on July 25, 2013, and shows the deck covered with plastic and being cured. The temporary bent's proximity to the old structure is also evident.

On July 29, Hotel Road was closed to traffic at the bridge. Traffic was detoured using Kittyhawk Avenue, US Route 202/Washington Street, and Rodman Road. The variable message sign shown in figure 17 informed motorists about the closure. Figure 18 shows Hotel Road in process of being closed to traffic.

Figure 16. Photo. View of new superstructure in relation to old structure.

Figure 17. Photo. Variable message sign alerting travelers of upcoming roadway closure.

Figure 18. Photo. Roadway closure in process.

The project team evaluated the feasibility, cost, and duration of several demolition alternatives:

- Single pick truss removal using a high-capacity lattice boom crawler crane.
- Two pick truss removal using a temporary pier bent in the river at mid-span.
- Float structure out on barges with temporary steel support frame.
- Lateral skid using temporary steel support frames and Hillman type rollers.

None of the alternatives stood out as significantly better or worse than the others, so Maine DOT decided to permit the use of any of these alternatives.

The contractor utilized cranes at the site to lift the truss off the bearings and push it over to the southern embankment of the project site, where it was demolished and hauled away (see figure 19). The existing abutments were cut off and completed to the elevations shown in figure 4. Items shown in stage II were then completed, setting the stage to slide the structure.

Figure 19. Photo. Old structure being demolished at site.

The contractor had prior experience sliding structures on rehabilitation type projects; however, this was the first time he was to move a new structure in its final position. The contractor chose not to go with Teflon pads or Teflon/stainless steel for sliding surfaces even though these systems have low coefficients of friction. He chose steel on steel as sliding surfaces with "Gorilla" grease as lubricant, a practice not uncommon in Maine's shipbuilding industry.

The sliding of the superstructure started on August 14 and took at least 10 hours to complete. The system used for the horizontal slide is a non-proprietary pull system that used dywidag rods. Figures 20 through 27 provide details. The superstructure slide-in was performed by the contractor's in-house personnel and not by a specialty subcontractor.

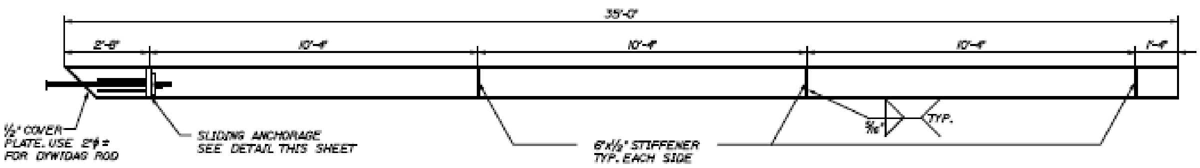


Figure 20. Diagram. HP 12x53 sled beam.

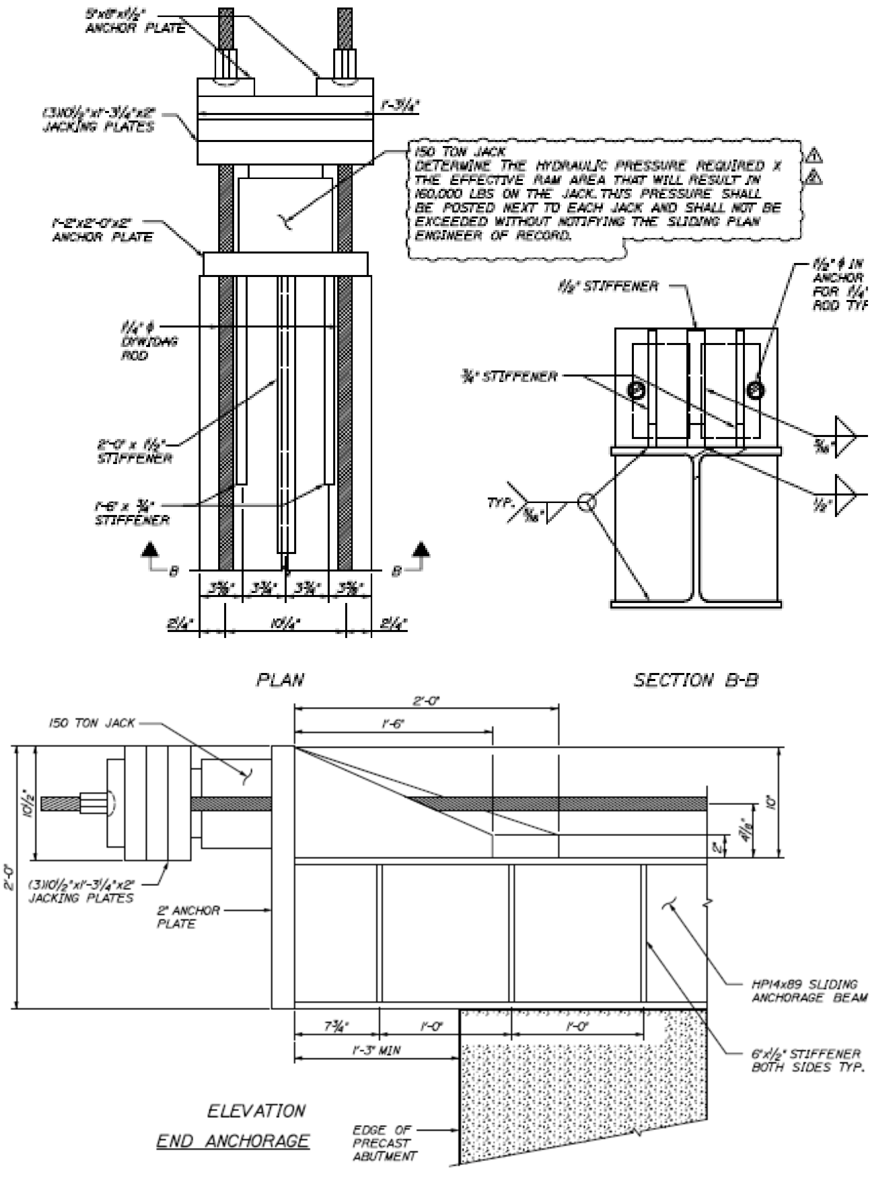


Figure 21. Diagram. End anchorage details.

Figure 22. Photo. Sliding of superstructure.

Figure 23. Photo. View of both abutments and anchor beam in foreground.


Figure 24. Photo. View of slide operation from the existing abutment side.


Figure 25. Photo. View of end anchorage.

Figure 26. Photo. Close-up of Dywidag rods, jack, and jacking plates.

Figure 27. Photo. Webcam view of sliding operation on August 14, 2013.

The horizontal slide was designed so that the maximum jacking force at each abutment would not exceed 160 kips and the maximum anticipated pile head deflection would not exceed 0.4 inches. The jacking system for each abutment was separate and not integrated. However, close communication was maintained by movement monitoring personnel, who guarded against one side advancing ahead of the other causing “fishtailing” or binding and possible damage to the structure. A special provision was included in the contract documents requiring a contingency plan for events such as equipment malfunction, binding of the slide system, differential movements, or excessive forces/deflections on the permanent bridge. Calibration records for the jacks utilized were also required.

The approach slabs on this project were precast. Their dimensions, in plan are 30 feet wide by 15.5 feet in length (along stationing). The slabs for each abutment are in four pieces, with each piece 7.5 inches wide by 15.6 inches long by 8 inches deep. Installation of the approach slabs is shown in figure 28.

Once the bridge work was completed, utilities were connected to the new bridge. Figure 29 shows a sample connection.

Figure 28. Photo. Installation of precast approach slabs.


Figure 29. Photo. Utility installation.

Figures 30 through 32 show various stages of approach roadway work beng performed. The pavement consisted of:

- 12-inch aggregate subbase course, gravel.
- 12-inch aggregate base course, crushed stone.
- 3-inch hot mix asphalt, 3/4 inch aggregate.
- 1.5-inch hot mix asphalt binder, 1/2 inch aggregate.
- 1.5-inch hot mix asphalt wearing course.

The roadway was opened for traffic use on August 30, 2013. Figure 33 shows the new, safer bridge that is wider, with improved alignment and upgraded traffic delineation and safety features in place. Figure 34 provides an elevation view of the new structure.

Figure 30. Photo. Preparation of subgrade for approach roadways.

Figure 31. Photo. Placement of asphalt material for surface courses.

Figure 32. Photo. Road opened for traffic use.

Figure 33. Photo. Guiderail installed, pavement striped, and new bridge in place.

Figure 34. Photo. Elevation view of completed bridge.

DATA ACQUISITION AND ANALYSIS

Data on safety, traffic flow, quality, and user satisfaction were collected before, during, and after construction to determine compliance with the HfL performance goals where appropriate. The primary objective of acquiring these types of data was to quantify the project performance, provide an objective basis on which 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 Maine DOT met the specific HfL performance goals related to this project.

SAFETY

The use of slide-in technology for this project provided several safety benefits. The technology enabled the superstructures to be built in the staging area adjacent to the existing bridge, yet away from the traffic using Hotel Road. Traditional construction methods would have required constructing the bridge while maintaining traffic through an onsite detour or staged construction. The innovation used allowed workers to work away from road traffic while Hotel Road was open and completely away from traffic when traffic was diverted during the month-long ABC period. Accordingly, throughout the construction period, workers were not exposed to traveler intrusion hazards and travelers were not exposed to construction work zone hazards. Also no crashes were reported during the ABC period during the traffic detour. With zero crashes, the project met the HfL goal of work zone crash rate equal to or less than the preconstruction rate at the project location.

There were no injuries reported on this project that were related to bridge construction. There was, however, one incident of a shoulder bruise reported away from the bridge when workers were filling a water tank using a fire hydrant as a source of supply. An employee of the firm fell from the second rung of a ladder. It is unknown at this time whether the injury resulted in lost time or restricted duties.

Crash data at the site pointed to the narrow width and limited sight distance caused by through truss members of the old structure as the causal factors for six crashes between 2008 and 2010. It is believed that these numbers will decrease in the 3 year period after construction by at least 20 percent (the HfL goal) because:

- The bridge is 12 feet wider.
- Sight distance is no longer hampered by truss members.
- Separate areas now exist for bicyclists (although there were no bicycle related crashes reported during the 2008-2010 period).
- The bridge no longer constricts the approach roadway.
- Safety features and traffic delineation have been improved.

CONSTRUCTION CONGESTION

An HfL performance goal on construction congestion is a 50 percent reduction in the time highway users are impacted, compared to traditional construction. The project team estimated that it would have taken 4 months (120 days) to build a replacement structure using traditional construction methods. Maine DOT was able to limit the impact on users to only 33 days, a reduction of more than 72 percent, easily exceeding the HfL goal.

The traditional option with a two-lane temporary bridge would not have had any delays. Maine DOT conducted traffic impact analysis to assess delays that construction would cause using a one-lane temporary bridge. Maine DOT evaluated the following options:

- Option 1 - Alternate traffic on temporary one-lane bridge.
- Option 2 - Allow inbound traffic only on temporary one-lane bridge.
- Option 3 - Allow outbound traffic only on temporary one-lane bridge.
- Option 4 - Detour both directions of traffic.

The analysis calculated total delay in terms of time and daily user costs using the Synchro/Sim traffic model. The results are shown in table 2.

Table 2. Time and user cost delays for various detour options.

Option	Total Delay (vehicle-hours)	Total Daily User Cost
Alternating one-way	60.0	$3,011.00
Outbound detour	9.7	$1,482.75
Inbound detour	4.8	$1,221.53
Combined detour	17.1	$2,704.28

If the one-lane temporary bridge option had been chosen, option 3 would likely have been selected, resulting in a total delay during the 4-month construction period of:

122 (days) x 4.8 veh-hrs = 585.6 veh-hrs.

For the innovative option used, the total delay during the 33-day period of bridge closure is calculated to be:

33 (days) x 17.1 veh-hrs = 564 veh-hrs.

Therefore, the aggregate delay for traditional construction with a one-lane temporary bridge would have been about the same as in the ABC construction used.

Maine DOT's analysis showed that the detour-affected intersections would maintain levels of service of C or better (under 35 sec/veh). The HfL goal for queue length in an urban area is 1.5 miles or less, which would take at least 15 minutes to clear. Therefore, it is evident that the construction congestion along the detour on this project easily met the HfL goal.

QUALITY

The old bridge and approaches to the bridge had an average IRI in the range of 204 to 256 inches per mile, as measured in 2011. Measurements following construction reduced the roughness of the section within the project limits to 143 inches per mile. Figure 35 presents the post construction IRI values at 20-ft intervals. Though the new bridge offered a much smoother and improved surface with a reduction in the IRI value from 204 to 256 in/mi to 143 in/mi, the HfL goal of less than 48 in/mi after construction was not met.

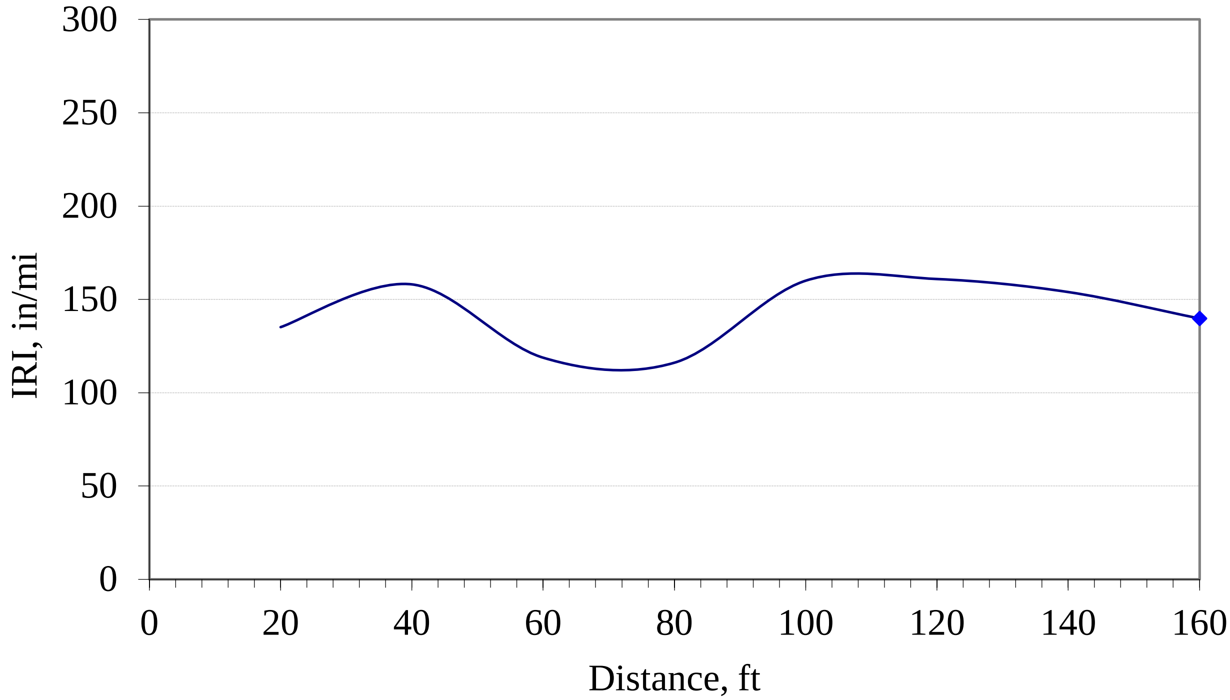


Figure 35. Chart. Post Construction IRI Measurements

To produce the global SI level, the average of the front and rear OBSI values from both lane directions was computed. The raw noise data were then normalized for the ambient air temperature and barometric pressure at the time of testing. The resulting mean SI level was A-weighted to produce the SI frequency spectra in one-third octave bands, as shown in figure 36. The bridge SI levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. The SI level was 99.2 dB(A) after construction. The new bridge, therefore, did not meet the HfL OBSI goal of 96.0 dB(A) or less. It can be safely assumed that the new texture of the bridge surface—while aiding traction and increasing safety—is prone to increasing noise.

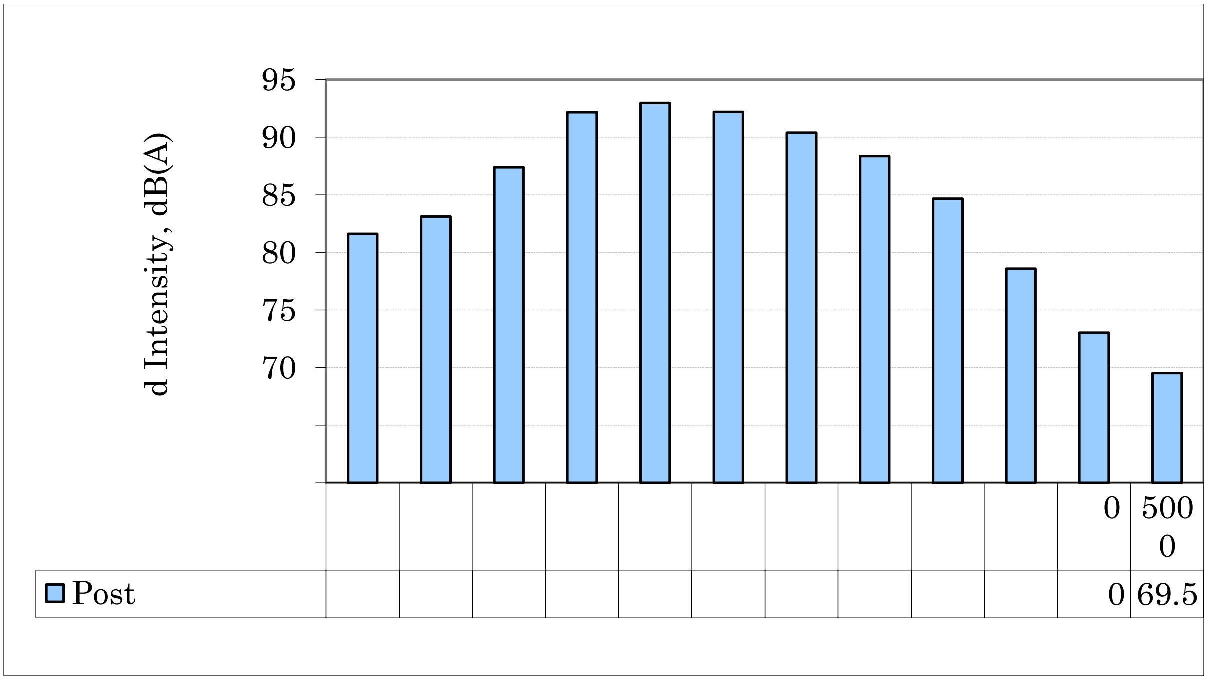


Figure 36. Chart. Post Construction SI Measurements

Besides improved ride quality and reduced noise, Maine DOT's initiatives will result in a more durable structure that will require less maintenance. The GFRP reinforcement will substantially reduce cracking of deck concrete despite the significant amounts of salt that States in the northeast typically apply during winters. The project team also addressed the detrimental effects of water through jointless construction. Therefore, water-induced damage common in most structures should not occur with the same extent and severity on this project. Furthermore, precast elements for abutments, approach slabs, wingwalls, and modular walls fabricated under controlled conditions with better curing and away from the traffic induced vibrations should result in a structure that is much more durable than the one replaced.

USER SATISFACTION

Maine DOT performed a user satisfaction survey through its website after the bridge construction was completed. Fifty-four participants responded. The questions and the tabulation of responses are shown in appendix C from Figures 37 through 42 and tables 5 and 10 respectively. When asked how satisfied they were with the new facility compared to its previous condition, the respondents gave an average rating of 4.72 out of a possible score of 5. This could be viewed as a score of 94 percent. This compares favorably with the HfL goal of 4 out of 7-point Likert scale, or a score of 57 percent. When asked how satisfied they were with the approach used to minimize disruption during construction, the average respondent score was 4.33 out of 5, or 87 percent—again, higher than the HfL goal of 57 percent.

The survey also showed that users prefer getting information regarding transportation issues through newspapers, Maine DOT's website and email notifications, and television.

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, Maine DOT supplied the cost figures for the as-built project as well as the baseline case.

CONSTRUCTION TIME

Through the use of innovative construction technology, Maine DOT was able to dramatically reduce the impact of this project on roadway users. What would have been a 4-month traditional construction project impacted users for only 33 days.

CONSTRUCTION COSTS

The preferred alternative from a traffic management perspective was the option that required construction of a two-lane temporary bridge. However, this would have cost approximately $350,000, and the approach roadway to the bridge would have come within 20 feet of the residence located at the northwest corner of the bridge. With the necessary grade change of the roadway and proximity to the bridge, the residents would have been required to be located. The cost of this alternative was estimated to be the same as the option ultimately chosen for this project (bridge closure with ABC). Table 3 shows the estimated construction cost for the ABC option at $2.2 million, which is in line with the low bid for this project of $2.1 million, validating the reasonableness of the estimates provided. Table 4 shows the estimated construction cost for the two-lane temporary bridge.

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.

The two-lane temporary bridge constructed adjacent to the existing alignment would have had no delays at this site. The cost for the ABC option calculated by Maine DOT was estimated at $2,704 per day. The total user cost for the 33-day period the detour was in effect therefore is estimated to be $89,232.

Table 3. Cost estimate for bridge closure and ABC.

PROJECT: Auburn, Littlefields Bridge #3338 - Alternative 1 Bridge Replacement 144' Steel span with Integral Abutments. Bridge closure with Accelerated Bridge Construction and traffic maintenance with an offsite detour. Deck Area: 144' x 37' - 4" = 5,380 SF						WIN: 19284.00 ESTIMATED BY: GAG
SUPERSTRUCTURE:	5,380	SF	x	$ 225.00	=	$ 1,211,000
ABUTMENTS:	2	EA	x	$ 100,000.00	=	$ 200,000
COFFERDAMS:	1	LS	x	$ 8,000.00	=	$ 8,000
STRUCTURAL EXCAVATION & BORROW:	1,300	CY	x	$ 30.00	=	$ 39,000
PRECAST MODULAR GRAVITY WALLS:	2,250	SF	x	$ 60.00	=	$ 135,000
RIPRAP:	70	CY	x	$70.00	=	$ 5,000
EXISTING BRIDGE REMOVAL:	1	LS	x	$ 190,000.00	=	$ 190,000
DETOUR AND/OR TEMPORARY BRIDGE:	0	LS	x	$ 0.00	=	$ 0
REHABILITATION CONTINGENCIES:				N/A	=	$ 0
MISCELLANEOUS (TCP'S, FIELD OFFICE, ETC.):				10%	=	$ 179,000
MOBILIZATION:				10%	=	$ 179,000
				STRUCTURE SUBTOTAL	**=**	**$ 2,155,000**
APPROACHES:	435	LF	x	$ 300.00	=	$ 131,000
MISCELLANEOUS:				7%	=	$ 10,000
MOBILIZATION:				10%	=	$ 14,000
				APPROACHES SUBTOTAL	**=**	**$ 155,000**
				TOTAL CONSTRUCTION COST	**=**	**$ 2,310,000**
PRELIMINARY ENGINEERING:				13%	=	$ 310,000
RIGHT OF WAY:					=	$ 20,000
CONSTRUCTION ENGINEERING:				11%	=	$ 260,000
OTHER:					=	$ 0
				TOTAL PROJECT COST	**=**	**$ 2,900,000**

Table 4. Cost estimate for two-lane temporary bridge option.

PROJECT: Auburn, Littlefields Bridge #3338 - Alternative 5 Bridge Replacement 144' Steel span with Integral Abutments and a two lane temporary bridge. Deck Area: 144' x 37' - 4" = 5,380 SF				WIN: 19284.00 ESTIMATED BY: GAG		
SUPERSTRUCTURE:	5,380	SF	x	$ 180.00	=	$ 969,000
ABUTMENTS:	2	EA	x	$ 60,000.00	=	$ 120,000
COFFERDAMS:	1	LS	x	$ 8,000.00	=	$ 8,000
STRUCTURAL EXCAVATION & BORROW:	1,300	CY	x	$ 30.00	=	$ 39,000
PRECAST MODULAR GRAVITY WALLS:	2,250	SF	x	$ 60.00	=	$ 135,000
RIPRAP:	70	CY	x	$70.00	=	$ 5,000
EXISTING BRIDGE REMOVAL:	1	LS	x	$ 150,000.00	=	$ 150,000
DETOUR AND/OR TEMPORARY BRIDGE:	1	LS	x	$ 350,000.00	=	$ 350,000
REHABILITATION CONTINGENCIES:				N/A	=	$ 0
MISCELLANEOUS (TCP'S, FIELD OFFICE, ETC.):				10%	=	$ 178,000
MOBILIZATION:				10%	=	$ 178,000
STRUCTURE SUBTOTAL					**=**	**$ 2,135,000**
APPROACHES:	435	LF	x	$ 300.00	=	$ 131,000
MISCELLANEOUS:				7%	=	$ 10,000
MOBILIZATION:				10%	=	$ 14,000
APPROACHES SUBTOTAL					**=**	**$ 155,000**
TOTAL CONSTRUCTION COST					**=**	**$ 2,290,000**
PRELIMINARY ENGINEERING:				11%	=	$ 255,000
RIGHT OF WAY:					=	$ 100,000
CONSTRUCTION ENGINEERING:				11%	=	$ 255,000
OTHER:					=	$ 0
TOTAL PROJECT COST					**=**	**$ 2,900,000**

The user cost for the two-lane temporary bridge option was estimated to $149,027 at $1,221.53 per day for 122 days. The user cost savings with the use of the ABC option was $59,795.

COST SUMMARY

It is estimated that the cost of delivering the project using traditional methods would have been the same as the innovative method used on this project. However, the innovative method resulted in user cost savings of $ 59,795 due to traffic being detoured during the roadway closure period.

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of FHWA Highways for LIFE Team Leader, Byron Lord; Program Coordinators, Mary Huie and Kathleen Bergeron; and Program Manager for FHWA's Center for Accelerating Innovation, Ewa Flom. 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 Maine DOT personnel Darryl Belz, Nate Benoit, David Doucette, Wayne Frankhauser, Jr., and Dale Peabody; and FHWA Engineers Maria Drozd, Benjamin Beerman, and Tim Cupples for their advice, assistance, and coordination during this project.

APPENDIX A—SPECIAL PROVISION FOR GFRP REBARS

SPECIAL PROVISION
SECTION 530
GLASS FIBER REINFORCED POLYMER

Section 530 Glass Fiber Reinforced Polymer of the Standard Specifications is added as follows:

530.01 Description This work shall also consist of furnishing and placing Glass Fiber Reinforced Polymer (GFRP) reinforcement bars, in accordance with these specifications and in conformance with the Plans, Supplemental Specifications and Special Provisions.

530.02 Materials All GFRP reinforcement will conform to the requirements shown in the AASHTO Bridge Design Guide Specifications for GFRP Reinforced Concrete Bridge Decks and Traffic Railings (November 2009), except as shown on the plans, and as stated herein. All GFRP reinforcement shall be deformed or sand coated.

GFRP bars shall be according to the modulus grade specified on the plans and shall be from one of the following approved manufacturers:

1. Aslan 100 by Hughes Brothers Inc.
2. V-Rod by Pultrall Inc.
3. ComBAR by Schoeck Bauteile
4. Mateen-bar from Sigma Development Group, LLC

All GFRP bars in the same structural component shall be supplied by the same manufacturer; there shall be no mixing of products from different manufacturers in a component unless permitted in the contract drawings.

Documentation For all GFRP reinforcement to be used on Department projects, the bar manufacturer is to furnish the Resident with two (2) copies of written certifications that the GFRP reinforcement meets the requirements of this specification. In addition, the certification is to list the test values and test procedures used to determine the physical properties of the GFRP reinforcement. Certifications bearing the notarized signature of a responsible authorized representative of the bar manufacturer are required. Each bundle of GFRP reinforcement will be identified with a corresponding lot number with the lot numbers affixed to each bundle by means of a durable tag.

Repair Material The material used to repair the cut ends of GFRP reinforcement shall comply with the requirements established by the bar manufacturer.

530.03 Schedule of Material When the Department does not furnish GFRP reinforcing bar schedules, the Contractor shall submit order lists, shape diagrams and bar layout drawings to the Resident for approval. The reinforcing bars shall not be ordered until these lists and drawings are approved. Approval shall not relieve the Contractor of full responsibility for the satisfactory completion of this item. When the Department allows the use of precast concrete deck panels, or any other significant changes that effect the quantity of reinforcing bars, the Contractor shall be responsible for revising the reinforcing bar schedule; the revised schedule shall be submitted to the Resident for approval.

530.04 Protection of Material Delivery, storage and handling of GFRP bars shall be in accordance with the manufacturer's instructions to prevent damage. Prevent bending, coating with earth, oil, or other material, or otherwise damaging the GFRP reinforcement. When handling GFRP reinforcement, use equipment that avoids damaging or abrading the GFRP bar. Do not drop or drag GFRP reinforcement.

GFRP reinforcement shall be stored on skids or other supports a minimum of 12 inches above the ground surface and protected at all times from damage and surface contamination. The storage supports shall be constructed of wood, or other material that will not damage the surface of the reinforcement or epoxy coating. Bundles of bars shall be stored on supports in a single layer. Each bundle shall be placed on the supports out of contact with adjacent bundles. If it is expected that GFRP bars will be required to be stored outdoors for a period in excess of two months, then they shall be protected from ultraviolet radiation. Prevent exposure of GFRP to temperatures above 120 degrees Fahrenheit during storage.

The maximum total un-repaired visible damage permitted on each liner foot of each GFRP bar shall not exceed 2 percent of the surface area in that linear foot of bar. The depth of the permissible damage shall not exceed 0.04 inches.

530.05 Fabrication Forming of GFRP reinforcing bars and tolerances for forming of GFRP reinforcing bars shall be in conformance with the latest edition of the "Manual of Standard Practice of the Concrete Reinforcing Steel Institute" and the "Detailing Manual of the American Concrete Institute".

All handling of GFRP reinforcing bars by mechanical means shall be done by equipment having padded contact areas, or by the use of nylon webbing slings. The use of chains or wire rope slings shall not be allowed, even when used with padding. All bundles of GFRP bars shall be lifted with a strong back, spreader bar, multiple supports or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles. Support points during lifting or transporting of bundled GFRP reinforcing bars shall be spaced at a maximum of 4.5 m [15 ft], or as required by the manufacturer, whichever is more restrictive. Bundled bars shall be strapped together with non-metallic or padded straps in a manner to prevent bar-to-bar abrasion due to relative movement between bars.

Individual bars shall be handled in a manner that prevents damage to the coating due to abrasion or impact, and at no time shall any bar be moved by dragging over any surface, including other reinforcing bars. Sufficient personnel shall be assigned to assure that there is complied with the above. Bars loaded for transport shall be loaded and strapped down in a manner that will prevent damage from motion and vibration, to the greatest extent possible. Bundles of bent bars shall be transported strapped to wooden platforms or shall be crated. All individual bundles and layers of bundles shall be separated, and supported by dunnage.

530.06 Placing and Fastening

All GFRP reinforcement shall be accurately placed in the positions shown on the plans and shall be firmly held there during the placing and setting of the concrete. Immediately before placing concrete, GFRP reinforcement shall be free from all foreign material, which could decrease the bond between the GFRP and concrete. Such foreign material shall include, but not be limited to: dirt, paint, oil, bitumen and dried concrete mortar.

GFRP bars within the formwork shall be secured to prevent movement during concrete placement. The bars must be adequately supported or tied to resist settlement, floating upward, or movement in any direction during concrete placement. Field bending of GFRP shall not be allowed.

Field cutting of GFRP will be permitted only with the approval of the Resident. The field cutting shall be with a high speed cutter, fine blade saw, diamond blade or masonry saw. The GFRP bars shall not be shear cut. The ends of all field cut bars shall be treated per the manufacturer's recommendations.

GFRP reinforcing bars supported on formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of 50 mm [2 in] from the point of contact with the reinforcing bars. Reinforcing bars used as support bars shall be epoxy-coated. Tie wire for GFRP reinforcing bars shall be soft annealed wire that has been nylon, epoxy or plastic coated.

Bars shall be fastened together at all intersections except where spacing is less than 300 mm [1 ft] in either direction, in which case, fastening at alternate intersections of each bar with other bars will be permitted providing this will hold all the bars securely in position. This fastening may be tightly twisted polymer coated wire or plastic ties.

Proper distances from the forms shall be maintained by means of stays, blocks, ties, hangers or other approved means. Blocks used for this purpose shall be precast portland cement mortar blocks of approved shape and dimensions. Chairs may be used for this purpose and, when used, must be GFRP or plastic. Layers of bars may be separated by precast portland cement mortar blocks or other approved devices. The use of pebbles, pieces of broken stone or brick, metal pipe or wooden blocks shall not be permitted. The placing of reinforcement as concrete placement progresses, without definite and secure means of holding the bar in its correct position, shall not be permitted. GFRP reinforcing bars supported on formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of 50 mm [2 in] from the point of contact with the reinforcing bars. Reinforcing bars used as support bars shall be GFRP. In walls, spreader bars shall be GFRP.

Ties for GFRP reinforcing bars shall be plastic ties or soft annealed wire that has been nylon, epoxy or plastic coated. Bars in bridge seats shall be placed so as to clear anchor bolts. When specified on the contract plans, reinforcing bars shall be anchored into drilled holes. The anchoring material shall be one of the products listed on the Maine Department of Transportation's list of Prequalified Type 3 Anchoring Materials. Installation shall be in accordance with the manufacturer's published recommendations.

At each anchor location, existing reinforcing will be located to avoid drilling through existing bars. Where interferences are found to exist, location adjustments will be determined by the Resident. Minimum embedment lengths of reinforcing bars shall comply with the manufacturer's published recommendations for the anchoring material selected. These embedment lengths shall be verified by the Resident before installation of the reinforcing bars. The reinforcing bar lengths indicated on the Plans may be reduced, at the Contractor's option, to the determined minimum embedment lengths.

Reinforcement shall be inspected and approved by the Resident before any concrete is placed.

530.07 Splicing Reinforcing bars shall be spliced in accordance with the requirements of this section, and in the locations shown on the plans. No modifications of, or additions to, the splice arrangements shown on the plans shall be made without the Resident's prior approval.

Any additional splices authorized shall be staggered as much as possible. All splices shall be made in a manner that will ensure that not less than 75% of the clear concrete cover and not less than 75% of the minimum clear distance to other bars will be maintained, as compared to the cover and clear distance requirements for the unspliced bar.

Lapped splices shall be made by placing the bars in contact and wiring/tying them together. Splice laps shall be made in accordance with the table provided on the plans.

530.08 Substitution Substitution of different size bars shall not be permitted except with the written authorization of the Resident.

530.09 Method of Measurement
GFRP reinforcing bars shall be measured by the linear feet reinforcement authorized.

530.10 Basis of Payment
The accepted quantity of GFRP reinforcing bars will be paid for at the contract unit price per liner feet, completed, and accepted. Payment for work associated with revisions to the GFRP reinforcing schedule, required for any significant changes that affect the quantity of reinforcing bars, shall be considered incidental to related contract items.

Payment will be made under:

Pay Item		Pay Unit
530.30	Glass Fiber Reinforced Polymer, Fabricated and Delivered	Linear Foot
530.31	Glass Fiber Reinforced Polymer, Placing	Linear Foot

APPENDIX B—SPECIAL PROVISION ON INCENTIVE/DISINCENTIVE

WIN 19284.00
January 11, 2013

SPECIAL PROVISION
SECTION 107

(Incentive/Disincentive, Supplemental Liquidated Damages, Contract Time)

SUPPLEMENTAL DEFINITIONS

Phase #1 This phase of the project begins when two, 11 foot wide travel lanes are not open to traffic, excluding any allowed short term lane closures.

Phase #1 will be considered complete when: the existing bridge is removed as shown on the Plans; the new pile supported abutments and wingwalls are installed; the new bridge superstructure is moved into its final position resting solely on the new abutments; the bridge rail and transition barriers are installed; and the work site is clear and available for use by the utility companies, with access unimpeded by the Contractor or its subcontractors.

Phase #2 This phase of the project begins at the completion of Phase #1 as defined above with the road still closed to traffic, and continues until the third-party utility relocations are complete (including utility acceptance testing), and as determined by the Resident.

Phase #3 This phase of the project begins at the completion of Phase #2 and continues until the point at which two, 11 foot wide travel lanes are open to traffic with all Roadway pavement complete including base and surface pavement. The Resident shall be the sole authority in determining when Phase #3 is complete.

No-Excuse Award Bonus A financial incentive provision tied to accelerated completion of construction activities, construction phases or major milestones, within a pre-determined time period, where the Contractor assumes all risks for completion and waives any right to claim.

INCENTIVE/DISINCENTIVE FOR EARLY OR LATE COMPLETION

Work Time Periods. The duration of Phase #1 shall not exceed a total of twentyfive (25) Days. During Phase #1 the existing bridge may be reopened to two 11 foot wide lanes of traffic after the completion of certain construction activities. Once the existing bridge is removed, the roadway shall not be reopened to traffic until Phase #3 is complete

Each Day or portion of a Day that two 11 foot wide travel lanes are not open to traffic, excluding any allowed short term lane closures, will be counted against the twenty-five (25) Day duration for Phase #1.

Phase #1 shall not begin prior to June 16, 2013 to limit the impact on school bus routes. The Contractor will be able to close the road prior to this date if the work is coordinated when school is not in session.

The duration of the Phase #3 portion of the Work shall not exceed four (4) consecutive Days.

Early Completion Incentives. The Contractor will be paid a $7,500 incentive for each complete Day that Phase #1 is completed early. In addition, the Contractor will be paid a single No-Excuse Award Bonus of $40,000 if Phase #2 and Phase #3 are completed within fifteen (15) consecutive Days or less.

Late Completion Disincentives. The Contractor will be assessed a $7,500 disincentive for each Day or portion of a Day that Phase #1 is completed after the allowed twenty-five (25) Day duration. In addition, the Contractor will be assessed a $7,500 disincentive for each Day or portion of a Day that Phase #3 is completed after the allowed four (4) Day duration. These disincentives will be deducted from any monies due or to become due to the Contractor.

Maximum Total Contract Incentives/Disincentive. The maximum combined monetary incentive, including any No-Excuse Award Bonus is capped at $100,000 for this contract. There is no upper limit to the dollar amount of the disincentive assessments.

Sunday Work. Sunday work will be allowed between the start of Phase #1 and up to the completion of Phase #3.

Work Hours and Night work: The Contractor may work from 6:00 am to 7:00 pm daily. With permission from the City of Auburn and Resident, the Contractor may extend the work hours up until 30 minutes after sunset. Night work is not approved for this project.

Short Term Lane Closures: Short term lane closures will be considered for approval by the Resident for delivery of materials.

APPENDIX C—USER SATISFACTION SURVEY RESULTS

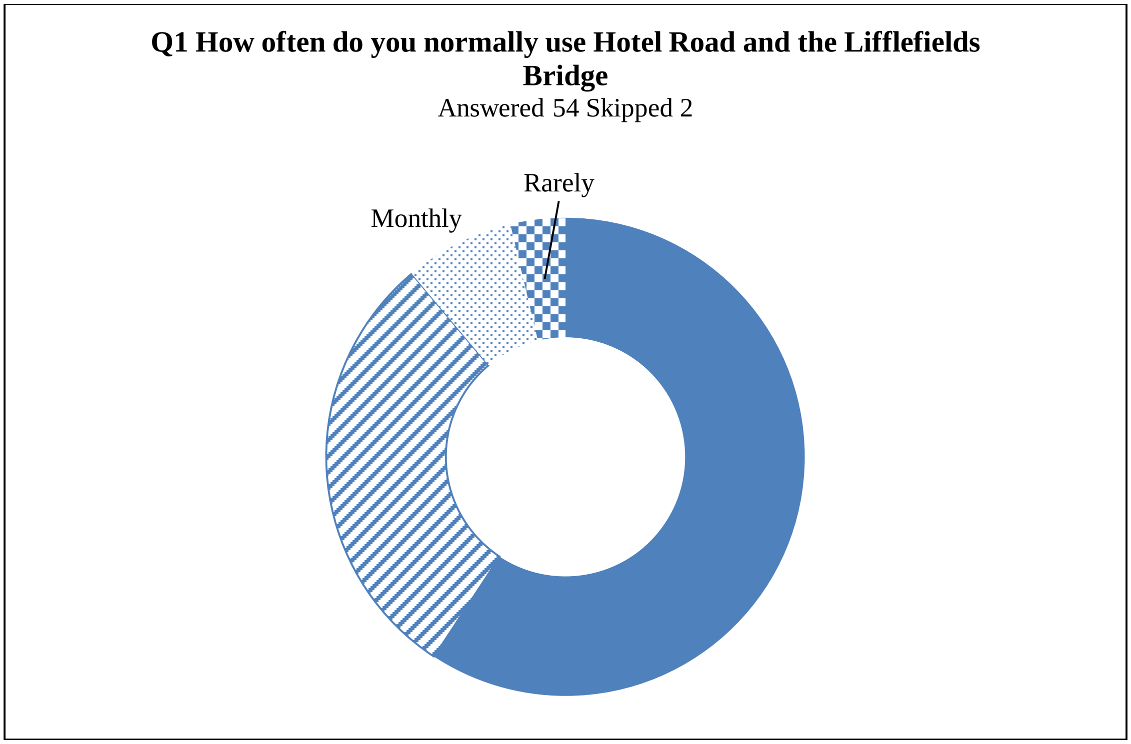


Figure 37. Chart. Survey responses on travel frequency.

Table 5. Survey responses on travel frequency.

Answer Choices	**Responses**	
	Number	Percent
Daily	32	59.26%
Weekly	16	29.63%
Monthly	4	7.41%
Rarely	2	3.70%
Total	54	100%

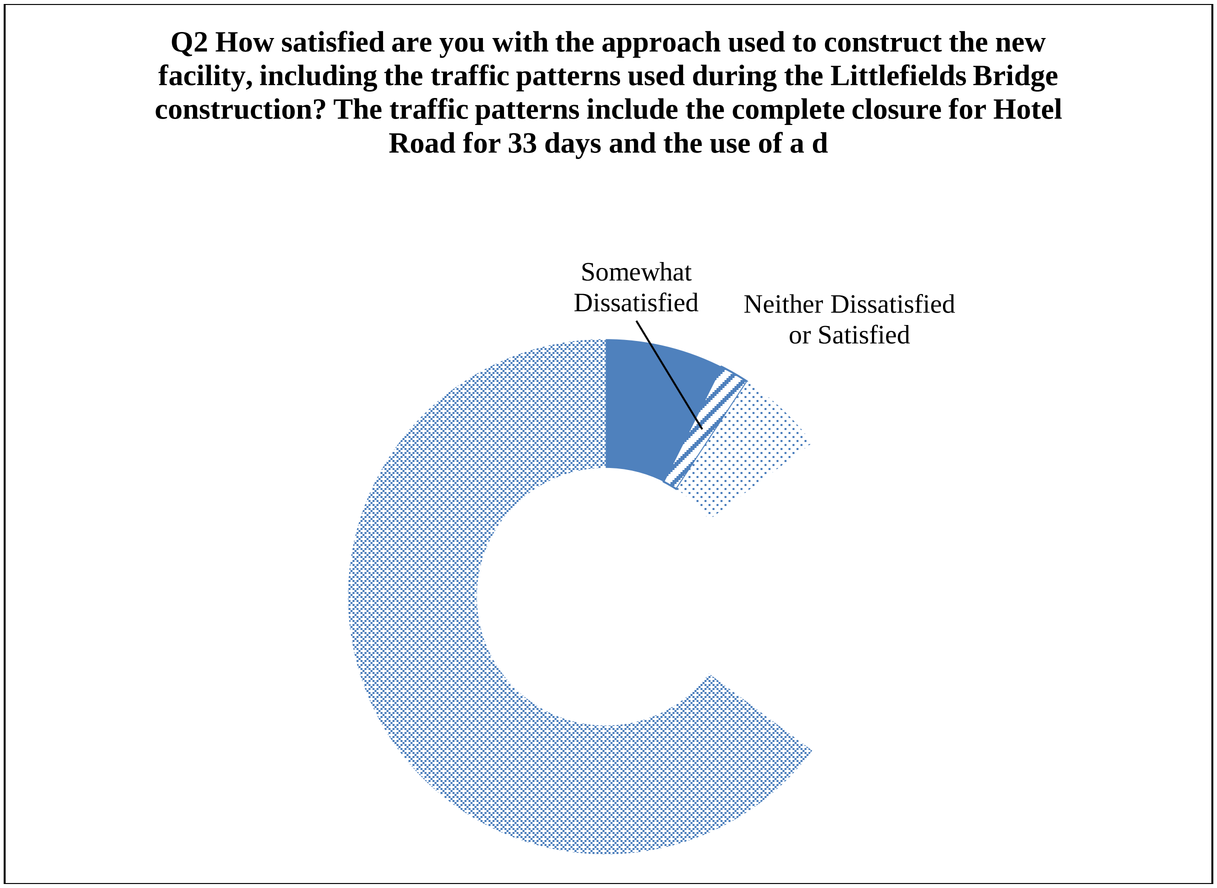


Figure 38. Chart. Survey responses on construction approach.

Table 6. Survey responses on construction approach.

Answer Choices	Responses	
	Number	Percent
Very Dissatisfied	4	7.41%
Somewhat Dissatisfied	1	1.85%
Neither Dissatisfied or Satisfied	3	5.56%
Somewhat Satisfied	11	20.37%
Very Satisfied	35	64.81%
Total	54	100%
Average Rating	4.33	

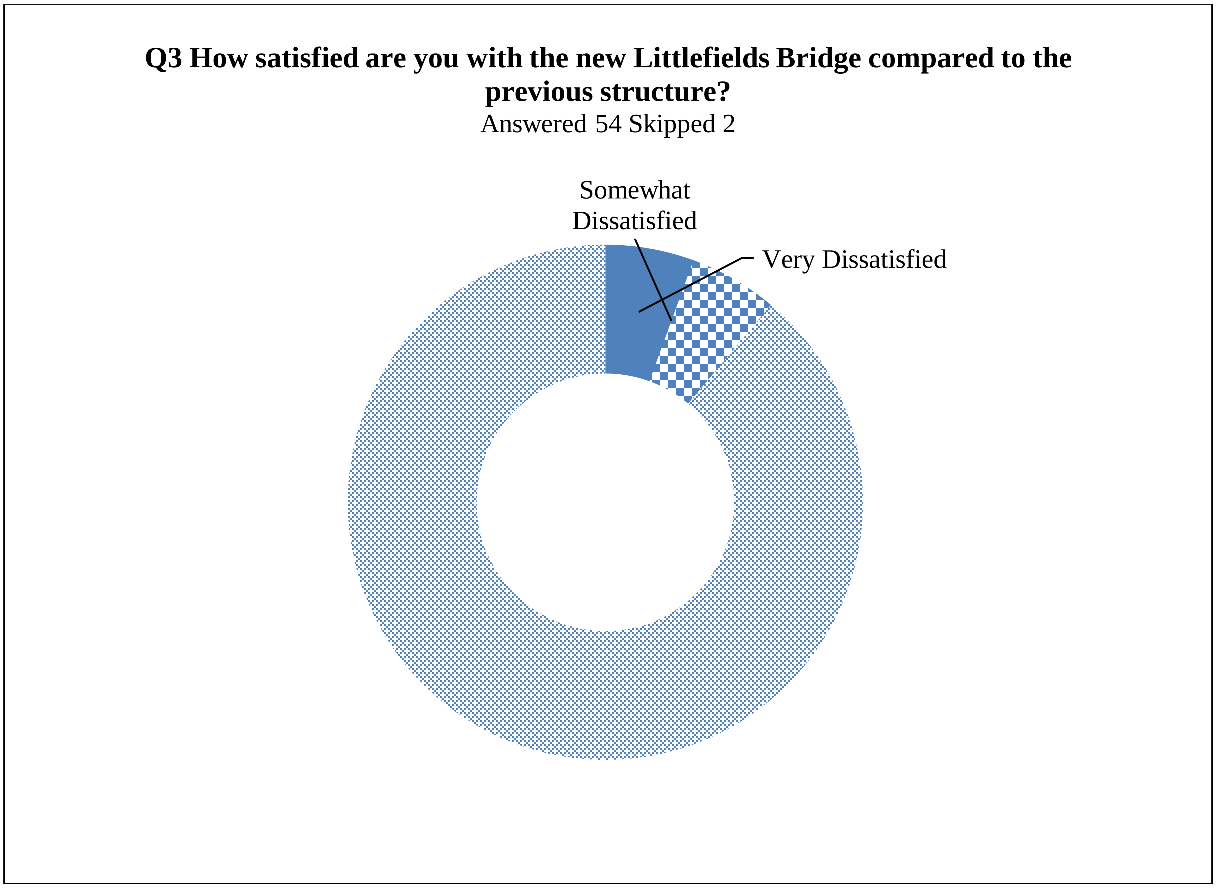


Figure 39. Chart. Survey responses on facility-related satisfaction.

Table 7. Survey responses on facility-related satisfaction.

Answer Choices	**Responses**	
	Number	Percent
Very Dissatisfied	3	5.56%
Somewhat Dissatisfied	0	0.00%
Neither Dissatisfied or Satisfied	0	0.00%
Somewhat Satisfied	3	5.56%
Very Satisfied	48	88.89%
Total	54	100%
Average Rating	4.72	

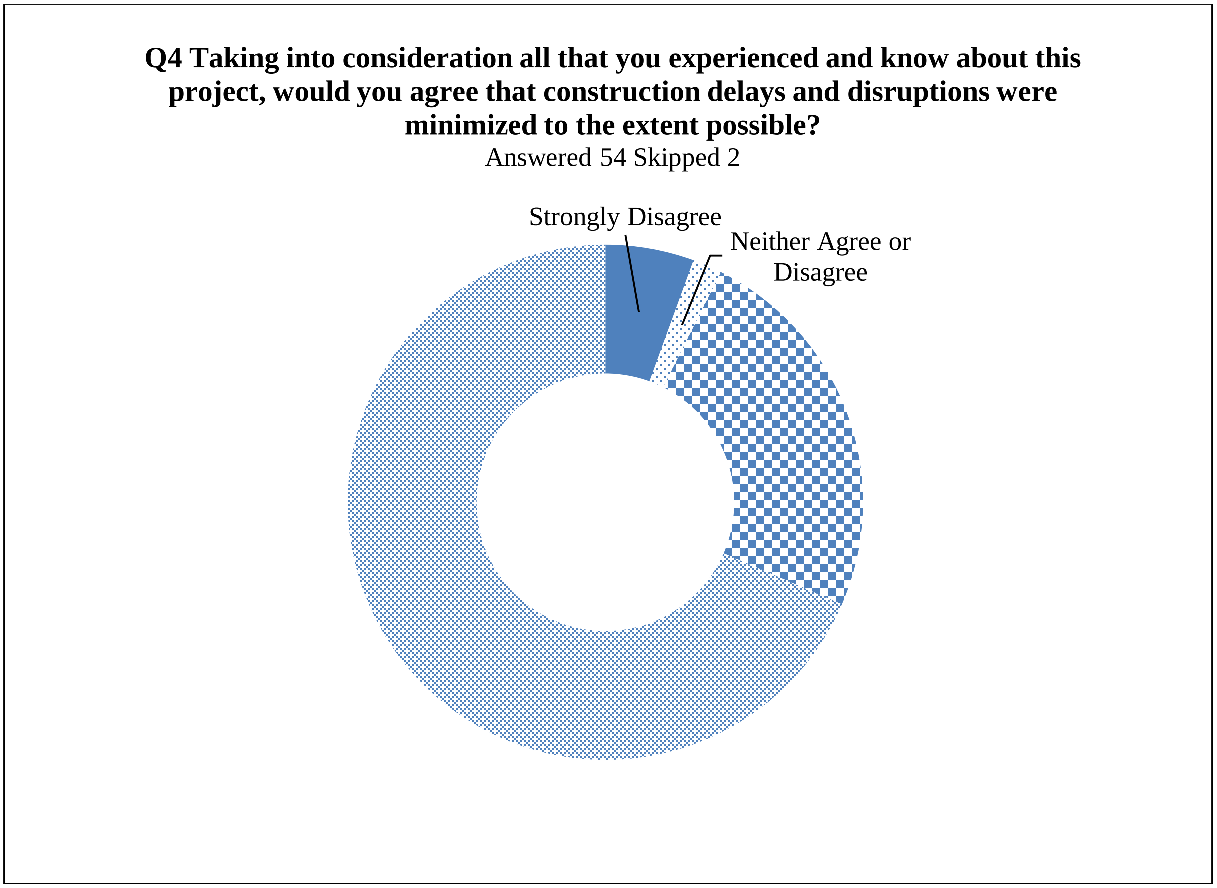


Figure 40. Chart. Survey responses on construction delays and disruptions.

Table 8. Survey responses on construction delays and disruptions.

Answer Choices	**Responses**	
	Number	Percent
Strongly Disagree	3	5.56%
Somewhat Disagree	0	0.00%
Neither Agree or Disagree	1	1.85%
Agree	13	24.07%
Strongly Agree	37	68.52%
Total	54	100%
Average Rating	4.5	

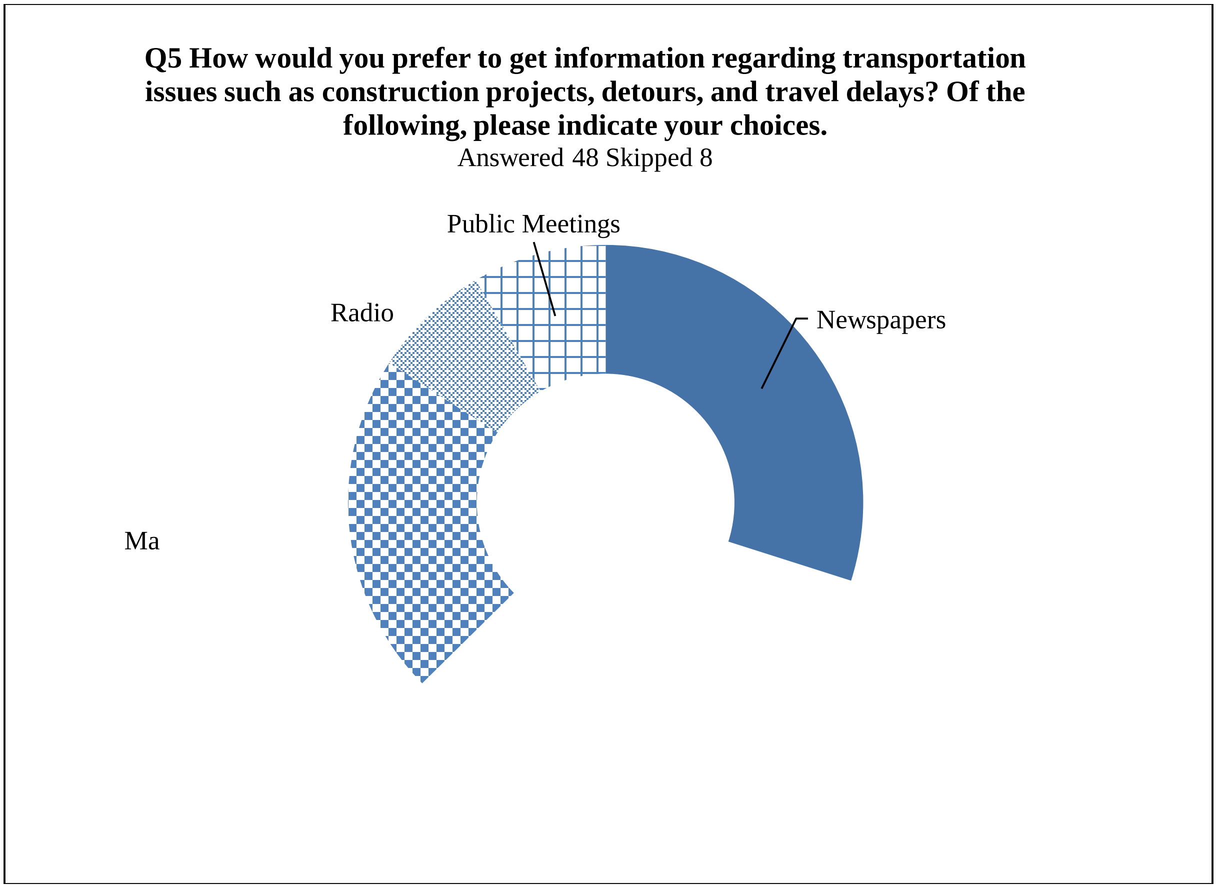


Figure 41. Chart. Survey responses on information availability.

Table 9. Survey responses on information availability.

Answer Choices	Responses	
	Number	Percent
Newspapers	32	66.67%
Television	22	45.83%
Social Media such as Facebook and Twitter	13	27.08%
Maine DOT website or Email Notifications	23	47.92%
Radio	8	16.67%
Public Meetings	9	18.75%
Total	48	100%

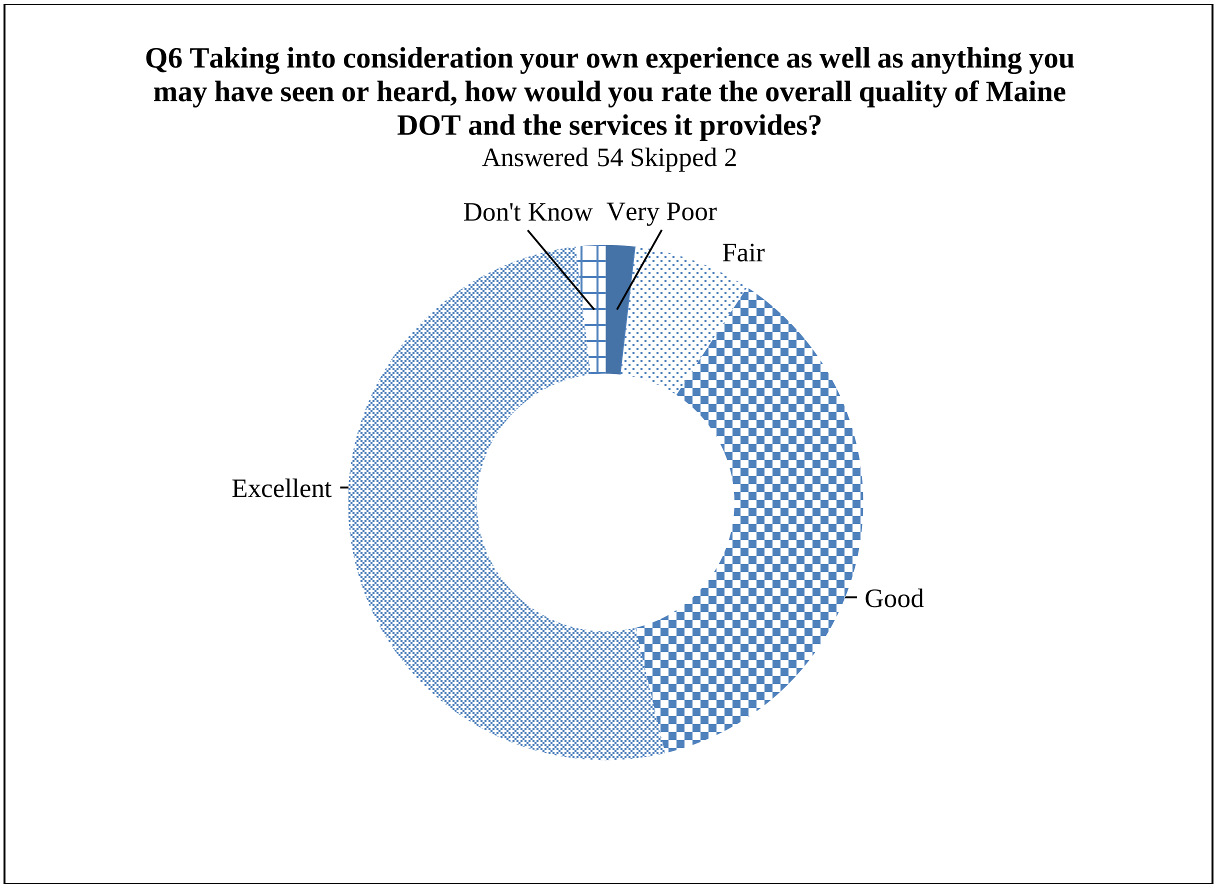


Figure 42. Chart. Survey responses on Maine DOT quality.

Table 10. Survey responses on Maine DOT quality.

Answer Choices	**Responses**	
	Number	Percent
Very Poor	1	1.85%
Poor	0	0.00%
Fair	4	7.41%
Good	20	37.04%
Excellent	28	51.85%
Don't Know	1	1.85%
Total	54	100%
Average Rating	4.4	