

Iowa Demonstration Project: Massena IA-92 Bridge Replacement Project

**Final Report
October 2014**

HIGHWAYS FOR LIFE

Accelerating Innovation for the American Driving Experience.



U.S. Department of Transportation
Federal Highway Administration

FOREWORD

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

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

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

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

Additional information on the HfL program can be found 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 Iowa Department of Transportation (DOT) was awarded a \$400,000 grant to demonstrate the use of proven, innovative technologies, including lateral bridge slide and prefabricated bridge element systems (PBES), to deliver this \$2.0 million project in less time and with less impact to motorists than conventional construction. The project consisted of replacing the Iowa Highway 92 bridge (Maint. No 1563.4S092) over a small natural stream, 1 mile west of Iowa Highway 148. The replacement bridge was designed to increase the structural capacity of the bridge, improve roadway conditions, and enhance user safety by providing a wider bridge and approaching roadway. This project focused on implementation of an accelerated bridge construction (ABC) policy and first-time use of the demonstrated innovative construction methods. This was the first lateral bridge slide project in the State of Iowa. The project was let on April 16, 2013 using a design-bid-build contract, and the winning bid amount was \$1.3 million. The project involved three phases: 1) construction of the bridge structure off-alignment, 2) the bridge slide-in, and 3) revetment, grading, and clean-up. The replacement structure was a single-span 120-foot by 44-foot bridge with cast-in-place abutment footings, precast wingwalls, and a precast superstructure fabricated adjacent to the existing bridge and moved into position by lateral slide. The ABC approach resulted in a full closure of 9 days with no incentives or disincentives awarded to the contractor at the end of this project. A 12.89 mile detour was utilized during the full closure, thus resulting in an out-of-distance mileage of 6.89 miles. To estimate the cost savings for the ABC method, the total costs were computed for both the as-built bridge and a baseline (cast-in-place) scenario by adding the agency costs and user costs. The results indicated a cost savings of around 43 percent over the baseline scenario, mainly attributable to the significantly reduced user costs of the as-built project.			
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
(none)	mil	25.4	micrometers	µm
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	Newtons	N
lbf/in ² (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in ² (ksi)	kips per square inch	6.89	megaPascals	MPa
DENSITY				
lb/ft ³ (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m ³

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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ABBREVIATIONS AND SYMBOLS

ABC	accelerated bridge construction
ADT	average daily traffic
dB(A)	A-weighted decibel
DOT	Department of Transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
NBI	National Bridge Inventory
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
PBES	prefabricated bridge element systems
PTFE	polytetrafluoroethylene
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
VOC	vehicle operating cost

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

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

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

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

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

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

Project Solicitation, Evaluation, and Selection

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

The project selection panel consisted of representatives of the FHWA offices of Infrastructure, Safety, and Operations; the Resource Center Construction and Project Management team; the Division offices; and the HfL team. After evaluating and rating the applications and

supplemental information, panel members convened to reach a consensus on the projects to recommend for approval. The panel gave priority to projects that accomplish the following:

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

HfL Project Performance Goals

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

- **Safety**
 - Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
 - Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.
 - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.
- **Construction Congestion**
 - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
 - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
 - Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).
- **Quality**
 - Smoothness—International Roughness Index (IRI) measurement of less than 48 in/mi.

- Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.
- **User Satisfaction**—An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report documents the Iowa DOT's HfL demonstration project featuring innovative lateral bridge slide and prefabricated bridge element systems (PBES). The report presents project details relevant to the HfL program, including project background and description, HfL performance metrics measurement, and economic analysis. Technology transfer activities that took place during the project and lessons learned are also discussed.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

The project consisted of replacing of the Iowa Highway 92 bridge (Maint. No 1563.4S092, National Bridge Inventory No. 17840) over a small natural stream, 1 mile west of Iowa Highway 148, near Massena in Cass County, Iowa. The bridge was replaced to increase the structural capacity of the bridge, improve roadway conditions, and enhance user safety by providing a wider bridge and approaching roadway.

This project focused on implementation of an accelerated bridge construction (ABC) policy and first-time use of the demonstrated construction methods, in preparation for more widespread use. The use of PBES and lateral bridge slide were promoted through this project. This was the first lateral bridge slide project in the State of Iowa.

The project used a design-bid-build contract. The project was let on April 16, 2013, and the winning bid amount was \$1.347 million. The bid amount included a maximum incentive amount of \$40,000; however, no incentives or disincentives were awarded at the end of this project.

The project involved three phases:

- Phase 1 – Construct bridge off-alignment.
- Phase 2 – ABC period.
- Phase 3 – Revetment, grading, and clean-up.

The replacement structure was a single-span 120-foot by 44-foot bridge with precast abutment footings, precast wingwalls, and a precast superstructure fabricated adjacent to the existing bridge and moved into position by lateral slide. The ABC approach resulted in a full closure of 9 days, during which time a 12.89-mile detour was utilized.

HfL PERFORMANCE GOALS

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

- **Safety**
 - Work zone safety during construction— No work zone related incidents occurred during the entire construction period including the closure period. This meets the HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate.
 - Worker safety during construction— No workers were injured on the project, so the contractor achieved a score of 0 on the OSHA Form 300, meeting the HfL goal of less than 4.0.
 - Facility safety after construction—HfL goal for facility safety is 20 percent reduction in fatalities and injuries in 3-year crash rates compared to preconstruction rates. The

deck width of existing bridge was widened from 31.8 ft to 44 ft (edge to edge) to improve the safety of this roadway facility. The net effect of the bridge widening on the facility safety is yet to be determined.

- **Construction Congestion**
 - Faster construction—The ABC approach shortened the duration of the traffic mobility impact time from 180 days to 9 days, meeting the HfL goal of a 50 percent reduction in the time traffic is impacted compared to traditional construction methods.
 - Trip time— Considering the cumulative trip time over the 9-day detour compared to 180 days of detour estimated for traditional construction, motorists experienced a reduction in trip time, meeting the HfL goal of no more than a 10 percent increase in trip time compared to the average preconstruction conditions
 - Queue length during construction—The project met the HfL goal of less than a 0.5-mile queue length in rural areas, as there were no traffic backups reported on the designated detour route.

- **Quality**
 - No IRI or OBSI data were collected for this project because the bridges were too short for any meaningful data to be obtained.
 - User satisfaction— The user satisfaction survey results indicated that the travelling public was satisfied with the new facility and the approach undertaken by Iowa DOT. The HfL user satisfaction criteria of 4-plus on a 7-point Likert scale were thus met.

ECONOMIC ANALYSIS

The costs and benefits of this innovative project approach were compared with those of a project of similar size and scope delivered using a more traditional approach. The agency cost of the as-built project was \$366,096.15—or 35 percent—more than the estimated agency cost using traditional construction methods. On the contrary, the total user cost savings realized using ABC approach was \$1,453,045, which in turn translates to 95 percent savings in total user costs compared to traditional construction. Overall, the Iowa DOT’s ABC approach resulted in a total cost savings of \$1,086,949 (43 percent) over conventional construction practices. A significant amount of the cost savings was attributable to the reduced user costs.

LESSONS LEARNED

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

- Both the Iowa DOT and the contractor felt the need for early letting of ABC projects, preferably during the fall season. The early letting would give the agency additional time for review of contractor submittals, drawings, and fabrication plans and falsework designs.

- Iowa DOT identified the need for designers' involvement in the post-letting phase to comprehensively evaluate the impacts of method changes made by the contractor.
- Iowa DOT's current Incentive/Disincentive clause is based on the unit of days. The agency considers amendments in their specifications to allow for proration of I/Ds for partial days.
- Per Iowa DOT, a specification requiring the falsework design engineer to inspect and accept falsework construction needs to be included. The contractor felt that having more time for falsework design would prove beneficial.
- Iowa DOT intends to provide an alternate bid item for contractors to select either a cast in-place or precast abutment in future bridge replacement projects. This would facilitate the contractors to select a better alternative for substructure. Iowa DOT also recommends the use of separate bid items for the falsework and the prefabricated bridge move.
- The contractor believes that communication among the construction personnel is the key during the slide-in process. Better communication helps to overcome coordination issues between construction personnel on either end of the bridge.

CONCLUSIONS

The Iowa DOT gained valuable insights into the ABC approach and the improvements needed to make this process a more viable tool. The use of innovations such as PBES and lateral bridge slide helped the project meet HfL performance goals by reducing construction time, reducing costs, reducing congestion, and increasing motorist and worker safety.

PROJECT DETAILS

BACKGROUND

The project involved the replacement of the Iowa Highway 92 bridge (Maint. No 1563.4S092, National Bridge Inventory No. 17840) over a small natural stream, 1 mile west of Iowa Highway 148. The bridge is located near Massena, Cass County, Iowa (see figure 1).

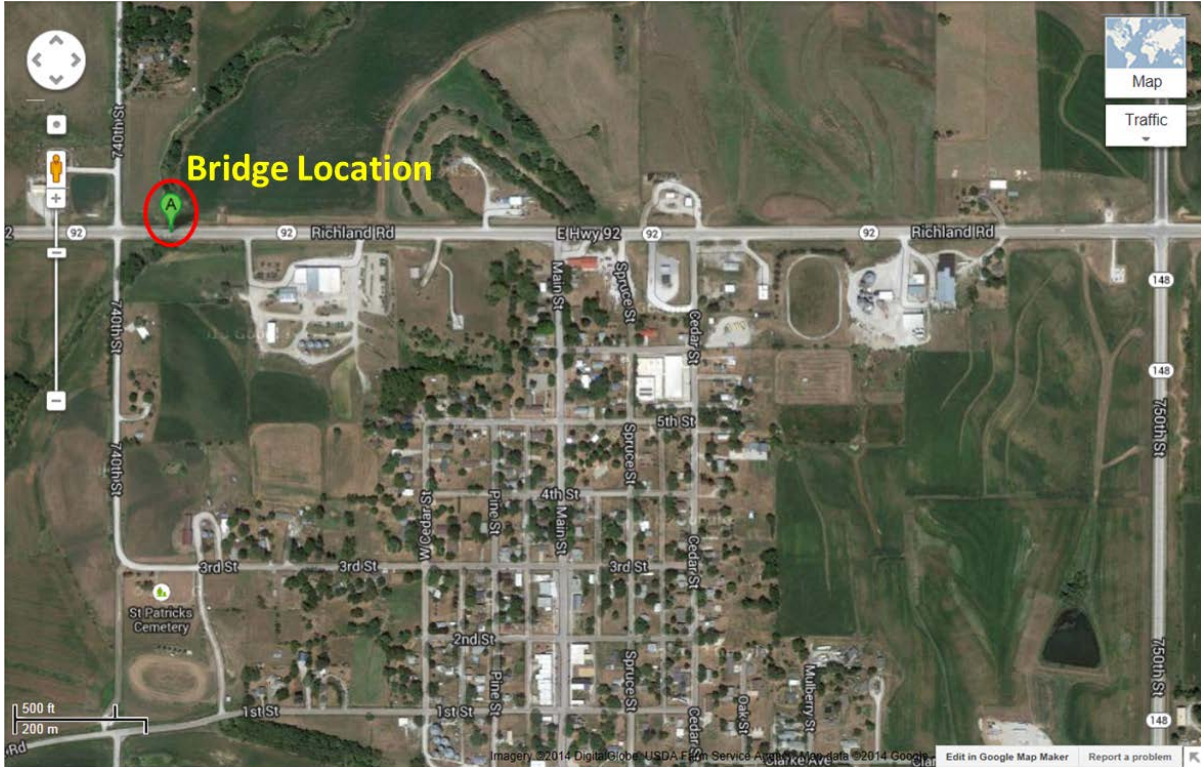


Figure 1. Map. Bridge location

Figure 2 presents the deck conditions before the bridge replacement.



Figure 2. Existing Bridge Deck and Approach Roadway Conditions

To learn more about the bridge slide process before the commencement of the project, the Iowa DOT officials visited UDOT, met with key staff, the designers, and the contractors, and witnessed an I-80 lateral slide over a weekend.

This project used a design-bid-build contract. The Office of Bridges and Structures coordinated the plan preparation with assistance from the Office of Design. The design for this project was carried out in-house at the Iowa DOT, and the constructability review was done by Michael Baker Corporation. Iowa State University was responsible for the structures lab testing on this project, which included testing the sliding system and the pile pocket connections respectively (see figure 3).



Figure 3. Photo. Structures lab testing (courtesy: Iowa DOT).

Herberger Construction Co., Inc. was the prime contractor for this project, and the erection engineering was carried out by Tometich Engineering, Inc. The winning bid for the project was around \$1.3 million, with the bridge unit cost and historic bridge unit cost estimated at \$112/ft² and \$85/ft², respectively. The bid highlights were as follows:

- Removal of existing bridge: \$60,000.
- H-piling: \$167,200.
- Mobilization: \$100,000.
- Prefabricated bridge superstructure move: \$172,000.

The incentive/disincentive on 9 days of ABC on this project was fixed at \$10,000 per day. The contractor received neither incentives nor disincentives since the project was completed in 9 days, as per the contract.

The Iowa DOT website has provided up-to-date information about this bridge project, including project information, extended construction visualization, a live project web camera, and the contract documents, including plans and specifications. Figure 4 is a screen shot from the website (<http://www.iowadot.gov/MassenaBridge/index.html>).

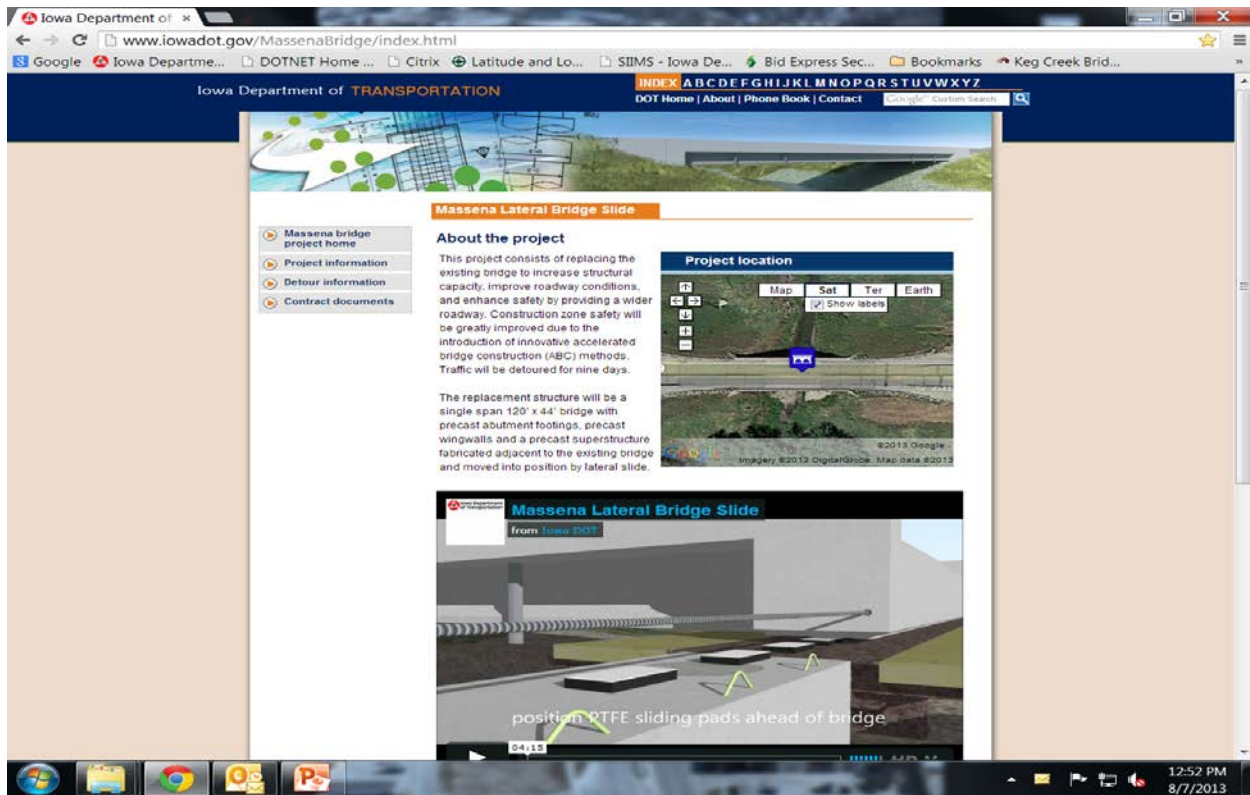


Figure 4. Screen shot. Massena bridge project web page (source: Iowa DOT website).

Figure 5 shows the visualization model for this project, which was internally built using Google SketchUp (a freeware product).



Figure 5. Illustration. Bridge construction visualization (source: Iowa DOT website).

Iowa DOT also had press releases for this project on September 11, September 13 and October 7, 2013, respectively.

Iowa DOT has presented project and detour information, photos, and videos of the Massena project on their website <http://www.iowadot.gov/MassenaBridge/index.html>.

PROJECT DESCRIPTION

Existing Bridge Information

The existing bridge was a 41-foot, 5-inch by 30-foot steel beam structure built in 1930, reconstructed in 1949, overlaid in 1968, rail retrofitted in 1992, and overlaid again in 1999. The roadway width between curbs was 29.9 ft and the edge-to-edge deck width was 31.8 ft¹. The bridge was classified as structurally deficient, with a sufficiency rating of 38.2, and was also deemed inadequate for legal loads (a sign was posted indicating “One truck at a time”). The need for replacement of the existing bridge arose due to the following reasons:

- Scour criticality of the bridge. The footings of the existing bridge were being protected with an articulating block mat.
- Structural deficiency of the bridge due to the condition of the deck, superstructure, and substructure.
- Poor condition of the concrete in the cantilevered ends of the abutment caps.
- Presence of several areas of section loss up to 100 percent on the beams. Girders were found to have section loss, large areas of severe rust, and pack rust.
- Presence of many spalls with exposed and deteriorated reinforcing at the bottom of the deck.
- Degradation/erosion of stream by 3 feet since bridge reconstruction in 1949.

Innovations

To increase the structural capacity of the bridge, improve roadway conditions, and enhance safety by providing a wider roadway, the bridge replacement was carried out using ABC methods. The ABC innovations used in this project included lateral bridge slide (the first use of this technology in Iowa) and prefabricated bridge components. The Iowa DOT selected this method primarily to address the layout of the project, existing right-of-way, and durability.

The use of ABC methods led to reducing the mobility impact time from the traditional 180 days to a minimal 9 days. Using ABC methods also resulted in an improved construction zone safety and minimized the need for future maintenance that interferes with traffic flow, thereby reducing congestion and crashes.

¹ Information from National Bridge Inventory

New Bridge Specification

The replacement structure is a single-span 120-foot by 44-foot pretensioned, prestressed concrete beam bridge with semi-integral abutment, cast-in-place abutment footings, and precast wingwalls. The replacement structure had no skew. The replacement bridge plans included the following:

- Semi-integral abutment details.
- Abutment diaphragm.
 - Jacking pockets for lifting.
 - Block for pushing/pulling the prefabricated superstructure.
- Cast-in-place abutment footing.
 - H-pile connections.
- Precast wingwalls.
 - H-pile connections.

Figure 6 through 9 show the plan details of the abutment, abutment diaphragm, jacking pocket, and sliding shoe.

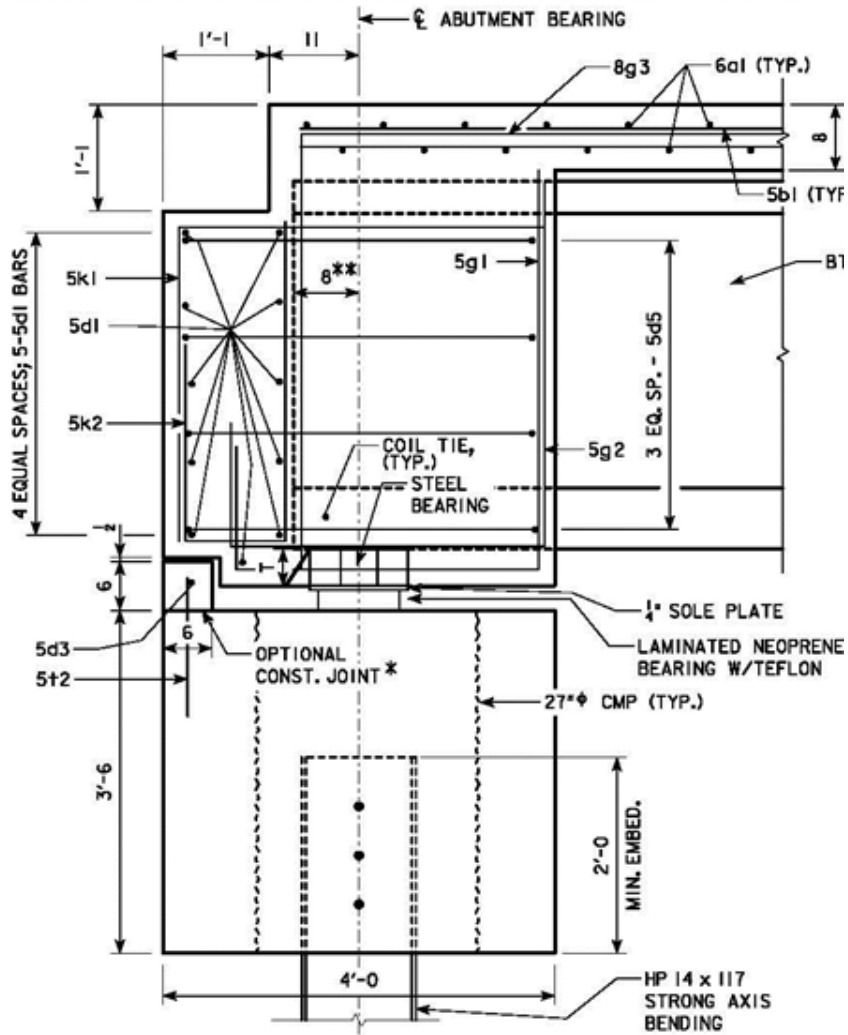


Figure 6. Diagram. Abutment details.

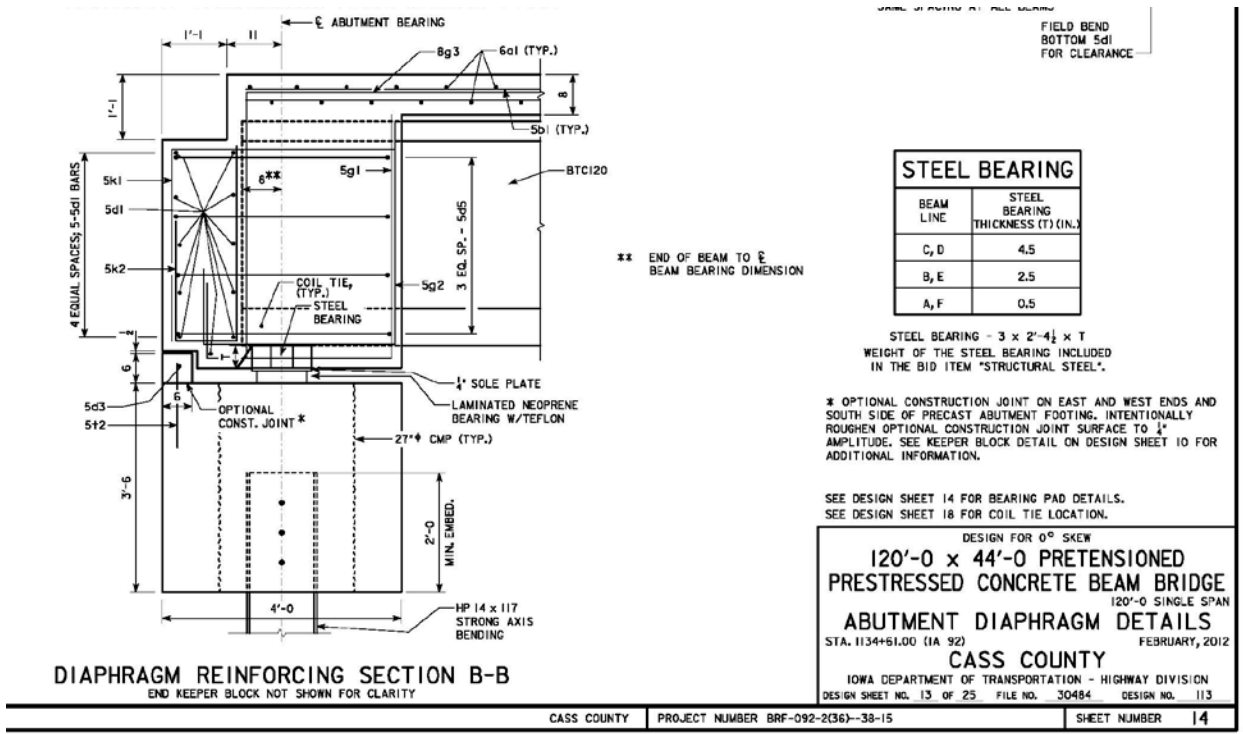


Figure 7. Diagram. Abutment diaphragm details

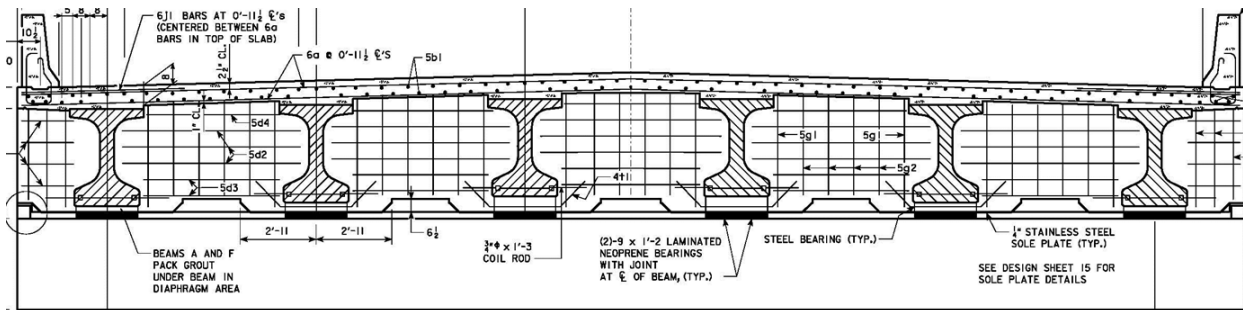
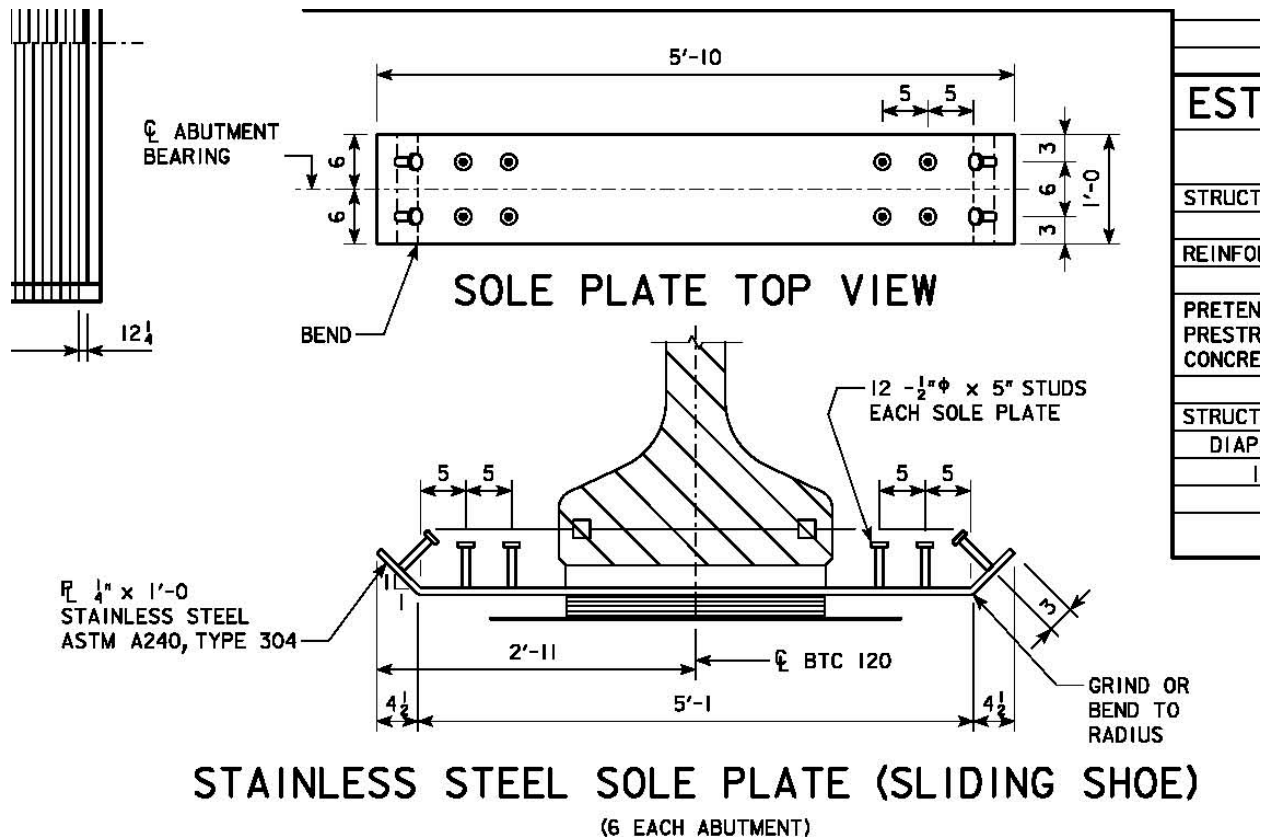


Figure 8. Diagram. Jacking pocket



STAINLESS STEEL SOLE PLATE (SLIDING SHOE)
(6 EACH ABUTMENT)

CASS COUNTY PROJECT NUMBER BRF-09

Figure 9. Diagram. Sliding shoe

Construction and Bridge Replacement

The bridge replacement involved fabricating the superstructure adjacent to the existing bridge and moving it into position using lateral slide. The following were employed during this project:

- Fabrication/casting of the precast substructure components at a casting yard off-site or near the bridge site prior to road closure.
- Construction of the bridge superstructure on temporary falsework adjacent to the existing structure while the roadway remained in service.
- Sliding the new bridge laterally into position once the roadway was closed, demolition of the existing bridge, and positioning of the precast substructure.
- Use of an offsite detour during the 9-day road closure to allow field erection and bridge completion.

The project was carried out in three phases:

- Phase 1 – Construct bridge off-alignment (number of working days not specified).
- Phase 2 – ABC period (9 calendar days).

- Phase 3 – Revetment, grading, and clean-up (15 working days).

The project milestones are listed in table 1.

Table 1. Project milestones.

Date	Milestone
July 8, 2013	Contractor moves in to site
August 12, 2013	Temporary structures for off-site bridge superstructure fabrication completed
September 6, 2013	Off-site fabrication of bridge superstructure completed
September 18, 2013	Bridge test slide (roll) conducted
September 27, 2013	Begin critical roadway closure
September 30, 2013	Bridge slide
October 6, 2013	End critical roadway closure

The project staging area, shown in figure 10, was located at the north side of the existing bridge.



Figure 10. Photo. Project staging area (courtesy: Iowa DOT).

Prior to starting the bridge construction, grading was carried out on the north side of the existing bridge. The contractor elected not to construct a temporary causeway on this project.

Phase 1 involved superstructure construction. The temporary work supports and platforms that would hold the diaphragm forms, blockouts, and sliding plates were then constructed. Figure 11 shows the falsework being prepared.



Figure 11. Photo. Falsework (courtesy: Iowa DOT).

The placement of diaphragm forms, blockouts, and sliding plates was followed by setting the bridge beams and intermediate diaphragms that connected the beams. The abutment diaphragm reinforcement and ducts were then laid out. This was followed by placing the forms and deck reinforcement and pouring the deck and diaphragm concrete. Figure 12 shows the decking process.



Figure 12. Photo. Concrete beams and decking (courtesy: Iowa DOT).

After deck placement, the barrier reinforcement and forms were installed. The superstructure construction was completed by September 6, 2013. Figure 13 shows the completed superstructure.



Figure 13. Photo. Completed superstructure (courtesy: Iowa DOT).

Phase 2 of the project included bridge demolition, substructure construction, concrete placement on barrier reinforcement and forms, slide preparation, setting up the jacking system, and the lateral bridge slide. This phase involved 9 days of full bridge closure for lateral slide purposes. Table 2 shows the critical closure schedule during this phase of the project.

Table 2. Phase 2 critical closure schedule.

Activity	Day								
	1	2	3	4	5	6	7	8	9
Start Critical Closure	September 27, 2013								
Bridge Removal and Grading									
Pile Driving									
Revetment									
Abutment Footing									
Bridge Slide									
Precast Wings									
Granular Backfill									
Bridge Barrier Rail									
Approach paving									
Barrier End Sections									
Steel Guardrail									
Longitudinal Grooving									
Pavement Marking									
Final Critical Closure	October 6, 2013								

The construction included preparation of cast-in-place abutment footings and precast abutment wings. The jacking pocket blockouts were removed, and the hydraulic jacks were positioned. Although the original design intent was to use stainless steel sliding shoes and laminated neoprene bearings with bonded PTFE, the contractor elected to use Hilman rollers on this project. To facilitate the bridge slide, the bridge was raised and laminated neoprene bearings were placed on top of the rollers. Figure 14 presents the slide channel on falsework.



Figure 14. Photo. Slide channel on falsework (courtesy: Iowa DOT).

Once the replacement bridge was set on the rollers, the roadway was closed and the existing bridge removed. Figure 15 shows the existing bridge being demolished. The berm grading and abutment pile driving followed. Figure 16 and figure 17 show the H-pile template and the HP 14x117 piles being used.



Figure 15. Photo. Bridge being demolished (courtesy: Iowa DOT).



Figure 16. Photo. H-pile template (courtesy: Iowa DOT).



Figure 17. Photo. HP 14x117 (courtesy: Iowa DOT).

To facilitate the slide, jacking anchorages were prepared, and corrugated metal pipe pile voids filled. For the cast-in-place abutment footings, the contractor elected to use the maturity method to verify if the design strength was achieved. Figure 18 and figure 19 present the abutment footing and the tied cage used for the footing, respectively.



Figure 18. Photo. Abutment footing (courtesy: Iowa DOT).



Figure 19. Photo. Pre-tied cage (courtesy: Iowa DOT).

The high-strength threaded rods (see figure 20) and accessories were then installed, and another set of laminated neoprene bearings were placed on the roller system (see figure 21) that rested on the cast-in-place abutment footings.

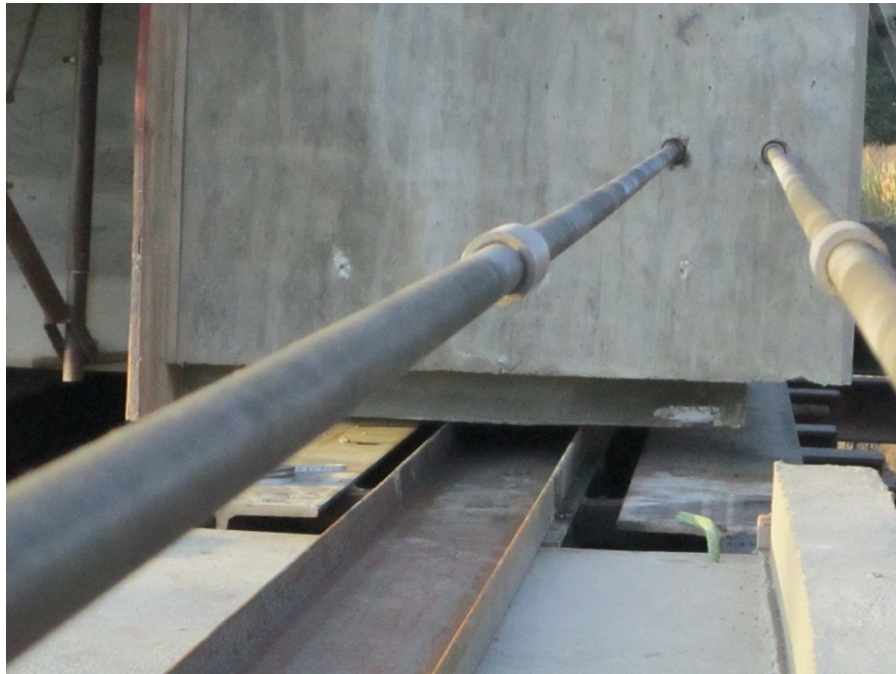


Figure 20. Photo. High-strength rods (courtesy: Iowa DOT).



Figure 21. Photo. Sliding pad and roller system (courtesy: Iowa DOT).

Next, the hydraulic center jacks and bearing plates were positioned, and then the bridge was slid. The hydraulic jacks were mounted on either side of abutment. Figure 22 and figure 23 present the slide jack control and the jacking system used for the lateral slide on this project. Figure 24 shows the slide transition zone.



Figure 22. Photo. Slide jack control (courtesy: Iowa DOT).



Figure 23. Photo. Jacking frame (courtesy: Iowa DOT).



Figure 24. Photo. Slide transition (courtesy: Iowa DOT).

The laminated neoprene bearings were positioned ahead of the bridge as a part of the sliding process. Figures 25 through 27 show the sliding process.



Figure 25. Photo. Start of slide (courtesy: Iowa DOT).



Figure 26. Photo. Bridge slide (courtesy: Iowa DOT).



Figure 27. Photo. Slide near completion (courtesy: Iowa DOT).

Once the slide was completed, the high-strength threaded rods were removed, the bridge raised, and the sliding pads replaced with final bearings (see figures 28 through 30).



Figure 28. Photo. Roller removal (courtesy: Iowa DOT).



Figure 29. Photo. Bridge jacking (courtesy: Iowa DOT).



Figure 30. Photo. Removed rollers (courtesy: Iowa DOT).

Forms were then placed and concrete poured for abutment keeper blocks. The contractor had switched from Teflon to rollers that resulted in the elimination of stainless steel sole plate and use of rolling in jacking pockets. Due to this switch, the thickness of Teflon and stainless steel had to be accounted for grades and interference with the keeper block and the diaphragm. The abutment wings were cast, and the wing footing pile voids were filled with concrete (see figures 31 through 33).



Figure 31. Photo. Precast wingwalls (courtesy: Iowa DOT).



Figure 32. Photo. Falsework seat (courtesy: Iowa DOT).



Figure 33. Photo. Bridge diaphragm and wing.

The anchorages and temporary bridge supports were removed, the abutments backfilled, 70 feet of approach roadway section paved at the end of the critical closure. Figures 34 through 38 show the post-slide work.



Figure 34. Photo. Subdrain (courtesy: Iowa DOT).



Figure 35. Photo. Abutment backfill (courtesy: Iowa DOT).



Figure 36. Photo. Approach and barrier (courtesy: Iowa DOT).



Figure 37. Photo. Approach connection (courtesy: Iowa DOT).



Figure 38. Photo. Expansion joint (courtesy: Iowa DOT).

Finally, the streambank revetment was placed, the bridge deck and approaches were longitudinally grooved, and the guardrails were installed. The roadway was then opened to traffic.

DATA ACQUISITION AND ANALYSIS

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

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

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

SAFETY

The Iowa DOT used the Crash Mapping Analysis Tool 3.6.0 to determine preconstruction crash statistics. As shown in table 3, in the past 5 years there were two animal-related crashes at the site resulting in property damage only.

Table 3. Crash history (source: Iowa DOT).

Crash Severity	Number of Crashes
5-Fatal	0
4-Incapacitating Injury	0
3-Non-Incapacitating Injury	0
2-Possible Injury	0
1-No Injury/Property Damage Only	2

Due to the accelerated bridge construction techniques used on this project and the significantly low traffic volumes at the project site, the worker and motorist safety during construction exceeded the HfL performance goals. No worker injuries were reported during construction, which means Iowa DOT exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate). In addition, the presence of a full detour ensured that no motorist crashes occurred within the project limits during construction. The HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate was thus met.

No traffic congestion was expected on the detour route given the low traffic volumes² (see figure 39) that range from 340 to 830 vehicles/day. Therefore, it can be safely assumed that the presence of a work zone would have little impact on the motorist safety on the detour route.

² Traffic Flow Map of Cass County, Iowa. <http://www.iowadot.gov/maps/msp/traffic/2012/counties/CASS.pdf>

To ensure worker safety, the contractor's safety officer was present at the job site to review of safety aspects of the system before the slide. Furthermore, since the slide-in process was slow paced, the contractor did not anticipate any significant safety hazards to workers.

The bridge conditions prior to replacement allowed only one truck to pass through at any given time. The deck width of existing bridge was thus widened from 31.8 ft to 44 ft (edge to edge) to improve the safety of this roadway facility. However, the net effect of the bridge widening on the facility safety is yet to be determined.

CONSTRUCTION CONGESTION

Faster Construction

The bridge replacement would have taken an estimated duration of 180 days (6 months) under traditional cast in-place construction; however, with the use of off-site fabrication of bridge elements and lateral slide-in, the actual traffic impact time was considerably reduced to 9 days. The roadway would have been fully closed under both traditional and accelerated construction. The use of accelerated construction techniques thus reduced the duration that highway users were impacted by more than 50 percent, and the HfL goal on faster construction was met.

Travel Time

In the first phase of construction prior to road closure, the precast substructure and superstructure components were fabricated/casted at a casting yard off-site or near the bridge site. During this period, the trip time across the bridge was not increased and met the HfL goal of less than a 10 percent increase in trip time during construction as compared to the average preconstruction time. The impact due to movement of supplies and equipment was insignificant.

During the lateral bridge slide, the bridge was closed for 9 days and traffic was detoured. The use of detour during the closure eliminated traffic queuing and congestion at the construction site. The traffic detour duration was significantly reduced due to the use of the ABC approach, resulting in considerable reduction of total trip time as compared to that during traditional construction methods.

During the 9 days of full closure on this project, traffic was detoured to Cass County Road N-28 north for 3 miles, then east on County Road G-43 for 6.5 miles to the junction with Iowa Highway 148. The detour then turned south on Iowa Highway 148 for 3.5 miles to rejoin Iowa Highway 92. The travel distance when no work zone was in place was 6 miles. Thus, the additional travel distance due to construction was 6.89 miles/vehicle. Figure 39 shows the detour route used for this project.

The detour routes considered for travel times were:

- Eastbound detour - Iowa 92 traffic was detoured on Cass County Road N-28 north to Cass County Road G-48, east to Iowa 148, and then back south to Iowa 92.

- Westbound detour - Iowa 92 traffic was detoured north on Iowa 148, west on Cass County Road G-48, and then south on Cass County Road N-28 to Iowa 92.

Floating car methodology was used to measure the travel times before and during construction of this project. Five runs of travel times were collected for both the eastbound and westbound directions of the baseline and detour routes. Prior to construction, travel time samples on Iowa 92 as well as the detour route were collected on September 25 and 26, 2013. The travel time data were collected again during construction on September 30 and October 1, 2013 to capture the impact of full closure of Iowa 92 on the detour route. The travel time data collected before and during construction are presented in tables 4 and 5, respectively.

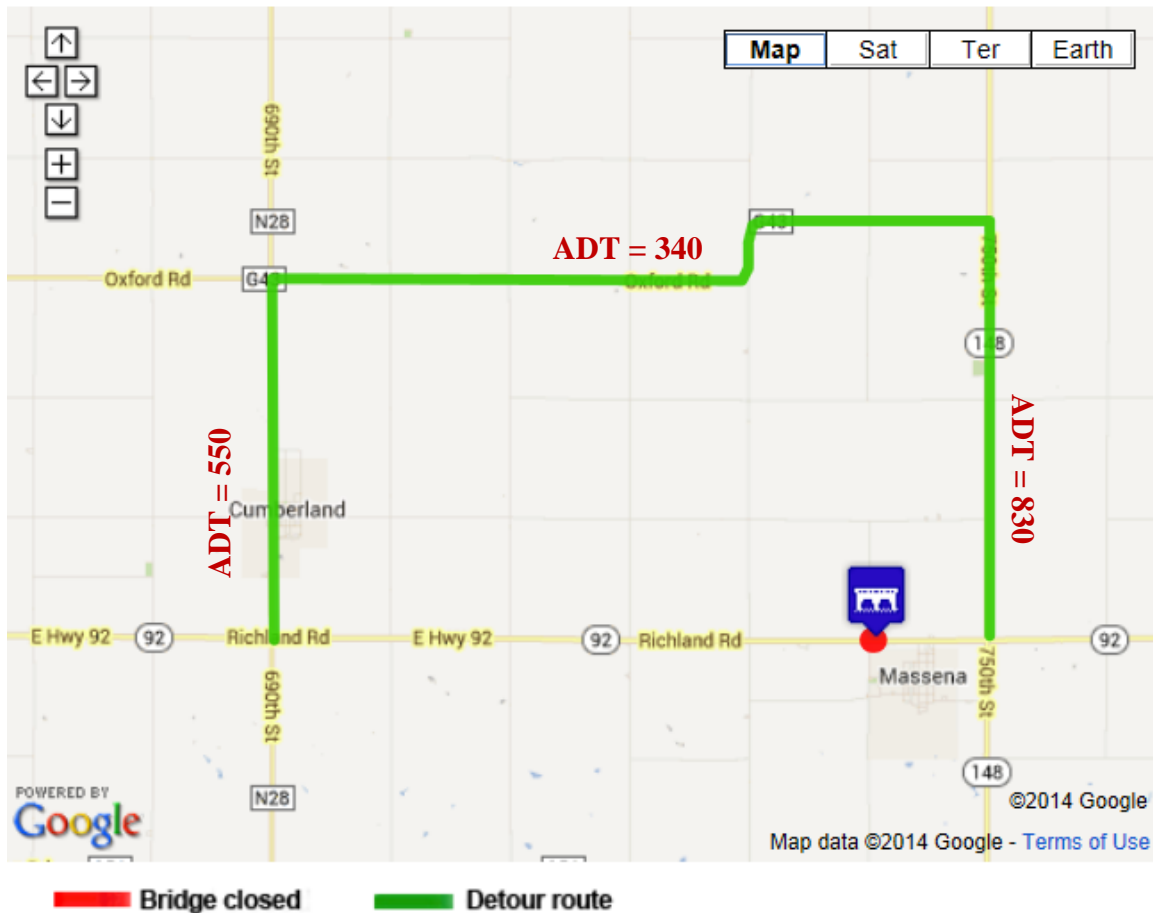


Figure 39. Map. Detour route (source: Iowa DOT website).

Table 4. Travel time data before construction.

Travel Routes	Run 1 (sec)	Run 2 (sec)	Run 3 (sec)	Run 4 (sec)	Average (sec)
Baseline (750th St and Richland Ave to 690th St and Richland Ave)	412.00	411.34	411.34	401.17	408.96
EB Detour (690th St and Richland Ave to 750th St and Richland Ave)	905.00	919.80	932.72	883.94	910.37

Travel Routes	Run 1 (sec)	Run 2 (sec)	Run 3 (sec)	Run 4 (sec)	Average (sec)
Baseline (690th St and Richland Ave to 750th St and Richland Ave)	415.22	416.09	388.72	410.94	407.74
WB Detour (750th St and Richland Ave to 690th St and Richland Ave)	927.31	920.16	893.27	878.94	904.92

Table 5. Travel time data during construction.

Travel Routes	Run 1 (sec)	Run 2 (sec)	Run 3 (sec)	Run 4 (sec)	Average (sec)
EB Detour (690th St and Richland Ave to 750th St and Richland Ave)	902.83	927.09	900.04	910.57	910.13
Travel Routes	Run 1 (sec)	Run 2 (sec)	Run 3 (sec)	Run 4 (sec)	Average (sec)
WB Detour (750th St and Richland Ave to 690th St and Richland Ave)	901.89	906.16	930.01	892.89	907.74

There was a negligible difference between the travel time data collected on the detour route before and during construction. Although the work zone across the bridge would have been closed and traffic detoured for 9 days (ABC approach) or 6 months (as estimated for traditional construction methods), the travel times before and during construction would have been comparable. Since the ABC approach reduced the number of days that motorists spent traveling the detour, the cumulative delay time was reduced and the project met the HfL goal of less than 10 percent increase in trip time compared to traditional construction.

QUALITY

Sound and Smoothness

No smoothness data were collected for this project because the bridge was too short (less than 100 feet) to obtain any meaningful data.

USER SATISFACTION

The HfL requirement for user satisfaction includes a performance goal of 4-plus on a Likert scale of 1–7 (in other words, 57 percent or more participants showing favorable response) for the following two questions:

- How satisfied is the user with the new facility compared with its previous condition?
- How satisfied is the user with the approach used to construct the new facility in terms of minimizing disruption?

As an alternative to the HfL questions, Iowa DOT's post-construction user survey on this project included a set of 12 questions to 36 participants. The roadway users were asked to rate their responses on the following:

1. Level of use of the Iowa 92 Massena bridge before construction.
2. How would you best describe yourself?
3. How important you believe each approach is and how well it was carried out on this project?
4. Knowing it would mean traffic delays and driving through construction areas, how important was it to close Iowa 92 during construction?
5. How satisfied are you with the way the Iowa DOT kept you informed about the construction work?
6. What means of communication do you USE MOST OFTEN to learn about traffic issues/roads information?
7. What are the BEST METHODS to keep you informed regarding traffic issues/road construction?
8. Following aspects of the new Iowa 92 Massena bridge and surrounding areas as compared to its previous condition: Lane width, Visibility, Signage, Lighting, Aesthetics (appearance), and Other
9. Level of inconvenience you experienced as a user of the Iowa 92 Massena bridge.
10. Did construction on the Iowa 92 Massena bridge deter you from visiting businesses along Iowa 92?
11. Were there any safety issues/concerns raised during the Iowa 92 Massena bridge project?
12. Importance in regard to designing and scheduling projects.

Overall, the responses to the questions were favorable and met or exceeded the HfL performance goal. The complete results of the survey are presented in the appendix.

ECONOMIC ANALYSIS

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

For this economic analysis, the DOT supplied the cost figures for the as-built project and baseline construction. Traditional methods would have involved the use of cast-in-place construction coupled with periods of curing, which would have prolonged the time motorist would have been impacted to 180 days.

CONSTRUCTION TIME

The baseline scenario would have involved using cast-in-place construction, for which the bridge would have been closed for around 180 days, thereby impacting the traffic significantly. The use of innovative technologies such as PBES and lateral bride slide resulted in a minimal 9-day bridge closure.

CONSTRUCTION COSTS

The lowest bid was selected for this project. Table 6 presents the bid comparison for the project.

Table 6. Bid comparison

Vendor Name	Total Bid	% Over Low Bid
Herberger Construction Co., Inc.	\$1,346,647.90	100.00
Christensen Bros., Inc.	\$1,381,733.70	102.60
Godbersen-Smith Construction Co. & Subsid.	\$1,476,320.60	109.62
Jensen Construction Co.	\$1,586,329.75	117.79

The construction costs and other costs for the as-built scenario are provided in tables 7 and 8. Note that the original bid included an additional incentive/disincentive amount of \$ 40,000 for early or late completion. Since the contractor completed the project in the contractually agreed duration of 9 days, no incentives or disincentives was paid to the contractor.

Table 7. Construction costs for as-built scenario.

Item	As-Built Cost
Bridge Related	\$1,089,019.50
Roadway	\$217,628.40
Incentive/Disincentive	\$0
Total Construction Costs	\$1,306,647.90

Table 8. Other costs for as-built scenario.

Item	As-Built Cost
Preliminary Engineering	\$9,439.00
Design	\$35,951.00
Contractor Submittal Review	\$9,985.00
Construction Engineering & Inspection	\$30,686.93
Total Other Costs	\$86,061.93

Summing the totals in tables 7 and 8, the total agency costs for the as-built project are \$1,392,709.83.

The Iowa DOT estimated that traditional construction would have resulted in construction costs of \$977,300 and other costs of \$49,313.68³, for a total of \$1,026,613.68.

The total cost of the as-built project is \$366,096.15—or 35 percent—more than the estimated total cost using traditional construction methods. This increase in agency costs for the as-built scenario could be attributed to the fact that this was the first slide project undertaken by Iowa DOT. Being the first bridge slide project, the contractor would have priced in the bid for potential construction related risks. The construction costs are expected to come down with subsequent slide projects.

USER COSTS

Generally, three categories of user costs are used in an economic analysis: vehicle operating costs (VOC), delay costs, and crash- and safety-related costs. As the bridge would have been closed to traffic under both the baseline and as-built cases, the possible safety hazard to the traveling public from a work zone was eliminated. Thus, the safety-related costs were not evaluated for this project. However, VOC and delay costs were compared and are discussed in the following subsections. The possible impact of passenger cars taking any alternate detour routes (including unpaved roads) has not been considered for the user cost analysis in this section.

VOC

The following data were used to calculate VOC:

- Travel distance when no work zone is in place = 6 miles.
- Travel distance on the designated detour route = 12.89 miles.
- Additional travel distance due to construction = 6.89 miles/vehicle.
- Average daily traffic (ADT) = 1,460.
- Percent trucks = 16%; percent autos = 84%.
- Unit rates = \$0.36/mile and \$1.08/mile, respectively, for out of distance detour travel for autos and trucks.⁴

³ Traditional construction costs were provided by Jim Nelson, Iowa DOT

- Days of traffic impact for as-built scenario = 9 days.
- Days of traffic impact for traditional construction = 180 days.

The VOC calculations due to full closure and detour are presented as follows:

$$\begin{aligned} \text{Additional daily VOC} &= 6.89 \text{ miles/vehicle} * (0.84*1460) \text{ automobiles} * \$0.36 /\text{mile} + 6.89 \\ &\text{miles/vehicle} * (0.16*1460) \text{ trucks} * \$1.08 /\text{mile} \\ &= \$3,041.96 + \$1,738.26 = \$4,780.23 \end{aligned}$$

For the traditional case, VOC = \$4,780.23 /day * 180 days = \$860,441.

For the as-built case, VOC = \$4,780.23 /day * 9 days = \$43,022.

Therefore, the savings in VOC = \$4,780.23 /day * (180 – 9) days = \$817,419. This translates to 95 percent savings in VOC compared to traditional construction.

Delay Costs

The following data were used to calculate delay costs:

- Average travel time when no work zone is in place = 408.3 seconds.
- Average travel time when detour is in place = 908.3 seconds.
- Additional travel time due to construction = 500 seconds/vehicle.
- Additional travel time per day = 500 /3600 * 1460 vehicles = 202.8 hours/day.
- Percent trucks = 16%; percent autos = 84%
- Cass County's median household income⁵ = \$ 43,114
- Average Vehicle Occupancy (AVO) = 1.0 (assumed)
- Unit delay cost for passenger cars⁶ = 0.5 (for local travel) * 1.67 (AVO) * \$ 43,114/2080 = \$17.31
- Unit delay cost for truck drivers of combination trucks = \$18.16 (wages) + 8.55 (benefits) = \$26.71
- Unit delay cost for truck drivers of single-unit trucks = \$12.12 (wages) + 8.55 (benefits) = \$20.67
- Average Truck Unit Cost = (\$26.71+\$20.67)/2 = \$23.69

The average delay was calculated based on the additional travel time that was required due to the presence of detour. The baseline and detour travel times before and during construction of this project have been presented in tables 4 and 5, respectively. The hourly value of passenger car delay of \$17.31 was computed based on Cass County's median household income for personal intercity travel. Since the project location was a rural area, the AVO was assumed to be 1.0 for

⁴ Unit rates for VOC were provided by Iowa DOT.

⁵ Median household income, 2008-2012 for Cass County, Iowa, State & County QuickFacts, US Census Bureau, <http://quickfacts.census.gov/qfd/states/19/19029.html>.

⁶ Unit costs of travel delay were computed based on USDOT Office of Surface Transportation guidelines.

the unit cost computation. The hourly value for truck delay was calculated based on Iowa’s prevailing wages⁷ and benefits⁸ for drivers of single-unit and combination trucks.

To calculate travel delay costs:

$$\text{Travel delay costs per day} = 202.8 * [(0.84 * \$17.31/\text{hr for cars}) + (0.16 * \$23.69/\text{hr for trucks})] = \$3,717.11.$$

$$\text{For the traditional case, delay costs} = \$3717.11 * 180 \text{ days} = \$669,080$$

$$\text{For the as-built case, delay costs} = \$3717.11 * 9 \text{ days} = \$33,454.$$

Therefore, the savings in travel delay costs = $\$3,603.35 * (180 - 9) \text{ days} = \$635,626$. This translates to 95 percent savings in delay costs compared to traditional construction.

$$\text{Total user costs (delay + VOC) for as-built scenario} = \$43,022 + \$33,454 = \$76,476$$

$$\text{Total user costs (delay + VOC) for traditional scenario} = \$860,441 + \$669,080 = \$1,529,521$$

The total user cost savings using ABC approach = Traditional user costs - As-built user costs $\$1,529,521 - \$76,476 = \$1,453,045$. This translates to 95 percent savings in total user costs compared to traditional construction.

COST SUMMARY

Table 9 presents the cost summary for both the as-built and baseline scenarios. The total costs were calculated by adding the agency costs and user costs (delay costs + VOC) for both scenarios.

Table 9. Final cost summary

	As-Built Scenario	Traditional
Agency Costs	\$1,392,709.83	\$1,026,613.68
VOC	\$43,022	\$860,441
Delay Costs	\$33,454	\$669,080
Total Costs	\$1,469,186	\$2,556,135

$$\text{Total cost savings using ABC approach} = \text{Total traditional costs} - \text{Total as-built costs} \\ \$2,556,135 - \$1,469,186 = \$1,086,949$$

$$\text{Percent savings} = (\$1,086,949 / \$2,556,135) * 100 = 43\%$$

⁷ Prevailing wages for single and combination truck drivers in Iowa, May 2012 State Occupational Employment and Wage Estimates, Iowa, http://www.bls.gov/oes/current/oes_IA.htm

⁸ Benefits for civilian workers involved in production, transportation, and material moving, Employer costs for employee compensation news release, Dec 11, 2013, http://www.bls.gov/news.release/archives/ecec_12112013.htm

Thus, the use of ABC methods (PBES and lateral bridge slide) on the Massena bridge slide project resulted in a total cost savings of \$1,086,949 (43 percent) over traditional cast-in-place construction.

TECHNOLOGY TRANSFER

Through means of presentations and webinars, Iowa DOT has been promoting the innovations used on this project, such as PBES and lateral bridge slide, through various presentations and webinars, as shown in table 9.

Table 10. Presentations and webinars on the Massena bridge project.

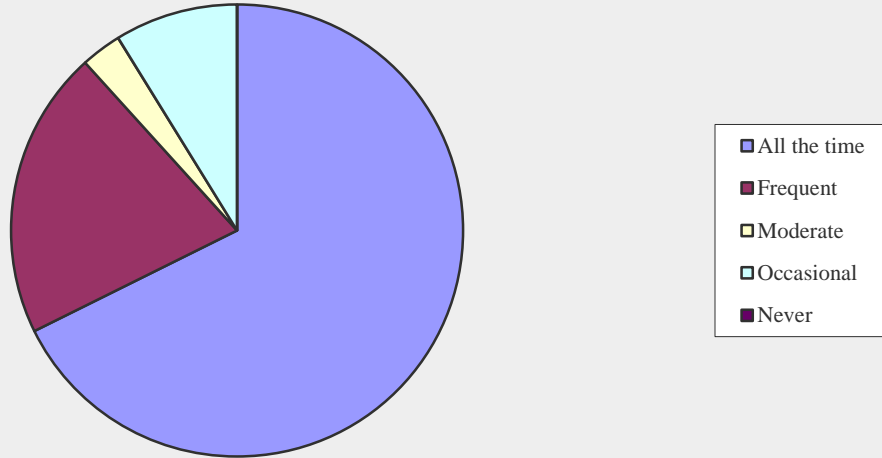
Conference/Workshop	Topic	Date	Speaker
2013 Mid-Continent Transportation Research Symposium	The Massena Lateral Bridge Slide: Design and Construction	August 15, 2013	Jim Nelson, Iowa DOT
2013 Precast/Prestressed Concrete Institute Convention and National Bridge Conference	Massena Lateral Bridge Slide Case Study	September 22, 2013	Jim Nelson, Iowa DOT
2013 Iowa American Society of Civil Engineers Structural Engineering Conference	Massena Lateral Bridge Slide: Design and Construction	November 4, 2013	Jim Nelson, Iowa DOT
Transportation Research Board Annual Meeting Workshop 183: PBES for ABC	Massena Lateral Bridge Slide Project	January 12, 2014	Ahmad Abu-Hawash, Iowa DOT

As a part of the Every Day Counts initiatives on ABC, the FHWA and Iowa DOT conducted a webinar for this project. The webinar was held on January 28, 2014, and focused on the Iowa DOT's perspective on slide-in bridge construction.

APPENDIX

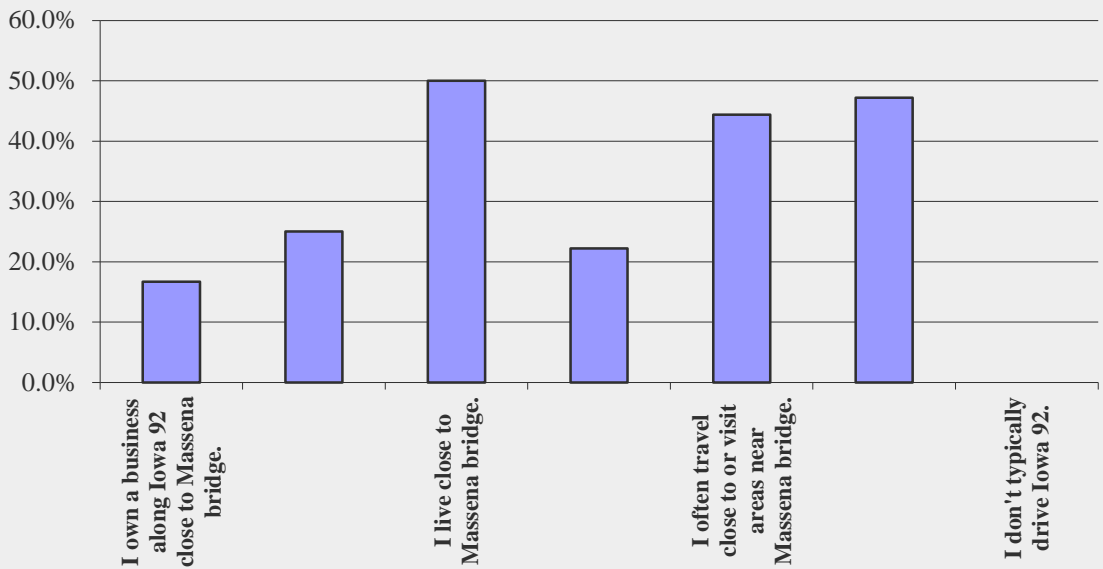
Q1. Rate your level of use of the Iowa 92 Massena bridge before construction?

Answered: 34 Skipped: 2



Q2. How would you best describe yourself (check all that apply).

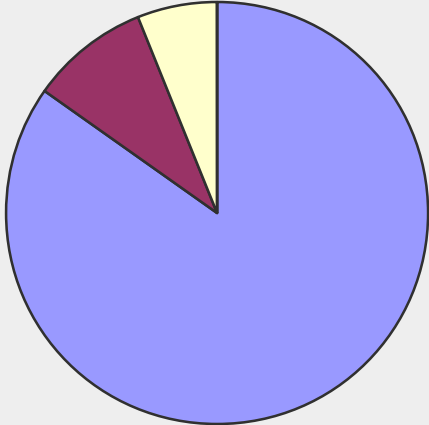
Answered: 36 Skipped: 0



Q3. Rate how important you believe each approach is and how well it was carried out on this project.					
Importance					
Answer Options	Important	Somewhat Important	Somewhat Unimportant	Unimportant	Response Count
Closing Iowa 92 during construction	28	3	2	0	33
Providing signage for commuters in the area	28	4	0	0	32
Condensing closure to nine days	32	0	0	1	33
Using stronger materials to extend bridge life and reduce future disruptions for maintenance	32	1	0	0	33
Using prefabricated components to speed construction	28	4	0	1	33
Using multiple methods (message signs, radio, texts, etc.) to advise motorists of construction and alternative routes	25	8	0	0	33
How well					
Answer Options	Important	Somewhat Important	Somewhat Unimportant	Unimportant	Response Count
Closing Iowa 92 during construction	26	6	0	0	32
Providing signage for commuters in the area	25	6	0	0	31
Condensing closure to nine days	31	1	0	0	32
Using stronger materials to extend bridge life and reduce future disruptions for maintenance	23	8	0	0	31
Using prefabricated components to speed construction	28	4	0	0	32
Using multiple methods (message signs, radio, texts, etc.) to advise motorists of construction and alternative routes	23	6	2	0	31

Q4. Knowing it would mean traffic delays and driving through construction areas, how important was it to close Iowa 92 during construction?

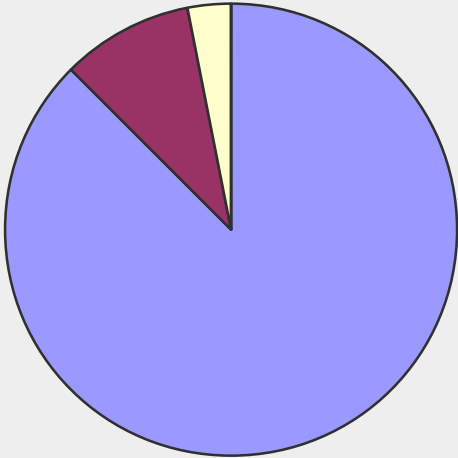
Answered: 33 Skipped: 3



- Important
- Somewhat important
- Somewhat unimportant
- Unimportant

Q5. How satisfied are you with the way the Iowa DOT kept you informed about the construction work?

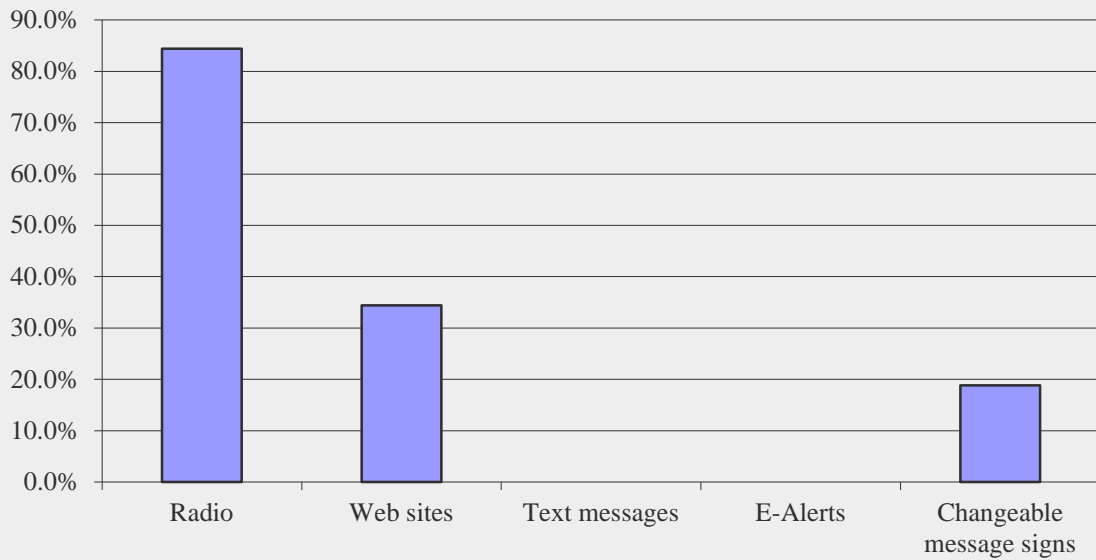
Answered: 32 Skipped: 4



- Satisfied
- Somewhat satisfied
- Somewhat dissatisfied
- Dissatisfied

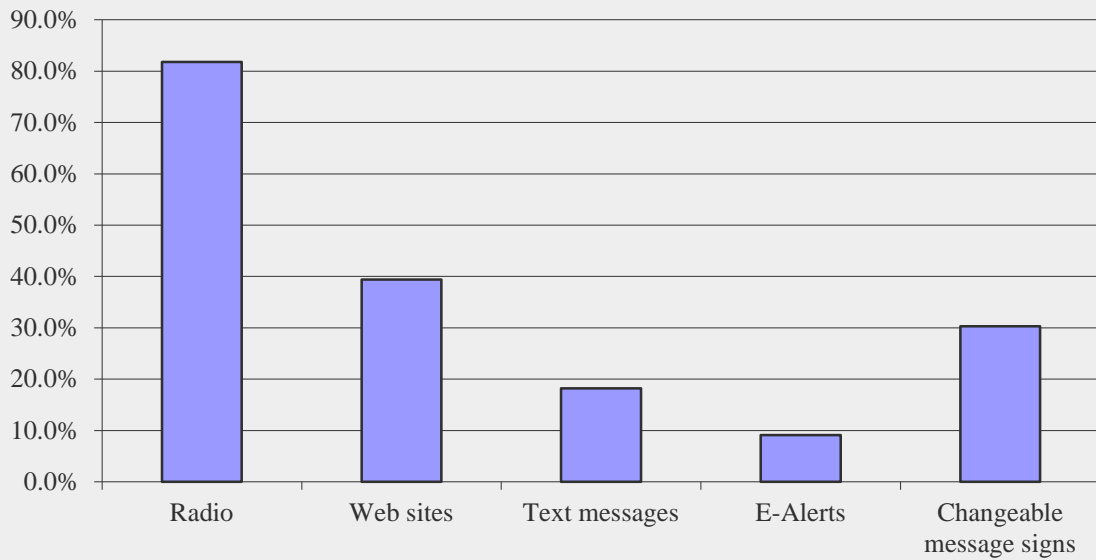
Q6. What means of communication do you USE MOST OFTEN to learn about traffic issues/roads information?

Answered: 32 Skipped: 4



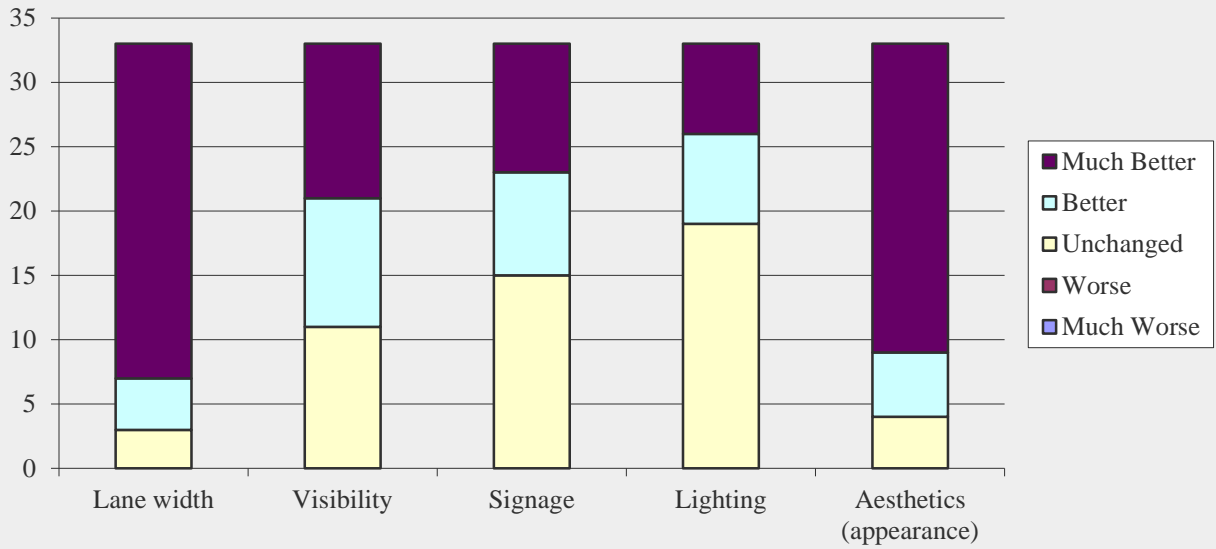
Q7. What are the BEST METHODS to keep you informed regarding traffic issues/road construction?

Answered: 33 Skipped: 3



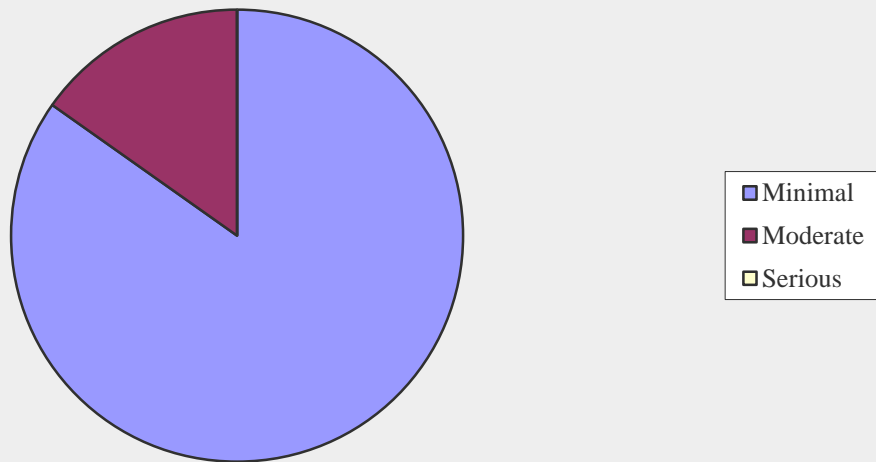
Q8. Rate the following aspects of the new Iowa 92 Massena bridge and surrounding areas as compared to its previous condition.

Answered: 33 Skipped: 3



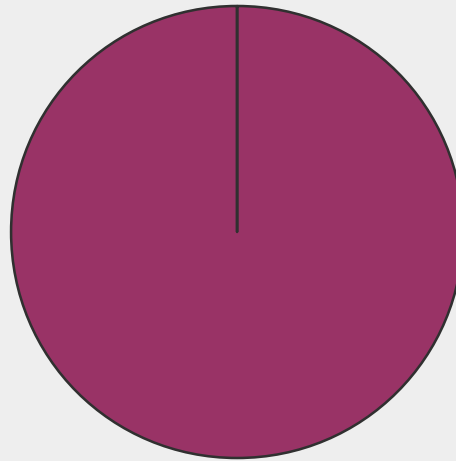
Q9. Rate the level of inconvenience you experienced as a user of the Iowa 92 Massena bridge.

Answered: 33 Skipped: 3



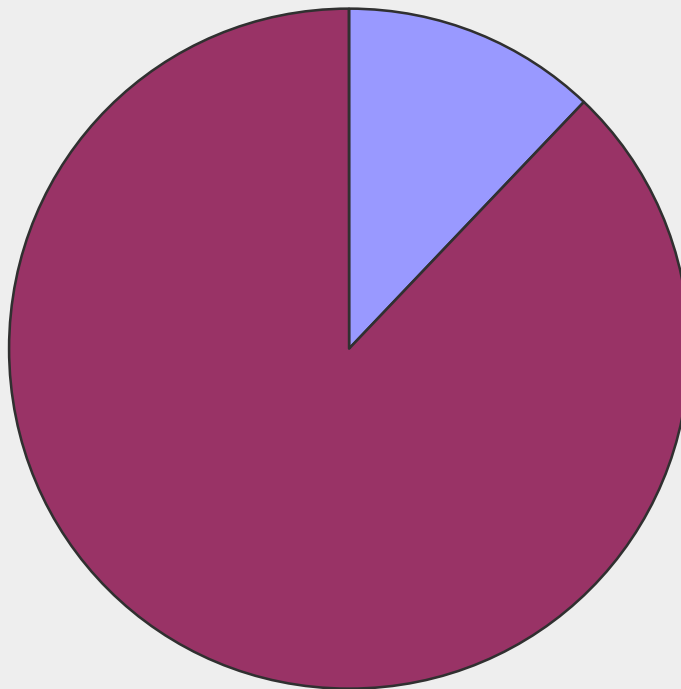
Q10. Did construction on the Iowa 92 Massena bridge deter you from visiting businesses along Iowa 92?

Answered: 33 Skipped: 3



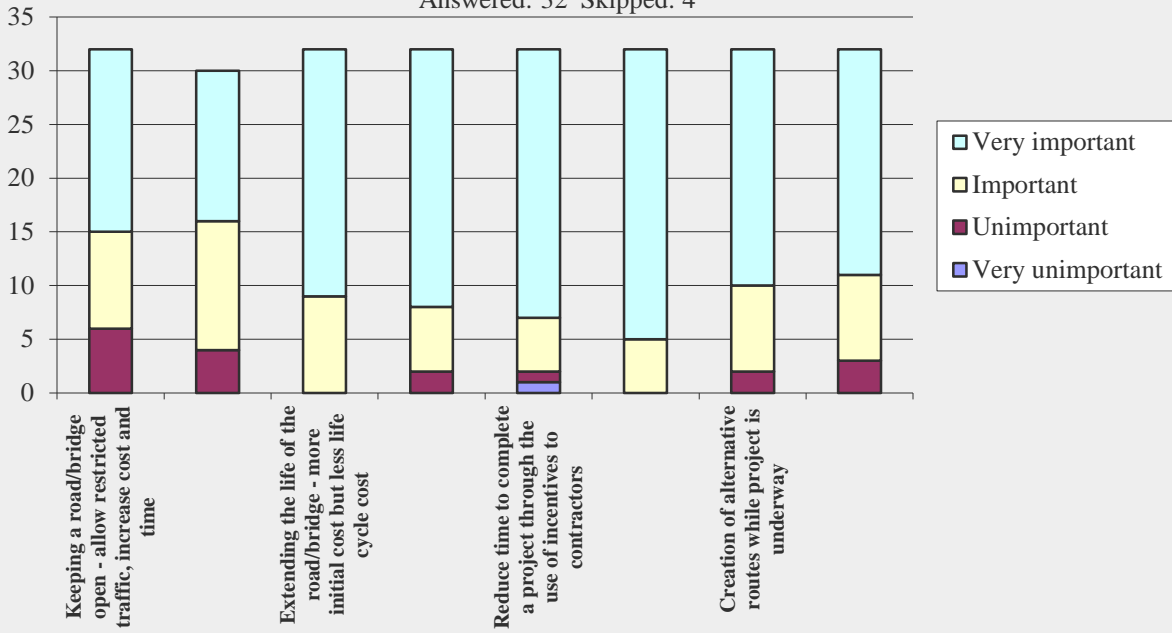
Q11. Were there any safety issues/concerns raised during the Iowa 92 Massena bridge project?

Answered: 33 Skipped: 3



Q12. Rate the importance in regard to designing and scheduling projects.

Answered: 32 Skipped: 4



ACKNOWLEDGMENTS

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