Oregon Demonstration Project:

Accelerated Bridge Construction over Burnt River on Old US30 using Prefabricated Elements and Ultra High Performance Concrete

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 is at www.fhwa.dot.gov/hfl.

NOTICE

QUALITY ASSURANCE STATEMENT

1. Report No.	2. Government Accession No	3. Recipient's Catalog No
3. Title and Subtitle Accelerated Bridge Construction over Burnt River on Old US30 using Prefabricated Elements and Ultra High Performance Concrete		5. Report Date October 2014 6. Performing Organization Code
7. Authors Shreenath Rao, Ph.D., P.E., and Jagannath Mallela, Ph.D.		8. Performing Organization Report No.
9. Performing Organization Name and Address Applied Research Associates, Inc. 100 Trade Centre Drive, Suite 200 Champaign, IL 61820		10. Work Unit No. (TRAIS) C6B 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Infrastructure Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590		12. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes
Contracting Officer's Representative: Julie Zirlin
Contracting Officer's Task Manager: Ewa Flom

16. Abstract
As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE (HfL) program, the Oregon Department of Transportation (ODOT) was awarded a $300,000 grant to develop plans and specifications, and then construct Bridge 21252 over the Burnt River on Old US30 near Huntington, OR. The key innovation included the use of accelerated bridge construction (ABC) techniques by precasting the deck panels off-site in the controlled environment of a fabrication facility, transporting the panels to the project site, and installing the panels onto prefabricated concrete girders. The innovation also included the use of Ultra High Performance Concrete (UHPC) for the shear pockets and the deck joints which allowed for elimination of post-tensioning of the deck panels. This report documents the entire work effort, including the innovative ABC techniques employed by ODOT, with specific focus on the connection details including haunches, blockouts, and joints.

Removal and replacement of the Burnt River bridge was a great success, and ODOT was able to meet the HfL program requirement related to the project goals of safety, construction congestion, quality, and user satisfaction. ODOT and the construction contractor learned some valuable lessons in the process. Since this was the first project of its kind undertaken in Oregon, ODOT's goal was to use it as learning and evaluation tool and chose a project site with low traffic volume and minimal anticipated impact to traffic. The overall costs for the construction of this bridge were higher than if the bridge had been constructed using traditional cast-in-place (CIP) techniques; however, if the bridge had been constructed in a location with shorter haul distances for the precast panels, higher traffic impacts, near urban areas with morning and evening peaks, and longer detours, it could potentially result in cost savings to ODOT and the traveling public.

17. Key Words	18. Distribution Statement
Accelerated bridge construction (ABC), precast bridge deck panels, prefabricated bridge deck, high performance concrete, ultra high performance concrete	No restriction. This document is available to the public through the Highways for Life website: http://www.fhwa.dot.gov/hfl/

Security Classif.(of this report)	19. Security Classif. (of this page)	20. No. of Pages	21. Price
Unclassified	Unclassified	60	

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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)

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration (FHWA) Highways for LIFE Team Leader Byron Lord and Program Coordinators Ewa Flom, Mary Huie, and Kathleen Bergeron, who served as the technical panel on this demonstration project. 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 is also indebted to the following Oregon Department of Transportation Engineers and Construction Staff: George Bornstedt, Teresa Bock, Doug Johnson, and Craig Shike, and FHWA Engineer Timothy Rogers for their assistance during this project.

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ABBREVIATIONS AND SYMBOLS

ABC	Accelerated Bridge Construction
ADT	Average Daily Traffic
CIP	Cast-in-place
dB(A)	A-weighted decibel
FHWA	Federal Highway Administration
HfL	Highways for LIFE
HPC	High Performance Concrete
IRI	International Roughness Index
MSE	Mechanically Stabilized Earth
OBSI	On-board Sound Intensity
ODOT	Oregon Department of Transportation
OHWM	ordinary high water mark
OSHA	Occupational Safety and Health Administration
RCDG	reinforced concrete deck girder
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
UHPC	ultra high performance concrete
UPRR	Union Pacific Rail Road

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, a 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 since fiscal year 2006. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, 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 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 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 Oregon Department of Transportation (ODOT) HfL demonstration project featuring innovative high performance prestressed precast concrete panels for deck construction to replace deteriorated bridge structure on Old US30. The project also featured innovative ultra high performance concrete for the closure pours which eliminated the need for post-tensioning the deck panels. The report presents project details relevant to the HfL program, including bridge replacement and construction highlights, methods and materials, and HfL performance metrics measurement. No technology transfer activities such as seminars, webinars, workshops, showcases, or open houses were performed for this project.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

US30 and Old US30 are regional routes for the movement of farm products and people to access Interstate 84 (I-84), Oregon's major east-west highway, and a component of the National Highway System (NHS). The construction project included replacement of one substandard bridge on Old US30 (Huntington Highway, State Highway 449) between Huntington and the I-84 Lime Interchange, in Baker County, Oregon. The traffic on Old US30 (a rural two-lane route that passes through agricultural land) and the bridge is extremely low. In 2008, average daily traffic (ADT) for the route ranged from of 60 to 230 vehicles, with a projected ADT increase of 10 percent by 2020.

The existing bridge (#0700) was built in 1922 and was nearing the end of its useful life. This bridge was designed to be replaced by a 160 foot, single-span bridge (#21252) constructed using precast concrete girders and precast concrete deck panels with ultra high performance concrete (UHPC) closure joints. The key innovation on this project was the use of the accelerated bridge construction (ABC) technique of prefabricated elements and UHPC connections to improve construction quality, improve worker and work zone safety, reduce construction time, and consequently reduce traffic congestion and delay times. ODOT developed detailed special provisions and plans for the construction of the bridge. Details included construction, transportation, and placement of deck panels; UHPC properties and testing; and connection and reinforcement details of haunches, shear pockets, and joints to ensure composite action between the concrete girders and the bridge deck. ODOT intended to use the construction of this bridge to put this research into practice and thereby enhance ODOT's ability to complete ABC on future projects. The UHPC connection details were based on research conducted by Ben Graybeal of the FHWA as no design codes have been established for the short development length of reinforcement cast in UHPC.

The work zone was closed to traffic in May 2012, for removal of bridge 0700 and construction of bridge 21252. Many project activities such as construction of prefabricated girders, and construction and curing of the precast deck panels were done at the fabrication facility prior to or concurrent with on-site activities. Following removal of the existing bridge and construction of the bents, the precast concrete girders were set on the bent walls. The precast deck panels were trucked to the project site and installed on top of the girders. This was followed by grouting of the transverse deck joints and the haunches and shear pockets using UHPC. The roadway was opened to traffic in December 2012.

DATA COLLECTION

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

The HfL performance goals for safety include meeting both worker and motorist safety goals during construction. During the construction of bridge 21252, no workers were injured, so the contractor exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate). There were also no reported work zone accidents because the work zone was closed to traffic which was detoured on to the adjacent I-84. Although the facility safety after construction for this project is yet to be determined, the increased bridge width, roadway shoulder additions, roadway realignments, and increased sight distances are expected to significantly enhance traveling safety and produce at least a 20 percent reduction in fatalities and injuries as compared to preconstruction rates.

Because of the extremely low traffic on this roadway, the number of vehicles affected by the closure was minimal. The detours are estimated to cause average delays (due to detours on to I-84) of approximately 6 minutes per vehicle for the 160 vehicles per day.

Producing the full-depth precast concrete deck panels at a climate-controlled fabrication facility outside the project critical path schedule is expected to result in higher quality control and increased durability. In addition, the use of UHPC for closure of the transverse joints is expected to provide further protection to the bridge structure, as well as reduce short- and long-term bridge maintenance.

IRI was reduced from 284 in/mi before construction to 178 in/mi after construction. Motorists will notice a somewhat smoother ride, but the bridge remains rough and does not meet the HfL goal for IRI of 48 in/mi. SI data showed a noticeable noise decrease of 3dB(A) from 98.2 dB(A) to 95.2 dB(A) which meets the HfL requirement of 96.0 dB(A) or less. Highway user satisfaction surveys were conducted after construction was complete. The survey results showed high levels of satisfaction with this construction.

ECONOMIC ANALYSIS

ODOT deliberately chose this project because of the rural location and the low traffic. Since this was the first project of its kind undertaken in Oregon, ODOT's goal was to use it as learning and evaluation tool without any substantial impact on motorists, and not necessarily to save costs on this specific project. The project is estimated to have cost 10 to 15 percent more than if constructed using traditional CIP construction.

Precast deck panels will likely always have a higher initial cost compared to traditional CIP construction. However, for locations with substantially higher traffic impacts--such as roadways with higher traffic volumes, urban locations with morning and evening peaks resulting in higher traffic delay times, and locations requiring substantial detours resulting in higher traffic delay times and vehicle operating costs--the as-constructed bridge may have a lower life-cycle cost. Since it was the first of its kind in Oregon, the life cycle cost was not reduced for the Burnt River Bridge. However, ODOT believes future bid costs are likely to come down as contractors and industry gain experience with these technologies resulting in projects which will have reduced life cycle costs.

Finally, the reduced maintenance and rehabilitation costs due to use of the precast HPC panels and UHPC closures is expected to result in savings to ODOT over the 75-year projected life of this bridge. However, due to the newness of the technology and materials used, the extent of savings is not known.

CONCLUSIONS

From the standpoint of speed of construction, motorist and user safety and delay, and quality, this project was an unqualified success and embodied the ideals of the HfL program. ODOT learned many valuable lessons through the construction of this bridge. Because of the success of this project, ODOT is expected to use ABC techniques of precast bridge decks and UHPC on future projects when appropriate. ODOT believes that it will be beneficial to track the performance of this bridge and noted assumptions for reduced long-term maintenance over time.

PROJECT DETAILS

BACKGROUND

US30 and Old US30 are regional routes for the movement of farm products and people to access Interstate 84 (I-84), Oregon's major east-west highway, and a component of the National Highway System (NHS). The construction project included replacement of one substandard bridge on Old US30 (Huntington Highway, State Highway 449) between Huntington and the I-84 Lime Interchange, in Baker County, Oregon. This bridge on Old US30, crosses the Burnt River as well as an active Union Pacific Rail Road (UPRR) track and is less than 500 ft from the exit 345 on-ramp to I-84. The project's overall construction zone extended approximately 1 mile along Old US30 from milepost (MP) 2.25 to MP 3.25.

At this location, the current (new) alignment for US30 runs concurrent with I-84 because the traffic on Old US30 (a rural two-lane route that passes through agricultural land) and the bridge is extremely low. In 2008, average daily traffic (ADT) for the route ranged from 60 to 230 vehicles, with a projected ADT increase of 10 percent by 2020. The percentage of truck traffic is estimated at 30 percent of the total daily traffic. Because this project is on a rural roadway with extremely low traffic volumes, it does not have any measurable morning or evening traffic peaks.

The existing bridge (#0700) was built in 1922 and was nearing the end of its useful life. The existing structure, was a 120 foot long, steel through truss, with two 40 foot long reinforced concrete deck girder (RCDG) approach spans. Figures 1 through 5 show the condition of the bridge in August 2011. The bridge had been selected for replacement under the Oregon Transportation Improvement Program State Bridge Program for a variety of reasons, including: (1) structural and functional deficiencies resulting in repair costs that exceed one-half of the replacement cost; (2) substandard bridge width (20 feet) and vertical clearance (13 feet); (3) load ratings insufficient to carry permit vehicle loads; and (4) significant impact damage to the end portals. This bridge is critical for unrestricted access (for weight, width and height) to a large undeveloped industrial zone acquired by Baker County. It is the intent of Baker County to fully develop this area. Planned development to date includes a large wind farm. Replacement of this bridge is critical for development of this wind farm.

This bridge was designed to be replaced by a 160 foot, single span bridge (#21252) constructed using precast concrete girders and precast concrete deck panels with ultra high performance concrete (UHPC) closure joints. Phasing of construction required a road closure while the new bridge and roadway approaches were completed. Accelerated construction measures were used to reduce the time of closure. The existing bridge was removed and the new bridge and new roadway approaches constructed using precast components to reduce construction time.

Figure 1. Overview of condition of existing bridge (#0700) over Burnt River and an active railroad track.

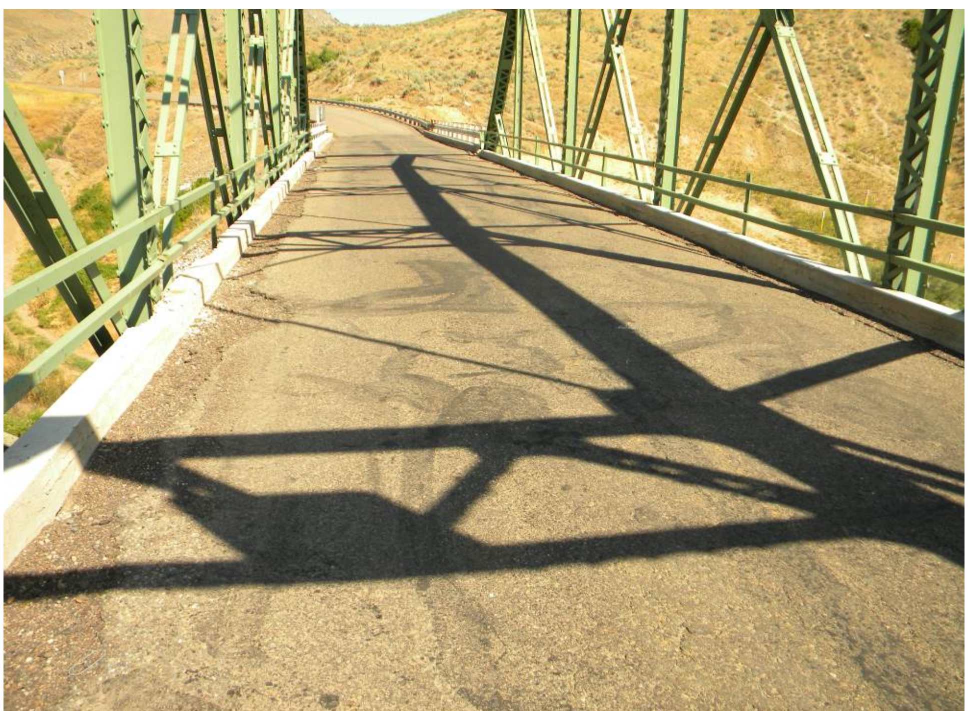


Figure 2. Substandard width of bridge 0700.


Figure 3. Deterioration of bridge 0700 deck.


Figure 4. Deterioration of bridge 0700 deck.

Figure 5. Deterioration of bridge 0700 abutment wall.

PROJECT DESCRIPTION

The key innovations of the construction of bridge 21252 included:

1. Precast high performance concrete deck panels designed to minimize rutting from studded tire use. ODOT has conducted research in cooperation with FHWA to develop a new concrete bridge deck mixture specifically formulated to reduce deck wear from studded tires. The research project identified a high performance mixture using silica fume and a special aggregate gradation to minimize abrasion. The mixture has had extensive lab testing but has not been used for any bridge construction project prior to this construction. A goal of this project was to test the constructability of the mixing in actual construction of precast deck panels.
2. Ultra High Performance Concrete for closure deck joints and to establish composite action between the precast deck panels and the precast concrete girders. FHWA Turner Fairbanks Lab and Coreslab corporation has developed the use of a UHPC mixture to a point where it is ready for production use in demonstration projects. This project used the UHPC mixture, “Ductile” provided by LaFarge Corporation, which has been proven to have very desirable properties for bonding precast panels together and establishing composite action with the girders. The material has extremely high strength (20,000 psi in field applications and 32,000 psi in plant produced applications with steam curing). It also is extremely abrasion resistant and nearly impermeable to chloride intrusion.
3. Rapid bridge construction using precast elements. Rapid construction using precast elements was done on this construction project through the use of precast deck panels. Oregon has not used full depth precast panels for deck construction in the past due to concerns with the connection to the girders and potential leakage at the deck panel construction joints. This project was used to demonstrate the practical field application of

the panels, the durability of the joints by using UHPC, and the savings in construction time when using precast elements. This project was also used as a basis for establishing standard details and standard drawings for the use of precast construction techniques in Oregon. For this project, the use of precast panels was expected to reduce construction time by about 2 weeks as compared to cast-in-place decks due to the elimination of falsework construction and the curing of the deck panels at the casting facility concurrent with other construction activities. The innovation was also expected to result in a reduction in worker injuries as well as reduce work zone motorist delays and user costs, as a result of using precast panels.

Design Plans

The final plans for the project were completed and signed off in March 2011. The project was let on October 20, 2011. Sixteen bids ranging from $2.34 million to $3.35 million were received for the construction of this project by ODOT. The project was awarded to the lowest bidder Hamilton Construction Company of Oregon.

Figure 6 shows the general plan and elevation for the new bridge. Figures 7 and 8 show the precast deck panel plan and typical section for the new bridge, respectively. The figures show the 8.5-inch thick bridge deck consisting of 15 precast reinforced concrete panels (P1 through P15) supported by four 7-feet 6-inches tall prestressed reinforced concrete girders (A1 through D1) spaced at 7-feet 4-inches, integrally placed on the reinforced north and south bents (Bent 1 and Bent 2, respectively). Bent 1 is supported by six HP 12×74 steel H-piles spaced 6 feet apart. Bent 2 is supported by a concrete footing placed on grade with a combination of limestone rock and concrete fill. Figure 9 shows the typical section for Bent 2 with the reinforced concrete girders resting on elastomeric bearing pads placed on the bent.

The 15 identical precast deck panels are equally spaced at 10 feet 3 inches. Figure 10 shows the details for one precast deck panel. The figure shows that each panel has a 15-degree skew and is 31 feet 9 inches long along the length of the skew (corresponding to both lanes of the bridge and roadway). Each panel is 9 feet 5 inches wide as measured perpendicular to the skew. Each panel is reinforced in both the transverse and the longitudinal direction. The two layers of longitudinal steel (one layer 2.5 inches from the top of the deck panel and one layer 1.5 inches from the bottom of the deck panel) consist of epoxy coated #5 bars spaced 8 inches apart and extending 6 inches into the field transverse joint and 2 feet 2 inches into the closure pours the north and south ends of the bridge (panels P1 and P15, respectively). The transverse steel consists of 0.5-inch diameter prestressing strands spaced between the shear blockouts and at the ends of the panels as shown in Figure 10.

Each deck panel consists of four rows of shear blockouts corresponding to each of the four girders, with each row containing five shear blockouts. Within each row, the blockouts are spaced at 2 feet 1.5 inches. Figure 11 shows that each shear blockout measures 11 inches by 6 inches. ODOT detailed rounded corners on the blockouts to minimize potential cracking from stress risers associated with square or angled corners. The deck panels are separated from the girders by Evazote® foam backer rod with a minimum 1-inch thickness. Composite action between the concrete girders and the deck is achieved by pouring UHPC in the shear blockouts and girder haunches contiguously. As a cost savings, the haunches cast with UHPC were reduced to 2 feet wide with a minimum thickness of 1 inch at midspan. The haunches at the closure pour are the full 5 feet width of the top of the girder. The plans called for four #5 bars, embedded a minimum of 3 feet into the girders and extending 1 foot 2 inches, and field bent into the shear blockout after placement of the deck to reinforce the composite action between the concrete girders and the deck. ODOT approved the contractor's request to use a #5 U-bar with the same embedment. This modification required more quality control at the plant for interface shear reinforcement layout but reduced construction time in the field.

Between two precast deck panels are transverse joints which range from 6 inches at the top and bottom of the panels and flaring to 9 inches at the center of the panels (see transverse joint detail and precast deck panel elevation in Figure 12). Using UHPC for closure deck joints allows for the elimination of post-tensioning. The specific details with regards to devices for lifting the precast deck panels into place and the corresponding design and details was left to the contractor.

Figure 11 also shows the vertical adjustment assemblies (leveling bolt details), which control the accurate placement of the individual deck panels. For each panel, two leveling vertical adjustment assemblies was specified at each girder supporting the panel for a total of eight vertical adjustment assemblies per panel. As shown in the figure, the vertical adjustment assembly consists of a 1-inch-diameter carriage bolt that passes through a threaded socket welded to a 3.5 inch by 3.5 inch steel plate. The entire assembly, with the exception of the leveling bolt, is precast into the panel at the fabrication facility. The tip of the leveling bolt after passing through the threaded socket rests on a standard nut welded to a 3-inch diameter steel plate placed directly on top of the girder. Turning the leveling bolt clockwise and counterclockwise raises and lowers the deck panel onto the girder, respectively; this action also increases and decreases the haunch height. Once the desired heights for all deck panels are achieved, and all shear blockouts have been grouted and cured, the portion of the carriage bolt exposed in the 3-inch diameter and 1.5-inch deep leveling bolt blockout at the top of the deck panels is cut, and the leveling bolt blockout is filled with nonshrink grout. The contractor was allowed to use an alternate coil bolt leveling rod with approval from ODOT.

The concrete pad and elastomeric bearing pad details that support the girders on Bent 1 and Bent 2 are shown in Figure 13. This project also included the construction of a Mechanically Stabilized Earth (MSE) retaining wall. Figures 14 and 15 show the plan, elevation, and two sectional views of the MSE retaining wall.

The deck placement sequence is summarized below:

1. Set girders and construct steel diaphragm at midspan.
2. Place precast deck panels starting at midspan and alternating outward in each direction, until panels P6 through P10 are set.
3. Contractor has option of setting panels P1 through P5 and P11 through P15 independently after Step 2.
4. Adjust panels as required.
5. Form, cast, and cure UHPC joints, shear pockets, and haunches.
6. Form, cast and cure HPC closure pours.

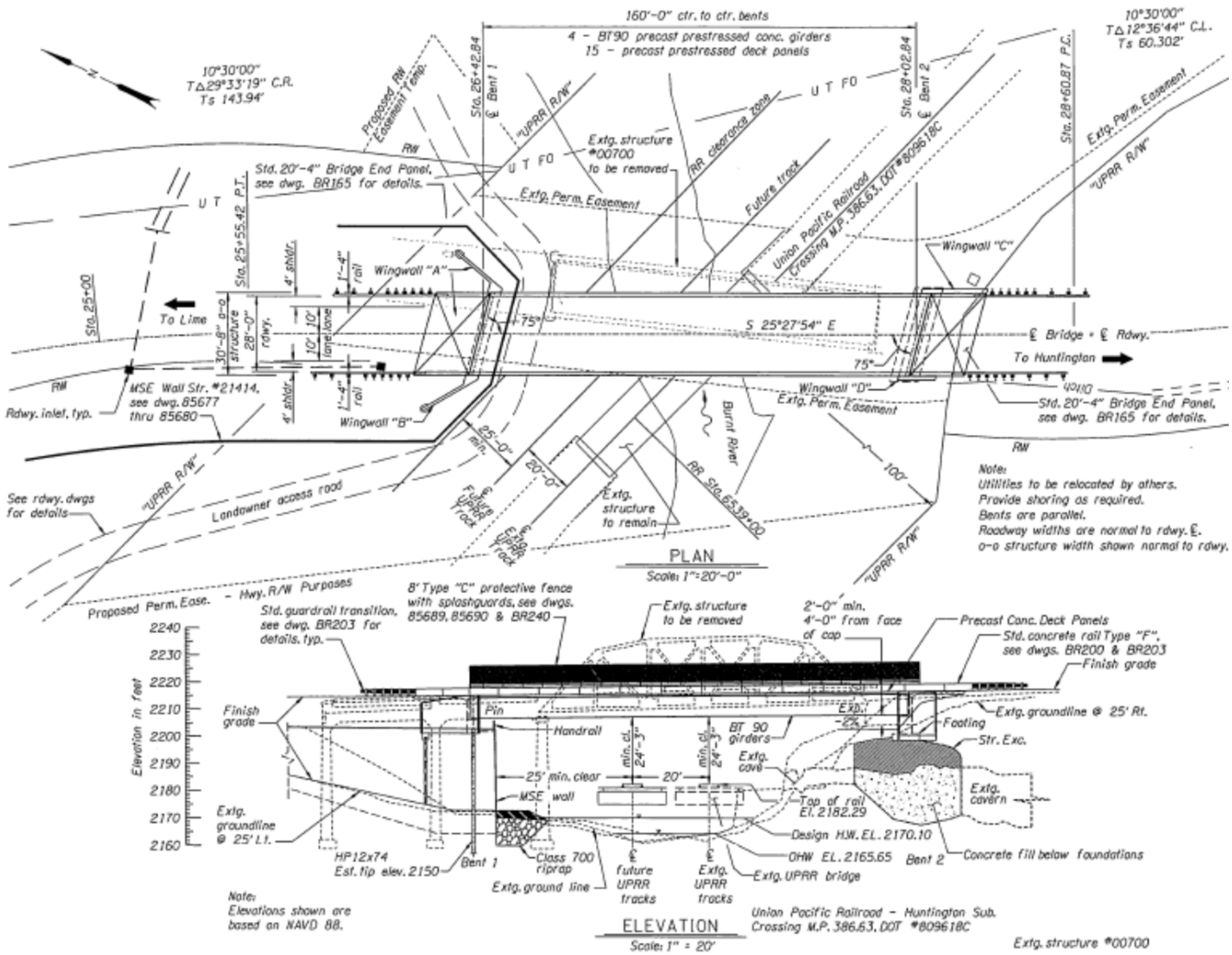


Figure 6. Diagram. General plan and elevation for bridge 21252.

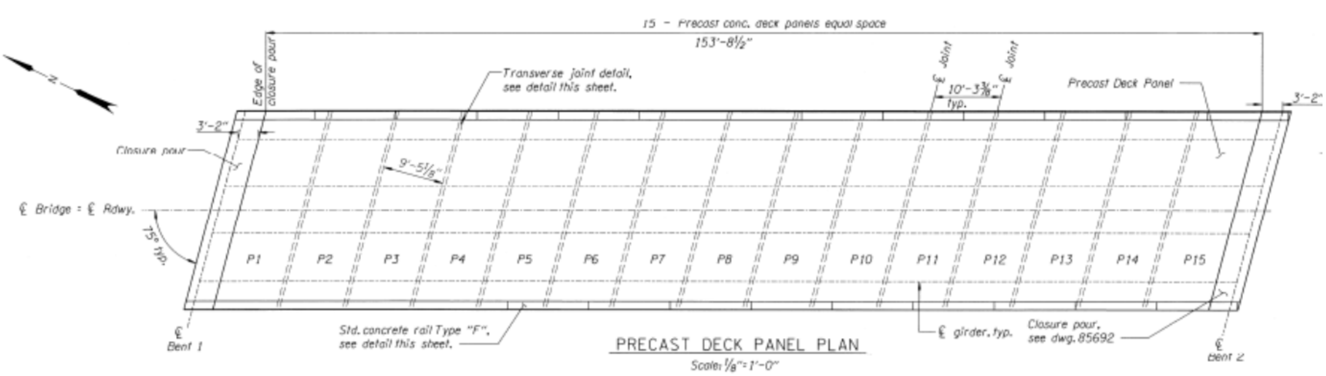


Figure 7. Diagram. Precast deck panel plan of bridge 21252.

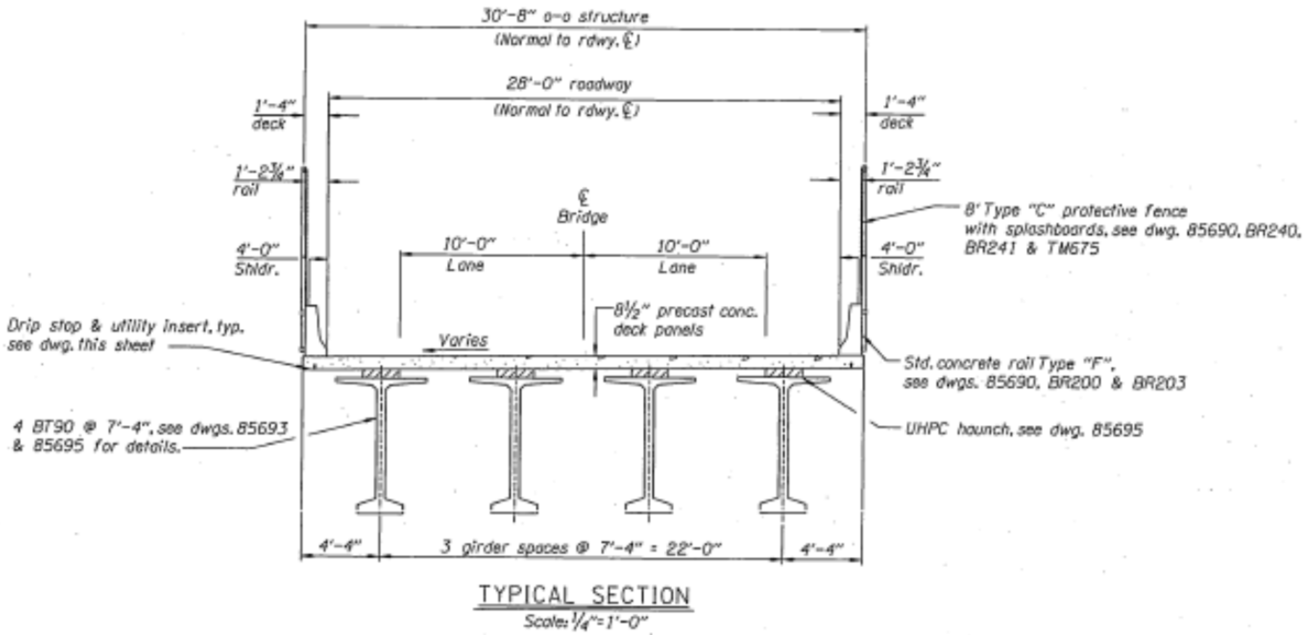


Figure 8. Diagram. Typical section of bridge 21252.

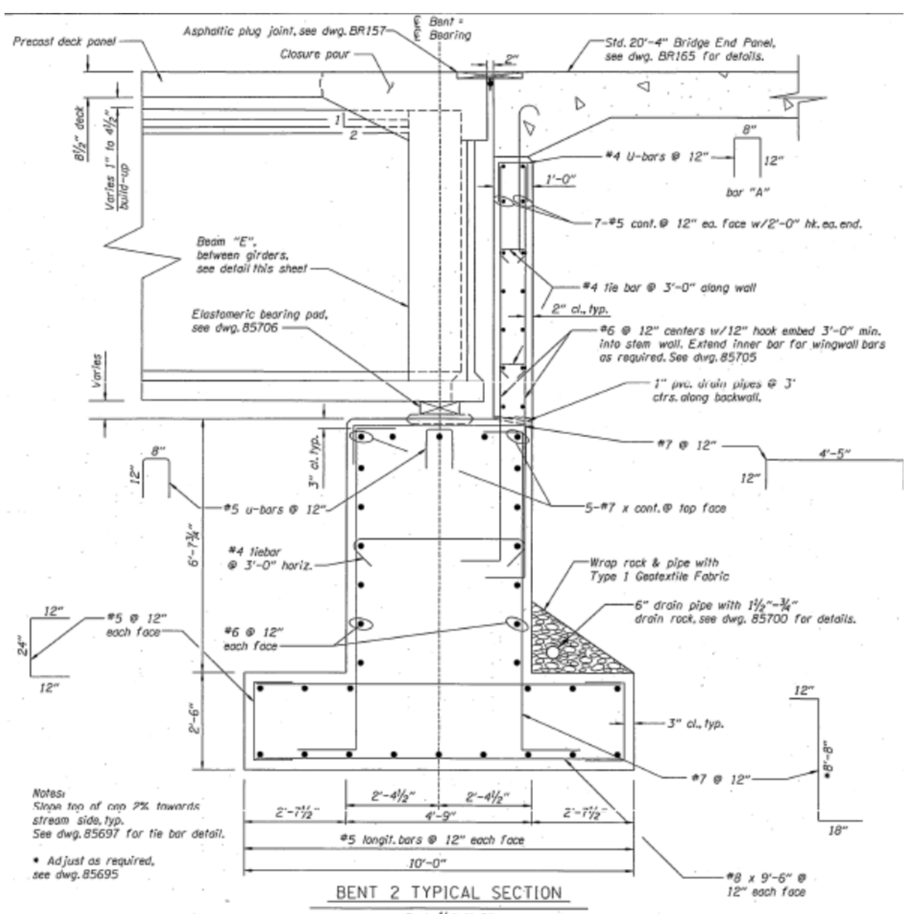


Figure 9. Diagram. Bent 2 typical section for bridge 21252.

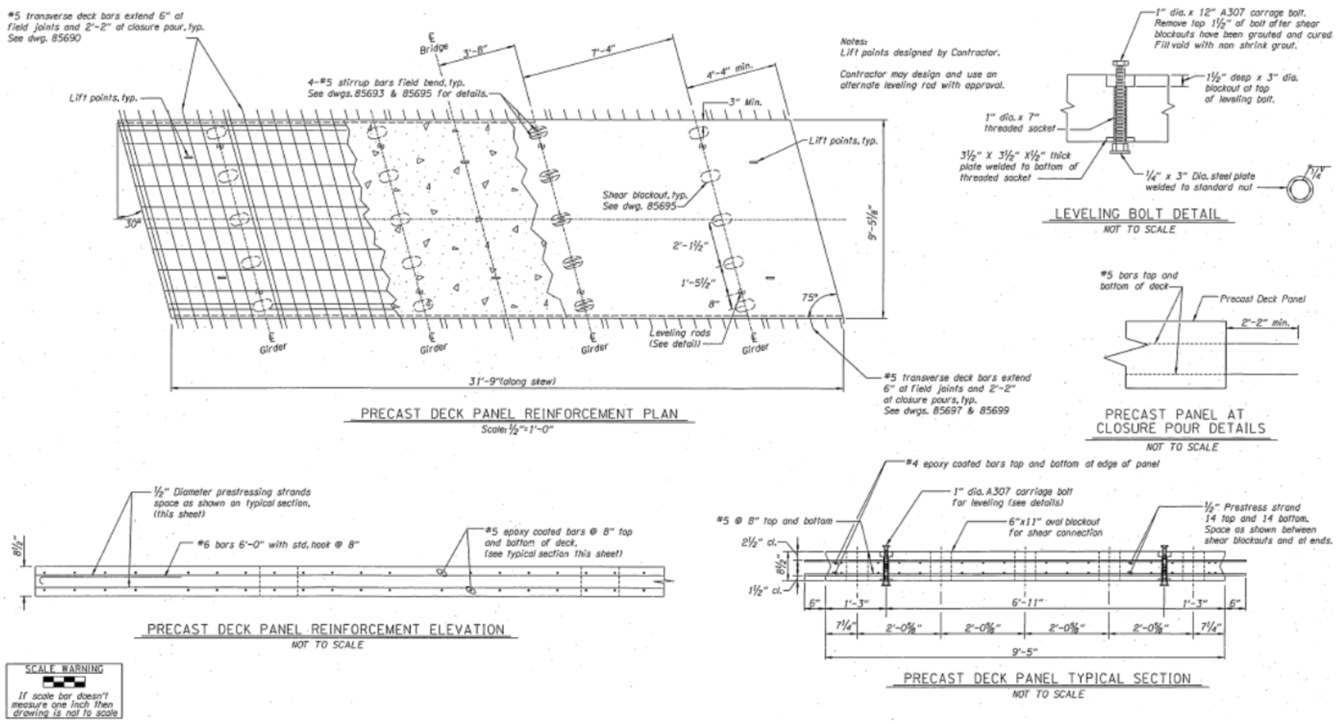


Figure 10. Diagram. Bridge 21252 precast deck panel details.

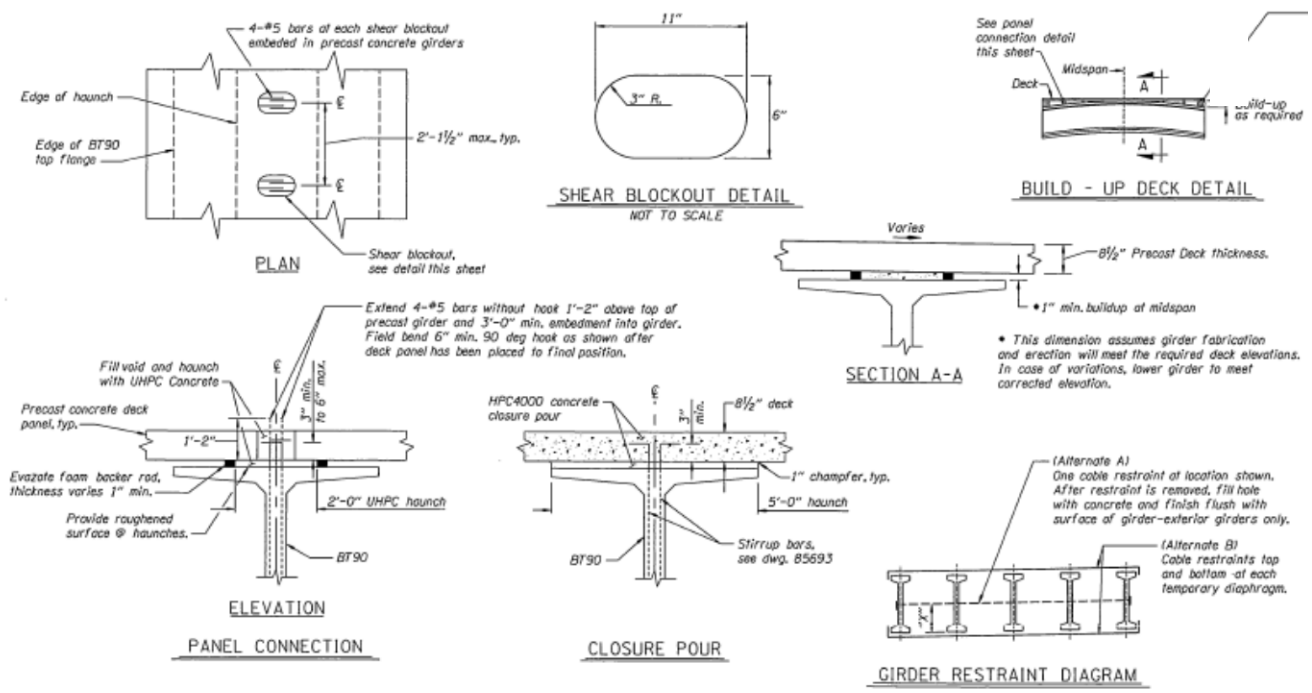


Figure 11. Diagram. Bridge 21252 shear pocket blockouts, haunch connections, and closure pour details.

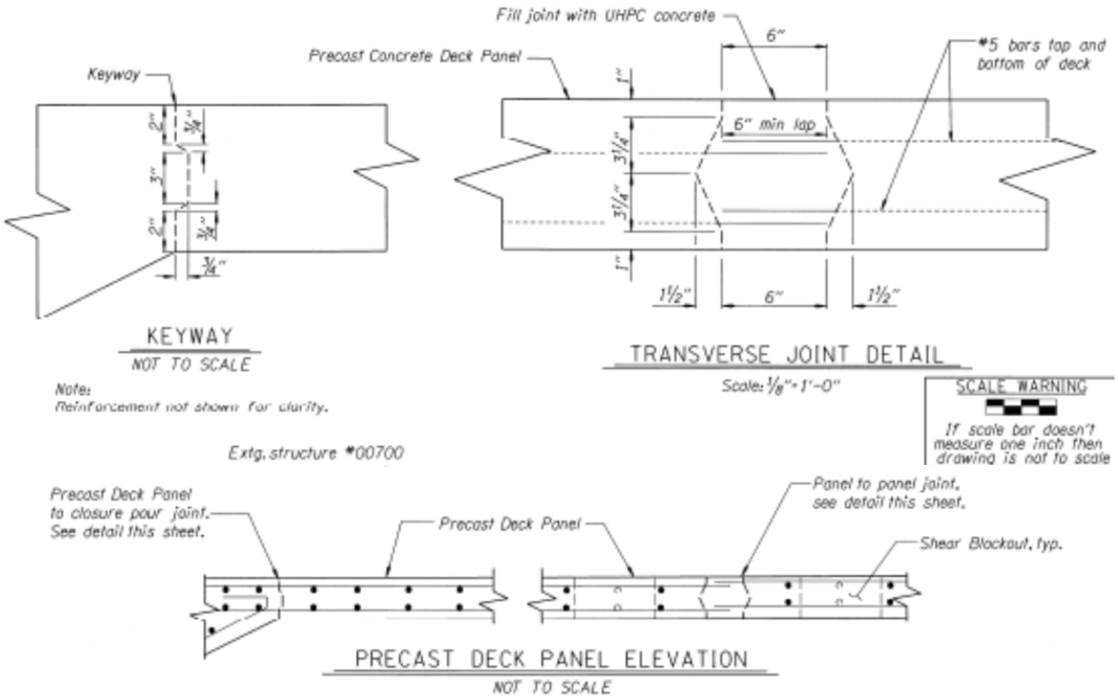


Figure 12. Diagram. Cross section showing deck panel elevation and joint details for bridge 21252.

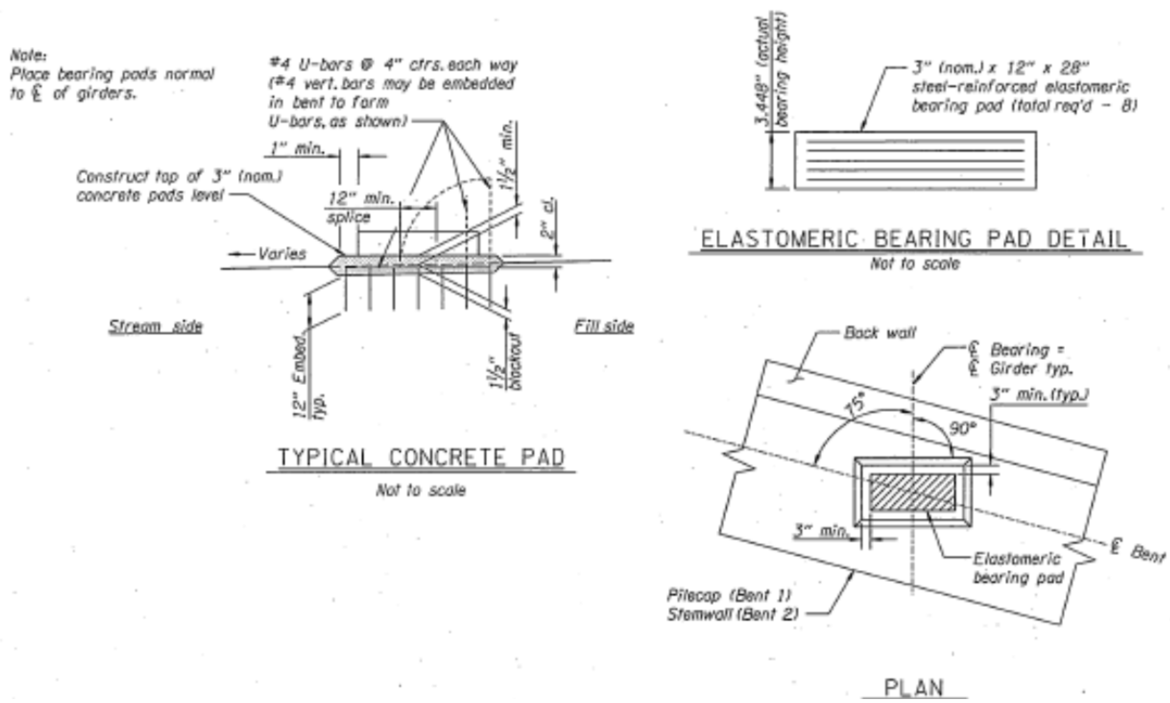


Figure 13. Diagram. Concrete pad and elastomeric pad details for bridge 21252.

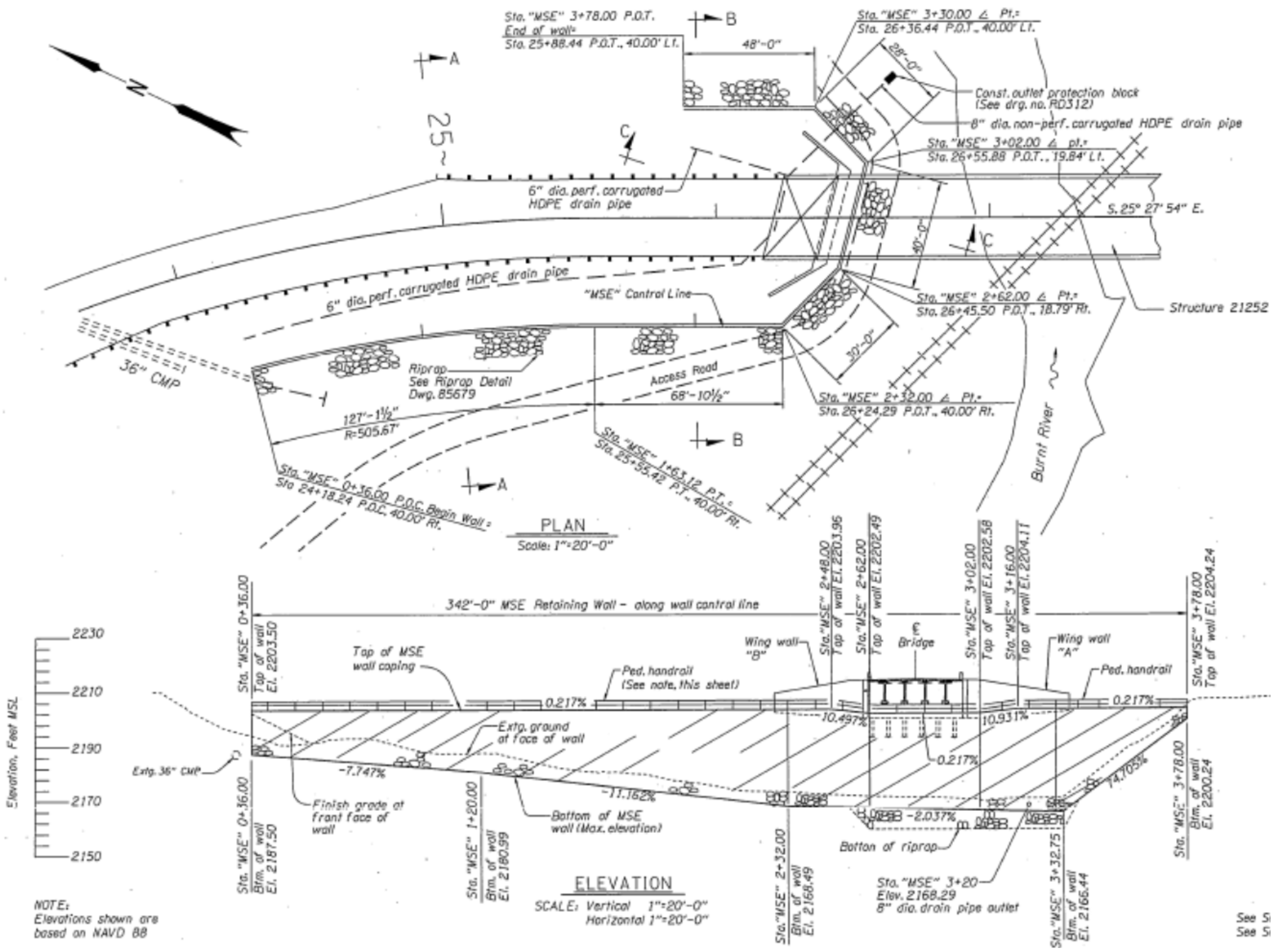


Figure 14. Diagram. MSE wall plan and elevation views for bridge 21252.

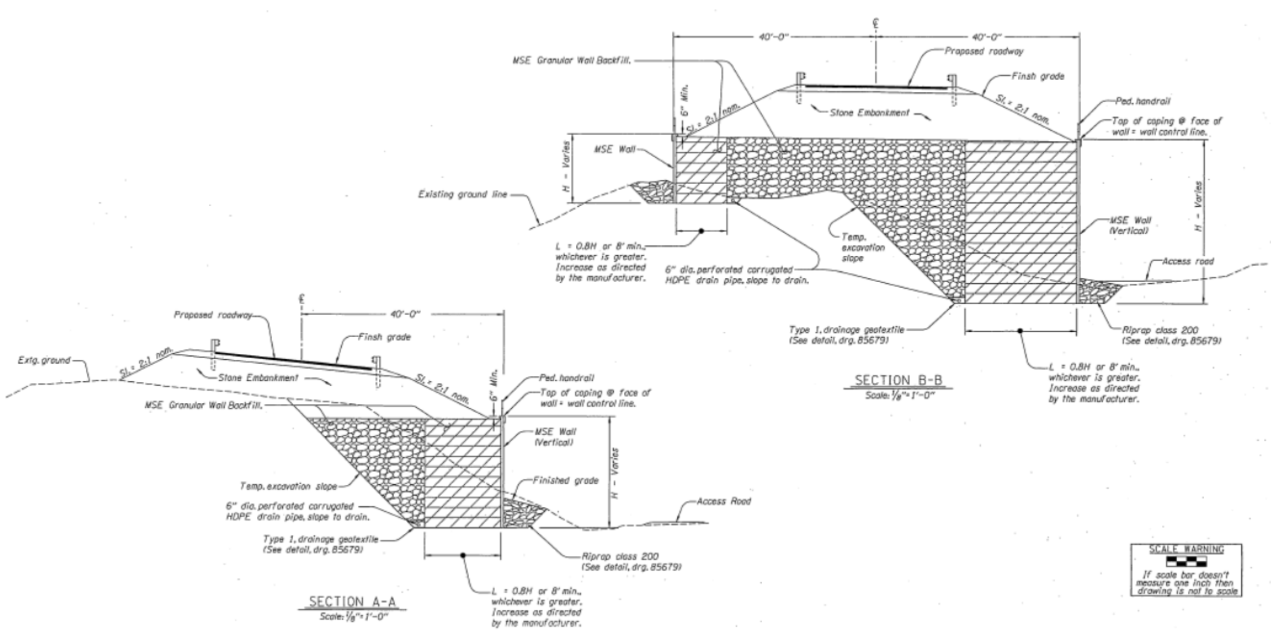


Figure 15. Diagram. Two MSE wall section views for bridge 21252.

The concrete placement sequence is shown below and in Figure 16.

- Fill/excavate and drive piles at Bent 1 and rock excavation at Bent 2.
- Pours 1 include concrete fill below foundations (Concrete Fill Below Foundation Class 3300 concrete).
- Pours 2 include footing at Bent 2 after concrete fill below foundations reaches design strength (Foundation Class 3300 concrete).
- Pours 3 include pilecap at Bent 1, stemwall at Bent 2, and wingwalls (General Structural Class 3300).
- Place prestressed girders and steel diaphragms after pile cap concrete and bearing pad grout have reached the design strength.
- Pours 4 include diaphragm beams “E” and “H” between the girders (General Structural Class 4000).
- Set precast concrete deck panels.
- Pours 5 at shear pockets, panel joints, and haunches (UHPC Class 17,000)
- Pours 6 include deck closure pours after beams “E” and “H” have reached the design strength (HPC Class 4000).
- Pours 7 includes backwalls (Foudation Class 3300).
- Pours 8 includes bridge end panels after backwalls have reached the design strength (HPC Class 4000).
- Pours 9 includes bridge rail after end panels have reached the design strength (General Structural Class 3300).

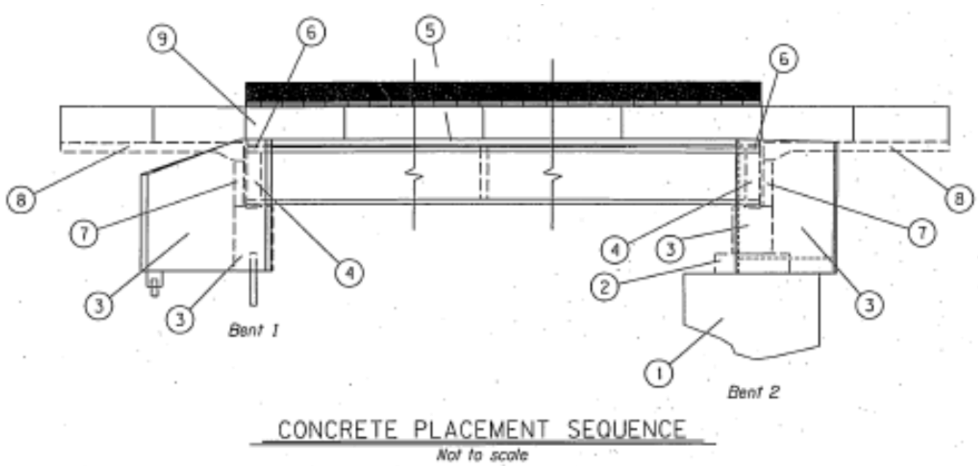


Figure 16. Diagram. Concrete placement sequence for bridge 21252.

Construction

Many key activities, such as concrete girders and deck panel fabrication and curing (done at the fabrication facility), were done prior to or concurrent with on-site activities such as removal of the existing bridge, excavation, piling and concrete placement for the abutments, and placement of the concrete girders. As a result, field construction time and road closure time were reduced (as compared to conventional cast-in-place construction), which consequently reduced the impact on traffic and improved safety.

Figures 17 through 57 show photographs of the construction process. The construction of the bridge began by demolition of the existing bridge with concurrent construction of the substructure and MSE walls (Figures 17 through 28). As shown in the figures, the contractor installed corrugated metal pipe at pile locations in the backfill of the MSE walls to protect the reinforcement when driving piles for bridge substructure. The corrugated pipe was appropriately located and capped for future pile construction.

Following construction of the substructure including driving piles and construction of Bent 1 and Bent 2, the girders were placed onto the bents as shown in Figures 29 through 33. The installation of the girders included setting up a girder launcher consisting of falsework, longitudinal beams, and temporary support towers for launching the girders across the river and active rail mainline before being lifted into place over the bents. Following placement of all the girders onto the elastomeric bearing pads placed on top of the bents, the girders were prepared for the placement of the prefabricated decks. The top of the girders were cleaned to remove all dirt, oil, grease, or other loose material. The haunch-forming material was placed at the edges of the girder. Steel leveling plates embedded in the tops of the precast girders along with leveling coil bolts and coil bolt inserts cast into the deck panel are used to level the deck panels following placement. Figures 34 through 36 show the installation of the deck panels. Figures 37 through 39 show views of the bridge deck following placement of all deck panels.

Figures 40 through 45 show closeups of the leveling bolt, lifting hardware, shear pockets, and transverse joints. The reinforcement cast in the girders pass through the shear pockets to connect the UHPC in the haunch and the pockets to provide composite action between the girder and the deck. Leveling bolts on each panel allow for an easy and efficient means of raising and lowering the deck onto the girder by screwing the leveling bolt clockwise and counterclockwise, respectively.

Figure 46 shows the view of the reinforced concrete girders and the wooden forms to hold the UHPC in the transverse joints from underneath the bridge deck. Figures 47 through 55 show placement details of the UHPC. Note that the UHPC is mixed in small batches and poured into the shear pockets and transverse joints. The pockets and joints are top formed to prevent overflow and chimneys are provided to allow for slight overpressure which assists in ensuring that the connection space is fully filled. Figure 56 shows a close-up view of the bridge deck following construction and Figure 57 shows the overview of the bridge following construction.

Figure 17. Demolition of approach to bridge 0700.

Figure 18. Demolished approach of brige 0700.

Figure 19. Closeup of demolition of approach to bridge 0700.


Figure 20. Excavation for building the substructure and installation of MSE wall.

Figure 21. Setting the forms for building the substructure and MSE retaining wall.


Figure 22. Pouring concrete for building the substructure and MSE retaining wall.

Figure 23. Installation of corrugated metal pile spacers for building the substructure and MSE retaining wall.

Figure 24. Installing MSE retaining wall (side view).

Figure 25. Installing MSE retaining wall around the corrugated metal pile spacers (side view).

Figure 26. Installing MSE retaining wall (top view).


Figure 27. Backfilling MSE retaining wall (long view).


Figure 28. Removal of truss frame of existing bridge 0700 (long view).

Figure 29. Installation of falsework to support the girders during construction of the superstructure.

Figure 30. Completed installation of falsework to temporarily support the girders during construction of the superstructure.

Figure 31. Girder being rolled onto the temporary support during construction of the superstructure.

Figure 32. Girder transferred from the temporary support to the bent abutments during construction of the superstructure.

Figure 33. Second girder transferred from the girder launcher to the bent abutments during construction of the superstructure.

Figure 34. Installation of the prefabricated bridge deck panel (P8) during construction of the superstructure.

Figure 35. Installation of the second prefabricated bridge deck panel (P9) during construction of the superstructure.

Figure 36. Continuing installation of the prefabricated bridge deck panels during construction of the superstructure.

Figure 37. View of the deck from south end of the bridge following installation of all prefabricated bridge deck panels.

Figure 38. Long view of the girder and deck from south end of the bridge following installation of all prefabricated bridge deck panels.

Figure 39. View of the deck from north end of the bridge following installation of all prefabricated bridge deck panels.

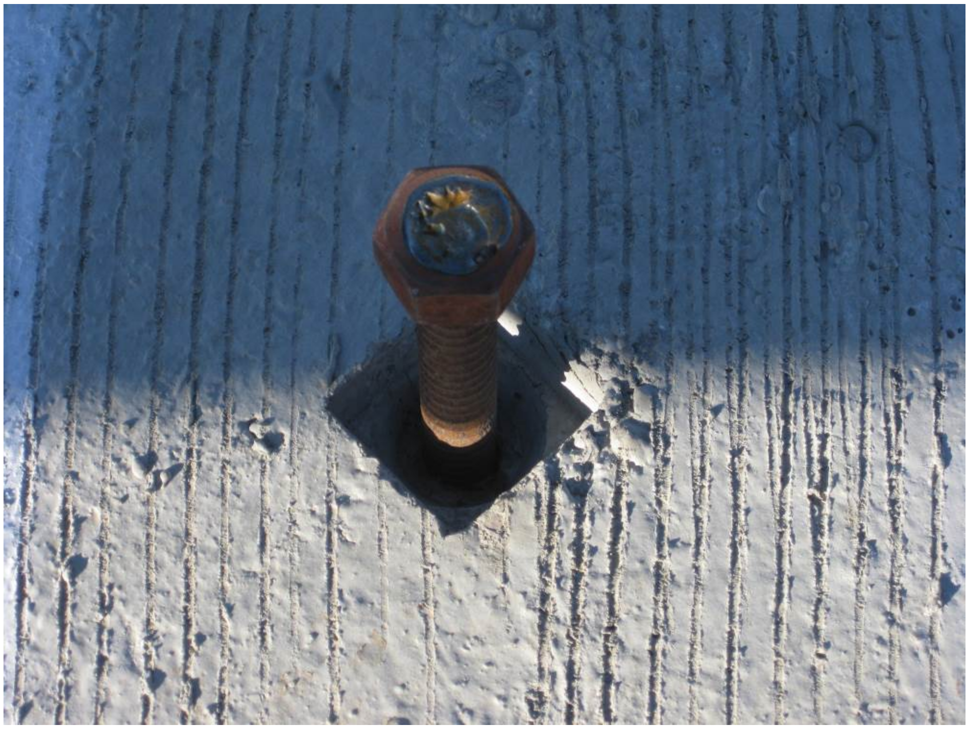


Figure 40. Leveling bolt for leveling an individual bridge deck panel.

Figure 41. Lifting hardware cast into each individual bridge deck panel.

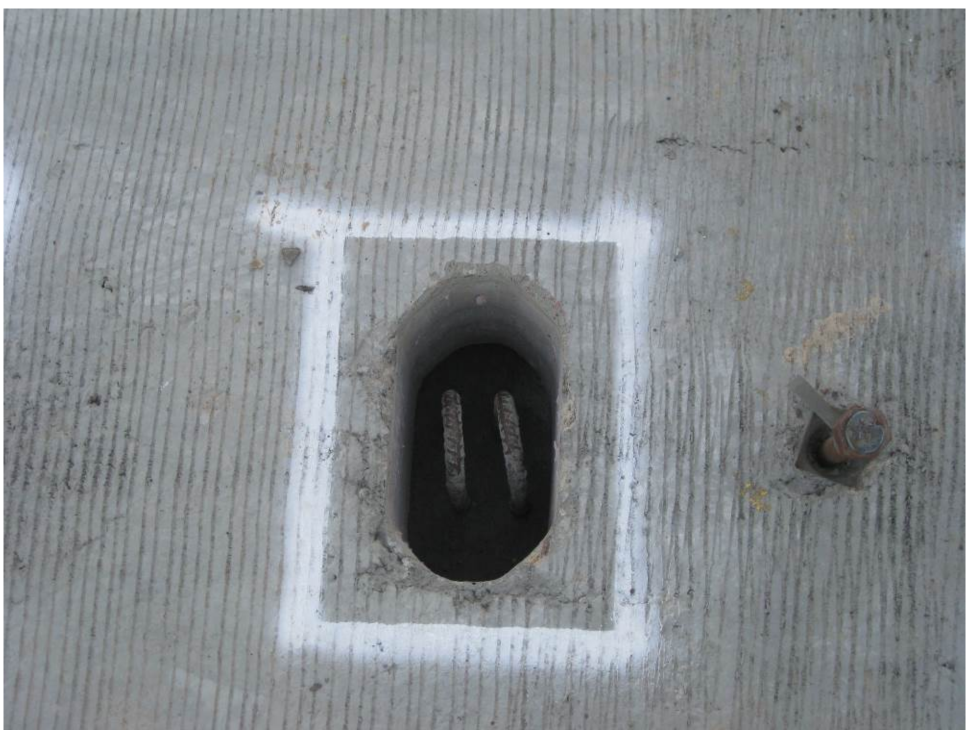


Figure 42. Close-up view of a deck panel shear pocket placed over reinforcement from the girder. Deck-girder composite action is obtained when the shear pocket and underlying haunches are filled with the UHPC.

Figure 43. Medium view of the deck panel shear pockets placed over reinforcement from the girder. Also in the view is a leveling bolt and the joint between the deck panels.

Figure 44. Transverse view of the joint between the deck panels. Composite action between panels is obtained when the reinforced transverse joints are filled with the UHPC. The use of UHPC also eliminates the need for longitudinal posttensioning.

Figure 45. Close-up of the joint between the deck panels. Below the joint is the top of the girder and the wooden forms to hold the UHPC in the transverse joints.

Figure 46. View of the reinforced concrete girders and the wooden forms to hold the UHPC in the transverse joints from underneath the bridge deck.

Figure 47. UHPC aggregate being put in the mixer.

Figure 48. UHPC fiber being put in the mixer.

Figure 49. Close-up view of UHPC fiber.

Figure 50. Measuring the flow using ASTM C1437—Standard Test Method for Flow of Hydraulic Cement Mortar.

Figure 51. Placing the UHPC in the shear pockets.

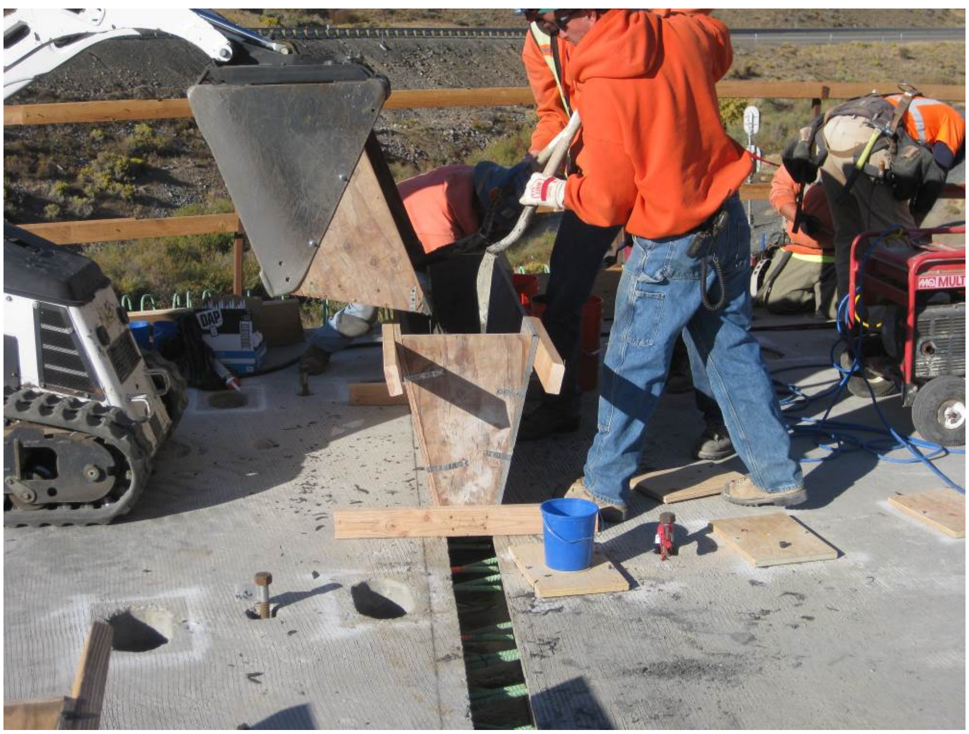


Figure 52. Placing the UHPC in the transverse joints.

Figure 53. UHPC flowing into the transverse joint.

Figure 54. Plywood used to top-form filled areas of UHPC to prevent overflowing.

Figure 55. Long-shot view of bridge deck showing top-formed filled areas of UHPC to prevent overflowing. The placement concludes at the chimney to allow for slight overpressure on the field-cast UHPC which assists in ensuring that the connection space is fully filled.

Figure 56. Close-up view of bridge 21252 deck surface after completion.

Figure 57. Overview of bridge 21252 after completion.

DATA ACQUISITION AND ANALYSIS

Data collection on the ODOT HfL project consisted of acquiring and comparing data on safety, construction congestion, quality, and user satisfaction before, during, and after construction. The primary objective of acquiring these types of data was to provide HfL with sufficient performance information to support the feasibility of the proposed innovations and to demonstrate that ABC using precast deck panels and UHPC can be used to do the following:

- Achieve a safer environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Deliver better quality.
- Produce greater user satisfaction.

This section discusses how well the ODOT project met the HfL performance goals in these areas.

SAFETY

The HfL performance goals for safety include meeting both worker and motorist safety goals during and following construction. The ODOT project established the following performance goals for work zone crash rate, incident rate for worker injuries, and roadway crash rate following construction:

- Achieve a work zone crash rate equal to or less than the existing condition
- Achieve a worker injury incident rate less than 4.0.
- Achieve a 20% reduction in fatality as reflected in a 3-yr average crash rate, using preconstruction data as a baseline.

Work Zone and Worker Safety

Though crashes in work zones are not uncommon, a key component of ODOT's philosophy on this project was that crashes must be avoided at all costs during construction. At a minimum, construction activities should not cause an increase in existing area crash rates. The ability to safely construct the replacement bridge at the bridge site was an overarching project requirement. The foremost solution to achieving work zone safety was to minimize traffic disruption and interaction with construction workers. Towards this end, the approach adopted for replacing the bridge was to close the bridge for the duration of construction as shown in the traffic control plan (Figure 58) and Figures 59 and 60. At the conclusion of the construction period, the new bridge was open to traffic in both directions.

In addition to using a construction approach that minimized the restricted movement of traffic and keeping the traveling public and freight carriers away from work zones as much as possible, a secondary solution to reducing work zone accidents was providing motorists and other stakeholders with up to-date construction scheduling and status information through regular press releases and other media communications, message boards placed along travel routes and in local communities, stationing of a radar speed sign in the most sensitive work zones, regular communications with freight carriers, city, county, region and state officials, local school districts, and internet postings to such popular sites as ODOT's TripCheck website. An innovative activity designed to improve work zone safety was the procurement of Oregon State Police services during major traffic changes and for added patrols during the peak construction periods. The reduced construction time due to using precast deck panels also reduced the exposure time for overall construction activity.

To maximize safety during the reconstruction, the posted speed zone was reduced as needed. All the activities and procedures to be used to achieve an incident rate for worker injuries to be less than 4.0 based on the OSHA 300 rate were identified in the project's Safety Plan. All construction workers received quarterly safety training and attended mandatory weekly safety meetings. All subcontractors received subcontractor packets and certified that they would abide by all OSHA standards and project safety policies such as the wearing of hard hats, safety vests, and work boots at all times while on construction sites. All site personnel, field crews, designers, inspectors, owner's representatives, etc. received site-specific orientation and safety training prior to working on this project. All work zone safety issues were recorded in daily diaries and documented with photographs. Any needed corrective actions were taken immediately. Workers and the public were encouraged to promote a safe work environment. A hot-line was established that was open to anyone wishing to report a perceived safety issue. All reported safety issues were to be investigated immediately and findings recorded and made available for public review.

Because of ODOT's proactive approach to work zone and worker safety, no workers were injured during the construction of the Old US30 Burnt River Bridge project, so the contractor exceeded the HfL goal for worker safety (an incident rate of less than 4.0 based on the rate reported on OSHA form 300). There were also no reported work zone accidents because the work zone was closed to traffic which was detoured on to the adjacent I-84. Thus, the Hfl goal for work zone safety during construction was met.

Roadway and Bridge Safety Improvements

There had been 3 injury crashes in the 10-year period on Old US30 between mile point 0.0 and 3.26 (the Burnt River bridge is at mile point 2.75 and spans less than 200 ft). The average annual daily traffic on this section of the highway during the 10-year period was extremely low (60 to 230 vehicles per day). The injury rate for this section of highway was 14 injuries per 100 million vehicle-miles prior to the construction of the new bridge, which was over 3 times the 2008 Statewide Crash Rate for Injuries and Fatalities for Rural Other Principal Arterials which is 4.52 fatalities per 100 million vehicle-miles.

The steel truss of the existing bridge 0700 had been impacted by over height vehicles 3 times in the last two years resulting in a bridge closure for assessment and repairs. Over the course of the last 10 years, a total of 4 crashes have occurred near the project bridge. Three of those were injury accidents, and three involved impacts to a fixed object. The new bridge is expected to reduce and potentially eliminate future injuries for 2 of the 4 crashes that have occurred within the last 10 years thus potentially improving the crash rate to a rate that is half the historical average for this section of highway. A characteristic of the existing bridge was the presence of a substandard structure width. The existing bridge roadway had no shoulders, and it had deficient bridge rails. The new bridge was constructed to modern design standards. The additional increase in bridge width permitted the shifting of the roadway's center lane which resulted in improved sight distances in both directions. The bridge construction also included the additional shoulders to increase sight distances and improve the movement of commercial and recreational vehicles. The bridge was reconstructed at a higher elevation and roadway approaches were realigned to further improve sight distances. Tall vegetation on roadway approaches to bridges was cleared and replaced with grasses and low-lying vegetation to further improve post-construction sight distances and to reduce future reductions in sight distances.

For this project, the facility safety after construction is yet to be determined. However, the increased bridge width, roadway shoulder additions, roadway realignments, and increased sight distances are expected to significantly enhance traveling safety and produce at least a 20 percent reduction in fatalities and injuries as compared to preconstruction rates.

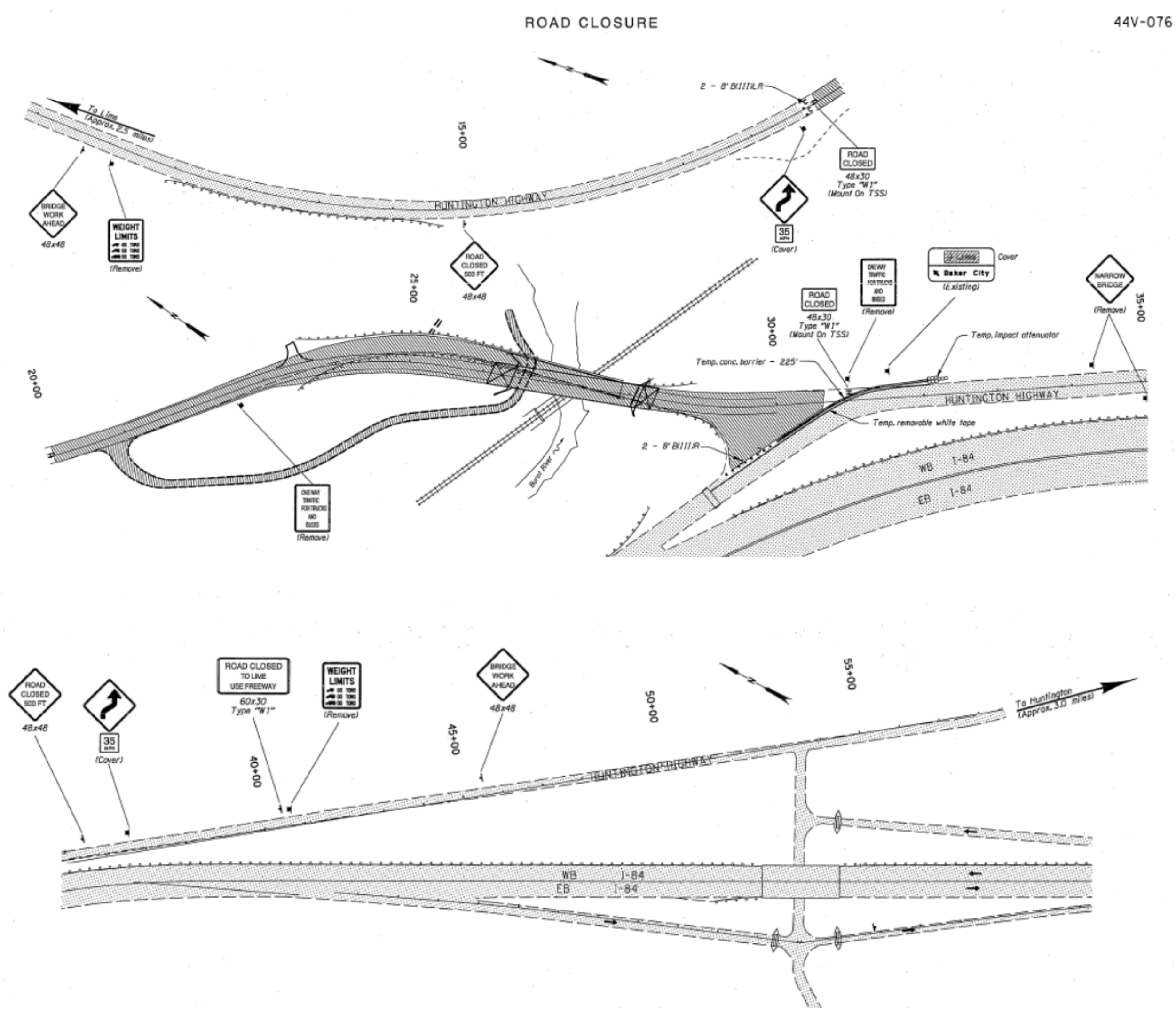


Figure 58. Traffic control plan showing closing of Old US30 for construction of the new bridge and detours around work zone on EB and WB I-84.

Figure 59. Closure of Old US30 at the north end of the project.

Figure 60. Closure and barriers detouring traffic on to WB I-84 at the south end of the project.

CONSTRUCTION CONGESTION

As noted previously, the work zone was completely closed for removal of the old bridge and construction of the new one, and all traffic was diverted to I-84. Based on visual observations and discussions with the ODOT project manager, the diverted traffic was free flowing at all times. The low traffic volume affected by the closure (two-directional ADT of 60 to 230; assumed 160 vehicles per day for this analysis) on the roadway without any significant morning or evening peaks allowed for this diversion without any impact to I-84 traffic. Because of the low traffic volume impacted by the construction and the complete closure of the bridge, there were no vehicles queued at the construction zone resulting in a queue length = 0. The traffic impacts is summarized as follows:

1. To the north of the bridge (located on Old US30 just north of I-84 interchange 345), the only access being affected are local residents with driveway access to Old US30.
    a. For residents going north (assumed 40 vehicles per day), their behavior is unchanged (travel north on Old US30 until reaching I-84 interchange 342) resulting in no additional travel time.
    b. For residents going south (assumed 40 vehicles per day), they must go north up to I-84 interchange 342 and continue north (because they would not be able to turn around at interchange 342) until they reach I-84 interchange 340 to turn around and go south. To measure the delay time due to this movement the travel time was measured several times over a period of two days during construction. The average additional travel time due to this movement from a location just north of the work zone to a location just south of the work zone was measured to be 13 minutes.
2. For someone traveling southbound on I-84 and wishing to visit a resident on Old US30 (assumed 40 vehicles per day), they could exit at I-84 interchange 342 and travel on Old US30 to reach the resident's driveway resulting in no additional travel time.
3. For someone traveling north and normally exiting right before the bridge to use Old US30 and the bridge (assumed 40 vehicles per day), they must now stay on I-84 up to interchange 340 to turn around and go southbound on I-84, and exit at I-84 interchange 342 to use Old US30. The average additional travel time due to this movement from a location just south of the work zone to a location just north of the work zone was measured to be 12 minutes.

Based on the movements described above, the average delay (additional travel time) per vehicle is estimated to be less than 6 minutes (0.1 hours) for a total of less than 16 vehicle-hours per day of work zone closure.

QUALITY

The bridge was designed to exceed a 75-year life expectancy. The bridge was constructed using a single long bridge span. Longer bridge spans reduce the number of needed bents and permit the location of as many bents as possible outside the ordinary high water mark (OHWM) or at least outside of the running waterway. Reducing the number of in-stream bents or bents located within the OHWM reduces potential adverse environmental impact resulting from construction activities and future debris accumulations.

The bridge was constructed using precast concrete girders and precast concrete deck panels. Producing the prefabricated elements at a climate-controlled fabrication facility outside the project critical path schedule is expected to result in higher quality control and increased durability. In addition, the use of UHPC to hold the panel joints tight is expected to provide further deck protection, as well as reduce short- and long-term bridge maintenance. Other design and construction specifications promoting enhanced durability and quality of work included: use of high-performance concrete decks, low porosity concrete, jointless (no expansion joints) and watertight decks, impact panels, minimization or elimination of deck drains, and combined definition of design and permit trucks in live loading criteria.

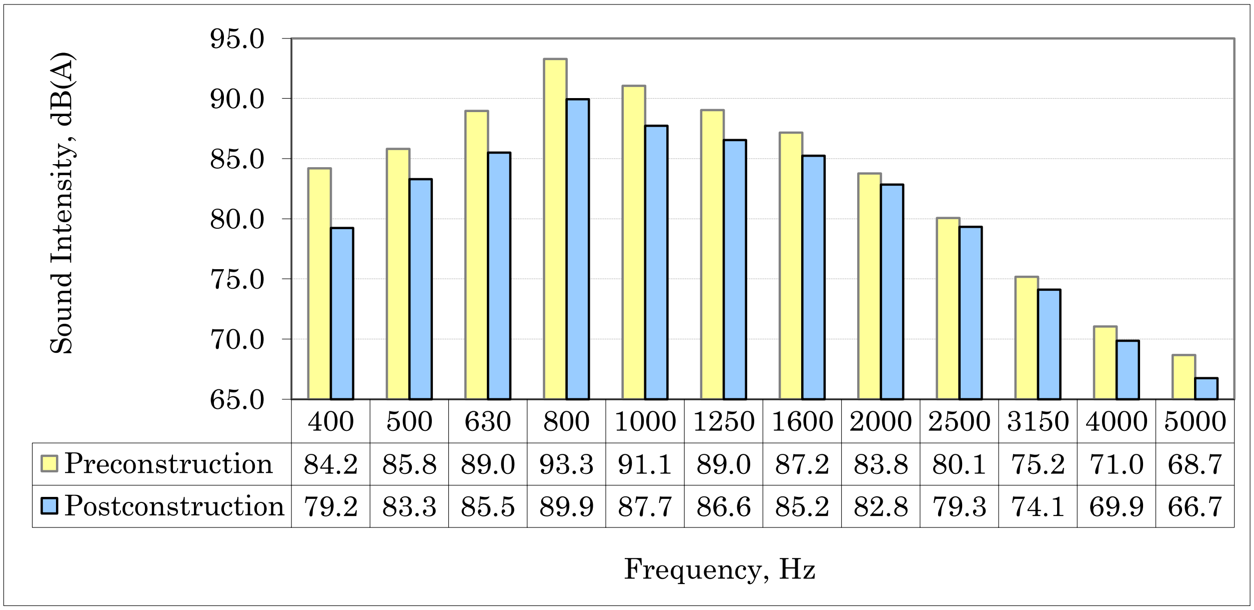
Sound intensity (SI) and smoothness test data were analyzed from a section of the project pavement that includes the new bridge. Comparing these data before and after construction provides a measure of the quality of the finished pavement.

Sound Intensity Testing

SI measurements were made using the current accepted OBSI technique AASHTO TP 76-10, which includes dual vertical SI probes and an ASTM recommended standard reference test tire (SRTT). The SI measurements were recorded and analyzed using an onboard computer and data collection system. Multiple runs were made in the right wheelpath with two microphone probes simultaneously capturing noise data from the leading and trailing tire-pavement contact areas. Figure 61 shows the dual-probe instrumentation and the tread pattern of the SRTT.

Figure 61. OBSI dual probe system and the SRTT.

The average of the front and rear SI values was computed to produce a global SI value. Raw noise data were normalized for the ambient air temperature and barometric pressure at the time of testing. The resulting mean SI levels are A-weighted to produce the SI frequency spectra in one-third octave bands, as shown in Figure 62.



	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
Preconstruction	84.2	85.8	89.0	93.3	91.1	89.0	87.2	83.8	80.1	75.2	71.0	68.7
Postconstruction	79.2	83.3	85.5	89.9	87.7	86.6	85.2	82.8	79.3	74.1	69.9	66.7

Figure 62. Mean A-weighted sound intensity frequency spectra before and after construction.

SI levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. The global SI value for the existing bridge was 98.2 dB(A) and 95.2 dB(A) for the new bridge. Thus the SI value for the new bridge, which is an improvement of 3 dB(A), meets the HfL goal of 96.0 dB(A). Overall, each frequency was reduced and no single frequency spiked, indicating the absence of the distinct tone or whine common to concrete surface with a transverse or aggressive surface texture.

Smoothness Measurement

Smoothness testing was done in conjunction with SI testing using a high-speed inertial profiler integrated with the test vehicle. The smoothness or profile data were collected from both wheel paths and averaged to produce an IRI value. Low values are an indication of higher ride quality (i.e., smoother road/bridge). Figure 63 shows the test vehicle with the profiler positioned in line with the right rear wheel. Figure 64 graphically presents the IRI values for the preconstruction and newly constructed bridge. The existing distressed bridge had a mean IRI of 284 in/mi, and the new bridge had a mean IRI of 178 in/mi. Motorists may notice a somewhat smoother ride, but the rehabilitated bridge did not meet the HfL goal of 48 in/mi.

Figure 63. High-speed inertial profiler mounted behind the test vehicle.

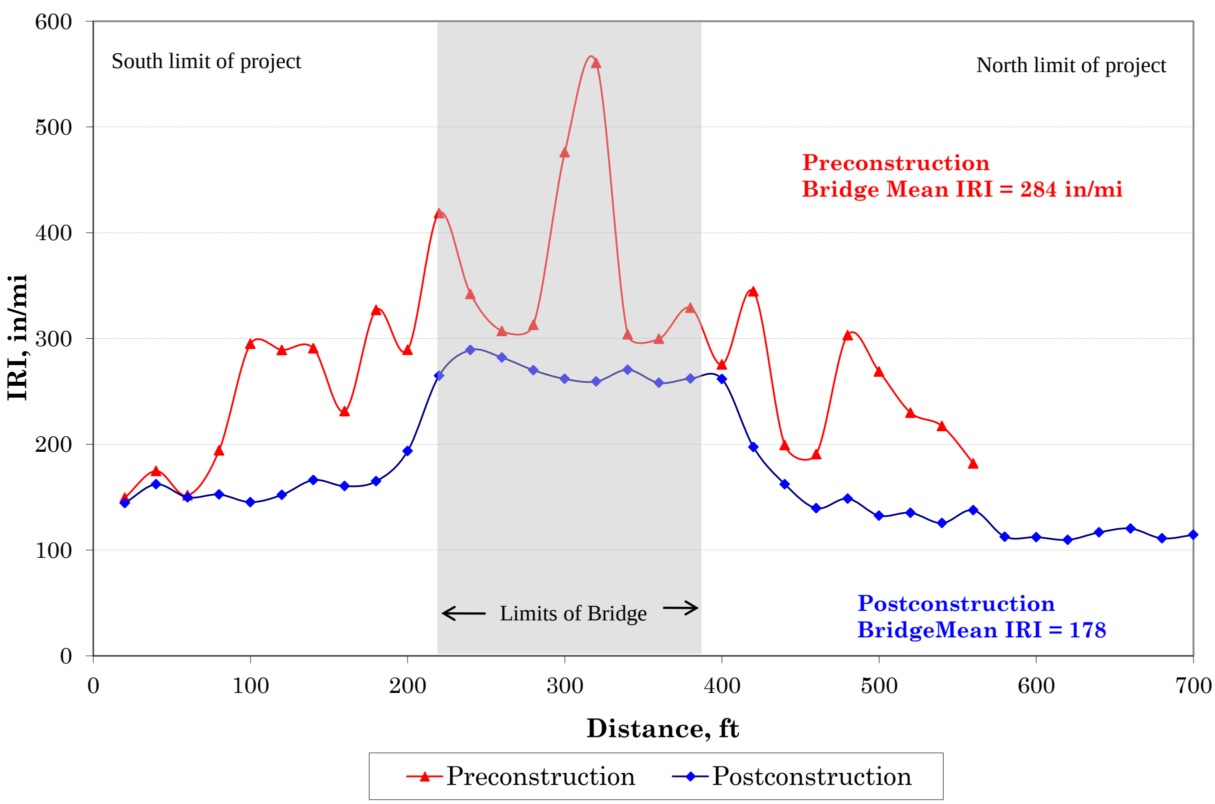


Figure 64. Mean IRI values before and after construction.

User Satisfaction

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

- How satisfied the user is with the new bridge, compared with previous bridges and roadway alignments?
- How satisfied the user is with the approaches used to construct the new bridge in terms of minimizing disruptions?

Overall, the response to the questions exceeded the HfL goal of 4 out of 7 (the majority of the respondents) or more showing favorable response.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This generally 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 on a project of similar size and scope. The latter type of project is referred to as a baseline case. For this economic analysis, ODOT supplied the cost figures for the as-built project. However, there is no baseline case for comparison because of some unique features on this project including:

- Extremely low traffic volume (ADT ranging from 60 to 230 in 2008) implying very low impact on traffic and cost savings due to traffic impacts.
- The technology provides ODOT with a tool to accelerate bridge construction activities and provide for a longer lasting bridge deck. The potential overall effect on the state's bridge construction program is expected to be significant in terms of the state's ability to deliver a higher quality product in an accelerated timeframe. ODOT intends to aggressively pursue precast deck panels where it is possible and cost-effective to do so thus making this innovation a standard practice in the future. However, ODOT clearly understood that on this specific project, the 20 to 30 percent increase in costs due to the ABC techniques and innovative materials used could not be justified by the savings in construction congestion, work zone safety, and reduction in delay times.
- The goal was to use this project as learning and evaluation tool without any substantial impact on motorists and not necessarily to save costs on this specific project.
- If this project would have been constructed at a location with substantially higher traffic impact (such as roadways with higher traffic volumes, urban locations with morning and evening peaks resulting in higher traffic delay times, locations requiring substantial detours resulting in higher traffic delay times and vehicle operating costs), the as-constructed bridge would likely be more cost effective as compared to the baseline case. ODOT also believes that costs for this type of project would come down as contractors and industry gain experience with ABC methods.
- Significant future savings are expected due to reduced maintenance and rehabilitation. The bridge is expected to have life expectancy of 75 years with minimal maintenance.

CONSTRUCTION COSTS

A total of sixteen contractors bid on this project with total bid price ranging from a low of $2.34 million to a high of $3.64 million. The three low bids on this project were $2.34 million, $2.41 million, and $2.43 million, respectively. Table 1 shows some of the relevant costs from the bid tabs for the three lowest bids. Several of the major cost items shown in the table (miscellaneous items, bridge removal, girders, and MSE retaining wall) would be the same regardless of whether the bridge was constructed using traditional cast-in-place (CIP) techniques or as constructed using UHPC and precast deck panels. Thus for this project, construction using UHPC and precast deck panels is estimated to be only 10 to 15 percent more than traditional CIP techniques.

Table 1. Relevant costs from the bid tabs for the three lowest bids.

Item	Quantity	Vendor 1 (Lowest Bidder)		Vendor 2		Vendor 3	
		Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
Mobilization	LUMP	230,000	230,000	238,000	238,000	243,000	243,000
Bridge Removal Work	LUMP	110,000	110,000	237,500	237,500	165,000	165,000
UHPC Concrete	LUMP	190,000	190,000	120,000	120,000	200,000	200,000
Precast Prestressed Girders	647 FT	445	287,915	400	258,000	389	251,683
Precast Prestressed Deck Panels	4,495 SQ FT	50	224,750	45	202,275	46	206,770
MSE Retaining Wall	LUMP	489,750	489,750	515,500	515,500	507,000	507,000
Deck Concrete, Class HPC4000	LUMP	75,000	75,000	35,000	35,000	55,000	55,000
Other Items*			738,430		803,157		803,693
Total			**2,345,845**		**2,409,432**		**2,432,146**

Miscellaneous items include seeding right of way, permanent traffic safety and guidance devices, pavement removal, aggregate base for approach and leave end of bridges, structural steel diaphragms, asphaltic plug joint seals, concrete rail with chain link fence, reinforced concrete bridge end panels, general structural concrete class 3300, general structural concrete class 4000, foundation concrete class 3300, reinforcement, coated reinforcement, steel pile splices, reinforced pile tips, pile load test (dynamic), drive steel piles, steel piles, pile driving equipment, HMA wearing surface, concrete fill below foundation, granular wall backfill, structural excavation, drainage and sewers, roadwork, and temporary features and appurtenances.

This project was first of its kind undertaken in Oregon, and ODOT's goal was to use it as learning and evaluation tool without any substantial impact on motorists, and not necessarily to save costs on this specific project. ODOT expects the future bid costs to come down as contractors and industry gain experience with these technologies resulting in projects which will have reduced life cycle costs. The reduced maintenance and rehabilitation costs due to use of the precast HPC panels and UHPC closures is also expected to result in savings to ODOT over the 75-year projected life of this bridge.