I-85 Interchange Design-Build Project Using Prefabricated Bridge Elements in West Point, GA

Final Report
June 2013

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S.Department of Transportation
Federal Highway Administration

FOREWORD

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

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

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

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

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

NOTICE

1. Report No.	2. Government Accession No	3. Recipient's Catalog No

3. Title and Subtitle I-85 Interchange Design-Build Project Using Prefabricated Bridge Elements in West Point, GA	5. Report Date June 2013 6. Performing Organization Code
7. Authors Jagannath Mallela; Paul Littleton, P.E.; Gary Hoffman, P.E., R.L.S.; Salil Gokhale (formerly ARA, Inc.); and Gerald L. Ullman	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	13. Type of Report and Period Covered Final Report May 2007–November 2009 14. Sponsoring Agency Code

15. Supplementary Notes
Contracting Officers Technical Representatives: Byron Lord, Mary Huie

16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE program, the Georgia Department of Transportation (GDOT) was awarded a $1 million grant to demonstrate the use of proven, innovative technologies to deliver an $81 million project in less time than conventional construction. In addition, this was a 100 percent Federally funded project. This report documents the design-build project in Troup County to construct a new Interstate 85 interchange, 10 miles (16 kilometers) of four-lane frontage and access roadway, another bridge, and all other items associated with this large economic development project. The interchange includes prefabricated bridge substructure elements, used for the first time in the State.

This report discusses the use of the design-build (D-B) contracting method, a first for Georgia, implemented under newly passed State legislation. The project also includes other firsts for Georgia, including requiring the D-B contractor to propose state-of-the-art methods to achieve performance expectations, the use of prefabricated elements to construct the bridge substructure and real-time traffic operations support through speed band monitoring on I-85. GDOT also set traffic incident response time goals for this project. Under conventional construction, the impact of this project on the traveling public was estimated at 30 months, but with the use of the D-B contracting technique and prefabricated bridge elements, the impact was reduced to only 16.5 months.

Using D-B and other innovative techniques to accelerate the delivery schedule had a significant influence on the net construction cost. A comprehensive economic analysis including construction costs and user costs shows that the project saved about $1.98 million or about 45 percent over traditional contracting and construction methods. Because of the success of this project, GDOT is more comfortable with using the D-B method and prefabricated bridge elements on future large-scale projects.

17. Key Words bridge connections, design-build, Highways for LIFE, PBES, prefabricated bridge elements and systems, performance contracting, real-time traffic operations management, return on investment, roller-compacted concrete, speed band monitoring	18. Distribution Statement 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) Unclassified	19. Security Classif. (of this page) Unclassified	20. No. of Pages 47	21. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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 yard	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 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 (metric tons)	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/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lb	pounds	4.45	Newtons	N
lb/in^2 (psi)	pounds 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	35.71	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 (metric tons)	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	pounds	lb
kPa	kiloPascals	0.145	pounds per square inch	lb/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)
		DENSITY		
kg/m^3	pounds per cubic foot	0.062	kilograms per cubic meter	lb/ft^3 (pcf)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised September 1993)

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration (FHWA) Highways for LIFE Team Leader Byron Lord and Program Coordinators Mary Huie and Kathleen Bergeron, 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 also is indebted to Gus Shanine and Christy Poon-Atkins from the the FHWA Georgia Division office and Darryl VanMeter, State Innovative Program Delivery Engineer at the Georgia Department of Transportation (GDOT). Our sincere gratitude is also due to Greg Wiggins and Greg Bowen of GDOT for their assistance and coordination during the construction of this project. Finally, the team also appreciates the technical support for this report provided by C.W. Matthews Contracting, Inc. and the Arcadis design-build team.

CONTENTS

FIGURES

TABLES

ABBREVIATIONS AND SYMBOLS

AADT	annual average daily traffic
ARAN	Automatic Road Analyzer
dB(A)	A-weighted decibel
D-B	design-build
DOT	department of transportation
FHWA	Federal Highway Administration
GDOT	Georgia Department of Transportation
HfL	Highways for LIFE
HMA	hot-mix asphalt
Hz	hertz
IRI	International Roughness Index
NB	northbound
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
PBSE	prefabricated bridge substructure element
PCC	portland cement concrete
RCC	roller-compacted concrete
RFP	request for proposal
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SB	southbound
SI	sound intensity
SRTT	standard reference test tire
VOC	vehicle operating cost

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

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

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

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

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

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

Project Solicitation, Evaluation, and Selection

FHWA issued open solicitations for HfL project applications in fiscal years 2006, 2007, 2008, and 2009. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, and contacted applicants to discuss technical issues and obtain commitments on project issues. Documentation of these questions and comments was sent to applicants, who responded in writing.

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

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

HfL Project Performance Goals

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

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

- **Construction Congestion**
    - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
    - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
    - Queue length during construction—A moving queue length of less than 0.5 mile (mi) (0.8 kilometer (km)) in a rural area or less than 1.5 mi (2.4 km) in an urban area (in both cases at a travel speed 20 percent less than the posted speed).

- **Quality**
    - Smoothness—International Roughness Index (IRI) measurement of less than 48 inches per mile.

- Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

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

REPORT SCOPE AND ORGANIZATION

This report documents the Georgia Department of Transportation's (GDOT) demonstration project, which involved constructing a new interchange on Interstate 85 as only one part of a comprehensive economic development plan. The site is located in Troup County, GA, near the city of West Point. The report presents project details relevant to the HfL program, including innovative design-build (D-B) contracting which incorporated performance measures and incentives and disincentives, roller-compacted concrete (RCC), and prefabricated bridge components used to accelerate construction and produce a high-quality finished bridge over I-85. HfL performance metrics measurement, economic analysis, technology transfer activities that took place during the project, and lessons learned are also discussed.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

This project, which includes a new interchange on Interstate 85 in Troup County in west central Georgia, is the State's first to use prefabricated substructure elements and D-B contracting. The innovative contract also required the D-B contractor to propose state-of-the-art methods to achieve specified performance goals. Construction time was reduced, impact to traffic was minimized, and worker and work zone safety was increased with the use of prefabricated columns and pier caps, an innovative approach that had never been used in Georgia to construct a bridge substructure. Further project enhancements were realized with real-time speed band monitoring and D-B contracting procedures recently approved for use by the Georgia General Assembly. The use of prefabricated bridge elements and speed-band monitoring were specified in the contract.

The bridge was planned to provide access to I-85 for a Kia Motors manufacturing plant and training facility being built on an adjacent tract of land, which will generate thousands of daily auto and truck trips. This project, the cornerstone of a larger economic development plan for west central Georgia, is critical to implementing safe, convenient, and efficient access to the region.

HFL PERFORMANCE GOALS

Safety, construction congestion, quality, and user satisfaction data were collected before, during, or after construction to demonstrate that innovations can be deployed while simultaneously meeting the HfL performance goals in these areas.

- **Safety**
  - Work zone safety during construction—Only one motorist incident occurred in the I-85 construction zone. It resulted in minor vehicle damage, but no personal injury. The contractor cleared the incident in less than 20 minutes as required by the project goals.
  - Worker safety during construction—During construction, no worker injuries were reported. Postconstruction facility safety will be checked in the coming years.
  - Facility safety after construction—The post construction safety statistics indicate that the safety performance of the facility fell shortly in achieving the HfL goal of twenty percent reduction in injuries and fatalities. There were two fatal incidents after construction, while there was a 17 percent reduction in post construction injury rate.

- **Construction Congestion**
  - Faster construction—Conventional bridge construction using cast-in-place technology and traditional contracting methods would have had an estimated construction schedule spanning 30 months for this type of project. The innovative construction and contracting approach reduced the construction time to only 16.5 months, which, while

not fully satisfying the HfL goal of 50 percent reduction in impact to users, comes very close.

- Trip time—Speed on I-85 was checked with real-time speed band monitoring, which kept trip times through the work zone to a minimum. Conventional construction would have caused a 25 percent increase in trip time, well over the HfL10 percent limit.

- Queue length during construction—Some minimal queue lengths were observed during construction, but none that exceeded the 0.5 mi (0.8 km) maximum queue length or 20 percent reduction in travel speed below the posted speed as required by the HfL program goals.

- **Quality**
  - Smoothness and noise—The tire-pavement noise and smoothness quality indicators measured for the interchange showed that they were far higher than the set goals for the HfL program. Considering that the program goals were set for a typical pavement structure, however, this was not surprising. It is worthwhile to note that the smoothness goal was easily achieved for the other roadways constructed for this project (tire-pavement noise was not recorded for these pavements).
  - User satisfaction—The goal for this project was to achieve 80 percent or greater satisfaction with the methods used to minimize disruption during construction. Seventy-five percent of respondents surveyed during construction and that frequently use the highway reported they were very to somewhat satisfied with the approach used to construct the new facility. After the project was complete, the project exceeded the 80 percent performance goal with 91 percent very to somewhat satisfied with the new I-85 interchange. As part of the project, a broad communication effort was implemented to provide construction information to the public through news releases, direct mailings, and a project Web site. Respondents who received factsheets through the mail were more likely to have a positive response to the satisfaction survey at the end of the project.

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. GDOT supplied most of the cost figures for the as-built project. The cost assumptions for the traditional approach were determined from discussions with GDOT employees and national literature.

The economic analysis revealed that GDOT's approach realized a cost savings of about $1.98 million or 45 percent of the interchange cost if built with conventional construction practices.[1] A significant amount of the cost savings was from not building temporary pavement to handle detour traffic associated with conventional construction.

---

[1] These costs were estimated in consultation with GDOT engineers and from publicly available traffic data for Georgia highways.

LESSONS LEARNED

Overall, the bridge construction went smoothly, resulting in a quality project completed ahead of schedule and in nearly half the time needed for conventional construction methods. Working under a D-B delivery method brought about a GDOT paradigm shift in communication from the old way of sculpting a project with separate departments working independently to working as a team and conducting regular meetings (often onsite) among the D-B project managers, construction project managers, and D-B contractor. The focus had to change from solely a design perspective to ownership of each design element and an emphasis on overall project delivery. It was also important to assign well-defined roles and responsibilities to GDOT staff to facilitate efficient project administration. The bottom line was teamwork because the D-B process requires staff continuity from preconstruction to construction, and teamwork was the key to fostering acceptance of the new D-B concept. Moreover, utility coordination was much more efficient with the D-B method because of constant communication with all stakeholders.

Because this project plays a major role in the regional economic development plan, it involved the interests of many parties, which most certainly increased the complexity level. The Georgia Department of Economic Development helped simplify things by seeing to it that Kia Motors' needs were met as much as possible. A lesson for future D-B projects is that heavy third-party involvement should be kept to a minimum.

From the contractor's point of view, one issue to consider in future bridge projects is starting the approval process for prefabricated bridge elements well in advance of the scheduled delivery dates to allow the DOT extra time to review and approve "shop drawings" for the new components. At the beginning of the project, the contractor experienced delay in getting approval because it was the first time these elements were used in a GDOT project. The delay was more than compensated in the schedule by time saved in the erection process. Nevertheless, early approval of prefabricated bridge elements (or any new technology) on future projects will help to ensure the construction schedule stays on track. From GDOT's perspective, prefabricated elements, while used with success in this project's rural setting, may be best applied in urban locations in the future. The specified 0.25 in tolerance for precast elements was able to be achieved and provided for satisfactory field assembly of the elements.

Using RCC was good for quick installation of shoulders and was demonstrated on this project to be a timesaver. However, a smooth surface profile was difficult to obtain with RCC. As constructed, it was suitable for shoulder-type work, but not necessarily for high-speed traffic lanes. RCC had the added benefit of a slightly different color than the adjacent travel lanes, which increased the delineation between the shoulders and mainline pavement. GDOT gained experience with RCC through this project and learned that RCC will be good for specific applications on future projects.

Close observation of traffic volume via real-time speed band monitoring through the work zone led to changes in the original lane closure plan from traditional nonpeak hours in the evenings, nights, and weekends to a new schedule from 8 p.m. Sunday to Tuesday evening. The speed band monitoring allowed GDOT and the contractor to see in real time an increase in traffic volume during Sunday commuting, so the contractor moved the lane closures to later in the evening to ensure less disruption to work zone traffic.

Lessons learned in the wording of customer survey questions can be applied to large projects encompassing multiple construction activities or separate active projects in close proximity. The lesson is to be specific in asking about the level of satisfaction on the approach used to construct the project. It was determined during this project that the public associated the new Kia Motors plant construction with the I-85 interchange project and scored the 25 percent project completion survey questionnaire poorly on traffic impact, even though the interchange construction had not involved any lane closures by that point in the schedule. This had a negative effect on the survey results. After the survey question was reworded to specifically reference the I-85 interchange, later surveys generated more representative—and favorable—responses. Moreover, survey results should target frequent travelers through the work zone to get a true assessment of the construction's impact on travelers. Furthermore, the survey revealed that those respondents who were well informed by PR campaign of the project specifics were much more satisfied with the project results. The responses gave the project team a good idea of who the real stakeholders were in this project.

CONCLUSIONS

This project achieved a high level of quality and was brought to completion quickly and safely as a direct result of innovative contracting and construction methods. The success of this project will serve as a vehicle for GDOT to advance the integration of D-B contracting and the use of prefabricated substructure elements on future bridge projects. The innovations were validated as a result of the many experiences gained through this project and have been shown to be valuable tools for future GDOT projects.

PROJECT DETAILS

BACKGROUND

The new I-85 interchange project in Troup County, Georgia, was selected as a recipient of a $1 million Highways for LIFE grant. In addition, they also received a waiver of the State funding match requirement making this a 100 percent federally funded project. The entire project covers the new interchange, a second bridge over Long Cane Creek, more than 10 mi (16 km) of four-lane frontage and access roadways, plus all the lighting, signals, and drainage improvements necessary to construct such a large-scale development. The overall project construction cost is about $81 million, of which the I-85 interchange is just over $4.3 million.

This entire infrastructure plan is in support of the new Kia Motors manufacturing plant and training center (the first Kia Motors plant in the United States) being built on a 2,200-acre (890-hectare) site along the west side of I-85, starting from north of State Route 18 and extending up to Gabbettville Road in Troup County. The site will generate thousands of daily auto and truck trips, most using I-85 to and from the site vicinity. This project is therefore critical to implementing safe, convenient, and efficient access to the area. The general project location and proposed interchange site are shown in figure 1.

Figure 1. General project location.

PROJECT DESCRIPTION

The entire project was implemented under the D-B delivery method and the new I-85 interchange was built with innovative construction strategies centered on the use of prefabricated bridge substructure and superstructure elements. The interchange has a diamond-type configuration with four access ramps and a bridge that carries Kia Boulevard (formerly Gabbettville Road) over I-85. The bridge is a four- span concrete structure with eight columns per bent. Prefabricated elements make up the substructure's columns, pier caps, and deck beams. The elements were fabricated at the Hansen, Inc. casting facility in Pelham, AL. The contract was awarded to C.W. Matthews Contracting, Inc. and Arcadis D-B team. The following subsections highlight the innovative features of this project.

D-B Contracting

This was the State's first project using contract methods under the new Georgia law based on the GDOT State Transportation Board-adopted rule governing D-B procedures. The rule includes prequalification requirements, public advertisement procedures, scope of service requirements, letter of interest requirements, and request for proposal (RFP) requirements, which were used in determining a minimum of three and maximum of five qualified D-B firms. The D-B contract was awarded on a technical proposal and low-bid basis. This project reduced traditional construction scheduling from 30 months to 18 months through application of the D-B method with built-in contractor incentives and disincentives.

The D-B RFP special provisions included an innovative contracting approach requiring the D-B contractor to propose state-of-the-art methods to achieve specified performance goals, therein providing innovative recommended methods for monitoring and reporting various performance measures to achieve the HfL goals. Requiring the D-B contractor to propose these methods to achieve performance expectations is essentially performance-based contracting and a new approach for GDOT. This is a way of asking the industry to buy into the approach which gives them more flexibility to innovate.

GDOT required the contractor to define the performance measure methods as project deliverables tied to an incentive-disincentive approach, which is unique in Georgia. Execution is as enforceable as any other deliverable in the contract. Data reporting assessment will help determine the performance measures for GDOT's future construction contracts.

Prefabricated Elements

Several types of prefabricated elements helped make this project a success:[2]

- Prefabricated columns, pier caps, and prestressed concrete beams
- Mechanically stabilized earth wall panels
- Metal bridge deck forms
- Sign bridges

---

[2] "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

- Precast culverts
- Sound wall panels
- Steel grid bridge deck with partial- and full-depth concrete infill

The focus of this subsection is the innovative prefabricated bridge substructure elements (PBSE) and how they were used to expedite construction, improve safety, and provide a high-quality finished bridge. The project plans incorporate prefabricated bridge columns and pier caps to construct the intermediate bents for the bridge. This is the first time PBSE were used in Georgia and is part of the strategy to incorporate innovation into the design.

The bridge components were cast offsite in a controlled environment and shipped to the site via conventional semitrailers. During fabrication a high level of care was taken to cast each component to within a 0.25-inch (in) (6.35-millimeter (mm)) tolerance so connections made in the field would fit precisely.

To take delivery, the contractor closed one lane of I-85 and offloaded up to four columns and pier caps at a time. Lane closure was kept to a minimum, normally for 1.5 hours or less, and occurred during nonpeak traffic hours, minimizing impact to the traveling public. The columns were temporarily stored onsite after delivery. Two columns per day were set early in the project, then, as experience grew, up to four columns a day were placed. Column placement is shown in figure 2.

Figure 2. Placement of precast columns.

Column footings (figure 3) were cast in place ahead of time with protruding reinforcing steel (12 bars per footing) that fit into a specialized coupler on the bottom of the columns. A bed of portland cement-based, nonshrink, high early strength grout was placed on the footing to receive the column, and additional specialized grout supplied by the manufacturer was hand pumped into the coupler’s inlet holes. The coupler is designed as an emulation connection and in effect forms a nonthreaded butt splice between the longitudinal reinforcing steel in the column and the reinforcing steel in the footing.

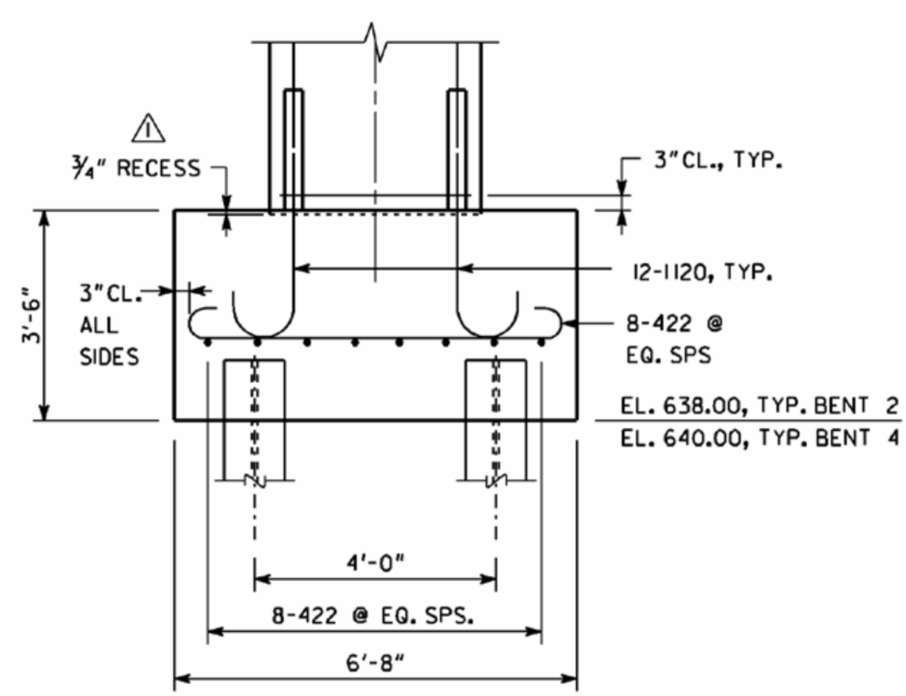


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 3. Footing detail.

Inside the coupler, the two ends of the rebars (about 12 in (304.8 mm) required for each rebar) come together and are surrounded by grout. The couplers are set in the column forms at the end of the main rebars during the precasting and embedded in concrete during the casting. The couplers have built-in tolerance of up to 0.5 in (12.7 mm) to accommodate rebar misalignment and to make field assembly between the substructure elements as quick and easy as possible. Figure 4 shows details of the coupler and figure 5 shows details of the column bar connection. Figure 6 provides details of typical intermediate bent construction and figure 7 shows details of a typical column.

Once the columns were set and checked for alignment with surveying equipment, the pier caps were placed on top of the columns in much the same way the columns were set on the foundations, except that the sockets in the pier cap had to simultaneously line up with reinforcing steel from two adjacent columns. At this point in assembling the elements, the 0.25-in (6.35-mm) tolerance became critical. Each intermediate bent has eight columns with four pier caps joining two columns each. Once the alignment was checked with the jig, the contractor was able to set one intermediate bent (four pier caps) in one day. Pier cap risers were cast in place to finish each intermediate bent (figure 9).

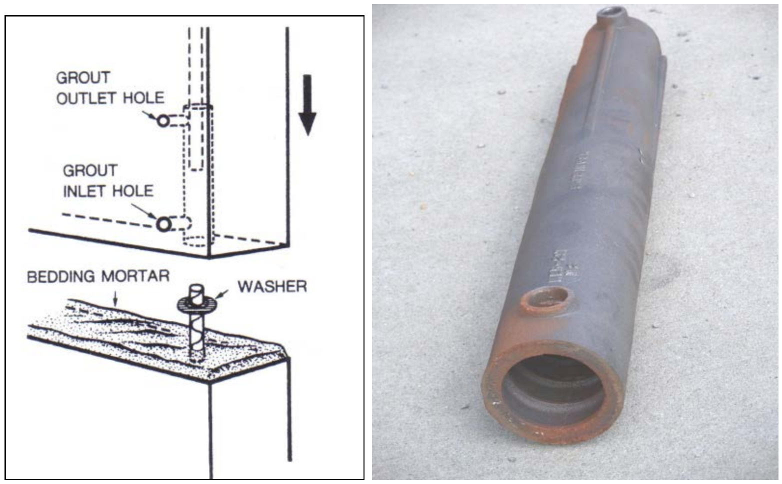


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 4. Coupler used to splice rebar to connect the footings, columns, and pier caps.

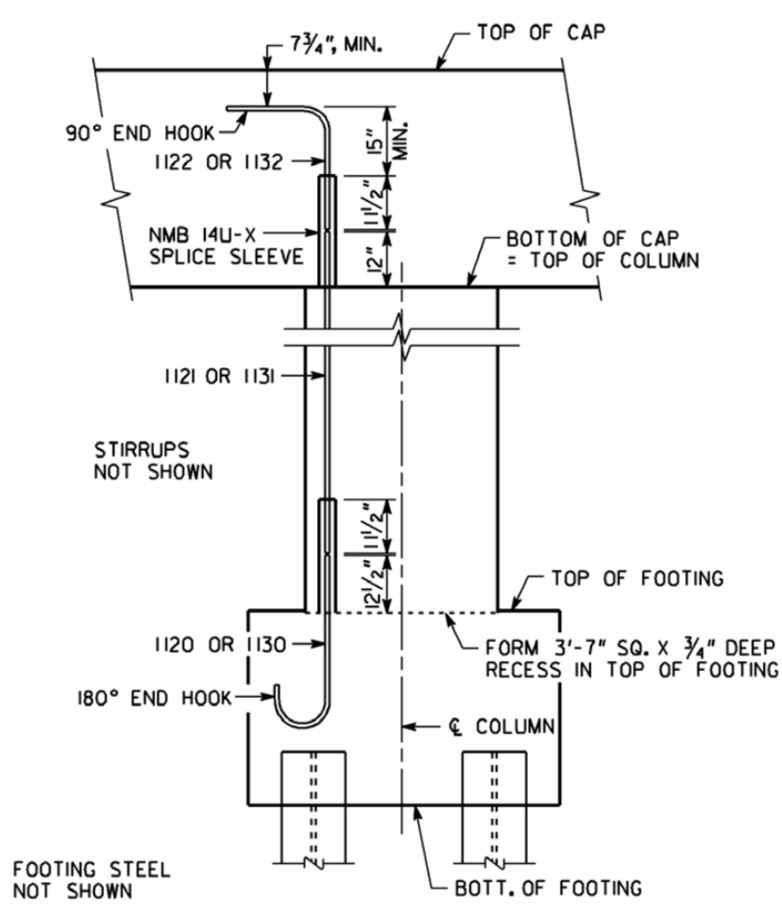


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 5. Column bar connection detail.

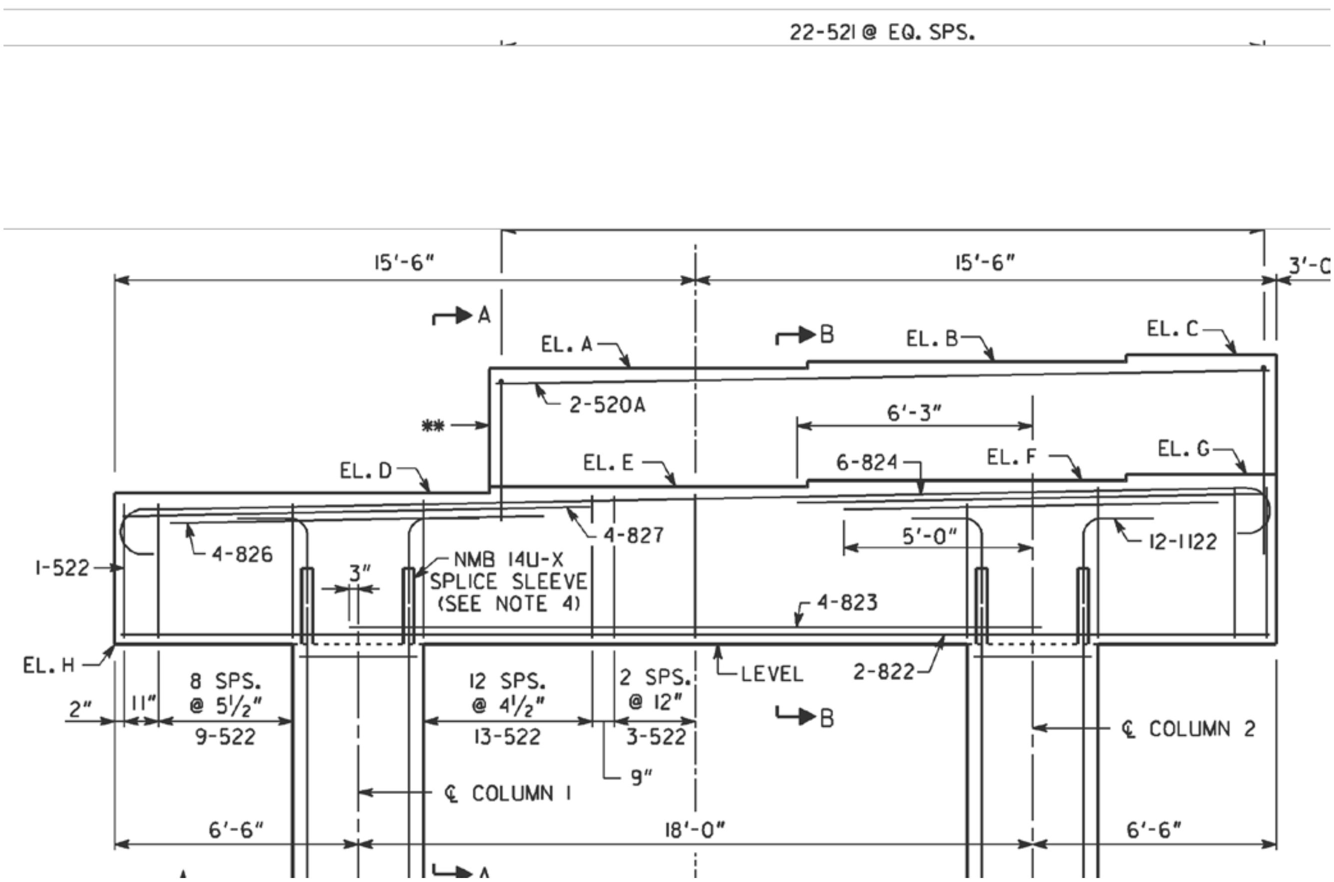


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 6. Typical intermediate bent detail.

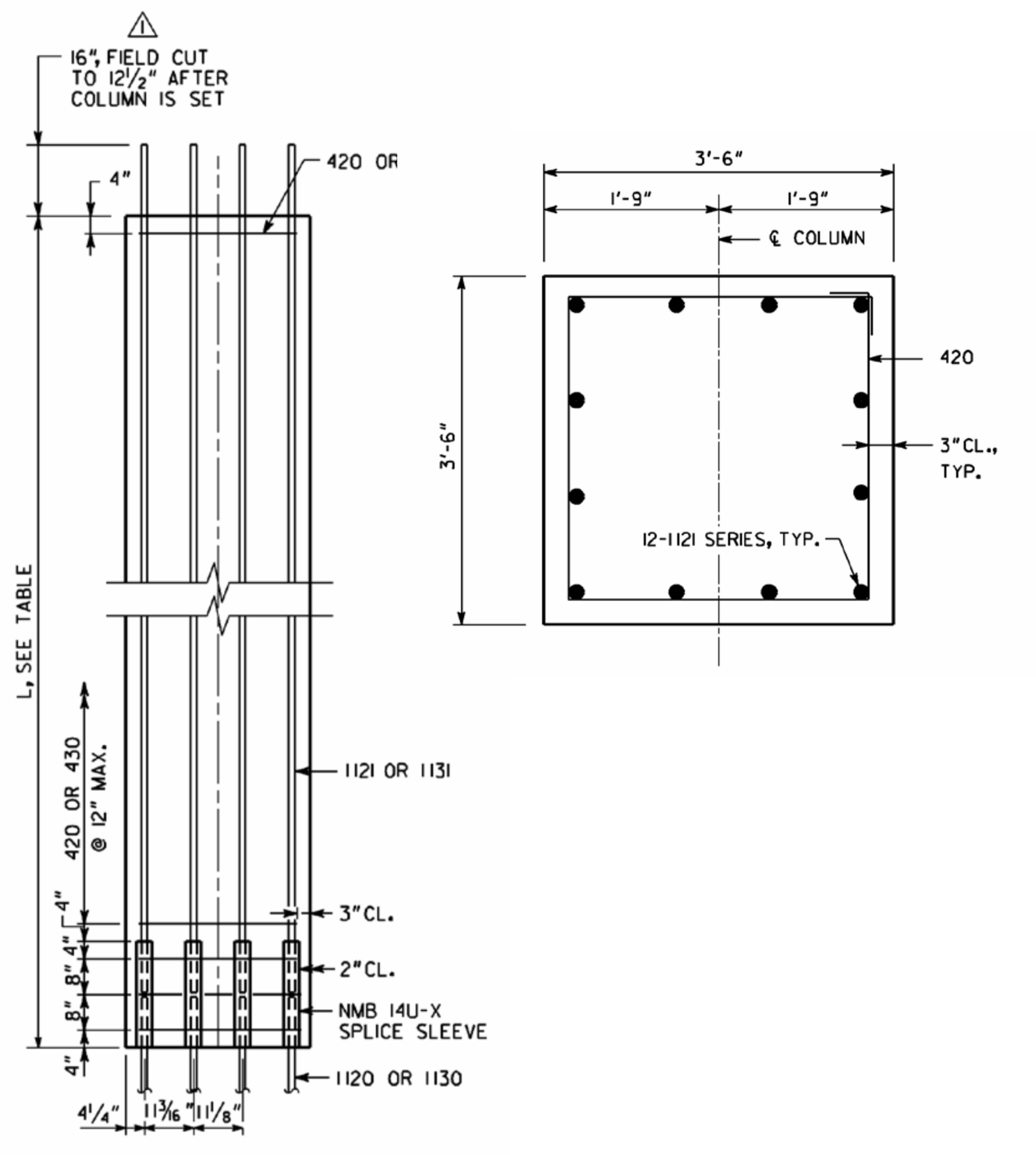


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 7. Column detail.

Similar connection was made between the top of the column and the pier cap. A steel jig was placed on top of the neighboring column as they were set to insure proper alignment (figure 8).

Figure 8. Workers check alignment of prefabricated columns with template.

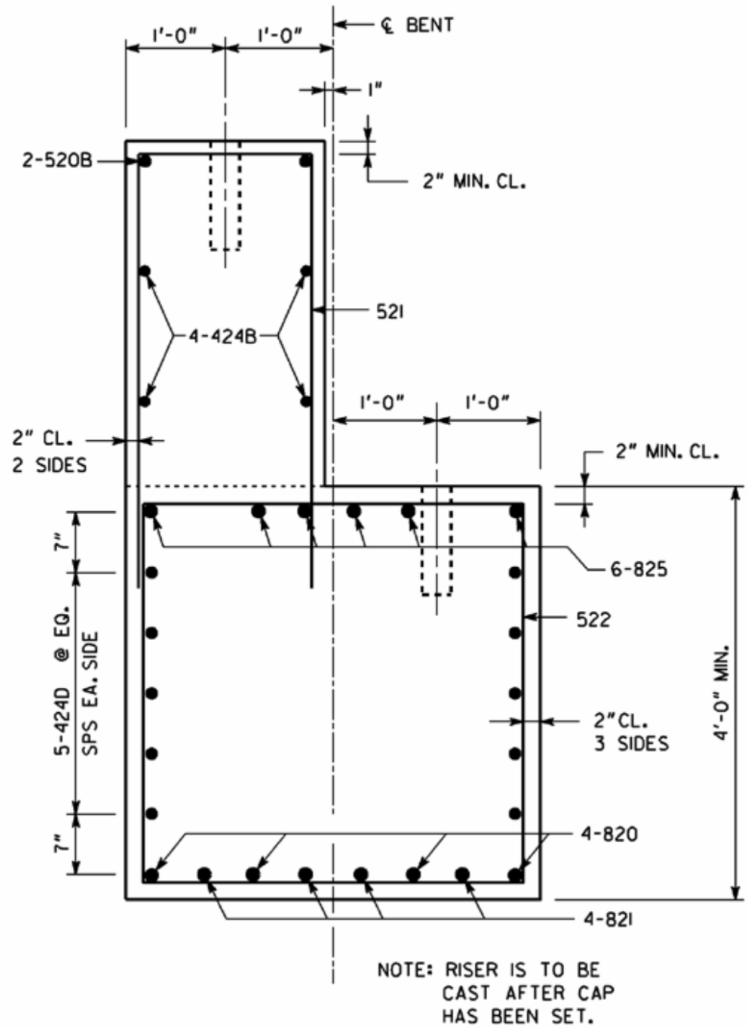


Image taken from "Prefabricated Bridge Elements" presentation, HfL Workshop, John Tiernan, Arcadis.

Figure 9. Pier cap detail.

After the intermediate bents were assembled, 130 ft long prestressed “bulb-I” bridge beams were installed. Beam delivery required the contractor to briefly close both lanes in either the NB or SB direction of I-85. Up to three beams were removed from the transport trucks and set into place using two cranes while the lane closure was in place. Disruption to I-85 traffic flow was kept to a minimum by using short-duration lane closures to briefly offload the beams during times of low traffic volume (as revealed through real-time speed band monitoring). Preset dowels in the pier caps protruding through elastomeric bearing pads provided fast alignment of the beams. Setting each beam usually took about 10 to 15 minutes, after which I-85 traffic was allowed to resume. Figure 10 shows the beam installation.

Figure 10. 130 ft long Prestressed “bulb-I” beam installation.

The real-time speed band monitoring program supplied key information on traffic speed and volume, enabling the contractor to choose the most effective time to implement lane closures to take delivery of the bridge elements. This valuable information was also used to schedule lane closures for finishing the bridge deck and paving portions of the ramps connecting to I-85.

Real-Time Speed Band Monitoring

Real-time speed band monitoring was included as part of the D-B contract. It was the first time a contractor was required to provide this service to GDOT. The objectives of the system were to provide advanced real-time traffic information to the traveling public and to provide real-time speed and volume data for evaluation.[3]

Traffic volume through the work zone was closely monitored with the system. Decisions on the times of the day and week best for lane closure were based on this information. This real-time input led to changes in the original lane closure plan from traditional nonpeak hours in the evenings, nights, and weekends to a new schedule of 8 p.m. Sunday and through Tuesday

[3] HfL showcase presentation, Dr. Prahlad Pant, PDP Associates.

evening. The contractor noted an increase in traffic volume during community activities on Sunday, which prompted rescheduling of the lane closures to later in the evening to ensure less disruption to work zone traffic.

Major components of the system include the folloring:[4]

- Portable dynamic message boards (figure 11)
- Solar-powered trailer with speed and traffic sensor stationed along the shoulder (figure 12)
- Sensors, radio communication, and modem
- Web site featuring a local highway map with hyperlink icons to traffic messaging (figure 13)
- Remote servers (personal computers) in Atlanta
- Software with intelligent algorithm at the heart of the system

Image taken from HfL showcase presentation, Dr. Prahlad Pant, PDP Associates.

Figure 11. Portable dynamic message boards.

Image taken from HfL showcase presentation, Dr. Prahlad Pant, PDP Associates.

Figure 12. Solar-powered trailer with speed and traffic sensor.

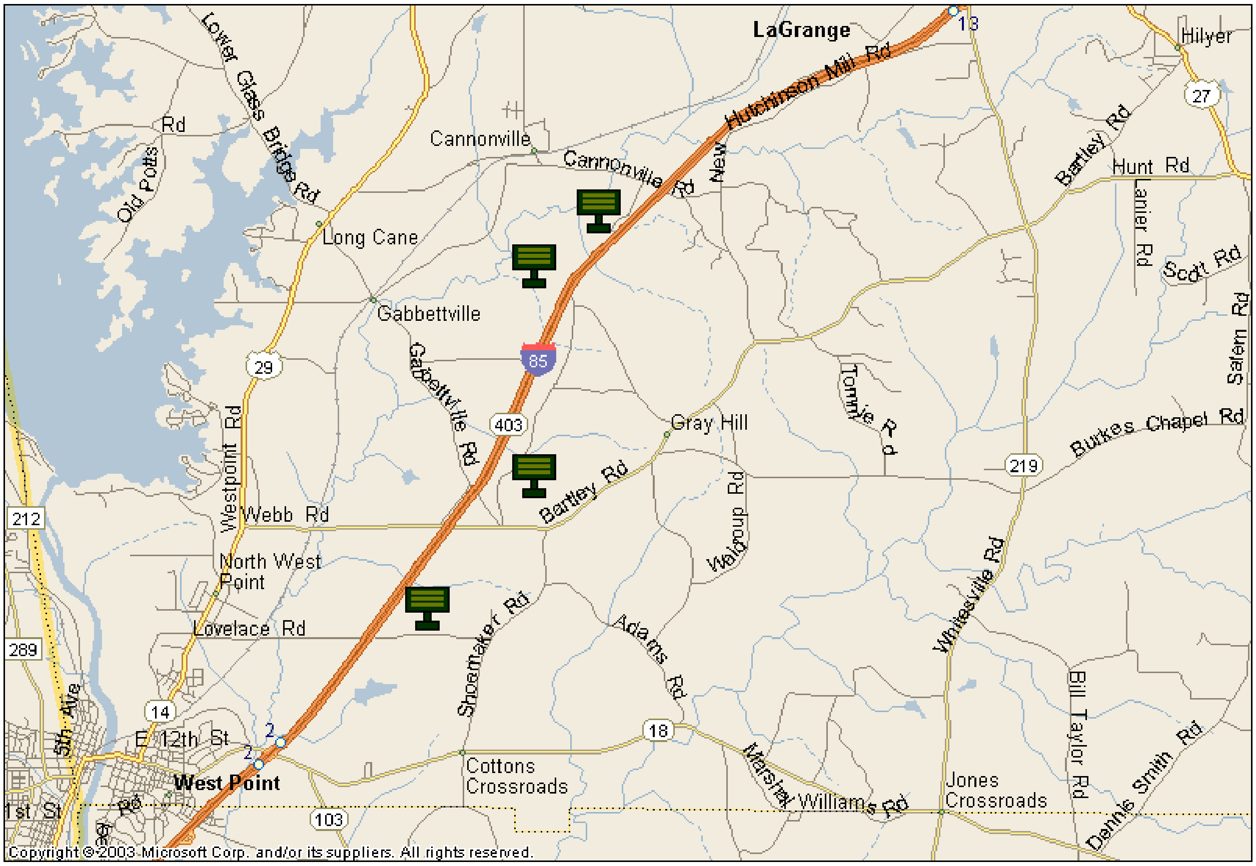


Image taken from HfL showcase presentation, Dr. Prahlad Pant, PDP Associates.

Figure 13. Web site display showing position of the message boards.

The system was able to successfully provide the following:[3]

- Real-time speed and volume data in an online spreadsheet for evaluation by the contractor and GDOT
- Remote control of the entire system through the Internet
- Remotely display customized messages on a network of dynamic message boards installed along I-85 to inform the traveling public of incidents or unexpected conditions

Roller-Compacted Concrete

The access ramp shoulders of the new interchange were paved with RCC. The finished color of the RCC is slightly different from the portland cement concrete (PCC) ramp travel lane, enhancing delineation and increasing roadway safety.

Using RCC was good for quick installation of the shoulders and was demonstrated on this project to be a timesaver. However, a smooth surface profile was difficult to obtain with RCC. As constructed, it was suitable for shoulder-type work, but not necessarily for high-speed traffic lanes.

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 GDOT project met the specific HfL performance goals related to these areas.

SAFETY

The crash data from the I-85 corridor (see table 1) shows many vehicular crashes resulting in 43 injuries and no fatalities within the project limits (mileposts 3 to 8) during the 3-year study period before construction. This is a significant numbers of crashes. To help keep all types of crashes to a minimum, concrete Jersey-type barriers were used instead of cones or barrels to permanently separate the traffic on I-85 from construction workers. For the first time, GDOT required the contractor to set these barriers along the I-85 shoulders within 6 months of the beginning of construction and maintain them until all final roadway features were installed (guardrail, striping, etc.) and construction equipment was removed at the end of the project. The post construction crash data from GDOT has been provided in table 2. The pre and post construction crash rates by severity type have been provided in table 3.

Table 1. Historical 3-year crash data.*

Year	Number of Crashes	Number of Vehicles	Number of Injuries	Number of Fatalities
2006	31	42	20	0
2007	21	29	14	0
2008	17	26	9	0
Total	69	97	43	0

*Data supplied by GDOT.

Table 2. Post construction crash data.*

Period	Fatalities	Injuries	Property Damage	ADT	VMT
2009	2	15	33	27690	297670
2010	0	16	28	28410	305410
2011	0	9	23	29720	319490
Total	2	40	84		

*Data supplied by GDOT.

Table 3. Pre and post construction crash rates.

	Preconstruction	Post construction	Difference
Days of Coverage	1095	1095	
Average ADT	26313	28607	
Section Length	10.75	10.75	
Million Vehicle Miles Travelled	309.7	336.7	
Total Crashes	0.36	0.37	3.4%
Fatalities	0.00	0.01	100.0%
Injuries	0.14	0.12	-16.9%
PDO	0.22	0.25	10.7%

As indicated in table 3, the total crashes increased marginally by 3.4 percent after construction; the injury rates decreased by 16.2 percent, while the property damage rates increased by 10.7 percent. There were two fatal events after construction. The post construction safety performance was close to the HfL goal of twenty percent reduction in fatalities and injuries.

This project was the first in which GDOT required the D-B contractor to provide the hardware, methods, and process to monitor speed bands during construction with the primary goal of improving work zone safety. Real-time monitoring enabled GDOT to evaluate daily reporting of traffic volumes and speeds through the construction zone.

As a result of the enhanced safety features included in this project, worker and motorist safety during construction exceeded the HfL performance goals. During construction, no worker injuries were reported, which means GDOT exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate). Only a single motorist incident occurred in the construction zone on I-85, resulting in minor vehicle damage and no personal injury.

CONSTRUCTION CONGESTION

Minimal queue lengths were observed during construction. To keep congestion down, GDOT required the contractor to prioritize work elements under the D-B delivery method, enabling the contractor to schedule the most efficient use of lane closures and lessen congestion. Additional methods used to limit congestion include the following:

- Restricting lane closures to 180 days in any given direction (NB or SB) and to a total of 270 days when overlapping work is done on both NB and SB lanes. The contractor realized its targets (SB took about 150 days to complete and NB took 120 days to complete).

- Restricting lane closures to offpeak times, typically 9 a.m. to 4 p.m. during the week and on weekends. The contractor had an option to close lanes after 7 p.m. on any day and up to 6 a.m. the following day on weekdays. However, a review of traffic data for this corridor indicated that starting work at 8 p.m. Sunday and working through Tuesday evening would have much less impact on the motoring public.

- An additional benefit of the contractor-installed speed band system was allowing GDOT to provide real-time traffic information on delays or incidents to the traveling public through remote dynamic message boards placed along I-85.

Finally, the project also required the contractor to provide methods for noninjury incident clearance time management. This included methods to reach a goal of clearing noninjury incidents from the construction zone travel lanes within 20 minutes. The one minor vehicle incident that did occur was promptly cleared in less than 20 minutes.

QUALITY

Pavement Test Sections

This is a unique HfL project in that the bridge construction did not replace an existing structure. Therefore, preconstruction test sections were chosen from the nearest interstate exit that represents typical in-service pavements. Interstate interchange ramps at Exit 13 and Exit 14 located just 6 mi (9.6 km) north were chosen for comparison with the postconstruction pavements of the new interchange on- and off-ramps for Exit 6. Exit 13 has an aged dense-graded asphalt surface and Exit 14 is transverse-tined concrete (figure 14). The new Kia Boulevard bridge deck and the off-ramp at Exit 6 both have a transverse-tined concrete surface, while the Exit 6 on-ramp is dense-graded asphalt (figure 15).

Figure 14. Comparison pavements (left to right): Exit 13 ramp and Exit 14 ramp.

Figure 15. Newly constructed pavement test sections (left to right): Kia Boulevard bridge deck, Exit 6 off-ramp, and Exit 6 on-ramp.

Sound Intensity Testing

Presently, GDOT does not use the onboard sound intensity (OBSI) test method on any projects. However, this method was used to collect tire-pavement sound intensity (SI) on the newly constructed pavements of this project and U.S. 27, Exit 13, and Exit 14 for comparison.

Sound intensity measurements were made by the National Center for Asphalt Technology personnel and equipment using the OBSI technique AASHTO TP 76-08, which uses dual vertical sound intensity probes and an ASTM-recommended standard reference test tire (SRTT). The sound measurements were recorded and analyzed using an onboard computer and data collection system. A minimum of three runs were made in the right wheelpath with two phase-matched microphone probes simultaneously capturing noise data from the leading and trailing tire-pavement contact areas. Figure 16 shows the dual probe instrumentation and the tread pattern of the SRTT.

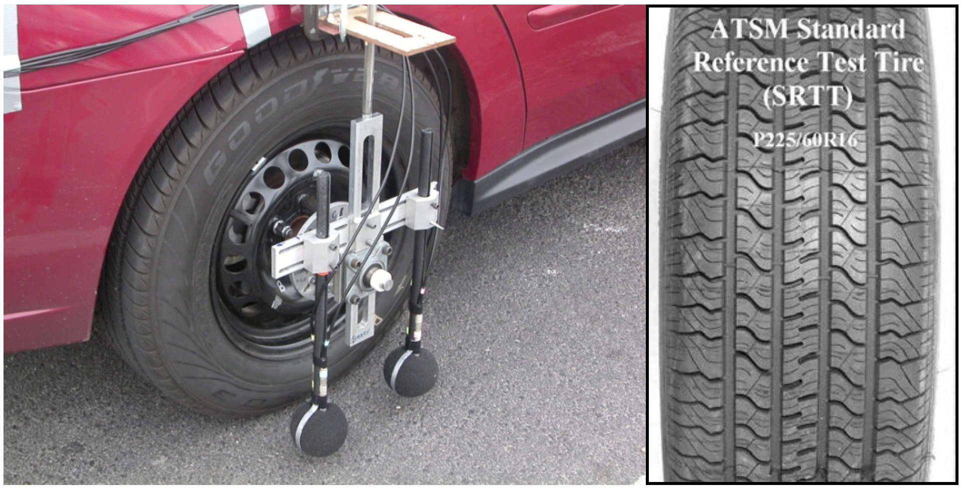
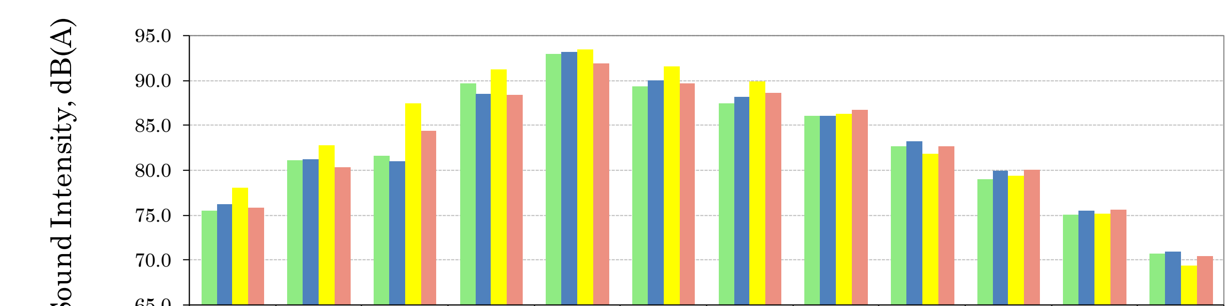


Figure 16. OBSI dual probe system and the SRTT.

The OBSI measurements were conducted at 45 miles per hour (mi/h) (72.4 kilometers per hour (km/h)). The average of the front and rear SI values was computed over the full length of the pavement sampled to produce SI values. Raw noise data are 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 sound intensity frequency spectra in one-third octave bands, as shown in figure 17 for the exit ramps and figure 18 for the Kia Boulevard bridge deck and U.S. 27.



	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
Exit 13 (HMA)	75.4	81.1	81.6	89.6	92.9	89.3	87.4	86.0	82.6	79.0	75.0	70.6
Exit 14 (PCC)	76.1	81.2	81	88.4	93.2	90	88.1	86	83.2	79.9	75.5	70.9
Exit 6 (HMA)	78.0	82.7	87.4	91.2	93.4	91.5	89.9	86.2	81.8	79.3	75.1	69.4
Exit 6 (PCC)	75.8	80.2	84.3	88.3	91.8	89.6	88.6	86.7	82.6	80.0	75.6	70.4

Figure 17. Mean A-weighted sound intensity frequency spectra for the exit ramps.

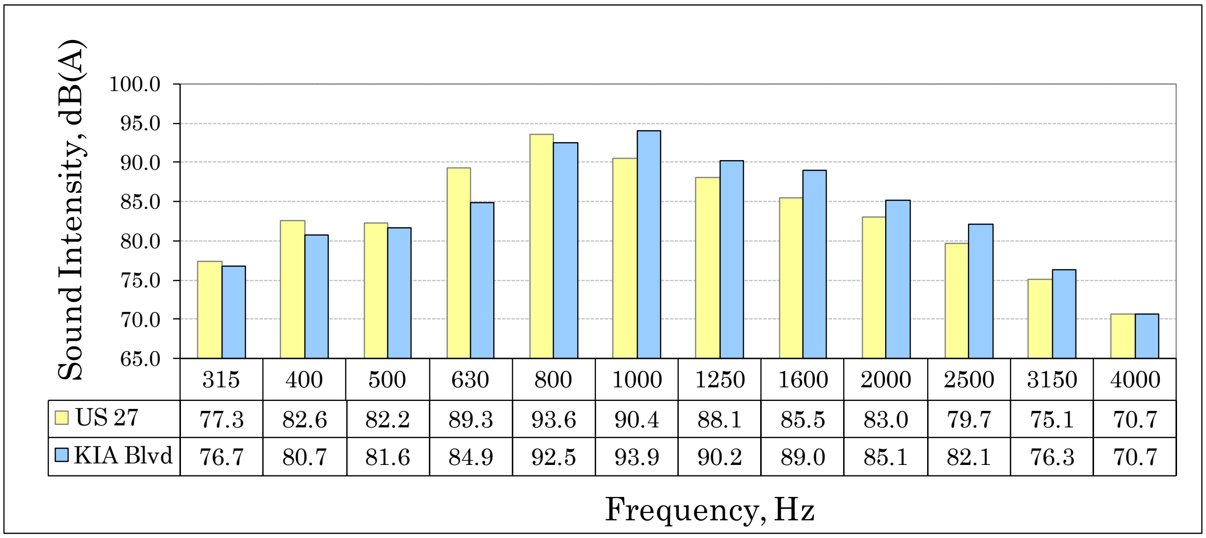


Figure 18. Mean A-weighted sound intensity frequency spectra for the Kia Boulevard bridge deck and U.S. 27.

The figures show that transverse-tined concrete pavement of Kia Boulevard has slightly higher decibel levels than the U.S. 27 pavement above about 1,000 hertz (Hz), which is typical of this type of surface texture. The ramps show generally similar spectra except for some variance in the lower frequencies.

Sound levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. The noise levels are presented in table 4. Overall, the sound levels among the existing and newly constructed pavements were very similar. However, the sound levels from the newly constructed ramps and bridge deck were slightly higher than the HfL goal (96.0 dB(A) or less) by a range of 1.0 to 2.7 dB(A). Note that the HfL goal of 96.0 dB(A) was intended for pavement surfaces, not elevated bridge decks. It is also noted that this goal is difficult to achieve on any concrete surface using current technology.

Table 4. OBSI summary.

Pavement Feature	Baseline* OBSI dB(A)	As-built OBSI dB(A)
Ramps (hot-mix asphalt (HMA) Surface)	97.2	98.7
Ramps (PCC surface)	97.4	97.0
Interchange (PCC Bridge Deck)	N/A	98.6

*Baseline ramp data taken from Exits 13 and 14.

Smoothness Measurement

Smoothness measurements on the test sections were collected by the Auburn University Automatic Road Analyzer (ARAN) van (figure 19). The ARAN is a high-speed inertial profiler able to perform roughness measurements of the pavement surface in both wheelpaths. Roughness is reported in inches per mile as recommended by the International Roughness Index (IRI) approach and consists of a mathematical assessment of the section profile aimed at quantifying the quality of the ride in a passenger car. The ARAN van performed three runs in each direction at a speed of 45 mi/h (72.4 km/h).

Figure 19. ARAN van.

The average of the left and right wheelpaths are calculated and presented in table 5.

Table 5. Mean roughness measurements.

Pavement Feature	Baseline* IRI (in/mile)	As-built IRI (in/mile)
Ramps (HMA Surface)	98	68
Ramps (PCC surface)	115	89
Interchange (PCC Bridge Deck)	N/A	77
*Baseline ramp data taken from Exits 13 and 14.		

Overall, the roughness values are lower for both the newly constructed asphalt and concrete pavements. However, the newly constructed bridge deck and ramp pavements did not reach the HfL goal of 48 inches per mile or less (43.8 inches per mile target value for this specific project). The contractor's testing of all other pavement sections of the project (excluding bridge deck and ramps) concluded that the project goal was indeed satisfied as reported by the project team and is included as following:[4]

[4] *Arcadis*, *HfL Performance Review*, West Point 85 Interchange Project.

The IRI for the West Point 85 Interchange ranges from 20.9 to 32.2 inches per mile, never exceeding the goal of a finished pavement smoothness of 43.8 inches per mile.

The IRI statistics above do not include smoothness data for concrete-paved facilities, such as shoulders, bridges, and ramps. Data for these facilities are reported as Profile Index. Georgia DOT uses a Rainhart-type profilograph with specifications for both overall smoothness and localized profile deviations (scallops) to determine initial smoothness. A Profile Index is determined from profilograms of pavements for every 0.25-mi (0.4-km) section of pavement. Vertical deviations exceeding 7 in (177.8 mm) on the mainline and 12 in (304.8 mm) on ramps were corrected. The finished Profile Index for all segments met these requirements.

Attention to pavement smoothness on this project contributed to the overall quality and durability of the West Point 85 Interchange.

USER SATISFACTION

Under the D-B contract, the contractor was required to involve the community and the traveling public through a public involvement and communications plan. Requiring the contractor to maintain communication is a new business practice for GDOT. The plan kept the public informed of the construction schedule through tactics such as the following:

- Online information
- News releases and mailings
- Local signage
- Construction information hotline

These communication efforts had a positive impact on the user satisfaction as indicated by the survey results. During construction and upon completion of the project, the contractor conducted four Likert scale user satisfaction surveys (at 25, 50, 75, and 100 percent of project completion). The approval rating goal was set at 80 percent or better (i.e., 80 percent of the surveyed customers approve of the job being done in the construction work zone). The remainder of this subsection is taken from *Arcadis, HfL Performance Review*.[5]

The project team successfully measured the level of user satisfaction by completing surveys via telephone interviews. An internal team goal of 300 respondents per round of surveys was established to obtain adequate statistical reliability and allow for breakouts in cross-tabulations. The target audience for the surveys included the following:

- Half were constituents living in a 3-mi (4.8-km) radius of the construction.
- The remaining 50 percent were taken from a random sample of constituents purchased by the surveyor who lived in West Point and Troup County, GA, and Lanett and Valley, AL.
- All respondents were age 18-plus and could drive.
- There was a 50-50 mix of males and females.
- GDOT employees were excluded.

At the 100 percent completion point for the project, respondents were asked to indicate their level of satisfaction with the new facility. At the 25, 50, 75, and 100 percent completion points for the project, respondents were asked to indicate their level of satisfaction with the approach used to construct the new facility in terms of minimizing disruption.

The level of user satisfaction was determined for all respondents. However, survey results showed that a large group of neutral respondents emerged for each survey. It was determined from cross-tabulation of the data that these respondents tended to be infrequent travelers into the construction area. Therefore, to get a better idea of actual user satisfaction, the project team also determined the level of satisfaction for non-neutral respondents who expressed an opinion during the survey. This group included those who were very satisfied, somewhat satisfied, somewhat dissatisfied, and not at all satisfied. The survey results for both non-neutral respondents and all respondents are provided in table 6.

Table 6. User satisfaction summary.

	% Very/Somewhat Satisfied With New Facility	**% Very/Somewhat Satisfied With Construction** (*average of all four surveys*)
Nonneutral Respondents	91%	75%
All Respondents	78%	49%

As table 6 shows, 91 percent of non-neutral respondents were very to somewhat satisfied with the new I-85 facility overall, and 78 percent of **all respondents** were very to somewhat satisfied. **Only 8 percent of all respondents indicated dissatisfaction (somewhat to very dissatisfied***)*. On average, over the four surveys, 75 percent of **non-neutral respondents** were very to somewhat satisfied with construction activities in terms of minimizing traffic delays. Forty-nine percent of **all respondents** were very to somewhat satisfied, and only 16.5 percent of **all respondents** were somewhat to very dissatisfied.

In addition, using cross-tabulations in the data, the project team determined that satisfaction levels among respondents increased with a respondent's frequency of travel through the construction zone. **This is a key indicator of project success.**

Strategies implemented by the project team to alleviate traffic congestion and improve work zone safety likely contributed to the level of user satisfaction. Other influencing factors include the following:

- **Other construction activities**: During the survey, considerable construction activity was occurring at the Kia Motors plant and on surrounding portions of I-85, which may have been confused with construction activities for the new I-85 interchange. This possibility is clearly seen in the results of the first survey (at the 25 percent project completion point). Almost 18 percent of the respondents expressed dissatisfaction with construction efforts in terms of delays experienced. However, no lane closures were implemented for this project until after the 25 percent complete survey was administered.

- **Survey question clarification**: The survey question asked at the 25 percent point did not specify construction activity along I-85. This was corrected for subsequent surveys. Specifically, the question changed from “How satisfied are you to date with the approach used to construct the new I-85 interchange near the Kia Motors plant in Troup County in terms of minimizing disruption?” to “How satisfied are you to date with the approach used to construct the new I-85 interchange near the Kia Motors plant in Troup County in terms of minimizing disruption to you on the new interchange and on I-85?”

- **Communication activities**: Communication activities (including news releases, postcard mailers, and the project Web site) likely called attention to construction activity in the area, regardless of the location of these activities. Communication efforts appear to have had a positive influence on user satisfaction and survey results as well. Respondents included in the project database for information dissemination activities (received postcard mailer and factsheet on construction activities), especially at the 50 percent complete point, were more likely to have an opinion and be satisfied with construction efforts.

- **Neutral responses**: A large group of respondents for each survey had a neutral opinion, and many respondents may not have encountered construction, particularly those who live outside the immediate area.

TECHNOLOGY TRANSFER

Bridge construction, traffic congestion, and safety were the focus of a demonstration showcase on May 1, 2008, in LaGrange, GA. Officials from GDOT and FHWA's Georgia Division and HfL team developed and implemented a technology transfer plan that included a showcase with a field demonstration on installation of the prefabricated bridge elements. The showcase agenda and speakers list are in the Appendix.

About 50 participants attended the showcase, which featured presentations by representatives of GDOT, FHWA, and the D-B contractor. GDOT Secretary of State Karen Handel discussed the project with the attendees. GDOT Commission GDOT Commissioner Gena Abraham (figure 20) and GDOT Deputy Commissioner Buddy Gratton welcomed the audience. Thomas Howell of GDOT introduced the speakers. Rodney Barry of the FHWA Georgia Division (figure 21) gave an overview of the HfL program and goals. Darryl VanMeter of GDOT provided a project description and overview on the need for the new interchange, multiple agency involvement, D-B procurement, coordination with Kia Motors, and the HfL application process GDOT (figure 22). Lamar Pruitt, also of GDOT, presented an overview of construction, covering topics related to the awarded contractor, HfL performance goals, and coordination between GDOT and the contractor (figure 23).

Figure 20. GDOT Commissioner Gena Abraham.

Figure 21. FHWA Georgia Division Administrator Rodney Barry.

Figure 22. Darryl VanMeter of GDOT addressing the audience.

Figure 23. Lamar Pruitt of GDOT presenting construction overview.

Brandy McDow of Arcadis explained the results of the survey conducted after 25 percent of the project was completed. Bill Holle of C.W. Matthews presented the goals and plans to safely minimize traffic congestion along I-85.

Details on the automated portable real-time speed advisory and reporting system were presented by Dr. Prahlad Pant of PDP Associates (figure 24). Pant provided an overview of the system and details of the major components. Those components range from speed and volume sensors to the dynamic message boards installed along I-85 used to provide construction zone information to the traveling public and valuable data to GDOT and the contractor to guide the timing of lane closures to minimize traffic interruptions.

Figure 24. Prahlad Pant discussing the real-time speed advisory and reporting system.

John Tiernan of Arcadis presented the use of prefabricated bridge elements to achieve the goals of reducing I-85 traffic delays, increasing safety, and providing economic benefits to the contractor. He outlined construction details on the prefabricated substructure elements and connection method and gave particulars on the splicing hardware used to make the connections between elements. After the presentations, Marc Mastronardi of GDOT fielded questions.

The attendees traveled to the construction site to observe firsthand the prefabricated bridge elements being set. After the site visit, a question-and-answer panel discussion was conducted back at the showcase conference center. To close the showcase, VanMeter discussed lessons learned from the project so far and the potential for future HfL projects.

The showcase demonstrated to the attendees that this type of construction using prefabricated bridge elements was feasible and provided significant advantages in reducing total construction time and negative impacts to traffic while at the same time providing a high quality project. Observing these innovations being used successfully added confidence to other state agency and contractor attendees to try them on other projects. The showcase also reinforced with GADOT attendees the ability expand the use of these technologies.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This entails comparing the benefits and costs associated with the innovative project delivery approach adopted on an HfL project with those from a more traditional delivery approach 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, GDOT supplied most of the cost figures for the as-built project. The assumptions for the baseline case costs were determined from discussions with GDOT and national literature.

CONSTRUCTION TIME

The project had an original construction schedule of 18 months, and GDOT reported that construction was completed in 16.5 months. Traditional contracting and construction would have taken 30 months for this type of project. Therefore, the project was completed in nearly half the time needed for traditional methods. The remarkable time savings are credited to the use of D-B contracting, which incorporated incentives and disincentives, and the use of prefabricated bridge elements allowing rapid assembly of the I-85 bridge substructure. In fact, the D-B delivery method and other innovations played a major role in advancing the construction schedule 6 weeks ahead of the already-condensed 18-month construction schedule.

CONSTRUCTION COSTS

Table 7 presents the differences in construction costs between the baseline and the as-built alternatives. All of the as-built cost estimates were provided by GDOT. Baseline cost was determined in consultation with GDOT engineering staff by (1) noting whether the itemized costs in the as-built cost table would have applied to the baseline case, (2) adjusting cost categories and costs as necessary, and (3) itemizing other costs associated with the baseline case that may not have been required for the as-built case. Therefore, the baseline cost estimate is inexact and the information presented is a most probable cost differential rather than a rigorous computation of a cost differential. Several other assumptions were made in selecting significant cost factors and determining some unit costs, as noted in table 7.

It can be estimated from table 7 that the adoption of the HfL innovations (as-built scenario) to build the I-85 interchange bridge resulted in a cost savings of $672,716 ($5,104,192 - $4,431,476) when compared with the baseline scenario.

Note: In table 7, as indicated, only the cost of the interchange bridge was considered in the cost analysis for the as-built case. The costs of the ramps and connecting roadway were not considered in the comparison.

Table 7. Capital cost calculation table.

Cost Category	Baseline Case	As-Built Case (D-B)
Design and Engineering[1]	$ 108,698	$ 110,390
Interchange Bridge Construction		
Construction Inspection[2]	$ 39,885	$ 42,770
Worker Training	$ 495	$ 503
I-85 Interchange Bridge	$ 3,988,526	$ 4,227,026
Law Enforcement[3]	$ 1,429	$ 786
Temporary Pavement[4]	$ 956,158	$ --
Total I-85 Interchange Bridge Costs[5]	**$ 5,104,192**	**$ 4,431,476**
Contract Incentives[6]	$ --	$ 380,000[7]
Other Construction Items	$ 71,440,420	$ 76,391,635
Total Cost[8]	**$ 76,544,612**	**$ 81,203,111**

Notes:
[1] Assumed to include quality assurance program costs as 1 percent of the construction cost, according to GDOT. Costs shown are from the actual contract bid and prorated for the I-85 interchange portion of the entire project.
[2] Costs are prorated.
[3] Cost to date for the as-built case and prorated for the baseline case.
[4] Estimated cost of constructing a temporary detour lane through the work zone in both directions of I-85. See table 8 for itemized cost estimate.
[5] These costs do not include the costs of the ramps and the connecting roadway that would constitute an "interchange
[6] Incentive collected for completing the entire project ahead of the planned 18-month schedule.
[7] Since the incentives were tied to the overall goals of this economic development project (i.e., speedy delivery) and were not specifically related to the construction of the I-85 Interchange, they have only been included as costs in the "Other Construction Items" category and not as cost of the I-85 Interchange construction portion of the project.
[8] As-built cost to date.

USER COSTS

Generally, three categories of user costs are used in an economic life-cycle cost analysis: vehicle operating costs (VOC), delay costs, and safety-related costs. However, considering that extensive detouring was not necessary for this project, VOC between the as-built and baseline cases was ignored. Therefore, only the differentials in the delay costs and safety costs were considered in the user cost analysis. The user cost impacts for I-85 were analyzed.

Table 8. Temporary detour pavement itemized cost estimate.

Item	Quantity	Cost	Amount
Temporary HMA pavement	6,969 tons	$ 90/ton	$ 627,210
Temporary pavement base	4,435 tons	$ 20/ton	$ 88,700
Temporary striping (wet reflective tape)	15,840 l.f.	$ 4/l.f.	$ 63,360
1.5 in mill surface of two mainline lanes	14,080 yd^2	$ 5/yd^2	$ 70,400
1.5 in HMA overlay on two mainline lanes	1,160 tons	$ 90/ton	$ 104,400
Final striping (polyurea)	15,840 l.f.	$ 0.70/l.f.	$ 11,088
		Total	$ 956,158

Note: Temporary lane assumed to be 2,640 ft x 12 ft, both directions of I-85.

Delay Costs

The traffic impact for the baseline case is based on maintaining each direction of I-85 traffic on the inside lane and an assumed temporary lane built on the inside shoulder (see table 7 for assumption) through about 0.5 mi (0.8 km) of work zone. This would allow the contractor to shift traffic from overhead construction activities. During this time, delivery of bridge substructure elements and all overhead cast-in-place construction would have taken place. Delay costs would have been impacted because traffic maintenance would have been in effect for the entire bridge construction duration in both directions of I-85. The following baseline information was available for I-85:

- Based on 2005 data taken from GDOT Web-based resources, the annual average daily traffic (AADT) on I-85 is 24,900 and the truck traffic is 8 percent.
- During construction the speed limit would be reduced from 70 to 50 mi/h (112.6 to 80.4 km/h). Reducing the speed limit through an approximate 0.5-mi (0.8-km) work zone would cause travel time to increase about 20.0 seconds or 69.2 hours per day of total vehicle time for NB and SB traffic.
- The estimated user cost of the delay costs amounts to $1,356 a day ($40,680 a month). These costs were based on costs of $14.60 an hour per private vehicle and $77.10 an hour per commercial truck.
- It was assumed that oversized loads on I-85 traffic would be diverted to detour roads if traditional traffic maintenance techniques were used. However, for simplicity the delay from detours is not included in the cost analysis.

Therefore, the delay cost was reduced from $1,220,400 (30 months x $40,680 a month) expected for the baseline scenario to $671,220 (16.5 months x $40,680 a month) for the as-built scenario. This reduction is based on reducing the construction schedule from 30 months (baseline construction schedule) to 16.5 months (as-built construction schedule). The net savings are therefore $549,180.

Safety Costs

As discussed earlier in this report, many crashes have occurred on this section of I-85 over the past years. Table 1 lists the number of 3-year vehicular crash rates for this section of highway as 69 total crashes. Forty-three crashes involve injuries and 26 are assumed to involve only property damage. Given the 2005 AADT of 24,900, this translates to the following injury and crash rates:

- Injury-causing crash rate: 1.57 injuries per million vehicles traveled.
- Noninjury crash rate: 0.95 per million vehicles traveled.

Ullman et al[5] investigated the safety of work zones for various scenarios: (1) crashes during daytime and nighttime work periods when lanes were closed and work was ongoing, (2) crashes when work was ongoing but no closures were required, and (3) crashes when no work was ongoing (the work zone was inactive). They concluded that crashes increased 60 to 66 percent (an average of 63 percent) when a traffic lane was closed day or night. Given this information and considering the traffic volumes and hourly traffic variations on this highway and the

---

[5] Ullman, G.L., M.D. Finley, J.E. Bryden, R. Srinivasan, and F.M. Council, *Traffic Safety Evaluation of Nighttime and Daytime Work Zones* (NCHRP Report 627), National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 2008.

expected construction schedules, table 9 presents the number of vehicles that would have passed through the work zone for the as-built and baseline projects.

Table 9. Estimated total traffic on I-85 used to compute safety impacts for baseline and as-built scenarios.

	Baseline Case		**As-Built Case**	
	Northbound	**Southbound**	**Northbound**	**Southbound**
Two-way AADT, vehicles/day	24,900	24,900	24,900	24,900
Directional traffic distribution factor (per GDOT data)	0.50	0.50	0.50	0.50
Fraction of AADT affected in a 24-hour period (per GDOT data)	0.63 (daytime construction assumed)	0.65 (daytime construction assumed)	0.37 (nighttime and weekend work)	0.35 (nighttime and weekend work)
Total number of construction days	450 (assumed)	450 (assumed)	120	150
Total Traffic Volume (millions) (2-way AADT x Directional Factor x 24-hour traffic fraction * Construction days)	**3.52**	**3.61**	**0.55**	**0.66**

Table 9 shows that the total volume of traffic exposed to crash risk was much lower for the as-built case than the baseline case. The faster construction and work schedules when traffic volumes are lower (nights and weekends) and other safety measures adopted by GDOT on this project resulted in only one non-injury-causing motorist incident in the work zone on I-85.

The estimated increase in crashes for the baseline case can be computed as the product of (1) the historical crash rate for each type of crash (number of crashes per million vehicles), (2) the total volume of traffic exposed to the risk, and (3) the risk escalation factor associated with work zones (= 0.63 as discussed earlier). This is computed for the NB and SB lanes for the baseline case as follows:

- I-85 NB lanes (baseline case)
  - Estimated personal injury-causing crashes due to work zone:

= Total traffic volume (million vehicles) * Crash rate (number/million vehicles) * risk escalation factor due to work zone
= 3.52 * 1.57 * 0.63 = 3.48 crashes

  - Estimated non-personal injury-causing crashes due to work zone:

= Total traffic volume (million vehicles) * Crash rate (number/million vehicles) * risk escalation factor due to work zone
= 3.52 * 0.95* 0.63 = 2.10 crashes

- I-85 SB lanes (baseline case)
  - Estimated personal injury-causing crashes due to work zone in I-85 SB lanes for the baseline case:

= Total traffic volume (million vehicles) * Crash rate (number/million vehicles) * risk escalation factor due to work zone
= 3.61 * 1.57 * 0.63 = 3.57 crashes

- Estimated nonpersonal injury-causing crashes due to work zone in I-85 SB lanes for the baseline case:

= Total traffic volume (million vehicles) * Crash rate (number/million vehicles) * risk escalation factor due to work zone

= 3.61 * 0.95* 0.63 = 2.16 crashes

The elevated risk noted above was monetized by assuming unit costs for the various types of historical crashes reported by GDOT from Council et al.[6] The following mean comprehensive costs per crash for a rural highway with a posted traffic speed greater than or equal to 50 mi/h (80.4 km/h) were used in the analysis:

- Injury-causing crash–$95,368 (injured, severity unknown, Level 5).
- Non-injury crash–$25,735 (nature of crash unknown, Level 5)

Table 10 presents the difference in safety costs for the baseline and as-built cases. It can be computed from the table that the total expected safety costs for the baseline case would have been $781,977 ($385,925 + 396,052) as opposed to the $25,735 for the as-built case. The expected cost differential between the two scenarios is therefore $756,242, which is essentially the safety benefit of the as-built case.

Table 10. Comparison of safety costs—baseline versus as-built.

	Baseline Case		**As-Built Case**	
	Northbound	**Southbound**	**Northbound**	**Southbound**
Personal injury-causing crashes (= Crash cost ($/crash) X Number of crashes)	$331,881 (= $95,368*3.48)	$340,464 (= $95,368*3.57)	$0 (No crashes)	$0 (No crashes)
Nonpersonal injury crashes	$54,044 (= $25,735*2.10)	$55,588 (= $25,735*2.16)	$25,735 (= $25,735*1)	$0 (No crashes)
Total Traffic Volume (millions) (2-way AADT x Directional Factor x 24-hour traffic fraction * Construction days)	**$385,925**	**$396,052**	**$25,735**	**$0**

COST SUMMARY

Construction costs for the I-85 interchange bridge would have likely placed traditional delivery and construction methods (baseline) at $672,716 more than the as-built case. Moreover, delivering the project in only 16.5 months saved I-85 users $549,180 in delay costs and $756,242 in safety costs. Therefore, the estimated total savings from using the innovative HfL project delivery approach are $1.98 million. In other words, the innovative approach to this $4.43 million interchange project had a 45 percent cost benefit over traditional methods.

---

[6] These costs were based on F. Council, E. Zaloshnja, T. Miller, and B. Persaud, *Crash Cost Estimates by Maximum Police-Reported Injury Severity Within Selected Crash Geometries* (FHWA-HRT-05-051), Federal Highway Administration, Washington, DC, October 2005.

APPENDIX

Showcase Agenda: May 1, 2008

9:30–10:30 a.m.	Call to order, introductions–Thomas Howell, GDOT–5 minutes Welcome–Gena Abraham, Commissioner, GDOT–10 minutes Highways for LIFE program overview–Rodney Barry, FHWA Georgia Division–15 minutes Project overview and innovative delivery–Darryl VanMeter, GDOT– 5 minutes Construction–Lamar Pruitt, GDOT–15 minutes
10:30–10:45 a.m.	Break
10:45 a.m.–Noon	Public involvement process during construction–Brandy McDow, Arcadis–15 minutes Congestion minimization–Bill Holle, C.W. Matthews–10 minutes Speed band monitoring–Dr. Prahlad Pant, PDP Associates–15 minutes Prefabricated bridge elements–John Tiernan, Arcadis–10 minutes Open Q&A–Marc Mastronardi, GDOT, moderator–15 minutes
Noon–1 p.m.	Lunch
1–2:30 p.m.	Travel to the I-85/CR 98 Gabbettville construction site–30 minutes Observe erection of prefabricated elements–30 minutes Q&A with field staff–30 minutes
2:30–3:30 p.m.	Return to conference center–30 minutes Review lessons learned and closing–Q&A panel discussion, all presenters–30 minutes

Showcase Speakers List

Rodney N. Barry
FHWA Georgia Division
61 Forsyth St. SW, Suite 17T100
Atlanta, GA 30303
Phone: (404) 562-3630, fax: (404) 562-3703, e-mail: rodney.barry@fhwa.dot.gov

Buddy Gratton
GDOT
2 Capitol Square, Room 356
Atlanta, GA 30334
Phone: (404) 656-5267, e-mail: bgratton@dot.ga.gov

Bill Holle
C.W. Matthews
PO Drawer 970
Marietta, GA 30061

Phone: (770) 422-7520, e-mail: wholle@cwmatthews.com

Thomas Howell
GDOT
115 Transportation Blvd.
Thomaston, GA 30286
Phone: (706) 646-6900, fax: (706) 646-6713, e-mail: thowell@dot.ga.gov

Marc Mastronardi
GDOT
2 Capitol Square, Room 356
Atlanta, GA 30334
Phone: (404) 656-5306, e-mail: mmastronardi@dot.ga.gov

Brandy McDow
ARCADIS
2849 Paces Ferry Road, Suite 400
Atlanta, GA 30339
Phone: (770) 431-8666, fax: (770) 435-2666, e-mail: brandy.mcdow@arcadis-us.com

Prahlad D. Pant, Ph.D.
PDP Associates, Inc.
PO Box 888264
Atlanta, GA 30356
Phone: (770) 352-0880, fax: (770) 352-0881, e-mail: pant@pdpassociates.com

Lamar M. Pruitt, Jr.
GDOT
115 Transportation Blvd.
Thomaston, GA 30286
Phone: (706) 646-6911, fax: (706) 646-6716, e-mail: lpruitt@dot.ga.gov

John Tiernan
ARCADIS
2849 Paces Ferry Road, Suite 400
Atlanta, GA 30339
Phone: (770) 431-8666, fax: (770) 435-2666, e-mail: jtiernan@arcadis-us.com

Darryl VanMeter
GDOT
2 Capitol Square, Room 356
Atlanta, GA 30334
Phone: (404) 657-0903, fax: (404) 657-7921, e-mail: dvanmeter@dot.ga.gov