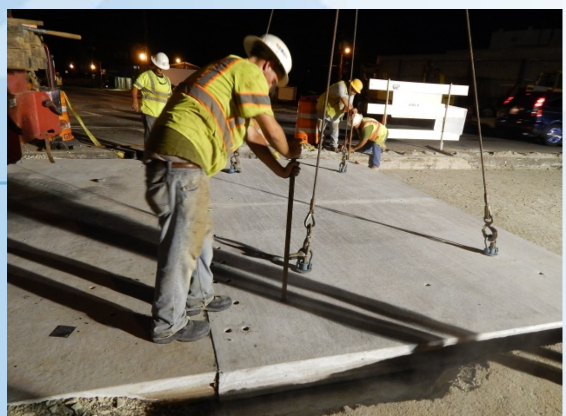
# GEORGIA DEMONSTRATION PROJECT:
# Pavement Replacement Using a Precast Concrete Pavement System along a Section of SR 11/Broad Street in Winder, Georgia

**Final Report**
**December 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. “Innovations” is an inclusive term used by HfL to encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

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

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

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

# NOTICE

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

| | |
|---|---|
| 3. Title and Subtitle<br>Georgia Demonstration Project: Pavement Replacement Using a Precast Concrete Pavement System **A**long a Section of SR 11/Broad Street in Winder, Georgia | 5. Report Date<br>December 2014<br>6. Performing Organization Code |
| 7. Authors<br>Shiraz Tayabji, Jay Bledsoe, Deepak Raghunathan, Suri Sadasivam, and Jagannath Mallela | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>Applied Research Associates, Inc.<br>100 Trade Centre Drive, Suite 200<br>Champaign, IL 61820 | 10. Work Unit No. (TRAIS) C6B<br><br>11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address<br>Office of Infrastructure<br>Federal Highway Administration<br>1200 New Jersey Avenue, SE<br>Washington, DC 20590 | 13. Type of Report and Period Covered<br>Final Report<br>June 2013 –December 2014<br>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 program, the Georgia Department of Transportation (GDOT) was awarded a $700,000 grant to demonstrate the use of precast concrete pavement systems (PCPS) in city of Winder. The project is located along a section of SR 11 (commonly referred to as Broad Street) in a historic downtown area with on-street parking and variable width roadway, typically three lanes wide. This project was a cooperative effort between the GDOT and the City of Winder. This report documents the application of PCPS technology for pavement rehabilitation of a 0.72 mile section on SR11/SR 53/SR 211/Broad Street from CSX R/R to Stephens Street in Downtown Winder.

Using PCPS technology on this project improved safety and mobility performance in the work zone. No incidents occurred or worker injuries during the construction period, including the lane closure periods. There was little impact on trip time through the length of the project primarily because of signalized intersections within the project length and the rail crossing at one end of the project. Several innovations included in this project are expected to improve the durability and performance of the roadway.

An economic analysis indicated that agency costs were $1,220,931 (54 percent) more for this project than they would have been using conventional construction practices, and user costs were $21,560 (35 percent) more. The as-built total project cost was $3,466,615 compared to $2,245,684 for the traditional alternative. Considering that the GDOT was using this innovation for the first time, and like with any innovation, the cost premium with the use of PCPS is expected to decrease with subsequent applications.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Highways for LIFE, precast concrete pavement system, construction | No restriction. This document is available to the public through the Highways for LIFE website:<br>http://www.fhwa.dot.gov/hfl/ |

| Security Classification (of this report) | 19. Security Classification (of this page) | 20. No. of Pages | 21. Price |
|---|---|---|---|
| Unclassified | Unclassified | 64 | |

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| SI* (MODERN METRIC) CONVERSION FACTORS | | | | |
|---|---|---|---|---|
| **APPROXIMATE CONVERSIONS TO SI UNITS** | | | | |
| **Symbol** | **When You Know** | **Multiply By** | **To Find** | **Symbol** |
| | | **LENGTH** | | |
| (none) | Mil | 25.4 | micrometers | μm |
| in | Inches | 25.4 | millimeters | mm |
| ft | Feet | 0.305 | meters | m |
| yd | Yards | 0.914 | meters | m |
| mi | Miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.836 | square meters | $m^2$ |
| ac | Acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | millimeters | mL |
| gal | Gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | |
| | | **MASS** | | |
| oz | Ounces | 28.35 | grams | g |
| lb | Pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| °F | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela per square meter | $cd/m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | Poundforce | 4.45 | Newtons | N |
| $lbf/in^2$ (psi) | poundforce per square inch | 6.89 | kiloPascals | kPa |
| $k/in^2$ (ksi) | kips per square inch | 6.89 | megaPascals | MPa |
| | | **DENSITY** | | |
| $lb/ft^3$ (pcf) | pounds per cubic foot | 16.02 | kilograms per cubic meter | $kg/m^3$ |
| **APPROXIMATE CONVERSIONS FROM SI UNITS** | | | | |
| **Symbol** | **When You Know** | **Multiply By** | **To Find** | **Symbol** |
| | | **LENGTH** | | |
| μm | Micrometers | 0.039 | mil | (none) |
| mm | Millimeters | 0.039 | inches | in |
| m | Meters | 3.28 | feet | ft |
| m | Meters | 1.09 | yards | yd |
| km | Kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | Hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | Milliliters | 0.034 | fluid ounces | fl oz |
| L | Liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | Grams | 0.035 | ounces | oz |
| kg | Kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE** | | |
| °C | Celsius | 1.8C+32 | Fahrenheit | °F |
| | | **ILLUMINATION** | | |
| lx | Lux | 0.0929 | foot-candles | fc |
| $cd/m^2$ | candela per square meter | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | Newtons | 0.225 | poundforce | lbf |
| kPA | kiloPascals | 0.145 | poundforce per square inch | $lbf/in^2$ (psi) |
| MPa | megaPascals | 0.145 | kips per square inch | $k/in^2$ (ksi) |

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# ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| AC | asphalt concrete |
| AADT | annual average daily traffic |
| ADT | average daily traffic |
| dB(A) | A-weighted decibel |
| CSX R/R | Rail road operated by CSX Transportation |
| DOT | Department of Transportation |
| FHWA | Federal Highway Administration |
| GDOT | Georgia Department of Transportation |
| HfL | Highways for LIFE |
| IRI | International Roughness Index |
| JPCP | Jointed Plain Concrete Pavement |
| LCCA | life cycle cost analysis |
| OBSI | onboard sound intensity |
| OSHA | Occupational Safety and Health Administration |
| PCPS | precast concrete pavement systems |
| RoW | Right of Way |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users |
| SHRP2 | Strategic Highway Research Program 2 |
| SR | State Route |

# INTRODUCTION

## HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

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

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

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

The performance goals emphasize the needs of highway users and reinforce the importance of addressing safety, congestion, user satisfaction, and quality in every project. The goals define the desired result while encouraging innovative solutions, raising the bar in highway transportation service and safety. User-based performance goals also serve as a new business model for how highway agencies can manage the 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 through 2013. 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 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 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 presents project details relevant to the HfL program, including safety, construction congestion and user satisfaction. HFL performance metrics and economic analysis lessons learned are also discussed along with innovative methods of public involvement and technology transfer.

The report is organized as follows:

- Project Overview and Lessons Learned
- Project Details
- Data Acquisition and Analysis
- Technology Transfer
- Summary and Conclusions
- References
- Appendix: User Satisfaction Survey

# PROJECT OVERVIEW AND LESSONS LEARNED

## PROJECT OVERVIEW

During 2013, the Georgia Department of Transportation (GDOT) reconstructed 0.313 miles of a section of SR 11 (Broad Street) from CSX R/R to Stephens Street in Downtown Winder, Barrow County. SR 11 is a major thoroughfare for the county residents and serves as a principal roadway for truck traffic that serves the industries in the area. This project was a cooperative effort between the GDOT and the City of Winder. The roadway carries an annual average daily traffic of approximately 19,000 with 13 percent trucks. Figure 1 shows a layout of the project.

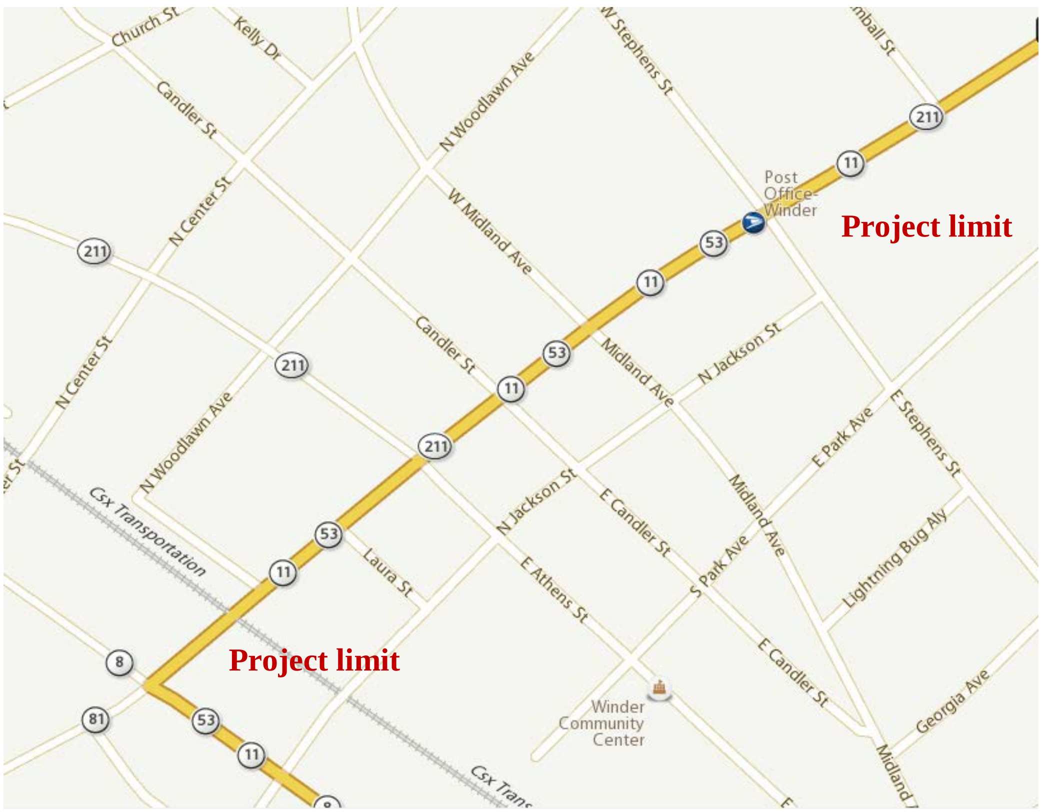



Figure 1. Map. General project location.

The existing pavement had been repaired and rehabilitated over the years and typically consisted of 4 to 8 inches of asphalt concrete (AC) over variable base materials, including concrete pavement of varying thickness, along the length of the project. The pavement evaluation of SR 11 conducted prior to the reconstruction indicated the pavement was in fair to poor condition, with the asphalt surface exhibiting significant levels of rutting and cracking, particularly at intersections.

The City of Winder and GDOT were looking for a long-term solution that would provide longer pavement life and require less maintenance time without significantly impacting local or through traffic. The project is located in a historic downtown area with on-street parking and variable width roadway, typically three lanes wide. Within a tighter radius of 0.35 miles there are a historic County Courthouse facility and a fire station, further complicating full-depth constructability. Furthermore, there was concern over the use of vibratory equipment due to the proximity of historic buildings and aging underground utilities. All construction work would have to be done overnight due to the business district, traffic volumes, and lack of a reasonable detour route. Total reconstruction would be very difficult because of these challenges.

As a result, GDOT wanted to use innovative construction practices, emerging technologies, and new products that would help achieve its project goals:

- Long-term solution to historic pavement rutting issues.
- Reduced future routine maintenance.
- Longer pavement life.
- Reduced work zone duration.
- Major pavement work done during overnight hours.

One of the technologies that GDOT has been tracking over the last few years is the use of precast concrete pavement systems (PCPS) for rapid repair and rehabilitation of concrete and asphalt pavements that result in economical long-life treatments and reduce construction related congestion and delays. GDOT selected the SR 11 section through Winder to demonstrate the technical and economic viability of PCPS. By using the Winder project as a demonstration project, GDOT expected to gain the experience and knowledge of the benefits and challenges of using a new technology for rehabilitation of high volume urban area intersections and for performing rapid full-depth repairs along sections of Georgia's primary highway system.

One benefit of PCPS is that it minimizes lane closures and allows traffic to return to the rehabilitated sections quickly (typically, by the next morning).

## HfL Performance Goals

The successful implementation of an HfL project is assessed with respect to how safety, construction congestion, quality, and user satisfaction were addressed during the construction of the project. On most HfL projects, data are collected before, during, and after construction where appropriate, to demonstrate that the featured innovations can be deployed while simultaneously meeting the HfL performance goals in these areas. For the Winder project, the HfL performance goals were met as follows:

- **Safety**
  - **Work Zone Safety—**No incidents occurred during the construction period, including the lane closure periods. This met the HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate.
  - **Worker Safety during Construction—**No worker injuries occurred during construction, which exceeded the HfL goal of less than a 4.0 rating on the OSHA 300 form.

- **Facility Safety after Construction—**The facility safety after construction is yet to be determined.

- **Construction Congestion**
  - **Faster Construction—** At this project, 348 precast concrete panels, or 6,212 $yd^2$ of pavement, were installed in a span of 39 working days (79 calendar days). Per GDOT's estimates, it would have taken 29 days to place 6,212 $yd^2$ of concrete pavement using CIP construction. Thus, the HfL performance goal on faster construction was not met on this project.
  - **Trip Time—**The use of precast concrete panels led to little impact to the travel times, and in turn resulted in reducing the delay time on this project to help meet the HfL goal of less than 10 percent increase in travel time compared to the average preconstruction scenario. The minimal impact on trip time through the length of the project was primarily because of signalized intersections within the project length and the rail crossing at one end of the project. Because of the presence of these features, traffic was in a stop-and-go mode both during the time of lane closures and during the time of no lane closures. The middle turn lane typically was closed to traffic during the panel installation period.
  - **Queue Length—**Traffic backup occurred because of stoppages at the intersections and the rail crossing. As a result, the queues that developed were a result of the delays that took place at the intersections and the rail crossing, and not directly attributable to the construction. Nonetheless, the queue lengths were shorter than 1.5 miles, meeting the HfL performance goal.

- **Quality**
  - **Smoothness—** On this project, the IRI values were found to be ranging from 56.8 in/mi to 57.3 in/mi across three segments. Although the panel placement on this project was well controlled so that the panel-to-panel elevation difference was typically less than ¼ inch, the HfL goal on IRI was not met.
  - **Noise—**No noise measurements were performed because of the designated speed limit of only 30 miles per hour for the completed project. Pavement-tire noise is not expected to be an issue.
  - **Durability—**Several innovations included in this project are expected to improve the durability and performance of the roadway:
    - The concrete quality is expected to be very good because of the tight control over concrete quality exercised at the precasting plant.
    - The precast concrete pavement includes a new and uniform granular base that should result in consistent performance along the full length of the project.
    - The typical intersection-related distress (AC shoving and rutting) will not develop.
    - The reinforcement in the precast panels will keep any cracking that develops tight without negatively impacting the performance of the pavement.

- **User Satisfaction—** GDOT conducted a user survey during fall 2014. The survey results were not available at the time of report completion.

## ECONOMIC ANALYSIS

The costs and benefits of this innovative construction technique were compared with those of a project of similar size and scope delivered using a more traditional technique. A comprehensive economic analysis revealed that the innovative approach resulted in agency costs that were $1,220,931 (54 percent) higher than those expected using conventional construction practices and user costs that were $21,560 (35 percent) more. The as-built total project cost was $3,466,615 compared to $2,245,684 for the traditional alternative.

## LESSONS LEARNED

Overall, the Winder PCPS project was a success. The pavement was reconstructed ahead of schedule with minimal negative impact to the traffic flow through downtown Winder during the 3-month period of precast panel installation. The following are some of the lessons learned:

- The precast concrete pavement technology can be implemented successfully—in this case, even though the agency, the contractor, and the precaster had no previous experience with PCPS implementation.
- Project staging is an important feature of any project in a downtown area.
- Near-site staging of panels is necessary to ensure that the rate of panel placement is not affected by traffic delays that may slow down delivery of panels to the project site.
- The PCPS was a tried and tested system. As a result, there were no technical issues related to the design and fabrication of the panels, including the use of panels with customized dimensions.
- The 18 ft wide precast panels were designed to incorporate a longitudinal joint. The sawcut for the longitudinal joint was made at the plant for each panel. However, the longitudinal sawcuts for a few panels did not line up in the field. To avoid this situation, it would be better to provide the longitudinal sawcut after the panels are installed near the end of each lane closure. In addition, dowel bars and dowel bar slots should not be located at the longitudinal sawcut locations.
- It is necessary to require the construction of a test section off-site prior to actual panel placement at the site. This allows all parties to understand the various requirements of the project and the owner’s expectations regarding the outcomes.
- In an urban setting, it is important to review the impact of overhead utilities and traffic signal mast arms on panel installation and crane access. These site constraints may require intermittent full closures of the traffic lanes.

For any new application of precast concrete pavement, it is important that a representative of the PCPS fabricator be on site for the first few days. This helps resolve any technical questions that may arise.

## CONCLUSIONS

GDOT gained valuable experience in using PCPS for rapid rehabilitation of an existing pavement. The DOT evaluated the PCPS application in Winder to:

- Determine the feasibility of applying the technology to other similar downtown roadway rehabilitation without significantly affecting traffic flow along these roadways.
- Determine the feasibility of applying the technology for rapid repair of concrete pavements, typically, full-depth repairs and full slab panel replacements.

GDOT is expected to move forward and implement the PCPS technology for these applications. The project in Winder was successful, and both the contractor and the precaster look forward to constructing more precast concrete pavement projects.

# PROJECT DETAILS

## PROJECT BACKGROUND

SR 11 (Broad Street) is a major roadway through downtown Winder. The 0.313-mile-long rehabilitated section of the roadway is typically three lanes wide, one lane in each direction and a middle turning lane, and it includes parking lanes along each side of the street. Four intersections are incorporated in the rehabilitated section of the roadway. Figure 2 shows a view of Broad Street.


Figure 2. Photo. View of Broad Street (as of August 2013).

The project was located in an urban area with annual average daily traffic on the mainline road being more than 19,000 vehicles per day. Traffic information was obtained from the Georgia State Traffic and Report Statistics (STARS) presented on the GDOT website (http://www.dot.ga.gov/informationcenter/statistics/stars/Pages/default.aspx).

Figure 3 illustrates the annual average daily traffic information for 2012 along Broad Street and Athens Street.

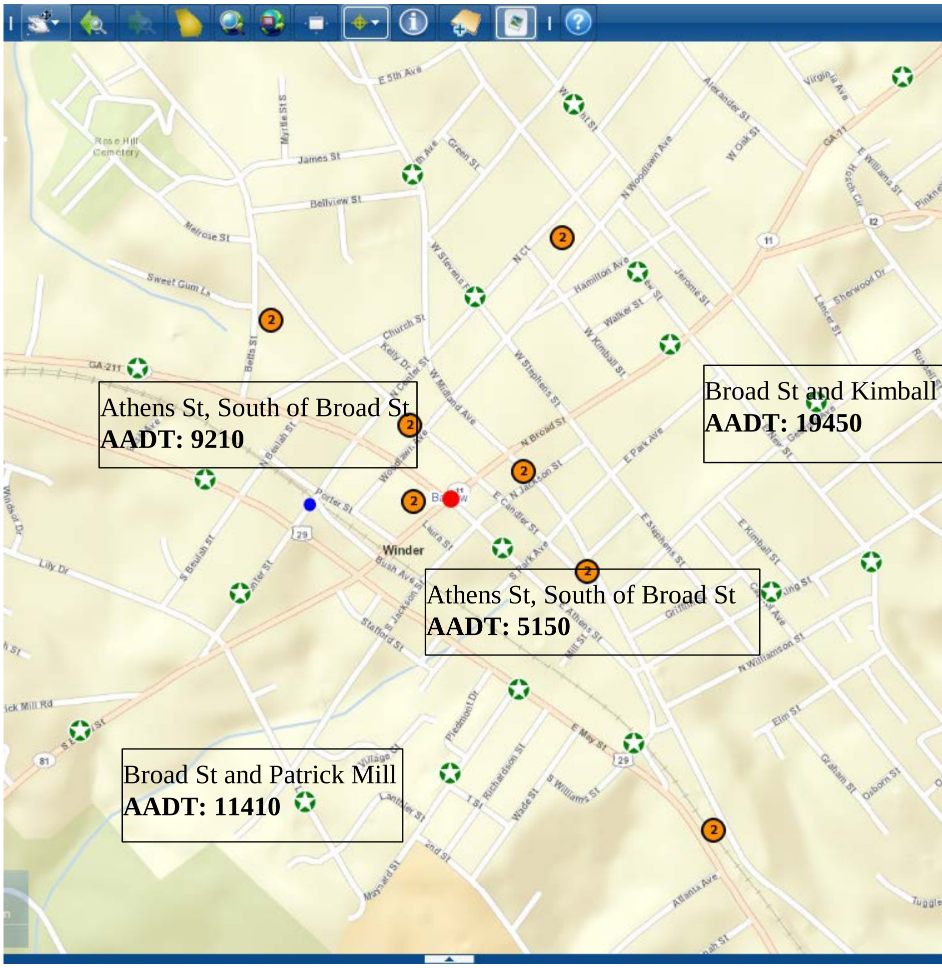


Figure 3. Map. Traffic information for the project location and surrounding area.

Traffic information for the intersection of Broad Street and Midland Avenue (see figure 4) is provided in table 1.

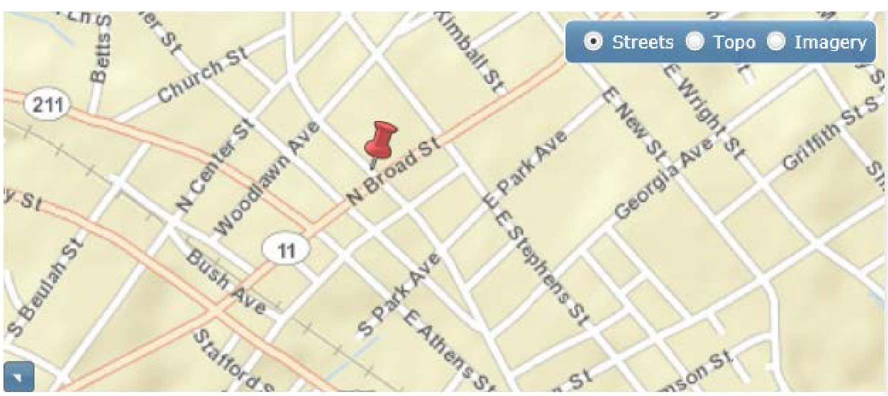


Figure 4. Map. Traffic counter at Broad Street and Midland Avenue.

Table 1. Traffic levels at the intersection of Broad Street and Midland Avenue.

| Year | Beginning Milepoint | Ending Milepoint | Actual/Estimate | Total AADT |
|---|---|---|---|---|
| 2012 | 6.96 | 7.06 | Estimate | 16,570 |
| 2011 | 6.93 | 7.14 | Actual | 16,490 |
| 2010 | 6.93 | 7.03 | Estimate | 16,980 |
| 2009 | 6.93 | 7.03 | Estimate | 17,180 |
| 2008 | 6.93 | 7.03 | Estimate | 16,980 |

*AADT = average annual daily traffic

**Existing Pavement Conditions**

The existing pavement exhibited significant levels of cracking and rutting, especially at signalized intersections, partly owing to the high percentage of trucks in the traffic stream and the posted speed limit of 30 miles per hour. Before the rehabilitation work, the average rutting at the intersections was measured to be about 5/8 inches, with some measurements as high as 1.5 inches. In addition, the thickness of the underlying base material was found to be variable and may have contributed to cracks and other forms of distresses. Figure 5 presents a view of the Broad Street showing typical rutting conditions.


Figure 5. Photo. View of Broad Street and typical rutting (as of August 2013).

Figure 6 and Figure 7 present the existing pavement conditions and rut depth measurements being taken.

Figure 6. Photo. Existing pavement conditions.

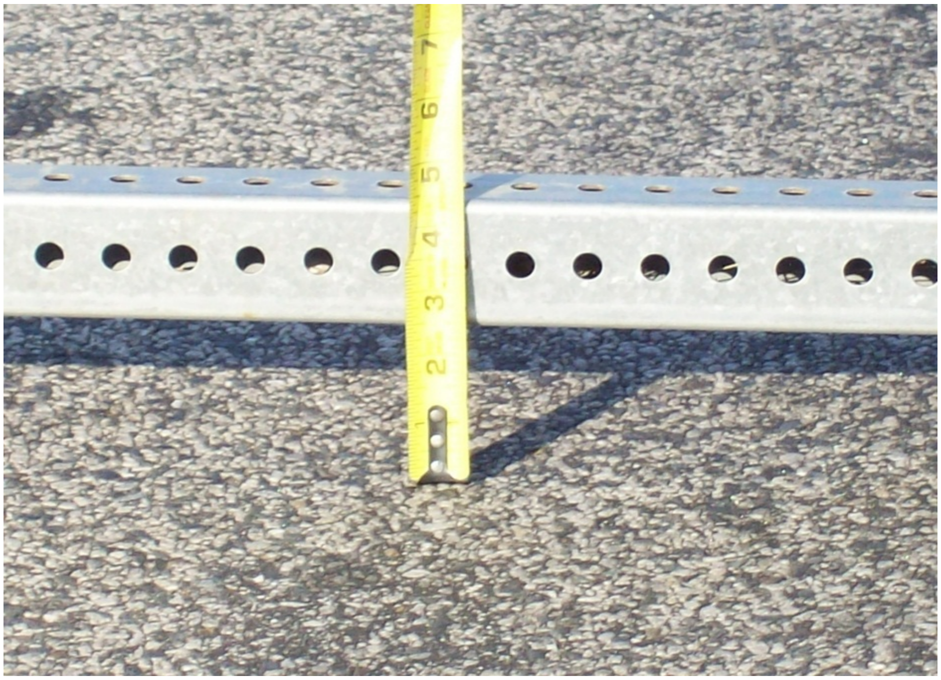


Figure 7. Photo. Rut depth measurement.

**Pavement Evaluation**

For pavement evaluation purposes, GDOT collected 22 cores samples from the existing pavement structure (see Figure 8). The core evaluation indicated that thickness of the AC over graded aggregate base layer ranged from 4 inches near the curb to 8 inches over an old concrete pavement. Some areas with below grade concrete pavement slabs were found to have varying thicknesses.

Asphalt Pavement Analyzer tests on the cores indicated poor pavement conditions. As a result, the mill and inlay strategy was not preferred since this strategy may not completely address the rutting problems and the existing pavement would not contribute much to the structural capacity of the roadway. Based on the pavement evaluation, the GDOT Office of Materials and Research recommended a full depth replacement of 25.5 inches using conventional AC or 22 inches using jointed plain concrete pavement (JPCP) for this roadway.

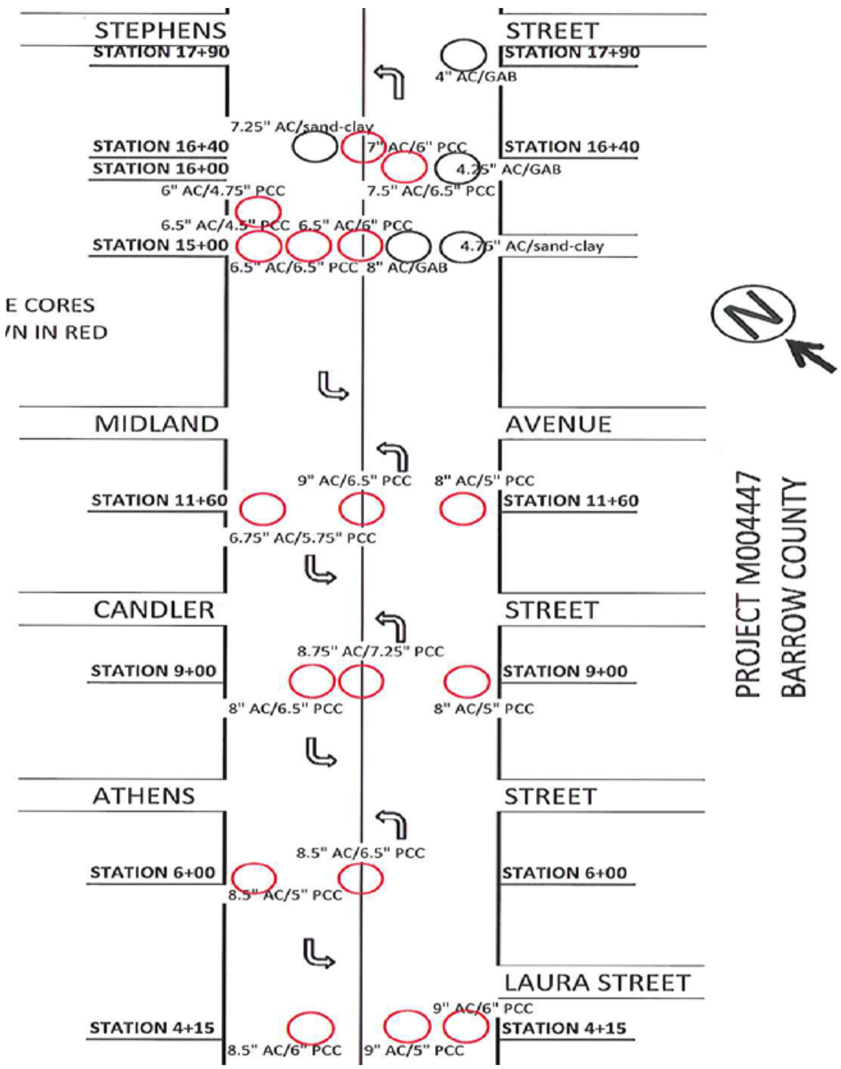


Figure 8. Diagram. Coring layout.

## Traditional Alternative and Related Concerns

For this project, the GDOT wanted to select a pavement alternative that would last longer, i.e. for 25 years or more, and eliminate the rutting problems. This would reduce the pavement maintenance needs and disruption to local businesses by having less frequent construction work zones. Total reconstruction using AC or cast-in-place JPCP would have been the GDOT's preferred alternatives traditionally, however, the reconstruction was less desired because of the following challenges:

- Concerns with damage to the historic buildings and aging underground utilities along Broad Street, due to vibratory compaction use.
- Reconstruction using cast in-place JPCP would have resulted in an extended curing period during which the intersections would have to be closed to traffic.
- All major pavement related work would have to be done overnight due to the business district, traffic volumes and lack of a reasonable detour route.

## PCPS and Other Improvements

The jointed concrete pavement option using PCPS was considered for this project. This option would result in:

- Less disruption to the traffic operation and business activity along and around Broad Street.
- Allowing for the work to be completed at night.
- Alleviating a previous long-term problem of rutting in this section of roadway.
- Maintenance of traffic through the site.

In addition to the pavement rehabilitation, the same section of Broad Street was planned for streetscape work under a GDOT transportation enhancement project. The streetscape project would enhance/add pedestrian and parking facilities and was scheduled to be completed after the pavement rehabilitation was completed. Also, as part of the Broad Street improvement program, all intersecting streets and parking areas along Broad Street were upgraded with a new AC surfacing.

Other SR 11/Broad Street enhancement project improvements included the following:

- New sidewalks.
- New pedestrian crossings and handicap access ramps.
- New lighting.
- New signage.
- New benches.
- New trash receptacles.
- New bike racks.
- New tree plantings.
- New landscaping.

- New traffic signals.
- Drainage system improvements.

The use of jointed precast concrete pavement was selected as the preferred alternative for the pavement rehabilitation. During the 2 years preceding the selection of the precast pavement alternative, GDOT engineers and planners reviewed the PCPS technology and participated in several presentations on the technology, including review of the products from the Strategic Highway Research Program 2 (SHRP2) Project R05, Precast Concrete Pavement Technology. GDOT developed project plans and specifications based on similar work performed by other agencies and information developed under SHRP2 Project R05.

**Project Scope**

The rehabilitation project was advertised in 2012 and was expected to be completed by July 31, 2014. The project scope included both the pavement rehabilitation work and streetscape work. Specifically related to the pavement rehabilitation, the project scope included the following:

- Use of precast concrete panels.
- Lane closures at night from 9 pm to 6 am.
- Management of street parking spots.
- Traffic to be limited to one lane in each direction in the work zone without access to the center turn lane.
- Integrate pavement rehabilitation work with the streetscape work that incorporates new curb and gutters, sidewalks, and landscaping.

**Bid Information**

GDOT developed customized project specifications and plans for this project, and the contract was let on November 16, 2012. The work was awarded to G.P.'s Enterprises, Athens, Georgia. G.P.'s Enterprises is located in Auburn, Georgia. The panel precasting work was subcontracted to Foley Products Company, Winder, Georgia. The PCPS used was Fort Miller Company's Super Slab system, as specified in the project plans. GDOT specified use of the Super Slab system to accommodate the cross-slope changes along Broad Street. Table 2 presents the bid summary.

Table 2. Bid summary.

| Bidder | Bid Amount |
|---|---|
| A (winning bid) | $4,949,306.21 |
| B | $5,097,272.80 |
| C | $5,663,917.45 |
| D | $5,980,797.62 |
| E | $6,064,523.92 |

This project did not include cost plus time bidding or lane rental clauses in the contract. The contract included a fine of $5,000 per calendar day to the contractor in case of a failure to meet the slab installation and traffic maintenance contractual requirements. In the end, the contractor paid no fines on this project.

## PROJECT DESCRIPTION

### PROJECT TEST FEATURES DETAILS

The project details are as follows:

- Total project length: 0.41 miles (from Porter Street to Stephens Street).
- Precast pavement length: 0.313 miles
- Design speed: 35 mph.
- Area of precast pavement: 6,212 square yards.
- Precast panel thickness: 8.5 inches.
- Precast panel length: 12.5 feet (as-designed); 11.25 feet (based on contractor proposal).
- Precast panel width: variable at 11, 12, 14, 16 and 18 feet.
- Base: 10-inch granular base.
- Bedding layer over the base: ¼- to ½-inch granular (stone sand), as designed.
- Shoulder/parking lanes: Existing AC shoulder milled and levelled as necessary and a new 3.5 in. Superpave AC mixture.

Figure 9 shows a partial panel layout, and Figure 10 shows the typical pavement cross sections.

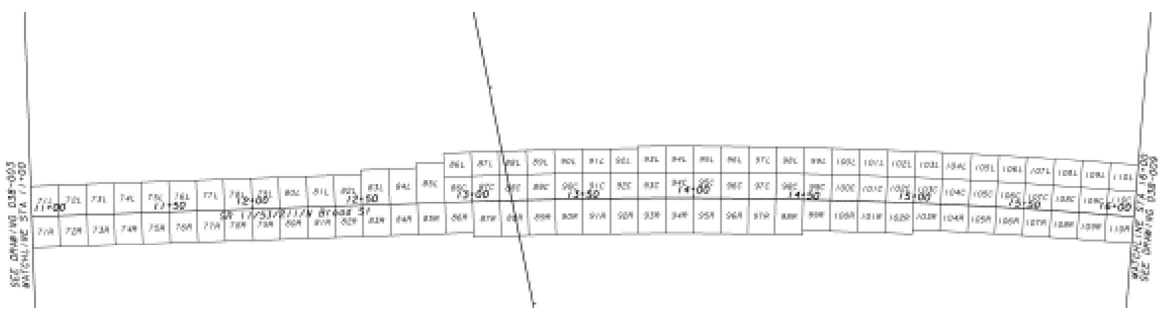


Figure 9. Diagram. Panel layout.

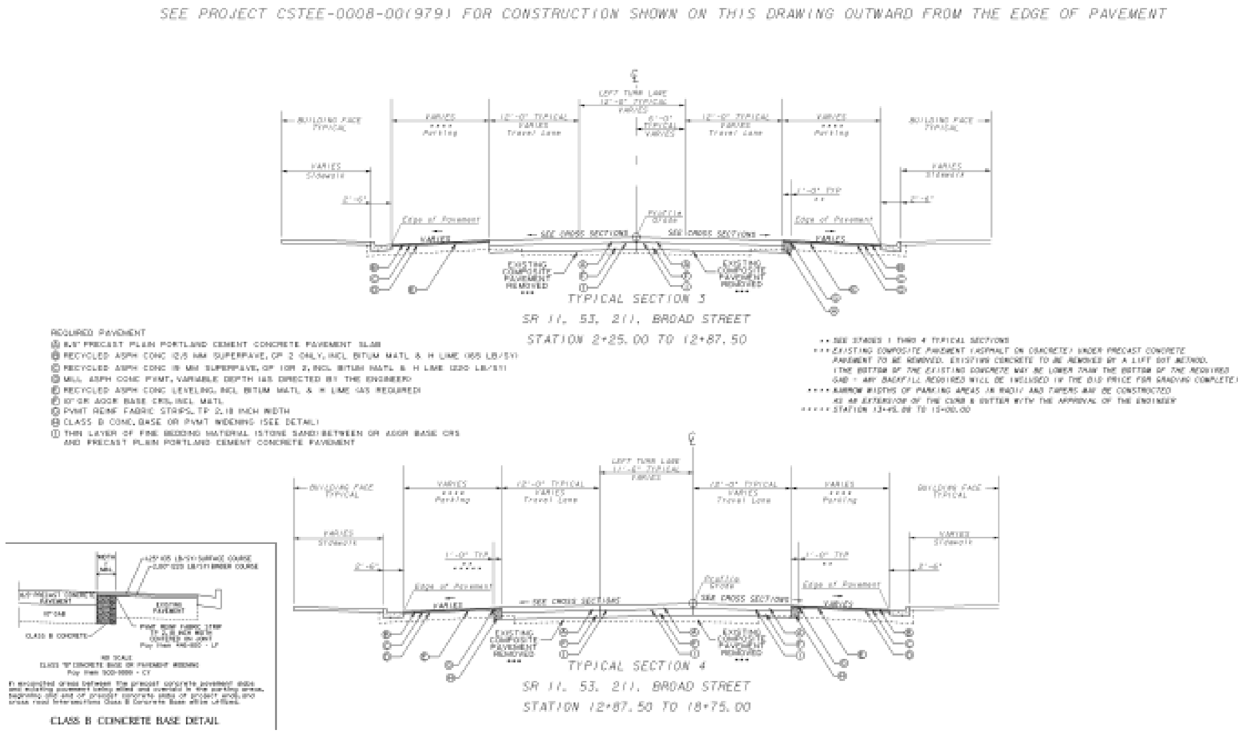



Figure 10. Diagram. Pavement cross sections.

**PRECAST CONCRETE PAVEMENT SYSTEM (SUPER SLAB SYSTEM)**

GDOT specified the use of Fort Miller Company's Super Slab system to accommodate the cross-slope changes along Broad Street. No alternative PCPS was allowed. The Super Slab system was first used during 2001 to rehabilitate the pavements at the Tappan Zee Toll Plaza (I-95) in New York State. Since then, the system has been used for repair and rehabilitation of concrete pavements in several States and has also been used to rehabilitate AC intersections, bridge approach slabs, and bus pads. The system incorporates the following features:

- Slots at the panel bottom for dowel bars and tiebars.
    - For repair applications, dowel bars (and tiebars, if specified) are installed in the existing pavement using the drill and epoxy grouting process. The panels are installed so that the slots are positioned over the epoxy-grouted dowel bars or tiebars. The slots are then filled using a high strength and rapid setting liquid grout material.
    - For rehabilitation (continuous) application, the panels are fabricated with bottom slots along one side of the panel and dowel bars (or tiebars, as the case may be) along the opposite side. The panels are installed next to each other so that the side with the slots sits directly over the embedded dowel bars in the adjacent panel. The slots are then filled using a high strength and rapid setting liquid grout material.
- Use of a thin granular bedding layer to provide a good grade for placing the panels over the base layer (existing or new).

- Undersealing after panel installation.

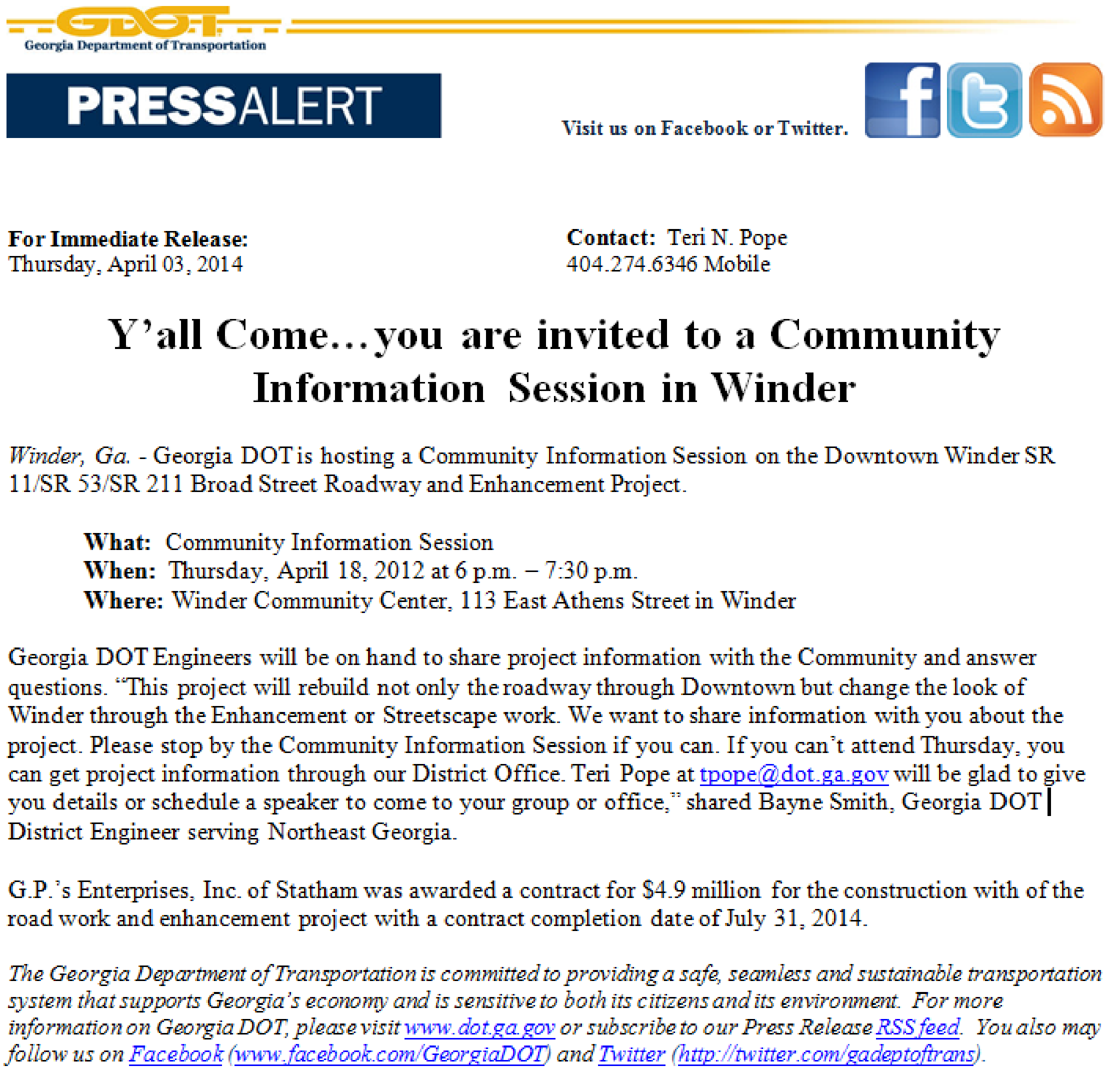
Typically, the panels are installed during one lane closure and the slot grouting and undersealing work is performed during the next lane closure. Traffic is allowed on the roadway section before the slot grouting and panel undersealing work are done.

The Super Slab system is available as flat panels or as non-planar (warped) panels to meet project-specific geometric requirements. Use of non-planar panels requires custom fabrication of each panel and placement of the customized panels at designated locations along the roadway.

### PUBLIC RELATIONS CAMPAIGN

GDOT and the City of Winder carried out an extensive public relations campaign before and during the construction to inform the local public and the trucking industry regarding the status of the Broad Street improvement program. Press releases and fact sheets were regularly distributed and posted at the GDOT website. A fact sheet provided information on the traffic staging during panel installation along different sections of Broad Street. In addition, several community information sessions were held at the Winder Community Center, the first of which was held April 18, 2013 (see Figure 11). The sessions were intended at sharing project information with the Winder community and answering project related questions.

GDOT also sent out email updates throughout the project. The Winder Downtown Development Authority shared project updates on its Facebook page (https://www.facebook.com/WINDERDDA?fref=ts), and GDOT maintained a webpage at http://winderdowntown.com/category/streetscape/ to inform the public of the Broad Street road improvement program, with street closure updates and progress photos related to the streetscape and pavement rehabilitation work.



Georgia Department of Transportation

**PRESS**ALERT

Visit us on Facebook or Twitter.

**For Immediate Release:**
Thursday, April 03, 2014

**Contact:** Teri N. Pope
404.274.6346 Mobile

## Y'all Come…you are invited to a Community Information Session in Winder

*Winder, Ga.* - Georgia DOT is hosting a Community Information Session on the Downtown Winder SR 11/SR 53/SR 211 Broad Street Roadway and Enhancement Project.

**What:** Community Information Session
**When:** Thursday, April 18, 2012 at 6 p.m. – 7:30 p.m.
**Where:** Winder Community Center, 113 East Athens Street in Winder

Georgia DOT Engineers will be on hand to share project information with the Community and answer questions. "This project will rebuild not only the roadway through Downtown but change the look of Winder through the Enhancement or Streetscape work. We want to share information with you about the project. Please stop by the Community Information Session if you can. If you can't attend Thursday, you can get project information through our District Office. Teri Pope at tpope@dot.ga.gov will be glad to give you details or schedule a speaker to come to your group or office," shared Bayne Smith, Georgia DOT District Engineer serving Northeast Georgia.

G.P.'s Enterprises, Inc. of Statham was awarded a contract for $4.9 million for the construction with of the road work and enhancement project with a contract completion date of July 31, 2014.

*The Georgia Department of Transportation is committed to providing a safe, seamless and sustainable transportation system that supports Georgia's economy and is sensitive to both its citizens and its environment. For more information on Georgia DOT, please visit www.dot.ga.gov or subscribe to our Press Release RSS feed. You also may follow us on Facebook (www.facebook.com/GeorgiaDOT) and Twitter (http://twitter.com/gadeptoftrans).*

Figure 11. Image. Community information session invite

## CONSTRUCTION STAGING AND TRAFFIC-RELATED REQUIREMENTS

### Preparatory Work

As part of the overall Broad Street improvement program, which began on April 2, 2013, the contract required the following preparatory activities:

- Drainage work and relocation of sewer lines along Broad Street.
- Railroad arm extension at western end of the project. This required railroad operational interruptions but no traffic lane shifts along Broad Street.

In addition, prior to the start of the panel installation activity, a sufficient number of panels were fabricated and held in storage at the precast plant, which was located about 1 miles from the project site.

**Construction Staging and Traffic Management**

The contract provisions incorporated the following clauses:

- The contractor was not allowed to detour Broad Street and the intersecting streets.
- The contractor was allowed to shift traffic as defined in the staging plans while work was being performed within a section of the roadway. However, if no work was being performed, the traffic was to stay in the existing traffic pattern. The minimum length traffic shift allowed for precast panel installation was one block section at a time. GDOT specified the allowable number of work periods (overnight hour segments) for each one-block section and each intersection.
- The work window was defined as 9 pm to 6 am. Work to be performed during a work window had to be completed before starting work scheduled for the next work window.

The concrete panel installation was carried out in two phases. During the first phase, the panels were installed along the eastbound lane of Broad Street. Every east lane panel that was installed involved the following steps:

1. Moving two-way traffic to the west side of SR 11 while work occurred on the east side of SR 11.
2. Beginning sidewalk closure on a single block, and later moving the closure sequentially from south to north starting on the east sidewalk.
3. Allowing pedestrians to access businesses from back entrances adjacent to parking lots along Jackson Street.
4. Returning the lanes to their original configuration and allowing street parking and center turn lane.

Figure 12 presents the typical work plan for east lane panel installation.

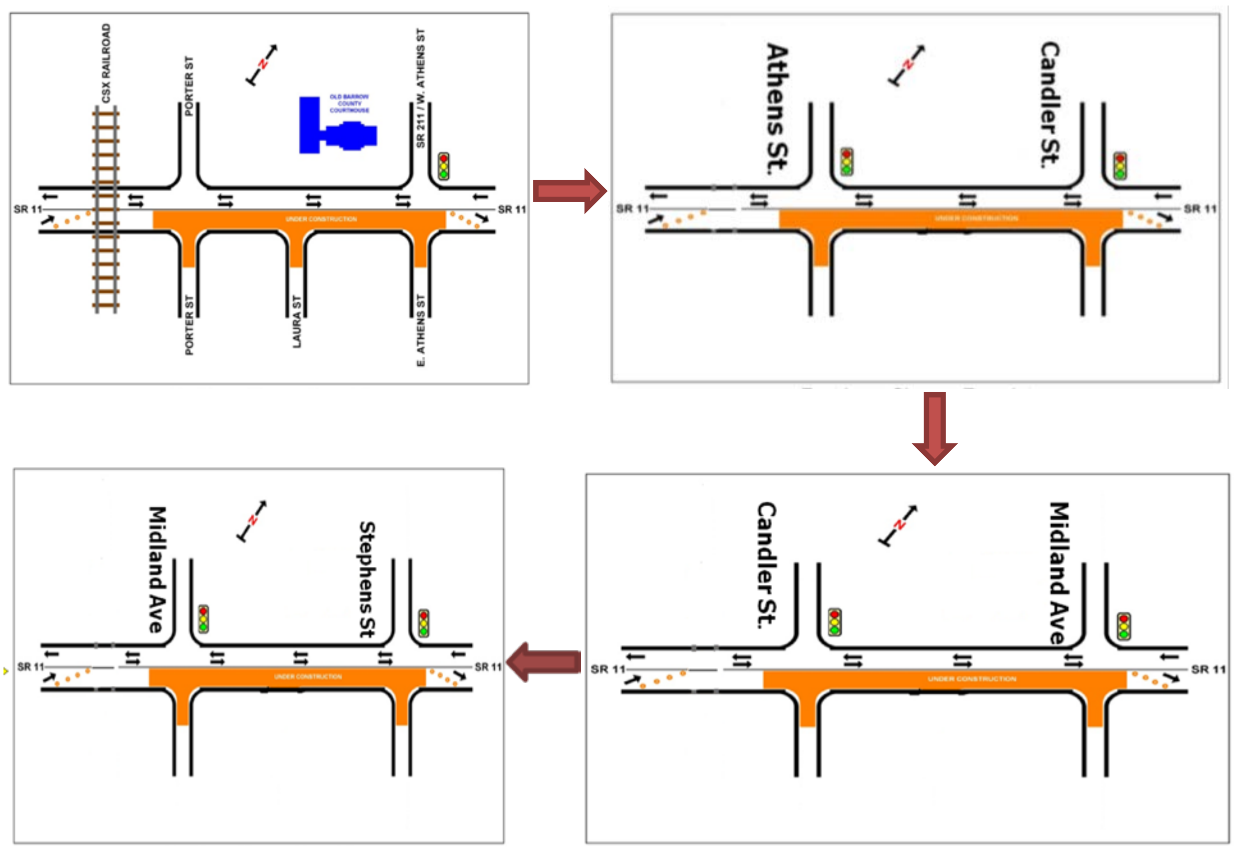


Figure 12. Diagram. Typical work plan for east lane panel installation.

During the second phase, the panels were installed along the westbound lane and center lane of Broad Street. Every west lane panel that was installed involved the following steps:

1. Moving two-way traffic to the east side of SR 11 while work occurred on the west side of SR 11.
2. Beginning sidewalk closure on a single block, and later moving the closure sequentially from south to north starting on the west sidewalk.
3. Allowing pedestrians to access businesses from back entrances and parking behind the businesses.
4. Returning the lanes to their original configuration and allowing street parking and center turn lane.

The two-way traffic was moved to the outside, southbound along the western side and northbound along the eastern side of SR 11 while the work occurred in the middle or center turn lane area.

Figure 13 presents the typical work plan for west and center lane panel installation.

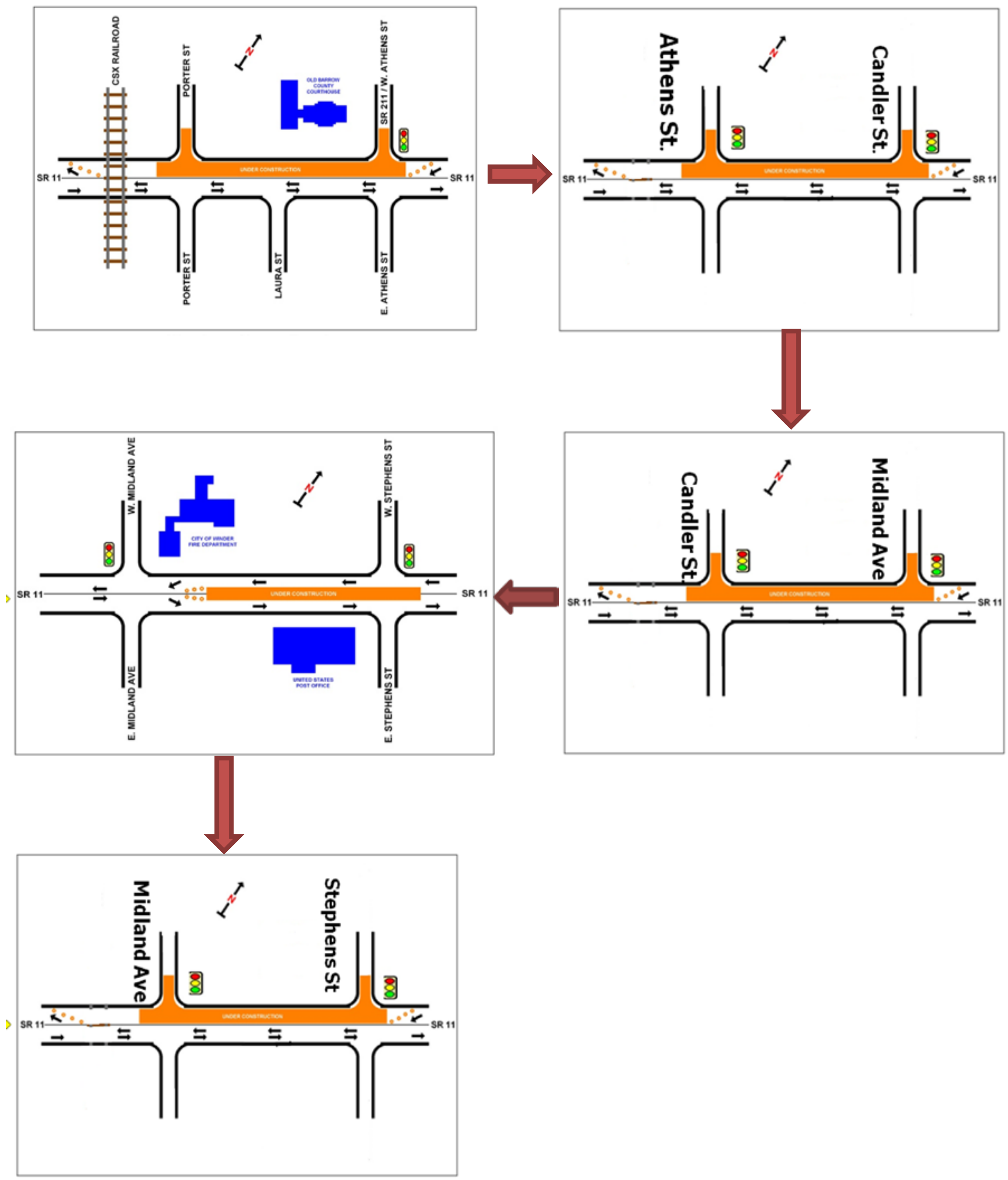



Figure 13. Diagram. Typical work plan for west and center lane panel installation.

The contractor was allowed to close the lane being worked on during the daytime, one block at a time, with two-way traffic maintained over the lanes not being worked on. Figure 14 shows the lane closure and two-way traffic operation at the start of the project. The ability to close lanes during the daytime allowed existing pavement removal work and precast pavement finishing work to be performed during the daytime. Nighttime work was limited to panel installation.

Figure 14. Photos. Lane closure and two-way traffic operation.

## TEST SECTION

A test section was constructed at the precast plant yard, and the panel installation operations were demonstrated on June 25, 2013. The test section incorporated the following:

1. Base Preparation – A granular base was used for the trial installation. A rail-mounted screed was used to grade the base to the desired grade. The base was compacted using a vibratory roller, as shown in Figure 15.


Figure 15. Photos. Base grading and compaction.

2. Bedding Layer – A thin granular bedding layer was placed over the compacted base, and the bedding layer was compacted and screened to achieve the final grade for panel installation, as shown in Figure 16.

Figure 16. Photo. Bedding layer grading.

3. Test Panel Installation – The panels were brought to the test section site from the storage area at the plant and installed over the granular bedding layer using a crane, as shown in Figure.

Figure 17. Photo. Panel installation over the prepared base and bedding layer.

4. Dowel Slot Grouting and Panel Undersealing – After the panels were in place, dowel slot grout was pumped into the dowel slots and the joint space between adjacent panels using a portable grout mixture. GDOT specifications required the dowel slot grout to achieve compression strength of 2,500 psi in 3 hours. The slot grouting and the grout pump used are shown in Figure 18. The panel undersealing grout was then applied. Grout was pumped at the low side of the panels until it was visible at the high side of the panel, indicating effective void filling under the panels.


Figure 18. Photos. Slot grouting and grout pump.

The trial installation was considered acceptable by GDOT, and the contractor was authorized to begin panel installation at the project site.

### PANEL FABRICATION

As indicated previously, GDOT had specified use of the Super Slab system. The panels were fabricated about 5 miles from the project site. The PCPS manufacturer provided complete formwork package and in-plant technical support to the fabricator, and the fabricator provided the equipment, space, and labor to fabricate the panels, store the panels on site, and deliver the panels to the project site.

Six panels were fabricated at a time. A panel fabrication bed is shown in figure 11, with steel reinforcement and load transfer hardware in place, just prior to concrete placement. Because of the need to use non-planar panels due to the variable geometry along Broad Street, a large number of panels were custom fabricated using shop drawings supplied by the PCPS manufacturer. Typical shop drawings are shown from Figure 19 through Figure 21.

Figure 19. Photo. Panel formwork ready for concrete placement.

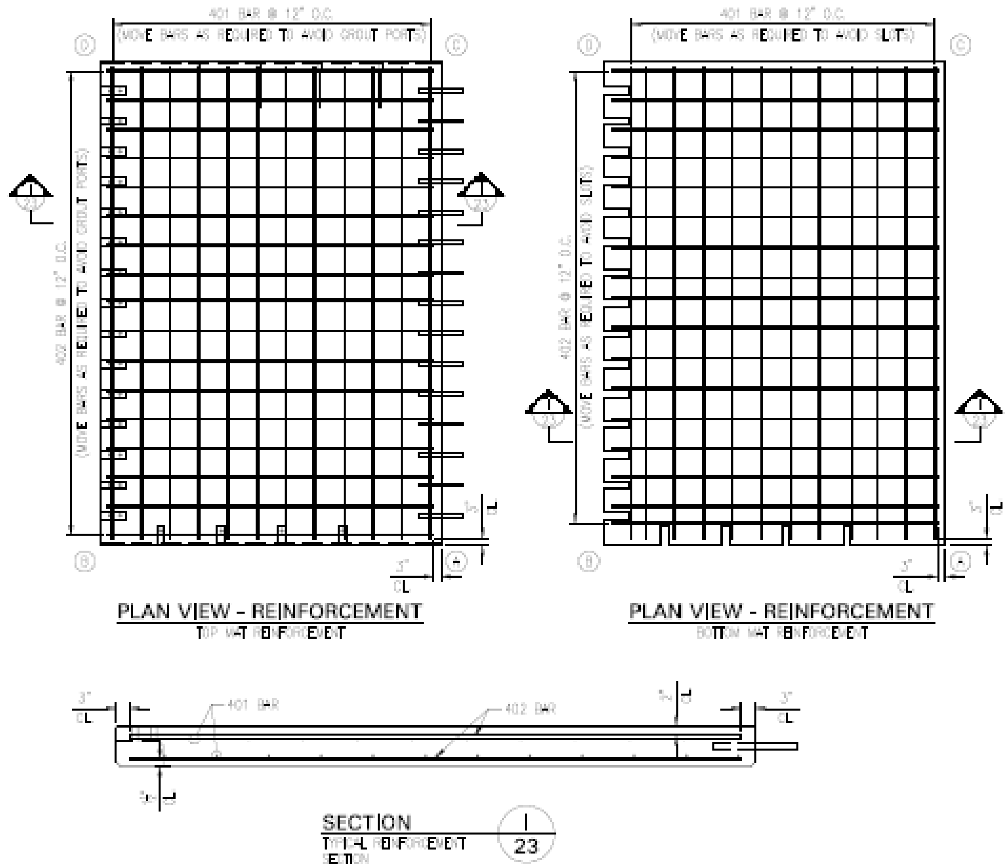



Figure 20. Diagram. Typical panel shop drawings (reinforcement details).

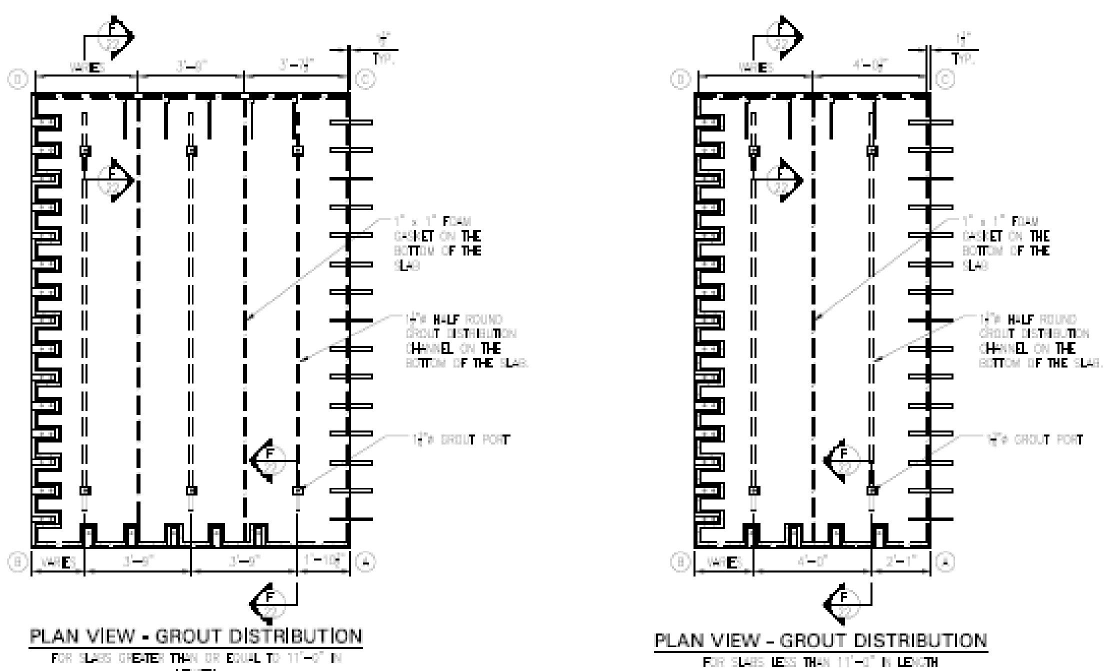



Figure 21. Diagram. Typical panel shop drawings (load transfer and undersealing details).

After forms are set, they are checked for accuracy to ensure specification limits on panel dimensional tolerances are met, as shown in Figure 22.

Figure 22. Photo. Formwork being checked for tolerances.

The concrete mixture approved for fabricating the panels is shown in Figure 23.

**Producer:** 958 - Foley Products Company Winder, GA

**DOT MIX DESIGN NO.:** 5976511101 **Design Air:** 4.5

**Class Concrete:** AAA M004447 Barrow - Super Slab

**Fine to Fine Ratio:** **Coarse to Coarse Ratio:** **Coarse Aggregate Size:** 67

**CONCRETE MIX DESIGN**

(1 CUBIC YARD PROPORTIONS - SSD WEIGHTS)

| MATERIAL | DESIGN WEIGHT | QPL CODE | SPECIFIC GRAVITY | SOURCE / PRODUCER LOCATION |
|---|---|---|---|---|
| CEMENT TYPE: 1 | 765 lbs | 46 | 3.14 | Argos Cement - Calera, AL |
| CEMENT TYPE: | lbs | | | |
| FLY ASH TYPE: F | 85 lbs | 51 | 2.28 | Boral - Plant Bowen - Stilesboro, GA |
| SILICA FUME | lbs | | | |
| SLAG GRADE: | lbs | | | |
| FINE AGGREGATE 1 | 1300 lbs | 164F | 2.63 | Vulcan - Friendship Quarry, Buford, GA |
| FINE AGGREGATE 2 | lbs | | | |
| COARSE AGGREGATE 1 | 1350 lbs | 102C | 2.64 | Vulcan - Friendship Quarry, Buford, GA |
| COARSE AGGREGATE 2 | lbs | | | |
| WATER | 39.0 gals | | | |
| AIR ENTRAINMENT | | 22 | | BASF - MB AE 90 |
| ADMIXTURE | | | | BASF - Delvo Stabilizer - May be used. |
| WATER REDUCER | | | | |
| HRWR | | 74 | | BASF - Glenium 7700 |

Figure 23. Image. Approved concrete mixture.

Fresh (slump, temperature, air content) and hardened concrete testing was conducted on a daily basis to comply with the requirements of GDOT 500 Class AAA concrete, designed to achieve strength of 5,000 psi at 28 days. The fresh concrete requirements were:

- Concrete slump: 4- to 8-inch target.
- Air content: 3 to 6 percent target.
- Concrete temperature: Less than 90 °F.

The testing of the fresh concrete was performed in the casting bed area (see Figure 24) with the concrete samples obtained from the concrete ready-mix truck. The concrete was produced at a batch plant located in the precast plant complex.


Figure 24. Photo. Testing of fresh concrete in the casting bay.

The concrete was placed in the formwork using an overhead bin, as shown in Figure 25. Concrete was consolidated using a hand-held vibrator.

Figure 25. Photo. Concrete placement and consolidation.

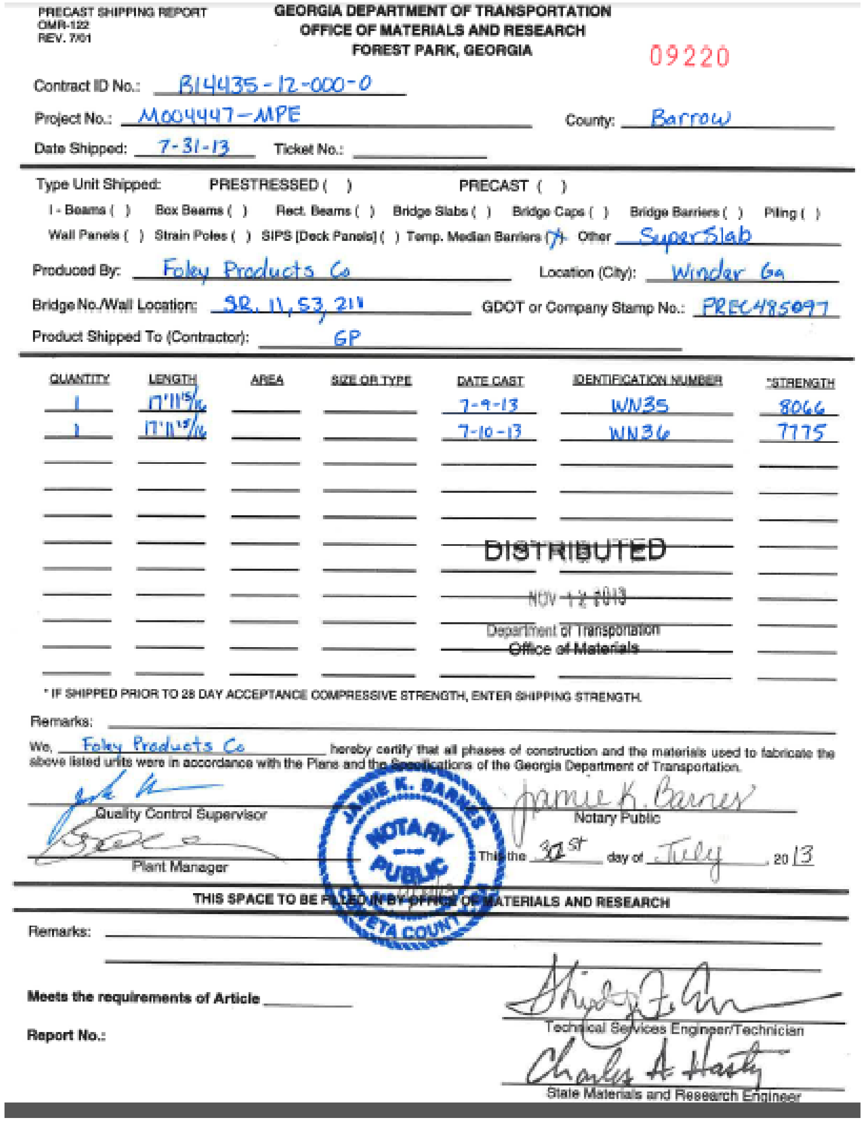
Concrete was finished using a roller screed, as shown in Figure 26, and a burlap drag texture was applied on the concrete surface. A curing compound was applied after the burlap drag.

Figure 26. Photo. Concrete surface finishing using a roller screed.

The forms were typically stripped after about 16 hours (next day) after the concrete had reached the specified strength for form stripping. The panels were then checked for dimensional tolerance. A longitudinal joint sawcut was then made in the two-lane-wide panels, as shown in Figure 27. After the panel finishing work had been completed, the panels were moved to outside storage locations using a gantry crane, as shown in Figure 28. A shipping report was prepared for each panel shipped to the site; Figure 29 shows a typical report. Flatbed trucks were used to transport panels from the plant to the site. Panel fabrication needs to precede the panel installation by several weeks to stockpile an adequate number of panels to be available once the installation work is performed at full speed. As noted, only six panels could be fabricated per weekday. However, at full production rate, the panel installation rate can be 15 to 20 panels per day.

Figure 27. Photo. Longitudinal sawcut in a two-lane wide panel (also showing dowel bar located at the sawed centerline).

Figure 28. Photos. Panels moved within the precast plant storage area using a gantry crane.



PRECAST SHIPPING REPORT
OMR-122
REV. 7/01

GEORGIA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS AND RESEARCH
FOREST PARK, GEORGIA

09220

Contract ID No.: B14435-12-000-0
Project No.: M004447-MPE County: Barrow
Date Shipped: 7-31-13 Ticket No.:

Type Unit Shipped: PRESTRESSED ( ) PRECAST ( )
I - Beams ( ) Box Beams ( ) Rect. Beams ( ) Bridge Slabs ( ) Bridge Caps ( ) Bridge Barriers ( ) Piling ( )
Wall Panels ( ) Strain Poles ( ) SIPS [Deck Panels] ( ) Temp. Median Barriers (X) Other Super Slab

Produced By: Foley Products Co Location (City): Winder Ga
Bridge No./Wall Location: SR. 11, 53, 211 GDOT or Company Stamp No.: PREC485097
Product Shipped To (Contractor): GP

| QUANTITY | LENGTH | AREA | SIZE OR TYPE | DATE CAST | IDENTIFICATION NUMBER | *STRENGTH |
|---|---|---|---|---|---|---|
| 1 | 17'11 5/16 | | | 7-9-13 | WN35 | 8066 |
| 1 | 17'11 5/16 | | | 7-10-13 | WN36 | 7775 |

DISTRIBUTED
NOV 12 2013
Department of Transportation
Office of Materials

* IF SHIPPED PRIOR TO 28 DAY ACCEPTANCE COMPRESSIVE STRENGTH, ENTER SHIPPING STRENGTH.

Remarks:

We, Foley Products Co hereby certify that all phases of construction and the materials used to fabricate the above listed units were in accordance with the Plans and the Specifications of the Georgia Department of Transportation.

Quality Control Supervisor
Plant Manager

JAMIE K. BARNES NOTARY PUBLIC COWETA COUNTY

Jamie K. Barnes
Notary Public
This the 31st day of July, 2013

THIS SPACE TO BE FILLED IN BY OFFICE OF MATERIALS AND RESEARCH

Remarks:

Meets the requirements of Article
Report No.:

Technical Services Engineer/Technician
State Materials and Research Engineer

Figure 29. Image. Typical precast panel report.

## PANEL INSTALLATION

Site preparation for panel installation began on July 22, 2013. Panel installation began during the night of July 23, 2013, and the last panels were installed on October 9, 2013. During that period, a total of 348 panels were installed. The panel installation rate was about 6 per night initially and increased to over 12 panels per night as work progressed and the contractor's crew gained more experience. The contractor had no previous experience with installing precast concrete panels. The later panel installation rate was in accordance with the contractor's planned installation rate based on late closure issues and crossing of intersections. During the first week of panel installation, a representative from the PCPS manufacturer was on site to assist the contractor's crew with the panel installation activities. The panel installation process typically included the following activities.

1. Established survey points for panel placement. The corner locations and elevations were marked on pavements in the adjacent lanes. Each panel was custom fabricated (typically, non-planar) and placed at a designated location.
2. After traffic closure was initiated during the daytime, the existing composite pavement was removed, typically to a depth of about 26 inches, using a hydraulic excavator, as shown in Figure 30. The work area opened up corresponded to the number of panels to be installed during a given lane closure. Any soft subgrade areas were removed (see Figure 31) and replaced using select subbase/fill material. For most precast concrete pavement projects, lane closures for existing pavement removal begins during late evening—no work is performed during the day—and the roadway section is opened to traffic the next morning.

Figure 30. Photo. Existing composite pavement removal.


Figure 31. Photo. Removing the softer subgrade material.

3. New granular base material was placed, graded, and compacted using a vibratory roller. Base compaction was regularly tested using a nuclear gage. Figure 32 and Figure 33show the base material placement and compaction being carried out.

Figure 32. Photos. Base material placement and compaction.


Figure 33. Photo. Granular base compaction testing using a nuclear gage.

4. Bedding material was spread over the base and graded to about 1/8 inch in 12-ft tolerance using a hand-operated screed, as shown in Figure 34. The bedding material thickness was variable, and up to a 1-inch-thick layer was used, as needed. The specified bedding layer thickness was a maximum of ¼ inch. The bedding material grading requires several successive passes of the hand-operated screed and additional hand work at the joint locations of a prior placed panel, as shown in Figure 35. This can become a time-consuming operation.


Figure 34. Photos. Bedding material placement and compaction.


Figure 35. Photos. Hand manipulation of the bedding material at a joint location.

5. The panels to be installed during a night closure were held in storage at a temporary holding location along a side street near the train station (along Porter Street near the start of the project).
6. The panel installation typically began after about 9 pm, after the crane was located on the previously placed precast panels. Traffic was maintained in both directions along the adjacent lanes. Views of the panel installation are shown in Figure 36. Panel installation typically lasted about 3 to 4 hours during the night. A typical panel installation layout is shown in Figure 37.

Figure 36. Photos. Typical views of panel installation along Broad Street.

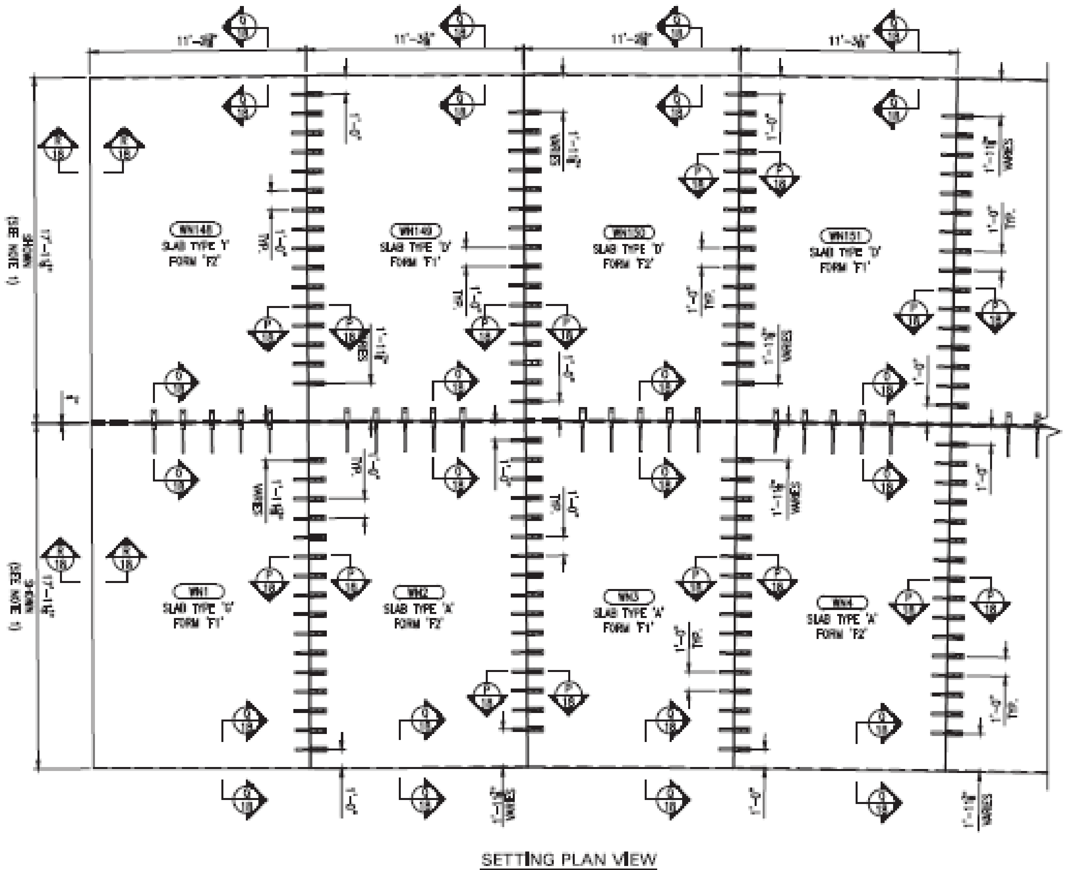



Figure 37. Diagram. Typical panel installation layout.

7. The panel installation required matching of elevations of adjacent panels. The GDOT specification allowed for elevation differential at joints of ¼ in. If the elevation of adjacent panels did not match at the transverse joint within the specified tolerance, the new panel was lifted out and the bedding grade adjusted. This process may need to be performed several times for a given panel and can be time-consuming. However, such situations did not occur frequently once the installation crew became more experienced.
8. The panels were opened to construction traffic the next day. Also, during the next day, the dowel slot grouting and undersealing operations were carried out.
    a. The non-shrink, high strength liquid dowel slot grout material used was designed to achieve 2,500 psi compressive strength in 2 hours. The grout material was pumped into the dowel slots using the two ports over each dowel slot. After the slots were filled, the grout material was poured into the joint gap along the perimeter of each panel and leveled off at the panel surface. The dowel slot grouting operation is shown in Figure 38.
    b. The bedding grout was a mixture of cement, water, and admixture, capable of flowing into thin voids under the panel. The bedding grout was designed to reach compressive strength of 600 psi in 12 hours. If the installed panels were opened to traffic before bedding grout was applied, GDOT specification required placement

of incompressible shims in each transverse joint to prevent the ungrouted slabs from hitting each other and causing concrete spalling.

Figure 38. Photo. Dowel slot grouting operation.

Table 3 summarizes the number of panels installed each night. As mentioned earlier, across a span of 79 calendar days (39 working days) from 23rd July, 2013 to 9th October, 2013, a total of 348 panels, at an average of 9 panels per day, were installed across the project location. Only 3 panels were installed on the first day. As the project progressed, the contractor's installation rates greatly increased from 6-8 slabs in the first few weeks to 10-14 slabs in the later weeks.

Table 3. Summary of the number of panels placed per closure.

| Winder Broad Street Daily Panel Installation | | | |
|---|---|---|---|
| Date | Starting Panel # Winder | Last Panel # Winder | Total Installed |
| 7/23/2013 | 1 | 3 | 3 |
| 7/24/2013 | 4 | 9 | 6 |
| 7/25/2013 | 10 | 15 | 6 |
| Day 7/29/2013 | 16 | 21 | 6 |
| Night 7/29/2013 | 22 | 28 | 7 |
| 7/30/2013 | 29 | 34 | 6 |
| 7/31/2013 | 35 | 40 | 6 |
| 8/1/2013 | 41 | 46 | 6 |
| 8/5/2013 | 47 | 52 | 6 |
| 8/7/2013 | 53 | 58 | 6 |
| 8/8/2013 | 59 | 66 | 8 |
| 8/12/2013 | 67 | 74 | 8 |
| 8/13/2013 | 75 | 82 | 8 |
| 8/14/2013 | 83 | 89 | 7 |
| 8/15/2013 | 90 | 93 | 4 |
| 8/20/2013 | 94 | 100 | 7 |
| 8/22/2013 | 101 | 110 | 10 |
| 8/23/2013 | 111 | 119 | 9 |
| 8/26/2013 | 120 | 130 | 11 |
| 8/27/2013 | 131 | 140 | 10 |
| 8/28/2013 | 141 | 147 | 7 |

Table 3. Summary of the number of panels placed per closure.

| Winder Broad Street Daily Panel Installation | | | |
|---|---|---|---|
| Date | Starting Panel # Winder | Last Panel # Winder | Total Installed |
| 9/4/2013 | 148 | 151 | 4 |
| 9/5/2013 | 152 | 173 | 22 |
| 9/6/2013 | 174 | 187 | 14 |
| 9/9/2013 | 188 | 197 | 10 |
| 9/10/2013 | 198 | 207 | 10 |
| 9/11/2013 | 208 | 213 | 6 |
| 9/16/2013 | 214 | 225 | 12 |
| 9/17/2013 | 226 | 239 | 14 |
| 9/19/2013 | 240 | 249 | 10 |
| 9/20/2013 (E) | 295 | 303 | 9 |
| 9/24/2013 | 250 | 261 | 12 |
| 9/25/2013 (E) | 304 | 315 | 12 |
| 9/26/2013 | 262 | 273 | 12 |
| 9/27/2013 | 274 | 283 | 10 |
| 10/3/2013 | 284 | 294 | 11 |
| 10/7/2013 | 316 | 326 | 11 |
| 10/8/2013 | 327 | 340 | 14 |
| 10/9/2013 | 341 | 348 | 8 |
| | | | 348 |

As work progressed on the installation along Broad Street, there were several parallel activities underway:

- Construction of the parking lanes adjacent to the precast pavement traffic lanes, as shown in Figure 39.
- Rehabilitation of the four intersecting streets. This work included new curb and gutter construction and AC resurfacing of the intersecting streets for about a block each, as shown in Figure 40.
- Streetscaping work that had started in April 2013. As of February 2014, the streetscaping work is in progress. Figure 41 shows Broad Street as of mid-February 2014.

Figure 39. Photos. Parking lane construction using asphalt concrete.


Figure 40. Photos. Resurfacing of an intersecting street.


Figure 41. Photo. A view of Broad Street as of mid-February 2014.

# DATA ACQUISITION AND ANALYSIS

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

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

This section discusses how well the GDOT met the specific HfL performance goals related to this project.

## SAFETY

The Winder PCPS project included the following HfL safety performance goals:

1. Achieving a work zone crash rate equal to or less than the existing conditions.
2. Achieving an incident rate for worker injuries less than 4.0 based on the OSHA 300 rate
3. Achieving a twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

No incidents occurred during the construction period, including the lane closure periods. The work zone safety was ensured through accelerated construction, lane closures, and use of offsite fabricated precast concrete panels. The HfL goal of achieving a work zone crash rate equal to or less than the preconstruction rate, was met.

The offsite fabrication of precast concrete panels limited the exposure of workers to typical on-site hazards associated with traditional cast-in-place construction methods. No worker injuries occurred during construction, which means GDOT exceeded the HfL goal for reducing incident rates and worker safety (incident rate of less than 4.0 based on the OSHA 300 rate).

In order to assess the safety conditions of the facility prior to the construction, the crash statistics were obtained for the project impact area, and are presented in Table 4. Table 5 presents the corresponding crash rates for the impact area, expressed as the number of crashes per 100 million vehicle miles traveled (VMT).

The facility safety after construction is yet to be determined. Pavement rehabilitation using the PCPS is expected to enhance the safety performance of this facility by reducing or eliminating potential safety issues resulting pavement rutting.

Table 4. Preconstruction crash statistics

| Route Description | Year | Beginning Mile Point | Ending Mile Point | No. Accidents | No. Vehicles | No. Injuries | No. Fatalities |
|---|---|---|---|---|---|---|---|
| SR 11/ North Broad Street (Mainline being reconstructed with Precast Concrete Pavement Slabs) | 2006-2008 | 6.80 | 7.23 | 150 | 304 | 28 | 0 |
| Bush Avenue | 2006-2008 | 0.01 | 0.06 | 3 | 6 | 2 | 0 |
| Porter St | 2006-2008 | 0.00 | 0.15 | 7 | 13 | 2 | 0 |
| Laura St | 2006-2008 | 0.00 | 0.04 | 1 | 2 | 0 | 0 |
| SR 211/Athens St West | 2006-2008 | 13.36 | 13.44 | 51 | 99 | 8 | 0 |
| Athens St East | 2006-2008 | 0.46 | 0.50 | 0 | 0 | 0 | 0 |
| Candler St West | 2006-2008 | 2.86 | 2.93 | 12 | 23 | 3 | 0 |
| Candler St East | 2006-2008 | 0.00 | 0.03 | 1 | 2 | 1 | 0 |
| Midland Ave West | 2006-2008 | 2.72 | 2.82 | 16 | 31 | 2 | 0 |
| Midland Ave East | 2006-2008 | 0.00 | 0.04 | 3 | 6 | 1 | 0 |
| Stephens St West | 2006-2008 | 0.25 | 0.31 | 15 | 32 | 2 | 0 |
| Stephens St East | 2006-2008 | 0.00 | 0.03 | 3 | 6 | 1 | 0 |

Table 5. Preconstruction crash rates

| Route Description | Year | Beginning Mile Point | Ending Mile Point | Total Vehicle Miles | Accident Rate* | Injury Rate* | Fatality Rate* |
|---|---|---|---|---|---|---|---|
| SR 11/ North Broad Street (Mainline being reconstructed with Precast Concrete Pavement Slabs) | 2006-2008 | 6.80 | 7.23 | 27056 | 4562 | 852 | 0 |
| Bush Avenue | 2006-2008 | 0.01 | 0.06 | 128 | 51370 | 34247 | 0 |
| Porter St | 2006-2008 | 0.00 | 0.15 | 897 | 6426 | 1836 | 0 |
| Laura St | 2006-2008 | 0.00 | 0.04 | 40 | 20145 | 0 | 0 |
| SR 211/Athens St West | 2006-2008 | 13.36 | 13.44 | 2178 | 19235 | 3016 | 0 |
| Athens St East | 2006-2008 | 0.46 | 0.50 | 554 | 0 | 0 | 0 |
| Candler St West | 2006-2008 | 2.86 | 2.93 | 629 | 15541 | 4245 | 0 |
| Candler St East | 2006-2008 | 0.00 | 0.03 | 150 | 5501 | 5501 | 0 |
| Midland Ave West | 2006-2008 | 2.72 | 2.82 | 1484 | 8825 | 1100 | 0 |
| Midland Ave East | 2006-2008 | 0.00 | 0.04 | 673 | 3436 | 1322 | 0 |
| Stephens St West | 2006-2008 | 0.25 | 0.31 | 155 | 79469 | 10621 | 0 |
| Stephens St East | 2006-2008 | 0.00 | 0.03 | 78 | 31738 | 10497 | 0 |

Note: * crash rates are expressed as the number of crashes per 100 million VMT.

Pavement rutting typically causes safety hazards for both motorists and pedestrians, and are listed as follows [1]:

For Vehicles

- Reduced frictional characteristics such as wheel path flushing
- Hazards during lane changes
- Increased risk of loss of driver control
- Presence of water ponds in wheel paths. These water ponds may form ice and the snow and ice removal may become more difficult.

For Pedestrians

- Reduced chances of tripping on the ruts during inclement weather.
- Reduced splashing by passing vehicles

The HfL goal for facility safety after construction will be evaluated later.

## CONSTRUCTION CONGESTION

### Faster Construction

On this project, 348 precast concrete panels, or 6,212 $yd^2$ of pavement, were installed in a span of 39 working days (79 calendar days). Per GDOT's estimates, it would have taken 29 days to place 6,212 $yd^2$ of concrete pavement using CIP construction. Thus, the HfL performance goal of achieving a fifty percent reduction in the time highway users are impacted, compared to traditional methods, was not met on this project.

### Travel Time and Queue Lengths

The travel time data for this project were collected using the floating car method. Several travel runs were performed before and during the project construction. The travel time data were collected during both peak and non-peak hours in mornings and evenings. The travel time runs were performed along the eastbound direction (from Porter Street & Broad Street to Stephens Street & Broad Street) and the westbound direction (from Stephens Street & Broad Street to Porter Street & Broad Street). Begin and end points of eastbound travel time data collection are presented in Figure 42 and Figure 43, respectively.

During the construction phase, for both the eastbound and the westbound direction, one of the two lanes was closed for panel installation purposes. Also, the GDOT maintained two-way traffic and removed turn lanes during the construction process. Tables 6 through 9 provide the travel time data. Given the urban nature of the project and the traffic variability, the travel times were collected for the following time periods:

1. Evening Peak (4:00 pm to 6:30 pm).
2. Evening Non-Peak (7:30 pm to 9:00 pm).
3. Morning Peak (7:00 am to 9:00 am).
4. Morning Non-Peak (10:00 pm to 1:00 pm).

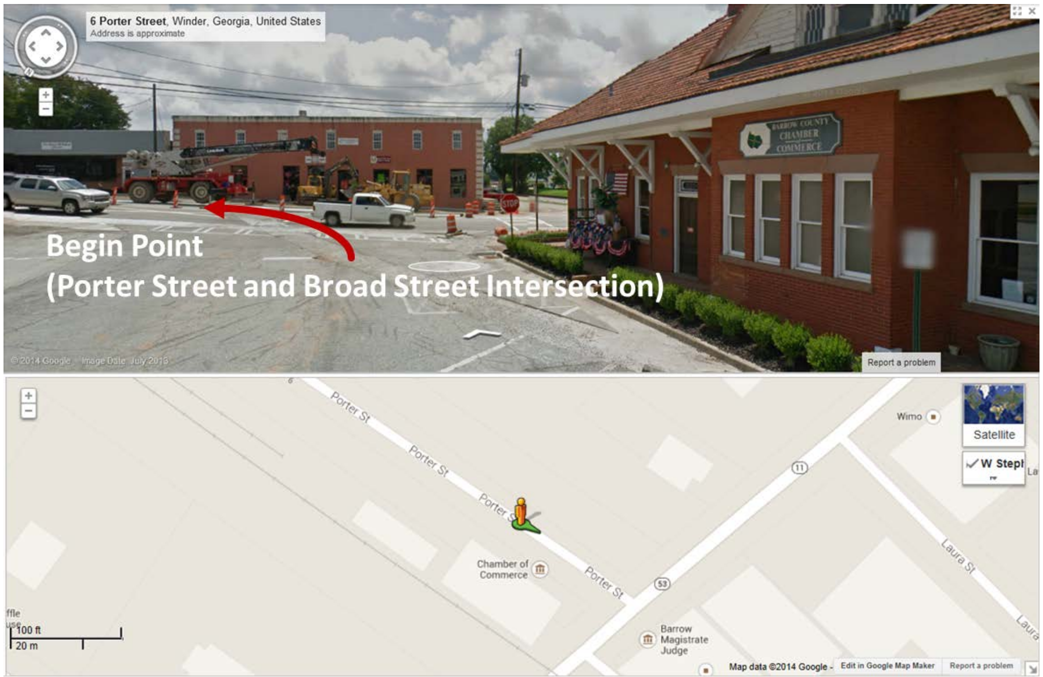



Figure 42. Map. Begin point for eastbound travel time data collection.

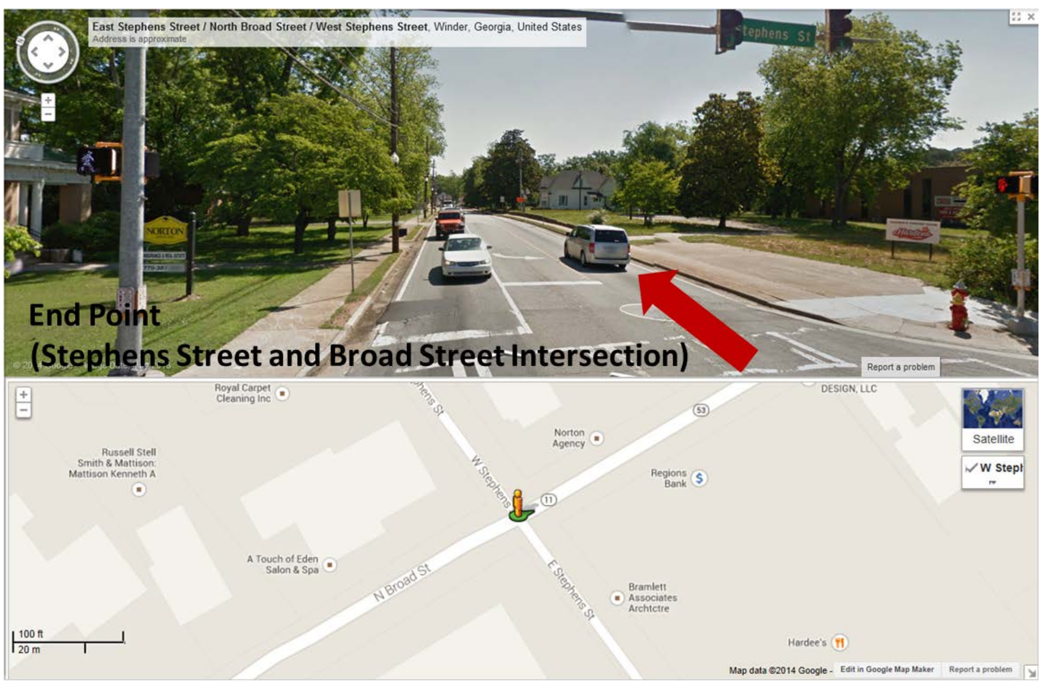



Figure 43. Map. End point for eastbound travel time data collection.

For each time period both before and during construction, the travel time data were averaged. The asterisked values presented in these tables were not included in the computation of the averages for each of the scenarios.

Table 6. Travel times before construction (eastbound).

| Measurement # | Evening Peak (min) | Morning Peak (min) | Evening Non-Peak (min) | Morning Non-Peak (min) |
|---|---|---|---|---|
| 1 | 2.30 | 1.39 | 0.89 | 0.79 |
| 2 | 1.94 | 1.43 | 0.79 | 0.74 |
| 3 | 2.21 | 1.46 | 0.71 | 0.78 |
| 4 | 2.33 | 1.27 | 0.65 | 0.73 |
| 5 | 2.54 | 1.45 | - | - |
| Average | 2.26 | 1.40 | 0.76 | 0.76 |

Table 7. Travel times before construction (westbound).

| Measurement # | Evening Peak (min) | Morning Peak (min) | Evening Non-Peak (min) | Morning Non-Peak (min) |
|---|---|---|---|---|
| 1 | 2.81 | 1.39 | 1.24 | 0.72 |
| 2 | 2.26 | 1.41 | 1.32 | 0.68 |
| 3 | 1.88 | 1.31 | 1.31 | 0.84 |
| 4 | 2.39 | 1.16 | - | 0.95 |
| 5 | - | 1.41 | - | - |
| Average | 2.33 | 1.34 | 1.29 | 0.80 |

Table 8. Travel times during construction (eastbound).

| Measurement # | Evening Peak (min) | Morning Peak (min) | Evening Non-Peak (min) | Morning Non-Peak (min) |
|---|---|---|---|---|
| 1 | 2.32 | 1.52 | 1.44 | 1.65 |
| 2 | 2.46 | 1.24 | 2.39* | 1.88 |
| 3 | 4.57* | 1.34 | 1.56 | 2.29 |
| 4 | 2.39 | 1.28 | 1.57 | 1.28 |
| 5 | 2.52 | 0.84** | 1.69 | 0.91** |
| 6 | 2.35 | 1.24 | 2.33* | 1.62 |
| 7 | 2.18 | 1.56 | - | 1.15 |
| 8 | 1.87 | 1.50 | - | 2.17 |
| 9 | 1.17 | 1.70 | - | 2.04 |
| 10 | 2.14 | 0.75** | - | 2.55* |
| 11 | 2.65 | 1.42 | - | - |
| 12 | 2.30 | 1.40 | - | - |
| 13 | 1.70 | - | - | - |
| 14 | 2.05 | - | - | - |
| Average | 2.16 | 1.42 | 1.56 | 1.76 |

*Increased travel times due to queuing (mainly because of the presence of commercial trucks)

**Reduced travel times due to absence of red signal phases along the route

Table 9. Travel times during construction (westbound).

| Measurement # | Evening Peak (min) | Morning Peak (min) | Evening Non-Peak (min) | Morning Non-Peak (min) |
|---|---|---|---|---|
| 1 | 1.96 | 1.34 | 0.98 | 1.02 |
| 2 | 3.78* | 1.54 | 1.16 | 1.29 |
| 3 | 2.52 | 1.17 | 0.84 | 1.69 |
| 4 | 2.69 | 1.48 | 1.10 | 1.58 |
| 5 | 2.87 | 0.85** | 0.87 | 1.87 |
| 6 | 4.47* | 1.38 | 1.31 | 1.39 |
| 7 | 2.73 | 1.64 | - | 2.99* |
| 8 | 3.26* | 0.69** | - | 2.25 |
| 9 | 3.16* | 1.68 | - | - |
| 10 | 1.83 | 1.36 | - | - |
| 11 | 2.12 | 1.39 | - | - |
| 12 | 2.70 | - | - | - |
| 13 | 2.79 | - | - | - |
| 14 | 1.56 | - | - | - |
| Average | 2.38 | 1.44 | 1.04 | 1.58 |

*Increased travel times due to queuing (mainly because of the presence of commercial trucks)
**Reduced travel times due to absence of red signal phases along the route

Travel time data indicate that, for both the eastbound and westbound traffic conditions, the average morning and evening peak travel times are comparable before and during construction. The morning non-peak travel times were found to be higher during construction than before construction. Compared to other time periods of the day, the trucks (commercial) passing through both directions were higher during the morning non-peak hours. The lane closure during this period resulted in increased travel times for trucks, which in turn affected the average travel time for all vehicles along the route. The reduced truck traffic during the evening non-peak hours resulted in less variability in travel times before and during construction in both directions. The travel time data were collected during this period to check if the panel installation process, usually 12 pm to 6 pm, led to increased travel times. There was no change in traffic plans during the panel installation, and the only traffic interruption of around 30 seconds to 1 minute occurred when the crane was moved from the traffic lane to the installation lane. Table 10 presents the travel times during the panel installations for both eastbound and westbound directions.

Table 10. Travel times during panel installation (eastbound and westbound).

| Measurement # | Eastbound (min) | Westbound (min) |
|---|---|---|
| 1 | 2.77 | 3.11 |
| 2 | 1.90 | 2.04 |
| 3 | 1.90 | 1.67 |
| 4 | 2.17 | 1.59 |
| 5 | 2.23 | 1.69 |
| Average | 2.19 | 2.02 |

The use of precast concrete panels led to little impact to the travel times, and in turn resulted in reducing the delay time on this project to help meet the HfL goal of less than 10 percent increase in travel time compared to average preconstruction scenario. The little impact on trip time through the length of the project was primarily because of signalized intersections within the project length and the rail crossing at one end of the project. Because of the signalized intersections and the presence of the rail crossing, the traffic was in a stop and go mode during the time of lane closures (typically at night) and during the time of no lane closures. It should be noted that the middle turn lane was typically closed to traffic during the panel installation period.

On this project, traffic backup occurred because of stoppages at the intersections and the rail crossing. As a result, the queue length that developed were a result of the delays that took place at the intersections and the rail crossing. The queuing was found to be higher during the morning non-peak hours due to increase in the number of trucks along the project route. However the queue lengths were shorter than 1.5 miles, and the HfL performance goal of less than a 1.5-mi queue length in urban areas was met.

In addition to the travel times, the traffic signal phase change intervals were clocked to determine the impact of the traffic signals on the vehicle travel times. The phase change intervals were collected for the signals at the following intersections:

- Broad Street and Athens Street.
- Broad Street and Candler Street.
- Broad Street and Midland Avenue.
- Broad Street and Stephens Street (during construction only).

Tables 11 and 12 present the traffic phase change intervals before and during construction.

Table 11. Preconstruction traffic phase change intervals.

| Measurement # | Athens to Broad (min) | Broad to Athens (min) | Candler to Broad (min) | Broad to Candler (min) | Midland to Broad (min) | Broad to Midland (min) |
|---|---|---|---|---|---|---|
| 1 | 1.83 | 1.70 | 1.82 | 1.82 | 2.00 | 1.98 |
| 2 | 1.84 | 1.95 | 1.90 | 1.83 | 2.00 | 1.99 |
| 3 | 1.83 | 1.93 | 1.77 | 1.85 | 2.00 | 2.00 |
| 4 | 1.84 | 1.72 | 1.91 | 1.83 | 2.00 | 2.00 |
| 5 | 1.83 | 1.95 | 1.79 | 1.82 | 2.00 | 2.00 |
| 6 | 1.83 | 1.45 | 1.76 | 1.83 | - | - |
| 7 | 1.83 | 2.22 | 1.83 | 1.84 | - | - |
| 8 | 1.83 | 1.68 | - | - | - | - |
| 9 | 1.84 | 1.84 | - | - | - | - |
| 10 | - | 1.63 | - | - | - | - |
| 11 | - | 2.10 | - | - | - | - |
| Average | 1.83 | 1.83 | 1.83 | 1.83 | 2.00 | 2.00 |

Table 12. During construction traffic phase change intervals.

| Measurement # | Athens to Broad (min) | Broad to Athens (min) | Candler to Broad (min) | Broad to Candler (min) | Midland to Broad (min) | Broad to Midland (min) | Stephens to Broad (min) | Broad to Stephens (min) |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.14 | 2.08 | 2.00 | 2.12 | 2.17 | 2.13 | 2.17 | 2.14 |
| 2 | 2.47 | 2.17 | 2.15 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 3 | 2.26 | 2.18 | 2.55 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 4 | 1.67 | 2.15 | 4.20* | 4.33* | 2.17 | 2.17 | 2.17 | 2.17 |
| 5 | 2.67 | 2.17 | 1.98 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 6 | 1.83 | 2.17 | 2.48 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 7 | 2.12 | 2.17 | 1.92 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 8 | 2.17 | 2.17 | 2.28 | 2.17 | 2.17 | 2.17 | 2.17 | 2.17 |
| 9 | 2.55 | 2.17 | - | - | 2.17 | 2.17 | 2.17 | 2.17 |
| 10 | - | - | - | - | 2.17 | 2.17 | 2.17 | 2.17 |
| Average | 2.21 | 2.16 | 2.20 | 2.16 | 2.17 | 2.16 | 2.17 | 2.16 |

*One signal cycle skipped due to the presence of just 1 vehicle on one of the approaching ends of the Candler Street

The average traffic phase change interval times during construction were higher than those before construction.

## QUALITY

### Smoothness

The GDOT specification for this project required pavement profile measurement using a Rainhart Profilograph. Profile testing was required to be conducted in accordance with Georgia test method GDT 78 along each lane. The testing was to be conducted after diamond grinding along the full width and length of the project. The ground surface profile was required to be corrected if the Profile Index was measured to be greater than 12 inches/mile. In addition, the specification required the following corrective work by additional grinding if:

- Individual bumps or depressions exceeded more than 0.2 inches.
- Any elevation differential between two adjacent edges exceeded 1/16 inch.

The profilograph results and the corresponding profile indices for three segments across the project section were obtained from GDOT. The profile indices and the equivalent IRI values for 3 segments tested across the project section have been presented in Table 13.

Table 13. IRI Data Summary

| Segment No. | From Location | To Location | Direction | Lane No. | Profile Index | Equivalent IRI, in/mi |
|---|---|---|---|---|---|---|
| 1 | 2+58 | 18+60 | North | 1 | 8.74 | 57.3 |
| 2 | 18+59 | 2+40 | South | 1 | 7.18 | 56.8 |
| 3 | 18+60 | 12+87 | South | 2 | 5.53 | 57.0 |

To estimate equivalent IRI from profile index, the following equation developed by Smith et al.[2] for concrete pavements in wet no freeze zone was used:

$$\mathrm{IRI} = 2.40731 * \mathrm{PI}_{2.5\mathrm{mm}} + 888.10 \tag{1}$$

The HfL performance goal on International Roughness Index (IRI) requires that the IRI value for the project section be less than 48 inches per mile. On this project, the IRI values were found to be ranging from 56.8 in/mi to 57.3 in/mi across three segments. Although the panel placement on this project was well controlled so that the panel-to-panel elevation difference was typically less than ¼ inch, the HfL goal on IRI was not met.

**Noise**

With a proposed speed limit of only 35 mph for the completed project, no HfL goal for noise was included.

**Durability**

Several innovations included in this project are expected to improve the durability and performance of the final project:

- Use of higher strength concrete with a required compressive strength of 5,000 psi at 28 days.
- Very durable precast panels incorporating good load transfer at transverse joints. In addition, the panels are adequately reinforced and will keep any cracking that may develop in the future very tight.

## USER SATISFACTION

GDOT conducted an initial public survey to gauge the traveling public opinion. A total of 232 responses were received on this survey. The travel frequency of the commuting public has been provided in Figure 44.

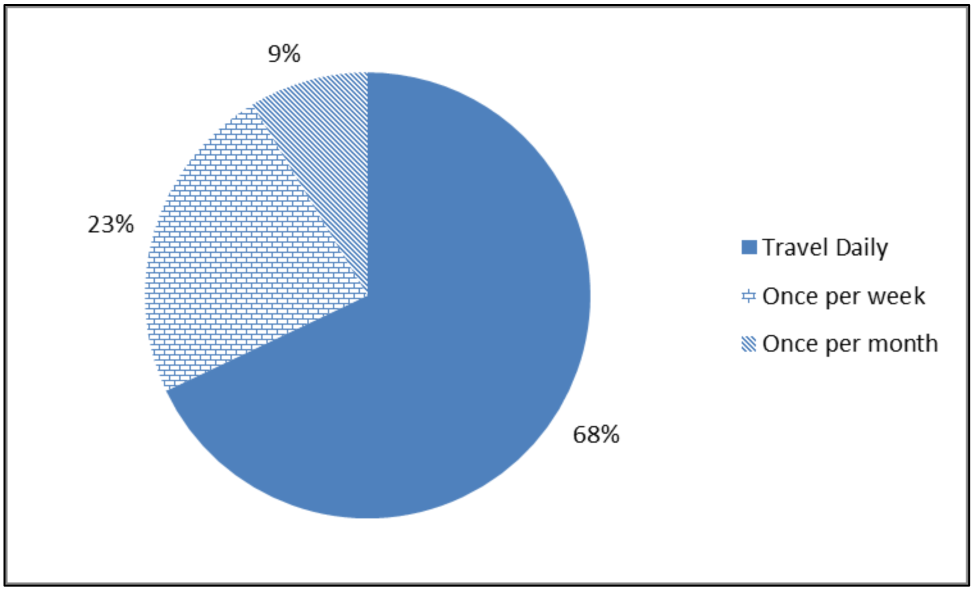


Figure 44. Initial survey results on the travel frequency.

The initial survey results indicated that around 90 percent of the commuters were the residents of the Winder area. The rest of the respondents were either non-resident commuters or business-owners. It was learnt from this survey that more than 95 percent of the respondents felt that the project area needed improvement.

The initial survey was followed by a second and final survey at the conclusion of the project, and the following areas were focused upon:

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

The final user satisfaction survey results are awaited from GDOT.

Increased public satisfaction is expected to result from the improved roadway surface and the streetscaping work performed along Broad Street.

# ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This involves comparing the benefits and costs associated with the innovative PCPS adopted on an HfL project with those from a more traditional construction technique on a project of similar size and scope. The latter type of project is referred to as a baseline case and is an important component of the economic analysis. For this economic analysis, the GDOT supplied the cost figures for the as-built project and baseline construction. Traditional methods would have involved the use of cast-in-place (CIP) concrete pavement construction.

## CONSTRUCTION TIME

As mentioned earlier in this report, it took 39 working days (79 calendar days) to install 348 precast concrete panels, or 6,212 $yd^2$ of pavement, on this project, which is 10 days more than that using the CIP construction technique.

The production rate with PCPS is expected to improve on future projects. Furthermore, the fabrication of concrete panels eliminated the need to have longer work zone hours for curing purposes (typically 6 to 24 hours of additional curing time).

## CONSTRUCTION COSTS

Table 13 presents a comparison of total project costs as well as concrete pavement construction costs of the baseline and the as-built alternatives. With the PCPS option, the unit price of concrete ($\$/yd^2$ for Item 439-0525) was $257.84, while the bid prices for this pay item varied between $257.84 and $431.36. With the baseline option, the GDOT estimated the unit price of concrete ($\$/yd^2$ for Item 439-0020) would have been $64.75. The estimate for Item 439-0020 was based on the mean and weighted cost of bid prices received between February 10, 2012, and February 10. 2014.

The comparison shows the as-built total cost was $3,466,615 compared to $2,245,684 for the baseline total cost. Considering only the concrete pavement-related portion of the contract and related inspection and engineering costs, the as-built PCPS costs were 265 percent higher than the baseline CIP concrete costs.

Table 14. Comparison of total project costs and concrete pavement related pay items.

<table>
<tr><th>Item Description</th><th>As-built PCPS</th><th>Baseline CIP Concrete</th><th>Difference</th></tr>
<tr><td>Item 439-0525<br>Precast Concrete Pavement<br>6,212 SY of 8.5-in. thick</td><td>$1,601,702<br>($257.84/ yd$^2$)</td><td></td><td rowspan="2">300 %</td></tr>
<tr><td>Item 439-0020<br>Plain Concrete Pavement<br>6,212 SY of 9.0-in. thick</td><td></td><td>$400,802.50<br>($64.75/ yd$^2$)</td></tr>
</table>

| **Item Description** | **As-built PCPS** | **Baseline CIP Concrete** | **Difference** |
|---|---|---|---|
| Inspection/Engineering | $277,329 | $112,284 | 147% |
| **Subtotal (Concrete Pavement Only)** | $1,879,031 | $513,086.50 | 266% |
| **Total Project Costs** | $3,472,211 | $2,245,684 | 55% |

### User Costs

Generally, three categories of user costs are used in an economic analysis: vehicle operating costs, delay costs, and crash- and safety-related costs. Only delay costs were considered in the user cost analysis for this project.

The difference in travel times before and during construction is used to calculate travel time delays and, in turn, the delay costs. Table 14 presents the travel time differences at morning and evening peak travel times, as well as at morning and evening non-peak times.

Table 15. Travel time delays before and during construction.

| | | Travel time (min) | | | |
|---|---|---|---|---|---|
| Direction | Construction Scenario | Evening Peak | Morning Peak | Evening Non-Peak | Morning Non-Peak |
| EB | Preconstruction | 2.26 | 1.4 | 0.76 | 0.76 |
| | During construction | 2.16 | 1.42 | 1.56 | 1.76 |
| | Delay | -0.1 | 0.02 | 0.8 | 1 |
| WB | Preconstruction | 2.33 | 1.34 | 1.29 | 0.8 |
| | During construction | 2.38 | 1.44 | 1.04 | 1.58 |
| | Delay | 0.05 | 0.1 | -0.25 | 0.78 |

The assumptions used in the computation of user costs are presented as follows:

- The average daily traffic (ADT) at the project location is 19,390 with 13 percent trucks.
- The estimated delay time per vehicle is an average of delay times measured during various peak and non-peak periods.
  - Estimated delay time per vehicle in the EB direction = 0.43 min/veh.
  - Estimated delay time per vehicle in the EB direction = 0.17 min/veh.
  - Total delay time per day = 19,390 * (0.43+0.17)/2 = 5817 min = 96.95 veh-hrs.
- The estimated monetary value of hourly delay costs for automobiles and trucks are $21.38 and $27.99/veh-h, respectively. The hourly delay cost for automobiles was estimated based on the median household income for Barrow County, Georgia, which was $51,202 for the years 2008-2012, and the procedures presented in Mallela and Sadasivam [(3) (4)]. The hourly delay cost for trucks was estimated as a sum of 2013 wages of truck drivers in Barrow County ($20 and $17.89 for heavy and light trucks, respectively) and the Bureau of Labor Statistics' Employer Cost of Employee Compensation ($9.04 in December 2013) [(5)].

Using these assumptions and cost figures, the delay costs are estimated as follows:

**<u>Baseline Case - CIP</u>**

Number of days of construction = 29

Total estimated delay = 29 days * 96.95 veh-hrs/day = 2811.55 veh-hrs

User delay costs = 2811.55 veh-hrs * ($21.38/veh-hr *0.87 (percent auto) + $27.99*0.13 (percent trucks)) = $62,525.08

**<u>As-Built Case - PCPS</u>**

Number of days of construction = 39

Total estimated delay = 39 days * 96.95 veh-hrs/day = 3781.05 veh-hrs

User delay costs = 3781.05 veh-hrs * ($21.38/veh-hr *0.87 (percent auto) + $27.99*0.13 (percent trucks)) = $84,085.45

The total difference in user delay costs between baseline and as-built scenarios is as follows:
Delay Differential = $62,525.08 (Baseline) - $84,085.45 (as-built) = - $21560.37

With the use of PCPS, there was an estimated increase of $21,560 in user delay costs, primarily due to the increase of number of working days.

### LIFE CYCLE COST ANALYSIS

A life cycle cost analysis is not required for this project. The difference in life cycle costs between the two alternatives is largely confined to their initial construction costs. The benefit of superior structural performance expected from the PCPS option was already incorporated through the reduction in design pavement thickness. Furthermore, the future maintenance requirements, in terms of joint resealing and grinding at about 15 to 20 years, would be similar for both options.

### SUMMARY AND CONCLUSIONS

The PCPS alternative cost more than the traditional alternative in terms of both agency and user delay costs. However, it is expected that the cost of using PCPS will decline as the GDOT and contractors gain more experience with this technology.

# TECHNOLOGY TRANSFER

To promote further interest and use of the innovations included in this project, GDOT, in conjunction with the City of Winder and the FHWA, sponsored a 1-day showcase. The showcase was held on September 26, 2013 at the Community Center in Winder. The event featured presentations by the FHWA, GDOT, the project contractor, the project precaster, and FHWA's HfL contractor. The presentations were followed by a field trip to the project site to observe the site preparation work during the late afternoon and to observe panel installation during the late evening. The attendees left the work site just before midnight.

The showcase activities were managed by the Florida Transportation Technology Transfer Center at the University of Florida Transportation Institute, Gainesville, Florida. About 86 people attended the showcase. The attendees included GDOT staff from the central office and several district offices, FHWA staff, local agencies from Georgia, engineering consultants, and contractors. Figure 45 shows photos from the showcase and Figure 46 is a copy of the showcase agenda.


Figure 45. Photos. Showcase photos.

U.S. Department of Transportation
Federal Highway Administration

# SR 11/Broad Street Pavement Rehabilitation Showcase

Utilizing Precast Concrete Pavement Systems (PCPS) in Historic Downtown Winder, GA

# AGENDA

HIGHWAYS FOR LIFE

**Thursday, September 26, 2013**
***Winder Cultural Arts Center Theater***

**Moderator: Dana Robbins, Technology Applications Team Leader – FHWA, Georgia Division**

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|---|---|
| **8:00am** | **Registration/Check-in** |
| **9:00am - 9:15am** | **Welcome Remarks**<br>Honorable David Maynard, Mayor – City of Winder |
| **9:15am - 9:25am** | **Highways for LIFE Overview**<br>Video Presentation |
| **9:25am - 10:00am** | **National Perspective of Precast Concrete Pavement Systems**<br>Shiraz Tayabji, Principal Engineer – Applied Research Associates |
| **10:00am - 10:45am** | **Project Design Overview**<br>Andy Casey, State Roadway Design Engineer – GDOT |
| **10:45am - 11:00am** | **Break** |
| **11:00am - 12:00pm** | **Project Construction Panel Discussion**<br>Brent Cook, Assistant District Engineer – GDOT<br>Jason Dykes, Assistant District Construction Engineer – GDOT<br>Shannon Giles, Complex Project Engineer – GDOT<br>Harold Mull, District Construction Engineer – GDOT<br>Tim Phillips, Vice President – GP's Enterpises |
| **12:00pm - 1:00pm** | **Lunch** ***(Conference Room)*** |
| **1:00pm - 1:20pm** | **Precast Presentation**<br>Peter Smith, Vice President – The Fort Miller Company |
| **1:20pm - 1:40pm** | **Precaster Presentation**<br>Denniss Morrissey, Operations Manager – Foley Products, Inc. |
| **1:40pm - 2:40pm** | **Lessons Learned Panel Discussion**<br>Brent Cook, Assistant District Engineer – GDOT<br>Denniss Morrissey, Operations Manager – Foley Products, Inc.<br>Harold Mull, District Construction Engineer – GDOT<br>Tim Phillips, Vice President – GP's Enterprises<br>Shiraz Tayabji, Principal Engineer – Applied Research Associates |
| **2:40pm - 3:00pm** | **Break** |

Figure 46. Image. Open house agenda.

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|---|---|
| 3:00pm - 4:30pm | Site Visit to View Grading and Grouting |
| 4:30pm - 5:00pm | Break |
| 5:00pm - 6:30pm | Dinner |
| 6:30pm - 9:00pm | Break |
| 9:00pm - 10:30pm | Site Visit to View Panel Placement |
| 10:30pm - 11:00pm | Questions/Wrap-up *(Cultural Arts Center)* |

## *Special Thanks to:*

U.S.Department of Transportation
**Federal Highway Administration**

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

GDOT
Georgia Department of Transportation

Keck & Wood, Inc.

Georgia Concrete Paving Association GCPA

Figure 46. Image. Open house agenda. (contd.)

# REFERENCES


1. Federation of Canadian Municipalities and Canadian National Research Council. “Roads and Sidewalks: Rut Mitigation Techniques at Intersections”, Issue No. 1.0, National Guide to Sustainable Municipal Infrastructure, Canada, September 9, 2014.
2. Smith, Kelly L., Leslie Titus-Glover, and Lynn D. Evans. Pavement smoothness index relationships. No. FHWA-RD-02-057, 2002.
3. State & County QuickFacts for Barrow County, Georgia, The United States Census Bureau. http://quickfacts.census.gov/qfd/states/13/13013.html (accessed October 11, 2014).
4. Mallela and Sadasivam, *Work Zone Road User Costs Concepts and Applications*, Report No. FHWA-HOP-12-005, Federal Highway Administration, Washington, DC, 2011.
5. GDOL, 2013 Occupational Wage Statistics for Barrow County, Georgia Department of Labor, Atlanta (accessed October 11, 2014). https://explorer.dol.state.ga.us/vosnet/Default.aspx

# ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of FHWA HfL Team Leader Byron Lord, Contracting Officer's Representative Julie Zirlin, and Program Managers Ewa Flom, Mary Huie, and Kathleen Bergeron, who served on the technical panel on the demonstration project. Also, the project team would like to thank the following for their support of the demonstration project and for providing information on the design, construction, and initial performance of the project:

- Kendra Fly, FHWA Georgia Division
- GDOT
    - Georgene Geary
    - C. Andy Casey
    - Teri Pope
    - Theresa Holder
    - Clay Bastian
    - Erik Rohde
    - Harold Mull
    - Kevin DeWitt
    - Marc Phillips
- G.P.'s Enterprises, Athens, Georgia
- Precaster
    - Foley Products Company
- Fort Miller Company