DOCUMENTATION OF THE RAPID REPLACEMENT

OF FOUR GDOT BRIDGE DECKS

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DOCUMENTATION OF THE RAPID REPLACEMENT OF FOUR GDOT BRIDGE DECKS

Joshua Matthew Umphrey

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DOCUMENTATION OF THE RAPID REPLACEMENT

OF FOUR GDOT BRIDGE DECKS

Joshua Matthew Umphrey

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Date of Graduation

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Joshua Matthew Umphrey, son of Frankie and Marsha Umphrey, was born November 17, 1981, in Gadsden, Alabama. He graduated from West End High School of Walnut Grove, Alabama in May 2000. He attended Snead State Community College in Boaz, Alabama, for two years, then entered Auburn University in August 2002 and graduated with a Bachelor of Science degree in Civil Engineering in December 2004. He married Neva Works, daughter of Autry and Diane Works, on December 18, 2004. He then entered Graduate School at Auburn University in January 2005 and completed a Master of Science degree in May 2006 with an emphasis in Structural Engineering.

THESIS ABSTRACT

DOCUMENTATION OF THE RAPID REPLACEMENT

OF FOUR GDOT BRIDGE DECKS

Joshua Matthew Umphrey

Master of Science, May 11, 2006
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226 Typed Pages

Directed by G. Ed Ramey

The Alabama Department of Transportation (ALDOT) has many interstate bridges near downtown Birmingham which have good substructures and superstructures, but suffer from significant deck cracking and deterioration. The bridges carry tremendous volumes of traffic with no good detouring routes and thus present a need for rapid bridge deck replacement. The ALDOT plans to place a field "test bridge" in the near future that utilizes four different rapid bridge deck replacement systems to determine the most efficient option for the Birmingham bridge decks.

The objectives of this research were to monitor and document the rapid bridge deck replacement work of the Georgia Department of Transportation (GDOT) on two bridges in Gainesville, GA and two bridges in the Atlanta, GA area, and to identify

design and construction problem areas and corrective actions that should eliminate these problems in future rapid deck replacements. In doing so, some of the problems and pitfalls of rapid bridge deck replacement via the use of precast Exodermic deck panels were identified. Documentation of the actual GDOT work included a time sequence, deck replacement square footage per work period, total construction time, typical nightly construction tasks, photographic display/discussion of the deck replacement and deck overlay work, and identification of design and construction problem areas.

The precast Exodermic deck panel system used by the GDOT provided an excellent means for rapid bridge deck replacement while under stage construction/concurrent traffic conditions. The GDOT work was completed within the imposed time limits while maintaining minimum traffic interruption. Identification of problem areas encountered while monitoring the rapid bridge deck replacement work offer potential improvements for future bridge deck replacement projects that employ precast Exodermic deck panels. It is recommended that the ALDOT employ the precast Exodermic deck panels as one of the replacement systems on its “test bridge” in Collinsville, AL with the suggested design and/or construction improvement ideas presented in this report. It is also recommended that the ALDOT employ unfilled Exodermic deck panels with a rapid-setting cast-in-place (CIP) concrete topping as one of the test systems on its “test bridge”.

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The author is also grateful for the help and assistance of Mr. Toby Hammonds, Construction Project Manager of the Gainesville, GA Area 1, during the deck replacement work in Gainesville, GA. The author is grateful to Gilbert Southern Corporation for allowing him to monitor work on the rapid deck replacement of two bridge decks in Gainesville, GA. Particular thanks are due to Mr. Brad Blough, Business Manager of Gilbert Southern, for his assistance in documenting the rapid deck replacement work in Gainesville, GA. The author is also grateful to L.C. Whitford Company, Inc. for allowing him to monitor and observe work on the rapid bridge deck replacement of two bridge decks in Atlanta, GA. Particular thanks are due to Mr. Ernie Clark, General Superintendent with L.C. Whitford Company, for his assistance in documenting the rapid deck replacement work in Atlanta, GA.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Statement of Problem

The Alabama Department of Transportation (ALDOT) has many bridges that have good substructures and superstructures, but suffer from significant deck cracking and deterioration. The ALDOT currently has over 600,000 square feet of interstate bridge decks near downtown Birmingham that fall into this category of badly deteriorating bridge decks (1). The deteriorating bridge decks have ALDOT engineers needing to decide on the best replacement/rehabilitation strategy for these decks. The bridges carry tremendous volumes of traffic with no good detouring routes. Hence, the replacement/rehabilitation deck work will have to be done in a staged construction manner with minimal traffic interference.

The factors that will help the ALDOT in deciding which replacement strategy will lend itself best to the Birmingham bridge decks are,

- construction “friendliness”
- required traffic disruptions
- costs.

Addressing these factors is the impetus and purpose of this Phase II research (1). The plan for addressing these factors is to place a field “test bridge” that utilizes the four rapid deck replacement systems as recommended in our earlier Phase I work. These replacement systems will be employed on different spans of the bridge. The “test bridge” is located on I-59 over SR68 at Collinsville, AL and is scheduled for deck replacement in the fiscal year 2006 (2). The "test bridge" only carries two lanes, but otherwise is quite similar to the bridges on I-65 and I-59/20 through Birmingham.

The Georgia Department of Transportation (GDOT) has four bridge decks that received rapid replacement/rehabilitation work due to deck deterioration. Two of these bridges are located in Gainesville, GA and the other two bridges in the Atlanta, GA area. The deck replacement plans for these bridges were similar to those in the Birmingham area and those for the "test bridge." It was recognized much could be learned from the four bridge deck replacements in Georgia, and this is precisely the motive and purpose of this investigation.

1.2 Objectives

The objectives of this research work were to monitor and document the rapid deck replacement work on two bridges in Gainesville, GA and two bridges in the Atlanta, GA area, and to identify design and construction problem areas and corrective actions that should eliminate these in future rapid deck replacements. This record will be beneficial to the ALDOT in that it will serve to identify some of the problems of rapid bridge deck replacement via the use of precast Exodermic deck panels. This in turn will help the ALDOT when doing similar deck replacement work on the many bridges in Birmingham, AL.

1.3 Work Plan

The work plan to accomplish the above objectives is briefly outlined below:

1. Review Phase I Report of Oliver/Ramey (1) and Phase II-Part III Report of Beck/Ramey (2), with particular attention on deck replacements using

Exodermic panels.

2. Review Phase II Report of Jacoway/Ramey (3) and Phase II-Part IV Report of Ramey (4), with particular attention to Flexogrid polymer concrete overlays.
3. Visit with Gilbert Southern Corporation (Gainesville bridge deck replacement contractor) to learn the tentative construction schedule and any design changes for the deck replacement work. Also coordinate with Gilbert Southern to permit us to observe and document the replacement work on the Longstreet Bridge and Bell's Mill Bridge.
4. Document deck replacement work on the two Gainesville bridges (i.e. Longstreet and Bell's Mill) to include construction stages, traffic control, deck replacement square footage, design and/or construction problem areas, and total construction time.
5. Visit L.C. Whitford Co. Inc. (Atlanta bridge deck replacement contractor), and learn the tentative construction schedule and any design changes for deck replacement work. Also coordinate with L.C. Whitford Co. Inc. to allow us to observe and document the replacement work on the I-285 bridges over Buford Highway and the I-285 bridges over U.S. 41.
6. Document deck replacement work on the two Atlanta bridges (i.e. I-285 bridges over Buford Highway and the I-285 bridges over U.S. 41) to include construction stages, traffic control, deck replacement square footage, design and/or construction problem areas, and total construction time.
7. Summarize problem areas observed and identify areas where improvements could be made in the deck replacement process. Make recommendations

which are appropriate for the ALDOT to employ in executing the replacement/rehabilitation strategies into their "test bridge" and bridges in Birmingham, AL.

8. Prepare thesis documenting and reporting on 1-7 above.

1.4 Scope

Gilbert Southern Corporation was awarded a contract by the GDOT in July 2004 for the deck replacement work on the Bell's Mill Bridge and the Longstreet Bridge in Gainesville, GA. Gilbert Southern was responsible for carrying out the deck replacement design and construction plans/documents for these two bridges. As with the bridges in Gainesville, GA, the two Atlanta bridges were also put out for bid together, and L.C. Whitford Co., Inc. was awarded the contract for carrying out the deck replacement design and construction plans in October 2004. Rapid bridge deck replacement was a vital task and was executed throughout the entire construction process. To accomplish this, the GDOT used precast Exodermic deck panels on all four of these bridge deck replacements. The Exodermic deck panels were overfilled ¼", and after all closure pours the deck was ground smooth for good rideability. The panels were designed explicitly for each bridge since each bridge possessed its own unique geometry.

This thesis was prepared to provide the ALDOT with detailed information on deck replacement using Exodermic deck panels, in order to assist them in the bridge deck replacements in Birmingham, AL. Documentation of the GDOT work included records of the time sequence, work window, traffic control, amount of deck replacement square footage per work period, total construction time, typical nightly construction tasks, and photographic display/discussion of the deck replacement work and deck overlay work. This work and its results are presented in this thesis.

2. LITERATURE REVIEW

2.1 General

The Alabama Department of Transportation (ALDOT) currently has over 600,000 square feet of interstate bridge decks in Birmingham, AL that are deteriorating badly and will need replacement in about 10 years (1). Traffic interference is a major concern on the Birmingham bridge decks and replacement in a rapid manner is desired. The ALDOT has decided to test four different deck replacement systems by placing each system on one span of a "test bridge" in a staged construction manner. The four deck replacement systems planned are (2):

- a continuous precast prestressed stay-in-place (SIP) form system with a cast-in-place (CIP) concrete topping
- an Exodermic steel panel system with a CIP concrete topping
- a steel grid panel system with a CIP concrete topping
- a fast-tracked SIP metal form system with a CIP concrete deck.

Placement of these four systems will allow the ALDOT to evaluate and compare the primary parameters of concern for each deck replacement system before choosing the preferred system. The GDOT rehabilitated four bridge decks using the Exodermic system (see Figure 2.1), and since their deck replacement plan closely parallels the Birmingham bridge plan, it is the ALDOT's goal to learn as much as they can about rapid Exodermic bridge deck replacement via monitoring of the GDOT work.

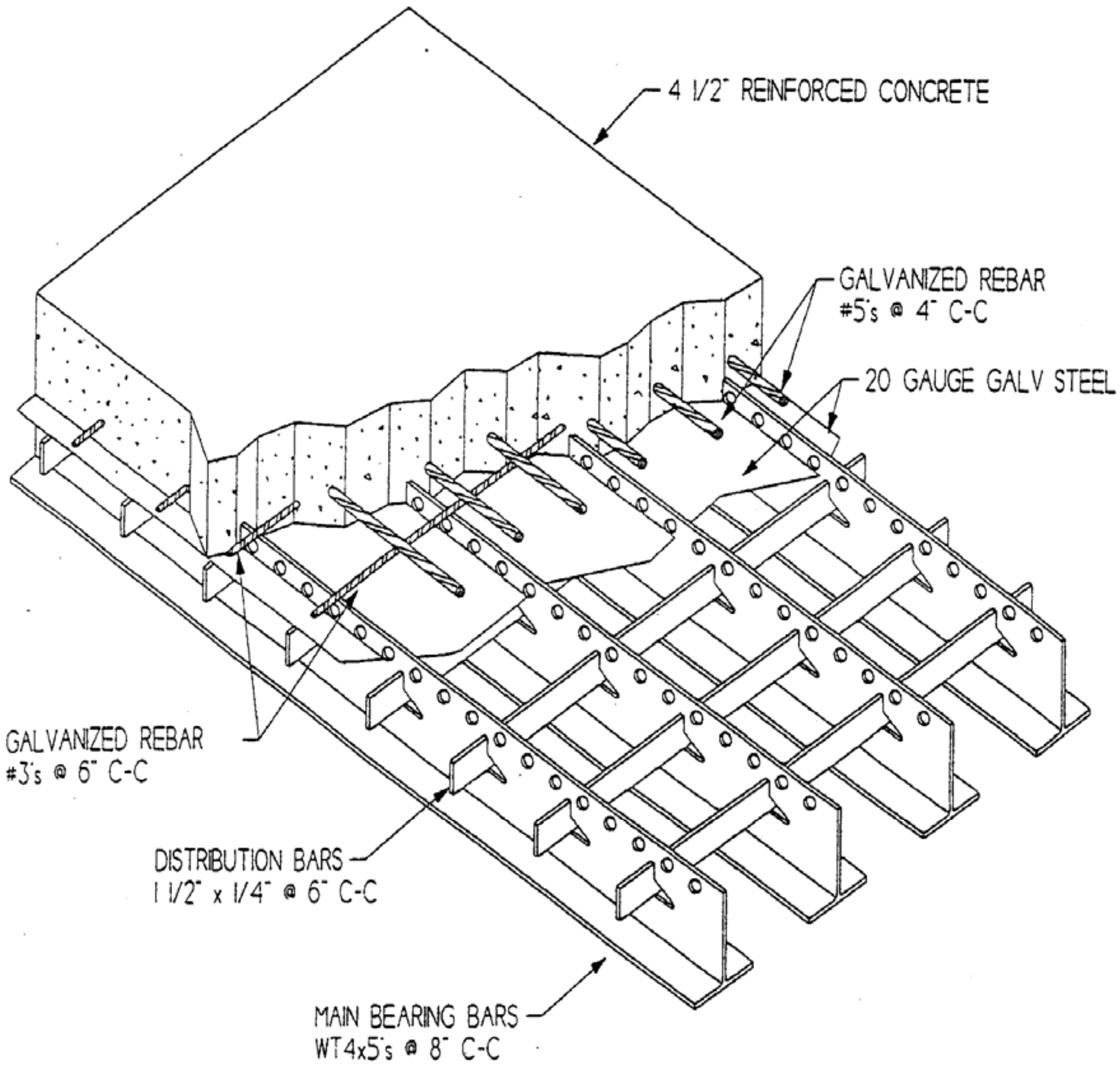


Fig. 2.1 Isometric Cut-Away View of Exodermic Deck Panel (2)

2.2 Literature Review

The Georgia Department of Transportation (GDOT) recently replaced two bridge decks in Gainesville, GA and two in the Atlanta, GA area in a rapid manner. The locations of the bridges in Gainesville and Atlanta are identified in Figures 2.2a and 2.2b. While the ALDOT is awaiting placement of decks on its “test bridge,” the current state of the four Georgia bridge decks were documented in the Beck/Ramey report (2). Also found in Chapter 3 of that report is the relevant information concerning each bridge.

Longstreet Bridge. The Longstreet Bridge is located in north Gainesville, GA. It has an Average Daily Traffic (ADT) of 18,300 vehicles with truck traffic making up only 5% of that total (2). Figure 2.3 shows plan and elevation drawings of the Longstreet Bridge. As can be seen in this figure, the bridge has a total structural length of 824 feet that is divided into six main spans (2). Photos of the Longstreet Bridge are shown in Figs. 2.4-2.8. Figure 2.4 shows the significant size of the bridge from an elevation view. Figure 2.5 shows an underneath view of the Longstreet Bridge. The superstructure consists of a concrete deck supported by five longitudinal stringers (WF 14 at approximately 6’-6” spacing) running the entire length of the bridge. The stringers are supported by cross-girders (WF 33 at approximately 13’ spacing), and these are supported at each end by a haunched girder (varying in depth from 5’-9” to 10’-9”) (2). It should be noted that the concrete deck and steel stringers were not connected for composite action. Figures 2.6 and 2.7 show the bridge deck from a topside overview and a close-up perspective. These figures show many transverse cracks and cracks previously repaired. Notice that the bridge is only two lanes wide with no shoulders, and has steel guard rails which remained in place during the deck replacement.

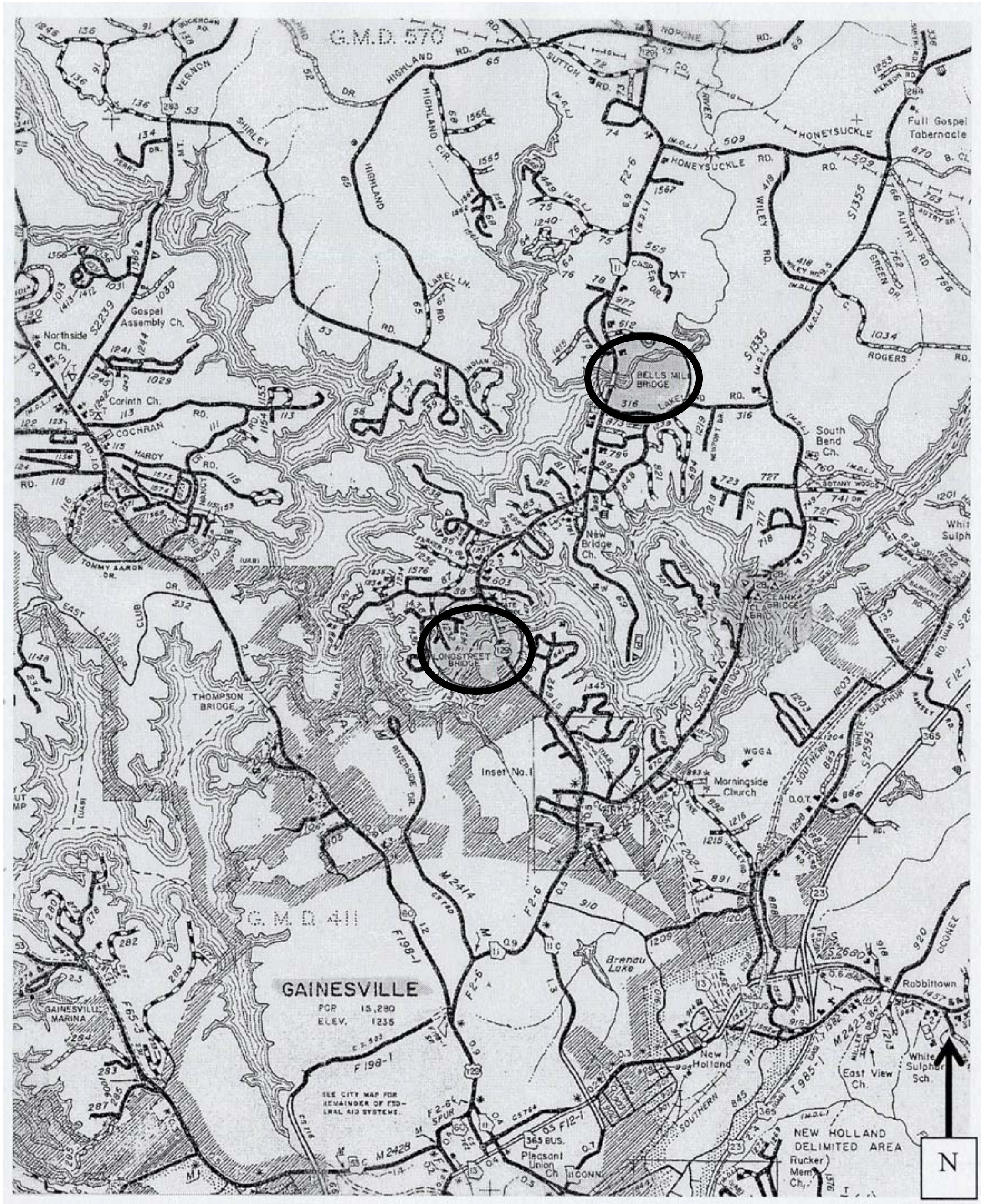


Fig. 2.2a Location of Two Gainesville Bridges (2)

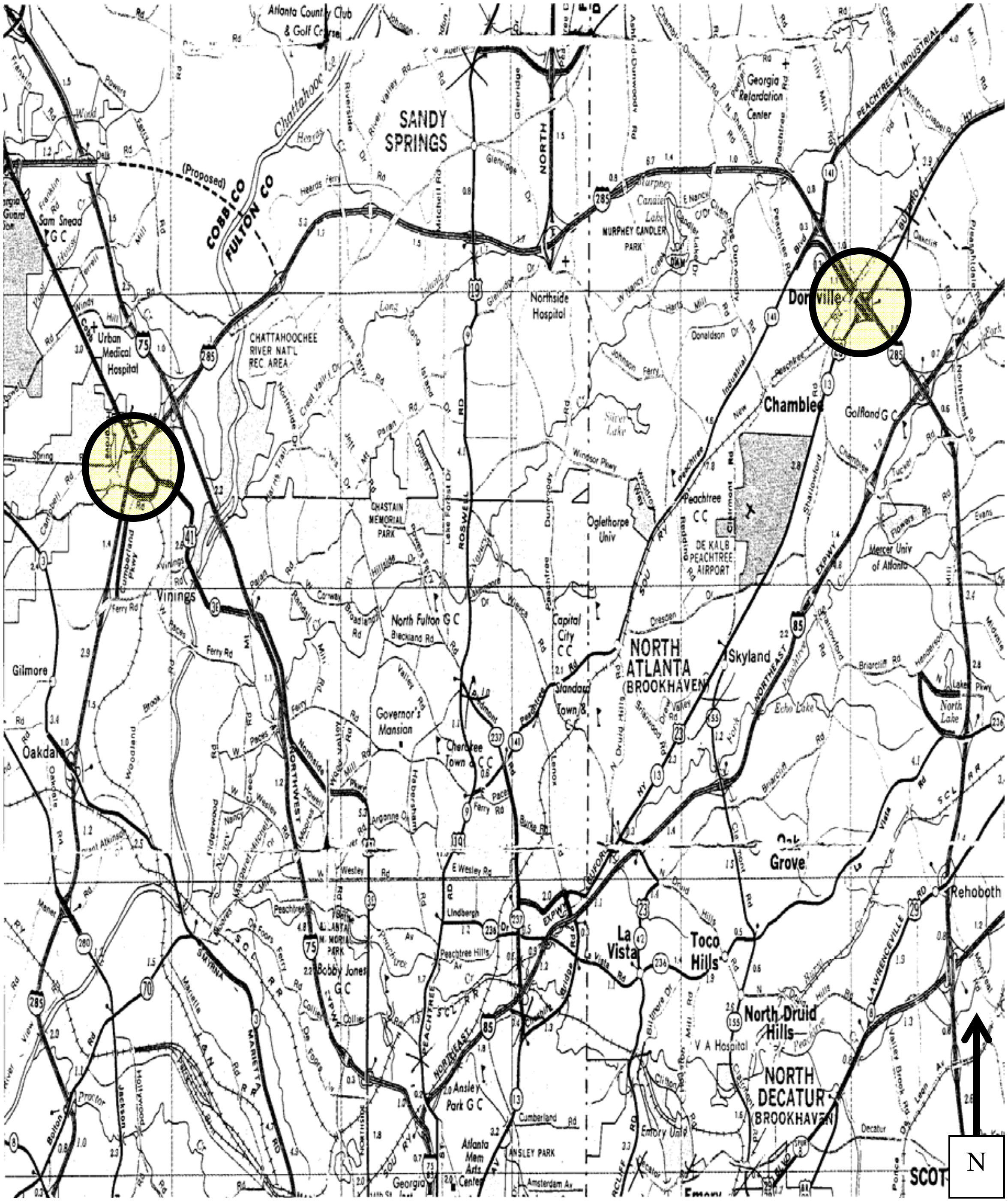


Fig. 2.2b Location of Two I-285 Bridges (2)

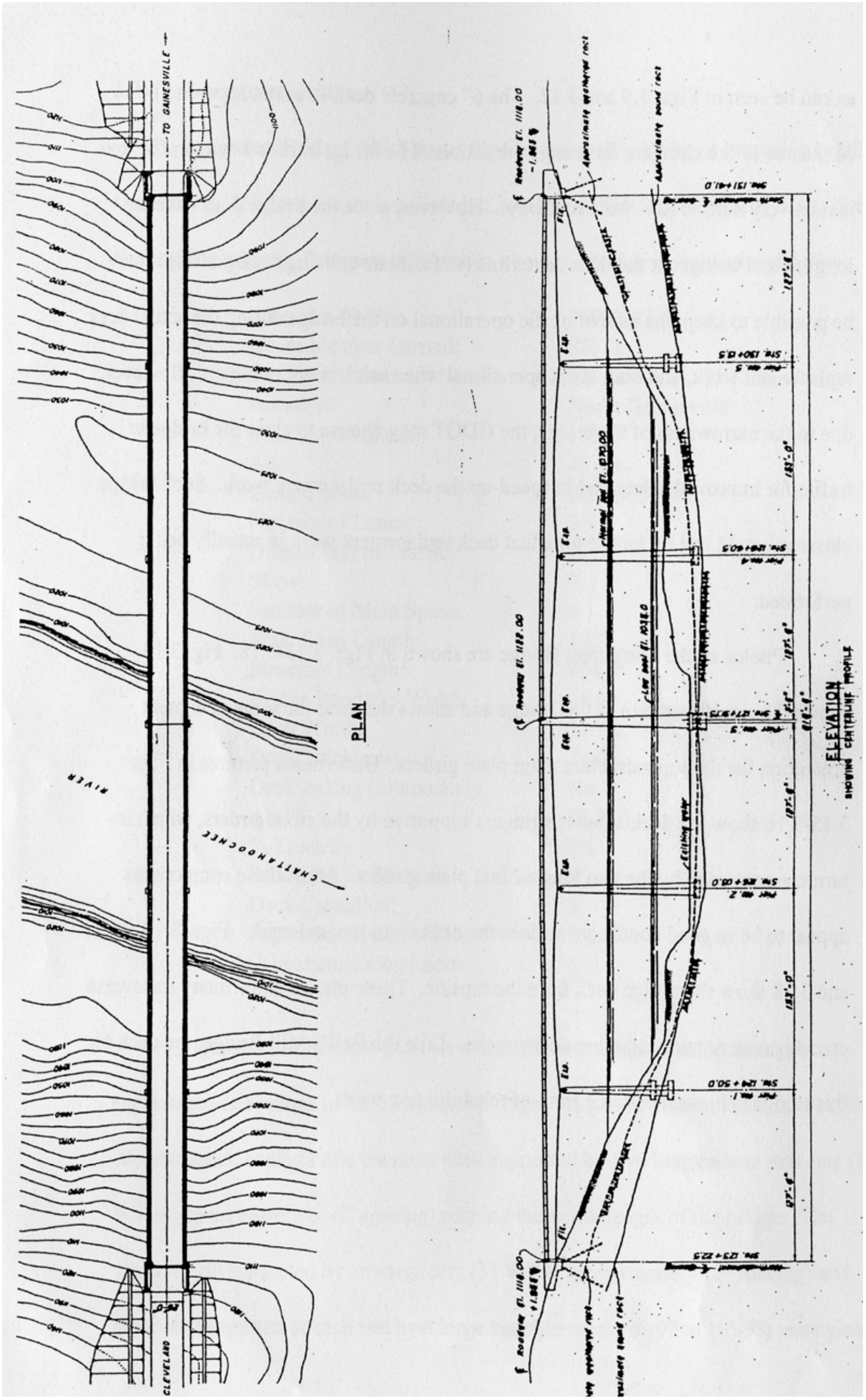


Fig. 2.3 Plan and Elevation of Longstreet Bridge (2)

Fig. 2.4 Angled Side Elevation View of Longstreet Bridge (2)

Fig. 2.5 Underneath Shot of Longstreet Bridge (2)

Fig. 2.6 Overview Shot of Longstreet Bridge Deck (2)

Fig. 2.7 Longstreet Bridge Deck (2)

Bells Mill Bridge. The Bells Mill Bridge is the oldest of the four bridges receiving deck replacement/rehabilitation work in Georgia. The Bells Mill Bridge has an Average Daily Traffic of 12,700 vehicles (slightly less than Longstreet), but has a larger percentage of trucks with 10% (2). Figure 2.8 shows the plan/elevation view of the Bells Mill Bridge. The bridge has an overall structural length of 388 feet with a total of six main spans. Figure 2.9 shows a side elevation view of the Bells Mill Bridge. Notice the telephone conduit attached to the concrete barrier that must be relocated. Figure 2.10 shows an underneath view of the bridge's superstructure. The concrete deck is supported by four longitudinal girders (WF 33) at approximately 8'-8"spacing. The longitudinal girders are continuous for 3 spans on each side of the bridge's centerline. The bridge deck and longitudinal girders were not connected for composite behavior. Figures 2.11 and 2.12 show the bridge from a topside overview and a close-up perspective. These photos show the state of the bridge deck and reflect many cracks and repairs. The Bells Mill Bridge and Longstreet Bridge were both in need of some type of deck rehabilitation.

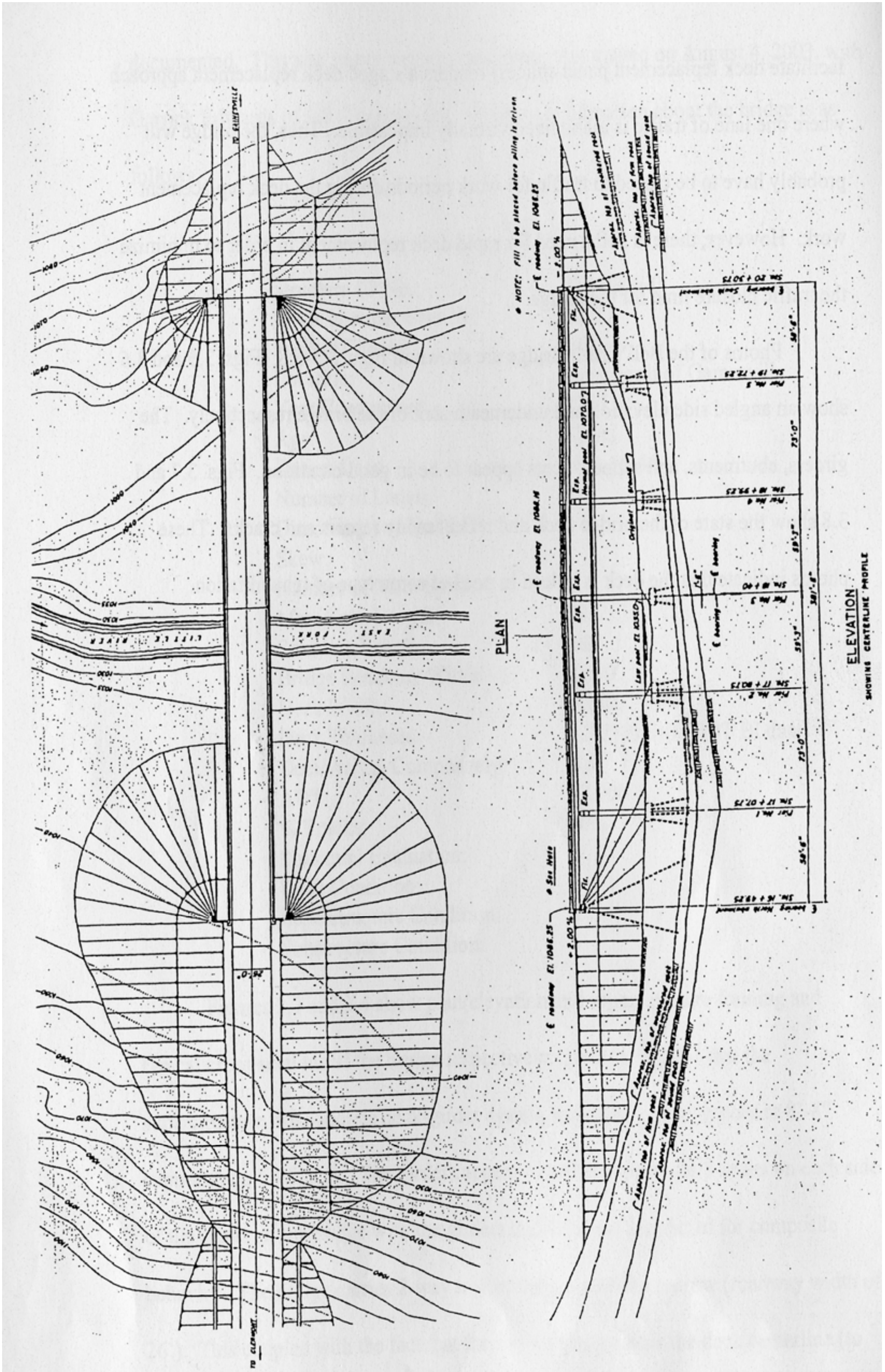


Fig. 2.8 Plan and Elevation of Bells Mill Bridge (2)

Fig. 2.9 Angled Side Elevation View of Bells Mill Bridge (2)

Fig. 2.10 Underneath View of Bells Mill Bridge (2)

Fig. 2.11 Overview View of Bells Mill Bridge Deck (2)

Fig. 2.12 Close-up of Bells Mill Bridge Deck (2)

I-285 Bridges over Buford Highway. These sister bridges were originally two lanes wide each and periodically widened until they reached their current state of 13 lanes (7 eastbound, 6 westbound). As shown in Figure 2.2, the bridges are located in the northeastern quadrant of I-285 approximately 1.2 miles north of I-85 and they carry I-285 over S.R. 13 (Buford Highway). Only the portions of the deck pertaining to the original lanes were replaced. The ADT for these sister bridges is 259,000 vehicles, of which 12% are trucks. These bridges boast the highest ADT of the four GDOT bridges studied in this investigation. Figure 2.13 shows the plan and elevation view of the I-285 bridges over Buford Highway. Figure 2.14 shows an aerial view of the sister bridges of I-285 over the Buford Highway. Notice from the photo that a staged construction approach, where some lanes of traffic are left open during deck replacement, lends itself well to this bridge. However, the traffic on Buford Highway will be affected by the deck replacement work and will require some type of traffic control measure. Figure 2.15 shows a photo underneath the original portions of the bridge deck. The superstructure is a concrete deck-girder system with 33 steel girders spaced at varying distances and a 7.5" deck (2). The concrete deck and steel girders were not designed to act compositely on the original lanes. Figure 2.16 shows an underneath view of the widened section of the bridge. Figure 2.17 shows a typical end joint of the bridge. It should be noted that this is the junction between the bridge deck and the backwall. The bridges posed some traffic control challenges, and the deck replacement work was limited to weekend construction only.

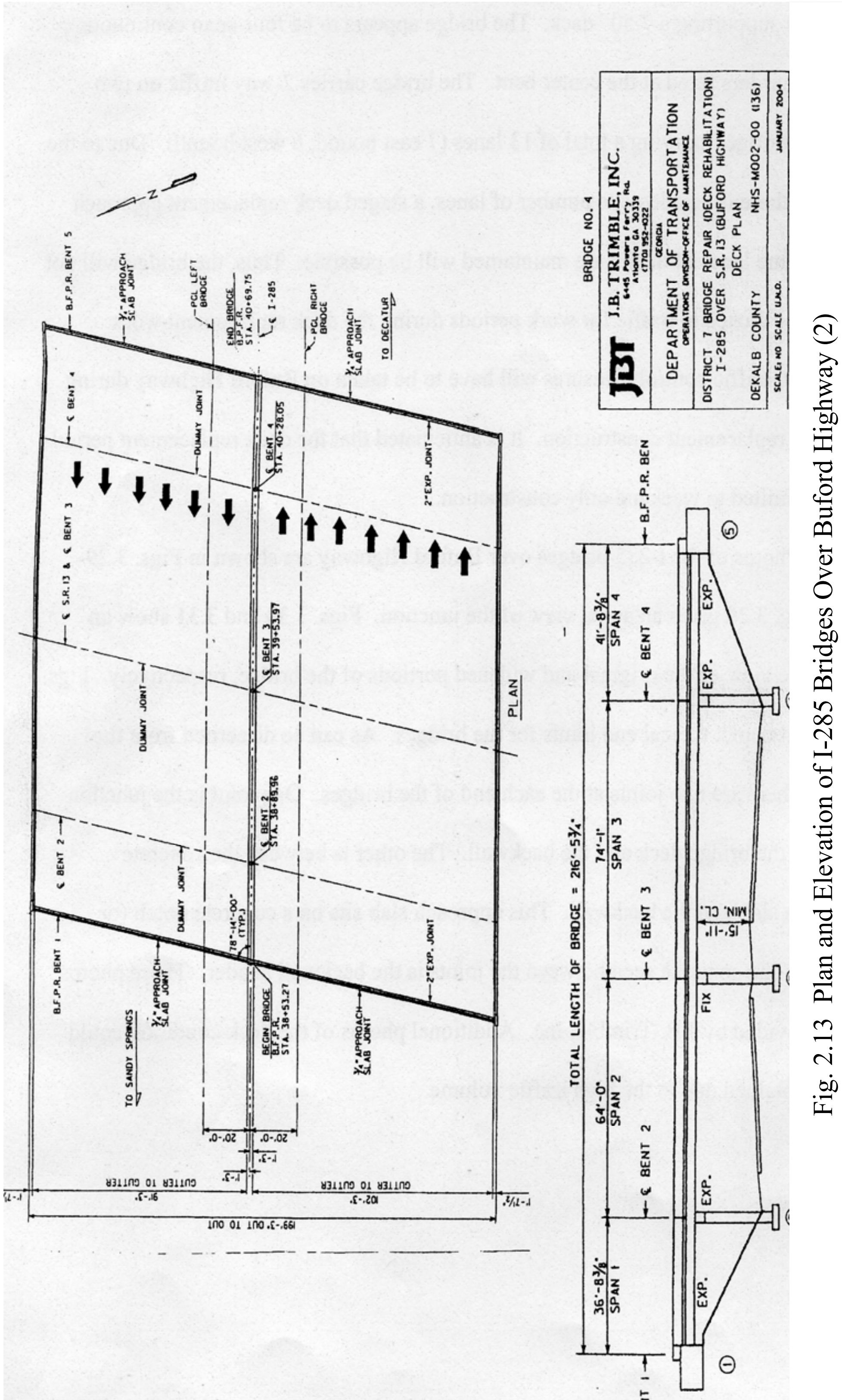


Fig. 2.13 Plan and Elevation of I-285 Bridges Over Buford Highway (2)

Fig. 2.14 Aerial View of I-285 over Buford Highway (2)

Fig. 2.15 Underside View of Original Section of Bridge (2)

Fig. 2.16 Underside View of Widened Section of Bridge (2)

Fig. 2.17 Typical End Joint (2)

I-285 Bridges over S.R. 3 (U.S. 41). This pair of bridges is located in the northwestern quadrant of I-285 approximately 3.1 miles east of Smyrna in Cobb County, GA. The sister bridges have 8 total lanes that carry traffic with 4 lanes in each direction. Like the I-285 bridges over Buford Highway, the bridge deck replacement work only involved the original two lanes for each bridge. Each bridge has a length of 240 feet that is divided into four main spans. The ADT for these pair of bridges is 157,000 vehicles, of which 12 % are trucks. As with the bridges over Buford Highway, these bridges over U.S. 41 are skewed and required Exodermic panels of trapezoidal shape to account for the skewness. Figure 2.18 shows the plan and elevation drawings of the sister bridges over U.S. 41. Figure 2.19 shows an aerial view of the sister bridges of I-285 over U.S. 41 and shows the complexity of the deck replacement project as US 41 is a major arterial and required additional traffic control measures. Figure 2.20 shows the underneath view of the original bridge superstructure and bents. The longitudinal girders are spaced at varying distances and are simply supported in each of the four spans. The original and widened sections have full depth concrete decks with the widened section having used SIP corrugated metal forms. Notice the skewness of the support bents in Figure 2.20. Figures 2.21-2.22 show the typical condition of the riding surface of the northbound bridge deck. The extensive spalling damage of the bridge deck warranted some type of deck rehabilitation work. Because only the original lanes of each bridge received the Exodermic systems, it was possible to maintain at least two lanes of traffic during the deck replacement work. As with the bridges over Buford Highway, the deck replacement work was executed during a weekend construction period. Figure 2.23 shows a typical transverse joint and its condition. The original lanes of each bridge were badly in need of deck rehabilitation, which was done in a rapid and staged construction manner to limited traffic disruptions.

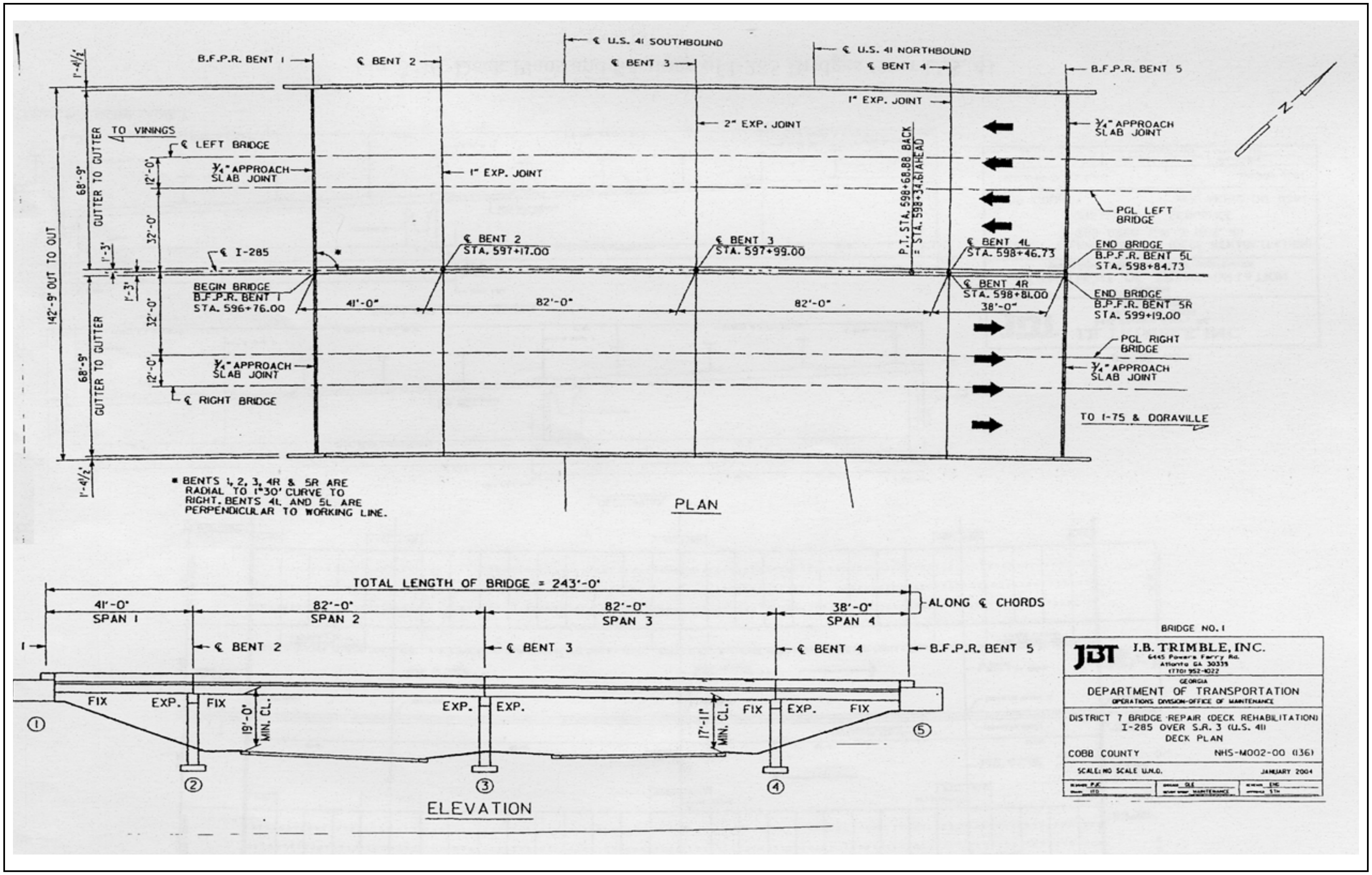


Fig. 2.18 Plan and Elevation of I-285 Bridges Over U.S. 41 (2)

Fig. 2.19 Aerial View of I-285 over U.S. 41 (2)

Fig. 2.20 Underneath View of Original Bridge Superstructure and Bents (2)

Fig. 2.21 Typical Spalling of Original Lanes (2)

Fig. 2.22 Typical Deck Spalling of Lanes to be Replaced on Northbound Bridge (2)

Fig. 2.23 Typical Transverse Joint on Northbound Bridge (2)

Cost Comparisons. A comparison of the major cost items of the bridge deck replacements for the aforementioned four GDOT bridges are summarized in Table 2.1. Itemized bids are very common to rapid bridge deck replacement and are affected by many factors. The single largest bid item is the composite steel grid deck with a precast concrete slab as is apparent from the unit costs shown in the table. This is primarily due to the large volume of required materials (steel grid, concrete, etc.) for constructing each Exodermic panel. The item with the greatest variation in cost was the removal of parts of the existing bridge. The main factor affecting this cost is whether the deck replacement is a partial replacement (Atlanta bridges) or full width replacement (Gainesville bridges). The partial deck replacement required extra saw cutting and special attention in areas between Exodermic panels and the existing deck that remained in place. Note that the unit cost of the Flexogrid overlay is approximately 10% of that of the composite steel grid (Exodermic) deck panels. A factor contributing to the high total deck replacement unit cost bids on the Atlanta bridges is the high priority of maintaining a safe construction zone. The work on the Atlanta bridges was performed under concurrent traffic conditions, making the extra staging area unavailable to the contractors. Also, extra safety provisions were required because of the traffic moving under the bridges.

Table 2.1 Unit Cost Bids for GDOT Bridge Deck Replacements (2)

Pay Item	Low Bid Costs				Average of All Bids
	Bells Mill Bridge	Longstreet Bridge	I-285 Bridge Over Buford Highway	I-285 Bridge Over U.S. 41	
FOUR-HOUR ACCELERATED CONCRETE IN-PLACE	$1,722.61/CY ($12.40/SF)[#]	$1,722.61/CY ($7.06/SF)[#]	NA	NA	$2,611.31/CY ($14.75/SF)[#]
TWENTY-FOUR HOUR ACCELERATED CONCRETE IN-PLACE	NA	NA	$1,075.00/CY ($9.78/SF)[#]	$1,075.00/CY ($9.95/SF)[#]	$2,132.66/CY ($19.57/SF)[#]
COMPOSITE STEEL GRID DECK WITH PRECAST CONCRETE SLAB	$59.00/SF	$59.00/SF	$47.25/SF	$47.25/SF	$58.47/SF
REMOVAL OF PARTS OF EXISTING BRIDGE (PRIMARILY DECK REMOVAL)	$12.01/SF	$9.46/SF	$17.71/SF	$28.92/SF	$31.23/SF
FLEXOGRID DECK OVERLAY IN-PLACE	$6.11/SF	$6.11/SF	$5.39/SF	$5.39/SF	$6.35/SF
TOTAL DECK REPLACEMENT UNIT COST*	$136.11/SF		$252.74/SF		$224.48/SF

* The Bells Mill and Longstreet bridge deck replacement bids were lumped together as were the two I-285 bridges

[#] Bid price per square foot of deck replaced

Flexogrid Overlay. Flexogrid is an epoxy-urethane co-polymer manufactured by Poly-Carb, Inc. The thin concrete overlay (≈ ⅜" thick) produces a bonded overlay system that is both strong and flexible. The urethane provides flexibility to the system so it can flex with the deck without cracking. The epoxy supplies durability, strength, and abrasion resistance to the system to develop the strong bonding properties with the overlay. The thin copolymer overlay has some unique characteristics in that it remains flexible at low temperatures and through its entire life cycle (4). Also, the Flexogrid overlay is impermeable, which helps ensure quality throughout the life of the overlay. Flexogrid offers all the properties/protection needed to be considered an efficient overlay choice.

The Alabama Department of Transportation placed overlays on approximately 17 bridge decks during the 1990's. Of these 17 overlays, two used the Flexogrid overlay; these have outperformed the others without question. In the summer of 2001, the ALDOT placed another Flexogrid overlay in Birmingham on the Northbound Route (NBR) of the Centralbound Route (CBR) bridge of I-59/20. The 1.3 mile long overlay covered approximately 50,000 yd^2. The cost of the bridge rehabilitation was \$89.45/yd^2 (\$9.94/ft^2) of overlay (4). Documentation of the overlay work is presented in Reference 3.

Some of the primary advantages and disadvantages of the Flexogrid overlay system are given below (5):

Advantages:

- Quality assurance throughout entire process
- Least dependent on human error

- More cost effective
- Low volume of traffic tie up
- Designed for long term performance
- Easy to maintain
- Safe to install
- Zero contribution to pollution
- Low contribution to dead weight

Disadvantages:

- System may be proprietary
- Still fairly new to the industry
- Limited performance history

Flexogrid Polymer Concrete Overlays in Birmingham, AL. The ALDOT rehabilitated eight bridge decks on the Southbound Route (SBR) of I-65 during the weekends of June 23-25, 2000 (Stage I) and June 30-July 2, 2000 (Stage II). The rehabilitation work utilized the Flexogrid overlay manufactured by Poly-Carb, Inc. To minimize traffic delays, the work was performed during concurrent traffic conditions over the 1-mile stretch of I-65.

A detailed description of the Stage I overlay work, which consisted of rehabilitation of the two left lanes and shoulder of the SBR of I-65, is given below. A work time schedule for the Stage I overlay work can be seen in Table 2.2. Stage II consisted of the overlay work on the remaining two right lanes and closely paralleled that of Stage I.

- Traffic signs and barriers were used to alert traffic to the construction zone and to allow traffic to shift to the half of the bridge where work was not being performed.

- The bridge deck surface was cleaned using shot blasting machines that operated longitudinally along the deck surface in approximately 2' strip widths (Figure 2.24).

- Spalls on the existing deck were patched using a mixture of aggregate and polymer binder just before the first application of the polymer overlay.

- Began placement of the first application of the epoxy based copolymer binder. It consisted of placing a low viscosity epoxy crack sealer and bond enhancer prior to the first overlay application (Figure 2.25).

- Broadcasting of the first layer of aggregate consisted of larger aggregate (≈ 3/8") to help achieve the proper overlay thickness. The broadcasting of the finer aggregate followed as the operation continued along the bridge (Figure 2.26).

- After the first application of the copolymer overlay was finished, the deck was swept and vacuumed to remove excess fine aggregate.

- The application of the second overlay layer was then applied and followed an identical procedure as that utilized for the first layer (Figure 2.27).

- Application of the seal coat was applied after the second epoxy copolymer (Flexogrid) application was in place.

The overlay work on these eight Birmingham bridge decks was completed on schedule (Figure 2.28). The eight bridge decks suffered from significant cracking prior to deck replacement, but required very little spalling repair work in order to rehabilitate them properly. The Flexogrid overlays have performed very well since the rehabilitation, and it was shown that they could be placed rapidly with minimum traffic interference.

Table 2.2 Work Time Schedule for Stage I Overlay on the Eight SBR Bridges (4)

DATE/TIME	WORK ITEM
Friday	
7:00 p.m.	Traffic Control South Bound I-65 2 Left Lane Closures from Mile Marker 260.64 to 259.64 (8 bridges)
8:00 p.m.	Shotblast Scarify Lines, Oil & Asphalt Spots Sandblast Edges Saw Cut & Chip any Delaminations Prepare Deck
Saturday	
7:00 a.m. - 6:00 p.m.	Patch any Delaminations Apply Pretreatment Apply 1st Coat of Overlay to all 8 Bridges
Sunday	
6:00 a.m.	Sweep Excess Aggregate Off
7:00 a.m.	Apply 2nd Coat of Overlay to all 8 Bridges
1:00 p.m.	Sweep Excess Aggregate Off
1:30 - 5:00 p.m.	Apply Finish Coat
6:00 p.m.	Line Striping
7:00 p.m.	Open Lane Closure

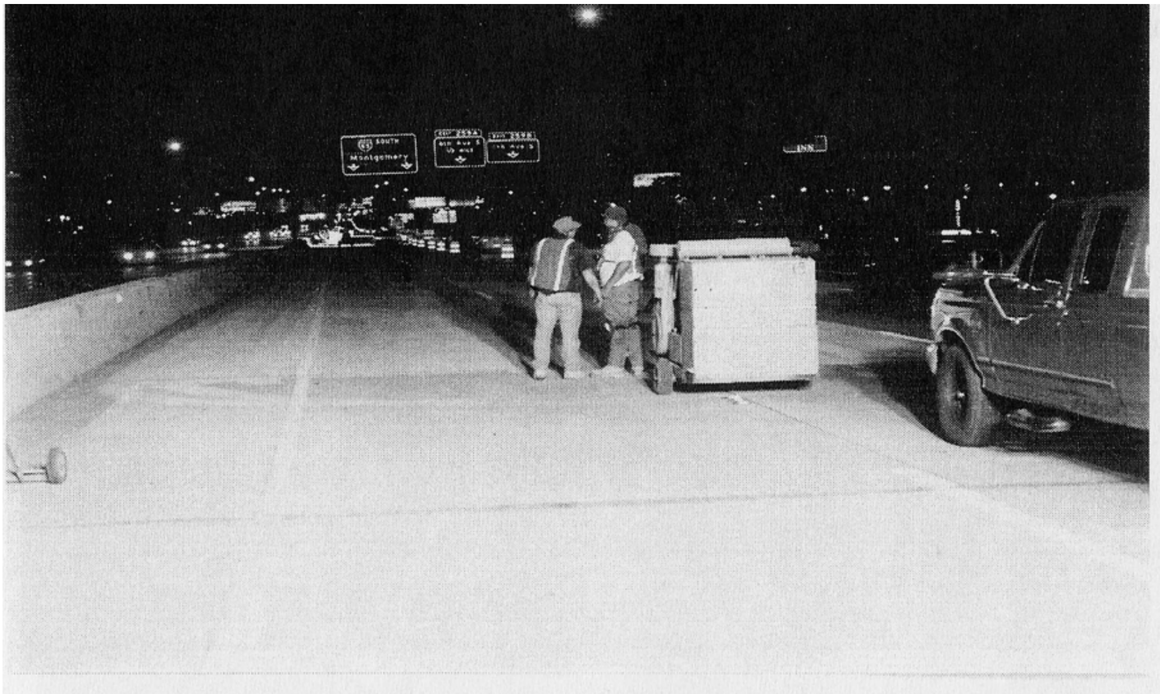


Fig. 2.24 Shot Blast Cleaning of Deck Surface (4)

Fig. 2.25 Squeegeeing-on of Epoxy Based Copolymer Binder (4)

Fig. 2.26 Broadcasting Fine Aggregate from Truck as it Moves Along Bridge Deck (4)

Fig. 2.27 Application of Second Polymer Concrete Layer (4)

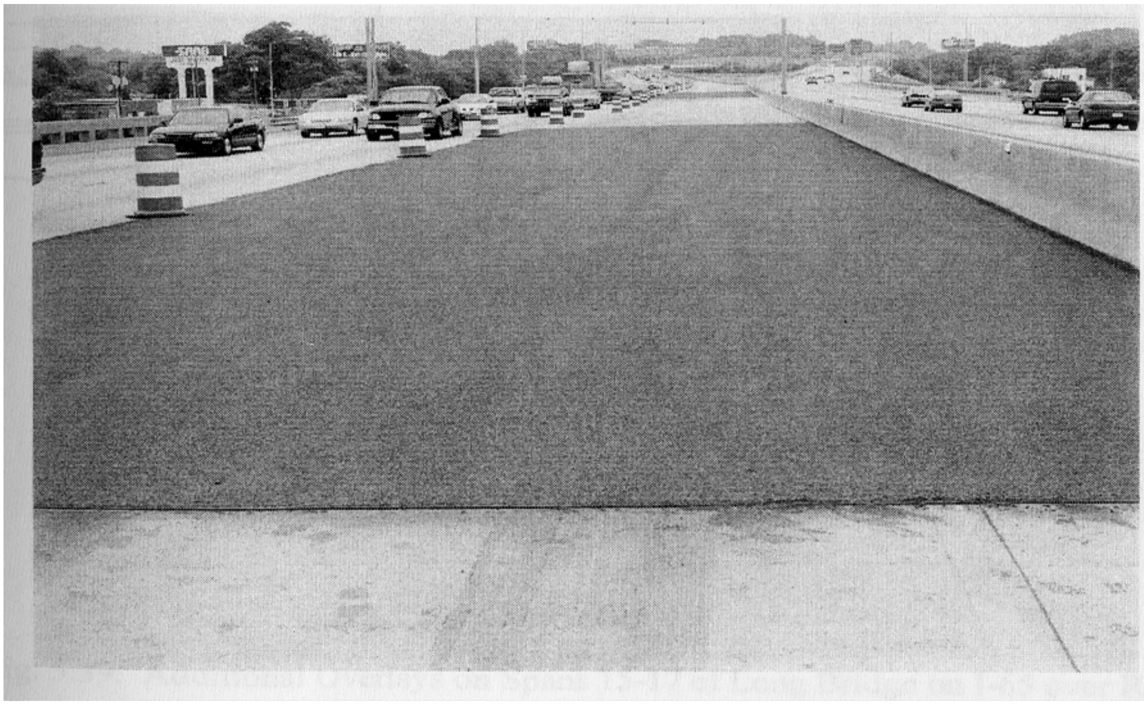


Fig. 2.28 Finished 3/8” Thick Polymer Concrete Overlay (4)

3. RAPID DECK REPLACEMENT OF THE LONGSTREET BRIDGE

3.1 General

Deck replacement for the Longstreet Bridge was completed during the period March – July 2005. The bridge is located in north Gainesville, GA and spans the Chattahoochee River. Due to the narrowness of the bridge, it was decided to close the entire bridge to traffic during each night's construction. The bridge was closed from 9:00 p.m to 5:00 a.m each work night and a traffic detour was executed during this time.

Exodermic grid fabrication was provided by L.B. Foster, a licensed supplier in the Pittsburgh, Pennsylvania area. Two other manufacturers considered were D.S. Brown Company and American Bridge Manufacturing; the latter is also based in the Pittsburgh area. The Exodermic steel grids were shipped to Anatek Inc., a local contractor in Gainesville, GA, who provided the panel concrete precasting and delivery to the job site.

The Longstreet and Bells Mill bridges were bid as a collective effort with only two bids being submitted. The lowest bidder, Gilbert Southern Corporation, received the contract to carry out the design and construction efforts for the deck replacement of two bridges. Gilbert Southern is a Kiewit affiliate that provides service in the southeast regions of the United States. Their main headquarters are located in Peachtree City, Georgia and two area offices are located in Sunrise and Tampa, Florida.

3.2 Time Sequence

Before deck replacement work could begin on the Longstreet Bridge, some preparation work was needed. A two inch asphalt overlay was placed over the existing deck throughout the night of February 15, 2005. The asphalt overlay was placed due to the fact that the replacement Exodermic deck panels were two inches thicker than the existing deck. This provided a level riding surface when a new panel to existing panel joint occurred during the construction phase. The deck replacement work was scheduled to begin on February 10, 2005, but due to unforeseen delays the actual deck replacement work wasn't started until February 27, 2005. The first night of deck replacement proved to be somewhat of a learning curve for Gilbert Southern, resulting in a late bridge re-opening of 90 minutes. The delay was primarily due to the contractor's unfamiliarity with precast Exodermic deck panels and with problems caused by the site cast joint concrete being too stiff and rapid setting. It was decided to readjust the concrete mixture and look for ways to make workers on hand more efficient. The stiff concrete mixture reached nearly 4000 psi in only one hour making the workability very poor. The contractor placed the second precast Exodermic panel on March 20, 2005. During the time interval of February 27-March 20, only preliminary deck work (e.g. transverse saw cuts, core drilling of existing deck pick-up/removal points) took place. The GDOT counted the deck replacement work on March 20 as the official beginning time of the 120 calendar day work period. The GDOT allowed Gilbert Southern to perform the finger joint replacement work during a weekend bridge closure on May 13-16. The finger joint replacement took approximately 16 hours to complete. Deck replacement work was executed during the remaining time left in the weekend bridge closure. The final

Exodermic deck panel was installed on June 30. The total construction time needed for the 824 linear feet or 21,342 square feet of deck replacement was 102 days. An approximately ⅜" thick epoxy overlay was placed on July 20-23. The epoxy overlay was added due to the fact that rideability and aesthetics were negatively affected by the large number of grouted joints. A more pleasurable riding surface was achieved after all surface grinding and the epoxy overlay were complete.

3.3 Nightly Construction Tasks and Sequence

The general construction tasks/sequence and provisions for the Longstreet Bridge can be seen in the Beck and Ramey report on "Rapid Rehabilitation/Replacement of Bridge Decks-Phase II" (2). The construction tasks and sequence for a typical night's work during each bridge closure (9 p.m. – 5 a.m.) were as follows:

1. At 9.00 p.m. install traffic detour.
2. Mobilize equipment onto closed bridge.
3. Make longitudinal saw cut.
4. Remove portion of steel curb plate.
5. Remove first portion of first section.
6. Remove last portion of first section.
7. Remove first portion of second section.
8. Remove last portion of second section.
9. Clean top flange of steel stringers.
10. Place sheet metal haunch forms on top of stringers.
11. Install first Exodermic panel and adjust leveling bolts.
12. Install second Exodermic panel and adjust leveling bolts.

13. Place shear studs to tops of steel stringers.

14. Install new steel curb plates.

15. Provide formwork at ends of second Exodermic panel-existing roadway joint.

16. Make closure pours over steel stringers and in shear keys.

17. Place curing blankets over deck closure pours.

18. Make preparations on adjacent existing deck for the next night's work.

19. Remove curing blankets and equipment from bridge and re-open at 5:00 a.m.

While a night's closure pours were curing, preparation for the next night's work was taking place. This work was not performed in any fixed sequence and consisted of the following:

- Make transverse saw cuts
- Cutting of steel curb plate
- Drill existing deck pick-up/removal points

Photographs showing the construction of the deck replacement work are presented and discussed in the following section.

3.4 Photographic Display/ Discussion of Deck Replacement Work

A photographic display of a typical night's work that consisted of placing 2 new 8'-8'' wide Exodermic deck panels is shown in Figs. 3.1-3.35. Figure 3.1 shows an 8'-8" x 26'-10" x 7-½" precast Exodermic deck panel sitting on a low-boy truck in an off-bridge staging area. The low-boy delivered the panels from the opposite end from which deck replacement work began to permit transporting the panels to the crane more easily. Figure 3.2 shows the lift spreader being assembled to the Exodermic panel directly from the bed of the low-boy. Due to the limited staging area, Gilbert Southern had only the number of Exodermic panels needed during each night's construction delivered to the job site at a time. Delivery of the Exodermic panels typically consisted of 2 panels a night, but ranged from 1 – 3 panels a night.

Figures 3.3-3.6 show deck preparation for the next night's work. Transverse saw cuts were made for the next two sections of deck removal, thus freeing up more time for deck panel installation the next night. It should be noted that only transverse saw-cutting was performed at this time. Required longitudinal saw cuts were performed at the time of the actual deck removal. Figure 3.4 shows a worker core drilling the deck pick-up points for the next night's deck removal. In Figures 3.5 and 3.6, two different approaches are shown for removing the existing curb plate. The first approach (see Figure 3.5) shows a worker drilling the weld plugs that attach the curb plate to the bridge's haunch girder. This proved to be very time consuming and it was estimated that over 3600 weld plugs would have to be drilled if another scheme was not developed. Thus a second approach to removing the curb plate was developed by cutting along the edge of the haunch girder with a cutting torch (see Figure 3.6). This approach proved to be much more time efficient than the first and was used throughout the rest of the rehabilitation process.

Figure 3.7 shows a longitudinal saw cut being made on the existing deck section that was to be replaced that night. Longitudinal saw cuts were implemented to avoid heavy pick-ups during the deck removal process. Longitudinal saw cutting of the existing deck was done on the night that the existing deck was replaced because these cuts greatly reduce the strength of the deck. Since the deck and steel stringers do not act compositely with one another, no other longitudinal saw cuts were necessary for deck removal. Figure 3.8 shows a close-up view of a typical saw cut (longitudinal or transverse).

Figure 3.9 shows the lifting apparatus being placed into the pick-up points on the first portion of the first section of the existing deck. Figures 3.10-3.12 show the section as it was removed and then placed onto the same low-boy trailer that delivered the Exodermic panels. Note in Figure 3.11 that the reinforcement bars next to the stringers didn't always get completely cut since the deck varied a little in thickness. A worker finished the cut with a cutting torch. Figure 3.13 shows the lifting apparatus being secured to the second portion of the first section. The lifting apparatus consisted of four steel rods that were driven at angles into the picking points on the existing deck. When lifted, enough friction developed to securely pickup the deck and transport it to the low boy. A better view of the lifting apparatus can be seen in Figure 3.14. Also shown in Figure 3.14 is the second half of the first section being removed. The same process was applied when removing the first and second portions of the second section of the existing deck.

Figure 3.15 shows the opening in the deck after the first section of the existing deck has been removed. The tops of the steel stringers were sand blasted to enhance bond between the concrete and steel (see Figure 3.16). Figure 3.17 shows a worker grinding the weld plugs that were left after the curb plates were removed. The grinding added another time consuming task for the crew, thus reinforcing the cutting torch approach as the method of choice in the remaining curb plates. Figure 3.18 shows the sheet metal haunch forms being placed over the top flange of the stringers.

Figures 3.19-3.21 show the placement of one 8'-8" x 26'-10" x 7-½" new Exodermic panel. Note that Gilbert Southern used a lift spreader for handling the Exodermic panels to reduce any chance of deflecting the steel grid and cracking the panel precast concrete. Figure 3.22 shows foam backer rods being placed below the panel concrete shear keys to keep rapid-setting CIP concrete from leaking out the bottom. Figure 3.23 shows the installation of shear studs with a shear stud gun. These shear studs were placed in pairs and spaced approximately 24 inches apart longitudinally to achieve composite action between the stringers and Exodermic deck panels. The shear studs are ¾ inches in diameter and have a 5 inch in-place length. Figure 3.24 shows a worker adjusting built-in panel leveling bolts while another worker gauges the Exodermic panel as it reaches the desired height.

Figure 3.25 shows a new curb plate section being set into place. Note that anchor bolts have been placed on the underside of the base plate prior to installation. When closure pours were made this created a positive connection between the base plate anchor bolts of the curb plate and the rapid-setting concrete. These curb plates were prefabricated and stored in the staging yard prior to the start of the deck replacement process. Note beside the worker's right foot that a temporary form was needed at the ends of all longitudinal closure pours that remained idle until the next construction night. A view of the steel curb plate in place is seen in Figure 3.26. It should be noted in Figure 3.26 that deck replacement work was taking place in a right to left manner. Figure 3.27 shows epoxy being applied to the sides of concrete where closure pours were to be made. The epoxy enhances the bond between the precast concrete and the fresh concrete.

Figures 3.28-3.30 show the placement of the rapid-setting and rapid strength gain concrete above each longitudinal stringer and at each panel transverse shear key. The concrete was consolidated using a pencil vibrator to reduce honeycombing of the concrete. Also, in the background of Figures 3.28 and 3.29 a mobile concrete mixer can be seen. This mixer was used to control mixtures in order to achieve a compressive strength of 3500 psi within 4 hours. It was noted that transverse joints between new Exodermic panels needed to be approximately 1.5 inches wide to make concrete consolidation an easier task. Figure 3.31 shows curing blankets being placed over all closure pours to accelerate the curing process of the field placed concrete. Once the concrete reached the specified compressive strength, the curing blankets and all equipment were removed from the bridge. The bridge was re-opened to traffic at 5:00 a.m.

Figures 3.32-3.34 show typical transverse joints encountered during the rapid deck replacement work. The titles of these figures are self-explanatory, and they need no further discussion. Figure 3.35 shows an overview of approximately 100 linear feet of completed deck replacement work. Notice that the closure pours appear to have a rough surface finish, resulting in the need for later deck grinding and an overlay.

The deck replacement work included resetting the existing finger joint located at Bent 4 of the bridge's substructure. The finger joint replacement work is shown in Figs. 3.36-3.42. Figure 3.36 shows transverse saw cuts made at about 18" on each side of the finger joint. The existing deck around the finger joint was removed by carefully jack hammering along each side of the existing finger joint (see Figure 3.37). Figure 3.38 shows a worker cutting the reinforcement next to the finger joint, to ease the deck removal process. Once the larger portions of concrete were removed, hand-operated jack hammers were used to remove any remaining pieces of concrete left bonded to the finger joint. Figure 3.39 shows a worker torch cutting the connections of the finger joint. Notice in the background of Figure 3.39 that the shim plates (four shims of approximately 3 3/8" in total height) are ready to be installed. The finger joint was cleaned prior to resetting and shimmed using the four prefabricated shims to ensure that constancy between the new panel height and finger joint were attained. Figure 3.40 shows a worker placing new A325 bolts in the finger joint's connections. The new A325 bolts were long enough to accommodate the additional depth the shim plates added. The finger joint required 4 bolts per connection with a total of 26 connections. Once the resetting of the finger joint was completed, the existing deck (adjacent to the finger joint) was removed and preparation for the setting of the replacement Exodermic panels was arranged (see Figure 3.41). Figure 3.42 shows the placement of two 5'4" Exodermic panels, one on each side of the finger joint. Special forms were provided between the finger joint and Exodermic panel where closure pours had to be made. Also seen in Figure 3.42 is some of the initial formwork needed to provide an adequate closure pour. Closure pours and installation of the curb plates were prepared to put the finishing touches on the replacement work of the finger joint.

3.5 Deck Overlay Work

Before Poly-Carb, Inc. could place the Flexogrid overlay, surface grinding on all closure pours (transverse and longitudinal joints) and within the area of the precast panels was executed. The purpose of the surface grinding was to correct any height variation between adjacent Exodermic panels to ensure a smooth riding transition. The co-polymer overlay was installed with a two layer application of approximately 3/8" total thickness. The overlay work was performed during the nights of July 20-23, 2005. During the author's visit on July 21, the first layer of the two-part epoxy-urethane co-polymer overlay was placed on spans 4 through 6 (approximately half of the bridge). The amount of work performed during the visit consisted of a total of 10,671 ft^2 of bridge deck area or 412 linear lane feet. Poly-Carb personnel planned to place the second layer of the overlay on spans 1 through 3 that same night, but were unable to do so because of an earlier rain that occurred evening, resulting in a damp deck surface.

Eagles Grooving (subcontractor) performed all surface grinding on the Longstreet Bridge. The Exodermic panels were overfilled ¼" to allow for deck grinding within the area of the precast panels. The bridge deck was ground to a specified surface tolerance as stipulated by the GDOT. This surface tolerance was checked by a Profilograph or "smoothness" test. Figure 3.43 shows the grinding machine used for all surface grinding. The grinding machine ground widths of approximately 3 feet, so multiple longitudinal passes were needed to grind the entire bridge deck width. Figure 3.44 shows a close-up of the deck surface just as the grinding blades have passed. Figure 3.45 shows the concrete slurry as the grinding blades are working. Notice the hose connected to the side of the machine that attaches to a vacuum to pick up the slurry residue.

Figures 3.46-3.53 show the deck preparation, application of the co-polymer overlay, and the resulting Flexogrid overlay. Figure 3.46 shows a test section that Poly-Carb performed to check the strength of the bond to the substrate. The test consisted of pipe caps that were epoxied directly to the concrete of the precast Exodermic panels and the Flexogrid overlay placed around these pipe caps. Once curing time was completed, the pipe caps were pulled perpendicularly to the concrete until a tensile failure between the concrete and pipe caps occurred. This tensile force was measured and recorded for each individual cap. The pull-off readings from the Longstreet Bridge ranged from 900-1200 psi. Figure 3.47 shows a sweeper being used to remove loose debris and dust before the application of the first layer of the overlay. The sweeper was used after each layer application (2) to remove the excess fine aggregate. Figure 3.48 shows a rotary fine aggregate spreader used to broadcast the fine aggregate as it was conveyed from the Poly-Carb truck. Figure 3.49 shows a worker squeegeeing-on the epoxy as the Poly-Carb truck moves forward. Placement of the Flexogrid overlay consisted of a continuing process of application of the low viscosity crack sealer, squeegeeing of epoxy, and broadcasting of aggregate (see Figure 3.50). Note that the low viscosity crack sealer was applied in front of the Poly-Carb truck with a hand sprayer as it moved along the bridge. Figure 3.51 shows the finger joint located at midspan of the bridge with the first layer of overlay placed on one side. Note that the first layer of the overlay was placed on the other side of the finger joint on the night of the author's visit. A view of the first layer of the co-polymer overlay on approximately half of the bridge is shown in Figure 3.52. The finished 3/8" thick Flexogrid overlay is shown in Figure 3.53.

Fig. 3.1 Exodermic Panels in Off-Bridge Staging Area

Fig. 3.2 Lift Spreader Being Assembled to Exodermic Panel

Fig. 3.3 Transverse Saw Cutting for Deck Removal

Fig. 3.4 Core Drilling of Pick-Up Points for Deck Removal Next Night

Fig 3.5 Drilling of Weld Plugs for Curb Plate Removal

Fig. 3.6 Cutting Curb Plate from Haunch Girder with Cutting Torch

Fig. 3.7 Longitudinal Saw Cutting for Deck Removal

Fig. 3.8 Close-Up of Typical Saw Cut

Fig 3.9 Preparing to Lift Out First Section of Existing Deck

Fig. 3.10 First Section of Existing Deck Being Removed

Fig. 3.11 Cutting of Reinforcement Bars Next to Stringers

Fig 3.12 First Section of Existing Deck Removed

Fig 3.13 Preparing to Lift Second Section of Existing Deck

Fig 3.14 Second Section of Existing Deck Removed

Fig. 3.15 Existing Deck Removed and Preparation for Top Flange Cleaning

Fig. 3.16 Sand Blasting and Torching of Stringer's Top Flange

Fig. 3.17 Grinding of Weld Plugs

Fig. 3.18 Setting of Sheet Metal Haunch Forms

Fig. 3.19 Setting of First Exodermic Panel

Fig. 3.20 Setting of Second Exodermic Panel

Fig. 3.21 First Exodermic Panel In-Place

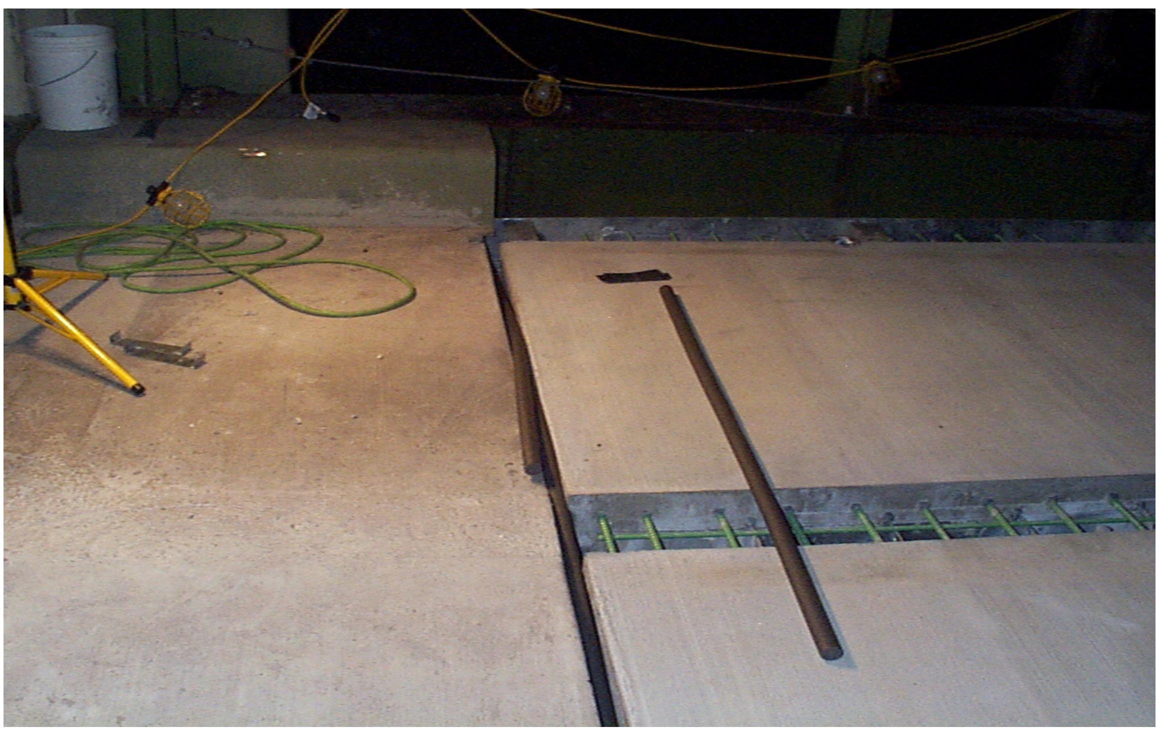


Fig. 3.22 Foam Backer Rods Placed Below Concrete Shear Keys

Fig. 3.23 Placing Shear Studs with Stud Gun

Fig. 3.24 Adjustment of Leveling Bolts on Exodermic Panel

Fig. 3.25 Placing of New Curb Plate

Fig. 3.26 New Curb Plate Set In-Place

Fig. 3.27 Placing Epoxy on Sides of Closure Pours

Fig. 3.28 Placement of Rapid-Setting Concrete at Stringers

Fig. 3.29 Vibrating of Rapid-Setting Concrete at Stringers

Fig. 3.30 Concrete Shear Key Just after Closure Pour

Fig. 3.31 Placement of Curing Blankets over Exodermic Panel Closure Pours

Fig. 3.32 Typical New Panel-New Panel Transverse Joint

Fig. 3.33 Typical Existing Deck-New Panel Transverse Joint

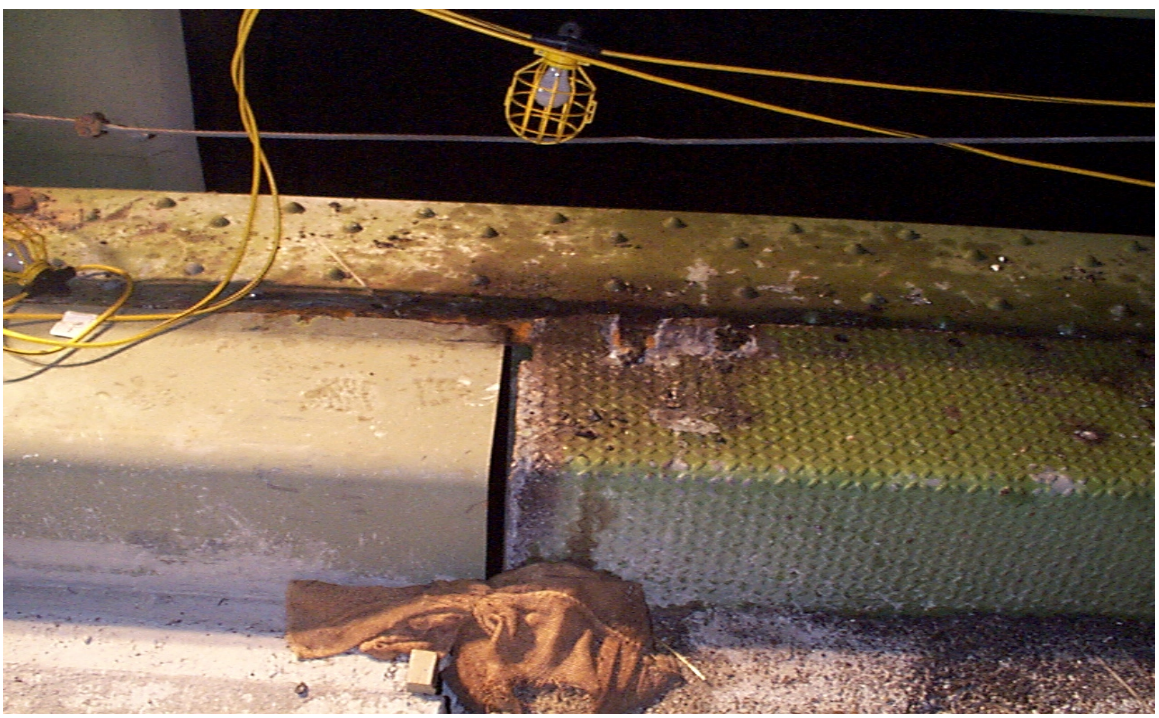


Fig. 3.34 Typical New Curb Plate-Existing Curb Plate Interface

Fig. 3.35 Overview Look of Exodermic Panels before Overlay

Fig. 3.36 Finger Joint View before the Replacement Process

Fig. 3.37 Jack Hammering Existing Deck around Finger Joint

Fig. 3.38 Torch Cutting Reinforcement around Finger Joint

Fig. 3.39 Cutting of the Existing Bolts of Finger Joint

Fig. 3.40 Setting of Finger Joint and Bolt Installation

Fig. 3.41 Existing Deck Removed and Setting of Newly Shimmed Finger Joint

Fig. 3.42 Placement of Exodermic Deck Panels around Finger Joint

Fig. 3.43 Diamond Grinding Machine

Fig. 3.44 Close-Up of Ground Bridge Deck Surface

Fig. 3.45 Section of Gang-Mounted Diamond Saw Blades

Fig. 3.46 Test Section Used to Perform Overlay Pull-Off Test

Fig. 3.47 Sweeping Deck Surface to Remove Any Loose Debris

Fig. 3.48 Rotary Fine Aggregate Spreader

Fig. 3.49 Squeegeeing-on of Epoxy Based Copolymer Binder

Fig. 3.50 Broadcasting of First Layer of Aggregate on Polymer Binder

Fig. 3.51 View of Finger Joint with Overlay on One Side

Fig. 3.52 View of First Layer of Overlay on Spans 1 through 3

Fig. 3.53 Finished 3/8" Thick Flexogrid Overlay

4. RAPID DECK REPLACEMENT OF THE BELLS MILL BRIDGE

4.1 General

The Bells Mill Bridge is located approximately five miles north of the Longstreet Bridge on US 129 in Gainesville, GA. Like the Longstreet Bridge, the Bells Mill Bridge carries only two lanes of traffic (1 lane in each direction) and was closed from 9:00 p.m. to 5:00 a.m. during each work night. The area of deck replaced on the Bells Mill Bridge, 11,200 ft^2, was approximately half that replaced on the Longstreet Bridge; the replacement was achieved using Exodermic deck panels that measured 29’-3” x 8’-8” x 7-½”. Replacement of the Bells Mill Bridge was conducted in a manner similar to that of the Longstreet Bridge, except that existing concrete barriers were replaced with precast Jersey Barrier Rails. The steel girders on the Bells Mill Bridge were continuous over each support and required the precast Exodermic panels to resist tension in the negative moment regions. The GDOT allowed Gilbert Southern to install the precast Exodermic panels in the negative moment regions using a 9:00 p.m. Friday to 2:00 p.m Saturday work period.

The Exodermic grid fabrication was provided by L.B. Foster, while the panel concrete precasting and delivery to the job site was supplied by Anatek, Inc. Gilbert Southern Corporation performed the deck replacement work on the Bells Mill Bridge while meeting the provisions set forth by the GDOT. In this chapter, a time sequence, description of nightly construction tasks and sequence, and photographic display/discussion of the deck replacement work are presented and discussed.

4.2 Time Sequence

The Exodermic panels designed for the Bells Mill Bridge were two inches thicker than the existing deck slab. To remedy this, a two inch asphalt overlay was placed on the existing deck on the night of February 16, 2005. The asphalt overlay was placed for the same reason as that for the Longstreet Bridge, i.e., it provided a level riding surface when a new-to-existing transverse joint occurred during the nightly deck replacement work. Before deck replacement work could begin on the Bells Mill Bridge, installation of the endposts was essential for public perception of safety, i.e., without first installing the endposts, a barrier gap would be present for the endposts to be installed later. The endposts were installed prior to the deck replacement work to avoid any misalignment of the modified Exodermic panel that was notched or "blocked-out" where the endposts protruded through the deck (see Figure 4.1). Deck replacement work began on July 27, 2005 on the north end of the bridge. The nightly (9:00 p.m. – 5:00 a.m. on Monday-Friday) deck replacement work consisted of placing two Exodermic panels (approximately 500 ft^2) with shear keys on the transverse face of each panel. The deck replacement work in the negative moment regions consisted of placing five Exodermic panels (approximately 1270 ft^2) with 2'-0" wide closure pours in each transverse joint. All five of these Exodermic panels were placed during the same work period since the transverse joints were unable to remain idle for the next work period. The extra panels and field placed reinforcing bars demanded a longer work period than the normal weeknight period of 8 hours. The GDOT solved this problem by performing deck replacement work in the negative moment regions during the weekend periods of 9:00 p.m. Friday – 2:00 p.m. Saturday. Regions of the precast Exodermic panels were blocked-out and not precast at locations adjacent to the bridge bents. These nonprecast sections allowed negative moment reinforcing bars to be installed to make the girder-deck system capable of supporting negative moments. Cast-in-place rapid setting and rapid strength gain concrete was cast (on placed) into the void areas around the panel main bearing bars and the longitudinal and transverse (negative moment) reinforcing bars. The existing deck slab in the negative moment regions was replaced in five partial weekend closures (9:00 p.m. Friday – 2:00 p.m. Saturday).

The GDOT allowed Gilbert Southern to perform the bridge center finger joint replacement work during a full weekend bridge closure (9:00 p.m. Friday – 5:00 a.m. Monday) on September 9-11. Once the resetting of the finger joint was completed, the final two Exodermic panels (one on each side of the finger joint) were placed on September 11, 2005. The 385 linear lane feet (or 11,200 ft^2) of deck replacement work required a total of 47 days to complete.

Deck surface grinding of the newly installed precast Exodermic panels took place during the weeknights of September 19-22. The Bells Mill Bridge deck was ground approximately ¼" to correct any height variation between adjacent panels and to smooth the CIP concrete at the panel joints. The approximately ⅜" thick epoxy overlay (Flexogrid overlay) was placed on September 23-25. The Flexogrid overlay was employed to improve the deck rideability and appearance (the deck appearance was negatively affected by the large number of grouted deck panel joints).

4.3 Nightly Construction Tasks and Sequence

The general construction tasks/sequence and provisions for the Bells Mill Bridge can be seen in the Beck and Ramey report on “Rapid Rehabilitation/Replacement of Bridge Decks-Phase II” (2). The construction tasks and sequence for a typical night’s work during each weeknight bridge closure (9 p.m. – 5 a.m.) were essentially the same for both Gainesville bridges. Refer to Section *3.3 Nightly Construction Tasks and Sequence* for the Longstreet Bridge for these construction tasks/sequence. Special construction tasks and their sequence concerning the deck replacement work in the negative moment regions for the Bells Mill Bridge were as follows:

1. At 9.00 p.m. Friday install traffic detour.
2. Mobilize equipment onto closed bridge.
3. Make longitudinal saw cut.
4. Remove first three sections of existing deck slab.
5. Clean top flange of steel girders.
6. Place sheet metal haunch forms on top of girders.
7. Install first three Exodermic panels.
8. Adjust Exodermic panel leveling bolts.
9. Install negative moment reinforcing bars.
10. Place shear studs on top of steel girders.
11. Install formwork (bulkheads) and foam backer rods.
12. Install drains.
13. Install barrier plates and bolts.
14. Move and reposition construction crane.

15. Remove last two sections of existing deck slab.
16. Clean top flange of steel girders.
17. Place steel metal haunch forms on top of girders.
18. Install last two Exodermic panels.
19. Repeat steps 8-13.
20. Install precast jersey barriers.
21. Make closure pours over steel girders and in negative moment regions.
22. Place curing blankets over deck closure pours
23. Remove curing blankets and equipment from bridge and re-open at 2:00 p.m. Saturday.

Photographs showing the deck replacement work for the Bells Mill Bridge are presented and discussed in the following section.

4.4 Photographic Display/Discussion of Deck Replacement Work

A photographic display of a typical weekend's work that consisted of placing 5 new 29'-3" x 8'-8" x 7-½" wide Exodermic panels (approximately 43 linear feet of bridge) in regions of negative moment is shown in Figures 4.2-4.26. Figure 4.2 shows the transverse saw cuts made during deck removal. Notice the transverse saw cuts were continuous throughout the width of the bridge, which included the existing concrete curbs. Longitudinal saw cuts were performed at the time of the actual deck removal and were made along the bridge's centerline (see Figure 4.3), which is half-way between girders 2 and 3. Figure 4.4 shows the removal of the existing concrete post and steel pipe barrier rails, thereby freeing up the section to be removed.

Figures 4.5-4.8 show the existing deck as it was removed in sections of two across the width of the bridge. Figures 4.5 and 4.6 show the removal of the existing deck slab with curb and remaining portion of the barrier rail. Since the existing deck and steel girders did not act compositely with one another, only one longitudinal saw cut was necessary for deck removal. Hence, only two picking points were needed to remove the existing deck across the width of the bridge. Figure 4.7 shows the approximately 26 feet (longitudinally) open section of existing deck needed for three Exodermic panel placements. Due to the crane limitations (reach limit), the first three Exodermic panels were placed before the remaining existing deck could be removed. Also seen in the foreground in Figure 4.7 is a pre-assembled sheet metal haunch form awaiting placement. The continuous steel girders located at the bents can be viewed in Figure 4.8. Figures 4.9-4.12 show the placement of three 29'-3" x 8'-8" new Exodermic panels. The Exodermic panels were delivered on low boy trucks the night of deck replacement work so that the Exodermic panels could be lifted directly from the low boy truck itself (Figure 4.9) and set in place on the bridge. Figure 4.10 shows the placement of the first of five precast Exodermic panels in the negative moment region. Figures 4.11 and 4.12 show the placement of the second and third precast Exodermic panels, respectively. Once the third Exodermic panel was placed, the crane was moved forward and repositioned so that the remaining existing deck could be removed and replaced. While the crane was being repositioned, alignment and shear stud work on the first three Exodermic panels was executed.

Figure 4.13 shows a typical transverse joint in the negative moment region. The transverse reinforcing bars were bent upward during placement to avoid interference with adjacent panels. Sheet metal was measured and placed between adjacent panels along transverse joints to provide formwork for the cast-in-place concrete. This formwork (sheet metal) rested on the bottom flange of the adjacent main bearing bars. When the formwork was completed, the negative moment reinforcing bars were bent back down and lapped next to the negative moment reinforcement of the adjacent panel (Figure 4.14). Figure 4.15 shows the placement of the longitudinal reinforcement located in the transverse joints of the negative moment region.

Figure 4.16 shows the installation of the barrier plates and bolts for later placement of the precast Jersey Barrier Rails. The barrier plates (¾" x 6" x 6") were spaced on 2'-0" centers with a ¾" diameter bolt threaded into the barrier plates. This barrier plate was welded to the bottom flanges of the main bearing bars to guarantee its position. The threaded bolt was left protruding out of the deck so the bolt could extend through the precast concrete barrier rail and a nut tightly threaded onto the bolt, thus securing the barrier to the new deck. A close-up of the barrier plates and bolts can be seen in Figure 4.17. Notice in Figure 4.17 that two main bearing bars have a built-up top flange. They were included so the precast concrete barriers could be installed before the field placed concrete was placed. Also, it ensures the threaded bolts protruding out of the deck were positioned and aligned properly. Drain pipes were also installed in these void areas where the installation of barrier plates, shear studs, and leveling bolts were necessary before the field placed concrete was placed.

Shear studs were installed on the top flanges of the steel girders (see Figure 4.18) to ensure composite behavior between the steel girders and deck. The presence of shear studs prevents movement in the horizontal plane of the deck, thus adding extra strength to the rehabilitated bridge. Figure 4.19 shows a close-up of the shear studs and their spacing. During installation of the first three Exodermic panels, placement of the final two Exodermic panels progressed.

Figure 4.20 shows the placement of the final two Exodermic panels. Notice most of the work was completed on the first three Exodermic panels, e.g.., shear studs installed, transverse reinforcement bent down, placement of longitudinal reinforcement, and barrier plates installed. Once the final two Exodermic panels were positioned, the same procedure was followed for installing the barrier plates/bolts, shear studs, and longitudinal reinforcement. Figure 4.21 shows the field placed concrete being cast over the steel girders and shear studs. A mobile concrete mixer was used to control the concrete mixtures in order to achieve a compressive strength of 3500 psi within 4 hours. Curing blankets were placed over each closure pour to accelerate the curing process of the field placed concrete. Once the concrete reached the specified compressive strength, the curing blankets and all equipment were removed from the Bells Mill Bridge. The bridge was re-opened to traffic by 2:00 p.m. Saturday.

Figure 4.22 shows the precast concrete barriers in-place and fastened securely to the bridge deck via a nut threaded onto the barrier bolt, which was embedded in the CIP concrete. A continuous shear key was placed in the horizontal plane of the precast concrete barriers and field placed concrete was poured to prevent horizontal movement between the barriers and new deck. The keyway was filled through a 1 ¼" diameter PVC grout tube, which was embedded into the precast barriers and spaced on 4'-0" centers.

Figures 4.23 and 4.24 show the closure pours in the negative moment regions after the hardening of the concrete. Figure 4.25 shows a typical "new deck-existing deck" interface that was left idle until the next work period. Figure 4.26 shows a typical CIP bridge endpost. Endposts are located at Bents 1 and 7 of the bridge as shown in Figure 4.1.

The resetting of the existing finger joint at Bent 4 of the Bells Mill Bridge closely paralleled that of the finger joint work on the Longstreet Bridge. Therefore, it was decided that detailed documentation of the Bells Mill finger joint work was unnecessary.

4.5 Deck Overlay Work

The bridge Flexogrid overlay was placed during the nights of September 23-25, 2005. The amount of overlay required for the Bells Mill Bridge totaled 11,200 ft^2 of deck area, which was approximately half that of the Longstreet Bridge. The Flexogrid overlay was installed in a two layer application and followed by a final seal coat. The overlay work was performed by Poly-Carb, Inc. with the assistance of Gilbert Southern. A finished view of the Bells Mill Bridge with the Flexogrid overlay is shown in Figure 4.27. The overlay work was performed in a manner identical to that for of the Longstreet Bridge; therefore, documentation of the Bells Mill overlay work is not presented in this chapter.

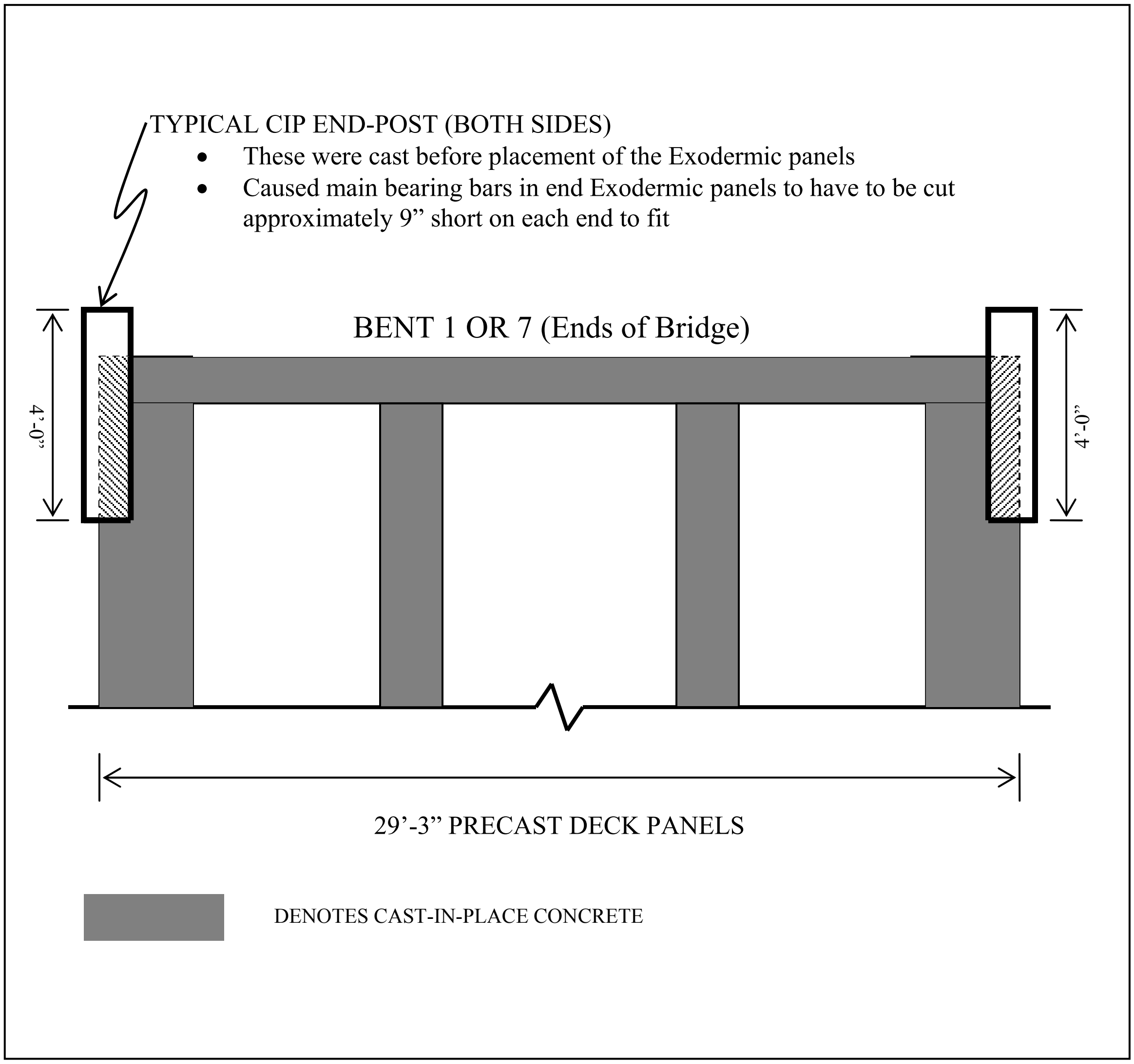


Fig. 4.1 Plan View of Endposts and Modified Precast Deck Panels
At One End of Bells Mill Bridge

Fig. 4.2 Typical Transverse Saw Cuts for Deck Removal

Fig. 4.3 Longitudinal Saw Cutting for Deck Removal

Fig. 4.4 Removal of the Barrier Rails

Fig. 4.5 Removal of Existing Deck Slab and Barrier

Fig. 4.6 Angled View of the Removal of Existing Deck Slab and Barrier

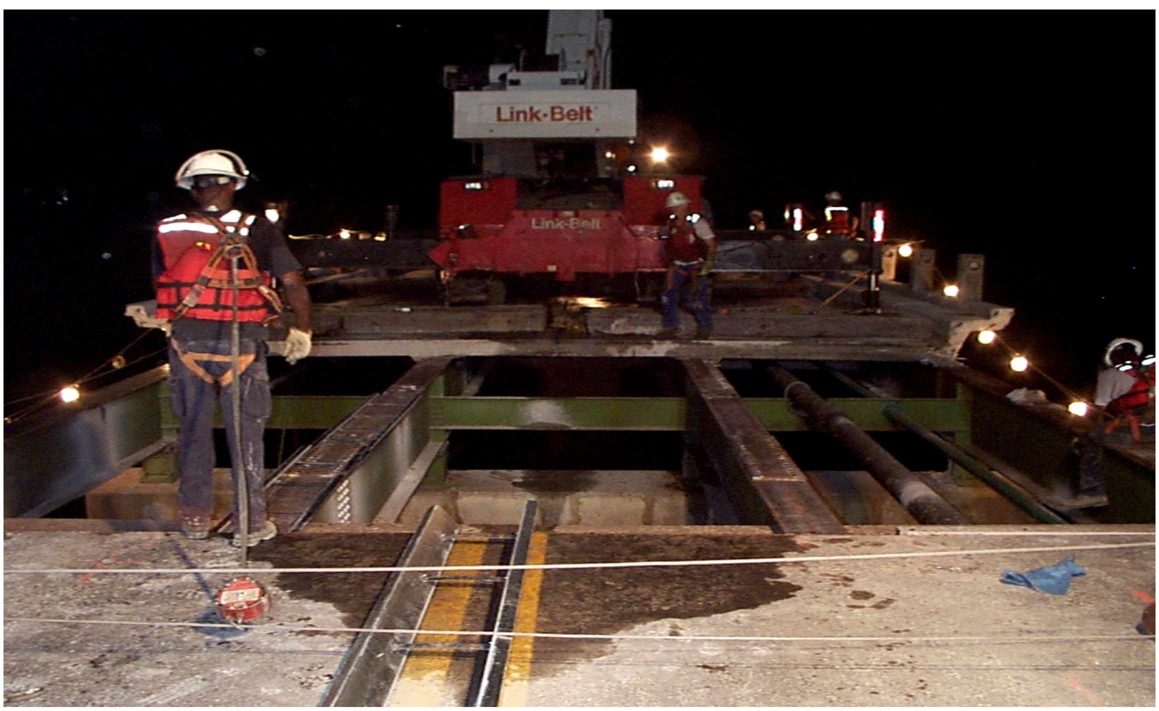


Fig. 4.7 View of Open Section for Three Exodermic Panel Placements

Fig. 4.8 Continuous Steel Girders

Fig. 4.9 Delivery of Precast Exodermic Panels on Low-Boy Truck

Fig. 4.10 Placement of First Exodermic Panel

Fig. 4.11 Placement of Second Exodermic Panel

Fig. 4.12 Placement of Third Exodermic Panel

Fig. 4.13 Typical Transverse Joint in Negative Moment Region

Fig. 4.14 Lapping of the Negative Moment Reinforcing Bars

Fig. 4.15 Steel Reinforcement in the Negative Moment Regions

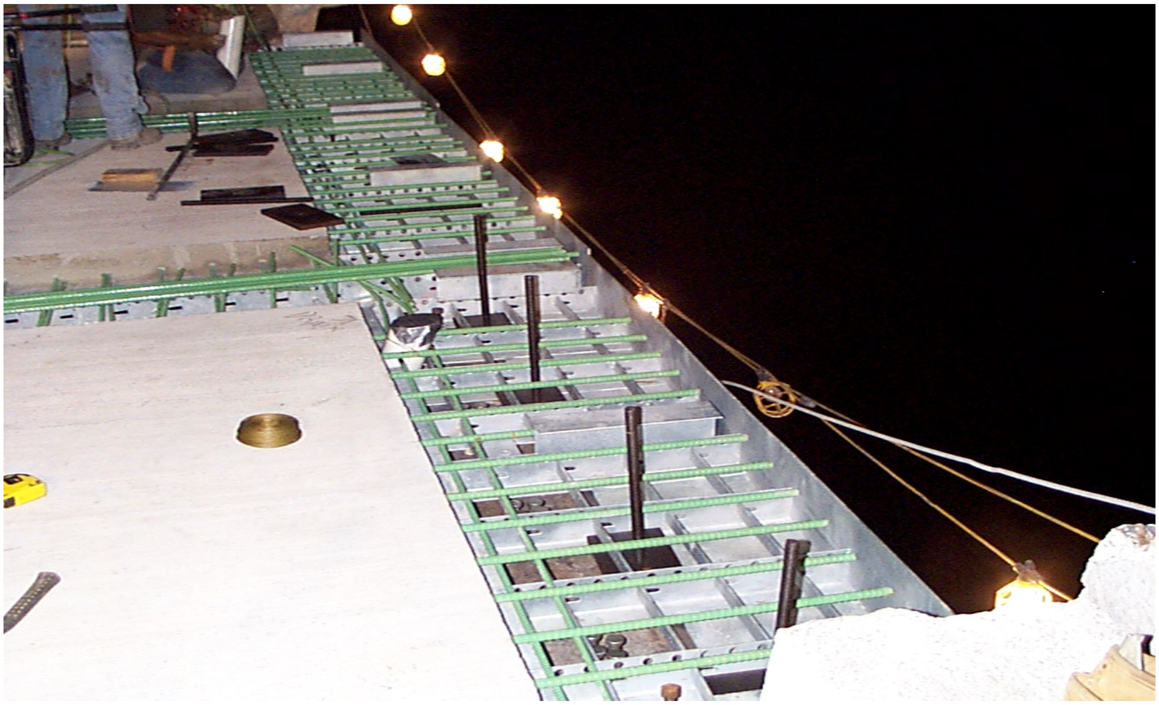


Fig. 4.16 Installation of the Barrier Plates and Bolts for Later Placement of Precast Jersey Barrier Rails

Fig. 4.17 Close-Up of the Barrier Plates and Bolts

Fig. 4.18 Placing Shear Studs with Shear Gun

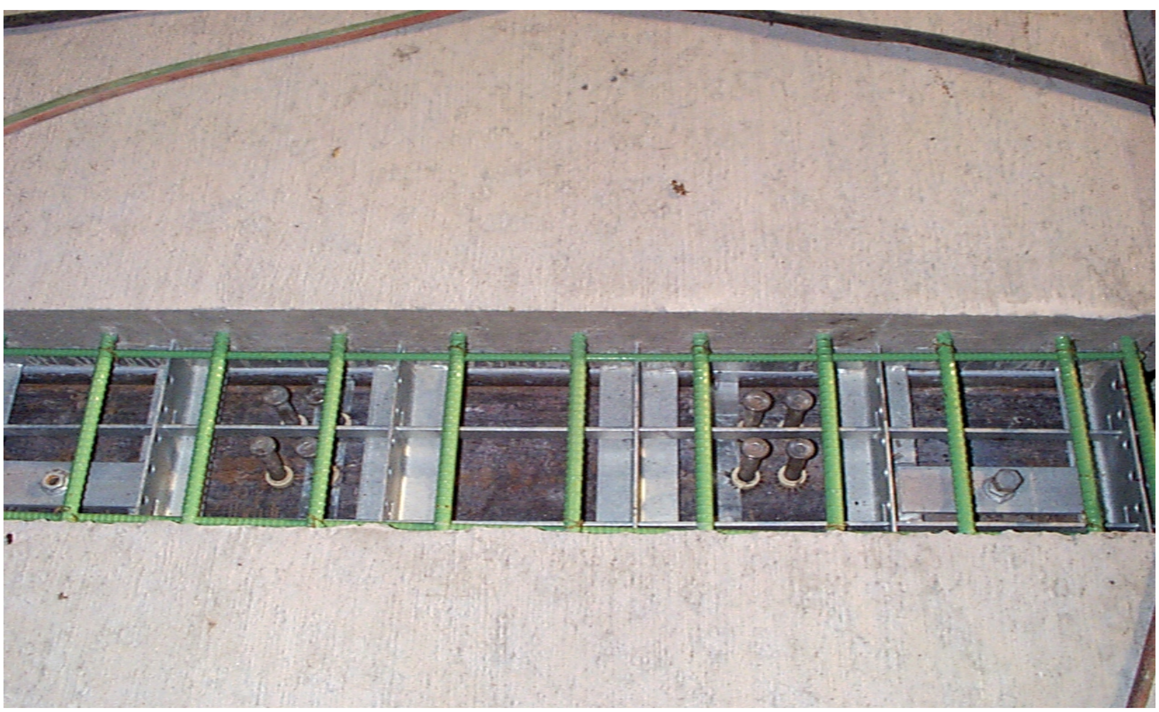


Fig. 4.19 Typical Shear Stud Spacing

Fig 4.20 Placement of Final Two Exodermic Panels

Fig. 4.21 Placement of Rapid Setting Concrete Above Stringers

Fig. 4.22 Precast Jersey Barrier In-Place

Fig. 4.23 Transverse Joint of Negative Moment Region After Concrete Hardening

Fig. 4.24 Overview of Negative Moment Region of New Deck

Fig. 4.25 Typical New Deck-Existing Deck Transverse Joint

Fig. 4.26 Typical Bridge Endpost – Endpost CIP Before
Deck Replacement (see Fig. 4.1)

Fig. 4.27 Finished ⅜” Thick Flexogrid Overlay With Precast Jersey Barriers

5 RAPID DECK REPLACEMENT OF THE I-285 BRIDGES OVER U.S. 41

5.1 General

In this chapter, a time sequence, description of construction tasks and sequence, and photographic display/discussion of the deck replacement work are presented. The I-285 bridges over U.S. 41 were visited regularly during the time interval of June-September 2005 to observe construction of the deck replacement project. The I-285 bridges over U.S. 41 carry 4 lanes in each direction with only the original portions of the deck being replaced, e.g., the two original lanes in each direction. The sister bridges were closed from 9:00 p.m. Friday until 5:00 a.m. Monday each work weekend for deck and transverse edge beam replacement work, and a partial lane closure (two lanes of traffic were maintained at all times) was established during this time. Also, while construction was ongoing on I-285, some lane closures were needed on U.S. 41 (SR 3) to perform the deck replacement work. Saw cutting transverse to the bridge centerline for deck removal, grinding, and installation of the thin co-polymer (Flexogrid) deck overlay were allowed during the time interval of 9:00 p.m. to 5:00 a.m., Monday through Thursday. The GDOT allowed a maximum of twelve weekend closures for this project, and all work was completed within this limit.

As with the bridges in Gainesville, GA, the two Atlanta bridges were bid as a collective effort. The winning bidder, L.C. Whitford Co., Inc., received the contract in October 2004 for the deck replacement work on the two bridges in Atlanta. L.C.

Whitford Co, Inc. has divisions in New York and Georgia and performs work in highway construction. L.C. Whitford specializes in bridge construction and was founded in 1916. Their corporate office is located at 164 N. Main Street in Wellsville, New York.

Deck replacement for the I-285 bridges over U.S. 41 (SR 3) employed precast Exodermic panels measuring 26'-0" x 8'-2"x 6" thick for the eastbound and westbound replacement bridge decks. A total of 12,636 ft^2 of bridge deck was replaced on these sister bridges in a rapid manner. The Exodermic grid fabrication was provided by L.B Foster, a licensed supplier in the Pittsburgh, Pennsylvania area. The Exodermic grids were then shipped to the L.C. Whitford precasting plant in Alpharetta, GA, where the concrete was placed to form the precast deck panels. The panels were then cured and stored at the plant until delivery to the bridge site.

5.2 Time Sequence

Preliminary work on the sister bridges of I-285 over U.S. 41 involved casting the precast sections of the Exodermic deck panels and allowing 28 days of proper curing time to gain efficient strength. Also, L.C. Whitford subcontracted the CIP closure pour concrete mix design to RMC-CEMEX to design a mixture with a targeted strength of 3500 psi in 6-8 hours. The concrete mixture proportions for the I-285 closure pours that were delivered on April 19, 2005 are shown in Table 5.1. The proportions given in the first column of Table 5.1 yielded a batch size of 0.96 cubic yards, therefore a scaled proportion yielding 1.0 cubic yard was specified in the second column. The fresh concrete properties for the Portland Cement Concrete (PCC) mixture are shown in Table 5.2. Table 5.3 shows the compressive strength (psi) of the concrete relative to its age.

The information regarding the concrete mixture design for the I-285 closure pours was provided by the GDOT.

Actual deck replacement work began on the weekend of June 17-20, 2005 on the eastbound bridge of I-285 over U.S.41. The work consisted of replacing the existing deck over span 4, which totaled 988 ft^2 of deck area. A plan and elevation view of the I-285 bridges over U.S. 41 can be viewed in Figure 2.18 (page 24). The second weekend (June 24-27) of the deck replacement work consisted of replacing the existing deck over span 3 (2132 ft^2 of deck area replaced). Spans 1 and 2 were replaced on the same weekend closure of July 15-18. The deck area replaced that weekend totaled 3198 ft^2 (17 Exodermic panels). Once the eastbound bridge (Stage I) was finished, L.C. Whitford started the westbound bridge (Stage II) deck replacement project on July 22-25. The entire westbound bridge of the two sister bridges only required two weekend closures to complete the deck replacement work using the precast Exodermic deck panels. L.C. Whitford finished deck replacement work on the weekend of August 5-8. The deck replacement work on the sister bridges of I-285 over U.S. 41 was completed in five weekend closures. An average of 2527 ft^2 of deck area was replaced during each of these five weekend closures for a total deck replacement area of 12,636 ft^2.

Deck surface grinding took place on the weeknights of September 6-9, 2005. Each sister bridge was ground approximately ¼" to correct any height variation between adjacent panels. Once grinding was completed, the entire surface area of each sister bridge deck (newly replaced portion and portion not replaced) received a thin (≈ 3/8" thick) co-polymer overlay (Flexogrid overlay) on October 14-31, 2005.

5.3 Weekend Construction Tasks and Sequence

The general construction tasks/sequence and provisions for the I-285 bridges over U.S. 41 can be seen in the Beck and Ramey report on "Rapid Rehabilitation/Replacement of Bridge Decks-Phase II" (2). Because of the importance of the I-285 route and the heavy traffic load that it carries, the deck replacement work had to be completed in two stages under concurrent traffic conditions. Figure 5.1 indicates the two construction stages of the deck replacement work. Note in this figure the locations of the temporary barriers. These barriers were positioned such that the maximum possible roadway width was achieved for concurrent traffic. The sections of the bridge deck replaced are shown in the shaded regions. The construction tasks and sequence for a typical weekend's work during each bridge closure (9 p.m. Friday – 5 a.m. Monday) were as follows:

1. At 9.00 p.m. Friday locate the temporary barriers such that two lanes of traffic are maintained on the bridge.
2. Place traffic cones in the right lane of the two lanes of traffic being maintained to allow workers enough space to securely fasten temporary barriers to the bridge deck (for Stage I work).
3. Remove traffic cones once barriers are bolted to the bridge deck.
4. Mobilize equipment onto partially closed bridge.
5. Make transverse and longitudinal saw cuts.
6. Remove existing endwall/transverse edge beams located at the bents.
7. Remove approximately 2' strip of existing concrete where existing rebar is lapped for continuity.
8. Cut and bend rebar up to allow placement of new deck panels.
9. Remove existing deck.
10. Remove concrete diaphragms.

11. Clean top flange of steel girders.

12. Install Exodermic panels and adjust leveling bolts.

13. Attach shear studs to tops of steel girders.

14. Install reinforcing bars in transverse edge beams and endwall chamfers.

15. Provide formwork at endwall and transverse edge beams.

16. Make closure pours over steel girders, shear keys, endwall, and transverse edge beams.

17. Place wet burlap over closure pours.

18. Remove wet burlap covering and equipment from bridge.

19. Remove temporary barriers.

20. Reopen traffic to entire bridge at 5:00 a.m. Monday.

The construction tasks and sequence presented above was for Stage I construction (eastbound bridge). However, it was essentially the same for Stage II. The construction tasks/sequence above only occurred during the 56-hour weekend closure. However, some construction tasks were completed during weeknights from 9:00 p.m. to 5:00 a.m., and these were as follows:

- Installation of protective platforms at the bents and between the girders
- Installation of new steel diaphragms
- Performance of desired saw cutting (deck transverse cutting) for deck removal
- Removal of formwork from the prior weekend
- Position temporary barriers onto shoulders for next weekend's work
- Surface grinding
- Installation of co-ploymer overlay

Photographs showing the construction of the deck replacement work are presented and discussed in the following section.

5.4 Photographic Display/ Discussion of Deck Replacement Work

Photos showing the poor deck condition of the I-285 bridges over U.S. 41 are shown in Figures 5.2 and 5.3. Figure 5.2 shows extensive spalling of the original lanes of the westbound bridge from a traffic approach view. The same extensive spalling from a side view can be viewed in Figure 5.3.

A photographic display of a typical weekend's work that consisted of placing 17 new 8'-2'' wide Exodermic deck panels (approximately 139 linear feet along the bridge or 3600 ft^2) is shown in Figures 5.4-5.52. Temporary concrete barriers were placed at 9:00 p.m. Friday to protect traffic from the open deck during the deck replacement work (see Figure 5.4). A saw cutting layout was marked during a weeknight closure and sawed on Friday night during the weekend bridge closure (see Figure 5.5). Figures 5.6 and 5.7 show a longitudinal saw cut taking place on the bridge deck. Notice the saw cutting pattern for deck removal in the foreground of Figure 5.7. The existing deck was cut so that two picking points would cover the full width of the deck replacement. The transverse saw cuts were approximately 6 feet apart while the longitudinal saw cut was located in the center of the deck portion being replaced. L.C. Whitford subcontracted the saw cutting to Atlanta Cutters, Inc. to enhance saw cutting productivity and gain expertise in that area of work. Figure 5.8 shows the depth of a typical transverse saw cut. The uncut portion below the transverse saw cut was snapped loose as the existing deck panel was removed for replacement. Figure 5.9 shows longitudinal saw cuts along the edge of the portion being replaced. The area of concrete between these two longitudinal saw cuts was chipped out carefully so that the existing rebar in the upper mat could be re-used to achieve continuity at the Exodermic panel to existing deck longitudinal joint. The left longitudinal saw cut was sawed to approximately a ½" – 1" so that the negative moment reinforcing bars were not damaged. The right longitudinal saw cut was sawed to normal depth to allow for a clean break when the existing deck panel was removed. It should be noted that there were no transverse saw cuts within these areas of deck removal.

Figures 5.10-5.12 show work being performed on the deck located above bent 3. Figure 5.10 shows two large hammers as they begin the removal process of the existing deck and transverse edge beam (work is only taking place on the right side of the existing expansion joint). Since the expansion joint on the bridge was maintained, it allowed replacement work the previous weekend to stop at the centerline of the bent. Figures 5.11 and 5.12 show top and underneath views of the deck and transverse edge beam work. The loose concrete was loaded onto a dump truck so traffic could be transferred quickly from the current lanes to the previously closed lanes of operation.

Figure 5.13 shows the negative moment reinforcing bars remaining in place as the existing concrete was removed carefully. These bars are required to create a minimum lap of 1'- 7" with the reinforcement in the new deck panels. The rebar was bent upward at a maximum angle of 60° from the horizontal to allow the precast Exodermic panels to be placed without interference (see Figure 5.14). Figure 5.15 shows the existing rebar that was bent upward to allow placement of the Exodermic deck panels from a U.S. 41 perspective. During deck removal along this joint, traffic on U.S. 41 was detoured as needed as deck work progressed across U.S. 41. Two lanes of traffic on U.S. 41 were maintained during this process while the other two lanes were closed for falling debris and cleanup. Figure 5.16 shows the approximately 2' width of deck removal around the perimeter receiving deck replacement.

Once the approximately 2' edges (longitudinal and transverse) were free of existing concrete, existing deck panels were ready for removal. Figures 5.17 and 5.18 show the first and last sections of the existing deck as they were removed and placed onto the same low-boy truck that delivered the precast Exodermic panels (see Figure 5.19). The existing deck panels were lifted in two sections with each section measuring approximately 6' x 10'. Figure 5.20 shows the opening of the deck after the existing deck panels were removed (approximately 26' transversely by 120' longitudinally). Notice that steel diaphragms were installed prior to deck removal and that the existing concrete diaphragms were removed concurrently with deck removal. Also, it should be noted that the temporary barriers were in place and fastened prior to any opening in the bridge deck. Figure 5.21 shows the same deck opening from the opposite direction. Figure 5.22 shows the falling debris from the transverse edge beam work located above U.S. 41. This photograph was taken from the same location as Figure 5.21 with the exception that the photographer was underneath the bridge deck. Also, notice that two lanes of U.S. 41 were operational and the other two lanes were closed where bridge work was occurring overhead. Figure 5.23 shows a close-up of just how difficult and extensive removal of the transverse edge beam can be. Figure 5.24 shows the longitudinal girders resting on the bent after the removal of the transverse edge beam.

Figures 5.25-38 show the placement of the precast Exodermic panels. Figure 5.25 shows the picking beam used during the deck replacement work. Figure 5.26 shows the placement of an Exodermic panel. Notice the panel was set at an angle and heaved into place. When bent at the 60° angle, the negative moment reinforcing bars interfered with the placement of the Exodermic panels (see Figure 5.27). As a result, one side of the negative moment reinforcement needed additional bend to allow the Exodermic panels to slide beneath the existing rebar (see Figure 5.28). Figure 5.29 shows the placement of the first Exodermic panel located at the endwall. Notice how the right side of the Exodermic panel was placed underneath the existing rebar so that the left side can be lowered directly into place. Figures 5.30 and 5.31 show the first and second Exodermic panels in place. Figure 5.32 shows four out of the seventeen panels positioned during the weekend replacement work. Figures 5.33 and 5.34 show the repetitive process of the deck replacement work. Figure 5.35 shows a worker adjusting the built-in panel leveling bolts to insure a level riding surface. Special skewed panels were designed at the bents to accommodate the horizontal curvature of the I-285 bridges over U.S. 41. A 1'-6" wide strip of cast-in-place (CIP) concrete was cast on each side of the expansion joints located at the bent centerlines (see Figure 5.36). To anchor reinforcing bars in all transverse edge beams (end spans and interior spans), a 1⅛" diameter swedged bolt was screwed into a threaded sleeve that was welded to the web of the girder. Figure 5.37 shows the Exodermic panels in place prior to any field placed concrete (note that the section pictured here was not the section that consisted of 17 panels of installment). The new deck was designed for composite behavior as seen by the shear studs, unlike the old deck. Shear studs were placed in pairs and spaced approximately 4-5 inches apart longitudinally (see Figure 5.38). The shear studs are ¾ inches in diameter and have a 4 inch in-place length.

Figures 5.39-5.46 show the placement of the 24 hour accelerated strength concrete. The field placed concrete was delivered in a ready-mix truck (see Figure 5.39). Figure 5.40 shows the workers placing the concrete in the transverse (shear keys) and longitudinal joints. The grout in the shear keys prevents the adjacent panels from moving vertically with respect to one another as traffic moves across the joint. The concrete was consolidated using hand held vibrators. A 2'-0" wide strip of CIP concrete was poured on the bridge side of the expansion joint located at the endwall (see Figure 5.41). A roughened existing endwall face was provided to assure a quality bond when the CIP concrete was placed (see Figure 5.42). All transverse edge beams and endwall chamfers were cast at the same time as the closure pours.

An overview of the accelerated concrete in place and finished properly can be seen in Figure 5.43. Figures 5.44 and 5.45 show the placement of the wet burlap for curing the field placed concrete. After the 24 hour accelerated concrete reached a minimum compressive strength of 3500 psi, the burlap covering was removed and the bridge reopened to traffic at 5:00 a.m. Monday. Figures 5.46 and 5.47 show the bridges after the deck replacement work was completed. Figure 5.46 shows an overview of 120 linear lane feet of completed deck replacement on the westbound side of I-285. The completed deck of the eastbound bridge before surface grinding and placement of the overlay can be viewed in Figure 5.47.

Figures 5.48-5.50 show some typical transverse joints encountered during the deck replacement work. Figure 5.48 shows a typical expansion joint located on the bridges. Notice that this figure is a follow up to Figure 5.36 after the closure pours were made. When deck replacement work occurred on the first half of the bridge, an expansion joint of new deck to existing deck was observed at bent 3 (see Figure 5.49). The type of expansion joint located at the endwalls of bents 1 and 5 is seen in Figure 5.50. Notice the approximately 2'-0" wide strip of CIP concrete. Figure 5.51 shows an underneath view of the bridge when deck replacement work was taking place overhead. Protective platforms were installed during the weeknights between 9:00 p.m. to 5:00a.m., and a partial lane closure on U.S. 41 was implemented. An underneath view of the bridge once the deck replacement work was finished can be viewed in Figure 5.52.

5.5 Deck Overlay Work

A photographic display of the deck preparation, application of the co-polymer overlay in progress, and the resulting Flexogrid overlay are shown in Figures 5.54-5.64. Poly-Carb, Inc. installed the Flexogrid overlay in stages to minimize the amount of traffic disruption. The four different stages (see Figure 5.53) were performed linearly from one end of the bridge to the other. Stages I and III were the first application of the co-polymer overlay while Stages II and IV were the second application of the co-polymer overlay. The overlay work was performed randomly during weeknights and weekend bridge closures; therefore, no viable timeframe of the overlay application was acquired.

Installation of the co-polymer overlay was performed over the entire deck surface (eastbound and westbound). The deck surface was ground approximately ¼" to correct any height variation between adjacent Exodermic panels and to provide a smooth riding surface. Once the deck surface was ground, shot blasting was performed until the desired cleanliness was reached (see Figure 5.54 and 5.55). The Flexogrid overlay was installed using the following process:

1. Surface preparation, e.g., grinding, shot blast

2. Application of low viscosity crack sealer/bond enhancer
3. Application of first coat of epoxy, coarse aggregate, and fine aggregate
4. Application of second coat of epoxy, coarse aggregate, and fine aggregate
5. Application of Seal Coat

Figure 5.56 shows the Poly-Carb truck as the second application of the co-polymer overlay was being installed (note the first application of the overlay was finished). The epoxy flowed readily from the Poly-Carb truck (see Figure 5.57) as the workers quickly squeegeed on the epoxy based co-polymer binder (see Figure 5.58). The broadcasting of the aggregate quickly covered the freshly placed epoxy as this continuing process was repeated throughout the length of the bridge (see Figure 5.59). The deck was swept and vacuumed to remove the excess aggregate after the proper curing time was achieved. After removing the excess aggregate, a seal coat (final application) was applied to the overlay surface using a hand sprayer and compressor (see Figure 5.60). Figure 5.61 shows a typical endwall joint during the application of the co-polymer overlay. The duct tape (located between the two workers) protected the endwall joint throughout the overlay application process and was removed after the final layer was completed. Figure 5.62 shows a finished view of a typical expansion joint on the I-285 bridges over U.S. 41. The finished ⅜" thick Flexogrid overlay is shown in Figures 5.63 and 5.64.

Table 5.1 Concrete Mixture Proportions for I-285 Closure Pours

Item	PCC Mixture	
*Coarse Aggregate (ASTM C-33 No.7 Granite) (lb/yd^3)	1841	1918
*Fine Aggregate (lb/yd^3)	950	990
Water (lb/yd^3)	267	278
Type III Cement (lb/yd^3)	705	734
Target Air (%)	4	4
High-Range Water Reducing Admixture (ADVA 140) (oz/yd^3)	75.2	78.3
Special Admixture (DCI) (gal/yd^3)	6	6.25
	0.96 yd^3	1.0 yd^3

* SSD Wt.

Table 5.2 Concrete Properties for I-285 Closure Pours

Item	PCC Mixture
Slump (in)	3.5
Air Content (%)	2.5
Mix Temperature (°F)	68
Air Temperature (°F)	71
1 Yard Weight (lbs)	3762.56

Table 5.3 Average Compressive Strength (6 x 12) Relative to Concrete Age

Age (hours)	Average Compressive Strength (psi)
4	300
6	2245
7	2950
7.5	3200

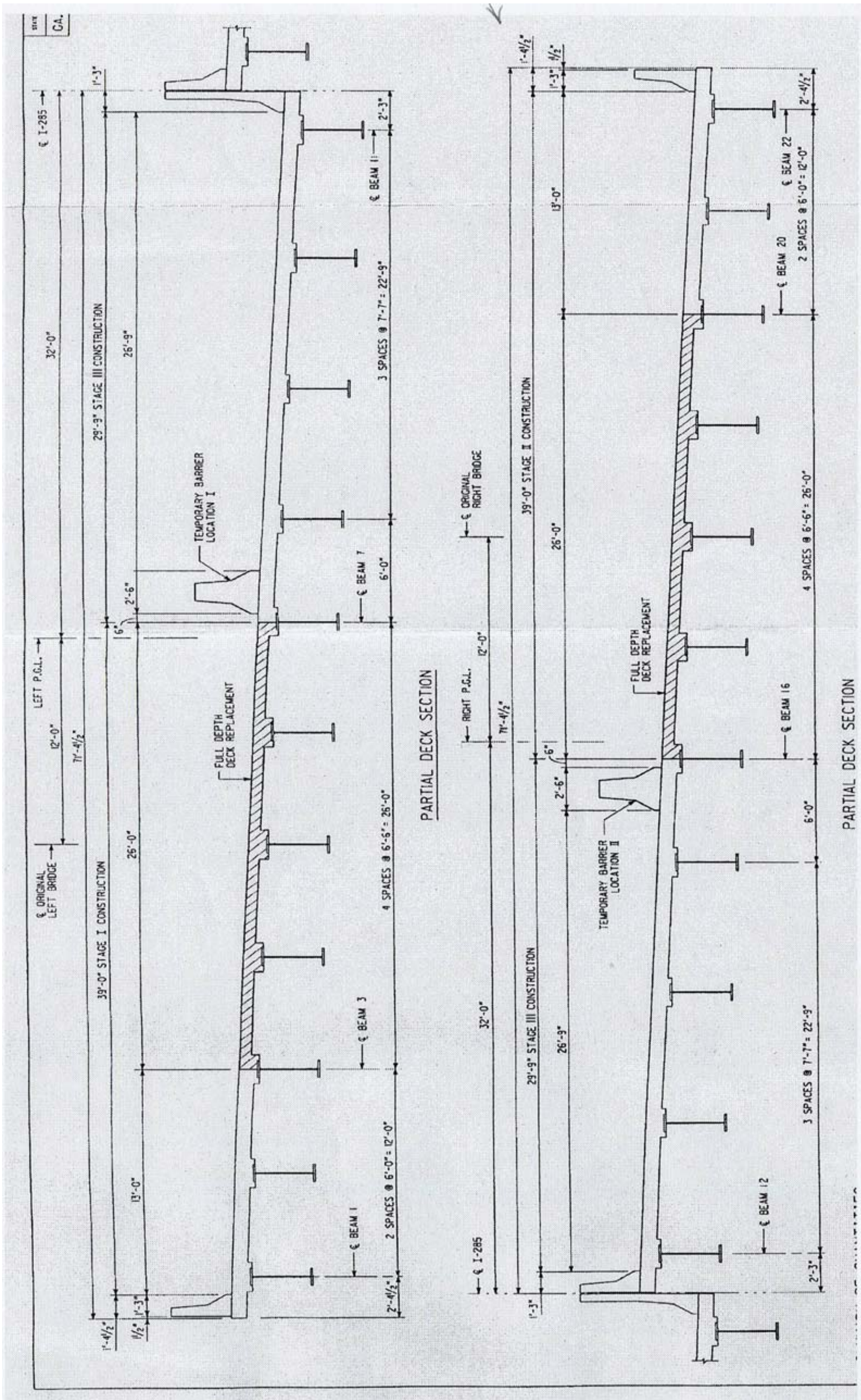


Figure 5.1 Construction Sequence (2)

Fig. 5.2 Approach View of Typical Spalling of Original Travel Lanes

Fig. 5.3 Side View of Spalling of Original Travel Lanes

Fig. 5.4 Temporary Concrete Barrier Used During Weekend Closure

Fig. 5.5 Layout of Saw Cutting

Fig. 5.6 Saw Cutting for Deck Removal

Fig. 5.7 Saw Cutting Grid Used for Deck Replacement

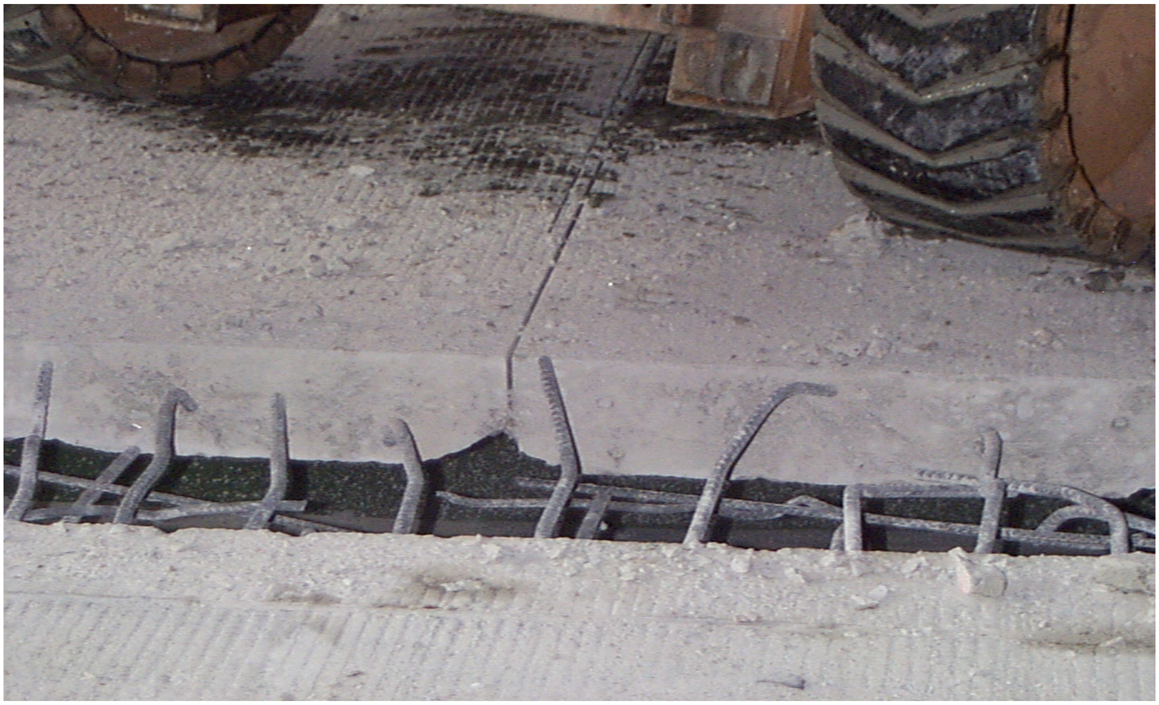


Fig. 5.8 Typical Depth of Transverse Saw Cuts

Fig. 5.9 Typical Longitudinal Saw Cuts

Fig. 5.10 Jack Hammering at Locations Above Edge Beams

Fig. 5.11 Removal of Edge Beam

Fig. 5.12 Falling Debris from Edge Beam Removal

Fig. 5.13 Deck Removal around Existing Negative Moment Reinforcing Bars

Fig. 5.14 Rebar with Approximately 60° of Bend

Fig. 5.15 Underneath View of Negative Moment Reinforcing Bars

Fig. 5.16 Approximately 2' Width of Deck Removal Around Perimeter

Fig. 5.17 Removal of First Section of Existing Deck

Fig. 5.18 Removal of Last Section of Existing Deck

Fig. 5.19 Loading of Deck Panels onto Low-Boy Trailer

Fig. 5.20 View of Steel Girders After the Removal of the Existing Deck

Fig. 5.21 Deck Opening for 17 Panels of Installment

Fig. 5.22 Underneath Shot of Traffic on U.S. 41

Fig. 5.23 Close-Up of Edge Beam Work

Fig. 5.24 Close-Up of Edge Beam After the Removal of the Existing Concrete

Fig. 5.25 Lift Spreader/Picking Beam Used During Deck Replacement Work

Fig. 5.26 Setting of First Exodermic Panel

Fig. 5.27 Setting of Exodermic Panel with Rebar at 60°

Fig. 5.28 Additional Bending of Rebar for Placement of Exodermic Panels

Fig. 5.29 Setting of Precast Exodermic Panel

Fig. 5.30 First Exodermic Panel In-Place

Fig. 5.31 Setting of Second Precast Exodermic Panel

Fig. 5.32 Overview Shot of Precast Exodermic Panels Being Set

Fig. 5.33 Continuous Setting of the Exodermic Panels

Fig. 5.34 Setting of the Exodermic Panels with Crane and Excavator

Fig. 5.35 Adjustment of the Leveling Bolts

Fig. 5.36 Typical Transverse Joint Over Each Bent

Fig. 5.37 Overview Shot of Precast Exodermic Panels In-Place

Fig. 5.38 Placement of Shear Studs

Fig. 5.39 Placement of 24 Hour Accelerated Strength Concrete

Fig. 5.40 Smoothing and Consolidating of the 24 Hour Accelerated Concrete

Fig. 5.41 Placement of the Accelerated Concrete

Fig. 5.42 Typical Endwall After Deck Removal

Fig. 5.43 Overview Shot of Longitudinal and Transverse Closure Pours

Fig. 5.44 Placement of Burlap on the Field Placed Concrete

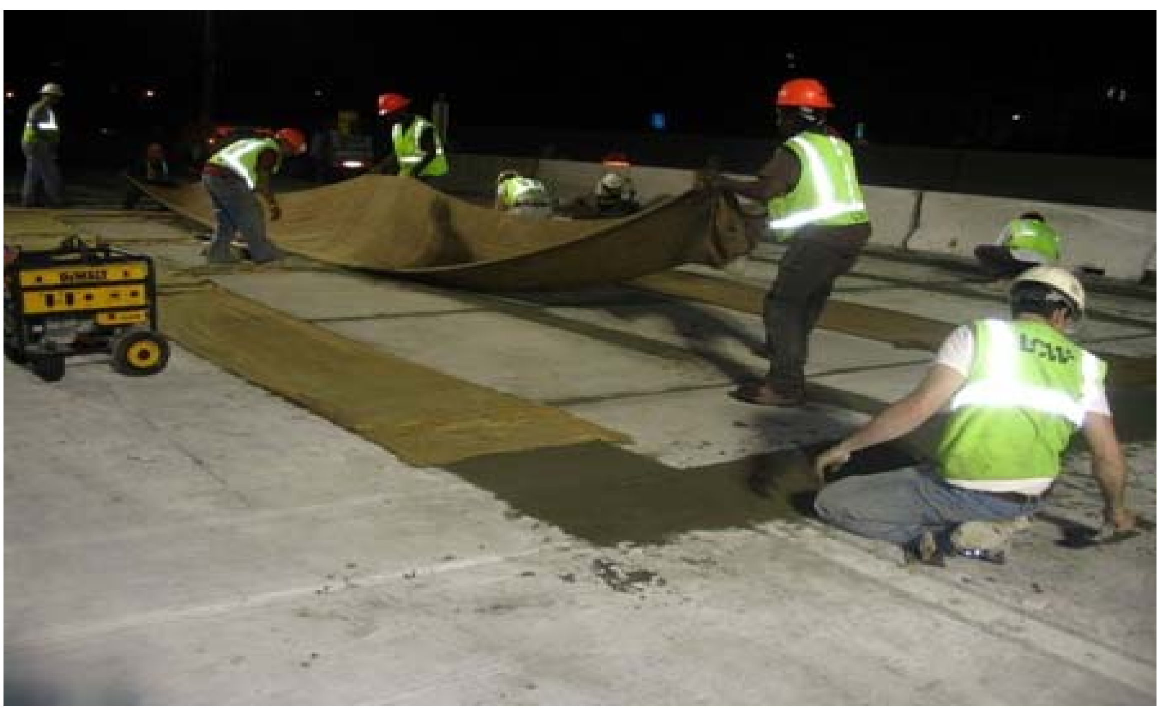


Fig. 5.45 Close-Up of the Burlap on the Field Placed Concrete

Fig. 5.46 Overview Shot of Approximately 120' of Deck Replacement

Fig. 5.47 Finished Deck Surface after Deck Replacement Work

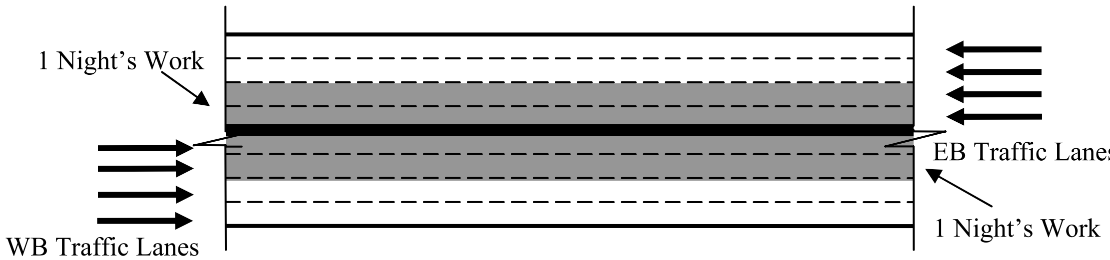
Fig. 5.48 Typical Expansion Joint Located above Each Bent after Deck Replacement

Fig. 5.49 Typical Existing Expansion Joint during Deck Replacement

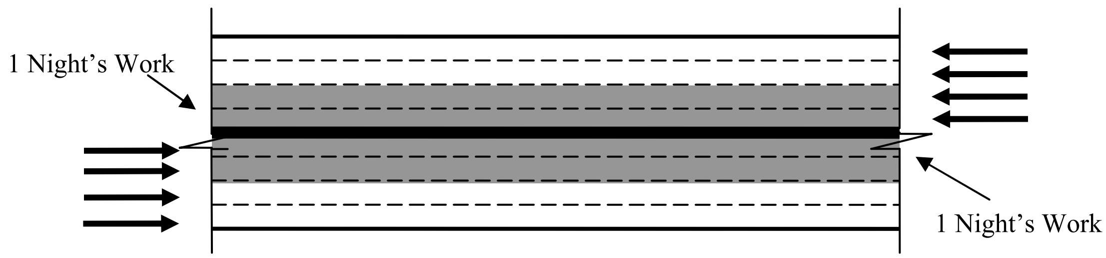
Fig. 5.50 Typical Expansion Joint Located at Endwall

Fig. 5.51 Protective Platform Used During Deck Replacement Work

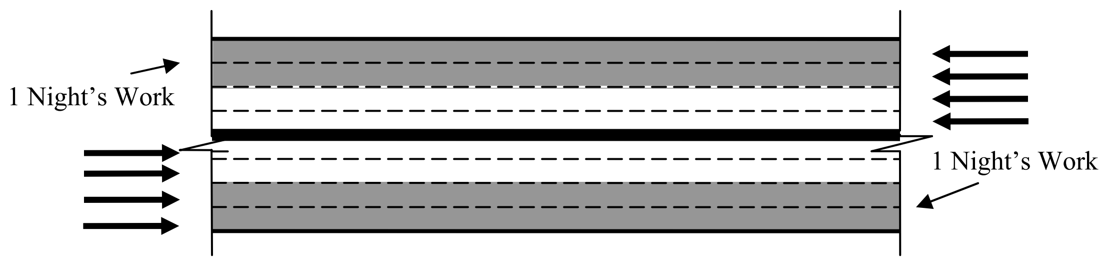
Fig. 5.52 Underneath Shot of Finished Replacement Deck



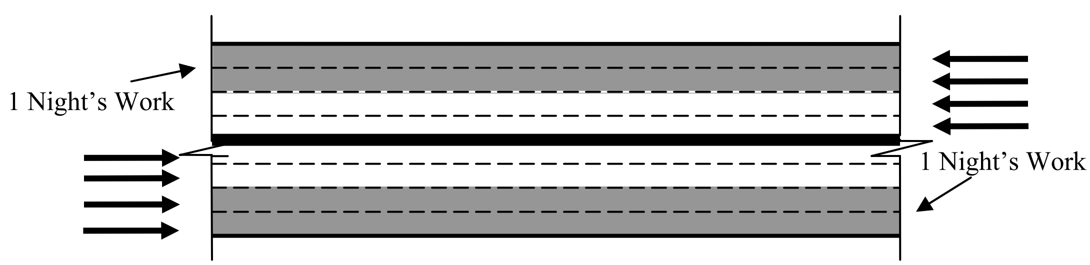
Stage I (First Application)



Stage II (Second Application)



Stage III (First Application)



Stage IV (Second Application)

Fig. 5.53 Staged Overlay Sequence for I-285 Bridge over U.S. 41

Fig. 5.54 Shot Blast Cleaning of Deck Surface

Fig. 5.55 Close-Up of Shot Blast Cleaning Machine

Fig. 5.56 Application of Second Co-Polymer Overlay Layer

Fig. 5.57 Epoxy Based Co-Polymer Binder

Fig. 5.58 Squeegeeing-on of the Epoxy Based Co-Polymer Binder

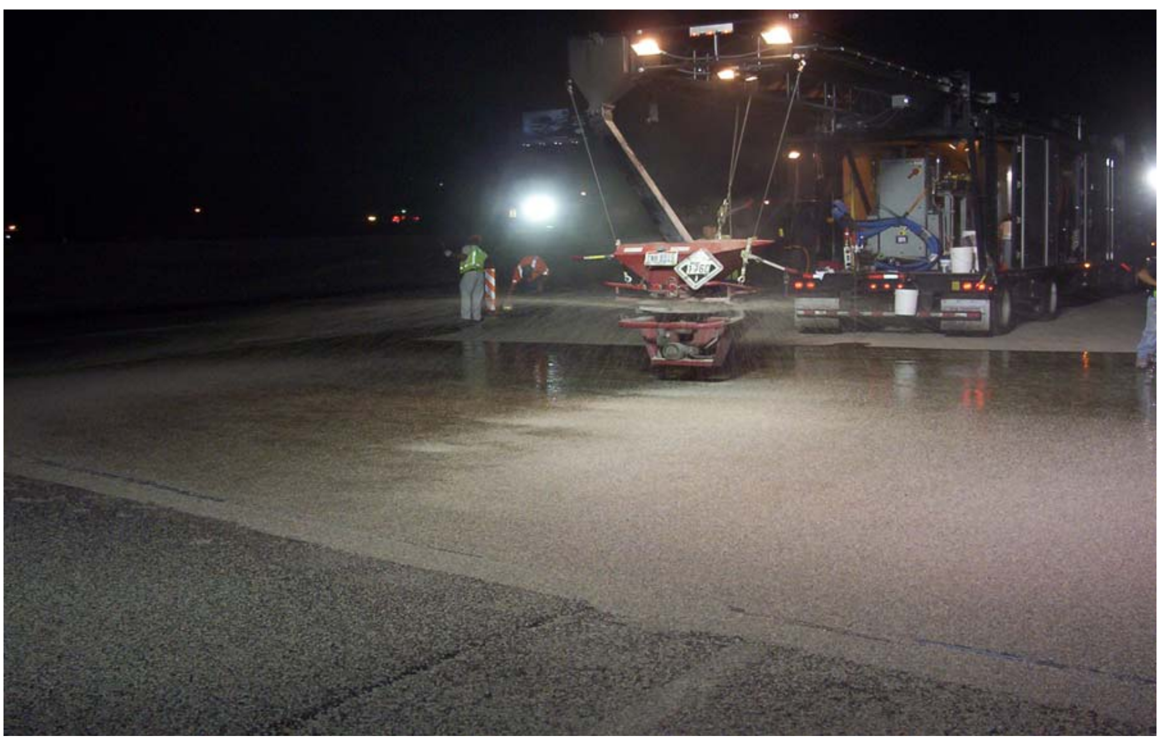


Fig. 5.59 Broadcasting of Second Layer of Aggregate on Polymer Binder

Fig. 5.60 Application of Seal Coat

Fig. 5.61 Typical Endwall Joint During Second Application of Co-Polymer Overlay

Fig. 5.62 Typical Expansion Joint on Finished Deck Surface

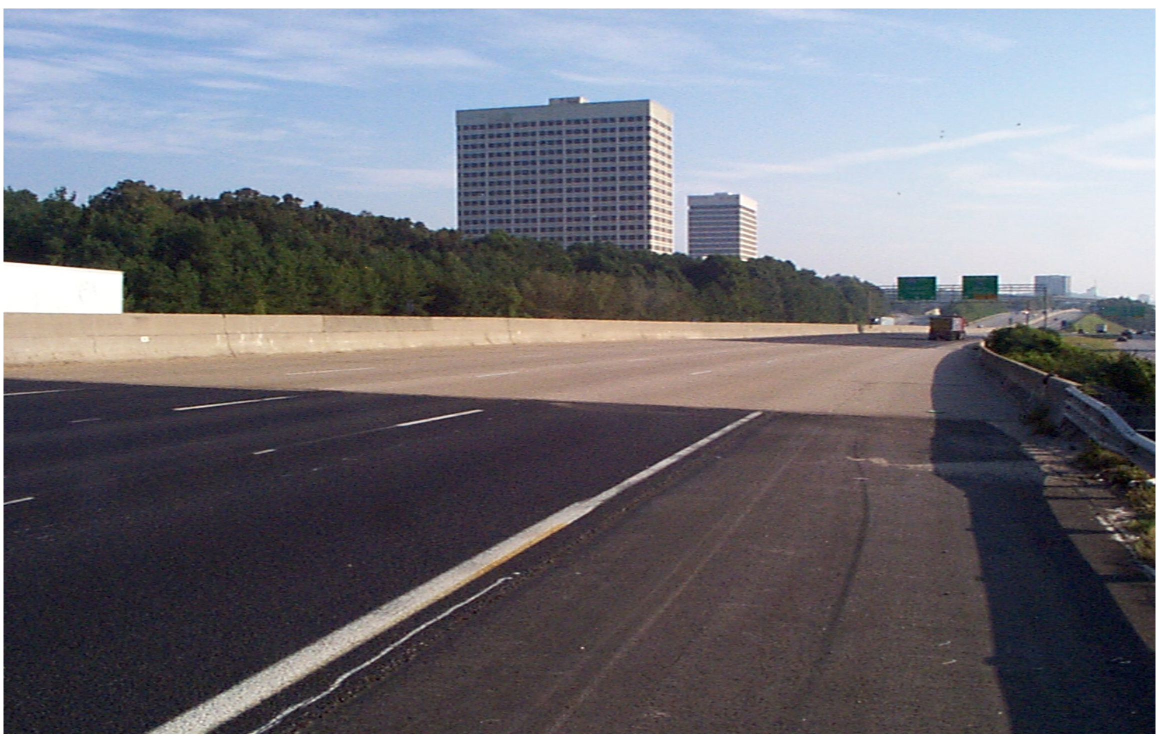


Fig. 5.63 Finished ⅜” Thick Flexogrid Overlay on Westbound Bridge

Fig. 5.64 Finished ⅜” Thick Flexogrid Overlay

6. RAPID DECK REPLACEMENT OF THE I-285 BRIDGES OVER BUFORD HIGWAY

6.1 General

The I-285 bridges over Buford Highway are located in Dekalb County, GA 1.2 miles north of I-85. The deck replacement work was completed in a rapid manner while maintaining the maximum possible number of traffic lanes operational. The sister bridges carry 13 lanes of traffic (6 lanes westbound and 7 lanes eastbound) over Buford Highway with only the original portions of the decks being replaced. The original portions of the decks consisted of the two original westbound lanes and three original eastbound lanes. The deck and edge beam replacement work were completed during five individual weekend partial lane closures, i.e., 9:00 p.m. Friday until 5:00 a.m. Monday. Deck replacement work was completed in one direction prior to beginning work in the opposite direction. Also, work was performed linearly from one end of the bridge to the other. As with the I-285 bridges over U.S. 41, work on the I-285 bridges over Buford Highway were completed within the set completion time (12 weekend closures) to avoid liquidation damages.

Partial replacement of the decks of the I-285 bridges over Buford Highway were conducted in a manner similar to that for the I-285 bridges over U.S. 41, with the exception of the additional skew introduced by the Buford Highway Bridges. Special trapezoidal Exodermic panels were designed at the end sections to accommodate the skewness of the sister bridges. The Exodermic panels measured 26’-0” x 8’-2” x 6” for the westbound replacement work and 35’–0” x 8’-2” x 6” for the eastbound work.

The Exodermic panel design was essentially the same for both Atlanta bridges, with the exception of the skewed panels and modification of the transverse joints in the negative moment regions. The steel girders on the I-285 bridges over Buford Highway were continuous over the supports, requiring the Exodermic panels to resist negative moments instead of pure shear over the supports. This modification of the transverse joint included installation of field placed reinforcement and installation of an approximately 2 feet wide closure pour. A total deck area of 13,176 ft^2 was replaced on the I-285 bridges over Buford Highway via the use of Exodermic deck panels. After all deck panel placements, closure pours, and surface grinding work were completed, the entire bridge deck surface was overlaid with a thin co-polymer overlay.

6.2 Time Sequence

L.C. Whitford began the deck replacement work on the eastbound bridge on August 12-15, 2005 after completing the deck replacement work of the I-285 bridges over U.S. 41 the prior weekend (August 5-8). Before deck replacement work could begin, a lane shift was installed to provide the maximum number of lanes (3) possible for concurrent traffic. The lane shift required an approximate shift of 6 feet in lanes toward the outside shoulder of the sister bridges. The asphalt roadway surface adjacent to each bridge was milled for approximately 800 feet on both sides of the sister bridges and new asphalt was replaced, along with the proper lane markings for implementation of the lane shift. The deck replacement work of August 12-15 consisted of replacing the existing deck over span 1 and the negative moment region over bent 2, which totaled 2380 ft^2 of deck area. A plan and elevation view of the I-285 bridges over Buford Highway can be viewed in Figure 2.13 (page 19). The second weekend (August 19-22) of the deck replacement work consisted of replacing the existing deck over spans 2 and 3 and the negative moment region over bent 3. This totaled 2940 ft^2 of deck area or 84 feet of linear lane footage. The third weekend closure (August 26-29) consisted of span 4 and the negative moment region over bent 4 (totaled 2240 ft^2 of deck area). The eastbound bridge deck replacement was finished in three consecutive weekends and was considered Stage I of the project.

Once the eastbound side of the bridge deck was finished, L.C. Whitford started the westbound side (Stage II) of the deck replacement project. The entire westbound side of the sister bridges was completed in only two weekend closures while employing the precast Exodermic deck panels. The fourth weekend of the deck replacement project began on September 9-12, and the replacement of span 4 and a partial of span 3 was performed (includes the negative moment region over bent 4). The 100 linear lane feet consisted of a total deck area of 2590 ft^2. L.C. Whitford finished the deck replacement work on the westbound bridge on the weekend of September 16-19 with a total of 3026 ft^2 of deck area replaced. The deck replacement work on the sister bridges of I-285 over Buford Highway was accomplished in five weekend closures completing the 13,176 ft^2 of total deck area replaced. An average of 2635 ft^2 of deck area was replaced each weekend during these five weekend closures.

Deck surface grinding took place during the weeknights of September 19-23. Each sister bridge deck was ground approximately ¼” to correct any height variation between adjacent panels. Once grinding was completed, the entire surface area of each sister bridge deck received a thin (approximately ⅜" thick) co-polymer overlay (Flexogrid overlay) on October 14-31.

6.3 Weekend Construction Tasks and Sequence

The general construction tasks/sequence and provisions for the I-285 bridges over Buford Highway can be seen in the Beck and Ramey report on "Rapid Rehabilitation/Replacement of Bridge Decks-Phase II" (2). Because of the importance of the I-285 route and the heavy traffic load that it carries, the deck replacement work had to be done in two stages under concurrent traffic conditions. Figure 6.1 indicates the two construction stages of the deck replacement work. Note in this figure the locations of the temporary barriers. The barriers are positioned such that the maximum possible roadway width is achieved for concurrent traffic. The sections of the bridge deck replaced are shown in the shaded regions. The construction tasks and sequence for a typical weekend's work during each bridge closure (9 p.m. Friday – 5 a.m. Monday) were as follows:

1. At 9.00 p.m. Friday locate the temporary barriers such that two lanes of traffic are maintained on the bridge.
2. Place traffic cones in the right lane of the two lanes of traffic being maintained to allow workers enough space to securely fasten temporary barriers to the bridge deck (for Stage I work).
3. Remove cones once barriers are bolted to the bridge deck.
4. Mobilize equipment onto partially closed bridge.
5. Make transverse and longitudinal saw cuts.
6. Remove existing transverse edge beams located at the endwalls.
7. Remove approximately 2' strip of existing concrete where existing rebar is lapped for continuity.

8. Cut and bend rebar up to allow placement of new deck panels.
9. Remove existing deck.
10. Remove concrete diaphragms and replace with steel diaphragms.
11. Clean top flange of steel girders.
12. Install Exodermic panels and adjust leveling bolts.
13. Attach shear studs to tops of steel girders.
14. Install reinforcing bars in transverse edge beams and endwall chamfers.
15. Provide formwork at endwall and transverse edge beams.
16. Make closure pours over steel girders, shear keys, endwall, and transverse edge beams.
17. Place wet burlap covering over closure pours.
18. Remove wet burlap covering and equipment from bridge.
19. Remove temporary barriers.
20. Reopen traffic to entire bridge at 5:00 a.m. Monday.

The construction tasks and sequence presented above were outlined for Stage I construction (eastbound bridge). However, the procedure was essentially the same for Stage II. The construction tasks/sequence above only occurred during the 56 hour weekend closure. However, some construction tasks were completed during weeknights from 9:00 p.m. to 5:00 a.m. and these were as follows:

- Installation of lane shift
- Installation of protective platforms at the bents and between the girders
- Installation of new anchor bolts and z-clips
- Completion of any desired saw cutting (deck transverse cutting) for deck removal

- Removal of formwork from the prior weekend
- Position temporary barriers onto shoulders for next weekend's work
- Surface grinding
- Installation of co-ploymer overlay

Photographs showing the construction of the deck replacement work are presented and discussed in the following section.

6.4 Photographic Display/ Discussion of Deck Replacement Work

A photographic display of a typical weekend's work that consisted of placing 10-12 new 8'-2" wide Exodermic panels (approximately 80–100 linear lane feet) are shown in Figures 6.3-6.42. Before deck replacement work began, a lane shift of approximately 6 feet was installed to allow the maximum number of lanes (3) possible for concurrent traffic. This is shown in Figure 6.2. The dashed line in that figure denotes the location of the temporary concrete barriers and traffic cones used for the bridge closure. The solid line (approximately 1' left of dashed line) indicates the edge of existing deck receiving replacement via precast Exodermic deck panels. Demolition of the existing deck of the I-285 bridges over Buford Highway followed a similar manner as that for the I-285 bridges over U.S. 41. After the placement of the temporary concrete barriers, saw cutting was performed (around 11:00 p.m Friday) on the portion of deck being replaced during that weekend closure (see Figure 6.3). A longitudinal saw cut was executed at the centerline of the portion being replaced so that only two picking points would be required for deck removal, i.e., the old deck was removed in two pieces across the width of the bridge. Also, longitudinal saw cuts were performed along the edges of the portion being replaced so the existing rebar (negative moment reinforcing bars) along these edges could be used to provide continuity with the section of deck not being replaced. Concrete removal around the existing rebar (negative moment reinforcing bars) was performed in a like manner to that for the I-285 bridges over U.S. 41. Transverse saw cuts were made approximately 5-6 feet apart to minimize the weight of each section as it was removed. Figure 6.4 shows two large hammers as they begin the removal process of the existing deck. Figures 6.5 and 6.6 show the approximately 2'- width of deck removed around the perimeter of the area receiving deck replacement.

Figure 6.7 shows the open section of the bridge deck after the existing deck was removed (approximately 26' transversely by 100' longitudinally). Notice that the temporary concrete barriers were set only along the deck opening, and traffic cones/barrels were placed the remaining distance of the safety zone. Figure 6.8 shows the existing transverse edge beam after removal at the endwall at bent 5 (note the existing edge beam outline on the steel girders). Figure 6.9 shows an underneath view of the transverse edge beam work and the loose debris from the edge beam work located at bent 5. The loose concrete debris from the edge beam work was loaded onto a dump truck while the right two lanes of Buford Highway were closed (see Figure 6.10). Notice the dump truck in the background of Figure 6.10. Figure 6.11 shows a worker welding a threaded sleeve to the web of the girder so that a 1⅛" diameter swedged bolt (held by left worker) could be anchored in the span end edge beams. Since the girders were continuous on the I-285 bridges over Buford Highway, transverse edge beams were present only at the span ends. Figures 6.12 and 6.13 show top and underneath views of the continuous steel girders at bent 4 (note the absence of edge beams).

Figures 6.14-6.20 show the placement of the precast Exodermic deck panels. Figure 6.14 shows the placement of the first Exodermic deck panel located at bent 5. Notice the special trapezoidal Exodermic deck panels that were designed for the end sections to accommodate the skew of the bridge. Figures 6.15 and 6.16 show the placement of the second and third Exodermic deck panels, respectively. Notice the panels were attached to the picking beam such that one end was lower than the other. This allowed the right side of the Exodermic panels to be placed underneath the existing rebar while the left side was lowered directly into place. Figure 6.17 shows a worker (bottom center) checking the spacing of the transverse joint in the negative moment region. As stated earlier, the steel girders are continuous over each interior support, therefore causing negative moment in this region. Special Exodermic panels were designed for this region such that negative moment reinforcing bars could be added along the transverse joint (see Figure 6.18). It should be noted that the negative moment reinforcing bars were installed prior to the setting of the next Exodermic panel. Figure 6.19 shows the precast Exodermic deck panels in place prior to any field placed concrete (note the negative moment region at bent 4). Figure 6.20 shows a worker adjusting the built-in panel leveling bolts to insure a level surface with the adjacent existing deck.

Figures 6.21-6.24 show the installation of the transverse edge beam reinforcement and endwall joint. Figure 6.21 shows the trapezoidal Exodermic panels located at the endwall prior to the installation of the endwall joint. Figure 6.22 shows a close-up of the transverse edge beam reinforcement at the endwall (notice the formwork is in place). Figure 6.23 shows the transverse edge beam formwork from an underneath I-285 perspective. Figure 6.24 shows the endwall joint in place with temporary support members insuring the proper height. Once the field placed concrete cured, the temporary support members were removed.

Figure 6.25 shows the negative moment reinforcing bars (existing rebar) and the Exodermic reinforcing bars being tied together along the longitudinal joint. Figure 6.26 shows the longitudinal joint after all rebar was tied. The two rectangular sections (approximately 6" x 8") missing in the existing deck were damaged during deck removal and repair/patching measures were taken to assure a quality bond with the field placed concrete. Figures 6.27 and 6.28 show the transverse joints of the negative moment region and the reinforcement used in this region. The negative moment reinforcing bars were placed in pre-drilled holes in the steel grid of adjacent Exodermic panels (see Figure 6.28). Notice that longitudinal reinforcement was installed in this region as well as the additional formwork needed for the field placed concrete. Figure 6.29 shows the installation of the shear studs so that composite behavior could be achieved. Shear studs were spaced approximately 4-5 inches apart longitudinally and placed in pairs along the interior steel girders (see Figure 6.30) and placed in singles along the exterior steel girders (see Figure 6.31). Figure 6.32 shows a typical shear key with a foam backer rod installed below the shear key.

Figures 6.33-6.40 show the placement of the 24 hour accelerated strength concrete. The field placed concrete was delivered in a ready-mix truck as seen in Figure 6.33. The accelerator and corrosion inhibitor admixture (DCI) was placed into the concrete mixture upon each truck's arrival. Figure 6.34 shows the equipment used to pump the admixture into the concrete mixture. The amount of admixture supplied was four gallons for every yard of concrete. Figure 6.35 shows the workers placing the concrete at the transverse edge beam along the endwall. The concrete was consolidated using hand held vibrators. Figures 6.36 and 6.37 show workers placing the concrete in the transverse and longitudinal joints of the replaced deck. Figure 6.38 shows the field placed concrete being smoothed and leveled at the closure pours. The approximately 2'-0" wide closure pours in the negative moment region were cast at the same time as the other closure pours (see Figure 6.39). An overview of the accelerated 24 hour concrete in place and finished can be seen in Figure 6.40. A curing compound was placed on the concrete after all closure pours were finished (background of Figure 6.40). After the 24 hour accelerated concrete reached a minimum compressive strength of 3500 psi, the bridge was reopened to traffic at 5:00 a.m. Monday. Figures 6.41 and 6.42 show the sister bridge after the deck replacement work was completed (before the surface grinding and overlay). The black lines with arrowheads in these figures identify the portion of bridge deck that received replacement. It should be noted that the lane shift was active until the surface grinding and overlay work were completed.

6.5 Deck Overlay Work

The bridge Flexogrid overlay was placed randomly during the interval of October 14-31, 2005. The overlay was installed in a two layer application and followed by a final seal coat. The overlay work was performed by Poly-Carb, Inc. with the assistance of L.C. Whitford Co, Inc. A finished view of the I-285 bridges over Buford Highway with the Flexogrid overlay on approximately half the bridge is shown in Figure 6.43. The overlay work was performed in an identical manner to that for the I-285 bridges over U.S. 41 and therefore documentation of the overlay work for the I-285 bridges over Buford Highway is not presented in this chapter.

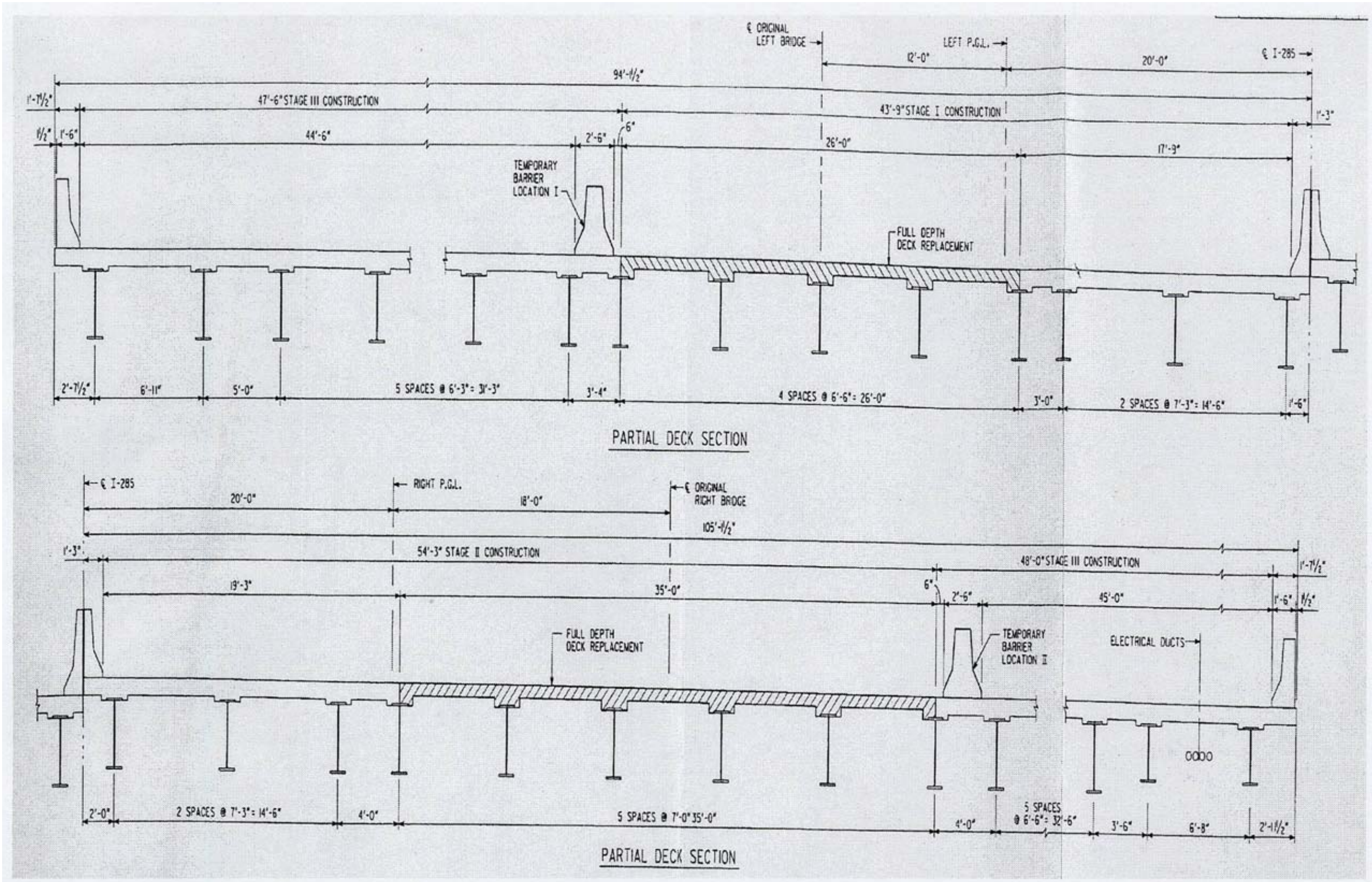


Fig. 6.1 Construction Sequence (2)

Fig. 6.2 Installation of Lane Shift

Fig. 6.3 Saw Cutting for Deck Removal

Fig. 6.4 Removal of Existing Deck

Fig. 6.5 Deck Removal around Existing Negative Moment Reinforcing Bars

Fig. 6.6 Chipping around Negative Moment Reinforcing Bars

Fig. 6.7 View of Steel Girders after the Removal of the Existing Deck

Fig. 6.8 Close-Up of Transverse Edge Beam After the Removal of the Existing Concrete

Fig. 6.9 Underneath View of the End –Span Transverse Edge Beam

Fig. 6.10 Loading of Reinforced Concrete Debris from End-Span Edge Beam

Fig. 6.11 Welding of Threaded Sleeve for Edge Beam Reinforcement

Fig. 6.12 Surface View of Continuous Steel Girders

Fig. 6.13 Underneath View of Continuous Steel Girders

Fig. 6.14 Setting of First Precast Exodermic Panel

Fig. 6.15 Setting of Second Precast Exodermic Panel

Fig. 6.16 Setting of Third Precast Exodermic Panel

Fig. 6.17 Spacing of Exodermic Panels in Negative Moment Region

Fig. 6.18 Installation of Transverse Joint Negative Moment Reinforcing Bars

Fig. 6.19 Overview Shot of Precast Exodermic Panels In-Place

Fig. 6.20 Surface Leveling of Exodermic Panels

Fig. 6.21 Typical Transverse Joint at the Endwall

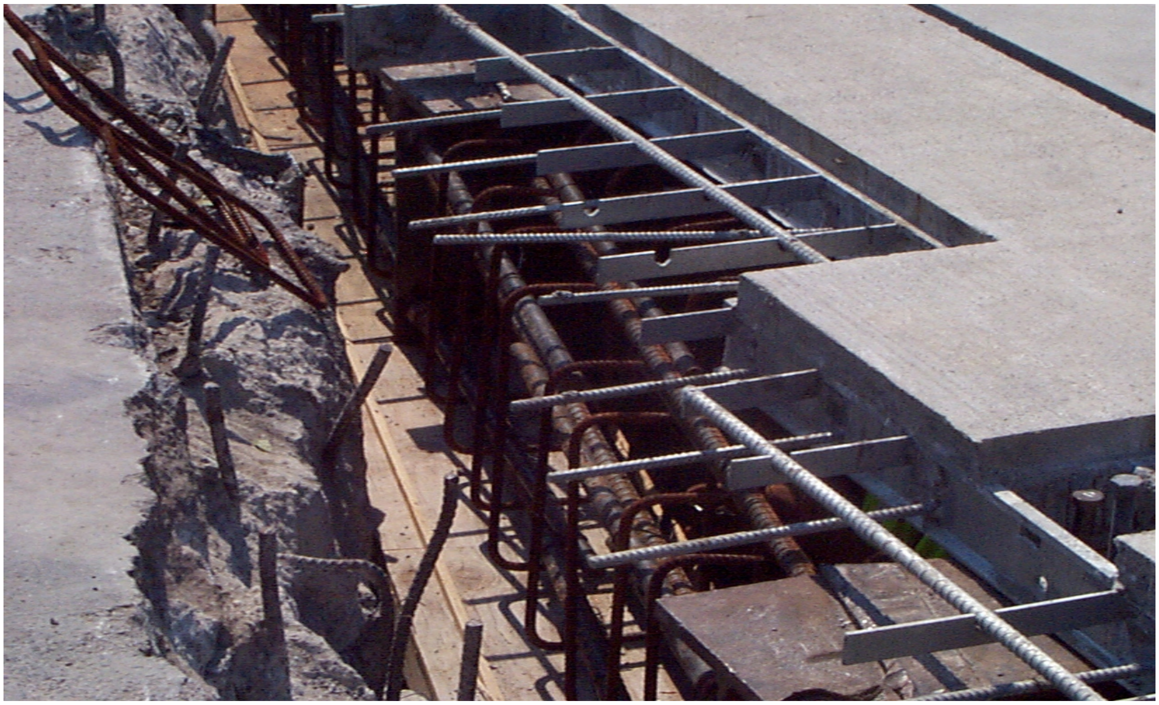


Fig. 6.22 Close-Up of Reinforcing Bars in the End –Span Edge Beam

Fig. 6.23 Underneath View of Span-End Edge Beam Formwork

Fig. 6.24 Placement of Endwall Joint

Fig. 6.25 Tying of Longitudinal Joint Negative Moment Reinforcing Bars

Fig. 6.26 Typical Longitudinal Joint

Fig. 6.27 Placement of Panels in Negative Moment Region

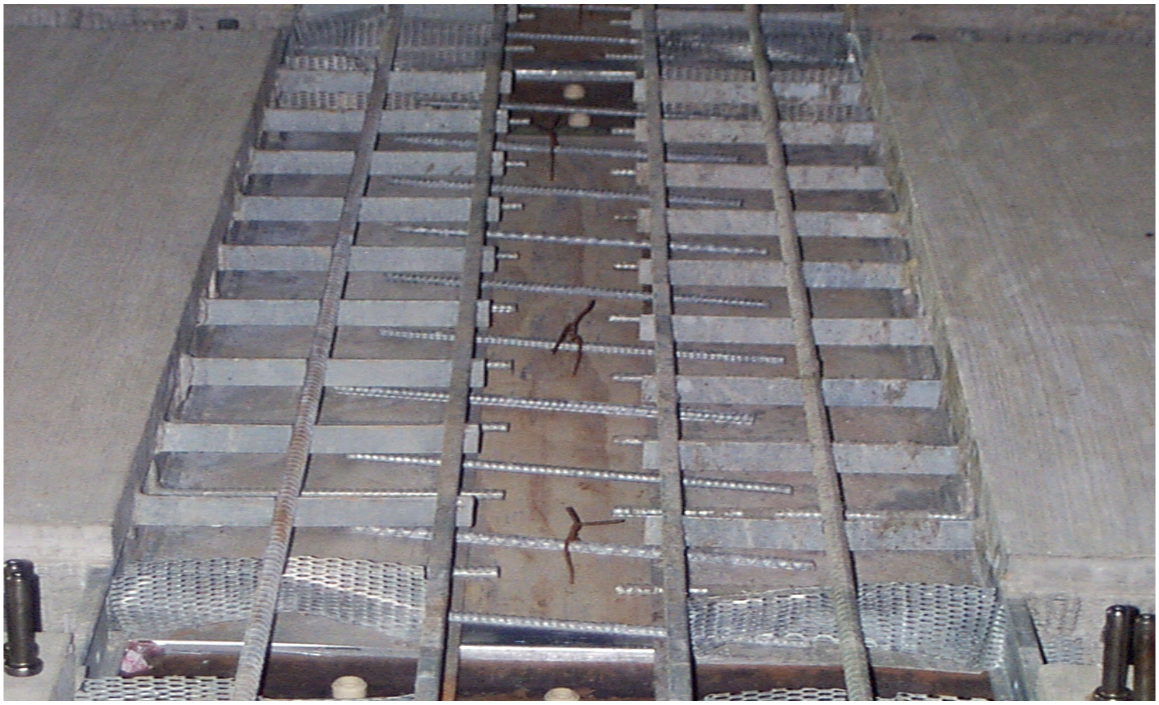


Fig. 6.28 Typical Formwork of Transverse Joint in Negative Moment Region

Fig. 6.29 Placement of Shear Studs

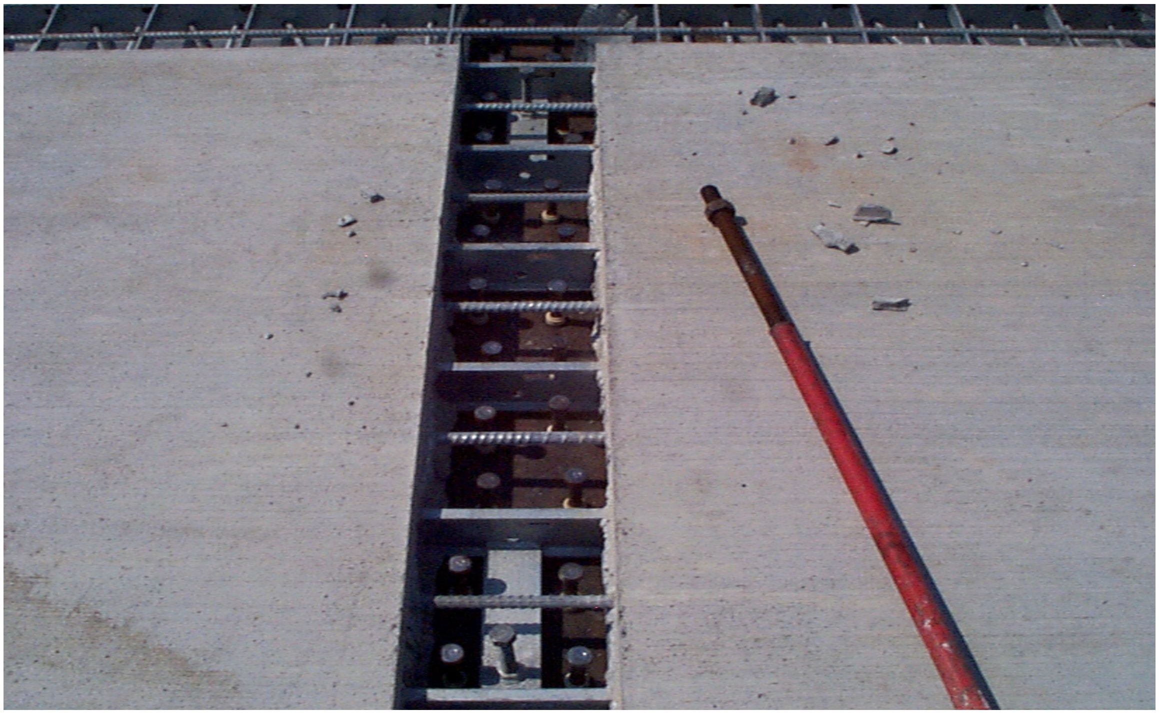


Fig. 6.30 Shear Studs Along Interior Steel Girders

Fig. 6.31 Shear Studs Along Exterior Steel Girders

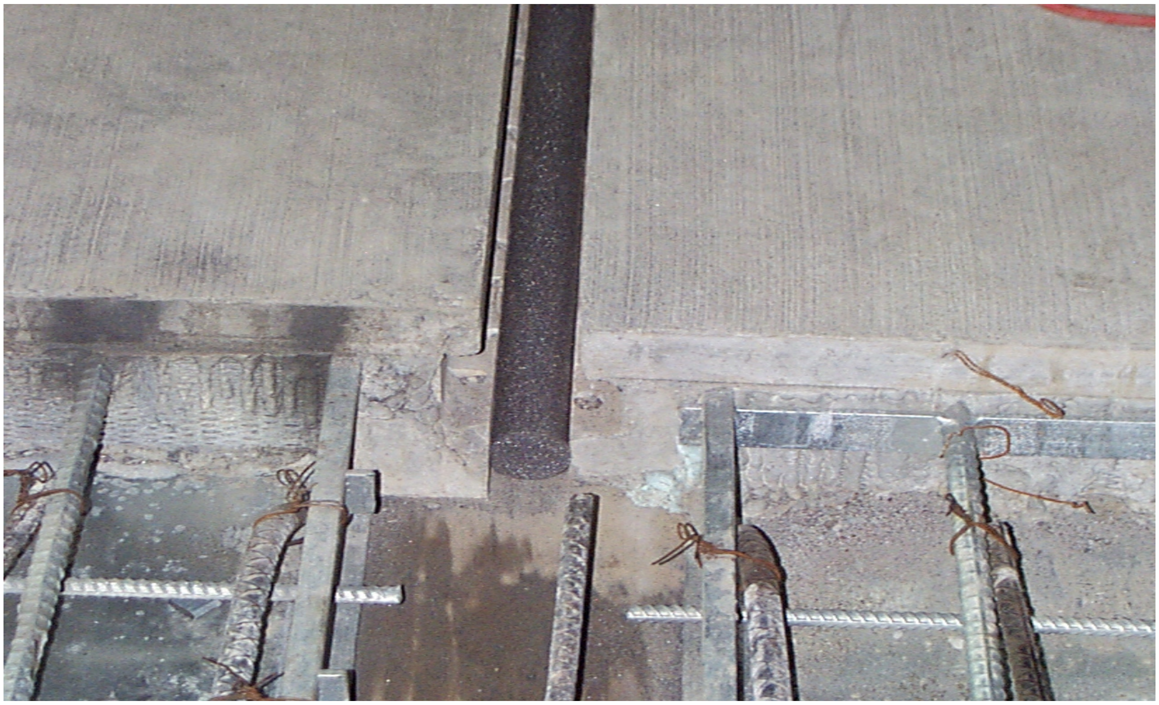


Fig. 6.32 Typical Transverse Shear Key With Foam Backer Rod Installed

Fig. 6.33 Placement of the DCI Corrosion Inhibitor and Accelerator Admixture

Fig. 6.34 Pumping Equipment Used for Admixture

Fig. 6.35 Consolidation of Field Placed Concrete

Fig. 6.36 Placement of 24 Hour Accelerated Strength Concrete

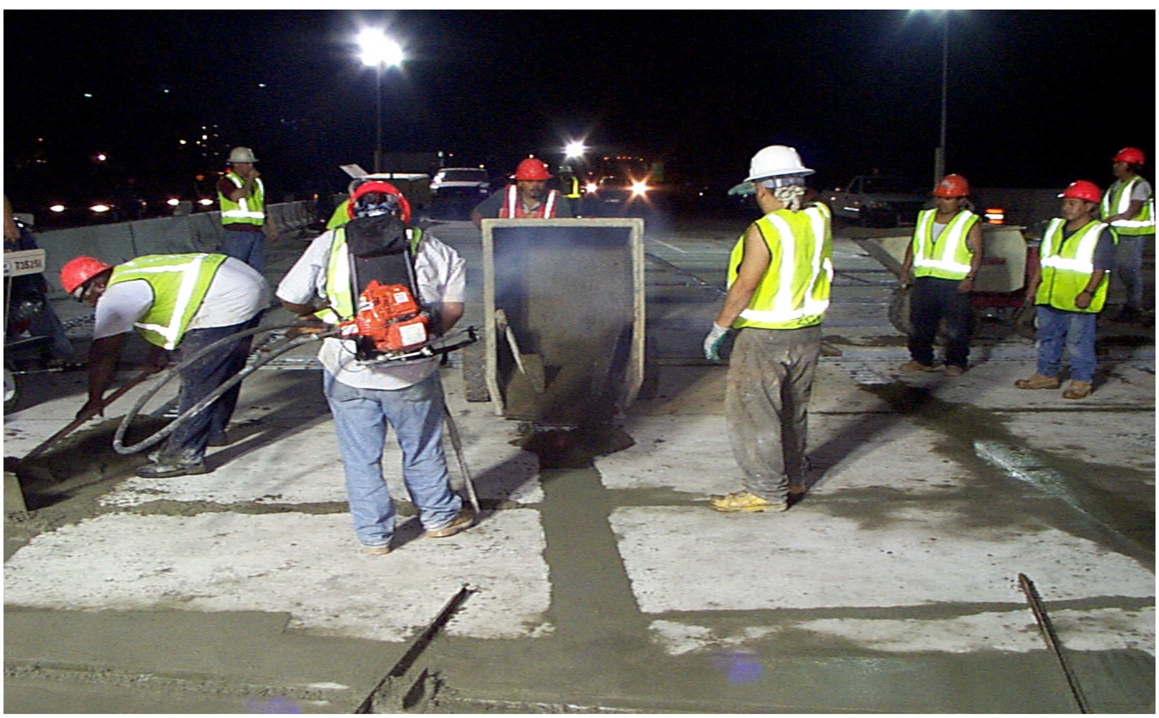


Fig. 6.37 Placement of Accelerated Concrete

Fig. 6.38 Smoothing of the 24 Hour Accelerated Concrete

Fig. 6.39 Finishing of the Accelerated Concrete

Fig. 6.40 Overview Shot of Longitudinal and Transverse Closure Pours

Fig. 6.41 Finished Deck Surface after Deck Replacement Work (between arrowheads) on Eastbound Bridge

Fig. 6.42 Close-Up of Finished Deck Surface after Deck Replacement Work (between arrowheads) on Eastbound Bridge

Fig. 6.43 Finished ⅜" Thick Flexogrid Overlay on Approximately Half of I-285 Bridges over Buford Highway

7. RAPID DECK REPLACEMENT PROBLEMS AND IDEAS FOR IMPROVEMENT

7.1 General

One of the greatest concerns facing many departments of transportation is the need for a rapid bridge deck replacement scheme that entails minimum traffic disruption. This makes for better public acceptance and increases the safety of a project. Rehabilitation via utilization of precast Exodermic deck panels is advantageous for these reasons, but improvements over current methods can be made and should be addressed.

In an attempt to accelerate the construction process for bridge deck replacement projects, the four case studies documented in Chapters 3-6 were evaluated. The construction procedures used by the contractors during the rehabilitation work were effective in terms of the actual work techniques. Nevertheless, some areas of the work could have been improved to make deck replacement work more rapid and/or to simplify constructability. There are two main categories where modifications could be made to make Exodermic deck systems more suitable for rapid replacement. These categories are the design phase and construction phase. However, many problems have aspects related to both categories. These will be listed as design problems because they are best dealt with during the design phase, rather than waiting until the actual construction begins. Problem areas observed while monitoring the deck replacement work during the field investigation are identified and discussed in this chapter, along with some proposals for improvement.

7.2 Design Problems and Ideas for Improvement

Design problems that were identified during the rapid replacement of the four GDOT bridge decks are listed and discussed below.

1. ***Problem***: Splicing of existing deck negative moment reinforcing bars across the longitudinal joint connecting new panels to the existing deck (see Figure 7.1) is needed to achieve continuity across the width of the bridge. On the two Atlanta bridges, the existing negative moment rebars were originally bent upward at a limited 60° angle from the horizontal to allow the new precast deck panels to be placed without interference. However, the new panels were unable to be positioned with the existing rebars at the 60° angle. As a result, one side of the negative moment reinforcement needed additional bending (approximately 90° from the horizontal) to allow the Exodermic deck panels to slide beneath the existing rebar. This approach was successful, but was very laborious, time consuming, and the damage to the existing rebars appeared to be substantial. A panel-to-existing deck longitudinal joint on one of the Atlanta bridges is shown in Figure 7.2.

Proposal for Improvement: Shrinkage and temperature reinforcement and the galvanized metal bottom pan (provides formwork for precast slab) should be withheld in regions where the existing rebar was lapped next to the longitudinal reinforcement of the Exodermic panels. Figure 7.3 shows a cross sectional view of the Exodermic panels and identifies the components suggested for omission or postponed installation. These omissions would allow the new precast deck panels to be set directly into place without the bending of the existing negative moment reinforcing bars. Figure 7.4 shows a typical plan view of the existing rebar and its lapping configuration. Notice from the figure that the panels could be set directly into place if the galvanized metal pan and temperature and shrinkage reinforcement (transverse to main bearing bars) were omitted in the region of overlap. The temperature and shrinkage reinforcement could be placed after the new deck panel is set by sliding them though the holes of the main bearing bars. The haunch forms could be modified to provide the formwork needed for the CIP concrete where the galvanized metal pan was omitted, or the galvanized metal pan could be slid into place after the panel is set in place. Figure 7.5 shows a typical haunch form in place along the longitudinal joint of a new deck panel to existing slab interface. The flange of the haunch forms could be extended and tack welded to the bottom side of the main bearing bars to serve as the formwork of the CIP concrete or any alternative that would serve as formwork for the CIP concrete. Although this proposal is not perfect, it would substantially decrease the field time needed to achieve continuity across a panel-to-existing slab interface.

2. ***Problem:*** The field placed concrete required mechanical consolidation at the shear keys of adjacent panel transverse joints, which are quite narrow, and located at longitudinal closure pours (see Figure 7.6). The high strength rapid setting grout was often stiff and resulted in poor workability. The conventional concrete used in the four GDOT bridge decks lacks the ability to fill every corner of the form and surrounding densely packed reinforcement without mechanical vibration. This poses the issue of how effectively the concrete is being consolidated at each closure pour.

Proposal for Improvement: To reduce honeycombing and additional field labor, a self consolidating concrete (SCC) should be considered for the concrete design mixture. This would better enhance the quality of each casting by eliminating the variable of consolidation by hand. Also, the extra field labor needed for mechanical vibration and trowel finishing would be unnecessary. SCC features the ability to flow quickly into place and would practically level itself while leaving a smooth appearance (see Figure 7.7). Self-consolidating concrete not only speeds the casting process, but offers increased strength, freeze/thaw durability, improved bond strength, and great aesthetic properties. Some advantages are as follows (6):

- High quality
- Aesthetic value
- Fast production
- Design flexibility
- Durability

3. ***Problem:*** The field placed shear studs (¾" diameter) on the longitudinal girders were placed in two rows and spaced approximately 5-8 inches apart. This was quite laborious and time consuming.

Proposal for Improvement: Extensive testing and research (7, 8) have shown that for steel girder/concrete deck connections a 1¼" diameter stud could replace the more conventional ¾" or ⅞" shear studs (see Figure 7.8). Full-scale girder testing demonstrated that the 1¼" diameter stud welding speed was approximately the same as for ¾" or ⅞" shear studs (about 2 studs a minute). As a result, the total time for welding 1¼" diameter shear studs would be about 50 percent less than that required to weld the smaller studs (¾" or ⅞") because only half as many are needed. The 1¼" diameter studs require only one row of studs as compared to the two or three rows needed with the smaller studs. The 1¼" diameter studs demonstrated adequate structural strength and fatigue performance without premature crushing or splitting of the surrounding concrete (8). These connections resist the horizontal shear at the girder-to-deck interface caused by composite action and offer the following advantages (7, 8):

- 1¼" diameter studs provide twice the capacity of a ⅞" diameter stud
- Use of the large stud size would allow positioning of studs in a single row
- Concrete removal around large studs would decrease the removal time for future rehabilitation.
- A much lower probability of damage to the girder top flanges would occur with the 1¼" diameter studs during future rehabilitation.

The welding machine and stud gun capable of welding the 1¼" diameter studs are now available from commercial vendors. Refer to the Appendix for specifications and features.

4. ***Problem:*** While an Exodermic steel panel system with precast concrete topping performs well and lends itself to a weeknight work period, the substantial weight of the precast panels often controls the amount of deck that can be replaced during a weekend work period. The extra weight of the precast concrete topping limits the radius at which a crane can safely lower and set a precast Exodermic deck panel. For example, on the I-285 bridges over Buford Highway, the 48 ton crane could only set new panels at a radius of 45 feet to prevent rotational overturning

or tipping of the crane. This restricted the square footage of deck that could be replaced during a weekend period. The extra weight also controlled the number of panels that could be delivered to the job site on one low boy truck, e.g., only three panels were delivered at a time on the I-285 bridges over Buford Highway.

Proposal for Improvement: An unfilled Exodermic steel panel system with rapid setting CIP concrete should be considered when construction occurs during a weekend work period (see Figure 7.9). The unfilled Exodermic panel system lightens the dead weight of the panels by approximately 400 %. This would allow the low boy trucks to deliver 4 times as many panels and would also reduce the field time spent waiting for the Exodermic panels to be delivered. Furthermore, the unfilled Exodermic panels would offer the crane an additional 40-50 feet in radius and allow the contractor to replace more square footage of deck area in a weekend work period. A pre-assembled rebar mat could be lifted and set directly into place after the unfilled Exodermic panels were positioned.

The unfilled Exodermic panel system with rapid setting CIP concrete would eliminate the many grouted joints and offer a better quality bridge deck. The CIP concrete topping would eradicate the need for an expensive overlay and all the preliminary work pertaining to the overlay (i.e., deck surface grinding, shot blasting, etc.). Due to the vague cost of each pay item, the economics of this system were not analyzed. However, a life cycle cost reduction should result and be justified in that less maintenance is needed with a CIP concrete deck. Conversely, the overlay will require maintenance about every ten years or so and the bridge would be re-closed during this time, causing an interruption to traffic flow. Increased durability and the reduced need for maintenance, along with the ability to maintain traffic with minimal interference are all positive attributes of utilizing a CIP concrete topping as opposed to an overlay.

Some advantages of the unfilled Exodermic steel panel system with a rapid setting CIP concrete are as follows:

- Increase trucking capabilities, i.e., can carry more panels per trip
- Crane could set panels at greater distances
- No overlay would be required
- No maintenance throughout the life of an overlay would be required
- No traffic disruptions during periods of overlay maintenance
- The number of grouted joints would be reduced, resulting in a smoother and quieter bridge.

The disadvantage of this system is the extra field time needed to place and cure the CIP concrete. The quantity of CIP concrete that could be placed during a weekend work period would probably control the amount of deck that could be replaced during that individual weekend.

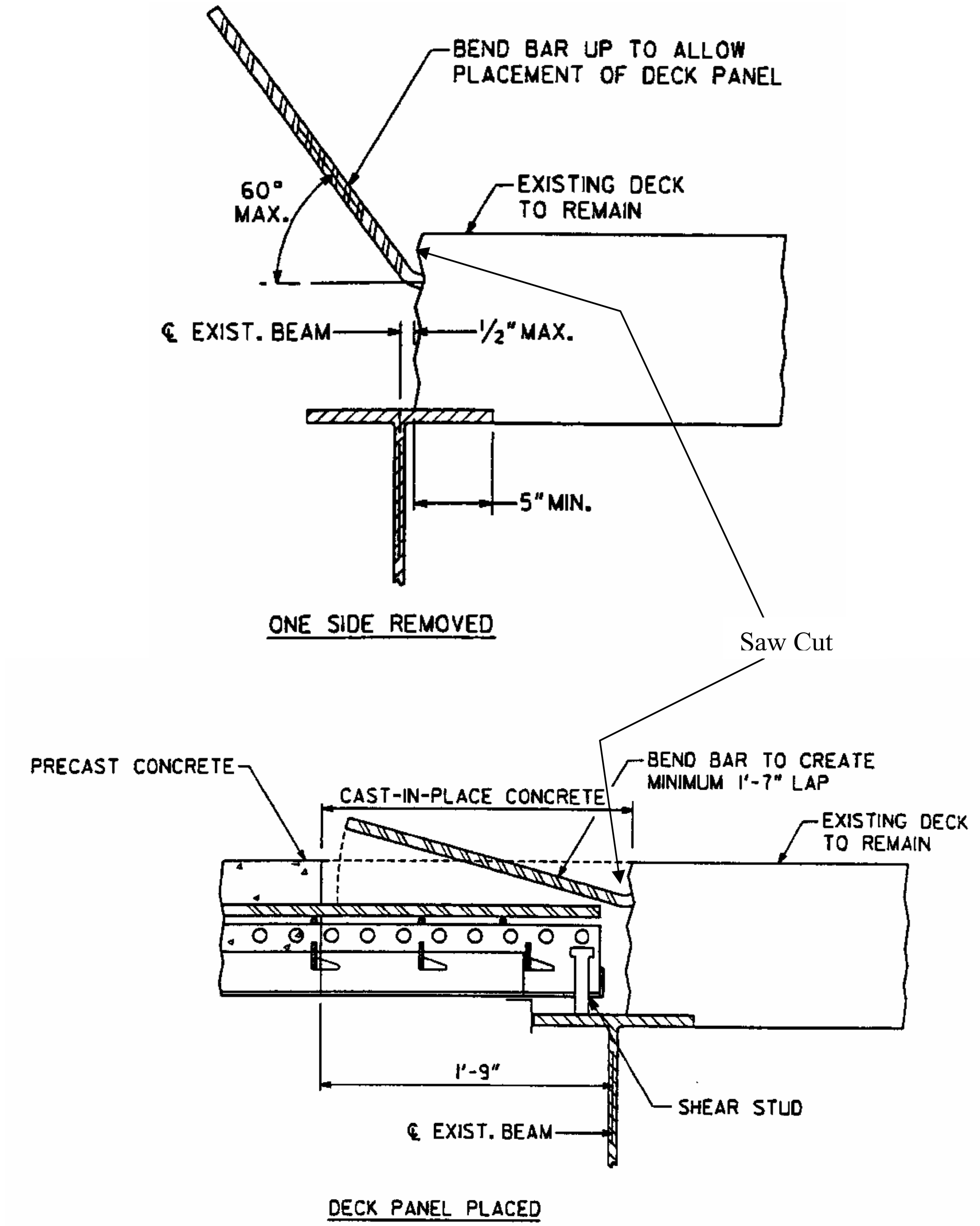


Fig. 7.1 Longitudinal Connection/Joint between Panel and Existing Deck (2)

Fig. 7.2 Longitudinal Joint of a New Deck Panel - Existing Slab Interface

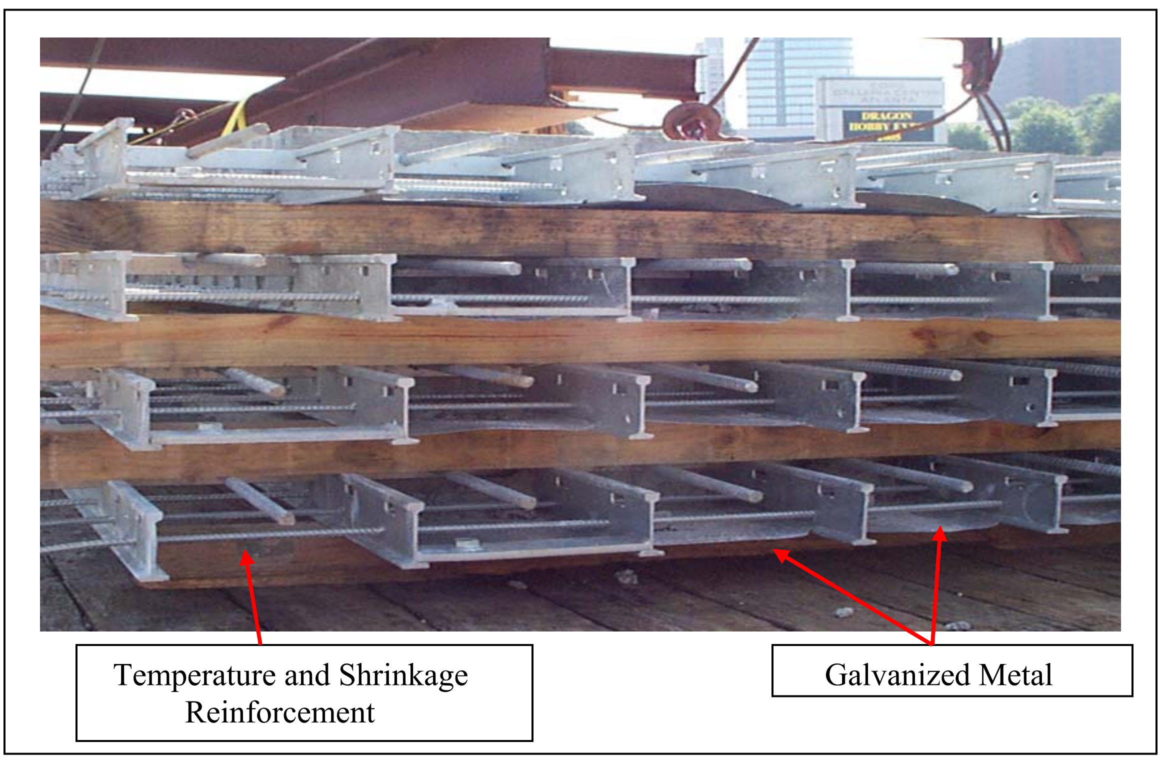


Fig. 7.3 Cross-Sectional View of the Exodermic Deck Panels

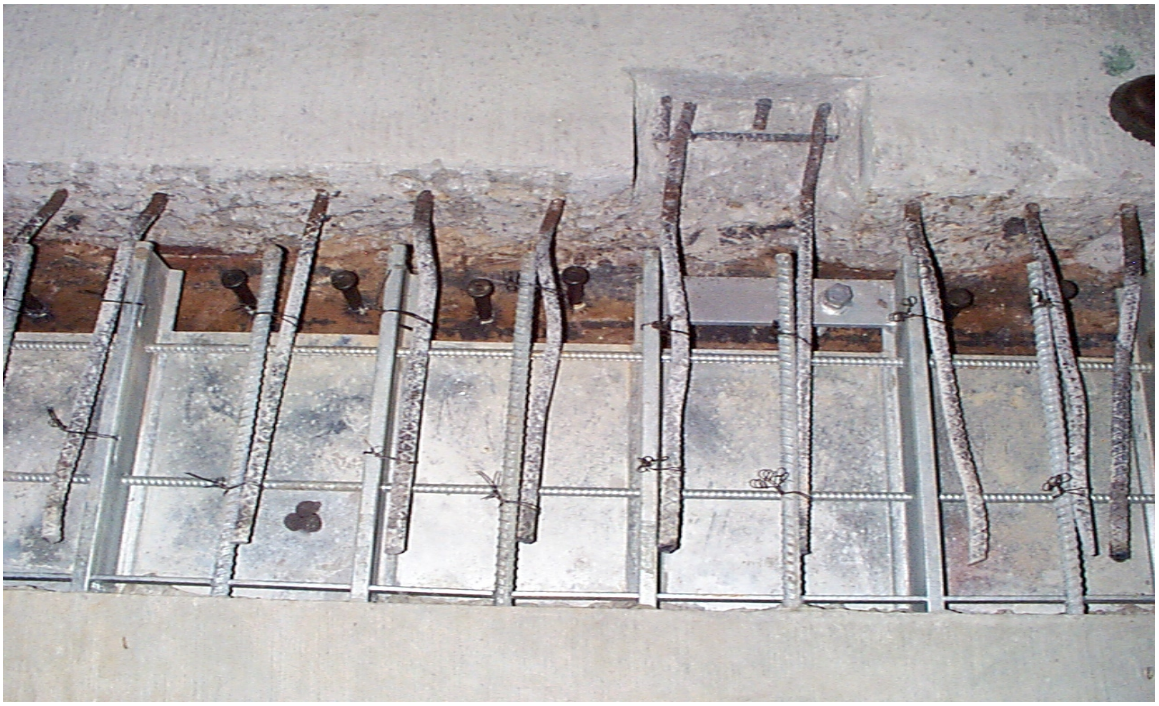


Fig. 7.4 Plan View of the Existing Rebar and Lapping Details

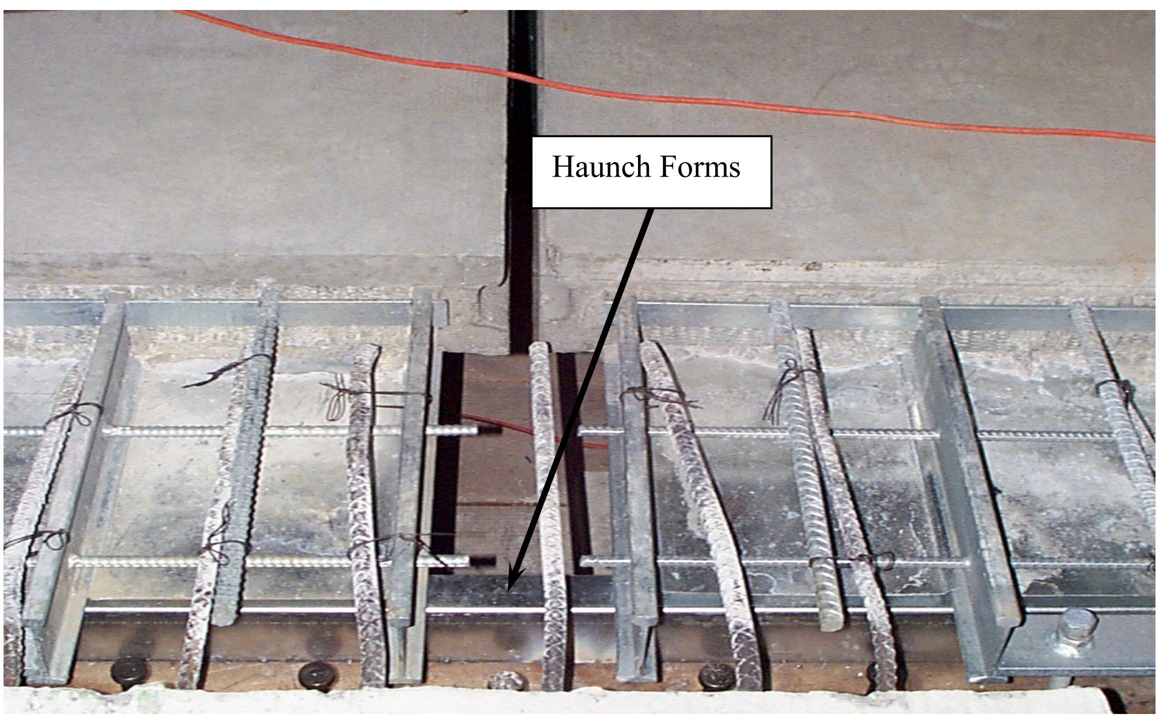


Fig. 7.5 Haunch Forms at the New Deck Panel – Existing Slab Interface

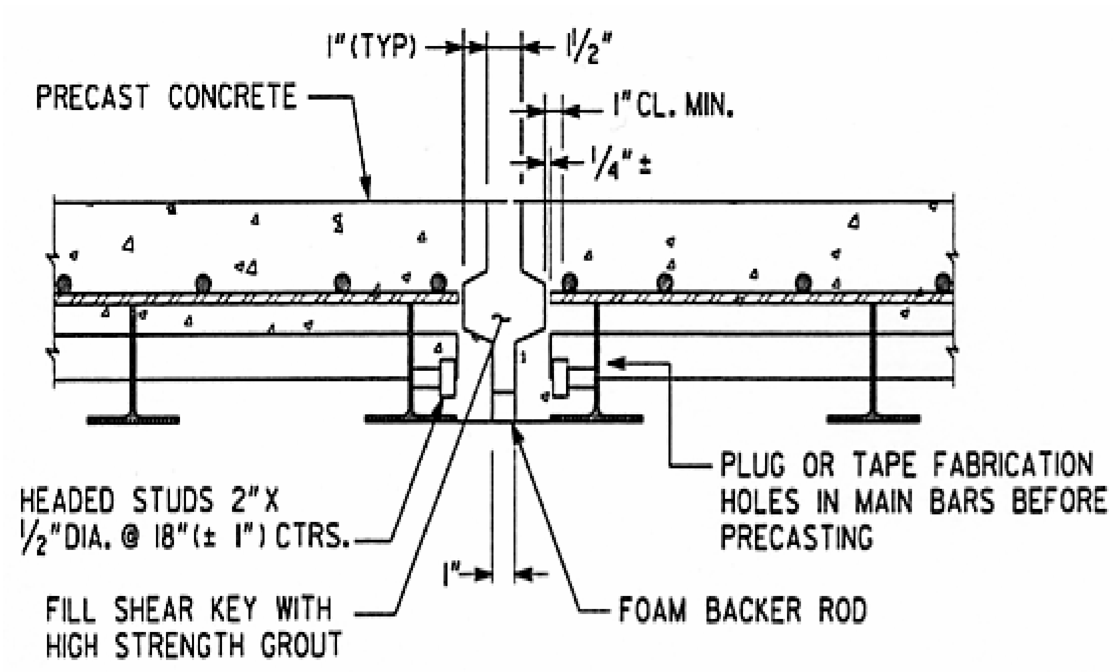
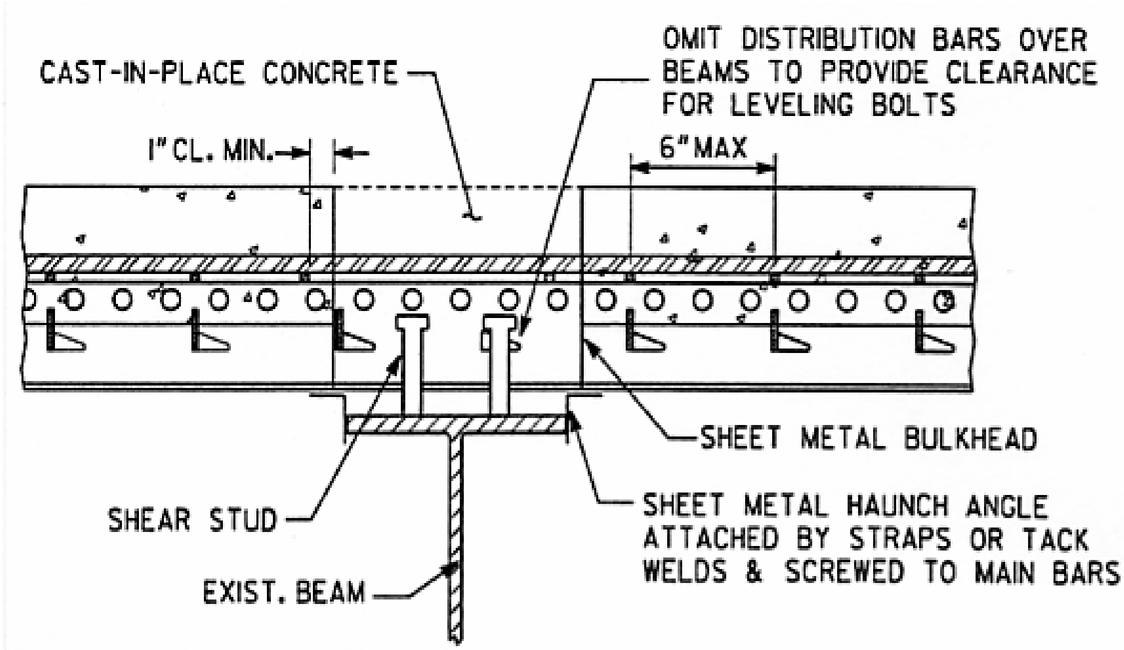
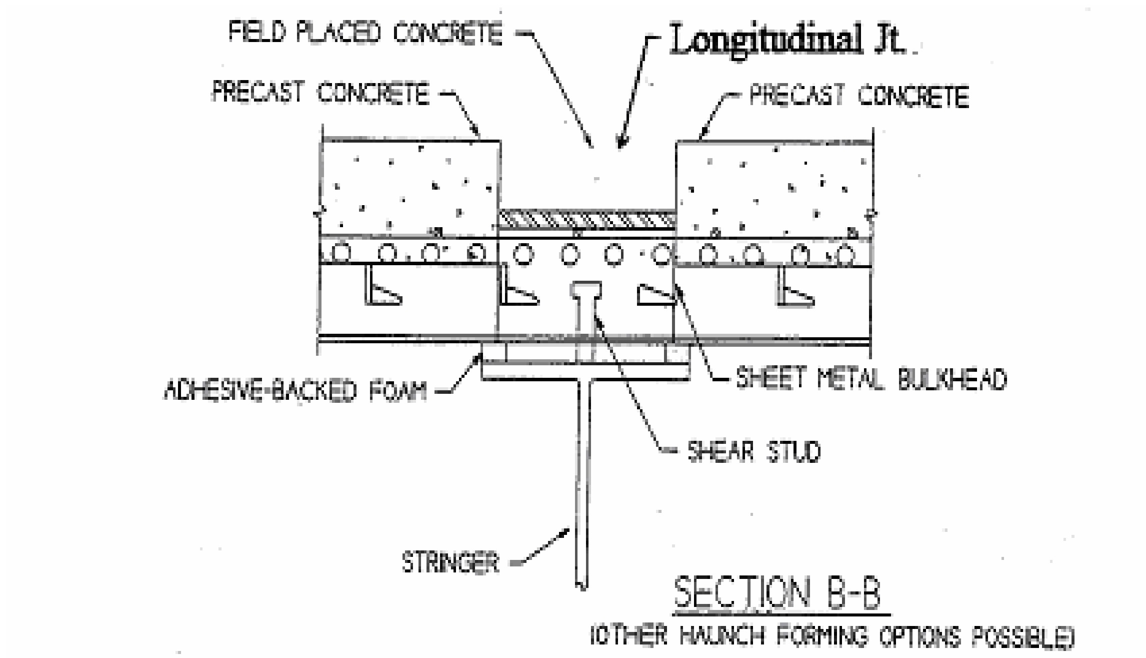


Fig. 7.6 Deck Transverse Shear Key (2)

Fig. 7.7 Self-Consolidating Concrete (9)

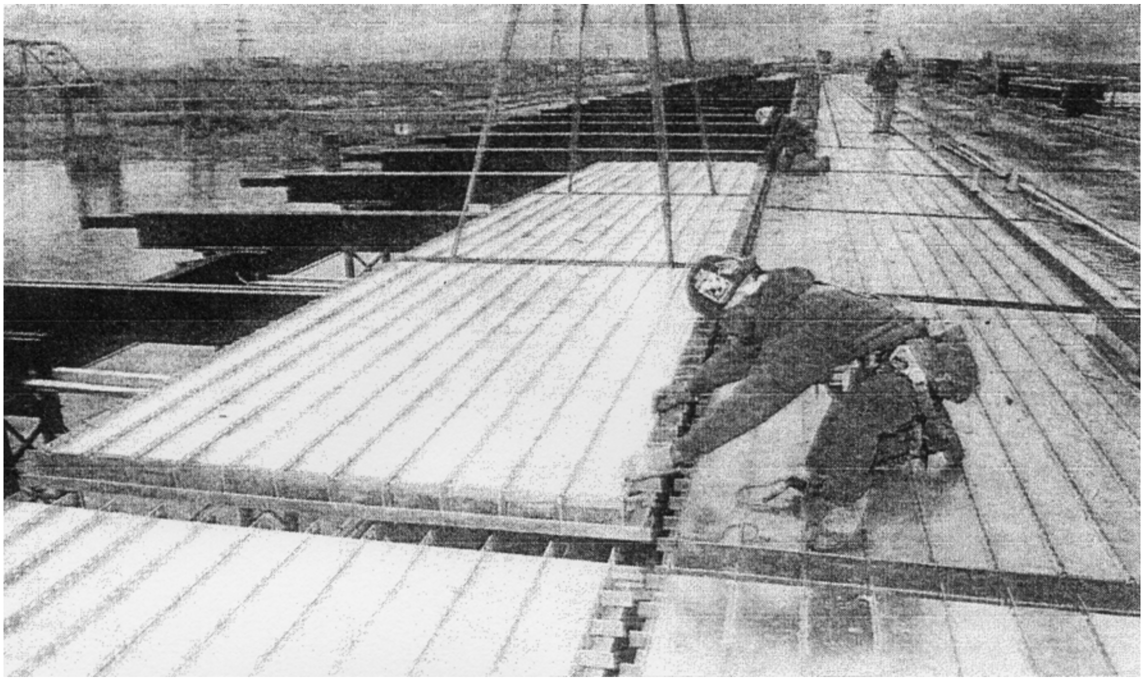


a. Conventional ¾" or ⅞" Diameter Shear Studs

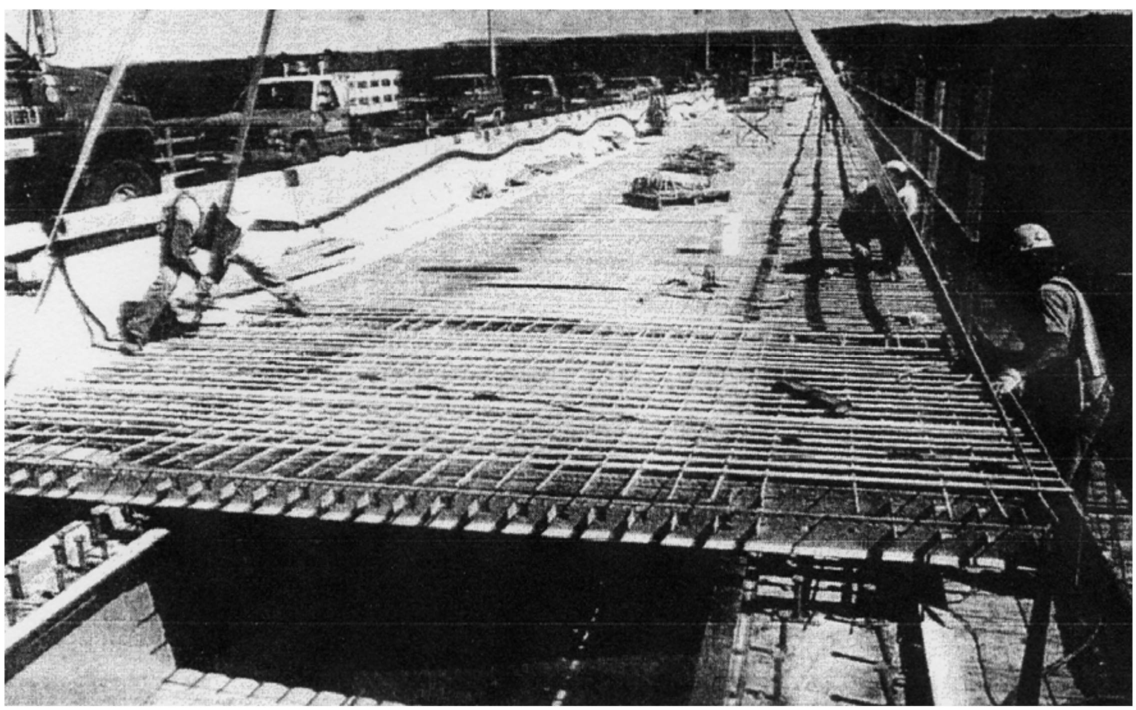


b. 1⅛" or 1¼" Diameter Shear Studs

Fig. 7.8 Deck Connection to Support Girders (2)



a. Exodermic Panels Set for Placement of Top Mat Rebar



b. Exodermic Panels with Top Mat Rebar Already Tied in Place

Fig. 7.9 Workers Setting Exodermic Panels for CIP Deck (2)

7.3 Construction Problems and Ideas for Improvement

Construction problems that were identified during the rapid replacement of the four GDOT bridge decks are listed and discussed below.

1. ***Problem:*** Unnecessary saw cuts on the night of deck removal extended the time required to remove the existing deck.

Proposal for Improvement: All transverse saw cuts should be completed prior to desired deck removal time period. For example, if the work takes place during a weeknight schedule, the transverse saw cuts for the next night's work period should be done while the field placed concrete is curing. If the work takes place during a weekend schedule, the transverse saw cuts should be made during a prior weeknight on the portion that is scheduled for replacement during the upcoming work period. This leaves only the longitudinal saw cuts for completion during the work period in which the existing deck is removed.

2. ***Problem:*** Deck demolition often controlled the rate of progress on the four GDOT bridge decks because deck removal was very rigorous and labor intensive. Limited or inadequate equipment would sometimes retard deck replacement during the demolition phase.

Proposal for Improvement: Although none of the bridges documented in this thesis were designed for composite behavior, a much slower rate of existing deck removal would be expected for decks designed for composite behavior. Some factors that significantly affected the deck demolition phase were the saw cutting techniques and the equipment used for deck removal. When weekend deck replacement work is preferred and the area of deck replaced is large, two saws should be used to make the necessary longitudinal cuts for deck removal (assuming that all transverse saw cuts are already completed). This would allow the existing deck to be removed at a much earlier time, therefore permitting replacement of a larger deck area.

The decision process for the choosing equipment used for deck removal should be conducted on a job-specific basis. However, some equipment and methods were better than others regarding speed of existing deck removal. Figures 7.10 and 7.11 show an excavator with a grapple attachment that removed the existing deck slab and placed it directly onto the bed of the truck. Figure 7.12 shows a crane with a lifting apparatus that required field labor for driving the steel rods into the pick-up points and for recovering them once the existing deck was placed on the low-boy. The excavator cut the loading time tremendously and allowed more area of deck removal per hour of work. Equipment is improving rapidly and could benefit rapid bridge deck replacement in many instances as long as environmental, traffic control, and space constraints are satisfied.

3. ***Problem:*** The newly placed asphalt wearing surface on I-285 was smeared onto the new bridge deck surface as seen in Figure 7.13. This smeared asphalt increased the shot blasting and deck grinding time tremendously for the deck surface to meet the requirements of the copolymer overlay. The asphalt wearing surface was placed due to the lane shift implemented for deck replacement.

Proposal for Improvement: Selection and design of any wearing surface placed onto the roadway that approaches a bridge with a possible overlay should consider the effects of this smearing and the resulting clean-up problem.

Fig. 7.10 Excavator with Grapple Attachment

Fig. 7.11 Loading the Existing Deck with Excavator

Fig. 7.12 Crane with Lifting Apparatus

Fig. 7.13 Smearing of Newly Placed Asphalt Wearing Surface Onto New Deck Surface

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 General

In an attempt to expedite the construction process for deck replacement projects, the GDOT decided to use precast Exodermic deck panels during staged construction work periods to minimize traffic disruption. The GDOT replaced two bridge decks in the Gainesville, GA area and two bridge decks in the Atlanta, GA area using these panels. The four bridge decks were replaced using rapid deck replacement techniques during periods of low traffic volume to reduce accident risk and improve public acceptance. The rapid deck replacement work on the four bridges was monitored and documented to provide the ALDOT with some of the problems and pitfalls of rapid bridge deck replacement via the use of precast Exodermic deck panels. The ALDOT plans to evaluate the precast Exodermic deck panels by implementing them in a portion of its "test bridge" in the near future. Also, documentation of the GDOT bridge deck replacement work will aid ALDOT engineers in deciding which replacement/rehabilitation strategy will lend itself best to the deteriorating Birmingham, AL interstate bridge decks, along with deteriorating decks in other locations throughout the state.

The Longstreet and Bells Mill bridges in Gainesville, GA are located in rural areas, but experience fairly high volumes of traffic with no good detouring routes. Therefore, the deck replacement work had to be done rapidly during a nightly construction work period to minimize disruptions to traffic. Due to the narrowness of each bridge (two lanes without shoulders), the entire bridge was closed to traffic during each construction period and a detour installed.

The I-285 bridges in Atlanta, GA carry extremely high volumes of traffic and closely parallel the I-59/20 and I-65 bridge decks in Birmingham, AL. The I-285 bridges over U.S. 41 and I-285 bridges over Buford Highway carry four or more lanes in each direction and received rapid bridge deck replacement on the original portions of their decks. All deck replacement work on the I-285 bridges in Atlanta was performed during weekend work periods while maintaining concurrent traffic conditions on the remaining/available bridge lanes. Since the characteristics of the GDOT work closely parallel the planned "test bridge" in Alabama, it behooved us to learn as much as possible by monitoring the GDOT bridge deck replacements. This was the objective and purpose of this research work.

8.2 Conclusions

Rapid bridge deck replacement via the use of precast Exodermic deck panels allowed the deck replacement work to be executed during the permitted work windows. Weeknight work and weekend work windows were utilized for the four bridge decks receiving rapid bridge deck replacement. The rehabilitation work was accomplished within the imposed time limits while maintaining minimum traffic interruption. A weekend work period allowed a significantly larger square footage of deck to be replaced each work weekend than the 9:00 p.m. to 6:00 a.m. weeknight work period. Each of the documented four bridges provided unique features concerning the rapid bridge deck replacement work. The Longstreet Bridge and I-285 bridges over U.S. 41 had simply supported spans while the Bells Mill Bridge and I-285 bridges over Buford Highway had continuous spans. The two Atlanta bridges received partial width deck replacement while the two Gainesville bridges received full width deck replacement. Of the two Gainesville bridges receiving rapid bridge deck replacement, only the Longstreet Bridge required the existing steel curb to be replaced as opposed to the Bells Mill Bridge where the existing bridge barrier rails were replaced with new precast Jersey barriers. All four of the GDOT bridge decks received a thin copolymer overlay since the appearance and rideability of the Exodermic deck panels without the overlay was poor due to the large number of grouted joints.

The construction sequence adopted by the contractors was effective in achieving the goal of minimum traffic interference. At the start of each bridge closure, transverse and longitudinal saw cuts were performed over the specified portion receiving deck replacement during that individual work period. Those specific portions of the existing deck were removed and replaced during the same work period. Following deck demolition, the existing flanges of the steel girders or stringers were cleaned and the precast Exodermic deck panels were placed. Exodermic deck panels were set in a fixed sequence, with special attention to alignment and positioning. Each precast Exodermic deck panel was leveled using panel built-in leveling bolts to achieve the proper height alignment with the adjacent deck slab. As placement of the Exodermic deck panels commenced, formwork within areas of closure pours was installed (e.g., haunch forms, transverse edge beams, negative moment regions). Also, shear stud attachments took place on the tops of the exposed steel support girders or stringers following the Exodermic deck panel placements. High early strength concrete was then placed in regions of closure pours and shear keys. The field placed concrete reached a strength of

3500 psi before the newly replaced bridge decks were re-opened to traffic. It should be noted that longer curing times were needed for deck replacement work during a weekend work period as opposed to the weeknight work period. This was primarily due to the different concrete mixture designs used for the closure pours. It should be stressed that the construction procedures used were very effective; deck replacement work proceeded with tremendous efficiency and was completed within an acceptable timeframe.

Problem areas observed while monitoring the rapid bridge deck replacement work offer opportunities for improvements that should be implemented in either the design or construction phase of future work. Modifications of the Exodermic deck panels are needed where continuity across the width of the bridge is desired, i.e., when only a portion of the bridge width receives deck replacement.

The substantial weight of the precast Exodermic deck panels often controlled the amount of deck that could be replaced during a weekend work period. As a result, an unfilled Exodermic steel panel system should be considered when construction occurs on a weekend work period. Utilization of an unfilled Exodermic steel panel system with a rapid setting CIP concrete topping would help resolve this problem while requiring no overlay or future maintenance of this overlay. Deck demolition and placement of the shear studs proved to be time consuming tasks. These tasks were critical to the rapid deck replacement work and improvements in these areas should be made so that the allotted construction time could be used more efficiently. Recommendations for improvements in these areas are given in the following section.

8.3 Recommendations

It is recommended that the ALDOT employ precast Exodermic deck panels system as one of the test systems on its “test bridge” in Collinsville, AL. Precast Exodermic deck panels achieved the goal of minimum traffic disruptions while under staged construction and/or concurrent traffic conditions. It is also recommended that the ALDOT employ unfilled Exodermic deck panels with a rapid-setting CIP concrete topping as one of the test systems on its “test bridge” when a weekend work period is applicable. This is advantageous in that it lightens the panels significantly, causing the alignment and placement of these panels to be substantially easier in the field. Another advantage of the unfilled Exodermic deck panels is that once filled with the CIP concrete, no costly overlay is necessary on the bridge deck or maintenance of this overlay.

A weekend work period is recommended, whenever applicable, when rapid bridge deck replacement work is desirable. The weekend work period proved to be more efficient in terms of square footage of deck replaced per hour of work. It is also recommended that preliminary deck replacement work, e.g., transverse saw cutting for deck removal, grinding, temporary striping for traffic shifts, edge beam formwork, etc. be completed from 9:00 p.m. to 5:00 a.m., Monday through Friday. This procedure permits the contractor to begin deck removal immediately after the bridge closure is established (9:00 p.m. Friday) for the weekend work period. This would allow construction time to be used more efficiently during the weekend work period and shorter construction times would be attainable.

Based on the knowledge gained while monitoring the deck replacement work in northern Georgia, the following recommendations are offered concerning the design and/or construction practices with Exodermic deck replacement panels. These recommendations will make deck replacement work via precast Exodermic panels more rapid and/or simplify constructability.

- In order to overcome precast Exodermic panel placement problems associated with existing negative moment reinforcing bars across the longitudinal joint between a new panel and the existing bridge deck, the transverse temperature and shrinkage reinforcement and galvanized metal pan should be omitted from the prefabricated panel in regions where the existing deck rebar is lap spliced to the longitudinal reinforcement of the Exodermic panels. The omitted pan and transverse rebar can be placed in the field after the new panels are set in place.
- It is highly suggested that a SCC or a very workable concrete mixture be used where closure pours must be made through small openings (e.g., shear keys having less than 1.5” width) or where they contain densely packed reinforcement. This will allow for better consolidation and reduce the construction time pertaining to the field placed concrete work.
- All transverse saw cuts on the existing deck should be performed prior to the time of bridge and/or lane closures for deck removal and replacement.
- The field placed shear studs of ¾” or ⅞” diameter should be replaced with the larger 1¼” diameter studs. This would require only one row of studs as opposed to the two or three rows needed with the smaller studs. Thus, the field time spent stud welding would be significantly decreased.

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APPENDIX

Shear Stud Placement Equipment

“Arc Stud Welder”

Equipment: ARC Stud Welders: ARC 3000

FEATURES

- Designed and built in U.S.A.
- Constant current output
- Single or Dual gun systems
- Independent gun controls
- Precise weld time and weld current adjustments
- Digital display of actual weld time and weld current
- Diagnostic LED's
- State of the art gun control circuitry
- Built in chuck saver
- Auto safety shutdown

DESCRIPTION

The ARC-3000 is a fully regulated stud welding power supply that is available in a single or dual gun version. Both versions have the constant output feature that allows the unit to be used as a power source that can operate external stud welding control units. An added feature in the ARC-3000 is the ability to dial in the desired weld time and weld current before even making a weld. By selecting the setup mode, the weld time and current can be adjusted and displayed on the front panel digital meters.

A specially designed electronic gun control circuit has been incorporated into the system. If a fault condition occurs due to a shorted gun solenoid or a faulty control cable, the circuit will prevent gun retriggering and eliminate damage to printed circuit boards. The ARC-3000 system is capable of welding studs from 1/4" diameter to 1-1/4" diameter with preciseness and repeatability.

SPECIFICATIONS	
DIMENSIONS	36" H x 28" W x 40" D
OUTPUT	3000 AMPS @ 44 VDC
WEIGHT	950 LBS.
DUTY CYCLE	1/4 - 3/8 Unlimited - 1/2" 60/Min 5/8" 30/Min 3/4" 20/Min 7/8" 15/Min 1"10/Min
INPUT	230/460/575 VAC 3 Phase 60 Cycle
FUSING	400/200/180 Delay Type
TIME CONTROL *(STEPLESS ADJUSTABLE)*	.1 - 1.8 sec.
CURRENT CONTROL *(STEPLESS ADJUSTABLE)*	400 - 3000 amp

COMPONENTS		
DESCRIPTION		**PART NUMBER**
SYSTEM:	Single:	100-0207S
	Dual:	100-0207D
POWER SUPPLY	Single:	200-0016
	Dual:	200-0017
WELD GUN		300-0601
GROUND CABLE: 25 FT. x 4/0		125-0110
COMBO CABLE: 50 FT. x 4/0		125-1002

Sunbelt Stud Welding, Inc.
6381 Windfern
Houston, TX 77040
Phone: 713-939-8903
Fax: 713-939-9013
Toll Free: 800-462-9353