ACCELERATED BRIDGE CONSTRUCTION PROJECT: THE REPLACEMENT OF MD 362 OVER MONIE CREEK

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ABSTRACT

The MDSHA replaced the bridge carrying MD 362 over Monie Creek using several new accelerated construction features. The contractor was required to install piles using temporary lane closures before detouring the roadway, and precast abutment caps were utilized after the bridge was closed. The bridge was completely closed to traffic for only five weeks.

INTRODUCTION

The Maryland State Highway Administration (MDSHA) identified the timber substructure on the existing bridge carrying Maryland Route 362 over Monie Creek in Somerset County as structurally deficient. The decision was made to replace the bridge.

Typically, a bridge of this size would be replaced within a ten week period during the summer months. Incentive clauses, based on user costs, are generally included in the contract to ensure that the ten week schedule is held. This is primarily done because schools are out of session and disruption to school bus traffic is not an issue. A public meeting was held where members of the MDSHA engineering staff presented various maintenance of traffic alternatives for public comment. The attendees unanimously supported the project scope but requested that SHA find a way to reduce the anticipated road closure duration from ten weeks to five.

TYPICAL MARYLAND STATE HIGHWAY BRIDGE FOR SPANS UNDER 55 FEET LONG

For spans under 55 feet long over water, the MDSHA has unique features that minimize both present construction costs and future maintenance costs. First, they start with solid prestressed concrete that are postensioned together. They have had problems in the past with voided slabs where the voids in the slab move and do not have consistent section properties. Additionally, the MDSHA has found that voided slab and box beams tend to fill with water even if drain holes are added. A frequently cited down side to utilizing solid slabs is that they weigh more than voided box beams, requiring larger substructures. However, the MDSHA is able to use shallow superstructures (i.e. 2'-3" deep beams on the subject project), allowing greater waterway openings. Finally, the MD SHA is able to provide more protection through additional clear cover to the strands than is generally available in the bottom flange for voided box beams.

On top of the solid slabs, the MDSHA places a minimum 5” thick cast-in-place concrete overlay made of modified latex concrete. An asphalt overlay is not used on these types of bridges since historically MDSHA has not had success with asphalt overlays and waterproofing membranes. These have not prevented leakage to the slab's top flanges, resulting in water intrusion into the beams, failed shear keys, and failed joints between the beams. Since the prestressed slabs are placed in the same plane, the cross slope or superelevation of the roadway has to be achieved with this overlay. The thickness varies across the bridge to create the cross slope. This overlay also includes an overpour at the ends of the slabs to protect them. There are no joints on these bridges providing greater protection to the beams. The approach roadway is set right up against the overlay. The MDSHA has found that the movement on these bridges is less than a ¼” which does not impact the road that much. They create a semi-integral connection between the abutment cap and the overlay with a horizontal bond beaker between them. This will allow for that ¼” movement.

A single row of piles is used to create a full moment connection between the abutment and piles. This will also allow for some of the movement to take place. When piles are used, the abutment will be a simple rectangular cap that sits on the piles. Sometimes we use a spread foundation if acceptable bearing material (i.e. rock) is found to be close to the surface.

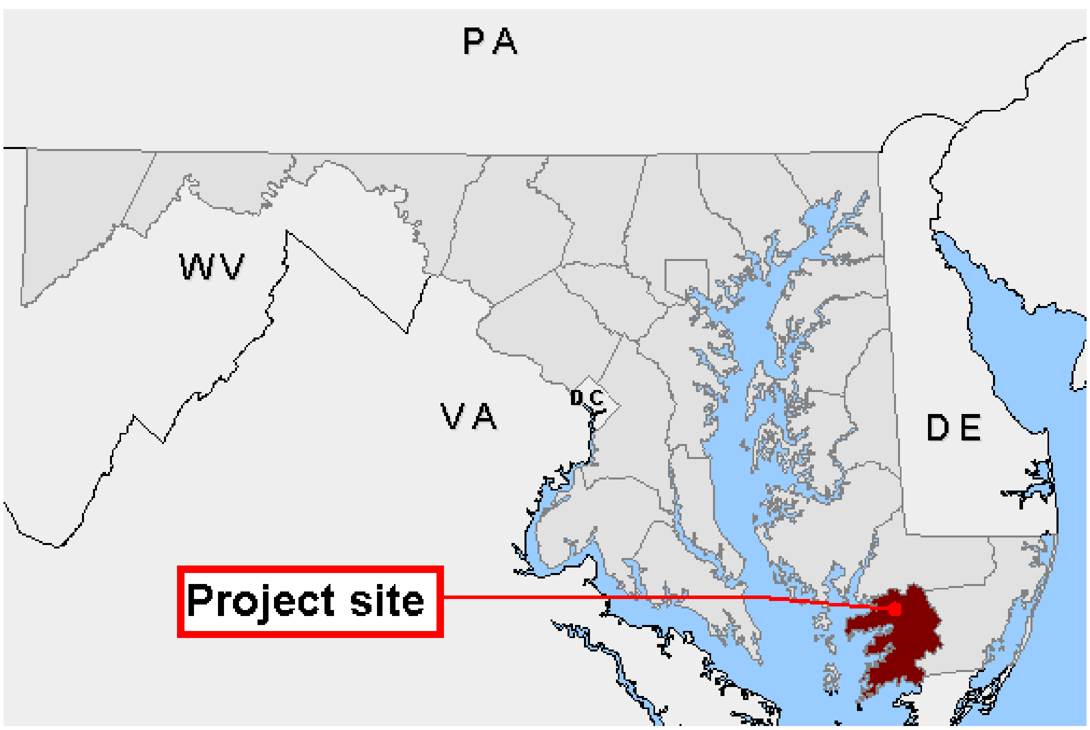
The MDSHA likes to construct this type of bridge with a detour in the summer months when schools are out. They cannot always get a detour approved on heavily travelled roads, but they always look at detouring as a first option. These bridges can be completed in a ten week duration so that they will not interfere with school bus schedules in the fall. Additionally, the summer months are conducive for the overlay pouring. An approximate schedule with removal, pile driving, abutments, slabs, overlay, curbs, and railings is shown below but it's really up to the contractor to set their schedule:

- 1 week for bridge removal & excavation
- 2 weeks for pile driving (or spread footings)
- 2 weeks for casting abutment stems and curing
- 1 week for scour protection and setting solid prestressed concrete slabs
- 2 weeks for casting concrete overlay and curing
- 1 week for curbs and curing
- 1 week for railing and approach roadway

MDSHA'S GOAL FOR ACCELERATED CONSTRUCTION

The MDSHA set the goal of cutting the time for these closures in half down to five weeks. To do this, they decided to try precast abutment caps to reduce the cure times for these elements.

A search for a site for a pilot project was conducted. The bridge had to have a short span, low ADT, an acceptable detour route, and public support. A low ADT was needed for two reasons: one to be able to justify a detour, and two, in case things did not work well for the precast elements, the MDSHA wanted to minimize disruptions to motorists. The MDSHA found their site on MD 362 in Somerset County.



EXISTING BRIDGE INFORMATION

At the bridge location, MD 362 was classified as a rural major collector type roadway. The current average daily traffic (ADT) was 1,700 vehicles per day with trucks comprising 7% of the total ADT. The ADT was projected to increase by 64% to 2,800 vehicles per day by the year 2030. The existing structure, built in 1934 and widened in 1963, was a single span steel beam bridge with a center to center bearing span length of 41'-0 "± supported on timber abutments. It had a clear roadway width of 48'-0"± that accommodated two 12'-0"± lanes and two 12'-0"± shoulders. The existing bridge typical section was wider than the roadway typical section on the approaches. The typical section on the approaches provided two 12'-0" ± lanes and two 8'-6"± shoulders. The local Resident Maintenance Engineer was contacted and indicated there is no history of flooding at the bridge.

The decision to replace the bridge was based on the condition of the timber substructure. The timber substructure was at the end of its useful service life and rehabilitating the substructure to extend the overall service life of the existing bridge was not feasible. The timber substructure was in poor condition and has a condition rating of 4, indicating that this element was structurally deficient (condition rating < 5). The deck and superstructure were both rated 6 indicating these elements are in satisfactory condition with evidence of some minor deterioration. These elements of the bridge were not structurally deficient.

DESIGN CONSIDERATIONS

The proposed bridge is a single span prestressed concrete slab bridge with a center to center span length of 55'-0".The proposed bridge typical section carries two 12'-0" lanes and two 8'-6" shoulders for a clear roadway width of 41'-0" Based on the 2030 ADT of 2,800 vehicles per day and a 50 MPH posted speed limit, the proposed 41'-0" of clear roadway width exceeds the Federal minimum bridge width requirements. Therefore, the bridge is not rated as functionally obsolete. The bridge is supported on two pipe pile bent type abutments. There is a 1'-6" curb supporting a two strand metal railing traffic barrier at the edge of each shoulder.

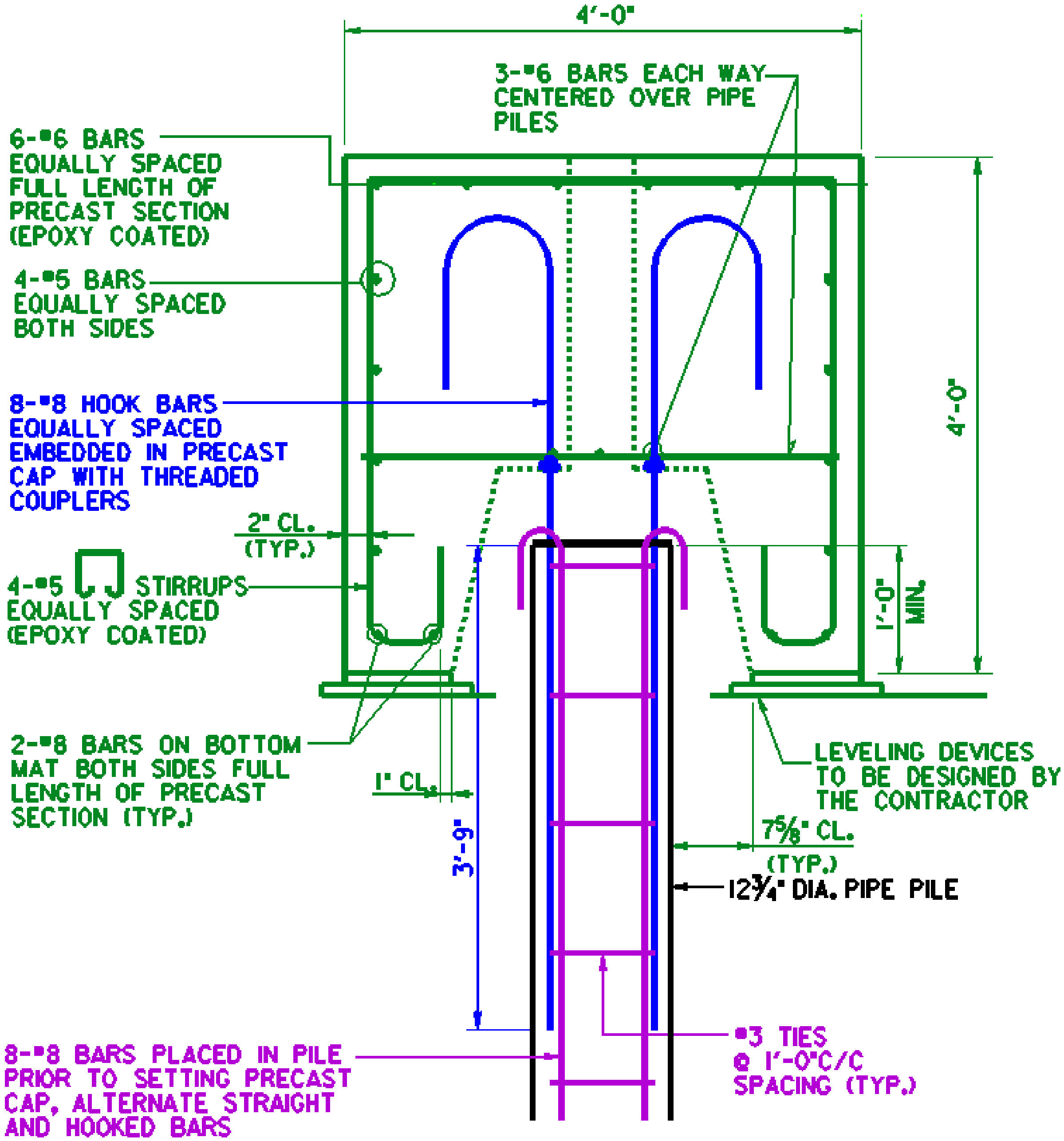
Some questions come up with the design of this structure. Mainly, how to you connect elements together? With the piles, the MDSHA has a 6" driving tolerance. How are the precast caps going to line up with the piles and still make that moment connection? The piles could be driven 6" in any direction away from where reinforcement is set in the cap. Since a full moment connection is required, special attention was made to ensure that this connection was secure. Additionally, the entire abutment weighs significantly more than a single prestressed beam. If the contractor wants to use the same crane for both slabs and the abutment caps, they would need to lift the precast caps in sections to place them on the piles. How is that connection between the precast sections made?

Another thing that the MDSHA is allowing the contractor to do is to precast the curbs on the exterior slabs. How will they line up exactly with the curbs on the wing walls if the wing walls are precast?

Finally, how is rip rap scour protection to be installed without having dewater the entire stream channel? The existing bridge abutments are directly adjacent to the edges of the creek. This operation could take a substantial time and lead to delays especially if a flood event caused failure to the dewatering devices during construction.

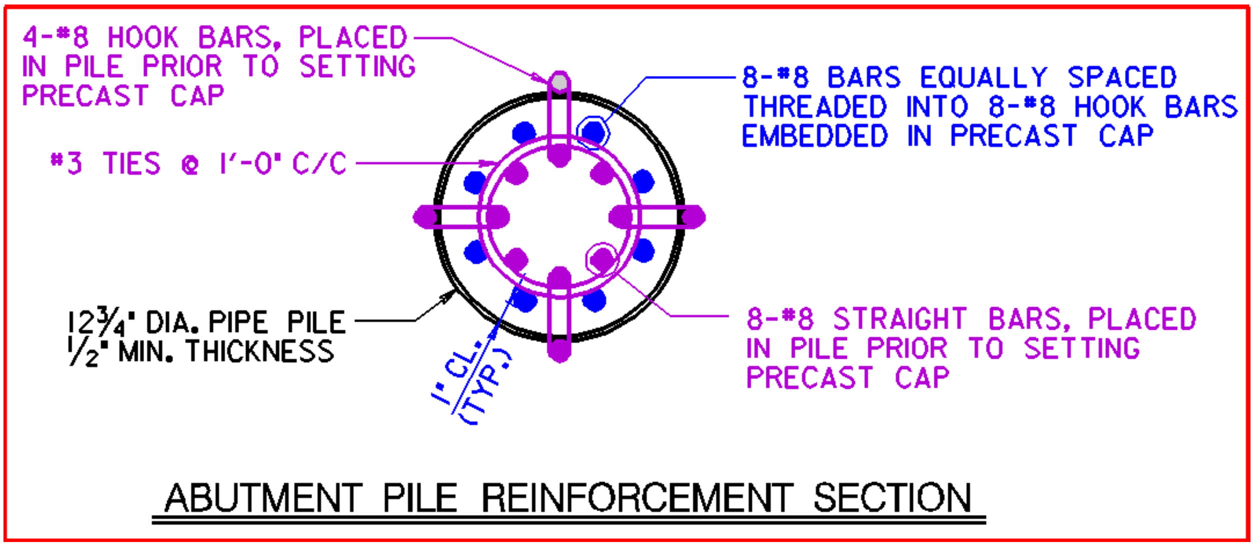
PILE TO ABUTMENT CAP CONNECTION

To solve the problem about the tolerance in the piles, the piles were driven before completely closing the roadway to traffic and before the abutment caps were cast. This work was done on the weekends with single lane closures and flagging operations. The contractor cut a hole through the existing pavement and pre-augured holes for the piles below the existing structure. This was done to prevent any damage to the existing bridge from the pile driving operation. The contractor selected an all-in-one piece of equipment that could augur holes, lift the piles, and drive them without a crane. This also limited the amount of equipment that had to be stored on the side of the roadway when it was not being used. Then the contractor field welded caps on top of the piles and surveyed their locations. This information was passed onto the pre-casting plant so that, when the abutments were cast, the reinforcement locations could be adjusted to match the actual location of the piles. The piles are backfilled and HMA is placed over top. As a side note, driving the piles ahead of time further saved on the overall bridge closure duration.



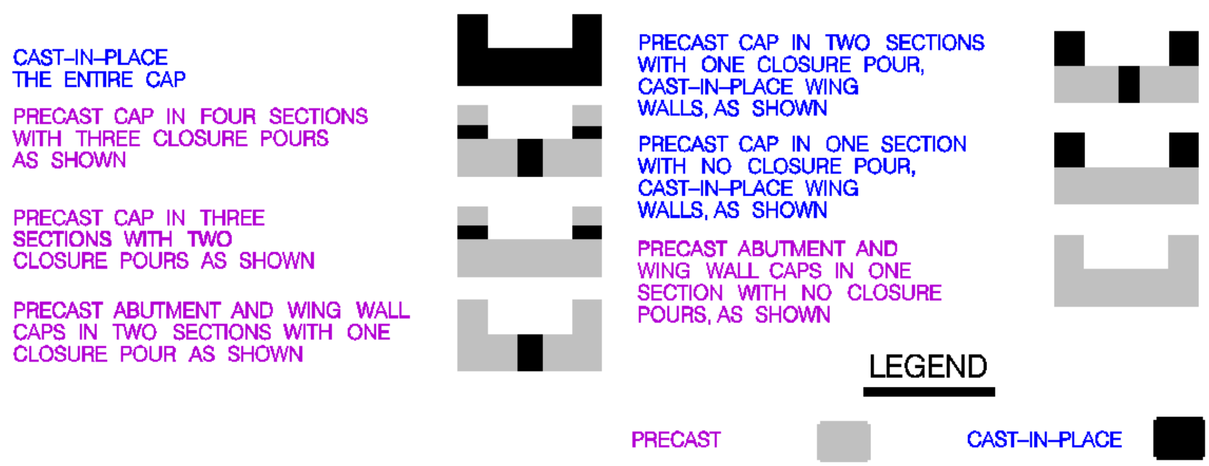
ABUTMENT SECTION

After the survey pile information was sent to the fabricator and the abutment caps were cast, the contractor then came back on site and closed the bridge to traffic. They removed the superstructure and excavated the piles. They then cut the piles to the correct elevation, and filled them with concrete up to about 20 feet below the bottom of footing elevation. A 19 foot long reinforcement cage that would resist the moment load created from the single row of piles was lowered into the piles. The contractor then welded temporary leveling pads to the piles for temporary placement of the abutment cap. The cap was then delivered to the site with cavities underneath that will allow it to fit over the piles. These cavities have circular pipes that extend up to the top of the cap for the completion of the closure pour. First, threaded bars were inserted into threaded inserts in the cavity. These threaded bars on the cap are only about 4 feet in length, just enough length for development. The MDSHA allowed the use of threaded inserts for two reasons. First, it would be easier for a fabricator to cast the cap and, second, it allowed the cap to be ship upright instead of upside-down. Flipping the caps in the field would not be easy for the contactor to complete and would have required additional reinforcement to resist the temporary load paths. Then the caps were lowered into the piles.

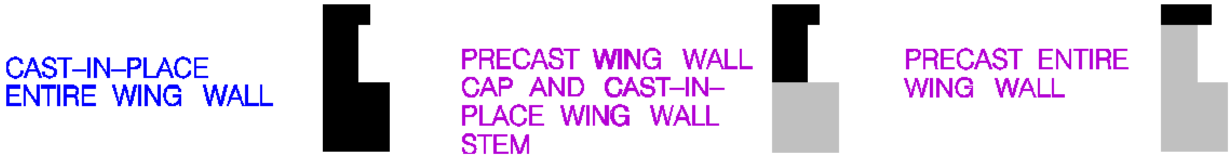


ABUTMENT CAP TO ABUTMENT CAP CONNECTION

Since the entire abutment cap weighs significantly more than a prestressed slab and would require a much larger crane to lift it, the contract included many options to construct these abutments in several pieces. The chart below shows a plan view of all of the options. The precast sections are shown in gray and the cast in place sections are shown in black. The first option included constructing it completely cast-in-place. Separate plan sheets were included in the contract that showed this option. Other options included two precast abutment sections and two precast wing wall sections, one precast abutment section and two precast wing walls sections, one that split the abutment in half, a couple more options with completely cast-in-place wing walls, and one to complete the abutment in one single piece. The contractor selected the option with two precast abutment sections and two precast wing wall sections.



There were also options on how to complete the wing walls as shown in the section views below. The contractor could cast-in-place the entire wing wall section, precast the wing wall up to the top of the abutment cap, or precast it to the bottom of the curb. The MDSHA required that the final curb section be cast-in-place to ensure that the curb lined up with the precast curb on the exterior prestressed slab beam. The contractor selected the option to precast the wing wall only to the top of the abutment and cast-in-place the rest.



How is connection to the precast abutment sections made? The adjacent sections of precast caps are separated by a two foot long closure pour. Horizontal reinforcement bars are extended straight out of each end of the abutment sections. Mechanical coupler splices are added to the top and bottom reinforcement in each closure pour section. Since the reinforcement in the middle of the abutment cap is only there for temperature and shrinkage, it was completed with a tied simple splice. A few vertical “C”-shaped stirrups bars were placed before the formwork was installed and a cast-in-place closure pour was performed. The cavities in the abutment caps over the piles were also filled with concrete at the same time.

SCOUR PROTECTION

The last design issue that was encountered was with the scour protection. Traditionally, the contractor would have to set up a stream diversion on each bank, dewater the area, excavate, place rip rap, and hope that the site stayed dry with this operation. Since the existing bridge was directly against the stream and the ground elevations on site are close to sea level, there was a great desire to stay out of the water in the initial design of the project. Instead of rip rap, the design called for driven sheeting piling. The contractor installed this sheeting right after excavation but before the pipe piles were cut off to their final elevation. They did this to help dewater the area around the abutment. After the precast abutment cap was set in place, the sheeting was connected it to the abutment caps with tie rods placed through preformed holes in the abutment caps. These tie rods connected to a small wailer in front of the sheeting. A top mat of reinforcement was placed over top of the wailer and sheeting, and the whole area between the existing and proposed abutment was filled with cast-in-place concrete to cap the sheeting. The scour protection and abutments were designed as a system, which helped to minimize the section requirements of both the pipe piles and the sheeting. In design, it was assumed that the contractor could use the existing abutment as formwork. This was true except at the wing walls, where the contractor had to put up some additional formwork for the sheeting cap. After pouring the cap, the contractor simply had to cut off the existing timber abutment to the top of that cap and remove the formwork around the wing walls.

SUPERSTRUCTURE PLACEMENT

The rest of the construction continued under a traditional construction schedule. To finish the bridge, the contractor placed the prestressed solid slab beams, filled in the shear keys between slabs, post-tensioned the slabs together, and added reinforcement to for the cast-in-place overlay. The exterior slabs had already been precast with the curbs on them. Just before the overlay was placed, the contractor was required to lift the reinforcement up with a crane and sweep a layer of grout on the slabs. This is required to ensure a good contact between the slabs and latex modified concrete in the overlay and is a standard procedure on all MDSHA bridges of this type. Continuing the construction, the contractor placed the overlay and lets it cure for seven days. In the meantime, they finished the cast-in-place wing walls and approach curbs, installed the railing on the bridge, backfilled behind the abutments, paved the approach roadway. After some striping and roadway signs were installed the roadway and bridge were open to traffic.

CONCLUSION

The MDSHA's goal was to only have the roadway detour and the bridge completed in five weeks or 35 days. The contract included an incentive of $6,000 per day if the detour was completed less than the 35 days. If the roadway was opened in 30 days or less, the contractor would get the full maximum $30,000 incentive. The contract also included a disincentive of $6,000 per day for every day that the roadway was not open to traffic beyond the 35th day. The bridge was closed on July 7, 2009 and reopened on August 14, 2009. The overlay was poured on August 5. With a 7 day cure, the bridge was ready to be opened on August 12, but the inspectors wanted to wait an additional two days to achieve additional concrete strength on the overlay. The first day of school in Somerset County was not until August 15, so there was no need to open the roadway sooner. The actual time including those additional two cure days was 37 days. So the project was an overall success and the goal was achieved. In summary, the key accelerated construction steps that allowed for the achievement of the time savings were to drive the piles with weekend lane closures prior to the full start of construction, to minimize the dewatering requirements by using sheet piling, and to use precast abutments and wing walls.