SLIDE-IN REPLACEMENT OF TWO I-84 BRIDGES IN NEW YORK STATE

Bala Sivakumar, P.E., HNTB Corporation, New York, NY
Steven Lin, P.E., HNTB Corporation, New York, NY
Cristina Brosio, P.E., HNTB Corporation, Albany, NY

ABSTRACT

This project involves the rapid replacement of the existing I-84 Bridges over Dingle Ridge Road in New York State using the slide-in construction method. The existing structures carry two travel lanes in each direction over Dingle Ridge Road and are too narrow to cross over traffic during replacement. I-84 is heavily traveled, with a peak AADT of up to 100,000, with 16% truck traffic. The existing structure has a 3-span steel girder superstructure with a total length of 135'-0". The new structures utilized 80'-0" single-span concrete NEXT beam superstructures.

The superstructure consists of adjacent NEXT beams made composite with one another through longitudinal Ultra High Performance Concrete (UHPC) closure pours for greater durability. The approach slabs consist of precast concrete modules that are also made composite through UHPC closure pours. The bridge replacements were done over two weekend nights using the slide-in construction method. Closure of the I-84 roadway was limited to just 20 hours for each bridge to allow for the rapid demolition of the existing bridge and slide-in of the new superstructure. Conventional bridge replacement would have extended over two years and would have required a temporary bridge in the median estimated to cost about $2.0 Million. Construction was started in March 2013, and the first slide-in was completed on Saturday Sept 21, 2013 between Saturday 5 PM and Sunday 1 PM. The second slide-in was completed on the weekend of October 19, 2013. Approach pavement work was performed during the closure period to raise the widened roadway to the same elevation as the raised section carrying two lanes.

Keywords: ABC,

INTRODUCTION

Accelerated Bridge Construction (ABC) techniques have the potential to minimize traffic disruptions during bridge renewals, promote traffic and worker safety, and also improve the overall quality and durability of bridges. Successful projects must be designed to be as light as possible, as simple as possible, and as simple-to-erect as possible. Minimizing road closures and traffic disruptions are key objectives of ABC. ABC entails prefabricating as much of the bridge components as feasible. The successful use of prefabricated elements to accelerate construction requires a careful evaluation of the requirements for the bridge, site constraints and an unbiased review of the total costs and benefits. For ABC systems to be viable and see greater acceptance, the savings in construction time should be clearly demonstrated.

The ABC design concepts can be classified into three tiers based on implementation duration as follows:

- Tier 1 – Bridge Move – ABC Concepts that can be completed over a weekend closure
- Tier 2 – Modular Construction – ABC Concepts that can be completed in a few weeks
- Tier 3 – Statewide ABC Bridge Program – ABC Concepts that accelerate larger, system-wide projects, and save months and/or years on the overall schedule

Modular bridge systems are particularly suited to be used as Tier 1 concepts for weekend bridge replacements or as Tier 2 concepts where the entire bridge may be scheduled to be replaced within one to two weeks using a detour to maintain traffic. Tier 1 concepts include preassembled bridges, completed at an off-alignment location and then moved via various methods into the final location using techniques such as lateral sliding, rolling, skidding, incremental launching, and movement and placement using SPMTs (Self-Propelled Modular Transporters). Tier 3 involves accelerating a statewide bridge renewal program by months or years by applying Tier 1 and Tier 2 ABC technologies.

Despite the gradual lowering of costs, DOTs are hesitant about using ABC techniques because of their perceived risks and higher initial costs. Thus, any technology recommended for field trials must meet minimum standards of apparent readiness for execution, a promise of durability and value to the owner. Additionally, rather than custom engineering every solution, pre-engineered modular systems configured for traditional construction equipment could promote more widespread use of ABC through reduced costs and increased familiarity of these systems among owners, contractors and designers. Furthermore, pilot projects, such as the one presented in this report, demonstrate successful implementations and foster more widespread use of ABC techniques.

PILOT PROJECT DESCRIPTION

In 2011, as part of an ongoing research project, the Strategic Highway Research Program, SHRP2 R04, of the Transportation Research Board identified the I-84 Eastbound and

Westbound Bridges over Dingle Ridge Road, owned by New York State Department of Transportation (NYSDOT), as an excellent candidate to demonstrate accelerated bridge construction (ABC) methods for replacing an existing structure via the lateral slide method while making use of a precast concrete superstructure. This project was the second pilot project completed under SHRP2 R04 and was selected from a number of potential projects received from several DOTs. This project was also awarded a $2 Million grant by FHWA's *Highways for Life* program for its innovative approach.


Figure 1: Original I-84 Bridges over Dingle Ridge Road

The original structures carried two travel lanes over Dingle Ridge Road, spanning 135'-0" with a 3-span steel girder superstructure (Figure 1). The replacement structures each carry three travel lanes. Given limited vertical clearance over Dingle Ridge Road, the structures utilize an 80'-0" precast concrete single-span NEXT beam superstructure. The abutments are semi-integral with elevated cap beams supported on drilled shaft foundations. The width of the new structure is 57'-0" to accommodate three 12'-0" travel lanes for traffic, with 6'-0" (left) and 12'-0" (right) shoulders and a TL-5 concrete barrier on each side.

The twin structures carrying I-84 in Putnam County, NY, between Danbury, CT and I-684, are heavily traveled, with a peak average daily traffic of up to 100,000, containing 16 percent truck traffic, and a projected 30 year AADT of 117,281. Conventional bridge replacement would have extended over multiple years and would have required a temporary bridge in the median (estimated to cost approximately $2 Million), as the original bridges were too narrow for cross-overs. Additionally, the elevation difference between the east and west bound roadways made cross-overs more difficult. Use of ABC methods eliminated the need for a temporary bridge and allowed for the replacement of each structure during a single night closure. Maintaining traffic on the original bridges during fabrication and assembly of the new bridges off alignment minimized traffic disruption and the costs of work zone traffic control, improved safety, and minimized environmental impacts.

PILOT PROJECT INNOVATIVE FEATURES

The new structure utilizes a no skew, 80'-0" single-span NEXT beam superstructure. The width of the new structure is 57'-0" to accommodate three 12'-0" travel lanes for traffic, with 6'-0" (left) and 12'-0" (right) shoulders and a TL-5 concrete barrier on each side. One of the main goals of this pilot project was to showcase a concrete superstructure system for ABC. The underpassing Dingle Ridge Road is on a 15.6% grade and the significant widening of the bridge created design challenges in maintaining the minimum underclearance requirements. NEXT beams were chosen for the superstructure to minimize structure depth due to critical under-clearance issues at this site and to expedite design and construction while maintaining cost efficiency to meet the goals of accelerated bridge construction. Precast approach slabs were placed at each approach. All field connections in the superstructure and approaches utilized ultra-high performance concrete (UHPC) closure pours.

A cast-in-place concrete straddle-bent abutment with 6'-0" diameter drilled shafts supports the new superstructure. Utilizing a straddle-bent allowed the drilled shafts to be installed outside the plan limits of the existing bridge, as under clearance for drilling rigs was limited. Columns, in-fill retaining walls, and cap beams were then formed and placed under the existing bridge with limited excavation and without disruption to traffic.

The contract was awarded at the end of December, 2012, construction of the twin I-84 bridges over Dingle Ridge Road began in March 2013, and the first slide-in occurred Saturday, Sept. 21, 2013. It is notable that the first slide was completed only 9 months after contract award. Use of precast elements minimized the duration of field construction activities, allowing for the construction of these two bridges off alignment in just a few months. Implementation of ABC methods allowed for the replacement of each bridge over one weekend night closure, minimizing impact on traffic. The lateral slide method eliminated the need for a temporary bridge located between the structures that would have been required to maintain traffic using conventional construction methods. The state realized significant cost savings by eliminating the need for a temporary bridge and associated roadwork. ABC minimizes traffic disruption and the costs of work zone traffic control, improves safety, and minimizes environmental impacts.

PILOT PROJECT CONSTRUCTION

PRE-BID MEETING

The pre-bid meeting and information session was organized to generate interest among potential bidders and answer any questions and concerns the contractors may have had regarding this new approach to bridge replacement. The goal was to avoid inflated bids that could arise from any perceived risks on the part of contractors. The design team also shared with the contractors sample plans for the rapid bridge demolition, temporary shoring for the superstructure, and the lateral slide system.

Given the large weekday traffic volumes of 40,000 vehicles per day on I-84, replacement of each bridge would occur during an approximately 16 hour directional weekend shutdown of I-84. An incentive/disincentive clause added to the contract would award or penalize the Contractor $10,000 per hour for early or late completion, respectively, during the ABC period to ensure I-84 would be open to two-way traffic by the following business day.

The directional shutdown of I-84 would be circumvented via a three mile detour on Rte. 6, which runs parallel to I-84 and would extend into Connecticut, while Dingle Ridge Road would likely be closed to traffic for approximately 5 days for each slide. Contractors were informed that NYSDOT and ConnDOT would be responsible for public outreach concerning the closure periods and associated detours.

At the prebid meeting, significant attention was paid to the three-phase project schedule that would be followed by the successful bidder. Essentially, the contract was separated into three phases with certain work that could be performed before the existing bridge was closed or after the new bridge was in place and, more importantly, the work tasks that could only be performed during the specified 16-hour ABC period.

Construction activities were divided into three phases: pre-ABC, ABC, and post-ABC. Activities were scheduled in such a way to minimize the work efforts required during the ABC closure period. Pre-ABC construction activities included casting the precast elements at the precast facility, erecting the falsework to support the new superstructure and approach slabs off alignment, erecting the superstructure and approach slabs on the falsework, constructing the abutments and wingwalls to the slide elevation, and approach widening to three lanes to meet the original roadway profile. ABC construction activities included demolishing the existing superstructure, piers and abutments, setting the sleeper slabs, placing bearings and slide pads on the abutments and sleeper slabs, horizontally sliding the superstructure and approach slabs onto the new abutments and sleeper slabs, placing joints, raising two lanes of the approach roadway to the final profile, and applying an overlay across the full length of the structure. Post-ABC activities included backfilling the abutment with flowable fill, raising the future third lane and shoulders of the approach roadway to the proposed profile, setting guiderail, capping the wingwalls, and casting the abutment cheekwalls.

In an effort to minimize the closure period, the Contractor removed as many tasks from the ABC window as possible. For example, the contractor placed the waterproofing membranes and tack coat for the final overlay on deck and approach slabs prior to performing the horizontal slide. The Contractor made adjustments to the schedule of activities prior to performing the second slide in an effort to further streamline the ABC period. For example, the Contractor elected to place temporary barrier and demolish the railing on the original structure prior to the ABC window, eliminating the activity from the closure period.

Careful scheduling of activities in the three phases of construction allowed for minimizing the closure period and disruption to the public.

SITE PREPARATION

Work commenced on February 07, 2013. Site preparation included clearing of a few small trees and grubbing the work areas,

Figure 2: Site Access Preparations

building of construction entrances (Figure 2), and installation of erosion and settlement controls and other environmental devices.

Considerable earthwork was included in the scope of the project. Widening of the existing approach roadways from two lanes to three lanes was primarily achieved by extending the roadway into the median area. Given the elevation difference between the eastbound and westbound roadways, considerable earthwork was required to achieve the desired profiles. The contractor also created access and work areas in the median and around the existing structures via temporary embankment.

In creating construction access on the existing slopes between the piers and stub abutments of the original structures, the contractor had to be mindful of not creating instability of the original abutments, as they were founded on shallow foundations built into the slopes. Over-excavation of the existing slopes could have resulted in a global stability failure of the structure abutments.

PRECAST ELEMENT FABRICATION

The superstructure and approach slabs of the bridges consist of precast concrete elements, which shortened the overall duration of field construction activities. Precast elements include end diaphragms with slide shoes, NEXT beams, approach slabs, and sleeper slabs.

NEXT Beams

Each new superstructure consists of six 36 inch deep Type D NEXT beams spanning 79'-4" and having a full thickness flange intended to serve as the riding surface at the conclusion of the ABC period.


Figure 3: NEXT Beam in Fabrication Yard (Photo Courtesy of NYSDOT)

The fabricator measured actual beam camber at transfer, at release, 3 days after release, one week after release, and every week thereafter until the beams left the yard. Initial measurements after release indicated larger camber than initially expected and caused concern that the cambers would be out of tolerance at delivery. Initially, camber was measured with the beams supported approximately 5'-0" from the actual final bearing locations (Figure 3). This decrease in the beam span decreased the downward deflections of the beams due to self-weight that would have countered the upward deflections from prestress. While changing the support location decreased the apparent camber, net camber growth values were still high due to time dependent camber effects caused by the decreased beam span length. The fabricator pre-loaded the beams to minimize further camber growth and camber at shipping remained within contractual tolerances.

The intention during design was to have traffic ride over the bare deck at the end of the ABC window. Plans called for a 2” asphalt top course to be placed over the full limits of construction for each roadway in the post-ABC timeframe. However, the camber of the beams after fabrication resulted in a step at the interface between the beams and the approach slabs (**Error! Reference source not found.**). This step necessitated the placement of an overlay within the ABC timeframe to provide an acceptable riding surface at the end of the closure period. Camber is an important element in ABC construction. Estimating camber in prestressed sections is difficult as camber is affected by many variables outside the designer’s control.

Figure 4: Step due to NEXT Beam Camber

Possible solutions include accounting for an asphalt overlay within the ABC window or providing a variable depth top flange on the NEXT beams to offset the effects of the camber and provide an acceptable riding surface at the completion of the ABC timeframe. The variable depth top flange would be thicker at the ends by an amount equivalent to the anticipated camber and would reduce to the minimum required flange thickness at midspan.

Anticipated final camber, camber and shipping, and camber at erection should be included on contract plans for precast elements which are intended to be used without the placement of a cast-in-place deck or overlay. As there are many variables unknown to the designer that factor into the computation of anticipated camber, the anticipated camber growth effects provided by the designer should be verified by the precaster during the shop drawing review phase. It is suggested that future specifications include the steps of verifying anticipated time dependent camber effects and providing any necessary geometric adjustability to accommodate anticipated camber growth. A monitoring plan should also be implemented to ensure that the camber remains within tolerance of the anticipated camber shown on the shop drawings. Corrective actions should be implemented to control camber growth, as necessary.

The exterior NEXT beams were cast integral with the standard NYSDOT curb/shear key detail for use with single slope concrete barriers. Prior to casting of the exterior beams, the curb detail was increased in height to accommodate beam camber. The beams were cast in pairs, and during curing of the initial two exterior NEXT beams, fine cracks formed in these barrier keys. The cracks were most likely a result of the monolithic curb base being in place at release of prestress, as there was no longitudinal reinforcement within the key detail. Although these cracks were expected to close under the weight of superimposed dead loads, such as barrier self-weight, the fabricator sealed the cracks prior to shipping the beams to the site. In the other two exterior beams that had not yet been cast when this cracking was observed, the fabricator placed two additional longitudinal bars (#5) in the barrier shear key to help prevent similar cracking.

End Diaphragms

The precast end diaphragm serves as a bridge between the slide elevation, which had to remain below the original structure, and the NEXT beam bearing elevation required to maintain adequate minimum overhead clearance over Dingle Ridge Road and to reach the desired final profile. It also transfers the loads from the next beam bearings to the slide shoes. Each precast end diaphragm is four feet wide and was cast monolithically with four slide shoes (Figure 5). The end slide shoe on the north end of each end diaphragm is flush with the outside face of the end diaphragm and creates the bearing surface for the push block used to push or pull the superstructure during the lateral slide. The precast end diaphragms vary in height to follow the roadway cross slope.

The NEXT beams sit on reinforced elastomeric pads that bear directly on the end diaphragms. Without a grout bed, there is no room for geometric adjustments of the NEXT beams on the end diaphragms to help achieve the appropriate final profile. The end diaphragms had not been cast when the NEXT beams were identified to potentially have more camber than anticipated. In order to provide the geometric adjustability required for the NEXT beams to meet the desired profile, the diaphragm depth was decreased by two inches prior to their fabrication.

Figure 5: End Diaphragm Fabrication (Photo Courtesy of NYSDOT)

While curing, cracks were identified in the end diaphragms. The cause of the cracks is unknown, but possible factors may include some or a combination of the following: early removal from forms and placement on temporary supports prior to the concrete achieving adequate strength, reduced moment capacity due to the two inch reduction in section depth, and/or the location of the temporary supports. All cracks were sealed by epoxy injection at the fabrication facility.

Approach Slabs

The precast approach slabs span 33’-1” from the end diaphragms to the sleeper slabs. The approach slabs have been designed for both dead load and live load, as they act as jump spans in the interim time between the end of the ABC period and completion of placement of the controlled low-strength material fill behind the abutments.

The contractor intended to slide the superstructure and approach slabs in place by pushing at the abutment end diaphragm location alone. Each approach slab was doweled into the end diaphragm. Although a final end diaphragm pour tied the approach slabs to the end diaphragm and NEXT beams, the Contractor elected to add additional dowels and reinforcement in the panels to carry the horizontal friction loads of the approach slab on the sleeper slab. The additional reinforcement served as added safety during the horizontal slide.

At the sleeper slab locations, the ends of the approach slabs were down-turned 90^{o} to meet the slide elevation. The surface had to be double beveled to account for the profile grade and cross slope of the roadway. Stainless steel plates were cast into the ends to ride over the PTFE sheets used during the slide.

Sleeper Slabs

The precast sleeper slabs are inverted tee sections, with the stem acting as the end dam for the approach roadway raising. The top of the stem was intended to serve as the riding surface prior to placement of the final asphalt course. The top of footing of the sleeper slab served as the sliding surface for the approach slab. The sleeper slabs were precast in three segments to allow installation of one of the exterior segments to be installed prior to the ABC period.

The top of the sleeper slab stem follows the roadway cross slope. The crown of roadway is not centered on the structure, so the sleeper slab is not symmetrical about the centerline of the bridge. Two of the sleeper slabs were incorrectly detailed and fabricated, as the cross slope was not mirrored correctly. This error in fabrication was not noticed until the precast segments were brought into the field. The contractor chose to sawcut the stem of the improperly fabricated sleeper slab segments to obtain the correct cross slope. This was done during the pre-ABC period without any schedule impact.

PTFE SLIDE BEARINGS

The slide bearings were designed as steel laminated elastomeric bearing pads with PTFE sheeting bonded to the top surface. The stainless steel sheeting on the bottom surface of the end diaphragm slide shoes sits on the PTFE sheeting. This interface has a very low friction coefficient, creating the slide surface. The elastomeric bearings serve the dual function of permanent expansion bearings for the structures.

The contract documents called for the PTFE sheet to be bonded to the top surface of the reinforced elastomeric pads with an epoxy adhesive meeting the requirements of ASTM D6412, which the bearing


Figure 6: Bearing Testing
(Photo Courtesy of NYSDOT)

manufacturer was not able to obtain. Various methods of bonding the PTFE to the elastomer were investigated, including using an alternate epoxy adhesive, bonding the PTFE to the elastomer, or providing a steel plate vulcanized to the top of the elastomer with the PTFE recessed into the plate. After some research and testing (**Error! Reference source not found.**), the bearings were fabricated by vulcanizing the PTFE to the top of the reinforced elastomeric pads.

ABUTMENT CONSTRUCTION TO SLIDE ELEVATION

Work on the new bridges commenced while the original bridges remained in service. Abutment drilled shaft foundations, columns, and cap beams were constructed up to the slide elevation under the existing structure using cast-in-place construction. A breast wall beneath the cap beam was cast concurrently with the columns to serve as a curtain wall, retaining soil behind the abutment. Precast modular T-Walls®, serving as wing walls were installed to an elevation just below the slide surface. The abutments were backfilled and compacted with select structural fill up to the sliding surface.

Drilled Shafts

Figure 7: Drilled Shaft Soil Auger

Abutment foundation selection was limited by construction sequencing, as it was necessary to construct the new substructures while the existing bridges were still in place. Foundation construction beneath the existing bridge would require low overhead clearance methods, and pile driving vibrations or excavation for pile caps could potentially destabilize the existing shallow foundations at the piers and stub abutments. Excavation support options were limited and costly as most typical excavation support systems require overhead clearance for installation. Options were further reduced by a low settlement tolerance necessary in order to maintain vertical alignment during the bridge slide. For these reasons, rock socketed drilled shaft foundations were selected as the most practical foundation type, to be installed on either side of the existing structures outside the existing bridge footprints. Each 6’-0” diameter shaft was designed to directly carry one of the two columns, as well as the earth pressure load on the curtain wall and cap beam connecting the columns.

Drilled shaft drilling operations commenced at the beginning of April. Shaft excavation was conducted using two self-erecting rotary drill rigs working concurrently with soil and rock augers (Figure 7) and core barrels (Figure 8). The upper ten feet of excavation was typically stabilized using an oversized casing, after which a full-length 6’-0” diameter interim casing to remain in place was installed to a minimum of 6” below top of rock to minimize soil intrusion. Rock sockets were excavated, the annulus between outer and interim casing was backfilled with flowable fill, and the outer casing was removed. Following satisfactory inspection, reinforcing cages were placed and concrete was poured.


Figure 8: Drilled Shaft Core Barrel

Crosshole sonic logging (CSL) was specified at all drilled shafts to verify concrete integrity; however, the design required column reinforcement to extend into the shafts. The column reinforcement would obstruct access to the top of the shafts, preventing coring or grouting in the event that a defect was encountered during CSL testing. To minimize the obstruction, the cold joint at the base of column/top of shaft was moved further down the shaft beyond the required column reinforcement embedment depth. This allowed for CSL testing to be completed prior to placement of column reinforcement, and maintained the option to core or remediate drilled shaft concrete if required. The remaining drilled shaft concrete was later poured in conjunction with the column above.

All drilled shaft work installation and CSL testing was completed by the middle of May, allowing construction to move forward with the columns and curtain wall.

Columns, Walls, and Cap Beams

Forming and rebar installation for the abutment columns and curtain wall commenced at the beginning of May. The contract plans called for the columns and curtain wall to be cast separately, with the columns calling for a higher strength concrete than the curtain walls. The contractor requested permission to cast the walls and columns concurrently. Permission was granted for the contractor to pour the walls and columns as one pour using the higher strength concrete and providing relief joints between the columns and curtain wall between the columns.


Figure 9: Eastbound East Abutment

With the columns and curtain walls in place, the contractor commenced backfilling operations while starting to form and place rebar for the cap beams. The contractor brought the fill to the elevation of the bottom of the cap beam, leaving no room for bottom formwork. The contractor used the fill as the bottom formwork for the abutment cap beam. Work on the cap beams was performed in tight quarters, as the top of the cap beam was just below the bottom of steel of the original structure. Placing and vibrating the concrete proved to be difficult given the limited overhead clearance available.

Abutment work was complete by the end of August to allow adequate cure time for the anticipated September slide dates. However, the limited vertical clearance available for the cap beam construction was further complicated by poor timing of concrete delivery (long gaps between ready mix deliveries) at the eastbound east abutment and inadequate pumpability of the concrete mix per specifications. When the forms were removed from the cap beam, several cold joints were identified (Figure 9), along with large areas of voids and poorly consolidated concrete, ultimately leading to the rejection of the cap beam. Originally, the eastbound structure was intended to be the first of the two structures to be slid into place. Reconstruction of the cap beam delayed the slide for the eastbound structure, and a decision was made to slide the westbound structure into place first.

Given the difficulties with the concrete mix at the eastbound east end, modifications to the mix were permitted, allowing the contractor to use a mix that provided the same concrete strength with increased flowability for pumping. In the reconstruction of the eastbound east abutment cap beam, details were revised to help obtain a more durable product. A bottom form was utilized to ensure adequate and even bottom cover. Bottom cover was increased from two inches to three inches. The main reinforcement was revised to be a single bar rather than being spliced at the columns. This rebar modification helped to alleviate congestion and facilitated concrete placement and access for proper vibration. The cap beam was demolished and reconstructed within the month of September.

T-Walls®

The T-Wall® modular precast concrete wall system was selected as the system of choice given the pace of the project, stepped embankment slopes, limited overhead access, and staged construction requirements. This system consists of stacked precast concrete face units with concrete stems located centrally behind each unit, extending back into the soil mass. Friction between the stems and the surrounding fill material, and shear blocks between the vertically stacked stems, cause the combined T-Wall® and surrounding soil mass to act as a gravity wall. Modular units were precast off-site well in advance, and once on-site, installation was quick and simple.


Figure 10: T-Wall® Wingwall

Grading for the wing walls commenced at the end of May, and setting of T-wall® units began in mid-June, following completion of the adjacent columns and curtain walls. The T-Walls® were placed concurrently with the abutment fill behind the curtain walls, beneath the existing structures, until the slide elevation was reached and overhead clearance became limited. The T-Walls® were installed to the slide elevation by the middle of August.

The remaining modular units for the uppermost wall course were installed following the ABC period to avoid conflicts with the new structures during the slide. As conventional backfilling and compaction was now obstructed by the new structure, the T-Walls® and abutments were backfilled to the bottom of approach slab using flowable fill, pumped in from the sides of the new structure and through grout ports near the crest of the new deck. Pumping of flowable fill proved difficult using the standard NYSDOT mix design, so the cement content of the mix was increased to improve pumpability.

The new wing walls span from the abutment columns to the sleeper slabs (Figure 10). As the sleeper slabs prevent placement of a T-Wall® unit, a gap existed between the sleeper slab stem at the end of each approach slab and the nearest T-Wall® unit. To close this gap, a precast panel was installed at each end of each sleeper slab. Inserts were cast into the sleeper slab ends to allow for the panels to be bolted into place during the post-ABC period.

ASBESTOS ABATEMENT

The original structures had asbestos sheeting between the abutment backwall and the deck, which was identified during the design phase. Asbestos abatement work must be performed within enclosures to properly contain asbestos during removal operations. No other work is permitted to be performed within the enclosure or the surrounding area. Given these constraints, asbestos abatement would not have been possible during the ABC closure period. Instead, abatement was performed as night work prior to the slide. The Contractor removed segments of deck over the abutment backwalls, performed the asbestos abatement, and dropped precast concrete blocks on temporary cribbing during various overnight closures.

TEMPORARY FALSEWORK AND TEMPORARY CRANE PLATFORMS

Figure 11: Primary Bent
(Photo Courtesy of NYSDOT)

In order to perform a lateral slide, the new superstructure and approach slabs needed to be constructed off alignment (alongside the existing bridges) and at the same elevation as their final location on the new substructure elements. Given the steep grade along Dingle Ridge Road, this resulted in the need for substantial temporary falsework located to the north of each structure. Braced double column primary bents were constructed in line with the new abutments (Figure 11). Header beams supported slide tracks which were used to support the end diaphragms. Secondary bents with a single column line were constructed adjacent to the new sleeper slab locations. These bents were also capped with a slide track on which the approach slabs were supported. Overall field construction durations were decreased by constructing the superstructure and approach slabs on the temporary falsework concurrently with substructure construction.

Pile driving equipment was mobilized and work on the temporary falsework commenced at the end of May. The temporary supports for the new superstructures were completed by the end of July and were ready for the delivery of the precast elements.

Given the steep grade along Dingle Ridge Road, crane platforms were required at either end of the new structure being constructed off alignment for the purposes of picking and placing the precast concrete elements that were delivered via night-time lane closures on I-84. The contractor made use of crane mats on built-up embankment in the median area to support the cranes picking the precast elements for the new eastbound structure. For the westbound structure, the Contractor constructed temporary crane platforms to the north of the westbound roadway on which the erection cranes were located. The platforms were completed by the middle of July and cranes mobilized soon thereafter, ready for the delivery of the precast elements.

SUPERSTRUCTURE AND APPROACH SLAB ERECTION

End Diaphragm, NEXT Beams, and Approach Slabs

Upon completion of the falsework erection, delivery and setting of the precast concrete superstructure elements commenced. New superstructure erection occurred concurrently with the construction of the new substructure elements.

The precast diaphragms and NEXT beams for the westbound structure were delivered over night on July 18th into July 19th (Figure 12). When the end diaphragms were lifted over the slide track, the contractor realized that the slide shoes would not fit within the slide track. The concrete faces of the slide shoes were ground down to allow the end diaphragms to sit within the slide track on the falsework. Once the end diaphragms were placed appropriately, the contractor set out reinforced elastomeric bearings for the NEXT beams. The NEXT beams were placed via dual crane picks given their weight and length. Both end diaphragms and the six NEXT beams were erected overnight for each structure.

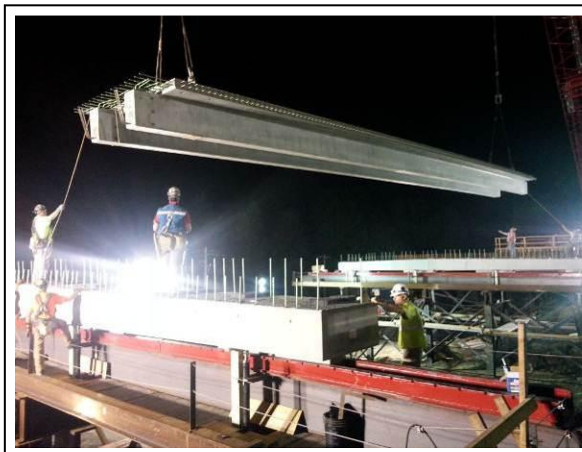

Figure 12: Setting of First NEXT Beam (Photo Courtesy of NYSDOT)

Each end diaphragm sits on four slide shoes. These slide shoes are narrower than the full width of the end diaphragm so they fit within the slide track. Given the narrow slide shoe width (1’-2” wide), the contractor made use of jacks on either side of the slide shoes to stabilize the end diaphragm throughout the various erection phases. Once the end diaphragms, NEXT beams, and approach slabs were all made integral with a cast in place end diaphragm closure pour, the jacks were no longer required.

The end diaphragm closure pour was performed in two lifts. The first lift was used to support the precast approach slab panels. Similar to the end diaphragms and NEXT beams, the approach slab panels were delivered via overnight lane closures on I-84. The approach slabs rested on the end diaphragm at one end and on the secondary bent at the other end. Prior to placement of the approach slabs, PTFE pads were placed at even intervals along the secondary bend slide track. These PTFE pads mated against stainless steel plates on the bottom surface of the approach slab stem.

The final end diaphragm closure pour was cast after the placement of the approach slab panels. This final closure pour served to make the approach slabs integral with the NEXT beams and end diaphragms and allow the superstructure and approach slabs to be slid into place as one unit. Both bridges are of jointless construction with expansion joints provided only at the ends of the approach slabs.

UHPC Closure Pours

Longitudinal closure pours were required to tie together adjacent NEXT beams and approach slab panels. UHPC with a strength of approximately 21 ksi was used to fill the joints (Figure 13). Contract drawings called for rebar to extend six inches from each panel into the 6” wide joint. During fabrication, the contractor requested to shorten the rebar protruding into the closure point by 1” at each end to ease fit-up in the field. Given the high concrete strength in the joint, the 5” bar extension was adequate to develop the bar in the closure pour.


Figure 13: Placing of UHPC

A Buy-America waiver was accepted for use of the steel fibers in the UHPC for this project. The product was mixed onsite in a pair of mixers for each structure, and the UHPC was transported to the joints using buggies. UHPC is very fluid and self-leveling in nature and required all formwork to be watertight to prevent leakage of the material. All formwork was tested prior to closure pour placement. The contractor used strips of 1/4” plywood on each side of the joint and top forms to allow a slight overfilling. The UHPC was placed in the joints, working from the low end to the high end of each structure, and was allowed to flow around the reinforcing steel and to completely fill the joint.

Concrete Barriers, Waterproofing, Tack Coat Application, and Sleeper Slabs

The concrete barriers were slip formed along both fascia of each structure after the completion of the longitudinal closure pours. These barriers were made integral with the deck via reinforcement bars that protruded from the deck into the barrier.

Just before the first slide, the deck surfaces were sprayed with a three coat waterproofing system. After the slide of the westbound bridge, the contractor chose to eliminate an additional task from the ABC window and placed the tack coat for the asphalt overlay on top of the waterproofing membrane prior to the slide.

The sleeper slabs were fabricated in three segments to allow for the installation of a portion of the sleeper slab prior to the lateral slide. The leading sleeper slab segment was installed prior to the trial slide, as the structure was required to slide a minimum of 5’-0” onto the new abutments and sleeper slabs.

TRIAL SLIDE

Within the last ten days prior to each ABC period, the contractor performed a trial slide to ensure the proper functionality of the slide systems. Contractually, the contractor was required to move each structure a minimum of 15’-0” and a minimum of 5’-0” onto the new substructure and return the structure back to its original position.

The westbound bridge trial slide occurred on September 13, 2013. During the westbound trial slide, the stem of the west approach slab was uneven and sloped downward a bit at the end, pinching the Teflon pads and pushing them rather than sliding over them. Additionally, after the first slide shoe was completely off the primary bent, the bearings on the abutment compressed such that the bottom of the slide shoe was lower than the slide track, requiring the superstructure to be jacked vertically in order to retract it onto the slide tracks and into its original position.

The eastbound bridge trial slide occurred on October 10, 2013. Having had difficulties with wracking of the superstructure during the westbound bridge slide, the contractor took meticulous measurements of each movement of the structure during the trial slide for the eastbound structure. While the measurements slowed the trial slide, the contractor was able to maintain proper alignment of the superstructure throughout the trial slide. In an effort to ensure that the slide shoes ride over the Teflon pads, the pads were tapered along the leading edge. However, at each abutment, a slide shoes pushed one Teflon pad on the slide track rather than riding over it. Part way through the trial slide, the contractor jacked the superstructure at each abutment to add the resulting missing Teflon pad. Finally, after having performed bot the successful trial and actual slides for the westbound structure, the contractor requested to leave the eastbound superstructure partially on the substructure, rather than retracting it to its original position. This modification allowed the contractor to save some time on the slide during the eastbound ABC period.

ABC PERIOD

The first lateral slide occurred on September 21 and 22, nine months after the award of the contract, and less than six months after the start of onsite bridge construction activities. The second slide occurred one month later, on October 19 and 20.

Once the initial substructure work was completed and the superstructure constructed, traffic was detoured to local State Route 6. NYSDOT and ConnDOT handled all traffic management during the ABC period. The original bridge was demolished, and the approach roadway was raised to the new profile. The bridge was dropped onto the closed roadway below and cleaned up by next morning. The remaining two segments of precast sleeper slab were placed at the end of either approach to serve as an end dam for the raised approaches and also to serve as a sliding surface for the approach slabs. The superstructure and approach slabs were then slid in place on PTFE pads against stainless steel mating surfaces, which offer very low friction resistance. Hydraulic jacks were used to push the new superstructure and approach slabs onto the new abutments and sleeper slabs. A mix of permanent elastomeric bearings with PTFE and temporary slide bearings (steel blocks with PTFE) were used for the slide. With the structure in place, joints were placed, and an asphalt overlay was placed over the length of the structure. The approach slabs were designed as a jump slab to temporarily carry traffic after the slide-in and before the abutment backfill was completed, allowing traffic to be re-routed onto the new structure at this point.

ABC TIMEFRAME AND SCHEDULE

The ABC timeframe is considered to begin with the closure of the original crossing and to end when traffic is rerouted over the new bridge. Closure of the roadway crossing lasted one night (20 hours) to allow for the rapid demolition of the original bridge and slide-in of the new superstructure and approach slabs. The existing bridge was closed at 5 PM on Saturday and the new bridge was opened at 1 PM on Sunday. Figure 14 depicts the schedule during the ABC timeframe for the replacement of each I-84 Bridge over Dingle Ridge Road.

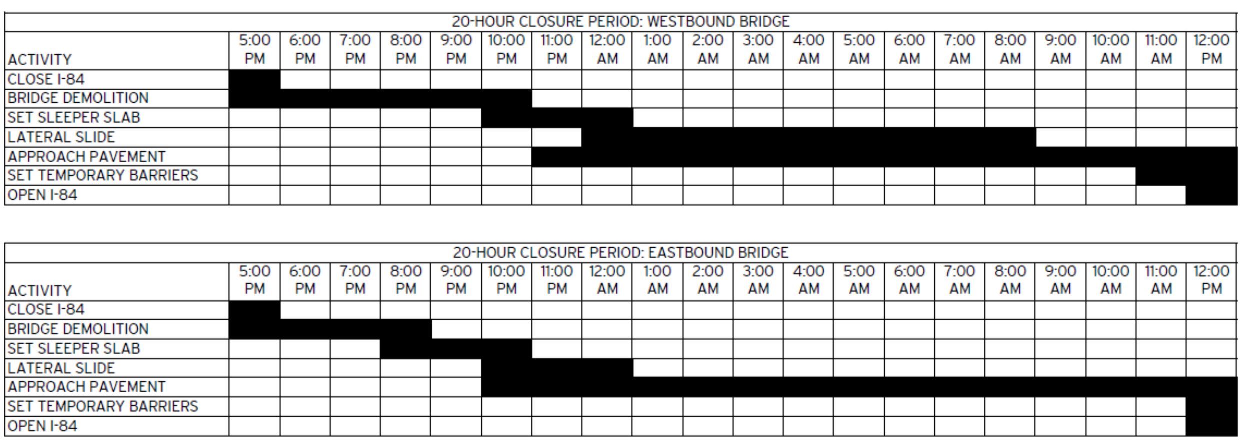

Figure 14: ABC Closure Period Construction Schedule

Demolition of Existing Bridge

Demolition of each bridge was performed by several crews working simultaneously. A hoe ram located at each approach commenced the demolition of span two by punched through the deck over the piers until span two was free to fall onto the roadway below which was closed to traffic and protected by a couple of feet of fill (Figure 15). Two shears working from Dingle Ridge road commenced the demolition of span two by first removing the bridge rails. Once the span was lowered to Dingle Ridge Road, the shears continued to work side by side until the span was completely demolished. Front end loaders hauled the concrete debris to a temporary spoils stockpile, while the shears collected the steel and reinforcement into a separate scrap metal stockpile.


Figure 15: Demolition of Span 2


Figure 16: Demolition of Approach Span

Demolition of spans one and three occurred simultaneously with the demolition of span two. An excavator and hoe ram located at each approach demolished spans one and three. The hoe ram was used to break up the railing and to punch through the deck (Figure 16). The excavator cleaned off debris, including all of the deck reinforcement. Once the deck was removed, ironworkers flame cut the diaphragms, and the excavators were used to lift out the stringers. Upon removal of the superstructure, the hoe rams continued with concrete removal at the abutments to the appropriate removal limits for sleeper slab placement.

With the superstructure removed from spans one and three and span two demolished, the shears began to break away the concrete at the base of the pier columns. Once the column sections were necked down, the shears worked together to rock the piers back and forth until failure (Figure 17). The shears continued to demolish the piers on the protected surface of Dingle Ridge Road.

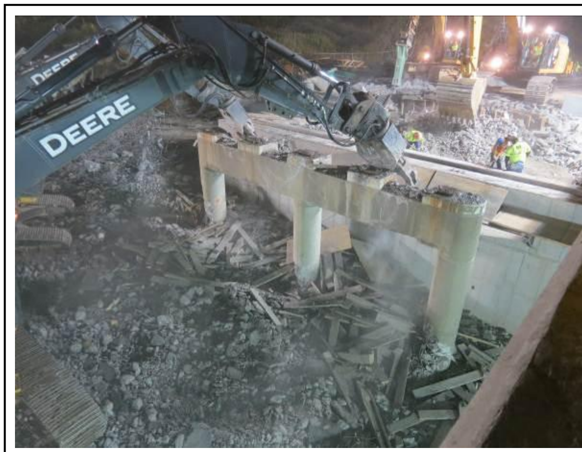

Figure 17: Pier Demolition

Approach Roadway

Two lanes of the approach roadway were raised during the ABC closure period. The new profile is approximately two feet higher than the original profile, so extensive approach roadway work occurred concurrently with bridge demolition and lateral slide activities. Several crews worked together to place and roll asphalt binder courses, tack coats, and top course throughout the closure period.

Lateral Slide

With demolition of the existing structure complete, crews quickly removed debris from the areas around the new abutments. All shielding and blast mats protecting the new abutments were removed. The abutment cap beams were swept clean of smaller debris. Temporary slide bearings were set along the full length of the abutment cap beam and regular intervals (Figure 18).


Figure 18: Temporary Slide Bearings on Abutment

At the approaches, excavators were used to perform the required earthwork for the sleeper slab and to lift the sleeper slab segments in place (Figure 19). Crews laid PTFE sheets along the length of the sleeper slab at regular intervals.


Figure 19: Sleeper Slab Placement

Hydraulic jacks were connected to gripper assemblies that pushed the push block on north end of the end diaphragms (Figure 20). The gripper assemblies had “dogs” that would engage notches on the slide track with small hydraulic jacks. With the gripper assembly engaged, the hydraulic jacks would extend and push the structure approximately one foot at a time. The dogs would release, and the main hydraulics would retract, pulling the gripper assembly forward. The grippers would then be engaged on the next set of notches, and the process continued until the bridge was slide into its final position.


Figure 20: Hydraulic Jacks and Gripper Assembly

At the westbound bridge slide, one end diaphragm led the other and the structure became skewed and wedged within the slide track, causing one of the hydraulic cylinders to fail. The contractor used hydraulic jacks to jack the structure vertically and realign it within the slide tracks. Two additional jacks were placed at the sleeper slab ends of the approach slab during the slide to control wracking of the span. During the eastbound slide, the contractor monitored movements closely at each sleeper slab to ensure that the structure did not begin to skew.

During the first bridge slide, the leading edge of the slide shoes and approach slab stem would occasionally catch the temporary slide bearings or PTFE sheets and push them rather than slide over them. The contractor elected to bevel the leading edge of the PTFE to help the structure ride up and over the slide bearings for the second slide.

Once the structure was in place, the expansion joints were filled with foam sealants. Upon completion of the approach roadway work, an asphalt overlay was placed over the structure. Temporary barriers were placed and lanes were striped prior to bridge opening. Both lateral slides were completed within the 20 hour ABC window allowed.

POST-ABC CONSTRUCTION ACTIVITIES

With the new structure in place and traffic restored to the new crossing, substructure and approach roadway work were finalized. The remaining precast modular wall sections and coping were placed along the abutment wing walls, up to the final elevation. Controlled low-strength flowable fill was used to complete the backfill under the approach slabs and create positive contact between the approach slabs and the underlying subgrade, while under live traffic. Approach pavement work continued to finalize raising the widened roadway to the final profile. The abutment cheekwalls were constructed. Finally, new guiderails and transition rails were installed.

PUBLIC OUTREACH

NYSDOT focused great efforts to reach out to the project stakeholders, trucking community, and general public to keep all informed on the project and timing and duration of closures associated with the project. Public outreach is an opportunity to educate and inform the public of new construction techniques and to build and foster relationships that allow an agency to establish credibility and trust with the affected community. These outreach efforts helped to minimize public resistance to the project and build support of the ABC replacement approach.

NYSDOT reached out to stakeholders in various different manners, including holding meetings with stakeholders, launching a project website, providing twitter and Facebook updates, providing statements with media and press, sending postcards to local residents and companies (see **Error! Reference source not found.**), setting up displays, and setting VMS displays to reach commuter traffic. Efforts to reach out to the public and trucking communities reduced traffic delays on the detours and surrounding roads by reducing traffic volumes, especially truck traffic, before and during the events. During the peak hours, traffic was reduced nearly 50%, from approximately 3,000 to 1,500 vehicles per hour, which allowed the one-lane detour to handle the interstate traffic. Increasing the public awareness of the project also helped minimize work zone related accidents. There was a significant reduction in total peak hour traffic volumes on the I-84 corridor during the ABC closures, which can be attributed to the effective public outreach and communication efforts implemented by NYSDOT and partner agencies.

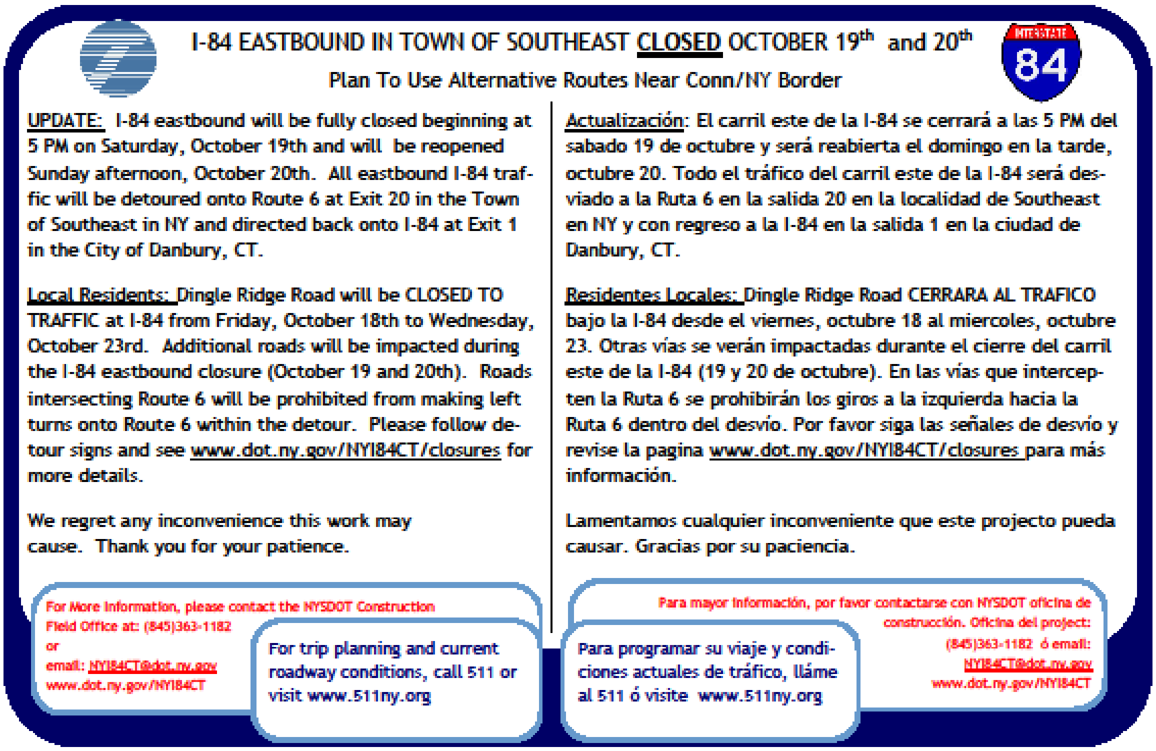

Figure 21: Postcard alerting public of closure period

The public had several opportunities to provide feedback to NYSDOT. The public responded to web surveys, wrote e-mails to the Regional office, provided statements in various local media reports, and spread comments via word of mouth. The various methods of communication allowed NYSDOT to work with the local community and respond to the needs of the people to help improve the community's satisfaction with and understanding of the project.

Responses from New York taxpayers were positive: the public took notice of the time savings. According to NYSDOT, the project received an 85-percent satisfaction rating in an informal, online survey. Comments ranged from 'Excellent job!" and "Completed so quickly!" to "Super fast!" and "Bravo to the workers and planners."

CONCLUSIONS

ABC minimizes traffic disruption and the costs of work zone traffic control, improves safety, and minimizes environmental impacts. Given the large weekday traffic volumes of 40,000 vehicles per day on I-84, replacement of each bridge via traditional methods would have necessitated the construction of a temporary bridge in the median, which would have significantly impacted the New York City watershed, and construction activities would have extended over two construction seasons. Making use of precast elements and replacing the bridges via the lateral slide method decreased the overall construction duration to approximately six months and eliminated the cost of a temporary bridge. The closure period for each bridge replacement occurred over a period of 20 hours, minimizing the disruption to the travelling public. The replacement of the I-84 bridges over Dingle Ridge Road successfully implemented ABC concepts.

Most of the structures along I-84 are of the same vintage of the replaced bridges over Dingle Ridge Road. With this successful implementation of the lateral slide ABC method and knowing that many of the other structures over I-84 are in need of replacement, NYSDOT is considering use of this ABC technique to replace other similar structures along the heavily trafficked corridor. Similarly, the New York State Thruway Authority, after visiting the site during the showcase, is considering replacement of various structures along the Thruway via the lateral slide method. This pilot project provided value to the owner and to the public, promoting ABC techniques for bridge replacement projects across the state of New York.

REFERENCES

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