

MCDOWELL OVERPASS WIDENING ON THE SR51 DESIGN BUILD PROJECT

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ABSTRACT

Precast spliced tub girders were used the first time in Arizona for a simple span widening on the McDowell Road Overpass on the State Route 51 (SR51) Design Build project that was completed in 2004. Another first for Arizona innovative solution was abutment extensions that were post-tensioned to existing abutments.

McDowell Road is a principal arterial street located in downtown Phoenix on the north side of the I-10/SR202L/SR51 traffic interchange. The existing McDowell Road Overpass was a 220 foot long by 129 foot wide single span cast-in-place post-tensioned box girder bridge over a single-point urban interchange. The bridge was widened on each side to accommodate new high occupancy vehicle lanes. Major design considerations included:

- Maintenance of traffic
- Accommodating initial creep, shrinkage and elastic shorting
- Matching the existing bridge profile
- Thermal expansion and contraction
- Construction and erection loading and hauling
- Staged post tensioning and construction, time dependent stresses analysis

The precast spliced tub girder solution was a cost competitive solution that offered the following advantages:

- Improved maintenance of traffic
- Reduced number of roadway closures
- Increased worker and public safety
- Shortened construction schedule
- Constructability
- Aesthetics

Keywords: Spliced, Girder, Precast, Tub, Widening, Innovative, Design, Build, Retrofit, Bridge, Precast, Hauling, Erection, Construction, Phoenix, Arizona, Ringwald, Kraemer, Miranda

INTRODUCTION

The State Route 51 Design Build Project in downtown Phoenix, Arizona provided opportunities for the designers and contractors to collaborate and provide innovative solutions for the widening of this freeway. The project was for the Arizona Department of Transportation and added one high occupancy vehicle lane on about 10 miles of State Route 51 in north and southbound directions and connected them to Interstate 10. This paper presents the bridge widening solution for the McDowell Overpass widening on SR 51, one of the bridge widenings on the project.

The McDowell Overpass is located just north of the Interstate 10, State Route 202 and State Route 51 freeway interchange and spans over a single point diamond interchange.



Fig. 1 This photo is looking south at the McDowell/SR51 Traffic Interchange during construction. The photo also shows I-10/SR51/SR 202L Freeway to Freeway Interchange directly south of McDowell Road.

Prior to the widening, the McDowell Overpass on SR51 consisted of a 220 foot single span cast-in-place box girder bridge with a structure depth of 10 feet and a 2% cross slope with a crown at the center of the bridge. The bridge was over 129 feet wide and had a 16'-9" minimum clearance over McDowell Road.



Fig. 2. This photo is of the McDowell Overpass taken at the onset of construction.

THE CHALLENGE

The bridge improvements consisted of widening the bridge by 13'-0" in the northbound direction and 14'-0" to 15'-3" the southbound direction. The final bridge width varies from 156'-2" to 157'-5". In order to maintain the required minimum vertical clearance the widen portions of the bridge were limited to an 8'-7" structure depth.

One of the main considerations for the project was to develop a cost effective solution that maintained traffic and reduced construction inconveniences to the public.

Our traffic control objective is as follows:

- Maintain four lanes of traffic on the mainline in each direction;
- Maintain two lanes of traffic on McDowell in each direction;
- Maintain one left turn lane for each left turn movement
- Maintain right turning movements

GENERAL LAYOUT CONCEPT

Our design concept was to provide a single main span bridge widening that was compatible with the existing single span superstructure without realignment and reconstruction of the freeway ramps.

In order to accommodate expansion and contraction of the existing bridge and bridge widenings, expansion joints located on the existing bridge were extended across the widenings. The widened bridge had a width that varied from 156'-2" to 157'-5". The design team was concerned about expansion and contraction in the transverse direction. Expansion bearings that allowed the bridge widening to expand and contract in the transverse direction were used to support the new girders at the abutment extensions.

The team investigated several alternatives for widening at the abutments. The first was to extend the existing abutments the full width of the widening. However, this alternative would have required the abutments to extend into the existing left turn ramps. This would have required the ramps to need to be realigned and reconstructed. Reconstruction of the ramps would not meet our goals of maintaining the traffic left turn movements at the intersection and would cause additional impacts to the public.

The solution was to reduce the width of the abutment extension by extending the abutment only enough to support the girder and placing short back spans from the abutment extension to new abutments located further back from the intersection. This reduced the width of the abutment extensions by the length of the bridge deck overhang and a portion of the taper girder web and allowed the left turn traffic lanes to remain in their existing configuration.



Fig. 3 This photo shows general layout concept. The main span is a simple span girder supported by abutment extensions. Short back spans were used so that the existing ramps would not need to be realigned.

The existing full height abutment was founded on 3 rows of 48 inch diameter shafts place at 6 feet on-center. The team determined that the existing abutments could support the additional loads from the abutment extensions and the widened bridge. The additional loading only increased the loads on the existing foundations by around 5% to 8%. The bridge could easily accommodate small settlements from the slight increase in loading because it was a simple span superstructure able to rotate at each end.

The team developed a concept to use corbels to extend the abutments and support the widened superstructure. Corbels were connected to the existing abutment with post-tensioned bars. The construction of corbels reduced the amount of construction impacts to the ramps. Another benefit was increased traffic sight distance for the left turning movements, thus increase traffic safety.

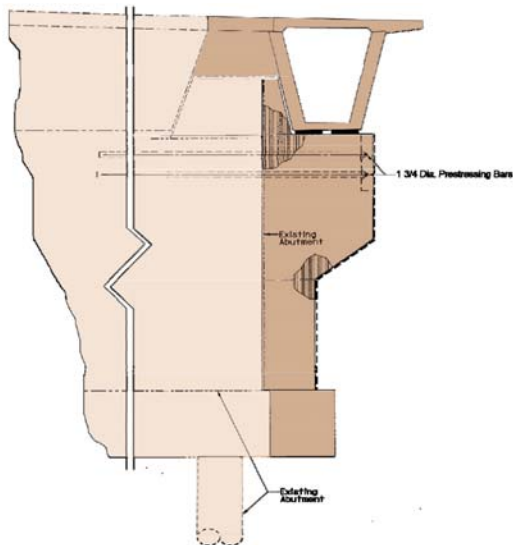


Fig. 4. This figure is an elevation of the abutment extension.

Five 1 $\frac{3}{4}$ inch prestressing bars were used for the main corbel reinforcement at each extension. Four inch diameter by sixteen foot-long holes were horizontal core drill into the sides of the existing abutment for each of the post-tensioning bars. The inside faces of the holes were roughed by the use of a smaller diameter core drill with high strength welds placed on the outer edges of the bit. After the holes were roughed and cleaned, the post-tensioned bars were grouted into the existing abutment.



Fig. 5. This figure shows the four inch diameter by sixteen foot-long holes that were horizontal core drill in the existing abutment.



Fig. 6. This figure shows the abutment extension after it was post-tensioned to the existing abutment.

A belt and suspenders approach was used for the design of the abutment extension. The abutment extension was design such that if the post-tensioned connection to the existing abutment failed, the bridge widening would not collapse.

MAIN SPAN SUPERSTRUCTURE SELECTION

The following alternatives were considered for the main span superstructure:

- Steel Tub Girders
- Cast-in-Place Concrete Post-Tensioned Box Girder
- Cast-in-Place Concrete Post-Tensioned Box Girder Lowered into Place
- Precast Segmental Sections with Deck
- Precast Spliced Tub Girders

The steel tub alternative was eliminated from consideration because of about a 50% higher cost, longer lead time and increased future maintenance costs. The team was also concerned with potential thermal expansion and contraction compatibility issues between a steel girder that would be direct sun light and the existing concrete post-tensioned box girder.

The existing bridge is a cast-in-place post-tension box. Widening in kind would reduce any compatibility issues and could be constructed to closely match the aesthetics of the existing bridge. However, this type of construction requires falsework to support the girder construction. Falsework placed below the girder would limit the temporary vertical clearance of the overpass and would require the use of crash beam during construction. Falsework towers would need to be placed in the center of the intersection. These towers would eliminate the left turning movements or reduce the number of through lanes, not allowing the maintenance of traffic objectives to be met. An additional issue was that the construction of the cast-in-place alternative would require work to be preformed adjacent to and over live traffic, thus reducing worker and public safety.

The next alternative considered was a cast-in-place post-tension box constructed above grade than lowered into place. This alternative could be constructed while maintaining construction temporary falsework traffic clearance without the need for crash beams. This option may have allowed longer falsework spans (around 90 feet) to be utilized so that maintenance of traffic objectives could be met. However, the longer falsework girders were a long lead item not readily available. The construction of this alternative also would require work to be preformed over live traffic, thus reducing worker and public safety.

Precast segmental girders with deck were considered but eliminated due to difficulty with construction, the special equipment (lifting truss) that is not readily available and the high construction cost.

The final alternative was precast spliced tub girders. According to the contractor, precast spliced tub girder alternative allowed the construction schedule to be shortened by about two and one half months. This solution allowed the precast elements to be constructed concurrently with substructure. It also eliminated limitations of constructing the boxes over traffic and a number of night and week end closures, which minimized disruption to traffic.

The team selected precast spliced tub girders. This alternative eliminated the need to place falsework for girder construction over traffic, met maintenance of traffic objectives, reduced construction adjacent to and over traffic which increased worker and public safety, provided a compatible solution, and accommodated aesthetics that matched the existing bridge.



Fig. 7. This photo shows the maintenance of traffic during construction with the support towers in place.

SPLICED GIRDER ALTERNATIVE

The spliced girder alternative consisted of one main span spliced girder on each side of the existing bridge. Each of the main span girders were trapezoidal boxes constructed in three precast segments without the deck. The precast segments were spliced together. The bridge deck was cast-in-place. The design strength of the concrete was limited to 7000 psi.

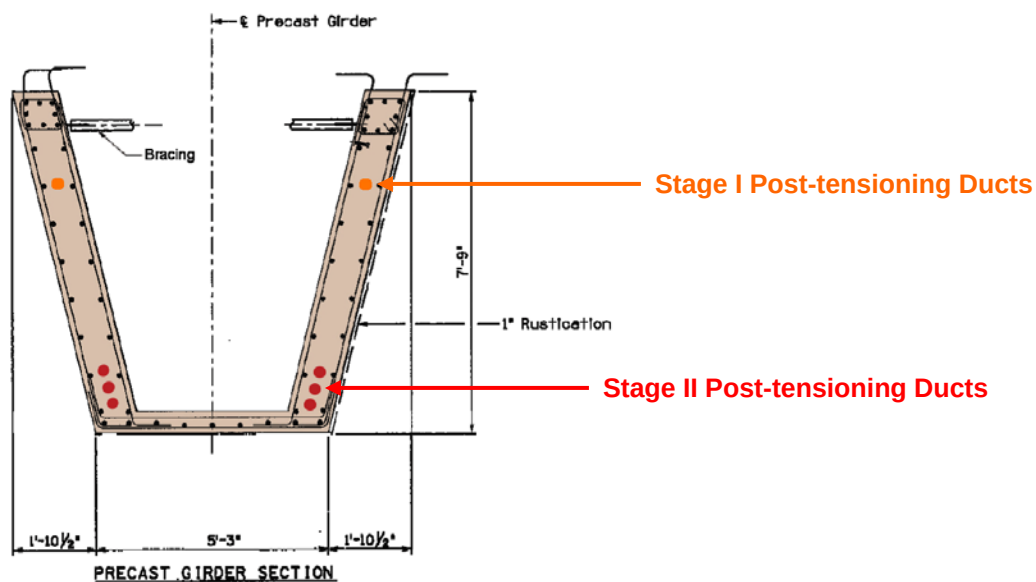


Fig. 8. The figure shows the typical precast girder section.

Splice girder design requires a design that accounts for the staged construction and time dependent stresses. Adapt computer software was used to design the structure.

In order to maintain vertical clearance an 8'-7" structure depth was used for the 220' main span. The depth to span ratio was 0.039. Typically for simple span cast-in-place box girders an economical depth to span ratio of 0.045 is used. The girder was extremely shallow for the given span which resulted in highly post-tensioned girders.

For this type of widening, the main span was post-tensioned and time was allotted for the girder to creep and shrink prior to connecting it to the existing bridge with a deck closure pour. One of the major concerns for the widening was matching the existing bridge profile. If the camber for the bridge was off by one-inch, that would equate to a about a 2% difference in cross slope over the four foot closure pour.

Testing for modulus of elasticity and creep and shrinkage coefficients were preformed for the concrete mix design used for the precast girder construction. The existing bridge edge profile was surveyed at each stage to allow adjustments to be made. The final profile matched the existing bridge and was with-in one quarter of an inch of the calculated profile elevations.

CONSTRUCTION OF THE WIDENINGS

During the first stage of construction, a temporary barrier was place two feet off of the edge of the traveled lane on the SR51 Freeway. All of the lanes of the freeway were able to remain open during construction, except for a few night and weekend closures. The existing outside bridge barriers and deck overhangs were removed.

Construction of the new abutments and abutment extensions began. One of the two left turn traffic lanes remained open at the intersection for construction of the adjacent abutment extensions.

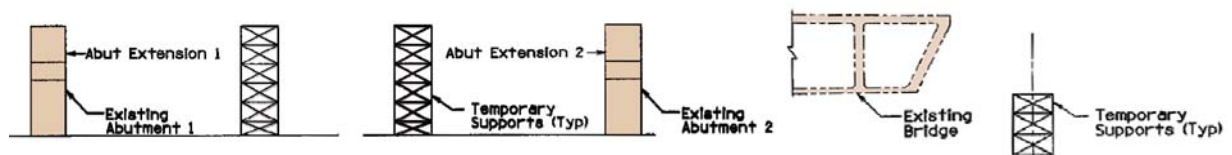


Fig. 9. Construction Phase 1.

Temporary support towers were constructed at each of the splice locations along the outside lanes of McDowell. The outside through lanes on McDowell were closed. However two through lanes, one left turn lane and the right turn lanes in each direction remained open per the maintenance of traffic objectives. Special bearings were place on top of the support tower below a support frame to allow for shrinkage of the girder during and after post-tensioning of the girder. Shim plates were place at each of these bearings to allow adjustments in elevations to be made.



Fig. 10. This photo shows the construction of the support towers.

Construction of the girder segments occurred concurrently with construction of the abutments, abutment extensions and support towers.

The tub girder section was chosen because of its easy of construction. The girder segments were constructed similar to a cast-in-place post-tensioned box girder on soffit fill, a common practice in Arizona. A waste slab was poured on grade with the girder camber and roadway profile built into the grading of the slab. The segments were built in a line, end to end, in order to facilitate alignment of the post-tensioning ducts and reinforcement that would be lapped or spliced with in the two foot closure pour. Tub girder segments were conventionally reinforced to support their own weight during transportation and erection.



Fig. 11. Photo shows girder formwork being place on waste slab.



Fig. 12. Aerial photo shows precast girder casting yard.



Fig. 13. Photo shows precast girders in casting yard.

The center girder segments weighted about 280,000 pounds, this is over twice as much as a standard AASHTO girder. Transporting these girders required an overload vehicle. It was important to locate the casting yard close to the site that did not require the girders to be transported over existing structures. The casting yard was located about one quarter of a mile south of the bridge on the west side of the McDowell southbound SR51 entrance ramp. The location of casting yard is part of what made this an economical alternative. The girders could be transport down the ramp to the site without crossing over existing structures. The same girder forms were used for both main span girders, which provide additional economics. The precast girder segments were constructed by the contractor's own forces.



Fig. 14. This photo shows the casting yard with respect to the McDowell Overpass.

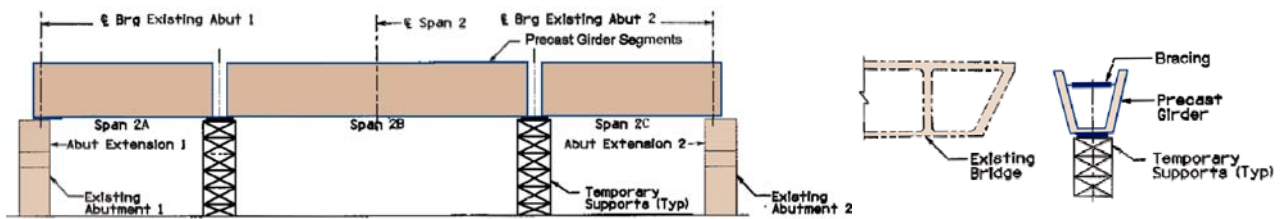


Fig. 15. Construction Phase 2.

After the girder segments were constructed, lateral pipe bracing was installed. The lateral pipe bracing was design to prevent buckling of the girder webs and was design to transfer eccentric loads from the deck placement and lateral load to the end diaphragms then to the support towers.

The next phase was transportation and erection of the girder segments. The girder placement was schedule for a weekend closure of McDowell Road and SR51 Freeway. Two cranes were used, a 240 ton and a 300 ton. The cranes were brought in early to set the girder segments on support blocks to allow the girder transporter to pick up the girders during erection with out the uses of a second set of cranes.



Fig 16. Photo shows girder on blocking being loaded on to transporter.

A heavy duty self-propelled modular trailer was used to transport the girders. The transporter had 12 axles and 48 tires and a 720,000 pound capacity. Each of the axles was independently steerable. The trailers were driven under the girder elevated on the support blocks. The operator then use the trailers hydraulic lift capability to elevate the girders off the supports. The operator then transported the girder segment to the site.



Fig. 17. Photo shows girder being transported.

Concrete lifting diaphragms were provided at near ends of each girder segment. These diaphragms were designed with additional reinforcing to accommodate the rigging.



Fig. 18. Photo shows rigging begin connected to girders. Girder diaphragms were design for the girder erection loading.

The six girders segments were erected. Four segments the first day and two the second.



Fig. 19. Photo shows the erection of a precast girder segment.

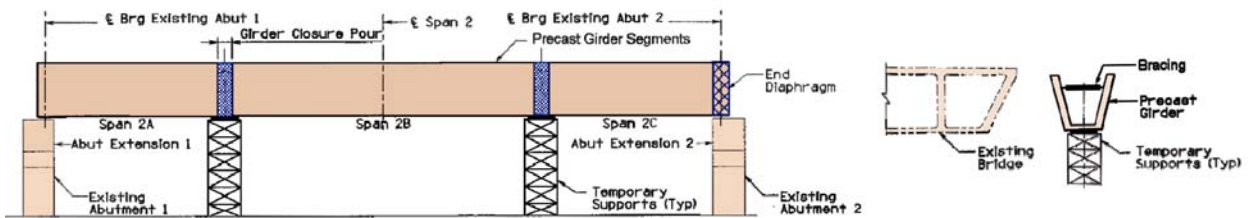


Fig. 20. Construction Phase 3.

The post-tensioning ducts were spliced and the girder closure pours were constructed.

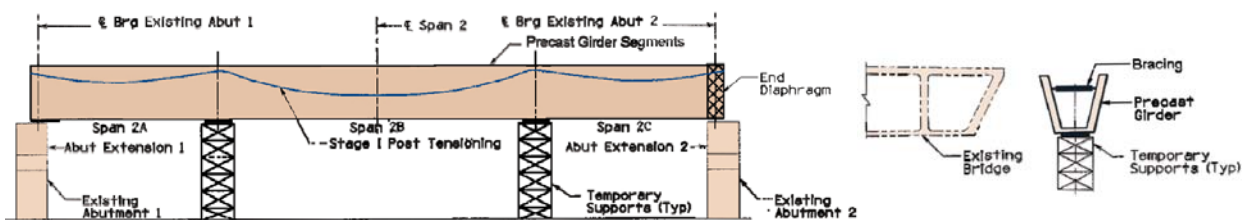


Fig. 21. Construction Phase 4.

After the girder closure pour concrete meet strength, the stage I post-tensioning was installed. For this phase the girder was design as a continuous three span bridge with zero tension under dead loads.

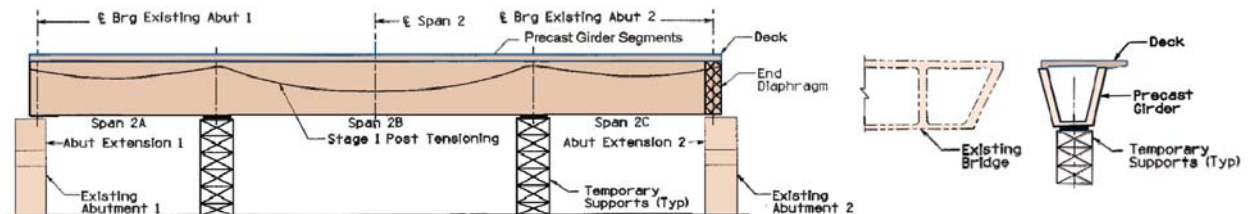


Fig. 22. Construction Phase 5.

The deck over the girder and overhang were then constructed.

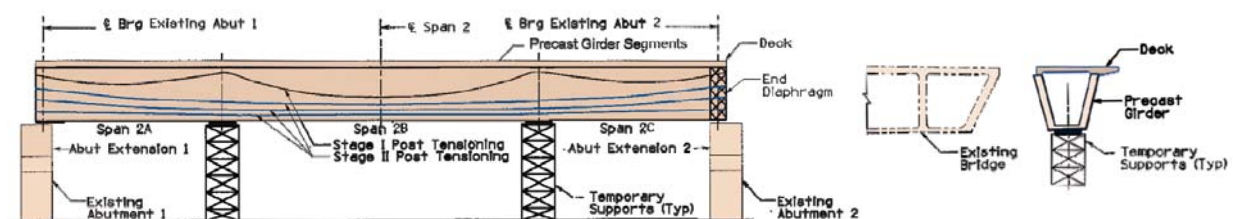


Fig. 23. Construction Phase 6.

Once the deck concrete meet strength, the stage II post-tensioned was installed. The total post tensioned force per girder was about ten million pounds per girder. The stage I post-tensioning was immediately de-tensioned. The stage II post-tensioning lifted the girders off of the temporary supports.

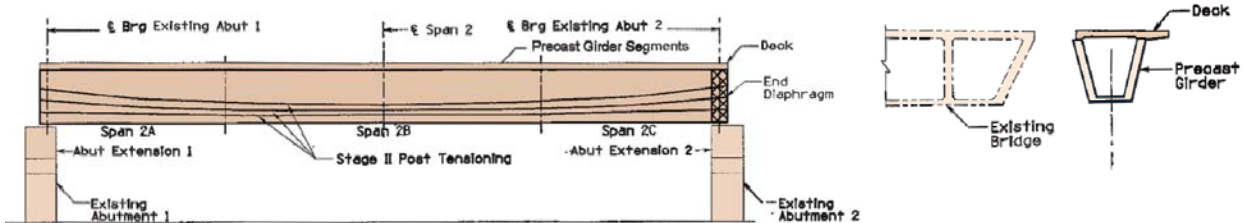


Fig. 24. Construction Phase 7.

The falsework towers were removed and the intersection was fully opened to traffic.

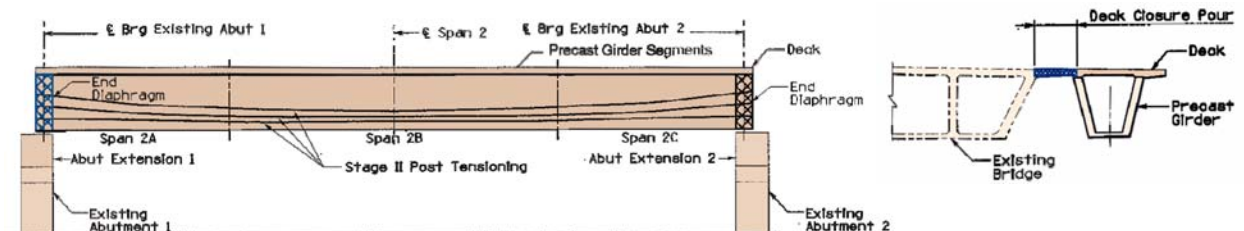


Fig. 25. Construction Phase 8.

Next was the closure pour. Sixty days was allotted from the time of the stage II post-tensioning to the closure pour to allow for the girders to creep and shrinkage. The girders shortened by over five inches after post-tensioning.

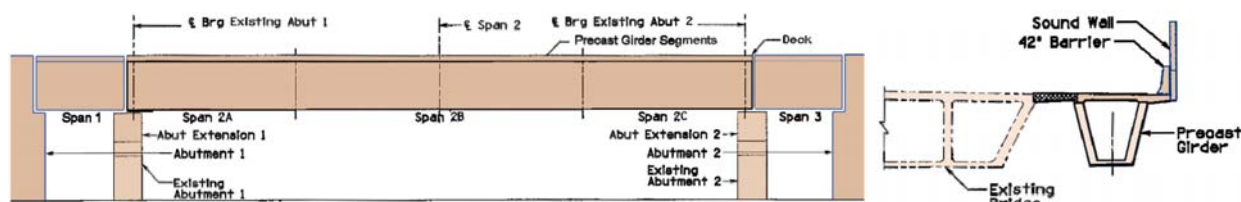


Fig. 26. Construction Phase 9.

The final stage was placement of the joints, barriers and sound walls. Construction was completed after eight months of construction. The widening was not on the critical path for construction of the overall project. If it had been the contractor felt that the bridge widening could have aggressive been constructed in six and one half months.



Fig. 27. Photo of completed just prior to the completion of the sound walls and painting of rustication.

CONCLUSIONS

The precast spliced tub girder solution was a cost competitive solution that offered the following advantages over a conventional cast-in-place alternative:

- Concurrent construction shortened schedule
 - 8 month duration vs. 10½ month for cast-in-place alternative
 - Aggressive 6½ month schedule possible
- Minimized disruption to traffic (vs. Elevated cast-in-place alternative)
 - Eliminated about 8 McDowell Rd. closures to erect & strip more elaborate falsework and to form/pour/strip bottom deck & stems
 - Cast-in-place alternative would likely have required more lane closures for additional falsework bents and for a longer duration
- Increased public and worker safety