

INNOVATIVE APPROACH TO AESTHETICS AND ACCELERATED CONSTRUCTION
THE 24TH STREET BRIDGE

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ABSTRACT

The 24th Street Bridge project is part of the \$1 billion-dollar interstate highway reconstruction effort that is under way in Council Bluffs, Iowa. The focus of this first structure is aesthetics and accelerated construction. The use of full-depth post tensioned deck panels provided a means for reducing the construction schedule. The inclusion of community-sponsored aesthetic features in the form of substructure shape, concrete texture and color, custom fencing, and accommodation of public art will establish the aesthetic theme for the entire corridor and surrounding community.

Many innovative features were made possible with the help of funding from the Highways for Life (HfL) and Innovative Bridge Research and Deployment (IBRD) programs. Some of these features are high performance materials (concrete and steel), state of the art health monitoring system and testing, accelerated contracting methodology, and Intelligent Transportation System (ITS).

The paper will focus on the aesthetic concept, accelerated construction techniques and other innovative features used on this project including precast/prestressed deck panels.

Keywords: Accelerated Construction, Aesthetics, Health Monitoring, High Performance Concrete, Innovative Contracting, ITS, and Precast Deck Panels.

INTRODUCTION

Across the nation, state Departments of Transportation (DOTs) are dealing with aging infrastructure that is in dire need of upgrade. Lower revenues and higher cost of construction projects have had dramatic impact on the transportation infrastructure budget, thus it is imperative that new transportation structures be cost effective and economically sound.

With increasing traffic volumes and an aging interstate system in Council Bluffs, the Iowa DOT has begun planning efforts toward a multi-year reconstruction of the 18-mile Interstate 80 (I-80) corridor running through the city. As part of the planned reconstruction of the Council Bluffs Interstate System (CBIS), the improvements project will focus on upgrades to Interstates 80, 29 and 480 within the Council Bluffs metropolitan area and will include 11 local interchanges and 3 interstate system interchanges.

The 24th Street interchange project is the first part of a multi-state (Iowa and Nebraska) effort to improve and upgrade the capacity of the CBIS. CBIS is composed of three highly congested corridors: I-80, I-29, and I-480. The 24th street interchange serves major attractions and businesses such as casinos, a conference/event center, hotels and major shopping outlets (see Figure 1). Therefore three lanes of traffic, one in each direction plus a turning lane, need to be maintained on 24th Street during construction.



Figure 1 - Project Site Overview Looking Southwest

The present 24th Street Bridge over combined Interstate 29 and 80 (I-29/I-80) in Council Bluffs, Iowa, features full-depth post tensioned deck panels supported on steel girders. The two-span steel bridge will serve as the primary access to some of the most popular attractions in Western Iowa and will highlight the aesthetic theme for the corridor.

A project of this magnitude is typically constructed over two consecutive construction seasons, but due to the critical location of this interchange, traffic restriction duration on 24th Street needed to be limited to a single season (April – October). With this in mind, accelerated construction techniques along with innovative methods were primary features for this project. Furthermore, the introduction of corridor wide aesthetic theme increased the level of complexity on this project substantially. These features made this challenging project

a very attractive candidate for both the Highway for Life (HfL) initiative and the Innovative Bridge Research and Deployment (IBRD) program.

The paper will focus on the innovations associated with the aesthetic concept, design, fabrication, construction acceleration, and health monitoring of the 354 feet long x 105 feet wide bridge. The information presented will help bridge owners, designers, and other industry professionals make the best use of the latest innovations on future projects.

HFL AND IBRD FEATURES

With the help of the HfL initiative and the IBRD program, the Iowa DOT has the opportunity to use proven innovations that are new to Iowa to meet the needs of the traveling public during and after construction.

The HfL and IBRD programs were used as a vehicle to achieve the project goals such as accelerating construction while maintaining traffic access, reducing future maintenance, and improving safety during and after construction. To accomplish these goals, the Iowa DOT proposed utilizing the following innovations:

- Prefabricated and post tensioned full-depth concrete deck panels with an overlay.
- High Performance Concrete (HPC). Although HPC has been successfully used in central Iowa, material suitability in the western part of Iowa has been an issue. The deployment of HPC in western Iowa will be considered an innovation.
- High Performance Steel (HPS) will be used to increase toughness and to improve corrosion resistance.
- A structural Health Monitoring System (HMS). A monitoring plan will be implemented to evaluate and document the innovative aspects of accelerated construction. The monitoring plan will include health monitoring instrumentation to assess the integrity of the structure and deck panel system during and after construction.
- Use of fully contained flooded backfill. This method involves placement of a granular wedge behind the abutment backwall that is flooded to achieve consolidation.
- Cost plus time bidding (A+B) bidding. A (construction cost) + B (number of calendar days to complete construction multiplied by a specified unit cost) bidding is proposed as an efficient contracting procedure that may reduce the project delivery time.
- Intelligent Transportation Systems (ITS). A system of cameras for the interchange will be installed in advance of construction. A system of sensors will have automated components to detect travel speed and queuing. A late merge system is also proposed to increase mainline traffic capacity during lane closures and provide traffic counts. Data from the ITS will be evaluated and used to optimize traffic control and refine the closure periods.

DEVELOPMENT OF AESTHETIC CONCEPTS

With the extent of the planned interstate reconstruction, the Iowa DOT commissioned HDR Engineering, Inc. to develop a corridor-wide aesthetics master plan that would create a consistent, attractive interstate corridor theme, complement the character of the existing landscape and incorporate locale-specific details. The resulting aesthetic master plan reflects both Council Bluffs' community values and natural assets while preserving and enhancing the distinctive features that contribute to Council Bluffs' quality of life.

Throughout the process of developing the master plan, the Iowa DOT was committed to involving the public in the planning decisions that would ensure the reconstructed interstate highways were appropriately integrated into the surrounding community. An Aesthetics Subcommittee (ASC) was selected from Council Bluffs stakeholder groups to represent the community in aesthetic decisions. The twenty two ASC members consisted of city political leaders, business leaders, members of the local arts community, planning commission and community development members, chamber of commerce representatives, casino representatives, city employees from the Public Works and Parks and Recreation Departments, charitable foundation representatives and members of local preservation, historical, conservation and natural resource organizations. The ASC met with the design team several times over the course of the project to assist in formulating recommendations for aesthetic improvements. Through visioning exercises, a week-long design charrette and ongoing interaction with the design team, the ASC helped shape the goals for the project and the guiding themes for the corridor improvements. Between meetings with the ASC, the design team incorporated input from the ASC to develop the overall master plan.

The design and ASC interaction process developed the following guiding principles:

- Timeless Design – The aesthetic enhancements should not appear dated at any point in the design life.
- Locale-Specific Details- Characteristic details of the Council Bluffs community should be incorporated into the design.
- Natural Environment - The design should complement the distinctive rolling loess hills and bluffs of the area.
- Cohesive Appearance- Utilize complementary materials and repeated design features to provide consistency throughout the corridor.

The local interstate interchange at 24th Street currently consists of a traditional diamond interchange with 24th Street passing over combined I-29/I-80. The interchange provides an access point to the city and it services an existing truck stop and hotels. However, the area has outgrown the capacity of the interchange after improvements to an existing casino and the addition of the Mid America Arena and Events Center, a Bass Pro Shops retail store, a local recreational sports complex, a multi-plex theater, restaurants and other commercial venues. Additional future development on other quadrants of the interchange would require widening of the existing overpass and thus dictated that the interchange needed immediate improvements. As such, replacement of the 24th Street Bridge and improvements to the interchange ramps became one of the first projects that would be let for the CBIS improvements project.

The accelerated schedule requirement to replace the 24th Street Bridge created a unique challenge for integrating the corridor-wide aesthetic master plan. Preliminary design of the 24th Street Bridge was nearly complete as the master planning process started. A master plan is typically conceptual in nature and results in a planning level document. For this aesthetic master plan, the effort began by looking at the broad spectrum of ideas, refining those ideas into several alternatives, narrowing the alternatives and selecting a preferred concept. That concept was then developed into a series of design features that could be incorporated into elements such as bridges, retaining walls, sound walls, and landscape designs. The process was iterative and required regular opportunities for input by the ASC. Because of the accelerated schedule for the 24th Street Bridge, the design team had to quickly take the proposed aesthetic design features and develop hard dimensions and details that could be used in the final bridge design. This proved to be an advantage to the aesthetics design team because the aesthetic concepts had to be refined to the point where the concepts could be translated to actual design details that were constructible.

The 24th Street Bridge is one of only two locations throughout the Council Bluffs Interstate System where a city street crosses over the top of the interstate. It is also located near the West end of the city and thus it is one of the first bridges encountered by interstate motorists as they cross into Iowa from Nebraska. With this high level of visibility to the interstate traffic below and its prominence in the corridor as a “gateway” structure, it was judged to warrant a higher level of aesthetic treatment. The aesthetic design of the 24th Street Bridge incorporates various design forms, textures and colors to represent the rolling curves and natural landforms evident in the surrounding loess hills (see Figure 2).

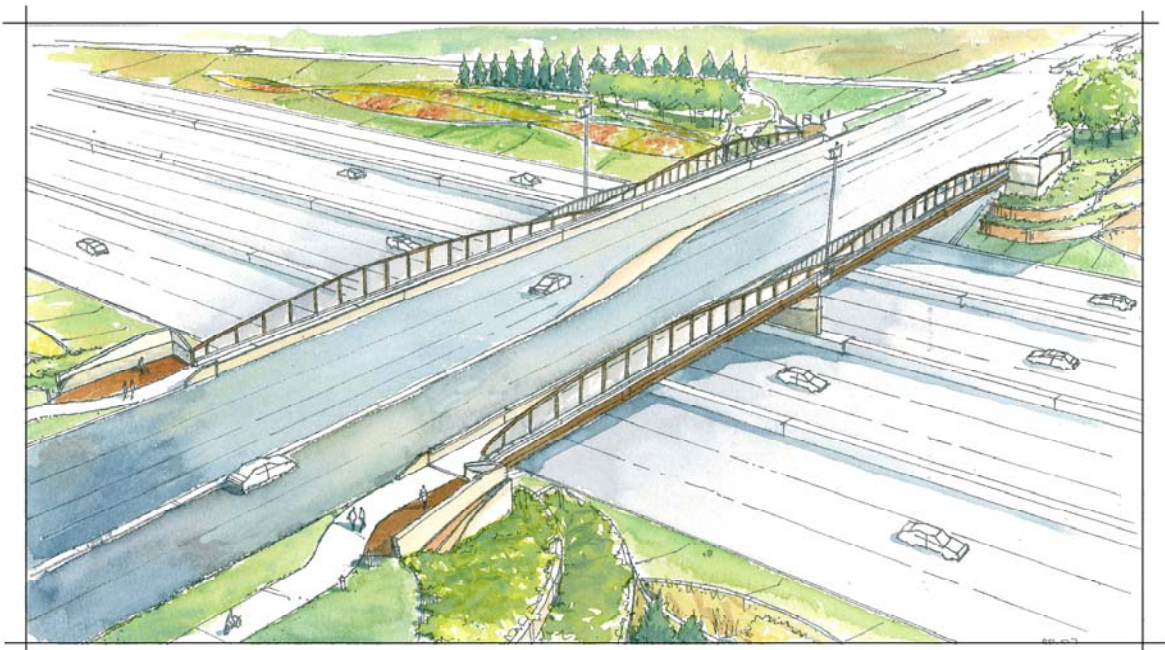


Figure 2 – Aerial Rendering of 24th Street Interchange

The 24th Street Bridge is the only bridge structure in the CBIS corridor that would need to accommodate pedestrian sidewalks, and so it presented the opportunity for unique fencing treatments. The fencing consists of three curved, overlapping fencing elements that span the 354-foot long structure. The fence posts and tubular steel frame have a dark bronze coating over a galvanized steel base and the fencing material varies from dark bronze lattice style fencing in the center section to a galvanized steel closed mesh in the flanking curved end sections.

The curving shapes and natural landforms of the loess hills are also incorporated into the pier details. Since the bridge will be built in two stages, the pier consists of two side-by-side wall piers that use concrete form liners to provide a textured stone base as shown in Figure 3. A four-color stain application will be used to create a dry stack limestone appearance. The caps for the piers display a curvilinear shape with a smooth texture that will be stained in a complementary color scheme.



Figure 3 – Wall Pier Under Construction

The bridge abutments incorporate similar stone texturing as the pier. The same stone form liner and four-color staining are used on the outside faces of the abutment and wings. In front of the abutments, short terraced walls are added to provide a larger scale to the bridge abutments, which helped balance the bridge's long length over the combined interstates. They also add visual interest to the foreslopes of the bridge. Like the abutments and piers, the terrace walls incorporate the simulated stone pattern and staining. To provide the additional massing at the abutments, the bridge wing walls are pushed outward and the tops of the wings are raised above the street level to create a plaza area at each corner of the bridge. The raised wing walls are topped with curved concrete cap elements with smooth texture and are stained to complement the stone texture.

The community expressed an early interest in allowing public art forms to be incorporated into the plaza areas at the abutments. As such, additional steel piles were provided at the corners of the bridge abutments to accommodate both gravity and wind loads for the anticipated large scale art pieces. Since pedestrians will have close visual access to the plaza areas, actual dry stacked limestone facing will be used on the interior surfaces of the raised wing walls in lieu of simulated stone created through form liners and staining (see Figure 4).



Figure 4 – Artist's Rendering of Typical Abutment Plaza

The bridge superstructure uses welded steel plate girders as the structural system. The choice of weathering steel to eliminate concerns over future steel repainting also works well with the aesthetic features, since the natural brown patina complements the overall color scheme (see Figure 5). The undersides of the deck cantilevers, the sidewalk separation barriers and external parapets will be coated with a buff colored concrete sealer in order to blend with the natural and simulated stone treatments used at the pier, abutments and terrace walls.



Figure 5 – Artist's Rendering of 24th Street Bridge as Viewed from I-29/I-80

A combination of both functional and aesthetic lighting will be utilized to accent the bridge so that its aesthetic features are also visible at night. Pole mounted high pressure sodium lights will be centered above the pier on each side of the bridge to provide functional lighting to the 24th Street roadway. Because of the numerous interstate lanes under the bridge and the wide bridge cross section required, high pressure sodium under-deck lighting will be provided over the traffic lanes. To outline the curving shape of the fence at night, Light Emitting Diode (LED) lighting will trace the outline of the upper fence rails (see Figure 6). Finally, accent lights will be provided to illuminate the stone texture on the center pier.

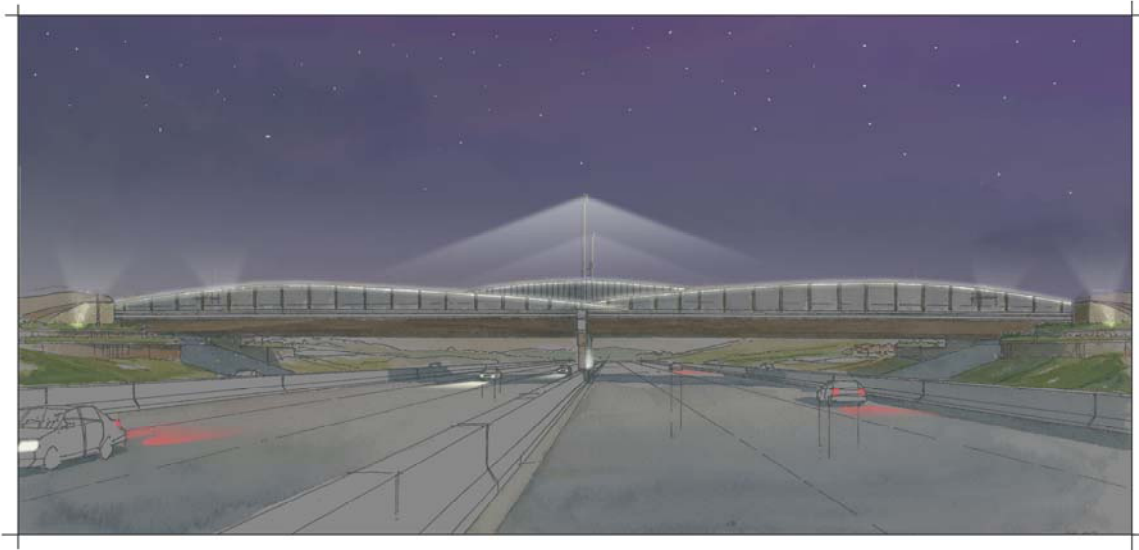


Figure 6 – Artist's Rendering of Nighttime View of Bridge From I-29/I-80

STRUCTURAL DESIGN CONCEPT

Design concept development for the 24th Street Bridge involved many considerations. Several bridge types and construction phasing options were considered to find the best solution to meet design and safety standards, facilitate traffic, comply with the aesthetic theme, and minimize right of way impacts. The existing four-span 216 feet x 64 feet prestressed concrete beam bridge spans five interstate traffic lanes. The proposed bridge needs to accommodate the future interstate expansion to a 12 lane dual-divided roadway section, with the I-29/I-80 centerline shift of approximately 42 feet at the bridge. The project concept required 24th Street and I-29/I-80 to remain open during phased construction of the new bridge.

A key constraint for the 24th Street Bridge was the shifted design location of the I-29/I-80 centerline, as it defined the location of the proposed bridge center pier. The solution for the 24th Street Bridge required that during the first phase of construction, traffic be maintained between existing piers and the proposed center pier (see Figure 7). Construction of any

additional piers to reduce span lengths was not feasible when considering existing, staged, and proposed roadway configurations.



Figure 7 – Two Lanes of I-29/I-80 Each Way Maintained During Construction

The desired solution was a two-span 354 feet x 105 feet welded plate girder bridge. Steel girders made this the most feasible option, as the required span lengths of 178.5 and 175 feet exceed Iowa's prestressed concrete beam standards. Longer spans worked well for the interstate final lane configurations and also allowed the flexibility to stage the I-29/I-80 traffic without reducing the number of traffic lanes during the phased construction of the bridge. The steel girder solution offers the contractor the flexibility of installing shear connectors in the field after the placement of deck panels which provides more tolerance and an opportunity to make any needed field adjustments.

The bridge cross section consists of six lanes (two lanes in each direction plus two turn lanes) along with a raised median, raised sidewalk and raised multi-use trail as shown in Figure 8. While the additional bridge length will accommodate the widening of I-29/I-80, the wider bridge roadway will improve traffic flow on 24th Street.

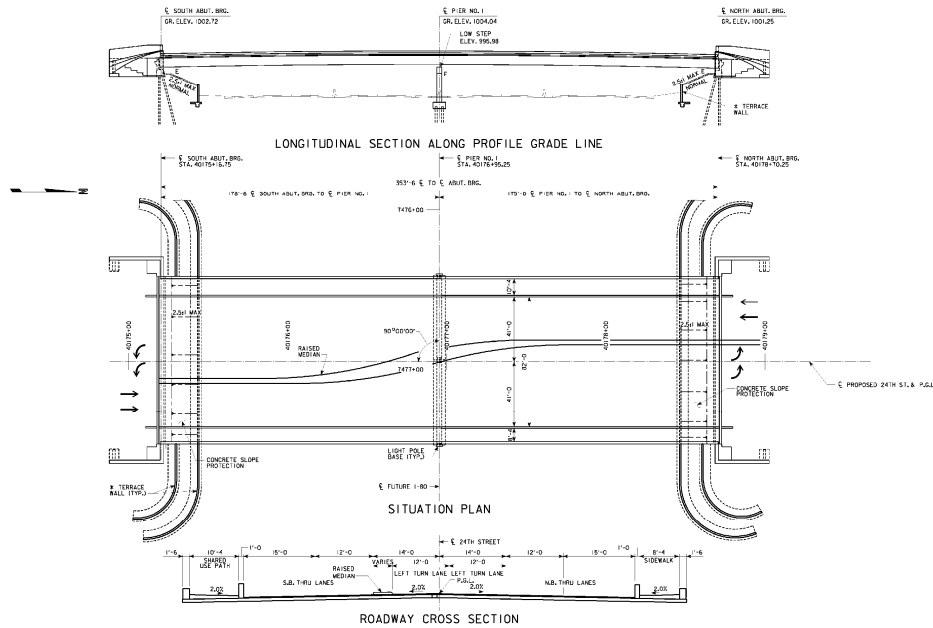


Figure 8 - 24th Street Layout and Roadway Cross Section

As discussed previously, the intent of this project is to stage-construct the new bridge in two phases while maintaining traffic on both 24th Street and I-29/I-80 at all times, with the exception of limited night time closures. Figure 9 shows the staging sequence for this construction project. Both phases of construction will be completed in one construction season with a spring start and fall completion. This aggressive schedule will require the use of innovative design, contracting, and construction techniques.

The two major components for the acceleration of the bridge construction involve: 1) The use of full depth, full width precast deck panels, in lieu of a traditional cast in place concrete bridge deck application and 2) Accelerated contracting techniques A+B bidding with incentives along with a delayed construction start to allow lead time for steel fabrication.

The bridge deck uses full depth precast deck panels with panel widths comprising roughly half of the new bridge width in each of two primary phases. A longitudinal closure pour will be utilized at the juncture between each half of the bridge deck. To improve deck smoothness and provide additional level of protection of the post tensioned deck system, the panels will be topped with a high density concrete overlay.

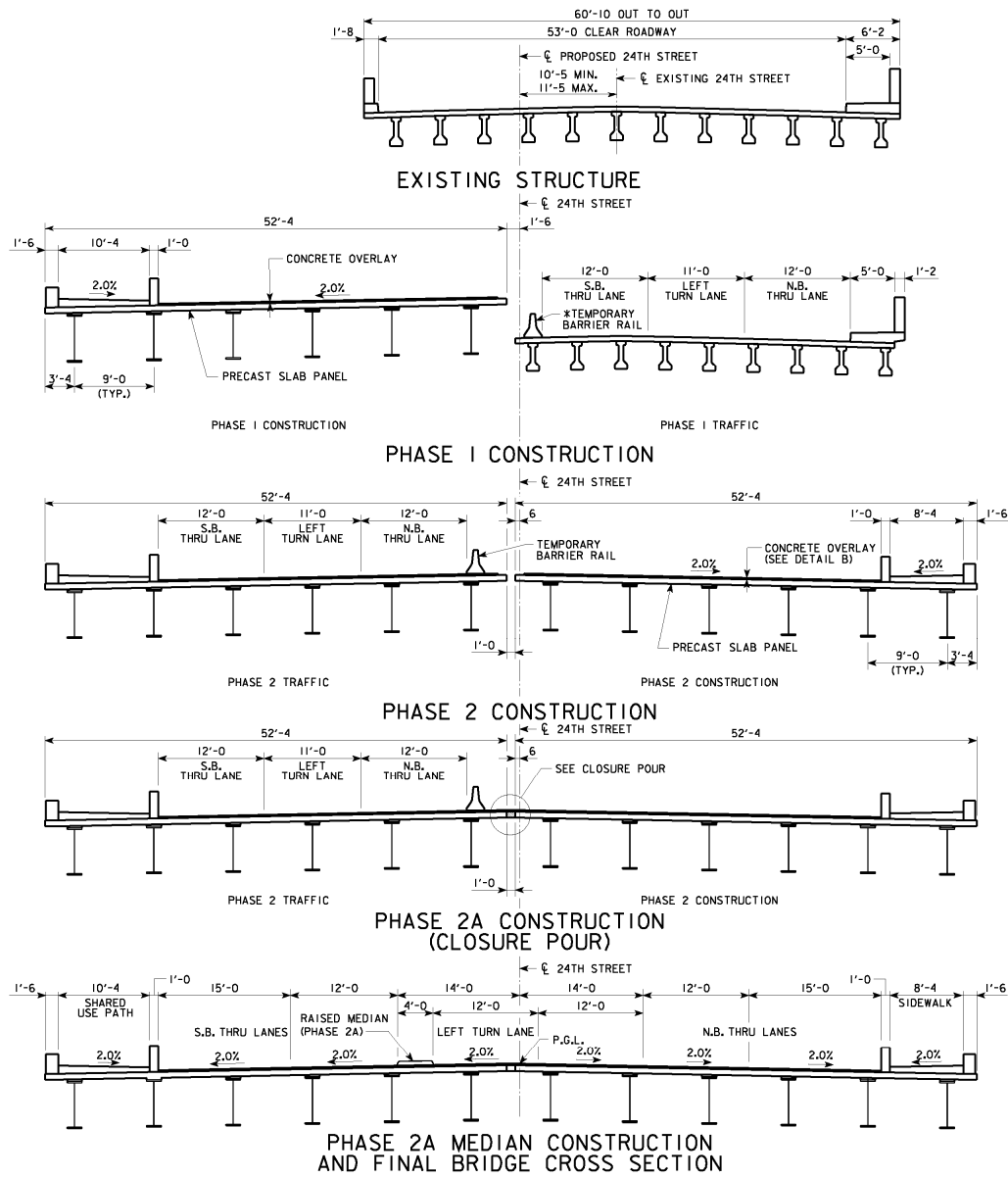


Figure 9 - Bridge Construction Phasing

To ensure that the construction of this bridge will be completed in one construction season, bidders were required to establish the number of calendar days to be used to complete construction on the critical closure activity. The product of the number of calendar days multiplied by a predefined daily user cost plus the contract sum determined the winning bidder (A+B). The maximum allowable number of 210 calendar days was stated on the proposal. Bids showing time in excess of this maximum were subject to rejection. With this contracting method, it was imperative for the contractor to complete construction within the specified days and avoid the cost of additional days. The winning bid by Cramer and

Associates Inc. was the low bid for both bid item cost and calendar days. Cramer bid a total of \$12,506,000 and 175 days for the critical closure activity. Runner up bidders all bid 210 days. Subsequent to the initiation of construction, contract modifications have added work to the critical path that required 4 more days to be added to the critical closure activity. Unit cost of the bridge bid was \$140/ square foot. Comparatively, steel bridges on the I-235 corridor in Des Moines, a similar urban area with Interstate traffic, were averaging \$120/ square foot two years prior.

COLLABORATION

In light of the high level of innovations that were incorporated into this project, it was important for the Iowa DOT/HDR design team to collaborate with partners from the bridge community including contractors, fabricators, Federal Highway Administration (FHWA), academia, and other agencies. Several meetings were held in conjunction with this effort ranging from constructability review meetings with the local industry to a technology transfer meeting involving national experts.

After meeting with local contractors to explore the feasibility of several accelerated construction concepts, a technology transfer meeting was organized and held in Omaha with participation from FHWA, Iowa Associated General Contractors (AGC), fabricators, Iowa State University, University of Nebraska, and the Nebraska Department of Roads (NDOR) along with the project team. The purpose of the meeting was generally to foster a transfer of technology among Iowa DOT, NDOR, and the FHWA in the area of precast concrete bridge components, with this bridge being of particular focus. It was important to take advantage of former experiences for similar types of construction and share ideas regarding the advantages and disadvantages of full depth precast deck panels. The participants identified potential problems that can arise during construction and during the service life of the structure and discussed preferences for details, economic considerations, size limitations of panels for fabrication, shipment and erection and the effect of these issues relative to accelerated construction.

Several different options for deck panel size, details of transverse joints, leveling of panels, incorporation of shear studs and post-tensioning strand arrangements were discussed in subsequent joint meetings among Iowa DOT, contractors, fabricators, post-tensioning suppliers, and HDR.

GIRDERS

The superstructure is made of precast/prestressed concrete deck panels supported on steel girders. Steel girders were chosen for the main load carrying system due to two main factors, the span lengths and the vertical clearance. The span lengths were above the Iowa DOT limit for the use of standard prestressed concrete bulb tee beams, and the constraints on vertical profiles required a shallower than optimum girder depth. The use of steel girders enabled greater flexibility to achieve the most feasible bridge design while maintaining the goal of accelerating construction.

The steel girders were designed to act compositely with the deck. This required that the deck be connected to the girders through the use of shear connectors. Composite action was achieved by the use of shear studs grouped together to maximize the economy of deck panel fabrication and were evenly spaced at 2 feet along the length of each girder. In addition, the plans allowed the contractor to install the shear studs in the field, rather than have the studs installed in the shop as is traditionally done with cast in place deck application. This shear stud installation method, will allow the contractor greater tolerance for the erection of the deck panels and erect the deck panels in an expeditious manner. This is because the deck panels are not required to be set over already installed shear studs, and the contractor would be able to move the panels in all directions to maintain geometry control without being restricted by the location of shop installed studs. Also, the installation of the shear studs in the field would not fall within the critical path for completion of this project.

The deck slab is supported by 12 lines of steel girders that are spaced at 9 feet on center with a maximum girder length between field splices of 121.75 feet. Because of the restriction to the girder depth, the design required the use of higher strength material than the traditional design. The designer determined the use of higher strength material for the bottom flange and the top flange between the two field splices of the pier section to be the most economical.

HPS 70W steel was used in these areas to take advantage of higher strength coupled with improved toughness and durability. All other steel including the web were specified to be A709, Grade 50 steel.

DECK SYSTEM

After weighing all the factors, it was determined that each deck panel would be 10 feet long x 52 feet 4 inches wide x 8 inches thick. Each panel will be pretensioned in the transverse direction with (10) ½ inch diameter, 270 ksi low relaxation strands at the top and (10) -1/2 inch diameter, low relaxation strands at the bottom of the panels. There will also be a total of 28 – flat ducts embedded in each panel to house the longitudinal post-tensioning. Four 0.6 inch diameter, low relaxation, 270 ksi strands will be installed in each of the embedded ducts. Pockets will be formed in the panels to accommodate headed shear studs to tie the deck to the girders to provide fully composite action with the deck in the positive moment regions. To provide economy of fabrication, phase 1 panels are geometrically similar to phase 2 panels. Each phase of the project will utilize 35 precast deck panels for a total of 70 panels. The deck panels were designed in accordance with the latest edition of the LRFD specifications. A plan view of a typical phase 1 panel is shown in Figure 10.

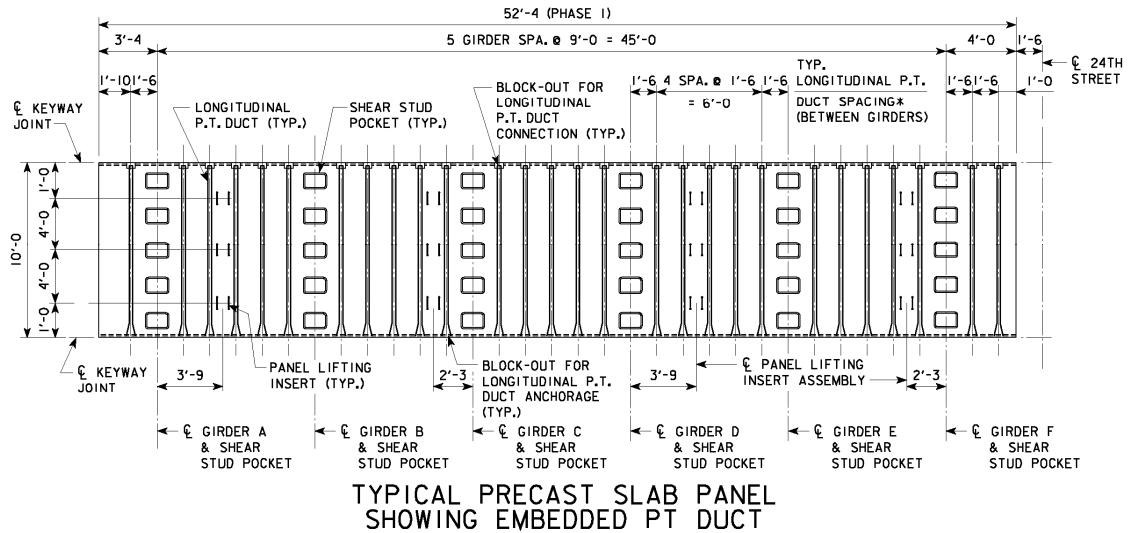


Figure 10 - Typical Precast Slab Panel, Showing Embedded PT Duct

The deck panels will be installed after the steel framing (girders and cross frames) have been erected and the slab buildup below the deck panels has been formed. Slab build-up forming methods and leveling the panels to the correct elevation are left up to the contractor. However, the plans include optional leveling bolts embedded in the deck panels that were used by the contractor to aid in setting the panels to the correct elevations (see Figure 11). After all the deck panels for a phase are erected, the transverse joints will be filled with high strength, non-shrink grout.

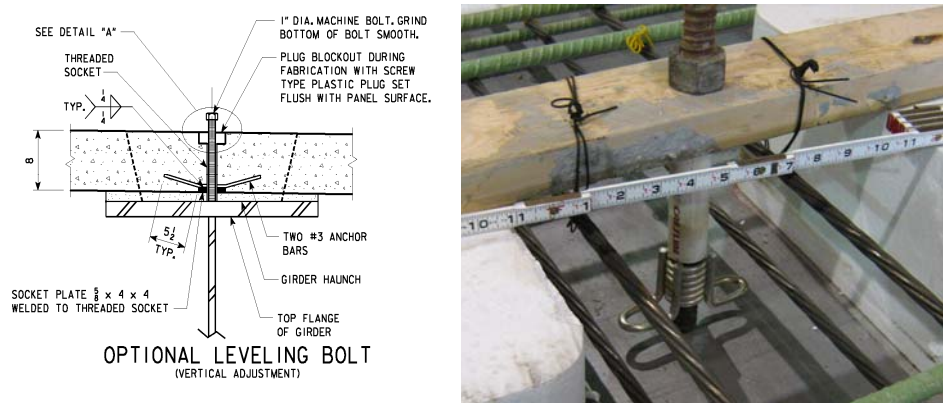


Figure 11 - Leveling Bolt Details

This project utilized a female to female transverse joint between panels eliminating the need for match casting and reducing the risk for damaging panel edges during erection and post tensioning. The decision to use this type of joint was largely based on Iowa DOT experience with other projects that showed that this type of joint tended to perform better than other

types of joints, especially where longitudinal post-tensioning has been utilized. The transverse joint configuration in the panels is a very important aspect to the design and successful service life of the structure. A poor detail of the transverse joint could result in leakage of the joint material and spalling adjacent to the joint. The transverse joint detail along with the blockout for splicing the post-tensioning ducts are shown in Figure 12.

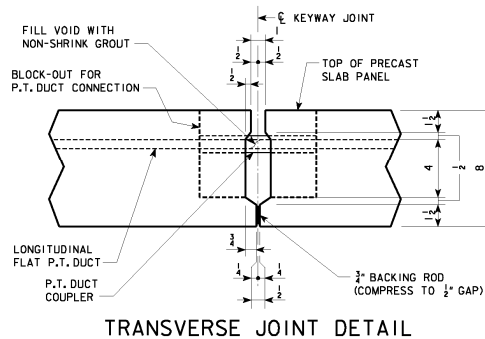


Figure 12 - Transverse Joint Detail

After the grout in the transverse joints attains required strength, the longitudinal post tensioning force will be applied and locked off. Several factors influenced the amount of post-tensioning force that panels were designed to accommodate. LRFD specifications do not allow any tension in areas where auxiliary reinforcement is not provided. Tension in the panels was caused by the composite dead load, live load and impact in the negative moment zone near the pier. This criterion controlled the post-tensioning design at the transverse joints between the panels. In addition, the depth of the panel can only accommodate anchorages for four standard strand tendons.

In order to determine the effects of long term losses, mainly creep and shrinkage, a computer model was created to estimate the losses at the end of the service life for the structure. This computer model was checked with hand calculation utilizing loss formulae in accordance with the latest LRFD specifications. Analysis showed that the age of the panels along with the strength of the panels at the time of post-tensioning have a significant effect on the amount of losses due to long term creep and shrinkage. In this case, and in order to maintain zero tension at the transverse joints, no more than 23% maximum loss of the post-tensioning force can be accommodated when considering all the factors mentioned previously. For example, a 6,000 psi strength panel would be required to be 100 days old before the post-tensioning force can be transferred to the concrete while a 12,000 psi panel would need to be 28 days old before post-tensioning (see chart in Figure 13). With an October 2007 letting date, and an expected June 2008 erection of the panels, this would require an accelerated winter fabrication schedule and storage of the panels. This could have resulted in an economic disadvantage to the project. To avoid this situation and in order to provide as much flexibility as possible during the construction stage, the contractor was given the option to design a concrete mix that would yield the required design strength while accommodating the

contractor's accelerated schedule and minimizing the fabrication costs. The chart below shows the relationship between the strength of the panel, the age at the time of release of post-tensioning strands and the percentage of long term creep and shrinkage losses.

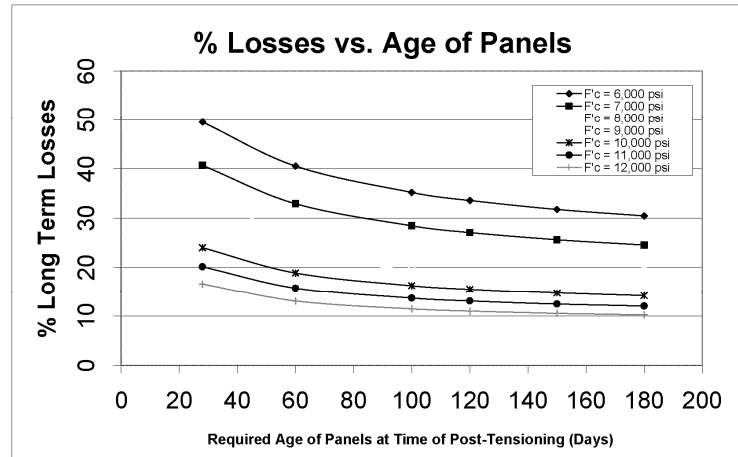


Figure 13 – Chart Showing Percent Losses vs. Age of Precast Slab Panels

After the release of the longitudinal post-tensioning force, the shear stud pockets as well as the gap between the top girder flange and the bottom of the deck (haunch) will be filled with concrete. The method for forming the haunch was left up to the contractor. Furthermore, the contractor was given the option to install all or a portion of the shear studs in the field. Field installation of the shear studs, if chosen, could commence after confidence is gained that the panels are set to their correct horizontal alignment. The field installation of the shear studs does not fall within the critical path for completion.

The design of the shear studs was carried out as would normally be done for a cast-in-place application. The spacing between the pockets was controlled by fatigue requirements, and the spacing of the pockets was kept at two feet. Research completed on grouping of studs would support larger spacing based on ultimate strength, but not based on the fatigue requirements. There will be two rows of three 7/8 inch studs in each pocket in the positive moment regions and one row of three 7/8 inch diameter studs in the negative moment regions. The shear stud pockets are the same size in the positive as the negative moment region to simplify the fabrication of the deck panels. The length of the shear studs in the negative moment zone was kept at 5 inches. However, due to concern with the possibility of creating a weak plane at the top of the headed studs in the positive moment regions, it was decided to vary the length of the shear studs in this zone. Therefore, three of the studs will be 6 inches tall while the other three were specified to be 7 inches in height. These different length studs were placed in an alternating pattern.

Concurrent with the concreting of the haunch and the shear studs, the sidewalk and barriers could be constructed. To connect the barrier and the sidewalk to the deck panels, threaded

inserts were included in the panels and capped so that no reinforcing steel extends out of the panels, thus simplifying panel finishing, storing, and shipping.

After the shear stud pockets and the haunch concreting have been completed, the driving surface of the deck will be topped with a 2-in. thick low slump, high density concrete overlay. The same process is then repeated for the second phase of construction.

To tie the two phases of construction together, a longitudinal closure pour near the centerline of the bridge will be cast in place. The longitudinal closure pour is located in the middle of the center girder bay and is designed as a moment connection carrying the full positive moment. The location of the closure pour was dictated by the number of temporary lanes and the location of the girder lines. Another advantage of locating the longitudinal joint in the area of positive moment between the girders is that the top of the joint is always under compression reducing the possibility of stress cracks and joint leakage. See Figure 14 for the detail of the longitudinal joint.

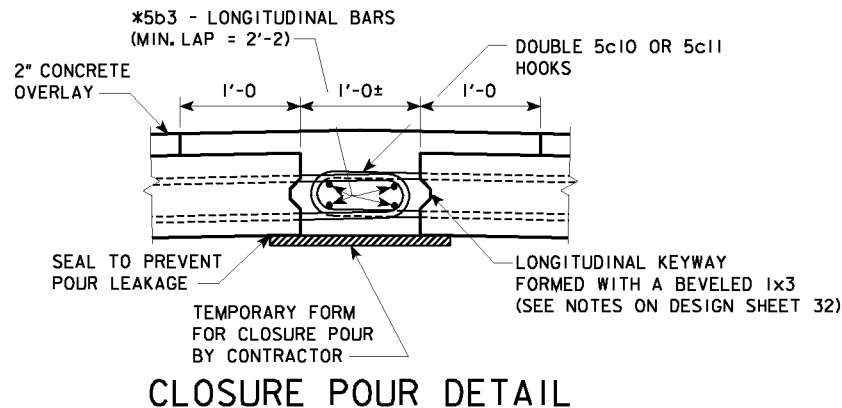


Figure 14 – Longitudinal Joint Closure Pour Detail

The final step of the bridge construction will be to construct the median with a similar construction method to the barriers and sidewalks.

DECK SYSTEM FABRICATION

Cramer and Associates selected Coreslab Structures, Inc. (Omaha) to fabricate the deck panels. Coreslab proposed using Self Consolidating Concrete (SCC) to cast the panels shown in Figure 15. Three panels were cast in the bed simultaneously. While initial castings took time to turn over the casting bed, increased experience allowed Coreslab to turn over the bed and cast panels every other day. The panels were initially cured within an enclosed heated casting bed that was covered with wet burlap and insulation. Upon reaching release strength the panels were removed from the forms and transferred to a steam cure enclosure for 7 days. The casting of all 70 panels took just under two months.



Figure 15 – Deck Panels Cast with SCC

LABORATORY TESTING

The laboratory test program conducted as part of this project consisted of evaluating three aspects of the bridge design prior to finalizing the overall design. The design details that were tested are of great importance both to constructability and to overall performance.

The initial design calls for shear studs to be welded to the top flange of the superstructure girders to provide composite action between the precast panels and the girders. These shear studs are to be placed in groups of six and those groupings would fall within a preformed deck panel “pocket” as mentioned earlier. Due to concerns related to the size of the confined space for the installation and testing of the studs and to gain confidence that this detail is constructible, a mock-up was created and tested (see Figure 16). The mock-up consisted of simulating a pocket of the same dimension as that originally specified. The research team installed shear studs (both 6 inches and 7 inches long) on a steel member placed below the pocket. The testing concluded that the shear studs could be installed with no interference issues. Additionally, it was determined that with a specially shaped wrench all shear studs could be tested for specification compliance.



Figure 16 - Haunch and Stud Pocket Mock-up

The shear stud pockets mentioned above are intended to be filled with concrete. There was a concern about the ability of the specified concrete mix to completely fill the area between the precast panels and the steel beam top flange (especially where the top flange is 32 inches wide). Thus, a mock-up of this set-up was created and material placement simulated. It was found that the specified mix design had no problems completely filling the haunches and shear stud pockets with only minor pockets of air remaining that can be attributed to the sealed form for the test mock-up. Production concreting will start at the lowest point proceeding up-hill with plenty of shear stud pockets to relieve the air. In addition, the contractor has proposed to use SCC for the haunches and stud pockets. The tested mix was a concrete mix with a low top aggregate size and a High Range Water Reducer (HRWR) used that created up to an allowable 10 in. slump. The contractor's proposal to use SCC has been accepted. Figure 17 shows the concrete after removal of the formwork that simulated the precast panels.

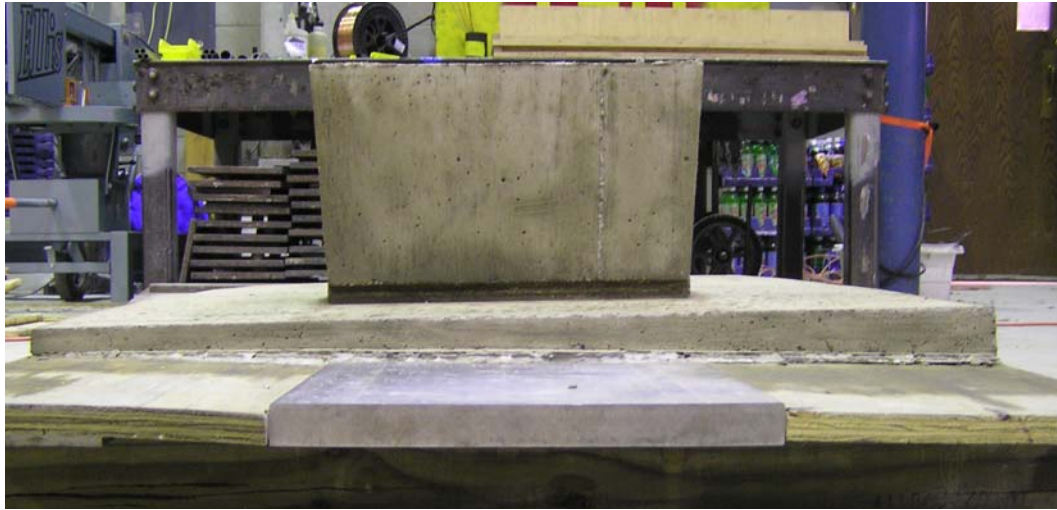


Figure 17 - Concrete Consolidation in Haunch and Shear Stud Pocket

Previous usage of similar precast panels specified that transverse joints be roughened by sandblasting. It has been proposed that the use of diamond plate formwork in the joint might provide sufficient texture in this joint. Thus, push-out tests (see Figure 18) were performed to evaluate the influence of surface treatment on shear transfer. In addition to the diamond plate texture several other conditions were evaluated including: sandblasting, chemical etching, and no treatment. It was found, with only minor variability, that the sandblasting condition provided the greatest amount of shear resistance.



Figure 18 - Push-out Specimen During Testing

The current design requires that post tensioning ducts in adjacent precast panels be joined together using duct materials and some type of a “shrink wrap”. The purpose of the shrink wrap materials is to seal the ducts from infiltration of grout when the transverse joints are being filled. To test the integrity of this joint plus shrink-wrap configuration, a mock-up of the system was made and the performance verified. This testing revealed that the shrink wrap is not water tight but is fully adequate at preventing infiltration of grout. Figure 19 shows the interior of a duct following extraction – note the lack of grout inside the duct.



Figure 19 - Interior of a PT Duct Following Extraction

FIELD TESTING AND MONITORING

The field test program is designed to focus on: 1) the structural performance evaluation of several critical components during construction of the bridge for correlation with expected design performance, 2) handling performance of precast deck units during delivery to the bridge site, 3) overall structural performance of the bridge after construction for comparison with expected design performance and 4) subsequent long term evaluation of some of these components after the bridge is constructed and in service.

HANDLING OF PRECAST UNITS DURING DELIVERY

To better understand the impact that handling and placement has on the deck panels, two panels will be instrumented with strain gages and monitored during placement at the bridge construction site. Specifically, monitoring will be conducted from the time the panels are picked off the truck to the time of placement on the bridge. The instrumentation of these panels will be such as to allow for the assessment of the bi-axial positive and negative bending moments in the panel.

OVERALL STRUCTURAL PERFORMANCE AFTER CONSTRUCTION

To monitor for post-construction expansion and contraction across the transverse deck joints, a series of load cells will be installed along a joint and will be monitored during normal in-service operation of the bridge. The intent of this monitoring will be to provide an indirect and relative measure of the load across the joint over time.

Dependent upon accessibility and traffic limitations, a diagnostic live load test will be conducted on the completed bridge, with the objective of comparing structural performance with expected design performance. During this load test, strain sensors will be installed on the critical superstructure members and monitored as either ambient or controlled vehicle loads cross the bridge.

LONG TERM EVALUATION

To determine the long term structural performance of prestressing and post-tensioning deck reinforcing, a corrosion monitoring system will be installed on six transverse prestressing deck strands and six transverse post-tensioning strands. A relatively simple device for monitoring reinforcing steel for the initiation and subsequent rate of corrosion has been successfully implemented on other projects. Monitoring on the transverse strands will be conducted on the “exterior quarter” of the bridge. Due to construction limitations, the longitudinal corrosion sensors will only be able to be safely installed over the end 20 feet of strand. Care will be taken, and formal communication made, with the construction contractor to allow survivability of the instrumentation.

CONCLUSION

The goals of this project were to utilize accelerated construction techniques and innovative construction methods while maintaining traffic access, reducing future maintenance and improving safety during and after construction. As an initial project within the context of the Council Bluffs Interstate System, the desire was to accomplish these goals for the 24th Street Bridge within the context of a corridor-wide aesthetics master plan. The use of an aesthetic subcommittee, which represented stakeholders in the community, was an effective means to provide the community an opportunity to identify and communicate guiding themes for the corridor improvements and provide direct input into the both the corridor-wide master plan and specific features incorporated into the 24th Street Bridge. Feedback from the subcommittee indicated that the guiding themes of timeless design, locale-specific details, incorporation of the natural environment and a cohesive appearance were achieved with the aesthetic features for the 24th Street Bridge.

By combining the latest research for full depth deck panels with details from past projects, integrating the use of high performance steel and concrete, utilizing flooded backfill methods and using A + B bidding methods, the project was successful in incorporating innovative construction methods and accelerated construction

Coordination among the designer, the owner, local contractors and fabricators was key to developing an economical design that could be constructed under an accelerated time frame. Some of the primary goals of this project are to minimize disruption to the traveling public during the reconstruction of the 24th Street interchange and enhance safety during and after construction.

The performance of the innovative components will be closely monitored and evaluated during and after construction because the success of these innovations along with lessons learned will be the basis for implementation on future projects.