Case Study:
MARTA Lindbergh Center Station Concourses and Roadway Expansion Over an Active Rapid-Rail Line

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ABSTRACT

Lindbergh Center Station is an existing rapid-rail transit station on the MARTA system with platform below grade and concourses at street level. This project included modifications and expansion of the station to accommodate a mixed-use commercial development over and around the station. Added station features included Main Street Bridge, a North Plaza, additional concourses, and an additional platform, all of which are located over or adjacent to the active rail line.

Major design considerations for new structures included durability and minimization of maintenance, structure depth to satisfy train clearance, aesthetics, and whether concourse and street bridges should be clear spans or have two span configurations with new bents on the center platform. Use of center bents reduced crane size and increased the work window available to the contractor from 2 hours to 7 hours per night by utilizing single tracking.

Precast concrete was chosen because it could be erected quickly and efficiently during single tracking windows and offered the advantage of immediate protection of the rails and platforms from the construction above. Box girders were chosen because they offered the lowest profile needed to address headroom restrictions and provided an architecturally acceptable smooth soffit. The resulting facilities were safely constructed during rail operation, are cost effective, require little maintenance and are aesthetically consistent with the original station design.

Keywords: Precast, Box Girders, Low Maintenance, Durability, Erection Efficiency

PROJECT DESCRIPTION: TRANSIT ORIENTED DEVELOPMENT

Transit Oriented Development (TOD) is a concept that embraces development that benefits from its proximity to a transit facility. The goal is to concentrate development around existing transit facilities benefiting the development through improved access through public transportation and benefiting the transit authority by generating significant additional transit ridership. Through TOD, the Metropolitan Atlanta Rapid Transit Authority (MARTA) is participating in development of live-work-play environments for Atlanta-area residents and visitors, addressing regional air quality problems and improving quality of life.

MARTA's flagship TOD is the 47-acre, 4.8 million square foot, mixed-use project known as Lindbergh City Center. The Lindbergh City Center Master Plan includes a "Main Street" concept with retail shops along the central axis of the new development perpendicular to and crossing the station. When completed, the development will include 1.23 million square feet of office space, 421 residential units, a 190 room hotel complex, 330,000 square feet of retail space and 5600 parking spaces in five parking decks.

MARTA operates and maintains approximately 700 buses of which 60% are CNG fueled, 338 railcars of which 100 are currently being brought into service, 47.3 route miles of track and 38 rail stations. The MARTA system boards an average of 550,000 passengers daily. The location of this station on the MARTA system is ideal for the TOD development. Lindbergh Center Station, is MARTA's busiest station on the North Line. It is located just south of the split between the North and Northeast Lines where many patrons transfer between trains. See Figure 1. This new development will contribute to a 75 percent increase in ridership at Lindbergh Center Station over the next 20 years.

Precast, prestressed concrete members were used to implement the design for transit station modifications resulting from this development. This paper discusses the design considerations, option evaluations, problems encountered, engineering solutions developed, and the reasons why precast, prestressed conrete members proved to be the best design solution for this project.

Figure 1: MARTA Rail System Map

DESCRIPTION OF EXISTING STATION

Lindbergh Center Station was originally built in 1980. It included a below-grade, cast-in place (CIP) track slab and retaining wall (U-wall) structure on which the north-bound and south-bound trackway and 600-foot long center platform were constructed. The station included north and south grade level concourses connected to the platform by elevators and stairs. The concourses were supported by the U-wall structure and clear spanned the trackways and platform using a two-foot thick CIP, reinforced concrete slab. The concourses were protected by large, open, structural steel framed canopies supported by two-foot diameter steel pipe columns. The platform between the two concourses was protected by a low, steel-framed roof between the concourses, which was also supported by two foot diameter columns. About 200 feet of platform south of the south concourse was open to the weather. Along the west side the station included a full length free intermodal busway, and an ancillary building that houses train control and traction-power equipment. The east side included a 1200-stall surface parking lot.

Figure 2: Station's 1980 Construction

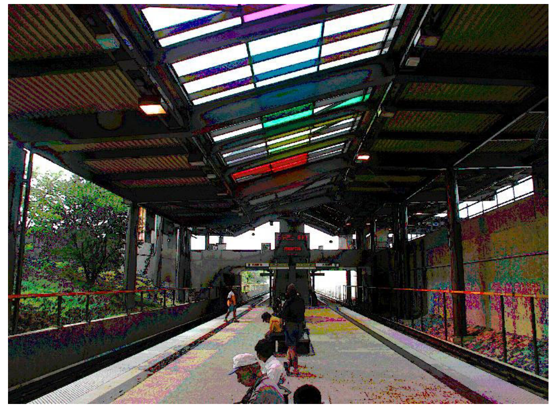

Figure 3: Platform before Renovation

RENOVATED STATION DESCRIPTION

The initial renovation concept for Lindbergh Center Station included a bridge at the concourse level (grade level) for Main Street and reconfiguration of the intermodal busway. Studies on future patronage led MARTA to add a second platform and additional concourse space for the projected increase in patronage. The station entrances were reconfigured for better service to patrons based upon the developers plans. To minimize the cost of construction MARTA decided to construct these facility improvements during TOD construction, since doing so in the future would have caused a major disruption to operations. The final scope of the station modification project included Main Street Bridge, a 600-foot east platform, two new concourses with connecting bridges to existing concourses and escalators from each concourse to the center platform and access to the new east platform.

Demolition of the existing low-platform roof system was required to accommodate the new concourses. The north and south concourse roofs needed to be extended over the new concourse areas. An elevator, stairs between the concourse and platform, and ancillary support rooms were added as part of the new east platform. Due to rerouted and increasing patron circulation, the existing north fare gates were relocated to the new North Plaza north of the existing North Concourse. The North Plaza area was originally open to the track below, and had to be in-filled to create the new plaza area. The existing free intermodal bus facility west of the station was split and relocated to accommodate the needs of the developer. See Figure 4.

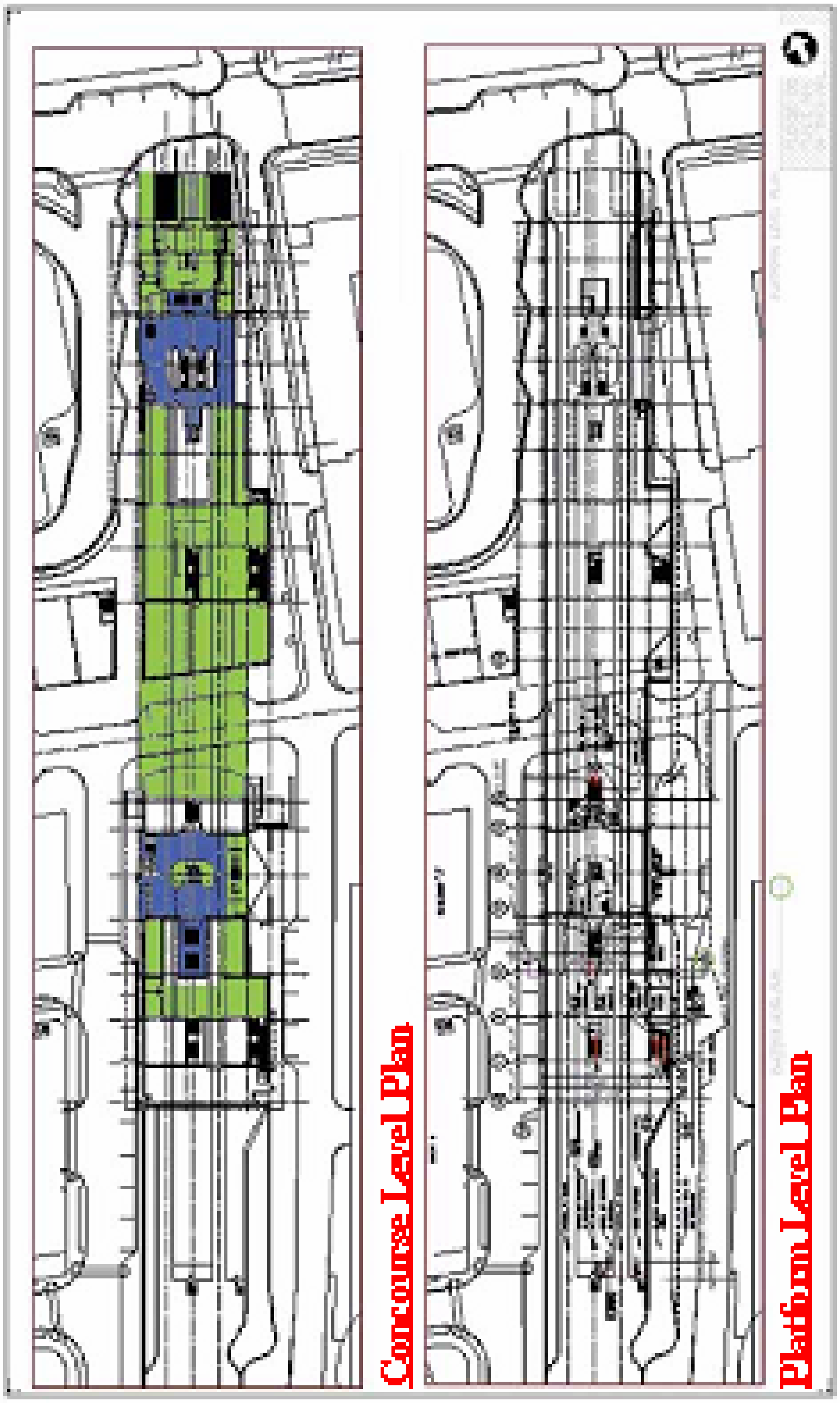

Figure 4: Lindbergh Center Station Concourse and Platform Plans

The Lindbergh Center Station expansion provided notable challenges. MARTA requires 600-foot platforms to accommodate trains with eight, 75-foot cars. Addition of the new platform east of the north bound tracks created a conflict with 11 feet of the north concourse east abutment and the entire south concourse's east abutment. The side platform conflict was resolved by shifting the new platform 11 feet to the south, and extending the center platform eleven feet further south.

The south concourse conflict could not be avoided requiring an innovative solution. Two small cross section tube columns and beams were addedat the center of the existing platform to provide additional support for the existing concourse, then extending the existing concourse slab was extended to a new east abutment and the existing east abutment was removed. The concourse slab extension used rebar couplers to the existing slab reinforcement for continuity.

CONSTRUCTION SYSTEMS UTILIZED

A number of factors were considered in choosing structural systems for this project, including economics, safety, construction sequencing, availability of track time, compatibility with existing construction, durability, and aesthetics. Precast, prestressed concrete was selected for the primary structural elements, including the concourse expansions, Main Street Bridge, and for the new East Platform slabs. Precast members were the right choice for this project because they satisfied stringent clearance requirements over MARTA rail, were competitively priced, were easily installed, provided immediate protection for the platform and trackway below, resulted in a structure that blended in with the existing reinforced CIP concrete concourse slabs, and will require little maintenance in the future. The maintenance issue is very important for transit agencies since operating and maintenance dollars are scarce, and any maintenance for these bridge structures has to be performed during non-revenue or single tracking hours. Structural steel was used for the roof construction to match the existing roof sections that were to remain. In isolated areas, steel beams were used because limited overhead access prevented placement of heavier concrete members by crane.

The structural system for the bridges consisted of standard precast box girders with a CIP concrete topping. Bridge girders were 36-inch and 42-inch deep by 36-inch wide and were placed in a two span configuration of 33 feet 6 inches and 35 feet 6 inches. All box girders were supported on two 1-1/2" x 4" x 0'-6" neoprene bearing pads at each end. Girders were supported on the existing U-wall or CIP L-beam at the east end, on a CIP T-beam at center platform, and on the U-wall cut down to the proper bearing elevation at the west end. The new CIP beams were supported on 32" diameter CIP columns dowelled into the existing station track slab.

The east platform structural system utilized precast hollow-core concrete planks. They were supported on the track side by the existing retaining wall cut down to the proper elevation, and on the back side by a ledge on the new CIP retaining wall. The new retaining wall was built on a track-slab extension bearing on rock. The precast planks were tied together with a structural CIP topping and finished with an exposed aggregate architectural topping slab.

CONTRACTUAL ARRANGEMENT

The contractual arrangement to make this project successful was unique. MARTA, as the property owner and ultimate owner of the infrastructure improvements, entered into a development contract with a developer to produce and implement the master plan, hire the construction contractor and obtain tenants for the lease spaces. Because the original project did not include such substantial improvements to the station, addition of the station work resulted in a very large change order to the contract. It also added work to the project that was significantly different from the expertise of the general contractor, whos experience was in office and retail construction. The general contractor had very little knowledge of how to perform this type of specialized work around an operating trackway. For this reason, the general contractor hired another general contractor with rail station construction experience and this contractor became know as the "Super Sub." This arrangement proved to be very beneficial in that it eliminated the learning curve for the general contractor, and allowed the design to proceed on a design-build basis with a very experienced design and construction team.

CONSTRUCTION SEQUENCING

Maintaining station operations 22 hours a day, 7 days a week throughout the construction schedule was the driving factor in developing the sequence of construction for this project. Detailed planning and preparation was required to keep the project on schedule. Track availability for construction tasks that had potential impact on both tracks of the station was limited to 2:00 am until 4:00 am nightly. This was the only time period during which the contractor could work over the unprotected trackway or to perform work impacting both tracks simultaneously. Single tracking from 9:00 pm to 2:00 am each night allowed the contractor to perform tasks that impacted only one of the two station trackways.

The construction was completed in two phases. Phase 1 predominately dealt with the North half of the station, Phase 2 with the south half of the station. East platform construction was continuous throughout both phases, and the fact that MARTA required six car trains be accommodate during special events during both phases, complicated construction. Had the train size been limited to four 75-foot cars, patron access could have been limited to the half of the station that was not under construction. Six-car trains required protective barriers over 150 feet of platform in the active construction area. In addition, protective barriers were required over the trackway throughout the construction zone in order to allow construction activities to progress during train operating hours.

With these restrictions, the construction sequencing for Phase 1 and Phase 2 followed the steps below. Construction for the east platform foundations, retaining walls and beams to receive the bridges were done during normal working hours:

- **Step 1:** Install temporary vertical protective barrier during non-revenue service on the east side of the trackway wall, allowing construction to proceed during normal working hours.
- **Step 2:** Install scaffolding and horizontal protection during non-revenue hours to protect patrons and trains from light overhead construction.
- **Step 3:** Remove roofing and roof deck and secondary roof framing during normal working hours.
- **Step 4:** Remove primary roof frame one bay at a time during non-revenue service. Frames were disassembled and hauled away during normal working hours.
- **Step 5:** Build center columns and inverted T beams.
- **Step 6:** Remove scaffolding and temporary horizontal protection in the bridge area.
- **Step 7:** Erect precast girders over trackway during non-revenue service and single tracking hours.
- **Step 8:** Install structural topping on precast box girders, including electrical systems for platform lights and communications below girders.
- **Step 9:** Install new roof over concourse extension.
- **Step10:** Install architectural treatment for bridge decks and center platform.
- **Step 11:** Open station half

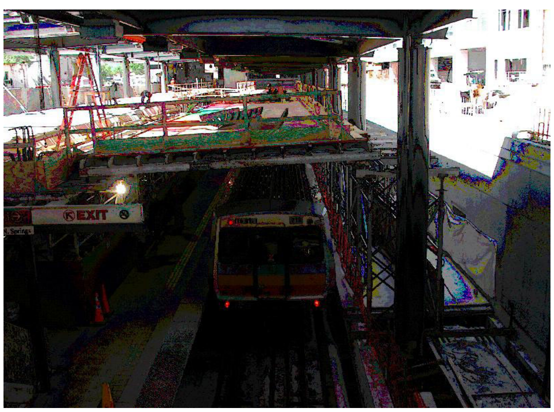

Figure 5: Protective Barrier Over Train

Figure 6: Precast Bridge over Trackway

CASE FOR PRECAST

Although many building systems were utilized for this project, the precast bridge solution was one of the most important design elements for the following reasons:

Simplicity of analysis: The design was very straight forward with two simple spans for dead load, and continuity over the center support for live load. Design simplicity was important due to a compressed design and construction schedule. Lindbergh Center Station had to be reopened by July 4, 2003 in order to meet the demands that special events place on the MARTA system. The design made it very easy to manage the sequence of construction, including construction live loads, and to achieve the project schedule.

Clearance: The precast, prestressed box girder profile chosen for these spans proved to be very stiff with a shallow profile. This was critical in maintaining at-grade elevations, as well as trackway clearances for rail cars and maintenance vehicles below. With girder depth limited to 36-inch under the Main Street bridge roadway, and with the requirement to support future retail space construction on the bridge, precast girders fit the need.

Safety: Although the platform and trackway had to be cleared for the short period of time required for box girder erection, the erected box girders provided immediate protection of the trains and patrons from continuing overhead construction, and allowed the contractor to proceed with overhead work without further concern for patron or rail car safety.

Minimal Disruption: By using precast box girders tight against one-another, there was no need to set deck forms between girders as would have been the case for steel. Saving this step minimized disruption to station operations.

Durability and Low Maintenance: This is a long-term benefit for MARTA. Anything in the trackway must be low maintenance. The finish of the precast soffits provided the desired low maintenance and durability, eliminating high maintenance activities such as painting that are very difficult to perform over the trackway. The selection of precast provided the desired durability.

Aesthetics: MARTA makes every effort to provide aesthetically pleasing and low maintenance finishes. For this reason, concrete is often the material of choice. The soffit finish specified was smooth and uniform. MARTA was able to work with the precaster to obtain the desired finish, complementing the architectural concrete finishes of the existing station and blending these significant additions to the station with the original architecture.

UNIQUE DETAILING

Bearing Detail: Each box girder was supported by two 60 durometer 1-½” x 4” x 0’-6” neoprene bearing pads that were laminated with two outer stainless steel load plates and three interior mild steel plates. The large number of laminations allow for greater bearing capacity with minimal pad deformation. To insure uniform bearing on the pad, an erection detail was employed where the pads were strapped to the girders before lowering the girders onto a 2” tube section. This resulted in a 1/2-inch gap below the bearing pad, that were filled with epoxy when track time was available. After the epoxy cured the steel tubes were cut out, leaving the box girders resting on bearing pads with uniform bearing on the supporting members. See Figures 7 and 8.

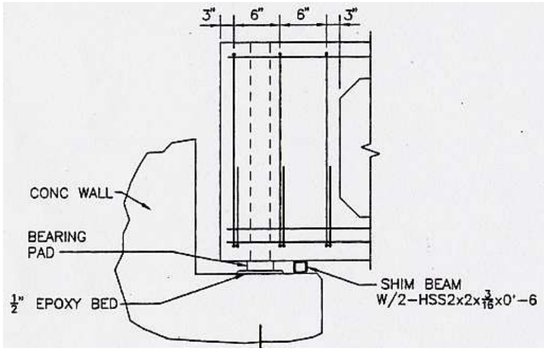

Figure 7: Box Girder Bearing Detail

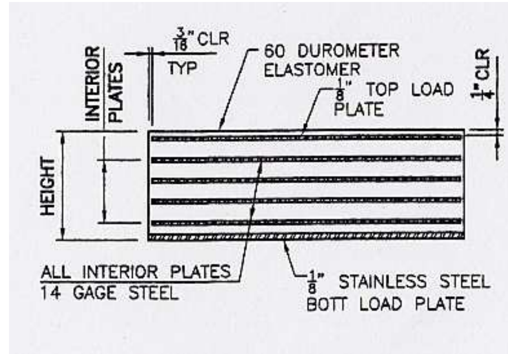

Figure 8: Bearing Pad Detail

Shear Keys: Holding construction tolerances for shear key placement is often difficult. The detail used on this project allowed for the necessary tolerance and was recommended by the contractor. The box girder was fabricated with a 2 1/2" diameter in the end diaphragm. Once the girder was installed, a 2 1/8" x 1'-0" hole was cored into the top of the wall through the sleeve in the box girder. Then a 2" diameter pipe section was lowered through the girder sleeve into the hole in the wall. The annular space between the cored hole and the pipe key was filled with epoxy, resulting in a fully functional and accurately placed shear key. See Figures 9 and 10.

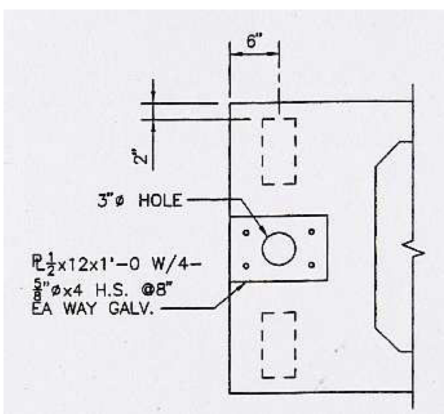

Figure 9: Shear Key Detail

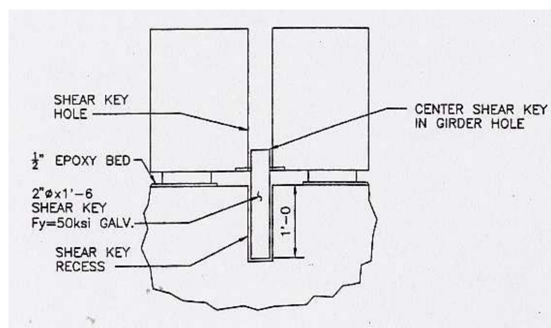

Figure 10: Sear Key Section

Attachment of Pedestrian Bridges and Escalators: There were several conditions where steel framing needed to be attached to the side of a box girder. This was needed for the attachment of escalator trusses, pedestrian bridges, and where the bridge deck needed to be extended under an existing roof. By casting in a coped 15-inch channel into the side of the box girder section, these connections were easily made in the field. See Figures 11 and 12.

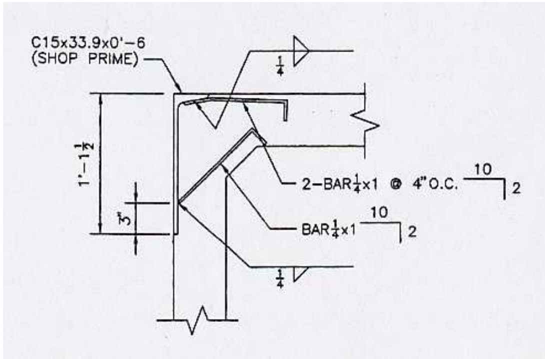

Figure 11: Embedded Channel Detail in Box Girder

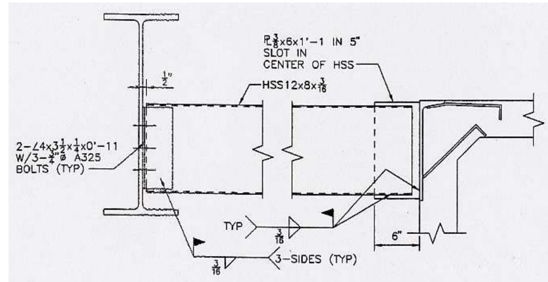

Figure 12: Steel Framing Connection to Box Girder

Conduit Runs: An interdisciplinary design problem required the identification of a method to deliver power for platform lighting and station communications to the soffit of the bridge deck. The simple solution was to run exposed conduit below the soffit of the box girders. However, this was architecturally objectionable. Consequently, a system of conduits cast in the bridge deck structural topping and dropping to the girder soffits through gaps between girders was utilized and coordinated so fixture locations lined up under the same girder joints. This resulted in a functional and architecturally acceptable electrical design, and made the use of less expensive PVC conduit possible. See Figure 13.

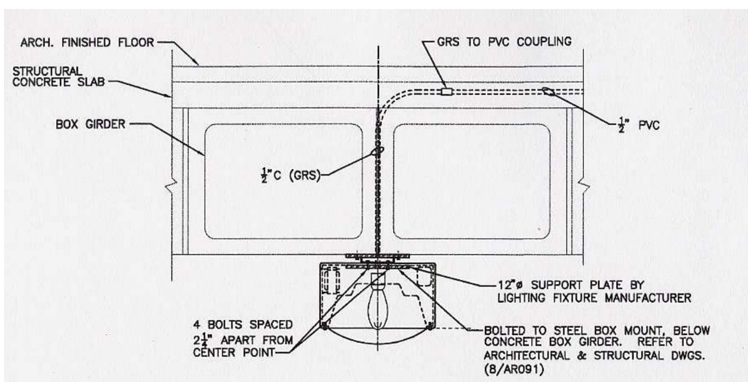

Figure 13: Light Mounting Detail in Box Girders

AASHTO Barrier Connection to Bridge: The Main Street Bridge carries a roadway over the trackway. This required a continuous barrier at the edge of the bridge designed to resist vehicular impact to protect the platform and trackway below from traffic accidents. The design problem to transfer barrier impact loads into the box girders was solved by casting #4 hooked dowels into the boxed girders. These hooked dowels extended from the top of the box girders and were spaced not less than 12-inches o/c. This allowed the wall dowels to be effectively developed in the topping slab and box girders. See Figure 14.

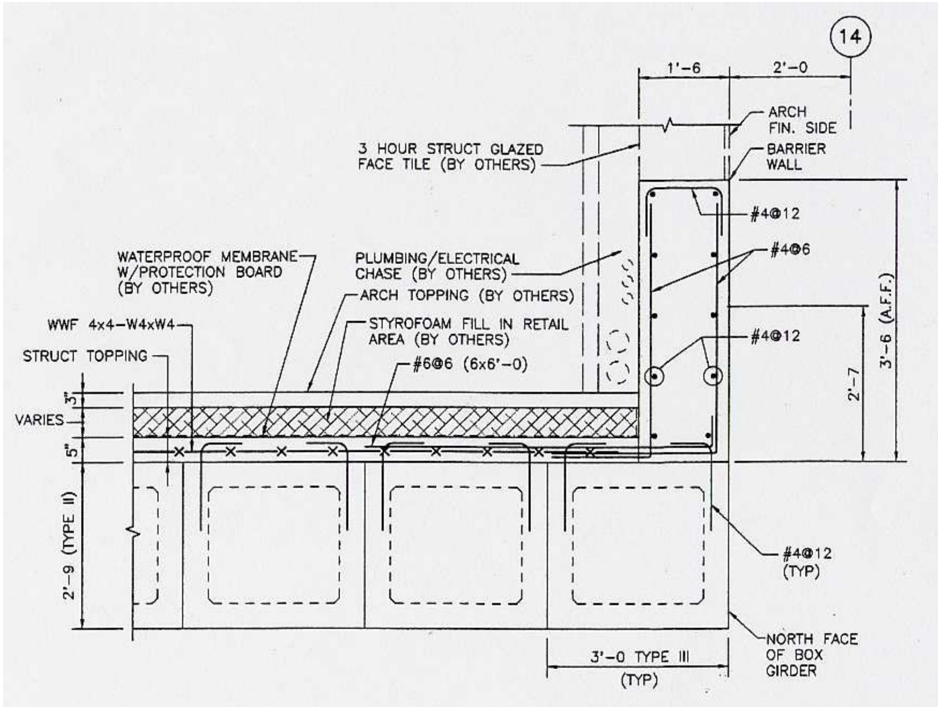

Figure 14: AASHTO Barrier Connection to Box Girders

Retail Space on Bridge: A further design requirement for the Main Street Bridge was to allow future retail buildings to be constructed on the bridge. For this reason, the roadway was designed for an AASHTO H-20 loading and the remainder was designed for a 200 psf live load. The live load of 200 psf was considered conservative enough to account for a 100 psf live load plus a building dead load and column loading. During retail building design the structure will be checked for the actual loads.

Another design consideration for the bridge was the close proximity of the retail space to the Main Street vehicle traffic. It was decided to introduce an expansion joint parallel to the span that separated the retail box girders from the roadway box girders. Although all girders had common supprts, it minimized the effect of traffic vibrations experienced by the retail tenants. Figure 15 shows how the box girders were transitioned from the roadway, sidewalk and retail space.

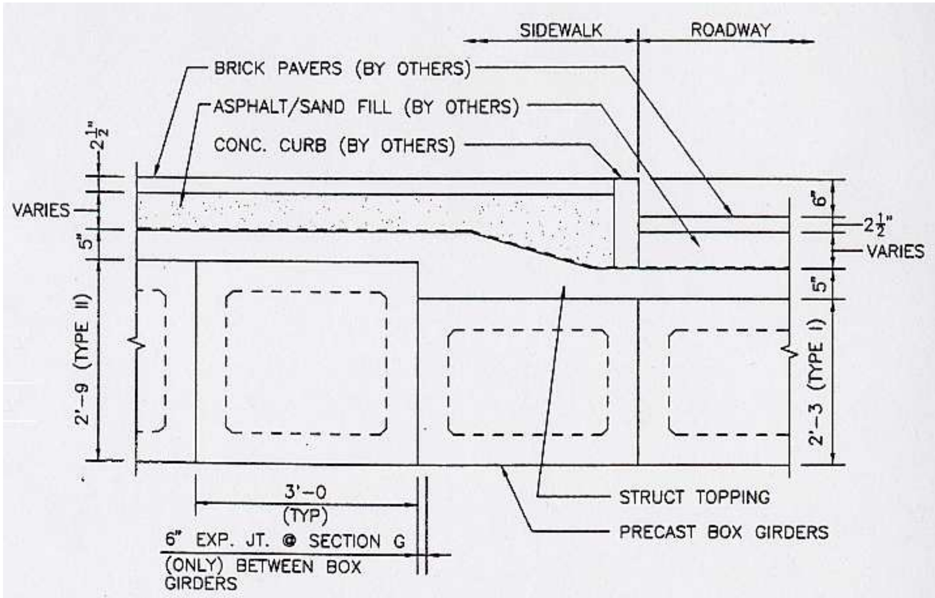

Figure 15: Box Girder Transition at Edge of Roadway

CONCLUSIONS

Precast concrete was chosen because it could be erected quickly and efficiently during single tracking windows. Box girders were chosen because they offered the lowest profile given the restricted headroom constraints of the original construction. Precast box girders also offered the advantage of immediate protection of the rails and platforms below once erected, and provided a smooth soffit for aesthetic appeal.

The knowledge and experience on this project is transferable to other transit agencies considering major reconfiguration and reconstruction of an existing station to introduce TOD while maintaining revenue service. The design constraints, limitations and construction methods for rehabilitation projects are completely different than for new construction and require creative and imaginative solutions. Precast concrete offered unique advantages over other materials and made the difference in the feasibility of this important project.

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