SOUTH 29th STREET BRIDGE OVER UNION PACIFIC RAILROAD, MILWAUKEE, WISCONSIN

Yan Nenaydykh, PE, Project Manager, Vista Design and Construction, LLC Division of Bloom Companies, LLC, Milwaukee, WI
Yakov Braverman, PE, Project Engineer, Bloom Companies, LLC, Milwaukee, WI

ABSTRACT

S. 29th Street Bridge over Union Pacific railroad provides and important connection for numerous businesses in the industrial zone southwest of downtown Milwaukee, as well as vital transportation and utility link for St. Lukes Hospital. The existing structure was structurally obsolete and had to be replaced.

The new bridge is a one-of-a-kind in Wisconsin, a hybrid concrete slab structure spanning two tracks of Union Pacific Railroad. The paper describes the design concept, construction challenges and innovative solution for the new bridge in Milwaukee.

Keywords: Bridge, Precast, Prestressed, Concrete, Hybrid Slab

INTRODUCTION

PROJECT LOCATION

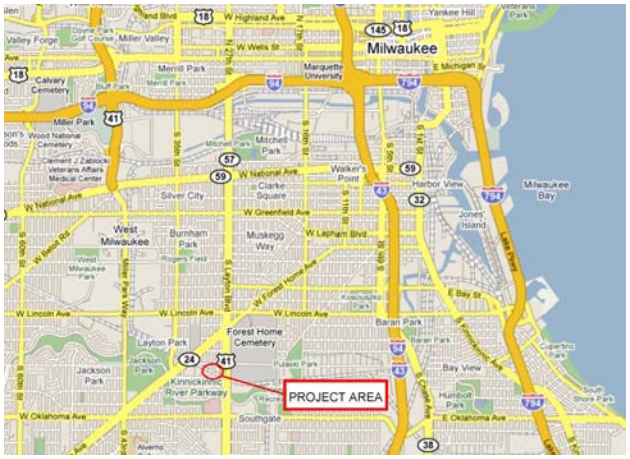

Fig. 1. Project location map.

The project is located in the industrial zone southwest of downtown Milwaukee. The prominent St. Lukes Hospital is just south of the project location. The S. 29th Street Bridge over Union Pacific Railroad provides important connection for numerous businesses, as well as vital transportation and a utility link for St. Lukes Hospital.

PROJECT GOALS

The existing 29th Street Bridge was built in 1923 and had deteriorated to the point that it was structurally obsolete. The vertical clearance (below 20') did not conform to AASHTO and Union Pacific Railroad requirements.

The main project goal was to replace the existing structure and to address the substandard vertical clearance. Given the location of the project and the extensive use of the 29th Street Bridge, the construction process to remove the existing structure and building the new bridge had to be completed on the most aggressive schedule possible (in order to minimize the period of 29th Street closure with the detour during construction), and at the same time to provide minimum interference with railroad operations (total of more than two dozen cranes per day for two tracks) while assuring the safety of construction and railroad operations in the very tight space.

PROJECT FUNDING AND PARTIES INVOLVED

The project was initiated, funded and managed based on the special agreement between Wisconsin Department of Transportation, the City of Milwaukee and Union Pacific Railroad with each party contributing to the cost of bridge replacement. The City of Milwaukee

Engineering Department provided the original design for the project, including bridge replacement and the approach roadway rehabilitation.

Vista Ruzic, LLC, - the joint venture of two Wisconsin bridge contractors Vista Design and Construction, LLC and Ruzic Construction Company, Inc won a bid and was awarded the contract in May 2007. Bloom Companies, LLC was a sub-contactor to Vista Ruzic joint venture. Bloom's scope of work included the design and preparation of necessary construction documents for the re-design of 29th Street Bridge structure replacement according to Cost Reduction Incentive Proposal submitted by Vista Ruzic and accepted by WisDOT, City of Milwaukee and Union Pacific Railroad.

DESIGN CONCEPT

EXISTING BRIDGE

The existing 29th Street Bridge was a one-span (76'-3") structure with massive full depth retaining abutments on 5' thick spread footings. The superstructure included two 8' tall thru plate steel girders connected with 2' tall transverse floor steel I-beams spaced at 3' and three rows of longitudinal diaphragms in the form of 18" tall steel I-beams. Sidewalk slabs on both sides were supported with 12" tall steel I-beams cantilevered from the main plate steel girders and spaced at 6'. All steel girders were enclosed in the concrete, originally built for the fire protection but significantly deteriorated in its 85 years with large concrete pieces falling on the railroad underneath.

Fig. 2. Existing 29th Street Bridge.

ORIGINAL BRIDGE DESIGN

Reinforced concrete bridges have long been a mainstay in the bridge world. They offer many advantages in comparison to other materials in terms of durability, economy, and maintenance. With increasing span lengths, the conventionally reinforced concrete slab bridges tend to get bulkier and are not efficient. The large self-weight and extended construction durations quickly add up in cost.

Original 29th Street Bridge design utilized cast-in-place single span concrete flat slab structure. Typical span limit for the single span slab bridges lies in the range of 50’-55’. The superstructure in this type of bridges is pinned supported by abutments. At the same time cast-in-place slabs are too time-consuming due to extensive formwork and its temporary supporting structure to be built on the site. In order to span of about 68.5’ (as per new bridge layout) and to fit it in the extremely tight vertical clearance constraints the structure was designed as a rigid frame with the fixed moment connections in between 2’-9” thick cast in place concrete flat slab and deep abutments to be supported with seventy HP 10x42 steel piles per each footing.

CONSTRUCTION CHALLENGES

The complexity of a project is recognized as an important factor affecting structure type and construction methods. Items contributing to the complexity include:

- Existing site conditions, numerous overhead utilities, including high-voltage transmission overload lines running alongside the north abutment (not to be relocated, de-energized or even insulated as per their owner WE Energies as well as nearby St. Lukes Hospital Emergency Room feeding from them)
- Strict vertical clearances required for railroad operations, - 20’ required during construction and 22’ final minimum vertical clearance, leaving only 2’ to fit the slab falsework and support structure, including shallow steel beams and decking lumber for 2’-9” thick cast in place concrete slab
- Tight horizontal space in railroad corridor with 18’ minimum horizontal clearance for each of the two tracks and just a 1’ wide horizontal space in between the 2 tracks horizontal clearances
- Combination of those clearance requirements above as well as the train derailing protection requirements (in case of single row of piles is to be installed to support steel beams) made building the falsework support structure practically impossible
- Union Pacific Railroad operations with up to 28 regular and switching trains’ movements per day.

ADVANTAGES OF CHOSEN SOLUTION

A new “hybrid” type of slab was proposed, accepted, designed and built for the first time in Wisconsin’s history according to the Cost Reduction Incentive (CRI) Proposal (as per section 104.10 of WisDOT Standard Specifications for Roadway and Structure Construction). It included re-designed, partially precast pre-stressed "Inverted T" beams and cast-in-place portion, including the sections between beams webs and topping.

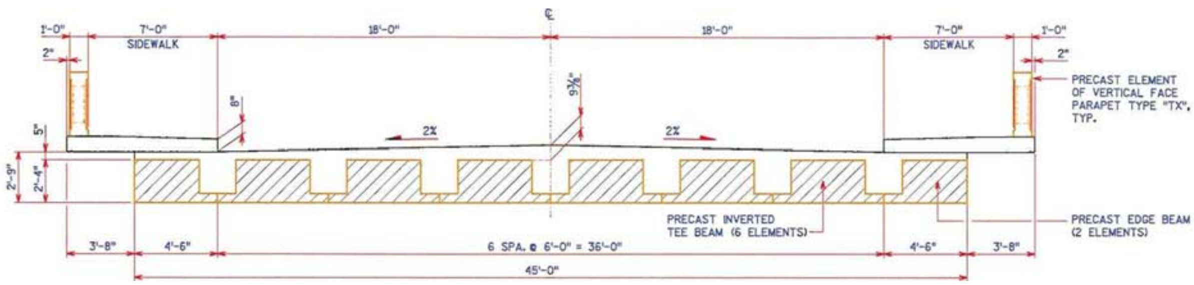

Fig. 3. Bridge Typical Section

Such a structure totally eliminated the need for cast-in-place slab falsework and its support structure (otherwise to be built within the tracks of Union Pacific Railroad with up to 28 trains per day) utilizing the precast beams as both falsework for the superstructure cast-in-place concrete and its support.

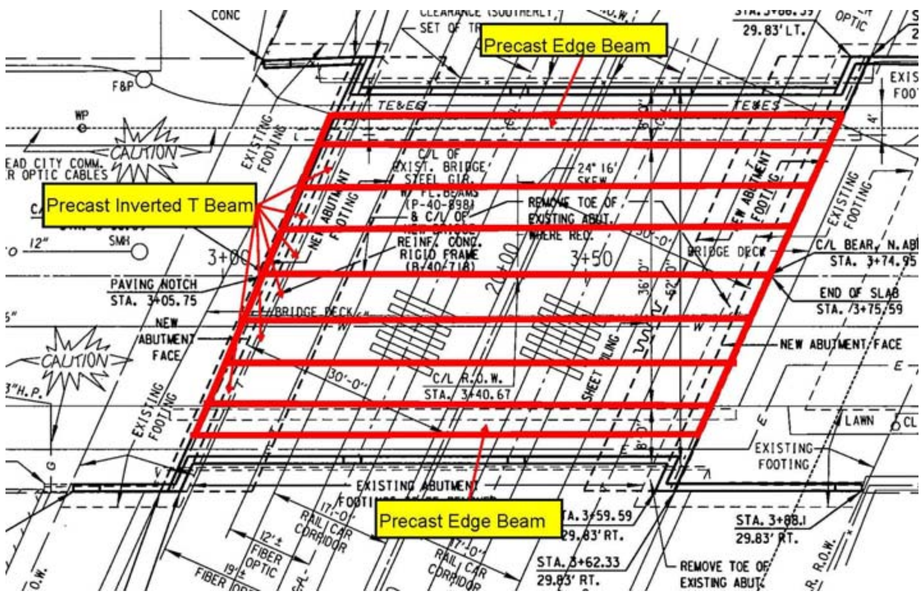

Fig. 4. Bridge Plan.

The proposed solution allowed eliminating the interferences of the bridge superstructure construction and Union Pacific Railroad operations, enhancing safety, accelerating construction, increasing product quality and significantly lowering the project construction cost.

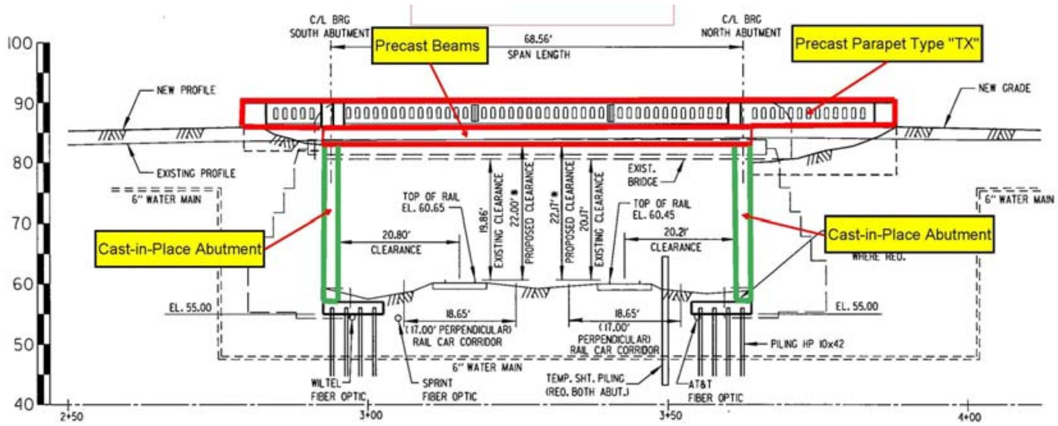

Fig. 5. Bridge Elevation.

The City of Milwaukee (Bridge Owner) and UNION PACIFIC Railroad (Right of Way space owner) wanted a bridge requiring the least amount of maintenance possible. The chosen alternative achieves this objective. There are no bearings or joints on the bridge that will deteriorate with seasonal changes. With the combined effect of high strength concrete, prestressed strands and conventional reinforcement assuring precast and cast in place concrete working together in this "hybrid" slab, there is an increased reserve load capacity and load distribution resulting in better resistance to damaging loads.

NEW BRIDGE DETAILS AND CONSTRUCTION

ABUTMENTS

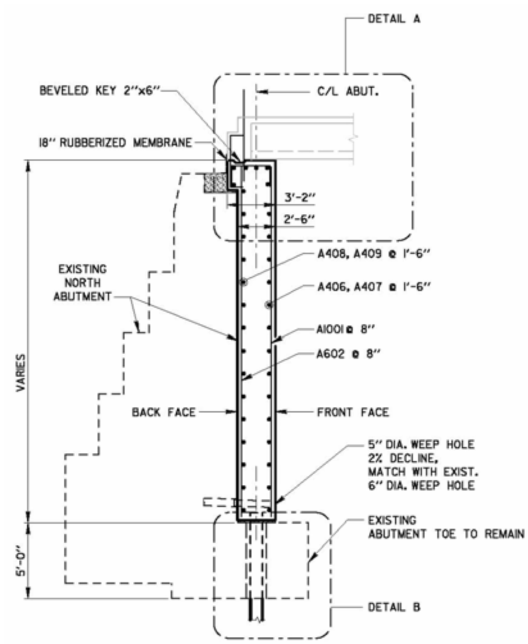

Fig. 6. Typical Abutment Section.

The new type of superstructure resulted in the elimination for the need for the rigid frame bridge structure (as per original design). The fixity between the superstructure and substructure) with the dead and live loads from the superstructure being transferred to the abutment footing would have resulted in the massive foundations with the large number (70 per each abutment) of lengthy (estimated length of 70 ft) piles to be driven and installed within the limited railroad corridor space. The proposed pin-supported superstructure allowed complete elimination of new abutment footing and significant reduction of the number of the piles. All new piles (steel HP 10x42) were installed in one row through the holes (15"DIA) predrilled in the existing abutment footings followed by placing concrete in the drilled holes.

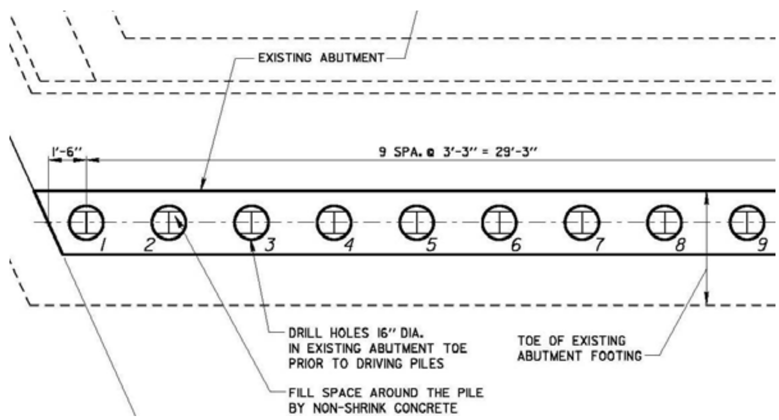

Fig. 7. Abutment Piling Plan.

ABUTMENTS CONSTRUCTION

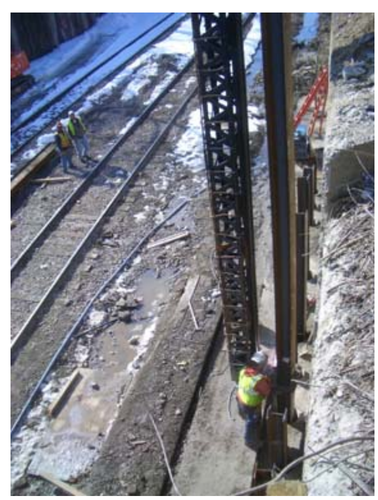

Fig. 8. (a) Holes Drilled in Existing Abutment Toe (b) Driving Piles

Fig. 9. (a) Holes with Grout (b) Pouring Concrete in Formed Abutments

SUPERSTRUCTURE AND PRECAST BEAMS

The proposed superstructure includes precast pre-stressed "Inverted T" adjacent beams with the height of h=2'-4" and CIP portion, including 2’-0”W x 1’-10”H section between precast beams and topping h=varies from 5" at the slab edges to 9 3/8" at the crown line. Six interior beams with 6’-0” wide bottom flange and two exterior beams with 4’-6” wide bottom flange with the cast-in-place portion will result in the same superstructure geometry (45’-0” width, 2’-9” thickness and 68.56’ span length) as in the original design.

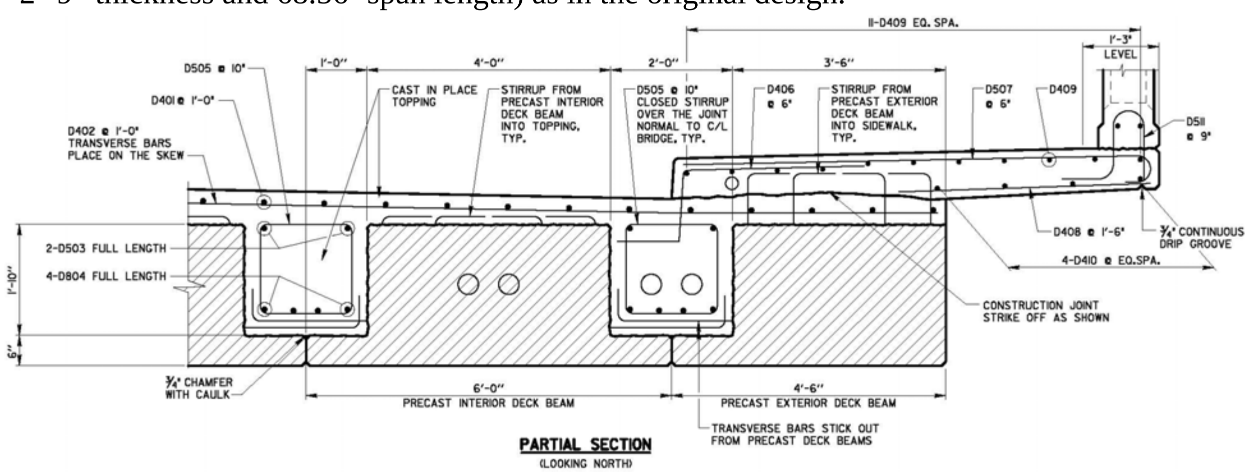

Fig. 10. Superstructure Partial Section.

The interior beams are prestressed with 42 and exterior with 27 - 0.6” DIA low relaxation strands with an ultimate strength of 270 kips-per-square-inch (ksi). High performance concrete (specified compressive strength, f’c = 8,000 pounds-per-square-inch, psi) was used for the precast beams. Properties of high performance concrete, such as exceptional durability and high strength, help extend the service life of structures and reduce maintenance concerns.

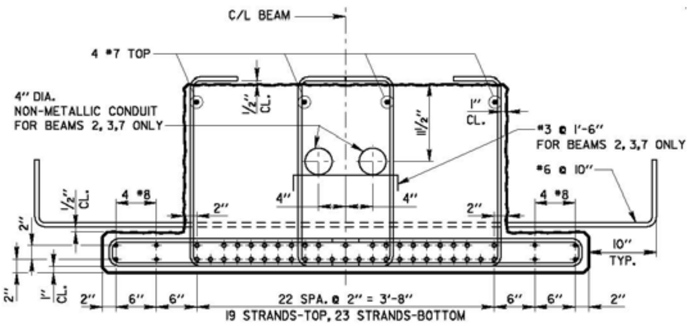

Fig. 11. (a) Interior Beam Section. (b) Exterior Beam Section

The design was based on the Strength Design Method as specified in AASHTO[1]. Stress checks were based on the Allowable Stress Design Method as specified in ACI[2].

MAKING BEAMS

Fig. 12. (a) Forming Interior Beam (b) Concrete Pour in Beam

Fig. 13. (a) Completed Interior Beam (b) Delivery of Exterior Beam

BEAMS INSTALLATION

Fig. 14. (a) First Exterior Beam (b) Exterior Beam in Place

Fig. 15. (a) First Interior Beam (b) Safe railroad operations during construction

HYBRID SLAB CONSTRUCTION

Fig. 16. (a) Slab Re-bar Cages Installed (b) Slab Pour in Process

BRIDGE PARAPETS

Decorative, but at the same time crash tested "Texas" style concrete parapets are detailed and built on both sides of the superstructure on the exterior edge of sidewalks. The parapets are 3'-6" high and conform to AASHTO requirements for pedestrian use.

The entire bridge parapets and the exposed concrete surfaces of the bridge superstructure were stained with two-coat penetrating, pigmented silicone acidic, salt resisted stain. The aesthetic opaque color matched the color of surrounding buildings in the project area. It also gives the 29th Street Bridge a clear definition as an object in the landscape.

PARAPET CONSTRUCTION

Fig. 17. (a) Forming Parapets (b) Completed and Painted Parapets

CONCLUSIONS AND SUMMARY

SUMMARY TABLE

Project Size	***$2,000,000***
Special Contract Requirements	***Cost Reduction Incentive (CRI) - complete Bridge re-design***
Cost Reduction Incentive Effect	***Reduction the total construction cost by $337,925 (17%), final net Cost Reduction Incentive savings of $266,674.73***
What the Structure Spans	***Single Span 68'- 6 ¾"***
Geometrics	***24°16' LW Skew***
Type of Substructure	***Full Height Retaining Abutments supported on the HP 10x42 steel piles driven through the holes drilled in the toes of existing Abutments to minimum bearing capacity 55 tons***
Type of Superstructure	***"Hybrid" concrete slab with precast prestressed "Inverted T" beams and cast in place topping***
Aesthetic requirements	***Stained "Texas" style parapet, reveals on Abutments***
Special Materials Requirements	***Concrete Strength: f'c = 8,000 psi & fci = 6,400 psi Beams; 5,000 psi - Topping; 3,500 psi – Abutments*** ***Re-bars: 60,000 psi*** ***0.6" DIA Low Relaxation Strands: 270,000 psi***
Precast Beams	***6 – Interior & 2 – Exterior beams, all 69'-7" Length***
Beam Weight	***Interior: 111.5 kip; Exterior: 93.5 kip***
Beam Strands Number	***Interior: 42; Exterior: 37***
Initial Prestress	***Interior: 1,845.6 kip; Exterior: 1,625.9 kip***
Final Structure Rating	***Design Rating: HS 25*** ***Inventory Rating: HS 32.4*** ***Operating Rating: HS 37*** ***Max Standard Permit Vehicle Load: 250 kip***

CONSTRUCTION TIME AND SERVICE DATE

The project was originally awarded in June 2007 with construction scheduled for summer and fall of 2007. Since the Cost Reduction Incentive concept and proposal development (including complete bridge structure re-design), as well as the review and approval by all stakeholders took significant time, the project was pushed back into the 2008 construction season with an early February start. The project was completed and traffic was open on schedule. The bridge was put into service in July 2008.

Fig. 18. Completed 29th Street Bridge.

SUMMARY

The re-designed and built under this Cost Reduction Incentive structure virtually eliminated any effect and interferences of the bridge superstructure construction and Union Pacific Railroad operations. It automatically provided the required final 22' minimum vertical clearance for the entire duration of bridge construction, enhanced safety and accelerated bridge construction. The new bridge structure built according to this Cost Reduction Incentive Proposal has a much higher structural capacity (Inventory Rating for CRI Bridge, - HS 32.4 is 30% higher than in the original design, - HS 25). This increased reserve load capacity, resulting in better resistance to damaging loads. Combined with high product quality of the precast beams manufactured in the plant with higher strength concrete (8,000 PSI precast beams) it will provide exceptional durability of the new bridge structure, extended service life and reduced maintenance costs. Finally project achieved significant savings:

1. Reduction in the construction cost $337,925 which represents more than 20% of bridge construction and 17% of entire project
2. Final net Cost Reduction Incentive savings (after subtracting costs of CRI proposal development, re-design, review and approval) of $266,674.73

REFERENCES

1. AASHTO, “Standard Specifications for Highway Bridges,” 17th Ed., 2002.
2. ACI Committee 318, “Building Code Requirements for Structural Concrete (ACI 318-02),” 2002.