SPANNING THE MISSISSIPPI

Though traditional in form, this new crossing utilizes high-strength steel to economize the truss design

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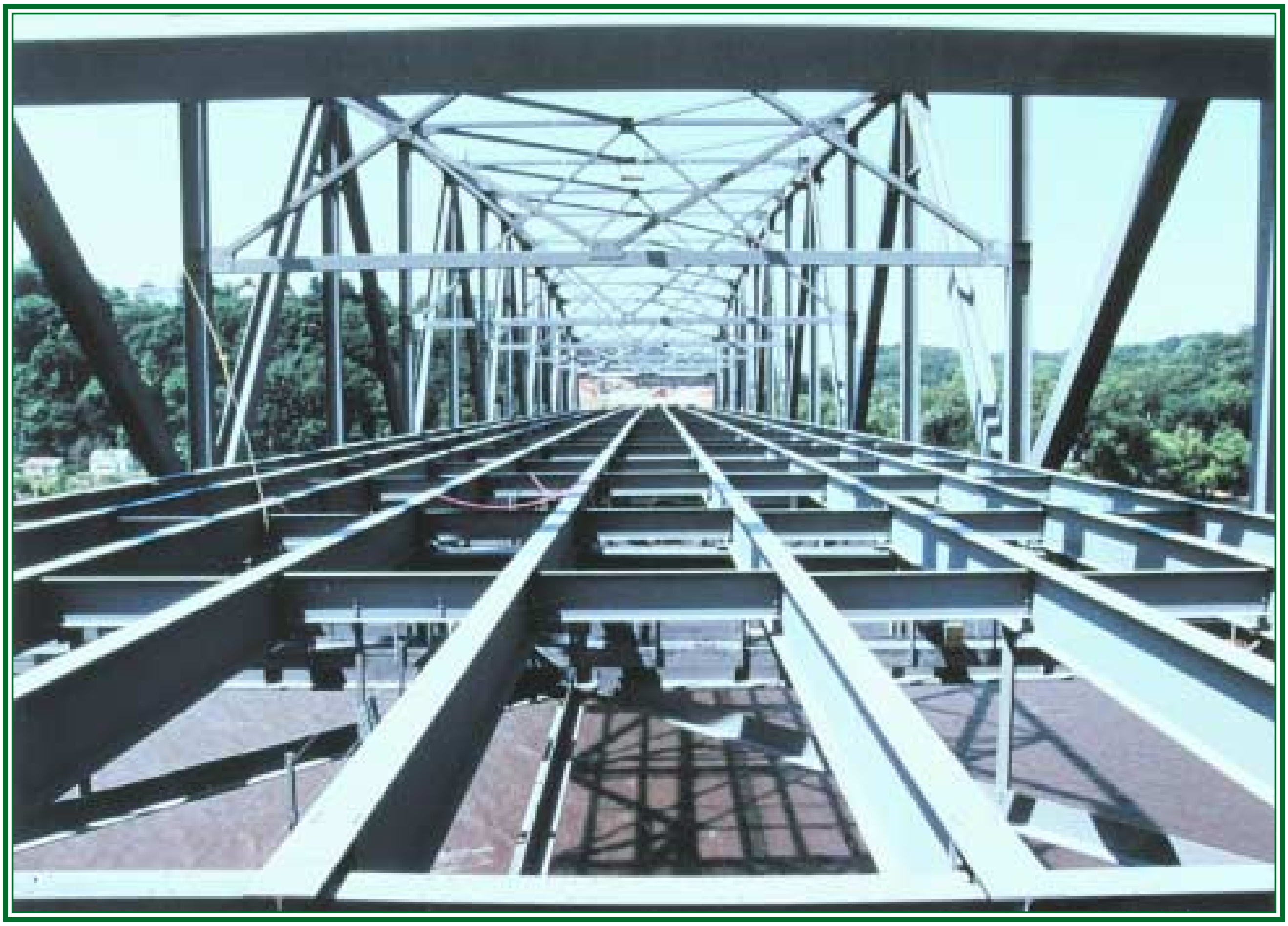
THE MISSOURI DEPARTMENT OF TRANSPORTATION AND THE ILLINOIS DEPARTMENT OF TRANSPORTATION, in conjunction with the Federal Highway Administration, are jointly funding the construction of the new U.S. Route 36 bridge over the Mississippi River in Hannibal, MO. This bridge will link the future extension of Interstate Highway 72 from Illinois into northern Missouri. The Missouri Department of Transportation is administrating the design and construction of this bridge, which is comprised of three separate contracts and has an overall construction cost of $42.3 million.

In July 1999, the second of the three contracts was completed, totaling $7.5 million. The extent of the work involved in this contract covered furnishing, erecting, and shop coating of structural steel for the 640'-long navigation truss span. In addi-



tion, service access, inspection platforms, ladders, and handrails were erected. Completion of the steel erection has brought to a close construction of the most significant components of the substructure and superstructure. The final phase of this project is the ongoing bridge deck construction. The fabrication and erection of the truss main span was completed by AISC-member Stupp Bridge Company of St. Louis, and their erection subcontractor, AISC-member Danny's Construction Company, Inc. of Shakopee, MN, respectively. The first contract, completed by another team, included construction of the entire substructure of the bridge and furnishing and erection of all approach span structural steel.

The third and final contract, also awarded to the same erector as the first contract, encompasses the construction of the concrete deck, parapets, lighting, and final painting for the entire bridge. The new U.S. Route 36 bridge is scheduled to be completed in the Fall of 2000 and will replace the existing two-lane bridge now carrying U.S. Route 36 over the Mississippi River. The completed structure will accommodate two full traffic lanes, a ten-foot wide shoulder, and a four-foot median safety shoulder in each direction.

Sverdrup Civil, Inc., a member of the Jacobs Engineering Group, designed the new Mississippi River Bridge in Hannibal. Founded in 1928 as Sverdrup and Parcel, Inc., Sverdrup Civil is the continuing bridge design division of Jacobs. Sverdrup and Parcel designed the existing U.S. Route 36 bridge in Hannibal in the early 1930's. The original design work was a major effort at the time and key to the survival of Sverdrup and Parcel during the Depression era. Although the new bridge design was completed by a following generation of Sverdrup engineers, the principal ideas and benefits of the truss structure have withstood the test of time.

The navigation span for this bridge was a single span through Warren Truss. The chosen span arrangement was based on a preliminary study that considered, in addition to this span arrangement, a continuous two-span truss, a steel tied arch, and a cable-stayed span. The Warren Truss was chosen because of its estimated economic advantage over the other alternates studied. This truss is the first such bridge structure designed by Sverdrup Civil using ASTM A709, Grade 70W steel.

Design Concept

The 1992 AASHTO Standard Specifications for Highway Bridges was used for design of

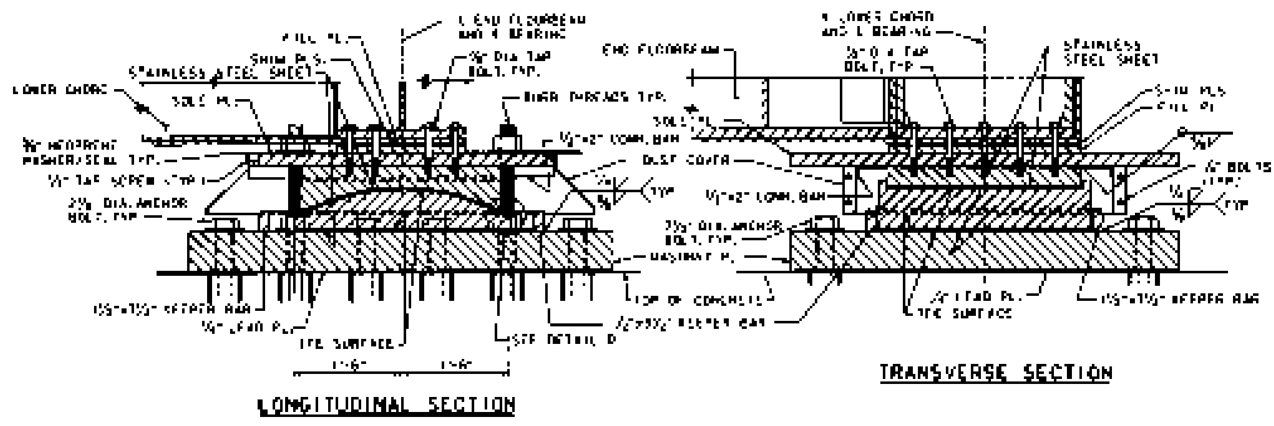
the truss span. The design live loading is HS25 with provision for 35 pounds per square foot future wearing surface. Based on the deck configuration, which may be altered to carry three lanes in each direction, a maximum of 2.34 fully loaded lanes of live load is attributable to each truss. Load Factor design was used in proportioning the members of the truss span, while allowable stress design was used for the slip critical connection design.

Span Arrangement

The truss span consists of fourteen equal panels measuring 45'-7¾" in a curved upper chord configuration. The upstream and downstream trusses are spaced at 89'-0" center-to-center, and support an 80'-11" wide normal weight concrete deck. Three continuous stringer units are made composite with the concrete deck and are supported by a transverse floorbeam at each of the panel points. The stringers are W33 x 118 ASTM A709, Grade 50 steel beams. The use of stringers supported on top of the floorbeams was chosen in part because it easily accommodates the differential movement between the lower chord of the truss and the floor system. As more dead load is continually added to the truss, by its self-weight during erection and construction of the deck slab, the differential movements between the major longitudinal structural components becomes significant.

Longitudinal forces applied to the deck are transferred to the lower chord of the truss via the lower lateral system, through the aid of a longitudinal force frame in each of the three stringer units.

The lower and upper chords of the truss are fabricated box sections. The sections are made of two main web plates connected by continuous weld to the upper and lower cover plates. The results of the load factor design methodology indicated that the most economic sections are on average a 30" x 34" upper chord and a 30" x 32" lower chord. Except for the end two truss panels, these sections are fabricated from ASTM A709, Grade 70W steel. All other primary truss members are fabricated from ASTM A709, Grade 50 and Grade 36 steel. The higher strength steel is considered to be advantageous because of the relatively high dead load to live load ratio imposed by the use of a conventional normal weight concrete deck. Many spans of this length use special lightweight decks to reduce this ratio. However, lower dead load to live load ratios may increase fatigue concerns if live load stresses rise. Considering that the primary tension members of the trusses are of fracture critical design, the lower live load stresses that may result from the heavier deck also increase the benefit of using Grade 70W steel. The use of this steel for the majority of the chord sections also reduces the overall depth of the truss normally expected for a span of this



EXPANSION BEARING DETAIL

length and width. This depth reduction contributes to steel weight savings by diminishing the length of the truss diagonals, verticals and hangers.

The use of quenched and tempered steel was discussed with fabricators and raised questions pertaining to weldability, hole drilling, plate size, and availability. The conclusions drawn from these conversations indicated that this steel was appropriate for fabrication of these sections despite a plate length limit of 50'. This length limit requires the use of one full penetration butt-weld every two panel lengths, which are approximately 91' in length.

The two end panels of the lower chord, the hangers and the diagonals are fabricated from ASTM A709, Grade 50 steel. The diagonals and hangers are three plate welded H-sections, as are the verticals. However, the verticals are fabricated from Grade 36 steel.

The use of Grade 70W steel and the resulting relatively high dead load stresses, as previously indicated, require that the elongation of the lower chord be carefully considered as the span is erected. The use of K-type bracing for the lower and upper lateral bracing system was determined to have the best ability to accommodate the movement of the chords, with the length of the stringers remaining fixed. The K- type bracing system, connected to the truss chords on one end and the center of the floorbeams on the other, utilizes the relative flexibility of the floorbeams about their weak axis to accommodate this movement. The diagonals of the lower lateral system are composed of two plate welded T-sections fabricated from Grade 36 steel.

The upper lateral bracing is also a K-type system, but uses structural tubes made of ASTM A500, Grade B steel. The diagonals of the upper lateral system are 14" x 14" x ⅜" in section and the struts are 16" x 16' x ½". The struts of the system are transitioned to the depth of the upper chord by the use of a welded box section. The use of the tube sections was chosen because of their good compression and torsional capacities.

The truss span joints, including those connecting Grade 70W members, are composed of gusset and splice plates fabricated from Grade 50 steel. The use of Grade 70W material for gusset and splice plates was decided against because the increased difficulty in producing holes in the quenched and tempered steel outweighed the limited weight savings resulting from a reduction in plate sizes. Both shop and field connections are made with galvanized 1" diameter ASTM A325 high strength bolts. All of the truss connections are considered slip critical with a class B surface finish specified.

The upper chord joints are designed to be milled-to-bear. By using a mill-to-bear joint, the size of these connections was reduced by using up to 50 percent member load transfer, through a minimum contact area of 75% of the member face. Inspection of these joints during erection verified that this amount of contact was attained.

The truss span rests on curved sliding cylindrical bearings with polytetrafluorethylene (PTFE) sliding surfaces. This bearing type was chosen, in part, because of its ability to accommodate the relatively large movements that occur at the expansion end of the truss due to placement of the concrete deck, as well as thermal expansion and contraction. During erection, this movement is estimated to be in the range of 4½ inches. The bearing's ability to handle small amounts of movement transverse to the longitudinal bridge axis and its low profile, for better resistance of horizontal loads, are also reasons for its selection. The Merriman Corporation of Hingham, Massachusetts manufactured the bearings for the truss.

Fabrication

As previously stated, Stupp Bridge Co. of St. Louis is under contract for the fabrication and erection of the steel for the truss span. The special provisions for this contract permit the use of computer numerically controlled (CNC) drilling for the bolted truss connections, except for the mill-to-bear joints. This was an alternate to providing finished connection holes while the pieces were assembled. Stupp used CNC drilling after verification of their equipment and methods through the use of check assemblies.

The mill-to-bear joints were assembled in their correct geometric position, adjusted for camber, and checked to verify that a minimum of 75 percent of the main member material was in contact across the joint. After the holes were drilled, the milled joints were disassembled for shipment.

All of the truss steel received a shop coat of inorganic zinc paint.

Erection

Danny's Construction Company, Inc. of Shakopee, Minnesota, under a subcontract to Stupp Brothers performed the erection of the truss span steel. During the planning for this project, provision was made either for erection of the span by the use of falsework in the navigation channel or by floating in the erected span after assembly away from its final location. Off-site erection was limited by the close proximity of the Norfolk Southern Railway lift bridge immediately upstream, the downstream location of the existing U.S. Route 36 bridge, the navigation channel adjacent to the west bank of the river and the environmental considerations of the east bank floodplain. Through coordination with the Rock Island District of the U. S. Army Corps of Engineers and the Illinois Department of Natural Resources, a designated area for off-site erection was established on the east bank between the railroad bridge and the existing Route 36 bridge.

Stupp Bridge Company and Danny's Construction Company, Inc. (DCCI) elected to erect the truss span by using falsework in the navigation channel. This was coordinated with U.S. Coast Guard in St. Louis in order to maintain a minimum channel opening, even during low traffic periods on the river. DCCI erected falsework piers at panel points L2 and L2' and began erection from substructure piers 5 and 6, working towards the falsework piers in the navigation channel. After erection reached the falsework piers it continued by cantilever construction method to panel point L3 and L3', respectively. Falsework piers were then erected at panel points L4 and L4' and the erection continued to these falsework piers. After support was made at L4 and L4', the falsework piers at L2 and L2' were removed. Erection continued simultaneously from L4 and L4' by cantilever construction method to the center of the truss at L7, where the span was closed. Slotted holes in the gusset plate connecting the lower and upper lateral systems at the centerline of the span at panel point 7 are used to accommodate further movement of the truss chords as the deck is placed in the third and final contract for the construction of this bridge. The connecting bolts to the lateral diagonals are installed finger tight at these locations and will be fully tightened after the concrete deck is in place.

The completed truss span contains approximately 484 tons of Grade 36 steel, 1,467 tons of Grade 50 steel and 802 tons of Grade 70W steel. In addition, approximately 91 tons of ASTM A500 steel was used in the tube sections of the upper lateral system.

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