Merit Award: Long Span

SECOND BLUE WATER BRIDGE

For almost 60 years international access between Port Huron, MI, and Point Edward, Ontario, has been provided by a cantilever truss bridge built near the north end of the river. The Michigan Department of Transportation and The Blue Water Bridge Authority in Ontario jointly own and operate the bridge - each collects tolls from traffic entering the bridge, and traffic leaving the bridge passes through customs and immigration on each end.

About 60 years ago, the firm of Modjeski and Masters, Inc. designed the river crossing and supervised its construction. The success of the crossing at this location has led to a steady growth of traffic. This helped speed up plans for an additional Blue Water Bridge.

SELECTED STRUCTURE

For the main river crossing, a continuous tied arch was selected with approaches of box girders and multi-girder spans. A requirement for the main bridge construction was that the work be divided equally between the owners. Also, the construction had to be equally divided between a contractor from Canada and one from the United States in a joint venture contract, which dictated that at least two fabricators and two steel suppliers would be required. A considerable effort was required during the design to ensure that the details, materials, standards and procedures in the plans were proper for con

The main span deck is reinforced concrete for three traffic lanes and a pedestrian sidewalk. The slab thickness was set at 7" in order to reduce dead load on the main span. The stringers are rolled beam sections, made continuous and composite with the deck slab. The floorbeams are welded I-sections with welded transverse stiffeners. Steep roadway grades (4.65 percent) and channel clearance requirements resulted in a shallow superstructure depth. This limited the available web depth for the floorbeams, resulting in the need for intermediate floorbeams between vertical locations. Welded I-members were used for the floor system lateral bracing.

A counterweight was added to provide a positive reaction under all loading conditions, except the most extreme live load case, and the bearings here are designed to resist the uplift resulting from that case. The floor system at the anchor end required modification to accept a concrete counterweight. Intermediate stringers were added to the typical cross-section in the two end panels. Stringer depth was increased to 36" in these two panels to support the concrete mass. The stringers were coped over the floorbeams to accommodate their increased depth.

Arch Details

The continuous tied arch requires a number of special design considerations, as do the LRFD requirements, and the demands of the owners for this crossing.

The arch rib is a box about 1.2 meters on a side made of welded steel plates, and near each end is a welded closure plate to seal the main length of the arch rib members. These sealed sections are not painted, but they have been partially evacuated, then filled with dried air and sealed. The tie girder is a steel box built up by bolting and it consists of steel plates with corner connecting angles - it is about 1.2 meters wide by 2.5 meters deep. The tie girder is the tension member that provides the sole horizontal support for the entire arch. In addition, it provides most of the flexural resistance of the arch segments.

Temperature changes and loads on the bridge cause movements at the supports. The main arch bearing in Ontario is fixed against sliding, and all the others are designed for longitudinal sliding. The capacity for sliding is provided by incorporating Teflon on polished stainless steel within the bearing. At the Michigan main pier, the bearing design accommodates movement of over 300 mm contraction and over 400 mm expansion. A tough flexible disk in compression is a part of the bearing's support for vertical load, and permits the small rotation that takes place at the support joints.

In addition to the bolting used to assemble the tie girder, all the member connections are made with high- strength bolts, and all the high-strength bolts are galvanized.

Special Details

At the ends of the bridge, the tie girder and the arch rib merge into a single variable-depth box member for several panels. In merging the two members, a large compression from the arch rib combines with a large tension from the tie girder to form a moment in the single member. The interrupted flanges of the rib and tie are continued well into the joint to help accomplish this transfer. The sizes of the plates became so large it was necessary to add a longitudinal field splice along the joint to make the sizes manageable.

The support joint at the main pier was a location made difficult by the fact that it is a major support for the bridge and also because of the large angle change in the arch rib. The general arrangement provides continuity for the heavily loaded arch rib plates in the large weldment at the base of the column. The vertical sides of the arch rib are backed up by the vertical plate of the column; the bottom flange of the arch rib bears on the bearing plate; and a special plate was added inside the column to back up the top flanges of the rib. Coming riverward from the main pier, the rising arch rib intersects the tie girder. This, again, is a location where large forces must be carefully carried. It was decided to carry the rib forces through the joint in a rib section, and build the tie girder to pass by it. At adjacent splices, the rib was reduced in width by two plate thicknesses so it would fit between the webs of the tie girder. Additional web plates were added to the tie girder, and special connections carried the flange strength and material outboard of the tie girder webs, so it was possible to create the opening in the tie girder needed by the rib.

Arch Erection

Erection from the water, which would have been difficult due to the speed of the current, was banned by the Coast Guard. In accordance with the LRFD Specifications, the design plans included a feasible erection procedure. This plan first erected the anchor span using temporary bents and then placed a falsework tower over the main pier. Erection of the main span was accomplished by cantilevering from this point, using stays secured at the anchor pier and passing over the tower to support the river span sections. To handle the uplift created by the cantilevering special, tie rods were set into the anchor pier footing and in the tie girder at the point of the stay attachment.

Approaches

Three continuous steel box girder spans are used for the flanking spans placed at each end of the tied arch to provide visual continuity, and beyond that the approaches vary in their makeup to suit local conditions. The flanking spans are supported by three box tube girders about 2.1 meters deep. These girders are composite with the concrete deck, and a plane of bracing is provided for the top flanges. The Michigan side has three spans of 61 meters, and the Ontario portion has three spans of 54 meters.

Beyond the flanking spans, the Michigan approach continues with 1.8 meter deep precast prestressed concrete girders in spans ranging from 28 to 36 meters. The girders are made continuous for live load in those spans where the roadway and cross-section are uniform. The last span is a simple span of steel girders. Near the Michigan Plaza a special crossover ramp is provided to permit traffic to access the proper lanes under specific conditions of operation, and this ramp is framed with composite prestressed concrete and steel girders.

Substructure

All the piers are of reinforced concrete founded on steel 'H' piles driven to rock. The main piers have a column under each of the arches, and are connected at the top by a strut. The remaining are hammerhead piers, except at the crossover and locations adjacent to the Plaza where the bridge widens to make a hammerhead impractical.

The loadings and traffic patterns on the existing bridge had been studied by Modjeski and Masters, Inc. previously, and a fairly common condition had been observed—bumper-to-bumper traffic with a high proportion of trucks over the full-length of the main bridge and approaches, all waiting to pass immigration and customs.

In mid-July 1997, the Second Blue Water Bridge opened with a two-day celebration.

For a more complete version of this story, please see MSC October 1997.The cooperation of all parties led to an opening of the bridges on August 10, 1997, 49 calendar days earlier than the contract date of September 28, 1997. All contract work was completed by October 31, 1997. Steel played a major role in this success story, enabling re-use of the old foundations to support a lightweight, attractive and maintenance free superstructure that was buildable in record time.

MSecond Blue Water Bridge

Owner:
Michigan Department of Transportation;
The Blue Water Bridge Authority

Designer:
Modjeski & Masters, Inc., Mechanicsburg, PA (NSBA Affiliate Member)

Buckland and Taylor, Ltd., Vancouver, BC, Canada

General Contractor:
PCL/McCarthy, A Joint Venture,
Denver, CO

Detailer:
Candraft,
Port Coquillam, BC, Canada

Fabricator:
PDM Bridge, Eau Claire, WI (NSBA Member)

Canron, Inc.,
Toronto

Erector:
Traylor Bros., Inc.
Westlake, TX