HEAVY MOVABLE STRUCTURES, INC.
FOURTEENTH BIENNIAL SYMPOSIUM

October 22 – 25, 2012

Adaptive Re-use of the C&WI RR Vertical Lift Bridge Chicago, Illinois

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CARIBE ROYALE HOTEL
ORLANDO, FLORIDA

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Abstract

Chicago is a city defined by its iconic movable bridge infrastructure. The City's Torrence Avenue Vertical Lift Bridge was slated for a major rehabilitation starting in the fall of 2011 which would require closing the bridge to all traffic for a period of over a year. Ford Motor Company has a major assembly plant located immediately south of the bridge that produces a new vehicle every 30 seconds, three shifts a day, seven days a week. The new cars are marshaled in a large parking lot north of the Torrence Avenue Bridge. Closing the Torrence Avenue Bridge for the rehabilitation would increase the travel distance to the marshalling yard from less than a mile to a nearly eight mile detour with significant cost implications. Fortunately, the City of Chicago owned the abandoned Chicago & Western Indiana Bridge located immediately to the east of the Torrence Avenue Roadway Bridge. The C&WI Bridge was last used in 1992.

The authors discuss the modifications required to the C&WI Bridge to convert it from a railroad to a highway bridge. They also discuss the challenges of bringing an abandoned bridge back to regular service after a hiatus of over 20 years. Control systems, electrical, mechanical and structural rehabilitation are discussed along with decisions concerning how to implement these changes in the most cost effective and timely manner.

Introduction

It isn't often that a Movable Bridge Engineer gets the opportunity to recommission an abandoned movable bridge and adapt the span to other purposes. Collins Engineers Incorporated (Collins), working with the Chicago Department of Transportation (CDOT), was recently presented with just this opportunity as part of a much larger movable bridge reconstruction project on Chicago's Southeast side. Collins is serving as Construction Manager overseeing the rehabilitation of CDOT's Torrence Avenue Vertical Lift Bridge over the Calumet River. The bridge opens over 2,500 times a year. The rehabilitation includes the major replacements of the roadway deck, floorbeams, stringers and extensive repairs to the deteriorated bottom chord. In order to perform the rehabilitation work without obstructing navigation, the movable span was locked in the open position which requires the closing of Torrence Avenue to all traffic. The expected length of the closure of the bridge is approximately nine months.

C&WI Bridge (left along abandoned track) and CDOT Torrence Avenue Bridge (right) looking south

The Torrence Avenue Vertical Lift bridge is located immediately north of Ford's Torrence Avenue Assembly Plant. Ford produces a new vehicle every 30 seconds and marshalls their vehicles for shipping in a parking lot north of the bridge. The closure of the Torrence Avenue Vertical Lift Bridge would require Ford to use an eight mile detour to access their marshalling yard. The detour would increase travel time to the marshalling yard from ten minutes to thirty minutes or more depending upon the time of day and traffic conditions. This would create a major logistics problem for Ford and significantly increase costs for marshalling the vehicles. The obvious solution to this problem was found immediately east of the Torrence Avenue Vertical Lift Bridge.

In 2003, CDOT purchased the abandoned Chicago & Western Indiana (C&WI) Railroad Vertical Lift Bridge as part of the land acquisition CDOT needed to re-align Torrence Avenue. This bridge is located immediately east of CDOT's Torrence Avenue Vertical Lift Bridge. The C&WI Bridge was built by American Bridge in 1972 and was last used in 1992 at which time its lift span was locked in the open position. With CDOT's Torrence Avenue Vertical Lift Bridge, the C&WI Bridge represents a unique pairing of vertical lift spans at a single river crossing and the two bridges are visual icons for the neighborhood. CDOT requested that Collins inspect the C&WI lift span and determine if it was feasible to re-commission the bridge and convert it to use as a roadway bridge.

Existing Bridge Condition

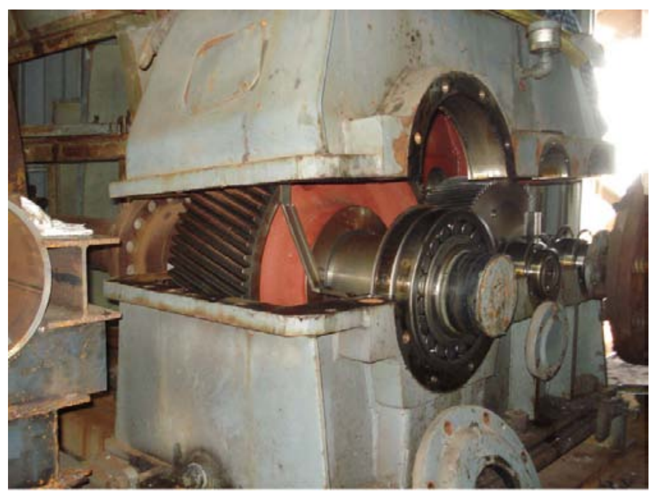
Tower Control Room showing main motor, reducer and main sheave

The C&WI Bridge is a tower drive, two track skewed through truss vertical lift span with a 281'-8" skewed movable span weighing 1.1 million pounds that provides a 125 foot clearance over the Calumet River when in the open position. The two track, four stringer movable span was designed to accommodate a Cooper E80 Railroad loading. There are short approach spans on either side of the movable span to bridge over the poor soils of the river bank. Electrical tie wires strung between the

Condition of Motor Generator Set in Bridge Tower

towers at the upper level provided connection between the two towers to allow for operation. The bridge uses a 125 HP AC motor with a 50 HP AC auxiliary motor as the main drive in each machinery room tower. The motors are coupled to the main sheaves through a central planetary gear set and reducers. Mechanical control of the bridge is accomplished through motor brake thrusters located on the main drive shaft from the motor and machinery brake thrusters on each shaft driving the sheaves. Electrical control of the bridge is accomplished through an early generation Programmable Logic Control (PLC) control system. Skew control had been achieved using electro-mechanical Selsyn controller coupled to each motor shaft.

Collins conducted an initial inspection of the bridge's structural, mechanical and electrical systems in July of 2011. Our initial inspection found that the motors, generator sets, gearing, bearings, brakes and other key components of the bridge's electrical and mechanical systems were all still in place with relatively little evidence of vandalism. There was, however, significant water damage to the electrical systems, particularly the motor generator sets, and that much of the connecting wiring was damaged or missing. Portions of the tower machinery rooms' roofs were missing allowing water and pigeons to enter into the machinery rooms. The control system for the bridge located in the bridge house had been vandalized and could not be salvaged. The only access to the tower machinery rooms was via ships ladder since the elevators had been extensively vandalized. All span locks, movable span guides and span buffers were still in place although there condition could not be readily assessed.



Gear Reducer before Rehabilitation

The bridge was given a structural inspection and found to be in excellent condition with little or no deterioration of the main and secondary members. There was, however, no information available on the balance state of the bridge and it was not known whether the counterweights were made heavier to ensure that the span remained in the open position. From inspection, however, it appeared that the movable span had not moved either up or down since set in the open position in 1992. Although the at grade approach trackage to the bridge had been removed, the tracks on the approach and movable spans were still in place and the bridge ties were found to be in good condition. Collins performed some quick calculations of the weight of the existing span with the ties, rails, bridge end castings and other appurtenances and compared this to the weight of a new riding surface for cars. The calculations showed that the addition weight of the roadway surface was not significantly heavier than the existing track and that the bridge could easily be balanced to accommodate the extra load. Based on the inspections and our initial calculation, Collins' recommendation to CDOT was that the bridge could be rehabilitated and adapted for use as a highway span to shorten the detour for Ford and that the work could be accomplished in a reasonable amount of time without significantly impacting the schedule of CDOT Torrence Avenue Bridge Rehabilitation Project.

Recommissioning

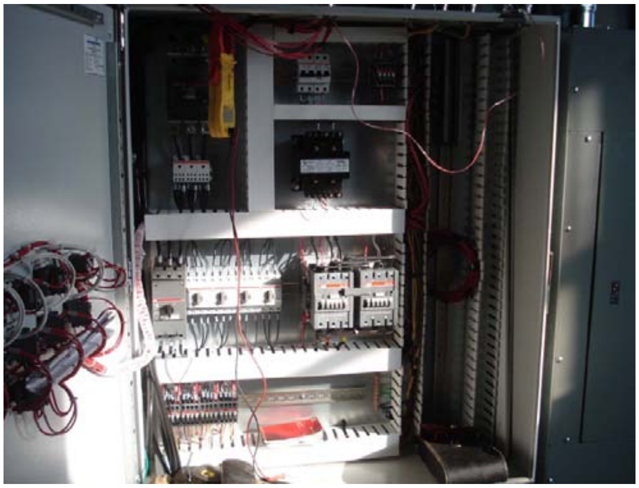
Working with CDOT and CDOT's contractor, F.H. Paschen, Collins developed a scope of work for the recommissioning of the C&WI Railroad bridge. The scope included:

- Modification of the existing open bridge deck that supported the railroad tracks to a closed deck to accommodate vehicles
- Preparation of the approach grades to the bridge
- Rehabilitation of the bridge machinery including draining and refilling of all sumps, dressing of all gear faces, rebuilding of all brake thrusters and dressing of brakes and drums and the inspection of all bridge span wire ropes
- Replacement of all damaged electrical system components and rehabilitation of all motors.

Because the work was on an aggressive timeline and plan preparation was limited, it was decided to handle the rehabilitation work essentially as a design/build project. Collins prepared roadway plans to handle the transitions between the bridge approach fill and the adjacent roadway, the details of the roadway deck and guard rails and details for roadway lighting and protection gates. The Contractor was provided with the existing bridge plans with shop drawings which included information on the bridge operating machinery and the electrical system. Working with CDOT and the Contractor, Collins established a set of operating parameters that must be met for the safe operation of the bridge. The criteria included:

- Provision of interlocks between bridge gates and controls to ensure that gates are closed before bridge operation can commence.
- Provision of interlocks to verify that bridge locks are removed and that brakes are released before the bridge can be opened.
- Control of skew of the movable span.
- Control of the bridge using PLC.
- Operation of the movable span with the main motors and auxiliary motor back up drive.
- Separate power feeds to each tower without the need for connection wires between towers.
- Balance of the lift span with the new roadway configuration.

Collins worked collaboratively with CDOT and the Contractor to review various proposals for the design of the electrical and control system improvements and the rehabilitation of the bridge operating machinery. The first task was to provide access to the bridge towers to allow work to proceed. Since the existing elevators could not be easily rehabilitated, the Contractor elected to install skip hoist elevators to access each tower. The elevators allowed workers to easily access the towers and move the materials needed to perform the necessary rehabilitations. The second task was to stabilize the movable span so that gearing could be disassembled and motors removed as necessary while ensuring that the bridge remained in the open position. Large pipes mounted to the tower machinery room floor were installed through the main sheaves to prevent movement. Additionally, the machinery brakes were lashed closed to prevent any movement. These measures remained in place until the motors and motor brakes could be rehabilitated. As a further precaution against movement, the motors were removed in pairs, main and auxiliary, so that the motor brakes could also be engaged.



New Tower Motor Control Generator Sets

Since there was extensive water damage in the towers and most control wiring had been damaged, it was decided to replace all of the motor generator sets and connecting wiring. The new motor generator set basically were replacement "in kind" of the existing water damaged equipment. The work generally followed the existing plans with necessary upgrades to comply with current codes. It was suspected that all electric motors were likely water damaged either through roof leakage or excessive humidity. All motors, including thruster motors, were meggered to determine if there were shorts and all but one motor was found to have a short. The motors were removed and rewound as necessary to ensure that they would operate properly. New electrical feeds were brought to each side of the bridge to power the motors. All wiring connecting the motor generator sets to the motors and other equipment was replaced in-kind.

Unlike the original bridge where electrical cables provided a physical link between the towers for control, the new control system monitors the speed of the motors and position of the movable span remotely via Ethernet and controlled directly from the bridge tower. New resolvers were employed to monitor relative position of the north and south ends of the span. Whenever the span was more than two feet out of skew between the north and south ends of the span, the motors would cut out and brakes were set. The operator could then bump each tower motor individually to bring the span back into level before resuming the raising or lowering operation. In actual operation, it has been found that the bridge movable span generally stays in relatively good vertical skew. A new control panel was installed in the bridge house to control the bridge. This panel uses touch screen technology to control all operation of the bridge.

Reducer Gear before Rehabilitation

The mechanical work was relatively simple compared to the electrical work. All gear boxes were opened and drained of oil, inspected and refilled. Where gearing was found to be rusted, the teeth were cleaned and lubricated. All grease fittings were cleaned and new grease pumped into the bearings until grease could be seen flowing from the bearings. The main lift cables were inspected for deterioration and then cleaned and greased. The span locks were rehabilitated to ensure reliable operation. Brakes cylinders were dressed and new pads installed. Brake thrusters were rebuilt to ensure reliable operation.

Special attention was given the balance of the movable span. Providing a closed deck for the vehicles would significantly increase the weight of the movable span. Working with the Contractor, Collins devised a plan to add weight to the counterweight boxes to maintain the balance of the bridge. Concrete jersey barriers were used to provide the additional weight to the counterweights before the bridge could be lowered. No work could begin on the movable span until it was lowered to the closed position and locked. This meant that all electrical and mechanical work had to be completed before the span could be moved. Electrical and mechanical work started in August of 2011 and was completed by mid-November.

Collins established a procedure for the lowering of the movable span. The procedure involved marking the tower guideways at five foot intervals to verify that the movable span remained in skew when lowering. Engineers equipped with two-way radios were stationed in each tower and to watch the span movement. Span position was called out in five foot intervals and the bridge was to be stopped with brakes set should the span be more than two feet out of skew. The initial procedure for moving the span involved setting then releasing the motor and machinery brakes. The span was observed to see if there was any span movement. If no movement was observed, then power was applied to lower the bridge span in approximately five foot increments. The span was to be lowered ten feet, the brakes set and the span stopped. The span would then be raised to the fully open position to verify that the span could be controlled. Motor amp readings were taken to verify that the amp draw for lowering was approximately equal to the amp draw for raising.

With all controls in place, the motors were given power and bumped. To everyone's great relief, the span started to move smoothly down. The span was gradually lowered teen feet verifying that the bridge span did not go out of skew and then raised back to the fully opened position. The amp readings showed that the span was in good balance. The procedure was then repeated bringing the span down 20 feet, then raising to the fully opened position. After bringing down the span 40 feet and verifying that the span could be safely raised, the span was brought down to the closed position. There were some initial problems with seating the span, principally due to the presence of water in the air buffers. Once the bridge was seated and locked into the closed position, work could begin on converting the open deck railroad structure to a closed deck bridge. The existing rail and end castings were removed and temporary jersey barriers installed

Installation of timber roadway decking on existing ties, approach spans

on the span to maintain balance until the asphalt topping could be installed.

Collins recommended installing 2 x 8's at a 45 degree angle to the existing railroad ties on the approach and movable spans and lagging the 2 x 8's to the ties. Timber curbs were then installed and a 2 ½ inch asphalt topping applied to serve as roadway. Since the bridge would only be used by Ford, two single lane paths were created, one for each former track position on the bridge. Steel guard rails were installed at the ends of the ties to prevent the cars from running off the roadway on the bridge. To provide safety for vehicular traffic, lighting was added to the roadway and barrier gates were installed at each end of the bridge. The barrier gates are interlocked with the movable span to ensure that the bridge cannot be opened without the gates in the closed position. Similarly, the gates cannot be opened until the bridge is fully seated and the span locks are set. Final balance adjustments were made to the counterweights and the bridge was placed into full service by the end of November, 2011. Since placing the bridge into service, there has been little or no problems with the bridge operation.

Conclusions

The recommissioning of the C&WI Railroad Vertical Lift Bridge provided a ready solution to the difficult problem of providing a quick means of accommodating Ford Motor's need to provide a short detour to their marshalling yard north of CDOT Torrence Avenue Bridge. The approximate cost of the work was $3.5 million which included all roadway approach work, new roadway surface on the bridge and approach,