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Design and Construction Engineering for the New ArcelorMittal Rail Bridge over the Indiana Harbor Canal

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Introduction

ArcelorMittal is the world's largest steel producer and the number one steel producer in the United States. ArcelorMittal's Indiana Harbor facility is the largest steelmaking complex in North America. This facility is located on the southern shore of Lake Michigan in East Chicago, Indiana, approximately 20 miles southeast of Chicago. A unique aspect of the plant is that it has facilities on both sides of the Indiana Harbor Canal. To improve plant operations, ArcelorMittal embarked on a project to construct a new rail bridge across the Canal to link facilities on both sides. The connection was needed to allow movement of materials, including hot metal, between adjacent plants to vastly improve efficiency of blast furnace operations.

To engineer the project, ArcelorMittal contracted with URS to perform preliminary engineering, final design, and construction oversight for a new single leaf, rolling-lift bascule railroad bridge. Structural and electrical control systems design was performed by URS's Chicago staff. Bridge machinery was designed by EC Driver and Associates, Inc., a URS subsidiary located in Tampa, Florida.

This paper discusses specific, and in some cases unique, measures taken in design, planning and construction engineering to produce a movable bridge that could be rapidly constructed to exacting tolerances. Topics include provisions for precision alignment of the tracks and treads, float-in erection of the bascule toe section, steel erection to exacting tolerances and bridge commissioning. The unique role of the design engineer as an integral member of the construction team is also presented.

Design

At the onset of the project the following criteria were established for the new bridge.

Design Standards:	AREMA ANSI/AASHTO/AWS Structural Welding Code D1.5
Design Loading:	Cooper E-80 Reichard 300 Ton Capacity Hot Metal Car
Channel Clearances:	90-foot Horizontal Unlimited Vertical Clearance – Span Open


Indiana Harbor Canal

In addition to the requirement to carry the heavy axle loads of the steel mill's hot metal rail cars and freight loading, the bridge was also required to carry the plant's truck traffic. To meet this requirement, a 5-inch galvanized open steel grid deck was incorporated into the design of the timber tie rail deck.

Preliminary engineering included concept plans, cost estimates, construction permitting documents, and coordination with the USACOE and the US Coast Guard during an Environmental Assessment. This early phase was a crucial step in the owner's investment planning and eventually led to project approval by upper management.

The Indiana Harbor Canal is an active navigable waterway that services heavy commercial traffic, specifically frequent barge/tug combinations. Discussions with the USCG established that the channel was to remain open during construction except for an allowed 72 hour closure window scheduled for erection of the bascule span. To facilitate this requirement, it was decided to design the movable span so that it could be prefabricated as much as practical and so that it could be field erected in two major sections to optimize the amount of erection that could be done while avoiding interruptions to the navigation channel.

The bascule span was designed so that the section on the back side of the center of roll (away from the channel), also referred to as the heel section, could be constructed over the bascule pier while the channel remained open to navigation. This allowed for the most time consuming construction activities, such as assembly and alignment of the segmental girders, machinery installation, and counterweight construction, to be performed outside the closure window. Similarly, the toe section, comprised of the portion of the structure, located channel side of the center of roll was designed so that it could be prefabricated off-site and erected using float-in methods. The key element of this approach to construction was the use of a main girder splice, located approximately 4 feet channel side of first position of roll.

Figure 1 shows the basic configuration and geometry of the new bridge in elevation. The movable span is 110 feet long from center of roll to toe. The counterweight is configured overhead and provides 22 feet of vertical clearance above the top of rail. Figures 2 and 3 portray the bridge in cross section on the span and at the bascule pier respectively. The main longitudinal load carrying elements of the bridge are plate girders connected to the counterweight and machinery frame with a tension tie and bracing. The heel section of each main longitudinal member is attached to a curved tread plate with a 25 foot radius. Based on traditional terminology developed by the Scherzer Rolling Lift Bridge Company, the heel section with a curved bottom flange is referred to as the segmental girder, even though in this case it is a single weldment rather than a series of segmented castings. The center to center spacing of the main members is 20 feet.

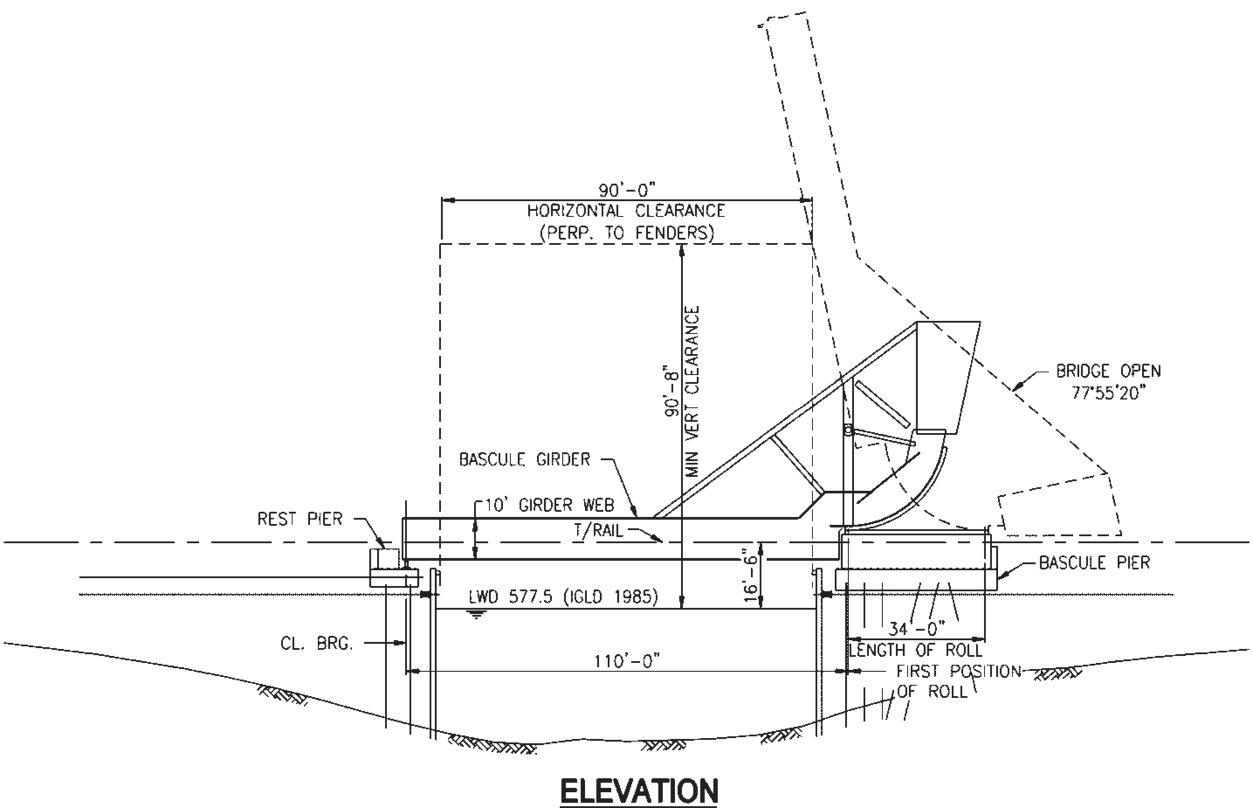


Figure 1

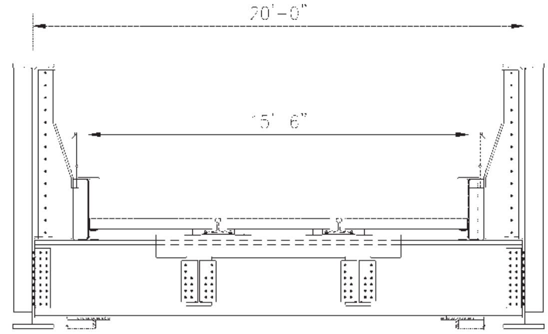
The bascule span design features an open deck plate girder with rolling segmental girders and an overhead counterweight. The counterweight consists of a steel plate shell supported on steel framing that is filled with concrete. The bascule span is supported on a large reinforced concrete bascule pier and rest pier that utilize 120 foot long steel H-piles driven to refusal in bedrock underlying very soft clay.

The bridge piers are constructed inside of new tied-back steel sheet pile enclosed peninsulas that extend roughly 100 feet out into the 300 foot wide canal from both dock walls. These walls were designed for the heavy rail surcharge as well as a 45 foot height of retained backfill. The excessive height of these walls coupled with the poor underlying soil conditions led to the use of lightweight geotechnical fill produced from expanded shale. Cold formed heavy wall sheet piles were used with lengths of 85 foot.

The movable span and associated machinery are controlled by a modern programmable logic controller based control system, operated from a control house on the east shore of the canal. The mechanical system utilizes two redundant 60 HP AC induction motors (used alternately), a four stage central speed reducer, two thruster brakes, and rack and pinion gear sets. Motion of the leaf is controlled by a modern flux-vector drive coupled with each motor.

For a movable bridge to function properly, key elements must be constructed to exacting tolerances. The following are some of the critical dimensional tolerances specified for the ArcelorMittal IHC Bridge:

Dimension	Tolerance
Roll Radius	300” ± 1/16”
Track Profile	Level within 1/64”
Track or Tread Centerline	Parallel ± 0.003’
Centers of Roll	Concentric ± 0.020”
Pinion Column Webs	Perpendicular to Axis of Roll ± 0.005°
Rack Girder Position	Plan Location ± 0.003’
Rack Girder Bottom Flange	Level ± .001’

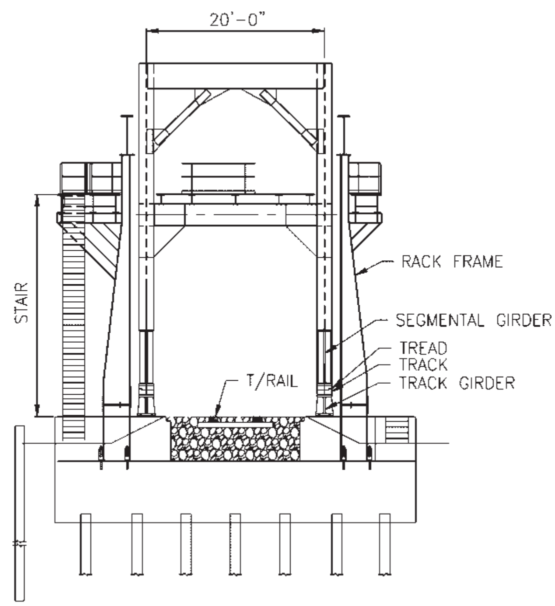


SECTION THRU BRIDGE

Figure 2

A key innovative element of the project was the design of a temporary shoring tower to support the counterweight during shop assembly and field erection. The contract with the structural steel supplier required full shop assembly and alignment of the movable span, including all structural steel, segmental girders with tread plates, counterweight box and machinery support framing. The bottom of the main girders is located 7.3 feet below the rolling track level. The bottom of the counterweight box is positioned 24 feet above the rolling track level. Therefore, the counterweight bottom is 31.3 feet above the low member of the toe section. The height of the counterweight bottom above the top of the bascule pier footing is a similar 33.75 feet. Rather than using different shoring towers in the shop and field a single tower was designed that could be used for both purposes.

The counterweight shoring tower was designed to fit the bascule pier and track girder geometry, and to support the full load of the counterweight and the steel framing of the heel section. It was also designed so that it could be readily jacked from its base for vertical adjustment on shims, or set on rollers for horizontal position fine-tuning. This feature, that enabled small adjustments, proved invaluable in optimizing the alignment of the bascule leaf in the shop prior to final bolt hole drilling during assembly, and again in the field where conditions for re-assembly were more challenging.



SECTION THRU BASCULE PIER

Figure 3

With the four column shoring tower required to carry a dead load of approximately 500 tons, its design utilized robust rolled sections with heavy welded stiffeners at load points and jacking locations. Its self-weight was 15 tons. The constraints of the bascule pier required that it be positioned eccentrically several feet forward from the center of gravity of the applied load, resulting in the two rear columns carrying 80% of the weight. Given the criticality of this temporary structure, the design team decided it should be monitored carefully during counterweight pours to ensure it was behaving as desired. In the field a strain gauge monitoring system was installed with one gauge attached to each flange of each of the four columns near the base. With the weather changing quickly, an additional gauge was attached to a separate unloaded plate for the purpose of temperature corrections to the strain readings. Prior to each concrete pour the estimated column loads were calculated and then compared to actual loads derived from the strains during the pour. This procedure worked well and kept confidence high that the design loads were accurate and the counterweight sized appropriately.

Construction

Engineer's Role

Design and Construction was fast-tracked on an accelerated schedule due to the value the project would bring to plant operations when completed. ArcelorMittal served as their own general contractor and constructed the project with the assistance of a labor and equipment contractor and a number of specialty subcontractors and suppliers.

To ensure the fast-tracked project delivery schedule, the design team provided 8 separate bid packages released in a critical path order in a design-build fashion. After concept phase, the process took 20 months from the time of management's project approval until the crossing of the first train on the completed bridge. The key phases and schedules were as follows.

PHASE	CONTRACT AWARD	FIELD/SHOP START UP	WORK COMPLETED	WORK SCOPE
Marine Work	Jan 2011	March 2011	Nov 2011	Sheet Piling, Bearing Piles, Lightweight Fill, and Protection Cells
Foundations	May 2011	Sept 2011	Nov 2011	Bascule Pier and Rest Pier Concrete Work
Superstructure Fabrication	Jan 2011	April 2011	Nov 2011	Bascule Span Steel Fabrication and Shop Assembly
Machinery Fabrication	Feb 2011	April 2011	Aug 2011	Shafts, Gears, Gear Boxes and Bearings
Track & Rail Work	Feb 2011	Sept 2011	March 2012	Track beds, Ties, Rails, Miter Joints, and Ballast
Electrical Equipment Supply	April 2011	May 2011	Sept 2011	Control System, Motors, Drives, and PLC
Electrical Installation	June 2011	Sept 2011	March 2012	Equipment installation, Wiring, and Conduit
Bridge Erection	July 2011	Dec 2011	March 2012	Steel Superstructure, Counterweight and Machinery Installation
Float - In	July 2011	Jan 2012	March 2012	Transport Shop Erected Toe Section from Shop to Site to Barge. Float span into position and assist erector during final connection.

Throughout construction the engineering team provided typical designer functions such as shop drawing reviews and responses to requests for information. However, the distinctive nature of this project, including the fast-track schedule and method of contracting, required the engineering team to take on a unique role. To best meet the needs of the owner, the engineering team functioned much more as an extension of the owner's staff than is typical. The engineering team became fully involved in steel fabrication inspection, shop test witnessing, assembly sequencing and field oversight of structural, mechanical and electrical installations. Engineers from the design team were embedded with the contracting team during several months of critical field erection and shop assembly. As the project evolved, the engineering team performed a number of construction engineering functions including preparing detailed balance calculations, performing strain gauge balance instrumentation, designing fabrication and erection falsework, and preparing detailed erection procedures for a number of key activities unique to movable bridge construction, including those related to toe assembly float-in.

Construction Team

The following firms contributed to the construction of this project:

ArcelorMittal USA, East Chicago, IL – Owner and General Contractor
URS, Chicago, IL & Tampa, FL – Construction Engineering
Superior Construction Co., Inc., Gary, IN – Labor and Equipment Contractor
Industrial Steel Construction, Gary, IN – Steel Fabrication
Production Tool Co. Chicago, IL – Shop Machining

DLZ Engineers, Drillers, Surveyors – Precision Surveying
American Marine Constructors, Inc., St. Joseph, MI – Pile Driving, Sheeting & Filling
Tranco Industrial Services, Inc., Burns Harbor, IN – Track and Rail
EMCOR Hyre Electric Co. Highland, IN – Electrical Installation
LML Automated Systems, Inc., Burns Harbor, IN – Electrical Equipment
Mammoet USA, Rosharon, TX – Float-In Equipment and Operation
GPL Industries, Inc., Thornton, IL – Shop Machining
In-Place Machining Company, Milwaukee, WI – Field Machining

Construction Plan

The engineering team worked with ArcelorMittal, Superior Construction and Mammoet to develop a detailed erection plan for the bridge aimed at meeting the allowed channel closure window while also achieving accurate dimensional control of the movable span. The resulting plan included general procedures and specifications for shop fabrication and assembly of the following items:

- Forging and machining treads and tracks
- Fabricating track girders
- Fabricating segmental girders
- Numeric roll testing of the mating tread and track pairs
- Fabricating machinery
- Fabricating structural steel of the toe and heel sections of the movable span
- Field installing and aligning the track girders
- Erecting and aligning the heel portion of the bascule span
- Counterweight construction and concrete unit weight testing
- Machinery installation, alignment and testing
- Erecting bascule span toe section
- Initial bridge operation
- Final testing and alignment
- Final bridge balancing

Shop Fabrication

The curved tread plates, segmental girders, track forgings and track girders were machined using a horizontal milling machine. The radius on the tread plates and flanges of the segmental girders was achieved using Computer Numerically Controlled (CNC) circular interpolation. Verification of dimensional control of these components was conducted while the element was still set up on the milling machine. Each pair of matching tread plates and track forgings was measured and a numeric roll test performed to confirm the relative positioning of the track lugs with the tread lug pockets.


Shop Assembly on Shoring Tower

Shop fabrication and complete bascule span preassembly was performed by Industrial Steel Construction, Gary, Indiana. The bascule leaf steel was fabricated with camber to offset dead load deflection. In the shop, the leaf was fully assembled in the cambered position. In this condition the tip of the toe section at the farthest point from the center of roll was cambered 2.5 inches upward and the girder incrementally blocked along its length to follow the design camber shape. At the main girder splice there is no bending stress present in the shop with the splice plates aligned. Similarly, the tension strut is under no load with the connection plates aligned at the connections to the girder and the portal framing.

At shop assembly critical fabrication dimensions were checked progressively throughout assembly using total station surveying equipment, standard steel tape measure, and/or a FARO Laser Tracker. The FARO Laser Tracker is a state-of-the-art interferometer (IFM)-based measurement system that provides three dimensional linear and positioning measurements with a tolerance in the range of ±0.001 to ±0.004 for elements the size of the bridge heel section.

Using the FARO enabled detailed examination of alignment not previously possible with traditional surveying and measuring equipment. When initial FARO surveys indicated deviations from the specified tolerances for the radius of the curved treads and positioning of pinion bearing bore hole at the center of roll of both girder assemblies (segmental girder, pinion column and associated bracing), the engineering team was at first skeptical of the accuracy of the measurements. After all, the radius of the tread plates and bore hole had been accurately machined and the tolerances verified in the shop. To confirm the accuracy of the measurements, two independent sets of measurements were made using the FARO with the shop temperature at a relatively constant value. Comparison of these measurements indicated very good repeatability with values consistently matching within a few thousandths of an inch. In addition, measurements were confirmed with a calibrated steel tape.

Once it was established that the method of measurement was reliable, the dimensional discrepancies became a major focus throughout shop assembly. Challenges were created by temperature variations as the work progressed through the fall and the shop temperature varied from 65 to 25 degrees Fahrenheit.

Tracking the radius of the curved treads measured with the FARO and calculating a best fit center, it was determined that the pinion bore holes were not located at the center of rotation within the specified tolerance. Through a series of checks it was determined that the bore holes were out of position by just under 9/64". At that point in fabrication, with the girder assembly, pinion column and associated bracing fully assembled and all bolt holes drilled, it was decided to relocate the bearing bore holes rather than try to reposition the columns. The specified fit of the bearing housing in the bore would be sacrificed in favor of more concentric and accurate center of roll locations.

From the outset the plan had been to wait and machine the webs of the pinion columns after shop assembly measurements, such that a truly perpendicular (to the axis of roll) mounting surface could be provided for the pinion bearings. Therefore, after the shop assembly was completed the pinion columns were shipped to GPL's machine shop and the bores were repositioned in the same set up that the webs were machined.

Originally the bearing was to have an LC6 fit in the column web for the purpose of locating the bearing. In repositioning the bore hole, it was enlarged and offset such that the hole became slightly irregular. To compensate, scribe lines were established to define the bearing centerline. Per the original design, turned bolts were used to fix the position of the bearing.


Pinion Column Web Machining

The web machining was done using a horizontal milling machine. Prior to disassembly and shipment to GPL, the webs of the pinion columns were surveyed with the FARO and a series of fixed points on the webs were marked for reference. These points were used in set up on the milling machine to position the column so that the web would be accurately cut perpendicular to the precise axis of roll determined during shop assembly of the bascule leaf. Given the importance of the desired results of this corrective procedure and the aggressive schedule, members of the design team directed this machine work face to face with the machine operator.

Field Erection

Field erection proceeded in the following general sequence:

1. Construct sheet pile peninsulas, backfill, and drive bearing piling
2. Construct bascule pier and rest pier concrete substructures
3. Establish survey control points on the concrete piers
4. Mount the 34 foot long track girder assemblies, including track forgings
5. Install the counterweight shoring tower
6. Erect the heel section of the bascule leaf on the tracks and counterweight shoring tower
7. Erect the rack frames
8. Install the shop assembled counterweight steel box
9. Install the machinery
10. Pour the concrete counterweight (four separate lifts)
11. Float in the toe section on barges and connect to the heel section
12. Complete the assembly and track work and test

When the track girder assemblies were being positioned on the bascule pier and survey checks performed, it was discovered that both tracks had a sweep of roughly 0.10 inches in them that had not been evident in the shop. Several attempts to remove the sweep by adjusting the anchor bolts and leveling bolts prior to grouting were not successful. Even heavy steel angles bolted to the pier, and used as jacking rails, could not secure the large forces needed to hold the track girders straight. In the end, the track assemblies were returned to the machine shop to be checked and corrected.

The sweep in the tracks appears to have resulted from the shop's process for mounting the 6-inch thick track forgings to the 2-inch top flange of the track girders. Prior to assembly, the forgings were machined and verified to be straight and true. They were then assembled to the track girders in a horizontal milling machine, where final holes were drilled through both parts and turned bolts installed while the assembly laid sideways in the machine. The 34 foot long track girders were not adequately supported in the center during this process. Despite the large stiffness of the girder about its weak axis, it was in a deflected shape under its own weight when the track plates were drilled and mounted. In the same set-up, final dimensions were checked and showed the tracks to be straight. Scribe lines were then cut, while the assembly was still in its sideways position in the mill. Once removed and stood upright the girders un-deflected, causing the track plates to sweep horizontally, undetected until field installation.


Track / Track Girder Dowel Pin

Shop correction of the track/track girder assembly sweep involved replacing the turned bolt connection between the track forging and flange plate. With the girder in the upright position, the 1.25-inch diameter turned bolts were removed and the girder sprung to its un-deflected shape, validating the assumed cause of the problem. Removing the deflection from the track girder and track left the original turned bolt holes misaligned in many cases. The hole overlap varied from 0.10 inches at the center of the girder to zero inches at the ends. To correct this, the turned bolts that did not fit their original holes were replaced with either dowel pins or high strength bolts. Custom made 1-5/8” diameter dowel pins were distributed over the length of the track to permanently position and secure the alignment horizontally. In between the dowel pins, high strength bolts were installed to clamp the track to the girder. The dowel pins, made of quenched and tempered 4140 steel (153 ksi tensile strength), were installed with an FN2 fit by shrinking in liquid oxygen. The work was performed on a horizontal milling machine using a right angle head so that the track girder was positioned vertically, rather than horizontally as had been the case initially. Care was taken to support the track girder at several points along its length to limit deflection.

Once the track/track girder assemblies were straightened, they were reinstalled and aligned on the bascule pier. The assemblies were positioned to align the tracks parallel to each other, level, and to position the first position of roll on each track at the proper longitudinal station.

Erection of the heel section was performed in a specific sequence aimed at achieving the desired alignment. Steel erection progressed in the following general manner:

a) Position steel members(s) using a crane,
b) Secure connection(s) with drift pins,
c) Stuff all bolts in the connection,
d) Snug tight a few bolts if needed to achieve tight steel,
e) Check alignment via surveying,
f) Make adjustments if needed to align,
g) Tension bolts with alignment confirmed.

Alignment surveys were performed to verify that the treads were aligned with each other and with their mating tracks. The position of the center of roll relative to the established first position of roll on the tracks was also carefully monitored. Adjustments were made by positioning the counterweight shoring tower and by use of chain hoists to pull the pinion columns into a plumb position and hold them in alignment while connection bolts were tensioned.

To facilitate erection and alignment of the heel section, the structure was designed with a pair of W40x149 cross beams connecting the segmental girders together and supporting the counterweight box. The shoring tower was designed to fit under these beams and be connected temporarily to the bottom flange of the W40s. Therefore, in both shop and field erection, the W40s were set on top of the shoring tower, positioned and locked in place with temporary bolts. The rear of the segmental girders was then connected to the ends of the W40s and secured at the design elevation and position (vertical and horizontal). The W40s, in conjunction with the shoring tower, provided a convenient support system for the back end of the segmental girders. The front end of the segmental girders was set on the track forgings with the first position of roll aligned. The jacking and positioning provisions designed into the shoring tower enabled precision alignment of the heel assembly until the connections were fully tensioned.

After the heel section of the bascule span and rack frames were erected and their alignment was verified, the counterweight was constructed. The machinery and bridge electrical power and control was installed on the heel section. Machinery was spin tested and the brakes verified before the racks were installed.

While the heel section was being erected and prior to the channel closure, the toe section was shipped from the shop as an assembly and moved onto a barge. The toe assembly, weighing approximately 225 tons, was placed on a pair of Mammoet's self-propelled transporter trailers. The toe assembly was aligned on the longitudinal axis of the barge with the transport trailers spaced at approximately 36 feet apart and oriented perpendicular to the longitudinal axis of the bridge. Each transport trailer has six pairs of independently controlled wheel bogies that allow the load to be maneuvered with precision. The transporters are also capable of controlled lifting and tilting to position and align the load.

Prior to moving the toe assembly into position, jacks and adjustable hard wood blocking were positioned on the rest pier and on the steel sheet pile enclosed peninsula just channel side of the bascule pier. Rest pier jacks were set on hardwood blocking on the bridge seat. Bascule pier jacks were set on steel mats to distribute the load between the peninsula sheet pile wall and bascule pier footing.

Once the channel closure was implemented, the barge and toe assembly were moved into position in the channel just north of the bridge location and secured in place. Using the transport trailers, the toe assembly was then rotated 90 degrees, lifted vertically and walked forward to align with the heel section. Once in position, with the main girder splice aligned, the leaf was adjusted with the transport trailers so that the splice plates could be installed and a number of drift pins driven in the bottom flange splice plate. The toe assembly was then set on the jacks at both ends. Using the jacks, the toe assembly was positioned so that the remainder of the splice connection could be pinned and stuffed with bolts.

A key element of the erection procedure was to properly address camber and deflection so that the finished structure conformed to the design geometry and unanticipated deformations were avoided. Throughout heel section erection and counterweight construction, the position of the center of roll was monitored relative to the first position of roll on the track forgings. Elastic deformation in the counterweight shoring tower and resulting movement of the center of roll was anticipated and adjusted for by initially setting the counterweight a little high and by jacking and shimming the tower as needed.

Pivoting Toe Assembly on Barge

The erection procedure was developed to recreate the shop alignment at the time the field splices were connected. However, in the field there is no shop floor to incrementally block the girder into its cambered position. To compensate for this, the tip of the leaf was positioned at a height of 4.5 inches above its final position when floated in and set down on jacks. This accounted for the vertical camber at the tip and the rotation of the girder at the splice which was created in the shop by the incremental blocking. During float-in, this position was held until the main girder splice was secured with enough drift pins and bolts to prevent movement. Once secured, the girder tip was lowered by jacks until the tension strut could be connected.

Aligning Girder Splice

After the tension strut was connected, but before the counterweight shoring tower could be removed, a series of tests were made to confirm alignment and the balance condition. Alignment of the bridge centerline, first position of roll and treads was performed using total station equipment. Although detailed balance calculations had been performed, a step by step procedure was implemented to confirm that the span was toe heavy and that the machinery was capable of holding the imbalance with adequate reserve for wind loads. The span balance field tests included the following steps.

a) Chain hoists were installed at the toe of the bascule span to hold the toe down to the rest pier.
b) The bolts connecting the framing under the counterweight to the shoring tower were removed.
c) The toe of the span was jacked down to rest in its final position (bridge lowered) on the load shoes. This effectively removed the dead load camber and tensioned the tension tie.
d) The strain in the counterweight shoring tower columns was monitored, confirming that the counterweight had been lifted some amount.
e) The brakes were applied.
f) The shoring towers were removed.
g) The chain hoists at the end were released slowly to create slack – the span tip lifted but only slightly – these results were not conclusive.

h) The chain hoists were further released and the span tip lifted a little more then stopped without applying the brakes indicating the span was near balanced at this position.
i) The span was lifted to approximately 7 degrees from fully closed using the drive machinery operated at creep speed. With one brake released the span did not move. With both motor and machinery brakes released the span drifted down slowly. This indicated that the span was in a somewhat toe-heavy balance condition, but well within the capacity of the drive system and brakes.

The span was raised slowly at creep speed through a series of positions and stopped at increments of approximately 5 degrees. At each position, the brakes were released one at a time to confirm that one brake (motor brake) was capable of controlling the unbalanced load. This allowed the capacity of the second brake (machinery brake) to be available in the event of wind gusts. Clearances between moving parts including the rack and pinion backlash and the track lug to tread pocket clearance were also checked at each position. Dykem Steel Blue layout fluid had been applied to the rack teeth and track lugs to allow contact patterns to be clearly observed. Initial rack/pinion measurements indicated that adjustment by way of shimming the racks would need to be performed to achieve the desired backlash. The track/tread alignment was confirmed as acceptable.

Following the initial operation of the bridge, the bridge was put through a number of test operations and the racks were shimmed to set the rack/pinion backlash. Electrical installation was completed including setting of limit switches. The span locks, centering device and connecting track were completed. Once all equipment was set and adjusted, full functional testing of the bridge was conducted. After functional testing the bridge was load tested with one of ArcelorMittal's engines and subsequently with various capacity hot metal cars.


First Engine across Bridge

Summary

ArcelorMittal, the world largest steel producer, embarked on a project to construct a new rail bridge across the Indiana Harbor Canal to link facilities it owns and operates on both the east and west sides. The new rail connection allows movement of materials, including hot metal, between adjacent plants, thereby greatly improving efficiency of operations.

To accomplish ArcelorMittal's objectives, URS designed a new rolling-lift bascule bridge with overhead counterweight. Specific and in some cases unique measures were taken by the owner and design team to produce a movable bridge that was rapidly constructed to exacting tolerances. Innovative design details, such as a main girder field splice, were combined with innovative construction methods, such as float-in erection of the toe assembly and design of a special counterweight shoring tower, to meet the demanding construction schedule and satisfy the USCG's requirements for maintaining marine traffic.

Working with the owner as an extension of their staff throughout the construction process, the engineer developed detailed construction procedures that were implemented to achieve the exacting construction tolerances necessary to produce a well-constructed movable bridge. These processes evolved with the project and were adapted to various challenges which occurred during fabrication and erection. This approach proved valuable as it allowed early identification of construction issues and provided a flexible format capable of adjusting to challenges. In general, the detailed procedures that were followed led to excellent results. In cases where construction tolerances were not initially met, processes were adapted or supplemented to produce the desired results.