Reconstruction of the Historic Animal Bridge

PROJECT OVERVIEW

The Animal Bridge was constructed in 1904 and is listed as an historic structure on the National Register of Historic Places. It was a single, 46 feet elliptical arch span of cast-in-place concrete faced with granite and sandstone. The bridge was and is ornamented with obelisks and carved stones, the most unique being hippopotamus and rhinoceros heads which give the bridge its name. The Animal Bridge is located in historic Jackson Park in Chicago, Illinois and carries Coast Guard Drive over a channel between two harbors.

The reconstruction of the Animal Bridge is part of a larger $162 million project to reconstruct 6 miles of roadway along Lake Michigan in Chicago, Illinois. South Lake Shore Drive runs from McCormick Place on the north to 67th Street on the south. The roadway was intended as a scenic "parkway" whose light traffic would not impede access by pedestrians to lakefront amenities. As the city and its suburbs grew and automobile traffic increased, Lake Shore Drive lost this purpose and was widened substantially, becoming a major, six-lane artery used to move north-south traffic to city destinations. The road over the Animal Bridge had been widened so much that no pedestrian access was allowed.

South Lake Shore Drive is located wholly within Burnham Park and historical Jackson Park with no official right-of-way. It is operated under the jurisdiction of the Illinois Department of Transportation (IDOT). The pavement had deteriorated and lots of unsightly guard rail and yellow barrier wall existed along the road. In addition, the lakefront was cut off from easy and safe pedestrian access. In Jackson Park, the lakefront could only be reached by means of two deteriorated, unsightly overpasses and one signalized intersection. Based on this, the project was designed to improve conditions and Reconstruction of the Animal Bridge was a key, but complicated, component.

DESIGN PARAMETERS FOR THE NEW BRIDGE

WIDENING: The Animal Bridge is located just north of the major intersection of Coast Guard Drive, Jeffery Boulevard, and Marquette Drive. The intersection had high accidents do to heavy traffic, large turning movements and poor site lines (do to a sharp drop in elevation from the bridge to the intersection). To reduce congestion and improve safety, the approaches needed to be widened and the profile raised.

The Chicago Park District maintains the Lakefront Bike Path between Lake Shore Drive and the shoreline, which is a major attraction in the city. Since there was no pedestrian access across the Animal Bridge, this Lakefront Bike Path crossed the harbor channel over a small unsightly pedestrian bridge next to the Animal Bridge. Bicyclists had to dismount to cross.

With these criteria, the new bridge needed to be widened to accommodate the new traffic lanes, the new Lakefront Bike Path, and a pedestrian crossing on the opposite side of the bridge. The width was nearly doubled from 67 feet to 120 feet.

RELOCATING: Because of the poor access across South Lake Shore Drive, five new pedestrians under passes were proposed in Jackson Park. One of these underpasses was to be placed adjacent to the Animal Bridge; but, because of the close proximity to the intersection, the underpass could only be 10 feet wide. This was unacceptable from a safety point of view. We determined that the underpasses needed to be a minimum of 25 feet wide. To accomplish this, the Animal Bridge was move 20 feet to the north. This also required the channel to be relocated also to line up with the new bridge.

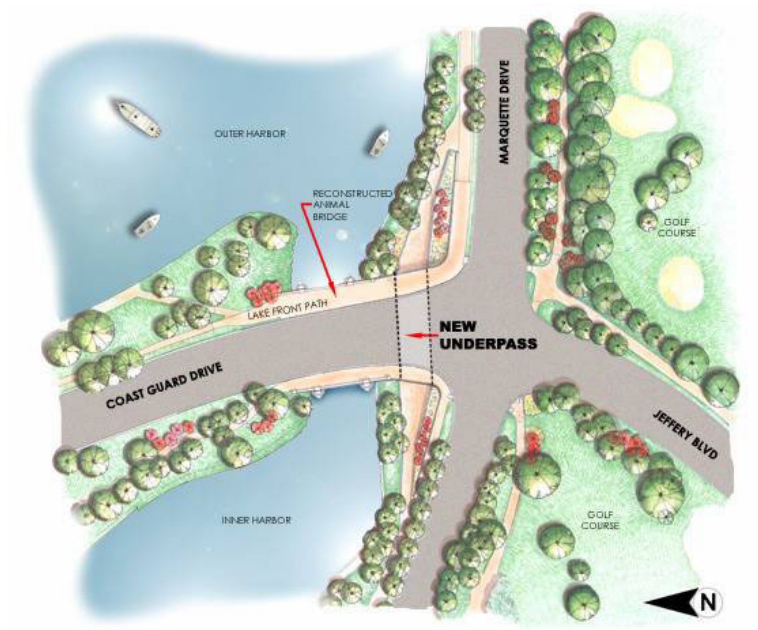

Figure 1 Site Plan

HISTORIC SLOPES: Because the bridge is historic, the grass slopes along the wing walls had to be maintained, but with the new underpass located immediately adjacent to the Animal Bridge, this could not be done. To mimic the historic slope, the façade of the new underpass was covered with a stainless steel mesh that was installed in the shape original grass slope. Boson Ivy was planted at the bottom of the wall. This ivy will grow only were the wire mesh is located.

Figure 2 Elevation (note historic slope on left)

STAGING: The overall South Lake Shore Drive project had to be completed in 2 ½ years so that it could be used as an alternate route when the Dan Ryan Expressway was reconstructed. This required construction work to begin as soon as possible. In addition, boat traffic needed to be maintained on the harbor channel during the boating season (May 15 to October 15 in Chicago) and roadway traffic needed to be maintained as long as possible over the bridge. Because of these constraints, the bridge was reconstructed under three contracts.

In the Advance Work Contract, the stones were removed, cataloged, cleaned and stored. Without the stones, the sides of the bridge were grouted to prevent the roadway from sloughing. Road traffic continued across the bridge. In the Mainline contract, the existing bridge was demolished (most of the bridge collapsed in the channel in one large piece), the new bridge and underpass were constructed, and the stones replaced. In the Architectural Contract, the underpass received the stainless steel mesh.

PRECAST STRUCTURES: With the fast pace of the project, the bridge needed to be done quickly and during winter. It was decided that Conspan precast concrete arches would be used for 3 of the underpasses because of their ease of construction. However, the Animal Bridge had a unique elliptical shape. After consulting with Egyptian Concrete (manufacturer of the precast arches), it was determined that the unique shape could be duplicated with a special set of form work. This allowed the Animal Bridge to be constructed as fast as the adjacent underpass.

EARLY DEVELOPMENT OF JACKSON PARK

The first formal plan for what was to become Jackson Park was put forth in 1871 by Frederic Law Olmsted and Calvert Vaux. Situated on nearly 600 acres of land on the shore of Lake Michigan, south of the city of Chicago, the site was a marshy series of sandbars with scrubby vegetation that the planners initially felt was not well suited to the development of a park. The design they developed, however, made the most of the water features of the site. A cobblestone beach was proposed along the shoreline. A long pier headed by a belvedere would accommodate the passenger boats bringing people to the park from the center of the city seven miles north and would mark the entrance to a harbor created from a large inlet. A series of lagoons would be dredged from the marshes with the soil used to create naturalistic islands and shorelines that would be lushly planted with native trees and vegetation. Winding roadways would circle the lagoons and a lakefront drive, later to become Lake Shore Drive would curve along the harbor and cross the channel between the harbor and the south lagoon. It would be more than thirty years before the bridge that was planned here would be realized.

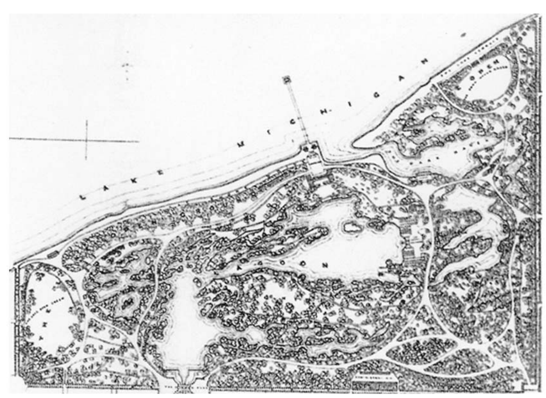

Figure 3 1871 Plan

The Great Fire that destroyed much of the city in the autumn of 1871 interrupted the development of the park. By 1890 the land had been annexed to the city but only a small part of the plan had been carried out in the northern part of the site. Chicago had just won the right to host the World's Columbian Exposition, and at the urging of Olmsted, the Jackson Park site became the location for the great fair. With his partner Henry Codman and the collaboration of local architects Daniel Burnham and John Root, a plan was laid out that combined a grand formal basin and terraces with the development of the lagoons and islands envisioned in the earlier plan for the park. These water features would be the setting for the great Beaux-Arts fair pavilions and monumental artworks that would be designed by the pre-eminent artists, architects and engineers of the day. The Exposition would also bring the designer of the Animal Bridge to Chicago and would prove influential in his concept for the structure.

Figure 4 World's Columbian Exposition

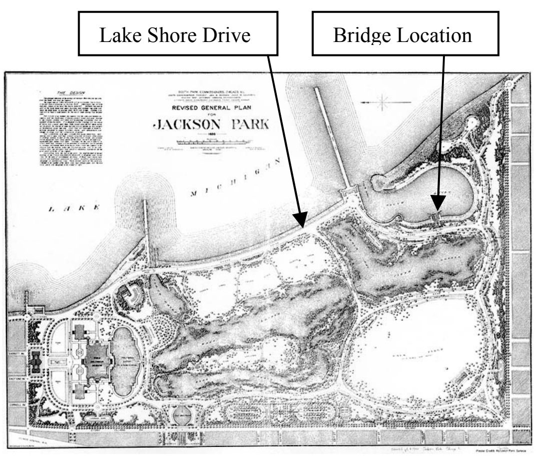

Figure 5 1895 Plan

After the Exposition ended most of the buildings would be removed and the site would revert to a park. The Olmsted firm was retained to produce a new plan in 1895 that incorporated many of the features of the original plan, including the lakefront drive and bridge over the south channel. This plan was largely implemented over the next ten years.

HISTORY AND DESCRIPTION OF THE ANIMAL BRIDGE

The South Park Commission solicited proposals in early 1903 for the design of the bridge. The advertisement that appeared in Inland Architect described the requirements as follows:

> The bridge is to carry a forty foot macadam driveway and two walks, not less than ten feet in width each, over the entrance from the harbor to the south lagoon, and shall not cost to exceed $35,000. There shall be a clearance over the water in the center of the opening or openings of thirteen feet when the water is standing one foot above city datum. It is desirable to keep the grade of the driveway as low as may be consistent with a suitable design and the requirements as to clearance over the water. A substantial and durable is desired, one which will require the minimum expenditure for maintenance, and of suitable strength to carry satisfactorily the greatest traffic which may come upon it. Whether of one or more arches or openings, there

> shall be not less than forty nor more than fifty four feet of clear waterway altogether and no one opening shall be less than eighteen feet wide at the water line. All plans and elevations shall be drawn to a scale of four feet to the inch. A half-plan, cross section and elevation shall be shown. Every design submitted shall be accompanied by a general description of the character of the bridge proposed, indicating the materials to be used, and an estimate of the cost. Should any design be accepted by the South Park Commissioners, the maker will be employed to make detailed plans and specifications for the bridge and will be paid therefor two and one-half per cent of the cost of the bridge. The Park Commissioners reserve the right to reject any or all designs. The designs must be submitted not later than 2 o'clock P.M. Wednesday, March 18, 1903, at the office of the Commissioners, Fifty-seventh Street and Cottage Grove Avenue.[i]

Fourteen proposals were submitted and on March 28 the design by Peter Weber was accepted. Weber was a German-trained architect who came to work on the World's Columbian Exposition for Daniel Burnham's office in the early 1890's. He established his own small practice in 1900 and worked primarily on commercial buildings. Although his buildings and projects are conventional by the period's standards, they exhibit a solid grasp of historical styles and a fondness for ornamentation. Weber's plans were completed and bids were received in short order, but because they were over budget, the project was reissued including alternates for different types of stone. In February 1904 Thomas E. Hill and Company was awarded the contract to construct the bridge for $37,321. Their bid included stones supplied from Minnesota – St. Cloud Granite for the cutwater bases with Kettle River Sandstone cladding the sides of the bridge above. The bridge was constructed that year for a final cost of $40,085 according to the Park Commission's annual report.

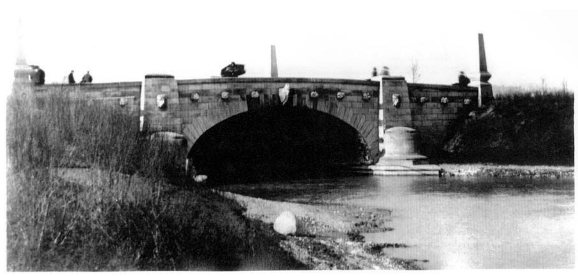

Figure 6 1905 Photo

The bridge was designed as a single span elliptical reinforced concrete arch. The overall length of the bridge is 117 feet, and the span is 46 feet with the concrete 18" thick at the center. The vertical height of the arch is 10'-6" although the height above the water is approximately 15 feet. The bridge is 62 feet wide. Each abutment is supported on 116 oak piles that were specified to be 12 to15 inches in diameter and driven to a depth of 29 feet below datum, or "to a depth that satisfies the engineer".

Concrete specifications were very thorough with a greater percentage of stone to Portland cement called for in the mix for the foundations than for the concrete above the water line. The concrete was to be poured in longitudinal sections, set in 6" layers starting as both sides of the bridge and working continuously to complete the section, working night and day if necessary.[ii],. Surfacing of the arch soffit was called out to have a 1" thick layer of concrete made with granite screenings, in order to harmonize with the pink granite base and sandstone facing. The specifications, however, do not mention concrete reinforcement. We know from shop drawings that the steel reinforcing was designed and supplied by the Trussed Concrete Steel Company of Detroit. This patented system was developed by Julius Kahn in 1902 and is more widely known for its use in slab and beam floor construction. The system consists of steel bars of several shapes, each having projecting fins. The fins are partially sheared along the center of the bar and are bent up at an angle. They are placed near the inside and outside surfaces of the arch.

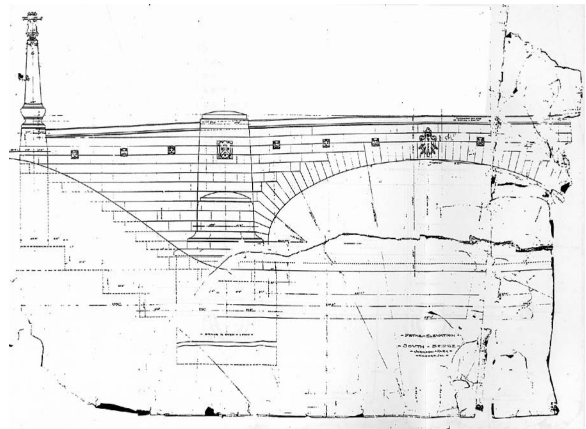

Figure 7 Original Plan

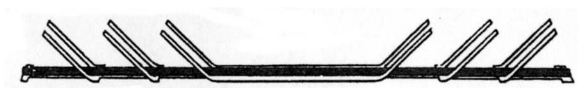

Figure 8 Kahn Bar

The bridge is designed with granite-faced cutwaters at the water line and sandstone facing above. The granite is a widely used medium-grained stone with pink white and gray crystals that is still quarried in St. Cloud Minnesota. The Kettle River sandstone is highly durable salmon colored silica-cemented sandstone. It was used throughout the upper Midwest though rarely in the Chicago area. The quarries closed in the 1930's and a source for replacement stone could not be found by the time the drawings were issued for bids.

Weber designed the bridge in a Beaux Arts style that reflected the influence of the World's Columbian Exposition. Carefully proportioned architectural elements were integrated into the design. Large bull nose capstones top the cutwaters, their projecting ends capped by semi-circular bulkheads that support ornamented pilasters. Obelisks on which light fixtures were to be mounted anchor the four corners of the bridge. The lower walls of the bridge are battered, with the height of the stone coursing decreasing toward the top of the walls. The specifications call for the stone to be axed, four cut work for the soffit of the arch stones, six cut work for the face stones except for the moldings which were to be eight cut work. Although not executed exactly to this specification, the bridge was built with a gradation of stone textures that greatly contributes to the refined character of the structure.

Figure 9-Stone Textures

One of the most notable features of the bridge is the set of carved stone sculptures that reflect the water themes of Jackson Park. A ship's prow with a decorative male figurehead projects from the center of the arch on each side of the bridge. The face of a water deity, his head encircled with water lilies, is centered over each of the projecting abutment pilasters. Six rhinoceros and hippopotamus heads alternate across each side of the bridge. The sculptor is not known. However, the architect's specifications indicate that models would be furnished to the contractor and instruct the bidders to set aside an allowance of $125 for the carving of the sculptures. [iii]

Figure 10 Decorative Figures

DOCUMENTATION

Prior to the disassembly and reconstruction of the bridge the State required that it be documented according to Level 1 Historic American Building Survey/Historic American Engineering Record standards. This is the most extensive level of documentation and consists of measured drawings, archival quality photographs and a narrative description of the history and design of the structure. Luckily the Chicago Park District had design drawings, some shop drawings and the original specifications in their archive. No construction photographs could be located and only a few views of the bridge taken shortly after it was completed could be found.

In addition, the specifications required the contractor to survey the elliptical arch on both ends so that formwork for the new arches could be duplicated.

DESIGN OF THE NEW BRIDGE

The new bridge was widened and relocated to accommodate traffic and pedestrians. The foundations were also lowered because of evidence of scour. The abutment foundations were found to be undermined for approximately 75 feet along the length of the abutment face. The undermining extended approximately 13 feet behind the north abutment face and 18 feet behind the south abutment face. The majority of the timber piles beneath the abutments were exposed, with a maximum vertical exposure of about 4 feet at the midpoint of the abutment.

Because the water table near Lake Michigan, and thus the bridge, was at a higher elevation than the bottom of the excavation, a cut-off wall was installed around perimeter of the proposed work area. The cut-off wall consisted of steel sheet piling from 1 feet above lake level extending a few feet into clay level. The average depth of cut-off wall was 30 feet. The joints between sheet piles were sealed with hydrophilic sealant to prevent water leakage.

To remove the stones, cofferdams were constructed approximately 65 feet on either side of the bridge. Braced steel sheeting system was used to construct cofferdams. Intersections of the cofferdam and existing seawalls were sealed with concrete plugs.

Approximately 350,000 cubic feet (2.6 million gallons) of water was pumped out from the enclosed area. Due to high water table in the vicinity, the enclosed area was constantly being recharged from the water seeping from beneath existing abutments, and pumps were running continuously to keep the work area dry.

After the work area was reasonable dry, false work was erected under the stone arches at either ends and stones were carefully removed and taken away to the storage area. Once the stones were removed, the arches and abutments were demolished. Portions of existing abutments, tied with cut-off wall and seawalls, were demolished in stages since it served as a cut-off wall.

Old timber piles, conflicting with locations of new steel H-piles were extracted. New steel H-piles were driven (372 – 50 feet steel HP12x53 piles with 120 kip design capacity). New reinforced concrete high wall abutments and wing walls were constructed. The abutments were 20 feet high and designed to resist thrust from the precast arches before backfill was in place. Riprap along the channel bed was placed.

Precast concrete arches, supplied by Egyptian Concrete and Conspan, were used as the superstructure. The precast arches were custom fabricated to exactly match the elliptical shape of existing arches. There were 21 – 5 feet wide precast arches that were 12 inches thick at the crown. The precast arches were 46 feet clear span, non-standard shape arch, custom made to match existing stone arch.

Figure 11 Arches under Construction

Despite the fact the construction was proceeding at an accelerated schedule, the work described above took almost seven months. The intent was to construct the substructure, entire superstructure and finish the stone replacement before May 15, the beginning of the boating season, but the work over winter took longer than expected. Therefore, the day before the new boating season, cofferdams were pulled out and the channel was flooded back. From May 15 to October 15, roadwork and construction of wing walls continued with the channel open. At the end of the boating season, cofferdams were installed again. Cut-off walls and seawalls were reconfigured, the enclosed area was drained, false work installed and stone placement work resumed.

Figure 12 Winter Construction

Precast arches did not extend the full width of the bridge. The last 8 feet end widths of the arches were cast-in-place reinforced concrete (4000 psi) to tie the precast arches to the stone arches. The precast arches were used as a template to construct elliptical shaped formwork for cast-in-place concrete and sandstone arches. The area between bottom of the roadway sub-base and arches was filled with controlled low strength material. When completed there was less than 8 inches between top of arch and top of roadway in some locations so that the road profile could be as low as possible and reduce fill at the nearby intersection.

A significant length of existing seawalls were required to be realigned and reconstructed due to the fact that the bridge was moved 20 feet to the north from its original location and a new underpass adjacent to the bridge was constructed. Existing seawalls consisted of combination of stones, timber and sheet pile system. Portions of existing seawalls adjacent to bridge were also severely deteriorated.

The new seawalls are a tied-back sheet pile system. The front row of sheeting is about 35 feet deep, braced by 12 feet deep anchor sheeting located 30 feet behind it. The two sheet pile walls are tied together with anchor rods spaced at 8.25 feet on center.

Along the south side of the bridge, a 4 feet wide concrete walkway is provided along the top of the sheeting.

STONE DISASSEMBLY

Because all the stone was to be reused, it would need to be disassembled and kept track of very carefully. A stone identification system was developed that would allow each stone to be tracked throughout the cleaning and repair procedures and would facilitate resetting in its original position. Plastic encased numbered tags were attached to non-visible surfaces of the stone after they were removed from the wall. Identifying numbers from the original construction were often visible once hidden surfaces of the stone were exposed.

The specifications were written to incorporate requirements for a three dimensional survey of the bridge. This information would be used to develop the geometry for the pre-cast concrete arches for the new bridge and would facilitate the construction of the centering for the stone arches and formwork for the cast-in-place end bays. It was discovered upon completion of the survey that the geometry of the arch and length of span were somewhat different on each side of the bridge. This would require the surface of the cast-in-place side bays in which the arch stones were embedded to be warped, in order to transition to the consistent shape of the pre-cast arches.

Figure 13 Stone Numbering

The contractor was also required to provide close-up photographs of all the stone surfaces in order to document any stone defects and provide a record of the conditions prior to disassembly. The architect's specifications for disassembly of stone structures typically prohibit the use of impact methods such as hammering and chopping. due to the risk of damaging the stone. These methods could not be avoided in the case of the Animal Bridge. Because the sandstone facings served as formwork for the sides of the original bridge with concrete poured directly against the stones, their removal needed to be accomplished largely by saw cutting and breaking off the concrete from behind. The soffit stones of the arch and stone coursing of the wing walls were of two alternating depths that formed a keying action with the concrete,

Figure 1 Stone Disassembly

complicating this work. No metal anchors or supports were used in the original construction. The removal work had to be accomplished on a tight schedule while traffic was maintained over the bridge and W. B. Weis, the stone subcontractor, took great care not to damage the stone.

The granite cutwater stones were easily removed as they were laid up against the previously poured concrete abutment walls and were set without any anchors. The cutwater capstones beneath the bridge presented a small challenge because the project schedule required they be removed while keeping the arched structure above intact, however the concrete arch had been poured over the top of the capstones. Over the course of a weekend, a large diameter circular saw was set up on a temporary aluminum track suspended under the span and the capstones were cut out at a 45 degree angle at the joint with the concrete arch. No part of the stone that would be visible in the reconstructed bridge was removed. The track was subsequently used to support carriers from which removed stones were suspended and rolled to the ends of the rails beyond the sides of the bridge. From this point the stones were lifted by crane to the beds of waiting trailers where they were tagged, secured on pallets and prepared for transport. The stone was taken to a warehouse where it would be stored, cleaned and repaired while the bridge structure was replaced.

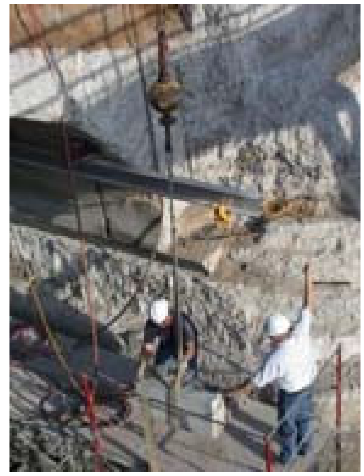

Figure 2 Raising Stone

STONE CLEANING

The bridge presented several cleaning challenges. In addition to being exposed to soiling from a century of vehicular traffic and deicing salts, the bridge was subject to pollutants from the nearby former United States Steel complex. Burning coal in the early 20th century also contributed to the heavy carbon deposits and dark staining that covered the bridge. On top of this were layers of graffiti and painted signs. A cleaning regimen would be developed to improve the appearance of the bridge and to remove the salt and contaminants that were detrimental to the stone and would adversely affect bonding of mortar repairs. Care had to be taken to avoid etching or discoloring the stone or damaging the distinctive surface textures which were remarkably intact after nearly a century. Despite extensive research the architects were unable to locate anyone who had successfully cleaned this type of sandstone. After the specifications were written they were able to travel to Minneapolis to look at buildings constructed of this stone. One had been cleaned “effectively” by sandblasting which had removed the stone surface, destroying detail and exposing swirling grain patterns that were not evident in the tooled stone. The other had been cleaned in the past by unknown means but the results were very uneven.

Figure 3 Cleaning Tests

The decision to clean the stone during storage in the warehouse was made prior to preparing the specifications. A schedule that required the roadway and channel be kept open as long as possible allowed only a short time for any stonework to be done on site. The limitations of cleaning above a waterway with chemicals that might prove detrimental to the environment and the advantages of being able to perform the cleaning and restoration work indoors were also factors in this decision.

Cleaning of the granite was not anticipated to present any difficulties. The stone has been widely used for over a century in the Chicago area and cleaning methods are well established. Preliminary cleaning tests were therefore not performed. . It was possible to conduct only abbreviated cleaning tests on a small sample of the sandstone before issuing specifications. From this and from experience cleaning other sandstones, it was determined that chemical cleaning methods would be reasonably effective, not detrimental to the stone and could be accomplished at moderate cost. Abrasive cleaning methods were ruled out as these can cause surface damage to the stone and are almost always inappropriate for historic masonry. A water-soaking cleaning method was considered but a test conducted on stone that had been exposed to 36 hours of water exposure revealed that a pressurized water wash was just as ineffective at removing soiling as it was on dry stone. The specifications that were developed included a clear water pressure rinse prior to disassembling the stone in order to remove loose surface contaminants and salt. After disassembly the paint would be chemically removed and acidic chemical cleaners would then be applied in concentrations and with dwell times that would be determined by more thorough testing under the conditions that existed in the warehouse. The stone would then be pressure rinsed with clear water. Once reinstalled the stone would also receive a detergent cleaning and clear water rinse to remove mortar smears and droppings.

Once all the stones had been brought to the storage warehouse further cleaning tests were performed on both the granite and sandstone to determine the exact cleaning procedures to be used. The light duty cleaner specified for the granite performed as expected. For the sandstone, a double application of chemical with adjustments to dilution and dwell times was established and a second water rinse was added following drying and brushing off the stone, in order to more fully remove the salt that came to the surface. Paint removal was conducted next. Both methylene chloride and sodium hydroxide type paint removers were used to remove the different types of paint after it was determined through testing that they would not have a harmful effect on the stone. Multiple applications were often required with dwell times dependent on ambient temperature. Some deeply-absorbed types of spray paint resisted complete removal by any method, leaving faint shadows on the stone.

Figure 4 Paint Removal

After the cleaning of the disassembled stone was underway it soon became evident that the stones on which previous tests had been conducted were not representative of the full range of conditions that would be encountered. Although newly cut sandstone exhibited a remarkable consistency of color, the cleaning results were highly variable from stone to stone and sometimes from one part of a stone to another. The patterns of sediment deposition in the stone were highlighted as surface layers with different densities or absorption characteristics reacted differently to cleaning. In many cases the soiling that was proving difficult to remove was more like a stain that had been absorbed into the surface of the stone. Every stone was examined and rated according to the degree of cleaning achieved. From this a map was prepared in an attempt to identify patterns to the soiling. As might be expected, the inner parapet stones along the roadway were typically less clean and parts of stone that were covered by the earth were cleaned as if they were new. The majority of residual soiling, however, was randomly distributed across the stones. A second round of cleaning tests was conducted, in one case with a product that was under development, and while more effective, the results were still somewhat variable. Those stones requiring supplementary cleaning were identified and re-cleaned using the most effective of the new methods.

Figure 5 Differential Cleaning Results

Figure 19 Second cleaning Test

Figure 20 Test Stain Patches


Figure 21 Cleaning the Animal Heads

STONE REPAIR AND RESTORATION

For the most part, typical stone repair methods were used on the granite and sandstone. Because the stones could be repaired outside of the wall, certain types of repairs could be more effectively done and would be less visible. Because of the variegated coloration of granite, patching mortars are often not aesthetically acceptable. A custom colored epoxy paste into which granite chips were pressed was used to treat surface spalls, however there were few of these defects. Smaller spalls were left untouched, as they would be less visible than patches. Broken stones were epoxied and pinned together using stainless steel threaded rods. The face of the break was surfaced with a custom colored epoxy into which crushed granite was pressed. This was finished off so that the surface texture matched that of the stone. No dutchman-type patches were required in the granite.

Great care was taken in the repair of the sandstone. A specialized stone patching mortar was specified and after numerous attempts the manufacturer was able to produce two shades that were nearly identical to the body of the stone. Because of the variability of the cleaning results, and the desire to have the patches match the color of the adjacent stone surface, a mineral stain was used to tint the surface of certain patches to better blend with the darker stones. If in the future more effective cleaning technologies are developed, this approach will allow the patching mortar and stone to be cleaned to match each other.

Surfacing the mortar patches to match the differing textures of the surrounding stone was an important consideration. The patching technique requires that the surface of the patch be built up beyond the stone surface and tooled back at the appropriate time during the curing process. In addition to the use of various stone mason’s chisels to texture the patches, a visit to the local Target store produced meat tenderizing mallets which were used to give some of the stone patches a surface texture matching the original bush hammered finish.

Figure 22 Mortar Patches

Where a stone defect was too large to be effectively patched with mortar or the mortar would provide insufficient structural integrity at a given location, dutchman type repairs were prepared. Stone for dutchmen was taken from the few broken pieces that were to be replaced or from the back side of stones. These were epoxied and pinned to the damaged stone. The epoxy was held back from the surface of the joint and the colored repair mortar matching the color of the stone was used to fill the gap.

STONE REPLACEMENT

Several stones had to be replaced, including two animal heads that were largely missing. A local stone supplier, Galloy and Van Etten, was finally able to locate a few pieces of Kettle River Sandstone in a yard in Duluth. The initial inspection of the stone did not look promising, since the surface was quite friable. After several test cuts, however, sound material was uncovered that was sufficiently large from which to cut the new units. In short order the stone supplier's carver was able to sculpt a new hippopotamus and rhinoceros head to match the originals and two new arch stones were fabricated.

The widening of the bridge caused the cutwaters to be extended, requiring that new granite cladding be fabricated. The same type of granite was available but because the part of the quarry where the original stone had been obtained was depleted, the new stone color was not a perfect match. The blocks were cut to the same dimensions as the original units and were placed at the center of the cutwaters under the bridge where the slight difference in color between the old and new units would be less noticeable.

STONE REASSEMBLY

In the original bridge above the stone was set up prior to pouring the concrete and acted as a form for it. The disassembly revealed that concrete behind the stone was poured in lifts of approximately 14 inches, double the height call for in the original specifications. Other than the arched side bays, construction methods requiring structural concrete to be poured sequentially with the laying up of the stone courses were avoided, as this would slow the reconstruction

Because the phasing of the project required the stone disassembly and reassembly to be part of the same contract and the drawings issued prior to the development of complete structural plans for the new bridge, the details of how the stone would be integrated into the new structure could only be shown in scope form. Further, the structural drawings had to be completed before the stone was disassembled and the depths of the stones and the existence of any anchorage systems could be confirmed. The original shop drawings did not include

Figure 23 Pre-cast Arches and Rail

Figure 6 Setting Cutwater Cap

this information for many of the stones. This required some guesswork as to where to locate the concrete wing walls so that sufficient setting space would be left to install the stones.
In reconstructing the bridge the cutwater stones were anchored to the abutment walls with stainless steel split tail straps anchored to the concrete with drilled-in fasteners and the shallow cavity space behind was filled with mortar. This was done after the pre-cast arches had been set and the overhead rail used for the disassembly process reinstalled. The wing wall stone was laid up in front of the poured concrete structure, but because a large space had been left behind the stones due to the unknown stone depth, the cavity would be filled with concrete. Stainless steel L-shaped anchors set in slotted holes in the sides of the stones were used to tie them to the concrete fill. Separate ties anchored the concrete fill to the concrete wing wall.

The arch stones were laid up in a manner similar to how they were erected originally. Scaffolding was erected on which the concrete forms for the side arches were built. These forms conformed to the geometry of the pre-cast arches. Provision was made to adjust the scaffolding for settlement and a monitoring system was put in place. The stone subcontractor began setting the arch stones on this formwork, only to discover that the differences in the geometry of the stone arch and of the formwork conforming to the pre-cast were more substantial than anticipated. To determine how extensive this would be throughout the entire arch, wood templates of each of the stones were cut, which then were assembled in position on top of the concrete forms. In some locations the templates fit the concrete form, in many locations the templates had to be shimmed up above the form and in a few locations the form would need to be lowered for the templates to fit. The forms were adjusted so that all stones could be accommodated in their desired position by shimming and the erection of the stones proceeded.

Figure 7 Wood Arch Templates **Figure 8 Cast-in-place Arch**

After all the stones were in place and the mortar had sufficient time to cure, the forms were lowered, the shims removed and the forms were refit to the bottom of the stones and to the pre-cast arches. The warping of the finished cast-in place concrete surfaces was barely noticeable once the forms were stripped.

Supplemental mortar patching was completed on site and staining of selected patches was accomplished. A pointing mortar harmonizing with the color of the sandstone and matching the original color from the bridge was applied and the bridge was given a final cleaning with a masonry detergent.

Figure 9 Restored Bridge

[i] _________, "Mosaics," *The Inland Architect and News Record* (March 1903): p.19.

[ii] Specifications for the construction of a concrete and granite bridge in Jackson Park, Chicago, to be known as the "The South Bridge" page 5

[iii] Weber, Bertram A. "Interviews with Chicago Architects/ compiled under the auspices of the Chicago Architects Oral History Project, the Ernest R. Graham Center for Architectural Drawings, Department of Architecture, The Art Institute of Chicago." Interview by Betty Blum, (August 4, 1983).