REMR TECHNICAL NOTE CS-MR-8.6

CASE HISTORY OF LOCK REHABILITATION: LOCKPORT LOCK, ILLINOIS WATERWAY

PURPOSE: To present a case history of rehabilitation of & navigation lock.

PROJECT: Lockport Lock is located about 2 miles north of Joliet, Illinois, on the Chicago Sanitary and Ship Canal, a part of the Illinois Waterway. The lock is at mile 291 on the Illinois Waterway. Constructed in 1933, the 110-ft-wide and 600-ft-long lock was shut down for rehabilitation on 5 July 1984.

REHABILITATION: J. A. Jones Construction Co. was the low bidder for Stage I rehabilitation of the lock. Bids ranged from $8.1 to $10.4 million as compared to the government estimate of $8.0 million. Principal features of the Stage I rehabilitation included:

a. Stabilization of the upper service gate sill with rock anchors.

b. Modification of the upper lift gate to allow operation against a head of water.

c. Removal of deteriorated concrete and resurfacing around the upper lift gate and the lower gate bay.

d. Installation of new miter gates and operating machinery including a new sill and modifications to the quoin and anchorage.

e. Installation of new ladders with protective armor inside the lock chamber.

f. Removal of deteriorated concrete around the floating mooring bitts and replacement with armored concrete.

g. Removal of shutter gate.

h. New cable trench and power lines.

Before drilling holes for rock anchors to stabilize the upper service gate sill, a slot was cut in the top of the sill. After reinforcement was installed, blackouts for anchor recesses were formed and concrete placed to original grade. Anchor holes were then drilled in each recess, anchors installed, embedment length grouted, anchors stressed, the remainder of each hole grouted, and recesses filled with concrete. A concrete mixture proportioned for a slump of 1 to 4 in., an air content of ± 6 percent, and 4,000-psi compressive strength at 7-day age was used in gate stabilization work.

As originally designed, the upper lift gate operated by sliding along steel inserts mounted in the gate recesses. This prevented operation of the gate against a head of water. The gate recess was modified and roller bearing assemblies installed to alleviate this operational constraint. The contractor's bid price for this modification was slightly over one-half million dollars.

The major effort in the lock rehabilitation involved the lower miter gates. The existing miter gates, complete with appurtenant parts, were removed and the quoin, anchorage, and sill were modified before installation of new miter gates and operating equipment. These modifications required removal of approximately 635 cu yd of concrete. This was accomplished by drilling three lines of small-diameter holes along the top of the lock walls parallel to the lock chamber. Alternating holes in the row nearest the chamber were filled with an expansive grout (S-Mite) in an attempt to presplit the concrete along the drill lines. However, the resulting cracks in the concrete were erratic in both direction and extent. The remaining holes along the first drill line were then loaded with detonating cord and the fractured concrete removed by blasting. A similar procedure was used for succeeding lines of drill holes. Extensive concrete removal by hand using jackhammers was still required to complete the removal operation.

A number of rock anchors were installed to strengthen the concrete sections near the miter gate anchorages. Following installation of dowels, gate anchors, and conventional reinforcing, these areas were formed and replacement concrete placed. Approximately 310 cu yd of concrete was required at the contractor's bid price of $728 per cu yd. A concrete mixture proportioned for a slump of 1 to 4 in., an air content of 6 ± 1-1/2 percent, and 4,000-psi compressive strength at 28 days was used in all concrete work with the exception of the upper service gate sill.

Modifications to the miter gate sill and quoin required approximately 325 cu yd of anchored and reinforced concrete at the contractor's bid prices of $174 and $792 per cu yd, respectively. These modifications plus the cost of the new gates, field erection, and new operating equipment totaled nearly $6 million or 70 percent of the cost for Stage I rehabilitation.

Resurfacing of the lower gate bay required removal of approximately 335 cu yd of concrete and replacement with new armored concrete. Approximately 960 dowels were required to anchor the replacement concrete. A roughly vertical crack which extended from the top of the emptying culvert for a distance of approximately 18 ft was pressure grouted prior to placing the new concrete.

New exit ladders with protective armor were installed in the lock chamber. This required removal of approximately 150 cu yd of concrete. In most cases, a nominal 14 in. of concrete was removed, except in the immediate vicinity of the ladders and the top corner of the lock wall, where 21 in. of concrete was removed. Concrete removal varied from approximately 50 ft to full face in the lock chamber (61 ft). Concrete removal lines were saw cut to a minimum depth of 3 in. before concrete removal. In spite of the saw-cut removal line, there was significant overbreak with the explosive blasting used to remove the concrete. The boundaries of these overbreak areas were saw cut to a minimum depth of 3 in. and concrete within these areas was removed by chipping with

handbeld breakers to a minimum depth of 3 in. The contractor proposed, and the Corps approved, the use of Weld-Crete as a concrete bonding agent in those overbreak areas in which the replacement concrete was not anchored to the existing wall. The primary factor in selection of this bonding agent was that, according to the manufacturer, Larsen Products Corp., the replacement concrete could be placed up to 10 days after application of the bonding agent with no effect on bond. This allowed the contractor more than enough time to complete forming of a given area after the bonding agent was applied to the existing concrete.

The bonding capacity of Weld-Crete was evaluated at WES as part of the second phase of a dowel spacing study. When tested according to the Arizona slant shear method, the strength of concrete bonded with Weld-Crete was less than one-fourth that of concrete to concrete bond without any bonding agent. This was attributed to degradation of the polyvinyl acetate bonding agent while the concrete test specimens were stored in the fog room. When contacted by WES, Larsen Products personnel reluctantly admitted that Weld-Crete probably should not be used under moist conditions. Although their literature does not include any such limitation, it does caution against using the material where hydrostatic pressure is present in the substrate; also, it states that a "wet" type saw should not be used to cut isolation joints. In addition, the literature emphasizes that all joints must be sealed against water penetration. When this information was brought to the attention of Corps project personnel, the use of a bonding agent was discontinued.

The contractor elected to use hooked bars, No. 6 on 2-ft centers each way to anchor the replacement concrete. These bars were grouted into 1-in.-diameter holes drilled 18 in. into the existing concrete using polyester-resin grout. Following installation of the ladders, conventional reinforcing, and armor, the ladder areas were formed in 5-ft lifts. Concrete placement on the land-side wall was accomplished by discharging the concrete directly from transit mixers into hoppers filled with flexible hose commonly known as elephant trunks. Concrete on the riverside wall was placed in a similar manner except the concrete was transported from the landside wall by concrete bucket and crane. Internal vibrators were used to consolidate the fresh concrete. Forms were usually stripped 1 day after concrete placement and a membrane-curing compound applied to formed surfaces. Some cracking was observed in the replacement concrete, particularly in the lower lifts where armor was not present. The contractor's bid price for ladder installation was approximately $350,000.

Deteriorated concrete around the floating mooring bitts was removed and replaced with armored concrete. This required removal of approximately 110 cu yd of concrete. Approximately 470 dowels were used to anchor the replacement concrete. Concrete removal, installation of dowels, forming, and concrete placing were accomplished in a manner similar to that previously described for the exit ladders. The contractor's bid price for this work was approximately $240,000.