The Setting

The tall, nearly vertical, 80-degree retaining wall overlooking Lock and Dam #1 on the Mississippi River in Minneapolis needed repair.

Using the hydraulic drill specially designed and

constructed in-house by The Judy Company of

Kansas City, workers install 15-foot percussion

drilled rock anchors 85 feet above ground level

on the retaining wall.

The 1,370-foot long retaining wall, constructed in the 1950s, was designed to protect the west bluff adjacent to the lock and a sprawling historic Veterans Home on top of the bluff overlooking the Lock. The bluff, an exposed rock face almost 100 feet high, was stabilized by the retaining wall built of concrete cribs on the lower 65 feet. The cribs created a vertical wall face in front of the natural rock face of the bluff.

Different length cribs were used because the distance created between the wall and rock face of the bluff varied from 5 feet to 12 feet. The distance, called a "bin," was backfilled with rock. Above the existing crib wall is 30 feet of exposed limestone with a 7-foot cast-in-place concrete wall near the top.

The Problem

Over time, the Army Corps of Engineers had recorded small movements in some areas in the crib wall sections, indicating instability of the bluff. The exposed limestone was disintegrating, dropping broken rock and undermining the cast-in-place wall.

The Corps issued a contract to Lametti & Sons of Hugo, Minn., to reinforce and rehabilitate the wall, and to extend its height. First, the top 3 feet of crib wall was to be removed. Then high

capacity, post-tensioned rock anchors with concrete walers were to be installed along the crib wall in limited sections.

To rehabilitate the exposed limestone above the crib wall, 15-foot rockbolts were to be installed and the surface shotcreted with reinforced concrete. Finally, the cribwall was to be capped with a concrete walk, and a poured-in-place wall constructed along the base.

Access was the project's greatest challenge. Adding to the difficulty of height and steepness, there was only limited access along the base of the wall. For the first 700 feet, there was a narrow paved area at the base of the wall. The remainder of the wall was over water or along unimproved riverbank. An equally great problem was that no standard equipment exists for drilling and installing rock bolts and anchors in instances of such limited access and steep, high walls.

The Solution

The innovative climbing drill conceived and

built by The Judy Company can climb,

telescope, and reach up to 85 feet from the

ramp with a footprint of only 8 feet by 16

feet. A crawler base levels itself on grades

of up to 7 percent and the drill works on a

vertical, 90-degree slope.

Known for innovative solutions to difficult

access construction, The Judy Company used

the new drill to install 88 high capacity rock

anchors through the crib walls and 1,350

rock bolts in the upper limestone face at

Mississippi River Lock and Dam Number 1.

The Judy Company, Inc., a Kansas City, Kan., geotechnical specialty contractor, was awarded the subcontract to install 88 high capacity rock anchors through the crib wall and 1350 rock bolts in the upper limestone face. In service since 1922, The Judy Company is known for

innovative solutions to difficult access construction and construction problems. Engineers from The Judy Company and Lametti teamed up to consider approaches to anchoring the wall, including the conventional barge-mounted crane and swinging drill platform approach.

However, this approach would have been difficult because the crane would have to be moved every time river traffic locked and barged through. Swinging platforms would also have been troublesome. It is difficult to drill into a wall without a landed base to anchor the rig because drilling pressure forces the platform away from the wall.

Judy's engineers decided that access would be best achieved from an anchored position at the base of the wall. A 12-foot-wide bridge would be constructed using railcars from the paved area to the riverbank and a berm for work access would be built along the bank to the end of the wall.

To achieve the needed access, The Judy Company designed and built an innovative elevating platform drill that could climb, telescope, and reach up to 85 feet from the ramp with a footprint of only 8 feet x 16 feet. The crawler base could level itself on grades of up to 7 percent and work on a vertical, 90-degree slope. The drill would be required to penetrate the crib wall and coredrill up to 60 feet deep for the high capacity anchors. For the upper, relatively quick setting rock bolts, the platform would be reconfigured with a percussion drill to drill through rock and concrete for the 15 feet deep, smaller diameter holes.

The Judy Company's engineers, along with a structural consultant, designed the drill and

platform using ANSI, OSHA and Army Corps of Engineers safety standards and requirements.

Truss-style leads from a pile driver were used as vertical members that were attached to a self-propelled crawler drill fitted with outriggers. The angle of the leads was hydraulically controlled allowing the leads to be lifted away from the wall. Hydraulics also permitted the rig to move under its own power.

For installation of the high capacity rock anchors, the mast and pedestal from a rotary drill used for coredrilling rock anchors were attached to the climbing work platform along with a hydraulic drill and power pack for the hoist controls.

For the 1,350 rock bolts to be installed through the concrete wall at the top of the bluff, a swinging drill platform was designed and built. The drill mast was designed to be controllable in 3 axes to accommodate the various orientations. For installation of the majority of the anchors, it was necessary to reconfigure the climbing tower drill for more height. The leads were extended an additional 30 feet and a special drill platform rigged with a percussion drill was built. To minimize the number of setups necessary, Judy's engineers fitted the platform with an indexing slide mechanism that allowed 5 foot of indexing in either direction, permitting the installation of 8 bolts per setup, significantly enhancing production. To facilitate handling of the longer bolts, the platform and handrails were designed to telescope.

The unit was pre-assembled and tested at The Judy Company's yard in Kansas City and ready

for installation of the rock anchors within three months.

Using the newly built rig, casing was seated in competent rock and the holes were advanced up to 60 ft. in sandstone. The 252 kip capacity anchors were pre-grouted inside corrugated sheathing for additional corrosion protection and the assembly was installed and grouted in place.

After the anchors were installed, Lametti, the general contractor, cast a concrete waler to allow the anchors to be pre-loaded against the cribwall. An innovative stair-step construction sequence allowed the forms and scaffolds to be supported from the waler below it, simplifying falsework requirements.

Next, the 1,350 15-foot rockbolts were installed into the upper limestone face. Installation of the shorter anchors required different drilling procedures and equipment because of the nature of percussion drilling and due to shorter bolt spacing. The limestone face was 5-8 feet behind the face of the crib wall. To allow the drill to pass the concrete walers, it was necessary for the workers to use the telescoping feature of the work platform. While drilling on the upper rows, the work platform was extended to the face of the wall for the crew to access the work.

The rock bolts were placed on 5-foot centers along the wall. To minimize the number of setups of the climbing drill, the hydraulic slide mechanism indexed the mast 5 feet either left or right to allow two columns of rock bolts to be installed from one setup. On one setup, two rows of four bolts each could be installed, saving a great deal of time. Installation of eight bolts on one setup was complete before the crew moved to the next hole.

The ingenuity of The Judy Company's equipment design, combined with close contractor-sub-contractor cooperation, assured the completion of the majority of the work within a single season, reducing schedule time and remobilization costs.