Jerry Reed

BUCKEYE LAKE DAM
FAIRFIELD AND LICKING COUNTIES, OHIO

EVALUATION OF EXISTING SHEET PILING

PREPARED FOR

OHIO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENGINEERING

PREPARED ~~FOR~~ BY

DODSON-LINDBLOM ASSOCIATES, INC
COLUMBUS, OHIO

August 23, 1995

Dodson-Lindblom Associates, Inc.

A DLZ Company

ENGINEERS • ENVIRONMENTAL SCIENTISTS • SURVEYORS

August 23, 1995

Mr. Bruce Pickens, P.E.
Chief Engineer
Ohio Department of Natural Resources
Division of Engineering
Fountain Square, Bldg. F-3
Columbus, Ohio 43224

Re: Buckeye Lake Embankment and North Shore Launch Ramp/Picnic Point Improvements Project

Evaluation of Existing Sheet Piling

Dear Mr. Pickens:

Pursuant to earlier discussions with your office, we are forwarding the enclosed report which outlines our evaluation of the existing sheet piling at Buckeye Lake. Based on our investigation, it is our recommendation that the sheet piling which was installed during the 1940's and 1960's be replaced during the Phase III project.

The 1940's sheet piling has clearly reached the end of its useful life. Approximately 1100 linear feet of replacement piling is required to repair the remaining 1940's sheet piling at Buckeye Lake. A total of 3680 linear feet of 1960's piling is present in two reaches. Based on our investigation, we anticipate that this piling has a remaining useful life of only 10 to 15 years. Therefore, it is our recommendation that his piling be replaced at this time as well. While this will result in a higher project cost, it will preclude the need for additional construction expenditures and the resultant inconveniences to adjacent residents in the near future.

Our current estimate for the project, including the 4780 linear feet of replacement piling, is $6,532,958.00.

6121 Huntley Road • Columbus, Ohio 43229-1003 • (614) 848-4141 • FAX (614) 848-6712
With Offices in Cleveland - Cuyahoga Falls - Hamilton, Ohio • Lansing, Michigan • Indianapolis - South Bend, Indiana

BUCKEYE LAKE EMBANKMENT AND NORTH SHORE LAUNCH RAMP/PICNIC POINT IMPROVEMENTS PROJECT

EVALUATION OF EXISTING SHEET PILING

INTRODUCTION

The proposed Buckeye Lake Embankment and North Shore Launch Ramp/Picnic Point Improvements Project is being undertaken by the Ohio Department of Natural Resources to complete dam safety repairs and improvements to the Buckeye Lake Dam. The proposed project is the third and final phase of an ongoing project to make improvements to the dam necessary to meet the requirements of the Ohio Dam Safety Laws under Chapter 1521 of the Ohio Revised Code. These improvements are being made in accordance with a 1987 report, entitled the Buckeye Lake Dam Spillway Capacity and Embankment Stability and Seepage Study, which recommended increasing the dam's spillway capacity in conjunction with improvements to raise the height of the embankment to a uniform elevation of 896.5 and to place a tied-back sheet pile wall in front the existing masonry wall where no sheet piling is currently present.

The spillway capacity issue was addressed under two previous projects which provided for the construction of an uncontrolled ogee spillway near Seller's Point and for the replacement of the original sluice-gated spillway with a self-actuating radial gate structure. The proposed "Phase III" project will address the issues of raising the embankment height and the installation of additional sheet piling.

An investigation of the condition of the existing sheet piling at Buckeye Lake was conducted during the development of the proposed Phase III improvements. This investigation indicated that the existing sheet piling, which provides upstream slope protection and a cut-off beneath the dam, is of varying ages, construction, and condition. Because of the deteriorated condition of some reaches of the existing sheet piling, replacement is recommended in three reaches as a portion of the Phase III project.

HISTORY OF THE EXISTING WALL AT BUCKEYE LAKE

The low, earthen embankment that impounds Buckeye Lake is approximately 4.1 miles in length. Constructed between 1825 and the mid-1830's, the upstream face of the dam was originally protected by dumped stone and/or a laid masonry wall. Deterioration of the masonry wall results in erosion of the upstream face and excessive seepage through the dam.

Since the 1940's, the State of Ohio has constructed a tied-back sheet pile wall in front of the masonry wall in many areas to provide additional upstream protection and to reduce seepage through and under the dam. Currently approximately 5700 linear feet of the original masonry wall remain exposed (Sta. 10+00 to Sta. 66+97) along the West Bank reach of the dam. The masonry wall is exposed in the vicinity of Sellers Point and Smitty's Restaurant (Sta. 101+00 to 102+00) along North Bank. Portions of the masonry are also visible along North Bank between Sta. 204+00 and 210+00 in the vicinity of the former Buckeye Lake Amusement Park. A sheet piling

cut-off wall has been constructed behind the masonry wall in this last reach. The remaining 15,000 feet (approximate) of the embankment has been protected by the tied-back sheet pile wall.

Record drawings on file with the Ohio Department of Natural Resources indicate that approximately 5000 linear feet of sheet piling was originally placed during the late 1940's. An additional 7900 linear feet of piling was installed during the early 1960's. Based on the record drawings and field investigations, this piling was generally a PSA 23 section. A channel section, bolted to the exterior (or lake) face of the sheet piling, was used as a waler for the tie-back system.

During the early 1980's, approximately 4100 linear feet of sheet piling was installed. In some instances, as reported by long time residents, the 1980's sheet piling was placed in front of existing sheet piling from the late 1940's which had deteriorated significantly. In other areas, the 1980's sheet piling completed the installation of steel in front of exposed masonry wall along North Bank. The 1980's installations were also generally PSA 23 sections, although some PMA 22 section was placed for approximately 800 linear feet east of Mud Island along West Bank. The waler generally consisted of an angle section and was welded to the interior surface of the piling.

The most recent sheet piling installations were completed in 1992 and 1993 in conjunction with the construction of the two spillway structures. Approximately 300 linear feet of sheet piling was installed.

The tie-back system for the existing piling generally consists of 1-inch diameter tie rods and short lengths (approx. 8-feet) of the sheet piling as anchors. The anchor pile is generally located 10 to 12 feet behind the face of the sheet piling wall. The downstream end of the tie-rods are provided with a washer and nut attachment through the anchor pile. The upstream end of the tie-rods attach through the exterior channel waler with a washer and nut on the 1940's and 1960's vintage sheet piling and with a clevis on the 1980's interior angle water. All have a turnbuckle connection at the midpoint of the tie-rod. The original masonry wall was slotted where necessary to allow penetration of the tie-rod to the anchor pile which was placed downstream of the masonry wall.

The area between the original masonry wall and the later sheet piling installations was backfilled with bank run sand and gravel to within about 1-foot of the top of the sheet piling. Soil material was then placed to the top of the piling to provide a seed bed for establishment of a grass cover. All tie-back trenches and anchor pile locations were backfilled and are not clearly evident on the surface of the dam at this time.

EVALUATION OF THE EXISTING SHEET PILING

Surveys conducted in 1985 along the top of the existing wall at Buckeye Lake indicated that both the masonry and sheet piling walls varied in height and were, on an average, 1.5 feet lower than the required design height of 896.5 to prevent overtopping by the Probable Maximum Flood (PMF) following completion of the recommended spillway improvements. The scope of services

for the Phase III project requires the design of a parapet (where a sheet pile wall was present) to achieve the proper design height.

The evaluation of alternative designs for the parapet indicated that a precast concrete parapet, supported by structural steel welded to the sheet piling, was the preferred alternative. This alternative, in which the parapet sets atop the existing sheet piling, was selected because it was the most cost effective and because it prevents storage of water from the PMF on top of Buckeye Lake Dam, which is of questionable design and construction relative to modern dam safety standards. Because this alternative relies on the existing sheet piling as a foundation, an inspection of piling was conducted to evaluate its condition and to determine the design details necessary to attach the proposed parapet section to the various sheet pile walls.

During normal summer pool conditions, the visual condition of the piling exposed above the waterline appears to be quite good. No excessive rusting or corrosion is noted. However, during site visits made following the winter drawdown of 1994-1995, it was noted that significant corrosion and scaling was apparent along some reaches on North Bank at an elevation below the normal summer pool. (See photos in Attachment A).

Therefore, in March 1995, a detailed visual inspection was made of the existing sheet piling along the dam. In particular the sheet piling was being checked for excessive vertical or horizontal misalignment, holes through the sheet piling (man-made or rusted), unlocked joints, tree or vegetation growth through the piling, as well as the general condition of the steel itself, i.e. excessive scaling or pitting. At that time it was noted that in some reaches the steel was deteriorating. Scaling and pitting was clearly evident in the zone between the summer and winter pool elevations, roughly between elevations 888.5 and 892.0, as was corrosion at the sheet pile/waler interface. Based on these observations, the condition of the existing piling warranted further investigation.

In April, 1995, ultrasonic testing was attempted to determine the section loss due to corrosion and scaling. Readings were taken at two (2) locations on each test pile. One reading, the control, was taken one to two feet below the top of sheet piling where no significant deterioration had occurred. These readings were consistent with the specified section thickness for the piling. The second reading could not be taken in the areas noted as being visibly in the worst condition due to an increased pool elevation since the March inspection and excessive wave action. Generally, the second reading was taken just below the normal summer pool elevations. Two readings showed section losses of 14 percent and 20 percent. In several other locations, three to four (3 to 4) layers of scale were noted and prevented obtaining an accurate reading. The data from the testing program is presented in Attachment "B". Coupons, or samples, of the actual sheet piling could not be taken due to the increased pool elevation and excessive wave action. Therefore, no laboratory testing was conducted to verify the limited ultrasonic testing results.

An analysis was performed to check the existing sheet piling and is included in Attachment "C". The results of the analyses indicate that while shear capacity due to the loss of section is not an immediate problem, significant overstressing due to bending does appear to be occurring in the zone where the deterioration is occurring. Based on the calculations, the existing sheet piling is

stressed above the normal allowable value in bending even excluding the effects of corrosion; the loss in steel section from corrosion produces even high overstress conditions.

The reaches which showed the most significant deterioration correlated to the record drawings as reaches which had been installed in 1948 or 1961/1962, or as being 47 or 33 years old, respectively. The 1960's piling appeared visibly to be as bad or worse than the 1940's steel in the zone between summer and winter pool levels.

Sheet piling manufacturers were queried to determine the life expectancy of sheet piling installations in conditions similar to Buckeye Lake. Opinions varied, but generally the consensus was that a 40 to 50 year life expectancy might be anticipated for the type of piling installed at Buckeye Lake, i.e., conventional structural carbon steel. A corrosion-resistant low-alloy steel which develops a tight oxide that inhibits further corrosion is anticipated to provide an additional 10 to 30 years of life expectancy.

Finally, constructibility problems were noted with both the 1940's and 1960's sheet piling installations. In an attempt to increase the height of the 1940's vintage piling following a near overtopping in 1968, ODNR added a 15-inch I-beam to the top of this piling in 1969. This added beam provides an unstable configuration for the attachment of the welded steel struts which would support the precast concrete parapet section. The 1960's vintage piling, with its exterior waler (which was also in poor condition in many areas) also creates problems with the design and attachment of the parapet supporting struts. The waler is located relatively high on the piling and is in the zone of strut attachment. Because of variations in the waler's actual location relative to the top of the piling, prefabrication of the struts would be limited and costly field fitting would be required.

RECOMMENDATIONS

Based on extensive visual inspections, review of record drawings, limited testing, and analyses, and discussions with piling manufacturers; it is recommend that the sheet piling that was installed during the 1940's and 1960's be replaced during the Phase III project.

As stated previously, the parapet option requires that the existing piling provide a suitable foundation for the installation. The 1940's vintage piling is obviously near or at the end of its expected useful life. Further, the existing I-beam atop the piling is unsuitable for installation of the parapet. Therefore, the existing 1940's sheet piling located between Sta. 101+00 and 112+50 (approximately 1100 linear feet) should be replaced. The proposed replacement piling will be of a corrosion-resistant alloy and will extend up to the required top-of-dam elevation of 896.5.

Replacement of the existing 1960's vintage sheet piling is also recommended during Phase III. This piling is estimated to have, at best, a remaining useful life at 10 to 15 years. As noted earlier, the exterior waler on this piling also poses construction problems. Replacement of this piling will require the installation of an additional 3680 linear feet of piling located between approximate Sta. 125+50 to 147+00 and Sta. 152+00 to 168+00. This piling to be installed will be of a corrosion-resistant alloy and will extend up to the design elevation of 896.5.

Replacement of the 1960's sheet piling will cost an estimated $2 million more than the installation of the precast parapet wall in those reaches. It is our opinion, however, that the short-term cost savings achieved by construction of a parapet on the 1960's piling do not offset the anticipated long-term benefits to the State of Ohio and the adjacent residents in the form of reduced future maintenance and repair costs and inconveniences.

Attachment A

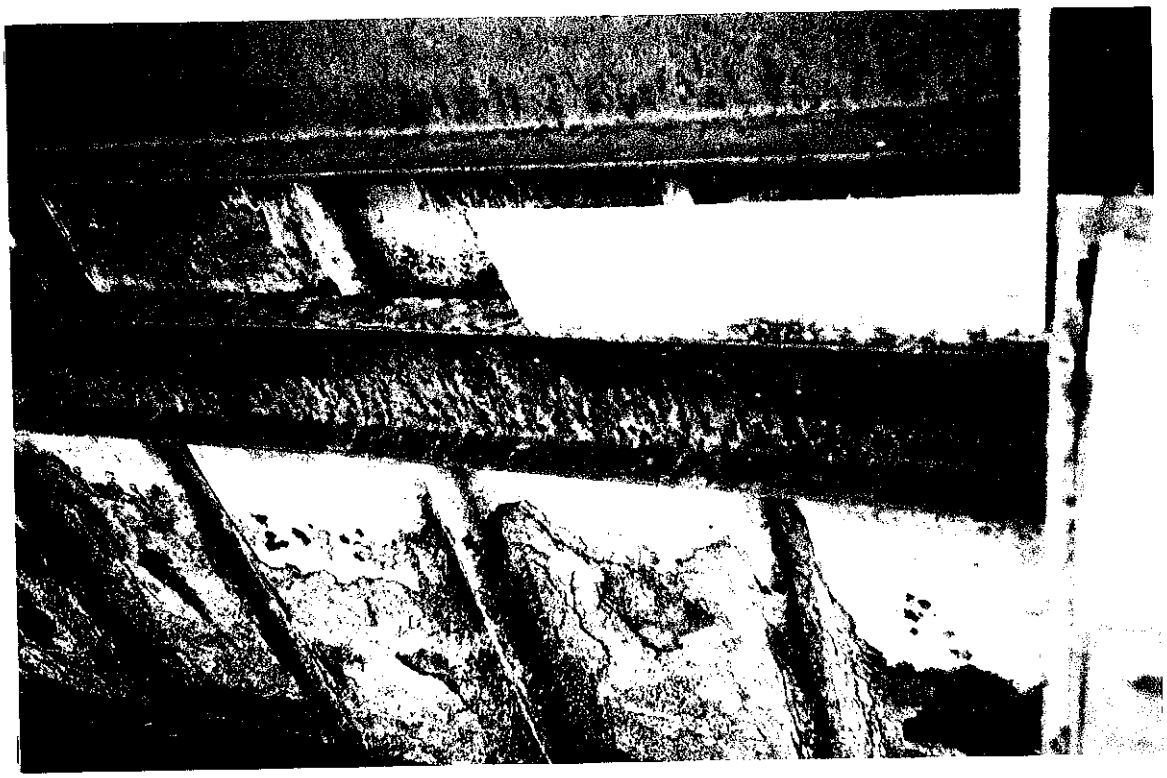

Photo 1. Typical corrosion and scaling on sheet piling installed during the 1940's.

Photo 2. Typical condition of 1960's vintage sheet piling.

Photo 3. Multiple layered scaling on 1960's sheet piling.

Photo 4. Close-up of pitting and scaling on 1960's sheet piling.