JSD Professional Services, Inc.
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November 20, 2014

Ms. Lauren Striegl
City of Madison Engineering Department
City-County Building, Room 115
210 Martin Luther King Jr. Boulevard
Madison, WI 53703

Subject: ***Professional Structural Engineering Services***
Arboretum Pond #3 - Screen Treatment Structure
Madison, Wisconsin
JSD Project No. 14-6456

Dear Ms. Striegl:

In October of 2014, JSD Professional Services, Inc. (JSD) completed a site review of the concrete perimeter walls of the City of Madison Arboretum Pond #3 Screen Treatment Structure. JSD had been retained by the City of Madison to review cracking present in the exterior concrete walls.

The rectangular structure consists of 12-inch thick concrete walls, 35 feet long at the East and West sides of the structure, and approximately 30 feet long at the North and South ends. There are interior concrete walls located at approximately third points of the structure width that extend the length of the structure and intersect with and tie into the end walls. Slabs to channel the stormwater flow within the Screen Treatment Structure are at varying elevations with the East and West slabs approximately 14'-8" below the tops of the exterior walls. The grade is fairly constant and level around the perimeter of the structure.

JSD observed cracks along the East and West side walls of the structure. These appear to be the result of lateral soil pressures placed on the walls. As observed viewing the top of the walls, the cracks are narrower at the outside face of the 12-inch concrete wall then at the interior wall face indicating an inward bow. JSD surveyors completed a survey of the walls and found that the West wall has deflected inward 2¼ inches near the center of the wall length while the East wall has deflected inward 1½ inches. The greater deflection of the West wall may be the result of the use of the site with an overburden force created by the presence of vehicular or machinery traffic adjacent to the wall. More traffic or larger vehicles operating on the West side may explain the difference in the two similarly constructed walls.

There were no cracks observed in the end walls. These walls are shorter in length than the side walls. They have higher interior slabs that reduce the wall heights. They also have the interior walls bracing them at the one-third points and have piping running into and out of the structure at the ends that reduces lateral soil loads on the walls.

The crack pattern on the side walls is typical of tank walls that are free at the top and are "fixed" along the other three edges, at the intersection of the side walls to the end walls and along the base of the wall. The cracks observed at the Screen Treatment Structure originate at the top of the wall, usually at a fence post insert, an area of reduced cross section. The cracks extend diagonally down the sidewalls, terminating at the intersection with the end walls or the base slab at the bottom of the wall. There are also cracks present at the corners where the side walls meet the end walls. These cracks are wider at the exterior wall face and narrower at the interior. These cracks indicate that there has been rotation of the walls at the corner as a result of the inward deflection of the side walls.

The original design drawings indicate that the 12-inch concrete perimeter walls were to be reinforced with #5 reinforcing bars spaced 12 inches on center vertically and horizontally. The drawings do not designate a location of the reinforcing in the 12-inch width of the wall but graphically show them centered in the wall rather than placed near the outside, tension face of the wall. Typically the rebar will be placed with a 2-inch clearance from the outside face of the wall. A section on the original drawing indicates that "L" bars

were to be placed at the intersection of the walls and the slabs. There is no detail indicating corner bars to be placed at the intersection of the side walls and the end walls, lapping the horizontal reinforcing from the two intersecting walls, and may be part of the reason that cracks at the corners currently exist.

A structural analysis of the side walls found them to be significantly under-designed. These walls were reviewed using a Rectangular Concrete Tank PCA Design Method and also reviewed as a cantilevered retaining wall. The length of the side walls and the length to height ratio of the long side walls negates the two-way action of the wall and the wall begins to act more as a cantilevered retaining wall fixed at the bottom and free at the top. The effects of the fixity at the corners is reduced as can be seen with the wall cracks as they become more vertical away from the corners.

JSD has completed a visual review of the Screen Treatment Structure and a survey of the perimeter walls to evaluate the alignment of the walls. We have done a structural evaluation of the walls to determine the design needs with the assumed lateral soil loading on the exterior of the reinforced concrete walls. Our conclusion is that the walls, especially along the East and West, are not adequate to support the lateral soil loads present and perhaps the temporary overburden from the vehicles and machinery operating adjacent to the structure.

We feel that steps should be taken at this time to stabilize and address the structural short comings present with the current design. We recommend a three-step approach to address the current situation. The initial step is to brace the East and West walls against further movement. As the soils behind the walls adjust to the new deflected locations of the walls, we feel that further movement will occur and perhaps at an increased rate from the initial movement as the walls went from non-cracked to cracked. Our preliminary concept is to brace the walls against one another. Additionally, we propose to "glue" the walls back together by epoxy injecting the cracks. As a third repair approach, we would evaluate strengthening the walls using carbon fiber strips.

Following your review of this report, please let me know if you have any comments.

Sincerely,

JSD Professional Services, Inc.

Jeffery J. Edge, P.E.
Senior Structure Engineer