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BARR

October 18, 2018

Sarah Moyer-Cale
Village Manager
Village of Paw Paw
111 East Michigan Avenue
PO Box 179
Paw Paw, MI 49079

Re: Briggs Mill Dam Inspection Summary and Preliminary Dam Repair Recommendations

Dear Ms. Moyer-Cale:

The Briggs dam is owned and operated by the Village of Paw Paw (Village). It was built approximately 120 years ago and is believed to originally produce power. Barr Engineering Co. (Barr) has been hired by the Village to inspect the dam and develop a preliminary opinion of probable cost for recommended dam repairs.

The Village has secured a USDA loan and needs a conceptual repair drawing and engineer's estimate to complete the loan process. The purpose of the inspection was to evaluate the condition of the spill tube structure to aid in the development of a conceptual repair plan to submit to the USDA. The Village is looking for a 30+ year solution.

Project Overview

The dam structure consists of the following from left to right (with the orientation looking downstream):

- Spill tube structure (Auxiliary Spillway)
- Earth embankment
- Control structure
- Emergency spillway
- Southern earth embankment

The spill tube structure is a concrete structure with two 6-foot diameter corrugated metal pipes (CMP) passing through the concrete. Upstream of the concrete structure is a containment pit and a concrete wall which acts as a weir (Photo 1). When the reservoir water is higher than the top of weir elevation, water passes over the weir and flows out the spill tubes. The weir and footings (approximately 1 foot upstream and downstream of the weir) were installed in the spring of 2018. A covered walkway extends across the top of the spill tube structure. The downstream side consists of an angled concrete face and a left wing wall (Photo 2).

The earth embankment extends between the spill tube structure and control structure (Photo 3). The embankment breached along the left abutment of the control structure during a storm event in October 2017 and was rebuilt in the spring of 2018. Embankment soils are assumed to consist of sandy clay based on field observations and is covered with vegetation. The downstream side of the embankment, adjacent to the control structure where the breach occurred, was repaired with riprap (nominal 12 inch diameter fieldstone) while the rest of the downstream side is covered in vegetation (Photo 4). The

riprap was added during the repair of the breach. A boardwalk extends across the crest of the earth embankment. On the left upstream portion of the embankment, nearest the spill tube structure, gabion baskets were in place. John Small (Village of Paw Paw) indicated these were installed approximately 10 years ago as part of a dredging project in the reservoir (performed to increase storage capacity) to retain soil on the earth embankment.

The control structure is a reinforced concrete structure extending between the earth embankment and the emergency spillway and consists of five bays for flow passage (Photo 5 and Photo 6). The middle bay has a deeper sill and can be adjusted for flow using a gate. Gates can be installed in all bays.

The emergency spillway crest is approximately 2 to 2.5 feet lower than the crest of the adjacent control structure and earth embankment. The emergency spillway consists of an earthen embankment covered with geotextile fabric and articulated concrete block (ACB) (Photo 7). This spillway was built in the spring of 2018.

South of the emergency spillway is an earth embankment with a walkway across the crest (Photo 8).

Flood History

In October 2017 a flow event occurred which caused the earth embankment between the spill tube structure and control structure to breach to an elevation approximately 8 feet lower than normal. A large tree which was located on the downstream slope of the embankment was uprooted and remains downstream of the embankment. At the time, the dam downstream (Maple Lake dam) had a 4-foot drawdown. There was no impact to downstream business or residents due to the flood or breach.

In the spring of 2018, the emergency spillway was installed because of a recommendation from the Michigan Department of Environmental Quality (DEQ) to increase spillway capacity at the dam to be able to pass the 200-year flood event.

Since installation, water has spilled over the emergency spillway once, in May 2018. After about 3 hours of flow passage over the emergency spillway voids were noted along the downstream slope of the spillway, and the water level in Briggs Lake was dropped to prevent flow passage over the emergency spillway. Since that event, seepage has been noted along the toe of the emergency spillway (Photo 9), and a drain was installed at the base of the emergency spillway and repairs were required to the articulated concrete blocks (ACB).

Operation

The dam is operated by Village staff who visually monitor the reservoir level and perform a visual review of the dam condition twice a day, Monday through Friday. On weekends, Village staff are on call. Weather is monitored regularly to predict gate adjustment at the dam. The gates at the control structure are greased regularly.

Inspection

On August 2, 2018, Chris Toulouse and Whitney Hansen of Barr performed an inspection of the Briggs Mill Dam. They were onsite from approximately 8:00 am – 2:30 pm. They met with Sarah Moyer-Cale and John Small from the Village of Paw Paw for an overview of the dam history. Limited information is known about the history of the dam or repairs performed on the dam. John has worked at the dam for 30 years and was able to provide partial historical information on the facility. During the inspection the water level of the reservoir was approximately 1 foot lower than normal water levels (normal is approximately El. 720.5).

Downstream Spill Tube Structure

The spill tube structure was inspected from a boat on the downstream side and visually from the upstream side. On the downstream side, the left abutment wall that extends downstream consists of a grouted cobblestone wall on the upstream 15-20 feet and an asphalt overlay downstream. The asphalt had exposed aggregate (Photo 10) and was deteriorating on at the base at both the upstream and downstream sides. It appears the asphalt was placed on the embankment surface to create a curb to re-direct surface water flow. Also, there was significant deterioration, visible soil, and loss of cobblestones and grout where the aggregate section connects to the grouted cobblestone wall (Photo 11). The area of deterioration was approximately 4.5 feet wide at the top, 8 feet high and 1-1.5 feet deep. Vegetation was growing throughout. The grout between the cobblestones was deteriorated in many locations, damp due to seepage, and crumbled when hit with a hammer. The upstream 10 feet of the cobblestone wall was observed to be in better condition. No depressions or signs of seepage or soil loss were noted on the soil adjacent to the top of the wall.

The cobblestone wall connects to a deteriorated concrete wall structure that extends downstream further than the rest of the spill tube structure. A portion of the deteriorated concrete wall fell on top of the lower portion of the wall approximately 20 years ago and still remains in place. Behind this wall is another concrete wall that was observed to be in better condition with some deterioration at the top (Photo 12). A camera was inserted into the void above this wall (below the top concrete slab). The area behind the wall was observed to be filled with sand and the void is completely filled with sand on the upstream side. The void area is approximately 3 feet wide and 1.5 feet tall, and extends approximately 5 feet upstream. The top slab was observed to be in good condition and the base of the slab appears to be poured on the sand fill. Hammer sounding on the top slab indicated the concrete was sound and was visually observed to be in good condition.

On the corner of the wall, multiple deteriorated concrete sections are held together with two separate pieces of wire rope (Photo 13 and Photo 14). Also, tree roots and vegetation is growing in this area. There is significant concrete deterioration and it is unclear that the concrete slab above is adequately supported from below. In the corner adjacent to the spill tube structure, deterioration was noted that extended approximately 4 feet tall, 3 feet deep (in the upstream direction) and 4 feet wide (left to right). The deterioration was measured from the edge of the downstream face of the concrete surrounding the spill tube to the closest soil or concrete structure encountered in the other directions.

The spill tubes themselves were observed to be in decent condition, with some rust and deterioration at the base of the pipes. Throughout the inspection the right (orientation looking downstream) spill tube continued to pass water. The left tube was dry. It was observed the sill elevation of the right spill tube was approximately 2 inches lower than the left spill tube. However, despite water not flowing over the top of the upstream weir wall, the water in the containment pit remained high enough for flow to continue passing through the right spill tube. This is an indication that seepage is entering the containment pit. It is possible water is flowing around the weir structure, under the weir structure, or through the side walls.

The angled downstream wall that surrounds the spill tubes appeared to be an older concrete structure with horizontal lift joints or blocks that was overlaid with a grout mixture (Photo 15). The grout overlay was deteriorated and in many locations missing, leaving the older concrete visible. The patch that was still intact appeared to be delaminated and below the spill tubes crumbled when hit with a hammer. The right side of the wall is covered in moss which indicates moisture in the area. John indicated the patch placed on the spill tubes was installed more than 30 years ago.

The concrete surface below the spill tubes but above the water level was soft and wet and crumbled when hit with a hammer. The area was damp indicating areas prone to seepage. The surface below the tubes was undercut and deteriorated. Centered under each spill tube was an area approximately 12-13 feet wide and 3 feet tall on the right side and 1-2 feet tall on the left. The depth of deterioration ranged from 1 to 1.5 feet on the right side and 6-8 inches on the left side. Rebar, approximately 4 feet in length extended out from the wall in 8 locations, but did not appear to have any function.

On the right side of the spill tube structure there was a gap between the edge of the concrete structure and the adjacent soil of the earth embankment (Photo 16). Concrete deterioration was evident on the edge and a portion of concrete that was falling apart was visible above the water surface. The soil gap was measured for approximately 10 feet high above the water level, extending approximately 6-8 feet deep (upstream) and between 1 to 3 feet wide (left to right). John indicated this erosion has occurred over time and not during high flow events or overland flow. He has not remembered finding wet soil in that area in the past.

Soundings

A survey rod was used to measure the depth of water downstream of the spill tubes. Readings were taken approximately every 3 feet from left to right and at approximately 5 foot intervals downstream. A scour hole was found from approximately 10 to 20 feet downstream of the concrete face extending the full width of the downstream pool. The maximum depth was approximately 3 feet deeper than surrounding riverbed elevations.

Upstream Spill Tube Structure

The slab above the box structure has some cracks and deterioration (Photo 17). Accessible areas that were sounded with a hammer were observed to have intact concrete.

The upstream retaining walls on both sides of the spill tube structure were observed to be in good condition, as visible above the water level (Photo 18). The weir also was observed to be in good condition. The containment pit had a concrete bottom, but the area upstream of the weir was covered in rocks.

The upstream face of the spill tube structure appears to be an overlay approximately 14 inches thick and extending upstream from what was believed to be the original structure. The concrete downstream of that overlay was in significantly worse condition with the worst concrete on the right side of the structure (when looking downstream) (Photo 19).

Earth Embankment

The earth embankment was reviewed to look for signs of seepage, wetness, or signs of piping. The vegetation was in good condition and there were no signs of overland flow, seepage, sink holes or wetness. The vegetation on the earth embankment on both sides was in good condition. John indicated that prior to reconstruction in the spring of 2018; the downstream right side of the earth embankment was often damp. During the reconstruction a layer of hydraulic cement was installed along the left edge of the control structure (Photo 20), and since then that damp area has not been noted. The area is covered in riprap but no visible wetness in this area was noted during the inspection. Soil sample #4 was taken from the upstream side of the earth embankment.

Emergency Spillway

The emergency spillway is starting to grow vegetation and seepage was observed on the downstream side, approximately 10 feet from the right edge of the control structure. According to John, this is a

typical situation. The 4 inch drain pipe was dry. Three soil samples were taken from the emergency spillway. Sample #1 was from the soil under the ACB, near the drain. Sample #2 was taken from native soil, downstream of the spillway and was a clay material. Sample #3 was gravel placed on the crest of the spillway.

North Embankment

The north embankment has a less steep upstream and downstream slope than the emergency spillway and therefore a longer seepage path for water flow. No seepage or wetness was observed along the embankment.

Recommendations

Existing structure is in poor condition and repair of the existing structure is unlikely to result in a 30-year fix. We recommend replacing the structure. It may be possible to stabilize the structure by building a buttress downstream but is unlikely to create a structure that will last for 30 years.

Several repair/replacement options were presented to the Village on September 5, 2018, along with preliminary opinions of associated probable implementation costs. These options included:

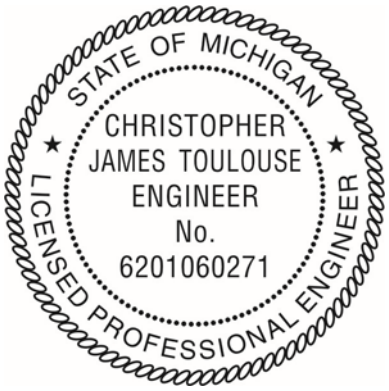
1. Stabilize the existing structure by placing a rock buttress with a filter;
2. Replace the existing structure with an earthen dam, and route all flows through the control structure, and emergency spillway;
3. Construct a new sheet pile weir with concrete cap immediately upstream of the existing structure; and
4. Construct a new spillway increasing the weir length such as a labyrinth spillway to pass all flows through the auxiliary and control structure.

Please contact me at 734.922.4426, Jon Ausdemore at 952.832.2611 or Chris Miron at 616.512.7022 if you have questions regarding anything presented here.

Sincerely,

Chris Toulouse

Chris J. Toulouse, PE #6201060271
Structural Engineer



Enclosure

Attachment A: August 2018 Field Photographs

Photo 1 Spill Tube Structure, upstream side

Photo 2 Spill Tube Structure, downstream

Photo 3 Earth Embankment, upstream

Photo 4 Earth Embankment, downstream

Photo 5 Control Structure, upstream

Photo 6 Control Structure, downstream

Photo 7 Emergency Spillway

Photo 8 Southern Earth Embankment

Photo 9 **Seepage on Downstream side of Emergency Spillway**

Photo 10 **Left Spill Tube Structure, downstream asphalt overlay**

Photo 11 **Left Spill Tube Structure, downstream wall deterioration**

Photo 12 **Left Spill Tube Structure, downstream wall and box structure**

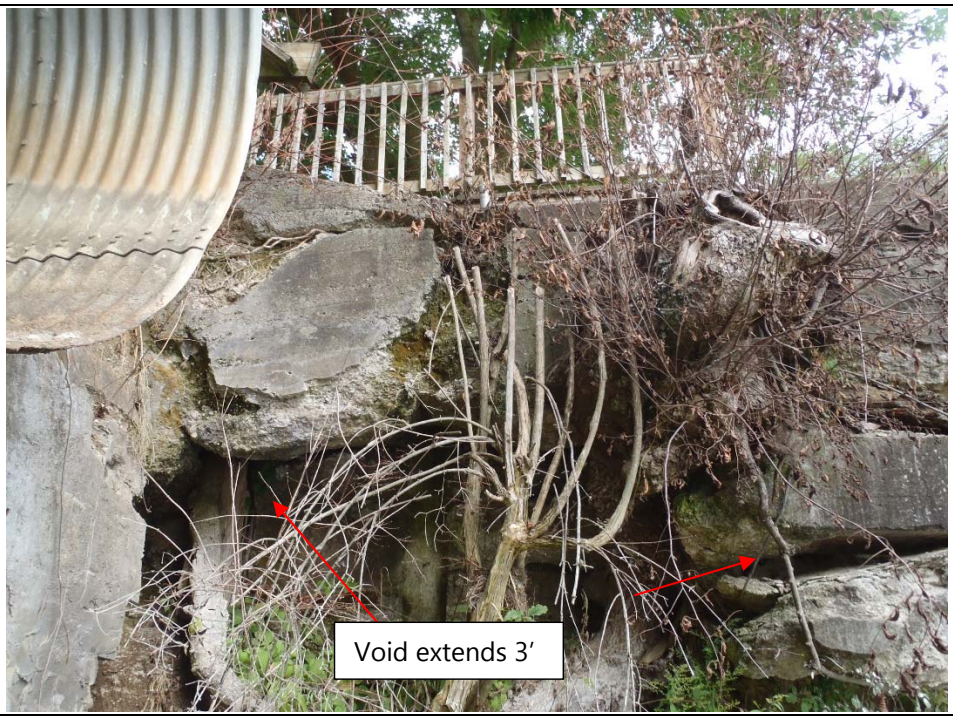


Photo 13 Spill Tube Structure, deteriorated box structure with arrow pointing to wire rope

Photo 14 Spill Tube Structure, arrow pointing to wire rope

Photo 15 Spill Tube Structure, downstream

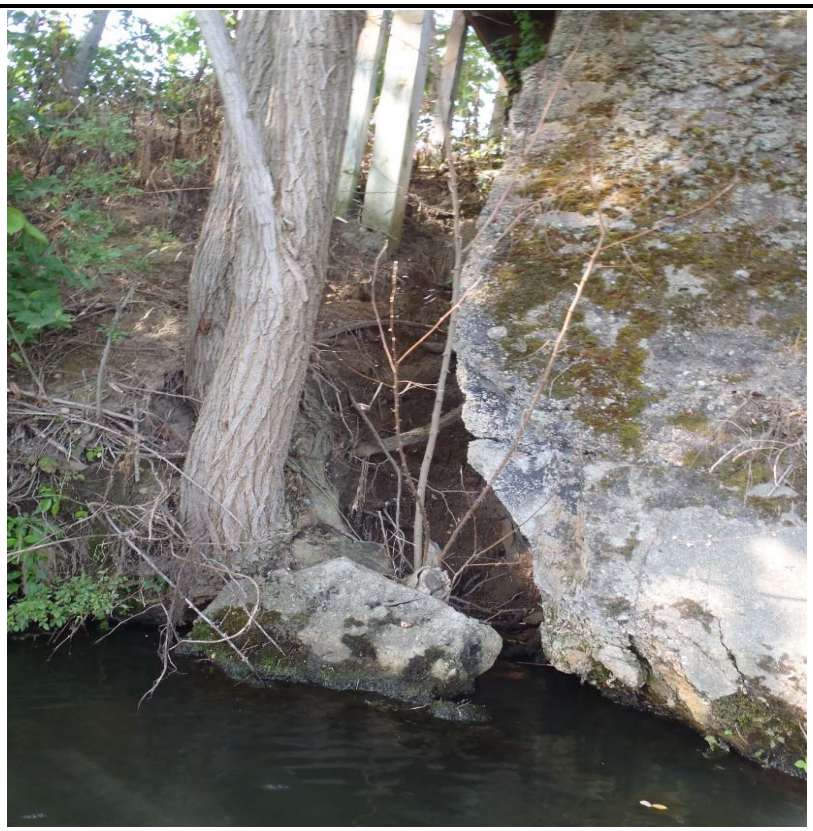


Photo 16 Gap between right edge of spill tube structure and right embankment soil

Photo 17 Downstream Box Structure top view

Photo 18 Upstream Spill Tube Structure Weir

Photo 19 Spill Tube Structure top view

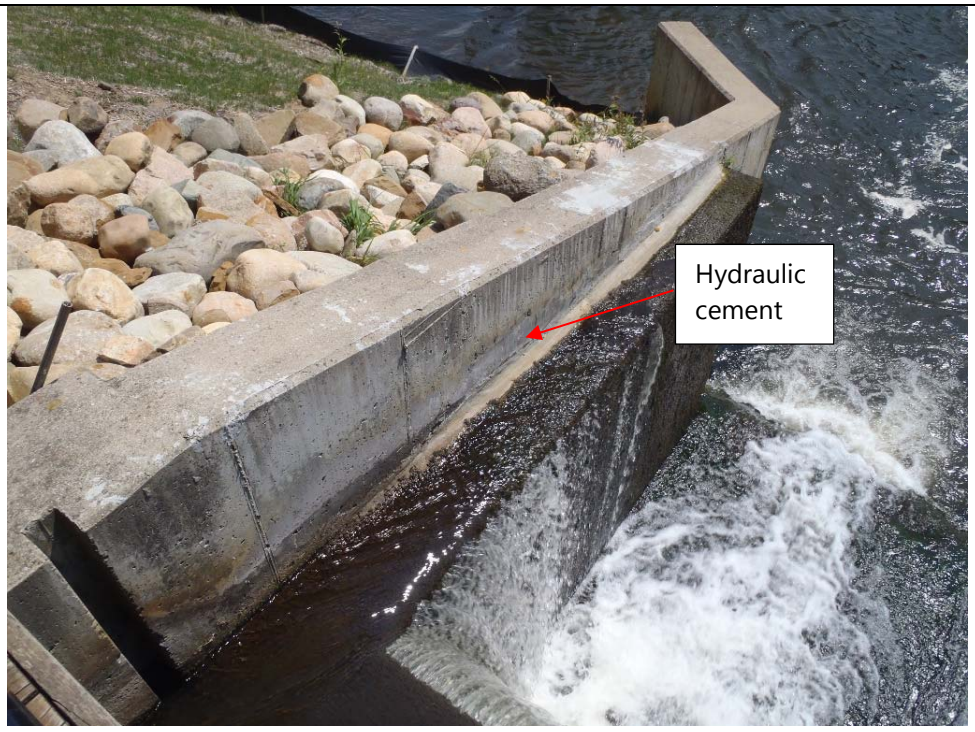


Photo 20 Control Structure and Earth Embankment