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Wisconsin Department of Administration
Division of Facilities Development
P. O. Box 7866
Madison, Wisconsin 53707-7866

Re: Potawatomi Observation Tower Structural Evaluation
DFD Project No. 19F3A
Brander No. 1508-092619

The Wisconsin Department of Administration, Division of Facilities Development, on behalf of the Wisconsin Department of Natural Resources, asked Brander Engineering, Inc. to provide engineering services required to observe the tower and evaluate its condition, review two existing tower assessment reports prepared by others, and make recommendations for possible repair methods that are deemed safe, acceptable, and cost efficient.

DESCRIPTION

Potawatomi Tower is located on the peak of Government Bluff in Potawatomi State Park in the Town of Nasewaupee (near the City of Sturgeon Bay), Door County, in northeast Wisconsin. The 75’ tall tower is square in plan, and tapers along its height from approximately 24’ square at ground level to approximately 16’ square at the top platform.

The framing is comprised of five full height log poles, four sloped poles at the tower corners, and one vertical pole at the tower center. The poles support the three wood-framed full platforms, which are located at approximately the 1/3rd height, 2/3rds height, and at the top of the tower. A wood-framed switchback stairway ascends and encircles the center pole, with landings approximately every 7’. Each bay of stairway and its intermediate landing is hung from the respective platform above by means of two 5x5 wood members.

At each of the four outer faces of the tower, the structure is braced by three pairs of steel tie-rod cross bracing that are attached to the corner poles with circular steel plate collars that clamp around the poles. The first pair of tie-rods extend from the base of the tower to just above the first platform (Ground Level to Platform Level 1), the second pair extends from the base to the second platform (Ground Level to Platform Level 2), and third pair extends from the first platform to the top platform (Platform Level 1 to Platform Level 3).

HISTORY

The Potawatomi Observation Tower was built in the Fall of 1931, on the peak of Government Bluff at Potawatomi State Park, one year after the park itself was established. According to the Door County Advocate, the tower was first opened to the public on Sunday, October 4, 1931. It was designed in a similar size and style to the then existing 1909 Eagle Bluff Tower at Peninsula State Park, approximately 20 miles to the north.

According to documents and newspaper articles at the Wisconsin State Historical Society, the construction materials for the project were funded by the local Sawyer Commercial Club, the design plans were approved (and possibly also prepared) by State of Wisconsin staff engineers, and the tower erection was performed mostly by volunteers under the supervision of the Wisconsin Conservation Commission (precursor to the present day Wisconsin Natural Resources Board, the policy setting arm of the Wisconsin Department of Natural Resources). Holes were blasted in the bedrock for the pole's concrete foundations, and "every bit of wood in the entire structure" was creosoted for decay prevention. According to a sign at the base of the tower, the main support timber poles were obtained from the western United States.

INFORMATION FROM OTHERS

2018 USDA-FPL Investigation

The Wisconsin DNR asked the USDA Forest Products Lab (FPL) of Madison, Wisconsin to visit the tower to inspect, assess, and make recommendations for the main timber pole support columns of the tower. Based on that February 6, 2018 visit, the FPL prepared a report entitled "Nondestructive Assessment of Wood Members in a Viewing Tower in Potawatomi State Park, Door County, Wisconsin, USA" dated December 2018. FPL used visual inspection, sound testing (ultrasound and stress-wave technologies), and mechanical tests (micro-drilling resistance) to detect deterioration at and beneath the surfaces of the timber poles. The report indicated the following:

1. **Visual inspection for water intrusion** - FPL observed evidence of and damage due to water intrusion, generally in the form of fruiting bodies (fungi), staining or discoloration, insect activity (in the form of holes, frass, and/or powder posting), and plant or moss growth in checks and splits.

2. **Visual inspection for structural distress –** FPL observed evidence of wood structure distress, generally in the form of fiber separation (splits and checks) and fiber crushing at the clamped tie-rod collars.

3. **Sound testing –** FPL used a commercially available nondestructive sound transmission testing device to test the interior integrity of a wood timber members. The device impacted one side of a timber to generate a stress wave and used a sensor to detect the wave on the opposite side.

4. **Mechanical tests –** FPL used micro-drilling resistance to identify and quantify decay and voids in areas of timber believed by visual assessment and sound transmission to contain deteriorated wood.

5. **Conclusions –** FPL concluded that there is significant internal and surface decay in the tower's five support poles, and that it would be difficult to accurately determine the extent to which the deterioration has spread. While the load-carrying capacity of the tower has certainly been compromised, the residual load-carrying capacity is unknown.

2019 WRD Investigation

The Sturgeon Bay Historical Society asked the firm Wood Research and Development, Inc. (WRD), to visit the tower to inspect, assess, and make recommendations for possible repair of the main timber pole support columns of the tower. Based on that visit during the week of January 14, 2019, WRD prepared a "Final Inspection and Condition State Report" (dated March 7, 2019). Later, WRD issued a "Design Summary" (dated June 4, 2019), which included five sheets of repair drawings (labeled 'Draft, Not for Construction") entitled "Potawatomi Tower for Sturgeon Bay Historical Society" (dated May 2019). In addition, on November 26, 2019, Brander discussed those findings and recommendations for the tower in a telephone conversation with Dan Tingley, Ph.D. of WRD. Those reports, drawings, and conversations are summarized as follows:

1. WRD performed visual examinations, which generally indicated the following:

   A. At the support pole timbers, there are many surface concerns, including UV deterioration, shrinkage cracks, malleable and easily indented wood surfaces, localized cavity repairs with a coal tar-like substance, painted coatings which inhibit moisture migration and evaporation, and localized animal and bird activity.

   B. At the bottoms of the four corner timber poles, shims have been inserted between the concrete foundation and the bottoms of the poles and the shims were "soft to the touch".

   C. At some locations, the tie-rod collars had shifted along or compressed into the surface of the timber pole.

   D. While the scope of the WRD report did not include the platforms and stairs, it was noted that the stairs, handrails, and platforms had heavy wear and UV surface deterioration, were sagging, and exhibited cracks and deterioration near nails and fasteners. The report indicates that "most of these components are past their life expectancy and should be replaced".

2. Microscopic observations of wood samples performed by WRD indicated that the wood species of the poles is Western Red Cedar.

3. WRD performed non-destructive tests using a psychrometer to make general atmospheric temperature and humidity readings and a Stress-Wave-Time (SWT) testing device that utilized compression wave technology to locate internal decay.

   A. SWT testing was performed at approximately every 3' along the lengths of the five timber poles. Based on the readings, test locations were then categorized as indicating minimal to no decay, early stages of decay ("significant enough to reduce structural capacity appreciably"), or advanced stages of decay ("significantly reduced structural properties such that the element in that zone could not support its own dead weight").

B. Test results indicated two approximately 5’ sections of advanced decay (at the bottoms of the two south timber poles) and sixteen sections of early decay ranging from 2’ to 10’ in length (distributed over the four corner poles).

4. Drilled core samples were taken at six different locations in the timber poles, two each from areas of minimal, early, and advanced decay, which confirmed the SWT readings in those areas.

5. Prof. Tingley stated that WRD had performed a structural analysis of the overall structural frame of the tower to confirm its structural capacity using current code loads, including snow, ice, wind, and 100 PSF floor loading (for assembly platforms). The analysis was based on the assumption that the damaged pole areas were repaired and the poles were sound except for the outer 1/2” perimeter of wood thickness, which was disregarded due to deterioration. Based on these design loads and assumptions, WRD determined that the poles would be structurally adequate.

6. The February 2019, WRD report indicated that the decayed portions of poles could be repaired by either in-kind partial pole replacement or by fiber wrap reinforcement. In the June 2019, follow-up Design Summary, however, in-kind replacement was determined to be the optimum repair method. The reports and drawings include the following recommendations for structural timber pole repairs:

A. **In-kind partial replacement** - WRD recommended full in-kind replacement of three locations of deteriorated portions of timber poles; the two approximately 5’ high areas of “advanced” decay at the bases of the SE and SW poles, and one approximately 10’ high section of “early” decay in the SW pole adjacent to the Level 2 Platform. The procedure would consist of the following:

i. Directly above the repair, shore the portion of pole to remain in place.

ii. Cut out the section of deteriorated pole to be replaced.

iii. Produce a section of new timber pole of the same diameter, taper, and length.

iv. At each mating surface, install a 12” long vertical alignment pin and bond the mating surface with epoxy.

v. Reinforce each mated joint with:

a) Four 24” long steel pins and timber keys, each set into a morticed notch equally spaced around the pole (to resist axial rotation at the joint).

b) Four 40” long x 4” wide strap plates, each through bolted to and equally spaced around the face of the pole (to resist bending at the joint).

In addition, at the bottoms of the tower legs where the poles are in contact with the concrete foundation, WRD recommends installation of a neoprene or malthoid (bitumen impregnated felt) barrier to prevent the wood from wicking moisture from the concrete base.

B. **Hardware adjustment** - WRD recommends that once the poles are repaired, the connection hardware is to be adjusted and tightened to assure that the structure is aligned and stable.

C. **Chemical treatment** - At the areas noted by WRD as exhibiting early stages of decay, WRD recommends the introduction of wood preservatives to inhibit further wood decay due to pests or fungi. This procedure would involve drilling holes into the wood and then inserting borate salt rods to leach salts into the wood to inhibit further decay. Even at areas of minimal-to-no decay WRD would typically propose that salt rods be installed every 6” along the height of the poles, but in this case, in an effort to reduce the total costs of repairs, salt rod installation is being limited to those decayed areas indicated by testing. It was noted that such chemical diffusion is a maintenance item that would need to be checked every year and replenished as needed. In addition, it was recommended that “bright wood” be treated with Copper Naphthenate and that end grains be sealed with a paraffin wax sealant.

D. **Optional repairs** -WRD lists the following as optional repairs:

i. Stair and Platform Repair – Replacement of all areas of degraded stairs, landings, and deck with new white oak materials.

ii. Cleaning and Staining - Media blast the wood structure with walnut shells or acrylic beads to remove the existing coatings and prepare the surface for a new stain and sealer.

7. WRD asked the firm Timber Restoration Services (TRS) to prepare a construction cost estimate for the above work, including the following:

A. Engineering, restoration design, CAD drawings, post project documentation, and final engineer’s site inspection of work (presumably to be performed by WRD).

B. Shop drawings, labor, and per diems based on six days of work.

C. New stairs and deck (additional five days of work).

D. Surface remediation, including walnut shell blasting, removal and infill of tar patches, and restaining of entire structure (additional four days of work).

E. Extra time beyond that stated would be billed on a time and expense basis.

According to an estimate prepared on May 14, 2019, costs for the above work would be $249,179. The estimate was referred to as a "Level D Estimate Only".

Historical Status

Mark Dudzik, former state archeologist, indicated in May 2018, that the tower does not have the integrity and significance of a historic structure as measured by federal NRHP (National Register of Historic Places) criteria, and as such, the tower is deemed "not eligible" for listing on the NRHP nor does it possess qualities to make it so.

BRANDER OBSERVATIONS

On Wednesday, November 20, 2019, James Giddings and Donald Kraft of Brander visited the site to observe and assess the condition of the tower. The outer perimeter surfaces of the poles and platform framing were observed by means of a 135' boom lift, while the remainder of the tower was observed from the stairs, stair landings, and main platforms. Brander relied on the documented tests and probes made by others, and as such, no testing regarding the strength or deterioration of wood or metal components was performed by Brander. Brander made the following observations and measurements:

1. **Foundations**

   A. The five tower poles are each supported by square concrete foundations with the top surface 12" above grade. The concrete, which is generally without significant cracks or spalls, appears in adequate condition.

   B. The two 5x5 stairway support poles extend to the ground, although there is no similarly raised concrete foundation visible for their support.

2. **Poles**

   A. The diameters of the four tapered full height corner poles ranged from approximately 17" at the base to approximately 10" at the top platform. The tapered full height center pole ranged from 15" at the base to 7-1/2" at the top platform.

   B. At the Level 2 Platform, the continuous center round pole ends transitions to an 8x8 square post.

   C. The four corner poles originally did not bear on the top of the concrete foundation. Instead, each pole was suspended approximately 2" above the concrete by means of two 3/4"x5" vertical steel straps embedded in the concrete and extending up to anchor to the pole (as is the case currently with the center pole). This 2" corner pole gap was subsequently infilled at a later date.

D. At several locations, there was evidence of movement of the tie-rod collar brackets. Some had slipped up or down along the pole, while others had rotated at the tie-rod connection. At some of these rotated collar locations, the collar had either cut into or crushed the pole's surface.

E. Brander observed similar surface deterioration as reported in previous investigations, including UV degradation, splits, checks, fungi, and insect and animal damage.

3. Guardrails

A. The typical guardrail construction consists of a 2x6 horizontal cap member (oriented on the flat) and two intermediate height members (oriented on edge) each spanning horizontally (approximately 8') between 4x4 or 6x6 posts.

B. The wood guardrail height was typically measured as only 40" to 41" above the platform floor.

C. There were areas of wood decay surrounding corroded fasteners.

4. Stairs and Landings

A. The stairs were typically 30" wide and constructed of 2-1/2" thick timber treads morticed into 2-1/2" thick timber stringers. There were areas of wood decay at the ends of some treads.

B. While each stair run had guardrails along the outer side of the stairs, many runs had neither guardrails nor handrails along the inner sides of the stairs.

C. Guardrails along the outer sides of the stairs were measured as only 36" high.

5. Main Platforms

A. Elevation measurements at the platform corners indicates that each platform slopes significantly from corner to corner, approximately 1" at the first platform, approximately 2" at the second platform, and approximately 4" at the top platform. The low corner did not always coincide from platform to platform.

B. The platform floor framing did not have bracing or blocking between the joists.

C. Some of the full 2x8 floor boards are cupped, twisted, and lifted, causing relative displacement from board to board of as much as 3/8".

6. **Steel Components**

   A. All of the visible steel components, including the tie-rods and turnbuckles, tie-rod collars, foundation strap anchors, connecting bars, and through-rod bolts, were all in good condition with the existing coating relatively intact. The threaded portions of these components had minor corrosion which would likely inhibit easy adjustment.

   B. Several of the tie-rod turnbuckles had been turned to their maximum extent of threads allowing no further adjustment.

CODE REVIEW

The possible scenarios for retaining a tower at this location would be governed by the 2018 Wisconsin Commercial Building Code (WCBC) which incorporates the 2015 International Building Code (IBC) series of codes by adoption. According to the IBC, miscellaneous structures, such as an observation tower, are classified as "Utility and Miscellaneous Group U" occupancy and thus come under the requirements of the building code.

The International Existing Building Code (IEBC) governs work on existing buildings and structures that would otherwise be governed by the IBC if new. The IEBC imposes incrementally more stringent requirements on a project, depending on the following extents of proposed work:

1. **Repair** - Patching, restoration, or replacement of damaged materials or dangerous conditions must be made in a manner that brings those affected components into compliance with the IBC requirements for new similar structures. The repaired structure does not need to meet current requirements for egress and accessibility.

2. **Alteration –** If removal and replacement of existing materials involves a reconfiguration of space, then current egress and accessibility requirements would apply.

3. **Change of Occupancy** – Any change of occupancy would require implementation of current egress and accessibility requirements.

If tower repairs do not involve a change of occupancy or a reconfiguration of space, the work would come under IEBC "Section 502 – Repairs" and "Chapter 6 – Repairs", rather than the more restrictive IEBC Alteration categories. According to IEBC Chapter 6:

1. Repairs are to be done in a manner that maintains the existing level of egress and accessibility.

2. All modifications performed to either repair or replace a damaged or unsafe structural component to its predamaged state must comply with the provisions of the IBC. If a structural component is undamaged but structural analysis determines that it does not have adequate structural capacity for current design loads, then it does not necessarily need to be reinforced or replaced for that reason alone.

IEBC Chapter 12 - Historic Buildings offers less restrictive requirements for buildings or structures listed or certified as eligible for listing, by the State Historic Preservation Officer (SHPO) or the Keeper of the National Register of Historic Places (NRHP). Since the tower has been determined to be “not eligible” for listing, Chapter 12 would not apply.

Brander contacted the International Code Council (ICC) (the association that develops the IBC), for a response regarding the code implications for the tower work options. If the space is not reconfigured and the occupancy is not changed, ICC offered the following comments:

1. **Demolish and Construct with New –** Demolition of the existing tower and construction of an identical tower with new materials would fall under the requirements of the IBC for new construction, including those for egress and accessibility.

2. **In-Situ Repair –** Repairing the individual deteriorated parts of the tower as it stands, without significantly altering the configuration of the tower, would be considered a repair under the provisions of the IEBC.

3. **Dismantle, Repair, and Re-Erect** - Dismantling the tower down to its individual parts, repairing or replacing the deteriorated/damaged parts, and remediating the dangerous/unsafe conditions, and then re-erecting the parts to the same original configuration, could still be considered an IEBC repair. However, depending on the extent of existing materials that are replaced with new, the code official having jurisdiction may determine that the work has crossed the line into new construction, which would be governed by the IBC. Since the project location is outside the city limits of Sturgeon Bay, Wisconsin, the code review for the project would be performed by the State Department of Safety and Professional Services (DSPS) rather than locally by the city. Once the scope of work for this scenario has been determined, a code interpretation should be secured by the State Plan Reviewer to determine whether this would be a viable path forward.

Brander also reached out to Steve Dobratz of DSPS and briefly discussed the proposed project. Although Mr. Dobratz did not issue a binding ruling, he did provide the following comments:

1. Mr. Dobratz stated that the tower is a non-building structure that would not require plan review by DSPS.

2. If the tower was repaired in kind with similar materials, it could be classified under Chapter 5 of the IEBC as a repair.

3. If existing fixtures or elements were replaced with new fixtures or elements that serve the same purpose, it could be classified as a Level 1 Alteration.

4. Although EIBC Section 705 has requirements for accessibility for Level 1 Alterations, there is an exception under 705.2 when costs for providing an accessible route exceed 20 percent of the cost of the alterations.

5. If the tower was completely deconstructed as part of the repairs and then reconstructed, it would be considered a new building/structure and would need to comply with the IBC. IEBC Chapter 13 “Relocated or Moved Buildings” provides some guidance on what work should comply with the IBC versus the IEBC in the case of relocation or partial deconstruction in addition to other IEBC Repair or Alteration requirements.

The comments from Mr. Dobratz corroborate the response from the ICC and offer additional depth, clarity, and guidance regarding upgrading elements, such as guardrails and stairs, and addressing deconstruction as a part of the repair project.

STRUCTURAL ANALYSIS

Brander performed a structural analysis to determine the load carrying capacity of the platform framing and the guardrails based on IBC required minimum live loads (Table 1607.1). Horizontal and lateral live loads used by Brander include the following:

1. Stairs and Exit Floor Areas – 100 PSF.
2. Elevated Platforms – 60 PSF (100 PSF needs to be used in exit path areas of the floors and could be used for all floors if assembly area person density is required).
3. Handrails and Guards – 200 LBS concentrated and 50 PSF linear, both applied in any direction (but not concurrently).
4. Uniform Snow or Ice – it is assumed that the tower would be used only when the platforms and stairs are cleared of significant snow or ice, and thus, the uniform occupancy loads listed above would govern.

As mentioned previously, the WRD structural analysis indicated that the timber support poles have adequate structural capacity, so Brander analyzed only the individual components of the platforms, including floor framing and guardrails. The Brander analysis indicated that the wood floor framing and the wood guardrails do not have adequate load carrying capacity to resist the IBC code required design loads.

DISCUSSION

Tower Lateral Bracing - Where the tie-rod collars wrap around and engage the support poles, several of the collars have moved as a result of either slipping along, rotating about, or crushing into the pole’s wood surface. This movement represents a performance failure of the tower’s tie-rod lateral bracing system. Given this tie-rod connection movement at the collars, and that some of the tie-rod turnbuckles have already been adjusted to their limits, it can be reasonably assumed that the tower had drifted out of plumb in the past and that attempts were made to try to retension the resulting loose tie-rods. While Brander did not have the means to determine the extent of any such drift, such vertical misalignment of the tower would need to be corrected as part of any repair. To realign the tower and ensure future performance of the lateral bracing system, the following action would likely be required:

1. The existing collars may need to be enlarged (to reduce the bearing/crushing stress of the wood that is in contact with the collar and to reduce the tendency of the collar to rotate) and anchored (to prevent slipping along the pole).

2. All of the existing threaded tie-rod turnbuckles would need to be freed in order to facilitate adjustment of the tie-rod lengths. It is possible that vertical realignment of the tower would restore the original tie-rod lengths and restore enough length of the threaded ends to facilitate adjustment. If that turns out not to be the case, select tie-rods may need to be modified in-situ to provide additional threads, or replaced with newly fabricated tie-rods with sufficient threads.

3. While the configuration of the lateral bracing tie-rod system is such that it appears to have some redundancy, structural analysis would be required to determine to what extent and in what sequence existing tie-rods could be safely disconnected or removed during the work.

Pole repair - As a pole repair option, the use of epoxy infills and partial height fiber wraps would introduce impervious materials to the pole that might inhibit moisture migration through and evaporation from the wood. For this reason, replacement of deteriorated sections of the poles, as described and detailed by WRD, would be a preferable repair option. However, it would not be possible to install the vertical pins noted on the WRD drawings to align the existing and new sections of poles. The installation of such pins would only be applicable if the new wood pole section could be placed atop the existing pole but would not be possible to install if the new replacement section of wood pole has to be slid between existing sections. In addition, bonding the mating surfaces with epoxy raises a concern, since any moisture that migrates down through the pole will hit the impervious epoxy layer, leaving adjacent areas of wood susceptible to rot.

Platforms - Since it was found that the platforms slope, and that the slope was not consistent from platform to platform, this finding suggests that several factors are at play, rather than just settlement of one pole. Other factors might include elevation variations in original construction, wood member dimensional changes (shrinkage, warping, etc.), or racking of the entire tower.

Without blocking or bracing, as required by the National Design Specification of the American Wood Council, the floor joists are subject to diminished structural load carrying capacity due to rotation.

According to the IBC building code, a 1/4” difference in elevation between floor boards is considered a walking surface trip hazard.

Guardrails - Even if constructed of new wood materials, the 2x6 wood guardrail members do not have adequate structural capacity to resist IBC code or OSHA mandated lateral loads for guardrails. In addition, the guardrails do not have IBC code required height. This is of particular concern at the bottom of a stair run where the user would not be adequately protected while standing in an elevated position on the lower treads. Contemporary guardrail design would include kickplates, a height not less than 42”, and openings less than 4”.

User Experience - While the stairs are of adequate width and slope, the areas of wood deterioration, incomplete or missing handrails/guardrails, and non-uniformity and slope of treads, makes for a very disquieting, if not completely unsafe, walking and climbing experience, given modern expectations and current IBC code requirements. Also, the slopes and unevenness of the stair landing and platform walking surfaces present similar risks of slipping or tripping, which is hazardous, given that the surrounding guardrails are structurally inadequate for protecting those walking surface edges.

Similar Projects - Brander was not able to find information regarding repairs to similar timber open-air structures, let alone observation towers. Much of the published information regarding timber pole reinforcement or repair is related to utility poles or wood timber piles that support shore piers. Such reinforcement is usually in the form of covering the pole with a carbon fiber wrap or jacketing the pole and injecting the space between the pole and the jacket with epoxy. These repair techniques would not be feasible for the tower, given that the tie-rod collars and the attached platform framing would prevent continuous wrapping or jacketing along the length of the pole without major shoring to allow temporary detachment of platform framing and collars.

Potential for Lead-Based Coatings - The coatings on the existing wood members of the tower have not been tested for lead. Depending on how extensive such coatings may be, costs for abatement could become significant, since the work would require that the member be shrouded during coating removal and the debris properly disposed of.

WRD/TRS Cost Estimate - It should be noted that the construction cost estimate prepared by TRS and provided by WRD was labeled as a “Level D Estimate”. Also referred to as an “Order of Magnitude” or “Conceptual Phase” estimate, costs indicated in a Level D Estimate could be expected to vary from -25% to +75%. In the case of the TRS estimate, the $249,179 estimated cost could vary from approximately $186,000 to $436,000.

CONCLUSION

Deteriorated portions of the tower’s main support poles can be structurally repaired using the majority of the methods described in the WRD reports and preliminary drawings. However, visual observations suggest that additional repairs would be required:

1. There is at least one other portion of a pole that warrants a repair. Further investigation may reveal additional locations.

2. There remain numerous other concerns with the tower that must be addressed structurally, such as dislocated tie-rod collars, deteriorated platform framing, uneven platform floor boards, dimensionally irregular stairs, and structurally inadequate guardrails. These additional items must also be addressed in order to provide adequate overall tower stability, structural floor and guardrail capacity, and safe walking and climbing surfaces to assure the safety of the tower users and to minimize liability concerns for the tower owner.

In addition to in-situ repairs, dismantling the tower, repairing or replacing the components, and then re-erecting the tower to its original configuration, might become more feasible if extensive abatement of lead-based coatings is required. However, prior approval of this procedure from the Wisconsin Department of Safety and Professional Services (WDSPS) would be required to assure that this work would remain a “Repair” under the IEBC (building code for existing structures) rather than new construction under the IBC (code for new structures).

RECOMMENDATIONS

The following repair work is recommended to stabilize the tower and to provide structurally and functionally safe walking surfaces and perimeter protection for the long term:

1. At the three locations noted by WRD (at the bottoms of the southeast and southwest poles and at the southwest pole adjacent to Level 2 Platform) replace the deteriorated segments of the timber poles with new infill sections.

2. Further assess at least two other support pole locations which have resulted in diminished pole cross sectional area; one of deep surface decay (southeast pole at Level 1 Platform) and one of damage from a tie-rod collar (southwest pole at the Level 1 Platform). Once the extent of wood affected by decay, moisture, infestation, and/or damage has been quantified, these areas may also require a similar segment replacement. If so, that would make three segment replacements in the southwest pole, and it should then be determined whether total replacement of the southwest pole might be the more feasible option.

3. Part of the WRD recommendations include chemical treatment of the timber poles. It should be noted that this treatment will be a maintenance item that will need to be checked over the full length of the poles on an annual basis and reapplied, as required. As part of that annual maintenance inspection, visual observations should also be made for any subsequent deterioration or damage.

4. The original wooden stair system (wood stair treads, stringers, handrails, and guardrails) and the platform guardrails are unsafe and should be replaced with new construction that meets code requirements for structural strength and dimensional measurements and uniformity. For long-term strength, stability, maintenance, and safety, structural steel construction should be considered for the stairs and guardrails.

5. Reinforce or replace existing deteriorated floor joists and deteriorated perimeter support beams at each of the three observation platforms to meet the requirements of the IBC code. While Brander determined that the existing platform floor framing is not structurally adequate to carry current IBC code required uniform loads, the code does not require that these members be replaced for this reason alone.

6. Address the platform floor board tripping hazards by either refastening loose boards, ripping and refastening cupped boards, or planing down raised edges.

7. Since many of the 16 existing tie-rod collar brackets are sliding, rotating, or crushing the adjacent wood surfaces, Brander recommends either modifying or replacing the brackets to mitigate those concerns. Related work would include verifying the vertical alignment of the tower, cleaning the threads of the tie-rods and turnbuckles, as required for proper adjustment, and re-tensioning each tie-rod. If realignment of the tower and repositioning of the collars does not provide adequate threaded end adjustment for the tie-rods, those rods may need to be modified or replaced.

It should be noted that the design for any repair or alteration of existing tower components or the design of any new tower components should be performed under the direction of a professional engineer licensed in the State of Wisconsin.

COST ESTIMATE

Brander cost estimates for work related to the tower are as follows:

1. Demolition - $153,100.
2. In-Situ Repair - $1,501,000.
3. In-Kind Replacement - $1,556,000 (does not included accessibility and egress).
4. Annual Inspection - $5000/year.
5. Triennial Maintenance - $14,000 every three years.
6. Future Repairs - $500,000 every 20 years.

Description and breakdown of the above estimates are listed below. Costs for construction work are considered +/- 40%. In addition, if the coatings of the existing wood materials are found to contain lead, then abatement costs could be as much as $200,000. These additional amounts are included in the contingencies where indicated. Where indicated, estimates for engineering include costs for design phase services to prepare detailed drawings and specifications required to obtain competitive bids from interested contractors, for bid phase services to assist in bid solicitation, and for construction phase services to observe the work and administer the contract.

1. **Demolition** (Performed as a stand-alone project with foundations to remain)

Construction	$100,000
Contingency (+40%)	$ 40,000
Engineering (bid phase services)	$ 7,500
DFD Fees (4% of construction and contingency costs)	$ 5,600
Total	**$153,100**

2. **In-Situ Repair** (With the tower standing as is, repair the poles, reinforce the platform framing, replace the stairs and guardrails, and clean and re-stain all wood materials. The option of dismantling and re-erecting the tower may become more feasible if there is extensive lead remediation that would be better performed on components at ground level. As mentioned previously, a proposed dismantling and re-erecting of the tower would need to be cleared with the WDSPS Plan Reviewer to assure that the project could still be classified as a “Repair”).

Construction (labor and materials)	$1,200,000
Contingency (+40% + $200K if coatings contain lead)	$ 140,000
Engineering (design, bid, and contract admin. services)	$ 100,000
DFD Fees (4% of construction and contingency costs)	$ 61,000
Total	**$1,501,000**

3. **In-Kind Replacement Without Accessibility/Egress Upgrades** (Demolish the existing tower and reconstruct to the original configuration using all new wood materials. Note that this estimate is for comparison purposes only, since a replacement would initiate new and additional egress and accessibility requirements).

Construction (labor and materials)	$1,000,000
Contingency (+40%)	$ 400,000
Engineering (design, bid, and contract admin. services)	$ 100,000
DFD Fees (4% of construction and contingency costs)	$ 56,000
Total	**$1,556,000**

4. **Annual Inspection** (a qualified person utilizes a lift to inspect the condition of the tower components, inspect each chemical treatment rod location, and document those locations where repair work or replacement chemical treatment rods are required).

Engineering (site work, including lift rental)	$4,000
Engineering (documentation drawings and specifications)	$1,000
Total	**$5,000/yr**

5. **Triennial Maintenance** (a contractor utilizes a lift to perform minor maintenance repairs and to replace the consumed chemical treatment rods documented in the previous annual inspections).

Construction	$8,000
Contingency (+40%)	$3,500
Engineering (bid and contract admin. services)	$2,000
DFD Fees (4% of construction and contingency costs)	$ 500
Total	**$14,000/3 yrs**

6. **Future Repairs** (assuming that continuing wood deterioration will require future replacement of elevated tower components, including pole segments, platform framing, stair sections, or guardrails).

Construction	$319,000
Contingency (+40%, assume lead is already abated)	$127,500
Engineering (design, bid, and contract admin. services)	$ 35,700
DFD Fees (4% of const. and cont.)	$ 17,800
Total	**$500,000/20 yrs**

These estimates are based on 2019 Means Construction Cost Data, on information gathered from consultation with qualified local contractors, and on Brander experience with similar projects.

Please call if you have any questions about the above report.

Sincerely,

BRANDER Engineering, Inc.

Donald F. Kraft, P.E.
Senior Engineer

James D. Giddings, P.E.
Senior Engineer

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