STRUCTURAL CONDITION ASSESSMENT REPORT FOR THE GRANARY ELEVATOR BUILDING PHASE II – FOUNDATION EVALUATION

Sturgeon Bay, Wisconsin
MBJ Commission No. W13-314.1

MEYER | BORGMAN | JOHNSON

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Date: November 25, 2013 (*revised December 12, 2013)*

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PROFESSIONAL CERTIFICATION

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Wisconsin.

David Holten, PE Wisconsin Reg. No. 31591

WISCONSIN COASTAL MANAGEMENT PROGRAM

Funded by the Wisconsin Coastal Management Program and the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act, Grant # NA13NOS4190043.

EXECUTIVE SUMMARY

The purpose of this analysis is to determine whether the elevator, in its current condition, has sufficient capacity to support the anticipated future loads. This report continues and refines a report produced by Meyer Borgman Johnson Structural Design and Engineering (MBJ), dated July 31, 2013. That report presented preliminary findings of the elevator superstructure – its construction, condition, and recommendations for future use. This report extends that evaluation into the elevator foundation. A site visit was conducted by Chris Hartnett, PE, on November 6th and 7th, 2013 to observe, measure and photo-document the building foundation.

The elevator can be described as having a 'soft-story', with a lower story (the 1st level) that is weaker and more flexible than the stories (the bins) above. This, when combined with the elevator's out-of-plumb condition, makes for the possibility of an unstable building. Based on the forces and deflections calculated during the analysis, a reinforcing strategy has been devised and preliminary recommendations made to modify the elevator for its proposed future use. These recommendations include sufficient detail for early cost-estimating.

The superstructure was described at length in Phase I of the evaluation, presented in our July 31, 2013 report. The foundation consists of 16" wide by 6'-0" deep concrete grade-beams that lie on the north/south lettered grids. The grade-beams bear on wood piles driven to competent soils. The wood piles lie below the water-table, are saturated with water, and are in very good condition. The western tilt of the building has caused the tops of the grade-beams to rotate several inches to the west. This rotation has rotated the interior grade-beams between 5 degrees and 16 degrees.

The original gravity-carrying system – 1st floor columns, concrete grade-beams, and wood piles – were designed for far higher loads than the future anticipated loads. The analysis presented in this report addresses whether deterioration or adverse modifications have reduced the elevator current capacity below acceptable levels. The slight westward movement of the elevator superstructure, and the resulting rotation of the concrete grade-beams, have caused the wood columns above to not align with the wood piles below. This misalignment, when combined with the weight of the elevator above, forces the grade-beams further out of alignment. A new system is required to resist the lateral wind forces and the overturning forces caused by this misalignment

CONCLUSIONS AND RECOMMENDATIONS

1. **Foundation Construction**

   The foundation consists of five concrete grade-beams supported on an array of 55 wood piles. The piles measure 12" in diameter.

   Recommendation 1: No recommendation for future action.

2. **Foundation Condition**

   The interior grade-beams are divided by construction joints at approximately 1/3 points along their length. The middle third between the joints is rotated 15 degrees to the west; the outside sections of the grade-beams are rotated five degrees. The tops of the wood piles lie below the water-table; therefore, there is insufficient oxygen to allow deterioration due to decay fungi or insect infestation.

   Recommendation 2: The actions required to repair the grade-beams are addressed in recommendation 5 below. The wood piles require no future actions.

3. **Gravity Loading**

   There is excess capacity within the original designs to respond to minor deterioration and adverse modifications. Several original columns were previously replaced with weaker built-up columns.

   Recommendation 3: During the design phase of the future adaptive reuse project, analyze the replacement columns; repair or replace the weakened columns, as required.

4. **Lateral Loading**

   The original lateral resisting system in the 1st level was not sufficiently stiff to resist wind loads without excessive deflections. New systems are required to resist future wind loads and to address the rotational forces caused by the rotated grade-beams.

   Recommendation 4 – Superstructure Lateral System: There are two cost-effective solutions to resist future wind loads in the superstructure:

a. Build an adjacent structure that the elevator can 'lean' against. The lateral forces required to brace the elevator are not unreasonable for an adjoining building to resist.
b. Install diagonal steel rod braces in eight exterior bays and four interior bays. These could be designed to match the historic elevator aesthetic.

Recommendation 5 – Foundation Lateral System: Two systems are required to restore a viable east/west lateral system within the foundation:

a. Construct 25 new concrete tie-beams on the numbered grids to tie the existing grade-beam together, and resist additional rotation.
b. Construct four below-grade buttresses constructed against the west face of the elevator to transfer the east/west wind forces from the foundation to the soils.

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INTRODUCTION

1. Purpose of Assessment

The City of Sturgeon Bay is investigating reusing the Midland Granary Elevator as part of a new waterfront redevelopment project. This report continues and refines a report produced by Meyer Borgman Johnson Structural Design and Engineering (MBJ), dated July 31, 2013. That report presented preliminary findings of the elevator superstructure – its construction, condition, and recommendations for future use. This report extends that evaluation into the elevator foundation. Some conclusions and recommendations from the July 31st report are refined in this report, based on the findings of this investigation. Finally, a preliminary design is described to resist lateral wind forces and overturning forces caused by the elevator's out-of-plumb condition.

2. Scope

a. Building Description

The elevator is a wood-framed structure that is clad in corrugated metal sheathing. A 15' tall gable roof bears on nineteen 30' tall grain bins, constructed of 'cribbed construction'. The bins bear on an array of thirty 15'-8" tall, heavy-timber columns. This superstructure is supported on concrete grade-beams that bear on heavy-timber piles.

b. Site Observations

A site visit was conducted by Chris Hartnett, PE, on November 6th and 7th, 2013 to observe, measure and photo-document the building foundation. Holes were cut in the main floor planks between the five lettered grids and a ladder was lowered to provide access to the grade-beams. The grade-beams were observed and measured for size, construction, deterioration and plumb.

Two heavy-timber piles were also investigated. The soil just west of the southwest corner of the building was excavated to expose two wood piles that support the westernmost grade-beam. These piles were measured, probed for deterioration, and a small sample was removed for species identification.

Measurements of the superstructure were taken to better understand the east/west and north/south deflections of the 1^{st} floor wood columns.

All measurements were recorded in a field notebook; the foundation and superstructure plumb and level were compared to laser-generated planes, and the building was photo-documented using a high-resolution digital zoom camera.

c. Analysis

While this investigation is somewhat preliminary in nature, the analysis required to determine the feasibility of using the elevator is quite extensive. The elevator can be described as having a 'soft-story', with a lower story (the 1^{st} level) that is weaker and more flexible than the stories (the bins) above. This, when combined with the elevator's out-of-plumb condition, makes for the possibility of an unstable building. This possibility requires a high degree of confidence, and analytical sophistication, early in the project. Due to this requirement, a detailed computer analysis model was constructed to capture the elevator behavior. The model includes over 1,000 pieces, over 700 plates, and over 1,200 connections. Twenty-six different load combinations of wind, self-weight, and live load were considered. See Diagram 1. The computer analysis was supplemented by hand calculations and MBJ analysis spreadsheets to determine loads and to confirm the computer results.

d. Conclusions and Recommendations

Based on the forces and deflections calculated during the analysis, a reinforcing strategy was devised and tested on the computer model to confirm the viability of saving the elevator. Based on the findings of the analysis and evaluation, preliminary recommendations are made to modify the elevator for its proposed future use. These recommendations include sufficient detail for preliminary cost-estimating.

DESCRIPTION OF THE STRUCTURE

Because this report focuses on the elevator foundation, the foundation is described in some detail below. The superstructure was closely analyzed in the July 31 report; therefore, the following description of the superstructure is taken from that report and edited for brevity.

1. General Description

The elevator elevator is a wood-framed structure that is clad in corrugated metal sheathing. It measures approximately 40' east/west by 50' north/south. Nineteen grain bins that each measure approximately 10' square x 30' tall bear on an array of 15'-8" tall heavy-timber columns. A 15' tall gable roof bears on the bins, and a 15' tall x 20' wide x 25' long head-house extends above the roof ridge. This superstructure is supported on a foundation of concrete grade-beams and heavy-timber piles.

2. Superstructure – First Level Framing, Grain Bins, and Roof Structure

The main floor of the elevator consists of wood planks that bear on wood joists, spaced at 16" on-center. The joists bear on concrete grade-beams, located on the lettered grids. Thirty 12"x12" wood columns extend from the foundation to support the bins. The top-of-column connections include 12"x2 ½" knee-braces that provide rotational resistance. See photo 1.

The grain bins were constructed using 'cribbed construction', which consists of hand-sawn 2x4 planks laid flatwise, with long steel spikes driven through the plies to tie the walls together. This creates a matrix of 4" thick wood walls that is rigid and strong to resist external wind loads and internal horizontal thrust loads created by the column of grain.

Sloped wood roof joists bear on the east and west exterior bin walls. Wood planks create the roof deck, which is covered by asphalt roof shingles.

The exterior skin is constructed of 4'x 8' sheets of corrugated metal that are nailed to the supporting wood structure. This cladding provides protection against water and snow. It also creates a system of shear walls to resist lateral wind loads.

3. Foundation

The July observations created the perception that relatively shallow grade-beams supported the building, and that a shallow crawlspace existed in the northwest corner of the building. The recent site visit uncovered that this is not the case. The foundation consists of 16” wide by 6’-0” deep concrete grade-beams that lie on the north/south lettered grids. A composite 12x10 wood beam (six 2x10s) bears on the grade-beam; 2x12 wood floor joists spaced at 16” on-center span across the composite beam. The building columns bear atop the grade-beams; it is not clear whether the columns bear directly on the concrete or sit atop the 12x10 wood beam. The grade-beams are tied together by 1” diameter rods that span east/west and are bolted to the grade-beams at approximately 9” below the top of concrete. Parallel to the rods, 6x10 wood beams spaced at 9’ on-center also tie the top of the grade-beams together. See Diagram 2 and Photo 2. The grade-beams bear on wood piles driven to competent soils.

OBSERVATIONS

1. Foundations

The east/west tilt of the building has caused the tops of the grade-beams to rotate several inches to the west. The extent of deflection varies across the building. The outside grade-beams (on grids A and E) are sloped only a few inches, while the interior grade-beams have greater deflections. The north and south ends of the interior grade-beams (B-D) are separated from the middle 18’ of the beams, near grids 3 and 5, by a construction joint. The grade-beams between the joints are rotated approximately 21” to the west (16 degrees); the grade-beams to the north and south are deflected approximately 6” to the west (5 degrees). See Diagram 3 and Photo 3.

The excavation at the southwest corner of the building exposed the bottom of the westernmost grade-beam, a 5” thick wood beam beneath the grade-beam, and the top 6” of two 12” diameter wood piles. These piles are spaced 5’ on-center. The wood piles lie below the water-table and are saturated with water. The excavation removed the water briefly for observation. The exposed portion of the piles were in very good condition, with no visible deterioration. See Photos 4, 5 & 6.

2. First Level Framing

Additional measurements were taken of the 1st floor superstructure to gather additional information regarding the building tilt. Deflections were measured and recorded in the north/south and east/west directions for columns that were sufficiently exposed to obtain accurate measurements. The measurements are shown in Tables 1 & 2. See Photos 7 & 8.

Table 1: Column Deflections to the West

Grids	E	D	C	B	A
1	1.75”		4”	4”	
2	3.5”				
3	5”	5.75”	5”		
4	4.5”				
5	3”				
6	1.5”				

Column 2: Column Deflections to the South

Grids	E	D	C	B	A
1				10”	
2					
3					
4		8.5”	7.5”		
5					
6					

ANALYSIS & PROPOSED MODIFICATIONS

1. Gravity Analysis

The purpose of this analysis is to determine whether the elevator, in its current condition, has sufficient capacity to support the anticipated future loads. The 30’ tall bins were designed to carry wheat and other grains. At a density of 47 pounds/cubic foot (pcf), a 30' column of grain weighs approximately 1,400 pounds/square foot (psf). This is significantly higher than the anticipated two stories of assembly (100 psf) loads. Therefore, the original gravity-carrying system – 1st floor columns, concrete grade-beams, and wood piles – were designed for far higher loads than the future anticipated loads. This analysis also investigates whether deterioration or adverse modifications have reduced the elevator capacity below acceptable levels. The answer to this question is more difficult to answer.

a. Superstructure

The July investigation and report focused on the elevator's superstructure. That investigation found that several of the original columns were previously replaced with built-up 2x6 wood pieces that have questionable strength and connections to the original building. These modifications require further analysis during the design phase of a future adaptive reuse project to identify which pieces require repair or replacement.

b. Grade-Beams

This investigation of the foundations was initially proposed to include a determination of the reinforcing bars within the foundation grade-beams. Given the size of the grade-beams– 6' deep – and the reduced future loads, there is no question that they have sufficient strength to carry the anticipated design loads. Therefore, this portion of the investigation was not conducted.

The slight westward movement of the elevator superstructure, and the resulting rotation of the concrete grade-beams, have caused the wood columns above to not align with the wood piles below. This misalignment, combined with a 5,000 pound vertical load (elevator self-weight, live load and wind overturning load), creates approximately 8,000 pound-feet of torsion (rotation) at each interior column. This torsion works to force the grade-beams further out of alignment. A new system is required to resist this force. This system is explained in the Lateral Analysis section below.

c. Wood Piles

A common problem with historic buildings founded on wood piles is the deterioration of the piles due to attack by decay fungi or insect infiltration. This generally occurs near the top of the piles where the water-table rises and falls cyclically, causing periodic wetting and drying of the piles. Piles that are continuously submerged do not suffer attack due to a lack of oxygen. The excavation of the piles in the southwest corner of the elevator showed that the piles lie below the water-table; the City staff noted that the water level is at an historically low level, which confirms that the piles have remained saturated for the history of the building. This makes a strong case for no past deterioration due to decay fungi or insect attack.

Because past damage to the wood piles is not visible, a calculation was conducted to confirm that the piles have sufficient excess capacity to account for possible unseen damage. The computer model calculates that the maximum load on a column is approximately 24,000 pounds. There are two piles for every wood column; therefore, the maximum load on a wood pile is approximately 12,000 pounds. This equates to 105 pounds/square inch (psi) of axial stress on the pile. The axial compressive strength of wood piles is assumed to be at least 425 psi; therefore, the piles have sufficient capacity to support the anticipated new loads. Note: the wood sample of one pile was sent to the University of Minnesota for species identification; when the results are known, the allowable stress reported above will be updated. In the absence of this, the weakest locally available species group (spruce-pine-fir) was used to estimate the 425 psi axial capacity.

2. Lateral Analysis

The lateral (wind) resisting systems in the elevator vary across the height of the building. At the upper levels the matrix of bins creates a stiff and strong box that transfers all wind forces on the bins down to the supporting columns below. The elevator structure beneath the bins relies on two distinct systems: diagonal wood knee-braces at the top of wood columns create a stiff connection between the columns and the bins above. See Photo 10. While these connections are stiff, they are not very strong. The majority of the wind loads are transferred from the bottom of the bins down to the foundation through the corrugated metal exterior walls. These act as stiff vertical shear walls that resist rotation and allow the wind forces to flow down to the foundation. See photo 11.

The horizontal deflections are greatest at the interior columns, indicating that the center of the elevator is deflecting in high winds, with the side wall panels working to resist the movement. Over time, the deflections to the west have become permanent, indicating that the original lateral designs were not sufficient. A new system is required to resist the lateral wind forces and the overturning forces caused by the building deflections. See recommendations 4 and 5 below.

CONCLUSIONS AND RECOMMENDATIONS

1. **Foundation Construction**

   The foundation consists of five concrete grade-beams supported on an array of 55 wood piles. The grade-beams and piles align north/south on the numbered grids. The grade-beams measure 16” wide x 6’-0” deep. They are tied together with 1” diameter tension rods at 1/3 points along their length. The piles measure 12” in diameter.

   Recommendation 1: No recommendation for future action.

2. **Foundation Condition**

   The interior grade-beams (grids A-C) are divided by construction joints at approximately 1/3 points along their length. They are rotated 15 degrees between the joints, and five degrees at the ends of the grade-beams. There is no additional damage to the grade-beams. The tops of the wood piles lie below the water-table and are not subjected to cyclical wetting and drying; therefore, there is insufficient oxygen to allow deterioration due to decay fungi or insect infestation.

   Recommendation 2: The actions required to repair the grade-beams are addressed in recommendation 5 below. The wood piles do not require future action.

3. Gravity Loading

The anticipated future loads are approximately 15% of the original design loads, which provides excess capacity within the original designs to respond to minor deterioration and adverse modifications. Several original columns were replaced with built-up columns that are likely weaker than the originals.

Recommendation 3: During the design phase of the future adaptive reuse project, analyze the modified columns; repair or replace the weakened columns.

4. Lateral Loading

The original lateral resisting system in the 1st level was not sufficiently stiff to resist wind loads without excessive deflections. As a result, the elevator is permanently deflected to the west and to the south. The deflections are largest in the interior bays (grids B-D and 2-5). New systems are required to resist future wind loads and to address the rotational forces caused by the rotated grade-beams.

Recommendation 4 – Superstructure Lateral System: There are two cost-effective solutions to resisting future wind loads in the superstructure:

a. Building an adjacent structure that the elevator can 'lean' against. The imposed lateral loads are approximately 1,000/foot (40,000 in the north/south direction; 50,000 in the east/west direction), which are not unreasonable for an adjoining building to resist. *(12/12/2013 revision: The construction of a second building, as described in this recommendation, will eliminate recommendation 5b below: the requirement for the four concrete buttresses against the elevator west wall.)*

b. The second solution includes installing diagonal steel rod braces in two bays along each exterior wall (8 exterior bays) and two interior bays in each direction (4 interior bays). The braces would likely be 1" - 1 ½" diameter steel rods with turnbuckles and fabricated steel sleeve attachments to the columns above and below. These could be designed to match the historic elevator aesthetic.

Recommendation 5 – Foundation Lateral System: As stated above, the east wind forces have caused the foundation grade-beams to rotate appreciably towards to the west. Two systems are required to restore a viable east/west lateral system within the foundation (see Diagram 4):

a. Install new concrete grade-beams on the numbered grids that tie the existing grade-beam together, and resist additional rotation. This would require 25 grade-beams (the grade-beams on grid 6 are intact); preliminary calculations indicate that these beams could be 10” wide x 30” deep beams, with (6) #5 horizontal reinforcing bars, and #3 closed stirrups spaced at 16” on-center.
b. The second system consists of four below-grade buttresses constructed against the west face of the elevator to transfer the east/west wind forces from the foundation to the soils. These could be 10” wide x 30” deep x 36” long, and would include two battered steel helical piers (driven into the soil at an angle).

Appendices: 1. Phase I Recommendations, modified to reflect Phase II findings.
2. Diagrams
3. Photographs

Appendix 1: Phase I Recommendations, with Modifications

Note: The recommendations shown below were presented in the Phase I report. Additions or modifications, based on the findings of Phase II of the study, are presented in italics.

1. General

Recommendation 1: Before future building observations are ordered, clean building of debris decaying grain. Disinfect elevator.

2. Future Uses

a. The City of Sturgeon Bay intends to salvage and adaptively reuse the elevator as part of its waterfront redevelopment program. Based on the information gathered during the site visit report and the subsequent calculations, it is our conclusion that the existing elevator is in generally good condition and retains sufficient capacity to support this intended use, with some modifications.

   Recommendation 2: As part of any adaptive reuse designs, perform additional investigations and calculations to confirm the findings in this report. Include in the redevelopment plans reasonable modifications to address the discrepancies described below. *The second phase of the project has provided sufficient information to confirm that the elevator can be modified for the anticipated future uses. Any additional investigation and analysis of individual pieces would be conducted in the design phase of the adaptive reuse project.*

b. The plan may include building a 'Granary Market' that attaches to the Elevator. This new structure may be incorporated into a new lateral system to replace the removal of the corrugated steel skin.

   Recommendation 3: Include the 'Elevator Market' concept into the lateral system modifications of the elevator. *A second possible lateral system includes diagonal steel braces in eight exterior bays and four interior bays.*

c. There has been some discussion about modifying the elevator to incorporate a viewing area within the grain bins. The discussion included removing an 8'-10' tall section of the bins for this use. It is feasible to remove the bin walls and replace them with a steel tube space frame that would bear on the bin walls at the perimeter of the elevator. The space frame would include a grid of horizontal tubes on-grid to support the bin walls above.

Recommendation 4: The existing structure has the strength and stability to accept modifications to the grain bins for a new viewing area.

3. Foundations

The foundations were designed to support heavier loads than the future anticipated loads; therefore, the foundations, as built, have sufficient capacity to support the anticipated retail loads.

Recommendation 5: Investigate further the foundation grade-beam conditions by removing selected main floor beams and visually inspecting a representative sample of the grade-beams. Repair or replace broken or cracked grade-beams. *This investigation is complete. See above.*

Recommendation 6: Remove the broken grade-beam on grid C and the steel beam under the north wall; replace these with new concrete grade–beams. *This is accomplished as part of recommendation 5 of the Phase II report above.*

Recommendation 7: Uncover a portion of the foundation to determine the foundation type. If the foundation is supported on wood piers, expose 3-4 piers to confirm their satisfactory condition. *This is complete. See above.*

4. Main Floor

a. Overall, the visible portions of the wood plank floor appear sound – the wear is reasonable and deflections are minimal. A portion of the main floor is likely not suitable for public traffic due to bacteria associated with decaying grain. This environment is conducive to decay fungi that eat wood, reducing its strength.

Recommendation 8: Remove the decaying grain and dry the floor. Investigate the affected floor planks for decay fungi and loss of strength.

Recommendation 9: Calculate plank wood joist strength and compare to the required strength for assembly loading (100 psf). Replace planks that do not have sufficient strength.

b. The floor deflections between grids are not excessive; however, the rise and fall of the floor across grids is higher than is typically acceptable for retail use. It appears from Table 1 that these deflections are caused by differential settlement of the foundation below.

Recommendation 10: Given the ease of shimming a wood floor versus raising a foundation, we recommend that the wood floor be shimmed, as needed, to meet retail use.

5. First-Level Framing

a. This preliminary investigation indicates that that first-level framing has sufficient capacity to support anticipated retail loads. The general condition was recorded and all obvious and significant defects were observed (there were none).

Recommendation 11: As part of the adaptive reuse designs, include a complete investigation that closely observes all wood posts, beams, diagonal kickers, and connections to ensure that all visible defects and deterioration are observed. This should include moisture content readings and probes for soft and deteriorated wood beneath the surface. Replace damaged pieces that don't meet required capacity.

b. The strength of the wood used in the capacity calculations assumes a Douglas Fir Larch (North) and a #2 grade of wood.

Recommendation 12: Confirm the species and grading of the wood to more accurately determine the elevator strength (and possibly increase calculated capacity). The species can be determined by sending wood samples to the University of Minnesota's Wood Sciences Lab for analysis. This is an inexpensive method to determine wood species. MBJ can determine the wood grade on-site, using a protocol developed by the Association of Preservation Technology (APT).

c. The small deflections and low stresses due to the out-of-plumb condition and wind forces, calculated by the 3-D computer model, indicate that the elevator is stable in its current configuration.

Recommendation 13: No actions are required to strengthen or stiffen the structure in its current configuration, beyond the identification and repair of deterioration. *The observed westward rotation of the grade-beams, and the removal of the adjoining shed have* *changed this recommendation to require new lateral systems described in Phase II recommendation 4, above. Additionally, the recommendation was made subsequent to the November site visit to add temporary steel diagonal wire-rope bracing in the north/south direction to temporarily replace any resisting force that may have been lost with the removal of the shed.*

d. One idea for future use is to remove a portion of the corrugated steel siding at the lower level to create an open market. The removal of the siding will eliminate the lateral load path for the building. A new lateral system will be required to replace this load path. This may include steel bracing within the existing structure, or the use of an adjacent new structure to brace/enhance the elevator.

Recommendation 14: Additional calculations and coordination with the architectural plans will be required to determine a suitable lateral system. *See Phase II Lateral Analysis section above for a discussion of this.*

6. Grain Bins

This preliminary investigation of the grain bins indicates that they are structurally sound and stable. A more thorough investigation is required to identify any local deterioration or decay that would affect strength. The wet and decaying grain at the bottom of two bins is accelerating the deterioration at the bottoms of the bins.

Recommendation 15: Confirm these findings during the adaptive reuse project with a close visual investigation of the grain bins.

Recommendation 16: Remove the decaying grain from the bins, allow sufficient time for the bins to dry, investigate for decay and deterioration of the bins in these areas.

7. Roofs and Head-House Structures

This preliminary investigation of the roof structure and the head-house uncovered no significant deterioration or overstress that would adversely affect their strength.

Recommendation 17: During the adaptive reuse design, confirm this with a thorough inspection of the roof and head-house structures that includes a close observation of the members, and measurement and strength calculations of selected members to confirm their capacity to meet current code-mandated loads.

Appendix 2: Diagrams

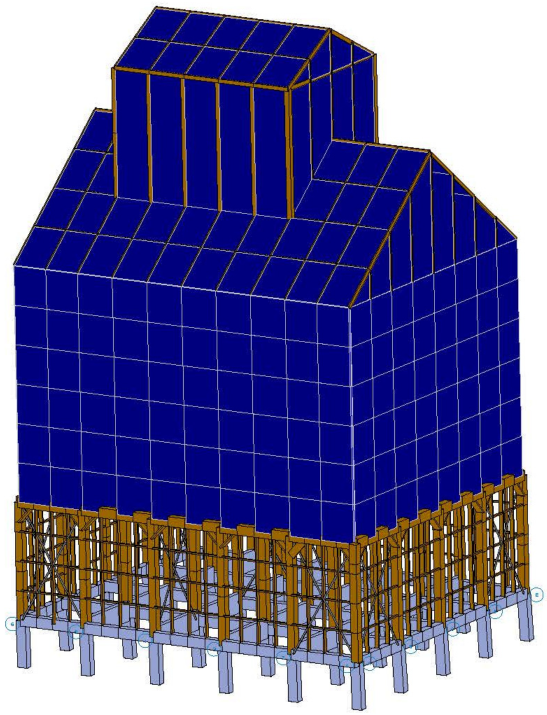

Diagram 1: Isometric of computer model.

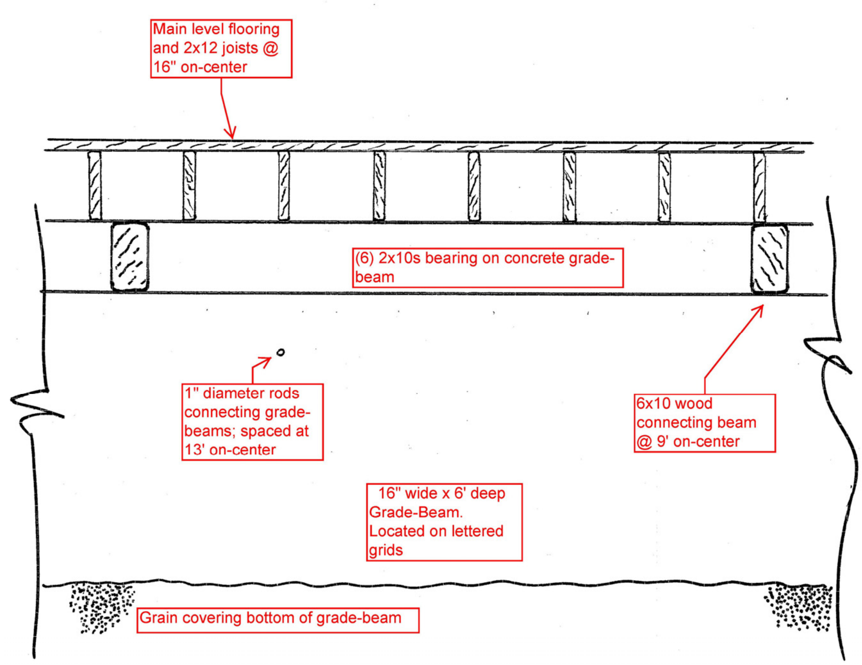

Diagram 2: Elevation of a grade-beam

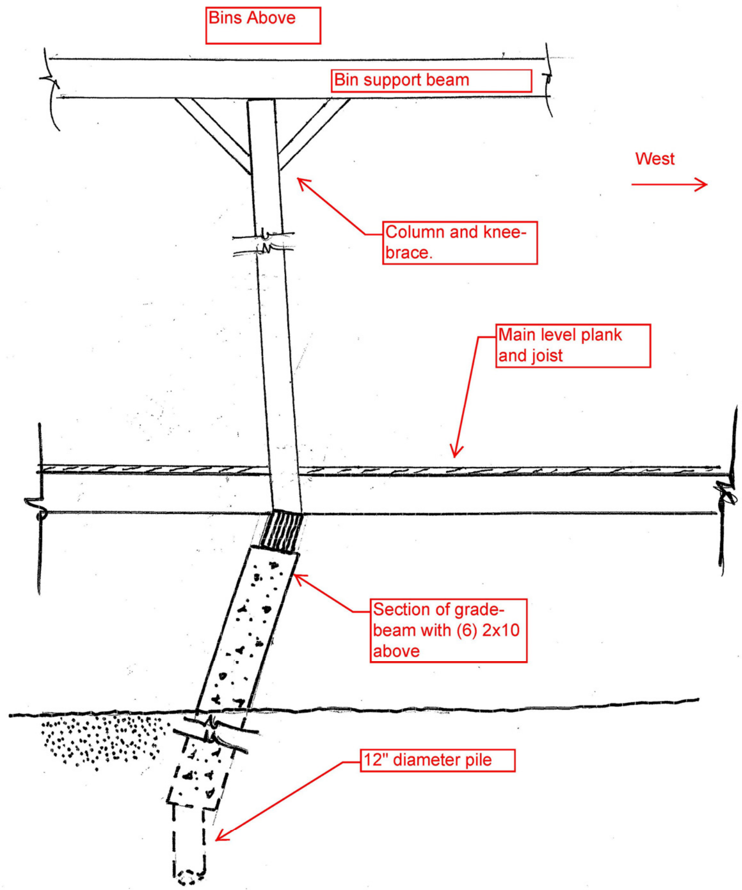

Diagram 3: Section of grade-beam

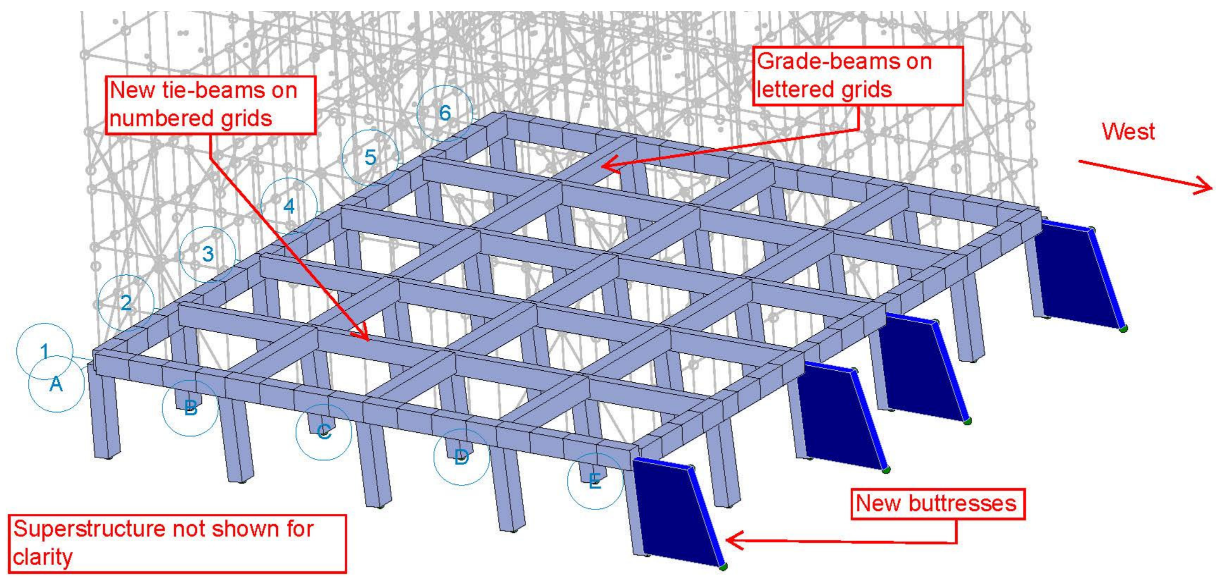

Diagram 4: Diagram of new grade beams and buttresses.

Appendix 3: Photographs

Photo 1: Main level column and beams

Photo 2: Foundation grade-beams & tension rod in the distance

Photo 3: Broken grade-beam showing 16 degree and 5 degree rotation

Photo 4: Excavation at southwest corner of elevator

Photo 5: Excavation showing two wood piles

Photo 6: Close-up of wood pile

Photo 7: Interior column with laser-generated plumb-line showing westward deflection

Photo 8: Interior column showing southward deflection

Photo 10: Close-up of knee-brace at top of column

Photo 11: Corrugated steel cladding