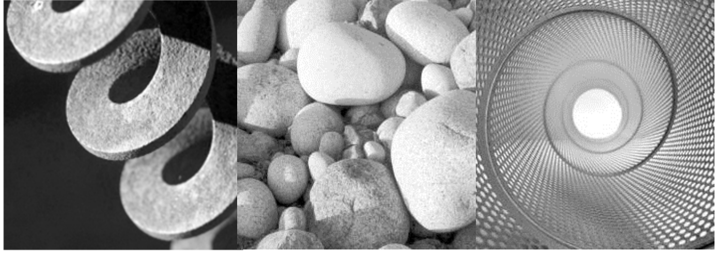

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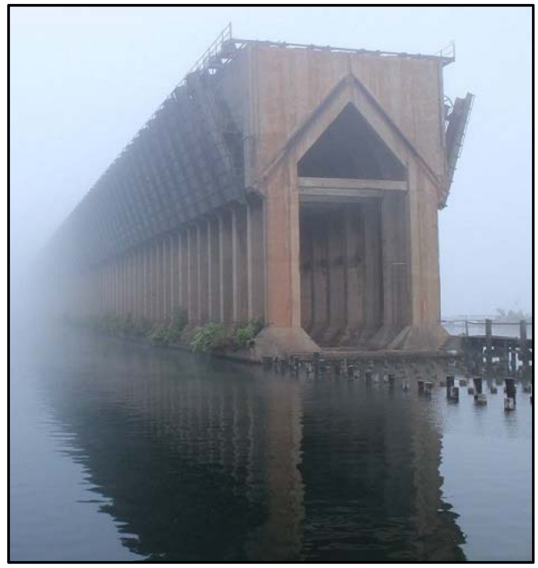

Lower Harbor Ore Dock Inspection Report

Marquette, Michigan

Submitted to:
Mr. Keith Whittington
City of Marquette
300 West Baraga Avenue
Marquette, Michigan 49855

Submitted by:
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109 West Baraga Street
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December 11, 2014

GEI Project No. 1330920

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Table of Contents

Figures

Appendices

Executive Summary

Project: Condition Assessment of the Lower Harbor Ore Dock in Marquette, Michigan

Purpose of Project: A conditional analysis of the Lower Harbor Ore Dock structure to evaluate its current condition as well as the potential for future development scenarios.

Inspection Team: GEI Consultants of Michigan, P.C. & Collins Engineers, Inc.

Inspection Dates: June 2, 2014 through June 6, 2014

Summary of Findings: Although the Ore Dock has sat idle for nearly 50 years, the bulk of structure remains in good condition.

The timber piles supporting the concrete superstructure are in good condition with minimal section loss and are estimated to have an individual capacity of 45 kips (22.5 tons). Some piles have experienced cracking, delamination, or are out of plumb. The damaged and out of plumb piles represent a small number of the, approximately 7,600 piles, supporting the dock. The average former ore live load and the dead load of the Ore Dock demands approximately 32 kips per pile (16 tons per pile).

The concrete superstructure is in good condition with no indications of significant movement or structural distress. However, due to shallow concrete cover over the steel reinforcement from the original construction, some localized areas of delamination and spalling, with exposed reinforcement (rebar) is present. Although these areas represent a hazard from falling concrete, they only represent a minor structural deficiency.

The steel chutes and appurtenances are in good condition with only minor areas of deterioration. Many areas remain coated with paint. The chute hinge pins and lifting system are sound with no evidence of distress or deterioration. The walkway and stair framing, including the deck top are in good condition. However, the wood planks are severely deteriorated, and at risk of falling.

The timber fender system around the Ore Dock is in very poor condition. Vegetation including small trees and shrubs are growing from the fenders.

Summary of Recommendations:

Based on the results of the inspection, the timber piles are generally sound and are capable of continued reliable long-term support of the Ore Dock. With some maintenance, the concrete superstructure, steel chutes and hoist equipment are capable of continued reliable performance. With respect to the possible proposed uses of the Ore Dock, GEI has provided recommendations related to the following uses:

- Do Nothing – Continue to prevent public access, and develop a safety plan for limited access to prevent injuries.
- Public Access – Remove hazards from falling debris and upgrade dock to meet public safety requirements
- Commercial Development – An allowable load of 16 kips per pile can be used for preliminary conceptual designs of future developments. Detailed structural analyses would be needed to support the design of any proposed development.

Regardless of the future use of the structure, it will require routine inspection and maintenance to prevent deterioration. The timber fenders along the outside of the dock are severely deteriorated, and should be replaced if boats are to be moored to the dock in the future. Mooring cleats would need to be added to accommodate smaller water craft.

1. Introduction

1.1 Background

The Lower Harbor Ore Dock in Marquette is a local landmark that garners significant interest from locals and tourists alike. Over the past several years, multiple groups have been interested in repurposing the Ore Dock. These scenarios have included condominiums, commercial use, a botanical center, and pedestrian use. In order to better understand the potential for future development scenarios of the Lower Harbor Ore Dock, the City of Marquette (City) requested a structural and condition assessment of the above and below water portions of the structure.

1.2 Project Description

The existing structure was built in 1931, and is approximately 970 feet long by 66 feet wide, and approximately 86 feet high above the Lake Superior water surface. It is comprised of a reinforced concrete superstructure founded on underwater timber cribs and over 7,600 closely spaced timber pilings. Figures 1 and 2 show the general arrangement and features of the Ore Dock. An historical record prepared by National Park Service in 1990 is included in Appendix F.

The piles were driven into the Lake Superior bottom, presumably to bedrock. Timber cribs are spaced approximately every 108 feet at the location of the expansion joints. There are eight individual sections of the Ore Dock that are separated by the expansion joints. Additionally, there are numerous piles remaining below water that were used to support a full-width timber trestle approach. The majority of these approach piles were cut off near the water surface. Some of the piles are still used to support a pedestrian approach to the dock. The piles are topped with a concrete pile cap. The cap contains octagonal openings within the center of the dock for uplift pressure release.

Seated on the pile cap are the bent (column) bases. The bent bases are trapezoidal and near the outside of the pile cap. They are approximately 16 feet long by nine feet wide at the base and six feet in height with a top width of approximately three feet. The bents that they support are approximately nine by 2.75 feet in plan dimensions and 50 feet tall at the highest point. The iron ore pockets are supported on top of the bents. The pockets have a sloped bottom which creates a peaked ceiling within the interior of the dock. The pockets are approximately 22 feet wide and triangularly shaped. Each pocket occupies the area from the outside wall to the centerline of the dock.

The chutes are supported by hinge pins and a braided steel belt, which is attached to a hoist at the top of the dock. Iron ore pellets were delivered to the dock via railroad on four sets of tracks, and then dumped into the pockets. When an ore boat arrived, it was filled by lowering the chutes and opening the pocket gates. The hoists were lever operated from the top of the dock, which were shaft driven by an electric motor. A walkway extends the entire length of each side of the dock at the level of the gates. Four stairways access the walkways from the top of the dock. The chutes, gates, deck, walkways and stairways are constructed of riveted steel members embedded into the concrete superstructure. The top of the dock was covered in timber decking supported by a steel frame. Railroad tracks were also at the top and were supported by concrete beams between the iron ore pockets.

1.3 Purpose

Since it's decommissioning in the 1960's, the Ore Dock has not been maintained and its current condition has not been assessed. The purposes of this assessment were to:

- Conduct a visual inspection of the wood piling and cribbing, concrete superstructure and steel elements of the Ore Dock;
- Document the findings using inspection forms, photographs and video;
- Assess the global structural adequacy of the current structure and estimate additional allowable loads that can be applied in consideration of future development possibilities;
- Prepare a "ball park" cost opinion to correct identified deficiencies for discussion purposes; and
- Present the findings to the City Commission.

2. Field Inspections

GEI Consultants of Michigan, P.C. (GEI) collected available information from the City and the Northern Michigan University (NMU) archives. GEI also visited the Marquette Regional History Center in an attempt to locate additional information that may be available. We also searched the online resources of the U.S. Library of Congress for pertinent material and photographs. In preparation of this report, we reviewed the available information in the archives. The plans in the archives are currently placed on long 24-inch rolls that contain approximately 10 plan sheets on each roll. The plans were scanned, photographed and cataloged to provide an organized set of available plans, photographs and notes for delivery to the City as part of this report. Unfortunately, the NMU archived plans are on rolls and cannot be scanned.

Using the historic information, inspection forms were generated to document the observed field conditions. The inspection approach for both the underwater and superstructure portions of the dock are summarized in the following sections.

2.1 Sub Structure (Below Lake Superior Surface)

The dive inspection was completed by Collins Engineers, Inc. (Collins), and included checking accessible portions of the concrete pile caps for cracking, erosion, wear, abrasion, scaling, spalling, and exposed reinforcement. In addition, divers checked the piling for misalignment and loss of section, and evidence of decay or weathering. The dive inspection was documented on project drawings during the inspection, and through the use of underwater photography and video recordings.

2.1.1 Inspection Approach

During the dive inspection, the channel bottom around the dock was probed to document the condition and nature of the bottom material at ten distinct locations (see Figures 2-8 in Appendix A). Sediment samples were collected, labeled, and stored for future analysis.

Prior to the dive inspection, the Collins dive team obtained bathymetric survey data within 125 feet from the Ore Dock. Sector scanning sonar was used in combination with a survey-grade GPS to create a point cloud. The information was used to develop a 1-foot contour map (see Appendix A). The sonar also helped determine if there was any debris or potential hazards that the divers might encounter adjacent to the dock. Bathymetric survey data is located in Appendix A.

According to the plans obtained by GEI, fill material was placed under the dock at a 3H:1V slope that peaks along the dock centerline. Years of dredging, currents, and wave action have likely affected this placement. Collins Engineers utilized weighted lines at the openings in the superstructure of the dock to document the elevation of the lake bottom along the interior of the Ore Dock. These elevations were input into the point cloud data set for use in development of the contour map.

Collins provided Level I, Level II, and Level III inspections for accessible portions of the dock, which included the dock perimeter and through select openings within the center of the pile cap. See Figures 2-8 in Appendix A for dive locations. A description of each type of dive is included in the following sections.

2.1.2 Level I – Visual & Tactile Inspection

Longitudinally there are 18 lines of vertical piles and 2 lines of battered piles along the dock. Divers accessed the 2 pile lines on either side of the dock, and 4 pile lines along the interior of the dock without performing any penetration dives. Therefore, 8 of the 20 pile lines were inspected along with their connection to the concrete pile cap. This provided an appropriate and representative sample of the submerged portions of the dock.

2.1.3 Level II – Up-close & Detailed Inspection

Approximately 10% of the accessible piles were inspected and measured by cleaning marine growth and utilizing picks or awls to determine the soundness of the timber. In addition, one of the timber crib structures was inspected to specifically assess the condition of the tie rods that assist with maintaining the stability of the timber cribbing. See Figures 2-8 in Appendix A for Level II inspection locations.

2.1.4 Level III – Coring

Timber cores were taken from 25 representative piles throughout the dock substructure and approach substructure. The 1/8-inch cores were placed on sample trays for examination and photographing. All core holes were plugged with treated timber plugs so that the structural integrity of the piles is maintained. See Figures 2-8 in Appendix A, for Level III inspection locations.

2.2 Superstructure (Above Lake Superior Surface)

2.2.1 Inspection Approach

GEI inspected the structure from the pile cap floor and walkways, and using rope access techniques to access the superstructure walkways, ladders, and top deck. To support the inspection, GEI developed field inspection logs to efficiently document the observed conditions. Copies of these forms are included in Appendix C. These forms were used to develop summary logs. Summary logs including photographs of each section of the Ore Dock are included in Appendix B. Note that the expansion joints between the sections are included in an independent summary log. Figures 1 and 2 identify typical nomenclature of superstructure features used in this report.

2.2.2 Surface Inspection

From the pile cap floor, each concrete bent, including the pile cap, columns, bracing beams, and ceiling were visually observed for signs of stress or deterioration. Each column and beam was numbered consistently with the original drawings, and cataloged with associated photographs and notes.

2.2.3 Rope Access

Using rope access techniques, GEI inspected the pocket wall concrete, chutes, gates, and ancillary equipment by traversing the walkway along the entire length of both sides of the dock at the level of the gates. In addition, each of the eight (four on either side) stairways to the top of the dock were inspected. Once on top, the inspections were limited to the area around the top of the stairs. To safely gain access to these areas, a three-person team of specially-trained and certified personnel ascended the structure. An estimation of corrosion, section loss, or other deficiencies in the steel structures was documented. The GEI rope access inspectors took detailed photographs and video of the Ore Dock superstructure during the inspection. A comparison of the actual steel dimensions to the available record drawings was conducted to confirm that the available drawings represent actual as-built conditions. Available record drawings are included in Appendix D.

3. Inspection Findings

3.1 Substructure

The following sections summarize the major findings from the substructure inspection. Refer to the dive report in Appendix A for detailed findings. Overall, the dive inspection report found that the Ore Dock was in good condition with the average pile being sound with no loss of cross-sectional area or evidence of marine borer damage, and ¼ inch knife penetration.

3.1.1 Lake Bottom

Soundings that were taken while collecting data for the bathymetric survey indicate approximately three to seven feet of infill beneath the dock and in the ship slip area adjacent to the dock compared to the record drawings. Soundings taken in the interior of the dock, combined with the data from the bathymetric survey, indicate that the lake bottom has infilled three to seven (3 to 7) feet immediately adjacent to the slip area and below the dock. This was confirmed by the presence of large amounts of iron ore on the lake bottom. The material encountered varied from fine particulate to large ore pellets. See Appendix A for a bathymetric map of current lake bottom topography around the Ore Dock and plan views of the dock which also show the soil sample locations.

3.1.2 Timber Piles

Generally, the piles supporting the Ore Dock are in good condition below the water line. The piles have experienced minimal loss of cross-sectional area and are in good condition at the interface with the concrete base of the dock. They vary in diameter, ranging from 10 inches to 16 inches, with an average of approximately 12 inches. The exterior rows of timber piles exhibited random areas of 10% to 15% section loss, probably due to abrasion from ships berthing and/or ice impact. These areas were located approximately six to 10 feet below the waterline. The average diameter of the timber piles was approximately 12 inches, but significant variation was found with piles ranging from approximately 10 inches to 16 inches in diameter.

The abandoned timber piles of the former trestle approach and the piles of the pedestrian approach were typically heavily weathered with splitting and significant section loss from the top of the piles extending down five feet. The piles below five feet to the lake bottom the piles appeared to be sound and in good condition. See Appendix A for additional information regarding the piles.

3.2 Superstructure

In general, the superstructure is in good to excellent condition with minimal signs of structural distress, and no evidence of settlement or differential movement between sections. However, GEI identified the following general findings for the concrete:

- Several areas of the concrete structure show various degrees of spalling with exposed reinforcement. Spalling is concrete that is popped off due to corroding reinforcement. Based on the depth of cover at nearly all of the spalled areas, the spalling is due to inadequate concrete cover over the reinforcement. In several areas, the spalled concrete is still attached to the parent concrete (delamination), but can fall at any time, which represents a safety hazard. Many photographs showing examples of the delaminated areas are included in Appendix B.
- Minor cracking was observed in the concrete fenders between the bent columns. These cracks are tight and likely shrinkage cracks, and do not represent a structural deficiency.
- Minor localized scaling was observed on the concrete fenders and pile cap floor.
- On the pile cap floor, several trees and bushes are growing within piles of remaining iron ore pellets between the bent columns. These tress and piles can contribute to accelerated deterioration of the concrete structure.

Other than the above findings, the concrete is sound with no evidence of structural distress. The following sections further summarize the findings for the individual components of the superstructure. Refer to the inspection summary logs included in Appendix B for representative photographs of the major findings for each of the Ore Dock components described in the following sections.

3.2.1 Fenders

The fenders were used to secure ships to the dock. The concrete was observed to be in good condition with no evidence of significant structural distress. Tight cracking was observed transverse to the fenders. The mooring points were sound and well anchored to the concrete. The timbers along the exterior of the fenders have significantly degraded and are no longer useable. Trees and brush are growing within the timbers at various locations along the perimeter of the dock. There are also grouped pile guards for protection at the east end of the dock that are no longer securely embedded in the lake bottom (see Dive Report, Appendix A) and are nearly free floating. These grouped pile guards consist of approximately six piles each.

3.2.2 Pile Cap/Floor Slabs

The pile cap was inspected from both underwater and above water. Some deterioration with exposed rebar was frequently observed along the bottom corners of the pile cap. From the top of the pile cap (dock interior floor), localized areas of deterioration were observed. Some areas of the floor were not inspected due to piles of iron ore pellets with growing trees and bushes. No other evidence of structural distress was observed in the pile cap.

3.2.3 Bent Bases

The bottoms of the bents were observed to have areas of spalled concrete with occasional exposed rebar. Generally, the spalled concrete has occurred at the lower corners of the bases. Minor tight shrinkage-related cracking is occasionally visible in the footings. No significant deterioration or distress was evident in any of the footings.

3.2.4 Bents

Delamination and spalled concrete with exposed rebar occurs on several bents throughout the structure. The corners are where the spalling was typically observed. Inadequate concrete cover over the reinforcement is the cause of the spalling.

3.2.5 Longitudinal Beams

Minor tight cracking is evident on many cross beams. It is likely that the cracking is related to early concrete spalling activity over thinly covered reinforcement, and not due to structural loading. The corners of the beams are where the spalling is concentrated with some exposed reinforcement.

3.2.6 Transverse Beams

Many of these beams have spalled concrete and exposed rebar along the base of the beam. Poorly consolidated concrete (honeycombed concrete) is visible in several locations. Generally these types of deficiencies occur near the bents on both the north and south sides. Note that some of these beams appear to have cracking evident on the bottoms of the beams. However, based on a close-up visual inspection (conducted using rope access techniques), these features were caused during the original forming of the structure, and do not represent a deficiency.

3.2.7 Ceiling & Chamfers

The underside of the iron ore pockets are subject to minor sections of poorly consolidated concrete, surface cracking, cold joints, and visible reinforcement bar. Exposed reinforcement bar is most common in the chamfer section of the ceiling located above the transverse beams. Cracking is most commonly located on the ceiling between the bents.

3.2.8 Chute Base

The chute bases were often observed to have localized minor areas of poorly consolidated concrete. Since these areas represent the base of the bin pours during original construction, evidence of trash dropped during construction of formwork prior to placing concrete was observed in this area. These areas contain visible cracking associated with the steel chute imbedded connection. Slight efflorescence (buildup of water deposited calcium carbonate) is evident at these crack locations.

3.2.9 Pocket Walls

The pocket walls were primarily observed from the walkway above the chutes, and at the top of the eight stair locations. Localized delamination and spalled concrete with exposed rebar occurs on several areas along the north and south bin walls throughout the structure. However, the south side of the structure contains significantly more spalled areas, with Section 6 containing the greatest concentration of spalling. Inadequate concrete cover over the reinforcement is the cause of the spalling.

3.2.10 Steel Chutes and Appurtenances

In general, the steel chutes and appurtenances are in good to excellent condition with minimal signs of structural distress or deterioration. In most cases, the steel components contained paint, and exhibited only localized areas of minimal corrosion or section loss. However, GEI identified the following general findings for the steel elements:

- All chutes have been abandoned in an upright, locked position. The chutes are in good condition with both the base and end hinge pins in operable condition. Some minor distress (bending) within the base hinge pins support members was observed.
- The bin gates were observed to be in a closed position, with a relaxed hoist cable. Two different gate construction geometries were observed. Chutes 1 to 27 (south side) contained skirts on the top of the gates, presumably to prevent iron ore pellets from escaping the bins. The gates appear to be in functional condition.
- Various steel, concrete, iron ore pellets, organic matter, and soil material was observed to be deposited in the bottoms of chutes. This material was not excavated to document if it is contributing to accelerated corrosion, but in most cases appears to be one to two feet thick.
- The walkway steel across and between the chutes, and the six stairways from the walkway to the top deck were observed to be in good to excellent condition. Some bent members were observed which was likely caused by impact from falling objects.
- The top steel deck was intact with little to no evidence of distress or deterioration. Some bent members were observed, likely caused during operation or removal of the deck when abandoned.
- The hoist winches were observed to be in fair condition with minor evidence of deterioration. They are securely fastened to the deck steel framing. The hoists both lower and raise the chutes, but also raise and lower the pocket gates. The steel belt cable connected to the chute rides on the main wheel of the hoist, and showed no signs of deterioration. This wheel is locked into position by a levered key securely locked into the gears on the wheel. Each hoist is operated via a drive shaft powered

by an electric motor (seven motors on each side of dock). A series of levers presumably engages the hoist for either the chute or gate.

- The steel member sizes were compared to the available design drawings, and were found to be consistent.
- Timber planking was used for the walkways and stairs. These timber planks range from good condition to deteriorated and/or missing. The remaining rotten timbers represent a falling hazard. Note that the top of the dock was stripped of timbers.

4. Structural Assessment

The purpose of this section is to assess the current structural condition of the Ore Dock, and provide design guidance for future development concepts. Future uses for the structure are speculative at this time, but include a public boardwalk, condominiums, commercial use, boat dock, arboretum, and etcetera. The following sections summarize the structural assessment of the structure.

4.1 Concrete and Steel Structural Assessment

GEI conducted measurements on the reinforced concrete and steel elements of the structure, and found the field conditions substantially meet the details of the available project drawings (see Appendix D). In addition, the exposed concrete and steel elements were in good condition with no evidence of structural distress or excessive corrosion. Based on these observations, and the fact that the structure operated under service loading conditions for 36 years, structural assessments of the concrete superstructure or steel appurtenances are not warranted at this time.

4.2 Timber Pile Load Assessment

Using the dive inspection results, the individual allowable pile capacity was estimated by Collins to be 50 kips (25 tons), with a recommended 10% reduction due to age (i.e., 45 kips). This assumes the piles were driven to refusal. This recommended allowable load is reasonable based on pile driving practices in place during past construction. To determine actual capacities of the piles, further field load testing and laboratory testing and analysis would be necessary.

In addition, GEI estimated the weight of one section of the superstructure using an AutoCAD generated drawing. The calculated weight matched closely with the weights reported in the 1990 NFS report. This dead weight in combination with the live weight from the iron ore pellets and train cars was used to estimate the total weight applied to the timber piles during service. Exhibit G-1 in Appendix G contains the GEI calculations, which are summarized as follows:

- Bent Dead Load — 1,570 kips
- Bent Live Load — 1,230 kips
- Bent Total Load — 2,800 kips
- Vertical Piles in Bent — 86
  - Load per Pile — 32.6 kips
- Vertical Piles in Bent (Crib Structure) — 77
  - Load per Pile (Crib Structure) — 36.4 kips
- Battered Piles in Bent (Crib Structure) — >4 (4.4)
  - Load per Pile (Crib Structure) — 15.3 kips

The load per pile values are less than the allowable pile load of 45 kips recommended by Collins Engineers, Inc. In addition, GEI calculated an estimated ultimate pile capacity assuming the piles are soil supported (Exhibit G-2), and driven to bedrock (Exhibit G-3). The ultimate capacity for a soil supported pile was estimated to be 45 kips, but is based on assumptions of soil conditions that are currently not verifiable. However, this demonstrates that even if the piles are soil supported, the piles likely have capacity greater than the actual loading since the structure has seen full live load (e.g., hoppers with iron ore and loaded rail car plus the dead load of the loading dock. According to the Manual for Engineered Wood Construction, the ultimate capacity of an average 12 inch bedrock supported cedar pile was estimated to be 102 kips. This was conservatively estimated assuming northern white cedar piles were used. Two of the timber pile core samples were sent for laboratory sampling at Michigan Technological University. One sample was determined to likely be red pine and the other was inconclusive, but likely a cedar. Using the ultimate capacity estimated assuming the piles are founded on bedrock, the factor of safety given the highest calculated load applied to the piles is 2.8 for a single pile. The accepted factor of safety for grouped piles that have not been load tested is 4, per the Unified Facilities Criteria, Geotechnical Engineering Manual and the Michigan Building Code. Note that these factors of safety assume live loads from past operations, which are not currently applied to the Ore Dock. When live loads are not considered, the piles currently have a factor of safety of 5.0.

For lateral loads (wind and ships), GEI only considered the capacity of the battered piles (see Exhibit G-4). The estimate batter slope was 1H:3V). Substantial additional lateral resistance is supplied by the timber cribs, but was not considered for this assessment. Using a 105 mph design wind load, the lateral load was calculated to be approximately 67.5 kips per bent. Using an allowable load equal to the maximum vertical load previously experienced by the piles (32.6 kips), an allowable lateral load per battered pile (assume a 30 degree batter) is 15.3 kips. There are 4.4 battered piles per bent, which gives an estimated 67.3 kips of allowable capacity per bent. Therefore, excluding lateral capacity of the timber cribs, it is our opinion that the battered piles have adequate capacity to resist the design wind load. Additional analysis would be needed to develop an allowable lateral capacity that includes the benefit of the timber cribs in each section. Lateral ore boat or ship berthing or impact loading was not included in our analyses.

5. Conclusions and Recommendations

Based on the results of the inspection, the timber piles are generally sound and are capable of continued reliable long-term support of the Ore Dock. The concrete superstructure exhibits no differential movement or structural distress, and the concrete quality is in good to excellent condition with only minor areas of deterioration. Deterioration is generally limited to surficial delamination and spalling of concrete where reinforcement was originally constructed too close to the concrete surface (inadequate concrete cover). With some maintenance, the concrete superstructure is capable of continued reliable performance. The steel chutes and hoist equipment were observed to be in good condition with no significant corrosion or other deficiencies noted. With some maintenance, the steel elements are capable of continued reliable performance.

With respect to the possible proposed uses of the Ore Dock, GEI describes the following options and associated recommendations:

- Do Nothing – Currently public access to the Ore Dock is prohibited. With the understanding that there are loose pieces of concrete and wood decking that is at risk of falling around the perimeter of the Ore Dock, the dock should remain closed to the public. In the cases where the City allows personnel or other people to access the dock, at a minimum GEI recommends hard hats and a safety plan be in place to limit the risks to anyone permitted access to the dock.

- Public Access – Currently there is a bottom lands agreement between the City of Marquette and the State of Michigan that prevents the dock from being used for anything other than maritime uses. We understand opening the dock to the public would not violate this agreement. To make the dock safe for public access, the walkway to the dock from the shore would need to be improved, and the hazards on the dock (snubbing posts, floor openings, and fall hazards) should be mitigated through the use of railings, covers or other safety measures. In addition, delaminated concrete, loose concrete on the upper walkway, deteriorated wood decking, and any other features at risk of falling from the perimeter of the Ore Dock should be removed. During this process, consideration should be given to repairing the delaminated/spalled concrete areas. A detailed inspection of all the chutes and associated hoisting equipment should be conducted to identify any areas were a redundant chute tie-off system may be needed.

- Commercial Development – GEI understands that the bottom lands agreement would need to be revised to allow commercial development that is not specifically a maritime activity. The development would need to consider the additional loads being applied to the structure. We recommend the allowable additional load applied to the Ore Dock not exceed 1,230 kips of vertical load per bent. This allowable load does not exceeding the historic loading on the structure. Lateral loads are not anticipated with any commercial development; however, a simple analysis indicates the dock has a minimum lateral capacity of 67.3 kips per bent to accommodate wind and other lateral loads. A detailed structural assessment should be conducted for any proposed modifications to the Ore Dock.

Regardless of the future use of the structure, concrete cores and rebar coupons should be taken to assess the actual strength of the concrete and steel reinforcement. A more detailed structural analysis should be performed to assess the capacity of floor slabs for the intended use of the structure. Given the architectural requirements and the content of the reuse a structural analysis of the new additions and how they impose load on the new structure will be required to show that no element of the superstructure and substructure will be overloaded. Renovations shall also meet all the latest, ASCE 7, IBC and the State of Michigan Building Code requirements.

Future development will require routine inspection and maintenance to prevent further deterioration due to freeze/thaw and wet/dry weather cycles. In particular, each steel belt, hoist and anchorage that supports the chutes in an upright position should be inspected (only a fraction of the hoists and belts were inspected as part of this evaluation). These appurtenances are critical for reliable long-term support of the chutes. In addition, the soil and debris within the base of each chute and pocket will accelerate deterioration of the steel and concrete in these areas. Consideration should be given to remove and prevent future buildup of soil and organic material within the pockets/chutes. Although corrosion was not prevalent, consideration should be given to painting the critical structural steel elements to ensure long-term reliability.

The timber fenders along the outside of the dock are severely deteriorated, and should be replaced if boats are to be moored to the dock in the future. Mooring cleats would need to be added to accommodate smaller water craft.

A conceptual cost estimate for addressing concerns found during the assessment is below:

City of Marquette
Lower Harbor Ore Dock
Engineer's Opinion of Costs

Item Description	Subtotal
Mobilization	$50,000
Vegetation Removal *Removal of vegetation and soils on the pile cap and fender of the superstructure of the ore dock.*	$25,000
Concrete Scaling *Physical removal of loose and spalling concrete from the superstructure of the ore dock. This includes the entire interior and exterior of the structure.*	$250,000
Concrete Patching *Patching ofsurface concrete that has broken, spalled, or been removed.*	$300,000
Electrical Appurtenance Removal *Removal of electrical cables, boxes, lights, and miscellaneous appurtenances.*	$25,000
Superstructure Timber Removal *Removal of remaining timber from stairs and fenders.*	$50,000
Superstructure Debris Removal *Removal of soils, vegetation, and debris from the base of chutes and pockets if gates are not tightly closed.*	$100,000
	$800,000

The cost estimate is for discussion purposes only and should be further investigated to determine costs for final budgeting purposes.

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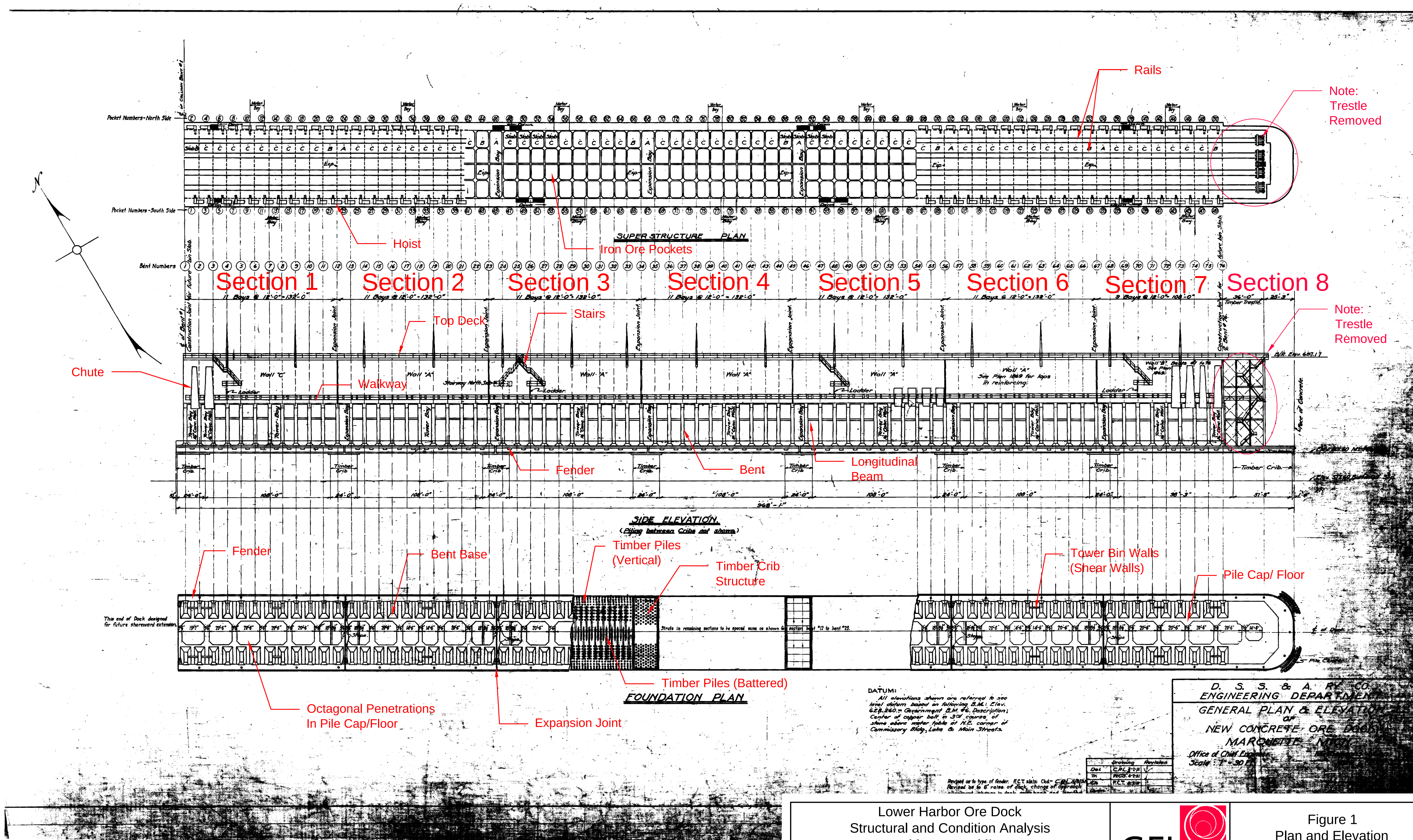
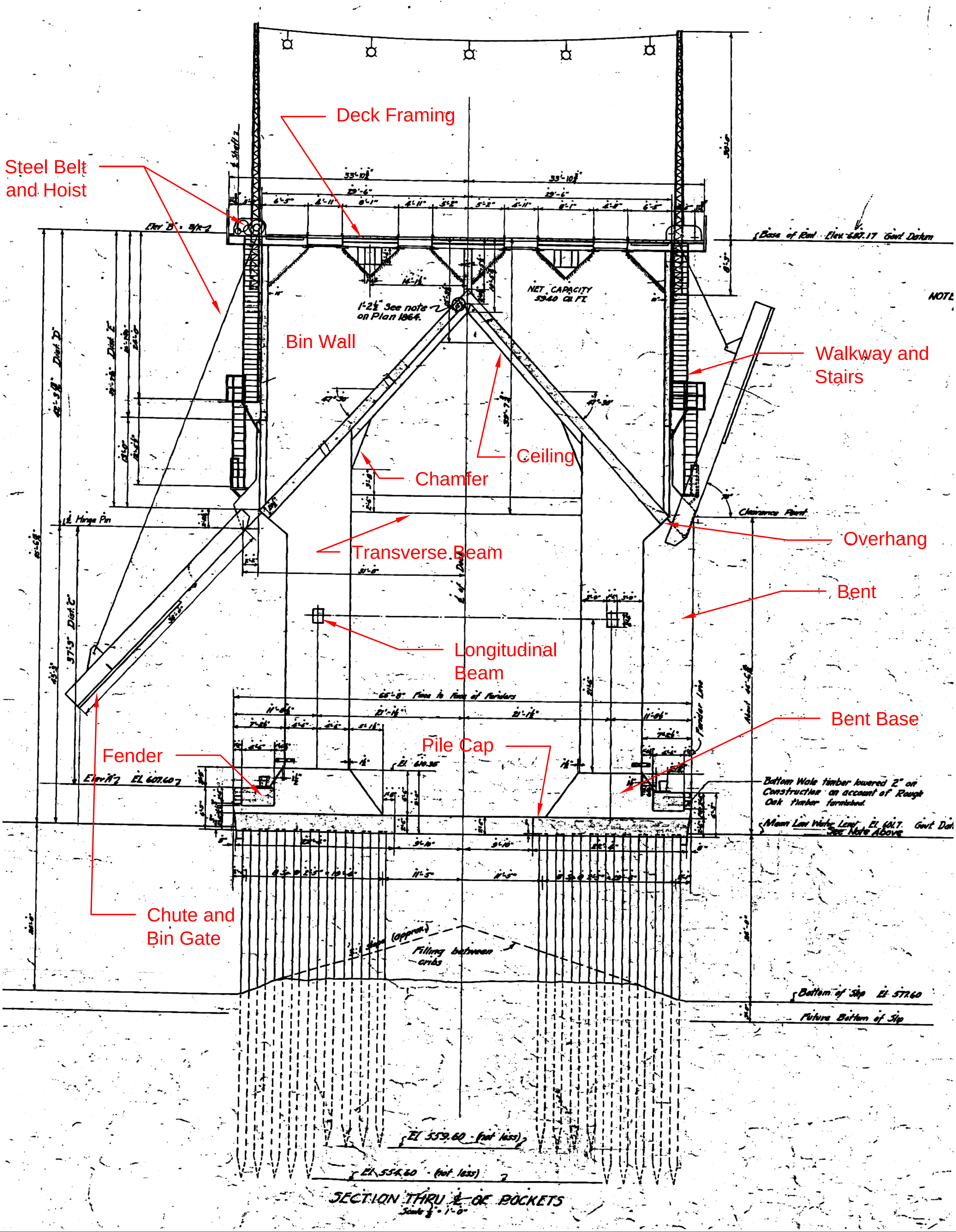
Figures



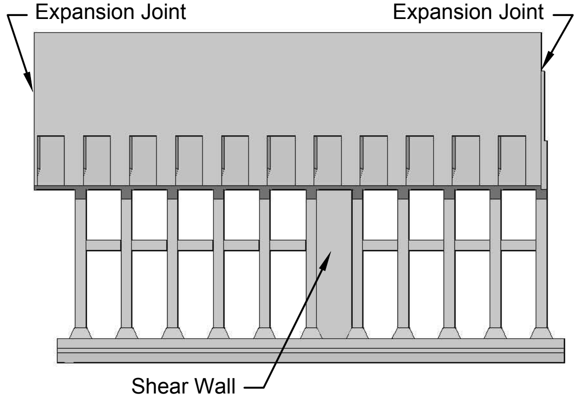
Lower Harbor Ore Dock Structural and Condition Analysis Marquette, MI	GEI Consultants	Figure 1 Plan and Elevation of Ore Dock
City of Marquette Marquette, MI	Project 1330920	August 2014 — Fig. 1

W:\Marquette_City\1330920_Marquette_City_Ore_Dock\Report\Final Drawings

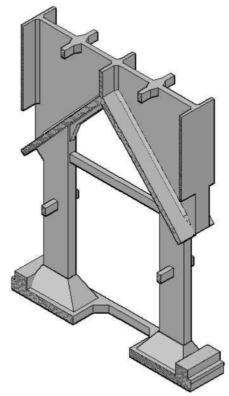


Lower Harbor Ore Dock Structural and Condition Analysis Marquette, MI	GEI Consultants	Figure 2 Section View Bent Drawing
City of Marquette Marquette, MI	Project 1330920	August 2014 Fig. 2

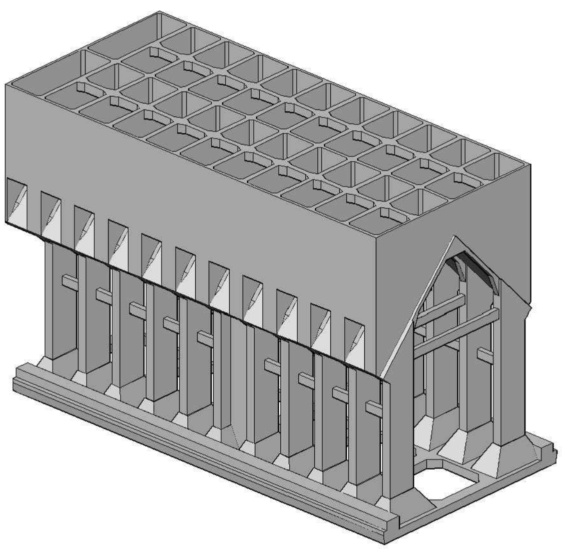
W:\Marquette_City\1330920_Marquette_City_Ore_Dock\Report\Final Drawings



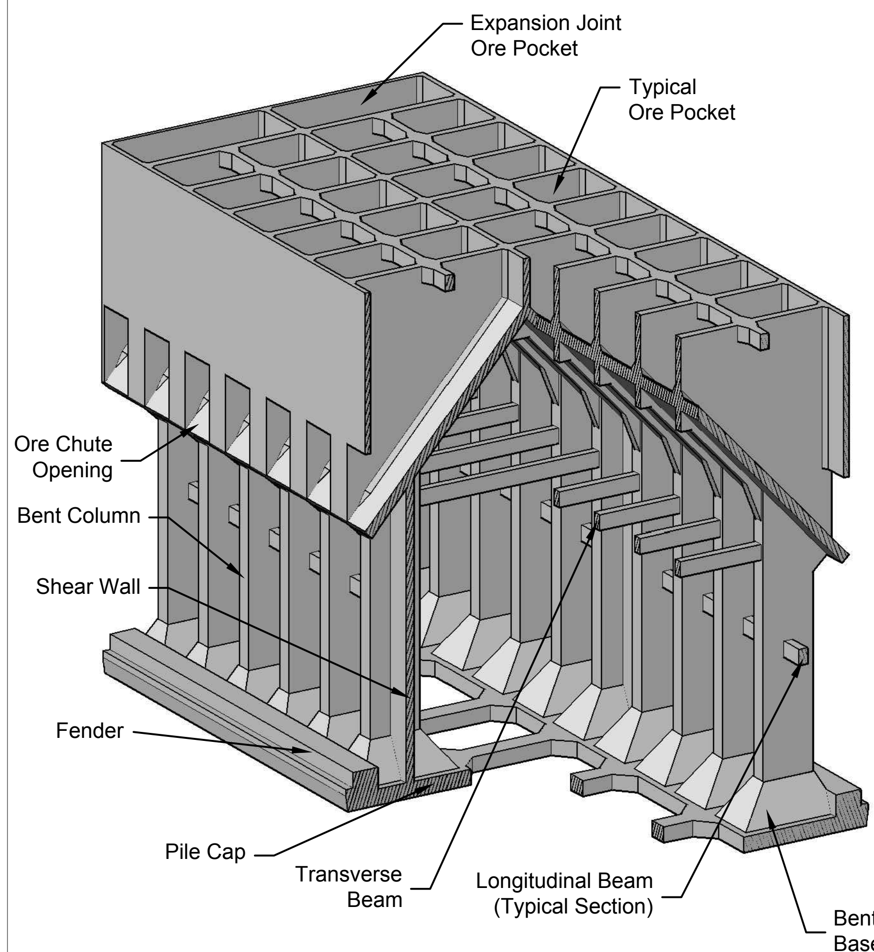
TYPICAL 11 BENT SECTION SIDE VIEW



TYPICAL BENT ISOMETRIC VIEW



TYPICAL 11 BENT SECTION ISOMETRIC VIEW



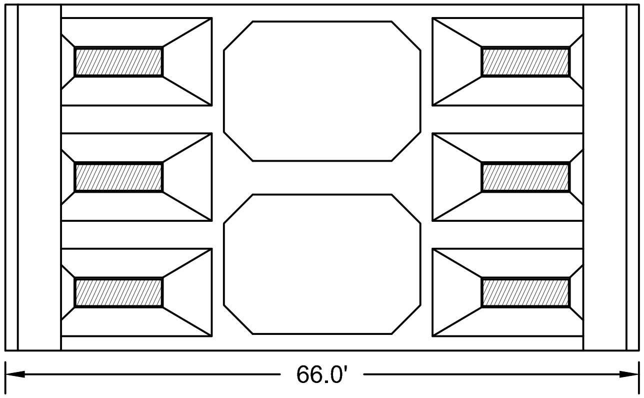
TYPICAL 11 BENT SECTION WITH SHEAR WALL AND TYPICAL BENT SECTION CUT-AWAY ISOMETRIC VIEW

NOTES:

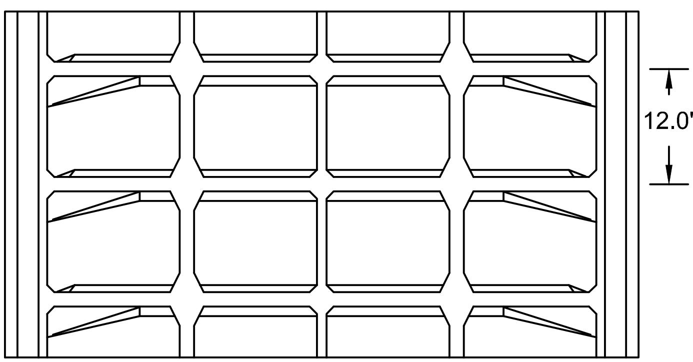
1. DIMENSIONS BASED ON DRAWING BY D.S.S & ARY CO TITLED "GENERAL CROSS SECTION" DATED 1931. PROVIDED BY CITY OF MARQUETTE.

Lower Harbor Ore Dock Structural Condition Analysis Marquette, MI	GEI Consultants	Ore Dock Model Isometric Details
City of Marquette Marquette, MI	Project 1330920	September 2014 Fig. 3

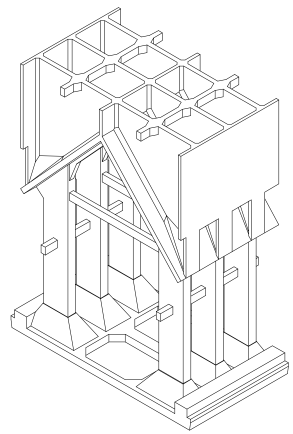
T:\Marquette_City\1330920_OreDockInspection\CAD\11 Bent Section Model Presentation



CUT-AWAY VIEW OF BENT BASES AND PILE CAP

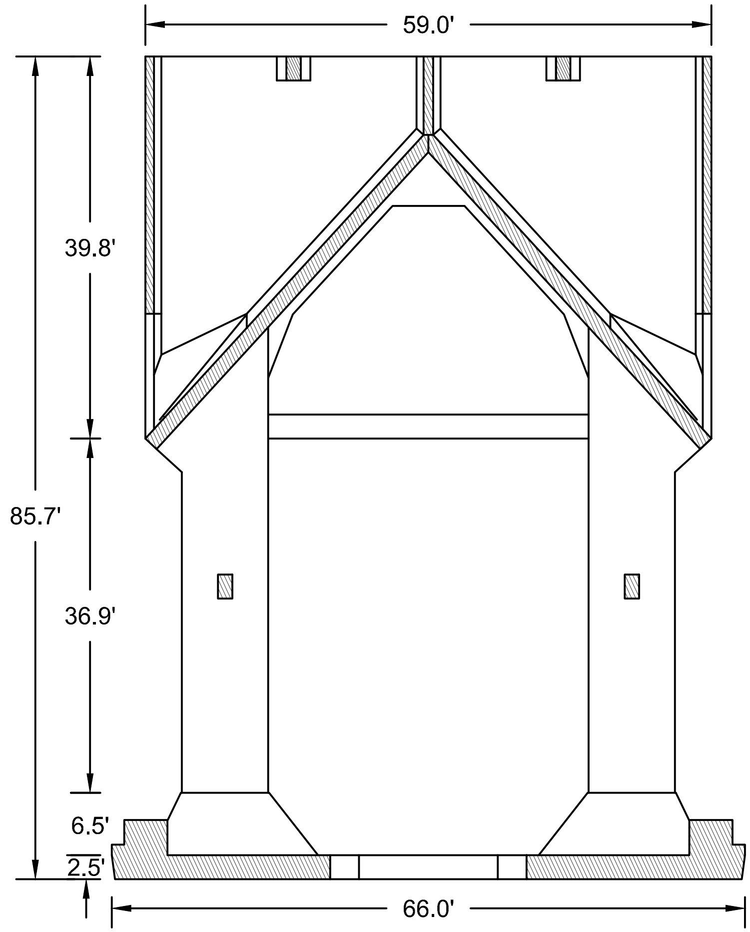


PLAN VIEW OF POCKETS



THREE BENT SECTION ISOMETRIC VIEW

0 20
SCALE



SECTION VIEW THROUGH POCKETS

NOTES:

1. DIMENSIONS BASED ON DRAWING BY D.S.S & ARY CO TITLED "GENERAL CROSS SECTION" DATED 1931. PROVIDED BY CITY OF MARQUETTE.

Lower Harbor Ore Dock Structural Condition Analysis Marquette, MI	GEI Consultants	Ore Dock Model Details	
City of Marquette Marquette, MI	Project 1330920	September 2014	Fig. 4

T:\Marquette_City\1330920_OreDockInspection\CAD\2D Presentation

Appendix A

Collins Engineers - Substructure Inspection Report

UNDERWATER INSPECTION
OF THE
LOWER HARBOR ORE DOCK
IN
MARQUETTE MICHIGAN

June 02-06, 2014

Prepared for:

GEI Consulting Engineers and Scientists

MARQUETTE *Michigan*

Prepared by:

COLLINS ENGINEERS INC.

2033 W Howard Ave
Milwaukee, WI 53202
414.282.6905 • www.collinsengr.com

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Project:	Underwater Inspection of the Lower Harbor ore Dock in Marquette, MI
Purpose of Project:	To perform a visual and tactile inspection of the timber piling and concrete pile cap, take sediment samples and timber cores, and to perform a bathymetric survey of the surrounding area.
Inspection Team:	Team Leader – Jordan Furlan, P.E. – Collins Engineers, Inc. Team Members – Charles Euwema, Chris Hartzell
Inspection Date(s):	June 02-06, 2014

Summary of Findings:

- A number of piles were found to have severe defects below water including: Splitting of the full or partial length of the pile, crushing of the pile, and significant section loss due to abrasion or deterioration of the outer shell. However, due to the relatively small number of these types of defects in relation to the number of piles in the foundation, the overall condition of the substructure is good.
- The perimeter of the concrete pile cap and the underside of the concrete sections separating the interior bays exhibited spalling and exposed corroded reinforcing steel. The underside of the remaining portions of the pile cap were in good condition with light scaling and some loss of aggregate.
- The bathymetric survey indicates that the lake bed has infilled approximately 3 to 7 ft immediately adjacent to the dock and below the deck when compared to the plan drawings.
- The sediment samples taken at various locations all consist of leftover iron ore from when the dock was in-service.

Summary of Recommendations:

- Replace the timber fender system if the ships will be moored or berthed in the future.
- Continue to monitor existing conditions for further degradation at 5 year intervals and reinspect after repairs are made or new construction are completed.

1.0 INTRODUCTION

1.1 Purpose and Scope

This report consists of the results of the underwater inspection of the Lower Harbor Ore Dock in Marquette, MI. Collins Engineers, Inc. (Collins) conducted the underwater inspection for the City of Marquette during the week of June 02, 2014. The primary purpose of the investigation was to determine the condition of the timber piling and concrete pile cap of the structure.

The following report includes a description of the structure, the method of investigation, a description of existing conditions, and an evaluation and recommendations based on the findings.

1.2 General Description of the Structure

The dock consists of a reinforced concrete superstructure founded on timber cribs and over 6,000 closely spaced untreated timber piles. Additionally, there are numerous piles remaining in the water that were used to support a full-width timber trestle approach. Some of the piles are still used to support a pedestrian approach to the dock. Longitudinally there are 18 lines of vertical piles and 2 lines of battered piles along the dock.

1.3 Method of Investigation

A three-person team consisting of a licensed Professional Engineer, an Engineer In Training, and a technician/Registered Land Surveyor conducted the inspection.

The inspection consisted of a Level 1 (Visual and Tactile) examination of the 2 pile lines on either side of the dock and 4 pile lines along the interior of the dock. Therefore, 8 of the 20 pile lines were inspected along with their connection to the concrete pile cap. This was to provide an acceptable representative sample of the submerged portions of the dock to make a structural assessment without incurring the expense of a penetration dive. A Level II (Up Close and Detailed) examination was performed on 10% of the accessible piles inspected by cleaning marine growth and utilizing picks or knives to determine the soundness of the timber. A Level III (Detailed Inspection and Coring) examination was performed on 25 representative piles throughout the dock substructure that consisted of taking timber cores. The 1/8 in. cores were placed on sample trays for examination and were photographed to help determine the nature and extent of any pile deterioration for potential future repairs. All core holes were plugged with treated timber plugs to prevent future deterioration by sealing the opening. Furthermore, 10 representative sediment samples were taken around the structure and stored for further analysis if modifications to the substructure are proposed. Lastly, a continuously recording fathometer connected to a GPS receiver was used to perform a bathymetric survey in a 125 ft wide area around the structure. Additional soundings were taken along the center of the structure and the data was used to create a contour map of the area which can be found in Appendix B.

2.0 EXISTING CONDITIONS

At the time of inspection the weather was good for this underwater inspection. On June 02, the day that the crew arrived on-site and performed the bathymetric survey, the weather was cool with scattered rain showers throughout the afternoon. On June 03-06 the weather was fair and sunny and did not impede the inspection work. The following sections below describe the inspection findings for this underwater inspection. For the purposes of this report, nomenclature was created to label the pile rows and columns. The dock structure is split up in to seven 108 ft long sections of exposed timber piling separated by timber cribs that are 24 ft long. For the purposes of the inspection, the sections were labeled 1 through 7 from west to east. The longitudinal pile rows were labeled Bent A through Bent R from north to south. The transverse pile columns were labeled from west to east within each section starting at Pile 1 through Pile 43, typically. The battered piles are designated with the letter 'B' next to the row letter and a '.5' for the column number. See Figures 1 through 8 in Appendix B for the pile plan and Photographs 1 through 4 in Appendix A for overall views of the dock.

At the time of inspection the waterline was located 4.8 ft below the Corps of Engineers bench mark on the east end of the dock and 0.7 ft below the top of the concrete pile cap. Based on construction plans, this corresponds to a International Great Lakes Datum 1955 waterline elevation of 603.1. Plans indicate that the lake bottom below the dock footprint was filled to elevation 583.6 (water depth of 19.5 ft) and the lake bottom adjacent to the north and south faces was dredged to elevation 577.7 (water depth of 25.5 ft). According to the plans, the piles in Bents A through E and

N through R were driven to a minimum elevation of 554.6. The piles in Bents F through M were driven to a minimum elevation of 559.6.

2.1 Inspection Findings

Overall the substructure units of the Lower harbor Ore Dock were in good condition below water. The timber piling were typically in good condition below water with the average pile being sound with no loss of cross-sectional area or evidence of marine borer damage and ¼ in. awl penetration. On the north side of Section 7 at the east end, there was a broken timber wale that was part of the fender system that was hanging 5 ft down from the bottom of the deck (See Photograph 23 in Appendix A). The interfaces of the timber piles with the concrete deck were generally sound with no major deficiencies. The exterior rows of timber piles exhibited random areas of 10% to 15% section loss, probably due to abrasion from ships berthing and/or ice impact. These areas were located approximately 6 to 10 ft below the waterline. It should also be noted that while the average diameter of the timber piles was approximately 12 in., significant variation was found with piles ranging from approximately 10 in. in diameter to 16 in. in diameter. See Photographs 5 through 7 in Appendix A for typical conditions and Table 2.2 for a list of defects.

Soundings taken in the interior of the dock, combined with the data from the bathymetric survey, indicate that the lake bottom has infilled 3 to 7 ft immediately adjacent to the slip area and below the dock. This was confirmed by the presence of large amounts of iron ore on the lake bottom. See Figure 9 in Appendix B for the Bathymetric Survey Plan.

2.2 Pile Defects

Table 2.2 PILE DEFECTS

Note #	Section	Bent	Pile No.	Level I, II,III	Location	Dimensions of damage			Photo #	Comments
						Height	Width	Pen.		
1	1	J	2	II	Top	2'	Full	1"		Delamination of outer shell
2	1	I	39	II	Top	2'	Full	1"		Delamination of outer shell
3	2	B	16	II	Full pile					Pile out of plumb. Extends 2' past fascia
4	2	R	6	II	Full pile				20	Pile out of plumb

Table 2.2 PILE DEFECTS CONTINUED

5	2	R	23	II	Top	4'	1'	3"		Abrasion damage, 25% loss of section
6	2	R	42	II	Full pile					Pile out of plumb
7	3	A	26	II	Top	2'	1/2"	2"		Two 1/2" wide splits in top of pile
8	3	I	9	II	Top				11	10% loss of bearing due to concrete det.
9	3	I	10	II	Top				11	10% loss of bearing due to concrete det.
10	3	I	11	II	Top				11	10% loss of bearing due to concrete det.
11	3	I	33	II	Top	3'	Full	6"	12	Delamination of outer shell
12	3	I	35	II	Top	2'	Full	1"	13	Delamination of outer shell
13	3	Q	34	II	Full pile		1'	4"		30% loss of section
14	3	R	40	II, III	Top	4'	1'	2.5"	19	Abrasion damage, 20% loss of section
15	3	R	41	II	Top	4'	1'	2.5"		Abrasion damage, 20% loss of section
16	3	R	42	II	Top	4'	1'	2.5"		Abrasion damage, 20% loss of section
17	4	A	2	II	Top	2'	Full	1"		Delamination of outer shell
18	4	J	33	II	Top	4'	2"	4"		2" wide split in top of pile
19	4	A	39	II, III	Top	1’	Full	6.5”	21	60% section loss at top of pile
20	5	A	9	II	Top	3'	Full	2"		Delamination of outer shell
21	5	K	18	II	Top	3'	1/2"	6"		1/2" wide 6" deep split in pile
22	5	J	30	II	Top	2'	Full	3"		Delamination of outer shell
23	6	Q	39	II	Full pile		1"	12"		Full depth split through entire pile
24	6	R	40	II	Top	6'	Full	4"	18	30% loss of section
25	7	B	19	II	Full pile		1.5"	12"		Full depth split through entire pile
26	7	A	35	II	Top	7'	4"	12"	22	Full depth split through top 7'
27	7	R	4	II	Top	5'	4"	12"		Full depth split through top 5'
28	7	R	5	II	-6’	19’	2”	4”	14	Split from 6 ft below deck to bottom
29	7	R	19	II	Top	5'	4"	12"	15	Full depth split through top 5'
30	7	R	22	II	-20	4’	Full	3”	16	Delamination of outer shell
31	7	Q	22	II	Top	5'	4"	12"		Full depth split through top 5'
32	7	Q	25	II	Top	5'	4"	12"	17	Full depth split through top 5'

Table 2.2 PILE DEFECTS CONTINUED										
33	7	I	35	II	Top	2'	1'	1"		Delamination of outer shell
34	7	J	35	II, III	Top	2’	1’	2.5”	8	Abrasion damage, 20% loss of section
35	7	J	33	II	Top	2’	1’	2.5”	9	Abrasion damage, 20% loss of section
36	7	J	30	II	Top	1'	Full		10	Evidence of crushing

The abandoned timber piles of the former trestle approach and the piles of the pedestrian approach were also inspected. The abandoned piles between the shore and the west end of the dock were typically heavily weathered with splitting and significant section loss from the top of the piles down 5 ft. From 5 ft below the top of the piles to the lake bottom the piles appeared to be sound and in good condition.

The timber piles of the pedestrian approach were in satisfactory condition with moderate weathering and random minor splits and checks in the splash zone. The 10th pile from the shore in the north row exhibited necking from 1.5 ft above to 1 ft below the waterline with approximately 25% loss of section. The 11th pile from the shore in the south row exhibited delamination of the outer 2 in. of the shell from 2 ft above to 2 ft below the waterline. See Photographs 8 through 23 in Appendix A for views of the dock structure timber defects. See Photographs 31 through 34 in Appendix A for views of the pedestrian approach piles.

2.3 Timber Cores

An increment borer was used to collect 25 timber cores on piles at random locations below water throughout the interior and exterior portions of the dock. They were placed into trays and photographed before being sealed with tape. A visual inspection of the cores shows that the timber was spongy and saturated with water, with high percentage of core recovery, indicating few voids in the timber. The majority are light in color and do not have any indication of rot. However, 8 of the 25 samples have a dark appearance. The Level 1 inspection did not show outer signs of rot and the piles appeared solid when sounded. Samples of the timber cores were sent to Professor Peter Laks at Michigan Tech University and Chris Barber at Timber Products Inspection for analysis. According to Professor Laks the light colored cores are most likely Red Pine (*Pinus resinosa*) and the dark colored ones Western Red Cedar (*Thuja plicate*) or another Cedar species, True Fir, or Bald Cypress. Timber Products Inspection found no detectable wood preservatives in either type of wood in the samples sent to them. See Photographs 29 and 30 in Appendix A for pictures of the timber cores.

2.4 Concrete Defects

Overall the concrete deck was in satisfactory to good condition below water. The underside of the concrete deck was typically rough with evidence of scaling and loss of aggregate up to 1 in. but did not have any significant section loss in proportion to the size of the deck. The exterior of the deck at the bottom edge, and specifically above the timber cribs, exhibited concrete spalling and exposed reinforcing steel. The spalling was typically 3 in. to 6 in. deep and extended the length of the exterior of the dock. The exposed steel exhibited only light surface corrosion. On the interior portions of the dock there was typically spalling and exposed reinforcing steel on the underside of the transverse concrete deck sections separating the open cells. See Photographs 24 through 28 in Appendix A for views of the concrete defects.

2.5 Sediment Samples

Ten sediment samples were collected throughout the interior and exterior portions of the dock. See Figures 2 through 8 in Appendix B for the locations of the samples. In collecting the samples the inspector dug through the layer of surface sediment and several inches down into the lake bed. A visual inspection of the sediment suggests that it is made up of iron ore that had fallen off the dock during the years it was in use. To obtain information about the native lake bottom, sub surface exploration would need to be done to determine the soil composition beneath the layer of iron ore.

3.0 EVALUATION AND RECOMMENDATIONS

Overall the timber piling of the Lower Harbor Ore Dock was found to be in good condition below water. Submerged timber piles are not subject to insect attacks and marine borers are not found in fresh water. Furthermore, the piles are not exposed to air, which contributes to rot in timber piles. The primary causes of degradation in submerged timber piles are anaerobic bacteria, which are very slow to degrade wood and the duration of loading. Under prolonged continuous loading, the compressive stress on the piles can cause microscopic mechanical damage to the wood's structure. The damage becomes less if the piles are loaded to a smaller fraction of their capacity, which is typically the case in older structures with a high factor of safety. The ultimate capacity of a timber pile is determined by the diameter of the pile, species of wood, and on the soil/pile interaction. Although sediment samples were taken around the dock, the inspectors were not able to penetrate below the layer of iron ore to the native lake bed. Soil borings and analysis to determine the friction and cohesion properties would need to be done to determine a range of possible ultimate pile capacities based on the variety of pile diameters and probable tree species found at the Marquette Ore Dock. Due to the pile driving equipment of the time period and the limited capacity of timber piles to resist damage during driving; as well experience with similar projects of the era, an estimated design capacity of 25 tons per pile is assumed. For piles that didn’t exhibit specifically noted defects, an estimated 10 percent reduction is capacity is assumed due to age and general degradation of piles over time. While some of the piles exhibited severe defects, the relatively small number and the cost of potential repairs make repair or replacement impractical at this time. The abandoned timber fender system around the dock no longer has the structural integrity to serve any useful function, and the system should be replaced if future mooring or berthing of ships is required.

The concrete deck exhibited many areas of spalling and exposed reinforcing steel; however they were generally located on the bottom edge of the deck around the perimeter of the dock. The extent of the spalling does not significantly affect the load bearing capacity of the deck and repairs are not necessary at this time. If the dock is to be redeveloped, the spalling on the underside of the transverse concrete sections separating the open bays should be removed down to sound concrete and repaired for preventative maintenance purposes.

The above report summarizes our inspection findings for the Lower Harbor Ore Dock in Marquette, MI. In accordance with ASCE’s Underwater Investigation Standard Practice Manual, it is recommended that all in service docks be inspected at least every 5 years to ensure safety and long-term serviceability. In addition, repairs or new construction should be inspected as soon after completion as practical. Should there be any questions, please do not hesitate to contact our office. We appreciate the opportunity to work with you on this project and look forward to working with you and your organization on any future projects.

Respectfully Submitted,

COLLINS ENGINEERS, INC.

Roy A Forsyth, P.E.

Appendix A

Photograph 1: Overall view of Ore Dock, Looking North.

Photograph 2: Overall view of Ore Dock, Looking West.


Photograph 3: Overall view of Ore Dock, Looking South.


Photograph 4: Overall interior view of Ore Dock, Looking West.

Photograph 5: Typical pile condition below water at interior of Ore Dock, Looking North.

Photograph 6: Typical timber crib condition at interior of Ore Dock, Looking West.


Photograph 7: Typical Wakefield Sheeting configuration of timber crib at interior of Ore Dock.


Photograph 8: View of delamination of outer shell at Pile 35J in Section 7.

Photograph 9: View of abrasion damage at Pile 33J in Section 7.

Photograph 10: View of crushed Pile 30J in Section 7.


Photograph 11: View of loss of bearing at Piles 9 through 11I in Section 3.


Photograph 12: View of delamination of outer shell at Pile 33I in Section 3.

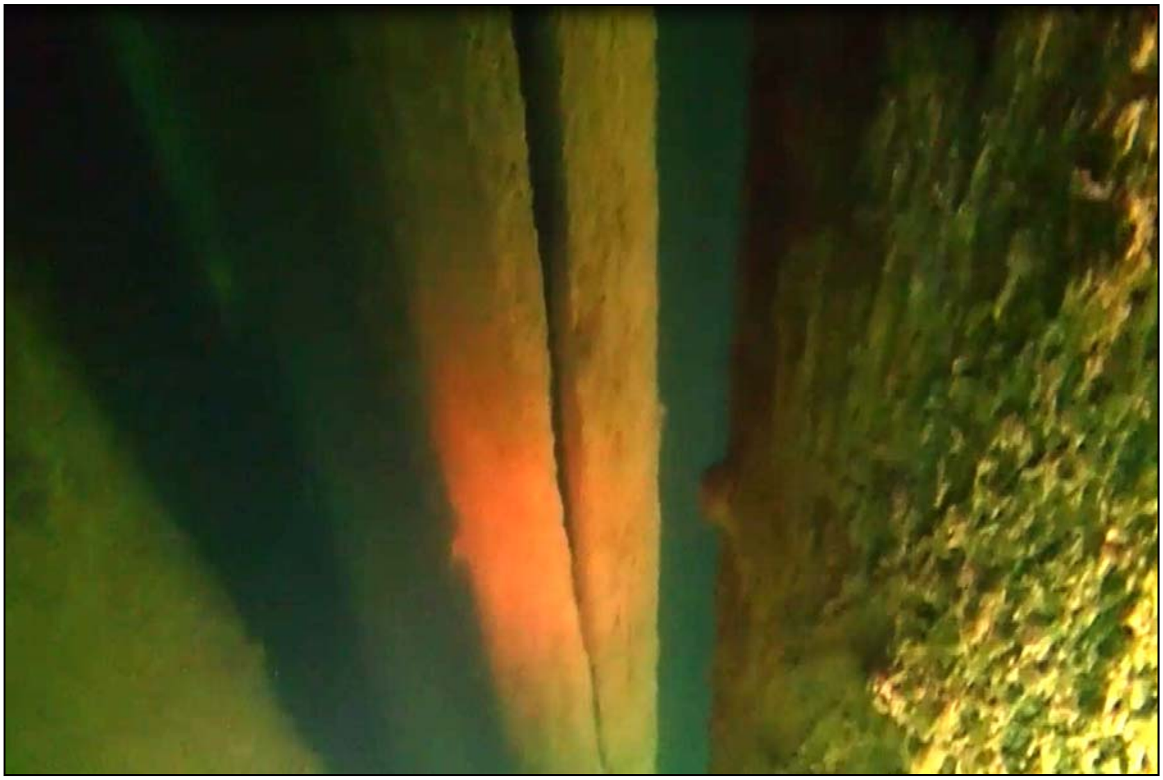
COLLINS ENGINEERS INC.


Photograph 13: View of delamination of outer shell at Pile 35I in Section 3.


Photograph 14: View of split at Pile 5R in Section 7.


Photograph 15: View of split at Pile 19R in Section 7.


Photograph 16: View of delamination and split at Pile 22R in Section 7.



Photograph 17: View of split at Pile 25Q in Section 7.

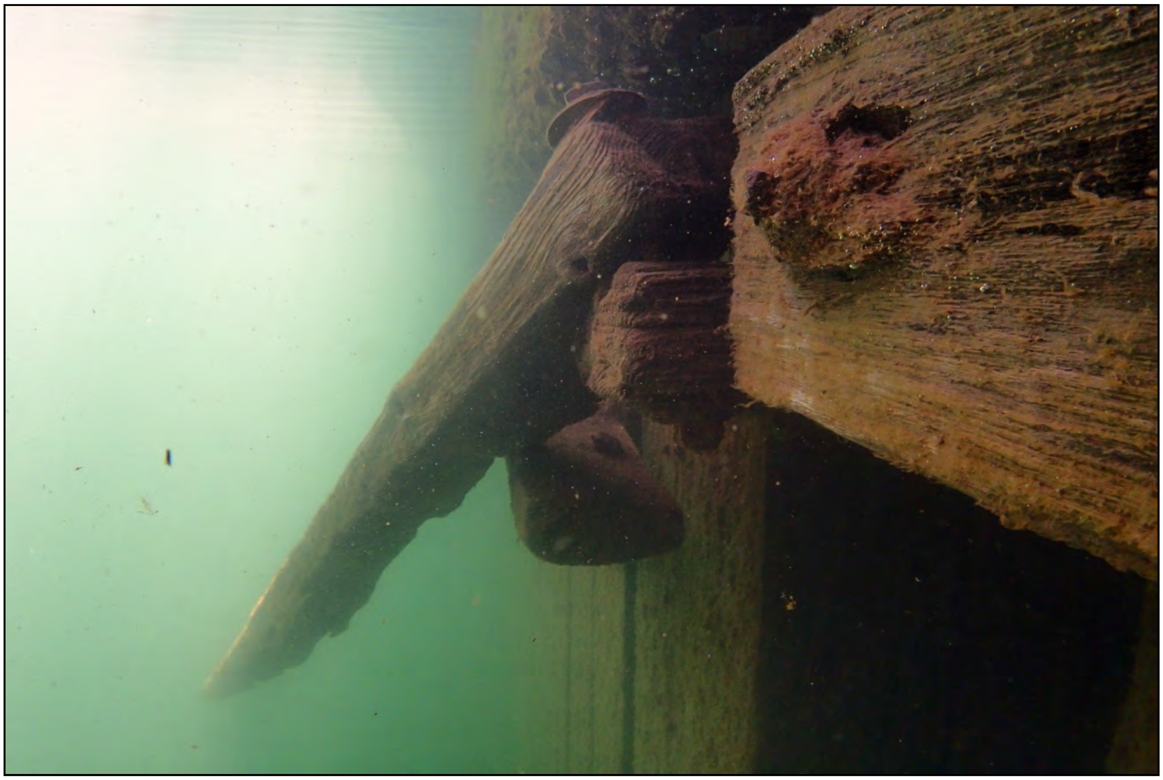
Photograph 18: View of loss of outer shell at Pile 40R in Section 6.

Photograph 19: View of abrasion damage at Pile 40R in Section 3.

Photograph 20: View of out of plumb Pile 6R in Section 2.

Photograph 21: View of section loss at Pile 39A in Section 4.

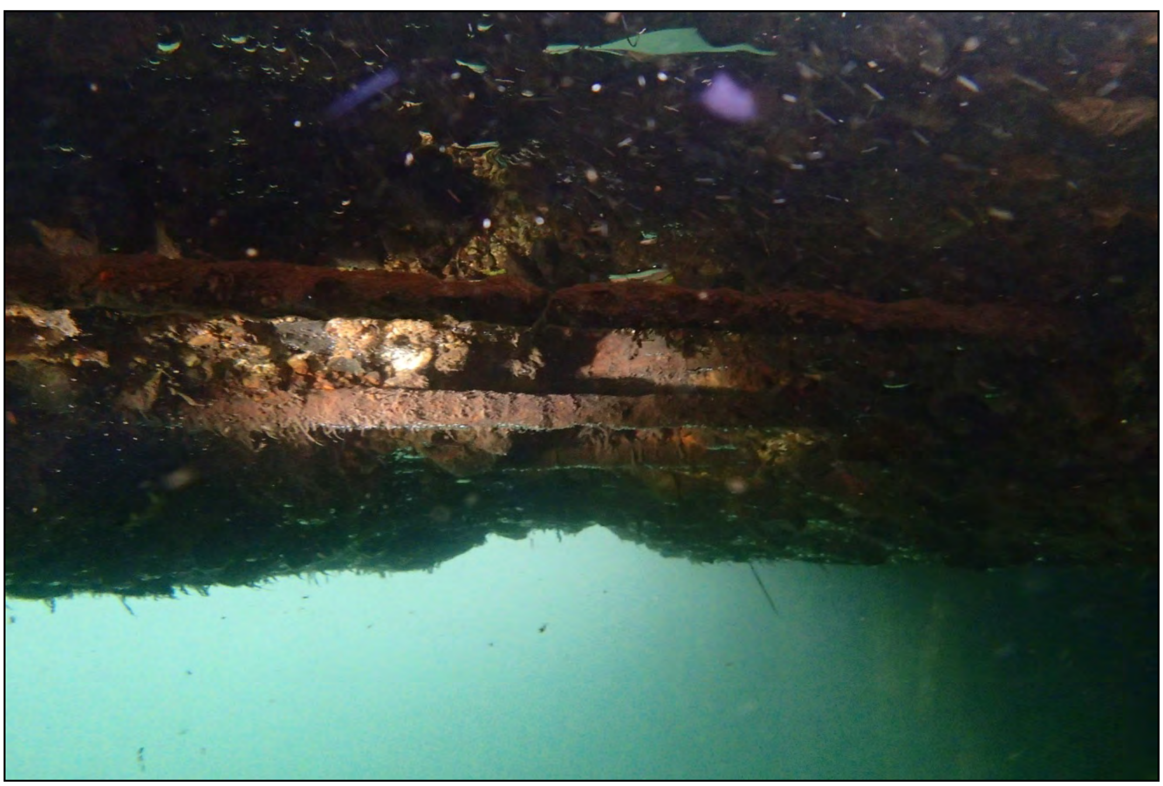
Photograph 22: View of split in Pile 35A in Section 7.



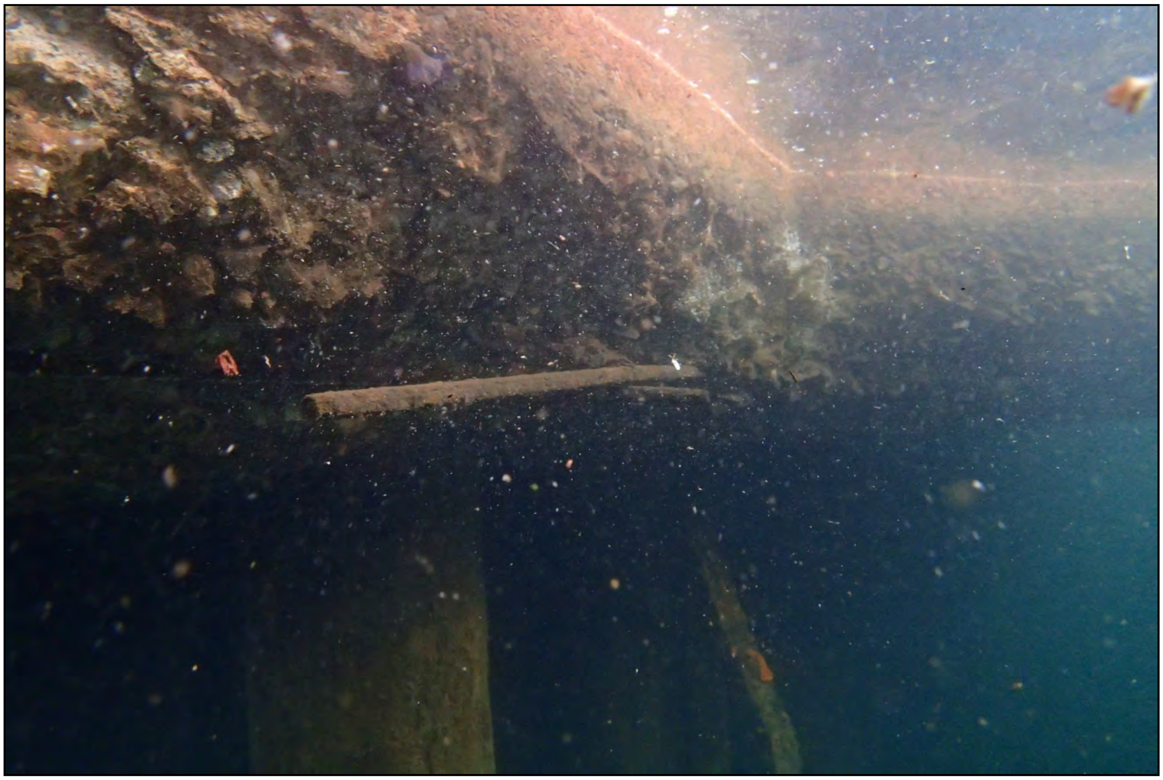
Photograph 23: View of broken timber wale on northeast side of Section 7, looking east.

Photograph 24: View of typical concrete scaling on north side of Section 2, looking southeast.

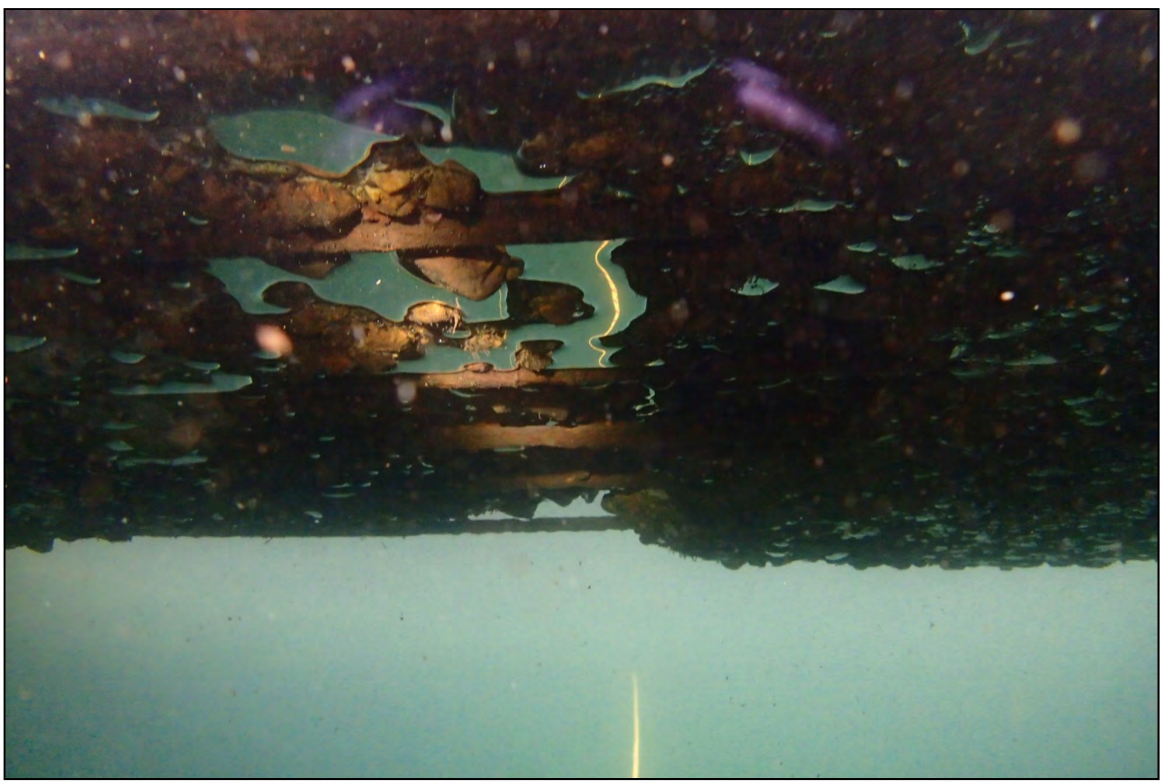
Photograph 25: View of typical concrete spalling above the timber cribs on the north side between Sections 5 and 6.



Photograph 26: View of concrete spalling at second transverse concrete section in Section 5.

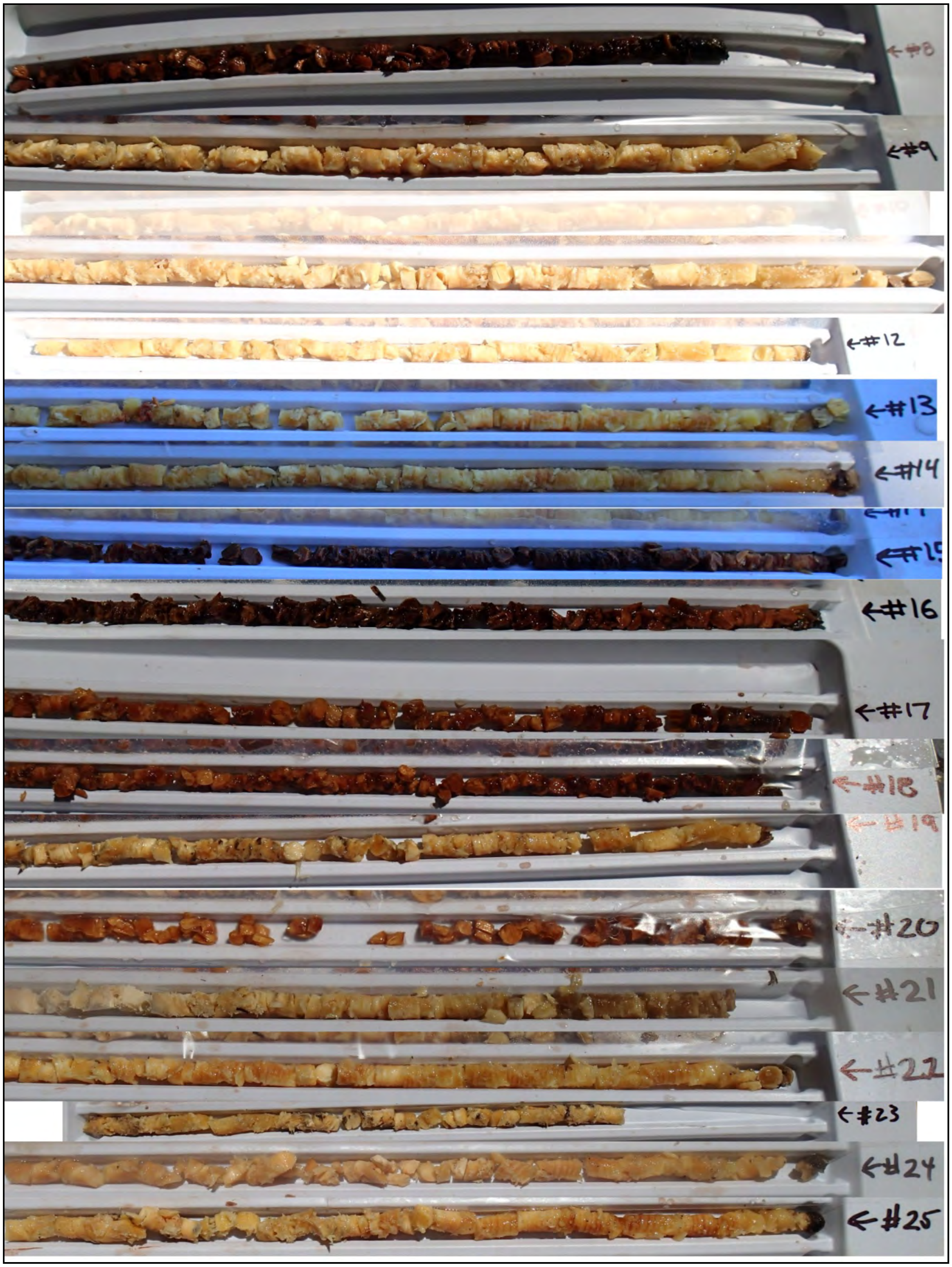


Photograph 27: View of concrete spalling on the north side of Bay 2 in Section 3.



Photograph 28: View of concrete spalling at fifth transverse concrete section in Section 2. Note the air bubbles trapped on the underside of the deck.

Photograph 29: View of increment core numbers 1 through 7 from the dock interior. Note that these cores fell apart upon removal from coring tool. These do not represent loss of section in the piles.



Photograph 30: View of increment core numbers 8 through 25 from the dock exterior.

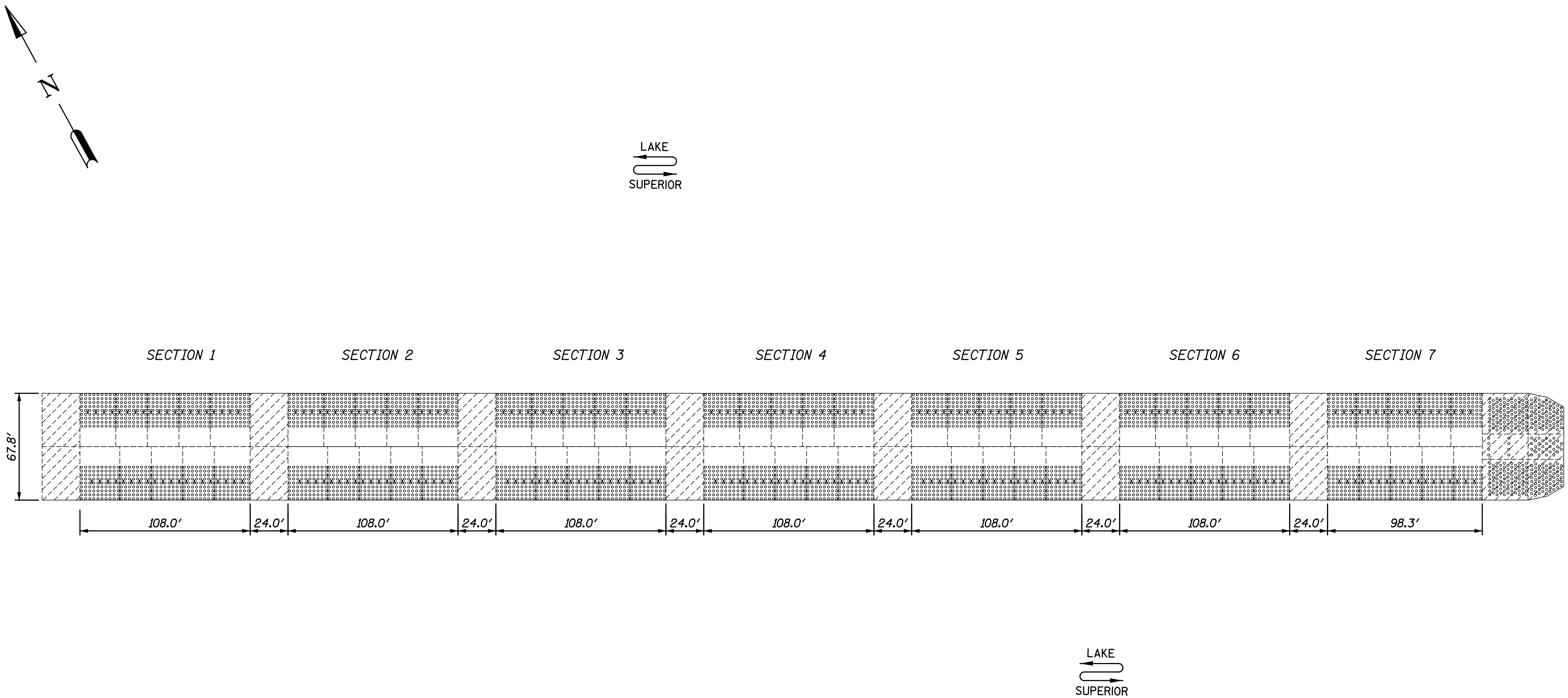
Photograph 31: Overall view of Pedestrian Approach, looking east.

Photograph 32: Overall view of Pedestrian Approach, looking west.

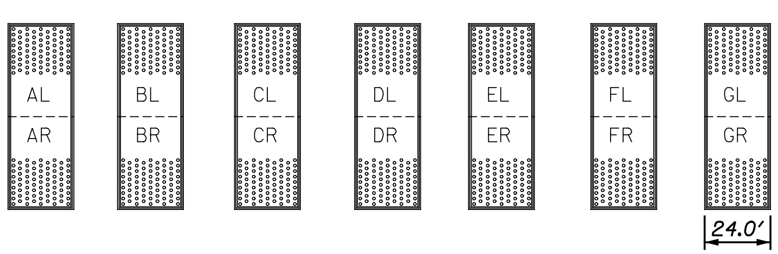
Photograph 33: 10th pile from shore in the north row of Pedestrian Approach, looking north.

Photograph 34: 11th pile from shore in the south row of Pedestrian Approach, looking south.

Appendix B



GENERAL PLAN



TIMBER CRIBS

GEI Consulting Engineers and Scientists

CITY OF
MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

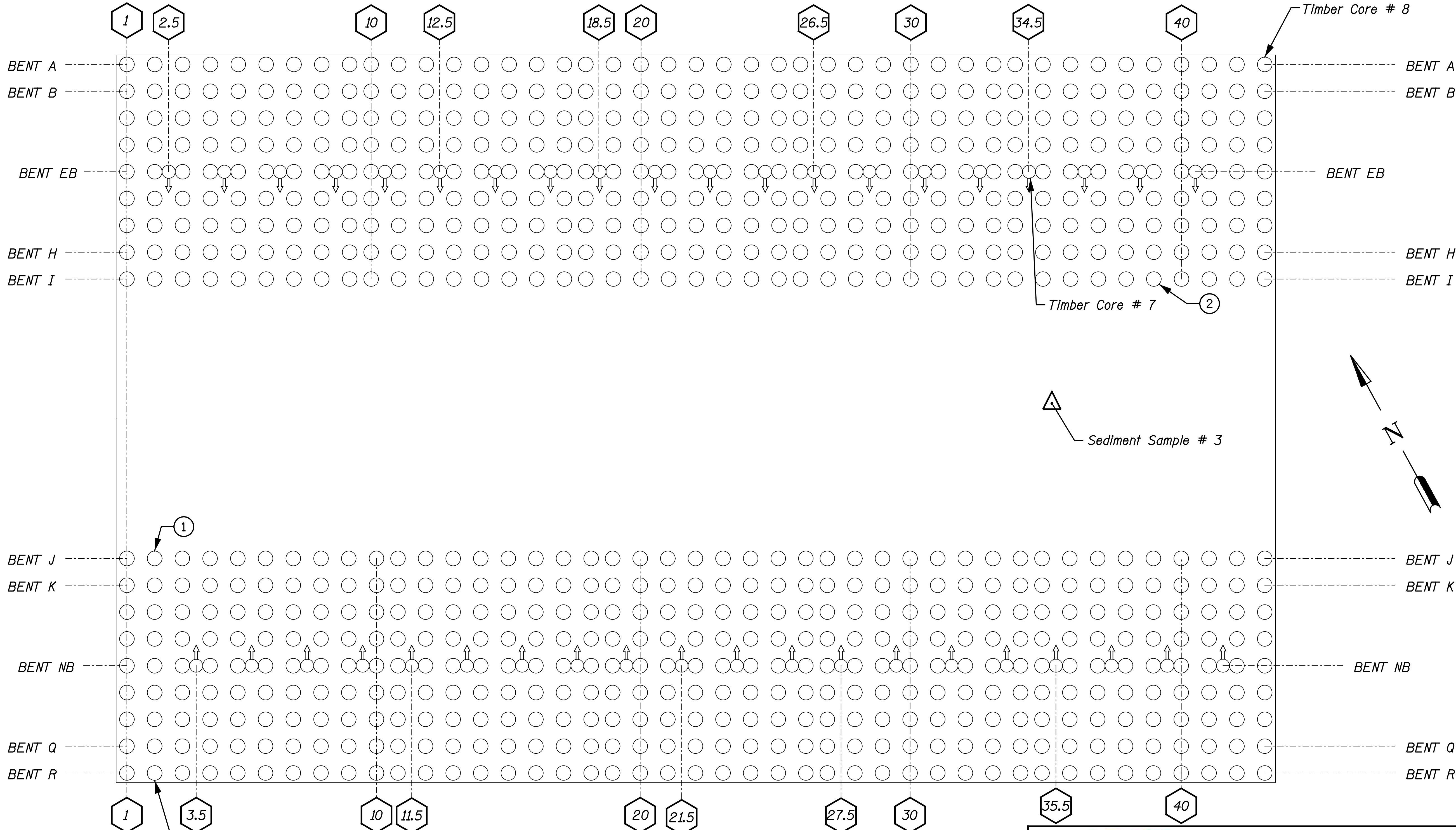
WATERLINE REFERENCE: Top of concrete deck = 603.8

6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/2/2014
DRAWN BY: JTF		SCALE: 1"=70'
CHECKED BY: RAF		FIGURE NO.: 1



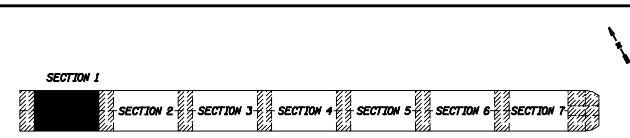
Legend:

- (1) Note Number
- △ Approximate Sediment Sample Location
- ⬡10 Pile Column Designation
- Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 1 PILE PLAN



KEY PLAN

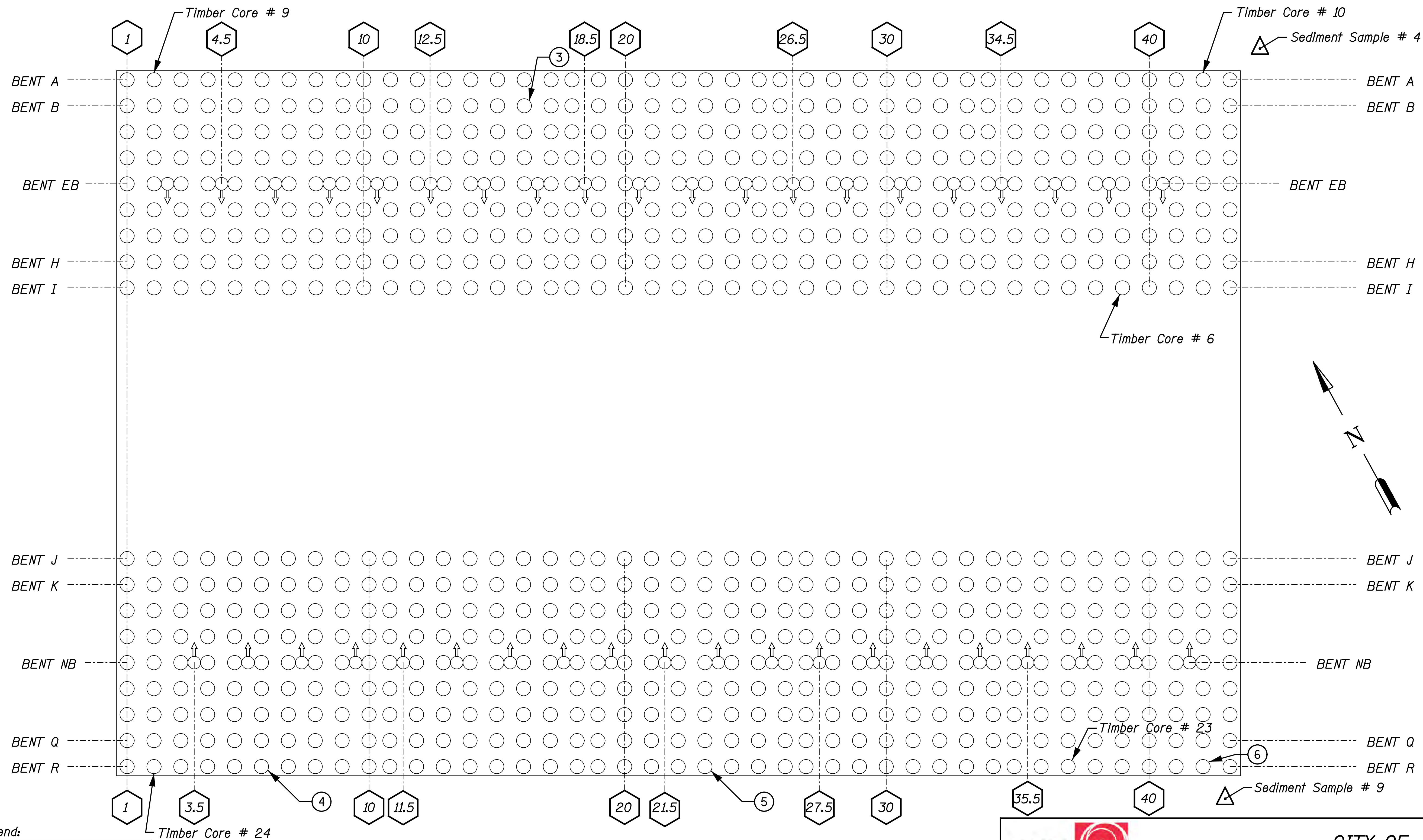
GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1
LOCATION: Marquette, MI
BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 2



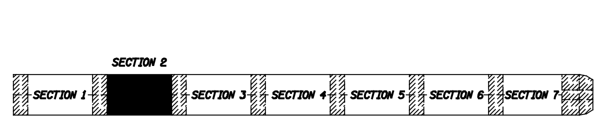
Legend:

1	Note Number
△	Approximate Sediment Sample Location
10	Pile Column Designation
	Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 2 PILE PLAN



KEY PLAN

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8

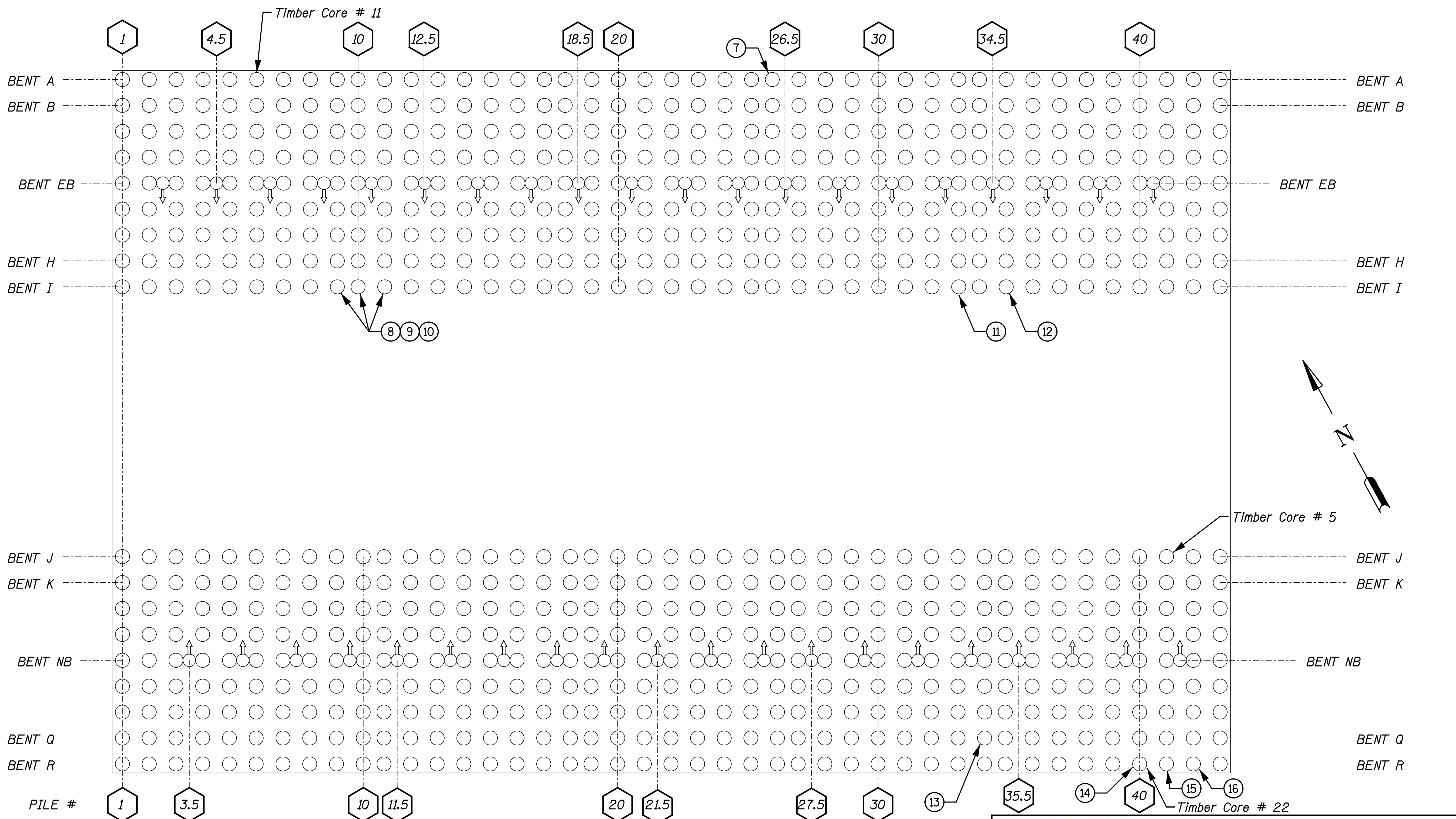
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 3

USER:Jordan Furlan Test PEN TABLE:CEI_TEXTSUB.TBL PLOT DRIVER:Pdf_bw_HS_by level.plt FILE:Ore Dock Plan Sheet.dgn



Legend:

① Note Number

Approximate Sediment Sample Location

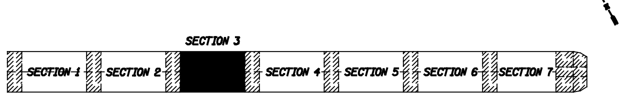
Pile Column Designation

Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 3 PILE PLAN



KEY PLAN

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8

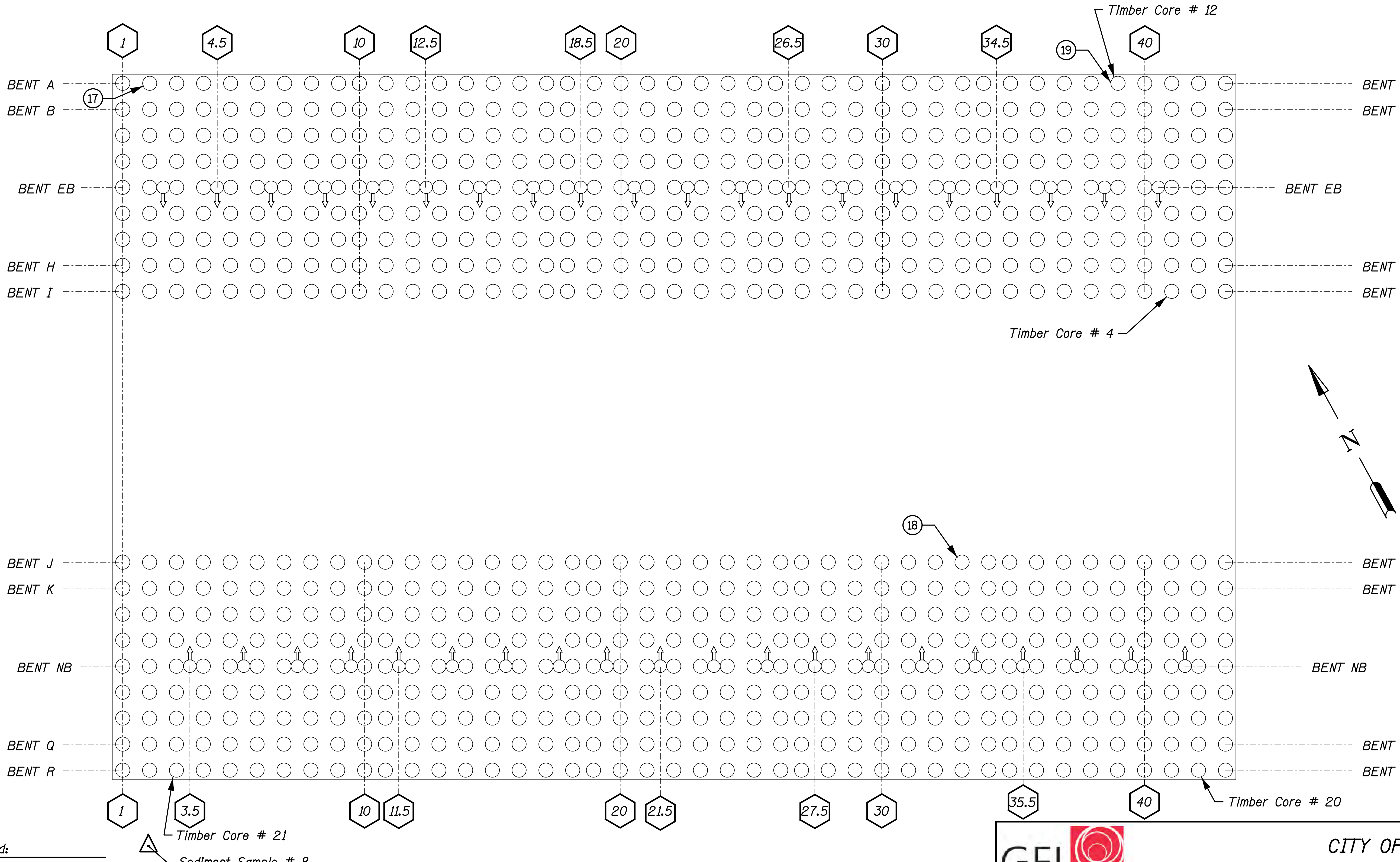
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 4

USER:Jordan Furlan Test PEN TABLE:CEI_TEXTSUB.TBL PLOT DRIVER:Pdf_bw_HS_by level.plt FILE:Ore Dock Plan Sheet.dgn



Legend:

1 Note Number

Approximate Sediment Sample Location

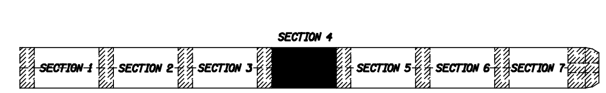
10 Pile Column Designation

Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 4 PILE PLAN



KEY PLAN

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

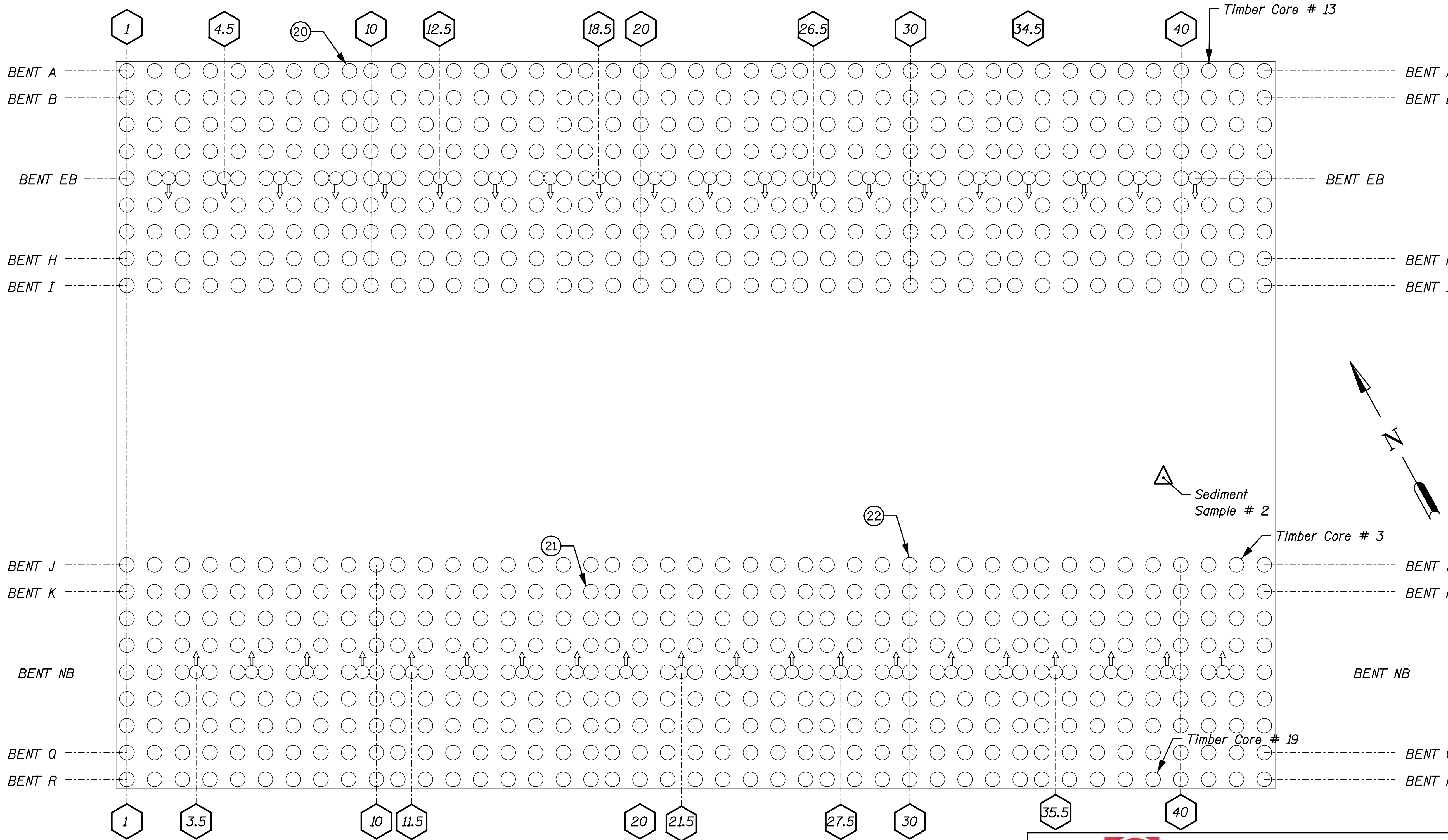
WATERLINE REFERENCE: Top of concrete deck = 603.8

6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 5



Legend:

1 Note Number

Approximate Sediment Sample Location

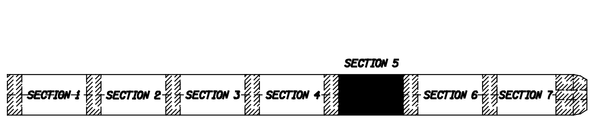
10 Pile Column Designation

Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 5 PILE PLAN



KEY PLAN

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8

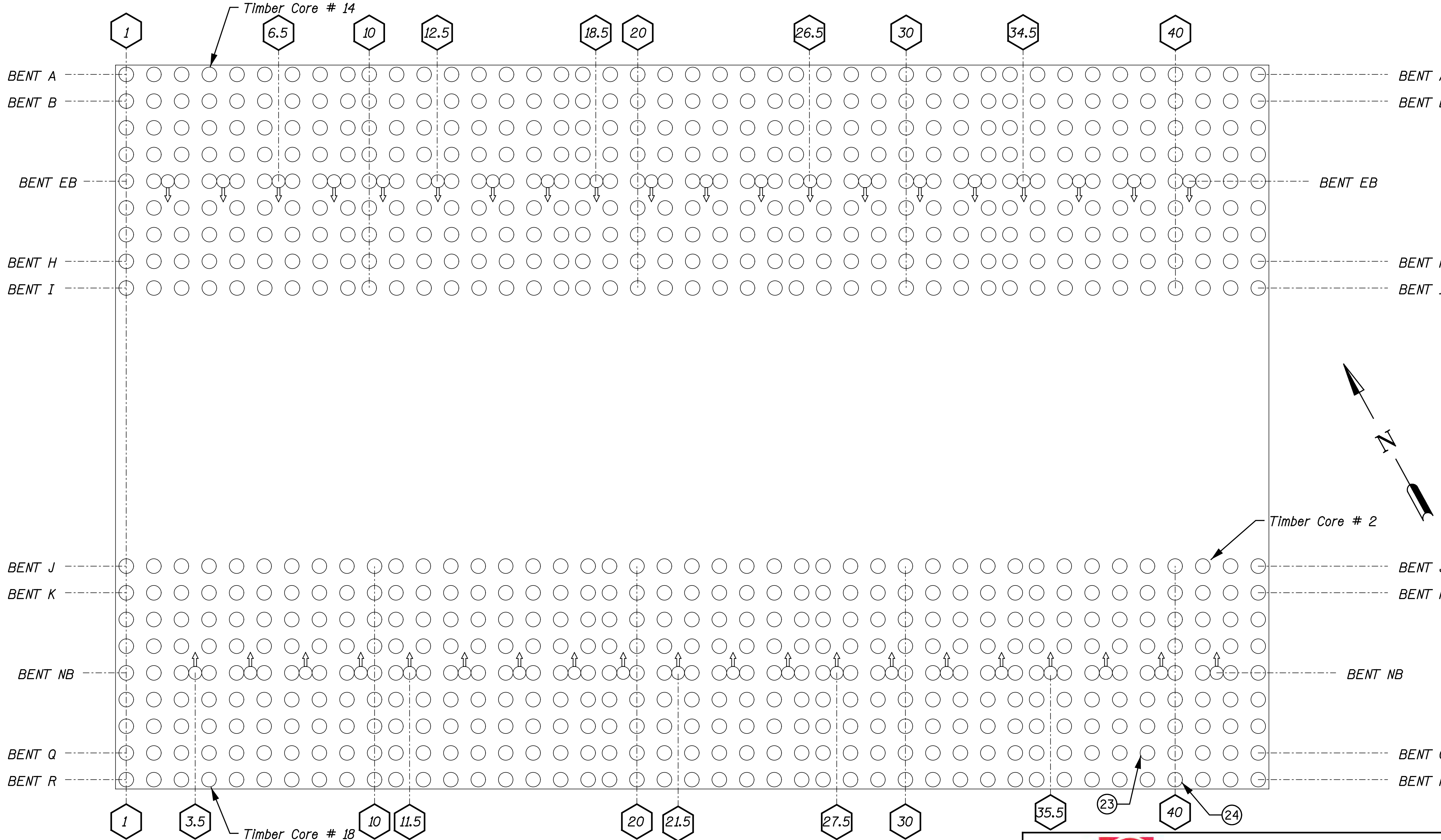
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 6

USER:Jordan Furlan Test PEN TABLE:CEI_TEXTSUB.TBL PLOT DRIVER:Pdf_bw_HS_by level.plt FILE:Ore Dock Plan Sheet.dgn



Legend:

1 Note Number

Approximate Sediment Sample Location

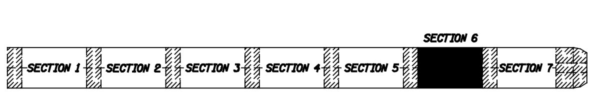
10 Pile Column Designation

Battered Pile

General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 6 PILE PLAN



KEY PLAN

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

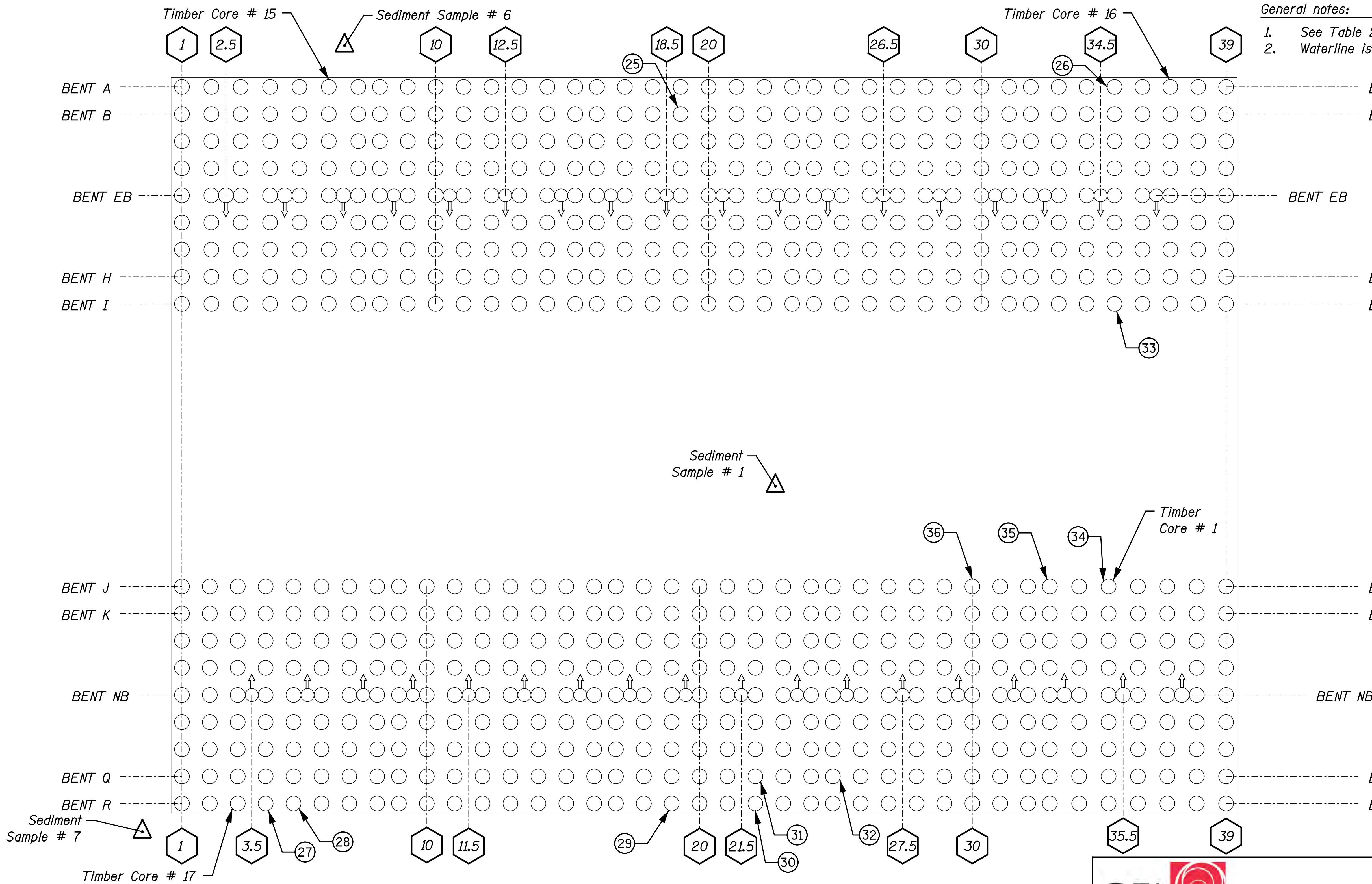
WATERLINE REFERENCE: Top of concrete deck = 603.8

6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1

LOCATION: Marquette, MI

BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 7



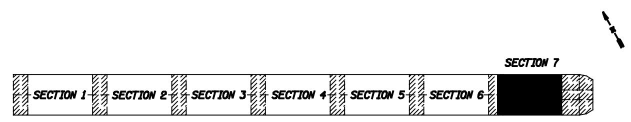
General notes:

1. See Table 2.2 on Page 3 of report for defect notes.
2. Waterline is referenced to IGLD -1955

SECTION 7 PILE PLAN

Legend:

- (1) Note Number
- △ Approximate Sediment Sample Location
- ⬡ 10 Pile Column Designation
- Battered Pile



KEY PLAN

GEI Consulting Engineers and Scientists

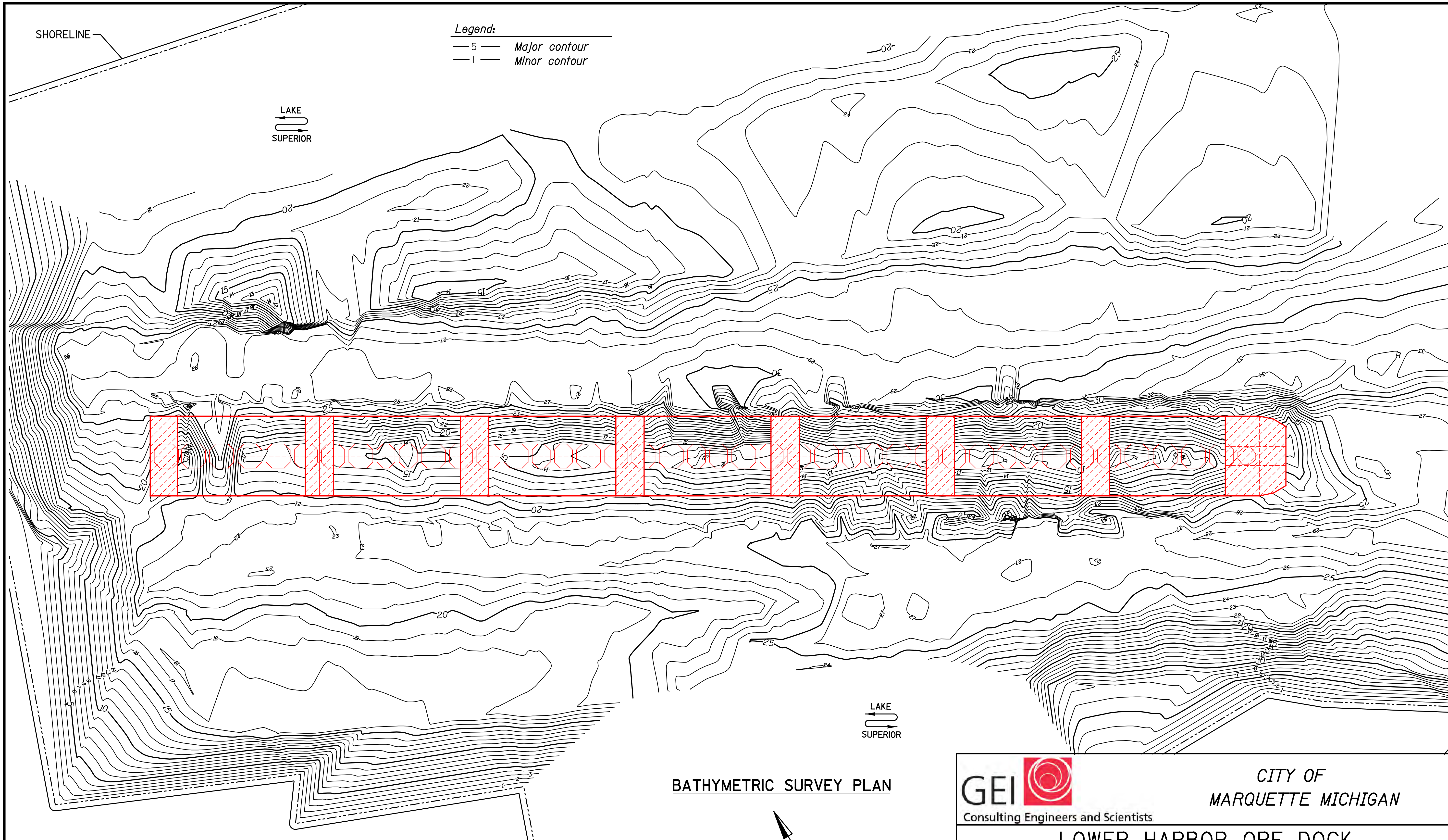
CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1
LOCATION: Marquette, MI
BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/02/2014
DRAWN BY: JTF		SCALE: 1"=10'
CHECKED BY: RAF		FIGURE NO.: 8

USER:Jordan Furlan Test PEN TABLE:CEI_TEXTSUB.TBL PLOT DRIVER:Pdf_bw_HS_by level.plt FILE:Ore Dock Plan Sheet.dgn



BATHYMETRIC SURVEY PLAN

General notes:

1. The bathymetric survey was completed on June 02, 2014 by Collins Engineers, Inc.
2. Soundings were obtained using a continuously recording fathometer operating at 200kHz and linked to a WAAS capable GPS receiver.
3. All water depths are in feet and are referenced to IGLD -1955 for consistency with construction plans.
4. Base map information shown on this drawing shall be considered approximate.

GEI Consulting Engineers and Scientists

CITY OF MARQUETTE MICHIGAN

LOWER HARBOR ORE DOCK

WATERLINE REFERENCE: Top of concrete deck = 603.8
6/2/2014 WATERLINE EL. = 0.7 below the top of concrete deck. 603.8 - 0.7 = 603.1
LOCATION: Marquette, MI
BOAT LAUNCH: Cinder Pond Marina

INSP BY: JTF/CRE/CSH	COLLINS ENGINEERS INC. 2033 W. HOWARD AVE. MILWAUKEE, WI 53221 (414) 282-6905	DATE: 6/2/2014
DRAWN BY: JTF		SCALE: 1"=80'
CHECKED BY: RAF		FIGURE NO.: 9

Appendix B

Inspection Summary Logs

APPENDIX B, EXHIBIT B-1

Section 1 - Inspection Summary Log

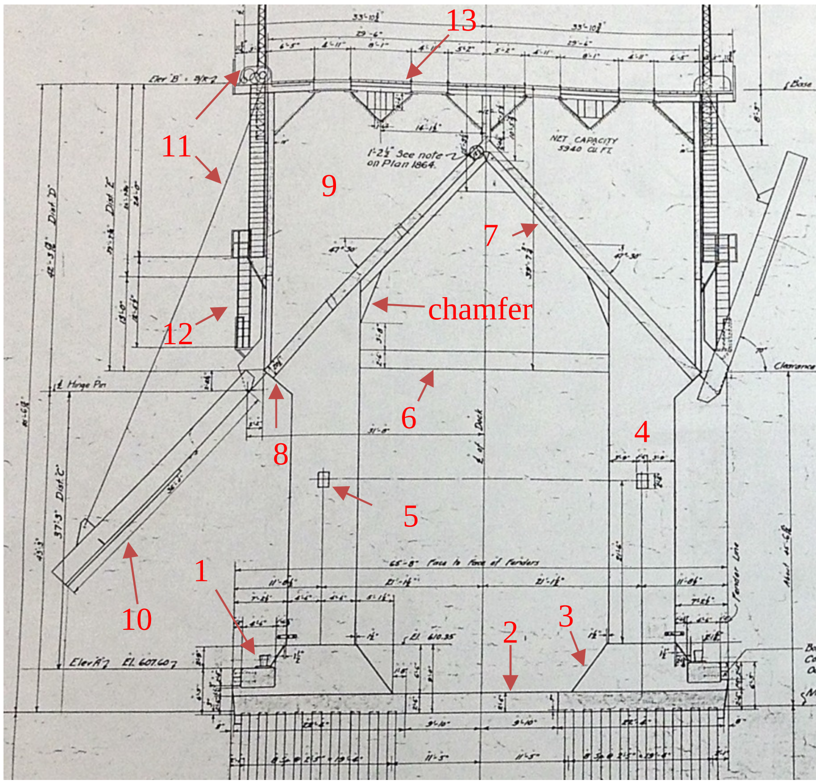
B1.1 Section 1: Bent 1 to Bent 12

Section 1 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Cracks were regularly observed transverse to the fender. They were approximately mid span between bent columns. The cracks were tight with occasional localized scaling. Photos 1-1 and 1-2 depict the typical condition of the cracks on the walkway. The timber bumper on either side of this section has substantially deteriorated. Brush and plants are growing within the rotten wood. Photo 1-3 shows the condition of the timber bumper.

2. Pile Cap/Floor

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between the bents. Some of these piles have vegetation and brush growing within them (Photo 1-4).

3. Bent Base

In localized areas, minor spalling has occurred due to shallow concrete cover over the steel reinforcement. This deterioration generally occurred on the upper corners of the footing, as shown in Photo 1-5. Minor shrinkage cracking is visible in localized areas of the footings (Photo 1-6).

4. Bents

On the bents, occasional areas of spalling concrete with exposed reinforcing were observed, particularly on the corners of the columns (Photo 1-7 & 1-8). The concrete cover over the reinforcement in these areas was thin.

5. Longitudinal Beams

Spalling concrete with exposed shallow reinforcement was observed on many of these beams. Cold joints were occasionally observed mid-span. Photos 1-9 and 1-10 show the worst-case examples of beam deficiencies.

6. Transverse Beams

These beams typically exhibit spalling and superficial rebar (rebar with no concrete cover), such as in Photo 1-11. Some localized areas of poorly consolidated concrete were observed (Photo 1-12). Generally these types of deficiencies occur near the ends of the beams, near the bents. Photo 1-13 represents the worst-case deficiencies observed within Bent 1.

7. Ceiling & Chamfer

The underside of the iron ore pockets is the ceiling as observed from the pile cap floor. This surface was in good condition with only minor areas of poorly consolidated concrete, tight cracks with minor efflorescence, cold joints mostly near the expansion joints, small spalls, and some areas of exposed rebar, as shown in Photo 1-14. In every pocket, the ceiling contained numerous small holes that penetrated the slab. These holes appear to be part of the original construction, and are evident by water staining (Photo 1-15). The chamfers typically exhibited some spalling and exposed rebar. Photo's 1-16 & 1-17 portray the average deficiencies of this element.

8. Overhang

The overhangs are the bottom of the pocket slab and lowest part of the ceiling. These areas were observed to have areas of poorly consolidated concrete, evidence of miscellaneous debris (possible trash that was dropped in the bottom of the formwork during original construction), and cracking with efflorescence. The cracks were typically associated within the chute steel imbeds. Photos 1-18 and 1-19 show examples of these deficiencies.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes, and from the top of the dock at two stair locations in this Section. The interior pocket walls and floors of the pockets were observed to be in good condition with no cracking, spalling, or exposed reinforcement. The exterior walls on the north and south sides of the dock did exhibit various degrees of spalled concrete with exposed rebar (Photo 1-20 and 1-26). Generally, the south pocket wall exhibited greater spalling than the north side.

Steel Components

10. Chutes and Pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. Measurements of the member sizes of various components of Chute 1 were documented, and were found to be consistent with the record drawings. In addition, the member sizes of the pocket Gate 1 were documented, and were found to be consistent with the record drawings. The pocket gates were observed to be in good condition and substantially identical, with the only noted difference being the top of the gate. Gates 1 through 27 on the south side have an additional member on top of the gate (Photo 1-21). This member does not have an apparent structural benefit, but may have prevented overflow of iron ore pellets. At the locations where the inspectors ascended and descended the access ropes, close-up inspections of the steel pins at the base of the chutes were inspected. These inspections were limited to Chute 1 and Chute 6 (Photo 1-22). The steel construction in the areas of the pins was observed to be consistent with the record drawings. Minor deterioration was noted, with no excessive wear on the pin or associated steel plate. Slight bending of the steel in the areas of the pins was noted. Photo 1-23 shows the condition of the chutes and gates.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the dock. Close-up inspections of the belts, connections and hoists were conducted from the two stairs. The belt was observed to be in good condition with no fraying corrosion or deterioration noted. The members that connect the steel belt to the chute were observed to be in good condition, and were measured on Chute 6. The measurements found the members to be consistent with the record drawings. The hoists were observed to be securely bolted to the deck steel frame. Each hoist real locks the steel belt in place through the use of a key or stop in the cogs of the main hoist real. Through some linkage controlled by levers, the hoist can also operate the pocket gates. The hoists are attached to a drive shaft, that is powered by an electric motor. Photos 1-24, 1-25 and 1-26 show the condition of the steel belt and hoists.

12. Walkway & Stairs

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. Measurements of the walkway members were conducted at Chute 1, and were also consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Two stairs (one on the north and one on the south side of the dock) are present within this section. The stair framing and attachments to the pocket walls were observed to be consistent with the record drawings. The members and attachments were observed to be in good condition with little to no evidence of deterioration. The timber decking used for both the walkways and stairs was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photos 1-27 & 1-28 show the condition of the walkway and stairs within this Section.

13. Deck Framing

The top of the dock was observed at the locations of the stairs on both the north and south sides of this Section. The framing was observed to be in good condition with little to no deterioration noted. However, some members were observed to be bent, and some localized areas of corrosion were noted. The geometry of the deck framing was not measured, but was observed to be not consistent with the record drawings. Measurements of the deck framing members was conducted, and found to be consistent with the record drawings.

Section 1 – Photo Log

Photo 1-1: Shrinkage crack in walkway between Bents 10 and 11, on the north side of the dock. Note deteriorated timber bumper.

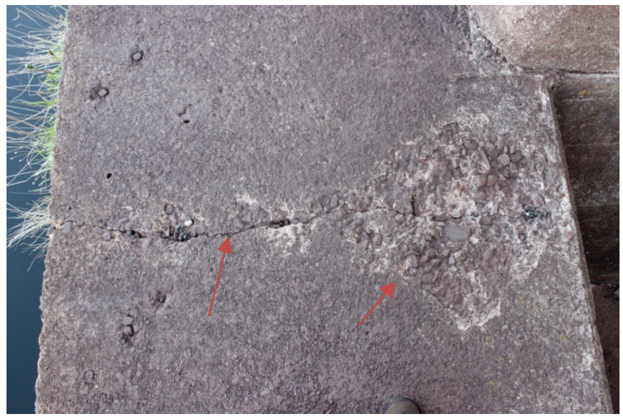


Photo 1-2: Shrinkage crack in walkway between Bents 2 and 3, on the south side of the dock. Note localized surface scaling.

Photo 1-3: Brush and vegetation growing in rotten timbers on fenders.

Photo 1-4: Vegetation growing in deposit of iron ore pellets.

Photo 1-5: Shrinkage cracks on face of south base of Bent 7.

Photo 1-6: Small localized area of delamination with rebar visible on Bent 6, north side.

Photo 1-7: Delamination/spalling on Bent 9, south side. Note exposed reinforcement with no concrete cover.

Photo 1-8: Delamination/spalling on Bent 10, south side. Note exposed reinforcement with no concrete cover.

Photo 1-9: Spalling with exposed reinforcement between Bents 5 and 6 on the south side. Note the cold joint mid-span on the beam.

Photo 1-10: Spalling with exposed reinforcement between Bents 5 and 6 on the north side. Note the cold joint mid-span on the beam.

Photo 1-11: Spalling with exposed reinforcement in the transverse beam at the north side of Bent 9.

Photo 1-12: Honeycombing in transverse beam at Bent 10.

Photo 1-13: Worst-case deterioration observed in the transverse beam at Bent 1.

Photo 1-14: View of ceiling between Bents 4 and 5 showing small spalls, exposed reinforcement, and holes penetrating the pocket slab.

Photo 1-15: Chamfer section of ceiling at south side of Bent 8 showing exposed rebar.

Photo 1-16: Another example of exposed rebar at a honeycombed area on the transverse beam and at the chamfer section of Bent 12.

Photo 1-17: Horizontal cracking on ceiling between Bents 3 and 4. Note minor efflorescence.

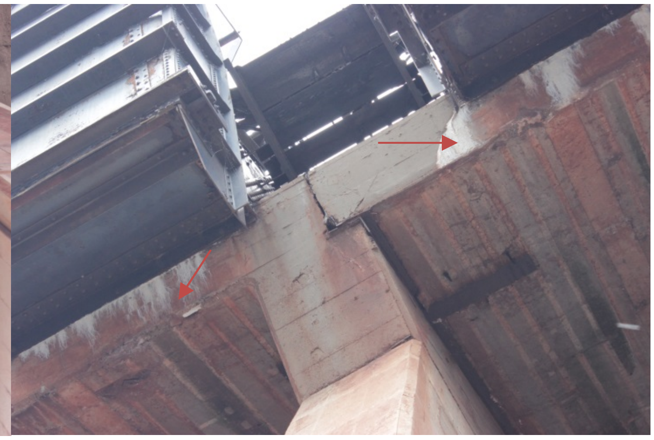


Photo 1-18: View of expansion joint between Section 1 and 2 at Bent 12. Note localized spalled concrete, honeycombed concrete is common. Cracking with some efflorescence is also observed at the location of chute steel imbeds.

Photo 1-19: View of cracks with efflorescence, with spalling and exposed rebar between Bents 1 and 2, north side.

Photo 1-20: Pocket wall showing spalling and rebar.

Photo 1-21: Additional steel top member found on pocket doors 1 through 27.

Photo 1-22: Side view of chute 4 showing hinge pin.

Photo 1-23: Close-up view of the underside of chute 1 showing hinge pin connection.

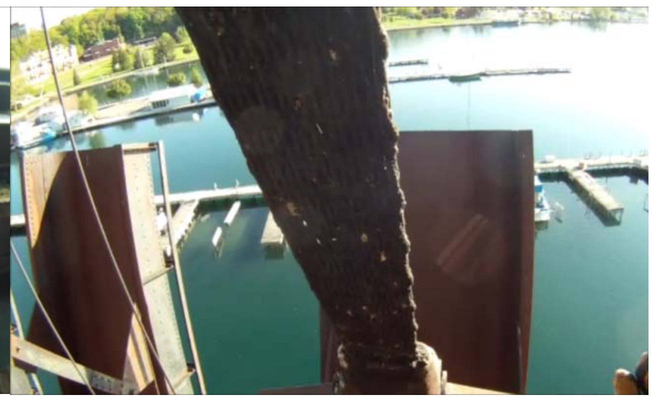


Photo 1-24: Close-up view of braded steel belt for hoisting chute 5.

Photo 1-25: View of hoist for chute 3 with braded steel belt.

Photo 1-26: Close-up view of hoist belt connection to chute 6. Note good condition of pocket wall.

Photo 1-27: View of upper portion of southwest stairs. Note spalled concrete and exposed rebar on pocket wall.

Photo 1-28: Typical view of pocket gate, walkway, and chute.

Photo 1-29: View looking south across top of the west end of the dock showing steel framing.

Section 2 - Inspection Summary Log

B1.2 Section 2: Bent 13 to Bent 23

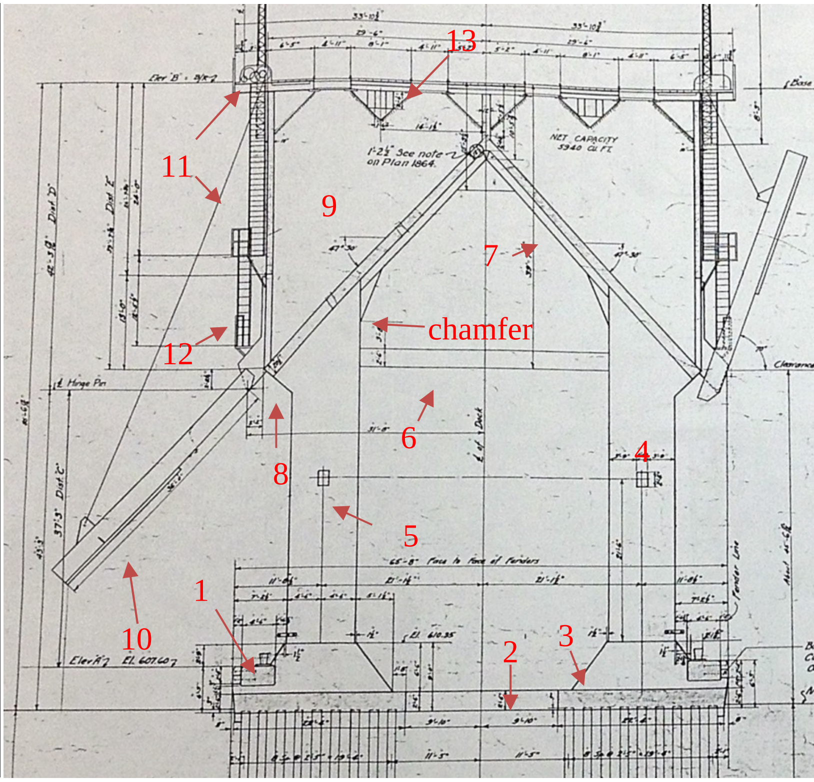
Section 2 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Figure 1: Section View of Bent.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 2: Section View of Bent.

Concrete Components

1. Fenders

Cracks were regularly observed transverse to the fender. They were approximately mid span between bent columns. The cracks were tight with occasional localized scaling. Photos 2-1 through 2-3 depict the typical condition of the cracks and scaling on the walkway. The timber bumper on either side of this section has substantially deteriorated. Brush and plants are growing within the rotten wood.

2. Pile Cap/Floor

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them (Photo 2-4).

3. Bent Bases

Minor spalling has occurred on the upper corners of the base, as shown in Photo 2-5. Minor shrinkage cracking is also visible in localized areas of some of the bases (Photo 2-6.)

4. Bents

On the Bents, delaminated and spalled concrete (Photos 2-7 & 2-8) are not as apparent compared to Section 1. A few protruding rebar ties were observed on some of the bents (Photo 2-9). Occasional tight vertical shrinkage cracks were observed towards the base of these bents (Photo 2-10).

5. Longitudinal Beams

The longitudinal beams contained some tight cracks in localized areas (Photo 2-11) and localized spalling and exposed rebar (Photo 2-12).

6. Transverse Beams

Superficial rebar was common along the bottoms of these beams (Photo 2-13). These types of deficiencies occur in localized areas towards the bents both the north and/or south sides.

7. Ceiling & Chamfers

The ceilings show minor sections of poorly consolidated concrete, cracking, and rebar as shown in Photo 2-14. Cold joints appear in this section in localized area as photo 2-15 shows. Rebar is most common in the chamfer section of this ceiling. Photo 2-16 portrays the average deficiencies of this chamfer area, and rebar is also visible in the top of the ceiling.

8. Overhangs

The overhangs are the bottom of the pocket slab and lowest part of the ceiling. These areas were observed to have areas of poorly consolidated concrete, evidence of miscellaneous debris (possible trash that was dropped in the bottom of the formwork during original construction), and cracking with efflorescence. The cracks were typically associated within the chute steel imbeds. Photos 2-17 and 2-18 show examples of these deficiencies.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes. The exterior walls on the north and south sides of the dock exhibited various degrees of spalled concrete with exposed rebar (Photo 2-19). Generally, the south pocket wall exhibited greater spalling than the north side.

Steel Components

10. Chutes and Pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. The pocket gates were observed to be in good condition and substantially identical, with the only noted difference being the top of the gate. Photos 2-20 & 2-21 show the condition of the chutes and gates.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the

dock. Close-up inspections of the belts, connections and hoists were not made on this section, as there is no stairway to the top.

12. Walkway

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Stairs are not located in this section. The timber decking used for the walkways was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photo 2-22 shows the condition of one area of the walkway within this Section.

13. Deck Framing

The top of the dock was not observed in this section, as stairs did not access the top.

Section 2 – Photo Log

Photo 2-1: This photo shows cracking on the south side of the fender between Bents 14 and 15.

Photo 2-2: Cracking on south side of fender with some spalling coming from the crack, between Bents 17 and 18.

Photo 2-3: Medium-size scaling on north side of fender, between Bents 13 and 14. Note rotten timber fender.

Photo 2-4: Small tree growing in iron ore pellet pile between bent bases.

Photo 2-5: Top of bent bases often have small spalls with rebar visible, this one is located on the north side of Bent 17.

Photo 2-6: Shrinkage cracking on Bent 23 base on south side of dock.

Photo 2-7: Spalls on Bent 23 on the north side of the dock.

Photo 2-8: Delamination of Bent 18 on the south side of the dock.

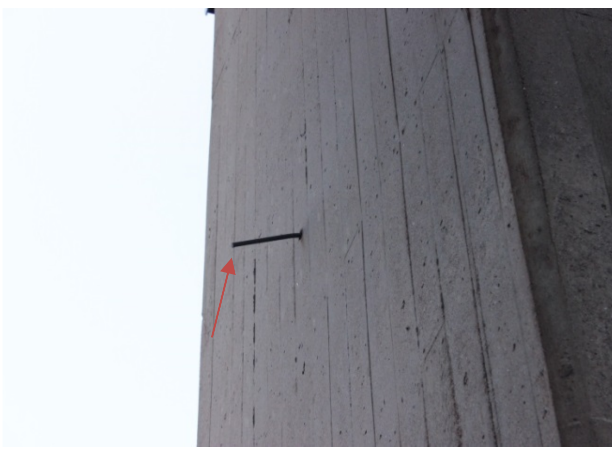


Photo 2-9: Protruding steel bar from the face of Bent 14 on the south side of the dock.

Photo 2-10: Cracking at the base of Bent 16 on the south side of the dock.

Photo 2-11: Delamination cracking in the longitudinal beam between Bents 15 and 16 located on the north side of the dock.

Photo 2-12: Delamination cracking with small spalls in longitudinal beam of Bent 13 with visible rebar on the south side of dock.

Photo 2-13: Spalls with rebar visible on transverse members, on the north side of Bent 21.

Photo 2-14: Honeycombing shown on the ceiling between Bents 13 and 14 on the south side of the dock.

Photo 2-15: Cold joint shown on the expansion joint in this section between Bents 12 and 13 on the north side of the dock.

Photo 2-16: Cracking with rebar showing on the chamfer section of Bent 15 on the north side of the dock.

Photo 2-17: Cracking on chute base of Bent 23 near the expansion joint on south side.

Photo 2-18: Delaminations with small spalls on chute base of Bent 18 on the south side of the dock.

Photo 2-19: Pocket wall where superficial thin spalls and rebar is apparent.

Photo 2-20: Fixed portion of pocket door 35. Note good condition of steel with remaining paint coating.

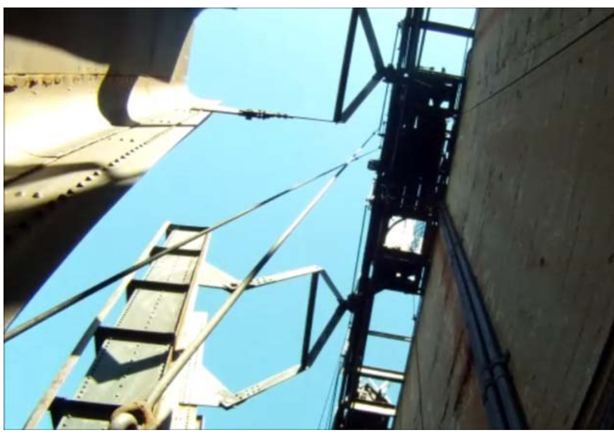


Photo 2-21: Typical view looking up at chutes and hoisting appurtenances.

Photo 2-22: View looking down at pocket gate and walkway timbers.

Photo 2-23: View of pocket gate, showing hoist connection on gate and gate guides. Note condition of walkway between chutes.

Section 3 - Inspection Summary Log

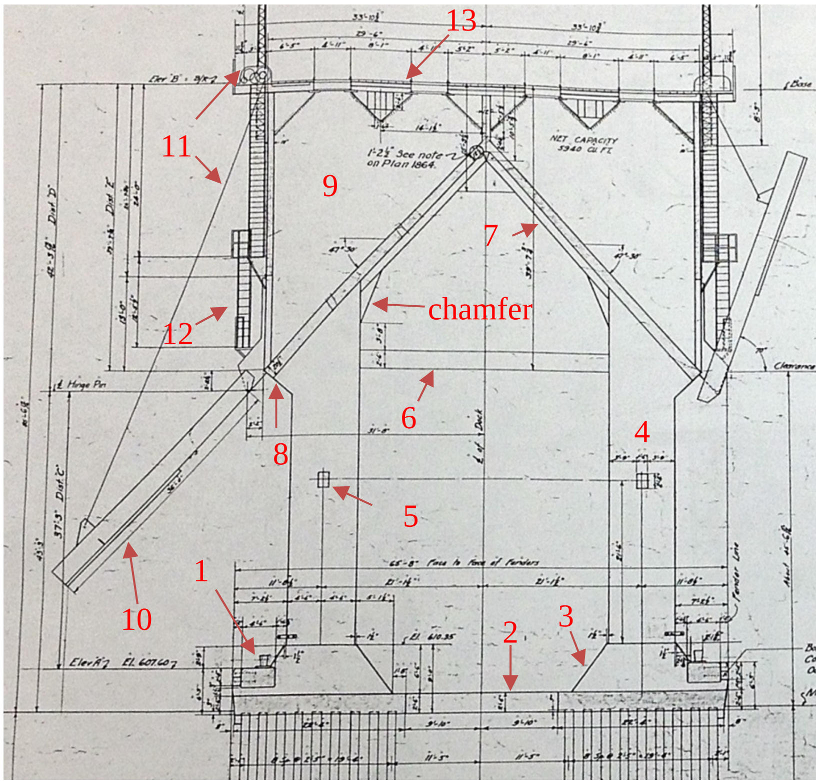
B1.3 Section 3: Bent 24 to Bent 34

Section 3 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Cracks are regularly observed perpendicular to the fender. They are approximately mid span between bent columns. The cracks were tight with occasional localized scaling. Photos 3-1 and 3-2 depict the typical condition of the cracks in the fender section.

2. Pile Cap

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them (Photo 3-3).

3. Bent Base

Some localized areas of minor spalling with visible rebar was observed. Photos 3-4 through 3-6 depict the typical conditions encountered.

4. Bent

On the bents, occasional areas of spalling concrete with exposed reinforcing were observed, particularly on the corners of the columns (Photo 3-7 & 3-8). The concrete cover over the reinforcement in these areas was thin.

5. Longitudinal Beams

On the longitudinal beams between bents are subject to delamination (Photo 3-9). Spalling of concrete with exposed rebar in localized areas of the beam is fairly regular (Photo 3-10).

6. Transverse Beams

Transverse beams reveal superficial rebar (Photo 3-11). These beams also show poorly consolidated concrete in some areas (Photo 3-12). Generally these types of deficiencies occur near the north and south bents.

7. Ceiling& Chamfer

The underside of the ceilings are subject to minor areas of poorly consolidated concrete, surface cracking, cold joints, small spalls and visible rebar (3-13). Deficiencies are most common in localized areas between bents (Photo 3-14).

8. Overhang

The overhang section was observed to have localized delaminations and spalling, with some cracking associated with the imbedded steel plates for the chutes (Photo's 3-15 & 3-16). Efflorescence was noted in some of the cracks.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes, and from the top of the dock at two stair locations in this Section. The interior pocket walls and floors of the pockets were observed to be in good condition with no cracking, spalling, or exposed reinforcement. The exterior walls on the north and south sides of the dock did exhibit various degrees of spalled concrete with exposed rebar (Photos 3-17 and 3-21). Generally, the south pocket wall exhibited greater spalling than the north side.

Steel Components

10. Chutes and Pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. The pocket gates were observed to be in good condition and substantially identical. Photo 3-18 shows a view of the chutes from the walkway.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the dock. Close-up inspections of the belts, connections and hoists were conducted from the two stairs. The belt was observed to be in good condition with no fraying corrosion or deterioration noted. The members that connect the steel belt to the chute were observed to be in good condition. The hoists were observed to be securely bolted to the deck steel frame. The lever that locks the steel belt in the main hoist real is identified in Photo 3-19.

12. Walkway & Stairs

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Two stairs (one on the north and one on the south side of the dock) are present within this section. The stair framing and attachments to the pocket walls were observed to be consistent with the record drawings. The members and attachments were observed to be in good condition with little to no evidence of deterioration. The timber decking used for both the walkways and stairs was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photos 3-20 & 3-21 show the condition of the walkway and stairs within this Section.

13. Deck Framing

The top of the dock was observed at the locations of the stairs on both the north and south sides of this Section. The framing was observed to be in good condition with little to no deterioration noted.

Section 3 – Photo Log

Photo 3-1: Cracking on fender between Bents 25 and 26 on the north side of the dock.

Photo 3-2: Showing fender between Bents 26 and 27 with scaling on the south side of the dock. Note tree growing in rotten timber fender.

Photo 3-3: Trees growing ina pile of iron ore pellets on pile cap/floor.

Photo 3-4: Spalls with visible rebar apparent at the top edges of Bent 28 base on the north side of the dock.

Photo 3-5: Delaminations and spalling on the bottom of Bent 34 located on the north side of the dock.

Photo 3-6: Spalls on the north face of Bent 34 base with shallow rebar exposed.

Photo 3-7: Delaminations on Bent 29 on the north side of the dock.

Photo 3-8: Small spall with some visible rebar on Bent 28 on the north side of the dock.

Photo 3-9: Delamination on cross beam between Bents 25 and 26 on the south side of the dock.

Photo 3-10: Shallow rebar on the cross beam of Bents 26 and 27 on the south side of the dock.

Photo 3-11: Shallow rebar on the underside of the transverse beam on Bent 26.

Photo 3-12: Small sections of honeycombing in transverse beam of Bent 24.

Photo 3-13: Rebar visible on ceiling between Bents 24 and 25 on south side of dock.

Photo 3-14: Spalling and delaminations with some exposed rebar between Bents 34 and 35 on the north side of the dock.

Photo 3-15: Spalls with shallow rebar on overhang between Bents 27 and 28 on the north side of the dock.

Photo 3-16: Delaminations and exposed rebar on overhang of Bent 32 on the south side of the dock.

Photo 3-17: Pocket wall where superficial thin spalls and rebar is apparent.

Photo 3-18: Typical view looking up at chutes and hoisting appurtenances.

Photo 3-19: View of typical hoist showing various levers used to operate the chutes and pocket gates. Note lever used to lock chute belt real into place.

Photo 3-20: View base of chute, walkway timbers, and pocket gate.

Photo 3-21: Looking up at bottom of stairs on north side. Note good condition of pocket wall.

Section 4 - Inspection Summary Log

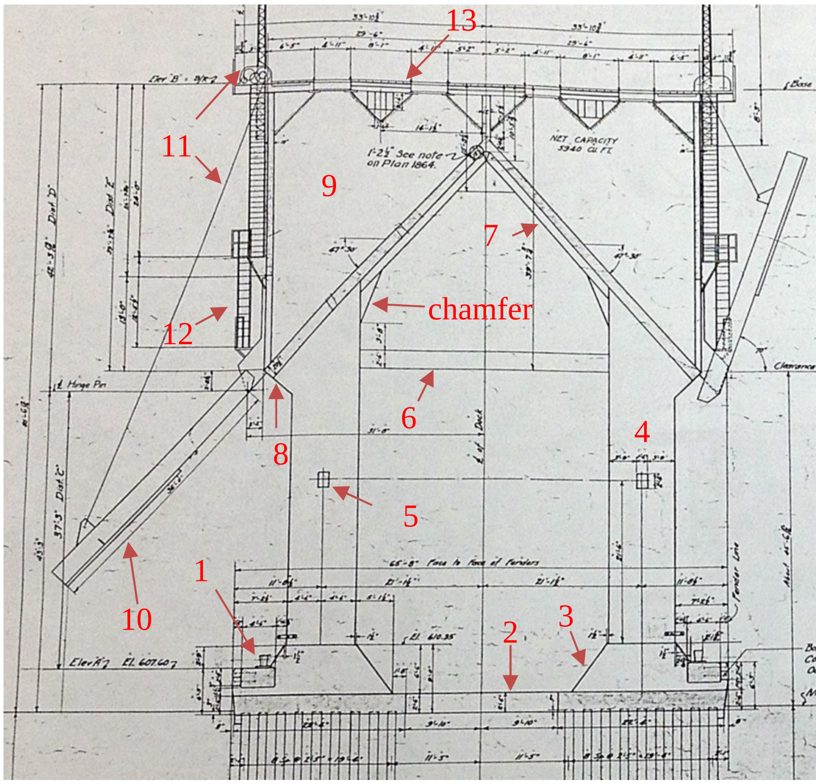
B1.4 Section 4: Bent 35 to Bent 45

Section 4 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Cracks are regularly observed perpendicular to the fender (Photos 4-1 and 4-2). They are approximately mid span between bent columns. The cracks were tight with occasional localized scaling. An area of scaling with exposed rebar was observed as shown in Photo 4-3. One of the cleats was observed to be broken as shown in Photo 4-4.

2. Pile Cap

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them. Photo 4-5 shows the general condition of the pile cap/floor.

3. Bent Base

Some localized areas of minor spalling with visible rebar were observed. The quantity of spalling was noticeably less than Sections 1 through 3.

4. Bent

Some localized areas of minor spalling with visible rebar were observed. The quantity of spalling was noticeably less than Sections 1 through 3. Photo 4-6 depicts the typical conditions encountered.

5. Longitudinal Beams

The longitudinal beams between bents are subject to delamination and spalling of concrete with exposed rebar is regularly evident (Photo 4-7).

6. Transverse Beams

Transverse beams reveal superficial rebar (Photo 4-8). Generally these types of deficiencies occur near the north and south bents.

7. Ceiling & Chamfer

The underside of the ceilings was observed to be in good shape, and in better condition than observed in Sections 1 through 3. Localized minor areas of poorly consolidated concrete, surface cracking, cold joints, small spalls and visible rebar were observed (Photo 4-9). Exposed rebar is common in the chamfer section of this ceiling (Photo 10). A localized area of cracking was noted between Bents 39 and 40 (Photo 4-11).

8. Overhang

The overhangs were observed to be in better condition than observed in Sections 1 through 3. These areas were observed to have areas of honeycombing and tight cracks with some efflorescence. The cracks were typically associated within the chute steel imbeds. Photo 4-12 shows an example of these deficiencies.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes. The exterior walls on the north and south sides of the dock exhibited various degrees of spalled concrete with exposed rebar. Generally, the south pocket wall exhibited greater spalling than the north side. The concrete cover over the rebar in these areas was observed to be thin (less than approximately 2 inches). Photo 4-13 shows a localized area of heavy spalling with a large area of exposed rebar.

Steel Components

10. Chutes and pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. The chute gates were observed to be in good condition and substantially identical. Photo 4-14 shows the condition of the chutes and gates.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the

dock. Close-up inspections of the belts, connections and hoists were not made on this section, as there is no stairway to the top.

12. Walkway

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Stairs are not located in this section. The timber decking used for the walkways was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photo 4-15 shows the condition of the walkway within this Section.

13. Deck Framing

The top of the dock was not observed in this section, as stairs did not access the top.

Section 4 – Photo Log

Photo 4-1: Crack in fender between Bents 36 and 37 on the north side of the dock.

Photo 4-2: Crack in fender on north side between Bents 39 and 40.

Photo 4-3: Scaling with exposed rebar in fender between Bents 40 and 41 on the south side of the dock. Note missing/rotted timber fender with grass growing in it.

Photo 4-4: Broken cleat on Bent 37 on the south side of the ore dock.

Photo 4-5:Construction joint in pile cap floor between Bents 40 and 41.

Photo 4-6: Spalls on base of Bent 36 with shallow rebar present on the south side of the dock.

Photo 4-7: Spall with rebar visible on longitudinal beam between Bent 37 and 38 on the north side of the ore dock.

Photo 4-8: Rebar visible on transverse beam between Bents 38 and 39 on the south side of the dock.

Photo 4-9: Ceiling that contains a cold joint with horizontal cracking and honeycombing between Bents 36 and 37 on the south side of the dock.

Photo 4-10: Rebar visible in thechamfer on Bent 37 on the north side of the dock.

Photo 4-11: Horizontal cracking in ceiling between Bents 39 and 40 on the south side of the dock.

Photo 4-12: Overhang with honeycombing and cracking on Bent 41 on the north side of the dock.

Photo 4-13: Area of heavy spalling with large quantity of exposed rebar on pocket wall at chute 89 on the south side.

Photo 4-14: Typical view of chute on south side showing riveted steel constuction.


Photo 4-15: View looking down between chutes from walkway. Note good condition of steel elements.

Section 5 - Inspection Summary Log

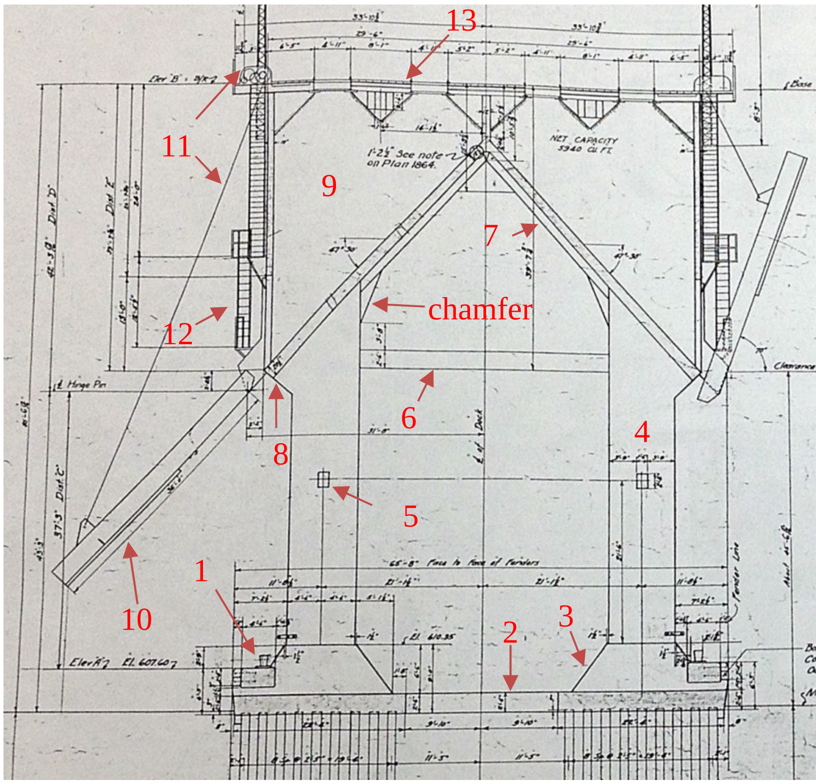
B1.5 Section 5: Bent 46 to Bent 56

Section 5 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Transverse cracking is commonly found mid span between the bents in the fender. These cracks were tight and often experienced surface scaling (Photo 5-1). Scaling had occurred in other localized areas such as shown in Photo 5-2. The timber fenders were found deteriorated and rotted away with shrubbery growing from existing timber bumper.

2. Pile Cap

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock (Photo 5-3). Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them.

3. Bent Base

At the base of the bents, minor spalling had occurred with visible rebar in localized areas due to shallow concrete cover (Photo 5-4). Shrinkage cracking is also visible in regions of the base (Photo 5-5). Minor popouts were noticeable in this section (Photo 5-6).

4. Bent

Similar to Section 4, the bents continue to have no major deficiencies.

5. Longitudinal Beams

Longitudinal beams have localized areas of delamination cracking and spalling (Photo 5-8 to 5-10).

6. Transverse Beams

These members were generally observed to be in better condition that in Sections 1 through 4. Minor areas of spalling with exposed rebar are present. Photos 5-11 through 5-13 show the condition of these beams.

7. Ceiling & Chamfer

The underside of the ceilings are subject to minor sections of poorly consolidated concrete, surface cracking, cold joints, small spalls, and visible rebar as shown in Photos 5-11 through 13. Exposed rebar is most common in the chamfer section of this ceiling.

8. Overhang

The overhangs were observed to be in better condition than observed in Sections 1 through 3. These areas were observed to have areas of honeycombing and tight cracks with some efflorescence. The cracks were typically associated within the chute steel imbeds. Photo 5-14 shows an example of these deficiencies.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes, and from the top of the dock at two stair locations in this Section. The interior pocket walls and floors of the pockets were observed to be in good condition with no cracking, spalling, or exposed reinforcement. The exterior walls on the north and south sides of the dock did exhibit various degrees of spalled concrete with exposed rebar (Photos 5-15). Generally, the south pocket wall exhibited greater spalling than the north side.

Steel Components

10. Chutes and pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. The pocket gates were observed to be in good condition and substantially identical. Photo 5-15 shows a view of the chutes from the walkway.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the dock. Close-up inspections of the belts, connections and hoists were conducted from the two stairs. The belt was observed to be in good condition with no fraying corrosion or deterioration noted. The members that connect the steel belt to the chute were observed to be in good condition. The hoists were observed to be securely bolted to the deck steel frame.

12. Walkway & Stairs

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Two stairs (one on the north and one on the south side of the dock) are present within this section. The stair framing and attachments to the pocket walls were observed to be consistent with the record drawings. The members and attachments were observed to be in good condition with little to no evidence of deterioration. The timber decking used for both the walkways and stairs was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photos 5-15 and 5-16 show the condition of the walkway and stairs within this Section.

13. Deck Framing

The top of the dock was observed at the locations of the stairs on both the north and south sides of this Section. The framing was observed to be in good condition with little to no deterioration noted.

Section 5 – Photo Log

Photo 5-1: Crack in fender between Bents 49 and 50 on the south side of the dock.

Photo 5-2: Crack and scaling on south fender between Bents 51 and 52.

Photo 5-3: Spalling on pile cap floor between Bents 52 and 53.

Photo 5-4: Bottom of Bent 47 showing shallow spall and exposed rebar on the north side of the dock.

Photo 5-5: Delamination crack noted, and patter cracking at bottom of base of Bent 49 on north side of dock.

Photo 5-6: Small popouts on face of bent base of Bent 53 on the north side of the dock.

Photo 5-7:Vertical cracking in Bent 52.

Photo 5-8: Spalling with shallow rebar visible in corner of longitduinal beam between Bents 50 and 51 on the south side of the ore dock.

Photo 5-9: Delamination on the south longitudinal beam between Bents 49 and 50.

Photo 5-10: Delamination cracking on the north longitudinal beam between bent 49 and Bent 50.

Photo 5-11: Horizontal cracking on north ceiling between Bents 54 and 55.

Photo 5-12: Popouts with horizontal cracking on north side of the ceiling between Bents 55 and 56.

Photo 5-13: Rebar visible in the chamfer section of the south side of the ceiling on Bent 47.

Photo 5-14: Cracking and minor spalls on north chute base between Bents 52 and 53.

Photo 5-15:View of chutes and stairway.

Photo 5-16: Typical view of pocket gate and walkway.

Section 6 - Inspection Summary Log

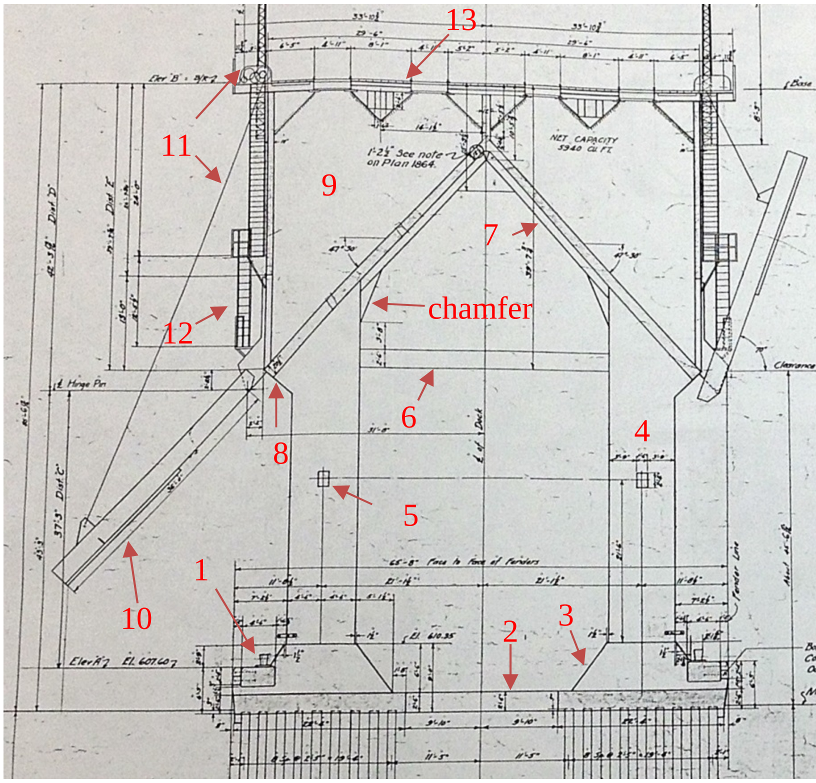
B1.6 Section 6: Bent 57 to Bent 67

Section 6 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Transverse cracking is commonly found mid span between the bents in the fender. These cracks were tight and often experienced surface scaling (Photos 6-1 and 6-2). The timber fenders were found deteriorated and rotted away with shrubbery growing from existing timber bumper. Photo 6-3 shows how the fender spans between the bent bases.

2. Pile Cap/Floor

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them (Photo 6-3).

3. Bent Base

Only minor areas of deterioration were noted on the bent bases.

4. Bent

Similar to Section 5, the bents continue to have no major deficiencies. Only minor areas of delaminations were observed (Photos 6-4 and 6-5). On the shear walls between Bents 62 and 63, no indication of structural distress was observed (Photos 6-6 and 6-7).

5. Longitudinal Beams

Longitudinal beams have localized areas of delamination cracking and spalling (Photos 6-8 and 6-9).

6. Transverse Beams

Transverse beams look sound with no visible rebar or honeycombing. The condition of these beams is noticeably better than Sections 1 through 5. Photos

7. Ceiling& Chamfer

The underside of the pockets or the ceilings to the pile cap are subject to minor sections of poorly consolidated concrete, surface cracking, cold joints that are found mostly near expansion joints, small pop outs, and visible rebar (photo 6-10). Rebar is most common in the chamfer section of this ceiling. Photo 6-11 accurately portrays the average deficiencies of this area, while tight cracking is most commonly located in localized areas of the ceiling (Photo 6-12).

8. Overhang

The overhangs are the bottom of the pocket slab and lowest part of the ceiling. These areas were observed to have areas of poorly consolidated concrete, evidence of miscellaneous debris (possible trash that was dropped in the bottom of the formwork during original construction), and cracking with efflorescence. The cracks were typically associated within the chute steel imbeds. Photos 6-13 and 6-14 show examples of these deficiencies.

9. Bin Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes, and from the top of the dock at two stair locations in this Section. The interior pocket walls and floors of the pockets were observed to be in good condition with no cracking, spalling, or exposed reinforcement. The exterior walls on the north and south sides of the dock did exhibit various degrees of spalled concrete with exposed rebar (Photos 6-15). Generally, the south pocket wall exhibited greater spalling than the north side. This section contained the greatest quantity of spalled areas.

Steel Components

10. Chutes and pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. The chute gates were observed to be in good condition and substantially identical, with the only noted difference being the top of the gate. Photo 6-17 shows the condition of the chutes and gates.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the

dock. Close-up inspections of the belts, connections and hoists were not made on this section, as there is no stairway to the top.

12. Walkway & Stairs

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Stairs are not located in this section. The timber decking used for the walkways was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing. Photo 6-17 shows the condition of the walkway within this Section.

13. Deck Framing

The top of the dock was not observed in this section, as stairs did not access the top.

Section 6 – Photo Log

Photo 6-1: Transverse crack in the north fender between Bents 58 and 59.

Photo 6-2: Transverse crack and scaling on the north fender between Bents 59 and 60.

Photo 6-3: View of tree growing in iron ore pile on north side of dock. Note elevated fender spanning between bent bases.

Photo 6-4: Small delamination on south side at the bottom of Bent 57.

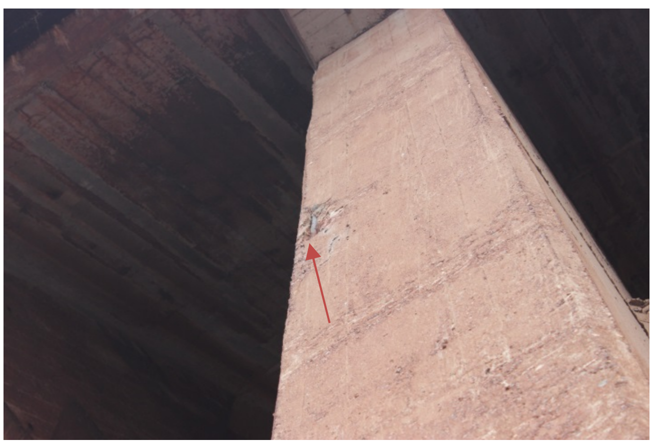


Photo 6-5: Spall with exposed rebar on the south side of ore dock between Bents 59 and 60.

Photo 6-6: View of good condition of shear wall between Bents 62 and 63 on the north side of the ore dock. Note protruding steel bar (possible form tie).

Photo 6-7: View of good condition of shear wall between Bents 62 and 63 on the south side of the ore dock.

Photo 6-8: Spall with exposed rebar and cracking in corner of longitudinal beam between Bents 59 and 60 on the north side of dock.

Photo 6-9: Exposed rebar and delamination visible on underside of the north longitudinal beam between Bents 63 and 64.

Photo 6-10: Small spalls on south ceiling along with minor honeycombing between Bents 56 and 57.

Photo 6-11: Minor honeycombing and exposed rebar on north side ceiling between Bents 63 and 64.

Photo 6-12: Minor honeycombing and exposed rebar in north side of ceiling between Bents 60 and 61.

Photo 6-13: Delamination cracking and spalled concrete at overhang between Bents 59 and60 on north side of ore dock.

Photo 6-14: Small delamination of concrete on the chute base between Bents 59 and 60 on the south side of the dock.

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Photo 6-15: View of pocket wall above pocket 111 on the south side of the dock showing large area of spalling with exposed rebar.


Photo 6-17: View looking down walkway showing the pocket gates, and the bottom of the chutes.

Section 7 - Inspection Summary Log

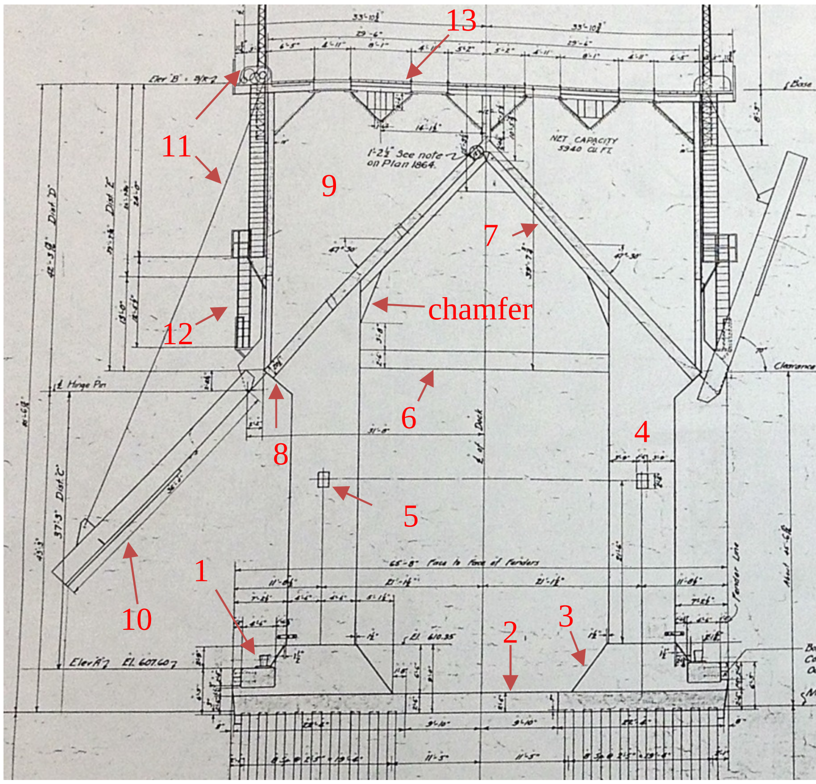
B1.7 Section 7: Bent 68 to Bent 76

Section 7 Components

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

Concrete Elements

1. Fender
2. Pile Cap
3. Bent Base
4. Bent
5. Longitudinal Beam
6. Transverse Beam
7. Ceiling
8. Overhang
9. Pocket Walls



Steel Elements

10. Chute and Pocket Gate
11. Steel Belt & Hoist
12. Walkway & Stairs
13. Deck Framing

Figure 1: Section View of Bent.

Concrete Components

1. Fenders

Transverse cracking is commonly found mid span between the bents in the fender. These cracks were tight and often experienced surface scaling (Photos 7-1 through 7-3). The timber fenders were found deteriorated and rotted away with shrubbery growing from existing timber bumper (Photo 7-4).

2. Pile Cap/Floor

Minor cracking and some localized areas of minor scaling were observed on top of the pile cap, or floor of the ore dock. Piles of iron ore pellets are present at localized areas between bents, some of which have trees and brush growing within them.

3. Bent Base

The bent bases contained no significant deterioration, only contained minor areas of spalling.

4. Bent

The bents have no major deficiencies, other than minor localized areas of spalling (Photo 7-5). On the shear walls between Bents 62 and 63, no indication of structural distress was observed (Photos 7-6).

5. Longitudinal Beams

The longitudinal beams have localized areas of delamination cracking and spalling (Photos 7-7 and 7-8).

6. Transverse Beams

These beams were observed to be in good condition, with only infrequent spalling (Photos 7-9 and 7-10).

7. Ceiling & Chamfer

The underside of ceilings are subject to localized areas of poorly consolidated concrete, surface cracking, cold joints, small spalls, and visible rebar (Photos 7-11 and 7-12).

8. Overhang

The overhangs were observed to have areas of poorly consolidated concrete, spalling, and tight cracks with efflorescence. The cracks were typically associated within the chute steel imbeds. Photo 7-13 shows an example of these deficiencies.

9. Pocket Walls

The pocket walls were inspected from the elevated walkway along the base of the chutes, and from the top of the dock at two stair locations in this Section. The interior pocket walls and floors of the pockets were observed to be in good condition with no cracking, spalling, or exposed reinforcement. The exterior walls on the north and south sides of the dock did exhibit various degrees of spalled concrete with exposed rebar (Photos 7-14). Generally, the south pocket wall exhibited greater spalling than the north side.

Steel Components

10. Chutes and pocket Gates

All of the chutes were inspected from the walkway at the base of the chutes. The chutes were observed to be identically constructed and in good condition, with minimal deterioration observed. At the locations where the inspectors ascended and descended the access ropes, close-up inspections of the steel pins at the base of the chutes were inspected. These inspections were limited to Chute 149 and Chute 150. The steel construction in the areas of the pins was observed to be consistent with the record drawings. Minor deterioration was noted, with no excessive wear on the pin or associated steel plate. Photo 7-15 shows the condition of the chutes and gates.

11. Steel Belt & Hoist

All of the chutes are abandoned in an upright condition, and held in place by the braded steel belt, associated attachments to the chute, and individual hoists located on the top of the dock. Close-up inspections of the belts, connections and hoists were conducted from the two stairs. The belt was observed to be in good condition with no fraying corrosion or deterioration noted. The members that connect the steel belt to the chute were observed to be in good condition. The hoists were observed to be securely bolted to the deck steel frame.

12. Walkway & Stairs

The walkway above the chutes is supported on the imbedded elements of the base of the chutes, which is consistent with the record drawings. The walkway railings and support steel members were observed to be in good condition with little to no evidence of deterioration. Occasional top railings were bent, likely due to impacts from falling objects. Two stairs (one on the north and one on the south side of the dock) are present within this section. The stair framing and attachments to the pocket walls were observed to be consistent with the record drawings. The members and attachments were observed to be in good condition with little to no evidence of deterioration. The timber decking used for both the walkways and stairs was in poor to good condition. Some timbers were in good condition with sound attachments to the steel members, while others were completely deteriorated or missing.

13. Deck Framing

The top of the dock was observed at the locations of the stairs on both the north and south sides of this Section. The framing was observed to be in good condition with little to no deterioration noted. The geometry of the deck framing was not measured, but was observed to be consistent with the record drawings. Photo 7-16 shows the east end of the ore dock.

Section 7 – Photo Log

Photo 7-1: Shallow cracking on north side of fender between Bents 72 and 73.

Photo 7-2: Cracking on south side of fender between Bents 72 and 73.

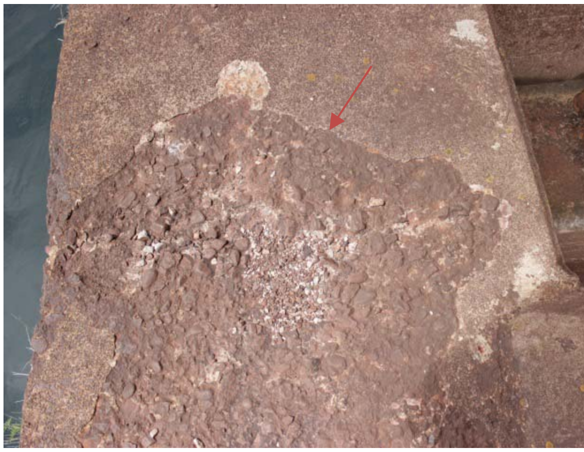


Photo 7-3: Scaling on south side fender between Bents 69 and 70.

Photo 7-4: Trees growing in rotten timber fender.

Photo 7-5: Spall on south base of Bent 68 exposing rebar.

Photo 7-6: Delamination cracking and spalling on the south shear wall between Bents 75 and 76.

Photo 7-7: Cracking and delaminations in corners of south longitudinal beam between Bents 72 and 73.

Photo 7-8: Spalls with visible rebar in sections of south longitudinal beam between Bents 72 and 73.

Photo 7-9: Rebar apparent on underside of transverse beam on Bent 76 on the north side of the dock.

Photo 7-10: Shallow rebar visible on bottom of transverse beam on Bent 76.

Photo 7-11: Spalls along with horizontal honeycombing along south side ceiling between Bents 69 and 70.

Photo 7-12: Cracking with efflorescence and exposed rebar in ceiling between Bents 68 and 69 on south side of dock.

Photo 7-13: Chute base with minor cracking with exposed rebar between Bent 70 and 71 on south side of dock.

Photo 7-14: View of pocket wall at chute 149 on the south side of the dock showing large area of spalling with exposed rebar.

Photo 7-15: View of gate 142.

Photo 7-16: Top of deck at east end of the dock looking east.

Section 8 - Inspection Summary Log

B1.8 Section 8

* Per shop drawings D.S.S. & A. RY. Co. dated 1931.

1. Fenders

Photo 8-1 depicts the typical condition of the scaling on the fender. The timber bumper on either side of this section has substantially deteriorated. No exposed reinforcement was identified. Photo 8-2 shows the condition of the timber bumper. These timbers are unstable and are easily rocked.

2. Pile Cap/Floor

Tight cracking and localized areas of scaling were observed on top of the pile cap. Photo 8-3 represents the worst area of this section.

Section 8 – Photo Log

Photo 8-1: Section at the end of the ore dock in which major scaling has taken place.

Photo 8-2: Piles at the end of the ore dock that have become rotten and loose.

APPENDIX B, EXHIBIT B-9

Expansion Joints – Inspection Summary Log

1. Section 1/2

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be open with no expansion joint material, and was measured to be 1.25 inches wide. The joint was observed at the overhangs between the chutes. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides to contain expansion joint material. The joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-1 through 9-3 show the condition of the expansion joint.

2. Section 2/3

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be filled with debris, and was measured to be approximately 1.0 inch wide. The joint was observed at the overhangs between the chutes. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides to contain expansion joint material. In each case, the joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-4 and 9-5 show the condition of the expansion joint.

3. Section 3/4

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be open with no expansion joint material, and was measured to be 1.25 inches wide. The joint was observed at the overhangs between the chutes. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides to contain expansion joint material. However, the joint was wider than the width of the joint material. In each case, the joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-6 and 9-7 show the condition of the expansion joint.

4. Section 4/5

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be open with no expansion joint material, exhibit surface scaling, and was measured to be approximately 1.0 inch wide. The joint was observed at the overhangs between the chutes. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides to contain expansion joint material. However, the joint was wider than the width of the joint material. In each case, the joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-8 and 9-9 show the condition of the expansion joint.

5. Section 5/6

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be open with no expansion joint material, and was measured to be 1.25 inches wide. The joint was observed at the overhangs between the chutes. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides. Some areas contained expansion joint material, while other areas the material had fallen out of the joint. In each case, the joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-10 through 9-12 show the condition of the expansion joint.

6. Section 6/7

The expansion joint was observed at various locations. On the pile cap/floor, the joint was observed to be open with no expansion joint material, and was measured to be 1.0 inches wide. The joint was observed at the overhangs between the chutes and from the top of the dock. The steel imbeds were observed to be in contact and in good condition. The joint was observed from the walkway on the north and south sides to contain expansion joint material. In each case, the joint width was observed to be consistent, with no measureable offset or differential movement. Photos 9-13 and 9-14 show the condition of the expansion joint.

7. Section 7/8

No formed expansion joint was constructed at the contact between these two sections. Although no formal expansion joint was constructed, differential movements between the sections have created a crack that acts as an expansion joint. As such, the joint does not contain joint filler material and is irregular with some concrete deterioration. Photos 9-15 and 9-16 show the condition of this joint on top of the north and south fenders.

Expansion Joint – Photo Log

Photo 9-1: View of the expansion joint between Sections 1 and 2 from the walkway on the south side of the structure. Note presence of expansion joint material.

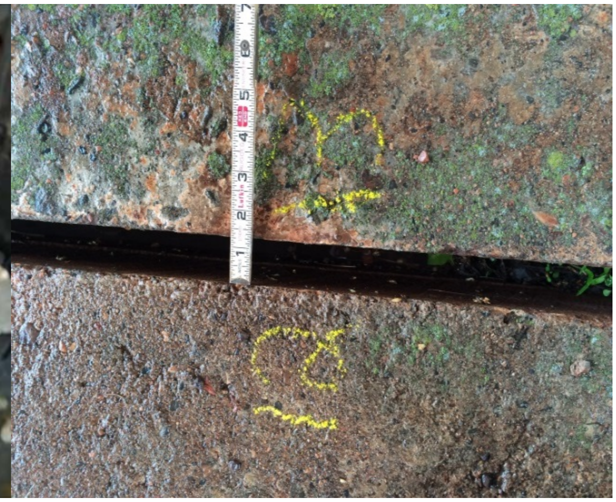


Photo 9-2: Expansion joint on pile cap floor between Sections 1 and 2. Note no expansion joint material contained within joint.

Photo 9-3: View of expansion joint between Section 1 and 2 on south side at Bent 12.

Photo 9-4: View of the expansion joint between Sections 2 and 3 from the walkway on the south side of the structure. Note good condition of expansion joint material.

Photo 9-5: Expansion joint on pile cap floor between Sections 2 and 3. Note debris and vegetal growth within joint.

Photo 9-6: View of the expansion joint between Sections 3 and 4 from the walkway on the south side of the structure. Note the joint is open more than the width of the expansion joint material, and presence of delamination in adjacent concrete.

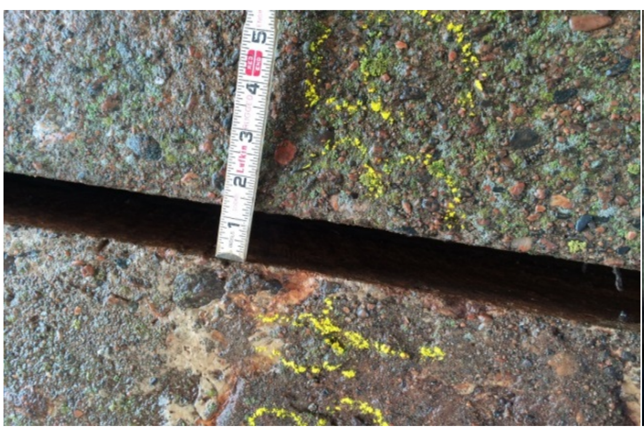


Photo 9-7: Expansion joint on pile cap floor between Sections 3 and 4. Note no expansion joint material contained within joint.

Photo 9-8: View of the expansion joint between Sections 4 and 5 from the walkway on the south side of the structure. Note the joint is open more than the width of the expansion joint material.

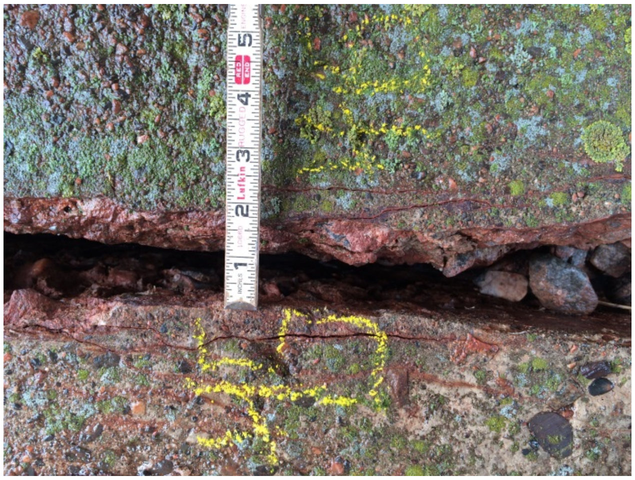


Photo 9-9: Expansion joint on pile cap floor between Sections 4 and 5. Note no expansion joint material contained within joint, and concrete scaling and cracking.

Photo 9-10: View of the expansion joint between Sections 5 and 6 from the walkway on the south side of the structure. Note the joint is open slightly more than the width of the expansion joint material (top), and the joint material has fallen out (bottom).

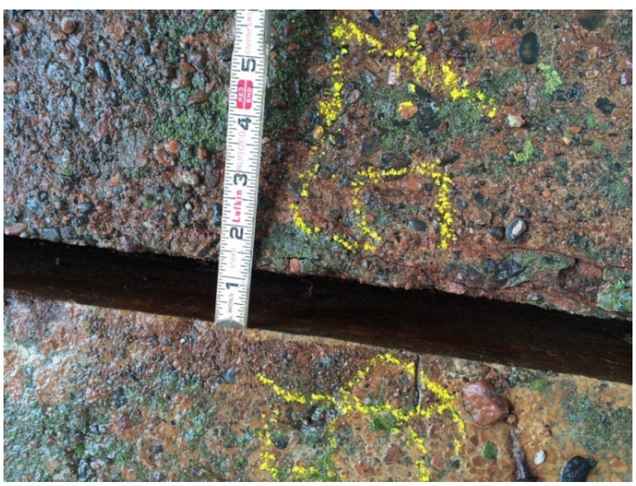


Photo 9-11: Expansion joint on pile cap floor between sections 5 and 6. Note no expansion joint material contained within joint.

Photo 9-12: View of expansion joint between section 5 and 6 on north side with delamination visible.

Photo 9-13: Expansion joint on pile cap floor between Sections 6 and7. Note expansion joint material contained within joint.

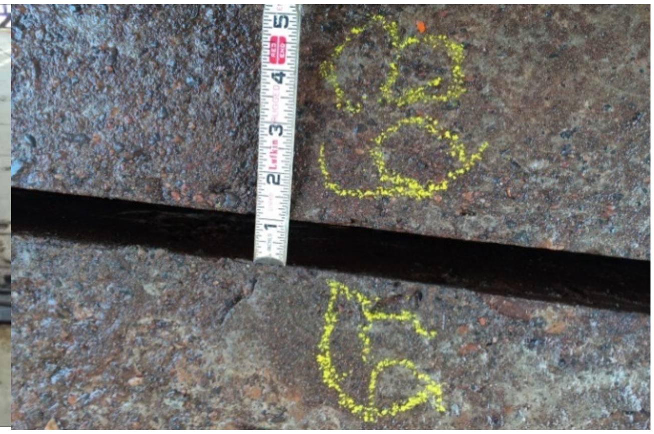


Photo 9-14: Expansion joint on pile cap floor between Sections 6 and 7. Note no expansion joint material contained within joint.

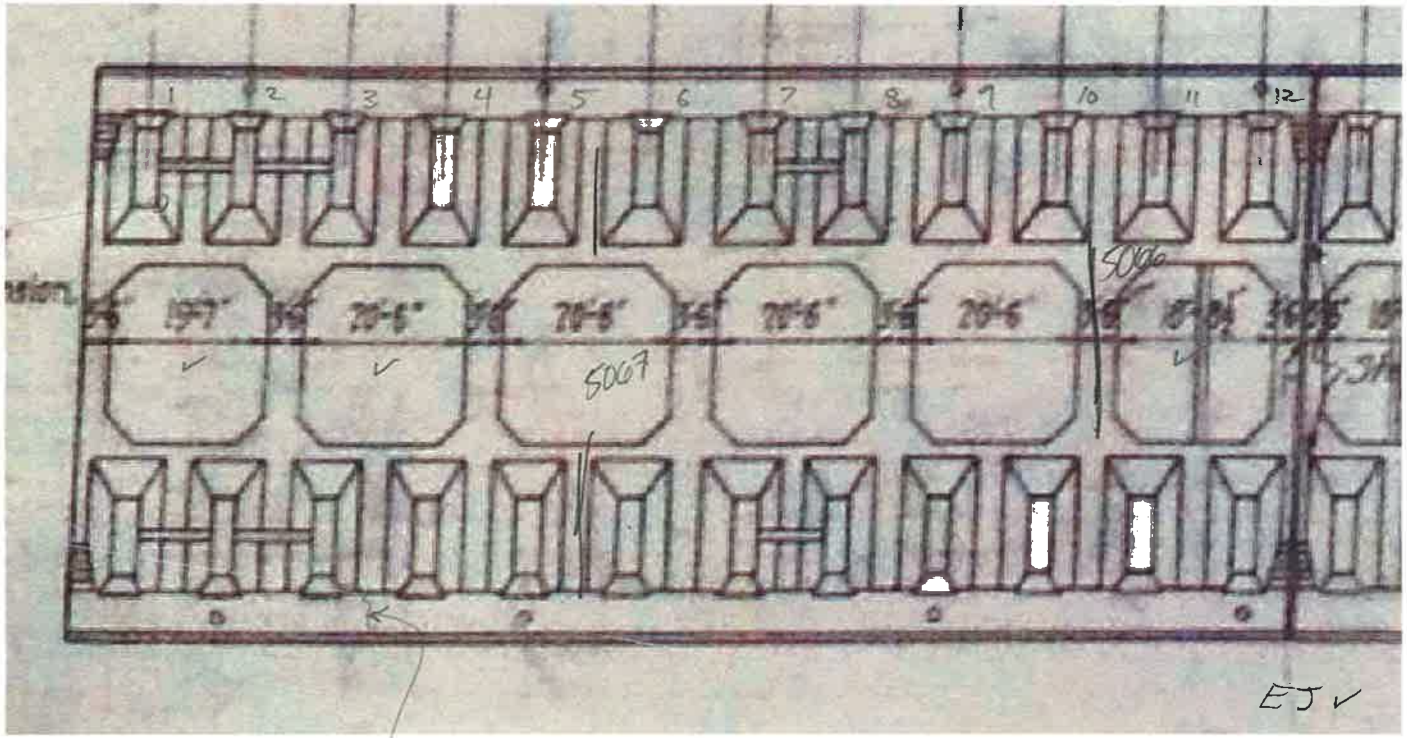
Photo 9-15: Crack in north fender that is serving as the expansion joint between Sections 7 and 8.

Photo 9-16: Crack in south fender that is serving as the expansion joint between Sections 7 and 8.

Appendix C

Field Inspection Logs

SECTION #: 1



cracks typical @ this locations

COMMENTS & OBSERVATIONS

Dimensions match field conditions

Minor localized concrete deterioration

5066 – Crack in pile cap with minor spalling

5067 – Construction joint in pile cap

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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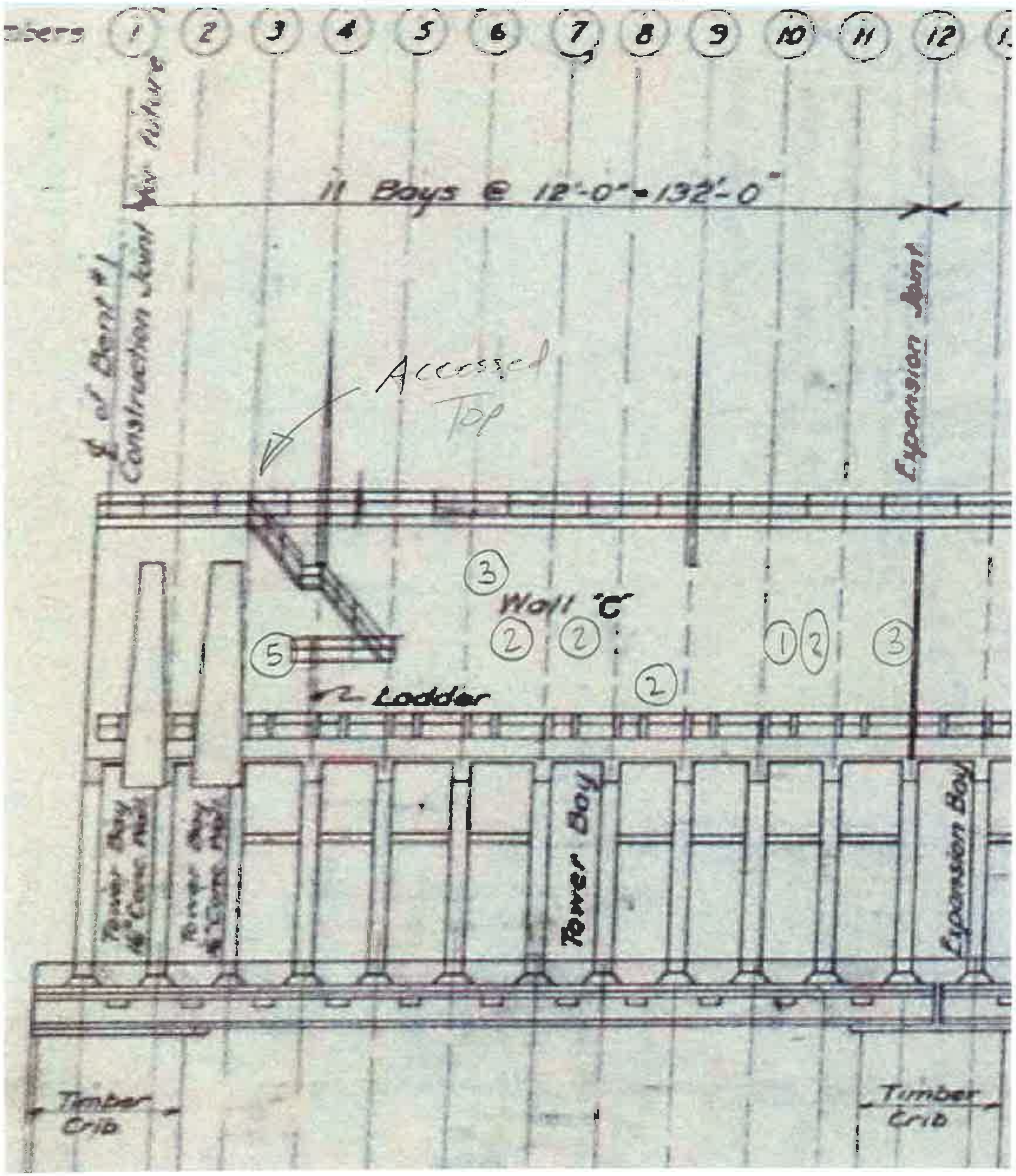
SECTION #:1 (SOUTH SIDE)



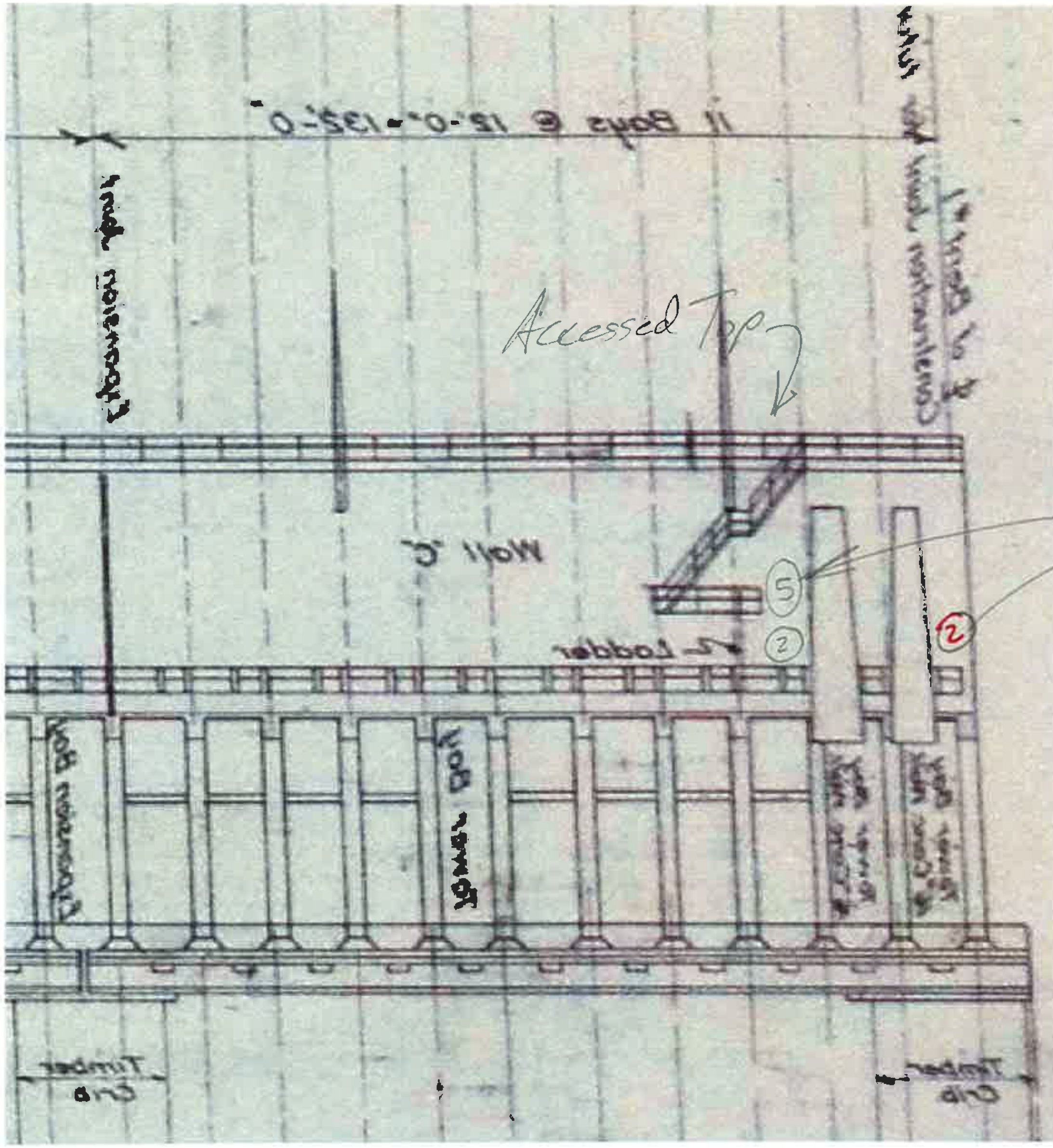
COMMENTS & OBSERVATIONS

Spalled concrete locations identified

MARQUETTE ORE DOCK INSPECTIONFORM-
ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #:1 (NORTH SIDE)



COMMENTS & OBSERVATIONS

20- Door bowing out Plate above gate - due to impact?

# of spalls - typical

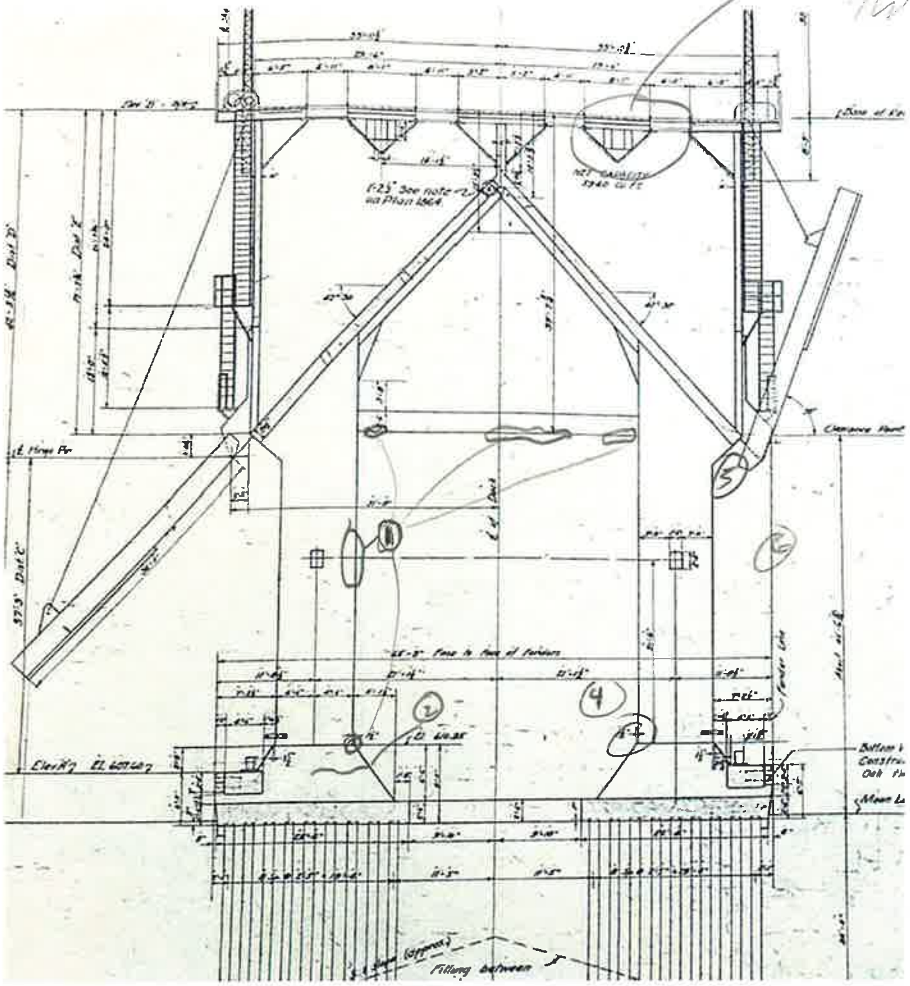
MARQUETTE ORE DOCK INSPECTIONFORM-ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 1

BENT #: 1

concrete extends to top everywhere this detail incorrect.



COMMENTS/OBSERVATIONS

1. Spalled conc w/ exposed rebar - 141 142, 143, 144

2. crack along cold joint 145

Bent up Railing on NorthWest Side of Vertical 1. 4282

South: Cracks on footing

4. spalling on corner north east Corner 4283 4284

Between 1&2 vertical Cracking

5. Spalling has occured. 4376

6. Spalling has also occured with visible Rebar on SW/SE & South Side of Vertical 4377

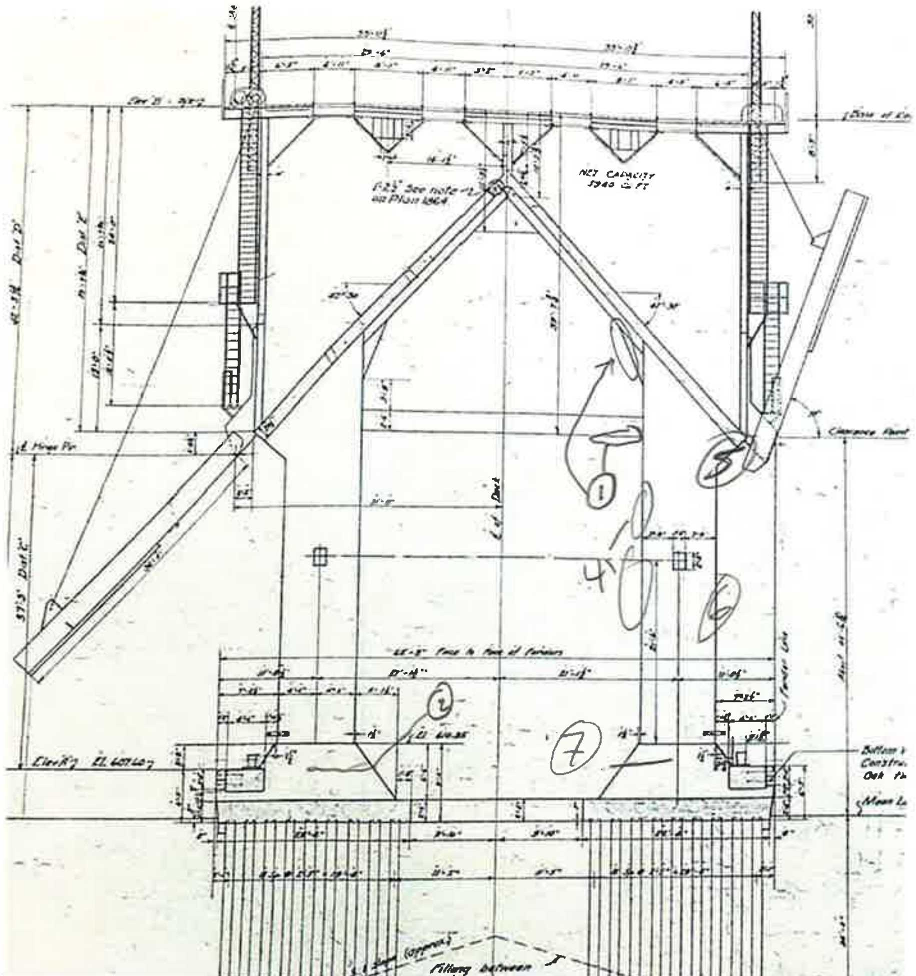
Cracking on South face between 1&2.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 1

BENT #: 2



6 Spalling on South Face & SE & SW of Vertical Beam. Rebar is Visible 4304 & 4365

7 Cracking occurred on footing (Horizontal)

- 4373

COMMENTS/OBSERVATIONS

2 Crack along cold joint

3 vert. crack btwn 1 & 2 (4207)

ON NORTH SIDE

1 Spalled w/ exposed rebar (4208)

Also cracks Along btwn of beam

Between 1 & 2 overlapping Construction Joint

4281

Between 1 & 2 vertical crack on North side, on South face

4 South: 4285/4286 Spalling & Cracking on

North West edge.

Between 2 & 3 vertical & Diagonal Cracking on

North face. 4287 4288

Horizontal & Vertical Cracking on South Face of 2&3

5 Cracking & Spalling occurred along w/overlay.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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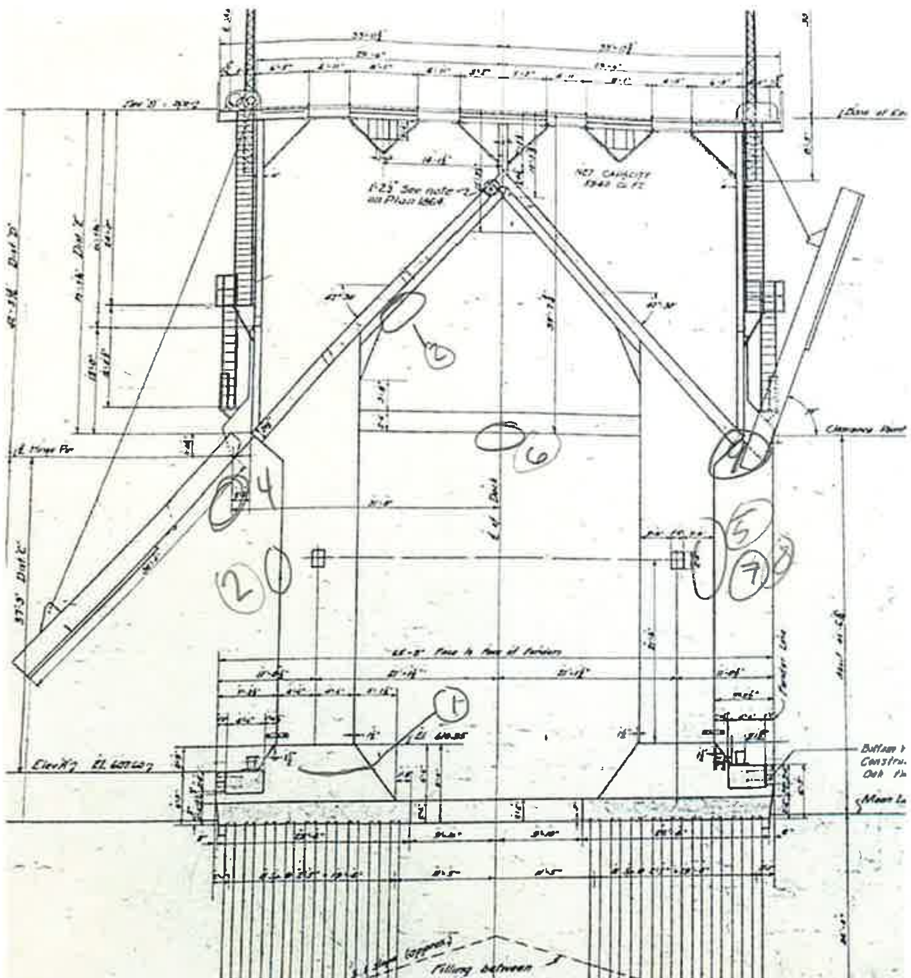
SECTION #: 1

BENT #: 3



COMMENTS/OBSERVATIONS

1	Some horiz. crack @ Lift joint
	PIC 4209
2	Spalled Concrete w/showing Rebar
	Photo 4210/4211
	Cracking North walkway at 4273
	- Northeast Spall on Vertical
	4275
4	Bottom side Spall and likely to fall
	427
	Northwest spall on vertical top and
	Bottom Rebar showing 4280
	Tie Bars loose 40' up.

South - Cracking & Spalling w/ Rebar Visible up entire North East edge
(5) also on Northwest edge about 3/4 up.
(6) Cracks along Cross Brace, Rebar visible in Section.
(7) Beam between 3+4 Spalling & Rebar 4292
Between 3+4 Crack on South Walkway. 4360 4361
Visible Rebar & spalling on Cross beam of 3+4
(8) Rebar Visible on SE of Vertical.
Spalling on Side Face of Vertical
(9) Vertical Crack 4362

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI	
PROJECT #-1330920	
DATE:	INSPECTOR:

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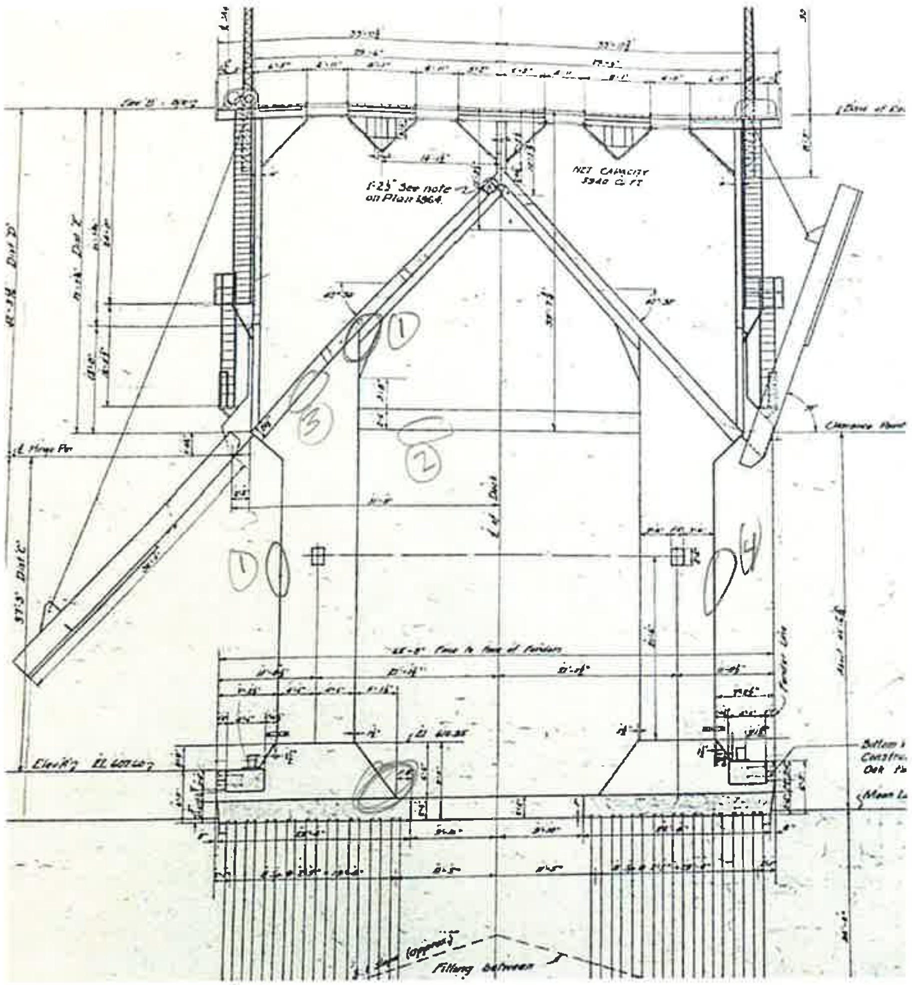
SECTION #: 1

BENT #: 4



COMMENTS/OBSERVATIONS

(1)	Spalled Concrete on Corner w/ Rebar Showing
	Photo - 4213
(2)	Cracks in Bottom on Cross Beam.
	Same as on Previous
	Photo 4214 - 4215
(3)	Photo 4216 - Cracks in Castings
(1)	Exposed Rebar w/ the Spalled Concrete
Side Note	Spalling Concrete @ base
	Cracking between 4-5 Northside walkway.
	Northside Vertical Spalling has occurred
	with Reber Visible 4270-71.
	- 4274

South: 4 Northwest Edge Spall w/ Rebar 4293

Tie Bar on face Between 4 & 5 4294

Rebar also visible on face 4295

Cross Beam Between 4&5 Cracking Visible 4296 97

Between 5-6 & 4-5 the Bottom of the Form is crumbly and Spalling 4272

Hazardous Falling Pieces likely 4355

Vertical crack 4358

MARQUETTE ORE DOCK BENT INSPECTION FORM

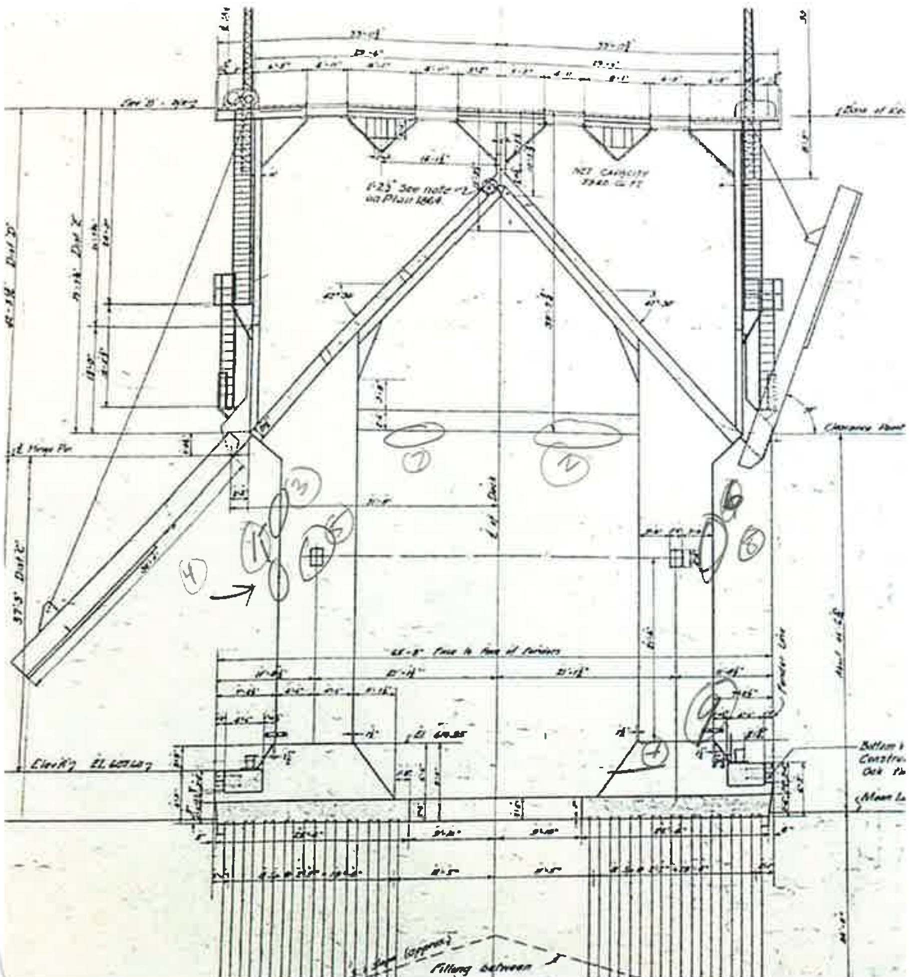
GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

Cracking & Spalling between 4&5 on Cross Beam 4356 4359 4360

SE & SW Edges of Vertical Rebar visible & Spalling occurred. Crack on South Pathway.

SECTION #: 1

BENT #: 5



South. (6) Cracking & Spalling on both NE + NW Edges
(7) Cracks Along Footing.
(8) Cross Beam Between 5+6 Is Spalled w/ Rebar visible
4300
SE & SW Sides of Vertical Rebar is Visible and Spalling.
8 Crack along Footing South Face. 4345-4353
9 Crack on South Walkway.

COMMENTS/OBSERVATIONS

(1)	Spalled Concrete on Corners
	Photo 4217
(2)	Spalled Concrete w/ Rebar Showing Cracks as well
	Photo 4219/4220
(3)	Spalled on Corner Previously Patched
	Photo 4218
(4)	Major Spall with Rebar
	# 4221
(5)	Spall on Cross Brace with Rebar visible
	# 4222
–	Cracking on 5-6 Northside walkway.
–	Between 5-6 spalling & Rebar on
	Cross Beam. 4263/64? 65
–	Spall on North side 66/67

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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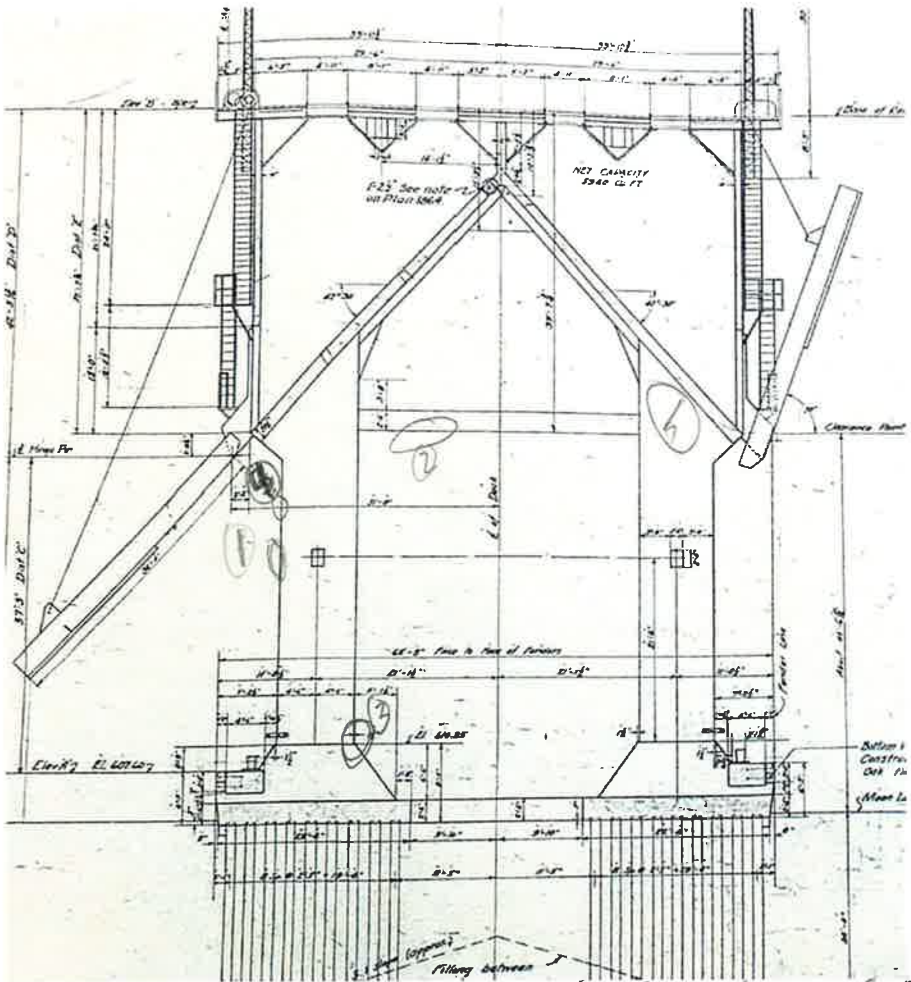
SECTION #: 1

BENT #: 6



South: Overlay > Possible Cracking on upper face of Vertical Western + Eastern sides

SE: Spalling on Edge and South Face 4345

Cracking on Cross Member of 5+6. Spalling w/ Rebar Visible

Between 5+6 Crack on South Walkway. 4346

4347

COMMENTS/OBSERVATIONS

① Same Previous Spalling w/ Rebar on Outside
edge. 4226
②. Cracks on beam along with spalling >
Rebar showing. 4262
③.) Cracks on Corner of feet.
④ East Corner Spalling off edge w/ Rebar
showing. Same as Bent #5.
* Between 6-7 Cracking visible on
North side Walkway!
4259
North side Cross Member between
6-7 Spall. 4260 - 4261
Potentially Hazardous Lamp
4262/4263

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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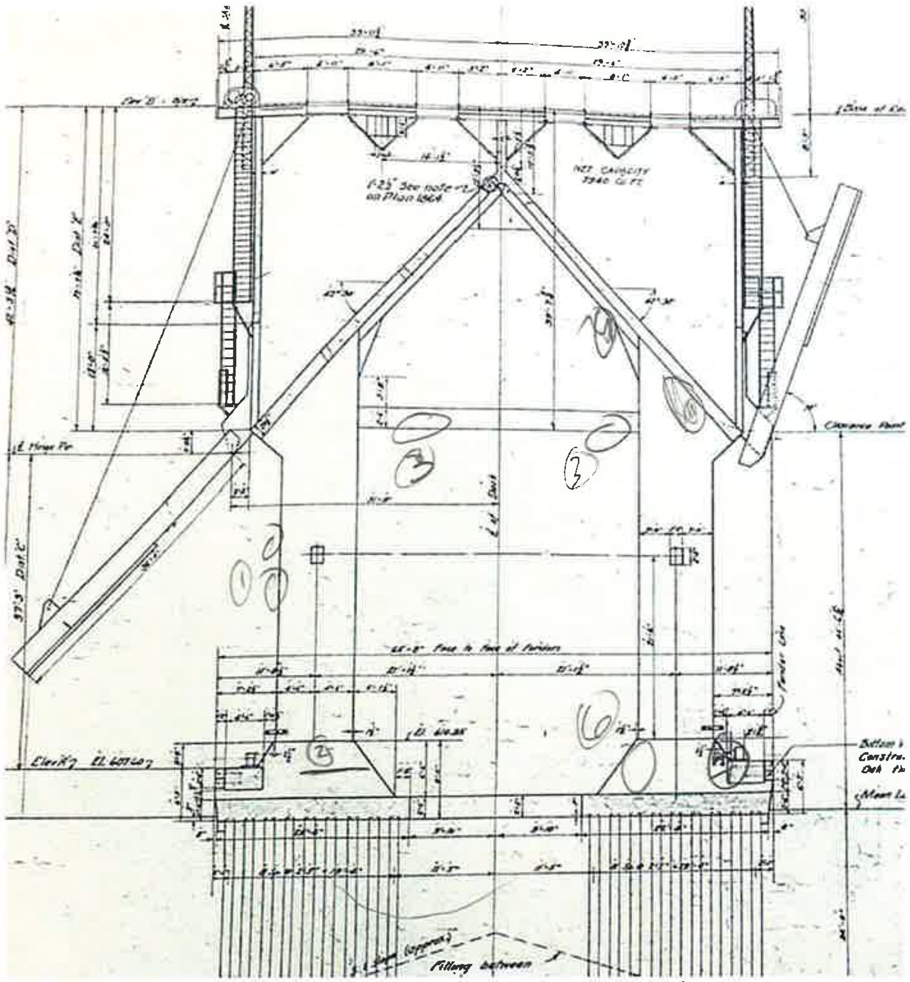
SECTION #: 1

BENT #: 7



8. Crossbeam at 6+7 West + East 4334
9. Between 6+7 Crack on South Walkway. Construction Line
4344

COMMENTS/OBSERVATIONS

1 West Side Edge spalled Concrete same on all
Mostly. 4227-30
2. Crack along feet.
3 A Few Pieces of Rebar Exposed
longitudinal Cracking up and down Beam.
4227-30
4 4258. North West Rebar exposed
South:
5 Overlay on W side of Vertical
6 Patched & cracking on footing
Between 7 + 8 on North face Vertical Cracking
302/303
Between 6+7 Light Fixture Hazard 301
7+8 South Face Vertical + Horizontal Cracking 4332

7 Cracking on Foot, South Face 4333

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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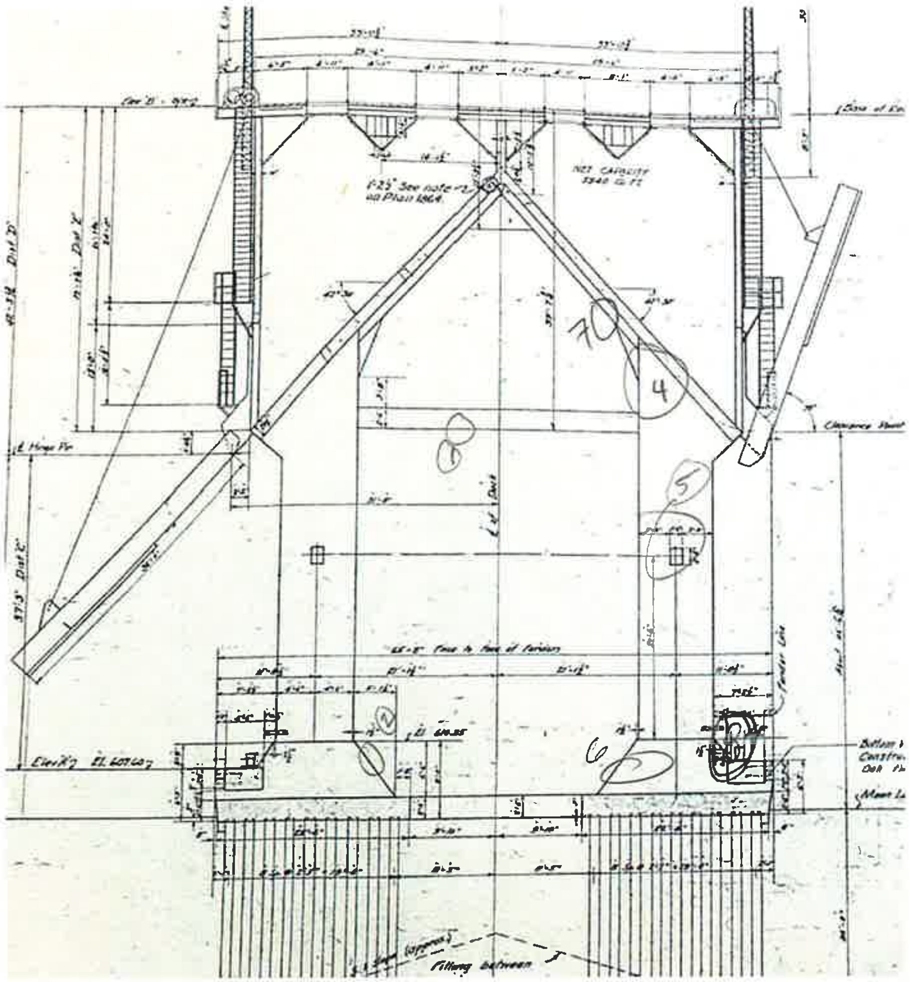
SECTION #: 1

BENT #: 8



South

(7)

COMMENTS/OBSERVATIONS

(1) Cracking in Bottom of Crossbeam

(2) Cracking and Spall in footing.

(3.) Cracking on North West
4257 Spalling occurred.

(4) Between 8 + 9 Rebar Visible and spalling

(5.) Patched up work on Cross Member of 8+9

(6.) Patched up Cracking on foot.

8+9 Rebar visible on Triangle 4305 4304

8+9 Crack on South Walkway 4328

Crack on Crossmember of 8+9 4330

(8) Vertical Crack on Foot South. 4331

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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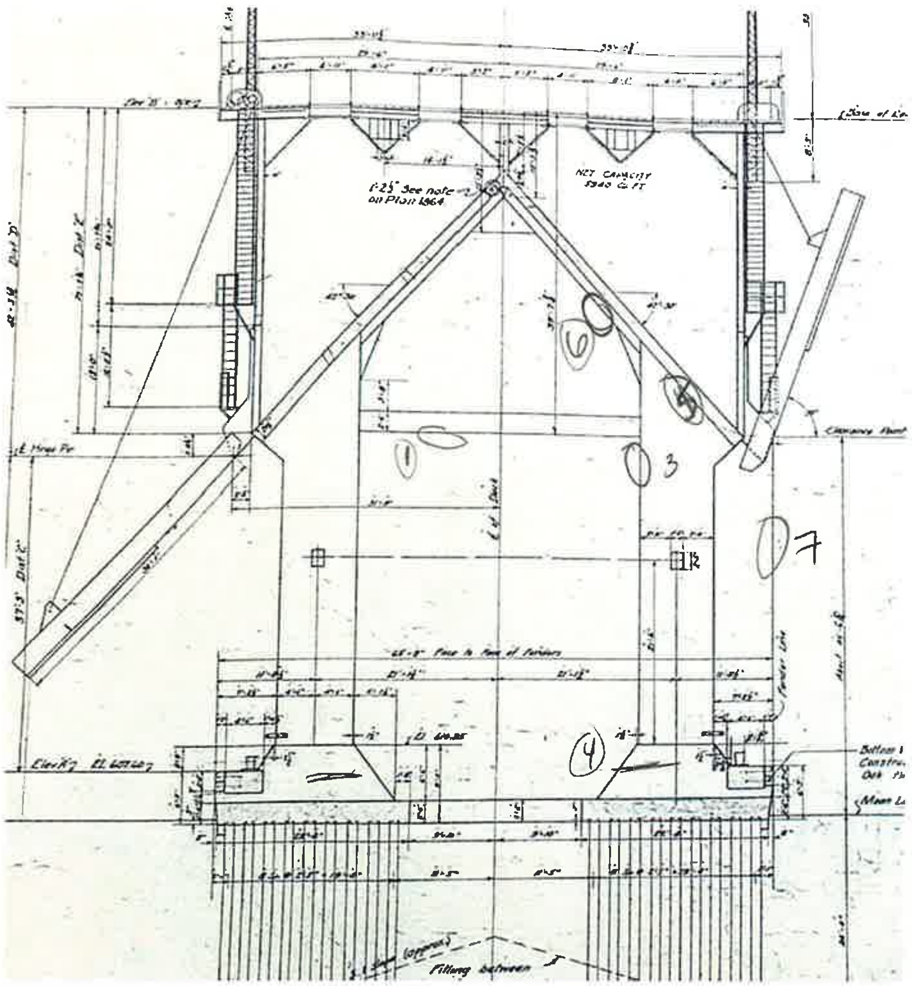
SECTION #: 1

BENT #: 9



COMMENTS/OBSERVATIONS

(1) Cross member experiencing spalling as
well as visible Rebar
4233

(2) Cracks on footing

Between 9-10 Spalling visible on Ceiling
Edge 4254/4255
Crack on North side walkway
Between 8-9
4256

South: (3) Overlay Possible Cracking
(4.) Cracking on foot.
(5). Between 9+10 spalling on Angled face
(6) Rebar visible and Spalling occurred.
Crack between 9+10 on South walkway
(7) 4826 Spalling on SE Corner

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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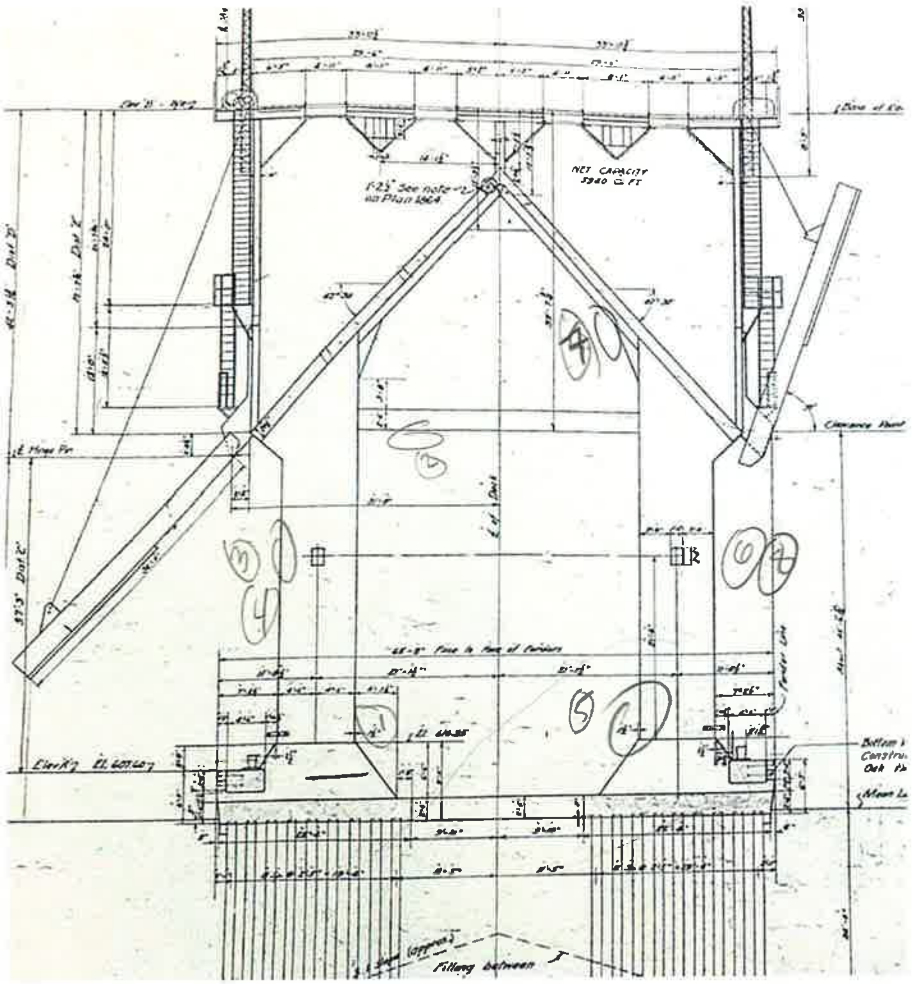
SECTION #: 1

BENT #: 10



COMMENTS/OBSERVATIONS

(1) Cracks on footing
4235
(2) Not Consolidated Concrete, exposed aggregate
Honey Comb feature
(3) Eastside Edge experience spalling on Corner
4236
4251
(4) Cracking on North walkway and
North side Crack of Vertical
South (5) Exposed Rebar 308
(6) Between 10 & 11 Crossbeam Spalling & Rebar Visible
4309 4310
(7) Cracking & Rebar 4311
8) Spalling + Rebar visible 4322 South East & SW 4325
Cracks on South Walkway 4324

MARQUETTE ORE DOCK BENT INSPECTION FORM

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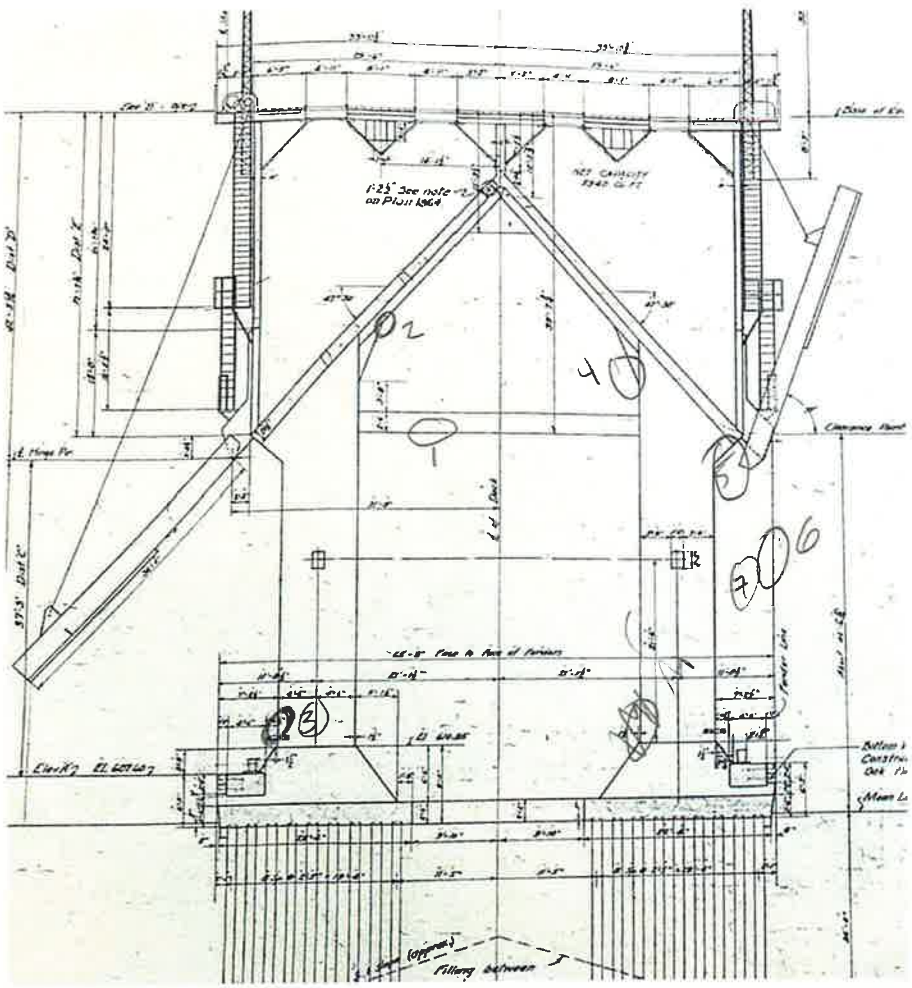
W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 1

BENT #: 11



COMMENTS/OBSERVATIONS

1. Poorly Consolidated Concrete w/ aggregate visible. Spalling w/ Rebar as well

2. Rebar exposed on Ceiling 4238/ 4239

3. Northeast side. Spall/Cracking 4250

Between 10/11 Cracking on North Walkway

South. Cross Member between 11+12 4312+4313 Spalling.

4. Cracking at Triangle Joint

5. Between 11+12 Cracking and Possible falling Debris 4319

6. Southwest Face - Spalling & Rebar Visible 4320

7. Cross beam of 10&11 - Crack 4321

MARQUETTE ORE DOCK BENT INSPECTION FORM

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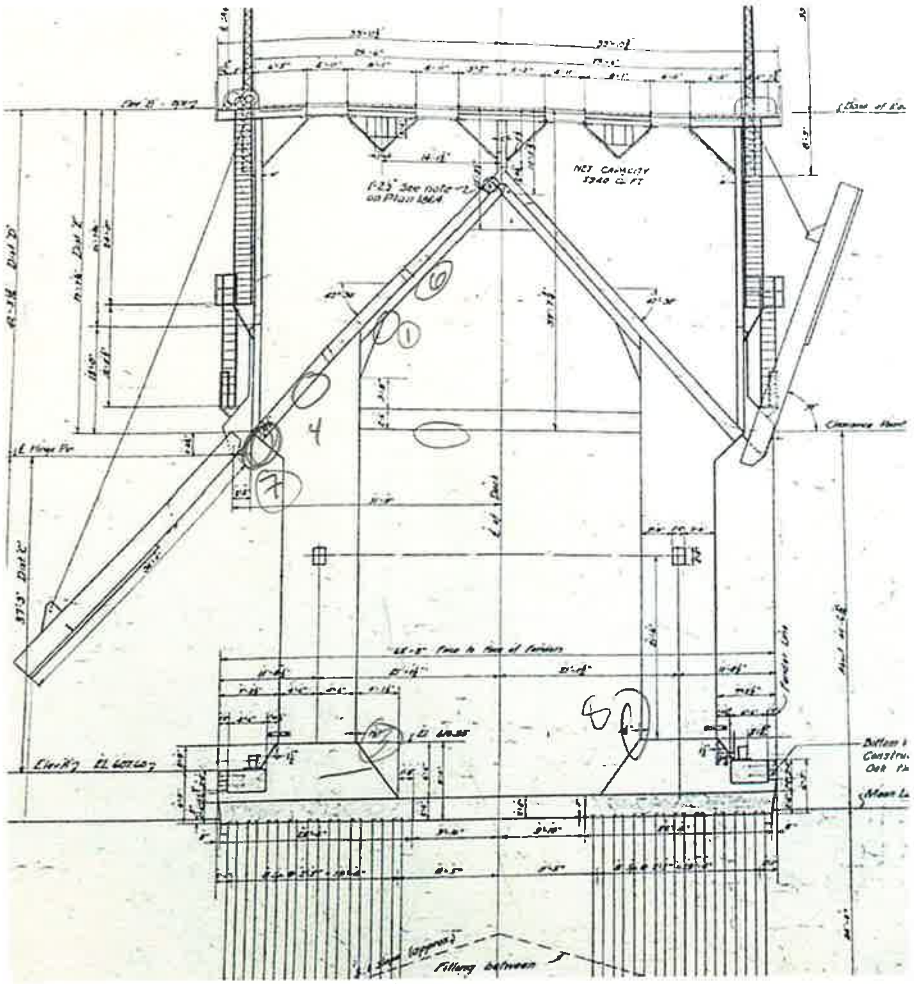
SECTION #: 1

BENT #: 12



Expanson Joint 4316-4318

COMMENTS/OBSERVATIONS

(1)	Rebar Showing on face
(2)	Aggregate showing on Cross beam same
	on Previous.
(3)	Cracks in Footing again
	Photo 4241
(4)	Deteriorated Horizontal, well spalled.
(5)	Expansion Joint 4243/4244
	4248
(6)	Between 12/13 Weathered Concrete
	Aggregate showing.
(7)	Spalled Concrete and Steel Showing
4	Lamp Above Possibly Hazardous.
South (8)	Rebar visible and Spalling 4314

MARQUETTE ORE DOCK BENT INSPECTION FORM

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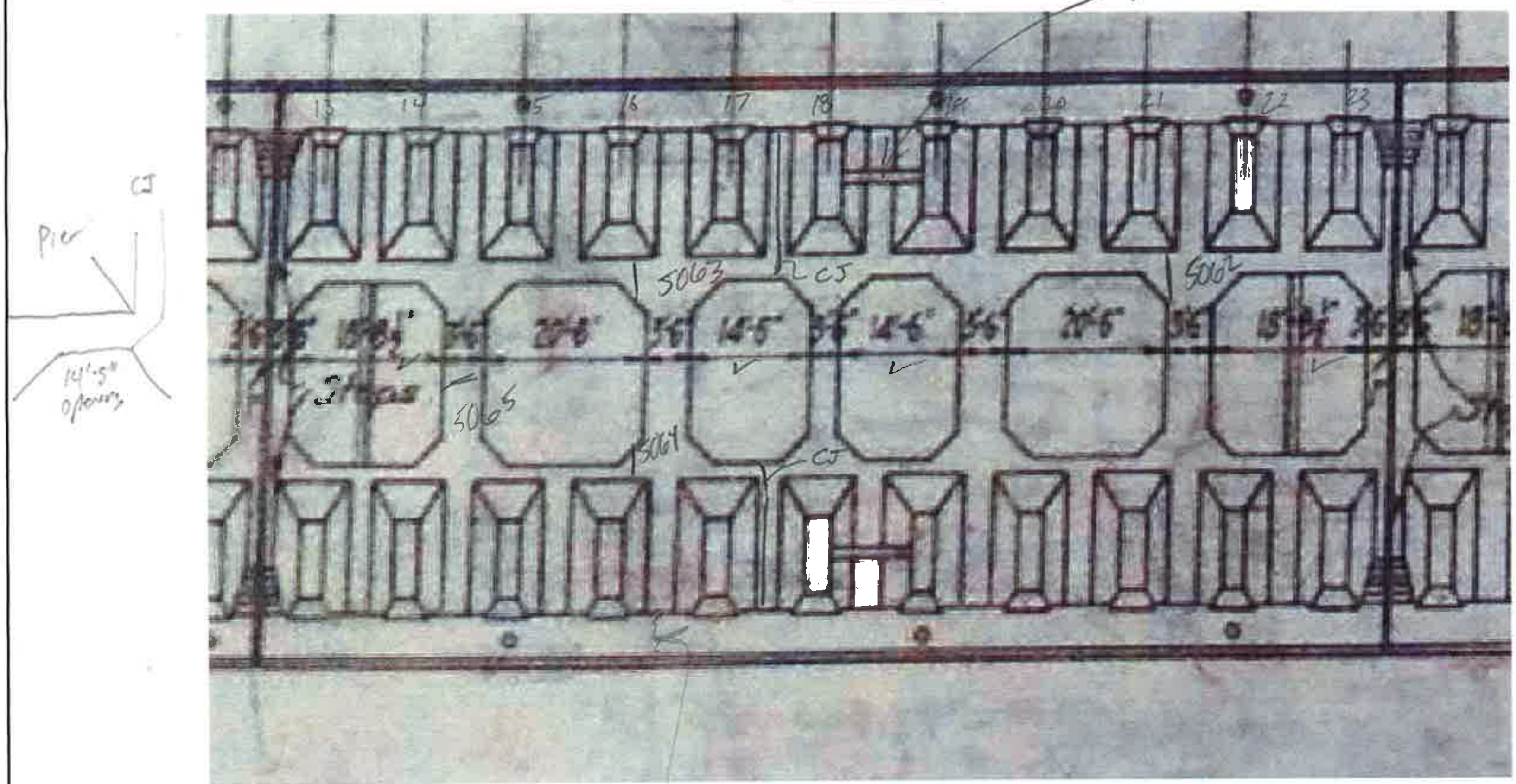
W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

No cracking in shear wall

SECTION #: 2



Cracks typical

COMMENTS & OBSERVATIONS

CJ is tight.

Dimensions match field conditions

Minor conc. deterioration

5062- Construction joint w/ spalling on pile cap

5065- crack across pile cap floor

5065 - Construction joint w/ ore pellet buildup on pile cap

5064 - Cracking in pile cap

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT

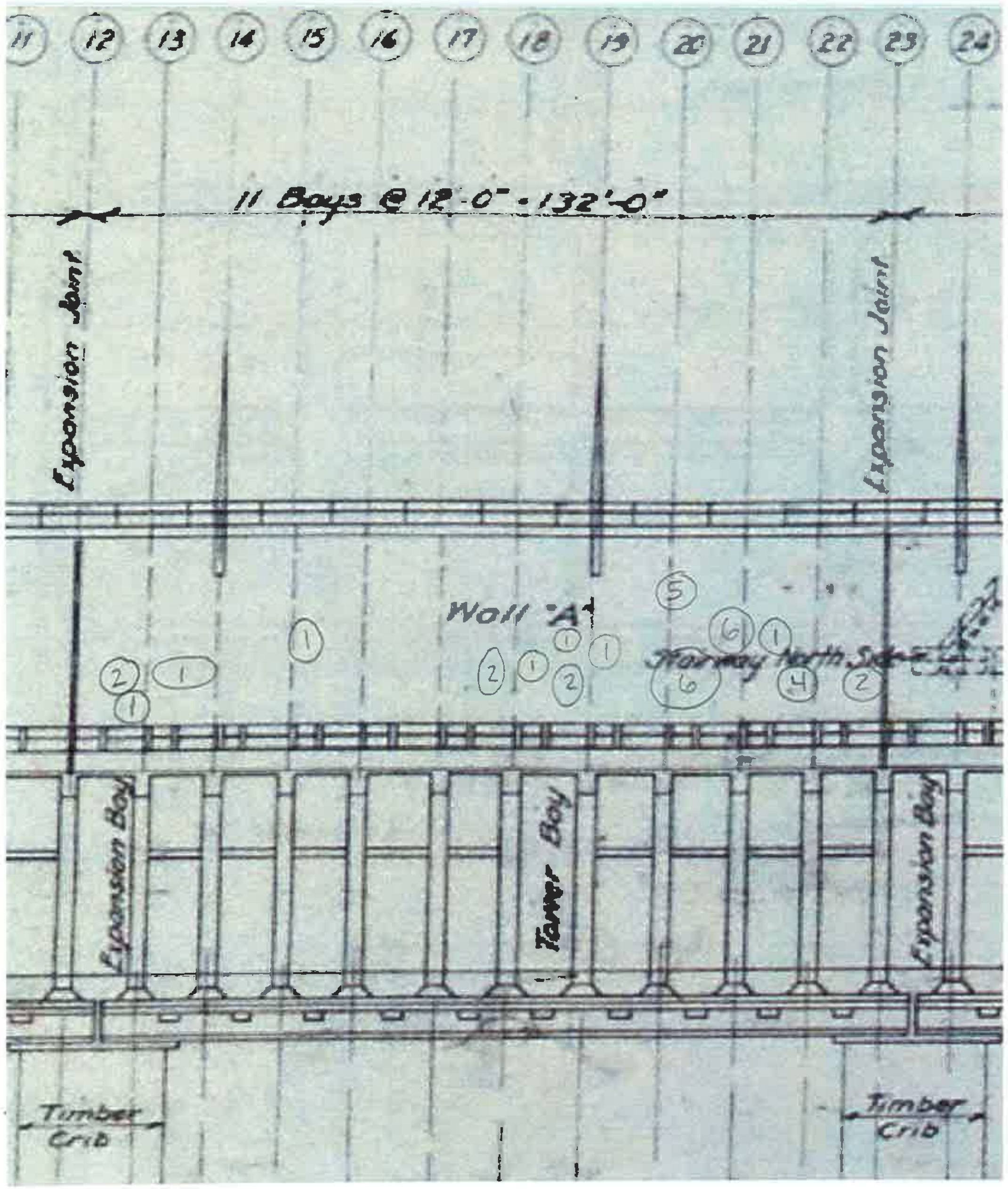
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #:2 (SOUTH SIDE)



COMMENTS & OBSERVATIONS

of spalls identified

Chunks of concrete on walkway

MARQUETTE ORE DOCK INSPECTION FORM-ELEVATION VIEW

GEI Consultants

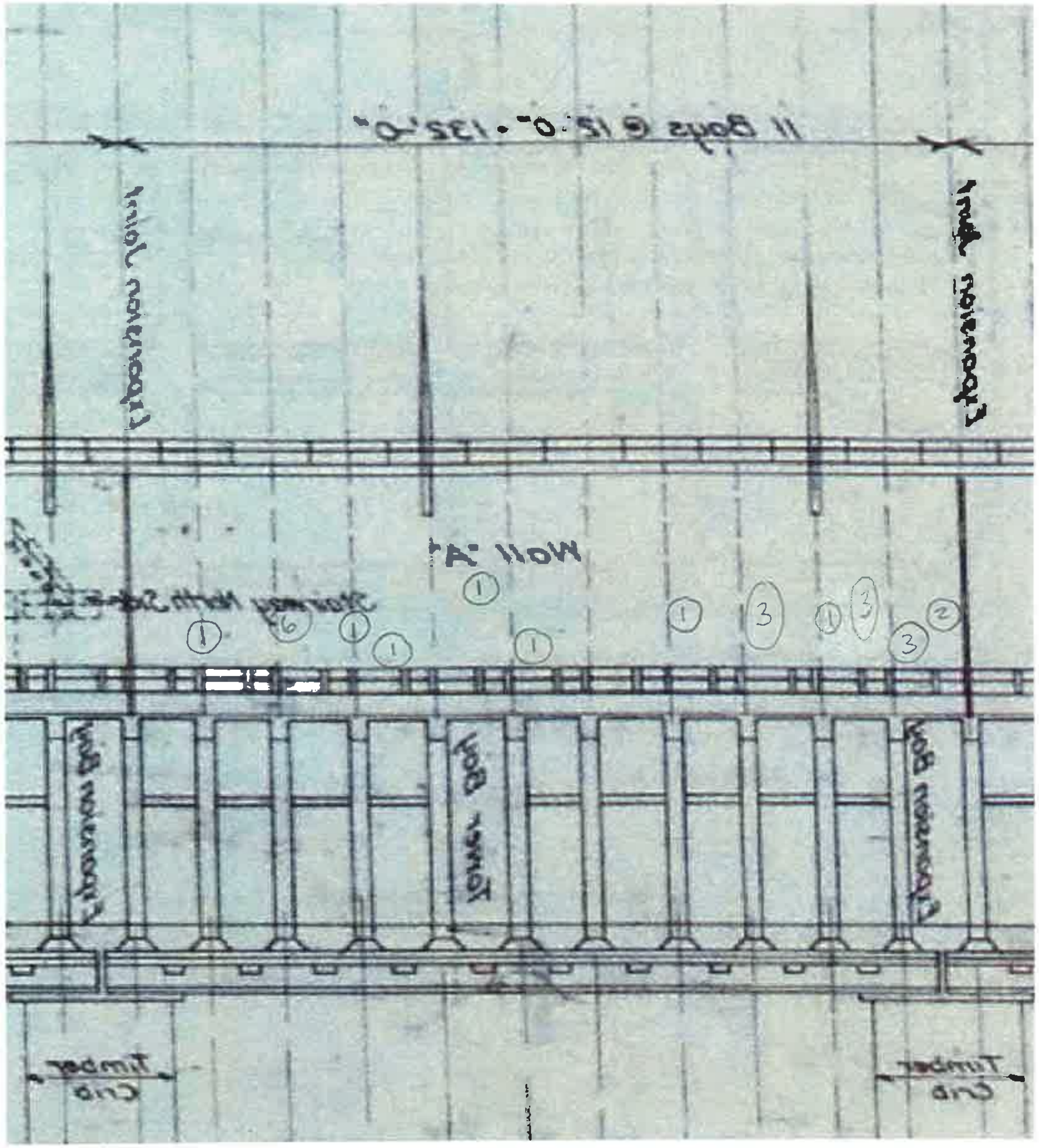
PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #:2 (NORTH SIDE)



COMMENTS & OBSERVATIONS

of spalls identified

MARQUETTE ORE DOCK INSPECTION FORM- ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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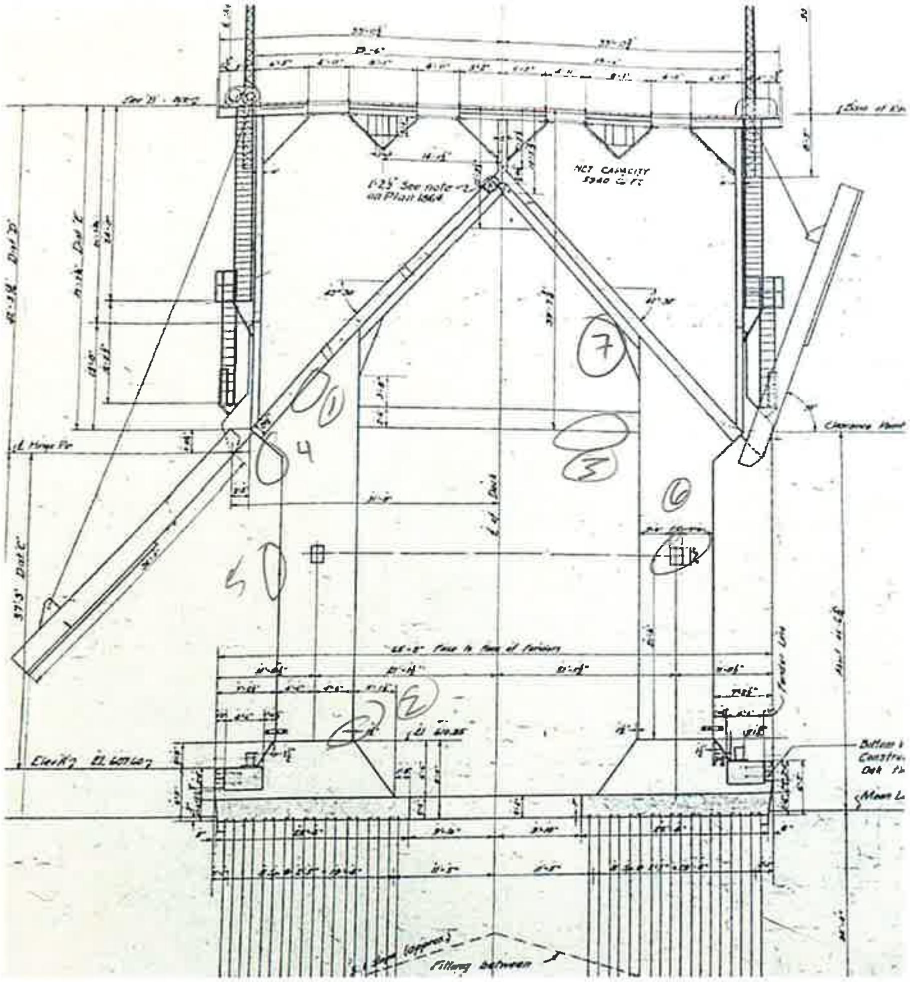
SECTION #: 2

BENT #: 13



COMMENTS/OBSERVATIONS

North ① 4380 Between 12-13 Aggregate showing

② Spalling on top of Foot 4381
SW

③ Rebar Visible on Cross Member

④ Spalling Has occurred 4442 4444

⑤ Exposed Rebar and Visible Spalling
Vertical Cracking on North Face

South
Lighting Fixture

⑥ Spalling on member between 13+14 4447

⑦ Badly Consolidated Concrete visible aggregate
4448

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

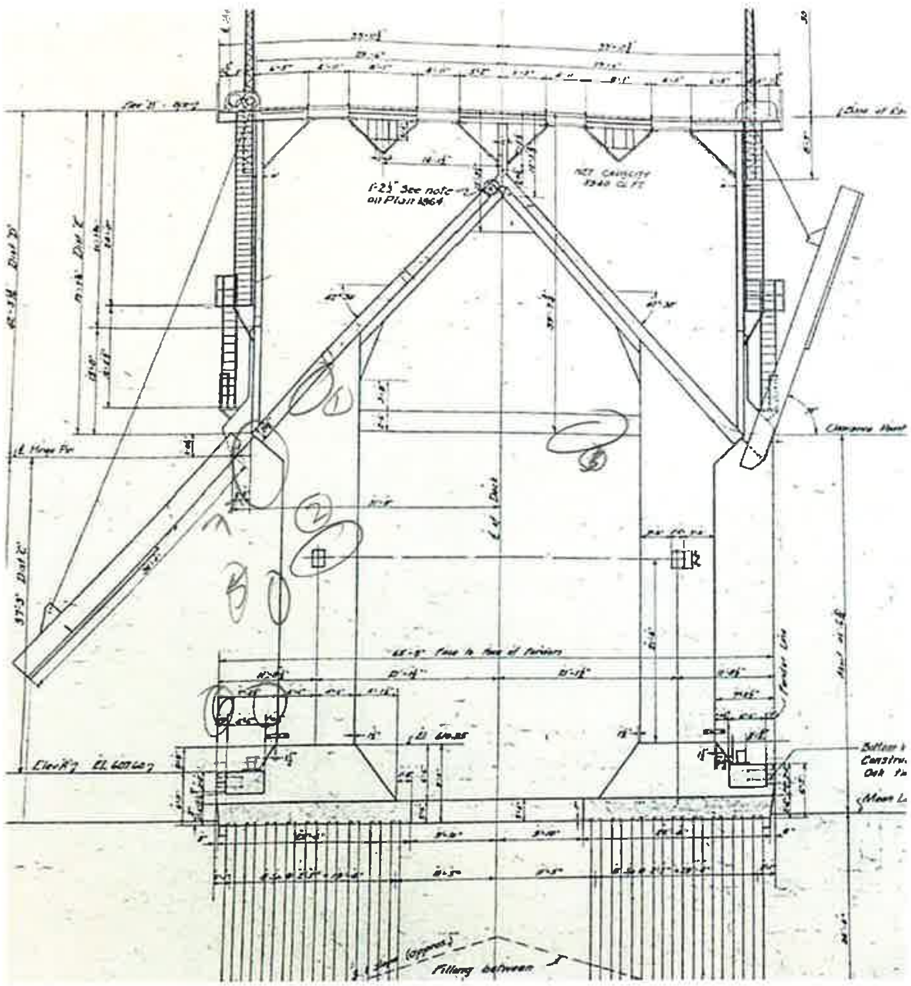
PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 2

BENT #: 14



South Rebar Visible on East Side of 14 vertical
4449

Cracking on South Walkway Reaching up foot of 14
4517-19

Cross Member of 13-14 Cracking and Spalling 4520

Hazardous Lamp 4521

COMMENTS/OBSERVATIONS

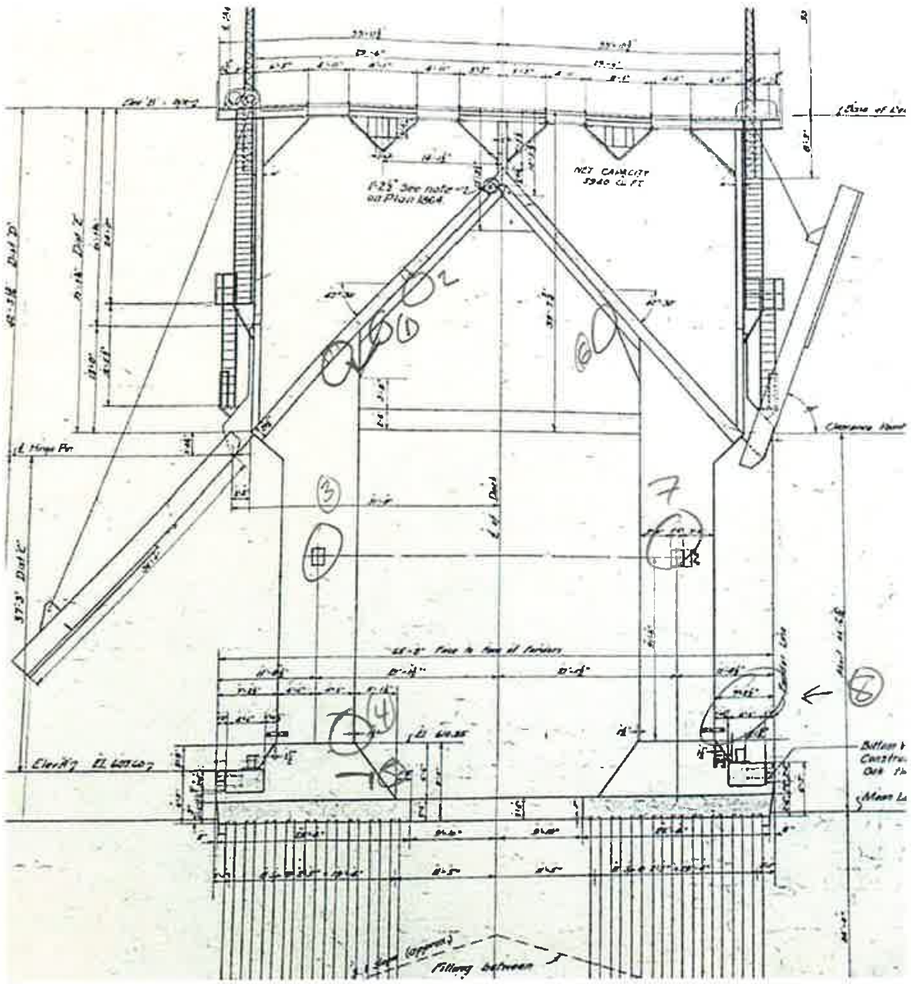
1	Spalling/Aggregate visible
	Between 13&14 4383
2	Cross Member of 13&14 Spalling.
3	Spalling and Rebar visible 4385
4.	4386 Horizontal Crack in First from S…
	Between 14&15
5.	4438 Spalling and Cracking Minor
6	Minor Vertical Cracking on North Face
	Spalling on North Walkway Pretty Severe compared
	to previous. Exposed Rebar 4439
7	4441 Piece of Rebar Visible

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 2

BENT #: 15



COMMENTS/OBSERVATIONS

North

(1)	Spalling and Rebar visible
	4387
(2)	Cracking along Divider 4388
(3)	Between 15+16 spalling on Cross Member
(4)	Rebar visible on upper footing
	4391
(5)	Vertical + Horizontal Cracking on footing
South	(6) Poorly Consolidated concrete becomes
	Increasingly more common
	(7) 4851 Cross Member has cracks
	between 15+16
(8)	Vertical cracks 4514-4515 on Vertical
	4516 Crack on South walkway 14-15

MARQUETTE ORE DOCK BENT INSPECTION FORM

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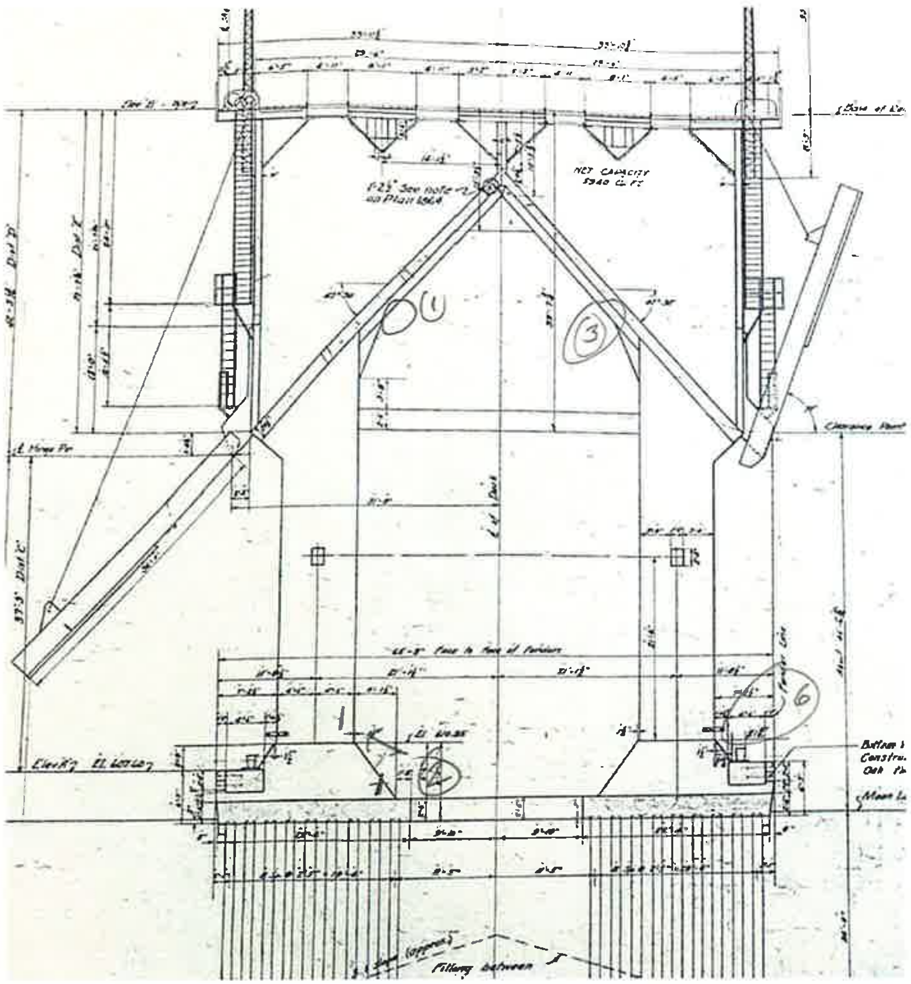
SECTION #: 2

BENT #: 16



COMMENTS/OBSERVATIONS

1	4393 Cracking on upper ceiling Joist.
2	4394/4395 Vertical Cracking running
	up face and Vertical
	4437 Cracking on Walkway of 15-16
South	West side of Vertical, Vertical Crack
	roughly 4 feet long.
	3 Patching taken place on ceiling
	Possible Cracking. 4454
6	4510-11 Vertical Cracks on 16.
	Poorly consolidated Concrete on Vertical
	15-16 Cracking and Spalling on CrossBeam
	Cracks in South Walkway

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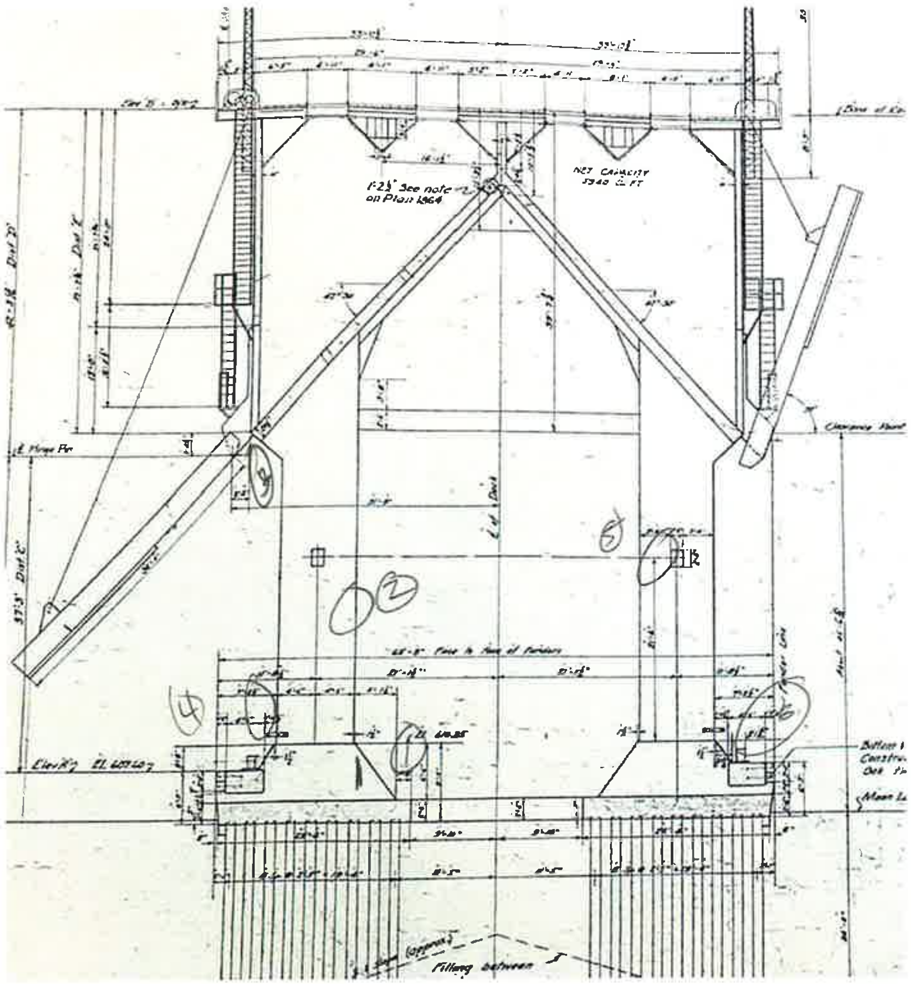
SECTION #: 2

BENT #: 17



North

South

COMMENTS/OBSERVATIONS

1. Miniature numerous Cracks on footing
2. Possible Hazardous light fixture

Note: Cracking and Patching Done on numerous Parts of Ceiling on the Section

3. 4435 Exposed Rebar
4. Vertical Cracking on Northface of Vertical
5. 4455 Rebar tie visible

Hanging Power Cable 4456

6. Miscellaneous Cracking on footing → 507

Cross Member Spalling 508 16-17

16-17 Crack on South walkway 509

MARQUETTE ORE DOCK BENT INSPECTION FORM

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PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

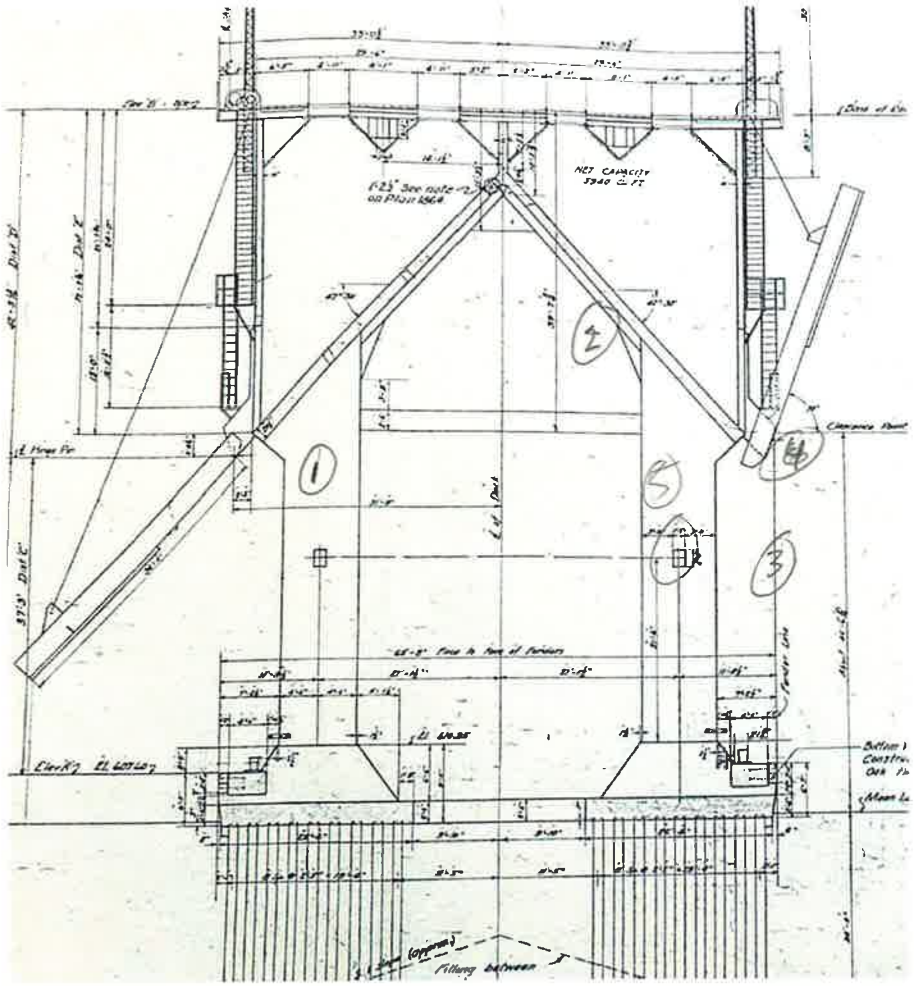
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 2

BENT #: 18



COMMENTS/OBSERVATIONS

North	①	Rebar sticking out between 18 & 19.
		Note: Same Cracking Visible on Ceiling
		Cracking on North Walkway of 17-18 4434
South	②	4458 Cracking on face of Ceiling
		4459 lighting fixture
	③	503 Spalling on South Face of Vertical
	④	502 Poorly Consolidated Concrete
	⑤	Cross Member Piping and Cracking 505 &
	⑥	504 Crack on South Walkway 17-18

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
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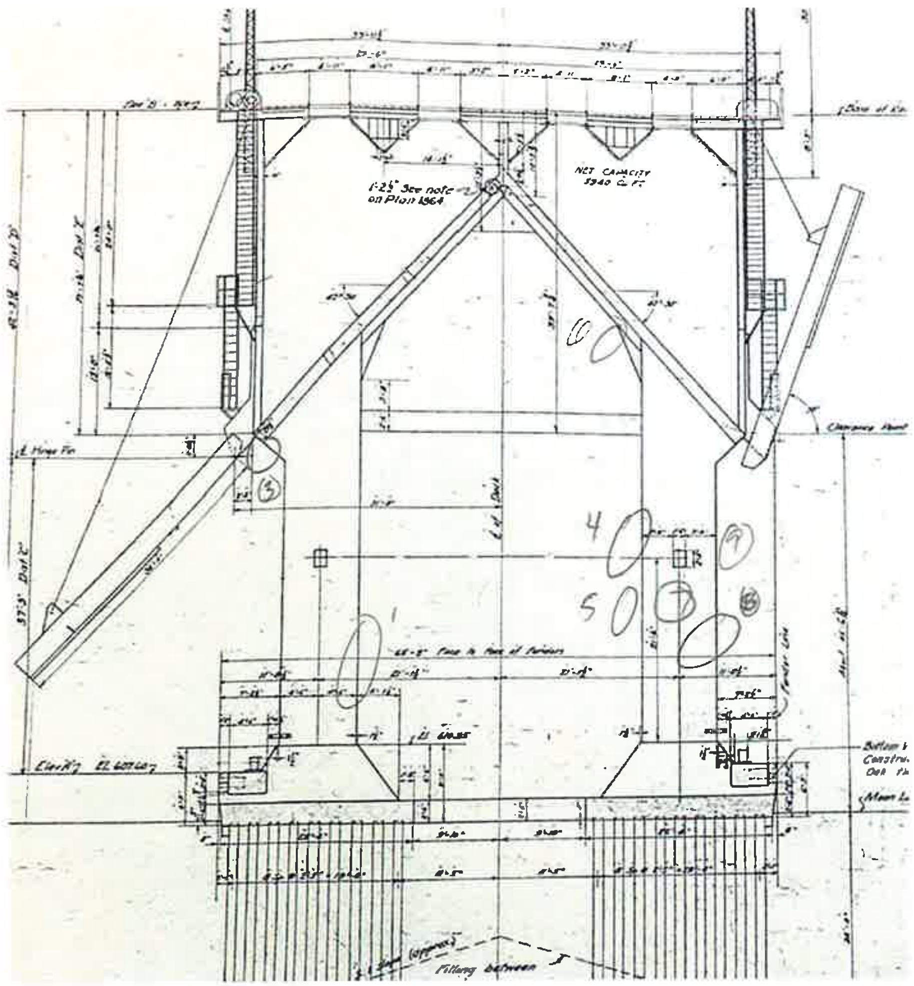
SECTION #: 2

BENT #: 19



North

South

COMMENTS/OBSERVATIONS

(1) Possible form work / Possible Vertical
Cracking
(2.) 4403 Crumbling on the bottom
of shoot. between 19 + 20
(3) Possible Spalling or form Piece ~~##~~ 33
(4) 4461 Piece of Rebar visible
(5) 4462 Cracking Diagonally along North face
between 18-19
Poorly Consolidated concrete
(6) and Possible Piece of Rebar 4463
(7) Cross Member 4464 4465 Spalling.
19-20
(8) Significant Patches on Vertical 4497-98
(9) Horizontal Cracking on South of Wall 18-19
4499-4500

MARQUETTE ORE DOCK BENT INSPECTION FORM

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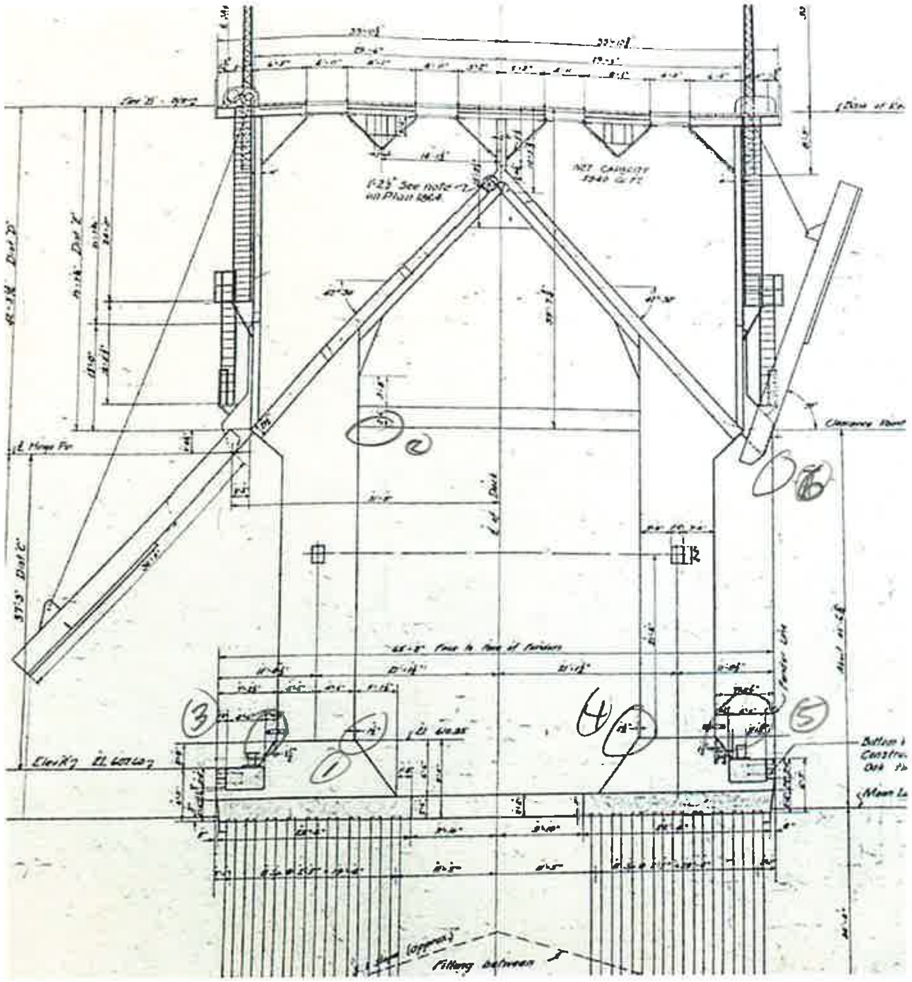
SECTION #: 2

BENT #: 20



COMMENTS/OBSERVATIONS

	(1) Spall with exposed Rebar
	4404
	(2.) Spalling with Rebar Tight
	(3) Spalling with Rebar visible 31
	Cracking on North Walkway 32 Between 19-20
(4)	4466 Spalling on Top of footing.
South	20-21 Spalling on Cross Member 4467?
	20-21 2 Cracks on South Walkway 89-90
(5)	Cracks and spalling on foot 91-93
(6)	Exposed Rebar.
(7)	4495 Crack on South Walkway 19-20
4496	Cross Member Rebar showing Spalling 4496

MARQUETTE ORE DOCK BENT INSPECTION FORM

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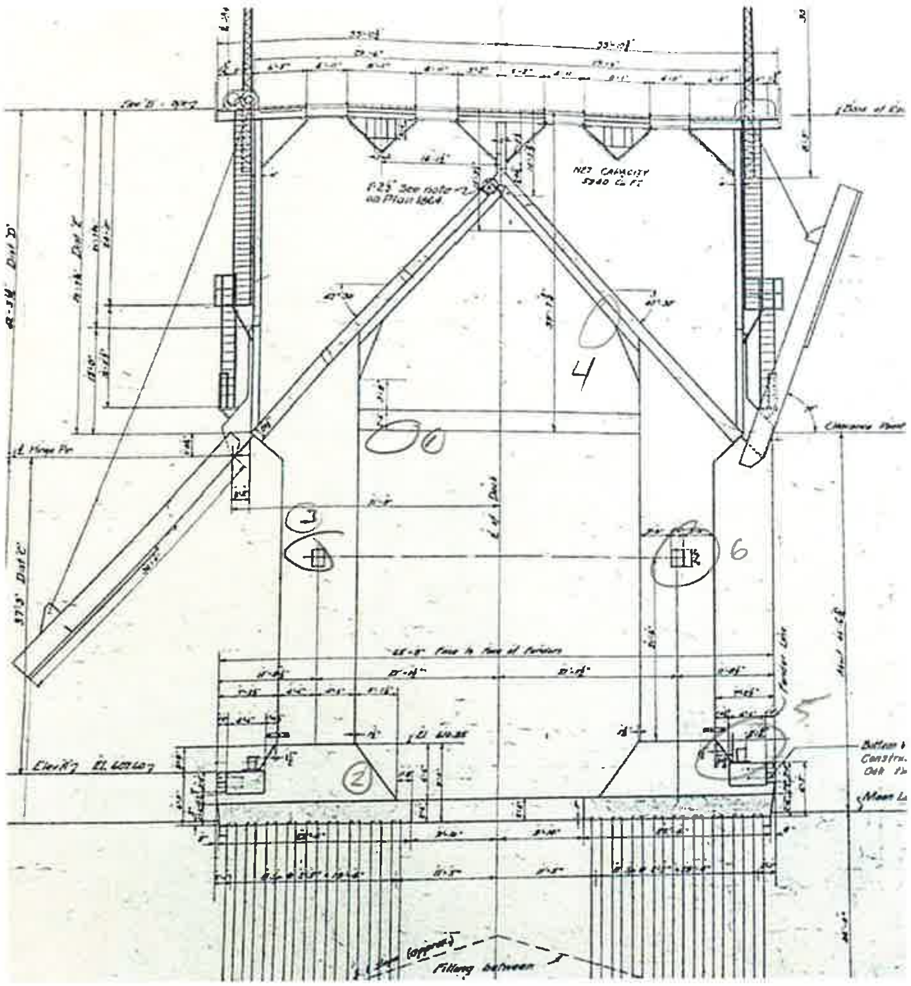
W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 2

BENT #: 21



COMMENTS/OBSERVATIONS

North

(1.) Rebar showing 4406

(2.) Vertical Cracking on Footing 4407
between 21+22
(7) Spalling on Cross Member
as well as aggregate showing.
430 Cracking on North Walkway between 20+21

South

(4) Poorly Consolidated Concrete.

(5.) Same Vertical Cracking on foot 4487.

(6) 4488 Top South East Corner of Cross Member

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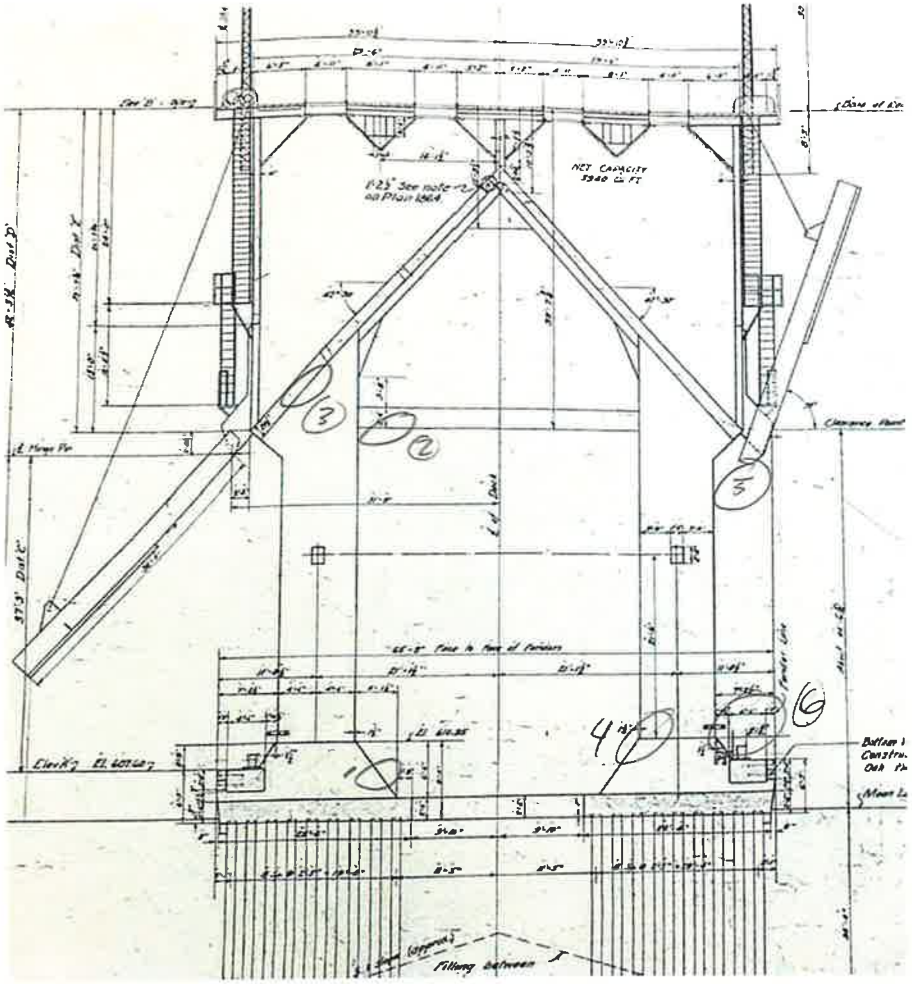
INSPECTOR:

SECTION #: 2

BENT #: 22



South (4.)

North

COMMENTS/OBSERVATIONS

① Vertical Cracking on Footing 11+12
② Some Rebar visible.
③. Between 22+23 Horizontal Cracking
④ Spalling between 22+23.
Between 22+21 Cracking on North Walkway
4468 + 4469 Vertical Cracking on
Footing West Side.
⑤. Horizontal Cracking 4471
⑥ Vertical Cracks 4484 on foot +
up Vertical,
Crack on South Walkway 21+22 4485

MARQUETTE ORE DOCK BENT INSPECTION FORM

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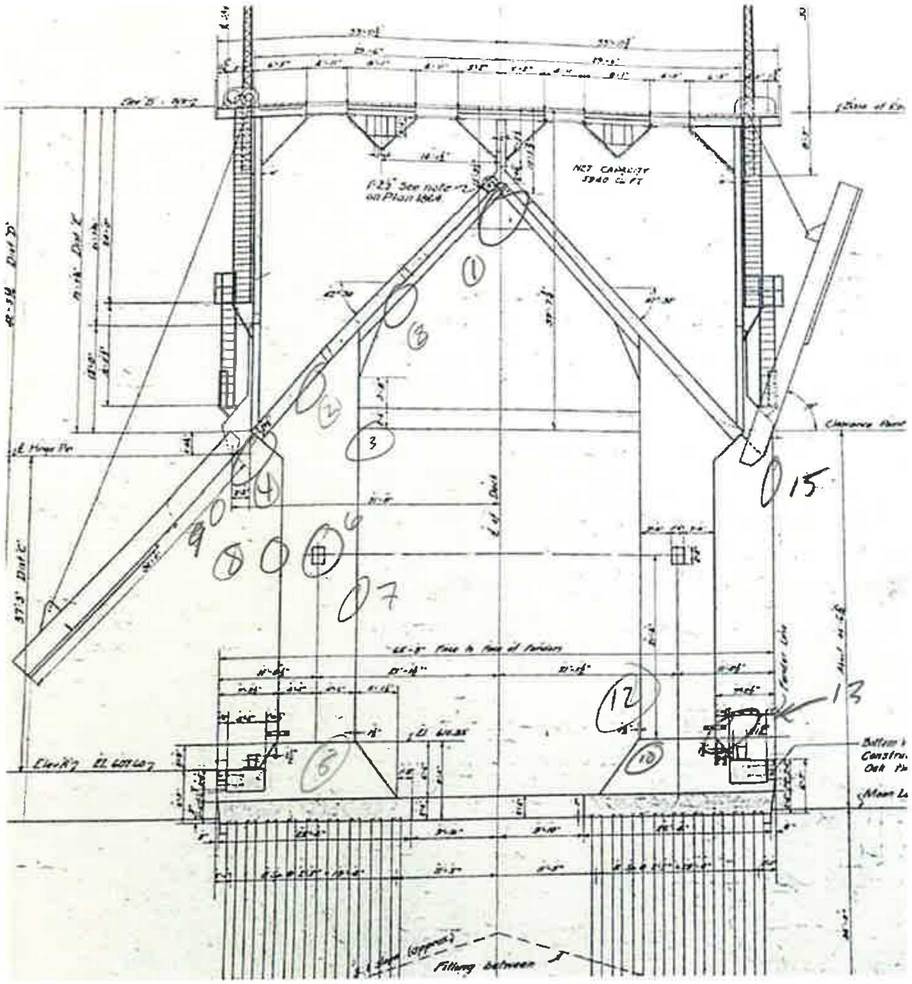
W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 2

BENT #: 23



North

South

COMMENTS/OBSERVATIONS

(1) Rebar visible in Crotch of Ceiling
(2) Horizontal Cracking in Ceiling 416 417
(3) ~~Inside~~ Rebar visible 4418
(4) Exposed Rebar on Bottom of Shoot
(5) Vertical Cracking on East Side Foot.
4421 4422
(6) Hazardous Lamp.
Cracking on SE Edge of Vertical 4423
(7) Sketchy expansion Joint 4424-4426
(8) Rebar Visible on NW Edge of Vertical
(9) Cracking on West of Vertical
(10) 4473 Vertical Cracking on footing West
(11) George Tolles Scenic Photo 4472.
(12) Vertical Cracking on Eastern Side of foot. 4474
Expansion Joint. 4475-77 Cracking.

South Spalling (13) 4479 Spalling on top of foot

(14) 4480 Photo of a duck

4481-82 Boat

(15) 4483 Spalling on SW Edge

MARQUETTE ORE DOCK BENT INSPECTION FORM

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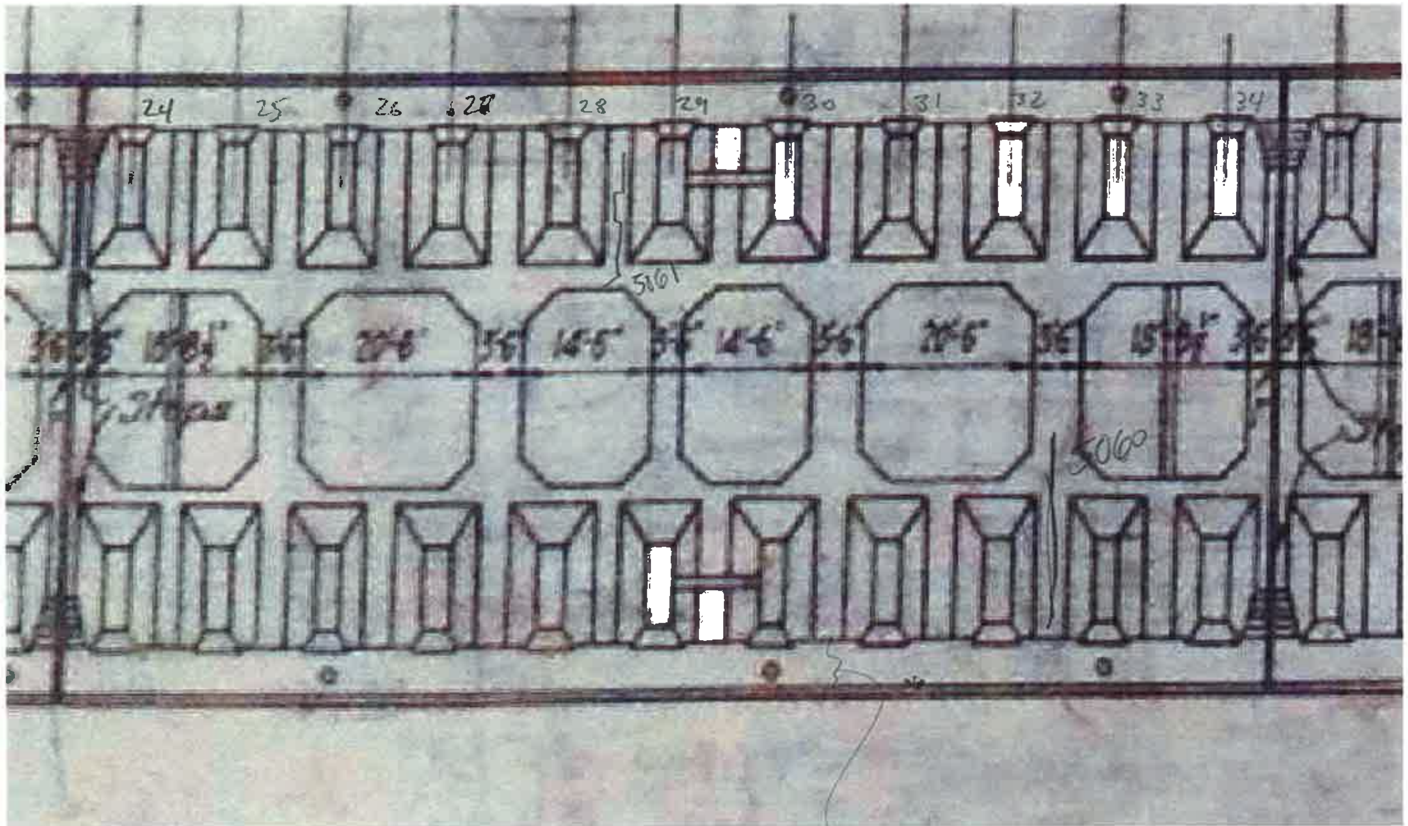
SECTION #: 3

Pier 28

Keyed CJ



Typical crack on fender

COMMENTS & OBSERVATIONS

Same CJ as Section 2

Dimensions match field conditions

Minor conc. deterioration

5060 – Crack w/ localized spalling on pile cap floor

5061 – Construction joint w/ spalling @ edge of pile cap opening

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT

LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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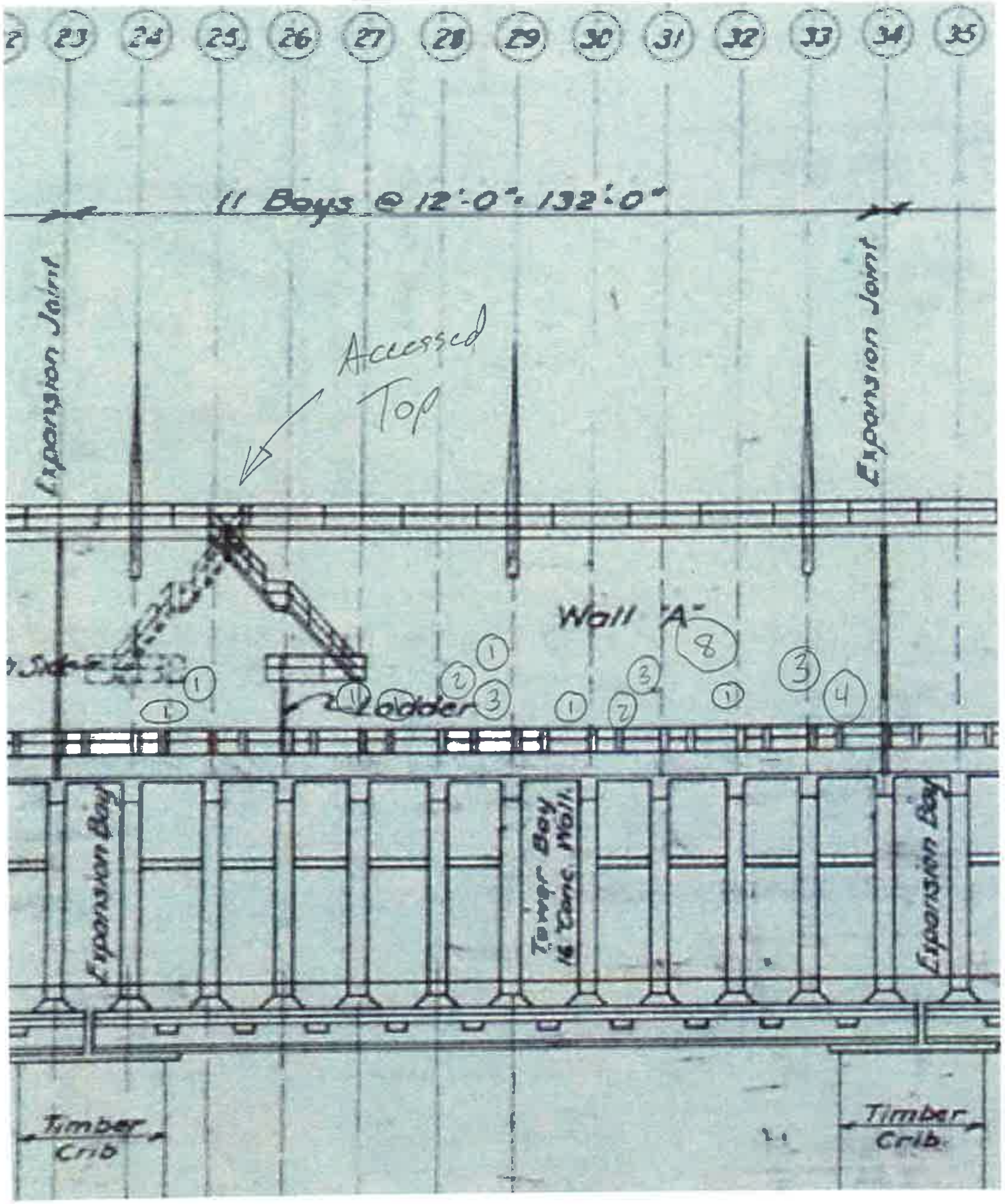
SECTION #:3 (SOUTH SIDE)



COMMENTS & OBSERVATIONS

# of spalls identified

MARQUETTE ORE DOCK INSPECTION FORM-ELEVATION VIEW

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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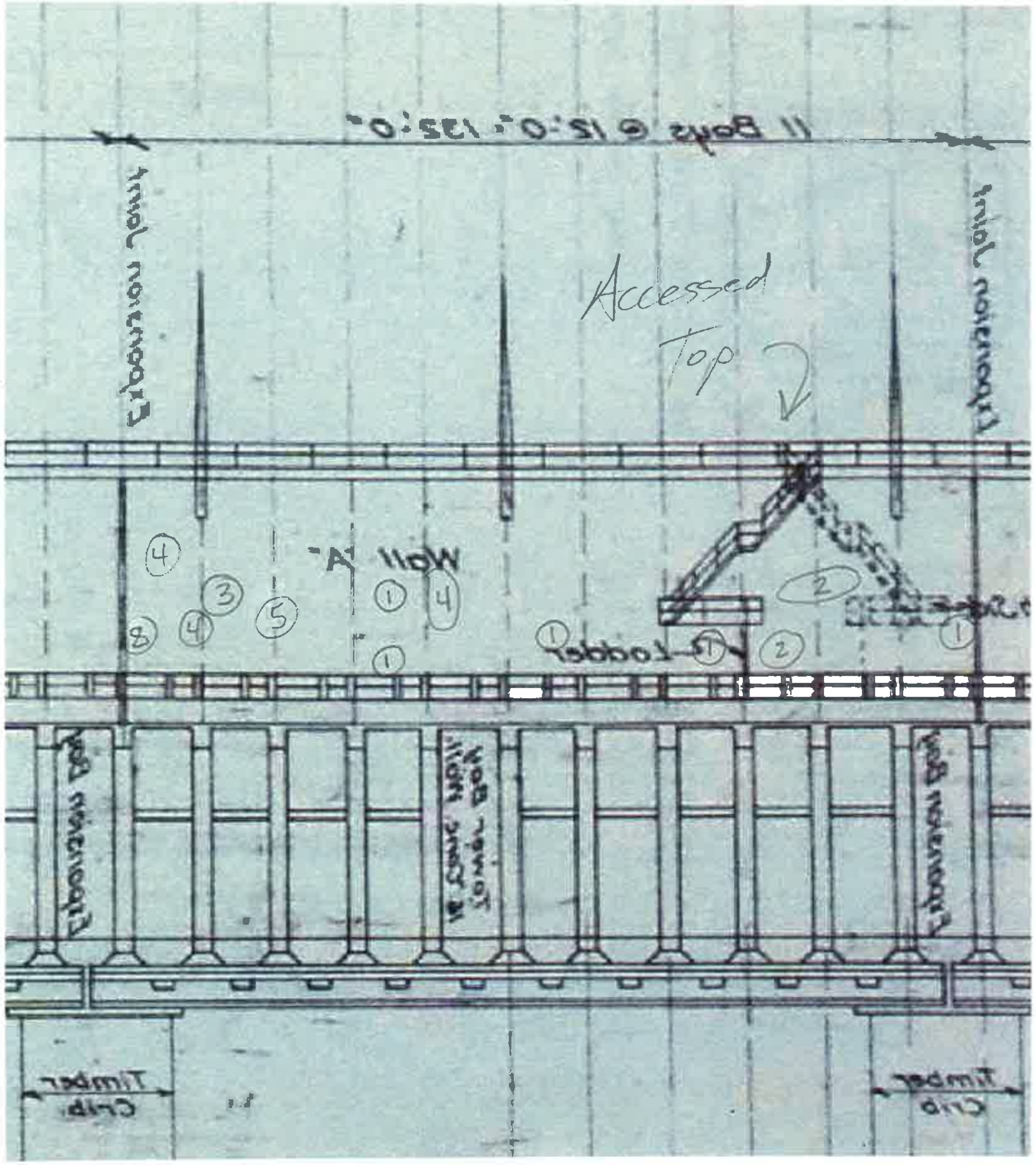
SECTION #:3 (NORTH SIDE)



COMMENTS & OBSERVATIONS

# of spalls identified

MARQUETTE ORE DOCK INSPECTION FORM-
ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
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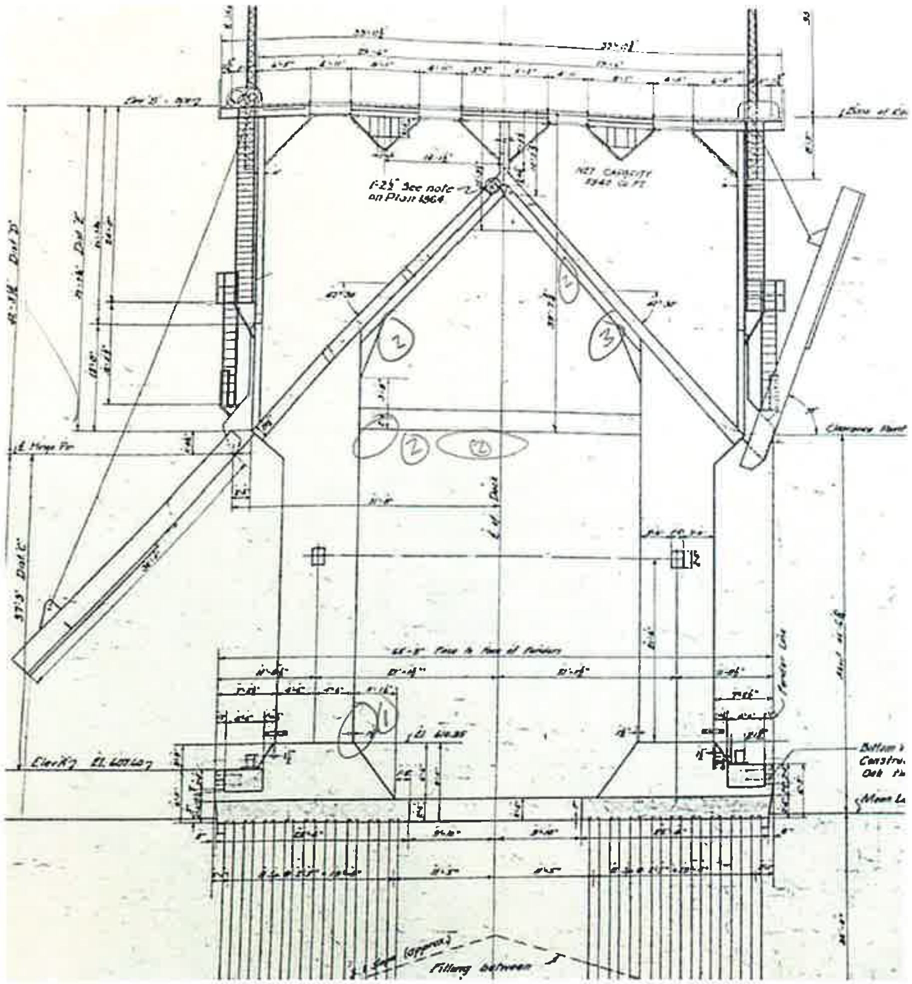
SECTION #: 3

BENT #: 24



COMMENTS/OBSERVATIONS

North Inside
4523 ① Spalling visible on SW Edge of Vertical above footing
4522 ② Consolidated Concrete throughout Central beam
occasional Cracking as well on Ceiling Structure
4524 ① Spalling Also on SE Edge of Vertical w/exposed
rebar.
North Outer
Overhang of 23-24 Spalling with
Exposed Rebar.
South Inside:
Lighting Fixture
24/25 ③ Exposed Rebar w/spalling 4559
④ Exposed Rebar on Cross Member with
some spalling. 4560

MARQUETTE ORE DOCK BENT INSPECTION FORM

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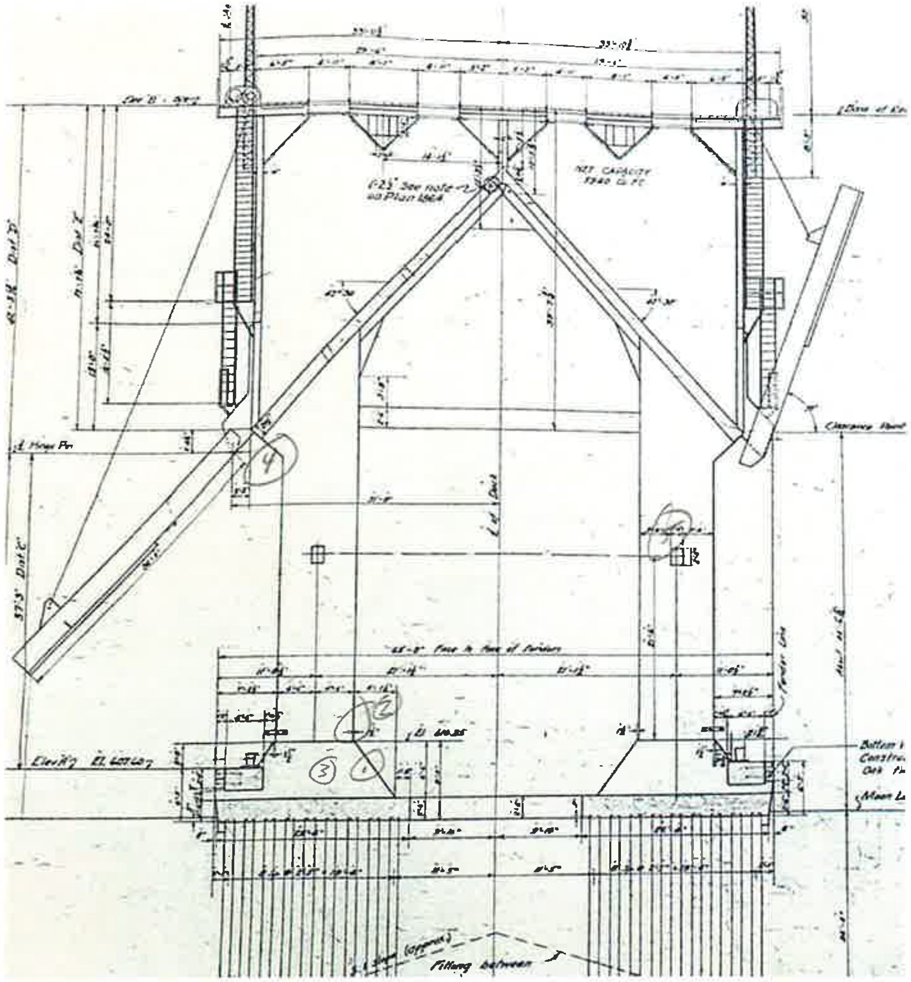
W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 3

BENT #: 25



COMMENTS/OBSERVATIONS

North Inside

(1) Spalling occurred on South face of foot

also w/some minor cracking 4525 4526

(2) Spall w/visible Rebar on SW Edge of

vertical near the top of the foot.

(3) Spall on West Side of foot.

North outer: (4) Delamination @

overhang. Cracking at 25-26 4552

(5) South Inner - Delamination throughout

Crossbeam of 25>26 with Rebar exposed.

4561

South Outer:

MARQUETTE ORE DOCK BENT INSPECTION FORM

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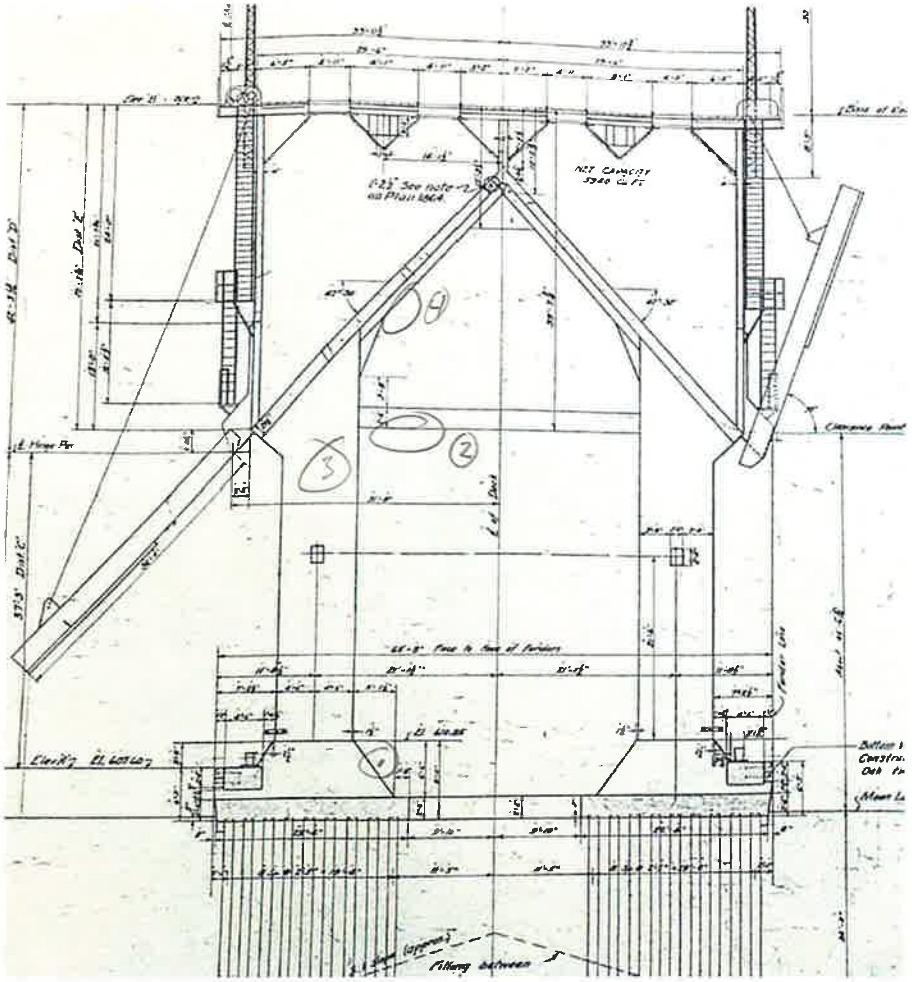
SECTION #: 3

BENT #: 26



COMMENTS/OBSERVATIONS

North Inside

① Spalling and Cracking occuring on

base of foot (South Side)

② Spalling w/visible Rebar apparent 4527

③ Overpour on East Side of Vertical

Cracking on Crossbeam of 26-27 4528

④ Possible Horizontal Cracking

Northouter. Small spall at

Cross beam 25-26 4555 4556

South Inner: Crossbeam has spalling

and Rebar visible 26/27 4562

4583 crack in walkway

4584 "Happy Climber"

25-26 Rebar visible 4585

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT

LOCATION- MARQUETTE, MI

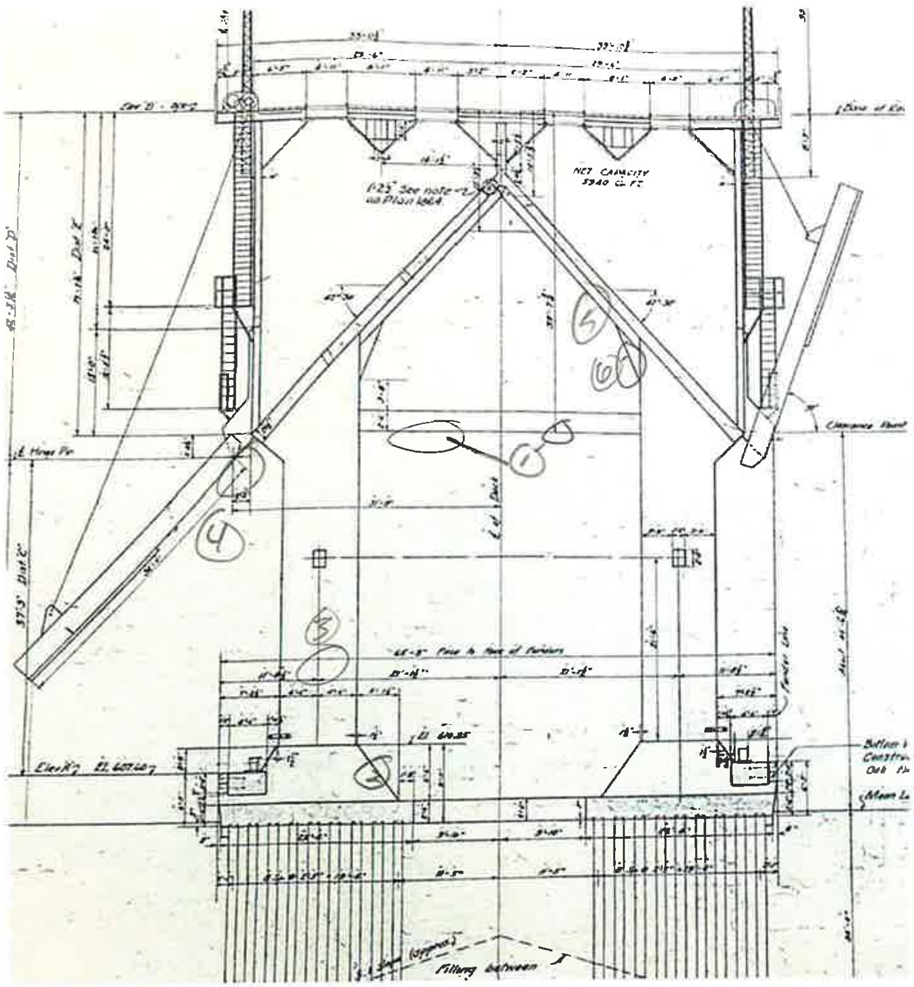
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 3

BENT #: 27



COMMENTS/OBSERVATIONS

North Inside

1 ~~Poorly Consolidated Concrete~~

2 Vertical Cracks along base of foot

3 ~~Possible Patched Horizontal~~ Crack on ~~East face of Vertical.~~

North Outer. Cracking on North walkway 26-27. 4554

4 Overhang spalling with exposed Rebar 26-27.

South Inner - 5 spalling off 26+27 Not Major

6 small spall @ triangle with Possible Rebar

South Out

26-27 4581 Crack in walkway

26-27 Beam Delamination 4582

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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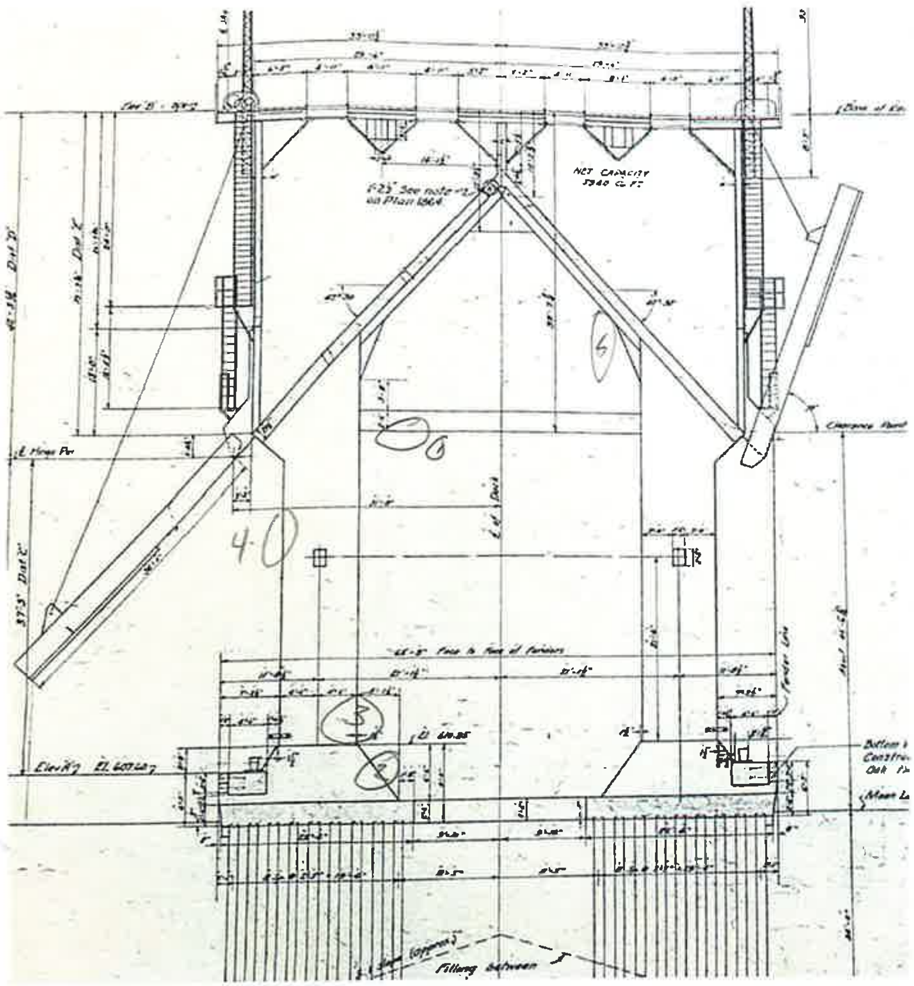
SECTION #: 3

BENT #: 28



COMMENTS/OBSERVATIONS

North Inside. (1) Some very slight
Poorly consolidated Concrete.
(2.) Some Spalling on South face of
footing.
(3) Spall w/exposed Rebar @ top of foot. 4529
Note Possible Hazardous Lamp.
4551
North Outer: Cracking on 2728 ~~[illegible]~~ North walkway
(4) Spalling and visible Rebar 4552
and Minor spall on Cross beam of
27-28. 4553
South Inner - (5) Some Minor Spalling
occurring on Ceiling / Triangle
South Out - 4579 Crack in walkway
27-28 4580 Exposed Rebar Cross beam

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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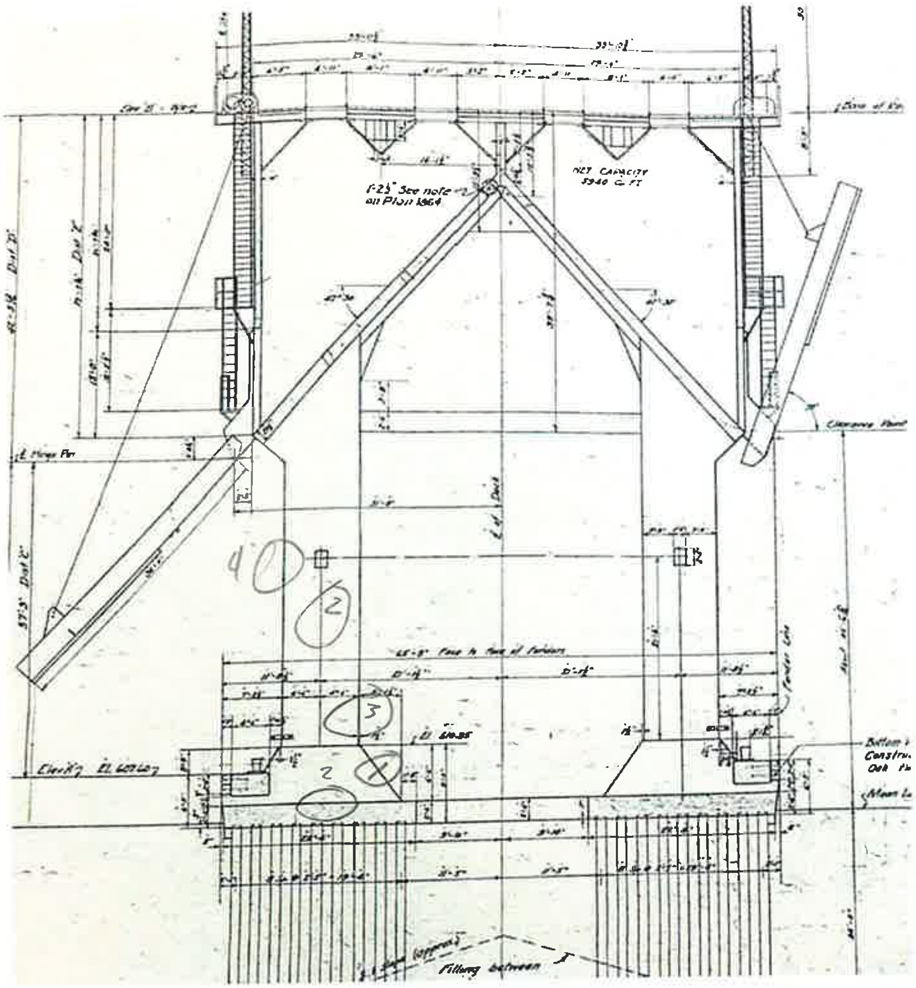
SECTION #: 3

BENT #: 29



COMMENTS/OBSERVATIONS

North Inside ① Minor spalling all
over footing, some South some SW
② loose nails on West Side of Foot
along with up West of Vertical
③ Cracking on SE Corner of Vertical.
North Outer:
④ Spalling on NW Edge of Vert.
Cracking on 28-29 North walkway 49
Minor Spalling on 28-29 crossbeam
South Inner – Spalling w/exposed Rebar
on Cross beam of 28-29 4563
Delamination as well on beam.
Light Fixture Overhead. 4578
South out 29-30
4576 Horizontal Cracking
4577 Crack walkway

4570

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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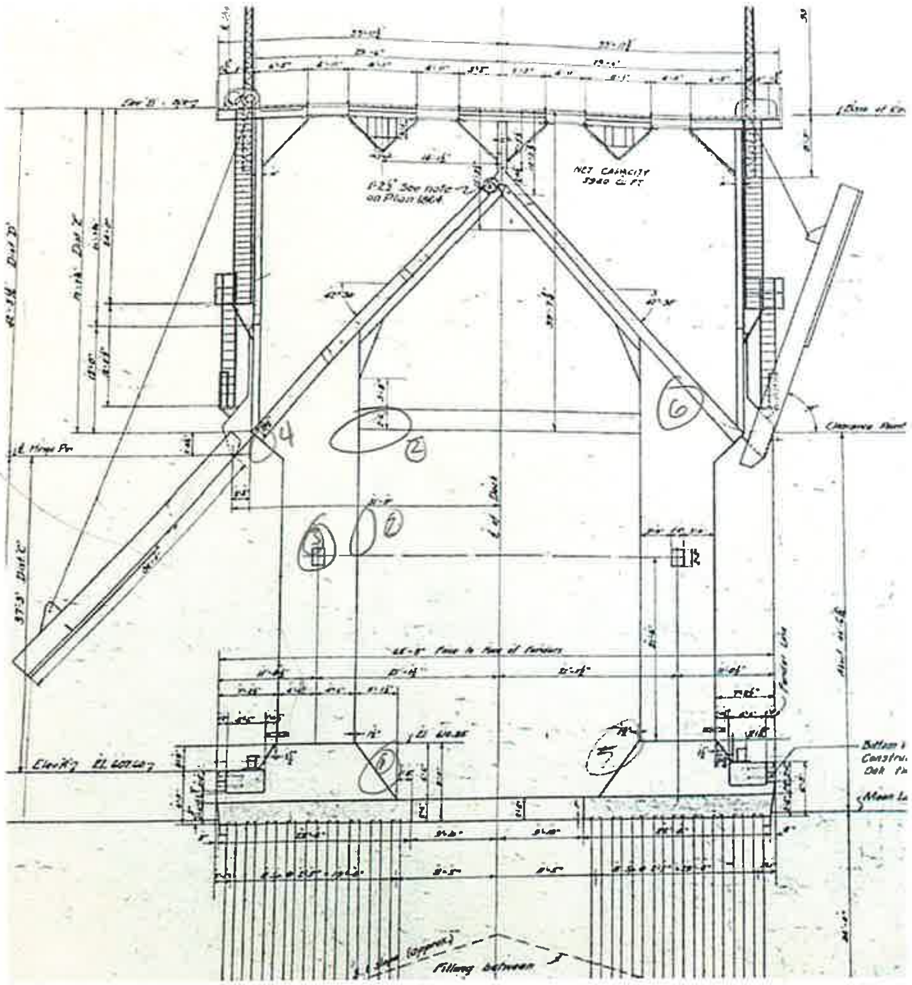
SECTION #: 3

BENT #: 30



4530

COMMENTS/OBSERVATIONS

North Inside 1 Vertical Cracking on South face of foot.

2 Poorly consolidated Concrete

3 Between 30+31 the Cross Member is Spalled and Reb as visible.

North Outer: 4 Crack Vertically on North face of Vert.

4 Minor Spalling on Overhang

South Inner 5 small delamination on North Face of foot.

6 Poorly Consolidated in Parts between 30-31

South Out.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT

LOCATION- MARQUETTE, MI

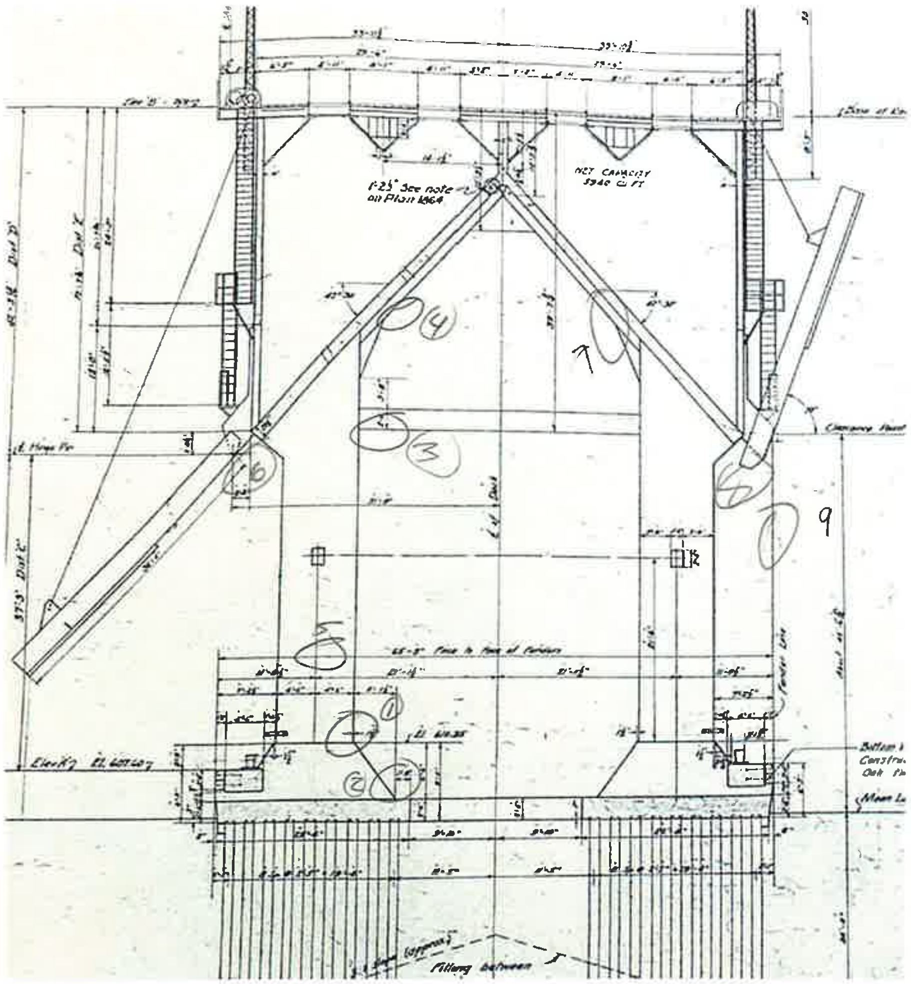
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 3

BENT #: 31



North Inside **COMMENTS/OBSERVATIONS**

(1) on South Face & SE Edge of Vertical
spalling is apparent & Rebar is
visible.
(2) Vertical Cracks on footing 4551
(3) Poorly Consolidated Concrete.
(4) Spalling has occured. Rebar
Possibly Visible.
(5.) Spalling on East face of Vertical.
North Outer.
(6) spalling and Visible Rebar.
Between 30+31 Spalling on overhang
30+31 Cross beam Spalling & Rebar. 4447
30+31 Cracking on North walkway. 4446
South Inner
(7) 31+32 4564? Rebar Exposed
South Outer (8) 4574 Spall
Walkway Spall 4575
(9) 4586 Spall / delamination

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

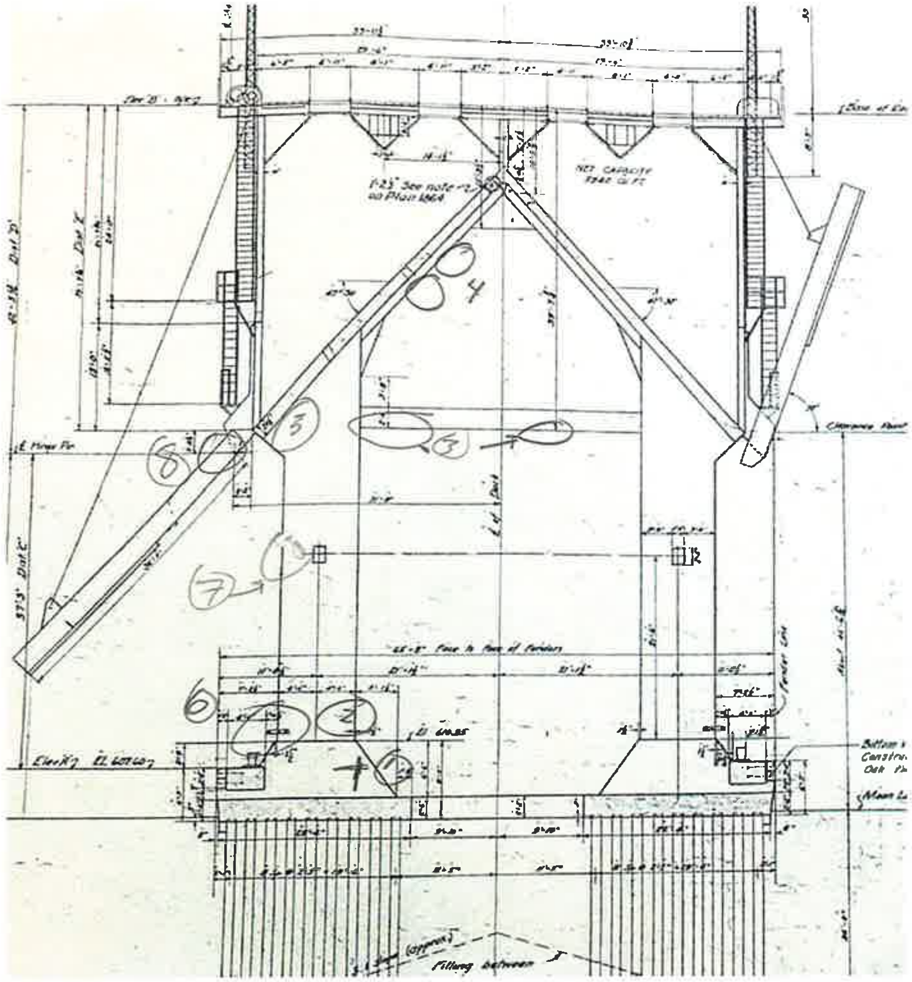
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 3

BENT #: 32



North Inside **COMMENTS/OBSERVATIONS**

	① Vertical Cracking on foot
	② Spalled on upper foot SW Side.
	③ Poorly Consolidated again/Rebar Visible
4531	④ Markings on Ceiling, Possibility of Spall
	⑤ Rebar visible on Ease of 32
	North Outer -
	Cracking on North Walkway (2 spots)
	Between 31+32 4544
⑥	Cracking on NW Corner (top of foot)
⑦	Spalling on NW Edge of Vert. 4445
⑧	Spalling on Overhang 31+32
South Out	4573 32-31 Crack walkway
	4574

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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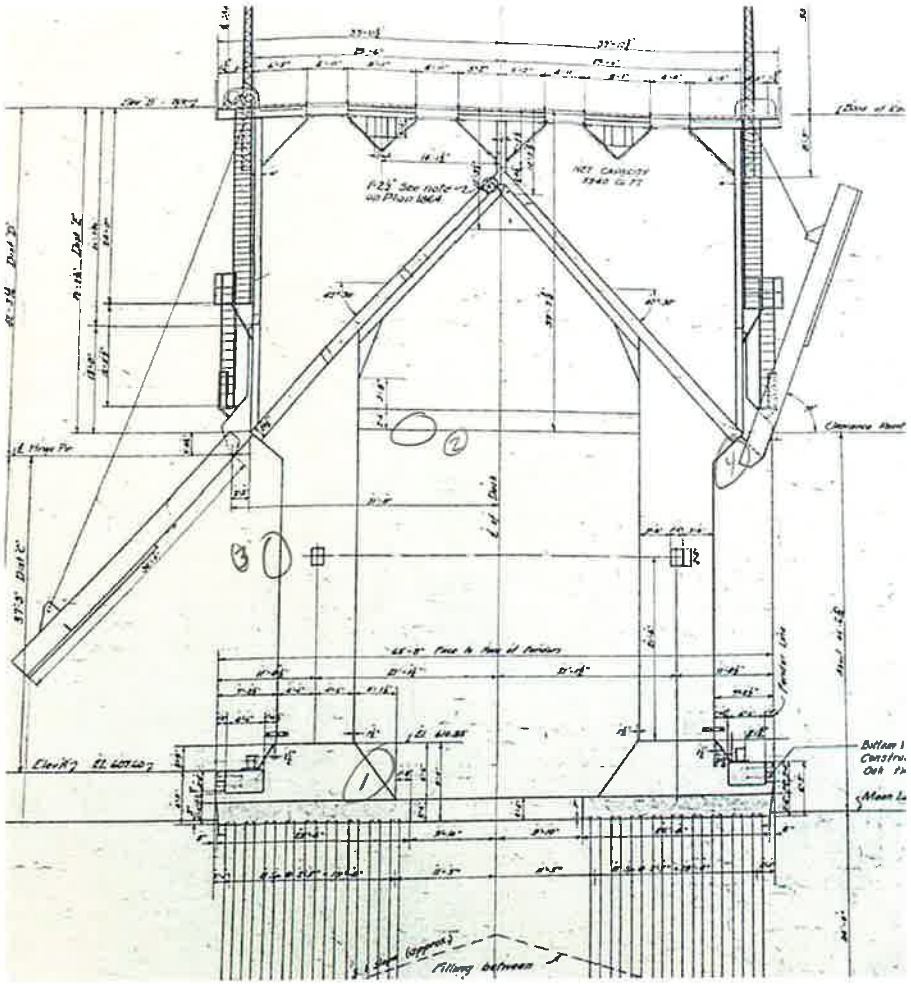
SECTION #: 3

BENT #: 33



COMMENTS/OBSERVATIONS

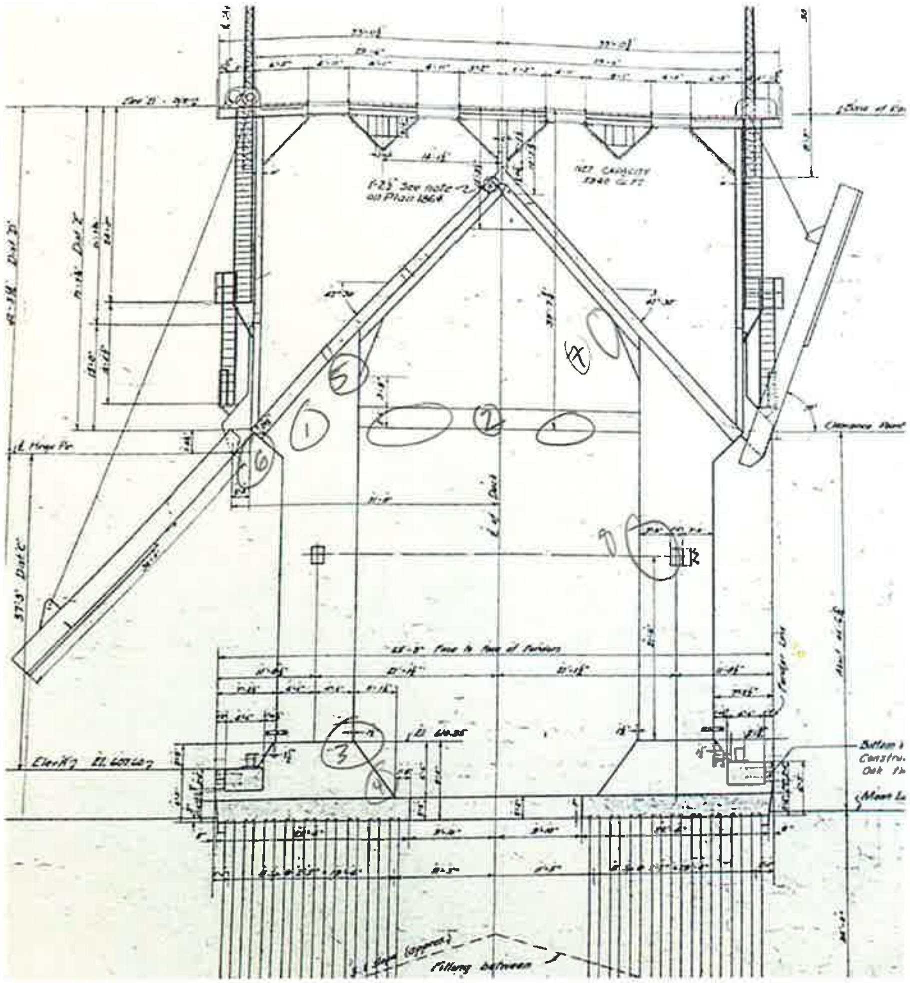
① Vertical Cracking on foot,
Not uncommon.
② Spall in Concrete w/Rebar showing
4533
* North Outer ③ Spalling is apparent on NW Edge
4542 4543 Cracking on North Walkway of 32→33
33→34 Cracking on North Walkway
South Inner
NE Corner delamination 4565
South Out Exposed Rebar 4571
32→33 4572 Cracking

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 3

BENT #: 34



Spalling on West of foot 3553

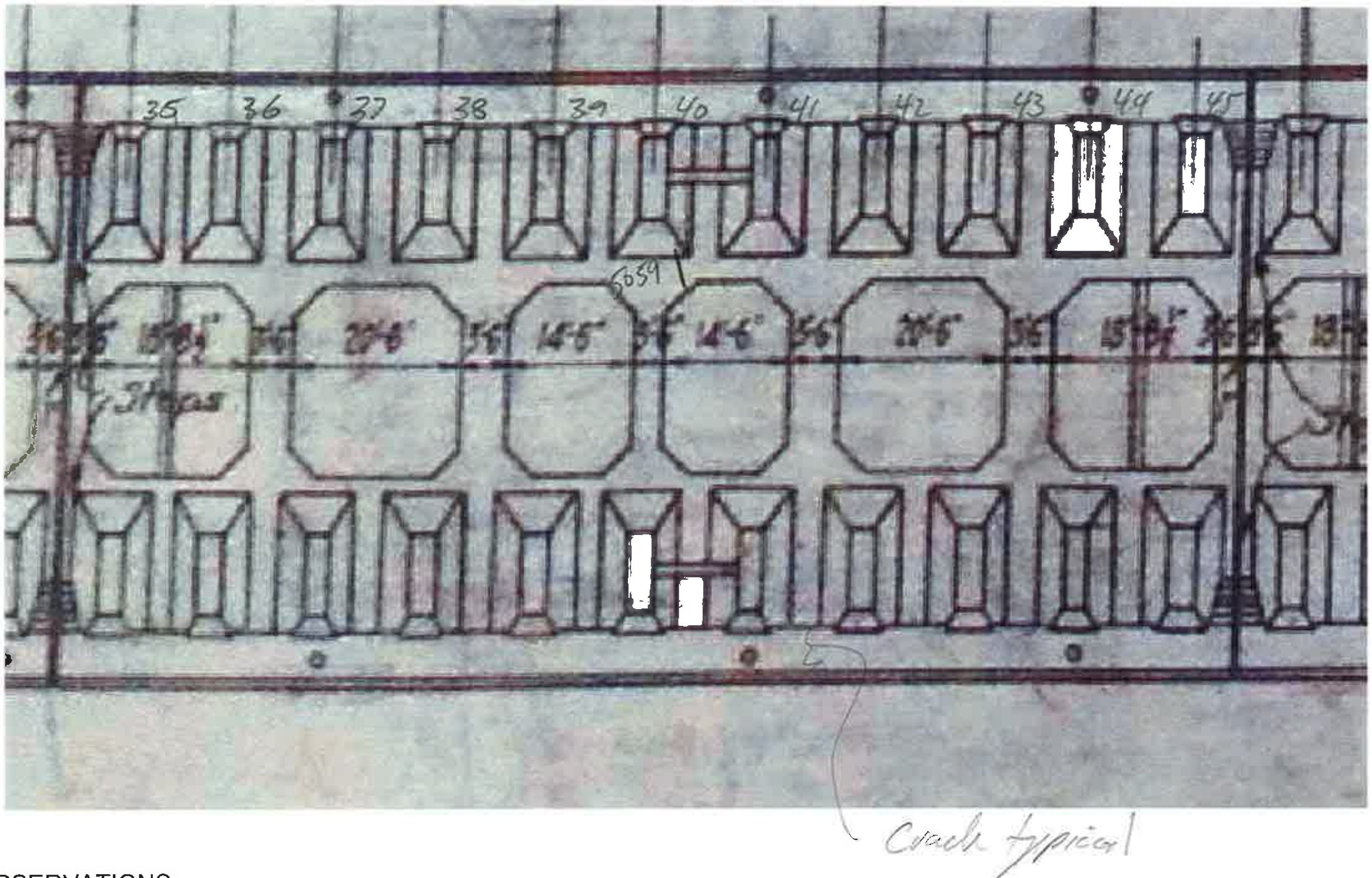
COMMENTS/OBSERVATIONS

North Inside (1) West Side of Vertical,
Spalling and Rebar Visible.
(2) Poorly consolidated Concrete.
(3) Spalling on SW + SE Edge of Vert.
Rebar is Visible.
(4) Slight Vert. Cracks in Concrete.
Lamp Overhead on East face.
(5) Between 34+35 Spalling has occurred. 3557
* North Outer - (6) Spalling has occurred on overhang
Not uncommon in this section.
(6.) Rebar is standing out + visible.
~~Cracking~~
South Inner
(7) "FF" Exposed Rebar 4566
(8) Patchwork 4567
South Out: Expansion Joint 4568 + 4569
Delamination on Cross Beam 4570

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 4



COMMENTS & OBSERVATIONS

Dimensions match.

Minor conc. deformations

5059 - Construction joint in good condition

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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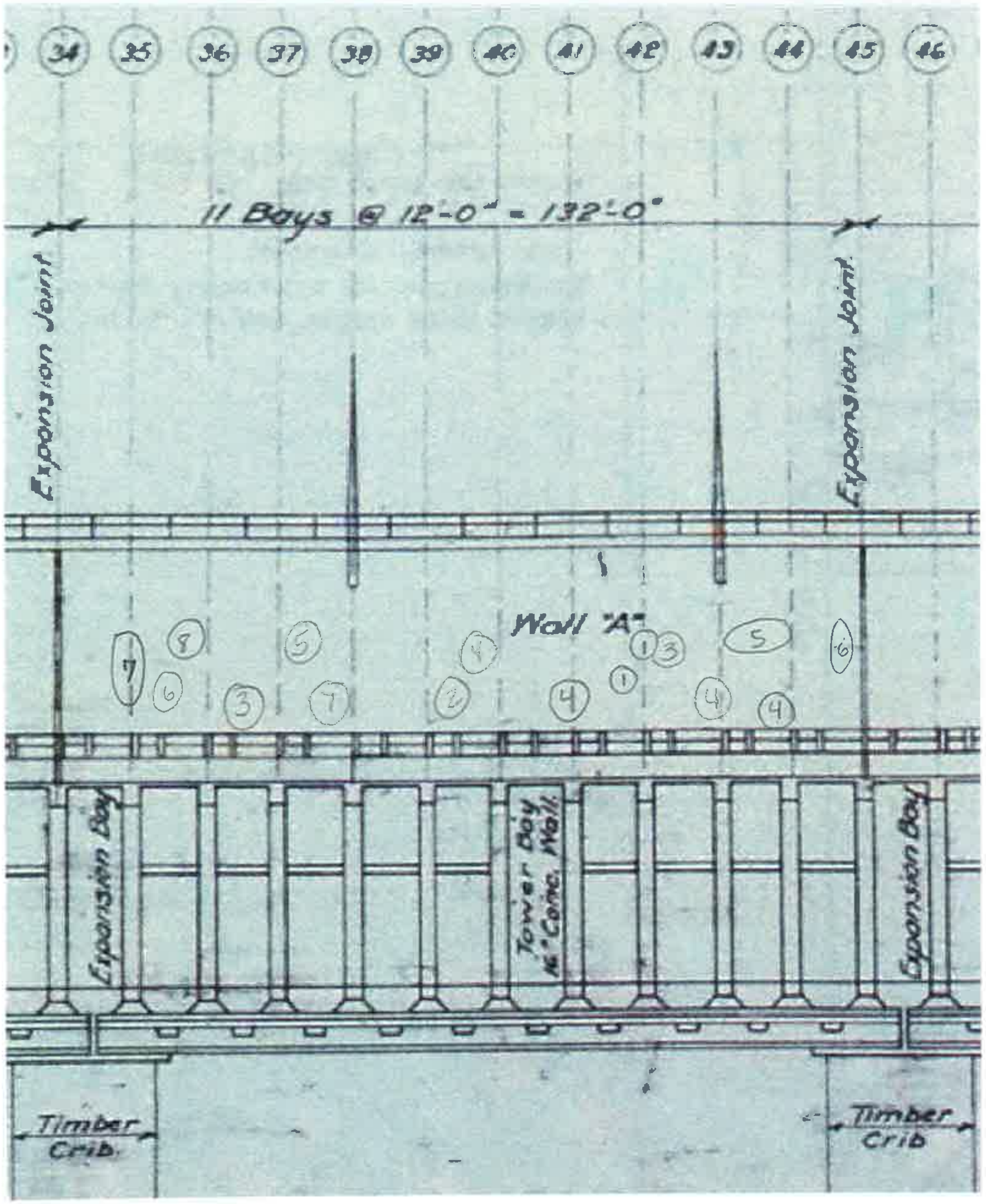
SECTION #:4 (SOUTH SIDE)



COMMENTS & OBSERVATIONS

# of spalls indicated

MARQUETTE ORE DOCK INSPECTION FORM-ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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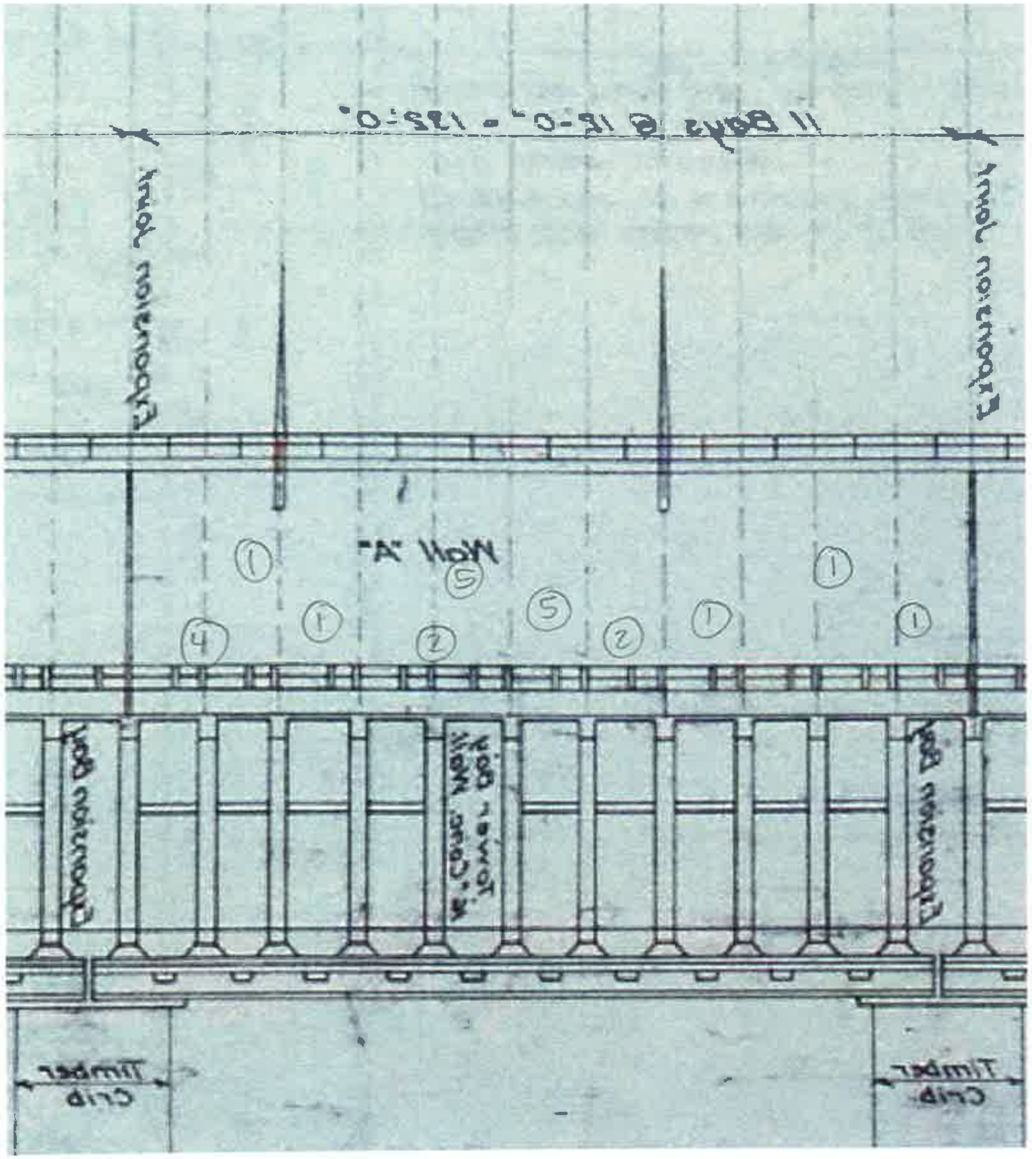
SECTION #:4 (NORTH SIDE)



COMMENTS & OBSERVATIONS

of spalls indicated

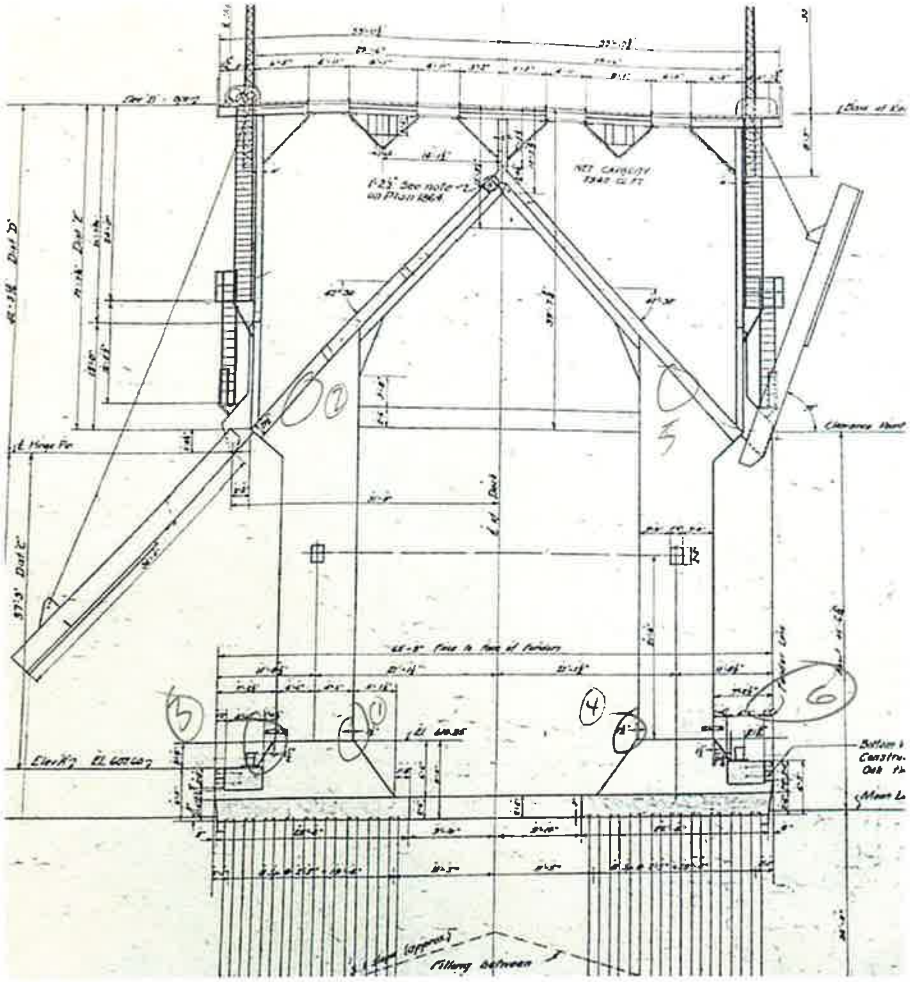
MARQUETTE ORE DOCK INSPECTION FORM- ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 4

BENT #: 35



COMMENTS/OBSERVATIONS

North Inside ① SE Edge Top of Foot Spalling
4587 with Visible Rebar
② Between 35-36 Visible Rebar, probable spalling
4588
③ Outer Vertical cracking & Spalling 4640
on footing 4641
South Inside
Spalling above foot Rebar Visible 4642
(5) 4643 Rebar visible
South Outer
⑥ Delamination - SE & SW Edges of Foot,
Overhead Lamp

4740
4741
4742

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

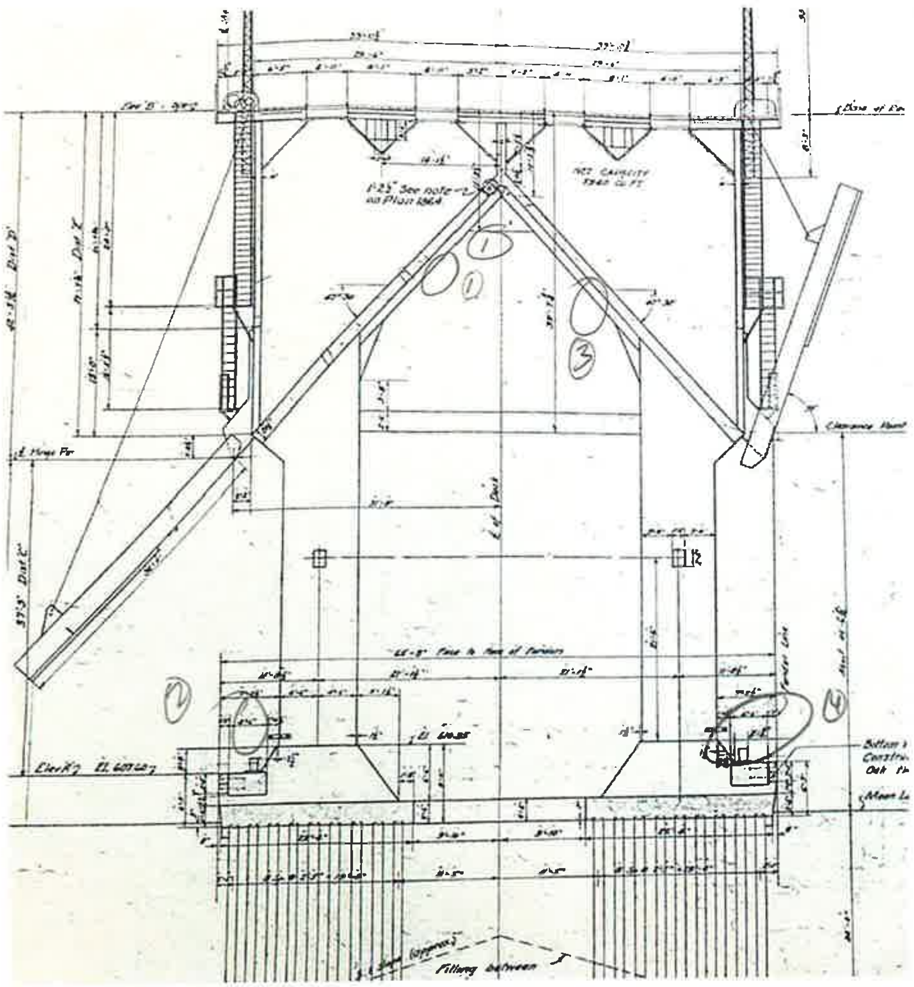
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 4

BENT #: 36



COMMENTS/OBSERVATIONS

North Inside: 1 Rebar visible in Crotch of Ceiling
4589 4590
Outer 4638 Crack in North Walkway
2 Delamination on lower NE 4639
South Inside.
3 Delamination in between 36-37
Rebar apparent. 4701
South Outer.
Crack in South walkway 36-37
Crack + Rebar in 36-37 Crossbeam.
4 Delamination on SE + SW Edges of Foot.
4738-39

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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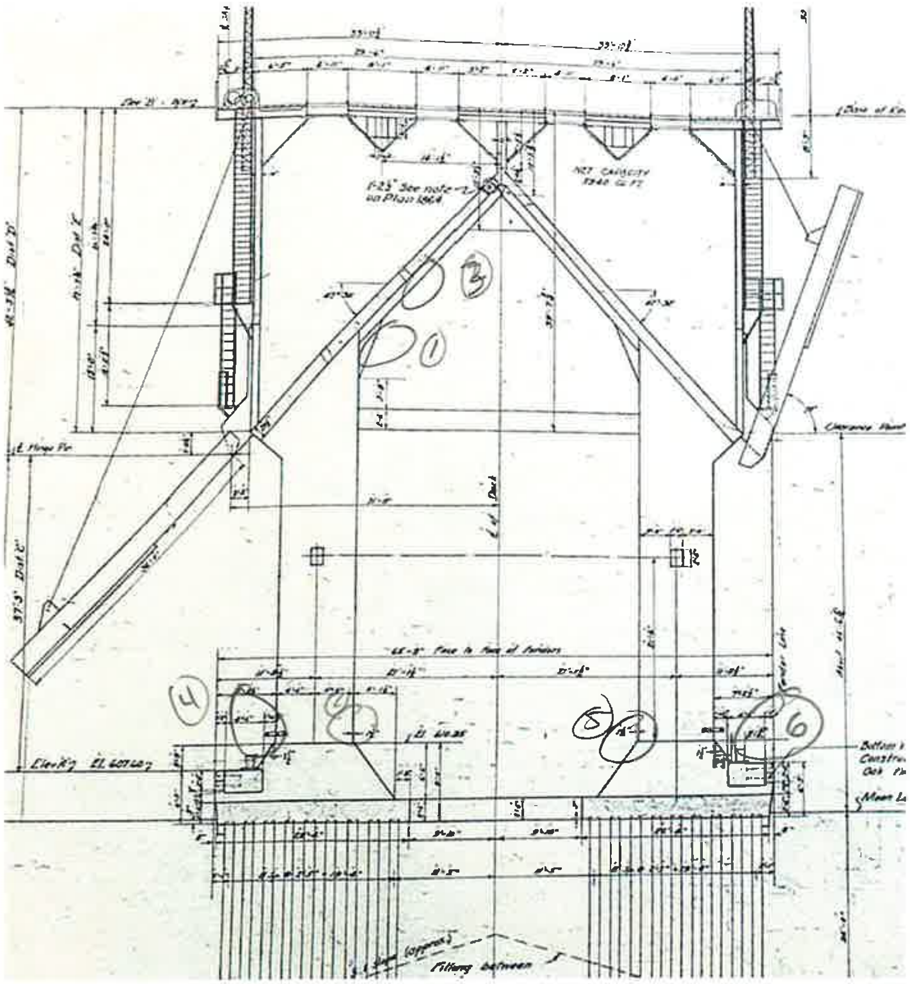
SECTION #: 4

BENT #: 37



COMMENTS/OBSERVATIONS

(1) Rebar Visible w/ spalling 4591
(2) Spalling / delamination SE 4592
Cross Member of 37-38 4593
Rebar Visible.
(3) 4594 Rebar
37-38 Cross Beam Spalling & Rebar
4634-4635
37-38 Crack in North Walkway 4636
(4) NW 4637 Spall w/ Rebar above foot.
South Inside:
(5) spalling and visible Rebar
NE of foot.
South Outer.
4734 (6) Delamination & Spalling of SE+SW foot.
4735 Cracking & Rebar of 37-38 Cross Beam.
Busted Ship anchor.

4736 Crack in Walkway

4737

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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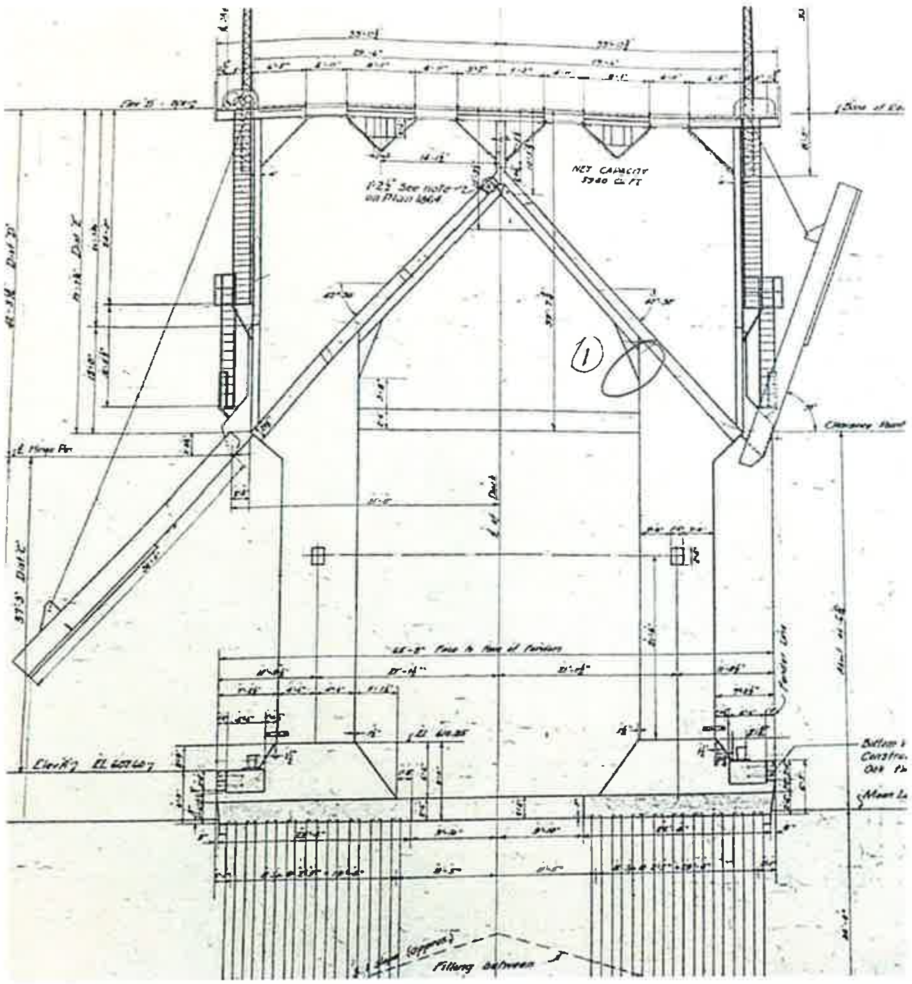
SECTION #: 4

BENT #: 38



COMMENTS/OBSERVATIONS

North Out.

Crack 38-39 4633 North Walkway

South Inside.

38-39

1 Small Piece of Rebar visible on Face.

4703

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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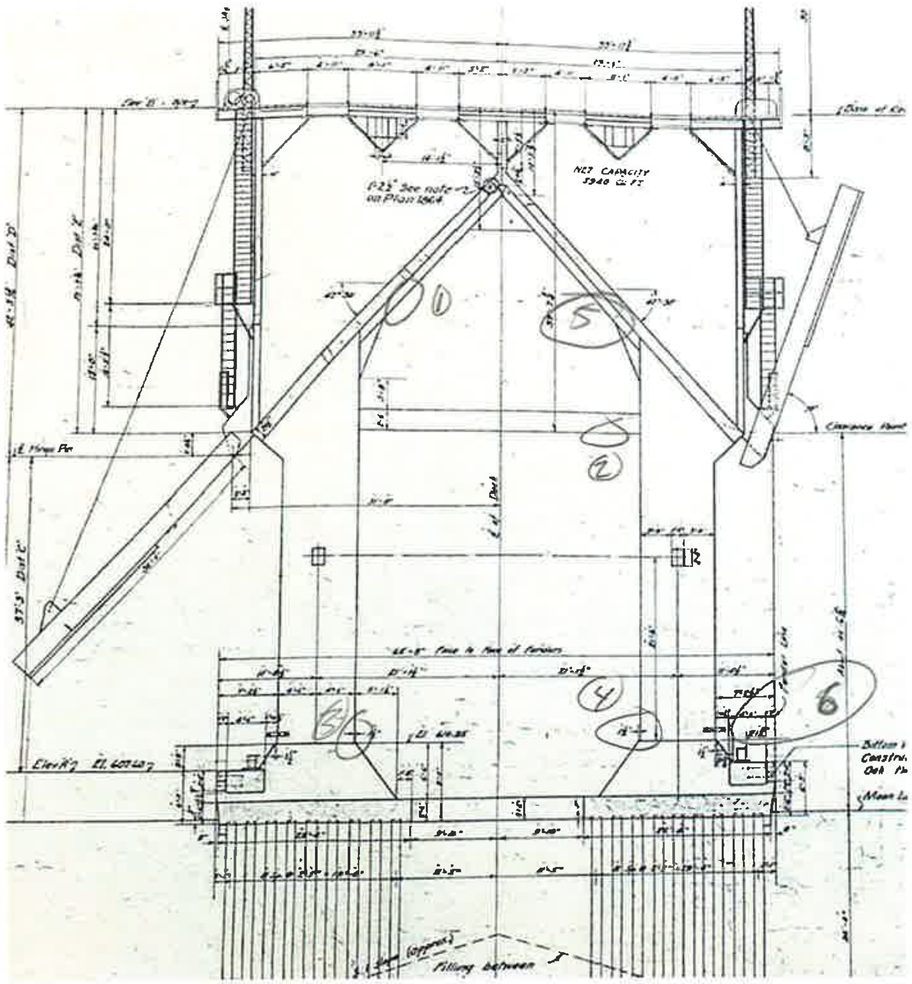
SECTION #: 4

BENT #: 39



COMMENTS/OBSERVATIONS

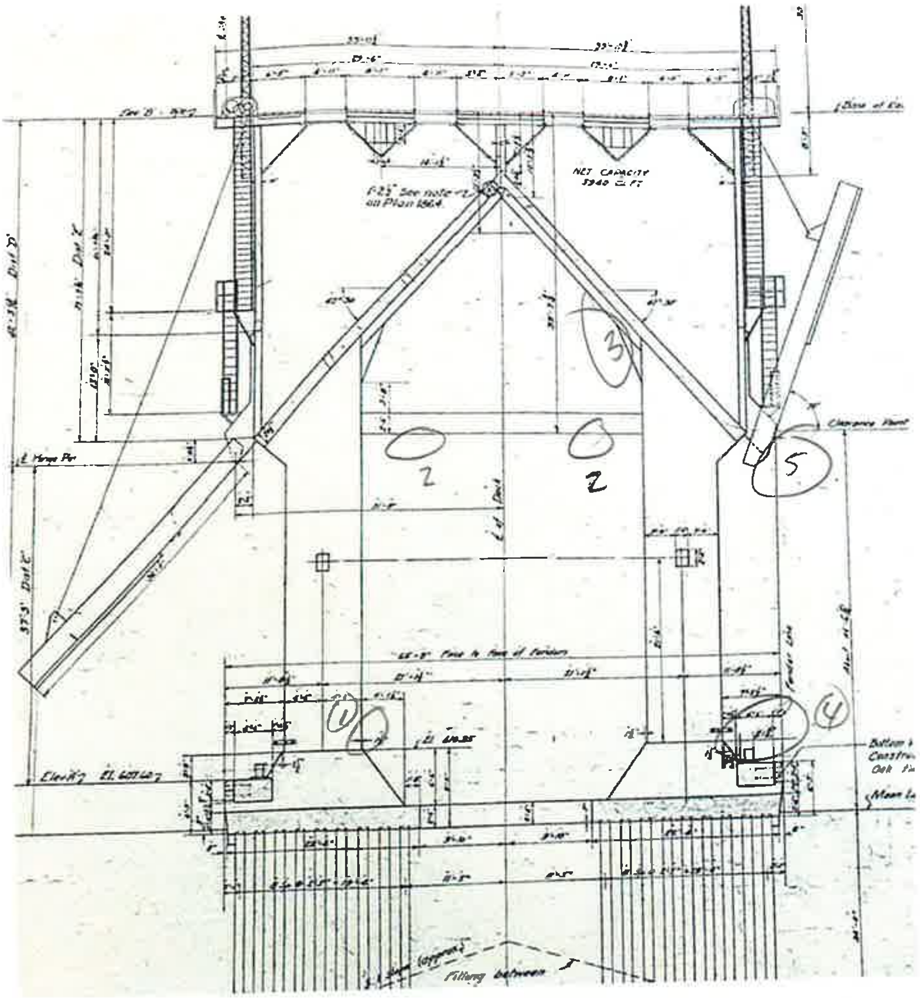
(1) 4595 Rebar Visible
(2) 4596 Rebar Exposed
(3.) Delamination 4597
Hazardous lighting Fixture 4598
South Fascia (4) small spalling on
NW of foot edge. 4704
(5) Cracking on face of Slant
4705 Possible poorly consolidated Concrete.
South Outer
(6) Delamination SO SW & SE Corners of Foot.
4733

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 4

BENT #: 40



COMMENTS/OBSERVATIONS

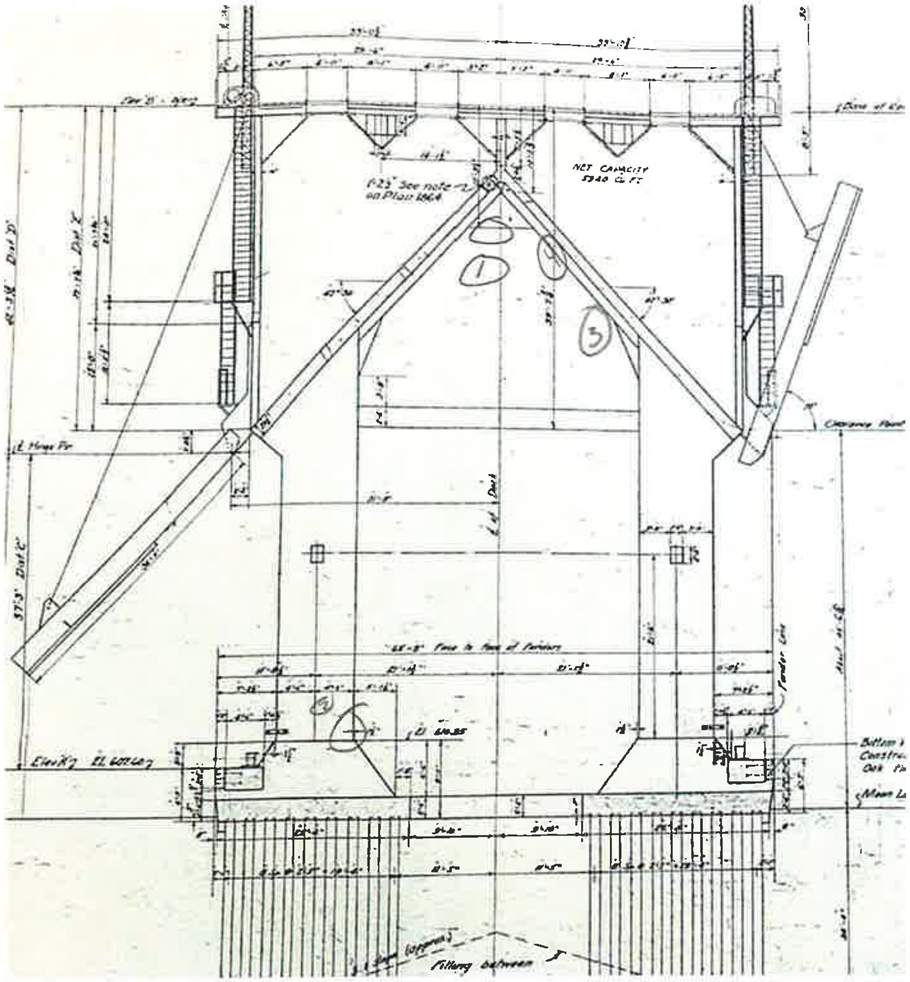
	(1) Spalling SW Edge Top of Foot
	4599
	4600 4601 Rebar Exposed
North OH Ext	4632 39-40 Crack Walkway North.
	South Inside:
	Note: Power Boxes & ladder
	Attached. 4706
4707	Vertical Cracking on North face of 40-41
4708	~~Gate~~ (3) Rebar exposed on slanted Ceiling Face
	South Outer
	Spalling w/exposed Rebar on
4720	South of Walkway.
4730	(4) Delamination of SW edge of foot.
4731	Lamp Overhead.
4732	(5) Cracking on Edge.
4729	40-41 Vertical Cracking

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 4

BENT #: 41



COMMENTS/OBSERVATIONS

Rebar exposed on South face of 40-41
4602
1 Rebar visible in Crotch of Ceiling.
4603
2 Spalling Rebar exposed 4604 SE Edge
North Outside - 4631 40-41 Bottom shoot Spalling.
South Inside.
Cross beam of 41-42 Has Cracking 4708
also Cracking on 3 ceiling.
4 Rebar exposed between 41-42
South Outer.
4726 Crack on 41-42 walkway Southside.
4727 Crack in 41-42 Cross Beam.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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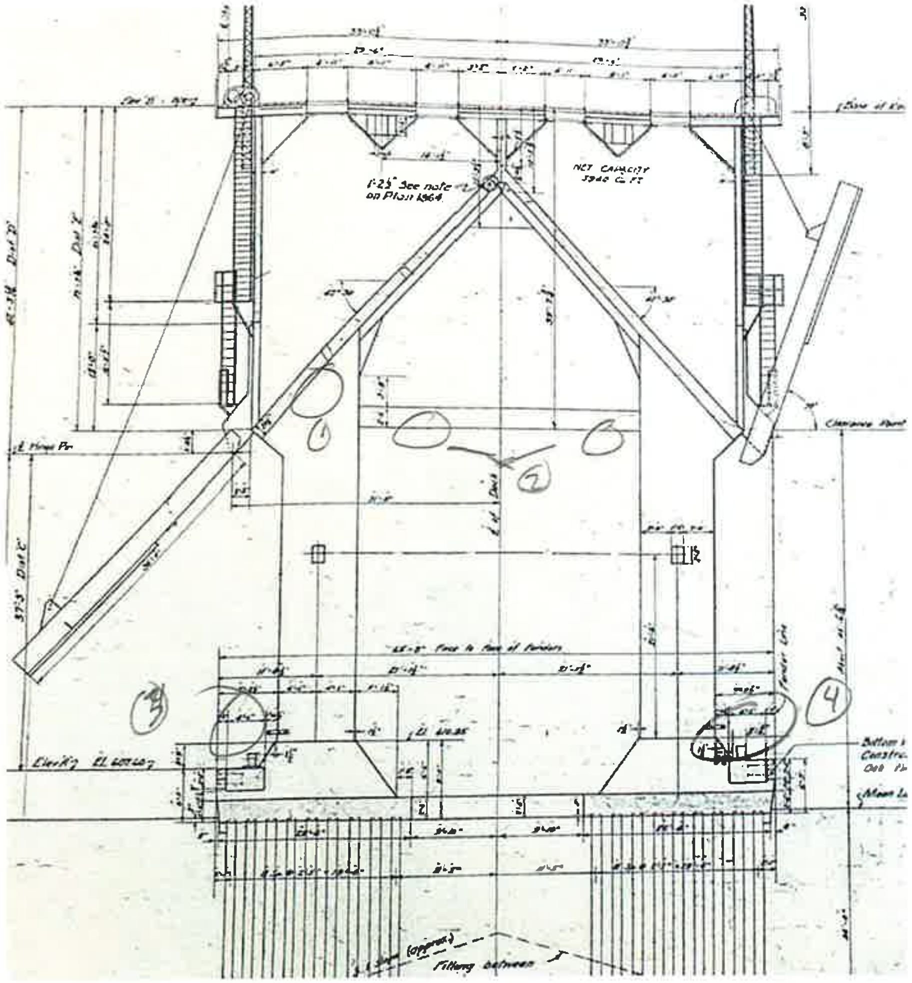
SECTION #: 4

BENT #: 42



COMMENTS/OBSERVATIONS

1	41-42 Rebar Exposed 4605
	2 Rebar exposed Cracking as well
North	Arch
	42-43 Crack on North Walkway
	3 NE Rebar Exposed 4628
	41-42 4629 Cracking on Crossbeam.
	41-42 4630 Crack on North Walkway.
	South Inside: 42-43 Crack on
	South walkway.
4	Delamination on SE & SW Edge of
	Top of Foot. 4724-25

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
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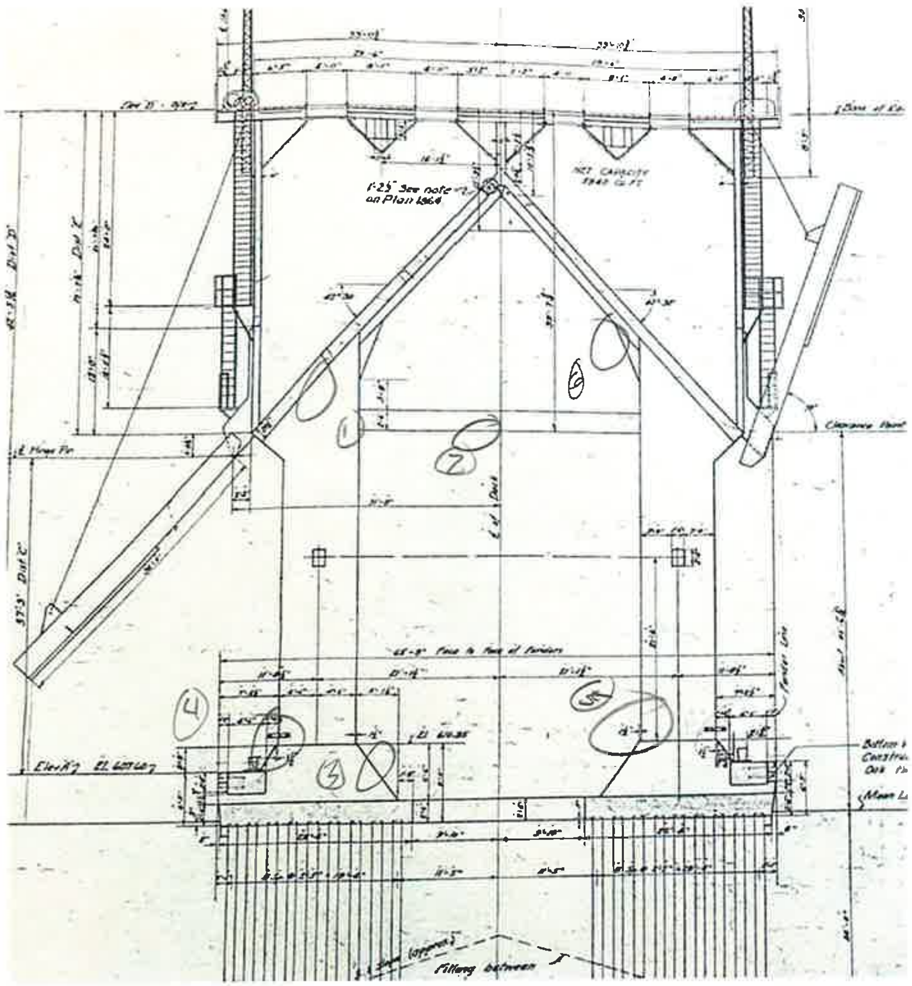
SECTION #: 4

BENT #: 43



COMMENTS/OBSERVATIONS

42-43 4608 (1) Rebar exposed
(2) Potential Cracking. 4609
(3) 4610 Vertical Cracking.
North Outer
Cracking on North Walkway 4624 43-44
(4) 4625 4626 Delamination on NE+NW Edges
South Inside:
(5) Top of Foot NE+NW Spalling
w/ exposed rebar. 4710 4711
4712 (6) Exposed Rebar 43-44 on Face of Slant.
South Out. Crack on 43-44
South Walkway. 4723

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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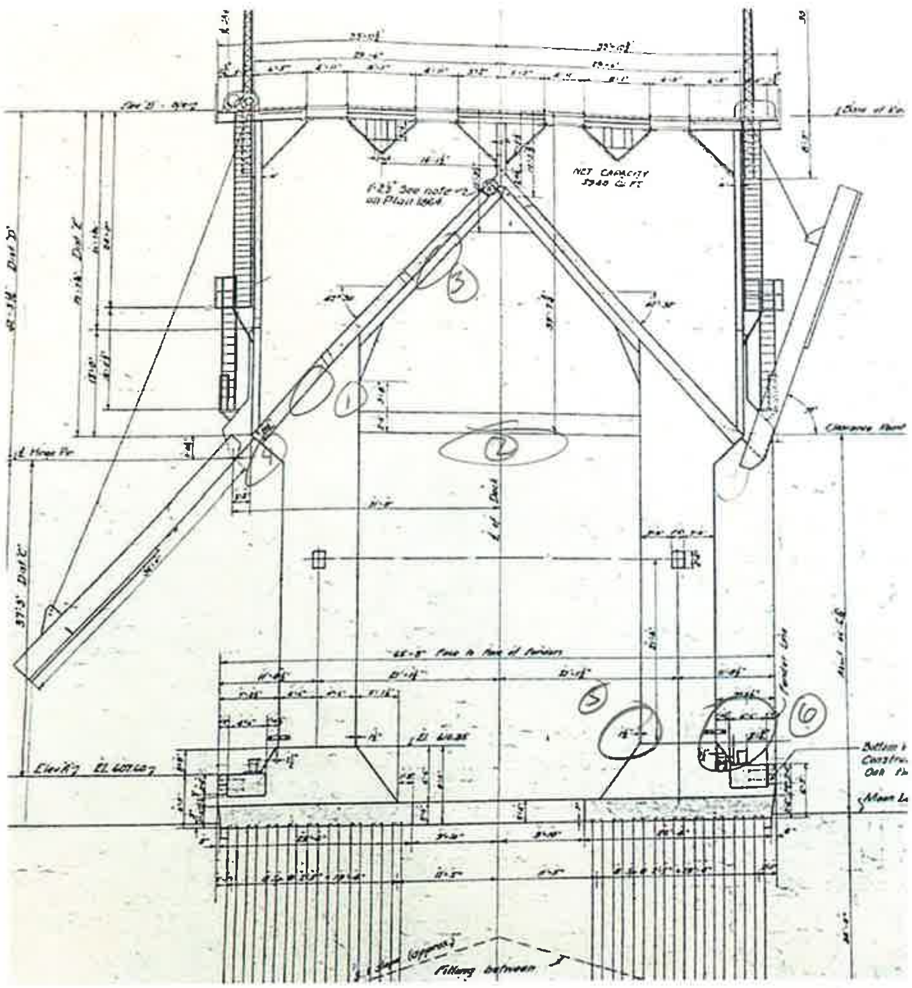
SECTION #: 4

BENT #: 44



COMMENTS/OBSERVATIONS

4611 (1) Rebar Visible between 43-44
4612 lower on Foot Rebar exposed.
(2) 4613 Possible Cracking
(3) 4614 Rebar exposed,
North Outer
4622 Spalling/exposed Rebar on
44-45 Cross Beams
(4) 4623 Spalling on shoot
South Inside
(5) Small delamination on NW Corner of foot
4715 Cracking on Crossbeam of 44-45.
4716 (6) Spalling + Rebar on Top of foot, SE + SW
Edges. 4721-22
(6) Protruding Rebar on West face

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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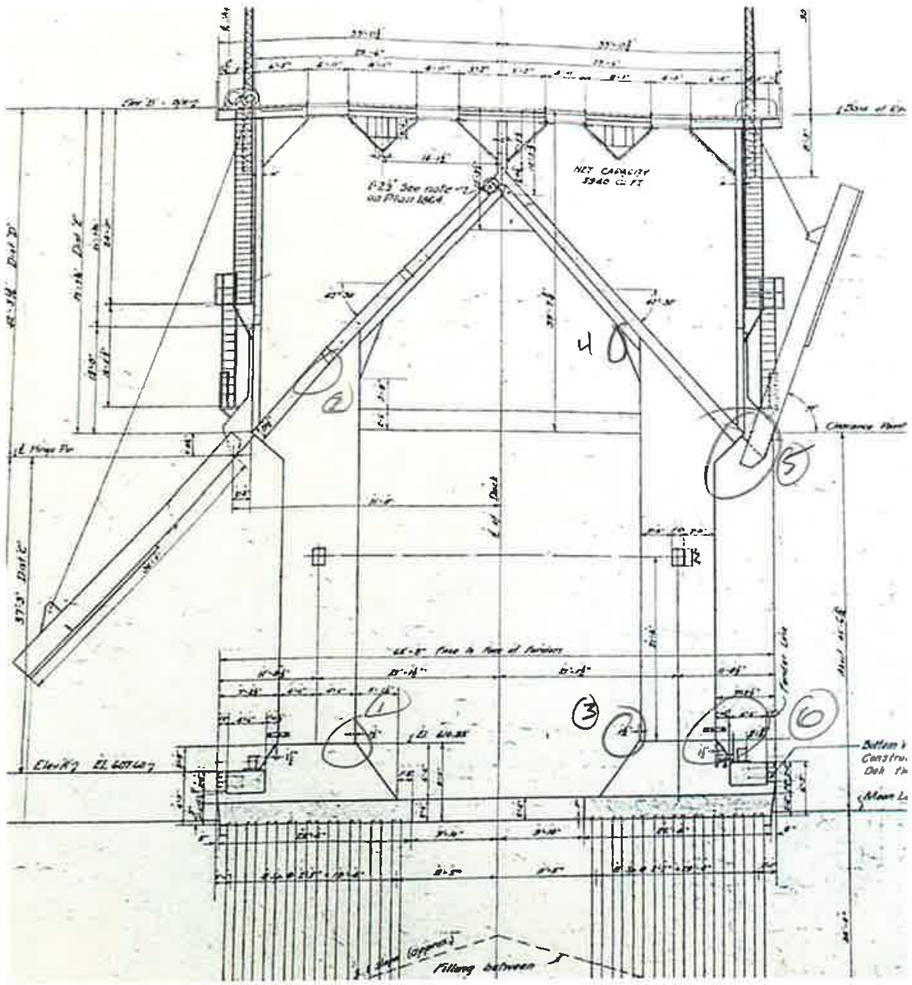
SECTION #: 4

BENT #: 45



COMMENTS/OBSERVATIONS

North Inner

(1) 4615 SW Edge / top of foot, Rebar exposed. 4618

(2) 45-46 4616 Rebar Exposed

4617 is expansion Joint

4619 lighting Fixture

4621 Mon on Expansion Joint

~~North Outer.~~

South Inside;

(3) Spalling on top of foot NW Edge. Rebar.

4715 West face of foot, spalling has occurred.

4716 (4) Slight Rebar visible.

4717 (5) Expansion Joint, some Rebar visible

4718 Cracking and Spalling on Edge

4719 South outer

4720 (6) Rebar visible w/spall on SE Edge of foot.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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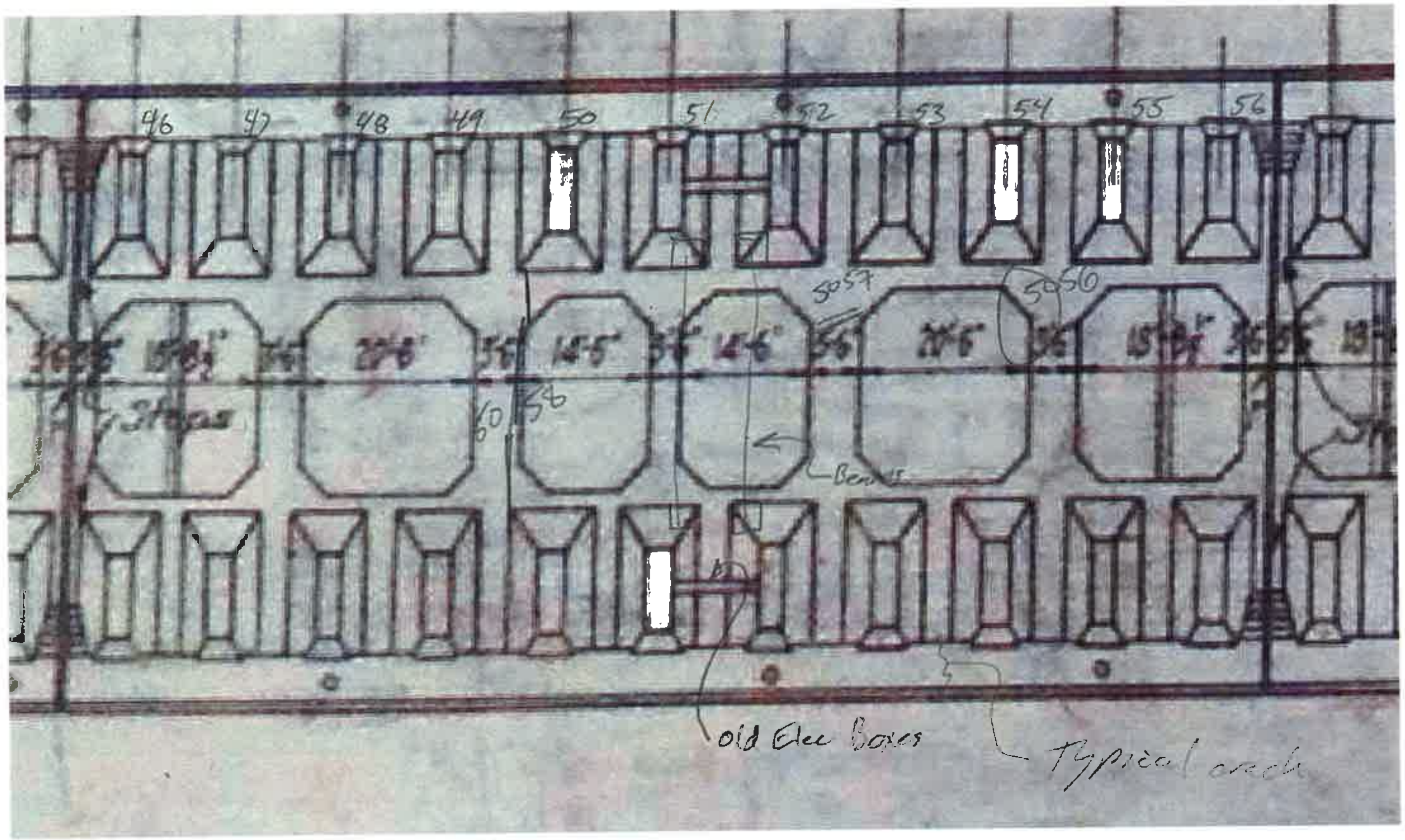
SECTION #: 5



COMMENTS & OBSERVATIONS

Elec Deck between bents 40+41

Dimensions match

Minor conc. deterioration

5056- spalling along interior opening of pile cap

5057- Spalling / delamination of pile cap floor

5058 - Construction joint w/ delamination

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

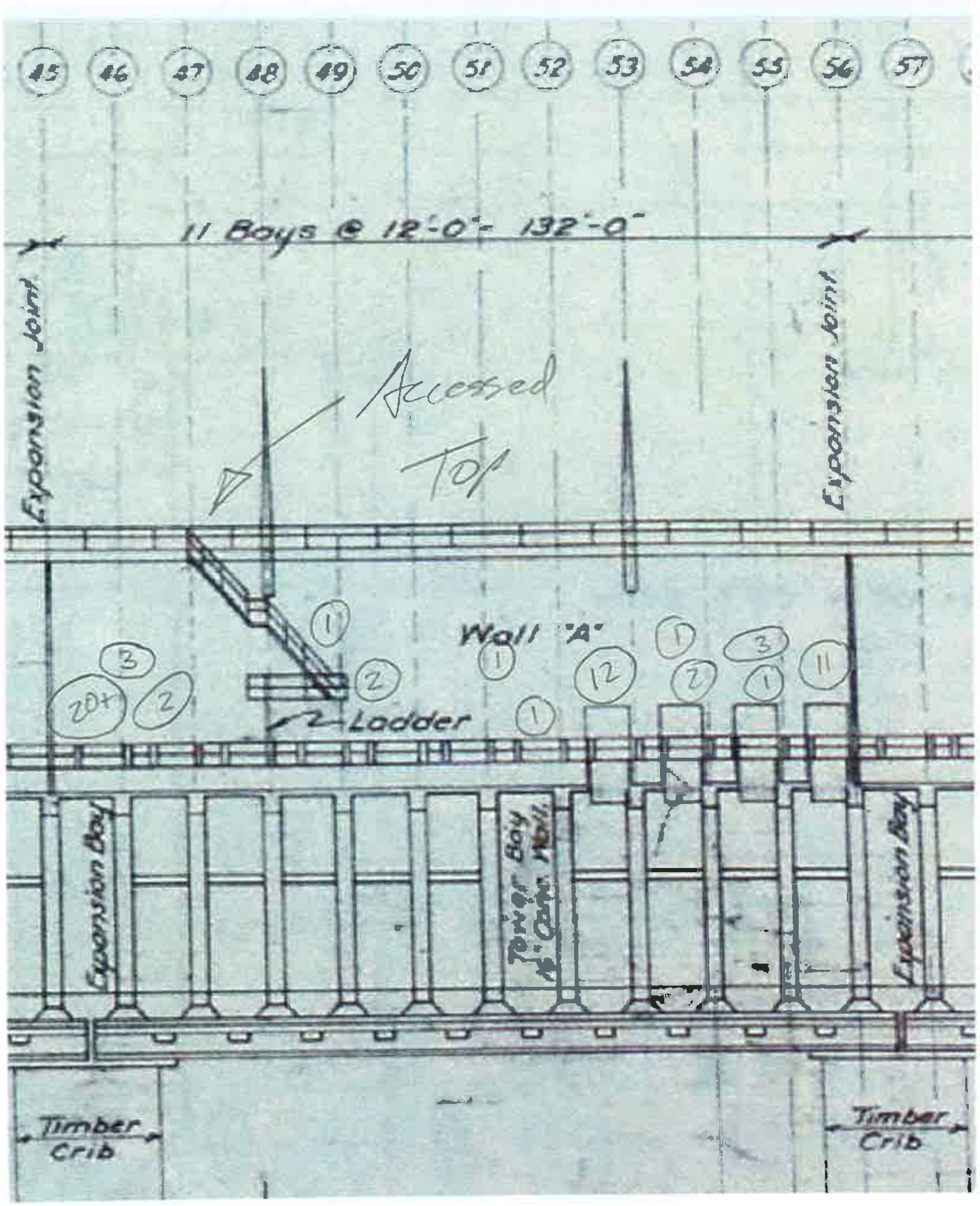
PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #:5 (SOUTH SIDE)



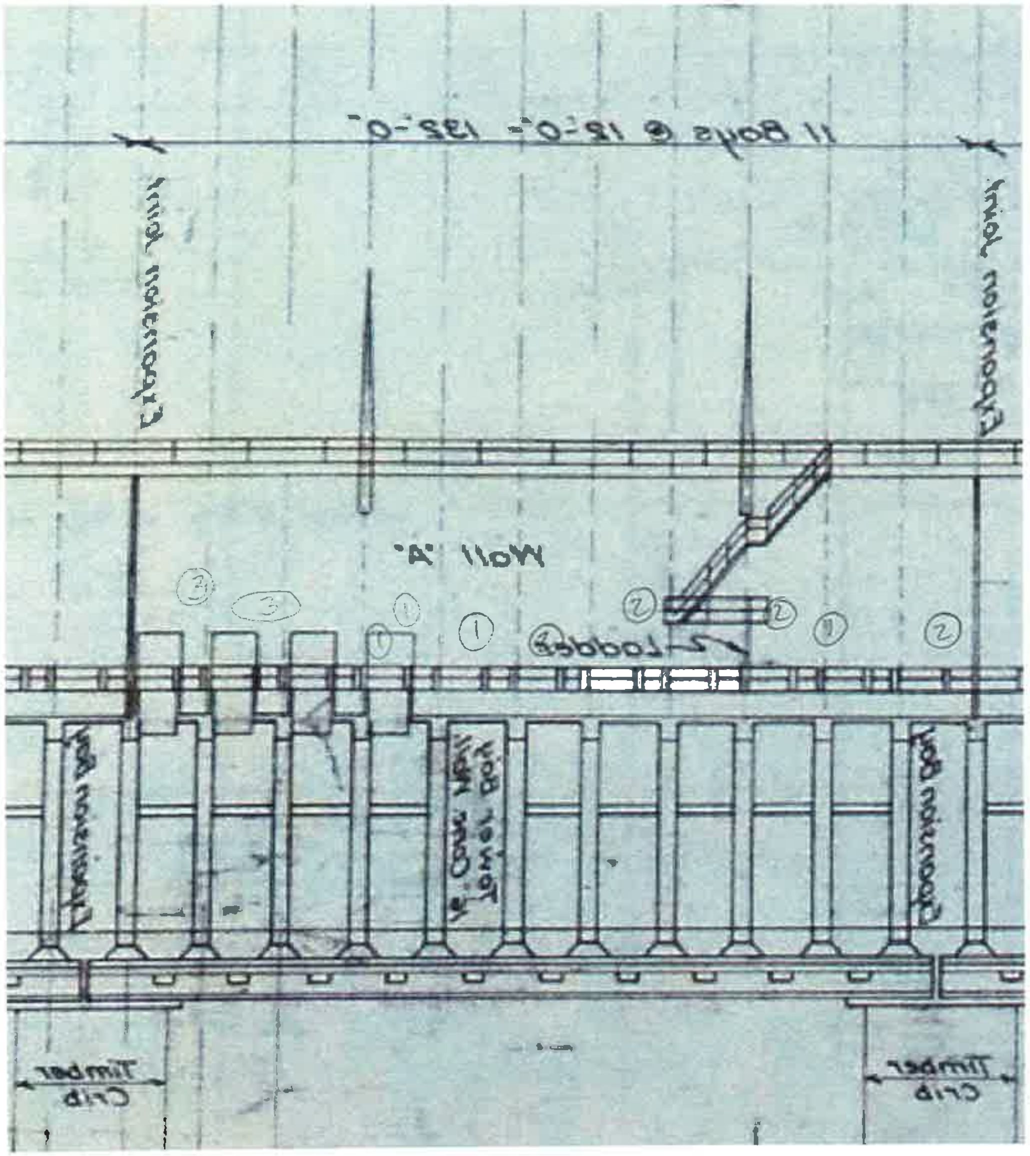
COMMENTS & OBSERVATIONS

# of spalls indicated

MARQUETTE ORE DOCK INSPECTION FORM-ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #:5 (NORTH SIDE)



COMMENTS & OBSERVATIONS

# of spalls indicated

MARQUETTE ORE DOCK INSPECTION FORM-ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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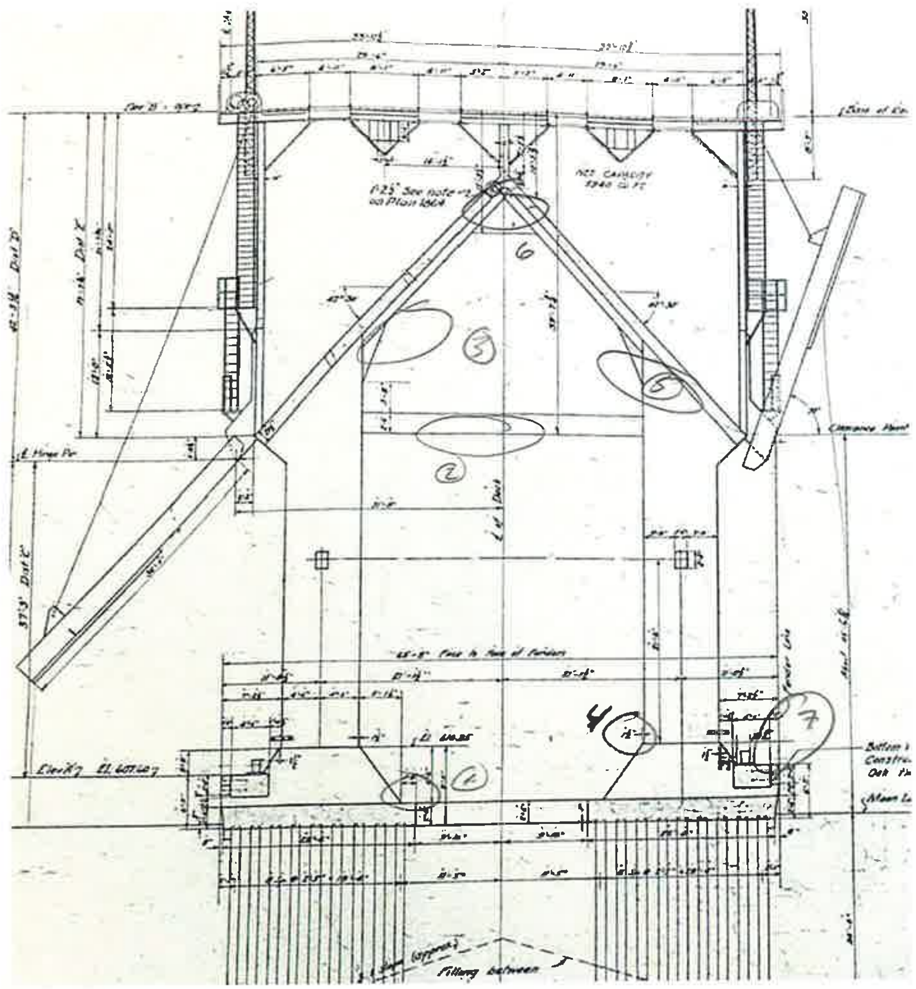
SECTION #: 5

BENT #: 46



COMMENTS/OBSERVATIONS

	North Inside ① Spalling on NW Bottom
	4743 of foot.
4744	② Possible Same Cracking on Crossmember.
	③ Rebar Visible in Several Areas of 46-47
4645	46-47 Cross Member has cracking and
	spalling.
	46-47 Crack in North walkway.
	South Inner
4783	④ Rebar visible NW edge of foot.
	as well as NE edge.
⑤	46-47 on Slanted Face Rebar exposed.
4784	Cracking on 46-47 CrossBeam.
	⑥ Rebar exposed in 46-47 Crotch.
4785	South Outer
4831	46-47 Cracking in Cross Beam
⑦	Delamination in SE + SW Edges of foot.
4832	Lighting Fixture.
4833	

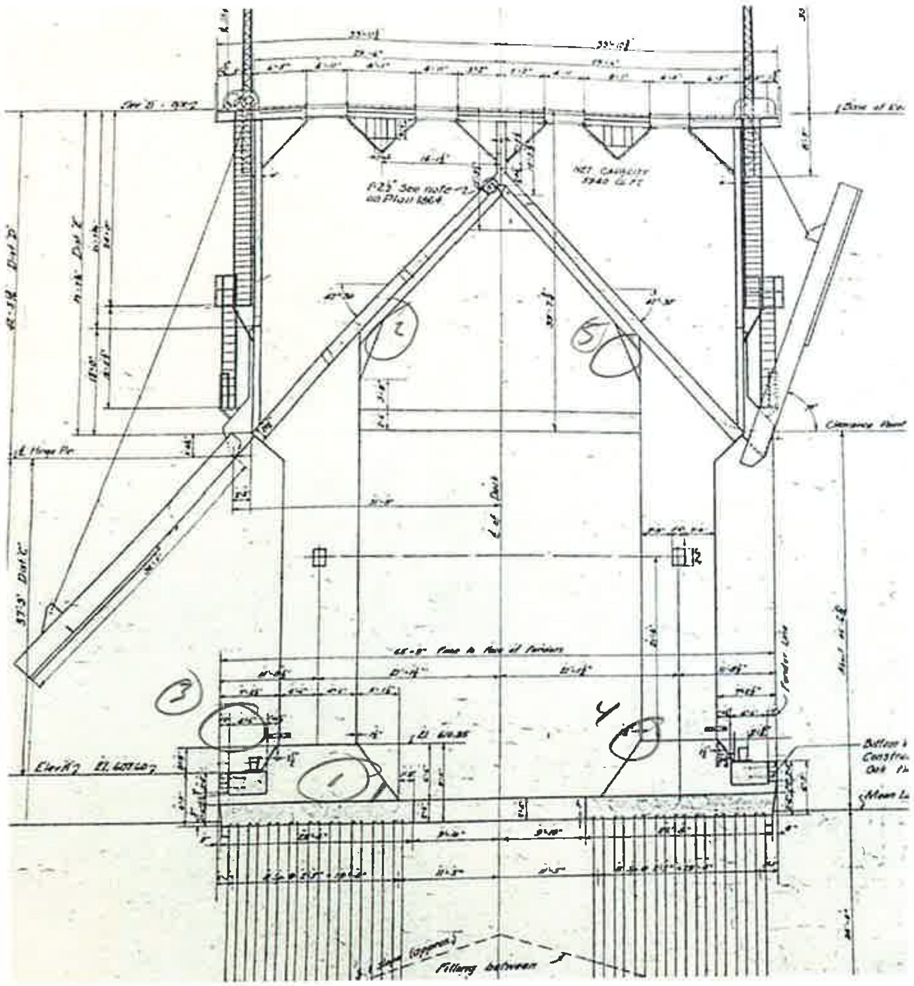
MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 5

BENT #: 47



COMMENTS/OBSERVATIONS

North Inside.

1 Spalling and delamination on base of Foot

4746 as well as SE upper edge. W/Rebar

Vertical Cracking also apparent.

2 Visible Rebar in spots on 47

4747 as well as slanted face of 47-48.

North Outer

4782 Crack in 47-48 North walkway.

3 Rebar exposed on NE side of Foot.

4780 81 as well as NW Edge.

South Inner:

4 Rebar visible on NW Edge. 4786

5 Rebar on triangle. 4787

47-48 Some Rebar on Slanted Face.

4729 South Outer 47-48 Crack in South walkway

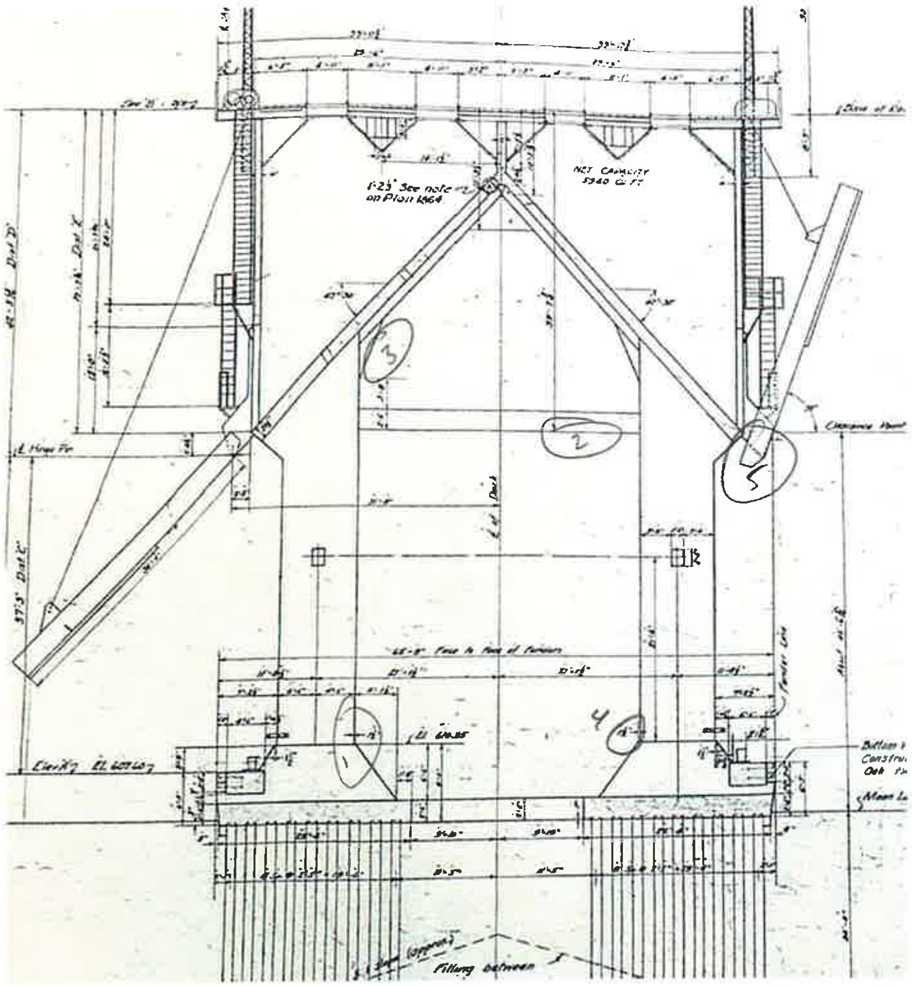
4730 Delamination 47-48 in Cross Beam.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 5

BENT #: 48



COMMENTS/OBSERVATIONS

	North Inside (1) Spalling w/exposed Rebar on SW Edge.
4748	(2) Spalling
(1)	Delamination of SE Edge
4749	(3) Rebar visible,
4750	48-49 Cracking on Slanted Face,
	North Outer
	Crack in 48-49 North walkway.
	South Inner
4788 89	(4) Rebar visible on NE+NW Edges of foot.
	South Outer
4807	48-49 Crack in South Walkway.
(5)	48-49 cracking in Overhang

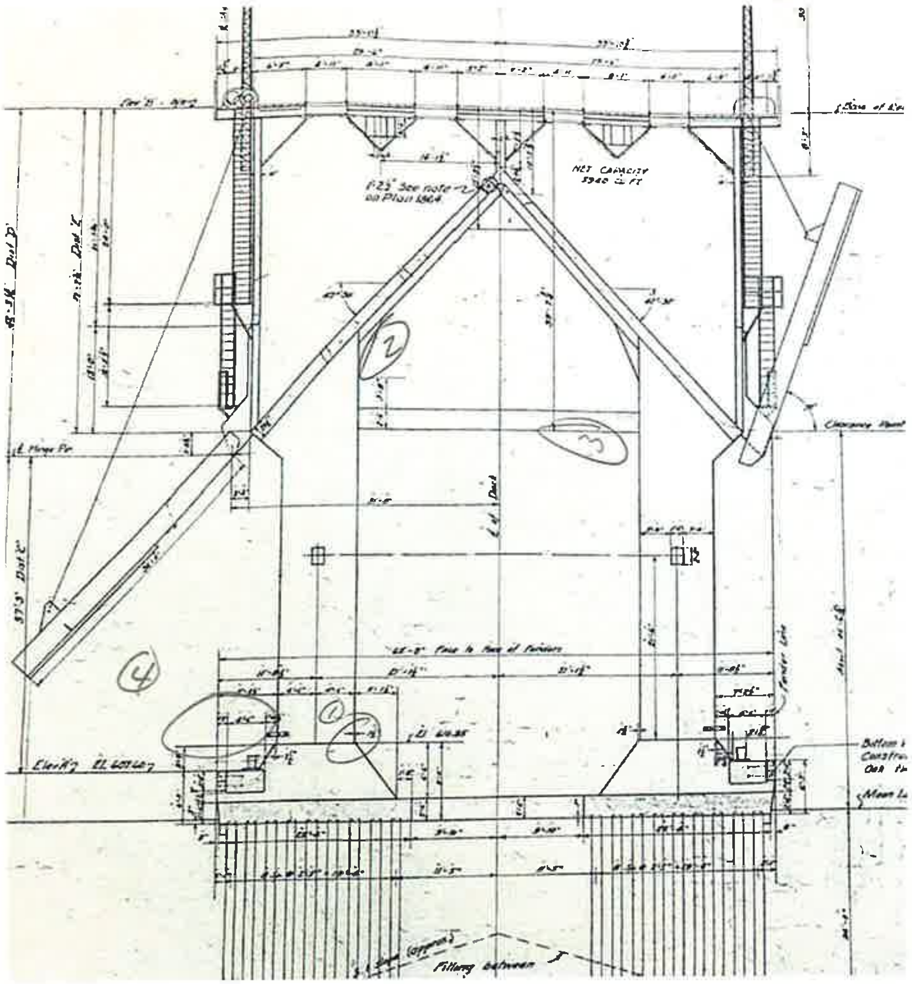
MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 5

BENT #: 49



COMMENTS/OBSERVATIONS

	North Inner 1 Delamination on SW Edge on top
4751	of foot & Spalling on SW Edge on
	4752 Bottom.
2	49-50 Rebar visible on slanted face
5	Rebar visible 4753
	North Outer 49-50 crack on
	North walkway. 4779
4778	49-50 Delamination on Cross Beam
4	Rebar exposed on NE Edge of foot
	South Outer
4824	49-50 Crack on South Walkway.
	49-50 Delamination in Overhang.
	Cross Beam 4825
	Crack in Walkway 4826

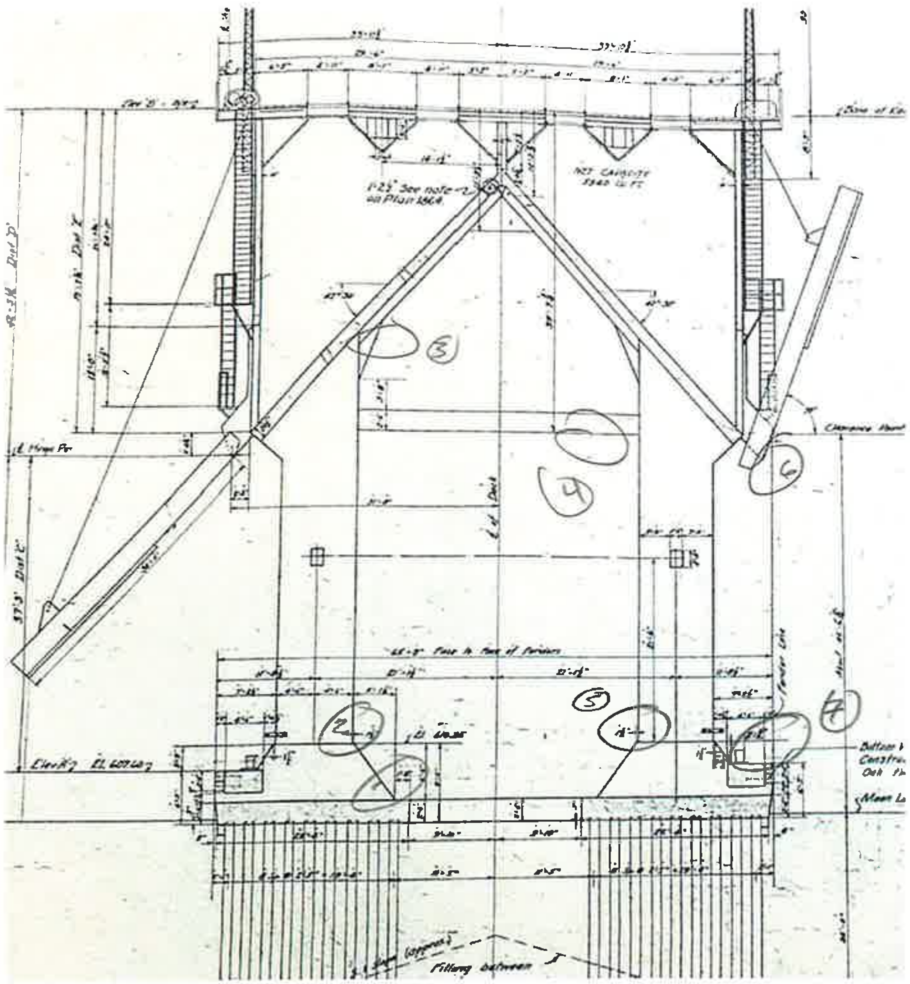
MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 5

BENT #: 50



COMMENTS/OBSERVATIONS

(1) North Inside, Spalling on SW Edge
of bottom foot 4755
(2) Spalling w/ Rebar on South side of Vert.
49-50 cracking on Cross Beam. 4754
(3) Rebar visible
49-50 Rebar visible on Skewed face
(4) Rebar on Ceiling Cross Member
North Outer.
4777 Crack in North Walkway 50-51
South Inside
4781 (5) Spalling ~~Over~~ NE Edge of Foot.
South Outer
(6) Vertical Cracks on Walkway 51-50
(7) Delamination 4823
Cross Beam 4822

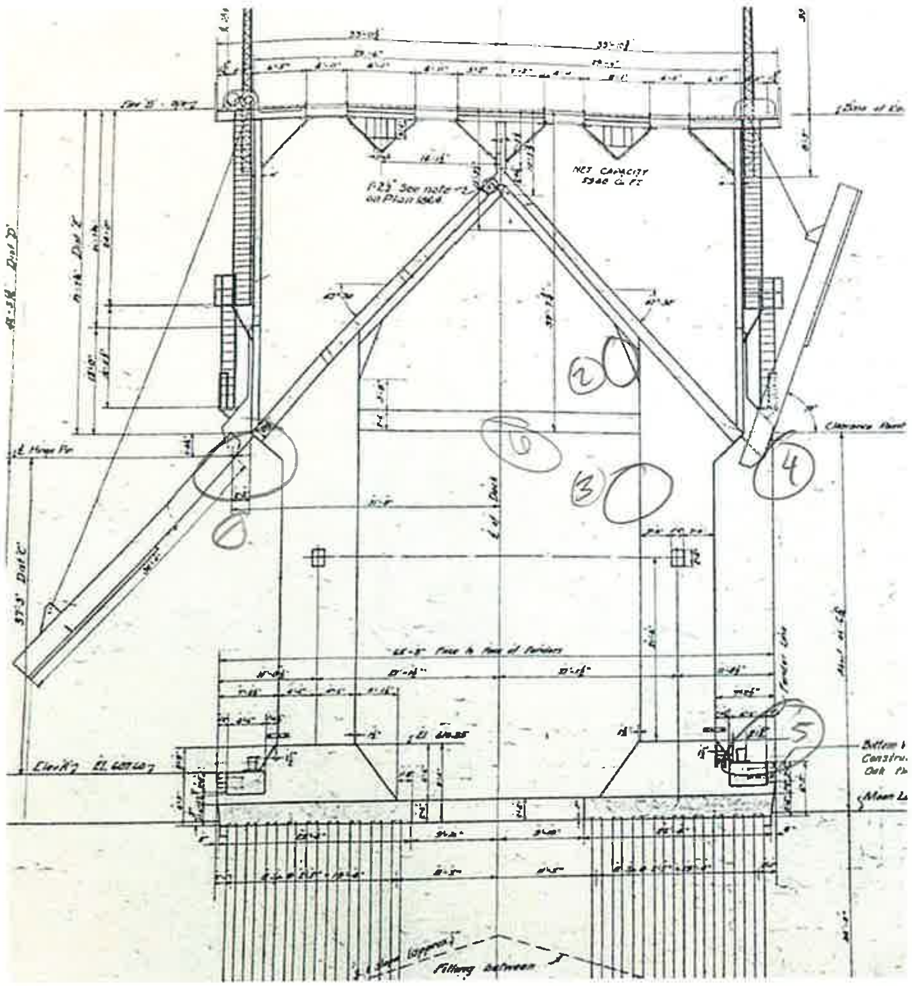
MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 5

BENT #: 51



COMMENTS/OBSERVATIONS

North Inside.
50-51 Rebar Visible on Slanted Face. 4756
North Oute.
① Poorly consolidated conc. on 51-52 on edge.
① Rebar exposed + Delamination.
South Inside. ⑥ 4758
lighting Fixture.
② Rebar Visible. 4757 4759
③ 51-52 Protruding Rebar. 4792
South Outer
4818 51-52 Cracking on Southside of Wall
④ Cracking also on 51-52 Overhang.
⑤ Spalling + Rebar exposed on SE Edge of foot. 4819
4820

MARQUETTE ORE DOCK BENT INSPECTION FORM

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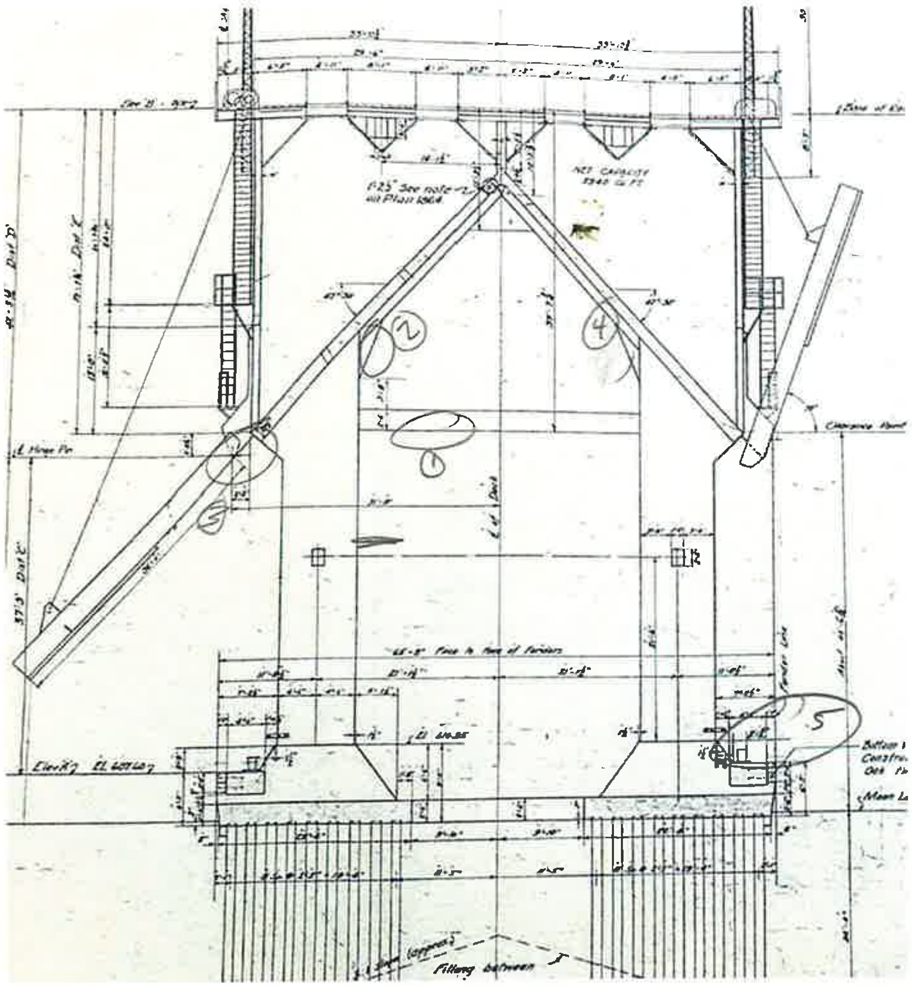
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 5

BENT #: 52



COMMENTS/OBSERVATIONS

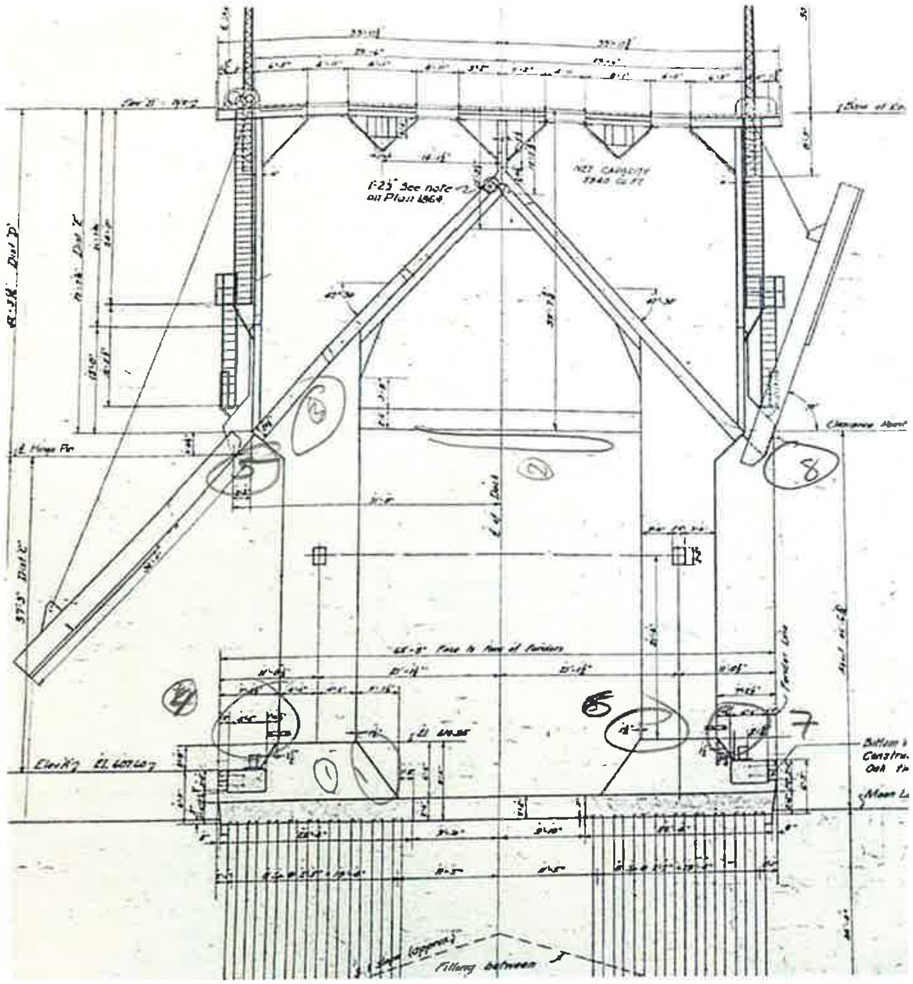
North Inside.
4760 ½ Horizontal Cracking 51-52 South Wall.
① Rebar > Cracking Visible. 4761
Rebar Protruding from 51-52 Wall
② Rebar exposed. 4762
North outer:
③ Poorly consolidated Concrete in [illegible].
52-53 4776
④ Rebar Exposed. 4794
South Outer
⑤ Spall > Rebar on SW Edge of foot. 4818
Crack in Walkway 4816

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 5

BENT #: 53



North Inside

COMMENTS/OBSERVATIONS

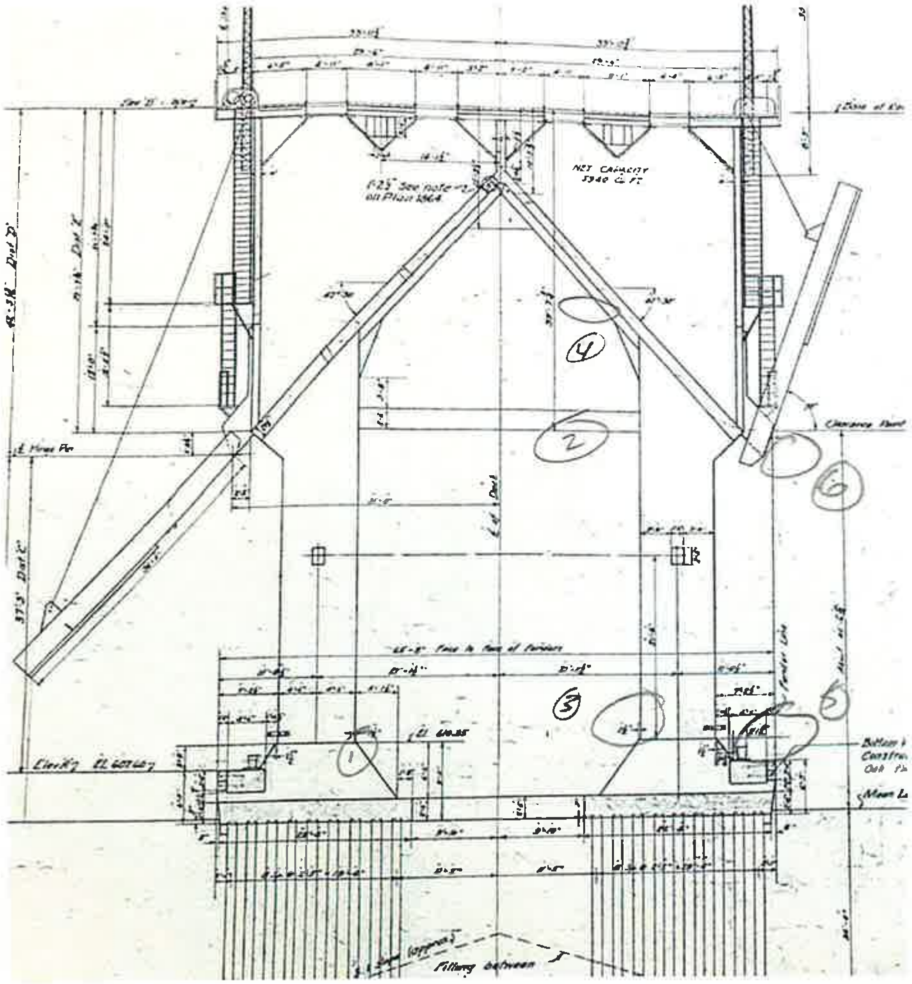
1	Spalling on South face of foot. 4763
	1 Cracking along Beam.
	3 Spalling on Slanted face of 54-53
	North Outer
	4 Delamination NE of foot 4775
	Crack in 53-54 North Walkway 4774
	South Inside
6	Delamination NE Edge of foot. W/Rebar.
4796	53-54 Spalling on Slanted Surface.
	South Outer
4813	Crack in 53-54 South Walkway.
4814 7	spall & Rebar on SE edge of foot.
4815 8	53-54 Vertical Cracking on overhang.
8	Rebar also Visible.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 5

BENT #: 54



COMMENTS/OBSERVATIONS

North Inside: 1 Delamination on SW Edge
at top of foot. 4764
2 Rebar exposed. 4765
South Inside -
4799 3 Spalling w/rebar on NE Edge of Foot.
4801 4 Rebar exposed.
South Outer
4811 54-55 Crack in South Walkway.
4812 5 Spall w/ Rebar on SE Edge of Foot.
6 Rebar Visible.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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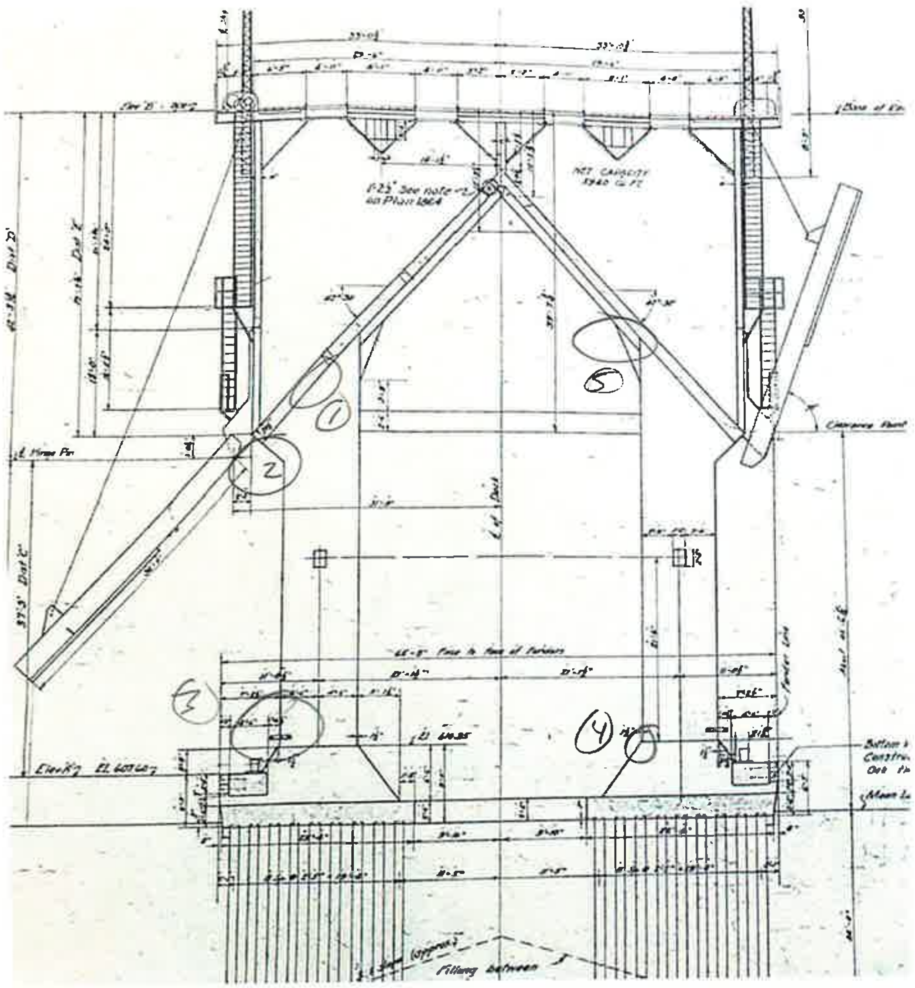
SECTION #: 5

BENT #: 55



COMMENTS/OBSERVATIONS

North Inside (1) Rebar exposed
on Slanted face of 55-56
Multiple Places, 4766
Cracking in Cross Beam 55-56. 4767
(2) Delamination. 55-56
(3) Delamination on top of Foot NE 4773
South Inside.
4802 (4) Spalling w/rebar on NE edge of foot
4803 (5) Rebar exposed.
South Outer.
55-56 Crack in South Walkway 4809

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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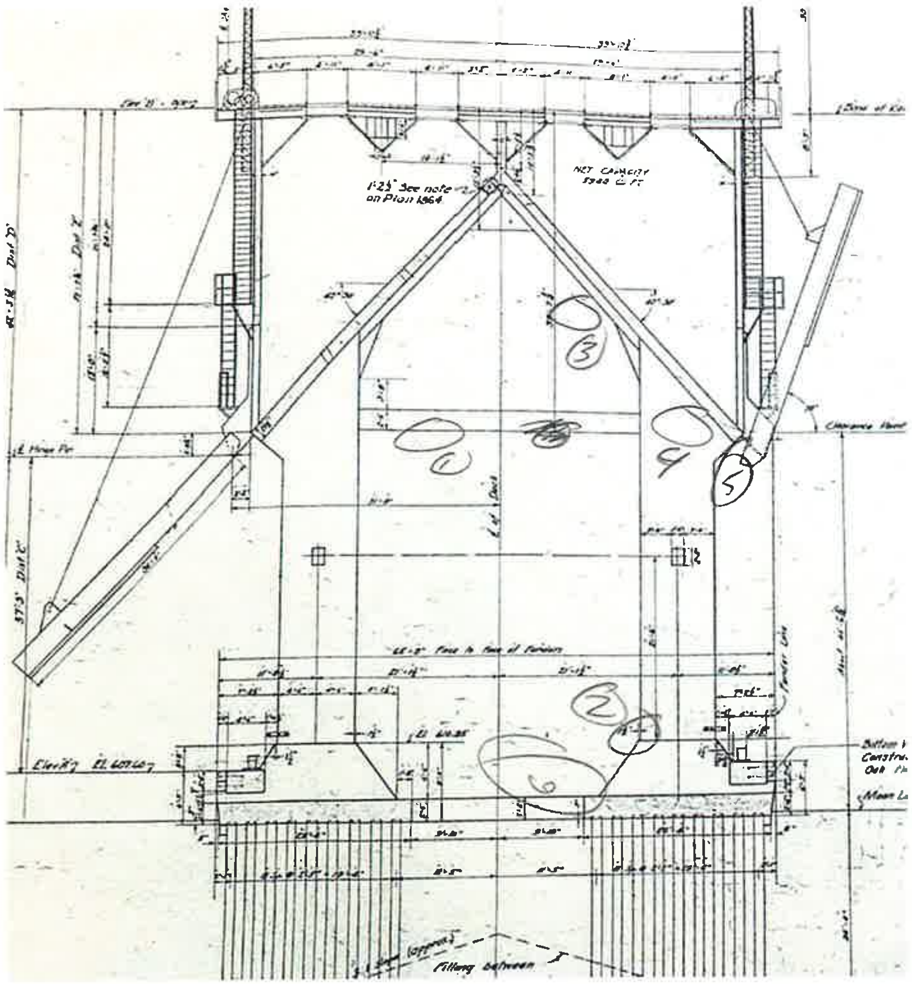
SECTION #: 5

BENT #: 56



COMMENTS/OBSERVATIONS

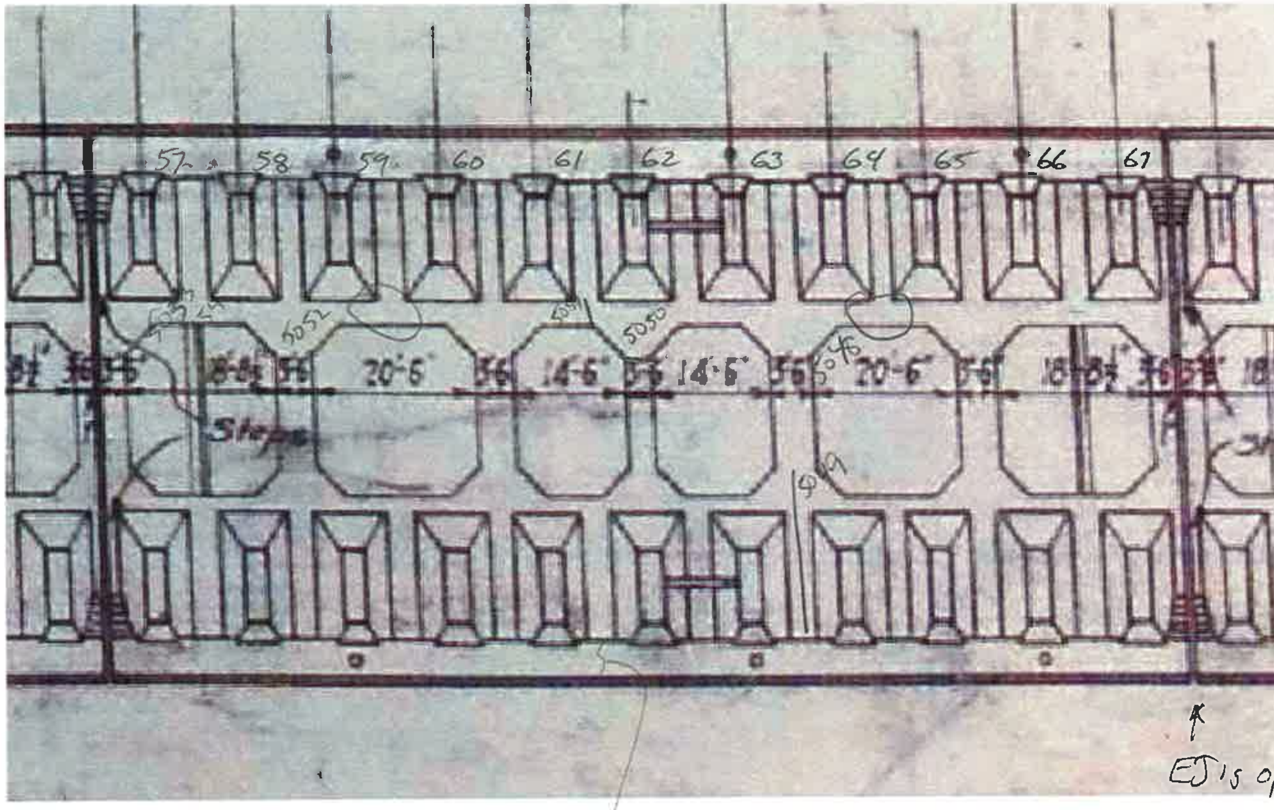
North Inside:
(1) Rebar exposed on Beam. 4769
Rebar exposed on Slanted Face 56-57
Expansion Joint. 4770 4771
Delamination on Expansion Joints
Lighting Fixture 4772
loose Cable. 4768
~~North Outer.~~
South Inner
4805 (2) Delamination on NE edge of Gate
(3) Spalling
4806 (4) Spalling on expansion Joint.
South Outer
(5) Cracking & Rebar visible.
4807 (6) Rebar Ground
4808 Expansion Joint

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 6



EJ is open by 1¼"

Typical crack

COMMENTS & OBSERVATIONS

Dimensions match | 5048 - Delamination @ construction joint

Minor conc. deterioration | 5049 - Construction joint

5050 - Crack across pile cap floor @ openings

5051 - Construction joint w/ localized delamination

5052 - Delamination/spalling along interior opening of pile cap floor

5053 - Delamination/spalling " " "

5054 - "

MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT

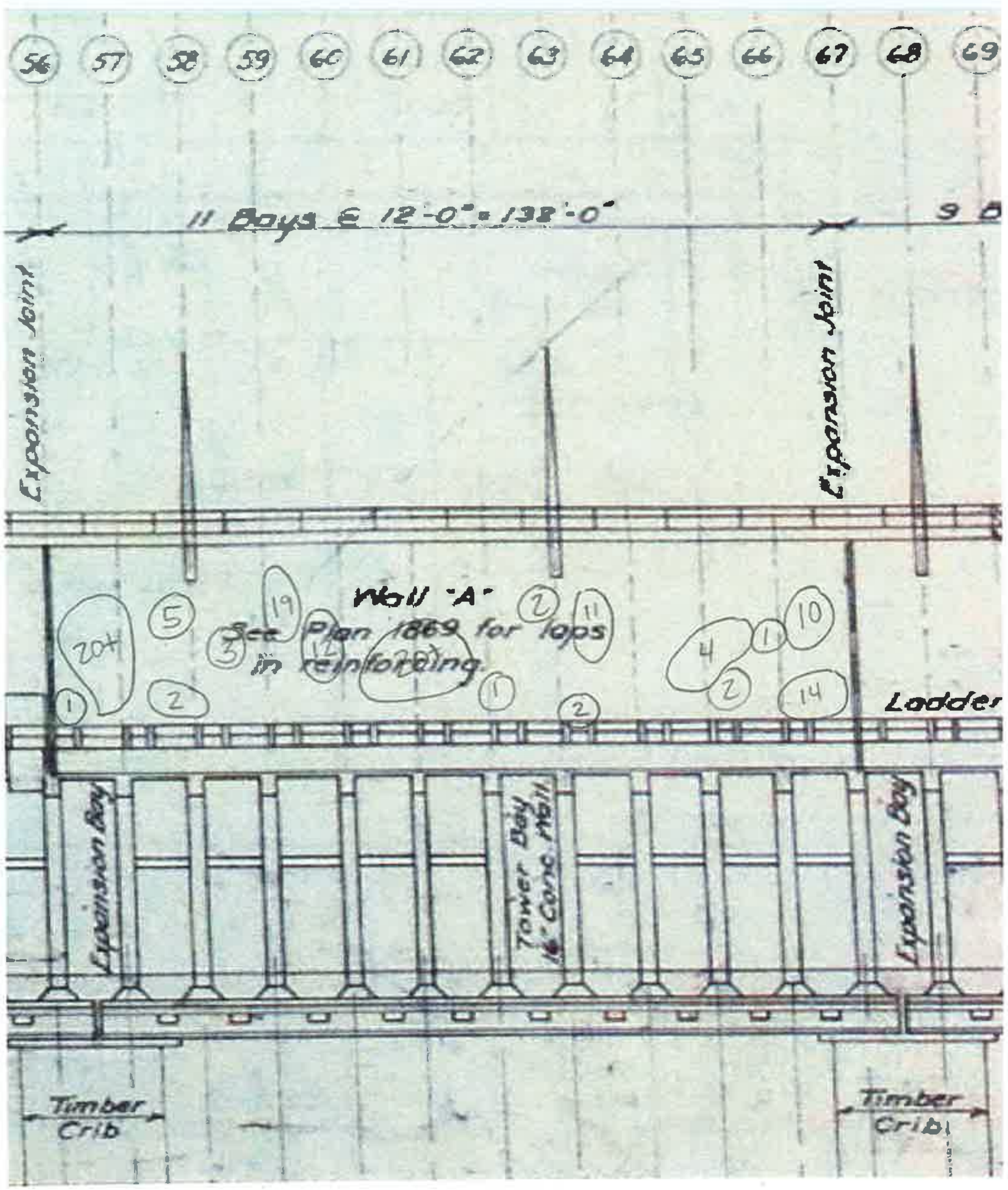
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #:6 (SOUTH SIDE)



COMMENTS & OBSERVATIONS

of spalls identified

Worst spot on ore dock

MARQUETTE ORE DOCK INSPECTION FORM- ELEVATION VIEW

GEI Consultants

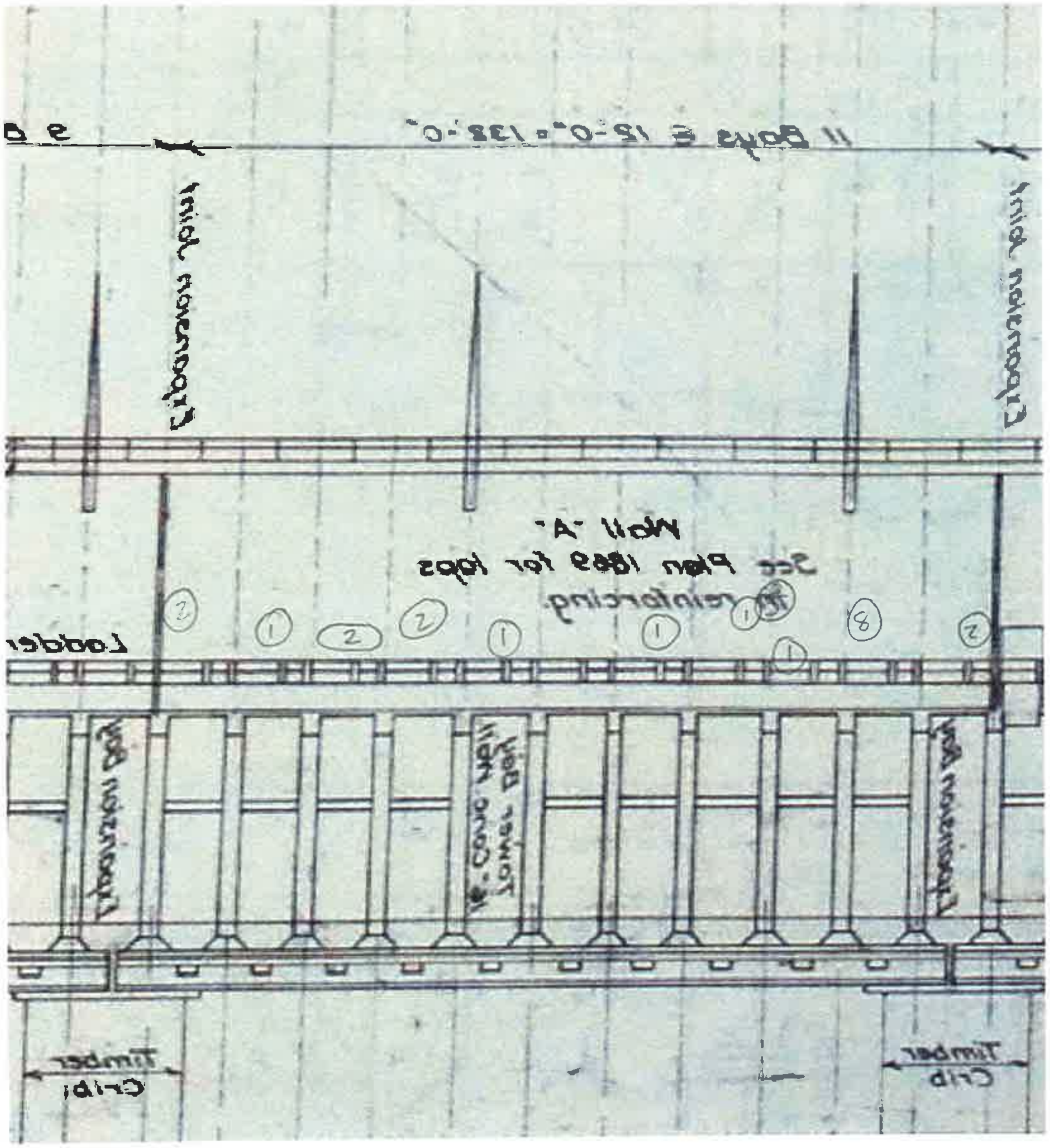
PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #:6 (NORTH SIDE)



COMMENTS & OBSERVATIONS

of spalls identified.

MARQUETTE ORE DOCK INSPECTION FORM- ELEVATION VIEW

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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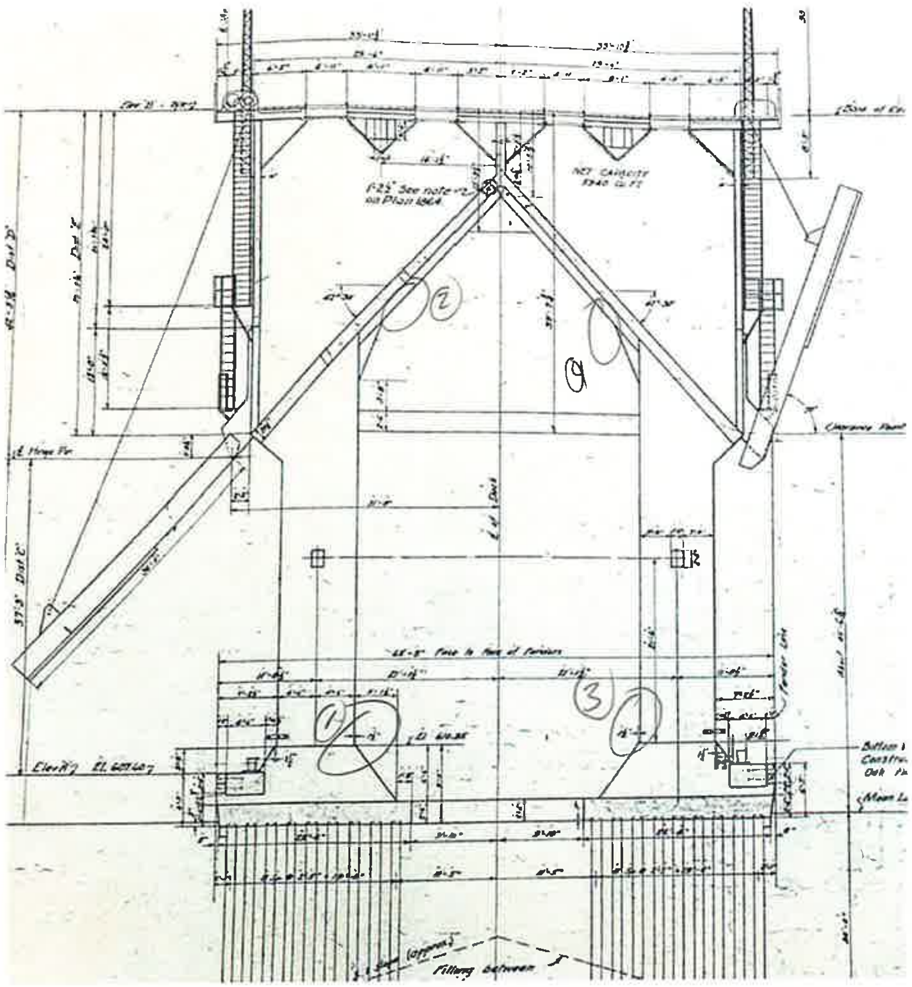
SECTION #: 6

BENT #: 57



COMMENTS/OBSERVATIONS

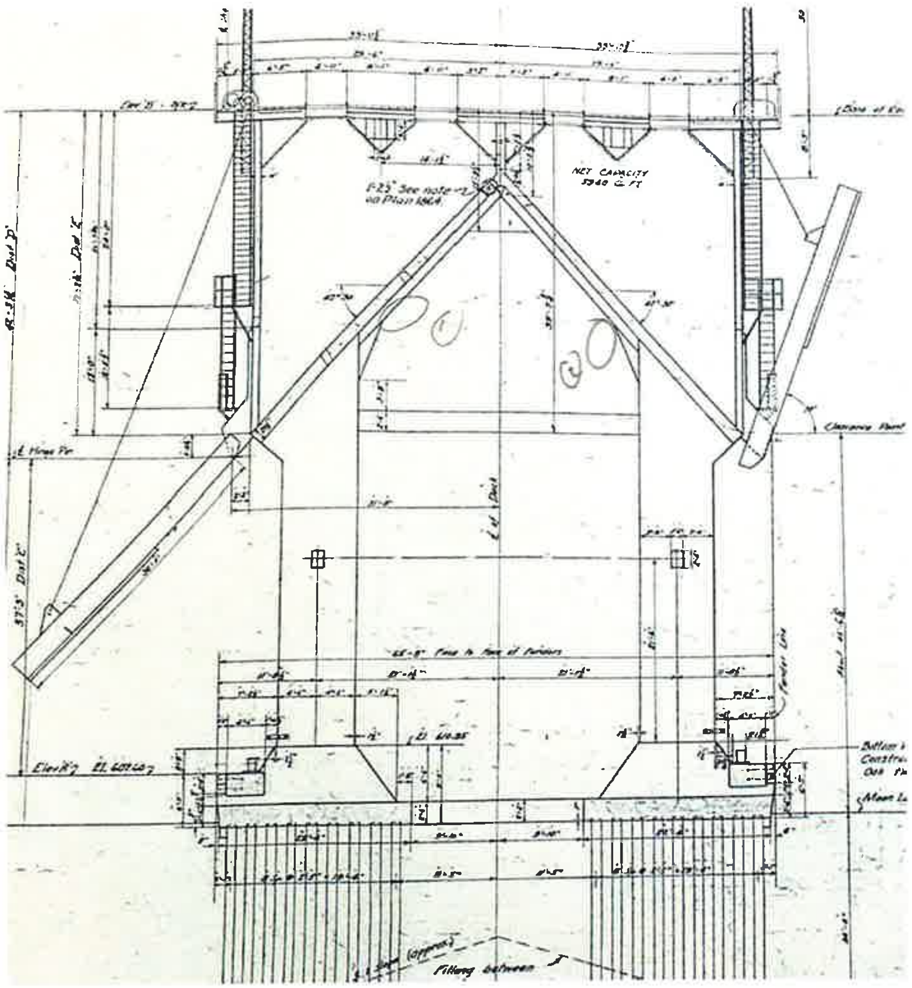
North Inside:
(1) Delamination Top of face 4910 NW
(2) Patches 4911.
Outer: 4947 Crack in N walkway.
South Inside
4948 Lighting Fixture
(3) NE Top of face 4949.
(4) 4950 Rebar Visible

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 6

BENT #: 38



COMMENTS/OBSERVATIONS

(1) Patches again 4912
Outer 58-59 Rebar on Crossmember 4945
4946 Crack in North walkway,
(2) 4951 Piece of Rebar

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

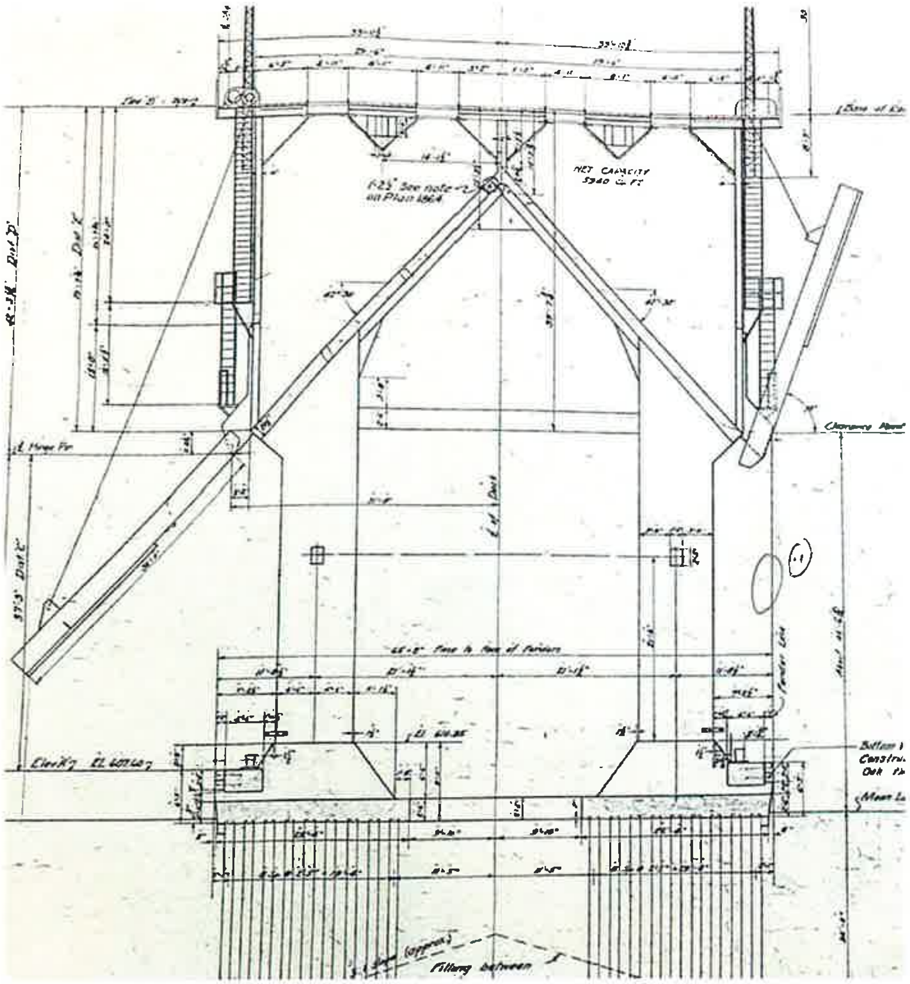
DATE:

INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 6

BENT #: 59.



COMMENTS/OBSERVATIONS

North Dock 59-60 4913 Cracking on Crossmember
Over 59-60 Rebar on Crossmember
Crack in Walkway > Deteriorating on upper face.
South Out. 4983 59-60 South Walkway Crack.
(1) Rebar exposed 4985.
4984 58-59 Crack Walkway

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI
PROJECT #-1330920

DATE:

INSPECTOR:

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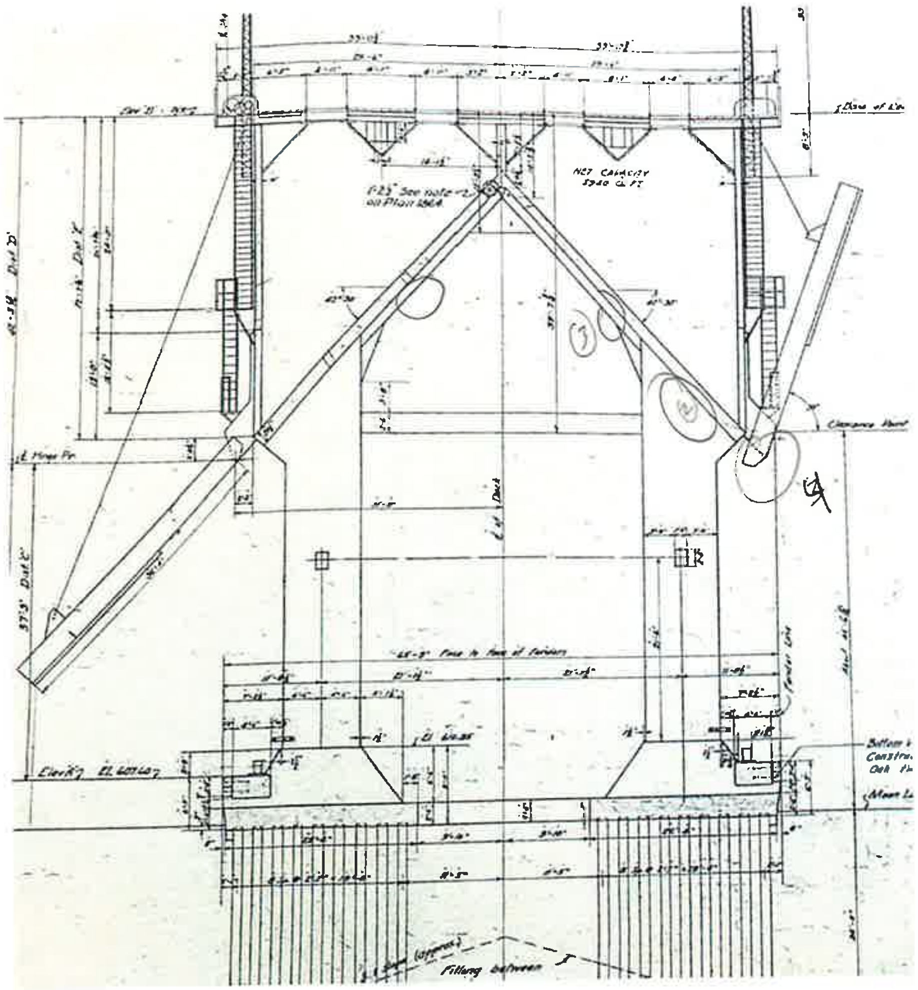
SECTION #: 6

BENT #: 60



COMMENTS/OBSERVATIONS

North Inside 60-61 4914 Exposed Rebar

60-61 Spalled Concrete + Rebar on Cross 4915

~~Over~~

South Inside.

(2) 4952 Cracking? Overpour?

(3) Visible Rebar 4953.

South Out: 4981 Construction Joint on Patch.

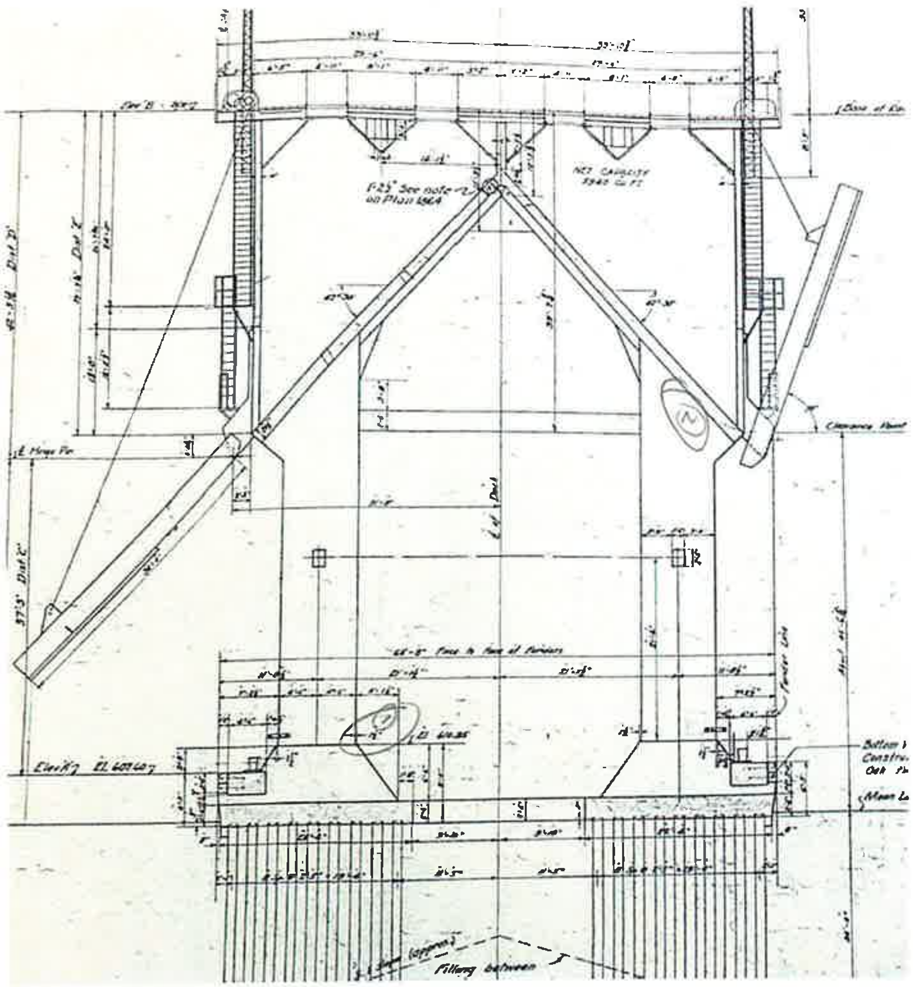
(4) Rebar 4952

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 6

BENT #: 61



COMMENTS/OBSERVATIONS

North Inside (1) NW 4916 Rebar exp + foot.
6162 4917 Cracking on Crossmember
4918 lighting Fixture
Outer 60-61 4940 Construction Joint
(2) South Inside 4954 Rebar
61-62 Cross member 4955 Cracking
61-62 4956 lamp,
Out. 61-62 Cross Member 4979
Cracking in Walkway 61-62 4980

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

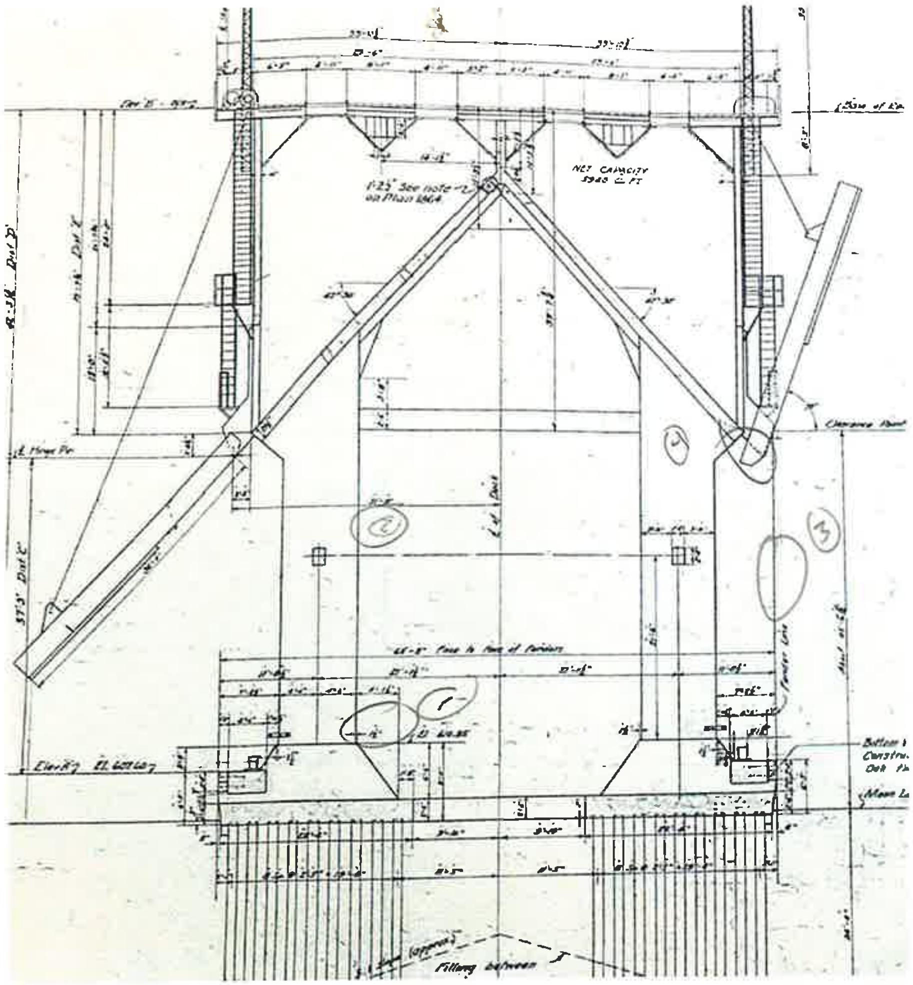
DATE:

INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 6

BENT #: 62



COMMENTS/OBSERVATIONS

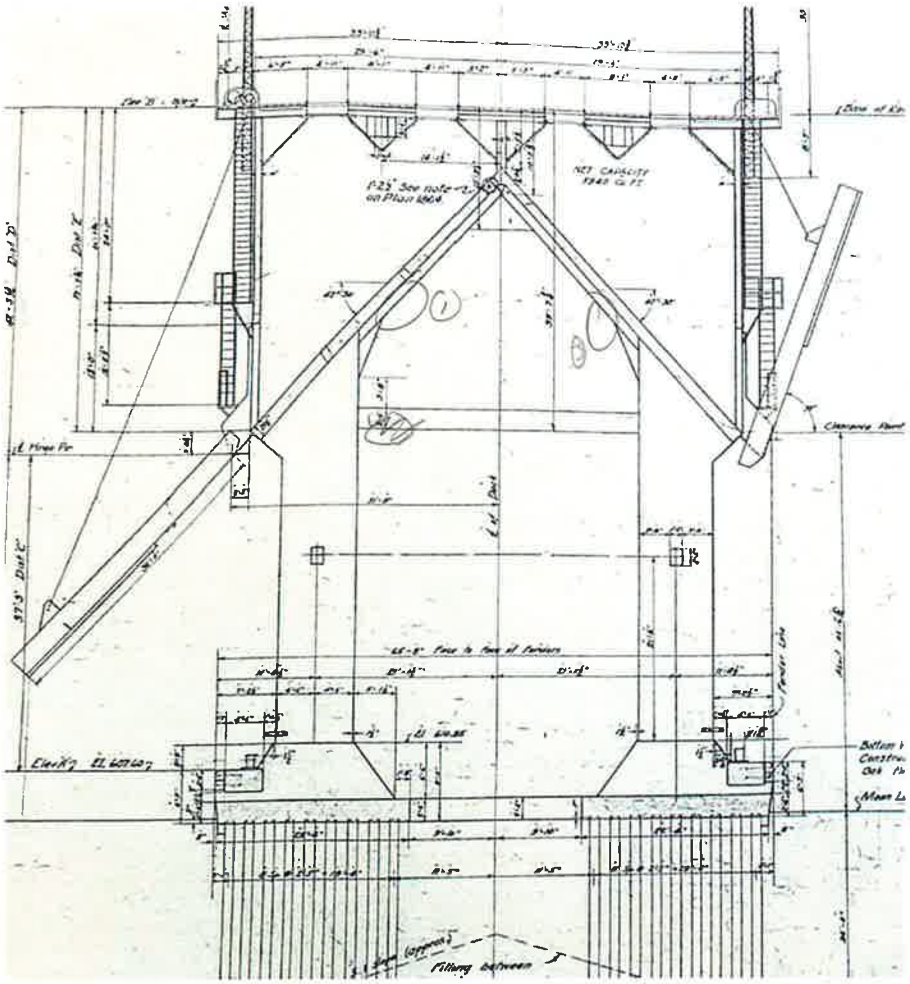
1	North Inside_4919 on NW Top of foot
	4920 Sticking out Rebar 62-63
	Outer 4938 Rebar in 61-62 Cross
	61-62 4939 Crack in North walkway.
	South Inside
	Cracking on 62-63 wall 4957
	Piece of Rebar 4958
3	Out. 4977 Cracking 62-63
	4978 Rebar on Overhang.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 6

BENT #: 63



COMMENTS/OBSERVATIONS

North Inside (1) 4921 Exposed Rebar
(2) 63-64 4922 Rebar Cross Member.
Outer 4937 63-64 Crack in North Walkway.
South Inside 4959 Rebar 63-64
Out. 63-64 4975 Crack in Walkway

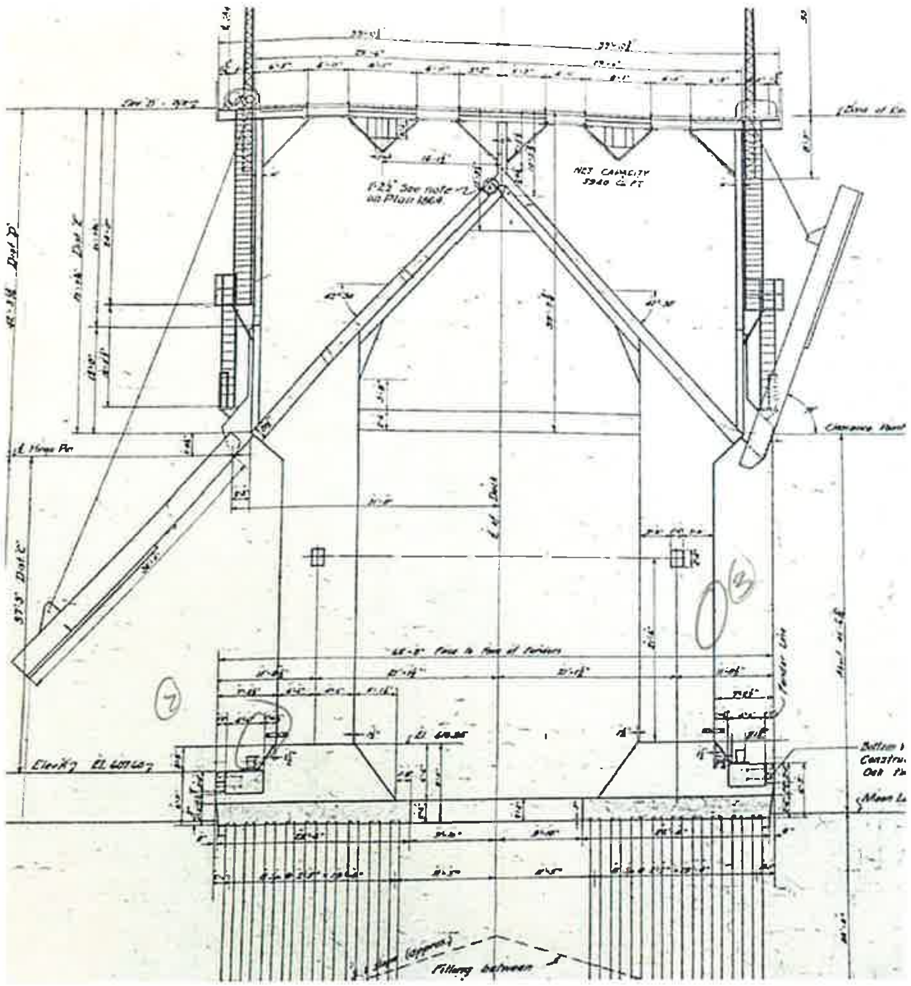
MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 6

BENT #: 64



COMMENTS/OBSERVATIONS

	North Inside. 64-65 Crack in Cross Member
	out. (2) Crack in NE Foot. 4935
	Crack 65-64 4936 North Walkway.
South Inside	4960 Cracking in Ceiling on 64-65
	4961 Cracking in Cross Member 64-65.
out.	(3) 4974 Delamination

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

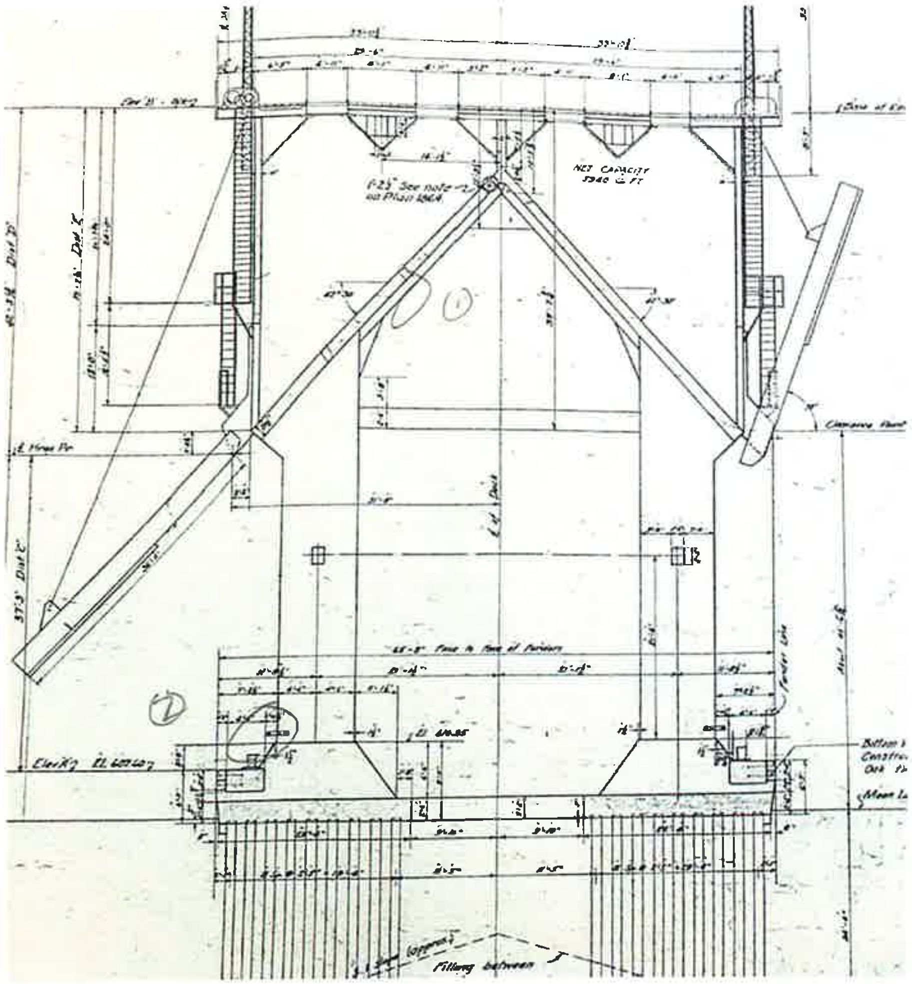
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 6

BENT #: 65



COMMENTS/OBSERVATIONS

North Inter (1) 4924 Rebar exposed,
Rebar again exposed 4925
(2) North Outer NE edge 4734
South Outer 4922 Cracking in Cross Beam
4973 64-65 Crack in Walkway.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

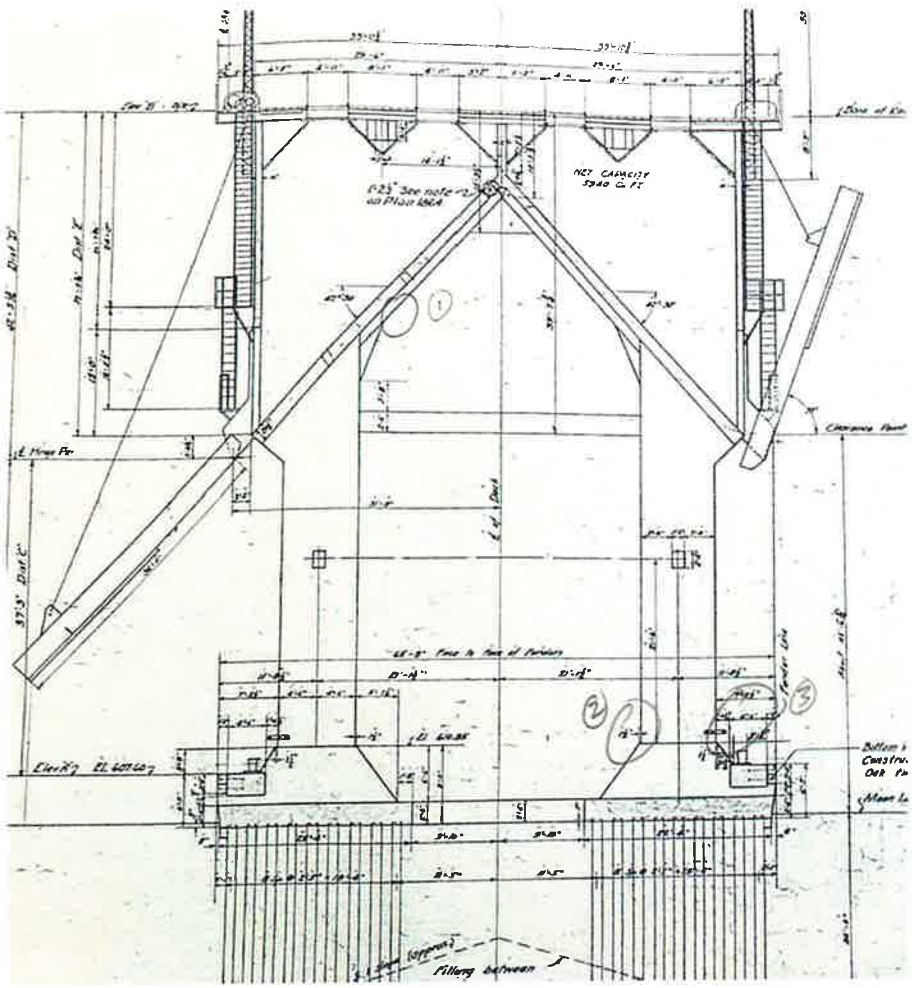
DATE:

INSPECTOR:

W:\Marquette_City\1330920-Marquette_City_Ore_Dock\CAD\Sheets\Marquette_Ore_Dock_Bent and Side View Inspection Forms

SECTION #: 6

BENT #: 66



COMMENTS/OBSERVATIONS

North Inside

① 4926 Exposed Rebar ?

66-67 4927 exposed Rebar on Cross Member.

North Out. Crack in North Walkway 66-67

South Inside - 4962 ② NW Edge of foot

4963 Cross Member Rebar 66-67

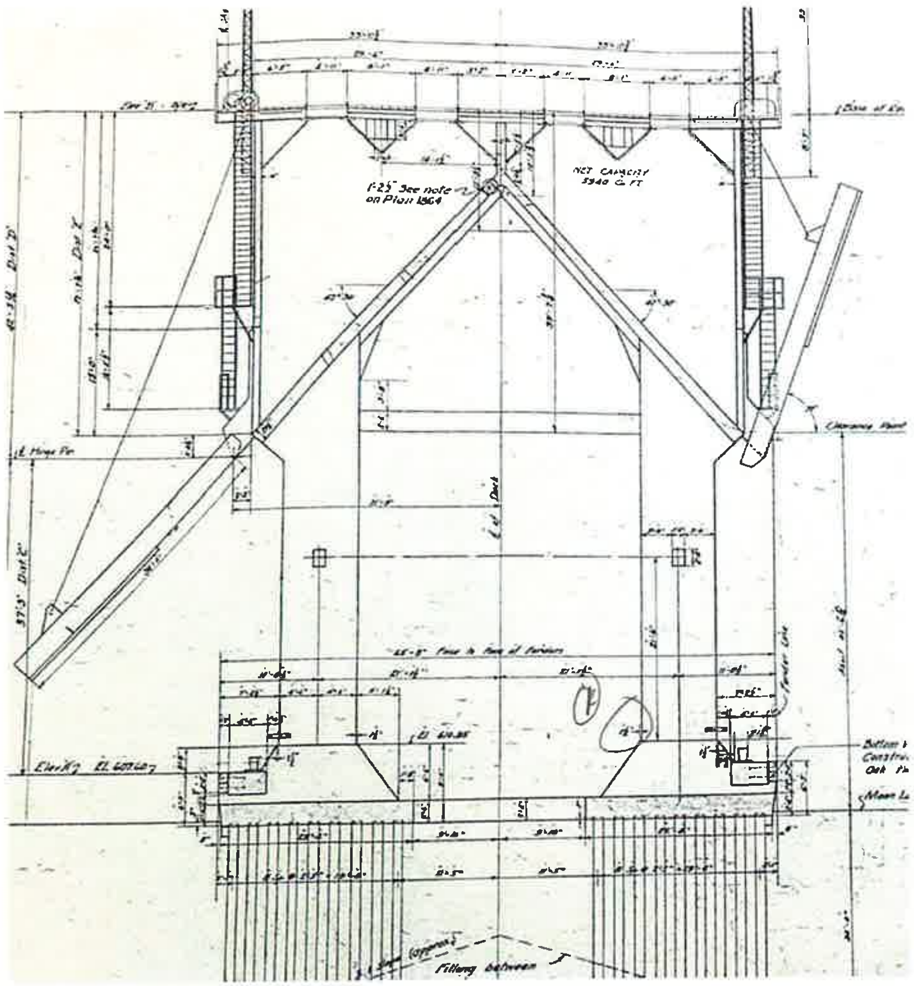
③ South Outside 4971, SW Rebar

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 6

BENT #: 67



COMMENTS/OBSERVATIONS

North Inside. Rebar 4928 expansion Joint 4929-31

North Out - 4932 lighting Fixture

South Inside ① 4964 Rebar NW Edge foot

Delamination 4965 NE Edge foot

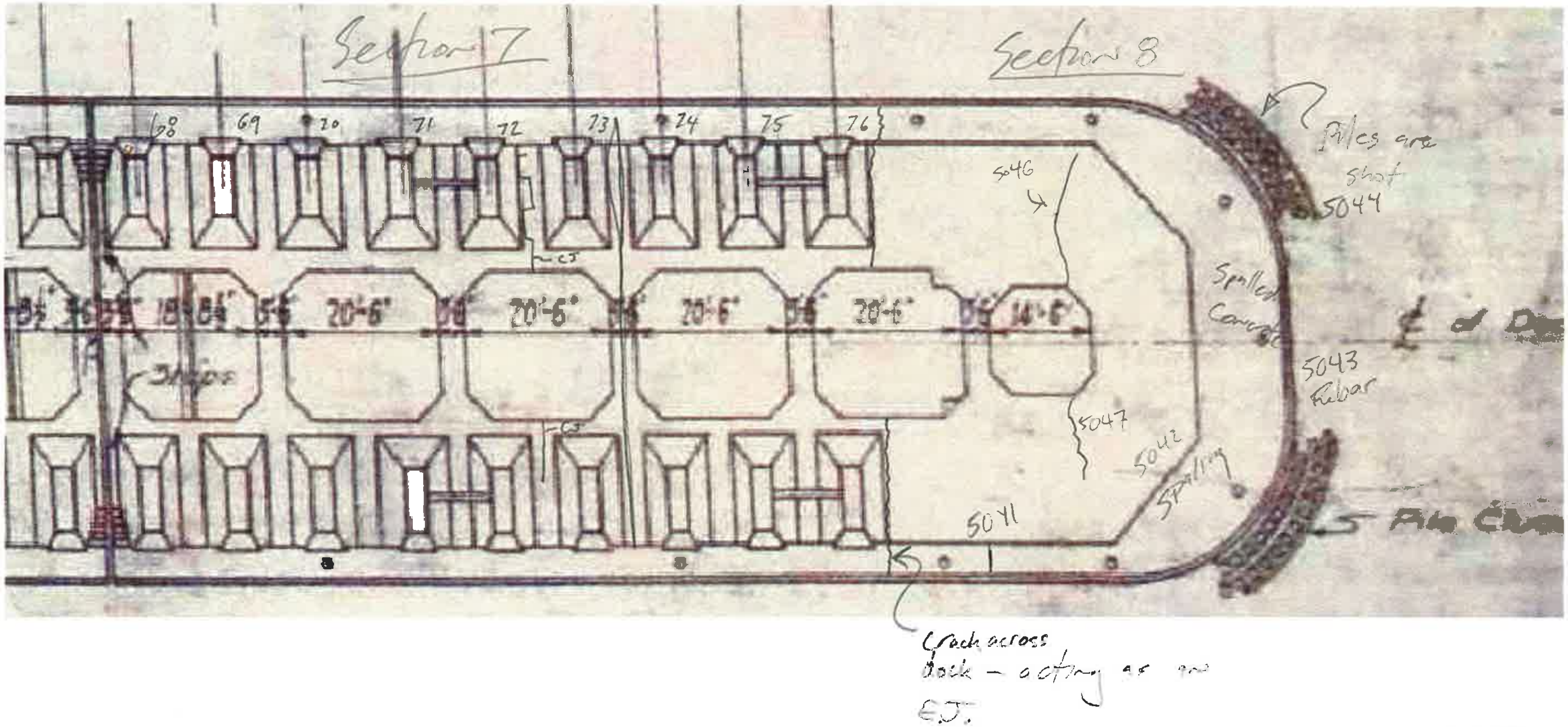
Rebar and Horizontal Crack 4966-69, +70.

Expansion Joint

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 7 & 8



COMMENTS & OBSERVATIONS

Dimensions match

Minor concrete deterioration observed.

5041 – Crack in fender
5042 – Spalled concrete on fender
5043 - Rebar protruding from fender
5044 - Pile group in poor condition
5045 - Crack in fender
5046 - Crack in pile cap

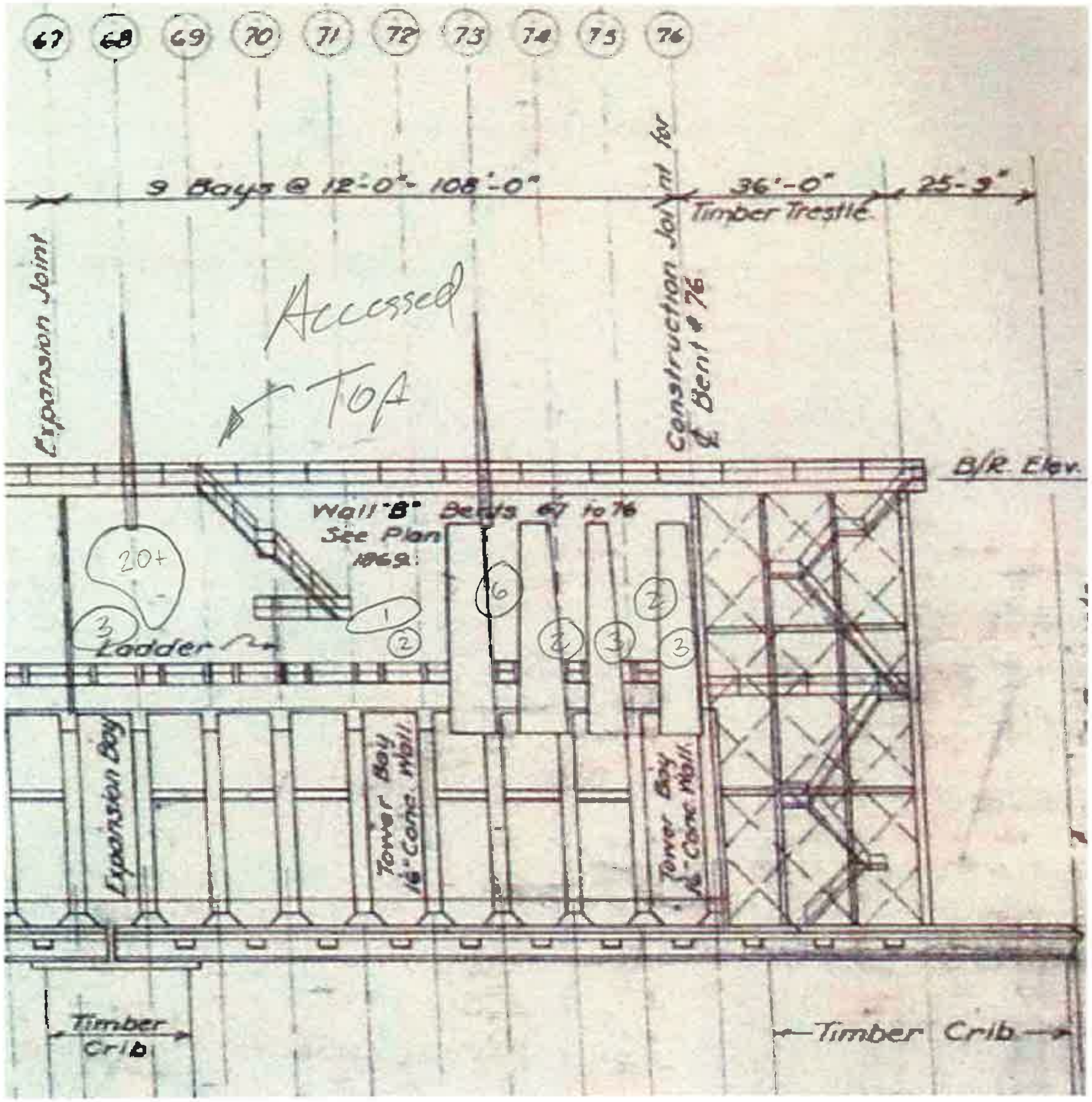
MARQUETTE ORE DOCK BENT FOUNDATION INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI
PROJECT #-1330920

DATE:
INSPECTOR:

SECTION #:7 (SOUTH SIDE)



COMMENTS & OBSERVATIONS

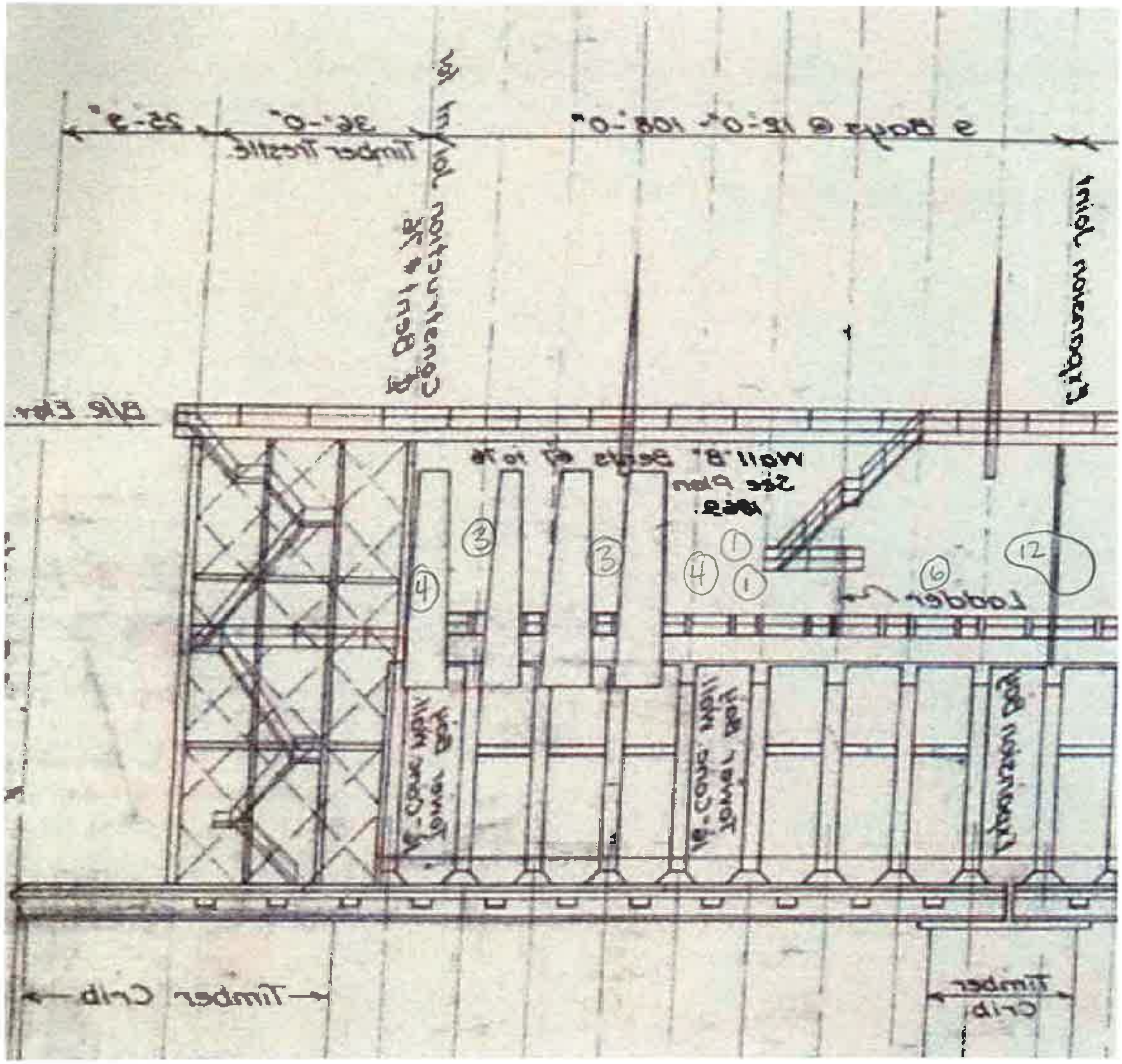
of spalls identified

MARQUETTE ORE DOCK INSPECTION FORM- ELEVATION VIEW

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920	
DATE:	INSPECTOR:

SECTION #:7 (NORTH SIDE)



14.5
2) 39
8
0 9

COMMENTS & OBSERVATIONS

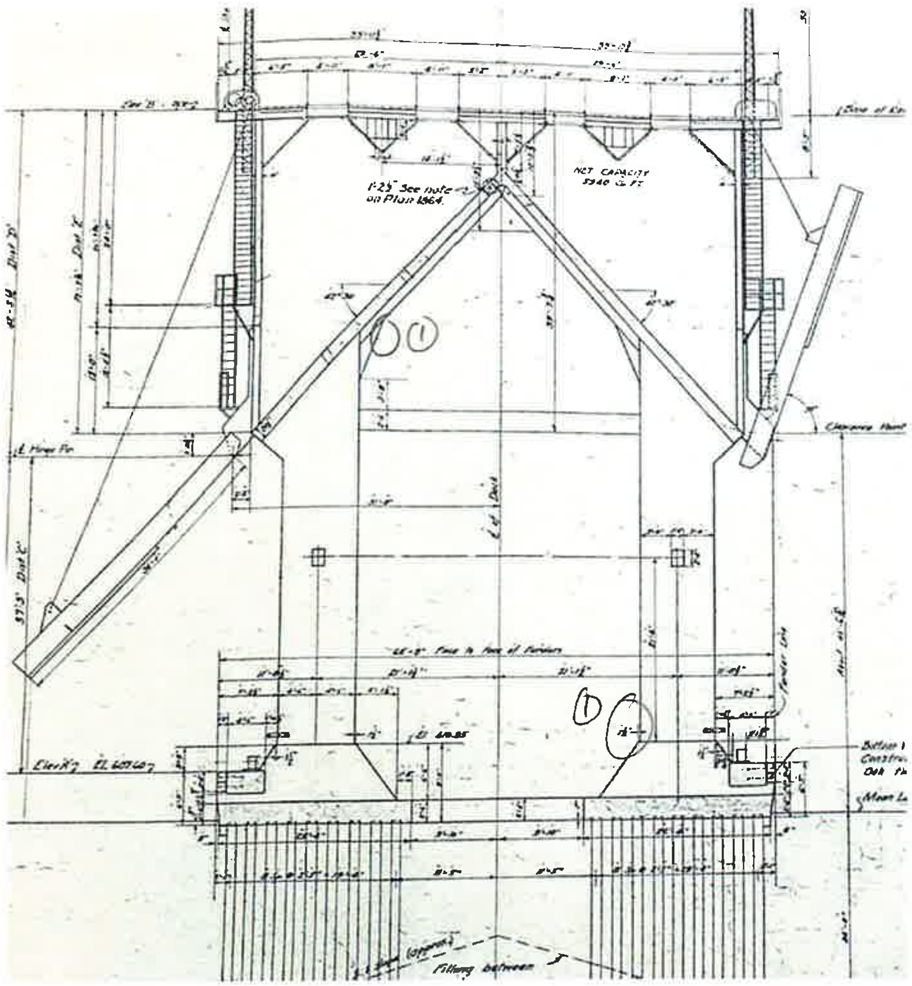
# of spalls identified

MARQUETTE ORE DOCK INSPECTION FORM-
ELEVATION VIEW

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 7

BENT #: 68



COMMENTS/OBSERVATIONS

North In - Rebar 4986 ▷ 87
South In. 5012 Cracks in top foot
68-69 Horizontal Crack 5013

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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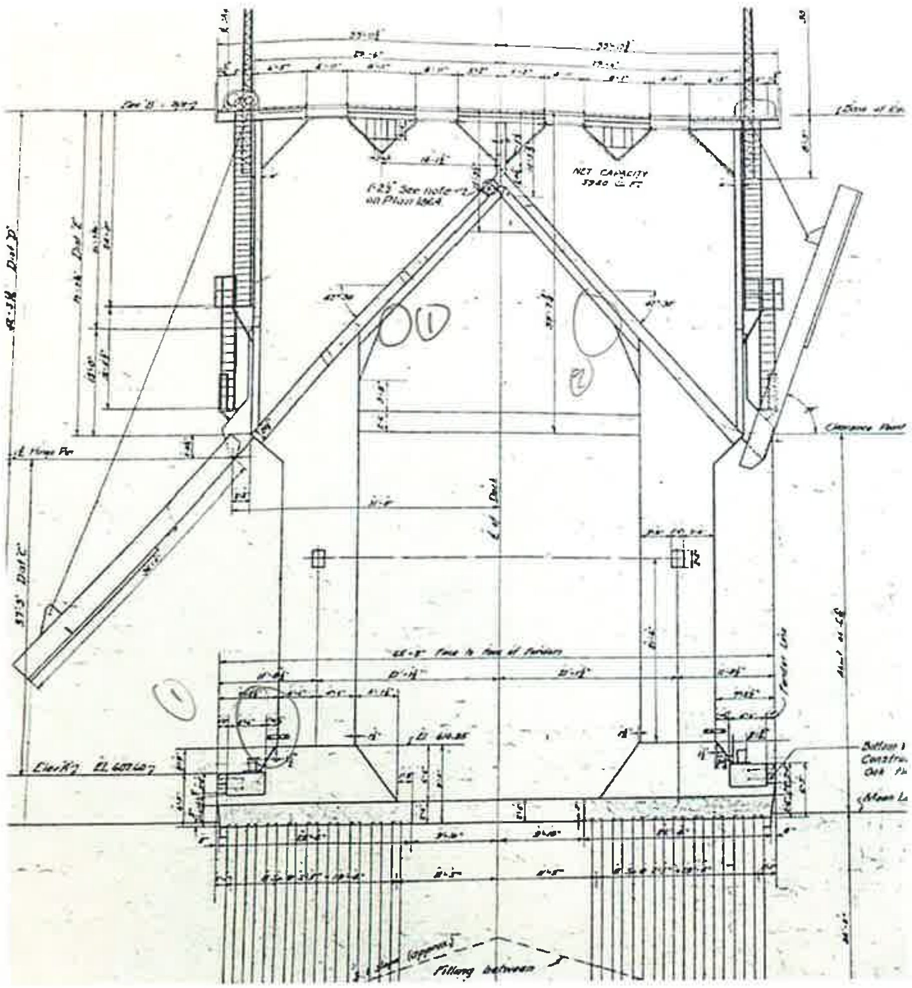
SECTION #: 7

BENT #: 69



COMMENTS/OBSERVATIONS

North In: 4988 Top of Triangle Rebar
Out ① Crack in Bottom @ 5010
South In ② Rebar in Ceiling 5014 69-70
out 5040 Crack in South Walkway.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

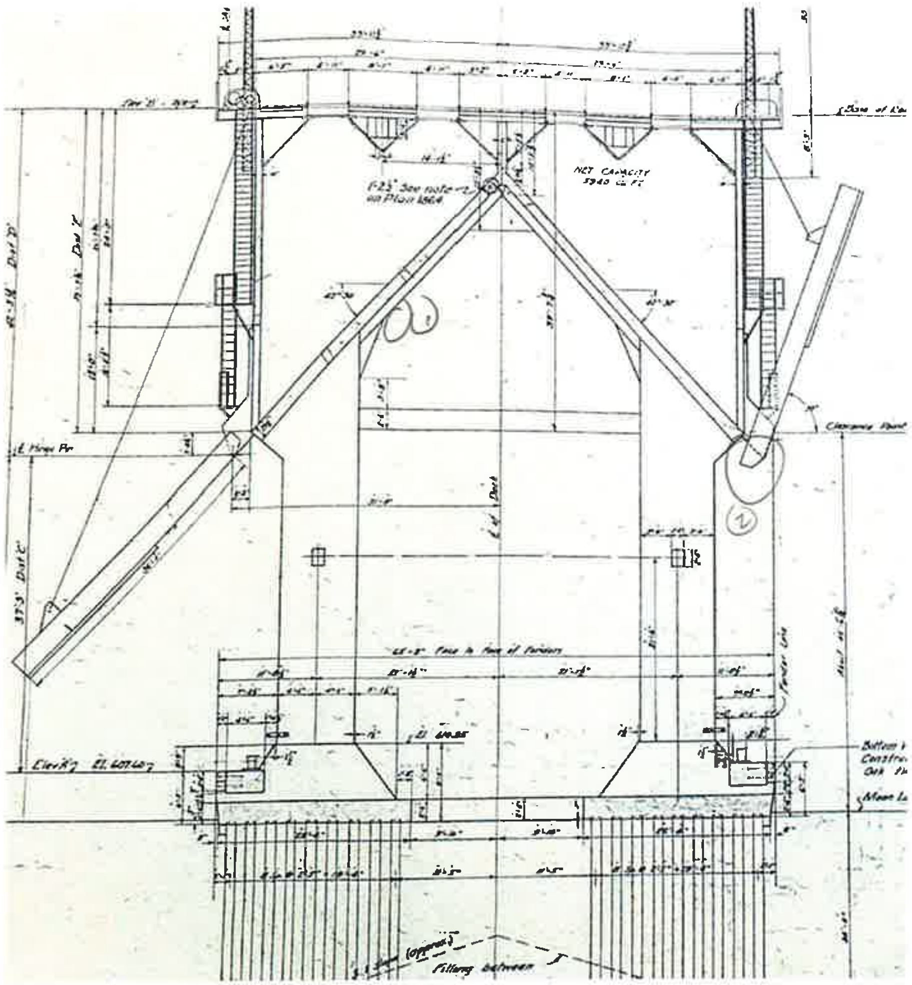
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 7

BENT #: 70



COMMENTS/OBSERVATIONS

North in ① 4989 Top of Triangle Rebar
69-70 Crack in North Walkway 5009.
South out — 70-71 Walkway Crack. 5038
① 5037.
70-71 Cross Member 5039.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI

PROJECT #-1330920

DATE:

INSPECTOR:

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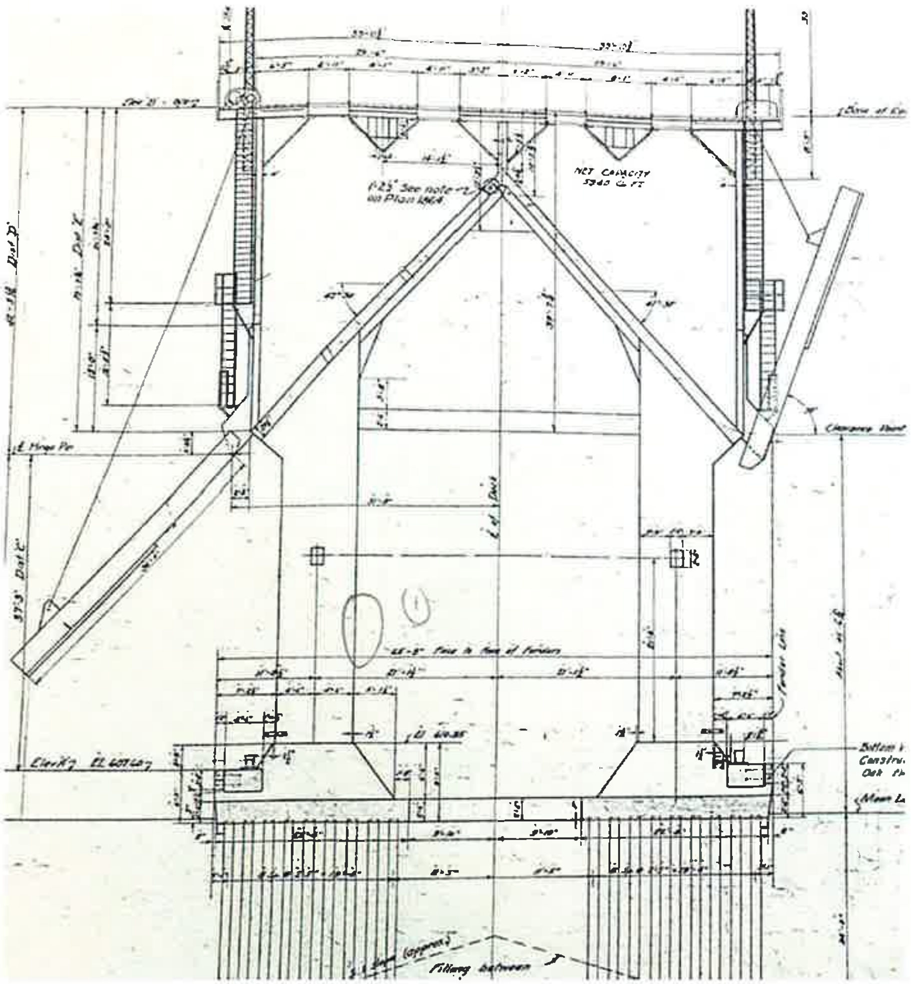
SECTION #: 7

BENT #: 71



COMMENTS/OBSERVATIONS

North Inside 71-72 4990 Rebar
4991 71-72 ① Cracking
Out 70-71 Construction Joint 5008.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants

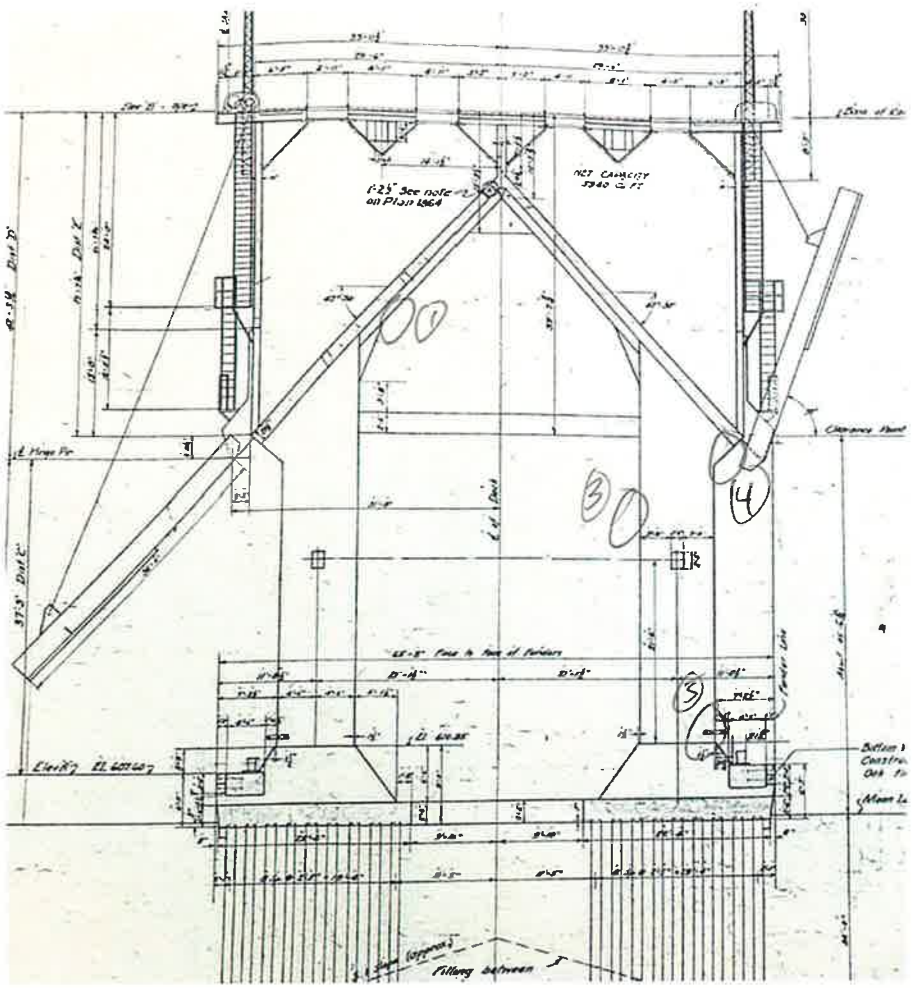
PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT
LOCATION- MARQUETTE, MI
PROJECT #-1330920

DATE:

INSPECTOR:

SECTION #: 7

BENT #: 72



COMMENTS/OBSERVATIONS

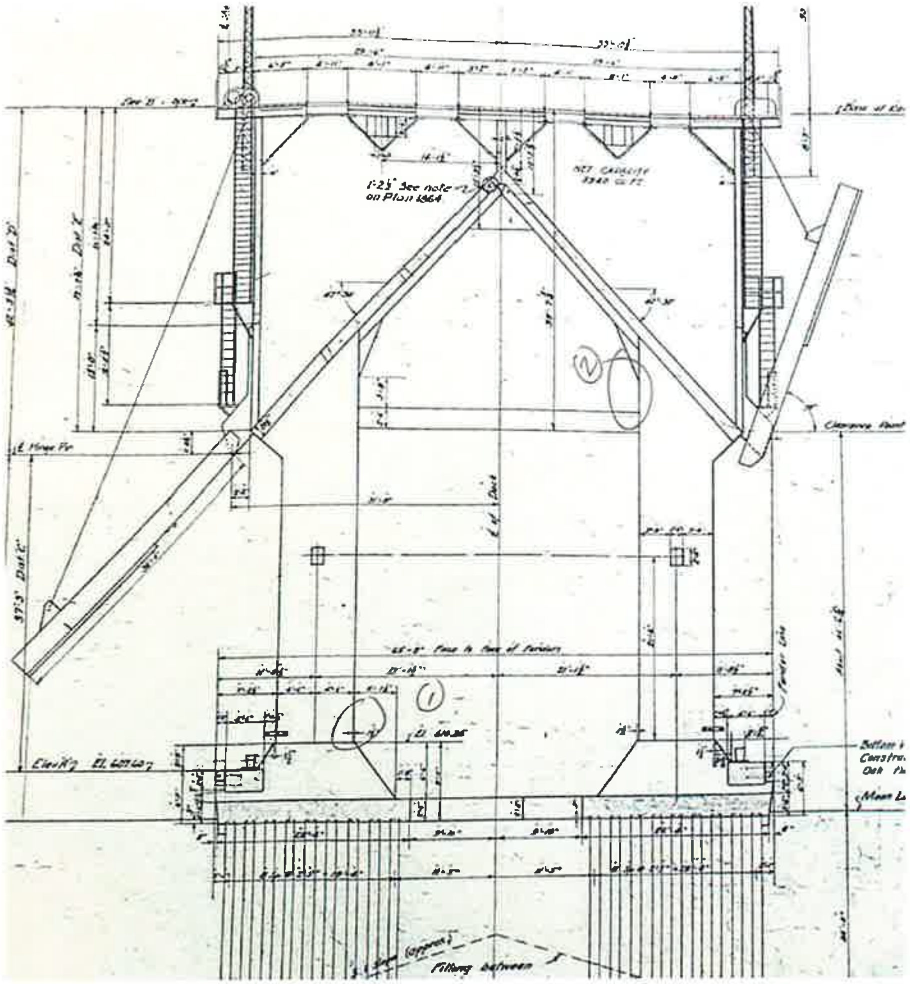
North In 4992 (1) Rebar.
(2) lighting fixture 4993.
South In (3) 5015 71-72 "Stuff"
5016 71-72 Vertical Crack.
Out (4) 5035.
5036 Delamination on top foot.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 7

BENT #: 73



COMMENTS/OBSERVATIONS

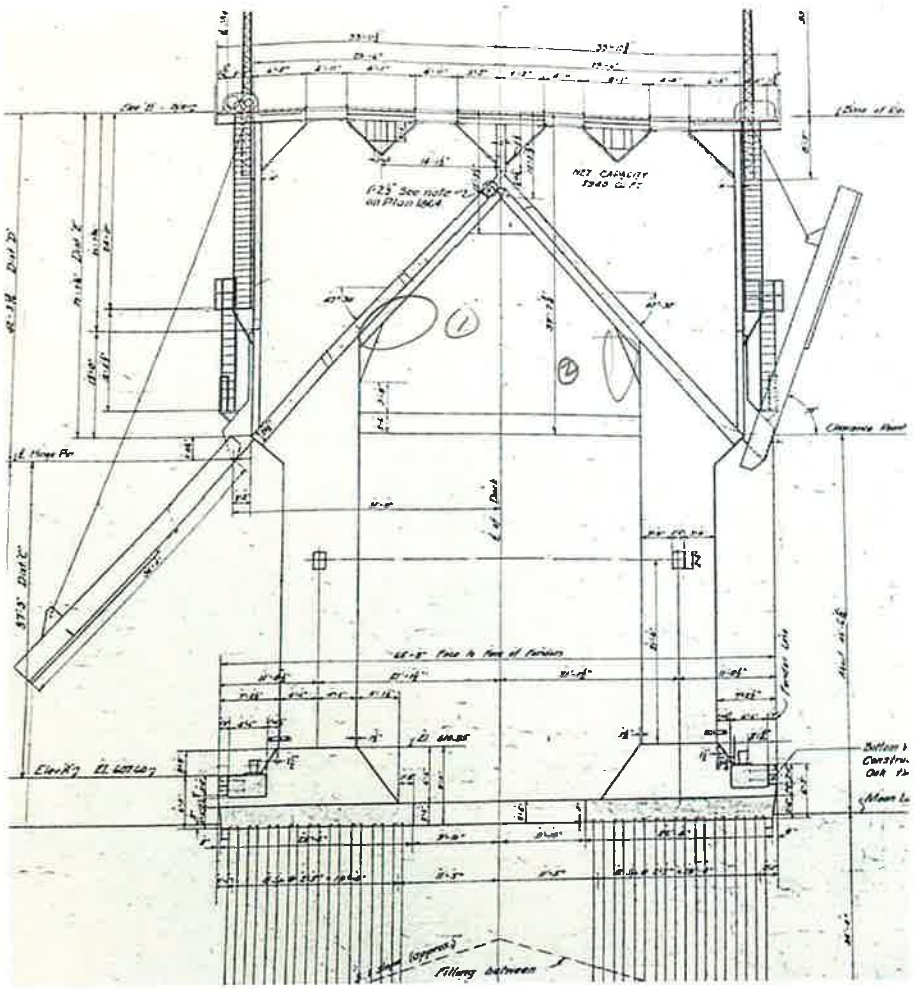
North In. ① SE Edge Delamination 4994
- Out- 72-73 Crack- wall 5005
72-73 Cross "has issues" 5006
South In ② Rubber 5014
5015 Cross Member of 72-73
- Out 5032 72-73 Crack Walkway
5033 Cross Member 72-73

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

SECTION #: 7

BENT #: 74



COMMENTS/OBSERVATIONS

North In ① Rebar exposed 4995 73-74
Out 74-75 Crack in Walkway 5004
② South In 5019 Rebar
Out 5029 73-74 Crack in South Walk
5030 73-74 Cross Member Rebar

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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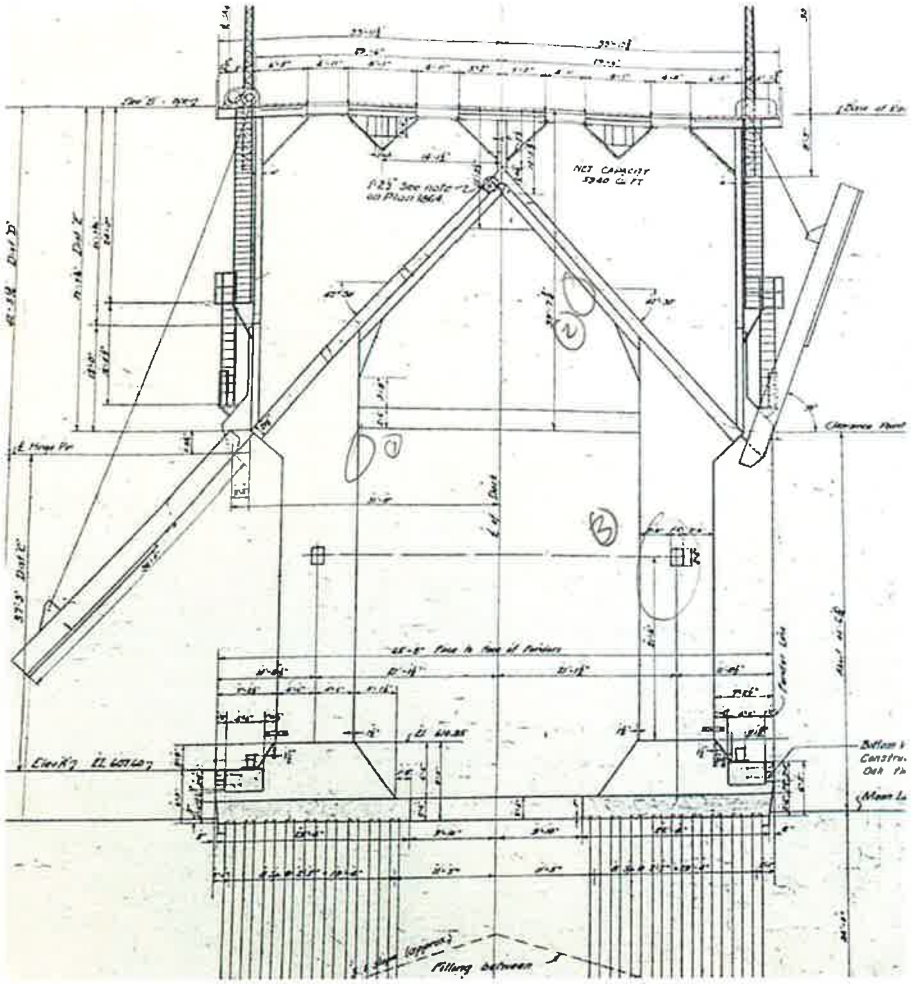
SECTION #: 7

BENT #: 75



COMMENTS/OBSERVATIONS

North In. ① Rebar 4997 & 96 Between 75-76
~~S~~South In. ③ Rebar 5020.
② 5021 Rebar
5022. White Cracking & Rebar 75-76.

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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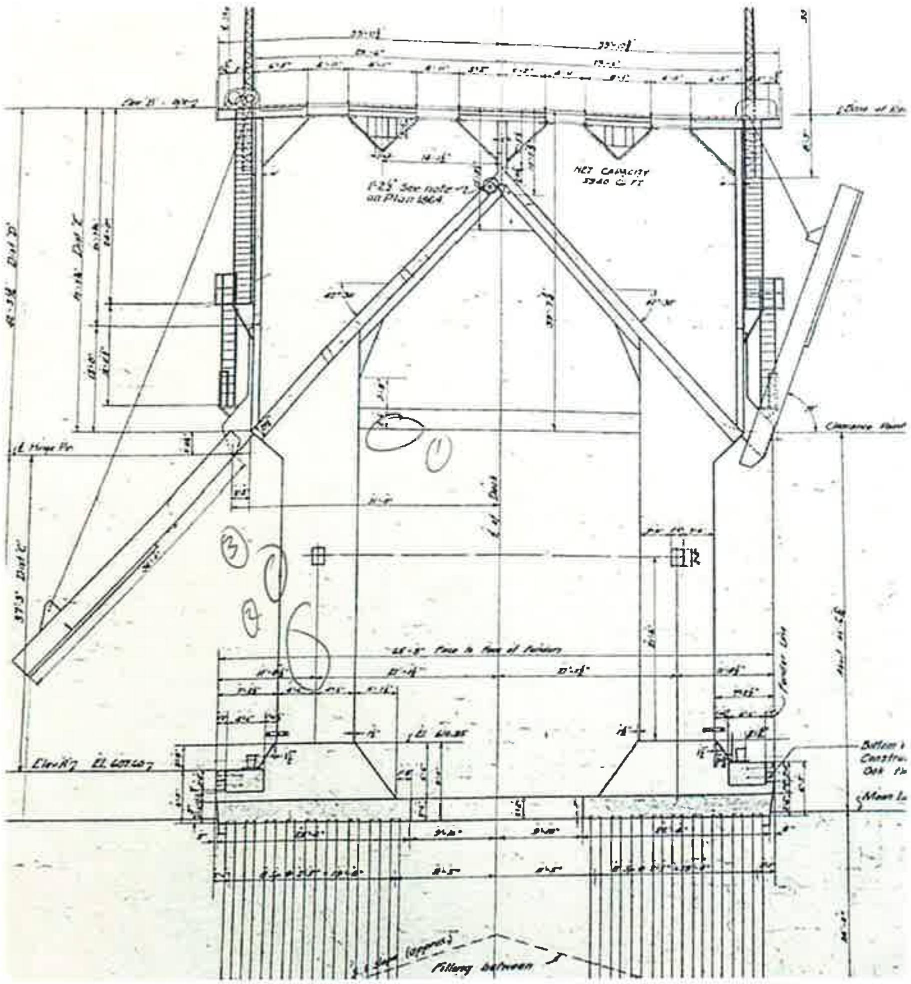
SECTION #: 7

BENT #: 76



COMMENTS/OBSERVATIONS

North In. ① 4999 5000 Rebar
② Rebar 5001
North Out 5002 Crack in Walkway
③ Crack on North Wall w/Rebar. 5003
Out 5025 Crack in Walkway
5026 Rebar in Wall
5027. George is attempting Photography
5028 Again.

South

MARQUETTE ORE DOCK BENT INSPECTION FORM

GEI Consultants	PROJECT- MARQUETTE ORE DOCK STRUCTURAL ASSESSMENT LOCATION- MARQUETTE, MI PROJECT #-1330920
DATE:	INSPECTOR:

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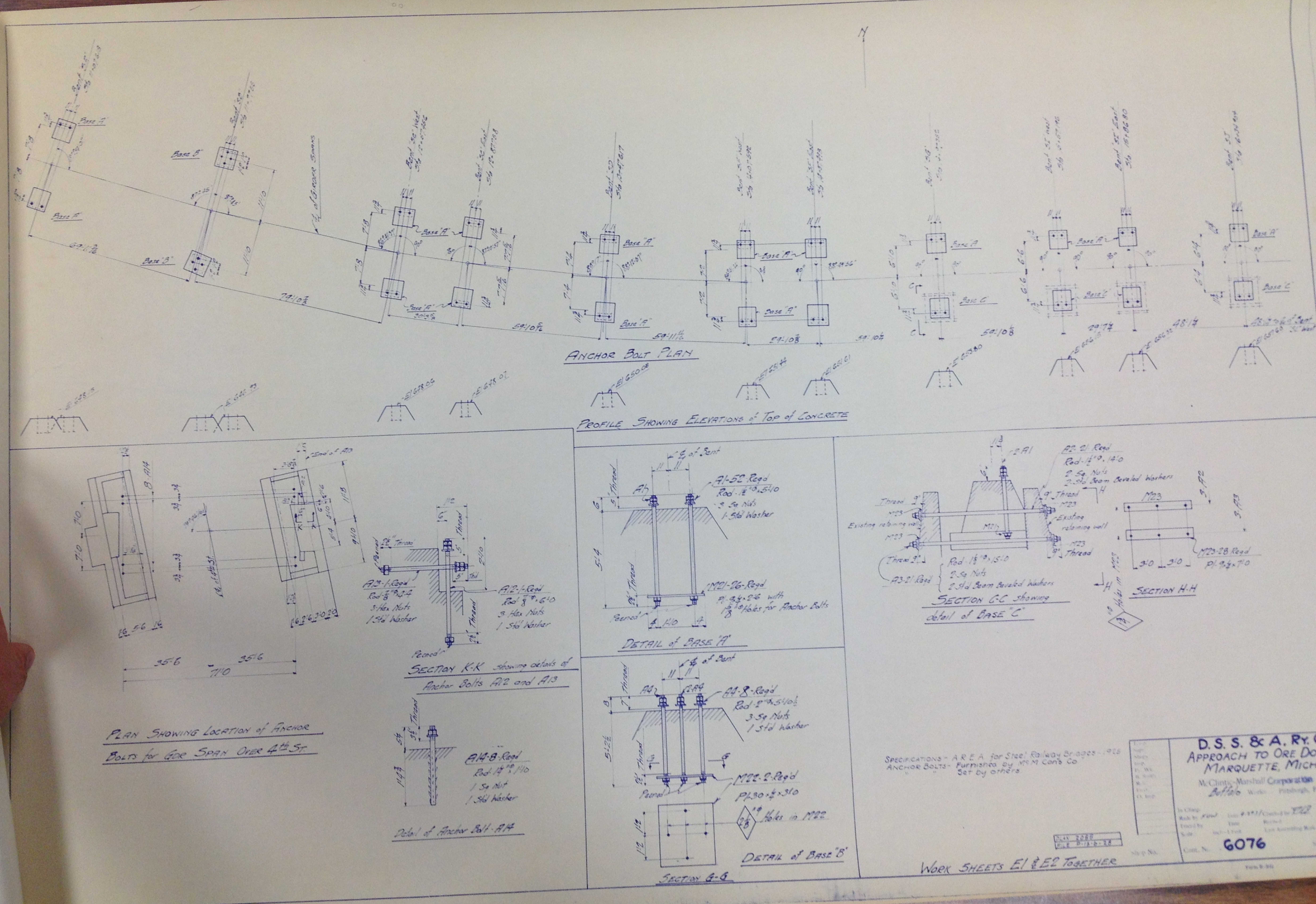
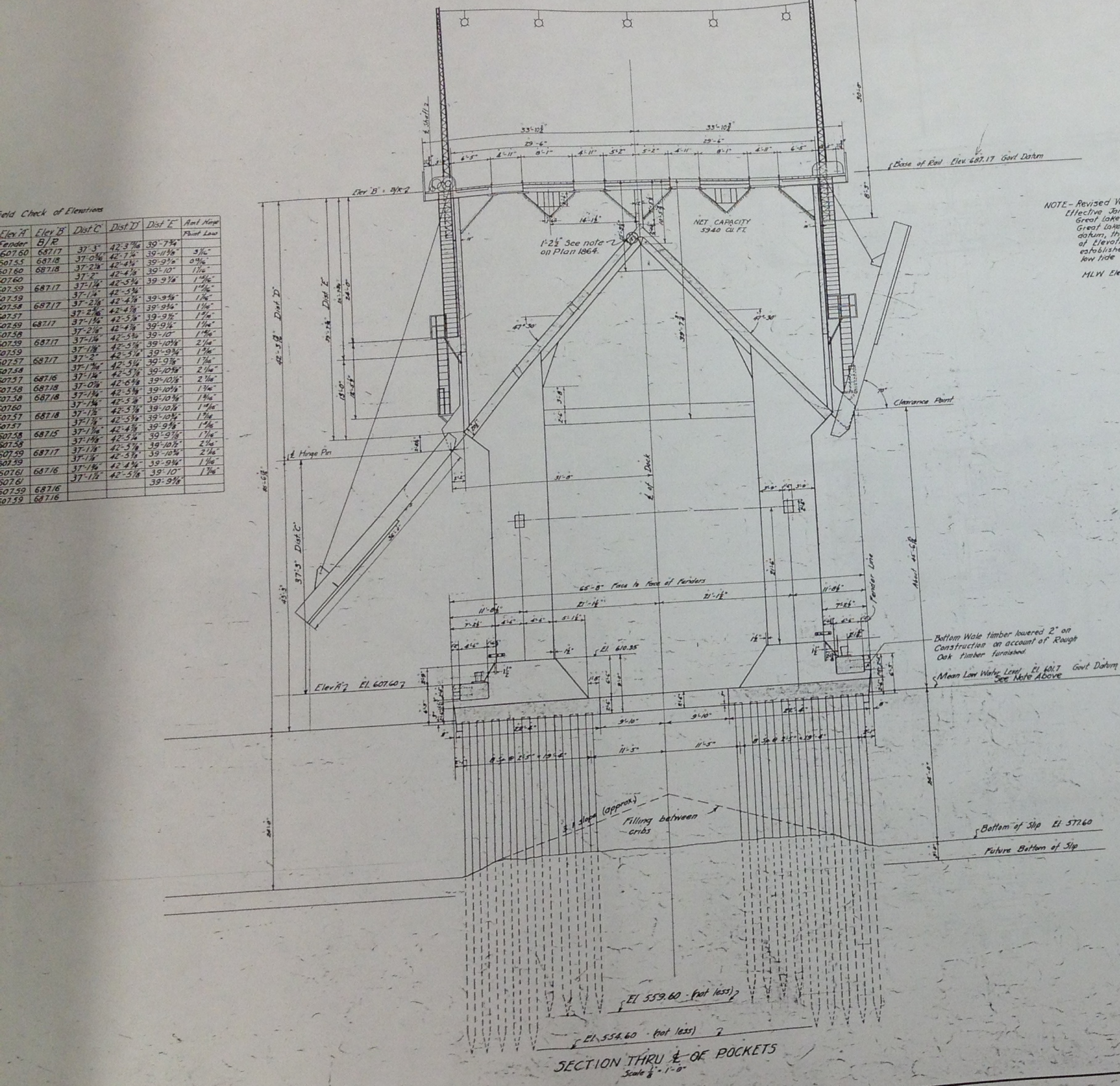
Appendix D

Historical Record Drawings

Mark	Shipments A	B	C	D	E	F	G	Total
CHI	22	22	22	22	22	22	18	150


ANCHOR BOLT PLAN
PROFILE SHOWING ELEVATIONS of TOP of CONCRETE
PLAN SHOWING LOCATION of ANCHOR BOLTS for GDR SPAN OVER 4th ST.
SECTION K-K showing details of Anchor Bolts A12 and A13
Detail of Anchor Bolt - A14
DETAIL of BASE "A"
DETAIL of BASE "B"
SECTION G-G
SECTION C-C showing detail of BASE "C"
SECTION H-H
SPECIFICATIONS - A.R.E.A. for Steel Railway Bridges - 1926
ANCHOR BOLTS - Furnished by McM Cons Co
Set by others
WORK SHEETS E1 & E2 TOGETHER
D. S. S. & A. RY.
APPROACH TO ORE DO
MARQUETTE, MICH
McClintic-Marshall Corporation
6076


SUPER STRUCTURE PLAN
Pocket Numbers - North Side
Pocket Numbers - South Side
Motor Bay
Bent Numbers
11 Bays @ 12'-0" = 132'-0"
9 Bays @ 12'-0" = 108'-0"
Timber Trestle
Expansion Joint
B/R Elev. 689.17
Wall "C"
Wall "A"
Wall "B" Bents 69 to 76 See Plan 1869.
Wall "A" See Plan 1869 for laps in reinforcing
Stairway North Side
Ladder
Tower Bay
Expansion Bay
Timber Crib
Elev. 601.60
Elev. 577.60
Face of Concrete
368'-1"
SIDE ELEVATION.
(Piling between Cribs not shown.)
This end of Dock designed for future shoreward extension.
Struts in remaining sections to be spaced same as shown for section bent #12 to bent #23.
Steps
5 Pile Clust
FOUNDATION PLAN
DATUM:
All elevations shown are referred to sea level datum based on following B.M.: Elev. 628.260 = Government B.M. #6. Description; Center of copper bolt in 3rd course of stone above water table at N.E. corner of Commissary Bldg., Lake & Main Streets.
Revised as to type of fender F.C.T. 5/8/31 Ckd- C.P.L. 5/8/31
Revised as to 6' raise of dock, change of approach alignment, change in deck over hang and lengthening of chute. F.C.T. 4/3/31 Ckd- C.P.L. 4/3/31
Drawing Revision
Del. C.P.L. 4-2-31
Tr. W.C.S. 4-2-31
Ck. F.C.T. 4-2-31
Quan.
Qu. Ck.
Est. No.
D. S. S. & A. R
ENGINEERING DEPAR
GENERAL PLAN & EL
OF
NEW CONCRETE ORE
MARQUETTE M
Office of Chief Engineer.
Scale: 1" = 30 Ft.
Sheet 1 of 60



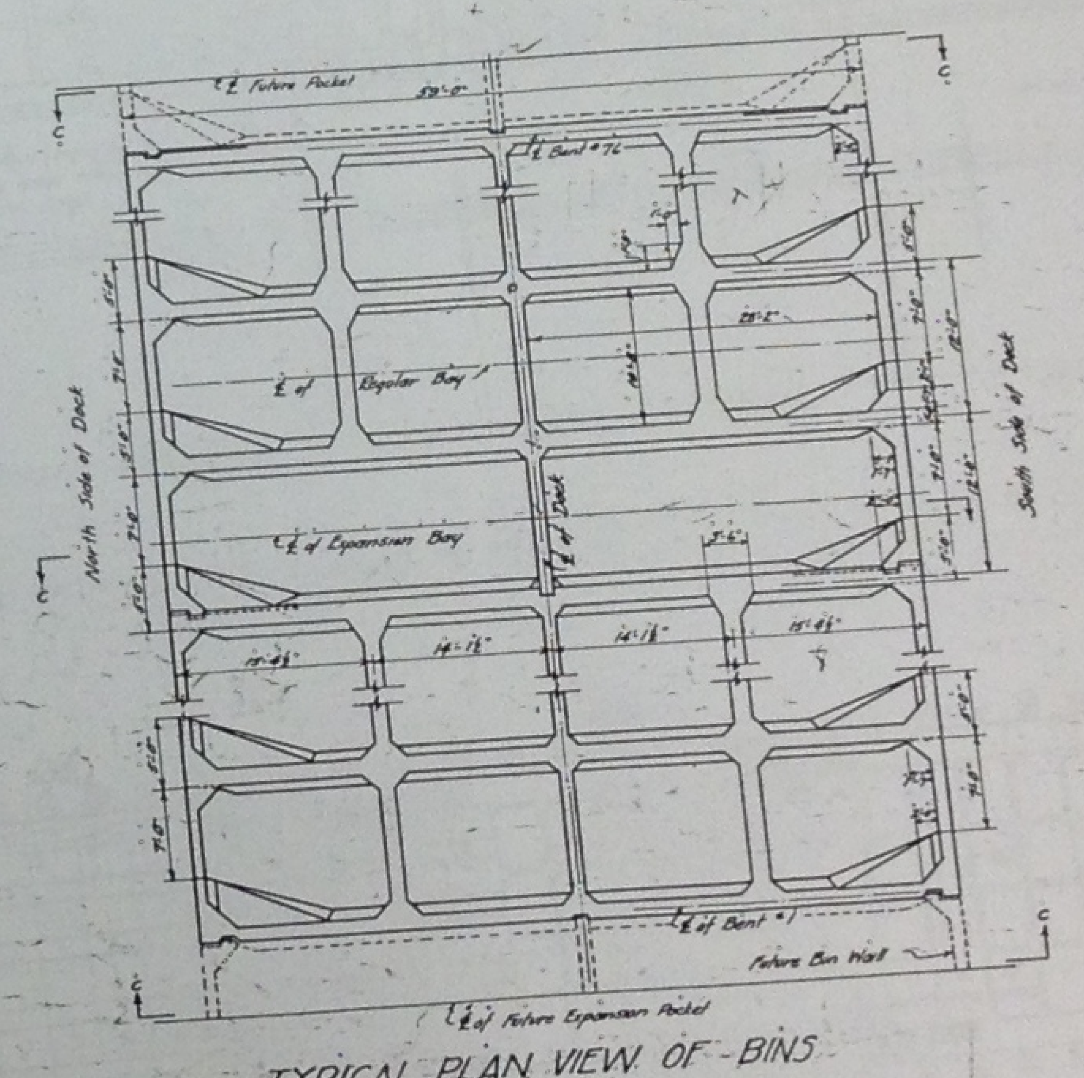
SECTION THRU ℄ OF POCKETS
Scale 1/8" = 1'-0"

NOTE - Revised Vertical Control Datum:
Effective Jan. 1, 1962, the vertical control on the Great Lakes is referred to the International Great Lakes Datum (1955 - IGLD). Using this new datum, the mean low water on Lake Superior is of Elevation 600.0 feet rather than the former established elevation of 601.7 feet above mean low tide at New York City.

MLW Elev. 600.0 IGLD = MLW Elev. 601.7 at N.Y.C.

SPECIFICATIONS

DECK LOADS	Live Load 125 # per sq ft
TRAIN LOADS	Cooper's E-55 Engine Load or a loaded Ore Car weighing 200,000 #
IMPACT	25% in design of all Track Stringers
WIND LOADS	30 # per Sq Ft on Loaded Structure and 50 # per Sq Ft on unloaded structure.
ORE LOAD	Weight of Ore in bins considered in design = 940,325 #. Wt. of Ore 145 #/Cu Ft. Bin Floors figured to carry entire weight. Lateral pressure of Ore figured at p = 27.2 h - where "p" is the horizontal pressure per Sq Ft at depth "h".
UNIT STRESSES	Structural Steel - A.R.E.A. Specifications of 1925 Reinforcing Steel - 18000 # per Sq In Concrete - f_c = 800 f_s = 18000 n = 12 for Superstructure Columns - 530 # per Sq In - Direct Compression
CLASS of CONCRETE	Superstructure - Concrete - f'_c = 2500 # Columns - 2500 # Concrete Mattress - Fenders - Pedestals - 2000 # Concrete



TYPICAL PLAN VIEW OF - BINS
Scale 1" = 10'-0"

For Sec C-C see plan 1865. Note that for Bent #1, expansion joint faces toward shore while for all other expansion bents (12, 23, 34, 45, 56, 67 & 76) it faces toward the lake. Section C-C for Bent #1 is the same as for other expansion bents except that concrete fillet is on the far side.

Revised as to type of fender. F.C.T. 5/8/31 Ckd - C.P.L. 5/8/31.
Revised as to 6" raise of dock, change of approach alignment, change in deck overhang and lengthening of chute. F.C.T. 4/3/31 Ckd. - C.P.L. 4/3/31

	Drawing	Revision
Del	C.P.L. 4/2/31	
Tr	I.W.M. 4/2/31	
Ck	F.C.T. 4/3/31	
Quant		
Qu Ck		
Est No		

D. S. S. & A. RY. CO.
ENGINEERING DEPARTMEN[T]

GENERAL CROSS SECTION
NEW CONCRETE ORE DOCK
AT MARQUETTE MICH.

Office of Chief Engineer — Minneapolis
April
Scales: 1/8" = 1'-0" & 1" = 10'-0"

Sheet 3 of 60

SPECIFICATIONS

DECK LOADS	Live Load 125 # per sq. ft.
TRAIN LOADS	Cooper's E-55 Engine Load or a loaded Ore Car weighing 200,000 #.
IMPACT	25% in design of all Track Stringers.
WIND LOADS	30 # per Sq. Ft. on Loaded Structure and 50 # per Sq. Ft. on unloaded structure.
ORE LOAD	Weight of Ore in bins considered in design = 940,325 #. Wt. of Ore 145 #/Cu Bin Floors figured to carry entire weight. Lateral pressure of Ore figured at $p = 27.2\,h$ - where "p" is the horizontal pressure per Sq. Ft. at depth "h".
UNIT STRESSES	Structural Steel - A.R.E.A. Specifications of 1925 Reinforcing Steel - 18000 # per Sq. In. Concrete - $f_c = 800$ $f_s = 18000$ $n = 12$ for Superstructure Columns - 530 # per Sq. In. - Direct Compression
CLASS of CONCRETE	Superstructure - Concrete - $f'_c = 2500$ # Columns - 2500 # Concrete Mattress - Fenders - Pedestals - 2000 # Concrete

SECTION A-A SHOWING PONY BENT
PLAN VIEW-END OF 70' N.S. GIRDER
DETAIL A
DETAIL B
SECTION D-D
...ON OF TIMBER PIERS ON EAST SIDE OF ... ST. LOOKING TOWARDS LAKE SUPERIOR
ELEVATION OF PIER "SU" AND ADJOINING BENTS
ELEVATION OF 26' TOWER "SR"
PLAN OF CONCRETE PEDESTALS FOR 26' TOWER "SR"
...DER BEARINGS
D. S. S. & A. RY. CO.
ENGINEERING DEPARTMENT
DETAILS OF TIMBER PIER "S..."
AND STEEL TOWER "SR"
APPROACH TO NEW ORE DOCK
AT MARQUETTE, MICH.
OFFICE OF CHIEF ENGINEER

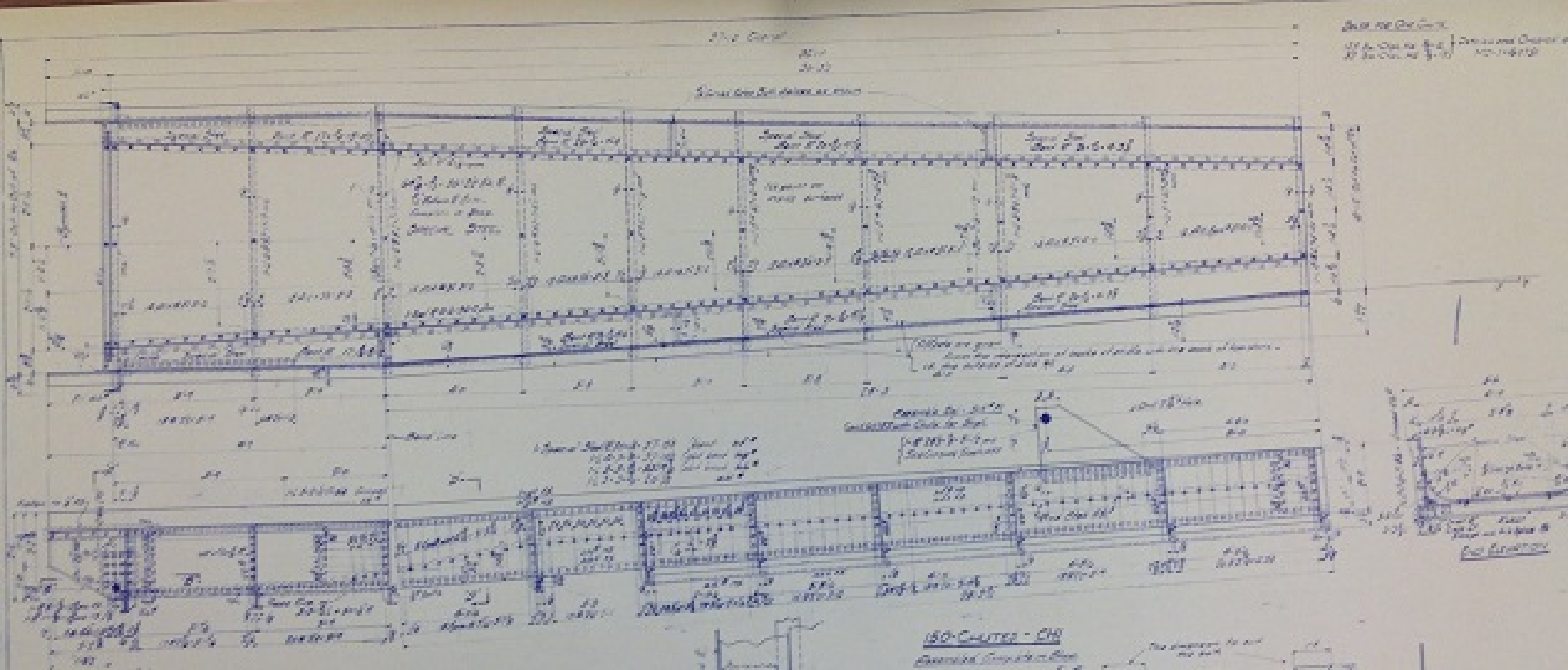

DETAIL OF HOOK BOLTS
8 Reqd
DETAIL OF SUPPORT FOR ROOF BOLTS
Scale 1" = 1'-0"
4 Complete Sets Reqd
PLAN
PLAN
Red (faint) lines show present piers
Red dotted (faint) lines part of present piers to be removed
Black (heavy) lines show new concrete
DETAIL OF SOLE PLATE
FOR 64-3¾ D.P.G
2 - Reqd To be furnished by Ry. Co.
72'-6" D.P. Girder
Base of Low Rail
66'-0"
ELEVATION ON LINE C-C
PIER "SN"
PIER "SO"
FRONT ELEVATION
FRONT ELEVATION
EAST PIER "SO"
SECTION B-B
PLAN
SECTION D-D
70'-6"
Note All anchor bolts for Girder Shoes to project 4" above masonry
LEGEND
Old Piers now in place shown by light lines
New remodeling work shown by heavy lines
D.S.S. & A. RY. CO.
ENGINEERING DEPARTMENT
DETAILS OF CONCRETE PIERS AT FRONT ST.
APPROACH TO NEW ORE DOCK
AT
MARQUETTE, MICH.
PIER "SN"


IDENTICAL SECTIONS AL-BL-CL-DL-EL-FL-GL
IDENTICAL SECTIONS 36-41-46-51-56-61
IDENTICAL SECTIONS 37-38-39-42-43-44-47-48-49-52-53-54 57-58-59-62-63-64-67-68-69
IDENTICAL SECTIONS 40-45-50-55-60-65
SECTION 66
SECTION 70
SUB-SECTION AL
SUB-SECTION AR
SUB-SECTION 36
SUB-SECTION 1
SUB-SECTION 40
SUB-SECTION 5
SUB-SECTION 66
SUB-SECTION 31
SUB-SECTION 70
SUB-SECTION 35
SUB-SEC. HL
SUB-SECTION HC
SUB-SEC. HR
These piling for bents of and Trestle
SECTION 31
SECTION 35
IDENTICAL SECTIONS AR-BR-CR-DR-ER-FR-GR
IDENTICAL SECTIONS 1-6-11-16-21-26
IDENTICAL SECTIONS 2-3-4-7-8-9-12-13-14-17-18-19-22 23-24-27-28-29-32-33-34
IDENTICAL SECTIONS 5-10-15-20-25-30
TYPICAL SECTIONS
Scale: ⅛" = 1'-0"
GENERAL PLAN
Scale: 1" = 30'
D. S. S.
ENGINEERI
PILE DR
NEW CONC
MARQ
Office of Chief Eng
Scale: As Noted
Revised as to 6" raise of dock, change of approach alignment, change in deck overhang and lengthening of chute FCT 4/8/81 Chd. CPL 4/8/81

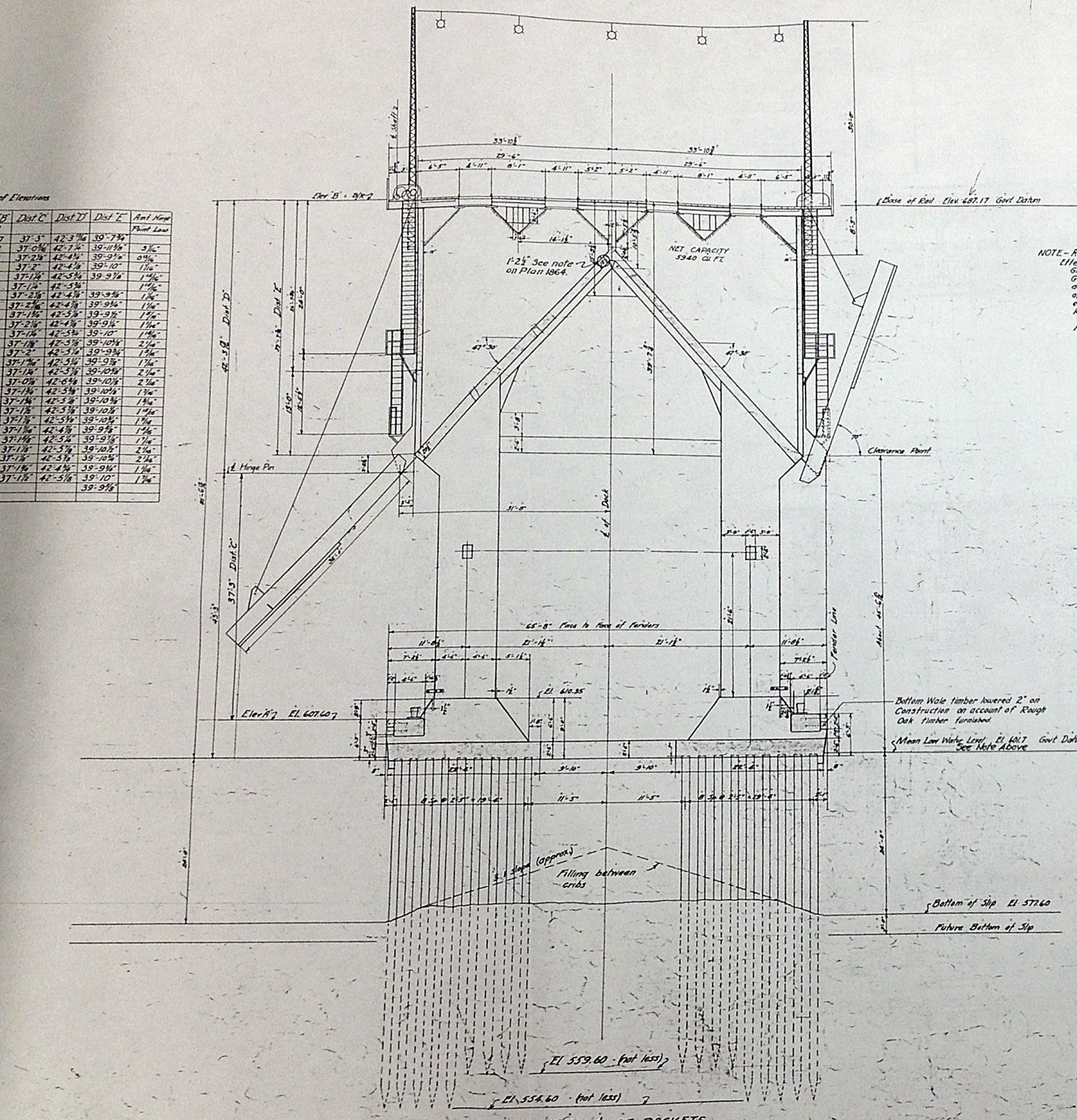
MSS 16
36'-0"
PLAN OF ORE CHUTE
Scale 3/4" = 1'-0"
SIDE ELEVATION
Scale 3/4" = 1'-0"
END ELEVATION
Scale 3/4" = 1'-0"
SECTION "D-D"
Scale 1 1/2" = 1'-0"
SECTION A-A
Scale 1 1/2" = 1'-0"
SECTION C-C
NOTE
Rivets 5/8". Holes 11/16", unless noted.
Spouts must be dust tight at all splices.
Inside of chutes not to be painted.
Side plates and bottom plates to be hard open hearth steel with an ultimate strength of from 70,000 to 75,000 pounds per square inch.
Rivet holes may be punched full size.
D. S. S. & A. RY. C
ENGINEERING DEPART
DETAILS OF ORE CH
NEW CONCRETE ORE
AT MARQUETTE, MI
Office of Chief Engineer


OLD COAL DOCK
U.S. GOV'T. DOCK LINE
HOLE No 1
HOLE No 7.
HOLE No 5
PRESENT TIMBER DOCK.
Area within shaded outline to be dredged to Elev. 577.60
Area within shaded outline to be dredged to Elev. 577.60
PROPOSED NEW DOCK.
Area within shaded outline to be dredged to Elev. 577.60
Area within shaded outline to be dredged to Elev. 577.60
30 Pile Cluster
PICKANDS COAL DOCK
RIPLEY'S ROCK
NOTE:--
For Sea Level elevation of bottom add 500 to all sounding figures. 'x' indicates location of rock, elevation of which is shown by circled figures.
It is to be understood that all borings or soundings shown on this Plan were obtained for guidance in the design of the structure and the Dock Company will assume no responsibility contingent upon the accuracy of the borings or soundings.
601.6
27
574.6 -27' DEPTH
Revised as to 6" raise of dock, change of approach alignment, change in deck overhang and lengthening of chute. A.J.K. 4/3/31 Ckd.-F.C.T. 4/3/31
DRAWING
REVISION
DEL.
TR. A.J.K. 4/2/31
CK. F.C.T. 4/2/31
QUANT.
QU. CK.
EST. NO.
D. S. S. & A. RY. CO.
ENGINEERING DEPARTMENT
SOUNDING MAP
FOR
NEW CONCRETE ORE
AT MARQUE
SCALE
OFF

FOR ELEVATION OF DOCK SEE PLAN 1863
Base of Rail Elev. 687.17
Conn. for fire hose
70' Span "5Q" From Old Approach
75' Span "5T" From Old Approach
Steel-Bent "5P"
Steel-Tower "5R"
Steel-Bent "5T"
LAKE STREET
Timber - Pier "5U"
℄ of first bent of dock
Present Ground Line Between Retaining Walls
Ground Line South of Retaining Walls
City Main
30" Brick Manhole
Mean Low Water Elev. 601.6
(Timber Frame Bents See Plans 1924 To 1929 Incl. & 1917)
Slip to be dredged to Elev. 577.60
G F E D C B A
Fender
Construction Note
Bents L and M driven and erected at right angles to ℄ of Dock and at 12' centers as adjacent bents.
26
27
28
29
30
31
32



CHUTES



SECTION THRU ℄ OF POCKETS
Scale 1/8" = 1'-0"

NOTE – Revised Vertical Control Datum:
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MLW Elev. 600.0 IGLD = MLW Elev. 601.7 at N.Y.C.

SPECIFICATIONS

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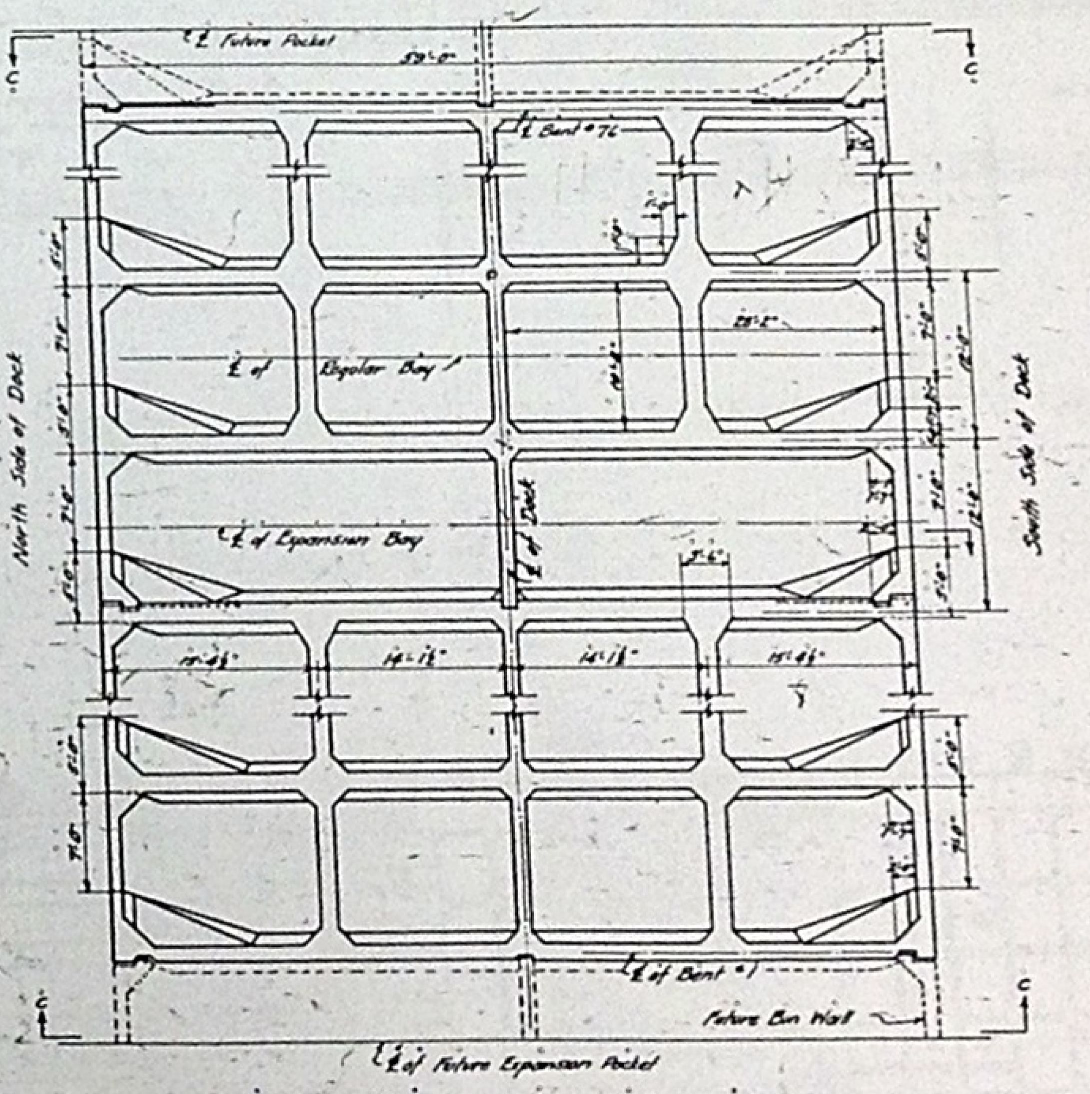
IMPACT	25% in design of all Track Stringers
WIND LOADS	30# per Sq Ft on Loaded Structure and 50# per Sq Ft on unloaded structure.
ORE LOAD	Weight of Ore in bins considered in design = 940,325#. Wt of Ore 145#/Cu Ft. Bin Floors figured to carry entire weight. Lateral pressure of Ore figured at p = 27.2 h - where "p" is the horizontal pressure per Sq Ft at depth "h".
UNIT STRESSES	Structural Steel - A.R.E.A. Specifications of 1925 Reinforcing Steel - 18000# per Sq In Concrete - f_c = 800 f_s = 18000 n = 12 for Superstructure Columns - 530# per Sq In. - Direct Compression
CLASS of CONCRETE	Superstructure - Concrete - f'_c = 2500# Columns - 2500# Concrete Mattress - Fenders - Pedestals - 2000# Concrete



TYPICAL PLAN VIEW OF BINS
Scale 1" = 10'-0"

For Sec C-C see plan 1865. Note that for Bent #1, expansion joint faces toward shore while for all other expansion bents (12, 23, 34, 45, 56, 67 & 76) it faces toward the lake. Section C-C for Bent #1 is the same as for other expansion bents except that concrete fillet is on the far side.

Revised as to type of fender. F.C.T. 5/8/31 Ckd - C.P.L. 5/8/31.
Revised as to 6" raise of dock, change of approach alignment, change in deck overhang and lengthening of chute. F.C.T. 4/3/31 Ckd. - C.P.L. 4/3/31

	Drawing	Revision
Del.	C.P.L. 4/2/31	
Tr.	I.W.M. 4/2/31	
Ck.	F.C.T. 4/3/31	
Quant.		
Qu. Ck.		
Est. No.		

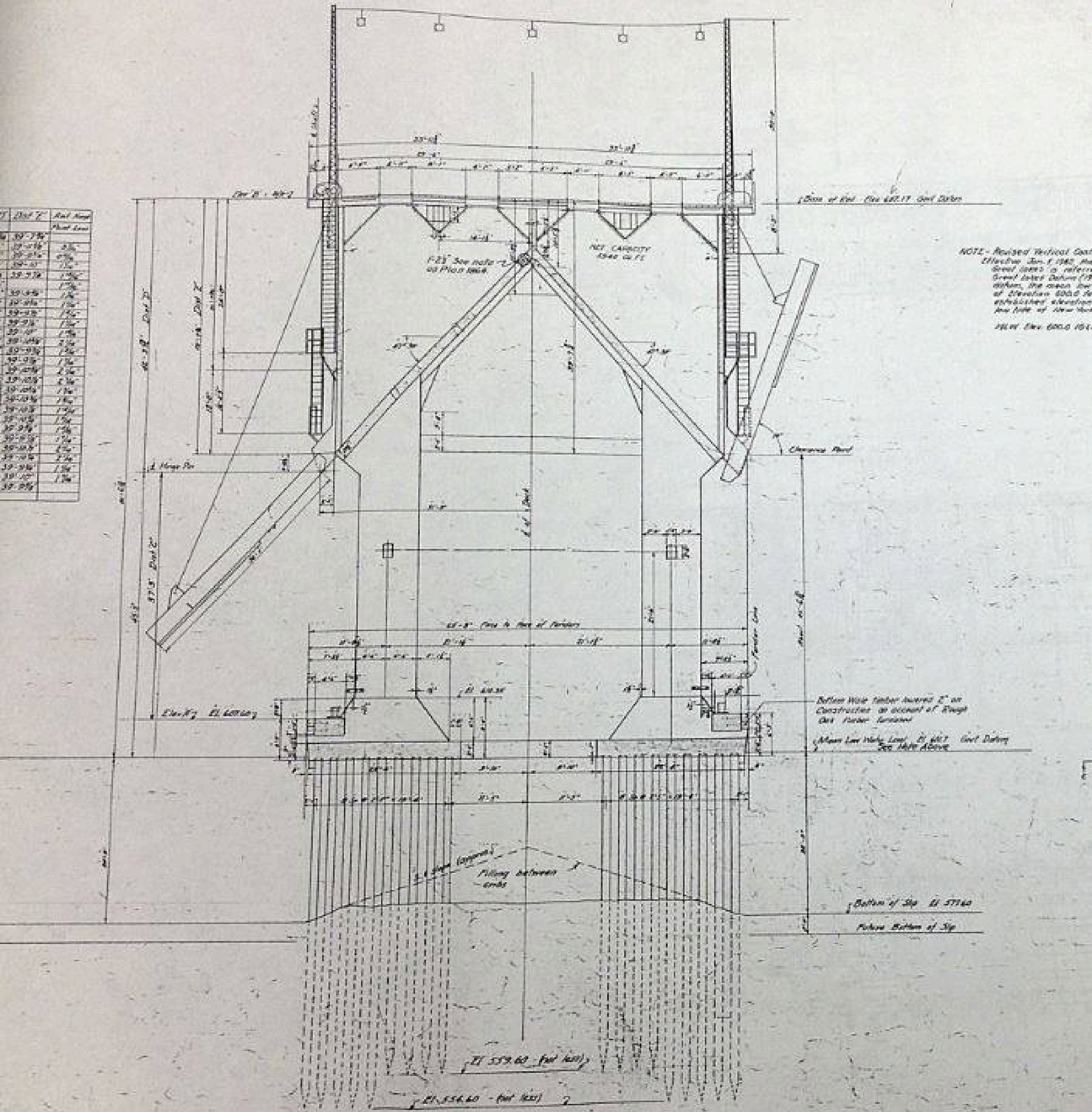
D. S. S. & A. RY
ENGINEERING DEPAR

GENERAL CROSS SECT
NEW CONCRETE ORE
AT MARQUETTE

Office of Chief Engineer Minn

Scales: 1/8" = 1'-0" & 1" = 10'-0"

Sheet 3 of 60



SECTION THRU ℄ OF POCKETS
Scale 1/8" = 1'-0"

Appendix E

Historical Photographs


GRAIN

HAER. NO. MI 45-1

HAER MI-45-1

HAER. No. MI-45-2.

HAER MI-45-2

HAER. No. MI 45-3

HAER MI-45-3

HAER No. MI-45-A-8


HAER No. MI-45-B-1

HAER. No. MI-45-B-2.

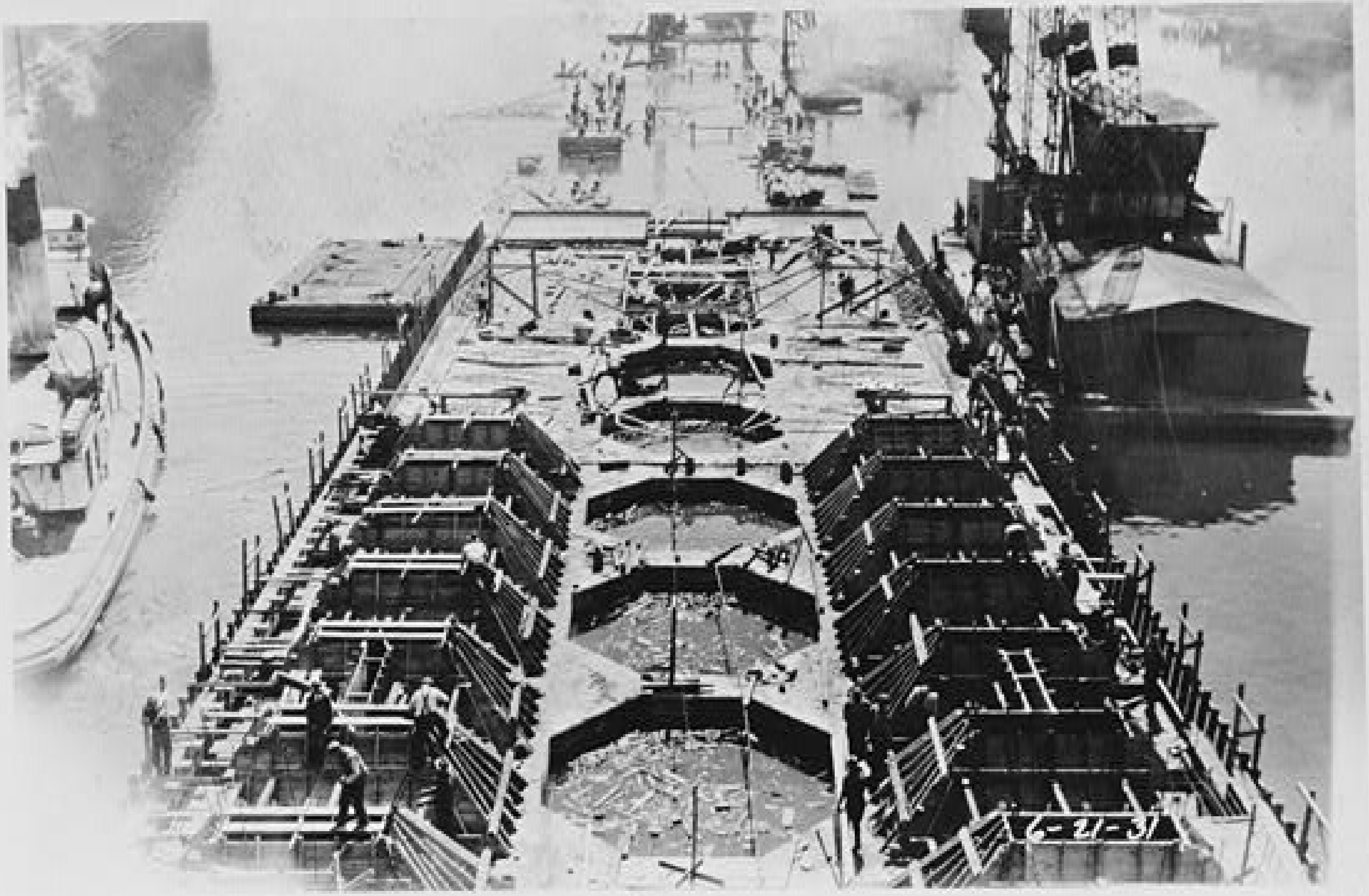
HAER NO. MI-45-B-3

HAER No. MI-45-B-4

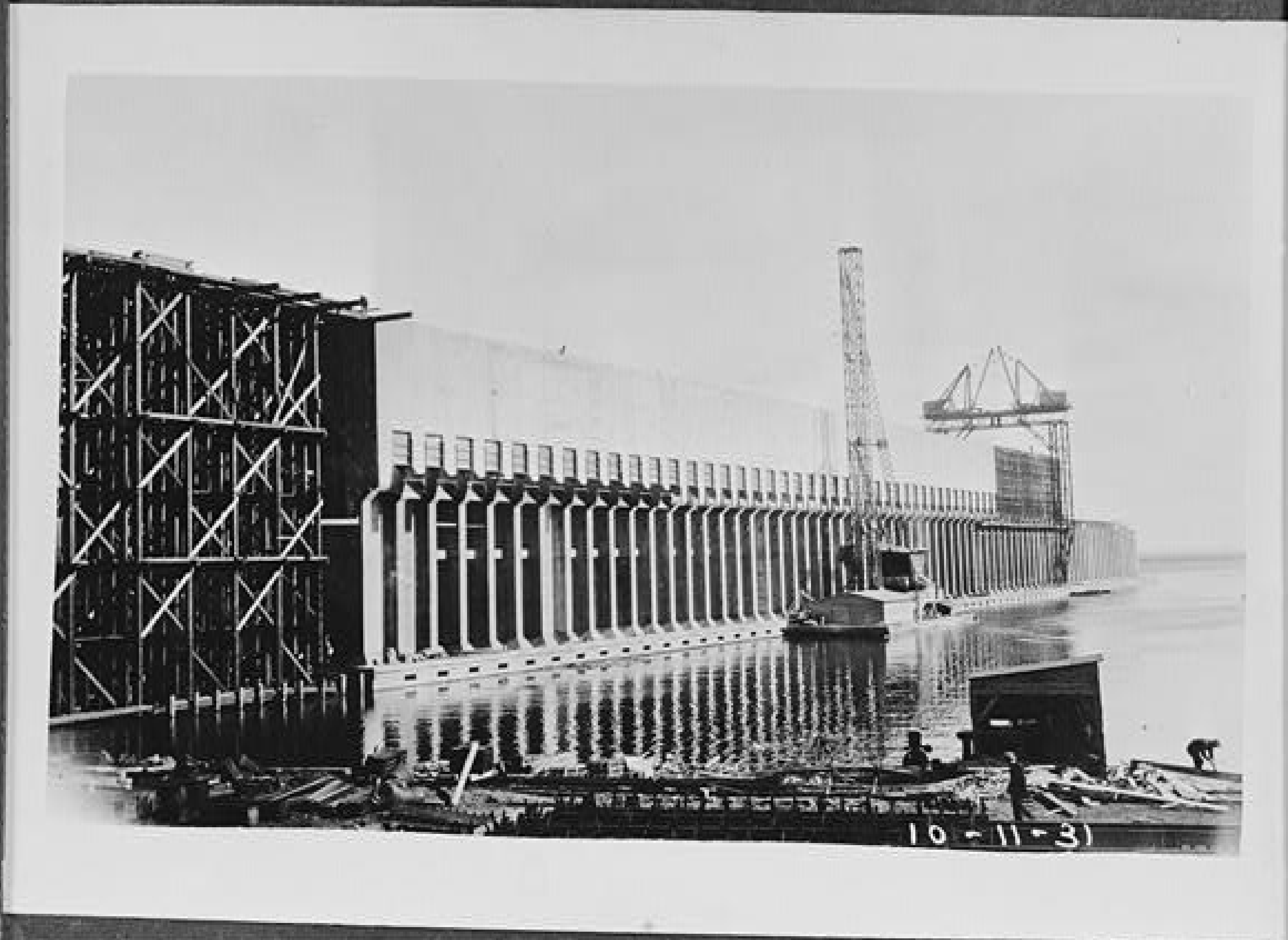
HAER No. MI-45-C-1

HAER No. MI-45-C-2

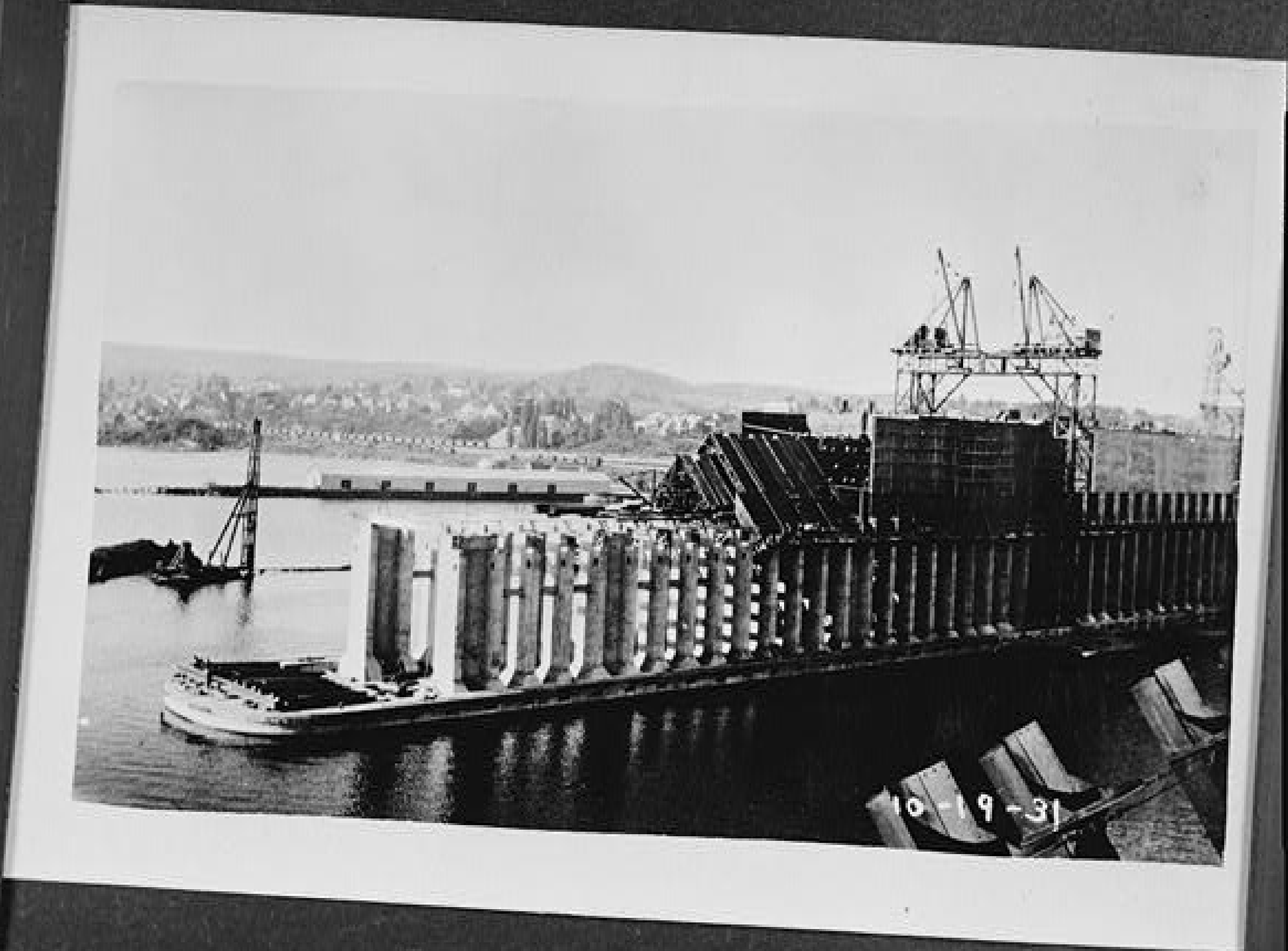
HAER NO. MI 45-C-3



HAER No. MI 45-C-4



HAER NO. MI 45-C-5



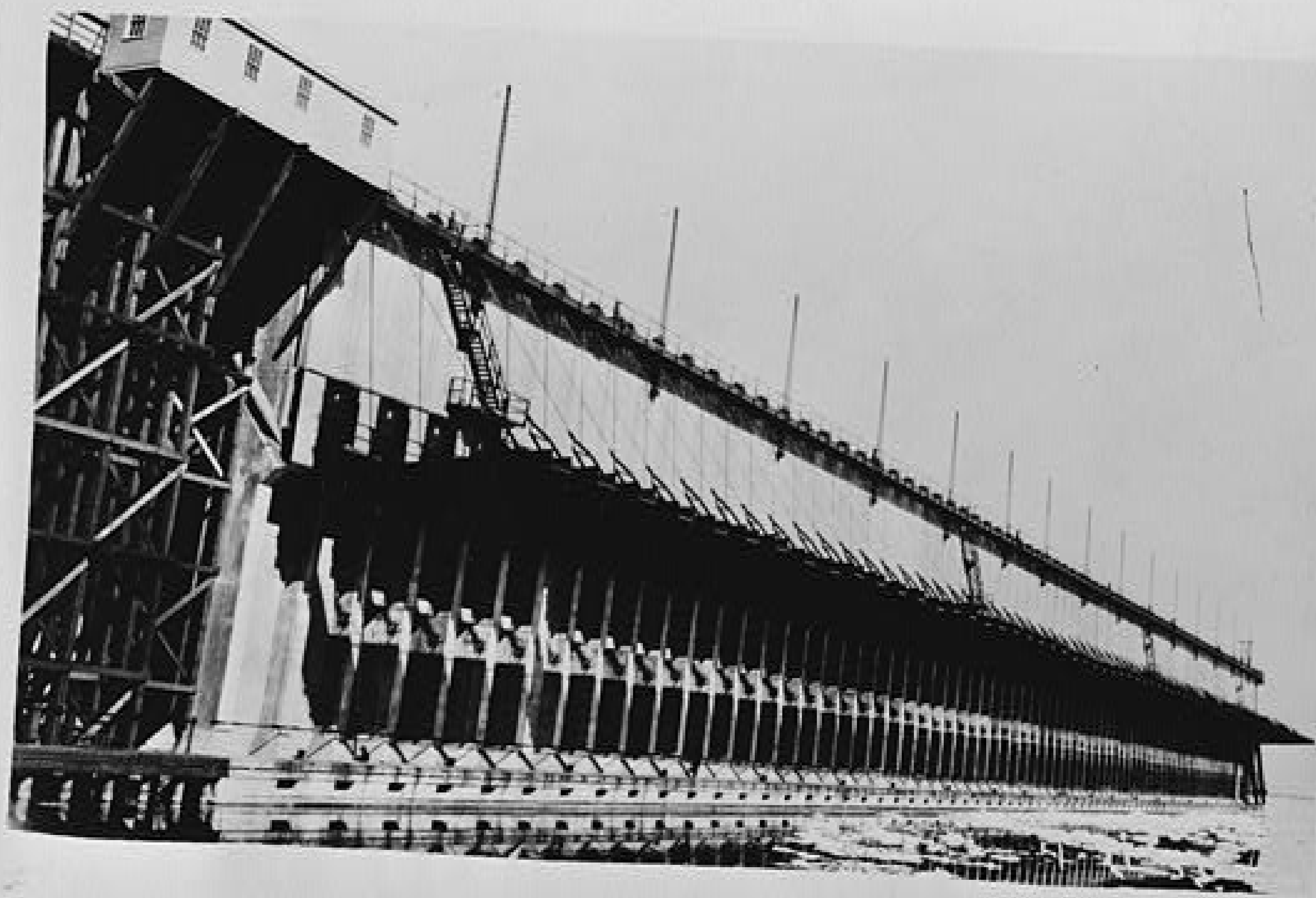
HAER NO. MI 45-C-6

Soo Line Steam Engine

HAER. No. MI-45-C-7

HAER. NO. MI 45-D-1

HAER. No. MI 45-D-2



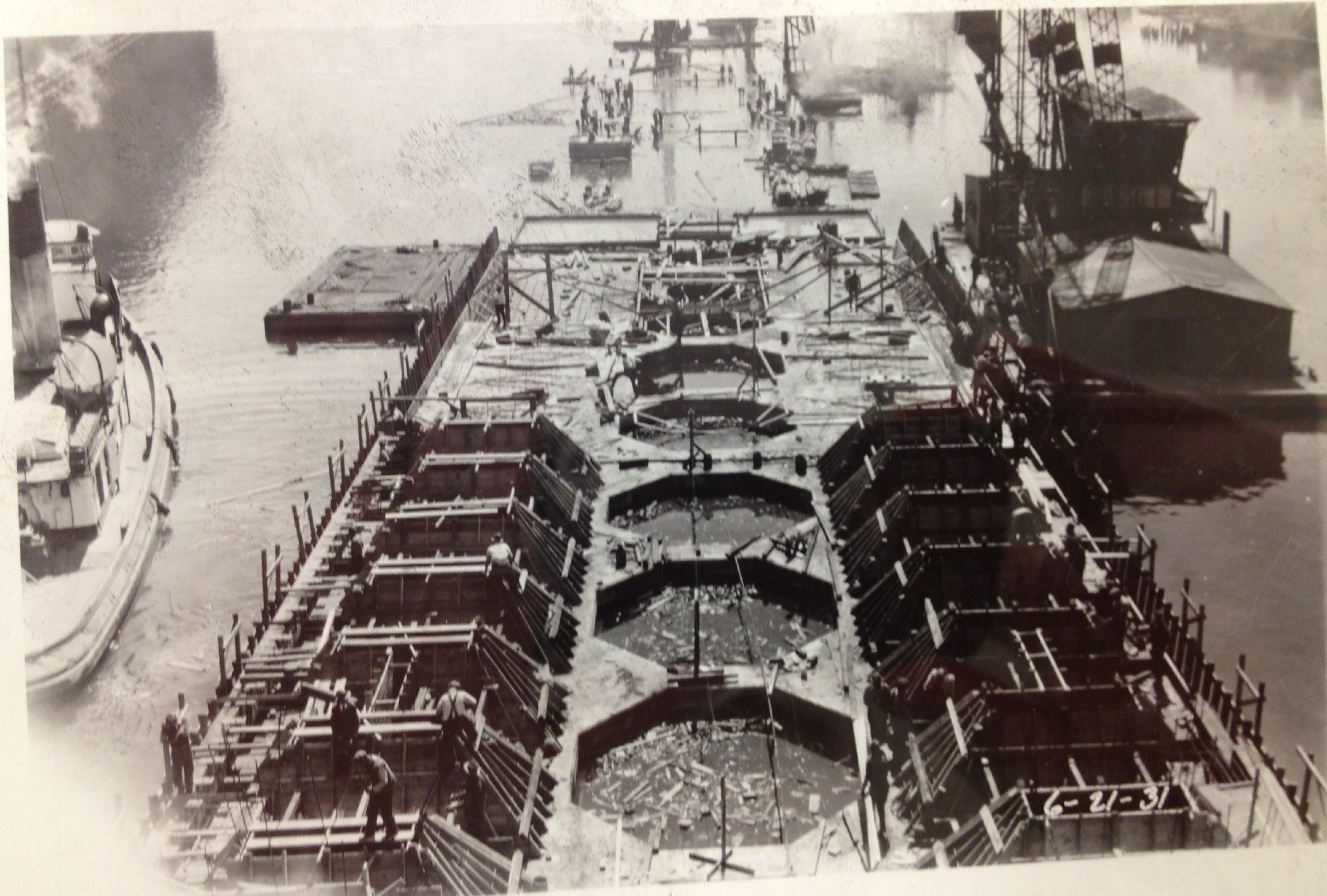
HAER No. MI-45-D-3

North Side


10-11-31


5-23-31


10-19-31


6-21-31


JOLIET

HAER No. MI-45-B-4

Appendix F

Historical American Engineering Record

Marquette Ore Dock No. 6
Fifth to Lake Streets
Marquette
Marquette County
Michigan

HAER No. MI-45

HAER
MICH
52-MARQ,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
MID-ATLANTIC REGION, NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
PHILADELPHIA, PENNSYLVANIA 19106

HAER
MICH
52-MARQ,
1-

HISTORIC AMERICAN ENGINEERING RECORD

MARQUETTE ORE DOCK NO. 6

HAER No. MI-45

Location: From Fifth Street on the west to a position jutting into the Lower Harbor off Lake Street on the east between Main and Spring Streets in Marquette City, Marquette County, Michigan.

UTM 16.470120.5154000
Quad: Marquette, MI

Engineer: Merritt-Chapman & Whitney Corporation, Duluth, Minnesota.

Date of Construction: 1931-1932.

Present Owner: Wisconsin Central, Ltd.
One O'Hare Center
6250 North River Road, Suite 9000
Rosemont, Illinois 60018

Present Use: Vacant.

Significance: The Marquette Ore Dock complex is an excellent example of the final phase in the evolution of the iron ore pocket dock in American industry. It was near this site that the first pocket dock ever used in the iron ore trade was developed (1857) in Marquette. The dock and its approach are fine and intact examples of mid-20th century industrial technology. The dock is a model of construction efficiency having taken one year to complete this massive structure. Locally it is a monument to the important role played by Marquette and its ore docks to the development of the Great Lakes iron ore trade and the American steel industry.

Project Information: This documentation was undertaken from June through August 1990 in accordance with agreements with Wisconsin Central, Ltd., the Interstate Commerce Commission, The National

Park Service, and the Michigan State Bureau of History.

Russell M. Magnaghi
Historian
Northern Michigan University
Department of History
Marquette, MI 49855-5352

The former Duluth, South Shore & Atlantic (DSS&A) Ore Dock No. 6 is the physical legacy of nearly 140 years of history. Marquette was established in 1849 as a shipping point for iron ore which was extracted to the interior some dozen miles. The dock is located in Marquette, Michigan's Lower Harbor. The structure juts into the harbor off of Lake Street in the block between Main and Spring Streets. The approach to the dock, which is part of the overall complex, commences some five blocks or half a mile to the west at Fifth Street.

The industrial history of the central Upper Peninsula of Michigan begins in September 1844 when William Burt, deputy of the linear survey of the region discovered iron ore in the present city of Negaunee. This and other ore bodies were located some dozen miles from the shore of Lake Superior.

As a result of this discovery of iron ore, the Marquette Range was first developed because of the range's close proximity to transportation on Lake Superior. In 1845 a group of speculators from Jackson, Michigan headed by Philo M. Everett explored the area and opened the Jackson Mine at Negaunee. Within the year the first iron was mined from an open pit. A small iron forge was established at Carp River, a few miles to the east of the mine and early in 1846 iron blooms were made from the Jackson ore. Then in 1849 the Cleveland Mine near Ishpeming was developed and in 1850 about five tons of ore was shipped to New Castle, Pennsylvania. News of the high quality of the ore spread among iron men in Pennsylvania and Ohio. Approximately seventy tons of ore were shipped from the Jackson mine to Sharon, Pennsylvania in 1852. It was the first Lake Superior ore to be made into pig iron. This experiment emphasized the value of this ore and it was realized that better transportation facilities to and from Lake Superior were necessary. With the opening of the St. Mary's River Canal at Sault Ste. Marie in 1855 which finally by-passed the twenty-seven foot drop between Lakes Superior and Huron, improvement in transportation of ore had begun.

The development of the city of Marquette as the major point of embarkation began because of the excellent harbor which was improved over the years with the addition of a breakwater. In the summer of 1849 Peter White a future community and business leader and ten associates arrived to develop a new community. While awaiting Amos Harlow and his crew and equipment, they visited the mines in the interior. By 10 July 1849 the various parties met at the future site of Marquette and began to clear the land. Anticipating the arrival of a supply ship, the laborers under the direction of Sam Moody constructed the first dock at Marquette. It was a crude affair of piled logs, stone and sand located near the end of Baraga Street. Unfortunately during the night of the third day it was destroyed by a lake storm and nothing remained. After that time ships anchored a mile or two offshore and all goods and passengers were taken ashore by lighter or if they could swim like animals or could be floated they were guided to shore. By the spring of 1850 there were a number of dwellings and shops concentrated at the foot of Baraga Street. The construction of a small dock allowed ships to land and ended the earlier inconvenience and inefficiency.

At first the heavy iron ore was shipped over rough roads through a wilderness filled with mosquitoes and black flies. In 1856 a plank road was constructed from the mines to Marquette. Later it was converted into a tramway and in 1857 it was supplanted by the Iron Mountain Railroad, the first in Upper Michigan. Previous to the construction of the railroad only 52,000 tons of ore were shipped and smelted at local forges. The entire output in 1857 was only 21,000 tons. Increased production brought the tonnage to 31,035 tons in 1858 and by 1860 it exceeded 100,000 tons.

Over the years the concept of the ore dock and ore boats evolved and was technologically refined as the demand for ore increased. When the first 1,447 tons of iron ore were shipped from Marquette there was no loading dock. After cargo had been stored in the hold of small schooners and steamers, ore was chiefly loaded on the decks.

The first ore dock ever constructed was built in Marquette's Lower Harbor in 1855 for the Jackson Iron Company by Jabez Smith of Sharon, Pennsylvania. It was located along the north side of the harbor where the Ellwood Mattson Park is located today. A wooden trestle extended from the end of Washington Street to the end of the dock. It gradually declined in height to about eight feet above the dock where the ore was unloaded or four and a half feet about the water level. At this time the ore was brought from the interior mines in four wheeled wooden wagons drawn by mules. The ore was shoveled from the wagons to the dock and then loaded into wheelbarrows and put into the hold of the waiting ships. It took twenty to thirty men three to six days to load a cargo of 200 to 300 tons. At that time the largest ships had a 300 ton capacity.

In the same year the Cleveland Iron Mining Company built a dock at the foot of Baraga Avenue. In contrast to the Jackson dock, the wagons proceeded onto the level dock where the ore was unloaded into wheelbarrows and reloaded aboard the vessels.

The first two docks proved to be inefficient. It was impractical to leave railroad cars loaded and standing idle until the arrival of a ship. In 1857 the Lake Superior Iron Company constructed a combination ore and merchandise dock at the foot of Main Street. This dock was 25 feet in height and was the first to have storage pockets for the ore. There were 27 pockets on the south side of the dock with a capacity of 2,000 tons. It is interesting to note that at first ship captains feared that ore falling from a height would damage or possibly sink a vessel. These objections were soon overcome. Then in 1858 the Cleveland dock was reconstructed with 29 pockets and a capacity of 2,300 tons. Storage capacity was increased by raising the pockets to 30 feet while the mouth of the pocket remained at the same height.

The last of the pre-1868 ore docks was constructed in 1864 by the Bay de Noquet and Marquette Railroad. It was a combination ore and merchandise dock located on the site of Marquette Ore Dock No. 6 between Spring and Main Streets. It extended 600 feet into the harbor, was 35 feet in height with a capacity of approximately 4,000 tons.

In June 1868 disaster struck the community. A fire broke out in the center of the town and quickly engulfed most of the buildings and destroyed all of the ore docks except the Cleveland dock. During the rest of the season all of the mining companies used this dock which operated 24 hours a day. Due to the great demand, ships had to anchor offshore for one to three weeks.

The Bay de Noquet and Marquette Railroad constructed a new dock in 1869 on the site of its old dock of which 200 feet were spared in the fire. This dock was larger than any of the older docks and shows the technological improvements. It was 1,300 feet in length, 38 feet high, 46 1/2 feet wide, and each of its 120 individual pockets held 55 tons for a total capacity of 6,600 tons of ore. This dock was in operation until 1894.

Over the years other ore docks were constructed, extended or improved in Marquette's Lower Harbor. In 1905 the Duluth, South Shore & Atlantic Railroad began constructing what became known as Dock No. 5. It was constructed on the site of the 1864 and 1869 docks. The wooden dock was 1,236 feet in length, 71 feet high, 53 feet 3 inches wide, and its 200 pockets had a storage capacity of 40,000 tons of ore. The first boat was loaded in August 1906 and the last one left in November 1931.

The dock under consideration known as Ore Dock No. 6, is a direct descendant of the many ore docks which have stood in Marquette's Lower Harbor. DSS&A officials knew that the life of Ore Dock No. 5 constructed in 1905-06 was twenty-five years. As a result in 1926 the DSS&A Railroad began to develop plans for a new dock. At first there was talk of constructing a wooden dock but this idea was changed as a steel and concrete dock would be more practical, as evidenced by such a dock built at Presque Isle in 1896. Between 1926 and 1930 data were assembled, preliminary surveys made, and diamond drill tests made of the harbor bottom.

In 1930 the Chief Engineer of Duluth, South Shore and Atlantic reported that the timber ore dock could not be maintained in a safe operating condition beyond the 1931 shipping season and that a new dock would have to be constructed as planned. The old dock was proving very expensive to maintain and operate. The average repairs costs between 1916 and 1930 amounted to $14,000 annually. On account of the fire hazard, insurance costs were high, and watchmen had to be employed. Furthermore, from an operational standpoint the dock was obsolete. Due to its insufficient height from the water, the larger boats could not be loaded to their maximum capacity; considerable ore was spilled into the slips; and serious delays were encountered by all of the boats. Since quick dispatch was imperative during the shipping season the company was subjected to numerous complaints.

As early as March 1929 there was talk that construction would begin immediately, but final plans were not completed until the fall of 1930. Furthermore there were some technical problems to be dealt with by the railroad. At the end of the year the railroad received permission from the Marquette City Commission that it could proceed with construction.

At this time the South Shore Railway Company was without funds to build a new dock and without a dock it would lose its iron ore business which represented 25% to 40% of its total tonnage and 11% to 20% of its earnings. Obviously this would have a disasterous affect on the Company's earning capacity and on its bond-holders. The financial problems were fully explained to officals of the Canadian Pacific Railway Company. In order to protect the future earnings of the Company, Canadian Pacific advanced South Shore $350,000 toward the cost of the new dock and made certain additional guaranties. A corporation known as the South Shore Dock Company, with a capital of $10,000 (subsequently reduced to $1,000), all owned by the South Shore Railway Company was then organzied. The articles of association were filed at the Marquette County Court House on 11 March 1931.

The proposed site for the new dock was on a piece of property on which the Marquette, Houghton & Ontonagon mortgage dated 1 April 1885 was a first lien and was also subject to the liens of the DSS&A mortgages of 15 April 1887 and 17 July 1890. This property was deeded to the South Shore Dock Company after releases had been obtained from the Marquette, Houghton & Ontonagon and South Shore Railway Company mortgages, giving the Dock Company unencumbered title to the site. It constructed the dock at a cost of approximately $1,350,000 and leased it to the Marquette, Houghton & Ontonagon Railroad Company for a period of 14 1/2 years at a rental of $4,166.67 per month up to and including 30 November 1931 and $8,350 per month from 1 December 1931 to 30 November 1945 in order to provide for interest charges and serial retirement of bonds. This lease was later assigned to the South Shore Railway Company.

To provide funds for this dock in excess of the money advanced by the Canadian Pacific, the South Shore Dock Company executed a first mortgage and issued $1,000,000 worth of bonds which were sold at 97, maturing serially to 1 December 1945 and pledged the dock and the lease as security. The payment of the lease rentals were guaranteed by the Canadian Pacific Railway which enabled the Dock Company to realize nearly par on its bonds.

The South Shore Dock Company later sold its property, subject to the Dock Company First Mortgage to the Marquette, Houghton & Ontonagon Railroad Company. This company immediately sold the same to the South Shore Railway Companay subject to the Dock Company First Mortgage, the Marquette, Houghton & Ontonagon mortgage of 1 April 1885 and a supplement dated 31 October 1931.

The construction process began with the awarding of contracts. The first one was awarded in March 1931 when the Lake Shore Engine Works of Marquette was contracted to construct 150 hoists for raising and lowering the dock chutes. The second contract was let out on 1 April, to the Merritt-Chapman & Whitney Corporation of Duluth. This company was the successor to Whitney Bros. which specialized in the building of docks, bridges, heavy construction work of all kinds as well as river and harbor improvements. They would bring their experiencee to this project. The fabricated steel for the dock including the large steel ore chutes would be furnished by McClintick, Marshall Corporation of Chicago. Jernstad Electric of Ishpeming would install the electrical work and the Woden-Allen Company of Chicago was given the contract for furnishing all of the reinforced steel for the dock and its approach.

The labor force on the project was primarily from the Marquette area. Since this was 1931 in the heart of the Great Depression, prior to 1D April the Marquette Chamber of Commerce had requested the DSS&A officials to pressure Merritt-Chapman & Whitney to hire Marquette laborers. By mid-May rumors began to circulate in the community that out-of-town workmen had been employed on the site. A quick investigation showed that Merritt-Chapman, & Whitney had brought in their own engineers and men familiar with pile driving. The latter laborers were brought in because pile driving was dangerous for unskilled laborers and it would have taken three months to train a Marquette work force. At the time 75% of the workers on the site were from Marquette and it was pointed out that more laborers would be needed to construct the land approach. By 7 July the dock construction crew had reached its maximum size although a few more men might be added in the fall if unfavorable weather should slow up the operations which were running a little behind schedule. There were approximately 325 men working in two shifts. Given the nature of concrete work, these crews were employed 24 hours a day while the rest worked two ten hour shifts. The percentage of Marquette workers remained the same. At the height of construction for a period of a month there were 340 men working on the site but by 9 September the figure had returned to approximately 250-275 men which was the average figure. Toward the end of the construction season in late October there were 290 on the payroll. As the dock neared completion in early November the demand for a large labor force and working in two shifts was ended. Since the start of construction there were both day and night shifts and this was reduced to the day shift. By February 1932 as completion of the dock approached the work force was down to 155 men.

Serious injuries on the work site were infrequent. However on 30 September, Floyd Balwanski fell 20 feet from the dock to the bottom of a pocket. He was taken to St. Luke's Hospital in Marquette with two right fractured ribs, a fractured wrist, torn ligaments and facial lacerations. It took him several months of recuperating before he returned to work. In mid-December the first fatal accident was reported since contractors began dismantling the old ore dock. Edward Magnuson of Twin Harbors, Minnesota fell from the dock into the water but struck a piece of floating timber. He died several days later from internal injuries.

The fact that dock construction work provided jobs for several hundred Marquette residents did not go unnoticed by them. In late January 1932 they contributed a percentage of their wages amounting to $308 to the Family Welfare Agency of Marquette.

Work on the dock was blessed with excellent weather. There were a number of hot spells which drove temperatures into the 100s but they soon passed and Marquette's cool summer weather prevailed. Between April and September only half a day had been lost to the weather. This mild weather continued through December and allowed work to progress ahead of schedule.

The shipping season closed on 16 November with the loading and departure of the <u>George R. Fink</u> with Buffalo as its destination. Prior to the actual razing of the timber dock the chutes and hoists had been removed and taken to the DSS&A west yards where they were stored for future disposition. Between 60-70 men were employed razing the old dock which began on 1 December. Work progressed rapidly. The electrical work was dismantled and then attention was directed toward dismantling the steel trestle over Front Street. The DSS&A salvaged the larger timbers which were sold. The scrap wood, small timber and planing was shipped to the Schneider sawmill in north Marquette. The work of dismantling the old dock was all but completed in early February 1932 and by the end of the month the refuse material and old timbers were removed from the site.

At the site of the new dock some last winterization was taking place in early December. The huge traveling crane which straddled the dock was used as a mount for booms. The latter were utilized to swing pockets, chutes, hoists, and other metal work into place. The crane was dismantled and stored for the winter. One tug and the barges, Four Spot and The Limit were wintered in Marquette. DSS&A cars were loaded with other pieces of equipment and shipped to Duluth.

Merritt-Chapman & Whitney reported in early February 1932 that the construction project was two months ahead of schedule and 1 March was to be the completion date. On the dock electrical equipment and machinery had to be installed along with general finished work such as cleaning and painting.

The dock was fully completed and ready for operation on 15 May 1932. The total cost to the companies involved was as follows:

Paid constructors..................	$558,716.72
Material purchased.................	501,597.02
Freight charges on material........	108,617.56
Rental of equipment................	3.00
Land and improvements..............	32,863.48
Discount on bonds..................	30,000.00
Michigan mortgage tax..............	5,000.00
Engineering and other expenses......	86,616.82
	$1,320.414.60

The South Shore Dock Company expended the following monies:

From its own funds..................	$350,000.00
From funds received from trustees on certificates Nos. 1 to 9, inclusive........................	$593,184.48

The Duluth, South Shore and Atlantic Railway Company has expnded:

From funds received from trustees on certificates Nos. 10 to 20, inclusive........................	$374,635.12
From its own funds subject to reimbursement by trustees..........	2,595.00
	$1,320,414.60

In the early part of June the U.S. Army Corps of Engineers announced that it would dredge the harbor to 24 feet for more efficient shipping. This was done in the latter part of June.

Although the dock was completed the Depression economy slowed its use. Most of the mines on the Range were closed since November 1931 because of the lack of steel orders. However the Ford Motor Company's Blueberry Mine in Ishpeming was open but operating at half capacity. It had accumulated a stockpile of 10,000 tons of iron ore which could be shipped from the new dock. DSS&A officials anxiously awaited the first shipment.

The new dock was put into service on 3 June 1932 when 30 cars arrived from the Blueberry mine and dumped the ore into the dock. On 6 June the _Henry Ford II_ tied to the north side of the dock at 1:20 p.m. 10,103 tons of ore were loaded into the _Henry Ford II_ by 4:08 p.m. and vessel left for the Ford Motor Company in Detroit. On 19 June the _Henry Ford II_ returned and loaded 3,000 tons of Imperial Mine ore and 7,000 tons of Blueberry Mine ore. The actual loading time was 2 hours and 58 minutes. The loss of time was due to sticky ore from the Imperial Mine and a shortage of help.

Over the next 39 years the following tonnage was shipped from Ore Dock No. 6:

1932-	122,314	1946-	340,299	1960-	600,713
1933-	442,496	1947-	524,055	1961-	499,792
1934-	636,353	1948-	437,839	1962-	597,648
1935-	617,826	1949-	462,729	1963-	681,079
1936-	941,473	1950-	619,469	1964-	844,697
1937-	867,367	1951-	578,876	1965-	1,068,355
1938-	178,539	1952-	398,110	1966-	1,158,617
1939-	639,622	1953-	471,108	1967-	875,307
1940-	642,837	1954-	309,779	1968-	1,018,068
1941-	860,674	1955-	474,309	1969-	1,108,316
1942-	684,603	1956-	492,023	1970-	590,972
1943-	601,735	1957-	361-362	1971-	258,039
1944-	308,306	1958-	491,371		
1945-	516,436	1959-	628,577		

The greatest tonnage year for either Ore Dock No. 5 or No. 6 was in 1911 when 1,383,206 tons of iron ore were shipped.

When the dock was completed its dimensions were not exceeded by any dock in the Lake Superior region. It was composed of the following materials:

Dock:

Structural steel..............	1,740	tons
Concrete......................	28,650	cubic yards
Reinforcing steel.............	1,370	tons
CI snubbing posts.............	11.5	tons
Hardware and iron.............	30	tons
Piling timbers (each 25 feet above lake bottom)...	7,600	

Underwater timber cribs	560,300	FBM

Approach:

Structural steel...............	945.5	tons
Concrete......................	1,360	cubic yards
Reinforcing steel..............	9.35	tons
Hardware and iron.............	34	tons
Pilings.......................	19,580	FBM
Timber........................	840,000	FBM

The length of the facility which includes the approach and the dock is 3,546 feet. The dock itself measures 969 feet from the beginning of concrete construction to the fender at the east end.

During its first year in service the dock handled a mere 122,314 tons. Planned in the prosperous 1920s it had potential for increased use in the future. Throughout its history the Ore Dock was maintained and improvements made but there were no major renovations which completely altered the nature nor utilization of the structure.

During World War II it operated efficiently although not at full capacity. Even in Marquette there was concern for espionage and on 8 July 1943, Walter Measure from the Continuous Security Branch of the Sixth Army inspected the facility. In a report issued on 20 July it was recommended that the railroad: 1) provide riot guns or sawed-off shotguns for its guards, 2)properly train the guards in the use of these firearms; and 3) increase the number of fire extinguishers throughout the timber deck area. Also during the war two wooden semaphores were placed at the end of the dock to signal approaching boats which side of the dock was available for loading. The dock entry lights were useful at night but during the day captains could not see them because of the glare. The semaphores were installed in May 1944.

Major improvements were made at the end of the 1947 season. The wooden fenders on the dock were rebuilt and pile drivers redrove the cluster piles. By mid-October the pilings for the protective fenders at the outer end of the ore dock had been redriven, but they had not been spaced nor the timber blocks installed. The cluster piles to the south near Ripley's Rock had been redriven and tied with cable. On the south side of the dock all of the pilings in the wood fender had been redriven but not cut off. The schedule called for work to be completed by the end of the month.

As the years passed due to the harsh weather conditions, repairs and improvements were constantly made on the dock. Early in 1953 it was observed that the overhead wiring on the upper deck had to be replaced. This work was completed by 1957. Poor lighting at the end of the dock caused a flood light and two lights twelve feet above the fender to be installed in 1961. The electric hoist motors went through gradual maintenance and repair at the rate of two motors per year between 1956 and the early 1960s.

The last major repair program dated back to 1954, however during the early 1960s there were a number of seasons of heavy repairs made on the dock. During the winters of 1965-1966 and 1966-1967 general dock work was carried out along with the construction of approach posts, bridge piling and crib construction. Costly steel work on the chute liners and ore pocket doors and linings was also completed and the wooden decking and walkways were repaired. Finally the untreated dock timbers were replaced with rot resistant treated timbers.

Besides the maintenance to the structure there were concerns for the depth of the slips for ships. Silt build-up caused the company to take periodic and detailed soundings of the north and south slips. Although the depth might be adequate, off-shore winds lowered the water level to a dangerous minimum and thus dredging had to be done. In 1954 some 22,300 cubic yards were removed from both sides of the dock. Again in 1965 21,500 cubic yards were removed from the north side only. Ripley's Rock along the south side limited ships to a depth of 25 feet.

Over the years the Ore Dock had been owned by a number of railroads. On 11 March 1931 the South Shore Dock Company was incorporated to manage the facility for the DSS&A Railroad. This company was finally dissolved on 13 September 1943. The DSS&A was bought by the Soo Line in 1961 and the dock had new owners who continued to operate it as in the past. Finally Wisconsin Central Ltd. purchased the Ore Dock and other Soo Line properties in Marquette in October 1987.

Although time and the elements did not treat Ore Dock No. 6 well, the structure remained an important Marquette landmark. In 1967 it was the subject of a popular painting. Robert Thom of Birmingham, Michigan was commissioned by Michigan Bell Telephone to produce a painting of the structure which was unveiled in Marquette during Michigan Week (late May) in Marquette. This painting was part of a series dealing with Michigan history which are available through the Michigan Bureau of History in Lansing.

The life of the ore dock was based on the ore production of the once numerous small, independent mines on the Marquette Range. The Cleveland Cliffs Iron Company (CCI) which was the major producer on the Range had its own ore dock at Presque Isle in north Marquette. By 1970 the Ore Dock No. 6 was receiving most of its ore from the Tracy Mine in Negaunee which was owned by the Jones & Laughlin Steel Corp. This underground mine, which shipped its first ore on 10 September 1955, supplied iron ore to Jones &

Laughlin steel mills in Cleveland, Pittsburgh and elsewhere. In 1962 the mine reached its peak of production employing over 350 men. In early 1971 Robert Prittenen announced to a stunned and silent Negaunee city council meeting, attended by miners, that the mine would be closed. He cited the fact that the ore was unsalable on the market due to the fact that it was between 11-13% iron while pelletized ore was 63-66% iron. Construction of a pellet plant was not possible because the mine was only one-tenth the size of CCI's Mather Mine in Negaunee.

As a result of this development the 1971 shipping season at the dock was short. Fifty ships followed the first one which was loaded on 4 May. The last ore car left the Tracy Mine on 9 July and on 28 July the J. Hutchinson was the last vessel to load from the dock. Throughout the season only 258,039 tons of ore had been shipped from the Lower Harbor dock. Between 1932 and 1971, 23,951,090 tons of ore were shipped from the Ore Dock which averaged 598,777.25 tons per year. In contrast the season at the Lake Superior & Ishpeming dock at Presque Isle, which handled CCI ore, ran from 13 April to 8 December 1971 and 201 ships were loaded with 3,157,474 tons of ore. As a result the Soo Line made the decision to terminate service at the dock on 31 December 1971.

After the Ore Dock was closed in 1971 there were a number of attempts at reopening it, dismantling the structure, fighting legal action to have it removed and developed for reuse. With the development of ore pellets, whereby low grade iron ore was crushed, the waste removed, and a new enriched pellet created, the iron industry on the Marquette Range had a new life. One of the major projects on the Range was the development of the Tilden Mine. Early in 1974 officials with the Soo Line and Cleveland Cliffs Iron Company discussed the possibility of reopening the Ore Dock. At the time the Tilden Mine was expected to commence production on 1 July 1974 at the rate of 4 million tons per year. It was anticipated that this production would rise to 8 million tons in 1978 and by 1982 this figure would rise to 12 million tons. It was hoped that within 8-10 years the mine would be producing 20-22 million tons of pellets. The Lake Superior & Ishpeming Railroad dock in north Marquette and the Escanaba facilities could not handle this tremendous increase in production, so Soo Line officials were asked to consider reopening the Ore Dock. A complete inspection was conducted in July 1972 and the dock and its approach were found to be in fairly good condition. There was some wear on the concrete in the pockets which would require future maintenance. The major work required on the dock would be the replacement of damaged and rotted planking on the deck proper, the straightening of chute angles, the installation of splash shields at the chutes, some welding on the chutes, and the replacement of some timber fenders. All of the electric motors which were last operated in the spring of 1973 appeared to be in good condition as well. Soundings along both sides of the dock were taken 28 December 1973 and it was found that dredging would have to be done in order to efficiently utilize the facility.

At the time a cost repair estimate was made by the Soo Line. The repairs to the dock and its approaches would be $38,000, while dredging would cost an additional $65,000 and $6,000 would have to be spent on the installation of splash shields on the pockets. Besides the regular maintenance it was anticipated that if the dock shipped 1.5 million ton of ore per year it would have to be extensively rehabilitated in 2004. Unfortunately nothing followed these reports.

In 1981 there was some renewed interest in utilizing the dock and its approaches. A complete inspection of the dock showed that it would have to be rehabilitated if it were to be reopened. The report showed that the deck proper was in poor condition and most of the ties would have to be replaced. The shakers and doors were beyond repair and would have to be replaced and 93 front covers and 81 rear covers on the chutes were missing. The sanitary facilities drained directly into the lake and they would have to be connected to the city sewer system. The hoists would have to be repaired along with the stairs, and the ore scale which had been destroyed by fire. The approach needed many replacements and it was recommended that the rails and switches be replaced with heavier gauge rails to more efficiently handle heavier loads. The Soo Line estimated proposed expenses according to the following schedule:

Dock and approach...........	$625,000
Dock electrical equipment and motors...	$ 19,000
Dredging (contract work)....	$ 70,000

In the course of the correspondence a review of the historical development of the structure was brought forth. Although the original cost of the structure was $1,297,900 in 1981 money, it would have cost $13,789,927 to replace the dock. Over the years the structure and its marine approaches had been improved according to the following schedule:

Electrical work (1933-1944).......	$ 323
Fenders (1947)....................	$19,322
Dredging (1954)...................	$ 9,935
Dredging one slip (1965)..........	$30,084
Approach improvement (1958).......	$21,320
Approach improvement (1959).......	$29,124

The status of the dock remained undecided. On 8 March 1985 Krech & Ojard Consulting Engineers based in Duluth, Minnesota released a report, "Removal Estimate of the Soo Line Ore Dock in Marquette MI" which had been ordered by the Michigan Department of Transportation. The demolition was to: 1) remove the dock superstructure to elevation 610.35 or roughly 9 feet above Mean Low Water; 2) remove the dock foundation; and 3) remove the approach trestle to the dock. This had to be done because a land title search found that the submerged land on which the ore dock was constructed was owned by the State of Michigan. Michigan's Great Lakes Submerged Lands Act (1945) requires that all structures which were constructed in State waters have to be removed when the use of the facility was terminated. At the time the cost estimate for demolition was:

* removal of the timber portion of the approach, the dock superstructure to elevation 610.35 and the outer timber tail trestle......... $3,D39,454

* removal of the dock foundation below elevation 610.35....................... $1,419,833

* removal of the steel portion of the dock approach together with the timber decking and concrete piers .... $ 70,635

with the total net cost $4,529,922.

The question of vandalism, trespass, liability and fire has been raised and dealt with since the construction of the structure. During World War II there was concern with sabotage and the dock was guarded as a precaution. The question of using the dock to unload petroleum products and gasoline was raised by the International Oil Company in May 1950. The company wanted to run a pipeline along the dock to its storage tanks in the vicinity. DSS&A officials citing a high fire danger to an extremely important facility declined the offer even though it meant the loss of tanker car traffic on the line.

The decade of the 1980s saw the residents of Marquette reevaluate the use of the lake shore area around the ore dock. The old Spear coal dock was purchased by the city of Marquette and gradually turned into an attractive city park and the site of major celebrations and events. In 1986 the Marquette Area Chamber of Commerce had an Ore Dock Committee chaired by Frank Stabile which formulated ideas of integrating the dock into the general development of the area as it would relate to tourism. The Committee's work culminated in the Gove Plan which was issued in July 1986 and called for the dock being used for: 1) commercial and public purposes: shops, museum, and observation deck or 2) the structure being removed leaving a dock 8-10 feet above water level for pedestrian and vehicle traffic.

Then in November 1986 the dispute over the dock between the state of Michigan and the Soo Line took a new twist. Attorney General Frank Kelley brought suit in Ingham County in order to halt any sale of the dock unless the potential buyer was financially able to remove the structure. The suit not only involved the Ore Dock but pilings which remained above water level throughout the Lower Harbor. The state was primarily concerned with the problem of liability, and clear title to the bottomlands under the dock either had to be transferred to the railroad or gained through a long-term lease.

However before more than a number of depositions could be taken a new owner came on the scene. On 11 October 1987 the Soo Line sold Marquette lake front property and the ore dock to Wisconsin Central Ltd. The law suit was temporarily suspended. In the meantime Wisconsin Central began the process of selling excess property. The railroad entered into discussions with the city manager of Marquette, David Svanda. The city wanted to have the approach removed to enhance the downtown area. However when it came to alterations or the sale of the ore dock the Interstate Commerce Commission entered the picture in April 1989. The Commission stated that the removal of the approach would have an "adverse" effect on the structure's historic value. The Michigan Bureau of History agreed with this action. The ICC wanted a report conducted which would study the impact of the sale or alternations of the ore dock and how this would affect the integrity of the structure.

At the present time the Ore Dock remains an dominant feature of Marquette's Lower Harbor. It is a symbol of the important role played by the iron ore industry in the central Upper Peninsula and specifically in Marquette. Furthermore the Ore Dock is an example of efficient construction being started in April 1931 and completed a year later at the low point of the Great Depression.

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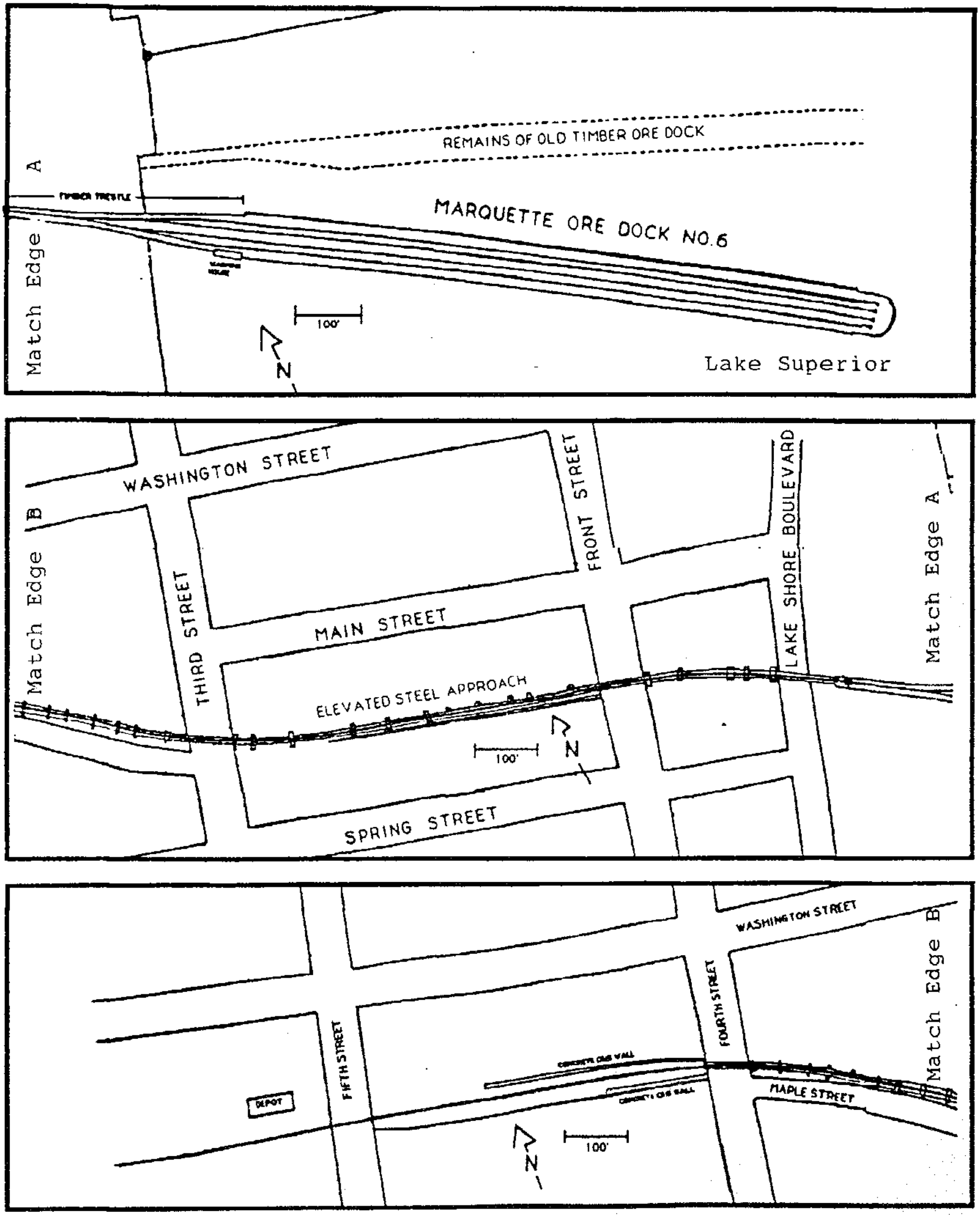
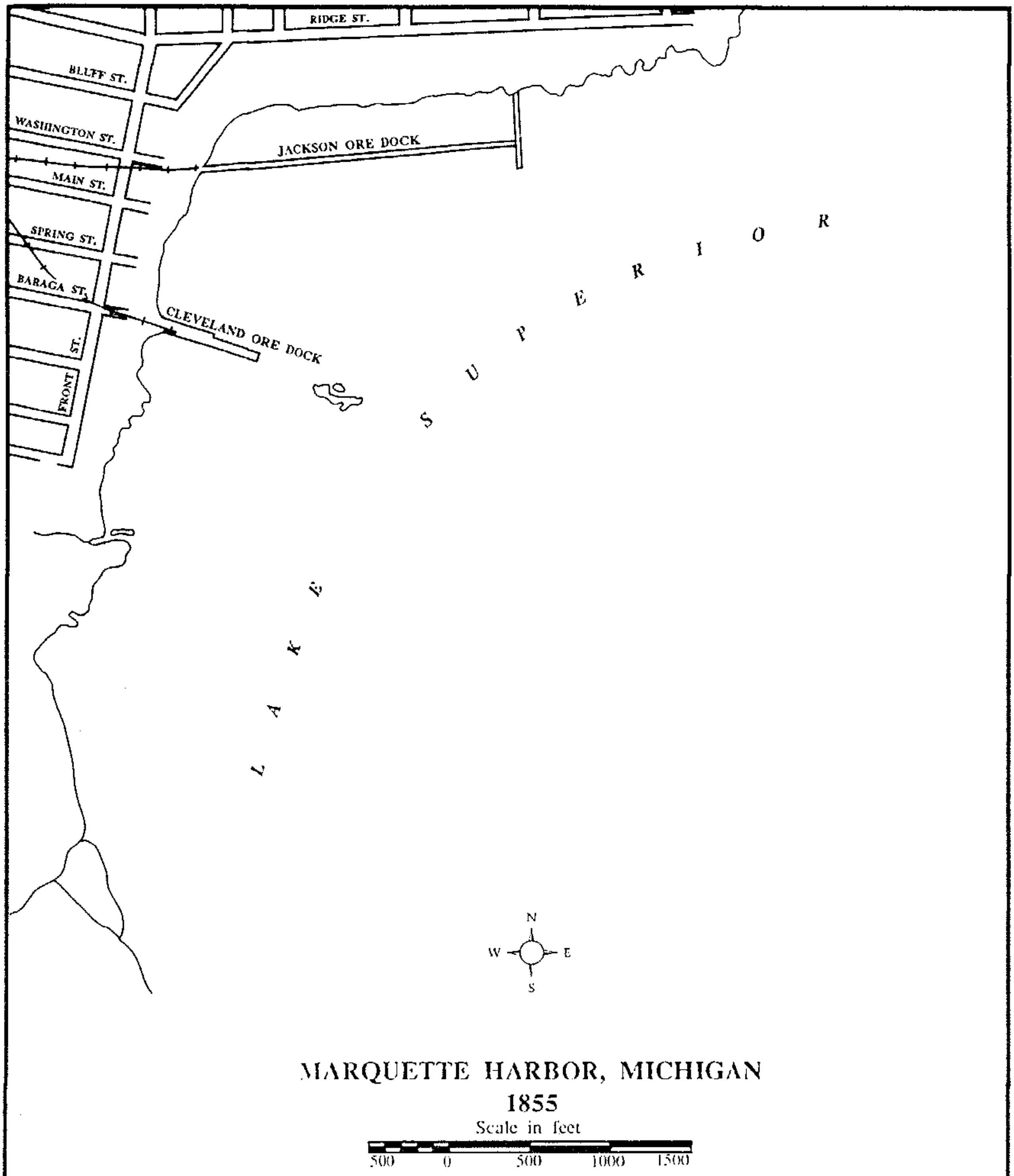
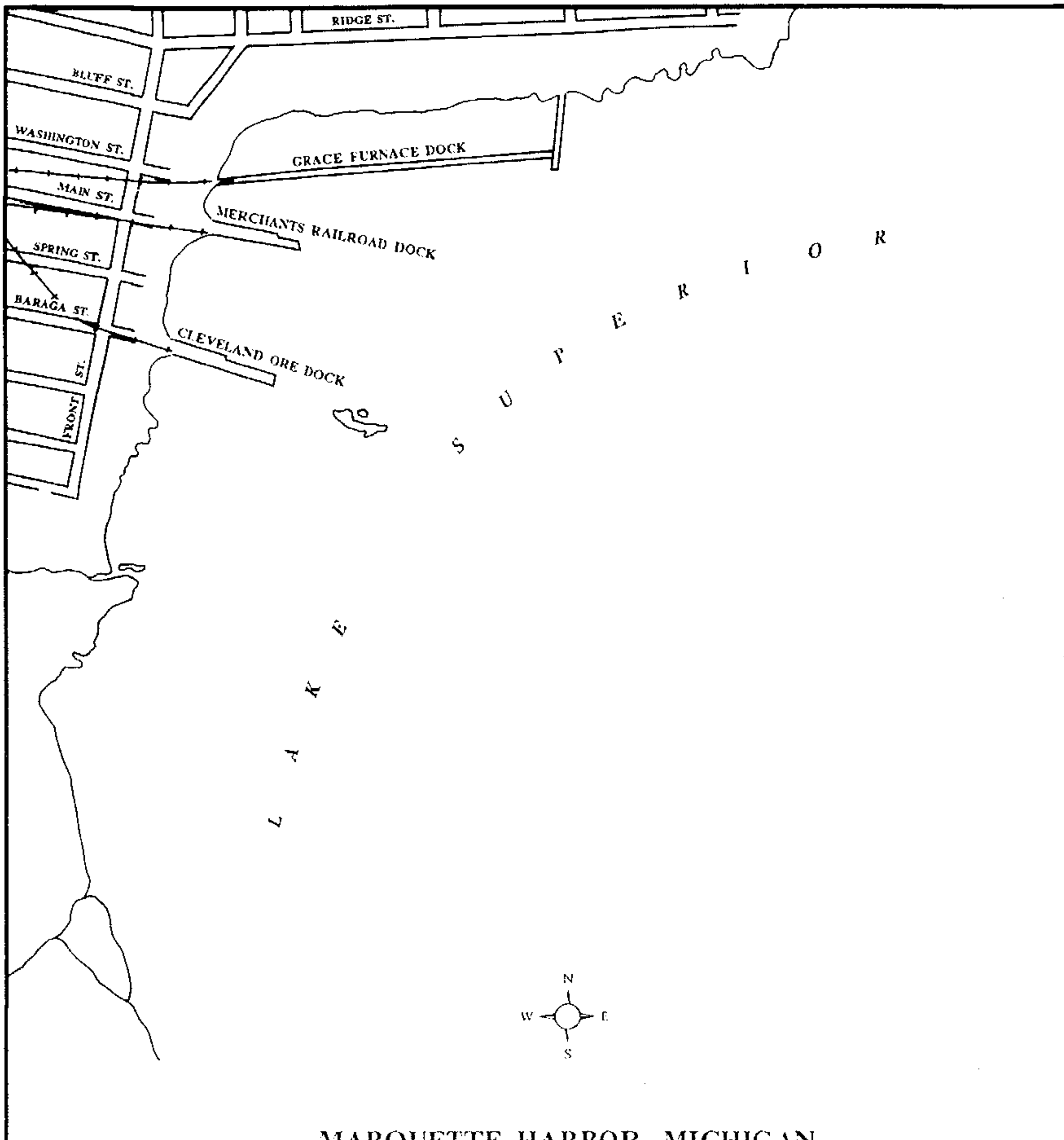
Marquette Ore Dock No. 6:
Dock and Approach Complex
HAER No. MI-45 (Page 24)





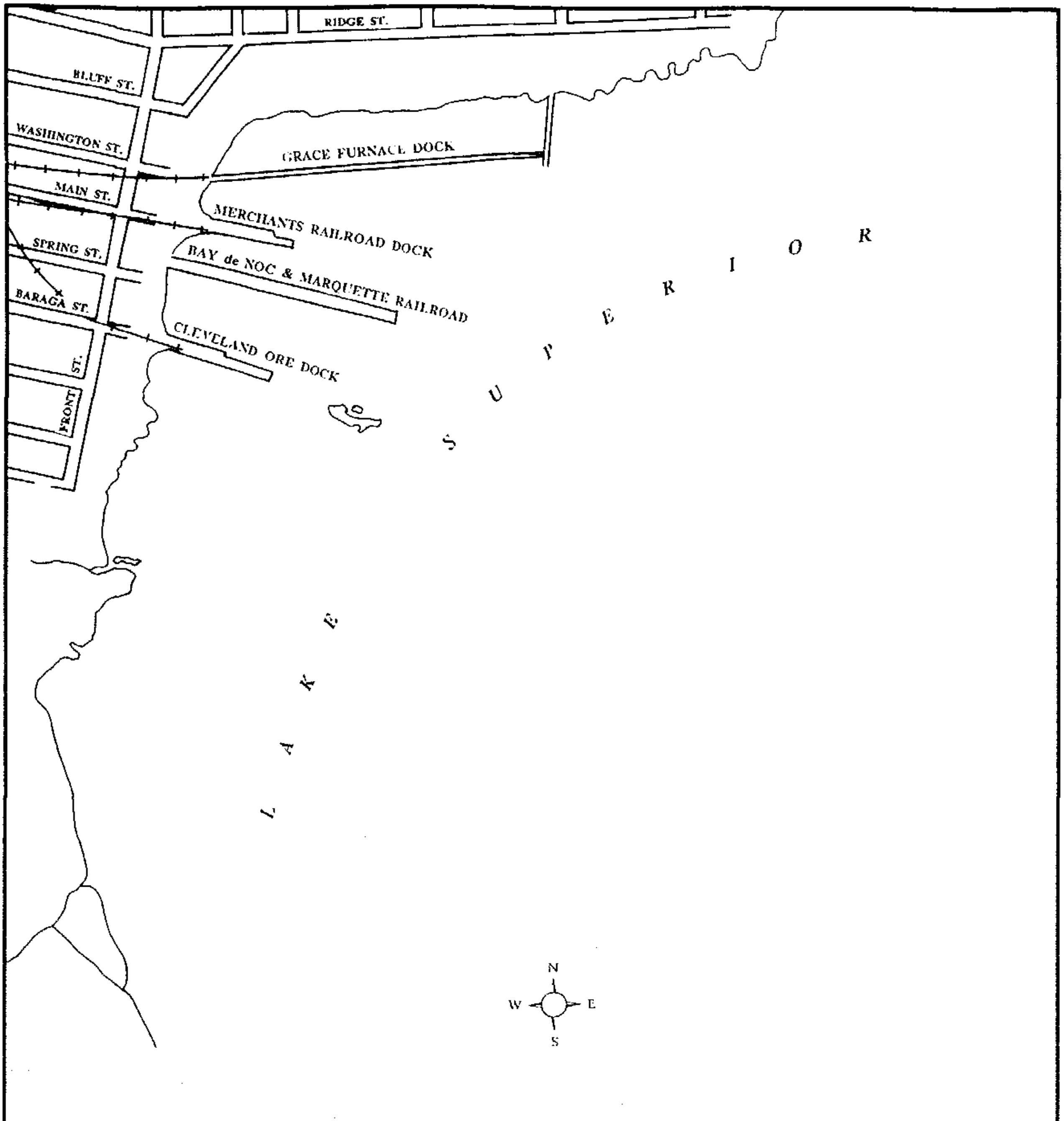
MARQUETTE HARBOR, MICHIGAN
1855



MARQUETTE HARBOR, MICHIGAN
1859

Scale in feet

500 0 500 1000 1500



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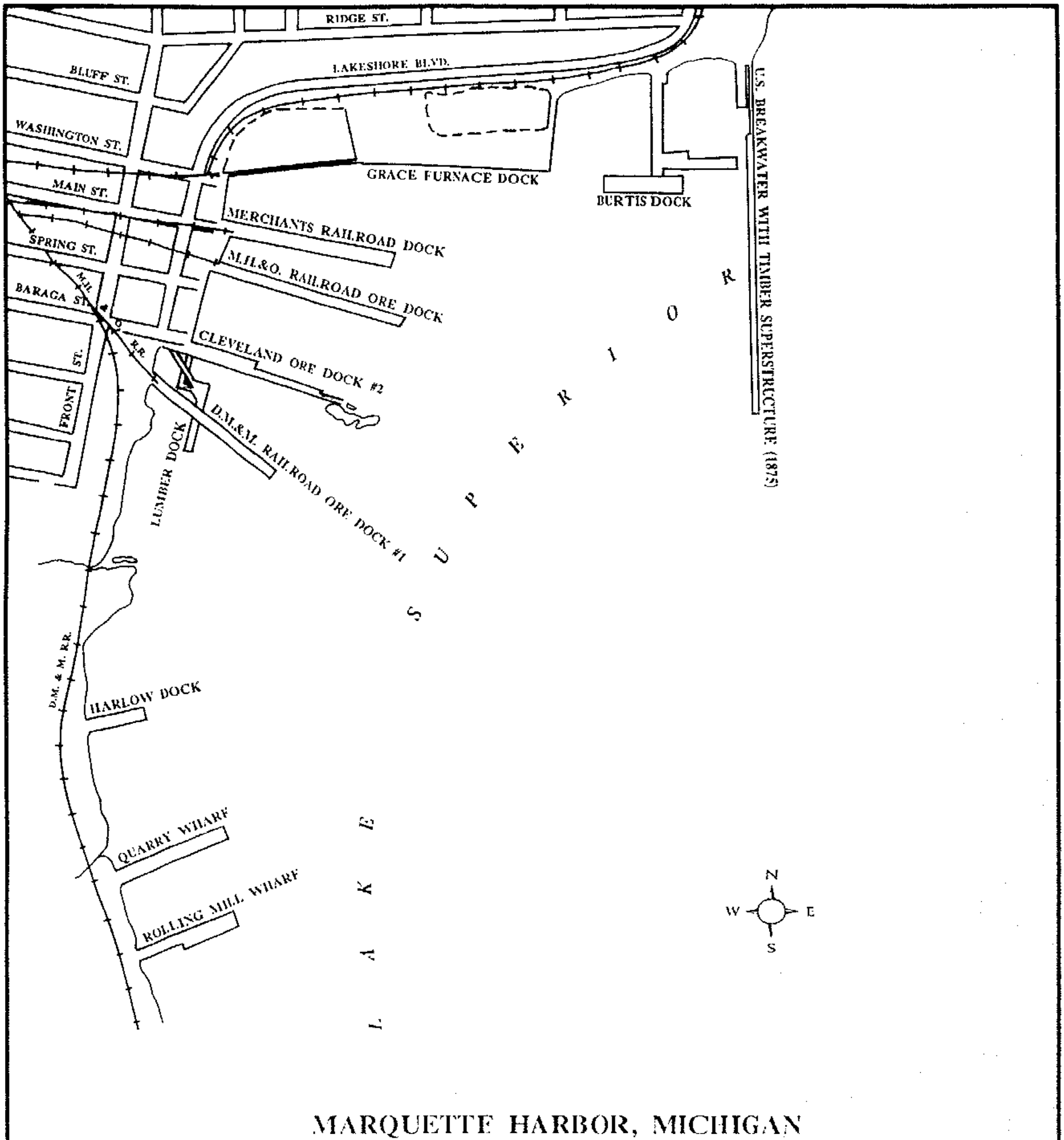
1869



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1885

Scale in feet
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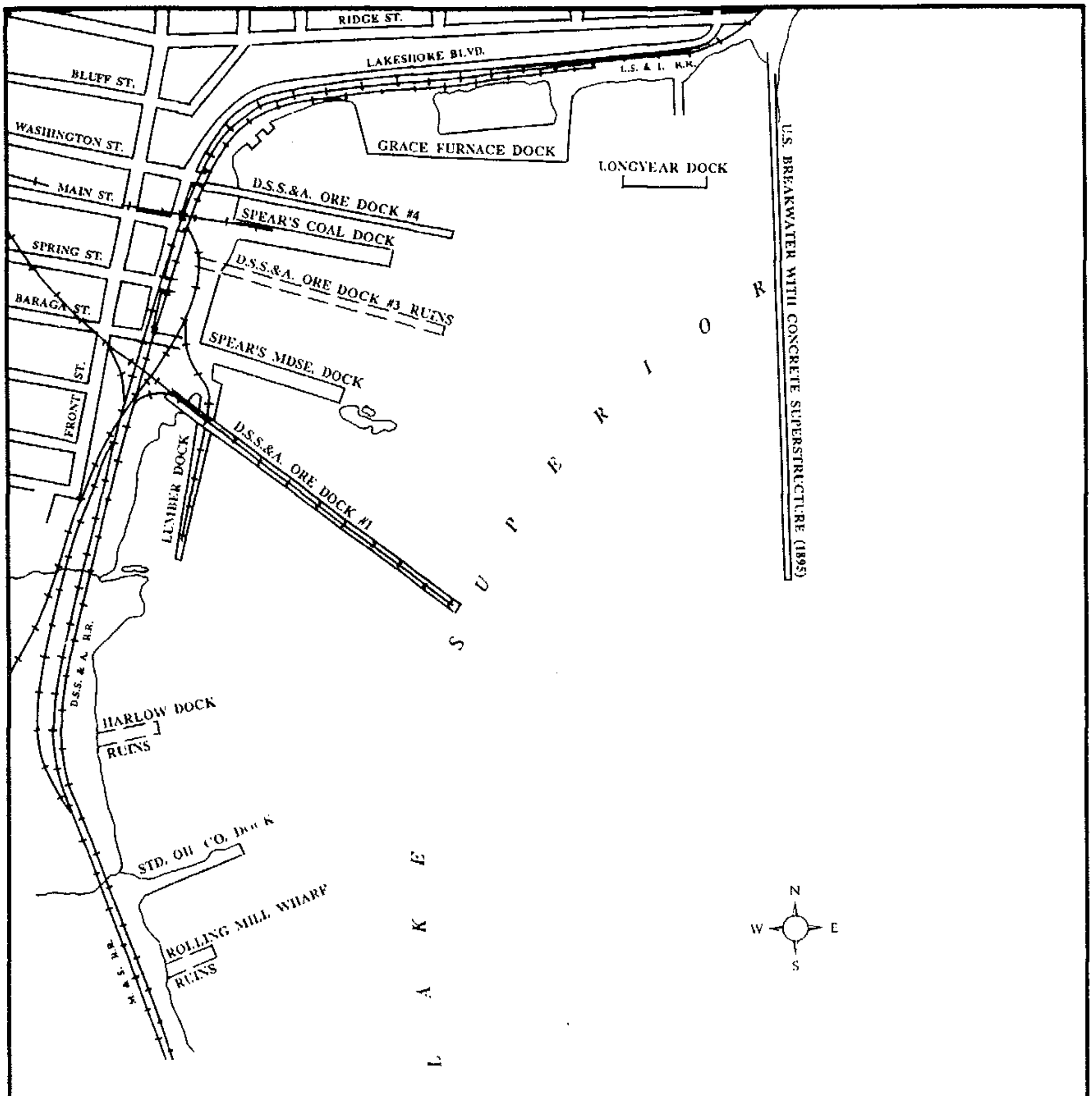

MARQUETTE HARBOR, MICHIGAN
1905
Scale in feet
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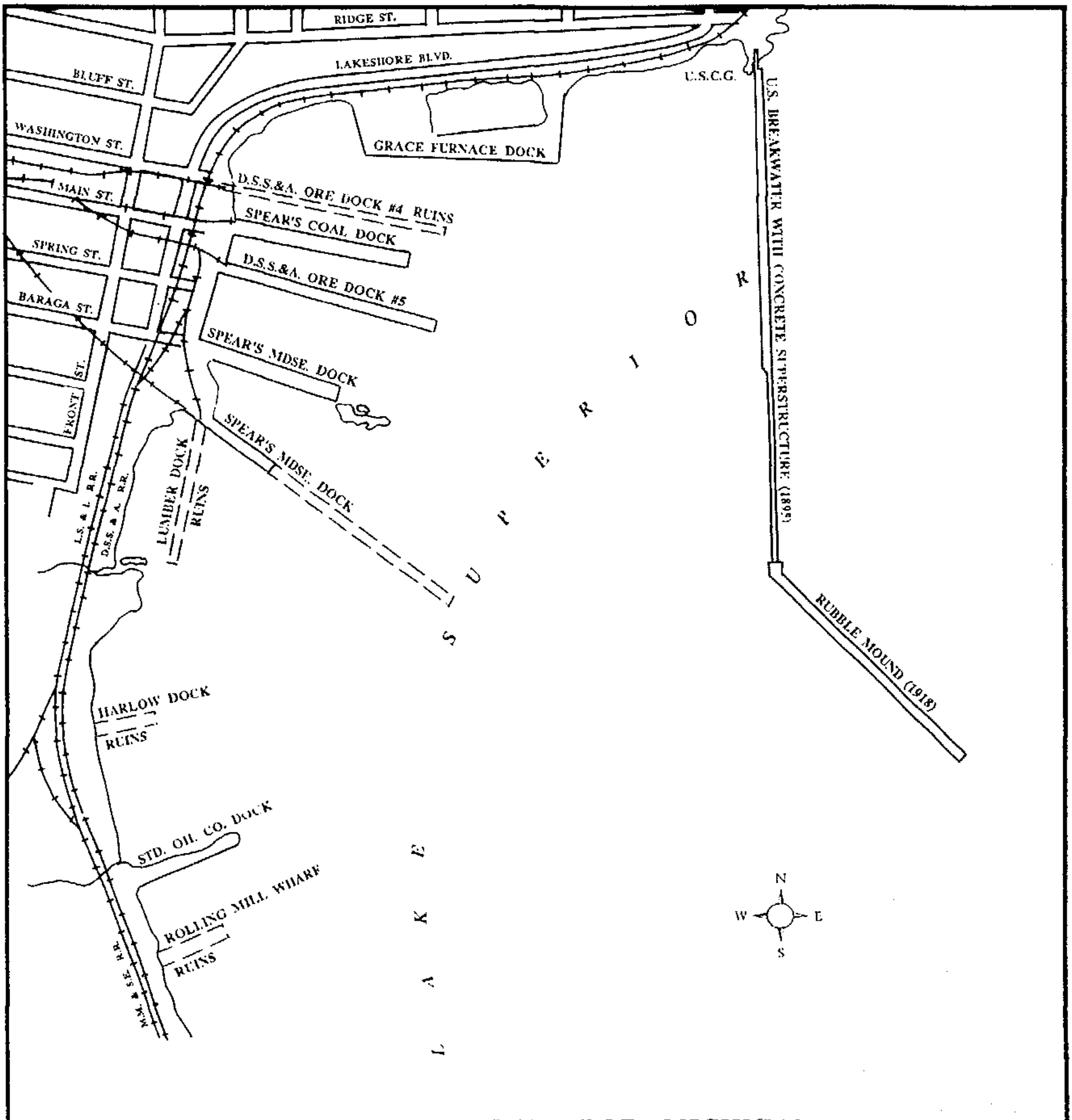

MARQUETTE HARBOR, MICHIGAN
1918
Scale in feet
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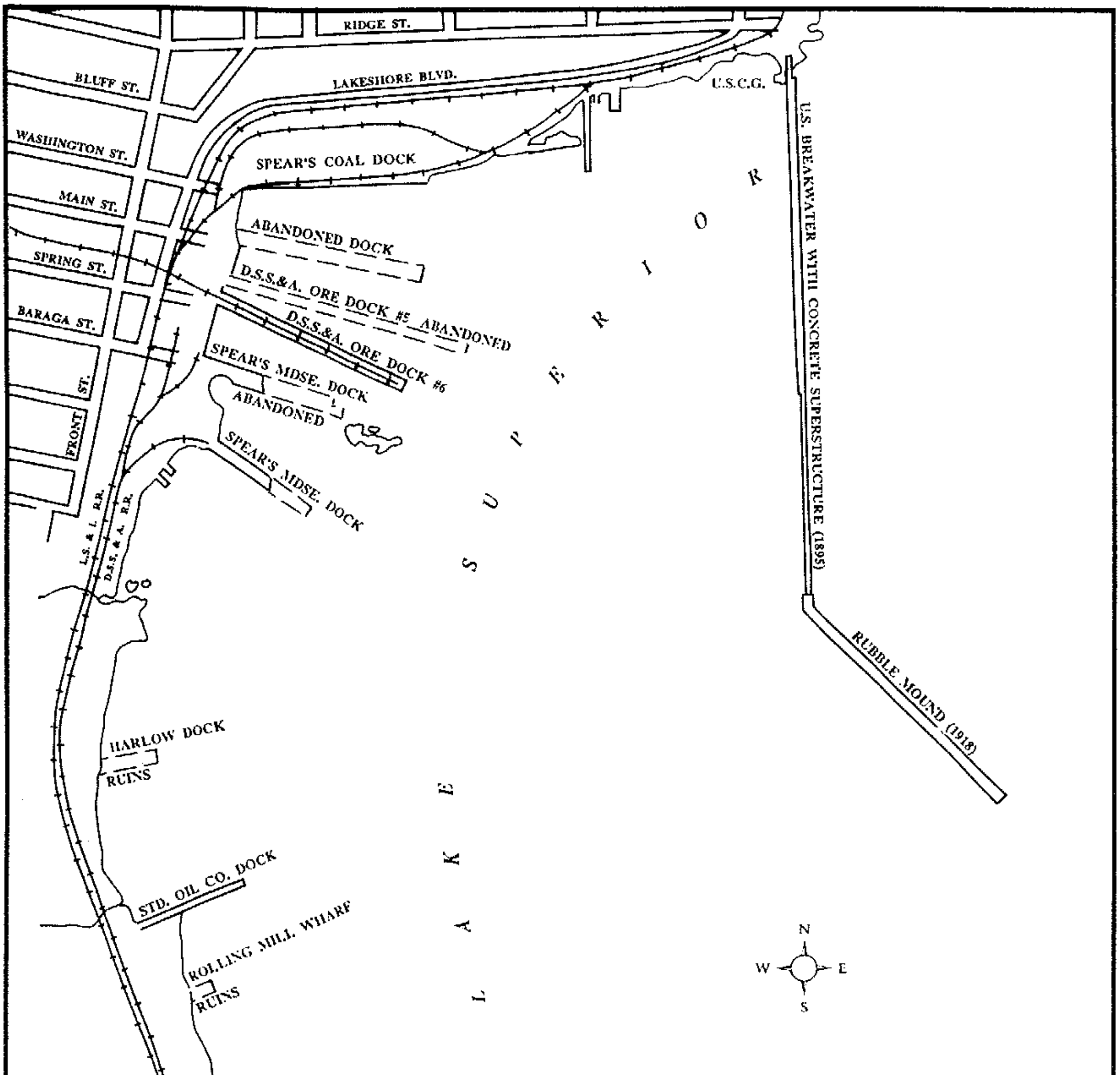

MARQUETTE HARBOR, MICHIGAN
1938
Scale in feet
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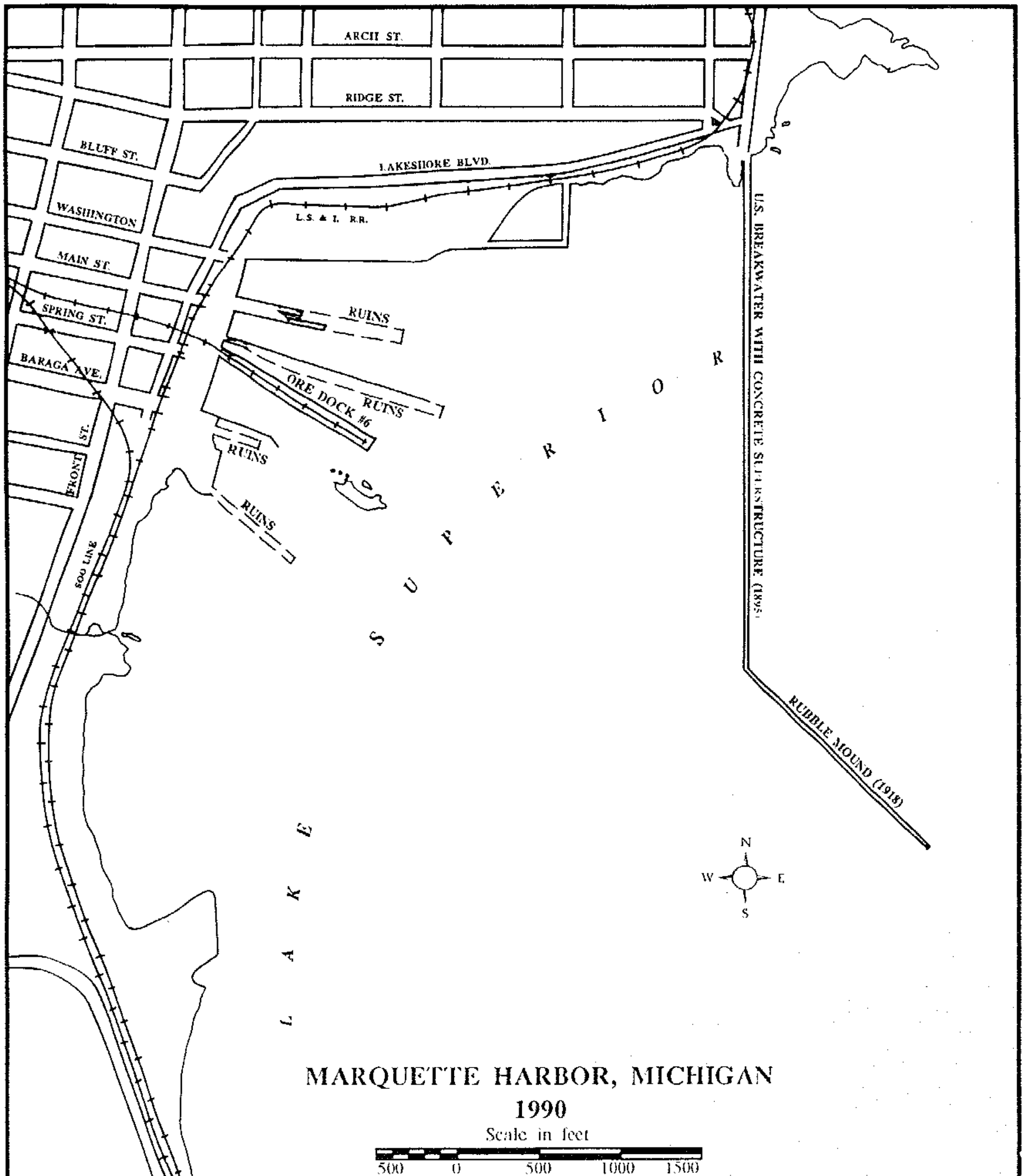


MARQUETTE HARBOR, MICHIGAN
1990
Scale in feet

Appendix G

Structural Calculations

GEI Consultants

		Project 1330920	Page
Client	CITY OF MARQUETTE	By RL	Date 9/3/2014
Subject	ORIGINAL VERTICAL LOADS - ORE DOCK	Checked MDC	Date 9/8/2014
		Approved	Date

VERTICAL LOADS (ORIGINAL)

[CALCULATE FOR 12' LONG, SINGLE BENT SECTION]

(1) DECK LIVE LOAD - 125 psf (A) [DECK DIMENSIONS → 12' × 590' = 708 ft²]

$\frac{125\ lb}{ft^2} \times (12\ ft \cdot 59.0'\ ft) \times \frac{1\ kip}{1000\ lb} = 88.5\ kip$ [76 BENTS ON THE DOCK]

(2) LOADED ORE CAR - 200,000 lb (A)

• ASSUMES ONLY ONE (1) CAR ON THE FOUR (4) AVAILABLE TRACKS

(3) DESIGN WEIGHT OF ORE IN BENT POCKETS - 940,325 lb (A)

(4) WEIGHT OF CONCRETE (REINFORCED) (B)

• GEI MODELED AN ELEVEN (11) BENT SECTION BETWEEN EXPANSION JOINTS USING AUTOCAD 2012 TO OBTAIN THE ESTIMATED CONCRETE VOLUME: 112,906 ft³

• ESTIMATED CONCRETE VOLUME / BENT = 112,906 ft³/11 BENTS = 10,264 ft³/BENT

• $10{,}264\ ft^3 \times 148.5\ lb/ft^3 = 1{,}524.2\ kip$ [VS 1511.5 kip AS REPORTED IN (C)]

(5) MISC. MATERIAL WEIGHTS FOR ENTIRE DOCK (C)

STRUCTURAL STEEL -	1,740 TONS =	3480 kip
CI SNUBBING POSTS -	11.5 TONS =	23 kip
HARDWARE & IRON -	30 TONS =	60 kip

TOTAL = 3,563 kip

TOTAL/BENT = 3563 kip / 76 BENTS = 46.881 kip/BENT

NOTES: (A) OBTAINED FROM NOTES ON DRAWING "GENERAL CROSS SECTION" BY DSS & ARY CO. SHEET 3 of 60. DATED 1931

(B) QUANTITIES PER GEI AUTOCAD MODEL. SEE ATTACHED FIGURES.

(C) FROM "MARQUETTE ORE DOCK NO. 6" - HAER No. MI-45. DATE 1990.

GEI Consultants

		Project 1330920	Page
Client	CITY OF MARQUETTE	By PJG	Date 9/3/14
Subject	ORIGINAL VERTICAL LOADS - ORE DOCK	Checked MPC	Date 9/8/14
		Approved	Date

PURPOSE: CALCULATE TOTAL LOAD PER PILE (ORIGINAL)

STRUCTURE WEIGHTS (KIPS)

CONCRETE : 1524.2 KIP

STEEL & MISC. HARDWARE : 46.8 kip

1,571 KIP

ORE LOADS / LIVE LOADS

LOADED RAIL HOPPER 200 kip

ORE WITHIN POCKETS : 940.3 kip

DESIGN LIVE LOAD 88.5 kip

1228.8 kip

TOTAL WEIGHT: 1571 kip + 1228.8 kip = 2799.8 kip / BENT

LOAD PER PILE

TYPICAL SECTION : 86 VERT. PILES / BENT (SEE NEXT PAGE FOR NO. OF PILES CALCULATION)

$$\frac{2799.8 \text{ kip}}{86 \text{ PILES}} = 32.6 \text{ kip / PILE}$$

CRIB SECTION : 77 VERT. PILES / BENT (SEE NEXT PAGE FOR NO. OF PILES CALCULATION)

$$\frac{2799.8 \text{ kip}}{77 \text{ PILES}} = 36.4 \text{ kip / PILE}$$ ← CONTROLS

GEI Consultants

Client CITY OF MARQUETTE	Project 1330920	Page	
Subject ORIGINAL VERTICAL LOADS - ORE DOCK	By PSG	Date 9/3/14	
	Checked MDC	Date 9/8/14	
	Approved	Date	

FOUNDATION PILE CONFIGURATION

PURPOSE: DETERMINE NUMBER OF VERTICAL (V) AND BATTERED (B) PILES PER BENT FOR TIMBER CRIB SECTIONS AND TYPICAL SECTIONS.

CRIB - V - 154 SECTION LENGTH: 24' - 2 BENTS @ 12' O.C.
B - 0

TYPICAL - V - 90 (1, 40) SECTION LENGTH 108' - 9 BENTS @ 12' O.C.
72 (2, 37)
72 (3, 38)
72 (4, 39)
81 (5, 36)

387 x 2 = 774 VERTICAL PILES

B - 4 (ALL 10 SECTIONS)

4 x 10 = 40 BATTERED PILES

NOTE: EXPLICIT DEFINITION OF BATTER ANGLE NOT AVAILABLE WITHIN REFERENCES. ASSUME 30 DEGREES FROM VERTICAL.

TOTALS

CRIB SECTION: 154 VERTICAL PILES

154 / 2 BENTS = 77 PILES / BENT

TYPICAL SECTION: 774 V. PILES / 9 BENTS = 86 V. PILES / BENT

40 B. PILES / 9 BENTS = 4.4 B. PILES / BENT

GEI Consultants

		Project 1330920	Page
Client CITY OF MARQUETTE		By PJG	Date 9/3/2014
Subject ORIGINAL VERTICAL LOADS - ORE DOCK		Checked MDC	Date 9/8/2014
		Approved	Date

PURPOSE: CALCULATE THE ESTIMATED REINFORCED CONCRETE UNIT WEIGHT AND WEIGHT OF CONCRETE PER BENT PER REPORTED VALUES IN THE HAER DOCUMENT. (A)

REPORTED CONCRETE UNIT WEIGHT

REINFORCING STEEL WEIGHT (ENTIRE DOCK): 1,370 TONS (A) = 2,740 kips

(PER BENT): 2,740 kips / 76 BENTS = 36.05 kip/BENT

VOLUME OF CONCRETE (ENTIRE DOCK): 28,650 yd^3 (A) = 773,550 ft^3

(PER BENT): 773,550 ft^3 / 76 BENTS = 10,178 ft^3/BENT

WEIGHT OF REINFORCING STEEL PER ft^3: 36.05 kip / 10,178 ft^3 = 3.5 lb/ft^3

REINFORCED CONCRETE UNIT WEIGHT: 145 lb/ft^3 + 3.5 lb/ft^3 = 148.5 lb/ft^3
(ASSUMING NORMAL WEIGHT CONCRETE)

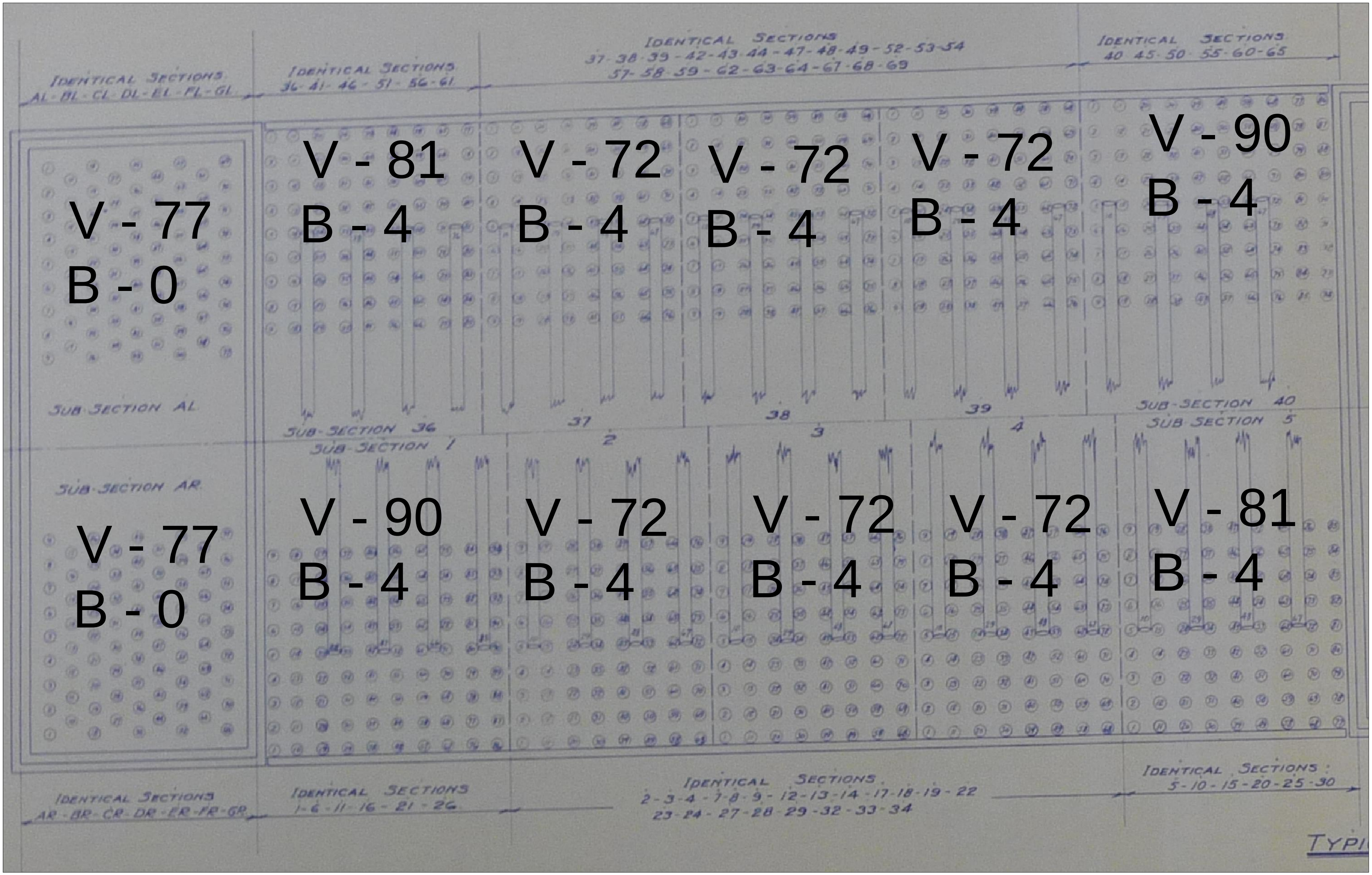
REPORTED WEIGHT OF REINFORCED CONCRETE PER BENT:

REINFORCED CONCRETE WEIGHT PER BENT = 148.5 lb/ft^3 · 10,178 ft^3/BENT

= 1,511.433 kip/BENT

[COMPARISON OF THE ABOVE VALUE (1511.4 kip) WITH THE GEI MODELED WEIGHT PER BENT (1,524.2 kip) YIELDS LESS THAN 1% DIFFERENCE]

NOTE: (A) "MARQUETTE ORE DOCK NO. 6" - HAER NO. MI-45. DATED 1990


IDENTICAL SECTIONS AL-BL-CL-DL-EL-FL-GL
IDENTICAL SECTIONS 36-41-46-51-56-61
IDENTICAL SECTIONS 37-38-39-42-43-44-47-48-49-52-53-54 57-58-59-62-63-64-67-68-69
IDENTICAL SECTIONS 40 45 50 55 60 65
V - 77
B - 0
V - 81
B - 4
V - 72
B - 4
V - 72
B - 4
V - 72
B - 4
V - 90
B - 4
SUB-SECTION AL
SUB-SECTION 36
37
38
39
SUB-SECTION 40
SUB-SECTION AR
SUB-SECTION 1
2
3
4
SUB SECTION 5
V - 77
B - 0
V - 90
B - 4
V - 72
B - 4
V - 72
B - 4
V - 72
B - 4
V - 81
B - 4
IDENTICAL SECTIONS AR-BR-CR-DR-ER-FR-GR
IDENTICAL SECTIONS 1-6-11-16-21-26
IDENTICAL SECTIONS 2-3-4-7-8-9-12-13-14-17-18-19-22 23-24-27-28-29-32-33-34
IDENTICAL SECTIONS: 5-10-15-20-25-30

Marquette Ore Dock No. 6
Fifth to Lake Streets
Marquette
Marquette County
Michigan

HAER No. MI-45

HAER
MICH
52-MARQ,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
MID-ATLANTIC REGION, NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
PHILADELPHIA, PENNSYLVANIA 19106

HAER
MICH
52-MARQ,
1-

HISTORIC AMERICAN ENGINEERING RECORD

MARQUETTE ORE DOCK NO. 6

HAER No. MI-45

Location:	From Fifth Street on the west to a position jutting into the Lower Harbor off Lake Street on the east between Main and Spring Streets in Marquette City, Marquette County, Michigan. UTM 16.470120.5154000 Quad: Marquette, MI
Engineer:	Merritt-Chapman & Whitney Corporation, Duluth, Minnesota.
Date of Construction:	1931-1932.
Present Owner:	Wisconsin Central, Ltd. One O'Hare Center 6250 North River Road, Suite 9000 Rosemont, Illinois 60018
Present Use:	Vacant.
Significance:	The Marquette Ore Dock complex is an excellent example of the final phase in the evolution of the iron ore pocket dock in American industry. It was near this site that the first pocket dock ever used in the iron ore trade was developed (1857) in Marquette. The dock and its approach are fine and intact examples of mid-20th century industrial technology. The dock is a model of construction efficiency having taken one year to complete this massive structure. Locally it is a monument to the important role played by Marquette and its ore docks to the development of the Great Lakes iron ore trade and the American steel industry.
Project Information:	This documentation was undertaken from June through August 1990 in accordance with agreements with Wisconsin Central, Ltd., the Interstate Commerce Commission, The National

Park Service, and the Michigan State Bureau of History.

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Historian
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Department of History
Marquette, MI 49855-5352

slowed its use. Most of the mines on the Range were closed since November 1931 because of the lack of steel orders. However the Ford Motor Company's Blueberry Mine in Ishpeming was open but operating at half capacity. It had accumulated a stockpile of 10,000 tons of iron ore which could be shipped from the new dock. DSS&A officials anxiously awaited the first shipment.

The new dock was put into service on 3 June 1932 when 30 cars arrived from the Blueberry mine and dumped the ore into the dock. On 6 June the Henry Ford II tied to the north side of the dock at 1:20 p.m. 10,103 tons of ore were loaded into the Henry Ford II by 4:08 p.m. and vessel left for the Ford Motor Company in Detroit. On 19 June the Henry Ford II returned and loaded 3,000 tons of Imperial Mine ore and 7,000 tons of Blueberry Mine ore. The actual loading time was 2 hours and 58 minutes. The loss of time was due to sticky ore from the Imperial Mine and a shortage of help.

Over the next 39 years the following tonnage was shipped from Ore Dock No. 6:

1932-	122,314	1946-	340,299	1960-	600,713
1933-	442,496	1947-	524,055	1961-	499,792
1934-	636,353	1948-	437,839	1962-	597,648
1935-	617,826	1949-	462,729	1963-	681,079
1936-	941,473	1950-	619,469	1964-	844,697
1937-	867,367	1951-	578,876	1965-	1,068,355
1938-	178,539	1952-	398,110	1966-	1,158,617
1939-	639,622	1953-	471,108	1967-	875,307
1940-	642,837	1954-	309,779	1968-	1,018,068
1941-	860,674	1955-	474,309	1969-	1,108,316
1942-	684,603	1956-	492,023	1970-	590,972
1943-	601,735	1957-	361-362	1971-	258,039
1944-	308,306	1958-	491,371		
1945-	516,436	1959-	628,577		

The greatest tonnage year for either Ore Dock No. 5 or No. 6 was in 1911 when 1,383,206 tons of iron ore were shipped.

When the dock was completed its dimensions were not exceeded by any dock in the Lake Superior region. It was composed of the following materials:

Dock:

Structural steel..............	1,740	tons
Concrete......................	28,650	cubic yards
Reinforcing steel.............	1,370	tons
CI snubbing posts.............	11.5	tons
Hardware and iron.............	30	tons
Piling timbers (each 25 feet above lake bottom)...	7,600	

Underwater timber cribs	560,300	FBM

Approach:

Structural steel...............	945.5	tons
Concrete........................	1,360	cubic yards
Reinforcing steel.............	9.35	tons
Hardware and iron.............	34	tons
Pilings........................	19,580	FBM
Timber.........................	840,000	FBM

The length of the facility which includes the approach and the dock is 3,546 feet. The dock itself measures 969 feet from the beginning of concrete construction to the fender at the east end.

During its first year in service the dock handled a mere 122,314 tons. Planned in the prosperous 1920s it had potential for increased use in the future. Throughout its history the Ore Dock was maintained and improvements made but there were no major renovations which completely altered the nature nor utilization of the structure.

During World War II it operated efficiently although not at full capacity. Even in Marquette there was concern for espionage and on 8 July 1943, Walter Measure from the Continuous Security Branch of the Sixth Army inspected the facility. In a report issued on 20 July it was recommended that the railroad: 1) provide riot guns or sawed-off shotguns for its guards, 2)properly train the guards in the use of these firearms; and 3) increase the number of fire extinguishers throughout the timber deck area. Also during the war two wooden semaphores were placed at the end of the dock to signal approaching boats which side of the dock was available for loading. The dock entry lights were useful at night but during the day captains could not see them because of the glare. The semaphores were installed in May 1944.

Major improvements were made at the end of the 1947 season. The wooden fenders on the dock were rebuilt and pile drivers redrove the cluster piles. By mid-October the pilings for the protective fenders at the outer end of the ore dock had been redriven, but they had not been spaced nor the timber blocks installed. The cluster piles to the south near Ripley's Rock had been redriven and tied with cable. On the south side of the dock all of the pilings in the wood fender had been redriven but not cut off. The schedule called for work to be completed by the end of the month.

As the years passed due to the harsh weather conditions, repairs and improvements were constantly made on the dock. Early in 1953 it was observed that the overhead wiring on the upper deck had to be replaced. This work was completed by 1957. Poor lighting at the end of the dock caused a flood light and two

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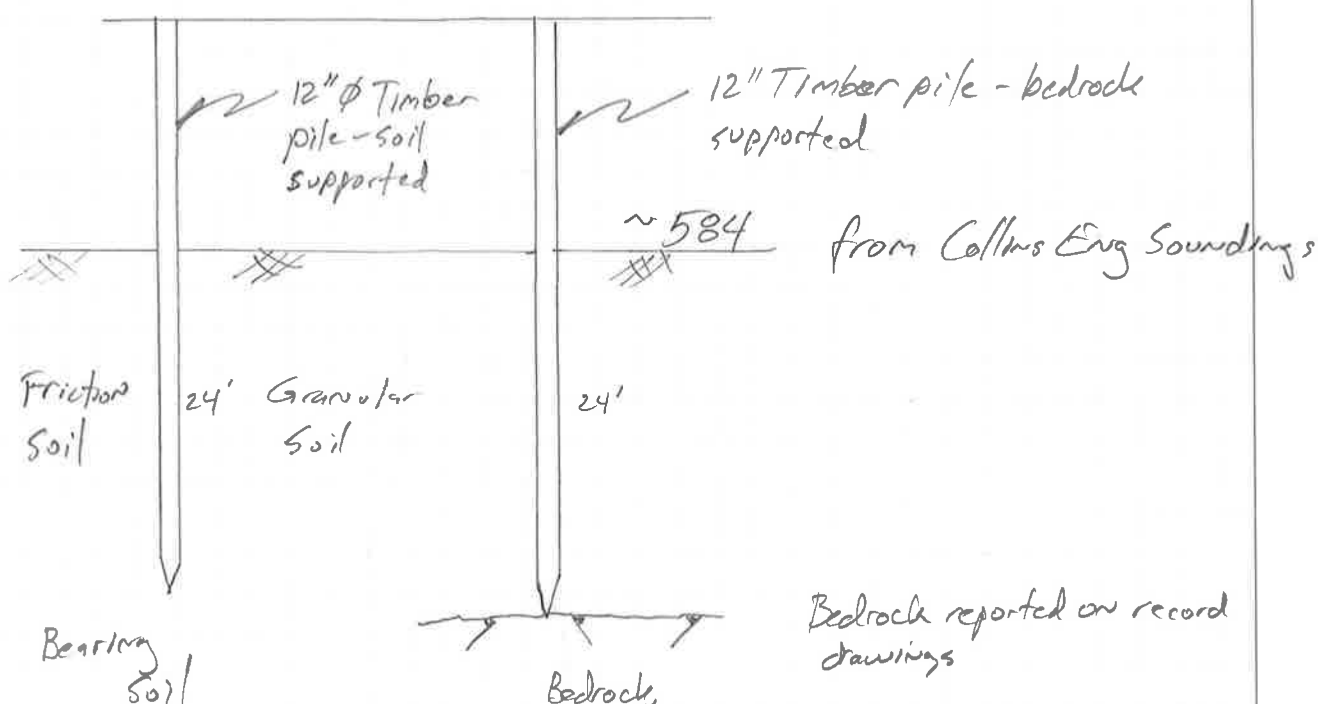
Client	City of Marquette	Project	1330920
		Page	1 / 8
		By	MDC
		Date	9/8/14
Subject	Single Pile Ultimate Capacity	Checked	
		Date	
		Approved	
		Date	

Develop Estimates of ultimate capacity for single timber pile.

Use two methods to develop 1) Assume piles supported w/in soil
2) Assume piles supported on bedrock (see Exhibit G-3)

Pile Assumptions



There is no historic soil strength data. Assume the following properties:

Friction Soil

$\gamma_T = 105\ pcf \quad \phi' = 28°$

Bearing Soil

$\gamma_T = 125 pcf \quad \phi = 32°$

This assumes piles were driven into a denser soil layer above bedrock

From NAVFAC 7.02 (pg 193+194)

$$Q_{ult} = P_T N_q A_T + \Sigma\left[K_{HC} \cdot P_o \cdot \tan\delta \cdot s\right]$$

where:

P_T = Effective Stress @ tip = $(105-62.4)\,24' = 1{,}022$ psf

N_q = Bearing capacity factor (pg 194) = 29 for $\phi = 32°$

A_T = Area of pile tip = $\frac{\pi D^2}{4} = 0.785\,ft^2$

K_{HC} = Horizontal to vertical stress ratio. = 1.5 for tapered pile

δ = pile to soil friction angle = $0.75\phi = 21°$

P_o = effective stress over length of pile = average over 24'

$= (105-62.4)\,24/2 = 511$ psf

s = surface area of pile per unit length. $= \pi D = 3.14\,ft^2$

$$Q_{ult} = (1022)(29)(0.785) + (1.5)(511)(\tan 21°)(3.14)(24')$$

$$= 23{,}265 \text{ lbs} + 22{,}173 \text{ lbs} = 45{,}440 \text{ lbs or } 45.4 \text{ Kips}$$

$$\text{Factor of safety} = \frac{Q_{ult}}{Q_{Actual}} = \frac{45.4K}{36.4K} = 1.2$$

A FS > 1.0 is ok due to the conservative assumption that piles were driven short of refusal

3/8

UFC 3-220-01
1 November 2012

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GEOTECHNICAL ENGINEERING

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(d) Full-scale load tests.

(e) Dynamic driving resistance.

(7) Determine design and construction requirements, and incorporate the requirements into construction specifications.

Inspection of foundation construction should be considered an integral part of the design procedures. Perform a pile test program as required. The pile test can also be used as a design tool in item (6).

2. BEARING CAPACITY OF SINGLE PILE

a. Allowable Stresses. See Table 1 for allowable stresses within the pile and quality requirements for pile materials. Allowable stresses should be reduced for column action where the pile extends above firm ground, i.e. through water and very soft bottom sediments.

b. Soil Support. The soil must be capable of supporting the element when it is in compression, tension, and subject to lateral forces. The soil support can be computed from soil strength data, determined by load tests, and/or estimated from driving resistance. These determinations should include the following stages:

(1) Design Stage. Compute required pile lengths from soil strength data to determine bidding length and pile type.

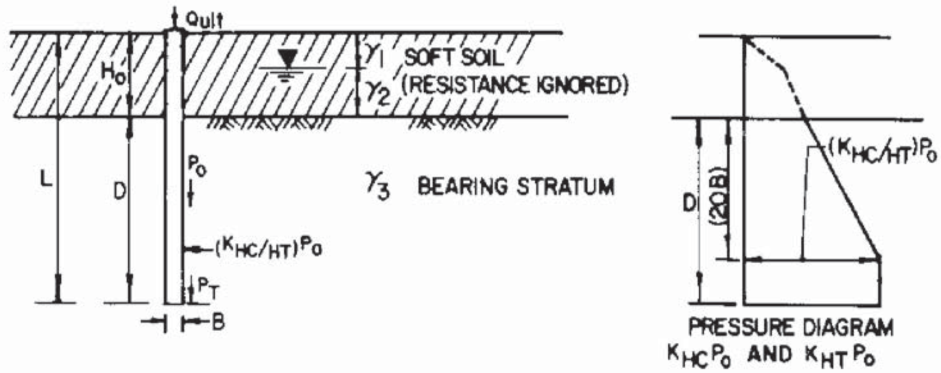
(2) Early in Construction Stage. Drive test piles at selected locations. For small projects where performance of nearby pile foundations is known, base design length and load capacity on knowledge of the soil profile, nearby pile performance, and driving resistance of test piles. On large projects where little experience is available, perform load tests on selected piles and interpret the results as shown in Figure 7.

(3) Throughout Construction Stage. Record driving resistance of all piles for comparison with test piles and to insure against local weak subsurface formations. Record also the type and condition of cushioning material used in the pile hammer.

c. Theoretical Load Capacity. See Figure 1 for analysis of ultimate load carrying capacity of single piles in homogeneous granular soils; for pile in homogeneous cohesive soil see Figure 2 (upper panel right, Reference 2, The Bearing Capacity of Clays, by Skempton; remainder of figure, Reference 3, The Adhesion of Piles Driven in Clay Soils, by Tomlinson).

(1) Compression Load Capacity. Compression load capacity equals end-bearing capacity, plus frictional capacity on perimeter surface.

(2) Pullout Capacity. Pullout capacity equals the frictional force on the perimeter surface of the pile or pier.



(A) ULTIMATE LOAD CAPACITY IN COMPRESSION

$$Q_{ult} = P_T N_q A_T + \sum_{H=H_o}^{H=H_o+D} (K_{HC})(P_o)(\tan\delta)(S)$$

WHERE Q_{ult} = ULTIMATE LOAD CAPACITY IN COMPRESSION

P_T = EFFECTIVE VERTICAL STRESS AT PILE TIP (SEE NOTE 1)

N_q = BEARING CAPACITY FACTOR (SEE TABLE, FIGURE 1 CONTINUED)

A_T = AREA OF PILE TIP

K_{HC} = RATIO OF HORIZONTAL TO VERTICAL EFFECTIVE STRESS ON SIDE OF ELEMENT WHEN ELEMENT IS IN COMPRESSION.

P_o = EFFECTIVE VERTICAL STRESS OVER LENGTH OF EMBEDMENT, D (SEE NOTE 1)

δ = FRICTION ANGLE BETWEEN PILE AND SOIL (SEE TABLE, FIGURE 1 CONTINUED)

S = SURFACE AREA OF PILE PER UNIT LENGTH

FOR CALCULATING Q_{all}, USE F_S OF 2 FOR TEMPORARY LOADS, 3 FOR PERMANENT LOADS. (SEE NOTE 2)

(B) ULTIMATE LOAD CAPACITY IN TENSION

$$T_{ult} = \sum_{H=H_o}^{H=H_o+D} (K_{HT})(P_o)(\tan\delta)(S)(H)$$

WHERE: T_{ult} = ULTIMATE LOAD CAPACITY IN TENSION, PULLOUT

K_{HT} = RATIO OF HORIZONTAL TO VERTICAL EFFECTIVE STRESS ON SIDE OF ELEMENT WHEN ELEMENT IS IN TENSION

FOR CALCULATING T_{all}, USE $F_S = 3$ ON T_{ult} PLUS THE WEIGHT OF THE PILE (W_P), THUS $T_{all} = \frac{T_{ult}}{3} + W_P$ (SEE NOTE 2)

NOTE-1: EXPERIMENTAL AND FIELD EVIDENCE INDICATE THAT BEARING PRESSURE AND SKIN FRICTION INCREASE WITH VERTICAL EFFECTIVE STRESS P_o UP TO A LIMITING DEPTH OF EMBEDMENT, DEPENDING ON THE RELATIVE DENSITY OF THE GRANULAR SOIL AND POSITION OF THE WATER TABLE. BEYOND THIS LIMITING DEPTH (10B± TO 40B±) THERE IS VERY LITTLE INCREASE IN END BEARING, AND INCREASE IN SIDE FRICTION IS DIRECTLY PROPORTIONAL TO THE SURFACE AREA OF THE PILE. THEREFORE, IF D IS GREATER THAN 20 B, LIMIT P_o AT THE PILE TIP TO THAT VALUE CORRESPONDING TO D = 20B.

NOTE-2: IF BUILDING LOADS AND SUBSURFACE CONDITION ARE WELL DOCUMENTED IN THE OPINION OF THE ENGINEER, A LESSER FACTOR OF SAFETY CAN BE USED BUT NOT LESS THAN 2.0 PROVIDED PILE CAPACITY IS VERIFIED BY LOAD TEST AND SETTLEMENTS ARE ACCEPTABLE.

FIGURE 1
Load Carrying Capacity of Single Pile in Granular Soils

BEARING CAPACITY FACTORS - Nq

[phi][*] (DEGREES)	26	28	30	31	32	33	34	35	36	37	38	39	40
N_q (DRIVEN PILE DISPLACEMENT)	10	15	21	24	29	35	42	50	62	77	86	120	145
N_q [**] (DRILLED PIERS)	5	8	10	12	14	17	21	25	30	38	43	60	72

EARTH PRESSURE COEFFICIENTS K_{HC} AND K_{HT}

PILE TYPE	K_{HC}	K_{HT}
DRIVEN SINGLE H-PILE	0.5 - 1.0	0.3 - 0.5
DRIVEN SINGLE DISPLACEMENT PILE	1.0 - 1.5	0.6 - 1.0
DRIVEN SINGLE DISPLACEMENT TAPERED PILE	1.5 - 2.0	1.0 - 1.3
DRIVEN JETTED PILE	0.4 - 0.9	0.3 - 0.6
DRILLED PILE (LESS THAN 24" DIAMETER)	0.7	0.4

FRICTION ANGLE - [delta]

PILE TYPE	[delta]
STEEL	20 deg.
CONCRETE	3/4 [phi]
TIMBER	3/4 [phi]

[*] LIMIT [phi] TO 280 IF JETTING IS USED

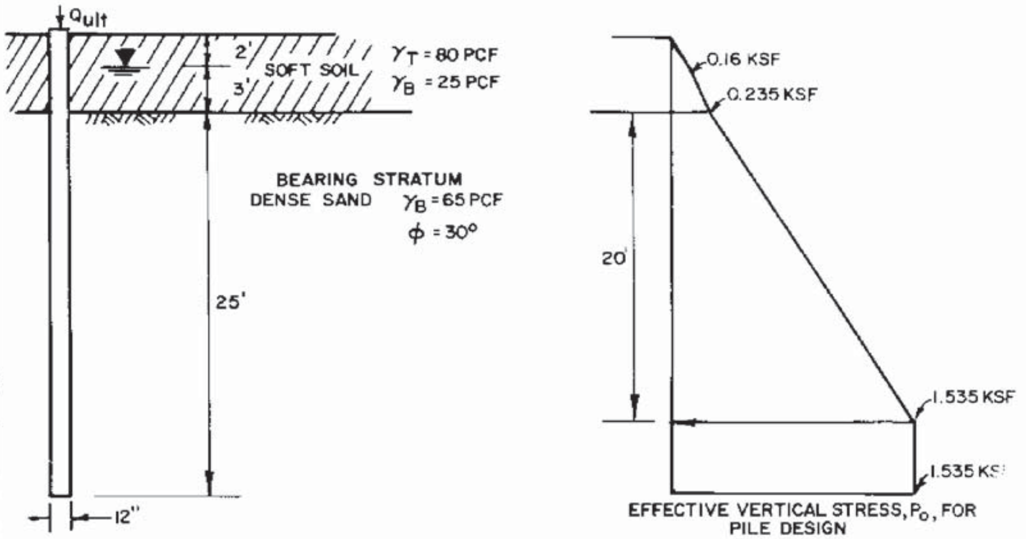
[**] (A) IN CASE A BAILER OR GRAB BUCKET IS USED BELOW GROUND WATER TABLE, CALCULATE END BEARING BASED ON [phi] NOT EXCEEDING 28 deg.

(B) FOR PIERS GREATER THAN 24-INCH DIAMETER, SETTLEMENT RATHER THAN BEARING

*   CAPACITY USUALLY CONTROLS THE DESIGN. FOR ESTIMATING SETTLEMENT, TAKE 50% *
*   OF THE SETTLEMENT FOR AN EQUIVALENT FOOTING RESTING ON THE SURFACE OF   *
*   COMPARABLE GRANULAR SOILS. (CHAPTER 5, DM-7.1).   *

.))-

FIGURE 1 (continued)
Load Carrying Capacity of Single Pile in Granular Soils



FOR A 12" DIAMETER CLOSED END, DRIVEN PIPE PILE, CONCRETE FILLED, FIND Q_{all} AND T_{all} FOR A 30 FOOT LONG PILE.

P_o MAX OCCURS AT 20B, OR 20' INTO BEARING STRATUM.

$\phi = 30°$, $N_q = 21$

$K_{HC} = 1.5$, $\delta = 20°$

$K_{HT} = 1.0$

$A_T = \pi \times 0.5^2 = 0.78$ SF

CIRCUM. AREA / lf $= 1 \times \pi = 3.14$ SF / lf

$$Q_{ult} = 1.535 \times 21 \times 0.78 + \left[\left(1.5 \times \left(\frac{0.235 + 1.535}{2}\right) \times \text{TAN } 20 \times 20 \times 3.14\right) + \left(1.5 \times 1.535 \times \text{TAN } 20 \times 5 \times 3.14\right) \right]$$

$$= 25.14 + [30.34 + 13.16]$$

$$= 68.64 \text{ K}$$

FOR $F_S = 3$, $Q_{all} = \dfrac{68.64}{3} = 22.9$ K

$$T_{ult} = 1.0 \times \left(\frac{0.235 + 1.535}{2}\right) \times \text{TAN } 20 \times 20 \times 3.14 + 1.0 \times 1.535 \times \text{TAN } 20 \times 5 \times 3.14$$

$$= 20.23 + 8.77$$

$$= 29.0 \text{ K}$$

$W_P \approx .117$ K/lf $\times$ 30' $= 3.5$ K

$T_{all} = \dfrac{29.0}{3} + 3.5 = 13.2$ K

FIGURE 1 (continued)
Load Carrying Capacity of Single Pile in Granular Soils

Timber pile resistance

$$P' = C_p A F_c^* = C_p P_o' \quad \text{(AF\&PA 4.3-1)}$$

C_p = Column stability factor

$$= \frac{1+\alpha_c}{2c} - \sqrt{\left(\frac{1+\alpha_c}{2c}\right)^2 - \frac{\alpha_c}{c}} \quad \text{(AF\&PA 4.3-2)}$$

where:

$$\alpha_c = \frac{\phi_s P_e}{\lambda \phi_c P_o'} \quad \text{(AF\&PA 4.3-3)}$$

$$P_e = \frac{\pi^2 E_{05}' I}{(K_e \ell)^2} \quad \text{(AF\&PA 4.3-4)}$$

Critical Buckling Resistance

And:

P_o' = Adjusted Resistance = 1.26 ksi (LRFD Timber Poles & Piles Supplement Table 4.1)

ϕ_s = Resistance factor for stability = 0.85 (AF&PA Table 1.4-1)

ϕ_c = Resistance factor for compression = 0.90 (AF&PA Table 1.4-1)

C = 0.85 for round piles (AF&PA 4.3.2)

λ = time factor = 0.80 (AF&PA Table 1.4-2)

E_{05}' = 640 (LRFD Timber Poles & Piles Supplement Table 4.1)

ℓ = 23.5 (Historical Drawings, Section through ℄ of Pockets)

K_e = End Restraint Coefficient = 0.65 (Civil Engineering Ref. Manual Table 45.1)

I = Moment of Inertia = $\frac{\pi r^4}{4}$ = 1017.9 (Civil Eng. Ref. Manual A-71)

$$P_e = \frac{\pi^2 * 640 * 1017.9}{(0.65 * 23.5\text{ ft})^2} = 2{,}758.57 \text{ kip}$$

$$\alpha_c = \frac{0.82 * 2{,}758.57 \text{ kip}}{0.80 * 0.90 * (113.1 \text{ in}^2 * 1.26 \text{ ksi})} = 22.0$$

$$C_p = \frac{1+22.0}{2 * 0.85} - \sqrt{\left(\frac{1+22.0}{2 * 0.85}\right)^2 - \frac{22.0}{0.85}} = 0.9952$$

$$P_o' = 0.9952 * 113.1 \text{ in}^2 * 1.26 \text{ ksi} = 141.82 \text{ kip}$$

$$P_u \le 0.80 * 0.90 * 141.82 \text{ kip} \Rightarrow \boxed{P_u \le 102.11 \text{ kip}}$$

Specification for Computing the Reference Resistance of Wood-Based Materials and Structural Connections for Load and Resistance Factor Design, are consistent with other standards in their use of reliability concepts only in the background calculations. The design equations include the end result of these calculations in the load factors and the resistance factors.

Nearly all of today's (i.e., ASD) standard design formulae and adjustment factors are directly applicable for use in LRFD, leading to maximum consistency between the familiar design concepts of Allowable Stress Design and the new LRFD procedures.

Basic LRFD Equations

The basic design equation for LRFD, as with all engineering safety checking equations, requires that the specified product strength or resistance meet or exceed the stress or other effect imposed by the specified loads. In ASD, the permissible stress levels are set very low and the load magnitudes are set at once in a lifetime levels. This combination produces designs that maintain high safety levels yet remain economically feasible. In LRFD the basic design equation follows a similar format, in which the factored resistance must be greater than or equal to the factored load effects.

From a user's standpoint, the design process is similar to ASD. The most obvious difference between LRFD and ASD is that both the resistance and load effect values in LRFD will be numerically much higher than in ASD. The resistance values are higher because they are very near test magnitudes rather than being reduced by a significant internal safety factor.

The load effects are higher because they are multiplied by load factors in the range of 1.2 to 1.6.

1.1.2 Load Combinations and Load Factors

The load combination equations for use with LRFD are given in AF&PA/ASCE 16-95 Sec. 1.3.2:

$1.4\,D$	(1.3-1)
$1.2\,D + 1.6\,L + 0.5\,(L_r \text{ or } S \text{ or } R)$	(1.3-2)
$1.2\,D + 1.6\,(L_r \text{ or } S \text{ or } R) + (0.5\,L \text{ or } 0.8\,W)$	(1.3-3)
$1.2\,D + 1.3\,W + 0.5\,L + 0.5\,(L_r \text{ or } S \text{ or } R)$	(1.3-4)
$1.2\,D + 1.0\,E + 0.5\,L + 0.2\,S$	(1.3-5)
$0.9\,D - (1.3\,W \text{ or } 1.0\,E)$	(1.3-6)

Refer to AF&PA/ASCE 16-95 and its commentary for additional details about application of these equations.

The load factors in these equations are intended to provide a consistent level of reliability across a range of ratios of the various load types.

1.1.3 Resistance Factors

To provide additional flexibility in achieving consistent reliability across a range of product applications, resistance factors are applied to the reference resistance values. Resistance factors (ϕ) are always less than unity. The magnitude of a resistance factor represents the relative reduction required to achieve comparable reliability levels.

AF&PA/ASCE 16-95 provides the following resistance factors for wood-based products and connections:

Compression	$\phi_c = 0.90$
Flexure	$\phi_b = 0.85$
Stability	$\phi_s = 0.85$
Tension	$\phi_t = 0.80$
Shear/Torsion	$\phi_v = 0.75$
Connections	$\phi_z = 0.65$

These factors provide roughly equivalent reliability among different stress modes for a given product type.

1.1.4 Time Effect Factors

The time effect factor (λ) is the LRFD-equivalent of the load duration factor in Allowable Stress Design. Time effect factors are tabulated in Table 1.4-2 for each load combination equation. The factors were derived based on reliability analysis that considered variability in strength properties, stochastic load process modeling and cumulative damage effects. Because reference strengths are based on short-term test values, time effect factors equal unity for load combinations in which no cumulative damage occurs. Time effect factors range in value from 1.25 for a load combination controlled by impact loading to 0.6 for a load combination controlled by permanent dead load. Examination of Table 1.4-2 from AF&PA/ASCE 16-95 reveals that common building applications will likely be designed for time effect factors of 0.80 for gravity load design (AF&PA/ASCE 16-95 Eq. 1.3-2 under occupancy floor load and 1.3-3) and 1.0 for lateral load design (AF&PA/ASCE 16-95 Eq. 1.3-4, 1.3-5 and 1.3-6).

1.1.5 Reference Conditions

Reference conditions have been defined such that a majority of wood products used in interior or in protected

TABLE 1.4-1.
Resistance factors, ϕ.

Application	Symbol	Value
Compression	ϕ_c	0.90
Flexure	ϕ_b	0.85
Stability	ϕ_s	0.85
Tension	ϕ_t	0.80
Shear/Torsion	ϕ_v	0.75
Connections	ϕ_z	0.65

mitted provided that substantiating data on behavior is available and approved by the authority having jurisdiction.

1.4.2.1 Modulus of elasticity. For determination of load effects in indeterminate structures and for calculation of deflections and other serviceability conditions, the adjusted mean value, E', shall be used.

The adjusted modulus of elasticity, E', that must be used in design, depends on the application. In design cases in which structural strength or stability are computed, the adjusted fifth percentile value, E_{05}', shall be used. The value of E_{05}' shall be computed as:

$$E_{05}' = 1.03E'(1 - 1.645(COV_E))$$

where 1.03 is the adjustment from tabulated E to shear-free E; and COV_E is the coefficient of variation of E.

Exception: For glued-laminated timber, the adjustment shall be 1.05, rather than 1.03.

Modulus of elasticity shall not be adjusted by the time effect factor, λ.

1.4.2.2 End restraints. The design of connections shall be consistent with assumptions in the structural analysis and with the type of construction called for on the design drawings. Simple framing, in which the rotational restraint is ignored, shall be assumed unless the capacity of the connection for a specified degree of restraint can be demonstrated by experimental or analytical means. Connections must have sufficient rotation capacity to avoid overloading connecting elements under design loads.

1.4.2.3 Long-term loading. Structures and members that accumulate residual deformations under service loads shall have the added deformations expected to occur during their service life included in their analysis when such deformations affect strength or serviceability.

1.4.3 Strength limit states. The design of structural systems, members, and connections shall ensure that the design resistance at all sections for each system, member, and connection equals or exceeds the force due to factored loads, R_u.

1.4.3.1 Force due to factored loads. Member and connection forces, R_u, shall be determined from the factored load combinations in Sec. 1.3.

1.4.3.2 Design resistance. The design resistance shall be calculated for each applicable limit state as the product of an adjusted resistance, R', a resistance factor, ϕ, and a time effect factor, λ. The design resistance shall equal or exceed the force due to factored loads, R_u:

$$R_u \leq \lambda\phi R' \tag{1.4-1}$$

where R' indicates the adjusted resistance of a member, component, or connection, such as adjusted flexural resistance, M', adjusted shear re-

TABLE 1.4-2.
Time effect factors.

Load Combination		Time Effect Factor (λ)
1.4D	*(1.3-1)*	0.6
1.2D + 1.6L + 0.5(L_r or S or R)	*(1.3-2)*	0.7 when L is from storage 0.8 when L is from occupancy 1.25 when L is from impact[2]
1.2D + 1.6(L_r or S or R) + (0.5L or 0.8W)	*(1.3-3)*	0.8
1.2D + 1.3W + 0.5L + 0.5(L_r or S or R)	*(1.3-4)*	1.0
1.2D + 1.0E + 0.5L + 0.2S	*(1.3-5)*	1.0
0.9D − (1.3W or 1.0E)	*(1.3-6)*	1.0

[2]For connections, λ = 1.0 when L is from impact.

not be avoided, mechanical reinforcement sufficient to resist the tension force shall be provided. Radial tension arising in curved members and in pitched and tapered members shall be limited by the provisions of Sec. 5.6.

3.4 Resistance of Built-up and Composite Members

3.4.1 Built-up members with components of similar materials. Built-up members include chords of multiple member roof trusses, diaphragm chords, drag struts, and similar members consisting of two or more parallel components of similar material strength and stiffness connected together.

The resistance of such built-up members shall be taken as the sum of the resistances of the individual components provided the connections are adequate to insure a distribution of the axial tension among the individual components in proportion to their area. The effects of splices on reducing the member strength shall be accounted for in the design.

3.4.2 Composite members with components of dissimilar materials. The design of tension members assembled from sawn, glued-laminated, or other wood-based components of differing stiffnesses acting in parallel or acting in combination with metal plates or bars shall be based on transformed section concepts. Components shall be connected so that they act as a unit with forces distributed in proportion to the component stiffnesses. For a composite member so connected, the member resistance shall be determined by summing the forces acting in the components at the axial deformation at which the first component reaches its individual resistance.

CHAPTER 4

Compression Members and Bearing

4.1 General

4.1.1 Scope. The provisions of this chapter apply to members subjected to concentric axial compression and to localized compression in locations of bearing. Members loaded in combined bending and axial compression, including members with eccentric axial loads, shall meet the requirements of Sec. 6.3.

4.1.2 Member design. Compression members shall be designed such that:

$$P_u \le \lambda \phi_c P' \qquad (4.1\text{-}1)$$

where P_u is the compression force due to factored loads, λ is the applicable time effect factor given in Table 1.4-2, ϕ_c is the resistance factor for compression parallel to grain = 0.90, and P' is the adjusted compression resistance.

The adjusted resistance shall be computed by multiplying the reference resistance by the applicable adjustments in Sec. 2.6.

Members with concentrated applied axial loads shall have sufficient local design resistance and stability in the affected end or connection regions to support these loads. Similarly, members shall have sufficient local design resistance and web stability at beam supports and at the locations of any concentrated transverse loads.

4.2 Slenderness and Effective Length Considerations

4.2.1 Effective column length. The actual unbraced length of a column or column segment, ℓ, shall be taken as the center-to-center distance between lateral supports. The unbraced length shall be determined for both the strong and weak axes of a column.

The effective column length, ℓ_e, for the direction considered shall be taken as $K_e\ell$, where K_e is the buckling length coefficient for compression members. K_e depends on the column-end restraint conditions and the presence or absence of sidesway.

For a compression member braced against sidesway in the direction being considered, the buckling length coefficient, K_e, shall be taken as unity unless a rational analysis shows that the end restraint conditions justify use of a smaller factor.

For a compression member unbraced against sidesway in the direction being considered, the buckling length coefficient, K_e, shall be greater than one and shall be determined by a rational analysis which accounts for the end restraint conditions.

4.2.2 Column slenderness ratio. The column slenderness ratio is given by the ratio of the effective length in the direction considered to the radius of gyration corresponding to that direction:

$$\text{slenderness ratio} = K_e\ell/r. \quad (4.2\text{-}1)$$

The radius of gyration shall be based on the gross area, using a transformed section when all components are not of the same material stiffness. For notched and tapered members, the radius of gyration shall be determined in accordance with Sec. 4.3.3 and 4.3.4, respectively.

The slenderness ratio, $K_e\ell/r$, of columns shall not exceed 175.

4.3 Resistance of Solid Columns Concentrically Loaded in Compression

4.3.1 Design material values and design factors. The modulus of elasticity used in the equations of this section shall be the adjusted value at the fifth percentile as specified for use in resistance equations, E_{05}'.

4.3.2 Resistance of prismatic columns. The column resistance shall be determined based on the most critical column direction and member slenderness ratio. The adjusted column resistance shall be computed as:

$$\begin{aligned} P' &= C_P A F_c^* \\ &= C_P P_0' \end{aligned} \quad (4.3\text{-}1)$$

The column stabiliy factor, C_P, shall be computed as:

$$C_p = \frac{1+\alpha_c}{2c} - \sqrt{\left(\frac{1+\alpha_c}{2c}\right)^2 - \frac{\alpha_c}{c}} \quad (4.3\text{-}2)$$

where:

$$\alpha_c = \frac{\phi_s P_e}{\lambda \phi_c P_0'} \quad (4.3\text{-}3)$$

$$P_e = \frac{\pi^2 E_{05}' I}{(K_e\ell)^2} = \frac{\pi^2 E_{05}' A}{\left(K_e \frac{\ell}{r}\right)^2} \quad (4.3\text{-}4)$$

and:

A = gross area;
F_c^* = parallel to grain compression strength multiplied by all applicable adjustment factors except C_P;
E_{05}' = adjusted modulus of elasticity at the fifth percentile;
P_e = critical (Euler) buckling resistance about the axis being considered;
P_0' = adjusted member axial parallel to grain resistance of a zero length column; (i.e., the limit obtained as length approaches zero);
c = 0.80 for solid sawn members;
c = 0.85 for round poles and piles;
c = 0.90 for glued laminated members and structural composite lumber;
ϕ_c = resistance factor for compression = 0.90;
ϕ_s = resistance factor for stability = 0.85.

The moment of inertia, I, the E_{05}' values, and effective length, $K_e\ell$, shall be for the direction being considered. The value of c for members other than glued laminated members, poles, and piles shall be 0.80 unless a larger value has been justified by tests.

4.3.3 Resistance of notched or bored prismatic columns. In addition to the provisions of Sec. 4.3.2, the adjusted compression resistance of a notched or bored prismatic column shall be evaluated as follows.

4.3.3.1 Notch in critical location.

$$P' = C_P A_n F_c^* \quad (4.3\text{-}5)$$

where C_P shall be computed by using properties of the net area when notches or holes are located in the middle half of a length between inflection points of the buckled shape and:

(a) the net moment of inertia at such locations is less than 80% of the gross moment of inertia; or
(b) the longitudinal dimension of the notch or hole is greater than the larger cross-sectional dimension of the column.

4.3.3.2 Notch in noncritical location. For cases other than noted in Sec. 4.3.3.1, the adjusted compression resistance shall be computed as the lesser of Eq. 4.3-6 and 4.3-7:

$$P' = C_P A F_c^* \quad (4.3\text{-}6)$$

where C_P shall be computed by using properties of the gross area:

$$P' = A_n F_c^* \quad (4.3\text{-}7)$$

4.3.4 Resistance of tapered columns.

4.3.4.1 Tapered circular columns. The adjusted compression resistance of uniformly tapered circular columns shall be determined using the

Table 4.1 Reference Strengths for Poles Graded in Accordance with ASTM D3200.

Species	Bending F_b	Shear F_v	Compression perpendicular to grain $Fc_\perp$	Compression parallel to grain F_c	Bearing P_g	Modulus of Elasticity MOE
	Design values in kips per square inch (ksi)					
Pacific Coast Douglas-Fir	4.70	0.33	0.78	2.40	2.88	1500
Jack Pine	3.81	0.27	0.58	1.92	2.10	1070
Lodgepole Pine	3.43	0.24	0.50	1.68	2.10	1080
Northern White Cedar	2.67	0.23	0.47	1.26	1.62	640
Ponderosa Pine	3.30	0.26	0.67	1.56	1.98	1000
Red Pine	3.68	0.24	0.55	1.74	1.92	1280
Southern Pine	4.32	0.30	0.67	2.16	2.70	1400
Western Hemlock	4.19	0.33	0.51	2.16	2.28	1310
Western Larch	5.21	0.35	0.78	2.58	2.70	1460
Western Red Cedar	3.43	0.27	0.53	1.80	2.88	940

Table 4.2 Reference Strengths for Treated Piles Graded in Accordance with ASTM D25.

Species	Compression parallel to grain F_c	Bending F_b	Shear F_v	Compression perpendicular to grain $Fc_\perp$	Modulus of Elasticity MOE
	Design values in kips per square inch (ksi)				
Pacific Coast Douglas-Fir[1]	3.00	6.22	0.33	0.48	1500
Red Oak[2]	2.64	6.22	0.39	0.73	1250
Red Pine[3]	2.22	4.83	0.24	0.32	1280
Southern Pine[4]	2.70	5.59	0.30	0.52	1400

1. Pacific Coast Douglas Fir reference strengths apply to this species as defined in ASTM Standard D1760-86. For connection design use Douglas Fir-Larch reference strengths.
2. Red Oak reference strengths apply to Northern and Southern Red Oak.
3. Red Pine reference strengths apply to Red Pine grown in the United States. For connection design use Northern Pine reference strengths.
4. Southern Pine reference strengths apply to Loblolly, Longleaf, Shortleaf, and Slash Pine.

4

REFERENCE STRENGTHS

1. SLENDER COLUMNS

Very short compression members are known as *piers*. Long compression members are known as *columns*. Failure in piers occurs when the applied stress exceeds the yield strength of the material. However, very long columns fail by sideways *buckling* long before the compressive stress reaches the yield strength. Buckling failure is sudden, often without significant initial sideways bending. The load at which a column fails is known as the *critical load* or *Euler load*.

The *Euler load* is the theoretical maximum load that an initially straight column can support without buckling. For columns with frictionless or pinned ends, this load is given by Eq. 45.1. r is the *radius of gyration*.

$$F_e = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 EA}{\left(\frac{L}{r}\right)^2} \quad 45.1$$

The corresponding column stress is given by Eq. 45.2. In order to use Euler's theory, this stress cannot exceed half of the compressive yield strength of the column material.

$$\sigma_e = \frac{F_e}{A} = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2} \quad 45.2$$

The quantity L/r is known as the *slenderness ratio*. Long columns have high slenderness ratios. The smallest slenderness ratio for which Eq. 45.2 is valid is the *critical slenderness ratio*. Typical critical slenderness ratios range from 80 to 120. The critical slenderness ratio becomes smaller as the compressive yield strength increases.

L is the longest unbraced column length. If a column is braced against buckling at some point between its two ends, the column is known as a *braced column*, and L will be less than the full column height. Columns with rectangular cross sections have two radii of gyration, r_x and r_y, and therefore, will have two slenderness ratios. The largest slenderness ratio will govern the design.

Columns do not always have frictionless or pinned ends. Often, a column will be fixed ("clamped," "built in," etc.) at its top and base. In such cases, the *effective length*, L', must be used in place of L in Eqs. 45.1 and 45.2.

$$L' = KL \quad 45.3$$

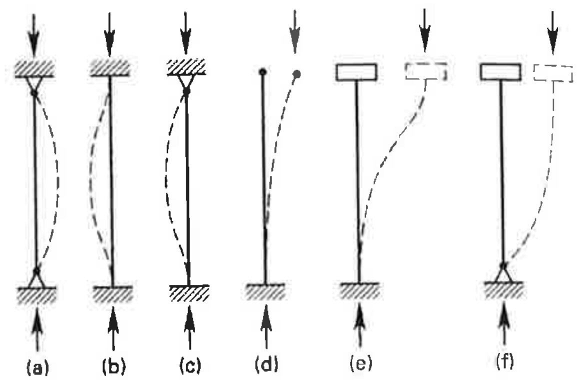
$$\sigma_e = \frac{F_e}{A} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} \quad 45.4$$

K is the *end restraint coefficient*, which varies from 0.5 to 2.0 according to Table 45.1. For most real columns, the design values of K should be used since infinite stiffness of the supporting structure is not achievable.

Table 45.1 *Theoretical End Restraint Coefficients*

illus.	end conditions	K ideal	recommended for design
(a)	both ends pinned	1	1.0*
(b)	both ends built in	0.5	0.65*–0.90
(c)	one end pinned, one end built in	0.707	0.80*–0.90
(d)	one end built in, one end free	2	2.0–2.1
(e)	one end built in, one end fixed against rotation but free	1	1.2*
(f)	one end pinned, one end fixed against rotation but free	2	2.0*

*AISC values



Euler's curve for columns, line BCD in Fig. 45.1, is generated by plotting the *Euler stress* (Eq. 45.2) versus the slenderness ratio. Since the material's compressive yield strength cannot be exceeded, a horizontal line AC is added to limit applications to the region below. Theoretically, members with slenderness ratios less than $(SR)_C$ could be treated as pure compression members. However, this is not done in practice.

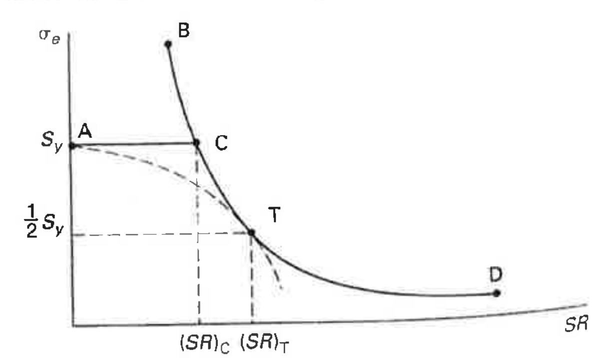
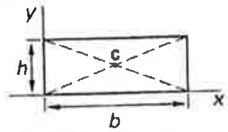
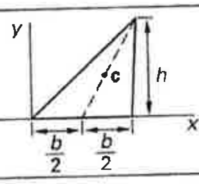
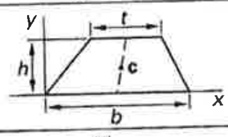
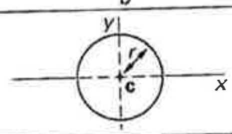
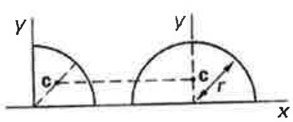
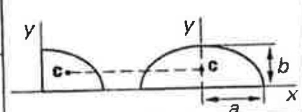
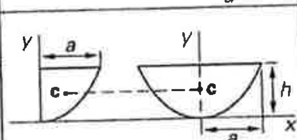
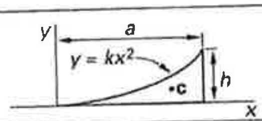
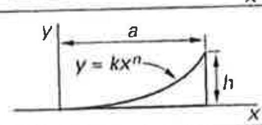
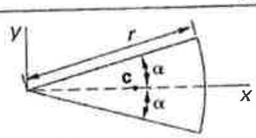


Figure 45.1 *Euler's Curve*

Defects in materials, errors in manufacturing, inabilities to achieve theoretical end conditions, and eccentricities frequently combine to cause column failures in the region around point C. Therefore, this region is excluded by designers.

APPENDIX 42.A
Centroids and Area Moments of Inertia for Basic Shapes

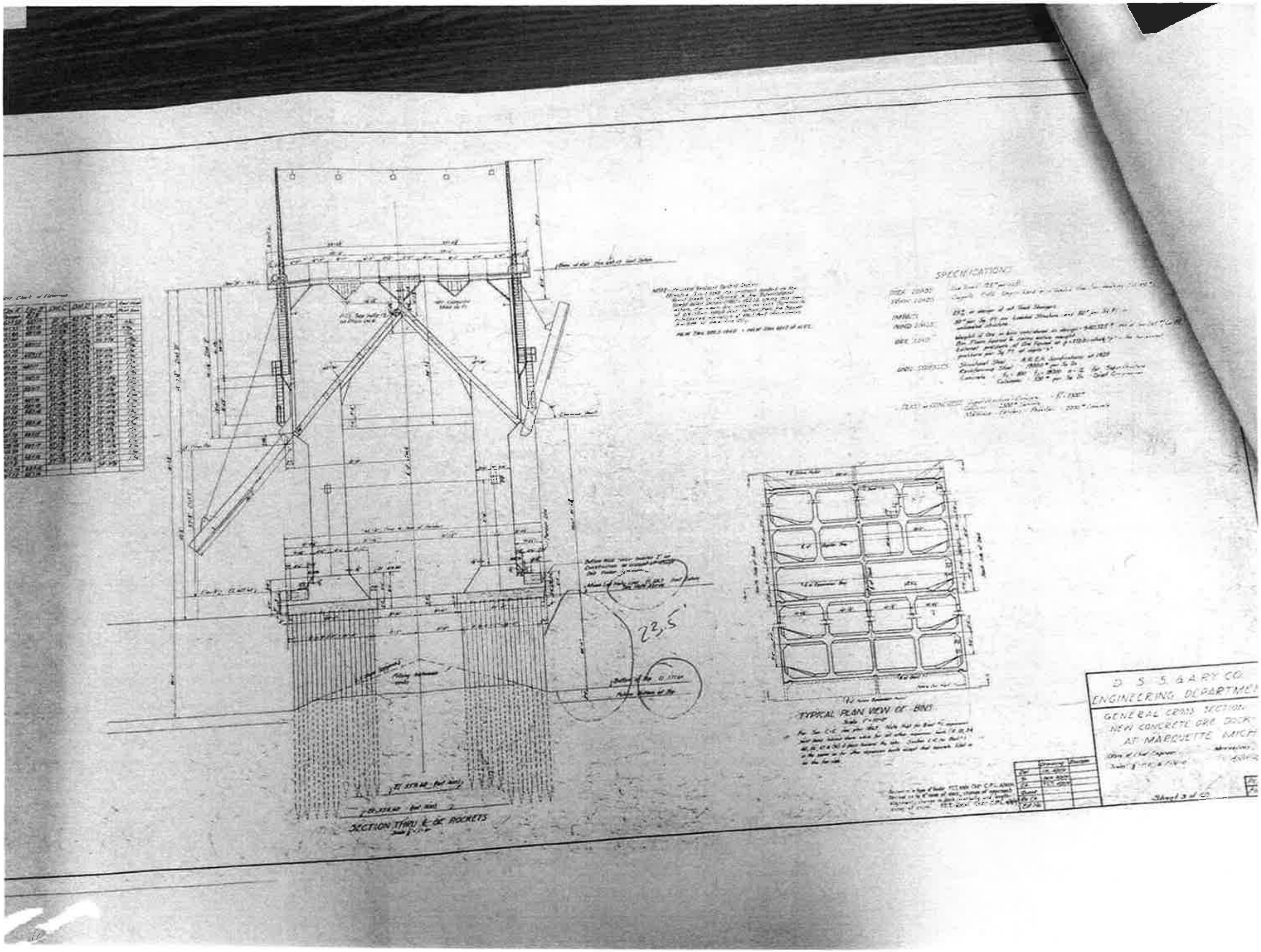
shape		centroidal location x_c	centroidal location y_c	area, A	area moment of inertia (rectangular and polar), I, J	radius of gyration, r
rectangle		$\frac{b}{2}$	$\frac{h}{2}$	bh	$I_x = \frac{bh^3}{3}$ $I_{c,x} = \frac{bh^3}{12}$ $J_c = \left(\frac{1}{12}\right)bh(b^2+h^2)$*	$r_x = \frac{h}{\sqrt{3}}$ $r_{c,x} = \frac{h}{2\sqrt{3}}$
triangular area			$\frac{h}{3}$	$\frac{bh}{2}$	$I_x = \frac{bh^3}{12}$ $I_{c,x} = \frac{bh^3}{36}$	$r_x = \frac{h}{\sqrt{6}}$ $r_{c,x} = \frac{h}{3\sqrt{2}}$
trapezoid			$h\left(\frac{b+2t}{3b+3t}\right)$	$\frac{(b+t)h}{2}$	$I_x = \frac{(b+3t)h^3}{12}$ $I_{c,x} = \frac{(b^2+4bt+t^2)h^3}{36(b+t)}$	$r_x = \left(\frac{h}{\sqrt{6}}\right)\sqrt{\frac{b+3t}{b+t}}$ $r_{c,x} = \frac{h\sqrt{2(b^2+4bt+t^2)}}{6(b+t)}$
circle		0	0	πr^2	$I_x = I_y = \frac{\pi r^4}{4}$ $J_c = \frac{\pi r^4}{2}$	$r_x = \frac{r}{2}$
quarter-circular area		$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{4}$	$I_x = I_y = \frac{\pi r^4}{16}$ $J_o = \frac{\pi r^4}{8}$	
semicircular area		0	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$	$I_x = I_y = \frac{\pi r^4}{8}$ $I_{c,x} = 0.1098r^4$ $J_o = \frac{\pi r^4}{4}$ $J_c = 0.5025r^4$	$r_x = \frac{r}{2}$ $r_{c,x} = 0.264r$
quarter-elliptical area		$\frac{4a}{3\pi}$	$\frac{4b}{3\pi}$	$\frac{\pi ab}{4}$	$I_x = \frac{\pi ab^3}{8}$ $I_y = \frac{\pi a^3 b}{8}$ $J_o = \frac{\pi ab(a^2+b^2)}{8}$	
semielliptical area		0	$\frac{4b}{3\pi}$	$\frac{\pi ab}{2}$		
semiparabolic area		$\frac{3a}{8}$	$\frac{3h}{5}$	$\frac{2ah}{3}$		
parabolic area		0	$\frac{3h}{5}$	$\frac{4ah}{3}$	$I_x = \frac{4ah^3}{7}$ $I_y = \frac{4ha^3}{15}$ $I_{c,x} = \frac{16ah^3}{175}$	$r_x = h\sqrt{\frac{3}{7}}$ $r_y = \frac{a}{\sqrt{5}}$
parabolic spandrel		$\frac{3a}{4}$	$\frac{3h}{10}$	$\frac{ah}{3}$	$I_x = \frac{ah^3}{21}$ $I_y = \frac{3ha^3}{15}$	
general spandrel		$\left(\frac{n+1}{n+2}\right)a$	$\left(\frac{n+1}{4n+2}\right)h$	$\frac{ah}{n+1}$		
circular sector [α in radians]		$\frac{2r\sin\alpha}{3\alpha}$	0	αr^2		

*Theoretical definition based on $J = I_x + I_y$. However, in torsion, not all parts of the shape are effective. Effective values will be lower.

$$J = C\left(\frac{b^2+h^2}{b^3h^3}\right)$$

b/h	C
1	3.56
2	3.50
4	3.34
8	3.21

Support Material


SPECIFICATIONS
TYPICAL PLAN VIEW OF BINS
SECTION THRU ℄ OF POCKETS
23.5'
D S S & A RY CO
ENGINEERING DEPARTMENT
GENERAL CROSS SECTION
NEW CONCRETE ORE DOCK
AT MARQUETTE MICH
Sheet 3 of 60

GEI Consultants

Update heading info - not currently correct
Add reference pages

Lower Harbor Ore Dock Wind Loads

Code References:

- ASCE. (2010). "Minimum design loads for buildings and other structures." ASCE 7-10, Reston, VA
- Michigan State Building Code

Structural Design:

The following shows the design criteria used in checking the wind load applied to the ore dock. The methods used below comply with ASCE 7-10.
Unless noted otherwise all referenced tables and section are from ASCE 7-10.

Overall Conditions

Overall Structure Properties:

Location:	Marquette, Michigan
County:	Marquette County
Structure Type:	Ore Dock
Risk Category: ~Table 1.5-1 (ASCE)	Low Risk in Event of Failure - Risk Category I

Wind Loads:

- Use ASCE 7-10 Chapters 29 - Main Wind Force Resisting System
- Treat Structure as "Design Wind Loads - Other Structures", Section 29.5

Insert Wind Load Condition

???

too much white space - tighten up.

Wind Loads Continued:

Parameters: Per ASCE 7-10

- Exposure Class "D"
- H = 85 ft
- Risk Category I
- G = 1.08 (Table 8)
- C_f = 1.3 (Table 12)
- q_z = Section 6.5 (See Below)
- I = 1.0 (Table 5)
- K_z = 1.67 (Table 6)

$$P_w = q_z \cdot G \cdot C_f$$

too much white space - tighten up.

- A = 85ft by 12ft

??

Wind Loads Continued:

q_z (Section 6.5):

Velocity pressure at a height, z: $q_z = 0.00256 K_z \cdot I \cdot V^2$

$K_z := 1.67$

$I := 1.0$

$G := 1.08$

$C_f := 1.3$

V (Michigan Building Code, Figure 1609C):

Basic Wind Speed:
(Risk Category I)

$V := 105\text{mph}$

$$q_z := .00256 K_z \cdot I \cdot \frac{V^2 \cdot \text{psf}}{\text{mph}^2}$$

$q_z = 0.33\,\text{psi}$

too much white space - tighten up.

Wind Loads Continued:

P_w Design Pressure (Ultimate Load):

Design Pressure applied Ore Dock:

$$P_w := q_z \cdot G \cdot C_f$$

$$P_w = 0.46\,psi$$

Use explicit function to show calculation

Not clear where these were defined.

$$A := 1020ft^2$$

Wind Force on Ore Dock Bent:

$$F := A \cdot P_w = 67.5 \cdot kip$$