INSPECTION REPORT FOR

SAN LUIS OBISPO COUNTY'S

CSA-7A LIFT STATION #3

MARCH 9TH, 2023

Advantage Technical Services, Inc.
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SAN LUIS OBISPO COUNTY'S
CSA-7A, LIFT STATION #3

MARCH 9TH, 2023
REVISION DATE: N/A

Pursuant to the California Business and Professions Code section 6735, the engineering report contained herein has been prepared by or under the direction of the following Registered Engineer:

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UNDER THE SUPERVISION OF:
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REGISTERED PROFESSIONAL ENGINEER
WILLIAM D. BELLIS
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EXP. 12/31/2024
CIVIL
STATE OF CALIFORNIA

EXECUTIVE SUMMARY

Advantage Technical Services, Inc. (ATS) inspected the wet well in the County of San Luis Obispo's Lift Station #3 at Oak Shores on March 9th, 2023. The wet well was entered pursuant to confined space entry procedures. The interior was visually inspected from the access tube ladder and the fiberglass grating. The existing corroded hoist beams were inspected and the remaining sound metal was measured in sample areas. A structural engineering evaluation was completed for the corroded beams using the loads associated with lifting one of the pumps. The following is a summary of what appear to be the most significant elements:

1. The hoist lifting system structure should not be used due to severe corrosion damage of various components and the inability to access important areas of the hoist end connections.
2. The end connections and tops of the hoist rail beams form inaccessible areas for original construction, maintenance and inspection
3. Welded repairs at the end connections could allow use of the beams in the corroded condition except that much of the corrosion damage on the beams is on the bottom flanges. The resulting uneven surface will make rolling a trolley carrying a load difficult.
4. The corrosion on the hoist trolley appears excessive and it should be replaced with a type appropriate for operation on the corroded beams.
5. Many areas of failed coatings and significant corrosion are present on the interior surfaces of the wet well and access tube.
6. Rehabilitation or replacement of the lifting beams, other structural components and piping within the wet well, should be completed as soon as possible

SCOPE, OBJECTIVE, AND LIMITATIONS

An inspection was completed on the interior of the steel wastewater lift station wet well by the ATS confined space inspection team.

ATS inspectors have experience and certifications that meet OSHA regulations for confined space access. Additionally, our team's certifications or licenses include a Registered Professional Engineer, AWS Certified Welding Inspector, National Association of Corrosion Engineers Level III Coating Inspector, and American Society of Nondestructive Testing Level III Engineer. With these applicable credentials and a combined experience of over two hundred confined space entry structural inspections, our team leads the industry.

The photographs provided within this report display representative views and subsequent analysis. Digital video, also included, provides additional documentation of the conditions.

The observations made during the inspection, and included in this report, provide a reasonable evaluation of the conditions at the time of the inspection. Considerations of safe access and reasonable care were observed in making and reporting the observations.

Latent defects or conditions found during subsequent cleaning, inspections, or other work at the tank must be brought to the Engineer's or Owner's attention.

OBSERVATIONS

General Data

Type: Welded steel lift station wet well
Depth: 60 feet
Approximate liquid level during inspection: 6 feet

Access Tube

The coatings on the interior shell plate are in poor condition. Scattered areas of significant corrosion are present. The locations of the corrosion are at seams, joints, attachment points and other scattered areas. Damaged coatings were left in place to avoid acceleration of corrosion. Metal loss from corrosion was not measured.

Wet Well Interior Shell

The coatings on the interior shell plate are in poor condition. Scattered areas of significant corrosion are present. The locations of the corrosion are at seams, joints, attachment points and other scattered areas. Damaged coatings were left in place to avoid acceleration of corrosion. Metal loss from corrosion was not measured.

Grating Support Structure

Three sections of grating were raised to allow a brief look at the condition of the support structure and to photograph the structure and piping.

Significant localized corrosion is present on approximately 10% of the surface area of the support structure. The amount of corrosion product present appeared to be similar to what was present on the hoist rails where corrosion was measured to be approximately 1/16".

Wet Well and Access Tube Exterior Surfaces

No exterior (soil side) surfaces were accessed or evaluated as part of this inspection work. It should be expected that some corrosion is present. The amount of corrosion on the soil side surfaces could vary dramatically depending on the amount of moisture, the chemistry of the surrounding soil and corrosion prevention methods among other factors.

Hoist Rails

Corrosion Removal - A step ladder was used to reach the beams. Portable lighting was used to complete a preliminary visual inspection. The top of the upper flange is approximately ¼" below the ceiling of the wet well and not accessible for inspection. The ends of the hoist rails were not accessible for inspection on the outer (away from the center of the wet well) sides due to the tight corner (crevice) between the end of the rails and the shell of the wet well.

Five sample areas on the beams, that were estimated to have the worst corrosion damage, were cleaned using hand and power tools. Corrosion product (rust) was removed to expose the remaining undamaged steel.

Hoist Rail Visual Inspection - The prepared areas were inspected visually. Significant metal loss is present. The worst corrosion damage appears to be on the top of the lower flange of the beams. The outer edges of the flanges in the worst area are reduced to a “knife edge”. Localized metal loss is approximately 1/16” in. The corrosion likely started where the trolley wheels damaged the coating or at poor coating application along the edge of the flanges.

Calipers were used to measure the thickness of the bottom flanges of the beams in the sample areas. A “pit gauge” was used to measure material loss relative to adjacent uncorroded areas. Localized corrosion was measured on the web as 1/32”-3/64”.

The hoist beams are attached to the shell at each end with welded connections. The welded connections provide the sole structural support of the beams. Each connection consists of one attachment plate (clip) which is welded to the shell then welded to the end of the beam. There is a tight angle that forms a crevice on the “back sides” (opposite the center of the wet well). Serious corrosion is evident at each end of the rail beams on the inaccessible side. The geometry of the connection prevented access to inspect and measure the sound metal of this connection. This same issue would have been present at the time of original welding and coating. This extremely limited access would likely have impacted the quality of welding and coating during original construction.

Hoist Rail Structural Evaluation - The measurements from the visual inspection were used to develop an estimated “worst case” corroded shape. The areas of maximum corrosion were used to develop the “worst-case” shape. The structural properties of this “worst-case” cross section were determined (see Structural Calculations, App. A, sheet 2). These properties were used to calculate the beam stresses with the pump load conditions used by Smith Structural Group during the original project design. Additionally, localized bending on the corroded flange was checked for the trolley wheel loads.

The structural engineering evaluation of the corroded hoist rails shows that significant loss of strength has occurred but the beams themselves are adequate for the design loads. Additional corrosion will further reduce the strength of the beams.

The lack of access for inspection and measurement of sound metal at the connections between the ends of the hoist rails prevented structural engineering evaluation.

Spot Coating Repair – Spot coating repairs were applied by ATS in the areas where corrosion and damaged coatings were removed to help slow additional corrosion. A 100% solids epoxy (aquatapoxy) was used. The repairs were applied in conditions that do not meet the manufacturer's recommendations so they should be considered temporary/short term repairs.

Hoisting Trolly

A beam trolly is in place on the eastern hoist rail. No trolley is present on the western hoist rail. The visible portions of the existing beam trolley are severely damaged by corrosion. It is likely that the wheel bearings and retainers are also damaged. This trolley should not be used.

Interior Ladder

The fiberglass ladder appears to be in good condition. The mounting brackets and shell attachments appear to be in good condition. There is PVC conduit that is mounted behind the ladder that appears to be hanging from the top only. It is swinging loosely and can enter the area behind the ladder that should be open for minimum footing clearance. No ladder safety device is mounted to the ladder. The davits above are present for fall protection when additional equipment is mobilized as was done for this work.

ENVIRONMENT AND OPERATING CONDITIONS

Wet well vapor spaces present challenging conditions for corrosion prevention. Anaerobic conditions can result in the presence of hydrogen sulfide gas (H2S). This gas, combined with moisture and air result in formation of sulfuric acid which is highly corrosive to steels and other metals.

COMMENTARY

The inability to access, inspect and evaluate the structural components of the connections between the wet well shell and the hoist rails prevented a complete engineering evaluation. The end connections are a critical aspect of the design. Failure at either end connection of a beam under load will result in failure of the lifting system. The geometry that creates the challenging access existed during original construction. This poor access during construction adds questions relating to original weld and coating quality. Difficult of access during construction increases the potential that corrosion started early and that damage could exceed what was found at accessible locations on the beam. Additionally, the existing crevice conditions are often associated with accelerated corrosion.

The use of nondestructive examination methods was considered for evaluation of corrosion on the beam to shell attachment clips. If the weld connection was a complete joint penetration type, shear wave ultrasonic testing may offer additional information supporting the structural adequacy of the lifting system. If is likely, however, that the information would still be inadequate to find the system structurally sound particularly when significant corrosion damage in other areas of the connection could go undetected.

Aside from the end connection geometry, other operational and service conditions of the pump lifting system are problematic. The primary issue is that wear and damage is normal on rail beam coatings where the hoist trolley wheels roll. In this case, the hoist trolley wheels roll on the lower beam flange. Some level of damage would be expected during the first use. After that, the corrosive environment in the lift station vapor space will cause metal loss on the structural element in an unacceptably short time. Possible improvements to future design and operation of the pump lifting system include the following:

- Lift station configuration that allows all lifting apparatus to be located on the top side of the manway (ie. larger access opening).
- Coating the carbon steel beam after each use (assumes trolley will damage rail coating).
- Corrosion-proof materials such as fiberglass reinforced plastic beams (may be available but this was not confirmed within the scope of this work).
- Lifting components that are removed after use for maintenance and storage outside of the lift station.

Additional challenges include the lack of space (approx. 1/4inch) between the top of the hoist beams and the ceiling. This causes the entire top of the hoist beams to be inaccessible for inspection and maintenance.

The issues discussed above cause a lack of confidence with the lifting system in the corroded condition. Additional evaluation with abrasive cleaning of the end connections and nondestructive testing could be helpful to gather more data and increase confidence with the ability of the structure but a severely corroded bottom flange and unknown conditions on the top flange would still exist. Alternatively, it is estimated that a similar amount of work could be completed to cut the shell connections, rehabilitate corrosion damage on the shell and install new hoist rails. The rail end connections could be designed to eliminate inaccessible areas or provide significant extra material for corrosion allowance. The inaccessible area at the top flange of the beams could also be eliminated. The rehabilitation of the lifting beams would be an option that would allow pump replacement until a time when the entire wet well is rehabilitated or replaced.

RECOMMENDATIONS

Our scope of work did not include a safety audit or evaluation but we are making recommendations where we have noted potential issues. Insurance providers or a safety professional should be consulted for a review of the safety features of this facility if desired.

1. Do not use the lifting beam in the current condition. Failure at either end connection of a beam under load will result in failure of the lifting system. The existing connection geometry prevented access for inspection. The same geometry existed during original construction so the potential for increased corrosion rates in the inaccessible areas is significant. The lifting hoist rail beams themselves are significantly damaged but marginally functional. Metal loss due to corrosion has reduced the strength of the beam significantly but adequate strength is present for lifting a pump (#1,800 or less).

2. Repair or replace lift station and/or damaged components as soon as possible. Conceptual scope options include the following:

a) Removal and replacement of the entire lift station wet well could allow redesign of the lifting system where the structural components are not exposed to the corrosive environment.

or

b) Rehabilitation of the existing wet well including (but not limited to) the following:
   - i) Provide preliminary evaluation of the buried exterior surfaces of the wet well and access tube shell to check for corrosion damage and verify viability of rehabilitation. The inaccessible (soil side) surfaces could likely be inspected by the magnetic flux leakage (MFL) method (check with Mistras or others in Bakersfield, CA)
   - ii) Project scope development, estimates for scope options, engineering drawings and specifications
   - iii) Temporary equipment and plan for operations during construction work
   - iv) Preliminary rehabilitation plan including what portions will be replaced (ie. hoist rails, piping valves, etc.) and which will be rehabilitated by welding (ie. deck support structure) and coating
   - v) Inspection blast (abrasive preparation to remove rust on corroded areas)
   - vi) Reinspection to determine extent and types of welded or other repairs
   - vii) Welded and mechanical and other repairs (replacement or rehabilitation of structure, replacement valves, piping and other)
   - viii) Redesign and replace pump lifting system to improve corrosion resistance and service life
   - ix) Preparation for coating full abrasive cleaning (ie. SP10 near white metal blast)
   - x) Coating (ie. modified polyurethane such as Sancon or Carboline Reactamine 760)
   - xi) If steel (or other corrodible metal) is used, provide high voltage holiday detection of all interior surfaces to help assure the integrity of the interior coatings
   - xii) Return to service

3. A plan should be developed for replacement of the pumps, if necessary, prior to replacement of the lift system. It is likely that strengthening of the shell to rail connections by addition of welded “clips on each end, would be an acceptable short-term option. A new trolley would be required since the existing trolley is severely damaged by corrosion. Plan for difficulty rolling the new trolly along the length of the hoist rail beam due to roughness from corrosion. Otherwise, a method of lifting that does not use the hoist beams would be required.

4. Do not attempt to lift a pump with the existing beam trolly. If the rail end connections are rehabilitated for short term use or if new beams are installed, purchase a new beam trolley and store it outside of the lift station to help protect it from corrosion. The current corroded condition (roughening) of the top of the bottom flange of the hoist rails will impact how the trolley rolls along the rail. This will be most notable when the hoist is under load. Trolleys vary with wheel design. Some ride on the outermost edge of the beam flange while others have a bearing area that extends further toward the beam web. The wheel configuration of the trolley will

affect both the rolling resistance and the structural loading of the web. The replacement trolley should have rollers with wider (1” min.) bearing to improve load conditions and make it roll easier when under load.

5. Make corrosion resistant design a priority with any future work. Steel or other materials subject to corrosion should be avoided or used with care. Areas that are not accessible for inspection and maintenance should be eliminated during any future replacement or rehabilitation design process. This includes but is not limited to the top of the top flanges of the hoist beams and the crevice areas at the “outer” sides of the beam to shell connections.

6. Check the plastic piping that is hanging behind the ladder. Checks should include verification that the piping cannot swing into the required 7-inch clear area behind the ladder. Adequacy of the support system for the piping should also be verified. Redundancy in the attachment/hangers is likely appropriate for even light weight piping since failure could be hazardous for ladder users or personnel inside the lift station.

7. Develop and maintain a corrosion prevention plan including periodic inspection (ie. every 5 years followed by spot coating repairs).

Overall view of the lift station #3 access


This view shows the conduit in the access tube.

Typical corrosion at failed coatings in the access tube. Coating failures are present on most attachment point and joints in the shell of the access tube.

Conduit in the access tube.

This view shows an area of the access tube. Damaged coating is visible at the arrow. Corrosion is present. under the coating.

Access tube with corrosion at the joint between sections. Large blisters are visible at the arrow. The light wall PVC tube on the right appeared to be suspended only at the top.

This view shows the south end of the eastern hoist beam (rails). The chain that is visible is part of a pipe support.

An additional view of some of the south end of the eastern beam from below. The arrow indicates the "outer" side of the hoist beam to shell connections that were inaccessible without abrasive blasting or similar cleaning methods.

Calipers were used to measure flange thickness in the sample areas where corrosion was estimated to be the worst.

This view shows the top of a hoist rail lower flange. Corrosion damage on the hoist beam flanges was worst at the edges. This may be due , in part, by damage from the hoist trolly wheels riding on the coating.

This view is taken looking upward at a sample area of a hoist beam. The bottom side of the bottom flange is shown after removal of most of the rust. The flange is approximately 4" wide.

Another view of the bottom side of the hoist beam at a sampled location after removal of looses material.

Measuring material loss on a sample area of the east hoist beam. Sound paint and metal are present adjacent to this area of localized corrosion that was checked.

Material loss was measured as 3/64" in the worst area of localized corrosion on the hoist beam web.

Hoist trolley in place on the northern end of the west rail. The hoist trolley is severely corroded along with the beam. It is recommended that this trolley be taken out of service immediately.

Additional view of the top of the hoist trolly from above on the west side.

Hoist rail end connection. This view shows the typical condition of the beam rail to shell connection. The side shown is toward the center of the lift station.

This view shows the typical condition at the hoist rail to shell connections at the outer side of the rails (opposite side as shown in the top photo). The design detail has created a crevice at the connection (arrow). The critical area is inaccessible for inspection and maintenance.

This view shows a hoist beam with what appeared to be some of the worst corrosion. This area was selected to be a sample area for rust removal, measurement and evaluation.

An additional view of some of the worst corrosion on the bottom flange of the hoist rails.

Top flange of hoist beam with inaccessible area above the beam.

Inaccessible side of the eastern hoist rail at the shell connection. Severe corrosion is present. Measurement and evaluation of corrosion was not completed due to access restrictive geometry on the "outer" side of the attachments (shown).

This view shows the typical sample area after most loose corrosion product was removed.

Underside of the east hoist rail after spot coating application was complete.

This view shows the spot coating application on a portion of the east beam. The coating was applied over the sample areas where loose materials were removed and the area surrounding the sample areas where loose coating remained.

This is an additional view of coating spot application. In this photo the west rail is shown.


Grating lifted for viewing conditions below.


Deck structure, pipe supports and pipe as viewed with the grating pulled away.

View with grating lifted to check conditions. Serious corrosion and significant metal loss are present in localized areas such as the grating support structure (arrow).

Another view of the deck support structure and pipe support turnbuckles.

Decking pulled away to view the conditions at the perimeter flange that appears to provide some support of the grating.

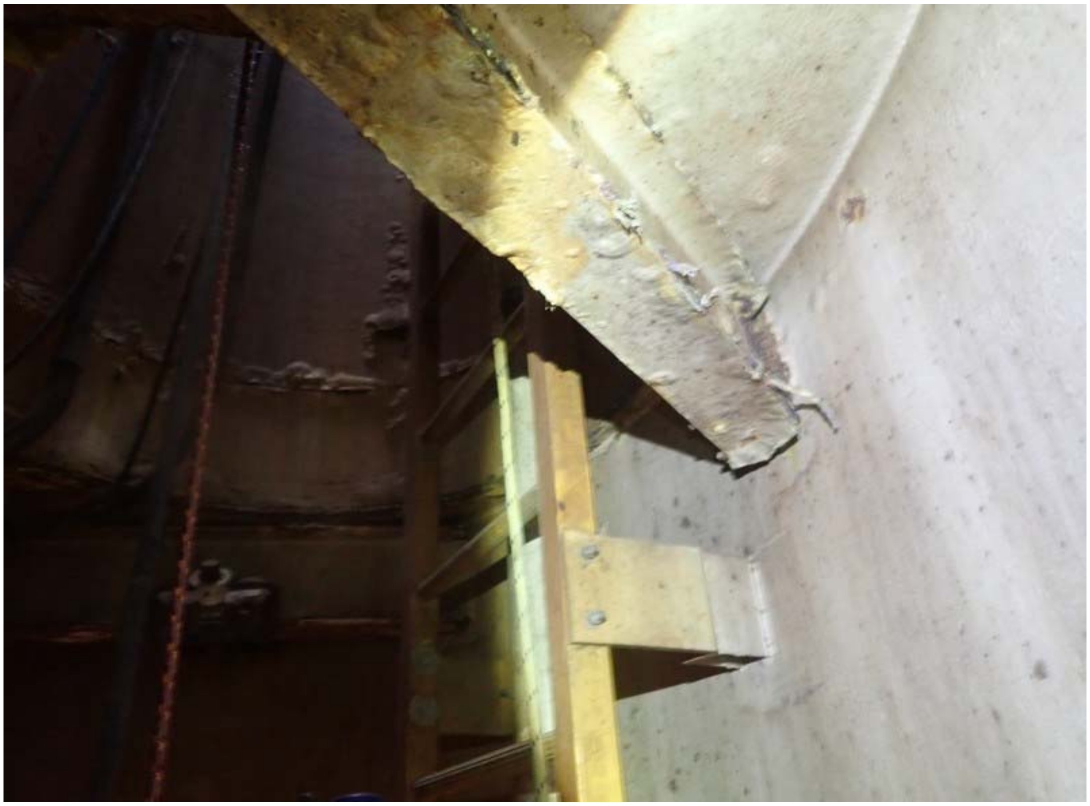
Perimeter "flange" (see top photo for location) after removal of oxides in a sample area (arrow). The corrosion appears the be similar to that found in other areas of the structure.

Valves, piping and structure under the grating.

Additional view of valves below the grating.

Pipe hanger on interior ceiling. Significant corrosion damage is present.

Pipes and hanger turnbuckles under the grating.



Fiberglass ladder and typical attachment.

Typical ladder attachment. Ladder supports appear to be in good condition.

Rev	Date	Description	Prepared by: **_John F. Bradley, S.E._** California Registered Structural Engineer Lic. #S4486 Atascadero, California		JOB NO.	3212030		
0	4/4/23	Orig			SHT	1	OF	5
1	4/14/23	Gen Rev			DATE	4/25/2023		
2	4/25/23	Sheets 1 & 2	FOR	San Luis Obispo Dept. of Public Works	DES. BY	JFB		
			DESCRIPTION	Check Corroded Hoist Rail Beams	REV	2		

STRUCTURAL CALCULATIONS FOR

San Luis Obispo Dept. of Public Works
Check Corroded Hoist Rail Beams

REVISION 2

Dated April 25, 2023

(Corrected Scope of Work)

LOCATED AT

Lift Station No. 3
Oak Shores, California

REGISTERED PROFESSIONAL ENGINEER
JOHN F BRADLEY
S4486
EXP 12/31/2023
STRUCTURAL
STATE OF CALIFORNIA
4/25/23

Calculations Prepared For:

ATS, Inc.
William Bellis, P.E.

For: ATS, Inc.
San Luis Obispo, CA
By: John F. Bradley, S.E.
April 25, 2023

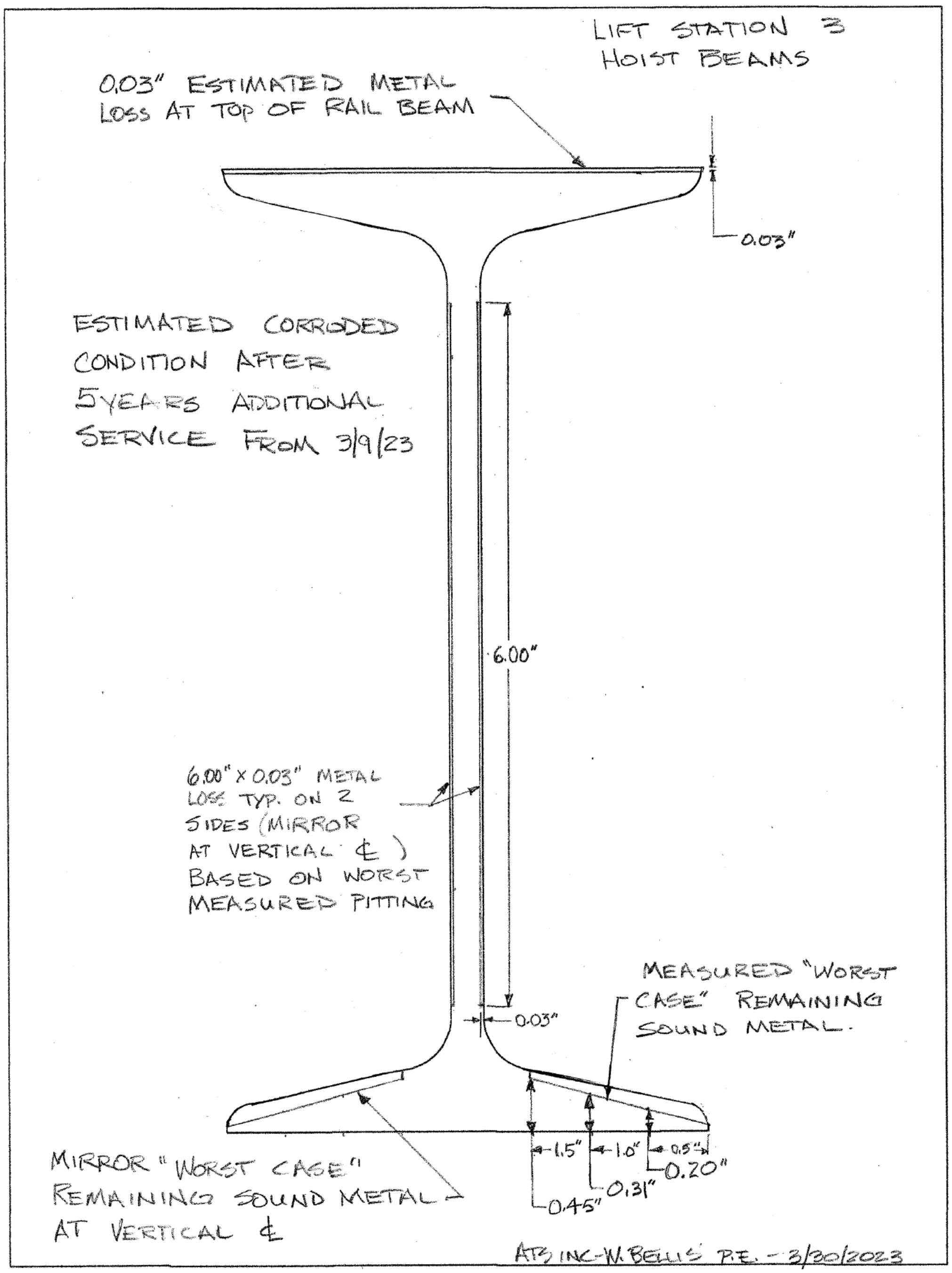
San Luis Obispo Dept. of Public Works
Location: City of Paso Robles, CA 93446
Check Corroded Hoist Rail Beams
Sheet 2

Design Summary

Design Code: 2022 CBC
OSHA for Lift Equipment

Description & Scope of Work 2

Two 8' long S8x18.4 (A36) hoist lift beams are mounted to the shell and are used to lift pumps located in the lift station. These beams have corroded over time, and current "worst case" remaining sound metal on beam cross section is shown below. Scope of these calculations is to check existing corroded beams for 2500 lbs design lift load (point load at center of beam) for pump & rigging per 2022 CBC & OSHA. OSHA requires lifting equipment to be designed for governing case of 1) Factor of safety of 3 applied to material yield strength, and 1) Factor of safety of 5 applied to material tensile strength. For A36 material, this results in a design allowable stress of (58,000 psi)/(5) = 11,600 psi. Since trolley wheels ride of bottom flange of beam, and this is where most of the corrosion has taken place, checks for bending of the bottom flange for 2500 lbs point load will also be included.



Per checks on sheets following, existing corroded S8x18.4 beams are still OK for design loads.

Check Bottom Flange Bending

Crane trolley wheels ride on the bottom flange, and bottom flange has the most corrosion. Following calcs check existing corroded bottom flange for 2500 lbs design point load (1250 lbs on each side of flange).

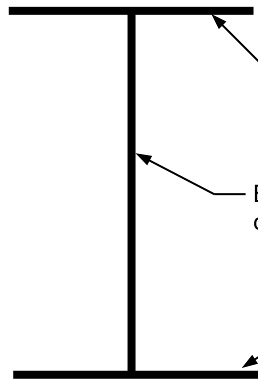
Consider 10" effective length of flange and 0.31" average thickness:

Max shear in steel: f_v = V/A = (1250 lbs)/[(10")(0.31")] =	2083	psi
Max bending in steel: f_b = M/S = (1250 lbs)(1.89")/[(10")(0.31")^2/6] =	14750	psi
Total Actual Stress =	16834	psi
Allowable stress = 0.6F_y =	21600	psi

<u>Since actual stress < allowable stress, (corroded) bottom flanges are OK for design loads</u>

Corroded Hoist Beam Section Properties

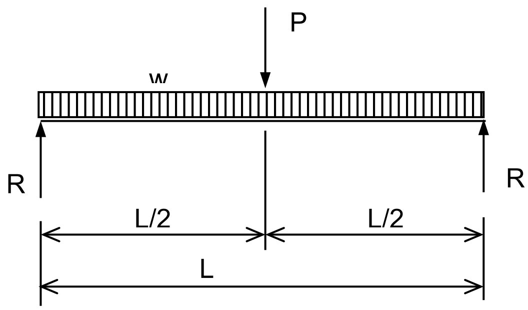
S8x18.4 Corroded Beam



	Previous Area	b	d	Theta	a	h	AREA	Y	AY	AY^2	Io
1	-	3.941	0.396	0	0.000	0.396	1.561	0.198	0.31	0.1	0.02
2	1	0.211	7.249	0	0.396	7.645	1.530	4.021	6.15	24.7	6.70
3	2	3.941	0.320	0	7.645	7.965	1.261	7.805	9.84	76.8	0.01
4	3	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
5	4	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
6	5	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
7	6	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
8	7	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
9	8	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
10	9	0	0	0	7.965	7.965	0.000	7.965	0.00	0.0	0.00
					TOTAL AREA =		4.351	in^2	16.30		108.3

TOTAL DEPTH =	7.965	in
CENTROID (Y) = SUM(AY)/SUM(AREA) =	3.746	in
C1 = Y =	3.746	in
C2 = DEPTH - Ybar =	4.219	in
I(total)= [SUM(AY^2)+SUM(Io)]-(AREA)(Y)^2 =	47.27	in^4
Sx1 = I/C1 =	12.617	in^3
Sx2 = I/C2 =	11.204	in^3 ← GOVERNS
Radius of gyration (r) = (I/A)^1/2=	3.296	in

Corroded Hoist Rail Beam Analysis



P_{DL} =	200 lbs
P_{LL} =	2300 lbs
DL =	0 psf
LL =	0 psf
Beam Wt/Extra Load =	14.8 plf
Tributary Loading Strip =	0 ft
w_{DL+LL} =	14.8 plf
w_{LL} =	0 plf
L =	8 ft
Max Unbraced Length (L') =	8 ft
R_{DL+LL} =	1309 lbs
R_{DL} =	159 lbs

Stress Criteria:

Allowable Stress (F_b) = min of :

1) $12000/[(L')(d/A_f)]$ = 19.8 ksi
2) $0.6F_y$ = 21.6 ksi
3) OSHA limit = 11.6 ksi

Case 1: Full DL + LL $M = (P_{DL+LL})(L)/4 + (w_{DL+LL})(L^2)/8$ = 61.4 in-k

For roof members check: Is this a roof member? (y/n) n

Case 2: DL + Pt. Load @ center $M = (w_{DL})(L^2)/8 + P'L/4$ = 0.0 in-k

Where P' = (P_{DL}+ 200 lbs) if tributary area < 200 ft^2 or (P_{DL}+2000 lbs) per UBC 1994 Section 1605.2.3

$M_{max} = (w_{DL+LL})(L^2)/8$ = 61.4 in-k

Min req'd Section Modulus (S_x) = M_{max}/F_b = 5.29 in^3

Deflection Criteria:

Max Allowable LL Deflection (Δ_{LL}) = L/360 = 0.27 in

Min Req'd I_x to not exceed $\Delta_{LL} = [(P_{LL})(L^3)]/[48E\Delta_{LL}] + [5(w_{LL})(L^4)]/[384E\Delta_{LL}]$ = 5.5 in^4

Max Allowable DL+LL Deflection (Δ_{DL+LL}) = L/240 = 0.40 in

Min Req'd I_x to not exceed $\Delta_{DL+LL} = [(P_{DL+LL})(L^3)]/[48E\Delta_{DL+LL}] + [5(w_{DL+LL})(L^4)]/[384E\Delta_{DL+LL}]$ = 4.1 in^4

Selected Beam:

Type Beam Desired = w   Material = A36

Suggested Shape = S4x7.4 F_y = 36 ksi

Beam Used = **S8x18.4 (corroded)** $f_b = M_{max}/S_x$ = 5.48 ksi

S_x = 11.20 in^3

I_x = 47.27 in^4 δ_{LL} = 0.03 in

d/A_f = 6.32 δ_{DL+LL} = 0.03 in