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DRY DOCK NO. 2 – FINITE ELEMENT ANALYSIS

Prepared for

BAE SYSTEMS
SAN FRANCISCO SHIP REPAIR

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Summary

BAE San Francisco Ship Repair Dry Dock No. 2 is an 800 ft. by 186 ft. by 69 ft. steel floating dry dock originally designed by Earl and Wright Consulting Engineers and built by Bethlehem Steel in 1969. The purpose of this strength analysis is to determine the safe dock lifting load based upon the current survey conditions. Doubler plating has been previously installed over much of the pontoon deck to help maintain lifting capacity. The last analysis of strength of the dock due to the corrosion effects was performed in 2012. Recertification of the dry dock is required periodically and the models created in 2012 have been refined and updated for steel thickness surveys performed in 2016.

We need to emphasize that the steel gauging is crucial to the performance of this task. This service provides a sample of the measured thickness of the steel, which then must be extrapolated to the dry dock. This analysis is based upon the reports from three surveys, which are presented by BAE as being competent measurements of the actual steel thicknesses.

The primary stress pattern shown by the 2012 analyses is that of transverse bending of the dry dock. This is due to the load of the ship being primarily carried through the keel blocks along the centerline of the dock, while the water pressure on the underside of the dock acts uniformly upward. This results in a significant transverse sagging moment in the dock. Longitudinal bending of the dock is smaller in comparison and is controlled by the dockmaster by monitoring and controlling the longitudinal deformation of the dock by varying the water levels of individual ballast tanks. Vertical deflections in the dock due to the longitudinal stresses are monitored throughout the lifting operation and kept to within a maximum of three (3) inches. However, there is no active way to mitigate the transverse bending of the dock throughout the lifting operation. Note that maximum transverse bending stresses occur in transverse web frames and bulkheads that are fabricated of ordinary steel whereas when combined with longitudinal bending stresses, the maximum stress occurs in shell plating that is higher strength steel. It is prudent to continue monitoring and controlling the vertical deflection of the dock from tank loading to within a maximum of three (3) inches, as this minimizes biaxial stresses that occur in the shell plating.

Analyses have been performed for the transverse bending of each of the 20 pair of ballast tanks based upon 65, 68, 72 and in one case 75 LT/ft. loading of the keel blocks. The results of these analyses were then used to assemble a Load Capacity Curve for the dry dock.

Results

The dock is constructed of ASTM A36 steel with swaths of Mayari-R steel in key areas. A36 steel is ordinary steel with yield strength of 36,000 psi. Mayari-R steel is a higher strength weathering steel with yield strength of 50,000 psi equivalent to ASTM A242. The original calculations assumed allowable stresses of 60% of yield, normal for when performing beam analyses. When performing FEA, it is realistic to assume a higher allowable stress depending on mesh size. This analysis is based on an allowable stress of 80% of yield.

Transverse bending load cases were performed for all twenty (20) pair of ballast tanks to determine dock capacity as a function of the length of the dry dock. The tank pair being examined and half of the tank pairs fore and aft are extracted from the global modal for these models. The maximum lifting capacity is determined for each of the segments of the dry dock and assembled into the Dock Lifting Capacity Curve. Maximum von Mises stress is 38,930 psi in the Mayari-R steel in the bottom plating, which is less than the allowable stress of 40,000 psi. There were two locations where the steel gauging yield thicknesses that experience this level of stress. Otherwise the maximum von Mises stress is 35,130 psi in the Mayari-R steel in the bottom plating. The maximum stress in the ASTM A36 steel is 31,190 psi in the lower portion of the transverse web frames, just outboard of the 9’-0” OCL WT longitudinal bulkhead and occurring in hot spots. A36 steel has an allowable stress of 28,800 psi and a yield stress of 36,000 psi. Hot spots are allowed to see stresses between allowable and yield strength because the stresses quickly dissipate moving away from the element located in the hot spot. Based on the local analyses of the dock in way of each pair of ballast tanks, the maximum ship load that can be lifted along the entire 800 ft. length of the dock is determined to be 56,160 LT.

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13. Bethlehem Steel Drawing: 2203-76883 Rev. G, “68,000 Ton Floating Drydock – Outboard Wingwall Plating”.
14. Bethlehem Steel Drawing: 2203-76884 Rev. J, “68,000 Ton Floating Drydock – Inboard Wingwall Plating”.
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16. Bethlehem Steel Drawing: 2203-76886 Rev. J, “68,000 Ton Floating Drydock – Typical Trans. W.T. BHD”.
17. Bethlehem Steel Drawing: 2203-76887 Rev. F, “68,000 Ton Floating Drydock – Transv. End Bhds Frames 0 & 80”.
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Method

Structural System of Drydock

A description of the structural system of the dock is taken from Earl and Wright's structural design report of the dock (Ref. 8) when it was originally built:

"Two 6 ft. deep plate girders support the keel blocks for the entire deck length. Transverse pontoon bulkheads spaced at 10 ft. centers carry the loads from these girders and the side block loads to the longitudinal bulkheads 9 ft. and 42 ft. off the centerline and to the wing wall sides 75 ft. and 93 ft. off the centerline. The longitudinal bulkheads 9 ft. off the centerline are watertight, thereby forming an 18 ft. x 20 ft. x 800 ft. buoyancy chamber. This is divided into four compartments, each 200 ft. long. The transverse pontoon bulkheads are watertight each 40 ft. The wing wall plating is supported by trusses spaced at 10 ft. centers and by watertight bulkheads which match the pontoon watertight bulkhead spacing of 40 ft.

At the top of each wing wall, four buoyancy chambers 18 ft. x 7.5 ft. x 200 ft. are formed between the safety deck and the wing wall deck. The upper part of each wing wall is stiffened to support a 60 ton gantry crane."

Finite Element Models

Twenty local models were derived from a global model that was specifically developed to analyze the strength of the dry dock using transverse bending load cases. Each local model consists of a full-beam portion of the dock that is truncated to 80 ft. of the dock length (60 ft. at the dock ends).

The global model developed in 2016 consists of the entirety of the dry dock and has the similar fineness to as was used for the single local model in 2012. This global model is used as a source for the local models. The local model is used to focus on the transverse bending of the dock, local plate stresses, hot spots, and buckling. Because transverse bending of the dry dock was found to be more critical than longitudinal bending, the 2016 keyed upon local models in evaluating the strength of the dry dock. And because gauging data was now available over the length of the dry dock, each local model is tailored for the as surveyed conditions.

Software

The dry dock was modeled in FEMAP Version 11.1.0, 64 bit, copyright © 2014 Siemens Product Lifecycle Management Software, Inc. The solver is NEi Nastran Version 10.2, published by NEi Software of Westminster, CA.

Material

Table 1 lists the two steels used in the construction of BAE SF Dry Dock No. 2 and examined in this analysis.

Table 1 – Steels in Model of BAE SF Dry Dock No. 2

Specification	Ultimate Stress psi	Yield Stress psi	Allowable Stress psi	Portions of Dry Dock
Mayari-R, ASTM A242	67,000	50,000	40,000	• Transverse WT Bhd and Transverse NT Web Frames – Rectangular Portion Bounded between 9’-0” to 42’-0” OCL, and Pontoon Deck down to 6’-8” below Pontoon Deck • Entirety of Original Pontoon Deck Plating • Bottom Plating Inboard of 51’-0”
ASTM A36	58,000	36,000	28,800	All non-Mayari-R steel, including the Pontoon Deck doubler plate

All steel is modeled with a Modulus of Elasticity (E) of 29,000,000 psi, a Poisson’s Ratio (ν) of 0.32, and a density (ρ) of 7.33 x 10^{-4} lbf-s^2/in^4. Appendix A lists all of the element properties in the model.

Allowable Stress

In the original design of the dry dock, the allowable stress was specified to be 60% of the yield stress of the material. This 60% allowable stress was based upon stresses determined from manual calculations of simplified beam sections. However, in using FEA, we are considering the entire three-dimensional grillage structure of the dock simultaneously, and the results incorporate bending and stresses not only in the primary members, but also in secondary members as well. FEA is determining stresses much more thoroughly and accurately than the manual calculations of 40+ years ago. Therefore, we can safely increase the allowable stress from 60% to 80% of the yield strength of the material. ABS recently published Ref. 26, Technical Guidance for the Review of Finite Element Analyses, which addresses allowable stress for an FEA. Fatigue damage is not a concern with the dry dock as the number of high stress cycles is low (one cycle per ship docking) compared to the number of stress cycles of a seagoing ship in waves.

In cases where elements are much smaller in size than the surrounding mesh in order to accommodate local details, these elements may yield hot spots that do not accurately reflect the stresses in the area. In these cases, reported stresses will be those of the elements surrounding the hot spots. Also, the constraints required to stabilize the local models are imposed on the end frames of each model. The stresses in end frames and in way of constraints are not considered.

The stresses of concern in this analysis are von Mises stresses, which arise from distortion energy theory. The use of von Mises stresses is quite accurate in predicting failure of steel parts. Von Mises stresses shown throughout the report indicate the maximum surface stresses on both sides of the plate members. The von Mises stress is defined as:

$$\sigma' = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2}$$

Where σ_1 and σ_2 are the principal stresses.

Lightship Weight Calculation

The lightship weight was estimated to be 19,268 LT based on the Elliott Bay Design Group Weight Report 08003-001-843-4B (Ref. 2) and discussion with A. Romanczuk on Aug. 23, 2012. Weights added to the lightship weight from the EDBG report include:

- Removal of temporary crane
- Addition of new East crane
- Two new transformers on Safety Deck
- Six sponsons (the EBDG lightship weight estimate specifically excluded the sponsons)
- Additional doubler plate on Pontoon Deck
- Accumulation of residual mud throughout the tanks

The lightship weight calculation is detailed in Appendix B. The only mass in the model is defined by the volume of the elements and their corresponding density. Because other dry dock masses besides the steel were not modeled, such as the cranes, dock blocks, residual mud in the ballast tanks, etc., the acceleration due to gravity in the model is modified so that the corresponding gravitational force on the dry dock steel in the model equals the lightship weight of the dry dock.

Global Finite Element Model

The global model consists of the entirety of the dry dock and is used as a source for the local models used to analyze the global longitudinal and transverse stresses in the dock.

Model Overview

The global FE model represents the full-length, full-beam dry dock, but does not include sponsons, fin recesses, and the truck ramp aprons on both ends. The global model consists of 719,605 nodes and 791,450 elements. All elements are modeled as plate elements, with the exception of the wingwall truss structure in the non-tight transverse frames modeled as beam elements, and the dock blocks modeled as rigid elements constrained in the vertical direction. The average mesh size of the plate elements is basically a function of frame spacing and varies with location within the dock; coarser in the wing walls and finer in the bottom tanks where stress is higher. See Figure 1 through 3 showing the full model after discussing properties. Note the locations of the dock blocks.

A right-handed rectangular coordinate system is used throughout the modeling process. The origin is located at Frame 0 (South end), on Centerline, at the Baseline of the dock. The X-axis is oriented longitudinally with positive north from Frame 0, the Y-axis is oriented transversely with positive west from CL, and the Z-axis is oriented vertically with positive upward from baseline.

Corrosion Properties

The corrosion of the dry dock is modeled by categorizing the corrosion into various levels and then applying a uniform percentage thickness reduction to all elements within that corrosion level. Different colors of corrosion levels are shown in the model to facilitate identification. A 10% reduced thickness is applied in addition to the maximum allowed corrosion within each corrosion level to allow for some amount of future additional corrosion. This additional corrosion allowance is applied to all corrosion levels except for "unsatisfactory" and "extreme", as these corrosion levels already reduce the thickness from the original by at least 50%. Based on UT surveys of the dry dock in 2016, the corrosion of the dry dock was modeled with varying properties as follows:

- Original/Renewed – Dark Green – Scantlings known to be in very good condition, such as the structure entirely inside the buoyancy compartment, are modeled with 15% reduced thickness.
- Satisfactory – Green – Scantlings with less than 15% corrosion are modeled with 25% reduced thickness.
- Marginal – Yellow – Scantlings with between 15% and 25% corrosion are modeled with 35% reduced thickness.
- Unsatisfactory – Red – Scantlings with between 35% and 50% corrosion are modeled with 50% reduced thickness.
- Extreme – Purple – Scantlings with greater than 50% corrosion are modeled with 75% reduced thickness.

This conservative method of accounting for the corrosion of the dock and allowing for future corrosion supports the use of the allowable stress of 80% of yield as previously mentioned. Figures 1 through 3 show the corrosion properties as modeled, with colors to indicate the corrosion level. For the corrosion applied to the model on the Bottom Plating, Pontoon Deck, and Transverse Bulkheads within the tanks, uniform thickness reductions were applied to all elements within the swath of plating that included the reading. In the Outboard Wingwalls, wherein the stress levels are not critical, uniform thickness reductions were applied to swaths of plating indicating the general corrosion in that area, rather than updating the corrosion properties of each element in the model individually. For example, in an area of plating that is primarily shown as "Marginal," a 35% thickness reduction is applied to that entire region of plating uniformly, although there may be some locations of "Satisfactory" and "Unsatisfactory" thickness measurements in that region. Appendix C shows plots of the corrosion from the UT inspections, as well as plots of the corrosion properties applied to the global model. The local models retain these properties as they are all created from the global modal.

The internal frames and stiffeners were modeled with corroded properties based on the 2016 surveys. These surveys provided steel gauging thicknesses for all watertight transverse bulkhead and the center of the three non-tight transverse bulkheads in each tank. Most of the internal structure is less than 15% corroded. However, there are areas where marginal or even unsatisfactory thicknesses are interpreted. Therefore the non-tight transverse bulkheads in each tank within the first 33 feet outboard of the buoyancy chamber are modeled with marginal (35% reduction) properties.

Outboard of the longitudinal belts, transverse belts were taken by International Inspection starting at FR 2½ and spaced every 4 frames afterwards. There were a total of four readings that exceeded 25% wastage, maximum 36% wastage, and a scattering of readings between 15% and 25% wastage. By far most readings were less than 15% wastage. We need not concern ourselves with detail as transverse bending is not a factor in this part of the bottom. Thus we are very comfortable and continue to be conservative in assuming 35% reduction for all elements outboard of the longitudinal belts reported by DRS Marine.

The only existing structure in the dock modeled as “new/renewed”, with only 15% reduced thickness, is the structure inside the buoyancy chamber. This does not include the boundary surfaces of the buoyancy chamber (Pontoon Deck, Bottom Plating, and WT Longitudinal Bulkheads 9’-0” OCL), which were modeled with corrosion per the UT inspection reports. Thickness measurements were not taken of the doubler plating on the Pontoon Deck. The Pontoon Deck in way of the doubler plating was modeled as a single 0.500 in. plate with 25% reduced thickness (therefore an effective thickness of 0.375 in.).

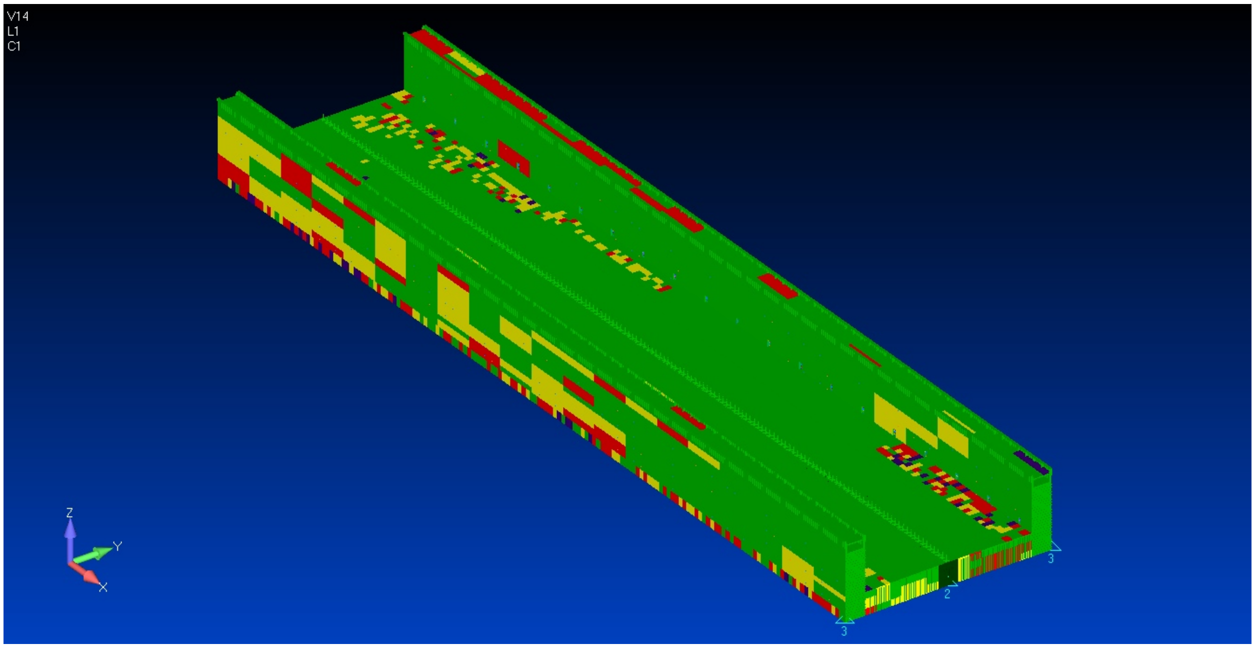

Figure 1 – Global FE Model of BAE Dry Dock No. 2

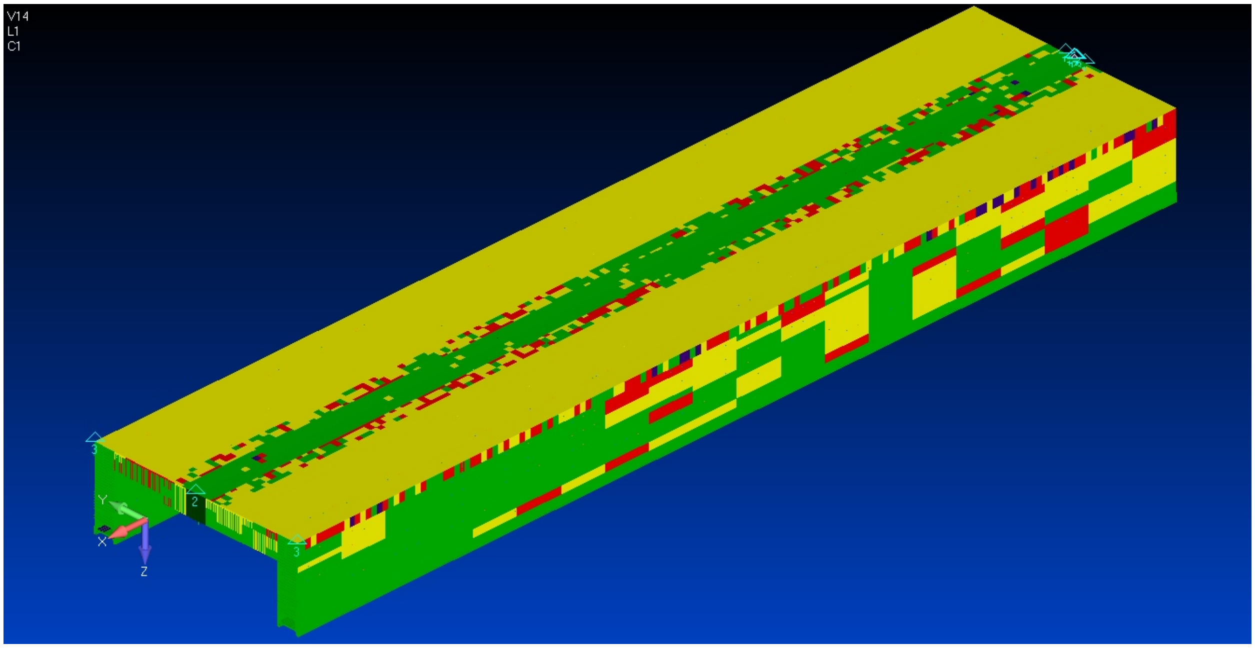

Figure 2 – Global FE Model of BAE Dry Dock No. 2 – Bottom

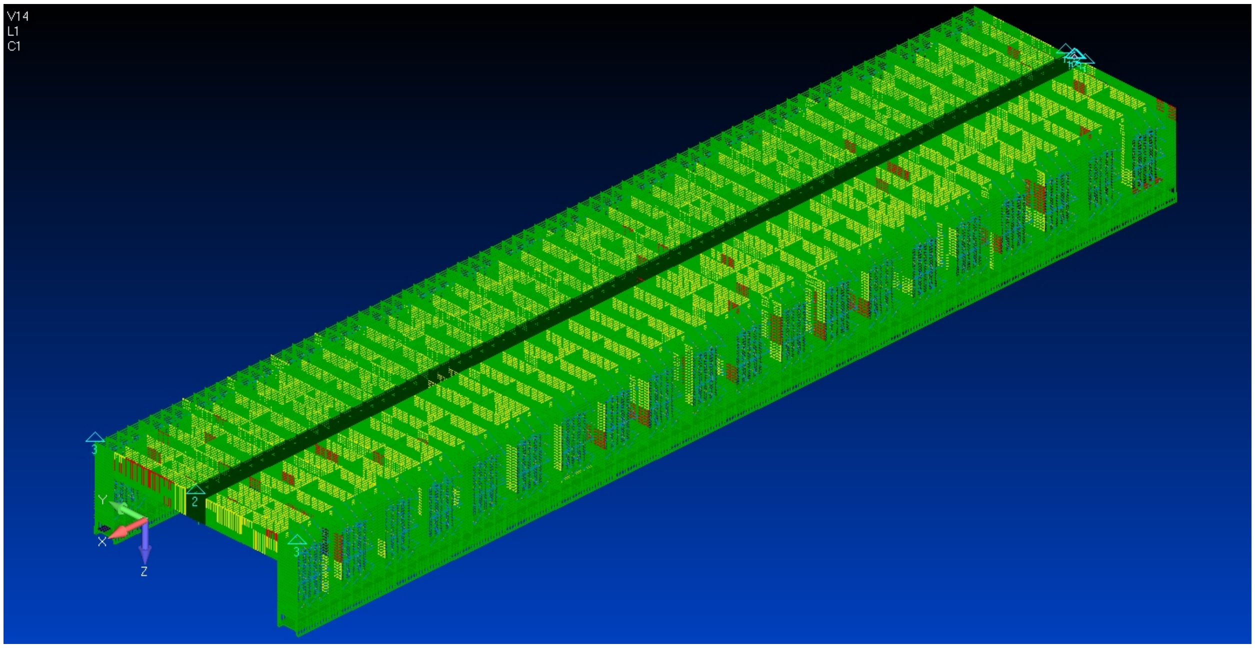

Figure 3 – Global FE Model of BAE Dry Dock No. 2 – No Shell

2012 Global Analysis

The global analysis performed in 2012 (Ref. 1) demonstrated the capability of the dock to lift a ship out of the water using four (4) different load cases. It then goes on discuss transverse bending as follows:

The primary stress pattern shown by the analysis of the global model is that of transverse bending of the dry dock. This is due to the load of the ship being primarily carried through the keel blocks along the centerline of the dock, while the water pressure on the underside of the dock acts uniformly upward (see Figure 4 – Concentrated Ship Load Inducing Transverse Sagging Moment). This results in a significant transverse sagging moment in the dock. Longitudinal bending of the dock is small in comparison and can be controlled throughout the docking operation by monitoring the vertical deformation of the dock and varying the water levels of individual ballast tanks to minimize longitudinal bending moments. However, there is no active way to mitigate the transverse bending of the dock throughout the lifting operation, other than what naturally exists through the transfer of loading into the side blocks, where present.

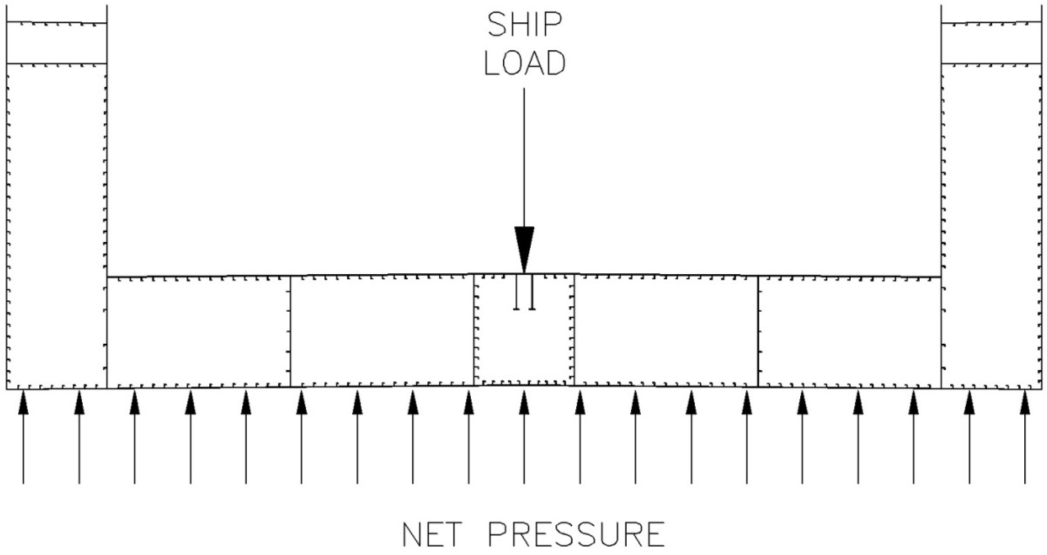

Figure 4 – Concentrated Ship Load Inducing Transverse Sagging Moment

The primary members of concern are the bottom portions of the transverse frames and the bottom plating, as these elements are under the maximum tension due to the transverse sagging of the dock. Stresses are highest near centerline and decrease going outboard. The stresses in the stiffeners were shown to be relatively small in comparison to the transverse frames and the deck plating.

We see no need to revisit the global analysis and the four (4) loading conditions representing a docking as this was presented in 2012. The global model has been updated to incorporate the 2016 surveys and has a mesh specifically intended to support the creation of the local models. Its mesh has been refined in critical areas and it is now three times the size of the 2012 model in nodes and elements.

Local Finite Element Models

The 2012 Finite Element Analysis of the dry dock (Ref. 1) established that it was the transverse bending local to each tank pair that determined dock capacity. There was survey data for only transverse frame, thus only one local model that include the corroded steel condition could truly be developed at that time. With the 2016 surveys providing gauging thickness for at least half of the transverse bulkheads, we can now examine the dock capacity for each tank pair. This is likened to taking the dock apart and putting it back together again.

Local models are used to focus on the transverse bending of the dock, local plate stresses, hot spots, and buckling. Each local model has a medium-size mesh that is finer than the mesh size used for the 2012 global model, but the local model's mesh is still relatively coarse. Areas of concern from previous analyses, such as the lower portions of the web frames, are investigated further. The availability of steel gauging reports allow the local models to be meaningful. Due to the smaller mesh size, the results from the local model are more accurate than those from the previous global model.

Model Overview

Each local FE model represents the tank pair being examined and half of the tank pairs fore and aft are extracted from the global modal for these models. This creates an 80 ft. long section of the dry dock for each local model except at the ends, which are 60 ft. long. The maximum lifting capacity is determined for each of the segments of the dry dock and assembled into the Dock Lifting Capacity Curve. The following assumptions are reflected in the models::

1. The linear loading from the ship in dock is transmitted by the keel blocks, which are represented by rigid elements with geometry equivalent to a keel block.
2. No side blocks are modeled. These will exist in mid-dock locations and will reduce the transverse bending moments locally. It is conservative to ignore these blocks.
3. Lightship weight of the dry dock is represented by acceleration applied vertically downward to the entire mass of the model. The acceleration is increased beyond the acceleration of gravity so as to include mud and other physical matter not modeled.
4. The dry dock is calculated to have a draft in equilibrium with the loading of the blocks. Hydrostatic pressure as a function of draft is applied to all elements representing the shell.
5. Minimal constraints are applied to the end bulkheads to balance the models for the resultant sum of forces.
6. No sponsons, fin recesses, or other unusual appendages are modeled because no high stress areas of concern were found in the 2012 global model in way of appendages.

The local model is intended to analyze a section that is one tank spacing long with a one-half tank length on both ends to provide accurate stiffness at the tank ends and to reduce the effects of boundary constraints in the transverse WT tank bulkheads.

Each local model consists of up to 83,000 elements and 76,000 nodes. All elements are modeled as plate elements, with the exception of the wingwall truss structure in the non-tight transverse frames modeled as beam elements, and the dock blocks modeled as rigid elements constrained in the vertical direction. The average mesh size of the plate elements is 2.5 ft. in the longitudinal direction to have four elements per frame spacing and approximately 2.5 ft. in the transverse direction (varying to match the local stiffener spacing, or one element per longitudinal frame). See Figures 5 through 8 showing the local model. The same origin and coordinate system from the global model are used for the local model.

Corrosion Properties

The same corrosion level categories from the global model are used for the local model. The thickness reductions applied to the local model are in 5 ft. by 5 ft. grids to use the full accuracy of the thickness measurements taken on the dry dock. Figures 5 through 8 show the corrosion properties as modeled, with dark green representing “new/renewed”, with green representing “satisfactory”, yellow representing “marginal”, red representing “unsatisfactory”, and purple representing “extreme”, as before with the global model. Figure 6 clearly shows the 50 ft. swath of diver readings about the centerline of the dock. All bottom plating elements outboard of the longitudinal belts are modeled with a 35% reduction based the transverse belts were taken by International Inspection. Figures 6 and 7 show the swaths of elements that have been modeled with “marginal” and even “unsatisfactory” properties based upon the 2016 surveys.

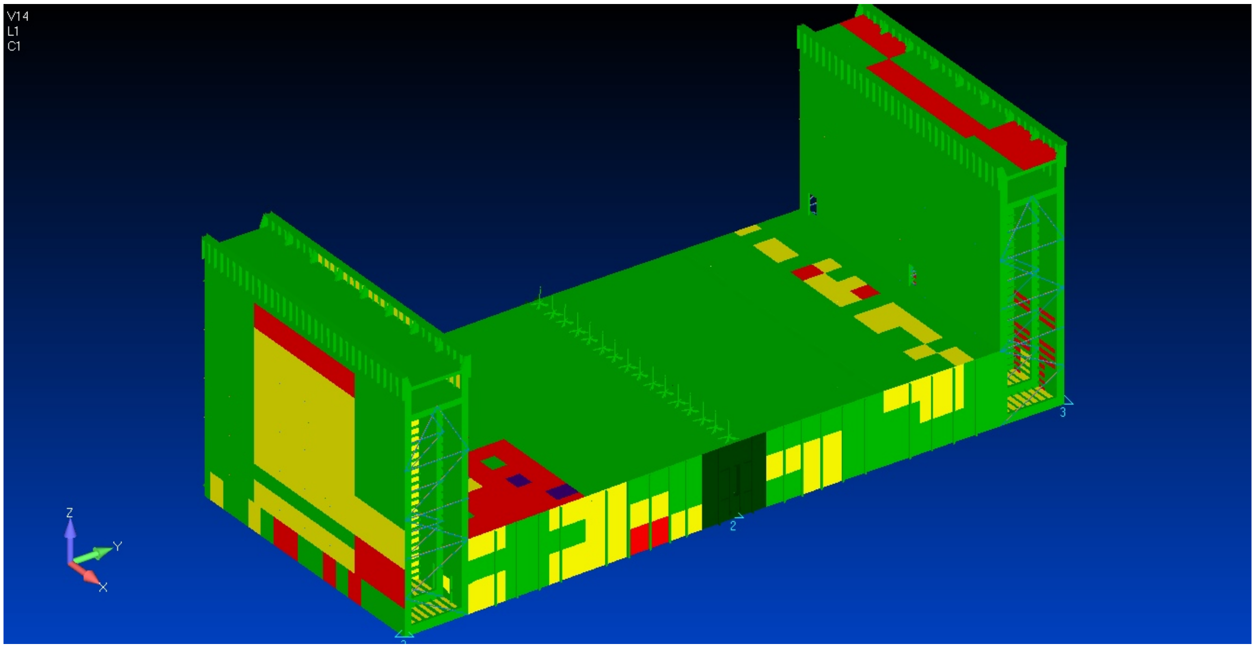

Figure 5 – Typical Local FE Model of BAE Dry Dock No. 2

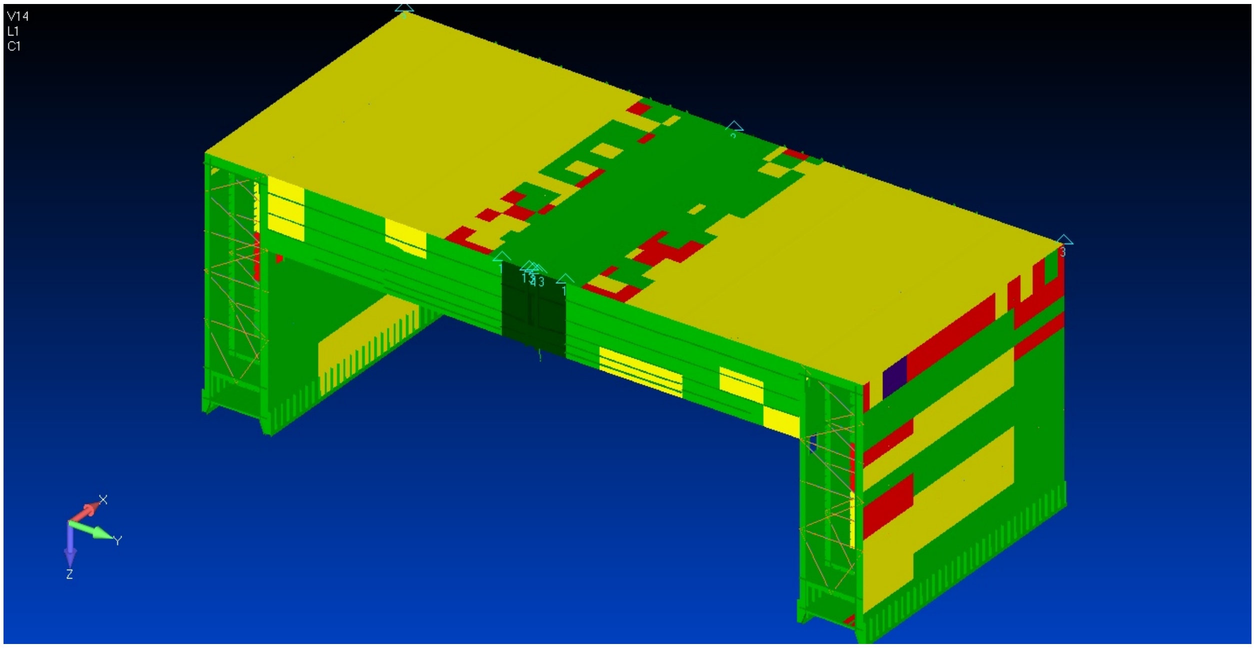

Figure 6 – Typical Local FE Model of BAE Dry Dock No. 2 – Bottom

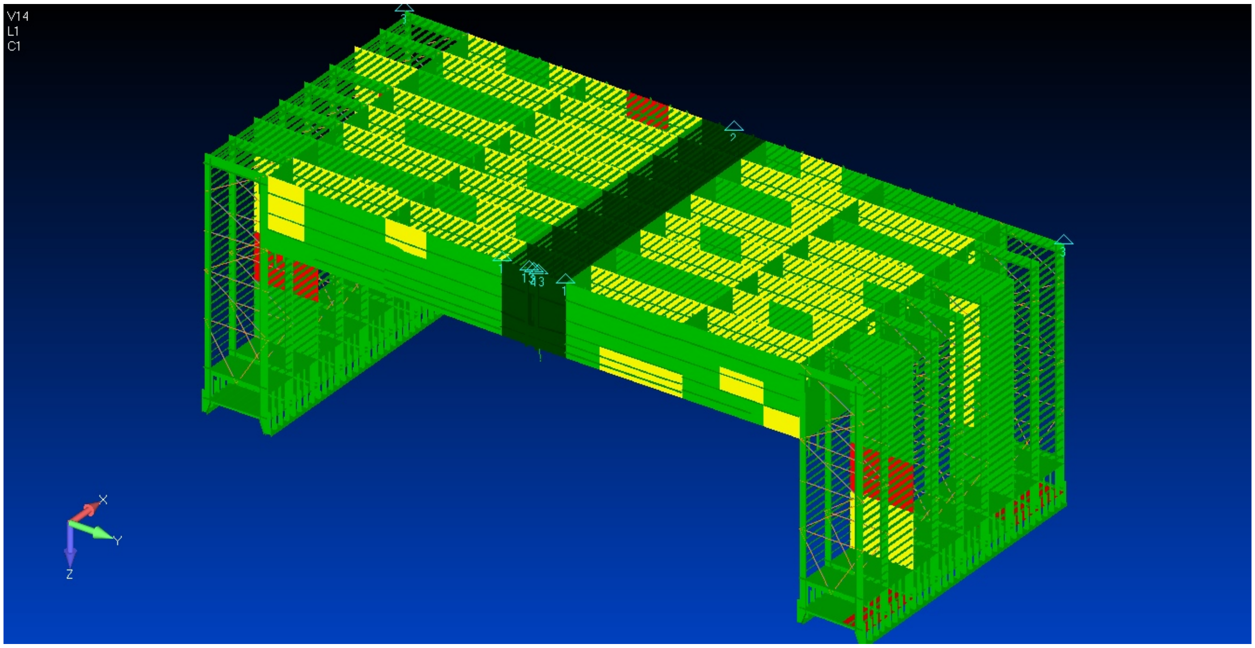

Figure 7 – Typical Local FE Model of BAE Dry Dock No. 2 – No Shell

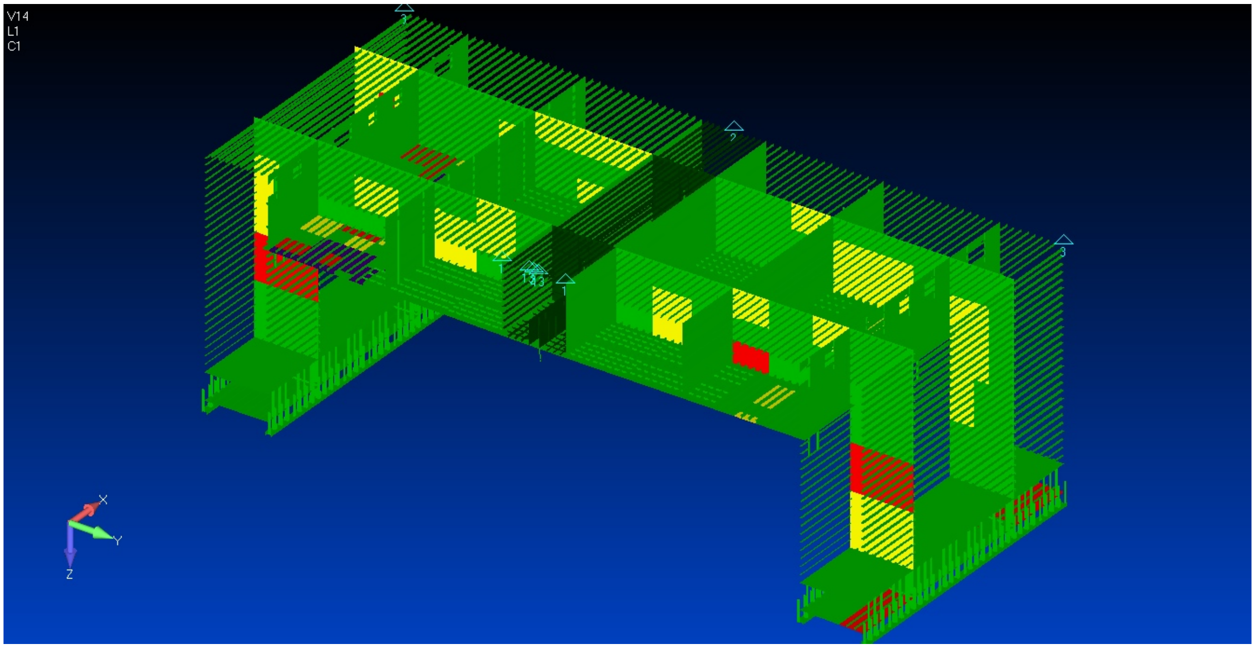

Figure 8 – Typical Local FE Model of BAE Dry Dock No. 2 – WT Bulkheads

2012 Local Model Analysis

The analysis performed in 2012, Ref. 1, was limited to one local analysis because only one transverse frame had been surveyed. Four (4) different load cases from the global model were analyzed with the local model. Ship loads on the blocks were applied as a constant weight distribution of 73 LT/ft. along the length of the 80 ft. long dock section. Table 2 – Local Model Load Cases lists the load cases tested in the 2012 analysis of its global model.

Table 2 – Local Model Load Cases

Load Case	Dock Draft ft.	Dock Ballast ft.	Dock Lightship per 80 ft. LT	Ship Weight on Dock LT/ft.
1	55.00	41.58	1,927	0
2	46.75	20.00	1,927	15.33
3	25.75	3.48	1,927	73
4	18.65	0	1,927	73

This analysis is not repeated herein; refer to Ref. 1 for these results. Load Case 3 for when the water level is at the top of the blocks and yielded the greatest stresses. Load Case 4 for when the dock is fully pumped out yielded similar stresses. The concern about the material condition of the bottom plating is mitigated by the diver surveys performed in 2016. We now know that there is more steel in the bottom plating and that issues in the bottom plating have been resolved. Note also that Ref. 1 examined buckling of the local model and buckling was not found to be an issue. Buckling was briefly examined for one local model with the first six modes and not found to be an issue.

Dock Capacity Load Cases

This analysis examined local models for all twenty (20) pair of ballast tanks to determine dock capacity as a function of the length of the dry dock. The following load cases are applied as loads, pressure, or acceleration as was discussed in Model Overview on page 16.

Table 3 – Dock Capacity Load Cases

Load Case	Dock Draft ft.	Dock Ballast ft.	Dock Lightship per 80 ft. LT	Ship Weight on Dock LT/ft.
1	17.15	0	1,927	65
2	17.72	0	1,927	68
3	18.47	0	1,927	72
4	19.03	0	1,927	75

Stress contour plots are presented below for one of the sixty plus analyses performed in support of this task. The model selected at random is for Tank Nos. 15 – 16 and the Load case is for a ship weight on dock of 72 LT/ft.

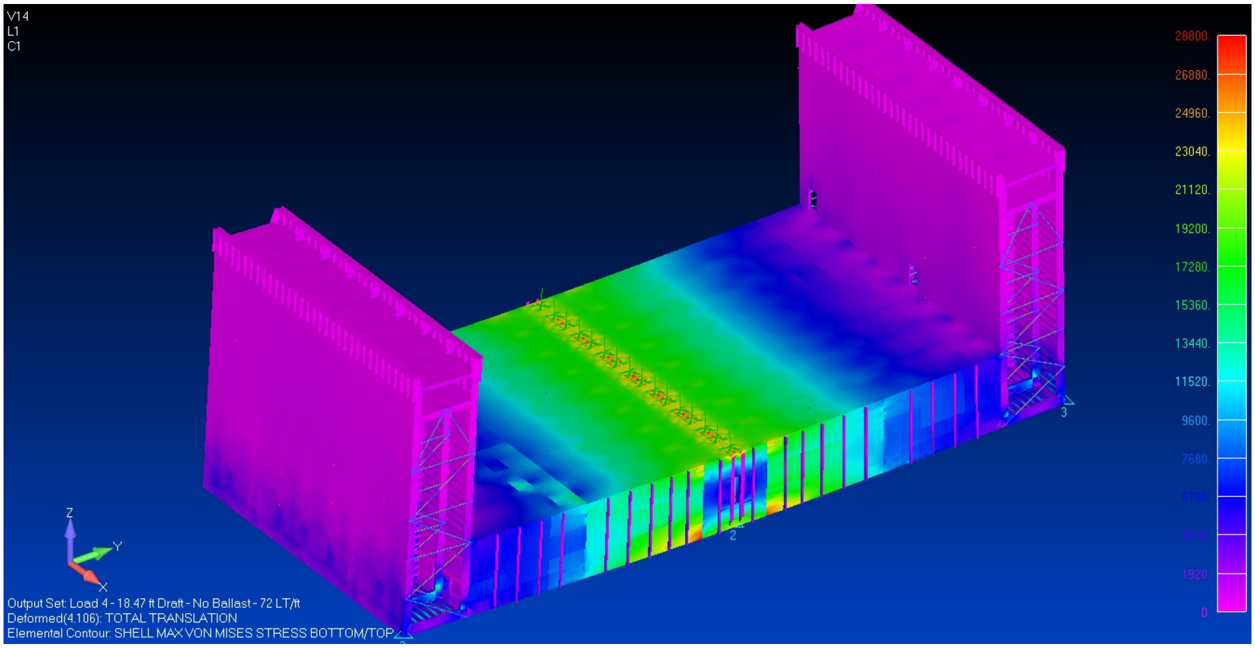

Figure 9 – Typical Local FE Model – Stress Contours

Stress contour plots immediately show why transverse bending is important. The maximum stresses occur just outboard of the buoyancy chamber. The plot is also allowed to show exaggerated deflection. In this case the maximum deflection is 4.1 in. of a node in the wingwall.

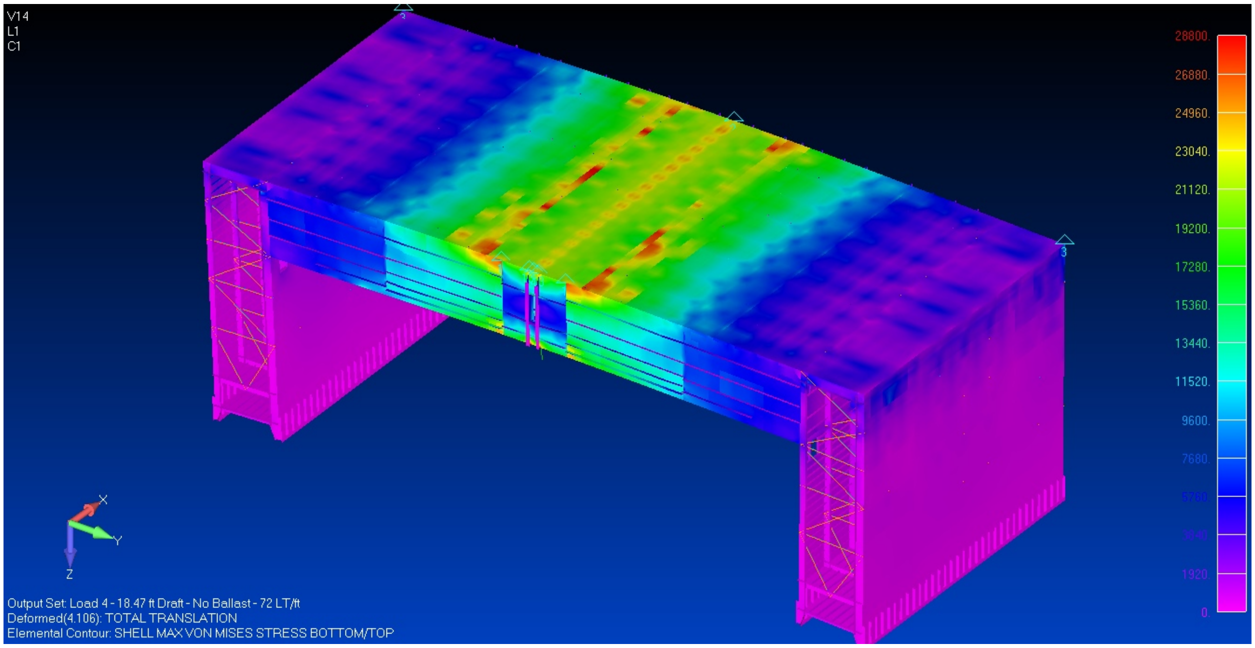

Figure 10 – Typical Local FE Model – Bottom Stress Contours

The contours in red are where we find the higher stresses in bottom plating and reflect the as-modeled thicknesses of the elements. The entire bottom plating area that is highlighted is Mayari steel with an allowable stress of 40,000 psi. The above red spots do not show when the criteria for the plot is reset as these stresses are well below the allowable.

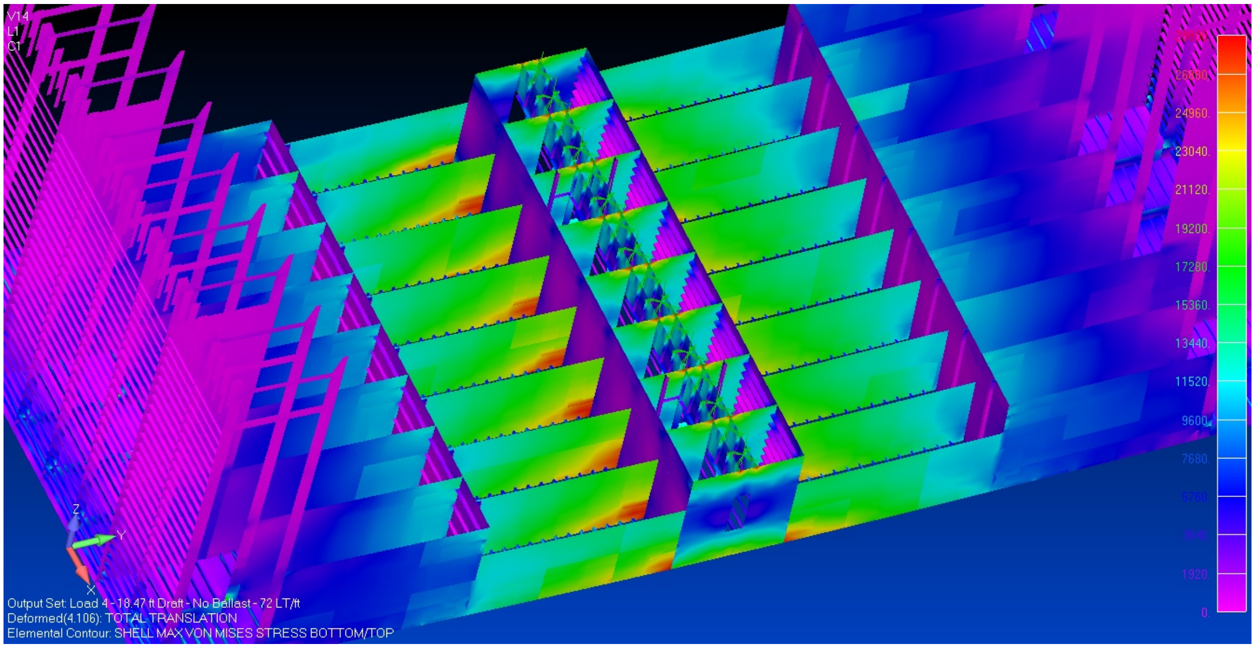

Figure 11 – Typical Local FE Model – Transverse Bulkhead Stress Contours

Layers are turned off as is all Mayari steel elements to expose the contours in the plating for the transverse bulkheads. The elements shown here are all for A36 steel with an allowable stress of 28,800 psi. The highest stresses occur just outboard of the buoyancy chamber and may exceed the allowable in local areas. Hot spots are allowed to see stresses between allowable and yield strength because the stresses quickly dissipate moving away from the element located in the hot spot. Also, the modeling for steel reduction is extremely conservative and we are not aware of any failure modes occurring with this steel such as cracking. The panels with high wastage will show the highest stresses. These panels can be renewed if concerned.

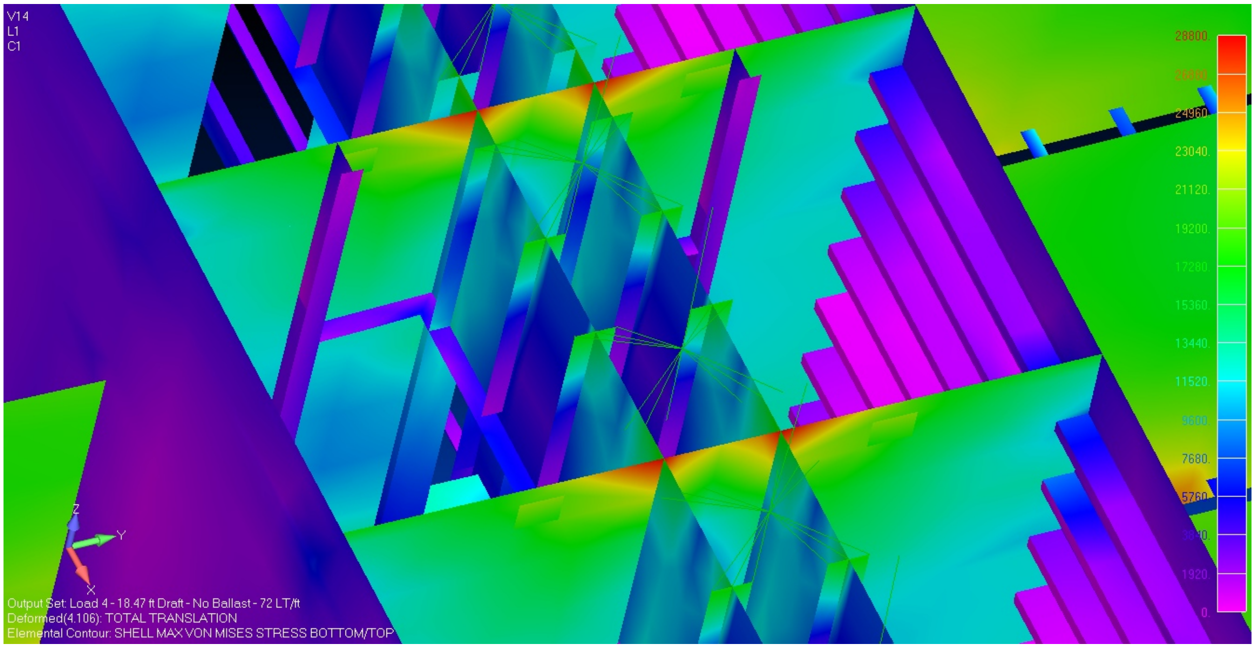

Figure 12 – Typical Local FE Model – Hot Spots

Hot spots are found at the intersection of the transverse bulkheads and the longitudinal girders below the keel blocks. These are triangular elements that do not give the best results and these stresses are ignored. Again, if there were actual issues with the structure, failures would have long ago been found in these locations.

Dry Dock Lifting Capacity

The maximum Von Mises Stresses are summarized in the following table. Only one case with 75 LT/ft loading was run for the entire analysis.

Table 4 – Maximum Von Mises Stresses

Tank Nos.	65 LT/ft		68 LT/ft		72 LT/ft		75 LT/ft	
	A36 psi	Mayari psi	A36 psi	Mayari psi	A36 psi	Mayari psi	A36 psi	Mayari psi
1 – 2	25,683	33,066	26,884	34,659	28,492	36,794		
3 – 4	29,574	37,165	30,975	38,931	32,844	41,305		
5 – 6	28,574	37,121	29,977	38,911	31,844	41,302		
7 – 8	27,820	28,387	29,131	29,723	30,886	31,518		
9 – 10	28,047	27,682	29,394	28,972	31,182	30,704		
11 – 12	29,565	29,291	30,938	30,635	32,769	32,436		
13 – 14	26,015	29,604	27,222	31,008	28,841	32,871		
15 – 16	25,558	26,157	26,778	27,394	28,391	29,046	29,597	30,286
17 – 18	28,867	28,958	30,208	30,333	32,002	32,155		
19 – 20	29,341	29,153	30,704	30,501	32,522	32,309		
21 – 22	26,319	29,036	27,547	30,380	29,190	32,185		
23 – 24	26,155	27,860	27,376	29,143	29,004	30,864		
25 – 26	26,455	29,584	27,688	30,947	29,337	32,775		
27 – 28	26,640	30,043	27,387	31,427	29,036	33,284		
29 – 30	26,123	29,982	27,367	31,369	29,033	33,228		
31 – 32	26,294	29,489	27,522	30,847	29,162	32,667		
33 – 34	27,735	31,682	29,045	33,154	30,807	35,127		
35 – 36	29,432	29,141	30,803	30,520	32,630	32,349		
37 – 38	29,803	30,220	31,186	31,617	33,036	33,490		
39 – 40	29,370	29,558	30,745	30,922	32,573	32,747		

The maximum Allowable Loading for each pair of tanks is selected from the above results and averaged with the lifting capacity of the set of tanks immediately forward and aft of it. We do not want a big step in capacity between two pair tanks, thus it results in the capacity being either 68 LT/ft. of 72 LT/ft. This serves to smooth out the discontinuities in the lifting capacity curve due to significant variations in corrosion between two tanks, as well as to account for the structural interaction between adjacent tanks that is not adequately represented by the local model that is only 80 ft. long. Figure 37 shows the allowable lifting capacity of the dock along the length of the dock developed according to the above-mentioned procedure. The integral of this allowable lifting load curve along the entire length of the dock yields the total maximum lifting capacity of the dry dock, which is 56,160 LT. The use of side blocks better distributes the weight of the ship transversely along the dock, thus decreasing the transverse sagging moment in the dock, but no credit is claimed. Appendix D details the allowable lifting capacity of the dock in way of each ballast tank.

Table 5 – Maximum Allowable Loading

Tank Nos.	Model Frame Nos.	Load per ft LT/ft	Load per Tank LT	Max. A-36 Stress psi	Max. Mayari Stress psi	Average Load LT/ft
1 & 2	0 to 6	68	2720	26,884	34,659	68.00
3 & 4	2 to 10	68	2720	30,975	38,931	68.00
5 & 6	6 to 14	68	2720	29,977	38,911	69.33
7 & 8	10 to 18	72	2880	30,886	31,518	70.67
9 & 10	14 to 22	72	2880	31,182	30,704	70.67
11 & 12	18 to 26	68	2720	30,938	30,635	70.67
13 & 14	22 to 30	72	2880	28,841	32,871	70.67
15 & 16	26 to 34	72	2880	28,391	29,046	70.67
17 & 18	30 to 38	68	2720	30,208	30,333	69.33
19 & 20	34 to 42	68	2720	30,704	30,501	69.33
21 & 22	38 to 46	72	2880	29,190	32,185	70.67
23 & 24	42 to 50	72	2880	29,004	30,864	72.00
25 & 26	46 to 54	72	2880	29,337	32,775	72.00
27 & 28	50 to 58	72	2880	29,036	33,284	72.00
29 & 30	54 to 62	72	2880	29,033	33,228	72.00
31 & 32	58 to 66	72	2880	29,162	32,667	72.00
33 & 34	62 to 70	72	2880	30,807	35,127	70.67
35 & 36	66 to 74	68	2720	30,803	30,520	69.33
37 & 38	70 to 78	68	2720	31,186	31,617	68.00
39 & 40	74 to 80	68	2720	30,745	30,922	68.00

Dry Dock Lifting Capacity 56,160 LT

The resultant Dock Lifting Capacity Curve is shown as follows. It shows for comparison the same curve from the 2012 analysis.

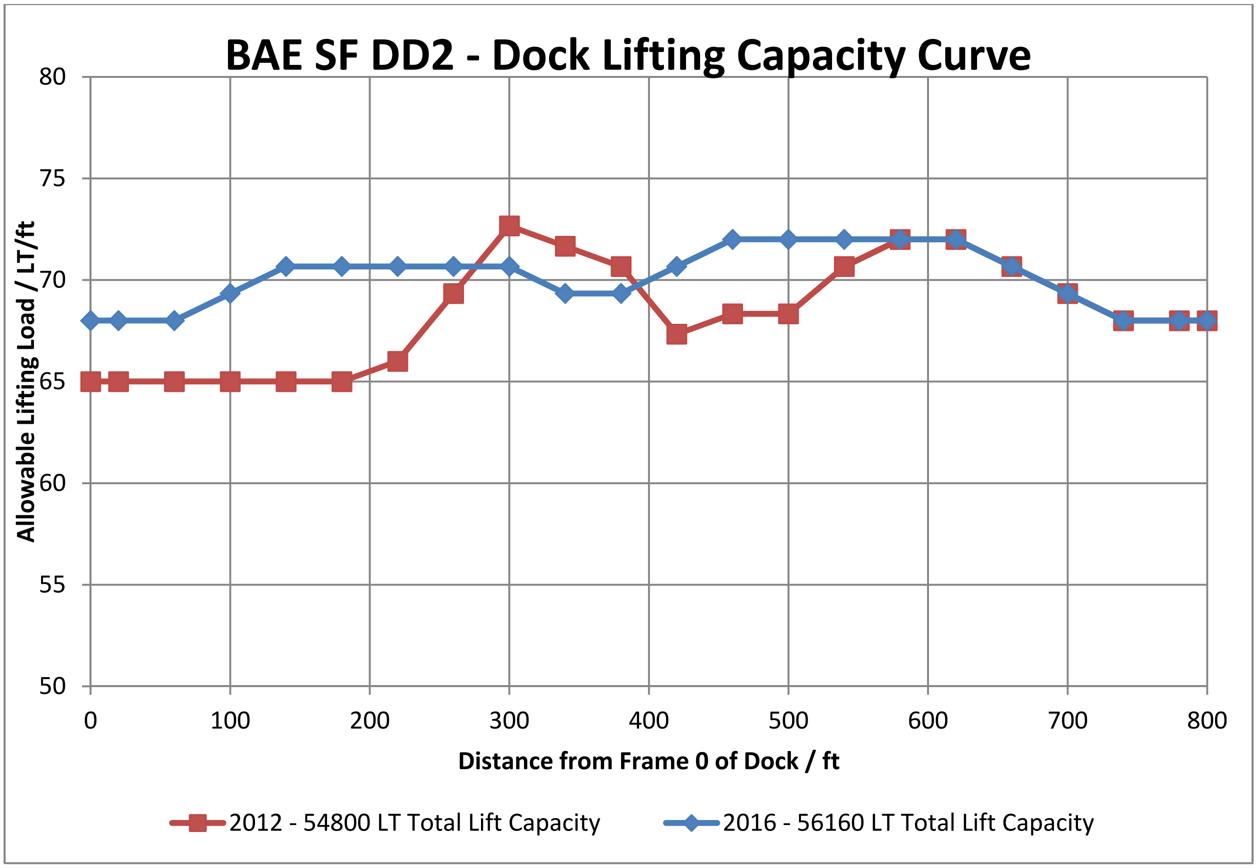

Figure 13 – Dock Lifting Capacity Curve

Results Discussion and Recommendations

We need to emphasize that the steel gauging is crucial to the performance of this task. This service provides a small sample of the measured thickness of the steel, which then must be extrapolated to the dry dock. This analysis is based upon the reports from three surveys, which are presented by BAE as being competent measurements of the actual steel thicknesses.

Transverse bending load cases were performed for all twenty (20) pair of ballast tanks to determine dock capacity as a function of the length of the dry dock. The tank pair being examined and half of the tank pairs fore and aft are extracted from the global modal for these models. The maximum lifting capacity is determined for each of the segments of the dry dock and assembled into the Dock Lifting Capacity Curve. Maximum von Mises stress is 38,930 psi in the Mayari-R steel in the bottom plating, which is less than the allowable stress of 40,000 psi. There were two locations where the steel gauging yielding thicknesses and this level of stress. Otherwise the maximum von Mises stress is 35,130 psi in the Mayari-R steel in the bottom plating. The maximum stress in the ASTM A36 steel is 31,190 psi in the lower portion of the transverse web frames, just outboard of the 9’-0” OCL WT longitudinal bulkhead and occurring in hot spots. A36 steel has an allowable stress of 28,800 psi and a yield stress of 36,000 psi. Hot spots are allowed to see stresses between allowable and yield strength because the stresses quickly dissipate moving away from the element located in the hot spot. Based on the local analyses of the dock in way of each pair of ballast tanks, the maximum ship load that can be lifted along the entire 800 ft. length of the dock is determined to be 56,160 LT.

BAE San Francisco Repair – Dry Dock No. 2 – Finite Element Analysis

Appendix A – Finite Element Model - Element Properties

Table of Contents

Appendix A – Finite Element Model - Element Properties

Plate Elements

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
1	Plate 10.2# (1/4)	0.25	0%	0.25	A-36
2	Plate 10.2# (1/4) - Sat. - 25% Red.	0.25	25%	0.1875	A-36
3	Plate 15.3# (3/8)	0.375	0%	0.375	A-36
4	Plate 15.3# (3/8) - Sat. - 25% Red.	0.375	25%	0.28125	A-36
5	Plate 15.3# (3/8) - Marg. - 35% Red.	0.375	35%	0.24375	A-36
6	Plate 15.3# (3/8) - Unsat. - 50% Red.	0.375	50%	0.1875	A-36
7	Plate 17.85# (7/16)	0.4375	0%	0.4375	A-36
8	Plate 17.85# (7/16) - New - 15% Red.	0.4375	15%	0.371875	A-36
9	Plate 17.85# (7/16) - Sat. - 25% Red.	0.4375	25%	0.328125	A-36
10	Plate 17.85# (7/16) - Marg. - 35% Red.	0.4375	35%	0.284375	A-36
11	Plate 17.85# (7/16) - Unsat. - 50% Red.	0.4375	50%	0.21875	A-36
12	Plate 17.85# (7/16) - Extreme - 75% Red.	0.4375	75%	0.109375	A-36
13	Plate 17.85# (7/16) - New - 15% Red. - Mayari-R	0.4375	15%	0.371875	Mayari-R
14	Plate 17.85# (7/16) - Sat. - 25% Red. - Mayari-R	0.4375	25%	0.328125	Mayari-R
15	Plate 17.85# (7/16) - Marg. - 35% Red. - Mayari-R	0.4375	35%	0.284375	Mayari-R
16	Plate 17.85# (7/16) - Unsat. - 50% Red. - Mayari-R	0.4375	50%	0.21875	Mayari-R
17	Plate 17.85# (7/16) - Extreme - 75% Red. - Mayari-R	0.4375	75%	0.109375	Mayari-R
18	Plate 20.4# (1/2)	0.5	0%	0.5	A-36
19	Plate 20.4# (1/2) - New - 15% Red.	0.5	15%	0.425	A-36
20	Plate 20.4# (1/2) - Sat. - 25% Red.	0.5	25%	0.375	A-36
21	Plate 20.4# (1/2) - Marg. - 35% Red.	0.5	35%	0.325	A-36
22	Plate 20.4# (1/2) - Unsat. - 50% Red.	0.5	50%	0.25	A-36
23	Plate 20.4# (1/2) - Extreme - 75% Red.	0.5	75%	0.125	A-36
24	Plate 20.4# (1/2) - New - 15% Red. - Mayari-R	0.5	15%	0.425	Mayari-R
25	Plate 20.4# (1/2) - Sat. - 25% Red. - Mayari-R	0.5	25%	0.375	Mayari-R

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
26	Plate 20.4# (1/2) - Marg. - 35% Red. - Mayari-R	0.5	35%	0.325	Mayari-R
27	Plate 20.4# (1/2) - Unsat. - 50% Red. - Mayari-R	0.5	50%	0.25	Mayari-R
28	Plate 20.4# (1/2) - Extreme - 75% Red. - Mayari-R	0.5	75%	0.125	Mayari-R
29	Plate 23# (9/16)	0.5625	0%	0.5625	A-36
30	Plate 23# (9/16) - New - 15% Red.	0.5625	15%	0.478125	A-36
31	Plate 23# (9/16) - Sat. - 25% Red.	0.5625	25%	0.421875	A-36
32	Plate 23# (9/16) - Marg. - 35% Red.	0.5625	35%	0.365625	A-36
33	Plate 23# (9/16) - Unsat. - 50% Red.	0.5625	50%	0.28125	A-36
34	Plate 25.5# (5/8)	0.625	0%	0.625	A-36
35	Plate 25.5# (5/8) - New - 15% Red.	0.625	15%	0.53125	A-36
36	Plate 25.5# (5/8) - Sat. - 25% Red.	0.625	25%	0.46875	A-36
37	Plate 25.5# (5/8) - Marg. - 35% Red.	0.625	35%	0.40625	A-36
38	Plate 25.5# (5/8) - Unsat. - 50% Red.	0.625	50%	0.3125	A-36
39	Plate 28.1# (11/16)	0.6875	0%	0.6875	A-36
40	Plate 28.1# (11/16) - Sat. - 25% Red.	0.6875	25%	0.515625	A-36
41	Plate 28.1# (11/16) - Marg. - 35% Red.	0.6875	35%	0.446875	A-36
42	Plate 28.1# (11/16) - Unsat. - 50% Red.	0.6875	50%	0.34375	A-36
43	Plate 30.6# (3/4)	0.75	0%	0.75	A-36
44	Plate 30.6# (3/4) - New - 15% Red.	0.75	15%	0.6375	A-36
45	Plate 30.6# (3/4) - Sat. - 25% Red.	0.75	25%	0.5625	A-36
46	Plate 30.6# (3/4) - Marg. - 35% Red.	0.75	35%	0.4875	A-36
47	Plate 30.6# (3/4) - Unsat. - 50% Red.	0.75	50%	0.375	A-36
48	Plate 33.2# (13/16)	0.8125	0%	0.8125	A-36
49	Plate 33.2# (13/16) - Sat. - 25% Red.	0.8125	25%	0.609375	A-36
50	Plate 33.2# (13/16) - Marg. - 35% Red.	0.8125	35%	0.528125	A-36
51	Plate 33.2# (13/16) - Unsat. - 50% Red.	0.8125	50%	0.40625	A-36
52	Plate 35.7# (7/8)	0.875	0%	0.875	A-36
53	Plate 35.7# (7/8) - Sat. - 25% Red.	0.875	25%	0.65625	A-36
54	Plate 35.7# (7/8) - Marg. - 35% Red.	0.875	35%	0.56875	A-36

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
55	Plate 35.7# (7/8) - Unsat. - 50% Red.	0.875	50%	0.4375	A-36
56	Plate 38.3# (15/16)	0.9375	0%	0.9375	A-36
57	Plate 38.3# (15/16) - Sat. - 25% Red.	0.9375	25%	0.703125	A-36
58	Plate 38.3# (15/16) - Marg. - 35% Red.	0.9375	35%	0.609375	A-36
59	Plate 38.3# (15/16) - Unsat. - 50% Red.	0.9375	50%	0.46875	A-36
60	Plate 40.8# (1)	1	0%	1	A-36
61	Plate 40.8# (1) - New - 15% Red.	1	15%	0.85	A-36
62	Plate 40.8# (1) - Sat. - 25% Red.	1	25%	0.75	A-36
63	Plate 40.8# (1) - Marg. - 35% Red.	1	35%	0.65	A-36
64	Plate 40.8# (1) - Unsat. - 50% Red.	1	50%	0.5	A-36
65	Plate 45.9# (1-1/8)	1.125	0%	1.125	A-36
66	Plate 45.9# (1-1/8) - Sat. - 25% Red.	1.125	25%	0.84375	A-36
67	Plate 45.9# (1-1/8) - Marg. - 35% Red.	1.125	35%	0.73125	A-36
68	Plate 45.9# (1-1/8) - Unsat. - 50% Red.	1.125	50%	0.5625	A-36
69	Plate ST 8x25# Flange (0.628)	0.628	0%	0.628	A-36
70	Plate ST 8x25# Flange (0.628) - Sat. - 25% Red.	0.628	25%	0.471	A-36
71	Plate ST 8x25# Flange (0.628) - Marg. - 35% Red.	0.628	35%	0.4082	A-36
72	Plate ST 8x25# Flange (0.628) - Unsat. - 50% Red.	0.628	50%	0.314	A-36
73	Plate ST 8x25# Web (0.380)	0.38	0%	0.38	A-36
74	Plate ST 8x25# Web (0.380) - Sat. - 25% Red.	0.38	25%	0.285	A-36
75	Plate ST 8x25# Web (0.380) - Marg. - 35% Red.	0.38	35%	0.247	A-36
76	Plate ST 8x25# Web (0.380) - Unsat. - 50% Red.	0.38	50%	0.19	A-36
77	Plate ST 9x27.35# Flange (0.691)	0.691	0%	0.691	A-36
78	Plate ST 9x27.35# Flange (0.691) - Sat. - 25% Red.	0.691	25%	0.51825	A-36
79	Plate ST 9x27.35# Flange (0.691) - Marg. - 35% Red.	0.691	35%	0.44915	A-36
80	Plate ST 9x27.35# Flange (0.691) - Unsat. - 50% Red.	0.691	50%	0.3455	A-36

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
81	Plate ST 9x27.35# Web (0.461)	0.461	0%	0.461	A-36
82	Plate ST 9x27.35# Web (0.461) - Sat. - 25% Red.	0.461	25%	0.34575	A-36
83	Plate ST 9x27.35# Web (0.461) - Marg. - 35% Red.	0.461	35%	0.29965	A-36
84	Plate ST 9x27.35# Web (0.461) - Unsat. - 50% Red.	0.461	50%	0.2305	A-36
85	Plate ST 9x30# Flange (0.695)	0.695	0%	0.695	A-36
86	Plate ST 9x30# Flange (0.695) - Sat. - 25% Red.	0.695	25%	0.52125	A-36
87	Plate ST 9x30# Flange (0.695) - Marg. - 35% Red.	0.695	35%	0.45175	A-36
88	Plate ST 9x30# Flange (0.695) - Unsat. - 50% Red.	0.695	50%	0.3475	A-36
89	Plate ST 9x30# Web (0.416)	0.416	0%	0.416	A-36
90	Plate ST 9x30# Web (0.416) - Sat. - 25% Red.	0.416	25%	0.312	A-36
91	Plate ST 9x30# Web (0.416) - Marg. - 35% Red.	0.416	35%	0.2704	A-36
92	Plate ST 9x30# Web (0.416) - Unsat. - 50% Red.	0.416	50%	0.208	A-36
93	Plate ST 10x32.7# Flange (0.789)	0.789	0%	0.789	A-36
94	Plate ST 10x32.7# Flange (0.789) - New - 15% Red.	0.789	15%	0.67065	A-36
95	Plate ST 10x32.7# Flange (0.789) - Sat. - 25% Red.	0.789	25%	0.59175	A-36
96	Plate ST 10x32.7# Flange (0.789) - Marg. - 35% Red.	0.789	35%	0.51285	A-36
97	Plate ST 10x32.7# Flange (0.789) - Unsat. - 50% Red.	0.789	50%	0.3945	A-36
98	Plate ST 10x32.7# Web (0.500)	0.5	0%	0.5	A-36
99	Plate ST 10x32.7# Web (0.500) - New - 15% Red.	0.5	15%	0.425	A-36
100	Plate ST 10x32.7# Web (0.500) - Sat. - 25% Red.	0.5	25%	0.375	A-36
101	Plate ST 10x32.7# Web (0.500) - Marg. - 35% Red.	0.5	35%	0.325	A-36
102	Plate ST 10x32.7# Web (0.500) - Unsat. - 50% Red.	0.5	50%	0.25	A-36
103	Plate ST 12x34# Flange (0.582)	0.582	0%	0.582	A-36
104	Plate ST 12x34# Flange (0.582) - Sat. - 25% Red.	0.582	25%	0.4365	A-36

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
105	Plate ST 12x34# Flange (0.582) - Marg. - 35% Red.	0.582	35%	0.3783	A-36
106	Plate ST 12x34# Flange (0.582) - Unsat. - 50% Red.	0.582	50%	0.291	A-36
107	Plate ST 12x34# Web (0.416)	0.416	0%	0.416	A-36
108	Plate ST 12x34# Web (0.416) - Sat. - 25% Red.	0.416	25%	0.312	A-36
109	Plate ST 12x34# Web (0.416) - Marg. - 35% Red.	0.416	35%	0.2704	A-36
110	Plate ST 12x34# Web (0.416) - Unsat. - 50% Red.	0.416	50%	0.208	A-36
111	Plate ST 12x38# Flange (0.682)	0.682	0%	0.682	A-36
112	Plate ST 12x38# Flange (0.682) - Sat. - 25% Red.	0.682	25%	0.5115	A-36
113	Plate ST 12x38# Flange (0.682) - Marg. - 35% Red.	0.682	35%	0.4433	A-36
114	Plate ST 12x38# Flange (0.682) - Unsat. - 50% Red.	0.682	50%	0.341	A-36
115	Plate ST 12x38# Web (0.440)	0.44	0%	0.44	A-36
116	Plate ST 12x38# Web (0.440) - Sat. - 25% Red.	0.44	25%	0.33	A-36
117	Plate ST 12x38# Web (0.440) - Marg. - 35% Red.	0.44	35%	0.286	A-36
118	Plate ST 12x38# Web (0.440) - Unsat. - 50% Red.	0.44	50%	0.22	A-36
119	Plate MC 13x35# Flange (0.61)	0.61	0%	0.61	A-36
120	Plate MC 13x35# Flange (0.61) - Sat. - 25% Red.	0.61	25%	0.4575	A-36
121	Plate MC 13x35# Web (0.447)	0.447	0%	0.447	A-36
122	Plate MC 13x35# Web (0.447) - Sat. - 25% Red.	0.447	25%	0.33525	A-36
123	Plate ST 13.5x42# Flange (0.636)	0.636	0%	0.636	A-36
124	Plate ST 13.5x42# Flange (0.636) - Sat. - 25% Red.	0.636	25%	0.477	A-36
125	Plate ST 13.5x42# Flange (0.636) - Marg. - 35% Red.	0.636	35%	0.4134	A-36
126	Plate ST 13.5x42# Flange (0.636) - Unsat. - 50% Red.	0.636	50%	0.318	A-36
127	Plate ST 13.5x42# Web (0.463)	0.463	0%	0.463	A-36
128	Plate ST 13.5x42# Web (0.463) - Sat. - 25% Red.	0.463	25%	0.34725	A-36

Property No.	Property Name	Thick.	%Reduction	Reduced Thickness	Material
		inches		inches	
129	Plate ST 13.5x42# Web (0.463) - Marg. - 35% Red.	0.463	35%	0.30095	A-36
130	Plate ST 13.5x42# Web (0.463) - Unsat. - 50% Red.	0.463	50%	0.2315	A-36
131	Plate WF 18x96# Flange (0.831)	0.831	0%	0.831	A-36
132	Plate WF 18x96# Flange (0.831) - Sat. - 25% Red.	0.831	25%	0.62325	A-36
133	Plate WF 18x96# Flange (0.831) - Marg. - 35% Red.	0.831	35%	0.54015	A-36
134	Plate WF 18x96# Flange (0.831) - Unsat. - 50% Red.	0.831	50%	0.4155	A-36
135	Plate WF 18x96# Web (0.512)	0.512	0%	0.512	A-36
136	Plate WF 18x96# Web (0.512) - Sat. - 25% Red.	0.512	25%	0.384	A-36
137	Plate WF 18x96# Web (0.512) - Marg. - 35% Red.	0.512	35%	0.3328	A-36
138	Plate WF 18x96# Web (0.512) - Unsat. - 50% Red.	0.512	50%	0.256	A-36
139	Plate WF 24x120# Flange (0.93)	0.93	0%	0.93	A-36
140	Plate WF 24x120# Flange (0.93) - New - 15% Red.	0.93	15%	0.7905	A-36
141	Plate WF 24x120# Flange (0.93) - Sat. - 25% Red.	0.93	25%	0.6975	A-36
142	Plate WF 24x120# Flange (0.93) - Marg. - 35% Red.	0.93	35%	0.6045	A-36
143	Plate WF 24x120# Flange (0.93) - Unsat. - 50% Red.	0.93	50%	0.465	A-36
144	Plate WF 24x120# Web (0.556)	0.556	0%	0.556	A-36
145	Plate WF 24x120# Web (0.556) - New - 15% Red.	0.556	15%	0.4726	A-36
146	Plate WF 24x120# Web (0.556) - Sat. - 25% Red.	0.556	25%	0.417	A-36
147	Plate WF 24x120# Web (0.556) - Marg. - 35% Red.	0.556	35%	0.3614	A-36
148	Plate WF 24x120# Web (0.556) - Unsat. - 50% Red.	0.556	50%	0.278	A-36

Beam Elements

Property No.	Property Name	Depth	Width	Flange Thick.	Web Thick.	% Reduced	Reduced Flange Thick.	Reduced Web Thick.	Material
		inches	inches	inches	inches		inches	inches	
151	Beam ST12WF60 (W24x120)	12.125	12.125	0.9375	0.5625	0%	0.9375	0.5625	A-36
152	Beam ST12WF60 (W24x120) - Sat. - 25% Red.	12.125	12.125	0.9375	0.5625	25%	0.703125	0.421875	A-36
153	Beam ST12WF60 (W24x120) - Marg. - 35% Red.	12.125	12.125	0.9375	0.5625	35%	0.609375	0.365625	A-36
154	Beam ST12WF60 (W24x120) - Unsat. - 50% Red.	12.125	12.125	0.9375	0.5625	50%	0.46875	0.28125	A-36
155	Beam ST12WF55 (W24x110)	12.0625	12	0.875	0.5	0%	0.875	0.5	A-36
156	Beam ST12WF55 (W24x110) - Sat. - 25% Red.	12.0625	12	0.875	0.5	25%	0.65625	0.375	A-36
157	Beam ST12WF55 (W24x110) - Marg. - 35% Red.	12.0625	12	0.875	0.5	35%	0.56875	0.325	A-36
158	Beam ST12WF55 (W24x110) - Unsat. - 50% Red.	12.0625	12	0.875	0.5	50%	0.4375	0.25	A-36
159	Beam ST9WF42.5 (18W85)	9.1875	8.875	0.9375	0.5	0%	0.9375	0.5	A-36
160	Beam ST9WF42.5 (18W85) - Sat. - 25% Red.	9.1875	8.875	0.9375	0.5	25%	0.703125	0.375	A-36
161	Beam ST9WF42.5 (18W85) - Marg. - 35% Red.	9.1875	8.875	0.9375	0.5	35%	0.609375	0.325	A-36
162	Beam ST9WF42.5 (18W85) - Unsat. - 50% Red.	9.1875	8.875	0.9375	0.5	50%	0.46875	0.25	A-36
163	Beam ST8WF32 (W24x110)	8	8.5	0.6875	0.4375	0%	0.6875	0.4375	A-36
164	Beam ST8WF32 (W24x110) - Sat. - 25% Red.	8	8.5	0.6875	0.4375	25%	0.515625	0.328125	A-36
165	Beam ST8WF32 (W24x110) - Marg. - 35% Red.	8	8.5	0.6875	0.4375	35%	0.446875	0.284375	A-36
166	Beam ST8WF32 (W24x110) - Unsat. - 50% Red.	8	8.5	0.6875	0.4375	50%	0.34375	0.21875	A-36
167	Beam T (W24x131)	24.48	12.855	0.96	0.605	0%	0.96	0.605	A-36

BAE San Francisco Repair – Dry Dock No. 2 – Finite Element Analysis

Appendix B – Dry Dock No. 2 Lightship Weight Calculation

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Appendix B – Dry Dock No. 2 Lightship Weight Calculation

TITLE: Weight Estimate
SHIP: BAE SF - DD #2
Plan No.
Section:
Frames:
WT Grp:

BRUCE S. ROSENBLATT & ASSOCIATES, LLC
NAVAL ARCHITECTS & MARINE ENGINEERS
OAKLAND OFFICE

ESTIMATE OF WEIGHT

SHEET No. 1 of 1
BSR CONT: 1043.005
DATE: 8/29/2012

Piece No.	Description, Material, Dimensions	Remarks	Weight	Abv Baseline		Ref to Fr 0		Ref to CL	
			(LT)	Vert CG (ft)	Vert Mom (ft-LT)	- South + North (ft)	Long Mom (ft-LT)	+ West - East (ft)	Transv Mom (ft-LT)
	Lightship Basis	Ref. EBDG Report 08003-001-843-4B	18329.27	25.00	458232	400.00	7331708		0.00
	Removal - Temporary Crane	Ref. EBDG Report 08003-001-843-4B	-71.43	89.00	-6357	400.00	-28572		0.00
	New East Crane	*VCG assumed 20ft above crane rails	450.00	89.00	40050	400.00	180000		0.00
	Transformer - Safety Deck West	*VCG assumed 3ft above safety deck	8.93	61.50	549	400.00	3571		0.00
	Transformer - Safety Deck East	*VCG assumed 3ft above safety deck	8.93	61.50	549	400.00	3571		0.00
	Sponsons - (6x)	Ref. EBDG Report 08003-001-843-4B	185.00	25.50	4718	400.00	74000		0.00
	Doubler Plate - Existing (36,900)	Ref. EBDG Report 08003-001-843-4B	-366.00	20.75	-7595	400.00	-146400		0.00
	Doubler Plate - Total (79,200)	Ref. DWG DD2 2012 Pontoon Deck Repairs	723.00	20.75	15002	400.00	289200		0.00
		A. Romanczuk - 06-25-2012							
	LIGHTSHIP TOTAL		**19267.70**	**26.22**	**505148**	**400.00**	**7707079**	**0.00**	**0.00**

Notes:

1. This lightship weight calculation is solely for the purpose of determining the drydock weight for loading the drydock in FEA Structural Model.
2. VCG data are approximations and may not accurately reflect the stability characteristics of the drydock.
3. LCG of drydock is assumed to be at 400ft North of Frame 0.
4. Reference data from EBDG Report 08003-001-843-4B and meeting with A. Romanczuk on 08/23/2012.

Estimated By: A Lachtman
Checked By: D Smith
Reviewed by:

BAE San Francisco Repair – Dry Dock No. 2 – Finite Element Analysis

Appendix C – Dry Dock No. 2 Corrosion Properties

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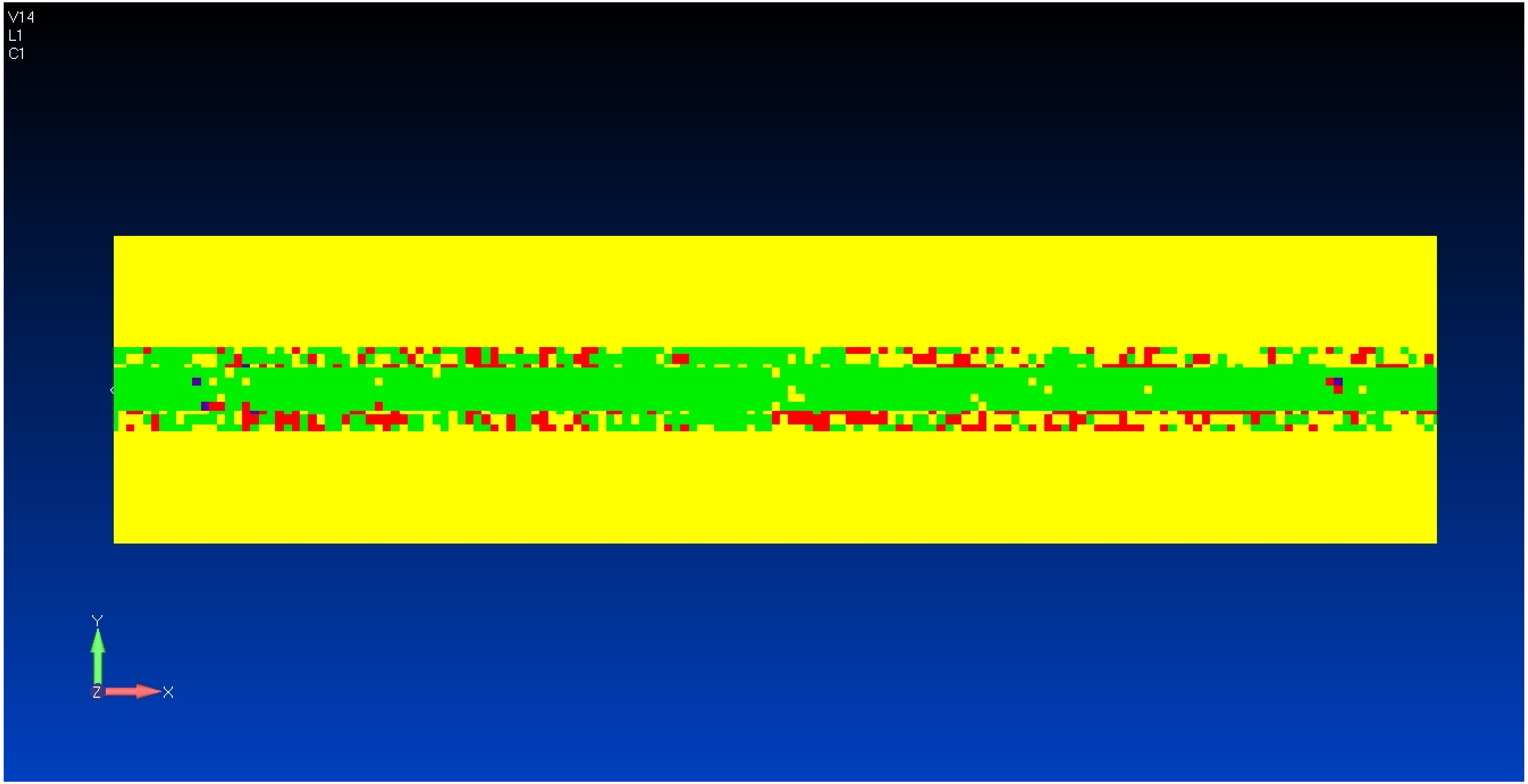
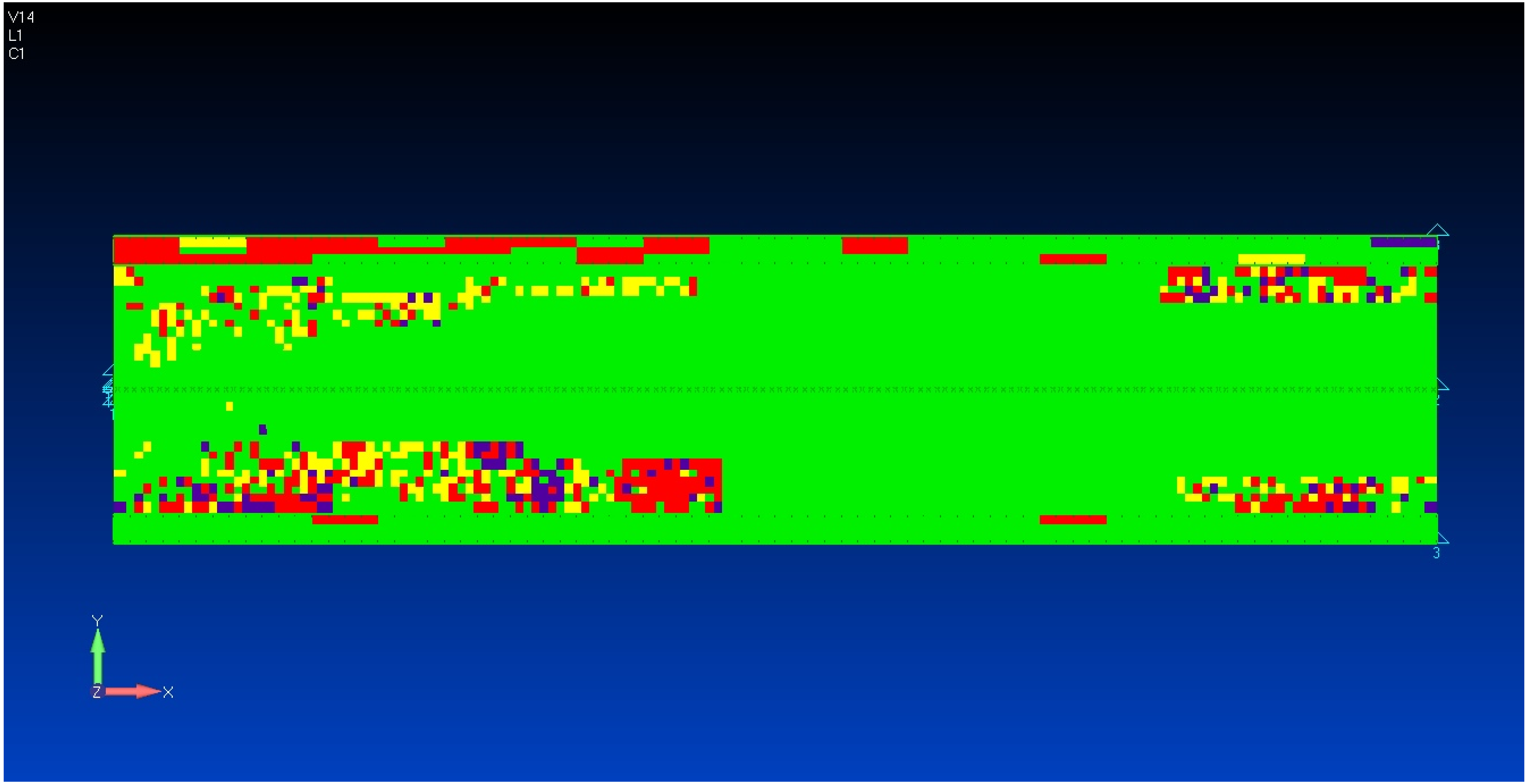
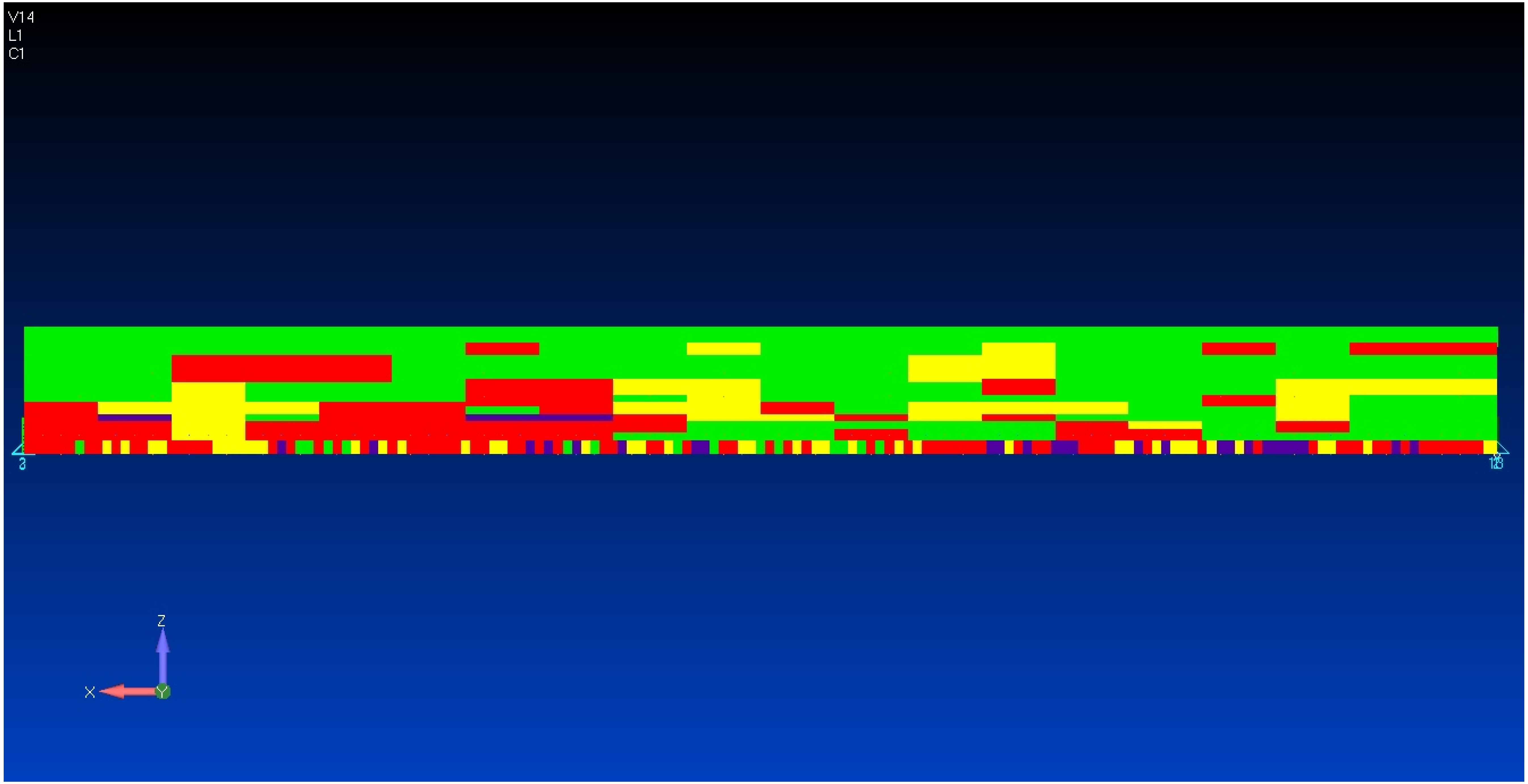
Dry Dock No. 2 Corrosion Properties – Bottom Plating – As-Modeled



Dry Dock No. 2 Corrosion Properties – Wingwall & Pontoon Deck Plating – As-Modeled



Dry Dock No. 2 Corrosion Properties – Outbd West Wingwall Plating – As-Modeled



BAE San Francisco Repair – Dry Dock No. 2 – Finite Element Analysis

Appendix C – Dry Dock No. 2 Corrosion Properties

Dry Dock No. 2 Corrosion Properties – Outbd East Wingwall Plating – As-Modeled