Concrete Preservation Institute

Preservation Field School
Alcatraz Island
Summer 2015 Project Report

Rehabilitation of the Main Cell House Roof Access Stair and Landing

Approximately seven tons of applied materials in preservation activities
(largest volume to date by a CPI team)

Summer 2015 Project Team

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Figure 1: Summer 2015 Team. Top from left: Kevin Dunn, Benjamin Carter. Middle from left: Tanya Komas (CPI Director), Andrew Vazquez, David Livingston, Daniel Weiss. Bottom from left: Abby sue Fisher (Chief of Cultural Resources, GGNRA, NPS), Taynara Lopes, Catrina Alexandre, Claudia Martinez, Kyle Bearden (CPI Project Manager).

About the Concrete Preservation Institute

The Concrete Preservation Institute partners with the US National Park Service and the Golden Gate National Parks Conservancy for our Field School program. Military veterans and students learn from leading industry experts about increasing the strength and longevity of structures as they complete significant repair projects on landmark buildings. We assist our alumni transition into positions across the country in management, skilled trades, additional industry internships, and university degree programs. The CPI Foundation contributes broadly to industry and society through developing talent, leading practical research, offering professional development, giving back through local youth mentoring, and advancing applied sustainability through preservation.

CPI Project Oversight

Tanya Wattenburg Komas, Ph.D., Founding Director & CEO/President

Scott L. Burghardt, Director of Operations & Vice President/CFO

Kyle Bearden, Instructor & Project Manager

Patrick Sparks, P.E., Sparks Engineering

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- **Historical Significance –** A brief view of stair and landing roof access existing conditions, historical significance, and future general access and operational role.
- **Existing Condition Assessment** – Description, illustrations, and images that depict the existing conditions of the staircase and its connected landing prior to any preservation activity for rehabilitation.
- **Safety Plan and Hazard Mitigation –** Safety plans at the job site for both interns and visitors, such as proper equipment training and techniques used to avoid injury during preservation activities.
- **Repair Process and Project Phasing –** All documentation for preservation approach, repair geometry, and demolition performed; reinforcement and forming plans for individual phases.
- **Waste Management** – Approach for disposing of debris, such as dry concrete from demolition, wet concrete from pouring, and wood from carpentry.
- **Repair Aesthetics –** Techniques developed and used to achieve compatible surface treatments with existing historic surfaces including appropriate material ratios, textures and colors.

2. Historical Significance

One of the projects tasked to the summer 2015 CPI team is the Alcatraz Main Cell House stair and landing system for rooftop access. However, it is not a simple landing and stairs. Constructed more than 100 years ago, the landing required extensive preservation from such deformation as severe spalling and dynamic forces applied from the expansion of steel structural I-beams that neighbor the landing. Severe corrosion at the perpendicular and horizontal I-beams was one of the many structural causes for decay within its support housing. The rehabilitated, single open-sided stair is the only roof access of the Cell House. A small set of metal stairs and a railing were present atop the landing platform. This provided the last 7 steps to access the roof. It was removed during CPI preservation activities as it did not require attention.

This single route access to the roof is situated on the second floor of the cell house south end. It begins in the existing Chapel where the Officers Break Room and Gun Galley are located. Some of the most recognizable detailed pieces of art (graffiti) that occurred during the 19 month Native American Occupation from 1969 to 1971, are depicted below. This graffiti is located on the south wall, separated from the stairs by only a shared 6-inch concrete vertical wall. The stairs are supported on this wall on the opposite side, thus it plays a major role in structural support of the stairs themselves. See below for Orientation.

Figure 2: View inside Chapel facing wall. Project site - stair & landing- are directly behind the wall. Only 6" of concrete separates the wall that acted as a canvas for markings during the Native American occupation of Alcatraz from the project work.

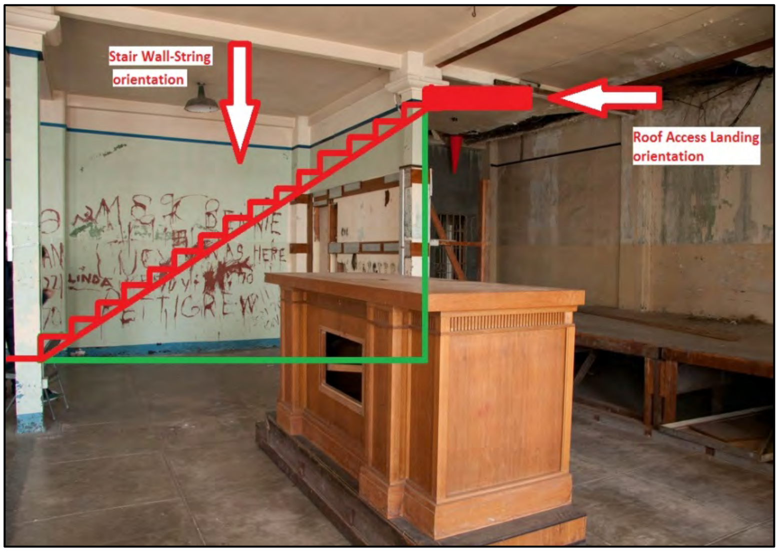

Figure 3: Diagram showing the locaiton of the stair and landing behind the wall.

Figure 4: Existing condition of the stairs. The preservation approach was to preserve the treads since they show so much history with their worn appearance. Repairs were done from below. These stairs share the wall with the historically significant graffiti.

Figure 3,, showing the worn concrete steps, shows that the roof access system has been extensively used throughout the Island's history, including serving as .access to the guard tower situated on the roof during the Federal Penitentiary times. Due to external factors such as high concentrations of moisture allowed to enter as a result of deteriorated weatherproofing at the roof access port above the landing, the 100-year-old structure possessed a high degree of deterioration. This condition had progressed to the point that the stability of the stair was concerning. With a preservation-focused approach, the repair plan included preserving the stair treads shown in Figure 3 and repairing/stabilizing the stair system from beneath. This was a difficult approach, but given that they are such a vivid record of history and use (how many pairs of boots walking up and down for over 100 years did it take to wear a pattern into the concrete?), the team decided it was the appropriate approach.

Figure 5: Severe delamination and spalling at the underside of stair landing with approximately 50-60% loss of reinforcement.


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Figure 6: Existing conditions of underside of stairs; extensive delamination due to corrosion of the reinforcing mat.

As a National Park, work at Alcatraz must consider maximizing visitor experience, facilitating Park operations, and preservation of history according to the Secretary of Interior Standards for the Treatment of Historic Properties. Once completed, a safe access to the rooftop of the "8th most visited attraction in the world" (Travelocity.com-2012/world) will allow increased traffic at the repair site for migratory bird monitoring, solar panel access, and even views of beautiful sunsets from the roof.

3. Existing Condition Assessment

Initial assessment revealed that the stair and landing were badly deteriorated, including reinforcing steel corrosion and spalling as shown in the pictures below. The landing had deteriorated to the point that a visible hole was beginning to form.

Figure 7: Top surface of the landing showing a void approximately 4" x 3"

Figure 8: Underside of the landing showing void appearing in Figure 6 as well as general concrete deterioration.

One of the most important tasks in concrete repair is to identify and understand cause and effect when considering how to approach problems. After CPI lectures and field demonstrations that addressed cause and effect, the team was able to determine the cause and resulting degree of corrosion and concrete deterioration.

Upon closer investigation, based upon training received in the field on the Island we as a team came to a firm decision that the cause of our structures rapidly deteriorating status was low pH levels within the concrete caused by CO2 entering the concrete causing carbonation together with high chloride levels. Inside the concrete, chloride ions make the electrolyte more conductive, which in turn speeds up the process between anode and cathode within the steel in the corrosion process. Penetrating the stairs and landing was salty, damp air from the roof access stair penthouse just above the landing. Insufficient waterproofing of the stair penthouse on the roof was the point of entry for the elements. The stair penthouse above the landing needed to be waterproofed to prevent the corrosion from continuing. Further inspection showed that adequate waterproofing and sealing of the stair penthouse had been conducted prior to our arrival and to an acceptable standard as determined by the team. High chlorides levels together with periods of wet and dry cycles common in the region lead to the corroded the steel.

Analyzing the conditions, we found corrosion of reinforcement greater than 20% section loss on two or more reinforcing bars and corrosion of the structural I-beams parallel and perpendicular to the landing, extensive delamination, and severe spalling. From lectures given by CPI leadership, our team understood that when the steel corrodes and expands in the concrete, it applies a dynamic, outward force in all directions within the concrete. This caused most of the conditions shown in the images below as concrete is not resistant to such interior tension. In addition, during demolition we found inadequate concrete coverage around reinforcing steel elements. This allowed a short pathway for chloride ions to travel through the concrete to come in contact with the steel reinforcing.

Our team confirmed that expansive corrosion products were forcing movement in the concrete by taking measurements of the beam connected to the landing. A difference of ½ inch on the height to ceiling dimension indicated such forces are acting in an upward direction lifting the platform above (originally out of the scope of intended preservation actions for this project). See figures that follow.

Figure 9: Severe corrosion on the I-beam parallel to the landing.

This difference shows that the south end of the landing was subjected to the dynamic force of corrosion. The following drawings show field verified dimensions substantiating that this dynamic force was being applied within the structure of the landing and I-beam configurations.

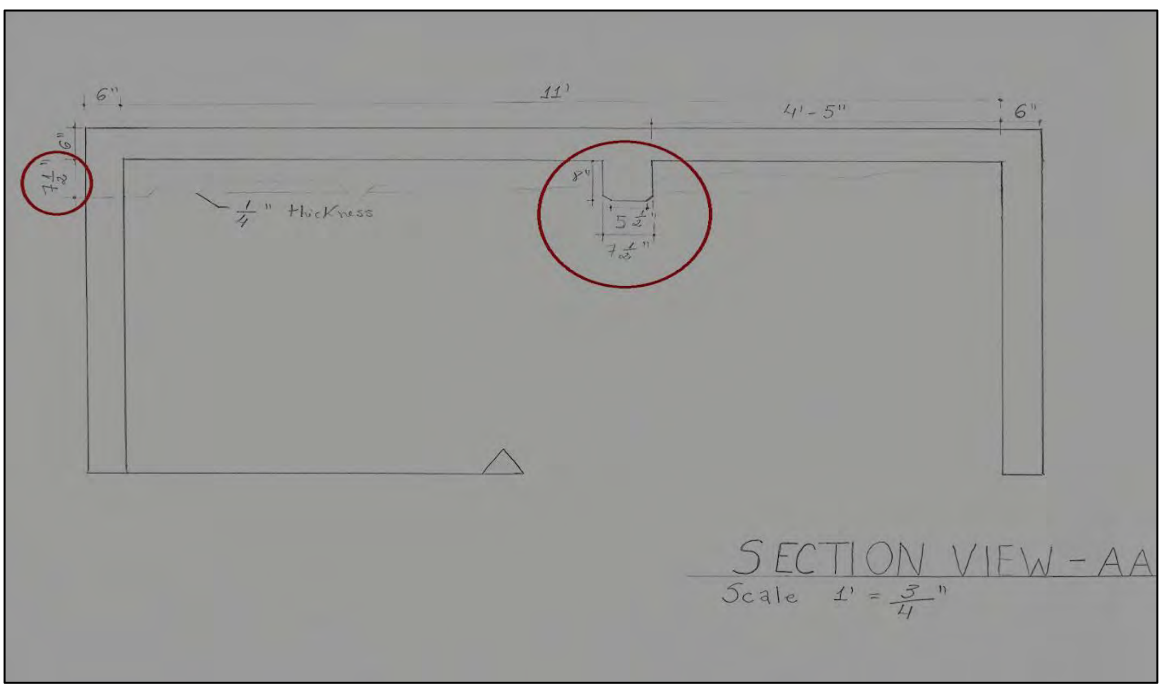

Figure 10: Landing section drawing.

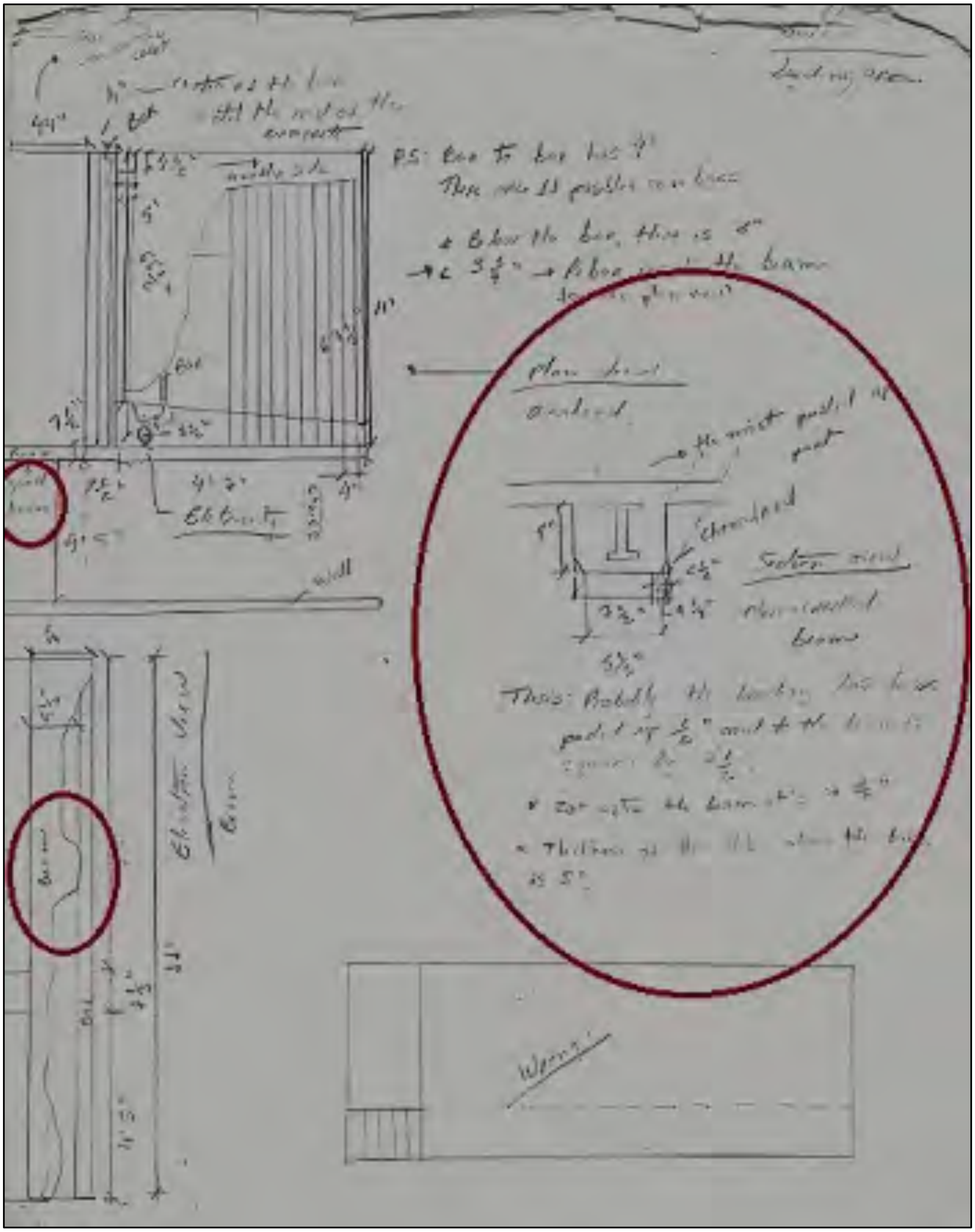

Figure 11: Landing detail drawing.

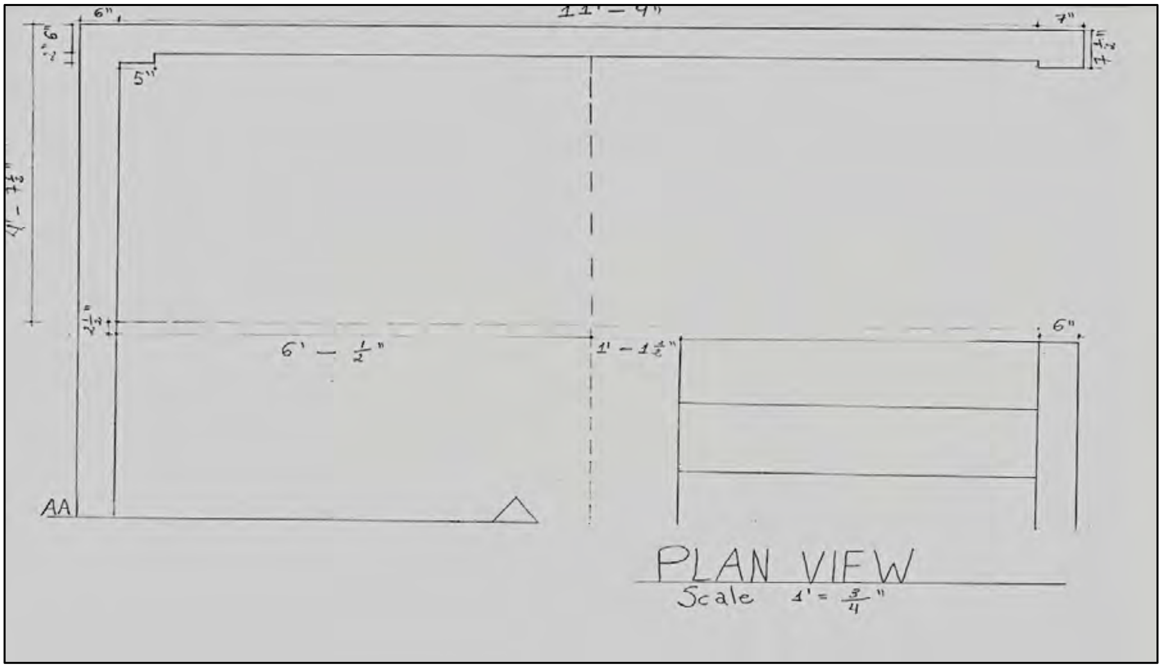

Figure 12: Landing plan view.

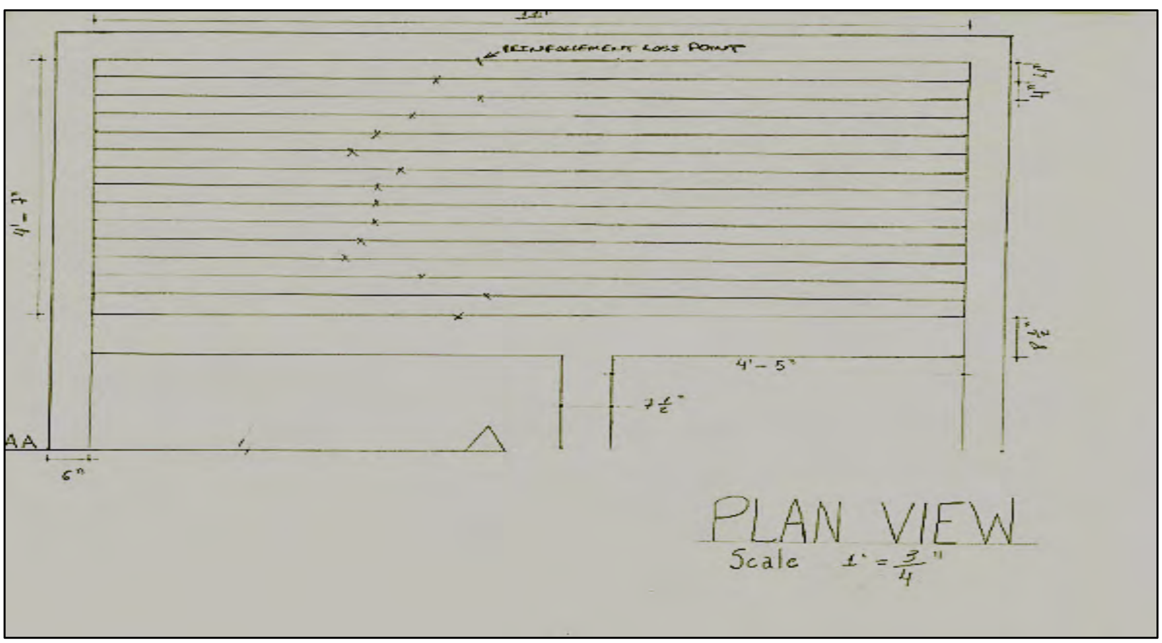

Figure 13: Landing plan view.

4. Safety Plan and Hazard Mitigation

When performing preservation activity in any location, and in particular in a confined space such as the stair and landing area, all personnel must be safety trained and pass the OSHA-10 certification, have complete situational awareness with all potential hazards, and commit to a zero injury tolerance. In our work area, any hazards were immediately identified, mitigated, and brought to the attention of all members. This awareness was discussed and noted during daily pre-work job safety assessment meetings and were recorded by the safety officers from each team. Items such as scaffolding systems were inspected by team safety officers as per OSHA-10 Regulations and CPI safety manual.

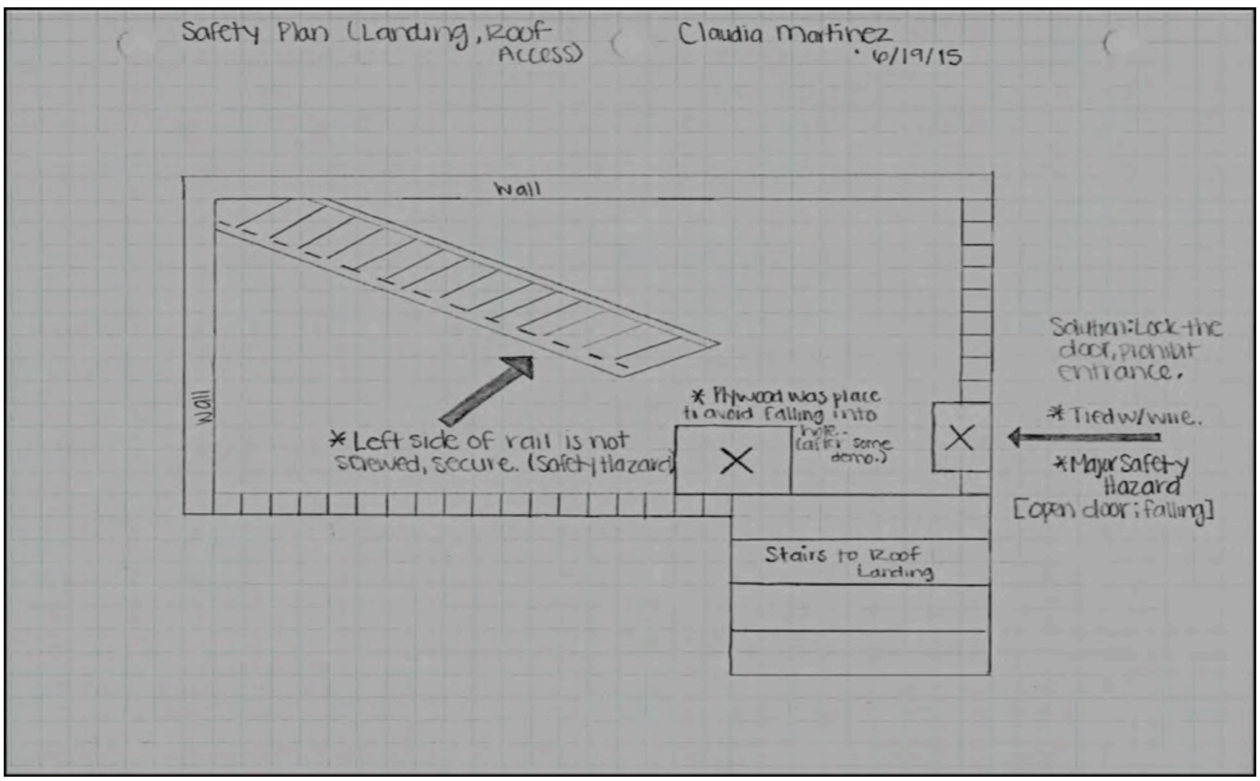

Figure 14: Safety plan for landing

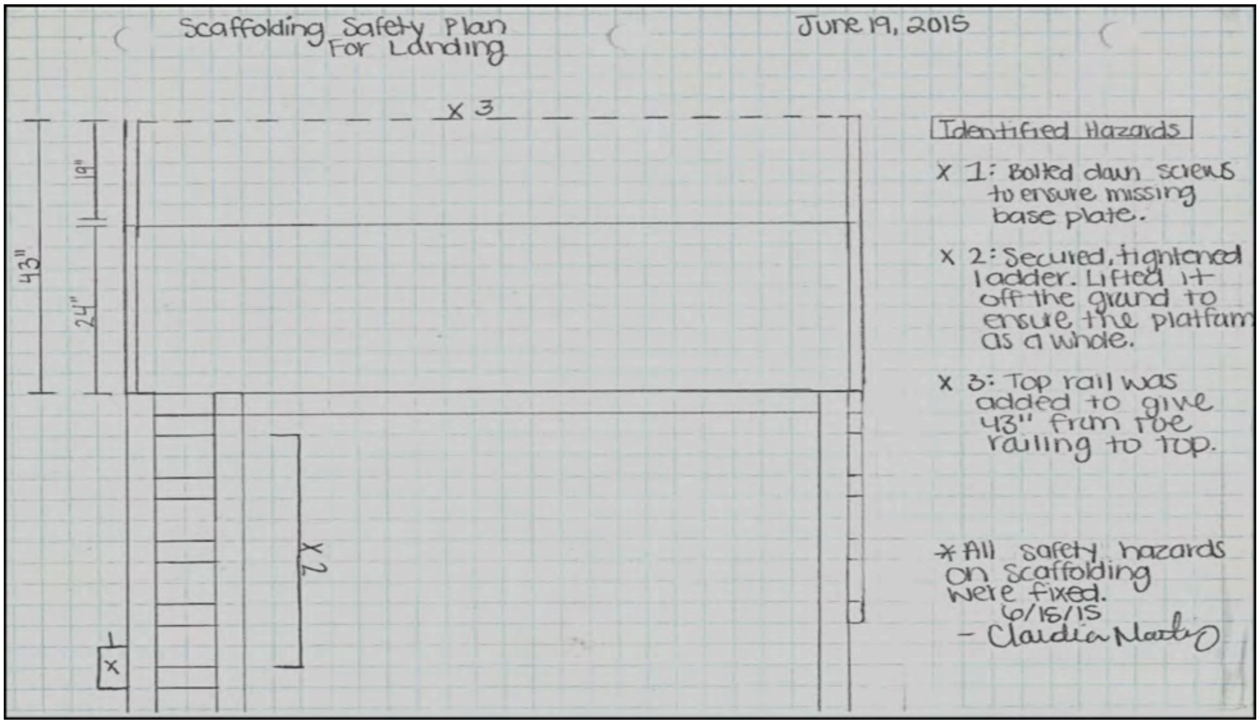

Figure 15: Safety plan for landing.

5. Repair Process and Project Phasing

Project Documentation

We began our project by defining our preservation strategy, the project phases, and the processes. We created drawings, including section, plan, and elevation views of the project to ensure proper communication among our team members and to CPI staff and project advisors. Additionally, we took over 800 photos to record existing conditions, work in progress, and the final product. Drawings and an extensive photographic collection ensured that all measurements for the landing and stair system necessary to build forms and calculate volume were accurate and verified by more than one source. Documentation also helps clarify preservation intent and success. Accuracy of mass and weight was a matter of safety in an overhead structural project such as ours.

Repair Geometry and Demolition

Demolition of deteriorated concrete in the landing was carried out in a meticulous manner to save and reuse a #8 reinforcement bar at the east end of the landing. It was the only historic reinforcing bar that met the standards of less than 20% section loss and could therefore be preserved in place. Being able to leave this substantial piece of original reinforcement intact was important to our preservation approach as was keeping intact a small 2”x3.25” cold joint curb at the east end of the landing through the careful use of our Hilti UH-700 Chipping Hammer/Hammer Drill. This cold joint curb was considered a valuable character-defining feature. Leaving it intact was important and avoided the additional work it would have taken to reconstruct it.

Demolition of deteriorated concrete on the stair underside was performed entirely overhead accessed by scaffolding. We carefully removed unsound concrete to allow ¾ inch coverage of new concrete to be pumped inside forms above the reinforcing steel. In the photo below, meticulous work with one of three HILTI steel-cutting tools was used to minimize the amount of reinforcing steel removed. Once again, our focus was rehabilitation while preserving as much historic fabric as possible and making the feature structurally sound and safe.

Reinforcement Plan

Figure 16: Removal of deteriorated steel reinforcing.

Approximately 40% of the original reinforcement in the stair soffit was reused in this project. Keeping history intact and alive on the Island was the focus day-after-day by the CPI cadre and NPS Historical Architect Jason Hagin.

Figure 17: New steel reinforcing spliced onto existing historical reinforcing that was in an adequate condition to be left in place.

Materials and Methods

- The repair plans that were given to the team by engineers instructed the team to field verify existing slab thickness and modify to 6” where needed.
- Existing prison bars had begun to help support the beams and slab due to diminishing strength of the concrete assembly area over time. After repairs, the beam and slab were supported by their own integrity as originally built.

- Form volume (cubic feet) calculations by the team determined that 66 bags of Master Emaco S466 self-consolidating concrete we would be needed for the landing.
- MasterEmaco S 466 was the type of concrete used for the stage 2 landing pour. The mix ratio was one bag per 14.5 Litres (90%) of water initially mixed, then an additional 1.5 Litres (10%) added after 1 minute mix time if needed. This product was selected for this project based on its unique formulation that included excellent bond, resistance to sulfates and chlorides, high electrical resistivity, low permeability, high-compressive strengths, protection from corrosion, and self-leveling properties (which demonstrated an example of an industry leading product that reduced labor hours for application). The confined spaces of the landing area and no accessibility for "screed board leveling techniques" for finishing work made this the optimal product for this project. It is specified for large volume repairs, including structural elements in applications from 1.5" (38 mm) to full depth. See www.basf/masteremaco.com for further information about this product.
- MasterEmaco S 440 was used for the wide flange member (I-beam) and Stage 3: Stair Soffit pumping procedure. A total of 66 bags were used. Each bag produced .43 cubic feet. It was chosen for its one-component, shrinkage-compensated, self-consolidating properties that were perfect for the intricate areas in which we needed to place concrete. We had created a complex form design and intended to place the concrete in a single pumping episode for both the parallel and perpendicular beams. This material is designed for large volume repairs, including structural elements in applications from 1" (50 mm) to full depth. It is a flow-able, shrinkage-compensated repair material. For more information on this material please see www.basf/masteremaco.com. Photos of this concrete placement follow below.
- The reinforcing steel installed during original construction circa 1908-1912 was severely corroded in multiple locations. According to ICRI standards, when 20% section loss of reinforcement has occurred, removal and replacement of the affected steel must be done. New steel reinforcing was spliced onto remaining intact steel with a lap distance of 20 times the diameter of the steel, as per industry standard.

Figure 18: Existing 4" on center, parallel, badly damaged reinforcing steel at landing.

- Upon inspection, we observed that the existing rebar had short spacing of 4” on center. With further inquiry with Sparks Engineering, we were advised that 12” on center spacing and both parallel and perpendicular placement was best. This was placed against the old lateral direction steel (see image below).

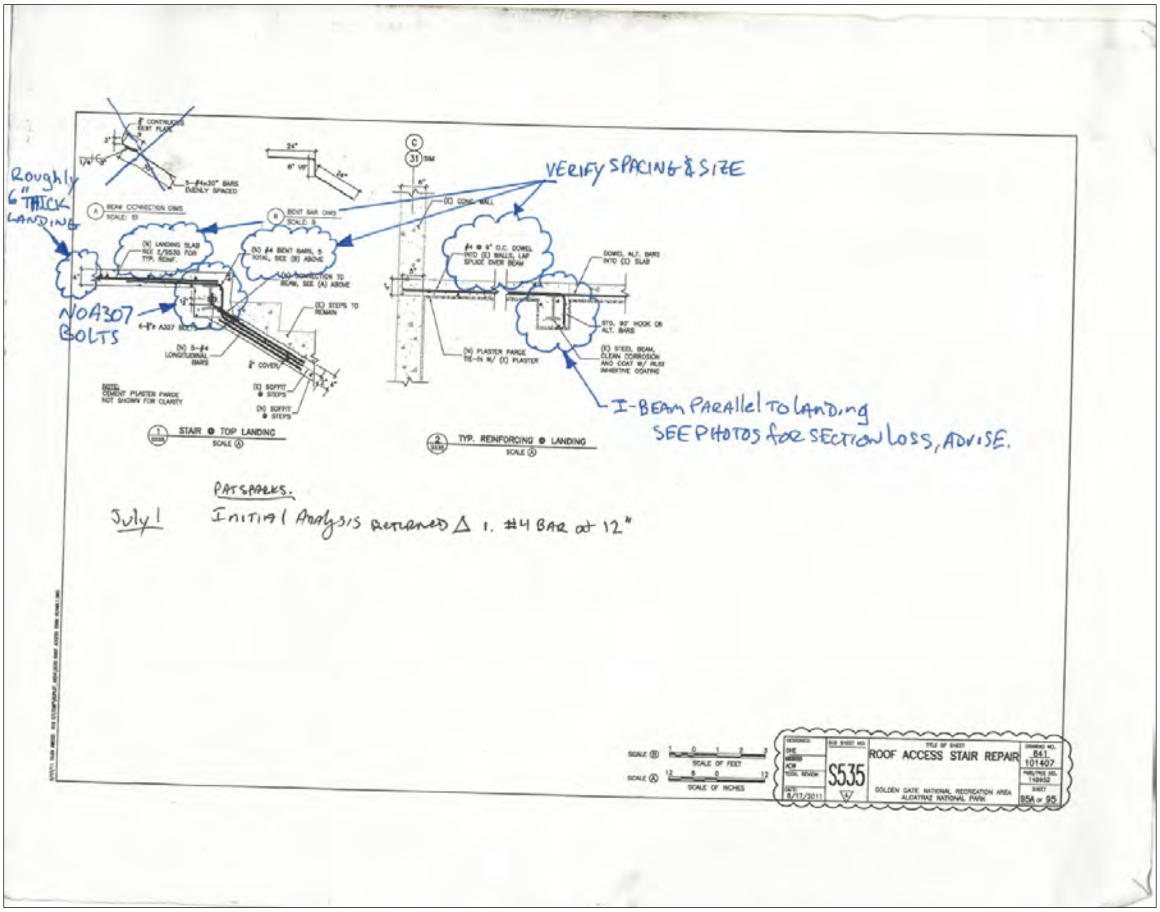

Figure 19: Detail of reinforcing steel.

Figure 20: New 12" on center steel reinforcing mesh.

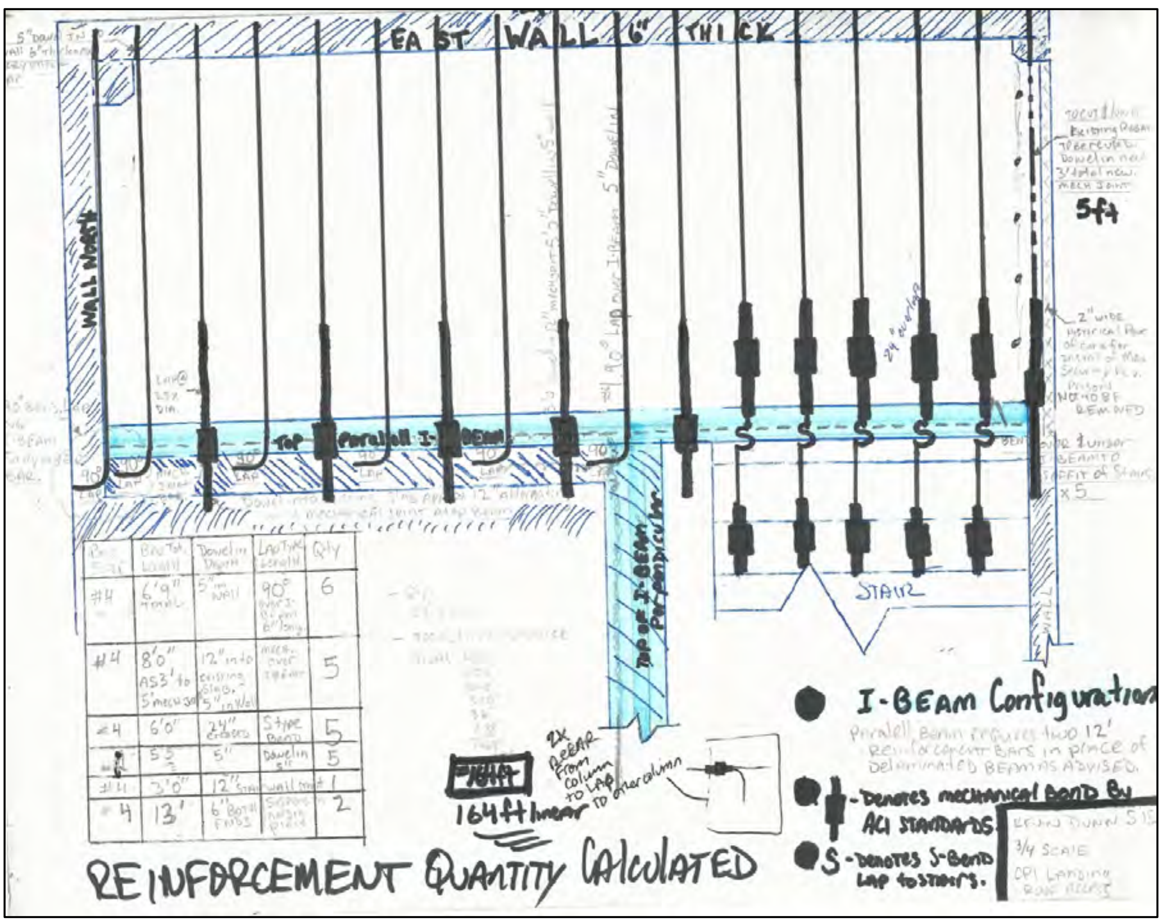

Figure 21: Reinforcement diagram and quantity calculations.

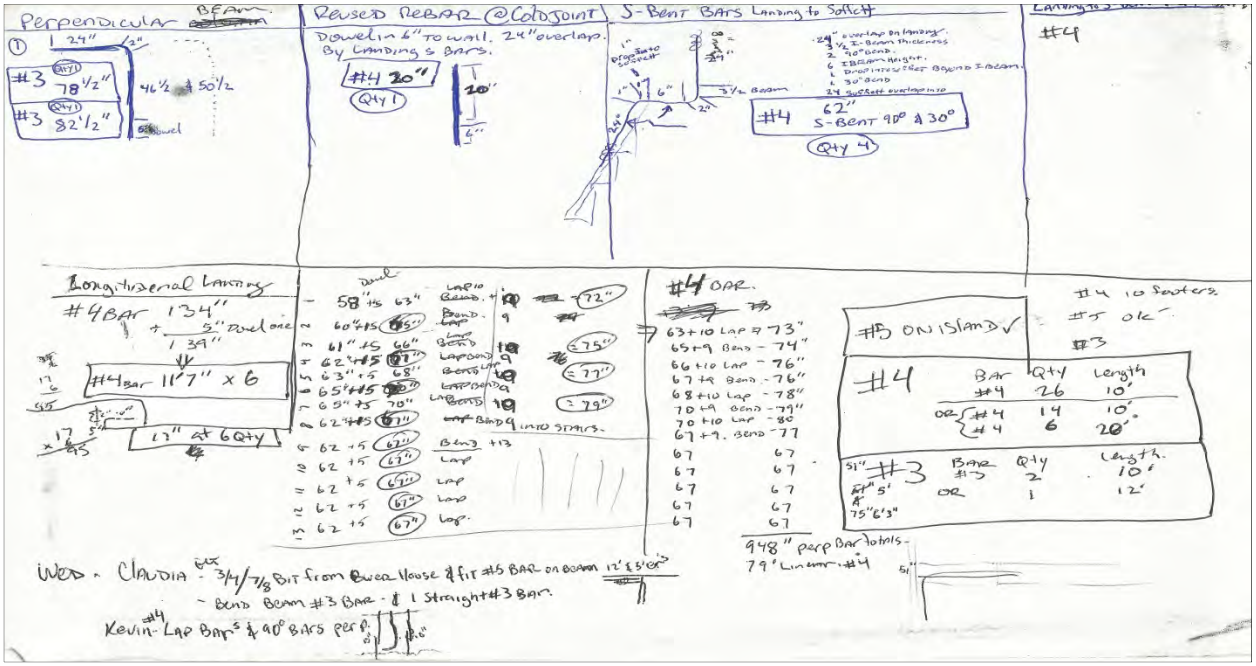

Figure 22: Reinforcing details.

- We decided to ensure adequate connectivity and continuity between landing and stair repair procedures using two methods. We used the S-bend lap method with #4 reinforcing steel. This tied in the landing over its parallel wide flange member (beam) by making a 90-degree downward bend thru a 5/8" drilled hole. We were advised to pass this through solid substrate at the toe-kick of the top step. It traveled 9 total inches before making a 36-degree bend into the bottom side soffit area. There it was lapped mechanically. This method was chosen over the Bolt and Bracket A307 method due to the section loss of steel within the body of the beam and the lack of substrate.

Figure 23: Upper side of s-bend lap reinforcing steel at landing connection to stairs

Figure 24: Lower side s-bend lap reinforcing steel at landing connection to stairs.

- The reinforcing bar at the east end of the platform was adequate in size and not corroded. This reinforcement was cleaned using three Hilti grinders. A rust inhibitor was applied to stop any further decay. The rest of the reinforcing steel in the landing was determined inadequate as per ICRI standards. Because of corrosion and the original construction design, after concrete placement it would have less than a 2" coverage. Therefore, it had to be removed. Once it was removed, we installed new reinforcing 1 ¼ " lower than the original design. We mechanically tied it to one 24” piece of #5 reinforcing bar that we dowelled into the existing wall using Hilti HIT-HY 200-A Epoxy.

Figure 25: Preserved in situ 5'9" section of steel reinforcing from original construction (circled in yellow).

- All new #4 bars in the 12” by 12” updated mesh grid were spaced at the specified 5” increment with lap joints at 10” lengths. The bars were anchored using Hilti Epoxy (HIT-HY 200-A).

Forming Plan

Materials and Methods

Using Structural Technologies Concrete Repair Guide, the team established that whalers would be installed at 4’ on center. Standard 1’ stiffbacks with ¾” plywood were also used. This support system could carry up to 2500 pounds per support, enough to support the calculated amount of S 466 material that would be placed. In addition to the eight support columns, we also used the north and west walls to anchor 4”x4” ledgers that could assist in load distribution due to the small confined work area. In both the stair and landing ledgers, we used HILTI 5/8” by 6-1/2” anchor bolts. These could hold the loads required by the ledgers and shoring posts (see following images for construction techniques and formwork details).

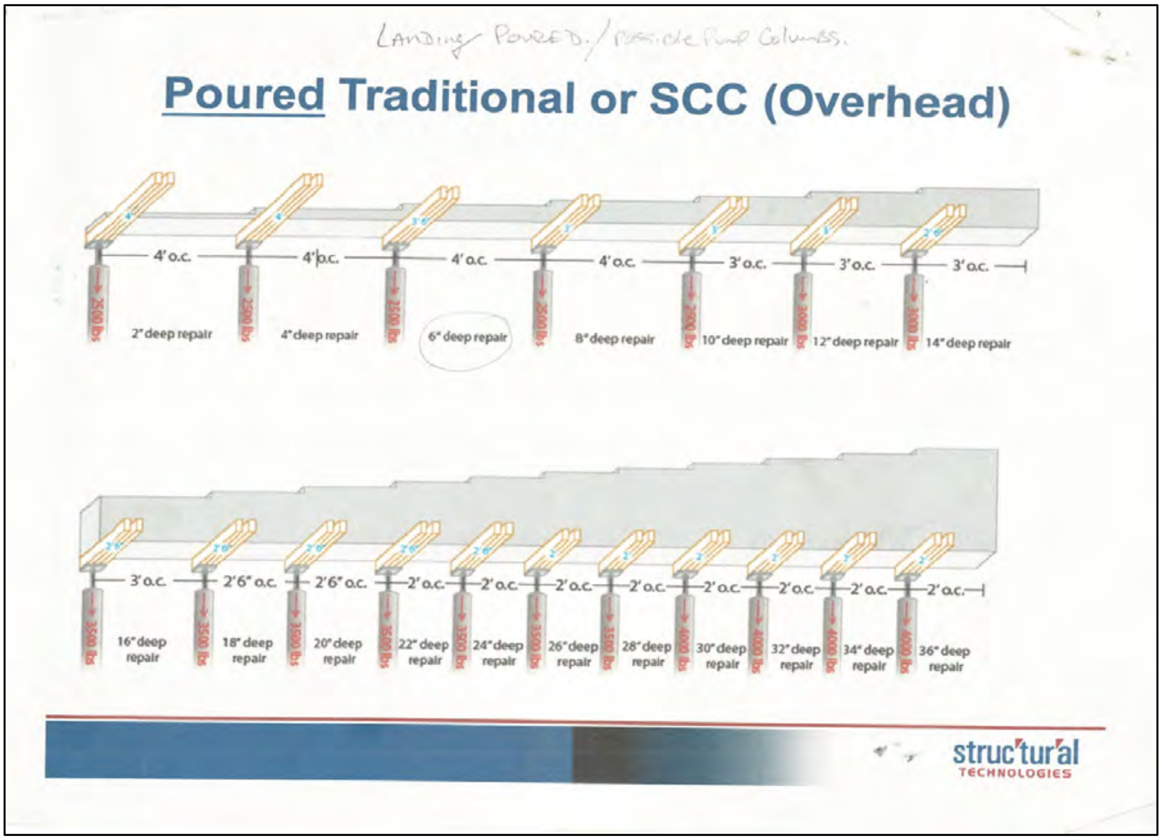

Figure 26: Page from Structural Technologies' Concrete Repair Guide – team used this to guide project.

We maintained the historical configuration of concrete in this location and around the Island by designing formwork solutions with ¾" chamfers. These are known as the "Alcatraz Chamfer".

See below drawing for Phase 1: Beam formwork. It shows the design for formwork that was needed beyond what the initial assessment showed.

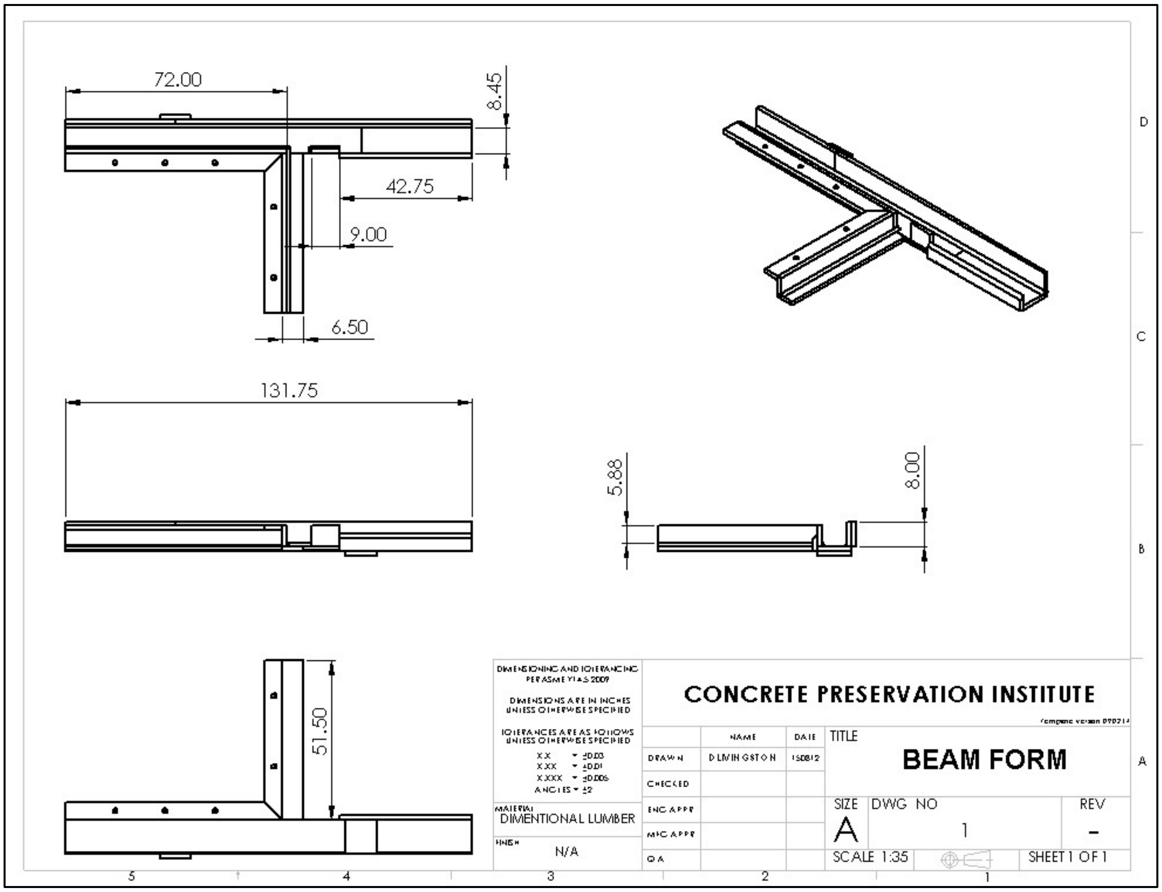

Figure 27: Formwork design for beams.

Figure 28: Beam formwork and shoring.

Figure 29: Beam formwork and shoring.

Figure 30: Beam formwork and shoring.

Figure 31: Landing slab formwork, shoring, stiff back, and whalers.

Figure 32: Landing slab shoring and formwork.

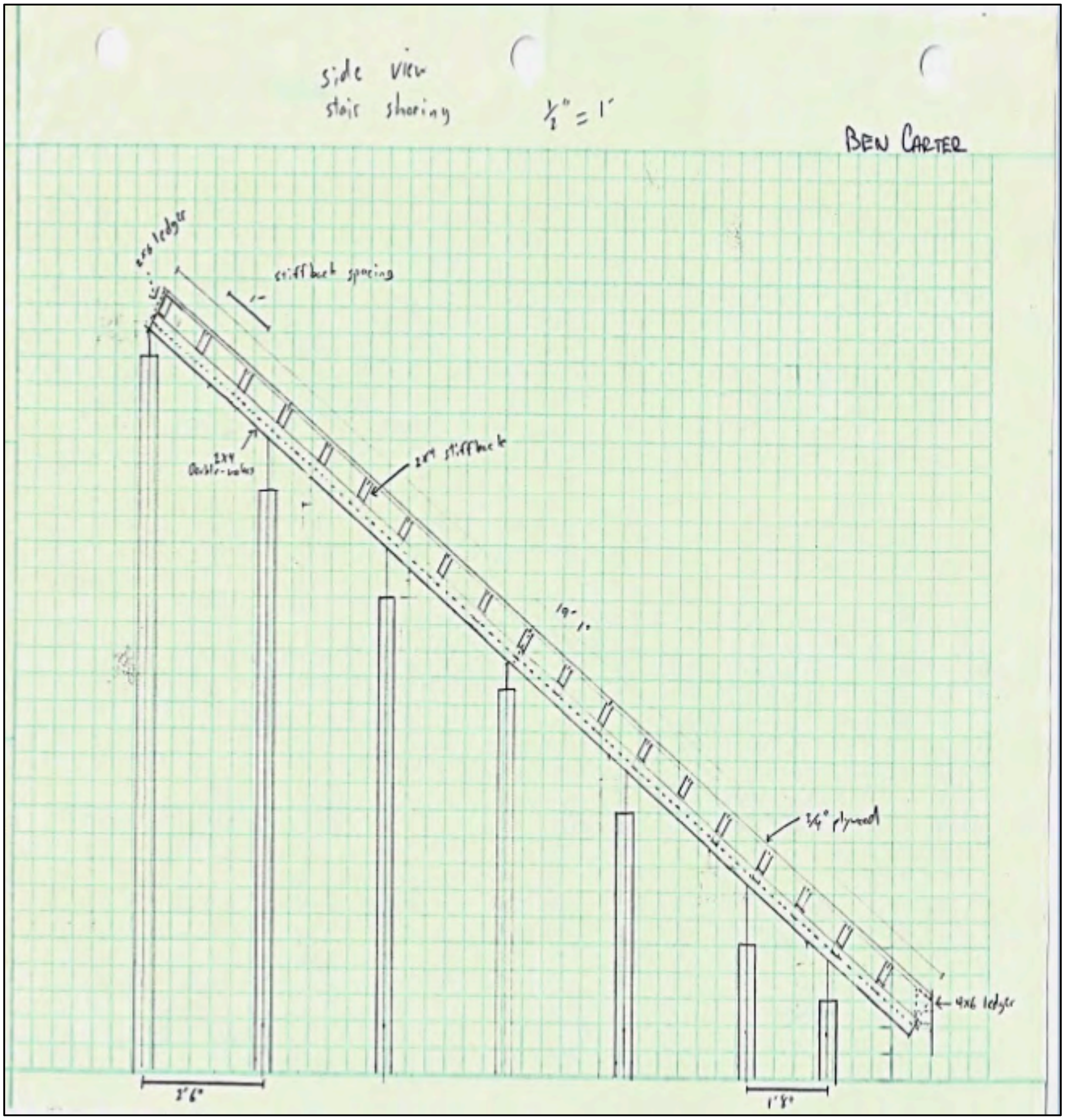

Figure 33: Stair soffit stiff back and whaler positioning diagram.

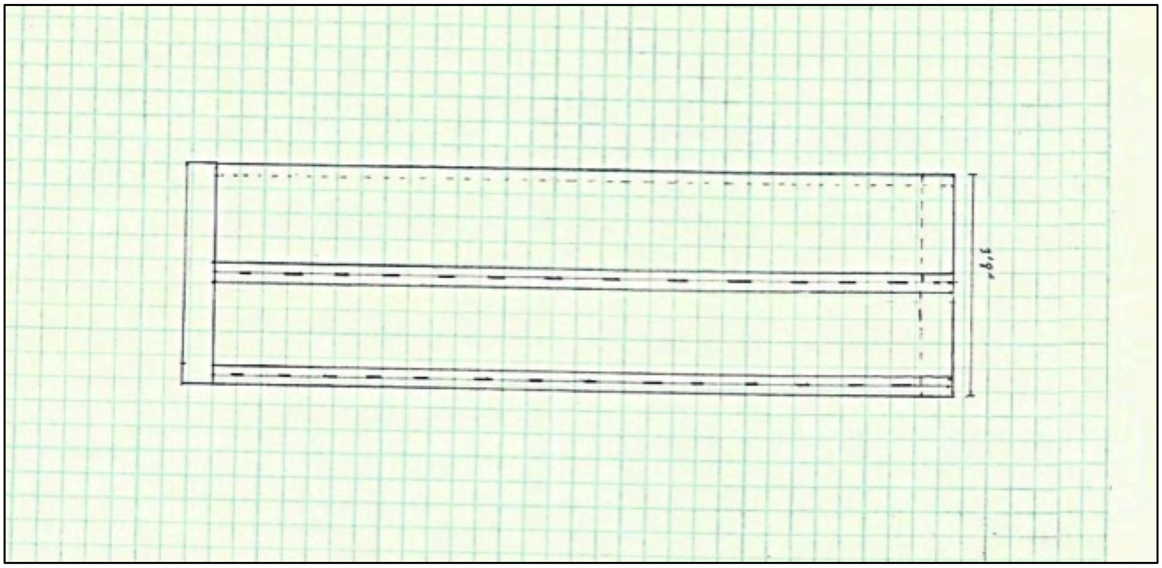

Figure 34: Stair soffit ledger and whaler positioning.

Figure 35: Stair soffit formwork and pump valve positioning.

Figure 36: Stair soffit formwork and pump valve positioning.

Concrete Placement

With the measurements presented in the existing conditions assessment section, the following calculations were completed for volume during repair Phase 1: Beams.

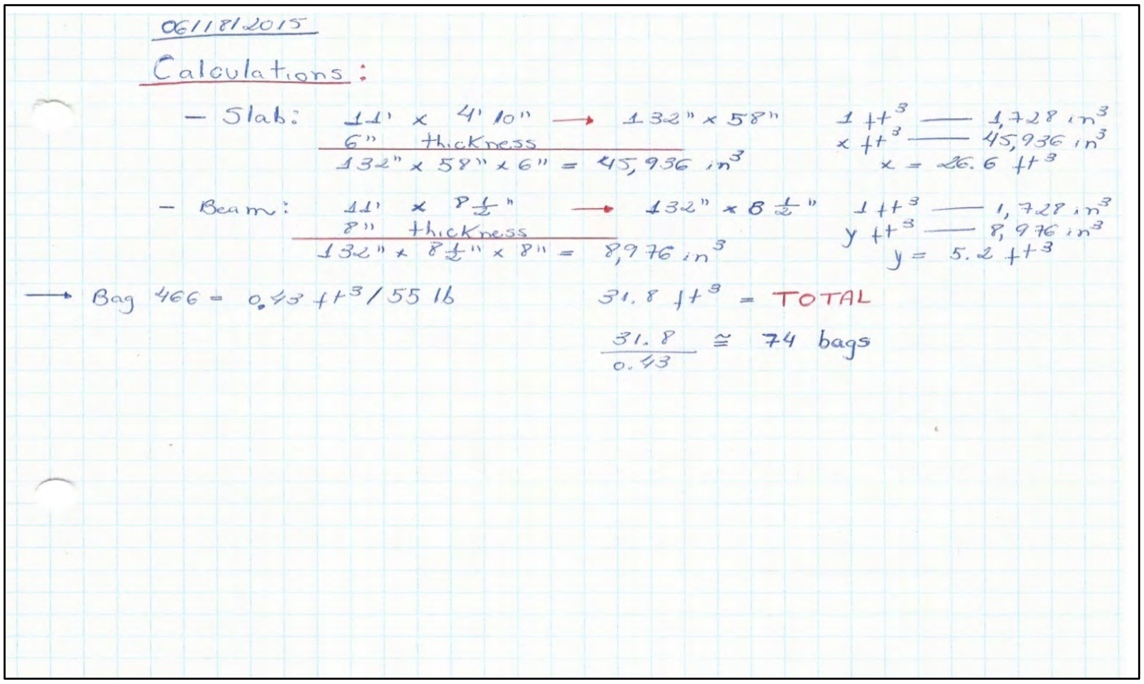

Figure 37: Phase 1 (beam) material volume calculations.

Knowing the types of concrete available for pouring slabs, stairs, and beams, and about corrosion inhibitors, self-consolidating products, and other specialized materials is an incredible benefit of working with CPI and their industry partners. We were able to take into account pumpability, consolidation, and workability for our materials. We were able to accurately calculate the amount of material necessary for mixing and pouring at each phase. Accurate calculations ensured proper quantities of materials shipped to the Island as well as estimates of man-hours for mix and pour coordination between teams. This ensured job safety, with adequate labor available, and the ability to maximize project productivity across four separate job sites.

The 66 bags of concrete used for the landing project had a total weight of approximately 3,630 lbs. We did that placement work in overnight shifts to avoid daily Park visitor interruption and hazards. The BASF S466 CI used in the landing, the 64 bags of S440 used in the stair soffit, and the 36 bags of S440 used in the beam were mixed with water content at the high end of the tolerable window recommended by the manufacturer. This aided in the pumping process for the bottom side (soffit) of the stairs, as increasing wind velocity on both nights of placement was a factor in the outdoor mixing area. In addition, the team decided to relocate the mix site form our intended location to ensure sensitivity to the nesting birds. Our form and shoring designs were validated during the mix and pour as all went well during pumping. The images below show forming and concrete once the forming was removed.

Figure 38: Formwork at landing.

Figure 39: Repair concrete at landing after removal of forms.

Figure 40: Repaired concrete at landing beam and slab after removal of forms (notice bottom side stairs at below/right/ demolition complete, awaiting formwork and repair).

Figure 41: Repaired concrete at landing.

6. Waste Management Plan

- Dried concrete from demolition was put in buckets.
- Transport of demolished concrete and waste slurry was made possible by using the Concrete Preservation Institute's 4x4 Diesel Kubota UTV.
- Unused wet concrete slurry was deposited in a container with the water utilized for cleaning buckets and left to settle until proper disposal.
- Wood waste was put in garbage cans and then disposed in specified containers.
- See following page map for locations of waste disposal.

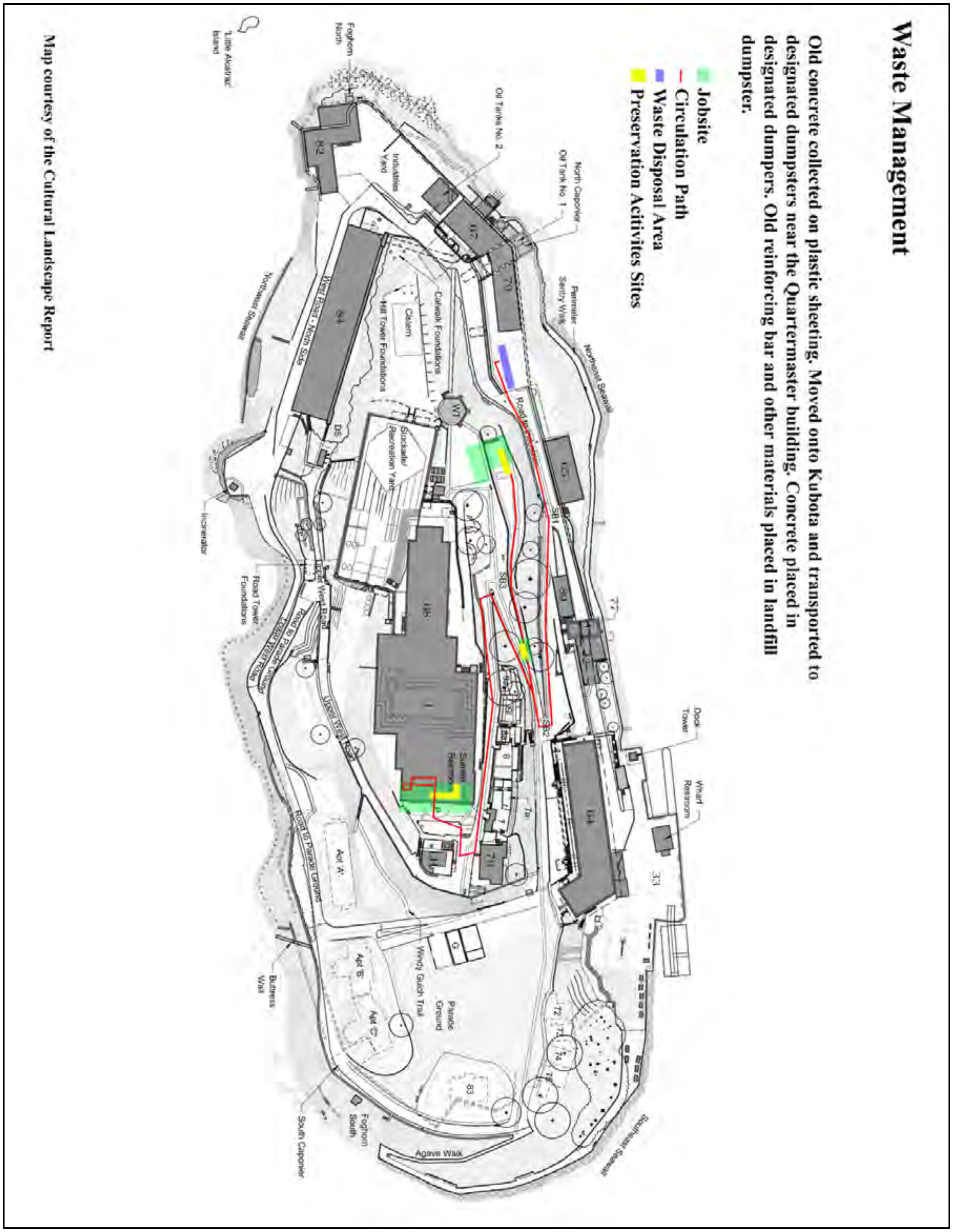

Figure 42: Waste disposal Plan

7. Repair Aesthetics

In order for repaired surfaces to be visually compatible with adjacent historic surfaces, the team applied a hand-pack and micro-topping materials all repaired surfaces.

Materials and Methods

- MasterEmaco S 1061 was mixed as per manufacturer specifications and hand-packed to fill-in minor cosmetic imperfections and necessary small voids that resulted from placing and pumping concrete into forms
- In order to smooth any rough surfaces, a grinder was used to remove all imperfections.
- Once the surfaces were sufficiently smooth, the surfaces were cleaned and a finish micro-top coat was applied over all repaired surfaces.
- Brickform brand Polymer micro-topping was the material used.
- The micro-topping was mixed with the specified 1 litre polymer per 10 lbs micro-topping. It was mixed using mixing paddles appropriate for the material. The mix was adjusted as needed within the product specifications.
- The micro-topping helped mitigate the markings left from the minor deformations of the wood formwork and other imperfections.

8. Completed Project Photos

Official recorded projects completion date: This 20th day, August 2015 at 12:55pm.

Figure 43: Completed landing.

Figure 44: Completed landing/stair connection.

Figure 45: Completed landing.

Figure 46: Completed beams and landing, view from beneath.

Figure 47: Completed beams, landing, and stair, view from beneath.

Figure 48: Completed beams and landing, close-up view from beneath.

Figure 49: Completed stair, view from beneath.

Stair Before and After Images

Figure 50: Stair before.

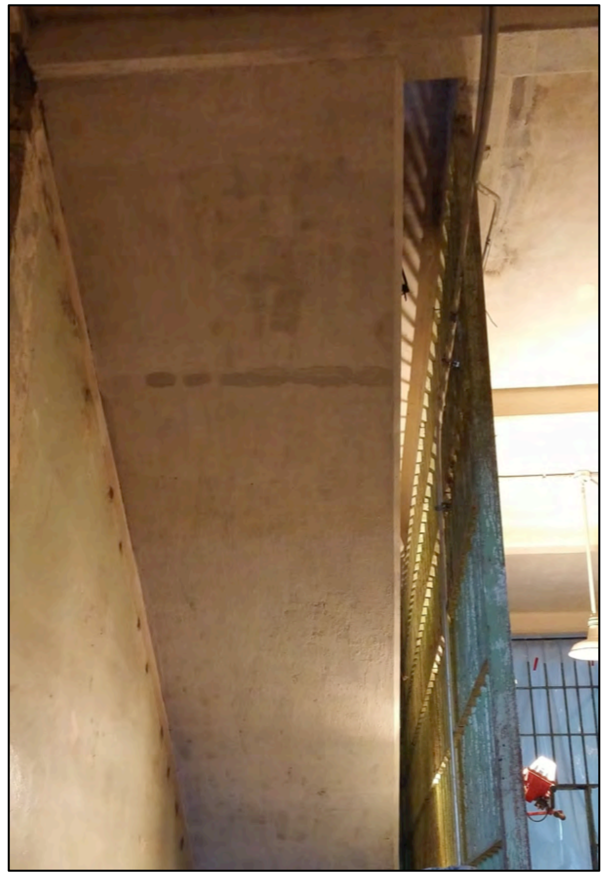

Figure 51: Stair after.

Landing and Beam Before and After Images

Figure 52: Landing and beams before.

Figure 53: Landing and beams after.