SITE PREPARATION AND CONSTRUCTION

The project sequence called for excavating and placing the units sequentially from west to east. Custom-designed trench boxes were used in the beginning to install the first precast wall pieces but were not needed later when AB discovered that the firm soil present allowed the trench to stay open. This allowed significant time saving for AB. As required, a layer of No. 57 stone bedding was placed in the trench before the units were placed and levelled. AB used a barge- mounted, long-arm excavator equipped with a global positioning system and specialized tools to excavate, place the stone layer, and grade it accurately. After advancing the wall sufficiently, AB placed the backfill behind the wall and prepared it for the eventual roadway and promenade; see Figure 11. The wall installation is expected to be completed in late summer 2019 with overall Phase 1 project completion expected in 2020.

CONCLUSION

The modular precast concrete gravity wall concept improved constructability, mitigated project risks, reduced costs, and provided a superior solution for the seawall alignment. It is expected that the owner will adopt this concept as the baseline in bidding the second phase of the project to be built east of the completed first phase. The concept can serve as a prototype for seawalls and shallow depth piers/wharves, where other conventional approaches, such as rock dike or driven sheet piles, are not practical.

Port of Long Beach Pier G Terminal: Terminal Rail Operation Efficiency Enhancement and Wharf Structural Integrity Improvements

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ABSTRACT

The Pier G Terminal Rail Operation Efficiency Enhancement and Wharf Structural Integrity Improvements Project at the Port of Long Beach (POLB), through collaboration, coordination, and innovative design accomplished the following objectives: 1. restored operational efficiency, previously impaired for terminal rail operations on the Metro bulk loading terminal, where they no longer could run around the railyard on the mainline tracks; 2. provided innovative retrofit repair of a crack in the concrete wharf structure; 3. minimal disruption of terminal operations during construction through a well-planned program requiring collaboration and flexibility in construction schedules to accommodate the dynamic schedules of train unloading and ship loading. The design team developed a plan to eliminate the terminal operator's use of the mainline tracks to run around the rail yard for access to the head end of the rail cars by constructing an 870-ft long lead track between POLB's mainline tracks and the rail yard. The team developed a simulation model of rail operations to demonstrate and confirm the benefits of the proposed track modifications in the project planning stage to obtain support for the project from the terminal operators and stakeholders. Another aspect of the project involved an innovative repair of a longitudinal crack, approximately 1,200 feet in length, on the existing reinforced concrete wharf structure. The repair restored the structural integrity of the wharf structure. One of the primary project accomplishments involved creative response measures and procedures addressing frequent schedule alterations for the highly dynamic train and ship schedules during construction. The bid documents outlined likely encountered issues during construction and established reactive procedures to accomplish the construction with minimal impacts to the terminal's operations and productivity. Despite the scheduling challenges and other difficulties at the site, construction was accomplished with efficiency and without visual loss in productivity for the terminal operators.

INTRODUCTION AND OBJECTIVES

The Port of Long Beach, California is the second busiest seaport in the United States and part of the largest port complex in North America. As a premier gateway for transpacific trade, POLB handles more than 6 million containers units a year with more than half of the inbound cargo going to points outside Southern California. With shipping volumes expected to increase significantly in the coming years, the POLB track facilities are a crucial link in the nation's efficient and sustainable goods movement system. Today, POLB is investing $1 billion on its Rail Enhancement Program and continues to invest heavily to improve the efficiency of rail operations throughout the POLB track system. The Terminal Rail Operation Efficiency Enhancement and Wharf Structural Integrity Improvements (the Project) was completed in 2017. It was a subsidiary project to the Green Port Gateway (first of the four vital rail construction projects completed in 2015) to increase rail capacity and improve rail efficiency throughout the POLB track system and improve rail access to POLB's marine terminals. Another objective of the POLB track improvement program is to make the rail facilities as efficient as possible to encourage movement of goods to and from the port by rail rather than by trucks because rail transport is much more efficient and environmental-friendly than transporting single loads via the roads and highways.

One of the major modifications in the Green Port Gateway Project was to separate the Metro rail yard from the mainline tracks, as a safety measure to fully separate Metro train operations from mainline track operations. Previously, POLB informed Metro they could not utilize the mainline tracks any longer to run around the rail yard. POLB and Jacobs recognized this would have a detrimental impact on the efficiency of Metro's rail operations and pursued to develope a plan for track improvements to restore efficiency in Metro's rail operations. POLB and Jacobs met with Metro to outline the proposed track modifications. In the early discussions, the terminal operators wanted to avoid any changes to the terminal rail facilities. Metro finally realized there may some be some potential benefits to modifying their operations and procedures; however, they remained skeptical of the overall effects of the proposed track modifications and continued to resist anything that would interrupt their established operations and procedures. Jacobs developed a computer simulation that clearly showed the improved efficiency of the Metro rail operations with the proposed track modifications. Metro went from opposing the changes to being advocates of the proposed changes; primarily due to the simulation, which clearly demonstrated the significant improvements in their rail operation efficiency with the proposed track modifications.

POLB had another reason to pursue the rail project due to a longitudinal crack in the existing wharf structure, that would threaten the integrity of the wharf structure. Accordingly, repair of the wharf structure was integrated into the project. This aspect of the project along with the need to maintain on-going train unloading and ship loading operations during the project construction required a highly developed phasing plan to ensure the terminal operations would not be interrupted during the construction.

DESIGN OF TRACK MODIFICATIONS

The basic concept of the proposed track modifications was to create additional railcar storage capacity away from the rail yard, so railcars that would occupy one track in the rail yard could be stored on temporary holding tracks while Metro's rail operations were in progress. The objective being to open one of the long storage tracks in the rail yard to have access to the other end of the yard, so the Metro engines can run around to the head end of the other yard tracks. With the new lead track constructed in the Green Port Gateway Project, the Metro engine would have access to the other three tracks to facilitate access to that end of the yard. The main yard has four tracks of almost ½-mile in length. Unit trains bound for Metro are limited to the number of cars that can fill two tracks in the yard. With a complex schedule of train movements consisting train arrivals via the mainline railroads, Metro unloading operations, Metro returning empty railcars to the main yard and train departures via the mainline railroads; the yard is fully loaded, or being utilized for operations, virtually all the time. Typically, there are no open tracks in the yard to gain access the head end of the yard.

In the planning for the track modifications, there is no space available to construct a runaround track adjacent to the main yard. Therefore, the plan came down to creating storage space in the southerly area of the terminal, located downstream of the railcar unloading facilities.

There are two types of unloaders at the facility. One is for bottom dump railcars and the other is for cars that do not have bottom dump trap doors. The unloaders are on opposite sides of the terminal, such that the bottom dump unloader has two tail tracks that extend down the length of the wharf. The other unloader and tail tracks are located on the other side of the facility. The basic concept of the track modifications was to create enough additional storage track capacity to store a number of railcars equivalent to the one full length of track in the rail yard. This was accomplished by providing additional storage tracks located downstream of each of the dumper units, which involved significant modifications to the terminal facilities and potential impacts to the terminal's standard operating procedures.

DESIGN OF STRUCTURAL REPAIRS TO THE WHARF DECK

Another major objective of the project was to provide retrofit repair of a longitudinal crack in the deck of the reinforced concrete wharf structure. The crack threatened the structural integrity of the wharf structure, which made the repair effort necessary. The crack was initially discovered in the wharf structure during a field exploration and assessment. The crack extended virtually straight through the full length of the 1,200-ft long wharf structure. Considering the terminal was in full operation with a busy schedule, POLB wanted to develop a plan to restore the structural integrity of the wharf structure while posing minimal impact on the terminal's train unloading and ship loading operations. Such plan was necessary to avoid the detrimental economic and financial impact to terminal operator and POLB.

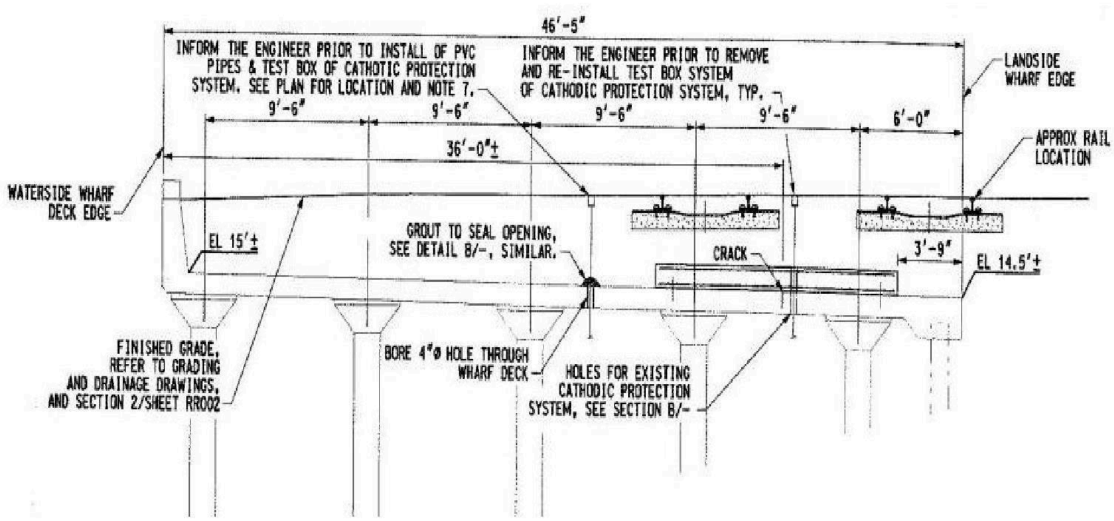

Figure 1. - Existing Wharf Section

The wharf was originally constructed in the 1961 time frame. The wharf has approximately 3.5- feet of fill over the top of the reinforced concrete wharf deck with a continuous paved surface extending across the full width of the wharf structure and beyond. The crack extended longitudinally through the entire wharf structure and all the way through the reinforced concrete deck. Exploratory excavations indicated the crack was no more than 1/8-inches wide at the most extreme areas. Throughout virtually the full length of the wharf structure, the wharf deck was not actually separated at the crack. The exact cause of the crack has not been determined and can only be speculated on at this time. There was virtually no variation in the alignment of the crack through the full 1,200-feet length of the wharf structure. The crack occurs 36.67-feet from the edge of the wharf structure, which is 47.42-feet wide overall. The crack is located partway between the first and second rows of support piers, where there is a total of five rows of supporting piling columns. In addition, heavy tieback rods end abruptly in the area of the first row of pilings, with additional reinforcing extending to the vicinity of the crack. Although there is some speculation that crack may be the result of abrupt changes in the reinforcing and variations in the stiffness of the support pilings. The length of the pilings becomes progressively longer with each row, due to the sloping revetment under the wharf.

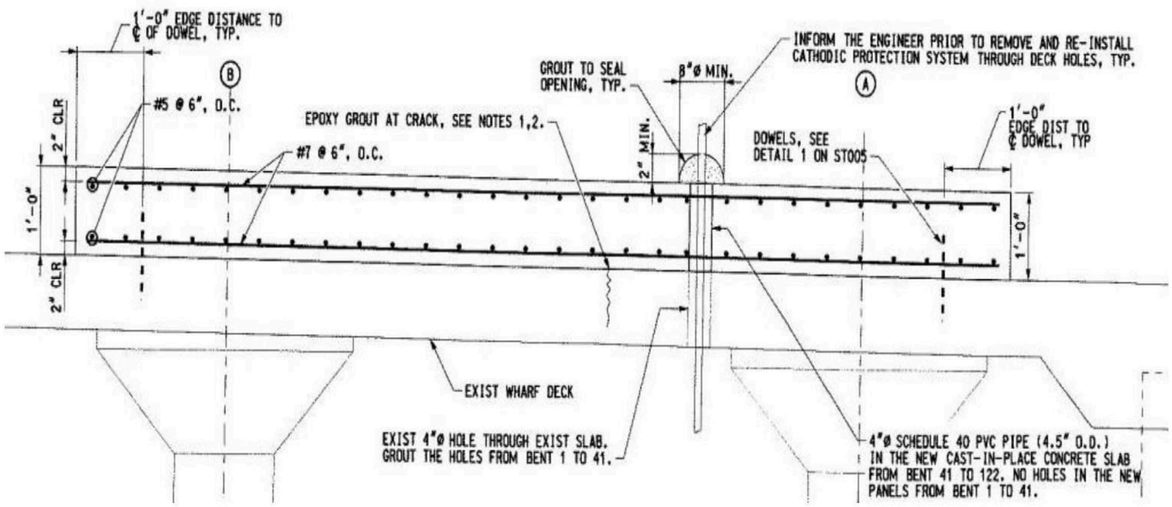

Figure 2. - Wharf Structural Retrofitting Repair

The progressively longer length of the rows of pilings above the sloped revetment makes them more flexible than the rows of pilings located adjacent to the landward edge of the wharf. The first piling column is the stiffest due to the shorter length above the point of embedment and the first row of pilings is on the landward side of the crack and all the others are on the other side of the crack. Changes in stiffness and abrupt changes in reinforcing may have contributed to creation of the crack.

The POLB structural engineers developed a repair for the crack consisting of a supplemental reinforced concrete slab tied to the deck on both sides of the crack. The new reinforced concrete slab extends several feet each side of the crack and is securely doweled to the existing wharf structure on both sides. We expect the slab will restore the structural integrity of the wharf structure and prevent continued separation at the crack (See Figures 1 and 2).

The crack is located part way between two exiting railroad tracks located on the wharf structure. These tracks were installed approximately 60 years ago and were known to be in poor condition, so we intended to replace them along with the other track modifications anyway.

POLB and Jacobs developed a phasing plan such that supplemental storage tracks that were part of the proposed track modifications anyway, would be constructed first to provide for terminal train operations while the repair slab was being constructed.

METRO OPERATIONS AND COMPUTER SIMULATION MODEL

Jacobs developed an operations model, simulating train operations at the terminal and railyard, that clearly demonstrated how the terminal rail operations could be conducted with the proposed track modifications and confirmed the benefits to Metro's operations (See Figure 3). The operations simulation was instrumental in winning the terminal operator's support for the full scope of changes. The model showed how the train of loaded railcars would be delivered to the rail yard at the Metro facility and showed how the cars would be maneuvered through the Metro unloaders, temporarily stored in the tail tracks, and eventually returned to the rail yard. The model showed how Metro's train operations would utilize the proposed additional storage tracks and use the new 870-ft long lead track to accomplish the train unloading with efficiency comparable to what they had prior to implementing the new restrictions forbidding Metro's use of the mainline tracks.

With the proposed operations, Metro can initiate the railcar unloading process and utilize the additional storage space in the southerly area of the terminal to temporarily store empty cars. With empty railcars temporarily stowed on the tail tracks, the Metro engine can gain access to the head end of the rail yard via an open track. The model showed the proposed track modifications would mitigate the loss of efficiency of the terminal's rail operations.

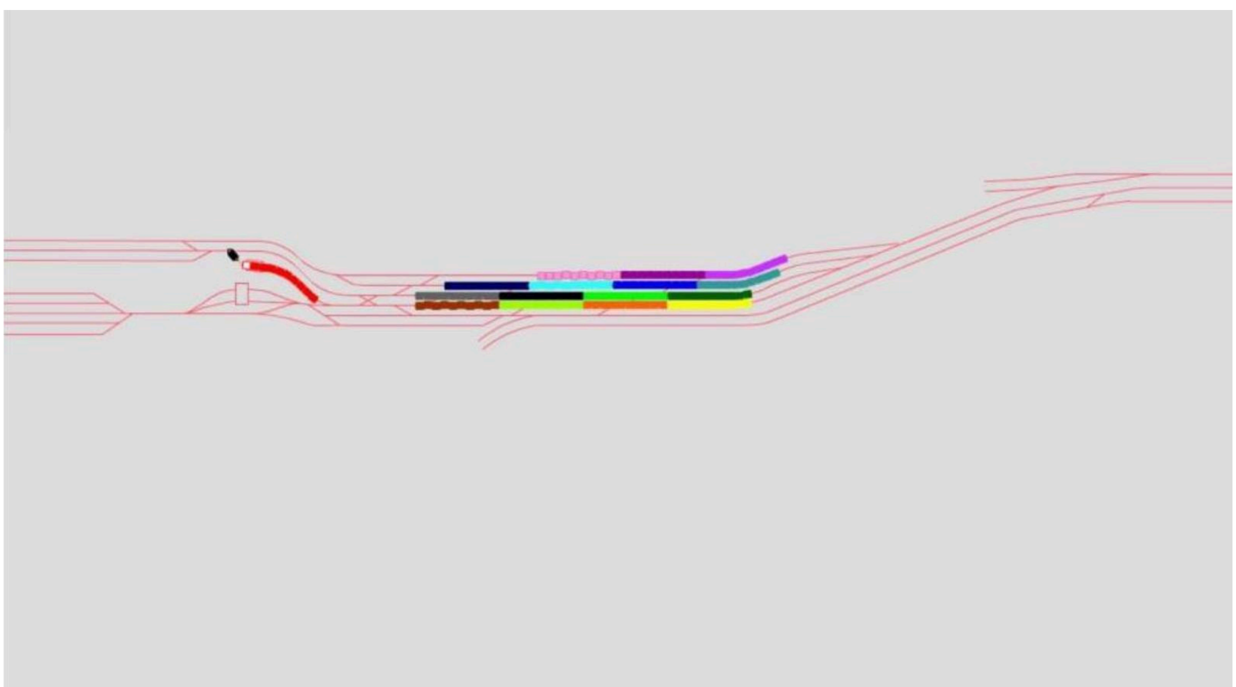

Figure 3. - Track Model Simulation

There are two unloaders at the Metro facility: one for bottom dump railcars and one for cars that have to be emptied by turning them over individually. The model was setup to show both operations. Operations related to the rotary dumper are considerably more complex than for the bottom dump unloader. In the case of the rotary dumper, there was space for additional storage tracks downstream of the dumper, so that could be implemented with no particular difficulties. The unloader for the bottom dump cars is located in the area adjacent to the wharf structure with two tail tracks located downstream of the dumper that extend the full length of the wharf. In the case of the bottom dumper, the plan included adding a new third tail track, located adjacent to the two existing tail tracks and out of the area where the wharf repairs were to be done. With the additional tail tracks, there would be sufficient temporary storage space to be equivalent to one track in the rail yard. With the open track, the Metro engine can have access to the head end of the rail yard. The new track at the wharf served a secondary, but important purpose by fulfilling the need for a tail track while the wharf repairs were in progress.

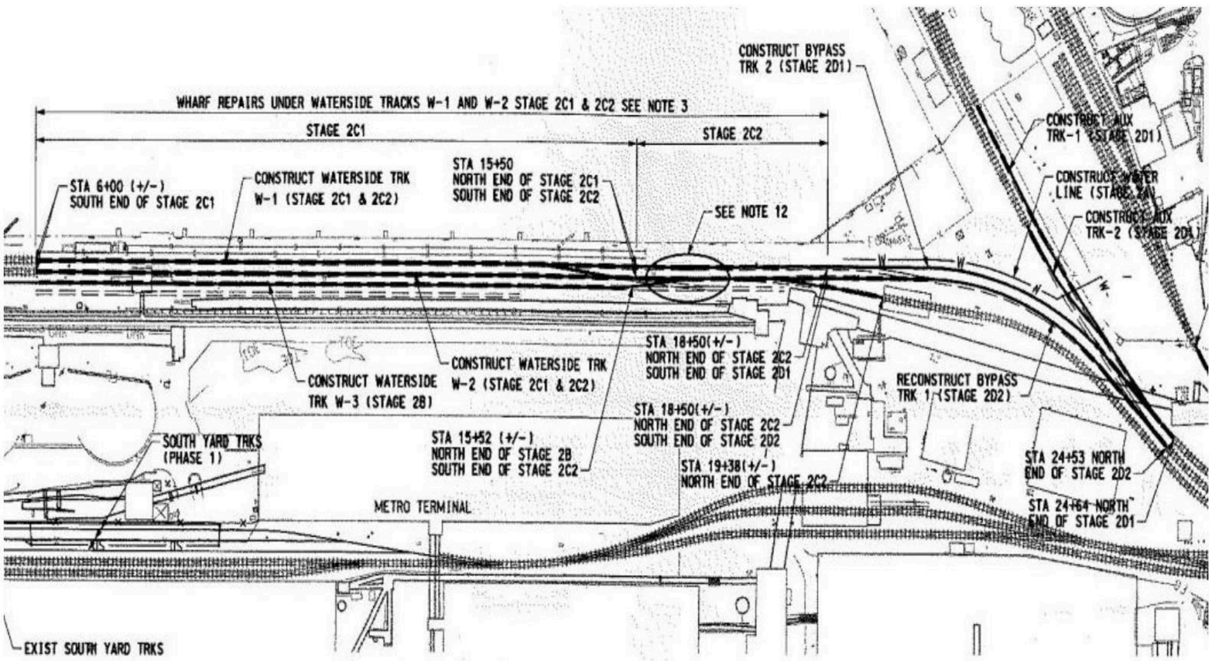

Figure 4. - Portion of Construction Phasing Plan

PROJECT PHASING

The project phasing plan included an additional track on the wharf to provide additional storage downstream of the railcar unloader facility, the purpose of which was to enhance the efficiency of rail operations upon completion of the project. This track is located to the side of the two existing tracks that were to be removed for construction of the wharf repairs and reconstruction of the two tracks. The new tail track is located away from the area where the two existing tracks would be removed for the wharf repairs. The phasing plan identified the new track to be constructed prior to initiating removal of the existing tracks and construction of the wharf repairs. This was the basis for maintaining the terminal's on-going rail operations while most of the crack repair slab was being constructed. However, one portion of the wharf repairs was in an area where train operations would have to be suspended at the bottom dump unloader while work was being conducted at that location. This was outlined in the phasing plan and Metro agreed to allow 14 days for this operation, but it had to be a time when they could schedule the break in bottom dump operations. A time was identified and the work was was accomplished as planned (See Figure 4). The project bid documents outlined the situation, required procedures and restrictions; and with commendable cooperation between all parties, the shutdown and timely construction was accomplished as planned.

CONSTRUCTION SCHEDULE

In order to accommodate the dynamic terminal train unloading and ship loading operations, both of which only had very short look-ahead schedules of less than two weeks, a collaborative approach was specified for the contractor to adjust their weekly and daily work programs when train and ship schedules dictated terminal operations should preempt conflicting construction activities. In addition, the contractor had to deal with the unique complications of water streaming from the conveyor systems located adjacent to and above the work site, and daily site wash downs, due to the terminal's on-going need to control dust from conveyor operations in compliance with air quality control regulations. The terminal operations included daily washdowns and water removal with vacuum trucks. The terminal does not have a drainage system throughout most of the facility because the terminal operator's emphatically expressed their preference for the vacuum truck water pickup method over a drainage system.

The required construction scheduling process was exceptionally effective in maintaining terminal operations throughout the construction process. A well-thought out phasing plan along with clear instructions to the contractor were instrumental in minimizing potential disruptions of the terminal operations and production throughout the construction process. In several instances, the contractor had to modify their work plan and schedule within one or two days in response to changes in ship and train schedules. Greater delay was encountered for work efforts that were dependent on longer outages of terminal operations. It is also noted the terminal operator and the contractor were extremely cooperative in reacting to unscheduled terminal activities throughout the construction program.

PREQUALIFICATION OF RAIL CONTRACTORS

In the early planning for this project, POLB and Jacobs were concerned about the prospect of contractors with little or no experience in track construction bidding on the project. We speculated this project was approximately eighty-percent about track construction and with the difficulties of scheduling crews etc.; we really wanted a contractor with proven record of success in track construction. Accordingly, a prequalification process was established that presented the full scope of the project to potential contractors and outlined the qualification criteria that would be applied to the review of the contractor's project prequalification documents. The process was extremely successful. In the final review, we received prequalification documents from six contractors. We deemed five of them as qualified under our predetermined review criteria. Later, in the bidding process for the final construction, bids from contractors that were not previously deemed qualified were disallowed. In the final bidding, we received bids from four prequalified contractors. In our opinion, the bids were in a tighter range than might occur with a more open process and we had more confidence in all of the bidders because we knew they had the ability to accomplish the specific needs of the proposed project construction. In the final analysis, we are confident this process was a critical element in the successful accomplishment of the project.

FINAL CONSTRUCTION PACKAGE

The total construction cost for the project was $8,981,705 and included the following improvements:

1. Realignment and modifications to 1,700-feet of existing rail yard tracks to improve efficiency of rail operations between the rail yard and the railcar unloaders.
2. Removal and replacement of 6,660-feet of terminal tracks and construction of new tracks to replace older track in poor in condition, accommodate retrofitting the wharf repair structural modifications and facilitate improved rail operations on the terminal.
3. Construction of a reinforced concrete slab on the wharf structure to retrofit a 1,200 long crack in the wharf structure.
4. Addition of 870-feet of new lead track (Constructed in the Green Port Gateway Project) to function as a buffer between the mainline tracks and Pier G rail yard. In addition, the new lead track allows the terminal's rail operators to have access to the rail yard tracks at the head end, whereas they previously utilized the mainline tracks for access between the tracks in the rail yard.

UNFORSEEN CONSTRUCTION COMPLICATIONS

During the construction, POLB and the construction support team became aware of advanced corrosion of track components in paved areas of the terminal where the track had been installed only 15 years earlier (See Photo 1). The degree of corrosion was highly variable. We observed some areas where there was no corrosion and areas where the corrosion advanced to the point the rail fasteners were completely corroded. This is in contrast to open ballast tracks in the rail yard, constructed in the same time frame, that had no corrosion problems at all. But, of course, the open ballast tracks are not under the conditions as the paved tracks within the terminal. A corrosion abatement procedure was developed in an effort to protect the new tracks being constructed. It was apparent the rail clips that hold the rails in place were experiencing the most corrosion. The rails and iron shoulders where holding up better, but still experienced more corrosion than was occurring for open ballast track.

Photo 1. - Tie Clip Corrosion

Evaluation and assessment of the problem was conducted and several potential methods of protecting the new track components were considered. However, time was of the essence because the much of the area was part way through the demolition process and could not be left open for an extended time. Some of the early options involving rapid cure asphaltic applications and other potential protective measures had to be dropped from consideration due to potential violation of air quality standards.

Specific circumstances and activities at the Metro terminal undoubtedly have contribute to the problem. The constant presence of water due to frequent washdowns is certainly a contributing factor in the advanced corrosion of the rail fasteners. In addition, residue from the bulk loading operations likely creates an additional dimension to the corrosion issue. Ultimately, we concluded the advanced corrosion must be related to penetration of water between the asphalt concrete and the rails. But, there are significant variations in circumstances at the terminal. Some areas have standing water virtually all the time, whereas, other areas are only rarely washed down. Even so, there was no correlation between the presence of water and degree of corrosion of the rail fasteners. Chemical analysis of the washdown water and residual material from the bulk loading operations indicated they were not particularly corrosive, but otherwise did not point directly at the water seepage or residual bulk materials as the primary source of the trouble. In the final review, two options were considered the best options to mitigate the conditions for the newly constructed track. Galvanizing the rail fastener clips or applying epoxy paint to metal components became the preferred alternatives as protective coating against corrosion. POLB selected the option for application of epoxy paint on the metal components of rail embedded in pavement to protect against the corrosive mix of water and residual materials, with the objective of extending the useful life of the track facilities (See Photo 2). However, the effectiveness of the efforts cannot not be verified until some later date.

Photo 2. - Epoxy Painting of Tie Clips

The rough nature of track construction, dumping ballast, tamping ballast and the whole