Santa Cruz Port District

Westside Seawall Replacement
Condition Assessment and Preliminary Engineering

SANTA CRUZ HARBOR

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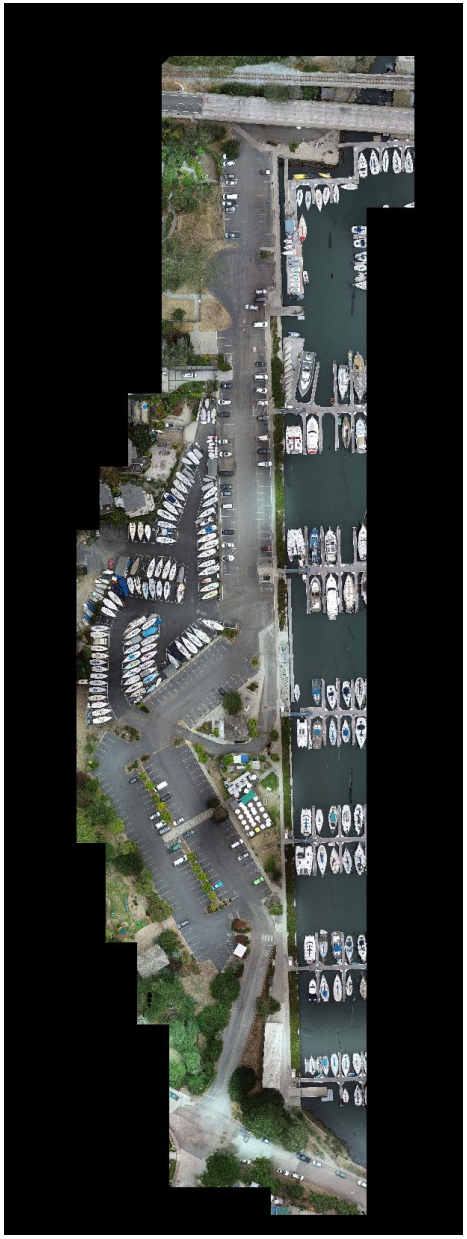
Introduction

The West Side Seawall was constructed in 1963 as part of the overall harbor improvements. The original construction drawings show a total wall length of 990 feet, however the wall was extended during construction and is actually 1240 feet.

The seawall consists of a row of sheet piles topped with a cast-in-place reinforced concrete cap beam (pile cap). The sheet piles are restrained by steel tie rods spaced at 9 feet on-center. The steel tie rods connect the seawall to buried concrete panels (deadmen) located a distance 50 feet behind the sheet pile wall.



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Project Site

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Structure Overview

Construction Information:

Year Built: 1963

Age: 60 Years

Structure Type: Steel sheet piles with concrete pile cap anchored to tie rods and buried concrete deadmen.

Length: 1240 feet

Sea Level Rise

Current Base Flood Elevation: +9.0 NAVD 88

Projected Base Flood Elevation: +10.0 NAVD 88 by 2070
(62% to 84% chance base flood elevation will exceed elevation 10.0 NAVD 88 by 2070)

Existing Top of Wall Elevation: Varies from +5.9 to +6.9

History

EARL AND WRIGHT INC CONSULTING ENGINEERS
49 FREMONT STREET · AN FRANCISCO 5, CALIFOR A

CONSTRUCTION REPORT
Report No. 248
Date. April 4, 1963

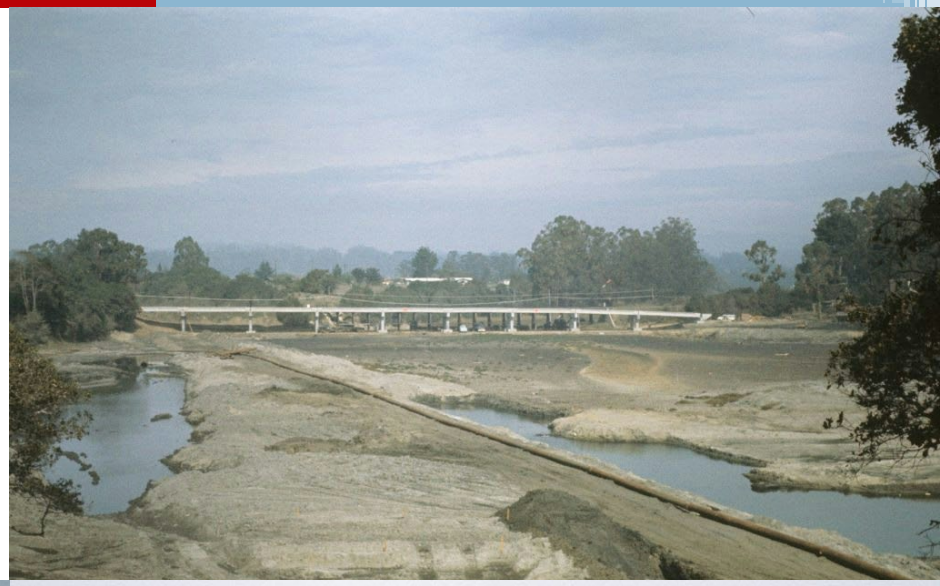
Contractor: GRANITE CONSTRUCTION CO.
Starting Date: April 4, 1962
Completion Date: June 28, 1963
Contract Time (Days) Total: 447
Elapsed: 366 Remaining: 81

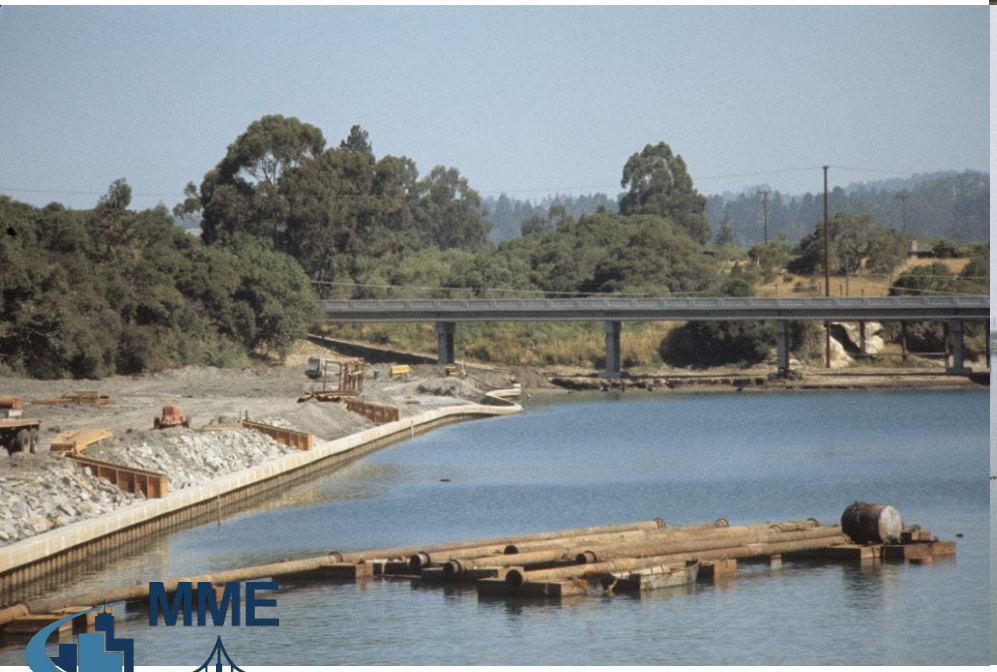
PROJECT I
SANTA CRUZ SMALL CRAFT HARBOR
SANTA CRUZ PORT DISTRICT
WORTH BROWN, CHAIRMAN
RALPH RING, PORT DIRECTOR

CONTRACTOR'S EMPLOYEES	
Superintendent	1
Foremen	1
Timekeeper	
Asst Engr	1

Weather: Clear
Material Received; Equipment Received or Released:
Construction progress and remarks:
Thursday
Sheet Pile Wall - West Side

EARL AND WRIGHT INC.
APR 10 '63
FILE





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Existing Conditions

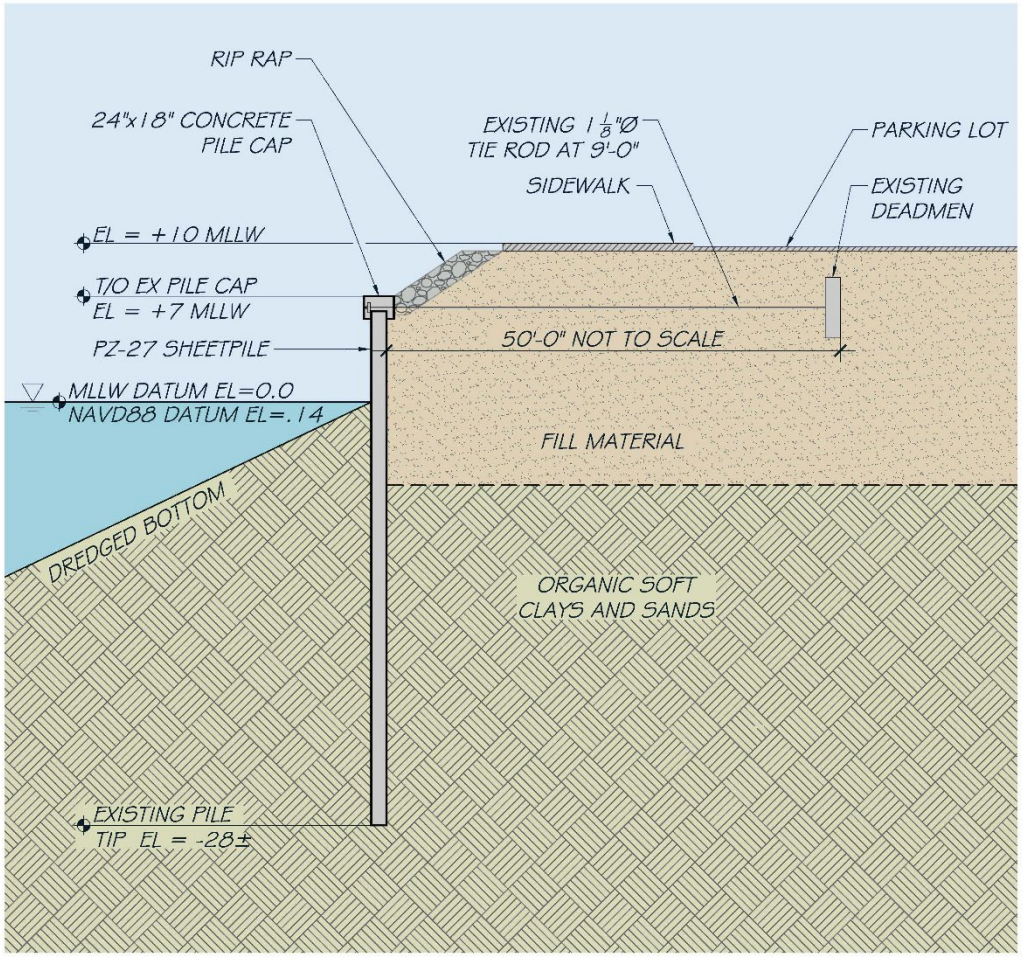

Figure 1 - Existing Seawall Section

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Sheet Pile Condition

Condition: Varies, Moderate to Severe Corrosion

- Thickness was tested at eight locations with ultrasonic thickness guage
- Original thickness of steel sheet piles was 3/8” (0.375 inches)
- Based on the average of our corrosion measurements, approximately 1/8” of steel has been lost to corrosion over 60 years (35% loss of thickness).
- Severe levels of corrosion are locations where there is 30% or greater loss of thickness.
- Several holes were found in the sheet piles near the mudline.

Table 3 – Corrosion Rate 2023			
	Thickness Loss	**Thickness Loss as a Percent of Original Thickness**	**Corrosion Rate**
Highest	0.24 inch	64%	0.004 inch/year
Lowest	0.04 inch	11%	0.0007 inch/year
Average	0.13 inch	35%	0.002 inch/year

Table 4 – Comparison of Corrosion Studies			
Study	**Thickness Loss**	**Period**	**Corrosion Rate**
1984 (Schaus)	0.06 inches	1963 to 1984 (21 Years)	0.0029 inch/year
2000 (Corrpro)	0.095 inches	1963 to 2000 (37 Years)	0.0026 inch/year
2023 (MME)	0.13 inches	1963 to 2023 (60 Years)	0.0020 inch/year

Pile Cap Condition

Condition: Varies, Moderate to Severely Deteriorated

- Condition varies from completely undamaged with no evidence of corrosion or spalling (almost like new condition) to significantly damaged with numerous cracks, splits and spalls.
- Pile cap was seriously damaged by the Loma Prieta earthquake of 1989
- Rust stains are visible which indicates the reinforcing steel is corroding

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Tie Rod Condition

Condition: Suspect Severely Deteriorated (not confirmed by visual examination)

- We did not conduct a detailed examination of the tie rods as part of this study
- There have been several studies of the tie rods over the years which have found mild to severe corrosion, kinks and even broken tie rods.
- Tie Rod Survey 1988/1989 by Schaus and Conmass Engineering estimated 10% reduction in the tie rod diameter due to corrosion in 1988.
  - ✓ A 10% loss in diameter corresponds to a 20% loss in cross sectional area and strength.
  - ✓ In 1988 (25 years after construction) the tie rods would have been at 101%+20% = 121% of the original design capacity. 35 years later, the extent of corrosion will have increased, resulting in more section loss and even larger over stress.
- Tie rod bearing assemblies embedded in the pile cap are exposed at several locations.
  - ✓ Some of the exposed bearing assemblies appear to be a stainless steel alloy which indicates the nut and threaded rod were replaced at some time
  - ✓ Other exposed bearing assemblies are heavily rusted and appear to be part of the original construction.
- The tie rods are critical for the support of the sea wall. The loss of a tie rod could lead to a progressive failure of the wall.

Evaluation Based on Original Design Criteria (No Corrosion / No Surcharge)

Objective:
Key structural engineering calculations from the 1963 seawall design were available for our review. Understanding the original design intent provides insight to the reserve capacity the wall possessed when it was new and how sensitive the wall will be to deterioration and corrosion.

Original Structural Design Criteria:

Design Loading:
Equivalent Fluid Pressure (EFP) = 30 psf/ft minus cohesion
Hydrostatic Pressure = 65 psf/ft
Passive Pressure (EFP) = 30 psf/ft plus cohesion
No allowance for live load surcharge
No allowance for seismic surcharge
Factor of Safety added to sheet pile embedment

Original Design Statistics:

Note: “Reserve Capacity” represents the amount of additional load a structural system can support before it becomes over stressed. “0% Reserve Capacity” would therefore indicate no additional load could be supported by the system and no additional corrosion could occur without causing over stress.

Table 1 – Original Design and Reserve Strength (Capacity)			
Wall Element	**Was The Original Design Structurally Adequate?**	**DCR Demand/Capacity Ratio**	**Reserve Capacity**
Sheet Pile	Yes	95%	5%
Tie Rods	No	101%	None (1% Over stressed)
Pile Cap	No	110%	None (10% Over stressed)
Deadmen	Not Analyzed	Not Analyzed	Not Analyzed

Conclusions and Recommendations

- It is our general opinion the majority of the 60 year old West Side Seawall has reached the end of its life cycle and will require replacement in the near future.
- The original design utilized the full design strength of the sheets piles, tie rods and pile cap.
- The original wall design had little or no reserve capacity (strength) to resist additional loads, such as those from live load surcharge or from earthquake surcharge.
- Because there is no reserve capacity, the wall is very sensitive to material loss or deterioration.
- By today's building design standards, the wall should have been designed to resist the additional load caused by earthquake surcharge and a live load surcharge.
- Based on our evaluation of the original design the tie rods specified utilized the full strength of the steel rods.
    - ✓ Corrosion and other damage to the tie rods has reduced their strength over time.
    - ✓ If a tie rod should become so overloaded that it breaks, a progressive failure could propagate down the wall.
    - ✓ If wholesale replacement is not feasible we recommend the tie rods be repaired.
- Due to the present condition of the West Side Seawall, the Port District should anticipate an increased chance of localized wall failures.

Photos of Westside Seawall

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Seawall Repairs

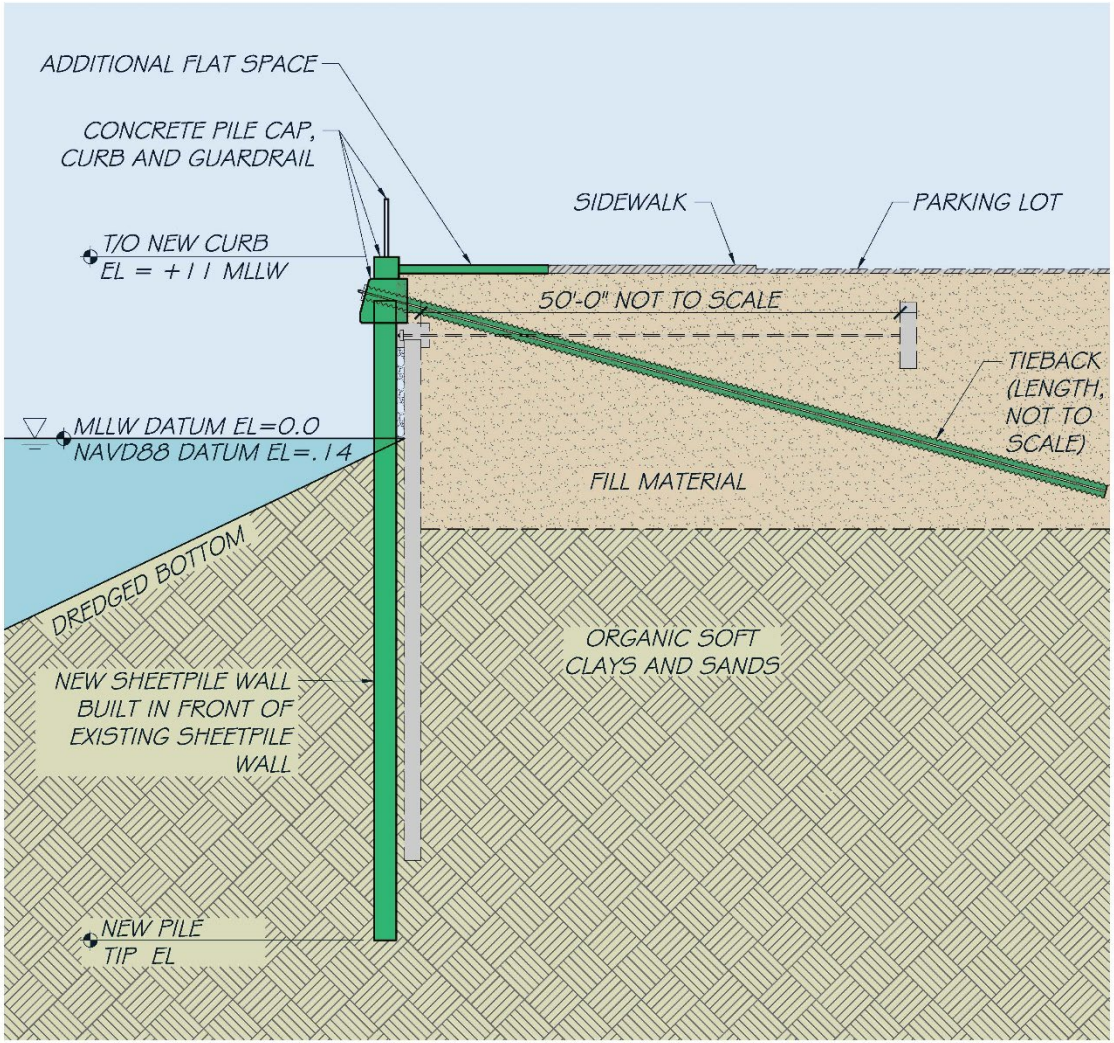

Figure 2 – Option #1 Outboard Wall

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Seawall Repairs

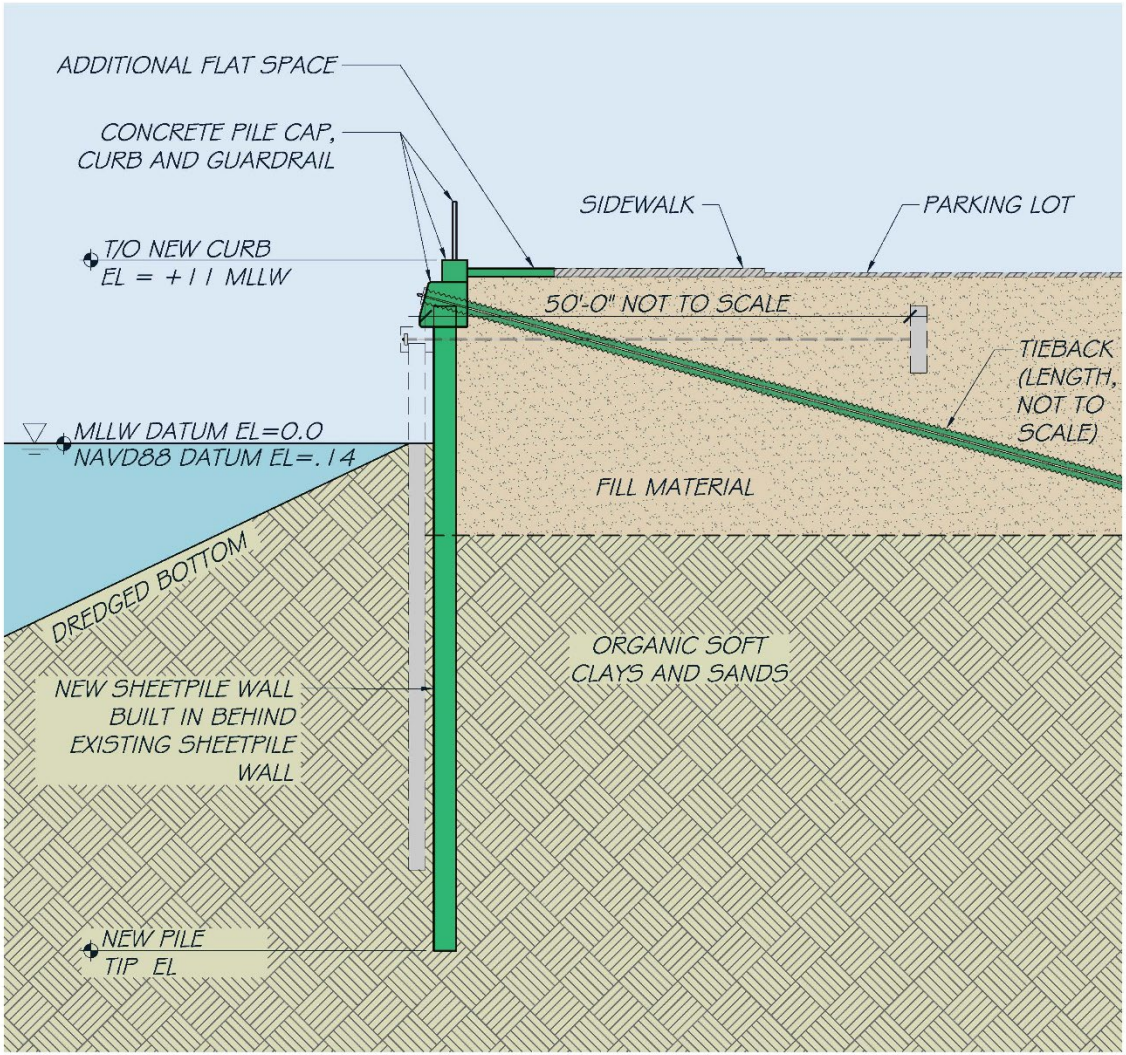

Figure 3 – Option #2 Inboard Wall

Questions

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