Appendix B
Structural Design Criteria

Anchorage Port Modernization Project
15 Percent Concept Plan Report
Structural Design Criteria

Prepared for

Port of Anchorage

December 8, 2014

CH2MHILL®

Revisions

Revisions					
Rev	**Description**	**Date**	**Prepared**	**Checked**	**Approved**
1	Updated Design Response Spectra	11/26/14	KJ	DGA	

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CLE	contingency level earthquake
COPRI	Coasts, Oceans, Ports & Rivers Institute
CVN	Charpy V-Notch
DC	Dead Load – Components and Attachments
DE	design earthquake
DW	Dead Load – Wearing Surface and Utilities
EL	elevation
g	Gravity
HOW	highest observed water
lb	pound
LOW	lowest observed water
LRFD	load and resistance factor design
MCE	maximum considered earthquake
MLLW	mean lower low water
MOTEMS	Marine Oil Terminal Engineering and Maintenance Standards
mph	miles per hour
$NOWL_{100}$	non-operating wind load 100 mph
OLE	operational level earthquake
OWL_{45}	operating wind load 45 mph
OWL_{70}	operating wind load 70 mph
pcf	pounds per cubic foot
PIANC	World Association for Waterborne Transport Infrastructure
PIEP	Port of Anchorage Intermodal Expansion Project
plf	pounds per linear foot
POLA	Port of Los Angeles
POLB	Port of Long Beach

psf	pounds per square foot
psi	pounds per square inch
RO/RO	roll-on roll-off
UFC	Unified Facilities Criteria
USACE	United States Army Corps of Engineers
USC	United States Code
V	velocity

I. DESIGN CODES AND REFERENCES

A. DESIGN SPECIFICATIONS—MARINE TERMINAL STRUCTURES

1. American Society of Civil Engineers (ASCE)/Coasts, Oceans, Ports, and Rivers Institute (COPRI) 61-14 *Seismic Design of Piers and Wharves*, 2014
2. *Marine Oil Terminal Engineering and Maintenance Standards* (MOTEMS) (California Building Code, Chapter 31F), 2011
3. American Association of State Highway And Transportation Officials (AASHTO) *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*, Sixth Edition with Interims, 2012
4. ASCE 7-10 *Minimum Design Loads for Buildings and Other Structures*, 2010
5. American Concrete Institute (ACI) 318-08 *Building Code Requirements for Structural Concrete*, 2008
6. American Institute of Steel Construction (AISC) *Steel Construction Manual*, 14th Edition, 2011
7. American Welding Society (AWS) D1.5 *Bridge Welding Code*, 2009

B. DESIGN SPECIFICATIONS—BUILDING AND BUILDING-LIKE STRUCTURES

1. International Building Code (IBC) (with Anchorage Local Amendments), 2009
2. ASCE 7-05 *Minimum Design Loads for Buildings and Other Structures*, 2005
3. ACI 318-08 *Building Code Requirements for Structural Concrete*, 2008
4. AISC 360-05 *Specification for Structural Steel Buildings*, 2005
5. AISC 341-05 *Seismic Provisions for Structural Steel Buildings*, 2005
6. AWS D1.1 *Structural Welding Code – Steel*, 2004

C. REFERENCE DOCUMENTS

1. ASCE *Seismic Guidelines for Ports*, 1998
2. Permanent International Association of Navigation Congresses (PIANC) *Seismic Design Guidelines for Port Structures*, 2001
3. Port of Long Beach (POLB) *Wharf Design Criteria*, v 3.0, 2012
4. Port of Los Angeles (POLA) *Code for Seismic Design, Upgrade and Repair of Container Wharves*, 2010
5. U.S. Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-2503, *Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures*, 1989
6. USACE Information Technical Laboratory (ITL) 92-11, *Seismic Design of Waterfront Retaining Structures*, 1992
7. USACE EM 1110-2-1100, *Coastal Engineering Manual*, 2011
8. United Facilities Criteria (UFC) 4-152-01 *Design: Piers and Wharves*, 2005
9. *Port of Anchorage (POA) Intermodal Expansion Project (PIEP) Suitability Study*, Final Summary Report, 2013

II. SERVICE LIFE

A. WHARF, TRESTLE, BULKHEAD, AND RETAINING WALL

1. All structural components will be designed for a service life of 75 years.

B. FENDER

1. Fenders will be designed for a service life of 25 years.

C. ROADS AND PAVEMENT

1. Pavement will be designed for a service life of 20 years.

D. BUILDINGS

1. Buildings will be designed for a service life of 50 years.

III. DESIGN LOADING AND LOAD COMBINATIONS

A. PERMANENT LOADING

1. Permanent loads will include the cumulative weight of the entire structure, including the weight of all structural components, pavement, utilities, and other permanent attachments. In lieu of specific material test data, standard unit weights below will be used to calculate permanent loads:

Cast-in-Place and Precast Concrete:	150 pounds per cubic foot (pcf)
Structural Steel:	490 pcf
Traffic Barrier:	Actual Load
Soil and Landscaping:	125 pcf
Compacted Sand, Earth, Gravel, or Ballast:	140 pcf
Asphalt Pavement:	150 pcf

Other dead loads such as utilities will be included as information becomes available.

B. LIVE LOADS

1. Uniform live load: The wharf will be designed for a uniform live load of 1,000 pounds per square foot (psf).

   - For pavement and local design, uniform live load should not be applied to the area occupied by truck, mobile crane, or loading and/or unloading equipment. When combined with rail-mounted crane loading, the uniform live load should be 300 psf with no uniform loading within 5 feet of either side of the crane rails.

   - For global stability use the large of specific equipment loads or 1,000 psf but not both.

2. Truck load: The wharf will be designed for AASHTO HS25 truck (HS20 truck with axle loads increased by a factor of 1.25). Impact will be in accordance with AASHTO LRFD Bridge Design Specifications Section 3.6.2.

3. Mobile crane load: The wharf will be designed for 275-ton crawler crane and /or truck crane.

4. Loading/unloading equipment: The wharf will be designed for equipment loads including 80,000-pound top-pick (Taylor TEC-950L loaded container handler or equivalent) and 100-ton forklift. An impact factor of 10 percent to the maximum wheel loads in the design of slabs, beams, and pile caps will be applied. Impact factor should not be used for the design of piles and other types of substructure.

5. Rail-mounted container crane load: All 50-foot-gage crane rail beam and supporting substructure will be designed for the maximum operating vertical load of 50 kips per linear foot, including impact based on wheel spacing shown in Figure 1. These rail loads include both dead and live loads and will be used with a load factor of 1.3. The crane stowage pins will be designed for a horizontal load of 50 kips per socket. Crane tie-down loads will be 800 tons at each corner.

Crane stops will be designed to resist a 200-kip load acting horizontally 3 feet-6 inches above the top of rail per stop.

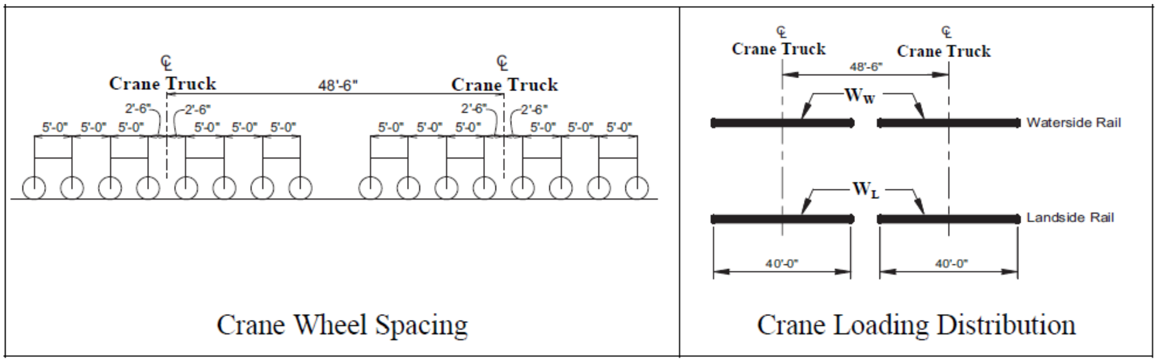


FIGURE 1. Crane Wheel Spacing and Load Distribution for 50 Foot Gauge Container Crane

6. <u>Roll-on roll-off (RO/RO) ramp</u>: RO/RO ramp axle loads will be as shown in Figure 2.

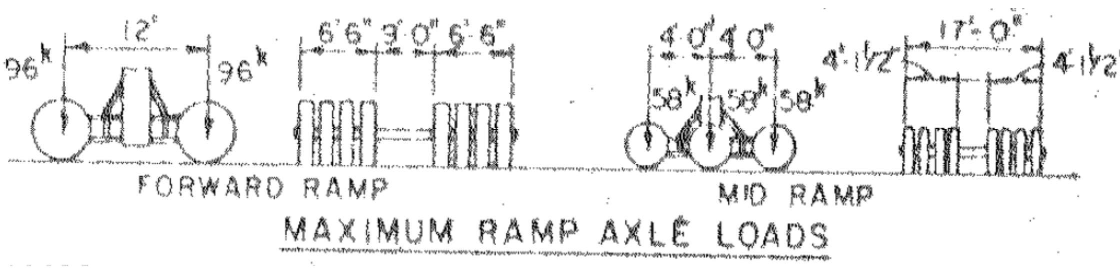


FIGURE 2. RO/RO Ramp Axle Loads

C. EARTHQUAKE LOADS

1. The description in accordance with ASCE/COPRI 61-14 Chapter 2 for seismic design classifications, performance levels, and hazard levels will be used for the following seismic design criteria. The seismic design criteria for each structure of Concept A, C, and D will be as specified in Tables 1, 2, and 3:

2. The three levels of earthquake ground surface accelerations were determined from a site-specific probabilistic seismic hazard analysis (PSHA) in combination with site-specific dynamic ground response analyses. The site-specific dynamic ground response analyses accounted for the effects of local soil conditions on ground response with resulting ground motions at the ground surface (mudline or backlands) as shown in Table 4. The level 3 (highest level) earthquake is denoted as Maximum Considered Earthquake (MCE).

3. Design response spectra for the three levels of earthquake loading are presented in Attachment A. "Maximum direction effect" is considered for the Maximum Considered Earthquake (MCE) by applying 1.3 factor to the MCE design response spectral acceleration at periods greater or equal to 1 sec.

4. Earthquake time histories for the three levels of earthquake will follow recommendations of the *Anchorage Port Modernization Project Seismic Ground Response Study Report* (November 25, 2014).

5. When liquefaction-related permanent lateral ground displacements (e.g., flow, lateral spreading, or slope instability) are determined to occur, the effect of lateral ground displacements on foundations and retaining structures will be evaluated in accordance with

requirements of ASCE/COPRI 61-14, Section 4.5.5; MOTEMS, Section 3106F.4; POLB *Wharf Design Criteria,* Section 2.9.2; and AASHTO *LRFD Bridge Design Specifications,* Section 10.5.4.

TABLE 1
Seismic Design Criteria – Concept A

Structure	Design Classification	Seismic Hazard Level	Seismic Performance Level
New Terminal 3 and approach trestles	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection
New Terminal 2 and approach trestles	High	OLE	Minimal damage
	High	CLE	Controlled and repairable damage
	High	DE	Life safety protection
New Terminal 1 and approach trestles	Moderate	OLE	Minimal damage
	Moderate	CLE	Controlled and repairable damage
	Moderate	DE	Life safety protection
New POL 1 and approach trestles	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection
Retrofitted POL 2			No change to existing structure

Notes:

DE level is equivalent to two-thirds of MCE per ASCE 7-10. Ground motions from ASCE 7-10 exceed those from ASCE 7-05 specified in ASCE/COPRI 61-14.

[a] Seismic performance level above that required by ASCE/COPRI 61-14

CLE contingency level earthquake
DE design earthquake
MCE maximum credible earthquake
OLE operating level earthquake

TABLE 2
Seismic Design Criteria – Concept C

Structure	Design Classification	Seismic Hazard Level	Seismic Performance Level
New Terminal 3 and approach trestles	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection
New Terminal 2 and approach trestles	High	OLE	Minimal damage
	High	CLE	Controlled and repairable damage
	High	DE	Life safety protection
New Terminal 1, POL 1, and approach trestles	Moderate	OLE	Minimal damage
	Moderate	CLE	Controlled and repairable damage
	Moderate	DE	Life safety protection
New POL 2 and approach trestle	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection
Retrofitted POL 2 (temporary structure)			No change to existing structure
Retrofitted Terminal 1, POL ,1 and approach trestle (temporary structures)			No change to existing structure

Notes:

DE level is equivalent to 2/3 of MCE per ASCE 7-10. Ground motions from ASCE 7-10 exceed those from ASCE 7-05 specified in ASCE/COPRI 61-14.

[a] Seismic performance level above that required by ASCE/COPRI 61-14

CLE contingency level earthquake
DE design earthquake
MCE maximum credible earthquake
OLE operating level earthquake

TABLE 3
Seismic Design Criteria – Concept D

Structure	Design Classification	Seismic Hazard Level	Seismic Performance Level
New Terminal 2 and approach trestles	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection
New Terminal 1 and approach trestles	High	OLE	Minimal damage
	High	CLE	Controlled and repairable damage
	High	DE	Life safety protection
New POL 2 and approach trestle	Moderate	OLE	Minimal damage
	Moderate	CLE	Controlled and repairable damage
	Moderate	DE	Life safety protection
New POL 1 and approach trestle	Seismic berth	OLE	Minimal damage
	Seismic berth	CLE	Minimal damage [a]
	Seismic berth	DE	Life safety protection

Notes:

DE level is equivalent to 2/3 of MCE per ASCE 7-10. Ground motions from ASCE 7-10 exceed those from ASCE 7-05 specified in ASCE/COPRI 61-14.

[a] Seismic performance level above that required by ASCE/COPRI 61-14

CLE contingency level earthquake
DE design earthquake
MCE maximum credible earthquake
OLE operating level earthquake

TABLE 4
Three Levels of Earthquake Ground Surface Accelerations

Earthquake	Return Period (years)	Peak Horizontal Ground Acceleration—Landward Location (g)	Peak Horizontal Ground Acceleration—Seaward Location (g)
OLE	72	0.17	0.21
CLE	475	0.31	0.23
MCE	2,475	0.39	0.27

CLE contingency level earthquake
g gravity
MCE maximum credible earthquake
OLE operating level earthquake

D. EARTH PRESSURE LOADS

1. Earth pressure loads used in the design will be per AASHTO *LRFD Bridge Design Specifications*, USACE *Seismic Design of Waterfront Retaining Structures*, and USACE *Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures*.

E. BUOYANCY LOADS

1. Buoyancy forces will be considered for any submerged or immersed substructures.

F. HYDROSTATIC AND HYDRODYNAMIC WATER LOADS

1. Hydrostatic water loads for sheet pile bulkhead structure will be calculated using the phreatic water table elevations presented in Table 5.

TABLE 5
Hydrostatic Water Table Elevation

	Limit Equilibrium	
Loading Case	**Water Elevation in Front of Wall (feet MLLW)**	**Water Elevation Behind Wall (feet MLLW)**
Static (construction/long-term undrained/post-earthquake)	-5	20
Static (drained)	7.5	20
Seismic	7.5	20

MLLW mean lower low water

2. Hydrodynamic water loads will be used for sheet pile bulkhead structures based on methods recommended by Westergaard as follows:

- **Sea side of wall—**The hydrodynamic water pressure force on the outboard side of the sheet pile bulkhead structure should be determined by using the Westergaard equation. The critical case for the bulkhead design is when this hydrodynamic pressure is acting away from the wall (i.e., seaward). In this condition, the hydrodynamic water pressure is subtracted from the hydrostatic water pressure. The magnitude of the hydrodynamic water pressure force is given by the following equation:

$$P_w = \frac{7}{12} K_h \gamma_w H^2$$

  Where k_h is the horizontal seismic coefficient, γ_w is the unit weight of water, and H is the water depth. This force is applied at 0.4 of the water depth (H) on the face of the wall. It is a temporary force during the seismic event, and therefore, use of this force results in design conservatism.

- **Land side of wall**—The additional force in the saturated soil behind the sheet pile bulkhead structure will depend on the relative movement between the backfill soil particles and the porewater that surrounds the particles. If the permeability (k) of the soil is small enough (for example, k ≤ 10-3 centimeters per second [cm/sec]), then the porewater moves with the soil during the earthquake (that is, no relative movement of soil and water), which is referred to as a restrained porewater condition. In this case, the inertial forces will be proportional to the total unit weight of the soil. If the soil has a high permeability, the water moves independent of the wall and produces an added force defined by the Westergaard equation given above.

G. WIND LOADS

1. Wind loads will be derived from three wind speeds: 45 miles per hour (mph), 70 mph, and 100 mph, as described below. All specified wind speeds are 30 seconds duration wind speed.
2. The cranes will operate normally at wind speeds of 45 mph. The wind loads acting on the ship, crane, and structure for this case will be referred to as OWL_{45}.
3. The cranes will be designed to travel to the tie-down position at wind speeds of 70 mph. This is also the maximum wind speed at which ships will remain at berth. Above these wind speeds, ships will be expected to leave the berth. The wind loads acting on the ship, cranes, and structure for this case will be referred to as OWL_{70}.
4. The cranes will be tied down at wind speeds greater than 70 mph. The maximum wind speed used for design in this non-operating position will be 100 mph. Ships will not be at berth during these wind speeds. The wind loads acting on the cranes and structure for this case will be referred to as $NOWL_{100}$.

H. MOORING LOADS

1. Wind loads on vessels moored at the wharf will be determined using wind speed specified in Section III.G.3 of these Structural Design Criteria. Extreme wind events are considered to be the following 50-year return period 1-hour averages:

   From the west: 9 knots
   From the north: 44 knots

2. Current loads on vessels will be calculated using the following current speed:

   Ebb tide average: 2.5 knots, southwest
   Flood tide average: 1.5 knots, northeast
   Ebb maximum average: 3 knots, southwest
   Flood maximum average: 2.9 knots, northeast

3. Wave loads on vessel will be calculated using the following significant wave height and period (correspond to 50-year, 1-hour extreme winds):

   Westerly: 3.5 feet (4.5 seconds)
   Northerly: 2 feet (3.5 seconds)

4. Mooring bollards will be placed at 60 feet on center.
5. Mooring load on bollards will be 150 tons with range of horizontal angle from 0 to 180 degrees and range of vertical angle from 0 to 45 degrees.

I. BERTHING LOADS

1. Ship berthing loads will be derived using the following approach velocities and berthing angles:

   Approach velocity when berthing: 0.66 feet per second
   Approach angle when berthing: 10 degrees
   (Assume reaction force = 200 tons)

2. Ship berthing loads will be derived using the following design vessel characteristics:

   Length: 1,000 feet
   Beam: 140 feet
   Draft: 45 feet
   Ship displacement: 76,000 deadweight tons

J. ICE LOADS

1. The wharf will be designed for ice loads in accordance with AASHTO *LRFD Bridge Design Specifications,* Section 3.9, and USACE *Coastal Engineering Manual,* Section VI-5-8b.

2. <u>Ice live loads</u>: The wharf will be designed for impact loads resulting from a slab of ice 24 inches in thickness crushing against the wharf. The crushing strength of the ice will be taken as 300 pounds per square inch (psi). The bending strength of the ice may be assumed to be 25 to 40 psi.

3. <u>Ice dead loads</u>: The wharf will be designed for a mass of ice 8 feet in diameter encircling and adhering to each pile. The unit weight of the ice will be taken as 40 pcf.

4. Ice dead load is considered as extreme load cases and should be combined with earthquake loads.

5. The mass considered for the seismic dynamic analysis will include mass due to ice dead load.

K. LOAD COMBINATIONS

1. LRFD load factors for all load combinations except load combination including seismic will be per MOTEMS Table 31F-3-12 or as shown in Figure 3.

2010 CBC TABLE 31F-3-12

LRFD LOAD FACTORS FOR LOAD COMBINATIONS

LOAD TYPE	VACANT CONDITION		MOORING & BREASTING CONDITION	BERTHING CONDITION	EARTHQUAKE CONDITION	
DEAD LOAD (D)	1.2	0.9	1.2	1.2	1.2+k[a]	0.9-k[b]
LIVE LOAD (L)	1.6		1.6[b]	1.0	1.0	
BUOYANCY (B)	1.2	0.9	1.2	1.2	1.2	0.9[a]
WIND ON STRUCTURE (W)	1.6	1.6	1.6	1.6		
CURRENT ON STRUCTURE (C)	1.2	0.9	1.2	1.2	1.2	0.9
EARTH PRESSURE ON THE STRUCTURE (H)	1.6	1.6	1.6	1.6	1.6[c]	1.6[c]
MOORING/BREASTING LOAD (M)			1.6			
BERTHING LOAD (Be)				1.6		
EARTHQUAKE LOAD (E)					1.0	1.0

a: THE K FACTOR (k = 0.5 (PGA) AND BUOYANCY (B) SHALL BE APPLIED TO THE VERTCAL DEAD LOAD (D) ONLY, AND NOT TO THE INERTIAL MASS OF THE STRUCTURE.
b: THE LOAD FACTOR FOR LIVE LOAD (L) MAY BE REDUCED TO 1.3 FOR THE MAXIMUM OUTRIGGER FLOAT LOAD FROM A TRUCK CRANE.
c: AN EARTH PRESSURE ON THE STRUCTURE FACTOR (H) OF 1.0 MAY BE USED FOR PILE OR BULKHEAD STRUCTURE.
d: FOR LEVEL 1 AND 2 EARTHQUAKE CONDITION WITH STRAIN LEVELS DEFINED IN DIVISION 7 OF THE 2010 CBC CHAPTER 31F, THE CURRENT ON STRUCTURE (C) MAY NOT BE REQUIRED.

FIGURE 3. LRFD Load Factors and Load Combinations

2. LRFD load factors for seismic load combination will be per ASCE/COPRI 61-14 Section 3.6 except that vertical earthquake loads do not need to be considered.

IV. MATERIALS

A. CONCRETE

1. Concrete used for structures will conform to requirements of ACI 318.
2. The durability of concrete will be assured through design and detailing, application of high-performance materials, protection of reinforcing steel, and application of concrete sealers.
   a. Water/cement ratio and air entrainment admixture will be in accordance with the structural requirements to establish a dense, low-permeability concrete. Refer to applicable sections of ACI 201.2R *Guide to Durable Concrete.*
   b. The 90-day chloride permeability for the concrete mix used in wharf, trestle, and other major structural components will not exceed 1,000 coulombs.

B. REINFORCING STEEL

Deformed steel bars for concrete reinforcement will conform to ASTM A706, *Low Alloy Steel Deformed Bars for Concrete Reinforcement*, which will be used for all cast-in-place concrete construction unless otherwise noted.

1. Confinement steel (spirals and hoops) will conform to ASTM A706, *Low-Alloy Steel, Deformed Bars for Concrete Reinforcement*.
2. Reinforcing steel used in wharf, trestle, and pile will be epoxy coated.

C. PRESTRESSING STEEL

1. Prestressing reinforcement will be high-tensile-strength, seven-wire low-relaxation strands conforming to the requirements of AASHTO M203, Grade 270.

D. STRUCTURAL STEEL AND MISCELLANEOUS METAL

1. <u>Rolled wide flange shapes</u>: ASTM A992.
2. <u>HP shapes, channels, angles, and plates</u>: ASTM A572, Grade 50.
3. <u>Steel pipe piles</u>: ASTM A572, Grade 50.
4. <u>Steel sheet piles</u>: ASTM A572, Grade 50. Steel sheet piles will conform to the requirements of ASTM A328 *Steel Sheet Piling* and ASTM A6 *General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*. All interlock group tests will provide a minimum of 20,000 pounds per linear inch ultimate interlock tensile strength.
5. <u>Hollow structural shapes</u>: ASTM A 500, Grade B. Welding of hollow structural section will be per AWS D1.1. HSS will not be used for dynamic loading conditions without additional minimum Charpy V-Notch (CVN) requirements being specified.
6. <u>Structural bolts</u>: AASHTO M164 or ASTM A325 with recommended nuts, washers, and direct tension indicators.
7. <u>Anchor bolts</u>: ASTM F1554, hot-dipped galvanized per ASTM A153A or AASHTO M232 with recommended nuts and washers. Bolt grades with tensile strengths over 145 kips per square inch =will be tested for embrittlement in accordance with ASTM A143.
8. <u>Galvanizing</u>: Hot dip galvanizing for steel pipe piles, steel sheet piles, and other structural steel attachments will conform to ASTM A123 or ASTM A153 as applicable.

V. PERFORMANCE CRITERIA

A. PILE-SUPPORTED WHARF

1. See section III.C.1 (EARTHQUAKE LOADS) for seismic performance criteria of pile-supported wharf.
2. Displacement-based design procedure in accordance with ASCE/COPRI 61-14, Chapter 6, will be used for seismic design of the wharf. The total displacement demand will not exceed the displacement capacity.
3. The displacement demand will be evaluated using either a nonlinear static procedure or linear modal procedure. The seismic mass will include the structural self-weight, 10 percent of the design uniform live load (100 psf), and 100 percent of the ice dead load. The displacement capacity will be evaluated using nonlinear static (push-over) procedure. Expected material properties in accordance with ASCE/COPRI 61-14, Section 6.5, and effective (cracked) section properties in accordance with ASCE/COPRI 61-14, Section 3.7.2, will be used for both demand and capacity analysis.
4. In determining structure displacement capacity, the strain limits in piles will not exceed the limits per ASCE/COPRI 61-14, Section 3.9. Pile type will be solid concrete pile for hinge at top of pile and steel pipe pile for in-ground hinge.
5. Pile shear capacity will meet requirements in ASCE/COPRI 61-14, Section 6.9.1 and 6.9.3.
6. Concrete pile cap, concrete deck, and pile-deck connection will be designed as capacity protected members according to requirements in ASCE/COPRI 61-14, Section 6.9; MOTEMS, Section 3107F.2.9; and POLB *Wharf Design Criteria,* Section 4.10.2.

B. SHEET PILE BULKHEAD

1. Performance and global stability criteria for sheet pile bulkhead will be per Table 5.
2. Other stability criteria for sheet pile bulkhead will follow recommendations in USACE *Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures*.

VI. DREDGE DEPTH, SCOUR, AND TIDAL INFORMATION

A. REQUIRED DREDGE DEPTH

1. Dry barge berth: +10 feet MLLW.
2. New berths Terminals 1, 2, and 3 and POL 1 and 2: -45 feet MLLW.
3. Over-dredging and storage-dredging allowance: 2 feet over-dredge and 4 feet storage-dredging (6 feet total).

B. SCOUR

1. An additional scour allowance of two times pile diameter will be used to account for localized scour around the piling where slope protection is not present.

C. TIDAL INFORMATION

1. Highest observed water (HOW): EL +34.6 feet
2. Mean lower low water (MLLW): EL 0 feet
3. Lowest observed water (LOW): EL -6.4 feet

TABLE 5
Performance and Global Stability Criteria for Sheet Pile Bulkhead

Loading Condition	Deformation Based Criteria Description	Allowable Bulkhead Deformation (inch)	Global Stability Factor of Safety (FS) Based Criteria
Short-term static	Moderate bulkhead movement without overstressing of structural components	Less than 18	1.3
Long-term static	Moderate bulkhead movement of structural components	Less than 18	1.5
Seismic: OLE	Very little additional bulkhead movement beyond static loading condition – damage repairable in a short time period and no interruption to wharf operations	Less than 3 (permanent)[a]	N/A [b]
Seismic: CLE	Small additional bulkhead movement beyond static loading condition – damage repairable with minimal interruption to wharf operations	Less than 12 (permanent)[a]	N/A [b]
Seismic: MCE	Moderate additional bulkhead movement beyond static loading condition – moderate damage but economically repairable with some significant interruption to damaged portions of wharf operation	Less than 30 (permanent)[a]	N/A [b]

[a] Displacements under seismic conditions are additional to those from static conditions. Temporary wall movements during a seismic event might exceed permanent wall displacements at the end of an earthquake.

[b] Bulkhead performance is controlled by deformation criteria.

CLE contingency level earthquake
MCE maximum credible earthquake
OLE operating level earthquake

VII. CORROSION PROTECTION

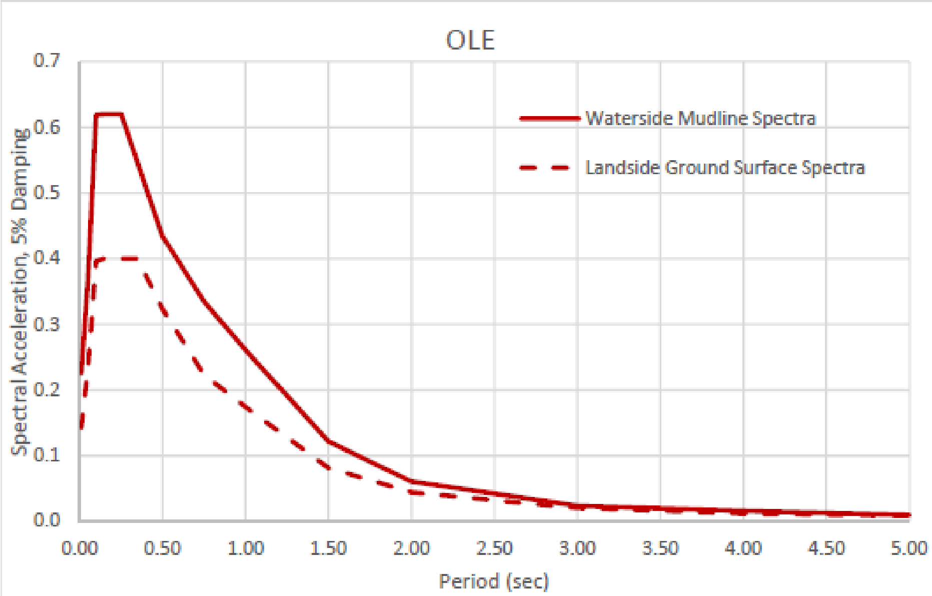
A. CATHODIC PROTECTION

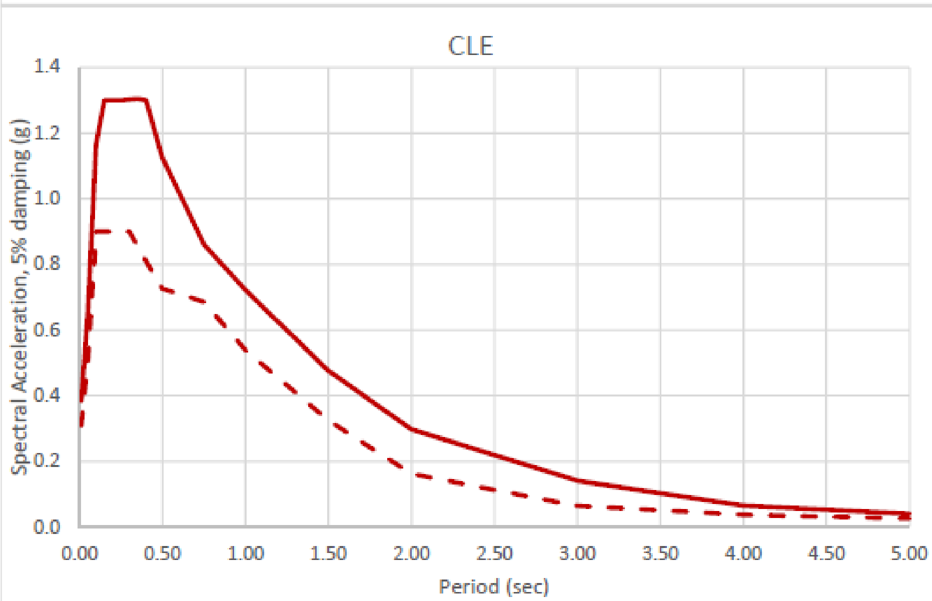
1. An impressed current cathodic protection system will be required to control corrosion on the sheet pile structures. An impressed current system will be necessary due to the large amount of surface area to be protected.
2. Cathodic protection system design will be based on theoretical calculations that include the following parameters:
    a. Estimated surface area of metals exposed to water and soil;
    b. Cathodic protection current density, depending on water or soil exposure condition;
    c. Estimated current output per anode;
    d. Estimated total number of anodes, size, and spacing;
    e. Minimum anode life of 20 years for anodes installed in water and 25 years for anodes installed in soil; and
    f. Estimated circuit resistance.
        i) Impressed current rectifier systems will be able to operate in constant voltage, constant current, or potential control mode. Rectifiers will be rated at a minimum of 25 percent above calculated operating levels to overcome a higher-than-anticipated circuit

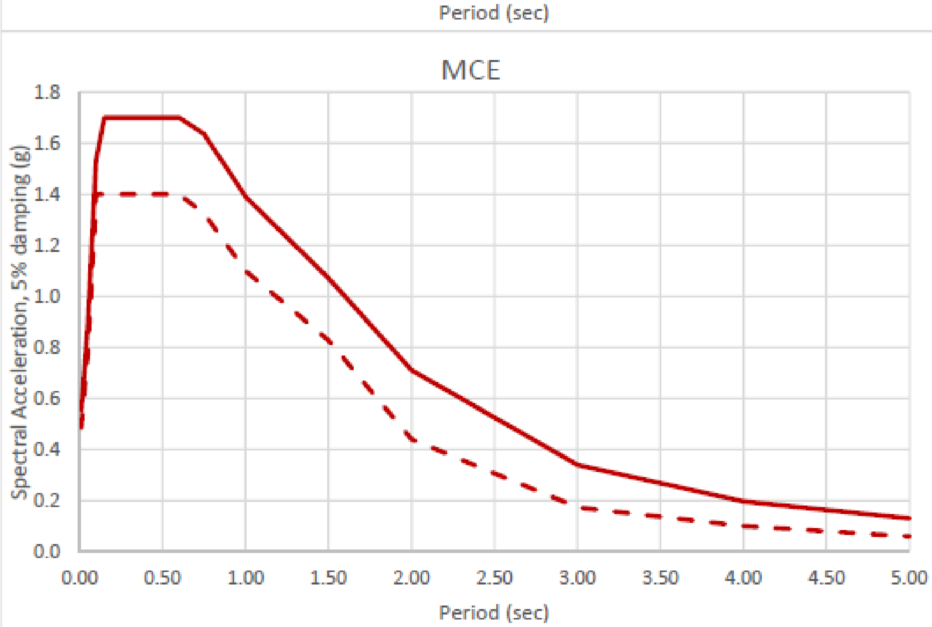
resistance or presence of interference mitigation bonds. Other conditions that may result in increased voltage and current requirements will be considered.

ii) Test facilities at structure connections, monitoring test wells (soil side), conduits, termination boxes, and anode junction boxes will be designed to permit initial and periodic testing of cathodic protection levels, interference currents, and system components.

Attachment A
Site-Specific Design Response Spectra


OLE
Spectral Acceleration, 5% Damping
Period (sec)
Waterside Mudline Spectra
Landside Ground Surface Spectra
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00


CLE
Spectral Acceleration, 5% damping (g)
Period (sec)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00


MCE
Spectral Acceleration, 5% damping (g)
Period (sec)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00

Waterside Mudline Spectra			
Period (sec)	**OLE**	**CLE**	**MCE**
	Sa (g)	**Sa (g)**	**Sa (g)**
0.01 (PGA)	0.23	0.38	0.55
0.05	0.37	0.65	0.89
0.10	0.62	1.17	1.54
0.15	-	1.30	1.70
0.25	0.62	-	-
0.30	-	-	-
0.35	-	-	-
0.40	-	1.30	-
0.50	0.43	1.12	-
0.60	-	-	1.70
0.75	0.33	0.86	1.64
1.00	0.26	0.72	1.39
1.50	0.12	0.48	1.07
2.00	0.06	0.30	0.71
3.00	0.02	0.14	0.34
4.00	0.02	0.07	0.20
5.00	0.01	0.04	0.13

Landside Ground Surface Spectra			
Period (sec)	**OLE**	**CLE**	**MCE**
	Sa (g)	**Sa (g)**	**Sa (g)**
0.01 (PGA)	0.14	0.31	0.48
0.05	0.23	0.51	0.78
0.10	0.40	0.90	1.40
0.15	-	-	-
0.25	-	-	-
0.30	-	0.90	-
0.35	0.40	-	-
0.40	-	0.81	-
0.50	0.32	0.73	-
0.60	-	-	1.40
0.75	0.22	0.69	1.32
1.00	0.17	0.54	1.10
1.50	0.08	0.32	0.83
2.00	0.04	0.16	0.44
3.00	0.02	0.06	0.17
4.00	0.01	0.04	0.10
5.00	0.01	0.03	0.06