Appendix B
Structural Design Criteria

Port of Anchorage Intermodal Expansion Project (PIEP)
15% Concept Design

Structural Design Criteria

Revisions

Revisions					
Rev	**Description**	**Date**	**Prepared**	**Checked**	**Approved**
A	Draft for Review	2013-01-10	HG		
B	2nd Draft for Review	2013-02-11	HG		
C	Final Draft	2013-02-26	HG		

Contents

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
DC	Dead Load – Components and Attachments
DW	Dead Load – Wearing Surface and Utilities
EL	elevation
HOW	highest observed water
klf	kips per linear foot
ksi	kips per square inch
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

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I. DESIGN CODES AND REFERENCES

A. DESIGN SPECIFICATIONS – MARINE TERMINAL STRUCTURES

1. Marine Oil Terminal Engineering and Maintenance Standards (California Building Code, Chapter 31F), 2011.
2. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Sixth Edition with Interims, 2012.
3. ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, 2010.
4. ACI 318-08 Building Code Requirements for Structural Concrete, 2008.
5. AISC Steel Construction Manual, 14th Edition, 2011.
6. AWS D1.5 Bridge Welding Code, 2009.

B. DESIGN SPECIFICATIONS – BUILDING AND BUILDING-LIKE STRUCTURES

1. International Building Code (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. PIANC Seismic Design Guidelines for Port Structures, 2001.
3. POLB Wharf Design Criteria, v 3.0, 2012.
4. POLA Code for Seismic Design, Upgrade and Repair of Container Wharves, 2010.
5. USACE EM 1110-2-2503, Design of Sheet Pile Cellular Structures Cofferdams and Retaining Structures, 1989.
6. USACE ITL92-11, Seismic Design of Waterfront Retaining Structures, 1992.
7. USACE EM 1110-2-1100, Coastal Engineering Manual, 2011.
8. UFC 4-152-01 Design: Piers and Wharves, 2005.
9. Port of Anchorage Intermodal Expansion Project Suitability Study - Final Summary Report, 2013.

II. SERVICE LIFE

A. WHARF, TRESTLE, BULKHEAD, AND RETAINING WALL

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

B. FENDER

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

C. ROADS, PAVEMENT

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

D. BUILDINGS

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

III. DESIGN LOADING AND LOAD COMBINATIONS

A. PERMANENT LOADING

1. Permanent loads shall 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 shall be used to calculate permanent loads.

Cast-in-Place and Precast Concrete	150 pcf
Structural Steel	490 pcf
Traffic Barrier	Actual Load
Soil & 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 shall be designed for a uniform live load of 1,000 psf.

- For pavement and local design uniform live load should not be applied to the area occupied by truck, mobile crane, or loading/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 shall be designed for AASHTO HS25 truck (HS20 truck with axle loads increased by a factor of 1.25). Impact shall be in accordance with AASHTO LRFD Bridge Design Specifications Section 3.6.2.

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

4. Loading/Unloading equipment: The wharf shall be designed for equipment loads including 80,000-lb Top-Pick (Taylor TEC-950L Loaded Container Handler or equivalent) and 100-ton forklift. Apply an impact factor of 10 percent to the maximum wheel loads in the design of slabs, beams, and pile caps. Impact factor should not be used for the design of piles and other types of substructure.

5. Rail-mounted container crane load: All 100-ft-gage crane rail beam and supporting substructure shall be designed for the maximum operating vertical load of 50 klf including impact based on wheel spacing shown in the Figure 1 below. These rail loads include both dead and live loads and shall be used with a load factor of 1.3. The crane stowage pins shall be designed for a horizontal load of 50 kips per socket. Crane tie-down loads shall be 800 tons at each corner. Crane stops shall be designed to resist a 200-kip load acting horizontally 3'-6" above the top of rail per stop.

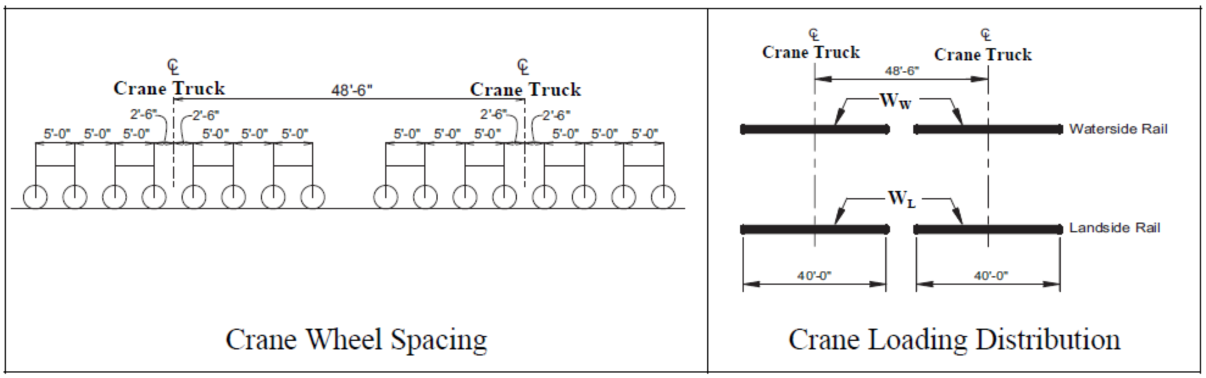


FIGURE 1 Crane Wheel Spacing and Load Distribution for 100-ft-gage Container Crane

6. Roll-on roll-off ramp: RO-RO ramp axle loads shall be as shown in Figure 2.

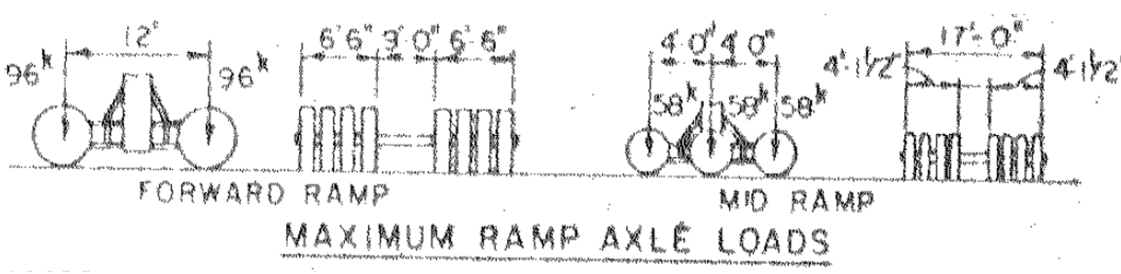


FIGURE 2 Roll-on Roll-off Ramp Axle Loads

C. EARTHQUAKE LOADS

1. The seismic criteria adopted for the PIEP Project were mandated by the Port of Anchorage Seismic Design Committee on June 29, 2004, as follows:

   A two-level seismic design approach is required as follows:

   LEVEL 1: Under the first level of design, Operating Level Earthquake (OLE) ground motions are established that, at a minimum, have a 50-percent probability of exceedance in 50 years (corresponding to an average return period of 72 years). Under this level of shaking, the structure shall be designed so that operations are not interrupted and any damage that does occur will be repairable in a short time.

   LEVEL 2: Under this second level of design, more severe Contingency Level Earthquake (CLE) ground motions are established that, at a minimum, have a 10-percent probability of being exceeded in 50 years (corresponding to an average return period of 475 years). Under this level of shaking, the structure shall be designed so as to undergo damage that is controlled, economically repairable, and is not a threat to life or safety.

   BE IT FURTHER RESOLVED that the Committee recommends that the Port Expansion Team continues to examine and evaluate the physical and economic feasibility of designing, at a minimum, one berth to withstand a seismic event greater in scope than a Level 2 Contingency Level Earthquake in order to provide an emergency point of entry for goods and supplies necessary to support the community. Said evaluation should consider cost and risk implications of such a design.

2. The three levels of earthquake loading were determined from a site-specific probabilistic seismic hazard analysis (PSHA) in combination with site-specific dynamic ground response analyses to account for the effects of local soil geology with resulting ground motions at the ground surface (mudline or backlands) as shown in Table 1. The level 3 (highest level) earthquake is denoted as Maximum Considered Earthquake (MCE).

TABLE 1
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

3. The structures at the Wet Barge Berth, RO/RO Berth, and Hybrid Berth shall be designed for the MCE earthquake load. The Container Berth shall be designed at a minimum for the CLE earthquake load but may be designed for the higher MCE earthquake load if justified from cost and risk perspective.

4. Design response spectra for the three levels of earthquake loading are presented in Attachment A.

5. Earthquake time histories for the three levels of earthquake shall follow recommendations of the *Port of Anchorage Intermodal Expansion Project Suitability Study Summary Report* (final report, February 14, 2013).

6. 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 shall be evaluated in accordance with requirements of MOTEMS Section 3106F.4, POLB *Wharf Design Criteria* Section 2.9.2, and AASHTO *LRFD Bridge Design Specifications* Section 10.5.4.

D. EARTH PRESSURE LOADS

1. Earth pressure loads used in the design shall 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 shall be considered for any submerged or immersed substructures.

F. HYDROSTATIC AND HYDRODYNAMIC WATER LOADS

1. Hydrostatic water loads for sheet pile bulkhead structure shall be calculated using the phreatic water table elevations presented in Table 2.

TABLE 2
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

2. Hydrodynamic water loads shall be used for sheet pile bulkhead structures based on methods recommended by Westergaard.

- **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 0.4H above the dredge line. 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, $k \leq 10^{-3}$ 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 shall be derived from three wind speeds: 45 mph, 70 mph, and 100 mph, as described below. All specified wind speeds are 30 seconds duration wind speed.

2. The cranes shall operate normally at wind speeds of 45 mph. The wind loads acting on the ship, crane, and structure for this case shall be referred to as OWL_{45}.

3. The cranes shall 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 shall be referred to as OWL_{70}.

4. The cranes shall be tied down at wind speeds greater than 70 mph. The maximum wind speed used for design in this non-operating position shall 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 shall be referred to as $NOWL_{100}$.

H. MOORING LOADS

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

   From the west: 29 knots
   From the north: 44 knots

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

   Ebb tide average: 2.5 knots, SW
   Flood tide average: 1.5 knots, NE
   Ebb maximum average: 3 knots, SW
   Flood maximum average: 2.9 knots, NE

3. Wave loads on vessel shall 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: Mooring load on bollards shall 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 shall be derived using the following approach velocities and berthing angles:

Approach velocity when berthing:	0.66 ft/sec
Approach angle when berthing:	10 degrees
(Assume reaction force = 200 tons)	

2. Ship berthing loads shall 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 shall 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. Ice live loads: The wharf shall 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 shall be taken as 300 psi. The bending strength of the ice may be assumed to be 25 to 40 psi.

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

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

K. LOAD COMBINATIONS

1. LRFD load factors for load combinations shall be per MOTEMS Table 31F-3-12 except for values specified 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. Live load factor for earthquake combination shall be 0.1.

IV. MATERIALS

A. CONCRETE

1. Concrete used for structures shall conform to requirements of ACI 318.

2. The durability of concrete shall 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 shall 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 shall not exceed 1000 coulombs.

B. REINFORCING STEEL

1. Deformed steel bars for concrete reinforcement shall conform to the following:

   ASTM A706, *Low Alloy Steel Deformed Bars for Concrete Reinforcement*, shall be used for all cast-in-place concrete construction unless otherwise noted.

2. Confinement steel (spirals and hoops) shall conform to ASTM A706, *Low-Alloy Steel, Deformed Bars for Concrete Reinforcement*.

3. Reinforcing steel used in wharf, trestle, and pile shall be epoxy coated.

C. PRESTRESSING STEEL

1. Prestressing reinforcement shall 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. Rolled wide flange shapes: ASTM A992.

2. HP shapes, channels, angles, and plates: ASTM A572, Grade 50.

3. Steel pipe piles: ASTM A572, Grade 50.

4. Steel sheet piles: ASTM A572, Grade 50. Steel sheet piles shall 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 shall provide a minimum of 20,000 lb per linear inch ultimate interlock tensile strength.

5. Hollow structural shapes: ASTM A 500, Grade B. Welding of hollow structural section shall be per AWS D1.1. HSS shall not be used for dynamic loading conditions without additional minimum CVN requirements being specified.

6. Structural bolts: AASHTO M164 or ASTM A325 with recommended nuts, washers, and direct tension indicators.

7. Anchor bolts: ASTM F1554, hot-dipped galvanized per ASTM A153A or AASHTO M232 with recommended nuts and washers. Bolt grades with tensile strengths over 145 ksi shall be tested for embrittlement in accordance with ASTM A143.

8. Galvanizing: Hot dip galvanizing for steel pipe piles, steel sheet piles, and other structural steel attachments shall conform to ASTM A123 or ASTM A153 as applicable.

V. PERFORMANCE CRITERIA

A. PILE-SUPPORTED WHARF

1. Displacement-based design procedure in accordance with MOTEMS Section 3104F and POLB *Wharf Design Criteria* Section 4 shall be used for seismic design of the wharf. The total displacement demand shall not exceed the displacement capacity.

2. The displacement demand shall be evaluated using either nonlinear static procedure or linear modal procedure. The seismic mass shall include 10% of the design uniform live load (100 psf). The displacement capacity shall be evaluated using nonlinear static (push-over) procedure. Expected material properties in accordance with MOTEMS Section 3107F.2.1.1 and effective (cracked) section properties in accordance with MOTEMS 3107F.2.2 shall be used for both demand and capacity analysis.

3. In determining structure displacement capacity, the maximum strain in structural components shall not exceed the limits shown in Tables 3 and 4.

4. Pile shear capacity shall meet requirements in MOTEMS Section 3107F.2.5.7 and 3107F.2.6.6.

5. Concrete pile cap, concrete deck, and pile-deck connection shall be designed as capacity protected members according to requirements in MOTEMS Section 3107F.2.9 and POLB *Wharf Design Criteria* Section 4.10.2.

TABLE 3
Solid Concrete Pile Strain Limits

Component Strain	OLE	CLE	MCE
MCCS *Pile/deck hinge*	$\varepsilon_c \le 0.004$	$\varepsilon_c \le 0.025$	No Limit
MRSTS *Pile/deck hinge*	$\varepsilon_s \le 0.01$	$\varepsilon_s \le 0.05$	$\varepsilon_s \le 0.8\ \varepsilon_{smd} \le 0.08$
MCCS *In-ground hinge*	$\varepsilon_c \le 0.004$	$\varepsilon_c \le 0.005+1.1\rho_s \le 0.008$	$\varepsilon_c \le 0.005+1.1\rho_s \le 0.012$
MRSTS *In-ground hinge*	$\varepsilon_s \le 0.01$	$\varepsilon_s \le 0.025$	$\varepsilon_s \le 0.035$
MPSTS *In-ground hinge*	$\varepsilon_p \le 0.005$ *(incremental)*	$\varepsilon_p \le 0.025$ *(total strain)*	$\varepsilon_p \le 0.035$ *(total strain)*

MCCS = maximum concrete compression strain, ε_c

MRSTS = maximum reinforcing steel tension strain, ε_s

MPSTS = maximum prestressing steel tension strain, ε_p

ε_{smd} = strain at maximum stress of dowel reinforcement

ρ_s = effective volumetric ratio of confining steel

TABLE 4
Steel Pipe Pile Strain Limits

Component Strain	OLE	CLE	MCE
Maximum Steel Strain *Concrete Filled Pipe*	$\varepsilon_u \le 0.008$	$\varepsilon_u \le 0.030$	$\varepsilon_u \le 0.05$
Maximum Steel Strain *Hollow Pipe*	$\varepsilon_u \le 0.008$	$\varepsilon_u \le 0.025$	$\varepsilon_u \le 0.035$
Maximum Steel Strain *Hollow Pipe – Deep In-ground Hinge (>10D_p)*	$\varepsilon_u \le 0.01$	$\varepsilon_u \le 0.035$	$\varepsilon_u \le 0.05$
MCCS[a] *Pile/deck hinge*	$\varepsilon_c \le 0.01$	$\varepsilon_c \le 0.025$	No Limit
MRSTS[a] *Pile/deck hinge*	$\varepsilon_s \le 0.015$	$\varepsilon_s \le 0.6\ \varepsilon_{smd} \le 0.06$	$\varepsilon_s \le 0.8\ \varepsilon_{smd} \le 0.08$

[a] For steel pipe pile connected to the deck through concrete plug with dowel reinforcement.

MCCS = maximum concrete compression strain, ε_c

MRSTS = maximum reinforcing steel tension strain, ε_s

ε_{smd} = strain at maximum stress of dowel reinforcement

B. SHEET PILE BULKHEAD

1. Performance and global stability criteria for sheet pile bulkhead shall be per Table 5.

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 6 (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 18 (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.

2. Other stability criteria for sheet pile bulkhead shall 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. Wet barge berth: varies from -25 feet MLLW at the north end to -35 feet MLLW at the south end.
3. New berth at North Extension: -45 feet MLLW.
4. New berth near existing Terminal II/III: -45 feet MLLW.
5. 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 2 times pile diameter shall 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’

2. Mean lower low water (MLLW): EL 0’

3. Lowest observed water (LOW): EL -6.4’

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;

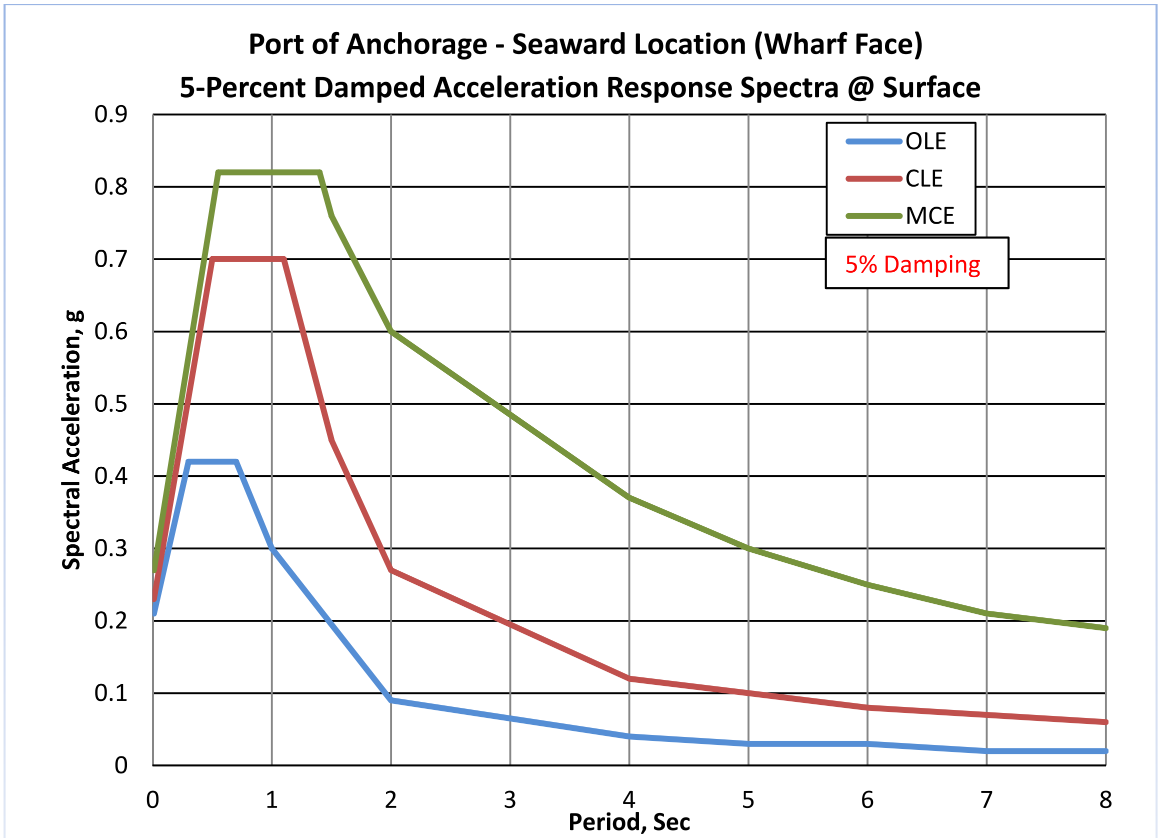
    e. Minimum anode life of 20 years for anodes installed in water and 25 years for anodes installed in soil; and

    f. Estimated circuit resistance.

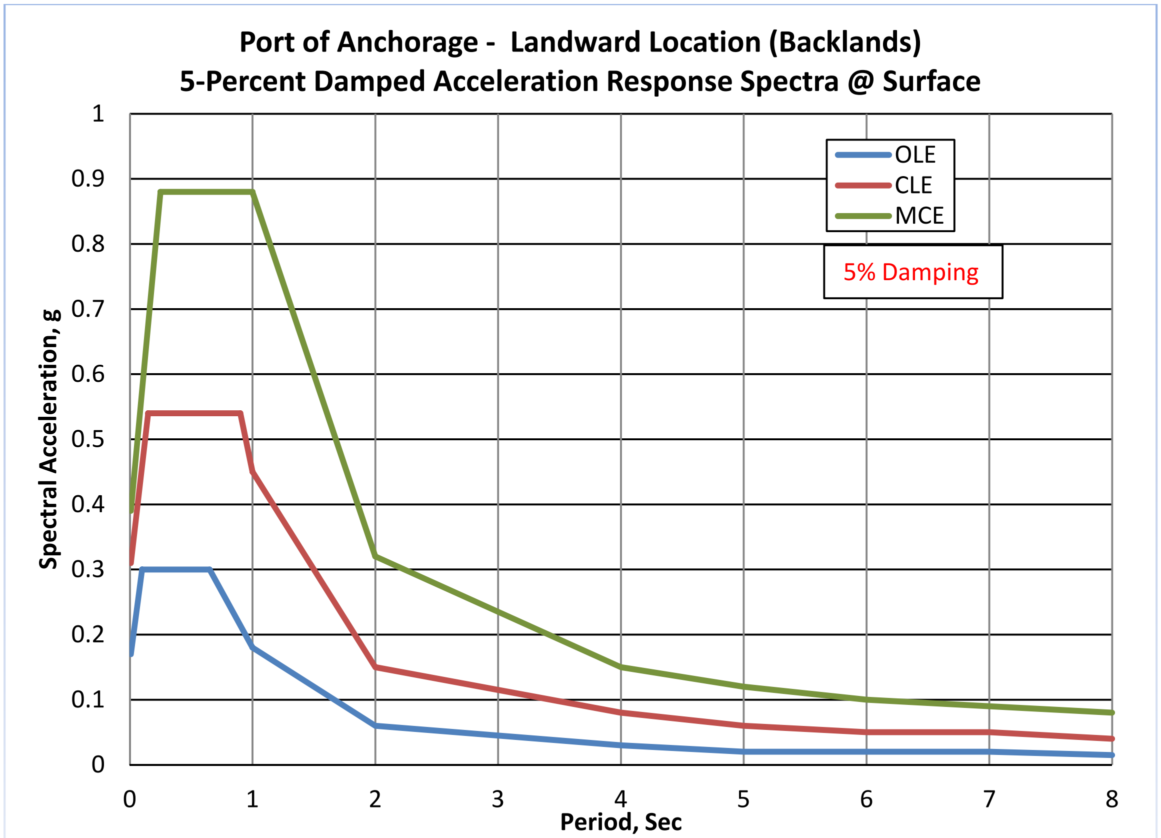
        1) Impressed current rectifier systems will be capable of operating in constant voltage, constant current, or potential control mode. Rectifiers shall be rated at a minimum of 25 percent above calculated operating levels to overcome a higher-than-anticipated circuit resistance or presence of interference mitigation bonds. Other conditions which may result in increased voltage and current requirements will be considered.

        2) 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



Seaward Location					
OLE		CLE		MCE	
Period (sec)	Sa (g)	Period (sec)	Sa (g)	Period (sec)	Sa (g)
0.01	0.21	0.01	0.23	0.01	0.27
0.3	0.42	0.5	0.7	0.55	0.82
0.7	0.42	1.1	0.7	1.4	0.82
1	0.3	1.5	0.45	1.5	0.76
2	0.09	2	0.27	2	0.6
4	0.04	4	0.12	4	0.37
5	0.03	5	0.1	5	0.3
6	0.03	6	0.08	6	0.25
7	0.02	7	0.07	7	0.21
8	0.02	8	0.06	8	0.19



Landward (Backlands) Location					
OLE		CLE		MCE	
Period (sec)	Sa (g)	Period (sec)	Sa (g)	Period (sec)	Sa (g)
0.01	0.17	0.01	0.31	0.01	0.39
0.1	0.3	0.15	0.54	0.25	0.88
0.65	0.3	0.9	0.54	1	0.88
1	0.18	1	0.45		
2	0.06	2	0.15	2	0.32
4	0.03	4	0.08	4	0.15
5	0.02	5	0.06	5	0.12
6	0.02	6	0.05	6	0.1
7	0.02	7	0.05	7	0.09
8	0.015	8	0.04	8	0.08