Wharf Structure Design Consideration of Pier E Redevelopment Project

Cheng Lai, PE, SE¹

¹ Deputy Chief Harbor Engineer, Port of Long Beach

Tuesday, June 26, 2018   Port Special Session from 3:30 - 5:00 PM
POLB – Circa 1911
San Pedro Bay 1872
1872 Comparison with 2000 S.P. Bay
San Pedro Bay
The Port Complex

3,200 acres of land
4,600 acres of water
31 miles of waterfront
10 piers, 62 berths
22 terminals (6 container)
66 post-Panamax gantry cranes
76-foot-deep main channel
Original Middle Harbor Terminals

Piers D and E

170-acre break-bulk/container terminal

Pier F

Long Beach Container Terminal (LBCT)

101-acre container terminal
From This
MHT Facilities

4,310 feet of pile-supported marginal wharf
75,000 TEU container storage slots
36 end-loaded container stacks
50,000 feet of on-terminal rail track
Two inbound and two outbound truck gates

Buildings
◦ Administration
◦ Terminal operations & control
◦ Marine operations / labor check-in
◦ Equipment maintenance and reefer service buildings
◦ AGV battery exchange/charging station (robotic)
Middle Harbor Terminal Phasing

Phase 1 - 2015

Phase 2 - 2017

Phase 3 - 2021
Fully Redeveloped 2025

- 345 acres
- 3.3 million TEUs
- 364 vessel trips a year
- 10,112 daily truck trips
- 2,098 trains a year
- 2,961 employees
14K TEU & 18K TEU STS Cranes

14,000 TEU - New Panamax
Single (or dual) Trolley
Twin 20’ / Tandem 40’ Spreader

18,000 TEU - EEE
Dual Trolley
Twin 20’ / Tandem 40’ Spreader
133’ Wharf Width
120’ Crane Gage
65 klf Crane Wheel Load
El. -55’ at Pier Headline
Seismic Design Criteria

POLB Wharf Design Criteria

- Performance based design
- 3-level design
Ground Motions

Operating Level Earthquake (OLE)
- 50% probability of exceeding in 50 yrs. (72-yr. Return Period)

Contingency Level Earthquake (CLE)
- 10% probability of exceeding in 50 yrs. (475-yr. return period)

Code-Level Design Earthquake (DE)
- Per CBC 2013 (ASCE 7-10)
Performance Criteria

Operating Level Earthquake (OLE)
• no interruption in operations.
• structural damage shall be cosmetic.

Contingency Level Earthquake (CLE)
• temporary loss operations that should be restorable within a few months.
• all damage shall be repairable and shall be located where visually observable and accessible for repair.

Code-Level Design Earthquake (DE)
• No collapse, maintain life safety
• the wharf should be able to support the dead load including the cranes.
Design for Service Static Loading

Determine Performance Criteria (OLE, CLE, DE)

Nonlinear Static Pushover

- Calculate effective Section & Material Properties ($A, I_{eff}, E$)
- Soil Springs (Upper Bound, Lower Bound)
- Seismic Mass
- Nonlinear Properties ($M-\phi, \theta_p, L_p$)

Irregular Structures or Special Cases

Displacement Capacity $\Delta_c$

Preliminary Design: Equivalent Lateral Stiffness Method

Initial Stiffness Method

Substitute Structure Method

Modal Response Spectra Analysis

$\Delta_p = \Delta_p \times DMF$

Displacement Demand $\Delta_d$

$\Delta_c > \Delta_d$

No

Yes

Revise Design

Component Capacities

Expansion Joint

Kinematic Loading

Seismic Detailing Requirements
Crane-Wharf Interaction Analysis Approach

The NTHA was performed using SAP2000 software for three earthquake levels (OLE, CLE, DE)

Each analysis was run for 7 time-history records with directions for fault parallel and fault normal

Each analysis was run for lower bond (LB) and upper bond (UB) soil springs
Wharf Model for NTHA

The wharf model was created using the super-pile modeling approach including four segments of the wharf
Kinematic Loading

- Kinematic lateral spread displacement demand
- Soft clay or liquefaction zone
- Inertial interaction displacement demand from structural analyses
- Potential plastic hinge locations
- Potential plastic hinge locations