Design of Earthquake Damage Repairs to Wharves Before the Earthquake Occurs

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A Different Approach
The Issue

With the design of a new container wharf the issue is not whether or not it will be damaged in an earthquake, but rather how to manage the damage when it occurs.
Current

Original Design

- criteria and codes
- minimize damage
- visible and repairable

Damage Repair

- designed post event
- time sensitive
Questions

What is acceptable risk?

How conservative is the design?

Does the owner understand these questions and what they are paying for?
Understanding

Costs of loss of operations is often higher than repair costs

Balance the economics of level of design in a new structure with future repair costs
Recommended

Look beyond design code and criteria
Anticipate the damage
Develop repair design criteria
Design the repairs
Integrate yard features at wharf interface
Document what is done
Do all this at the beginning, before the earthquake
Approach

Expedites repairs

Repair solutions built into initial design

Design so that damage is away from critical components
Components Vulnerable to Earthquake Damage
Deformation of Slope, Piles and Cutoff Wall
Damage of Expansion Joint and Crane Rail
Crane Stranded at Displaced Expansion Joint
Case Studies and Design Details to Facilitate Repair
Repairs to the Ben Nutter Terminal Wharf, Berths 35 – 37 after the Loma Prieta Earthquake

Typical Damage to Piles
Pile Damage & Repair at Berths 35-37
Pile Damage & Repair at Berths 35-37
Matson Wharf, Berths 32 and 33 after the Loma Prieta Earthquake

Batter Pile Repair Detail
Damage Limiting and Repair Friendly Design Features of the New Berths 57 – 59 Wharf
Bolted Pre-cast Cutoff Wall

Allows Cutoff Wall to Rotate

Anchor Bolt

Pre-cast Cutoff Wall

Damage

Visible From Under Wharf

Pile
Bolted Pre-cast Cutoff Wall

Keep Clear of Utilities

Access to Damage

Remove wall for access for pile repair
Setting Pre-cast Cutoff Wall
Accessible, Ductile, and Replaceable Shear Keys at Expansion Joints

Expected Deformation
One of 3 Installed
W36x256
Shear Key Beams
Changed Location of Seismic Pile

- Increased size from 24-inch octagonal to 48-inch pipe pile.
- Set seismic restraint pile at Row G instead of Row H.

Increase size from 24-inch octagonal to 48-inch pipe pile.
Allowance for Offsets at Expansion Joints

Widen slot crane rail sits in

Widen base plate with moveable clips

Modifications in crane power trench width
Space for Inspection

Leave space to inspect top of piles
Dike Densification and Soil Treatment
Cement Deep Soil Mixed Walls
Construction Inspection

Inform field crew of design rationale for considerations for future repairs
Thank You

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