Design of Earthquake Damage Repairs to Wharves Before the Earthquake Occurs

Ports 2004

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A Different Approach

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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.

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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

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Approach

Expedites repairs

Repair solutions built into initial design

Design so that damage is away from critical components

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Components Vulnerable to Earthquake Damage

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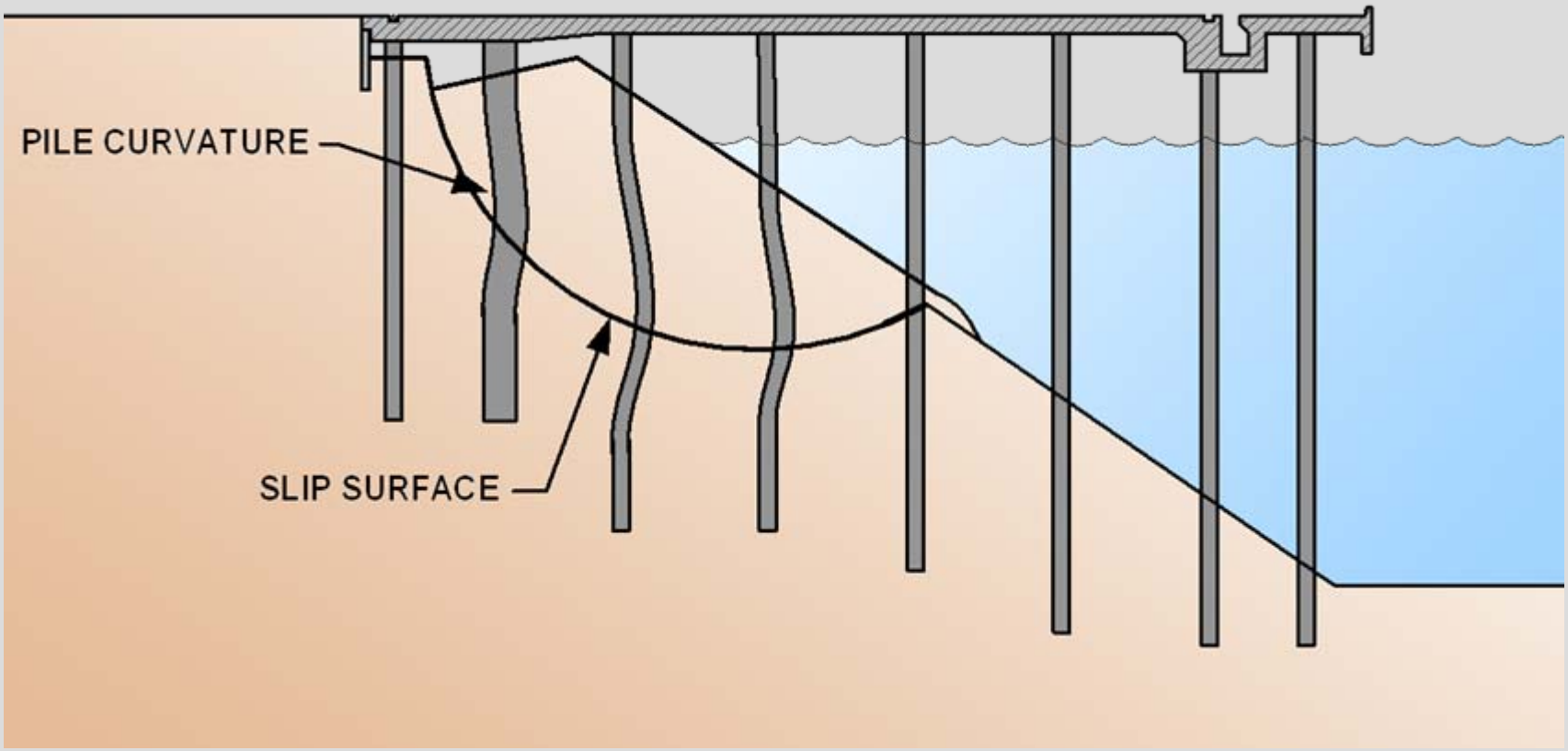
Deformation of Slope, Piles and Cutoff Wall



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Damage of Expansion Joint and Crane Rail

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Crane Stranded at Displaced Expansion Joint

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Case Studies and Design Details to Facilitate Repair

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Repairs to the Ben Nutter Terminal Wharf, Berths 35 – 37 after the Loma Prieta Earthquake

Typical Damage to Piles

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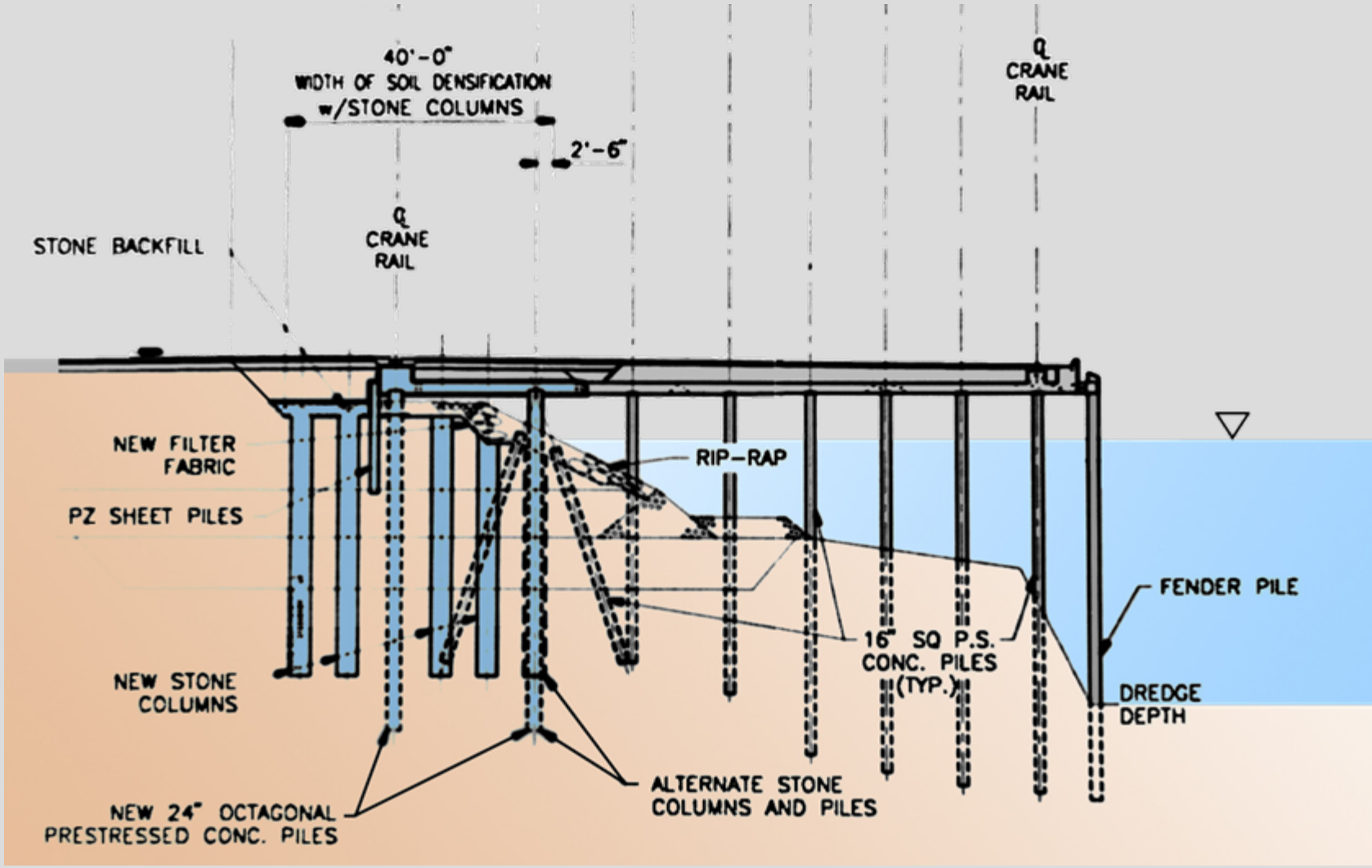
Pile Damage & Repair at Berths 35-37



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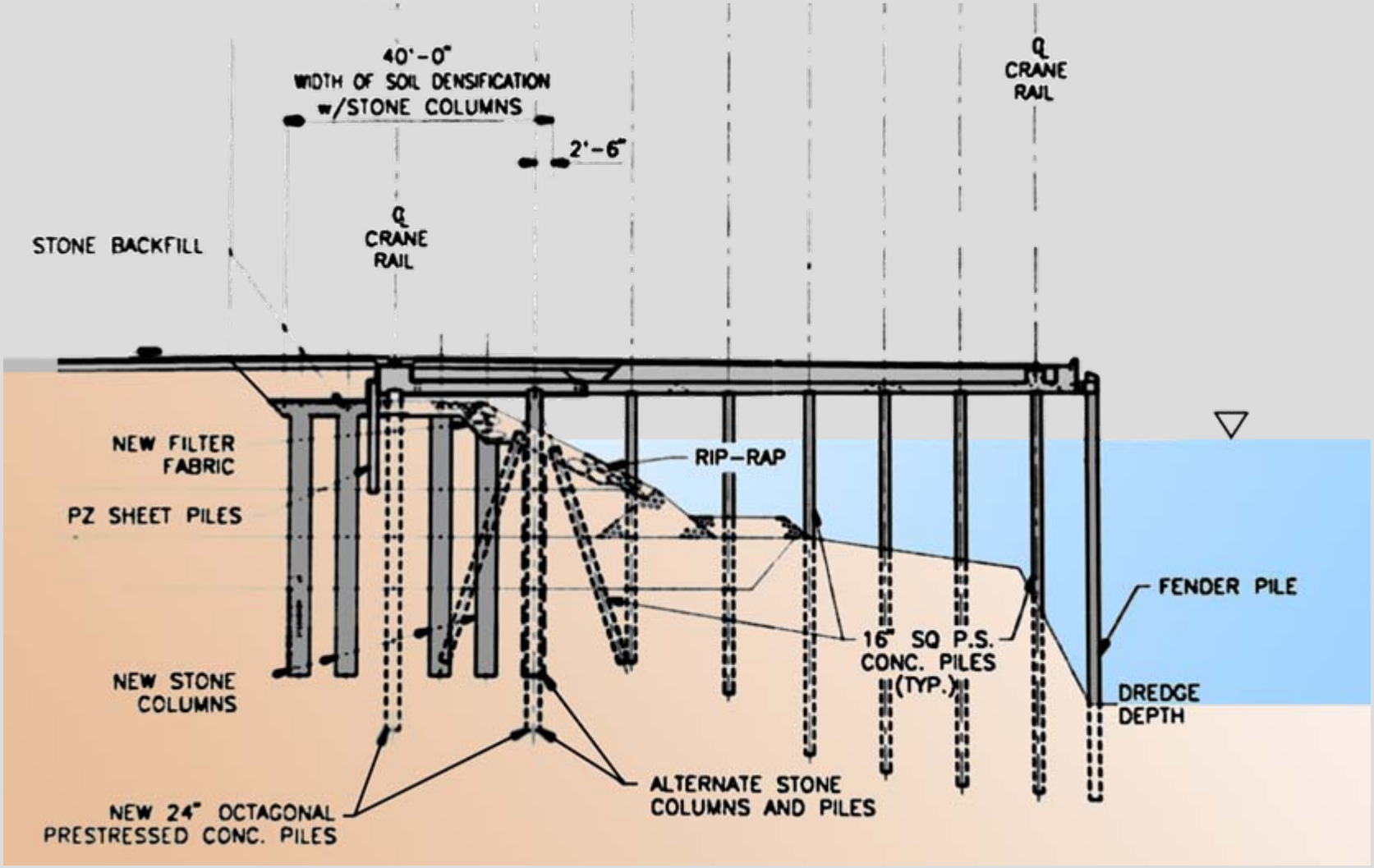
Pile Damage & Repair at Berths 35-37



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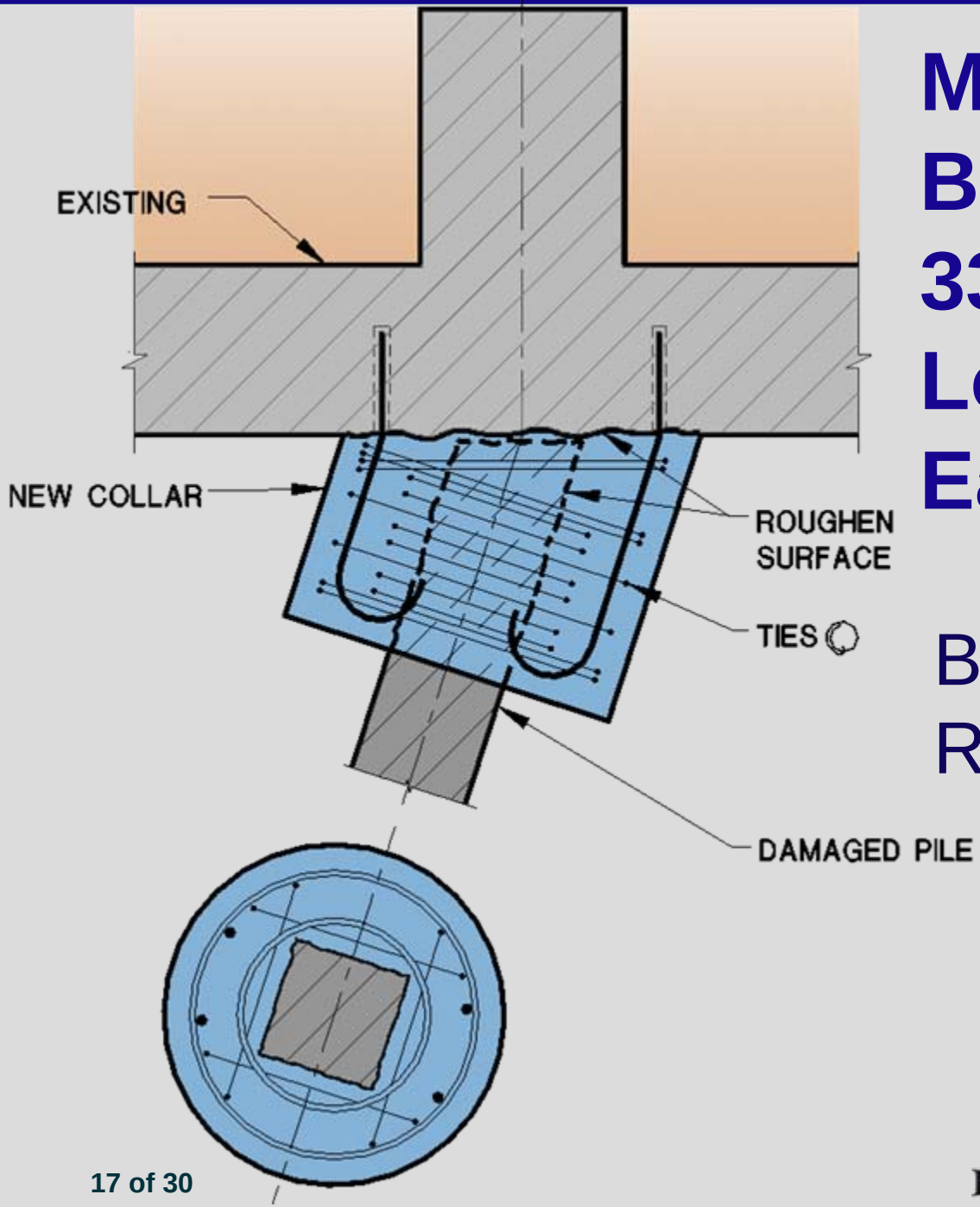
Matson Wharf, Berths 32 and 33 after the Loma Prieta Earthquake



Batter Pile Repair Detail

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Damage Limiting and Repair Friendly Design Features of the New Berths 57 – 59 Wharf

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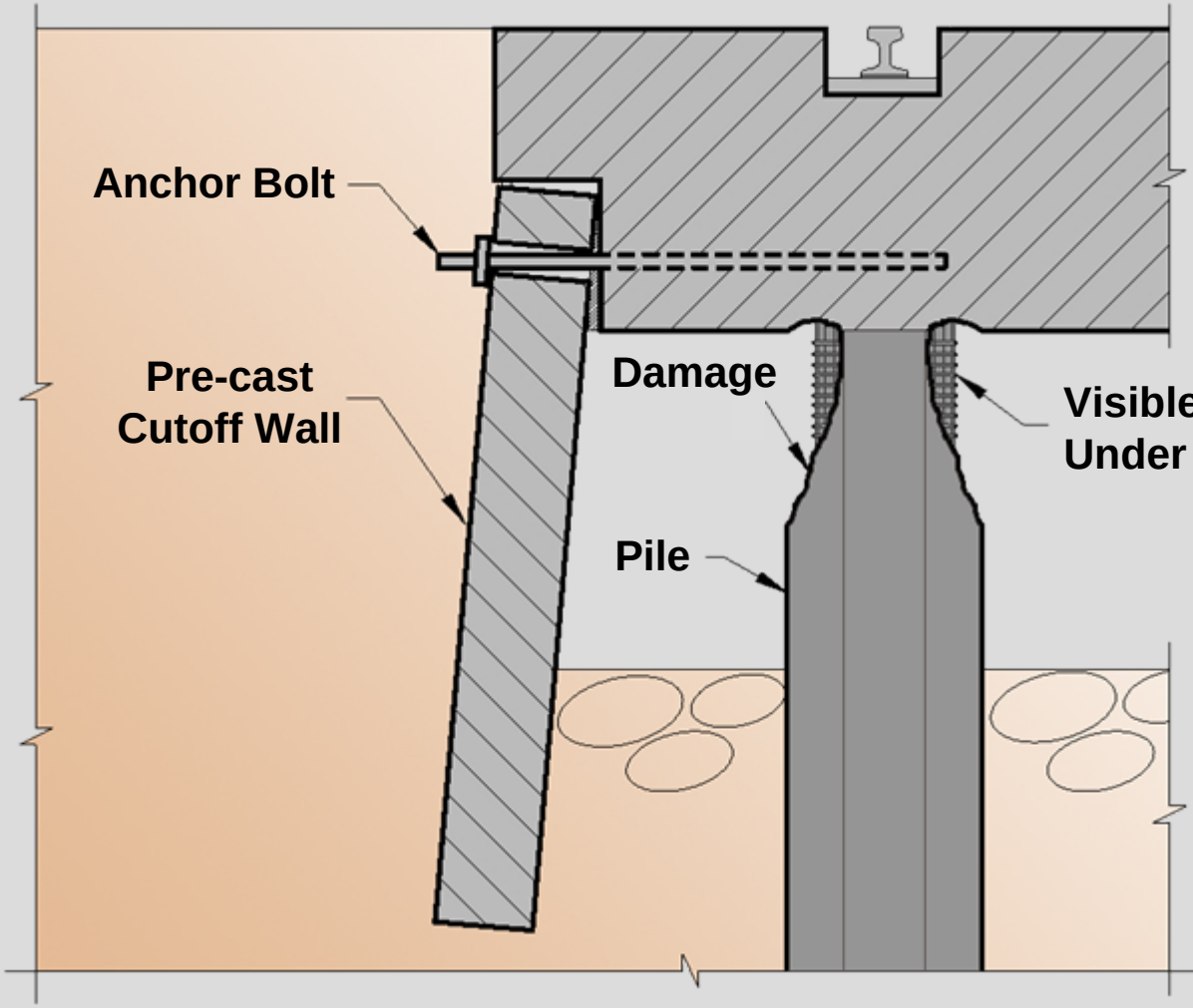
Bolted Pre-cast Cutoff Wall



Allows Cutoff Wall to Rotate

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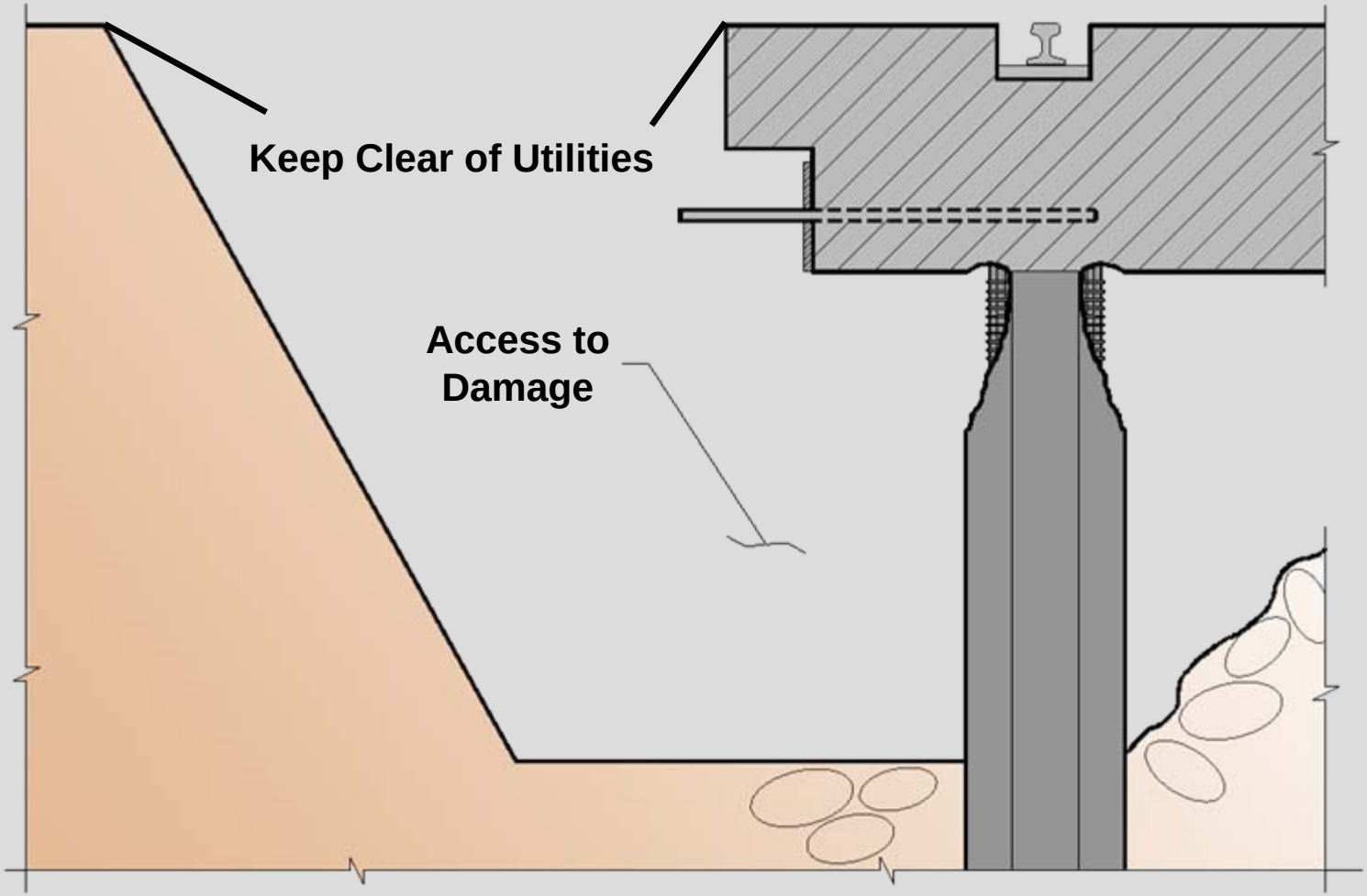
Bolted Pre-cast Cutoff Wall



Remove wall for access for pile repair

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Setting Pre-cast Cutoff Wall

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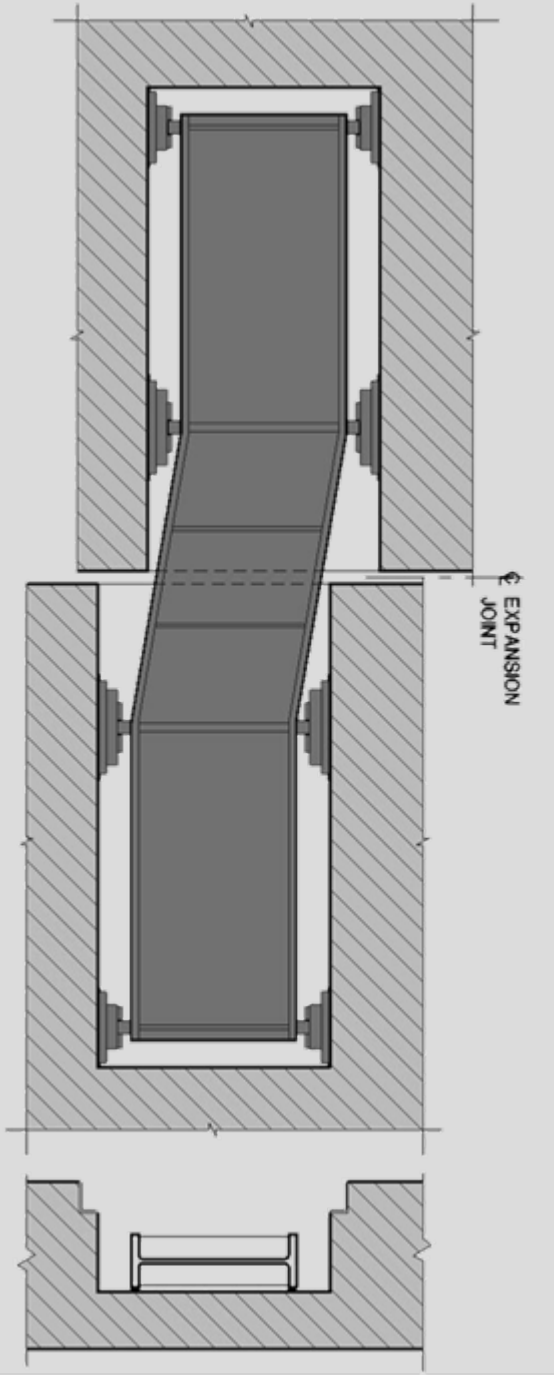

Accessible, Ductile, and Replaceable Shear Keys at Expansion Joints

Expected Deformation

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One of 3 Installed W36x256 Shear Key Beams

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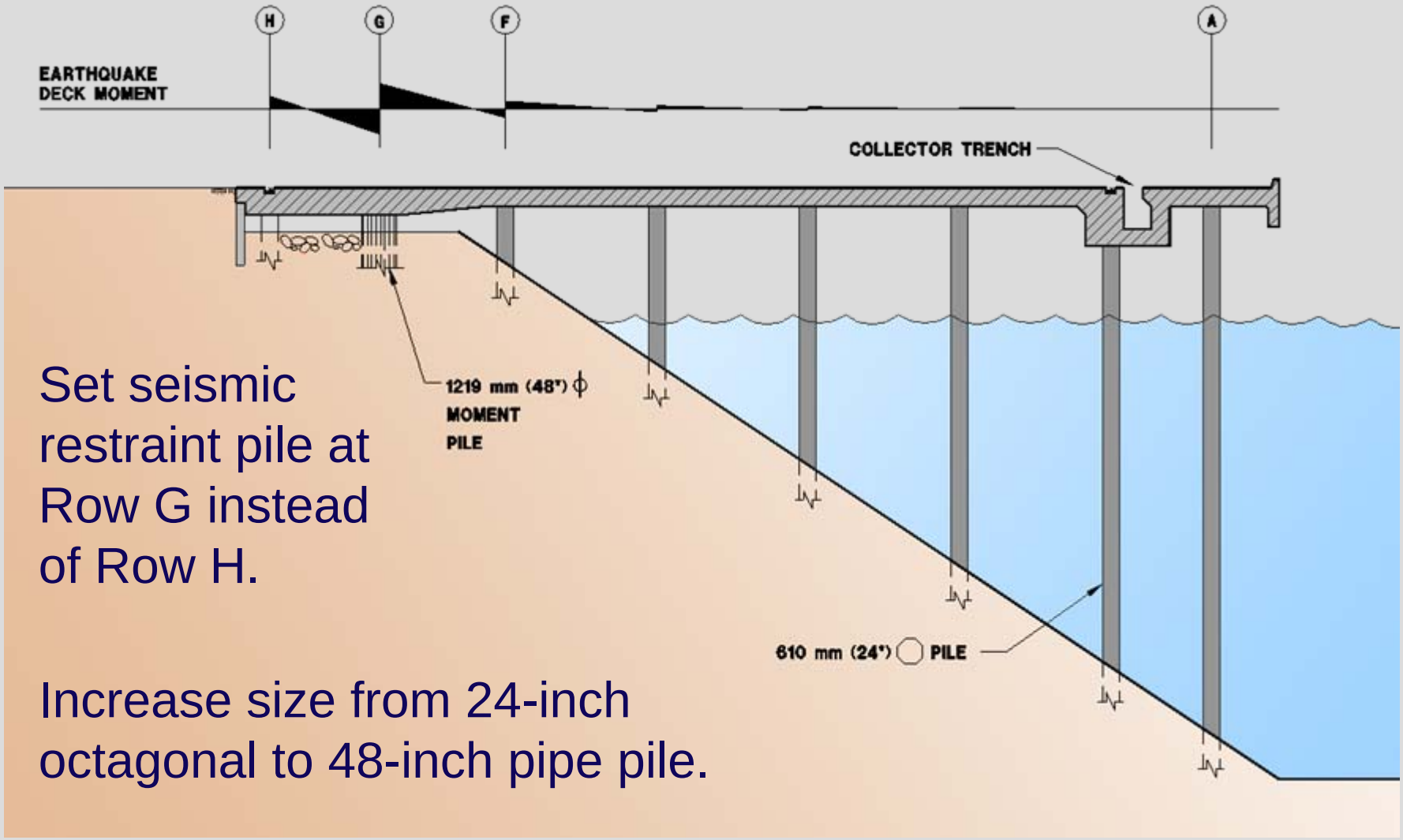
Changed Location of Seismic Pile



Set seismic restraint pile at Row G instead of Row H.

Increase size from 24-inch octagonal to 48-inch pipe pile.

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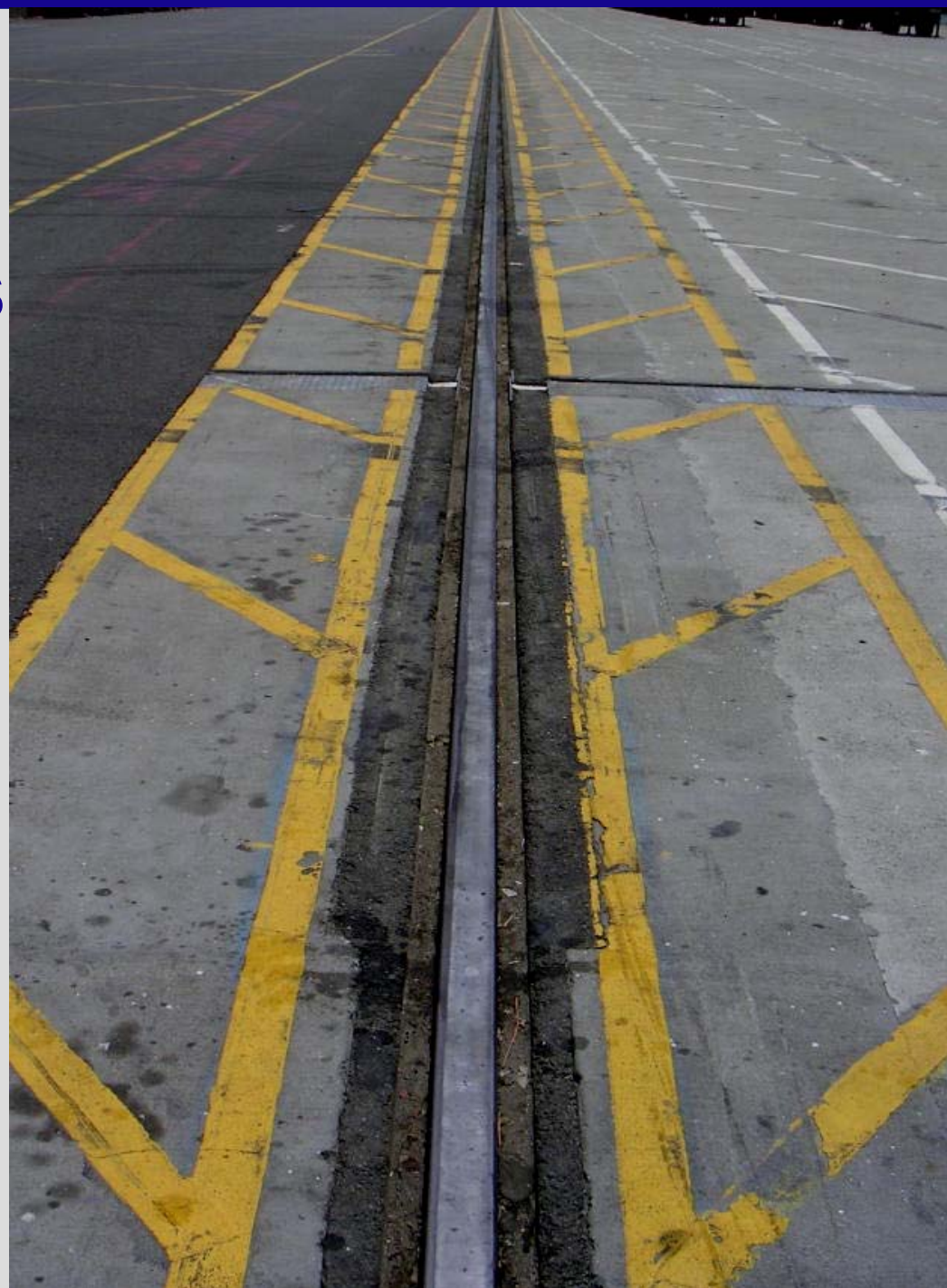
Allowance for Offsets at Expansion Joints

Widen slot crane rail sits in

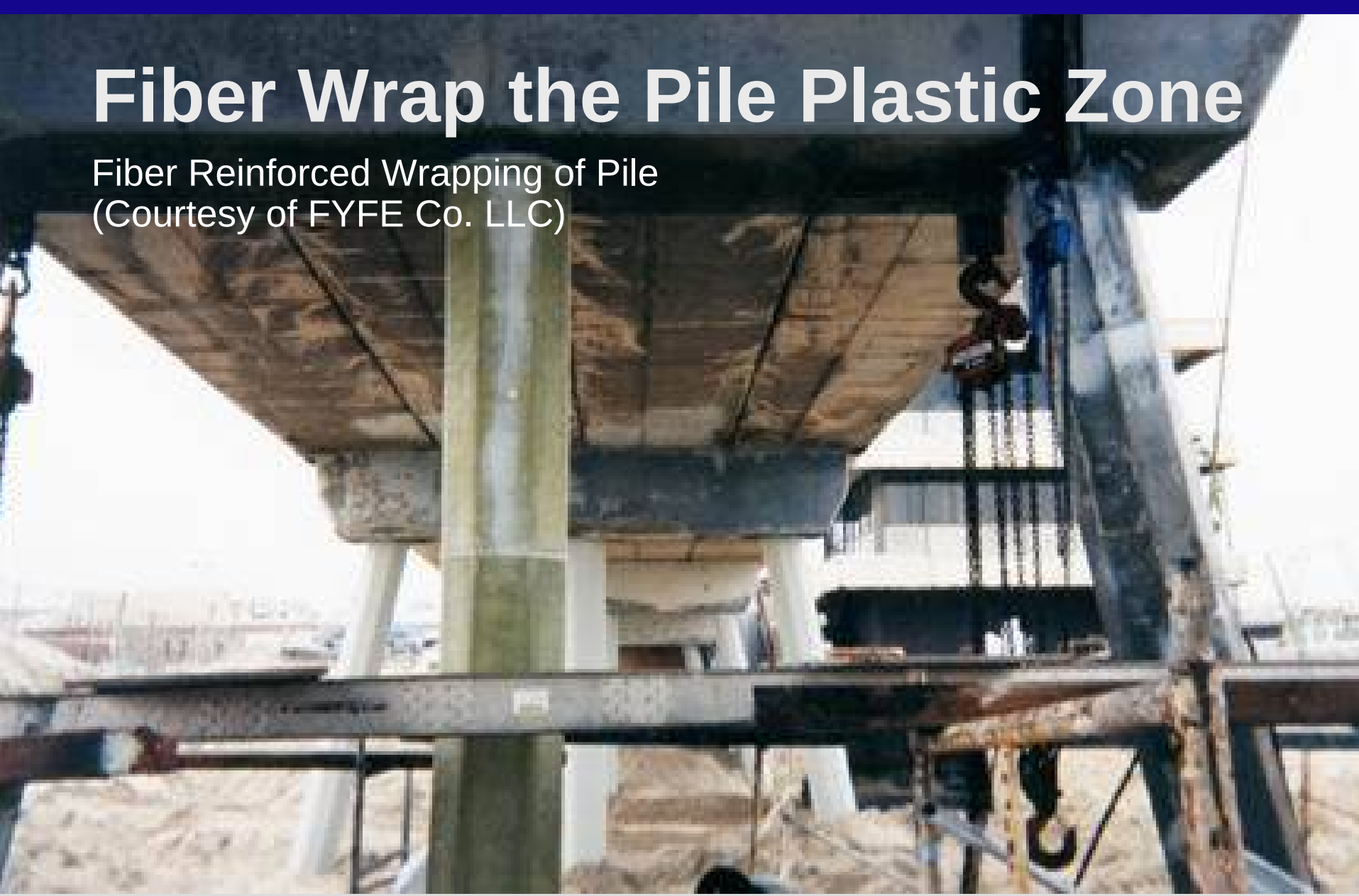
Widen base plate with moveable clips

Modifications in crane power trench width



Fiber Wrap the Pile Plastic Zone

Fiber Reinforced Wrapping of Pile
(Courtesy of FYFE Co. LLC)



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Space for Inspection

Leave space to inspect top of piles

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Dike Densification and Soil Treatment

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Cement Deep Soil Mixed Walls

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Construction Inspection

Inform field crew of design rationale for considerations for future repairs

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Thank You

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