Chevron Eureka MOT Seismic Upgrade – Assessment to Retrofit Design, Permitting and Construction

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Background

• **Original 1900 construction, ~1950 expansion**
  – No drawings
• **Timber structure**
  – 600 ft trestle
  – 150 ft wide wharf
• **Fuel Deliveries**
  – 1 barge every 2 weeks
  – No equipment on dock
Location

- Eureka located approximately 260 miles from the San Francisco Bay Area
  - Isolated geographically
  - Approximately 150 miles from closest marine fuel terminal (Coos Bay)
Existing Structure

- Light timber construction
- Simple pin or through bolt connections
- Piping seated on pile caps or wharf deck
- Plumb pile dominated response
- Batter piles w/ weak connections
- MOTEMS Seismic “Low” Risk
  - Level 1: 36 year return period
  - Level 2: 224 year return period
  - Large acceleration due to nearby subduction zone
Initial Audit Conclusions

• Initial Audit performed by others
  – Concluded structurally deficient and required upgrade
  – Used conservative approach for soil spreading (up to 7 ft soil movement)
Refined Analysis and Retrofit Design

- **Refined seismic and geotechnical analysis**
  - Refined seismic analysis (Moffatt & Nichol)
  - Geotechnical assessment with state of the art methods (EMI)
  - Materials testing (Scientific Construction Laboratories)

- **Retrofit strategy**
  - Support critical elements (pipelines, loading platform)
  - Keep terminal in operation as much as possible

- **Retrofit design**
  - Design (Moffatt & Nichol)

- **Construction**
  - Contractor (West Coast Contractors)
  - Construction support services (M&N, Pacific Affiliates, ORCA, Points West Surveying, EMI)
M&N Refined Seismic Analysis

- M&N performed refined seismic analysis, including refined kinematic load determination (by EMI)
  - Reduced initial 24-84” movement to 23”
  - Now manageable
- Used more refined analysis methods, material testing

Figure 7: Soil Lateral Spread [EMI, 2014]
M&N Refined Seismic Analysis
Findings Tree

- Many cases based on soil conditions and pile type
  - Vertical stability maintained
  - No loss of containment
- Seismic retrofit
  - Critical elements protected
M&N Refined Seismic Analysis
Summary of Findings

- System response controlled by inertial and kinematic loading in different areas for different failure modes
- Retrofit required to satisfy MOTEMS requirements
Seismic Retrofit Design
Boundary Conditions

• Environmental
  – Eel grass + acoustic monitoring →
    VERY expensive driving →
    minimize # of piles
  – Drive at minimum tide
  – Vibratory driving preferred

• Existing Piping
  – Cannot be removed, so nothing w/in footprint of piping
Seismic Retrofit Design
Alternate Concepts – Cantilevered Trestle Bents (Option 2B)

- Underpin trestle (pipeway only)
  - 1 pile bent
  - Steel or concrete piles w/ steel framing
- Underpinning only activated when timber piles fail
Seismic Retrofit Design Pipeway

- Cantilever beam design for
  - Minimize pile quantity
  - Minimum footprint
  - Adjustability
    - Sliding brace into connection, shear tab to beam for erection
  - Simplicity
- Will also support new utility racks
- Two bents in Season 1, remainder in Season 2
2015 Retrofit Design
Global Modeling

• SAP2000 Steel Design
  – Hand calcs to verify results
• Conservatively designed using RSA with $R = 1.0$
  – Elastic for inertia, kinematic, both (easy $\rightarrow$ superposition)
  – Global Model w/ trestle & Cabling
  – Cable takes compression (wrong)
• Differential displacements don’t capture out of phase movement
2015 Retrofit Design
Combined Inertial and Kinematic

- CSLC wanted site specific rationalized combo
  - No direction in code(s)
- Use early (full inertial) and late (full kinematic) combinations
- Shallow slope → EMI agreed with 25% combination factors

Source: Percher M., Iwashita R., Kinematic Loading from a Structural Perspective, Ports 2016
Seismic Retrofit Design
Unloading Platform

• Replacement Platform
  – Staged construction
    – Pre shutdown
    – 2-3 week shutdown
  – Post shutdown
  – Concrete deck with steel framing and steel pipe piles
  – Isolated from existing timber structure
  – Supports critical utilities
2015 Retrofit Design
Unloading Platform – Shutdown

- **Detailing for rapid construction**
  - Lots of shop welding for framing
  - Galvanized assemblies
  - CIP concrete deck on the barge
  - Verify pile locations prior to fabrication
- **Conventional offshore stab detail**
  - Minimize field welding
Permitting

• Pacific Affiliates as lead
• CSLC provided context of project to other agencies

• Permitting effort of 8 – 9 months
  – Typical expectation of 18 months
  – Early stakeholder meetings
  – Local and responsive presence
Summary

• **Retrofit cost approximately 25% of structure replacement cost**
  – Reduced footprint
  – Saved on number of piles (easier to permit, reduced construction time, reduced cost)
  – Phase 1 shut down of 17 days
  – Manageable seismic loads

• **Permitting**
  – Early stakeholders meeting put project on agencies radar
  – CSLC involvement elevated importance of project to other agencies
Seismic Retrofit Construction Photos
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Questions?