Design of Marine Loading Arms & Hose Towers for MOTEMS Compliance

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Agenda

• What’s happening in the world of MLAs and hose towers

• Issues with MOTEAMS compliance
  – Seismic

• Future efforts
Oil products transferred through marine loading arm
Oil products transferred through hoses supported by tower
What’s New with MLAs and Hose Towers?

- 1st MLAs since MOTEMS installed 2015
  - Last MLA installed in California ~early to mid 2000’s
  - Previously 1990’s (?)

- 1st Hose Towers designed per MOTEMS being built
  - Last new hose tower was (ever ???)
Southern California MLAs
Northern California MLAs
New Hose Towers
New Hose Towers
Typical Design Practice – MLAs

• MLA designed by vendor
  – May be international with no knowledge of MOTEMS
  – Seismic design is pipe stress

• Anchorage and maybe base riser designed by structural engineers
  – To CBC requirements (ASCE 7)

• Entire design may be subject to local building officials review
  – Likely CBC / ASCE 7

• Local engineers need to review and coordinate the vendor seismic design
  – Loads factored properly
  – Units the same
MLAs - OCIMF

- 1999 Edition
- Outdated: References “UBC” for seismic design
- No consensus on how to map with ASCE 7
- ASD
- Requires project-specific seismic design basis
Seismic Design Code Issues - MLAs

- Categorizing structure
  - Nonbuilding structure
  - Equipment
  - Piping

- R / Rp values

- Code-based seismic input

- Period limitations

- Scaling dynamic results

- Drift limitations
MOTEMS Compliance – not just seismic

- Operating envelope
- QC/DC and ERS
- Markings
- Alarms
- Hazard classification
- Drainage
- Electrical isolation
Typical Design Practice – Hose Towers

- Designed by structural and mechanical engineers
- Seismic design to building codes (ASCE 7 in US)
Hose Towers

- Looks like a structure
- Straightforward
- Not so fast!!!
Seismic Design Issues for Hose Towers

- Categorizing structure
  - Nonbuilding structure similar to building
  - Penthouse
  - Pipe support

- Code-based seismic input

- Structure on structure

- Amplification
  - Elevation
  - Flexibility

- Cranes on top
Similar Issues for all Deck-Mounted Equipment & Structures
ASCE 7

- Chapter 13 (Nonstructural Components) and Chapter 15 (Nonbuilding Structures) both revert to same equation

- 3 separate terms require interpretation

\[ F_p = \frac{0.4a_p S_{DSW_p}}{R_p \left( \frac{I_p}{I_p} \right)} \left( 1 + 2 \frac{z}{h} \right) \]  

(13.3-1)
Definition of: $S_{DS}$?

USGS Code-based Spectrum

Site-Specific Spectrum
Definition of: $1 + 2(z/h)$?

“$h$”? “$h$”?
Help is on the way!
Changes to ASCE 61-19

- Equations will look like ASCE 7, but not reference ASCE 7 explicitly
- Take advantage of single-degree of freedom dynamic behaviors
- Use site-specific spectrum at period of wharf structure, $S_w$

$$F_P = \frac{a_p S_w W_p}{\left(\frac{R_p}{I_p}\right)} \left(1 + 2 \frac{z}{h}\right)$$
Proposed Changes to ASCE 61-19

- Choice of “simplified” with amplification of 3 or “coupled” model with dynamic analysis

- Table with choice of $R_p$ values for different items
  - $R_p = 3.0$ for MLAs

- Period dependent $a_p$ values

![NCEER Formulation for $a_p$ as Function of Structural and Component Periods](image)
Summary

• First new design and construction of MLAs and hose towers in years is happening now

• First ever with MOTEMS in place

• MOTEMS compliance is a challenge but can be done

• Lessons learned in seismic design will be helpful next time

• Experience in seismic design will be used to improve practice industry-wide