SIMPSON GUMPERTZ & HEGER

Engineering of Structures
and Building Enclosures

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 MOTEMS compliance
  - Seismic
- Future efforts


Oil products transferred through marine loading arm


SHARON SEA
Oil products transferred through hoses supported by tower

What's New with MLAs and Hose Towers ?

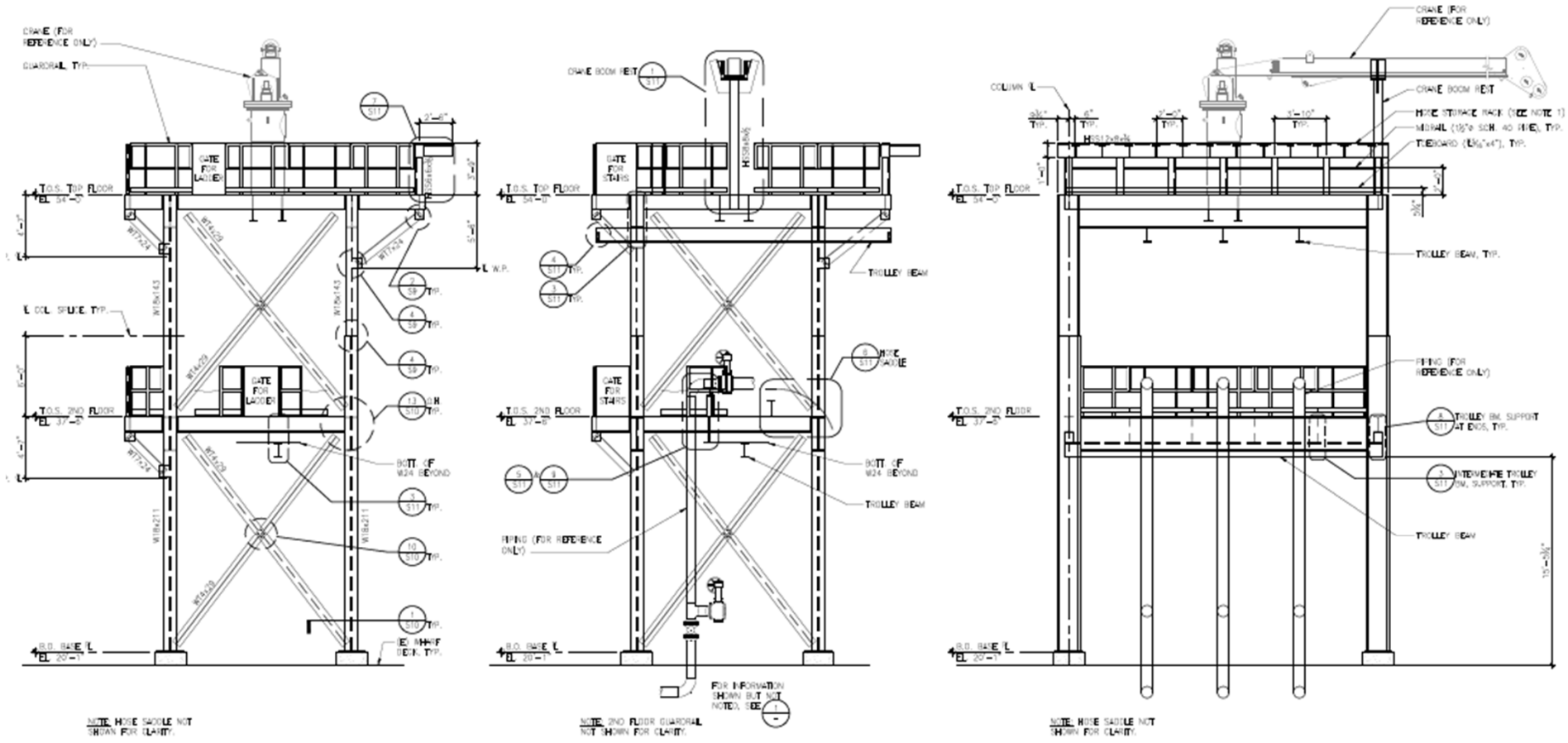
- 1st MLAs since MOTEMS installed 2015
  - Last MLA installed in California ~early to mid 2000's
  - Previously 1990's (?)

- 1st Hose Towers designed per MOTEMS being built
  - Last new hose tower was (ever ???)

Southern California MLAs

Northern California MLAs

New Hose Towers

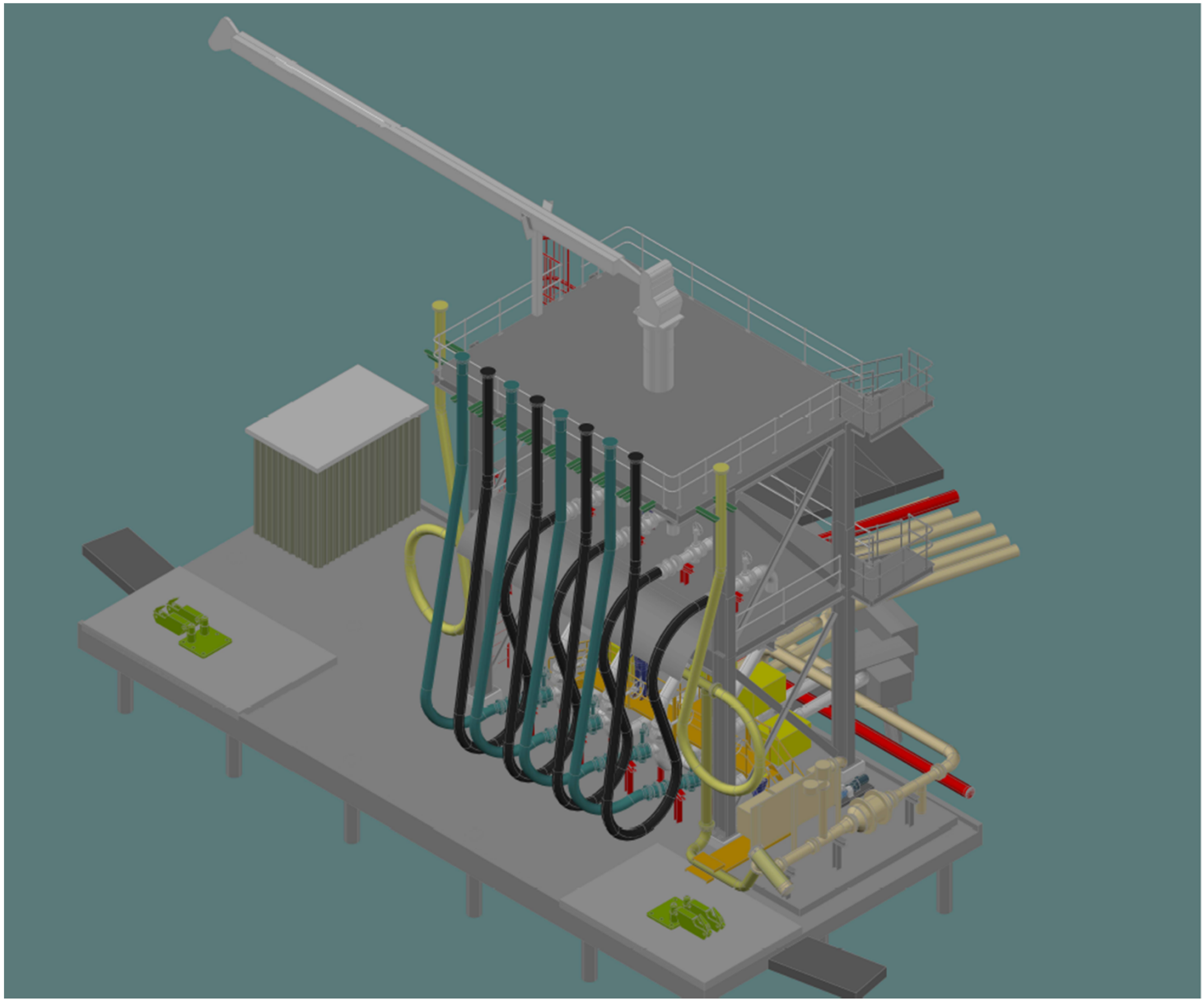


1 WEST ELEVATION TYP. ALL TOWERS SCALE: 1/4"=1'-0"

2 SECTION TYP. ALL TOWERS SCALE: 1/4"=1'-0"

3 SOUTH ELEVATION B7R—W TOWER SCALE: 1/4"=1'-0"

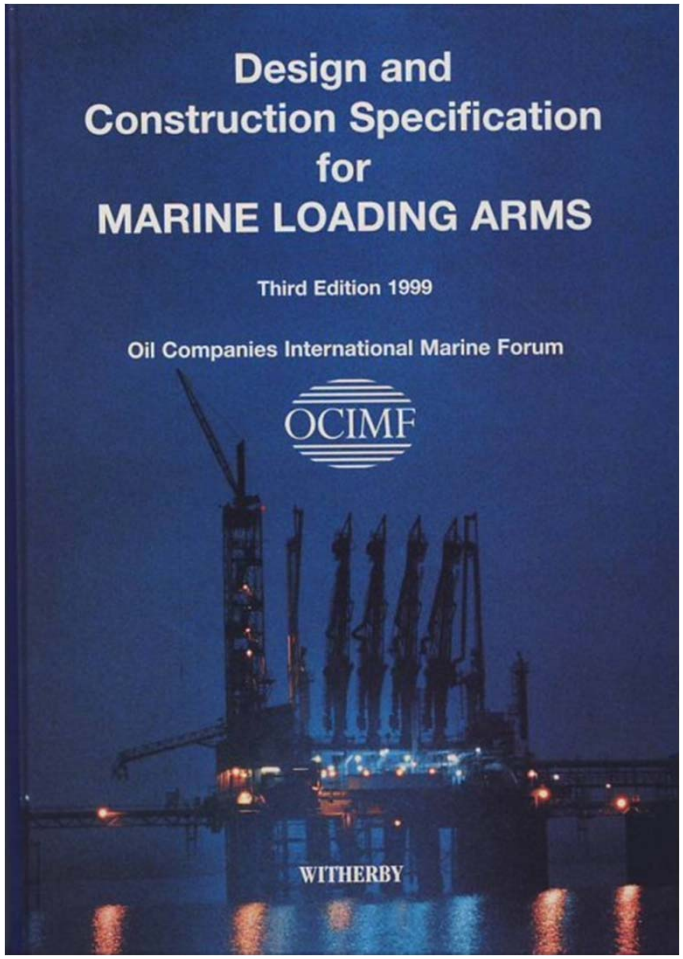
New Hose Towers



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

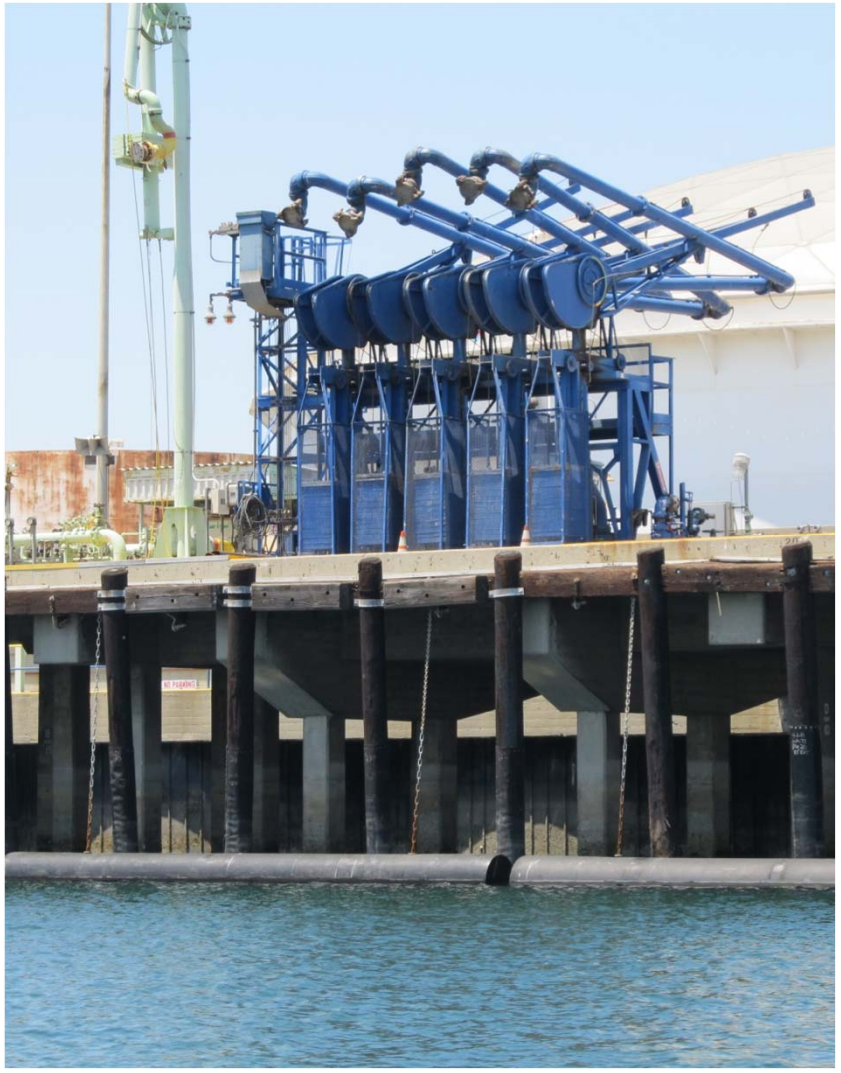
MLAs - OCIMF



- 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- Outdated: References “UBC” for seismic design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

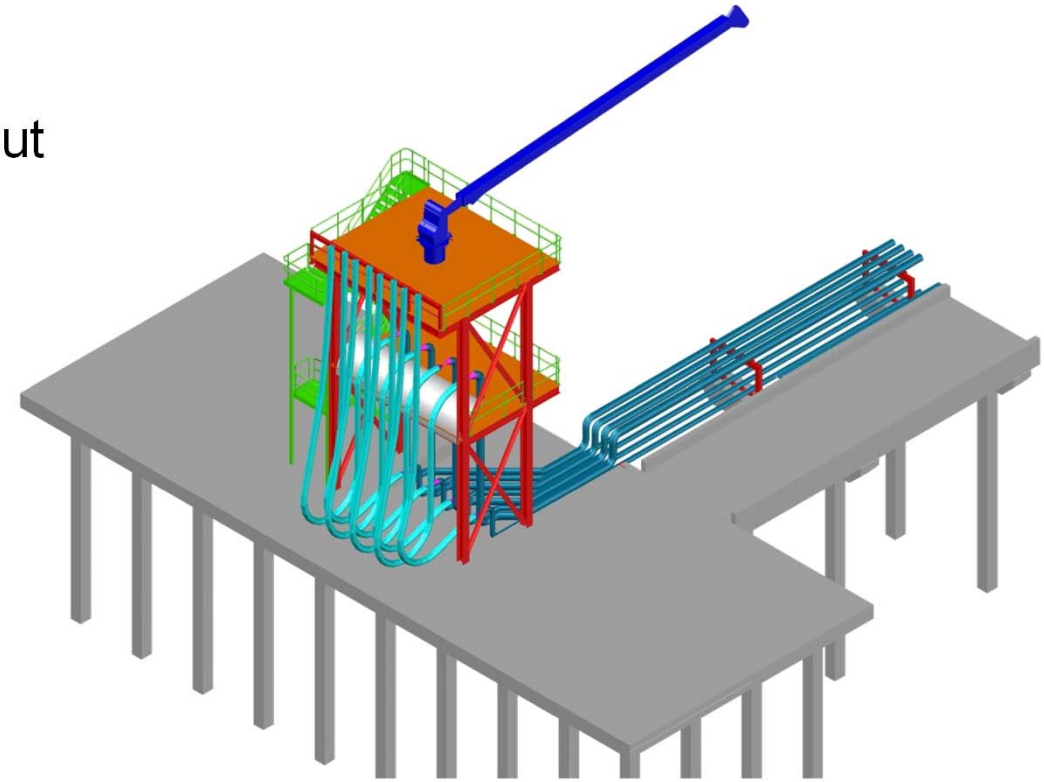
- Designed by structural and mechanical engineers
- Seismic design to building codes (ASCE 7 in US)

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

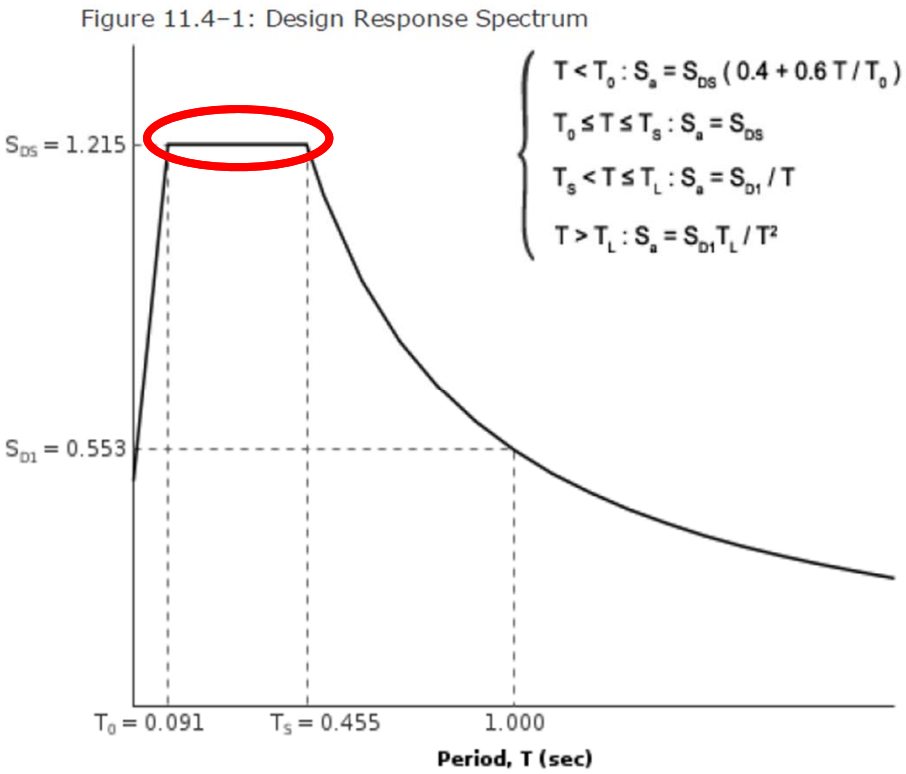
- Chapter 13 (Nonstructural Components) and
  Chapter 15 (Nonbuilding Structures) both revert to same equation

- 3 separate terms require interpretation

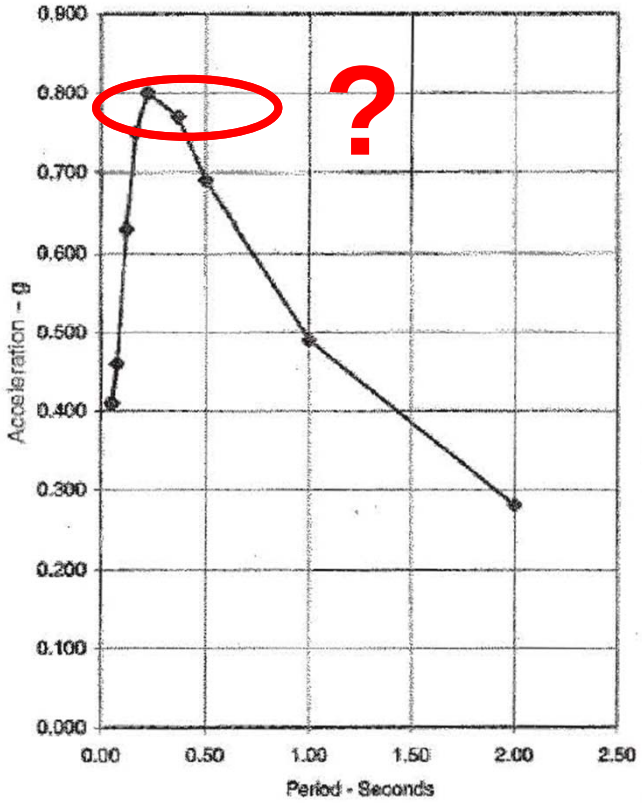
$$F_P = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)} \left(1 + 2\frac{z}{h}\right) \qquad (13.3\text{-}1)$$

Definition of: S_{DS} ?

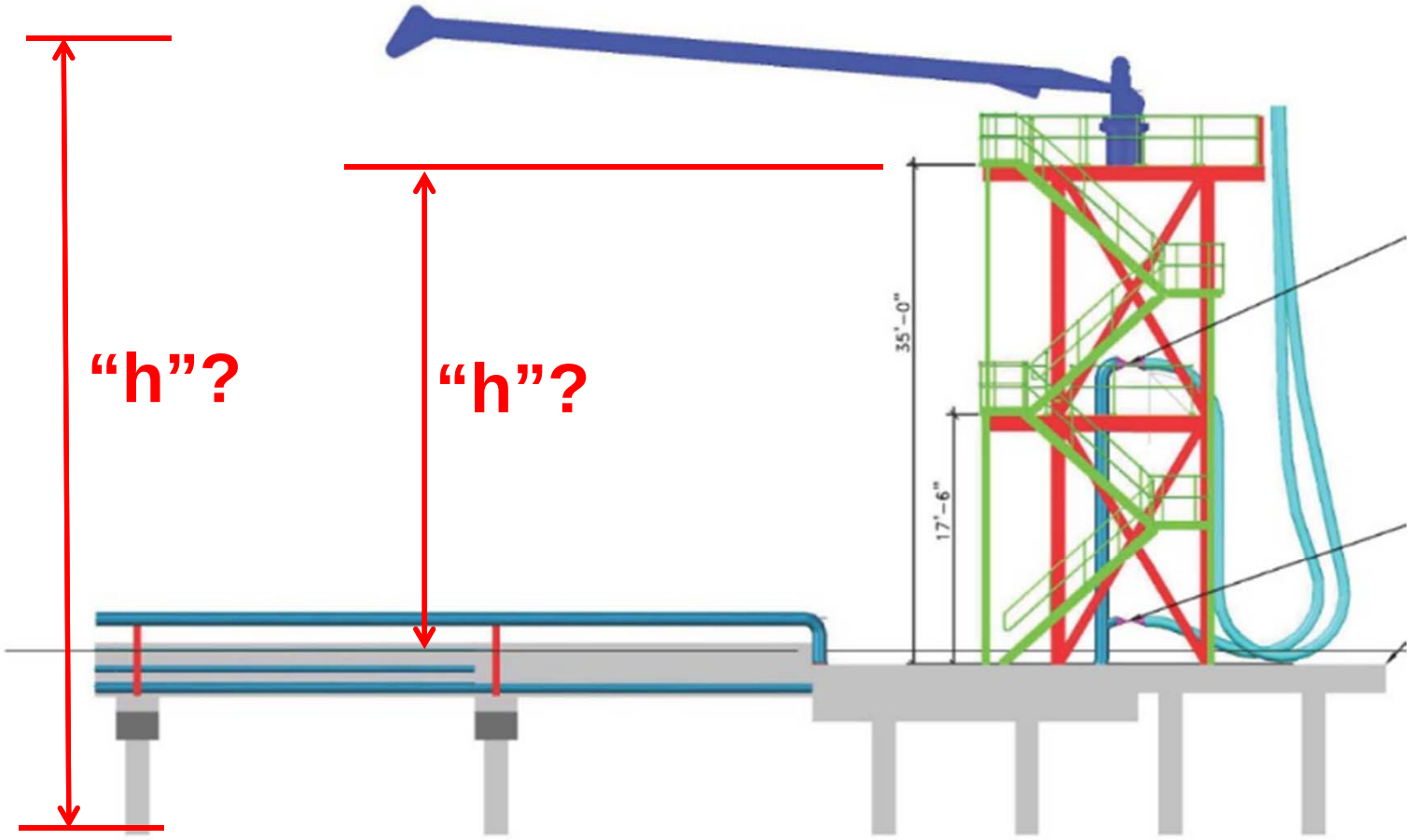
USGS Code-based Spectrum



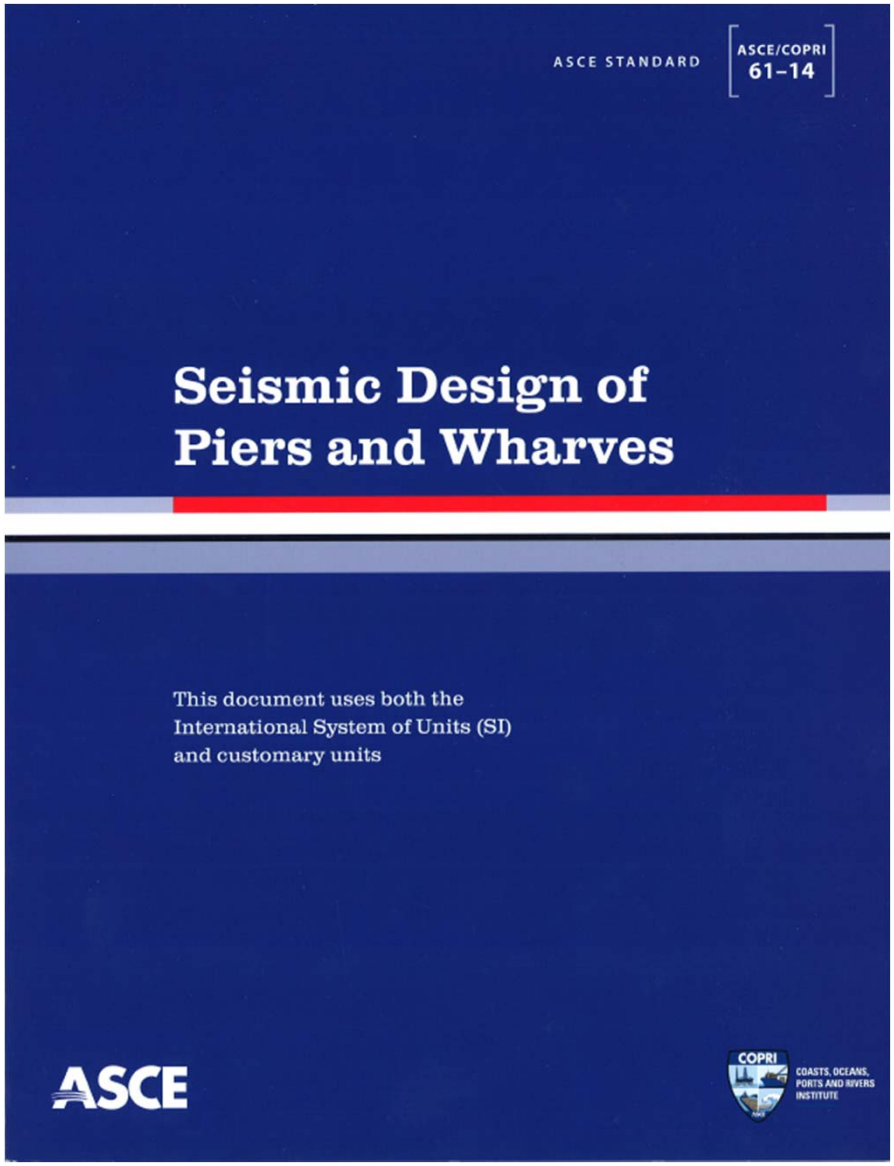
Site-Specific Spectrum



Definition of: 1+2(z/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

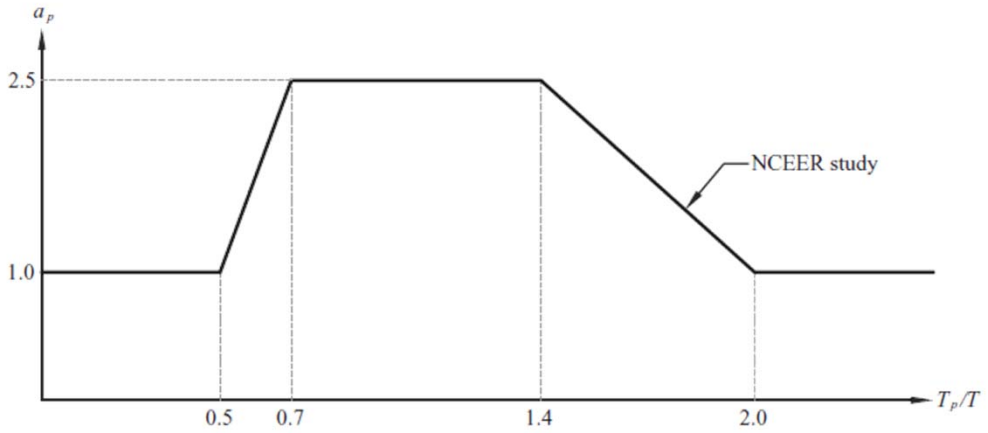


FIGURE C13.3-1 NCEER Formulation for a_p as Function of Structural and Component Periods

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