Seismic Evaluation of Nonstructural Components and Non-Building Structures

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Objectives

- Review specifications in current MOTEMS
- Identify needs for improvement
- Recommendations

Current MOTEMS Specifications

- 3104F.5.3: Fire protection, emergency shutdown, electrical power systems
  - Reference documents
    - New - None
    - Existing – CalARP (CalARP refers to ASCE 7)
  - Evaluation for survivability and continued operations during Level 1 earthquake

Current MOTEMS Specifications

- 3108F.7: Fire detection, fire protection, emergency shutdown
  - 3104F.5.3 for assessment - Reference documents
    - New - None
    - Existing – CalARP (CalARP refers to ASCE 7)
  - 3110F.8 for anchorage and support – Reference documents
    - New – FEMA 450
    - Existing – Cal ARP, ASCE Guidelines 2011 (both refer to ASCE 7), or FEMA 356

Current MOTEMS Specifications

- 3109F.4: Piping and pipelines
  - Reference documents
    - New – ASCE Guidelines 2011 (refers to ASCE 7)
    - Existing – CalARP (refers to ASCE 7) or FEMA 356

Current MOTEMS Specifications

- 3110F.2.1: Marine Loading Arms
  - Reference documents
    - New – 2CCR 2380, 33CFR 154.5 and OCIMF
    - Existing – 2CCR 2380, 33CFR 154.5 and OCIMF
  - 33CFR indirectly refers to ASCE 7
  - OCIMF is outdated because it refers to UBC

Current MOTEMS Specifications

- 3110F.8: Equipment anchors and supports
  - Reference documents
    - New – FEMA 450
    - Existing – Cal ARP, ASCE Guidelines 2011 (both refer to ASCE 7), or FEMA 356

Current MOTEMS Specifications

- 3110F.11: Critical systems seismic assessment
  - 3104F.5.3 for assessment - Reference documents
    - New - None
    - Existing – CalARP (CalARP refers to ASCE 7)
  - 3110F.8 for anchorage and support – Reference documents
    - New – FEMA 450
    - Existing – Cal ARP, ASCE Guidelines 2011 (both refer to ASCE 7), or FEMA 356

Current MOTEMS Specifications

- 3111F.11: Electrical systems
  - 3104F.5.3 for assessment - Reference documents
    - New - None
    - Existing – CalARP (CalARP refers to ASCE 7)
  - 3110F.8 for anchorage and support – Reference documents
    - New – FEMA 450
    - Existing – Cal ARP, ASCE Guidelines 2011 (both refer to ASCE 7), or FEMA 356

Summary of Current MOTEMS

- Three main reference documents
  - FEMA 450, FEMA 356, and ASCE 7
    - Several other documents (e.g., Cal ARP, ASCE Guidelines 2011, and 33CFR refer back to ASCE 7)
  - OCIMF for Marine Loading Arms is outdated
    - Refers to UBC
- Seismic provisions are spread over multiple chapters
- Lack of clarity on design level earthquake
- Silent on seismic design and assessment of control rooms and other building-like structures mounted on deck

FEMA 450, FEMA 356, ASCE 7 Seismic Force Computation

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\frac{R_p}{I_p}} \left(1 + 2\frac{z}{h}\right)$$

$$0.3 S_{DS} I_p W_p < F_p < 1.6 S_{DS} I_p W_p$$

FEMA 450, FEMA 356, ASCE 7 Seismic Force Computation

S_{DS} = Short period spectral acceleration

a_p = Component amplification factor

I_p = Component importance factor

R_p = Component response modification factor

W_p = Component operating weight

z = height in structure of point of attachment of component with respect to base

h = average roof height of structure with respect to the base

FEMA 450, FEMA 356, ASCE 7 Seismic Force Computation

- Amplifies ground acceleration, represented by $0.4S_{DS}$, by a factor of (1+2z/h): maximum factor of 3
- Further amplifies acceleration due to flexibility of the component itself by a factor of a_p

FEMA 450, FEMA 356, ASCE 7 Seismic Force Computation

- R_p and a_p values are provided in tables
- a_p = 1 for rigid components;
- a_p = 2.5 for flexible components
  - Lower value permitted if justified by detailed dynamic analysis
- Types of nonstructural systems included in these documents differs
  - R_p values also may differ slightly

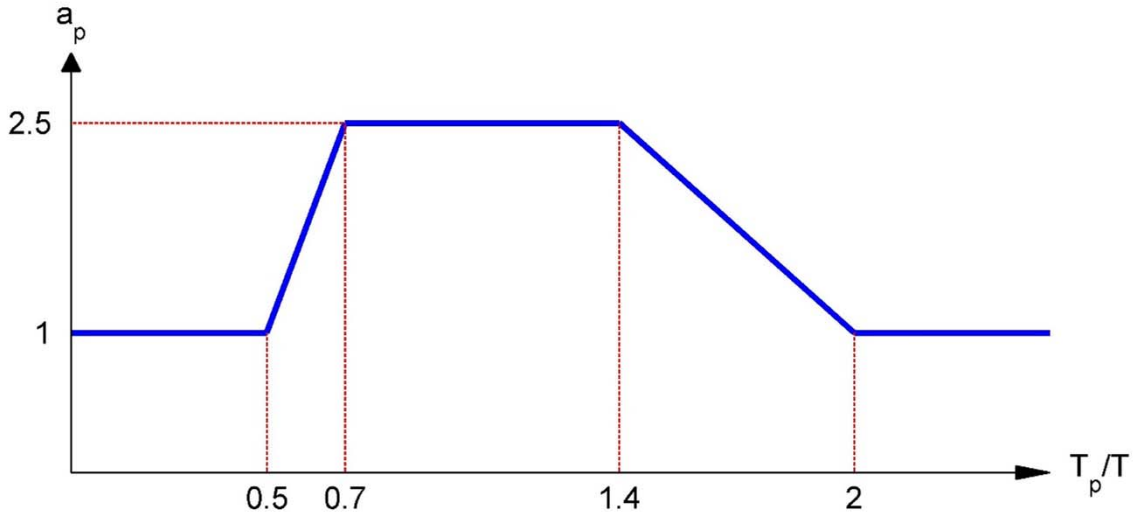
FEMA 450 and ASCE 7 Alternate Equation

- If acceleration, a_i, at the point of attachment of the component can be computed from modal (or response spectrum) method

$$F_p = \frac{a_i a_p W_p}{\frac{R_p}{I_p}} A_x$$

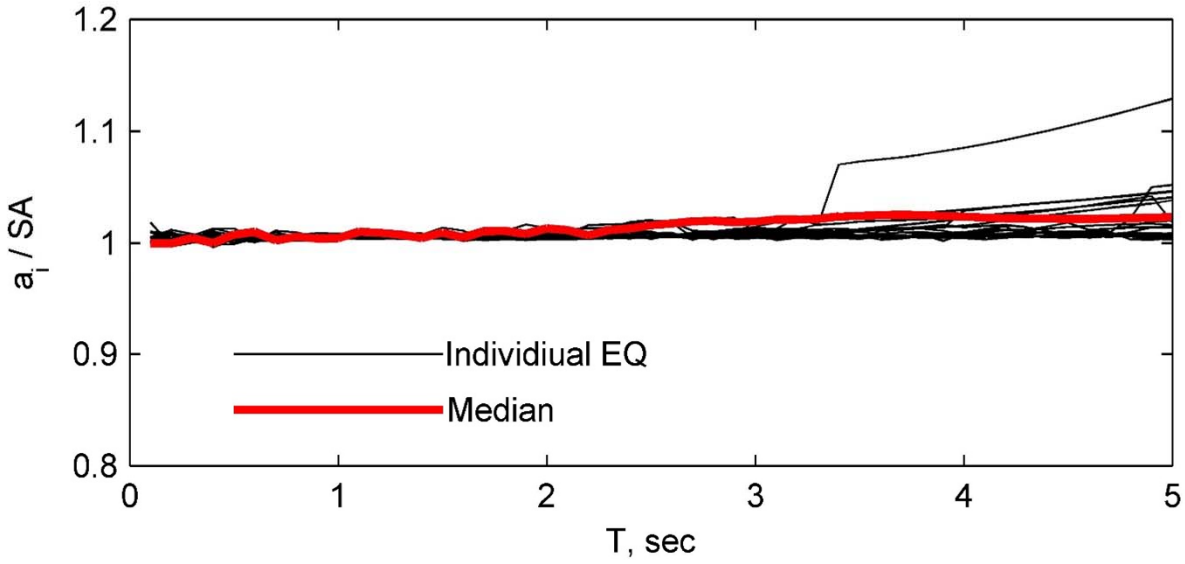
ASCE 7
Alternate Procedure to Estimate a_p

- If fundamental period of the structure, T, and of the component, T_p, are know, a_p may be estimated from



Relationship between a_i and SA

- For low damping values (e.g., 5%), a_i for a SDF system is essentially equal to spectral acceleration



Estimation of a_i

- Marine Oil Terminals are, in most cases, similar to single-degree-of-freedom (SDF) systems
- Damping is typically low (5%)
- For such cases, a_i = spectral acceleration for design earthquake

Recommendations

- Consolidate seismic provisions for nonstructural components
- Compute design forces for MOTEMS Level 2 earthquake
  - I_p = 1.5 may be used for critical components to ensure survivability at Level 1 earthquake
- If needed, replace $0.4S_{DS}$ with PGA for MOTEMS design earthquake
- When appropriate, use alternate method with a_i = SA for design earthquake
- When structural and component periods are available, estimate a_p from provided figure

Other Recommendations

- Professionals connected to seismic design of piers and wharves should
  - Identify types of nonstructural and non-building structures typical for Marine Oil Terminals
  - Develop consensus a_p and R_p values if needed
  - Prepare a standard of its own, instead to referring to ASCE 7, if needed