ASCE 4-16

Seismic Analysis of Safety-Related Nuclear Structures and Commentary/DOE NPH Meeting

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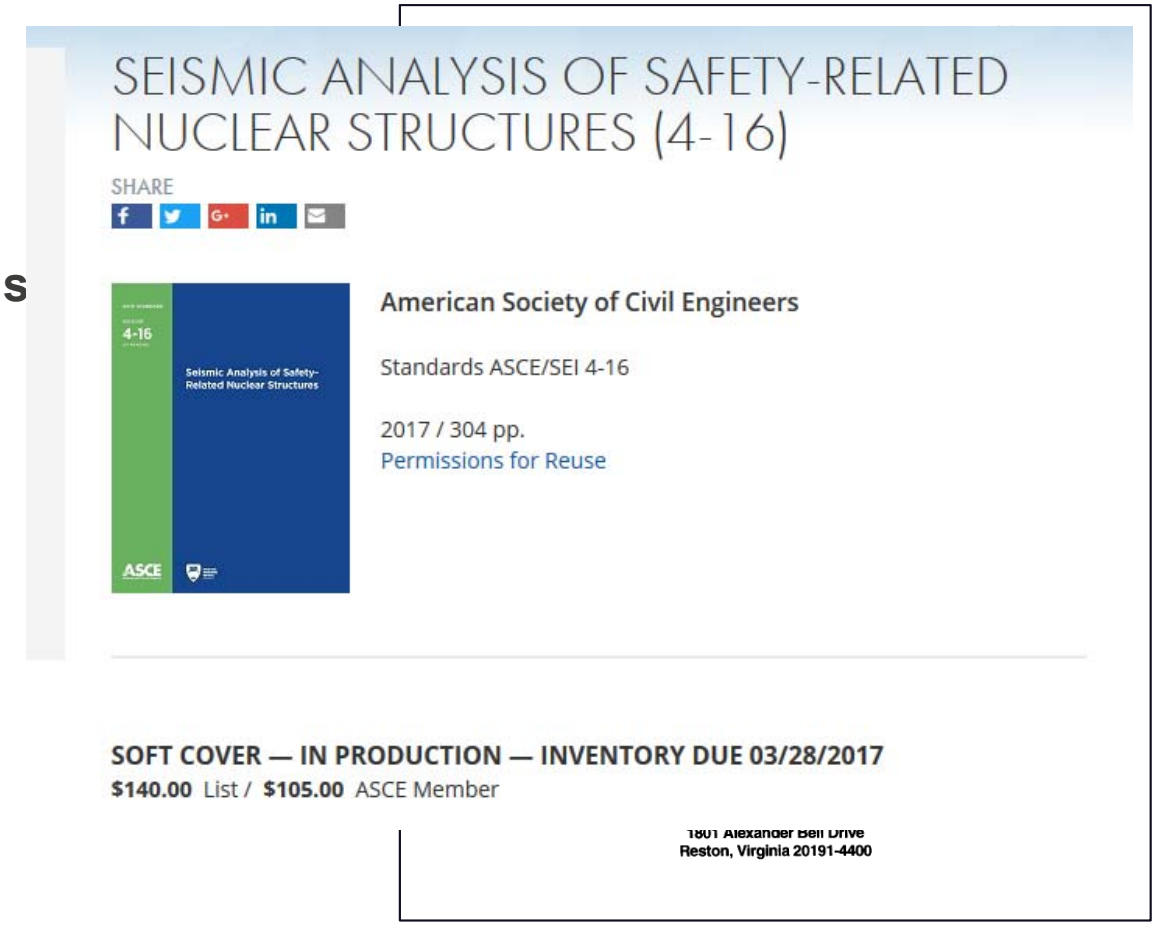
Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

Presentation

- Background
- New Structure/Content
- New Technical Sections/Provisions
- Revision Cycle



SEISMIC ANALYSIS OF SAFETY-RELATED NUCLEAR STRUCTURES (4-16)

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Standards ASCE/SEI 4-16

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1801 Alexander Bell Drive
Reston, Virginia 20191-4400

ASCE Is moving towards a 5 year revision cycle

Background

- **ASCE 4 - 86 - Original Working Group**
  - First published in 1987
  - Provided general guidance in dynamic analysis of structure
- **ASCE 4 - 98 – First Major Revision**
  - Published in 1998
  - Major update of 86
  - Moved to targeted demand levels (90% Nep based on 84% input)
  - Primarily aimed at elastic analysis – discusses some nonlinear methods but provides little guidance other than pointing to references.
  - Provided guidance on analysis using standard techniques (response spectrum methods, time history methods, complex frequency and equivalent static)
  - Provided guidance on SSI, subsystem, and special structures
- **ASCE 4 – 16 – 2nd Major Revision (In Publication)**
  - Nonlinear response methods now included
  - Criteria for analysis of sliding and rocking of unanchored components
  - Major update to criteria on base isolated structures

You too can provide suggestions for improvement

Content

1. General/Introduction
2. Seismic Input
3. Modeling of Structures
4. Analysis of Structures
5. Soil-Structure Interaction Modeling and Analysis
6. Input for Subsystem Analysis
7. Buried Pipes and Conduits
8. Dynamic Soil Pressures on Walls
9. Vertical Liquid-Storage Tanks
10. Distribution Systems
11. Dynamic Sliding and Uplift Analysis
12. Seismic Isolated Structures

Appendix A – Seismic PRA and Seismic Margin Assessments

Appendix B – Nonlinear Time Domain Soil-Structure Interaction Analysis

New Technical Provisions

- Seismic Quality Provisions
- Performance-Based Ground Motion
- Probabilistic SSI
- Deterministic SSI to simulate probabilistic SSI
- Nonlinear Response Methods
- Sliding and Rocking of Unanchored Components
- Seismically Isolated Structures

Seismic Quality Provisions

- **Seismic Quality Provisions**
  - Most of the Seismic QA provisions in ASCE 4 are high level requirements.
  - Corporate QA programs designed to meet ASME NQA-1 or DOE O 414.D will have provisions that address the requirements, but it is recommended that project or corporate QA contacts review ASCE 4 to identify holes
- **Three specific requirements are called out in ASCE 4-16**
  1. Analysis verification and documentation
  2. Load path study
  3. Independent peer review

Performance-Based Design Motions

- **Chapter 2 of ASCE 4**
  - Presents acceptable procedures to incorporate local site effects (site response) into calculation of ground motion at different elevations in a soil profile
  - Starts with UHRS developed based on a probabilistic seismic hazard analyses at the annual frequency of exceedance appropriate for seismic design category (ASCE 43)
  - Can be used to generate surface and foundation-level spectra
- **Provisions**
  - Probabilistic site response evaluations (2.3)
  - Strain-Compatible Soil Properties (2.4)
  - Design Response Motions (2.5)
  - DRS-Compatible Time Histories (2.6)
- **Number of time histories**
  - One or more*
  - Five are required for linear elastic analysis (2.6.1)
- **Structures Sensitive to Low-Frequency Motions**
  - Additional criteria for structures with fundamental modes f < 0.5 Hz.
- **Alternate Definitions (2.8)**

Probabilistic SSI

- Section 5.5 is new and presents methods for probabilistic soil structure interaction analysis
- Aim is to produce distribution on response - response can vary from moment, axial loads on components but probably most common is a probabilistic response in-structure response. 80% demand is targeted for use with ASCE 43 and will result in HCLPF exceeding the design basis motion
- Random variables include structures stiffness, structure damping, soil stiffness and damping and input motion (time history seeds).
- Soil profiles are consistent with strain-iterated developed in PSHA
- Input motions are either N acceleration time series or N response spectra sets.
- 200 Simulations required when Monte Carlo methods are used. Minimum of 30 simulation considered when Latin Hypercube Sampling is done.

Deterministic SSI to Simulate Probabilistic

- **Probabilistic SSI is preferred, however, deterministic methods similar to ASCE 4-98 are still allowed**
- **Target non-exceedance probability remains 80% response to achieve performance prescribed in ASCE 43**
- **Fixed base analysis are permitted in some cases**
- **Effects of structure-soil-structure interaction should be considered for light structures in proximity to massive structures**
- **It is acceptable to account for uncertainties in SSI by varying the high-strain soil shear modules**
  - Best Estimate soil shear modulus
  - Lower bound (G/(1+Cv))
  - Upper bound (G * (1+Cv))
  - Note that minimum Cv is 0.50 and 1.0 "*if insufficient data are available to address uncertainties in soil properties*"
- **Methods used to perform SSI analysis shall be validated (5.1.11)**
- **ISRS and 80% demand is obtained as an envelope of the UB, LB, BE soil cases. Peak clipping and broadening is permitted (6.2.3)**

Nonlinear Response Methods

- **4-16 Includes additional criteria on the use of nonlinear methods to compute structure response**
- **Nonlinear Response History Analysis (4.7)**
  - Required for analysis and design of seismically isolated nuclear structures
  - May be used for evaluation of unanchored components
  - Numerical models of components shall be based on test data
  - Requires a minimum of five time history analysis
  - Seismic response is taken as the average from five analyses
- **Approximate Inelastic Response Spectrum Analysis (4.8)**
  - $D_{NL} = \frac{D_{elastic}}{F_{\mu}}$
- **Nonlinear Static Analysis (4.9)**
  - Subject to limitations of ASCE/SEI 41-06
  - Target displacements are computed using either coefficient method of ASCE/SEI 41-06 or capacity spectrum method of FEMA 274

Sliding and Rocking of Unanchored Components

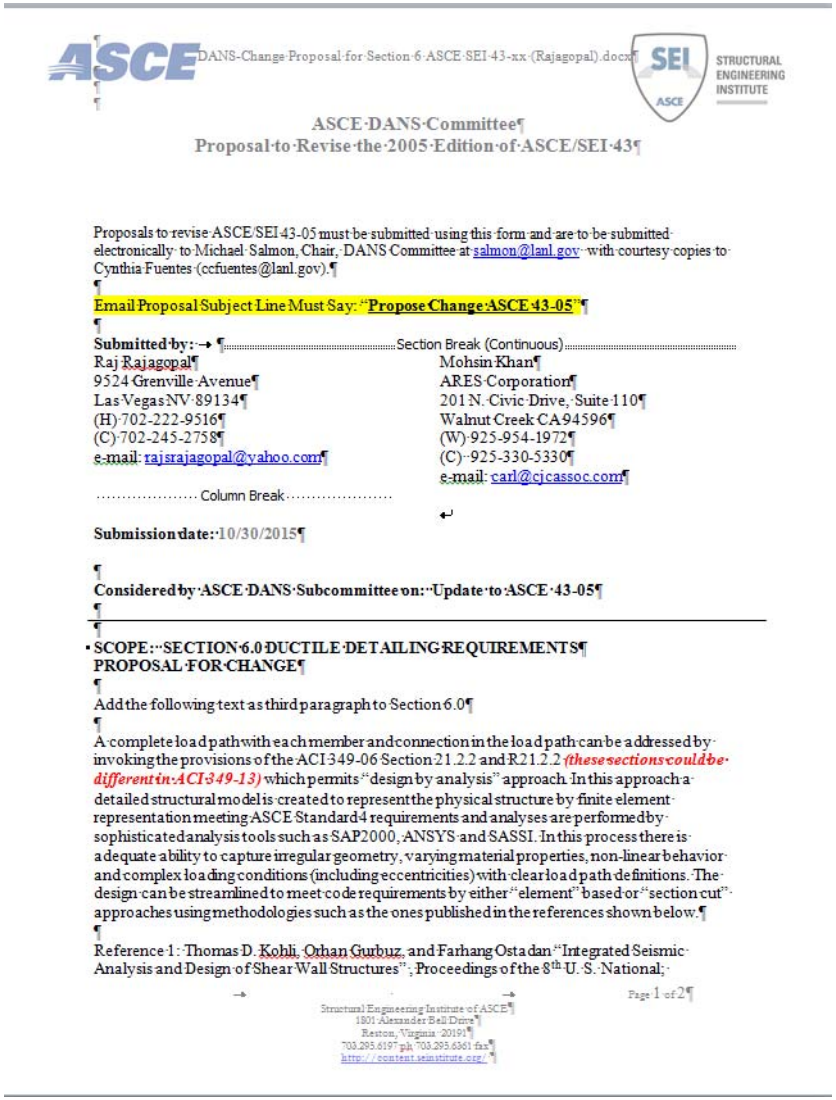
- **Sliding and Rocking of Unanchored Components**
- **Earthquake experience has demonstrated that anchored components generally perform well – anchoring is preferred**
- **If estimated sliding or rocking displacements can be tolerated without loss of function, then anchoring is not necessary**
- **Design values of sliding and rocking are provided in 43-05**
- $\Delta_{design} = 3.0 \times \overline{\Delta}$**, where** $\overline{\Delta}$ **is best estimate of sliding**
- $\phi_{design} = 2.0 \times \overline{\phi}$**, where** $\overline{\phi}$ **is best estimate of rocking angle**
- **ASCE 4 suggests two methods are available for computation of sliding displacements and rocking angles**
  - Nonlinear response history analysis
  - Approximate methods

Seismically Isolated Structures

- Criteria for design of seismically isolated structures has been greatly expanded.
- Written for application to power plants and structures
- Limited to horizontal isolation only
- Two levels of design demand are required (DBE and 1.5xDBE)
- Stop is required at 90% displacement demand at 1.5xDBE input
- Qualification of isolators and isolation system require dynamic testing
- Design and analysis provisions are presented
- Peer review of isolation system and related test programs are required.

Proposal Process for Change

- **Create and Submit Proposed Change**
  - Any person shall be permitted to submit proposed standard provisions at any time to the Chair with a request that the proposed provision be considered by a letter ballot of the Committee
- **Submit to DANS Committee**
  - salmon@lanl.gov,
  - gabatt@becht.com
  - nstoeva@vecsa.com
- **Ballot and appeals process**
  - Appeals are filed to ASCE, Codes and Standard Committee (CSC)
  - jneckel@asce.org
  - jesslinger@asce.org



DANS-Change Proposal for Section 6 ASCE SEI 43-xx (Rajagopal).docx

STRUCTURAL ENGINEERING INSTITUTE

ASCE DANS Committee
Proposal to Revise the 2005 Edition of ASCE/SEI 43

Proposals to revise ASCE/SEI 43-05 must be submitted using this form and are to be submitted electronically to Michael Salmon, Chair, DANS Committee at salmon@lanl.gov with courtesy copies to Cynthia Fuentes (ccfuentes@lanl.gov).

Email Proposal Subject Line Must Say: "**Propose Change ASCE 43-05**"

Submitted by: → Section Break (Continuous)

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Column Break

Submission date: 10/30/2015

Considered by ASCE DANS Subcommittee on: "Update to ASCE 43-05

SCOPE: "SECTION 6.0 DUCTILE DETAILING REQUIREMENTS
PROPOSAL FOR CHANGE

Add the following text as third paragraph to Section 6.0

A complete load path with each member and connection in the load path can be addressed by invoking the provisions of the ACI 349-06 Section 21.2.2 and R21.2.2 *(these sections could be different in ACI 349-13)* which permits "design by analysis" approach. In this approach a detailed structural model is created to represent the physical structure by finite element representation meeting ASCE Standard 4 requirements and analyses are performed by sophisticated analysis tools such as SAP2000, ANSYS and SASSI. In this process there is adequate ability to capture irregular geometry, varying material properties, non-linear behavior and complex loading conditions (including eccentricities) with clear load path definitions. The design can be streamlined to meet code requirements by either "element" based or "section cut" approaches using methodologies such as the ones published in the references shown below.

Reference 1: Thomas D. Kohli, Orhan Gurbuz, and Farhang Ostadan "Integrated Seismic Analysis and Design of Shear Wall Structures", Proceedings of the 8th U. S. National;

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Summary

- ASCE 4-98 has been revised, ASCE 4-16 is in publication
- ASCE 4-16 has a significant amount of new content that may be helpful in updating PRAs for 10CFR 50.54 evaluations (Fukushima) and DOE Evaluation of older facilities subjected to updated seismic hazard curves
- You can help improve by review and submittal of changes that you feel are needed
- We are moving to a 5 year revision cycle (3 years accepting change proposals, 2 years balloting and processing through ASCE)

ASCE 4-98 has been updated. ASCE 4-16 is in publication,