

Lessons Learned in Design Certification of Civil Structures for the U.S. EPR

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Outline

- ▶ Seismic Design Challenges
- ▶ Structural Design Challenges
- ▶ Considerations of COL Applicants



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Seismic Design Challenges

- ▶ Objective for a standard design certification is to provide a design broadly applicable to a range of site characteristics
- ▶ Challenging for seismic design because actual site characteristics of importance to C/S design may vary widely from location to location
 - ◆ There are a large number of C/S related parameters that must be considered in combination rather than individually in the design
 - ◆ Variation in site characteristics generally has less impact to mechanical design since it may be easier to identify enveloping design parameters
- ▶ To address this challenge, designers select standard design parameters which bound or cover a broad range of possible inputs. However, the design parameters may be excessively conservative with respect to actual site characteristics
 - ◆ Actual site characteristics are inherently unique and are typically less demanding overall when considered in combination



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Seismic Design Challenges (continued)

- ▶ To minimize excessive conservatism, more sophisticated modeling techniques were utilized to demonstrate acceptability of the design
 - ◆ embedment modeling was to demonstrate stability (accounts for resistance to sliding from lateral soil pressure) and reduce ISRS
 - ◆ consideration of high frequency ground motion required a change from use of a stick model to the use of finite element models for seismic analysis
- ▶ Changes in modeling and analysis approaches were also driven by changes in NRC guidance during application development
 - ◆ new guidance influenced by early ESP application reviews and new plant activity
 - ◆ resulted in additional analysis to address new guidance



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Seismic Design Challenges (continued)

- ▶ Difficult to establish a generic seismic design response spectra (SSE) for design of SSCs at all potential sites
 - ◆ Prior designs were based on deterministic approach, e.g., RG 1.60
 - ◆ New designs are based on probabilistic seismic hazard analysis (PSHA), therefore “unique” for a given site
- ▶ The U.S. EPR design established a “representative” certified seismic design response spectra (CSDRS) considered adequate for design of SSCs and added a high frequency ground motion
 - ◆ Differences are between the “generic SSE” and the actual site SSE are reconciled in the COL application



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Structural Design Challenges

- ▶ 10 CFR 52 requires a standard design certification application provide an “essentially complete” design
- ▶ Not required or practical to complete all structural design results for a design certification
- ▶ Use of “critical sections” is an accepted method to address completeness of the structural design within the standard design certification
- ▶ Structural analysis (static and dynamic) is performed and methods and procedures are specified.
- ▶ Design results are provided only for representative “critical sections” of the structures





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Structural Design Challenges (continued)

- ▶ Guidance for selection of critical sections does not exist generically
- ▶ AREVA established a combination of quantitative, and qualitative, and supplementary criteria to select structural elements to perform detailed design
- ▶ Qualitative Criterion
 - ◆ SC I structures that perform a safety critical function (e.g. barrier to radioactive releases)
- ▶ Quantitative Criterion
 - ◆ Identifies sections that are highly stressed
 - ◆ Selected through numerical analysis of finite element analysis results
- ▶ Supplementary Criterion
 - ◆ Uses engineering judgment and obtains adequate representation of typical structural elements

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Structural Design Challenges (continued)

- ▶ For the structural design to be broadly applicable, multiple soil conditions must be considered
 - ◆ Results in a large number of seismic load combinations that must be included in the design
 - ◆ Requires significant effort to identify controlling load combination due to volume of data
 - ◆ Affects stability analysis and analysis of interactions between adjacent structures
- ▶ Difficult to evaluate the effects of settlement generically
 - ◆ Actual site conditions are non-uniform
 - ◆ Impractical to consider all possible soil property variations that could occur on an actual site
 - ◆ U.S. EPR design established assumed settlement profiles to be reconciled with actual site

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Consideration of COL Applicants

- ▶ Knowledge of actual site characteristics is beneficial for selecting design parameters
- ▶ Design certifications desire to minimize activities required during implementation by COL applicants
- ▶ Details were included in the U.S. EPR design certification to describe methods for reconciling differences between the design parameters and actual site characteristics
 - ◆ Difficult to establish a “generic” reconciliation process
 - ◆ Reconciliation approach is influenced by the magnitude and nature of the difference (each site is different)
- ▶ Other approaches may also be technically acceptable but may result in a “departure” from methods described in the design certification

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Conclusions

- ▶ A standardized design that is broadly applicable is an important objective for design certifications.
- ▶ There are challenges associated with establishing generic design parameters while avoiding excessive conservatism.
- ▶ It is difficult to establish a single generic reconciliation process. Alternative approaches may be acceptable depending on the nature of the difference.
- ▶ Actual site characteristics are inherently unique and may be less demanding when considered overall.



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