Civil/Structural Lessons Learned on the U.S. EPR™ Project

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NRC Regulatory Information Conference
March 12-14, 2013

Outline

- Generic Lessons Learned
- Seismic Design Challenges
- Structural Design Challenges
- Considerations of COL Applicants
- Conclusions

Generic Lessons Learned

- The use of broad design parameters in the standard design certification potentially yields to excessive concrete and reinforcement requirements for a site
- Effective design change controls during the design process are key for success
- Level of analysis / design detail in the certification process must be closely monitored and assessed against the Regulations
- Application submittals must be complete with sufficient level of detail

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

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
- Soil Structure Interaction Analyses
  - DNFSB letter in 2011 related to technical concerns with SASSI
  - Justification of SASSI methods required extensive re-work
  - Complexity of models exceeded current day computing capabilities
  - SASSI was upgraded to take advantage of computer clustering capabilities
  - Supercomputing data centers were used to execute the analyses

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

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

Structural Design Challenges (continued)

- For the structural design to be broadly applicable, multiple soil conditions must be considered
  - Design load combinations for containment and other Category I structures are different
  - The permutations of load combinations are numerous
  - Resulting is a large set of computer data to analyze and narrow down to the controlling combinations
  - Structural Design software for Nuclear Codes are not readily available or require significant development
  - With the use of broad parameters the design yields excessive concrete and reinforcement configuration

Consideration of COL Applicants

- Knowledge of actual site characteristics early 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

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
- Actual site characteristics are inherently unique and may be less demanding when considered overall

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