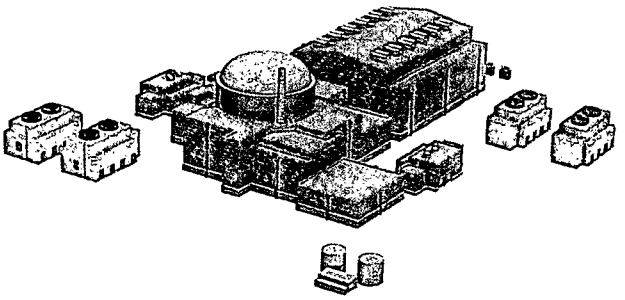
U.S. EPR Civil Structural RAI Update



AREVA NP and the NRC
May 6, 2009

EPR by AREVA

Topics

- > Status of responses to RAIs 155 and 161
- > Seismic analysis methods
- > Addition of COL ground motions
- > Soil cases
- > Critical sections selection
- > Summary

EPR by AREVA

Remaining RAIs

- RAI 155 (Section 3.8)
  - FSAR clarifications
  - Design and analyses (Revisions to 3.8)
    - Load combinations
    - Sliding
    - Overturning
    - Ultimate capacity
  - Design implementation
    - Deterministic critical section selection criteria
    - Appendix 3E inclusion of new sections
  - Follow-Up RAIs (RAI 211 RG 1.90)
- RAI 161 (Section 3.10)
  - Implementation of high frequency Results In Structure

Overview of RAIs

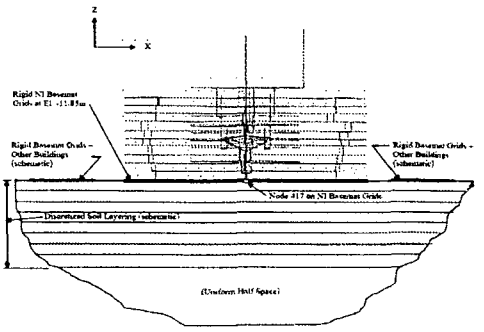
- NRC areas of concern
  - Sliding and overturning evaluations - factor of safety
    - RAI-155, Supplement 5
      - RAI-155, 03.08.05-8 (NI) 03.08.05-12 (ESWB/EPGB)
  - High frequency content in Central and Eastern U.S.
    - Addition of Bell Bend and Callaway ground motions
    - RAI 161, Supplement 1
      - RAI-161, 3.10-19, 3.10-20
  - Critical sections - criteria developed and applied
    - RAI-155, Supplement 6
      - RAI-155, 03.08.01-3, 03.08.01-20, 03.08.01-24

Seismic Analysis

- Current seismic analysis methods in FSAR
- Additional seismic analysis methods to respond to RAIs
- Soil profile adjustments
  - Identification of bounding soil profiles
  - Addition of Bell Bend and Callaway

Current FSAR Seismic Analysis Methods

- Stick model tuned to finite element model
- Stick model analyzed using SASSI
- 12 analysis cases
- Surface Founded Analysis

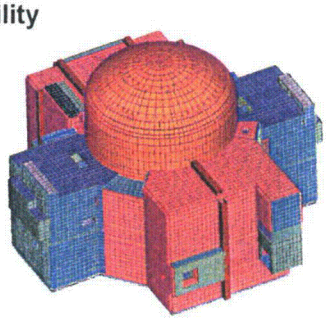


Additional Seismic Analysis Methods

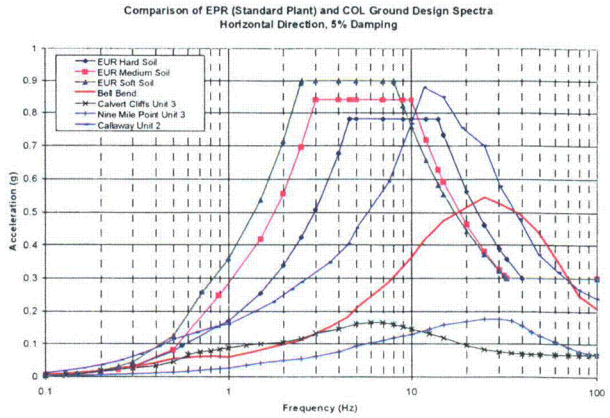
- Introduction of a 3D Finite Element Model
- Drivers and benefits of a revised approach
  - High frequency input motions (RAI-161, 03.10-19/-20)
  - Sliding and overturning (RAI-155, 03.08.05-8/-12)
  - Embedment effects (RAI-155, 03.08.05-4)
  - Basemat flexibility (RAI-130, 03.07.02-4)
  - Account for flexible slabs
  - Improved floor acceleration distribution

3D FEM Seismic Model

- Finite Element Model attributes
  - Shell, solids and beam elements
  - Meshed to capture:
    - more acceleration output nodes
    - high frequency response
    - basemat flexibility
    - flexible slabs
  - ~55,000 nodes



Addition of Bell Bend and Callaway Motions



U.S. EPR Soil Cases

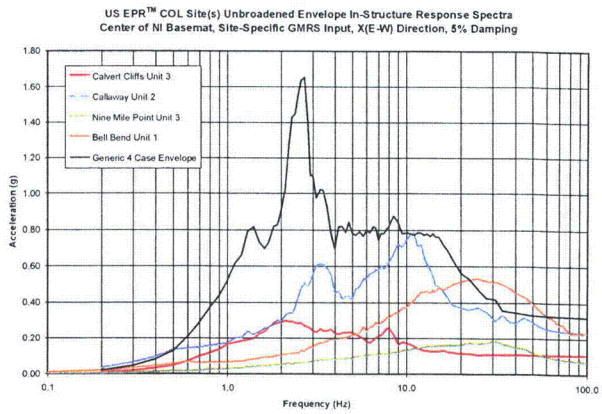
- Original 10 generic soil profiles
  - Yellow cases are controlling
- Bell Bend and Callaway added

Soil Case No.	Seismic Control Motion Applied	Soil Profile (Half-space or Layered)	(1)Shear-wave Velocity of Soil (ft/sec)
1u	EUR Soft	Half-space	700
2u (A and B)	EUR Soft and Medium	Half-space	1640
3u	EUR Medium	Half-space	2625
4u (A and B)	EUR Medium and Hard	Half-space	3937
5u	EUR Hard	Half-space	5249
5a	EUR Hard	Half-space	13123
1n2u	EUR Soft	Linear gradient within a 100 ft layer over a half-space	820 to 1640
2sn4u	EUR Medium	49 ft uniform layer over a half-space	1640/3937
2n3u	EUR Medium	Linear gradient within a 200 ft layer over a half-space	1640 to 2625
3r3u	EUR Medium	20 ft uniform layer over 33 ft stiffer layer followed by soil half-space	2625/5249/2625

Final Soil Cases for U.S. EPR

- 1n2u, 2sn4u, 4um and 5a (Controlling Generic Soil Cases)
- Bell Bend (Upper Bound, Lower Bound, Best Estimate)
- Callaway (Upper Bound, Lower Bound, Best Estimate)

Addition of Bell Bend and Callaway Motions Response Spectrum Comparisons Basemat



Critical Sections Selection for U.S. EPR Nuclear Island (NI) Common Basemat Structures

> Critical Sections

Structural components (individual shear walls and slabs, structure-to-structure connections, or portions thereof) that are necessary to demonstrate the structural adequacy of safety-significant structures pertaining to the U.S. EPR Nuclear Island (NI) common basemat.

Critical Sections Selection for U.S. EPR Nuclear Island (NI) Common Basemat Structures

> Critical sections selection criteria

- *Qualitative Criteria:* Applied to the U.S. EPR NI common basemat structures critical to support safety functions and to provide protection of public safety through the physical plant boundaries to release.
- *Quantitative Criteria:* Analyzed force and moment results extracted from the ANSYS global static model for U.S. EPR NI common basemat structures not already evaluated by the qualitative criteria and identification of areas with the largest structural demand
- Criteria developed and applied in a formal calculation

20 Critical Sections for U.S. EPR NI Common Basemat Structures

> Critical sections per qualitative criteria:

- *Reactor Containment Building – (5)*
- *Reactor Building Internal Structures – (1)*
- *NI Basemat & Reactor Building Internal Structures Base Slab, (1)*

20 Critical Sections for U.S. EPR NI Common Basemat Structures

> Critical sections per quantitative criteria

- *Reactor Building Internal Structures – (3)*
- *Safeguard Building 2/3 Hardened Shell – (1)*
- *Safeguard Building 2/3 Internal Structures – (2)*
- *Safeguard Buildings 1 & 4 – (2)*
- *Fuel Building Hardened Shell – (1)*
- *Fuel Building Internal Structures – (2)*
- *Reactor Shield Building Typical Wall Areas & Connection Between Reactor Shield Building Wall and Safeguard/Fuel Building Roof Slabs, (1)*
- Reactor Shield Building – (1)

Critical Sections: Next Steps

- Concurrence on selection criteria and application
- Process FSAR changes
  - Describing critical section selection methodology
  - Identifying the critical sections
  - Revising impacted FSAR text
- Perform critical section reanalysis and expansion of number of sections
  - Confirmatory analysis

Summary

- Responses to RAI 155 and 161
  - Submittals phased
  - Additional tool for seismic analysis (3D FEM Model)
- Soil cases revised
  - Controlling generic cases identified
  - Bell Bend and Callaway added
- Critical section criteria developed and applied
  - Available for audit and concurrence
- Confirmatory detailed critical section results