

# **Key Seismic Issues for NPPs Consultant Perspective**

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Aerial photograph of Vogtle 3 and 4 construction site. Unit 3 is located at left and top of photo and Unit 4 to the right and bottom. Heavy lift derrick crane foundation in center. August 11, 2011

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# Standard Designs

- Perform seismic analysis and design for a series of site conditions and select design motions
- Prepare and get approval for the Design Certification Document (DCD)
- Utilities submit COLA (construction/operation license application)
- Once approved, plant is built and operation starts

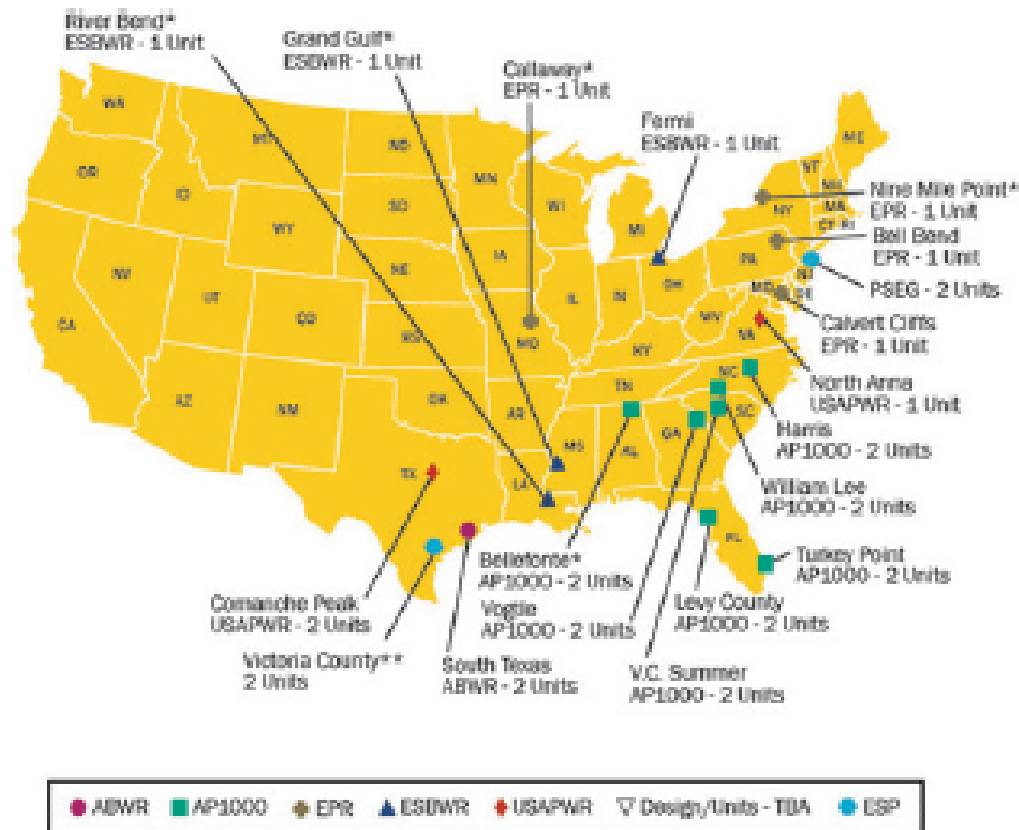
# Standard Designs – US Market

- Westinghouse AP1000
- General Electric ABWR and SBWR
- AREVA US EPR
- Mitsubishi US APR

# Standard Designs

## Location of Projected New Nuclear Power Reactors

*For applications that have been received by the NRC, you may select a site name to view the NRC's web site for the specific COL application. Websites for the remainder of the applications will be created when they are received*



\*Review Suspended by Applicant

\*\* COL Application Amended by Applicant to ESP on 03/28/2010

# Modular Reactors

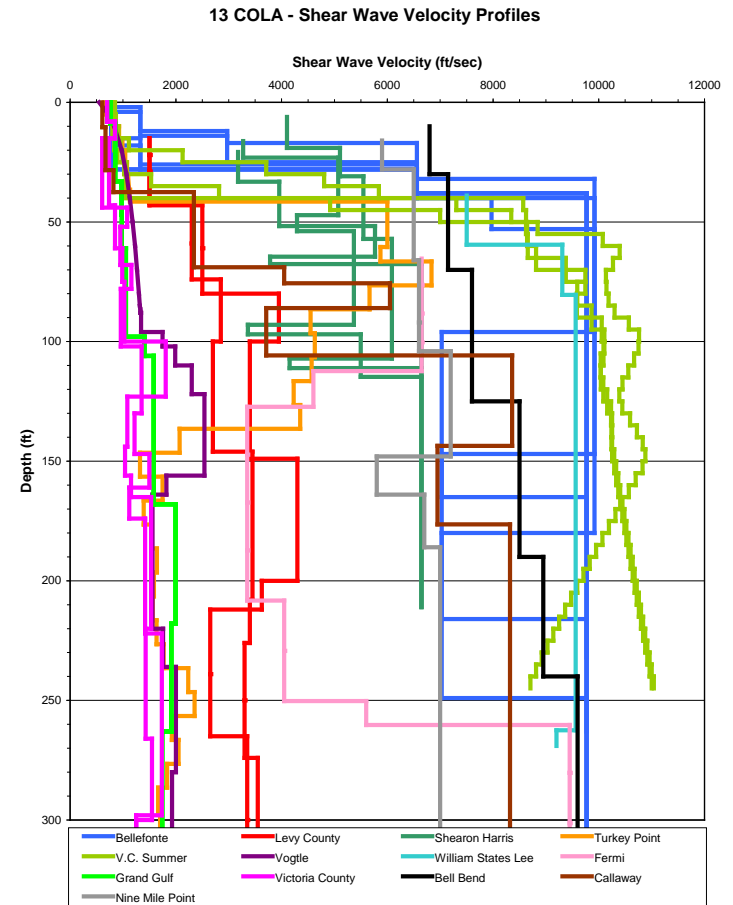
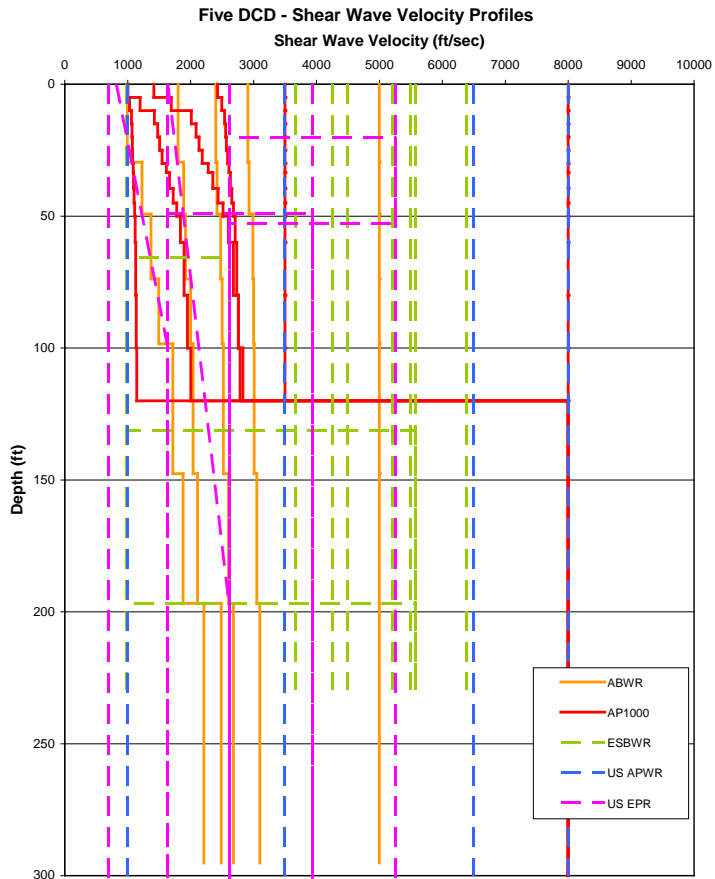
- Nuscale, 24 units, 45 MWe each, 2018
- B&W mPOWER, 150 MWe, DCD 2012
- WEC IRIS, 335 MWe, DCD 2012
- ARC-100, 50-100 MWe
- Toshiba 4S, 10 MWe
- Terrapower
- Pebble Bed Modular Reac
- ...

# Design Soil Profiles

- Selection of limited set of design profiles at the DCD stage is very challenging
- The design is intended to be applicable to as many sites as possible
- The dynamic properties of the plant structures are different
- An optimum set can be developed by a series of SSI analysis



# Design Soil Profiles



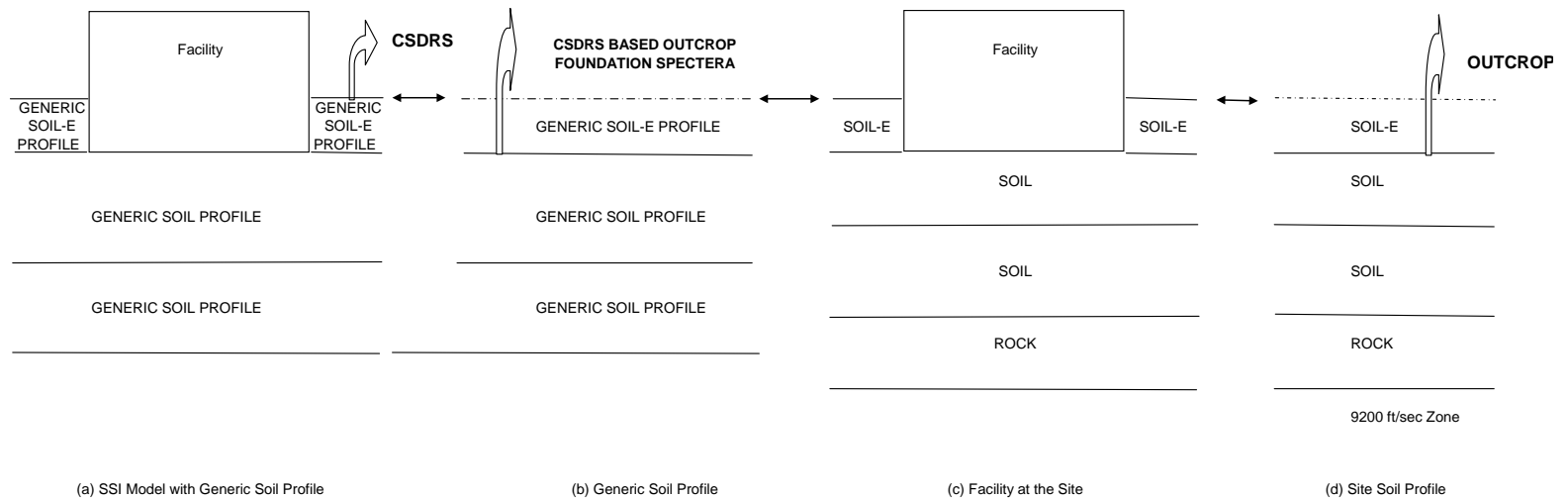
# Design Motion

- In most currently used methods, hazard curves are defined at 9200 fps Rock
- Must start with 9200 fps Rock Motions & Convolve through soil profile to the various elevations of interest
  - Obtain Mean 10-4 & 10-5 UHRS at each elevation of interest
  - Determine DRS from 10-4 & 10-5 UHRS at each elevation of interest
- Given the performance based approach and the target, the most appropriate elevation for specifying seismic input is at the foundation level of the structure
- Specifying the seismic input at any other location leads to unrealistic response spectra at the foundation level (either seriously unconservative, or unrealizably high)

# Design Motion

- FIRS and GMRS are developed using either the NEI or the BNL Methods
- Deconvolution of the broad band design spectra from surface is no longer permitted
- ISG 17 and New ASCE4, Chapter 2 defines the details

# Foundation Input Response Spectra (FIRS)

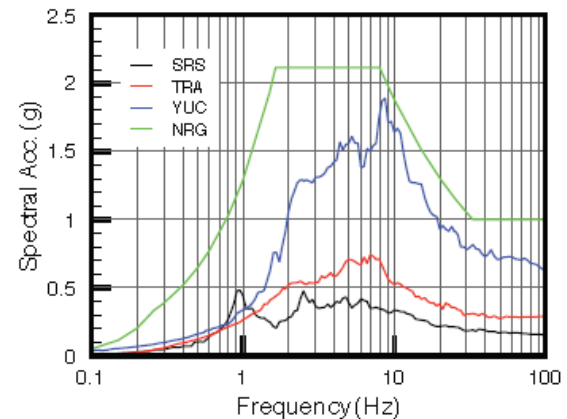
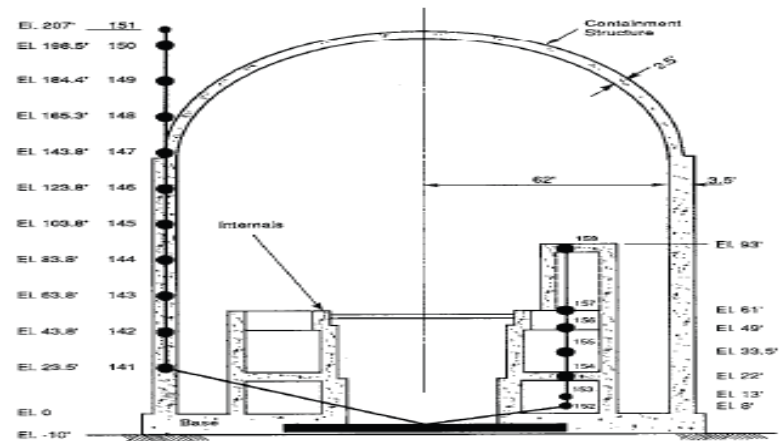


# Time History

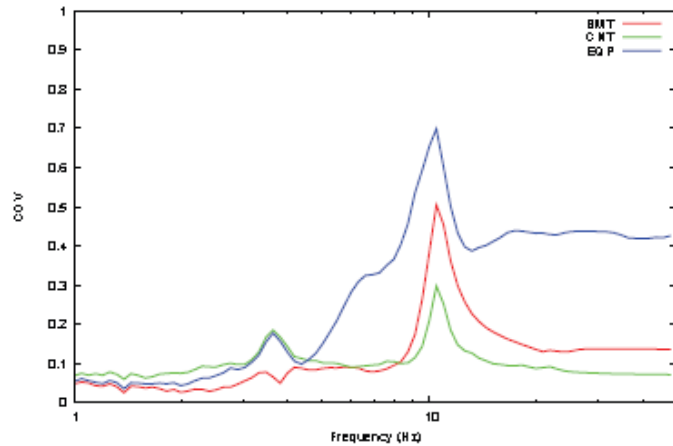
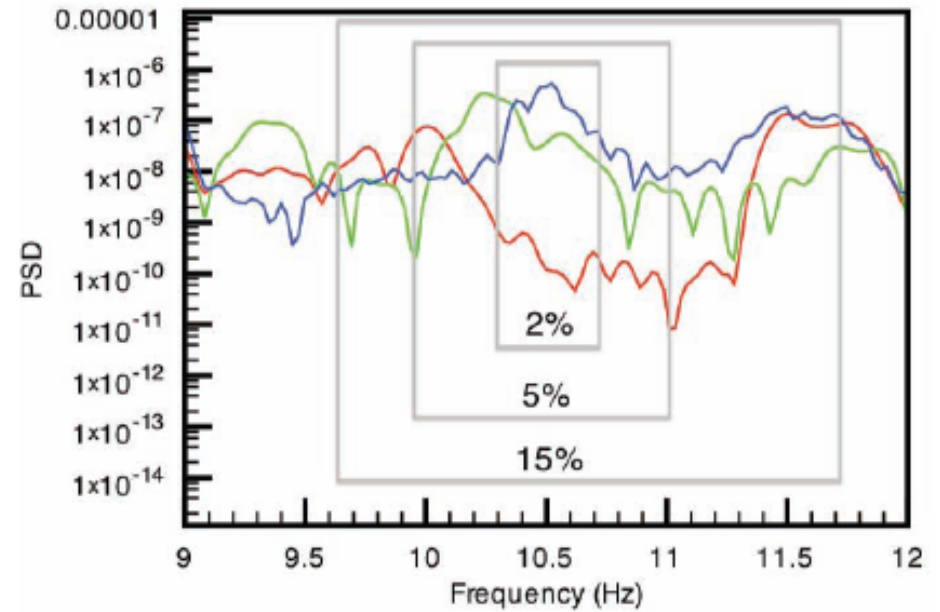
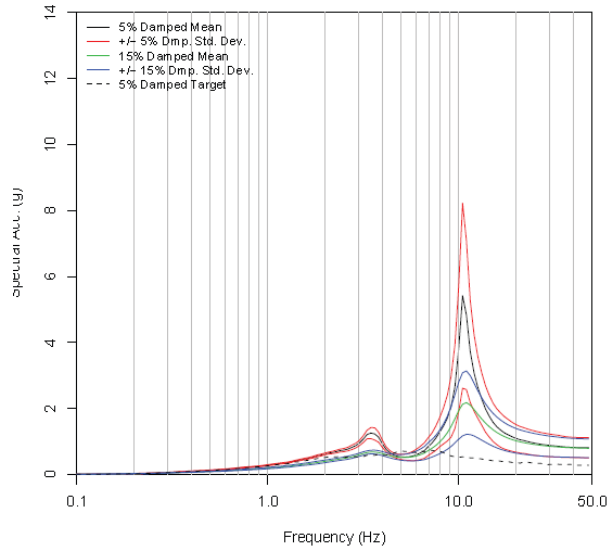
- Matching to DRS
  - Old requirements included matching to multiple target spectra and checking on power spectra
  - New criteria matches/envelops only 5% target spectra at more frequency points
- It has been determined that even for linear analysis using one time history for each direction is deficient

# Time History

- SSI analyses for several target spectra
- Surface and embedded structures
- Over 200 time histories matching the target



# Time History

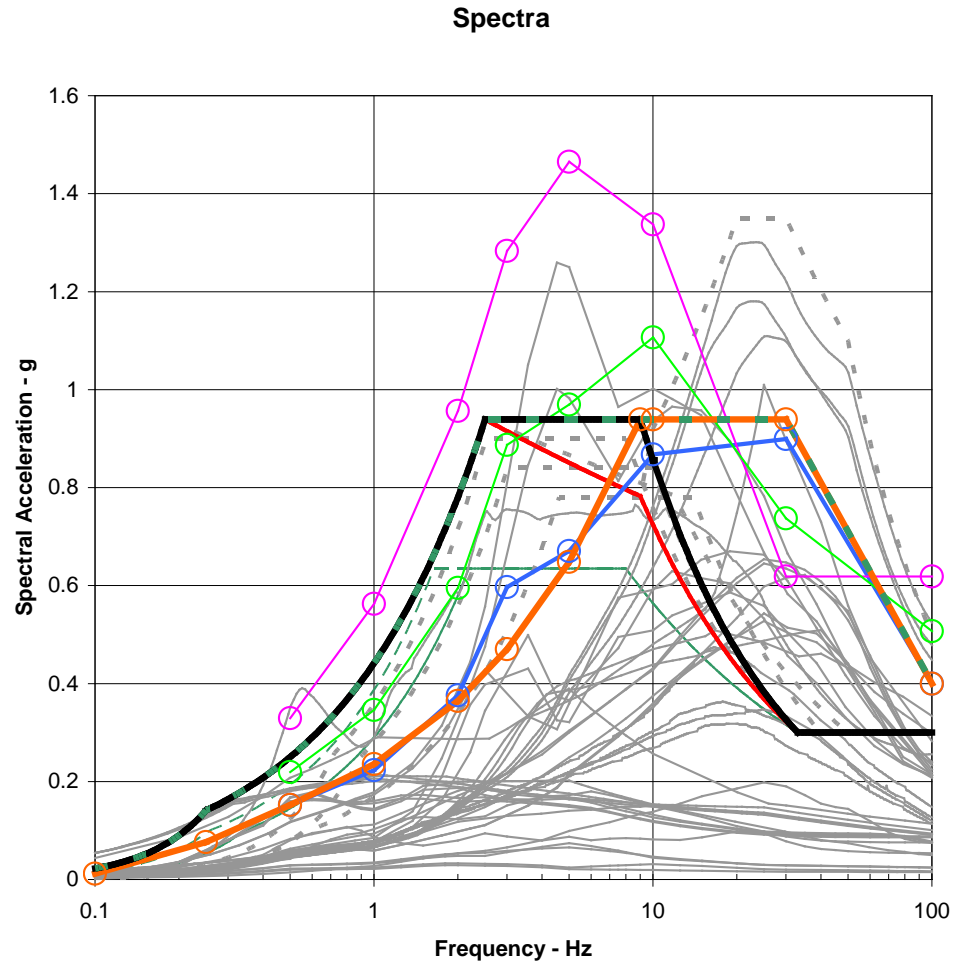


# Time History

- New ASCE4 under preparation recommends 5 sets and taking average of the results
- Alternatively the adequacy of motion must be illustrated for low and high damping (2% and 20%)
- Use of RVT is encouraged



# Design Motion FOR NPPs



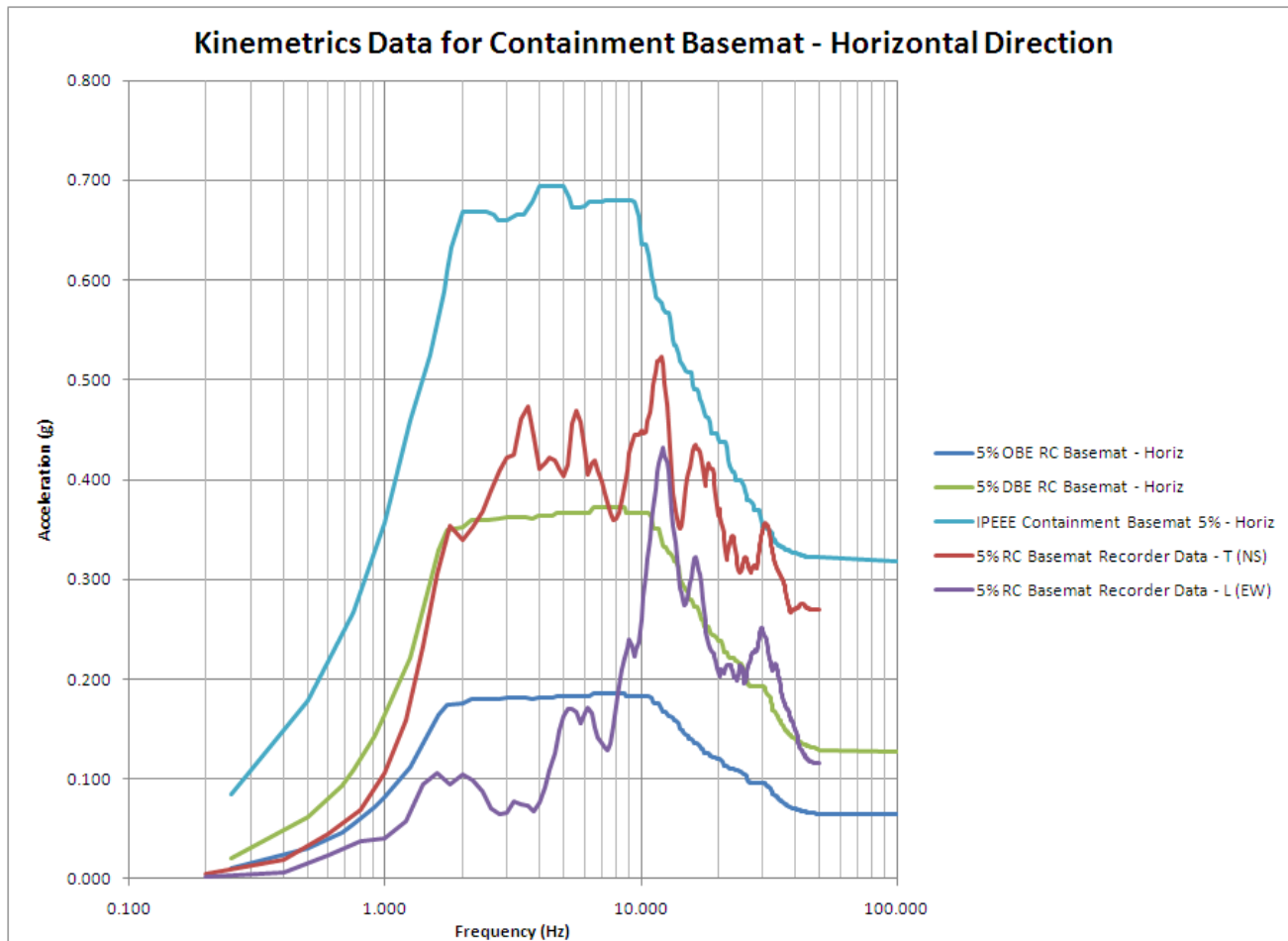
# Recent EQs, NRC Letter, GI-199

- Fukushima
  - Made a rare event a possible event
  - This event and its impact on NPPs will be studied for years to come
- Central Virginia EQ of 8/23/11
  - North Anna Units 1 and 2 were shut down
  - Re-start evaluation is under way
- NRC recent letter requiring seismic risk evaluation of all operating reactors

# Mineral Virginia EQ and North Anna Plants

- 11 miles south west of the plant
- Magnitude 5.8
- Both units were shut down
- No significant damage
- OBE and DBE exceeded

# Containment Basemat NAP 1



# NAP-1



# GI-199 and New NRC Letter

- Use of updated seismic data
  - Update of source modeling and activities due Dec 2011
  - NGA-East
- SMA or SPRA when GMRS exceeds SSE
- Plant improvement as needed to reduce seismic risk

# GI-199 and New NRC letter

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# Look Ahead

- New CEUS seismic data, critical
- Emphasis on beyond design evaluation
- SPRA, probabilistic SSI and RVT
- System reliability evaluation as opposed to individual structures and components
- Modular reactors will be in demand
- Application of the current methodologies for seismic analysis of very deeply embedded structures need to be confirmed/modified



# SMiRT22

- San Francisco
- August 18-24, 2013
- NGA-East has an extended session
- Special topics on Fukushima
- Reliability assessment



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Aerial photograph of Vogtle site, with Vogtle 1 and 2 operating units to the left and Vogtle 3 and 4 construction site to the right. August 11, 2011

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**Thank You**