

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

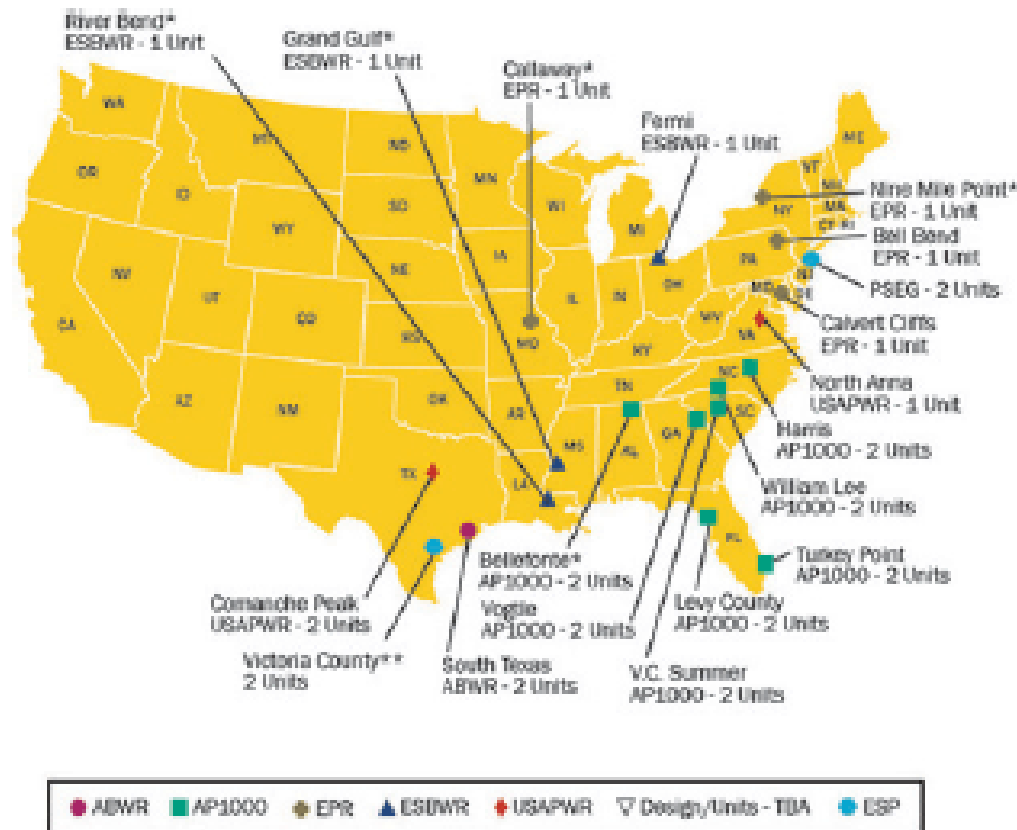
Standard Designs – US Market

- 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

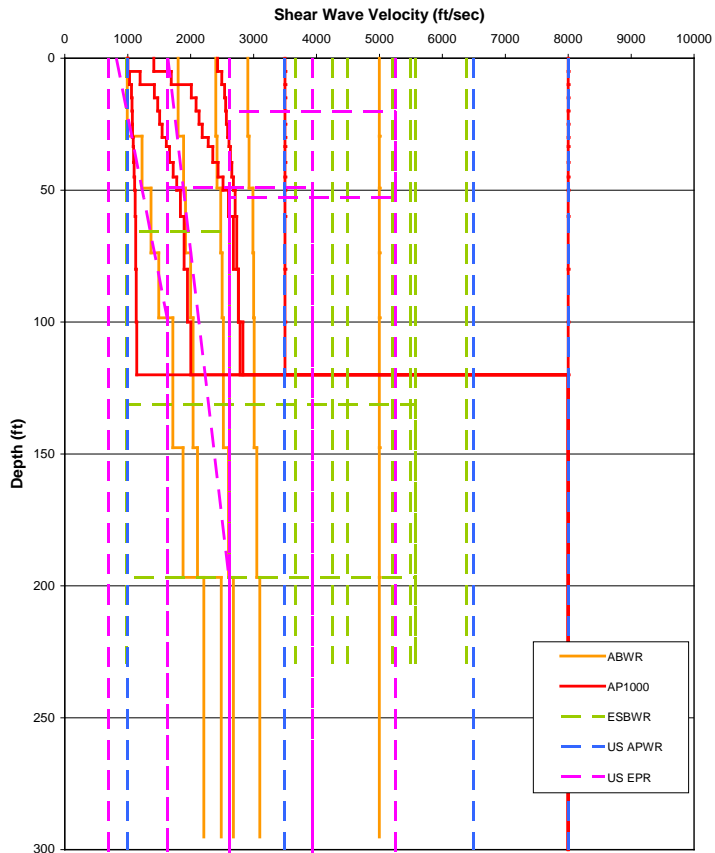
- Nuscale, 24 units, 45 MWe each, 2018
- B&W mPOWER, 150 MWe, DCD 2012
- WEC IRIS, 335 MWe, DCD 2012
- ARC-100, 50-100 MWe
- Toshiba 4S, 10 MWe
- Terrapower
- Pebble Bed Modular Reac
- ...

Design Soil Profiles

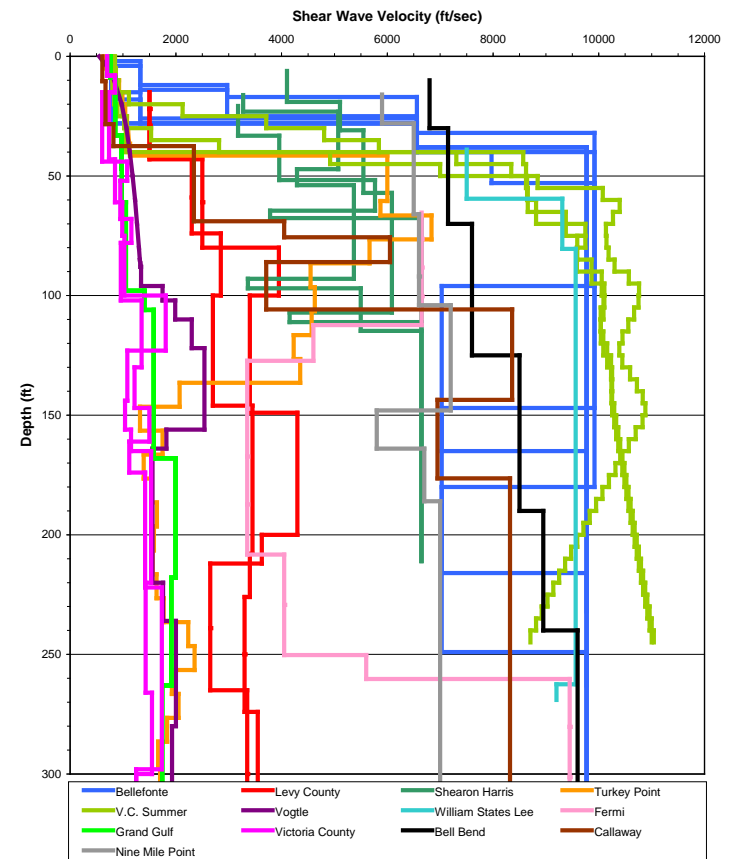
- Selection of limited set of design profiles at the DCD stage is very challenging
- The design is intended to be applicable to as many sites as possible
- The dynamic properties of the plant structures are different
- An optimum set can be developed by a series of SSI analysis

Design Soil Profiles

Five DCD - Shear Wave Velocity Profiles



13 COLA - Shear Wave Velocity Profiles



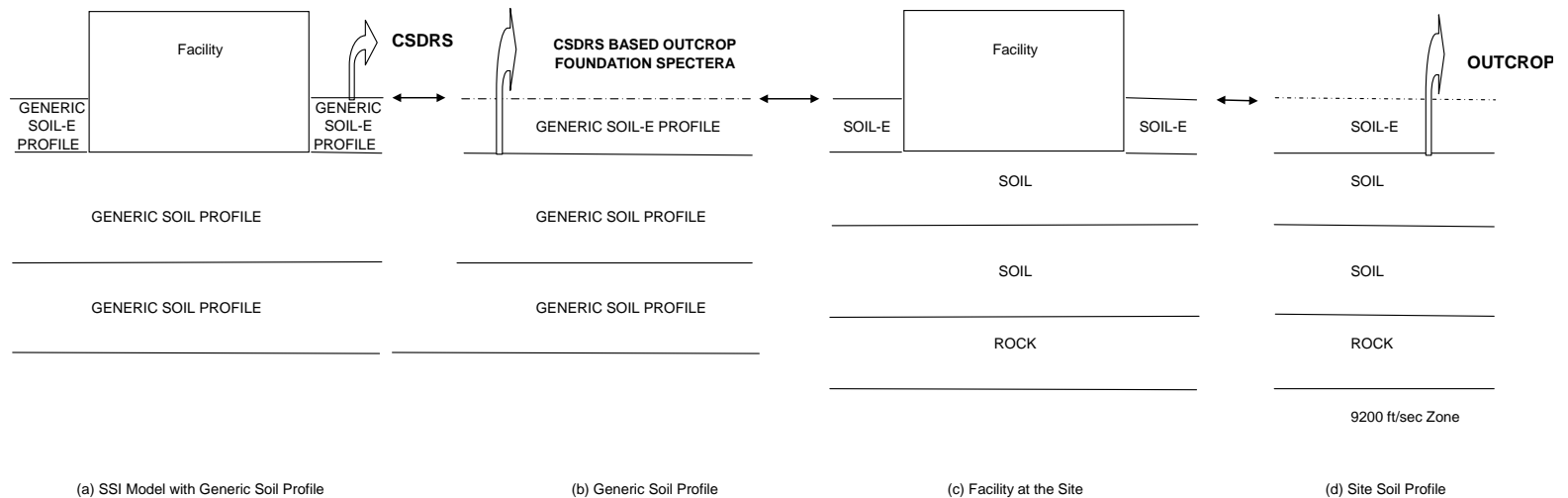
Design Motion

- 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)

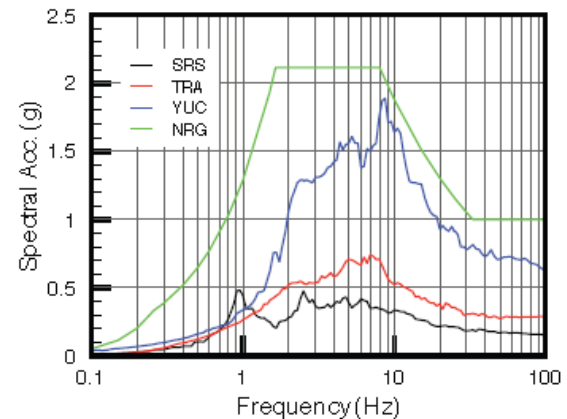
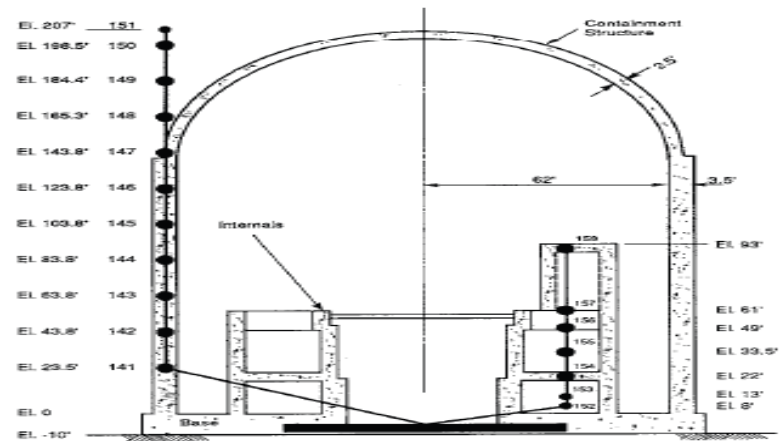


Time History

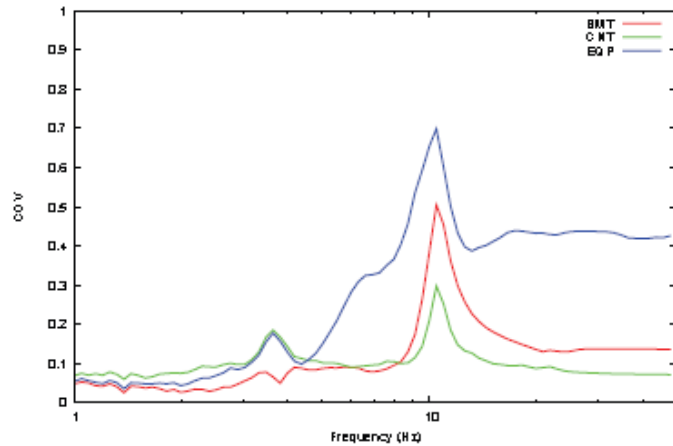
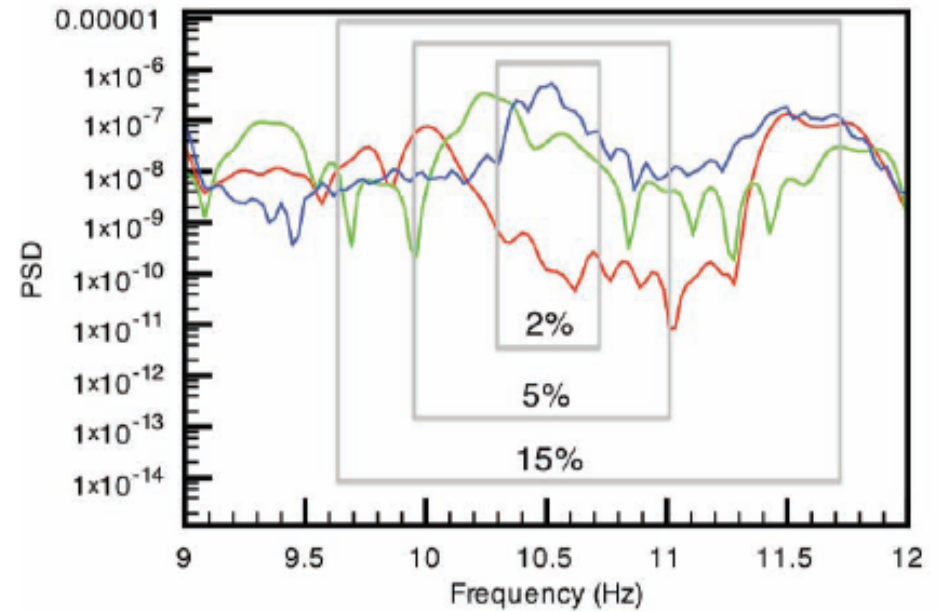
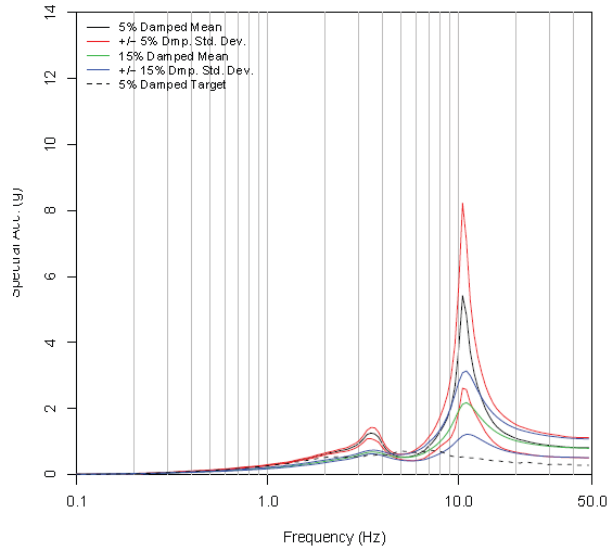
- Matching to DRS
 - Old requirements included matching to multiple target spectra and checking on power spectra
 - New criteria matches/envelops only 5% target spectra at more frequency points
- It has been determined that even for linear analysis using one time history for each direction is deficient

Time History

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



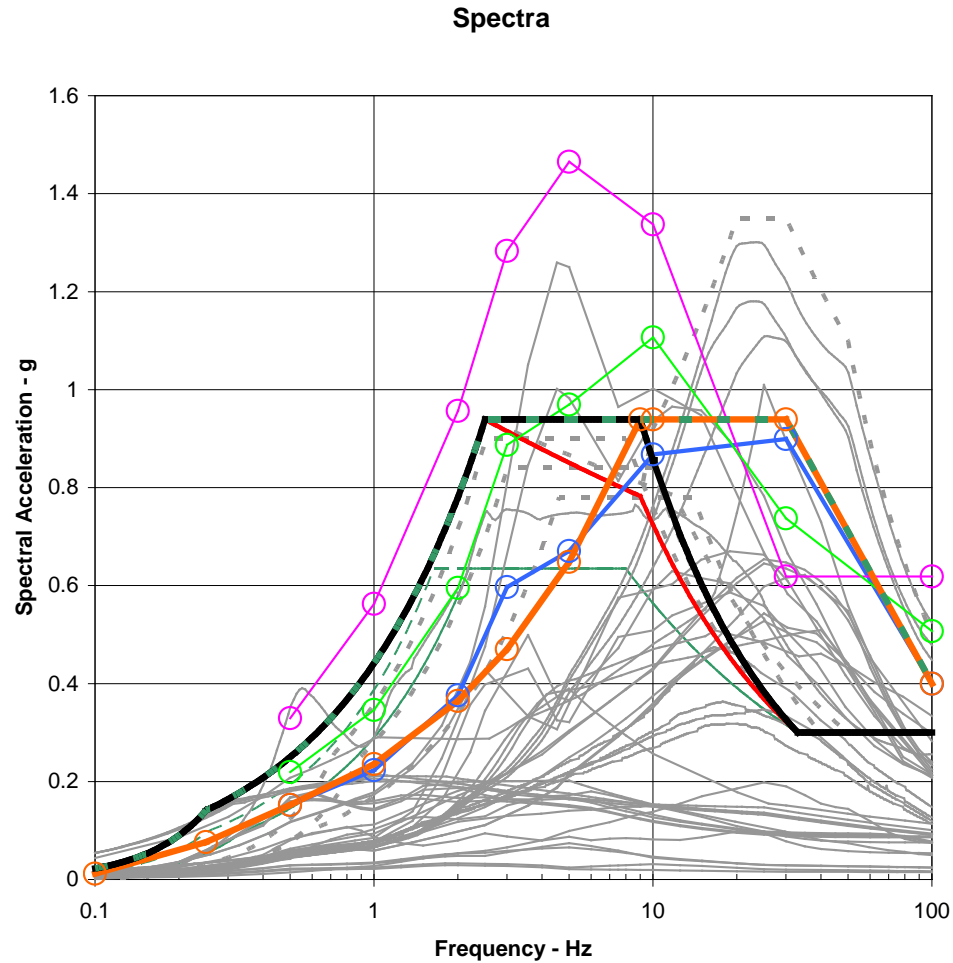
Time History



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



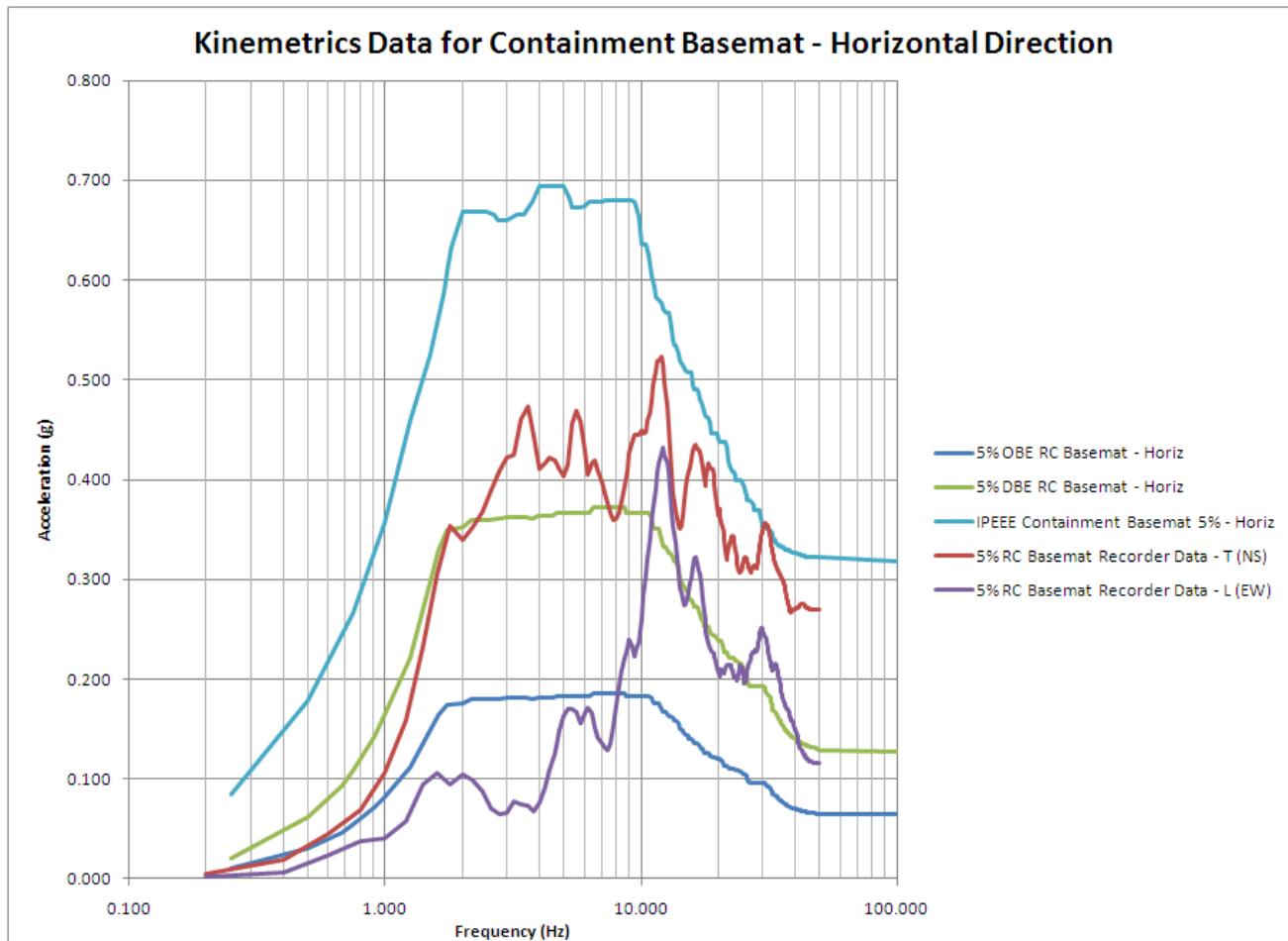
Recent EQs, NRC Letter, GI-199

- 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



SMiRT22@Bechtel.com



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