North Anna 3

North Anna Unit 3 COLA

Seismic Closure Plan

November 20, 2014

Dominion

Agenda

- Introduction
- Comparison of Ground Motion Response Spectra – EPRI 2004 GMM vs. EPRI 2013 GMM
- Site-Specific Seismic Analyses and Design
- Summary and Schedule
- Action Items

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Introduction

- North Anna Unit 3 Seismic Closure Plan (SCP) submitted to NRC October 22, 2014
- Changes described in SCP:
  - Meet NRC requirements and guidance
  - Simplify site-specific analyses
  - Increase consistency with DCD methodologies
  - Apply most current ground motion model (GMM) approved by NRC

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Introduction (cont)

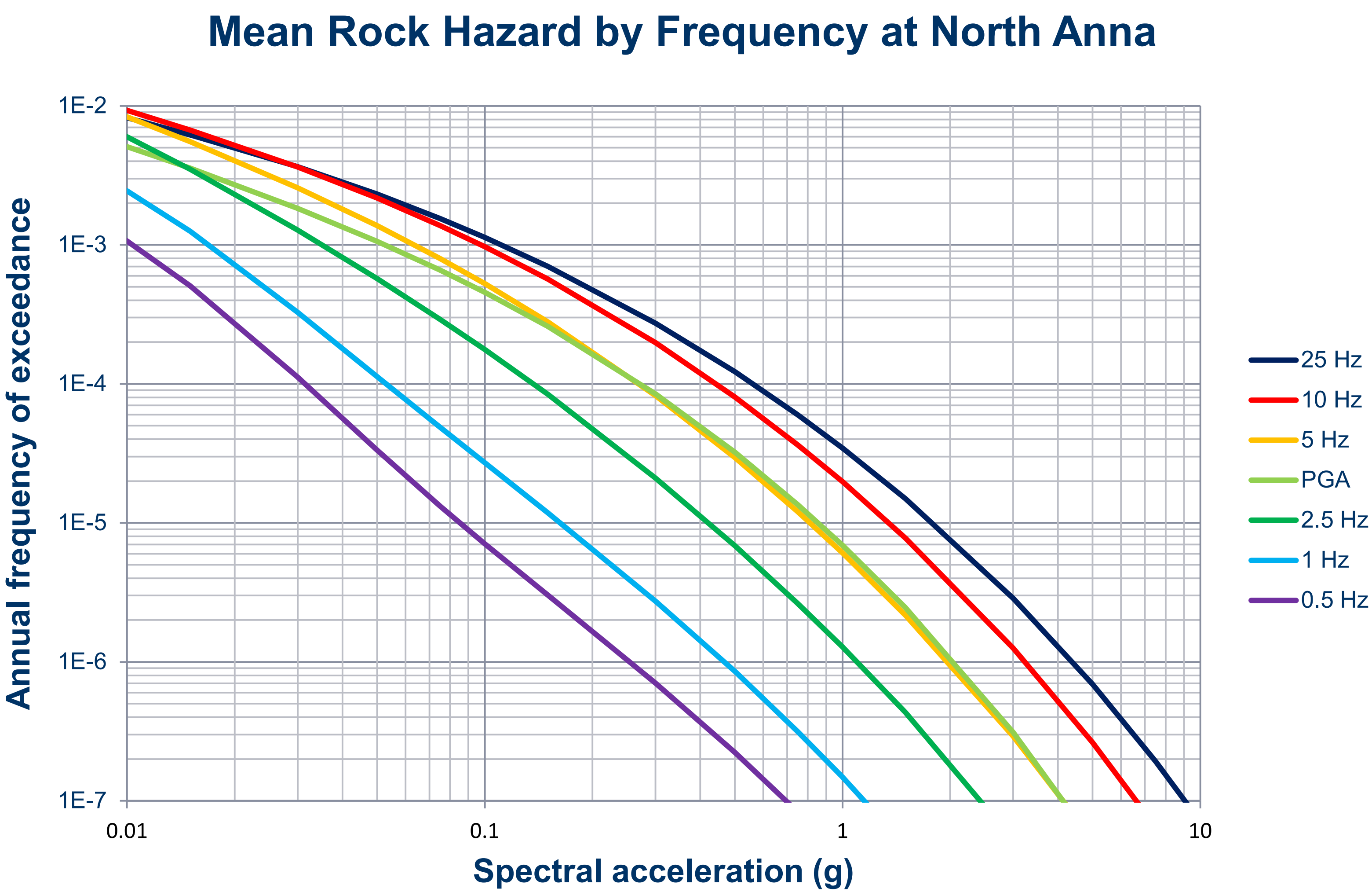
SCP topics to be covered today

- GMM
- SSI analyses cases
- Model design
- SSSI effects
- Site-specific evaluations for Seismic Category I structures
- Component seismic analyses
- Sliding stability of Seismic Category I foundations
- Seismic Margin Analysis

Use of EPRI Updated (2013) Ground Motion Model

- 2013 COLA applied EPRI 2004 GMPEs and 2006 aleatory uncertainties
- EPRI issued Updated GMM for CEUS in June 2013
  - 80% of earthquake records in the ground-motion database used in development of the new GMPEs are from earthquakes which occurred after 2004 GMM was developed
  - Eliminates 7 of 13 developers' GMPEs determined to be out of date and adds 3 new GMPEs developed over the past 10 years
  - Addresses over-prediction of ground motions at some magnitude-distance and spectral frequency ranges important to PSHAs
  - EPRI's 2013 GMM was endorsed by the NRC (2013)
- COLA will apply 2013 GMM

EPRI 2013 GMM Based PSHA



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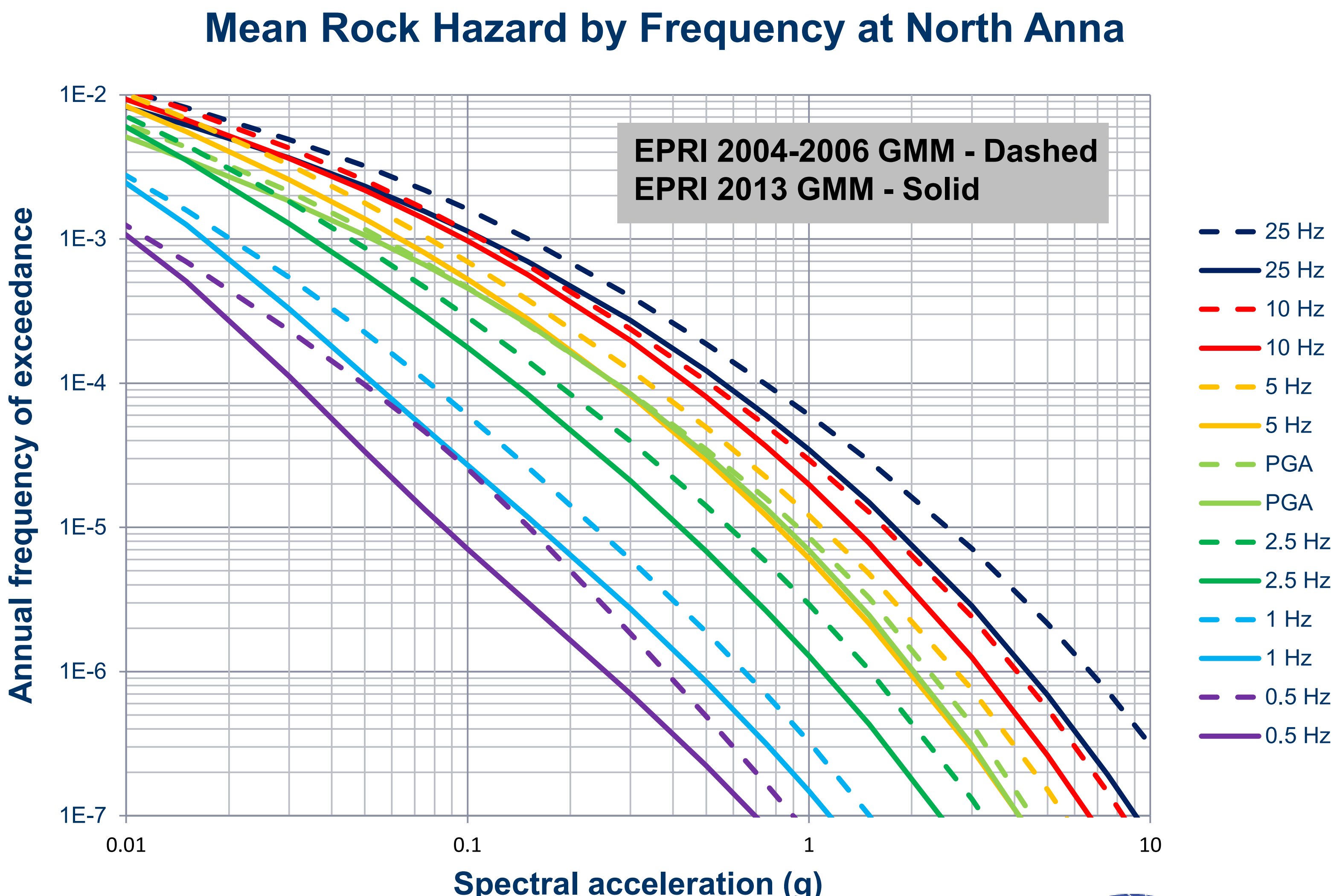
Comparison of PSHA Utilizing EPRI 2004/2006 GMM with PSHA Utilizing EPRI 2013 GMM



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EPRI 2013 GMM-Analysis Update

- Series of new/revised analysis performed to address change in GMM basis
- Same methodology as described in FSAR Rev. 8 is utilized through each step with two exceptions to address related RAI questions

EPRI 2013 GMM-Analysis Update (cont)

- Updated site PSHA and associated deaggregation of rock hazard (FSAR 2.5.2.4)
- Recalculated strain compatible soil profiles, amplification factors, and UHRS (FSAR 2.5.2.5)
- Recalculated GMRS for NA3 site and FIRS for Seismic Category I structures (FSAR 2.5.2.6)
- Addressed impacts on the liquefaction and slope-stability calculations (FSAR 2.5.4 and 2.5.5)

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EPRI 2013 GMM-Analysis Update (cont)

- Recalculated SSI input response spectra, and associated strain compatible SSI input profiles (FSAR 3.7.1.1.4)
- Recalculated spectrum compatible time histories (FSAR 3.7.1.1.5)
- Recalculated site-dependent at-grade SSE and OBE response spectra (FSAR 3.7.1.1.6)

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EPRI 2013 GMM-Analysis Update (cont)

- RAI Question 03.07.01-11 addressed by recalculating two sets of SSI input response spectra for FWSC building: (1) control point at the bottom of the foundation (Elv. 282 ft) ; (2) control point at the average elevation of the bottom of concrete fill (Elv. 220 ft) (FSAR 3.7.1.1.4)

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EPRI 2013 GMM-Analysis Update (cont)

- RAI Question 03.07.01-12 addressed by the enveloping of the CSDRS spectrum over the site specific spectra for frequencies less than 0.2 Hz.
- RAI Question 03.07.01-12 addressed by re-performing Power Spectral Density (PSD) checks (FSAR 3.7.1.1.5)
- Justification presented in supplemental response, reference letter NA3-14-030D (Oct.13, 2014)
- Digital values will be provided for input response spectra, time histories, and PSDs

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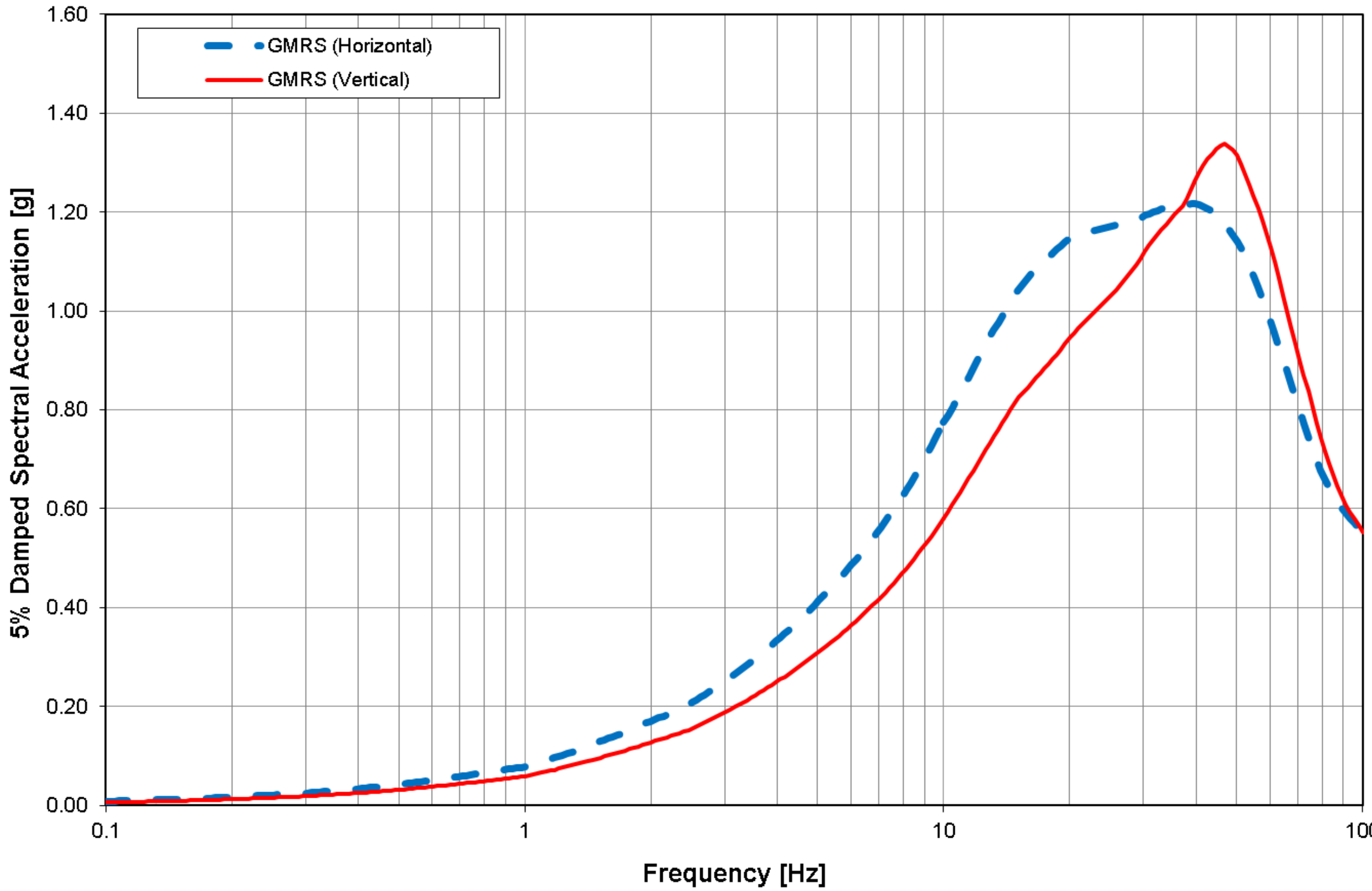
2013 GMM Based Horizontal and Vertical GMRS



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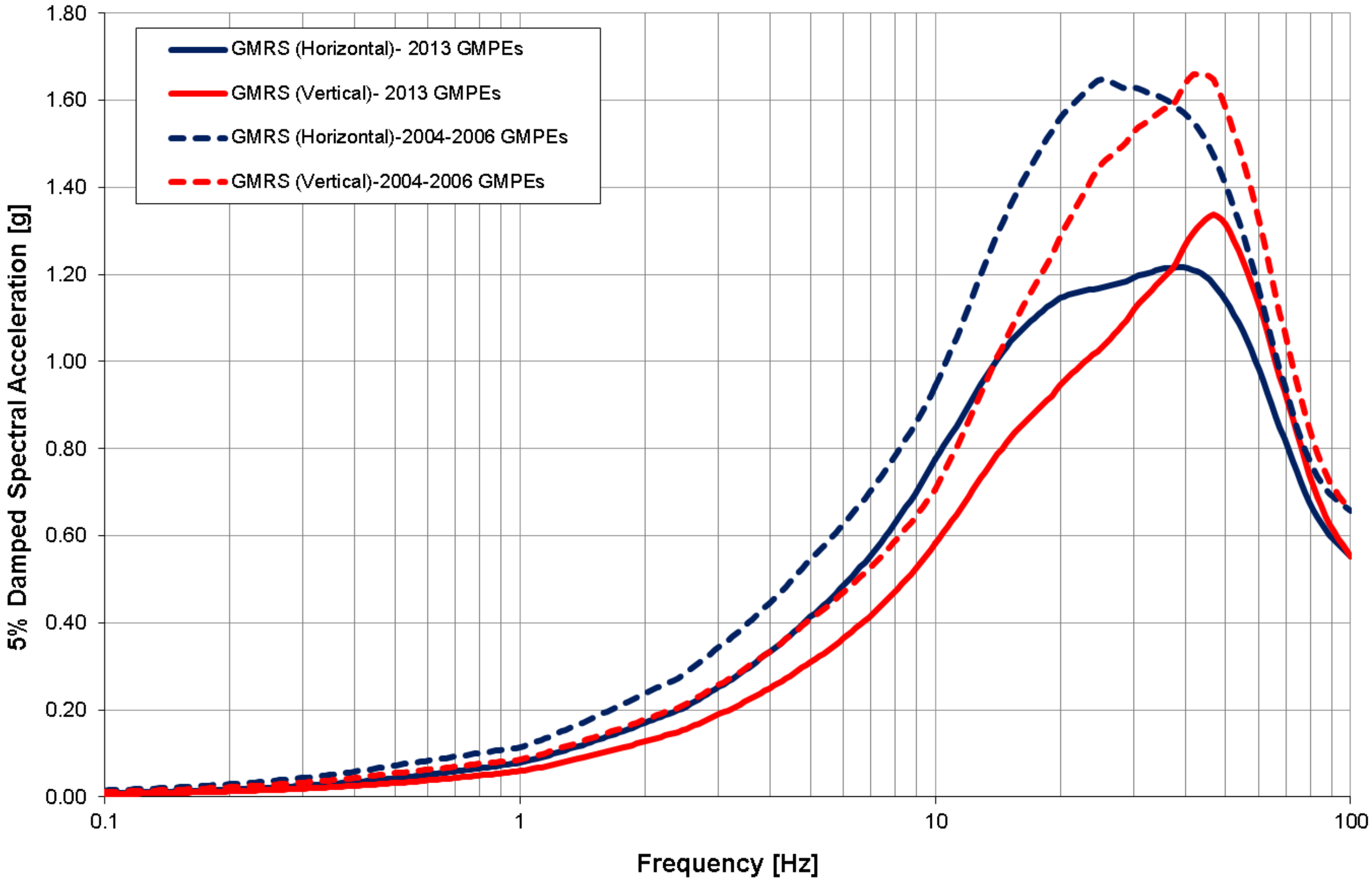
Comparison of GMRS Utilizing EPRI 2004/2006 GMM with GMRS Utilizing EPRI 2013 GMM



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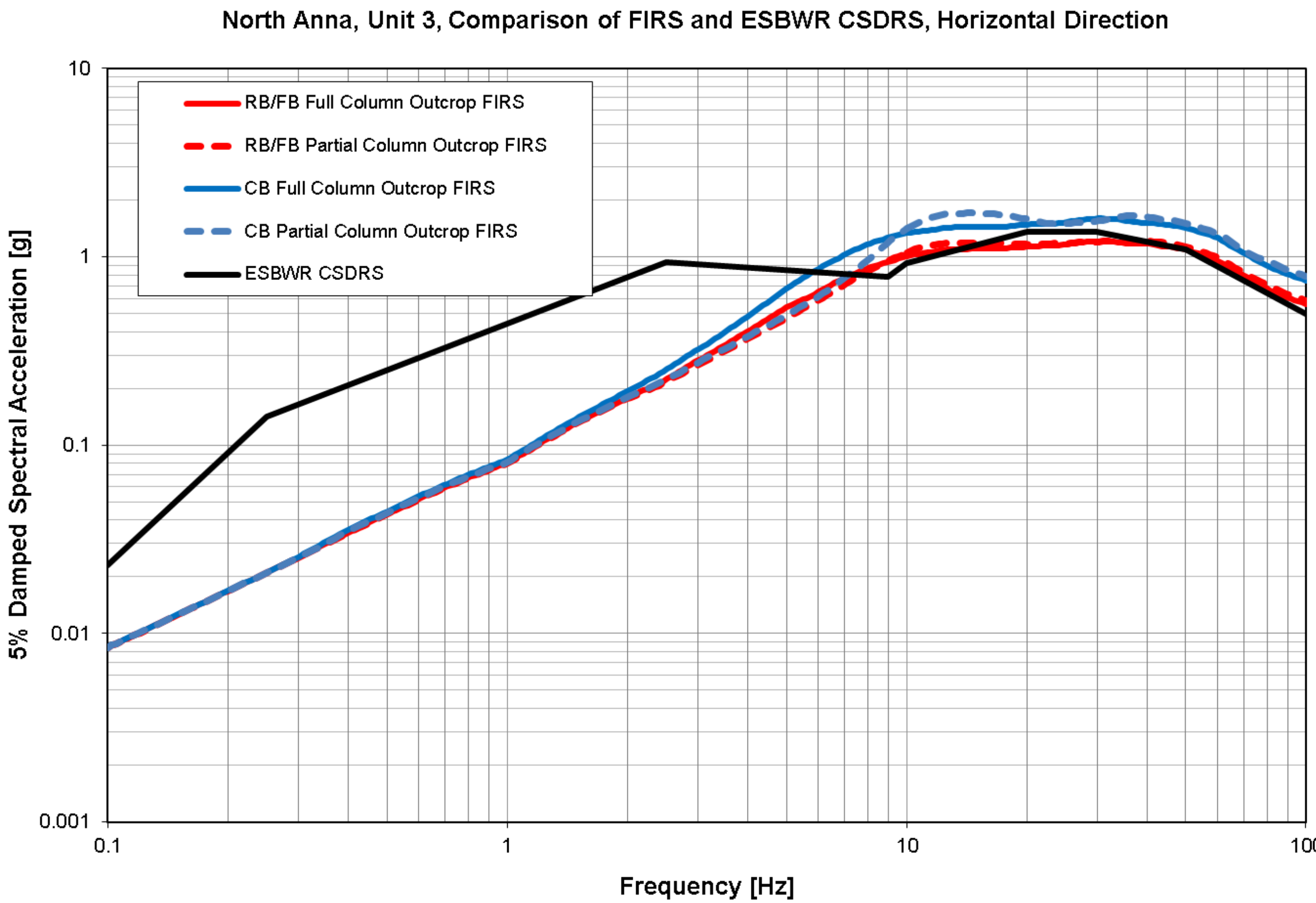
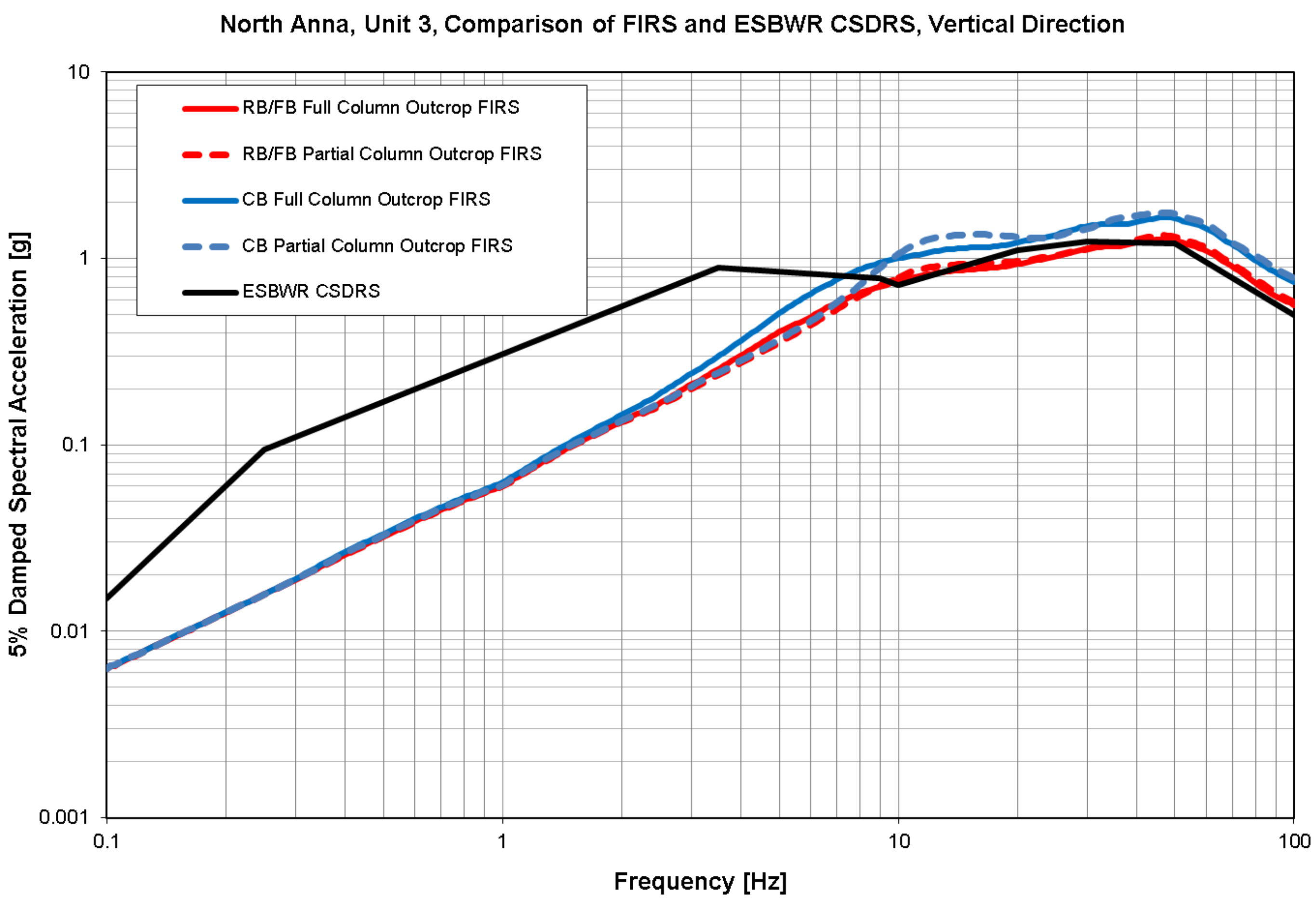
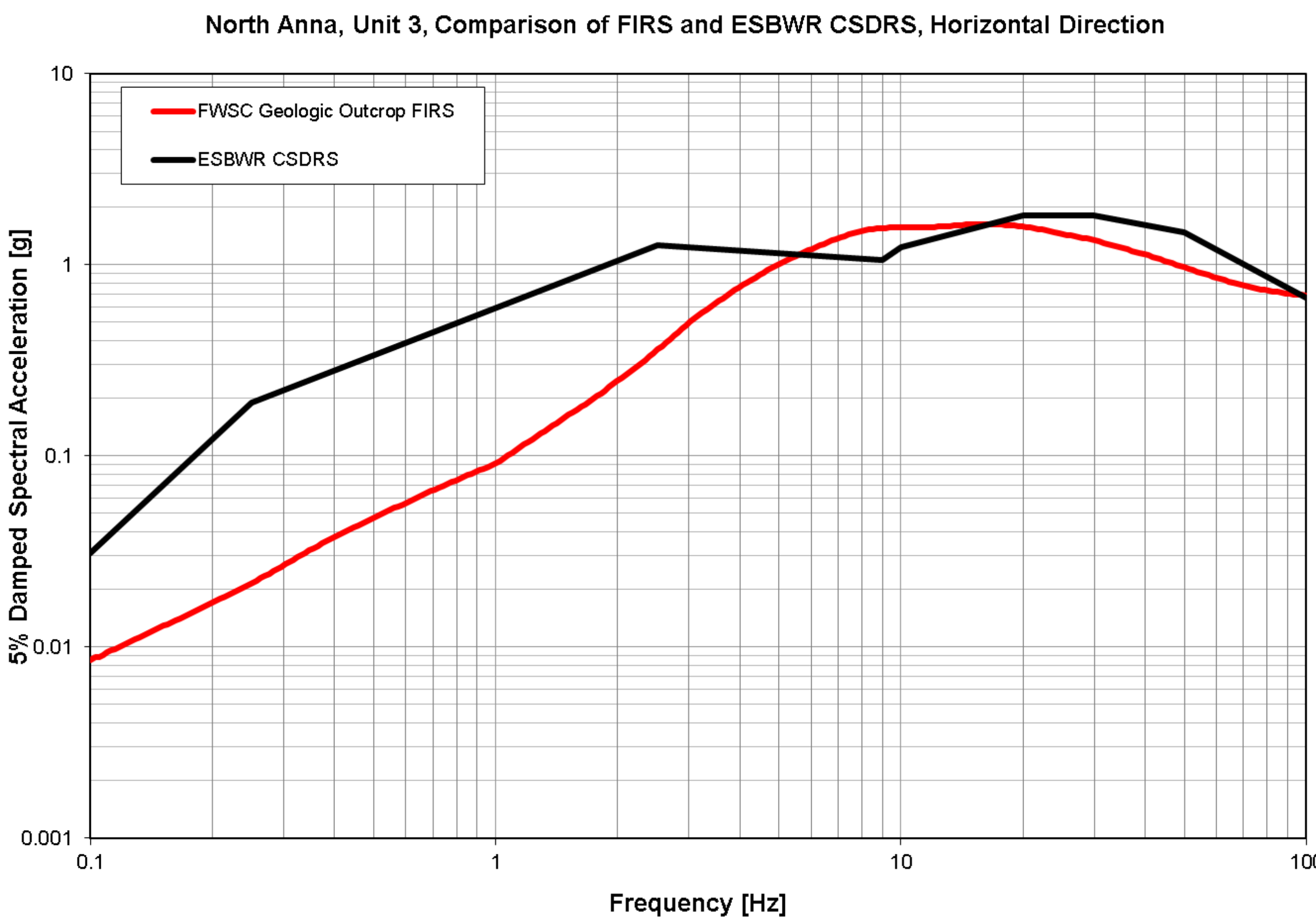
FSAR Figure 2.0-201



FSAR Figure 2.0-202



FSAR Figure 2.0-203



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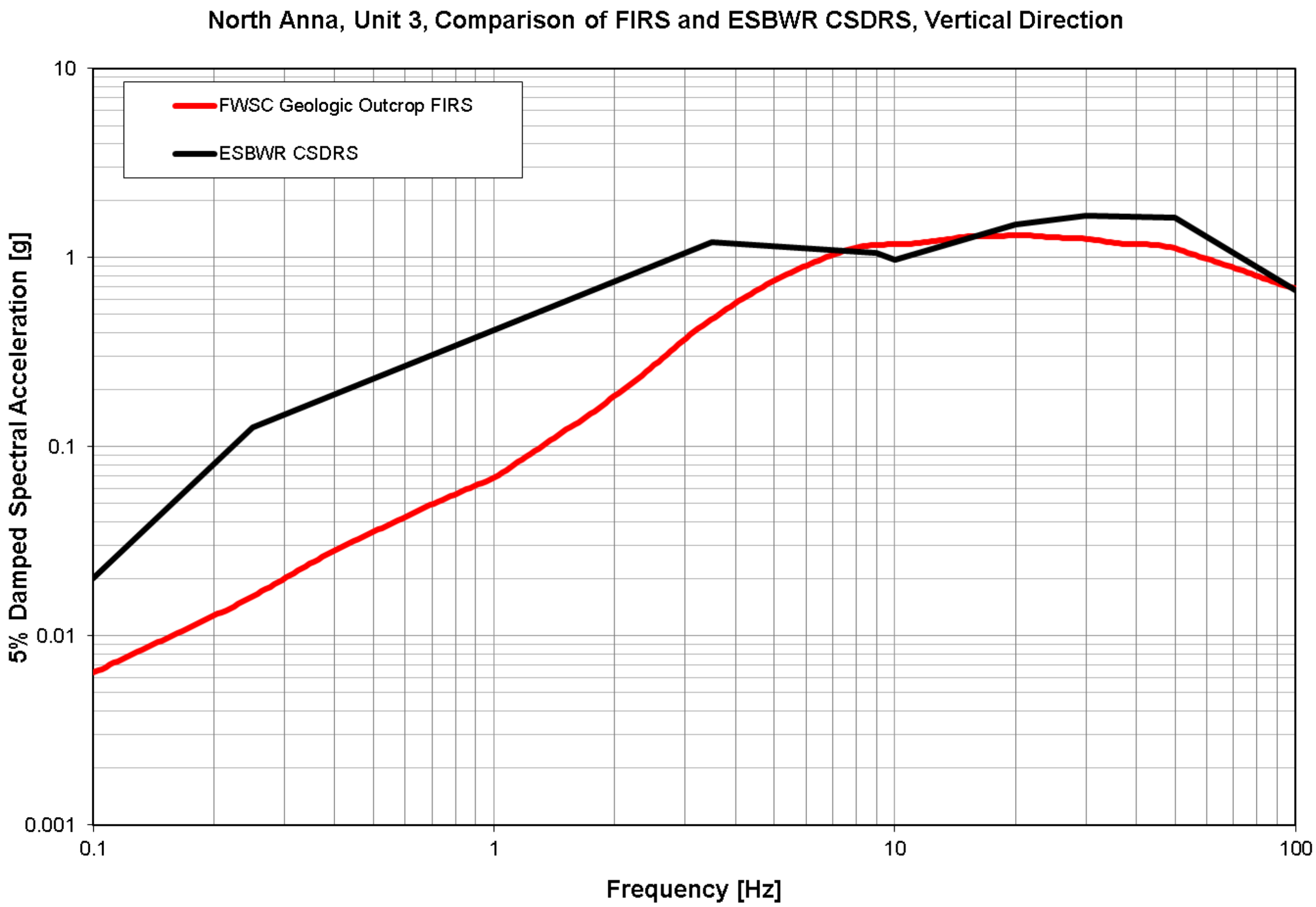
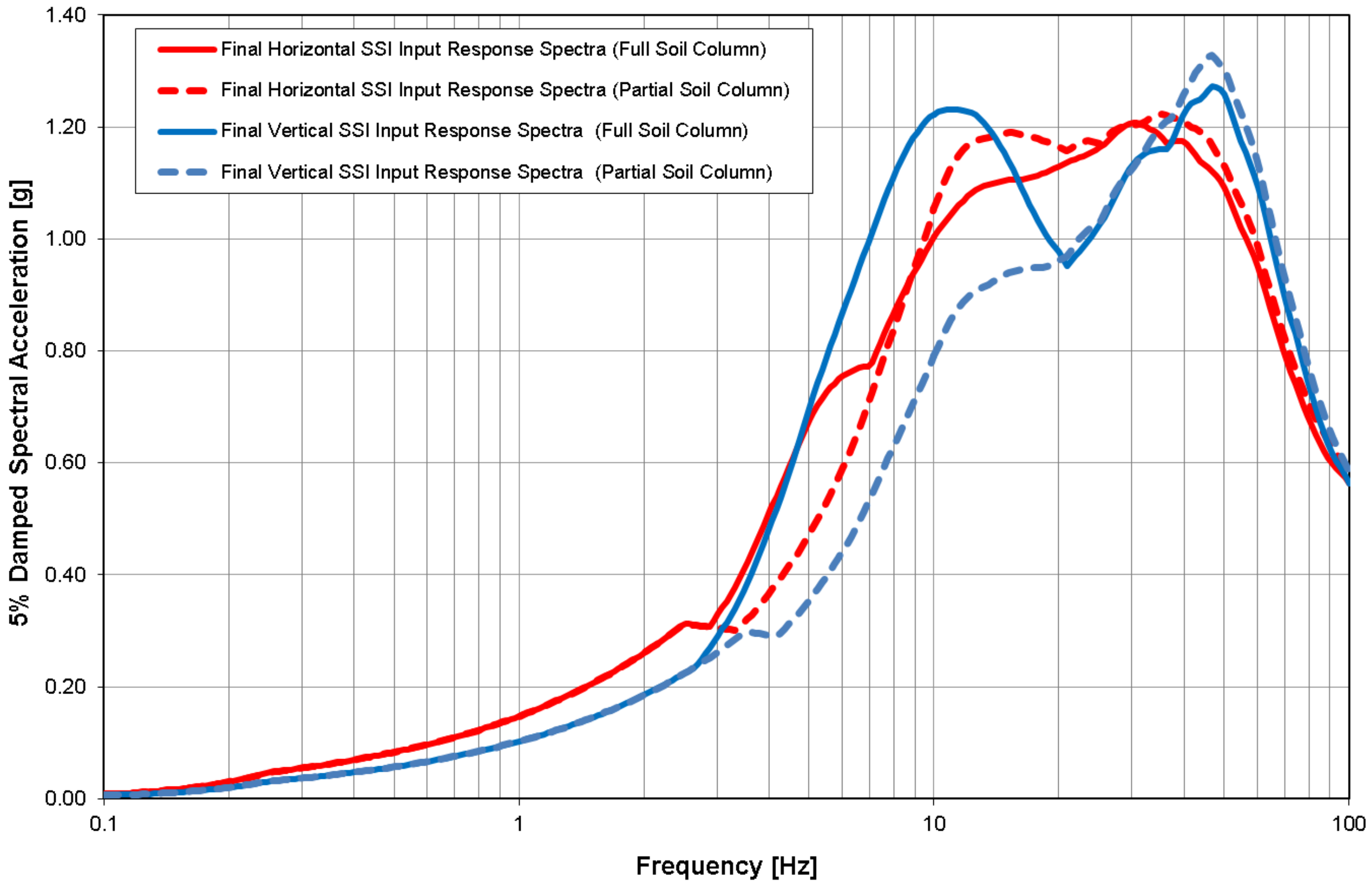
FSAR Figure 2.0-204



2013 GMM Based SSI Input Response Spectra for RB/FB



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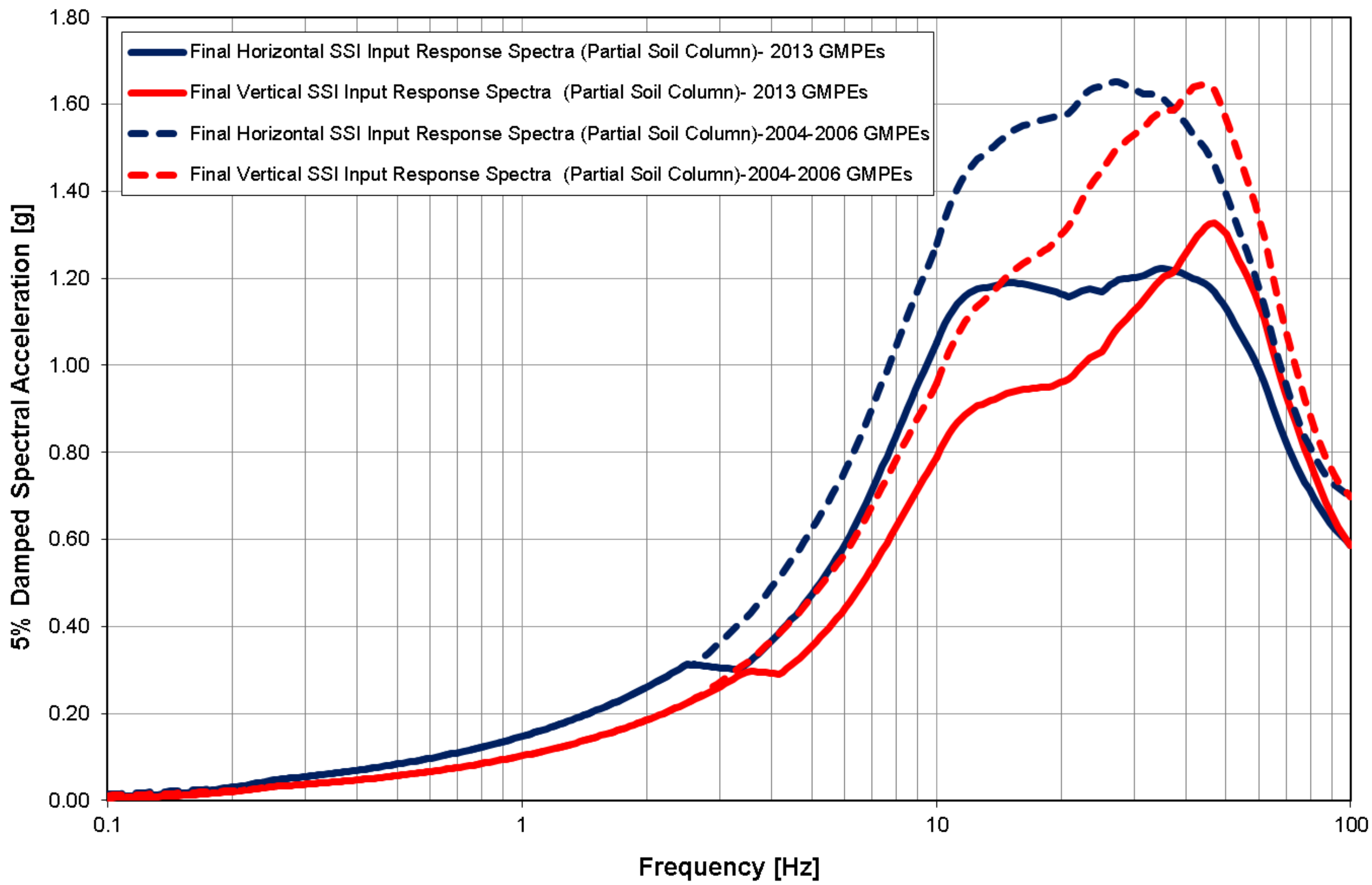
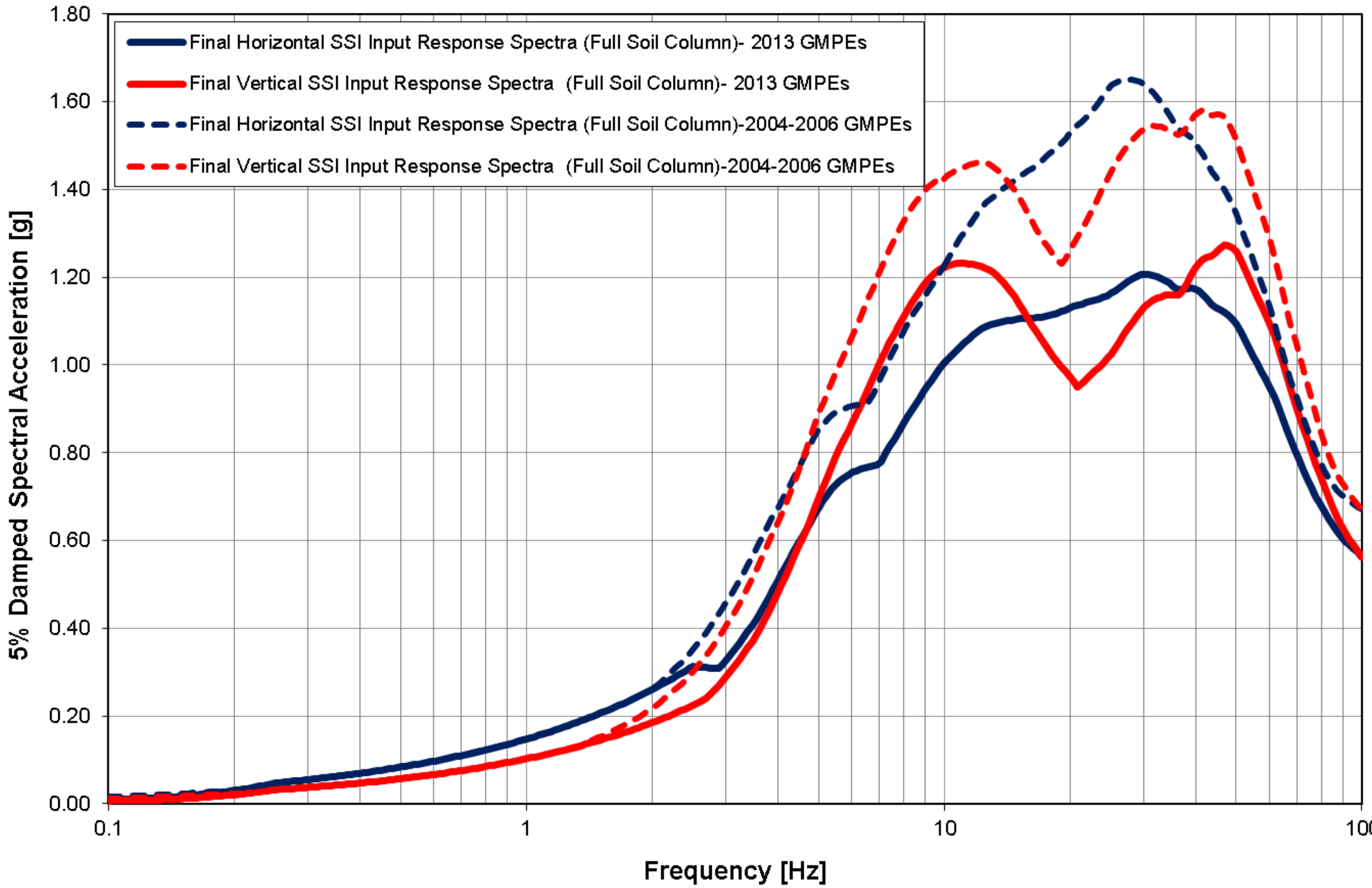
Comparison of Partial Column SSI Input for RB/FB Utilizing EPRI 2004/2006 GMM and EPRI 2013 GMM



Comparison of Full Column SSI Input for RB/FB Utilizing EPRI 2004/2006 GMM and EPRI 2013 GMM



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Summary: FSAR Section 2.0

- Revision of SSE comparison tables and CSDRS and ESP SSE comparison figures to reflect updated analysis results

Summary: FSAR Section 2.5.2, Vibratory Ground Motion

Change to EPRI 2013 GMM will require revision to multiple subsections:

- 2.5.2.2 Geologic and Tectonic Characteristics of the Site and Region
- 2.5.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquakes
- 2.5.2.5 Seismic Wave Transmission Characteristics of the Site
- 2.5.2.6 Design Response Spectra (FIRS included here)
- Revision of tables and figures to reflect updated analysis results

Dominion

Summary: FSAR Section 2.5.4/2.5.5: Liquefaction, Slope Stability, Lateral Earth Pressure

The change in surface acceleration based on use of 2013 GMM is addressed in these sections:

- 2.5.4.8 Liquefaction Potential
- 2.5.4.10.3 Earth Pressures
- 2.5.5 Stability of Slopes

Summary: FSAR Section 3.7.1
Seismic Design Parameters

- Change to EPRI 2013 GMM is reflected in the following subsections:
  - 3.7.1.1.4 Site-Specific Design Ground Motion Response Spectra
  - 3.7.1.1.5 Site-Specific Design Ground Motion Time History
  - 3.7.1.1.6 Site-Dependent At-Grade SSE and OBE Response Spectra
- Revision of tables and figures to reflect updated analysis results

Seismic Analyses and Design

Site-specific seismic response analysis objectives:

- Demonstrate acceptability of standard design of Seismic Category I structures for NA3 site and present actual design margins through FE Analysis
- Demonstrate seismic stability of Seismic Category I foundations at NA3 site
- Provide In-Structure Response Spectra (ISRS) for design and qualification of equipment and components in Seismic Category I structures
- Demonstrate acceptability of standard design of key Seismic Category I components and equipment for NA3 site

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Seismic Analysis and Design (cont)

Seismic analysis and design approach:

- Consistent with standard design methodology in ESBWR DCD
- Consistent with methodology used for R-COLA (when applicable)
- Appropriate for NA3 site-specific geological and seismological conditions (rock site with high frequency design ground motion)
  - Analysis considers cases and uses models that ensure design basis is developed based on conservative responses
  - Sensitivity studies will be performed to demonstrate design basis adequately addresses effects of concrete cracking and Structure-Soil-Structure Interaction (SSSI)
- Addresses NRC reviewers’ concerns in RAI Letters 121, 123, 124 and 125

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Seismic Analysis and Design Summary

- Site-specific SSI analyses will use 2013 GMM-based input ground motion and strain compatible properties
- RB/FB and CB design bases will be developed as envelope of responses from analyses of partial and full column profiles (RAI Questions 03.07.01-7, 03.07.02-11 and 03.08.04-37)
  - Two limiting embedment stiffness conditions are considered that envelope effects of soil separation, ground water level variations with time and variations of horizontal extent of fill materials
- FWSC design basis will be developed as envelope of SSI responses using control motion applied at bottom of foundation and bottom of concrete fill (RAI Question 3.7.1-11)
- Analyses will be performed using higher cut-off frequencies to capture energy of input motion beyond 50 Hz and dynamic models with improved ability to pass high frequency waves (RAI Questions 03.07.02-15 and 03.07.02-13)

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Seismic Analysis and Design Summary (cont)

- Dynamic models with upper bound (uncracked concrete) stiffness and lower OBE damping will be used to obtain conservative responses and ISRS for the Unit 3 rock site with high frequency motion (RAI Question 03.07.02-14)
- Fuel stiffness in RB/FB dynamic models used for site-specific analyses is corrected to properly simulate different OBE damping values for the fuel in horizontal and vertical directions
- Sensitivity analyses will be performed to ensure site-specific design basis adequately addresses effects of:
  - Concrete cracking on reinforced concrete members stiffness and out-of-plane vibrations of flexible slabs and walls (RAI Question 03.07.02-14)
  - Concrete and Steel Internal Structures stiffness variations (RAI Question 03.07.02-14)
  - SSSI (RAI Question 03.07.02-16)

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Seismic Analysis and Design Summary (cont)

- Finite Element analysis will be performed for all Seismic Category I structures that can experience site-specific seismic load demands that exceed standard design loads:
  - Provide explicit calculations of site-specific stress demands, allowable stresses and design margins for Unit 3 Seismic Category I structures (RAI Question 03.07.02-17), flexible walls (RAI Question 03.07.02-19) and foundations (RAI Question 03.08.05-7)
  - Additional sections beyond those considered in standard design will be evaluated as needed to ensure differences in stress distributions and governing stresses are captured
  - Stress checks will be performed for same governing seismic load combinations considered in DCD that are also governing for NA3 because only the seismic loads are different from those used for DCD standard design

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Seismic Analysis and Design Summary (cont)

- RB/FB SSI analysis will provide seismic design basis input for evaluations demonstrating acceptability of standard design of:
  - RPV, RPV support structures and anchorage (RAI Question 03.07.02-18)
  - Spent fuel pool and buffer pool structures and storage racks (RAI Question 03.07.02-20)
  - PCCS Condensers and support structures (RAI Question 03.07.02-21)
  - Seismic Margin Analysis (SMA) (RAI Question 19.02-1)

Seismic Analysis and Design Summary (cont)

- Site-specific sliding stability evaluation of Seismic Category I foundations will be performed using standard design methodology (RAI Question 03.08.05-6)
  - Will not apply moving average window to filter out high frequency content from base reaction time histories
  - Demonstrate adequacy of base friction coefficient based on SASSI results for displacements relative to free field motion
  - Provide lateral bearing pressure capacity of subgrade materials for critical locations
  - Shear keys will be added to CB foundation (if needed) to ensure sufficient lateral resistance of subgrade to resist lateral force demands
  - Provide evaluations of stability for additional sliding planes to demonstrate shear keys effectively lower critical sliding plane

Seismic Analysis Inputs

- Site response analyses performed on randomized in-situ full and partial column profiles (RAI Question 03.07.02-12):
  - Provide LB, BE and UB subgrade profiles of dynamic properties of in-situ materials compatible to strain generated by 2013 GMM-based design ground motion
  - In SSI models, strain compatible in-situ properties are assigned to far field elements in SASSI SITE models and excavated volume elements of SASSI HOUSE models
- Site response analyses performed on randomized full column fill profiles:
  - Provide LB, BE and UB companion profiles of dynamic properties of engineered fill materials around RB/FB and CB that are compatible to strain generated by 2013 GMM-based design ground motion
  - In SSI models, strain compatible fill properties are assigned to near-field elements in SASSI HOUSE models
- Subgrade strain-compatible properties for seismic analyses with 2013 GMM-based design ground motion are only slightly stiffer with slightly less damping than those documented in current FSAR revision

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Seismic Analysis Inputs (cont)

- Site-specific seismic response analyses directly use strain compatible subgrade properties developed from site response analyses that will be provided in FSAR Section 3.7.1.1.4.1 (RAI Question 03.07.02-13):
  - Only layering of profiles is adjusted to match configurations of buildings and meet SSI model passing frequency requirements
- Poisson ratio of saprolite and engineered fill materials located below ground water table is set to 0.48 to capture effect of ground water on P-wave velocity of saturated soil
- Seismic response analyses of RB/FB and CB structures consider two limiting embedment stiffness conditions:
  - Lower bound stiffness represented by partial column profiles that neglect stiffness of softer soil materials located above rock top elevation
  - Upper bound stiffness represented by full column profiles simulating full contact of embedment with below grade exterior walls (no soil separation) and fully saturated stiffness properties of soil located below Unit 3 nominal ground water level

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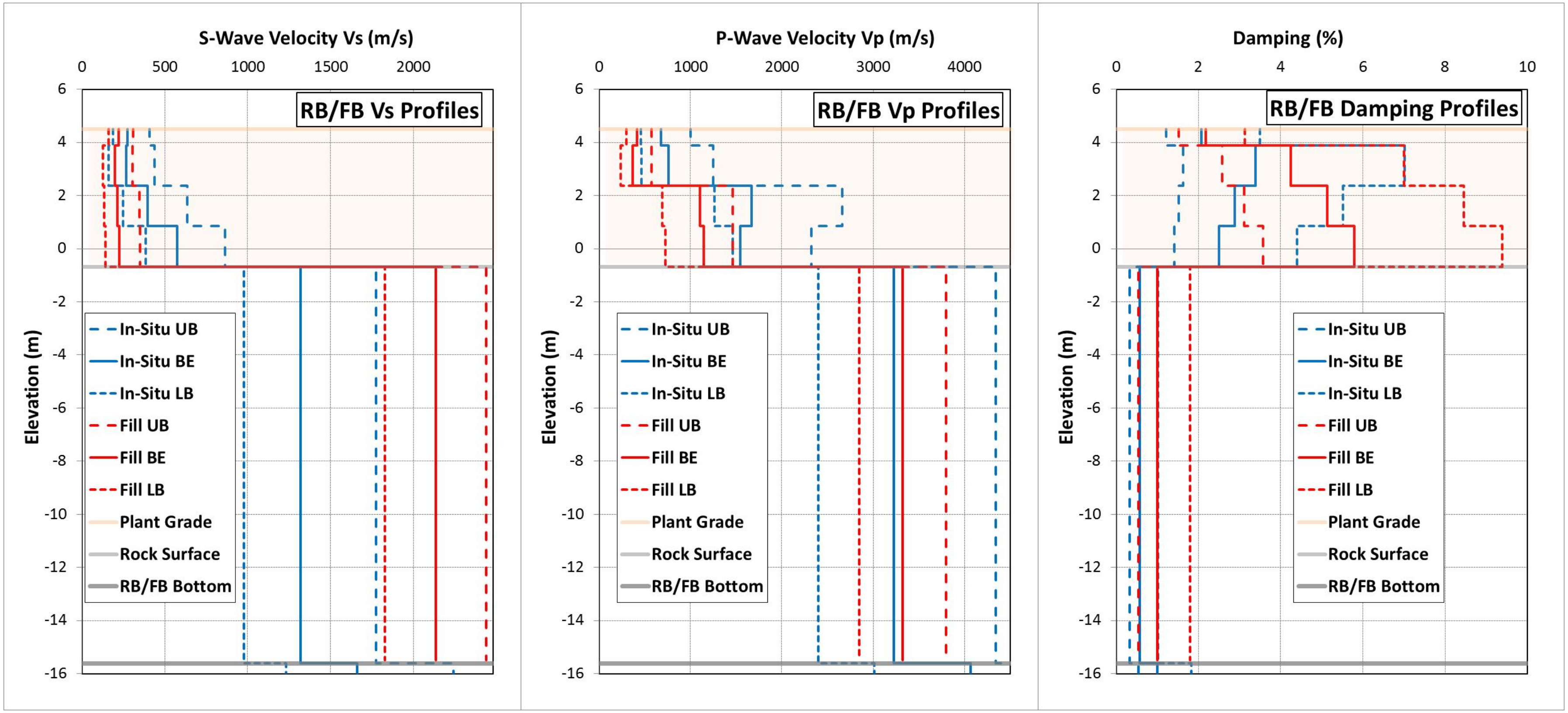
Seismic Analysis Inputs (cont)

- Site-specific RB/FB SSI analyses will use partial and full column profiles of subgrade dynamic properties compatible with strains generated by 2013 GMM-based ground motion



Preliminary/Unverified Results

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Seismic Analysis Inputs (cont)

- RB/FB Embedment Dynamic Properties
  - Average strain-compatible shear wave velocities ($V_{s\ ave}$) and shear column frequencies (f_{sc}) of fill and in-situ materials for RB/FB profiles

Soil Case	Concrete Fill/ Zone III Rock Embedment					Engineered Fill/ Saprolite Embedment				
	Depth	Backfill		In-Situ		Depth	Backfill		In-Situ	
		$V_{s\ ave}$	f_{sc}	$V_{s\ ave}$	f_{sc}		$V_{s\ ave}$	f_{sc}	$V_{s\ ave}$	f_{sc}
	m	m/s	Hz	m/s	Hz	m	m/s	Hz	m/s	Hz
LB	14.9	1829	30.9	979	16.4	5.2	137	6.6	228	11.0
BE		2134	36.0	1318	22.1		213	10.3	360	17.4
UB		2438	41.2	1774	29.7		331	16.0	566	27.3

Preliminary/Unverified Results

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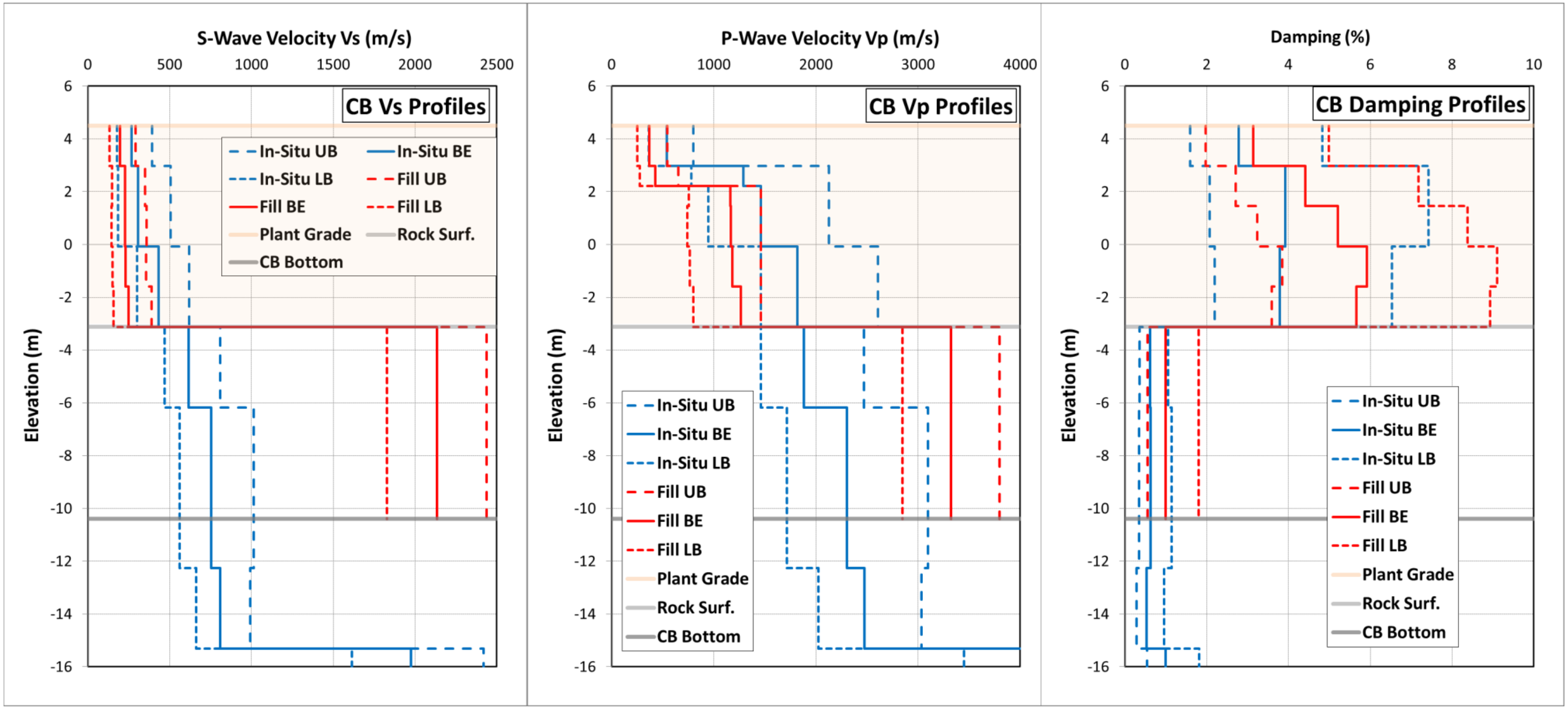
Seismic Analysis Inputs (cont)

- Site-specific CB SSI analyses will use partial and full column profiles of subgrade dynamic properties compatible with strains generated by 2013 GMM-based ground motion



Preliminary/Unverified Results

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Seismic Analysis Inputs (cont)

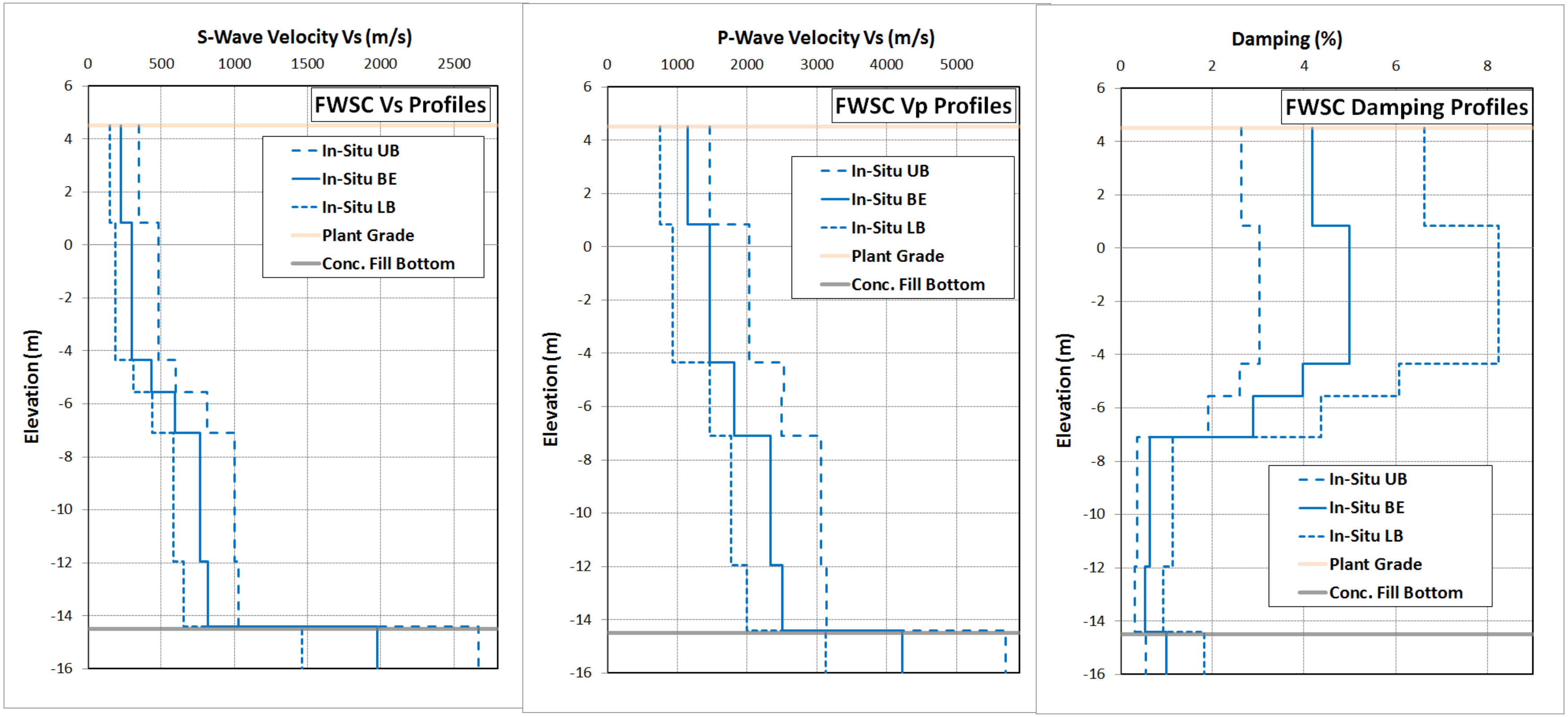
- CB Embedment Dynamic Properties
  - Average strain-compatible shear wave velocities ($V_{s\ ave}$) and shear column frequencies (f_{sc}) of fill and in-situ materials for CB profiles

Soil Case	Concrete Fill/ Zone III Rock Embedment					Engineered Fill/ Saprolite Embedment				
	Depth	Backfill		In-Situ		Depth	Backfill		In-Situ	
		$V_{s\ ave}$	f_{sc}	$V_{s\ ave}$	f_{sc}		$V_{s\ ave}$	f_{sc}	$V_{s\ ave}$	f_{sc}
	m	m/s	Hz	m/s	Hz	m	m/s	Hz	m/s	Hz
LB	7.3	1829	62.8	520	18.9	7.6	147	4.8	218	7.2
BE		2134	73.3	690	25.2		226	7.4	336	11.0
UB		2438	83.7	917	33.4		347	11.4	515	16.9

Preliminary/Unverified Results

Seismic Analysis Inputs (cont)

- Site-specific FWSC SSI analyses will use full column profiles of subgrade dynamic properties compatible with strains generated by 2013 GMM-based ground motion



Preliminary/Unverified Results

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Seismic Analysis Inputs (cont)

- FWSC Concrete Fill Embedment Dynamic Properties
  - Average strain-compatible shear wave velocities ($V_{s\ ave}$) and shear column frequencies (f_{sc}) of in-situ materials surrounding FWSC concrete fill block

Soil Case	Saprolite Embedment		
	Depth	$V_{s\ ave}$	f_{sc}
	m	m/s	Hz
LB	7.3	261	3.1
BE		391	4.7
UB		584	7.0

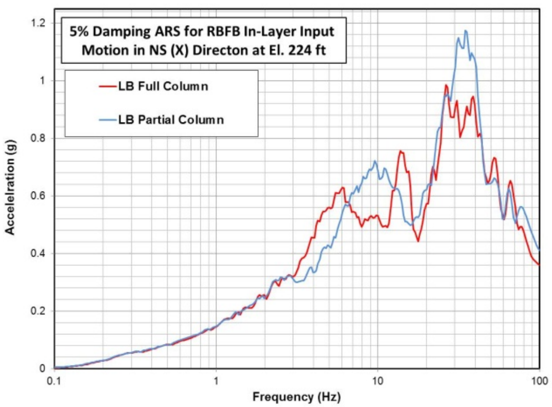
Preliminary/Unverified Results

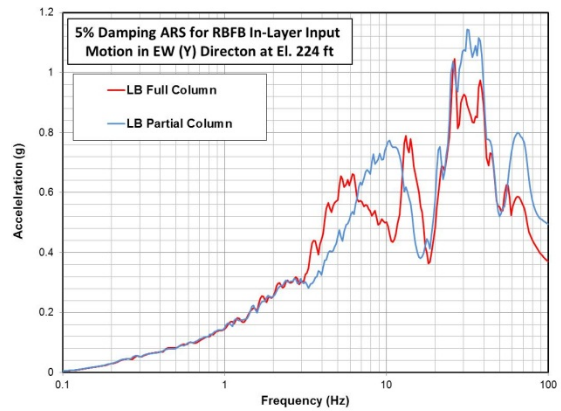
Seismic Analysis Inputs (cont)

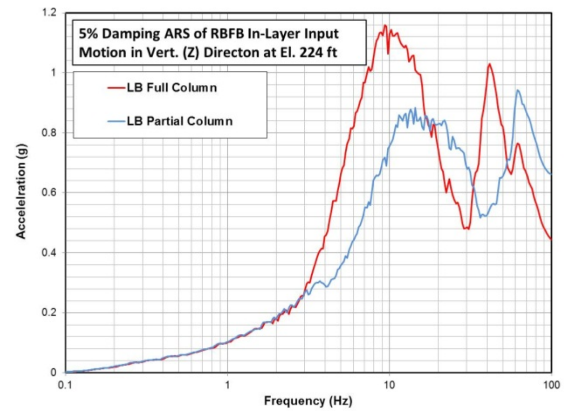
- Time histories of in-layer ground motion at control point elevations located below ground surface are obtained:
  - From linear-elastic site response analyses performed on LB, BE and UB full and partial column profiles of strain-compatible in-situ subgrade properties (no soil property interaction performed)
  - Consistent with time histories of outcrop motion compatible to SSI response spectra that will be presented in FSAR Section 3.7.1.1.5.1
- Seismic analysis of FWSC as surface mounted foundation with control motion applied at basemat bottom elevation will directly use surface outcrop motion input motion time histories that are compatible to surface motion SSI response spectra and will be presented in FSAR Section 3.7.1.1.5.1.3
- Input motion for analyses of full column profiles in lower frequencies have higher energy content than those for analyses of partial column profiles resulting from NEI check
- Frequency distribution of energy content of 2013 GMM-based input ground motion is similar to that of input ground motion used for SSI analysis documented in current FSAR revision

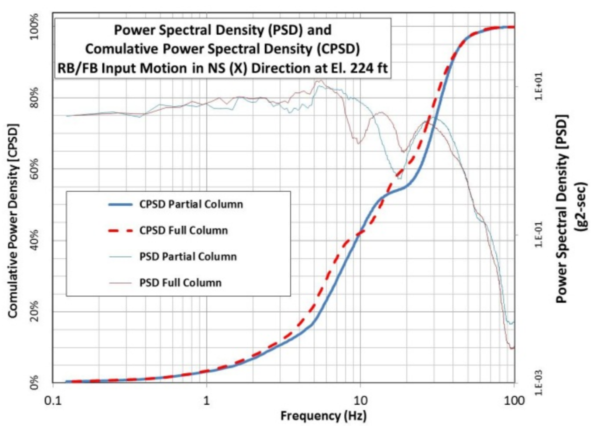
Seismic Analysis Inputs (cont)

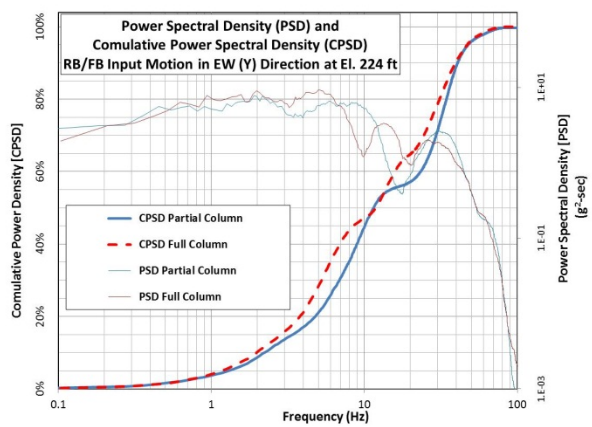
- 2013 GMM-based in-layer input control motion for RB/FB SSI analysis of LB partial and full column profiles

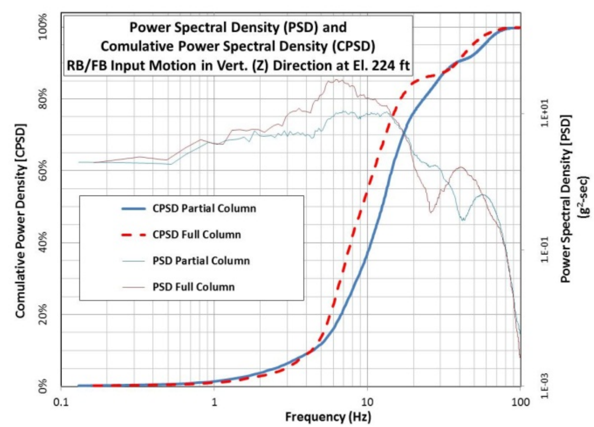












Preliminary/Unverified Results

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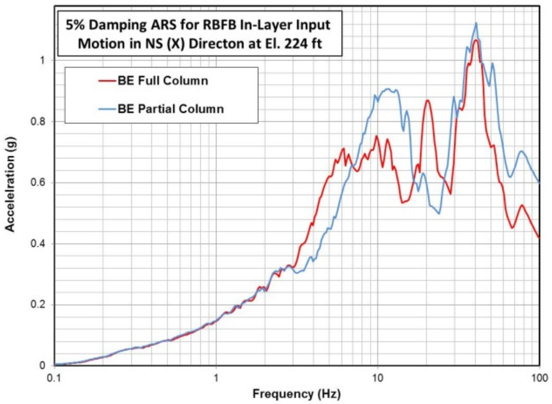
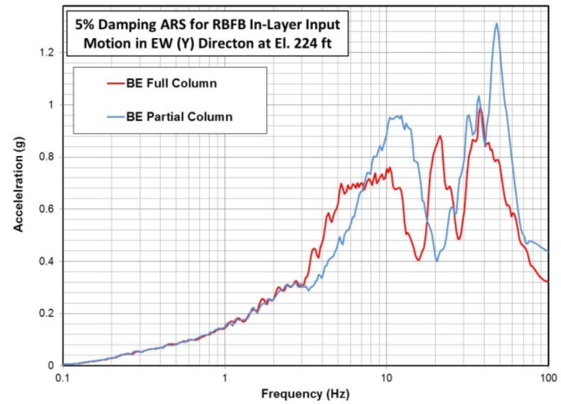
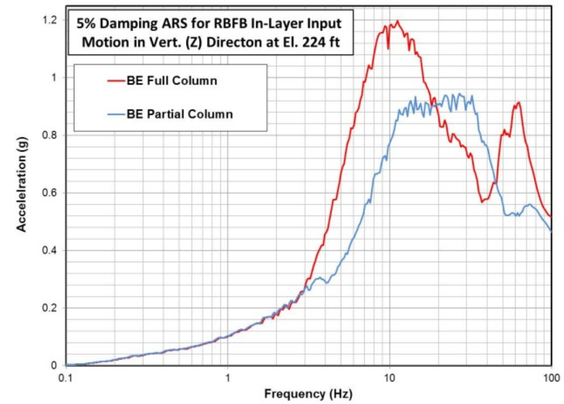
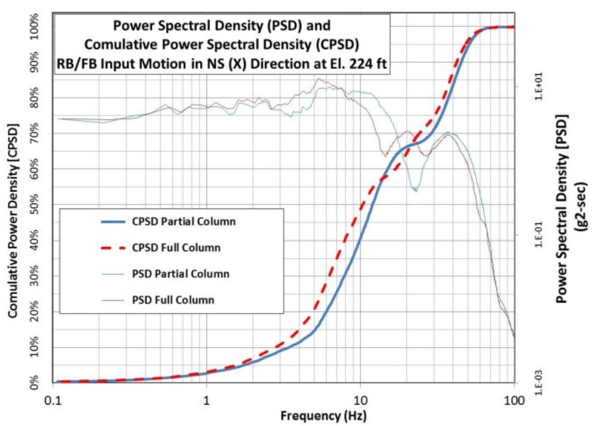
Seismic Analysis Inputs (cont)

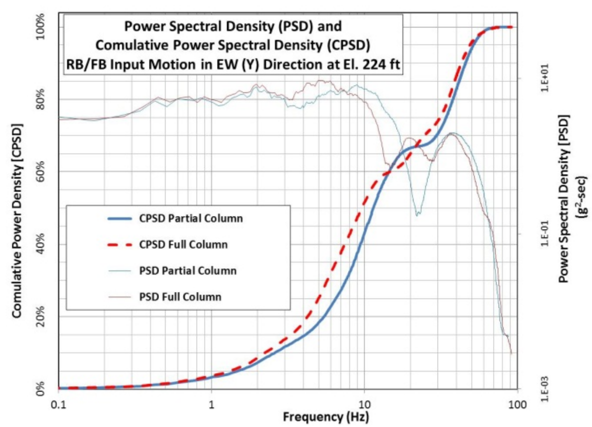
- 2013 GMM-based in-layer input control motion for RB/FB SSI analysis of BE partial and full column profiles

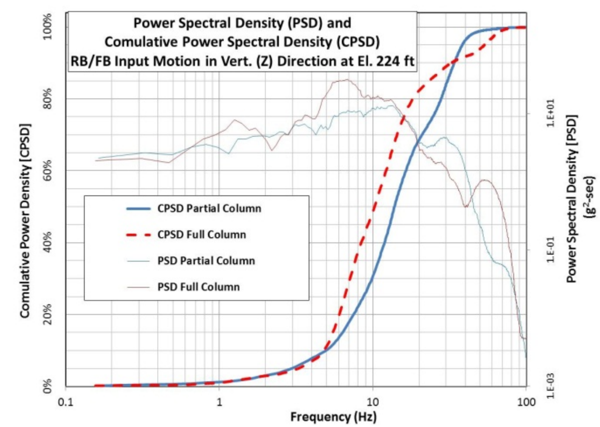












Preliminary/Unverified Results

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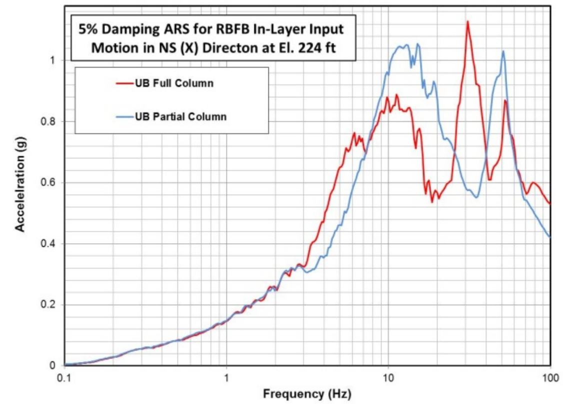
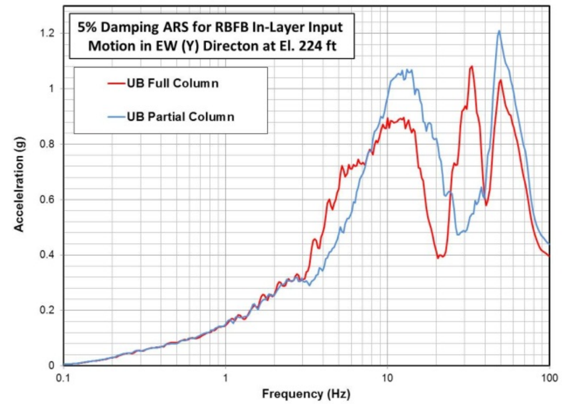
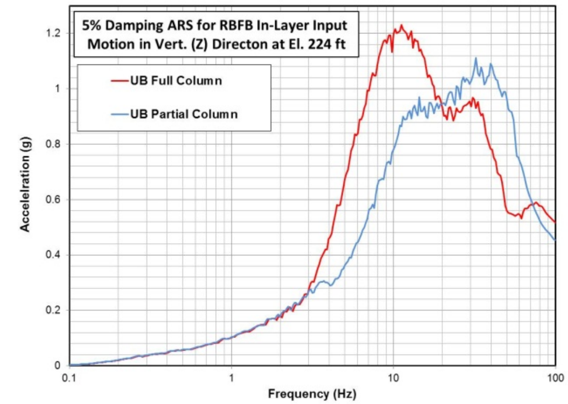
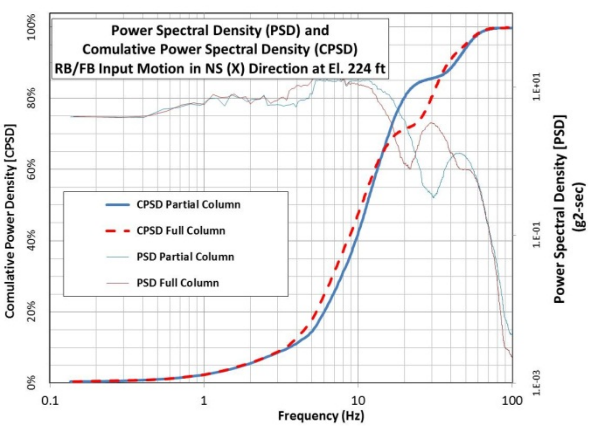
Seismic Analysis Inputs (cont)

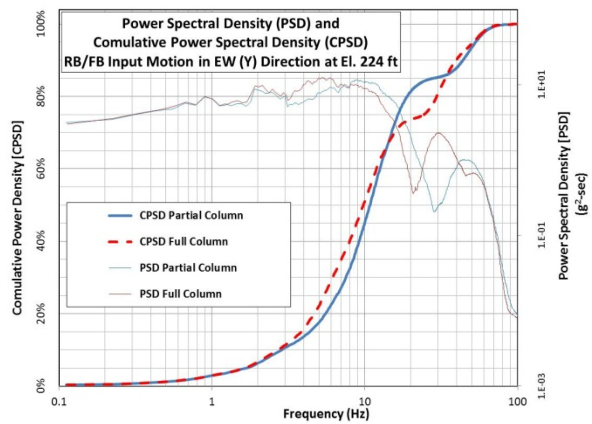
- 2013 GMM-based in-layer input control motion for RB/FB SSI analysis of UB partial and full column profiles

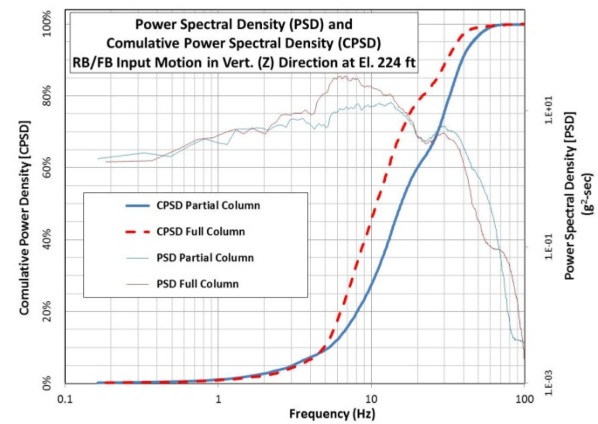










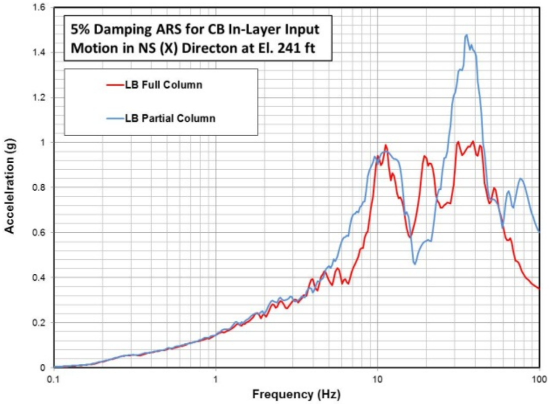


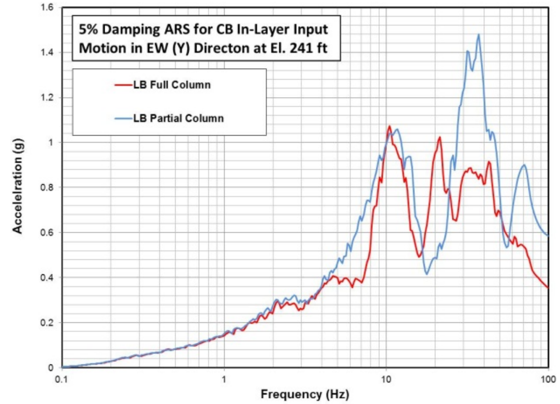
Preliminary/Unverified Results

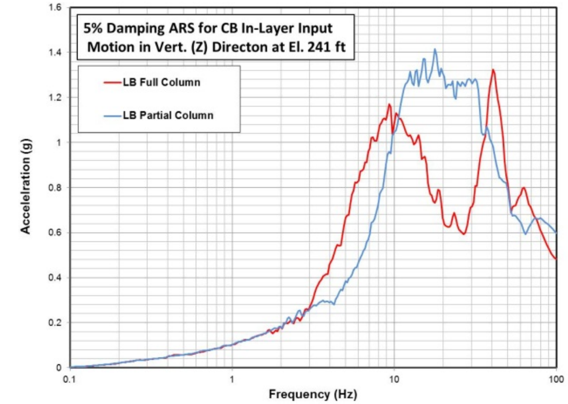
Dominion

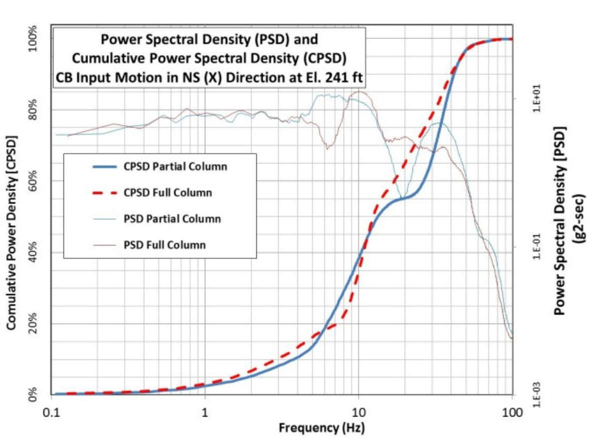
Seismic Analysis Inputs (cont)

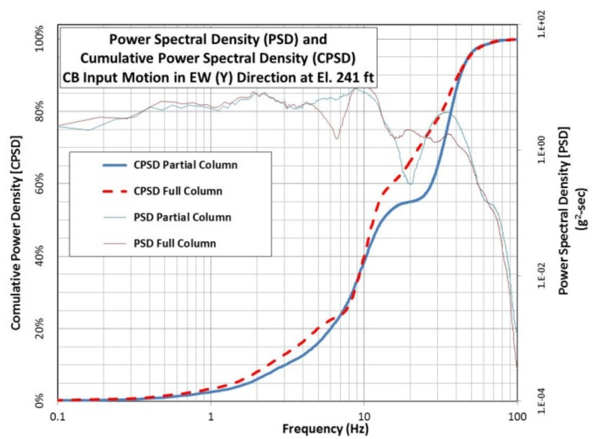
- 2013 GMM-based in-layer input control motion for CB SSI analysis of LB partial and full column profiles

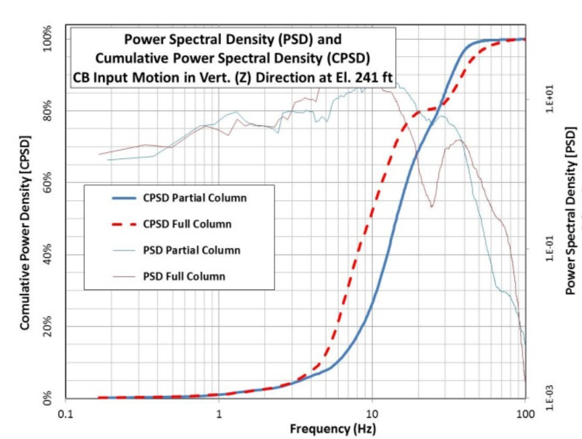










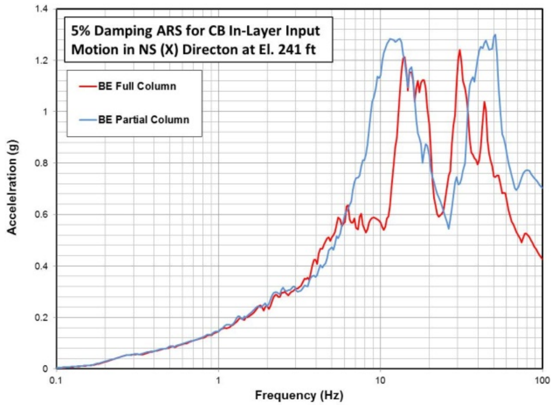


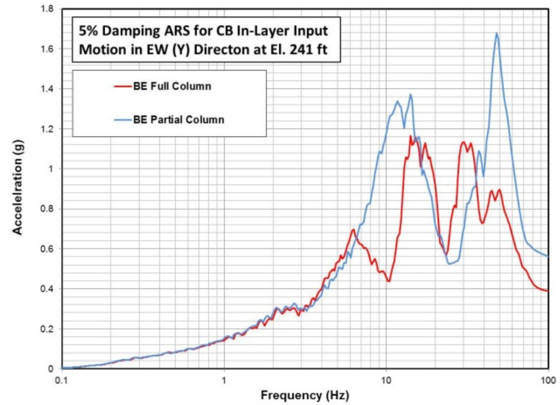
Preliminary/Unverified Results

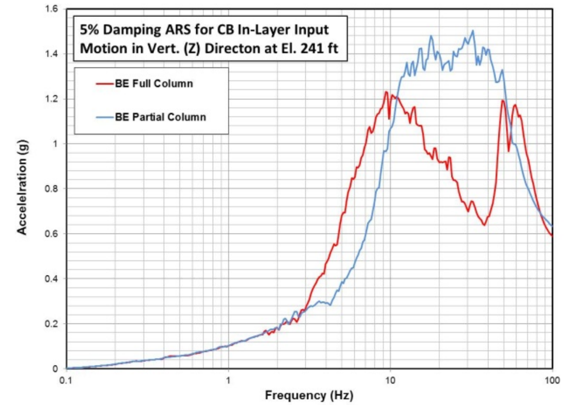
Dominion

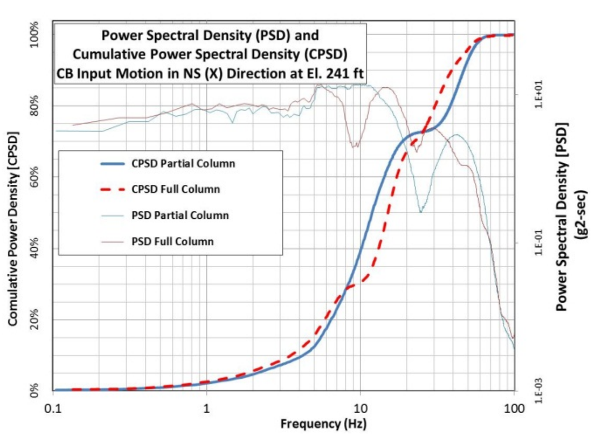
Seismic Analysis Inputs (cont)

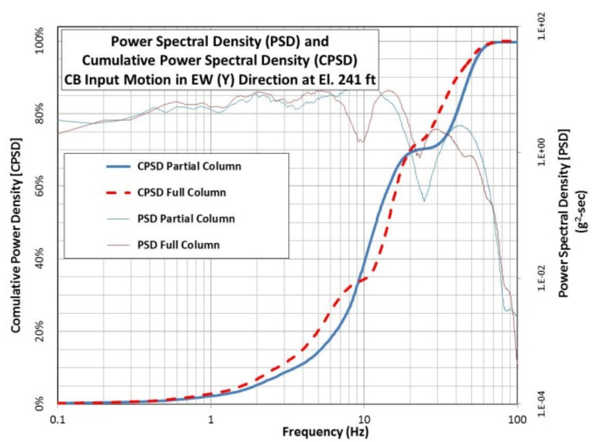
- 2013 GMM-based in-layer input control motion for CB SSI analysis of BE partial and full column profiles

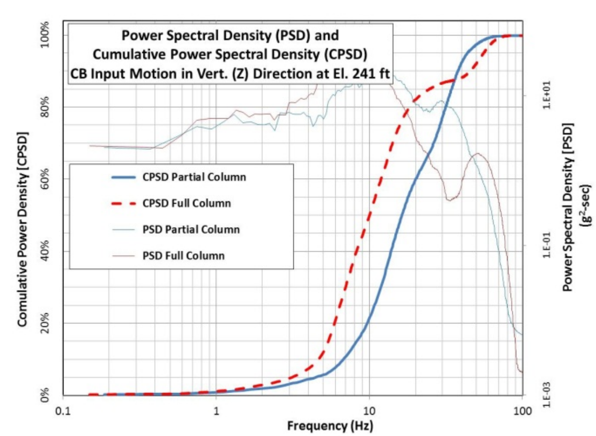










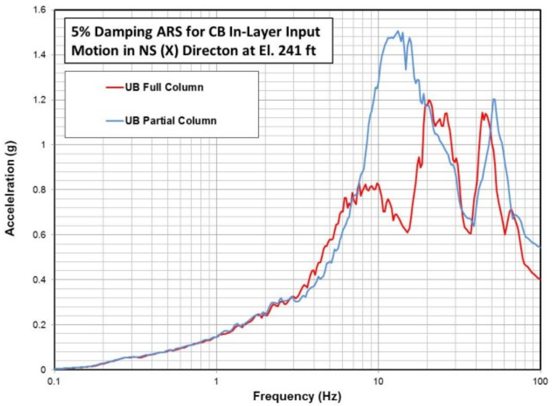


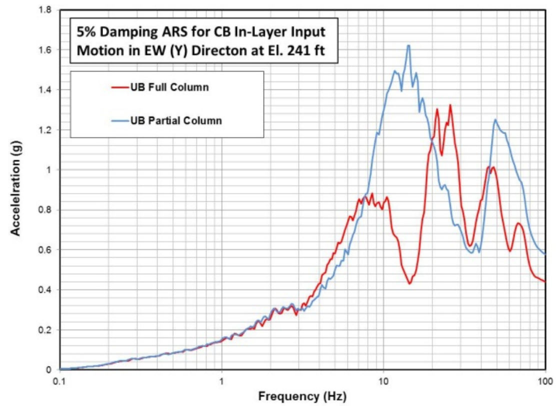
Preliminary/Unverified Results

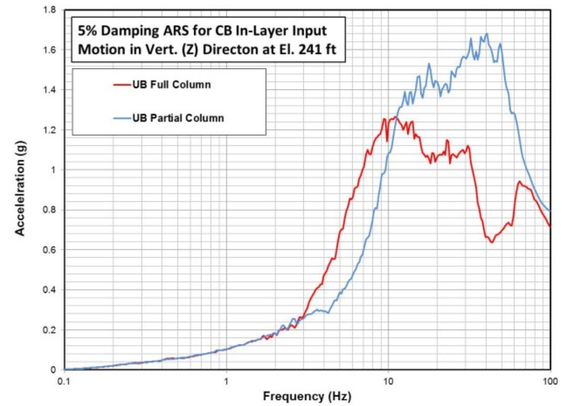
Dominion

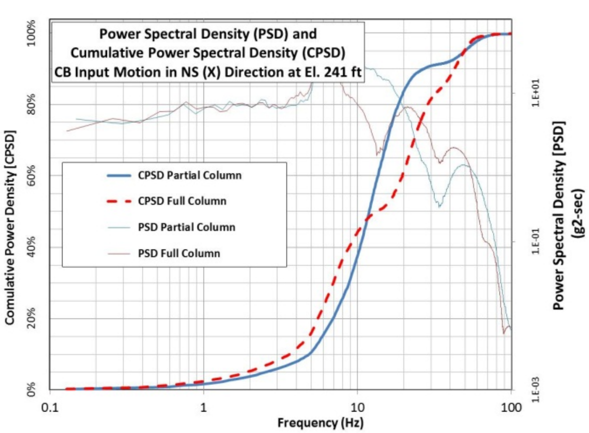
Seismic Analysis Inputs (cont)

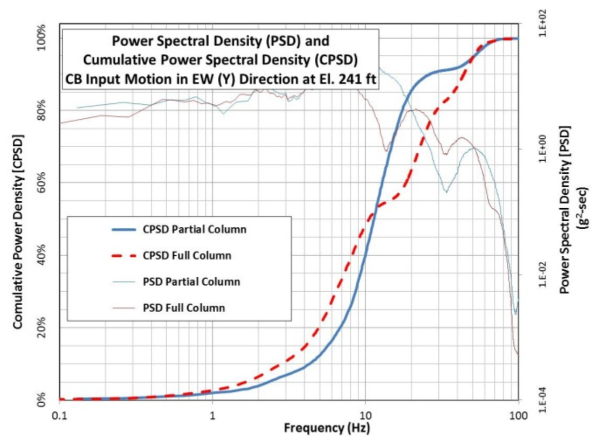
- 2013 GMM-based in-layer input control motion for CB SSI analysis of UB partial and full column profiles

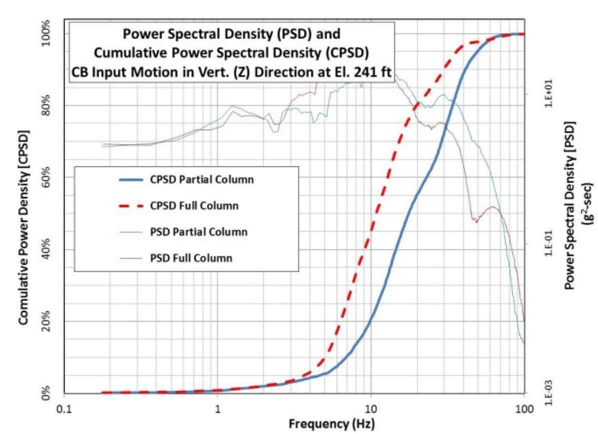












Preliminary/Unverified Results

Dominion

Seismic Analysis Cases

Design Basis Analysis Cases

Uncracked Model with OBE Damping (SSI Cases)

No.	Building	Embedment Assumption	Soil Condition	Model	Analysis Method	Case
1	RB/FB	Partially Embedded	BE	Full	DM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
2	RB/FB	Partially Embedded	UB	Full	DM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
3	RB/FB	Partially Embedded	LB	Full	DM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
4	CB	Partially Embedded	BE	Full	DM	
5	CB	Partially Embedded	UB	Full	DM	
6	CB	Partially Embedded	LB	Full	DM	
7	FWSC	Surface Founded	BE	Half	DM	Input at Bottom of Basemat
8	FWSC	Surface Founded	UB	Half	DM	Input at Bottom of Basemat
9	FWSC	Surface Founded	LB	Half	DM	Input at Bottom of Basemat
10	FWSC	Surface Founded	BE	Half	DM	Input at Bottom of Concrete Fill
11	FWSC	Surface Founded	UB	Half	DM	Input at Bottom of Concrete Fill
12	FWSC	Surface Founded	LB	Half	DM	Input at Bottom of Concrete Fill
13	RB/FB	Fully Embedded	BE	Full	MSM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
14	RB/FB	Fully Embedded	UB	Full	MSM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
15	RB/FB	Fully Embedded	LB	Full	MSM	100% Stiff. Diaphragm Floor (DF) &Vent Wall (VW)
16	CB	Fully Embedded	BE	Full	MSM	
17	CB	Fully Embedded	UB	Full	MSM	
18	CB	Fully Embedded	LB	Full	MSM	

DM =Direct Method
MSM = Modified Subtraction Method

Dominion

Seismic Analysis Cases (cont)

Sensitivity Cases:

SSSI Analyses of Uncracked Combined Models with OBE Damping

No.	Building	Embedment Assumption	Soil Condition	Model	Analysis Method	Case
19	CB-RBFB	Fully Embedded	UB	Full	MSM	CB Soil Profile & CB FIRS
20	CB-RBFB	Partially Embedded	LB	Full	MSM	CB Soil Profile & CB FIRS
21	CB-FWSC	Fully Embedded	UB	Half	MSM	Input at Bottom of CB Basemat
22	FWSC-CB	Fully Embedded	UB	Half	MSM	Input at Bottom of Concrete Fill
23	CB-FWSC	Fully Embedded	LB	Half	MSM	Input at Bottom of CB Basemat
24	FWSC-CB	Fully Embedded	LB	Half	MSM	Input at Bottom of FWSC Basemat

Fully Cracked Model with SSE Damping (SSI Cases)

No.	Building	Embedment Assumption	Soil Condition	Model	Analysis Method	Case
25	RB/FB	Partially Embedded	LB	Full	DM	0% Stiff. Diaphragm Floor (DF) & Vent Wall (VW)
26	RB/FB	Partially Embedded	LB	Full	DM	50% Stiff. Diaphragm Floor (DF) & Vent Wall (VW)
27	CB	Partially Embedded	LB	Full	DM	
28	FWSC	Surface Founded	LB	Half	DM	Input at Bottom of Basemat
29	RB/FB	Fully Embedded	LB	Full	MSM	0% Stiff. Diaphragm Floor (DF) & Vent Wall (VW)
30	RB/FB	Fully Embedded	LB	Full	MSM	50% Stiff. DF&V/W
31	CB	Fully Embedded	LB	Full	MSM	

Dominion

SSI Analyses Cases (cont)

- RB/FB and CB seismic design bases will be developed as envelope of responses obtained from a set of six SSI analyses of:
  - LB, BE and UB partial column profiles that exclude soil located above the Zone III rock
  - LB, BE and UB full column profiles that include soil located above the Zone III rock
- Envelope of responses from set of six SSI analyses ensure that per guidance of SRP 3.7.2, RB/FB and CB seismic design bases envelope effects of:
  - Subgrade properties variations
  - Soil separation
  - Variability of ground water level (GWL) with time
- Use of LB, BE and UB subgrade properties developed from randomized profiles ensure SSI analyses capture effects of variations of subgrade strain compatible properties

Dominion

SSI Analyses Cases (cont)

- Partial column and full column profiles represent lower and upper bound stiffness of RB/FB and CB embedment that envelope subgrade stiffness variations due to soil separation and variability of ground water level
- Lower bound values are used for horizontal extent of concrete fill and engineered fill near-field elements:
  - 3.13 m for fill around 4 sides of RB/FB standalone model is used that is determined as 1/2 distance between RB/FB and TB
  - 3.73 m for fill around 4 sides of CB standalone model is used that is determined as 1/2 distance between CB and Service Building
- Envelope of responses from partial and full column profiles bound variations of subgrade stiffness related to backfill horizontal extent and soil separation effects (RAI Question 03.07.01-7)
  - Engineered fill has lower stiffness and higher damping properties than the surrounding in-situ saprolite
  - Use of lower bound estimate values for horizontal extent of engineered fill maximizes stiffness and minimizes damping of embedment above Zone III rock

SSI Analyses Cases (cont)

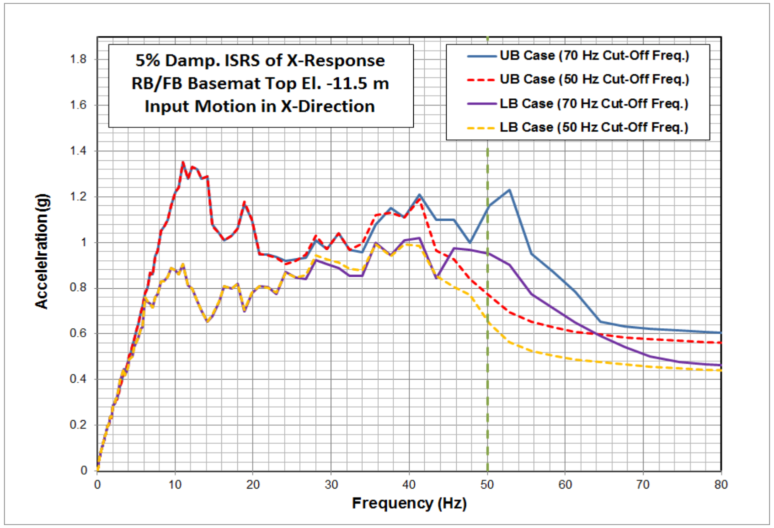
- FWSC design basis will be developed as envelope of SSI responses from a set of 6 SSI analyses of:
  - LB, BE and UB full column profiles with input control motion applied at bottom of FWSC foundation
  - LB, BE and UB full column profiles with input control motion applied at top of Zone III rock (bottom of concrete fill)
- Subgrade profiles used for SSI analyses represent dynamic properties of far-field in-situ rock and saprolite at FWSC locations
- Concrete fill below FWSC foundation is represented by embedded block of solid elements
- Use of input motion at two different control motion evaluations ensure that FWSC design basis meets the intent of DC/COL-ISG-017, Section 5.2
- SSI analyses with deep input motion control point capture effects of seismic wave propagation through concrete fill block to ensure that high frequency content that is otherwise filtered out from time histories of outcrop surface motion is included in FWSC site-specific design basis (RAI Question 03.07.01-7)

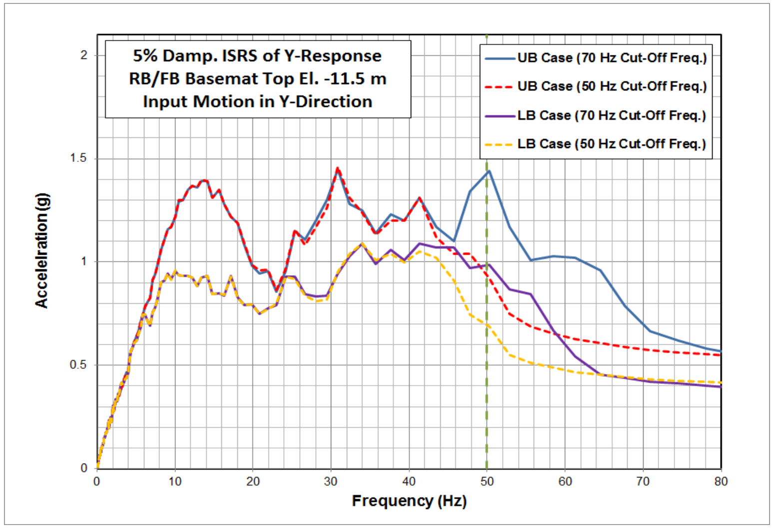
Dominion

Frequencies of SSI Analyses

- SSI analyses of UB subgrade profiles that bound responses at high frequencies will all be performed using 70 Hz cut-off frequency to capture virtually entire energy content of NA3 high frequency input motion
- Results of study performed on RB/FB model to support response to RAI Question 03.07.02-15 showed that input motion content above 50 Hz can amplify ISRS close to 50 Hz and affect maximum vertical accelerations

5% Damped ISRS for RB/FB Basemat Top Elevation 24.2 m (Node 2)





Preliminary/Unverified Results based on 2004 GMM input motion

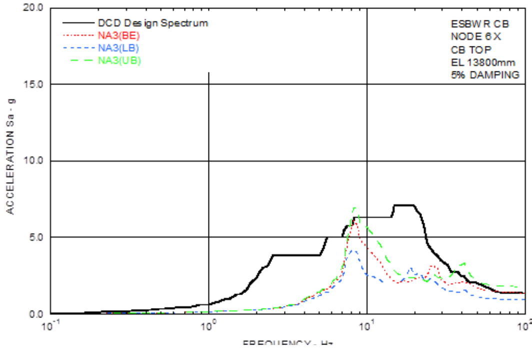
Dominion

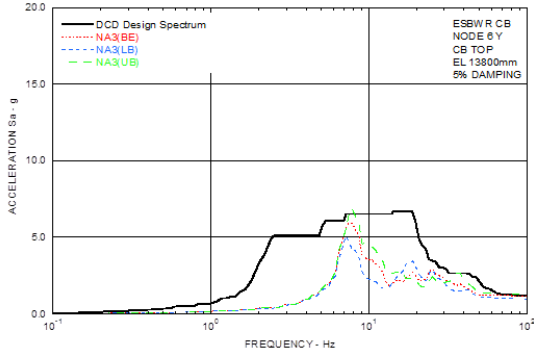
Frequencies of SSI Analyses (cont)

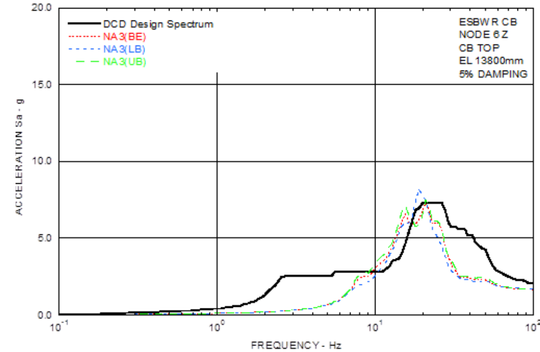
- Finite Element (FE) meshing of excavated volume and near field elements is refined to improve ability of dynamic models to transmit seismic waves with higher frequencies (RAI Question 03.07.02-13)
- SSI analyses will be performed for range of frequencies that are within the 20% wavelength SASSI criteria to ensure any response amplification within analyzed frequency range is appropriately captured
- Range of frequencies will be used to ensure that SSI analyses of:
  - Partial column profiles capture more than 95% of input motion energy
  - LB full column profiles capture more than 80% of input motion energy
  - BE full column profiles capture more than 90% of input motion energy
  - UB full column profiles capture at least 99% of input motion energy
- Envelope of responses from all 6 analysis cases will ensure per guidelines of DC/COL-ISG-01, site-specific design basis ISRS are adequate for frequencies up to 50 Hz

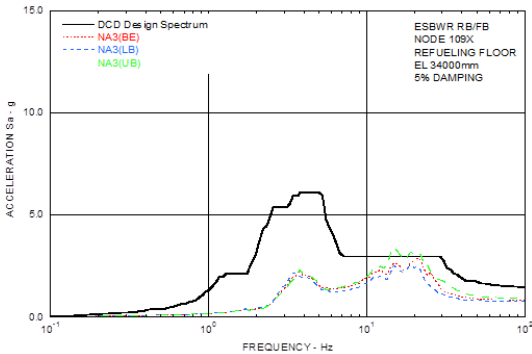
Frequencies of SSI Analyses (cont)

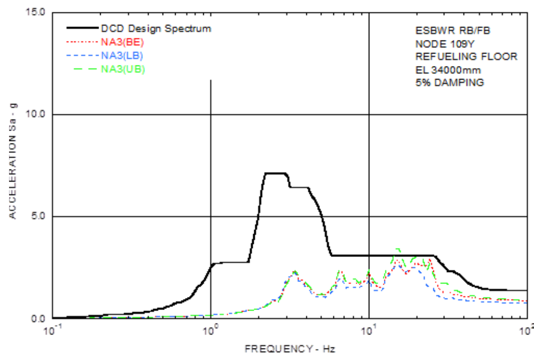
- Comparisons of ISRS results in Figures 3.7.2-212 to 228 and 3.7.2-257 to 252 of current FSAR revision show that UB case governs RB/FB and CB response at high frequencies

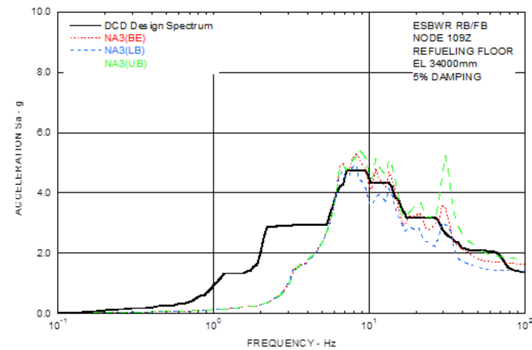












- Results of RB/FB and CB SSI analyses of partial column profiles that are run for frequencies up to 60 Hz will be used to confirm that UB cases govern high frequency responses

Dominion

Frequencies of SSI Analyses (cont)

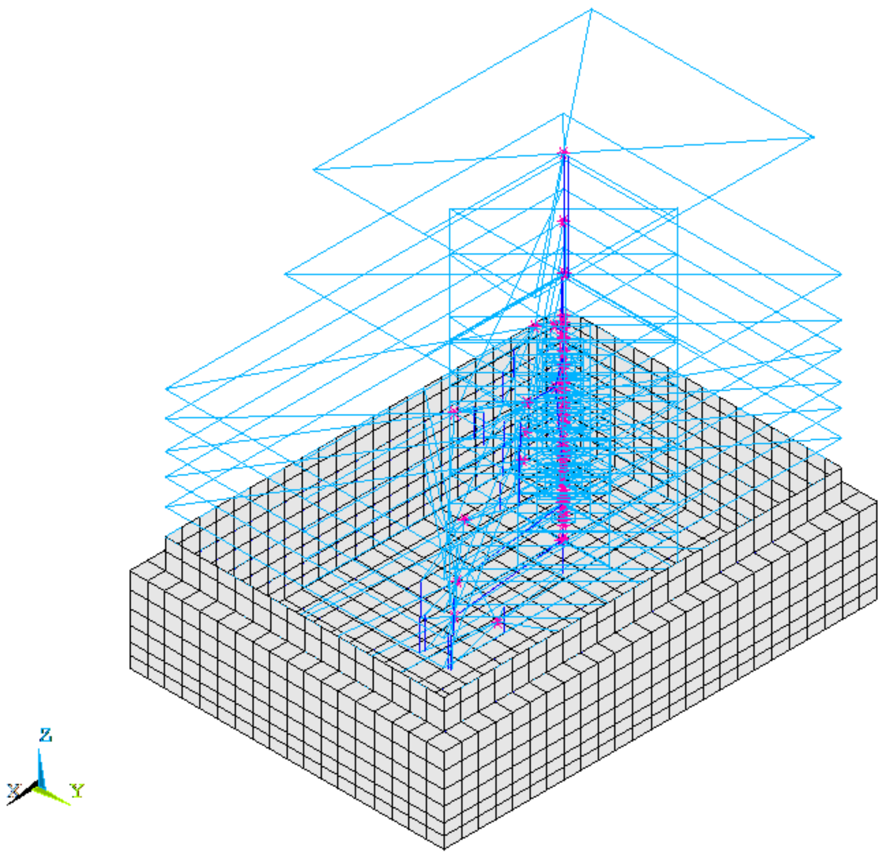
- RB/FB SSI analysis cut-off frequencies and model passing frequencies

Subgrade Profile		Method	Control Motion El.	Passing Freq. (Hz)	Cut-off Freq. (Hz)	Captured Motion Energy X	Captured Motion Energy Y	Captured Motion Energy Z
Partial Column	LB	DM	224 ft	62	62 Hz	99%	98%	96%
	BE			84	70 Hz	100%	100%	100%
	UB			112	70 Hz	99%	99%	100%
Full Column	LB	EMSM		33	33 Hz	83%	83%	88%
	BE			52	50 Hz	96%	96%	94%
	UB			80	70 Hz	99%	99%	100%

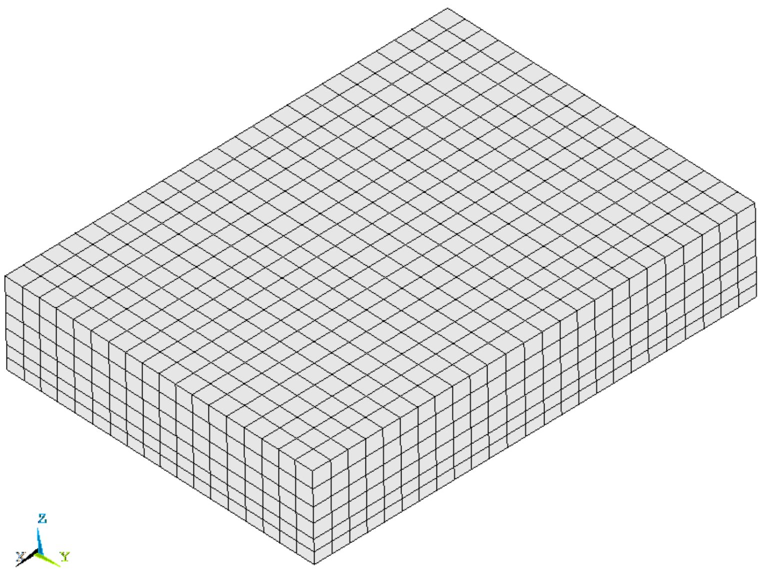
Preliminary/Unverified Results

Frequencies of SSI Analyses (cont)

- Partially Embedded RB/FB Dynamic Model
  - Direct Method (DM) used with all nodes of excavated volume specified as interaction nodes



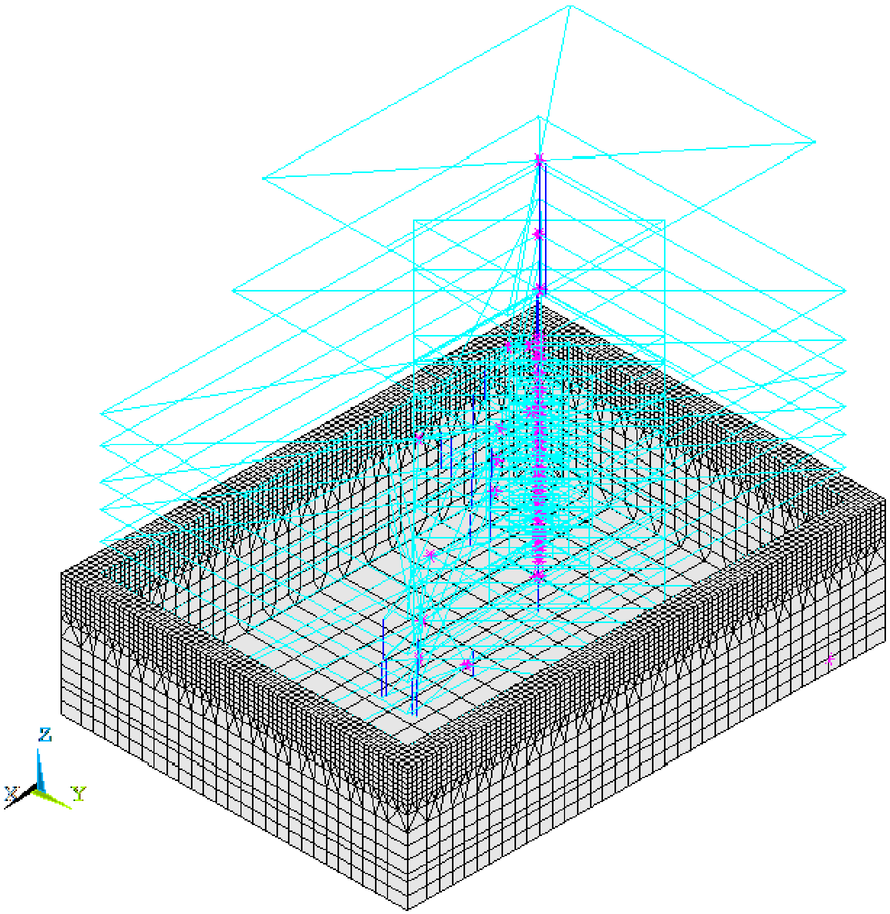
Structural and Near Field Model



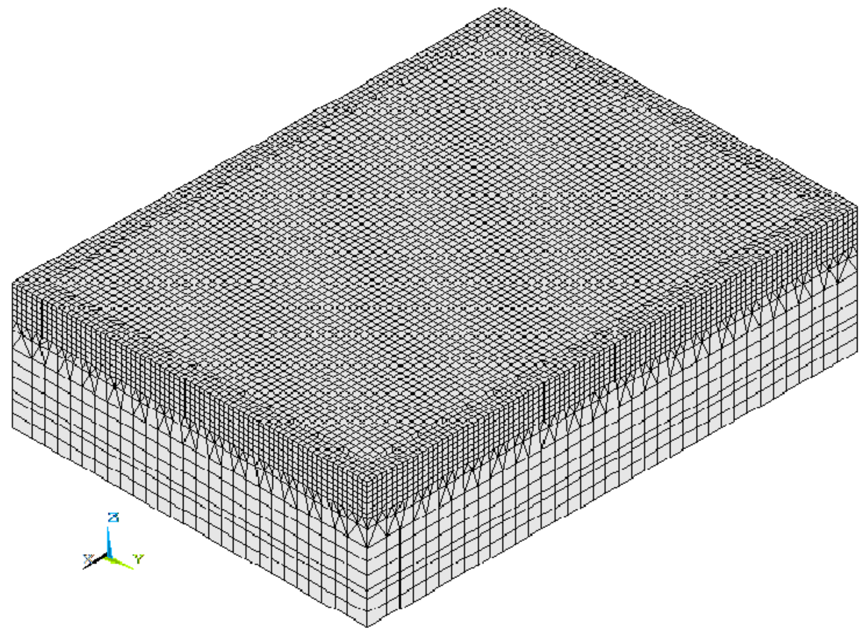
Excavated Volume Model

Frequencies of SSI Analyses (cont)

- Fully Embedded RB/FB Dynamic Model
  - Enhanced Modified Subtraction Method (EMSM) used with interaction nodes specified at excavated volume 6 outside surfaces and one internal horizontal plane



Structural and Near Field Model



Excavated Volume Model

Dominion

Frequencies of SSI Analyses (cont)

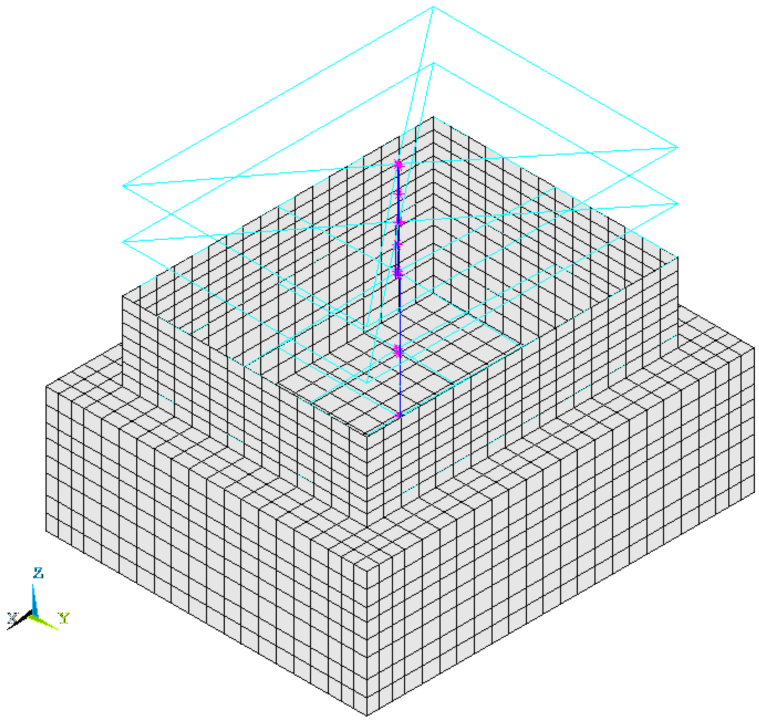
- CB SSI analysis cut-off frequencies and model passing frequencies

Subgrade Profile		Method	Control Motion El.	Passing Freq. (Hz)	Cut-off Freq. (Hz)	Captured Motion Energy X	Captured Motion Energy Y	Captured Motion Energy Z
Partial Column	LB	DM	240 ft	50 Hz	50 Hz	97%	96%	99%
	BE			66 Hz	66 Hz	100%	99%	100%
	UB			86 Hz	70 Hz	99%	99%	99%
Full Column	LB	EMSM		34 Hz	34 Hz	83%	82%	86%
	BE			51 Hz	50 Hz	96%	95%	92%
	UB			77 Hz	70 Hz	99%	99%	99%

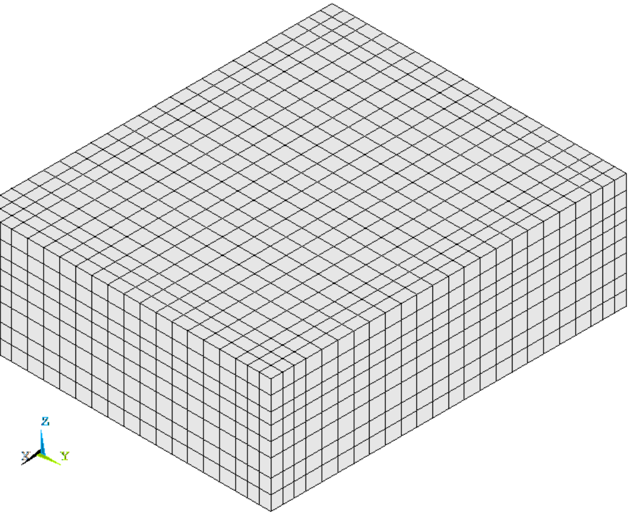
Preliminary/Unverified Results

Frequencies of SSI Analyses (cont)

- Partially Embedded CB Dynamic Model
  - Direct Method (DM) used with all nodes of excavated volume specified as interaction nodes



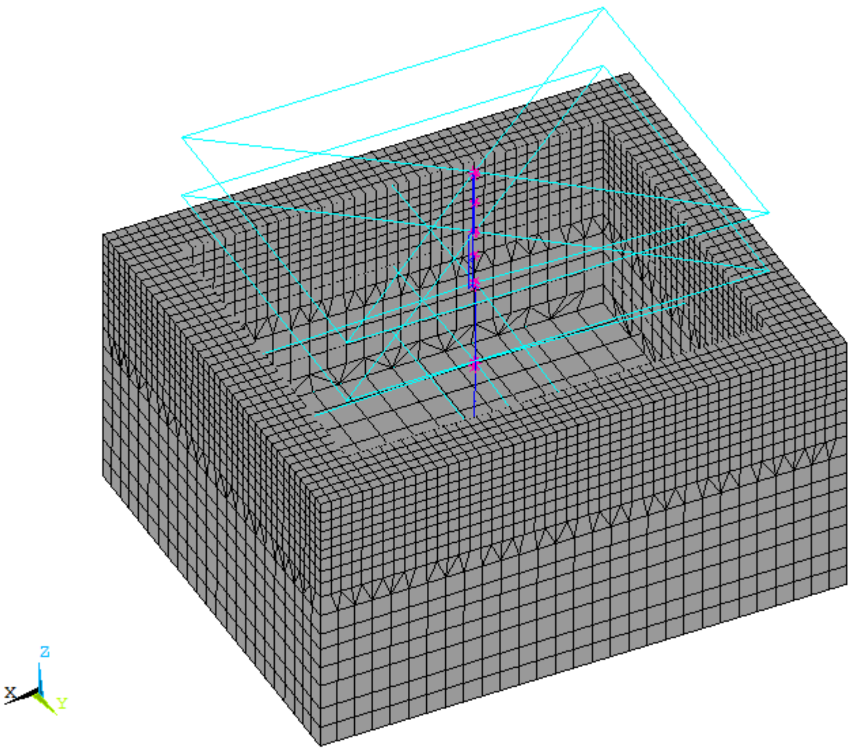
Structural and Near Field Model



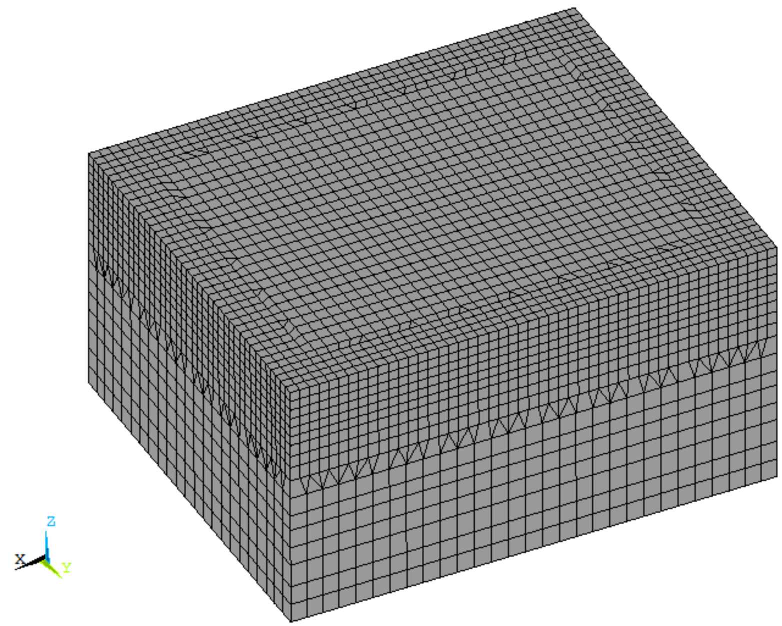
Excavated Volume Model

Frequencies of SSI Analyses (cont)

- Fully Embedded CB Dynamic Model
  - Enhanced Modified Subtraction Method (EMSM) used with interaction nodes specified at excavated volume 6 outside surfaces and two internal horizontal planes



Structural and Near Field Model



Excavated Volume Model

Frequencies of SSI Analyses (cont)

- FWSC SSI analysis cut-off frequencies and model passing frequencies

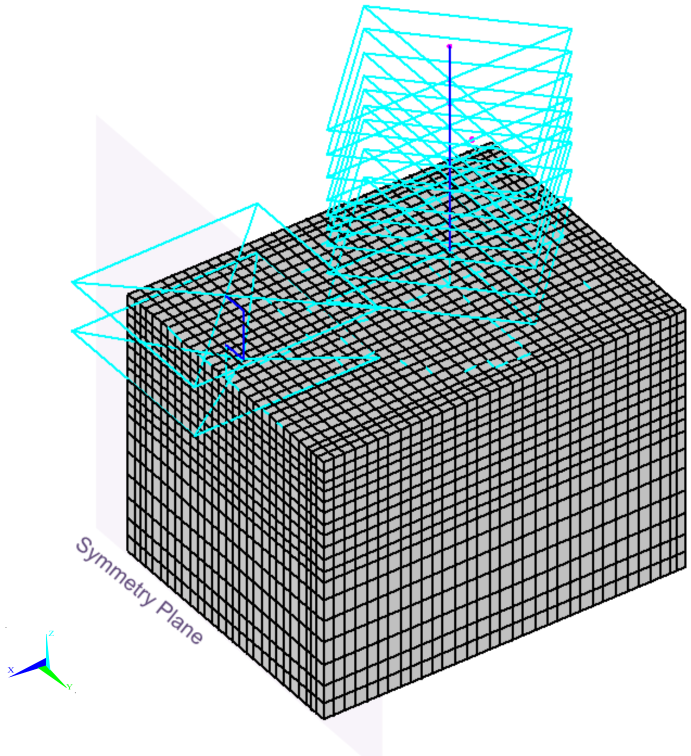
Subgrade Profile		Method	Control Motion El.	Passing Freq. (Hz)	Cut-off Freq. (Hz)	Captured Motion Energy		
						X	Y	Z
Full Column	LB	EMSM	282 ft	36	36	89%	87%	83%
	BE			55	55	97%	97%	95%
	UB			84	70	100%	100%	99%
Full Column	LB		220 ft	36	36	87%	81%	84%
	BE			55	55	98%	96%	95%
	UB			84	70	100%	99%	99%

Preliminary/Unverified Results

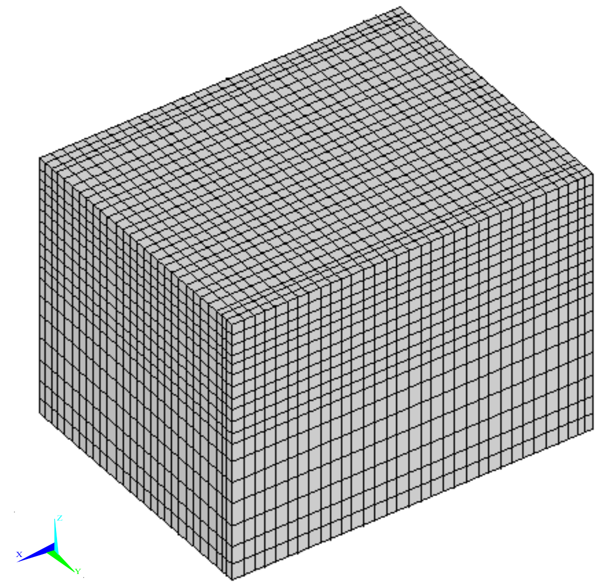
Dominion

Frequencies of SSI Analyses (cont)

- FWSC Dynamic Model
  - Enhanced Modified Subtraction Method (EMSM) will be used with interaction nodes specified at excavated volume 6 outside surfaces and three internal horizontal planes



Structural and Near Field Model



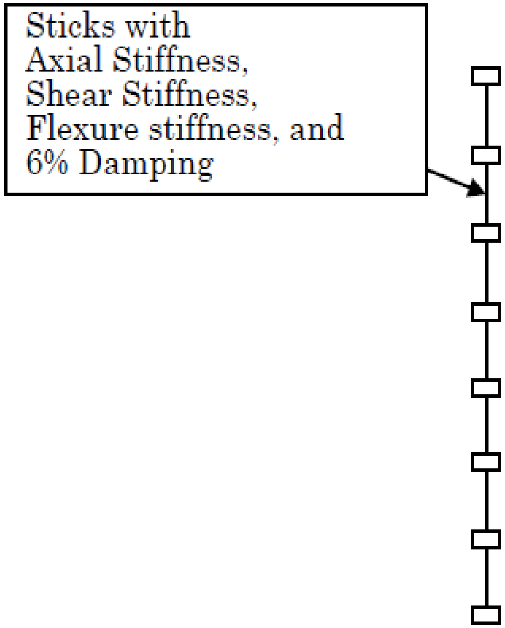
Excavated Volume Model

SSI Analysis Structural Models

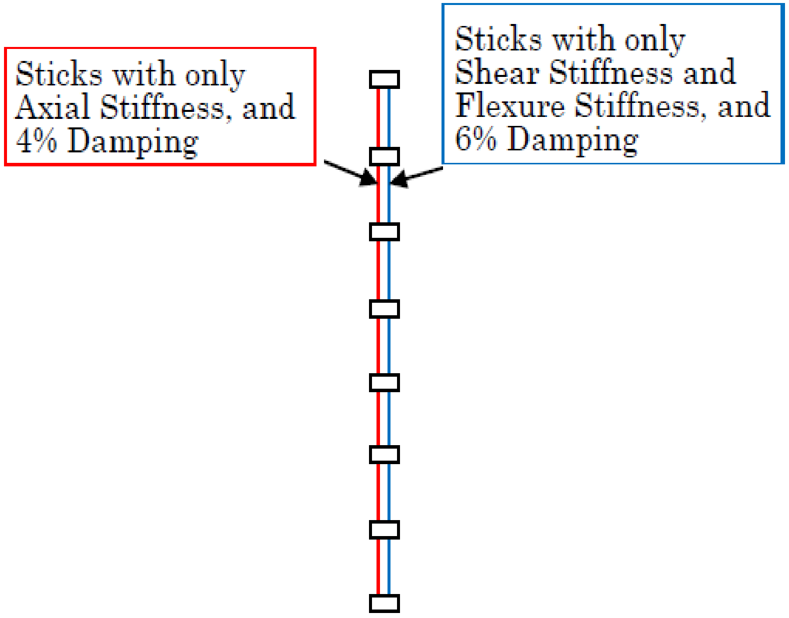
- SSI analysis will use the same lumped mass stick models (LMSMs) and SDOF oscillators as those of standard design basis models with exception of:
  - Lower OBE damping values will be assigned to model
  - Upper bound stiffness assigned to concrete and steel internal structures in RB/FB dynamic model reflecting a 100% stiffness contribution of concrete inside the steel plates
  - Outriggers installed to facilitate calculation of ISRS and displacements at floor edges
- Stiffness properties and configuration of shell models representing basemats and below grade walls will be identical to that of standard design basis with mesh adjusted for site-specific conditions
- Single Degree of Freedom (SDOF) oscillators represent out-of-plane modes of vibration of flexible slabs and walls under full stiffness (uncracked concrete) conditions
- Models with upper bound stiffness and OBE damping structural properties will yield conservative seismic responses and adequate ISRS results for the Unit 3 rock site with high frequency design motion according to guidance in SRP 3.7.2.II.3.C.iv.

Fuel Modeling

- RB/FB standard design dynamic model is modified in order to enable modeling of different OBE damping values for the fuel in horizontal and vertical direction
  - Two sets of stick elements are used for fuel in RB/FB LMSM providing separate representations of fuel axial and flexure stiffness



Fuel Model for
Standard Design Analysis



Fuel Model for
Site-Specific Analysis

Fuel Modeling (cont)

- Fuel stiffness in model used for RB/FB analyses in previous FSAR revision is corrected to closely match those of the standard design dynamic model

Property		Site-Specific			Standard Design	Difference (%)
		Horiz.	Vertical	Total		
Top Elements	Axial Area (m^2)	**0.0010**	1.3146	**1.3156**	1.3146	**0.08**
	Shear Area (m^2)	0.6573	**0.0010**	**0.6583**	0.6573	**0.15**
	Flexural Inertia (m^4)	0.0042	**0.00001**	**0.00421**	0.0042	**0.24**
	Torsional Inertia (m^4)	0.1000	**0.00001**	**0.1001**	0.1000	**0.10**
Bottom Element	Axial Area (m^2)	**0.0010**	1.0000	**1.0010**	1.0000	**0.10**
	Shear Area (m^2)	0.5000	**0.0010**	**0.5010**	0.5000	**0.20**
	Flexural Inertia (m^4)	0.0050	**0.00001**	**0.00501**	0.0050	**0.20**
	Torsional Inertia (m^4)	0.1000	**0.0001**	**0.1001**	0.1000	**0.10**
Damping (%)		6	4	N/A	6	N/A

Values of 0.100 corrected to 1% or less of actual cross sectional property.
Preliminary/Unverified Results.

Dominion

Fuel Modeling (cont)

- Results of comparative study of fuel error effects showed that:
  - Modeling error mainly impacted response of RPV LMSM whose purpose is only to capture effects of dynamic coupling between heavy equipment and RB/FB structures
  - Impact of fuel error on responses of RCCV, Pedestal, RSW, VW and RB/FB structures are small and limited to locations close to RPV supports
  - Impact of fuel modeling error on calculations of site-specific seismic loads on RCCV, Pedestal, RSW, VW and RB/FB structures is very small, with minimal effect on results of evaluation of RB/FB structures presented in current FSAR
  - Impact of fuel modeling error on ISRS was relatively small and manifested by errors in calculated peak responses at frequencies above 15 Hz for ISRS close to RPV support locations

Fuel Modeling (cont)

- Benchmark analysis is performed to check accuracy of modified RB/FB LMSM model based on comparison of results from SSI analysis of:
  - Corrected Unit 3 site-specific RB/FB Complex seismic model with 6% SSE damping assigned both to horizontal and vertical fuel stick elements
  - Standard design RB/FB Complex seismic model with 6% SSE damping assigned to single set of fuel stick elements
- Benchmark analysis is performed for Best Estimate (BE) partial column profile
- Accuracy of corrected site-specific RB/FB Complex seismic model demonstrated by showing that two analyses yielded identical results

Dominion

Structural Properties Variation Evaluation

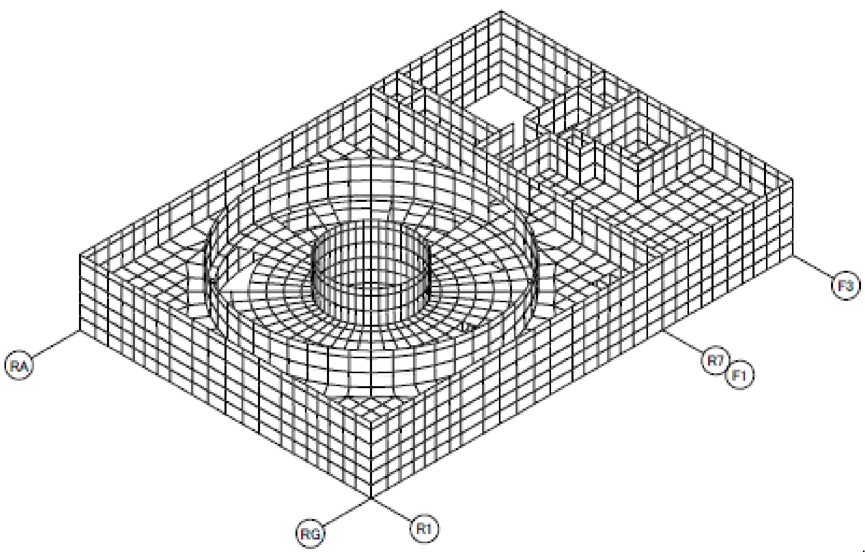
- Sensitivity study will be performed to ensure site-specific design bases envelope effects of:
  - Concrete cracking on reinforced concrete members' stiffness
  - Concrete cracking on out-of-plane vibrations of flexible slabs and walls
  - Concrete and Steel Internal Structures stiffness variations
- Study will be based on results obtained from SSI analyses of models with lower bound stiffness properties :
  - 50% reduced stiffness properties of reinforced concrete members representing fully cracked condition per ASCE 43-05
  - Concrete and Steel Internal Structures with 50% and 0% concrete stiffness contribution
  - SDOF oscillators representing out-of-plane vibrations of slabs under fully cracked conditions

Structural Properties Variation Evaluation (cont)

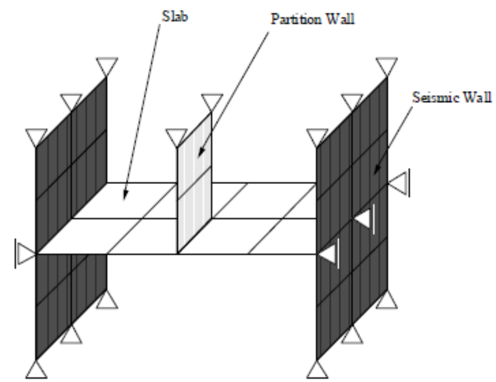
- Evaluation of structural properties' variation on site-specific design will be evaluated based on comparison of responses obtained from analyses of reduced stiffness models
  - LB subgrade profiles representative of lower bound subgrade stiffness will be used to emphasize effects of peak response frequency shifts on ISRS
  - LB full and partial column profiles will be considered to account for higher energy of full column input motion at lower frequencies
- If results of evaluation indicate that responses obtained from models with upper bound stiffness properties and OBE damping do not envelope concrete cracking and/or Concrete and Steel structures stiffness variations:
  - Analyses of models with reduced stiffness properties and SSE damping will be performed for BE and UB profiles
  - Responses obtained from models with reduced stiffness properties will be included in site-specific design bases

Structural Properties Variation Evaluation (cont)

- SDOF oscillators capturing out-of-plane response of fully cracked slabs and walls are obtained from results of NASTRAN eigenvalue analyses:
  - Same DCD methodology used for development of oscillators for standard design dynamic LMSM models is used
  - Eigenvalues up to 70 Hz are extracted from same DCD partial floor FE models used for standard design analyses and results are divided by $\sqrt{2}$ to determine slab out-of-plane modes of vibrations with frequencies < 50 Hz under fully cracked condition



Partial FE Model for Eigenvalue Analysis of Slabs at El. -1.0 m

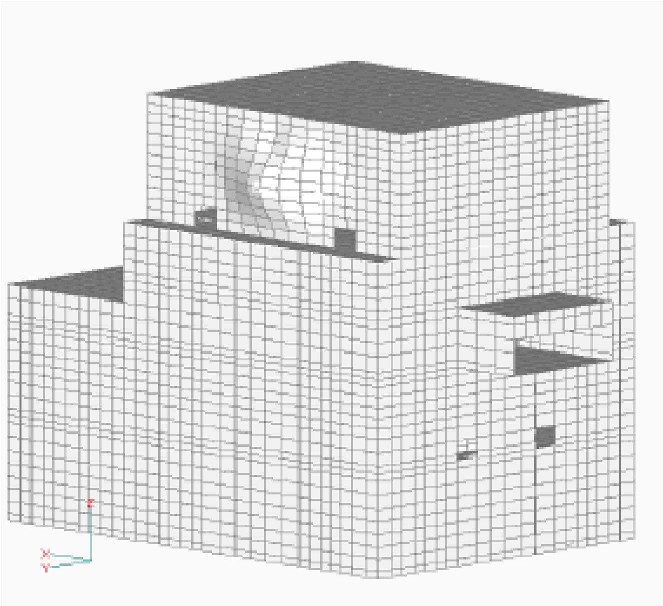


Boundary Conditions

	Translation			Rotation			
	X	Y	Z	θxx	θyy	θzz	
▽ △	fixed	fixed	fixed	free	free	free	nodes of wall elements at the upper and lower floor levels
▷ ◁	fixed	fixed	free	free	free	free	all nodes of slab elements

Structural Properties Variation Evaluation (cont)

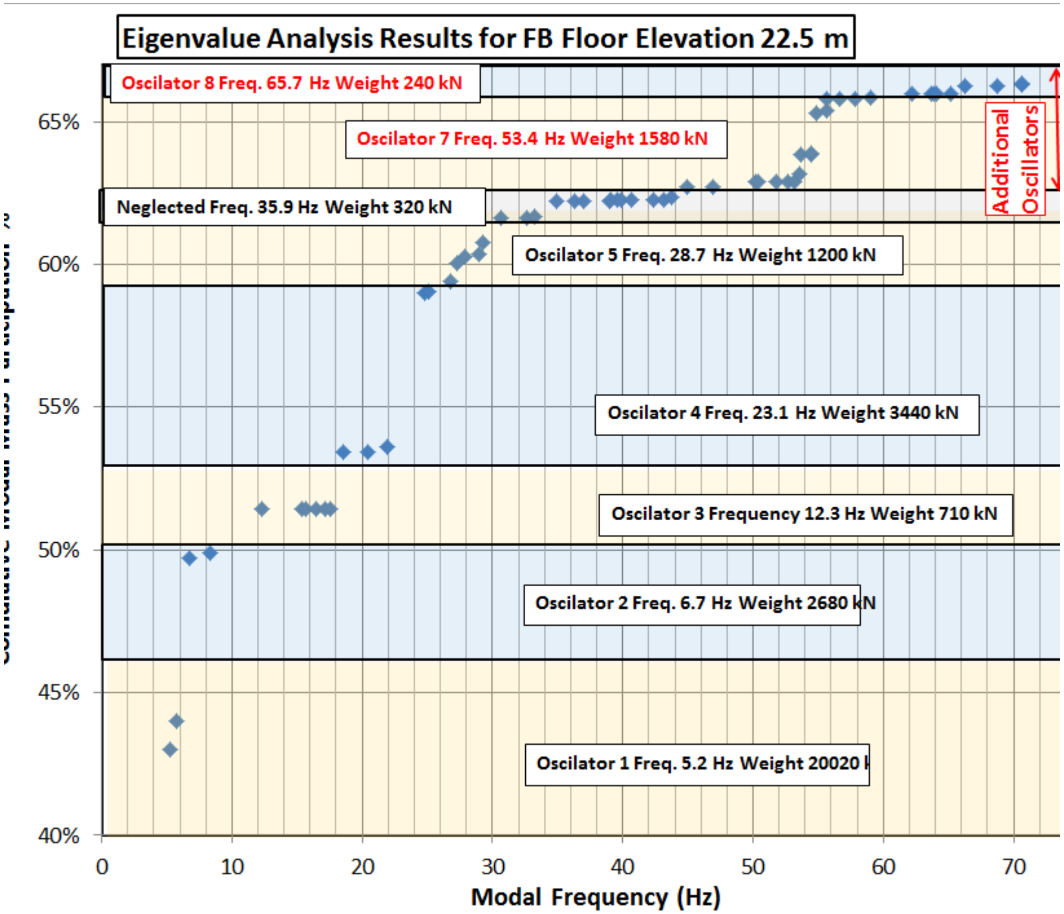
- As explained above, eigenvalues up to 70 Hz are extracted from same DCD FE models used for standard design analyses and results are divided by $\sqrt{2}$ to determine wall out-of-plane modes of vibrations with frequencies < 50 Hz under fully cracked condition



FE Model for Eigenvalue Analysis of RB Walls above El. 34 m

Structural Properties Variation Evaluation (cont)

- Dynamic properties of SDOF oscillators are developed from results of eigenvalue analysis following same DCD methodology:
  - Modes extracted from eigenvalue analysis are lumped in groups based on modal frequency and mode shapes
  - Oscillator frequency is determined as weighted average of all modes in the group



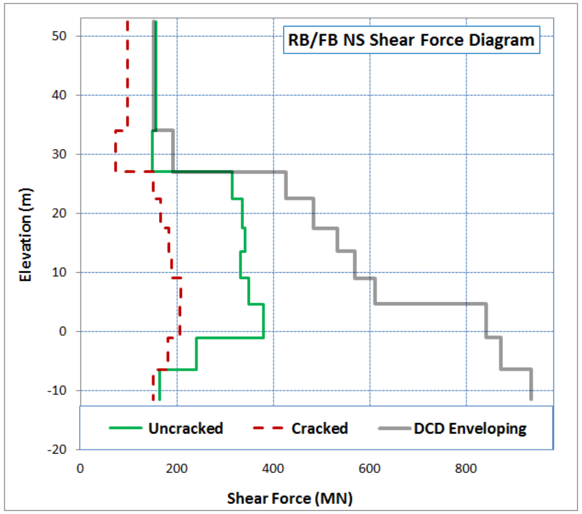
Dominion

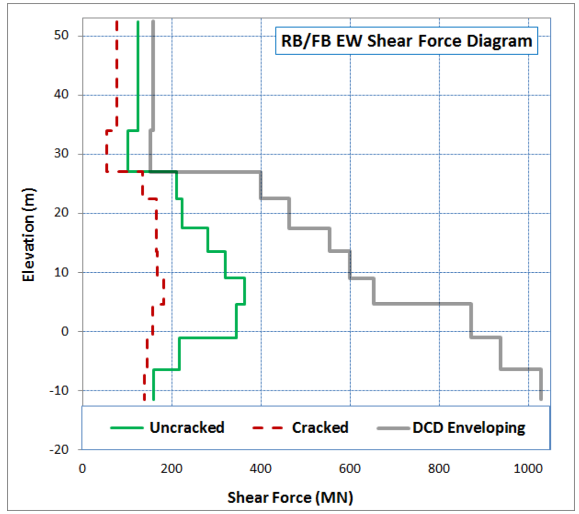
Structural Properties Variation Evaluation (cont)

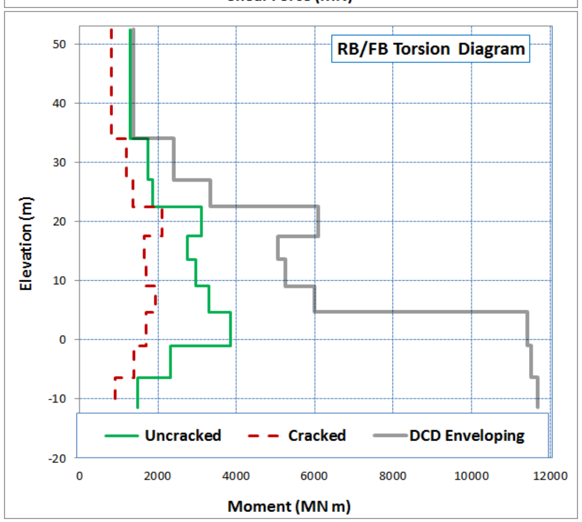
- Preliminary evaluations on effects of concrete cracking show that models with upper bound stiffness properties will bound results for site-specific seismic demands on RB/FB and CB structures
- Evaluations were based on results from analyses of RB/FB and CB for partial column profiles in current FSAR revision:
  - Existing results for transfer functions obtained from analyses of partial column rock profiles are also applicable for 2013 GMPE motion because properties of rock subgrade are virtually independent of strain
  - Evaluations based on responses for UB profiles that provide bounding results for site-specific seismic demands on RB/FB and CB structures
- Evaluations considered responses obtained from RB/FB and CB models with:
  - Full (uncracked concrete) stiffness and OBE damping properties
  - Best estimate stiffness and damping properties of structures used to develop site-specific design basis in current revision of FSAR
- Maximum shear force, torsion moment and vertical acceleration results are also compared with corresponding DCD diagrams of standard design SSE loads to assess effects on structural evaluation

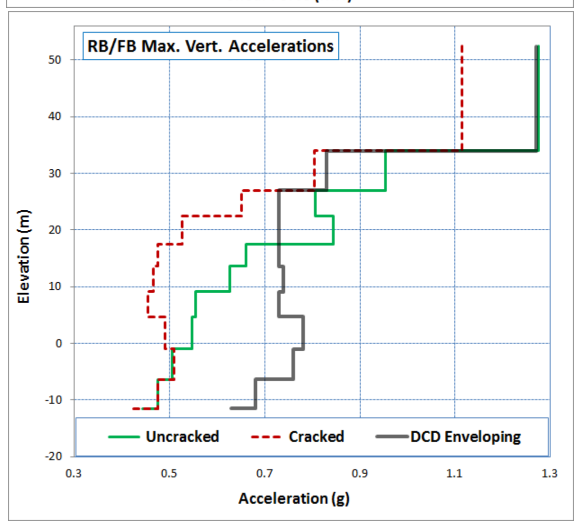
Structural Properties Variation Evaluation (cont)

- Concrete cracking effect on RB/FB LMSM maximum forces and vertical accelerations:







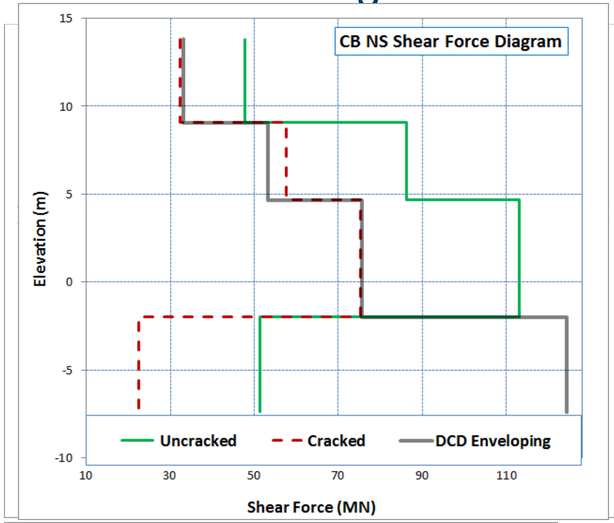


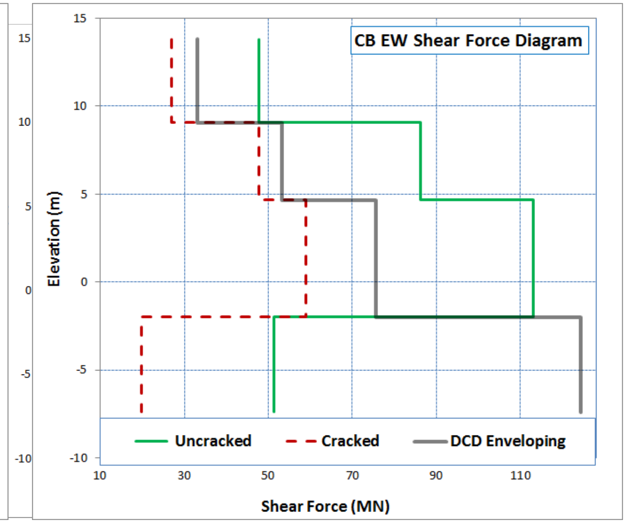
Preliminary/ Unverified Results

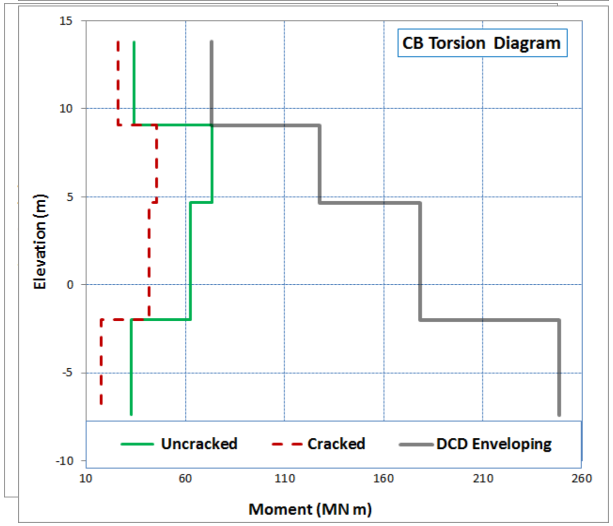
Dominion

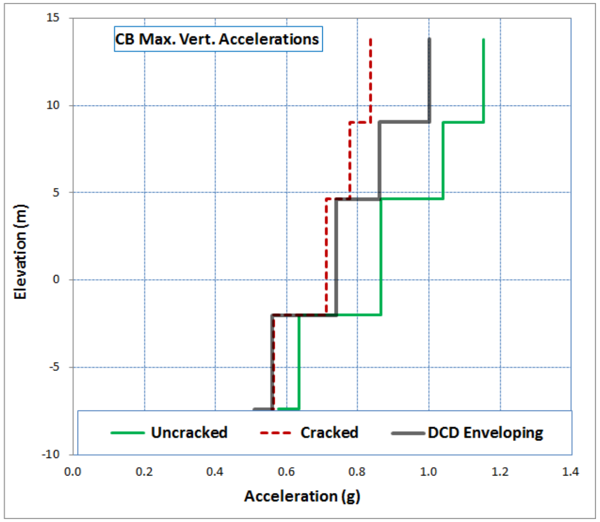
Structural Properties Variation Evaluation (cont)

- Concrete cracking effect on CB LMSM maximum forces and vertical accelerations:







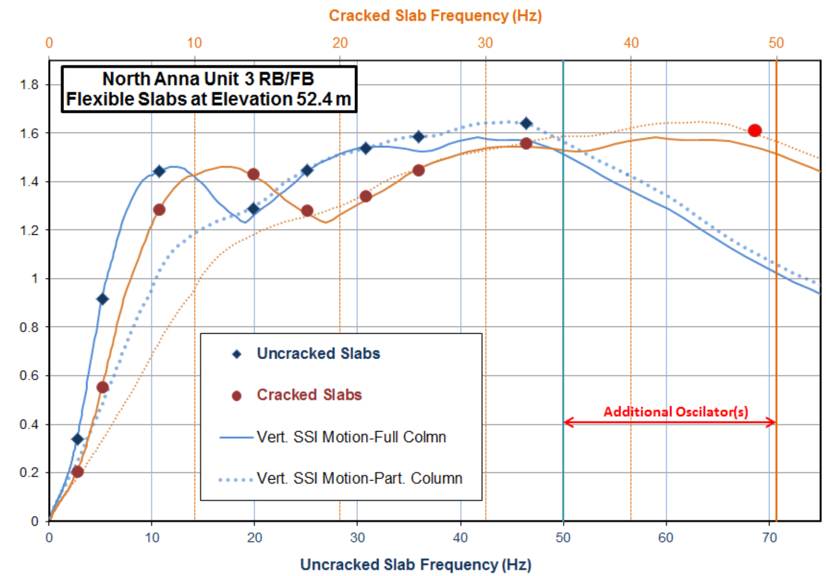


Preliminary/ Unverified Results

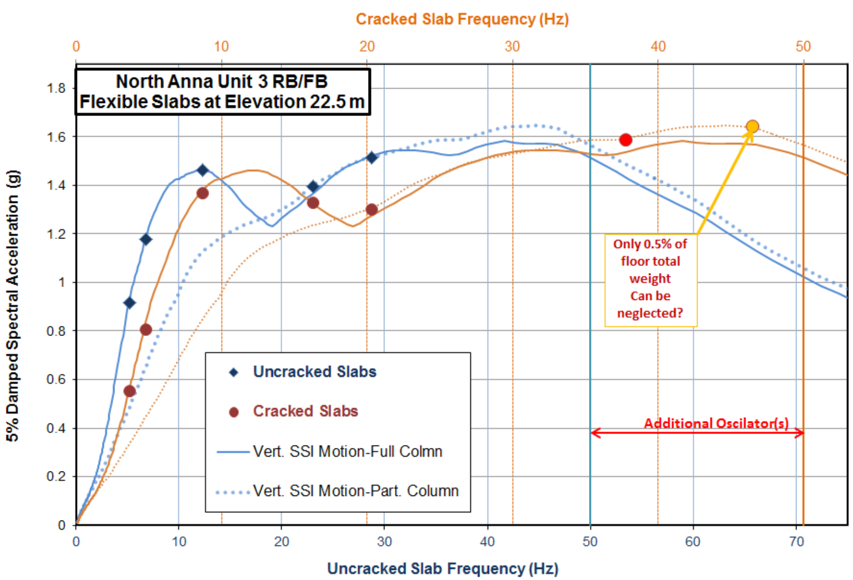
Dominion

Structural Properties Variation Evaluation (cont)

- Preliminary evaluation indicates that consideration of uncracked slabs and walls will yield conservative results for specific out-of-plane seismic loads:
  - Uncracked concrete conditions will result in higher amplitudes of first modes' out-of-plane vibrations that have larger modal mass contributions than modes with higher frequencies



Eigenvalue analysis results for RB/FB Slabs at El. 52.4 m and 22.5 m:



Preliminary/Unverified Results based on 2004 GMM input motion

SSSI Effects Evaluation

- Site-specific sensitivity evaluations of SSSI effects will be performed to respond to RAI Question 03.07.02-16:
  - Effect of heavy RB/FB on response of smaller CB based on results of 2 SSSI analyses of CB-RB/FB combined model for CB LB partial column profile and CB UB full column profile and corresponding in-layer input motions applied at bottom of CB
  - Effect of FWSC on response of CB based on results of 2 SSSI analyses of CB-FWSC combined model for CB LB and UB full column profiles and corresponding in-layer input motions applied at bottom of CB
  - Effect of CB on response of FWSC based on results of 2 SSSI analyses of FWSC-CB combined model for FWSC LB and UB profiles with motion applied at ground surface and FWSC UB profile with motion applied at bottom of concrete fill placed below FWSC foundation

Dominion

SSSI Effects Evaluation (cont)

- Effects of SSSI on seismic response and design will be evaluated by comparing SSSI analyses' results of combined models with corresponding SSI analyses' results of standalone models for:
  - Acceleration transfer functions at selected locations
  - Seismic force and moment load diagrams for stick members
  - Maximum acceleration at floor lumped mass and SDOF mass locations
  - 5% damped ISRS at selected locations
  - Dynamic lateral pressures
- SSSI effects will be included in site-specific seismic design bases if results of SSSI analyses exceed standalone model responses:
  - Exceedances of no more than 10% in ISRS results at higher frequencies are deemed insignificant for design of equipment and components
  - 10% exceedance is considered to be insignificant due to the various conservatism introduced in design such as neglecting effects of incoherency of input ground motion

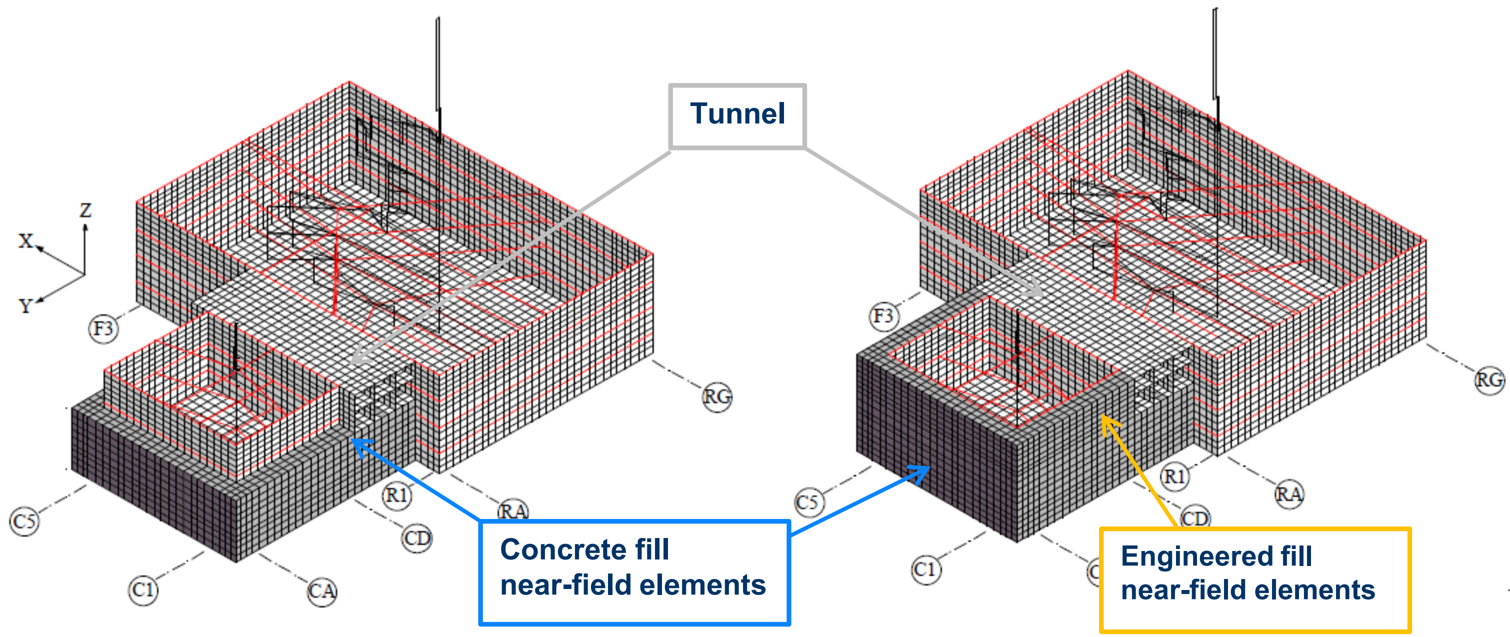
SSSI Effects Evaluation (cont)

- CB-RB/FB SSSI analysis will be performed using input motion defined by CB FIRS and two bounding subgrade profiles capturing full range of variations of subgrade stiffness at NA3 CB location:
  - CB UB full column profile that includes soil and granular fill above Zone III rock
  - CB LB partial column profile that neglects effect of soil and granular fill
- SSSI effects of RB/FB on CB will be evaluated by comparing CB responses obtained from SSSI analyses of CB-RB/FB combined model and SSI analyses of standalone CB models
- Dynamic properties of CB and RB/FB in combined model will be identical to properties of standalone models
- CB-RB/FB combined model will include concrete fill and tunnel located between two buildings to capture their effect on SSSI responses
  - Tunnel is seismically isolated from the RB/FB and CB below grade walls

SSSI Effects Evaluation (cont)

CB-RB/FB Combined SSSI Model

- Two CB-RB/FB combined models will be used for site-specific SSSI analyses:



Partially embedded combined CB-RB/FB model

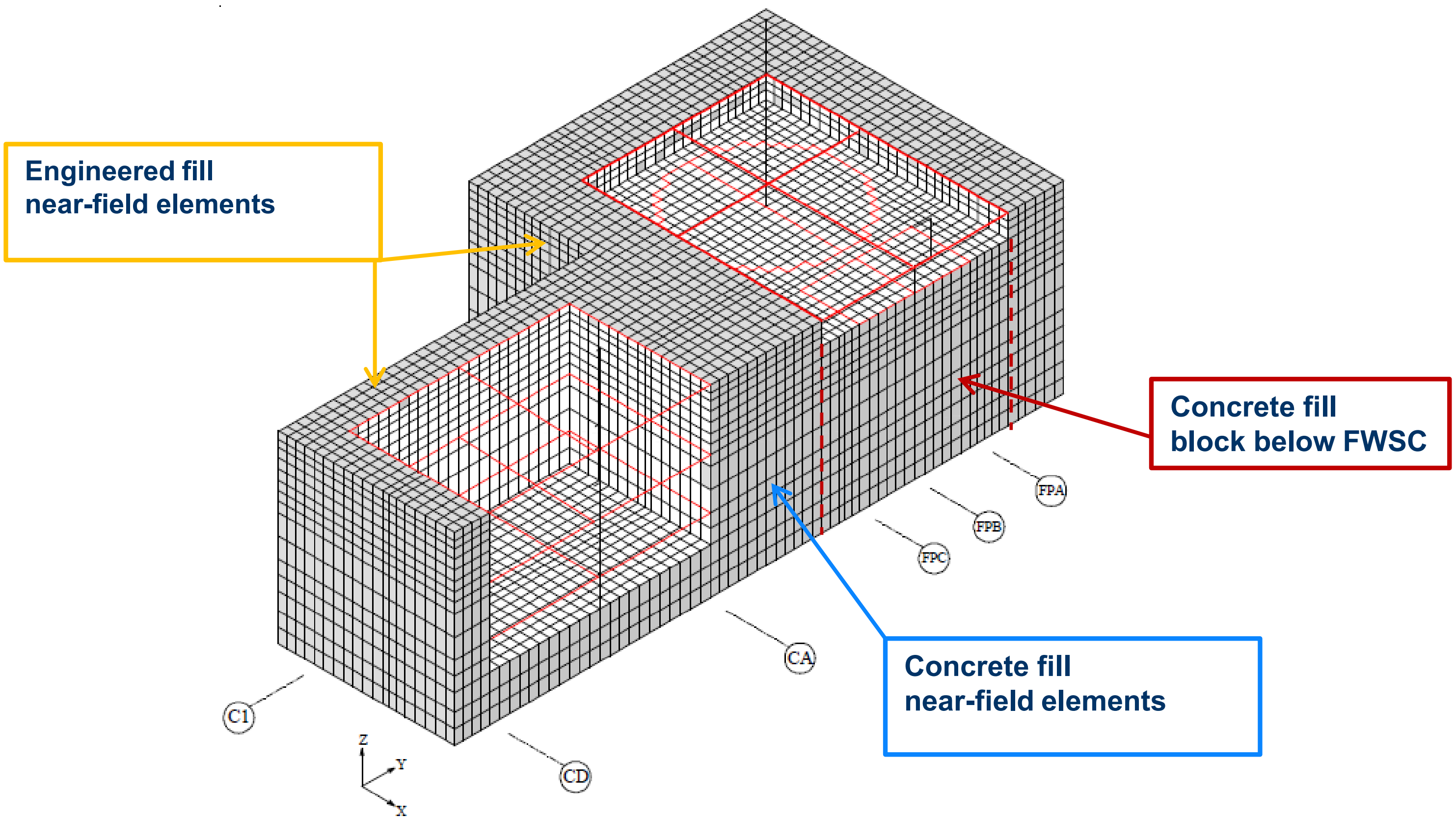
Fully embedded combined CB-RB/FB model

SSSI Effects Evaluation (cont)

- CB-FWSC SSSI analysis will be performed using input motion defined by CB FIRS and two subgrade profiles capturing range of variations of subgrade stiffness at NA3 CB location:
  - CB UB full column profile
  - CB LB full column profile
- SSSI effects of FWSC on CB response will be evaluated by comparing results of SSSI analyses of CB-FWSC combined model and SSI analyses of CB standalone model
- Dynamic properties of CB and FWSC in combined model will be identical to properties of standalone models
- CB-FWSC combined models will include granular fill above Zone III rock and concrete fill around CB and below FWSC to capture their effect on SSSI responses

SSSI Effects Evaluation (cont)

- CB-FWSC Combined SSSI Model for evaluation of effect of FWSC on CB response:
  - Half model is used with plane of symmetry along y – axis



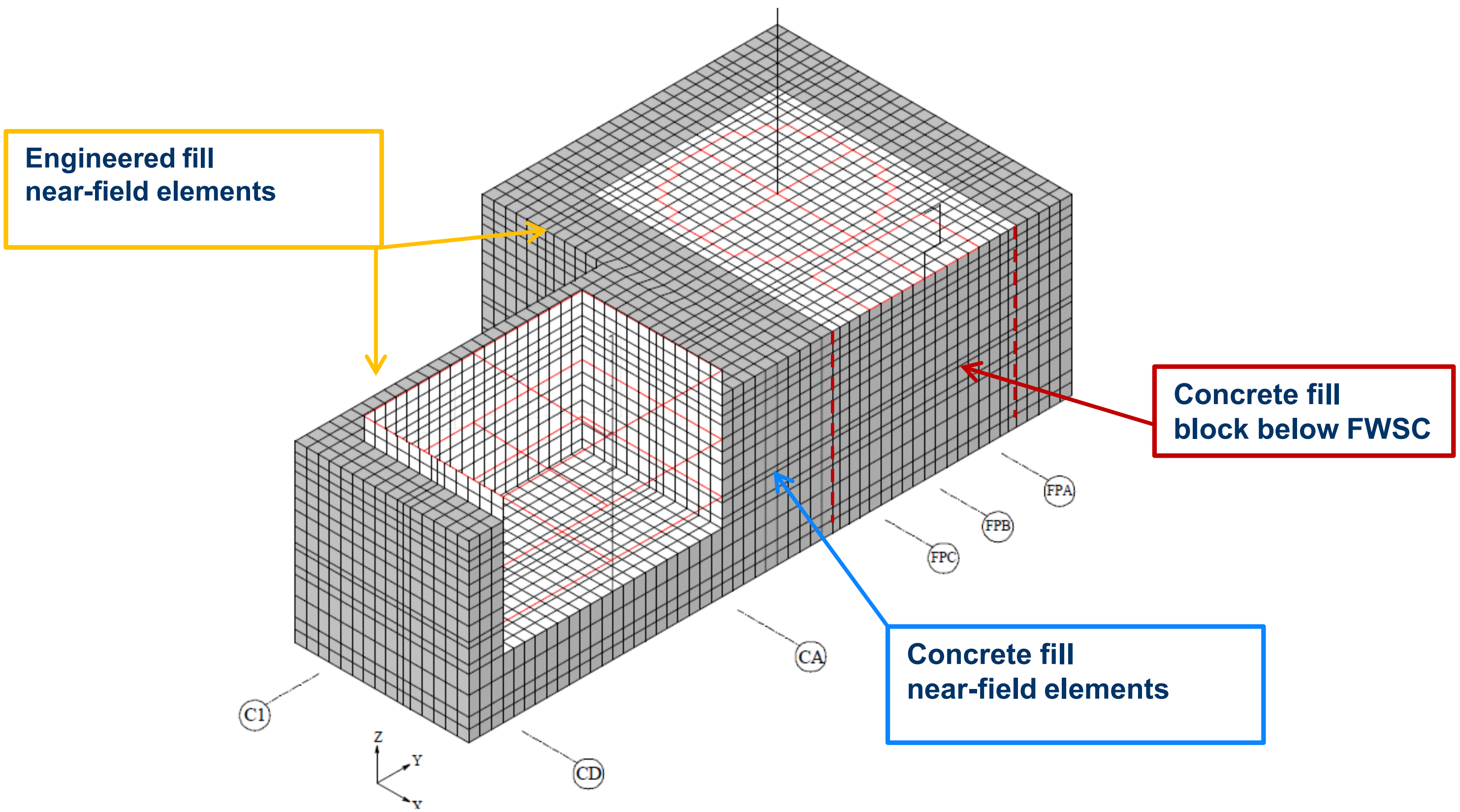
SSSI Effects Evaluation (cont)

- Three FWSC-CB SSSI analyses will be performed using FWSC input motions and subgrade profiles to capture a full range of responses:
  - FWSC UB profile with input motion at bottom of concrete fill
  - FWSC UB profile with input motion at ground surface
  - FWSC LB profile with input motion at ground surface
- SSSI effects of CB on FWSC response will be evaluated by comparing results of SSSI analyses of FWSC-CB combined model and SSI analyses of FWSC standalone models
- Dynamic properties of FWSC in combined model will be identical to properties of corresponding FWSC standalone models
- FWSC-CB combined models will include granular fill above Zone III rock and concrete fill around CB and below FWSC to capture their effect on SSSI responses

Dominion

SSSI Effects Evaluation (cont)

- FWSC-CB Combined SSSI Model for evaluation of effect of CB on FWSC response:
  - Half model is used with plane of symmetry along y – axis



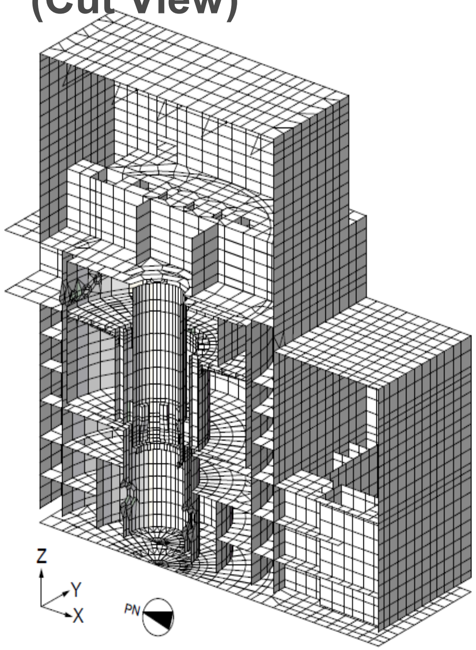
Site-Specific Structural Evaluation

- Explicit site-specific evaluation will be performed for all Seismic Category I structures subjected to site-specific seismic load demands higher than loads used for standard design to provide:
  - Actual site-specific stress demands on various structural members
  - Detailed calculations of shear and flexural strength (allowable stresses) of reinforced concrete sections that depend on axial load magnitude
  - Actual bending moments and shears induced in basemats by seismic load combinations that include NA3 site-specific seismic loads
  - Explicitly calculated design margins for NA3 Seismic Category I structures under NA3 site-specific loads

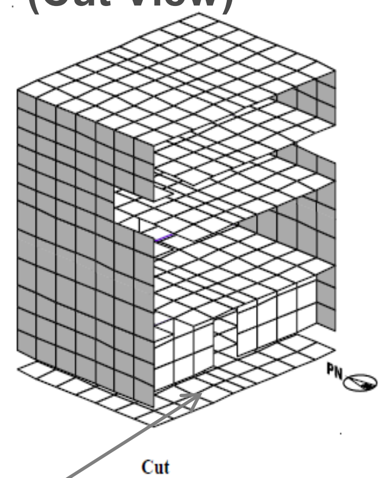
Site-Specific Structural Evaluation (cont)

- Explicit site-specific evaluations of RB/FB and CB structures will use methodology consistent with standard design methodology per DCD Appendix 3G.
- Site-specific seismic stress demands will be obtained from equivalent static analyses performed on same FE models used for standard design:

RB/FB NASTRAN FE Model (Cut View)



CB NASTRAN FE Model (Cut View)



3 independent spring elements at each basemat node model horizontal and vertical stiffness of subgrade

Dominion

Site-Specific Structural Evaluation (cont)

- Site-specific NASTRAN analyses will use same standard design foundation models described in DCD Section 3G.1.4.2:
  - Elastic (compression and tension) spring constants represent subgrade stiffness of soft generic site with shear velocity Vs = 1,000 ft/s
  - Soft soil spring constants provide bounding results for deformations and stresses of RB/FB and CB foundations resting on stiff NA3 subgrade with Vs ≥ 6,000 fps
- Site-specific uplift analysis performed only if SSI analyses' results for base contact stresses indicate uplift:
  - Iterative analyses performed following DCD Section 3G.1.5.5.1 methodology where tension capability is removed in the next iteration for those vertical springs that are in tension until full convergence of results is reached
  - Spring constants representing stiffness of Unit 3 stiff rock/concrete fill subgrade will be used to maximize foundation uplift

Site-Specific Structural Evaluation (cont)

- Site-specific seismic lateral pressure loads are applied on below grade external walls that are envelope of:
  - Dynamic lateral pressure results for SASSI analyses of LB, BE and UB truncated and full column profiles amplified if necessary for SSSI effects based on results of CB-RB/FB and CB-FWSC SSSI analyses
  - Required lateral passive resistance pressures obtained from RB/FB and CB sliding stability calculations
- Seismic hydrodynamic pressures are applied on RB/FB pool walls and floors following same methodology as one used for standard design
- Site-specific seismic demands obtained from site-specific NASTRAN FE analyses will be combined with DCD NASTRAN results for non-seismic load cases in seismic load combinations
- Consideration of non-seismic load combinations is not necessary because, besides seismic loads, all other load demands on NA3 Seismic Category I structures are enveloped by non-seismic design loads considered in DCD standard design

Dominion

Site-Specific Structural Evaluation (cont)

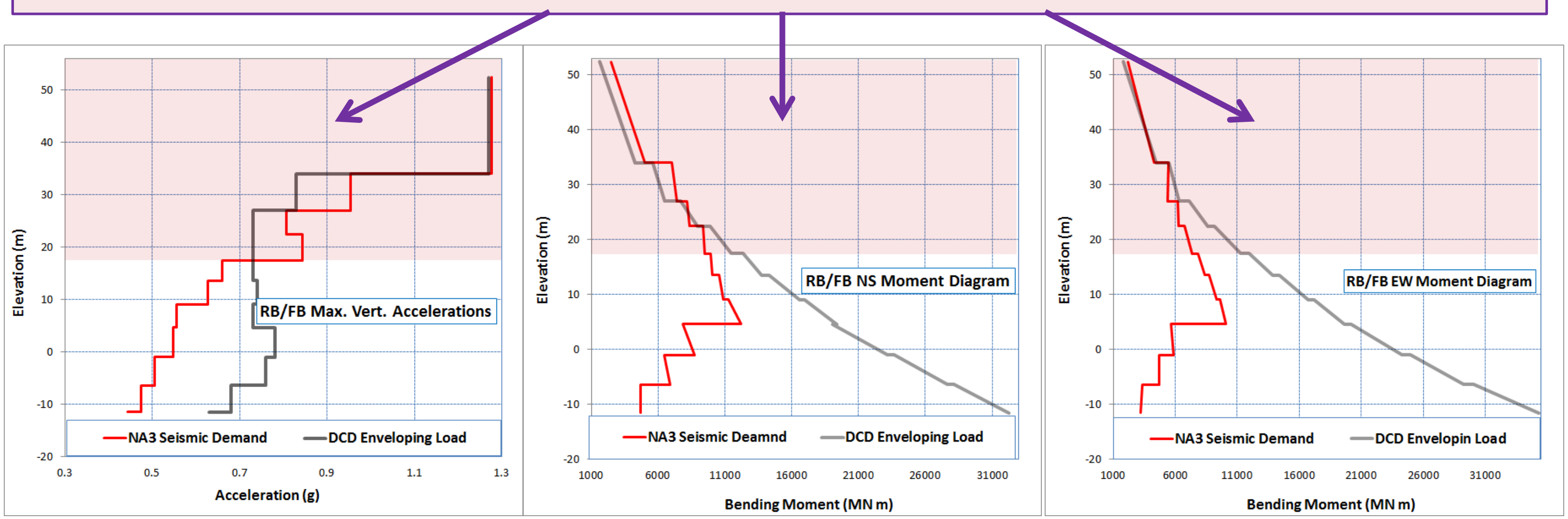
- Applicability of standard design of Seismic Category I structures for NA3 site will be demonstrated by showing that design margins are higher than 1.0:
  - Allowable design stress will be calculated considering effects of interaction between load components (axial with bending and shear) using same methodology and SSDP computer code utilized for standard design
  - SSDP will provide available Unit 3 design margins as ratio of allowable stresses and site-specific demands
- Stress checks will be performed for critical seismic load combinations and critical sections in structures and basemats that were considered in standard design
- Stress checks will also be performed for additional sections based on results of SSI analyses' results for distributions of stick member forces and moments considering all applicable seismic load combinations

Dominion

Site-Specific Structural Evaluation (cont)

- Site-specific high frequency ground motion may excite higher modes of structural vibration, resulting in different seismic load distributions than those of standard design loads
- Additional stress checks will be performed at critical sections where site-specific force and/or moment diagrams indicate any of site specific demands exceed standard design loads

Additional shear wall stress checks due to exceedance in axial load demand



Preliminary/Unverified Results

Dominion

Site-Specific Component Seismic Evaluation

Equipment Seismic Analyses

- Site-Specific Seismic Analyses
  - Performing for equipment seismically analyzed in DCD
  - Analysis methodologies consistent with DCD methodologies
  - Results addressed in COLA/FSAR

Site-Specific Component Seismic Evaluation (cont)

Site-specific seismic analyses will be performed for equipment analyzed in DCD with same methodology as DCD using NA3 seismic inputs to ensure seismic adequacy of standard design, or analyzed/adjusted as necessary.

Component	Related RAI	As-Built ITAAC Verification	FSAR Section
RPV Support Loads*	RAI 03.07.02-18	DCD ITAAC 2.1.1-3#6	3.7.2 *Decoupled model, if used, will be described and basis for acceptance included in FSAR.
New and spent fuel racks	RAI 03.07.02-20	DCD ITAAC New: 2.5.6-1#1 Spent: 2.5.6-1#2	9.1
Passive Containment Cooling System Condensers	RAI 03.07.02-21	DCD ITAAC 2.15.4-2#5	3G.1, 3.8
Fuel Assemblies	RAI 04.02-1	DCD ITAAC 2.1.1-3	4.2
Control Rod Blades	RAI 04.02-1	COLA Part 10 ITAAC Table 2.4.19-1 #1	4.2

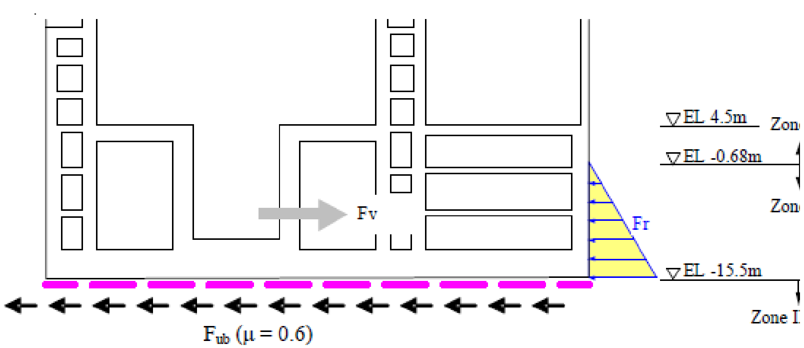
Sliding Stability Evaluations

- Site specific sliding stability evaluations use same methodology used for DCD standard design (RAI Question 03.08.05-6):
  - Evaluations performed in time domain by calculating at each time step safety factors (SF) against sliding for two horizontal directions separately
  - Time histories of horizontal and vertical seismic driving forces calculated as sum of the reactions at all SSI interfaces obtained directly from SASSI results
  - +/-3 point moving window averaging will not be applied on seismic base reactions time histories
  - Base sliding resistance calculated using effective weight of building and minimum value of 0.60 for coefficient of friction among those of concrete fill, Zone III and Zone III-IV rock (FSAR Table 2.5.4-208) considering two different orientations (upward and downward) of vertical seismic base reaction
  - Effective weight of building equals total dynamic (dynamic model) weight minus buoyancy calculated using site-specific ground water level values
  - For instances of time when SF<1.1, lateral resistance force required for SF=1.1 is calculated

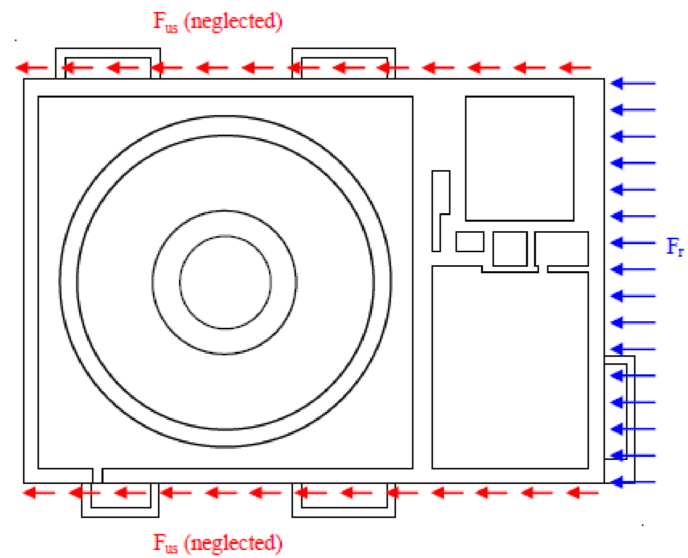
Sliding Stability Evaluations (cont)

- RB/FB Sliding Stability Evaluation Force Diagram

Horiz. Cross Section



Basemat Plan View



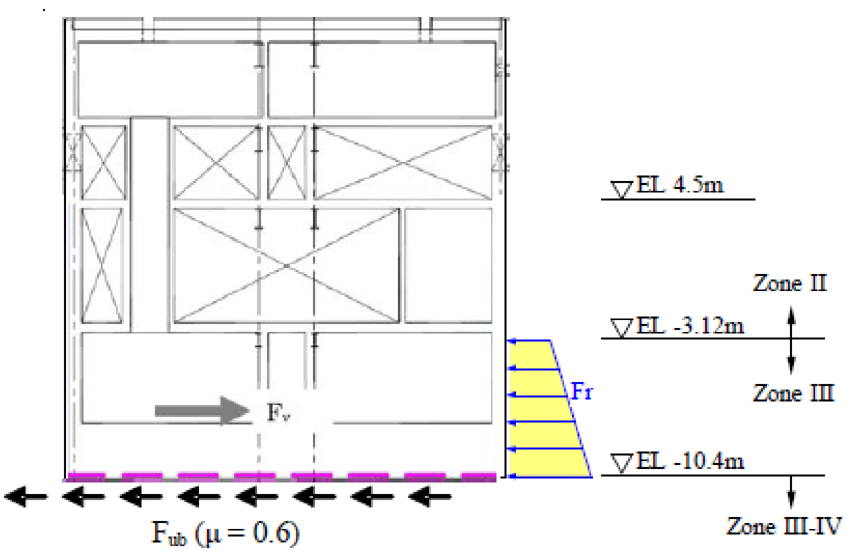
— Resistance provided by: engineered fill and in-situ soil above rock; skin friction at basemat sides and below grade exterior walls interfaces; and shear keys is neglected

— Calculation provides maximum magnitude of lateral force and resulting lateral pressure resistance required for SF ≥ 1.1

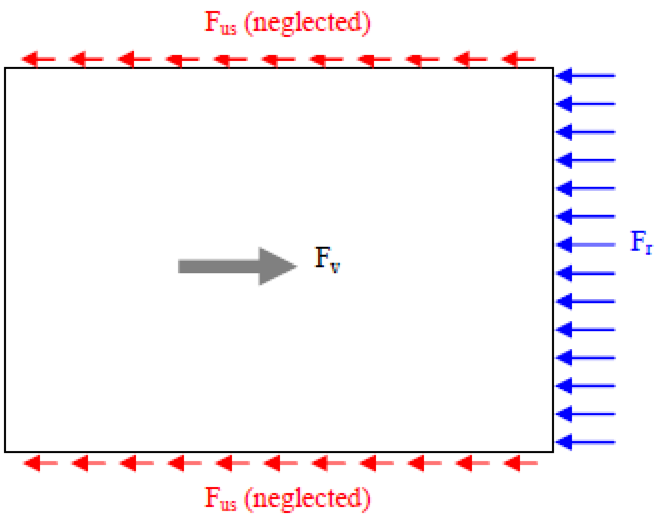
Sliding Stability: FSAR Methodology

- CB Sliding Stability Evaluation Force Diagram

Horiz. Cross Section



Basemat Plan View



— Resistance provided by: engineered fill and in-situ soil above rock; skin friction at basemat sides and below grade exterior walls interfaces is neglected

— Calculation provide maximum magnitude of lateral force and resulting lateral pressure resistance required for SF ≥ 1.1

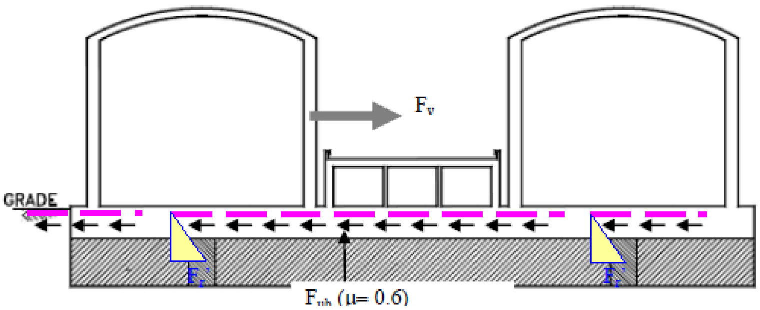
— If CB shear keys are required, stability at additional sliding plane will be considered to demonstrate shear keys' effectiveness

Dominion

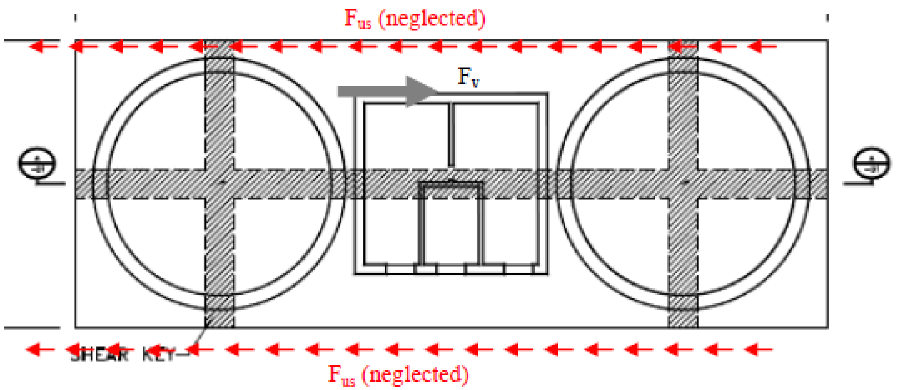
Sliding Stability: FSAR Methodology (cont)

- FWSC Sliding Stability Evaluation Force Diagram

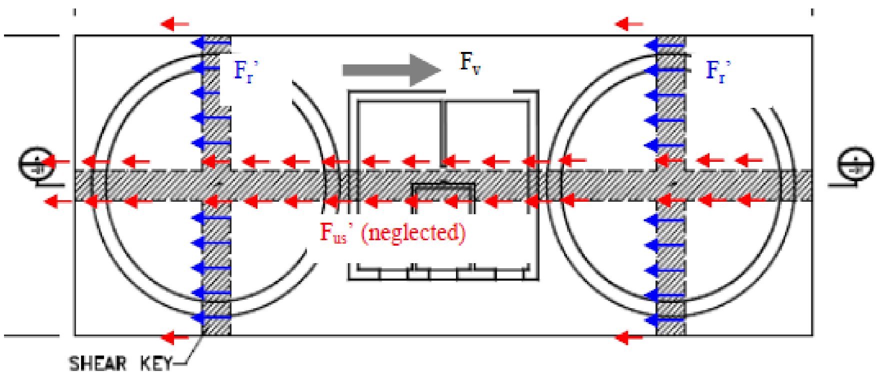
Horiz. Cross Section



Basemat Plan View



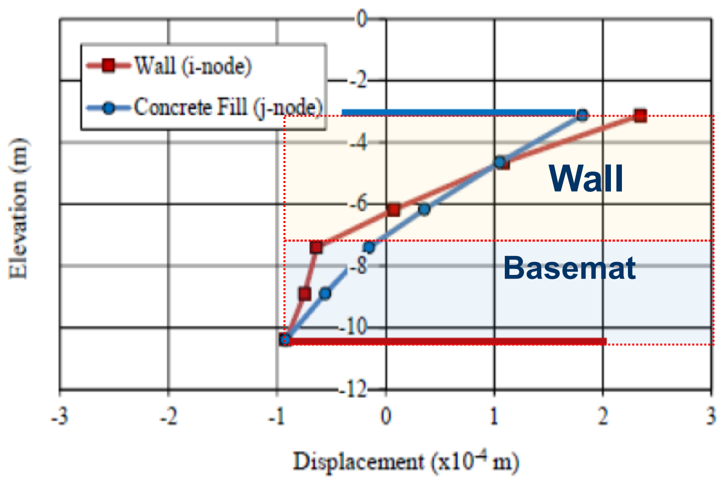
Shear Keys Plan View



- Resistance provided by: engineered fill and skin friction at basemat sides are neglected
- Calculation provide maximum magnitude of shear keys lateral force resistance required for SF ≥ 1.1
- Stability at additional sliding plane will be considered to demonstrate shear keys' effectiveness

Sliding Stability: Alternative Evaluation

- SSI analyses results for displacements relative to free field will be used to demonstrate use of static friction coefficient is adequate:
  - Preliminary results of SSI analyses using 2004 GMM input motion indicate that CB experiences very small displacements when base shear has largest amplitude

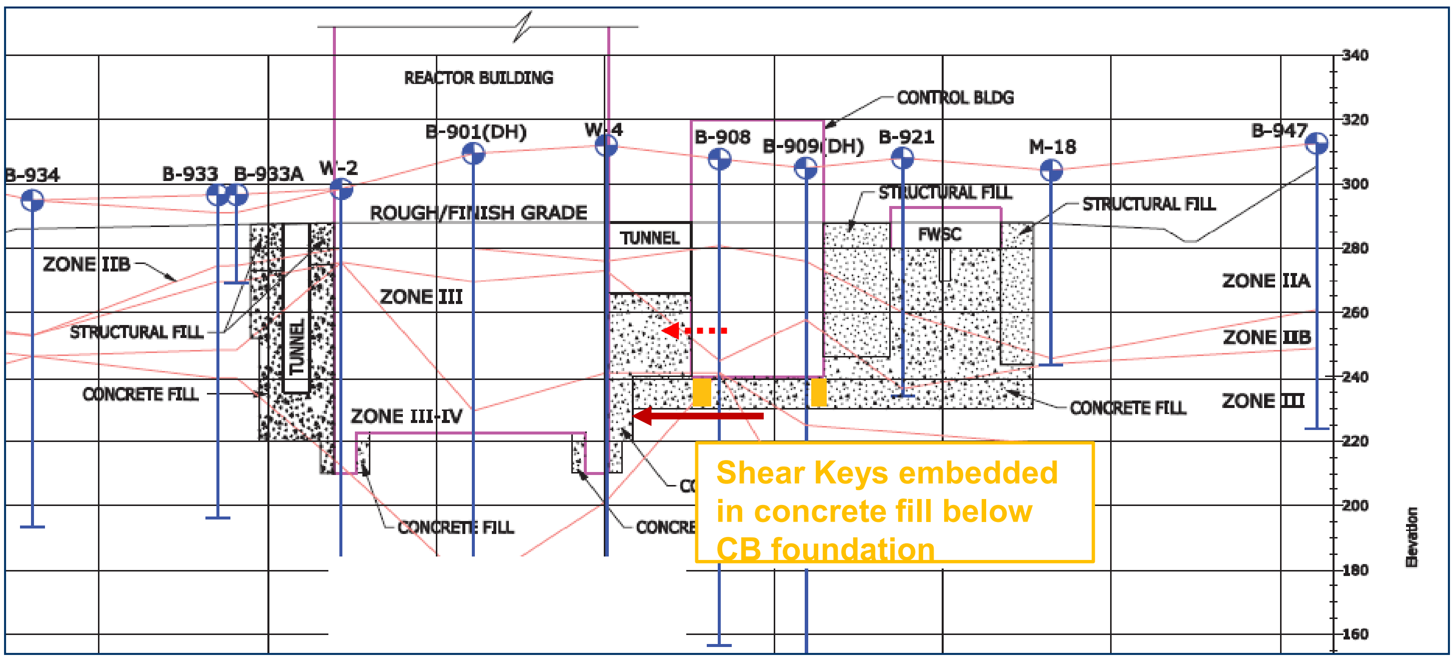


CB West Side	Displacements (mm)		
	Relative to Free Field		CB relative to Subgrade
El. (m)	Subgrade	CB	
-3.12	-0.11045	-0.05750	**-0.05295**
-4.65	-0.02465	-0.01587	-0.00878
-6.17	0.03528	0.02088	0.01440
-7.50	0.09262	0.05316	0.03946
-8.90	0.10017	0.08055	0.01962
-10.4	0.11036	0.11039	**-3.5E-05**

Preliminary/Unverified Results

Sliding Stability Evaluations

- Lateral load capacity of NA3 subgrade
  - CB applies largest lateral load demands on rock/concrete fill subgrade required to ensure sliding stability SF≥1.1
  - Variation of Zone III top surface results in portions where depth of CB embedment in Zone III is small with relatively low lateral load capacity



Dominion

Sliding Stability: Conclusions

- If resistance of shallow rock embedment is not sufficient to resist lateral loads demands from CB, shear keys will be added to CB foundation to lower critical sliding plane to bottom of Zone III rock
  - Shear keys will be added to CB similar to the existing shear keys for RB/FB and FWSC in DCD
  - Shear keys will be embedded in ≈5 m thick concrete fill placed below CB foundation
  - Shear keys will be designed to withstand total lateral force resistance required to achieve CB sliding stability SF ≥ 1.1
  - Additional stability calculations will be performed considering critical sliding plane located at bottom of CB shear keys to provide required lateral loads applied on surrounding Zone III rock subgrade

Dominion

Seismic Margin Analysis

- NA3 plant-specific PRA-based Seismic Margin Analysis (SMA) will be performed to address NA3 seismic demands consistent with standard design methodology
- Results will be included in COLA/FSAR Chapter 19
- Analyses will be available for NRC audit
- Related RAI 19.02-1 (12/2015)

Dominion

Seismic Margin Analysis (cont)

- Perform site-specific calculations to show the 1.67*SSE HCLPF capacity is met for structures shown in DCD Table 19.2-4 using the DCD approach
- For NA3 components listed in Table 19.2-4, design and qualification of SSCs will assure that the HCLPF margin of 1.67 will be achieved
- SMA will be performed in accordance with DC/COL-ISG-020 and will demonstrate that the NA3 site-specific plant-level HCLPF value is equal to or greater than 1.67 times the site-specific GMRS PGA
- Preliminary results using the preliminary GMM inputs indicate that the 1.67*SSE criteria is achievable

Summary of Modifications

Modifications described in SCP:

- Revise Ground Motion Model (GMM) to EPRI 2013
- Revise analyses (refine models and methods and maintain greater consistency with DCD in treatment of frequencies, mesh, damping, cracking, outriggers, SDOF oscillators, etc.)
- Include partial and full column embedment in licensing basis
- Present SSSI sensitivity and stability evaluations

Summary of Modifications (cont)

- Incorporate site-specific SSI structural models for RB/FB, CB, and FWSC using stiffness properties and damping values that provide conservative responses. Sensitivity studies will address other effects.
- Perform finite element analyses to provide updated evaluation of adequacy of standard design and to provide explicitly calculated design margins.

Summary of Modifications (cont)

- Perform seismic analyses on components that are seismically analyzed in DCD following DCD methodologies and using Unit 3 seismic inputs
- Perform Seismic Margin Analysis for equipment fragility using Unit 3 seismic inputs

Preliminary analyses results indicate that structures and components are seismically adequate for Unit 3

COLA Revisions

COLA revisions are detailed in SCP

- Sections 2.5 and 3.7.1 to address updated GMM, response spectra, time histories, PSD check, and updated site-dependent OBE and PBSRS
- Section 3.7.2 to include updates to SSI analyses, including partial and fully embedded cases, enveloping load results, stress check, structural loads, and SSSI effects
- Sections 3.8, 4.2, 9.1, and 19.2 and new Appendix 3G-S to address below grade wall design, in-structure response spectra, sliding, stability, stress evaluations, equipment analyses, and SMA
- Conforming changes in Chapter 1 tables and Part 7 departure description

Dominion

Schedule: Technical Reports

Date	Title of Technical Report
Report Submitted to NRC 08/11/2014	Benchmarking of SASSI2010 MSM Results from NA3 Site-Specific SSI Analysis
11/2014	Validation Test Report for SASSI2010 Version 1
11/2014	Commercial Grade Dedication Plan for SASSI2010 Version 1
05/2015	Seismic Structure-Soil-Structure Interaction Analysis Report for CB and FWSC
06/2015	Licensing Basis Seismic Analysis Report for CB
06/2015	Licensing Basis Seismic Analysis Report for FWSC
06/2015	Licensing Basis Stability Report for CB
06/2015	Licensing Basis Stability Report for FWSC
07/2015	RB/FB Licensing Basis Seismic Analysis Report
07/2015	Licensing Basis Stability Report for RB/FB
07/2015	Seismic Structure-Soil-Structure Interaction Analysis Report for RB/FB and CB
08/2015	North Anna 3 Fuel Racks Evaluation Report
08/2015	North Anna 3 PCCS Condensers Evaluation Report
08/2015	GE14E Fuel Assembly Mechanical Design Report
08/2015	ESBWR Marathon Control Rod Mechanical Design Report
10/2015	Licensing Basis CB Structural Design Report
10/2015	Licensing Basis FWSC Structural Design Report (if required)
10/2015	Licensing Basis Stress Analysis Report for Drywell Head
10/2015	Licensing Basis Containment Metal Components Structural Design Report
10/2015	Licensing Basis Containment Internal Structures Structural Design Report
11/2015	Licensing Basis RCCV Structural Design Report
11/2015	Licensing Basis RB/FB Structural Design Report
12/2015	North Anna Unit 3 COLA RB/FB Seismic Fragility Report
12/2015	North Anna Unit 3 CB Seismic Fragility Report
12/2015	North Anna Unit 3 COLA FWSC Seismic Fragility Report (if required)

Dominion

Schedule: COLA Markups and RAIs

Submittal Date	Revised COLA/FSAR Sections	RAI Responses	
Submitted previously		02.05.02-7 02.05.05-4 03.07.01-9 03.07.01-10 03.07.01-11 and S01 03.07.01-12 and S01 03.07.02-10 03.07.02-11 03.07.02-12	03.07.02-15 03.07.02-19 03.07.02-22 03.07.02-23 03.07.02-24 03.07.02-25 03.07.03-1 03.08.05-7
02/2015	FSAR Section 2.0, Site Introduction FSAR Section 2.5.2 FSAR Section 3.7.1	02.05.02-6 03.07.01-8 03.07.01-11 S02	
07/2015	FSAR Section 3.7.2 FSAR Sections 3.8.2 FSAR Section 3.8.4 FSAR Section 3.8.5 FSAR Section 3G-S.1.5	03.07.01-11 S03 03.07.01-12 S02 03.07.02-10 03.07.02-11 (revised) 03.07.02-15 (revised)	03.07.02-16 03.07.02-23 (revised) 03.08.05-6 03.09.02-3
12/2015	FSAR Section 1.6 FSAR Section 3.7.2 FSAR Section 3.8.2 FSAR Section 3.8.3 FSAR Section 3.8.4 FSAR Section 3.8.5 FSAR Section 3G-3 FSAR Section 4.2 FSAR Section 9.1 FSAR Section 19.2 COLA Part 7	03.07.02-17 03.07.02-18 03.07.02-19 (revised) 03.07.02-20 03.07.02-21 03.08.04-37 03.08.05-7 (revised) 04.02-1 19.02-1	

Dominion

Conclusions

- Changes described in SCP
  - Meet NRC requirements and guidance
  - Address NRC feedback and RAIs
  - Simplify the site-specific seismic analyses
  - Increase consistency with seismic analyses in DCD
  - Apply most current ground motion model approved by the NRC
- Questions?
- Actions?

Dominion