ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Friday, December 18, 2009 4:23 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 248, FSAR Ch 3, Supplement 3
Attachments: RAI 248 Supplement 3 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 25 questions of RAI No. 248 on August 14, 2009. AREVA NP submitted Supplement 1 to the response on September 29, 2009 to address 5 of the remaining 23 questions. AREVA NP submitted Supplement 2 to the response on November 18, 2009 to address 8 of the remaining 18 questions. The attached file, "RAI 248 Supplement 3 Response US EPR DC.pdf" provides technically correct and complete responses to 8 of the remaining 10 questions, as committed. Two responses, RAI 248, Questions 03.07.02-50 and 03.08.01-51, have been deferred because supporting analysis work remains in progress.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 248 Questions 03.07.01-25, 03.07.02-48 and 03.08.01-36.

The following table indicates the respective pages in the response document, "RAI 248 Supplement 3 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 248 – 03.07.01-25	2	8
RAI 248 – 03.07.02-43	9	24
RAI 248 – 03.07.02-44	25	26
RAI 248 – 03.07.02-46	27	28
RAI 248 – 03.07.02-47	29	30
RAI 248 – 03.07.02-48	31	31
RAI 248 – 03.07.02-54	32	32
RAI 248 – 03.08.01-36	33	34

The schedule for technically correct and complete responses to the remaining 2 questions has been changed and is provided below:

Question #	Response Date
RAI 248 – 03.07.02-50	March 2, 2010
RAI 248 – 03.07.02-51	March 2, 2010

Sincerely,

Ronda Pederson
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Lynchburg, VA 24506-0935
Phone: 434-832-3694
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From: WELLS Russell D (AREVA NP INC)
Sent: Wednesday, November 18, 2009 7:25 PM
To: 'Getachew Tesfaye'
Cc: Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 248, FSAR Ch 3, Supplement 2

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 25 questions of RAI No. 248 on August 14, 2009. AREVA NP submitted Supplement 1 to the response on September 29, 2009 to address 5 of the remaining 23 questions. The attached file, "RAI 248 Supplement 2 Response US EPR DC.pdf" provides technically correct and complete responses to 8 of the remaining 18 questions, as committed. Two responses, RAI 248, Questions 03.07.02-44 and 03.08.01-36, have been deferred because supporting analysis work remains in progress.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 248 Questions 03.04.02-12, 03.07.02-53, 03.07.02-56, and 03.07.02-57.

The following table indicates the respective pages in the response document, "RAI 248 Supplement 2 Response US EPR DC.pdf" that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 03.04.02-12	2	2
RAI 03.07.02-45	3	3
RAI 03.07.02-49	4	4
RAI 03.07.02-52	5	5
RAI 03.07.02-53	6	8
RAI 03.07.02-56	9	12
RAI 03.07.02-57	13	14
RAI 03.08.04-7	15	15

The schedule for technically correct and complete responses to the remaining 10 questions has been changed and provided below:

Question #	Response Date
RAI 03.07.01-25	December 18, 2009
RAI 03.07.02-43	December 18, 2009
RAI 03.07.02-44	**January 28, 2010**
RAI 03.07.02-46	December 18, 2009
RAI 03.07.02-47	December 18, 2009
RAI 03.07.02-48	December 18, 2009
RAI 03.07.02-50	December 18, 2009
RAI 03.07.02-51	December 18, 2009
RAI 03.07.02-54	December 18, 2009
RAI 03.08.01-36	**January 28, 2010**

Sincerely,

(Russ Wells on behalf of)
Ronda Pederson

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From: Pederson Ronda M (AREVA NP INC)
Sent: Tuesday, September 29, 2009 7:16 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 248, Ch. 3, Supplement 1

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 2 of the 25 questions of RAI No. 248 on August 14, 2009. The attached file, “RAI 248 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to 5 of the remaining 23 questions. One response, RAI 248, Question 03.08.04-7, has been deferred because a supporting FSAR change remains in progress.

The following table indicates the respective pages in the response document, "RAI 248 Supplement 1 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 03.07.02-58	2	7
RAI 03.08.01-33	8	9
RAI 03.08.01-34	10	15
RAI 03.08.01-35	16	16
RAI 03.08.03-19	17	18

The schedule for technically correct and complete responses to the remaining 18 questions has been changed and is provided below:

Question #	Response Date
RAI 03.04.02-12	November 18, 2009
RAI 03.07.01-25	December 18, 2009
RAI 03.07.02-43	December 18, 2009
RAI 03.07.02-44	November 18, 2009
RAI 03.07.02-45	November 18, 2009
RAI 03.07.02-46	December 18, 2009
RAI 03.07.02-47	December 18, 2009

RAI 03.07.02-48	December 18, 2009
RAI 03.07.02-49	November 18, 2009
RAI 03.07.02-50	December 18, 2009
RAI 03.07.02-51	December 18, 2009
RAI 03.07.02-52	November 18, 2009
RAI 03.07.02-53	November 18, 2009
RAI 03.07.02-54	December 18, 2009
RAI 03.07.02-56	November 18, 2009
RAI 03.07.02-57	November 18, 2009
RAI 03.08.01-36	November 18, 2009
RAI 03.08.04-7	November 18, 2009

Sincerely,

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From: Pederson Ronda M (AREVA NP INC)
Sent: Friday, August 14, 2009 5:05 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 248, Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 248 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the 25 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 248 Question 03.07.02-55.

The following table indicates the respective pages in the response document, "RAI 248 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 03.04.02-12	2	2
RAI 03.07.01-25	3	3
RAI 03.07.02-43	4	4
RAI 03.07.02-44	5	5
RAI 03.07.02-45	6	6

RAI 03.07.02-46	7	7
RAI 03.07.02-47	8	9
RAI 03.07.02-48	10	10
RAI 03.07.02-49	11	11
RAI 03.07.02-50	12	12
RAI 03.07.02-51	13	13
RAI 03.07.02-52	14	14
RAI 03.07.02-53	15	16
RAI 03.07.02-54	17	17
RAI 03.07.02-55	18	20
RAI 03.07.02-56	21	22
RAI 03.07.02-57	23	23
RAI 03.07.02-58	24	24
RAI 03.08.01-32	25	25
RAI 03.08.01-33	26	26
RAI 03.08.01-34	27	27
RAI 03.08.01-35	28	28
RAI 03.08.01-36	29	29
RAI 03.08.03-19	30	30
RAI 03.08.04-7	31	31

A complete answer is not provided for 23 of the 25 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 03.04.02-12	November 18, 2009
RAI 03.07.01-25	December 18, 2009
RAI 03.07.02-43	December 18, 2009
RAI 03.07.02-44	November 18, 2009
RAI 03.07.02-45	November 18, 2009
RAI 03.07.02-46	December 18, 2009
RAI 03.07.02-47	December 18, 2009
RAI 03.07.02-48	December 18, 2009
RAI 03.07.02-49	November 18, 2009
RAI 03.07.02-50	December 18, 2009
RAI 03.07.02-51	December 18, 2009
RAI 03.07.02-52	November 18, 2009
RAI 03.07.02-53	November 18, 2009
RAI 03.07.02-54	December 18, 2009
RAI 03.07.02-56	November 18, 2009
RAI 03.07.02-57	November 18, 2009
RAI 03.07.02-58	September 29, 2009
RAI 03.08.01-33	September 29, 2009
RAI 03.08.01-34	September 29, 2009
RAI 03.08.01-35	September 29, 2009

RAI 03.08.01-36	November 18, 2009
RAI 03.08.03-19	September 29, 2009
RAI 03.08.04-7	September 29, 2009

Sincerely,

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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]

Sent: Tuesday, July 14, 2009 7:50 PM

To: ZZ-DL-A-USEPR-DL

Cc: Candra, Hernando; Chakravorty, Manas; Xu, Jim; Patel, Jay; Miernicki, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource

Subject: U.S. EPR Design Certification Application RAI No. 248(2934,3030,3034,3098,3099,3100), Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on June 18, 2009, and discussed with your staff on July 14, 2009. No changes were made to the draft RAI questions as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,

Getachew Tesfaye

Sr. Project Manager

NRO/DNRL/NARP

(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 1061

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D31017E3835)

Subject: Response to U.S. EPR Design Certification Application RAI No. 248, FSAR Ch 3, Supplement 3
Sent Date: 12/18/2009 4:22:58 PM
Received Date: 12/18/2009 4:23:00 PM
From: Pederson Ronda M (AREVA NP INC)

Created By: Ronda.Pederson@areva.com

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RAI 248 Supplement 3 Response US EPR DC.pdf		192983

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No. 248, Supplement 3

7/14/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.04.02 - Analysis Procedures
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis
SRP Section: 03.08.01 - Concrete Containment
SRP Section: 03.08.03 - Concrete and Steel Internal Structures of Steel or Concrete Containments
SRP Section: 03.08.04 - Other Seismic Category I Structures

Application Section: FSAR Ch 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

Question 03.07.01-25:

Follow-up to RAI Question 03.07.01-11

The applicant in the RAI response states that SSE damping values are consistent with the level of stress for load combinations that contain the SSE. However, the stress levels that were requested in Question 03.07.01-11 have not been provided. To support the basis for the development of In-Structure Response Spectra (ISRS) for the certified design, the applicant is requested to provide justification for the use of SSE structural damping values by providing a table of stress levels for each of the structures represented by the stick models in the dynamic analysis. This should include representative examples of stresses in both walls and floors and a comparison of these stress levels to code allowable stresses. Comparisons should be provided for in-plane stresses as well as for out-of-plane stresses. Based on the comparison of actual stress levels to code allowable stresses, a technical justification should be provided for the damping value selected for each of the structures. In addition, the technical justification for using the SSE damping should be included in the FSAR.

Response to Question 03.07.01-25:

For generating input motions to subsystems, damping values depend on the stress level imposed on structural elements by the limiting seismic event. Table 03.07.01-25-1 and Table 03.07.01-25-2 present comparisons of critical section strength demands with capacity for the controlling in-plane shear, out-of plane-shear, and combined axial and bending. These comparisons consider load combinations containing SSE and the range of soil cases established for U.S. EPR design.

NI Common Basemat structures critical sections, excluding reactor containment, are designed in accordance with ACI 349, strength design methodology. Structural element demands are compared to section nominal strengths (i.e., strength reduction (phi) factors are not considered in the computations). For critical sections designed in accordance with ACI 359, reactor containment, the structural element demands are compared to the ACI 359 allowable stresses.

Table 03.07.01-25-1—ACI 349 Critical Section Loads, Capacities and Ratios

Critical Section	Required Section Strength (kips/ft; kip-ft/ft)		Nominal Section Strength (kips/ft; kip-ft/ft)	Ratio column 2 / column 3
SGB 1 (Wall A13001)	In-plane shear	281.00	439.18	0.64
	Out-of-plane shear	103.61	158.04	0.66
	Combined bending	8.11	374.58	0.02
SGB 1 (Wall A13003)	In-plane shear	227.79	439.18	0.52
	Out-of-plane shear	47.64	162.27	0.29
	Combined bending	24.80	429.40	0.06
SGB 4 (Wall A33008)	In-plane shear	293.49	439.18	0.67
	Out-of-plane shear	123.45	153.83	0.80
	Combined bending	49.27	522.75	0.09
SGB 4 (Wall A33003)	In-plane shear	253.03	439.18	0.58
	Out-of-plane shear	59.59	103.60	0.58
	Combined bending	23.19	259.34	0.09
RB Shield Wall Below Roof	In-plane shear	285.00	375.63	0.76
	Out-of-plane shear	56.77	197.90	0.29
	Combined bending	164.29	242.78	0.68
RB Shield Wall Above Roof	In-plane shear	310.84	461.79	0.67
	Out-of-plane shear	102.33	338.96	0.30
	Combined bending	401.40	1227.80	0.33
FB Roof	In-plane shear	379.95	527.00	0.72
	Out-of-plane shear	115.43	333.36	0.35
	Combined bending	372.02	715.95	0.52
SG2/3 Roof	In-plane shear	210.60	409.08	0.52
	Out-of-plane shear	110.45	332.27	0.33
	Combined bending	250.93	480.28	0.52

Critical Section	Required Section Strength (kips/ft; kip-ft/ft)		Nominal Section Strength (kips/ft; kip-ft/ft)	Ratio column 2 / column 3
FB Foundation	In-plane shear	378.86	878.21	0.43
	Out-of-plane shear	667.60	860.49	0.78
	Combined bending	520.19	1253.30	0.42
SB1 Foundation	In-plane shear	414.87	878.21	0.47
	Out-of-plane shear	532.24	858.48	0.62
	Combined bending	916.72	1308.11	0.70
SB 2/3 Foundation	In-plane shear	170.81	878.21	0.19
	Out-of-plane shear	612.02	882.21	0.69
	Combined bending	1562.22	2290.85	0.68
SB4 Foundation	In-plane shear	332.68	878.21	0.38
	Out-of-plane shear	428.48	829.36	0.52
	Combined bending	3296.13	4070.05	0.81
RBIS Foundation (59.5'')	In-plane shear	212.79	442.45	0.48
	Out-of-plane shear	440.66	505.45	0.87
	Combined bending	2400.62	3699.20	0.65
RBIS Foundation (217'')	In-plane shear	420.79	1613.64	0.26
	Out-of-plane shear	891.25	1116.17	0.80
	Combined bending	625.00	2635.46	0.24
Slab (78.75'')	In-plane shear	96.98	585.60	0.17
	Out-of-plane shear	212.92	229.44	0.93
	Combined bending	831.65	1238.32	0.67
Slab (39.38'')	In-plane shear	213.84	292.98	0.73
	Out-of-plane shear	98.34	139.70	0.70
	Combined bending	179.95	358.73	0.50

Critical Section	Required Section Strength (kips/ft; kip-ft/ft)		Nominal Section Strength (kips/ft; kip-ft/ft)	Ratio column 2 / column 3
RCP/SG Wing Wall (Bottom)	In-plane shear	283.76	351.28	0.81
	Out-of-plane shear	177.33	193.44	0.92
	Combined bending	1021.15	1321.16	0.77
CP/SG Wing Wall (Top)	In-plane shear	231.47	292.76	0.79
	Out-of-plane shear	109.03	135.85	0.80
	Combined bending	541.78	677.09	0.80
SG Separation Wall (Bottom)	In-plane shear	188.89	268.56	0.70
	Out-of-plane shear	103.59	127.33	0.81
	Combined bending	317.41	471.80	0.67
SG Separation Wall (Top)	In-plane shear	169.09	292.76	0.58
	Out-of-plane shear	147.27	154.22	0.96
	Combined bending	813.34	979.21	0.83
Pressurizer Slab	In-plane shear	76.70	248.81	0.31
	Out-of-plane shear	109.92	141.38	0.78
	Combined bending	336.80	359.59	0.94
Pressurizer West Wall	In-plane shear	147.95	234.24	0.63
	Out-of-plane shear	45.04	80.24	0.56
	Combined bending	73.60	136.96	0.54
Reactor Operating Floor: RM15	In-plane shear	36.06	129.53	0.28
	Combined bending	5.81	70.48	0.08
Reactor Operating Floor: RM16-1	In-plane shear	112.67	270.95	0.42
	Out-of-plane shear	69.43	128.42	0.54
	Combined bending	57.46	73.50	0.78
Reactor Operating Floor: RM16-2	In-plane shear	272.29	292.83	0.93
	Combined bending	60.63	229.18	0.27
Reactor	In-plane shear	215.44	393.78	0.55

Critical Section	**Required Section Strength (kips/ft; kip-ft/ft)**		**Nominal Section Strength (kips/ft; kip-ft/ft)**	**Ratio column 2 / column 3**
Operating Floor: RM16-3	Out-of-plane shear	76.91	152.82	0.50
	Combined bending	30.97	306.56	0.10
Reactor Operating Floor: RM18	In-plane shear	13.99	62.51	0.22
	Combined bending	16.24	29.85	0.54
Reactor Operating Floor: RM22	In-plane shear	59.52	234.24	0.25
	Out-of-plane shear	73.09	83.46	0.88
	Combined bending	31.78	246.38	0.13

Table 03.07.01-25-2—ACI 359 Critical Section Loads, Capacities and Ratios

Critical Section	Required Section Stress (kips/ft; psi/ft; kip-ft/ft)		Allowable Section Stress (kips/ft; psi/ft; kip-ft/ft)	Ratio column 2 column 3
Primary Gusset	Tangential shear	647.00	2017.65	0.32
	Radial shear	267.34	375.56	0.71
	Combined bending	6229.00	10394.10	0.60
Equipment Hatch (94.5")	Tangential shear	1199.00	2292.44	0.52
	Radial shear	313.85	440.16	0.71
	Combined bending	3211.00	3236.70	0.99
Dome	Tangential shear	315.41	517.20	0.61
	Radial shear	68.56	617.87	0.11
	Combined bending	287.04	441.60	0.65
Dome Ring	Tangential shear	301.94	780.24	0.39
	Radial shear	250.86	707.59	0.36
	Combined bending	628.29	756.98	0.83
Typical Wall	Tangential shear	297.00	502.38	0.59
	Radial shear	148.27	211.68	0.70
	Combined bending	418.00	1530.74	0.27
Narrow Buttress	Tangential shear	225.00	241.38	0.93
	Radial shear	163.91	189.85	0.86
	Combined bending	746.00	1740.59	0.43
RCB Basemat	Tangential shear	608.38	1267.92	0.48
	Radial shear	445.55	585.52	0.76
	Combined bending	1789.67	2118.59	0.85

Code stress limits demand-to-capacity ratios for primary load resisting elements in Table 03.07.01-25-1 and Table 03.07.01-25-2 are predominately greater than half their ultimate capacity, and a significant number are near or above 80 percent of their ultimate capacity. Thus, SSE damping values in U.S. EPR FSAR Tier 2, Table 3.7.1-1 are used to generate the NI Common Basemat Structures ISRS.

The current U.S. EPR FSAR Tier 2, Section 3.7.1.2 sentence:

> "Because the standard plant seismic design basis (see Section 3.7.1.1) coupled with the broad range of soil cases (see Section 3.7.1.3) results in high enveloping structural loads on both the walls and floor diaphragms of the NI Common Basemat Structures it is reasonable to conclude, on an overall stress level basis, that it is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS."

Will be revised to state the following:

> "It is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS. This approach is used because the standard plant seismic design basis (see Section 3.7.1.1) coupled with a representative set of soil cases (see Section 3.7.1.3) results in structural loads on both walls and floor diaphragms of NI Common Basemat Structures that are expected to produce cross section demands greater than 50 percent of ultimate capacity."

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.1.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.02-43:

Follow-up to RAI Question 03.07.02-1

The response states that the two versions of the code are functionally the same and produce equivalent results with no significant differences. However, it does not provide a comparison of results from a building seismic analysis using the two versions (AREVA SASSI v. 4.1B and Bechtel SASSI2000, v. 3.1) as requested in Question 03.07.02-1. Because each code is being used in the analysis of Seismic Category I structures, it should be demonstrated that the codes provide similar results for the SSI analysis. The applicant is requested to run an analysis of an embedded seismic Category I structure using both versions of the code and demonstrate that the seismic response of the structure is similar for each of the programs.

Response to Question 03.07.02-43:

AREVA NP ported SASSI, Version 4.1B to the Windows Personal Computer (PC) platform as AREVA SASSI, Version 4.2PC with enhanced capabilities. AREVA NP SASSI, Version 4.2PC results have been validated against AREVA NP SASSI, Version 4.1B results. The following benchmarking studies were performed using AREVA NP SASSI, Version 4.2PC in lieu of AREVA NP SASSI, Version 4.1B.

Two problems were benchmarked to demonstrate that structure seismic response is similar for each of the programs. One is a documented embedded structural SSI problem and the other a Category I structure analyzed using Bechtel SASSI2000, Version 3.1 and documented in the U.S. EPR FSAR, Tier 2, Section 3.7.2.3.2.

- The first problem is the embedded Lotung SSI experiment conducted in the late 1980's by the Electric Power Research Institute (EPRI) in cooperation with Taiwan Power Company (TPC) and the U.S. Nuclear Regulatory Commission (NRC) (Reference 1). This is a standard embedded benchmark problem and is described in the SASSI2000 User's Manual (Reference 2). The Lotung problem was analyzed using SASSI2000 Version 3.0. The same problem was analyzed using AREVA NP SASSI, Version 4.2PC and the results compared with the SASSI2000 Version 3.0 results. This comparison established that AREVA NP SASSI, Version 4.2PC properly performs embedded SSI analysis with results that do not significantly differ from results produced by using SASSI2000.
- The second problem is the surface-founded Emergency Power Generating Building (EPGB) model described in the U.S. EPR FSAR, Tier 2, Section 3.7.2.3.2. This is a Seismic Category I structure originally analyzed using Bechtel SASSI2000 Version 3.1. This problem demonstrates that the results from AREVA NP SASSI, Version 4.2PC are similar to the results from Bechtel SASSI2000, Version 3.1.

Comparing results from the two computer codes shows good agreement for both problems studied.

Problem 1 – Lotung SSI Experiment

Problem Description

In the late 80's EPRI, in cooperation with TPC and the NRC, conducted large-scale experiments in Lotung, Taiwan with the objective of validating SSI analysis methodologies and reducing design uncertainties. In this experiment, a ¼ scale containment model was constructed and instrumented to record containment SSI motions at several locations in the model. The problem description and results of these studies are available in Reference 1. In this problem, containment model seismic SSI responses during one of the strong seismic excitations are computed using AREVA NP SASSI, Version 4.2PC and compared with established benchmark results from SASSI2000 Version 3.0 (Reference 2).

Comparison of Seismic Responses

SASSI analysis results, in terms of 5 percent damped acceleration response spectrum at four structure locations, are computed and compared with other results (i.e., SASSI2000 Version 3.0). The four containment locations are 1 point at the top (Node 311 in SASSI model) of containment and 1 point at the base (Southern end, Node 178), plus 1 point at the top steam generator platform support and 1 point at the lower steam generator platform support (Nodes 302 and 300, respectively). Model details are available in References 1 and 2.

Acceleration response spectra of motions recorded at these four points are compared with AREVA NP SASSI, Version 4.2PC in Figures 3.7.2-43-1, 3.7.2-43-2, 3.7.2-43-3, and 3.7.2-43-4. Acceleration-time histories are obtained by running the MOTION module of SASSI, and the response spectra are generated using AREVA NP RESPEC, Version 1.2PC code. Results show that structural seismic responses calculated by the two programs are comparable.

Figure 3.7.2-43-1—Comparison of the Responses at the Top of the Basemat

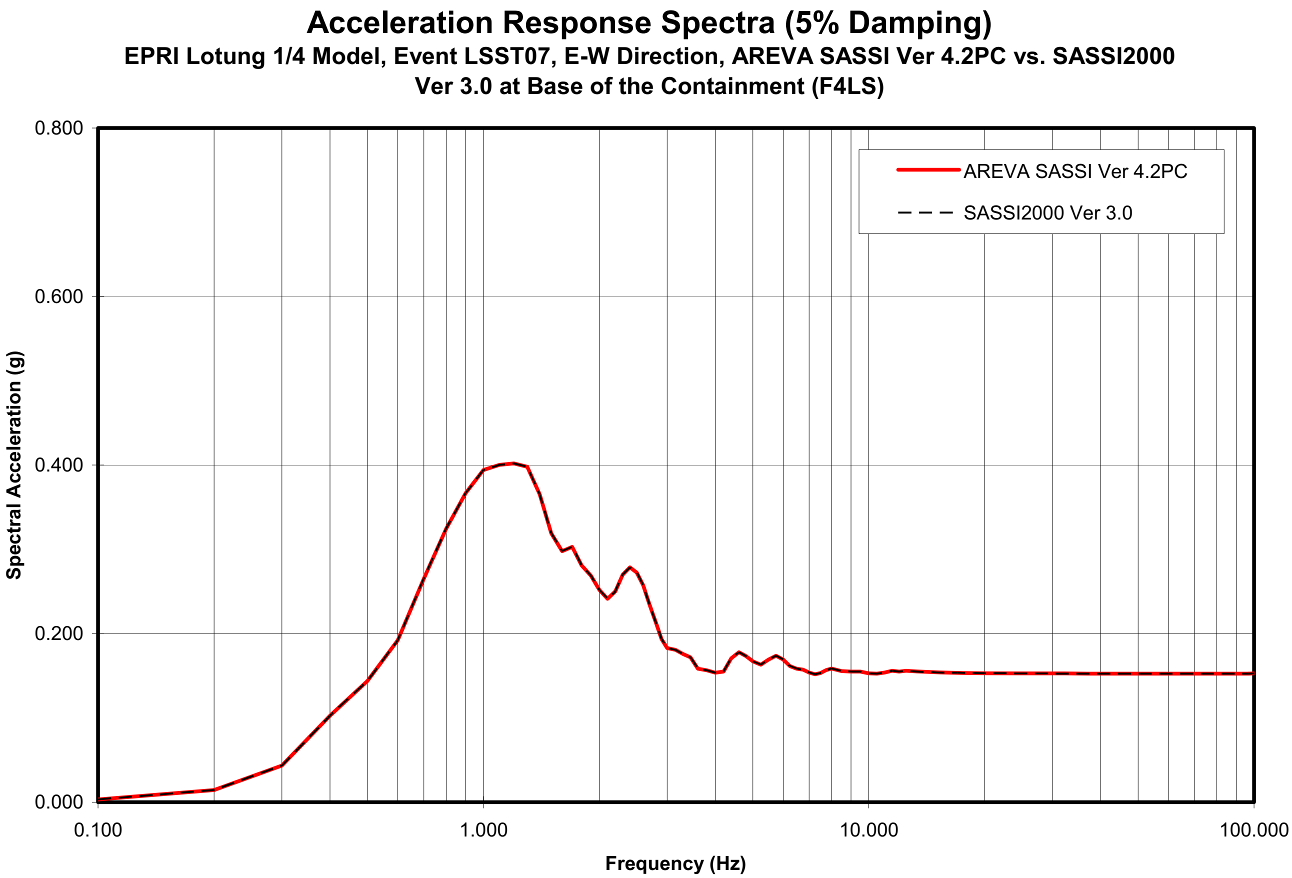


Figure 3.7.2-43-2—Comparison of the Responses at Top of the Containment

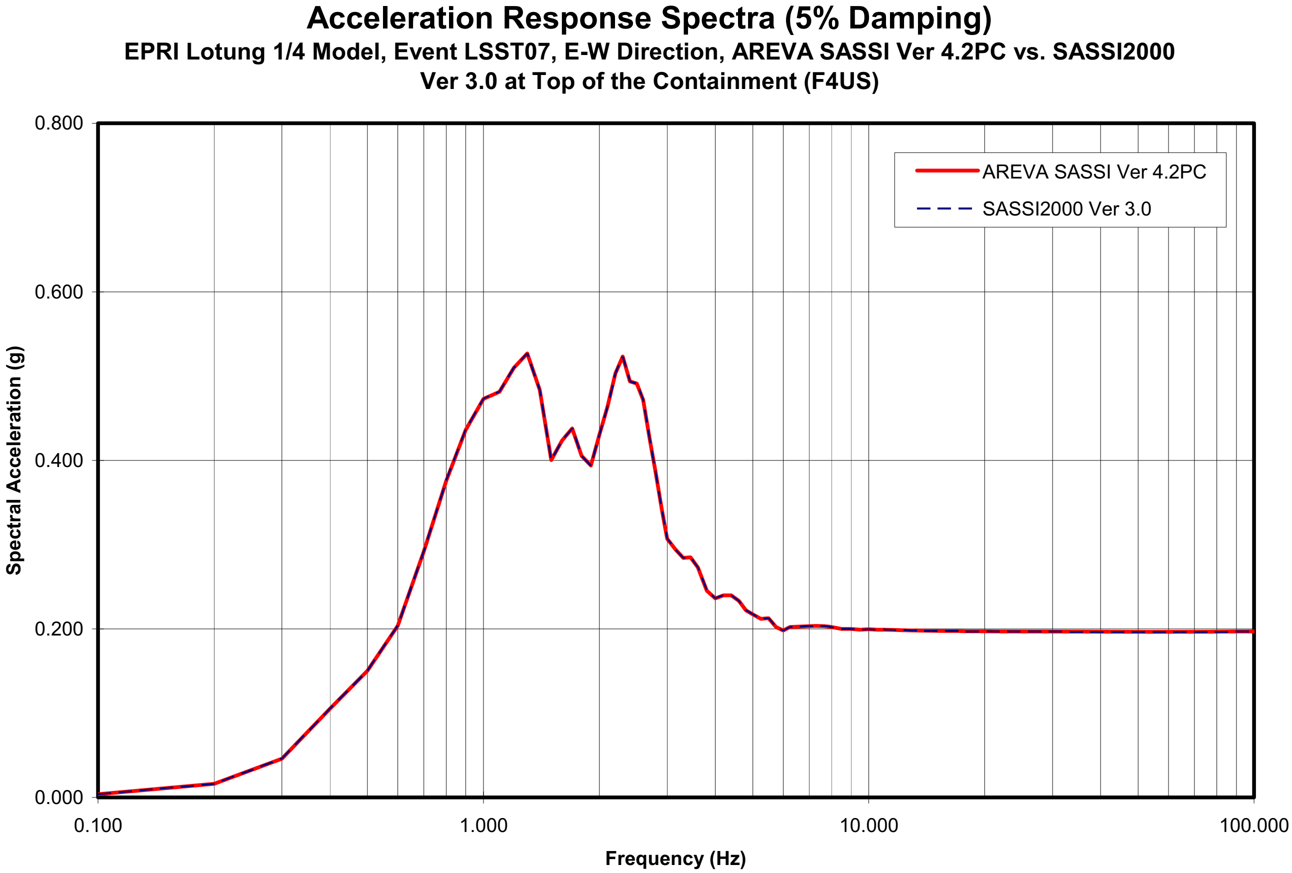


Figure 3.7.2-43-3—Comparison of the Responses at the Base of Steam Generator

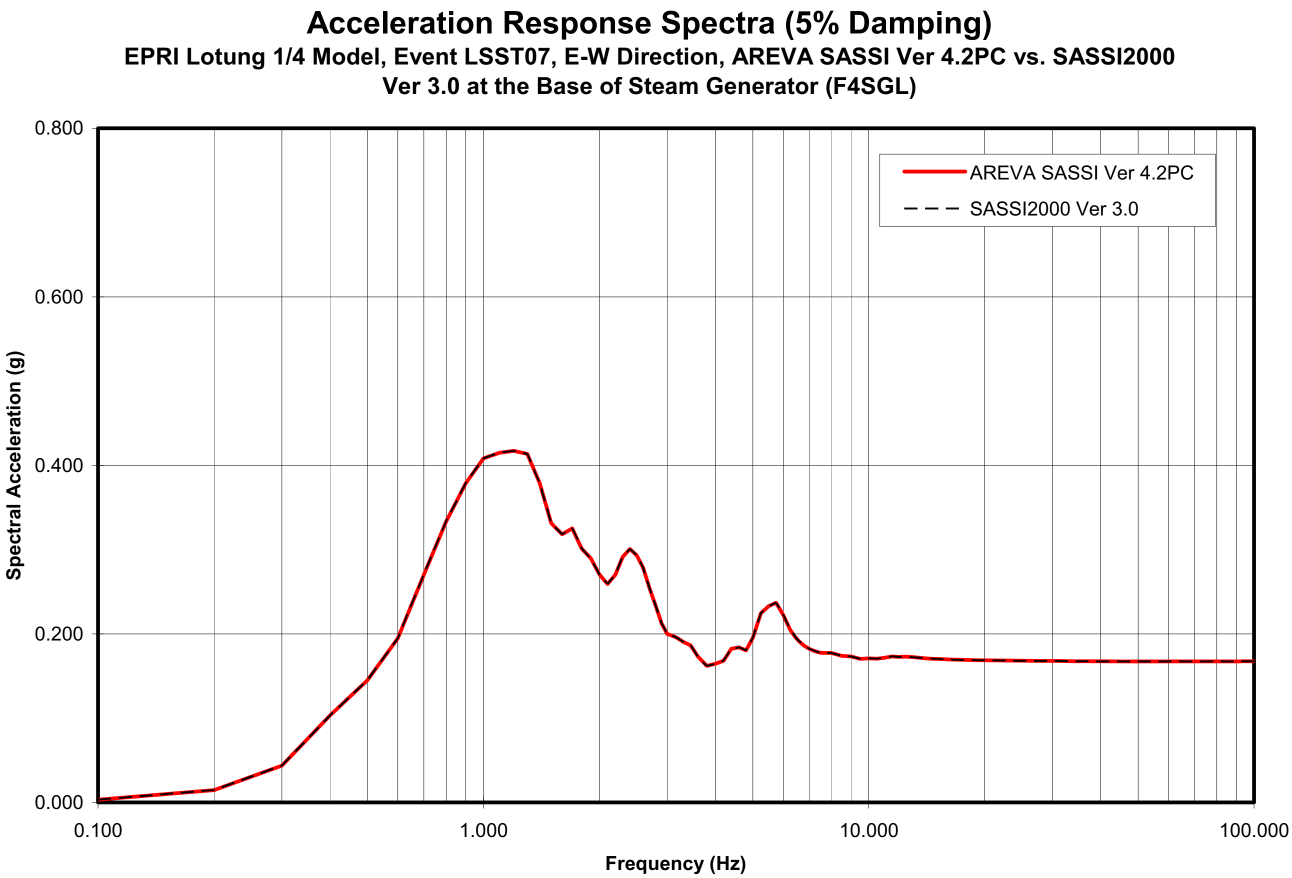
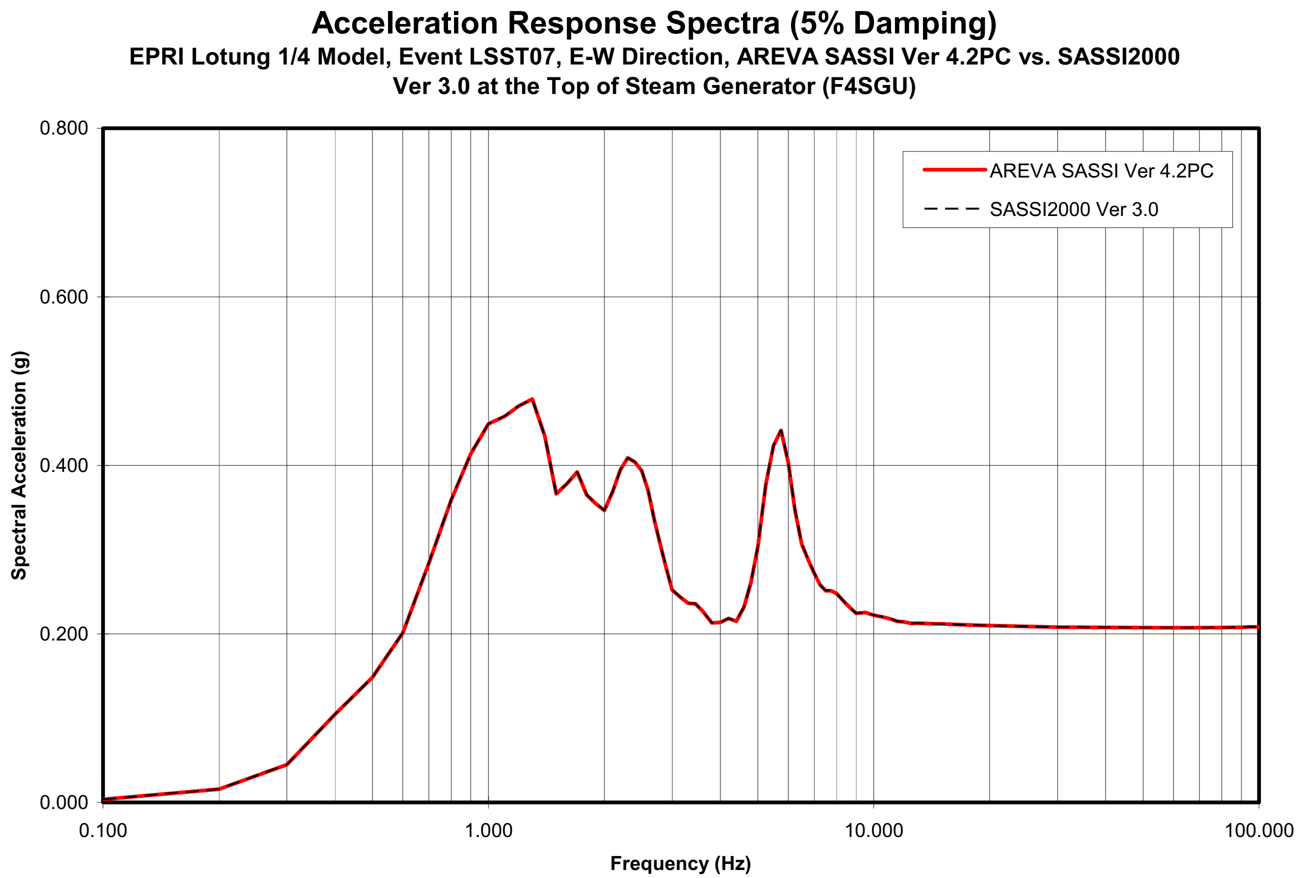


Figure 3.7.2-43-4—Comparison of the Responses at the Top of Steam Generator



Problem 2 – Emergency Power Generating Building (EPGB)

Problem Description

EPGB is an embedded structure with an embedment depth of about 5 ft (1.5m) and it was analyzed as a surface founded structure. The EPGB is a safety-related Category I reinforced concrete shear wall structure. The structure is 91’-6” wide, 176’-0” deep, and 68’-0” high. The SSI model for EPGB is discussed in U.S. EPR FSAR Tier 2, Section 3.7.2. The EPGB is analyzed for soil profile 2sn4um using AREVA NP SASSI, Version 4.2PC and the results compared with results generated using Bechtel SASSI2000, Version 3.1.

Comparison of Seismic Responses

Transfer functions at three selected nodal points from the SASSI analysis were computed and plotted. The transfer function plots serve as the basis of judgment for reasonableness of the results. The three selected nodal points are:

- Node 1179 – Center of the EPGB Basemat at Elev. 0’0”.
- Node 1001 – Corner of the EPGB Basemat at Elev. 0’0”.

- Node 4048 – Center of the Roof Slab at Elev. 68’0”

Figures 3.7.2-43-5 through 3.7.2-43-13 show the transfer function comparisons in the three directions for the above nodes. The results show that the seismic response of the structure is comparable for each of the programs.

Figure 3.7.2-43-5—Center of EPGB Basemat Transfer Functions (Node 1179), Elev. 0’0”, X-Direction, 2sn4um profile

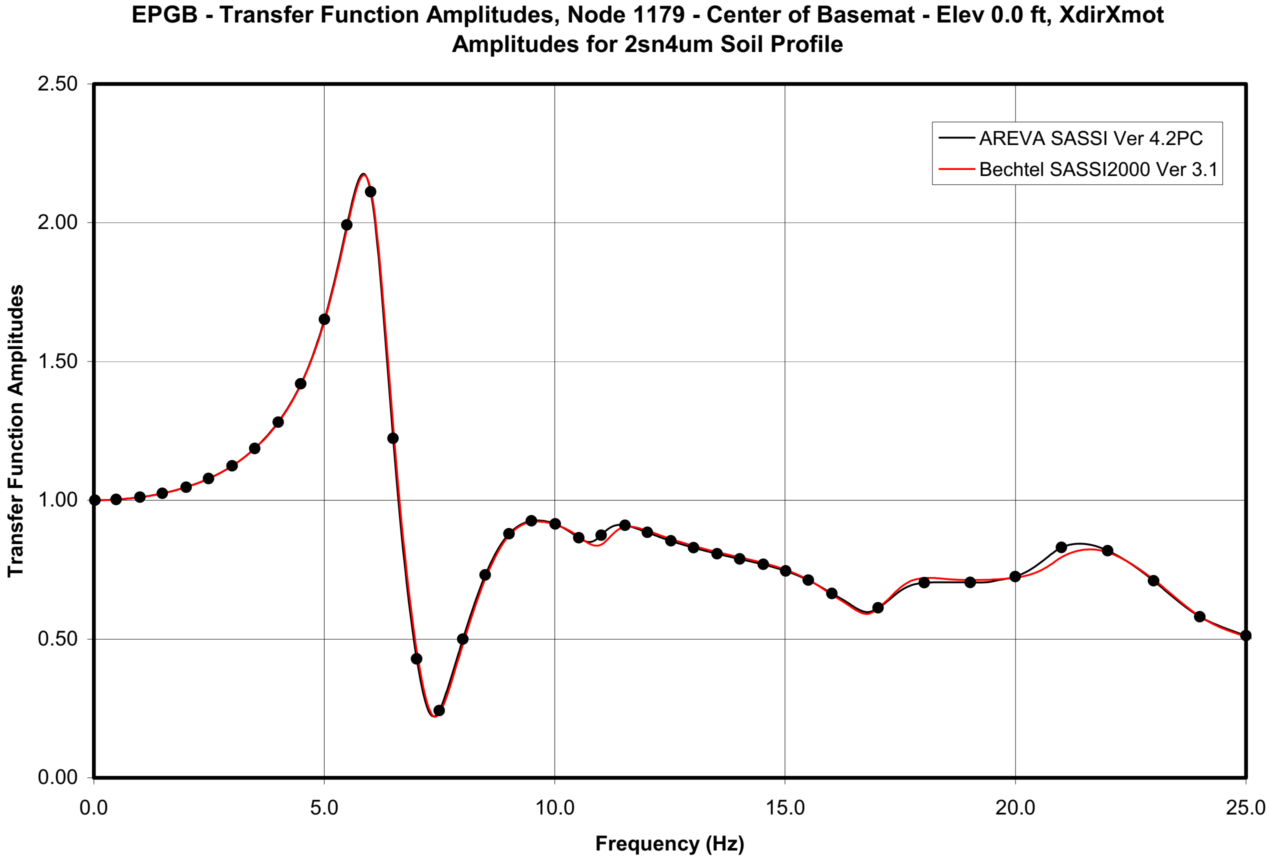


Figure 3.7.2-43-6—Center of EPGB Basemat Transfer Functions (Node 1179), Elev. 0'0", Y-Direction, 2sn4um profile

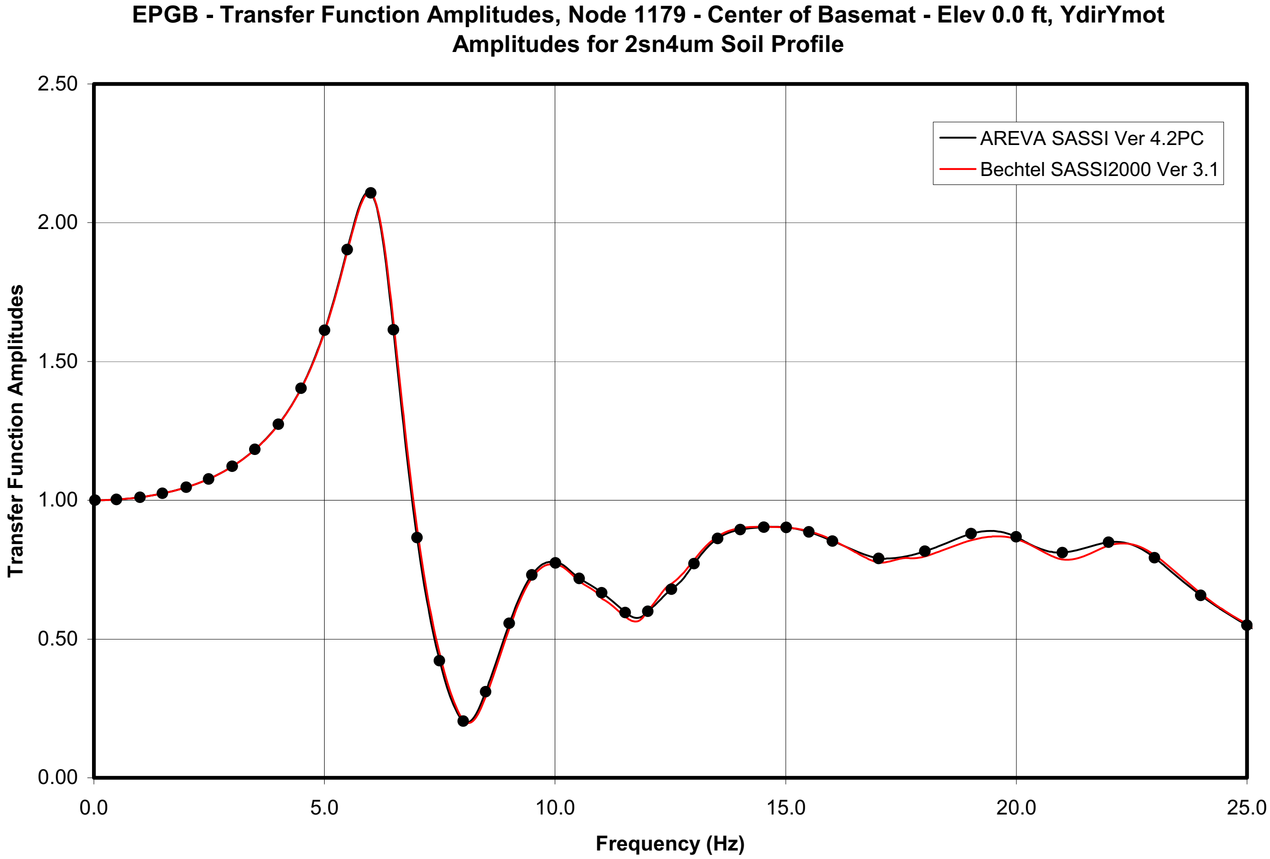


Figure 3.7.2-43-7—Center of EPGB Basemat Transfer Functions (Node 1179), Elev. 0'0", Z-Direction, 2sn4um profile

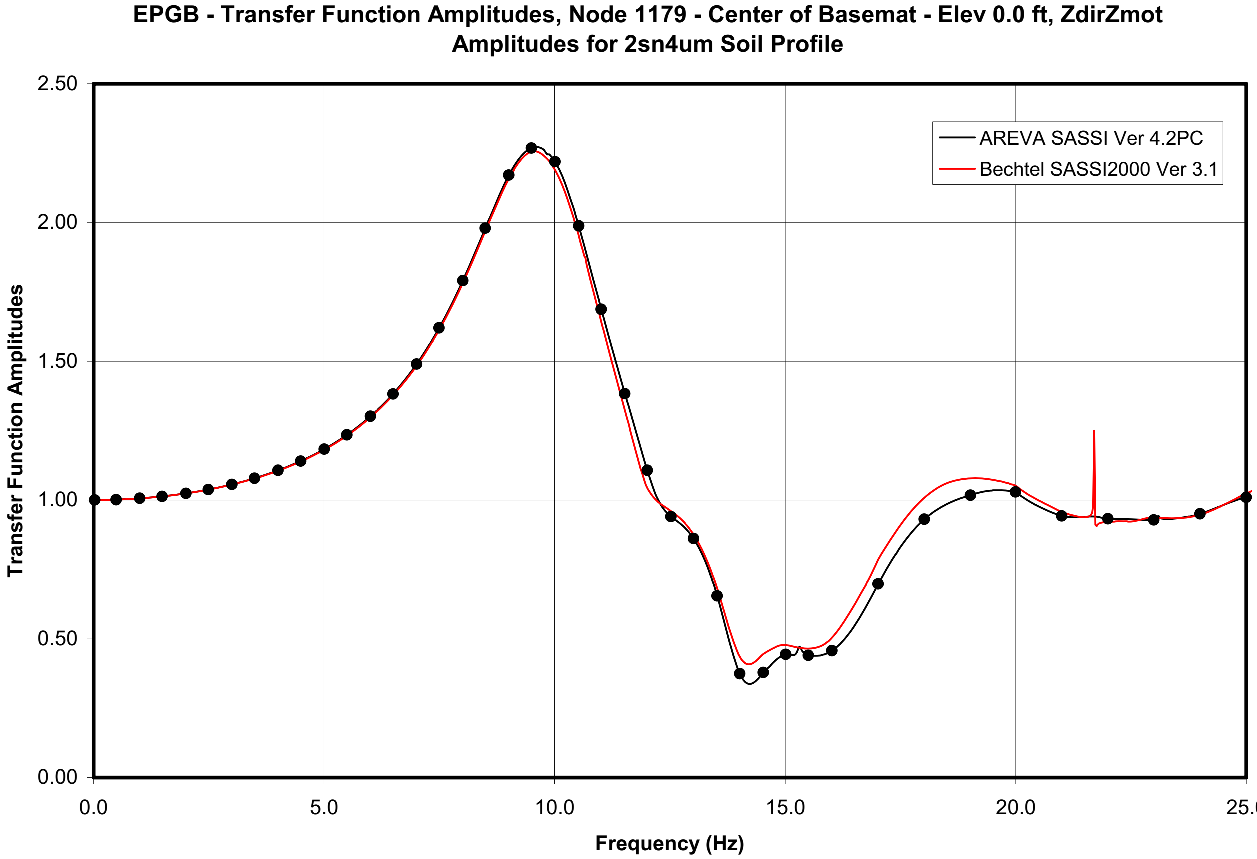


Figure 3.7.2-43-8—Corner of EPGB Basemat Transfer Functions (Node 1001), Elev. 0’0”, X-Direction, 2sn4um profile

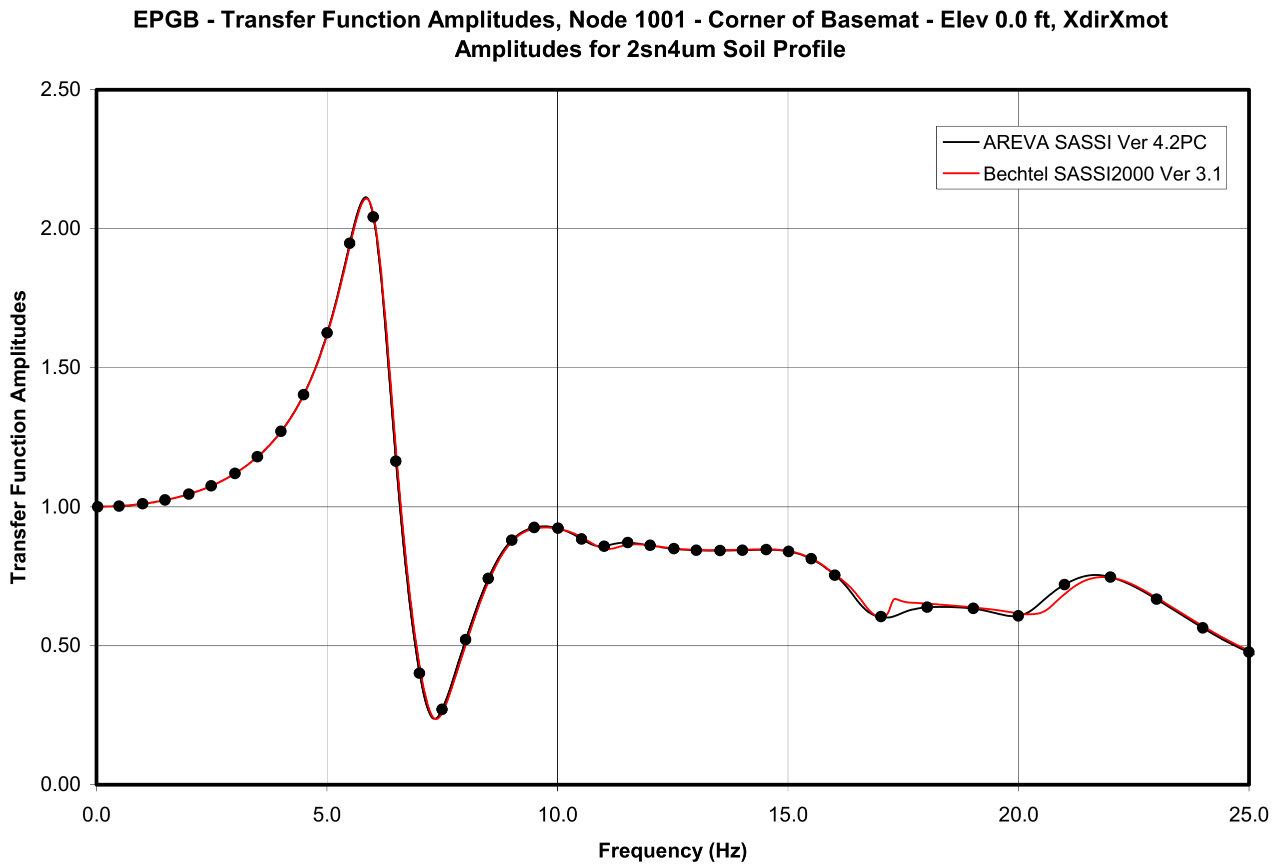


Figure 3.7.2-43-9—Corner of EPGB Basemat Transfer Functions (Node 1001), Elev. 0'0", Y-Direction, 2sn4um profile

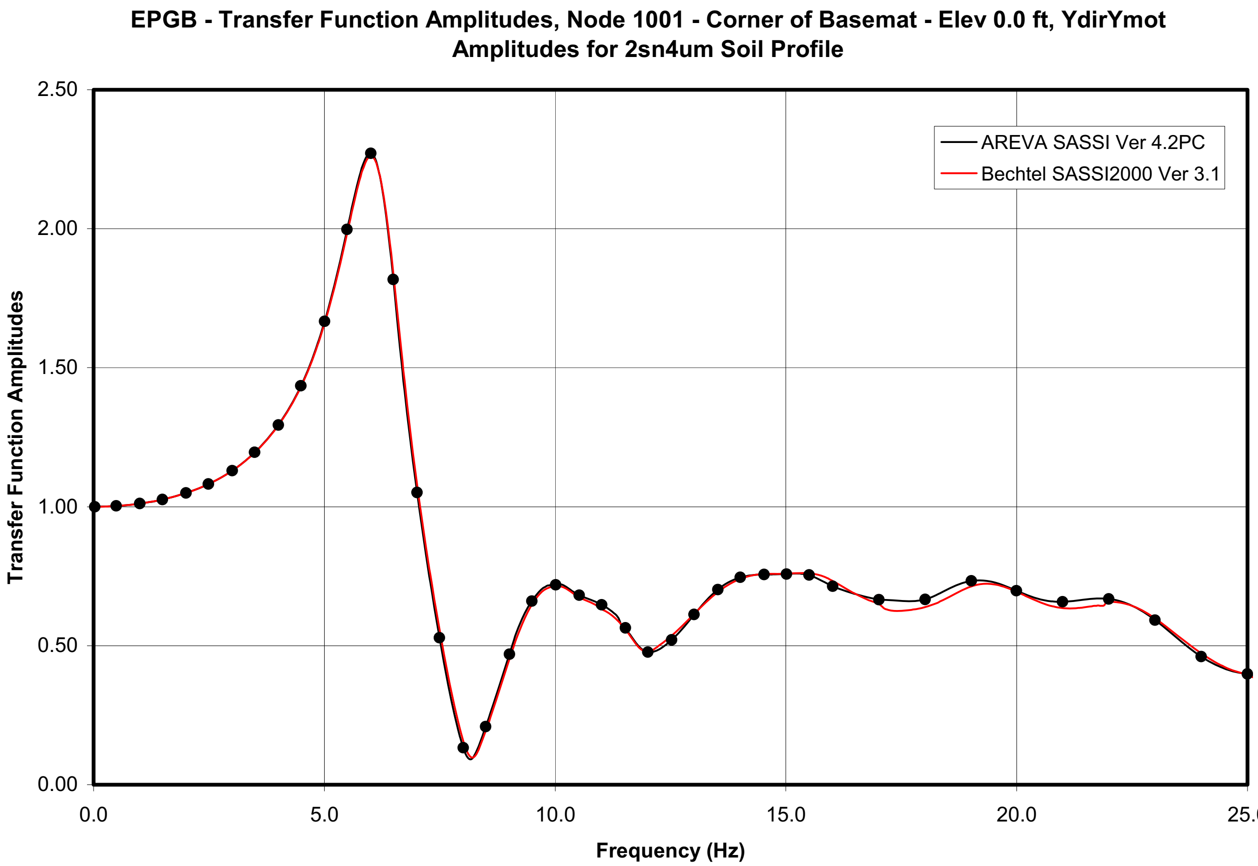


Figure 3.7.2-43-10—Corner of EPGB Basemat Transfer Functions (Node 1001), Elev. 0'0", Z-Direction, 2sn4um profile

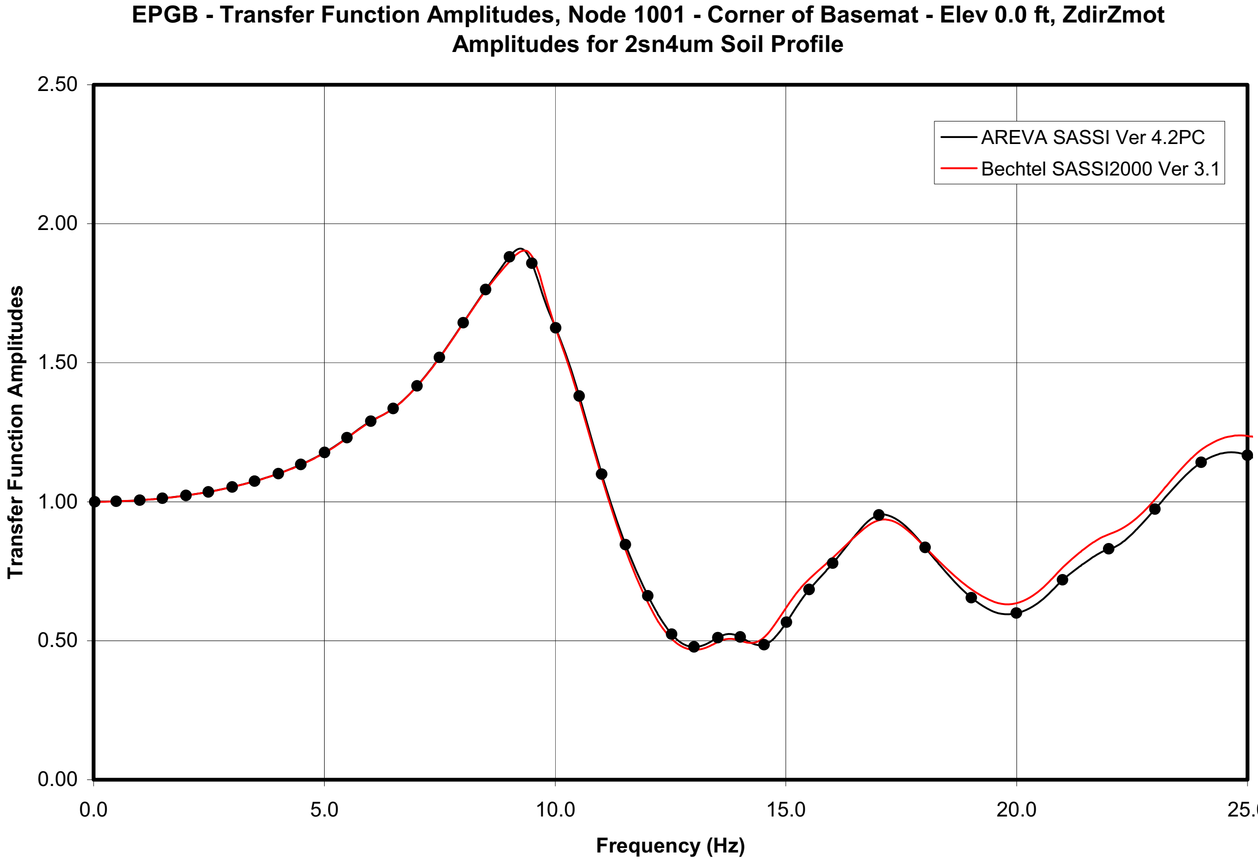


Figure 3.7.2-43-11—Center of EPGB Roof Slab Transfer Functions (Node 4048), Elev. 68'0", X-Direction, 2sn4um profile

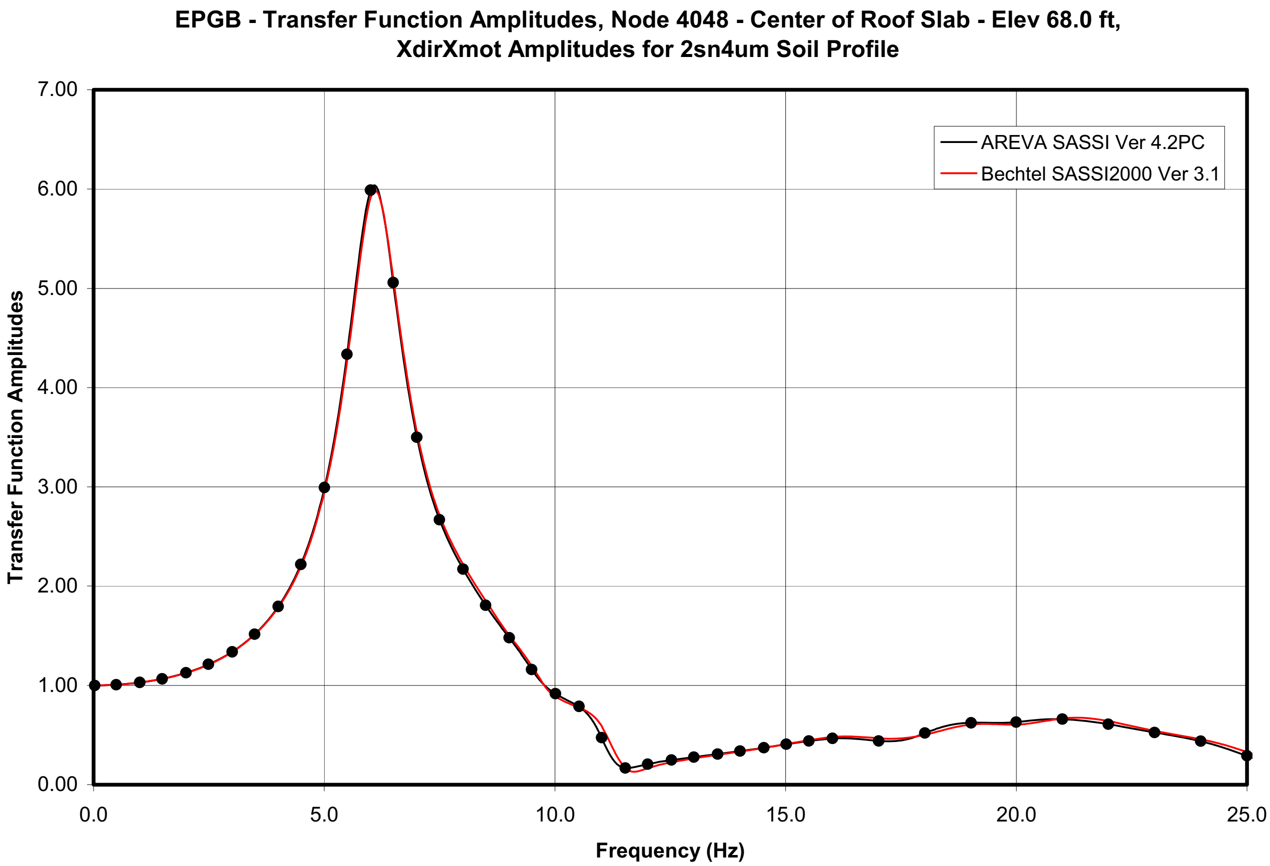


Figure 3.7.2-43-12—Center of EPGB Roof Slab Transfer Functions (Node 4048), Elev. 68’0”, Y-Direction, 2sn4um profile

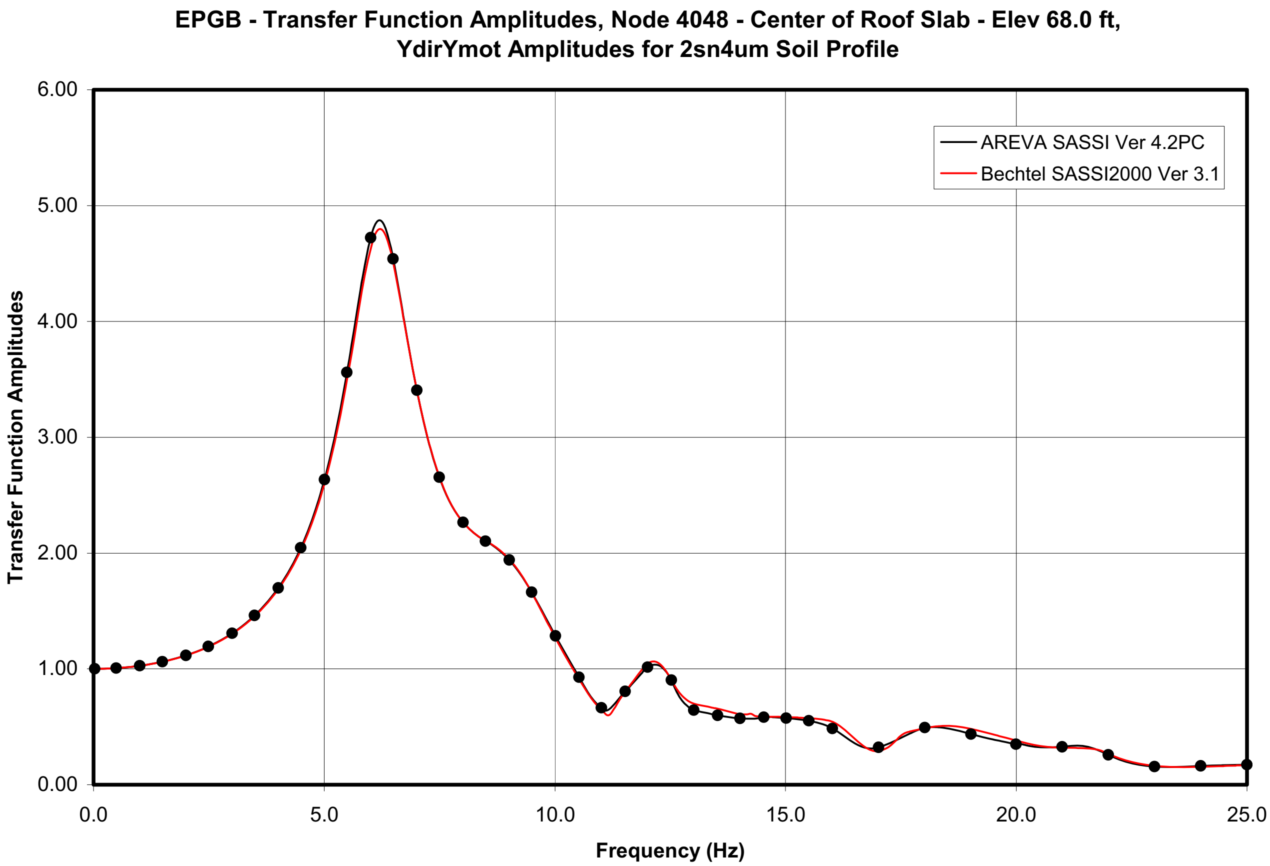
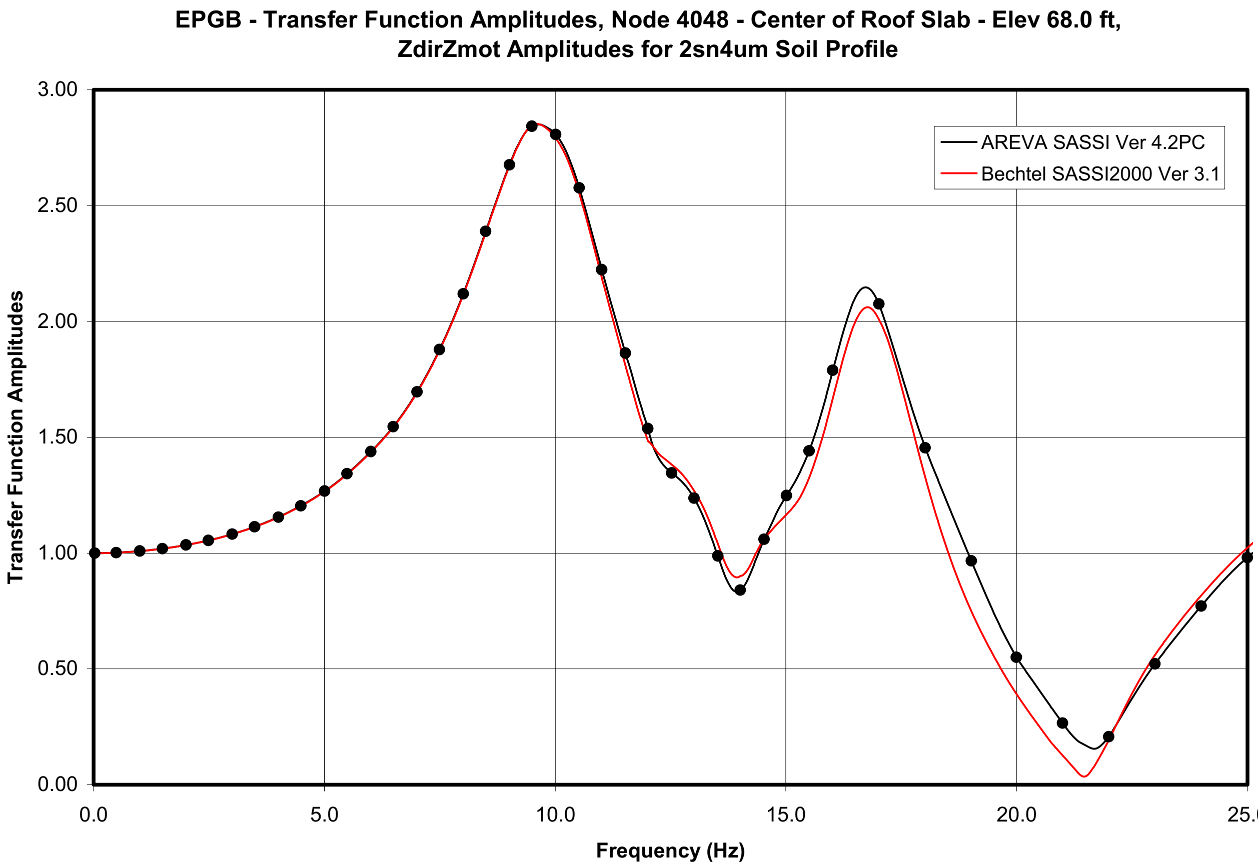


Figure 3.7.2-43-13—Center of EPGB Roof Slab Transfer Functions (Node 4048), Elev. 68'0", Z-Direction, 2sn4um profile



References

1. EPRI NP-6154, "Proceedings: EPRI/NRC/TPC Workshop on Seismic Soil-Structure Interaction Analysis Using Data from Lotung, Taiwan,"Project 2225, Palo Alto, California, Electric Power Research Institute, March 1989.
2. Lysmer, J., et al., SASSI 2000 User's Manual, Revision 2, Geotechnical Engineering Division, Department of Civil Engineering, University of California, Berkeley, 2006.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.07.02-44:

Follow-up to RAI Question 03.07.02-3

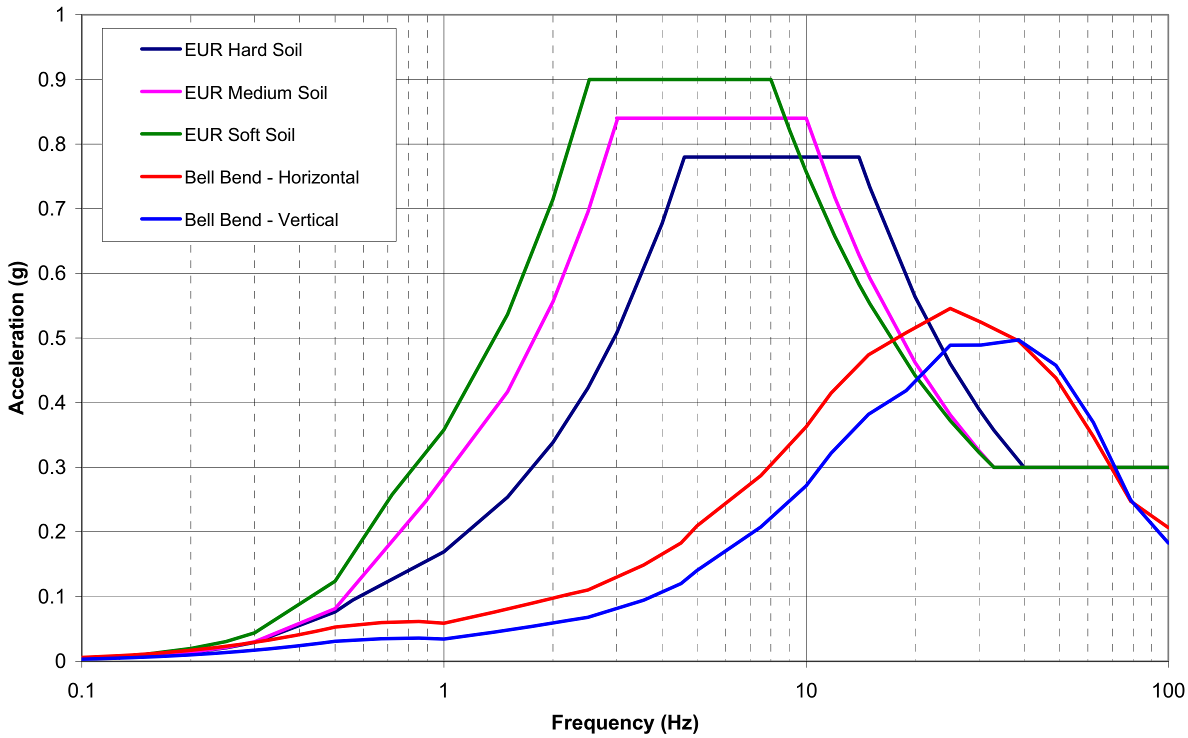
The response does not adequately address the question which asked for the frequency transmission characteristics of the stick model as well as the FEMs used for seismic analysis. In reviewing the modal frequencies of the stick models, it is noted that for the balance of NI Common Basemat Structures, the Reactor Containment Building, and the Reactor Building Internal Structure, the highest reported frequencies as reported in FSAR Tables 3.7.2-1, 3.7.2-2, and 3.7.2-3 are 28.65 Hz, 34.98 Hz, and 35.44 Hz, respectively. As such, these models may not be appropriate for many Eastern U.S. sites where earthquakes are characterized by high frequency input. The applicant is requested to add a COL information item that requires the COL applicant to determine if the U.S. EPR seismic models are appropriate for use at the COL applicant's site because of the limitation of the seismic models to transmit high frequency input.

Response to Question 03.07.02-44:

The stick model for the NI Common Basemat Structures has been replaced by the finite element model (FEM) which is meshed to capture high frequency response. Additional details on the FEM will be provided in response to RAI 320.

Additionally, the U.S. EPR certified seismic design response spectra (CSDRS) will be revised to include the Bell Bend Nuclear Power Plant (BBNPP) ground motion response spectra (GMRS). The addition of the BBNPP GMRS to the U.S. EPR CSDRS assures that the high frequency input at each of the currently proposed U.S. EPR sites will be enveloped by the CSDRS. Figure 03.07.02-44-1 is provided for reference and shows the new CSDRS including the higher frequency content of the BBNPP curve. The three additional soil SSI analyses cases encompassing the BBNPP GMRS, the site-specific soil profiles (Upper Bound, Best Estimate, and Lower Bound), as well as the FSAR changes associated with the revised CSDRS will be provided in response to RAI 320.

Figure 03.07.02-44-1—Design Response Spectra for EUR Control Motions (hard, medium, soft sites) and Bell Bend Nuclear Power Plant Site – Horizontal and Vertical Directions, 5% Damping



FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.07.02-46:

Follow-up to RAI Question 03.07.02-05

The stick model represents a significant structural condensation of the FEM and is expected to model the global response of the structure to seismic input. The applicant in its response states that additional amplification due to flexible walls and floors is captured by the finite element model and incorporated into the tuning process. The majority of the structural resistance will be provided by in-plane shear and axial forces. It is unlikely the stick model by itself will capture the out-of-plane response of flexible floors and walls from the tuning process with the FEM. In its response to Question 03.07.02-9, the applicant states that vertical floor frequencies are determined from the independent modal analysis of the FEM. These determine SDOF oscillators for the stick models. A SDOF model is generated with the slab properties modeled in the vertical direction considering cracked and un-cracked concrete conditions. These are seismically excited and the envelope of the responses of both sticks is used to obtain zero period accelerations used in slab design. For walls, out-of-plane vibrations are evaluated in the same way as for floor slabs. However, on page 3.7-73, the FSAR states that floor and roof slabs are assumed rigid when developing the stick models for the NI Common Basemat Structures except that out-of-plane flexibilities of the following slabs and walls are explicitly accounted for by SDOF oscillators in the stick models:

- The removable walls at the steam generator (SG) towers above elevation +63 ft, 11-1/2 inches of the RBIS.
- The walls and roof slab of the SBs 2 and 3 shield structure and FB shield structure.
- The two flexible slabs at elevation +26 ft, 7 inches of SBs 2 and 3.

The applicant's response to Question 03.07.02-9 suggests that the use of SDOF oscillators is a general practice applicable to all walls and slabs not just those listed on page 3.7-73. As the FSAR and the responses to Questions 03.07.02-5 and 03.07.02-9 do not provide a clear or consistent picture of the treatment for these structural elements the applicant is requested to provide for the NI Common Basemat Structures the step-by-step process that is used to determine the amplified response of flexible slabs and walls and the generation of their respective ISRS. As part of this response the applicant is requested to address the following:

a. What are the criteria for decoupling flexible floors and walls from the main stick model?
b. Why were the walls and slabs identified on page 3.7-73 included in the stick model?
c. Identify any other flexible walls and slabs that are included in the stick model and provide the reasons they are included.
d. Identify the flexible slabs and walls that are excluded from the seismic stick model and provide the reasons for not including them.

Describe the impact of the decoupling approach on the seismic response (displacement, acceleration, ISRS) of both the NI Common Basemat Structure stick model and on the seismic response of the decoupled walls and floors.

Response to Question 03.07.02-46:

The NI Common Basemat Structures stick model has been replaced by a finite element model (FEM). Additional details on the FEM will be provided in the responses to RAI 320.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.07.02-47:

Follow-up to RAI Question 03.07.02-06

The final ISRS is obtained by first developing an envelope of ISRS for the 12 soil cases for the NI common basemat structures and the 10 soil cases for the EPGB and ESWB. These are then peak broadened by 15 percent. Given that the variability in the soil has been accounted for by using this method, the staff finds the response regarding the difference in peak frequencies between the stick model and the FEM could be acceptable except as noted below that the applicant first demonstrate that the FEM itself is sufficiently detailed such that it provides accurate results for its intended use and therefore can be used as a benchmark for determining the validity of the stick model for calculating the seismic response of the NI Common Basemat Structures.

Regarding the difference between the peak acceleration of the stick model and the FEM, the applicant states that ten percent is the accuracy tolerance of loads, stresses, FS, etc. The applicant is requested to provide further basis for this statement, its relevance to the issue of the acceptability of the 10 percent difference in peaks between the two models and identify the meaning of the acronym FS. If there is a potential 10 percent tolerance in the results of the stick model and a 10 percent tolerance in the results of the FEM, collectively, there is the potential for an additional 20 percent difference in the results from that shown in the FSAR. The staff finds the response provides an insufficient basis for accepting the difference in the peaks and requests the applicant to provide additional technical justification. In addition, the applicant has not addressed the impact of the difference in results on the subsequent analysis of supported systems and equipment as requested in Part B of the original question and is requested to do so. Finally, The response provided in part (c) does not address the purpose of SRP 3.7.2-SAC-3.C.ii which is to provide assurance that the finite element model is sufficiently detailed to provide accurate results for the intended use. The applicant is requested for the NI common basemat structure, EPGB, and ESWB to demonstrate that further refinement in the finite element models of these structures would have a negligible effect on the results they produce. In summary, the applicant is requested to provide the following additional information in support of its response to Question 03.07.02-6.

a. Per SRP 3.7.2-SAC-3.C.ii, demonstrate for the NI Common Basemat Structures that the FEM is sufficiently detailed such that it can be used as a basis for determining the adequacy of the NI stick models to reasonably represent the seismic response of the NI Common Basemat Structures.

b. Although the seismic response of the EPGB and ESWB were based on FEMs and not stick models, the applicant is requested to demonstrate that the seismic models for each of these structures is sufficiently detailed that they provide accurate results from the seismic analysis of each of these structures.

c. Further clarify and provide the basis for the statement that ten percent is the accuracy tolerance of loads, stresses, FS, etc., and provide the meaning of the acronym FS. Discuss how this tolerance justifies the acceptance of a 10 percent difference between the ISRS peaks from the two seismic models.

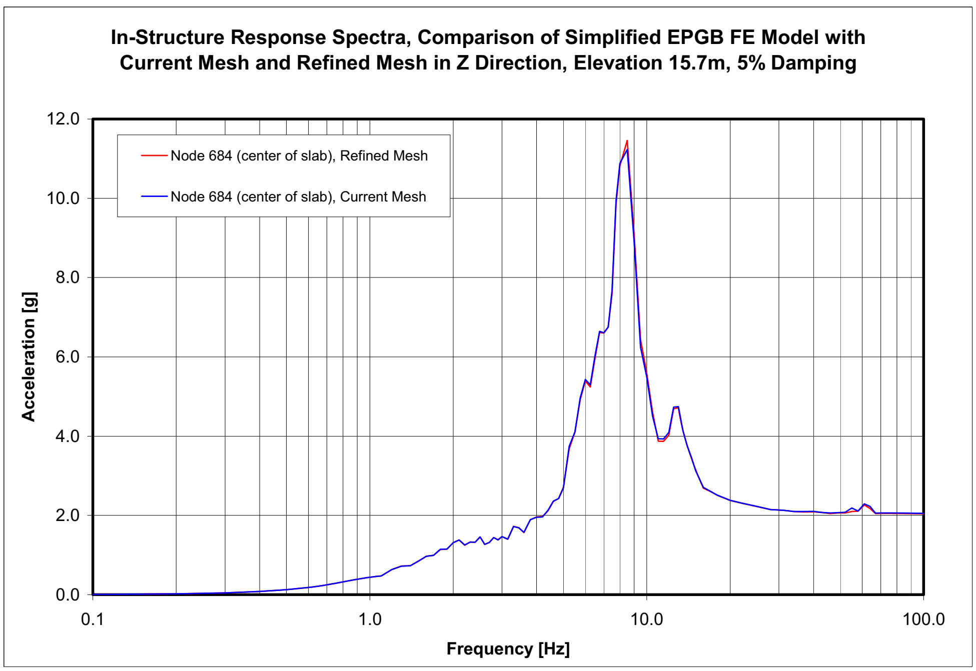
In addition, the applicant is requested to address the impact of the difference in results on the subsequent analysis of supported systems and equipment as requested in Part B of the original RAI question 03.07.02-06.

Response to Question 03.07.02-47:

a. The NI Common Basemat Structures stick model has been replaced by a finite element model (FEM). Additional details on the FEM will be provided in response to RAI 320.

b. The EPGB and ESWB were reanalyzed using a finer mesh (half the size). The comparison between the two models is shown in Figure 03.07.02-47-1 and it can be concluded that the current mesh is acceptable..

Figure 03.07.02-47-1—In-Structure Response Spectra, Comparison of Simplified EPGB FE Model with Current Mesh and Refined Mesh in Z Direction, Elevation 15.7m, 5% Damping



c. Since the stick model for the NI Common Basemat Structures has been replaced by the finite element model (FEM), this question is no longer applicable.

Since the stick model for the NI Common Basemat Structures has been replaced by the finite element model (FEM), the question regarding the impact of the difference in results on the subsequent analysis of supported systems and equipment is no longer applicable.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.07.02-48:

Follow-up to RAI Question 03.07.02-7

The applicant cites as a basis for accepting up to a 10 percent increase in ISRS due to design changes the guidance provided for determining if a time history response spectra is acceptable when compared to its corresponding design response spectra. The guidance provided for time history generation is at a specific frequency in which the design response spectrum is compared with the response spectrum of the time history. The purpose of the guidance is to provide an acceptable basis for developing the input to the analysis. It does not state that if the input increases by up to 10 per cent at some later date that the results of the analysis are still acceptable. The criteria cited in ASCE Standard 4-98, Section 3.2.2.2.1(f) provides guidance for including a sufficient number of modes in a modal analysis, but the Standard has not been accepted by the NRC and the specific criteria does not meet the guidance of RG 1.122 regarding modal combination. Furthermore, the example cited is not the same as accepting a 10 percent increase in loads or response spectra that has occurred due to a design change or for some other reason after the initial design has been completed. A 10 percent increase may be acceptable but its acceptability must be based on a technical evaluation that documents the effect of the increase not only on the structure but also on equipment qualification, piping design, and any other subsequent analysis that used the results from the original design. The applicant is requested to provide the additional following information for staff evaluation:

a. Describe how the ISRS provided in the U.S.EPR FSAR are used in the certified design and quantify the effect of a ten percent increase in ISRS on these applications. Cite specific examples in your response.

b. Identify whether the approach of accepting up to a ten percent increase in ISRS is also applied to an increase in design loads for critical sections and if so provide a technical justification for doing so.

Provide the specific code references (ASME, AISC, ACI) that allow the use of up to a 10 percent increase in loads without performing a technical evaluation and demonstrating that the design still meets code allowables.

Response to Question 03.07.02-48:

U.S. EPR FSAR Tier 2, Section 3.7.2, will be revised to state: "The combined deviations in amplitude of the in-structure response spectra will be evaluated on a case-by-case basis.”

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.7.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.07.02-54:

Follow-up to RAI Question 03.07.02-21

In its response to Question 03.08.01-13 the applicant states that SASSI Versions 4.1B, 4.2, and SASSI2000 Version 3.1 are used to analyze soil structure interaction of the Nuclear Island Basemat, Emergency Power Generating Building and Essential Service Water Buildings. SASSI Versions 4.1B, 4.2, and SASSI2000 Version 3.1 are validated through meeting an allowable percentage to a chain of test problems. It is not clear what criteria are used to establish the allowable percentage to a chain of test problems which the validation must meet in order to be acceptable. In addition for GT STRUDL Versions 27, 28, 29 and 29.1 the applicant states that these programs are validated by confirming the computer program's solutions to a series of test problems substantially identical to those obtained from classical solutions. Input files are supplied and used in the program to correlate supplied output files. These results must meet a required allowance. It is not clear what is meant by the phrase the results must meet a required allowance. The applicant is requested to provide additional information regarding how the terms "allowable percentage" and "required allowance" are used in the validation of these programs.

Response to Question 03.07.02-54:

The allowable percentage (or the required allowance) is used to confirm that the test problems results match known benchmark/classical solutions. Control measures that use alternate or simplified methods are used to establish acceptability. The allowable percentage (or the required allowance) provides adequate assurance that SSC analyzed using verified computer software satisfactorily perform their safety functions as required by 10 CFR Part 50, Appendix B.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 03.08.01-36:

Follow-up to RAI Question 3.8.1-21

The applicant's response states that Combustible Gas Loads (CL) will be added to Table 3E.1-1 and Construction Loads (C) will be added to Table 3E.1-2. The response also states that the containment accident pressure loads (Pa) are applied to the basemat and that Table 3E.1-1 will be modified to clarify. The following additional information is needed to resolve this RAI:

1. The response states that construction loadings will be incorporated into the structural design, in combination with other loadings, as needed to produce an overall design. Clarify that these loads will be incorporated into the structural design before the completion of the design certification process. Also identify the Design Calculation Number that will document the results and when it will be available should the staff decide to perform an audit of this document.

2. The staff understands that the combustion gas loads (C), design methodology and results will be provided as part of the response to RAI 3.8.1-6. To complete the response to RAI 3.8.1-21, clarify that C loads will be incorporated into the structural design before the completion of the design certification process. Also identify the Design Calculation Number that will document the results and when it will be available should the staff decide to perform an audit of this document.

3. The response stated that Table 3E.1-1 will be modified to address the staff's question about Pa only being considered for the containment wall. The EPR FSAR markup does not appear to show the proposed modification. Please provide an appropriate markup of the FSAR.

Response to Question 03.08.01-36:

1. U.S. EPR design geometry dictates that its construction sequence will begin at the center of the cruciform basemat and proceed outward, which implicitly achieves a reasonable degree of balance. However, specific magnitude and location of construction loads are based on construction methods, equipment operation, and sequence of construction, which are functions of site-specific geology, application of codes and standards, and construction methods used by the licensee during construction. Because these factors are not related to the U.S. EPR design process, construction loads are not applied as global structural design loads. Evaluation of structures and members for load combinations to determine construction loads and construction sequence are the responsibility of each COL applicant and must be accomplished on a site-specific basis. U.S. EPR FSAR Tier 2, Sections 3.8.1.3, 3.8.3.3 and 3.8.4.3 indicate that the COL applicant is responsible for determining construction sequence and confirming that the as-built U.S. EPR remains within the standard plant design envelope or perform additional analyses to verify structural adequacy. U.S. EPR, Tier 2, Appendix 3E, Table 3E.1-2 will be revised to place double brackets around construction loads to indicate that these loads are site-specific and the responsibility of the COL applicant.

2. As stated in the Response to RAI 03.08.01-21, information pertaining to combustion gas load will be provided as part of the Response to RAI 155, Question 03.08.01-6.

3. U.S. EPR FSAR Tier 2, Appendix 3E, Table 3E.1-1 will be revised to indicate that accident pressure loads (Pa) are considered for the containment.

FSAR Impact:

The U.S. EPR FSAR Tier 2, Appendix 3E, Tables 3E.1-1 and 3E.1-2 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

03.07.01-25

In-structure response spectra (ISRS) for the NI Common Basemat Structures are generated using SSE damping values rather than the OBE damping values suggested in Table 2 of RG 1.61. ~~Because the standard plant seismic design basis (see Section 3.7.1.1) coupled with the broad range of soil cases (see Section 3.7.1.3) results in high enveloping structural loads on both the walls and floor diaphragms of the NI Common Basemat Structures it is reasonable to conclude, on an overall stress level basis, that it is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS.~~ It is appropriate to use SSE structural damping for the NI Common Basemat Structures to generate ISRS. This approach is used because the standard plant seismic design basis (see Section 3.7.1.1) coupled with a representative set of soil cases (see Section 3.7.1.3) results in structural loads on both walls and floor diaphragms of NI Common Basemat Structures that are expected to produce cross section demands greater than 50 percent of ultimate capacity.

The ISRS for the Emergency Power Generating Building and the Essential Service Water Buildings are based on OBE structural damping.

The damping values for conduits and cable tray systems are presented in Table 3.7.1-1. Several test programs and studies have demonstrated that higher damping values may be utilized for certain ~~kinds of~~ cable tray~~s with flexible support~~ systems (References ~~2~~3 through 5). ~~Flexible support systems include the rod-hung and strut-hung trapeze systems, and the strut-type cantilever and braced cantilever support systems discussed in regulatory position C.3 of RG 1.61.~~ For cable tray~~s with flexible support~~ systems that are similar to those tested by Bechtel-ANCO Engineers, Inc. (Reference 3) and satisfy tray loading criteria of RG 1.61, the damping values in Figure 3.7.1-16—Damping Values for Cable Tray~~s with Flexible Support~~ Systems, may be used on a case-by-case basis and are limited to maximum ~~20~~15 percent damping. For cable tray systems that are significantly different than those tested by Reference 3, ~~but satisfy loading criteria, a maximum~~ the damping values of ~~15 percent may be used in accordance with ASCE 43-05 (Reference 2)~~RG 1.61 shall be used. See Appendix 3A for additional discussion on cable tray and conduit system damping.

Heating, ventilation, and air conditioning duct systems use damping values of 10 percent for pocket-lock construction, seven percent for companion-angle construction, and four percent for welded construction. The damping values provided in Table 3.7.1-1 are applicable to time history, response spectra and equivalent static analysis procedures for structural qualification as discussed in regulatory position C.4 of RG 1.61.

The seismic qualification of passive electrical and mechanical equipment by analysis is performed using the damping values listed in Table 3.7.1-1, which are in conformance with regulatory position C.5 of RG 1.61. The seismic qualification of active electrical and mechanical equipment is performed by testing as described in Section 3.10.

EPR structures is defined in Section 3.2. These seismic analyses meet the requirements of 10 CFR 50, GDC 2 and 10 CFR 50, Appendix S, with respect to the capability of the structures to withstand the effects of earthquakes. Application of the criteria in Section 3.7 to the seismic analysis and design of the U.S. EPR results in a robust design with significant seismic margin, as demonstrated in the seismic margin assessment of Section 19.1. A COL applicant that references the U.S. EPR design certification will confirm that the site-specific seismic response is within the parameters of Section 3.7 of the U.S. EPR standard design. The impact of changes to the standard design at the detailed design stage is evaluated using the following criteria.

- The effects of deviations are evaluated using methods that are consistent with those of Section 3.7 as used for the certified design.

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- The evaluation considers the combined effect of such deviations.
- The combined deviations ~~are acceptable if the amplitudes of the in-structure response spectra increase by less than 10 percent~~in amplitude of the in-structure response spectra will be evaluated on a case-by-case basis.
- Changes, either individually or cumulatively, that exceed these thresholds result in the evaluation of the need for reanalysis.

3.7.2.1 Seismic Analysis Methods

The response of a multi degree-of-freedom system subjected to seismic excitation may be represented by the differential equations of motion in the following general form:

Equation 1

$$[M]\{\ddot{X}\}+[C]\{\dot{X}\}+[K]\{X\}=-[M]\{\ddot{u}_g\}$$

Where:

$[M]$ = mass matrix (n x n)

$[C]$ = viscous damping matrix (n x n)

$[K]$ = stiffness matrix (n x n)

$\{X\}$ = column vector of relative displacements (n x 1)

$\{\dot{X}\}$ = column vector of relative velocities (n x 1)

$\{\ddot{X}\}$ = column vector of relative accelerations (n x 1)

n = number of degrees of freedom

Table 3E.1-1—Independent Loads Considered in the FEM

D	Dead Loads
L	Live Loads
J	Post-tensioning Loads
H	Lateral Earth Pressure Loads
F	Hydrostatic Loads
F_b	Buoyancy Loads
E’	Seismic Loads
R_o	Piping Loads (normal operating conditions)
R_a	Piping Loads (accident conditions)
W	Wind Loads (severe environmental)
W_t	Wind Loads (extreme environmental)
P_t	Pressure Loads (test conditions)
P_a (only for containment ~~wall~~)	Pressure Loads (accident conditions)
T_a (only for containment ~~wall~~)	Temperature Loads (accidental conditions)
~~C~~	~~Combustible Gas~~

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Table 3E.1-2—Independent Loads Not Considered in the FEM

G	Relief Valve Loads
R_r	Pipe Rupture Loads
F_a	Compartment Flood Loads
T_o	Temperature Loads (normal operating)
T_t	Temperature Loads (test conditions)
P_v	Containment Wall Pressure Variant Loads
P_a	Sub-compartment pressurization
[[CL	Construction Loads]]

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