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Your ref: Project Number 740
Our ref: DCP/NRC2022

October 19, 2007

Subject: AP1000 COL Responses to Requests for Additional Information (TR 85)

In support of Combined License application pre-application activities, Westinghouse is submitting responses to the NRC requests for additional information (RAIs) on AP1000 Standard Combined License Technical Report 85, APP-GW-GLR-044, Nuclear Island Basemat and Foundation. These RAI responses are submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in the responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification.

Responses are provided for RAI-TR85-SEB1-12, -14, -18, -20, -26, -31, and -33, transmitted in an email from Dave Jaffe to Sam Adams dated August 9, 2007. With these responses, twenty-eight of thirty-nine total requests received to date for Technical Report 85 have been completed. Responses to RAI-TR85-SEB1-10, -11, -15, -24, -25, -28, -29, -30, -34, -35, -37, and -39 were submitted under Westinghouse letter DCP/NRC2016 dated October 4, 2007. Responses to RAI-TR85-SEB1-03, -13, -27, and -38 were submitted under Westinghouse letter DCP/NRC1999 dated September 18, 2007. Responses to RAI-TR85-SEB1-01, -09, and -16 were submitted under Westinghouse letter DCP/NRC2002 dated September 21, 2007. Responses to RAI-TR85-SEB1-02 and -21 were submitted under Westinghouse letter DCP/NRC2006 dated September 28, 2007.

Pursuant to 10 CFR 50.30(b), the responses to the requests for additional information on Technical Report 85 are submitted as Enclosure 1 under the attached Oath of Affirmation.

Questions or requests for additional information related to the content and preparation of these responses should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

D063
D079
NRO

Very truly yours,

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Attachment

1. "Oath of Affirmation," dated October 19, 2007

/Enclosure

1. Responses to Requests for Additional Information on Technical Report No. 85

cc:	D. Jaffe	-	U.S. NRC	1E	1A
	E. McKenna	-	U.S. NRC	1E	1A
	G. Curtis	-	TVA	1E	1A
	P. Hastings	-	Duke Power	1E	1A
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	C. Pierce	-	Southern Company	1E	1A
	E. Schmiech	-	Westinghouse	1E	1A
	G. Zinke	-	NuStart/Entergy	1E	1A
	B. Laskey	-	Westinghouse	1E	1A

ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:	)
NuStart Bellefonte COL Project	)
NRC Project Number 740	)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

W. E. Cummins, being duly sworn, states that he is Vice President, Regulatory Affairs & Standardization, for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

W. E. Cummins
Vice President
Regulatory Affairs & Standardization

Subscribed and sworn to
before me this 19th day
of October 2007.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Patricia S. Aston, Notary Public
Murrysville Boro, Westmoreland County
My Commission Expires July 11, 2011
Member, Pennsylvania Association of Notaries

Notary Public

ENCLOSURE 1

Responses to Requests for Additional Information on Technical Report No. 85

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-12
Revision: 0

Question:

Section 2.4.2 indicates that the 2D ANSYS nonlinear time history analyses were performed for dead load plus EW and vertical SSE loads. The analyses and results are described in greater detail in Section 7.0 of TR-03, Revision 0. The following information is requested relating to these analyses:

a. Section 2.4.2 states that a comparison of floor response spectra and the maximum member forces and moments for the linear and nonlinear soil spring cases show that liftoff has an insignificant effect on the SSE response. This statement needs to be clarified or revised because based on Figure 2.4-5, for the soft to medium soil case, the bearing reactions increase by 16%, which suggest that the nonlinear effect is important and does need to be considered.

b. Based on the 3D ANSYS equivalent static approach, Figure 2.6-7 shows that more than 50% of the basemat lifts up and the bearing pressure for this case is much higher than that for the 2D ANSYS nonlinear case. Since the 2D ANSYS model represents the basemat as a rigid beam and has some other simplifying assumptions, explain why the maximum bearing pressure from the more accurate 3D ANSYS model, which includes the flexibility of the basemat and considers the three dimensional features of the NI structures, is not used to define the maximum bearing pressure in addition to its use for designing the basemat.

c. The 2D ANSYS nonlinear time history analysis only considers uplift between the soil and the NI basemat. Explain how the potential uplift and sliding between the containment internal structures (CIS) concrete base and the steel containment shell is addressed for the various soil conditions. Also, provide the basis for the statement in Section 3.8.2.1.2 of the DCD which indicates that the shear studs provided between the containment and concrete basemat below the containment are not required for design basis loads, but provide additional margin for earthquakes beyond the SSE. Have analyses been performed for the AP1000 design (based on the SSE) to demonstrate that there is no uplift or sliding of the containment with respect to the basemat for the various soil conditions? If not, explain why.

d. Section 7.2 of TR-03, Revision 0, indicates that the soil damping is low (2%) for the soft rock case, 5% for the soft-to-medium case and increases to 30% for the soft soil case. Since radiation damping at layered soil sites may in fact be low, provide the technical basis for the use of these damping values. If the conservatism of the selected values is not clearly demonstrated, then these should be considered as site interface parameters to be met by the COL applicant.

Westinghouse Response:

a. This statement has been clarified as shown in the revisions to the Technical Report shown below. The comparison of the maximum member forces and moments for the linear and nonlinear soil spring cases is discussed in the response to RAI-TR85-SEB1-14.

b. The bearing pressures and lift-off in the 3D ANSYS non-linear analyses exceed those from the 2D ANSYS time history analyses. This is due to the conservatism inherent in the equivalent static method. The 2D ANSYS bearing pressures in Figure 2.6-7 show fairly uniform spacing between contours. In addition the location of maximum bearing pressure in both the 2D and 3D analyses is below the west side of the shield building where the nuclear island is nearly rigid due to the thickness of mass concrete and the stiffening of the superstructure. Thus the flexibility of the basemat and the three dimensional features of the NI structures are not significant in defining the maximum bearing pressure and the results of the dynamic analysis are used rather than the conservative results of the equivalent static analysis.

c. The design analyses of the nuclear island basemat include consideration of sliding and lift-off between the containment internal structures and the containment vessel, and of sliding between the containment vessel and the nuclear island basemat as described in the response to RAI-TR85-SEB1-21. Analyses of stability for the hard rock site demonstrated that there was no uplift or sliding at the interface of the containment internal structures and the containment vessel. These analyses showed potential uplift of the containment vessel and containment internal structures from the nuclear island basemat for the Review Level Earthquake (RLE). Based on these analyses, Westinghouse provided shear studs between the containment vessel and the nuclear island basemat to provide additional margin for the Review Level Earthquake (RLE). These studs were then designed to accommodate pressurization of the containment vessel. The number of studs required for containment pressure was more than double the number required for seismic overturning for the RLE at the hard rock site. Since the overturning moments for soil sites are similar to those for hard rock, the number of shear studs provided is also sufficient to prevent uplift or sliding of the containment vessel with respect to the basemat for the various soil conditions. The NRC staff audited calculation "Containment Vessel Shear Studs", APP-1100-S2C-102, Revision 0, during the December 15–16, 2003 audit.

d. Section 7.2 of TR-03, Revision 1, has been revised to show only the damping value of 5% used in 2D ANSYS lift-off analyses for the soft-to-medium case. This value was based on comparison to the 2D SASSI analyses for the soft-to-medium site.

Reference: None

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

Revise fifth paragraph of Section 2.4.2 as follows:

Comparison of floor response spectra for these two cases shows that the liftoff has insignificant effect on the SSE floor response spectra. Thus, the superstructure may be designed neglecting liftoff. The basemat design considers the effects of liftoff as described in Section 2.6.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-14
Revision: 0

Question:

In Section 2.4.2, the last paragraph (Page 11 of 83) states that comparison of floor response spectra and the maximum member forces and moments for the two cases (the case of linear soil springs able to take both tension and compression, and the case of nonlinear soil springs where the vertical springs act in compression only and the horizontal springs are active when the vertical springs are closed and inactive when the vertical springs lift off) show that the lift-off has insignificant effect on the SSE response. Provide these comparisons (figures and/or tables) in the technical report.

Westinghouse Response:

The floor response spectra comparisons were provided in Figure 7.2-1 of Reference 1 (TR03) for soft to medium soil. They are shown in Figure RAI-TR85-SEB1-14-1. The lift-off has insignificant effect on the SSE response.

The effect of lift off on the maximum member forces are shown in Table RAI-TR85-SEB1-14-1 for the hard rock site. A similar comparison was not made for the soft to medium soil since the floor response spectra comparisons showed no significant differences.

Reference:

1. APP-GW-S2R-010, Rev 1, “Extension of Nuclear Island Seismic Analyses to Soil Sites”, September, 2007

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:

Revise last paragraph of section 2.4.2 as follows:

Comparison of floor response spectra for these two cases show that the liftoff has insignificant effect on the SSE response.

TABLE RAI-TR85-SEB1-14-1- MAXIMUM MEMBER FORCES AND MOMENTS (×10^3)

HARD ROCK SITE

Stick	Elem	Elevations		Linear (*rocks_di*)			Non-linear (*liftoff*)			Ratio Non-linear / Linear		
				Axial	Shear	M	Axial	Shear	M	Axial	Shear	M
ASB	1	60.50	66.50	47.34	50.65	5020.9	46.58	52.94	4982.3	0.984	1.045	0.992
	2	66.50	81.50	16.05	10.54	2634.2	15.76	10.83	2616.0	0.982	1.028	0.993
	3	81.50	91.50	53.57	14.24	6474.3	52.10	14.31	6453.8	0.973	1.005	0.997
	4	91.50	99.00	49.52	12.20	6340.9	48.23	11.96	6307.9	0.974	0.980	0.995
	5	99.00	106.17	46.34	54.86	6253.7	45.22	54.49	6195.8	0.976	0.993	0.991
	6	106.17	116.50	44.23	53.50	5884.3	43.25	53.18	5783.9	0.978	0.994	0.983
	7	116.50	134.87	39.33	48.07	5366.4	38.71	48.04	5222.2	0.984	0.999	0.973
	31	134.87	145.37	34.35	40.81	4592.7	34.15	40.87	4532.8	0.994	1.001	0.987
	32	145.37	153.98	32.44	37.66	4210.7	32.39	37.75	4193.3	0.998	1.002	0.996
	33	153.98	164.51	30.52	34.71	3929.2	30.34	33.80	3912.9	0.994	0.974	0.996
	34	164.51	179.56	28.77	31.99	3591.0	28.64	30.84	3576.2	0.995	0.964	0.996
	35	179.56	200.00	26.46	28.88	3110.1	26.44	28.75	3097.4	0.999	0.995	0.996
	36	200.00	220.00	24.82	27.39	2482.6	24.80	27.26	2477.4	0.999	0.995	0.998
	37	220.00	242.50	22.93	24.87	1918.2	22.85	24.82	1889.7	0.997	0.998	0.985
	38	242.50	265.00	20.77	21.41	1337.2	20.68	21.13	1336.5	0.996	0.987	0.999
	301	265.00	295.23	17.53	15.77	896.0	17.60	15.88	900.3	1.004	1.007	1.005
	303	295.23	333.13	3.08	6.82	277.6	3.09	7.00	284.3	1.003	1.026	1.024
SCV	401	100.00	104.12	4.05	6.85	869.5	3.94	6.77	867.2	0.973	0.988	0.997
	402	104.12	110.50	4.02	6.80	840.7	3.89	6.72	838.7	0.968	0.988	0.998
	403	110.50	112.50	4.02	6.80	797.4	3.89	6.72	795.8	0.968	0.988	0.998
	405	112.50	131.68	3.90	6.63	781.6	3.75	6.56	780.1	0.962	0.989	0.998
	406	131.68	138.58	3.71	6.39	650.6	3.58	6.32	650.4	0.965	0.989	1.000
	407	138.58	141.50	3.71	6.39	606.5	3.58	6.32	606.8	0.965	0.989	1.000
	408	141.50	162.00	3.51	6.11	583.4	3.38	6.05	583.7	0.963	0.990	1.001
	409	162.00	169.93	3.26	5.73	452.5	3.15	5.69	453.7	0.966	0.993	1.003
	410	169.93	200.00	2.84	5.09	397.3	2.75	5.06	398.5	0.968	0.994	1.003
	411	200.00	224.00	2.36	4.22	232.6	2.29	4.21	234.3	0.970	0.998	1.007
	412	224.00	244.21	1.32	2.59	114.2	1.27	2.60	115.4	0.962	1.004	1.011
	413	244.21	255.02	1.00	1.90	54.4	1.00	1.90	55.2	1.000	1.000	1.015
	414	255.02	265.83	0.76	1.36	29.0	0.78	1.37	29.4	1.026	1.007	1.014
	415	265.83	273.83	0.51	0.84	11.1	0.53	0.85	11.2	1.039	1.012	1.009
	416	273.83	281.90	0.21	0.31	2.5	0.22	0.31	2.5	1.048	1.000	1.000
CIS	500	60.50	66.50	46.41	35.78	4344.1	45.66	37.40	4310.9	0.984	1.045	0.992
	501	66.50	82.50	65.96	66.94	6267.2	64.75	67.80	6220.9	0.982	1.013	0.993
	502	82.50	98.00	17.05	55.76	1668.4	17.07	55.30	1674.0	1.001	0.992	1.003
	503	98.00	103.00	8.82	16.38	628.0	8.80	16.45	628.9	0.998	1.004	1.001
	504	103.00	107.17	5.84	14.44	544.0	5.84	14.52	544.5	1.000	1.006	1.001
	505	107.17	134.25	3.24	11.75	478.8	3.33	11.62	479.0	1.028	0.989	1.000
	506	134.25	153.00	0.16	1.64	31.2	0.17	1.60	30.5	1.063	0.976	0.978

	507	134.25	153.00	0.45	4.78	124.7	0.47	4.76	125.0	1.044	0.996	1.002
	508	153.00	169.00	0.11	1.99	32.9	0.11	1.99	32.9	1.000	1.000	1.000

Note: the axial force in liftoff case shows 1G-subtracted values

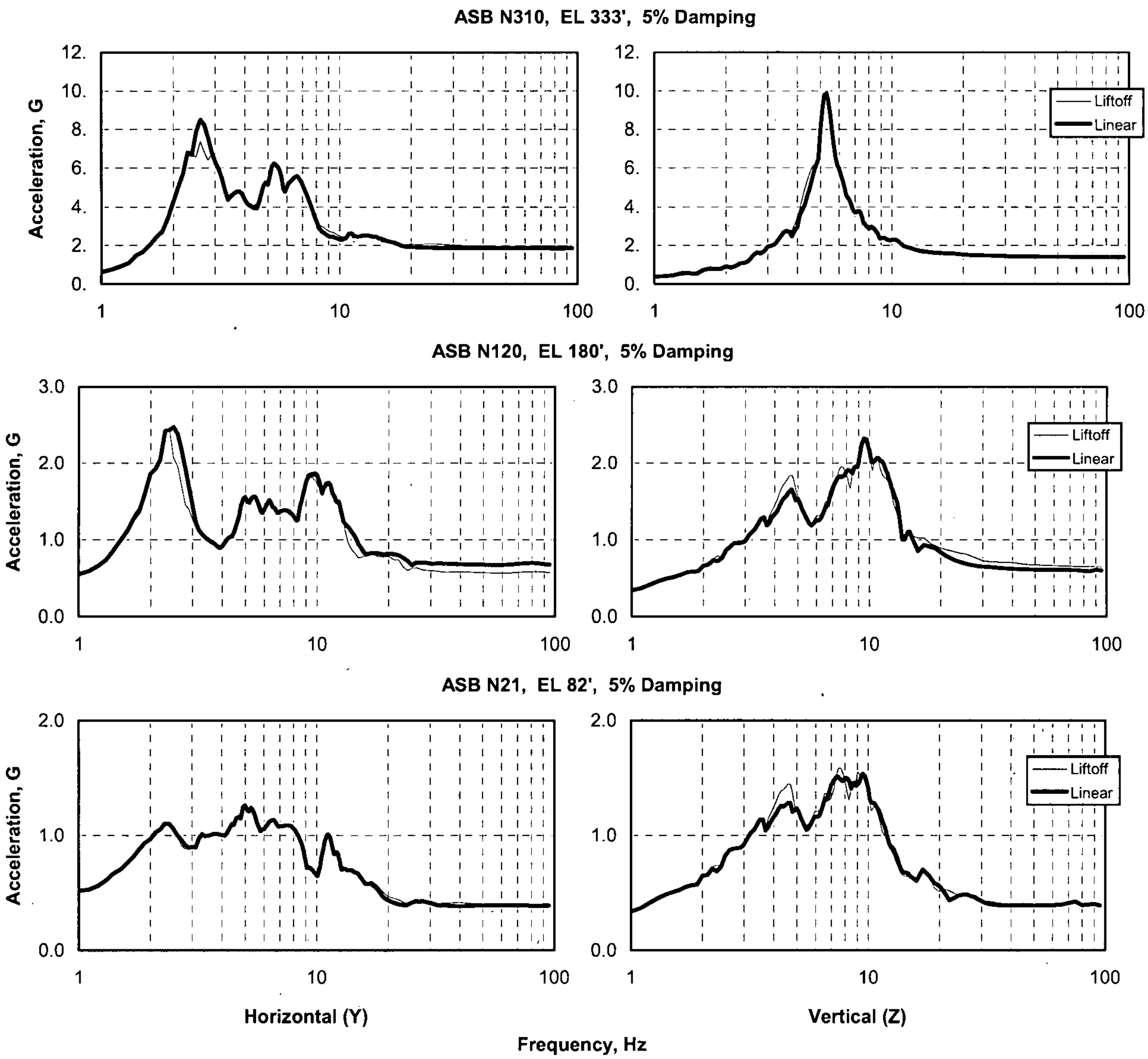

Figure RAI-TR85-SEB1-14-1- SSE Comparison of Linear Springs to Non-Linear (liftoff)

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-18
Revision: 0

Question:

In Section 2.6, the first paragraph (Page 20 of 83) states that the design of the NI basemat is described in the basemat design summary report prepared in accordance with the guidelines of SRP Section 3.8.4. From reading this sentence, it is obvious to the staff that this report is different from TR-85. Where is this report? What are the differences between these two reports (TR-85 and basemat design summary report)? Is the report completed and available for staff review?

Westinghouse Response:

The basemat design summary report is the report described in DCD subsection 3.8.5.4.3. It is an internal Westinghouse report (APP-1010-S3R-001) that provides a detailed summary of the design of the nuclear island basemat. It satisfies the guidelines of SRP Section 3.8.4 and is available for use by the NRC staff during the structural audit. This report is reconciled as required for any deviations from the design due to as-procured or as-built conditions and becomes the as-built design report.

TR85 is a higher level summary report submitted on the docket for staff review.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

RAI Response Number: RAI-TR85-SEB1-20
Revision: 0

Question:

From its review of the second paragraph of Section 2.6.1.1 (Page 21 of 83), the staff identified the following issues:

a. The first sentence of the second paragraph indicates that the subgrade modulus used for each of the 2D SASSI cases are based on the Steinbrenner method previously used for the AP600. These calculations used the same degraded shear modulus properties in each layer as used in the SASSI analyses. Provide a detailed description of how these properties were developed using the Steinbrenner method.

b. The fifth sentence states that floor response spectra from the ANSYS analyses compared well in the frequency range of soil structure interaction to the results of 2D SASSI. Since this paragraph discussion is under the title "3D ANSYS Equivalent Static Non-Linear Analysis," it is not clear which ANSYS analyses were performed for this purpose. This needs to be explained.

Westinghouse Response:

a. The degraded shear modulus properties used in the SASSI analyses are calculated from a one dimensional soil column using SHAKE. These degraded properties are input in an EXCEL spreadsheet. Settlement is calculated due to each soil layer using the Steinbrenner formula. A typical worksheet is shown in Figure RAI-TR85-SEB1-001 for the dry soft to medium soil profile. Additional information on use of the Steinbrenner method is provided in the response to RAI-TR85-SEB1-005.

b. The comparisons described in the fifth sentence of section 2.6.1.1 were comparisons of 2D ANSYS to 2D SASSI results.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:

Revise second paragraph of section 2.6.1.1 as follows:

Table 2.6-1 shows the subgrade modulus calculated for each of the 2D SASSI cases using the Steinbrenner method previously used for the AP600. These calculations used the same degraded shear modulus properties in each layer as used in the SASSI analyses. They used a constant Poisson's ratio and do not consider the effect of the water table up to grade. The subgrade moduli shown in Table 2.6-1 were used in the 2D ANSYS analyses described in section 2.4.2. Floor response spectra from the 2D ANSYS analyses compared well in the frequency range of soil structure interaction to the results of 2D SASSI. These comparisons confirmed that the subgrade moduli provide a close match for the overall dynamic response.

Soft-to-medium Soil

B	140 ft
L	234.5 ft
l (= L / B)	1.675

Depth ft	*H* ft	*Density* kcf	*VS* ft/s	*ν*	*G* ksf	*d* (= H / B)	*F1*	*F2*	*FS*	*Settlement* ft per 1 ksf
5.0		0.110	939	0.35	3012					
10.0		0.110	939	0.35	3012					
15.0		0.110	1045	0.35	3731					
20.0		0.110	1045	0.35	3731					
25.0		0.110	1231	0.35	5177					
30.0		0.110	1231	0.35	5177					
33.5		0.110	1305	0.35	5818					
39.5		0.110	1305	0.35	5818					
45.0	5.5	0.110	1356	0.35	6281	0.039	0.000	0.010	0.004	3.395E-05
52.5	13.0	0.110	1480	0.35	7483	0.093	0.002	0.022	0.010	4.186E-05
60.0	20.5	0.110	1480	0.35	7483	0.146	0.004	0.033	0.017	4.522E-05
66.0	26.5	0.110	1554	0.35	8250	0.189	0.007	0.041	0.022	3.492E-05
73.0	33.5	0.110	1554	0.35	8250	0.239	0.010	0.049	0.029	4.297E-05
80.0	40.5	0.110	1554	0.35	8250	0.289	0.015	0.057	0.036	4.518E-05
90.0	50.5	0.110	1675	0.35	9584	0.361	0.023	0.067	0.047	5.850E-05
100.0	60.5	0.110	1675	0.35	9584	0.432	0.032	0.075	0.058	6.141E-05
110.0	70.5	0.110	1675	0.35	9584	0.504	0.042	0.082	0.070	6.371E-05
120.0	80.5	0.110	1675	0.35	9584	0.575	0.053	0.088	0.082	6.539E-05
										4.931E-04

---> Kv = 2028 kcf

$$Settlement = q \cdot B \cdot \left[\frac{FS_1}{2 \cdot (1+\nu_1) \cdot G_1} + \sum_{k=2}^{N} \frac{FS_k - FS_{k-1}}{2 \cdot (1+\nu_k) \cdot G_k} \right]$$

$$FS = (1-\nu^2) \cdot F_1 + (1 - \nu - 2 \cdot \nu^2) \cdot F_2$$

$$F_1 = \frac{1}{\pi} \cdot \left[l \cdot \log_e \frac{\left(1+\sqrt{l^2+1}\right)\sqrt{l^2+d^2}}{l\left(1+\sqrt{l^2+d^2+1}\right)} + \log_e \frac{\left(l+\sqrt{l^2+1}\right)\sqrt{1+d^2}}{l+\sqrt{l^2+d^2+1}} \right]$$

$$F_2 = \frac{d}{2\pi} \cdot \tan^{-1} \frac{l}{d\sqrt{l^2+d^2+1}}$$

FS : settlement factor

q : uniform stress on soil under a rectangular loaded area

Table below shows settlement below locations on nuclear island.

Results from multiple uses of spreadsheet changing B and L

Locations		*B'*	*L'*	*Corner Settlement of B' x L'*	*Settlement at the Locations*
X / B	*Y / L*	ft	ft	ft per 1 ksf	ft per 1 ksf
0	0	140	234.5	0.000493	0.000493
0.5	0.5	70	117.25	0.000540	0.002162

Stiffness = 0.8 / center S kcf
578

Figure RAI-TR85-SEB1-001
Calculation of Subgrade Modulus by Steinbrenner Formula

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-26
Revision: 0

Question:

Section 2.6.1.4 refers to Figures 2.6-4 to 2.6-8 for the bearing pressure contours for the five load cases resulting in the maximum bearing reactions. Provide an explanation for the following:

a. If these results are for the 3D ANSYS nonlinear (uplift) analysis with no tension in the soil springs, then why does Figure 2.6-7 show in the north-east corner of the NI a bearing pressure value labeled "MN" which according to the text in the upper left portion in the Figure is equal to -77.5 ksf (negative value presumably representing tension/uplift)? This observation is also applicable to the other figures in Section 2.6.

b. The maximum bearing pressure value of 52.8 ksf in compression is larger than the maximum bearing pressure calculated using the 2D ANSYS nonlinear time history analysis shown in Figure 2.4-5 and tabulated in the site interface soil data for use in DCD Table 2-1 (see Section 2.4.3 of the technical report). Therefore, explain why isn't this higher value from the 3D ANSYS analysis used as the maximum bearing pressure for the site interface requirement? While the 2D ANSYS analysis is more accurate in terms of being a dynamic time history analysis, the 3D ANSYS analysis is more accurate in terms of having a three dimensional model, representing all of the NI structures as separate cantilevers and in much greater detail, and including the flexibility of the foundation basemat thereby eliminating the assumption of a single rigid beam to represent the entire basemat in the 2D ANSYS model.

c. Provide the contour plot for the case of +0.4 NS +1.0 EW +0.4 Vertical, which may be a worst case since the dimension of the auxiliary building in the North direction from the centerline of the NI is smaller than the dimension in the South direction. Was a review done to ensure that the figures in Section 2.6 represent the bounding maximum and minimum cases?

Westinghouse Response:

a. The results shown in Figure 2.6-7 are for the 3D ANSYS nonlinear (uplift) analysis with no tension in the soil springs. The plots were created by multiplying the downward deflections by the subgrade modulus and then plotting the tension values in gray. The north-east corner of the NI has the maximum upward deflection and would have a value of -77.5 ksf. This value appears in the ANSYS plot. This observation is also applicable to the other figures in Section 2.6.

b. See response to part (b) of RAI-TR85-012.

c. The contour plot for the case of +0.4 NS +1.0 EW +0.4 Vertical is shown in Figure RAI-TR85-SEB1-1. The figures in Section 2.6 represent the bounding maximum and minimum cases at the corners and west edge of the shield building as summarized in Table 2.6-3. Results for 16 cases were considered in the basemat design as identified in the response to RAI-TR850SEB1-27.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

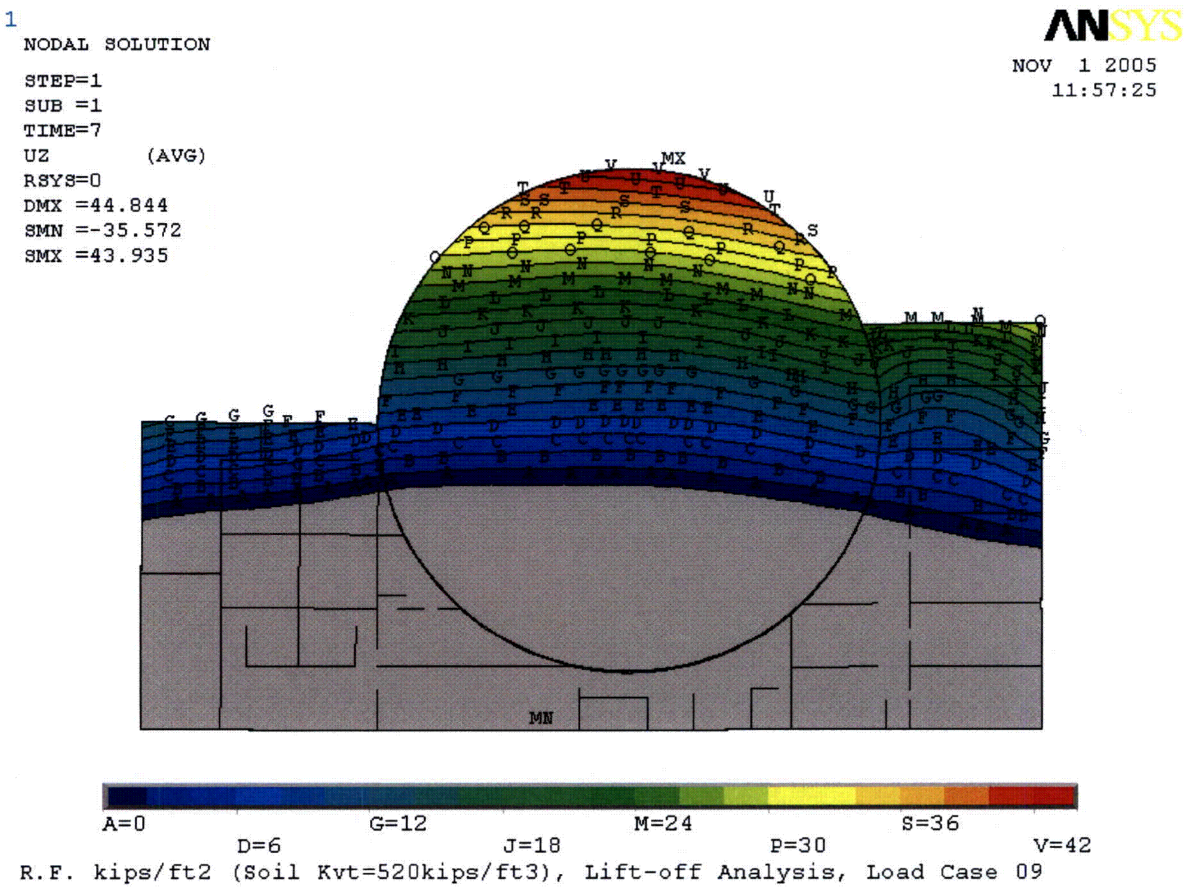

Figure RAI-TR85-SEB1-1 Soil Bearing Pressure in Load Case 3-9 (+0.4xSns+1.0xSew+0.4xSvt)

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-31
Revision: 0

Question:

Section 2.7 describes various basemat design studies performed to evaluate the effect of lower stiffness soil springs, effect of soil depth under vertical loads, effect of side soils under vertical loads, and characteristics of horizontal loading. However, there was no study for the AP1000 to evaluate the effect for horizontal variation in soil stiffness. Section 2.2.1 did discuss a study for the AP600 to evaluate the effect of horizontal stiffness variation. However, in view of the changes made in the AP1000 design, the use of two way slab design for the AP1000 versus one way slab design for the AP600, and the need to check more than just one bay which was done in the AP600 basemat, provide the technical basis for demonstrating that the AP1000 design is adequate for horizontal variation in soil stiffness. If the 20% margin requirement used in design is meant to account for the horizontal soil variation, then provide the basis for the 20% criteria. Note that the 20% margin criteria was already used to address the effect of lower stiffness soil springs discussed in Section 2.7.1.1, and therefore, the 20% may not be available to also address the horizontal stiffness variation in the soil. The response to this issue should address the horizontal soil variation effects for calculating the maximum bearing pressure, loadings for stability evaluation, and the design of the basemat.

Westinghouse Response:

The variation of foundation stiffness in the horizontal plan is addressed in the criteria for evaluation of the site in DCD subsection 2.5.4.5.3 (this is shown in Section 5 of TR85 and has been included in DCD Rev 16). The maximum bearing pressure, loadings for stability evaluation, and the design of the basemat have been addressed for uniform sites, as shown below. Additional analyses would be required for non-uniform sites.

For a site to be considered uniform, the variation of shear wave velocity in the material below the foundation to a depth of 120 feet below finished grade within the nuclear island footprint shall meet the criteria outlined below:

- The depth to a given layer indicated on each boring log may not fall precisely on the postulated "best estimate" plane. The deviation of the observed layers from the "best-estimate" planes should not exceed 5 percent of the observed depths from the ground surface to the plane. If the deviation is greater than 5 percent, additional planes may be appropriate or additional borings may be required, thereby diminishing the spacing.

- For a layer with a low strain shear wave velocity greater than or equal to 2500 feet per second, the layer should have approximately uniform thickness, should have a dip no greater than 20 degrees and the shear wave velocity at any location within any layer should not vary from the average velocity within the layer by more than 20 percent.

- For a layer with a low strain shear wave velocity less than 2500 feet per second, the layer should have approximately uniform thickness, should have a dip no greater than 20 degrees and the shear wave velocity at any location within any layer should not vary from the average velocity within the layer by more than 10 percent.

The 20% margin requirement used in design is intended to account for all possible sources of variation within a site meeting the criteria for a uniform site.

Local variations in shear wave velocity affect the subgrade modulus in local areas. The variation in subgrade modulus will be less than the variation in the shear wave velocity due to 3D effects in the soil. The effect of variations on the AP1000 will be similar to those evaluated for the AP600 and described in Section 2.2.1 of the report. The use of two way slab design for the AP1000 versus one way slab design for the AP600 does not affect the conclusions from the AP600 study since the significant parameter is the bearing pressure. The AP600 studies included:

- Local variation of soil stiffness was considered. A buried rock pinnacle was considered at a soft-to-medium soil site and the increase in reactive soil pressure was estimated using linear elastic models. The analysis indicated that the increase in soil pressure was less than 15 percent for 15 feet of cover and less than 5 percent with 20 feet.

The studies described in Subsection 2.7.1.1 reducing the subgrade modulus from 520 kcf to 260 kcf increased bearing pressures and reinforcement demand at some locations (less than the 20% margin). A subgrade modulus of 260 kcf could represent a deeper soft to medium soil site. Subsection 2.7.1.2 and 2.7.2 describe 2D and 3D analyses with finite element models of the soil. These studies demonstrated that the effects of the soil directly below the basemat were significant and reduced the member forces in each bay of the basemat. This effect is not included in the Winkler spring subgrade modulus model. The studies showed that the design of the basemat using soil springs with a subgrade modulus of 520 kcf would bound other soil profiles.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR85-SEB1-33
Revision: 0

Question:

Section 2.7.2 describes the study of the two critical bays of the basemat using the VECTOR computer code. From the very short description of the three analytical models (a, b, and c), which are also shown on Figures 2.7-5, 2.7-6, and 2.7-7, it is not evident what the models consists of and the associated loading. Provide further information to describe the model and loading, including labeling of the models to explain each feature shown in the figures. Also, describe how the horizontal restraint from the soil (referred to in Section 2.7.2, fifth paragraph) was modeled since it appears to have a very significant impact on the half-space model.

Westinghouse Response:

The models shown in Figures 2.7-5, 2.7-6 and 2.7-7 represent 3 ½ bays on the north end of the auxiliary building. They include one half of the critical bay between column lines K and L and have a symmetric boundary condition at mid bay.

Figure RAI-TR85-SEB1-1 provides an enlarged view of the west end (bay Q to P) of the model of the basemat (Figure 2.7-6). The concrete and reinforcement is represented in the model as described in the annotations to the figure. Vertical displacements are imposed at the location of the auxiliary building walls Q, P, N, and L, thereby pushing the model down onto the soil springs.

In the model on soil (Figure 2.7-7), the soil springs were replaced by soil elements connected directly to the concrete elements. Shear transfer between the concrete and soil elements was checked and found to be less than the frictional capacity.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

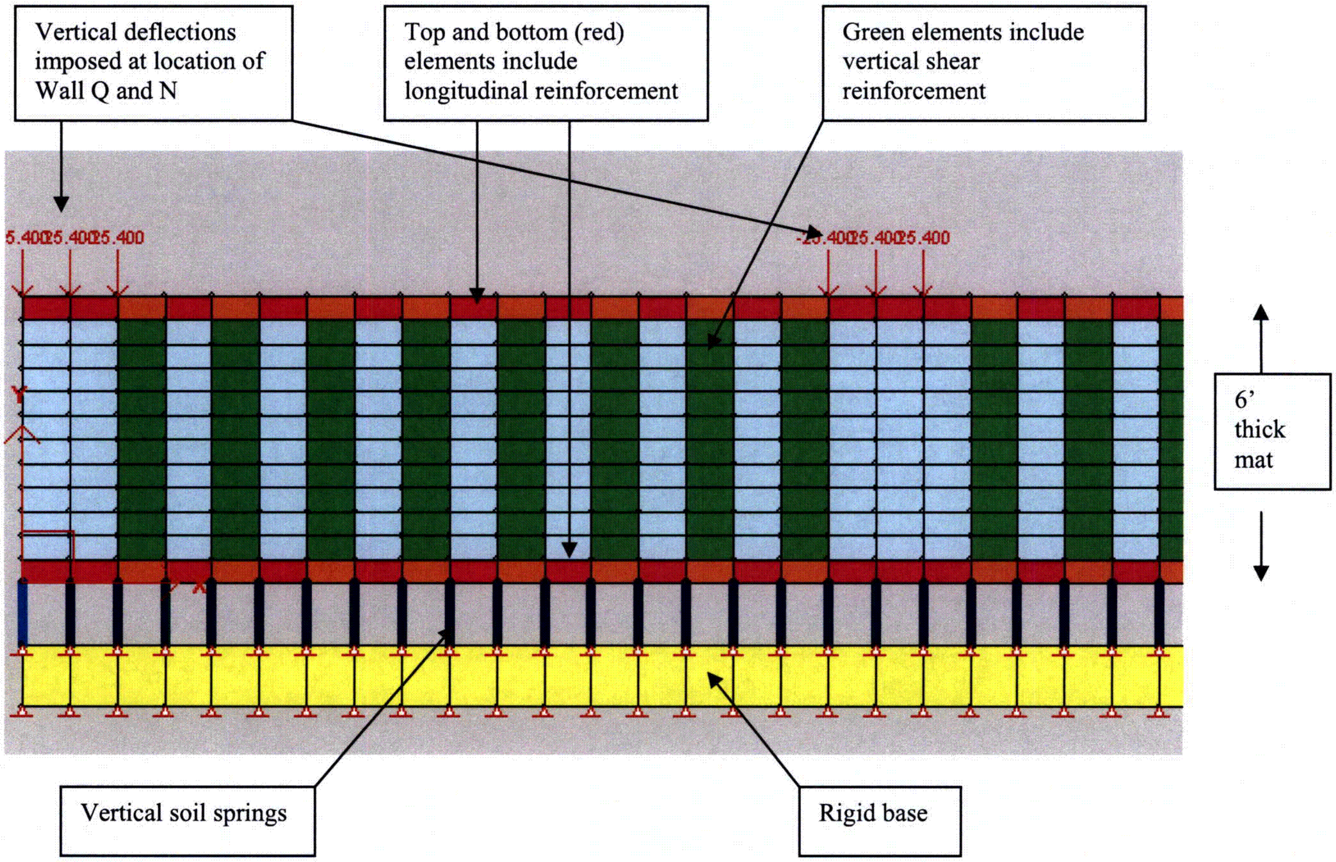

Figure RAI-TR85-SEB1-1 Enlarged View of East End of Vector2 Model on Soil Springs