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NSD-NRC-96-4825
DCP/NRC0608
Docket No.: STN-52-003

September 25, 1996

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: RESPONSE TO NRC QUESTIONS ON SEISMIC ANALYSIS

Dear Mr. Quay:

Attached are responses for three questions discussed at the meeting on seismic analysis in San Francisco from June 17 through June 20, 1996. These discussions, questions, and comments are documented in an NRC letter dated July 18, 1996, Subject: "Summary of Meeting to Discuss Westinghouse AP600 Seismic Analysis."

The questions from the NRC letter that are addressed include the follov ıg:

B.4.a. (DSER Open Item 3.7.2.4-7, OITS #649) Seismic Soil Pressu ɔn Exterior Walls

B.5. (RAI 230.96, OITS #3245) Seismic Analysis Model and Design Moments and Shears

C.8. 60 Percent Response Spectra Requirement at Basemat Level

The conclusion of our review of these issues is that previous work is acceptable and no additional analysis or SSAR change is required. The detailed responses are attached.

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If you have any questions or require additional information, please contact Donald Lindgren at (412) 374-4856.

D. A. Lindgren /FOR
Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

Attachment

cc: D. Jackson, NRC
G. Bagchi, NRC
T. Cheng, NRC

4. Design of Nuclear Island External Walls Below Grade

a. Westinghouse needs to modify the 2-D SASSI structure-to-structure interaction analyses to determine the effects of adjacent non-seismic Category I buildings on the lateral pressure on NI external walls below grade due to horizontal seismic ground motions. The modified analysis will use models that will represent the material (or gap) between the buildings.

A refined two-dimensional SSI model of the NI and the Annex Buildings was prepared. The SSI model is shown in Figure 1. The dynamic properties of the Annex Building were represented by a stick lump mass model. The analysis was performed in the EW direction for the soft rock profile for both cases of the NI alone and the NI with the Annex Building. The results in terms of maximum lateral soil pressure on the East Wall (Annex Building side) and the West Wall were obtained and enveloped for the two cases analyzed. The results corresponding to the mid-height elevations of the soil elements of the previous SSI model are compared with the respective previous soft rock case results in Figures 2 and 3. As shown in these figures, the change in the maximum lateral soil pressure is insignificant. The increase near the basemat elevation (Figure 2) is considered insignificant for the design application.

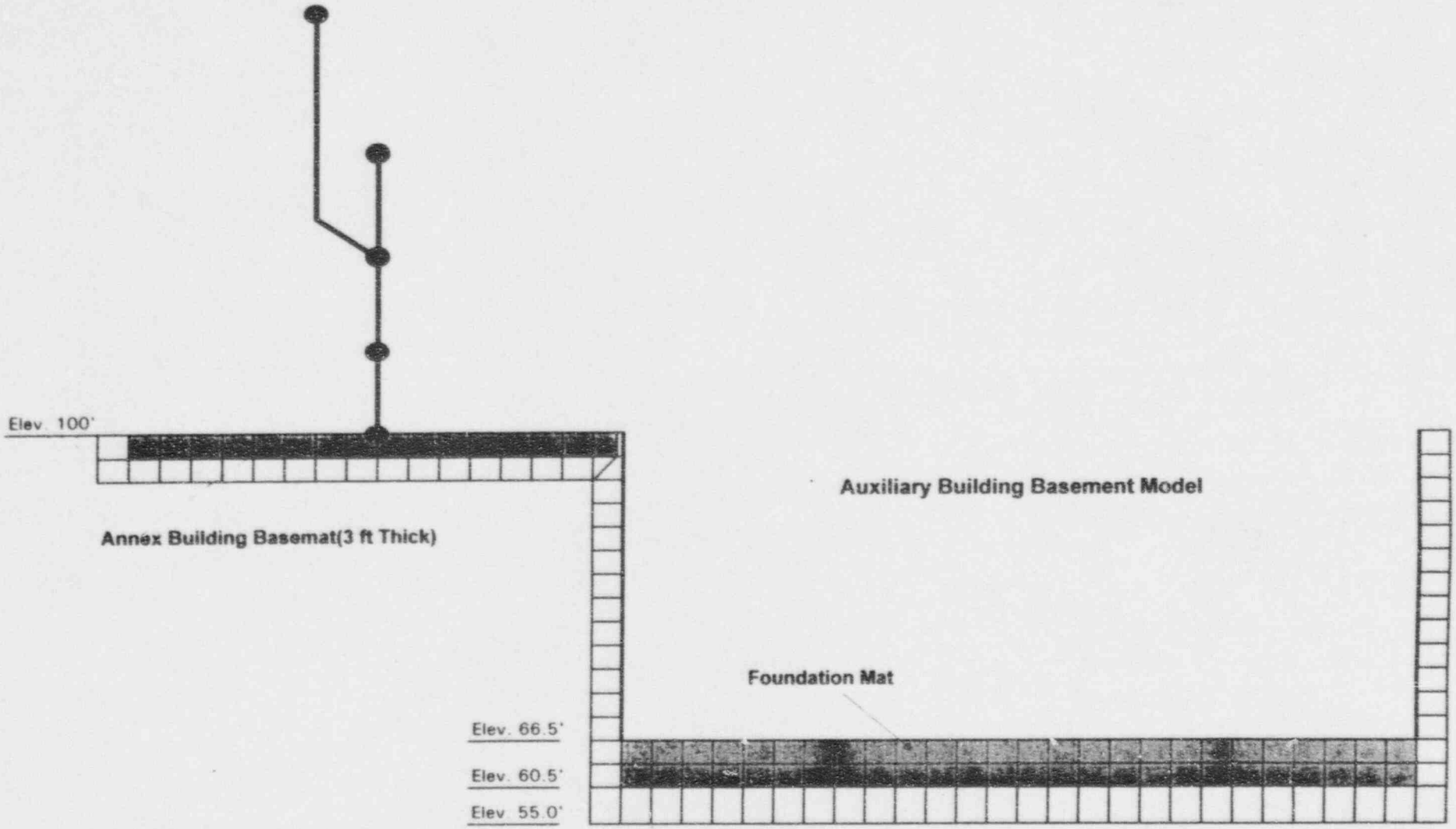


Figure 1 - Refined NI and Annex Building Models

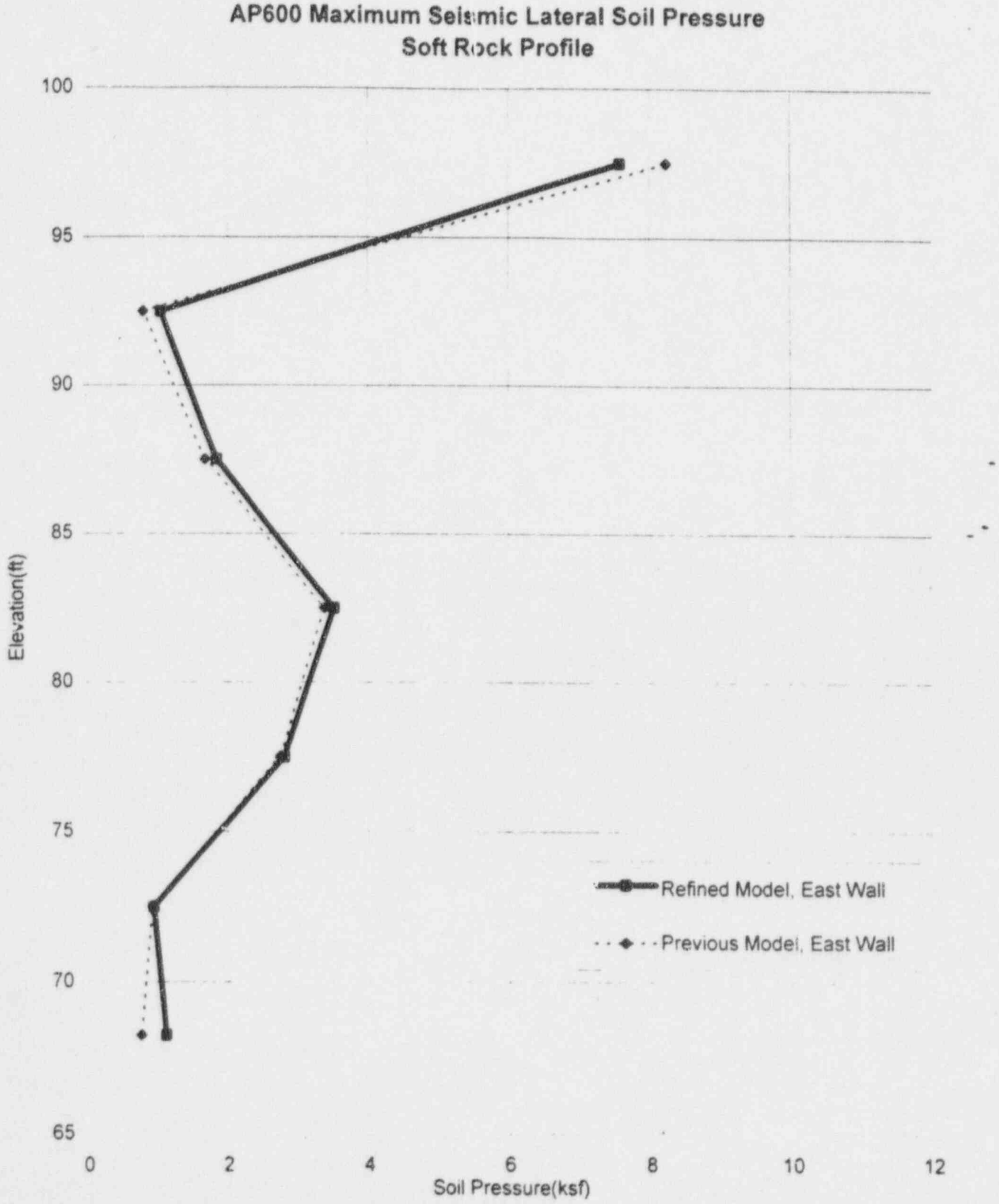

AP600 Maximum Seismic Lateral Soil Pressure
Soft Rock Profile
100
95
90
85
80
75
70
65
Elevation(ft)
0
2
4
6
8
10
12
Soil Pressure(ksf)
Refined Model, East Wall
Previous Model, East Wall

Figure 2

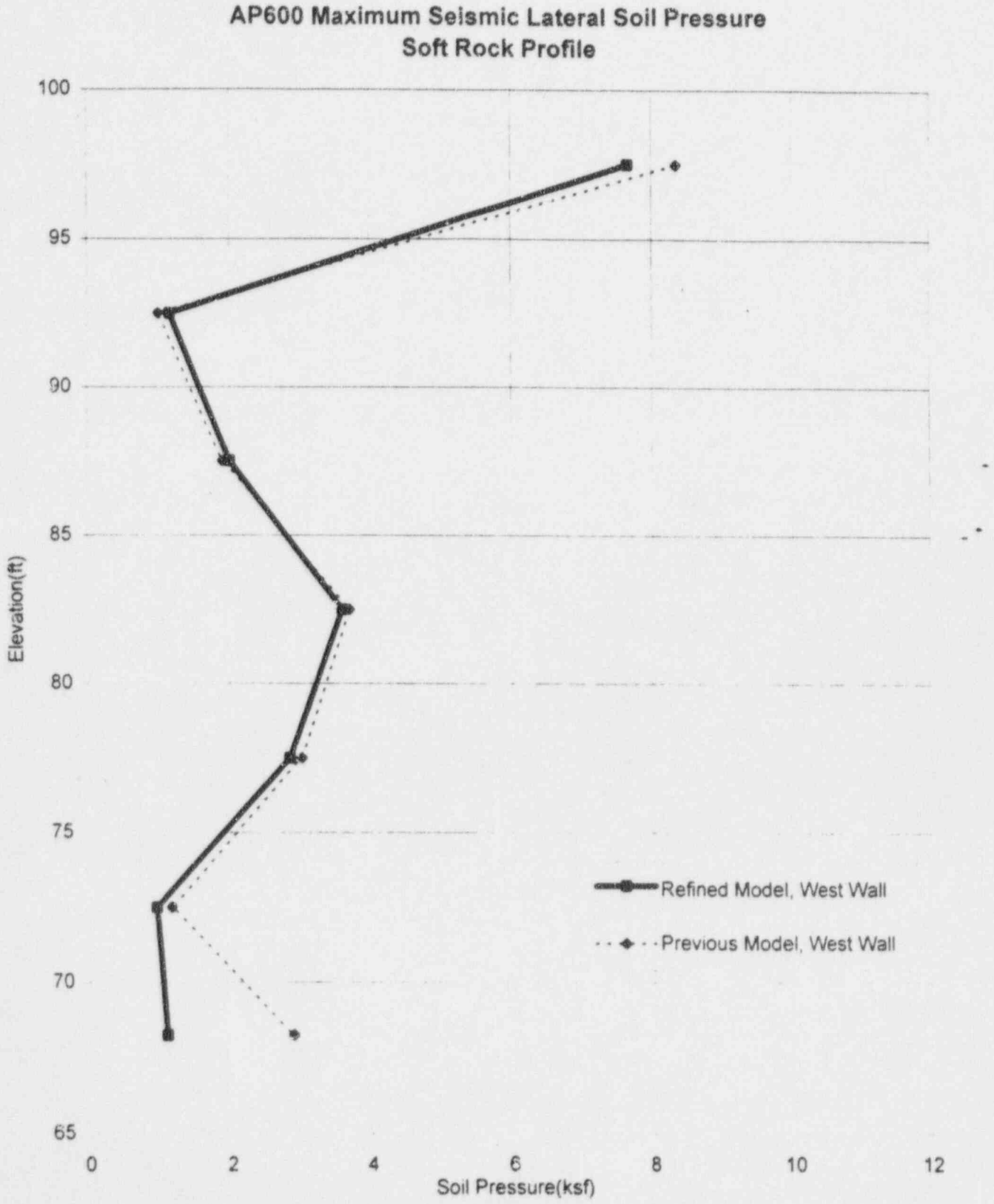


Figure 3

PRSSUREY XLS S R Chart West 96/09/11

B.5. Seismic Analysis Model and Design Moments and Shears

Compare the member forces of the shield building roof structure from the finite element model analysis with those to be calculated based ont he stick model.

We have completed the comparison of seismic member forces in the shield building roof based on the 3D lumped mass stick model and the 3D finite element model (Item 1 in the referenced letter).

A table showing the comparison of the member forces and moments is attached. The forces and moments from the two models compare as follows:

Axial Forces

Consistently higher for the FEM, ranging 6% to 7%.

N-S Shear Forces

Consistently higher for the FEM, ranging 1/2% to 5%.

E-W Shear Forces

Forces in the FEM differ within - .9% to .4%.

N-S Moments

Consistently higher for the FEM, ranging 7% to 14%.

E-W Moments

Generally lower for the FEM, ranging from 1/2% to 5%.

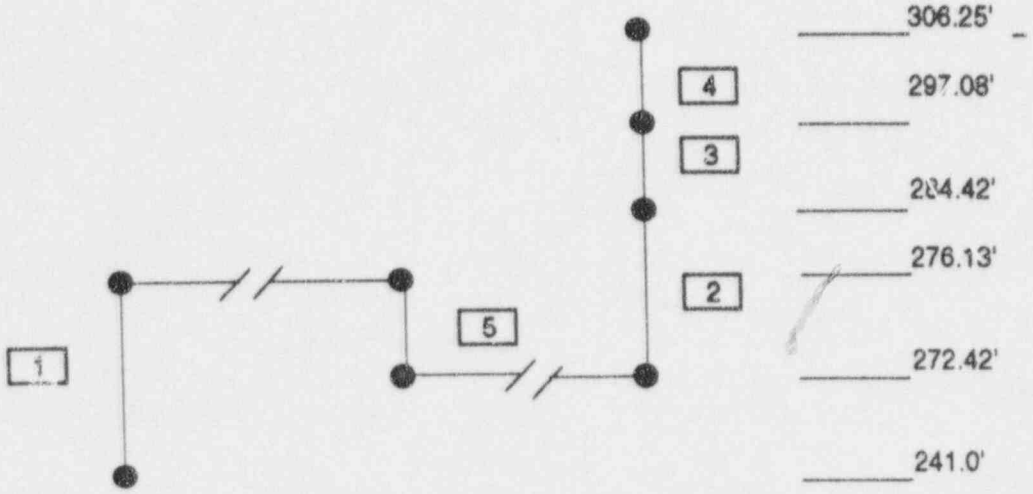
Torque

Consistently higher for FEM, ranging from 24% to 37%.

All the forces and moments compare well between the two models. The 24% to 37% difference in the torque is acceptable, since the contribution from torque is not significant in the design of the shield building.

Therefore, it can be concluded the 3D lumped mass stick models and 3D finite element models give acceptable results.

3D LUMPED MASS STICK MODEL OF OF SHIELD BUILDING ROOF



SHIELD BUILDING ROOF

COMPARISON OF SEISMIC MEMBER FORCES
3D Lumped Mass Model Vs. 3D FEM

FORCES ($X10^3$ KIPS) ; MOMENTS ($X10^3$) K-FT.

MEMBER FEM	NODE	EL.	AXIAL		N-S SHEAR		E-W SHEAR		TORQUE		N-S MOMENT		E-W MOMENT	
			STICK	FEM	STICK	FEM	STICK	FEM	STICK	FEM	STICK	FEM	STICK	FEM
	3016	306.25									24.35	27.69	22.97	24.13
4			1.48	1.58	2.40	2.29	2.51	2.50	20.50	28.02				
	3015	297.08									63.50	71.11	61.50	61.18
3			3.46	3.68	4.40	4.25	4.63	4.60	47.96	65.03				
	3014	284.42									186.00	206.88	181.00	178.02
2			7.76	8.25	8.26	8.22	8.80	8.72	128.49	168.40				
	3013	272.42									260.63	278.84	255.14	243.98
	3017	276.13									344.21	383.83	334.08	329.97
5			11.66	12.41	12.39	12.64	13.22	13.27	220.13	273.89				
	3013	272.42									367.90	405.53	359.01	349.68
	3017	276.13									344.20	383.83	334.08	329.97
1			11.66	12.41	12.39	12.64	13.22	13.27	220.00	273.90				
	3011	241.00									685.70	707.40	668.10	638.43

8. 60 Percent Response Spectra Requirement at Basemat Level

Westinghouse needs to verify the present SSI analysis results to ensure that the SSI and structural frequencies are such that the "dips" in the floor response spectra corresponding to individual soil column frequencies are enveloped by the final enveloping floor response spectra. Westinghouse has agreed to provide for each of the 4 soil categories:

a. SSI and free-field (soil column) frequencies,
b. In-structure spectra at the foundation level, and
c. Free-field spectra at the foundation level.

For the four design soil profiles consisting of the hard rock, soft rock, soft to medium stiff upper bound (2 x G_{max}), and soft medium stiff mean (1 x G_{max}) profiles, the following responses were retrieved.

- The acceleration response spectra at 2 percent damping from the free-field EW analyses at the depth of 40 ft corresponding to the basemat elevation. The results are shown in Figure 1.

- The acceleration response spectra at 2 percent damping corresponding to the basemat of the NI from the SSI EW analysis of the NI. The results are shown in Figure 2.

- A table of frequencies showing the soil column (upper 40 ft), the SSI, and the fixed base frequencies of the NI.

Based on the above results and since $f_{struct} > f_{SSI}$, the concern stated under Comment No. 8 does not apply.

Table 1

AP600 Nuclear Island

Case	Hard rock	Soft Rock	Parabolic 2 x G_{max}	Parabolic 1 x G_{max}
Soil Column Frequency(CPS)	50.00	15.21	10.45	7.15
SSI Frequency(CPS)	-	3.52	3.42	2.76
Fixed-Base Frequency(CPS)	4.35			

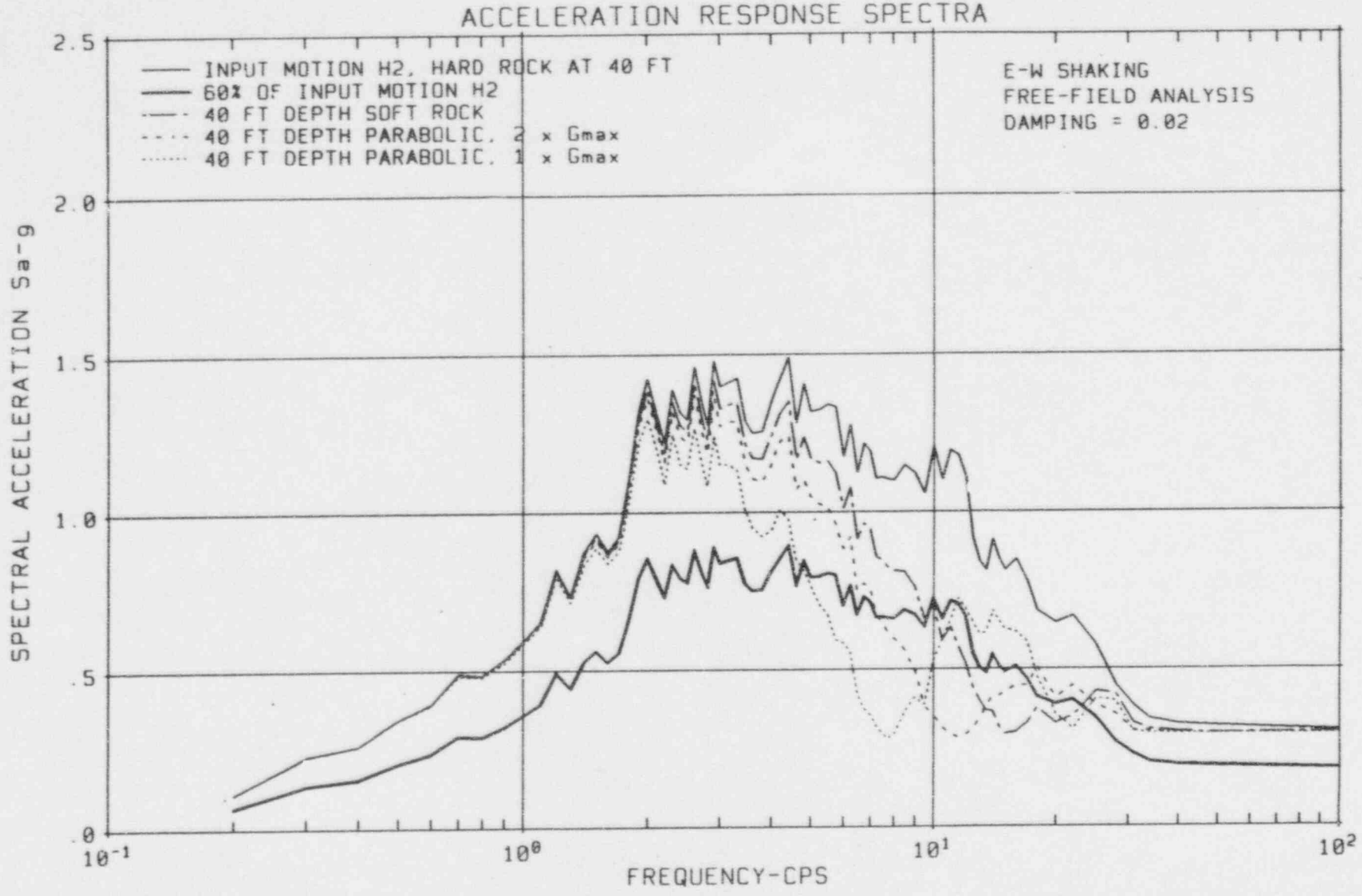

ACCELERATION RESPONSE SPECTRA
INPUT MOTION H2, HARD ROCK AT 40 FT
60% OF INPUT MOTION H2
40 FT DEPTH SOFT ROCK
40 FT DEPTH PARABOLIC, 2 x Gmax
40 FT DEPTH PARABOLIC, 1 x Gmax
E-W SHAKING
FREE-FIELD ANALYSIS
DAMPING = 0.02
SPECTRAL ACCELERATION Sa-g
2.5
2.0
1.5
1.0
.5
0
10^{-1}
10^{0}
10^{1}
10^{2}
FREQUENCY-CPS

Figure 1

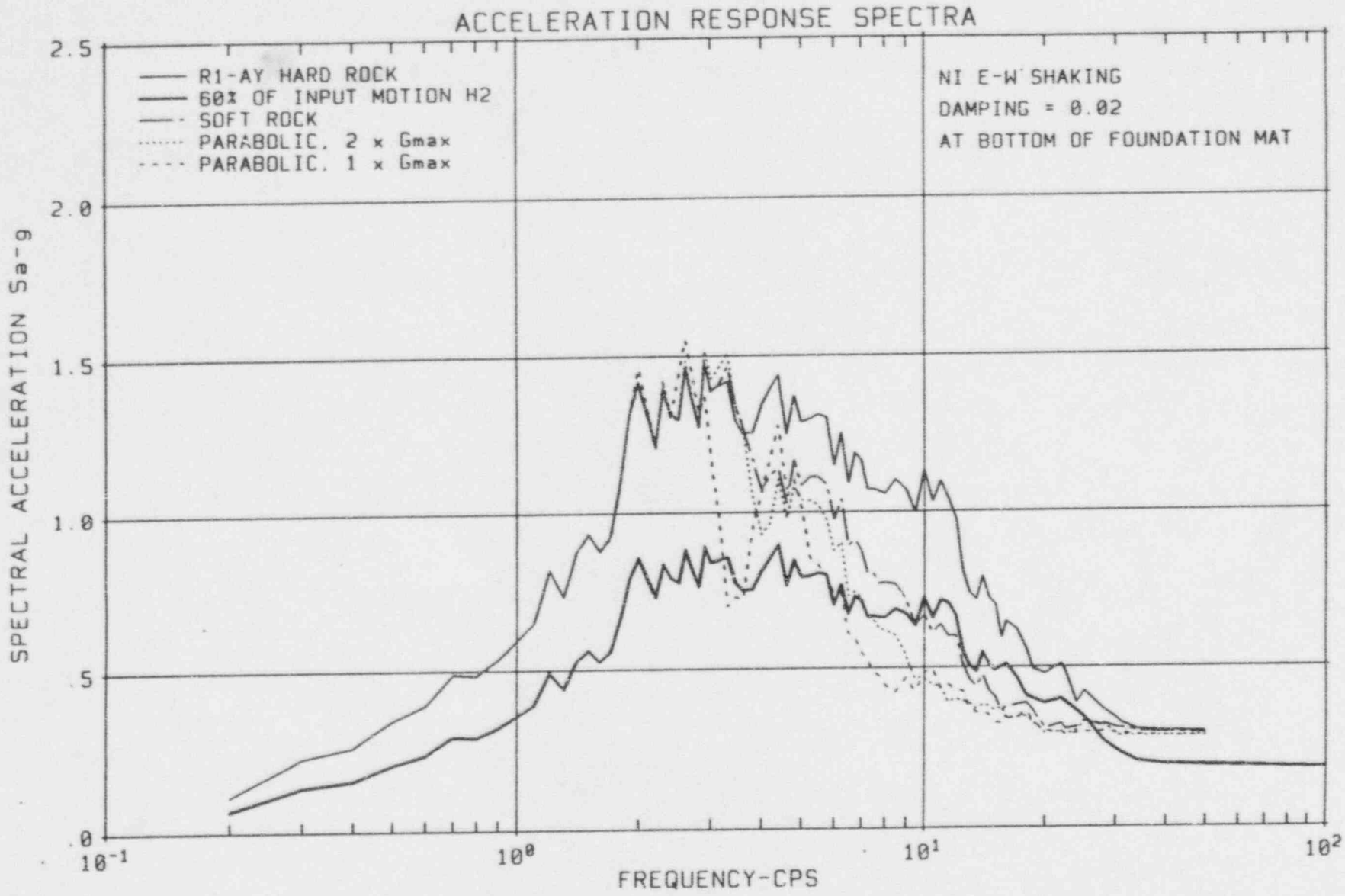

ACCELERATION RESPONSE SPECTRA
R1-AY HARD ROCK
60% OF INPUT MOTION H2
SOFT ROCK
PARABOLIC. 2 x Gmax
PARABOLIC. 1 x Gmax
NI E-W SHAKING
DAMPING = 0.02
AT BOTTOM OF FOUNDATION MAT
SPECTRAL ACCELERATION Sa-g
2.5
2.0
1.5
1.0
.5
0
10^{-1}
10^{0}
10^{1}
10^{2}
FREQUENCY-CPS

Figure 2