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D'APPOLONIA

Report

Parametric Study Soil Structure Interaction

Big Rock Point Nuclear Power Plant
Charlevoix, Michigan

Consumers Power Company
Jackson, Michigan

Report

Parametric Study
Soil Structure Interaction

D'APPOLONIA

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REPORT

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1.0 INTRODUCTION

D'Appolonia Consulting Engineers, Inc. (D'Appolonia), is pleased to submit this report to Consumers Power Company (Consumers Power) on parametric studies related to soil-structure interaction at the Big Rock Point Nuclear Power Plant. The specific studies performed and described in this report were performed in accordance with the request by the United States Nuclear Regulatory Commission (USNRC) transmitted to D'Appolonia by telephone on April 5, 1982.

1.1 BACKGROUND INFORMATION

1.1.1 "Spent Fuel Pool" Analytical Model

Since 1978, D'Appolonia has participated in two seismic evaluation studies of the reactor building structure at the Big Rock Point Nuclear Power Plant. The first study, performed in 1978, was confined primarily to the evaluation of the floor responses at the spent fuel pool level. The analytical model of the reactor building for this analysis (henceforth called the "spent fuel pool" model) consisted of a three-dimensional stick model for the reinforced concrete reactor internal structure and a single-mass representation of the steel containment shell. The analytical model of the reactor building structure, shown in Figure 1, incorporated the anticipated increased mass of the stored spent fuel pool racks.

The structure is considered to interact with the subgrade through stiffness and damping coefficients associated with the constitutive properties and stratification of the soil and rock which comprise the subgrade. The subsurface material beneath the reactor building consists of approximately 20 feet of glacial till overlying a limestone formation. At the time the 1978 study was conducted, the available subsurface data consisted of material classification and penetration resistance indicated on boring logs. No direct measurements of dynamic soil or rock properties were available. The available information was combined with results of published data and D'Appolonia's previous experience with similar subsurface materials to develop the three translational and three rotational springs and dampers. These soil-structure interaction (SSI) parameters were termed "best estimate" parameters, and their values are shown in Figure 1.

The 1978 evaluation of the reactor building was performed using an artificial earthquake time history (henceforth called the "R.G. 1.60 earthquake") which satisfies the basic requirements of the USNRC Regulatory Guide 1.60 (1973) design spectrum requirements and has a zero-period horizontal ground acceleration equal to 0.12g. The zero-period vertical acceleration was taken as two-thirds of the horizontal, i.e., 0.08g. The two spectra are shown in Figures 2 and 3. The floor time histories were evaluated using a linear numerical time-history integration technique, the artificial earthquake being used as excitation to the analytical model. The floor responses so evaluated were considered as the "best estimate" responses of the reactor building.

Because no direct information regarding dynamic soil and rock properties was available, effects of variation in SSI parameters were also evaluated in the 1978 study. The soil spring constants used in the "best estimate" analysis were reduced by a factor of 0.5 for a lower bound analysis and were also increased by a factor of 1.5 for an upper bound analysis. Mode frequency analyses of these three models (best estimate, lower bound, and upper bound) were performed. The results of the mode frequency analyses, summarized in Table 1, indicated that the effects of SSI parameter variation on the natural frequencies of the analytical model are small. However, D'Appolonia recommended a procedure (D'Appolonia, 1978) that would envelop the anticipated responses of the reactor building associated with variations in the SSI parameters.

Following the evaluation of the floor response spectra, the results of a geophysical cross-hole survey at the plant site became available. The SSI parameters were then reevaluated and the revised parameters ("cross-hole value") were compared with the best estimate values. In the derivation of the SSI parameters, a reduced shear modulus, estimated at 90 percent of the small-strain shear (cross-hole test) modulus, was used to account for possible strain softening in the glacial till. It may also be mentioned that the SSI spring constants used in the analysis were based on a continuum solution, which is generally considered to yield lower values of stiffness than those based on a finite element representation. The comparison indicated that the soil springs based on cross-hole data are about 5 to 35 percent greater than the corresponding best estimate values, depending on the displacement mode considered. The damping values based on cross-hole data are approximately 5 to 20 percent higher than the corresponding best estimate values (D'Appolonia, 1979).

Because these ranges of parameter variations are within the limitations generally associated with dynamic analyses, and because the cross-hole based estimates of springs and dampers were well within the ranges considered in the floor response evaluation study, additional studies were deemed unnecessary and thus were not recommended.

1.1.2 "Systematic Evaluation Program (SEP)" Model

Since the performance of the 1978 study, D'Appolonia has been participating in the seismic safety margin evaluation of the Big Rock Point Nuclear Power Plant under the auspices of the Systematic Evaluation Program (SEP). The analyses of the plant structures, including the reactor building, were completed by D'Appolonia for the same earthquake (R.G. 1.60 earthquake) input used in the spent fuel pool evaluation study. The scope of work in the SEP investigation included evaluation of structural safety and generation of floor response spectra at all significant elevations of the reactor building. The analysis of the reactor building was similar to that used to model the response of the spent fuel pool, with the following minor changes:

- The spent fuel pool model accounted for the presence of the Primary Coolant Loop (PCL) system by including it as lumped masses. In the SEP analysis, the PCL system was represented as detailed substructures. The connection between these substructures and the reactor internal structures was accomplished through a system of rigid links extending from appropriate levels of the reactor building;

- The best estimate SSI parameters were replaced by cross-hole value SSI parameters; and

- To accommodate proper connection between the PCL and the reactor building, an additional node was introduced in the SEP stick model of the reactor internal structure at Elevation 608.5 feet. The calculated lumped masses used in the spent fuel pool analysis between Elevations 614.5 and 598.5, therefore, had to be revised slightly. The representation of the reactor building so developed for the SEP analysis is also shown in Figure 1.

In all other respects, the analytical methodologies used in the SEP evaluation using the R.G. 1.60 earthquake are the same as those used in the spent fuel pool analysis.

Having completed the above-cited investigation using the R.G. 1.60 earthquake, D'Appolonia is currently engaged in the generation of floor response spectra using the site-specific spectra developed by the USNRC for the Big Rock Point Nuclear Power Plant. The horizontal site-specific spectra are anchored at 0.105g, and the vertical spectra are anchored at two-thirds of the horizontal. The two spectra are shown in Figures 2 and 3. As part of the current study, artificial earthquake time histories matching the site-specific spectra have been developed using procedures similar to those described in the previous reports on the spent fuel pool and SEP investigations. Although this work is currently underway, some of the results obtained using the site-specific input have also been compared with those associated with the R.G. 1.60 earthquake input as part of the study described herein.

1.2 OBJECTIVES OF THE PRESENT STUDY

The basic objectives of this study may be stated as follows:

- Demonstrate that the floor response spectra developed in the seismic safety margin evaluations include adequate conservatism such that the use of such floor response spectra in subsequent analyses of subsystems (e.g., equipment) can be properly justified within levels of engineering accuracy.

- Demonstrate that any differences in the analytical results of the spent fuel pool evaluation and the SEP evaluation are within the bounds of acceptable engineering accuracy.

In the evaluation of the results of the present study, the recommendations of NUREG/CR-0098 by Newmark and Hall (1978) and the SSRT (Senior Seismic Review Team) guidelines for SEP soil-structure interaction review by Newmark, et al. (1980), may be considered.

2.0 FORMULATION OF THE PRESENT STUDY

On the basis of the telephone conversation of April 5, 1982 with the USNRC, studies dealing with parameter variations were formulated and may be described in terms of three individual tasks:

- Task 1 - Evaluate Effects of SSI Parameter Variation
- Task 2 - Evaluate Effects of Structural Damping Variation
- Task 3 - Compare Floor Response Spectra Derived Using the Spent Fuel Analytical Model with the Corresponding Spectra Derived Using the SEP Analytical Model

Subsequent paragraphs describe these tasks in detail along with relevant conclusions.

2.1 TASK 1 - EVALUATE EFFECTS OF SSI PARAMETER VARIATION

With respect to the uncertainty in soil properties, the SSRT suggested general guidelines are

> "To account for uncertainty in soil properties, the soil stiffnesses (horizontal, vertical, rocking, and torsional) employed in analysis shall include a range of soil shear moduli bounded by (a) 50 percent of the modulus coresponding to the best estimate of the large strain condition, and (b) 90 percent of the modulus corresponding to the best estimate of the low strain condition. For purposes of structural analysis, three soil modulus conditions generally will suffice corresponding to (a) and (b), above, and (c), a best estimated shear modulus." (Newmark, et al., 1980).

The subsurface conditions at the plant site consist of a relatively thin layer of glacial till deposit underlain by limestone. The shear wave velocities in the till range from approximately 1,200 feet per second at the top of the layer to about 2,700 feet per second at the interface of the till and limestone. The shear wave velocity in limestone ranges from approximately 3,300 feet per second in broken zones to about 7,000 feet per second in competent zones (D'Appolonia, 1979). These velocity measurements have been obtained through geophysical cross-hole test measurement procedures which can determine velocities within ±5 percent of the actual values (Woods, 1978). On the basis of shear wave velocity measurements, therefore, the subsurface material is very competent. Hence, for the low-level earthquake postulated for the Big Rock Point site (ZPA $\leq$ 0.12g), a large shear strain condition, generally considered to be greater than 10^{-3}, will not occur. As an estimate, the simplified procedure given by Seed and Idriss (1971) leads to the maximum strain level being not more than 2.5×10^{-5}. The reduced shear modulus associated with such strain levels is no less than 90 percent of the maximum shear modulus (cross-hole modulus). Note that the 10 percent shear modulus reduction was initially incorporated in the SEP cross-hole based SSI parameters.

Therefore, because the large shear strain condition will not occur at the Big Rock Point site, the variation of shear modulus should be no greater than 20 percent of the cross-hole modulus, for conducting parametric studies, after accounting for uncertainties in the cross-hole measurements. The usually recommended 50 percent reduction in soil modulus at a large strain level should therefore be considered as very unrealistic for the Big Rock Point site. The effects of a 50 percent reduction of the spring constants, evaluated on the basis of the cross-hole value, were, nevertheless, determined. However, D'Appolonia considers this to be an extreme lower bound condition. Similarly, an upper bound analysis was formulated, whereby the SSI spring constants based on the cross-hole value were increased by a factor of 1.5.

2.2 TASK 2 - EVALUATE EFFECTS OF STRUCTURAL DAMPING VARIATION

In the analysis of the reactor building, structural damping was represented through Rayleigh damping factors, α and β given by

$$\xi = \alpha[M] + \beta[K]$$

where [M] and [K] are the structural mass and stiffness matrices, respectively.

The value of α was considered to be zero. The value of β was calculated in accordance with the generally accepted procedure, whereby the appropriate damping levels are prescribed at the most predominant natural frequency of the structure.

Structural damping values used in the analysis of the reactor building assumed damping equal to 7 percent of critical for concrete and 4 percent of critical for the steel containment shell in accordance with the recommendations of the USNRC Regulatory Guide 1.61 (1973) for SSE conditions. The values of β were calculated to satisfy there damping levels at frequencies equal to approximately 10 Hertz for the concrete internal structure and approximately 7 Hertz for the steel structure.

The SSI damping values were calculated in a manner which is conservative compared with the SSRT recommendations. The SSRT recommends that the calculated damping values should be reduced by a factor of 0.75 for translational modes and that no reduction should be imposed on the calculated values for the rotational modes. In both the spent fuel pool and the SEP evaluations, the damping values were reduced by a factor of 0.5 for all translational and rotational modes.

Therefore, to evaluate the conservativeness of the recommended floor response spectra, it was decided that the results of the following analyses, which include the cross-hole value soil springs, should be compared:

- Case 1 - Previously reported and recommended 7 percent and 4 percent of critical damping in concrete and steel, respectively, and the 50 percent reduced soil damping values associated with cross-hole stiffness values.

- Case 2 - Assumed structural damping equal to 5 percent of critical in concrete and 2 percent of critical in steel and the revised soil damping values conforming to the SSRT recommendations.

- Case 3 - Assumed structural damping equal to 3 percent of critical in concrete and 2 percent of critical in steel and the revised soil damping values conforming to the SSRT recommendations.

It was further decided to conduct two sets of analyses for the above three cases, whereby the seismic input in the first set consists of the site-specific earthquake and in the second set the seismic input consists of the R.G. 1.60 earthquake.

2.3 TASK 3 - COMPARE FLOOR RESPONSE SPECTRA DERIVED USING THE SPENT FUEL ANALYTICAL MODEL WITH THE CORRESPONDING SPECTRA DERIVED USING THE SEP ANALYTICAL MODEL

The floor response spectra presented in the report on the spent fuel pool analysis consisted of plots which were not broadened nor smoothed. Herein, these spectra are compared with the corresponding unbroadened floor response spectra derived using the SEP model. Additionally, a mode-frequency analysis of the SEP stick model was performed to compare the participation factors with those associated with the spent fuel pool model. The differences between the two stick models are shown in Figure 1.

3.0 RESULTS OF ANALYSES

3.1 EFFECTS O. SSI PARAMETER VARIATION

The results of analyses for Task 1 are presented in Figures 4 through 6 for Node 650; Figures 7 through 9 for Node 652; and Figures 10 through 12 for Node 661. The recommended peak broadened and smoothed response spectra for the original SEP analysis are compared with the unbroadened spectra associated with the parametric analyses. For ease of review, the spectra have been compared for only two damping values, 2 and 10 percent of the critical damping.

The results indicate that for the upper bound case (Case 3), the computed floor response spectra are almost always enveloped by the recommended spectra. In general, the peaks of the upper bound spectra are 10 to 15 percent below the corresponding ordinates of the recommended spectra. The only exception occurs at Node 650 along the Y direction where, at approximately 10 Hertz and for 2 percent damping, the recommended spectral ordinate is exceeded by approximately 2 percent.

For the lower bound case, major portions of the generated spectra are well within the bounds of the recommended spectra. Although excursions outside the bounds of the spectra occur for this case, they generally do not exceed 10 to 15 percent of the recommended spectral ordinates; the largest deviation of approximately 20 percent occurs near 6 Hertz for 10 percent damping at Node 661 along the X direction (Figure 10).

As the lower bound case is, in D'Appolonia's opinion, an extreme and unrealistic condition, the generally good envelopment of the unsmoothed spectra by the recommended smooth spectra indicates an appropriately conservative representation of the response of the structure.

3.2 EFFECTS OF STRUCTURAL DAMPING VARIATION

The results of analyses for Task 2 are presented for Node 650 (the highest point on the structure). Figures 13 through 15 show the effects of structural damping variation for the site-specific earthquake input, and Figures 16 through 18 show the corresponding effects for the R.G. 1.60 earthquake input. For each input, the results are shown for three damping values: 0.5, 3, and 10 percent of critical for the site-specific earthquake input and 0.5, 2, and 10 percent of critical for the R.G. 1.60 earthquake input.

The results indicate that for Case 2 (i.e., 5 percent of critical damping in concrete and 2 percent of critical for steel), the computed spectra for the site-specific case are always enveloped by the recommended spectra. The same statement applies for the R.G. 1.60 spectra with one minor exception--the computed spectral ordinate along the X direction exceeds the recommended value by approximately 10 percent near 6 Hertz for damping equal to 0.5 percent of critical (Figure 16).

For Case 3, the computed maximum spectral ordinates for both earthquake inputs exceed the recommended spectral value along the two horizontal directions. The largest exceedance usually occurs at a single point at damping equal to 0.5 percent of critical. For damping equal to 2 percent or more, the exceedances are quite small and are rarely greater than 5 percent; a maximum difference of about 15 percent occurs along the X direction for the R.G. 1.60 case (Figure 16). All exceedances occur for frequencies below 10 Hertz.

It may be noted further that the computed spectra for all cases along the vertical direction are always enveloped by the smoothed response spectra.

On the basis of this evaluation, it is concluded that:

- The specification of the Rayleigh damping factor, β, at a frequency of about 10 Hertz has a negligible adverse effect on the high frequency response of the structure;

- For subsystem damping values equal to or greater than 2 percent of critical, the effects of lowering the structural damping are small and are well within the accuracy associated with engineering computations; and

- For very low damping values, e.g., 0.5 percent of critical, the peak of the recommended spectra would be exceeded by approximately 15 percent if concrete damping is assumed to be equal to 3 percent of critical. Furthermore, the floor response spectra for damping equal to 0.5 percent of critical would be well within the engineering level of accuracy for concrete damping assumed at 5 percent of critical.

3.3 COMPARISON OF FLOOR RESPONSE SPECTRA FOR SPENT FUEL POOL AND SEP ANALYSES

As part of Task 3, comparisons were made between floor response spectra for the spent fuel pool and SEP analyses. Figures 19 through 27 include comparisons of the two sets of floor response spectra for damping equal to 2 and 7 percent of critical. Figures 19 through 21 show comparisons for Node 650, the highest point on the structure, along the X, Y, and Z directions (note that node numbers referred to here relate to the SEP model and correspond to the node numbers for the spent fuel pool model summarized in Figures 19 through 27). Figures 22 through 24 show the corresponding spectra for Node 652 and Figures 25 through 27 for Node 661. The comparisons indicate an excellent agreement between the two models in all but one of the spectra presented. The only significant discrepancy occurs at Node 661 along the X direction (Figure 25) where the maximum ordinate of the spectra in the SEP model is obtained at a different frequency than that obtained for the spent fuel pool model. The deviation is associated with certain mass redistributions made at the level of Node 661 in order to accommodate the PCL system in the SEP analysis. Also, the reactor vessel mass, which originally was included as a rigidly supported mass in the spent fuel pool model, was included in the SEP model as a flexibly supported mass. This effect is further evidenced by the higher ordinate of the floor response spectra obtained from the spent fuel pool analysis.

As summarized in Table 2, the natural frequencies for the two stick models used in the spent fuel pool and SEP analyses are in excellent agreement. Good agreement also exists between the two models as regards the highest participation factors for each frequency.

4.0 CONCLUSIONS

The results of this study indicate that:

- A variation of not more than ±20 percent of the cross-hole shear modulus should be considered in determining soil springs. The attendant responses would be within the bounds of the recommended analytical results. However, even for an upper bound 50 percent variation in SSI parameters, the recommended spectra demonstrate adequate conservatism. For an extreme lower bound 50 percent variation in SSI parameters, the response spectra of the structure are in good agreement with the recommended spectra. Minor deviations occur at a few frequencies.

- For damping as low as 3 percent of critical for concrete structures, the recommended floor response spectra (derived using 7 percent damping) demonstrate appropriate conservatism. Most exceedances occur at a few frequencies for floor response spectra at 0.5 percent damping. These variations will not influence the design of subsystems.

- The response spectra of the two analytical models--the spent fuel pool model and the SEP model--are in close agreement. The variations noticed are commensurate with the minor differences that exist between the two models.

5.0 SUMMARY

An extensive parametric study has been performed to evaluate the conservativeness of the reactor building analysis and to examine the levels of response variation between the spent fuel pool and the SEP models. Variations in soil-structure interaction parameters and structural damping values have been examined, and the participation factors and the floor response spectra of the two analytical models have been compared. The results of the study indicate that for all variations considered, the recommended floor response spectra are adequate for engineering purposes. Also, the differences in the two analytical models used in the spent fuel pool and in the SEP evaluations do not lead to any significant variations in the response of the structure.

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REFERENCES

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TABLES

TABLE 1

EFFECTS OF SSI PARAMETER VARIATION
SPENT FUEL POOL MODEL

MODE NO.	ANALYTICAL FREQUENCIES IN HERTZ		
	LOWER BOUND(1)	BEST ESTIMATE	UPPER BOUND(2)
1	4.03	4.08	4.10
2	6.07	6.77	6.95
3	6.19	6.87	7.04
4	8.36	9.27	9.89
5	8.47	9.50	10.22
6	14.24	17.55	18.47
7	14.84	18.25	19.31

(1) Best estimate soil springs were multiplied by 0.5 in this analysis.

(2) Best estimate soil springs were multiplied by 1.5 in this analysis.

Note: For details, refer to D'Appolonia (1978).

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TABLE 2

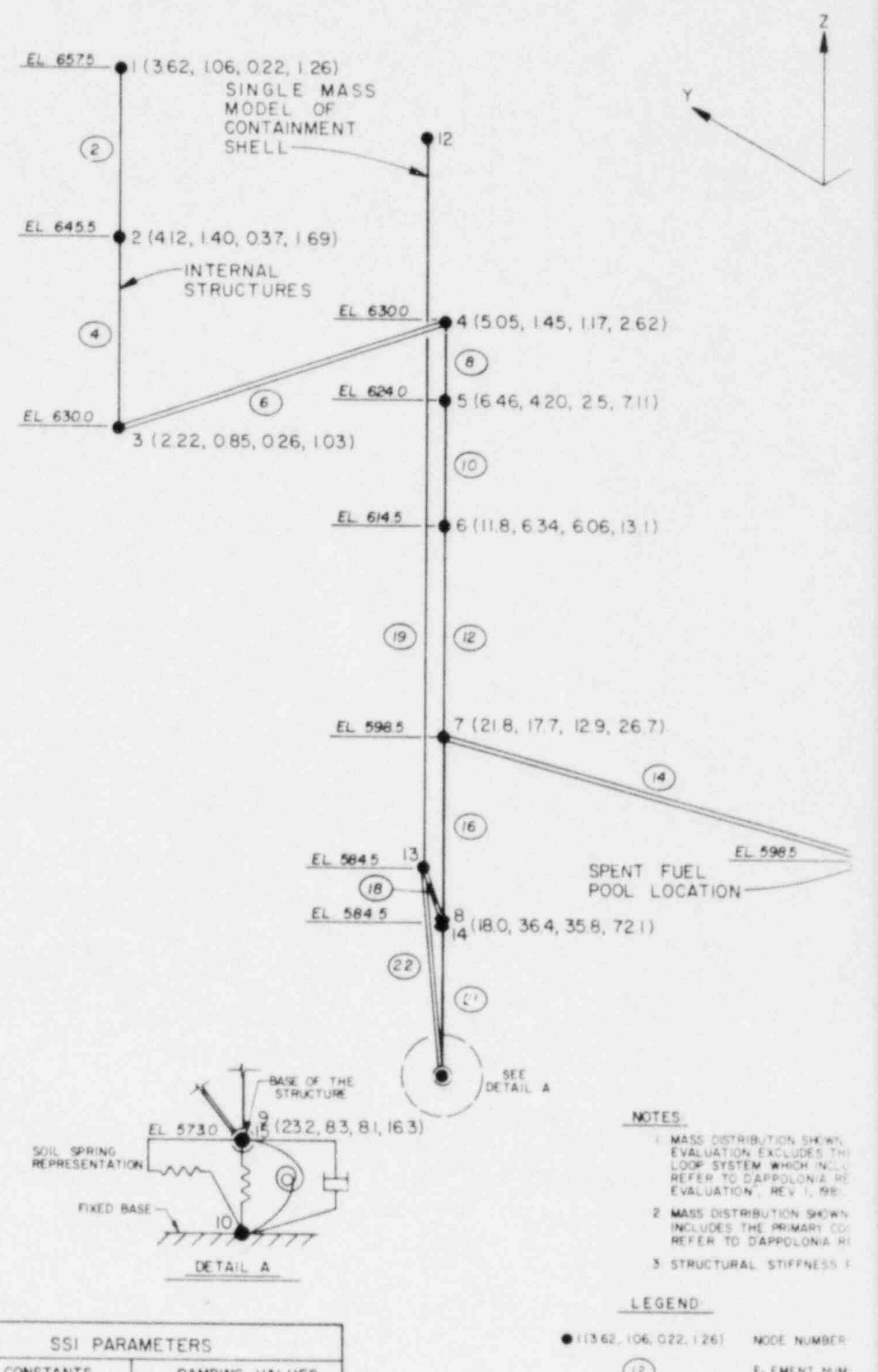
COMPARISON OF PARTICIPATION FACTORS
SPENT FUEL POOL MODEL VERSUS SEP MODEL

MODE	SPENT FUEL POOL ANALYSIS				SEP EVALUATION*			
	FREQUENCY (Hz)	PARTICIPATION FACTORS			FREQUENCY (Hz)	PARTICIPATION FACTORS		
		X	Y	Z		X	Y	Z
1	4.04	35.0	130.0	0.13	4.04	16.8	124.1	0.16
2	6.76	599.0	44.5	8.75	6.85	570.2	21.2	5.83
3	6.86	36.5	573.9	6.18	6.95	16.8	545.2	3.41
4	9.30	631.3	109.8	31.5	9.49	659.9	74.6	27.1
5	9.51	114.2	654.3	5.56	9.72	79.3	682.8	0.14
6	17.6	382.0	99.5	385.9	18.1	319.7	65.5	399.6
7	18.3	205.9	11.3	414.1	18.5	278.9	40.4	249.8
8	18.7	70.7	425.8	20.9	19.4	64.5	419.4	1.47
9	22.2	42.7	36.7	792.9	22.5	2.47	19.2	14.0
10	24.5	17.8	44.1	10.2	23.3	33.2	26.4	821.4
11	25.2	35.8	74.1	17.2	26.1	35.8	87.0	55.0
12	28.4	164.7	12.0	93.0	28.5	175.6	6.96	120.9

*The frequencies and participation factors shown correspond to the mode-frequency analysis of the stick model alone. The complete SEP model includes the Primary Coolant Loop system which was attached to the stick model as substructures. For details, refer to D'Appolonia (1978, 1981).

FIGURES

ANALYTICAL MODEL-SPENT FUEL POOL EVALUATION



MODE	SSI PARAMETERS	
	SPRING CONSTANTS	DAMPING VALUES
VERTICAL	2.27×10^{10} LB/FT	1.07×10^{8} LB SEC/FT
HORIZONTAL	6.22×10^{9} LB/FT	3.54×10^{7} LB SEC/FT
ROCKING	2.33×10^{13} LB FT/RAD	6.03×10^{10} LB SEC FT/RAD
TORSION	2.08×10^{13} LB FT/RAD	3.92×10^{10} LB SEC FT/RAD

NOTES

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LEGEND

● 1 (3.62, 1.06, 0.22, 1.26)	NODE NUMBER
(12)	ELEMENT NUM...
◉ 8 14	COINCIDENT NO...
MASS	LUMPED MASS
IXX, IYY, IZZ	MASS MOMENT ... X, Y, AND Z AX... (LB SEC² FT...)
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═══	RIGID LINK

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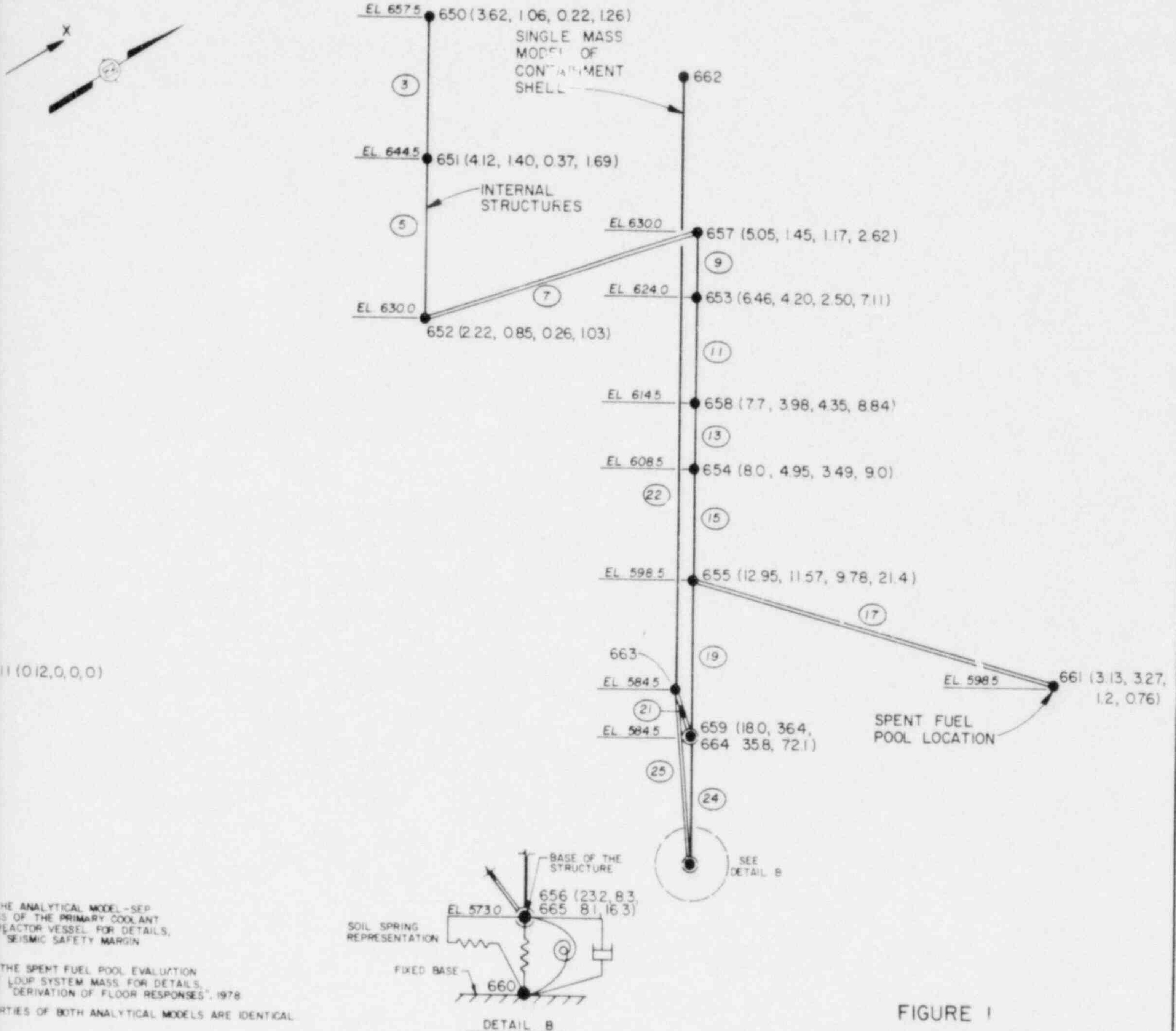
ANALYTICAL MODEL-SEP EVALUATION



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...RTIES OF BOTH ANALYTICAL MODELS ARE IDENTICAL

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MODE	SSI PARAMETERS	
	SPRING CONSTANTS	DAMPING VALUES
VERTICAL	2.65×10^{10} LB/FT	1.15×10^{8} LB. SEC/FT
HORIZONTAL	6.66×10^{9} LB/FT	3.64×10^{7} LB. SEC/FT
ROCKING	3.16×10^{13} LB.FT/RAD	7.27×10^{10} LB. SEC.FT/RAD
TORSION	2.16×10^{13} LB.FT/RAD	4.25×10^{10} LB. SEC.FT/RAD

FIGURE 1

COMPARISON OF THE TWO ANALYTICAL MODELS SEP VS. SPENT FUEL POOL

PARAMETRIC STUDY-SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT

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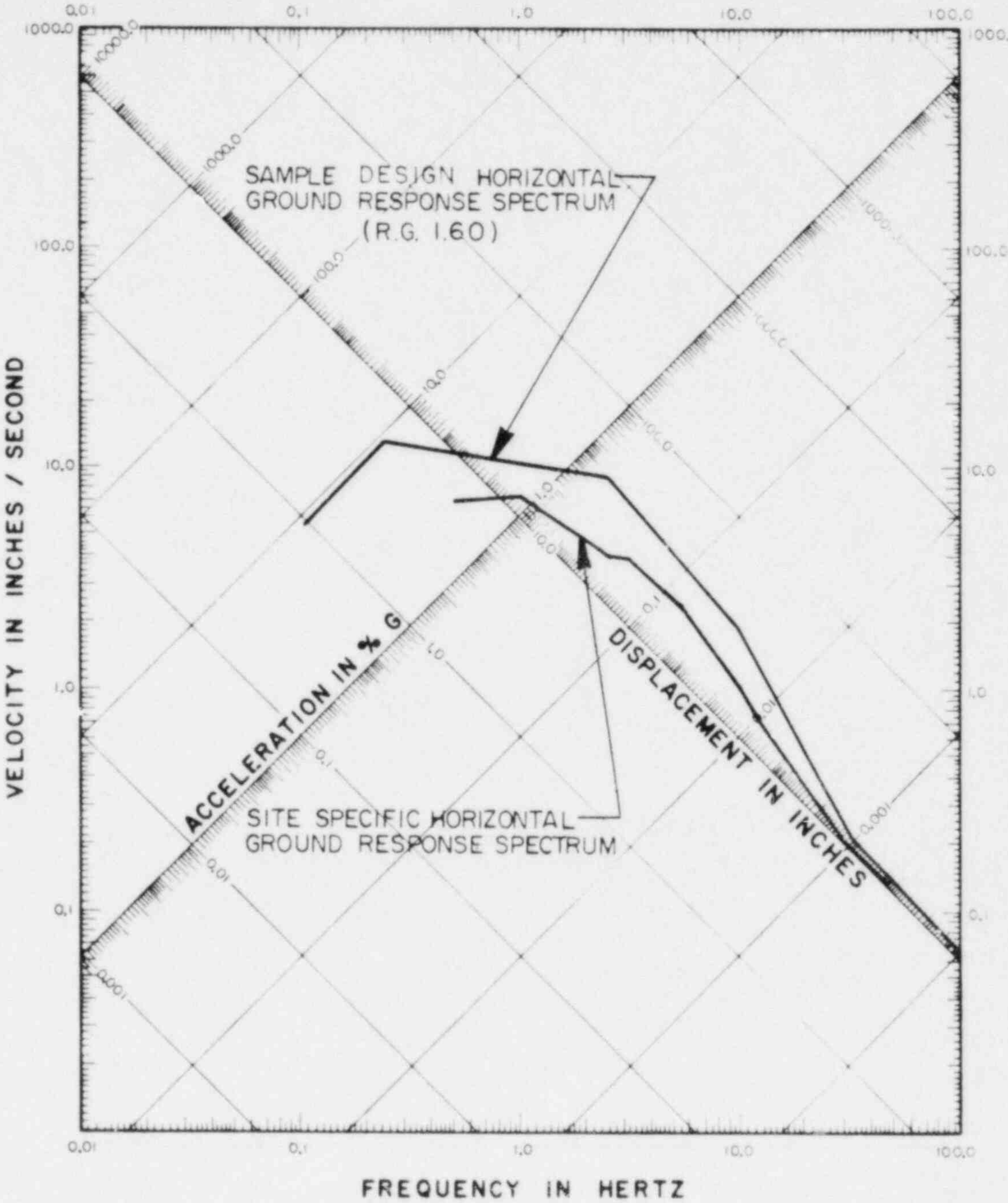

FIGURE 2
COMPARISON OF HORIZONTAL GROUND RESPONSE SPECTRA FOR 5 PERCENT OF CRITICAL DAMPING
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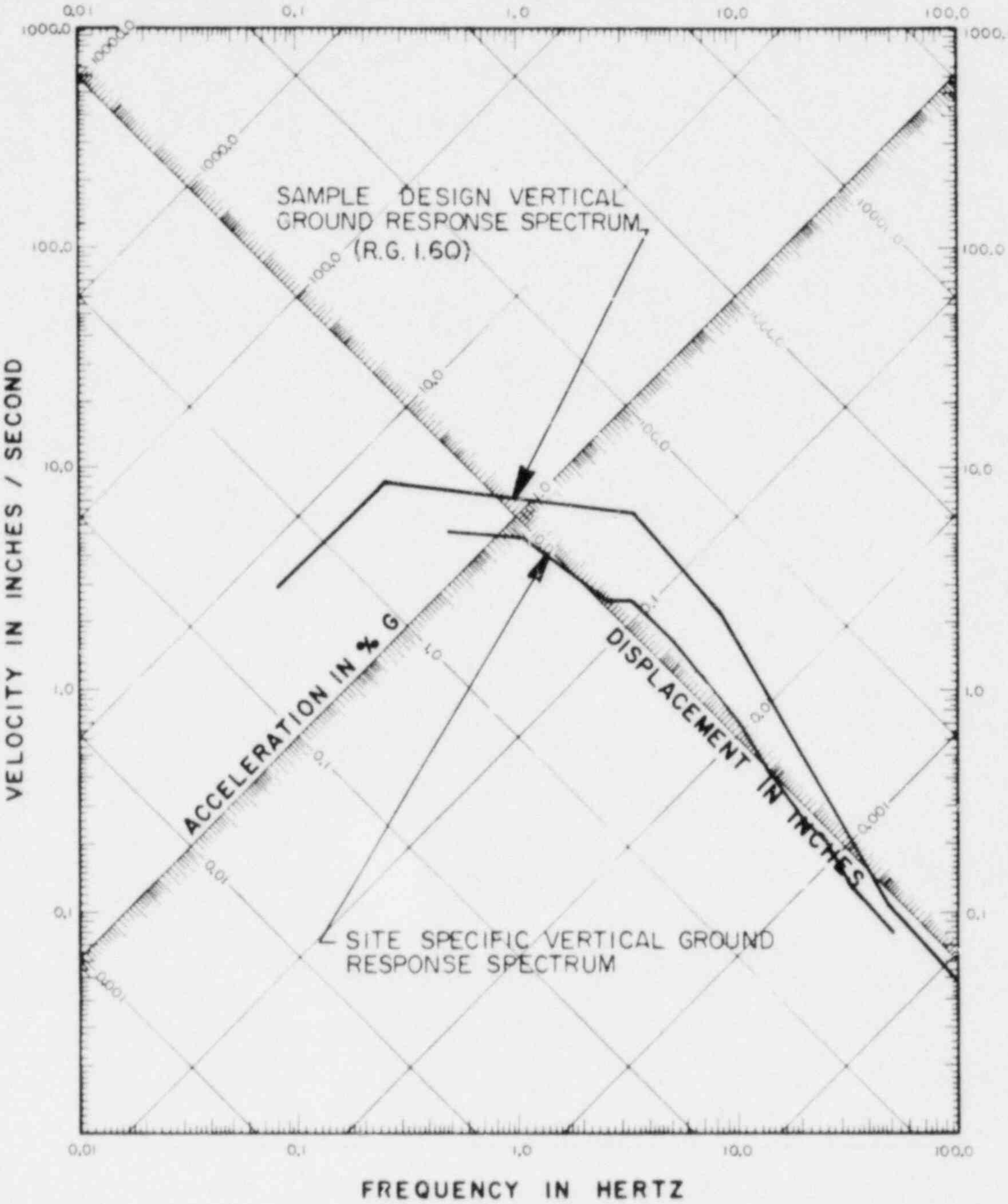

FIGURE 3
COMPARISON OF VERTICAL GROUND RESPONSE SPECTRA FOR 5 PERCENT OF CRITICAL DAMPING
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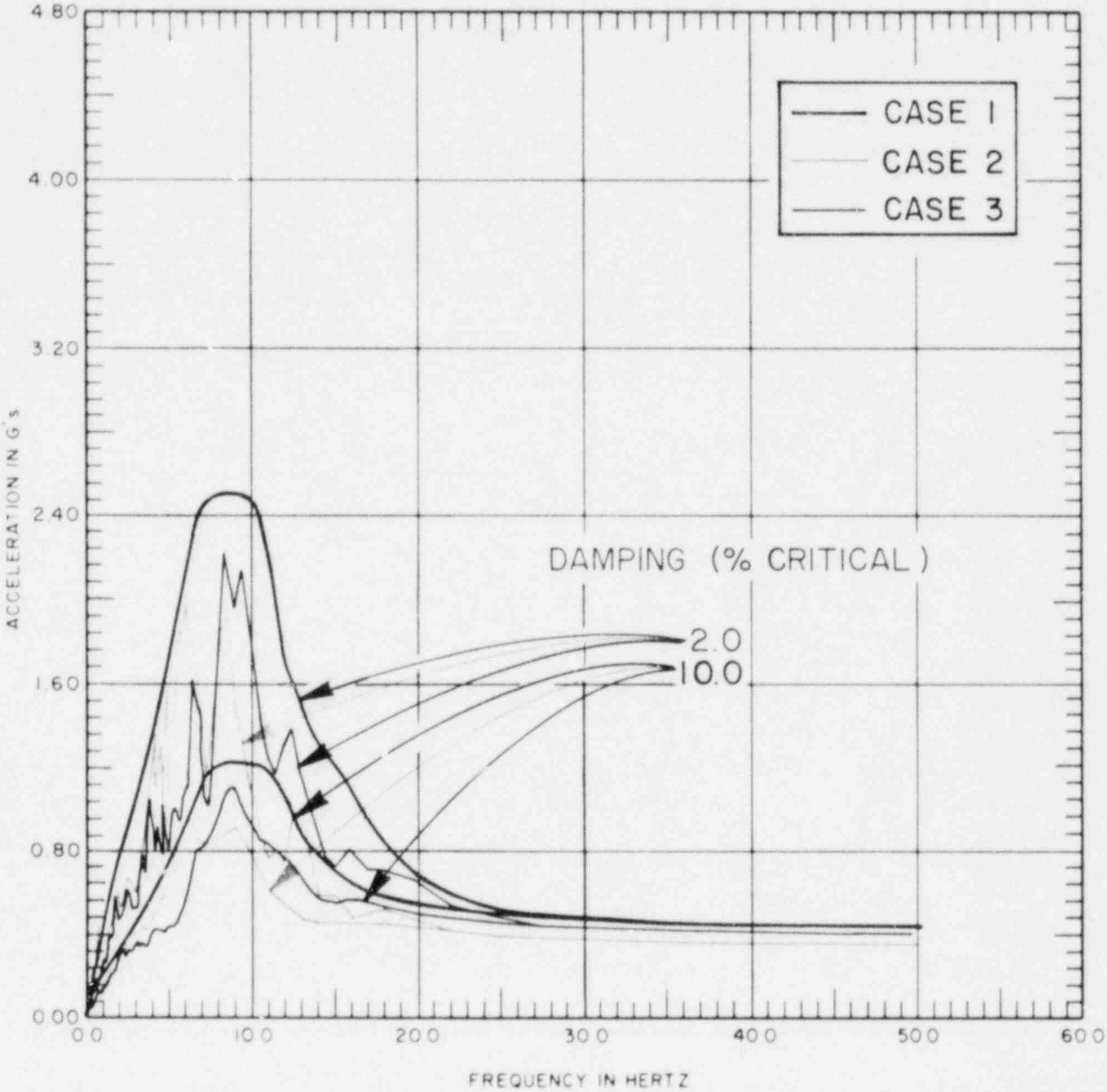

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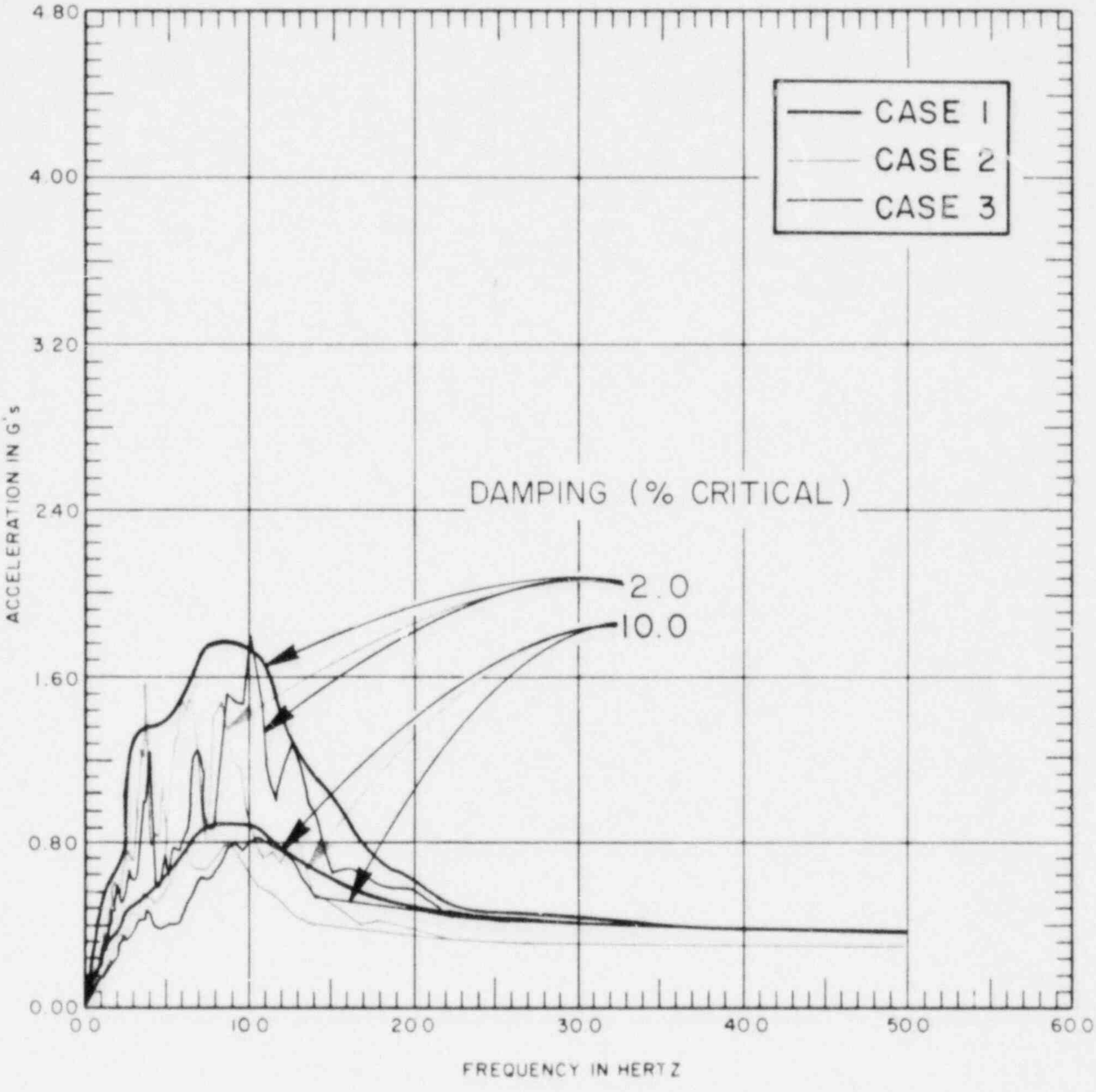
FIGURE 4
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION X
NODE 650 ELEVATION 657'-6"
SHEET 1 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE



DRAWN BY	MEL 4-8-82	CHECKED BY / APPROVED BY	PJG / AJW	4-14-82 / 14Apr82	DRAWING NUMBER 78-435Y-A372

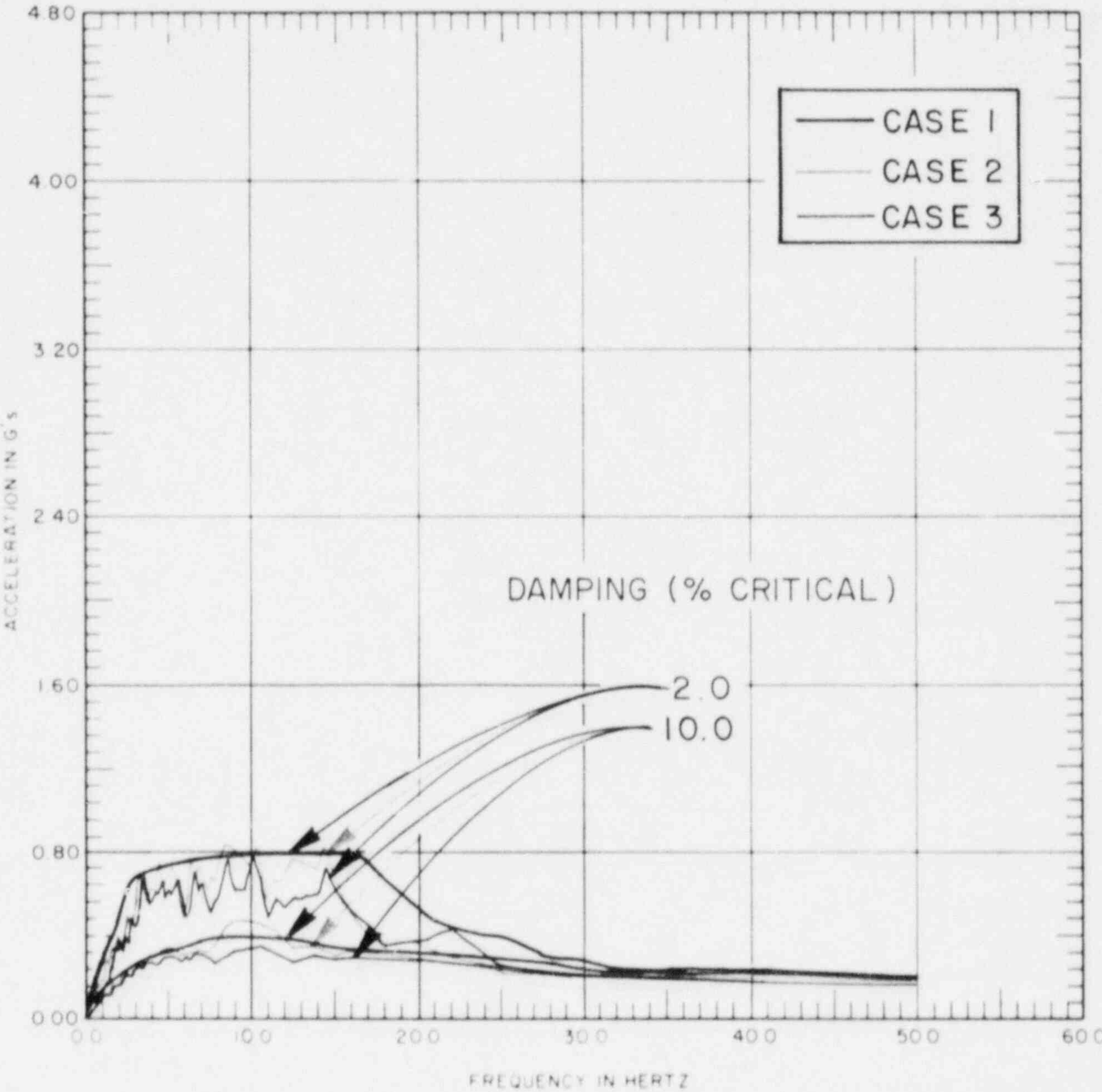
FIGURE 5
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Y
NODE 650 ELEVATION 657'-6"
SHEET 2 OF 3
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

DRAWN BY MEL 4-7-82 | CHECKED BY PJG | APPROVED BY | DRAWING NUMBER 78-435Y-A373



INPUT EARTHQUAKE R.G. 1.60 ANALYTICAL MODEL SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

FIGURE 6
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Z
NODE 650 ELEVATION 657'-6"
SHEET 3 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY MEL 4-7-82 | CHECKED BY PJG | APPROVED BY AJE 4/15/82 | DRAWING NUMBER 78-435Y-A374

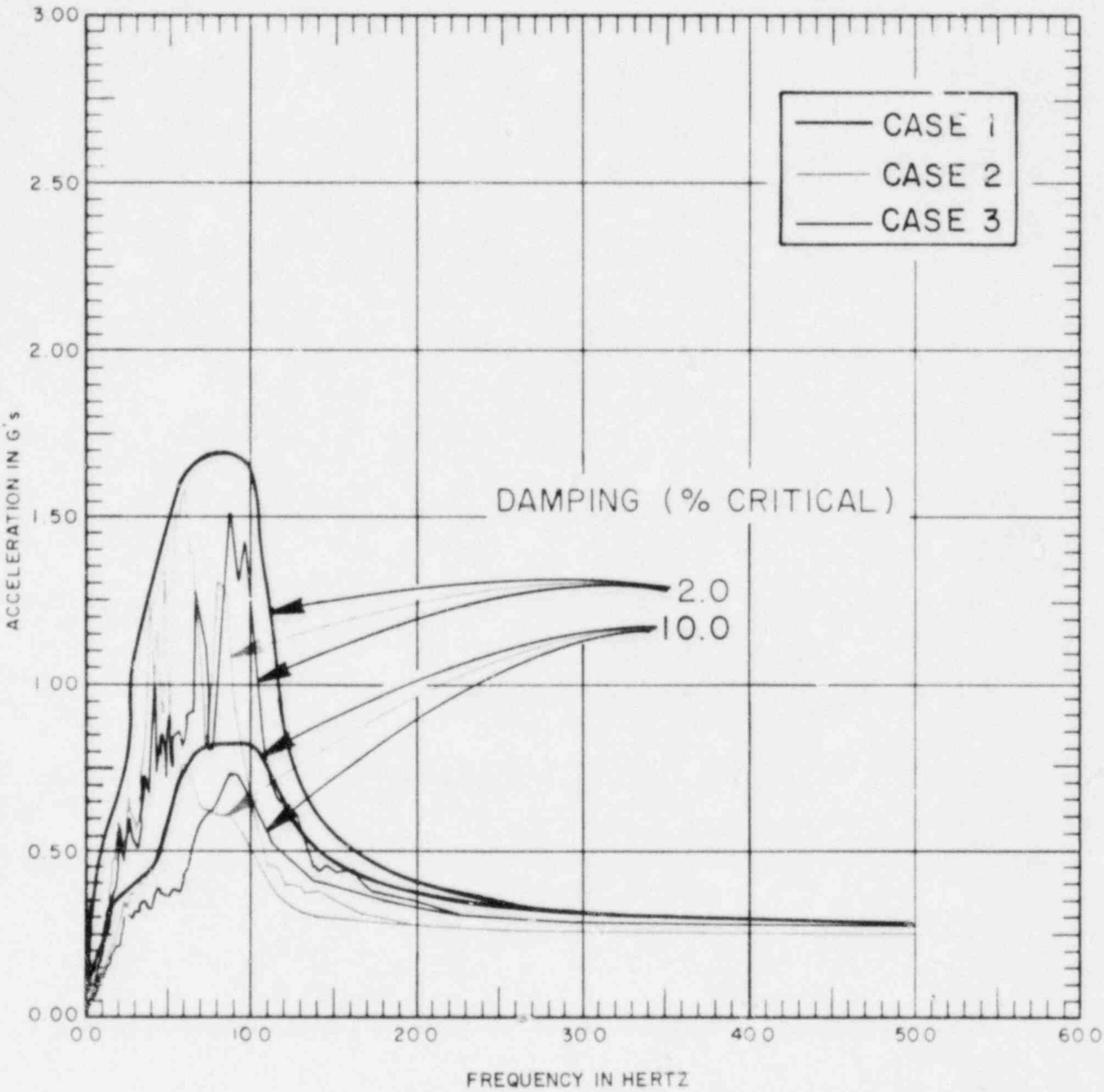


FIGURE 7
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION X
NODE 652 ELEVATION 630'-0"
SHEET 1 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

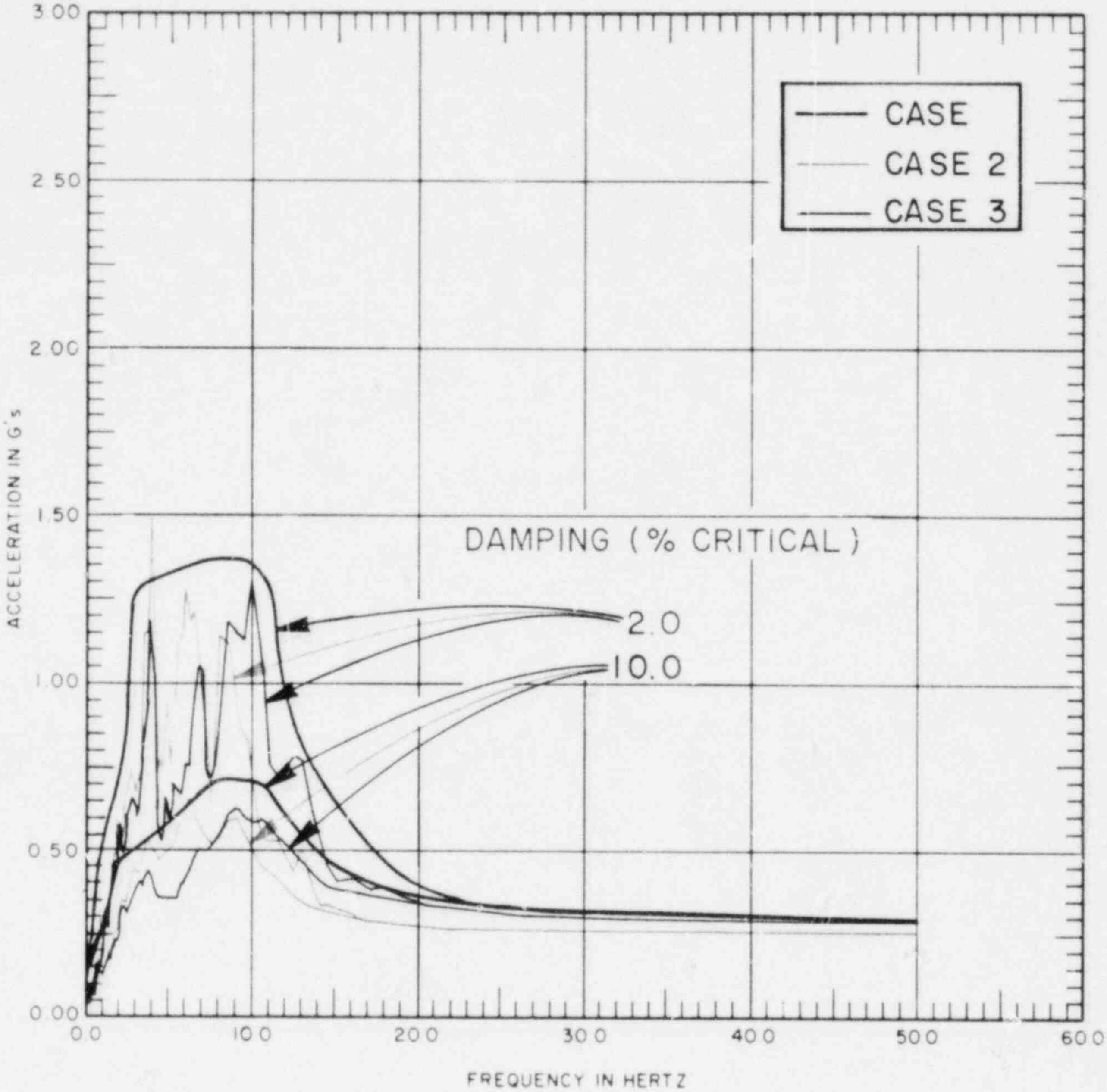
INPUT EARTHQUAKE: R.G. 1.60
ANALYTICAL MODEL: SEP

PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

D'APPOLONIA

100 BLK	16 16	100	15	DRAWN BY	MEL 4-7-82	CHECKED BY APPROVED BY	PJG AJE	4-14-82 14 Apr 82	DRAWING NUMBER 78-435Y-A375



INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

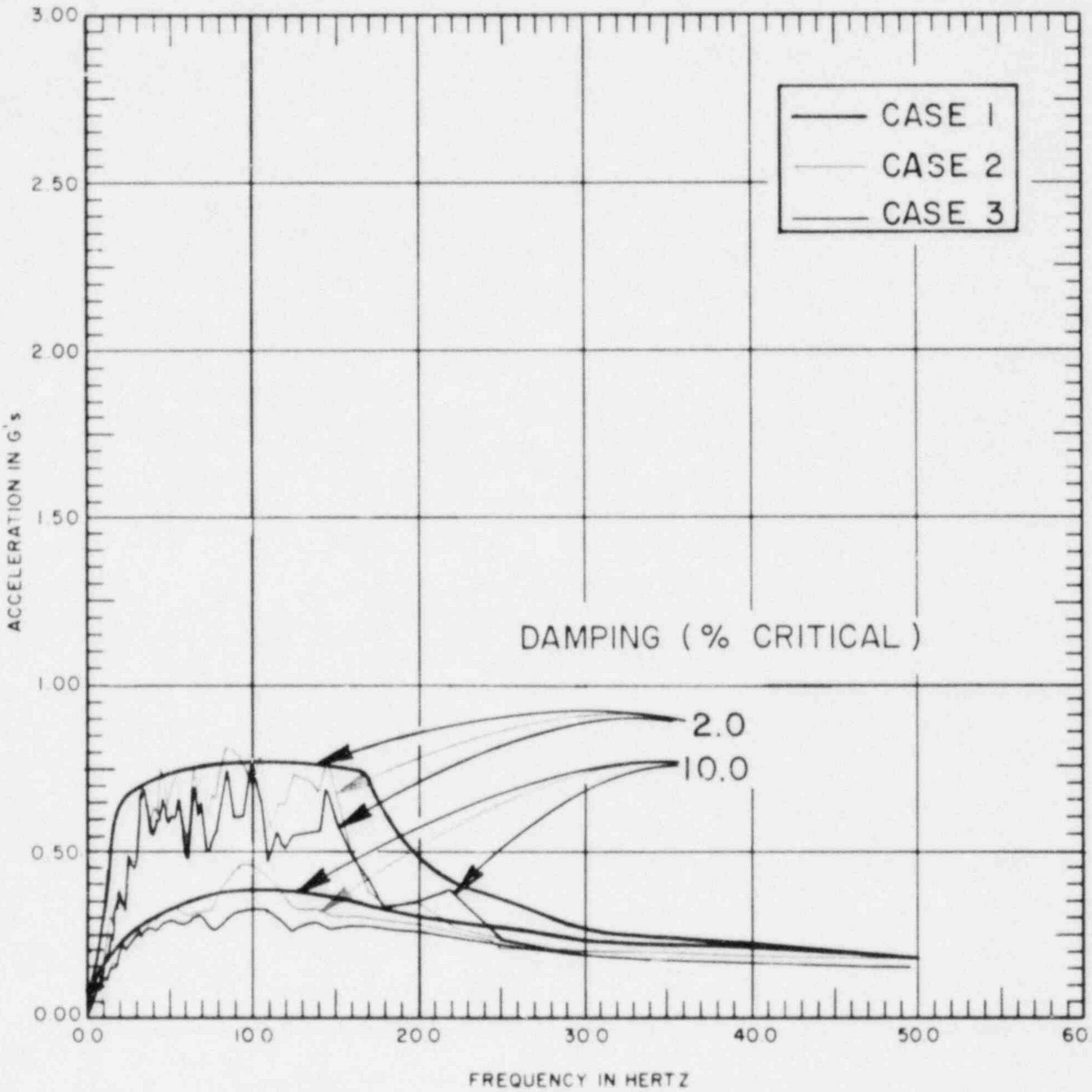
FIGURE 8
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Y
NODE 652 ELEVATION 630'-0"
SHEET 2 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY MEL 4-7-82 | CHECKED BY PJG 4-14-82 | APPROVED BY AJE 14 Apr 82 | DRAWING NUMBER 78-435Y-A376

100 18 100 17 / BLK 18 17



INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

FIGURE 9
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Z
NODE 652 ELEVATION 630'-0"
SHEET 3 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWING NUMBER 78-435Y-A377
DRAWN BY MEL 4-8-82 | CHECKED BY PJG | APPROVED BY AJG
100 20 100 19 | BLK 20 ORG 19

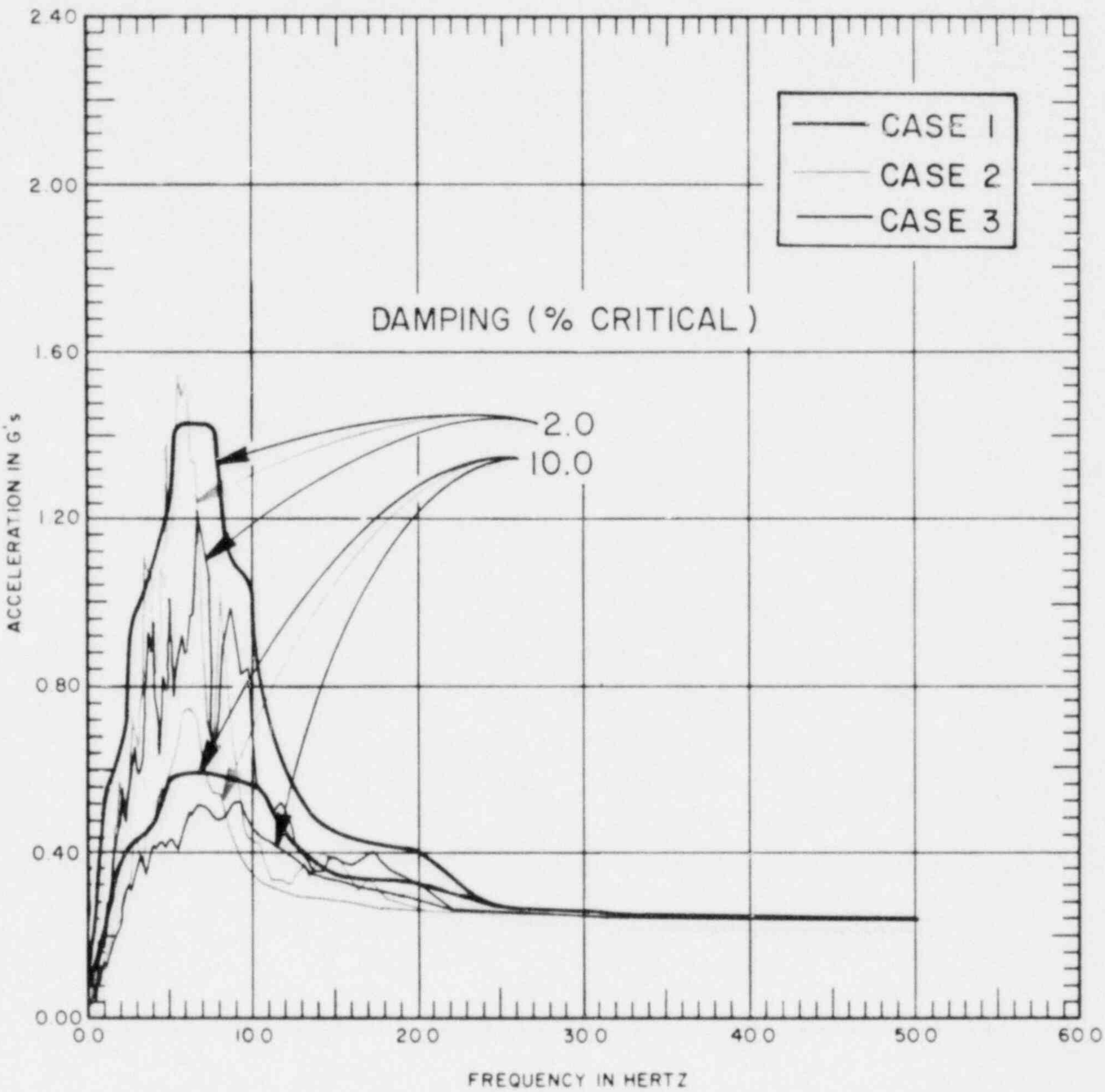


FIGURE 10
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION X
NODE 661 ELEVATION 598'-6"
SHEET 1 OF 3

INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

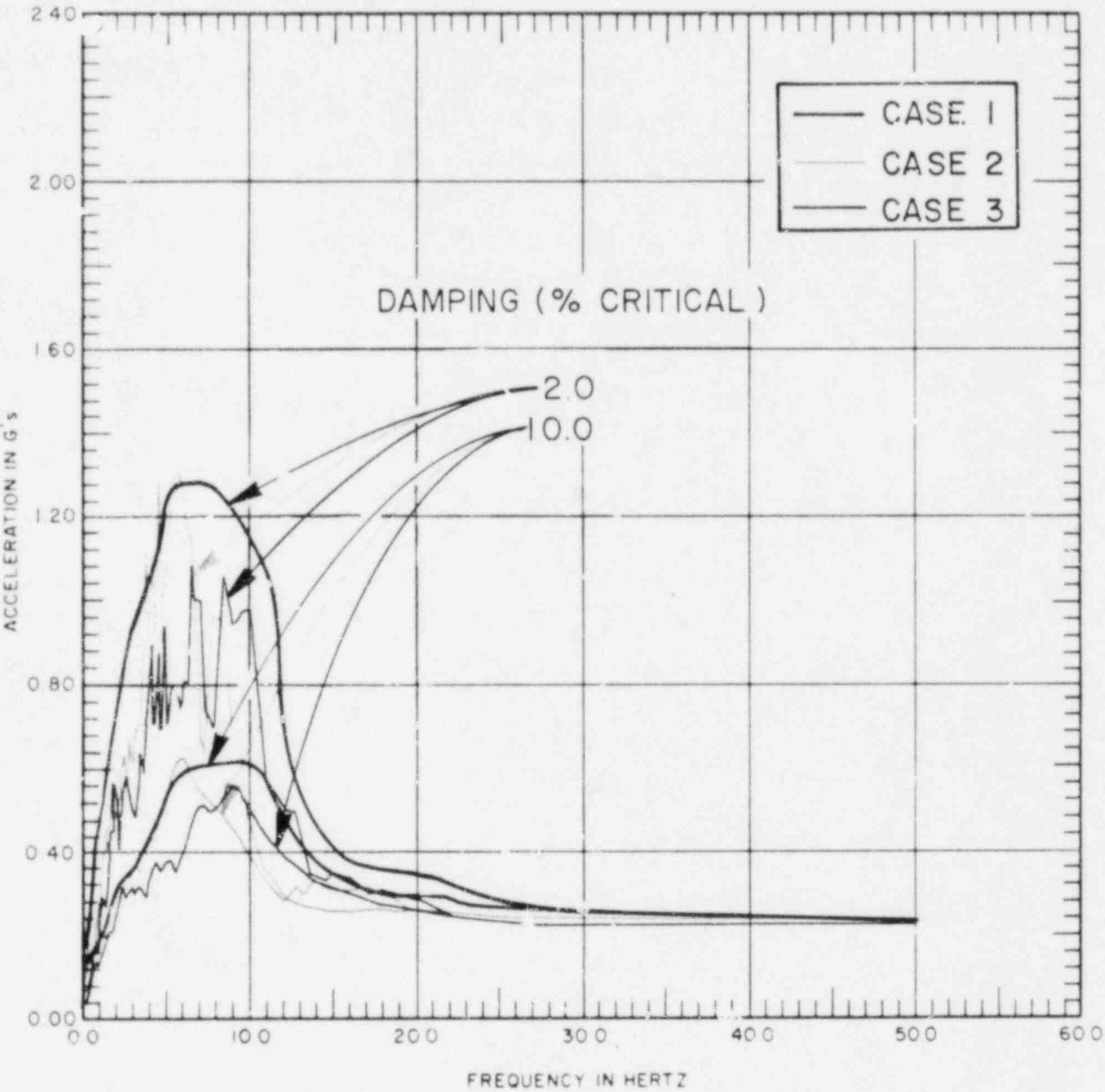
* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON MICHIGAN

D'APPOLONIA

DRAWING NUMBER 78-435Y-A378

BLK	100		DRAWN BY	CHECKED BY	APPROVED BY
22	22	21	MEL 4-7-82	AJG 4-14-82	AJG 14 Apr 82



INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

FIGURE 11
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Y
NODE 661 ELEVATION 598'-6"
SHEET 2 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY M.E.L. 4-7-82 | CHECKED BY PJG 4-14-82 | APPROVED BY AJE 14 Apr 82 | DRAWING NUMBER 78-435Y-A379

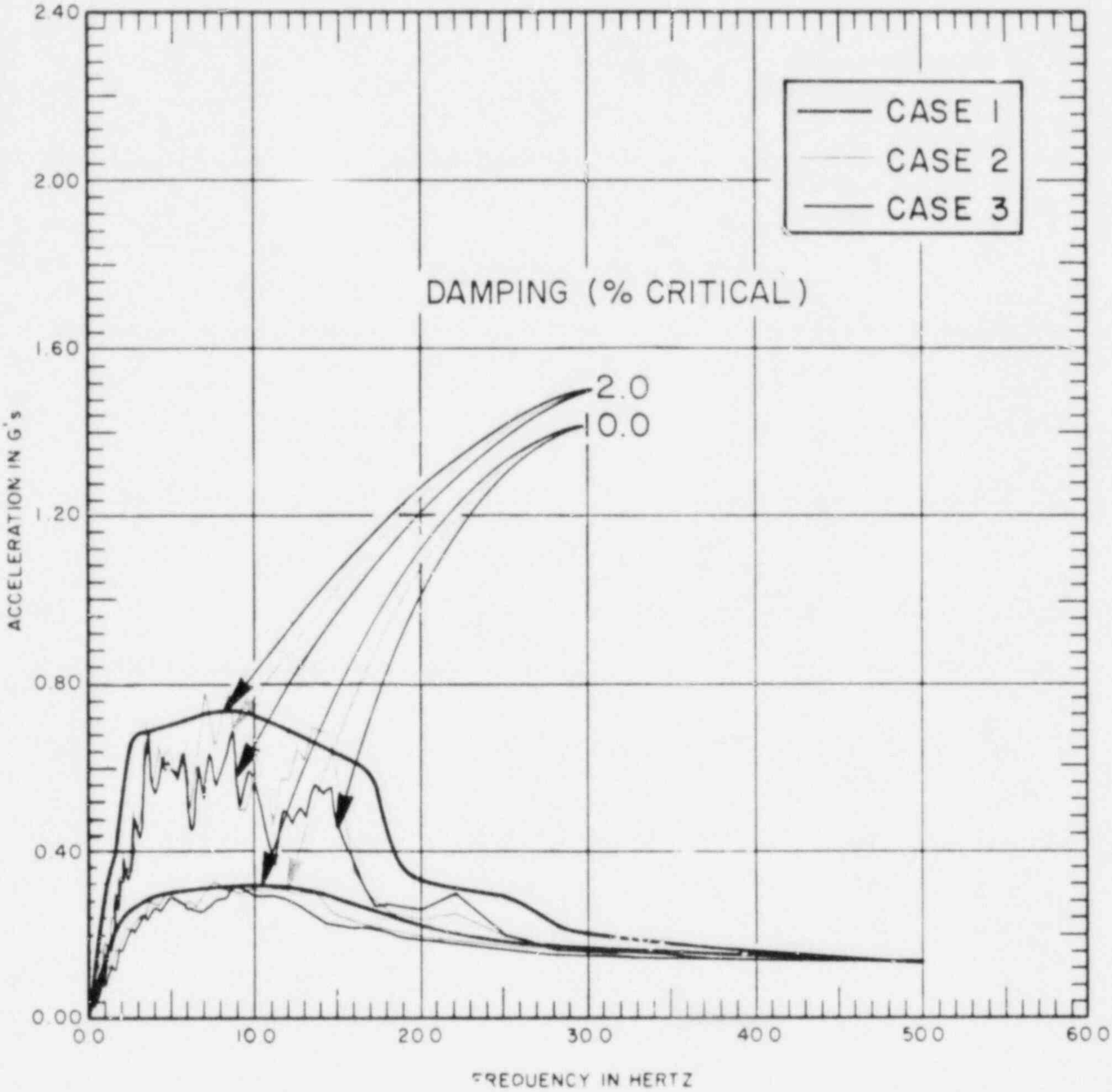


FIGURE 12
EFFECTS OF SSI PARAMETER VARIATIONS
DIRECTION Z
NODE 661 ELEVATION 598'-6"
SHEET 3 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

INPUT EARTHQUAKE: R.G. 1.60
ANALYTICAL MODEL: SEP

PARAMETERS	CASE 1*	CASE 2 (LOWER BOUND)	CASE 3 (UPPER BOUND)
SSI PARAMETER REDUCTION FACTORS SPRING CONSTANTS	1.0	0.5	1.5
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

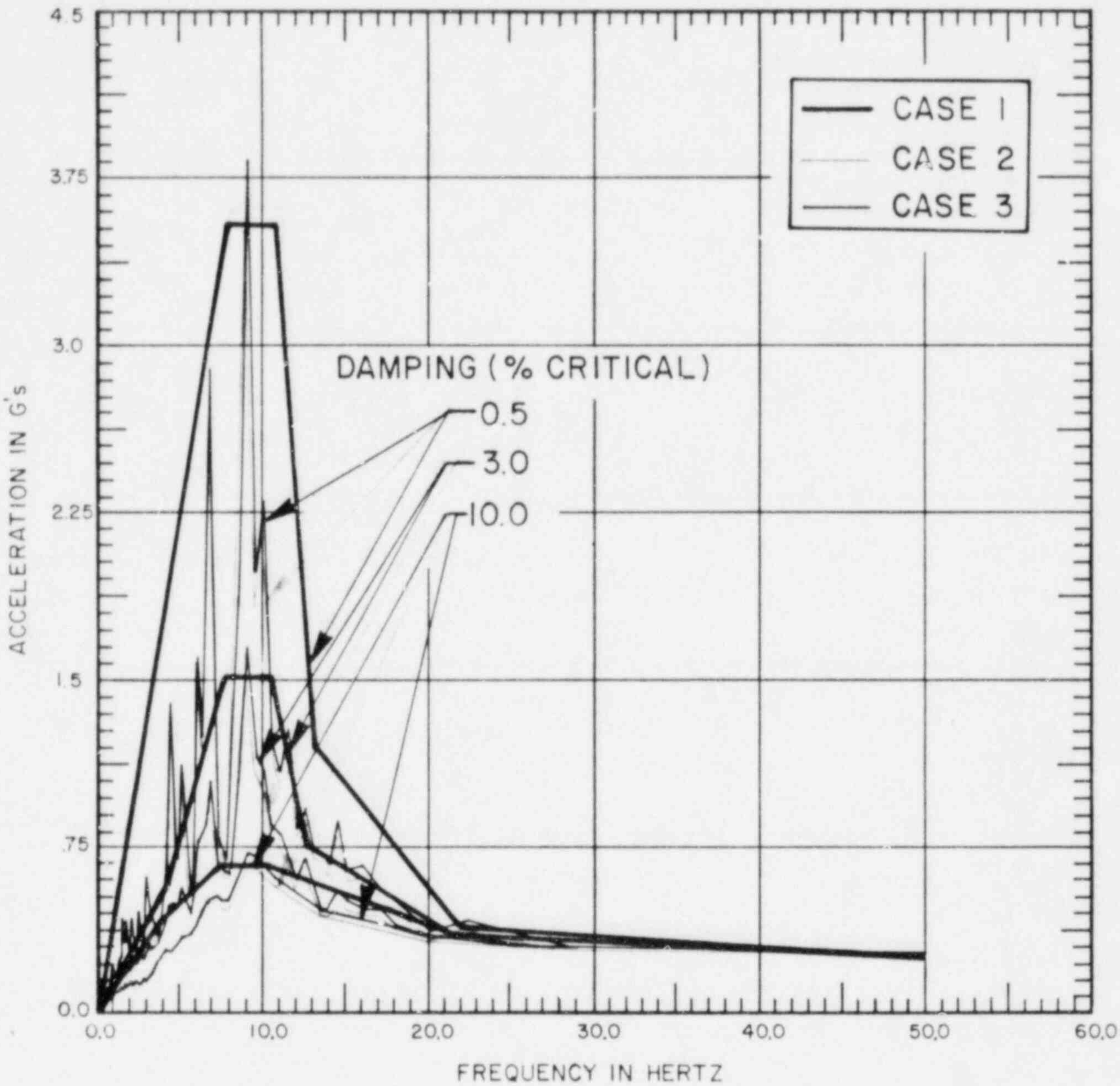
* SSI PARAMETERS ARE BASED ON CROSS-HOLE ESTIMATE

D'APPOLONIA

DRAWING NUMBER 78-435Y-A365

DRAWN BY	MEL	4-7-82
CHECKED BY	PJG	4-14-82
APPROVED BY	[illegible]	14 Apr 82

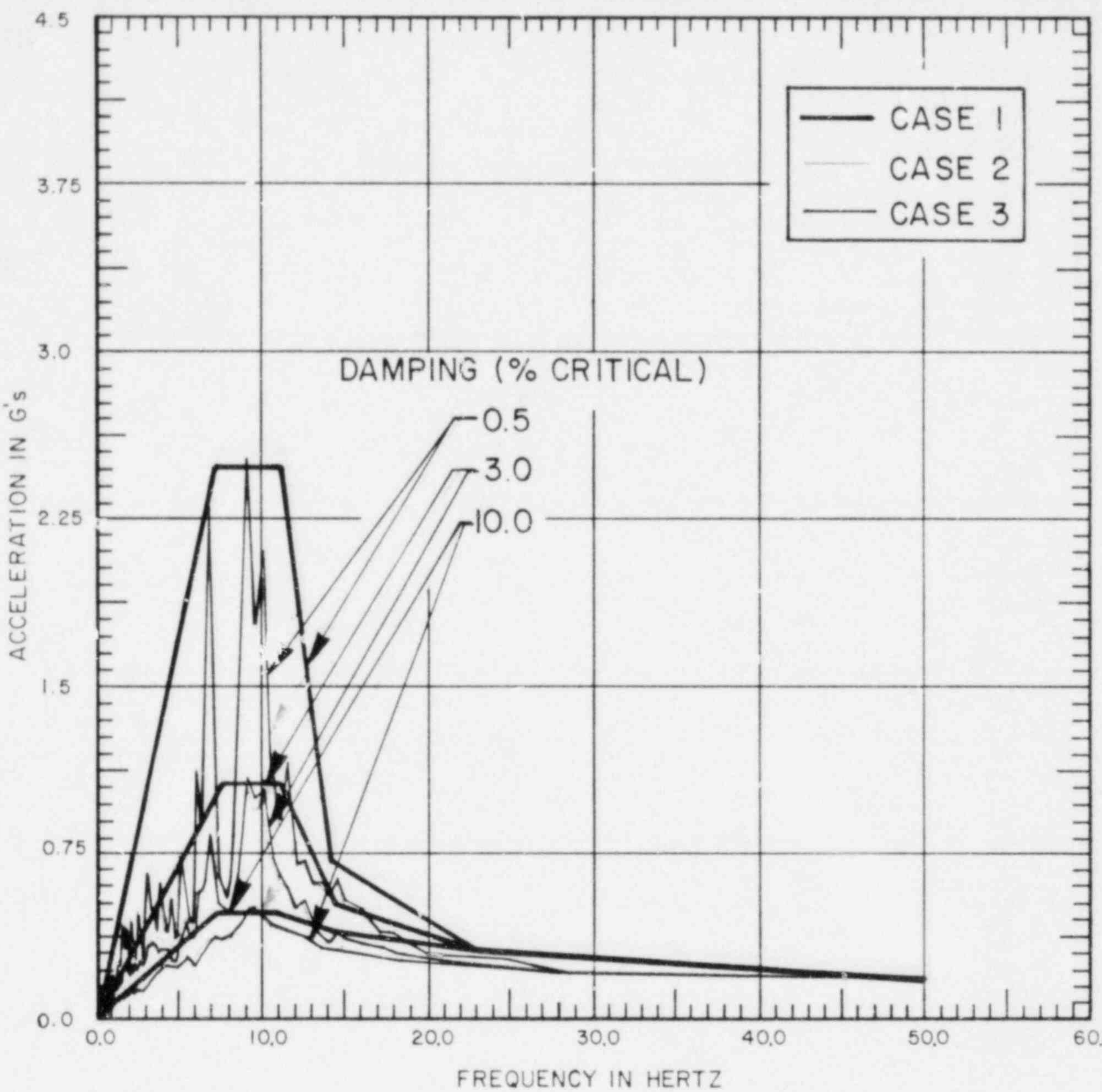
100 2 100 1 — BLK 2



INPUT EARTHQUAKE : SITE SPECIFIC ANALYTICAL MODEL : SEP			
PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

FIGURE 13
EFFECTS OF STRUCTURAL DAMPING
SITE SPECIFIC EARTHQUAKE
DIRECTION X
NODE 650 ELEVATION 657'-6"
SHEET 1 OF 3
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA



INPUT EARTHQUAKE : SITE SPECIFIC ANALYTICAL MODEL : SEP			
PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

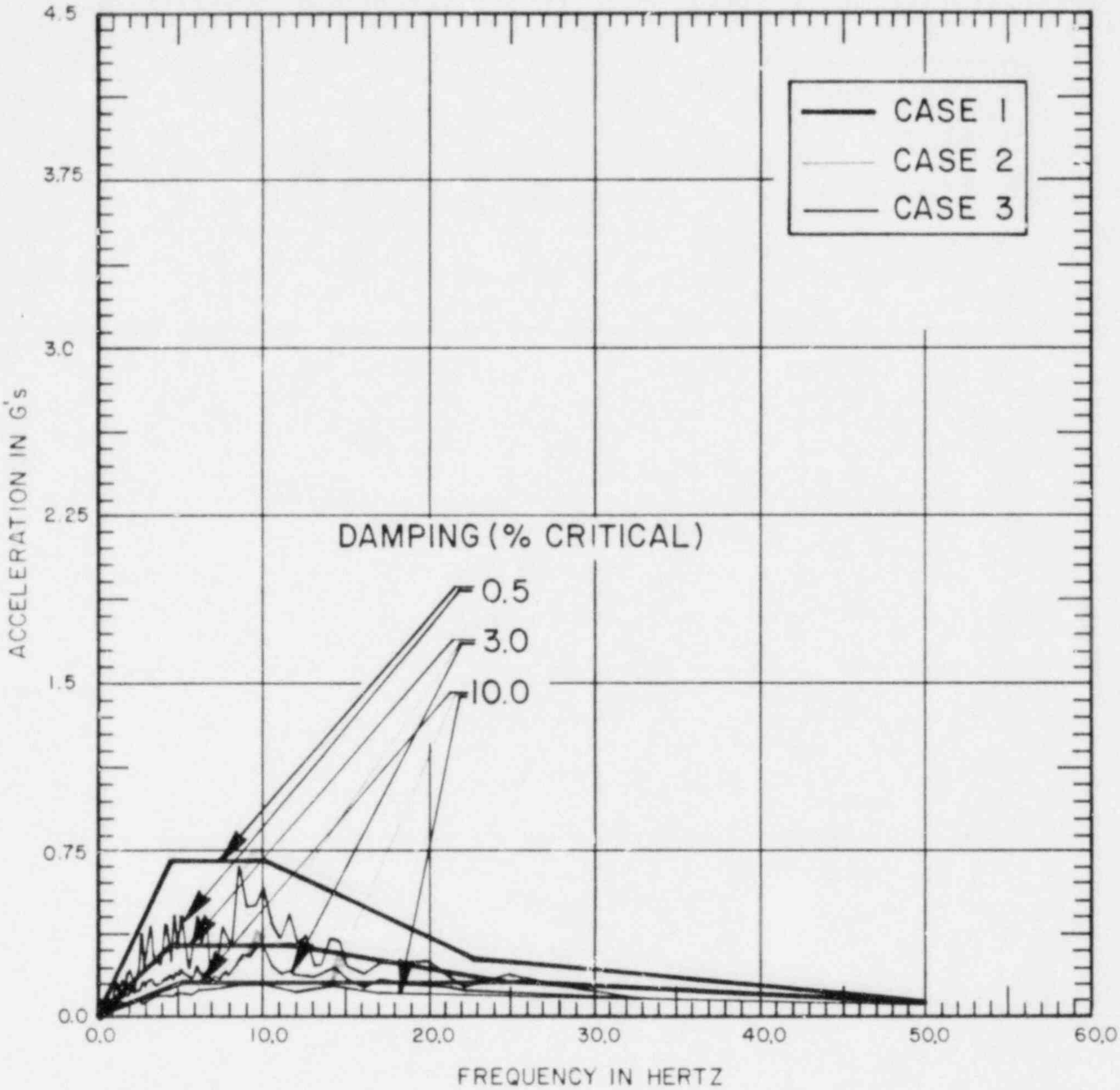
FIGURE 14

EFFECTS OF STRUCTURAL DAMPING
SITE SPECIFIC EARTHQUAKE
DIRECTION Y
NODE 650 ELEVATION 657'-6"
SHEET 2 OF 3
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR

CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWING NUMBER 78-435Y-A366
DRAWN BY MEL 4-7-82 | CHECKED BY PJG 4-14-82 | APPROVED BY AJa 14 Apr 82



DRAWN BY	MEL	CHECKED BY	PJG	4-14-82	DRAWING NUMBER 78-435Y-A367
	4-7-82	APPROVED BY			

INPUT EARTHQUAKE : SITE SPECIFIC ANALYTICAL MODEL : SEP			
PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

FIGURE 15
EFFECTS OF STRUCTURAL DAMPING
SITE SPECIFIC EARTHQUAKE
DIRECTION Z
NODE 650 ELEVATION 657'-6"
SHEET 3 OF 3
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

100 26 100 25 BLK 26
DRAWN BY: M.E.L. 4-8-82 | CHECKED BY: PJG 4-14-82 | APPROVED BY: AJS 14 Apr 82 | DRAWING NUMBER 78-435Y-A380

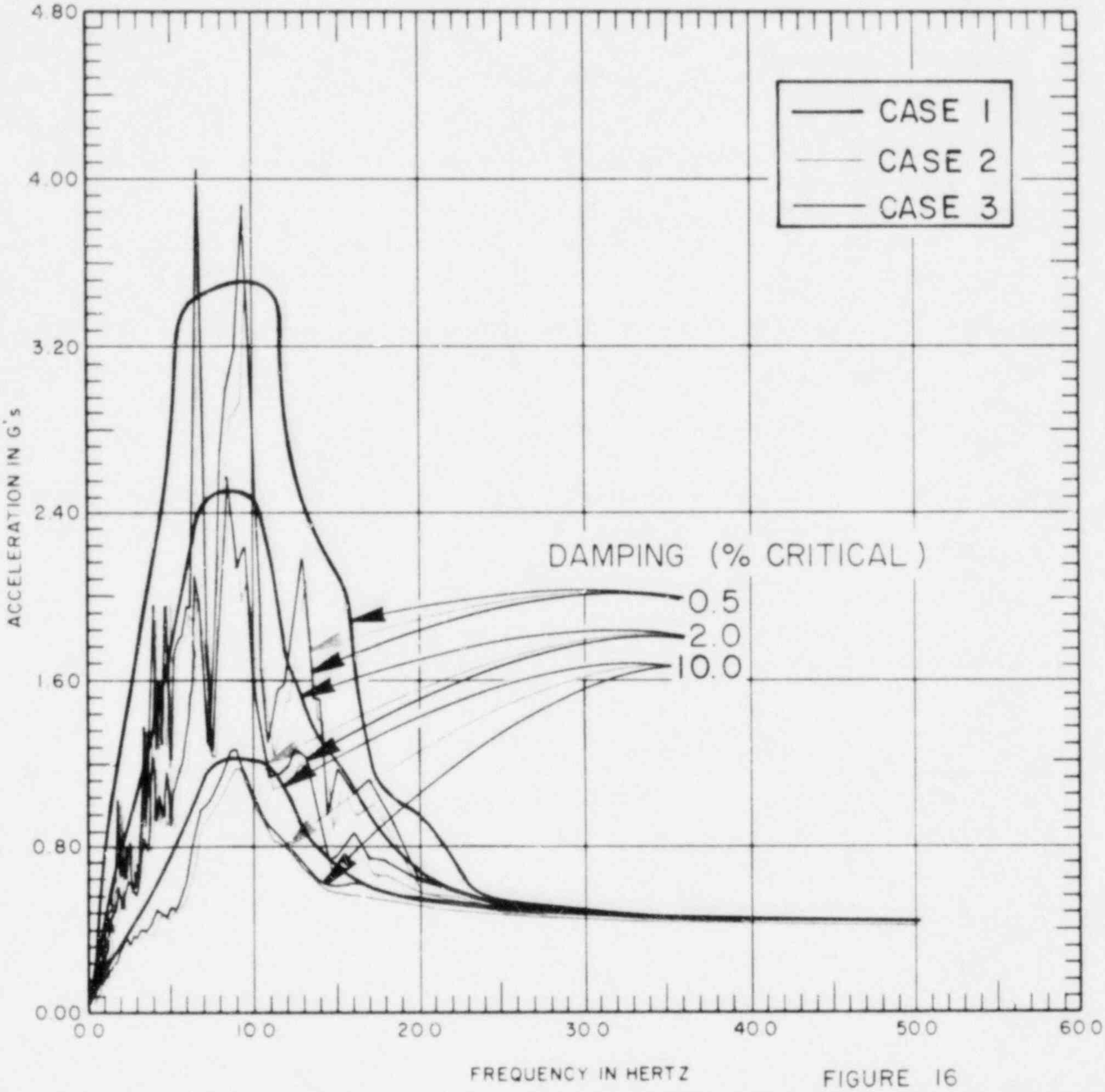


FIGURE 16
EFFECTS OF STRUCTURAL DAMPING
R.G.1.60 EARTHQUAKE
DIRECTION X
NODE 650 ELEVATION 657'-6"
SHEET 1 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR

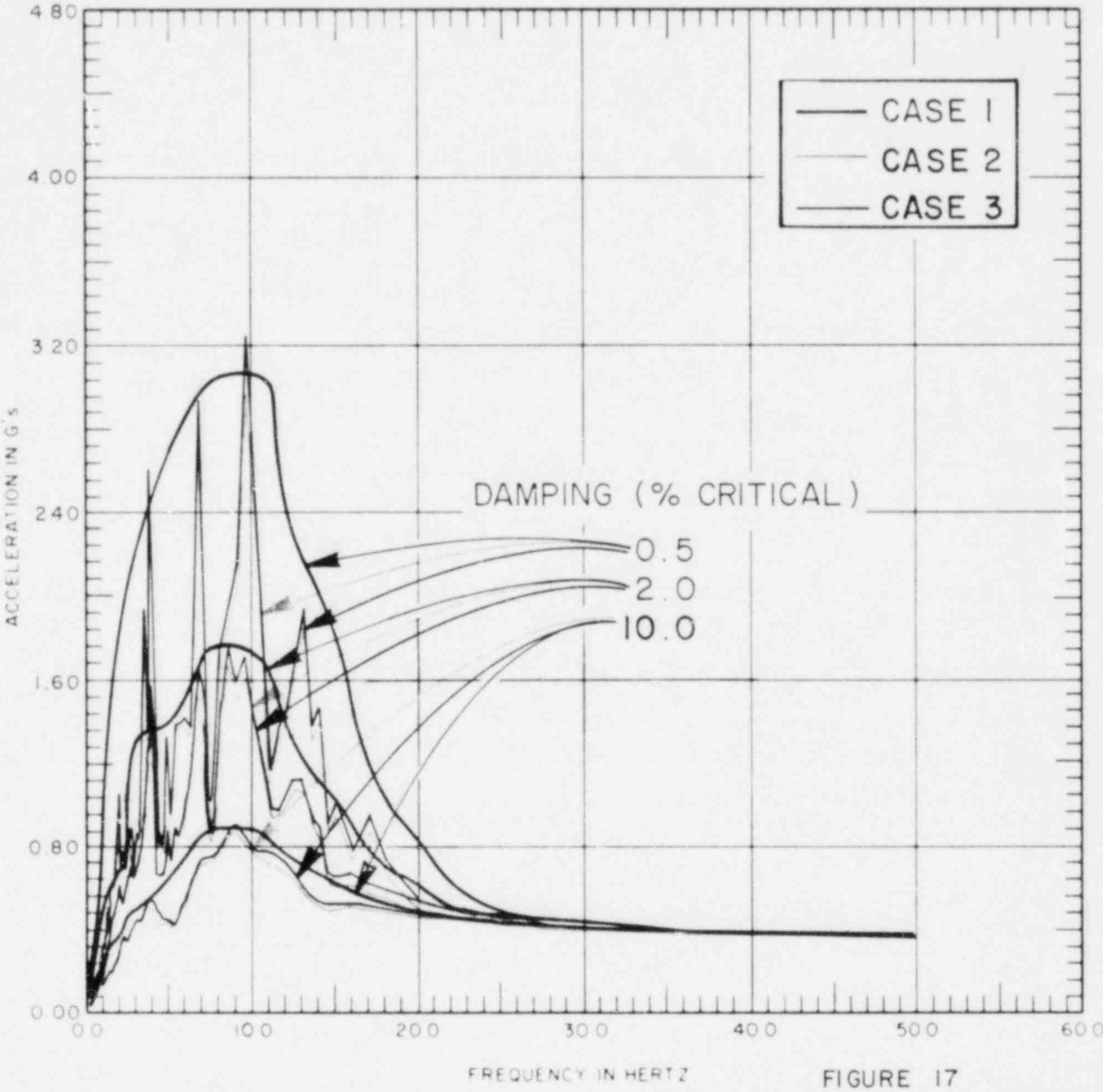
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

INPUT EARTHQUAKE: R.G. 1.60
ANALYTICAL MODEL: SEP

PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

D'APPOLONIA

100	28	27	DRAWN BY	MEL 4-8-82	CHECKED BY	PJG 4-14-82	DRAWING NUMBER 78-435Y-A381
BLK	28				APPROVED BY		



INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL : SEP			
PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADENED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

FIGURE 17
EFFECTS OF STRUCTURAL DAMPING
R. G. 1.60 EARTHQUAKE
DIRECTION Y
NODE 650 ELEVATION 657'-6"
SHEET 2 OF 3

PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT

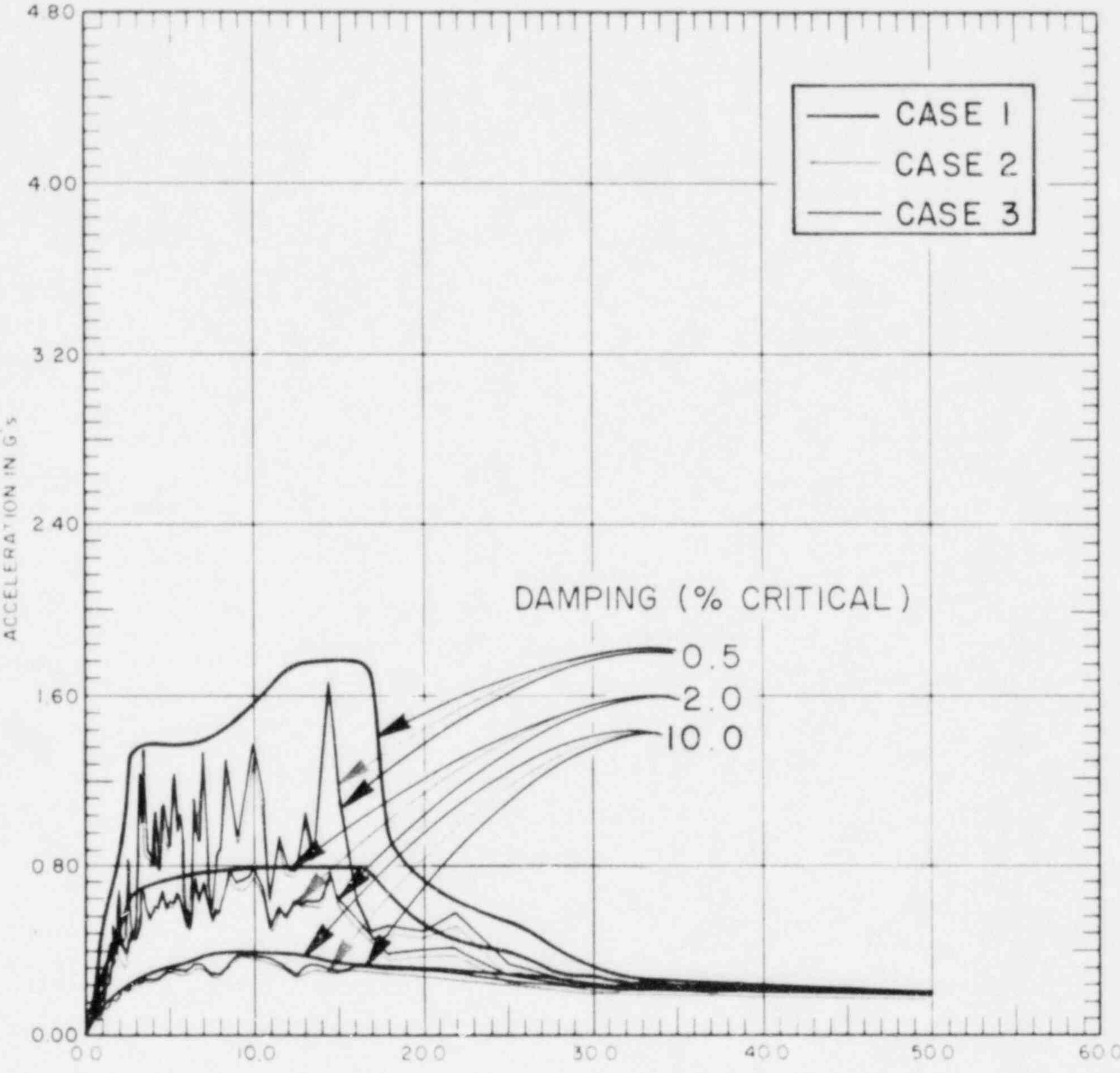
PREPARED FOR

CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWING NUMBER 78-435Y-A382

DRAWN BY	MEL	4-8-81	CHECKED BY	PJG	4-14-82
			APPROVED BY	[illegible]	14 Apr 82



INPUT EARTHQUAKE: R.G. 1.60 ANALYTICAL MODEL: SEP			
PARAMETERS	CASE 1	CASE 2	CASE 3
STRUCTURAL DAMPING % CRITICAL			
CONCRETE	7	5	3
STEEL	4	2	2
SSI DAMPING REDUCTION FACTORS			
TRANSLATIONAL MODES	0.50	0.75	0.75
ROTATIONAL MODES	0.50	1.0	1.0
SPECTRA PLOTS	BROADZNED AND SMOOTHED	NOT BROADENED UNSMOOTHED	NOT BROADENED UNSMOOTHED

FIGURE 18
EFFECTS OF STRUCTURAL DAMPING
R.G. 1.60 EARTHQUAKE
DIRECTION Z
NODE 650 ELEVATION 657'-6"
SHEET 3 OF 3

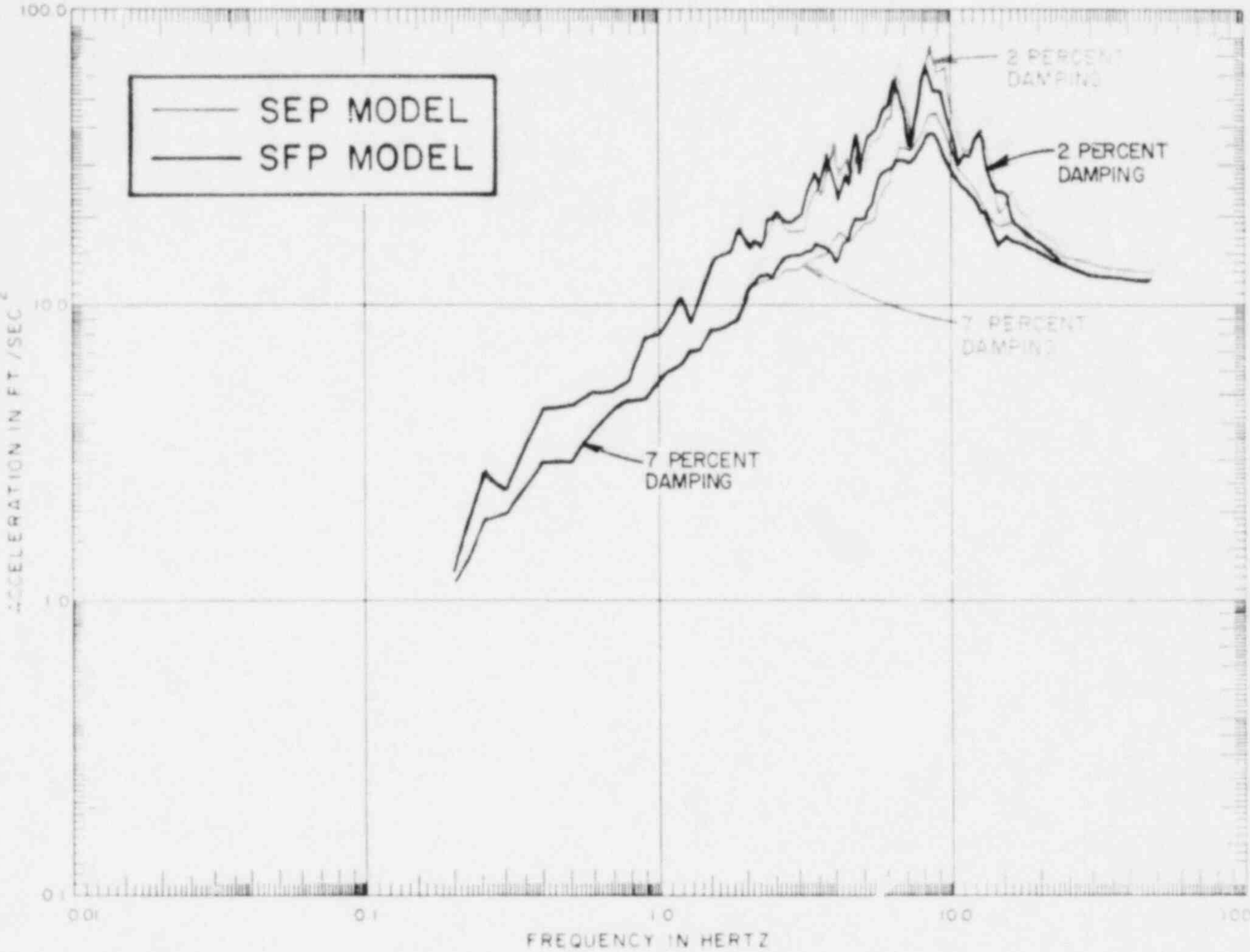
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT

PREPARED FOR

CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY	G.J.Graham 4-8-82	CHECKED BY	PJG 4-14-82	DRAWING NUMBER	78-435Y-A389
		APPROVED BY	AJB		



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

NOTES:

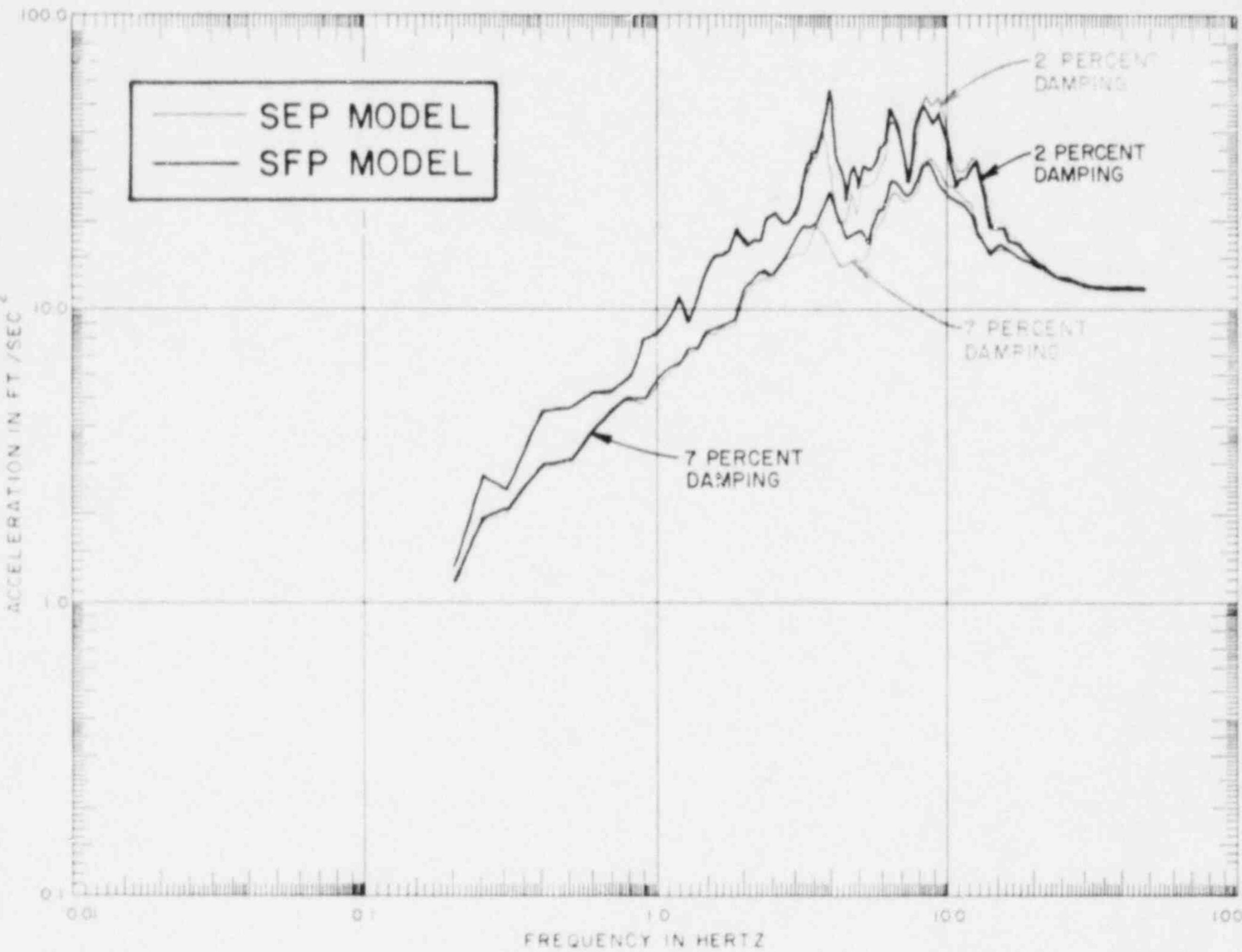
1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 19
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS SPENT FUEL POOL
X DIRECTION
NODE 650 ELEVATION 657'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION

BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY G.J.Graham 4-8-82 | CHECKED BY PJG 4-14-82 | APPROVED BY | DRAWING NUMBER 78-435Y-A390



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

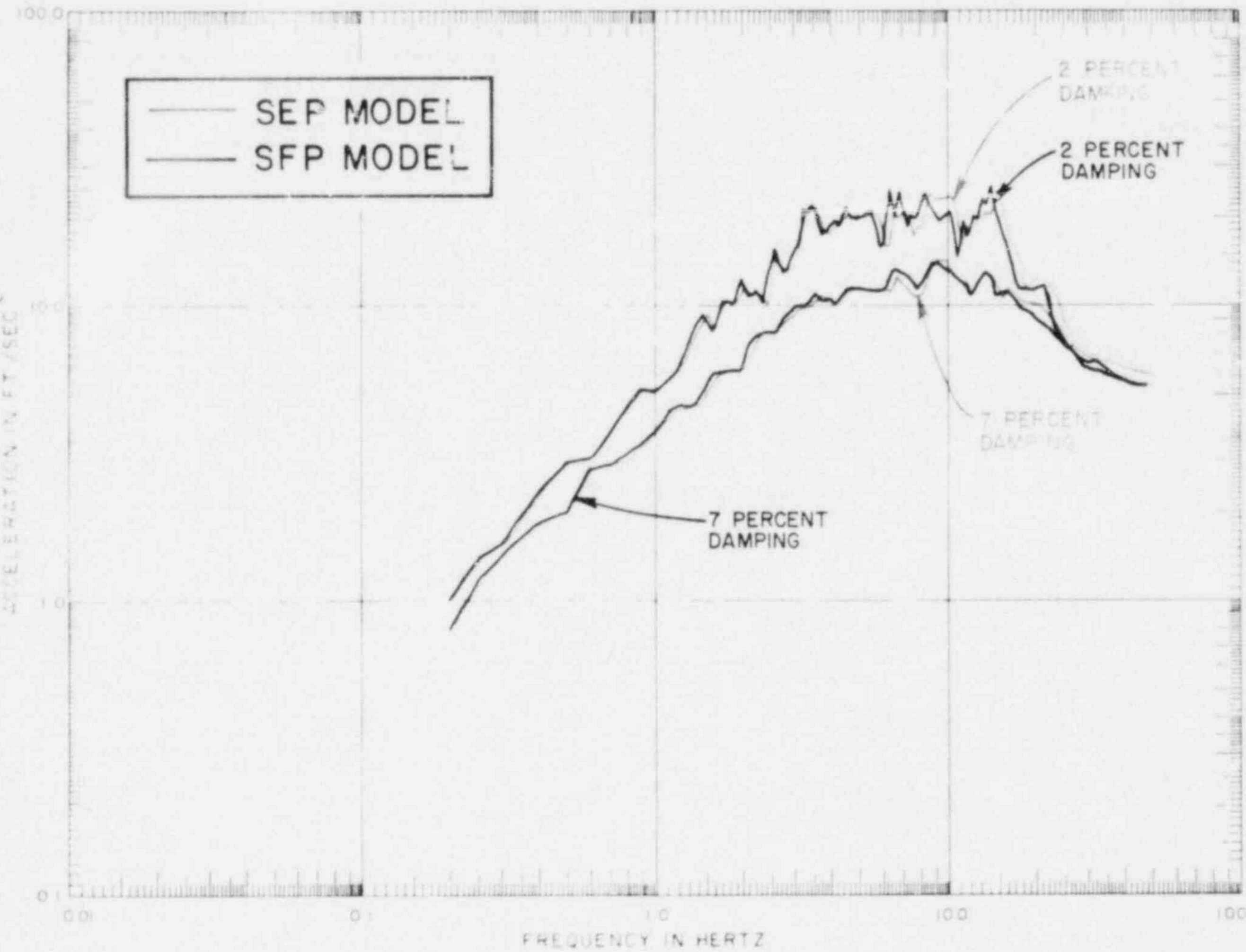
NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 20
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS SPENT FUEL POOL
Y DIRECTION
NODE 650 ELEVATION 657'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY G.J.Graham 4-8-82 | CHECKED BY PJG 4-14-82 | APPROVED BY JE 14 Apr 82 | DRAWING NUMBER 78-435Y-A391



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

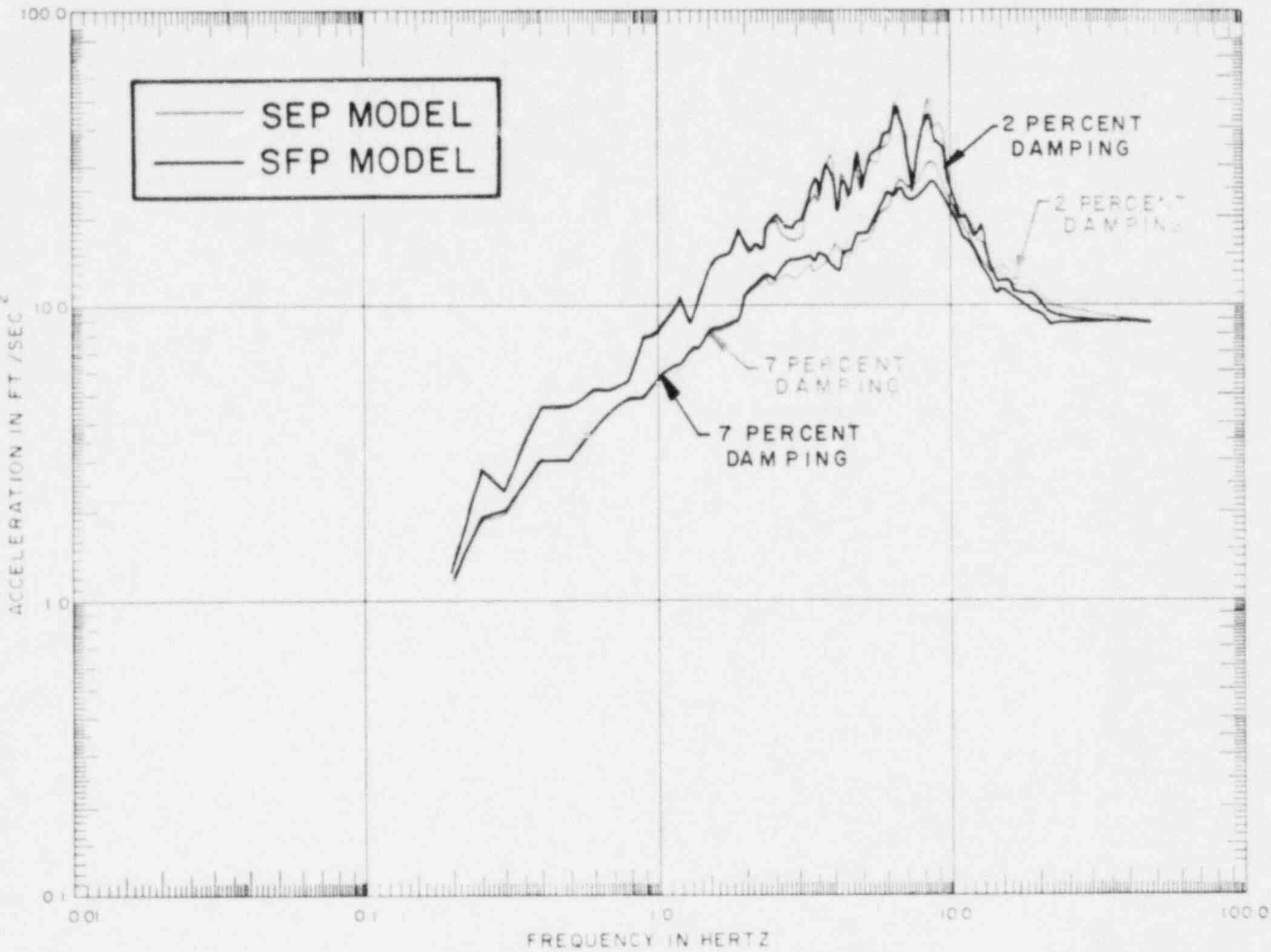
*SFP = SPENT FUEL POOL

NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 21
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS SPENT FUEL POOL
Z DIRECTION
NODE 650 ELEVATION 657'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

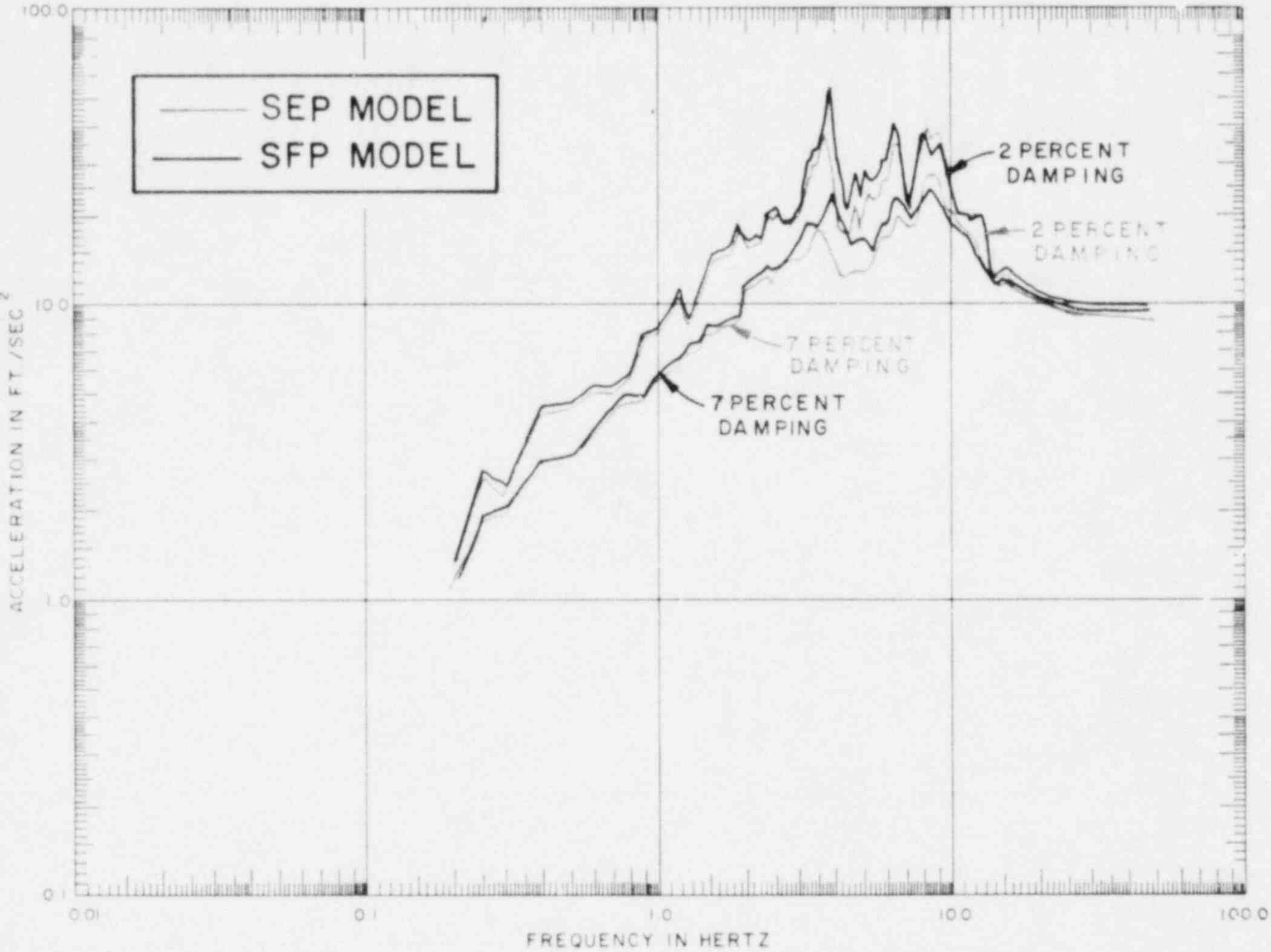
NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 22
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS SPENT FUEL POOL
X DIRECTION
NODE 652 ELEVATION 630'-0"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWING NUMBER	78-435Y-A393
CHECKED BY	PJG 4-14-82
APPROVED BY	AJE 14Apr82
DRAWN BY	D. Weick 4-8-82
DOC	35
ORG	35



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

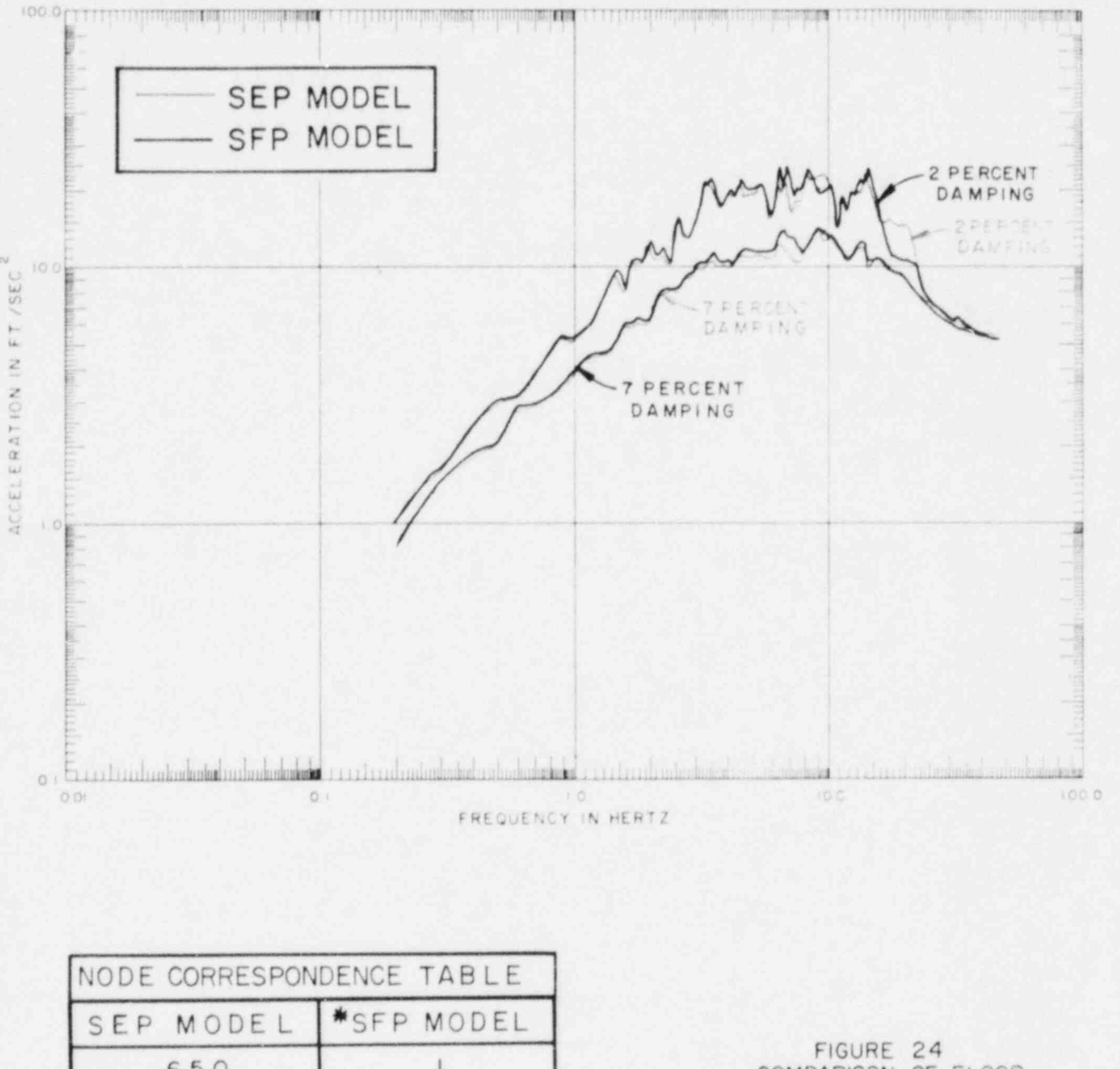
*SFP = SPENT FUEL POOL

NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 23
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS. SPENT FUEL POOL
Y DIRECTION
NODE 652 ELEVATION 630'-0"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

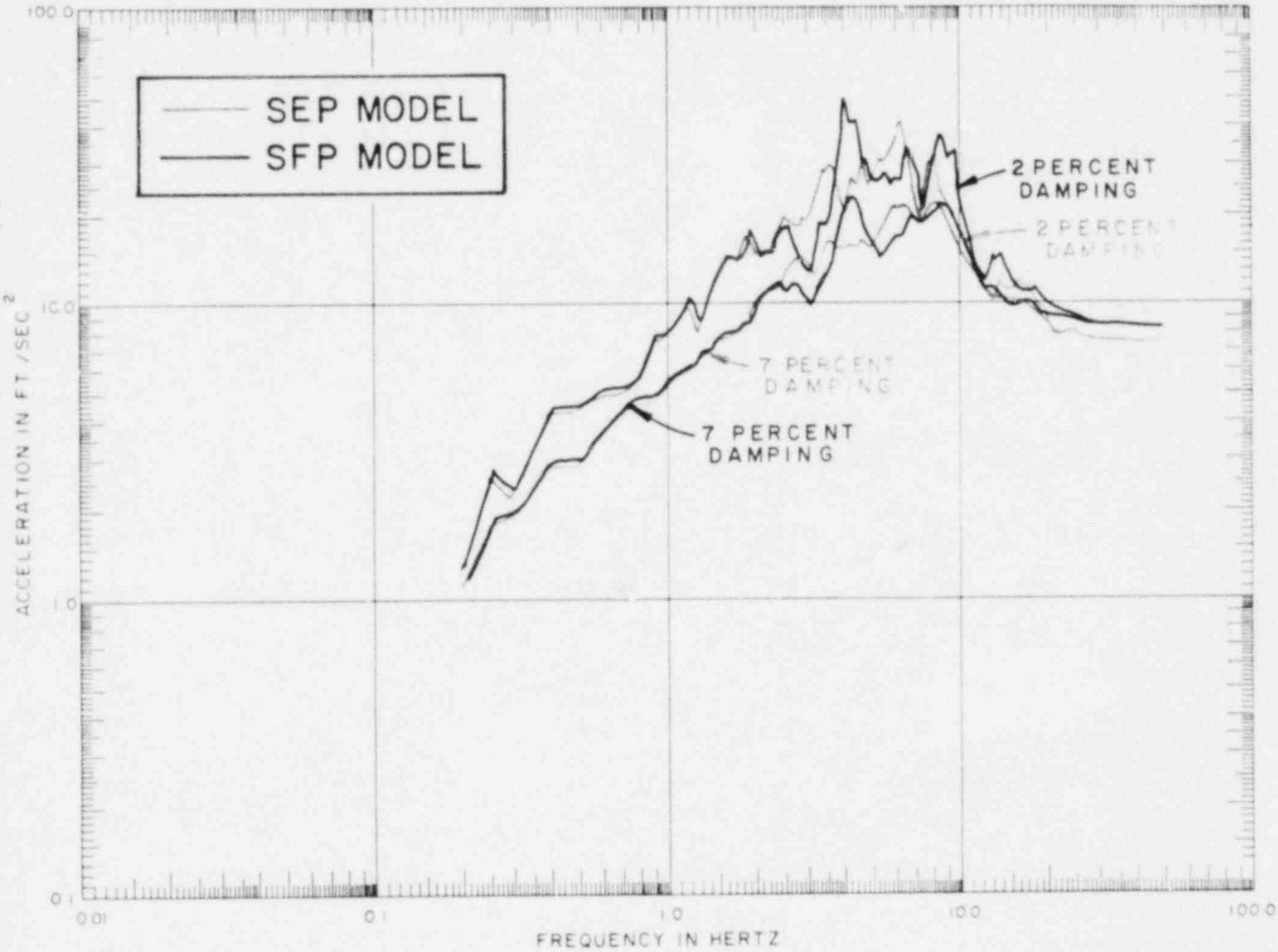
FIGURE 24
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS. SPENT FUEL POOL
Z DIRECTION
NODE 652 ELEVATION 630'-0"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION
BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY	D. Weick 4-8-82	CHECKED BY	PJG 4-14-82	DRAWING NUMBER 78-435Y-A394
DRW 36		APPROVED BY	AJW 14 Apr 82	

DRAWING NUMBER 78-435Y-A395

DRAWN BY	D. Weick 4-8-82	CHECKED BY	PJG 4-14-82	APPROVED BY	AJK [illegible]



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 25
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS. SPENT FUEL POOL
X DIRECTION
NODE 661 ELEVATION 598'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION

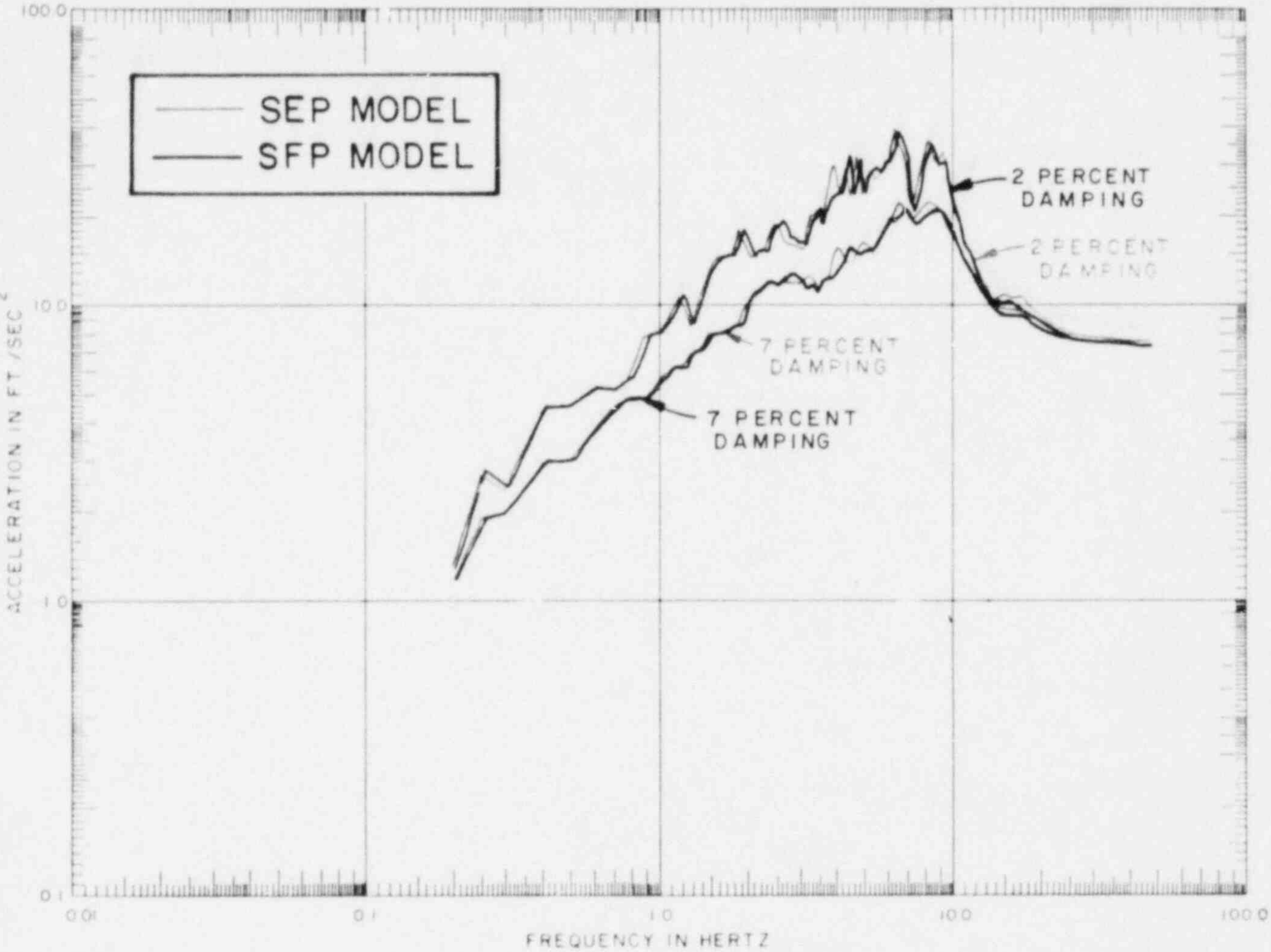
BIG ROCK POINT NUCLEAR POWER PLANT
PREPARED FOR

CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWING NUMBER 78-435Y-A396

DRAWN BY	D. Weick 4-8-82	CHECKED BY	PJG 4-14-82	APPROVED BY	AJM 14 Apr 82



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

NOTES:

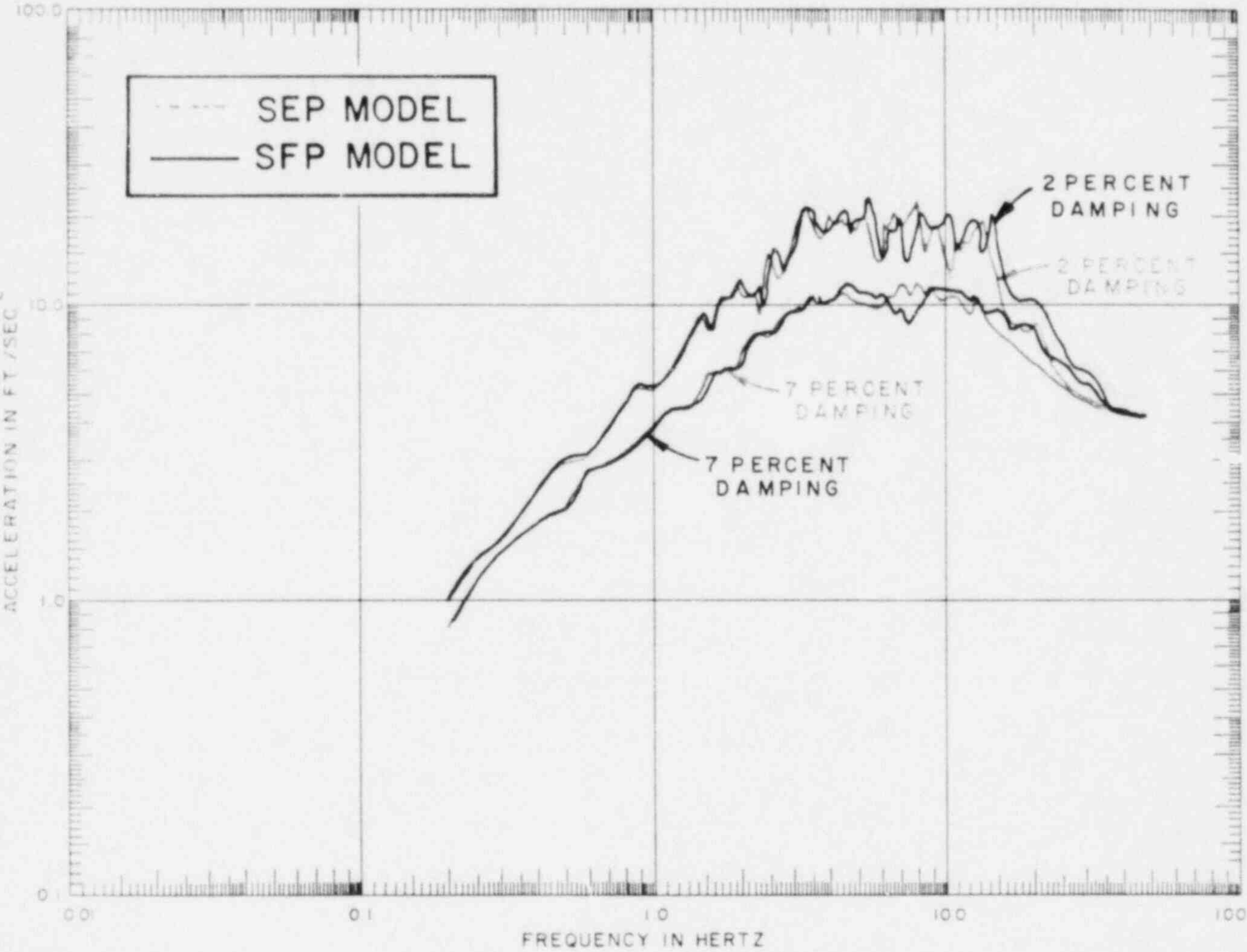
1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 26
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS. SPENT FUEL POOL
Y DIRECTION
NODE 661 ELEVATION 598'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION

BIG ROCK POINT NUCLEAR POWERPLANT
PREPARED FOR
CONSUMERS POWER COMPANY
JACKSON, MICHIGAN

D'APPOLONIA

DRAWN BY	D. Weick	4-8-82	CHECKED BY	PJG	4-14-82	DRAWING NUMBER	78-435Y-A397
39			APPROVED BY	DJM			



NODE CORRESPONDENCE TABLE	
SEP MODEL	*SFP MODEL
650	1
652	3
661	11

*SFP = SPENT FUEL POOL

NOTES:

1. REFER TO FIGURE 1 FOR DIFFERENCES BETWEEN THE TWO MODELS AND D'APPOLONIA (1978, 1981)
2. INPUT EARTHQUAKE: R.G. 1.60

FIGURE 27
COMPARISON OF FLOOR RESPONSE SPECTRA
SEP VS. SPENT FUEL POOL
Z DIRECTION
NODE 661 ELEVATION 598'-6"
PARAMETRIC STUDY
SOIL STRUCTURE INTERACTION

BIG ROCK POINT NUCLEAR POWERPLANT
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D'APPOLONIA