VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

May 24, 1979

Mr. Victor Stello, Jr., Director
Division of Operating Reactors
Office of Nuclear Reactors Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Serial No. 392/051879
PSE&C/CMRjr.:jpj

Docket Nos.: 50-280
50-281

License Nos.: DPR-32
DPR-37

Dear Mr. Stello:

We have received your letter of May 18, 1979 concerning information required for your review of our methodology in the use of soil structure interaction. Our response is contained in the attached document entitled "Response to NRC Letter of May 18, 1979 Concerning Use of Soil Structure Interaction."

If you should require additional information, please contact us as soon as possible.

Very truly yours,

W. C. Spencer
W. C. Spencer
Vice President - Power Station
Engineering & Construction
Services

Attachment

Add: W. Russell

A001 S 40/40

7905250092

ATTACHMENT

RESPONSE TO NRC LETTER OF

MAY 18, 1979 CONCERNING

USE OF SOIL STRUCTURE INTERACTION

MAY 24, 1979

SURRY POWER STATION UNITS 1 AND 2

VIRGINIA ELECTRIC AND POWER COMPANY

May 24, 1979
Dockets Nos. 50-280 and 50-281

USE OF SOIL PROPERTIES IN DEVELOPMENT OF SOIL-STRUCTURE INTERACTION AMPLIFIED RESPONSE SPECTRA

The following procedures were followed to obtain soil properties for the soil-structure interaction analyses at the Surry site for development of SSI based ARS:

First, a small strain soil profile was developed from the best available soil data, including cross hole seismic shear wave velocity measurements, as well as data from borings and samples.

Second, the effect of an earthquake in the free field was evaluated using the SHAKE computer program. The control motion was specified at the surface of the free field; two real records were used - El Centro and Taft - normalized to the acceleration level of the specified design earthquake (OBE or DBE). The program iterated to obtain values of shear modulus and damping compatible with the levels of strain developed during the earthquake. The average of the results from the two records was used in further analyses and is here called the strain compatible, free field profile.

Third, the moduli and material damping for the strain compatible, free field profile were used for the REFUND/FRIDAY analyses.

Fourth, the motion at the base of the profile obtained in the SHAKE analysis of the free field was input to several profiles representing the soil column under the Category I buildings. The top layers of these profiles had masses and fundamental periods equivalent to those of the corresponding buildings. The small strain values of soil shear moduli were adjusted to account for the additional static stresses imposed by the buildings. The computer program SHAKE was run to obtain strain compatible moduli and damping values for each building profile. The average of results for the two time histories established each profile.

Fifth, the strain compatible properties under each building were used in the finite element dynamic analyses as soil properties directly under the corresponding buildings. The strain compatible, free field soil properties were used for the elements representing the free field. Strain compatible soil properties were interpolated between these values for two columns of elements adjacent to the building.

Sixth, no further iteration on soil properties was performed in either the REFUND/FRIDAY or the finite element analysis.

SHAKE ANALYSIS

SURRY POWER STATION - UNITS 1 AND 2

The effect of increasing and decreasing the average low strain shear moduli (Gmax) by a factor of 50 percent was evaluated with SHAKE. The El Centro and Taft earthquake records, normalized for the DBE, were input at the ground surface in the free field, deconvoluted to the base layer and then amplified up through the soil to the containment structure. All soil parameters other than the low strain shear moduli remained unchanged.

The depth of the soil profile for the analysis using one half of the average low strain shear modulus (Gmax) was reduced from 406 ft to 261 ft. The use of such low values of shear moduli with a deep soil profile causes the iterations for strain dependent properties to diverge. Convergence was attained by eliminating the frequency content of the time histories above 10 hz and by establishing the half space at a higher elevation. The full profile was used in the soil-structure interaction analysis, using extrapolated values of strain compatible modulus and damping for the bottom layers of the profile.

The strain compatible soil properties for average Gmax plus 50 percent and average Gmax minus 50 percent are listed on Tables 2-12 and 2-13, for the free-field and under the reactor containment, respectively.

Strain compatible soil properties for average Gmax are included in Tables 2.4.2-1 and 2.4.2-2 for the free-field and containment, respectively.

TABLE 2.4.2-1

STRAIN COMPATIBLE SOIL PROPERTIES

Free Field

Gmax

Layer No.	Thickness (ft)	Top of Layer Elev.	Low Strain Values Gmax (ksf)	Low Strain Values Cs (fps)	Total Unit Wt (kcf)	Soil Unit	DBE = 0.15g Shear Modulus (ksf) Taft S69E	DBE = 0.15g Shear Modulus (ksf) ElCentro N-S	DBE = 0.15g Shear Modulus (ksf) Average	DBE = 0.15g Damping Taft S69E	DBE = 0.15g Damping ElCentro N-S	DBE = 0.15g Damping Average	OBE = 0.07g Shear Modulus (ksf) Taft S69E	OBE = 0.07g Shear Modulus (ksf) ElCentro N-S	OBE = 0.07g Shear Modulus (ksf) Average	OBE = 0.07g Damping Taft S69E	OBE = 0.07g Damping ElCentro N-S	OBE = 0.07g Damping Average
1	21	+26	1585		.120	Pleistocene Clay	581	547	564	.069	.072	.071	840	823	832	.051	.051	.051
2	25	+5	3310		.120	Pleistocene Sand	1859	1746	1802	.071	.076	.074	2468	2380	2424	.044	.048	.046
3	20	-20	3310		.120	Pleistocene Clay	793	766	780	.070	.071	.071	1255	1201	1228	.052	.054	.053
4	25	-40	3310		.110	Miocene Clay	760	797	778	.068	.067	.068	1149	1155	1152	.053	.053	.053
5	25	-65	3310		.110	Miocene Clay	881	895	888	.060	.060	.060	1190	1261	1226	.050	.047	.049
6	33	-90	3530		.120	Miocene Clay	976	909	943	.056	.058	.057	1476	1405	1441	.041	.043	.042
7	33	-123	3530		.120	Miocene Clay	916	879	898	.055	.056	.056	1425	1323	1374	.041	.043	.042
8	34	-157	3530		.120	Miocene Clay	908	890	899	.053	.053	.053	1368	1304	1336	.040	.042	.041
9	45	-190	3530		.120	Miocene Clay	871	843	857	.051	.052	.052	1349	1344	1347	.039	.039	.039
10	45	-235	3530		.120	Miocene Clay	854	742	798	.049	.053	.051	1298	1301	1300	.038	.038	.038
11	50	-280	8225		.135	Eocene Sands	5497	4018	4758	.034	.051	.043	6459	6195	6327	.024	.027	.026
12	50	-330	8225		.135	Paleocene Sands	4696	3309	4003	.041	.059	.050	6105	5654	5880	.026	.031	.029

TABLE 2.4.2-2

STRAIN COMPATIBLE SOIL PROPERTIES

Reactor Containment

Gmax

							DBE = 0.15g						OBE = 0.07g					
			Low Strain Values				Shear Modulus (ksf)			Damping			Shear Modulus (ksf)			Damping		
Layer No.	Thickness (ft)	Top of Layer Elev.	Gmax (ksf)	Cs (fps)	Total Unit Wt (kcf)	Soil Unit	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average
1	21	+26		1073	.1106	Structure												
2	45	+5		1073	.1106	Structure												
3	25	-40	3310		.110	Miocene Clay	720	728	724	.072	.071	.072	1175	1138	1157	.054	.055	.055
4	25	-65	3310		.110	Miocene Clay	728	861	795	.068	.062	.065	1121	1196	1159	.053	.051	.052
5	33	-90	3530		.120	Miocene Clay	959	845	902	.058	.062	.060	1423	1405	1414	.044	.044	.044
6	33	-123	3530		.120	Miocene Clay	935	881	908	.055	.057	.056	1396	1299	1348	.042	.045	.044
7	34	-157	3530		.120	Miocene Clay	909	878	889	.054	.055	.055	1325	1343	1334	.042	.041	.042
8	45	-190	3530		.120	Miocene Clay	853	799	826	.053	.054	.054	1318	1325	1322	.040	.040	.040
9	45	-235	3530		.120	Miocene Clay	838	751	795	.050	.053	.052	1284	1269	1277	.039	.039	.039
10	50	-280	8225		.135	Eocene Sands	5430	3937	4684	.035	.053	.044	6509	6239	6374	.024	.027	.026
11	50	-330	8225		.135	Paleocene Sands	4518	3225	3872	.043	.061	.052	6117	5721	5919	.026	.030	.029

SURRY POWER STATION, UNITS 1 AND 2

TABLE 2-13

STRAIN COMPATIBLE SOIL PROPERTIES

Reactor Containment

							Average Gmax + 50% (DBE)						Average Gmax - 50% (DBE)					
							Shear Modulus (ksf)			Damping			Shear Modulus (ksf)			Damping		
			Low Strain Values															
Layer No.	Thickness (ft)	Top of Layer Elev.	Gmax (ksf)	Cs (fps)	Total Unit Wt (kcf)	Soil Unit	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average
1	21	+26		1073	.1106	Structure												
2	45	+5		1073	.1106	Structure												
3	25	-40	3310		.110	Miocene Clay	1337	1255	1296	.064	.067	.066	310	330	320	.076	.074	.075
4	25	-65	3310		.110	Miocene Clay	1261	1278	1269	.063	.063	.063	308	279	294	.072	.077	.075
5	33	-90	3530		.120	Miocene Clay	1549	1635	1592	.055	.053	.054	335	349	342	.068	.067	.068
6	33	-123	3530		.120	Miocene Clay	1617	1478	1548	.051	.054	.053	333	299	316	.065	.069	.067
7	34	-157	3530		.120	Miocene Clay	1558	1478	1518	.049	.051	.050	310	274	292	.063	.072	.068
8	45	-190	3530		.120	Miocene Clay	1528	1483	1505	.047	.048	.048	305	209	257	.061	.084	.073
9	45	-235	3530		.120	Miocene Clay	1449	1406	1428	.047	.047	.047	-	-	-	-	-	-
10	50	-280	8225		.135	Eocene Sands	8798	7790	8294	.031	.038	.034	-	-	-	-	-	-
11	50	-330	8225		.135	Paleocene Sands	7941	6918	7430	.035	.042	.039	-	-	-	-	-	-

TABLE 2-14

STRAIN COMPATIBLE SOIL PROPERTIES

Free Field

							Average Gmax + 50% (DBE)						Average Gmax - 50% (DBE)					
							Shear Modulus (ksf)			Damping			Shear Modulus (ksf)			Damping		
			Low Strain Values															
Layer No.	Thickness (ft)	Top of Layer Elev.	Gmax (ksf)	Cs (fps)	Total Unit Wt (kcf)	Soil Unit	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average	Taft S69E	ElCentro N-S	Average
1	21	+26	1585		.120	Pleistocene Clay	1058	1038	1048	.058	.059	.059	192	172	182	.090	.094	.092
2	25	+5	3310		.120	Pleistocene Sand	3351	3149	3250	.054	.060	.057	672	674	673	.099	.098	.099
3	20	-20	3310		.120	Pleistocene Clay	1463	1367	1415	.062	.065	.064	334	359	347	.076	.074	.075
4	25	-40	3310		.110	Miocene Clay	1290	1263	1277	.064	.065	.065	351	334	343	.070	.072	.071
5	25	-65	3310		.110	Miocene Clay	1287	1330	1309	.061	.060	.061	323	329	326	.070	.069	.070
6	33	-90	3530		.120	Miocene Clay	1665	1656	1661	.052	.052	.052	340	358	349	.066	.065	.066
7	33	-123	3530		.120	Miocene Clay	1629	1475	1552	.050	.053	.052	328	316	322	.064	.065	.065
8	34	-157	3530		.120	Miocene Clay	1568	1435	1502	.048	.051	.050	327	271	299	.061	.071	.066
9	45	-190	3530		.120	Miocene Clay	1531	1426	1479	.047	.049	.048	316	219	268	.059	.080	.070
10	45	-235	3530		.120	Miocene Clay	1455	1412	1433	.046	.047	.047	-	-	-	-	-	-
11	50	-280	8225		.135	Eocene Sands	8723	7903	8313	.031	.037	.035	-	-	-	-	-	-
12	50	-330	8225		.135	Paleocene Sands	7953	6831	7392	.034	.043	.039	-	-	-	-	-	-

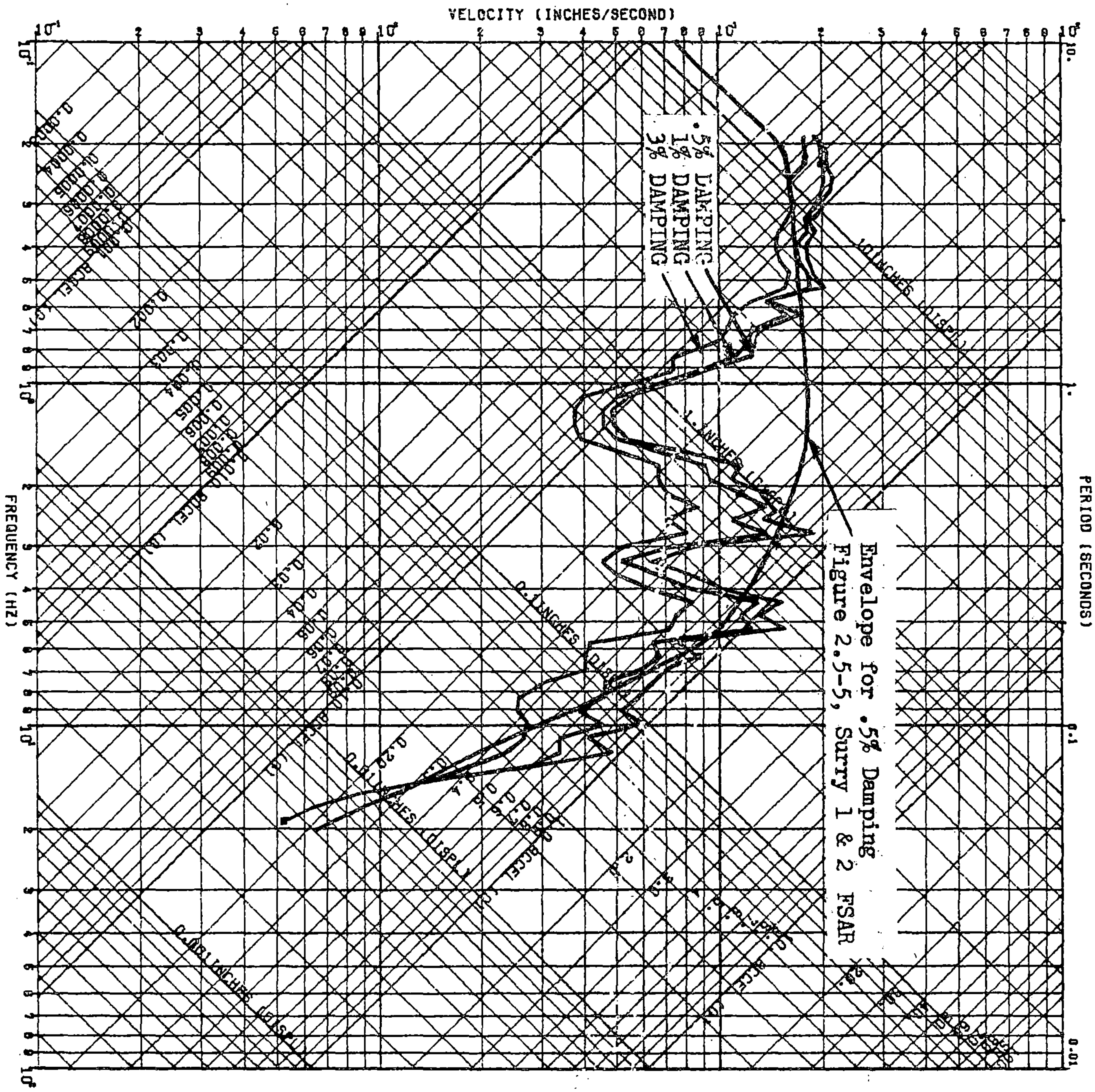
RESPONSE SPECTRA AT BASE OF CONTAINMENT

SURRY POWER STATION - UNITS 1 AND 2

The ground response spectra at the base of the reactor containment structure were calculated and plotted using SHAKE. The artificial earthquake developed for the Surry site was normalized to the Design Basis Earthquake (DBE) maximum acceleration of .15g and input at the ground surface of the free-field profile. The earthquake motion was deconvoluted to the base of the profile and the computed motion at elevation -40 ft, the containment founding grade, was used to calculate the real velocity and acceleration response spectra and the tripartite plot of real displacement, pseudovelocity and pseudoacceleration vs. frequency. These spectra are plotted for damping ratios of .5, 1.0, and 3.0 percent.

Response spectra were calculated for three soil profiles, represented by the average low strain shear modulus, Gmax, calculated from seismic cross-hole surveys, Gmax plus 50%, and Gmax minus 50%. The spectra for each soil profile are plotted on Figs. 3-3, 3-4, and 3-5 respectively. Also plotted on these figures is the envelope for .5 percent damping, as presented on Figure 2.5-5 of the Surry 1 and 2 FSAR.

RUN NUMBER S1752941 051779



ARTIFICIAL EQ. (DBE)-FREE FIELD FREE FIELD DECONVOLUTE(-50%OMAX)

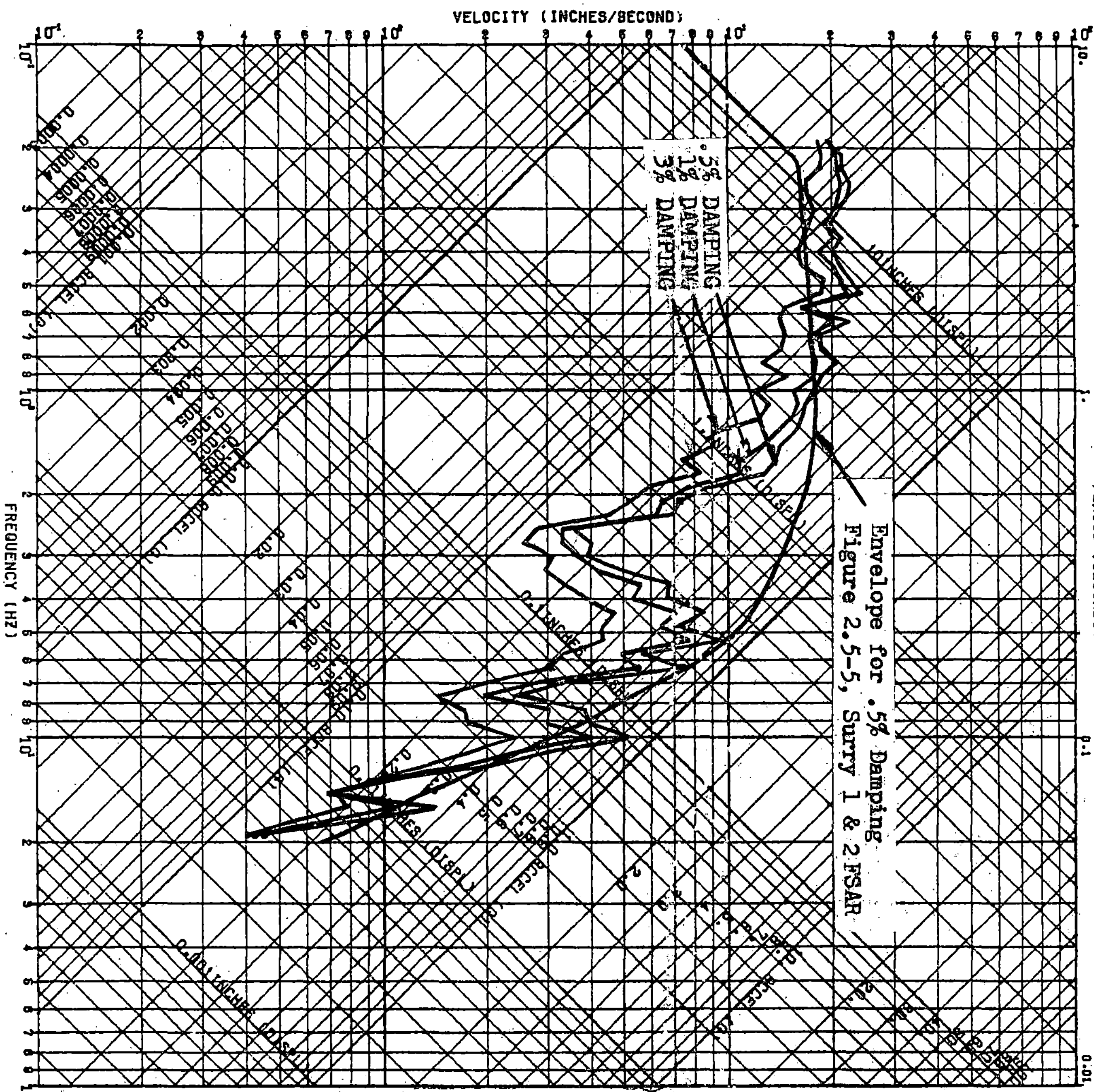
SPECTRA FOR TOP OF LAYER 4

DAMPING VALUES

- ⊡ 0.005
- ⊙ 0.010
- ▲ 0.030

FIGURE 3-3
GROUND RESPONSE SPECTRA
AVERAGE Gmax
SURRY POWER
UNITS 1 & 2

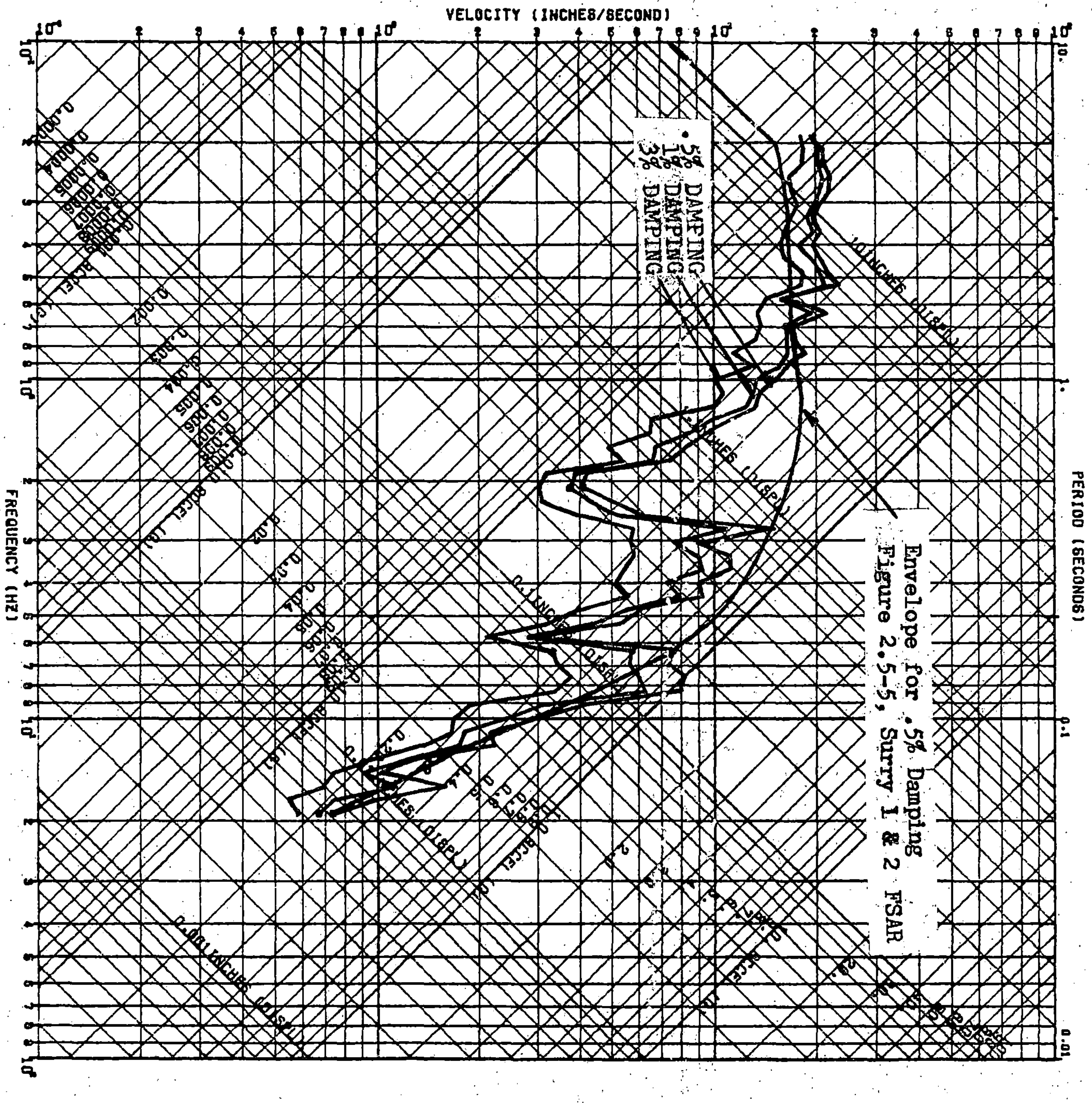
RUN NUMBER S1752940 051779



ARTIFICIAL EQ FREE FIELD FREE FIELD DECONVOLUTE(+50%GMAX)
SPECTRA FOR TOP OF LAYER 4
DAMPING VALUES
□ 0.005
○ 0.010
▲ 0.030

FIGURE 3-4
GROUND RESPONSE SPECTRA
AVERAGE Gmax + 50%
SURRY POWER STATION
UNITS 1 & 2

RUN NUMBER 81752942 061779



ART EQ(DBE)-FREE FIELD FREE FIELD DECONVOLUTE(DMAX)
SPECTRA FOR TOP OF LAYER 4
DAMPING VALUES
□ 0.005
⊙ 0.010
▲ 0.030

FIGURE 3-5
GROUND RESPONSE SPECTRA
AVERAGE Gmax - 50%
SURRY POWER STATION
UNITS 1 & 2

SURRY POWER STATION - UNITS 1 AND 2

STRUCTURAL DAMPING

5% DBE - FOR ALL CURVES

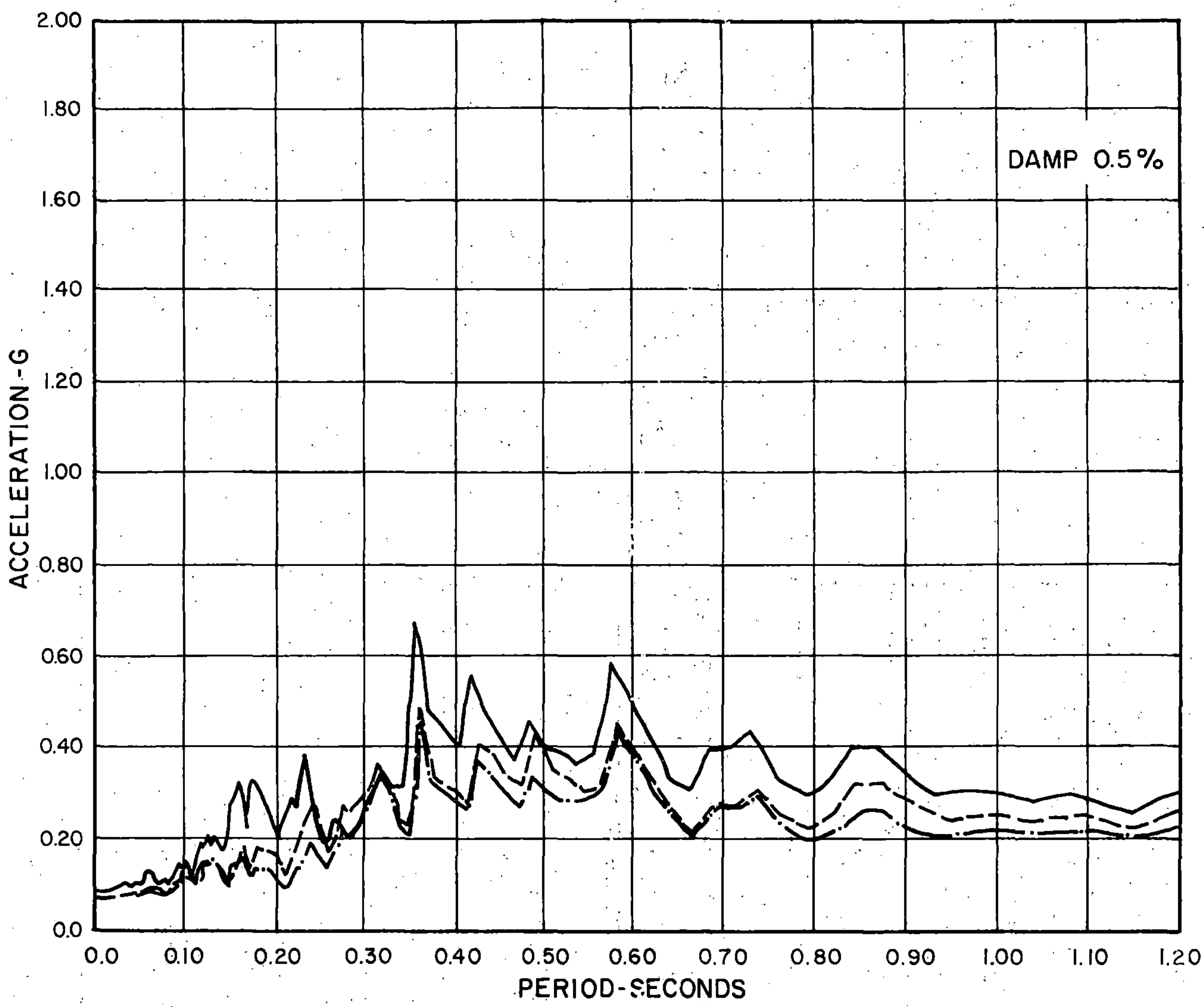
SOIL-MATERIAL DAMPING

LOW STRAIN G = 5%

G + 50% FROM SHAKE	USED OUTPUT VALUES FROM SHAKE RUN
FIRST ITERATION FROM SHAKE	
LAST ITERATION FROM SHAKE	
G - 50% FROM SHAKE	

EQUIPMENT DAMPING

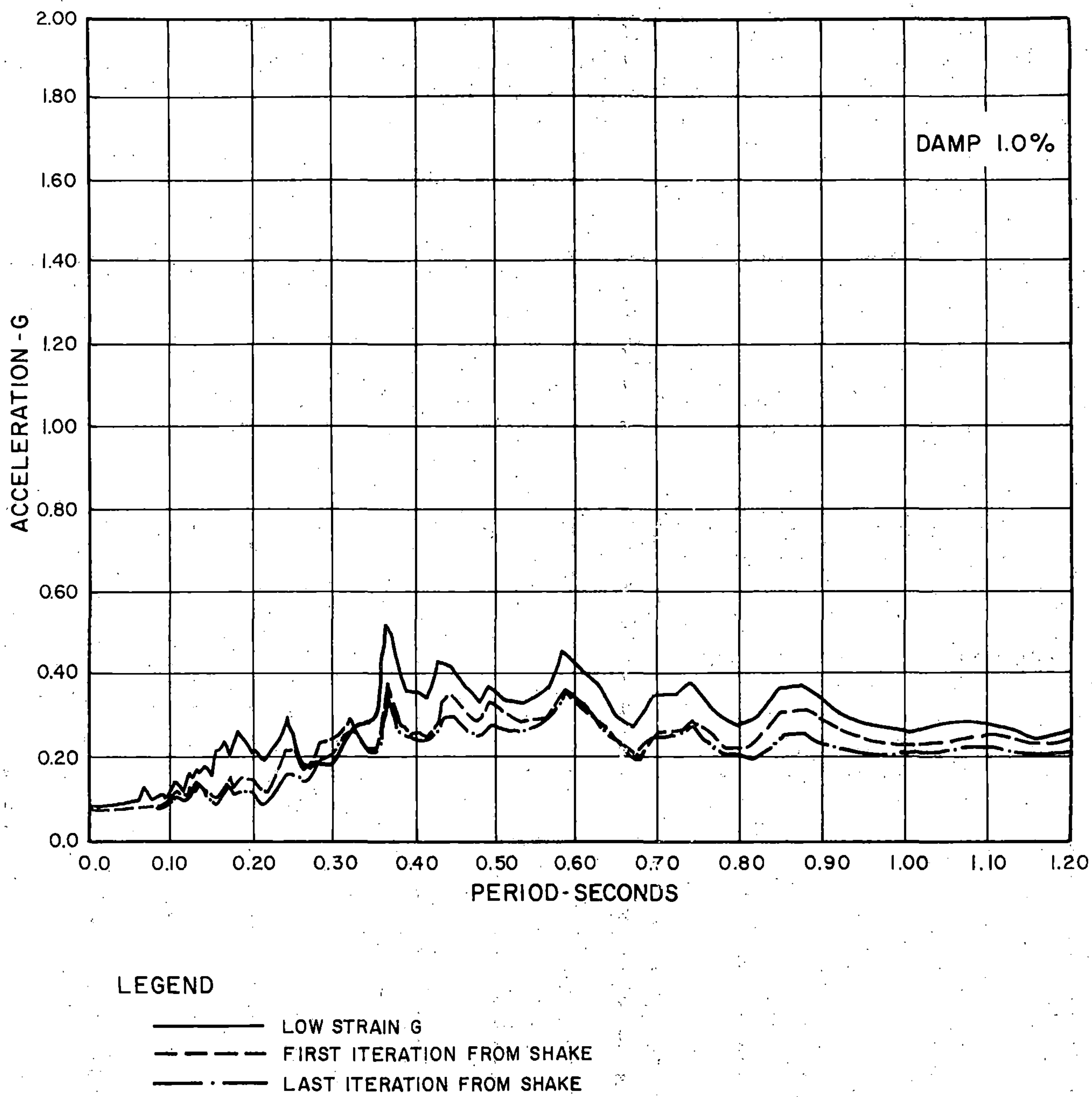
ARS CURVES PROVIDED FOR EQUIPMENT DAMPINGS OF .0.5%, 1.0%, and 3.0%



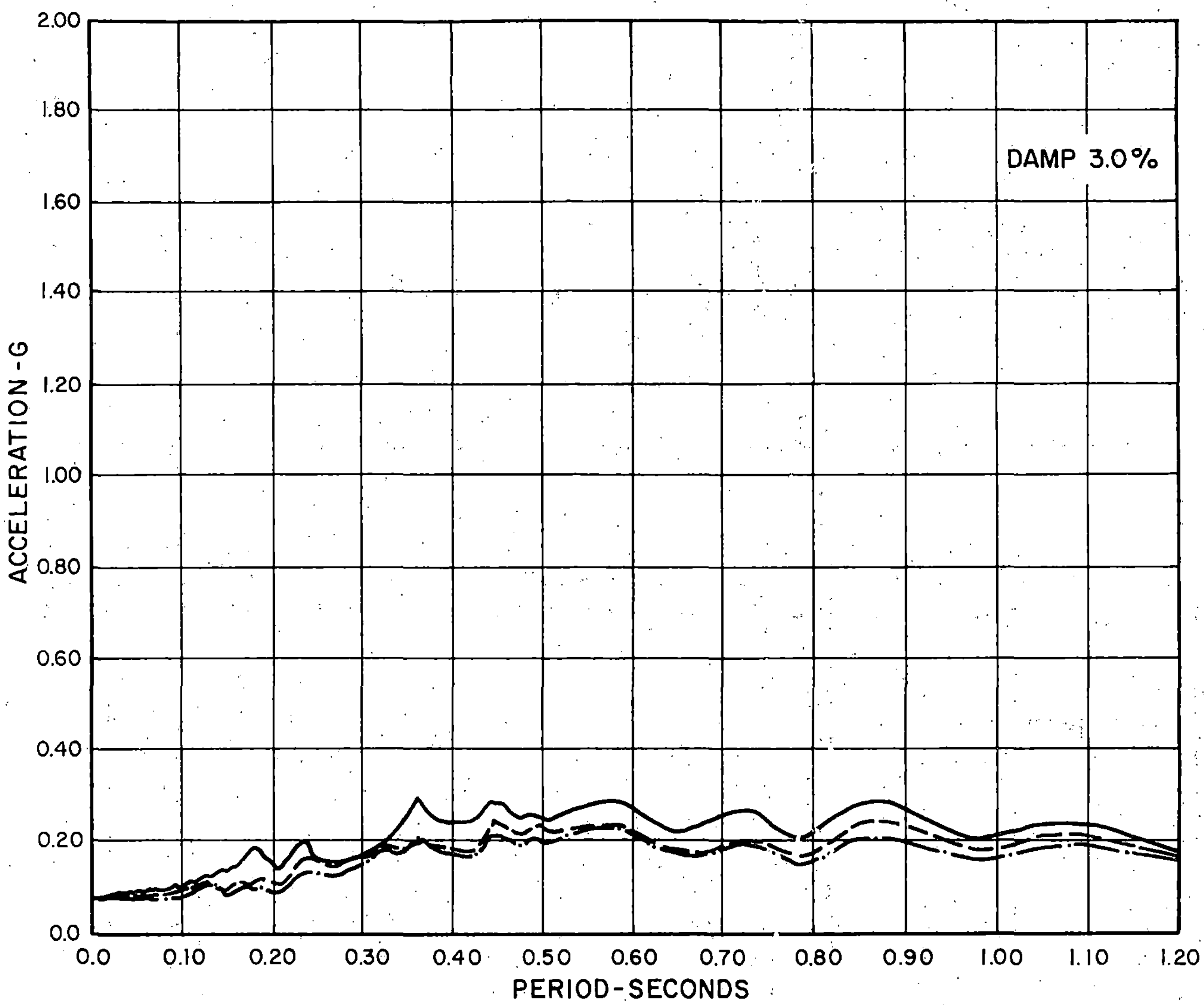
LEGEND

- LOW STRAIN G
- FIRST ITERATION FROM SHAKE
- LAST ITERATION FROM SHAKE

SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION - UNITS 1 AND 2



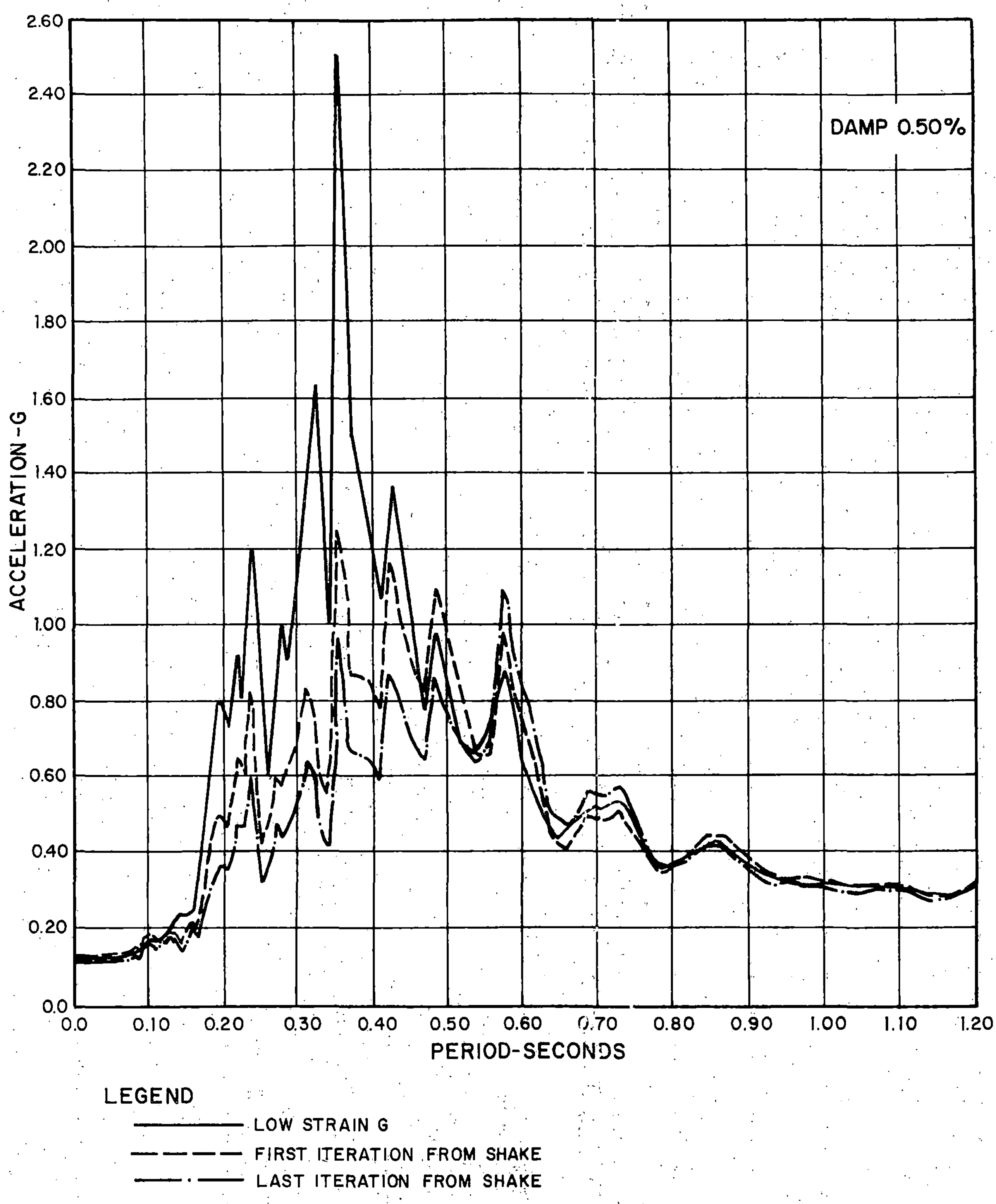
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION-UNITS 1 AND 2



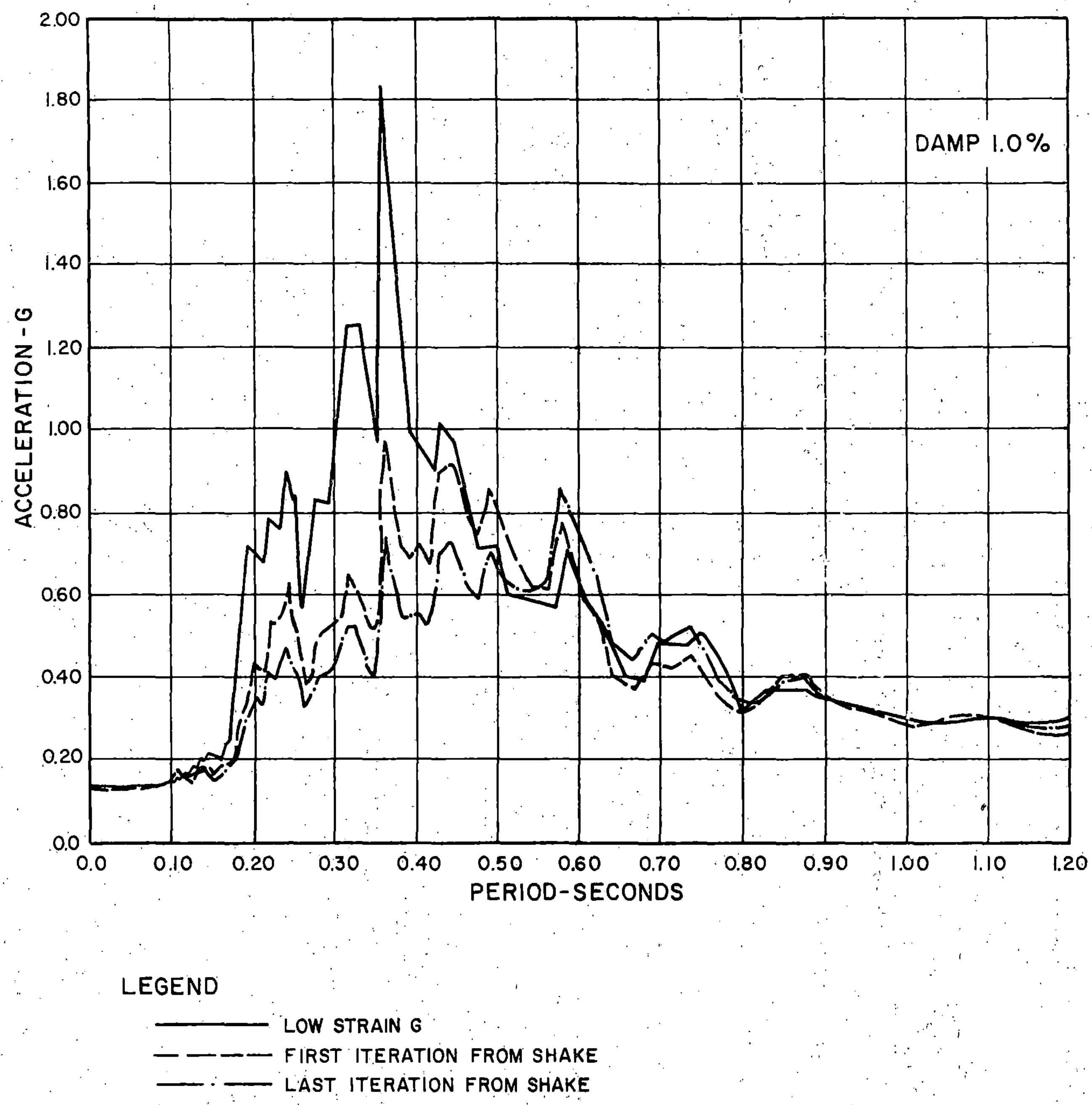
LEGEND

LOW STRAIN G
FIRST ITERATION FROM SHAKE
LAST ITERATION FROM SHAKE

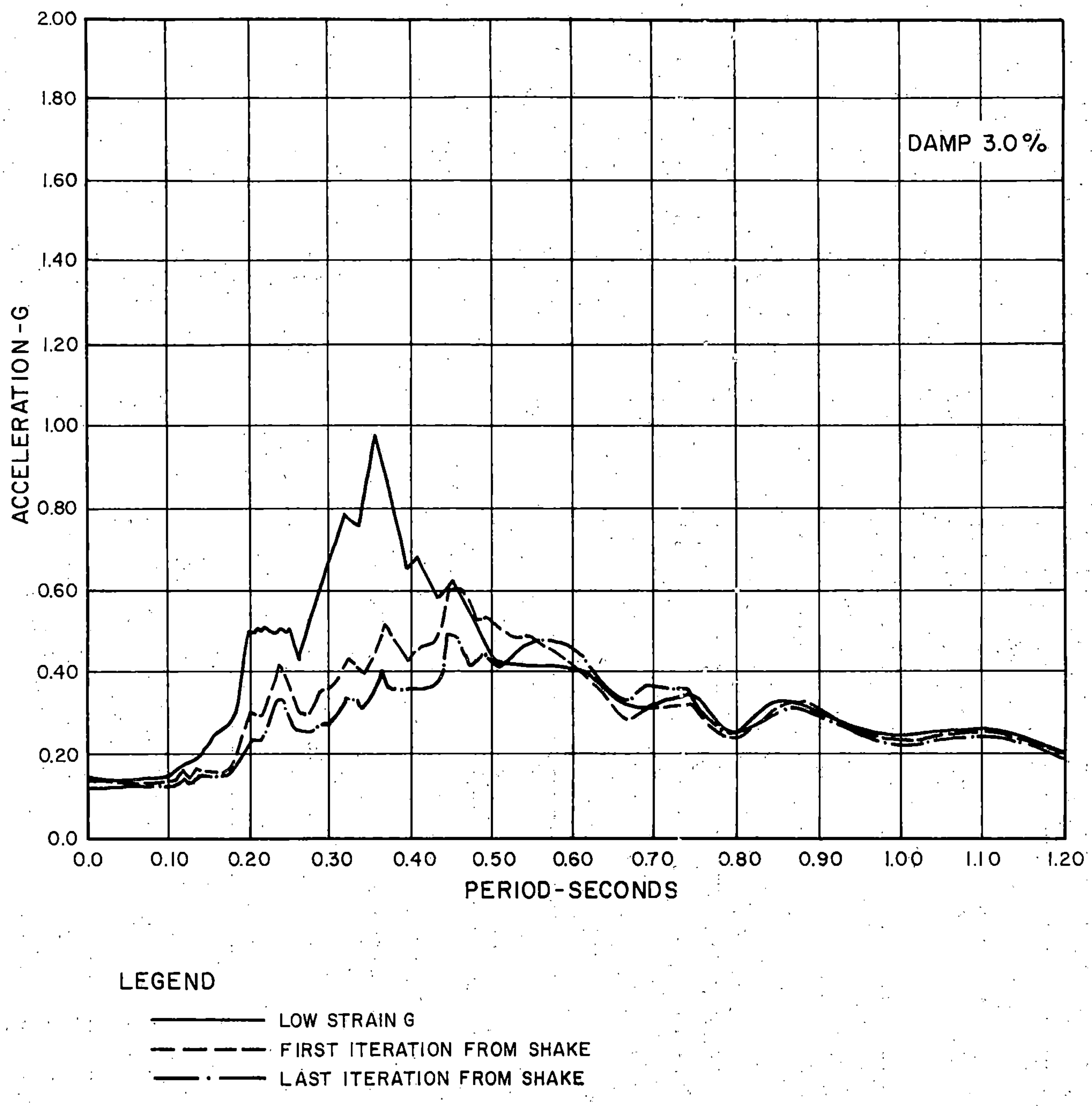
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION-UNITS I AND 2



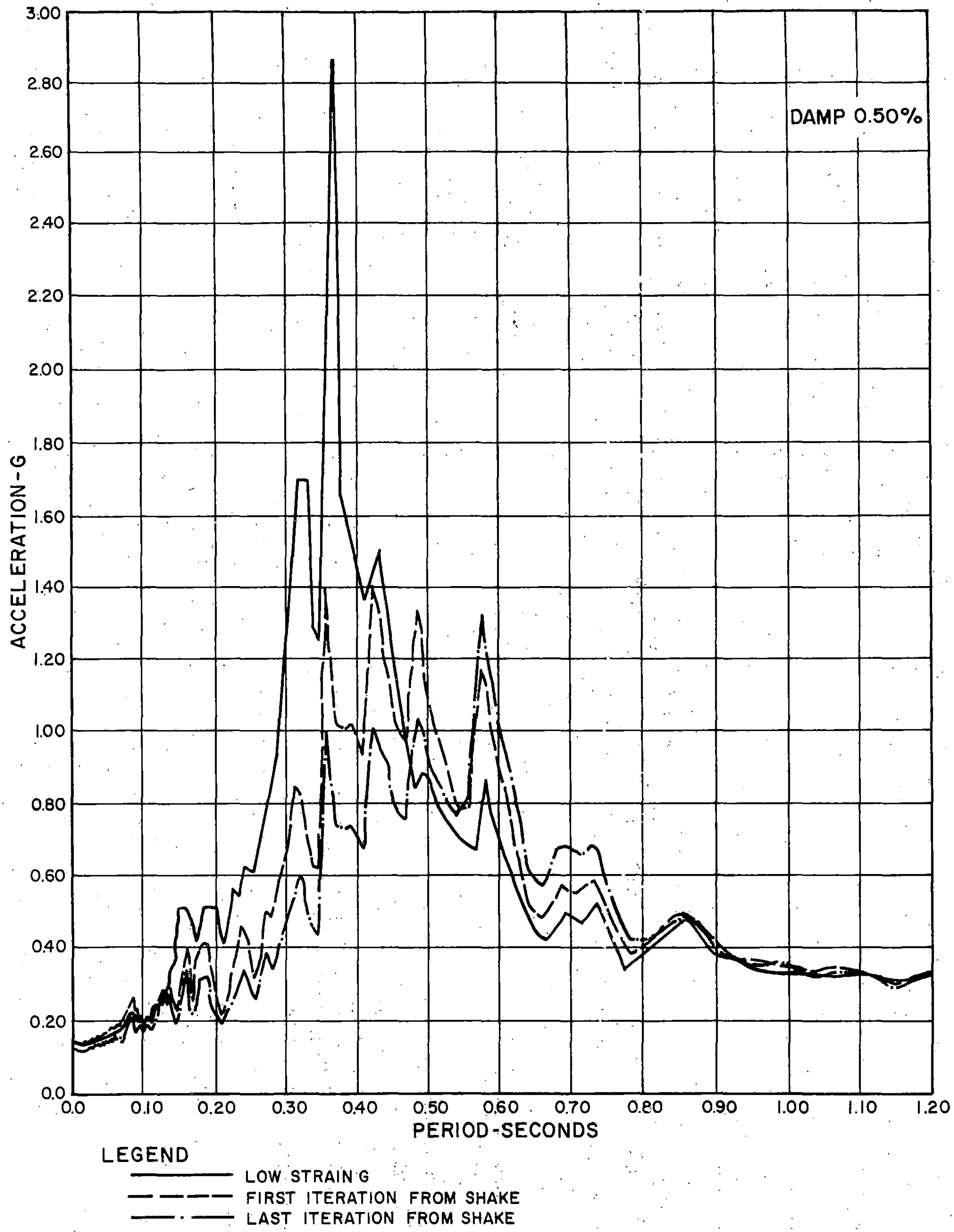
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT
OPERATING FLOOR
SURRY POWER STATION-UNITS 1 AND 2



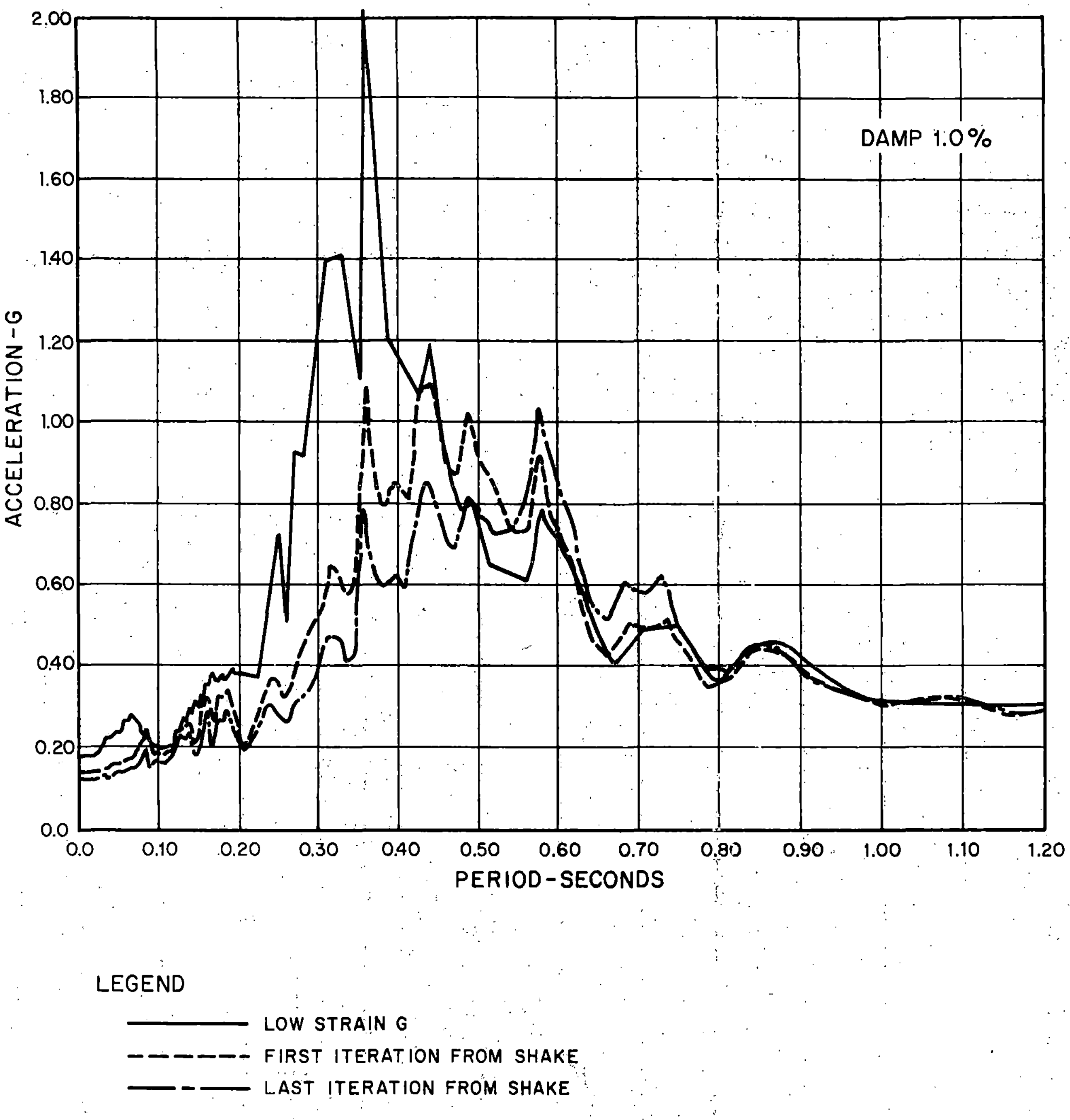
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT
OPERATING FLOOR
SURRY POWER STATION-UNITS 1 AND 2



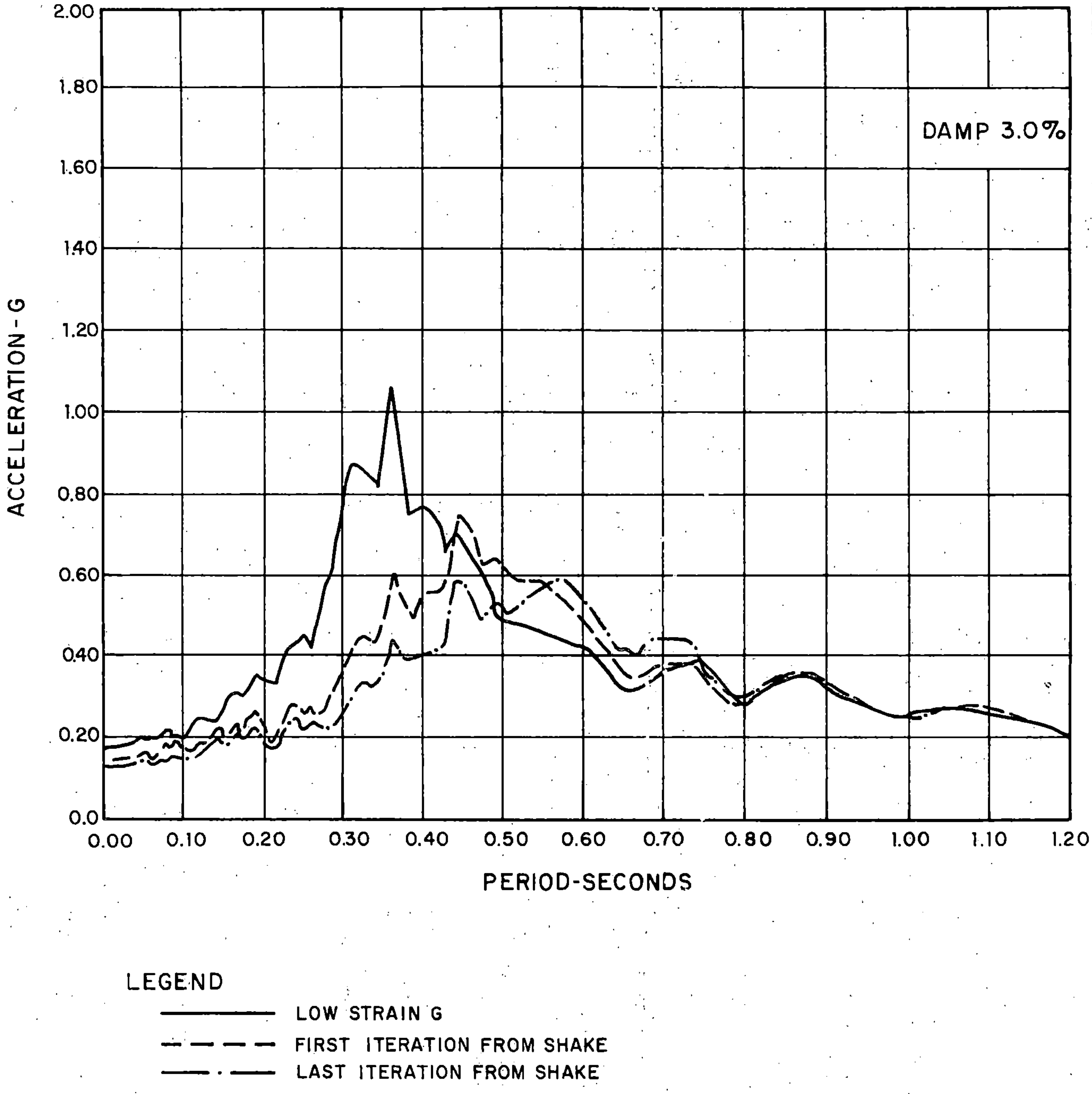
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT OPERATING FLOOR
SURRY POWER STATION-UNITS 1 AND 2



SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT SPRINGLINE
SURRY POWER STATION-UNITS 1 AND 2

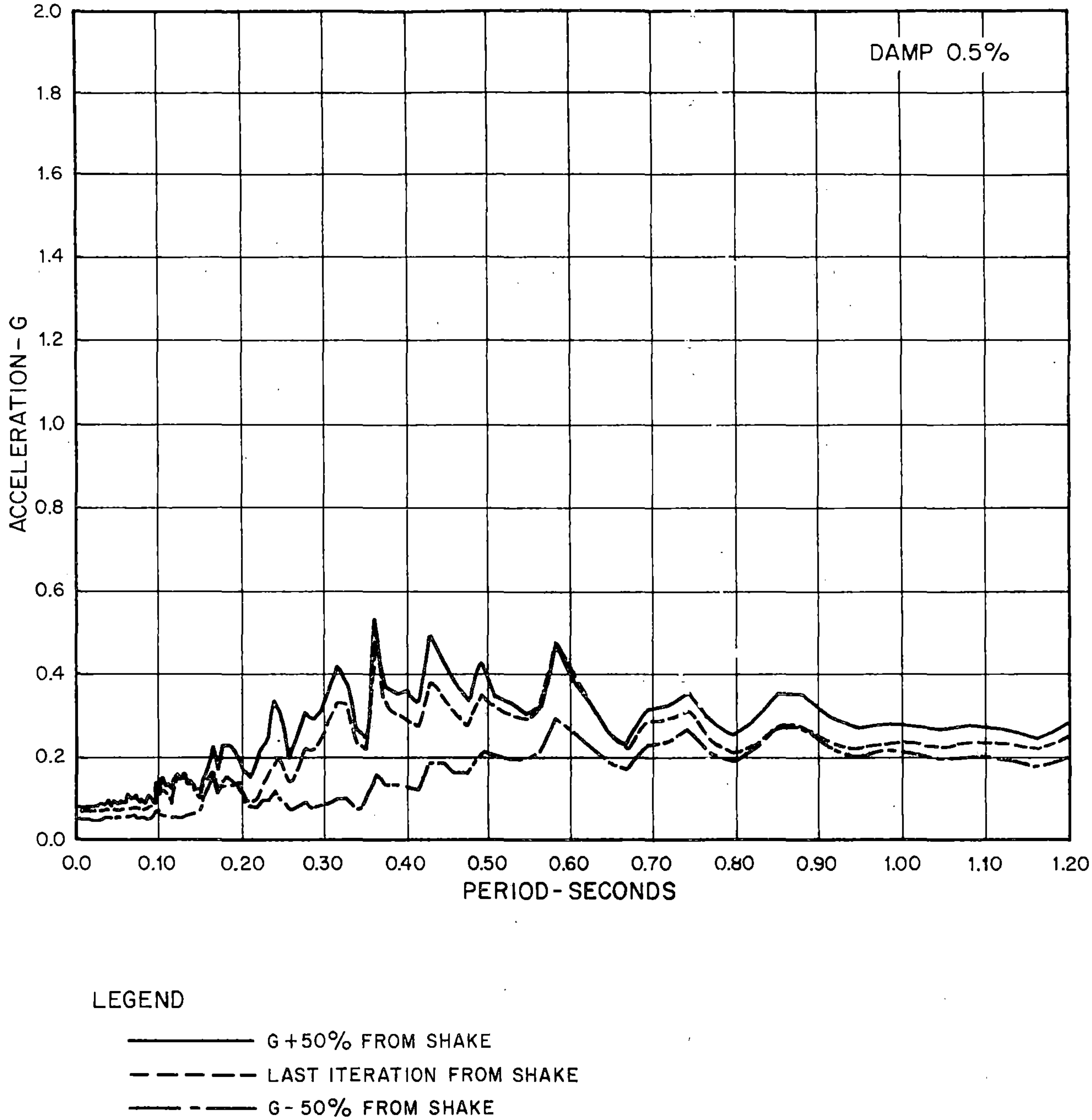


SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM
AT SRINGLINE
SURRY POWER STATION - UNITS 1 AND 2

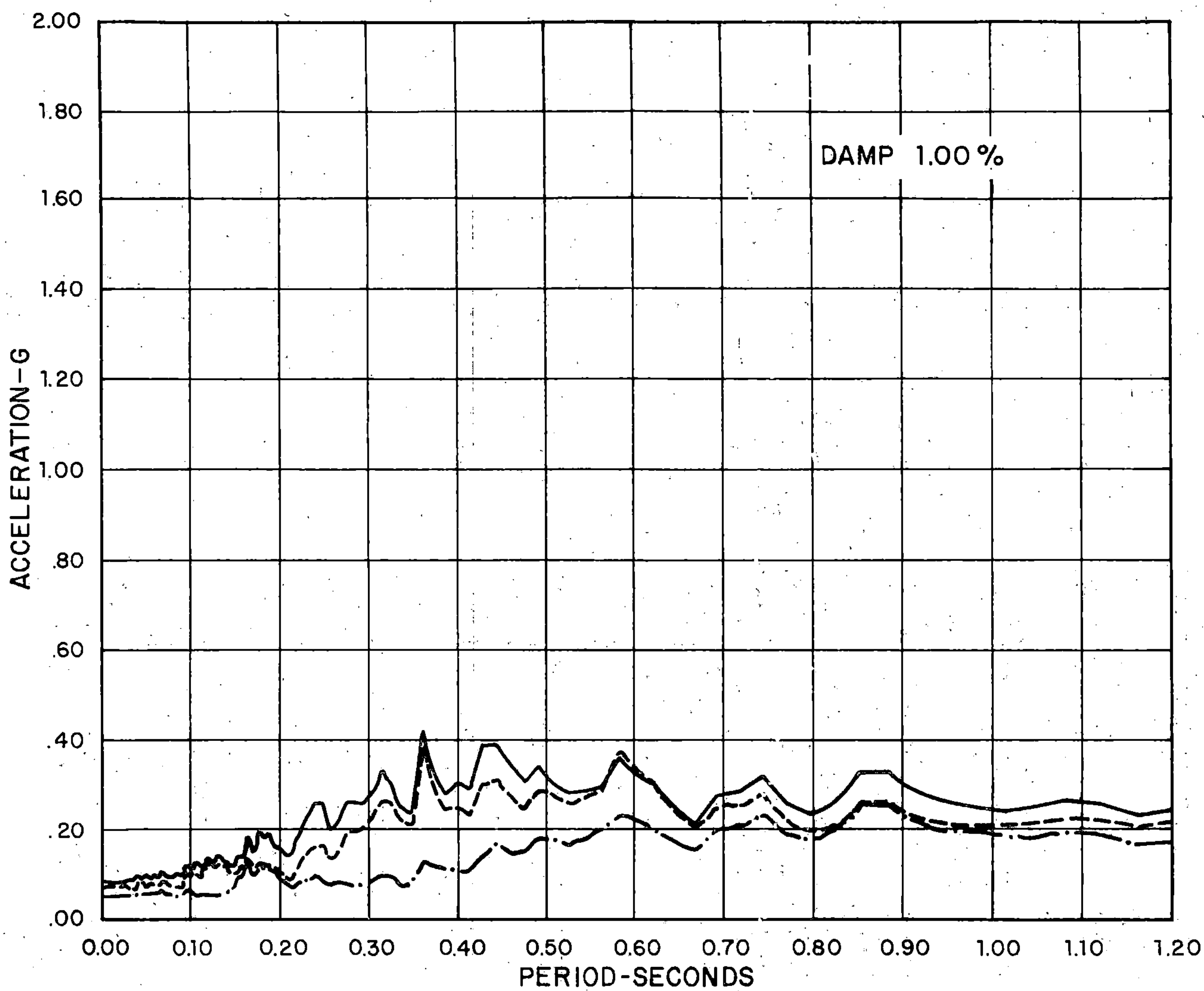


SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE

HORIZONTAL RESPONSE SPECTRUM
AT SPRINGLINE
SURRY POWER STATION-UNIT 1 AND 2



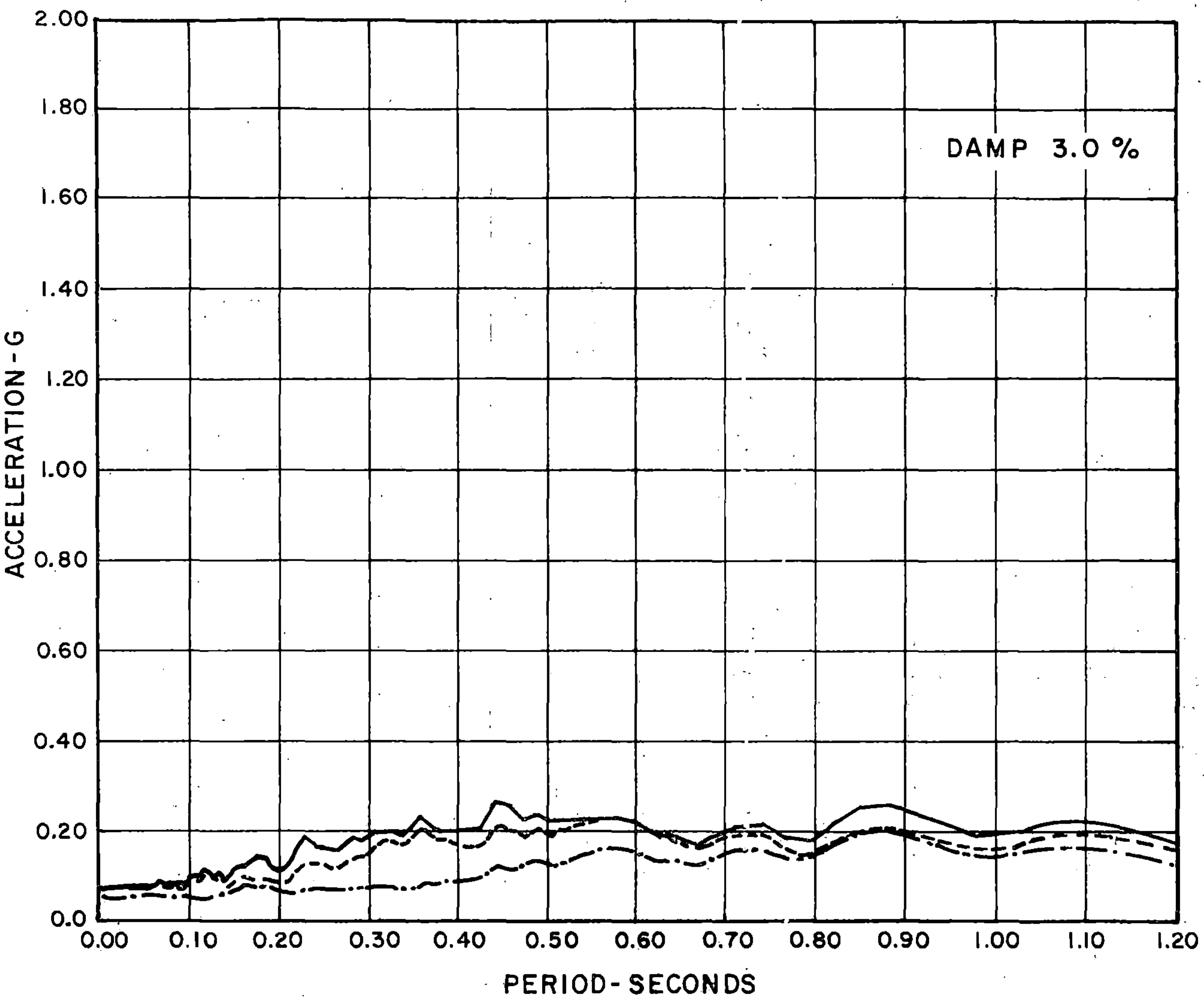
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION - UNITS 1 AND 2



LEGEND

- ——————— G + 50% FROM SHAKE
- — — — — — LAST ITERATION FROM SHAKE
- ——·—— G − 50% FROM SHAKE

SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL DBE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION – UNITS 1 AND 2



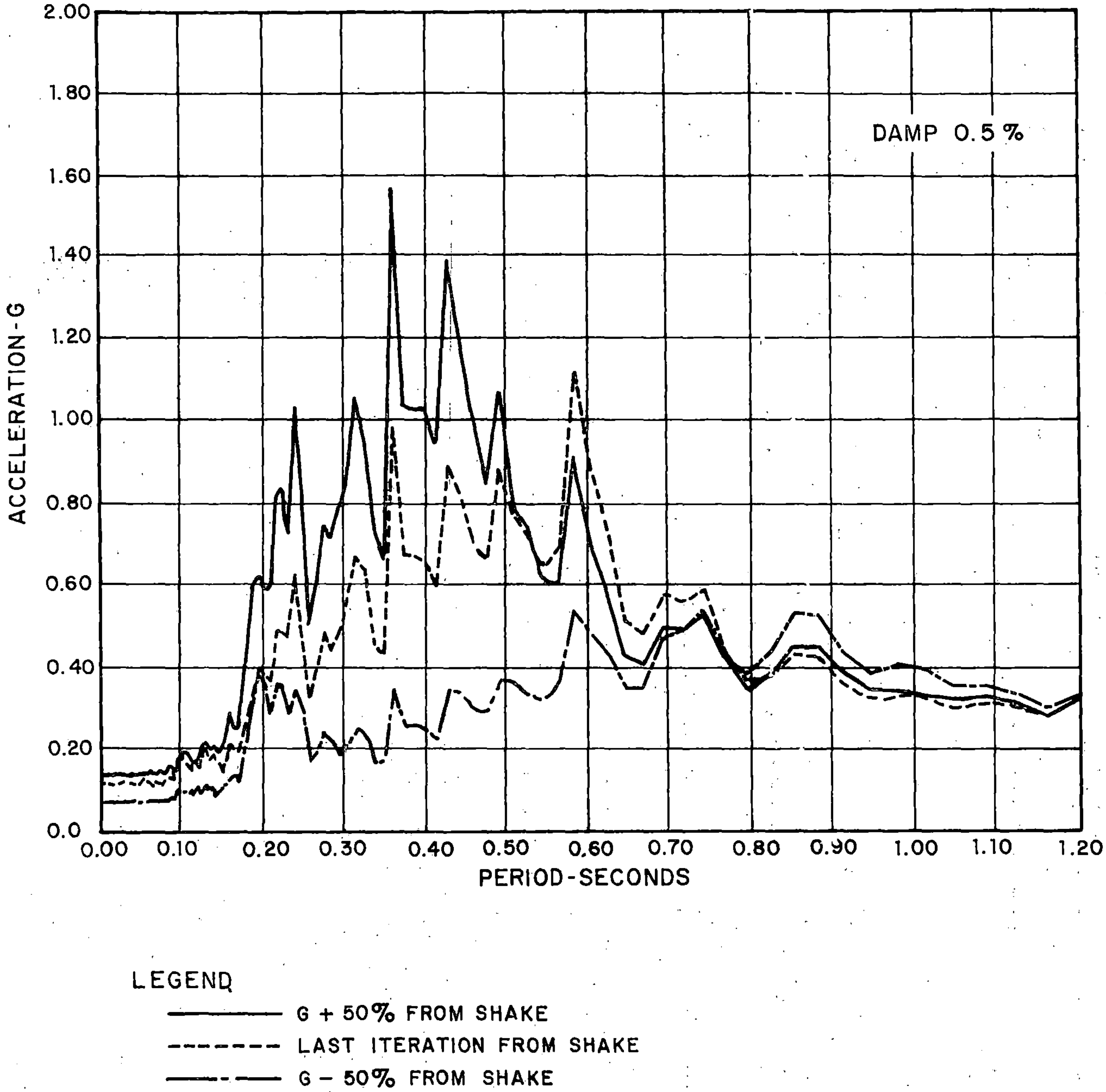
LEGEND:

———— G + 50 % FROM SHAKE

– – – – – LAST ITERATION FROM SHAKE

—·—·— G – 50 % FROM SHAKE

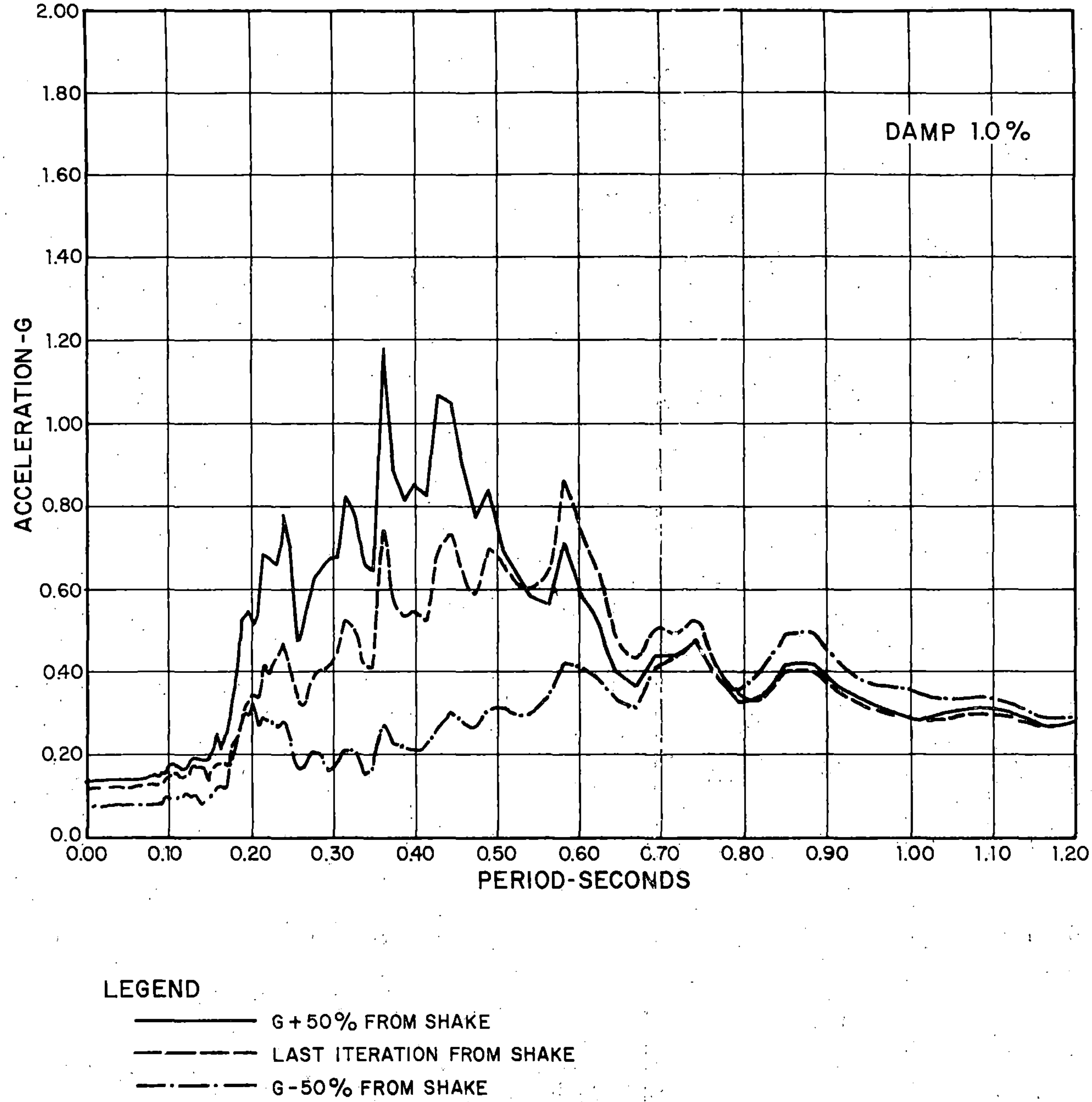
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT MAT
SURRY POWER STATION-UNITS 1 AND 2



SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE

HORIZONTAL RESPONSE SPECTRUM AT
OPERATING FLOOR

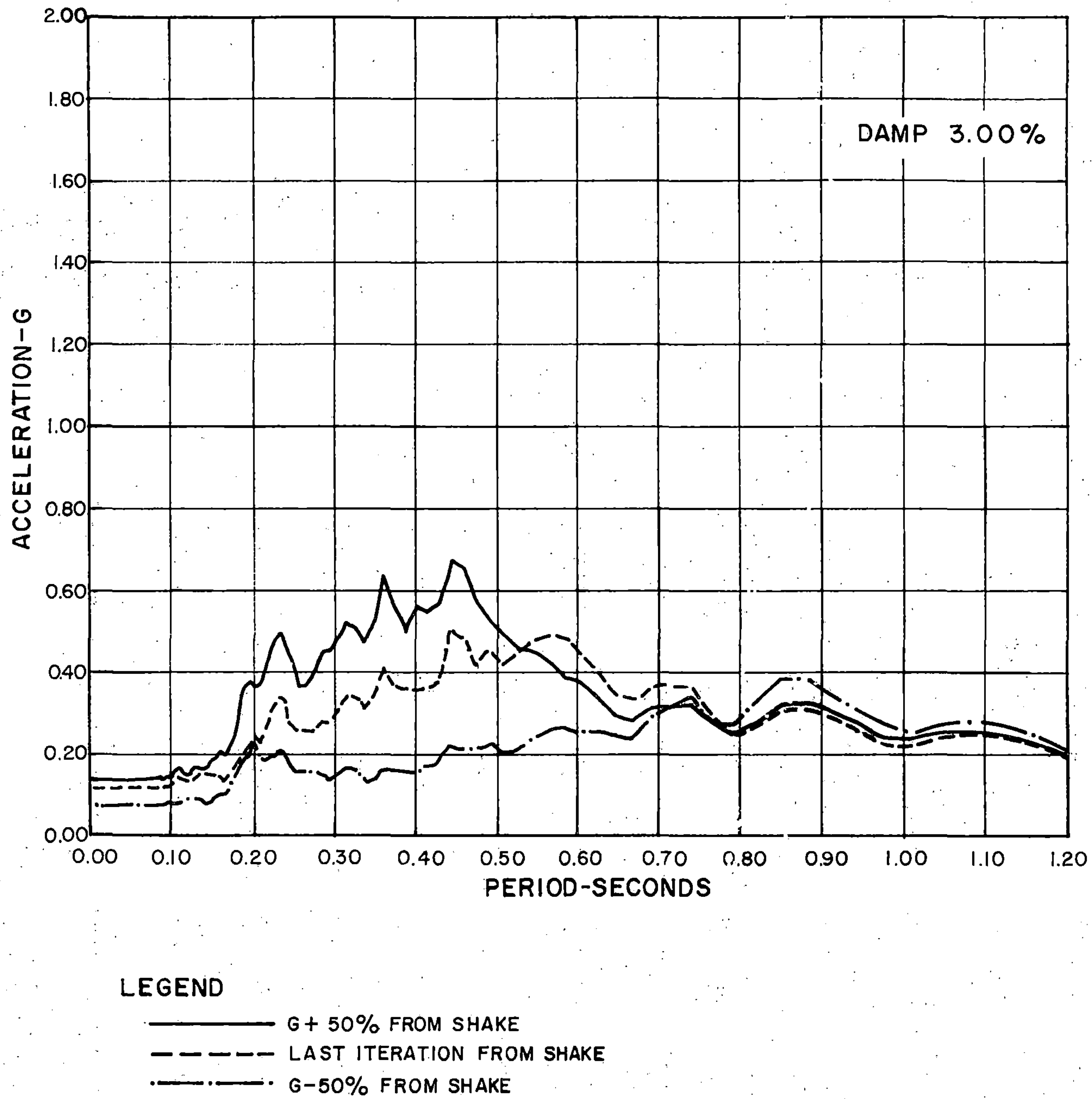
SURRY POWER STATION - UNITS 1 AND 2



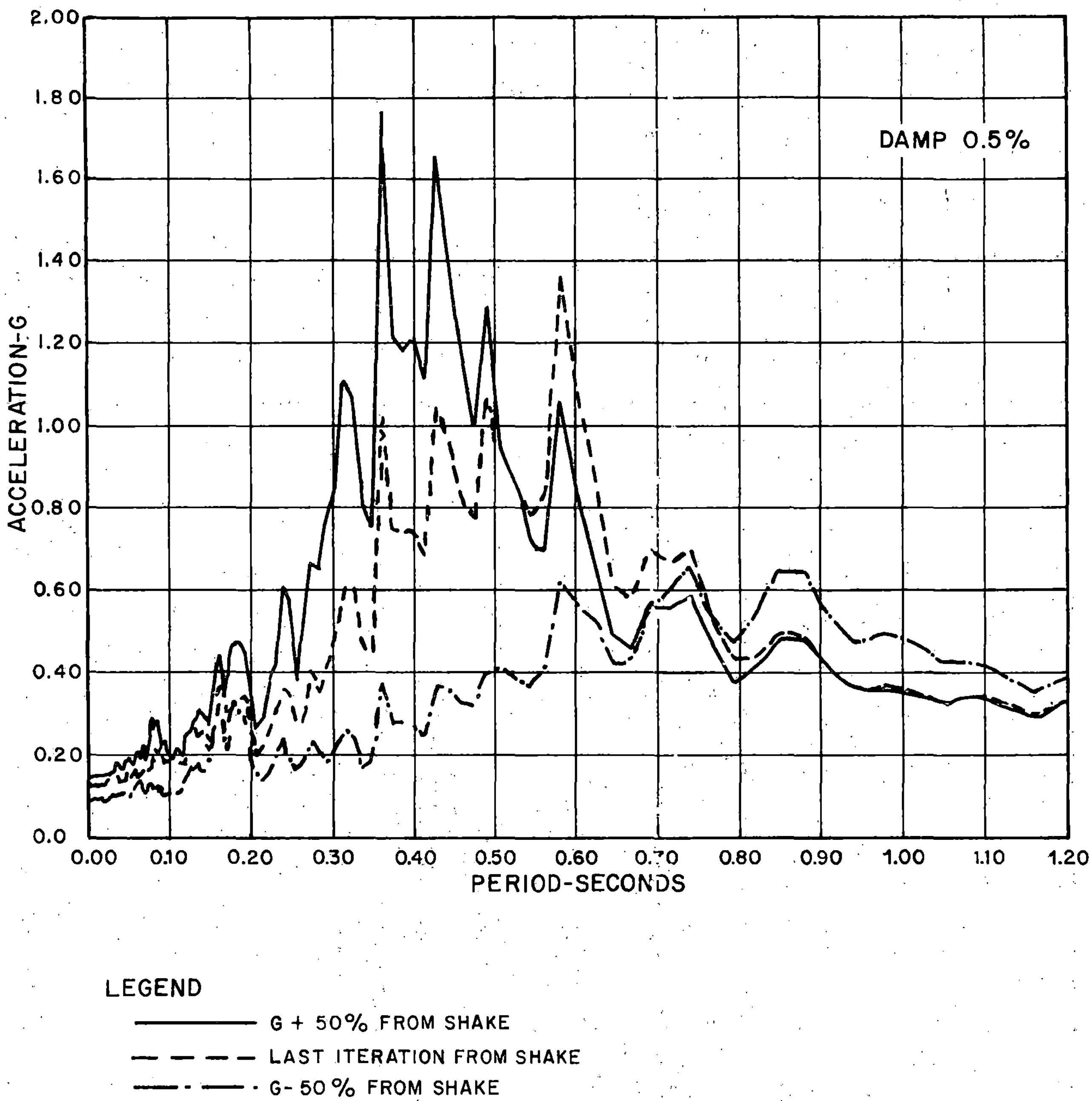
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE

HORIZONTAL RESPONSE SPECTRUM
AT OPERATING FLOOR

SURRY POWER STATION - UNITS 1 AND 2



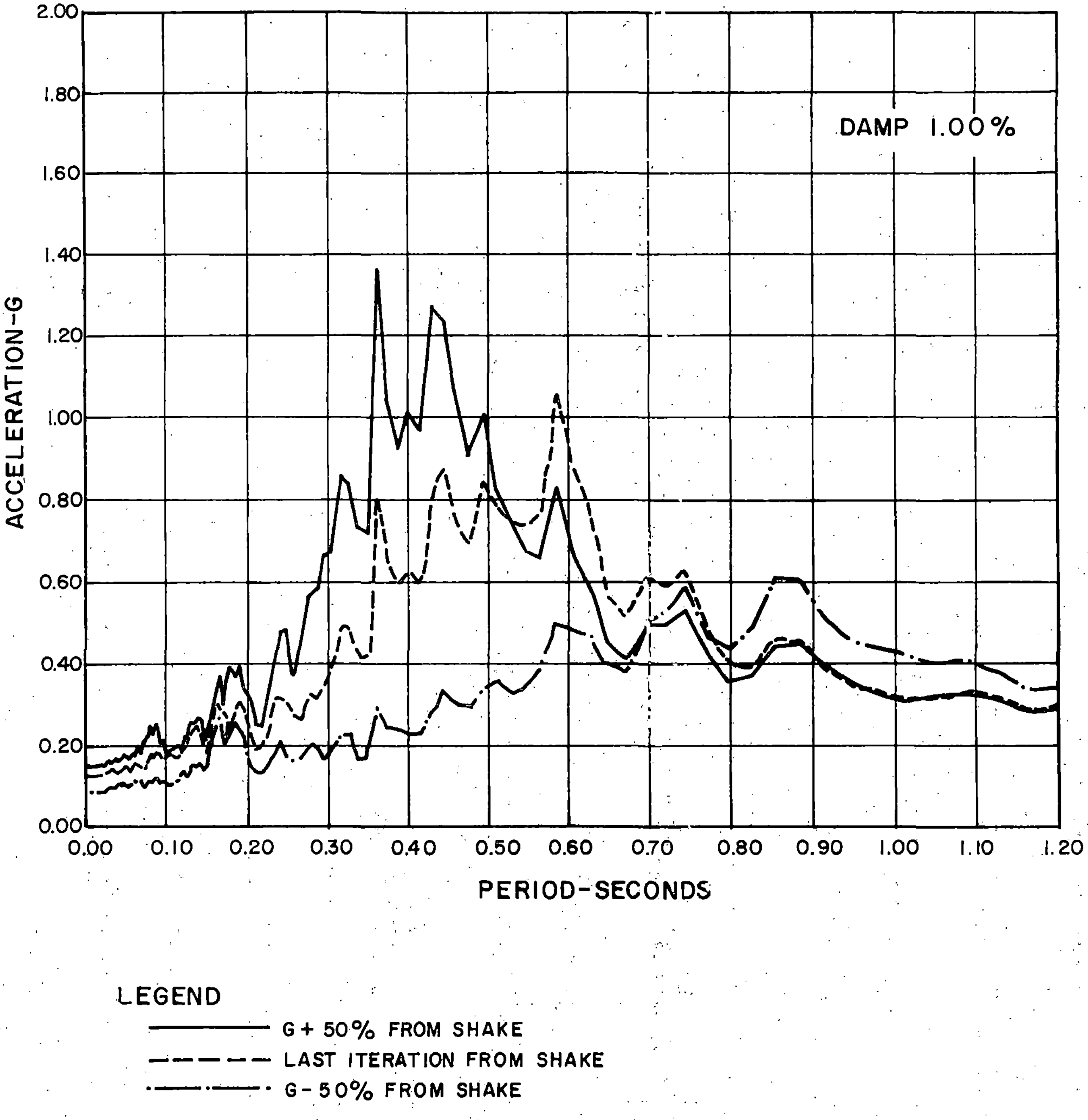
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM
AT OPERATING FLOOR
SURRY POWER STATION-UNITS 1 AND 2



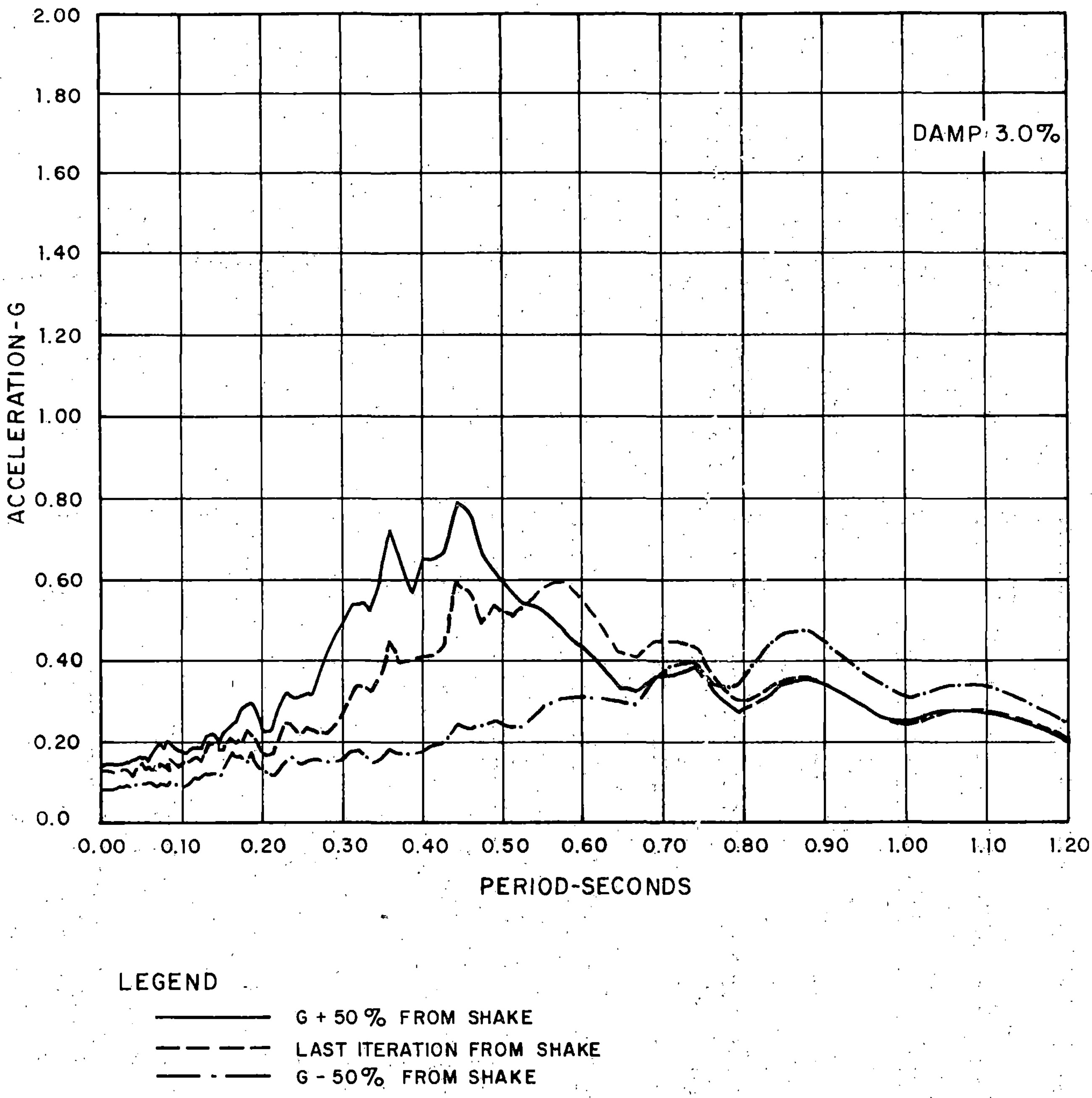
SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE

HORIZONTAL RESPONSE SPECTRUM
AT SPRINGLINE

SURRY POWER STATION UNITS 1 AND 2



SEISMIC ANALYSIS OF CONTAINMENT
HORIZONTAL SSE
HORIZONTAL RESPONSE SPECTRUM AT SPRINGLINE
SURRY POWER STATION - UNITS 1 AND 2



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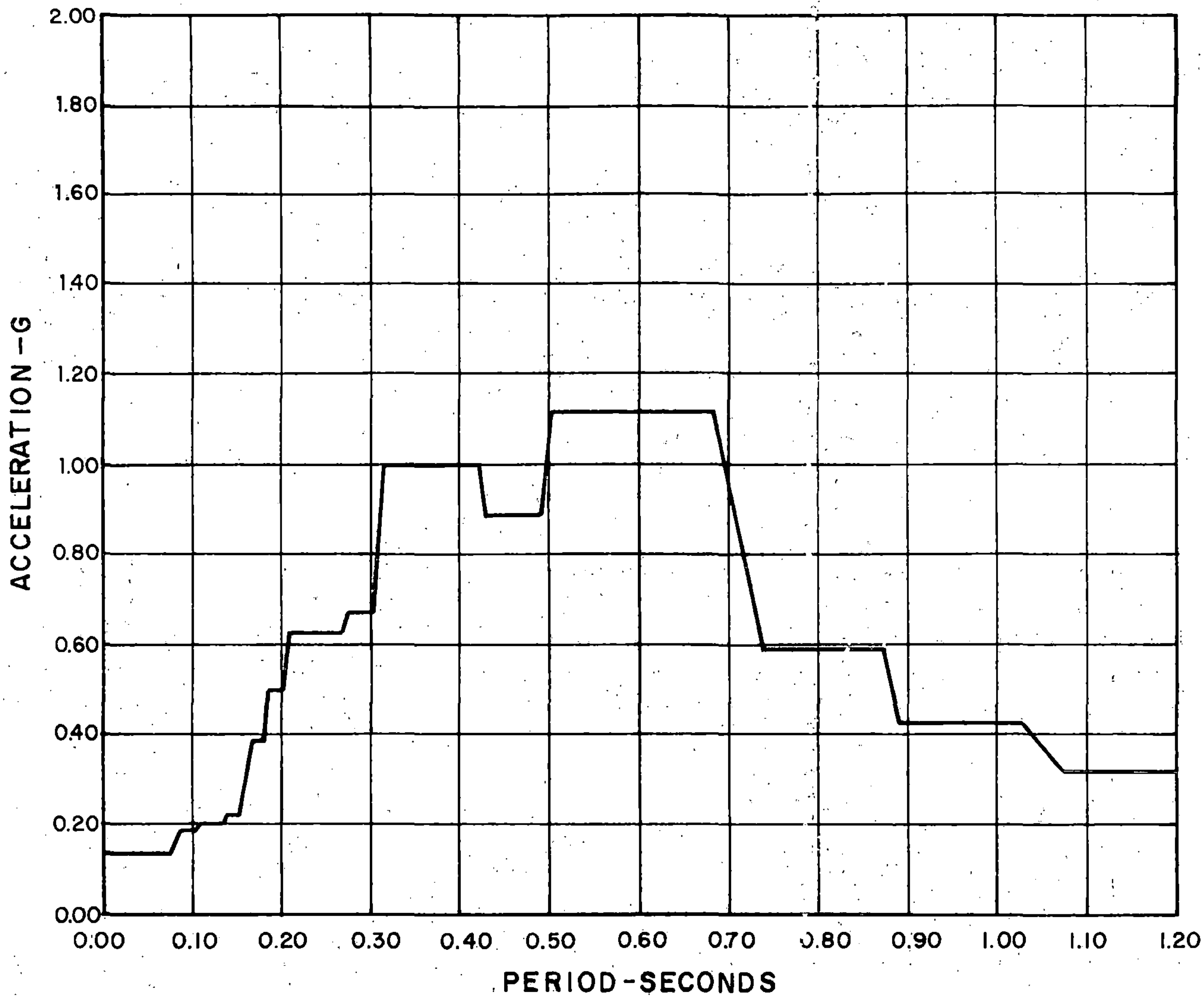
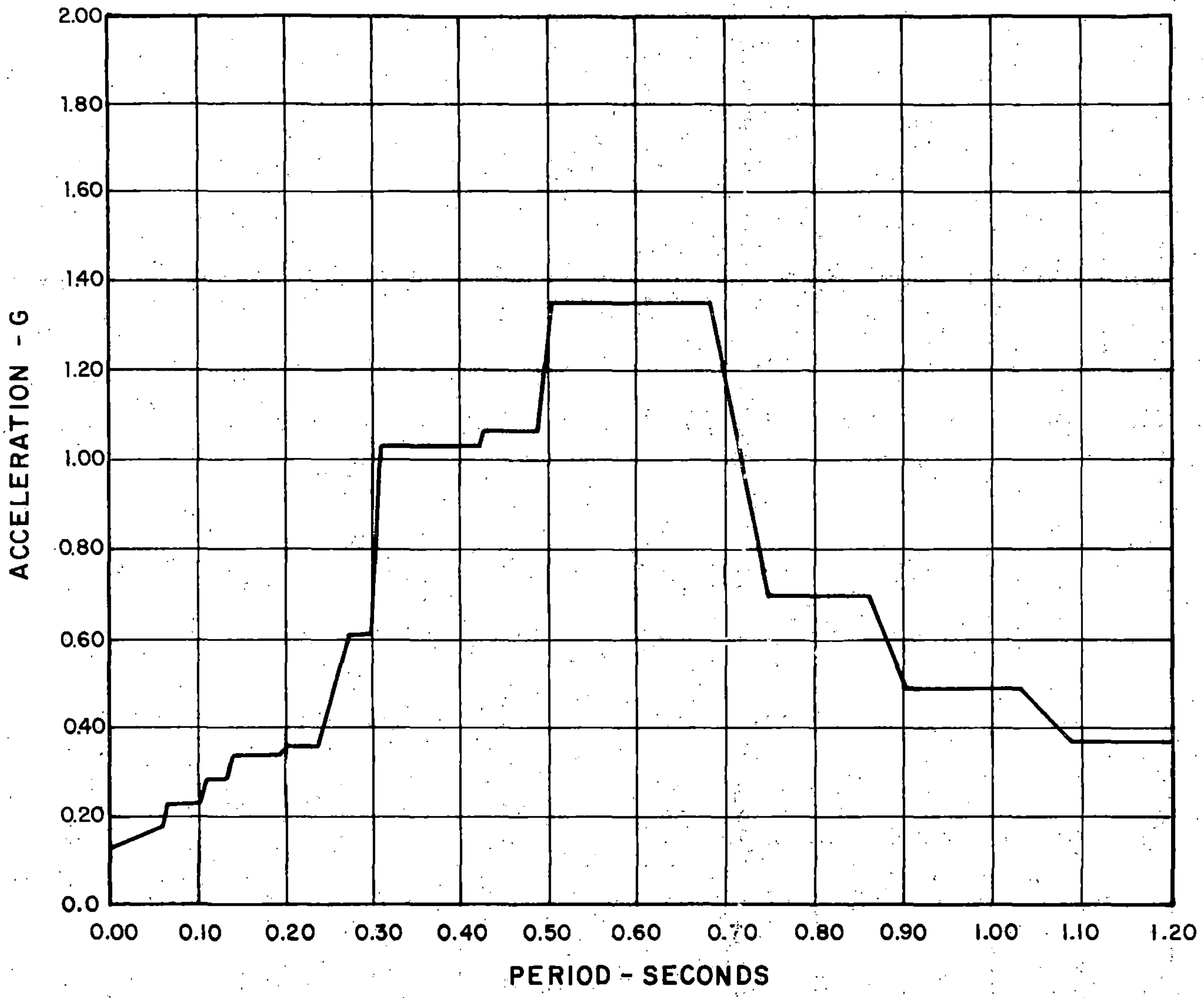


SURRY CONTAINMENT
ARS AT OPER. FLOOR HORIZONTAL DBE
OSC. DAMPING = 1/2 %
LAST ITERATION
PEAK BROADENED ± 15 %
SURRY POWER STATION - UNITS 1 AND 2



SURRY CONTAINMENT
ARS AT SPRINGLINE HORIZONTAL DBE
OSC. DAMPING = 1/2 %
LAST ITERATION
PEAK BROADENED ±15%
SURRY POWER STATION - UNITS 1 AND 2