VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

September 13, 1979

Mr. D. G. Eisenhut, Acting Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Serial No. 429
PSE&C/CMRjr:mac:wang

Docket Nos. 50-280
50-281

License Nos. DPR-32
DPR-37

Dear Mr. Eisenhut:

OPERATING BASIS EARTHQUAKE
REANALYSIS OF PIPING SYSTEMS
SURRY POWER STATION UNITS 1 AND 2

The NRC letter of May 25, 1979, signed by you, requested that the following two points be addressed:

1. "Discuss in detail why it can be concluded that piping analyzed for the SSE condition will safely withstand all earthquakes up to and including the SSE."

2. "For any piping systems which meet SSE requirements but do not meet OBE requirements, provide the level of earthquake for which the FSAR OBE design requirements are met."

Point 1. has been addressed in the submittal of June 8, 1979, on "Soil Structure Interaction in the Development of Amplified Response Spectra for Surry Power Station Units 1 & 2." Section 7 of that report develops a basis for concluding that ARS resulting from the DBE are not exceeded by those of smaller earthquakes. Therefore, the inertial pipe stresses due to the DBE are an adequate basis for qualification of piping.

Point 2. has been the subject of discussion with the NRC staff during our meeting in Bethesda on May 10, 1979, and subsequent phone calls to clarify this request. Determination of the new level of earthquake for which the FSAR OBE design requirements are met can be approximated using the following equation:

$$a_N = a_0 \left[1 - \left(\frac{S_t - S_a}{S_s} \right) \right] \quad \text{Equation 1}$$

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where: $S_t > S_a$ at the point of maximum stress.

a_N = new level of OBE (acceleration in terms of g)

a_O = original level of OBE (acceleration in terms of g)

S_a = allowable stress of OBE load condition

S_s = seismic stress for OBE load condition

S_t = total stress for OBE load condition

Equation 1 may be applied to cases of maximum stress in piping or members of support systems that are over allowable stress based on the total stress for the OBE load.

A new level of OBE (a_N) for piping systems or their supports is determined using values of S_s based upon ARS consistent with the FSAR committed damping values for soil, structure, and piping using SSI analysis as described hereafter.

Based upon analysis of 33 problems reported as of June 4, 1979, one problem would require restatement of the OBE from a value of 0.07g to approximately 0.064g, using an increase factor of 25 percent for the amplitude of SSI-ARS as discussed below. In light of these results, we do not anticipate substantial changes in the OBE.

A third point, concerning the application of Equation 1, involves an extension of the work contained in our June 8, 1979 report on SSI for the Surry Power Station. An evaluation of the effects of varying soil properties upon the OBE amplified response spectra (ARS) has been made to serve as a basis for determining appropriate values of S_s.

Our evaluation has involved the development of SSI-ARS for the OBE at the mat, operating floor, and springline of the containment based upon the following:

1. Use of the REFUND/FRIDAY analysis procedure,

2. A profile of strain compatible soil properties for the free field, and

3. Soil shear moduli from the last iteration of SHAKE using Gmax as input to SHAKE.

These spectra have been compared with spectra based on the following variations in soil parameters:

4. Soil shear moduli from the last iteration of SHAKE using Gmax plus 25 percent as input to SHAKE, and

5. Soil shear moduli from the last iteration of SHAKE increased by 50 percent, using Gmax as input to SHAKE.

The results of these spectra are shown on the attached Figures 1 through 6, together with peak broadened envelopes based upon Items 1, 2, and 3, using peak spreading of $\pm$ 15 percent and a 25 percent increase in amplitude. The 25 percent increase in amplitude was selected as a generally conservative means of enveloping ARS based upon meaningful variations in soil properties.

Inspections of these results indicates the following:

a. Spectra resulting from parameter variations described in 4 and 5, above, are essentially the same, and

b. Spectra resulting from parameter variations described in 5 are consistent with a meaningful range in soil property variations based upon a standard deviation of measured values for saturated clays as reported in the June 8 report, Section 2.4.2.6 and 8.2, and Attachment A to this letter.

The seismic stress (S_s) for the OBE load condition actually consists of two components: seismic inertia stress acting on the piping or support system (S_i) and stress due to seismic induced anchor movements (S_A). The seismic stress for the OBE load condition may be determined as follows:

$$S_s = S_i + S_A \qquad \underline{\text{Equation 2}}$$

It is concluded that a meaningful basis for the definition of seismic stress, considering the foregoing observations, for the FSAR OBE design requirements based upon SSI would be as follows:

a. Calculate the seismic inertia stress (S_i) in the piping or support system using SSI-ARS (peak broadened $\pm$ 15 percent), developed by the REFUND/FRIDAY analysis procedure with strain compatible soil properties from the last iteration of SHAKE using Gmax as input.

b. Increase the resulting seismic inertia (S_i) by a factor of 1.25 to determine values of S_s.

Therefore:

$$S_s = 1.25\ S_i + S_A \qquad \underline{\text{Equation 3}}$$

c. For those cases where $S_t > S_a$, perform calculations using Equation 1 from which the lowest value of a_N can be selected, defining the new OBE.

The approach described herein should provide an acceptable basis for redefining the OBE in cases where the FSAR design requirements have been exceeded. This approach is consistent with the SSI analysis as outlined in our June 8, 1979 report.

Very truly yours,

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

Attachments

VARIATION OF SOIL SHEAR MODULUS

SURRY POWER STATION - UNITS 1 & 2

The expected variation of shear modulus at low strain levels and at strain levels associated with strong motion earthquakes was evaluated using cross-hole data from the site and laboratory data used to obtain the shear modulus factor for clays curve in Figure 2-13, of the Surry SSI report.

In this analysis, the shear modulus factors G/Su were normalized with the low strain value of Gmax/Su from the same curve, resulting in a G/Gmax versus shear strain relationship. To determine the variation of G, which is calculated from the product of Gmax and G/Gmax, it is assumed that Gmax and G/Gmax are uncorrelated.

Thus:

$$V_G^2 = V^2_{Gmax} + V^2_{G/Gmax} + V^2_{Gmax} V^2_{G/Gmax}$$

where:

V_{Gmax} = coefficient of variation of in situ Gmax values from shear wave velocities determined from cross-hole data (Figure 2-11, Surry SSI report)

$V_{G/Gmax}$ = coefficient of variation of G/Gmax from SW-AJA curves (Ref. 11, Surry SSI report)

V_G = coefficient of variation of G values at various shear strain levels

From V_G, the expected variation as a percentage of the average G value for a particular shear strain level can be estimated. The effective strain induced by the OBE at the foundation level of the containment structure is approximately 2×10^{-2} percent. At this strain level, the variation of the average G/Su corresponding to one standard deviation has been calculated as $\pm$ 46.1 percent. Therefore, varying the iterated shear moduli by $\pm$ 50 percent is within an acceptable range of expected values.

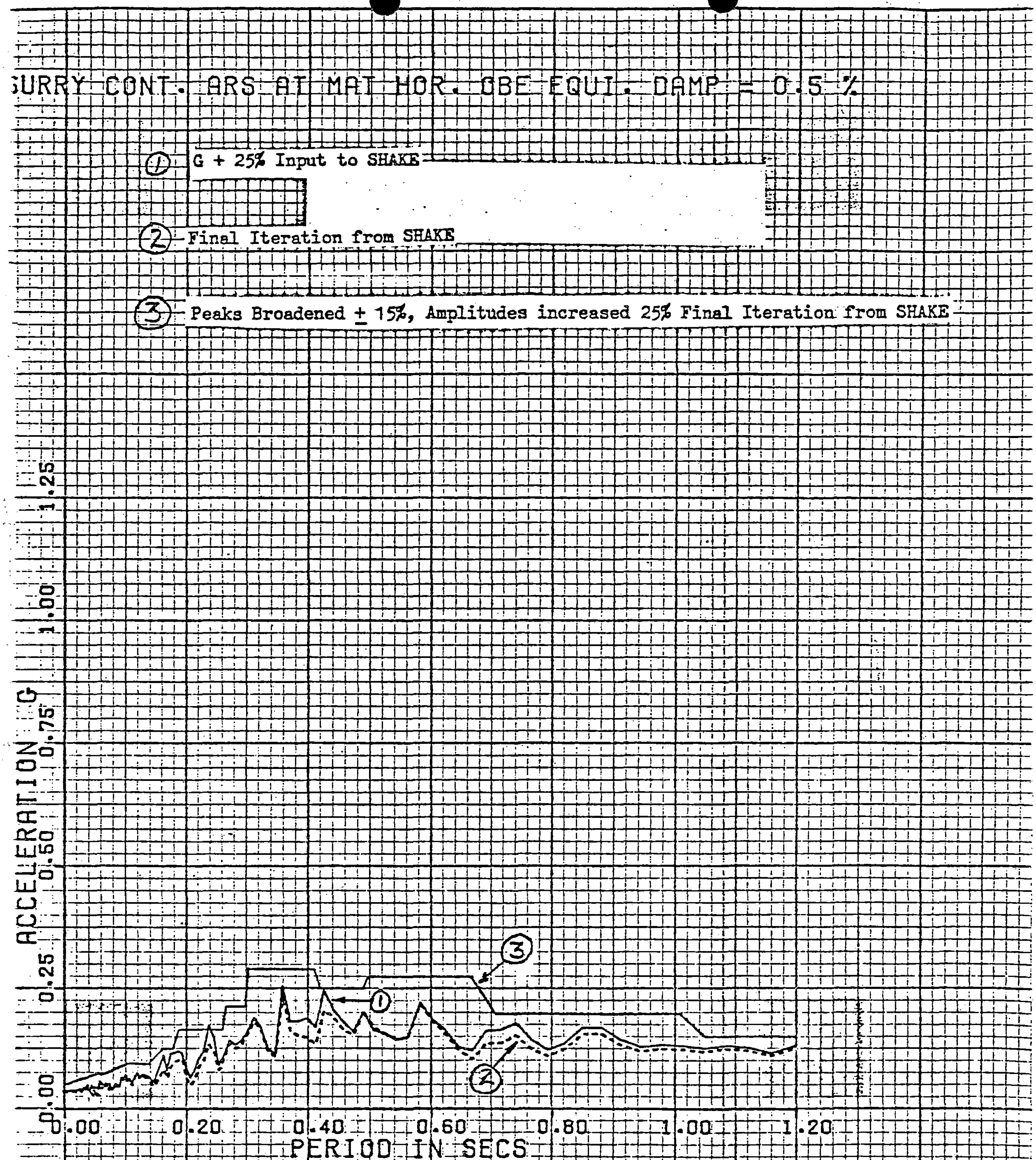

SURRY CONT. ARS AT MAT HOR. OBE EQUI. DAMP = 0.5 %
① G + 25% Input to SHAKE
② Final Iteration from SHAKE
③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from SHAKE
ACCELERATION G
0.00
0.25
0.50
0.75
1.00
1.25
PERIOD IN SECS
0.00
0.20
0.40
0.60
0.80
1.00
1.20

FIGURE 1

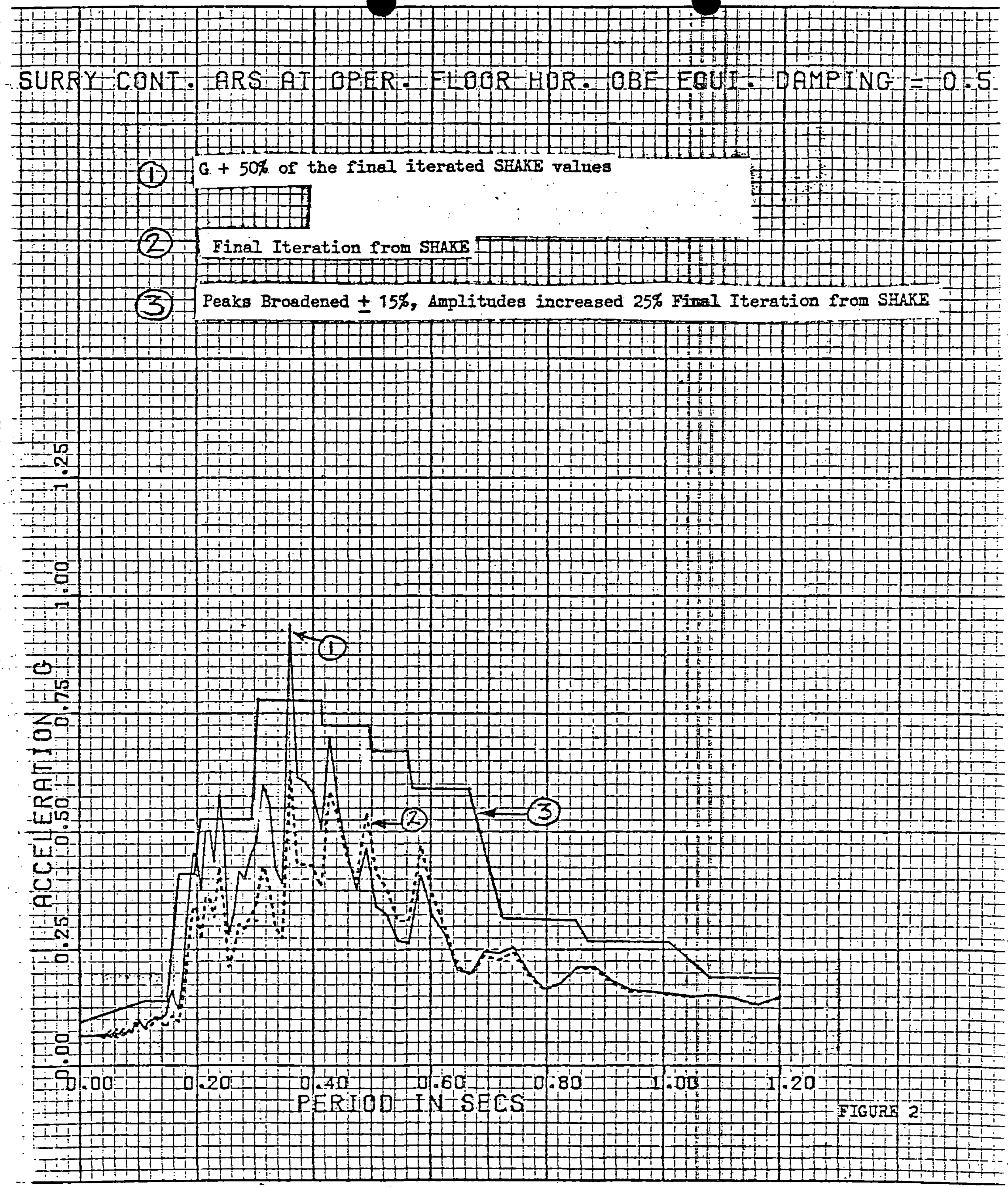
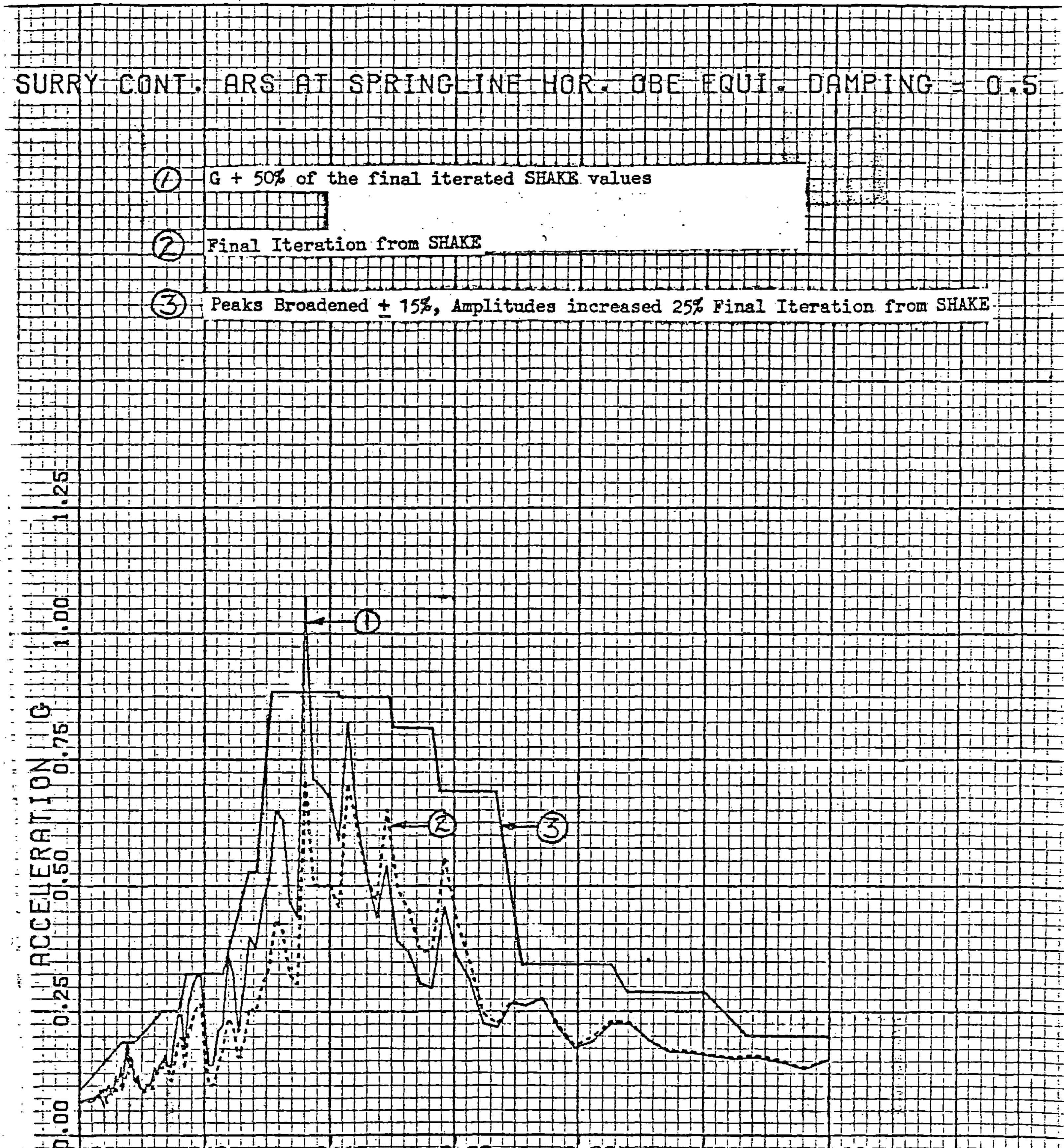

SURRY CONT. ARS AT OPER. FLOOR HOR. OBE EQUI. DAMPING = 0.5
① G + 50% of the final iterated SHAKE values
② Final Iteration from SHAKE
③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from SHAKE
ACCELERATION G
0.00
0.25
0.50
0.75
1.00
1.25
0.00
0.20
0.40
0.60
0.80
1.00
1.20
PERIOD IN SECS
①
②
③

FIGURE 2


SURRY CONT. ARS AT SPRINGLINE HOR. OBE EQUI. DAMPING = 0.5
① G + 50% of the final iterated SHAKE values
② Final Iteration from SHAKE
③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from SHAKE
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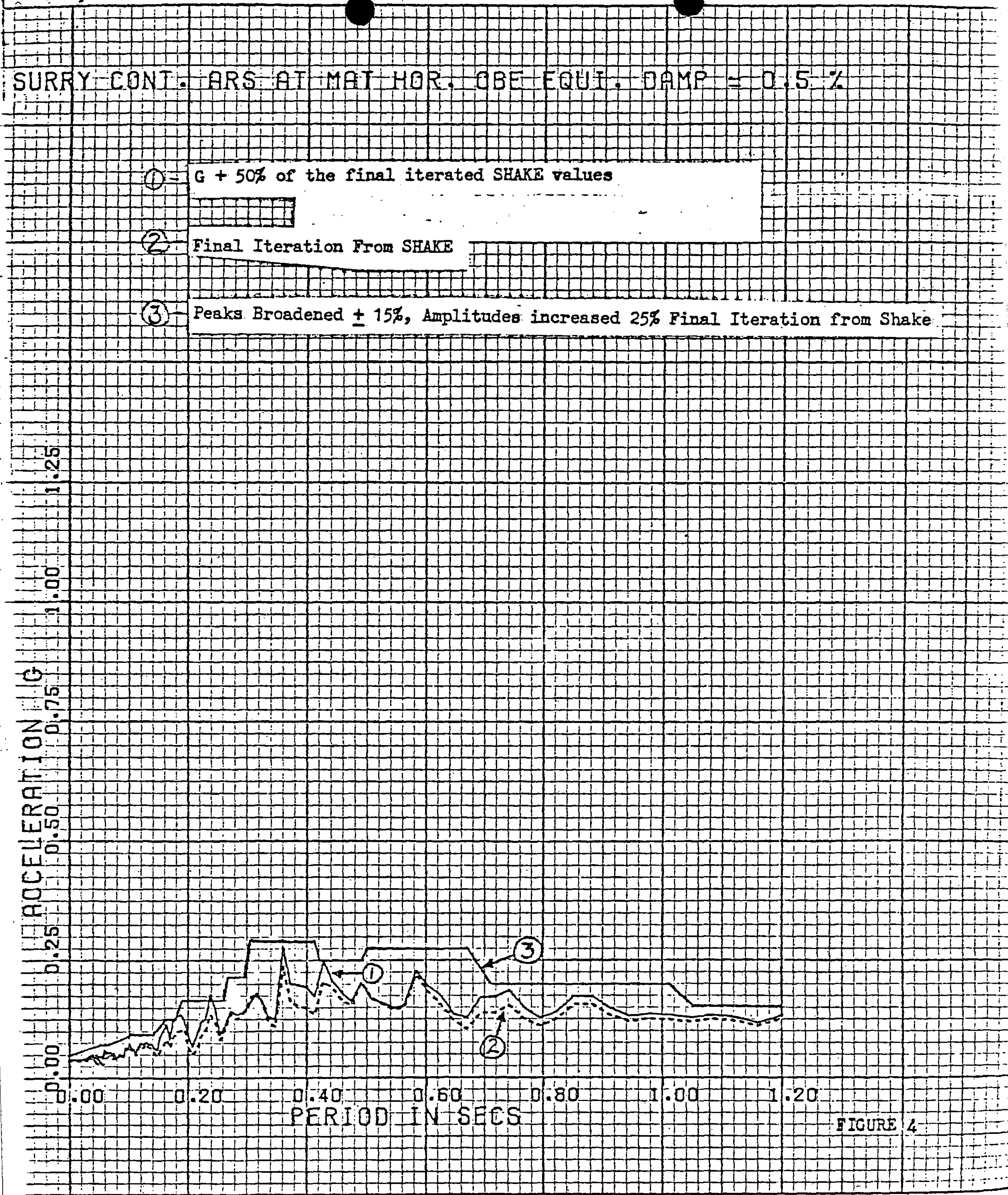
0.25
0.50
0.75
1.00
1.25
0.00
0.20
0.40
0.60
0.80
1.00
1.20
PERIOD IN SECS
①
②
③

FIGURE 3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① G + 50% of the final iterated SHAKE values
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③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from Shake
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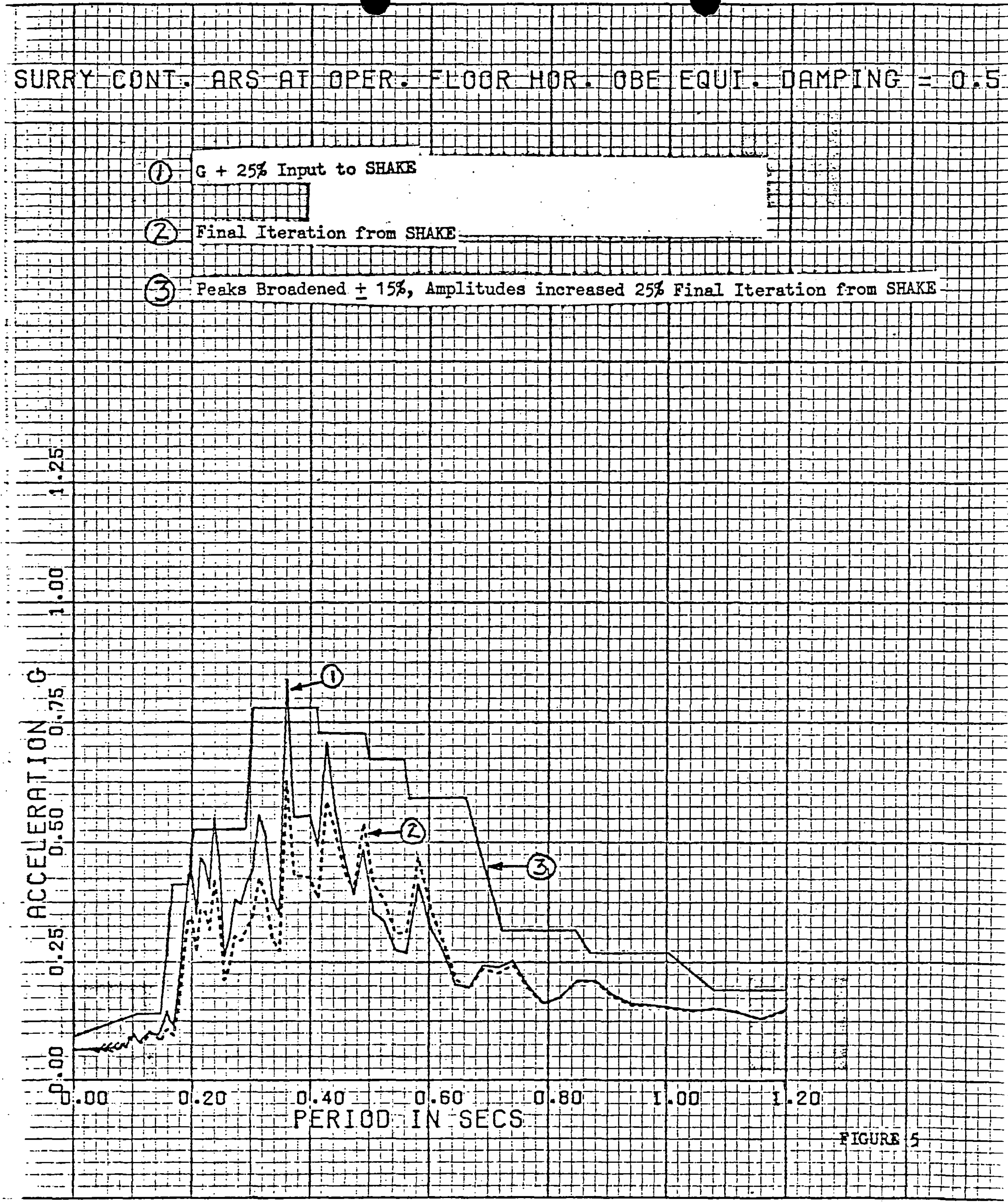
0.00
0.25
0.50
0.75
1.00
1.25
0.00
0.20
0.40
0.60
0.80
1.00
1.20
PERIOD IN SECS
1
2
3

FIGURE 4


SURRY CONT. ARS AT OPER. FLOOR HOR. OBE EQUI. DAMPING = 0.5
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③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from SHAKE
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0.50
0.75
1.00
1.25
0.00
0.20
0.40
0.60
0.80
1.00
1.20
PERIOD IN SECS
①
②
③

FIGURE 5

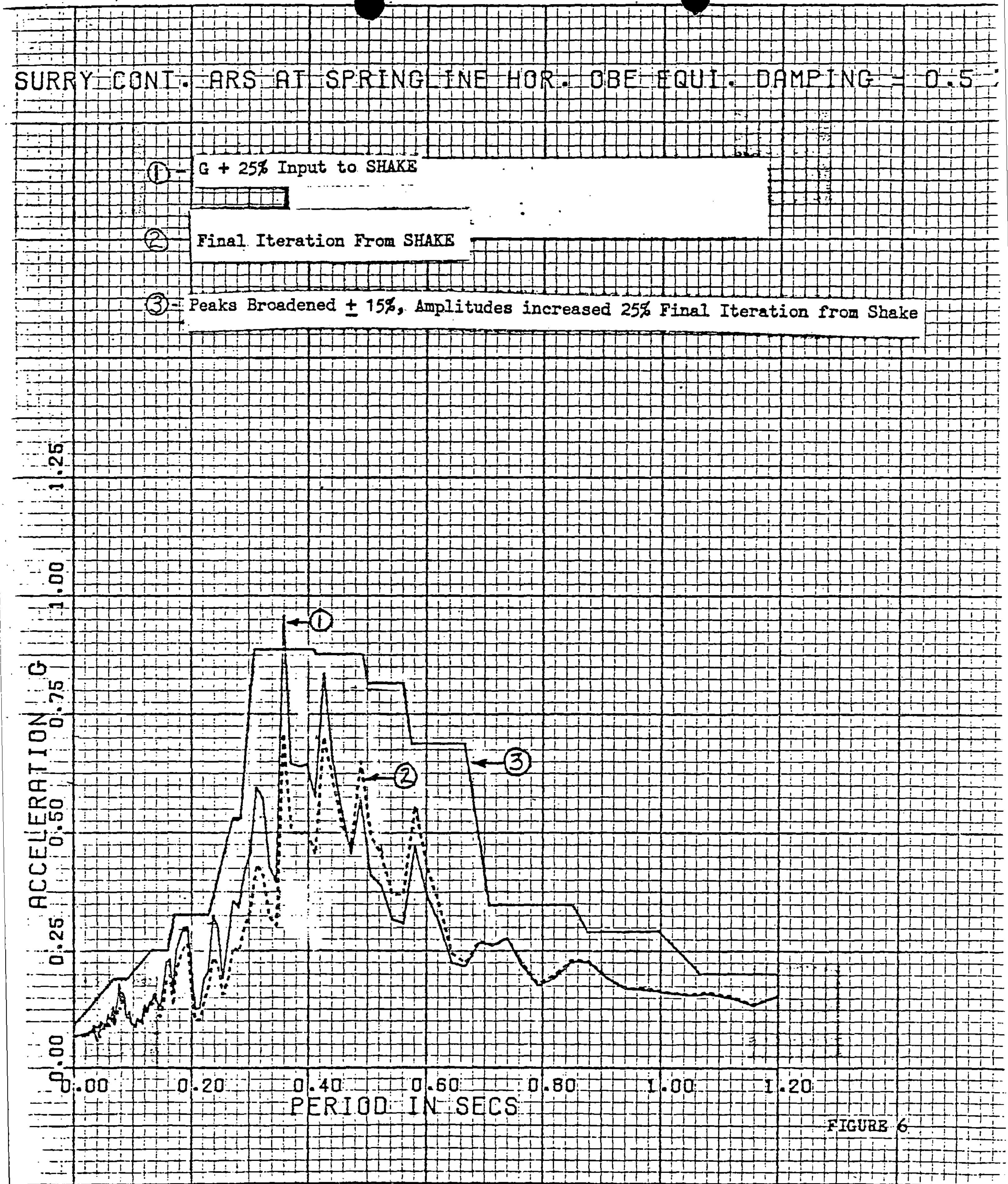
SURRY CONT. ARS AT SPRINGLINE HOR. OBE EQUI. DAMPING = 0.5
① G + 25% Input to SHAKE
② Final Iteration From SHAKE
③ Peaks Broadened ± 15%, Amplitudes increased 25% Final Iteration from Shake
①
②
③
ACCELERATION G
0.00
0.25
0.50
0.75
1.00
1.25
0.00
0.20
0.40
0.60
0.80
1.00
1.20
PERIOD IN SECS

FIGURE 6