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October 22, 1984

Director, Office of Nuclear Reactor Regulation
Attention: Mr. W. A. Paulson, Acting Chief
Operating Reactors Branch No. 5
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket No. 50-206
Seismic Withstand Capability
San Onofre Nuclear Generating Station
Unit 1

On October 10 and 16, 1984 SCE met with the NRC to provide additional information regarding the seismic capability of those systems which have not been completely upgraded to 0.67g as part of the current return to service seismic upgrade program. This information was documented in a letter from Kenneth P. Baskin to H. R. Denton dated October 17, 1984.

Subsequent to the above meetings, the NRC requested additional information. This information is provided as an enclosure to this letter.

If you have any questions on this information, please call me.

Very truly yours,

M. O. Medford

Enclosure

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<u>ENCLOSURE</u>

<u>Question 1.</u> Explain the basis for the judgement that secondary steel flexibility will not amplify the spectra that are used in piping analysis.

<u>Response</u>: We agree that secondary steel flexibility could amplify the spectra that are used in the piping analysis. However, we feel that there is adequate conservatism in the analysis procedure and in the instructure response spectra to compensate for these localized effects.

The design floor response spectra, as developed by Bechtel by time history methods and using detailed mathematical building models, are conservative. Impell regenerated some of these spectra using the FLORA code, using the same building models (see Figure 1). The FLORA code calculates response spectra using the direct generation technique.

Four of these regenerated spectra are shown in the attached Figures 2-5. These show large reductions in the spectra for two reasons. First, the artificially generated input spectra are greater than the smooth Housner input ground spectra. Second, pipe-structure coupling interaction reduces response in the amplified portions of the spectra for cases in which interaction effects are significant, i.e., when the pipe/structure mass ratio is high. In the amplified range of the spectra, reductions of about 20% are common due to the artificial versus smooth spectra. In specific cases analyzed by use of pipe/structure coupled models, reductions up to 50% have been see (see Figure 2-5). The floor spectra used in the recent evaluations for out of scope safe shutdown/accident mitigation systems do not take credit for these reductions.

Additional conservatism in the floor spectra is caused by the conservative enveloping procedures used to develop these spectra. For example, the spectra incorporate enveloping for different soil profiles, and some spectra envelope the raw spectra of several nodes of the building model at the same elevation.

Finally, the San Onofre Unit 1 turbine building model explicitly includes many of the interior steel structures. Thus, the flexibility of these steel structures is already accounted for in the design floor spectra.

In Summary:

1. The use of artificial versus smooth input motion results in a 20% reduction in floor spectra.

2. Where interaction effects are significant explicit pipe-structure coupling and the use of the artificial versus smooth input motion results in up to 50% reductions in floor spectra.

3. The floor spectra have extra conservatism due to the conservative enveloping of multiple soil conditions and multiple building model nodes. In addition, computer piping analyses have been performed using the envelope of all spectra at all support points.

4. The floor spectra already account for the flexibility of some secondary steel structures.

We believe that the design floor spectra already incorporate large margins which can accomodate any changes in the spectra due to secondary steel flexibility.

Question 2: Describe the technique used to generate floor spectra.

Response: The Design Basis Earthquake (DBE) postulated for the San Onofre Unit 1 site has a Zero Period Acceleration (ZPA) of 0.67g. The current evaluation of Accident Mitigation (AM) and Out of Scope Safe Shutdown (OSSS) piping was based on ZPA of 0.5g.

To develop the in-structure spectra for the 0.5g event for the current evaluation, generic scale factors were developed to reduce the in-structure spectra already developed for the 0.67g DBE. Reduction factors were also developed to generate in-structure response spectra for a 0.4g ZPA.

To adjust the amplitude of the spectra for a lower level of earthquake, a reduction of 35 percent was established between the response level of the horizontal input and the response to half its value (0.33g). A reduction of 40 percent was established for the vertical input. These reduction factors are based on the actual ratios of in-structure spectra for the SSE and OBE events for the Hope Creek Nuclear plant and are consistent with other SSE/OBE ratios seen in the industry. Using these generic factors, scale factors were linearly interpolated to scale the amplitudes of the spectra for both 0.5g and 0.4g events. These factors are summarized in Table 1.

In addition, a review of soil behavior for a reduced level of earthquake was evaluated. A comparison of soil strains for the 0.33g and 0.67g earthquakes shows that the soil stiffness increases by about 25 percent when the level of earthquake is reduced to half its value for a horizontal earthquake. This is shown in Figure 6 attached. There is insignificant effect on soil strains for the vertical earthquake. To conservatively account for the higher soil stiffness for a lower level earthquake, the first mode peaks in the response spectra were shifted toward the high frequency end by 6 percent and 10 percent for the 0.5g and 0.4g horizontal earthquakes, respectively. Only the first mode peak was broadened, since this peak represents the soil mode. These results are given in Table 2, attached.

The above technique to generate the 0.5g spectra conservatively assumes that lower damping occurs in a 0.5g earthquake as compared to a 0.67g earthquake. However, review of the 0.5g scenario shows that the same damping values can be taken for both the 0.67g and 0.5g earthquakes. This is justified for both structure and soil damping for the following reasons:

(1) Both the 0.5g and 0.67g events cause stresses at or near yield in structures, equipment and piping. Therefore, it is appropriate to use Reg. Guide 1.61 "SSE" damping values for both levels of earthquake.

(2) The 0.67g earthquake causes soil damping near 35%. This is for the rocking mode; other directions are higher. For a 0.5g earthquake, soil damping is near 30%. For San Onofre, we have limited our allowable soil damping to no more than 20% for the 0.67g earthquake. Therefore, the same damping value (20%) is also justified for the 0.5g earthquake.

The 0.5g spectra reduction factors are conservative. As damping can be justified as being at the same levels for both the 0.67g and 0.5g earthquakes, the spectra reduction factor could be taken as 0.75. Furthermore, these factors are based on standard procedures, i.e., time history analyses. As discussed in the response to question No. 1, even larger reduction factors could be justified if interaction effects are considered, and if the conservatisms in the time history analysis procedures are eliminated.

For structures where the instructure response spectrum is the 0.67 Housner free field spectrum, the reduction factor utilized is 0.75 with no additional broadening.

Question 3: Clearly state what factors were considered for analysis of tanks in the area of anchorages and nozzles.

Response: The two tanks included in this work scope are the refueling water storage tank (RWST) and the component cooling water (CCW) surge tank.

The RWST is an anchored steel water storage tank which rests on a concrete slab. The concrete slab partially rests on in situ backfill soil, which subjects the tank and slab to settlement following a seismic event. An evaluation was performed to assess the effects of seismic loading and settlement on the tank, its attachment to the slab, and the concrete. The slab and anchorage were qualified by standard industry procedures. Bolt pullout was evaluated in accordance with ACI rules and steel anchorages were evaluated to the Level D limits of ASME Section III Subsection NF and Appendix F (1983 Edition). The nozzles in the RWST were evaluated for piping loads and loads produced by tank settlement. The nozzle stresses were calculated using a Bijlaard analysis and evaluated to ASME Level D limits.

The CCW surge tank is a horizontal tank supported on saddle supports. The supports were evaluated to ASME Section III Level D limits also. Nozzle stresses were evaluated with the same techniques and to the same limits as the RWST. The nozzles had been previously qualified to .67g. For the one attached piping problem which is also within the scope of this evaluation, the loads have changed insignificantly. For the other attached pipe, the pipe support configuration is the same as that used to calculate the original loads, and thus the prior nozzle evaluations are acceptable.

Question 4: What is the status of the piping and support evaluation?

Response: The analyses examined approximately 220 supports. All supports for which analyses are complete meet the acceptance criteria. Only three supports (for which original design information was not available and as built information is being developed) have yet to be analyzed. However, SCE anticipates that these three supports will also meet acceptance criteria.

Question 5: Has the current evaluation included piping which runs between buildings?

Response: Seven of the thirteen large bore piping problems evaluated run between buildings or other major independent substructures. In every instance the evaluations have included the effect of the relative seismic anchor motion displacement of these substructures. The effects of the seismic anchor motion have been evaluated in accordance with the return to service criteria for hot safe shutdown large bore piping and supports.

Question 6: How did SCE develop stiffness values used for pipe supports in piping analysis?

Response: For all piping analyses in this out-of-scope safe shutdown/accident mitigation study, the pipe support stiffness values shown in the attached Table 3 were used. The pipe support is defined as the assemblage which extends from the pipe to any major structures.

These stiffness values were developed based upon typical values for supports at other nuclear plants. These values are substantiated as being in the range of stiffnesses of supports typically designed for the given pipe sizes.

JLR:2736F

TABLE 1

SCALE FACTORS TO DEVELOP REDUCED SPECTRA

EARTHQUAKE LEVEL (ZPA)	RATIO TO 0.67G	SCALE FACTORS USED	
		HORIZONTAL EQ	VERTICAL EQ
0.5G	0.75	0.825 (1)	0.800 (2)
0.4G	0.60	0.720 (1)	0.685 (2)

(1) INTERPOLATED FROM 0.65 HORIZONTAL FACTOR FOR OBE/SSE RATIOS AT OTHER NUCLEAR PLANTS

(2) INTERPOLATED FROM 0.60 VERTICAL FACTOR FOR OBE/SSE RATIOS AT OTHER NUCLEAR PLANTS

TABLE 2

BROADENING FACTOR FOR RESPONSE SPECTRA

EARTHQUAKE LEVEL	STRAIN-ITERATED SOIL "K" FACTOR	SOIL STRAIN (%)	SOIL MODE BROADENING FACTOR
0.67	40 TO 55	0.25 TO 0.40	1.0
0.50	45 TO 62 (1)	--	1.06
0.40	48 TO 67 (1)	--	1.10
0.33	50 TO 70	0.08 TO 0.12	1.13

(1) INTERPOLATED FROM 0.67G AND 0.33G RESULTS

TABLE 3

GENERAL SUPPORT FLEXIBILITIES FOR VARIOUS PIPE SIZES

Pipe Diameter (inch)	Translational Flexibility (in/lb)
2 1/2	1.60×10^{-4}
3	1.11×10^{-4}
4	6.25×10^{-5}
6	2.78×10^{-5}
8	1.56×10^{-5}
10	1.00×10^{-5}
12	6.94×10^{-6}
14	5.10×10^{-6}
16	3.91×10^{-6}

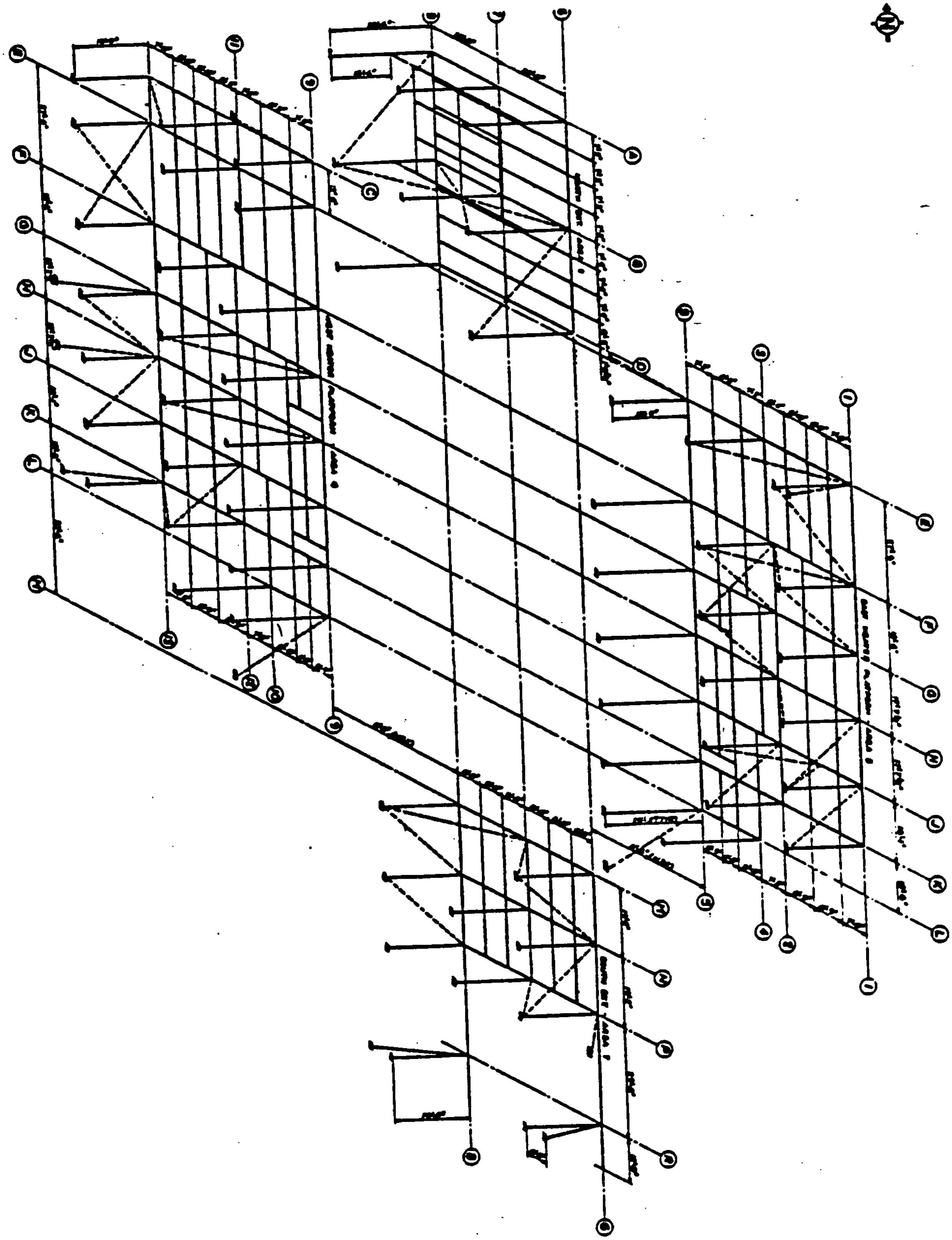
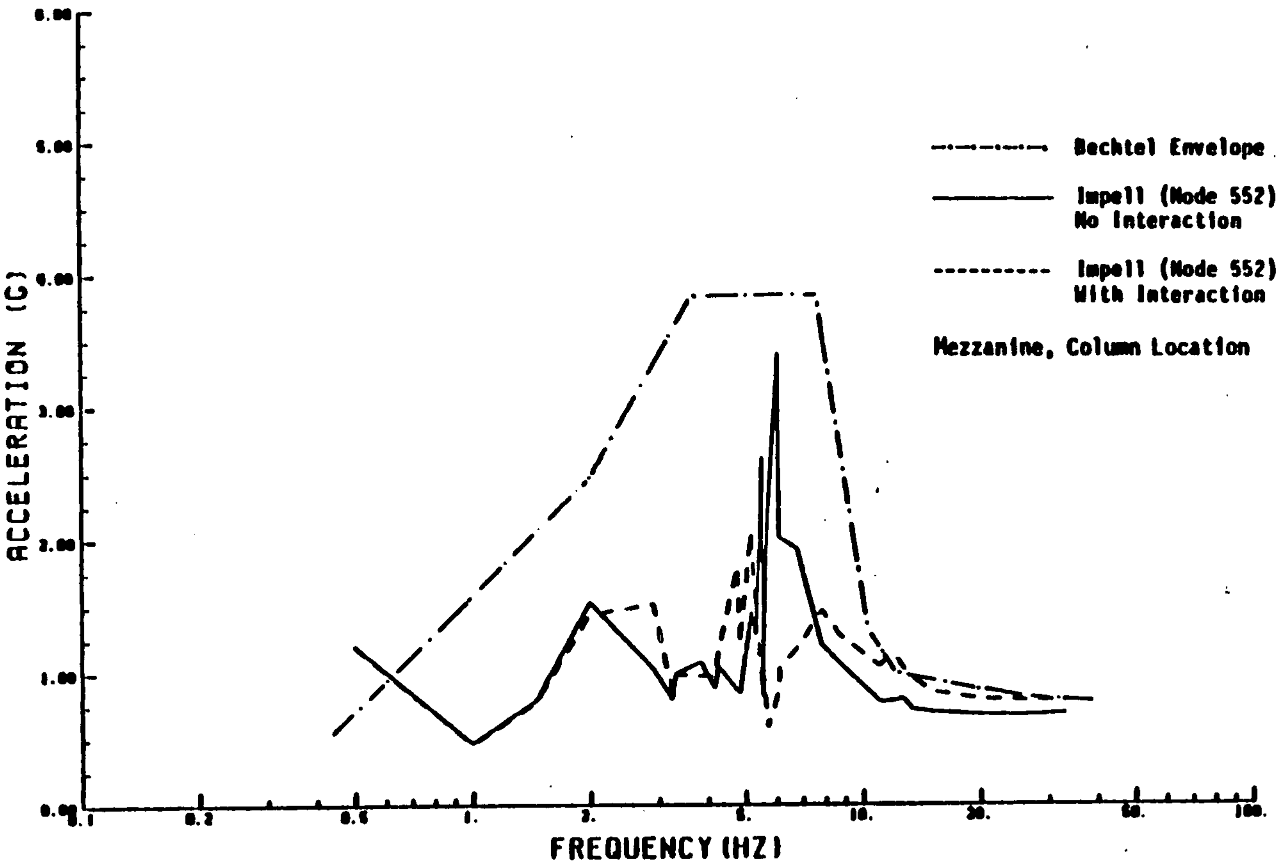


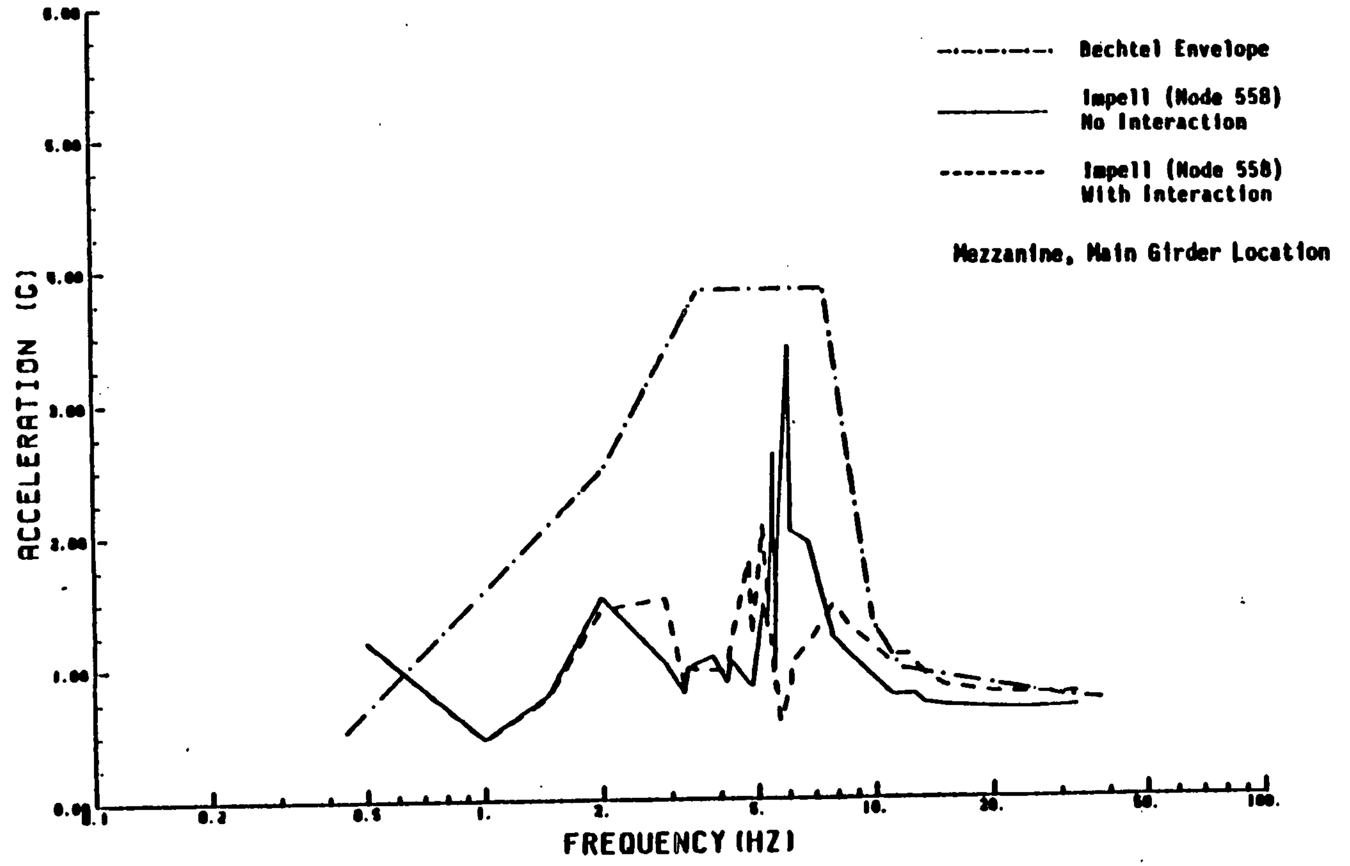
Figure 1 Turbine Building Math Model, San Onofre Unit 1



FLOOR RESPONSE SPECTRA: MEZZANINE, NODE 552, 2% DAMPING
SS - W/O INTERACTION, SD - W/ INTERACTION

FLOOR RESPONSE SPECTRA: TURBINE BUILDINC. SCE.

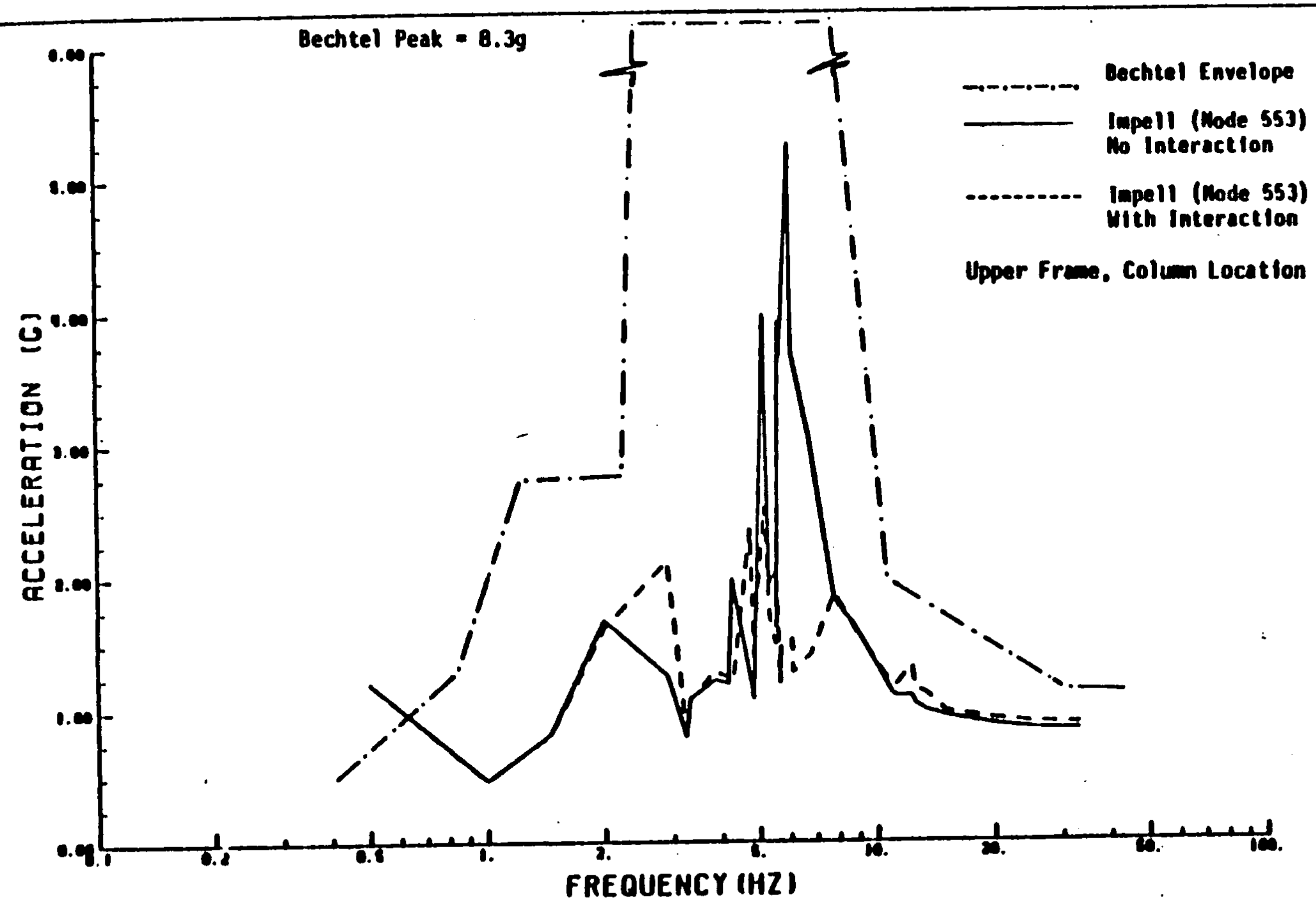
Figure 2



FLOOR RESPONSE SPECTRA: MEZZANINE, NODE 558, 2% DAMPING
SS - W/O INTERACTION, SD - W/ INTERACTION

FLOOR RESPONSE SPECTRA: TURBINE BUILDING, SCE.

Figure 3

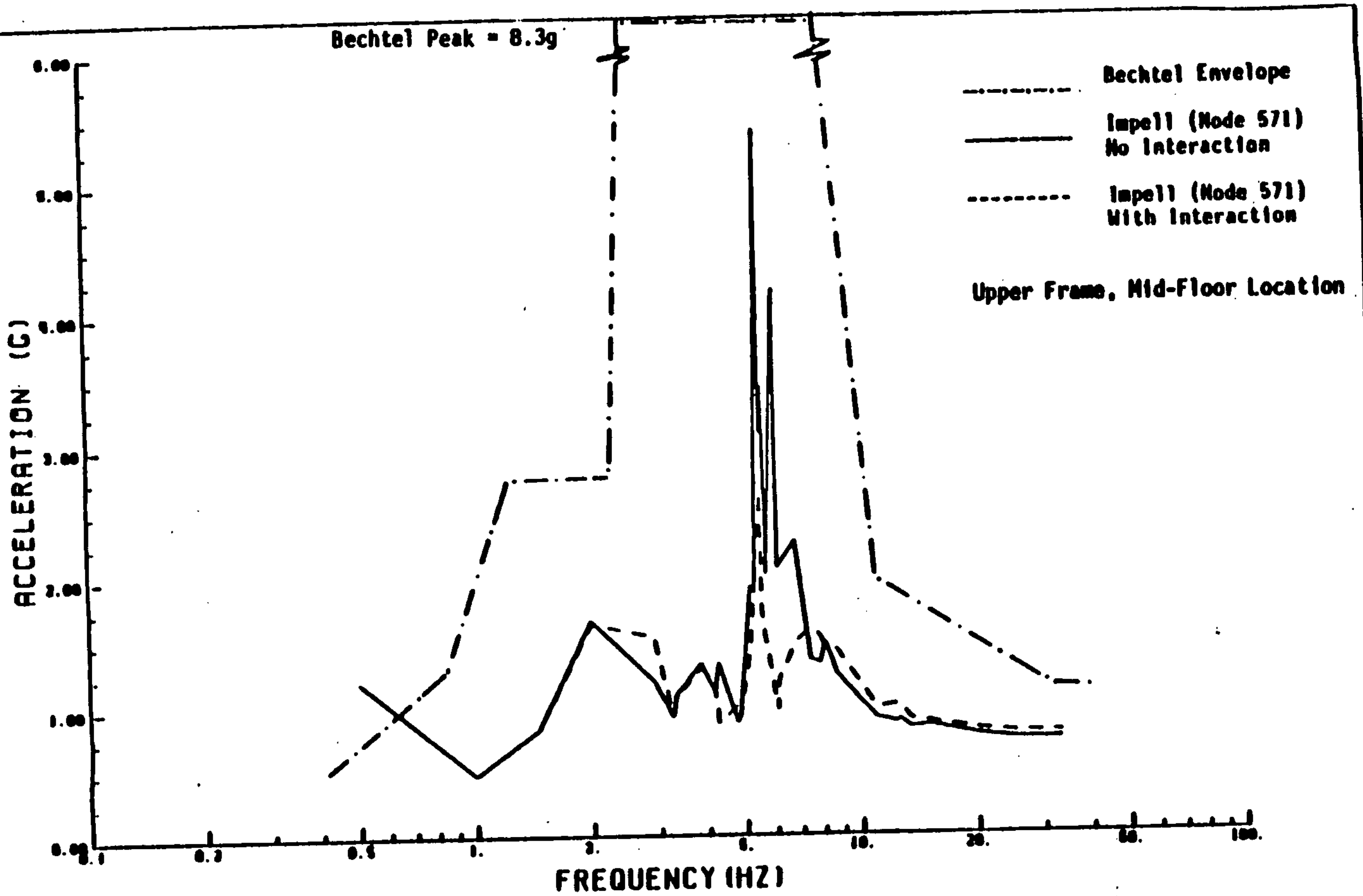


FLOOR RESPONSE SPECTRA: ELEV 42 , NODE 553, 2% DAMPING

55 - W/O INTERACTION, 5D - W/ INTERACTION

FLOOR RESPONSE SPECTRA: TURBINE BUILDING. SCE.

Figure 4



FLOOR RESPONSE SPECTRA: ELEV 42 , NODE 571, 2% DAMPING
55 - W/O INTERACTION, 5D - W/ INTERACTION

FLOOR RESPONSE SPECTRA: TURBINE BUILDING. SCE.

Figure 5

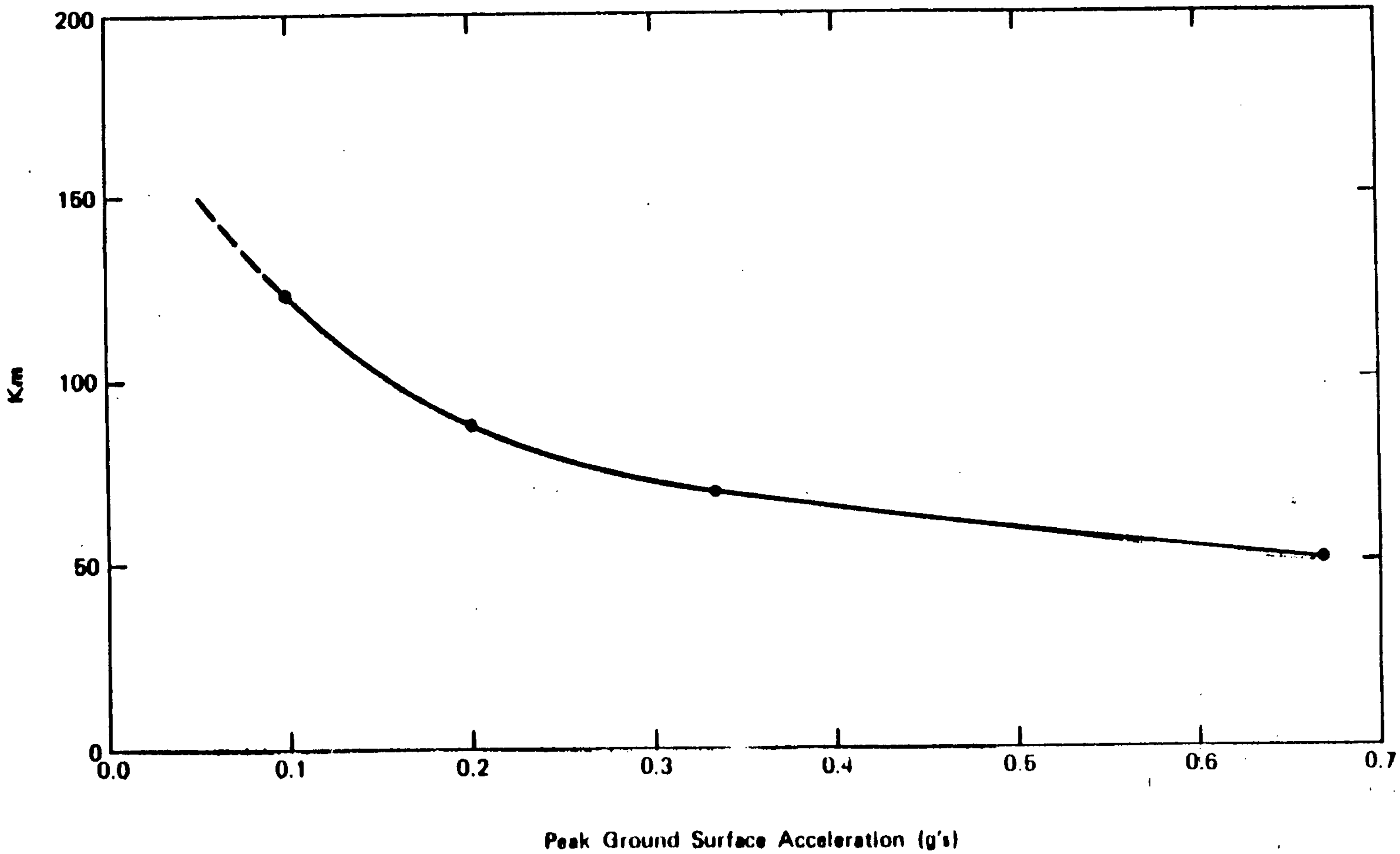


Figure 6 VARIATION OF Km WITH PEAK GROUND SURFACE ACCELERATION