Re: V.C. Summer, License Condition 2.C.(25), Docket 50-395

United States Department of the Interior

GEOLOGICAL SURVEY

OFFICE OF EARTHQUAKES, VOLCANOES, AND ENGINEERING
Branch of Engineering Seismology and Geology
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April 8, 1983

Dr. Jerry L. King
U. S. Nuclear Regulatory Commission
Mail Stop P-514
Washington, D. C. 20555

Dear Jerry:

Bill Joyner and I agreed that he would review the explosion tests, and I would review the forced vibration tests on the pad.

I have found no analytical errors in either the stiffness or modal approach. The stiffness method which was correctly elected to be the fundamental method of analysis is a rigorous method and involves no assumptions, except that of linearity. However, it is obvious from the results that something is amiss. This is shown by the negative damping obtained, by the large value of the transfer functions, by the fact that the resonance of the hut appears in the value of the stiffness functions K_{11}, K_{12}, K_{21}, and especially in K_{22}, by the strange behavior of K_{12} and K_{21}, and by the fact that the real part of K_{θ} should be approximately a constant value. It is hard to suggest why this is all so. Suggestions about the phases being difficult to determine are a possibility. Certainly, it is difficult to separate out the needed information from complex data where all the modes are being excited at the same time, unless the measurements are very clean and the equations well conditioned. Possibly, it would be better experimentally if the hut was removed and treated separately and a pure torque obtained from two out of phase vibrators, symmetrically placed, be applied. Similarly, a translation motion with minimum rotation could be obtained by exciting the pad through its center of gravity by a horizontal rod connected to a vibrator COOl

placed on the adjacent ground. This would be experimentally more difficult, but may produce more tractable measurements.

The essential assumption in the modal approach is that classic normal modes exist. This is not strictly the case in this application because the compliance functions are frequency dependent. This frequency dependence is shown in Figures 4 and 5 of the enclosed paper for the case of translation and rotation of a circular plate on the surface of an elastic halfspace. If we assume a shear wave velocity of 600 ft/sec then for an effective r_o value of 2.3 ft., the value of the non-dimensional frequency factor a_o is about 1.2 for the resonant frequency of, say, 50 Hz. For this value of a_o and below it is to be noticed that the values of f_{1_H} and f_{1_R} are not too different from their values at $a_o = o$ and consequently, the modal approach is a reasonable approximation. C. B. Crouse, in a private communication, has pointed out that this is an embedded foundation (18" embedment) and that Dominguez (referenced in the Ertex Appendix A) has shown that this degree of embedment substantially changes the compliance functions from those of a foundation on the surface. I have not yet seen this reference. Presumably, Dominguez assumes that the sides of the foundation can take tension as well as compression. I assume that compaction takes place at the sides and so the effective embedment is somewhat less than 9" and that the plate on the surface is a reasonable approximation. The results obtained from the modal approach appear entirely feasible. We have programmed Eq. 58 of the enclosed paper in order to make an analytical assessment of the problem and initially obtained values of the free-field similar to those of Appendix A. The effect of the hut was not included on the assumption that we are most interested in the region of the second resonance. However, at the last minute of writing this note, we suspect our computer program and are currently checking it out. We used the following values of the parameters:

Shear wave velocity = 600 ft/sec

b_1 = 3.0

b_2 = 1.0

λ_1 = 0.45

λ_2 = 1.2

The value of R discussed in the enclosed paper for these parameters has not yet been calculated. Figure 8 in the enclosed paper shows R for values of the parameters somewhat different from the above values but roughly in the same region. Remembering that a_o = 1.2 corresponds to about 50 Hz a comparison between Figures 8 and 9 of the enclosed paper and Figures 4 and 13 of Appendix A shows that they fall in the same ballpark for the second resonance. The relevant larger value of b_1 = 3.0 will increase the value of R shown in Figure 8.

Bill Joyner notes that as the modal approach is not completely rigorous, it would be useful to make a comparison between the observed displacement amplitude and phase such as shown in Figure 4 of Appendix A and the predictions of the model obtained by the modal approach.

Conclusions

1. The results of the stiffness method are invalid.
2. The results of the modal method appear entirely acceptable.

Sincerely,

G. N. Bycroft
Physical Scientist

Copy to:
T. Algermissen