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SUBJECT: Submits answers to NRC request for addl info re seismic analysis performed for small magnitude/short epicentral distance (SM/SD) earthquake.

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May 28, 1982
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Docket No. 50-397

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Subject: NUCLEAR PROJECT NO. 2
ADDITIONAL INFORMATION FOR SEISMIC ANALYSIS PERFORMED FOR SMALL MAGNITUDE/SHORT EPICENTRAL DISTANCE (SM/SD) EARTHQUAKE

Reference: B&R Memo, D.T. Mucichescu to J. O'Donnel (forwarded to NRC during NRC/WPPSS/B&R May 18, 1982, meeting in Bethesda)

As agreed during the telephone conversations of May 20, 1982, and May 21, 1982, between D. Teng and K.C. Liu of NRC and Messrs. B. Bedrosian, D.T. Mucichescu, and A.J. Lageraaen of Burns and Roe, Inc., below please find our answers and/or additional details to the questions raised and/or clarifications requested by the NRC:

a. The time-history analysis of the WNP-2 two-dimensional soil-structural model submitted to small magnitude/short epicentral distance (SM/SD) earthquakes is based upon the model shown in Figure 1 of the reference memo. Nonlinear effects in soil are taken into account by means of the equivalent linearization technique, as provided by the algorithm of computer program FLUSH; both soil shear moduli and damping ratios are, therefore, assumed strain-dependent. As discussed during the NRC/WPPSS/B&R meeting of September 19, 1981, held in Woodbury, these dependencies meet specific limitations, namely, the damping ratios are less than 15% and the shear moduli, normalized with respect to their initial small-strain values, are greater than 40%, for any value of the shear strains. The soil profile is the same as that used in previous similar analyses of the WNP-2 Reactor Building model. However, in order to provide for uncertainties in soil material properties, the small-strain soil shear moduli were assumed to be 200% of those which define the average (best estimate) soil properties at the WNP-2 Site. This option is motivated by our previous experience with both time-history and response spectrum analyses of soil-structural systems, which shows that the stiffer the

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soil, the higher is generally the structural response. This feature is expected to be enhanced when ground motions richer in high frequency components are used, as in the case of SM/SD input. As for the magnitude of the assumed variation, it is mentioned that the original FSAR analysis was performed or three soil conditions, namely, 67%, 100%, and 133%. By choosing a 200% upper bound for soil stiffness, the present approach is, therefore, conservative.

b. The reactor building structural response to the SM/SD earthquakes was obtained via a response spectrum modal analysis. This approach allowed a direct comparison with the design values obtained before (see FSAR, Section 3.7). Initially, the analysis was performed using the preliminary estimate of horizontal acceleration response spectrum, s(f), for the SM/SD earthquakes supplied by Woodward/Clyde Consultants (WCC). The maximum response at any degree of freedom i in natural mode k was obtained as

$$u_i^k = p_k v_{ik} s(f_k)/w_k^2$$

where P_k is the participation factor in mode k, v_{ik} is the modal ordinate at degree of freedom i in mode k, $w_k = 2\pi f_k$, and f_k is the natural frequency. Later the 84th percentile horizontal acceleration response spectrum S(f), for the SM/SD earthquakes became available from WCC. Since the model is unchanged, P_k, v_{ik}, f_k and w_k are the same, and the new modal maximum responses will be

$$U_i^k = p_k v_{ik} S(f_k)/w_k^2$$

and hence $U_i^k = u_i^k S(f_k)/s(f_k) = u_i^k \sigma_k$.

When the contribution of the first n modes is considered using the SRSS method, one has

$$U_i = \sqrt{\sum_{k=1}^{n} (U_i^k)^2} = \sqrt{\sum \sigma_k^2 (u_i^k)^2} \leq \sigma_{max} u_i$$

where U_i, u_i are the corresponding SRSS values and σ_{max} is the maximum modal spectral ratio for the two inputs under consideration. Its value was found as $\sigma_{max} = 0.788$.

The radwaste/control room building structural responses to the SM/SD earthquakes were obtained directly for the 84th percentile horizontal acceleration response spectrum, S(f).

c. Comparative examination of the reactor building and radwaste/control room building responses to the 84th percentile horizontal acceleration response spectrum for SM/SD earthquakes and the responses to the original safe-shutdown earthquake (SSE) response spectrum, defined in the FSAR, shows that the latter are larger than the former and by a significant margin.

It is our considered opinion, based on previous experience, that this trend should hold true for the vertical component of earthquake motions as well.

d. The radwaste/control room building is the only Seismic Category I structure (other than the reactor building) having significant mass and extended dimensions, and thus expected to amplify the free field motions associated with the specified design earthquakes. On this basis, it was selected with the reactor building to be analyzed for the SM/SD earthquakes, and, in view of the large margin by which the responses to the original SSE spectrum enveloped the responses to the SM/SD earthquakes spectrum, it was not considered necessary to address any other building.

Very truly yours,

G. D. Bouchey
Deputy Director, Safety and Security

MKC/jca

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