NATHAN M. NEWMARK
CONSULTING ENGINEERING SERVICES

1211 CIVIL ENGINEERING BUILDING
URBANA, ILLINOIS 61801

14 April 1980

SEISMIC EVALUATION OF VALLECITOS SITE

by

N. M. Newmark & W. J. Hall
Nathan M. Newmark Consulting Engineering Services
1211 Civil Engineering Building
Urbana, Illinois 61801

I. CONDITIONS CONSIDERED AND BASIS OF EVALUATION

The purpose of this report is to define a rational basis for seismic evaluation of the General Electric test reactor and other facilities located near Vallecitos, California. The major facilities considered are within three miles of the Calaveras Fault and very close to, or possibly just over, a fault identified as the Verona Fault.

After discussion with a number of persons and a review of reports, documents, and letters from NRC, the U.S. Geological Survey, and the TERA Corporation, studies for Diablo Canyon, and recognizing the lack of correlation of damage to structures and equipment in relation to peak acceleration (including the 6 August 1979 Coyote Lake earthquake and the 15 October 1979 Imperial Valley earthquake), in the light of our judgment and experience we recommend the use of the criteria described herein for the seismic evaluation of the site and for the review of structures and equipment in structures at the site. It is noted that these recommendations are the writers' sole responsibility and do not represent the official views of NRC or the USGS.

It is considered that an earthquake of magnitude 7 to 7.5 might occur on the Calaveras Fault and the epicenter might be located close to the site. A considerably smaller magnitude of earthquake, in the range of magnitude from 5 to certainly no more than magnitude 6 might occur on the Verona Fault.

It appears that the site conditions involve a fairly thick layer of sediment or sedimentary material, which in general for the same magnitude of earthquake would be expected to have a smaller peak ground acceleration than would occur in competent crystalline rock. However, the peak ground velocities would not be greatly different in the sediment from that expected in rock. The transient displacements, however, would generally be expected to be larger in the sediment.

In general, the most serious conditions arising from earthquake induced motions at the site come from earthquakes with the source close to the site rather than from more distant earthquakes along the fault system. This has been taken into account in the recommendations made herein.

Although the writers in general would prefer to use probabilistic approaches to seismicity and also to seismic design, considering probabilistically the response and the strength of structures and equipment subjected to dynamic motions, the recommendations given herein are based on essentially deterministic criteria using NUREG-CR 0098 spectra with an SSE acceleration defined as anchoring the spectrum in accordance with the procedures in that report. To draw the NUREG spectrum, it is our recommendation that a peak velocity of 48 in./sec and a peak displacement of 36 in. be used when scaled to 1 g. For 0.75 g, then, the peak velocity is 36 in./sec and the peak displacement is 27 in. The acceleration used to anchor the near source SSE spectrum will generally be somewhat smaller than the maximum ground accelerations recorded by an instrument in the free field. The reduction from the maximum free field acceleration to a so-called "effective" peak ground acceleration to which the spectrum is anchored, is generally negligible for earthquake sources that are more than 30 to 40 kilometers distant, but there is a well defined body of data indicating that the response of structures and the damage to the structures of all kinds close to an earthquake source corresponds to a smaller acceleration than that recorded instrumentally in the free field.

Moreover, in the Pacoima Dam earthquake record, with a maximum recorded acceleration of the order of 1.2 g, the response spectrum is enveloped by the Regulatory Guide 1.60 spectrum or a NUREG-CR 0098 spectrum anchored to an acceleration of 0.75 g. This is described in some detail in Ref. 4. These facts are considered in the derivation of the recommendations contained in the following sections of this report.

II. PROBABILISTIC VERSUS DETERMINISTIC CRITERIA

It is the intention of the writers to establish deterministic criteria for the seismic motions to be expected at the site in a manner consistent with a probabilistic approach, in order that the two procedures might be used in such a way as to give nearly the same results. Since almost all of the information available about earthquake motions is probabilistic in nature, although some information is available from maximum expected values, it appears that one can arrive at better deterministic values through upper bound approaches alone. In this regard, consideration was given to the various fault systems on which motions are expected in California and their relative frequencies of major earthquakes.

Clearly the San Andreas-San Jacinto Fault system is the most active, with probably the highest acceleration level, and was used as a basis, with a return period of the order of approximately 300 years for earthquakes having a maximum effective acceleration in the range from about 0.5 to 0.8 g. The writers ascribed to four other fault systems approximately one-third the frequency of occurrence, with relative effective acceleration levels in the range from about 0.4 to 0.7 g. This would give a return period of the order of about 1,000 years on the Calaveras, Hayward, San Gregorio, and the White Wolf and associated fault systems. Smaller earthquake accelerations with definitely smaller magnitudes, having return periods of the order of 2,000 years or more, with accelerations in the range of 0.3 to 0.6 g are considered reasonable for the Hosgri Fault, and the Newport-Inglewood Fault system. Other systems have a much smaller probability of motion.

Various estimates of seismic motion intensities are given in reports and papers. The most applicable for the current problem are the report by Ang and Newmark (Ref. 1), and the TERA report by Wight (Ref. 2). The probabilities for the Hosgri Fault given in Ref. 1 are probably near a lower bound to the probability distribution to be expected on the Calaveras Fault, and those given in Ref. 2 are probably an upper bound. A more reasonable value would be something between these two limits, which would be consistent with an accleration of about 0.75 g with a return period of the order of somewhat more than 1,000 years. In Ref.1, and in a recent paper by Cornell and

Newmark (Ref. 3), it is pointed out that an SSE corresponding to a properly anchored value will be generally in the range of a 1,000 to 2,000 year return period. The probability distributions of the accelerations in a set of earthquakes having the same 1,000 to 2,000 year acceleration return period will not affect in an important manner the overall probabilisitic response of a structure, even though the seismicity varies over a wide range above and below that SSE level.

III. SSE ACCELERATION FOR DESIGN SPECTRA AND DESIGN FAULT DISPLACEMENT

Based on the above considerations, it is considered reasonable, therefore, to ascribe an acceleration level of the order of 0.6 to 0.75 g as a deterministic level to use in anchoring a Regulatory Guide 1.60 spectrum or a NUREG-CR 0098 spectrum for the motions on the Calaveras Fault. It is considered that the lower level, 0.6 g, is a more realistic expectation on the sediments at the site. However, for conservatism, the value of 0.75 g is suggested. Combined with this, there is probably no fault motion that will be transmitted to the site, although the fault motions on the Calaveras Fault itself, some three miles distant, may be several meters.

On the Verona Fault, it is believed that a reasonable value of acceleration experienced by the site will correspond to something of the order of about half as much as that for the Calaveras Fault, or about 0.35 to 0.4 g. However, we recommend, for conservatism, a value of 0.6 g, together with a maximum fault motion of the order of about 1 meter. This fault motion should be taken as the resultant gross motion, but it may occur in any arbitrary direction.

It is noted that, in both instances, higher accelerations might be recorded by instruments in the free field at the site. Because we are dealing with near field effects, it is not considered desirable or even rational to take these expected free field maximum motions as a basis for anchoring a Regulatory Guide or NUREG design spectrum.

IV. REFERENCES

1. Ang, A. H.-S. and Newmark, N. M., "A Probabilistic Seismic Safety Assessment of the Diablo Canyon Nuclear Power Plant," A Report to the U. S. Nuclear Regulatory Commission, Washington, D. C., November 1977.
2. Wight, L., Draft Report, "Seismic Risk Analysis for General Electric Nuclear Center, Pleasanton, California, Part I," submitted to Lawrence Livermore Laboratory by TERA Corporation, July 31, 1978.
3. Cornell, C. A. and Newmark, N. M., "On the Seismic Reliability of Nuclear Power Plants," Invited Paper, ANS Topical Meeting on Probabilistic Reactor Safety, Newport Beach, California, May 1978.
4. Newmark, N. M., "A Rationale for Development of Design Spectra for Diablo Canyon Reactor Facility," Report to the U. S. Nuclear Regulatory Commission, 3 September 1976.