UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of PACIFIC GAS AND ELECTRIC COMPANY (Diablo Canyon Nuclear Power Plant, Units 1 and 2)	Docket Nos. 50-275 OL 50-323 OL

Prepared Direct Testimony of James N. Brune

on Behalf of Governor Edmund G. Brown, Jr.

Regarding

APPEAL BOARD QUESTION 7

August 8, 1980

Testimony of James N. Brune

On Behalf of Governor Edmund G. Brown, Jr.

Regarding Appeal Board Question 7

The purpose of my testimony today is to address Question 7 proponded by the Appeal Board in the Appendix to ALAB 598.[1] I have already expressed certain views relating to this question in my prepared testimony on behalf of Joint Intervenars. There I stated:

> In ALAB-598, the Appeal Board stated that, "Intervenors (Brune affidavit, p. 5) . . . have suggested that the strong motion data obtained from stations along the direction of the Imperial fault evidence the 'focusing' of earthquake motions." Acutually, I suggested in my 1980 affidavit that focussing may have been operative in three other earth-

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[1] Question 7 states:

> "Intervenors (Brune Affidavit, p. 5) and the applicant (Frazier Affidavit, Para. 3) have suggested that the strong motion data obtained from stations along the direction of the Imperial Fault evidence the 'focusing' of earthquake motion. Yet, when the acceleration data of two such stations, El Centro Array Numbers 6 and 7, are plotted as a function of distance from the fault (e.g., Blume Affidavit, Figures 1 and 2), the horizontal acceleration values fall well below the regression line mean for the 1 km distance. The vertical acceleration values are also lower than the mean on such a plot. To the extent possible, the parties should analyze the seismic records for the IV-79 earthquake as they pertain to the focussing phenomenon and relate the results of such analyses to the likelihood that, in the event of an earthquake anywhere along the Hosgri Fault, focussing might result in amplified seismic motion at Diablo Canyon."

quakes (Santa Barbara, 1978, Gilroy, 1979, and Livermore, 1980). The Evidence for the effect of focussing on the observed accelerations in the case of the IV-79 earthquake is not clear to me at this time, and I believe that it is necessary to further analyze the data and the rupture mechanism before the effect of focussing can be assessed. It may turn out that the IV-79 earthquake is better represented as a sequence of multiple events than as a continuous rupture. Thus, it may be that focussing from a more continuous rupture would have led to even higher accelerations.

My purpose in this additional testimony is to express further views on this subject.[2]

INTRODUCTION

In Question 7 appended to the NRC Atomic Safety and Licensing Appeal Board decision of June 27, 1980, ALAB-598, the Appeal Board said that the parties should "analyze the seismic records for the IV-79 earthquake as they pertain to the focussing phenomenon and relate the results of such analyses to the likelihood that, in the event of an earthquake anywhere along the Hosgri Fault, focussing might result in amplified seismic motion at Diablo Canyon." I concur with the Board that this analysis is important to understanding the seismic hazard at Diablo Canyon.

IMPORTANCE AND RELEVANCE OF COMPUTER MODELLING

I believe that it is important that one aspect of the analyses for carrying out the boards directive be use of computer modelling of fault

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2 A statement of my professional qualifications and publications has previously been submitted as Attachment A to my ASLB testimony dated November 15, 1978.

rupture to simulate strong motion. Without this modelling, we will not be able to make full use of important new data from the Imperial Valley earthquake. Modelling, along with new information provided by the Imperial Valley earthquake, will provide improved understanding of the strong motion, especially the effects of focussing by rupture propagation and localized concentrations of high stress drop, which might occur at the Diablo Canyon Nuclear Plant from a rupture on the Hosgri Fault. This modelling can significantly reduce our uncertainties about the expected ground motion at Diablo Canyon. It will provide a range of realistic models of ground motion records from which to predict expected response spectra parameters.

In previous testimony (prior to the existence of the Imperial Valley data), I indicated that computer modelling would be important in estimating the strong motion to be expected at Diablo Canyon (ACRS testimony, 1977, p.4). The main reason for this was that because of the lack of data it is not possible to establish empirically the average peak acceleration at close distances (<10 km) for large earthquakes (M>7), nor to establish the standard deviation of peak accelerations from this mean. There was only one data point for an M>7 event at close distances (< 10 km) (Gazli earthquake). Since new data can only be accumulated with time,[3] as important future earthquakes are recorded on strong motion instruments, numerical modelling represents the best and most timely way to reduce existing uncertainties in the expected

[3] I indicated in my NRC testimony that about 10 earthquakes of magnitude near 7.5 would have to be recorded at close distances before we could be confident of the expected accelerations.

ground motion at Diablo Canyon. Modelling provides a method of assessing the importance of phenomena such as focussing of energy due to rupture propagation and anomalously high stress drop.

The existence of the Imperial Valley earthquake data will further decrease the uncertainty and non-uniqueness in the modelling process and thus increase the value of modelling at Diablo Canyon since this earthquake is the first with multi-station near-fault strong motion observations. Once the data from the Imperial Valley earthquake are modelled, including the effects of parameters such as focussing and local concentrations of high stress drop, we will be able to better assess their importance for Diablo Canyon.

Computer modelling capabilities have improved in recent years. Computer modelling is in the process of being developed for the San Onofre Nuclear Plant (Del Mar Technical Associates, 1978, 1979). In the case of San Onofre and Diablo Canyon the distance of the postulated design earthquake from the nucelar plant is very small (5 km for Diablo Canyon), and thus in the range where, due to the lack of empirical data, modelling is most important.

FEASIBILITY

In my previous testimony before the ACRS and NRC, I indicated that useful numerical modeling techniques were available to aid in estimating the expected ground motion at Diablo Canyon. The capability for doing site specific calculations similar to those proposed here has been developed by my colleagues at UCSD (Apsel and Luco, 1978) and I have been involved, along with other colleagues and students, in using their computer program (PROSE) and its results to interpret strong

motion records from several earthquakes, including earthquakes in 1977 near Acapulco, in 1977 along the Imperial fault, and in 1978 along the Cerro Prieto fault. At the present time I am working on a modelling study of the Imperial Valley earthquake of October 15, 1979. The above studies are briefly described here.

Hartzell, et al (1979) used the PROSE program to model the strong motion records from the October 1977 Acapulco earthquake. In another study (Nava and Brune, 1980) the PROSE program was used to model strong motion records of the double-event Mesa de Andrade earthquake of magnitude 5.3. In an unpublished study, Adair, et al (1979) found, using the PROSE program, that earthquakes recorded at Imperial Valley College from a 1978 earthquake swarm along the Imperial fault could be closely matched by a simple concentrated stress drop. In another study underway, (Munguia, et al, 1980), we are comparing strong motion records from the Victoria earthquake swarm of March 1978 (records shown in Appendix II of my ASLB testimony). I am presently involved in a modelling study of strong motion records from the Imperial Valley earthquake of October 15, 1979 using results from the PROSE program.

The basic difference between the modelling studies referred to above and the modelling which I am recommending for the Diablo Canyon site is one of scale. With the limited funding available at my institution, it is not possible to make the multiple computer runs with variations in parameters that would be required for the Diablo Canyon study. To estimate the effects of uncertainties in the parameters for the Diablo Canyon modelling, reasonable variations in model parameters will indicate worst-case or conservative conclusions.

GEOLOGIC PARAMETERS FOR MODELING

The numerical modeling would include effects of rupture on all faults considered capable. In particular, the orientations and locations of fault ruptures should be varied to take into account possible effects of focussing, i.e., whether fault rupture could proceed toward the plant, thus focussing energy in that direction. A conservative approach in this case would be to choose fault orientations as close to the direction toward the plant as allowed by the data.

It is also important to consider the effect of possible rupture on the several splay or branch faults of the Hosgri indicated on various maps (see Geologic Map References). These maps show splay or branch faults which point in a more easterly direction than the overall fault zone. Especially important would be splays or branches which strike toward the Diablo Canyon site. The most general model should include both a rupture on the main fault and superimposed effects of rupture on branch faults.

The calculations should also consider the possible range of fault orientations and mechanism, in particular the type of motion (normal, thrust or strike slip), and the possibility that the faults may dip under the plant.

The layered geologic model used in the numerical modeling should be chosen to be as representative as possible of the site-specific geologic structure at Diablo Canyon, based on appropriate geologic mapping, and refraction and reflection profiling. The effects of reasonable variations in structure, given the existing uncertainties, should be taken into account.

STRESS DROP

The main physical parameter necessary as an anchor value for the numerical modeling is stress drop. The 1979 earthquake is the first earthquake for which we will be able, after modeling studies are done, to determine the stress drop with some certainty, and this will aid in predicting the stress drop which might occur along the Hosgri fault. In my NRC testimony, I indicated that most earthquakes have stress drops less than 100 bars, but there was evidence that in some circumstances stress drops of over 100 bars could occur over volumes at least a few km in dimension relatively near the surface.

A reasonable initial model for an earthquake on the Hosgri fault would be a model with a uniform stress drop of 100 bars (over the entire fault rupture), and superimposed local stress drops of about 500 bars for local stress concentrations of about 5 km in radius, located at several points along the main fault branch and on splay or branch faults which are judged capable. Refined estimates for these values could be made when the initial results of the modeling are obtained (by comparison with existing strong motion records from the Imperial Valley earthquake and with other strong motion records considered important). It should be emphasized that it is not necessary to arrive at a final choice on faulting parameters before important and useful reduction of the uncertainties in the strong motion to be expected at Diablo Canyon are achieved. Initial results from the modeling will be of great benefit in this respect, since the information from empirical data is so limited.

CONCLUSION

I believe that it is important that one aspect of the analysis of the seismic records for the IV-79 earthquake as they pertain to the focussing phemonemon and the possibility of amplified seismic motion at Diablo Canyon, suggested in Question 7 of the appendix to ALAB-598, be use of computer modeling. Such modeling is presently feasible and represents the best and most timely way to reduce the uncertainties in the expected ground motion at Diablo Canyon for an M=7.5 earthquake on the Hosgri fault, particularly as these uncertainties relate to the possibility of focussing and localized stress drop.

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