UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	
PACIFIC GAS AND ELECTRIC CO.	)	Docket Nos. 50-275 O.L.
	)	50-323 O.L.
(Diablo Canyon Nuclear Power	)	
Plant, Unit Nos. 1 and 2	)	
	)	

DIRECT TESTIMONY OF JOSE M. ROESSET

Q. Please state your name, address, and occupation.

A. My name is Jose M. Roesset and my business address is the ECJ Building, Suite 46, University of Texas at Austin, Austin, Texas 78712. I am a professor of civil engineering at the University of Texas.

Q. Which of your qualifications and what among your experience are relevant to the design assurance matters you address in this testimony?

A. I am the Paul D. and Mary Robinson Meek Centennial Professor at the University of Texas at Austin, where I teach in the areas of structural analysis, structural dynamics, and earthquake engineering. I hold a degree in Civil Engineering from the Escuela Especial de Ingenieros de Caminos of Madrid, Spain (1959), and a Doctor of Science degree from the Massachusetts Institute of Technology (1964). I have twenty years of experience teaching, doing research, and publishing in the fields of structural analysis, dynamic analysis, and earthquake engineering.

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In addition, I have performed consulting work on the seismic design of structures in both the nuclear and nonnuclear areas. My work in the area of nuclear power plants has included extensive review of and consulting on the structural design of the Angra II Nuclear Power Plant in Brazil, consulting on soil structure interaction and other soils work for Stone and Webster Engineering Company, for Woodward-Clyde (South Texas Nuclear Power Plant), for Hochtief (Iran I Nuclear Power Plant), and for Dames and Moore (Koeberg Nuclear Power Plant, South Africa), and on other plants.

In addition, I have published numerous papers in the areas of structural analysis, soil structure interaction, and others. A list of my publications is included in the affidavit of my qualifications, also filed in this proceeding.

I am the Chairman of the Executive Committee of the Engineering Mechanics Division and was Chairman of the Dynamics Committee of the same Division of the American Society of Civil Engineers.

A fuller description of my experience and qualifications may be found in my affidavit of qualifications, also filed in this proceeding.

Q. What sources of information have you relied upon in preparing this testimony?

A. In general, I have based my opinions and evaluations on information served on the parties in this licensing proceeding. I have reviewed the PG&E Phase I Final Report,

the Independent Design Verification Program Final Report, the Semi-monthly status reports provided by Pacific Gas and Electric Company (PG&E) and by Teledyne Engineering Services on behalf of the Independent Design Verification Program (IDVP). I have also reviewed those Interim Technical Reports (ITR's) issued by the IDVP that deal with structures, dynamic analysis, or soils. (I reviewed ITR's 1-7, 10-13, 16, 40, 50, 51, 54-61, 63, 65, 67 and 68, and have read others.) Further, I have reviewed the reports prepared by Brookhaven National Laboratories for the NRC staff on the containment annulus, selected piping problems, and diesel fuel tanks, and documents transmitting to the NRC staff comments by the Brookhaven staff on selected ITR's. I have read the NRC staff reviews as documented in Safety Evaluation Report (SER) Supplement 18, and the PG&E replies filed with the NRC staff replying to open items in that SER Supplement. I have also reviewed discovery material and transcripts of depositions taken in these proceedings. Finally, I have attended some meetings and reviewed notes of other meetings with NRC staff, PG&E employees and other persons during the time I have been employed as a technical consultant to the counsel for the Governor of California. I have appeared before the NRC staff and the Commission at public meetings on September 9, 1982, and November 10, 1982, respectively, to give my opinion as to the usefulness of independent modeling by the Brookhaven National Laboratory of the Diablo Canyon Unit 1 containment annulus.

Q. Are you presently retained by counsel to Governor Deukmejian?

A. Yes.

Q. What work have you performed in that capacity?

A. I have been retained to provide advice and opinions on the adequacy, from a structural engineering standpoint, of the reanalysis and design verification efforts being conducted by the Diablo Canyon Project (DPC) and the IDVP in relation to the Diablo Canyon Nuclear Power Plant. In general, I have been concerned with the adequacy of design of structures, and have reviewed the DCP and IDVP efforts in the areas of seismic and dynamic models, analysis procedures, soils properties, soil structure interaction, values of material properties, damping, allowable stresses, and the like. I provided comments to counsel based on my reviews. In general, I have reviewed the DCP and IDVP work for use of sound and well justified engineering principles, rather than against specific licensing criteria.

I.

PURPOSE

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to present opinions and conclusions I have formed as to the adequacy of seismic modeling by PG&E of structures and soils at the Diablo Canyon Nuclear Power Plant, and as to the adequacy of the review of PG&E's work by the IDVP. It is also my purpose to set out areas where additional work should be done by PG&E and by the

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IDVP in order to provide confidence in the seismic verification work at Diablo Canyon.

II.

UPLIFTING OF THE CONTAINMENT MAT

Q. What contention addresses the possibility of uplifting of the foundation mat of the containment?

A. Contention 3(f)(iii). That contention, as set forth in the Board's Order, states:

> "The ITP's modeling of the soil properties for the containment and auxiliary building was improper in that the dynamic analysis of the containment for all earthquakes omit any analysis of uplifting of the foundation mat."

Q. What is the containment mat?

A. It is the foundation slab on which the containment building rests.

Q. Could you describe the phenomenon of uplifting of the mat?

A. It is normally assumed in seismic analysis that the base of the building always remains in contact with the underlying medium (soil or rock). The inertia forces in the structure will, however, cause an overturning moment that will tend to make the structure rock around a horizontal axis. If due to the combination of the vertical force (caused by the weight of the structure increased or reduced by the vertical acceleration) and the overturning moment the stresses at any point between the slab and the soil (or rock) become tensile the building will tend to uplift. During uplifting a part of

the mat will no longer be in contact with the soil and the area of contact will thus be reduced.

Q. What is the significance of the possibility of uplifting?

A. Uplifting may cause increased stresses in parts of the structure, and may cause increases in vertical acceleration that can affect the design of equipment within the containment.

Q. Has much research been done on the effects of uplifting of the foundation mat of a nuclear power plant containment building from the soil?

A. The possibility of separation of the mat from the soil or rock is a topic on which relatively little research work has been done until now. Most of this work was started in the middle 1970's.

Q. What, in general, are the effects of uplifting of the mat?

A. While separation of the mat and uplifting of the building will have some beneficial effects, it will have some detrimental effects. Typically, gross forces such as base shear or overturning moment may decrease. Horizontal accelerations may also be reduced or experience little change. When sliding of the mat takes place in addition to uplifting the beneficial effects are increased (the more so the smaller the coefficient of friction between the mat and the rock or soil). In the case of Diablo Canyon, however, because of the geometry of the mat, no sliding should take place. The two areas in which some detrimental effects can occur are that stresses in the lower part of the shell may

increase, and that vertical accelerations under a horizontal excitation may appear due to the shifting of the axis of rotation (the centroid of the area of contact). Work done by Kennedy (ref. 5[1/]) in relation to this problem indicated an increase in the response spectra in the high frequency range. Work done by Scaletti (ref. 10) under my supervision showed that this effect is decreased considerably if one accounts for nonlinear soil behavior, but pointed out the increase in axial forces and the appearance of vertical accelerations.

Q. Under what circumstances might uplifting occur?

A. Work by Wolf (ref. 14) indicated that for a typical reactor building uplifting might start at a peak ground acceleration of 0.167g if founded on rock, 0.260g if founded on medium soil and 0.408g for soft soil (see figure 6a, page 13 of ref. 14.)

Q. What, in your opinion, is the application of this research to Diablo Canyon?

A. The results by Wolf mentioned above are likely to be conservative because the reactor building considered there had a horizontal base, while the slab of the containment building for the Diablo Canyon Nuclear Power Plant has a different geometry. In addition, while the material at Diablo Canyon may be considered as rock for engineering purposes, it is not infinitely rigid. Taking this into consideration, one may expect that uplifting would not occur

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1. All references herein refer by number to the reference list at the end of this testimony.

until accelerations of the order of 0.2 to 0.4g were attained. My opinion is, however, that for an earthquake like Hosgri some uplifting of the containment at Diablo would indeed take place. The paper by Wolf also points out the beneficial effects of uplifting (it concludes in fact that there seems to be no reason for preventing lifting off from occuring) as well as the increase in forces in the base mat and neighboring walls (page 24 of ref. 14) and the response in the vertical direction due to horizontal motion, which can be important (page 18).

Q. Did the Diablo Canyon Project (DCP) consider the possible effects of uplifting?

A. Dr. White indicated in his deposition that some work had been done to evaluate the potential uplifting, although neither the work nor the results are mentioned in the Phase I Final Report or the ITRs. During the meeting of October 11 between Dr. White and myself he indicated that the possible increase in displacements was evaluated and was found by the DCP to be acceptable. Additional stresses on the slab, shell or walls would also, the DCP judged, be of little consequence.

Q. What do you recommend that the DCP and the IDVP do now?

A. The remaining questions are the possible effects of shifting of the axis in the frequency of the peaks in the response spectra and, more importantly, the additional vertical accelerations. These accelerations should be estimated by the DCP using a simple model, and some justification should

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be provided to show that they will not affect the design of equipment. The IDVP should verify this work.

III.

AUXILIARY BUILDING

Q. What contentions address the modeling of the soil springs for the seismic analysis of the Auxiliary Building?

A. Contentions 3(f) (iv) and 3(f)(v). Those contentions, as set forth in the Board's Order, state:

> "The ITP's modeling of the soil properties for the containment and the auxiliary buildings was improper in that:
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> ". . . .
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> "(iv) the modeling of the soil springs for the auxiliary building does not specify soil properties;
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> "(v) in the modeling of the soil springs for the auxiliary buildings, the motion inputs to the lower ends of the springs does not account for all soil structure interaction phenomena that could be expected."

Q. Briefly, what are soil springs?

A. Soil springs are a fictional way of representing, in a seismic analysis, certain characteristics of the foundation medium underlying a structure. The springs are so named because, in the model, springs are used to portray the underlying soil or rock. The soil springs can be assigned differing values depending on the softness or stiffness of the soil they represent. In addition, some damping may be associated with the springs.

Q. What do you understand the DCP to have intended the soil springs referred to in these contentions to represent?

A. Soil structure interaction analyses were conducted by the DCP for the auxiliary building in order to account for the fact that the foundation is at more than one elevation. For this purpose equivalent springs were placed at elevation 100 feet and their properties were computed from the theory of plates on an elastic half space (actually a layered elastic half space).

Q. What in general, have been your concerns regarding these soil springs?

A. The values used for the properties of the springs were questioned by the IDVP (ITR 6). My concerns were, however, with the physical meaning of the springs, the values of damping associated with the springs, and the motions specified as input at the ends of the springs.

Q. What are the reasons for your concerns?

A. The reasons for these concerns are:

(a) The use of half space theory to determine the stiffness of parts of a foundation at different elevations has not been justified. It is not clear what this approximation entails, since it involves replacing a rather complex geometry by a series of independent half spaces. This is not a normal approach and its validity should have been documented.

(b) If the properties of the material (soil or rock) at elevation 100 feet are similar to those of the rock at

elevation 85 feet there is little sense in putting springs at one elevation and not the other. The best estimate of the shear wave velocity of the material at elevation 100 feet reported by the IDVP in ITR 55 is 3500 feet per second. Yet 3500 feet per second is the velocity for which no soil structure interaction effects are considered.

If, however, the properties of the material were substantially different at elevations 85 feet and 100 feet, the motion that would occur at these two elevations would also be different. Use of soil springs together with use of the same motion at both elevations takes into account one part of the interaction phenomenon (the so called inertial interaction) but not the other part (kinematic interaction). This is not appropriate in general terms. The motion at elevation 100 feet should show an amplification in the frequency range corresponding to the fundamental frequency of the soil (or rock) layer between 85 feet and 100 feet.

(c) Due to the geometry and embedment of the foundation the motion that can be expected at elevation 100 feet will not only be somewhat different from that at elevation 85 feet, as previously discussed, but it will also exhibit rotational components (rocking and possibly torsion). It is not clear how important these additional effects can be, and the subject has not been addressed in any of the documents reviewed.

(d) Knowledge of the treatment of the damping associated with the soil springs is important to determine

whether the values of effective damping in each mode are within reasonable ranges. The damping was not specified in the Phase I Final Report nor in ITR 6.

Q. How, in your opinion, should the soil structure interaction effects have been accounted for?

A. It is my opinion that the two logical alternatives would have been:

(a) to assume a rigid base both at elevations 95 feet and 100 feet since the material is basically rock from an engineering standpoint at both locations; or

(b) to do a soil structure interaction analysis including all pertinent effects (both kinematic and inertial interaction) and modeling properly the difference in elevations. While this was not possible in the 1960's it could be done with present day technology. At least some studies could have been conducted on simple models to verify the adequacy of the springs computed from half space theory and the importance of the kinematic effects. One should notice, however, that the use of a soil structure interaction analysis in combination or in addition to tau effects is questionable (ref. 6).

Q. Has the IDVP's work adequately addressed your concerns?

A. None of these matters had been discussed in the Phase 1 Final Report and ITR 6 only questioned the values of the springs. ITR 55, on the auxiliary building (dated September 8, 1983, for revision 0), shows the results of parametric studies changing the soil/rock properties. The results in that ITR

indicate that as the stiffness of the springs is increased, simulating a stiffer material, most effects will decrease, the only excepton being the forces in the walls at elevation 100 feet. In addition, the report indicates that no damping was used in conjunction with these springs.

Q. Do you still have concerns regarding the soil springs?

A. I still believe there could be an increase in forces in the walls at elevation 100 feet if the springs were rigid. A demonstration that these walls have a sufficient margin of safety to take this increase should be provided by the DCP and verified by the IDVP.

Q. What contention addresses the seismic modeling of the slabs in the Auxiliary Building?

A. Contention 3(p). That contention, as set forth in the Board's Order, states:

"The ITP has not demonstrated, and the IDVP has not verified, that the DCP seismic model of the slabs in the auxiliary building is proper, in relation to the use of vertical and rotational springs to model the columns, and the motions used as inputs at the ends of the springs not connected to the slabs. In addition, in the study of the diaphragms, the ITP has not adequately accounted for the inplane flexibility of these slabs, and has not adequately demonstrated that stresses are within allowable limits at all elevations. (ITR 55.)"

Q. How did the DCP model the slabs in the Auxiliary Building?

A. In the vertical analysis of the slabs of the Auxiliary

Building, these slabs were uncoupled from the rest of the structure and modeled with finite elements, replacing the columns by vertical and rotational springs.

Q. Is such uncoupling a common procedure?

A. Uncoupling of a piece of equipment or part of the structure for modeling purposes is commonly done when its mass is very small compared to the overall mass. Even so it is also necessary for the subsystem or substructure to have a natural frequency which is not close to that of the structure.

Q. Have any studies been done to determine the adequacy of such uncoupling?

A. Most studies related to this topic have been performed in relation to the design of equipment and considering a two-degree-of-freedom system. (Ref. 1.) When dealing with a part of the structure which is uncoupled or isolated from the rest, the uncoupling process is delicate and should be properly documented and justified.

Q. What are your concerns with regard to the uncoupling?

A. An important issue is what motions are specified as input. In this particular case, the motion used as input at the edges of the slab or the connections of the slab to the walls was the motion computed at that level from the overall model of the structure, which is appropriate. The Phase I Final Report and the ITRs did not indicate, however, what the motion was at the base of the springs simulating the columns.

Q. In your opinion, how could the input motion be derived?

A. Two simple alternatives seem to be exist: to use the motion

at the level of the slab being considered, or to use the motion at the lower level (or upper level depending on the connectivity of the column). While both approaches are approximate it would appear that the second one might lead to more questionable results.

Q. Since you originally formed your concern regarding the input to the base of the springs, have you learned anything further regarding the DCP work on this subject?

A. I met with Dr. White of the DCP on October 11. He informed me that the motion used at the base of the springs was the same one applied at the edges of the slab, that is to say, the motion computed at the level of the slab.

Q. Did this information satisfy your concern regarding the input at the base of the springs?

A. As pointed out above, this is a less questionable method. However, because of the existence of the springs some amplification of this motion will take place and the results near the columns may be conservative in some ranges of frequencies but perhaps smaller than they should be in others. Moreover, some rotational motion should be associated with the rotational springs, which has not been considered.

Q. Did Dr. White provide you with any additional information regarding your concerns?

A. He also pointed out that the number of columns is relatively small compared to the walls and that the response spectra obtained at different points in the slab were enveloped to

obtain a unique spectrum applicable to any location on the slab. Under these conditions any possible reduction in response in a given frequency range near the column would be of no consequence since the response at other points would be larger. Thus while the model has not been properly justified I am satisfied that any possible errors associated with the solution would not be of great practical significance.

Q. Do you have any remaining concerns with respect to the modeling of the slabs?

A. Yes. A second point related to the modeling of the slabs that I questioned concerned the use of rotational springs to reproduce the bending stiffness of the columns. A finite element model is a discrete representation of a continuum. As the size of the elements is decreased, refining the mesh, one must expect the results to converge to the exact solution. When, on the other hand, a concentrated moment is applied at one point of the slab an analytical solution does not exist (a singularity exists at the point of application of the moment). Thus as the mesh is refined the rotation at the point of application of the moment should increase without bound. Within a certain range of sizes of the finite elements the computed rotation will still be reasonable but beyond that range the result will deteriorate. This is due, of course, to the fact that in physical reality the column is three-dimensional and is not merely a line. The moment is not therefore concentrated at a point but the result of stresses distributed over a finite area.

Q. What, in your opinion, should the DCP do to account for the effect of the rotational springs?

A. While the effect of the rotational springs is again of a local nature I believe that a justification for the mesh size selected should be provided by the DCP, showing that the results will remain within the reasonable range for the dimensions used. The IDVP should verify this work.

IV.

SOILS WORK

Q. What contentions deal with the soils properties and soils analysis?

A. Contentions 3(q) and 3(r). These contentions, as set forth in the Board's Order, state:

"(q) The ITP has not demonstrated and the IDVP has not verified, that the soils analysis for the buried diesel fuel oil tanks is proper in that the values of the exponent shown in figure 14 of ITR 68 have not been demonstrated to be appropriate and the variation of shear velocity with depth is not properly justified. (ITR 68.)

"(r) The ITP has not demonstrated and the IDVP has not verified that the soils analysis for the auxiliary saltwater piping and circulating water intake conduits is proper in that the selection of the modulus versus strain curve utilized is not justified. (ITR 68.)"

Q. What, in general, is the basis for these contentions?

A. The concern in relation to these two contentions is based on the contents of ITR 68, Verification of HLA Soils Work. It

relates to the values of the properties (shear modulus and damping) reported for the rock and the soil. These values are important for all soil structure interaction analyses as well as the remaining soils work.

Q. What concern led you to raise the question in contention 3(q)?

A. Contention 3(q) was raised because the values of the exponent in the curves showing the variation of shear modulus with mean effective stress in figures 13 and 14 for the fill did not seem reasonable, and the variation of the shear wave velocity of the rock with depth implied by the formula in page 38 and figure 15 was not justified.

Q. What is your concern regarding the properties of the fill?

A. Figures 13 and 14 show results for the variation of the modulus of elasticity of the fill in the analysis of the buried diesel fuel oil tank as a function of the confining stress and the effective mean stress. The modulus is considered proportional to the stress raised to a power that changes from 0.18 to 0.70 (an exponent as high as 0.75 is shown in figure 22 of the ITR). A more typical value in the literature of this exponent is between 0.4 and 0.5 (see for example work by Hardin and Drnevich (refs. 3 & 4). A value of 0.18 is much lower than typical and a value of 0.7 or 0.75 is too high. What is more, the variation in properties between the different lines shown in figure 14 is very large, larger than one would expect. There seems therefore to be a large uncertainty in the properties of the soil used for this analysis and determined by HLA.

Q. What is your concern regarding the properties of the rock?

A. Typical rock properties are shown in figure 15 of ITR 68. On page 30 of ITR 68 it is stated that these properties are expressed as shear wave velocity as a function of elevation, and that the values are in the range of those expected for rocks of these types with these overburdens. Values of shear wave velocities of 2400 to 3000 feet per second are shown in Table 2, page 56 of the ITR, and are being used in the various analyses, so I assume that this is the range that is considered typical. Yet in page 38 of the same ITR it is stated that the shear modulus of the rock was based on the HLA linear relationship

$$V = 9,667-83.3x$$

where V is the compression wave velocity and x the elevation in feet. This is the same relationship shown in figure 15 where it is indicated again that this is the compressional wave velocity and not the shear wave velocity. At elevation 85 this would result in a compressional wave velocity of 2587 feet per second, and in a shear wave velocity well below the range assumed as typical (of the order of 1000 to 1500 feet per second lower). There are therefore a number of inconsistencies and contradictions in the report and confusion as to what the real properties are.

Moreover, the use of this linear variation shown above is never justified. Figure 25 of ITR 68 shows another set of variations of shear wave velocity with depth which should be somewhat similar (unless there are very different rocks along

the site). Yet the average curve on figure 25 is given by 2000 + 40x, a very different slope in the variation with depth from the one of the formula on page 38 of the ITR.

Q. What concerns led you to raise the question expressed by contention 3(r)?

A. Contention 3(r) was raised because the soil properties reported in the analysis of the auxiliary saltwater piping and circulating water intake conduits again seemed questionable. For the shear modulus of the backfill (page 42), the results of three tests are shown in figure 23 together with the Seed and Idriss curve for sands. Since laboratory tests will generally produce values smaller than those measured in situ (see for instance work by Richart, et al., and Slokoe and Lodde (refs. 4, 8 & 13)) it is common to apply a correction to obtain the curves of variation of modulus with strain. This is particularly important if the values at low levels of strain are measured in the field as reportedly done here (page 42). Yet there is no indication of whether a correction was applied or, if so, which one. If the 3 points shown are uncorrected, the actual values in the field will be higher, indicating a smaller reduction with level of strain than implied by the curve of figure 23.

Three values of damping are shown in figure 24. These values fall much closer to the Seed and Idriss curve for clays than to the one for sands (notice that the variation of shear modulus for clays was not shown in figure 23). Again it is not explained whether these values were corrected in

any way; if not corrected, they may be too high. On page 42 it is indicated that the shear modulus used for the backfill ranged from 18.5 to 108.8 ksf and the damping ratio varied from 20 to 21 percent.

The values of the modulus are extremely low and the values of damping are very high, suggesting strains of the order of 1 percent or more. These values may be exaggerated if the curves of figures 23 and 24 are not appropriate. It should be noted that, in contrast, for the soil around the intake structure shear wave velocities ranging from 400 to 850 feet per second were used as shown in Table 4. These values are 5 times or more larger than those used for the backfill of the auxiliary saltwater piping and circulating water intake conduits.

Q. What are your conclusions and recommendations regarding the soils work?

A. Both contentions address a common theme: an apparent uncertainty in the actual soil and rock properties, a lack of adequate justification for the values and procedures used, and lack of detail in the documentation. In my opinion, this work should be reviewed in more detail by the DCP to gain adequate confidence on the values of the parameters. The IDVP should verify this work.

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V.

VERIFICATION METHODOLOGY

Q. What contention deals with the performance of independent verification of PG&E's seismic structural modeling done by the IDVP?

A. Contention 1(d). That contention, as set forth in the Board's Order, states:

> "The scope of the IDVP review of both the seismic and non-seismic aspects of the designs of safety-related systems, structures, and components (SS&Cs) was too narrow in the following respects:
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> ". . . .
>
> "(d) The IDVP failed to verify independently the analyses but merely checked data of inputs to models used by PG&E."

Q. What concern did you have regarding the seismic portion of the work done by the IDVP that is reflected in this contention?

A. I have been, and am, concerned that, in its seismic work, the IDVP did not conduct complete independent analyses of the structures it verified.

Q. Can you explain of what such an independent analysis would consist?

A. Such a complete independent analysis would consist of the IDVP developing its own models and carrying the solution until the final results are obtained, in the way Brookhaven National Laboratory did with the Annulus Structure. While I

believe that the work done by the IDVP is important to identify potential errors, the work done by BNL represented a valuable addition. A direct comparison of the final results permits one to determine directly if large discrepancies occur and if there have been some hidden mistakes. While it would be illogical to require many independent reviews, the second type of verification provided by BNL is an important complement to the work of the IDVP.

Q. What do you think has been the value of the work done by Brookhaven?

A. The value of the work done by BNL in relation to the Annulus Structure and the diesel fuel tank is, in my opinion, hard to deny. The report on the vertical analysis of the Annulus pointed out the importance of local modes due to the flexibility of the floor system. It is hard to say whether this could have been detected by the IDVP without BNL's work or not. Also, the influence of the BNL vertical report on the later analysis for the horizontal earthquake is not known. (The BNL study for horizontal excitation showed again important points in relation to the deformation of the floor system.) BNL's work on the diesel fuel tank apparently led to the new analyses conducted in this respect. It appears that the concerns raised by BNL in relation to the modeling of the fluid inside the tank were justified, although the tank was qualified in any event.

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Q. Do you think it would have been useful for such an independent analysis of other structures at Diablo Canyon to have been done by Brookhaven or others?

A. In my presentation to the Commission in November of 1982 I had recommended that BNL be requested to do similar studies of other complex structures to have an additional and different point of reference in evaluating the safety of the plant and the appropriateness of the analyses conducted. I believe this would have been a valuable contribution.

Q. In general, in your review of the structural and soils ITRs, have you found that the ITRs contained sufficient information to permit you to make judgments regarding the adequacy of the analyses?

A. No. One of my main problems in reaching conclusions with respect to the adequacy of the analyses performed has been the lack of detailed documentation provided in the PG&E Final Report and the early ITRs. Sentences indicating that a procedure has been reviewed and that it was found acceptable, such as often appear in the ITRs, do not provide enough basis for an independent judgment. This is particularly important when a procedure seems questionable and the data required to estimate the potential impact of an error are not presented. It should be noted that similar comments were made by BNL's staff in their reviews. While the latest ITRs are somewhat more explicit in many cases they still lack all the necessary information.

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VI.

CONCLUSIONS

While there are a number of models and analysis procedures that I originally found questionable, through the discovery process I have been able to ascertain that several of them do not result in serious concerns in relation to the safety of the structures. There are still, however, four remaining issues that require further verification. These are:

-- The effect of possible uplift of the mat of the containment building on vertical accelerations and the design of the equipment.

-- The ability of the walls of the auxiliary building at elevation 100 feet to carry the increased forces that might result from considering a fixed base at elevations 85 feet and 100 feet, neglecting the soil structure interaction effects (considering the springs at elevation 100 feet to be rigid).

-- The adequacy of the rotational springs used to model the columns in the vertical analysis of the slabs of the auxiliary building in relation to the size of the finite elements.

-- The adequacy of the soils work performed by HLA in relation to the determination of rock and soil properties, variation of these properties with depth and their variation with level of strain.

In each of these four areas, I believe that further justification is required from the DCP and that the justification

should be verified by the IDVP. Without this additional work, it is very hard for me to assess the possible importance or impact of these concerns in relation to the adequacy of the design.

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6. Newmark, N. M., testimony presented before the Atomic Safety and Licensing Appeal Board, in In the Matter of Pacific Gas and Electric Company (Diablo Canyon Nuclear Power Plant, Units 1 and 2), Docket Nos. 05 -275 O.L. and 50-323 O.L., testimony on Imperial Valley earthquake.

7. Richart, F. E., Jr., Anderson, D. G. and Shokoe, K. H., II, "Predicting in Situ Strain Dependent-Shear Moduli." Proceedings of the Sixth World Conference on Earthquake Engineering. New Delhi, India. January 1977.

8. Richart, F. E., Jr. and Woods, R. D., "Vibrations of Soils and Foundations." Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1970.

9. Roesset, J. M., "A Review of Soil Structure Interaction." Chapter of Report UCRL 15262 by Lawrence Livermore Laboratory. Seismic Safety Margins Research Program, Phase I, Project III. June 1980.

10. Scaletti, F. H., "Nonlinear Effects in Soil Structure Interaction." Ph.D. Thesis Department of Civil Engineering, M.I.T. September 1977.

11. Seed, M. B., and Idriss, I. M., "Soil Moduli and Damping Factors for Dynamic Response Analyses." Report EERC 70-10, University of California, Berkeley. February 1970.

12. Seed, M. B., Whitman, R. V., and Lysmer, J., "Soil Structure Interaction Effects in the Design of Nuclear Power Plants." Structural and Geotechnical Mechanics, Prentice Hall. 1977.

13. Slokoe, K. H., II and Lodde, P. F., "Dynamic Response of San Francisco Bay Mud." Proceedings of the ASCE Specialty Conference on Earthquake Engineering and Soil Dynamics, vol. II. Pasadena, California. June 1978.

14. Wolf, J. P. and Skrikeru, P. E., "Seismic Excitation with Large Overturning Moments: Projecting Base Mat or Lifting-off?" Papcr presented at the Conference on Structural Analysis, Design and Construction in Nuclear Power Plants, Porto Alegre, Brazil. April 1978.

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

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

STATE OF CALIFORNIA)
) ss.
COUNTY OF LOS ANGELES)

AFFIDAVIT OF RICHARD B. HUBBARD

Richard B. Hubbard, being first duly sworn, attests:

1. I am a Professional Quality Engineer licensed by the State of California (License Number QU 805). I am currently a vice-president of MHB Technical Associates, a corporation engaged in the business of technical consulting on nuclear power facilities which I co-founded in 1976. My business address is 1723 Hamilton Avenue, San Jose, California.

2. I hold a B.S. in Electrical Engineering from the University of Arizona (1960), and an M.B.A. from the University of Arizona (1969). I have 19 years' experience in the design and manufacture of systems and equipment for nuclear power generation facilities, including 11 years' experience in responsible engineering and manufacturing managerial positions in the Nuclear Instrumentation Department (1965-1971), Atomic Power Equipment Department (1971-1975), and Nuclear Energy Control and

Instrumentation Department (1975-1976) of the General Electric Company (GE).

3. For the past 7 years, I, along with my co-founders of MHB Technical Associates, have conducted numerous studies pertaining to the safety, quality, reliability, and economic aspects of nuclear power facilities. I have been a consultant in this capacity to California, Massachusetts, Oklahoma, and Illinois Attorneys General, Minnesota Pollution Control Agency, German Ministry for Research and Technology, Governor of California, Swedish Energy Commission, Swedish Nuclear Inspectorate, Suffolk County in New York State, Ohio Consumer's Counsel, New Jersey Public Advocate, and U.S. Department of Energy.

4. I have testified on safety-related aspects of nuclear power facilities' quality assurance programs as an expert witness before the NRC Licensing Boards; before and at the request of the NRC's Advisory Committee on Reactor Safeguards; before the Joint Committee on Atomic Energy of the United States Congress; and before various federal and state legislative and administrative bodies.

5. From November 1971 to February 1976, I was a manager of Quality Assurance for the manufacturing operations at the San Jose, California, headquarters of GE's Nuclear Energy Division. I was responsible for the development and implementation of quality plans, programs, methods, and equipment to assure that equipment for nuclear plants designed, manufactured

and procured by GE met quality requirements as defined in NRC regulation 10 C.F.R. Part 50, Appendix B; ASME Boiler and Pressure Vessel Code; customer contracts; and GE corporate policies and procedures. The product areas include radiation sensors, reactor vessel internals, fuel handling and servicing tools, nuclear plant control and protection instrumentation systems, containment electrical penetrations, and control room panels for the Nuclear Steam Supply System (NSSS) and Balance of Plant (BOP). I was responsible for approximately 45 exempt personnel, 22 non-exempt personnel, and 129 hourly personnel with a yearly expense budget of nearly $4 million and an equipment investment budget of approximately $1.2 million. While employed by GE, I was responsible for developing a quality system which received NRC certification in 1975. The QA system was also successfully surveyed for ASME "N" and "NPT" symbol authorizations in 1972 and 1975, plus ASME "U" and "S" symbol authorizations in 1975. I was also responsible for the quality assurance program and its implementation at GE's spare and renewal parts warehouse in San Jose.

6. I am a member of the IEEE Nuclear Power Engineering Standards Subcommittee responsible for the preparation and revision of a number of Quality Assurance standards for safety-related aspects of nuclear power facilities.

* * * * * *

7. A summary of my experience and professional qualifications is set forth in Attachment A, which is appended to this affidavit.

Richard B. Hubbard

RICHARD B. HUBBARD

Subscribed and sworn to before me
this ____ day of _____, 1983.

_____
Notary Public in and for Said
County and State

TO BE REFILED WITH NOTARIZATION

ATTACHMENT A

PROFESSIONAL QUALIFICATIONS OF RICHARD B. HUBBARD

RICHARD B. HUBBARD
MHB Technical Associates
1723 Hamilton Avenue
Suite K
San Jose, California 95125

EXPERIENCE:

9/76 - PRESENT

Vice-President - MHB Technical Associates, San Jose, California.
Founder, and Vice-President of technical consulting firm. Specialists in independent energy assessments for government agencies, particularly technical and economic evaluation of nuclear power facilities. Consultant in this capacity to California, Massachusetts, Oklahoma and Illinois Attorney Generals, Minnesota Pollution Control Agency, German Ministry for Research and Technology, Governor of California, Swedish Energy Commission, Swedish Nuclear Inspectorate, Suffolk County, Ohio Consumer's Counsel, New Jersey Public Advocate, and the U. S. Department of Energy. Also provided studies and testimony for various public interest groups including the Center for Law in the Public Interest, Los Angeles; Public Law Utility Group, Baton Rouge, Louisiana; Friends of the Earth (FOE), Italy; and the Union of Concerned Scientists, Cambridge, Massachusetts. Provided testimony to the U.S. Senate/House Joint Committee on Atomic Energy, the U.S. House Committee on Interior and Insular Affairs, the California Assembly, Land Use, and Energy Committee, the Advisory Committee on Reactor Safeguards, and the Atomic Safety and Licensing Board. Performed comprehensive risk analysis of the accident probabilities and consequences at the Barseback Nuclear Plant for the Swedish Energy Commission and edited, as well as contributed to, the Union of Concerned Scientist's technical review of the NRC's Reactor Safety Study (WASH-1400).

2/76 - 9/76

Consultant, Project Survival, Palo Alto, California.
Volunteer work on Nuclear Safeguards Initiative campaigns in California, Oregon, Washington, Arizona, and Colorado. Numerous presentations on nuclear power and alternative energy options to civic, government, and college groups. Also resource person for public service presentations on radio and television.

5/75 - 1/76

Manager - Quality Assurance Section, Nuclear Energy Control and Instrumentation Department, General Electric Company, San Jose, California. Report to the Department General Manager. Develop and implement quality plans, programs, methods, and equipment which assure that products produced by the Department meet quality requirements as defined in NRC regulation 10 CFR 50, Appendix B, ASME Boiler and Pressure Vessel Code, customer contracts, and GE Corporate policies and procedures. Product areas include radiation sensors, reactor vessel internals, fuel handling and servicing tools, nuclear plant control and protection instrumentation systems, and nuclear steam supply and Balance of Plant control room panels. Responsible for approximately 45 exempt personnel, 22 non-exempt personnel, and 129 hourly personnel with an expense budget of nearly 4 million dollars and equipment investment budget of approximately 1.2 million dollars.

11/71 - 5/75

Manager - Quality Assurance Subsection, Manufacturing Section of Atomic Power Equipment Department, General Electric Company, San Jose, California. Report to the Manager of Manufacturing. Same functional and product responsibilities as in Engagement #1, except at a lower organizational report level. Developed a quality system which received NRC certification in 1975. The system was also successfully surveyed for ASME "N" and "NPT" symbol authorization in 1972 and 1975, plus ASME "U" and "S" symbol authorizations in 1975. Responsible for from 23 to 39 exempt personnel, 7 to 14 non-exempt personnel, and 53 to 97 hourly personnel.

3/70 - 11/71

Manager - Application Engineering Subsection, Nuclear Instrumentation Department, General Electric Company, San Jose, California. Responsible for the post order technical interface with architect engineers and power plant owners to define and schedule the instrumentation and control systems for the Nuclear Steam Supply and Balance of Plant portion of nuclear power generating stations. Responsibilities included preparation of the plant instrument list with approximate location, review of interface drawings to define functional design requirements, and release of functional requirements for detailed equipment designs. Personnel supervised included 17 engineers and 5 non-exempt personnel.

12/69 - 3/70

Chairman - Equipment Room Task Force, Nuclear Instrumentation Department, General Electric Company, San Jose, California. Responsible for a special task force reporting to the Department General Manager to define methods to improve the quality and reduce the

installation time and cost of nuclear power plant control rooms. Study resulted in the conception of a factory-fabricated control room consisting of signal conditioning and operator control panels mounted on modular floor sections which are completely assembled in the factory and thoroughly tested for proper operation of interacting devices. Personnel supervised included 10 exempt personnel.

12/65 - 12/69

Manager - Proposal Engineering Subsection, Nuclear Instrumentation Department, General Electric Company, San Jose, California.
Responsible for the application of instrumentation systems for nuclear power reactors during the proposal and pre-order period. Responsible for technical review of bid specifications, preparation of technical bid clarifications and exceptions, definition of material list for cost estimating, and the "as sold" review of contracts prior to turnover to Application Engineering. Personnel supervised varied from 2 to 9 engineers.

8/64 - 12/65

Sales Engineer, Nuclear Electronics Business Section of Atomic Power Equipment Department, General Electric Company, San Jose, California.
Responsible for the bid review, contract negotation, and sale of instrumentation systems and components for nuclear power plants, test reactors, and radiation hot cells. Also responsible for industrial sales of radiation sensing systems for measurement of chemical properties, level, and density.

10/61 - 8/64

Application Engineer, Low Voltage Switchgear Department, General Electric Company, Philadelphia, Pennsylvania
Responsible for the application and design of advanced diode and silicon-controlled rectifier (SCR) constant voltage DC power systems and variable voltage DC power systems for industrial applications. Designed, followed manufacturing and personally tested an advanced SCR power supply for product introduction at the Iron and Steel Show. Project Engineer for a DC power system for an aluminum pot line provided to Anaconda beginning at the 161KV switchyard and encompassing all the equipment to convert the power to 700 volts DC at 160,000 amperes.

9/60 - 10/61

GE Rotational Training Program

Four 3-month assignments on the GE Rotational Training Program for college technical graduates as follows:

a. Installation and Service Eng. - Detroit, Michigan
Installation and startup testing of the world's largest automated hot strip steel mill.

b. Tester - Industry Control - Roanoke, Virginia
Factory testing of control panels for control of steel, paper, pulp, and utility mills and power plants.

c. Engineer - Light Military Electronics - Johnson City, New York
Design of ground support equipment for testing the auto pilots on the F-105.

d. Sales Engineer - Morrison, Illinois
Sales of appliance controls including range timers and refrigerator cold controls.

EDUCATION:

Bachelor of Science Electrical Engineering, University of Arizona, 1960.

Master of Business Administration, University of Santa Clara, 1969.

PROFESSIONAL AFFILIATION:

Registered Quality Engineer, License No. QU805, State of California.

Member of Subcommittee 8 of the Nuclear Power Engineering Committee of the IEEE Power Engineering Society responsible for the preparation and revision of the following national Q.A. Standards:

a. IEEE 498 (ANSI N45.2.16): Requirements for the Calibration and Control of Measuring and Test Equipment used in the Construction and Maintenance of Nuclear Power Generating Stations.

b. IEEE 336 (ANSI N45.2.4): Installation, Inspection, and Testing Requirements for Class 1E Instrumentation and Electric Equipment at Nuclear Power Generating Stations.

c. IEEE 467 : Quality Assurance Program Requirements for the Design and Manufacture of Class 1E Instrumentation and Electric Equipment for Nuclear Power Generating Stations.

I am currently a member of the IEEE Committee which is preparing a standard relating to the selection and utilization of replacement parts for Class 1E equipment during the construction and operation phase.

PUBLICATIONS AND TESTIMONY:

1. In-Core System Provides Continuous Flux Map of Reactor Cores, R. B. Hubbard and C. E. Foreman, Power, November, 1967.

2. Quality Assurance: Providing It, Proving It, R. B. Hubbard, Power, May, 1972.

3. Testimony of R. B. Hubbard, D. G. Bridenbaugh, and G. C. Minor before the United States Congress, Joint Committee on Automic Energy, February 18, 1976, Washington, D.C. (Published by the Union of Concerned Scientists, Cambridge, Massachusetts.) Excerpts from testimony published in Quote Without Comment, Chemtech, May, 1976.

4. Testimony of R. B. Hubbard, D. G. Bridenbaugh, and G. C. Minor to the California State Assembly Committee on Resources, Land Use, and Energy, Sacramento, California, March 8, 1976.

5. Testimony of R. B. Hubbard and G. C. Minor before California State Senate Committee on Public Utilities, Transit, and Energy, Sacramento, California, March 23, 1976.

6. Testimony of R. B. Hubbard and G. C. Minor, Judicial Hearings Regarding Grafenrheinfeld Nuclear Plant, March 16 & 17, 1977, Wurzburg, Germany.

7. Testimony of R. B. Hubbard to United States House of Representatives, Subcommittee on Energy and the Environment, June 30, 1977, Washington, D.C., entitled, Effectiveness of NRC Regulations - Modifications to Diablo Canyon Nuclear Units.

8. Testimony of R. B. Hubbard to the Advisory Committee on Reactor Safeguards, August 12, 1977, Washington, D.C., Risk Uncertainty Due to Deficiencies in Diablo Canyon Quality Assurance Program and Failure to Implement Current NRC Practices.

9. The Risks of Nuclear Power Reactors: A Review of the NRC Reactor Safety Study WASH-1400, Kendall, et. al., edited by R. B. Hubbard and G. C. Minor for the Union of Concerned Scientists, August, 1977.

10. Swedish Reactor Safety Study: Barseback Risk Assessment, MHB Technical Associates, January 1978 (Published by Swedish Department of Industry as Document DSI (1978:1).

11. Testimony of R. B. Hubbard before the Energy Facility Siting Counsil, March 31, 1978, in the matter of Pebble Springs Nuclear Power Plant, Risk Assessment: Pebble Springs Nuclear Plant, Portland, Oregon.

12. Presentation by R. B. Hubbard before the Federal Ministry for Research and Technology (BMFT), August 31 and September 1, 1978, Meeting on Reactor Safety Research, Risk Analysis. Bonn, Germany.

13. Testimony by R. B. Hubbard, D. G. Bridenbaugh, and G. C. Minor before the Atomic Safety and Licensing Board, September 25, 1978, in the matter of the Black Fox Nuclear Power Station Construction Permit hearings, Tulsa, Oklahoma.

14. Testimony of R. B. Hubbard before the Atomic Safety and Licensing Board, November 17, 1978, in the matter of Diablo Canyon Nuclear Power Plant Operating License Hearings, Operating Basis Earthquake and Seismic Reanalysis of Structures, Systems, and Components, Avila Beach, California.

15. Testimony of R. B. Hubbard and D. G. Bridenbaugh before the Louisiana Public Service Commission, November 19, 1978, Nuclear Plant and Power Generation Costs, Baton Rouge, Louisiana.

16. Testimony of R. B. Hubbard before the California Legislature, Subcommittee on Energy, Los Angeles, April 12, 1979.

17. Testimony of R. B. Hubbard and G. C. Minor before the Federal Trade Commission, on behalf of the Union of Concerned Scientists, Standards and Certification Proposed Rule 16 CFR Part 457, May 18, 1979.

18. ALO-62, Improving the Safety of LWR Power Plants, MHB Technical Associates, prepared for U.S. Department of Energy, Sandia National Laboratories, September, 1979, available from NTIS.

19. Testimony by R. B. Hubbard before the Arizona State Legislature, Special Interim House Committee on Atomic Energy, Overview of Nuclear Safety, Phoenix, AZ, September 20, 1979.

20. "The Role of the Technical Consultant", Practising Law Institute program on "Nuclear Litigation", New York City and Chicago, November, 1979. Available from PLI, New York City.

21. Uncertainty in Nuclear Risk Assessment Methodology, MHB Technical Associates, March, 1980, prepared for and available from Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

22. Italian Reactor Safety Study: Caorso Risk Assessment, MHB Technical Associates, March, 1980, prepared for and available from Friends of the Earth, Rome, Italy.

23. Development of Study Plans: Safety Assessment of Monticello and Prairie Island Nuclear Stations, MHB Technical Associates, August, 1980, prepared for and available from the Minnesota Pollution Control Agency.

24. Affidavit of Richard B. Hubbard and Gregory C. Minor before the Illinois Commerce Commission, In the Matter of an Investigation of the Plant Construction Program of the Commonwealth Edison Company, prepared for the League of Women Voters of Rockford, Illinois, November 12, 1980, ICC Case No. 78-0646.

25. Systems Interaction and Single Failure Criterion, MHB Technical Associates, January, 1981, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

26. Summary of Emergency Response Planning Criteria for Regional and Local Authorities Near Nuclear Electric Generating Stations, MHB Technical Associates, June, 1981, prepared for and available from Friends of the Earth, Rome, Italy.

27. Economic Assessment: Ownership Interest In Palo Verde Nuclear Station, September 11, 1981, prepared for and available from the City of Riverside, California.

28. Systems Interaction and Single Failure Criterion: Phase II report, MHB Technical Associates, December, 1981, prepared for and available from the Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

29. Testimony of Richard Hubbard and Gregory Minor on Emergency Response Planning, Diablo Canyon Operating License hearings before ASLB, January 11, 1982.

30. Statement of Richard Hubbard before the U.S. House Subcommittee on Energy and Environment concerning QA program breakdowns, November 19, 1981.

31. Testimony of Richard Hubbard on Quality Assurance, South Texas Operating License hearing before ASLB, prefiled June, 1981.

32. Presentation of Richard Hubbard for Governor Edmund G. Brown, jr. concerning PG&E's Proposed Seismic Design Reverification Program, Diablo Canyon Nuclear Power Plant, February 1982.

33. Testimony of R. B. Hubbard, G. C. Minor, M. W. Goldsmith, S. J. Harwood on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Contention 7B, Safety Classification and Systems Interaction, April 13, 1982.

34. Testimony of R. B. Hubbard and D. G. Bridenbaugh, in the matter of Jersey Central Power and Light Company For an Increase in Rates for Electrical Service, on behalf of New Jersey Department of the Public Advocate, Division of Rate Counsel, Three Mile Island Units 1 & 2, Cleanup and Modification Programs, May, 1982.

35. Testimony of R. B. Hubbard and G. C. Minor on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 27 and SOC Contention 3, Post-Accident Monitoring, May 25, 1982.

36. Presentation of R. B. Hubbard for Governor Edmund G. Brown, Jr. concerning Diablo Canyon Reverification Program, Diablo Canyon Nuclear Power Plant, September, 1982.

37. Testimony of R. B. Hubbard on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contentions 12, 13, 14, and 15, Quality Assurance/Quality Control, June 29, 1982.

38. Presentation of Richard B. Hubbard on Behalf of the State of California, Before the NRC Commissioners, Proposed Phase II Diablo Canyon Reverification Program (IDVP), November 10, 1982.

39. Testimony of R. B. Hubbard and Dr. Francisco J. Samaniego on behalf of Suffolk County, Before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Torrey Pines Technology's Inspection of Shoreham Nuclear Power Station, December 21, 1982.

40. Supplemental testimony of G. C. Minor, R. B. Hubbard, and M. W. Goldsmith on behalf of Suffolk County, before the Atomic Safety and Licensing Board, in the matter of Long Island Lighting Company, Shoreham Nuclear Power Station, Unit 1, regarding Suffolk County Contention 7B, Safety Classification and Systems Interaction, March 23, 1983.

41. Supplemental Affidavit of R. B. Hubbard before the Atomic Safety and Licensing Appeal Board Concerning Breakdowns in the Diablo Canyon Quality Assurance Program, March 29, 1983.

42. Declaration of R. B. Hubbard before the Atomic Safety and Licensing Appeal Board, Concerning Breakdowns in Construction Quality Assurance at Diablo Canyon, May 6, 1983.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the matter of	)	
	)	Docket No. 50-275
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket No. 50-323
	)	
(Diablo Canyon Nuclear Power Plant, Units 1 and 2)	)	
	)	
	)	

AFFIDAVIT OF QUALIFICATIONS OF
JOSE M. ROESSET

Jose M. Roesset, being first duly sworn, deposes and says as follows:

1. My name is Jose M. Roesset, and my business address is ECJ Building, Suite 4.6, University of Texas at Austin, Austin, Texas 78712.

2. My educational background is as follows: I received a degree in Civil Engineering from the Escuela Especial de Ingenieros de Caminos in Madrid, Spain, in 1959. I received the degree of Doctor of Science from the Massachusetts Institute of Technology in 1964 with primary emphasis in structures, secondary emphasis in soil mechanics and in systems, and a minor in mathematics.

3. I currently hold the position of the Paul D. and Mary Robertson Meek Centennial Professor at the University of Texas at Austin. I teach courses in the

general subject areas of structural analysis, structural dynamics, and earthquake engineering. Previous to holding that position, I held the position of Professor of Civil Engineering, University of Texas at Austin, from 1978 to 1983. From 1975 to 1978, I held the post of Professor in the Department of Civil Engineering at the Massachusetts Institute of Technology, where I taught in the areas of structural engineering, dynamic analysis, and earthquake engineering. Prior to that time, my professional employment can be summarized as follows:

Associate Professor, M.I.T., Dept. of Civil Engineering	1969-1975
Visiting Professor, University of Chile	1966-1967
Assistant Professor, M.I.T., Dept. of Civil Engineering	1964-1969
Teaching Assistant, M.I.T.	1963-1964
Research Assistant, M.I.T.	1962-1963
Civil Engineer, Agroman Empresa Constructora, Madrid	1959-1961
Assistant Engineer, Agroman Empresa Constructora, Madrid	1954-1959

3. In addition to the professional employment listed above, I have performed consulting work in the areas of structural engineering, dynamic analysis, and earthquake engineering, both in the nuclear and in nonnuclear areas, for various public and private entities.

In the nonnuclear areas, my consulting work has included, among other jobs, work with the blue ribbon commission that investigated the collapse of a 17-story building on Commonwealth Avenue in Boston, study of the design of the Standard Oil of Indiana Building in Chicago,

and some work for the North Texas State University.

In the area of nuclear power, I have performed consulting work in several forms. I was employed by the Kraftwerk Union (KWU) Company of Germany, to perform an extensive oversight role in the structural design of the Angra II nuclear power plant, located in Angra Dos Reis, in Brazil. I had sat on an international arbitration panel of experts that arbitrated areas of disagreement concerning that plant between KWU and CNEN, which was the regulatory licensing authority in Brazil. At the close of that work, I was retained by KWU, with CNEN's approval, to review the revisions and redesign KWU made to the Angra plant to accommodate an increase in the safe shutdown earthquake by a factor of two to two and a half. In that capacity, I reviewed the design of the containment, other buildings, piping, and ducts. I cosigned technical reports made by KWU, and presented portions of the work before CNEN. This work was done from 1979 to 1982.

I have also done consulting work for Stone and Webster Engineering dealing with seismic spectra, soil amplification, and soil structure analysis for more than one nuclear power plant.

I have also done consulting work on soil structure interaction for Woodward-Clyde on the South Texas Nuclear Power Plant, for Hochtief on the Iran I Nuclear Power Plant,

and for Dames & Moore, of London, on the Koeberg Nuclear Power Plant in South Africa. The Koeberg plant work involved analysis of the dynamic behavior of the plant and of the possibility of uplift or separation; this plant was one of the first to be built on neoprene pads.

I have also done consulting work on reactors in Cordoba, Argentina, and in Peru, involving soil structure interaction analysis and calculation of stresses in buildings.

Additionally, I have done work on the subject of soil structure interaction for the Lawrence Livermore Laboratory, under a contract from the NRC, as part of the Seismic Safety Margins Research Program. As part of this work, I authored a chapter of the publication, A Review of Soil Structure Interaction (UCRL-15262, 1980), and contributed to other reviews being done by Lawrence Livermore as part of the program.

I have also performed other, more minor, consulting work in both the nuclear and nonnuclear areas.

4. I am a member of the American Society of Civil Engineers (ASCE), of the Earthquake Engineering Research Institute, and of the Colegio de Ingenieros de Caminos, Canales Y Puertos. I am now Chairman of the Executive Committee of the Engineering Mechanics Division,and a past Chairman of the Dynamics Committee of the same Division of the ASCE, and have held various other ASCE posts.

5. Among the honors I have received are the following:

Paul D. & Mary Robertson Meek Centennial Professor, University of Texas at Austin.

Moiseif Award, ASCE: Award for the best structural engineering paper of 1972.

Fulbright Scholar.

6. A list of publications I have authored, coauthored, or supervised through 1982 is as follows:

"The Use of Amplication Functions to Derive Response Spectra, Including the Effect of Local Soil Conditions," with M. Sarrazin and E. Vanmarcke, MI.T. Civil Engineering Report, R69-48, July, 1969.

"Analysis of Building Frames for Natural Frequencies and Natural Mode Shapes," with R. LaTona, MI.T. Civil Engineering Report R69-59, August, 1969.

"A Consistent Set of Finite Elements for Continua and Linear Members," by Rene W. Luft (J.J. Connor and J.M. Roesset, supervisors). M.I.T. Civil Engineering Report R69-51, August, 1969.

"Effect of the Angle of Incidence on the Amplication of SH Waves," Quarterly Progress Report of the Inter-American Program, R69-73.

"Soil Amplification of SV and P Waves," with Thomas J. Jones, M.I.T. Civil Engineering Report R70-3, January, 1970.

"Influence of Damping on Response Spectra," with Freddy Garcia, M.I.T. Civil Engineering Report R70-4, January, 1970.

"Fundamentals of Soil Amplification," page 183, Seismic Design for Nuclear Power Plants, M.I.T. Press, Cambridge, Mass., 1970.

"Seismic Analysis of Equipment Mounted on a Massive Structure," page 319, Seismic Design for Nuclear Power Plants, M.I.T. Press, Cambridge, Mass., 1970.

"Statistical Properties of Strong Earthquakes," with Edmund Sixsmith, M.I.T. Civil Engineering Report R70-7, January, 1970.

"Nonlinear Analysis of Building Frames for Earthquake Loading," by P. W. Latona (J.M. Roesset, supervisor), M.I.T. Civil Engineering Report R70-59, September, 1970.

"Automatic Generation of Finite Element Matrices," with R.W. Luft and J.J. Connor; Paper presented at the Fifth Conference on Electronic Computation, Purdue, September, 1970 Journal of the Structural Division, ASCE, Bol. 97, January, 1971.

"Soil Properties and the One-Dimensional Theory of Earthquake Amplification," with R. Dobry and R.V. Whitman, M.I.T. Civil Engineering Report R71-18, May, 1971.

"The Conception and Design of the Structural System for the Standard Oil of Indiana Building - A Collection of Three Papers," Co-author of one of the papers) M.I.T. Civil Engineering Report R72-3, January, 1972.

"Risk Analysis and Decision Models in the Planning of Housing Projects," by J.A. Machado (J.M. Roesset, supervisor), M.I.T. Civil Engineering Report R72-44, June, 1972.

"Dynamic Soil Structure Interaction," with M.A. Sarrazin and R.V. Whitman, Journal of the Strucutral Division, ASCE, July, 1972.

"Modal Analysis for Structures with Foundation Interaction," with R.V. Whitman and R. Dobry, Paper presented at the Cleveland Convention of ASCE, April, 1972.

"Bridge Design System," with C.A. Cornell and J.F. Brotchie, M.I.T. Dept. of Civil Engineering Report R65-26, September, 1965.

"Fundamentos de Programacion y Uso de Computadores," (Basic Programming and Use of Computers), published by University of Chile, 1966 (in Spanish).

"Analisis de Muros y Fachadas Mediante Elementos Finitos," paper presented to Pan American Symposium, Caracas, 1967 (in Spanish) with T. Guendelmann, R. Luft, and M. Sarrazin.

"Fundamentos del problema de optimizacion del Diseno Estructural," Materiales, Maquinaria Y Metodos para la Construccion, No. 41, 1967 (in Spanish).

"ICES-STRUDL - Student Manual," M.I.T. Civil Engineering Report R68-71, September, 1968.

"The Use of ICES-STRUDL I in Design Courses," M.I.T. Civil Engineering Report R68-72, September, 1968.

"Theoretical Background for Amplification Studies," with R.W. Whitman, M.I.T. Civil Engineering Report R69-15, March, 1969.

"Hysteretic Damping in Inelastic One-Degree-of-Freedom Systems," with H. Kamil, M.I.T. Civil Engineering Report R69-52, August, 1969.

"Nonlinear Dynamic Response and Ductility Requirements of Building Structures Subjected to Earthquakes," by S.A. Anagnostopoulos (J.M. Roesset and J.M. Biggs, supervisors) M.I.T. Civil Engineering Report R72-54, September, 1972.

"Accuracy of Modal Superposition for One-Dimensional Soil Amplification Analysis," with R.V. Whitman and L. Ayestaran. Paper presented at the Conference on Microzonation for Safer Construction Research and Application, Seattle, Washington, October, 1972.

"Ductility Requirements for Some Nonlinear Systems Subjected to Earthquakes," with S.A. Anagnostopoulos. Paper presented at the Fifth World Conference on Earthquake Engineering, Rome, June, 1973.

"Nonlinear Dynamic Analysis of Buildings with Torsional Effects," with S.A. Anagnostopoulos and J.M. Biggs, Paper presented at the Fifth World Conference on Earthquake Engineering, Rome, June, 1973.

"A Comparison of Linear and Exact Nonlinear Analyses of Soil Amplification," with I.V. Constantopoulos and J.T. Christian. Paper presented at the Fifth World Conference on Earthquake Engineering, Rome, June, 1973.

"Planning and Cost Evaluation Program for Comparing Preliminary Design Schemes for Highrise Apartments," by T.G. Harmon (R.J. Hansen and J.M. Roesset, supervisors), M.I.T. Civil Engineering Report R73-39, September, 1973.

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"Solution of Nonlinear Problems in Civil Engineering," Proceedings, Symposium on the Use of Computers in Civil Engineering, Santander, Spain, August 15-22, 1982.

Jose M. Roesset

JOSE M. ROESSET

Subscribed and sworn to before me this 15th day of OCTOBER, 1983.

Rose Chelsey

Notary Public in and for Said County and State

ROSE CHELSEY
NOTARY PUBLIC - CALIFORNIA
COUNTY OF LOS ANGELES
My commission expires June 6, 1985

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

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

STATE OF CALIFORNIA)
) ss.
COUNTY OF LOS ANGELES)

AFFIDAVIT OF GEORGE APOSTOLAKIS

George Apostolakis, being first duly sworn, attests:

1. I am Professor of Engineering and Applied Science at the University of California, Los Angeles, where I have taught since July 1974. I am currently a member of the faculty of the Mechanical, Aeronautical, and Nuclear Engineering Department in the School of Engineering ad Applied Science.

2. I hold a Ph.D. in Engineering Science and Applied Mathematics and an M.S. in Engineering Science, both from the California Institute of Technology. I also hold a diploma in Electrical Engineering from the National Technical University, Athens, Greece.

3. I am a member of the American Nuclear Society and the Society of Risk Analysis. I am a past recipient of the Mark Mills Award from the American Nuclear Society. I serve as a reviewer to AIChE Journal, Nuclear Safety, Nuclear Science and

Engineering, Nuclear Technology, IEEE Transactions on Reliability, Reliability Engineering, and Risk Analysis.

4. For the past ten years, I have been continuously engaged in research in risk assessment, including the conduct of probabilistic risk analyses for nuclear power plants; probability theory, decision theory, and statistics; reliability analyses; and nuclear engineering.

5. Since 1977, I have served as a consultant to Pickard, Lowe and Garrick, Inc., where I participated in probabilistic risk analyses of the Oyster Creek, Zion, Indian Point, Browns Ferry, and Midland Nuclear Generating Stations; I also served for Pickard, Lowe and Garrick on the technical review board for the Seabrook Probabilistic Safety Study. For the past three years, I have also served as a consultant to the Bechtel Power Corporation on probabilistic risk assessment. In the past I have served as a member of the Peer Review Panel for the Load Combination Program of the Lawrence Livermore National Laboratory, as a consultant to the Seismic Safety Margins Research Program of Lawrence Livermore National Laboratory, as a consultant on risk methodology for geologic disposal of radioactive waste for the Sandia National Laboratories, and as a member of the research review group for the Probabilistic Analysis Staff of the U.S. Nuclear Regulatory Commission.

6. I have chaired conferences and participated in seminars on probabilistic risk analyses for nuclear power plants, reliability studies, and risk assessment.

7. I was an editor of G. Apostolakis, S. Garribba and G. Volta, Editors, Synthesis and Analysis Methods for Safety and Reliability Studies, Plenum Press, 1980, and I wrote the chapter on "Bayesian Methods in Risk Assessment" in Advances in Nuclear Science and Technology, J. Lewins and M. Becker, Editors, vol. 13, Plenum Press, 1981.

8. I have authored and co-authored the following articles:

Madrid, A., Apostolakis, G., and Conn, R. W., "On the Development of Accident Sequences Involving Tokamak Impurity Control System," Nuclear Technology/Fusion, 4:1135-1140, September 1983.

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Quantification of Risks: Reducing the Uncertainties, Annual Meeting, Pacific Division, American Association for the Advancement of Science, Section P, Industrial Science, Santa Barbara, California, June 21-22, 1982.

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Apostolakis, G., and Kazarians, M., "The Frequency of Fires in Light Water Reactor Compartments," ANS/ENS Topical Meeting on Thermal Reactor Safety, Knoxville, Tennessee, April 7-11, 1980.

Apostolakis, G., Kaplan, S., Garrick, B. J., and Duphily, J. R., Data Specialization for Plant Specific Risk Studies," Nuclear Engineering and Design, 56:321-329, 1980.

Apostolakis, G., Kaplan, S., Garrick, B. J., and Dickter, W., "Assessment of the Frequency of Failure to Scram in Light Water Reactors," Nuclear Safety, 20:690-705, November-December 1979.

Lee, T. Y., Okrent, D., and Apostolakis, G., "A Comparison of Background Seismic Risks and the Incremental Seismic Risk Due to Nuclear Power Plants," Nuclear Engineering and Design, 53:141-154, June 1979.

Apostolakis, G., and Mosleh, A., "Expert Opinion and Statistical Evidence: An Application to Reactor Core Melt Frequency," Nuclear Science and Engineering, 70:135-149, May 1979.

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Apostolakis, G. E., and Bansal, P. P., "Effect of Human Error on the Availability of Periodically Inspected Redundant Systems," IEEE Transactions on Reliability, R-267: 220-225, August 1977.

Wu, J. S., Salem, S. L., and Apostolakis, G. E., "The Use of Decision Tables in the Systematic Construction of Fault Trees," International Conference on Nuclear Systems, Reliability Engineering and Risk Assessment, Gatlinburg, Tennessee, June 20-24, 1977.

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Apostolakis, George E., "An Analytical Estimate of the Error in Conventional Point Kinetics Reactivity Due to Spatial Effects," Nuclear Science and Engineering, 53:141-152, February 1974.

George Apostolakis

GEORGE APOSTOLAKIS

Subscribed and sworn to before me
this 14th day of October, 1983.

Judith M. Ranger

Notary Public in and for Said
County and State

JUDITH M. RANGER
NOTARY PUBLIC - CALIFORNIA
COUNTY OF LOS ANGELES
My Commission Expires July 10, 1985