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Department of Nuclear Energy

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November 29, 1989

Dr. Raman Pichumani  
Mail Stop 8D22/OWFN  
U.S. Nuclear Regulatory Commission  
Rockville, Maryland, 20852

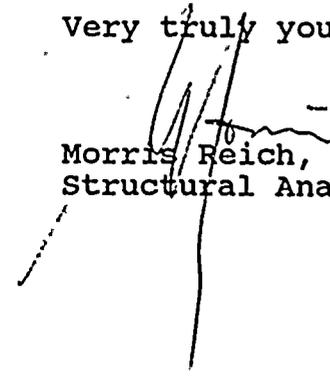
Dear Raman:

Re: Task Assignment 17, FIN A-3841

Enclosed are Professors C. Costantino's and A.S. Veletsos' reports dealing with comments pertaining to the November 2-3, 1989 Diablo Canyon Long Term Seismic-Soil Structure Interaction Review Panel Meeting, held at the PG&E offices in San Francisco, California. While the comments address the important issues, it is my opinion that the most critical items are those given under Item No. 3 in Professor Veletsos' report and those presented in the next-to-last paragraph of Professor Costantino's report (on the bottom of Page 4).

If you have any questions pertaining to these reports, please do not hesitate to contact me.

Very truly yours,



Morris Reich, Head  
Structural Analysis Division

MR: gfs  
Enclosures

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A. S. VELETOS

BROWN & ROOT PROFESSOR • DEPARTMENT OF CIVIL ENGINEERING,  
RICE UNIVERSITY • HOUSTON, TEXAS 77001 • (713) 527-8101, EXT. 2388  
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November 16, 1989

Dr. Morris Reich  
Structural Analysis Division  
Brookhaven National Laboratory  
Department of Nuclear Energy  
Building 129  
Upton, Long Island, NY 11973

Dear Morris:

Following is my report on the November 2-3, 1989 meeting of the Soil-Structure Interaction (SSI) Panel for the Diablo Canyon Long Term Seismic Studies:

1. This meeting was extremely valuable. It has helped to resolve the outstanding soil-structure interaction issues and to clarify the interrelationship of the deterministic and fragility studies and the scope of the deterministic studies conducted so far. The detailed answers to the questions posed by members of the SSI Panel were particularly helpful.
2. As indicated in previous reports to you, the approaches used to assess the effects of soil-structure interaction have been well founded, and there are no unresolved issues, in my view, remaining in this regard. The latter statement refers to the methodologies employed, but not to the appropriateness of the site-specific design spectrum used in the deterministic assessment of plant responses. Final judgement on the adequacy of the latter spectrum and of the associated ground motions is deferred pending resolution of outstanding ground motion issues.
3. It is now clear that the so-called deterministic evaluations of seismic margins for structures and equipment items presented in Chapter 7 of the PG&E Final Report were back-figured from fragility analyses utilizing high-confidence-of-low-probability-of-failure (HCLPF) estimates. No truly deterministic evaluations of these margins have been made. This approach does not conform to what I thought was expected by NRC in this regard.
4. I continue to feel that the so-called deterministic studies presented in Chapter 7 of the Final Report were not sufficiently comprehensive or conclusive, and recommend that they be expanded to include the following:
  - Identification of the weak links for the structures and critical equipment items as determined in the original design, in subsequent evaluations, and in the long-term seismic program.



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- Evaluation of the seismic margins for a reasonably large number of these links using purely deterministic approaches. These should include comparisons of the load demands and the capacities involved, along with detailed descriptions of the procedures and assumptions used in their computation.
- Detailed explanations for all significant differences in seismic margins computed at different stages of the program.

These studies should be undertaken only after resolution of the outstanding ground motion issues.

5. Finally, I believe that the results of the proposed deterministic studies should be compared with those obtained from fragility analyses, and any significant differences that may be revealed should be reconciled.

Sincerely yours,



A. S. Veletsos  
Brown & Root Professor



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DEPARTMENT OF CIVIL ENGINEERING  
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New York, New York 10031  
212-690-8145

8 November, 1989

Dr. Morris Reich  
Head, Structural Analysis Division  
Department of Nuclear Energy  
Brookhaven National Laboratory  
Upton, Long Island, New York 11973

Re: Diablo Canyon Long Term Seismic Program  
Trip Report for Meeting of Soil-Structure Interaction  
Review Panel held on November 2-3 at PG & E

Dear Dr. Reich:

This trip report presents a summary of my activities at the subject meeting and an evaluation of the responses provided by the DCLTSP Project Team to my comments on the Final Report issued by PG&E in July 1988. The meeting was attended by Professor Veletsos and myself from the Review Panel as well as Messrs. Chokshi, Pichumani, Rood and Rothman of the Nuclear Regulatory Commission. A number of DCLTSP Project Team members took part in the discussions and made presentations during the two day meeting. In my letter to you dated 31 August, 1989, I presented specific comments and questions on the Final Report which I felt remained to be answered or clarified by the Project Team. The purpose of this meeting was to address and clarify these remaining items. My evaluation of these responses and other aspects of the Final Report with which I am interested follow.

1. In the discussions of Chapter 5 of the Final Report, which are associated with the descriptions and usages of the CLASSI/SASSI computer programs, the DC Project Team did not indicate the frequency range over which the calculations were considered acceptable. Based on the results of the audit of June 87, they provided a detailed report on their computational program to be made a part of the Final Report, for both comparison problems as well as for those used for the DC site specific calculations. These latter results were to be presented so as to clearly specify the frequency ranges over which the calculations are applicable. The additional reports did not present the required data. Based on the discussions, it was indicated that the CLASSI/SASSI SSI calculations for the



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various buildings at the site were adequate up to a frequency of 25 hz, and that this upper bound frequency is already above the frequency at which the PGA value is reached at the various locations of interest. This result is an adequate response on this issue which is to be documented by the DCLTSP Project Team.

2. The issue of potential lift-off effects and its impact on SSI predictions for the DCNPP was brought up in my review of the Final Report. The Project Team found in these calculations that lift-off effects were negligible, provided that the lateral sidewall stiffness (which were found to be important) were not seriously degraded. Their analyses, described at several workshops, made use of several assumptions with which I was concerned and which I felt were not adequately addressed in the Final Report. These items were discussed at the meeting and the results can be summarized as follows.

- a. Since I felt that lift-off effects were relatively important to the SSI evaluation, I spent part of the time reviewing the computer program used and audited the calculations performed to assess these effects. The Bechtel program UPLIFT was used which is described in two reports by W. S. Tseng, and D. W. Wing entitled "Seismic Soil-Structure Interaction Analysis with Basemat Uplift", Theoretical Manual and Verification Manual, Revision 1, Computer Program CE444, Bechtel Power Corporation, July, 1984. Copies of these manuals were requested for use on a proprietary basis for the preparation of the TER.

The verification problems considered were a comparison for a linear problem with the results from the computer program FASS, comparisons for nonlinear problems with the results from the computer programs ANSYS and ADINA and hand calculations for stiffness and damping coefficients for circular and rectangular foundation shapes. The program was also benchmarked against the results obtained by I. N. Psycharis and presented in "Dynamic Behavior of Rocking Structures Allowed to Uplift", Report No. EERL 81-02, Earthquake Engineering Research Laboratory, CIT, August, 1981.

- b. The impact of the potential loss of sidewall support due to compaction of the surrounding backfill around the Reactor Containment Building was addressed in the Final Report. It is my opinion that the response provided by the DCLTSP Project Team is a reasonable engineering approach to



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evaluating the potential impact of the loss of sidewall support on the computed seismic response of the RCB. The results indicate that even assuming full tension cutoff on one side throughout the rocking motion leads to only a small change in spectra, while not severely overstressing the foundation bedrock through excessive bearing pressure. The computer output from UPLIFT specific calculations was reviewed in detail to check these conclusions. The calculation reviewed used the TABAS NS component as input to the stick model of the RCB. The input motion was scaled to reach an average of 2.25g spectral acceleration in the 3 hz. to 8.5 hz frequency range. Data output for the full lateral and 1/2 lateral rocking impedance cases was reviewed to support the conclusion that loss of tension sidewall support did not significantly impact the calculated spectral responses.

- c. The neglect of the effects of slap-down damping was shown in these calculations to yield only small changes in spectral responses for the configuration and amount of uplift computed for the RCB. The data reviewed satisfies my original question of this point.
- d. For the study of the hazards associated with higher spectral accelerations required for the hazards assessment study, the Project Team stated that lift-off effects at higher acceleration levels will not be significant. This result was determined by using previously available data obtained for the HTGR containment and presented in the paper "Effect on Nonlinear Soil-Structure Interaction Due to Base Slab Uplift on the Seismic Response of a High Temperature Gas-Cooled Reactor (HTGR)", by R.P. Kennedy, et al., published in Nuclear Engineering and Design, volume 38, 1976. The building configuration is similar to that of the DCRCB and the effects of uplift were found to be scalable by using the ratio of the square of the PGA's. The application of the results to the DCRCB indicate that such uplift effects even at the 3g level are small.
- e. The Project Team indicated that in the six sets of uplift calculations made, the effects of small perturbations in the time phasing between horizontal and vertical input motions on potential lift-off effects and equipment support point spectra were included. The six sets included the vertical motion applied with each of two horizontal motions for three record sets to form the six computational sets. Comparisons of accelerogram plots between vertical and



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horizontal motions were presented for the three input data sets which indicate that the phasing of the strong motion shaking is in fact different for the six record sets.

- f. The three sets of input seismic motions used for the lift-off calculations were different from those site specific inputs defined and used for the remainder of the SSI study. It was found that the differences are in fact small.
3. The DCLTSP Project Team provided results of SHAKE calculations which indicate that the reduction in spectral accelerations due to depth of burial effects at the RCB do not exceed 25% over the frequency range of interest. Although not specifically applicable to the DCLTSP, the reductions are shown to conform to the latest recommendations from NRC on the A-40 issues.
4. A long and detailed discussion was conducted which had to do with the calculation of deterministic seismic margins, and their applicability to the deterministic evaluation of the plant. This has been a topic which has remained unanswered throughout the DCLTSP evaluation. It is my understanding that NRC personnel will recommend the scope of such deterministic calculations to the Project Team for eventual evaluation by our SSI Panel. This approach hopefully will satisfy our continued request for specific calculations of demands and capacity estimates from the current study and comparison of same from the previous Hosgri or design evaluations. The approach will include evaluations for those design items which were found to be an issue previously (old "weak links") as well as those which control margin estimates in the current program. The extent of this evaluation and the specific items to be evaluated are to be selected by the Project Team, but hopefully it will be extensive enough to provide a reasonable spectrum of items of interest in such a facility. I would strongly recommend that the results of such a study be issued in a separate report which would replace Chapter 7 of the Final Report, which I found to be confusing and incomplete.

Finally, a number of questions raised in the past about ground motion studies applicable to the development of the site-specific spectra used as input to the SSI and fragility studies remain. Questions associated with weighting factors, sensitivity of the target spectra to weighting factors, sensitivity of the target spectra to change in earthquake magnitude, topographic effects,



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Page 5  
M. Reich  
8 November, 1989

etc., were put off for this meeting and are to be addressed in a future meeting to be scheduled with the member of the Ground Motion Panel members.

To summarize, the results of this meeting indicate that there remain no open issues associated with the methodology employed by the Project Team for the various SSI calculations. As I have stated in the past, they Team did an outstanding job in this study area to provide a reasonable and consistent procedure to arrive at seismic response calculations which include at least all the refinements contained in the current state of the art of such studies. The remaining issues of consequence reside in the definition of the site specific ground motion to be used as well as the definition of the scope of a deterministic seismic assessment of the plant.

Respectfully submitted,



Carl J. Costantino  
Professor of Civil Engineering



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DIABLO CANYON LONG TERM SEISMIC PROGRAM  
FINAL REPORT REVIEW  
SOIL-STRUCTURE INTERACTION (SSI) ANALYSIS  
REQUEST FOR ADDITIONAL INFORMATION  
(TAC NOS. 55305 AND 68049)

(Prepared by R. Pichumani, Structural and Geosciences Branch)

1. Provide written responses to all the questions that were sent to PG&E with letter dated September 29, 1989 from H. Rood to J. D. Shiffer and discussed at the SSI meeting held on November 2-3, 1989 at San Francisco.
2. Provide copies of the reports by W. S. Tseng and D. W. Wing entitled "Seismic Soil-Structure Interaction Analysis with Basemat Uplift", Theoretical Manual and Verification Manual, Revision 1, Computer Program CE444, Bechtel Power Corporation, July 1984.
3. (a) Provide a summary of the pertinent input and output data that demonstrate the final results of deconvolution analyses performed using the SHAKE and the SASSI programs.  
(b) Discuss and document the adequacy of using the SHAKE results for the strain-dependent material properties in the SASSI program in view of the differences in the analysis procedures adopted in these two programs.



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