ENCLOSURE

DIABLO CANYON POWER PLANT LONG TERM SEISMIC PROGRAM

QUARTERLY PROGRESS REPORT NO. 6

PACIFIC GAS AND ELECTRIC COMPANY

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1. INTRODUCTION

This is the sixth quarterly progress report for the Diablo Canyon Power Plant (DCPP) Long Term Seismic Program (LTSP). This report describes activities during the period November 1, 1986, through January 31, 1987.

During this reporting period, Phase III activities continued in all program elements: Geology/Seismology/Geophysics, Ground Motions, Seismic Hazards Analysis, Soil/Structure Interaction (SSI), Fragilities, and Probabilistic Risk Assessment (PRA). The following important meetings and workshops were held during this period:

November 14-15, 1986	PGandE Consulting Board Meeting
December 10-12, 1986	NRC/PGandE Workshop on Soil/Structure Interaction
December 15, 1986	NRC/PGandE meeting with U.S. Geological Survey (USGS) on Earthquake Ground Motions
January 7, 1987	PGandE Consulting Board Meeting

During the upcoming reporting periods, the following meetings and workshops are planned:

February 17-18, 1987	NRC/PGandE Workshop on Probabilistic Risk Assessment
April 29-30, 1987	PGandE Consulting Board Meeting
May 1987	NRC/PGandE Workshop on Geology/Seismology/Geophysics

2. GEOLOGY/SEISMOLOGY/GEOPHYSICS

2.1 Geology and Geophysics

2.1.1 Field Geologic Studies, Los Osos Valley

Field geologic studies were initiated in Los Osos Valley during the reporting period. These studies were conducted to assess the activity, geometry, and behavior of the Los Osos fault. Field studies were divided among the following activities: (1) mapping of Quaternary deposits and geomorphic features indicative of faulting between San Luis Obispo and Los Osos; (2) detailed mapping and longitudinal profiling of fluvial deposits, geomorphic surfaces, and topographic scarps; (3) subsurface exploration (trenching, drilling, and seismic refraction) of several strands of the Los Osos fault near the intersection of Foothill Boulevard and Los Osos Valley Road; and (4) age dating studies including radiocarbon analyses of organic material and soil stratigraphic studies.

Results to date from this work on the Los Osos fault suggest that: (1) the Los Osos fault displaces late Pleistocene or younger deposits; (2) the fault consists of three or more subparallel northwest-trending

strands; (3) the northeasternmost strand dips shallowly to the southwest in the near surface; (4) displacement is predominantly reverse slip with little to no observed lateral slip; (5) the fault persists laterally to the southeast to the vicinity of the Edna fault near San Luis Creek; and (6) the fault persists laterally to the northwest as a range front structural boundary along the northeastern flank of the San Luis-Pismo synform.

2.1.2 Field Geologic Studies, Montana De Oro to Mallagh Landing

Field geologic studies have been initiated in the area between Montana De Oro and Point San Luis. These studies are to evaluate the activity, geometry, and behavior of the Edna and San Miguelito faults and associated deformation of the San Luis-Pismo synform. These studies include: (1) bedrock geologic mapping to investigate the lateral extent of the San Miguelito and Edna faults; (2) preparation of structural cross sections orthogonal to the regional structural grain to evaluate the subsurface geometry and structural relationships between the San Luis-Pismo synform and the Los Osos, Edna, San Miguelito, and other faults; (3) detailed mapping of marine terraces to evaluate the presence of late Pleistocene deformation; (4) detailed mapping of fluvial terraces along San Luis Creek to evaluate the presence and rate of Holocene deformation; (5) age-dating studies including amino-acid racemization, uranium series, absolute and relative dating of invertebrate fossils, radiocarbon dating of organic carbon, and soil stratigraphic studies.

Studies in this region are continuing and results are preliminary. A marine terrace stratigraphy has been defined and dated, and additional mapping is in progress. Bedrock mapping has confirmed the existence of the San Miguelito fault as a bedrock structure along the southwestern flank of the San Luis-Pismo synform. The fault does not appear to vertically displace marine terraces near Mallagh Landing and is not seen to the northwest at potential coastal intersections of a projection of the fault (such as along Coon Creek). Structural cross sections suggest that the San Luis-Pismo synform is flanked on the northeast side by northwest-trending reverse faults that steepen with depth.

2.1.3 Field Geologic Studies, Pismo Beach-Nipomo Mesa Areas

Field geologic studies were continued in the Pismo Beach and Nipomo Mesa areas. These studies are being conducted to evaluate the existence, location, and activity of the Wilmar Avenue, Pismo, and Santa Maria River faults and the Oceano monocline. Studies have included: (1) regional and detailed bedrock and Quaternary mapping; (2) subsurface exploration (drilling, trenching, seismic refraction); (3) review of existing borehole data; and (4) age dating studies. Results of these studies will be used to provide improved understanding of the deformation occurring along the southwestern margin of the San Luis-Pismo synform and the tectonic development of the Santa Maria Basin.

Preliminary results suggest that the Wilmar Avenue fault probably extends to the southeast as a poorly defined zone of deformation; however, a primary fault trace southeast of the shoreline exposure has not been identified. Detailed mapping, trenching, drilling, and seismic refraction surveying in the quarry and surrounding area south of Pismo Beach indicate that a zone of folding and conjugate shearing exists along the projected trend of the fault. The conjugate shears displace a late Quaternary marine terrace, indicating continuing late Quaternary deformation. Studies in the Nipomo Mesa area indicate that one to three preserved marine terraces extend beneath the mesa and thus may provide stratigraphic datums for evaluating the existence, location, and activity of the Oceano monocline and the postulated Santa Maria River fault. No evidence for Quaternary deformation along these structures has yet been identified. A program of increasingly focused field studies is planned in the Nipomo Mesa area to define a mappable Quaternary stratigraphy, to locate zones of Tertiary and Quaternary deformation, and to evaluate the activity, geometry, and behavior of any Quaternary structures.

2.1.4 Low Sun-Angle Photography

Low sun-angle photographs were taken during the reporting period in the following areas: along the Los Osos-Edna structural trend between Morro Bay and Lopez Reservoir; along the coast between Arroyo Grande and Morro Bay; and along the San Miguelito fault trend. The photographs were taken at a scale of 1:6000 using high-contrast black-and-white film. Interpretation of the photographs is in progress to aid in mapping Quaternary deposits and in identifying and mapping geomorphic features that may indicate Quaternary faulting.

2.1.5 Acquisition, Processing, and Interpretation of Geophysical Data

- Acquisition of High-Resolution Seismic Data

  Between late November and early December 1986, new high-resolution common depth point (CDP) and analog seismic data were collected in the offshore region from Pismo Beach to near Cape San Martin. Interpretation of these data is now in progress.

- Acquisition of Deep Crustal Reflection and Refraction Seismic Data

  The program of deep crustal data acquisition begun in late October 1986 was completed on November 9, 1986. Although the program was complex, it was successfully carried out on a tight schedule in the face of unstable weather conditions. The program succeeded in providing good coordination for shared data acquisition with the participation of the USGS and Rice University. The acquired data are of good quality, and analysis of the data has begun. The first stacked reflection line has been received, and additional processing is being planned. Preliminary interpretation of the analog refraction records appears to be consistent with regional Franciscan crustal velocity models and suggests that the low-velocity zone identified by Trehu and Wheeler is not of great lateral extent.

- 2- to 5-Second Seismic Program

  Interpretation of the LTSP 2- to 5-second suite of CDP seismic reflection records continued with development of extensions of the structural trend and contour maps to the north and south of their boundaries as of the date of the last progress report. Using Western Geophysical data, reconnaissance mapping was completed in the area between the latitudes of Morro Bay and Point Piedras Blancas. Particular emphasis was placed on evaluating the age of the complex of unconformities occurring within the Sisquoc Formation. The seismic imagery was calibrated to data derived from offshore wells and was used to assess the age of a prominent unconformity within the Sisquoc Formation. This unconformity has been designated as a primary mapping horizon for use in construction of isopach maps. Previously this horizon had been identified as mid-Pliocene in age, but now it is considered to represent the age of the top of Miocene deposition.

- Processing and Reprocessing of Marine Seismic Data

  The program of reprocessing marine seismic data continued with the GSI-80 data set. After examination of the results from migrated lines, it was decided to remigrate the data using a variable velocity model to further improve the imaging of intermediate-depth seismic events believed to be related to the down-dip geometry of the Hosgri fault zone. In addition to the GSI data, Nekton and Western marine data were selected and submitted for reprocessing. The progress and products of the reprocessing have been continuously monitored by PGandE, with several trips to Houston and Denver to allow onsite inspection at the reprocessing facility. The data acquired for PGandE by Comap and Digicon were also submitted for processing during this reporting period. An aggregate of approximately 500 miles of seismic data was collected by these two contractors. Results derived from the processing and reprocessing efforts are being interpreted in the next reporting period.

- Offshore Geologic Cross Sections and Well Analysis

  Subsurface analysis continued with the completion of offshore well statistical sheets for 20 wells of primary interest in the vicinity of the Hosgri fault zone. Also during the reporting period, preliminary work was completed on a 1 inch = 400 feet scale cross section traversing the offshore Santa Maria Basin from the "Queenie" structure 20 miles offshore from Point Sal through the Hosgri fault zone. This traverse is tied to the only well thus far available in the offshore on the east side of the Hosgri fault zone. Preliminary analysis of this section has suggested the occurrence of lateral slip faulting along the Hosgri fault zone and has also provided evidence of the timing and variation in intensity of tectonic episodes in the vicinity of the Hosgri fault zone.

2.2 Central Coast Seismic Network

The five-station network continued in operation during the reporting period. A local earthquake of interest occurred in Estero Bay on Sunday, December 7, 1986. PGandE located the event using combined USGS and PGandE readings, with the epicenter computed to lie 10 km west of the city of Morro Bay and 4 km east of the Hosgri fault zone. The focal depth was calculated to be 5 km, with an uncertainty of ±3 km. The USGS local magnitude value of 2.9 was reported. The focal mechanism solution derived from P-wave first motion data suggests predominantly right slip on a fault plane striking about N30W with a high-angle southwest dip. PGandE has begun to receive the 18-station network instrumentation. Items received so far are low-power radios used to upgrade the presently operating stations and a complement of electronic test equipment. Details of the field station design have been finalized in preparation for seismic vault and field telemetry installation to occur during the next reporting period.

3. GROUND MOTIONS

3.1 Empirical Ground Motion Investigations

During this reporting period, progress in the empirical ground motion investigations consisted of the following:

(1) Available empirically derived ground motion relationships for horizontal acceleration response spectra were reviewed and evaluated for their applicability to DCPP conditions. On the basis of these evaluations, a set of attenuation relationships for horizontal acceleration response spectra for five periods up to 0.4 seconds was selected for use in LTSP Phase IIIA probabilistic seismic hazard analyses.

(2) Work progressed on the development of attenuation relationships for use in LTSP Phase IIIB studies. The effort in this reporting period consisted of five main activities: (a) development of the strong motion data base, definition of the earthquake parameters, and selection of ground motion parameters; (b) compilation of peak parameters and response spectra for 2, 5, and 10 percent damping values for the candidate recordings; (c) preliminary examination of the ground motion characteristics of individual recordings as well as statistics of the subsets of the candidate recordings; (d) development of the attenuation model and the procedures for analyzing the ground motion data; and (e) exploratory regression analysis of horizontal peak ground acceleration to evaluate the data base and the attenuation model.

3.2 Numerical Modeling Program

The simulation procedure to incorporate radiation pattern incoherence at high frequencies has been refined and calibrated against the Imperial Valley strong motion records. This calibration was done using comparisons of waveforms, spectral values, and the attenuation of peak motion with distance. Strong motion recordings of the Coalinga aftershock of May 9, 1983, have been prepared for use as an alternative empirical source.

Calculated Green's functions have been successfully calibrated against strong motion recordings of small earthquakes at the site. The most prominent feature of the propagation path is the velocity increase at the base of the Franciscan formation at a depth of 12 km. This generates strong postcritical reflections at ranges beyond 20 km from earthquakes occurring near the base of the Franciscan. These calculated Green's functions have been used to generate simulated accelerograms at the site. The wave composition and orientation of the simulations are being analyzed in detail in preparation for providing input into the SSI analysis.

4. SEISMIC HAZARDS ANALYSIS

During this reporting period, the ground motions input for seismic hazards analysis was reviewed and updated, and preliminary seismic hazards curves were generated for use in the Phase IIIA PRA. The Phase IIIA seismic hazards analysis utilized response spectral values determined directly from attenuation relationships. Seismic hazards curves were generated at five periods up to 0.4 seconds.

5. SOIL/STRUCTURE INTERACTION

5.1 Development of Building Models

The 3-D SSI dynamic models of the power block structures, including the containment with internal structure, the auxiliary building, and the turbine building, have been developed. The available low-level earthquake data recorded at the DCPP site have been analyzed to assess, to the extent possible, the empirical SSI frequencies of these structures. These frequencies are used to evaluate the analytically obtained values.

5.2 Parametric Studies

By comparing the results of the analyses performed for the parametric studies, the following conclusions can be drawn:

- CLASSI and SASSI analyses yield consistent results for all cases studied.
- Effect of foundation embedment is relatively significant.

- Effect of through-rock, structure-to-structure interaction is relatively insignificant when compared with the effect of other parameters, such as the inertial interaction and foundation embedment. Thus, it may be ignored in the SSI analyses.

- Assumption of vertically propagating shear wave for horizontal responses is conservative. Inclined body waves (SV and SH) will further reduce the horizontal responses.

5.3 NRC/PGandE Workshop

The results of SSI analyses to date, including those of the various parametric studies, were reviewed and discussed in the workshop held December 10-12, 1986. Proposed methodologies for implementation of spatial incoherency of ground motions for SSI analyses, as well as nonlinear SSI analysis for containment base uplifting effect, were also discussed. Efforts are being directed to develop the computational procedures to incorporate the ground-motion incoherency and base uplifting.

6. FRAGILITIES

6.1 Lower Tail Cutoff Study

A representative civil structure corresponding to the auxiliary building and four equipment groups with various central frequencies was studied to assess whether a cutoff of the lower tail of the fragility curve existed. The results showed no apparent cutoffs in the range of minus three standard deviations. Also, using the same time-history results, fragilities computed using the conventional separation of variables approach were compared with fragilities predicted from the time-history methods.

6.2 Reevaluation of Component Fragilities

The structures and components that were identified as dominant contributors to seismic risk were reviewed, and their fragilities were reassessed. The fragilities of the remaining items were also adjusted by making minor changes to the randomness variabilities to incorporate the variability in the peaks and valleys inherent in any real ground motion spectrum.

7. PROBABILISTIC RISK ASSESSMENT

Initiating event analysis, event sequence analysis, data analysis, systems analysis, spatial interaction analysis, plant damage state definition, and human actions analysis part 1 are complete and are under review by PGandE. Human action analysis part 2, seismic analysis, internal fire and flood analysis, other external events analysis, and quantification of results are in progress and are scheduled to be completed by midyear.

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JAMES D. SHIFFER
VICE PRESIDENT
NUCLEAR POWER GENERATION

April 2, 1987

PGandE Letter No.: DCL-87-066

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Long Term Seismic Program - Quarterly Progress Report No. 6

Gentlemen:

In compliance with License Condition 2.C.(7) of Facility Operating License DPR-80, enclosed is the Long Term Seismic Program Quarterly Progress Report No. 6 for work performed from November 1, 1986, through January 31, 1987. Copies of the progress report are also being forwarded to NRC Staff consultants and to the ACRS Staff.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J. D. Shiffer

Enclosure

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