PG&E Letter No: DCL-87-299

ENCLOSURE

DIABLO CANYON POWER PLANT LONG TERM SEISMIC PROGRAM

QUARTERLY PROGRESS REPORT NO. 9

PACIFIC GAS AND ELECTRIC COMPANY

DECEMBER 1987

TABLE OF CONTENTS

1 INTRODUCTION

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

During this reporting period, Phase III activities continue in all major program elements: geology/seismology/geophysics (G/S/G), ground motions, soil structure interaction (SSI), fragilities, and probabilistic risk assessment (PRA). The following significant meetings and workshops were held during this period.

August 26-27, 1987	PG&E meeting with PG&E's technical advisors to review G/S/G program.
October 12, 1987	PG&E Consulting Board Meeting

The following meetings and workshops are planned for the next several months:

November 2-3, 1987	NRC/PG&E Fragility workshop, at NTS Engineering office in Long Beach, CA.
November 4-6, 1987	NRC/PG&E SSI workshop, in San Francisco, CA
January 8, 1988	Fragility Audit meeting in San Francisco, CA
January 14-15, 1988	NRC/PG&E PRA workshop in Bethesda, MD
mid-February, 1988	ACRS subcommittee meeting on Diablo Canyon in San Francisco, CA
February 19, 1988	PG&E Consulting Board meeting.

2 GEOLOGY/SEISMOLOGY/GEOPHYSICS

2.1 GEOLOGY AND GEOPHYSICS

2.1.1 San Luis-Pismo Structural Block

During the reporting period, geomorphic and geologic analyses were conducted to define and characterize the San Luis-Pismo (SLP) structural block. The block is an elevated topographic range consisting of the Irish Hills and Newsom Ridge. Analysis of marine terrace elevations indicates that the block is rising as a rigid structure with no observable internal fold deformation. Abrupt changes in rates of uplift from northwest to southeast, however, suggest that the SLP block consists of several segments or subblocks with different behavioral characteristics. An analysis of topography supports a division of the block into three subblocks with different geomorphic expressions: the Irish Hills, Edna, and Newsom Ridge subblocks.

The SLP block is bounded on the northeast by the Los Osos fault and on the southwest by a complex, diffuse zone of faulting and folding including the Wilmar Avenue fault, San Luis Bay fault, Oceano monocline, and Pecho fault. Two additional down-to-the-southwest steps in bedrock are recognized beneath the Nipomo Mesa between the Wilmar Avenue and Oceano monocline. Their origin is not well understood, but vibroseis data suggest that they are faults or monoclines rather than erosional features. These two structures, called the Los Berros and Black Lake Canyon structures, are part of the diffuse southwestern structural boundary of the SLP structural block. To the northwest, the SLP block is truncated by the more northerly trending Hosgri fault zone.

2.1.2 Segmentation

A primary focus of study during the reporting period was segmentation of the Los Osos, Wilmar Avenue, and San Luis Bay faults. Segments were defined on the basis of geomorphic expression, differences in behavioral characteristics, spatial separation of en-echelon fault traces, association with segments of the SLP structural block, and association with branching or crossing structures. The Los Osos fault is divided into four segments: the Estero Bay segment offshore, and the Irish Hills, Edna, and Newsom Ridge segments onshore. The Wilmar Avenue fault is tentatively divided into three segments: the Bird Rock segment offshore, and the Pismo Beach and Picacho segments onshore. Further analysis is in progress to identify and define the segment boundaries and to assess the seismic character of each segment.

2.2 OFFSHORE GEOPHYSICAL INVESTIGATIONS

2.2.1 High-Resolution Seismic Program

A dredge hauling survey was performed on a topographic high in Estero Bay named Fifty-Nine Meter Ridge after the water depth of its highest peak. This survey included permitting, surveying, echo sounder data analysis, and dredge haul sample identification. Fifty-Nine Meter Ridge was identified as a resistant knob of early Miocene rock uplifted in the zone of interaction between the Hosgri fault and the San Luis-Pismo structural block.

D-series (1:24,000 scale) map sheets D-4 through D-7 were edited and revised. Data displayed on these map sheets include detailed bathymetry, post-late Wisconsinan isopachs, seafloor geomorphic trends, shallow structural trends and submarine geology. These maps were integrated with both onshore geologic mapping and subsurface (trenching and drilling) investigations and with the deeper horizon maps made with use of CDP reflection data. Particular attention was paid to the development of map symbols and legends that accurately reflect the state of understanding of the faults between San Simeon Point and Point Sal.

Retrodeformable cross section techniques were applied to structures in the offshore Santa Maria Basin. A basic structure map, an outcrop map, and two retrodeformable cross sections were made for the Queenie structure. Timing of compressional events associated with this structure was analyzed.

2.2.2 Two to Five Second Seismic Program

Interpretations on sheets D-1 through D-9 were refined during this period as a result of an extensive vertical integration of the deep seismic data with the shallow high resolution seismic data suite.

2.2.3 Deep Crustal Studies Seismic Data

Preliminary interpretations were generated for lines FLEC 1 and 3 which integrated gravity and magnetic data with the seismic data in order to develop a preliminary chronology of the development of the offshore Santa Maria Basin.

2.3 CENTRAL COAST SEISMIC NETWORK

Seismic activity within the south coastal area returned to the level typical of several years ago during the month of October 1987. After two quiet months (August and September), 23 events with coda magnitudes of 1.0 or larger and located within or adjacent to the Central Coast Seismic Network were recorded in October. The largest event, with magnitude 2.8, occurred in the vicinity of the Santa Lucia Bank about 35 km offshore from Point Arguello and 75 km south of Diablo Canyon. The closest earthquake activity was of magnitude 1.0 and occurred at a distance of about 20 km from the plant site along the Nacimiento fault zone. Most of the recorded events took place in the San Simeon/Piedras Blancas region to the north along the coast.

The Central Coast Seismic Network was brought to a total of 17 installed stations during the quarter. Station calibration will be conducted during November 1987, along with completion of the 18th station installation.

3 GROUND MOTIONS

3.1 EMPIRICAL GROUND MOTION STUDIES

3.1.1 Site-Specific Response Spectra

Site-specific response spectra previously developed in the 3 to 8.5 Hz range (using a set of 18 strong motion records obtained from seven earthquakes of magnitudes greater than 6.25 and recorded within 24 km) were reanalyzed for individual frequencies. Sensitivity studies were started to examine the effect of scaling relationships used in modifying these records to the site conditions.

3.1.2 Sensitivity Studies in Regression Procedures

Sensitivity studies were conducted to examine the effect of weighting on the regression results for horizontal response spectral ordinates. Regression analyses were also conducted on horizontal peak ground velocity.

3.1.3 Documentation of Strong Motion Data Base

Further documentation of the strong motion data set, including both rock and soil data bases, was in progress. A significant part of this effort involved

documentation of earthquake characteristics and recording station conditions (instrument housing and subsurface characteristics) for the soil site data.

3.1.4 Development of Covariance Matrix for Soil/Structure Interaction Analysis

The covariance matrix of the free-field ground motions derived from the 12 strong motion recordings selected previously for the fragility analysis was finalized for use as input to the SSI analysis.

Also in progress during this period was a review of NRC questions related to empirical ground motion investigations and preparation of responses to these questions.

3.2 NUMERICAL MODELING PROGRAM

3.2.1 Goodness of Fit Between Observed and Simulated Ground Motions

Procedures have been developed and applied to the measurement of goodness of fit between observed and simulated ground motions of the 1979 Imperial Valley earthquake. Ground motion measures that have been used include peak acceleration, cumulative squared acceleration (Husid plot), and response spectral ordinates. The procedures have been used to demonstrate that the asperity model of the 1979 Imperial Valley earthquake gives a better fit to the observations than does a smooth rupture model.

3.2.2 Validation of the Numerical Modeling Method by Use of Other Earthquakes

The numerical modeling methods have been applied to the simulation of the three accelerograms of the December 23, 1985, Nahanni earthquake. Using the Imperial Valley aftershock recordings as empirical source functions, preliminary simulations have been obtained whose envelopes agree with the recorded data, with the exception of the large late arrival at Station 1. The frequency content of the data is considerably richer than that of the simulations using the Imperial Valley source functions. However, if an accelerogram of an aftershock of the Nahanni earthquake is used as the empirical source function, the simulated time histories show spectral content that agrees well with the recorded data.

3.2.3 Spatial Incoherence Model

Refinements have been made in the spatial incoherence model for use in SSI analyses. Data from the offshore airgun shots recorded in the site vicinity have been found to have spatial incoherence similar to that of the land shot. Frequency domain measurements of spatial incoherence have been found to be similar to time domain estimates. A preliminary analysis of the sensitivity of spatial incoherence to earthquake source parameters has been made. Spatial incoherence is found to increase as the distance to the fault decreases. While the incoherence of small earthquake and explosion accelerograms increases into the coda, the incoherence of large earthquake accelerograms (both recorded and simulated) remains relatively uniform through the duration of strong shaking.

3.3 STRONG MOTION INSTRUMENTATION

Both the Supplementary Seismic Monitoring System and the Free-Field Array at the Diablo Canyon Power Plant functioned normally. No earthquake was recorded by either system during this reporting period.

4 SOIL/STRUCTURE INTERACTION

4.1 DEVELOPMENT OF METHODOLOGIES

The procedures and methodologies for analyzing SSI responses for effects of spatial incoherency of ground motions and containments uplift were developed and were benchmarked against corresponding published results. The various computer programs which were specifically developed for these analyses were verified and appropriately documented.

4.2 INPUT TO FRAGILITY ANALYSIS

Actual records from three different earthquakes, namely, Pacoima, Tabas, and El Centro No. 4, were modified so that their respective spectra resembled closely the site-specific spectra for each damping value. Three simultaneous components of motion of each of these modified events were to be used for generating SSI responses. Since the responses were very similar, only two of these three events were used. The resulting floor response spectra, along with the results of spatial incoherency of ground motion and containment uplift analysis, were provided to the Fragility Group for Phase IIIB fragility calculations.

5 FRAGILITIES

The median floor response and variability study for the auxiliary building has been completed. A simplified CLASSI soil-structure interaction model of the auxiliary building was developed in such a way that its median SSI frequency closely resembled the corresponding frequency of the detailed SSI model. The study involved development of random variables including structural damping, structural frequency, and soil variabilities. Independent random distributions of these variables were developed by use of latin hypercube simulation with a population of 24 empirically generated and 14 numerically generated site-specific time-history motions. The resulting 50th and 84th percentile floor response spectra for various damping ratios provided the median and the associated variabilities of the floor response spectra at various elevations in the core west portion of the auxiliary building.

The floor response spectra deterministically generated by the SSI group were considered median centered and thus provided a benchmark for the probabilistically developed spectra at different elevations of the core west portion of the auxiliary building. The deterministic spectra for other locations in the auxiliary building and various locations in the containment and the turbine building will be used to develop median responses of the equipment and components for fragility reevaluation in Phase IIIB. The response variabilities in these locations will be accounted for by the separation of variables approach. The final responses will include

adjustments for effects of spatial incoherency of ground motion and uplift of containment from results provided by the SSI group.

6 PROBABILISTIC RISK ASSESSMENT

Work began on Phase IIIB of the PRA. PG&E's initial review of the Phase IIIA work is complete, and comments are being incorporated by the consultant. A detailed review of the human actions analyzed in the DCPRA is underway; licensed operators and engineers at DCPP are providing input on each action to make the model as realistic as possible.