UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 1 3 1983

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SUBJECT: TRIP REPORT FOR HEADQUARTERS STAFF ASSISTANCE TO REGION V INSPECTION OF DESIGN CALCULATIONS

On April 6 and 7, 1983, members of the NRC staff assisted Region V Project Inspector, P. J. Morrill, in an inspection of the technical calculations that are in support of the PG&E Diablo Canyon Project (DCP) Internal Technical Program (ITP). The personnel involved were J. P. Knight and H. E. Polk of the headquarters staff and C. A. Miller and A. J. Philippacopoulos of Brookhaven National Laboratory. The inspection took place in the offices of PG&E/Bechtel in San Francisco, California.

The structural calculations inspected were for the Containment Shell, the Containment Annulus Steel Structure, the Turbine Building, the Auxiliary Building and the Fuel Handling Building. Details pertaining to the inspection are delineated below.

CONTAINMENT SHELL

The containment shell calculations had been reviewed by the Blume Internal REview (BIR) committee in the summer of 1982. Six areas of concern were identified. These were:

1. Use of incorrect moment area for node 8 of the seismic model used for calculating the torsional response.

2. Error in length of torsional arm for node 8.

3. Use of approximate method used to generate floor response spectra.

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4. Averaging of floor response spectra peaks and valleys outside the frequencies where spectral peaks appear.

5. Lengthy method of hand transferring data between computer programs used to generate the floor response spectra from the vertical seismic analysis.

6. SRSS of maximum horizontal response with vertical instead of using the 3 components of motion.

The BIR concluded the above 6 departures in the seismic analysis did not produce results that were significantly different from the results of a seismic analysis without the departures. The engineering calculations used in determining that the differences were not significant appeared reasonable.

The containment tilting calculations were examined for conformance to NRC requirements. The DCP calculations dated January 1983 showed that the containment was stable against tilting with a minimum factor of safety of 1.27. The staff requires a factor of safety of 1.1 and the calculations are consistent with the current state-of-the art for this requirement. The calculations show the containment is stable against tilting.

CONTAINMENT ANNULUS

According to the DCP technical staff, the objective of the horizontal evaluations is to stiffen the annulus structure in the horizontal direction so that structural frequencies higher than 20 Hz can be achieved. The procedure followed by DCP consists of eigenvalue analysis using detailed dynamic models of the annulus floors to determine their members and to subsequently stiffen them. The dynamic models used in floors at elevation 140 feet is considered rigid in the horizontal direction. For these three floor models the determination of modes/frequencies is being performed iteratively to ensure that modifications of the structure will produce higher structural frequencies (i.e., at least 20 Hz). This analysis is still underway. Final results and field modifications are not available at this time. However, from the review of the procedures followed by the DCP technical staff, the approach used for the horizontal evaluations should yield acceptable results.

When the annulus steel is stiffened, as discussed above, the only remaining flexibility is in the crane wall itself. The crane wall acts as a shear beam. The mass and stiffness calculations for this beam were reviewed and found to be reasonable. The spectra generated with this model were examined and found to be consistent with the results of the BNL study of the horizontal annulus region.

The vertical annulus seismic analysis is almost complete. The approach used here is different from that used in the horizontal direction. Specifically, twenty-eight (28) two-dimensional (2D) radial frame models were employed to perform the vertical seismic evaluations and to obtain the vertical floor response spectra. These models are subdivided into column lines (i.e., partial frames). The tangential beams are also incorporated into the 2D models by single degree-of-freedom oscillators. Tangential beams having frequencies above 40 H_z were not included. Additional modes were assigned to the beam members of the (new additional) radial frame models. In general, the method used for the vertical seismice analyses seems adequate in the sense that it should produce reasonable results for the response of the structure. After obtaining floor response spectra from all radial 2D models, a procedure similar to that reported in the BNL analysis was carried out to produce representative floor response spectra. These spectra are defined on the basis of the orientation of five fan coolers. The spectra were then smoothed and broadened for subsequent piping analysis application.

TURBINE BUILDING

The vertical analysis was reviewed. For this analysis 4 two-dimensional models were used. These models were made up from beams ans shear wall elements. The model and the results of the analysis look reasonable. The horizontal seismic analysis was also reviewed. This model consists of a 3 dimensional finite element idealization of the structure with some condensation of the roof members. The model and the results of the analysis seem reasonable.

The member analysis of the roof structure reveals that 8 bolted joints, in four members, are over stressed based on the AISC Edition 7 structural steel building code. This is still the case when compared with the current (Edition 8) AISC code. The original Hosgri committment was the AISC code, Edition 7. The significance of this change will have to be evaluated by the staff.

The over stressing, shear tearout at the bolt edge margin, occurs in the gusset plates that tie the four bracing members into the roof grid. Preliminary calculations indicate that a more refined analysis of the bracing system could reduce the loads somewhat. However, it still may not meet the Edition 8 of the AISC code requirements. When ductility is accounted for, as allowed in the criteria, the joints may be shown capable of withstanding the loads. The engineering approach to solving the problem looks reasonable and should lead to an acceptable solution.

The relative seismic displacement calculations of the Turbine Pedestal and the Turbine Building operating floor at elevation 140 feet were reviewed along with the field measurements of the gap between the pedestal and the operating floor. The calculations show the pedestal and the building will not impact each other during the postulated earthquake.

AUXILIARY BUILDING

The parametric study with respect to the elastic half space soil springs used in the seismic model was reviewed. The DCP maintained that the parametric studies showed insignificant variations in the results when the value of the soil springs were varied over a large range. The IDVP parametric study on the other hand, showed the seismic analysis results were sensitive to the value of these springs. The staff review of the DCP study showed that the base shear and torsional spectra were sensitive to the spring values. The engineering approach to the soil spring study carried out by the DCP seems reasonable. However, the differences in interpretation between the results of the DCP and the IDVP studies should be resolved.

The procedure used to identify flexible floor slabs in the vertical (out of plane) direction was reviewed. The DCP used a conservative screening criteria to identify slabs which were subsequently analysed by a finite element method. This analysis showed that the screening procedure under predicted the frequency, thus identifying a larger number of flexible slabs. The engineering approach to the selection process was reasonable.

The 3 stick seismic model parametric study used to address the floor slab horizontal (inplane) flexibility around the spent fuel pool was reviewed. The parametric study used 3 different values for the floor flexibility, namely, zero beam stiffnesses, calculated upper bound beam stiffnesses, and infinitely stiff beams. The results of this parametric study were then compared with those of the original single stick model. From this comparison it was concluded by the DCP that the translation response of the building to the earthquake is insensitive to the floor slab stiffness. The engineering calculations seem reasonable.

FUEL HANDLING BUILDING

The seismic models were reviewed. The Fuel Handling Building is part of the Auxiliary Building. Three-dimensional models were used to analyse the fuel handling building. These models seem to adequately represent the structure. The input time history was obtained from the Auxiliary Building seismic analysis. The results of the analysis seem reasonable and should adequately predict the response of the structure to the earthquake.

The staff anticipates additional review of the DCP calculations.

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