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NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

NEW SWITCHGEAR BUILDING AND SEP TOPIC III-6, SEISMIC DESIGN CONSIDERATIONS

CONNECTICUT YANKEE ATOMIC POWER COMPANY

HADDAM NECK PLANT

DOCKET NO. 50-213

1.0 INTRODUCTION

On May 20 through 23, 1991, the NRC staff met with Northeast Utilities staff to discuss the analysis and design of the new switchgear building and Systematic Evaluation Program (SEP) Topic III-6, seismic design considerations. As a result of the discussion, the NRC staff was generally satisfied with the analysis and design of the new switchgear building and SEP Topic III-6, seismic design considerations. Nevertheless, some issues that needed to be resolved were documented in a letter (Reference 1) from the NRC to Connecticut Yankee Atomic Power Company (CYAPCO). CYAPCO submitted its response to the NRC in a letter dated September 30, 1991 (Reference 2). After reviewing the submittal and other documentations of plant design change records, the staff concludes its evaluation results as follows.

2.0 EVALUATION

The issues that need to be resolved are all seismic related to the new switchgear building, pipe gallery structure, auxiliary feedwater pumphouse, and primary auxiliary building. Evaluation on the issues of each building is stated below.

2a. The new switchgear building

The new switchgear building is 34 feet by 64 feet in size, and is three stories high. The superstructure consists of 2 feet thick reinforced concrete walls to provide tornado wind and missile protection. Lateral stability for wind and earthquake is ensured by shear wall action of interior and exterior walls, with the roof and intermediate floors acting to stiffen the structures. The staff has sample checked the design of lateral stability of the building, and found that it was properly done. The foundation mat is 4 feet 6 inches thick, and is placed on a 4 inches thick concrete mud mat which is supported for the most part by natural soils consisting of dense to very dense silty sand with gravel and rock fragments.

The tornado wind and the effect of tornado missiles were considered in the design. The postulated tornado has a rotational wind velocity of 290 mph and a translational velocity of 70 mph which gives a basic wind pressure of 330 psf. An external pressure drop of 3 psi was applied to the building. Postulated tornado generated missiles are in accordance with Section 3.5.1.4 of NUREG-0800 Region I, Spectrum II. These criteria are acceptable to the staff.

The building was designed as a seismic Category I structure. Analyses were performed for two orthogonal horizontal directions as well as for the vertical direction for each earthquake. The responses from these three analyses were combined for each earthquake in accordance with Regulatory Guide 1.92. Structural damping values of 7% and 4% of critical damping were used in the safe-shutdown earthquake (SSE) and operating-basis earthquake (OBE) analyses, respectively, in accordance with Regulatory Guide 1.61. The OBE and SSE design spectra, for the horizontal and vertical directions, were defined by Regulatory Guide 1.60 using maximum ground acceleration of 0.09g and 0.17g, respectively. However, the NRC approved SEP site spectrum has a peak acceleration of 0.21g for the SSE. CYAPCO made a comparison of the two spectra by superimposing the design spectrum of Regulatory Guide 1.60 normalized to 0.17g with the site specific spectrum with a peak acceleration of 0.21g. By observing the plots, it was found that the Regulatory Guide 1.60 spectrum had consistently higher acceleration intensities for all frequencies up to 25 hz. In the seismic analyses, the fundamental frequencies of the building in the three orthogonal directions were determined to be 7 hz, 9 hz, and 13.5 hz in the East-West, North-South, and vertical directions, respectively, which are all less than 25 hz, and 84% to 98.8% of the modal participating mass out of the total system mass had participated in the above frequencies. CYAPCO, therefore, judged that the structural responses produced by using the 0.17g Regulatory Guide 1.60 spectrum were conservative. The staff agrees with CYAPCO's assertion.

CYAPCO applied the ground motions at the bottom of the base mat of the building. However, the NRC SEP position requires that the ground motions to be input at the bedrock level if the depth of soil between the structure and bedrock is shallow, which is the case for this building. CYAPCO responded that computer code FLUSH had been used by Bechtel Power Corporation to perform the soil-structure interaction and building responses, and that Bechtel had used the FLUSH code extensively to perform soil structure interaction (SSI) on similar structures having shallow soil media between the bedrock and the foundation of structures. Although Haddam Neck is a SEP plant, the new switchgear building was designed and built in the time frame of about 1987 to 1989 and had used the most current requirements Title 10 of the Code of Federal Regulations, Part 100, Appendix A, Section VI(a) for the location of the input motions for seismic analyses which is at the bottom of the foundation of a structure. The NRC Regulatory Guides 1.60, 1.61, and 1.92 were followed by CYAPCO for the seismic analyses. Although the peak acceleration of the Regulatory Guide 1.60 design spectra of 0.17g for SSE used for the new switchgear building was slightly lower than that of the approved SEP site specific spectra of 0.21g, it was demonstrated by CYAPCO and agreed by the staff, as described in the previous paragraph that the design spectra used by CYAPCO was actually more conservative than the SEP spectra for the new switchgear building design. In addition to the use of FLUSH code for performing the soil-structure interaction analyses, CYAPCO also used CLASSI computer code to verify the adequacy of the FLUSH code results. The staff believes that the seismic analyses performed by CYAPCO is adequate, and the soil-structure interaction analyses for the new switchgear building and the seismic design of the building based on these analyses is acceptable.

2b. Pipe gallery structure

The staff required a clarification from CYAPCO as to how the 0.02 inches differential end displacement of the pipe gallery structure was obtained. CYAPCO responded that the method used to determine the differential displacement was by performing time-history analysis on a coupled three-dimensional dynamic lumped-mass model of the primary auxiliary building and containment exterior shell connected by the pipe gallery structure. The analyses included the input ground motions in both North-South and East-West directions and the effect of the displacement generated in the North-South direction due to the East-West input motion and vice versa were considered. The differential displacement of the 0.02 was conservatively taken as the absolute sum of the displacement at the two ends of the pipe gallery structure. The staff considers CYAPCO's explanations to be adequate and acceptable.

The staff also required CYAPCO to justify for the adequacy of determining the end forces/moments of the pipe gallery structure. CYAPCO responded that the end forces/moments of the pipe gallery structure were determined from the maximum relative displacements of the pipe gallery structure in East-West and North-South directions from a dynamic analysis. In the dynamic analysis, both the primary auxiliary building and the containment exterior shell were assumed to have fixed at the foundation level, and the pipe gallery structure was represented by two beam elements with their proper cross-sectional properties. The mass contribution from the pipe gallery structure was lumped at the ends of two beam elements that represented the pipe gallery structure. Time-history analyses were performed for the model in both East-West and North-South directions to obtain the maximum end forces/moments of the pipe gallery structure. The vertical inertia forces of the pipe gallery structure were determined manually and then added to the end forces/moments, which were obtained from the dynamic analyses. The staff believes such an approach is adequate and acceptable.

2c. Auxiliary Feedwater Pumphouse (AFWP)

The staff requested CYAPCO to provide justification for not considering soil-structure interaction. CYAPCO responded that the effect of soil-structure interaction had been considered and provided the mathematical model and analyses results. The staff now agrees with CYAPCO that it had considered the effect of soil-structure interaction.

The staff requested CYAPCO to provide justification for decoupling the Turbine/ Service Building from the AFWP Structure in the analysis. CYAPCO responded that it had intentionally notched the flanges of the girders that run in the East-West direction between the AFWP Structure and the Turbine/Service Building to create the decoupling effect in the North-South direction, and it proposed to provide an expansion joint to the girders by cutting the web to create the decoupling effect in the East-West direction. The staff believes that CYAPCO's action and proposal is reasonable and acceptable.

The staff requested CYAPCO to provide detailed drawings of the beam and column connections to the containment exterior shell, the tornado wall, and the shield wall. CYAPCO has provided the detailed drawings as requested. The staff has found that the beam column connection details are similar to the typical details of the American Institute of Steel Construction (AISC), Manual of Steel Construction, and therefore are acceptable.

The staff requested a clarification as to how the shield wall and the tornado wall as well as their connecting beams were analyzed. CYAPCO responded that seismic analyses were performed on a coupled three-dimensional lumped-mass model of the AFWP house, including the shield wall and the tornado wall and their connecting beams, and the containment's outer shell structure, and that the model was subjected to a loading combination of dead weight, live load, operating temperature and pressure load, and SSE loads. The staff believes that such a model and loading combination are acceptable.

The staff requested the information as to how the steel floor plates were included in the seismic model representing the AFWP structure. CYAPCO responded that the mass of the steel plates had been included at the appropriate floor level of the lumped-mass model representing the AFWP structure. The staff believes that such a representation of modeling is acceptable.

The staff requested the justification of the sufficiency of a static analysis of the AFWP structure. CYAPCO responded that a seismic analysis had been performed and the stresses resulting from the seismic analysis had been added to the stresses due to dead weight and live load resulting from a static analysis to reach final total stresses. This approach is acceptable to the staff.

The staff requested a clarification as to how the hor zontal motions in two orthogonal directions of the containment was accounted for in the AFWP structural analysis, and a justification for using the equivalent static analysis of the AFWP structure in the vertical direction with 0.3g. CYAPCO responded that the seismic analysis of the AFWP structure had been performed by developing a three-dimensional lumped-mass model coupled with the lumped-mass model representing the containment and with SSE response spectra as input at the support level in three orthogonal directions (the response spectrum in the vertical direction being 2/3 of the horizontal). These responses clarify and justify the analytical model being used by CYAPCO, and are acceptable to the staff.

The staff requested CYAPCO to provide the details of the design modifications made to the AFWP structure. CYAPCO responded that the AFWP structure did not require any structural modifications for subjecting to loading conditions of dead weight, live loads, and SSE in accordance with analysis results. However, CYAPCO stated that it had not reanalyzed the main steam and the feedwater piping systems, and that it would evaluate the effect of the piping restraint load on the AFWP structure later for any structural modification needs. CYAPCO's response is acceptable to the staff.

The staff requested CYAPCO to provide an evaluation of the soil bearing pressure under the foundation of the AFWP structure. CYAPCO responded that the soil bearing pressures at the foundation of the shield wall and the tornado wall had been evaluated for loading combinations of dead weight, live load, and SSE, and that the maximum compressive pressures were determined to be 5.0 ksf under the shield wall and 7.1 ksf under the tornado wall, which were less than the allowable pressure 7.5 ksf. CYAPCO's response is acceptable to the staff.

3.0 CONCLUSION

Based on the results of the audit and site inspection and the review results of CYAPCO's submittals, the staff has concluded that the analysis and design of the new switchgear building are adequate and that SEP Topic III-6, seismic design considerations, related to the pipe gallery structure, auxiliary feedwater pumphouse, and primary auxiliary building has also been satisfactorily resolved.

References:

1. "Summary of May 20 to 23, 1991 meeting regarding SEP Topics III-6, Seismic Design Considerations, and III-2, Wind and Tornado Loadings and Switchgear Room" Haddam Neck Plant, date June 11, 1991, by A. B. Wang of NRC.

2. "Haddam Neck Plant Seismic Design Considerations, Wind and Tornado Loadings/Tornado Missiles, and New Switchgear Building", September 30, 1991, E. J. Mroczka of Northeast Utilities to NRC.

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