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

RELATING TO SITE-SPECIFIC RESPONSE SPECTRA

GPU NUCLEAR CORPORATION

OYSTER CREEK NUCLEAR GENERATING STATION

DOCKET NO. 50-219

BACKGROUND:

The Oyster Creek Nuclear Generating Station (OCNGS) was one of the nuclear power plants required to perform reanalyses under the Systematic Evaluation Program (SEP) (Reference 1). For this program site specific response spectra (SSRS) were developed for each of the SEP sites (Reference 2). In the "SEP Safety Topic Evaluation" (Reference 3) for OCNGS the staff identified areas of concern which required further analyses.

In a letter from NRC, to GPU Nuclear Corporation (GPUN/the licensee) (Reference 4), the staff identified problem areas with respect to the design spectra intended for use by the licensee for further seismic qualification work and recommended two options to resolve the concerns. One option recommended the development of "free field" site specific response spectra from a suite of appropriate earthquake records from magnitude 5.3 ± 0.5 (m_{blg}) earthquakes recorded at distance of 25 km or less, at sites whose local soil conditions are similar to the OCNGS site.

In a meeting of May 22, 1988, in which GPUN presented materials related to the generation of SSRS for OCNGS the staff raised the following concerns:

Certain data presented at the meeting were recorded in the basements of tall buildings; these could potentially have a soil-structure interaction (SSI) effect that would lower the recorded peak accelerations and/or spectral ordinates.

Site conditions were not precisely matched and additional parameters such as primary wave velocity profiles, water table levels, bulk soil properties, etc., were not considered.

Vertical response spectra were not discussed.

Accelerograms and response spectra for recently recorded significant events were not adequately addressed. In particular, data from the recent Whittier Narrows earthquake of October 1987, were not included.

On October 11, 1989 the licensee submitted a report to the NRC discussing the development of the OCNGS SSRS and justifying the criteria upon which the development was based (Reference 5).

In a letter from NRC to GPUN, (Reference 6) the staff requested additional information (RAI) with respect to the input data used to generate the SSRS. The information requested dealt with the reported epicentral distances at which pertinent earthquake records were recorded.

In response to the RAI the licensee submitted a report to the NRC consisting of a reanalysis of the OCNGS SSRS and further justification for the input data used (Reference 7).

EVALUATION:

Overview: The evaluation of the SSRS development for OCNGS was based upon a number of conditions which the staff considers necessary for the results to be appropriate. These conditions included the vintage and number of earthquake records used, the site condition underneath the recording stations, the type of structure in which the recording instruments were housed, the distances between the earthquake epicenters and the recording stations, the magnitudes of the recorded earthquakes and the accuracy of the coordinates of both the earthquake epicenters and the recording stations. The reports submitted by the licensee (References 5, 6, and 7) provide detailed discussions on all of the above issues which the staff considered sufficient to arrive at the conclusions reached in this report.

Vintage and Number of Records

The earthquake records were mainly California earthquake records dating from 1941 to 1987 including aftershock records of such relatively recent earthquakes as the Coalinga earthquake of May 2, 1983 and the Whittier earthquake of October 1, 1987. Other earthquake records used were recorded in Italy (Friuli earthquake of September 1976) and in Nicaragua (Managua earthquake of December 1972). A total of 73 records were considered to be appropriate for the OCNGS SSRS.

Site Conditions

The Oyster Creek site is underlain by an 1800 feet thick layer of sandy soil over bedrock which puts the Oyster Creek site in the "deep soil site" category. To match the site conditions the licensee compared the shear wave velocity profiles of the recording stations with that of the site. Eighteen stations were found with similar velocity profiles. To increase this relatively small suite of records the licensee used records from stations when site conditions were listed as "deep soil" but for which no shear wave velocity profiles were available.

Type of Structure

The type of structure that houses a recording station may have influence on the recording because of (a) soil-structure interaction which could result in a lower response than that of a "free field" station, or (b) structural amplification if the recording station is located at a floor level higher than the foundation level.

A study by NRC (NUREG/CR-3839) reported reductions in earthquake response by as much as 24 percent in the basements of structures with more than three stories when compared to free field motions. Ten of the 73 records used by OCNGS for the site-specific spectrum were obtained from recording stations inside structures with more than four stories. Removal of these 10 records from the SSRS results in a slight but consistent increase in response. A study submitted by the licensee analyzed the structures used in the OCNGS SSRS and its conclusion was that the number of stories of the structures did not significantly affect the ground motions recorded at the foundations.

Epicentral Distances of Recorded Earthquakes

The staff recommended that in order to obtain an estimate of the ground motion at a particular locality by using a suite of earthquake recordings, the distances between the earthquake epicenters and that of the recording stations should not exceed 25 km. In the OCNGS SSRS report several earthquake records used exceeded this distance criterion. Upon request from the NRC staff the licensee submitted two additional analyses; (1) a sensitivity study to ascertain the influence of earthquake records with reported epicentral distances beyond 25 km, and (2) a literature search to ascertain the accuracy of the reported epicentral distances (Reference 7).

The first study (1) indicated that the SSRS did not change significantly if records with distances outside the 25 km criterion were eliminated. The second study (2) indicated that upon checking the accuracy of the coordinates, there were sufficient deviations in the reported distances between earthquake epicenters and station locations to allow the inclusion of the records with distances marginally larger than 25 km.

Earthquake Magnitude Range

The average of the magnitudes of the earthquakes used in the original study (73 records) was 5.3 ± 0.3 (M_L). The average of the magnitudes used after eliminating records from structures with more than four stories (63 records) was unchanged, 5.3 ± 0.3 (M_L). The average of the magnitudes of the earthquakes used after eliminating an additional 10 records with reported distances exceeding the 25 km limit (53 records) decreased to 5.2 ± 0.3 (M_L).

The actual magnitudes of the earthquakes used in the original study ranged from 4.9 to 5.9 (M_L). During the selection of appropriate records for the OCNGS some records which at first sight were considered applicable were later omitted by the licensee because:

(a) the accelerations recorded were considered too high to be included as representative of a magnitude of 5.3 ± 0.5 (M_L) earthquake. Specific records eliminated were:

1. Coalinga aftershock of July 25, 1983, magnitude 5.1 (M_L), distance 9.2 km (Weston geophysical (WG) records # WCPEV7).

2. Hollister earthquake of January 26, 1986, magnitude 5.5 (M_L), distance 12.0 km (WG records # WGLOR86).

3. Palm Springs earthquake of July 8, 1986, magnitude 5.9 (M_L), distance 5.9 km (WG records # WPSA86).

4. Santa Barbara earthquake of August 13, 1978, magnitude 5.9 (M_L), distance 12.0 km (WG records # WU299H).

(b) the accelerations recorded were considered too low to be included in the suite of applicable earthquake records. Specific records eliminated were:

1. Imperial Valley earthquake of July 13, 1953, magnitude 5.5 (M_L), distance 23.6 km, N-component (WG record # WT2888 H2.050).

It is the staff's position that the uncertainty associated with estimating ground motion response spectra from earthquake records recorded near their respective epicenters is such that selecting records on the basis of expected levels of acceleration is unwarranted. For this reason the staff recommended that the records listed under (a) 1, 2, 3, and 4 and the record listed under (b) 1 be included in the SSRS analysis.

In a letter from GPUN to NRC (Reference 8) the licensee responded to the staff's recommendations. The licensee agreed to include in the SSRS analysis records from earthquakes (a) 1 and 2 and provided arguments why records from earthquakes (a) 3 and 4, and (b) 1 should not be included in generating the OCNGS SSRS.

CONCLUSION:

The development of new floor response spectra was intended for use in the analysis of equipment such as piping, piping supports, and support anchorages. The reported critical frequencies for this equipment ranged from 0.5Hz to 17.5Hz. The staff evaluated the site specific spectrum obtained by including all records recommended by the staff and the SSRS proposed by the licensee (where the 1986 Palm Springs, the 1978 Santa Barbara, and the 1953 Imperial Valley, N-Component earthquake records were excluded).

The differences in the 5% damped SSRS proposed by the licensee (Reference 8, 67 record SSRS) and the 5% damped SSRS recommended by the NRC (Reference 8, 72 record SSRS) range from 4% in the 15Hz range to 7.5% in the 2Hz range. The

staff does not agree that the five records omitted are inappropriate for the SSRS generation. However, based upon the above observation that the differences between the two 5% damped spectra are ess than 10% over the entire frequency range, the staff considers the SSRS based on the 67 record data set acceptable for use in the SSI analysis.

When performing the SSI analysis the procedures indicated in the Standard Review Plan (NUREG-0800 Revision 2, 1989) should be adhered to. The most significant of these procedures pertaining to an SSI analysis are:

1. The SSRS or the equivalent earthquake time history shall be applied at a "free field" location at plant-grade elevation. The deconvolved spectral amplitudes at the foundation depth of the "free field" location shall not be less than 60 percent of SSRS spectral amplitudes defined at plant grade free field elevation.

2. The soil properties should consist of:

   (a) An average (or best estimate) soil property derived from in situ geophysical and geotechnical data,

   (b) An upper bound soil property equal to twice the average soil property, and

   (c) A lower bond soil property equal to half the average soil property.

3. The material damping assumed for the soil shall not exceed 15 percent.

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References

1. "Seismic Hazard Review for the Systematic Evaluation Program - A Use of Probability in Decision Making" NUREG-0967, March 1983.

2. "Seismic Hazard Analysis" NUREG/CR-1582, 5 Volumes

3. Letter from D. Crutchfield, NRC to P. Fiedler of GPUN of May 12, 1982. Subject: SEP Safety Topics III-6, Seismic Design Consideration and III-11, Component Integrity - Oyster Creek Nuclear Generating Station.

4. Letter from A. Dromerick, NRC to P. Fiedler, GPUN, of December 16, 1987. Subject: Methodology to Develop New Seismic Floor Response Spectra for Oyster Creek Nuclear Generating Station.

5. Letter from D. Croneberger, GPUN to NRC of October 11, 1989. Subject: Oyster Creek Nuclear Generating Station - Free Field Site Specific Response Spectra.

6. Letter from A. Dromerick, NRC to E. Fitzpatrick, GPUN, of September 20, 1990. Subject: Request for Additional Information concerning Site Specific Response Spectra - Oyster Creek Nuclear Generating Station.

7. Letter from J. Devine, Jr., GPUN to NRC of February 6, 1991 Subject: Oyster Creek Nuclear Generating Station - Response to Additional Information Concerning Site Specific Response Spectra.

8. Letter from J. Devine, Jr., GPUN to NRC of December 30, 1991. Subject: Oyster Creek Nuclear Generating Station - Response to NRC Request for Changes to SSRS for use in Soil Structure Interaction.

9. Letter from D. Croneberger, GPUN to NRC of November 1, 1989. Subject: Oyster Creek Nuclear Generating Station - Upgrade of Pipe Supports and Anchorages to Meet IEB 79-02 and IEB 79-14 Using the New Floor Response Spectra