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402/636-2000

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LIC-92-016R

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, DC 20555

References:
1. Docket No. 50-285
2. Letter from OPPD (K. J. Morris) to NRC (Document Control Desk) dated December 2, 1988 (LIC-88-506)
3. Letter from NRC (W. C. Walker) to OPPD (W. G. Gates) dated June 3, 1991, "Questions and Comments on Alternate Seismic Criteria and Methodologies for Fort Calhoun Station"
4. Letter from NRC (W. C. Walker) to OPPD (W. G. Gates) dated June 17, 1991, "Review and Evaluation of Alternative Seismic Criteria and Methodologies (ASCM) for the Fort Calhoun Station (FCS), Unit 1"
5. NUREG-0800, USNRC Standard Review Plan

Gentlemen:

SUBJECT: Resolution of Remaining NRC Open Items on Alternate Seismic Criteria and Methodologies (ASCM)

Attached are Omaha Public Power District's (OPPD) responses to the ten remaining open items resulting from the NRC's review (References 3 and 4) of OPPD's ASCM submittal (Reference 2). The open items are listed in the order in which the items were discussed at the NRC-OPPD meeting held on April 23, 1992.

Based on discussion with the NRC staff at the April 23, 1992 meeting, this letter addresses each remaining NRC question on this issue.

If you should have any questions, please contact me.

Sincerely,

W. G. Gates

W. G. Gates
Division Manager
Nuclear Operations

WGG/sel

Attachment (1)
Enclosures (5)

c: LeBoeuf, Lamb, Leiby & MacRae (w/o Enclosures)
J. L. Milhoan, NRC Regional Administrator, Region IV (w/o Enclosures)
R. P. Mullikin, NRC Senior Resident Inspector (w/o Enclosures)
S. D. Bloom, NRC Acting Project Manager

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<u>Open Item 1. HOUSNER GROUND RESPONSE SPECTRA (GRS) (Related to Reference 4)</u>

NRC Position: **The use of ASME Code Case N-411 damping, for design basis, is unacceptable if used in combination with ground response spectra that are less conservative than Regulatory Guide (RG) 1.60 spectra.**

OPPD Response: The OPPD Alternate Seismic Criteria Methodologies (ASCM) criteria has been revised to delete reference to ASME Code Case N-411 as an acceptable design basis criteria, and the revised pages are included in Enclosure 1. This item is considered closed.

<u>Open Item 2. OVERTURNING AND SLIDING (Related to Reference 4)</u>

NRC Request: **NRC reviewers requested that documentation be provided to show that the pile system design accounted for the overturning and sliding components of seismic inertial force acting on the supported structures. This documentation need not be complete (the plant design basis records on pile design are known to be incomplete) as long as sufficient evidence is provided to satisfy the concern.**

OPPD Response: The original design basis documentation was reviewed and it was determined that in the Class 1 structures, seismic vertical and shear forces and overturning moments were calculated from a seismic response spectrum analysis of those structures.

The piles on which the structures are founded were designed to withstand the concurrent loads of normal, accident and seismic forces in accord with Section 5.7.3 of the plant Updated Safety Analysis Report (USAR). The tops of the piles were assumed to be restrained against rotation since they are embedded in the foundations. All lateral loads were assumed to be resisted directly by the piles, and then transmitted to the soil and bedrock through the piles. Pile tests, as described in Section 5.7.2 and Appendix C & D of the USAR, established maximum compression, uplift and lateral load capacities. Pile loads were further limited by material stress allowables per the criteria of Section 5.7.3. The resultant maximum pile design loads for each of the required loading combinations are tabulated in Table 5.7-2 of the USAR.

As shown in the table below, a comparison of the pile stresses, based on the ASCM seismic accelerations of structures, and those assumed in the design of the plant, reveals that the original design stresses are equivalent (i.e., within 10%) to those predicted by the ASCM. Thus, the original design was found to adequately account for seismic overturning and shear loads on the piles. This item is considered closed.

Stresses on Piles = Normal + Safe-Shutdown Earthquake (SSE)	Design Stress [ksi]	ASCM Stress [ksi]
Intake Structure	21.9	23.1
Auxiliary Building	29.7	29.3

Open Item 3, ACCIDENTAL TORSION (Related to Reference 4)

NRC Request: **NUREG-0800 (Reference 5), Section 3.7.2 SEISMIC SYSTEM ANALYSIS, Subsection II.11, requires that accidental torsion be accounted for by including in the dynamic model of the structure an additional eccentricity of +/-5% of the maximum building dimension at the level under consideration (in both directions).**

Provide additional discussion regarding accidental torsion and the method of generating spectra for the ASCM. Justification for not explicitly including accidental torsion in the derivation of spectra should be provided.

OPPD Response: The ASCM dynamic model is a 3 dimensional model based on the as-built eccentricities and properties of the plant. The model includes offsets between the mass and stiffness centers for each major elevation of the plant structures.

The responses of the structures, in the ASCM, are calculated for the simultaneous excitation due to three directions of earthquake motion. Torsional degrees of freedom are included in those responses.

Floor response spectra were derived in the ASCM as an envelope of the responses obtained at the extreme corners of each floor elevation and that at the center of mass. The enveloping of maxima from all floor response spectra curves for each floor elevation introduces enough margin of conservatism to accommodate possible effects due to accidental torsion.

A comparison plot of the resultant 2% envelope spectra and that at the center of mass is provided in Enclosure 2. From a comparison of the 2% damped spectral curves, the enveloping procedure results in higher spectra than at the center of gravity. For the location shown, the increase is seen to be about 8% at the main spectral peak and about 50% at the secondary peak.

During original plant construction, the underlying soils for seismic Class 1 structures were consolidated to achieve a uniform relative density over the entire foundation area. Therefore, the dynamic properties of the soils are substantially uniform and their seismic response would not be conducive to causing accidental torsion of the structure. No modifications have been performed to seismic Class 1 plant structures or underlying soils, which would alter the conclusions of the original foundation studies on which the 1973 Safety Evaluation Report (SER) was based. Thus, the effects of torsion are adequately accounted for in the dynamic analysis performed for the ASCM and this item is considered closed.

Open Item 4. UPPER BOUND SOIL PROPERTIES (Related to Reference 4)

NRC Request: **NUREG-0800 Revision 2 (Reference 5), Section 3.7.2 SEISMIC SYSTEM ANALYSIS Subsection I.4, recommends that the variation in soil properties should be considered by performing soil structure interaction (SSI) analysis using three sets of values (defined in terms of shear modulus and soil hysteretic damping ratio). These three analyses should be performed using the average (or best estimate) value, twice the average value and half the average value of the low strain shear modulus.**

Perform select parametric studies, using simplified SSI models, to show the effects of recommended soil property variation on spectra generation. Demonstrate that variation is bounded by the peak broadening method of RG 1.122, which was used in the ASCM.

In addition, provide clarification on how radiation damping is considered in the SSI analysis methodology. Estimate the amount of radiation damping due to piles. Clarify that the contribution of the basemat impedances is not added to the pile impedances.

OPPD Response: Open Item 4a. UPPER BOUND SOIL PROPERTIES

An upper bound uncertainty factor that applies to the soil shear modulus for FCS is estimated at 30%. This factor is based on the following FCS-specific information:

1) Statistical evaluation of existing geotechnical and geophysical information has been performed.

2) Variability in soil properties has been substantially reduced by their extensive treatment at the time of construction. A statistical analysis (performed after densification of the site) of 696 standard penetration test results indicated that the average relative density for the entire area is not less than 85% at an overall confidence level of 96.5% (Section 5.7.2.1 of FCS USAR).

3) Use of a detailed finite element soil-pile-structure model reduces uncertainty associated with the analysis procedure.

To account for the ± 30% variation in soil properties, the SASSI/CLASSI model of the Auxiliary/Containment Building described in the documents previously submitted and reviewed were used to determine the SSE response of the structure for an Upper Bound (UB) case using 1.3 times Best Estimate (BE) soil shear modulus and a Lower Bound (LB) case using 0.7 times BE. These results were then enveloped with the previously derived ±15% broadened BE case. For further discussion, refer to the report in Enclosure 3. The revised spectra generation is considered to close this item.

OPPD Response: <u>Open Item 4b, RADIATION DAMPING</u>

Radiation damping has been conservatively incorporated in the ASCM SSI analysis. This results from: (i) The ASCM SSI model conservatively neglects embedment of the structures and the additional radiation damping resulting from the site soil due to this embedment, and (ii) no contribution to radiation damping from the basemat has been considered in the SSI analysis. The UB and LB SSI analyses were performed using BE soil damping properties.

To evaluate the overall damping of the soil/pile structure system, a free-vibration analysis of the SSI model was performed and the logarithmic decay of the basemat response was calculated. Based on this basemat response, the total damping is estimated to be about 13%. Based on SHAKE analysis results of the soil column, the contribution from the soil material damping averages approximately 6.2% for the SSE case. The radiation damping was then determined to be 6.8% by subtracting the material damping from the total damping. For further discussion refer to Enclosure 3. This item is considered closed.

OPPD Response: Open Item 4c, LIQUEFACTION

A review of design basis documentation, on liquefaction, disclosed the following:

Soil studies, as described in Section 5.7.4 and Appendix C of the plant USAR, were previously performed to ascertain the potential for liquefaction during seismic excitation. It was previously concluded that compaction of the soils, to an average relative density of 85%, was required to prevent liquefaction during a design basis earthquake.

After installation of the foundation piles, the Vibroflotation system was used to densify the soils from the top of bedrock to the underside of the foundation. Densities were again measured and it was confirmed that an average relative density of 85% was achieved.

In Supplement 1 to the SER dated April 23, 1973 for Fort Calhoun Station Unit 1, the NRC's consultant concluded that the resulting foundations of the plant were adequate to support all imposed loadings, including those arising from the SSE.

Formal surveillance inspections of the tendon tensioning gallery, performed every three years, have demonstrated that no growth has occurred in the minor cracks (surface cracks ≤ 1/32 inch wide) which were noted shortly after construction (first recorded in 1976). In addition, no new cracks have been observed since 1976. The results of the most recent surveillance inspection are provided in Enclosure 4. This stable condition is interpreted as evidence that no significant settlement has occurred in the supporting soils beneath the gallery. Although OPPD does not have a surveillance program to check for elevation levels, no observable settlement has occurred in the soils beneath seismic Class 1 and non-Class structures.

As stated in OPPD's response to Open Item 3, no modifications have been performed to seismic Class 1 plant structures or underlying soils which would alter the conclusions of the original foundation studies on which the SER was written in 1973. Since the input ground motion to the ASCM analysis are based upon the original design basis GRS, the potential for liquefaction has not been increased and this item is considered closed.

Open Item 5, ASME CODE CASE N-411 DAMPING AND MULTIPLE LEVEL RESPONSE SPECTRUM ANALYSIS (Related to Reference 3)

NRC Position: **The use of ASME Code Case N-411 damping in a multiple level response spectrum analysis is not acceptable without further justification. RG 1.84 currently limits the use of N-411 damping to a single level response spectrum analysis.**

OPPD Response: As stated in OPPD's response to Open Item 1, references to ASME Code Case N-411 as design basis criteria have been deleted from the ASCM. The revised pages of the ASCM document are included in Enclosure 1. This item is considered closed.

Open Item 6, INDEPENDENT SUPPORT MOTION LINEAR TIME HISTORY ANALYSIS INPUT PHASING (Related to Reference 3)

NRC Request: **For Independent Support Motion (ISM) linear time history analysis, responses at support levels will be combined by algebraic summation at each time step. This is acceptable provided that the input to the two analyses retains the correct phasing. OPPD is requested to confirm that proper phasing for the inputs is retained.**

OPPD Response: The ASCM has been revised to indicate that proper input phasing must be accounted for to apply ISM linear time history analysis. The revised pages of the ASCM document are included in Enclosure 1. This item is considered closed.

Open Item 7, HVAC DESIGN BASIS CRITERIA

NRC Request: **For HVAC criteria, OPPD should provide more detailed and quantitative information and comparisons, including tables of original load combinations and allowables as well as proposed alternate load combinations and allowables for normal, upset, emergency, and faulted conditions.**

OPPD Response: The design basis documentation for HVAC systems was reviewed and disclosed the following:

> HVAC ductwork, located in safety related areas, was designed as seismic Class 1. Seismic restraints were nominally installed at 8'-0" maximum spacing. The ductwork was attached to the restraints by welding or with screws.
>
> Duct layout drawings show restraint locations and hanger type. Hanger drawings show details of each hanger type. A "Seismic Loaded Hanger Details" drawing shows additional requirements for seismic restraints on rectangular and circular ducts. Most restraints provide two directions of restraint, but some are designated as three-way restraints.
>
> Seismic loads for rigid duct ($f \geq 35$ Hz) were based on SSE accelerations for EL 1091'-0" Intervals of Containment. For non-rigid ducts, response spectra analysis was performed with spectra from the USAR.

OBE allowable stresses were based on increasing normal allowables by one-third in accordance with Section 2303 of the Uniform Building Code.

$$F_b = 1.33 * 0.66F_y = 0.88F_y$$

SSE allowable stresses were defined as 0.9 times yield, per Section 5.01.a.iii of Specifications (Contract 763, Section H20).

$$F_b = 0.9F_y$$

Design was based on SSE loads which are the most limiting.

Duct systems were designed for the simultaneous SSE horizontal and vertical accelerations in addition to normal loads.

A frequency analysis of the duct and restraint system was performed to establish fundamental frequency and applicable seismic accelerations.

A comparison of the design basis criteria and that proposed in the ASCM is provided in Enclosure 5. This item is considered closed.

<u>Open Item 8, FAULTED ALLOWABLE FOR HVAC COMPRESSION MEMBERS (Related to Reference 3)</u>

NRC Request: **The proposed stress increases of 1.33 for emergency and 1.6 for faulted conditions are acceptable with one exception: The 1.6 increase should not be applied to compression members since it may result in insufficient safety margin against buckling. The licensee should modify its criteria to limit the faulted compressive stress increase to a lower value consistent with AISI or ASME Appendix F faulted allowables.**

OPPD Response: Criteria for HVAC compression members have been revised to restrict seismic compression stresses to the faulted allowables of AISI. The revised pages of the ASCM document are provided in Enclosure 1.

Open Item 9, INCREASE IN YIELD STRENGTH (20%) FOR HVAC RESTRAINTS (Related to Reference 3)

NRC Position: **The NRC does not accept the proposed 20% yield strength increase for the design of HVAC supports since it will reduce built-in Code safety factors.**

OPPD Response: The ASCM criteria have been revised to delete reference to the use of a 20% increase in yield strength for design of HVAC supports. The revised pages of the ASCM document are provided in Enclosure 1.

Open Item 10, REVISE ORIGINAL ASCM DOCUMENTS TO INCORPORATE NRC COMMENTS (Related to Reference 3)

NRC Request: **OPPD should revise the original alternate seismic criteria documents contained in the December 2, 1988 submittal to incorporate NRC comments, and submit them for further staff review.**

OPPD Response: The original ASCM documents have been revised to incorporate NRC comments and are included as Enclosure 1. Also, criteria in the original ASCM submittal which have not been addressed by OPPD have been deleted from the revised ASCM documents. This submittal constitutes the requested update to the December 2, 1988 submittal (Reference 2).