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1CAN069008

U. S. Nuclear Regulatory Commission
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Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Response to Remaining NRC Questions
on QCST Seismic Qualification

Gentlemen:

Your letter dated June 11, 1987 (1CNA068702) transmitted questions raised during an NRC site visit regarding the ANO-1 Seismically Qualified, Partially Tornado Protected, Condensate Storage Tank (QCST). Our letter dated July 10, 1989 (1CAN078903) provided a partial response to those questions. The final response was delayed due to reasons discussed in our letter dated March 9, 1990 (1CAN039009). The responses to the remaining questions have now been completed and are provided in the attachment. The previously answered questions were also reviewed against the revised QCST design report prepared by the tank vendor, CBI. The analyses in the associated calculations demonstrate that the QCST tank, foundation and drilled piers are adequate without modification.

If you have additional questions regarding this issue, please do not hesitate to contact my office.

Very truly yours,

James J. Fisicaro
Manager, Licensing

JJF/RBT
Attachment

A001
1/11

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Attachment to 1CAN069008

NRC Question 1:

Nutech used a soil shear wave velocity of 1100 fps for the FLUSH runs. A review of the geophysical data indicates that this is perhaps closer to the compression wave velocity. In general, it appears that there is a lack of good data for the clay upon which to base the selection of an appropriate wave speed.

Response:

ANO performed soil testing at the ANO plant site to determine actual soil properties for the tank foundation design. Weston Geophysical/Bechtel performed the geophysical survey and Grubbs, Garner & Hoskyn, Inc. the soil testing services. The results of this testing program were reviewed with Professor H. Bolton Seed and appropriate soil properties selected for the QCST tank foundation soil-structure interaction reanalysis. Shear wave velocities derived from the testing program ranged from 580 fps to 700 fps depending on the depth below the surface.

NRC Question 2:

Poisson's ratio of 0.2 was used in the FLUSH runs for the clay. A review of the soil data indicate that the clay is saturated. One would expect the Poisson's ratio for a saturated clay to be larger than 0.2.

Response:

As part of the soil testing program mentioned above in the response to Question 1, Poisson's ratio values were measured. The Poisson's ratio values (ranging from .45 to .42 depending on depth below surface) were used in the reanalysis of the QCST tank foundation.

NRC Question 3:

The motion developed from the criteria design spectra was assumed at the surface and deconvolution methods were used to calculate a consistent bedrock motion. This bedrock motion was then used as input to the FLUSH program. Since the primary support of the tank (especially for vertical and rocking motions) is the caissons which are founded on bedrock, a more consistent application of NRC guidelines would be to use the criteria motion as input to the base of the caissons (at bedrock).

Response:

The original method of analysis used to design the tank foundation represents what an observer located at the ANO plant would report for a design basis earthquake at the New Madrid fault. The application of the control motion to the free field surface has been proven by studies performed for the Taiwan Power Company and reported under EPRI project RP2225, and has been accepted by the NRC as an appropriate methodology. Also, the caissons were provided to prevent potential differential settlements of the tank foundation which could impair proper functioning of tank and associated piping. However, in the extreme, if complete failure of all caissons occurred the clay subgrade will easily support the 2.5 ksf bearing pressures with any possible settlement taking a very long time to occur.

Following detailed discussions with Dr. H. Bolton Seed and Dr. J. Lysmer, it was agreed that the analytical method would be modified to use both the SHAKE and FLUSH computer programs. The method of analysis as recommended by Dr. Lysmer was as follows:

> Horizontal Motions: The control motion was applied at a rock outcrop and the rock motion and free field surface motion computed using SHAKE. The calculated free field surface motion was input to FLUSH and deconvoluted to bedrock and the soil-structure response calculated using this motion.
>
> Vertical Motions: A similar method was used to calculate the vertical response except that P-wave velocities were used to compute the shear modulus and only one iteration of the SHAKE program is required to perform the vertical motion deconvolution.

The final results of the QCST foundation reanalysis were reviewed by Professor H. Bolton Seed who concurred with the analytical approach taken and appropriateness of the final results.

NRC Question 4:

A 10 second duration pulse was used as input to the FLUSH model. Response spectra developed from the FLUSH results were then used by CBI to calculate the effects of water sloshing. The frequency of the sloshing mass was calculated to be about 0.25 cps. It is questioned whether the input spectra, developed from a 10 second duration pulse, is adequate to evaluate the response of a 0.25 cps system.

Response:

As part of the QCST foundation reanalysis, a 24 second duration time history was used as input to the FLUSH model. The 24 second time history is in accordance with the ANO-2 design basis for seismic design of Class I structures.

NRC Question 5:

Response spectra were reported at the foundation level. These spectra were then used by CBI to evaluate stresses in the tank. This approach neglects any inertial that would occur as a result of rocking of the tank. Some rationale for neglecting this effect is required.

Response:

CBI used the response spectra as representing a foundation already including soil translational and rocking effects. Techniques are available for evaluating coupling of structures, however, CBI's experience with studies on this subject indicate that, generally, damping increases and loads decrease when more sophisticated seismic investigations are performed. Therefore, we believe the inertia associated with the tank rocking has been adequately accounted for in the tank stresses.

NRC Question 6:

The CBI calculations do not seem to account for an increase in fluid pressure as a result of the vertical seismic input. This increase in pressure would result in higher hoop stresses in the tank walls.

Response:

CBI has included the effects of vertical seismic acceleration on the tank. The latest revision (May 1990) of the CBI design report (AP&L Calculation #82-2086-60) accounts for the additional circumferential and vertical stress.

NRC Question 7:

CBI calculates a wave height due to sloshing effects which is higher than the available freeboard in the tank. No consideration is given as to the potential impact this may have on the tank design.

Response:

CBI supplied the AP&L specified freeboard of 1 foot. The predicted wave height is 1.6 feet for a full tank during SSE seismic loading. Calculations performed to evaluate the effect of a wave height of 1.6 feet and freeboard of 1 foot resulted in a stress of 1,760 psi at the roof to shell junction of the tank, which is the point of most concern for stresses due to a wave height of over 1 foot. When compared to allowable stresses of 18,055 psi for this point, it can be seen that a wave height of 1.6 feet is acceptable.

NRC Question 8:

The seismic loads used to design the foundation and caissons are not consistent with the latest seismic analysis.

Response:

It has been confirmed by Nutech for AP&L that the foundation and caisson design loads envelop the forces and moments predicted by the latest FLUSH seismic analysis results, as modified in response to Questions 1 through 4. In addition, it was confirmed that the calculated tank and anchor bolt foundation loads are less than the loads use to design the concrete foundation and caissons.

NRC Question 9:

The CBI report uses a Rayleigh-Ritz procedure to calculate tank frequencies. No detail on the assumed shape function is given and should be provided.

Response:

CBI has generically described the dynamic mode shape of vibration for the tank structure in the latest revision of the CBI design report. The CST is assumed to be a fixed cantilever-shear beam for purposes of deflection calculation. Detailed Rayleigh-shear models were used to determine the fixed base period for the full and the 1/2 full condition.