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November 25, 1981

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Byron Station Units 1 and 2
Braidwood Station Units 1 and 2
Response to FSAR Questions
NRC Docket No. 50-454, 50-455, 50-456, and 50-457

Reference (a): August 25, 1981 letter from B. J. Youngblood to L. O. DelGeorge

Dear Mr. Denton:

This is to provide advance copies of responses to NRC questions on the Byron/Braidwood FSAR. Enclosed are the responses to geotechnical questions 241.6 and 241.7 which were transmitted in reference (a). These responses will be incorporated into the FSAR in the next amendment. One signed original and fifty-nine copies of this letter and the enclosures are provided for your review and approval.

Please address further questions to this office.

Very truly yours,

T. R. Tramm

T. R. Tramm
Nuclear Licensing Administrator

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Enclosures

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QUESTION 241.6

"Pipeline Settlement & Seismic Responses

1. Provide the final ground surface profile along the pipeline on Plate 3.

2. Although the weight of the pipeline, as stated, is less than the weight of the excavated soil; settlement along the pipeline should be anticipated in areas where site grade has been raised by filling and the compressible soil underneath the pipeline has variable thickness and compression characteristics. Provide settlement estimates of the pipeline located in the areas identified as Areas of Concern No. 11 and 12. Actual testing data should be used in the analysis.

3. The pipeline as shown on Plate 1, is approximately 3 miles long and extends from the River Screen House on the Rock River to the Essential Service Cooling Tower in the plant site area. The soil supporting the pipeline has variable properties and has thicknesses varying from about three feet to about 100 feet over bedrock. The seismic amplification characteristics are affected by the thickness and properties of the soil deposit. Provide analytical results showing the seismic amplifications along the pipeline and discuss their impact on the pipeline design.

4. Poorly graded, loose, non-plastic soils were encountered at Areas of Concern No. 11 and 12. Provide an evaluation fo the liquefaction potential and seismically induced settlements of these soils. Since surface water could percolate around the edges of the cohesive cover, the degree of saturation for the soil beneath the pipeline should be considered in the analysis."

RESPONSE

1. The final ground surface along the pipeline is shown in Figure 2.5.G-3 and is labeled on this figure as either the ground surface, 1977, or existing ground surface.

2. Estimated settlements induced by the fill and backfill in Areas of Concern Nos. 11 and 12 range from 0.25 to 0.75 inch in Area of Concern No. 11 based on the variations in soil thickness and are on the order of 0.5 inch in Area of Concern No. 12.

3. The shear modulus of the soils underlying the pipeline were estimated utilizing the data in Figures 2.5-83

and 2.5-89 and mean effective over-burden soil pressures (Table Q241.6-1).

In design of the buried piping, the variability of the supporting soil strata has been accounted for by conservatively choosing the design particle velocity and the apparent shear wave velocity.

4. Recent studies (Chaney 1978, and Martin et al, 1978) show that the resistance to liquefaction increase substantially following reduction of the degree of saturation to levels below 99%. Chaney states that a degree of saturation in excess of 99% must be achieved before liquefaction occurs in less than 1000 cycles. Martin et al, shows that the stress ratio required to cause liquefaction in 10 cycles for loose sands (relative density 45%) increases by approximately 100% to 200% when the degree of saturation decreases from 100% to 99% and 98%, respectively.

The ground water table was not encountered within the soils which underlie the pipeline in Areas of Concern 11 and 12. The moisture content determined by testing samples obtained during the investigation along the pipeline range from 2.5% to 17.4% with a mean value of 10.6%. Assuming a minimum void ratio of 0.60 for the loose sands, this moisture content corresponds to a mean degree of saturation of 47%. Air filled pore space, therefore, makes up approximately 20% of the soil matrix, i.e., for a 10-foot thick deposit to become saturated, a water column of 24 inches must infiltrate and remain in the soil.

Since liquefaction will not occur, the settlement caused by seismically induced loads were calculated based on Silver and Seed, 1971, and Pyke et al, 1975. The estimated maximum settlements, according to these procedures, in Areas of Concern 11 and 12 are 1.5 and 0.5 inches, respectively.

Since the soil profiles in the sections in question appear to be relatively homogeneous with respect to permeability characteristics, i.e., obvious impervious layers were rarely encountered in the borings, and since the bedrock contains numerous joints and fractures, most of the water that infiltrates the soils along the pipeline route should be quickly lost by percolation through the near-surface soils and joints and fractures in the bedrock. During summer months, transpiration and evaporation will account for additional loss of soil moisture. Therefore, it appears that the geohydrological conditions in the area are not conducive to the development of perched water conditions or saturation of the subsurface soils. The soils underlying the pipeline, therefore, are not susceptible to liquefaction.

REFERENCES

1. R. C. Chanel, "Saturation Effects on the Cyclic Strength of Sands," Earthquake Engineering and Soil Dynamics, Volume 1, American Society of Civil Engineers, New York, pp. 342-358, 1978.

2. G. R. Martin et al, "Effects of System Compliance on Liquefaction Tests," Journal of the Geotechnical Engineering Division, Volume 104, No. GT4, American Society of Civil Engineers, pp. 463-479, 1978.

3. R. Pyke et al, "Settlement of Sands Under Multidirectional Shaking." Journal of the Geotechnical Engineering Division, Volume 101, No. GT4, American Society of Civil Engineers, pp. 379-398, 1975.

4. M. L. Silver, and H. B. Seed, "Volume Changes in Sands During Cyclic Loading," Journal of the Soil Mechanics and Foundation Division, Volume 97, No. SM9, American Society of Civil Engineers, pp. 1171-1182, 1971.

TABLE 241.6-1

SHEAR MODULUS FOR SOILS ALONG THE ESWS PIPELINE

DEPTH FEET	EFFECTIVE OVERBURDEN PRESSURE, PSF	MEAN EFFECTIVE PRESSURE PSF	DYNAMIC SHEAR MODULUS Gmax, KSF
Upland Section			
5	650	430	1,330
10	1,300	870	1,880
15	1,850	1,230	2,240
20	2,400	1,600	2,560
25	2,950	1,970	2,840
30	3,500	2,330	3,090
35	4,050	2,700	3,320
40	4,600	3,070	3,540
Flood Plain Section			
5	670	450	1,910
10	1,040	690	2,360
15	1,400	930	2,740
20	1,760	1,180	3,090
25	2,130	1,420	3,390
30	2,490	1,660	3,670
35	2,850	1,900	3,920
40	3,220	2,150	4,170
45	3,580	2,400	4,410
50	3,940	2,630	4,610
60	4,670	3,110	5,020
70	5,390	3,600	5,400
80	6,120	4,080	5,750
90	6,850	4,570	6,080
100	7,570	5,050	6,400
110	8,300	5,530	6,700
115	8,660	5,770	6,840

QUESTION 241.7

"Concrete Cracks

During our site visit of May 19, 1981, cracks were observed in the mat connecting the two essential cooling towers. Investigate and determine the cause of the crakcs."

RESPONSE

Cracking was observed on the two longitudinal short walls between the cooling towers and on the end transverse walls. Two types of cracks were obsreved on the longitudinal short walls: shrinkage cracks affecting the surface of the concrete; and cracks at the construction joints between the short walls and the end transverse walls. The shrinkage cracks are narrow, less than 0.001 inch, and random in nature. The construction joints cracks are caused by the seasonal thermal movement of the end transverse walls. The end short walls are not part of the lateral load resisting system. At the end transverse walls, vertical cracks were observed. These are shrinkage and thermal cracks. Horizontal cranks in these walls, at about 2 feet from the top surface of the mat foundation, are thermal cracks caused by the contraction of the hot water basin. Both the shrinkage and the thermal cracks are on the order of 0.001 inch wide or less. On the outside surface of the end transverse walls and on the longitudinal short walls, some diagonal cracks and wedge shaped cracked concrete were observed. These are localized cracks caused by the alternating thermal movements of the end transverse walls. These localized cracks do not affect the structural resisting capability of the cooling tower. Additionally, the towers are founded on rock, and no settlement pattern of cracks can be seen.

Shrinkage cracks and horizontal thermal cracks are typical of structures the size of these cooling towers. The observed crack widths are less than the limiting crack width of 0.013 inch allowed in Section 10.6 of the ACI 318-77 "Commentary on Building Code Requirements for Reinforced Concrete." The cracks observed do not reduce the structural resistance capability of the towers. Therefore, no structural repair is needed. Spalled concrete at the construction joint will be repaired and a flexible sealer will be placed at the joint between the longitudinal short walls and the end transverse walls.