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July 15, 1978

Mr. R.F. Fraley, Executive Secretary
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Beaver Valley Power Station-Unit No.1-Soil Study, Category I Structures

Dear Mr. Fraley:

In his letter of March 24, 1978, Mr. Ragnwald Muller forwarded a request from Dr. W. Kerr that I review papers No. (1), (2), and (3), noted below, and return my comments on NRC Staff actions thereon. In reviewing these papers, I noted that a report of laboratory tests was anticipated on April 1, 1978, and I requested this report. The paper covering laboratory soil tests, noted as (4) below, was sent to me on June 5, 1978.

(1) Summary of Meeting with Dusquesne Light Company on Nov. 15, 1977, to discuss the Soil Study Program at Beaver Valley Power Station-Unit No.1 (U.S. NRC letter, 12/22/77)

(2) Soils Study-Category I Structures (Response to NRC letter of 11/17/76) Beaver Valley Power Station- Unit No.1. Duquesne Light Company, Feb., 1977.

(3) Supplement to Soil Study-Category I Structures (Response to NRC Meeting of 11/15/77) Beaver Valley Power Station-Unit No.1. Shippingport, Pa., Jan.13, 1978.

(4) Supplement No.2 to Soil Study-Category I Structures (Response to NRC Meeting on 11/15/77), Beaver Valley Power Station-Unit No.1, Shippingport, Pa., May 1, 1978.

The procedures described in paper (3) represent the present state-of-the-art for evaluating the liquefaction potential of soils, based on observations from previous earthquakes. The improvements to include the effect of gravel on the observed blow count and the reanalysis of N_1 values, based on recently published C_N curves were needed to update the previous study. From this study it appears that liquefaction should not occur during the simultaneous occurrence of the SSE and the 25-year flood. I agree with this presentation.

PDR

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The NRC staff request for a check on potential liquefaction based on laboratory test data seems reasonable. Paper (4) describes the tests, briefly, and gives most of the test data. The results of the laboratory tests also indicate that liquefaction should not occur during the simultaneous occurrence of the SSE and the 25-year flood. However, some details of the testing program are not adequately described in the paper (4), and it would assist evaluation of the presentation if information could be obtained from Duquesne Light Company (or Stone & Webster) concerning the following points.

(a) In the triaxial tests it is indicated that the reconstituted samples were-"anisotropically consolidated and tested isotropically-". The Summary Sheet in Appendix A of paper (4) gives $\bar{\sigma}_c$ which should be the isotropic effective confining pressure. However, I find no indication of the anisotropic consolidation pressures.

(b) The cyclic triaxial test data have the usual appearance, but the stress history applied to each sample is not clearly identified. For example, from p.5,"Initially a sample (Test No.1) was anisotropically consolidated, backed off to isotropic conditions and statically tested by increasing the pore pressure to approximately 85 percent of the chamber pressure. The pore pressure was then gradually released and the change in volume recorded as the pore pressure dissipated. The sample was then cyclically loaded for 10 cycles at a stress ratio of 0.09." Then, apparently after all pore pressures had dissipated, the sample was tested in the undrained condition at $\bar{\sigma}_c$ = 39.6 psi and $(\sigma_1 - \sigma_3)_{cy}$ = 11.2 psi. until liquefaction occurred at about 46 cycles. It would be useful to have the stress histories defined for each sample.

(c) The dynamic settlement analysis described on p.5 of paper (4) was based on the average of the pore pressures developed in the three samples after 8 cycles, as noted in Appendix B. I do not find numerical identification of $\bar{\sigma}_c$ applied to these samples, but the text, p.5, states,-"A stress ratio of 0.09 corresponds to the applied shear stress during the SSE for the deepest sample of interest." The value of $\bar{\sigma}_c$ is 46.8 psi (from Summary Sheet) for the deepest sample. Then the stress ratio of 0.09 requires that $\sigma_1 - \sigma_3$ = 8.42 psi, which checks with the value scaled from the Test#1 and Test#3, Cyclic Stress, Strain, and Pore-Water Pressure Time History plots in Appendix B. The stress ratio of 0.12 gives $\sigma_1 - \sigma_3$ = 11.2 psi, which also checks with the diagram. At 8 cycles the $\Delta U/\bar{\sigma}_c$ values scaled from the diagram are about 0.11 and 0.09 for Tests#1 and #3, and 0.24 for Test#2. An average of these three values is less than the 0.16 noted on p.6. There is no indication of how the value for Test#2 was

corrected to correspond to a stress ratio of 0.09, or why the maximum value from the three tests was not used.

The section in paper (4) covering Dynamic Settlement Analysis should be amplified to include a complete description of the tests and method of analysis.

Conclusions:

From a review of the papers (1) through (4), I am satisfied that the present state-of-the-art has been followed to evaluate the liquefaction potential of the loose soils below Beaver Valley Power Station-Unit No.1. The factor of safety against liquefaction is calculated to be adequate. I do suggest that the section on Dynamic Settlement Analysis in paper (4) be amplified for the benefit of future readers.

Very truly yours,

F.E. Richart, Jr.

F.E. Richart, Jr.
W.J. Emmons Professor
of Civil Engineering

FER/b