Attachment 2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 30 1982

Docket No. 50-155

MEMORANDUM FOR: William T. Russell, Chief
Systematic Evaluation Program Branch
Division of Licensing

FROM: George Lear, Chief
Hydrologic and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: GEOTECHNICAL REVIEW OF SEISMIC SAFETY MARGIN STUDY

Plant Name: Big Rock Point Nuclear Power Plant
Owner/Licensee: Consumers Power Company
Docket Number: 50-155
Responsible Branch: SEPB, T. Cheng, LPM
Document Reviewed: D'Appolonia, April 1982 - "Report on Parametric Study, Soil-Structure Interaction, Big Rock Point Nuclear Power Plant, Charlevoix, Michigan," A report for Consumers Power Company

This memo is in response to a verbal request from K. Herring of SEPB during a meeting on May 24, 1982, to B. Jagannath of HGEB for staff's opinion on statements in the above document on the low bound value of the soil shear modulus used in the soil-structure interaction analysis (SSI).

My staff has: (1) reviewed the above report, (2) reviewed a report on ground motion amplification at this site, and (3) had telephone discussions with the licensee's representative. The attachment to this memo presents the references and the results of our review.

My staff has concluded that the range of the soil shear modulus values used in the parametric study by the licensee adequately envelopes the expected range of values appropriate for SSI analyses at the Big Rock Point plant. However, the staff does not agree with the licensee's statement that 80 percent of the low-strain modulus is a reasonable representation of the low bound value of the shear modulus at BRP (see conclusions, page 6 of attachment). The staff position for the range of soil modulus values is shown in Figure 1 (Table) of the attachment.

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This memo was prepared by Dr. B. Jagannath of my branch; he may be reached at 492-8368.

Original signed by George Lear

George Lear, Chief
Hydrologic and Geotechnical
Engineering Branch
Division of Engineering

Enclosure:
As stated

cc: J. Knight
G. Lear
R. Jackson
L. Heller
T. Cheng
K. Herring
B. Jagannath

*SEE ATTACHED FOR PREVIOUS CONCURRENCES

OFFICE	HGEB:DE	HGEB:DE	HGEB:DE				
SURNAME	*BJagannath/mc	*LHeller	GLear				
DATE	7/27/82	7/28/82	7/31/82				

Geotechnical Review of Seismic Safety Margin Study
Big Rock Point Nuclear Power Plant
Charlevoix, Michigan

By Banad N. Jagannath, GES, HGEB, DE

Introduction

The Big Rock Point Nuclear Power Plant (BRP) is an SEP (Systematic Evaluation Program) plant and the licensee has completed Seismic Safety Margin Study for the plant. As part of this study, the licensee performed a parametric study of the effects of changing the soil modulus values (Reference 1). The parametric study was to be in compliance with the guidelines (Reference 2) recommended by a Senior Seismic Review Team (SSRT). The licensee's study is not in full compliance with the SSRT guidelines and the parametric study report takes exception to the SSRT recommendation on the low bound value of the shear modulus to be used in the soil-structure interaction (SSI) analysis. This attachment presents the staff's opinion on the above position by the licensee and staff's conclusions on the range of shear modulus for the soil to be investigated in SSI analysis at the BRP site.

SSRT Recommendations for Parametric Study

The parametric study, as per recommendations of the SSRT, is intended to account for uncertainty associated with the determination and use of soil shear modulus in the dynamic analysis. The SSRT recommended guide lines are:

"To account for uncertainty in soil properties, the stiffnesses (horizontal, vertical, rocking and torsional) employed in the analysis shall include a range of soil shear moduli bounded by (a) 50 percent of the modulus corresponding to the best estimate of the large-strain condition, and (b) 90 percent of the modulus corresponding to the best estimate of the low-strain condition. For purposes of structural analysis, three soil modulus conditions generally will suffice corresponding to (a) and (b), above, and (c) a best estimated shear modulus".

Figure 1 shows the range of shear modulus values to be used in the analysis as per the above recommendations. Generally, the modulus determined from field geophysical tests (cross-hole survey) is considered as a low-strain (10^{-4}% strain) modulus. Large-strain is the maximum strain in the soil estimated for the seismic design conditions.

Parametric Study by the Licensee

The parametric study report by the licensee states that:

(1) The best estimate shear modulus is 90 percent of the low-strain shear modulus (low-strain shear modulus from cross-hole survey data, Reference 3).

(2) The licensee's parametric study envelopes $\pm$ 50 percent variation of the low-strain shear modulus.

Licensee has performed SSI analyses using the above range of shear modulus. The low bound shear modulus value used (50 percent of the low-strain shear modulus) is not in compliance with the SSRT guidelines (50 percent of the large-strain shear modulus). The licensee states that 80 percent of the low-strain shear modulus is a reasonable representation of the low bound value of the shear modulus, and that 50 percent of the large-strain shear modulus is an extreme low bound value, considered very unrealistic for the BRP site.

Figure 1 shows the range of shear modulus investigated by and recommended by the licensee.

As a basis for the above statements, the licensee states that: (1) the subsurface material at this site is very competent, (2) for the design basis earthquake (zero period acceleration (zpa) 0.12g) a large strain condition generally greater than 10^{-3} percent will not occur and (3) reduction in shear modulus associated with such strain level is 10 percent of the low-strain shear modulus.

Review by the Staff

Staff has reviewed the licensee's parametric study report (Reference 1), geophysical test data from the BRP site (Reference 3), and results of SHAKE analyses performed (in connection with site amplification studies) by the staff's consultant, Lawrence Livermore Laboratory (LLL) (Reference 4). In

addition, staff had the benefit of discussion with the licensee's representatives via telephone on July 12, 1982. Based on the above, the staff has formed the following opinions:

1. The magnitude of soil shear modulus is strain dependent and the range of shear strain under seismic design condition should be considered in selecting the values of the shear modulus to be used in SSI analysis.

   The magnitude of the large-strain (maximum shear strain not greater than 10^{-3} percent) mentioned in the licensee's report was computed using a simplified procedure (Reference 5). However, results of the SHAKE analyses by the staff's consultant, LLL, indicate that the maximum shear strain as a result of a 0.1g (zpa) earthquake at this site is approximately 5×10^{-3} percent. The staff believes that the strain predicted from the SHAKE analyses are representative of the strain condition to be expected at this site.

   For this soil (till), the reduction in the shear modulus is approximately 10 percent at a shear strain of 10^{-3} percent and is approximately 25 percent at a shear strain of 5×10^{-3} percent, based on Murphy et al 1978, Reference 6. The staff recommends that the reduced shear modulus for the large-strain condition at BRP site (shear strain 5×10^{-3} percent) should be about 75 percent of the low-strain modulus.

2. The geotechnical data for the BRP site indicates that

   - fairly uniform subsoil conditions exist within the limits of the plant,
   - the predominant load bearing material, glacial till, is a very stiff material,
   - the scatter in the geophysical cross-hole survey data is approximately ± 7 percent,
   - the shear wave velocity of the till material (determined from cross-hole survey) is in general agreement with the values of shear wave velocities determined for similar till materials at other projects in Michigan and the Northern midwest region. The measured shear wave velocity is a reasonable representation of the dynamic property of the soil at the site.

3. The SSRT guidelines were developed to cover all possible site conditions and is conservative. The in situ shear wave velocity data for the BRP site shows a scatter of only ± 7 percent from the mean value. In addition to this, the mass inhomogeneity and nonlinear effects of soil at higher strain levels is estimated to result in a total of approximately ± 30 percent accuracy in determining the shear modulus of the soil. Therefore, considering the quality of the geotechnical data for this site, the low bound value of the shear modulus to be investigated in the

parametric study may be limited to a 33 percent reduction in shear modulus rather than the 50 percent reduction recommended in the SSRT Guidelines.

Conclusions

1. The staff does not agree with the licensee's statement that 80 percent of the low-strain modulus is a reasonable representation of the low bound value of the shear modulus at BRP.

2. The shear modulus for the large-strain condition is expected to be about 75 percent of the low-strain modulus at the BRP plant.

3. The SSI parametric study should envelope $\pm$ 33 percent variation from the best estimated shear modulus vs shear strain curve (See Figure 1).

4. The low bound shear modulus which was used for this soil is 33 percent less than the large-strain modulus.

5. The licensee's parametric study included a $\pm$ 50 percent variation of low-strain shear modulus; this envelopes the range of values of the shear modulus estimated by the staff. Figure 1 shows the staff's recommendation of the range of shear modulus values to be used in the SSI analyses at BRP.

References

1. D'Appolonia, April 1982 - "Report on Parametric Study, Soil-Structure Interaction, Big Rock Point Nuclear Power Plant, Charlevoix, Michigan, a report for Consumers Power Company.

2. Newmark, N. M., et al (1980), "SSRT Guidelines for SEP Soil-Structure Interaction Review", Letter to USNRC, SEP Branch, Division of Licensing December 8, 1980.

3. D'Appolonia, January 1979 - "Report, Geophysical Cross-Hole Survey, Big Rock Point Nuclear Power Plant, Charlevoix, Michigan," a report for Consumers Power Company.

4. Lawrence Livermore National Laboratory, 1982, "Assessment of the Need to Correct the Probabilistic Spectra Developed for the Big Rock Point Site to Account for the Site's Soil Column", a report to Geoscience Branch, NRC, June 17, 1982.

5. Seed, H. B., and Idriss, I. M., 1971, "Simplified Procedure for Evaluation of Soil Liquefaction Potential," Journal of the Soil Mechanics and Foundations Division, ASCE, September, SM9.

6. Murphy, D. J., et al, 1978, "Dynamic Properties of Hard Glacial Till," Earthquake Engineering and Soil Dynamics, ASCE Speciality Conference, Pasadena, California.

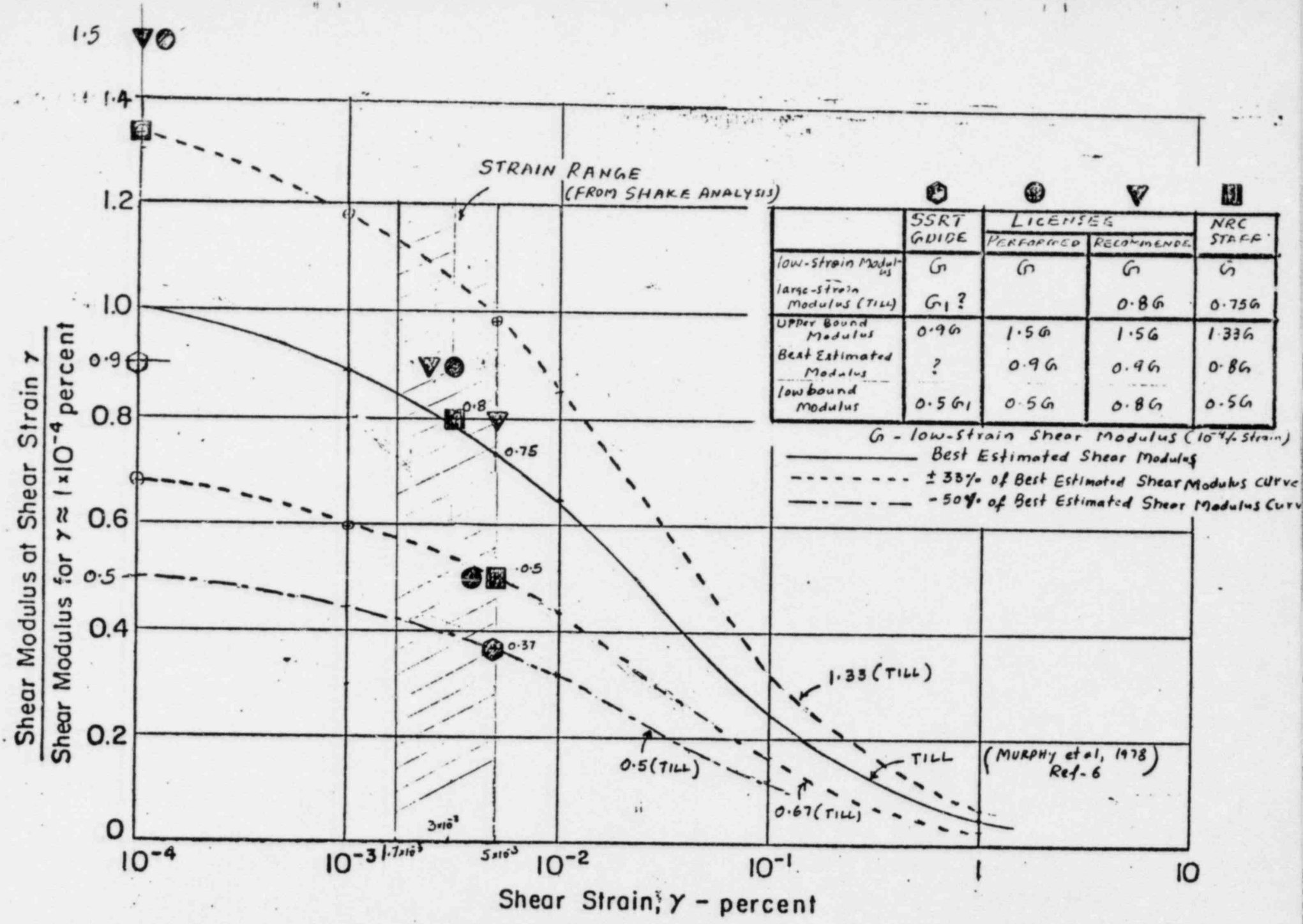

Fig. 1 TYPICAL REDUCTION OF SHEAR MODULUS WITH SHEAR STRAIN FOR TILL AT BIG ROCK POINT SITE