DEC 2 2 1980

Docket No.: 50-70

MEMORANDUM FOR: Robert A. Clark, Chief
Operating Reactors Branch No. 3
Division of Licensing

THRU: James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

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

SUBJECT: DRAFT SER SUPPLEMENT - GEOTECHNICAL ASPECTS

Plant Name: General Electric Test Reactor
Project Manager: C. Nelson, LPM

References:

1. Letter, with enclosure, dated October 27, 1980, to R. Darmitzel, Manager, Irradiation Processing Produce Section, General Electric Company, from D. Eisenhut Director, Division of Licensing, NRC.
2. Letter, with attachment, dated December 3, 1980, to D. Eisenhut, NRC from D. Gilliland, GE, subject "Analysis of the Subgrade Rupture Mechanism at the General Electric Test Reactor - License TR-1 Docket 50-70."

Reference 1 indicated that additional work by the staff and applicant would be necessary regarding the effects of soil properties on the seismic analysis of the GETR. Reference 2 was submitted by the licensee and has been reviewed by my staff. Enclosed is our report entitled "Evaluation of Soil Properties and Sub rade Rupture Mechanism Analysis" to be included as Appendix B to the enclosure to Reference 1. This report was prepared by Messrs. Pichumani, Philip, and Greeves, Geotechnical Engineering Section, Hydrologic and Geotechnical Engineering Branch.

Based on our review of Reference 2, we conclude that, under a combined load case comprised of a ground acceleration vibratory motion and a subgrade rupture offset due to thrust faulting in the reactor region, a potential fault plane located beneath the reactor will be deflected away from the base of the reactor slab because of the influence of the weight of the reactor and the surrounding soil surcharge on the shearing resistance of the soil beneath the reactor.

We suggest that the last sentence of the first paragraph on page C-8 in Section II-C of the enclosure to reference 1 above should be amended to read as follows:

However subsequent geotechnical engineering analysis, described in Appendix B, demonstrates that the postulated "unsupported cantilever length" is not expected to develop, for the combined load case comprised of a ground acceleration vibratory motion and a surface rupture offset because the fault plane will be deflected away from the base of the GETR foundation mat.

Original signed by George Lear

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

Enclosure:
As stated

cc: R. Vollmer
J. Knight
G. Lear
L. Heller
J. Philip
R. Pichumani
J. Greeves
C. Nelson
R. Jackson
R. Morris, USGS

HGEB:DE
JGreeves
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JPhilip/mc	RPichumani	LHeller	GLear	JPKnight
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Appendix B

Evaluation of Soil Properties and Analysis of the Subgrade Rupture Mechanism at the General Electric Test Reactor

Reviewed by: J. Greeves, R. Pichumani, J. Philip, and L. Heller, HGEB, NRR

BACKGROUND

This report is an evaluation by the NRR geotechnical engineering staff of the results of analyses and investigations presented by the General Electric Company to evaluate the soil pressures at the foundation subgrade interface, beneath the GETR reactor and to determine the effects of combined vibratory motions due to an earthquake and surface rupture offset caused by the postulated Verona fault. This evaluation is based on a review of references given at the end of this report, on numerous telecons, and meetings between NRC and GE.

General Electric and their consultants have made extensive studies to evaluate the soil properties of the subgrade beneath the reactor. Subsurface conditions in the vicinity of the GETR were interpreted from borings, and recent trenches, and geologic mapping of the area. The investigations revealed that the base of the GETR foundation mat, which is located 20 feet below grade, is underlain by very dense clayey sand and gravel with occasional layers of very dense sandy and/or gravelly clay to a depth of 70 feet (Ref. 1). For a description of the soil profile below a depth of 70 feet from the ground surface, indirect geologic evidence must be sought in the Livermore Formation (bedrock in this region) below that depth. Of potential significance is a hard, cemented stratum known as the middle conglomerate unit of the Livermore Gravels, which crops out in hills on the west and south of the site. However, projection of this stratum beneath the GETR places it at a depth of 200 feet or more, which is below the level considered as subgrade in this analysis (Ref. 4).

SOIL PROPERTIES

Standard Penetration Tests performed (References 1 and 2) on the materials underlying the GETR foundation mat show blow counts of from 50 to 100 blows/ foot penetration, affirming to the very dense nature of these soils. Groundwater levels at GETR were shown to vary from 20 feet to 28 feet below plant grade (Ref. 4). Laboratory testing was conducted to ascertain soil parameters for design (References 1, 2 and 3). For purposes of fault plane analysis, (Ref. 4) soils beneath GETR were assigned drained strength parameters of c' = 0 and Ø' = 36° and an undrained shear strength of 4000 psf for soils fully saturated. The selected strength parameters are reasonable bounding values for the analysis of fault plane behavior.

BEARING CAPACITY HYPOTHESIS

Based on their soil properties evaluation, GE proposed an analytical model to determine the load limits on the foundation due to the combined loading case comprised of a ground acceleration vibratory motion and a surface rupture offset (i.e., vertical slip) of one meter (Ref. 5). The surface rupture offset was represented analytically as an "unsupported length" of the reactor foundation slab. Engineering Decision Analysis Company (EDAC), who proposed the above analytical model, determined an ultimate bearing capacity of 20 ksf for the subgrade beneath the reactor based on their interpretation of the soil properties.

Using 20 ksf as the ultimate bearing capacity of the soil, EDAC performed analyses for several cases of unsupported lengths. Figure C-1 in Section IIC of this SER shows a plot of the horizontal ground accelerations (at which incipient local yielding of the soil occurs) as a function of unsupported lengths. "Incipient local yielding" was defined by EDAC to mean the loading combination that produces bearing pressure at the edge of the supporting soil equal to the ultimate bearing capacity.

The NRC geotechnical engineering staff, who reviewed the EDAC report, did not agree with the value of 20 ksf for the ultimate bearing capacity of the soil beneath the reactor building because the chosen undrained strength values were the lowest tested strengths and because overburden soils were not considered. Discussions between the NRC staff and the applicant's soils consultant, Earth Sciences Associates (ESA), and preliminary calculations, resulted in the possibility that an unsupported cantilever condition was not likely to occur beneath the reactor. GE revised their original subgrade model and performed additional calculations to support this latter position (Ref. 4).

FAULT PLANE ANALYSIS

The NRC Staff concurred with the approach used by Earth Sciences Associates to show that the previously hypothesized cantilever condition is not expected to materialize. Briefly, the analysis technique consists of a comparison of the static stability of two-dimensional soil wedges formed by thrust fault planes meeting the reactor foundations at different locations. As described in reference 4, the hypothetical thrust fault is visualized as a passive Rankine wedge being pushed by a major principal stress, P_p.

For soil strength parameters $c' = 0$, and $\phi' = 36^\circ$ the preferred failure surface (defined as the plane requiring a minimum value of P_p) is inclined at an angle = $45 - \phi/2$ when there is no surcharge. With a surcharge load S, the optimum failure plane may vary, depending on the magnitude and distribution of the surcharge. By trial and error the most probable failure plane corresponding to the minimum value of P_p was obtained by GE for the low water table (drained) case. The locations of the failure planes were varied for an assumed wedge depth of 70 feet below the reactor foundation slab. The results of analyses by GE showed that, for the 21 feet of surcharge of the GETR, the preferred failure plane passes through the edge of the slab. This indicates that a thrust fault plane will be deflected away from the base of the reactor slab because of the weight of the reactor and the surcharge. A similar behavior was observed in the 1972 Managua earthquake in Nicaragua (Ref. 6). Surface faulting occurred on a trace of the fault that passed under the Banco Central Building. Near the building, the rupture deviated from the active trace, and the building survived. Therefore, the theoretical calculations establish the validity of the assumption that a cantilever condition may not materialize.

As a check on the licensee's work, the NRC geotechnical staff performed additional calculations for an assumed wedge depth of 100 feet, and found the above findings to be correct for the 21 feet surcharge load. The staff noted that this result was dependent on the presence of the 21 feet high surcharge within about 170 feet of the reactor building. If, for any reason, a significant part of this surcharge were excavated a reevaluation would be necessary.

General Electric has also performed calculations using assumed undrained strength parameters of $c' = 4000$ psf and $\varnothing' = 0°$ that would be appropriate for very rapid loading of a saturated subgrade for the high water table condition. In this case also they found that the preferred failure planes (that required minimum passive pressure) did not fall beneath the reactor or within the zone that may create a cantilever span of the reactor mat. (Ref. 4). The NRC geotechnical staff also analyzed the three-dimensional aspects of the failure plane deflection around the GETR and found that the conclusion based on a two-dimensional analysis remains valid.

CONCLUSIONS

The above evaluation of the soil properties and the subgrade rupture mechanism indicates that Figure C-1 in Section II-C remains an acceptable and conservative representation of the limiting load combinations resulting from the specified design basis events because the cantilever condition hypothesized is not expected to occur. The "incipient local yielding" and "limiting load combinations" curves shown in this figure therefore shrink to a point at the origin of figure C-1 and become a conservative bound on this point.

References

1. Shannon and Wilson, 1973, 'Investigation of Foundation Conditions G.E. Test Reactor: for URS - John A. Blume and Associates.

2. Dames and Moore, 1960, "Foundation Investigation, Proposed Boiling Water Reactor, Vallecitos Atomic Laboratory, California, February 1978: report to General Electric Co., Vallecitos, California.

3. Earth Sciences Associates, (August 1980, GETR Stability Analysis, report for General Electric Company, Vallecitos Nuclear Center, Pleasanton, California.

4. Earth Sciences Associates, December 1980, Analyses of the Subgrade Rupture Mechanism at the General Electric Test Reactor submitted by the General Electric Company, Pleasanton, California to Mr. Darrell G. Eisenhut, Director, Division of Operating Reactors, NRC.

5. Engineering Decision Analysis Company Inc., June 1980, Expanded Description of Soil Pressure Analyses, Supplement No. 1 to "Additional Investigations to Determine the Effects of Combined Vibratory Motions and Surface Rupture Offset Due to an Earthquake on the Postulated Verona Fault."

6. L. Cluff, K. Weaver and M. Niccum, Zoning for Surface Fault Rupture, Managua, Nicaragua, Sixth World Conference on Earthquake Engineering, New Delhi, India, January 1977.