SEP 0 2 1982

Docket No. 50-29
LS05-82-09-009

Mr. James A. Kay
Senior Engineer - Licensing
Yankee Atomic Electric Company
1671 Worcester Road
Framingham, Massachusetts 01701

Dear Mr. Kay:

SUBJECT: SEP TOPIC II-4.D, SLOPE STABILITY
YANKEE NUCLEAR POWER STATION

We have completed our review of the subject topic for Yankee Nuclear Power Station at Rowe, Massachusetts. Enclosed is a copy of our evaluation report for this topic.

You are requested to examine the facts upon which the staff has based its evaluation and respond either by confirming that the facts are correct, or by identifying errors and supplying the corrected information. We encourage you to supply any other material that might affect the staff's evaluation of this topic or be significant in the integrated assessment of your facility.

Your response is requested within 30 days of receipt of this letter. If no response is received within that time, we will assume that you have no comments or corrections.

Sincerely,

SEO4

Ralph Caruso, Project Manager
Operating Reactors Branch No. 5 DSU USE(11)
Division of Licensing

ADD.
M. Boyle

Enclosure:
As stated

cc w/enclosure:
See next page

OFFICE	SEPB:DL	SEPB:DL	SEPB:DL	SEPB:DL	ORB#5:PM	ORB#5:BC	AD:SA:DL
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DATE	8/27/82	8/27/82	8/27/82	8/27/82	8/31/82	9/1/82	9/1/82

cc
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Systematic Evaluation Program Topic Assessment

Topic: II-4.D - Stability of Slopes
Plant Name: Yankee Nuclear Power Station, Rowe, MA
Docket Number: 50-029
Prepared By: Dinesh Gupta, Geotechnical Engineer, HGEB

I. INTRODUCTION

This topic pertains to the Geotechnical Engineering Review of the stability of slopes, whose failure could adversely affect the safety of the plant. The scope of the review embraces the following subjects which are evaluated using data developed by the licensee and information available from all sources:

1. slope characteristics;
2. design criteria and analyses;
3. results of field and laboratory tests;
4. excavation, backfill, and earthwork in slopes;
5. liquefaction potential affecting slopes; and
6. proposed instrumentation and performance monitoring.

II. REVIEW CRITERIA

The applicable rules and basic acceptance criteria pertinent to the review of this topic are:

1. 10 CFR Part 50, Appendix A: General Design Criteria 1, 2 and 4
2. 10 CFR Part 100, Appendix A

3. Regulatory Guides

   (a) Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants".

   (b) Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants".

III. RELATED SAFETY TOPICS AND INTERFACES

1. SEP Topic II-4.F "Settlement of Structures and Buried Equipment"

2. SEP Topic II-4, "Geology and Seismology"

3. SEP Topic III-1, "Classification of Structures, Components and Systems"

4. SEP Topic III-6 "Seismic Design Considerations"

IV. REVIEW GUIDELINES

In general, the review process was conducted in accordance with the procedures described in Standard Review Plan Section 2.5.5. The geotechnical engineering aspects of the design and as-constructed condition of slopes were reviewed and compared to current procedures and criteria and the safety significance of any differences was evaluated.

Pertinent reference documents not cited in SRP Section 2.5.5 are included in part V "Topic Evaluation".

V. TOPIC EVALUATION

The Yankee Nuclear Power Station at Rowe, MA is located in a small valley adjacent to the Deerfield River, east of the pond formed by Sherman Dam. The Nuclear Power Station is bordered on the north, east and south by Berkshire Mountains and by Sherman Dam on the west. The natural slopes of these mountains rise to heights of about 1,000 feet above the site to either side and immediately behind it. This staff assessment deals with the static and seismic stability of those slopes.

1. Slope Characteristics

The licensee has selected two cross-sections of the slopes to the southwest and southeast of the plant to be representative of all the on-site slopes. The slopes begin to rise up at a distance of about 150 feet from plant structures, and rise from about elevation 1030 feet to 2000 feet. The licensee has stated that the slopes on the east side of the plant structures are likely to be better from a stability point of view than slopes on the south side because of the presence of a wooded knoll at the toe of the slope with frequent rock outcrops. The staff agrees with the licensee that the analyses of two selected cross-sections would therefore, lead to conservative results.

The licensee has also stated that the slope topography along the above two cross-sections was surveyed in 1981 by New England Power Company. The profiles of the two selected cross-sections of the slope were

determined using this survey data. The licensee checked the accuracy of the profiles by superimposing data from an enlarged USGS 7.5 minute quadrangle sheet for Rowe, Mass.-Vt., and found good correlation. We find this procedure to be acceptable for determining suitable profiles for stability analyses.

2. Results of Field and Laboratory Tests

To meet the current criteria, a comprehensive program of site investigations including borings, sampling, geophysical surveys, test pits, trenches, and laboratory and field testing is usually carried out to define the physical characteristics of all safety-related soil and rock slopes. Also, a summary and description of static and dynamic properties of the soil and rock comprising all slopes whose stability would directly or indirectly affect safety-related facilities should be provided. The text should include a complete discussion of procedures used to estimate, from the available field and laboratory data, conservative soil properties and profiles to be used in the analysis. This information is needed for the staff to ascertain that the program of field and laboratory tests has been adequate to define the in situ soil and rock characteristics to be used in slope stability evaluations.

The licensee has conducted seismic refraction surveys, excavated five 10 ft. deep test pits, and conducted laboratory tests on samples taken from these pits. We find that the scope and applicability of the

results meets current licensing criteria, as explained in the following paragraphs.

The soil exploration related to the slopes at Yankee site consisted of seismic velocity measurements in 1978 by Weston Geophysical along seven lines using seismic refraction survey. These survey lines extend through part of the face of the slope at various locations. The results of the survey indicate that the surface of the bedrock is very irregular. Generally, the soil cover over the bedrock decreases at higher elevations and ranges from a few tens to about 200 feet in thickness along the slope. The shear wave velocity for soil cover ranges from 1500 to 2000 fps.

Results of five 10-feet deep field exploratory test pit-logs are available. These logs indicate the presence of lodgement till at shallow depths along the slope in the area of the test pits location. Lenses of both gravel and clay were observed in the till. The licensee, however, has concluded that these lenses are generally less than 50 feet in length and are rarely more than 100 ft long; so he ignored them in the stability analysis of the slopes. The staff finds this approach to be reasonable.

From triaxial test results on till samples obtained from the test pits, the licensee has assigned the following undrained shear strength parameters to the soils forming the slopes:

Depth	Angle of Internal Friction, Ø
0 to 30 feet	46°
30 to 90 feet	40°
Greater than 90 feet	35 °

The bedrock was assigned value of angle of internal friction of 70°. The groundwater along the slope was assumed at the surface.

Based on a review of the above information, the staff concludes that the scope of field and laboratory tests and the resulting values of shear strength parameters used in the analyses are reasonable and acceptable.

3. Design Criteria and Analyses

To meet current regulatory requirements, the discussion of design criteria and analyses is considered acceptable if

(a) Appropriate state-of-the-art methods have been employed.

(b) Conservative assumptions regarding soil and rock properties have been used in the analysis of slopes.

(c) Appropriately conservative margins of safety have been incorporated in the analysis.

To be acceptable, the static analyses should include calculations with different assumptions and methods of analysis to assess the following factors:

The uncertainties with regard to the shape of the slope, boundaries of the several types of soil within the slope and their properties, the forces acting on the slope, and pore pressures acting within the slope; failure surfaces corresponding to the lowest factor of safety; the effect of the assumptions inherent in the method of analysis used.

To be acceptable, the dynamic analyses must account for the effect of cyclic motion of the earthquake on soil strength properties. Actual test data are needed for in situ soils. The various parameters, such as geometry, soil strength, modeling method and hydrodynamic and pore pressure forces, should be varied to show that there is an adequate margin of safety. The results of stability analyses must be presented in tables identifying design cases analysed, strength assumptions for materials, and type of failure surface. Assumed failure surfaces should be graphically shown on cross sections and

appropriately identified on both the tables and sections. The computer analyses should be explained and justified and an abstract of computer programs used should be provided. If the safety factors resulting from the analysis are not appropriate to the hazards posed by a slope failure and other than clearly conservative soil properties and profiles were used, additional data should be obtained to verify assumptions, or to show that, even if the worst possible conditions are assumed, there is an adequate margin of safety.

The licensee used a computer program, SSTAB 1 (August 1974) written by Prof. Wright of University of Texas, Austin, TX to assess the static and seismic stability of the slopes. The staff finds that the method used in this computer program utilizes state-of-the-art technique. For static stability, the licensee calculated minimum factors of safety for the two analyzed cross-sections to be 1.46 and 1.62, respectively; these are acceptable static results.

The licensee also analyzed the two selected cross-sections for seismic stability using a pseudo-static approach; this is acceptable. The results indicate that the seismic coefficients for the two cross-sections, which reduce the minimum factors of safety to 1.0, are 0.15g and 0.19g respectively. Since the peak ground acceleration, for which

all components essential for equivalent safe shutdown of the plant must be analyzed, is 0.2g for Yankee site (see topic III-6, Seismic Design Considerations), the licensee's seismic analyses indicate slopes to be unstable.

In view of the above results from pseudostatic analysis of the stability of slopes, the licensee performed an analysis to evaluate the effect of potential slope failure on the plant safety. The two cross-sections previously selected for pseudo-static analysis were analyzed for predicting permanent displacements due to postulated seismic loads using Newmark's Method (Ref. 4). The results from the Newmark sliding block analysis show that the permanent displacements in the event of a slide due to seismic loads would be negligible. The licensee has concluded that these small displacements will not have any adverse impact on the plant safety. The staff finds this analysis procedure to be appropriate and the results to be reasonable.

VI. CONCLUSIONS

On the basis of the analyses performed and the available site data, the staff concludes that the stability of natural slopes at the Yankee Nuclear Power Station, Rowe, MA is adequate. Sufficient margins of safety exist against slope failure under postulated static loading conditions. For seismic loading, the predicted negligible permanent displacements of the slopes during earthquake should have no adverse impact on the plant safety systems.

VII. REFERENCES

1. Letter from J. A. Kay, Yankee Atomic Electric Company, to D. Crutchfield, NRC, Subject, "SEP Topic Assessment Completion (Topic II-4.D) February 26, 1982.

2. Letter from D. Crutchfield, NRC to J. A. Kay, Yankee Atomic Electric Company, Subject "Request for Additional Information for SEP Topic II-4.D, Stability of Slopes - Yankee Nuclear Power Station", March 31, 1982.

3. Letter from J. A. Kay, Yankee Atomic Electric Company to D. Crutchfield, NRC, Subject "Additional Information on SEP Topic II-4.D, Stability of Slopes", May 17, 1982.

4. "Effects of Earthquakes on Dams and Embankments", by N. M. Newmark, the Fifth Rankine Lecture, Geotechnique, 1965.

5. Undocketed, Information Package received from T. Cheng on August 19, 1982, containing discussion on (i) Information on Rock Knoll, (ii) Geologic Profile, (iii) Dynamic Stability of Natural Slopes, (iv) Slope Failure into Sherman Reservoir, and (v) Specification for Site Cleaning and Rough Grading for Yankee Atomic Electric Plant.