J. Knight

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

APR 06 1982

Docket Nos. 50-329/330

MEMORANDUM FOR: Robert L. Tedesco, Assistant Director
for Licensing
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: FINAL SAFETY EVALUATION REPORT - GEOTECHNICAL ENGINEERING

Plant Name: Midland Plant, Units 1 and 2
Licensing Stage: OL
Responsible Branch: Licensing Branch No. 4; D. Hood, LPM
Status: Continuing review and subject to ASLB hearing decisions

Enclosure 1 is the geotechnical engineering input for inclusion in the Midland Plant Safety Evaluation Report.

The following sections of this evaluation are essentially complete, except as may be impacted by the resolution of the HES concern regarding adequate height of the dikes to resist wave run-up:

Section 2.5.5 Stability of Slopes
Section 2.5.6 Embankment and Dams

SER Section 2.5.4, Stability of Subsurface Materials and Foundations, remains an open issue and is significantly impacted by the current hearings before the ASLB. In our input to SER Section 2.5.4 we have attempted to identify those seismic Category I structures and utilities which are affected by the plant fill problem and to indicate where the GES is essentially in agreement with the applicant's proposed remedial measures to improve foundation stability to acceptable requirements.

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This SER input was prepared by Joseph D. Kane, Geotechnical Engineering Section, Hydrologic and Geotechnical Engineering Branch.

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Geotechnical Engineering Summary

Midland Plant

Docket Numbers 50-329/330

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Midland Plant, Units 1 and 2

Docket Numbers: 50-329/330

Subject: Safety Evaluation Report - Geotechnical Engineering

Prepared By: Joseph D. Kane, HGEB, DE, NRR

2.5.4 Stability of Subsurface Materials and Foundations

This and following sections 2.5.5 and 2.5.6 provide the status and results of the Staff's geotechnical engineering review of the Midland Plant, Units 1 and 2 based on the Final Safety Analysis Report (FSAR) through Amendment 42, dated February 1982; 10 CFR Section 50.54(f) reports, entitled Responses to NRC Requests Regarding Plant Fill" and testimony presented during the current hearing sessions before the Atomic Safety and Licensing Board (ASLB) on the NRC December 6, 1979 Order Modifying Construction Permits No. CPPR-81 and CPPR-82. The stability of subsurface materials and foundations (FSAR Section 2.5.4), the stability of slopes (FSAR Section 2.5.5) and embankment and dams (FSAR Section 2.5.6) are being evaluated in accordance with the applicable criteria outlined in 10 CFR Part 50; 10 CFR Part 100; Appendix A of 10 CFR Part 100; Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 2; Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants"; Regulatory Guide 1.138 "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants"; and NUREG-0800, "Standard Review Plan, Sections 2.5.4 and 2.5.5.

The stability of subsurface materials, as exemplified by foundation problems for several of the seismic Category I structures, has been a major review area during the construction of the Midland Plant. These problems were caused by inadequate compaction of the plant fill. As a result, specialized remedial treatments such as underpinning are required to improve the foundation stability of nearly completed structures. Because the above references on review criteria do not explicitly provide guidance in this specialized area of foundation engineering, the adequacy of underpinning as a remedial fix is being evaluated, with the help of consultants, to state-of-the-art conservative criteria as recommended in NUREG-0800, Standard Review Plan, Section 2.5.4. Consultants who have assisted the Staff in the geotechnical engineering area of review include the U.S. Army Corps of Engineers and Geotechnical Engineers, Inc.

On December 6, 1979 the NRC Staff issued an Order Modifying Construction Permits which prohibited specified soil construction activities. On December 26, 1979 the applicant filed a request for a hearing before the ASLB. The actual ASLB hearings began in July 1981 and are currently nearing completion on the problems associated with plant fill. One of several reasons for the Staff's issuance of the Order was whether the applicant's criteria and design details on the variously proposed remedial measures were sufficient for the Staff to conclude with reasonable assurance that the affected safety-related structures would be adequately repaired to permit safe operation of the plant. Table 2.5 lists the seismic Category I safety-related structures and utilities which are known to be affected by the plant fill problem. This table also identifies the foundation problems which investigations have shown to exist and the various remedial measures currently proposed by the applicant to correct those problems.

Except for consideration of differential settlement that has already occurred for ~~resolution of~~ the Diesel Generator Building ~~foundation problem,~~ the Staff and the applicant have essentially reached agreement on the ~~concepts of the~~ remedial fixes. Resolution of design details to assure foundation stability and the implementation of adequate construction controls to safely complete this work are currently being worked out by the ~~between the Staff and~~ applicant for the variously proposed fixes. The Staff's evaluation of the stability of subsurface materials and foundations for seismic Category I safety-related structures and components will be presented in a supplement to this SER following the completion of the ASLB hearings and decision on the plant fill settlement problem.

2.5.5 Stability of Slopes

This section deals with the Staff's evaluation of soil slopes for static and dynamic stability which are associated with the main power plant facilities. The dike embankments associated with the cooling pond are discussed in Section 2.5.6. FSAR Figure 2.5-46 provides a plan view of both the plant area dikes and cooling pond dikes. Typical sectional views of plant area dikes are presented in FSAR Figures 2.5-49 and 2.5-50.

TABLE 2.5

SAFETY-RELATED STRUCTURES AND UTILITIES AFFECTED BY THE PLANT FILL PROBLEM

Structures	Foundation Support Problem	Proposed Remedial Measures
Control Tower	Void located beneath mudmat in fill soils	Underpin with permanent concrete wall extended to undisturbed natural soil.
Electrical Penetration Areas	Loose and soft fill layers	Underpin with permanent concrete wall extended to undisturbed natural soil.
Feedwater Isolation Valve Pits	Loose and soft fill layers	Replace loose and soft fill soils with compacted granular fill.
Railroad Bay	Liquefaction potential in loose fill	Eliminate problem with permanent dewatering system.
Diesel Generator Building	Experienced large settlements	Completed surcharge program to consolidate fill and accelerate settlement.
	Liquefaction potential in loose fill	Eliminate problem with permanent dewatering system.
Service Water Pump Structure	Loose and soft fill layers	Underpin with permanent concrete wall extended to undisturbed natural soil.
Diesel Fuel Oil Tanks	Isolated layer of loose fill	Not required because of limited extent
Borated Water Storage Tanks	Experienced large settlements and cracking of ring beam foundations.	Completed surcharge program to consolidate fill. Plan to construct new ring beam foundations and relevel Unit 1 tank
Underground Piping	Experienced large settlements	Replace or rebed lengths of pipes most affected by settlement or liquefaction. Rely on monitoring during plant operation for other piping lengths.

The plant area dikes form the northern boundary of the main power plant complex along the Tittabawassee River. In this area, approximately 35 feet of fill had been placed and compacted in order to raise the plant grade to elevation 634. On the easterly side of the plant area dikes, there is a transition into the cooling pond perimeter dike. This transition is the beginning of the boundary embankment that retains the large cooling pond; ie: the cooling pond dikes.

The materials within the plant area and cooling pond dikes were selected and placed to safely control seepage and to best utilize soil materials which were available from excavation of the cooling pond area. These materials were zoned (selectively placed) within the embankment to result in a stable slope that is capable of withstanding both static and dynamic loading.

The applicant has used results from his stability analysis on the cooling pond dikes to make conclusions on slope stability of the plant area dikes. Foundation conditions and embankment materials for the plant area dikes are similar to the cooling pond dikes. Also, the embankment materials were placed and compacted to comparable specifications. Since the applicant concluded that the more severe condition for slope stability would exist for the slightly higher cooling pond dike section, which has a lesser crest width, the applicant further concluded that the factor of safety against slope stability failure for the plant area dikes would be higher. We concur that this is an acceptable method for addressing the slope stability of the plant area dikes. Our evaluation of the cooling pond dikes is presented as part of the following Section 2.5.6.

2.5.6 Embankments and Dams.

2.5.6.1 General

This section presents the Staff's evaluation of slope stability for the earth fill embankments and excavation slopes. As shown on FSAR Figure 2.5-46 the earth fill embankments were constructed for flood protection and for impounding cooling water that is required for normal plant operation. In addition to the perimeter dikes (cooling pond dikes) which confine the approximately 880 acre cooling pond, there is an interior baffle dike whose function is to assure adequate circulation between the intake and outlet areas. In the northeast corner of the cooling pond, an area labeled the Emergency Cooling Water Reservoir (ECWR) has been excavated below the original ground surface for a depth ranging from 9 feet to 12 feet. The stability of the excavation or cut slopes of the ECWR is considered to be seismic Category I related because the function of the ECWR is to retain sufficient water, without allowing for make-up, for 30 days continuous cooling during plant shutdown (the ultimate heat sink). The perimeter and baffle dikes are not classified as Category I structures because, in the unlikely event that these dikes would fail and permit release of the cooling pond waters, sufficient cooling water would remain available in the ECWR for plant shutdown. Although the perimeter and baffle dikes are not classified as Category I, their failure has the potential to adversely affect the function of the two Category I emergency discharge conduits and the ECWR. Based on guidance provided in Regulatory Guide 1.29, "Seismic Design Classification," the Staff required that the design of the affected perimeter and baffle dike slopes be equal to Seismic Category I requirements. This requirement of the applicant was made by the Staff during the investigation of the plant fill problem and is discussed in detail in the ASLB transcripts for the August 7 and 11, 1981 hearing sessions.

2.5.6.2 Dike Section

Typical sectional views and foundation profiles of the perimeter dikes and ECWR are presented on FSAR Figures 2.5-53 through 2.5-60. Additional sectional views and subsurface information on the ECWR were provided by the applicant in the 50.54(f) reports in response to Question 45. The tops of the perimeter and baffle dikes were designed to be at elevation 632 except at the transition sections with the plant area dikes where the top rises to elevation 634. The operating level of the cooling pond water surface will be at elevation 627 with most of the cooling pond bottom surface between elevation 605 to 610. The bottom of the ECWR ranges between elevation 593 to 596. As previously indicated in Section 2.4.2 of this SER, the applicant is required to address the effect on the slope stability of the ECWR due to an estimated wave run-up reaching elevation 635.5 during the probable maximum flood condition.

The crest width of the perimeter and baffle dikes is 20 feet except at the northern section where it is widened to allow for railroad lines. The maximum height of the dike embankment is approximately 35 feet high. The dikes have interior slopes (pond side) of 1 vertical on 3-1/2 horizontal and outer slopes (river and property boundary side) of 1 vertical on 3 horizontal.

2.5.6.3 Dike Zoning and Materials

The baffle dike is not zoned but consists of random fill which is primarily clay with smaller amounts of silty sands. Both sides of the baffle dike slopes are protected with 18-inch thick riprap overlying a gravel filter that extends from elevation 615 to top elevation 632. The perimeter dikes are zoned embankments consisting of impervious and random fill sections and a clean sand chimney drain that separates the impervious and random fill zones. On the interior slopes 18-inch thick riprap protection has been placed over a gravel filter extending from elevation 615 to 632. The river side slope is protected with 18-inch thick riprap from original ground line up to elevation 614. From elevation 614 to top of dike elevation 632 the slope has been topsoiled and seeded for erosion protection. The 9 to 12 foot high excavated slopes of the ECWR are relatively flat ranging from 1 vertical on 5 horizontal to 1 vertical on 20 horizontal. The natural soils which are exposed in the ECWR excavation include clays, silty sands and glacial tills.

2.5.6.4 Foundation Preparation

Treatment of all dike foundations consisted of the removal of topsoil and surficial silts within the limits of the final dike section. To control seepage through the foundations of the outer perimeter and plant area dikes, cutoff trenches were excavated a minimum depth of 8 feet through the upper sand layers and 2 feet into the underlying soil of low permeability. In areas where the depth of the foundation sands were too deep or existing groundwater conditions made it impractical to fully penetrate the sands, a slurry trench cutoff was constructed to reach the lower impervious soils.

2.5.6.5 Subsurface Investigations

FSAR Figure 2.5-16 provides a plan view of the extensive number of borings or probes which were completed in the exploration program for the dike system. Most of these explorations had been completed before the dikes were constructed in order to define the top of the impermeable foundation layer and to permit undisturbed foundation soil samples to be recovered for laboratory testing. In June 1980, when the extent of the plant fill problem was known to be widespread, the Staff and its consultant (Corps of Engineers) recommended that seven additional borings be drilled in order to clearly demonstrate that the fill materials placed in the perimeter and baffle dikes in the vicinity of the ECWR had been adeqately compacted. Laboratory testing of samples recovered in the embankment materials was requested in order to establish that shear strength properties of the fill were equal to values assumed in design at the PSAR stage. The objective of the requested borings and testing, whose results were eventually provided to the Staff in July 1981, was to obtain reasonable assurance that the slopes of the perimeter and baffle dikes in the area of the ECWR would remain stable during years of plant operation under all anticipated conditions of loading.

The results of explorations in the foundations of Midland dikes indicate that the dikes are founded on very dense glacial till deposits in the northeastern and eastern portions of the cooling pond. The till materials are relatively impervious and broadly graded and include gravel, sand, silt and clays. From deeper explorations in the plant area it is known that the till materials extend to elevations between elevation 365 to 431 where the tills then overlie a very dense water bearing sand layer containing cobbles and boulders. Beneath the thick, very dense sand layer, the black shale of the Saginaw formation has been encountered. Buried channels and depressions do occur on the surface of the glacial till and have been found to be filled with a uniform silty sand. Over the western and southwest portion of the site the till is blanketed by a preconsolidated silty clay which is referred to as a lacustrine clay. The lacustrine clay has a maximum thickness of 13 feet in the southwest corner of the pond and disappears near the middle of the pond. Over much of the cooling pond area the dikes have been founded on a uniform silty sand of varying thickness which overlies either the lacustrine clay or glacial till.

2.5.6.6 Laboratory Testing

In order to analyze the stability of dike slopes the applicant initially had to establish the engineering properties of both the embankment and foundation materials by conducting laboratory testing on representative soil samples. Soil shear tests that duplicate the pore water draining conditions that these materials could potentially experience during the years of plant operation are the most important. Such data was obtained by the applicant. The design values of soil properties adopted by the applicant for use in analyzing slope stability are presented on Table 2.5-22 ~~25.-22~~ of the FSAR. The later results of testing, required by the Staff to demonstrate that acceptable engineering properties actually had been achieved in the constructed dike embankments, were provided in the applicant's report of July 27, 1981.

Based on the Staff's and its Consultant's review of the information provided by the applicant which includes the dike's section, zoning and materials, foundation preparation measures, the results of extensive subsurface explorations and laboratory testing to establish required engineering properties on both foundation and embankment materials, we conclude that the applicant has met the Commission's regulations, regulatory guides, applicable Standard Review Plans (NUREG-0800), and we find this information to be acceptable.

2.5.6.7 Slope Stability Analysis

The applicant analyzed the slope stability of the various dike sections by the circular arc method using soil properties found acceptable to the Staff. Analyses were conducted on perimeter and baffle dike sections of greatest embankment height, at locations considered to have the most unfavorable foundation conditions, and at locations with the greatest potential to impact the function of a seismic Category I structure. Stability conditions analyzed include after construction when excess pore pressures due to dike construction were assumed not to have dissipated; long term steady seepage condition with reservoir at pond operating elevation 627; rapid drawdown condition where rapid loss of cooling pond water was assumed to occur from elevation 627 to elevation 604; and seismic loading. The conditions analyzed and the resulting factors of safety are presented on FSAR Table 2.5-20 and in the applicant's testimony of August 11, 1981 before the ASLB. The stability of the dikes under seismic loading were initially analyzed by the pseudostatic method using a maximum seismic coefficient of 0.12g. In recognition of a potential increase in peak seismic ground acceleration that the Midland Plant could be required to address, the applicant also analyzed the dynamic stability of the dike embankment slopes using the Newmark method in order to calculate the dynamic yield acceleration of the cooling pond dikes.

The results of the applicant's slope stability studies indicate that the calculated factors of safety are acceptable and are appropriate and conservative for the stability conditions required to be analyzed. The results of the state-of-the-art Newmark method indicate that a maximum seismic peak acceleration well in excess of 0.19 g would have to occur to develop yield accelerations which would cause the dike slopes to suffer unacceptable movement.

Based on the Staff's and its Consultant's review of the stability studies conducted by the applicant which include conservative adoption of material properties, groundwater and loading conditions, we conclude that the studies are acceptable and the plant area dikes and the perimeter and baffle dikes in the vicinity of the ECWR will remain stable under static and SSE conditions. This Staff conclusion may be impacted by the resolution of the concern for adequate wave run-up which has been identified in Section 2.4.2 of this SER.

2.5.6.8 Instrumentation

Piezometers were installed before the pond was filled at two sections along the perimeter dike which parallels the Tittabawassee River. The piezometers were installed to record piezometric levels which develop during various operating conditions and to check the performance of the chimney drain and the effectiveness of the impervious cutoff and slurry trenches. The applicant will be requested to provide a commitment and a monitoring plan to visually inspect the diking system and to record and evaluate the results of the piezometric readings for comparison with design expectations during years of plant operation on a regularly scheduled basis.

2.5.6.9 <u>Contentions</u>

During the hearing process associated with the 1979 Order, a contention was raised on slope stability of the cooling pond dikes by Mrs. Barbara Stamiris (Contention 4.B). The safety concern expressed in this contention was that the slope stability of the cooling pond dikes was not assured because the dikes had been built with the same improper soils and procedures as the problem plant fill.

The Staff provided testimony before the ASLB on August 7, 1981 regarding this contention, and as previously stated in this SER, we have concluded that the slope stability of the cooling pond dikes has been acceptably demonstrated and that the materials placed and compacted in the diking system have been shown to have acceptable engineering properties.

2.5.6.10 Conclusions

Based upon the Staff's and its Consultant's review, ~~we~~ as summarized in the preceding paragraphs, we conclude that the plant area dikes and the perimeter and baffle dikes in the vicinity of the ECWR are stable under static and SSE conditions and will provide a reliable water retention system to permit safe operation of the Midland Plant.