UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CONSUMERS POWER COMPANY	)	Docket Nos. 50-329-OM & OL
	)	50-330-OM & OL
(Midland Plant, Units 1 and 2)		

TESTIMONY OF HARI NARAIN SINGH CONCERNING

AUXILIARY BUILDING

Q.1. Please state your name and position with the U.S. Army Corps of Engineers.

A. My name is Hari N. Singh. I am a Civil Engineer in the Geotechnical Branch of the Engineering Division, NCD Chicago District of the U.S. Army Corps of Engineers.

Q.2. How did the U.S. Army Corps of Engineers get involved in the review process of the Midland Plant, and what are the areas of its responsibilities?

A. Pursuant to an interagency agreement between the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Army Corps of Engineers (the Corps) which became effective in September 1979, the Corps undertook to provide technical assistance to the NRC. The Corps provides assistance on the geotechnical engineering aspects of the Midland Plant.

Q.3. Have you prepared a statement of your professional qualifications?

A. Yes, a copy is attached.

Q.4. Please state the nature of your responsibilities with respect to the Midland Plant.

A. My involvement with the Midland Plant began in May 1980, when I was assigned the responsibility as the Corps' lead reviewer of engineers and geologists of the Geotechnical Section of the Detroit District, who were engaged in reviewing the materials used in the foundation design of the plant. As the full-time lead reviewer, my responsibilities were to coordinate with all the reviewers, examine their comments, perform my own review, discuss comments with the Section Chief and prepare a final letter report to be transmitted to the NRC. The structures being reviewed include the following: 1) Auxiliary Building, 2) Reactor Building Units 1 and 2, 3) Diesel Generator Building, 4) Borated Water Storage Tanks Units 1 and 2, 5) Service Water Pump Structure, 6) Diesel Fuel Storage Tanks, 7) Seismic Category I Piping and

Conduits, 8) Retaining Walls, and 9) the dikes adjacent to the Emergency Cooling Water Reservoir (ECWR).

Q.5. What remedial measures did the applicant propose for the Auxiliary Building?

A. (a) The original remedial measures proposed by the applicant were reported in Interim Report 6, June 11, 1979, MCAR 24, 10 CFR 50.55(e). It consisted of; (1) pressure grouting to fill the void under the mudmat of the Control Tower; (2) removing unsuitable backfill materials from beneath the Electrical Penetration Areas (EPA) and the Feedwater Isolation Valve Pits (FWIVP), and replacing them with lean concrete with compressive strength of 2000 lbs per square inch.

(b) On 18 July 1979, in a meeting with NRC officials in Bethesda, MD, the applicant presented a new plan for the remedial measures for the Electrical Penetration Areas. The new plan called for providing caissons at the extremities of both the Electrical Penetration Areas. With the caissons' supports at the ends, the EPA's would act as propped cantilevers on either side of the Control Tower, relieving the fill materials under the EPA's from pressure created by the structure loads, and transmitting them to the competent natural soils through the caissons and to the foundation of the Control Tower. The remedial measures for the Feedwater Isolation Valve Pits remained same as original.

(c) On 5 May 1981, in its meeting with NRC the applicant presented another remedial action plan for the Electrical Penetration Areas. This plan consisted of providing solid concrete support instead of the caissons as mentioned in paragraph (b) at the extremities of both the EPA's, and also to extend the solid concrete support under the nearby Turbine Building to spread the structure loads on larger foundation areas to keep the foundation pressure under permissible limits.

(d) On 1 October 1981, in its meeting with the NRC and the Corps of Engineers, the applicant presented a plan for the remedial measures for the Auxiliary Building (EPA's and FWIVP's) which was different from the ones mentioned in paragraph (a), (b) and (c). This plan, the most recent one, calls for providing (1) continuous underpinning walls resting on undisturbed natural material, under the external walls of the Electrical Penetration Areas, the Control Tower, and the Feedwater Isolation Valve Pits; (2) three isolated supports to the Control Tower along a east-west line through the center of structure and parallel to its south external cross walls; and (3) underpinning wall supports to the external cross walls of the Control Tower, and also one intermediate cross wall support to each EPA. Attachment 1 shows the details of this remedial measure.

Q.6. Did the Corps of Engineers evaluate various remedial measures proposed by the applicant? If yes, then what were the results of its reviews?

A. The Corps of Engineers entered into an interagency agreement with the NRC in September 1979, to assist the NRC in evaluating the geotechnical aspects of the Midland Nuclear Power Plant. The remedial action for the

Auxiliary Building under consideration at that time was to provide caisson supports at the extremities of the Electrical Penetration Areas (See paragraph a, Question No. 5). Therefore, Corps did not evaluate the original remedial measures proposed by the applicant on 11 June 1979. The remaining three proposals have been evaluated by the Corps of Engineers, and the following are the review comments:

(a) Remedial action with caissons support (proposed on 18 July 1979):

(i) This proposal had effects of transforming the continuously soil supported EPA structures into propped cantilever structures, fixed with the Control Tower at one end and supported on caissons on the other end. Consequently, approximately half of the EPA's load (approximately 9000 kips) was going to be transferred on the Control Tower increasing the foundation pressure on the compacted fill supporting the structure resulting in additional settlements.

(ii) The design information about caissons: The capacity of each caisson to carry vertical and lateral loads, the capacity of caissons as a group (group effects), settlements of caissons' group, negative skin friction on the caissons due to future settlements of the fill materials in which caissons were to be installed, the bearing capacity and the factor of safety against shear failure of the soils supporting the caissons were not furnished. The Corps of Engineers, in paragraph d(e) of Page 6 of its letter report of 7 July 1980 (attachment No. 2), requested the applicant to furnish this information. The applicant response provided through Amendment 85 was not satisfactory. The Corps' report of 16 May 1981 attachment No. 3 (See Q. 42, Page 7) provides the reasons.

(iii) The soil parameters (shear strength parameters of fill materials and glacial till) controlling the design of caissons were not furnished. The Corps of Engineers requested the applicant through NRC to perform soil exploration testing on representative soil samples to obtain shear strength parameters.

(b) Remedial measures with solid concrete support at the extremities of the EPA's (proposed on 5 May 1981):

The applicant had not furnished any design information regarding this scheme after its brief verbal presentation of the scheme on 5 May 1981, in a meeting with NRC, in Bethesda, MD. Therefore, there was no information available to evaluate the adequacy of the scheme.

(c) Remedial measures with underpinning walls (proposed on 1 October 1981):

This is the currently proposed remedial measures. A detailed evaluation of this scheme has been made in Question - 3.

Q.7. Did you evaluate the currently proposed remedial measures for the Auxiliary Building? If yes, then what are the results of your evaluation?

A. The remedial measures currently under consideration to stabilize the portions of the Auxiliary Building (EPA's, FWIVP's and Control Tower) have been described in Paragraph (d) of answer to Question No. 5. The Corps of Engineers has reviewed the applicant's technical report and associated appendices (Attachment No. 1) which include the design details. The results of the review are as follows:

a. Bearing capacity of underpinning walls:

(i) The bearing capacity analysis using an average of undrained shear strength values of 6.6 ksf is not appropriate. While it provides a conservative design for the underpinning walls which are adjacent to Boring No COE-18, (samples from COE-18 shows shear strength more than 6.6 ksf), it overestimates the bearing capacity of the foundation soils supporting the underpinning walls adjacent to Boring No. COE-17, since the soil samples from these borings, taken from the potential zone of influence under the footings of underpinning walls, have indicated shear strength much less than 6.6 ksf (shear strength of 5.18 ksf and less). Therefore, it is advisable to proportion the foundation width of the underpinning walls adjacent to COE-17 on the basis of shear strength obtained from tests on samples from COE-17.

(ii) The actual factors of safety against the shear failure of foundation soils under the dynamic load for various underpinning walls have not been furnished.

(iii) The bearing capacity analysis and the resulting factor of safety under drained conditions have not been furnished. The consolidated undrained tests have shown that true cohesion of the foundation soils are much less than the apparent cohesion shown by unconsolidated undrained tests. Therefore, it is advisable to verify the ultimate bearing capacity on the basis of drained test results.

b. Settlements:

(i) The settlements for the proposed underpinning walls provided on Page 9 of the technical report have not been demonstrated to be justified by the applicant. The total settlement of foundation soils constitute three parts: (1) immediate settlement at constant volume, (2) consolidation settlement due to change in soil volume caused by expulsion of excess pore water, and (3) secondary settlement. For highly overconsolidated soil where settlement is primarily the results of recompression, the soil would behave elastically and it would be reasonable to compute settlements using the Young's modulus of the soil. However, such settlement computation does not include the secondary settlement, therefore, secondary settlements should be computed separately using the coefficient of secondary consolidation and be added to the immediate settlement.

The applicant's computations for settlements appear to be based on the assumptions that the soil is highly overconsolidated, and the settlements will be the results of recompression of foundation soils. However, the applicant has not computed and presented the preconsolidation pressures for the

foundation soil to demonstrate that the foundation soils are overconsolidated. Therefore, whether the elastic approach used by the applicant to compute settlements is applicable or not is not known.

(ii) Methods of computing secondary settlements are not presented in the report. It is our understanding the applicant has used coefficients of secondary consolidation, C_α, determined by the consolidation tests to determine the secondary settlement. However, as mentioned earlier in answer to Question 8, since results of consolidation tests are questionable, the determination from consolidation tests are not appropriate for computing secondary consolidation.

(iii) Settlement monitoring during construction:

The applicant's program to insure stability of the existing structures (EPA's and Control Tower) during the period when some of the soils underlying their foundations will be removed to make room for construction of underpinning walls, consists of monitoring the settlements of the structures at critical points. The applicant's monitoring program presented in its technical report has been reviewed by the Corps of Engineers and the NRC and their review comments were transmitted to the applicant on 30 October 1981 through a telephone conference (Attachment---).

On 4 November 1981 in a meeting with NRC and Corps officials, the applicant clarified some of the discrepancies, however, probably due to lack of time, the applicant was not ready to respond to some of the questions which are critical to the safety of the structure during the construction of the underpinning walls. Therefore, the staff could not reach an agreement with the applicant on the adequacy of its settlement monitoring program. The applicant's responses to questions No. 9, 15, 18, 20, 23, 24, 25, 27, 28, 29 and 30 of Attachment No. 4, and their evaluation by the Corps are necessary before providing its concurrence to the proposed settlement monitoring program.

(iv) Long-term differential settlements:

Most of the computed settlement under the underpinning walls would occur prior to the permanent transfer of the structure loads on the underpinning walls. Nevertheless, because of secondary settlement and part of primary settlement, the structures (EPA's and Control Tower) would undergo some differential settlements creating some additional stresses in the structure. The applicant must evaluate these differential settlements and effects such settlements have on the structure. In Question 14 of Attachment - 1, the Corps of Engineers has requested the applicant to establish the soil spring constant which would help evaluate the stresses due to differential settlement.

Conclusions:

a. The overall concept of the currently proposed remedial measures appears to be satisfactory. The remedial measures, if built satisfactorily, would transmit the structure loads to the competent soil layers, relieving

the fill materials from any external load. It will also eliminate the problem of overstressing the foundation soils of the Control Tower, which was inevitable with the previously proposed caissons support. However, a proper foundation design based on actual soil parameters, as mentioned in portions of Paragraph a(i), is essential and the Corps of Engineers must review the final design before giving its concurrence.

b. Evaluation of long-term differential settlements based on elastic theory using Young's modulus of the soils is applicable to highly overconsoldiated soils. The applicant has not yet demonstrated that soils under the underpinning walls are preconsolidated sufficient enough that settlements produced by the load imposed on the underpinning walls will be the results of recompression only, and therefore, the use of elastic theory is justified. Further, the Young's modulus of soils to be used in settlement analysis should be determined from a stress-strain curve obtained from drained tests.

c. Although, the magnitudes and the methods of computing secondary settlements were discussed in 4 November 1981 meeting in Bethesda, they have not been documented in the technical report. It is advisable to document the analyses including values of "C_α", stresses and thickness of compressible material considered in the analyses.

d. Monitoring of settlements of the structures to be underpinned, and determination of acceptance criteria for settlements during the construction are of paramount importance for preserving the structural integrity of the EPA's and Control Tower. Therefore, resolution of questions raised by the Corps and NRC staff regarding the monitoring program is essential.

Q.8. Did you review the Woodward-Clyde consultants' report which included the results of soil exploration and testings of samples taken from the area of the Auxiliary Building? If yes, then what information was included in the report, and what are the review comments?

A. a. The volume I of the Woodward-Clyde report concerning the Auxiliary Building was received in the last week of September 1981. The report contains the following information:

(1) Boring log information for Boring No. COE-17 and COE-18.

(2) Results of gradation tests of soils from these borings.

(3) Results of unconsolidated undrained (UU) tests.

(4) Results of consolidated undrained ($\overline{CIU}$) tests.

(5) Results of consolidation tests.

(6) Backup materials for UU tests.

(7) Backup materials for $\overline{CIU}$ tests.

(8) Backup materials for consolidation tests.

b. The results of UU tests on representative soil samples taken from the potential zone of influence (between EC-560 and 570) of the underpinning wall foundations, indicate that soils of Boring No. COE-17 have lower shear strength than those of Boring No. COE-18. Therefore, it will be appropriate to proportion the foundation for the underpinning walls for Unit - 1 EPA and FWIVP, which are closer to COE-17, using the lower shear value from COE-17. However, the lowest shear strength value of 2.57 ksf obtained from sample no. 5-29-D is not correct; the Corps of Engineers concurs with the Woodward-Clyde remark that the low shear strength is the result of sample disturbance. This value should be disregarded.

c. The drained shear strength parameters (true cohesion C and $\overline{\emptyset}$) obtained from the CIU tests indicate that the shear strength of soils, at normal stress at potential failure plane, is lower than their undrained shear strength (Su = 5.18 ksf and more), therefore, in our opinion the bearing capacity of foundation soils should be checked using drained shear strength.

d. Preconsolidation pressures and the overconsolidation ratio for the soils in the zone of influence of the underpinning walls have not been determined. Therefore, use of the elastic approach to compute the settlements, which is applicable in the cases where soil is highly overconsolidated and the settlement would be the results of recompression, has not been resolved. No volume charge during UU tests and development of zero to slight negative value for the pore pressure parameter, A, at failure loads, indicates indirectly that the soil is moderately overconsolidated, however, their definite values are not known.

e. The e-log p curves for the consolidation tests indicate that the inundations of consolidation samples were done at 21 tsf stress. This appears to have considerably influenced the shape of e-log p curves and as such the results of the consolidation tests are questionable. According to the Corps of Engineers manual EM 1110-2-1906, Page VIII-8, the specimen should be inundated immediately after applying the first load increment of .25 tsf. If swelling occurs apply additional load increments until swelling ceases.

JAN 8 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: INSPECTION OF UNDERPINNING WORK AT MIDLAND

Plant Name: Midland Plants, Units 1 and 2
Licensing Stage: Post CP
Docket Numbers: 50-329/330
Responsible Branch: LB No. 4, D. Hood, LPM

It is the understanding of the Hydrologic and Geotechnical Engineering Branch that a meeting will be held in the office of NRC Region III with Division of Licensing and the Office of Inspection and Enforcement on January 12, 1982 and will include discussions on NRC needs for inspection of the remedial underpinning work that is now beginning at the Midland site. In recognition of the complex and unprecedented nature of the underpinning work to be undertaken at Midland, we recommend that Region III be encouraged to provide annexperienced geotechnical engineer on site to inspect completion of the underpinning operation for the Auxiliary Building, Feedwater Isolation Valve Pits, and Service Water Structure.

MEMO 4

We would anticipate the time that an experienced inspector would be required at the site would vary with the criticalness of the underpinning operation being performed and would range from a few weeks of full time inspection to occasional visits during the less active construction periods.

The reasons which prompt us to recommend that I&E utilize an experienced engineer include the following:

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1. The underpinning work to be completed at Midland is not readily available for visual inspection and approval since it is performed below ground beneath the foundations of completed safety related structures and piping. This work, which is to be completed in confined areas with very limited access, has the potential, not only to adversely impact the structures which are to be fixed, to also impact adjacent structures by causing a loss in their foundation stability due to excavations needed to reach the structures to be underpinned. For these reasons, a carefully planned sequence of construction, complete with detailed monitoring of this work has been developed by the Applicant and reviewed by the NRR staff. To assure fulfillment of the detailed design and monitoring plans during actual construction in the field, a vigorous inspection, significantly beyond the customary audit inspection by someone knowledgeable of the established requirements and commitments, is essential.

2. The critical nature of some aspects of the underpinning work requires immediate decisions by experienced engineers in resolving unanticipated developments, without delays for deliberations. The availability of an experienced on-site NRC engineer during these periods of the underpinning operation would be beneficial to the Applicant by avoiding delays and to the NRC by documenting safety items.

3. Having an experienced NRC engineer on-site in close contact with the NRR staff would permit early confidence to be gained for accepting the construction, as completed. This early confidence is important in recognition of the compressed Midland schedule between completion of construction and the requested OL completion date.

HGEB staff will be available to either DL or Region III office to further discuss this matter, if you desire. Please contact Joseph Kane at 28153 for further information.

We request that you submit our recommendation to James G. Keppler at the above referenced January 12, 1982 meeting.

Original signed by George Lear

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

cc: R. Vollmer
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