J. Kane

OCT 14 1982

Docket Nos.: 50-329/330

MEMORANDUM FOR: Elinor G. Adensam, Chief
Licensing Branch #4, DL

THRU: James P. Knight, Assistant Director
for Components & Structures Engineering, DE

FROM: George E. Lear, Chief
Hydrologic and Geotechnical Engineering Branch, DE

SUBJECT: MIDLAND ASLB HEARINGS - GEOTECHNICAL ENGINEERING INPUT

Plant Name: Midland Plant Units 1 and 2
Licensing Stage: OL
Responsible Branch: LB No. 4, M. Miller, D. Hood and R. Hernan, LPM
Requested Completion Date: October 13, 1982
Status: Completed

In response to the verbal requests of W. Paton and M. Wilcove of OELD, we have enclosed our input for staff testimony in preparation for the upcoming ASLB hearings. The hearings scheduled for October 27 through November 4, 1982 are to cover (1) bearing capacity beneath the Diesel Generator Building, (2) underground piping, (3) Service Water Pump Structure and (4) Permanent Dewatering.

In the enclosure under Part I, we have identified the pertinent SSER sections where the geotechnical engineering staff has addressed the topics scheduled for the upcoming hearings. Under Part II of the enclosure we have identified either the SER or SSER sections or we have provided our response to the safety issues listed in the Stamiris and Warren contentions that are related to the identified hearing topics.

Any questions that you may have on the enclosed input may be referred to J. Kane (28153), Geotechnical Engineering Section, HGEB.

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

Enclosure:
As stated

cc: See next page

cc w/o encl:
R. Vollmer
W. Paton
M. Wilcove
T. Novak

cc w/encl:
L. Heller
E. Sullivan
M. Miller
D. Hood
R. Hernan
R. Gonzales
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J. Kane
S. Poulos, GEI
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Midland Plant, Units 1 and 2

Docket Numbers: 50-329/330

Geotechnical Engineering Input into Staff Testimony

Prepared by: Joseph D. Kane, HGEB, NRR

PART I - PERTINENT SSER SECTIONS FOR HEARING TOPICS

1. Hearing Topic: Bearing Capacity beneath the Diesel Generator Building
   SSER Section with Staff Safety Evaluation: Section 2.5.4.4.2, 2.5.4.5.1

2. Hearing Topic: Underground Piping
   SSER Section with Staff Safety Evaluation: Sections 2.5.4.4.5, 2.5.4.6.2, 2.5.4.7, 2.5.4.8

3. Hearing Topic: Service Water Pump Structure
   SSER Section with Staff Safety Evaluation: Sections 2.5.4.4.1, 2.5.4.5.2, 2.5.4.5.3, 2.5.4.6.1.1, 2.5.4.6.1.2, 2.5.4.7, 2.5.4.8

4. Hearing Topic: Permanent Dewatering
   SSER Section with Staff Safety Evaluation: Sections 2.5.4.4.4, 2.5.4.5.5.

PART II - RESPONSE TO CONTENTIONS

1. Stamiris Contention 4.C.b, as supplemented on 4/20/81 and as it pertains to this hearing session, reads as follows:

   "Consumers Power Company performed and proposed remedial actions regarding soils settlement that are inadequate as presented because:

   A. ------

   B. ------

   C. Remedial soil settlement actions are not based on adequate evaluation of dynamic response regarding dewatering effects, differential soil settlement, and seismic effects for these structures:

   a. ------

   b. Service Water Intake Building and Its Retaining Walls "

   c. ------

   d. ------

   e. ------

   f. ------

Staff Response:

With respect to the concern on differential soil settlement, it is the staff's understanding of this contention that it is directed to the adequacy of the soil-structure interaction study for earthquake loading and whether that study for the underpinned Service Water Pump Structure properly evaluated the effects of differential soil settlement.

During earthquake loading the amount of settlement which will result in the foundation soils has been estimated using dynamic soil spring constants. As indicated in SSER Section 2.5.4.5.6, the staff has concluded that the soil shear moduli values, adopted by the applicant for use in dynamic analysis, are reasonable and acceptable and the applicant's decision to allow ± 50% variation in the resulting soil spring constants is conservative. Therefore, the staff concludes that differential soil settlements have been properly addressed in the dynamic analysis of the underpinned Service Water Pump Structure.

See attached for discussion on soil input required for dynamic analysis

Remedial foundation measures for the seismic Category I retaining wall adjacent to the SWPS were not required. The staff has concluded that the plant fill problem did not extend to the foundation of this retaining wall.

2. Stamiris Contention 4.D, parts 1) and 2) reads as follows:

"4.D. 1) & 2):

Consumers Power Company performed and proposed remedial actions regarding soils settlement that are inadequate as presented because:

A. ------

B. ------

C. ------

D. Permanent dewatering

1) would change the water table, soil and seismic characteristics of the dewatered site from their originally approved PSAR characteristics - characteristics on which the safety and integrity of the plant were based, thereby necessitating a reevaluation of these characteristics for affected Category I structures;

2) may cause an unacceptable degree of further settlement in safety related structures due to the anticipated drawdown effect; ....."

Response to Part 1) of 4.D:

The NRC staff has considered the following information in its evaluation of the dewatering effects on the various plant subsoil layers at the Midland site.

a. Because the long term dewatering will lower the groundwater level in the upper perched groundwater system to approximately el. 595 feet, there will be minimum effect to plant subsoils below this level which would include the approximately 150 feet thick preconsolidated impervious clay layer which separates the two groundwater systems. This impervious clay layer has been shown by subsurface explorations to be located between approximately el. 580 feet and bottom el. 430 feet in the auxiliary building area.

b. In the depths of subsoils which will be affected by dewatering, the staff anticipates both improvements to the engineering properties of the foundation soils above el. 595 and certain adverse effects due to dewatering as discussed below. Reevaluation of soil engineering properties has been performed by methods that include additional subsurface explorations, laboratory testing and seismic surveys in the field. The staff's conclusions on this work are presented in SSER Sections 2.5.4.1.3, 2.5.4.2 and 2.5.4.3.

c. An increase in the shear strength of the subsoils would reasonably be expected as dewatering would remove pore water and lower the water content of the foundation soils. This increased shear strength would result in higher margins of safety against bearing capacity type failures. The staff has not required the applicant to estimate the improvement in safety if acceptable levels of safety had been demonstrated under the more severe conditions (e.g. non-dewatered condition).

d. Lowering the groundwater to levels below the walls of embedded structures will reduce lateral forces on foundation walls by removing water pressures. This reduction will result in an increase in structure stability.

e. A potential adverse effect of long term dewatering could be the removal of soil finds caused by lowering and pumping of the groundwater in the dewatering wells. The staff's position has been, since the time dewatering was initially selected as a remedial measure, to ensure that a high quality dewatering system would be designed and properly controlled and installed in the field so as to avoid the loss of soil fines problem. The staff efforts in this regard are documented in 50.54(f) questions numbered 24, 47, 49, 50, 51, 52 and 53. The staff has met on several occasions and has participated in numerous conference calls with the applicant to resolve its safety concerns on the design and installation of the dewatering system. One of the more important documents which summarizes the staff's review effort is the letter of June 18, 1981 from R. Tedesco, NRC to J. Cook, Consumers Power Company.

As a check on the acceptability of the dewatering system design and field installation, the applicant has successfully completed the full scale field drawdown and recharge test. The monitoring of loss of soil fines which has been completed with portions of both the temporary construction and permanent dewatering wells in operation has indicated that the dewatering system can safely operate and meet the required conservative acceptance criteria on loss of soil particles. The established criteria which ensures that the detrimental loss of soil particles will not occur requires that soil fines larger than 0.005 mm that are measured in the collected seepage water are not to exceed 10 parts per million. If this level is reached during plant operation the applicant is required to determine which well or wells are causing the loss of fines and to stop pumping from the well(s). If necessary, the problem well(s) will be repaired or replaced.

On the basis of the above information and our review of additional information provided by the applicant on permanent dewatering in the FSAR and technical reports, the staff has concluded in SSER Section 2.5.4.5.5 that the permanent dewatering system will eliminate the potential for liquefaction.

Response to Part 2) of 4.d.

The major disadvantage of dewatering on the plant subsoils is the removal of buoyancy. This removal causes an increase in the effective weight of the soil mass which in turn places greater loads on the foundation soils leading to greater soil compression. The staff pursued resolution with the applicant of its concern for increased soil compression due to dewatering in 50.54(f) questions numbered 33, 39(1), 40(1), 41(2)(b), 42(2)(e), 44(2) and 47(9). The staff is satisfied that the settlements estimated by the applicant to occur due to dewatering during plant operation are conservative and acceptable for use in structural analysis which evaluate the effects of these settlements. In addition, long term settlement monitoring during plant operation will be carried out to verify that estimated settlements are not being exceeded.

3. Warren Contention 2B expresses a concern for liquefaction of the foundation soils. The staff's evaluation of this issue has been provided in Section 2.5.4.5.5 of the SSER.

Attach to response to Stamiris Contention 4.C

Subject: Soil input required for dynamic analyses - Midland project

1. Dynamic soil shear modulus (in range of 10^{-2}% to 10^{-3}% shear strain, γ), G
2. Shear wave velocity, V_s (in geophysical surveys, is in 10^{-4}% strain range)
3. Poisson's ratio, ν
4. Damping parameters, J and D (sometimes C)
5. Spring constants (k_z, k_x, k_ψ, k_θ) vertical, sliding, rocking, torsional

For the design of structures @ Midland:

- V_s was established from geophysical surveys (in till in 19 and in fill by crosshole seismic test survey in Nov-Dec 1979). The presence of water does not significantly influence the velocity of the shear wave (From SW-AA 197? Rpt., Page 83)

- Dynamic soil shear modulus, G was checked by the COE using relationship $G = \rho V_s^2$ where G would be @ approx. 10^{-4}% shear strain

ρ = mass density = unit weight of soil / g (= 32.2 ft/sec²)

Since V_s is not affected by presence of water and only slight change in unit weight would be expected from watered to dewatered condition, then little effect on G would be expected between watered & dewatered condition

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- Poisson's ratio (For typical values of Poisson's Ratio - See Lambe-Whitman - pg. 110)

Unsaturated clay 0.35 to saturated clay 0.50

Sands 0.30 to 0.35

Sandy soil 0.15 to 0.25

A ν value = 0 implies a very soft material, where vertical strain and no bulging occurs entirely under loading (like sponge rubber)

A ν value = 0.5 implies significant bulging (like jelly) without a change in volume (bulges rather than compresses)

– Poisson's ratio (cont.) See SW-AP 1972 Rpt Pg.

No reliable field or lab test has been developed for DIRECT measurement of ν. Usually treated as a constant since it has LITTLE effect and is selected between 0.35 to 0.5 depending on its degree of saturation & cohesive soil content.

For Midland values of $\nu = 0.42$ for clay soils were selected and $\nu = 0.40$ for backfill soil

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– Damping parameters (Discussions pertain to damping in soil mass)

There are two types of damping:

1. Geometrical [loss of energy (as reflected by decay in amplitude of wave motion) as waves propagate away from immediate vicinity of structure foundation towards infinity. Also called radiation damping.
2. Material (soil) damping [Energy lost internally within the soil due to hysteretic and viscous effects, significantly affected by SHEAR STRAIN which occurs under repetitive loading.

TOTAL DAMPING = GEOMETRICAL (RADIATION) + Material Damping when under seismic loading

(is called damping ratio, D, and is commonly expressed as decimal or percent $D = \frac{C_{\text{ }}}{C_{c} \text{ (critical)}}$

Geometrical or Radiation Damping – Each time, the foundation of a structure is forced downward against the soil, a stress wave is originated and the wave moves, radially downward and away carrying some of the energy. This energy is lost and unable to participate in resonance phenomenon, therefore damping has been introduced

To determine radiation damping (C), the applicant used equations (Richart, 1966) based on theory of a rigid disk resting on an elastic half space. Need to establish radiation damping coefficients for vertical C_{zz}, (or horizontal) translational C_{xx} & C_{yy}, rocking $C_{\psi xx}$ & $C_{\psi yy}$ and torsional $C_{\psi zz}$ types of motion. Units for C_{xx}, C_{yy} & C_{zz} are $\frac{K\text{-sec}}{ft}$ and for $C_{\psi xx}$, $C_{\psi yy}$, $C_{\psi zz}$ are $\frac{K\text{-ft-sec}}{radian}$

Example of radiation coefficient for vertical motion C_{zz}

$$C_{zz} = 0.85\, K_{zz} R \sqrt{\rho / G}$$

where K_{zz} = spring constant for vertical motion

R = radius of circular foundation in contact w/soil

ρ = mass density = $\frac{\text{unit weight}}{g}$

G = dynamic soil shear modulus

$$K_{zz} = \frac{4GR}{1-\nu}$$

~~and R for circular foundations~~

D = damping ratio = $\frac{C \text{ (coefficient for selected type motion)}}{C_c \text{ (critical damping = spring constant × mass)}}$

Notice that radiation damping is a function of the spring constant, structure's dimension and the square root of the product of the mass density and dynamic soil shear modulus

Generally, for rotational motions (also torsional), RADIATION DAMPING is SMALL and MATERIAL DAMPING (hysteretic) is the major part of total damping.

For horizontal and vertical translation motions - RADIATION DAMPING is LARGE in comparison to MATERIAL DAMPING.

MATERIAL DAMPING (also called INTERNAL) (is expressed as a percent of critical damping (See Fig. 5.14 of SW-AP 1972 Rpt., Page 156)) (hysteretic and viscous effects) is energy lost within the soil. In this type of damping, where under EARTHQUAKE loading, there is a loss in wave energy as soil particles SLIDE UPON ADJACENT PARTICLES. This damping is VERY DEPENDENT on the amount of SHEAR STRAIN - the greater the movement (or straining) under load, the greater the DAMPING. Strain energy during unloading is less than strain energy during loading

Total damping $= D + \lambda$

Total Damping to be used in dynamic analysis is the sum of radiation (or geometrical) damping plus material damping.

For the Midland project, the applicant estimated the radiation damping based on the theory of a rigid disk resting on an elastic half-space. He then took 75% of this value to be used for radiation damping in design. The 25% reduction was made in recognition that in a layered system, the radiation damping IS NOT AS EFFECTIVE as in a half space system (homogeneous and isotropic).

To establish TOTAL DAMPING to be used in design, the applicant added 3% of critical damping (Material damping) to the established RADIATION DAMPING which he computed as explained above

A value of Material Damping, $\lambda_1 = 3\%$ is considered conservative for shear strain range of $10^{-2}\%$ to $10^{-3}\%$

The applicant did take advantage of embedment and its increase on the damping parameter, c, and spring constant k (See Sept. 31, 1981 submittal - Encl. entitled "Auxiliary Building Seismic Model - Rev. 3", pg 3-3

* The TOTAL DAMPING (Radiation + Material) was LIMITED by the applicant to 10% in all except the rigid body modes

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