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

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MEMORANDUM FOR: P. T. Kuo, Section Leader
Section B
Structural and Geotechnical
Engineering Branch, DE

FROM: Frank Rinaldi, Structural Engineer
Section B
Structural and Geotechnical
Engineering Branch, DE

SUBJECT: R. LANDSMAN'S CONCERNS ON INTEGRITY OF DIESEL GENERATOR BUILDING AT MIDLAND SITE

Enclosed please find the initial response to R. Landsman concerns on the integrity of the Diesel Generator building at the Midland site, as prepared during a working meeting on July 28, 1983, by myself and our consultants, John Matra and Gunnar Harstead.

NRRESSTC

Frank Rinaldi, Structural Engineer
Section B
Structural and Geotechnical
Engineering Branch, DE

cc: H. Denton
D. Eisenhut
R. DeYoung
E. Christenbury
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R. Vollmer
R. Warnick
J. Knight
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J. Kane
R. Landsman
J. Matra
G. Harstead
F. Rinaldi

XA Copy Has Been Sent to PDR

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REPLY TO R. B. LANDSMAN'S CONCERNS ON THE STRUCTURAL INTEGRITY OF THE DIESEL GENERATOR BUILDING FOR MIDLAND NUCLEAR POWER PLANT

The structural engineering staff and their consultants have reviewed and evaluated the structural adequacy of the Diesel Generator Building (DGB) to determine the functionality of the DGB and compliance of the design to the structural engineering requirements of NRC for the licensing of a nuclear power plant.

The Midland Nuclear Power Plant (NPP) has had a number of technical reviewers throughout the licensing period, Construction Permit (CP) and Operating License (OL) stages.

This report concentrates on the period following the determination by Consumer Power Co. (CPCo) that the fill material under the DGB did not meet the design specifications and that remedial actions were necessary. The applicant, under advice of their consultants, surcharged the structure with approximately 30 feet of sand and implemented a permanent dewatering program to correct the poor soil conditions under the DGB. In addition, electrical ducts were discovered to be supported by a competent foundation and were structurally connected to the base of the DGB. This condition imposed new loads on the structure in addition to all other design loads (Dead Loads, Live Loads, Tornado Loads, Earthquake Loads, Temperature Loads), and the abnormal differential settlement loads. Considerable cracks developed as a result of these additional loads. In order to eliminate this condition, the duct banks were released, thereby removing one of the abnormal loads.

The DGB is a reinforced concrete structure with three crosswalls that divide the structure into four cells. Each cell contains a 6 ft-6in.-thick concrete pedestal to support a diesel generator unit. The building is supported on continuous footings that are founded at el 628 ft and rest on backfill that extends down to approximately el 603 ft. This rectangular boxlike structure

covers an area of approximately 70 ft by 155 ft. The exterior walls are 30 in. thick, and the interior walls are 18 in. thick. The foundations of the exterior and interior walls of the DGB consist of continuous reinforced concrete footings, 10 ft wide and 2 ft 6 in. thick, with their base at el. 628 ft. The walls rise from an elevation of 628 ft (bottom of footing) to el. 680 ft (top of roof slab).

Sections 3.8.3.4 and 3.8.3.5 of Supplement No. 2 to the Midland NPP Safety Evaluation Report summarized the NRC structural staff and consultants evaluation of the DGB. This document was modified during the (ASLB) hearing of December 10, 1982, by the additional written testimony of Frank Rinaldi, John Matra, and Gunnar Harstead and all oral correction introduced by the same witnesses.

The concerns documented by R. Landsman regarding the DGB by his memorandum to R. F. Warnick, Director, Office of Special Cases, Region III, dated July 19, 1983, transmitted to D. G. Eisenhut, Director, Division of Licensing, NRR, by memorandum dated July 21, 1983, were received by the undersigned on July 27, 1983. This memorandum identifies, in general, concerns previously discussed by the staff during internal meetings and at the ASLB December 1982 hearings related to the DGB. The undersigned fail to understand why R. Landsman has not chosen to participate more fully during these meetings, or why he had not documented his concerns during the review process. The concerns identified in his July 19, 1983 memorandum in some cases are not clear, do not give specific reference to transcripts and other official documents, and in some cases references to various statements are not fully correct. We will first summarize our understanding of his concerns and then address them in the following order:

First Concern: Claim of inadequacy of the Finite Element (FE) Analysis performed by the applicant for the DGB as applies to the following:

(a) Effect of cracks on stiffness of DGB
(b) Validity of straight line settlement data

(c) Time dependency effects of settlements

(d) Corley statement on cracks and time dependency effects of settlement

(e) Staff's offical position on FE analyses as stated by F. Schauer.

SECOND CONCERN:

(a) Claim that the analyses performed by NRC staff consultant (NSWC) is not properly documented in the SSER #2 based on their testimony at ASLB hearing.

(b) Claim that different analyses (Plastic) should have been used.

(c) Claim that F. Rinaldi stated that the staff cannot rely on the results of the NSWC analyses using actual settlement values.

THIRD CONCERN: Claim that the crack evaluation used to determine the stress in the reinforcing steel is not an adequate practical engineering approach.

FOURTH CONCERN: Claim that the crack monitoring program accepted by the staff to evaluate the rebar stresses during the service life of the building is not adequate.

SUMMARY: Recommendation for new remedial structural fixes required to ensure structural intergrity and provide adequate margins of safety.

Reply to First Concern:

Part (a) Rigid in structural engineering terminology is defined as absolute. To characterize cracking of a structure as reducing its rigidity is a contradiction of terms. Therefore, to speak of reduced rigidity is incorrect. We assume that stiffness is intended in the analyses.

In the design of reinforced concrete structures, the composite of concrete and rebars is ~~assumed~~ modeled as a homogeneous material with the concrete expected to crack under tensile loads. It is acceptable to assume concrete sections as uncracked for calculational purposes. The assumption of uncracked concrete neglects ~~neglects~~ both the expected cracks and the stiffness of reinforcing bars which are compensating effects in the calculation of stiffness. Also, a reduced stiffnesses would reduce moments and forces due to settlement, therefore reducing some conservatism from the structural analyses.

In conclusion, we find the design practice of neglecting the cracks in an analysis of the reinforced concrete structure is acceptable. Note that extensive crack evaluation efforts have been carried out by the applicant and their consultants and by the staff and our consultants, to determine the effects of cracks on the structure.

Part (b) The direct use of settlement data can give results which can be used to develop indications of the state of stress in the structure. The applicant used the best practical approach to consider the effects of the measured displacements on the structure, based on the available number of measured points and on the accuracy of the measurements.

The DGB is a stiff structure. The characterization of the boundary conditions used in the analyses should be consistent with that of a stiff structure; namely, linear. Also, settlement data has an inaccuracy inherent in the readings. The applicant's engineers claimed to have an accuracy no better than 1/8" ~~and 1/16"~~. Bending moments are proportional to the second derivative of displacement with respect to length and shear is proportional to the third ~~deviative~~ derivative of displacement with respect to length. A mathematical error analysis shows that the accuracy diminishes with subsequent differentiation. Therefore, the accuracy of the moments and shears will be unreliable if the raw settlement data is used. Structural engineering judgement must ~~be~~ be exercized in the formulation of the models and in the evaluation of the results.

The applicant performed many of analyses to represent various stages of construction, including a completed model, a 40-year life-model and a model using no soil support in an area where we could not rely on the competence of the soil.

Attempts to directely use the raw settlement data resulted in anomalies such as tension in the soil and moments and forces in the structure that cannot be justified by prudent engineering judgment, analyses, and observations of the structure.

In conclusion we agree that the use of the straight line representation of the settlement data is a good engineering approach.

Part (c) The fact that settlement took place over a period of time was accounted for in the applicant's and in NSWC's analyses. Settlements that took place prior to the completion of construction had less affect on the final stresses in the structure, for the following reasons:

a. the partially constructed structure is less stiff and therefore moments and forces were minimized

b. reinforced concrete that had not yet been installed could not be subjected to stresses resulting from previous settlement. We, therefore find that the time dependent effect was used to our satisfaction.

Part (d) We recommend contacting W. G. Corley and request his direct comments to R. Landsman's in First Concern Part (d).

Part (e) F. Schauer did make the statement identified by R. Landsman during the ASLB hearing of December 10, 1982 (p. 11149). However, we suggest that R. Landsman read the cross-examination by the ASLB on page 11150 of the December 10, 1983 hearing to fully understand the staff position as stated by Dr. F. Schauer.

The answers provided on that page of the transcripts states that one cannot fully rely on all of the analyses, and that engineering judgement needs to be exercised.

Reply to Second Concern:

Part (a) The summary report on the NSWC analyses was entered into evidence at the ASLB, December 10, 1982, hearing. It was discussed in detail by J. Matra and commented on by F. Rinaldi, G. Harstead, and F. Schauer. In summary, that report stated the following points:

1. The behavior of this structure as shown by the results of the analyses is inconsistent with respect to the actual observations in the structure as far as crack locations. (Not for duct bank impingement consideration).

2. Analyses of the partial structure, including duct impingement, resulted in very high stresses in the walls at the duck banks. With these stresses over twenty times yield, a great possibility of cracks in these areas existed. A comparison between the crack mapping survey at this time of construction (3/78 to 1/79) and the analyses are in good agreement as far as the location of structural cracks in the area of the duct banks are concerned. However, the analyses show that other areas of the DGB walls still have high stresses and in all probability should also be cracked. But no cracks were observed in these areas.

3. In all cases where the duct banks have been released, the measured or predicted settlement values imposed on the analytical models resulted in very high stresses in areas where no cracks now exist. Thus, indicating that these settlement values as such were not seen by this structure.

4. Imposing the measured settlement values on a partially completed model, and then considering these values as part of the total settlement values for the completed structure without considering the following effects:

   (a) redistribution of loads once yield is reached,

   (b) the relaxation effects.

   (c) the accuracy of the measured data, and

   (d) the location of the measured settlement value relative to the footings where the actual displaced values were input are discussed, but not actually input into the analysis,

   can and does lead to large errors. Thus, this structure will never undergo the differential settlements as predicted nor the patterns of settlement indicated in the measured and or predicted settlements.

Also, as indicated in the reply to First Concern Part (b), the results indicate tension in the soil and moments and forces in the structure that cannot be accounted for using sound engineering practice.

The analyses indicated that the direct use of the limited number of actual measured settlement data in the engineering analyses cannot be used without proper structural engineering judgment. (The analyses were used) also in selecting a monitoring point for the service life of the DGB (a location of high stress derived from these analyses, but having no major cracks was selected).

Part (b) The elastic analyses performed by the applicant give correct and conservative indications of stress. This is concluded after having reviewed the structural model, the analyses and the results. If an

elastic analysis shows a region of high bending moment such that reinforcing bar stresses exceed their yield stress, the section may then be considered plastic; i.e., increasing rotation will not increase moments or stresses. However, there is no indication of yielding rebars or spalling of concrete which would indicate that a portion of the structure has become plastic. In fact, the formation of plastic sections in a structure mitigates the secondary stress effects of conditions such as differential settlement. To state that "supposed areas of high stress, where cracks are not located, may not exist due to redistribution of loads," is indicative of serious lack of familiarity with basic structural analysis.

Part (c) The claim that F. Rinaldi stated, "that the actual settlement values could not be relied upon to determine if the DGB meets the regulatory requirements" is not complete. The additional testimony clearly states that the applicant's analyses using linear settlement data was not fully relied upon in our evaluation. This is stated on pages 11084 - 11087 of the ASLB hearing transcripts, dated December 10, 1982. The staff performed an additional crack evaluation as stated in our written testimony presented on the pages following page 11086 of the above mentioned ASLB hearings. All stress levels were below code allowable. Therefore, we found the concrete cracking levels in the DGB, as reported by the applicant, acceptable.

Reply to Third Concern:

The evaluation of cracks as performed by the Staff is not a structural analysis, but rather a method of estimating upper bound stresses in the rebars of an existing reinforced concrete structure. These values were used as conservative values for stress due to differential settlement, shrinkage and other secondary effects.

The structural analyses of the DGB were performed by the applicant considering all loads combinations as documented in their report, "Structural Stresses Induced by Differential Settlement of the DGB "

The results are documented in the additional written testimony. See transcripts for the ASLB hearing of December 10, 1982. The DGB is not a complex structure, instead it is a simple box-like structure. Also, all reinforced concrete structures have cracks and we disagree with the statement that "there is no practical method available today to analyze a complex structure with cracks in it." Note that the applicants' structural consultants and our structural staff and their consultants have performed several evaluations of the DGB without finding any unresolved concerns.

Reply to Fourth Concern:

The DGB was not accepted by the staff solely by relying on a crack monitoring program. On the contrary, the acceptance was based upon reviews of the analyses and designs prepared by the applicant as well as independent calculations. Furthermore, the stresses caused by settlements are secondary stresses. Secondary stresses are defined as those stresses which can exist in a structural material which do not impair that capability of the structural material to carry primary stresses, provided the secondary stresses do not cause rupture or gross distortions of the structural material. From a variety of evaluations, the indications are that the stresses in the reinforcing bars are well below yield and far from rupture. The compressive stresses in the concrete are very low. There are no indications of gross distortions of the structure. Therefore, the cracks that have occurred merely indicate that the reinforcing bars will carry imposed tensile forces while imposed compressive forces will cause the cracks to close. While there are no expectations of rupture or gross distortions in the future, a crack monitoring program has been established to provide engineers with information to assess the condition of the structure, as a prudent measure.

The criteria for the monitoring program is identified as ASLB exhibit #29.

Reply to Summary:

It is surprising that with all of the data and information available on the subject of DGB there still exists such a misunderstanding. Beyond this response we would respectfully direct R. Landsman to evaluate all of the information currently available in the field of structural analysis and specifically to that available in the docket of the Midland project.

It is our conclusion that all analyses, designs, crack mapping and evaluations and the monitoring program are adequate to establish the structural integrity of the DGB. Only unexpected results during the monitoring program would necessitate a reassessment of the DGB.

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August 8, 1983

Director
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FREEDOM OF INFORMATION ACT REQUEST
FOIA-83-454
Rec'd 8-10-83

To Whom It May Concern:

Pursuant to the Freedom of Information Act (FOIA), 5 U.S.C. §552, the Government Accountability Project (GAP) of the Institute for Policy Studies requests copies of any and all agency records and information, including but not limited to notes, letters, memoranda, drafts, minutes, diaries, logs, calendars, tapes, transcripts, summaries, interview reports, procedures, instructions, engineering analyses, drawings, files, graphs, charts, maps, photographs, agreements, handwritten notes, studies, data sheets, notebooks, books, telephone messages, computations, voice recordings, and other data compilations, interim and/or final reports, status reports, and any and all documents relating to the re-review of the structural adequacy of the Diesel Generator Building at the Midland Plant.

Specifically, we request all information subsequent to the May testimony of Dr. Ross Landsman in the ASLB proceedings about the adequacy of the Diesel Generator Building.

If any records have been destroyed and/or removed, please provide all surrounding records, including but not limited to a list of all records which have been or are destroyed and/or removed, a description of the action(s) taken, relevant date(s), individual, office and/or agency-wide policies and/or justification(s) for the action(s), identification of all personnel involved with the action(s), and any and all records relevant to, generated in connection with, and/or issued in order to implement the action(s).

GAP requests that fees be waived, because "finding the information can be considered as primarily benefitting the general public." 5 U.S.C. §552(a)(4)(A). The Government Accountability Project is a non-profit, non-partisan public interest organization concerned with honest and open government. Through legal representation, advice, national conferences, films, publications and public outreach, the Project promotes whistleblowers as agents of government accountability. GAP requests the above information as part of an ongoing monitoring project on the adequacy of the NRC's efforts to protect public safety and health at nuclear power plants.

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For any documents or portions that you deny due to a specific FOIA exemption, please provide an index itemizing and describing the documents or portions of documents withheld. The index should provide a detailed justification of your grounds for claiming each exemption, explaining why each exemption is relevant to the document or portion of the document withheld. This index is required under Vaughn v. Rosen (I), 484 F.2d 820 (D. C. Cir. 1973), cert. denied, 415 U.S. 977 (1974).

We look forward to your response to this request within ten days.

Yours truly,

Billie Pirner Garde

Billie Pirner Garde
Director, Citizens Clinic for
Accountable Government

pdc