Stephen H. Howell
Vice President

General Offices: 1945 West Parnall Road, Jackson, Michigan 49201 • Area Code 517 788-0453

September 29, 1978
Howe-183-78

Mr J G Keppler, Regional Director
Office of Inspection and Enforcement
Region III
US Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

MIDLAND NUCLEAR PLANT -
UNIT NO 1, DOCKET NO 50-329
UNIT NO 2, DOCKET NO 50-330
SETTLEMENT OF DIESEL GENERATOR FOUNDATIONS AND BUILDING

In accordance with the requirements of 10 CFR 50.55(e), this letter constitutes an interim report on the status of the settlement of the diesel generator foundations and building.

A description of the conditions relative to the settlements and the investigative actions planned are documented in the enclosures to this letter.

Another report, either interim or final, will be sent on or before November 17, 1978.

[signature]

Enclosures: 1) Quality Assurance Program, Management Corrective Action Report, MCAR-1, Report 24, dated September 7, 1978.

2) Letter, P A Martinez to G S Keeley, BLC-6578, MCAR-24, Interim Report #1, dated 9/22/78, with attached report.

CC: Director, Office of Inspection & Enforcement
Att: Mr John G Davis, Acting Director, USNRC (15)

Director, Office of Management
Information and Program Control, USNRC (1)   ... 2 1978

7810060285

PDR

QUALITY ASSURANCE PROGRAM
MANAGEMENT CORRECTIVE ACTION REPORT
MCAR-1

REPORT NO. 24

JOB NO. 7220 Q NO. 1.40 DATE 9/7/78

I *DESCRIPTION (Including references):

The Bechtel "Foundation Data Survey Program" has indicated that the settlement of the Diesel Generator Building has been greater than expected. This has been documented in NCR-1482 dated (8/21/78). A preliminary evaluation of soil boring data from an investigation being conducted by Project Engineering indicated that the magnitude of the investigative tests and analysis of test results makes this item reportable under 10CFR50.55 e, 1, iii.

*RECOMMENDED ACTION (Optional)

1. Determine the amount of settlement of the Diesel Generator Building (DGB) and increase the frequency of foundation survey measurements to find if the settlement is or will be excessive.
2. Determine the cause of the settlement.
3. If the settlement is or will be excessive, determine what actions are required to correct the condition and preclude recurrence.

REFERRED TO [X] ENGINEERING [ ] CONSTRUCTION [ ] QA MANAGEMENT [ ] ____

ISSUED BY L. A. Dreisbach (W. Moring for) 9/7/78
Project QA Engineer Date

II REPORTABLE DISCREPANCY [ ] NO [X] YES

NOTIFIED CLIENT 9/7/78 Date
Project Manager (signature) Date 9/7/78

III CAUSE

CORRECTIVE ACTION TAKEN

SEP 8 1978
QUALITY ASSURANCE

AUTHORIZED BY ____ Date

DISTRIBUTION:
Project Manager J.B. Violette
Construction Manager S.I. Heisler
Engineering Manager L.A. Dreisbach
Project Engineer
Proj. Supt. / Proj. Const. Mgr. or P & I Procurement Mgr. J. Amaral (Gaithersburg)
Chief Field QC Engineer or Procurement Insp. Mgr. J.E. Bashore (Norwalk)
QA Supervisor
Client

FORMAL REPORT TO CLIENT ____ Date
(If Section II Applies)

CORRECTIVE ACTION IMPLEMENTED

VERIFIED BY ____
Project QA Engineer Date

*Describe in space provided and attach reference document.

BPC 70883
G1001451-01

Enclosure 2
Hove-183-78

Becht Power Corporation

777 East Eisenhower Parkway
Ann Arbor, Michigan
Mail Address: P.O. Box 1000, Ann Arbor, Michigan 48106

September 22, 1978

BLC-6578

Mr. G. S. Keeley
Project Manager
CONSUMERS POWER COMPANY
1945 West Parnall Road
Jackson, Michigan 49201

Midland Units 1 and 2
Consumers Power Company
Bechtel Job 7220
MCAR 24 INTERIM REPORT 1
Files 2417/2801

Dear Mr. Keeley:

Attached is Interim Report 1 addressing the Deisel Generator Building Settlement as described in MCAR 24 (issued September 7, 1978).

As agreed with W. R. Bird on September 21, 1978, the next report will be issued November 3, 1978.

Very truly yours,

for P. A. Martinez
Project Manager

PAM/WGM/pp

cc: Mr. R. C. Bauman
Mr. W. R. Bird
Mr. J. L. Corley
Mr. B. W. Marguglio

Attachment (5 pages).

RECEIVED
SEP 25 1978
QUALITY ASSURANCE

Bechtel A ociates Professional C rporation

Attachment to BLC-6578

SUBJECT: MCAR #24 (Issued 9/7/78)

Settlement of the diesel generator foundations and building

INTERIM REPORT # 1

DATE: September 22, 1978

PROJECT: Consumers Power Company
Midland Plant Units 1 & 2
Bechtel Job 7220

Introduction

This report summarizes the project's actions relating to the settlement of the diesel generator foundations and building as described in MCAR #24 and NCR 1462.

The fill material in this area was placed between 1975 and 1977. Construction was started on the diesel generator building in mid-1977. The diesel generator building settlements were noticed to exceed anticipated values in July 1978. The diesel generator building construction was placed on hold on August 23, 1978. A diesel generator building soil boring program was started on August 25, 1978. Based on preliminary soil boring data evaluation, MCAR #24 was issued.

The actions requested by MCAR #24 are being performed as follows:

1) The Foundation Data Survey Program, Specification 7220-C-76, has been expanded by increasing the number of data locations and the frequency of measurements.

2) The cause of the settlement and the corrective actions required to preclude the recurrence of this condition will be addressed after the testing and monitoring programs have been evaluated.

3) The options available to resolve the existing settlement conditions will be discussed in the Corrective Actions section.

Deficiency

The Bechtel Foundation Data Survey Program (Specification 7220-C-76) generated data that indicated the settlement of the diesel generator foundations and building was greater than anticipated. Nonconformance Report 1482 was generated on August 21, 1978, describing the settlements.

The general foundation and building settlements, as of September 19, 1978, are shown on Figure 1 (attached).

Due to the magnitude of the settlements observed, a soils boring program was started. Based on the borings completed to date, the fill under the building has variable strength properties ranging from good to poor.

Further clarification of the fill deficiency will be made when the soil test results have been completed and evaluated.

An independent soils consultant has been retained to help in the data evaluation and feasibility of the corrective actions.

Safety Implications

Large settlements can pose possible safety problems for buildings. A preliminary evaluation of soil boring data from the investigation being conducted indicates that the magnitude of the investigative tests and analysis of test results makes this item reportable under 10 CFR 50.55 e, 1, iii.

These structures are monitored for settlement as part of the foundation data survey program. Hence, any unusual settlement of the structure would be detected before the diesel generators would be rendered inoperable due to the resulting distortions.

Activities in Progress

Several activities are in progress to generate information needed to evaluate the feasibility of possible corrective actions. The activities are:

1) The Foundation Data Survey Program has been expanded to include additional settlement data locations as well as monitoring these data locations more frequently. Building time rate of settlement curves are being developed based on this datum for a better understanding of the problem.

2) A boring program has been initiated to provide better definition of the fill conditions under the building and to obtain soil samples for laboratory tests. Dutch cone penetration tests are also being performed under the building area to better define the variable strength properties of the fill material.

3) Laboratory tests being performed are:

   a. Shear strength tests to determine fill characteristic for bearing capacity evaluation

   b. Consolidation tests to predict building settlement for the present fill material

   c. Soil classifications

   d. Mineralogy tests to evaluate the swelling potential of the fill material

This portion of the Bechtel Report is deleted because it contains a premature discussion of possible corrective action options. Specific options will be included in subsequent reports following a complete evaluation of soil conditions.

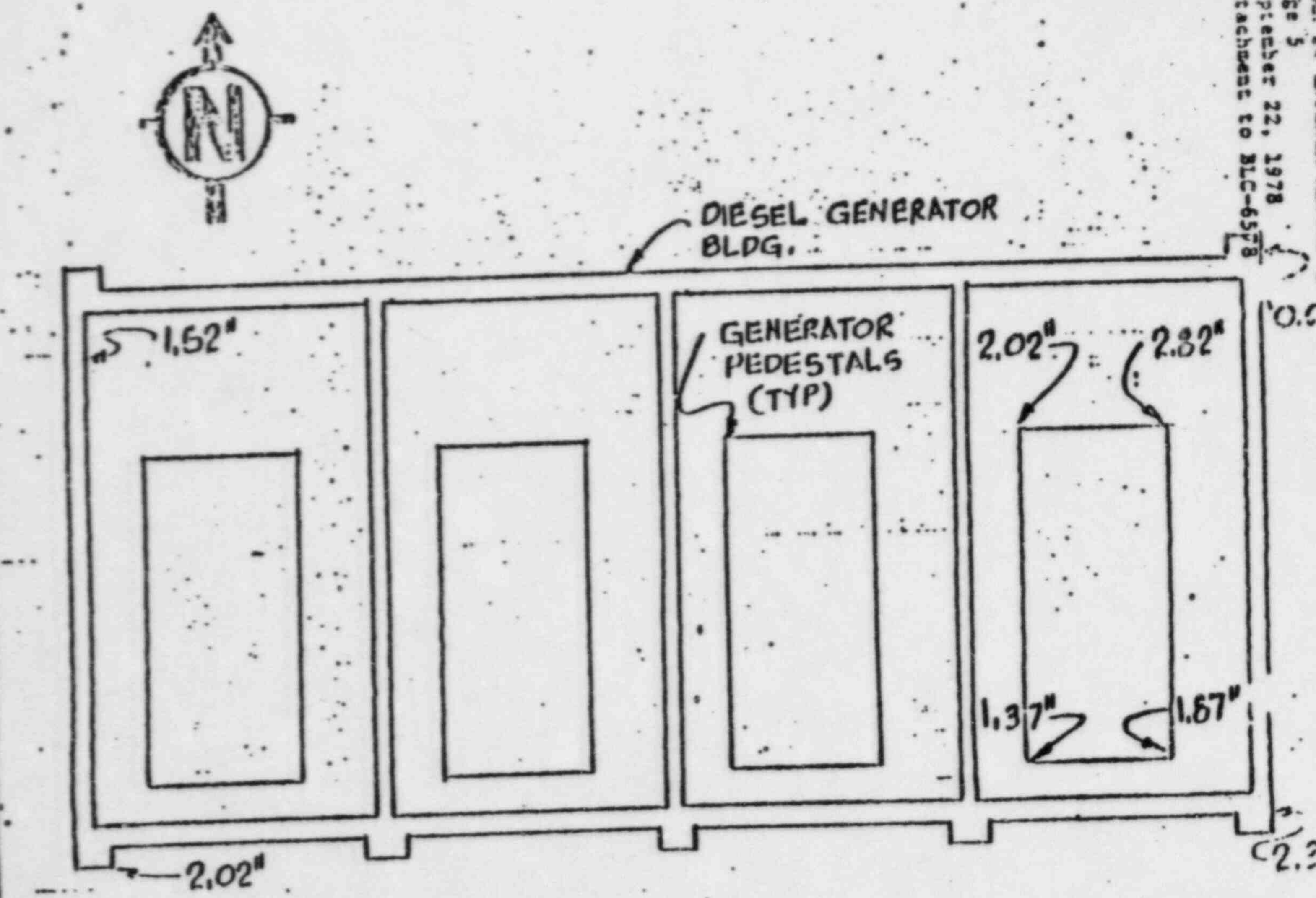
Detailed descriptions of the selected options will be presented in subsequent reports.

Submitted by: B Charles Mc Cormel

Approved by: [signature]

Concurrence by: [signature]

JH/cap
9/19/6



DIESEL GENERATOR BLDG.

SETTLEMENT DATA AS OF 9-19-78 (INCHES)

1	9-22-78	ISSUED FOR INFO. TO MCAR # 24, INTERIM REPORT # 1

CONSUMERS POWER COMPANY
MIDLAND PLANTS UNITS 1 AND 2
MCAR # 24

FIGURE 1

ANTHONY J. CAPPUCCI, JR.

PROFESSIONAL QUALIFICATIONS
MECHANICAL ENGINEERING BRANCH
DIVISION OF ENGINEERING
U. S. NUCLEAR REGULATORY COMMISSION

I am a Mechanical Engineer in the Mechanical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation. In this position, I am responsible for the technical monitoring ot two technical assistance contracts at the Department of Energy National laboratories. One at the Energy Technology Engineering Center (ETEC) for the review of the adequacy of the Final Safety Analysis Reports tendered in application for an operating license and the other at the Idaho National Engineering Laboratory (INEL) for the review of Inservice Testing programs. In addition to this work, I am responsible for the review of issues pertaining to operating reactors concerning inservice testing of pumps and valves and the adequacy of the testing programs concerning RCS pressure isolation valves for near term operating license applicants (NTOL).

I received an associate's degree in applied science in 1970 and an associate's degree in Aeronautical Engineering in 1971 from Wentworth Institute in Boston, Massachusetts. I received a Bachelor of Science degree in mechanical engineering from North Eastern University in 1974. While at North Eastern University, I was a student member of ASME.

Prior to entering Wentworth Institute in 1968, I was an enlisted man in the U. S. Army on active duty for three years (October 1965 to September 1968). I was honorably discharged in 1971.

My employment upon receiving my B.S. degree commenced with Bechtel Power Corporation in Gaithersburg, Maryland in July 1974 and terminated in September 1976. While at Bechtel, I was employed as a Mechanical Engineer assigned to the control systems group responsible for the design of safety-related instrument tubing and piping and their supports. This work consisted of reviewing field run piping/tubing isometrics to determine if the support locations were consistent with the field specification requirements. In those cases where the field run

Cappucci depo Ex 1
11-22-81

piping/tubing was out of the specification scope, a stress analysis was performed using the Bechtel computer program ME-632.

In September of 1976, I joined Potomac Research, Inc. of Alexandria, Virginia as a Senior Mechanical Engineer responsible for supervising and performing engineering research, design, development and testing, I have performed analysis and conceptual design of toxic vapor removal system for the U. S. Army and fault tree analysis of the electric power plant for the Patriot Missile System. This work included development and analysis of failure rate data, determination of failure modes and producing combinatorial logic diagrams depicting these failure modes. Directed and participated in joint Army/Navy program to design, fabricate, install and interface a "Rider Block Tagline System" with a 20 ton Bucyrus-Erie 38B crane. Analyzed design and associated design drawings, performed stress analysis, designed test apparatus, retrieved data, and wrote the final report.

In November of 1977, I became the Mechanical Engineering Department Manager with responsibility for the U. S. Postal Service hardware analysis and design project. My responsibilities included managing and supervising a staff of engineers, designers, checkers and draftsmen. Other duties included customer liaison, contract administration, personnel management, project staffing, task management, coordination of work processes and project progress reporting.

In June of 1979, I joined the U. S. Nuclear Regulatory Commission as a member of the Mechanical Engineering Branch performing the work as previously described.

Other employment held prior to receiving my bachelor's degree is described below:

DATES	DESCRIPTION
April 1973 to June 1973	Stone & Webster Engineering Corporation, Boston, Massachuseets. (Coop term) Engineering Aide in the design of pressure vessels for Nuclear Power Plants, using ASME Section III and Section VIII.
June 1971 to September 1972	Avco Everett Research Laboratory, Inc., Everett, Massachusetts. Research Technician. Participated in an experiment to separate the uranium isotopes using lasers. Ran experimental apparatus, did data reduction, maintenance, repair and design of control equipment. Worked with high vacuum, electron beam evaporators, lasers, mass spectrometers and radioactive materials.

MIDLAND RESPONSE TO 10 CFR 50.54 REQUEST

ON PLANT FILL: MEB COMMENTS

1. With respect to buried and exposed piping subjected to differential settlement, the applicant has profiled and analyzed a few sample piping runs already. It states that the evaluation of piping will be completed by June 29, 1979. We believe that at the conclusion of the preload program, the applicant can make a reasonably accurate prediction of the expected settlement during the plant life. The applicant must analyze its essential piping for the maximum expected differential settlement. This analysis must be at least as conservative as the criteria of NC/D-3652.3(b). Additionally, periodic monitoring of the settling of these lines must be performed to detect any unexpected settlement. We will require that all essential piping runs be profiled initially and during the long term monitoring program. This includes adjacent lines located in a common trench.

2. The applicant must perform a more quantitative assessment to determine if the nozzle loads transmitted from the settled pipes to the attached valves, pumps, tanks, etc., are still within ASME Code allowables. The effect of any increased nozzle loads upon the operability of active pumps and valves must be determined. The effect of misalignment on essential equipment due to the settlement and tilting of buildings must be determined.

3. The applicant states that the soil properties of the [illegible] fill tend to increase and broaden the peaks of the seismic response spectra of the various buildings. Similarly, other factors under

active review by the staff (basic g level, shape of ground response spectra) affect the various building response spectra. The applicant must reevaluate its seismic Category I mechanical and electrical equipment for these new and increased seismic loadings when the overall seismic issue is settled.

4. Our early assessment is that the effect of settlement upon piping and other mechanical components may not be very severe. As discussed above, extensive analyses must be performed to demonstrate this. If problems are found, we believe the piping and other mechanical components can be fixed. If the plant's seismic response spectra are substantially increased by the variation in soil properties or other issues under review, the reevaluation and requalification of equipment will take one or two years to perform.

MIDLAND

ETEC HAS REVIEWED RESPONSES TO THE 50.54(f) QUESTIONS ASKED [illegible] IN REGARDS TO THE SETTLEMENT PROBLEMS ASSOCIATED WITH THE [illegible] OF THE DIESEL GENERATOR BUILDING. They have Reviewed ALL [illegible] AND RESPONSES FOR INFORMATION AND question 16 thru 20 IN SOME DETAIL. THEIR COMMENTS BY TELECON ON 1/10/80 ARE AS FOLLOWS:

[illegible]

- [illegible] the case [illegible] fig 19.3 [illegible] and [illegible] to [illegible] (MEASURED [illegible] PROFILES)?
- NEED TO [illegible] THE TOTAL SETTLEMENT FOR THE LIFE OF THE PLANT AFTER THE CONCLUSION OF THE PRELOAD PROGRAM. ANY ANALYTICAL EVALUATION OF PIPING MUST BE BASED UPON THE TOTAL PREDICTED SETTLEMENT.

question 17

- CRITERIA IS ADEQUATE - ANALYSIS IS INCOMPLETE
  - ANALYSIS APPEARS TO BE BASED ON CONSTANT CURVATURE, should also evaluate for changes in curvature.
  - QUALIFICATION OF PIPING BY AMERICAN WATER WORKS CRITERIA [illegible] AND DESIREABLE
  - SHOULD ALSO EXAMINE LOCAL BUCKLING OF PIPE DUE TO SETTLEMENT DIFFERENTIAL.
- ACCORDING TO TABLE 17-1, NOT ALL [illegible] HAVE BEEN [illegible]. IF [illegible] DOES CONSUMERS INTEND TO [illegible] ALL [illegible] PIPING? IF NOT, WHAT CRITERIA DO THEY INTEND TO USE FOR PIPING SELECTION?

[illegible] dep Ex 3
1-22-81 [illegible]

116B - LES RUBENSTEIN - ANNEX 10:00 AM

Question 17 Continued

- DRAWINGS WHICH DEPICT PROFILES ARE NOT LEGIBLE.

Question 18

IF [illegible] AGREED TO ANALYZE PIPING [illegible] #3 [illegible] CRITERIA AS MENTIONED IN question 17:

(1) NC 3652.3

(2) [illegible] CRITERION

(3) LOCAL BUCKLING ANALYSIS

[illegible] to question 18 would be acceptable, ALSO [illegible] BASE ANALYSIS ON PREDICTED LIFETIME SETTLEMENT.

Question 19

- SAME AS 18
- REQUIRE COMPLETE EVALUATION OF SAFETY RELATED PIPING [illegible] IN LAST PARAGRAPH ON Pg 19-3

Question 20

① GENERAL

- A[illegible] SHOULD ADDRESS SOME SORT OF BUCKLING CRITERIA [illegible] – ASME NC-3652.3 (b) + AWWA DO NOT ADDRESS THIS CRITERIA COMPLIANCE ANALYSIS SHOULD BE BASED UPON [illegible] SETTLEMENT OVER PLANT LIFE.

b [illegible] CURRENT LOCAL SETTLING – SHOULD INCLUDE EXPECTED SETTLEMENT OVER THE LIFE OF THE PLANT

[illegible] 17", THE SETTLEMENT STRESSES [illegible] EXCEED THE CODE ALLOWABLES WHAT STEPS WILL BE TAKEN TO ALLEVIATE THIS CONDITION

© [illegible] FOR SAMPLING OF SEISMIC CATEGORY I PIPING IF ALL PIPING IS NOT TO BE [illegible]

D [illegible] EXPERIENCE THE SAME TYPE SETTLEMENT DEFORMATIONS

[illegible]

OPEN ITEM (as of 2/1/79)

1. ORT (INEL)
2. Qualification of 18 + 78 CPV's
3. Qual of active SRV's
4. [illegible] Deformation of Honeycomb Pipe [illegible] Restraints
5. Asymmetric Loads
6. [illegible] of Reactor Internals for LOCA + SSE
7. Finite Break Times and Openings
8. IST (INEL)
10. Comb[illegible] of Dynamic Responses
9. Pipe Vibe Test Program
11. Compliance with RG 1.121
12. Functional Capability of Essential Piping
13. Bolt + Baseplate Design

Criteria for Construction Permit Amendment?
- What information do we need?
- Look at it from CP stage point of view?
- [illegible] was asked

16 January 80 - Meeting on 54(F); 55(E)

[illegible] Ex 4
1-22-8[illegible]

10CFR 50.54 QUESTIONS ON THE MIDLAND SOIL SETTLEMENT PROBLEM
MEB ONLY

(19) IDENTIFY CRITICAL PIPING WHICH DOES NOT MEET THE CODE STRESS CRITERIA; ALSO IDENTIFY CRITICAL PIPING WHOSE FUNCTIONAL CAPABILITY CANNOT BE VERIFIED. REQUIRE THE CRITERIA TO BRING STRESSES WITHIN CODE ALLOWABLES AND TO VERIFY THE functional CAPABILITY of piping, for the 40 yr lifetime of plant.

(20) REQUIRE EXTENT OF DEFORMATION OF UNDERGROUND PIPING IN THE FILL AREAS AROUND DIESEL GEN BLDG AND OTHER STRUCTURES. CRITERIA TO CORRECT DEFORMATIONS CONSIDERED TO BE EXCESSIVE.

(21) ABILITY OF SEISMIC CAT. I PIPING to WITHSTAND PREDICTED OR INCREASED SETTLEMENT INCLUDING DIFFERENTIAL SETTLEMENT BETWEEN BLDGS, WITHIN BLDGS AND FROM SEISMIC ANCHOR MOVEMENTS

(22) Verify: LOADINGS DUE TO increased settlement ON EQUIPMENT (PMP, VALVES, PIPING) supports are WITHIN code ALLOWABLES
Verify operability of active pumps and valves due increased settlement, ie, deformations due to settlement will not impair operability.

[redacted]

Gow[redacted]ough

16th ... 20 ... detail   Section III, NC.

Criterion spelled in Rev 2

NC 3652.3 – thermal expansion

Eq. 10

July 9, 1979 -3

19   16-1

(1) How does the ... in 19-3
 W... + How accounted in it. } 16

(2) Total settlement over life of plant? – Any evaluation ... used on that number

17

(1) Constant curvature calc is demonstration
(2) Analysis is ... – criterion is adequate   max 27KSI
(3) Evaluate for change in curvature $3S_c$ – 40KSI
(4) Our ... – Argonne ... works
(5) ... local buckling of pipe
 NC criterion is spelled out

[redacted] 17-1 – Profile of ... I piping
 Do they need to profile all piping and if not what criterion for profile selection

... and ... to table ... not all ... [redacted] profile

Drawings are illegible

18

Piping WITH ANALYSIS by 3 criterion it would cover

P... ... treatment for life of plant and base analyses

19

... - ... ore

...ation of ALL SAFETY RELATED PIPING (1-3)

20

... NOZZLE LOADS

NC 3652.3

AWWA CRITERION

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

FEB 4 1980

Docket Nos.: 50-329/330

APPLICANT: CONSUMER POWER COMPANY

FACILITY: MIDLAND PLANT, UNITS 1 & 2

SUBJECT: SUMMARY OF JANUARY 16, 1980 MEETING ON SUPPLEMENTAL REQUESTS REGARDING PLANT FILL

On January 16, 1980 the NRC staff and its consultants from the U.S. Corps of Engineers met with Consumer Power Company and Bechtel Corporation in Bethesda, Maryland. Attendees are listed in Enclosure 1. The principal purpose of this meeting was to discuss the status of the staff's supplemental requests for additional information regarding plant fill settlement and effects. These requests were issued November 19, 1979. Earlier requests issued March 21, 1979 were discussed to a lesser extent. Enclosure 2 is the meeting agenda.

The staff's requests of March 21 and November 19, 1979 were issued on the basis of Section 50.54(f) to 10 CFR 50, which is applicable to construction permits by virtue of Section 50.55(c). The staff's 50.54f position requiring modification of the Midland construction permits was subsequently issued December 6, 1979. Consequently, it was recognized that any replies outstanding after December 6, 1979 were no longer needed in the 50.54(f) context, but that replies should be submitted nevertheless since the December 6 order states that the absence of certain information prevents the staff from reaching essential conclusions. It was suggested that the replies be submitted in the normal "Q-1, Q-2" context typically associated with the radiological safety reviews of nuclear power plants. The applicant also reported that the December 6 order, its subsequent request for hearing, and FSAR Amendment 72 provides the basis for concluding its 50.55(e) reports regarding this matter, as further reporting would be by FSAR amendments and by hearing documents, as may be appropriate. The applicant acknowledged its intent to further update the FSAR to reflect appropriate changes associated with the soils settlement matter at an appropriate point in the future; in the interim, those FSAR sections which are subject to change will be flagged.

Staff comments based upon review of the applicants reply to questions 16 through 20 were provided as a handout (Enclosure 3 hereto). These comments relate to mechanical engineering effects of the soil settlement

8002200343

Ex. 5 11-22-81

which are being reviewed with the assistance of a staff's consultant, Energy Technology Engineering Center.

The proposed responses to questions 24 through 35, 4 and 14 were summarized by the applicant and Bechtel. Since these responses will be submitted on the docket within two to three weeks, no summary of these presentations is provided in this report. The response to questions 25 and 26 involve seismic analyses which require additional time to complete prior to submittal of a final reply. Copies of the vugraph slides used during these presentations are maintained by the staff's Licensing Project Manager and are available upon request.

Darl Hood

Darl S. Hood, Project Manager
Light Water Reactors Branch #4
Division of Project Management

Enclosures:
As stated

cc: See next page

Consumers Power Company

ccs:

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Grant J. Merritt, Esq.
Thompson, Nielsen, Klaverkamp & James
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Mr. Don van Farowe, Chief
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Resident Inspector/Midland NPS
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Midland, Michigan 48640

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Vice President
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Jackson, Michigan 49201

Mr. Larry Auge
Energy Technology Engineering Center
Canoga Park, California 91304

Mr. William Lawhead
U. S. Corps of Engineers
NCEED - T
477 Michigan Avenue
7th Floor
Detroit, Michigan 48226

ENCLOSURE 1

LIST OF ATTENDEES

JANUARY 16, 1980

Name	Organization
Darl Hood	DPM/NRR
Joe Kubinski	COE Detroit Dist.
William Paris, Jr.	Bechtel-Geotech
Jo Wayzeck	Bechtel - Geo Tech
S. S. Afifi	Bechtel
W. R. Ferris	Bechtel
Morothwell	Bechtel
K. Wiedner	Bechtel
Gil Keeley	Consumers Power
T. C. Cooke	Consumers Power
F. Schauer	NRC-SEB
J. J. Zabritski	Consumers Power Co.
S. Lo	Bechtel
T. E. Johnson	Bechtel
John F. Horton	COE NC Division Chicago
James W. Simpson	Army Corps NCO Chicago
William Lawhead	U. S. Army COE, Detroit
R. E. Lipinski	NRC-SEB
Gene Gallagher	NRC Region III:IE
Ross Landsman	NRC Region III:IE
Daniel M. Gillen	NRC - NMSS
A. J. Cappucci	NRC/DSS/MEB
R. O. Bosnak	NRC/DSS/MEB
H. L. Brammer	NRC/DSS/MEB

ENCLOSURE 2

MEETING WITH NRC STAFF IN BETHESDA, MD
January 16, 1980

Agenda

I. INTRODUCTION : Gil Keeley

Purpose of meeting; background, etc

II. WORK ACTIVITY UPDATE : Jim Wanzeck

Summary of work activities and settlement surveys for all Category I structures and facilities founded partially or totally on fill

III. 10 CFR 50.54(f) REQUESTS

Presentation of Information related to:

- Question #4 - Soils Engineering and Civil/Structural } Afifi
- Supplemental Questions #27, 31, 33 and 35 - Soils Engineering } Afifi
- Supplemental Question #24 - Dewatering
- Question #14 - Civil/Structural
- Supplemental Questions #28, 29, 30 and 34 - Civil/Structural } Ted Johnson
- Supplemental Questions #25 and 26 - Seismic Analysis } Ted Johnson

IV. FORMAT AND SCHEDULE OF FUTURE RESPONSES (50.55(e), 50.54(f), FSAR)

ATTENDEES:

Bechtel	Consumers Power
S Afifi	G S Keeley
T Johnson	T C Cooke
S Lo	J J Zabritski
W Paris	
M Rothwell	
J Wanzeck	
K Wiedner	
W Ferris	

GSKeeley/cg
1/15/80

ENCLOSURE 3

COMMENTS ON 50.54(f) RESPONSES FOR MIDLAND (MEB)

1. GENERAL

A review of the Response to Questions 16-20 of the Subject document indicates that the applicant proposes to impose the 3.0 Se criterion of subparagraph NC-3652.3(b) of the ASME B&PVC, Section III and the 5% radial deformation limit of the AWWA. Additional criteria which address buckling of the piping should be imposed since neither of the two proposed criteria are based on this failure mode. Additionally, criteria compliance analyses should be based on maximum expected differential settlement over the life of the plant.

2. RESPONSE TO QUESTION 16, PAGE 16-1

The response addresses stresses based on representative pipes being profiled, i.e. on current local settlements. The response should be modified to include settlements over the life of the plant.

3. RESPONSE TO QUESTION 17, PAGE 17-1, PARA. 1

If all Seismic Category I piping is not to be profiled, criteria for selection of piping to be profiled should be documented.

4. RESPONSE TO QUESTION 17, PAGE 17-2, PARA. 2

The calculation assumes that the curvature is constant over the length of pipe. In general, this condition will not be met. Criteria for changes in curvature should be addressed.

5. RESPONSE TO QUESTION 17, PAGE 17-3, PARA. 2

If the settlement stresses are based on current profiles only, the analysis should be extended to include settlements over the life of the plant and effects of change in curvature (See item 3).

6. RESPONSE TO QUESTION 17

The question regarding measures to be taken to alleviate conditions if settlement stresses approach code allowables or cannot be determined has not been addressed.

7. RESPONSE TO QUESTION 18, PAGE 18-1, PARA. 2 & 3

It is not clear that most of the anticipated differential settlement will occur by the time of final closure (Para. 2). Provisions for effects of settlements occuring after final closure should be specified. The evaluations of Para. 3 addresses this issue partially.

8. RESPONSE TO QUESTION 18, PAGE 18-2, PARA. 2 & 3

Criteria for assessment of the flexibility of piping to accomodate more than the expected differential settlement should be specified.

9. RESPONSE TO QUESTION 19, PAGES 19-1 TO 19-3

The disposition of this response will be delayed pending receipt and review of evaluations based on the preload program (See last paragraph on Page 19-3).

10. RESPONSE TO QUESTION 20

The first paragraph of the response is acceptable. However, the remainder of the response requires clarification.

Consumers Power Company

Midland Project: P.O. Box 1963, Midland, Michigan 48640 · Area Code 517 631-0951

January 25, 1980

Mr. M. O. Rothwell
Bechtel Power Corporation
P.O. Box 1000
Ann Arbor, MI 48106

MIDLAND PROJECT GWO 7020 -
SOILS RESPONSES TO 50.54(f) QUESTIONS
File: 0485.16 UFI: 00234(S), 71*01 Serial: CSC-4763

After discussions in Bethesda, Maryland, with the NRC on January 16, 1980, and the CP/Bechtel discussions in Ann Arbor on January 22, 1980, the following areas should be clarified and/or amplified in our responses to the 50.54(f) questions.

1. J. Wanzeck should clarify the slide shown in Washington to indicate the day the tank foundation was placed and it should be noted that this is a six month settlement update only. This can be accomplished possibly via an MCAR update or old question response update.

2. The alledged quarter inch diesel fuel oil tank settlement needs to be verified or deleted from wherever it was supposedly reported to the NRC. (J. Wanzeck)

3. S. Afifi, in the response to Question 4, should explain that table 4-1 is a projection (show totals only) and not what the structure can stand. He will also relocate this table to Question 27.

   S. Lo should verify that "to date" settlement plus additional future settlement will cause no problems to the diesel generator structure in the response to Question 14.

4. S. Afifi will indicate how we arrived at the half-inch figure for settlement caused by vibration of the diesel generator pedestals due to operation of the diesel generators. In response to Question 27, Dr. Woods analysis to include his method of calculation will be utilized.

5. S. Afifi will delete the word "clay" from the third line under note on table 4-1. (Renumbered 27-). He will also include the total settlement graph instead of only the portion utilized for predictions.

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1-22-81 ue83

6. Table 4-1 footnote 2 (Renumbered 27-) - S. Afifi will explain how the settlement of the borated water storage tank is based on measurements of the Diesel Generator Building settlement here and in the response to Question 31.

7. The individual best fit curves projecting diesel generator settlement allow no margin for standard deviation on the best fit. Therefore, this appears to be unconservative. We need to amplify the fact that the curves assume the surcharge remains and that the worst data points are utilized for total settlement. This also would, of course, include something on the worst settlement being utilized for differential settlement calculations and their affect on the structure and connections. S. Afifi will add some discussion to amplify the conservative aspects and a statement on the piezometer in response to Question 27.

8. Our outline of response to Question 27 states: Item B. basis for accuracy. The outline will be changed and one sentence will state that the basis for accuracy is conservatism. We do not appear to be getting the response across on the borated water storage tanks. It is necessary to show that the soil is adequate in more concise terms. S. Afifi will add emphasis to the acceptable quality of the soil and that filling the tanks is only being done to verify the settlement prediction. It will be noted that this is not a soils problem; rather it is more like normal practice. We also have to verify that the tank foundation is adequate and that we will not have the problems which could arise if the foundation should somehow fail and you would have a subsequent stretching of the bottom membrane of the tank followed by a tear in the tank wall. All loads must be considered in this analysis. We should also state that we do not have the same degree of randomness in the soil as was present in the Diesel Generator Building. S. Lo will provide analysis to show that the tank foundation will be able to withstand seismic events. S. Afifi will do more research on the overload test necessity.

9. Our response to Question 33 needs to be amplified to include the effect of bouyancy on the load tests and what effect the lack of water (if any) from site dewatering will have on the tank settlement. Possibly there will be a retest after dewatering (S. Afifi).

10. B. Paris will address whether or not there will be any effect on the ultimate heat sink pond seal due to site dewatering in response to 24. f. and note why we are using timers instead of float switches in the pumps in response to 24. c., utilizing Loughney's input. The basis for the gradation of the gravel pack material will also be addressed by B. Paris in the response to 24. d. The slide for the individual wells freeze protection on the riser pipes will be shown by B. Paris on the response to Question 24.

11. S. Lo, K. Wiedner and T. Johnson will show that all past loads have been accounted for in the analysis of the future settlements of the Category I structures in response to Question 28 and 29. The NRC questioned whether the stress induced by differential settlement in the past was now locked

in the structure and additive to future loads, such as, additional settlement, seismic, etc. Our response will include some crack investigative depth core drilling and analysis of relief of stress due to identified positive remedial measures.

12. A response on the Q-ducts has to include an analysis as a category one structure. It was noted that this may not have been used as criteria in 1970, however, in 1976 this was checked per BC-TOP 4. This will be included in our response to Question 30. (S. Lo)

13. The response for 24. c. will include an analysis for the concrete service water pipes in the cooling pond and any other concrete pipes embedded in the class one fill. In the 24. c. response, B. Paris will also note that concrete pipes are generally away from critical structures and discuss probability failures.

14. After considerable discussion, it appears that the NRC is desirous of having Bechtel's proposed detailed method of analysis for the seismic event (Question 25). Bechtel will provide their normal analysis for new soils conditions under affected category I structures. (M. Rothwell)

Bechtel plans a lump mass analysis to include an envelope for settlement. In discussing Question 26, the NRC noted that they are not in a position to adopt new methods or codes at this point in time, however they (on their own) wish to compare the new methods with earlier analysis to establish some level of margin. S. Lo's analysis will be complete sometime in mid 1980.

15. Miscellaneous:

A. General

A review of the response to Question 16-20 of the subject document indicates that the applicant proposes to impose the 3.0 S_c criterion of subparagraph NC-3652.3(b) of the ASME B&PVC, Section III and the 5% radial deformation limit of the AWWA. Additional criteria which address buckling of the piping should be imposed since neither of the proposed 2 criteria are based on this failure mode. Additionally, criteria compliance analyses should be based on maximum expected differential settlement over the life of the plant.

B. Response to Question 16, Page 16-1 (Civil)

The response addresses stresses based on representative pipes being profiled, i.e.; on current local settlements. The response should be modified to include settlements over the life of the plant.

C. Response to Question 17, Page 17-1, Paragraph 1 (Riat)

If all Seismic Category I piping is not to be profiled, criteria for selection of piping to be profiled should be documented.

D. Response to Question 17, Page 17-2, Paragraph 2 (Riat)

The calculation assumes that the curvature is constant over the length of pipe. In general, this condition will not be met. Criteria for changes in curvature should be addressed.

E. Response to Question 17, Page 17-3, Paragraph 2 (Riat)

If the settlement stresses are based on current profiles only, the analysis should be extended to include settlements over the life of the plant and effects of change in curvature (See item C).

F. Response to Question 17 (Riat)

The question regarding measures to be taken to alleviate conditions if settlement stresses approach code allowables or cannot be determined has not been addressed.

G. Response to Question 18, Page 18-1, Paragraph 2 and 3 (Riat)

It is not clear that most of the anticipated differential settlement will occur by the time of final closure (Paragraph 2). Provisions for effects of settlements occuring after final closure should be specified. The evaluations of Paragraph 3 addresses this issue partially.

H. Response to Question 18, Page 18-2, Paragraph 2 and 3 (Riat)

Criteria for assessment of the flexibility of piping to accomodate more than the expected differential settlement should be specified.

I. Response to Question 19, Pages 19-1 to 19-3 (Civil)

The disposition of this response will be delayed pending receipt and review of evaluations based on the preload program (See last paragraph on Page 19-3).

J. Response to Question 20 (Riat)

The first paragraph of the response is acceptable. However, the remainder of the response requires clarification.

T. C. Cooke
Project Superintendent

TCC/ps

Attachment: Attendees List

CC: CAHunt
GSKeeley
DBMiller
KWiedner (Bechtel)
SAfifi (Bechtel)
ABoos (Bechtel)
[illegible]hr (Bechtel)
LCurtis (Bechtel)
LDavis (Bechtel)

Attendees

1/16/80

Name	Organization
Darl Hood	DPM/NRR
Joe Kubinski	COE Detroit Dist.
William Paris Jr.	Bechtel - Geotech
Jo Wanzeck	Bechtel - Geotech
S. S. Afifi	Bechtel
W. R. Ferris	Bechtel
M. O. Rothwell	Bechtel
Karl Wiedner	Bechtel
Gil Keeley	Consumers Power
T. C. Cooke	Consumers Power
F. Schaufig	NRC-SEB
J. J. Zabritski	Consumers Power
S. Lo	Bechtel
T. E. Johnson	Bechtel
John F. Horton	COE NC Division Chicago
James W. Simpson	Army Corps NCD Chicago
William Lawhead	U.S. Army COE, Detroit
R. E. Lipinski	NRC-SEB
Gene Gallagher	NRC Region III:IE
Ross Landsman	NRC Region III:IE
Daniel M. Gillen	NRC NMSS
A. J. Cappucci	
R. O. Busnak	NRC/DSS/MEB
H. L. Brammer	NRC/DSS/MEB
Ray Gonzales	NRC/DSE/HMB
J. P. Knight	NRC/DSS
R. E. Jackson	NRC/DSS/GSB
J. G. Spraul	NRC/NRR/OAB
R. E. Shewmaker	NRC/IE/RCI

1/22/80

M. Rothwell	Bechtel
S. Afifi	Bechtel
J. Wanzeck	Bechtel
B. Paris	Bechtel
S. Lo	Bechtel
T. Cooke	Consumers Power Company

Preliminary Evaluation of 50.54(f) Responses for Midland (MEB)

1. GENERAL

A review of the Response to Questions 16-20 of the Subject document indicates that the applicant proposes to impose the 3.0 Sc criterion of subparagraph NC-3652.3(b) of the ASME B&PVC, Section III and the 5% radial deformation limit of the AWWA. Additional criteria which address buckling of the piping should be imposed since neither of the proposed 2 criteria are based on this failure mode. Additionally, criteria compliance analyses should be based on maximum expected differential settlement over the life of the plant.

2. RESPONSE TO QUESTION 16, PAGE 16-1

The response addresses stresses based on representative pipes being profiled, i.e. on current local settlements. The response should be modified to include settlements over the life of the plant.

3. RESPONSE TO QUESTION 17, PAGE 17-1, PARA. 1

If all Seismic Category I piping is not to be profiled, criteria for selection of piping to be profiled should be documented. FOR ... JUDGEMENT

4. RESPONSE TO QUESTION 17, PAGE 17-2, PARA. 2

The calculation assumes that the curvature is constant over the length of pipe. In general, this condition will not be met. Criteria for changes in curvature should be addressed. SUBMITTING UPDATED ... WITH MORE DET...

Cappucci depo Ex 7
11-22-81

5. RESPONSE TO QUESTION 17, PAGE 17-3, PARA. 2

If the settlement stresses are based on current profiles only, the analysis should be extended to include settlements over the life of the plant and effects of change in curvature (See item 3).

6. RESPONSE TO QUESTION 17

The question regarding measures to be taken to alleviate conditions if settlement stresses approach code allowables or cannot be determined has not been addressed.

7. RESPONSE TO QUESTION 18, PAGE 18-1, PARA. 2 & 3

It is not clear that most of the anticipated differential settlement will occur by the time of final closure (Para. 2). Provisions for effects of settlements occuring after final closure should be specified. The evaluations of Para. 3 addresses this issue partially.

8. RESPONSE TO QUESTION 18, PAGE 18-2, PARA. 2 & 3

Criteria for assessment of the flexibility of piping to accomodate more than the expected differential settlement should be specified.

9. RESPONSE TO QUESTION 19, PAGES 19-1 TO 19-3

The disposition of this response will be delayed pending receipt and review of evaluations based on the preload program (See last paragraph on Page 19-3).

10. RESPONSE TO QUESTION 20

The first paragraph of the response is acceptable. However, the remainder of the response requires clarification.

Preliminary Evaluation of 50.54(f) Responses for Midland (MEB)

ENERGY TECHNOLOGY ENGINEERING CENTER

DOCUMENT REVIEW COMMENTS

TO: A.J. Cappucci Jr., M.E.B., D.S.S., NRC (492-7538)
FROM: W.P. Chen, ETEC
SUBJECT: DOCUMENT REVIEW Consumer Power Company Howe 121-79
REVIEW SUBJECT Response To Questions 16-20 Of Consumer Power C... Response To 10 CFR 50.54 Request On Plant Fill (Fi... Dated July 9, 1979)

REVIEW NO.
FILE
DATE
PAGE 1 OF 3

ITEM	LOCATION OR PARAGRAPH	COMMENT	ACTION
1	General	A Review Of The Response To Questions 16-20 Of The Subject Document Indicates That The Applicant Proposes To Impose The 3.0 S_c Criterion Of Subparagraph NC-3652.3 (b) Of The ASME B&PVC, Section III And The 5% Radial Deformation Limit Of The AWWA. Additional Criteria Which Address Buckling Of The Piping Should Be Imposed Since Neither Of The Proposed 2 Criteria Are Based On This Failure Mode. Additionally, Criteria Compliance Analyses Should Be Based On Maximum Expected Differential Settlement Over The Life Of The Plant.	
2.	Response To Question 16, Page 16-1	The Response Addresses Stresses Based On Representative ~~Basis~~ Pipes Being Profiled, i.e. On Current Local Settlements. The Response Should Be Modified To Include Settlements Over The Life Of The Plant.	
3	Response To Question 17 Page 17-1 Para. 1	If All Seismic Category I Piping Is Not To Be Profiled, Criteria For Selection Of Piping To Be Profiled	

ETEC DOCUMENT REVIEW COMMENTS (CONT) REVIEW NO. ________ PAGE 2 OF 3

REVIEW SUBJECT ________

ITEM	LOCATION OR PARAGRAPH	COMMENT	ACTION
		Should Be Documented	
4	Response To Question 17 Page 17-2 Para. 2	The Calculation Assumes That The Curvature Is Constant Over The Length Of Pipe. In General, This Condition Will Not Be Met. Criteria For Changes In Curvature Should Be Addressed.	
5	Response To Question 17 Page 17-3 Para. 2	If The Settlement Stresses Are Based On Current Profiles Only, The Analysis Should Be Extended To Include Settlements Over The Life Of The Plant And Effects Of Change In Curvature (See Item 3).	
~~6~~	~~Response To Question 17 Tables 17-1 & 17-2.~~	~~Table 17-2 Indicates That Service Water Line 8"-1HBC-82 Was Profiled. Table 17-1 Indicates That This Line Was Not. The Discrepancy Should Be Clarified.~~	
6	Response To Question 17	The Question Regarding Measures To Be Taken To Alleviate Conditions If Settlement Stresses Approach Code Allowables Or Cannot Be Determined Has Not Been Addressed.	
7	Response To Question 18 Page 18-1 Para. 2&3	It Is Not Clear That Most Of The Anticipated Differential Settlement Will Occur By The Time Of Final Closure (Para. 2). Provisions For Effects Of Settlements Occuring After Final Closure Should Be	

ETEC DOCUMENT REVIEW COMMENTS (CONT) REVIEWING: ______ PAGE 3 OF 3

REVIEW SUBJECT ______

ITEM	LOCATION OR PARAGRAPH	COMMENT	ACTION
		Specified. The Evaluations Of Para. 3 Addresses This Issue Partially.	
8	Response To Question 18 Page 18-2 Para. 2&3	Criteria For Assessment Of The Flexibility Of ~~Steel~~ Piping To Accomodate More Than The Expected Differential Settlement Should Be Specified.	
9.	Response To Question 19 Pages 19-1 To 19-3	The Disposition Of This Response ~~Should Be~~ ~~[illegible]~~ will be delayed Pending Receipt And Review Of Evaluations Based On The Preload Program (See Last Paragraph On Page 19-3)	
~~10~~	~~Response To Question 19 Page 19-1 Para. 1~~	~~Validation Of The Hold Aquaducer Profile Gage Should Be Documented.~~	
~~11~~ 10	Response To Question 20	The First Paragraph Of The Response Is Acceptable. However. The Remainder Of The Response ~~Dilutes And Negates What Was Said In The First Paragraph. This Discrepancy Should Be Clarified.~~ requires clarification.	

FORM T2506-001 REV 6/78

What criteria did you use to select underground pipes to be profiled?

~~List your procedures~~ that the profile measurements for underground pipes performed and reported to date includes the worst ~~[illegible]~~ existing case of stress in any underground pipe experiencing bending stresses due to differential soils settlement? If so, how?

~~[illegible]~~ Does your selection criteria assume

Have any underground pipes been profiled for which the results have not been reported to the NRC?

Have you performed any analyses of the stresses in underground piping due to future projection of differential soil settlement? If so, which pipes were analyzed, on what basis were these pipes selected for analysis, and what resultant stresses were predicted?

Have any underground pipes been removed, rerouted or replaced as a result of profile measurements or because the rapid change in slope in some area of a line suggests high local loads?

Cappucci depo Ex 8
11-27-81

- Figure 1 - Typical Pipe Profile
- Conduits?
- Aux Building - Settlement Problems?
- Condensate lines in Building
- Piping from tank farm (Control Room Pressurization Tanks) to Control room - underground?
- Equipment Qualification?
- Settlement of Borated H_2O Storage Tank - Is tank built, Did they surcharge tanks or do they plan to?
- Dynamic Forces on dike wall and other tanks due to BST Rupture (instantaneous).

Piping

- 14KSI - 27KSI allowable = 48KSI
- Analysis is in progress for operability of pumps and valves
- Constant curvature analysis?

what pipe are connected?

- Rotations in addition to linear displacements
- Anchor Points - effects of settlement
- Displacement over 40 years - final settlement ✓
- ~~need to pipe layout - whats above & whats below ground~~
- Comments to 16 - 20 did you answer these questions
- what stresses so far in pipe - stress intensification at elbows, etc.
- Profiling
- what assumptions he made in analysis - how is piping supported? will non-uniform support cause additional stresses.

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11-22-81 WRB

near Piles - valve pit

CONCRETE OBSTRUCTIONS IN THE FILL - SAME IN PIPE LOCATIONS?

3 in 4 inches on S-Side at Diesel Gen Bldg.
- Rotation around S-Side -

Soil Settled faster than Building - ~~Same for pipe?~~

Response Spectra Dynamic Analysis has been complete, however changes to equipment Specifications have not been made at this time

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Gravel deposit 10
11-22-81

σ'_{sh} = portion of σ'_i contributed by stress history;
σ'_{ir} = portion of σ'_i contributed by interparticle repulsions;
σ'_{is} = portion of σ'_i contributed by suction;
σ_m = mean total principal stress;
σ'_m = mean effective principal stress;
σ_y = yield stress of the soil particle;
τ = shear stress (resistance);
τ_f = shear strength;
ϕ' = angle of friction in the effective stress representation;
ϕ^* = intrinsic angle of friction;
ϕ'_r = true residual angle of friction; and
χ^* = proportionality coefficient between number of bonds and true contact area.

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Settlement Comparison Used in Tank-Failure Study

By Roy A. Bell,[1] M. ASCE and Jun Iwakiri[2]

Introduction

An investigation into the possible causes that led to the failure of Tank T-270, a 315,000 bbl (50,000 m³) oil-storage tank in Japan, included a comparative study of the settlement behavior of 33 large tanks on soft ground sites in Japan and other countries. The comparative study included the evaluation of the measured tank-shell and tank-floor settlements with respect to the tilt plane of the tank shell. The results of these comparative studies provide empirical data on the behavior of many tanks that experienced large settlements yet continued to perform satisfactorily and on a few tanks that failed. Some of the factors that were thought to have contributed to the failure of Tank T-270 are described. Many tanks that experienced more severe settlements than Tank T-270 did not fail, yet some movements that occured in and below the floor of Tank T-270 probably contributed to its failure.

It is hoped that the data presented in this paper will provide a basis of comparison for others who may want to evaluate the possible severity of the settlement behavior of tanks for which they are concerned. Acceptable tolerances of tank movements that have been suggested by others are summarized. These methods are all empirical. They appear to be valid for properly designed and constructed tanks on the bases of these additional case studies.

Failure of Tank T-270

On December 18, 1974, the 172-ft (52.3-m) diam, 78-ft (23.7-m) high, hot-oil storage Tank T-270 at the Mitsubishi Oil Company Refinery in Mizushima,

Note.—Discussion open until July 1, 1980. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. This paper is part of the copyrighted Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. GT2, February, 1980. Manuscript was submitted for review for possible publication on May 29, 1979.

[1] Sr. Engr., Dames & Moore, San Francisco, Calif.
[2] Mgr., Civ. Engrg. Dept., Chiyoda Chemical Engrg. and Construction Co. Ltd., Yokohama, Japan.

pan, rupture. The contents flooded much of the refinery property and flowed to the adjacent Inland Sea causing severe damage to the fishing industry. As a result, the 270,000 bbl/day refinery was shut down for about 9 months, largely because of public reaction. By the time the refinery was permitted to resume operation the accident had cost the refinery more than $150,000,000.

The failure included separation of welds along about 11.5 ft (3.5 m) of the 3/8 in. (9-mm) thick, mild steel tank floor; a 3.5 ft (1.06 m) long tear through the 1/2 in. (12-mm) thick high strength steel annular plate; and a 42-ft (12.8 m) long tear through the annular plate along the base of the inside shell weld to annular plate. The edges of the ruptured bottom plates were bent down 8 ft-10 ft (2.5 m-3 m) into a cavity eroded into the tank pad as the contents flowed through the ruptured area. The failure occured approx 7 months after the tank had been placed in service. The consequences of the failure were greatly aggravated by the collapse of a stair tower that had been constructed adjacent to the tank. The stair tower and its foundation were washed into the side of the concrete block fire wall causing it to rupture, thus permitting the contents to flow out into the refinery area and beyond.

Tank T-270 Foundation and Loading Conditions

The tank was constructed on a site that had been developed by placing weak hydraulic fill materials over weak natural deposits that totaled about 50 ft (16 m) in thickness. Prior to tank construction the site was preloaded with a sand-drain, well point, earth-fill surcharge program. The supporting soils were improved by controlled water testing of the tank. A cross section of the tank and subsurface soil profile is shown in Fig. 1.

Approximately 3,000 sand drains, each 4-3/4 in. (120 mm) in diameter, 56 ft (17 m) long, and spaced 4 ft (1.2 m) C to C were installed below the tank pad prior to the preloading program. An earth fill preload about 15 ft (4.5 m) thick was placed on the tank site. Wellpoints 1-1/2 in. (38.1 mm) in diameter, 27 ft (8.3 m) long, and spaced at 5-ft (1.5-m) intervals surrounded the preload fill. Three vacuum wells were installed near the center of the surcharge.

The water table was pumped down about 18 ft (5.5 m) so that together with the earth fill there was an effective preload equivalent to about 43 ft (13 m)

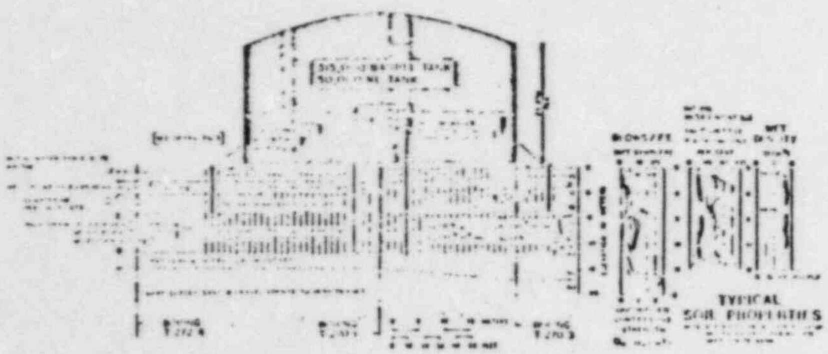

FIG. 1.—Cross Section of Tank T-270 Showing Subsurface Profile

of water load above tank floor elevation. The center of the preload area settled about 35 in. (889 mm) and the perimeter portion at the planned tank shell location settled about 24-28 in. (610 mm-711 mm) in a period of about 2 months. A sketch of the preload schedule and settlement is shown in Fig. 2.

The domed roof tank was erected by the tank airlift (TAL) method in which the roof and upper course of shell are fabricated first, then lifted by air that is blown into the tank as the remaining lower courses of steel shell are welded into place. The last weld was therefore at the bottom of the shell to annular

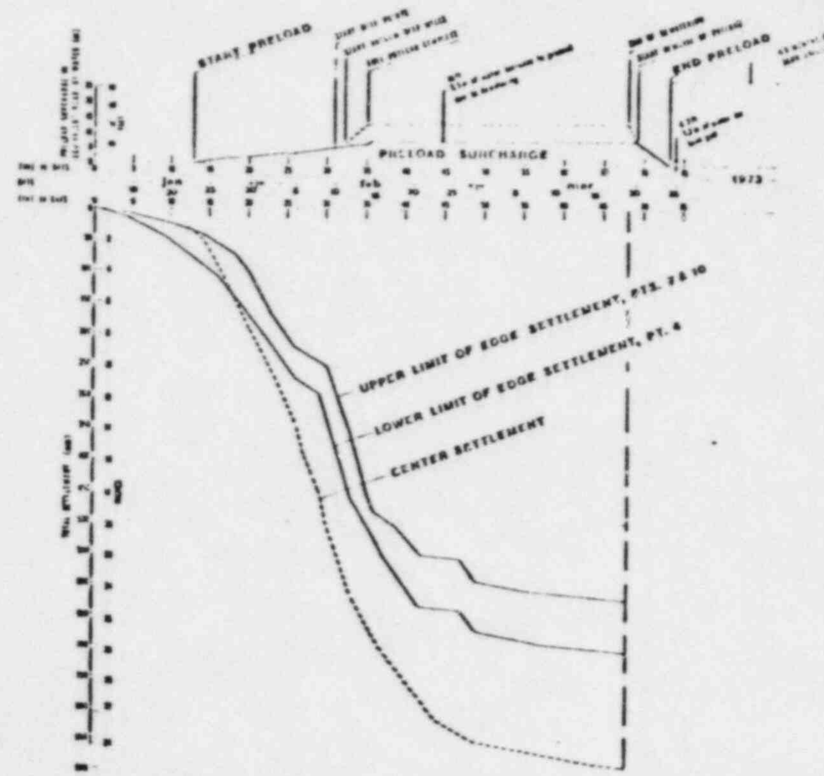

FIG. 2.—Tank T-270 Preload Schedule and Settlements

floor plate. The poor quality of this weld was evaluated as one of the primary factors that contributed to the cause of the failure.

The portion of tank pad below the tank shell consisted of a ring of concrete blocks over a ring of crushed stone. The remainder of the pad was compacted sand about 6-1/2 ft (2 m) thick. A cross section of the as-built tank pad detail is shown in Fig. 3.

The tank was filled incrementally with sea water with increasing loading about every 10 days to a final depth of 77 ft (23.5 m) over a period of 90 days. During the water testing when the water was 40 ft (12 m) deep (20 days-30 days into the water test) an excavation was made for a 8-ft by 18-ft (2.3-m

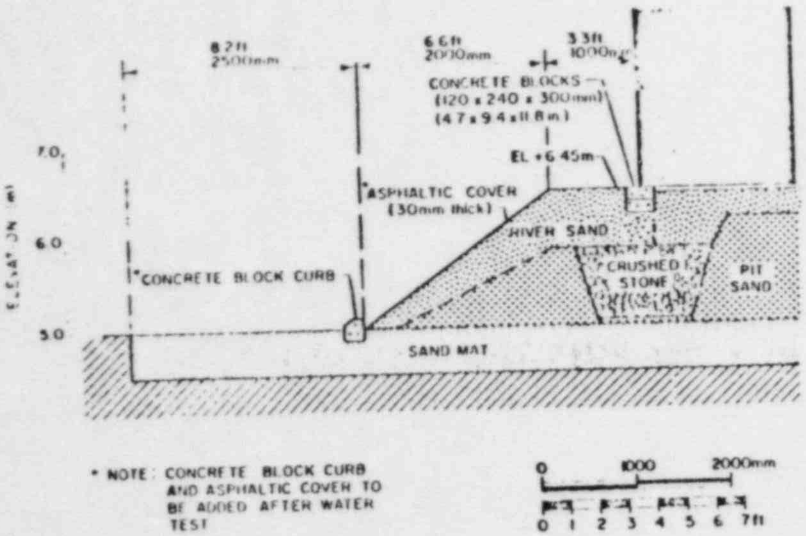

FIG. 3.—Tank T-270 Pad Detail

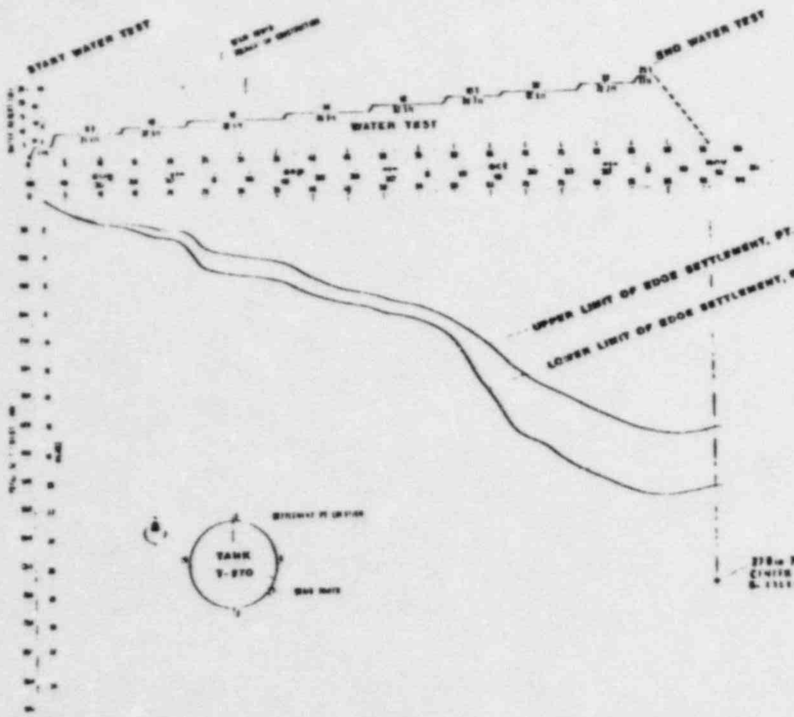

FIG. 4.—Tank T-270 Water-Test Load/Settlement Diagram

by 5.4-m) concrete mat footing causing a segment of the tank shell to be undermined. The footing was used to support a stair tower to the roof of the tank. The tank floor subsequently ruptured in the vicinity of the stair-tower footing. The strains induced into the tank floor during the time of excavation for the stair-tower foundation were judged as contributing to the cause of the failure.

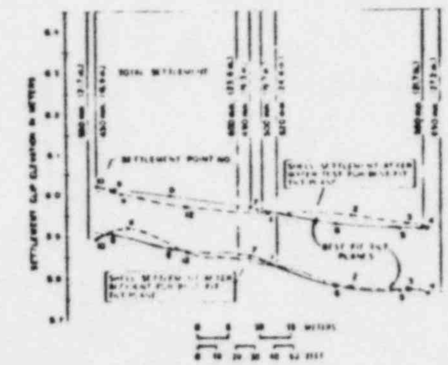

FIG. 5.—Tank T-270 Shell Settlement Profile after Water Test

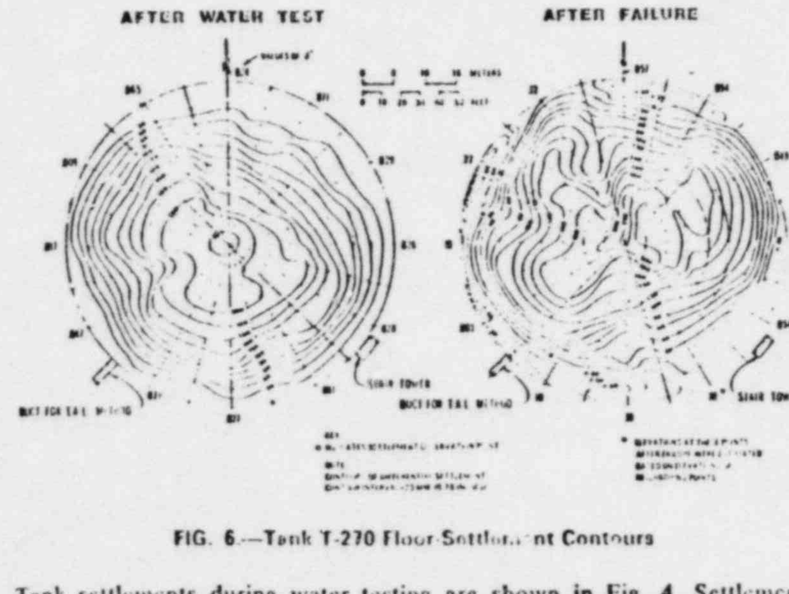

FIG. 6.—Tank T-270 Floor-Settlement Contours

Tank settlements during water testing are shown in Fig. 4. Settlement as measured after completion of the water testing was about 28 in. (711 mm) in the central floor area. Shell settlements were from 17 in.-22 in. (502 mm-559 mm), distributed along the shell so as to result in nearly rigid tilt of the tank shell. A plot of the tank-shell settlements that oriented along the best-fit rigid-settlement tilt plane after the water test and again after the failure are shown in Fig. 5. Contours of tank floor settlements at the end of water testing

and after failure with respect to the best-fit rigid-settlement tilt plane of the shell are shown in Fig. 6. The values of δ' signify the out-of-plane distortion of each settlement measurement point as defined by Bellon', et al. (1). (see Appendix I for solution of best-fit rigid-settlement tilt plane and calculation of δ'.)

The Tank T-270 shell settlement was about 20 in. (508 mm) and the center of floor settlement was about 28 in. (711 mm) during water testing plus another 4 in. (102 mm) during product service. Both the total amounts and rates of settlement can be theoretically accounted for on the basis of settlement analyses. Soil failure or plastic deformations are not needed to account for this settlement behavior. The measured settlement configuration of Tank T-270 at the time of water testing, when the highest loading was applied and when the supporting soils were still consolidating and gaining strength, shows no indication of foundation soil failure. Also, the fact that 20 other large-diameter tanks, of about the same height and on essentially the same soil and foundation conditions

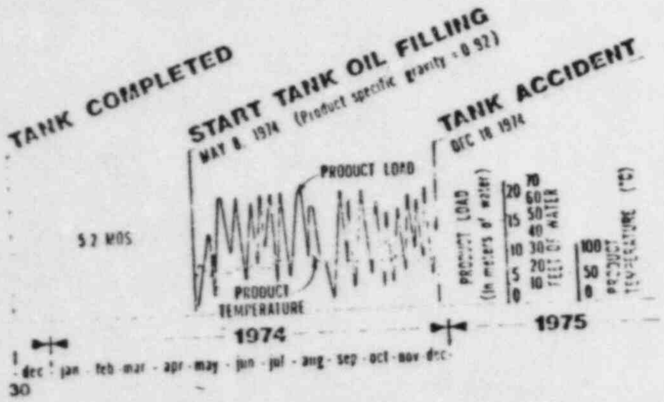

FIG. 7.—Tank T-270 Product Load and Temperature Record

at the Mizushima Refinery, performed satisfactorily would tend to support the idea that the failure of the Tank T-270 was not due to a soil bearing failure.

Following the water test, the tank was in service for about 7 months. During this period, product loading cycled from near empty to near full about three times each month. Product temperature ranged from about 70°-80° C. A plot of the product load and temperature is shown in Fig. 7. The cyclic nature of load at high temperature was judged to have also contributed to the failure by causing humping of the floor plates and fatigue of the metal in the annular plate where failure took place.

A companion tank, number T-271 of the same size was constructed next to Tank T-270 about the same time, by the same TAL method, was water tested, excavated under for a stair-tower foundation installation, and placed into nearly identical service. It did not fail, but it was taken out of service and used for extensive experiments involving strain measurements of the shell

Tank T-270 Failure Investigation and Comparative Studies

Following the failure of Tank T-270 a committee of experts on various aspects of tank and foundation design and construction from industry and the academic communities of Japan performed extensive investigations into the causes of failure. Prior to making these investigations and prior to identifying the various causes that have already been mentioned, the committee issued a preliminary report citing the many possible things that could have contributed to the failure. Their preliminary report indicated the suspicion that a foundation failure (soil-bearing failure) or excessive foundation settlement, or both, may have caused the accident.

At this time, on behalf of the tank foundation designers and constructors, the writers conducted an evaluation of the foundation stability and settlement behavior. Data on foundation soil properties, preload settlements, water-test settlements, and foundation stability from Tanks T-270 and T-271 were analyzed and compared with similiar data from other large tanks at the Mizushima refinery and from other sites in Indonesia, Puerto Rico, Iran, Canada, England, and the United States plus data taken from the literature on nine other tanks. A total of 33 large storage tanks on soft-ground sites were studied. Technical information for each tank: size, roof type, floor crown, foundation soil properties, water test load, and settlement behavior is summarized in Fig. 8.

Tank Tilting.—Fig. 8 includes the best-fit rigid-settlement tilt angle for those cases where sufficient edge settlement readings were available to make such a calculation. As shown, three tanks, cases F, P, and R-4, tilted (0.84%, 0.40% and 0.34%, respectively) more than the T-270 tank (0.30%). These tanks remained in service without releveling. Other tanks, Cases O and R-5, tilted twice as much as the T-270 tank, but because of more severe differential floor settlements these tanks were releveled. It is the writers' opinion that the tilt experienced by Tank T-270 was insignificant from an operational standpoint. Greenwood (10) suggested that an average tilt of possibly more than 0.5% of the best-fit rigid-settlement tilt plane could be experienced before the differential product storage loading, due to tilting, would induce out-of-roundness at the top ring girder of a floating roof tank.

Differential Shell Settlement.—Fig. 8 also contains various shell settlement information, including the maximum out-of-plane edge settlements as defined by Belloni, et al. (1). In their method, the maximum change in slope between three adjacent settlement points on the shell is computed in relation to the best-fit rigid-settlement tilt plane through all the shell-settlement measurement points. Of the cases listed in Fig. 8, the only tanks that required releveling of the shell because of out-of-plane settlement were T-16 in Case 5 and Case R-2. No detailed settlement records were available to us for Case R-2, and we understand some faulty erection procedures in Case 5 may have been more influential than the differential shell settlements. Nevertheless, the maximum out-of-plane differential settlement of Tank T-16 in Case 5 was 0.25%. The maximum out-of-plane differential settlement of the T-270 tank at the maximum water-test load was 0.08% whereas it was 0.20% at the maximum water load for Tank T-271. Belloni, et al. (1) suggest as a "working hypothesis" a value of 0.22% as a safe operating value for large floating roof tanks. They also

and after failure with respect to the best-fit rigid-settlement tilt plane of the shell are shown in Fig. 6. The values of δ' signify the out-of-plane distortion of each settlement measurement point as defined by Belloni, et al. (1). (see Appendix I for solution of best-fit rigid-settlement tilt plane and calculation of δ'.)

The Tank T-270 shell settlement was about 20 in. (508 mm) and the center of floor settlement was about 28 in. (711 mm) during water testing plus another 4 in. (102 mm) during product service. Both the total amounts and rates of settlement can be theoretically accounted for on the basis of settlement analyses. Soil failure or plastic deformations are not needed to account for this settlement behavior. The measured settlement configuration of Tank T-270 at the time of water testing, when the highest loading was applied and when the supporting soils were still consolidating and gaining strength, shows no indication of foundation soil failure. Also, the fact that 20 other large-diameter tanks, of about the same height and on essentially the same soil and foundation conditions

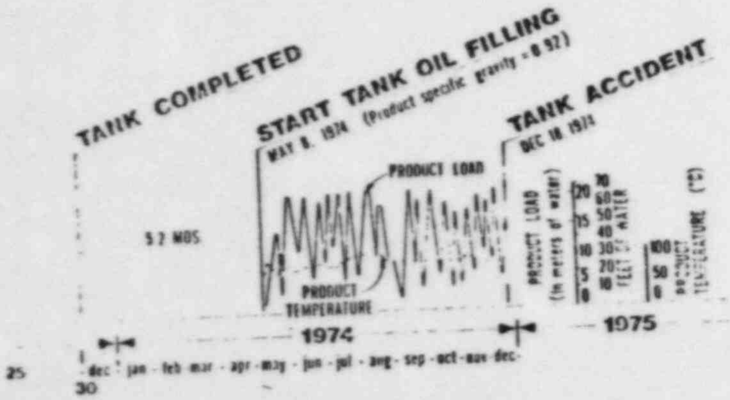

FIG. 7.—Tank T-270 Product Load and Temperature Record

at the Mizushima Refinery, performed satisfactorily would tend to support the idea that the failure of the Tank T-270 was not due to a soil bearing failure.

Following the water test, the tank was in service for about 7 months. During this period, product loading cycled from near empty to near full about three times each month. Product temperature ranged from about 70°-80° C. A plot of the product load and temperature is shown in Fig. 7. The cyclic nature of load at high temperature was judged to have also contributed to the failure by causing humping of the floor plates and fatigue of the metal in the annular plate where failure took place.

A companion tank, number T-271 of the same size was constructed next to Tank T-270 about the same time, by the same TAL method, was water tested, excavated under for a stair-tower foundation installation, and placed into nearly identical service. It did not fail, but it was taken out of service and used for extensive experiments involving strain measurements of the shell

Tank T-270 Failure Investigation and Comparative Studies

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At this time, on behalf of the tank foundation designers and constructors, the writers conducted an evaluation of the foundation stability and settlement behavior. Data on foundation soil properties, preload settlements, water-test settlements, and foundation stability from Tanks T-270 and T-271 were analyzed and compared with similiar data from other large tanks at the Mizushima refinery and from other sites in Indonesia, Puerto Rico, Iran, Canada, England, and the United States plus data taken from the literature on nine other tanks. A total of 33 large storage tanks on soft-ground sites were studied. Technical information for each tank: size, roof type, floor crown, foundation soil properties, water test load, and settlement behavior is summarized in Fig. 8.

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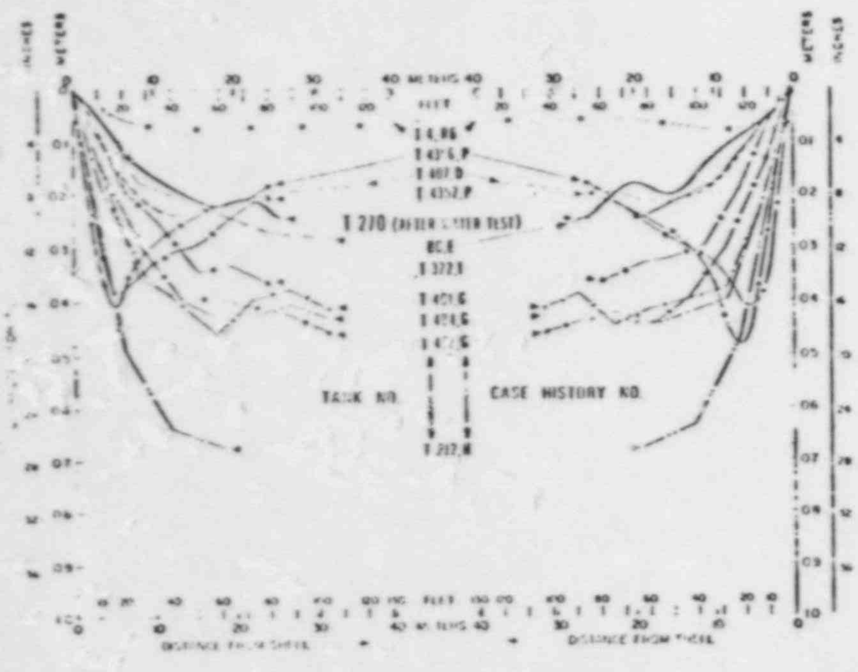
Differential Shell Settlement.— Fig. 8 also contains various shell settlement information, including the maximum out-of-plane edge settlements as defined by Belloni, et al. (1). In their method, the maximum change in slope between three adjacent settlement points on the shell is computed in relation to the best-fit rigid-settlement tilt plane through all the shell-settlement measurement points. Of the cases listed in Fig. 8, the only tanks that required releveling of the shell because of out-of-plane settlement were T-16 in Case 5 and Case R-2. No detailed settlement records were available to us for Case R-2, and we understand some faulty erection procedures in Case 5 may have been more influential than the differential shell settlements. Nevertheless, the maximum out-of-plane differential settlement of Tank T-16 in Case 5 was 0.25%. The maximum out-of-plane differential settlement of the T-270 tank at the maximum water-test load was 0.08% whereas it was 0.20% at the maximum water load for Tank T-271. Belloni, et al. (1) suggest as a "working hypothesis" a value of 0.22% as a safe operating value for large floating roof tanks. They also

1.1% of the tank diameter in order to limit stresses in the 0.25 in. (6.35 mm) ... plates to 9,000 psi (62,010 kPa). Clarke (6) suggested a maximum of 2 (51 mm) of differential floor settlements within any 30 ft (9 m) diam floor (approx 0.5%).

Floor Crown.—The significance of tank-floor settlements can also be influenced the initial shape of the floor crown. Considering an initially flat floor 100



CASE NO.	TANK NO.	[illegible]	[illegible]
1	T-270	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]
G	[illegible]	[illegible]	[illegible]

FIG. 9.—Tank Floor Settlement Profiles of Tanks that Performed Satisfactorily

(30 m) in diameter, a differential floor settlement of about 30 in. (762 mm) would result in the bottom plates being stretched radially about 1.6 in. (41 mm); this would tend to pull the bottom edge of the shell plate into a smaller ... or it would stretch the floor plates, or both. However, if the floor ... initially crowned up so that it became flat after settlement, then the strains ... would be the reverse of the preceding example. The comparative

profiles and referenced evaluation criteria tabulated in Fig. 8 would indicate no alarming condition in the floor of Tank T-270 at the time of water testing.

In Fig. 10 the tank floor profiles are shown for tanks that failed or required releveling. Tanks in Cases O, and R2, and Tank T-270 after failure show indications of edge cutting or floor humping. (Humping is considered in more detail in a subsequent part of this paper.) Note that the slope of the differential floor settlement profile indicates the degree of distortion along the profile without the influence of the initial crown of the floor. The steepest sloping segment for all tank floors shown in Fig. 10, except T-270, are much steeper than the

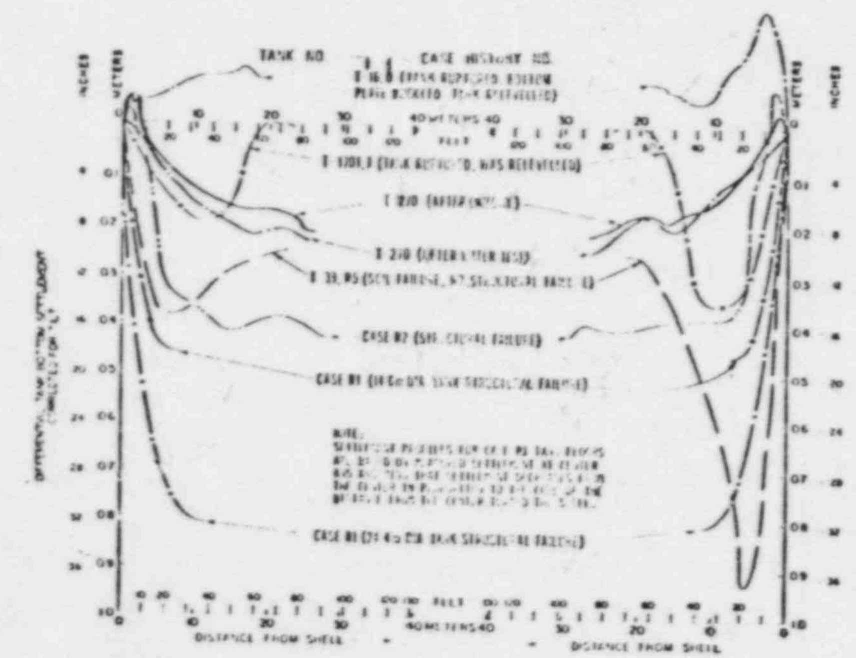
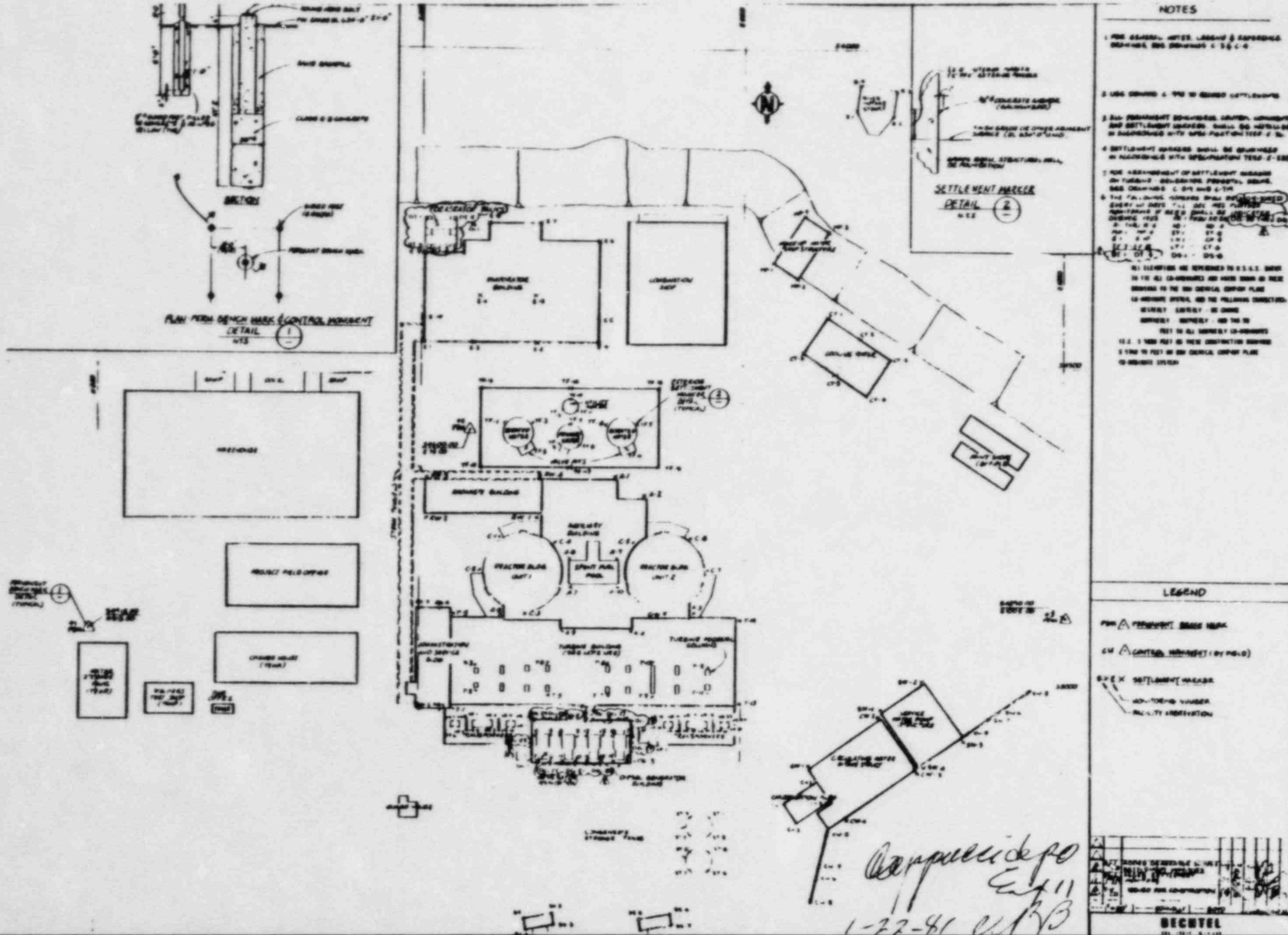


FIG. 10.—Tank Floor Settlement Profiles of Tanks that Did Not Perform Satisfactorily

initial floor crowns and thus imply the possibility of localized excessive straining, irrespective of the initial crown.

Floor to Shell Connection: Radial Movements.—Large tanks, even if built on a rigid foundation undergo appreciable radial shell movements. Langeveld (11) gave the example of a 630,000 bbl (100,000 m³) high strength steel tank designed to be stressed to about two thirds the yield point of the steel increasing in radius about 1.6 in. (41 mm) upon loading. The annular floor plate will normally restrain nearly all of this movement at the base of the shell resulting in bending of the bottom portion of the shellplate. In addition to these elastic movements will be bending due to differential floor settlements.

The slopes of the radial line tangent to the differential settlement profile at the shell connections were computed and are tabulated in Fig. 8. (Slope ...



NOTES
SETTLEMENT MARKER
DETAIL 2
SECTION
PLAN PERM BENCH MARK & CONTROL MONUMENT
DETAIL 1
REACTOR BLDG UNIT 1
SPENT FUEL POOL
REACTOR BLDG UNIT 2
TURBINE BUILDING
PROJECT FIELD OFFICE
LEGEND
SETTLEMENT MARKER
BECHTEL

SEISMIC ANALYSIS

GENERAL

(1) RESPONSE SPECTRA PRESENTED IN FSAR

(2) STICK MASS MODELS WITH FOUNDATION SPRINGS

(3) MATERIAL DAMPING VALUES PRESENTED IN FSAR (MODAL DAMPING LIMITED TO 10% EXCEPT RIGID BODY MODES)

(4) SPECTRUM RESPONSE AND TIME HISTORY MODAL ANALYSES

DIESEL GENERATOR BUILDING

(1) ORIGINAL (V_s = 1360 FPS) - ONE ANALYSIS EQUIPMENT SPECTRA WIDENED BY ± 15%

(2) NEW (V_s = 500 FPS) - NEW SPECTRA WILL ENVELOP BOTH V_s = 500 FPS AND 1360 FPS

SEISMIC ANALYSIS

SERVICE WATER BUILDING

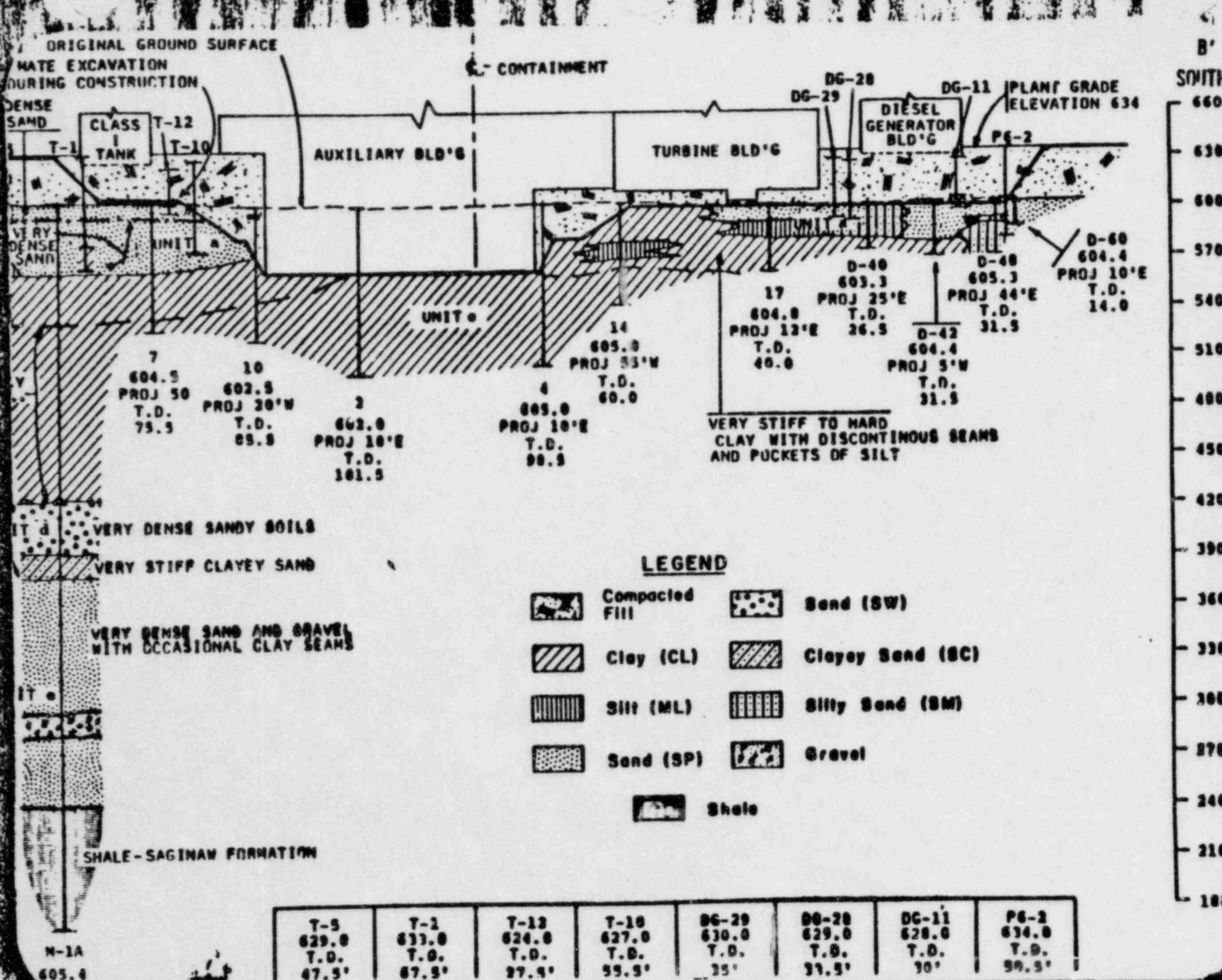
(1) ORIGINAL (V_s = 1360 FPS BASE CASE) THEN G VARIED BY ± 50% - EQUIPMENT SPECTRA ENVELOP

(2) NEW (V_s = 1360 FPS) - PILING IS MODELED FOR VERTICAL DIRECTION AND TORSION IS CONSIDERED

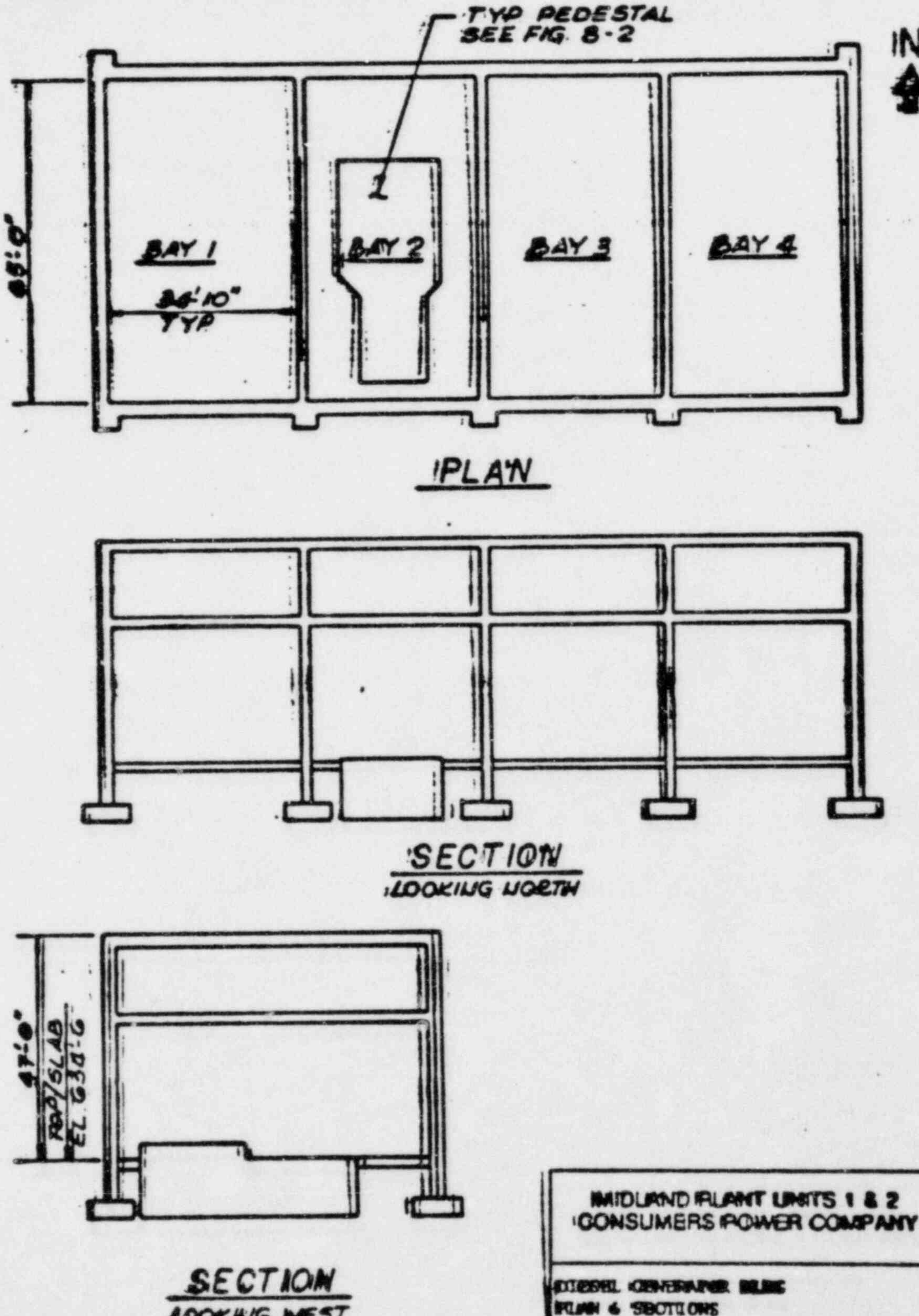
AUXILIARY BUILDING (INCLUDE CONTROL TOWER AND ELECTRICAL PENETRATION AREAS

(1) ORIGINAL - ONE ANALYSIS USING COMPOSITE FOUNDATION SPRINGS WITH EQUIPMENT RESPONSE SPECTRA WIDENED BY ± 15%

(2) NEW - ONE ANALYSIS INCLUDING CAISSONS UNDER ELECTRICAL PENETRATION AREAS, EQUIPMENT RESPONSE SPECTRA WIDENED BY ± 15%



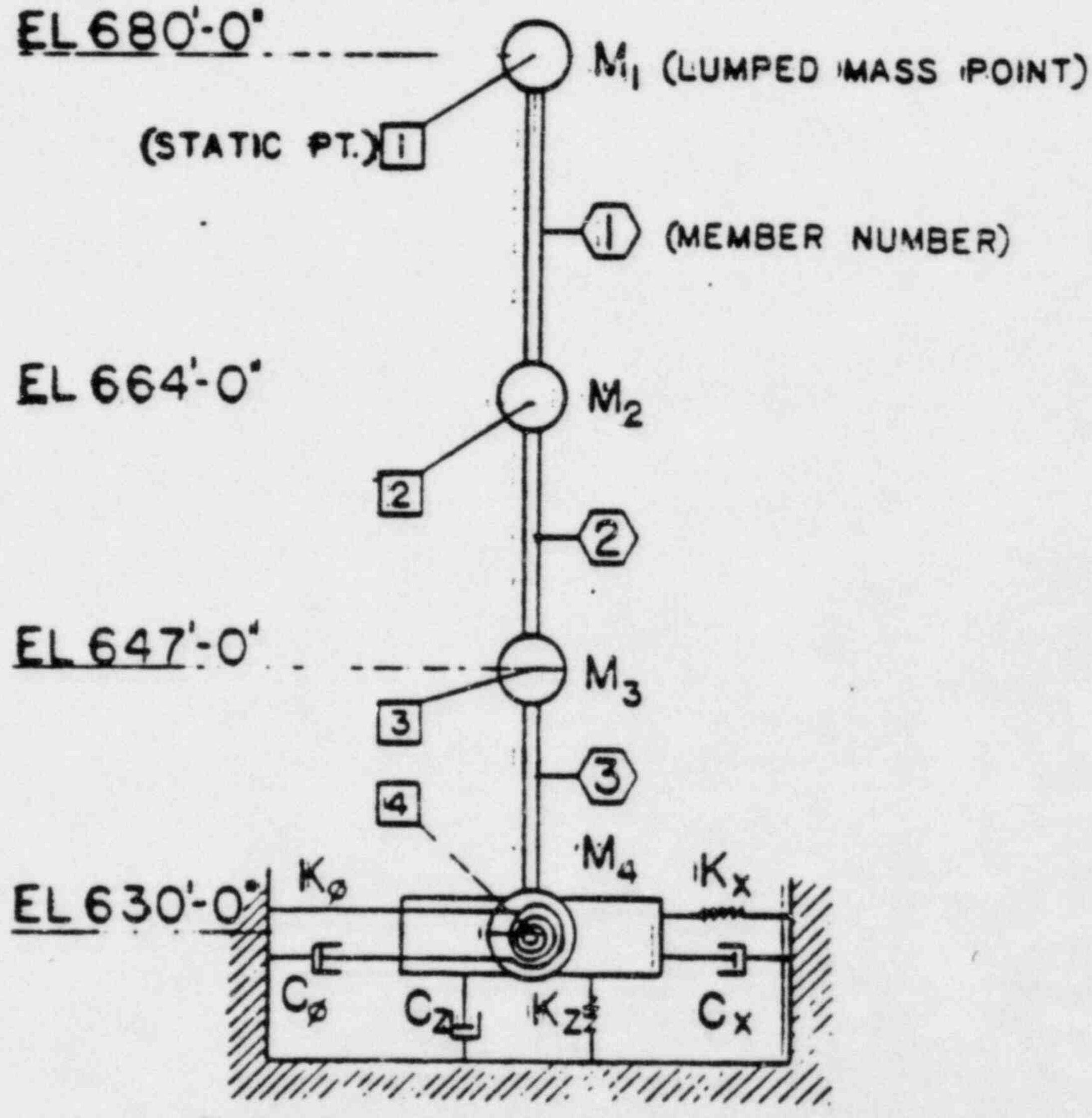
T-5	T-1	T-12	T-10	DG-29	DG-28	DG-11	PG-2
629.0	633.0	624.0	627.0	630.0	629.0	628.0	634.0
T.D.	T.D.	T.D.	T.D.	T.D.	T.D.	T.D.	T.D.
47.5'	67.5'	27.5'	55.5'	35'	33.5'	30'	50.5'



MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

DIESEL GENERATOR BLDG
PLAN & SECTIONS

FIGURE 10-9 DATE 6/24/79



DIESEL GENERATOR BLDG.
SEISMIC MODEL

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

DIESEL GENERATOR BLDG
SEISMIC MODEL

FIGURE 13-1 DATE 4/24/79

CONSUMERS POWER COMPANY
MIDLAND UNITS 1 & 2 - JOB 7220

DIESEL GENERATOR BUILDING

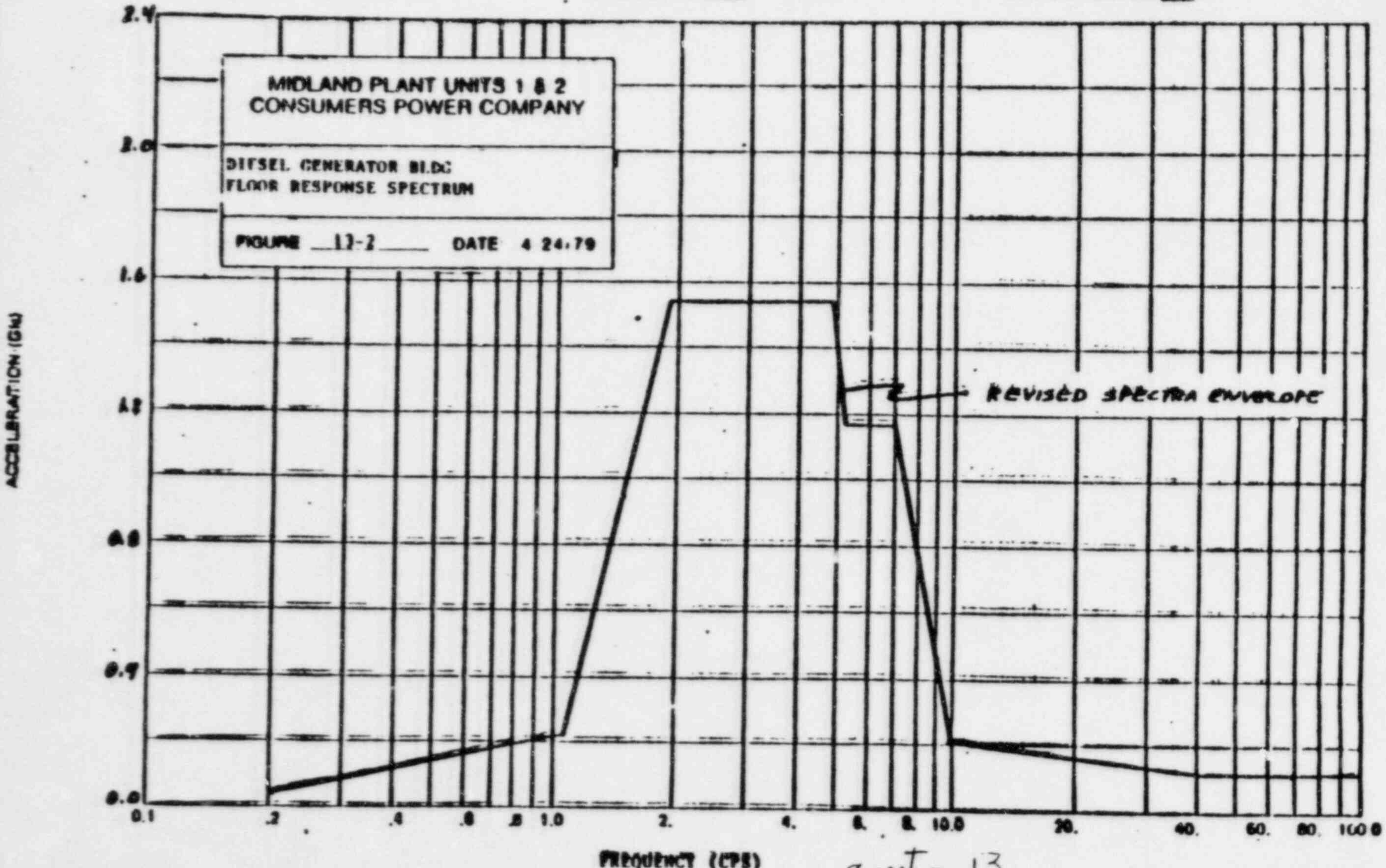
- ORIGINAL ANALYSIS
  - Elastic Modulus (ksf) 22,000
  - Poisson Ratio 0.42
  - Unit Weight (pcf) 135
  - Shear Wave Velocity (f/s) 1,369
- NEW ANALYSIS
  - Based on a Lower Bound Shear Wave Velocity of 500 ft/sec. The Design Forces and Floor Responses will Envelope the Original and New Analysis
  - Elastic Modulus (eff) (ksf) 2,646
  - Poisson Ratio 0.42
  - Unit Weight (pcf) 120
  - Shear Wave Velocity (f/s) 500

G-1036-01

MIDLAND PLANT UNITS 1 & 2
JOB NO. 7220
DIESEL GENERATOR BLDG.

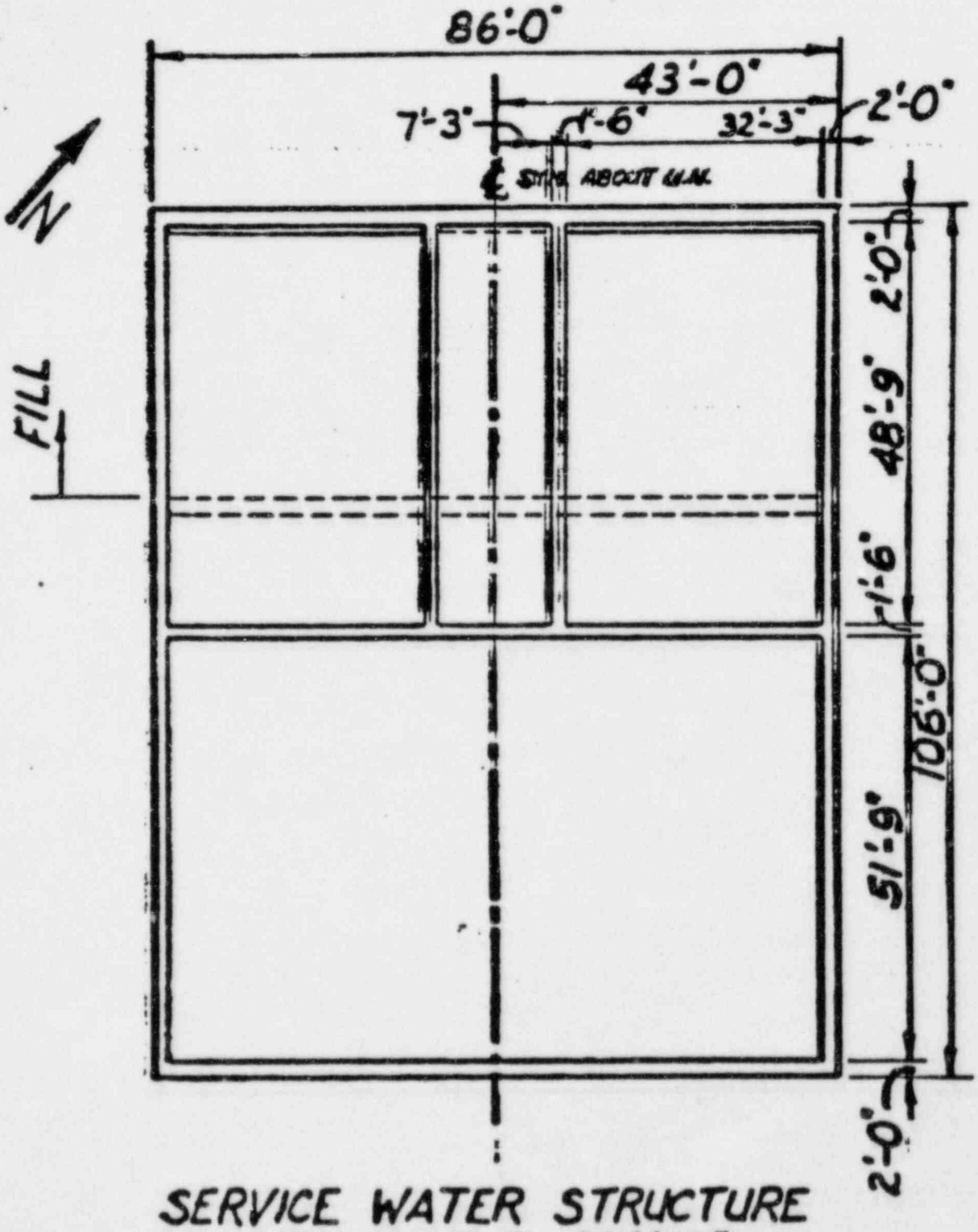
FLOOR RESPONSE SPECTRUM
MASS POINT 1 AT ELEV. 680'0"
NORTH-SOUTH DIRECTION

OBE & ZG GROUND ACCELERATION
(SSE USE MULTIPLIER OF 2)
DAMPING RATIO: 1.0%

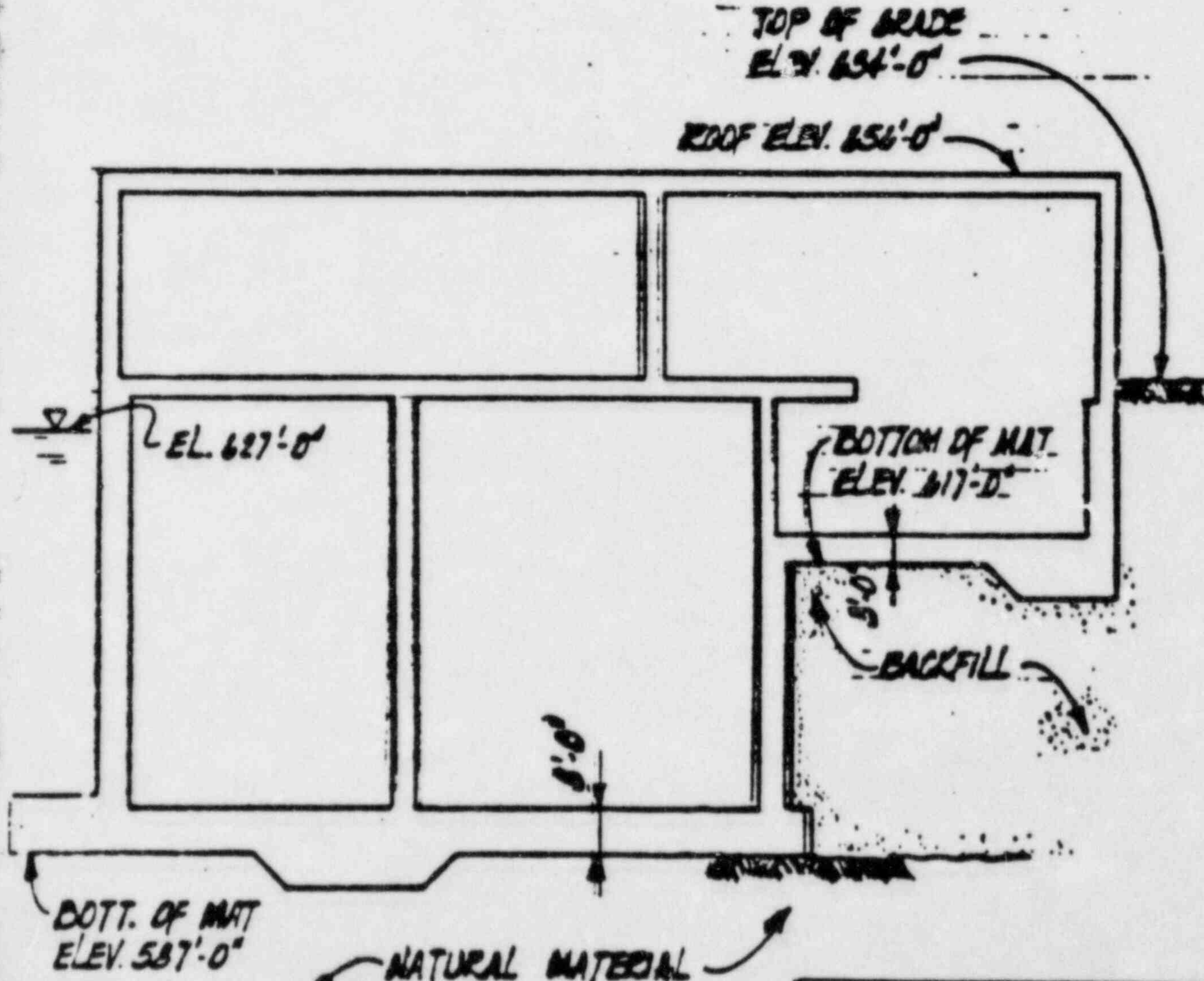


Question 13

4-7-81



SERVICE WATER STRUCTURE
PLAN AT EL. 634'-6"



TYPICAL SECTION

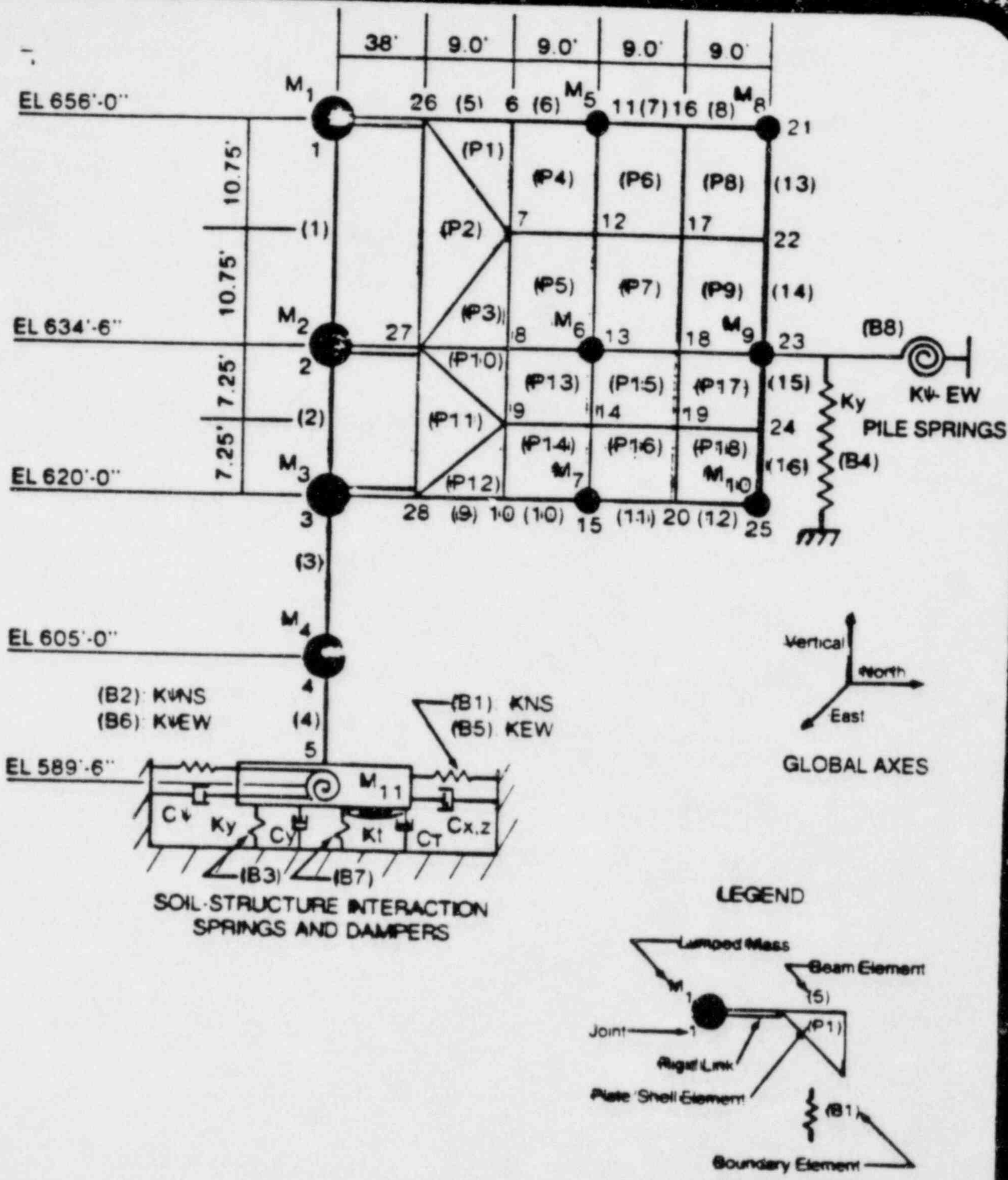
(LOOKING WEST)

SERVICE WATER STRUCTURE

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

SERVICE WATER PUMP STRUCTURE TYPICAL SECTION

FIGURE 81 REV.



CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

Mathematical Model for
Service Water Pump
Structure Seismic Analysis

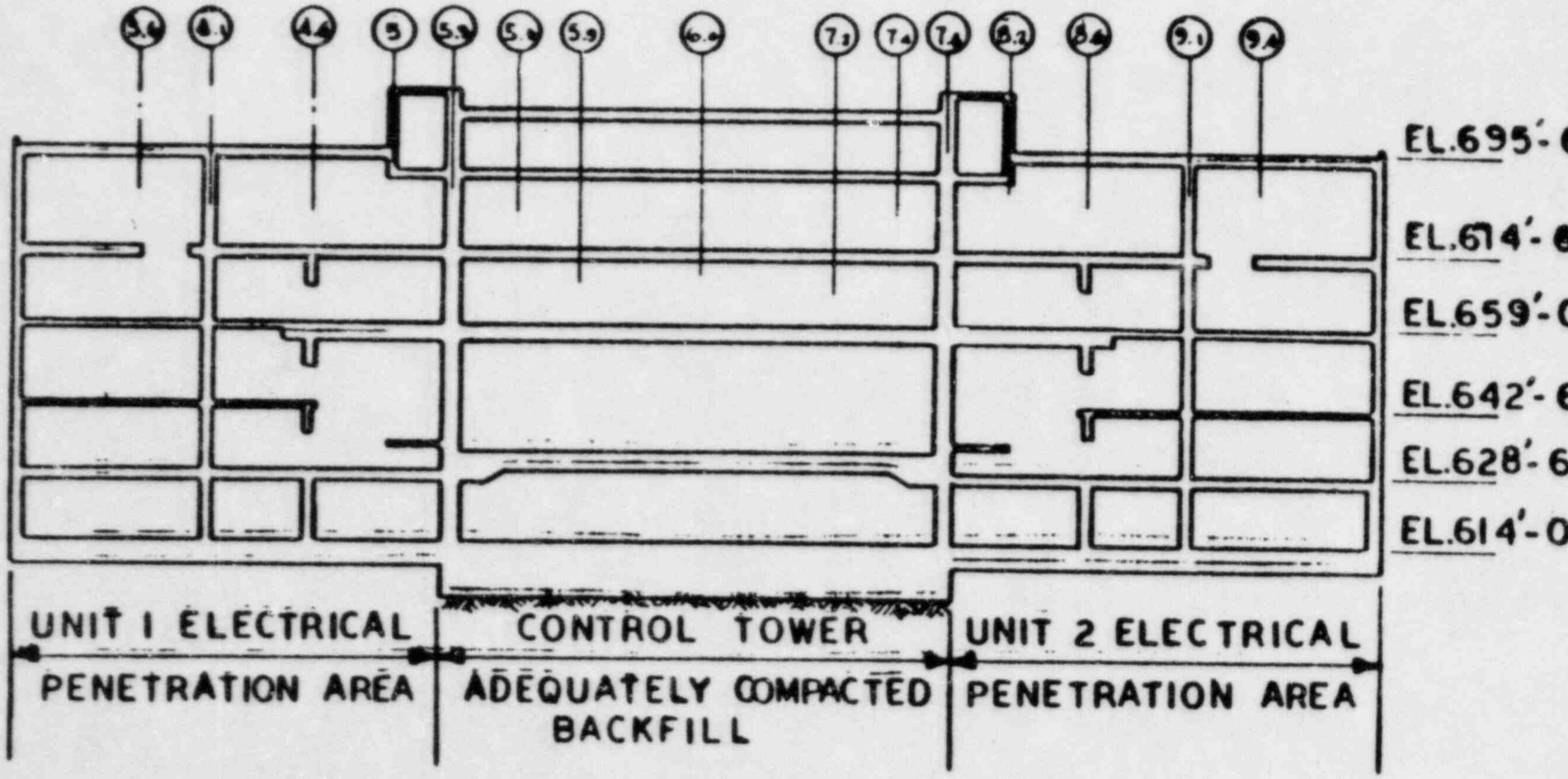
CONSUMERS POWER COMPANY
MIDLAND UNITS 1 & 2 - JOB 7220

SERVICE WATER STRUCTURE

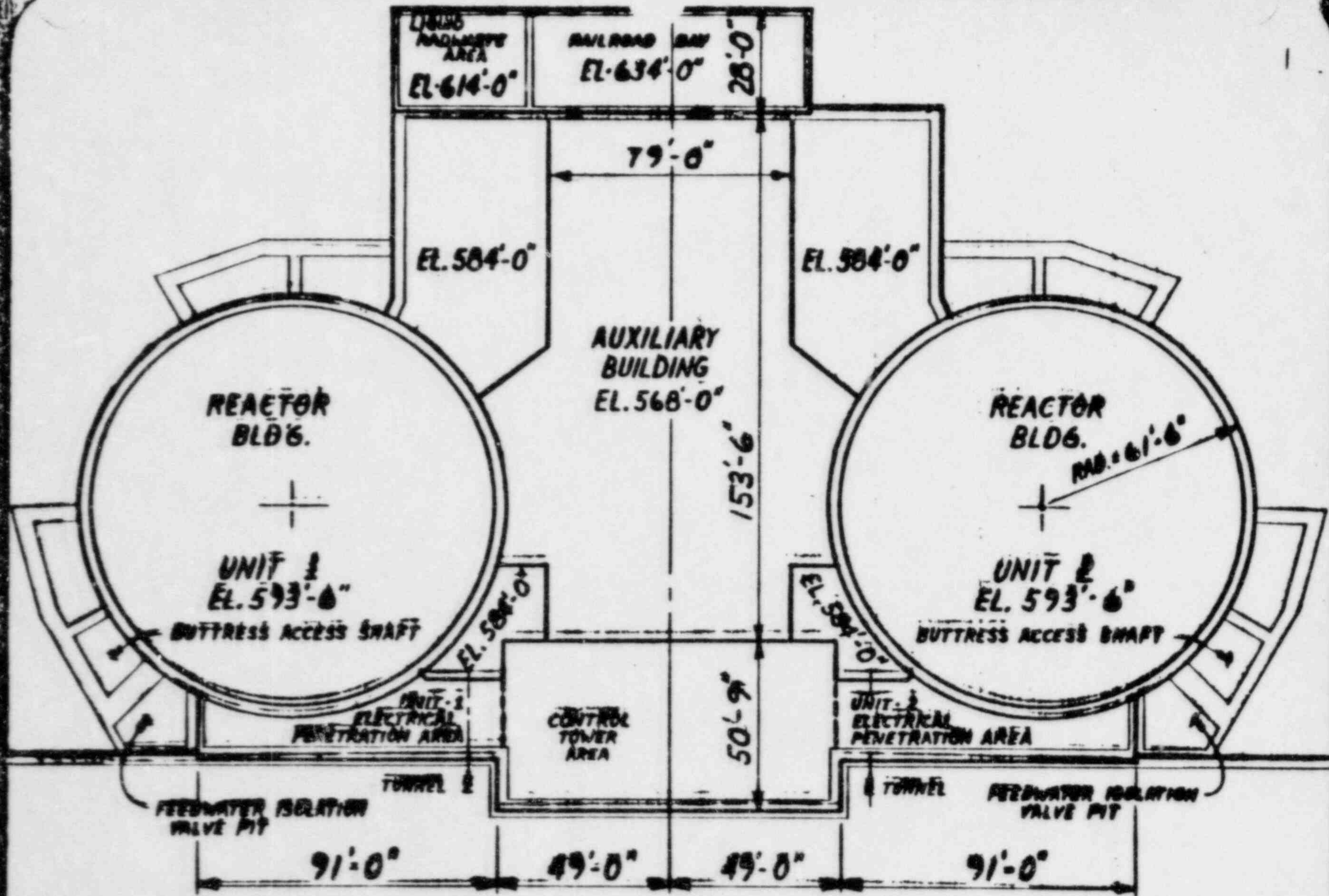
- ORIGINAL ANALYSIS
  - Elastic Modulus (ksf) 22,000 ± 50%
  - Poisson Ratio 0.42
  - Unit Weight (pcf) 135
  - Shear Wave Velocity (f/s) 1,359

- NEW ANALYSIS
  - Elastic Modulus (ksf) 22,000
  - Poisson Ratio 0.42
  - Unit Weight (pcf) 135
  - Shear Wave Velocity (f/s) 1,359
  - Fnd Area 74 ft x 90 ft
  - Vetical Stiffness 30,000 k/ft/pile
  - E-W Rocking Pile Stiffness 25,000 k/ft/pile

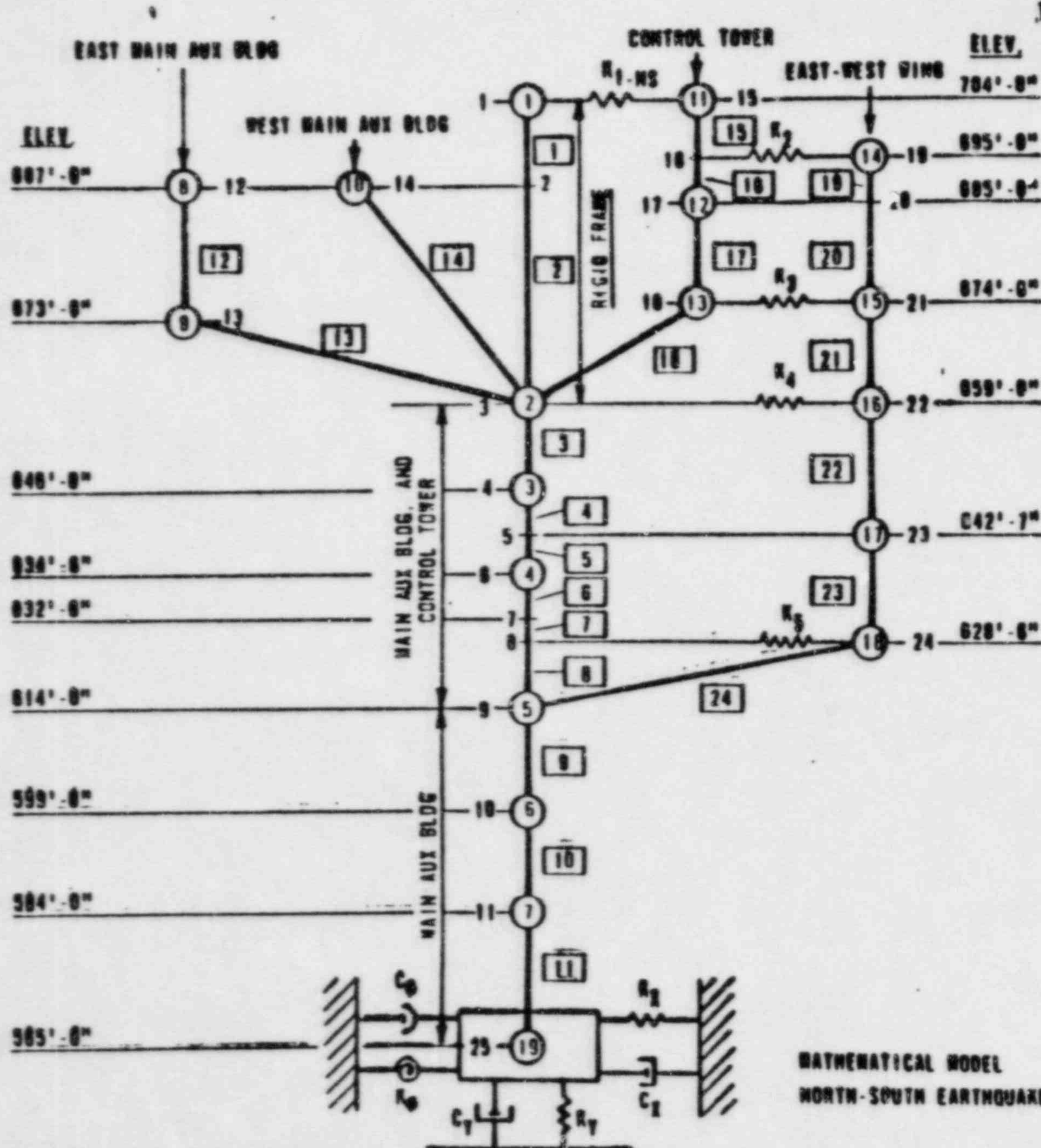
G-1038 02


EL.695'-6
EL.674'-6
EL.659'-0
EL.642'-6
EL.628'-6
EL.614'-0
UNIT 1 ELECTRICAL
PENETRATION AREA
CONTROL TOWER
ADEQUATELY COMPACTED BACKFILL
UNIT 2 ELECTRICAL
PENETRATION AREA

SECTION B-B



TURBINE BUILDING



MATHEMATICAL MODEL
NORTH-SOUTH EARTHQUAKE

CONSUMERS POWER COMPANY
MIDLAND UNITS 1 & 2 - JOB 7220
AUXILIARY BUILDING

- **ORIGINAL ANALYSIS**

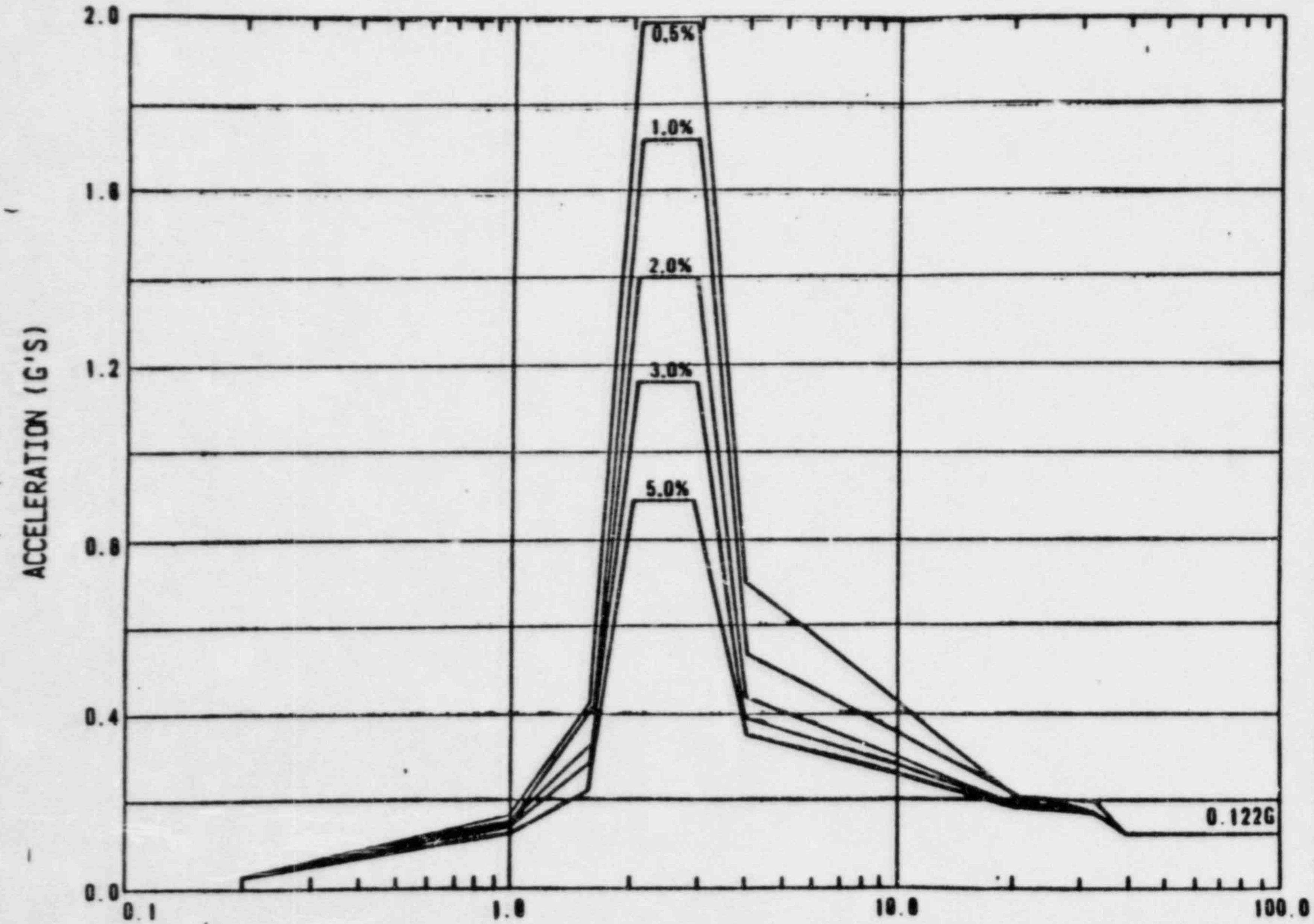
	Natural	Backfill
• Elastic Modulus (ksf)	22,000	7,650
• Poisson Ratio	.042	.042
• Unit Weight (psf)	135	120
• Shear Wave Velocity (f/s)	1,359	850

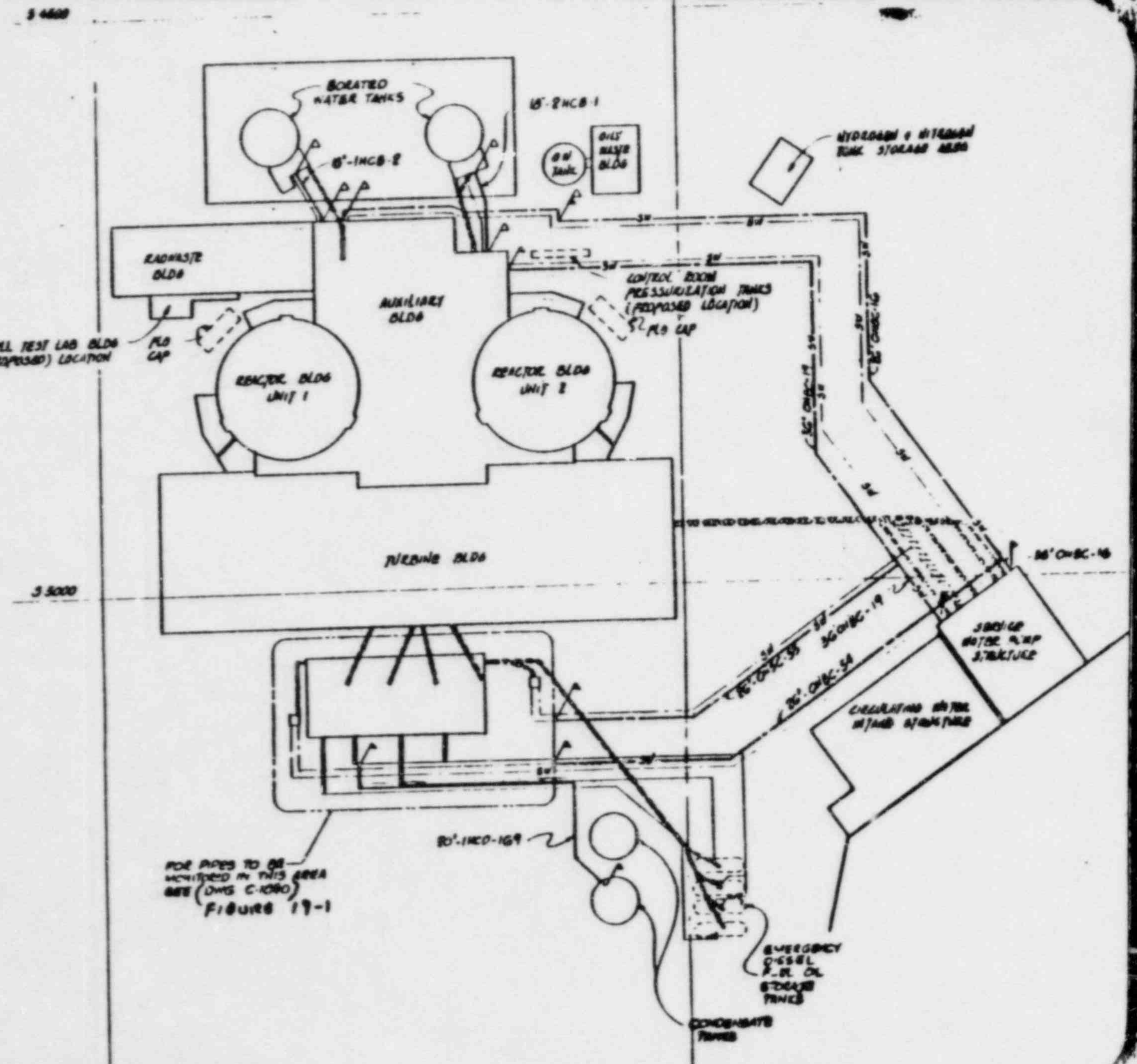
- **NEW ANALYSIS**

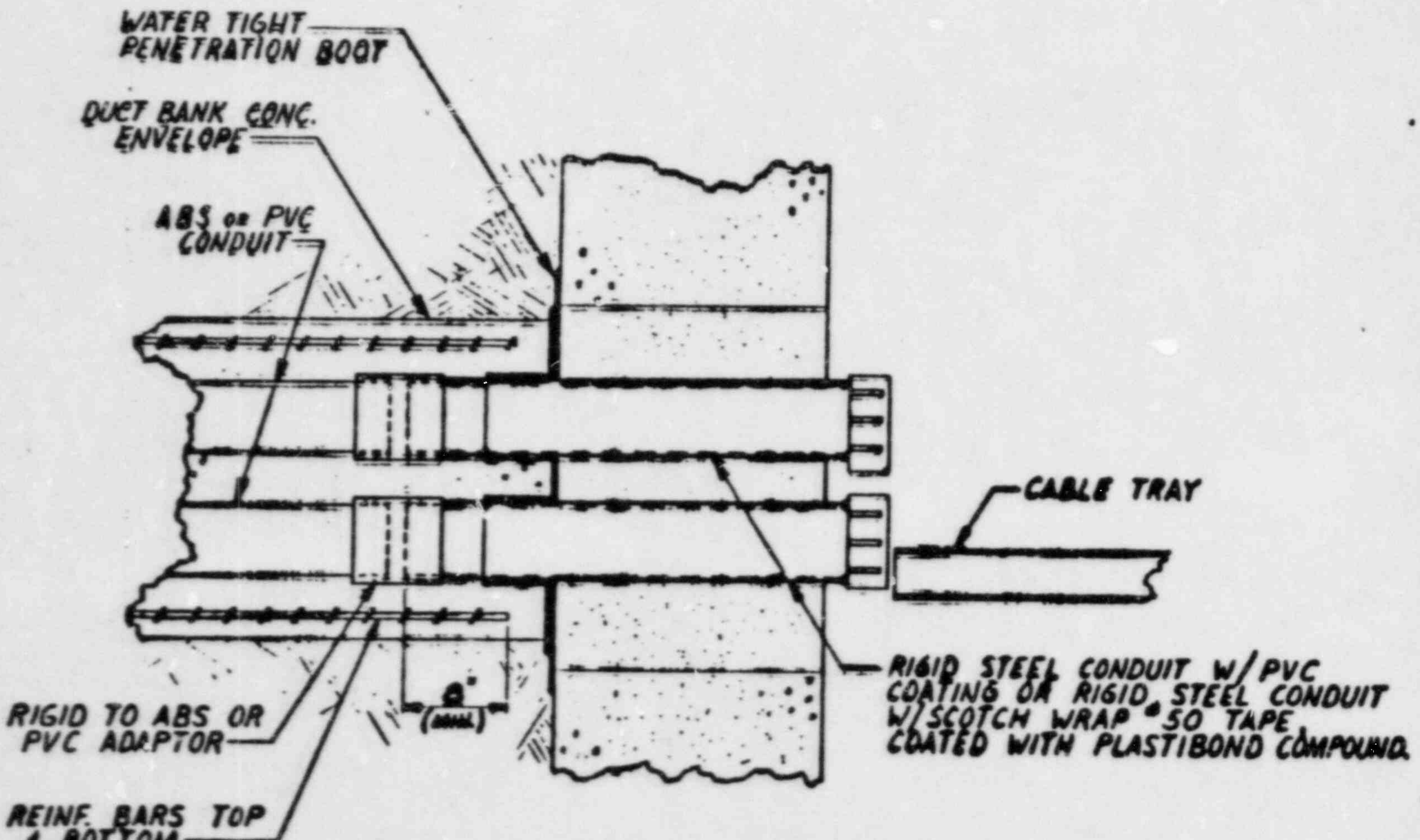
	Natural	Control Tower	Railroad Bay Area
• Elastic Modulus (ksf)	22,000	9,520	7,498
• Poisson Ratio	0.42	0.4	0.4
• Unit Weight (psf)	135	120	120
• Shear Wave Velocity (f/c)	1,359	955	848
• Cassion Stiffness	4×10^{10} k/ft		
• Feedwater Isolation Valve Pit			

G1036-03

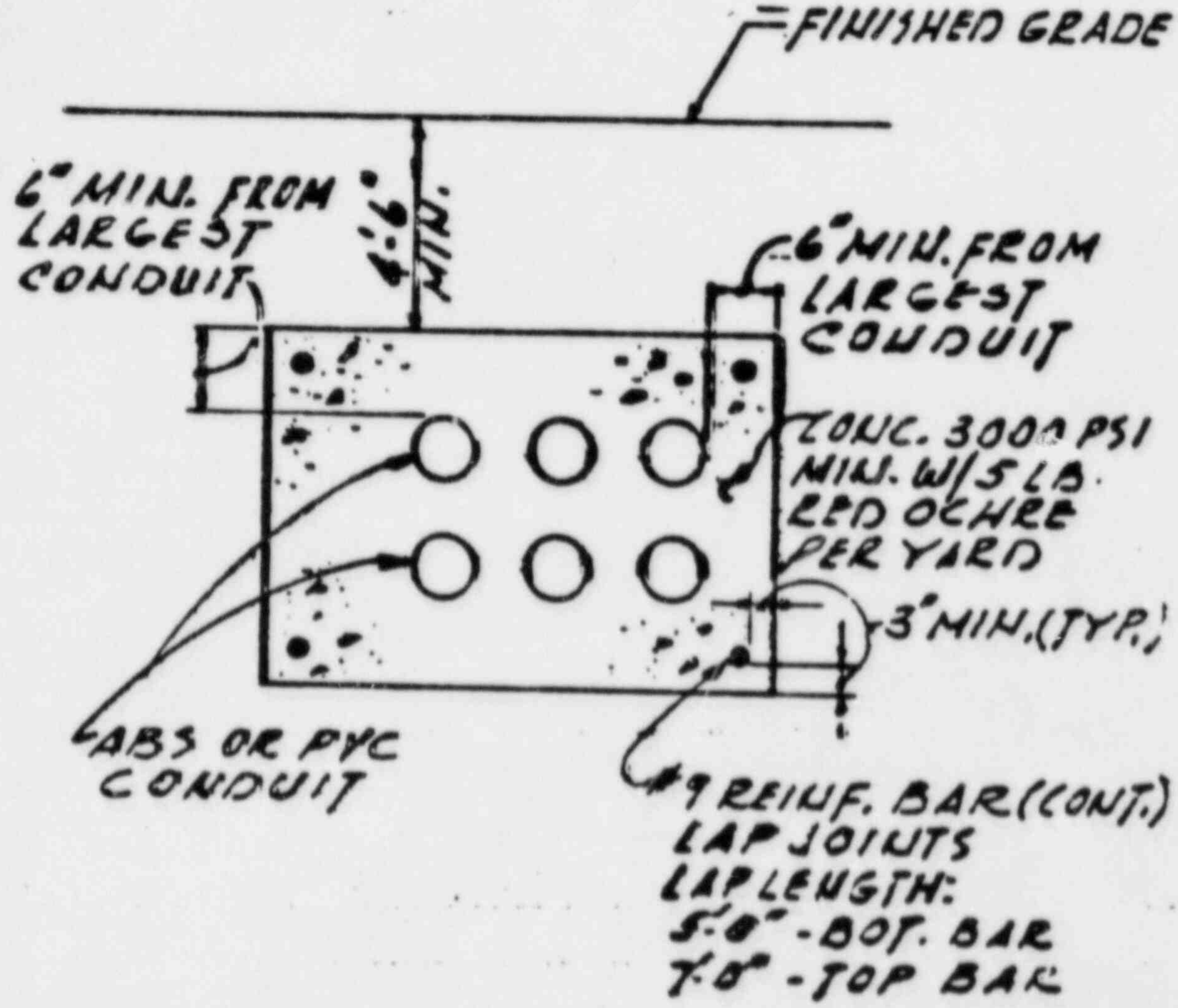
3
5


ACCELERATION (G'S)
2.0
1.6
1.2
0.8
0.4
0.0
0.1
1.0
10.0
100.0
0.5%
1.0%
2.0%
3.0%
5.0%
0.122G


BORATED WATER TANKS
15"-2HCB-1
18"-1HCB-2
RADWASTE BLDG
AUXILIARY BLDG
REACTOR BLDG UNIT 1
REACTOR BLDG UNIT 2
TURBINE BLDG
WELL TEST LAB BLDG (PROPOSED) LOCATION
CONTROL ROOM PRESSURIZATION TANKS (PROPOSED LOCATION)
HYDROGEN & NITROGEN TANK STORAGE AREA
SERVICE WATER PUMP STRUCTURE
CIRCULATING WATER INTAKE STRUCTURE
EMERGENCY DIESEL F.O. OIL STORAGE TANKS
CONDENSATE TANKS
FOR PIPES TO BE MONITORED IN THIS AREA SEE (DWG C-1090)
FIGURE 19-1

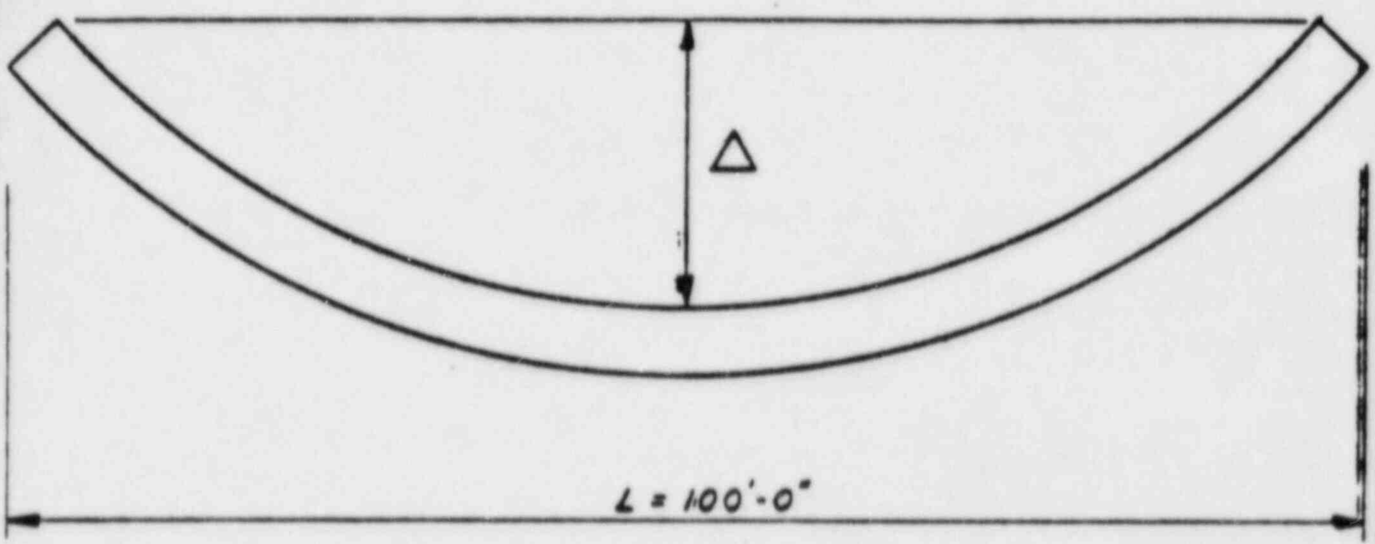


DUCT BANK & CONDUIT TERMINATION
AT BUILDING WALL



TYPICAL CONSTRUCTION - SEISMIC UNDERGROUND DUCT BANK

DUCT BANK DEFLECTION



CONSTANT RADIUS OF CURVATURE IS ASSUMED

f'c = 3000 PSI

Ec = 1,734 KSI (MODIFIED FOR LONG TERM DEFLECTION PER ACI 318-77 SECTION 9.5.2.5)

FOR A DUCT BANK 43" x 18" DEEP
△ WHEN STEEL YIELDS = 43"

FOR A DUCT BANK 54" x 35" DEEP
△ WHEN STEEL YIELDS = 15"

TABLE 30-1

FREE FIELD DUCT BANK STRAINS FOR SHEAR WAVE AND COMPRESSION WAVE (SSE)

	Ratio of Strain in Reinforcing Steel to Yield Strain		
Duct Size	Bending	Axial	Combined
30 x 34	0.0007	0.082	0.0827
+10%	0.0008	0.082	0.0828
+20%	0.0009	0.082	0.0829
+50%	0.0012	0.082	0.0832

Notes:

ε_y = yield strain of reinforcing steel = 0.00207 in./in.

f'_c = concrete design compressive strength = 3,000 psi

F_y = reinforcing steel yield stress = 60,000 psi

C_s = shear wave velocity = 2,000 fps

TABLE 30-2

REDUCTION IN AREA FROM DIFFERENTIAL MOVEMENT

(Auxiliary Building from El 593'-0" to 608'-0")

	OBE		SSE	
Direction	Differential Displacement	Percent Reduction in Area	Differential Displacement	Percent Reduction in Area
E-W	0.021"	0.7	0.042"	1.4
N-S	0.024"	0*	0.048"	0*
Vertical	0.001"	0.03	0.002"	0.06

*Axial movement, no reduction in area for this direction

TABLE 30-3

AUXILIARY BUILDING
INTERFACE STRAINS

(Differential Movement Due To SSE)

	Ratio of Strain in Reinforcing Steel to Yield Strain			
		Direction of Earthquake		
Duct Size	Vertical (Bending)	E-W (Bending)	N-S (Axial)	Combined
30 x 34	0.012	0.097	0.615	0.623
+10%	0.012	0.100	0.615	0.623
+20%	0.012	0.103	0.615	0.624
+50%	0.013	0.109	0.615	0.625

Kane

5/29/80
J. Kane

Midland - Pipe Stress Analysis

Section 3.9.3

Where in FSAR is results of pipe stress analysis presented
Are there special reports or preliminary reports that have been submitted? but yet not documented

In analysis what input in geotechnical engr. field is USED in computation of pipe stresses & strains. WHAT is needed from GES?

Profile of fdn. mat'ls & bedding beneath piping & conduit? (Likely several profile conditions needed to bracket heterogeneous nature of fill)

How does analysis use settlement data measurements. Is it a straight line interpretation between measuring points. How are settlement measurements coordinated w/ profiling of pipes?

Tony Cappucci 492-7479
Mech. Engr. Branch

I Called Tony on 5/29/80
Not available

NRC Consultant
FTS Supervisor Paul Chen
791-1120 Ext. 661

Cappucci depo Ex 13
1-22-81 [illegible]

NOTE:

The contents of this package are maintained in a three-ring notebook by William Paton Titled: DEPS. EXS. 1981

January 19 – January 22, 1981