6/B3

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

FEB 2 2 1984

ocket Nos.: 50-329
and 50-330 OM, OL

APPLICANT: Consumers Power Company

FACILITY: Midland Plant, Units 1 and 2

SUBJECT: SUMMARY OF FEBRUARY 2-5, 1982 MEETING AND AUDIT ON AUXILIARY BUILDING UNDERPINNING

On February 2-5, 1982, the NRC Staff and its consultants met in Ann Arbor, Michigan with Consumer Power Company, Bechtel and their consultants to discuss and audit preparations for underpinning the southern portion of the auxiliary building. Discussions also included underground utilities, the diesel generator building and the service water pump structure.

Enclosure 1 is a summary of this meeting and audit.

The first three columns of Enclosure 2 provide a listing of review issues that were to be audited and were provided by the NRC staff at the start of the audit. The last column of Enclosure 2 was added after the audit and indicates the resolutions reached during the audit on the identified review issues.

Darl Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosure:
As stated

cc: See next page

6/133

FEB 22 1984

ocket Nos.: 50-329
and 50-330 OM, OL

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FACILITY: Midland Plant, Units 1 and 2

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As stated

cc: See next page

OFFICE	DL:LB#4	DL:LB#4					
SURNAME	DHood:eb	EAdensam					
DATE	/ /84	/ /84					

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Darl Hood

Darl Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosure:
As stated

cc: See next page

MIDLAND

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Michael I. Miller, Esq.
Ronald G. Zamarin, Esq.
Alan S. Farnell, Esq.
Isham, Lincoln & Beale
Suite 4200
1 First National Plaza
Chicago, Illinois 60603

James E. Brunner, Esq.
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Ms. Mary Sinclair
5711 Summerset Drive
Midland, Michigan 48640

Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Wendell Marshall
Route 10
Midland, Michigan 48640

Mr. Roger W. Huston
Suite 220
7910 Woodmont Avenue
Bethesda, Maryland 20814

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Cherry & Flynn
Suite 3700
Three First National Plaza
Chicago, Illinois 60602

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

William J. Scanlon, Esq.
2034 Pauline Boulevard
Ann Arbor, Michigan 48103

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Ms. Barbara Stamiris
5795 N. River
Freeland, Michigan 48623

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrato
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Steve Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

cc: Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

Charles Bechhoefer, Esq.
Atomic Safety & Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. Ralph S. Decker
Atomic Safety & Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Frederick P. Cowan
Apt. B-125
6125 N. Verde Trail
Boca Raton, Florida 33433

Jerry Harbour, Esq.
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Geotechnical Engineers, Inc.
ATTN: Dr. Steve J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

ENCLOSURE 1

Bechtel Associates Professional Corporation

777 East Eisenhower Parkway
Ann Arbor, Michigan

Mail Address: P.O. Box 1000, Ann Arbor, Michigan 48106

MEETING NOTES NO. 1600

MIDLAND PLANT UNITS 1 AND 2

CONSUMERS POWER COMPANY

BECHTEL JOB 7220

DATE: February 2 through 5, 1982

PLACE: Bechtel Ann Arbor Office

SUBJECT: Nuclear Regulatory Commission Audit - Midland Auxiliary Building Underpinning

ATTENDEES:

Nuclear Regulatory Commission	Consumers Power Company	NRC Consultants	Bechtel
D.S. Hood	D. Budzik	G. Harstead	S. Afifi
J.D. Kane	J.K. Meisenheimer	P. Huang*	J. Anderson
F. Rinaldi	K. Razdan	S. Poulos*	T. Bell*
	T. Thiruvengadam	R. Samuels*	T. Chipman*
		H. Singh	M. DasGupta*
			B. Dhar
			S. Lo*
			N. Rawson
			G. Robers*
			S. Rys
			N. Swanberg
			G. Tuveson
			V. Verma
			D. Zanese*

Other	Bechtel Consultants
M. Sinclair*	D. Bartlett
	E. Burke

*Part-time

REFERENCE: CPCo letter, Serial 16246, J.W. Cook to H.R. Denton, 3/10/82

PURPOSE: To enable the NRC to perform an audit of the design and calculations for the temporary support system during underpinning and construction condition analysis for the auxiliary building

(Note: The audit is to satisfy Special Licensing Condition 5 of Table A.20 of the NRC testimony submitted for the auxiliary building underpinning as part of the soils public hearings. Satisfaction of these conditions will permit removal of soil from beneath the auxiliary building and installation of temporary supporting systems.)

PRINCIPAL AGREEMENTS:

1) D. Bartlett presented a discussion of the construction sequence for installing the temporary support system for the auxiliary building. This system utilizes steel grillage beams supported on concrete piers and steel columns to support the electrical penetration areas, piers, and control tower. The control tower piers will eventually be incorporated into the permanent underpinning system. Viewgraphs used by D. Bartlett are included as Attachment 1.

2) M. DasGupta presented the analysis of the existing structure for the temporary support condition. The analysis considers the staged removal of soil from beneath the structure and the replacement of support by piers and steel beams with hydraulic jacks. Viewgraphs used by M. DasGupta are included as Attachment 2.

3) N. Rawson provided a presentation on the design of the temporary support system. The presentation included details of the grillage beams supported on concrete piers and steel columns for support of the electrical penetration area, struts and bracing for lateral support of the turbine building and control tower piers, and access drifts below the turbine building. It was agreed to provide a method of protecting the face of drifts if left exposed for long periods of time (see the referenced letter). Viewgraphs used by N. Rawson are included as Attachment 3.

4) S. Lo presented the construction and design details of the temporary post-tensioning system which was installed at the roof connections between the electrical penetration areas and the control tower. This system was installed to resist forces induced into these connections resulting from loss of buoyancy during dewatering. Viewgraphs used by S. Lo are included as Attachment 4.

Bechtel Associates Professional Corporation

5) For the auxiliary building, design calculations for the temporary support system and construction condition of the existing structure were reviewed by the NRC staff. Discussions were also held regarding underground utilities and tanks, diesel generator building, and service water pump structure (SWPS). Outstanding items from this review and discussions are listed below in the action items.

ACTION ITEMS:

Responsibility		Action	Date Due	Status
Bechtel	1)	Perform calculations to verify passive resistance of soil for lateral forces at truss to pier connection	3/16/82	Calculations revised
Bechtel	2)	Provide justification in the calculations for lateral soil spring constants (sand and clay) for beam on elastic foundation analysis of control tower piers	3/16/82	Calculations revised
Bechtel	3)	Use unreduced value for concrete modulus in calculations for differential settlement effects	2/26/82	Calculations* revised
Bechtel	4)	Perform calculations to verify that the gap between the turbine building and auxiliary building will accommodate settlement and seismic movements		Discussed in 2/26/82 meeting at Bethesda, MD
Bechtel	5)	Perform an analysis of the construction condition with soil removed from the tip of the electrical penetration area assuming a subgrade modulus of 70 kcf under the main part of the auxiliary building	2/26/82	Results provided 2/26/82
NRC	6)	Review pier instrumentation	2/26/82	Comments provided
Bechtel	7)	Provide acceptance criteria for building movements during Phases II and III	2/26/82	Provided at 2/26/82 meeting at Bethesda, MD

*Results to be submitted to the NRC soon

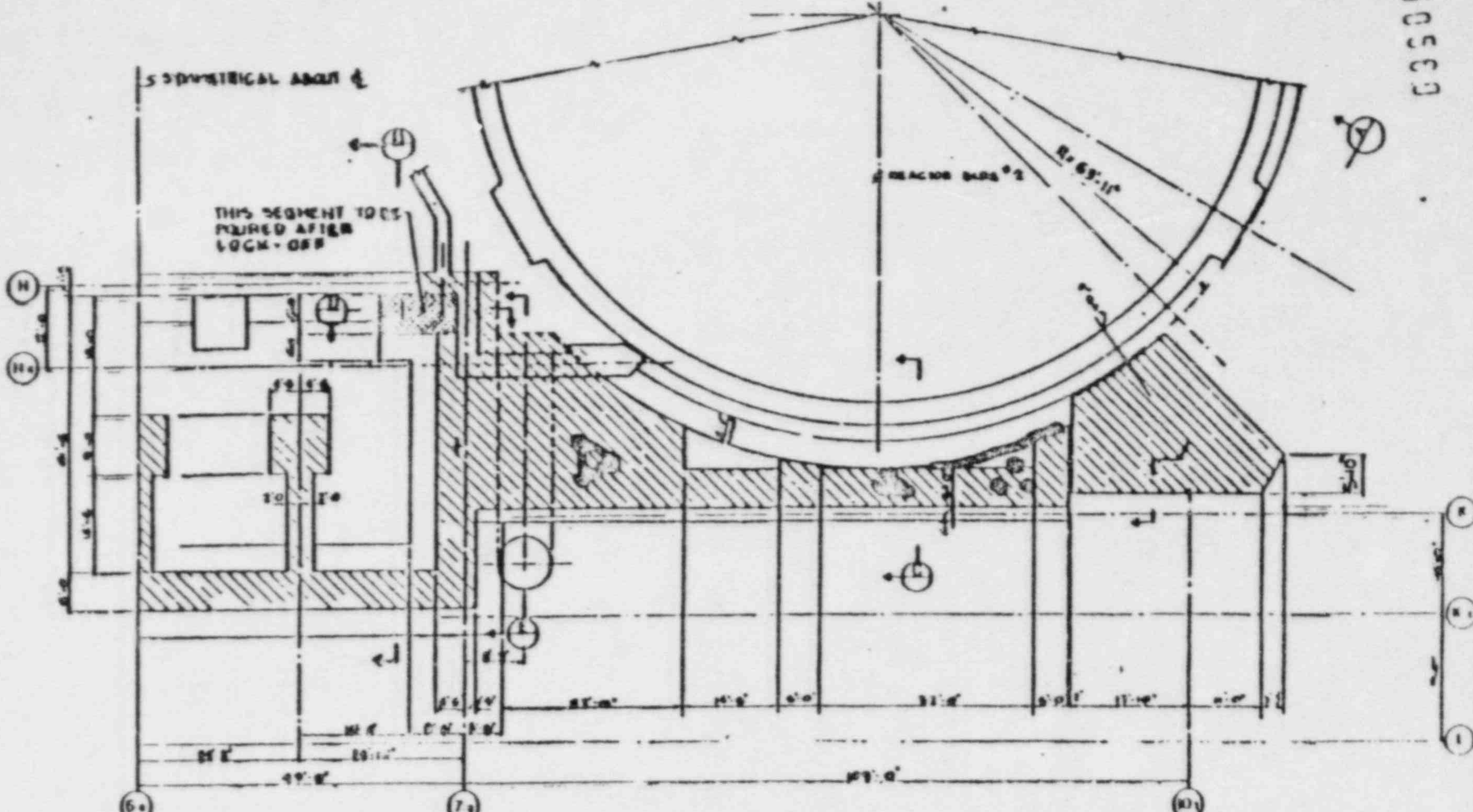
Bechtel Associates Professional Corporation

Responsibility		Action	Date Due	Status
Bechtel	8)	Provide jacking procedures and criteria for Phase III	2/26/82	Provided at 2/26/82 meeting at Bethesda, MD
NRC	9)	Review cracking criteria in auxiliary building report on cracking effects	2/26/82	Comments provided
Bechtel	10)	Provide maximum and minimum jacking loads for Phase III	2/26/82	Provided at 2/26/82 meeting at Bethesda, MD
Bechtel	11)	Include post-tensioning forces in SWPS construction condition analysis	3/16/82	Calculation revised and results discussed during SWPS audit
CPCo	12)	Consider additional finite element analyses of the diesel generator building for the effects of cracking	2/26/82	Position provided at 2/26/82 meeting

5/12/9

Attachments:
1. Construction Sequence
2. Construction Condition Analysis
3. Temporary Support System
4. Temporary Post-Tensioning System

ATTACHMENT #1

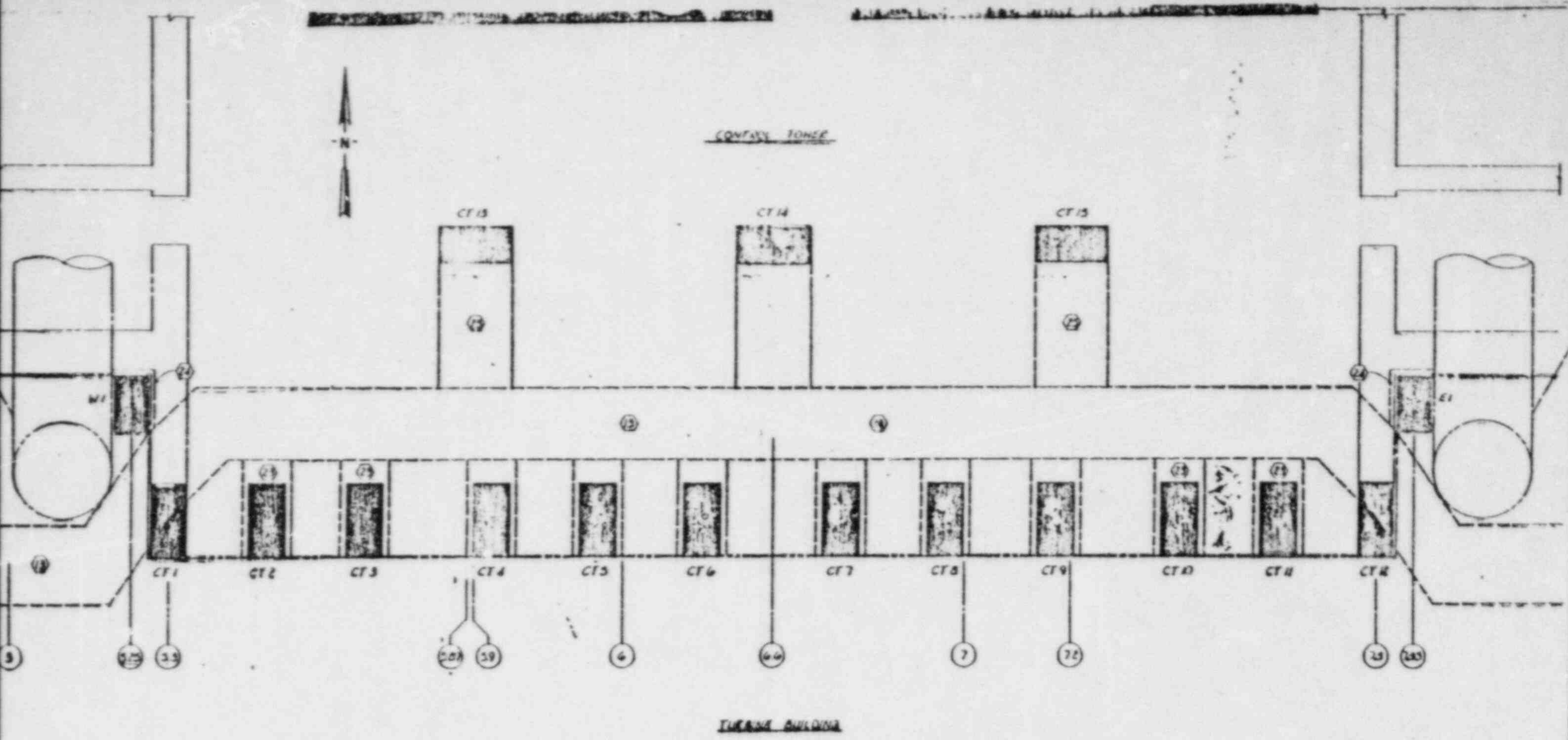


PLAN AT EL 603'-0"

UNDERPINNING PLAN AT EL 603'

FIG AUX-22

1



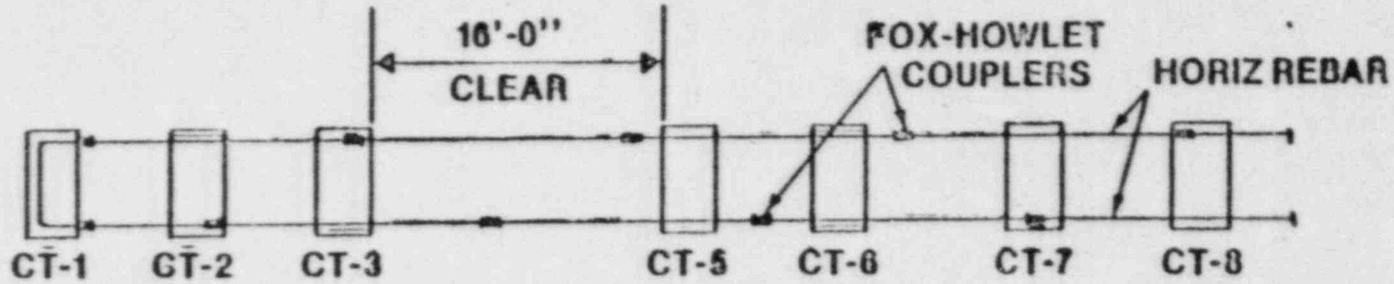
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

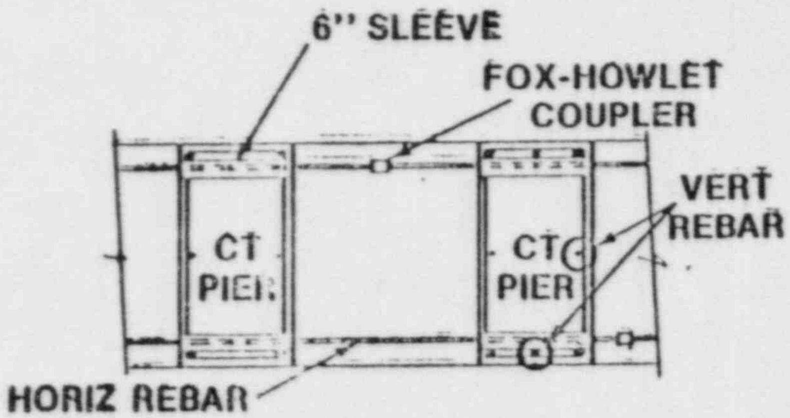
UNDERPINNING AUXILIARY BUILDING

CONSTRUSTION SCHEMATIC 3

2

PLAN - CONTROL TOWER
METHOD TO INSTALL HORIZONTAL REINFORCEMENT

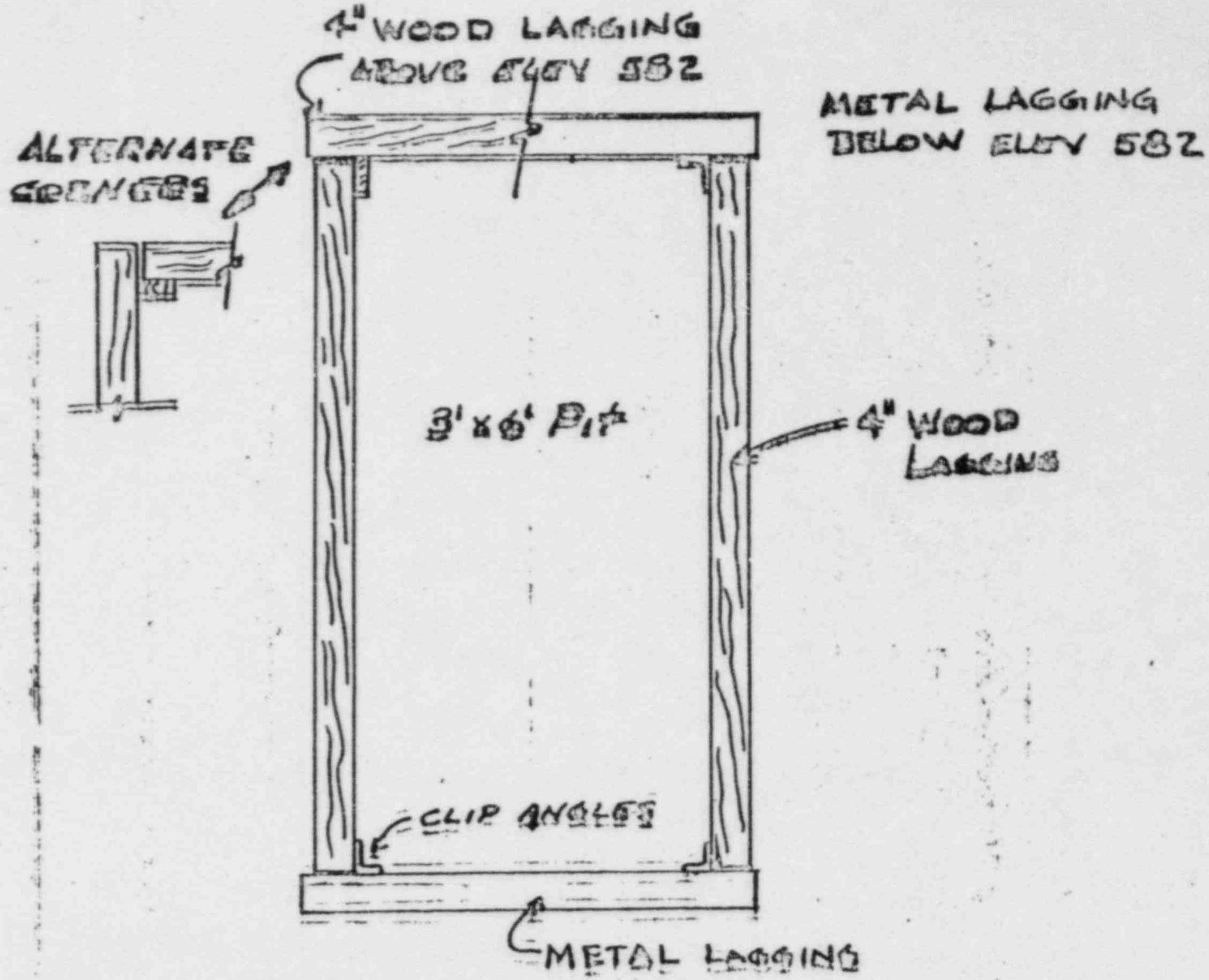




ENLARGED PLAN VIEW

NOTE:

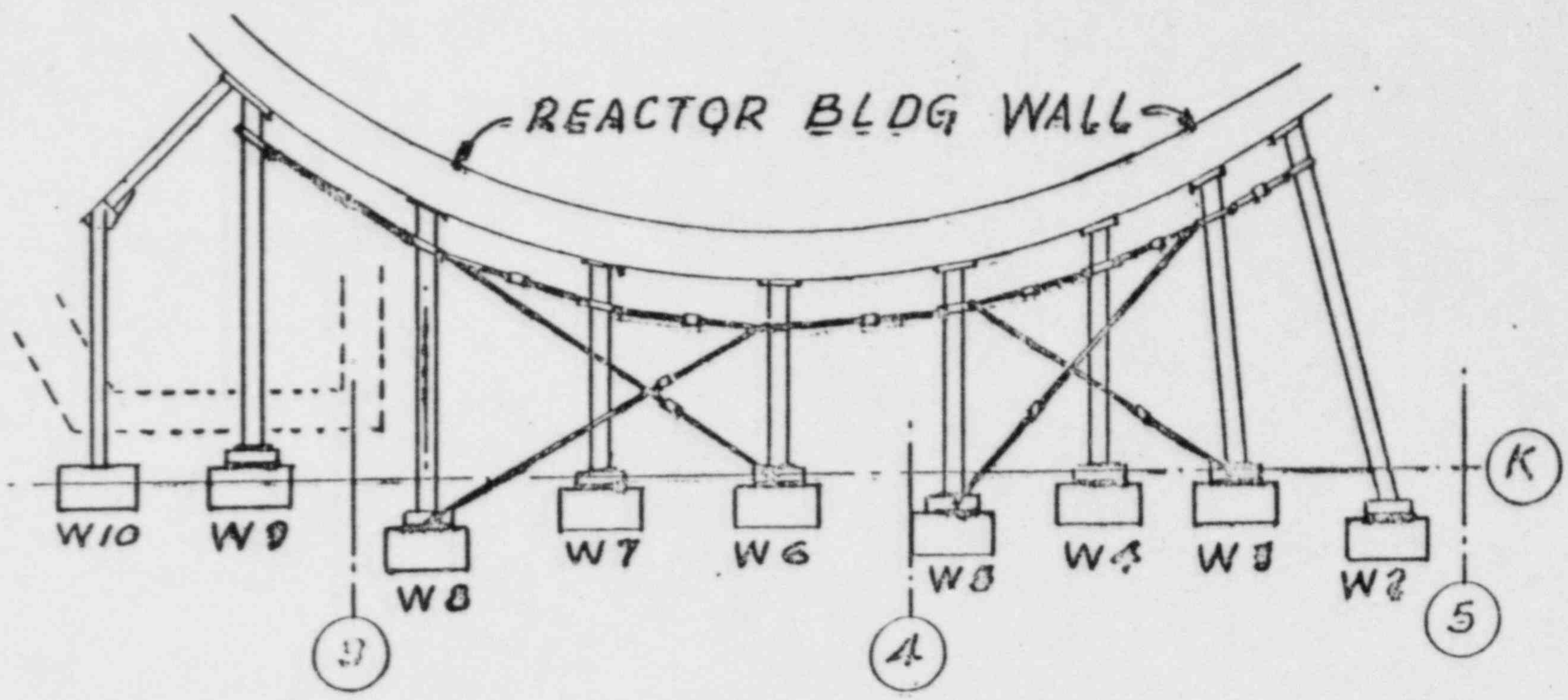
REINFORCING BARS INSTALLED IN 15'-0" LENGTHS WITH FOX-HOWLETT COUPLERS AT STAGGERED LOCATIONS

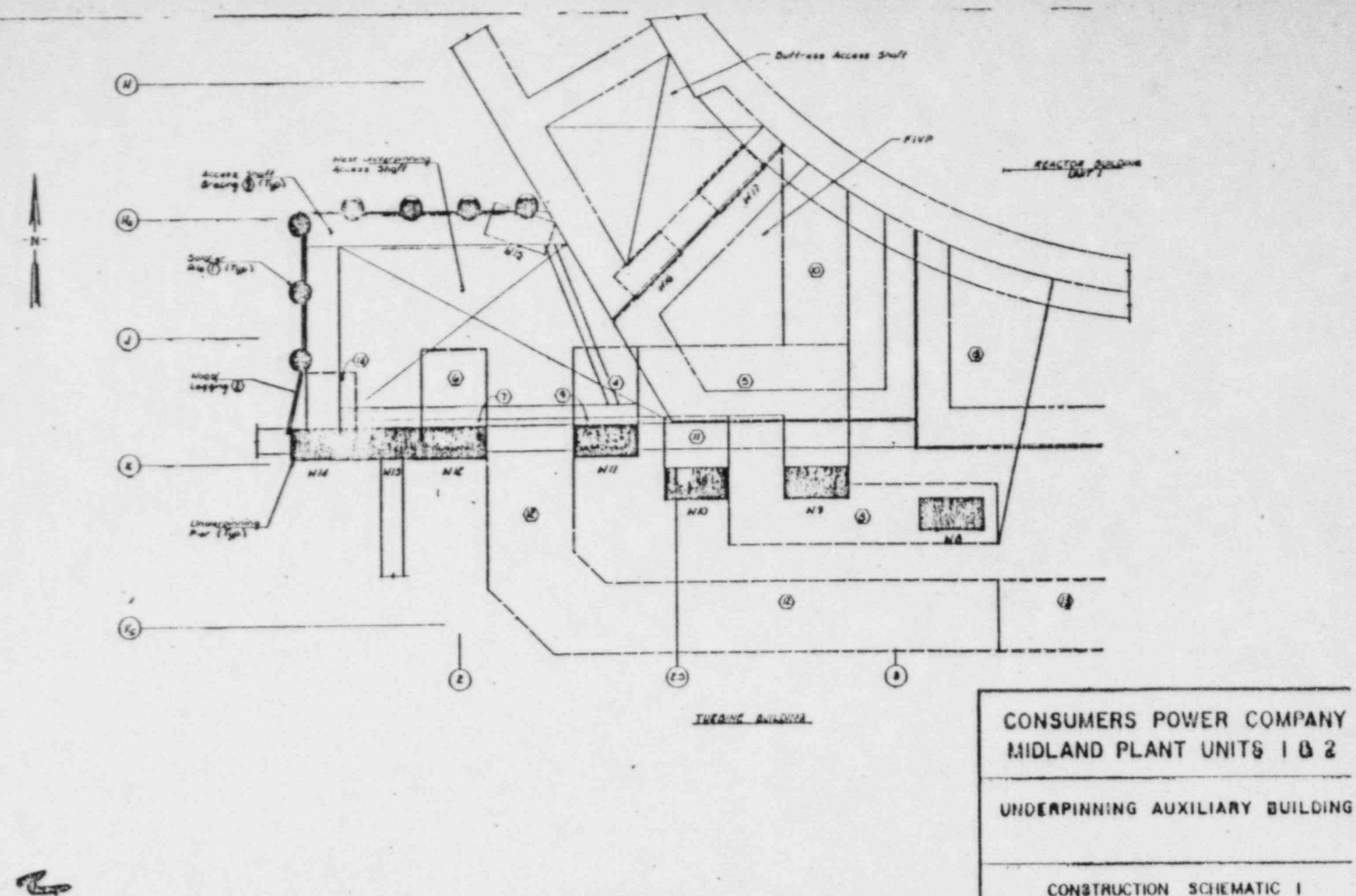


PLAN VIEW OF
CONTROL TOWER PIT LAGGING

4

PLAN- STRUT BRACING



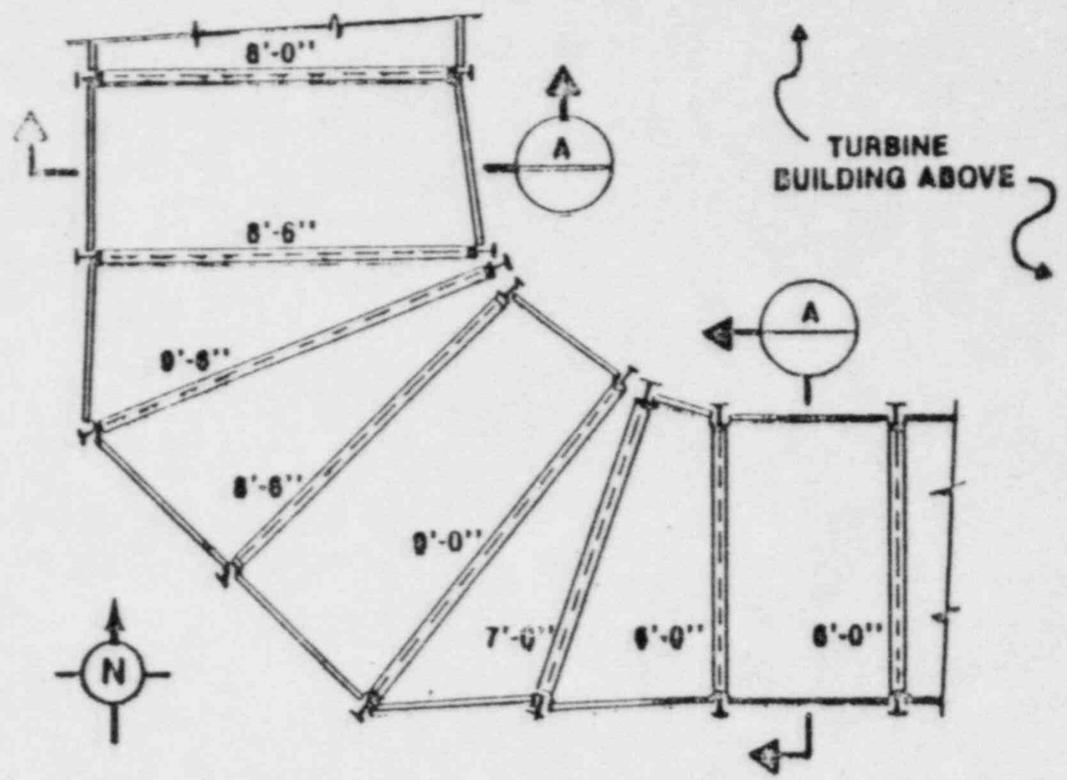


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION SCHEMATIC 1

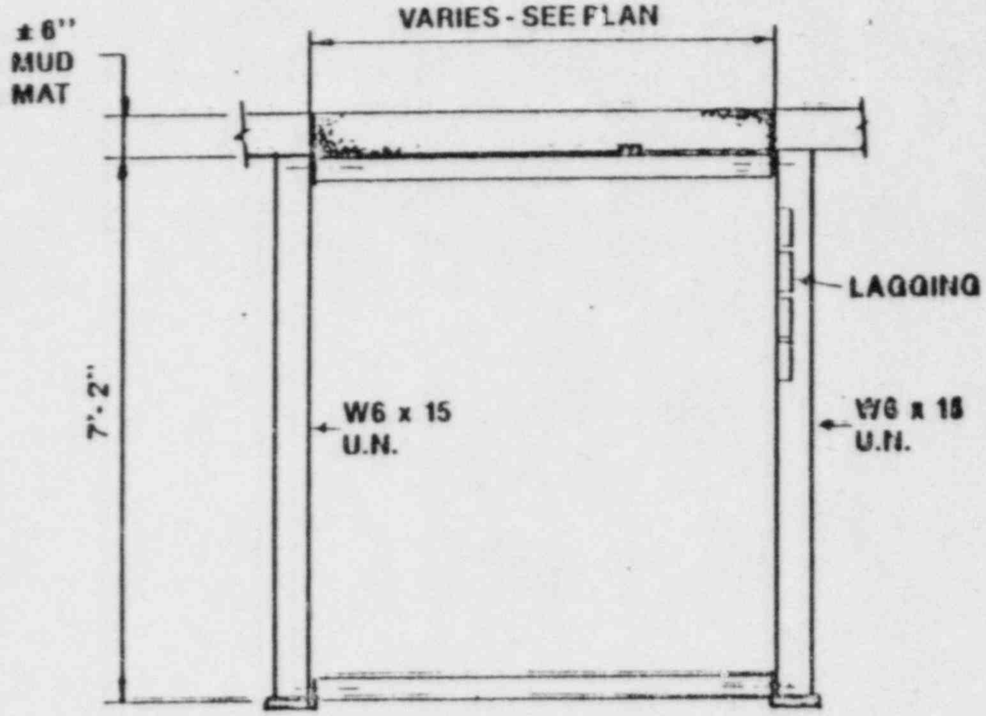
PARTIAL PLAN - ACCESS DRIFT



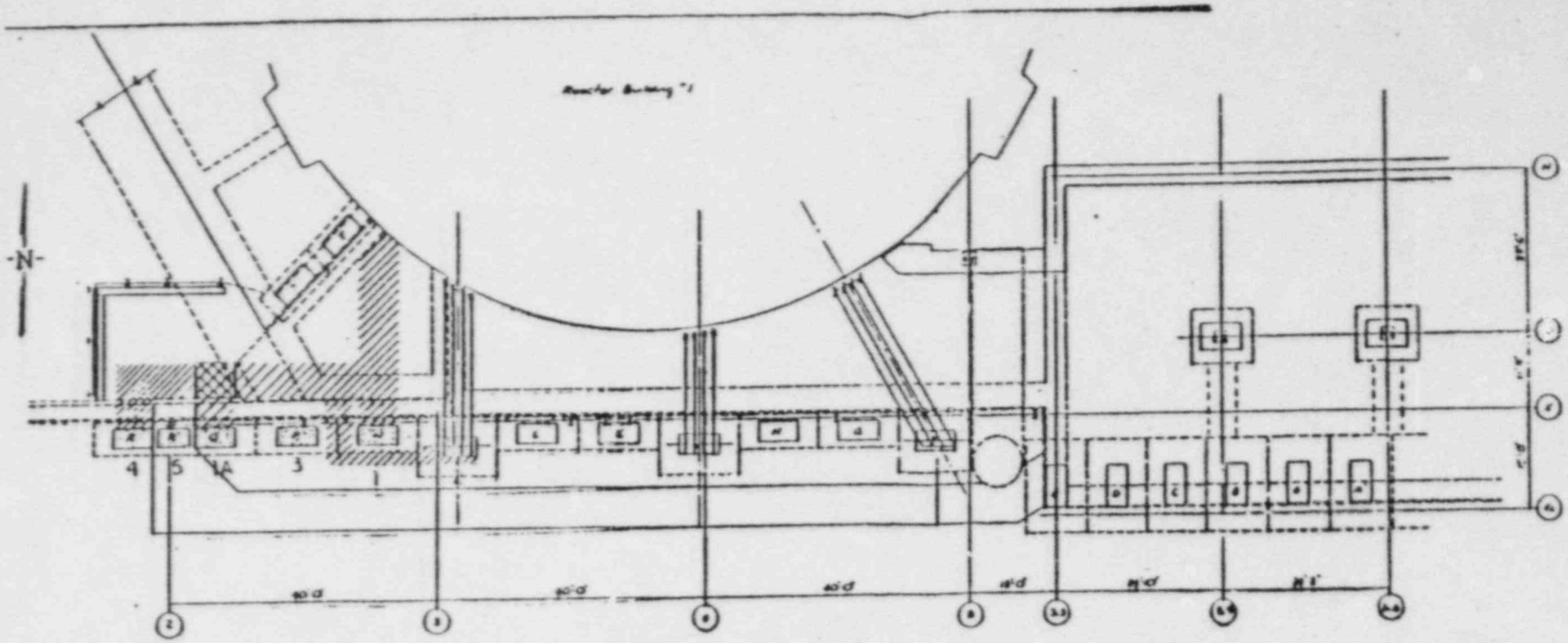
MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1-12-82

Q 1929 02

TYPICAL ACCESS DRIFT FRAME



SECTION A

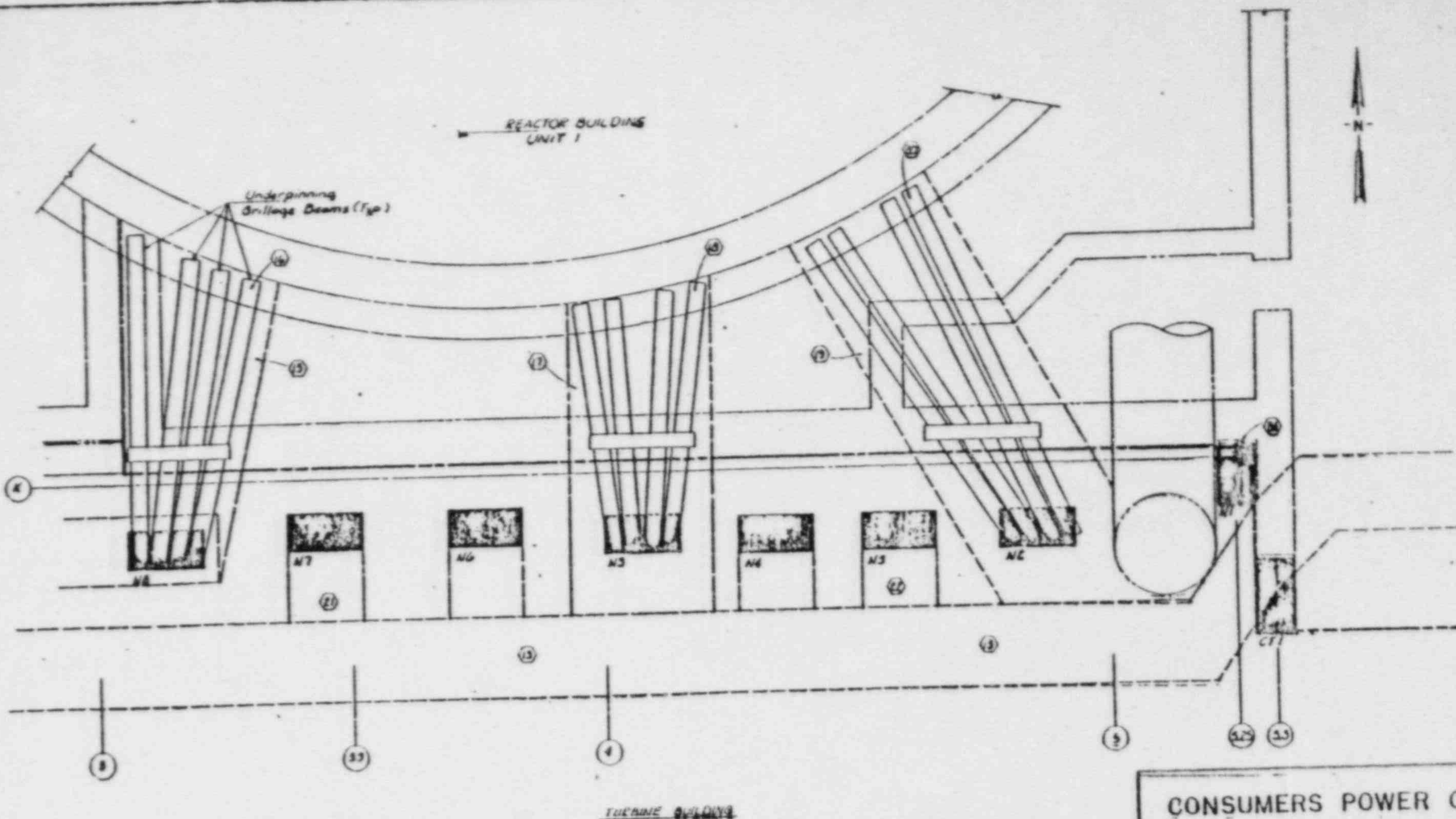


GENERAL PLAN
(WEST SIDE)

CONSUMERS POWER COMPAN
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDI
GENERAL PLAN

APPENDIX C FIGURE 1

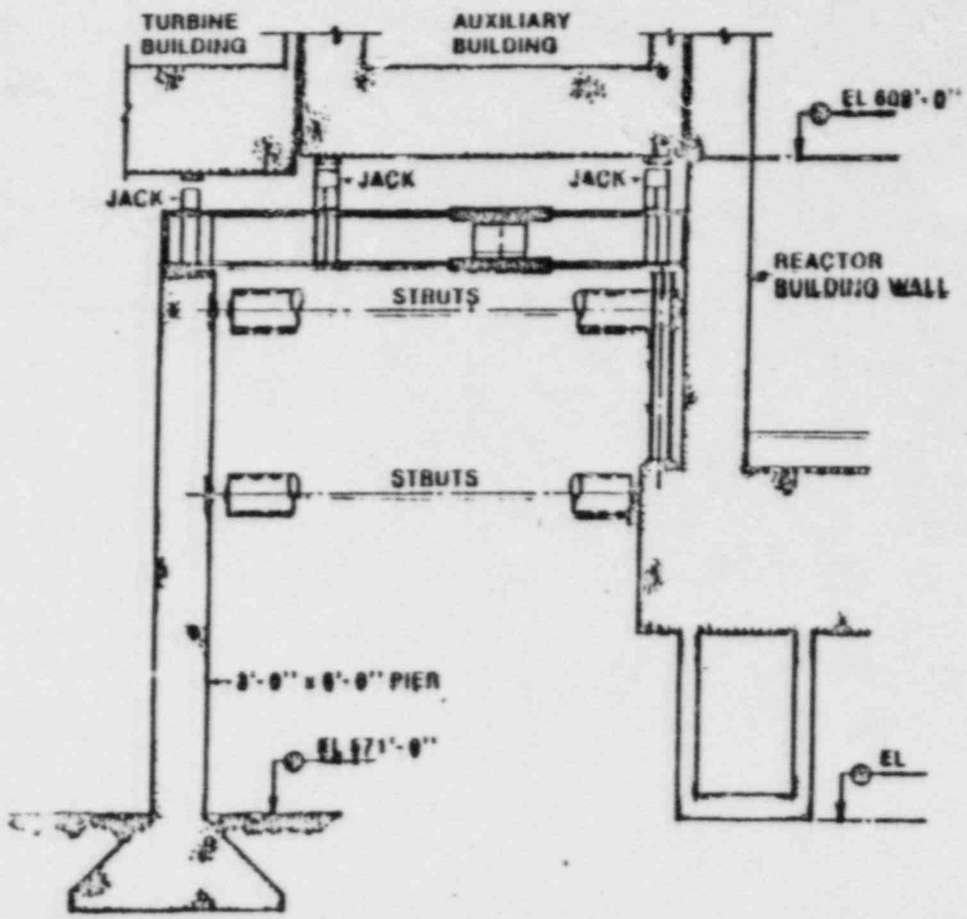


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

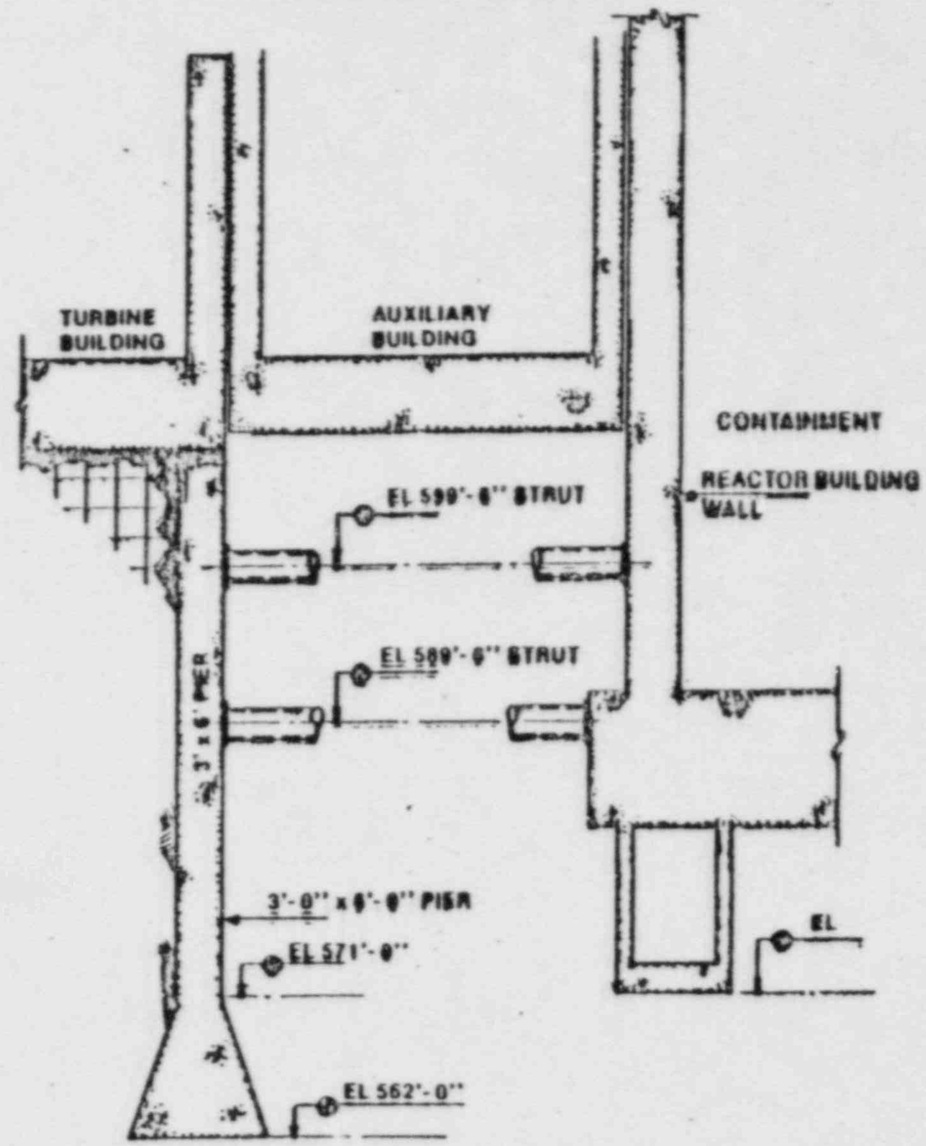
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION SCHEMATIC 2

SECTION AT UNDERPINNING GRILLAGE

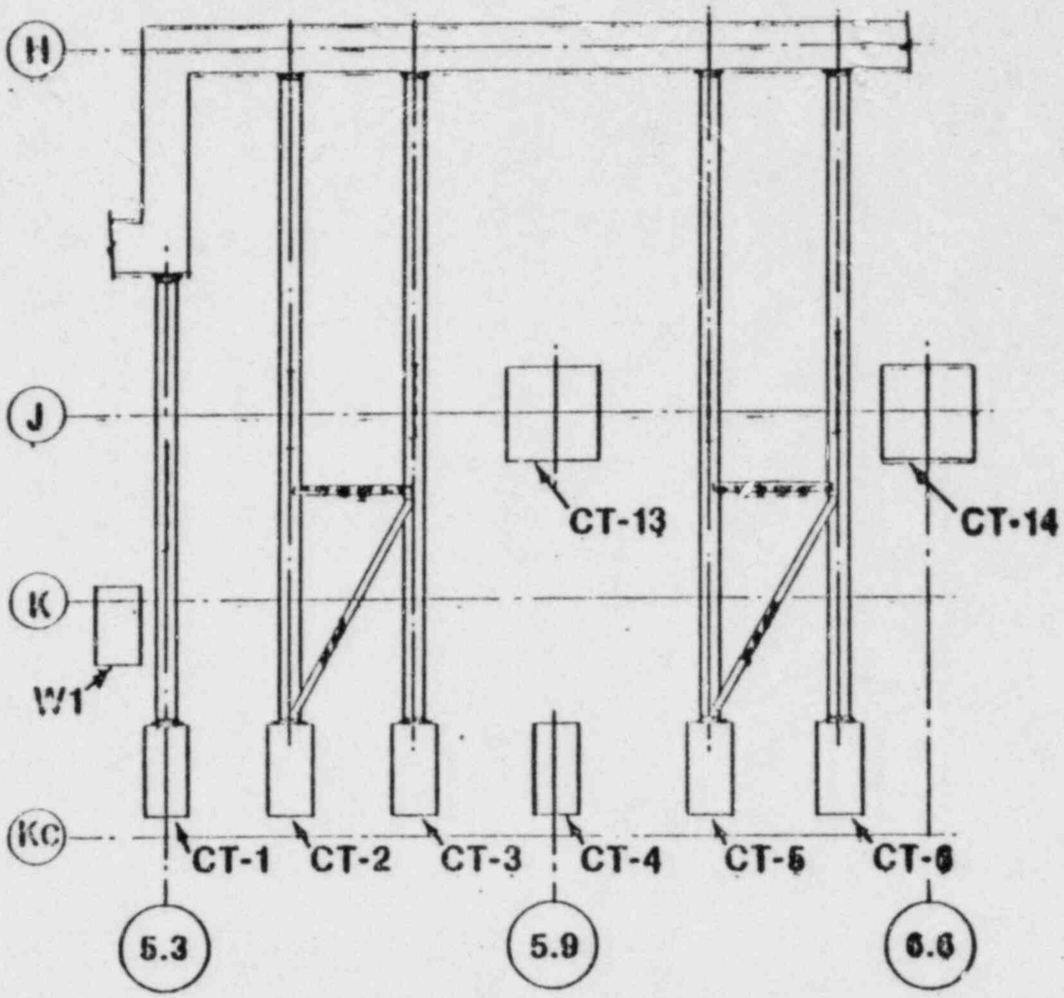


PIER BRACING

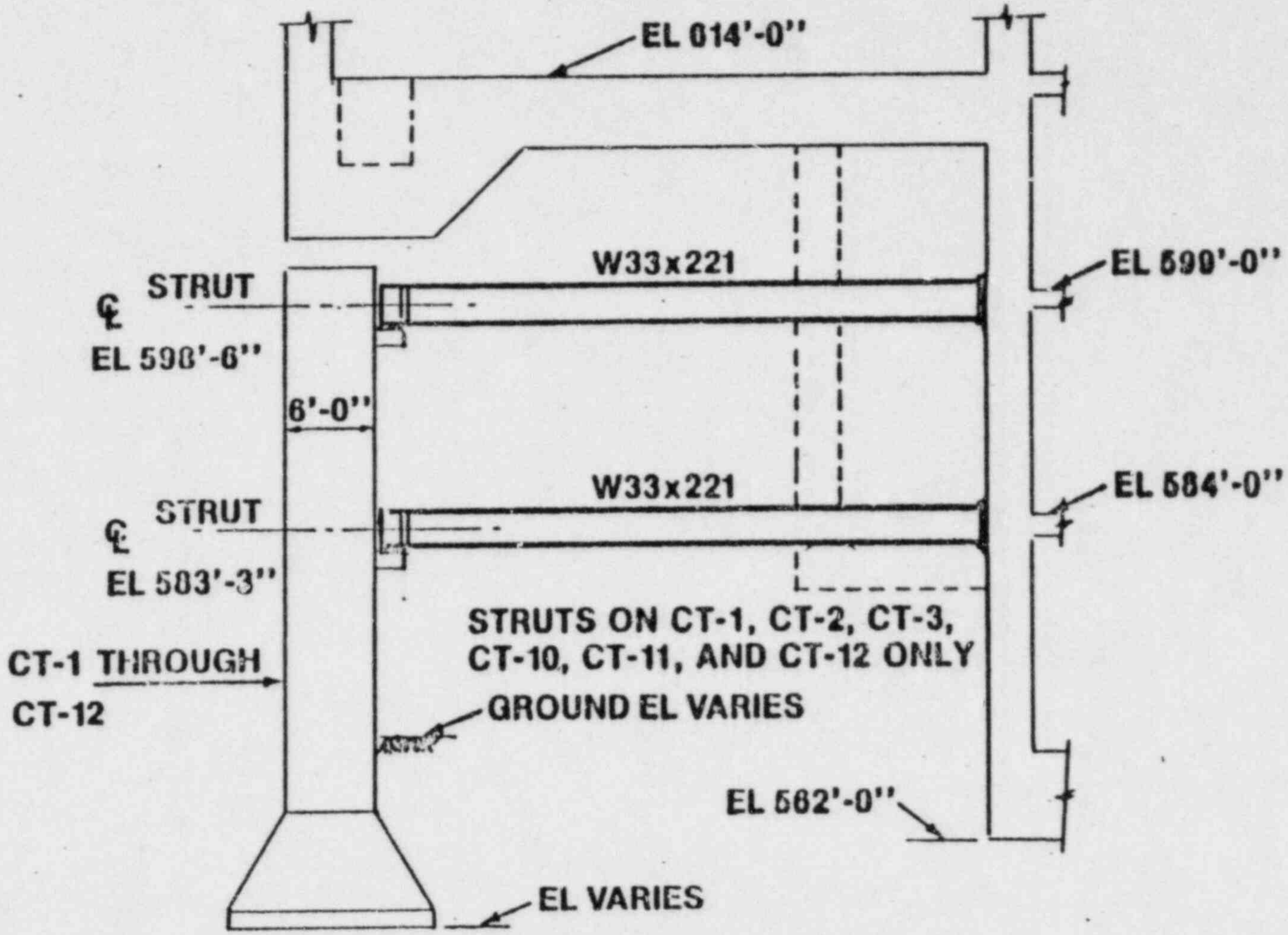


12

PLAN - CONTROL TOWER
PIERS AND STRUTS



SECTION - CONTROL TOWER
PIERS AND STRUTS



SECTION R-R

AUXILIARY BUILDING UNDERPINNING CONSTRUCTION CONDITION ANALYSIS

- PURPOSE - TO VERIFY THAT THE STRESSES IN THE STRUCTURE ARE ACCEPTABLE ACCORDING TO DESIGN CRITERIA

- ANALYSIS CLOSELY FOLLOWS CONSTRUCTION SEQUENCES

- CONSTRUCTION SEQUENCES SIMULATED WITH CONSERVATIVE ASSUMPTIONS

AUXILIARY BUILDING UNDERPINNING

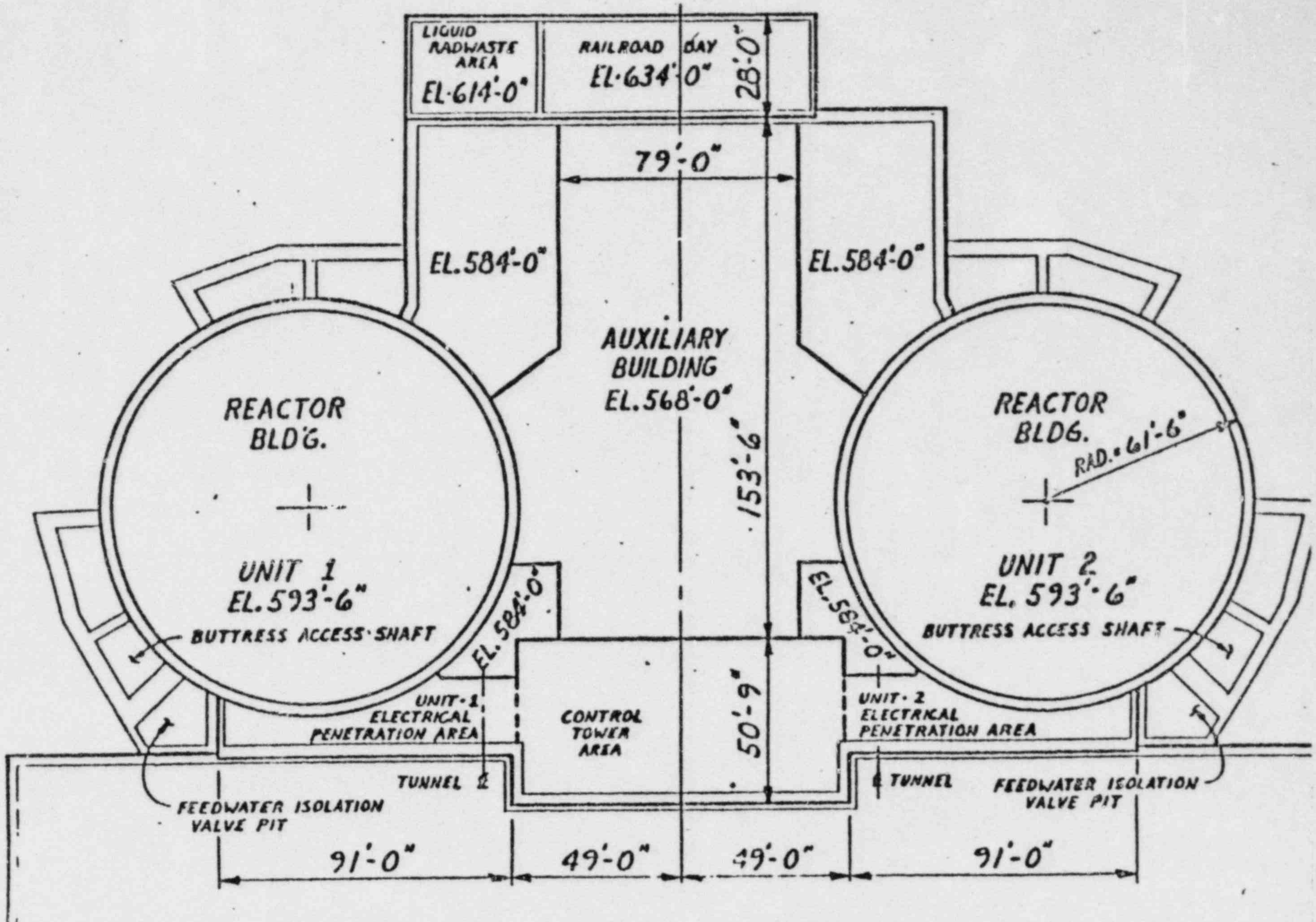
CONSTRUCTION CONDITION ANALYSIS

- ANALYTICAL MODEL
- LOADS
- ALLOWABLE STRESS
- BASE LINE

  EXISTING CONDITION WITH BEST ESTIMATED SUPPORT FROM BACKFILL
- INCORPORATE ESTIMATED UNDERPINNING FOR MAJOR CONSTRUCTION STAGES IN MODEL AND EVALUATE CHANGE IN STRESS
- INCORPORATE PROGRESSIVE JACKING
- FINAL STAGE - STRUCTURE ON TEMPORARY SUPPORT
- SOIL PRESSURES
- AREAS FOR MONITORING

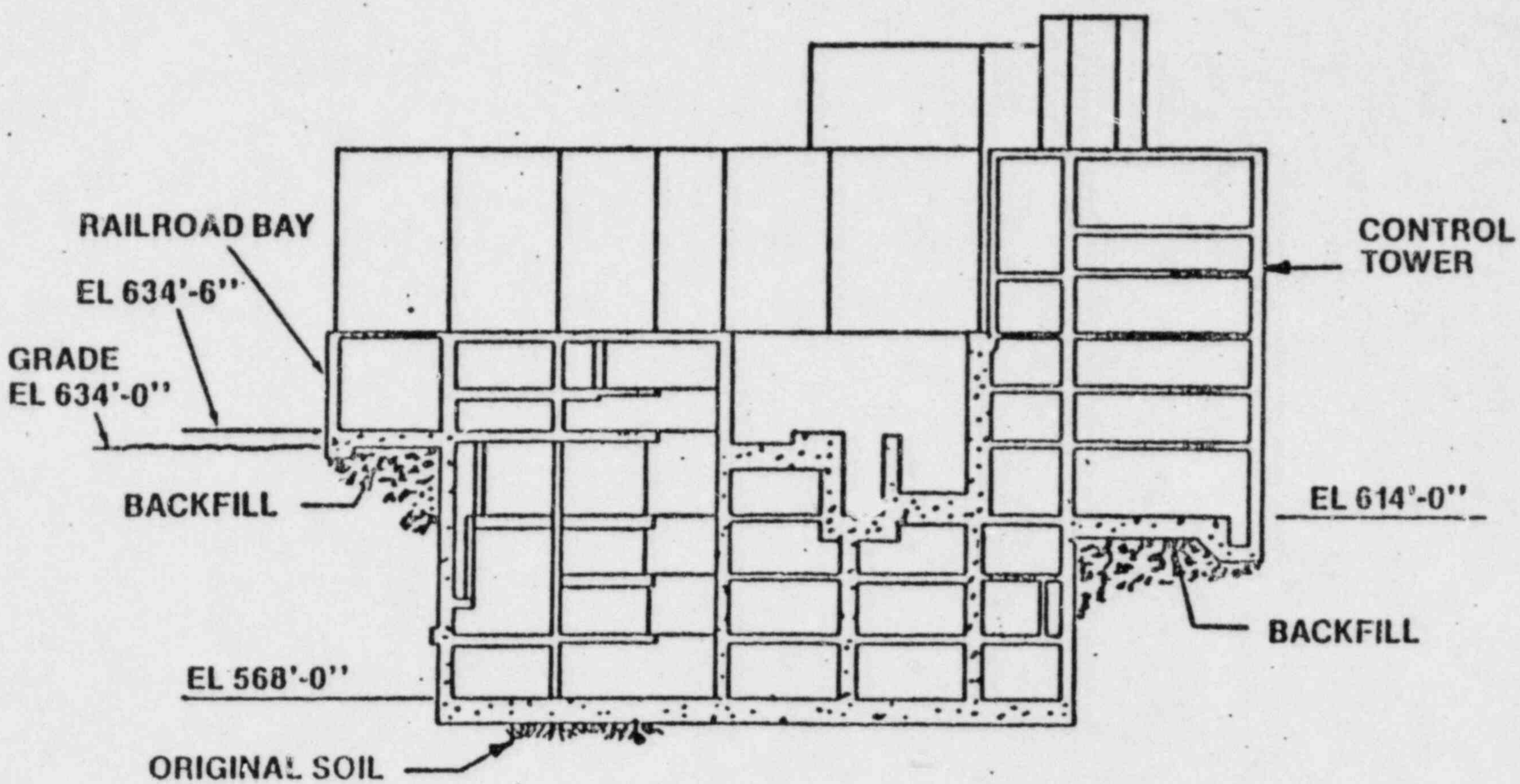
2

N



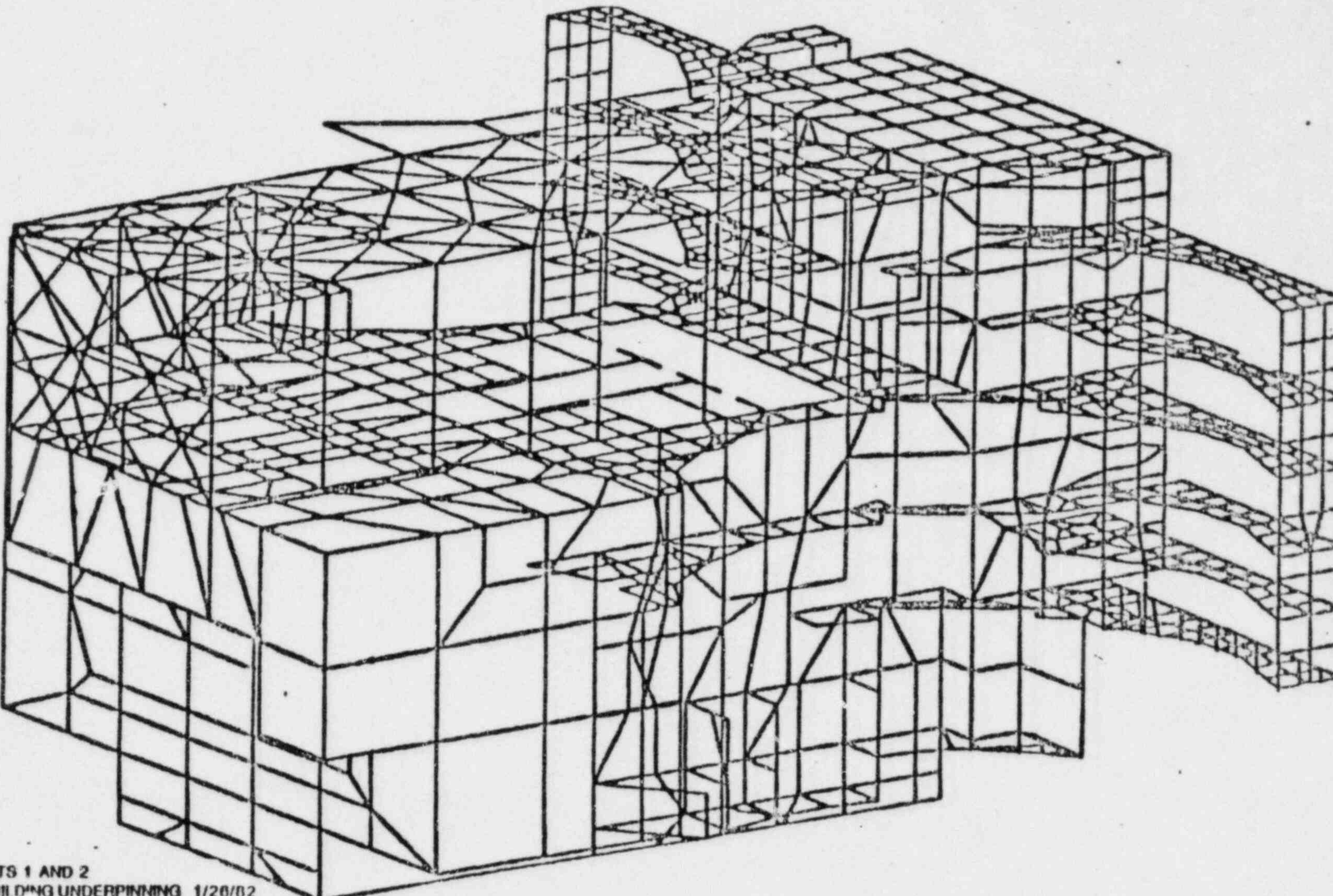
LIQUID RADWASTE AREA
EL·614'-0"
RAILROAD BAY
EL·634'-0"
28'-0"
79'-0"
EL.584'-0"
EL.584'-0"
AUXILIARY BUILDING
EL.568'-0"
153'-6"
REACTOR BLD'G.
UNIT 1
EL.593'-6"
BUTTRESS ACCESS·SHAFT
REACTOR BLDG.
RAD.=61'-6"
UNIT 2
EL. 593'-6"
BUTTRESS ACCESS SHAFT
EL.584'-0"
EL.584'-0"
50'-9"
UNIT·1 ELECTRICAL PENETRATION AREA
CONTROL TOWER AREA
UNIT·2 ELECTRICAL PENETRATION AREA
TUNNEL
TUNNEL
FEEDWATER ISOLATION VALVE PIT
FEEDWATER ISOLATION VALVE PIT
91'-0"
49'-0"
49'-0"
91'-0"
TURBINE BUILDING

AUXILIARY BUILDING
TYPICAL SECTION
(Looking East)



G 1555-07

AUXILIARY BUILDING UNDERPINNING
ISOMETRIC VIEW OF MODEL

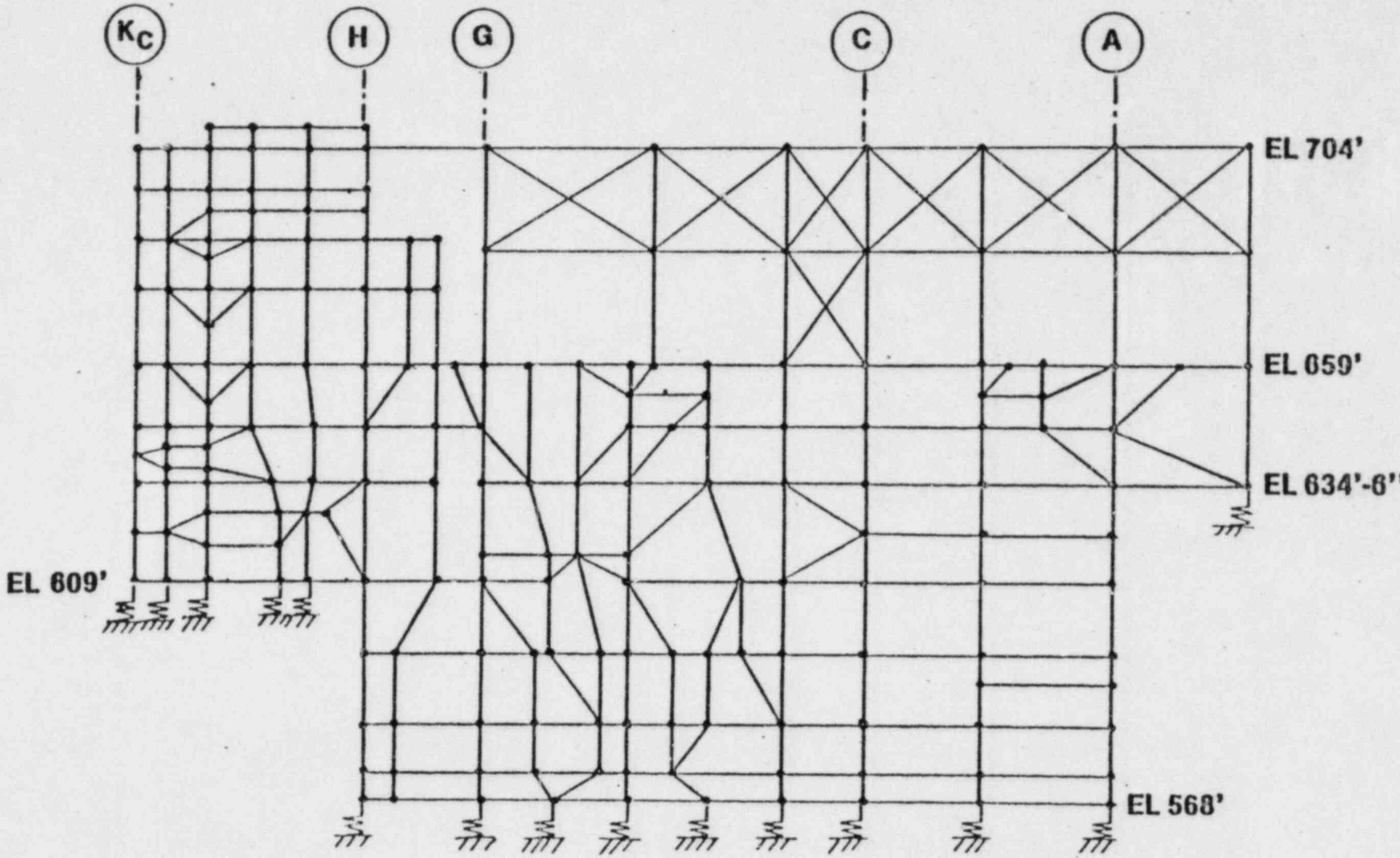


MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/26/82

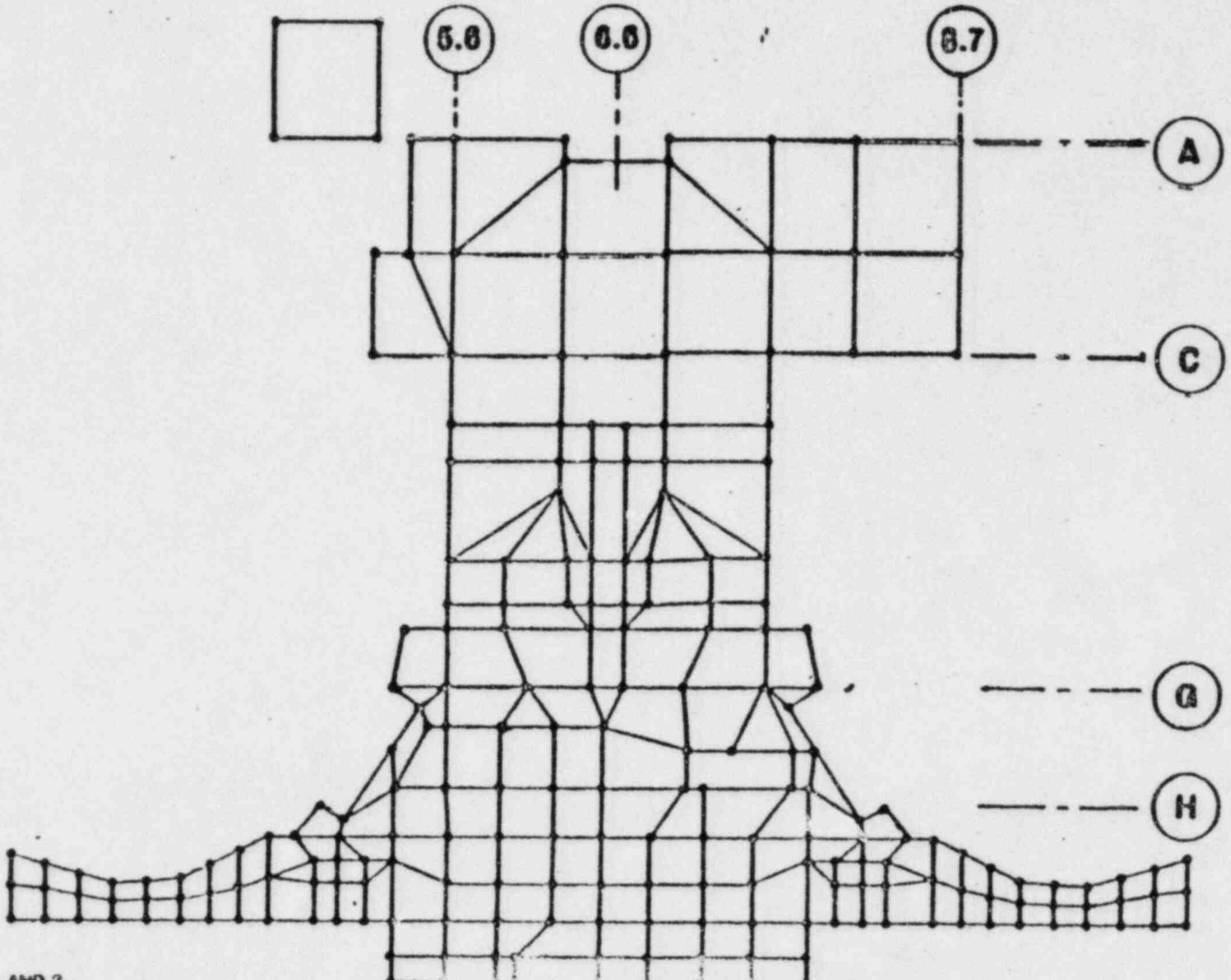
G-1862-23

AUXILIARY BUILDING UNDERPINNING

NODAL MESH AT COLUMN LINE 5.6
ELEVATION VIEW



AUXILIARY BUILDING UNDERPINNING
NODAL MESH AT ELEVATION 614'
PLAN VIEW



AUXILIARY BUILDING UNDERPINNING CONSTRUCTION CONDITION ANALYSIS
FINITE ELEMENT MODEL

- USE BSAP CE 800
- NO. OF NODES = 2,800
- NO. OF ELEMENTS, INCLUDE BEAMS, PLATES AND TRUSS = 4,000
- BOUNDARY ELEMENTS = 402
- MESH SOUTH OF G-LINE IS FINER THAN MESH NORTH OF G-LINE
- STEEL BEAMS BELOW SLABS NOT MODELED
- OUT OF PLANE BENDING FOR SLABS ANALYZED SEPARATELY

AUXILIARY BUILDING UNDERPINNING
EXISTING STRUCTURE ANALYSIS

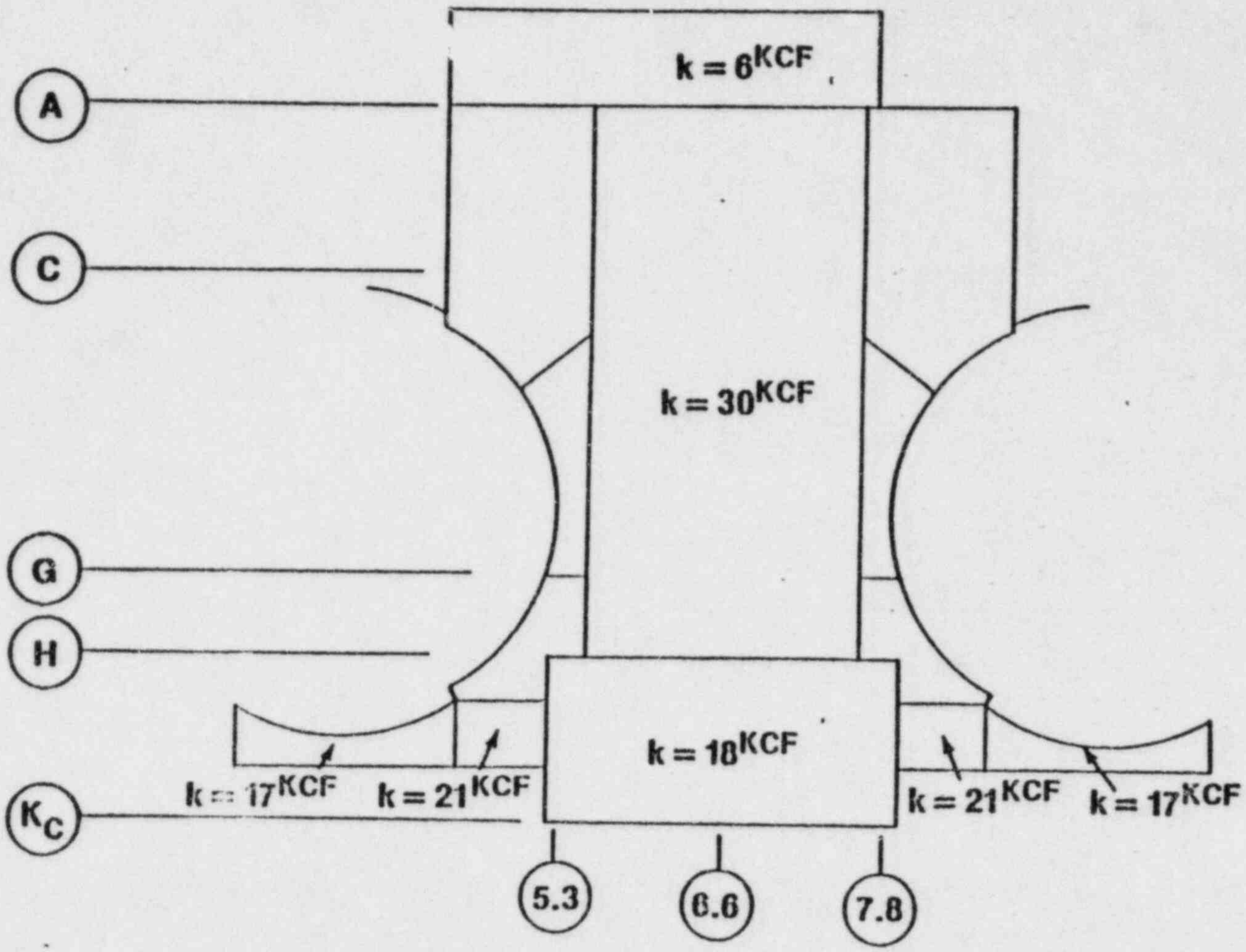
- MODEL BOUNDARY CONDITIONS REPRESENTED AS NODAL SPRINGS

- NODAL SPRINGS = SOIL SUBGRADE MODULUS x CONTRIBUTORY AREA

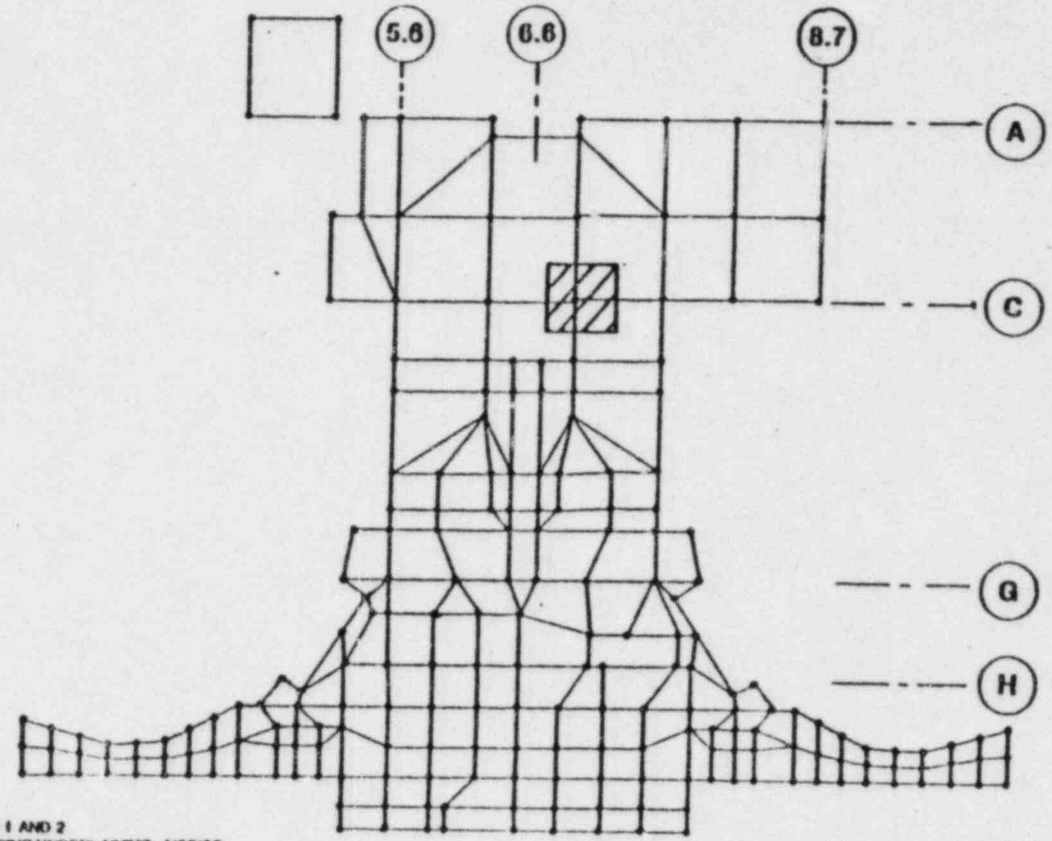
- SUBGRADE MODULUS VALUES COMPUTED BY GEOTECH AND SUBMITTED TO NRC

AUXILIARY BUILDING UNDERPINNING

EXISTING SOIL SPRINGS UNDER AUXILIARY BUILDING



AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
NODAL SPRINGS



MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/29/82

G-1929-26

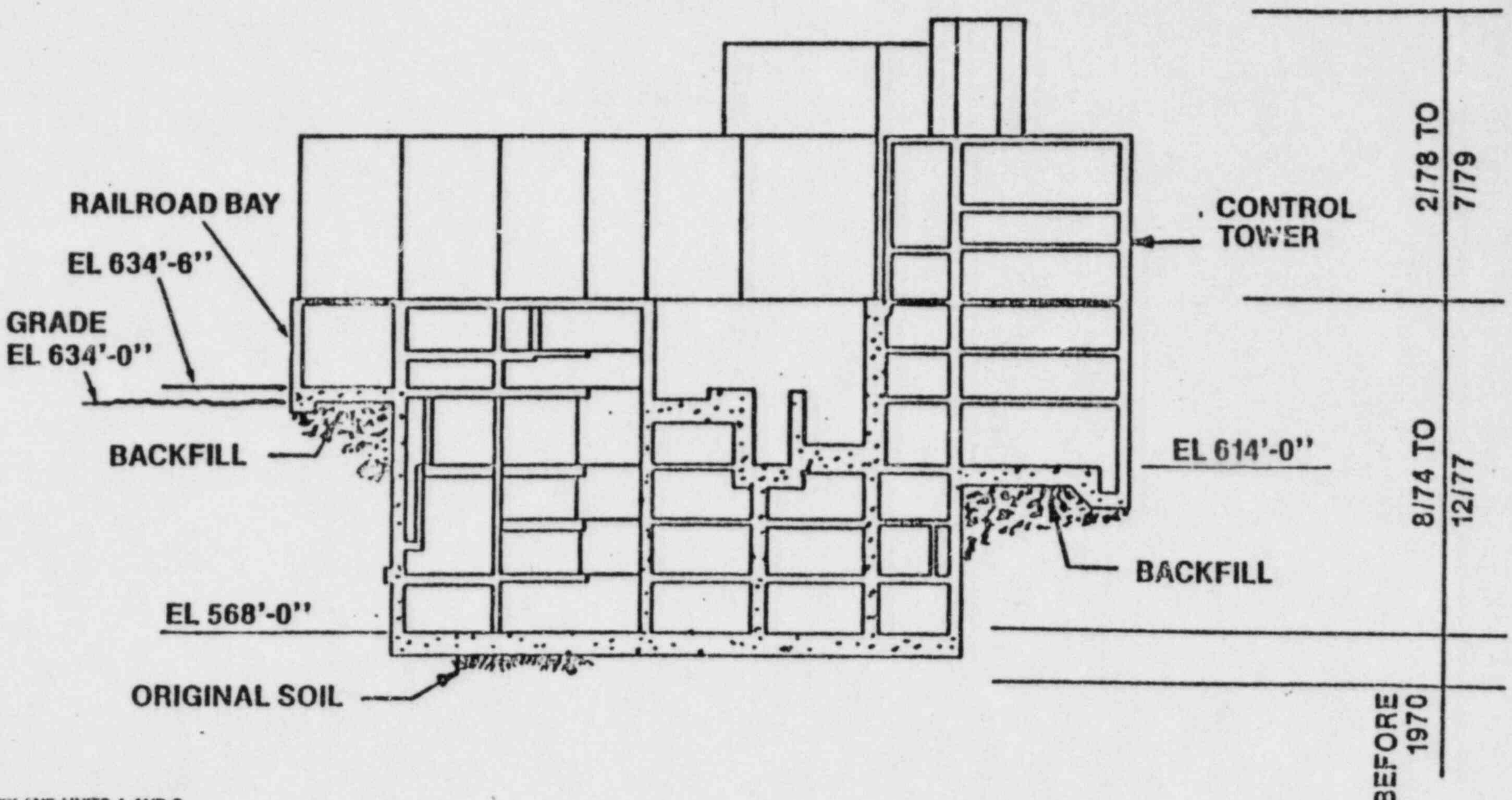
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS

- DEAD WEIGHT OF STRUCTURE
- WEIGHT OF BLOCKWALLS
- EQUIPMENT LOADS
- 25 PERCENT LIVE LOAD ON FLOORS
- JACKING LOAD (progressive)

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
ALLOWABLE STRESSES AND LOAD FACTORS

- BASED ON ACI 318-71
- AISC, SEVENTH EDITION
- RESULTS FROM COMPUTER MULTIPLIED BY FACTOR 1.43 TO CORRESPOND TO 1.4D + 1.7L
- CONSERVATIVE ESTIMATE DL= 90% OF TOTAL LOAD
  LL= 10% OF TOTAL LOAD
- 1.4D + 1.7L = 0.9 x 1.4 + 0.1 x 1.7
  = 1.26 + 0.17
  = 1.43
  (weighted load factor)

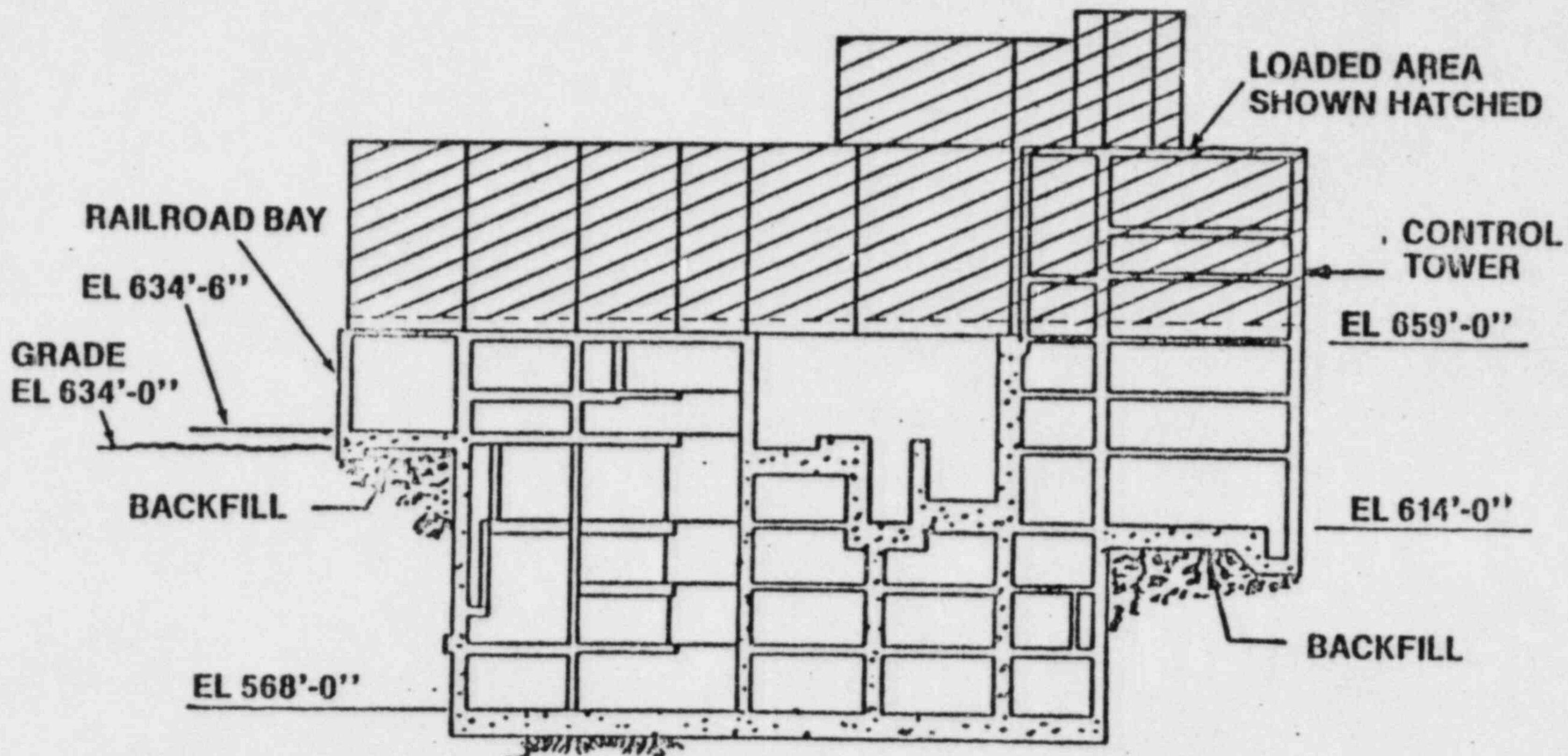
AUXILIARY BUILDING UNDERPINNING
TYPICAL SECTION
(Looking East)



MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/20/82

G-1555-07

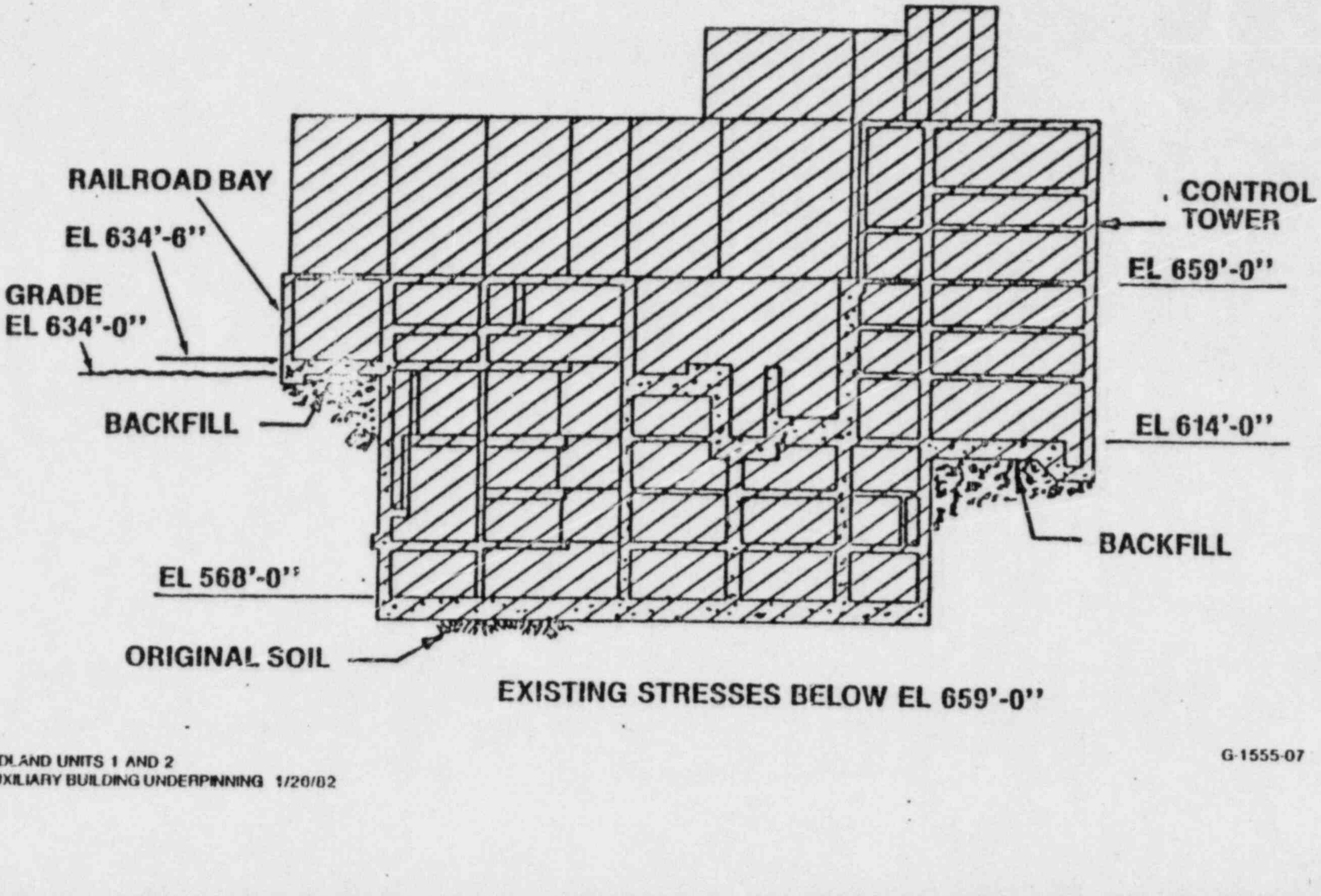
AUXILIARY BUILDING UNDERPINNING
TYPICAL SECTION
(Looking East)



EXISTING STRESS ANALYSIS

LOADING CONDITION FOR EL 659'-0" AND ABOVE

AUXILIARY BUILDING UNDERPINNING
TYPICAL SECTION
(Looking East)



EXISTING STRESSES BELOW EL 659'-0"

AUXILIARY BUILDING UNDERPINNING CONSTRUCTION CONDITION ANALYSIS

- EXISTING STRESS DETERMINATION
- TWO MODELS USED TO REPRESENT CONSTRUCTION PROGRESS
- LOADING CONDITION - EL 659' AND ABOVE
- LOADING BELOW EL 659'
- REDUCED MODULUS OF CONCRETE = $\frac{Ec}{1.8}$

  IN ACCORDANCE WITH ARTICLE 9.5.2.3 (ACI 318-71) TO ACCOUNT FOR CREEP AND SHRINKAGE IN CONCRETE

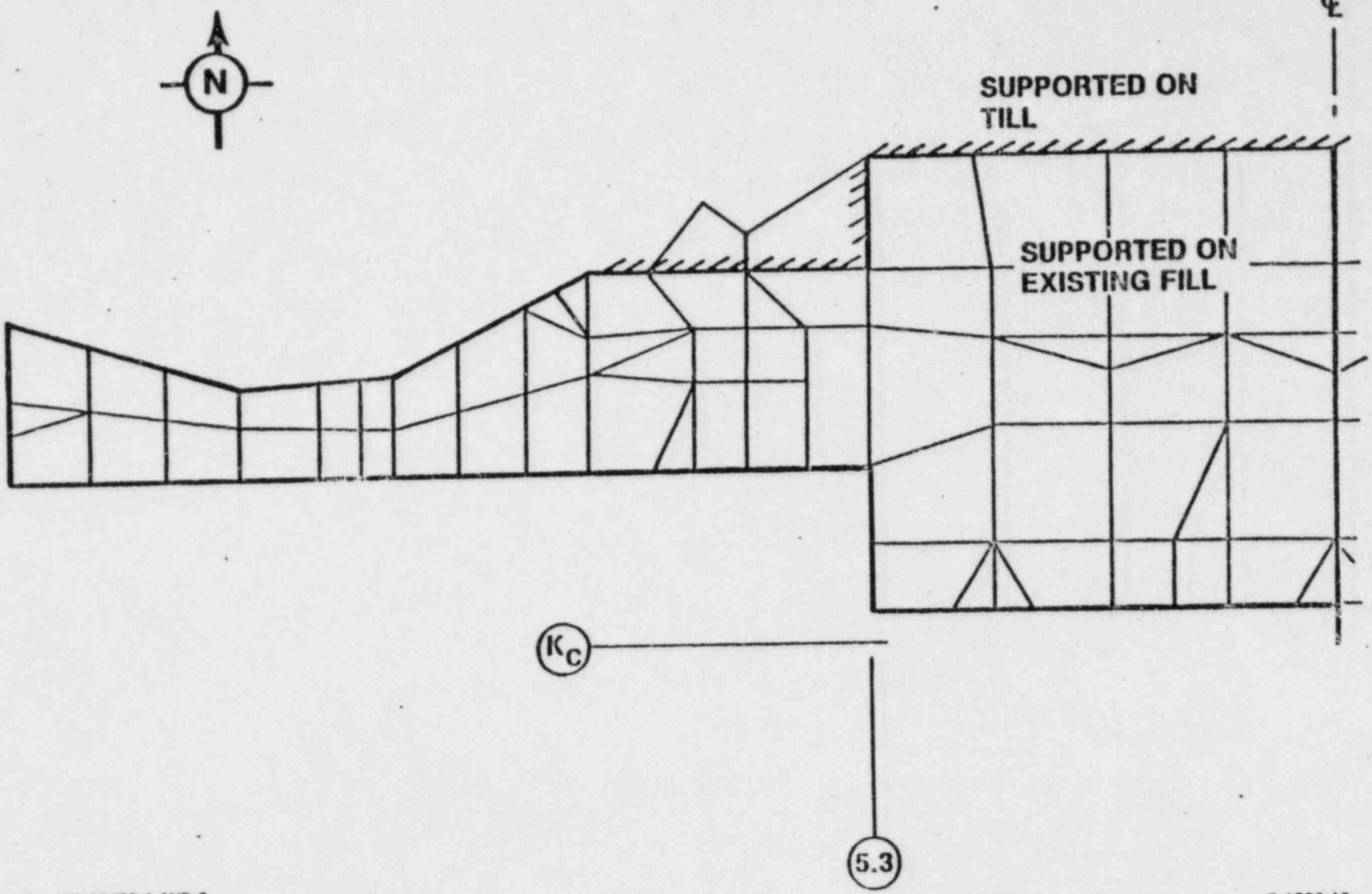
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS

- EXISTING STRESS VALUES
  MAXIMUM TENSION = 30 K/FT

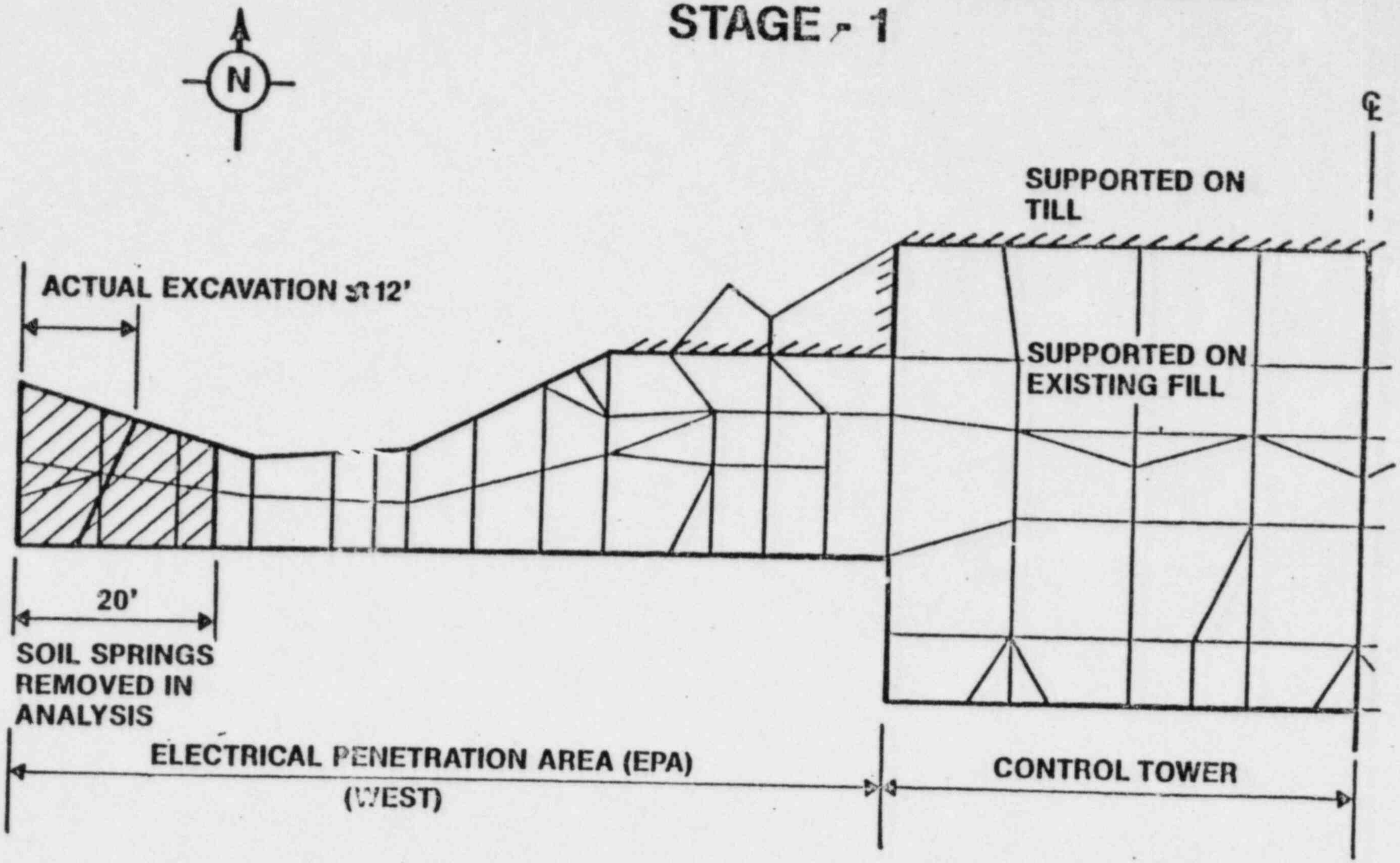
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS

- TEMPORARY CONDITION
- Ec VALUE IN ACCORDANCE WITH ARTICLE 8.3.1 OF ACI 318-71

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION AREA
PLAN



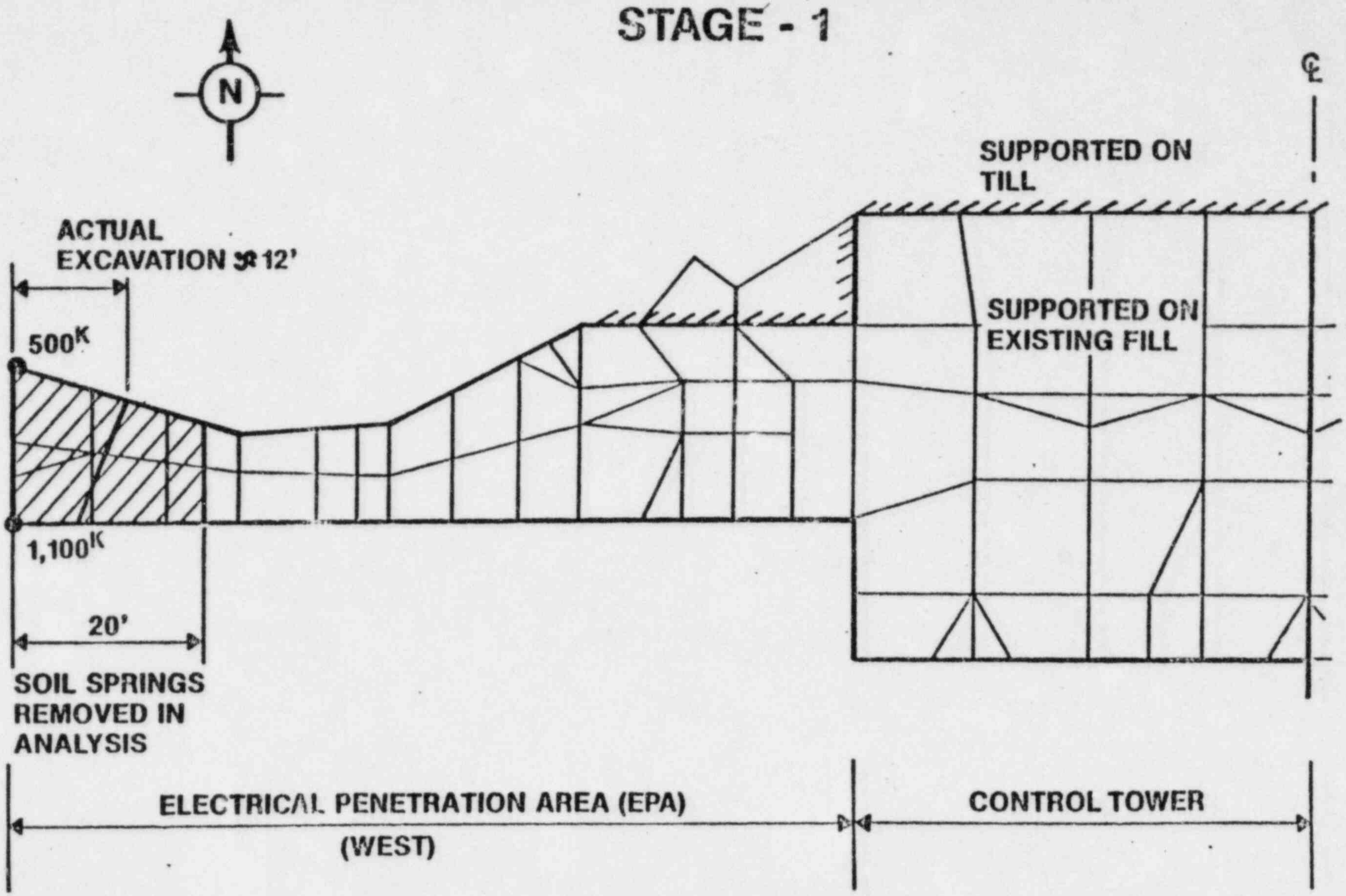
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION SEQUENCE
STAGE - 1



MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/28/82

G-1862-21

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION SEQUENCE
STAGE - 1



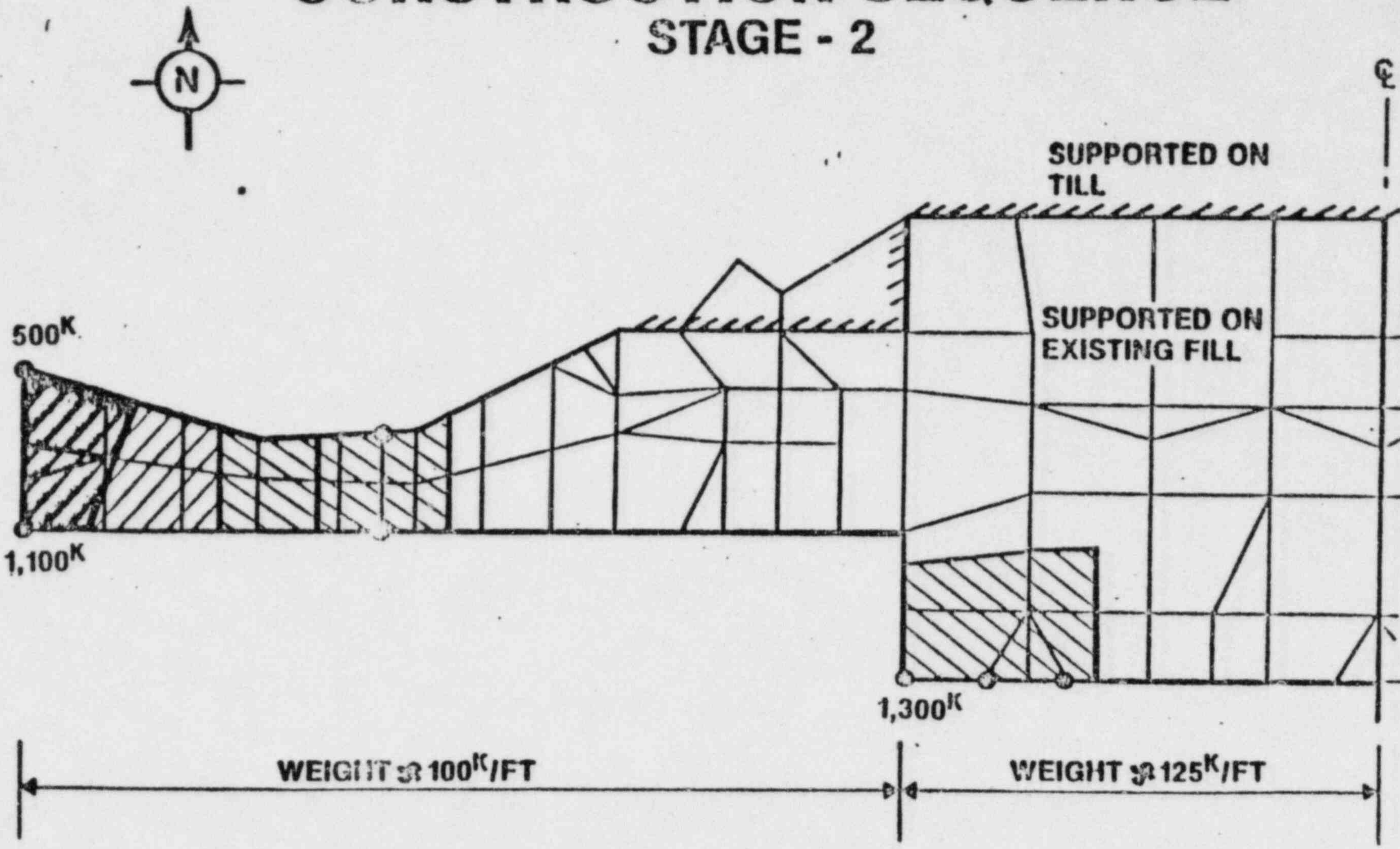
MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/20/82

G-1832-22

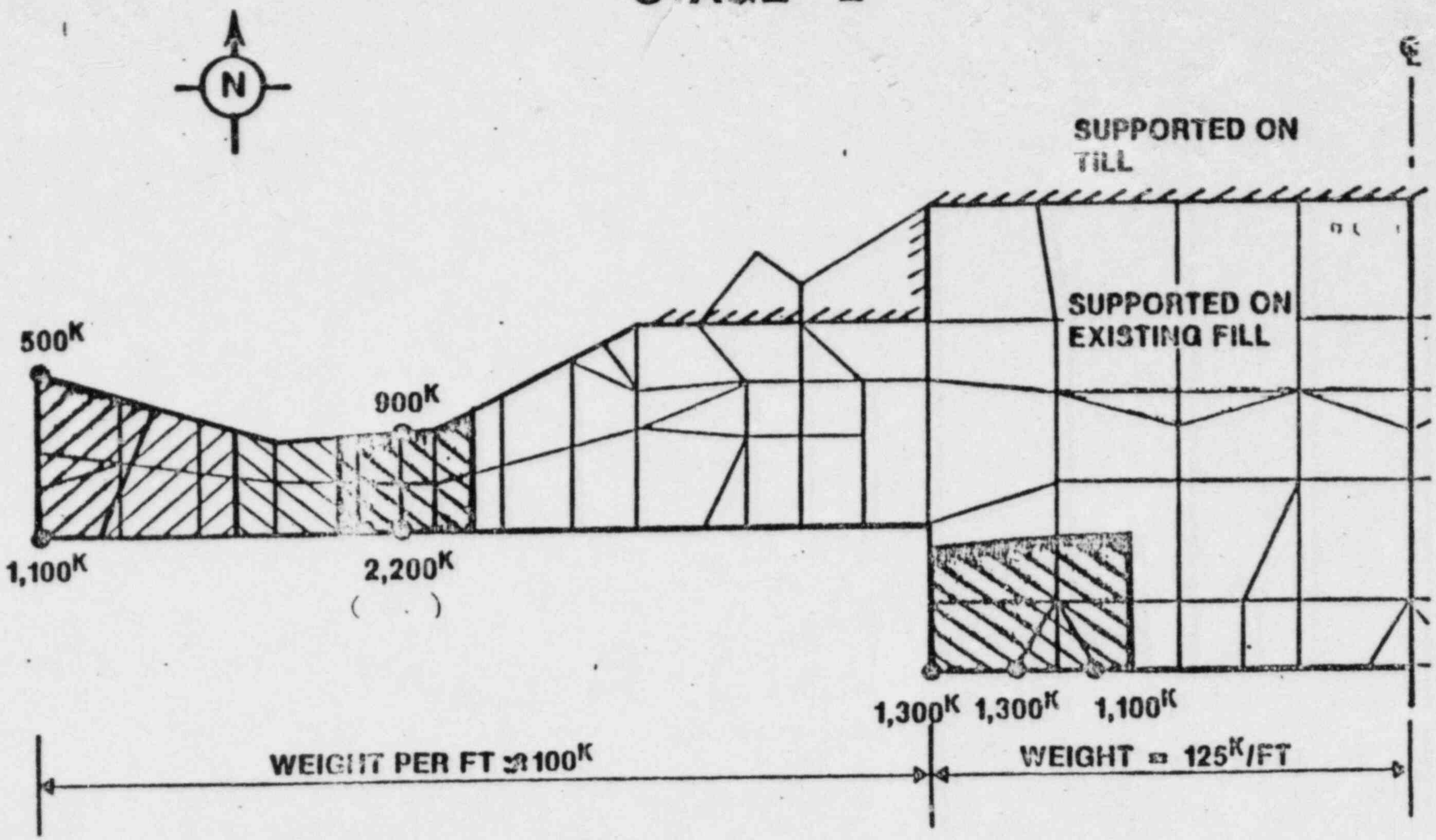
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
MAXIMUM STRESS (Tension)
CONSTRUCTION STAGE 1

	Existing Stress	Change in Stress	Total Stress
• DUE TO SOIL REMOVAL	30 K/FT	7 K/FT	37 K/FT
• DUE TO SOIL REMOVAL AND JACKING	30 K/FT	-2 K/FT	28 K/FT

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION SEQUENCE
STAGE - 2



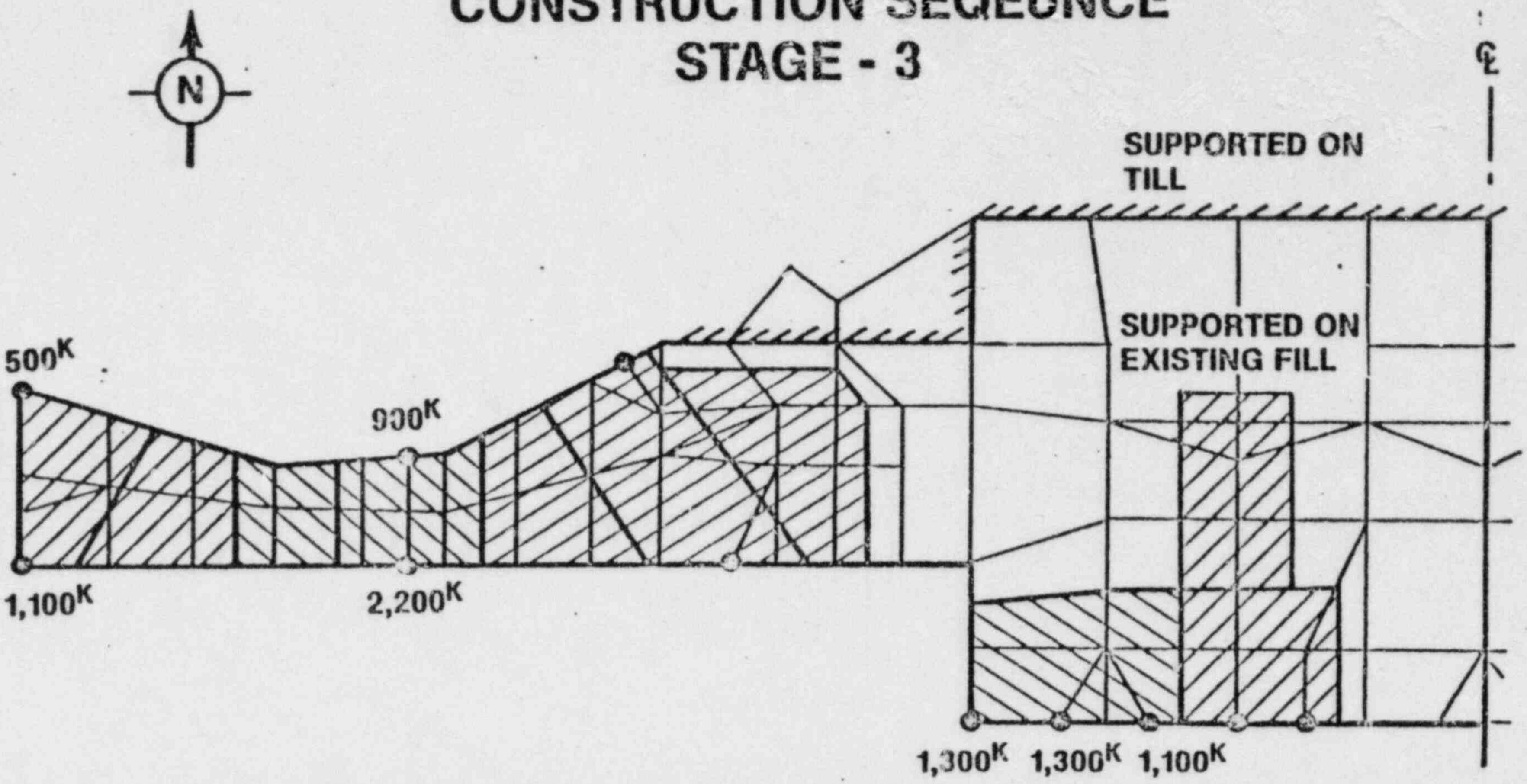
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION SEQUENCE
STAGE - 2



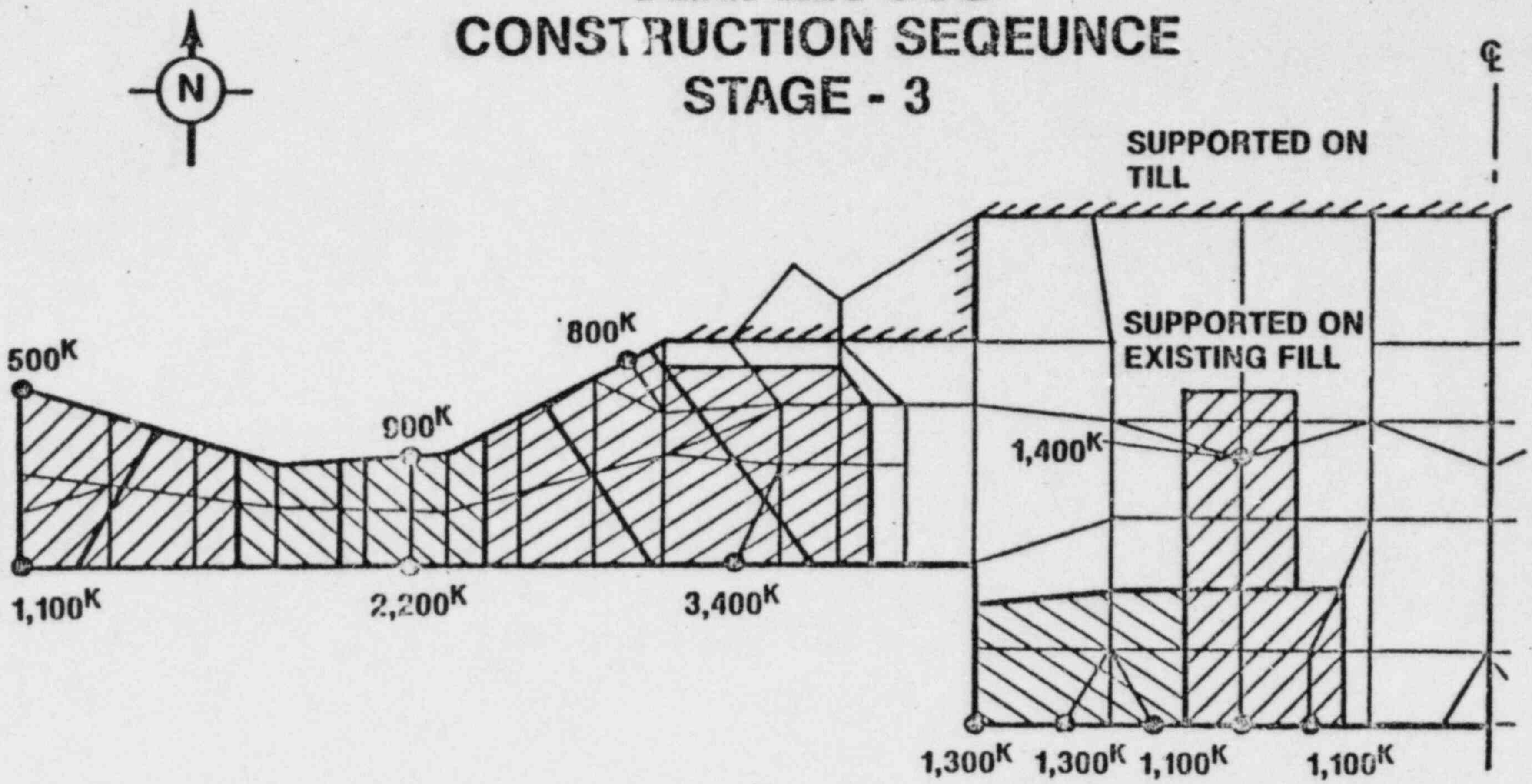
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
MAXIMUM STRESS (Tension)
CONSTRUCTION STAGE 2

	Existing Stress	Change in Stress	Total Stress
• DUE TO SOIL REMOVAL	30 K/FT	1 K/FT	31 K/FT
• DUE TO SOIL REMOVAL AND JACKING	30 K/FT	-65 K/FT	-35 K/FT

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
CONSTRUCTION SEQEUNCE
STAGE - 3



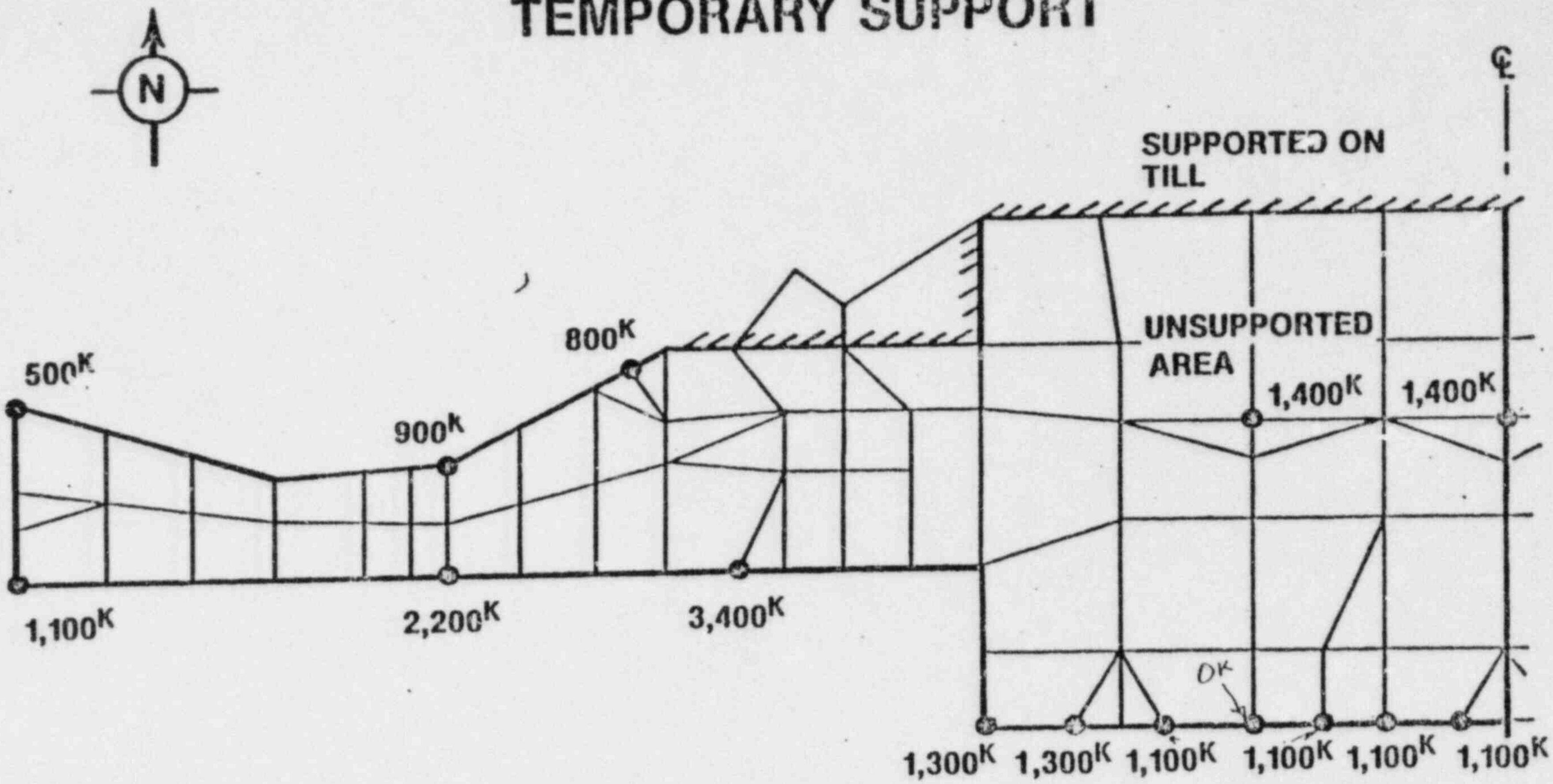
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
CONSTRUCTION SEQEUNCE
STAGE - 3



AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
MAXIMUM STRESS (Tension)
CONSTRUCTION STAGE 3

	Existing Stress	Change in Stress	Total Stress
• DUE TO SOIL REMOVAL	30 K/FT	-20 K/FT	10 K/FT
• DUE TO SOIL REMOVAL AND JACKING	30 K/FT	-95 K/FT	-65 K/FT

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION SEQUENCE
TEMPORARY SUPPORT



AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
FINAL CONSTRUCTION STAGE

EXISTING STRESS = 30 K/FT

CHANGE IN STRESS = -65 K/FT

TOTAL STRESS = -35 K/FT

AUXILIARY BUILDING UNDERPINNING CONSTRUCTION CONDITION ANALYSIS

MAXIMUM LOADS IN HIGHLY STRESSED AREAS

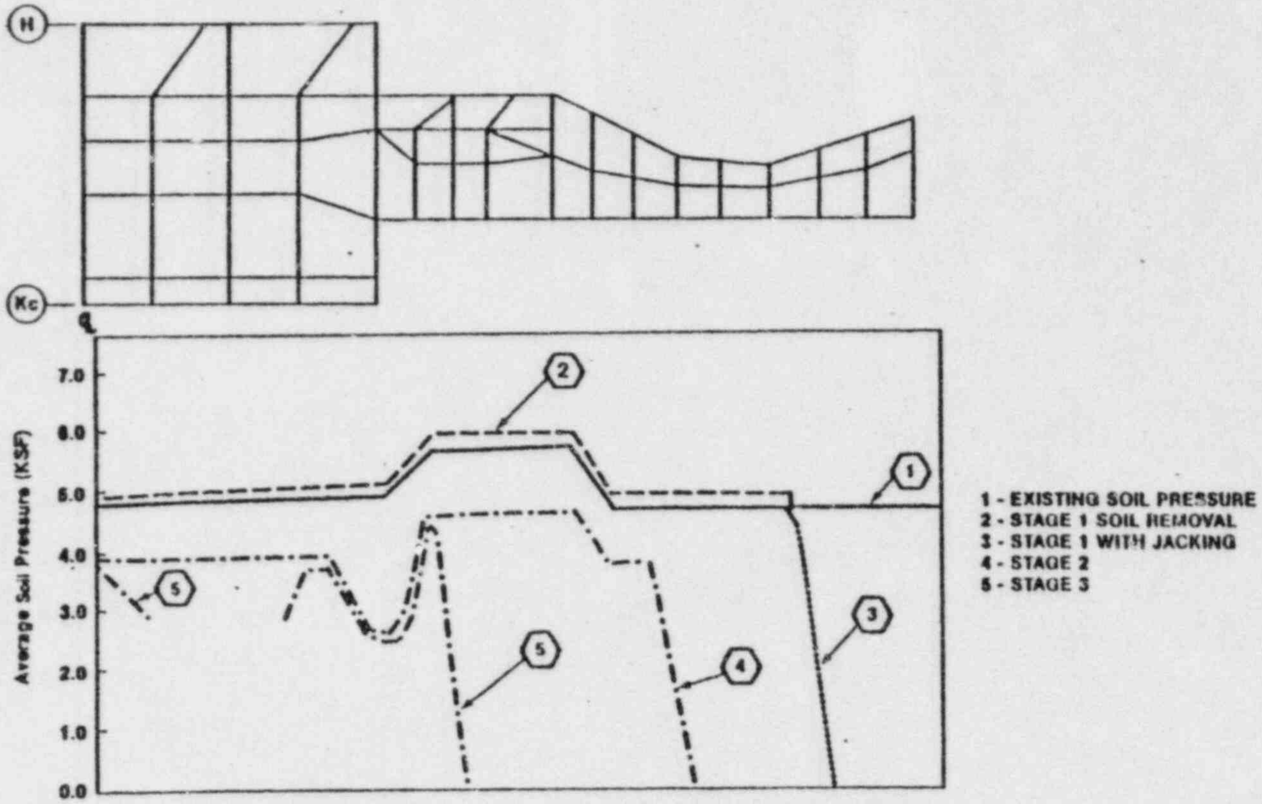
MAXIMUM TENSION

Location	Capacity	Existing Load	Stage 1 Constr	Stage2 Constr	Stage 3 Constr	Final Constr
Slab At El 659' (local area)	321K	258K	318K	260K	86K	Compression
Wall Below El 659' Between G and H	830K	333K	411K	351K	147K	Compression

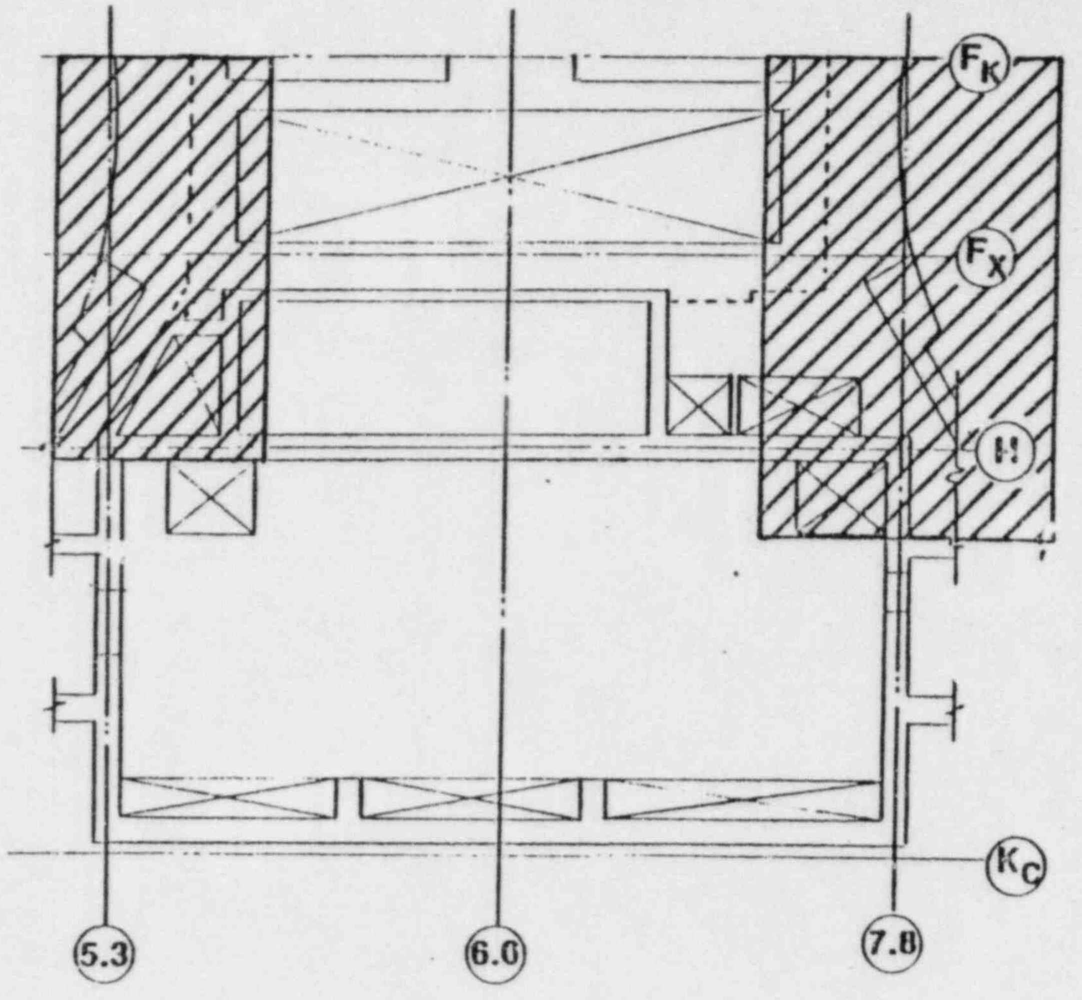
MAXIMUM SHEAR

Location	Capacity	Existing Load	Stage 1 Constr	Stage2 Constr	Stage 3 Constr	Final Constr
Wall Below El 659' Between G and H	290K	38K	76K	63K	98K	132K

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
SOIL PRESSURES (KSF)



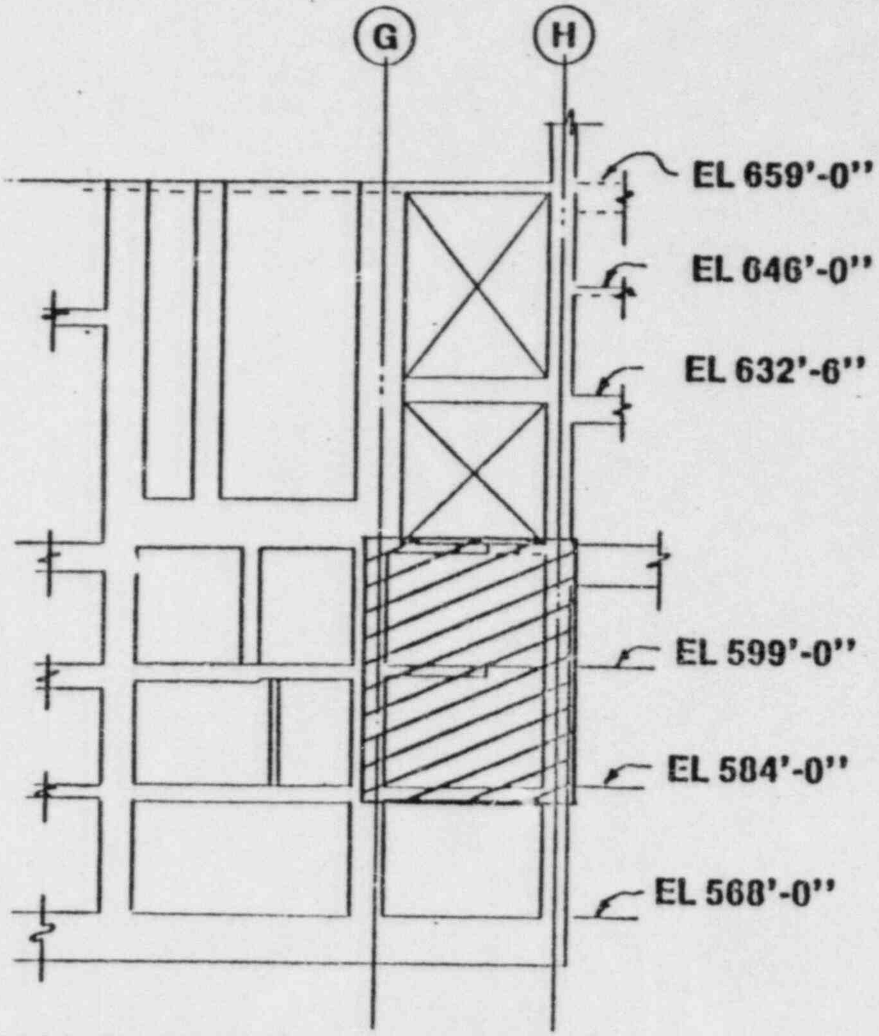
AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
AREAS FOR CRACK MONITORING



PLAN AT EL 659'-0"

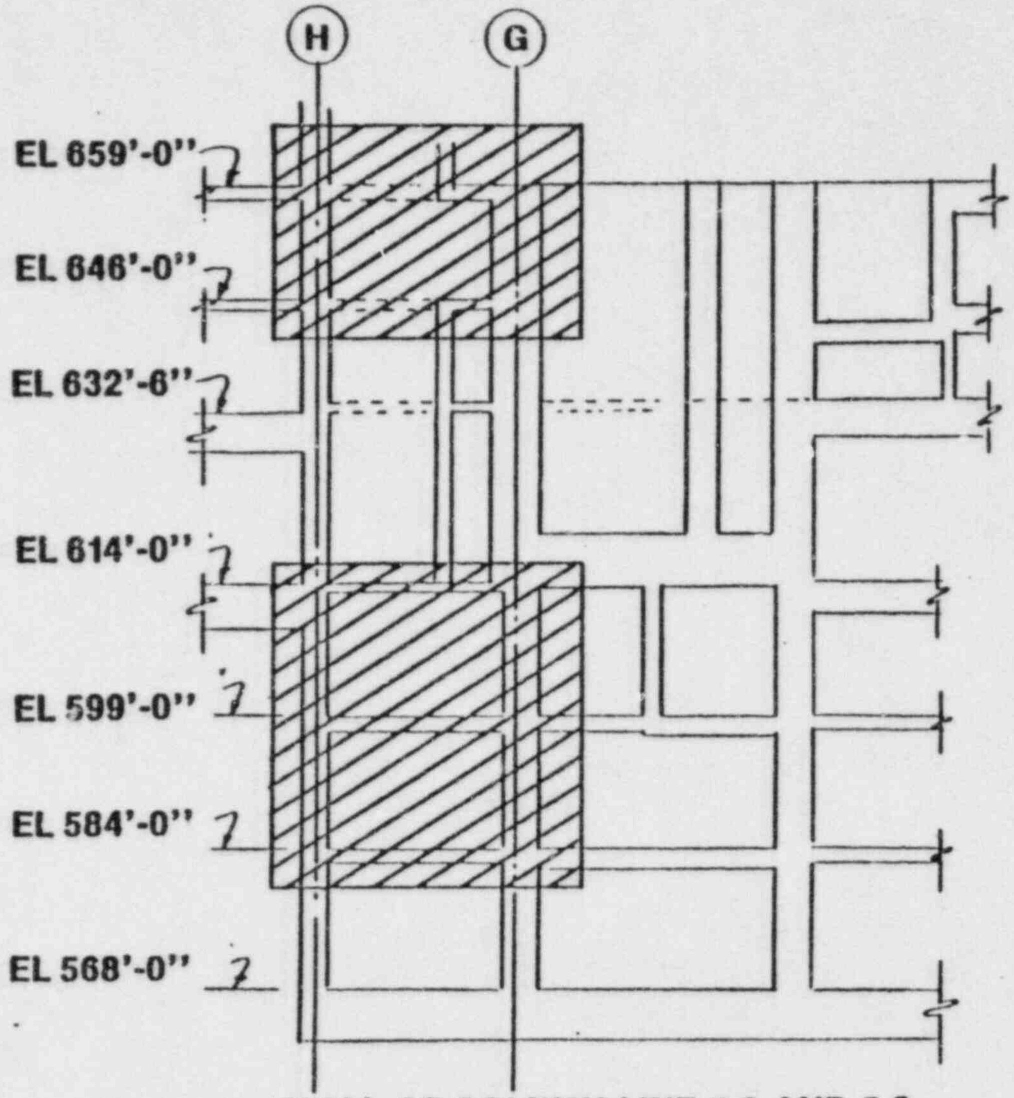
AUXILIARY BUILDING UNDERPINNING CONSTRUCTION CONDITION ANALYSIS

AREAS FOR CRACK MONITORING



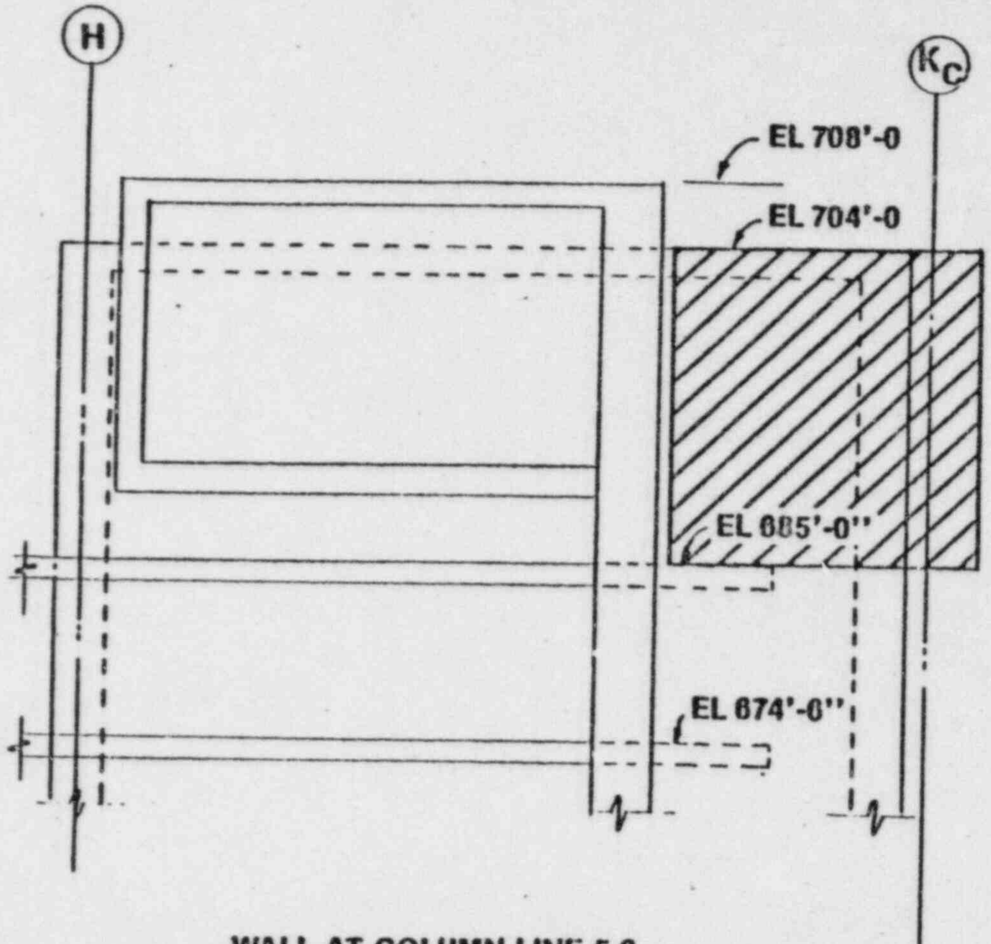
WALL AT COLUMN LINE 7.4 AND 7.8

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
AREAS FOR CRACK MONITORING



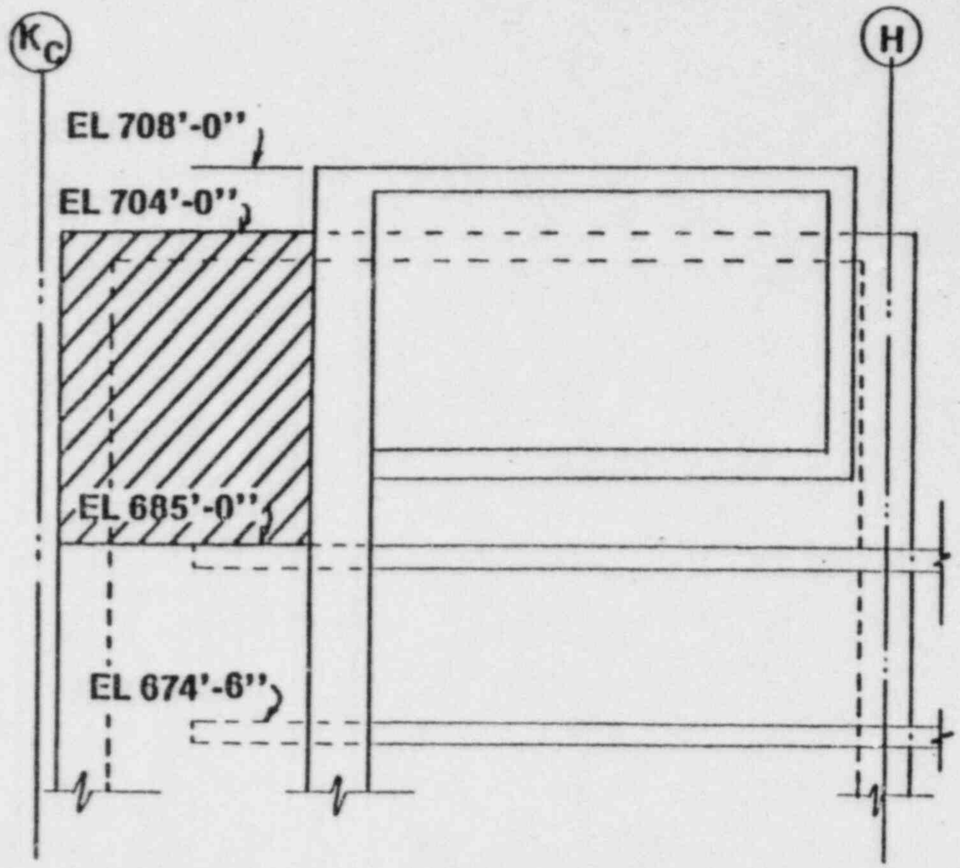
WALL AT COLUMN LINE 5.3 AND 5.6

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
AREAS FOR CRACK MONITORING



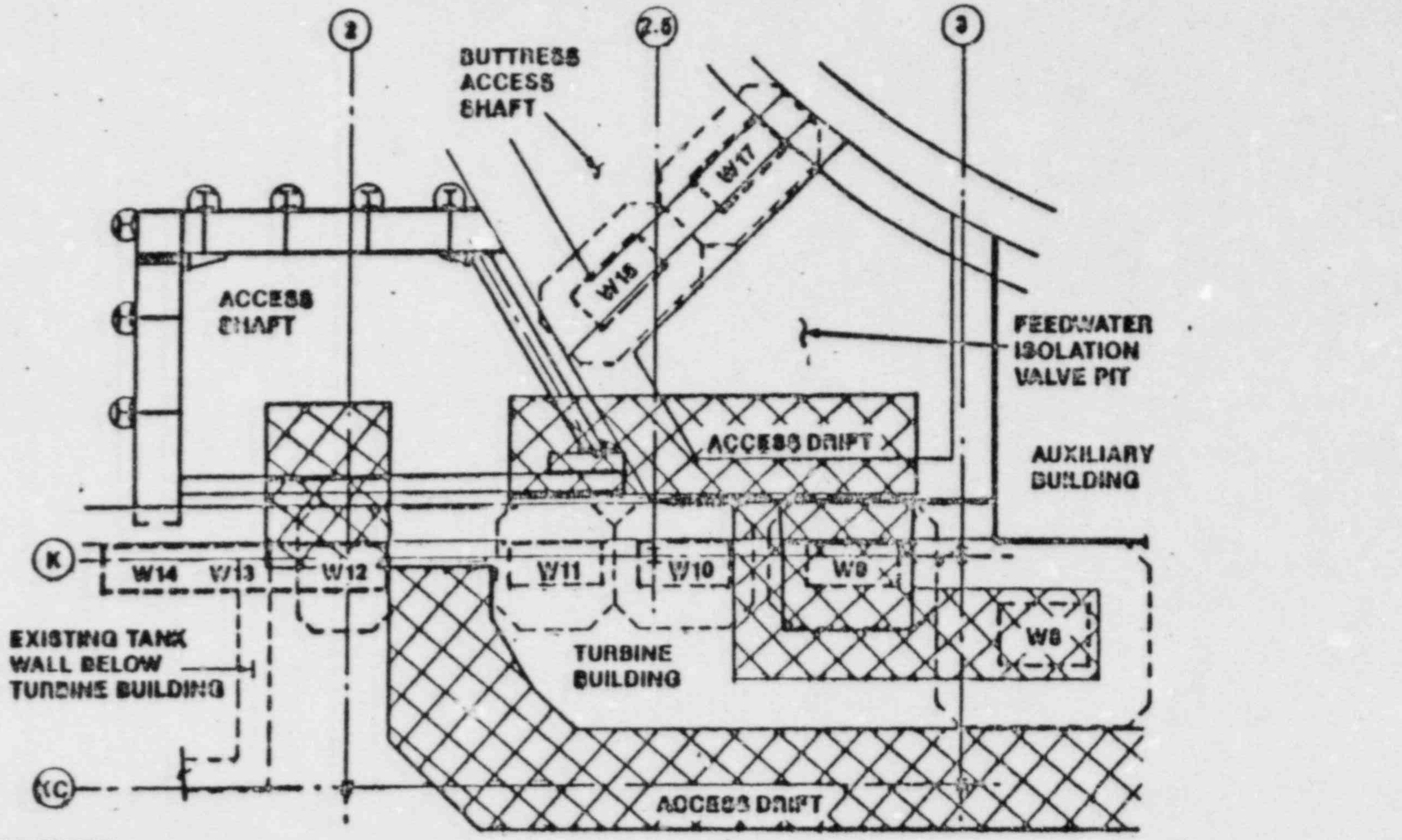
WALL AT COLUMN LINE 5.3

AUXILIARY BUILDING UNDERPINNING
CONSTRUCTION CONDITION ANALYSIS
AREAS FOR CRACK MONITORING



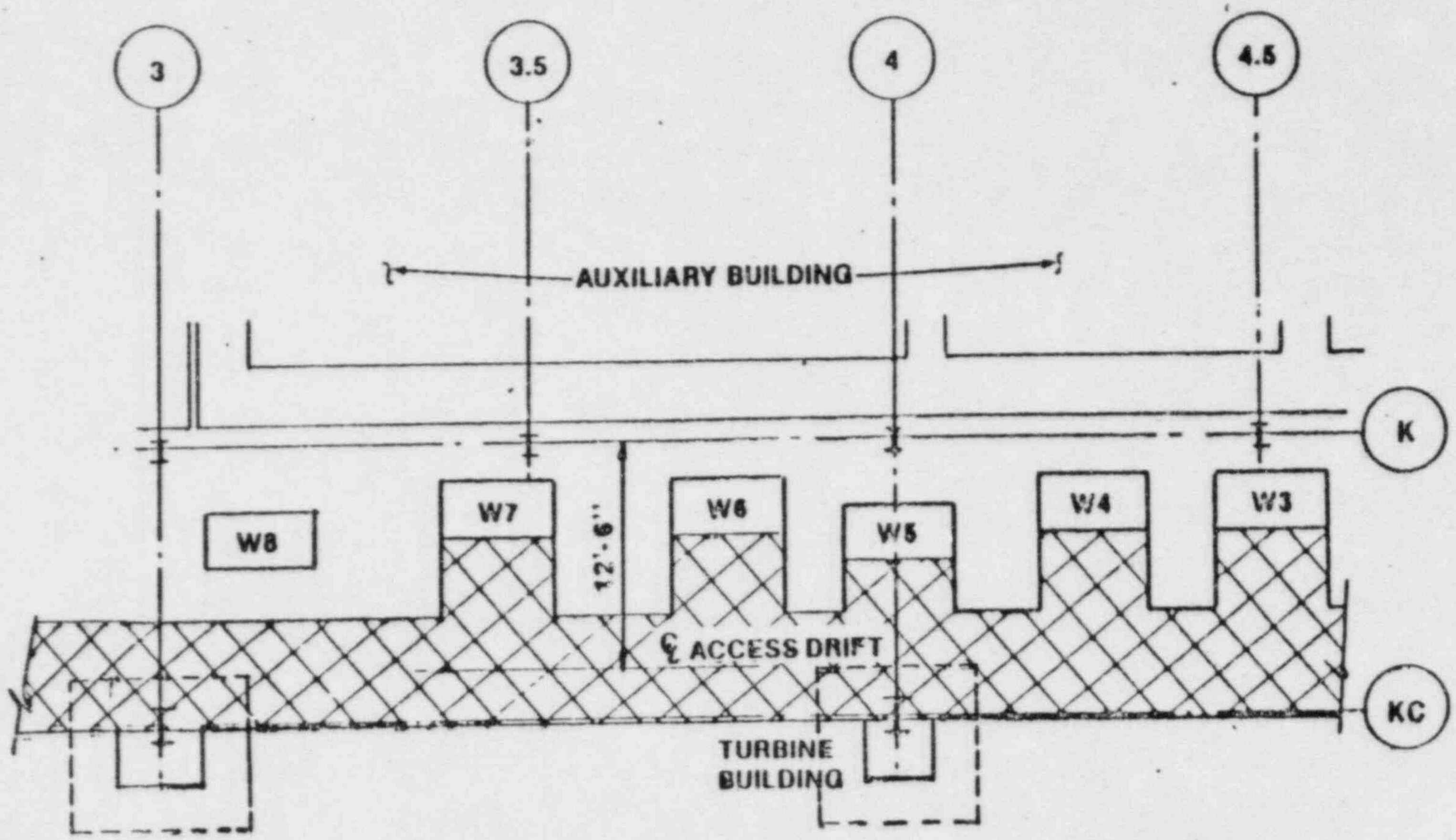
WALL AT COLUMN LINE 7.8

PLAN - ACCESS SHAFT AND ACCESS DRIFT

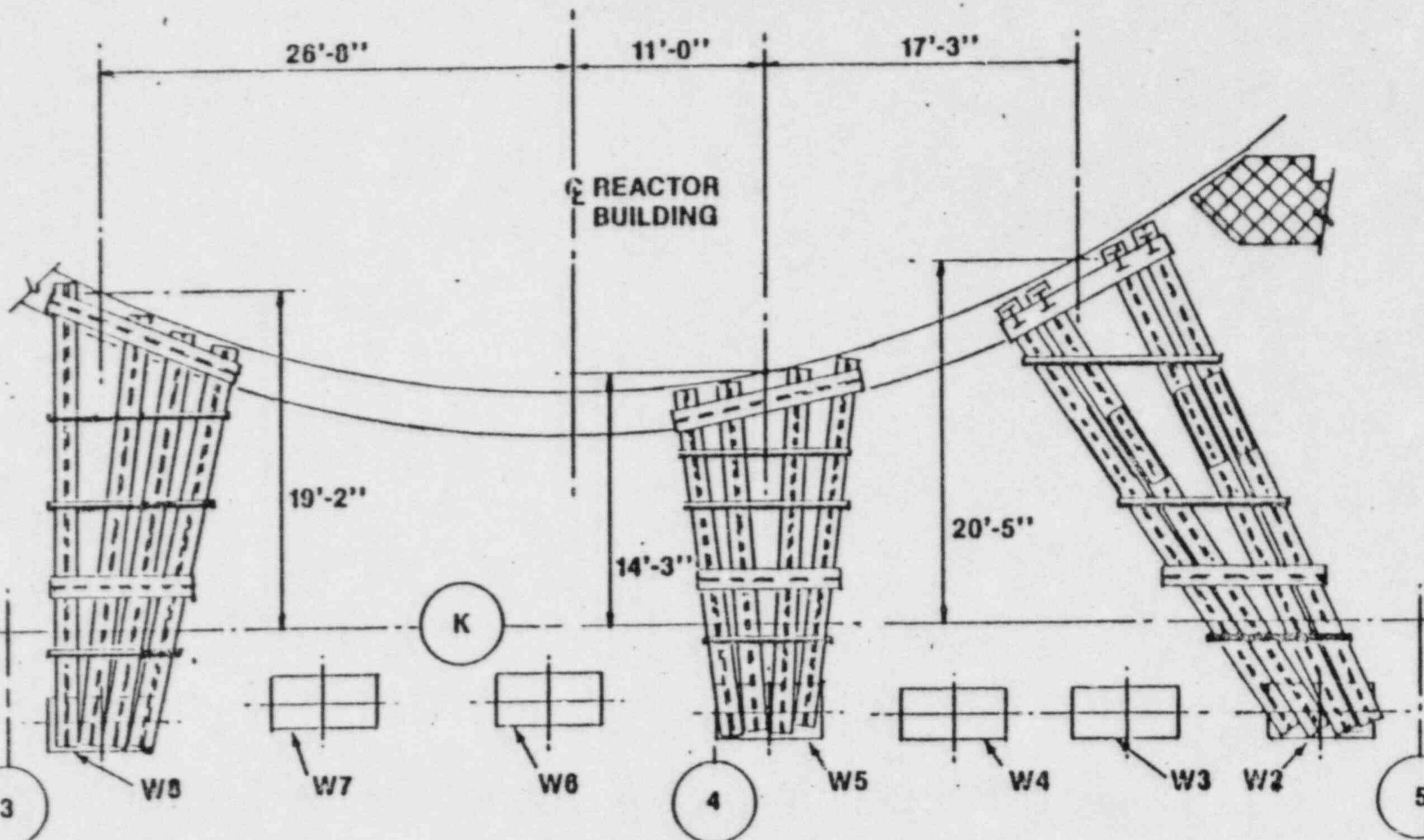


MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING

PARTIAL PLAN OF ACCESS DRIFT



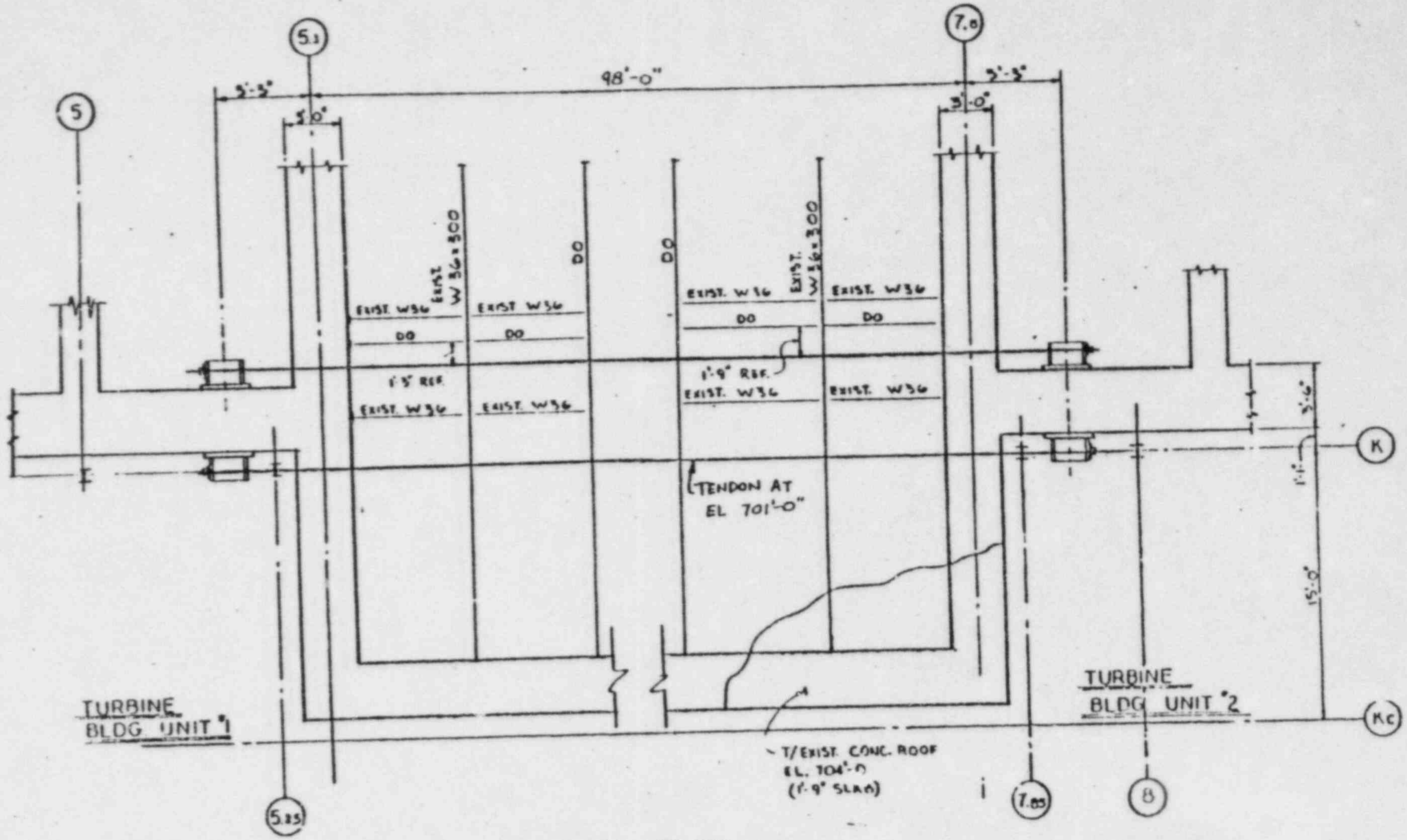
PLAN - UNDERPINNING GRILLAGE



MIDLAND UNITS 1 AND 2
AUXILIARY BUILDING UNDERPINNING 1/27/82

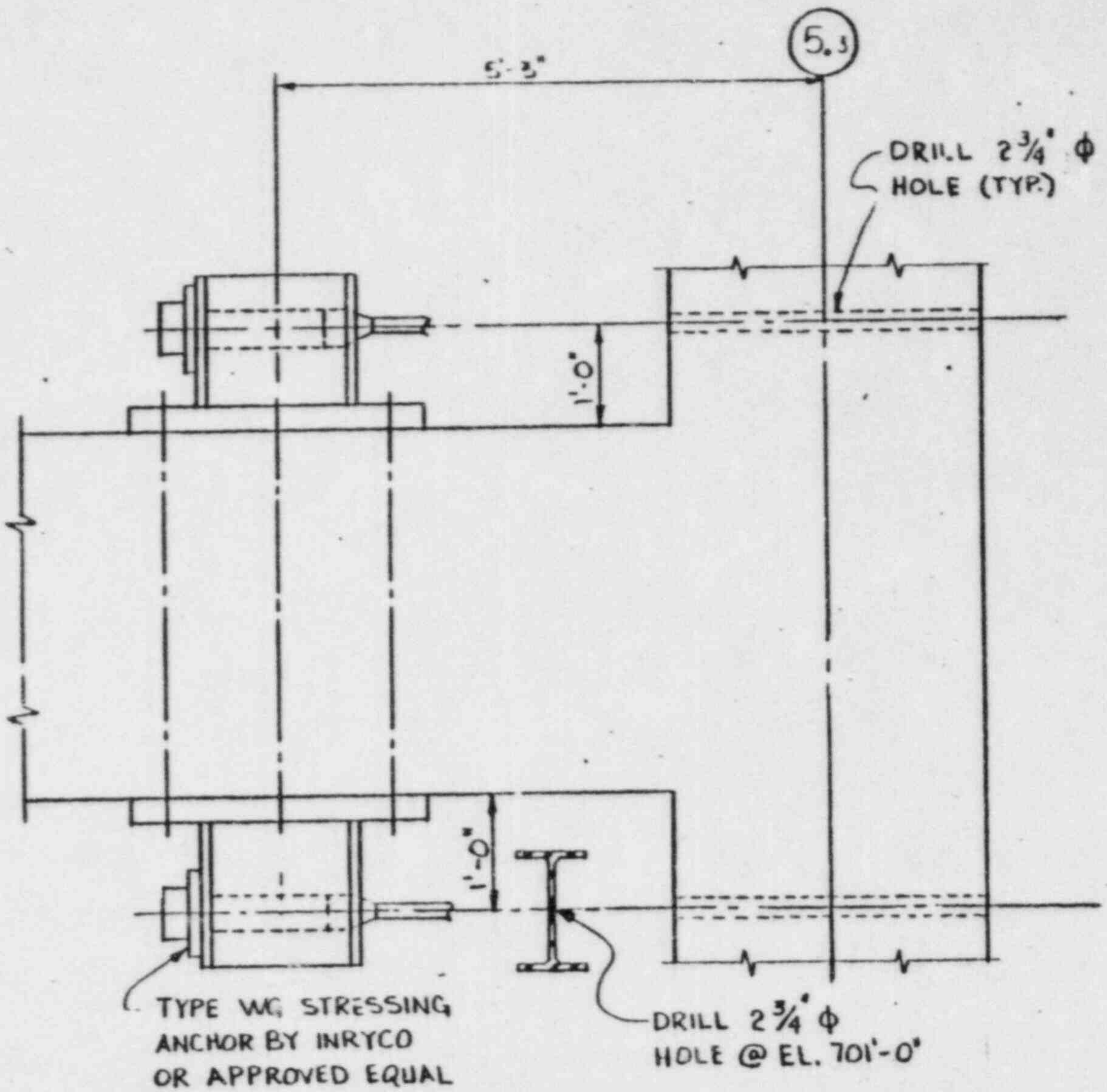
Q-1920-17

AUXILIARY BUILDING PRESTRESSING TENDON



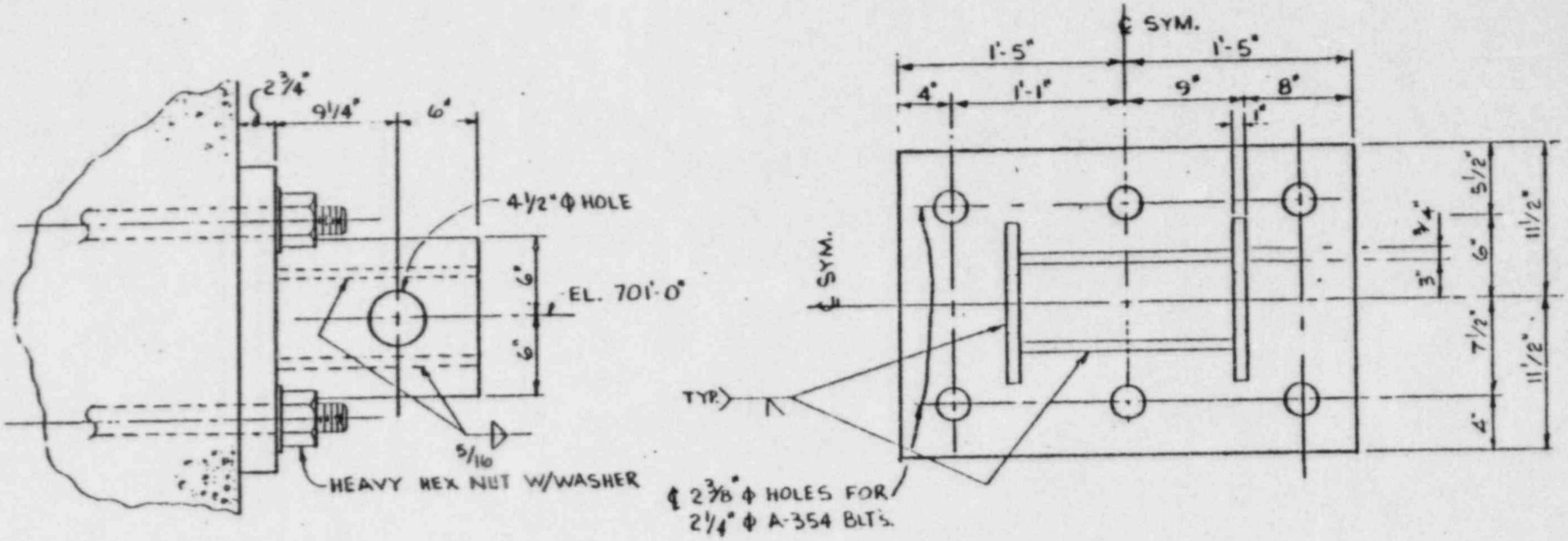
LOCATION PLAN

AUXILIARY BUILDING PRESTRESSING TENDON



CONNECTION DETAIL

AUXILIARY BUILDING PRESTRESSING TENDON



SUPPORT BRACKET DETAIL

AUXILIARY BUILDING PRESTRESSING TENDON

MATERIAL

- CONA MULTISTRAND SYSTEM MANUFACTURED BY INRYCO
- 2 TENDONS OF 10-½" DIAMETER STRANDS EACH
- ULTIMATE STRENGTH OF 270 Ksi

AUXILIARY BUILDING PRESTRESSING TENDON

DESIGN CONDITION

- BASED ON PRELIMINARY ANALYSIS OF EPA ONLY
- EPA TREATED AS A CANTILEVER WITH LIMITED SOIL SUPPORT OF 3 Ksf

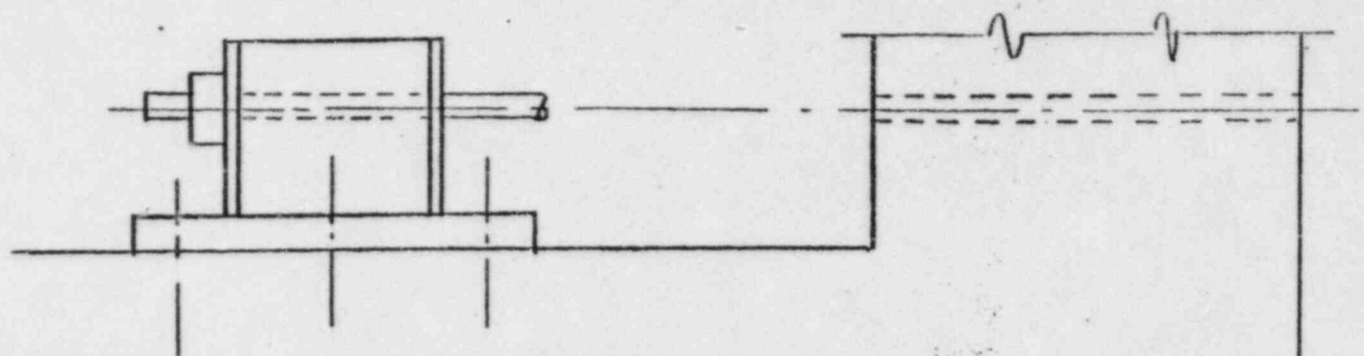
  (CURRENT ANALYSIS INDICATED SOIL PRESSURE OF 5 Ksf UNDER EPA)
- TO PROVIDE TENSILE CAPACITY OF 616 Kips FOR CONTROL TOWER ROOF

AUXILIARY BUILDING PRESTRESSING TENDON

INSTALLATION PROCEDURE

- SINGLE END STRESSING SIMULTANEOUSLY FOR BOTH TENDONS FROM UNIT 1 SIDE
- STRANDS STRESSED INDIVIDUALLY FOR EACH TENDON
- LOCKED OFF EACH STRAND AT 189 Ksi
- RECHECK AND ADJUST LOCKED OFF STRESS AFTER ALL STRANDS ARE TENSIONED

AUXILIARY BUILDING PRESTRESSING TENDON



EXISTING BRACKET CONDITION

AUXILIARY BUILDING PRESTRESSING TENDON

AS BUILT CONDITION

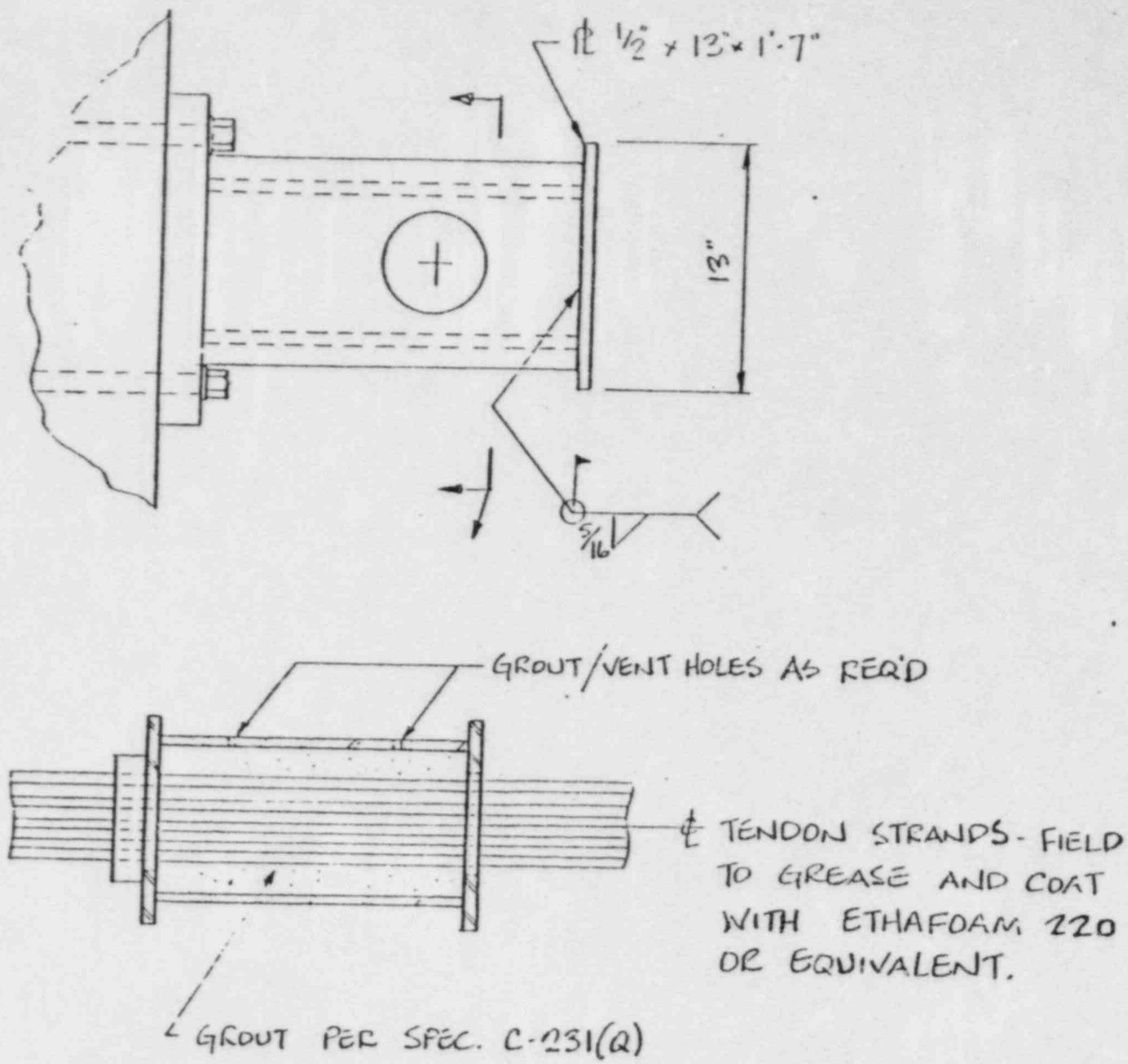
- BEARING PLATE UNDER ANCHOR HEAD OMITTED
- NO UNUSUAL DISTORSION OF BRACKET OBSERVED
- CAPACITY OF BRACKET IS 470 Kips BASED ON LIMIT ANALYSIS
- FACTOR OF SAFETY AGAINST BRACKET FAILURE IS 1.5

AUXILIARY BUILDING PRESTRESSING TENDON

FUTURE ACTIONS

- GROUT SPACE IN BRACKET BETWEEN WEB PLATES AND FLANGE PLATES BEFORE UNDERMINING AUXILIARY BUILDING EPA

- CHECK TENDON LOAD BY LIFT OFF



℄ 1/2" × 13" × 1'-7"
13"
5/16
GROUT/VENT HOLES AS REQ'D
℄ TENDON STRANDS - FIELD TO GREASE AND COAT WITH ETHAFOAM 220 OR EQUIVALENT.
GROUT PER SPEC. C-231(Q)

AAO-520 6/76

ENCLOSURE 2

J. Kane
HGEB

Subject: Design Issues to be Audited by HGEB at February 3-5, 1982 Audit in Ann Arbor, Michigan

License Condition No.	Review Issue	Documentation Anticipated to be Presented to HGEB	Design Audit Feb. 3-5, 1982
5a	Auxiliary Building Temporary Support System During Underpinning (EPA and Control Tower)	Plan and sectional views showing the locations in the structures and on the foundation bearing layer where temporary underpinning loads have resulted in the largest stresses. Drawings should indicate assumed exc. conditions at the various stages of construction.	Information was provided in Dasgupta presentation and handouts, but results are impacted by the requested sensitivity study on soil spring constant variations.
		Calculations that provide the magnitude of the above stresses.	Checked by SEB
		Calculations providing the factors of safety against bearing failure.	Provided in Dasgupta Presentation
5b	Auxiliary Building Temporary Support System During Underpinning (EPA & Control Tower)	Sketches showing deformation measuring instruments attached at top of pier at the selected locations.	Provided by Bob Adler. NRC needs to review
		Description of frequency of readings to be required.	Provided on drawing entitled "Instrumentation Matrix"
		Identification of the ALLOWABLE movements, strains or stresses at the selected monitoring locations and CALCULATIONS which are the basis for those allowable movements. What are crack monitoring plans?	Criteria given for FIVP piping. Tolerance criteria on movements is still required for both Phase II and Phase III instrumentation.
		Criteria to be followed for READJUSTING jacking load (?Settlement).	Criteria on jacking is controlled by both settlement and stress considerations CPC to provide drawings, procedures and criteria to NRC on Feb. 26, 1982.

Encl. 2

License Condition No.	Review Issue	Documentation Anticipated to be Presented to HGEB	Design Audit Feb. 3-5, 1982
5b (continued)		This is ALLOWABLE movements. What valves (limiting) of movement or cracking or stress will require re-evaluation and stopping of underpinning? How established? Provide the time interval (maximum) between observing limiting movement or stress and time for action (re-evaluation or stopping).	Tolerance criteria will identify both an action level and a stopping level. CPC still needs to address crack propagation. NRC needs to review criteria on cracking provided in Auxil. Bldg. report and be prepared to discuss at Feb. 25, 1982.
5c	NRC Testimony (11/20/81) Attachment 21, Q.6	Previous discussions have resolved this issue.	Previously resolved.
5c	Attachment 21, Q.7	Provide explanation on how measured jacking load and pier settlement will be used in NAV-FAC DM-7, Fig. 11-9 to establish equivalent soil modulus.	By knowing the shape, embedment, deflection — Fig. 11-9 is used to establish coefficient which permits modulus to be computed. Issue is resolved.
5c	Attachment 21, Q.17	Provide CALCULATIONS which determined the magnitude of the test load for temporary support pier. What part of this load is due to Turbine Bldg. and what part is due to EPA? (Is this a location of large stress which has been covered in Lic. Cond. 5a?)	@ Pier W5, the Turbine Bldg load is 878^k. Total load is 2513^k (maximum).
5c	Attachment 21, Q.18	Does previous discussion under license condition 5b on ALLOWABLE movements cover Q.18?	Refer to status of 5b.
5c	Attachment 21, Q.19	Question has been adequately addressed including discussions at last audit of Jan. 18-20, 1982.	Previously Resolved.

License Condition No.	Review Issue	Documentation Anticipated to be Presented to HGEB	Design Audit Feb. 3-5, 1982
5c	Attachment 21, Q.20	Previous discussions have resolved this issue.	Previously Resolved
5c	Attachment 21, Q.21	Describe what makes up the working load and calculations that establish it. Explain basis for 1.25 times the working load = Proof load. Provide calc laticps on resistance capacity of the EPA.	Working load - DL + Eqpt. loads + 25% LL + wt. block wall Proofload = Working load +25% working load Capacity of pier W8 is 4000 Kips
5c	Attachment 21, Q.22	Provide magnitude of jacking load for each control tower pier and method to establish it. Refer to CPC Auxil. Bldg testimony, Pg. 24. Describe criteria for monitoring jacking loads on Control Tower (if not covered in 5b). What method will be used to assurance maintenance of jacking loads on Control Tower? Request further discussion on load transfer beyond response to Q.22.	Jacking loads provided in Dasgupta presentation. Refer to previous response to license condition no. 5b for jacking criteria. Anticipate maximum & minimum loads will be provided by Feb. 26, 1982. Load transfer to final underpinning wall to be covered in May 1982 Audit.

Detach and Retain Completed Stub for Record.

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SENT	
DATE 2/2/84	TIME 4:00
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TO: Correspondence & Record H-Street M.S. H-1153	

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BY: TMNovak	
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TO: Charles Bechhoefer, Esq. Atomic Safety & Lic. Board U.S. Nuclear Regulatory Comm Washington, D.C. 20555	

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TO: ASLAB	

NRC FORM 234 (6-76)

BN 84-019
7/B3

DISTRIBUTION LIST FOR BOARD NOTIFICATION

Midland Units 1&2,
Docket Nos. 50-329/330

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FEB 0 2 1984

Docket Nos.: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: Atomic Safety and Licensing Board for the Midland Plant, Units 1 and 2 (C. Bechhoefer, J. Harbour, F. Cowan)

FROM: Thomas M. Novak, Assistant Director for Licensing, Division of Licensing

SUBJECT: MIDLAND ISSUES, BOARD NOTIFICATION 84-019
(1) Lifting of Soils Remedial Stop Work Order
(2) Potential 50.55(e) Involving Differential Settlement of Diesel Pedestals and Diesel Building
(3) Crack Monitoring

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide new information material and relevant to issues in the Midland OM-OL proceeding. This information concerns the licensee's January 19, 1984, lifting of the soils remedial stop work order; the licensee's December 14, 1983, reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a follow-up of the crack monitoring issue. Details of these items are provided in Enclosure 1. The staff will provide follow-up to the Board on these issues when available.

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

SECY (2)
OPE
OGC
EDO

~~8402110018~~

N 005

OFFICE	LB#4:DL	DL	LB#4:DL	AD:DL			
SURNAME	MMiller:tgf	SBlack	EAdensam	TNovak			
DATE	2/1/84	2/1/84	2/1/84	2/2/84			

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

Enclosure 1

January 25, 1984

MEMORANDUM FOR: D. G. Eisenhut, Director, Division of Licensing,

FROM: R. F. Warnick, Director, Office of Special Cases

SUBJECT: RECOMMENDATION FOR NOTIFICATION OF LICENSING BOARD

In accordance with present NRC procedures regarding Board Notifications, the following information is being provided as constituting new information relevant and material to the Midland OM/OL proceedings. This information deals with the licensee's January 19, 1984, lifting of the soils remedial stop work order; the licensee's December 14, 1983 reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a followup of the crack monitoring issue.

A. The pertinent facts that relate to the lifting of the soils stop work are as follows:

1. On October 22, 1983, the licensee issued stop work number FSW-38 on all remedial soils work because of problems with referencing of drawings and specifications in the Bechtel FCR/FCN process. This created an indeterminate condition with respect to work that has been or could be performed.

2. This stop work was one of nine stop work orders which halted all safety-related activities at the Midland site. They were issued as the result of a quality assurance audit of the design document control system (Board Notification dated October 25, 1983).

3. The licensee reviewed potential impact of hardware and plant equipment to ensure it was built to the proper drawings. No significant construction problems were found in the review and the drawing change and review process has been changed to improve the processing of the engineering documents.

4. Project corrective actions were reviewed by Stone & Webster, the independent assessment organization, and were found to be acceptable.

5. Stop work was lifted in the soils area on January 19, 1984.

6. Mergentine and Spencer, White & Prentis will begin rehire of construction workers as work resumes.

7. The Region III staff plans to follow up on this issue as a matter of routine inspection.

8402100232

B. The pertinent facts that relate to the 50.55(e) are as follows:

1. On October 14, 1983, RIII received an allegation by the way of a GAP affidavit that Bechtel had not taken into account the effect that the anticipated differential settlement between the diesel pedestals and the diesel building itself would have on associated connecting equipment.

2. On November 3, 1983, RIII requested NRR assistance in pursuing this allegation.

3. On December 2, 1983, CPCo was notified of the allegation for the purposes of obtaining design information for NRR's review of the allegation.

4. On December 14, 1983, CPCo notified RIII of a potential 50.55(e) on this matter.

5. On January 13, 1984, the licensee issued the official 50.55(e) report to the NRC.

6. The 50.55(e) report states that Bechtel discovered this deficiency during a system review of the diesel generator on November 21, 1983.

7. A meeting is tentatively scheduled for February, 1984, to pursue this issue.

8. Furthermore, the licensee's 50.54(f) response to Question 18, Revision 5, dated February 2, 1980, states, "Piping will be designed to accomodate the expected future differential settlement", between the diesel pedestals and the building structure. In the 50.55(e) report the licensee states, "requirements for differential settlement between the Diesel Generator Building Structure and Diesel Generator Pedestals were not accounted for in the design of the piping equipment conduits, and pipe supports."

9. The Region III staff plans to follow up on this matter as a routine inspection item.

C. The pertinent facts that relate to the crack monitoring issue are as follows:

1. The NRC staff during the Stone & Webster public meeting on November 10, 1983, imposed a hold point on resuming soils remedial underpinning until the crack monitoring issue was resolved. This resulted from the NRC's review of Stone & Webster's weekly reports which indicated some problems in the crack monitoring area.

2. On November 30, 1983, the licensee provided RIII with an update of the crack monitoring issue. In summary, the licensee indicated that QA/QC inspections and overviews were incomplete for crack mapping. This resulted in the issuance of 59 NCR's and 11 QAR's that included a magnitude of problems for example:

   a. Inadequate specification, procedures and Project Quality Control Instructions (PQCI's)

   b. Some cracks were not being monitored

   c. Some cracks were not identified

   d. QA/QC inspection functions not completed

   e. Crack mapping issues were not being resolved in a timely manner

3. During an ASLB hearing session on December 3, 1983, Mr. D. Hood, NRR Project Manager, verbally notified the ASLB of this condition.

4. On December 6, 1983, RIII documented this as a formal hold point in a letter to CPCo.

5. On December 23, 1983, corrective actions taken on crack mapping were reviewed by Stone & Webster and were found to be acceptable.

6. On December 29, 1983, a letter to CPCo from RIII documented the completion of the review of the corrective actions taken, found them to be acceptable, and released the NRC hold point.

7. The NRC Hold Point was released prior the licensee releasing its stop work of October 22, 1983, and therefore, the NRC hold point had no impact on the licensee's schedule.

If you have any questions or desire further information regarding this matter, please call me.

R F Warnick

R. F. Warnick, Director
Office of Special Cases

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

FEB 0 2 1984

Docket Nos.: 50-329 CM, OL
and 50-330 OM, OL

MEMORANDUM FOR: Atomic Safety and Licensing Board for the Midland Plant, Units 1 and 2 (C. Bechhoefer, J. Harbour, F. Cowan)

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: MIDLAND ISSUES, BOARD NOTIFICATION 84-019
(1) Lifting of Soils Remedial Stop Work Order
(2) Potential 50.55(e) Involving Differential Settlement of Diesel Pedestals and Diesel Building
(3) Crack Monitoring

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide new information material and relevant to issues in the Midland OM-OL proceeding. This information concerns the licensee's January 19, 1984, lifting of the soils remedial stop work order; the licensee's December 14, 1983, reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a follow-up of the crack monitoring issue. Details of these items are provided in Enclosure 1. The staff will provide follow-up to the Board on these issues when available.

T. M. Novak

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

SECY (2)
OPE
OGC
EDO

8402110078

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental Protection Division
720 Law Building
Lansing, Michigan 48913

Ms. Julie Morrison
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P. O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspector's Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission, Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6F 5 Mercantile Way
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Ctr.
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P. O. Box 1449
Canoga Park, California 91304

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

cc: Mr. I. Charak, Manager
NRC Assistance Project
Argonre National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

ATTN: Clyde Herrick
Franklin Research Center
20th & Race Streets
Philadelphia, Pennsylvania 19103

Mr. Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquette
Minneapolis, Minnesota 55479

NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

Enclosure 1

January 25, 1984

MEMORANDUM FOR: D. G. Eisenhut, Director, Division of Licensing,

FROM: R. F. Warnick, Director, Office of Special Cases

SUBJECT: RECOMMENDATION FOR NOTIFICATION OF LICENSING BOARD

In accordance with present NRC procedures regarding Board Notifications, the following information is being provided as constituting new information relevant and material to the Midland OM/OL proceedings. This information deals with the licensee's January 19, 1984. lifting of the soils remedial stop work order; the licensee's December 14, 1983 reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a followup of the crack monitoring issue.

A. The pertinent facts that relate to the lifting of the soils stop work are as follows:

1. On October 22, 1983, the licensee issued stop work number FSW-38 on all remedial soils work because of problems with referencing of drawings and specifications in the Bechtel FCR/FCN process. This created an indeterminate condition with respect to work that has been or could be performed.

2. This stop work was one of nine stop work orders which halted all safety-related activities at the Midland site. They were issued as the result of a quality assurance audit of the design document control system (Board Notification dated October 25, 1983).

3. The licensee reviewed potential impact of hardware and plant equipment to ensure it was built to the proper drawings. No significant construction problems were found in the review and the drawing change and review process has been changed to improve the processing of the engineering documents.

4. Project corrective actions were reviewed by Stone & Webster, the independent assessment organization, and were found to be acceptable.

5. Stop work was lifted in the soils area on January 19, 1984.

6. Mergentine and Spencer, White & Prentis will begin rehire of construction workers as work resumes.

7. The Region III staff plans to follow up on this issue as a matter of routine inspection.

8402100232

B. The pertinent facts that relate to the 50.55(e) are as follows:

1. On October 14, 1983, RIII received an allegation by the way of a GAP affidavit that Bechtel had not taken into account the effect that the anticipated differential settlement between the diesel pedestals and the diesel building itself would have on associated connecting equipment.

2. On November 3, 1983, RIII requested NRR assistance in pursuing this allegation.

3. On December 2, 1983, CPCo was notified of the allegation for the purposes of obtaining design information for NRR's review of the allegation.

4. On December 14, 1983, CPCo notified RIII of a potential 50.55(e) on this matter.

5. On January 13, 1984, the licensee issued the official 50.55(e) report to the NRC.

6. The 50.55(e) report states that Bechtel discovered this deficiency during a system review of the diesel generator on November 21, 1983.

7. A meeting is tentatively scheduled for February, 1984, to pursue this issue.

8. Furthermore, the licensee's 50.54(f) response to Question 18, Revision 3, dated February 2, 1980, states, "Piping will be designed to accomodate the expected future differential settlement", between the diesel pedestals and the building structure. In the 50.55(e) report the licensee states, "requirements for differential settlement between the Diesel Generator Building Structure and Diesel Generator Pedestals were not accounted for in the design of the piping equipment conduits, and pipe supports."

9. The Region III staff plans to follow up on this matter as a routine inspection item.

C. The pertinent facts that relate to the crack monitoring issue are as follows:

1. The NRC staff during the Stone & Webster public meeting on November 10, 1983, imposed a hold point on resuming soils remedial underpinning until the crack monitoring issue was resolved. This resulted from the NRC's review of Stone & Webster's weekly reports which indicated some problems in the crack monitoring area.

2. On November 30, 1983, the licensee provided RIII with an update of the crack monitoring issue. In summary, the licensee indicated that QA/QC inspections and overviews were incomplete for crack mapping. This resulted in the issuance of 59 NCR's and 11 QAR's that included a magnitude of problems for example:

   a. Inadequate specification, procedures and Project Quality Control Instructions (PQCI's)

   b. Some cracks were not being monitored

   c. Some cracks were not identified

   d. QA/QC inspection functions not completed

   e. Crack mapping issues were not being resolved in a timely manner

3. During an ASLB hearing session on December 3, 1983, Mr. D. Hood, NRR Project Manager, verbally notified the ASLB of this condition.

4. **On December 6, 1983, RIII documented this as a formal hold point in a letter to CPCo.**

5. On December 23, 1983, corrective actions taken on crack mapping were reviewed by Stone & Webster and were found to be acceptable.

6. On December 29, 1983, a letter to CPCo from RIII documented the completion of the review of the corrective actions taken, found them to be acceptable, and released the NRC hold point.

7. **The NRC Hold Point was released prior the licensee releasing its stop** work of October 22, 1983, and therefore, the NRC hold point had no impact on the licensee's schedule.

If you have any questions or desire further information regarding this matter, please call me.

R F Warnick

R. F. Warnick, Director
Office of Special Cases

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

FEB 0 2 1984

Docket Nos.: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: Atomic Safety and Licensing Board for the Midland Plant, Units 1 and 2 (C. Bechhoefer, J. Harbour, F. Cowan)

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: MIDLAND ISSUES, BOARD NOTIFICATION 84-019
(1) Lifting of Soils Remedial Stop Work Order
(2) Potential 50.55(e) Involving Differential Settlement of Diesel Pedestals and Diesel Building
(3) Crack Monitoring

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide new information material and relevant to issues in the Midland OM-OL proceeding. This information concerns the licensee's January 19, 1984, lifting of the soils remedial stop work order; the licensee's December 14, 1983, reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a follow-up of the crack monitoring issue. Details of these items are provided in Enclosure 1. The staff will provide follow-up to the Board on these issues when available.

T M Novak

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

SECY (2)
OPE
OGC
EDO

8401190018

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Ms. Julie Morrison
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P. O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspector's Office
Route 7
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Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

James G. Keppler, Regional
Administrator
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Ctr.
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P. O. Box 1449
Canoga Park, California 91304

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

cc: Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

ATTN: Clyde Herrick
Franklin Research Center
20th & Race Streets
Philadelphia, Pennsylvania 19103

Mr. Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquette
Minneapolis, Minnesota 55479

NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

Enclosure 1

January 25, 1984

MEMORANDUM FOR: D. G. Eisenhut, Director, Division of Licensing,

FROM: R. F. Warnick, Director, Office of Special Cases

SUBJECT: RECOMMENDATION FOR NOTIFICATION OF LICENSING BOARD

In accordance with present NRC procedures regarding Board Notifications, the following information is being provided as constituting new information relevant and material to the Midland OM/OL proceedings. This information deals with the licensee's January 19, 1984. lifting of the soils remedial stop work order; the licensee's December 14, 1983 reporting of a potential 50.55(e) condition involving differential settlement between the diesel pedestals and the diesel building itself; and a followup of the crack monitoring issue.

A. The pertinent facts that relate to the lifting of the soils stop work are as follows:

1. On October 22, 1983, the licensee issued stop work number FSW-38 on all remedial soils work because of problems with referencing of drawings and specifications in the Bechtel FCR/FCN process. This created an indeterminate condition with respect to work that has been or could be performed.

2. This stop work was one of nine stop work orders which halted all safety-related activities at the Midland site. They were issued as the result of a quality assurance audit of the design document control system (Board Notification dated October 25, 1983).

3. The licensee reviewed potential impact of hardware and plant equipment to ensure it was built to the proper drawings. No significant construction problems were found in the review and the drawing change and review process has been changed to improve the processing of the engineering documents.

4. Project corrective actions were reviewed by Stone & Webster, the independent assessment organization, and were found to be acceptable.

5. Stop work was lifted in the soils area on January 19, 1984.

6. Mergentine and Spencer, White & Prentis will begin rehire of construction workers as work resumes.

7. The Region III staff plans to follow up on this issue as a matter of routine inspection.

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B. The pertinent facts that relate to the 50.55(e) are as follows:

1. On October 14, 1983, RIII received an allegation by the way of a GAP affidavit that Bechtel had not taken into account the effect that the anticipated differential settlement between the diesel pedestals and the diesel building itself would have on associated connecting equipment.

2. On November 3, 1983, RIII requested NRR assistance in pursuing this allegation.

3. On December 2, 1983, CPCo was notified of the allegation for the purposes of obtaining design information for NRR's review of the allegation.

4. On December 14, 1983, CPCo notified RIII of a potential 50.55(e) on this matter.

5. On January 13, 1984, the licensee issued the official 50.55(e) report to the NRC.

6. The 50.55(e) report states that Bechtel discovered this deficiency during a system review of the diesel generator on November 21, 1983.

7. A meeting is tentatively scheduled for February, 1984, to pursue this issue.

8. Furthermore, the licensee's 50.54(f) response to Question 18, Revision 5, dated February 2, 1980, states, "Piping will be designed to accomodate the expected future differential settlement", between the diesel pedestals and the building structure. In the 50.55(e) report the licensee states, "requirements for differential settlement between the Diesel Generator Building Structure and Diesel Generator Pedestals were not accounted for in the design of the piping equipment conduits, and pipe supports."

9. The Region III staff plans to follow up on this matter as a routine inspection item.

C. The pertinent facts that relate to the crack monitoring issue are as follows:

1. The NRC staff during the Stone & Webster public meeting on November 10, 1983, imposed a hold point on resuming soils remedial underpinning until the crack monitoring issue was resolved. This resulted from the NRC's review of Stone & Webster's weekly reports which indicated some problems in the crack monitoring area.

2. On November 30, 1983, the licensee provided RIII with an update of the crack monitoring issue. In summary, the licensee indicated that QA/QC inspections and overviews were incomplete for crack mapping. This resulted in the issuance of 59 NCR's and 11 QAR's that included a magnitude of problems for example:

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7. The NRC Hold Point was released prior the licensee releasing its stop work of October 22, 1983, and therefore, the NRC hold point had no impact on the licensee's schedule.

If you have any questions or desire further information regarding this matter, please call me.

R F Warnick

R. F. Warnick, Director
Office of Special Cases

8/B3

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

JAN 17 1984

Docket Nos: 50-329, OM, OL
and 50-330, OM, OL

MEMORANDUM FOR: The Atomic Safety and Licensing Board for Midland Plant, Units 1 and 2 (C. Bechhoefer, J. Harbour, F. Cowan)

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: SUPPLEMENTAL BOARD NOTIFICATION REGARDING MIDLAND DIESEL GENERATOR BUILDING (BN 84-010)

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide information material and relevant to safety issues in the Midland OM/OL proceeding. The appropriate Boards and parties are being informed by copy of this memorandum.

On December 2, 1983, the NRC staff sent this Licensing Board a supplemental Board Notification (83-185) regarding the Midland diesel generator building which contained geotechnical engineering review comments on the Applicant's proposed findings, Corps of Engineers memoranda on the diesel generator building, comments by Joseph Kane on the October 21, 1983 task group report and an evaluation by Frank Rinaldi of evidence on the diesel generator building.

We enclose a document entitled "Meeting Notes" by John P. Matra, Jr., of the Naval Surface Weapons Center, a staff consultant. The document responds to concerns expressed by Joseph Kane contained in the information sent to the Board on December 2, 1983. We wish to emphasize that the staff's review of the Task Force report is on going and the views expressed in the December 2, 1983 Board Notification and in the enclosed document are preliminary.

The NRC staff's re-examination is also proceeding with the benefit of a recent report by the TERA Corporation entitled "Structural Evaluation of the Diesel Generator Building". That report provides an assessment of the structural performance capability and serviceability as potentially affected by settlement - induced cracking. The report was performed in accordance with TERA's Independent Design and Construction Verification Program as part of their broader assessment of the diesel generator standby electric power system. Copies were forwarded to this Licensing Board and hearing parties under TERA's cover letter dated January 4, 1984.

Dupe
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During the evidentiary hearing on December 3, 1983, this Board stated that it would postpone its decision on reopening the record with respect to the diesel generator building pending receipt of further information from the staff (Tr. 22,687). As soon as that information is available we will forward it to the Board.

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
J. Matra Meeting Notes
SECY(2)
OPE
OGC
EDO

MEETING NOTES

ATTENDEES: Joe Kane
Chen P. Tan
John P. Matra Jr.
Bill Patcn (Came in near end of discussion)

Talked to Joe Kane - Started by telling Joe that the total completed structure has never nor will ever undergo the predicted differential settlement. In my analyses I have agreed only for academic purposes to place the measured and or predicted settlement values on the Diesel Generator Building (DGB) to determine the stresses in the structure under these conditions if they ever existed. Pointed out that as the analyses was performed, reinforced concrete that has not been installed (for the complete time period) would be subjected to stresses resulting from the settlement values of earlier time periods. The structure stiffnesses are also changing with each poring of a new slab of concrete. To correct this a lot more (>100) analyses steps need to be performed. It was also concluded that though it is possible to perform a finite element analyses of the DGB using as input the measured settlement data, a lot more measured settlement date points as well as finer construction details and material property data is required before an accurate analyses can be made. It was stated that rarely any building is designed in partial stages of contruction and to impose these measured deflection for each of the stages of construction as was done; is not only unheard of, but can lead to large fictitious errors.

Because of the rigidity of the structure it required hypothetical, imaginary forces to deform the structure to match the nominal measured values. I stated that for this to happen, certain areas of the soil would have to be pulling the structure down to make the model exactly fit the measured values, which is a physical impossiblity.

It was for these reasons that I could not put any credence to these analyses, but will still discussed the analyses with him.

The discussion then turned to Joe Kanes concerns. Joe stated that his comparision of my results and crack maping records indicated that the calculated high stresses at most locations of structure and cracks locations were in good agreement. However, I stated, that the analyses also showed that other areas of the DGB still have high stress and in all probability should also be cracked (in the conclusion of my report) but no cracks were observed in these areas. Again I pointed out to him that the construction time frame, crack mapping survey time frame as well as the analyses time frame, must be the same before any comparisons or results of the analyses can be concluded. You can not have the building being contructed to a given elevation (therefore time frame), the analyses done at the end of the time frame and the crack mapping survey done at a later time frame and expect to get good correlation between analytical and actual results.

Joe then mentioned that one of the reasons that I got tension in the soil is the fact that I did not include the surcharge load in the analysis. I told him that the way I ran the analysis, I do not have to put the surcharge as a load on the model. What I do is pull the structure down (deform the structure) to the measured and/or predicted, deflection and the program calculates the stresses. The density of the material therefore the weight of the structure is included. To account for the surcharge only a change in density is required and the program will do the rest. I also told Joe that this tension force also exist after the surcharge is removed how do you explain this? He stated that after the structure is deformed it stays deformed and does not completly bounce back and therefore, some form of load still exist in structure. I told him I just don't see how this effect can cause the amount of residual load required to keep the structure in equilibrium. Once you remove the surcharge I continued; this load is gone-you may have some residiual stress-though this is small and will never equal the large tensil force that must exist to pull the structure down-still a physical impossibility.

The discussion then went back to the crack map comparison with the analytical results. Again I reiterated my concerns with using the analysis this way and we again reached an impasse.

About this time Bill Paton entered the room, I tried to explain to Bill our problem-but before this was done-discussion broke up-with no satisfication as far as Joe Kane was concerned. Since I only pointed out the highest stresses in each wall, I told Joe-if I get a chance I will show the high stresses in other parts of the wall further justifing my conclusion-thus the discussion ended.

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Ms. Julie Morrison
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P. O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspector's Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

James G. Keppler, Regional
Administrator
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Ctr.
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P. O. Box 1449
Canoga Park, California 91304

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

cc: Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

ATTN: Clyde Herrick
Franklin Research Center
20th & Race Streets
Philadelphia, Pennsylvania 19103

Mr. Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquette
Minneapolis, Minnesota 55479

DISTRIBUTION LIST FOR BOARD NOTIFICATION

Midland Units 1&2,
Docket Nos. 50-329/330

Charles Bechhoefer, Esq.
Ms. Lynne Bernabei
James E. Brunner, Esq.
Dr. John H. Buck
Mr. Ronald C. Callen
Gerald Charnoff, Esq.
Myron M. Cherry, P.C.
Dr. Frederick P. Cowan
Barton Z. Cowan, Esq.
T. J. Creswell
Gary J. Edles, Esq.
Steve J. Galder, P.E.
Dr. Jerry Harbour
Samuel A. Haubold, Esq.
Mr. Wayne Hearn
Dr. W. Reed Johnson
Mr. James R. Kates
Frank J. Kelley, Esq.
Christine N. Kohl, Esq.
Dr. J. Venn Leeds, Jr.
Mr. Howard A. Levin
Steven Lewis, Esq.
Dr. Emmeth A. Luebke
Mr. Wendell H. Marshall
Marshall E. Miller, Esq.
Michael I. Miller, Esq.
Thomas S. Moore, Esq.
William C. Potter, Jr.
Mr. Paul Rau
Harold F. Reis, Esq.
Ms. Mary Sinclair
Ms. Barbara Stamiris
Frederick C. Williams, Esq.

Atomic Safety and Licensing Board Panel
Atomic Safety and Licensing Appeal Panel
Docketing and Service Section
Document Management Branch

ACRS Members

Dr. Robert C. Axtmann
Mr. Myer Bender
Dr. Max W. Carbon
Mr. Jesse C. Ebersole
Mr. Harold Etherington
Dr. William Kerr
Dr. Harold W. Lewis
Dr. J. Carson Mark
Mr. William M. Mathis
Dr. Dade W. Moeller
Dr. Milton S. Plesset
Mr. Jeremiah J. Ray
Dr. David Okrent
Dr. Paul C. Shewmon
Dr. Chester P. Siess
Mr. David A. Ward

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

December 20, 1983

Docket Nos: 50-329
and 50-330

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

Dear Mr. Cook:

Subject: NRC 1983 Schedule for Midland

Your letter of October 28, 1983, recommends deferring further Case Load Forecast Panel (CFP) meetings for Midland Plant, Units 1 and 2 pending completion of your new Unit 2 schedule shortly after the first of the year. You note that Dow's termination and delays in approval of the CCP have invalidated the plan set forth and reviewed with the CFP in April 19-21, 1983. You provide no estimate when your decision for Unit 1 will be available.

Based upon the information and observations as of April 19-21, 1983, the staff concluded that some months beyond the second quarter of 1986 was the earliest date that completion of Unit 2 could reasonably be expected, and that Unit 1 was expected to be completed about 6 to 9 months thereafter. The staff's 1983 projection assumed approval of the Construction Completion Plan in May 1983. The actual approval occurred on October 6, 1983. Subsequently, several stop work orders were issued by CPCo which are currently impacting all safety-related construction.

In a November 9, 1983, press release, CPCo announced preliminary indications that commercial operation of Unit 2 may be delayed until mid-1986, rather than February 1985, based upon the study to be completed by the end of 1983.

Accordingly, for our planning purposes, we intend to use September 1986 as our planning date for completing the licensing review process for Unit 2. We will reevaluate our projection in 1984.

Sincerely,

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

cc: See next page

Dupe ~~8403190186~~ 4pp

MIDLAND

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Michael I. Miller, Esq.
Ronald G. Zamarin, Esq.
Alan S. Farnell, Esq.
Isham, Lincoln & Beale
Three First National Plaza,
51st floor
Chicago, Illinois 60602

James E. Brunner, Esq.
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Ms. Mary Sinclair
5711 Summerset Drive
Midland, Michigan 48640

Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Wendell Marshall
Route 10
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Cherry & Flynn
Suite 3700
Three First National Plaza
Chicago, Illinois 60602

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

Mr. Steve Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Ms. Barbara Stamiris
5795 N. River
Freeland, Michigan 48623

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

cc: Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Mr. Howard Levin, Project Manager
TERA Corporation
7101 Wisconsin Avenue
Bethesda, Maryland 20814

Ms. Lynne Bernabei
Government Accountability Project
1901 Q Street, N.W.
Washington, D. C. 20009

cc: Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P. O. Box 1449
Canoga Park, California 91304

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

Charles Bechhoefer, Esq.
Atomic Safety & Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Frederick P. Cowan
Apt. B-125
6125 N.Verde Trail
Boca Raton, Florida 33433

Jerry Harbour, Esq.
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Geotechnical Engineers, Inc.
ATTN: Dr. Steve J. Paulos
1017 Main Street
Winchester, Massachusetts 01890

ATTN: Clyde Herrick
Franklin Research Center
20th & Race Streets
Philadelphia, Pennsylvania 19103

Mr. Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquette
Minneapolis, Minnesota 55479

10/83

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

December 2, 1983

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: The Atomic Safety and Licensing Board for Midland Plant, Units 1 & 2

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: SUPPLEMENTAL BOARD NOTIFICATION REGARDING MIDLAND DIESEL GENERATOR BUILDING (BN 83-185)

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide information material and relevant to safety issues in the Midland OM/OL proceeding.

Board Notification 83-165 dated October 26, 1983, transmitted the report of a special task group on the re-evaluation of the structural design and construction adequacy of the Midland Diesel Generator Building (DGB). The re-evaluation had been prompted by the concerns of Dr. Landsman provided to you in BN 83-109. Also, BN 83-153 dated October 11, 1983, had transmitted a reply to an inquiry by NRR's Director of the Division of Engineering as to whether or not any member of that Division or NRC consultant shared Dr. Landsman's specific technical concerns.

Review of the task group's report by others, and the NRC's internal process of soliciting comments on the Applicant's Proposed Findings of Fact and Conclusions of Law on Remedial Soils Issues, has resulted in recent comments on the DGB which are material and relevant to issues before the Board. The comments further indicate the views of NRR members and consultants regarding Dr. Landsman's concerns. The comments prepared by J. Kane at page 12 (Enclosure 1) note the results of his examination of a report by the U.S. Naval Surface Weapons Center (NSWC). Mr. Kane notes that if his conclusions on cracks appearing in NSWC calculated areas of high stress are correct, "both the applicant's findings and the hearing record need to be corrected in order for the Board to make the proper findings." Mr. G. Lear's memorandum of November 16, 1983 (Enclosure 2) transmits an October 28, 1983, cover letter from the Corps of Engineers (COE) with two memoranda containing the comments of H. N. Singh. Mr. Singh's comments further explain why "the Corps is not in a position to certify the adequacy of the structure."

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Because of the contents of the task group's report, but also, in part, because of these supplemental comments, the NRC staff stated during the Midland OM-OL hearing session of November 19, 1983, it would advise the Board by December 1, 1983, of its position on the need to reopen the record on the special task group's re-review of the DGB. The staff also noted during the November session that if it takes the position that the record need not be re-opened, it will file responsive findings with respect to the DGB on December 9, 1983. As part of this decision process, Messrs. J. Kane and F. Rinaldi were requested to provide comments on the task group's report and to provide their recommendation as to whether or not the hearing should be reopened. Both replied November 18, 1983 (Enclosures 3 & 4). Enclosures 3 and 4 are material and relevant to the issue as to whether or not the task group's report provides a sufficient basis to reopen the hearing.

Further reporting to the Board regarding this matter will either be addressed as part of our decision to be reached early December 1983, or as part of subsequent events flowing from that decision.

T M Novak

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosures:
1. G. Lear Memo dated 10/14/83,
   pg. 12 and 3 tables
2. G. Lear Memo dated 11/16/83,
   with McCallister letter and
   2 Singh Memoranda
3. J. Kane Memo dated 11/18/83,
   with enclosure
4. F. Rinaldi Memo dated 11/18/83,
   with 2 enclosures

cc: See next page

DISTRIBUTION LIST FOR BOARD NOTIFICATION

Midland Units 1&2,
Docket Nos. 50-329/330

Charles Bechhoefer, Esq.
Ms. Lynne Bernabei
James E. Brunner, Esq.
Dr. John H. Buck
Myron M. Cherry, P.C.
Dr. Frederick P. Cowan
T. J. Creswell
Steve J. Gadler, P.E.
Dr. Jerry Harbour
Samuel A. Haubold, Esq.
Mr. Wayne Hearn
Mr. James R. Kates
Frank J. Kelley, Esq.
Christine N. Kohl, Esq.
Mr. Howard A. Levin
Mr. Wendell H. Marshall
Michael I. Miller, Esq.
Thomas S. Moore, Esq.
Mr. Paul Rau
Ms. Mary Sinclair
Ms. Barbara Stamiris
Frederick C. Williams, Esq.

Atomic Safety and Licensing
Board Panel
Atomic Safety and Licensing
Appeal Panel
Docketing and Service Section
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ACRS Members

Dr. Robert C. Axtmann
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Dr. Dade W. Moeller
Dr. Milton S. Plesset
Mr. Jeremiah J. Ray
Dr. David Okrent
Dr. Paul C. Shewmon
Dr. Chester P. Siess
Mr. David A. Ward

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Enviornmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

cc: ATTN: Clyde Herrick
Franklin Research Center
20th & Race Streets
Philidelphia, Pennsylvania 19103

Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquette
Minneapolis, MN 55479

Enclosure 1

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

OCT 1 4 1983

MEMORANDUM FOR: William D. Paton, Attorney
Office of the Executive Legal Director

FROM: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: GEOTECHNICAL ENGINEERING REVIEW COMMENTS ON THE APPLICANT'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW - MIDLAND PLANT

We have enclosed the final phase of geotechnical engineering input on Midland's Finding of Fact in response to OELD request. Comments 1 through 23 were previously provided to you in my memos of September 27, 1983 and September 30, 1983. The enclosed comments cover our review of the Applicant's Findings on the Borated Water Storage Tanks, Diesel Fuel Oil Tanks, Underground Piping, Liquefaction and Dewatering, Slope Stability of Baffle and Perimeter Dikes and the Diesel Generator Building.

The enclosed comments were prepared by Joseph Kane (28153) who may be contacted if you wish to further discuss the comments.

Lyman W. Heller
for George Lear, Chief
Structural and Geotechnical
Engineering Branch
Division of Engineering

cc: w/attachment
R. Vollmer
J. Knight
T. Sullivan
E. Adensam
G. Lear
[illegible]
L. Heller
D. Hood
N. Wright
M. Wilcove
R. Gonzales
F. Rinaldi
J. Kimball
H. Singh, COE
J. Kane

Dupe ~~8310200429~~

actual Finding discussions. Because of the above effects we feel major revisions to the Applicant's Findings are needed in order to adequately reflect the Staff's SER positions and conclusions in the NRC Findings.

Diesel Generator Building

6. (Page 134, Par. 166). In this paragraph the Applicant's Findings cite the results of the Naval Surface Weapon Center (NSWC) study which ultimately concludes that when the measured settlement values are imposed on the analytical models of the DGB, very high stresses result in areas where no cracks now exist. In response to this study conclusion, we have examined the results of the NSWC report. As indicated in the attached tables where we have compared the areas of high stress computed by the NSWC with areas of recorded cracking (visible signs of potential structural distress) our conclusions in this review indicate that in the majority of locations cracks do appear in the identified areas of high stress. Because the NSWC conclusions are so significantly different from our conclusions we feel it is necessary to resolve this difference with the NSWC. If our conclusions are correct we feel both the Applicant's Findings and the hearing record need to be corrected in order for the Board to make the proper Findings.

Comp[illegible]son of Computed Hi[illegible] [illegible]ress Areas [illegible] Crac[illegible]d A[illegible]

WEST CENTER WALL

Observ[illegible] of J. Kane in Comp[illegible] with High Stress Area[illegible]

NSWC Figure	Computed High Stress Areas	[illegible]iod of [illegible]sured [illegible]tlement	Fig. 14 [illegible]Mapping Decemb[illegible] 1978	Figs. 28-2 and 28-3 Mapping Dec 1978; Sept 1979 to Jan 1980	[illegible] Mapping July 19[illegible]	Conclusions on Comparison
31	On south side (1) below El. 650	[illegible]28/78 to [illegible]15/78 ([illegible]esurcharge)	*No cra[illegible]s shown on 12/7[illegible] Map	Crack observed in 9/79 is recorded in this area and is identified as crack due to structural displacement	Same crack observed in 9/79 is again recorded in 7/[illegible].	Cracks do appear in all NSWC identified areas of high stress when incremental settlements for a given time frame are imposed and the latest crack mapping (July 1981) is used.
32	On north side (2) below El 650	[illegible]/78 to [illegible]15/78 ([illegible]esurcharge)	*Crack [illegible]own in 12/78 [illegible]p	No cracks shown on 9/79 Map	Cracks [illegible] in 7/81 [illegible]	
33	On north side (3) above El 634.	[illegible]78 to 1/79 ([illegible]esurcharge)	*Cracks [illegible]hown in 12/78 [illegible]	No cracks show[illegible] on 9/79 Map	Cracks [illegible] 7/81 [illegible] slight [illegible] of 12/78 mappe[illegible] cracks.	If comparision is limited to available maps closest to dates of measured settlement, then cracks appear in 4 out of the 6 locations (shown by asterisks) of high stresses. The fact that cracks were observed in 12/78, not observed in 9/79 but reappear in same locations in 7/81 could mean the cracks were missed in 9/79.
35	On north side (2) below El 650	[illegible]8 to 1/79 ([illegible]esurcharge)	*Crack [illegible]own in [illegible] 12/78 [illegible]	No cracks shown on 9/79 Map	Cracks shown [illegible] 7/81 Mapping	
37	On north side (3) above El 634	[illegible]9 to 8/79 ([illegible]charge [illegible]iod)	Fig 14-[illegible]Mapping not applicab[illegible] as it predates t[illegible] period of settlem[illegible]	*No cracks shown on 9/79 Mapp	Cracks shown in 7/81 mapping [illegible] slightly exten[illegible] 12/78 mapped cracks.	
39	On south side (4) above El 634	[illegible] to 8/79 ([illegible]charge [illegible]iod)	Fig. 14 Mapping not app[illegible]cable.	*Crack shown in 9/79 map and is identified as structural displacement crack.	Same crack observed in 9/79 is again recorded in 7/[illegible].	

Com[illegible] on of Computed Hi[illegible] Areas with Recorded Crac[illegible]

CENTER WALL

NSWC Figure	Computed High Stress Areas	[illegible]riod of [illegible]sured [illegible]tlement	Obser[illegible]ions of [illegible] wi[illegible] — Fig. [illegible] Ma[illegible] Decem[illegible] 197[illegible]	[illegible]n Compar[illegible] Stress Ar[illegible] — [illegible]s. 28 2 and 3 Mapping Dec. 1978; Sept 1979 to Jan 1980	Fig. [illegible] July 1981	Conclusions on Compariso
31	On north side (1) above El. 634	[illegible]8/78 to [illegible]15/78 ([illegible]resurcharge)	Crack[illegible] [illegible] in 12/78 [illegible]	Cracks shown and increase from 12/78 to 9/79	Cracks shown 7/81 Mapping	Cracks do appear in 5 out of the 6 locations where NSWC has computed areas of high stress and on crack maps with dates closest to the periods of measured settlements.
32	On north side (2) below El. 650	[illegible]28/78 to [illegible]15/78 ([illegible]esurcharge)	Cracks [illegible]hown in 12/78 [illegible]p	Cracks shown and increase from 12/78 to 9/79.	Crack shown 7/81 Mapping	
33	On north side (1) above El. 634	[illegible]/78 to 1/79 ([illegible]resurcharge)	Cracks [illegible]hown in 12/78 [illegible]p	Cracks shown and increase from 12/78 to 9/79.	Cracks shown in 7/81 Mapping	
35	On north side (1) above El. 634	[illegible]/78 to 1/79 ([illegible]resurcharge)	Cracks [illegible]hown in 12/78 [illegible]p	Cracks shown and increase from 12/78 to 9/79.	Cracks shown [illegible] 7/81 Mapping	
37	On north side (1) above El. 634	[illegible]/79 to 8/79 ([illegible]rcharge [illegible]iod)	Fig. [illegible] Mapping not ap[illegible]icable as it pre[illegible] this period [illegible] settle[illegible].	Cracks shown and increase from 12/78 to 9/79	Cracks shown [illegible] 7/81 Mapping	
39	On south side (3) above El. 634	[illegible]/79 to 8/79 ([illegible]urcharge [illegible]riod)	Fig. [illegible] Mapping not ap[illegible]icable	No cracks shown on 9/79 Map	No cracks Sho[illegible] on 7/81 Map	

Compari[illegible] f Comp[illegible] [illegible]as with Recorded Cracked Areas

EAST CENTER WALL

NSWC Figure	Computed High Stress Areas	[illegible] of [illegible]ured [illegible]lement	Observat[illegible] J. Kane in Comparision of Cracked Are[illegible] with High Stress Areas: Fig. 14-[illegible] Mapping December [illegible]978	Figs. 28-2 and 28-3 Mapping Dec. 1978; Sept. 1979 to Jan 1980	Fig. 49 [illegible] July 1981	Conclusions on Comparison
31	On south side below El 663 (not reasonable since wall is built only to El 556 at this time).	—	—	—	—	Location of high stress is unreasonable for this stage of construction. No comparison therefore can be made.
32	On north side ① below El. 650	[illegible]/78 to [illegible]/78 ([illegible]urcharge)	*Cracks [illegible] in 12/78 [illegible]	No cracks shown in 9/79 Map	Cracks [illegible] in 7/81 [illegible]	Cracks do appear in all NSWC identified areas of high stress when incremental settlements for a given time frame are imposed and the latest crack mapping (July 1981) is used.
33	On north side ② above El. 634	8/[illegible] to 1/79 ([illegible]urcharge)	*Cracks [illegible] in 12/78 Ma[illegible]	No cracks shown in 9/79 Map	Cracks shown in 7/81 Mapping	
35	On south side ③ above El. 640	8/[illegible] to 1/79 ([illegible]urcharge)	*Cracks [illegible]ear very close to [illegible]his location [illegible] 12/78 Map	Crack shown in 12/78 Map	Crack shown in 7/81 mapping	*If comparison is limited to available maps closest to dates of measured settlements, then cracks appear in [illegible] out of the 5 locations (shown by asterisks) of high stresses.
37	On north side ④ above El 640	1/[illegible] to 8/79 ([illegible]charge period)	Fig. 14-[illegible] Mapping not appl[illegible]able as it preda[illegible] this period [illegible] settlement	*No cracks shown in 9/79 Map	Cracks shown in 7/81 mapping	
39	On south side ⑤ above El. 634	1/[illegible] to 8/79 ([illegible]charge Period)	Fig. 14-[illegible] Mapping not appl[illegible]able.	*Crack shown in 12/78 Map but not in 9/79 Map	Crack shown in 7/81 Mapping	

Enclosure 2

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

NOV 15 1983

MEMORANDUM FOR: Elinor Adensam, Chief
[illegible]

FROM: George Lear, Chief
[illegible]
Division of Engineering

SUBJECT: CORPS OF ENGINEERS MEMORANDA ON DIESEL GENERATOR
BUILDING [illegible]

We have recently received the attached letter from P. McCallister, Chief, Engineering Division, U.S. Army Corps of Engineers which is dated October 28, 1983 and includes two enclosures that pertain to the Diesel Generator Building at the Midland plant. The enclosures were originated by the Corps reviewer for the Midland project, Mr. Hari N. Singh.

The October 28, 1983 letter and two enclosures are being forwarded to DL for your information and appropriate licensing action.

We plan to address the items identified in the two enclosures to the [illegible] letter [illegible] Findings of Fact for the Diesel Generator Building.

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

Attachments:
As stated

R. Vollmer	G. Lear
D. Eisenhut	L. Heller
J. Knight	P. Kuo
	D. Hood
	F. Rinaldi
	J. Kane

50-329
50-330

DEPARTMENT OF THE ARMY

DETROIT DISTRICT, CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231

REPLY TO ATTENTION OF

Design Branch

[illegible] Concerning [illegible]

Mr. G. [illegible] Lear
U.S. Nuclear Regulatory Commission
Chief, Hydrologic and Geotechnical [illegible]
Division of Engineering
Mail Stop P-21[illegible]
Washington, D. C. 20555

Dear Mr. Lear:

Attached are two memoranda providing Corps of Engineers comments regarding the recent controversy over the structural adequacy of the Diesel Generator [B]uilding (D.G.B.). These memoranda are Midland Nuclear Power Plant, Midland, [Mi]chigan dated 28 September 1983 and Applicant's Proposed Finding of Fact and [Con]clusions of Law on Remedial Soils Issues-Midland Nuclear Power Plant, Midland,

Sincerely,

Enclosures

P. McCallister, P. E.
Chief, Engineering Division

8311030133 831025
CF ADOCK 05000329
CF

XE02
1/1

NCDID-G 28 September 1983

SUBJECT: Midland Nuclear Power Plant, Midland, Michigan

TO: File

FROM: H.N. Singh

[illegible]

Independent Review Committee of four experts by the Nuclear Regulatory Commission.

2. Pursuant to an interagency agreement between the U.S. Army Corps of Engineers (the Corps) and the U.S. Nuclear Regulatory Commission (NRC), [illegible] effective in September 1979, we have reviewed the geotechnical aspects of the Midland Nuclear Power Plant, and have concluded that the DGB has not been correctly analysed (H.N. Singh's testimony of 10 December 1982 before the U.S. Atomic Safety Licensing Board, ASLB). Therefore, the Corps is not in a position to certify the adequacy of the structure.

3. The NRC geotechnical experts have also concluded that the effects of the foundation settlement have not been considered in the analyses, therefore, the structural analyses performed by the Consumers Power Company (CPCO) are not appropriate. Dr. R. B. Landsman of the NRC Region III office has testified to [illegible] aspect before the Congressman Udall's subcommitte, and before the ASLB. Mr. [illegible] Kane, Principal geotechnical Engineer of the NRC also expressed his concern before the ASLB hearing on 10 December 1982.

4. On [illegible] September 1983, I was called upon by the [illegible] formed Independent Review Committee to explain the committee of the Corps' concerns regarding the [illegible]

[illegible] informed the Committee that the details of my concerns are provided in my testimony of 10 December 1982 before the ASLB, and in the Corps' report of July 1980, and 16 April 1981. An abstract of th Corps' concerns are:

a. The CPCO has not considered the effect of differential settlement of the DGB in structural analyses.

b. The DGB has numerous cracks on its walls. These cracks have reduced the [illegible] of the structure, therefore, the effects of cracking must be considered [illegible]

c. CPCO method of computing stresses in the reinforcing bars on the basis of the crack width is not appropriate.

6. A list of concerns resulting from the review of the CPCO's "Proposed Findings of Fact and Conclusions of Law in the Midland Proceeding" is inclosed.

H. N. Singh, PESE
Lead Reviewer
Midland Nuclear Power Plant

NCDED-G

SUBJECT: Applicant's Proposed Findings of Fact and Conclusions of Law on Remedial Soils Issues - Midland Nuclear Plant, Midland, Michigan

[illegible] has reviewed [illegible] subject report. The following are the [illegible]

1. Para. [illegible] The main reason for uneven settlement of the Diesel Generator [illegible] is variable soil stiffness [illegible] soil. [illegible] the duct banks did contribute to uneven settlement [illegible] beginning, [illegible] significant uneven settlement subsequent to [illegible] release [illegible] in December, 197[illegible].

2. Para. [illegible]: The major cracks in the east wall of the DGB developed subsequent to the release of the duct banks from the building. The number of cracks prior to the release of the duct banks are shown in Attachment #1 of the original testimony of H. N. Singh. This attachment shows only 10 cracks on the east wall, but today there are 16 cracks on the wall.

3. Para. 92: The settlement of the D.G.B. after the release of the duct banks is not uniform as claimed by the Applicant in the last sentence of this paragraph. As shown in Attachment No.-2 (Fig-2) of the testimony of [illegible]r. H. N. Singh, there has been considerable differential settlement after the [illegible]lease of the duct banks.

[illegible]a. 93: The settlement of the D.G.B. during the surcharge has created [illegible] original testimony [illegible] number of [illegible] increased from 10 to 16. Therefore, [illegible] did reduce the struc- [illegible]

[illegible] accuracy of the D.G.B.

5. Para. 95: Partially saturated soil will not consolidate as saturated clay as claimed by the Applicant in this paragraph. The Corps of Engineers' concern as to this matter was communicated to the Applicant through the Corps' report of [illegible] July 1980 para. [illegible].

6. Para. 96,97, 98: We do not understand the intent of providing the contents of these three paragraphs. The matter described is well-known. Every soil [illegible]

scale.

7. Para. 99: Surcharging of a completed or partially completed structure is not a well established and widely accepted technique as claimed by the Applicant in this paragraph. A number of precedents described in Dr. Peck's testimony are nothing but surcharging of foundations; the portions of structures which are

affected by the differential settlement were not completed. The case o[illegible] the D.G.B. is entirely different, where almost entire structure was completed during the surcharge. Therefore, surcharging has created major structural distress in different parts of the building.

[illegible] settlement. This has been substantiated by the excessive measured settlement [illegible]

[illegible] not a sound engineering practice to cast concrete, [illegible] the [illegible] moving (settling). The Applicant's decision to cast concrete [illegible] does not comply with the sound construction practice.

10. The piezometer readings and the shape of the consolidation curves did not confirm that all the excessive pore pressures were dissipated. The reasons [illegible] given in the Corps of Engineers report of 16 April 1981 (Question No. 40).

11. Para. 106: To limit the accuracy of survey instruments (transit) to 1/8" is too [illegible] to be realistic. The normal measuring devices in leveling instruments can read up to 1/1000 of a foot, therefore, it appears that Applicant's settlement measuring method was not appropriate. Further, the error in measurement can be either plus or minus resulting in uncertainty in the measured settlement. In such case, to insure safety of the structure, it is reasonable to use higher values of settlement. The Applicant's method of computing settlement and creating error band of 1/4", and neglecting the differential settlement [illegible] are not [illegible]

[illegible] are [illegible] susceptible to errors than the reading on the markers which were located at the fixed points on the walls of the D.G.B.

13. Para. 112: Although, the pond level was raised to elevation 627.00, there is no evidence that water level below the D.G.B. rose above elevation 622.0 (Corps' report of 16 April 1981, see piezometer 12, 17, 23, 25, 2[illegible], 34, 36, 40, and 43).

[illegible] The [illegible] under the D.G.B. was not completed [illegible]

15. Para. 117: The foundation of the D.G.B. did not remain in plane after the removal of the surcharge. There has been considerable warping of the structure during and subsequent to the removal of the surcharge (see Singh's original testimony).

16. Para. 121: The reduction in stresses due to the surcharge removal did not exceed the stresses due to the added loads. For example the dewatering has added so much stress in excess of the surcharge stress that the foundation soils started showing primary consolidation.

17. Para. 125: The settlement due to the dewatering is primary settlement. I don't know when and how Dr. Peck added this settlement to the secondary settlement. It should be the part of the primary settlement. Part of this might be compensated by the additional settlement for continuing the surcharge load which [illegible] but [illegible] it has not

18. Para. 130: There is no justification for correcting the measured settlement [illegible] has consistently made unjustified [illegible] settlement in the structure. If there [illegible] possibility that corrections might increase the [illegible]. But the [illegible] corrections have always reduced the settlement.

19. Para. 131: Dr. Peck's conclusion that piezometer observations are prone to anomalies is correct. But in the case of Midland Plant, a substantial number of [illegible] consistently [illegible] that pore pressures under the D.G.B. have not been completely dissipated. Hence taking advantage of anomalies to justify an [illegible] result is not [illegible].

20. Para. 132: Dr. Peck's calculations of permeability are based on many questionable assumptions. Therefore, there is no merit in the values of the permeability calculated.

[illegible] Para. 135: Dr. Peck's conclusion in para. 135 is not appropriate. In case [illegible] cracks, a redistribution of stresses will take place, and the soil [illegible] was bridged by the structure before cracking will be subjected to more [illegible]

23. Para. 147: Dr. Peck's and Hendron's conclusion that the structural integrity of the structure has not been impaired is not correct. Mr. Singh has already shown in his original testimony that number of cracks on the east wall has increased from 10 to 16 after the surcharge. The curvature of the structure has considerably increased after the surcharge. This is a clear indication that stresses in the structure had increased to such a level due to the surcharge that numerous new cracks developed. Further the analysis of the D.G.B. struc- [illegible]

[illegible] stress evaluation.

24. Para. 150, 151: The soil spring constant used in the analysis is not appropriate. Bechtel did not consider the correct values of spring constant.

25. Para. 154: It is clear from the east wall that all the cracks which are inclined and have developed after the release of the duct banks are shear cracks. These cracks have bent towards south, indicating shear stree due to excessive settlement at the southeast corner.

[illegible] The [illegible] was then informed by Mr. [illegible] and Mr. [illegible] on 10 December 1982 regarding [illegible]

[illegible] Dr. Corley [illegible] the statement that there is no [illegible] structure [illegible] I do not know what is the [illegible] the conclusion. There are evidences of large cracks on the east wall [illegible] This clearly establishes [illegible] large shear cracks [illegible] following the settlement of the [illegible] Further, settlement patterns developed after the release of [illegible] clearly indicate that there are many soft spots under the D.G.B. Further, the variation made in the spring constant over a 15' length was not [illegible] to reflect the softness of the large area under the foundation.

Para. 169: No cracks have been considered in the analysis.

Para. [illegible]0: If the Applicant can not analyse the structure correctly, that [illegible]es not [illegible] that he will perform incorrect analysis to justify the adequacy of [illegible]e structure. Obviously, all of the Applicant's analyses are erroneous. If the structure can not be correctly analyzed, that is not a justification to [illegible]

NCDED-G
Lead Reviewer
Midland Nuclear Plant

Enclosure 3

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

NOV 18 1983

[illegible]

[illegible] Engineering [illegible]
[illegible] Branch
Division of Engineering

FROM: [illegible], Sr. Geotechnical Engineer
Geotechnical Engineering Section
[illegible] Engineering Branch
Division of Engineering

SUBJECT: COMMENTS ON OCTOBER 21, 1983 REPORT BY INDEPENDENT TASK GROUP REVIEW OF THE DGB AT THE MIDLAND PLANT

In response to your verbal request, I have enclosed my review comments on the [illegible]ctober 21, 1983 report by the Independent Task Group which was formed [illegible] [ev]aluate the concerns expressed by R. B. Landsman of Region III for the [illegible] Generator Building.

[illegible]

[illegible] by [illegible] relative to their decision which I have used in identifying the potential hearing considerations are the following:

1. Does the issue which I have identified in the Independent Task Group report provide new evidence that affects or modifies the hearing record evidence?

2. Are the facts or expert opinions which are expressed in the Independent Task Group Report significant and different [illegible] affect a conclusion with respect to the structural adequacy of the DGB?

3. Although the information from the Independent Task Group report does not change the Staff conclusion with respect to the DGB - in "fairness to the Board" should the Board have the benefit of reviewing the evidence in the report in order to reach its conclusion?

On the basis of my review of the Independent Task Group report and my comparison with the guideline provided by OELD, I have provided my [illegible]

[illegible]

Division of Engineering

[illegible]

cc: w/enclosure
R. Vollmer
J. Knight
T. Novak
L. Heller
P. Kuo
T. Sullivan
E. Adensam
[illegible]
[illegible], OELD

[illegible], OIE
J. Kane

Subject: Review Comments on October 21, 1983 Report by Independent Task
Group on the DGB
Plant: Midland Plant Units 1 and 2, 50-329/330
Prepared by: Joseph Kane, [illegible]

1. [illegible] <u>[illegible] Hearing Consideration</u> - There are statements in the [illegible] Group Report [illegible] the completeness and accuracy [illegible] settlement data and history that are in conflict with [illegible] testimony of [illegible] from the NRC geotechnical engineering staff and the Corps of Engineers. The specific areas [illegible] are:

a. Group Report, Pg. 6. "a complete and accurate settlement history [illegible] exist."

b. Group Report, Pg. 12. "there are no such detailed settlement measurements available, especially for the early stages of construction."

c. Group Report, Pg. 15. "Given the unavailability of the data necessary to complete the input to the analysis by the staff's consultant, the previously stated staff position is reasonable."

d. Group Report, Pg. 20. "However, such settlement history for the DGB does not exist."

e. [illegible]

f. Appendix III, Pg. 5. "However, it should be mentioned that the exact settlement history at the various settlement markers at the DGB is open to question." (Reasons for this statement are subsequently given).

g. Appendix III, Pg. 7. "These analyses, though different in detail, lead to the similar conclusion that the settlement measurements [illegible]

h. Appendix III, Pg. 8. "[illegible] period (where measured settlements are being used to compute stresses) spans from the <u>beginning</u> of construction through August 1978 at which time construction was halted."

i. Appendix III, Pg. 17. "However, it is recommended that the anomalies in the documentation of the settlement history be resolved" (Last paragraph of App. III, Section 2.2).

These nine statements are in conflict with SSER No. 2, pg. 2-33 and the testimony of J. Kane and H. Singh during the week of December 6 - 10, 1982.

B. Applicable OELD Guidelines - Guidelines Nos. 1, 2 and 3

C. Basis for Identifying Issue As Potential Hearing Consideration - Because the nine [illegible] statements in the Independent Task Group report [illegible] DGB [illegible] [illegible] item 4. in the [illegible] identified statements appropriately [illegible] be resolved. [illegible] three of [illegible] identified by OELD would apply when considering the need [illegible] in order to straighten out the hearing record on this [illegible].

I. Potential Hearing Consideration. At this particular time there are questions and [illegible] doubts as to the defensibility of NRC position in concluding there is reasonable assurance that the structural integrity of the DGB will be maintained and its functional requirement fulfilled (See October 21, 1983 memo from P. T. Kuo to J. P. Knight, pg. 1; Group Report, pg. 21, Conclusion no. 5; App. III, pg. 17, Conclusion no. 6). The questions and doubts result from the following items in the Independent Task Group report:

a. The report in several locations identifies the need for the Applicant and the NRC staff to properly document the information [illegible] for crack width approach for all DGB walls in order for the stresses that are induced by settlements to be [illegible] item 1).

b. Closely related to this issue is the report's acknowledgement that the crack method approach is questionable where relatively few cracks occurred (App. III, pg. 11) and the absence of written justification in the FSAR for using this approach for structures like the DGB (App. III, pg. 16).

c. In addition the report in several locations points out the [illegible] pgs. 13, 16 and 17) and the need to establish action levels (Oct. 21, 1983 memo, pg. 2 item 5; App III, pgs. 16 and 17 item 4).

d. The NRC Staff position on DGB acceptability uses the crack width approach to estimate settlement induced stresses and this position is heavily dependent on the accuracy of available crack maps. In several locations in the Task Group report, the reliability and accuracy of presently available crack maps are questioned and the Group report cites concern that cracking in the DGB has not stabilized and the cracks are growing (See Oct. 21, 1983 memo, pg. 2 item 4; App. III pgs. 6, 7, 13 and 17 item 3). In my opinion it will be necessary to obtain and use more recent and accurate crack maps of the DGB before the recommendation of the [illegible]

[illegible], pg. [illegible] 5).

[illegible] 2 and 3.

[illegible] for Identifying Issue as Potential Hearing Consideration. For [illegible] to have a [illegible] defensible position in judging [illegible] adequacy of the DGB there is a need to have a good data basis. The Task Group report, as indicated by the above comments, correctly [illegible] out that at this time we do not have that basis. The report [illegible] some specific recommendations that should be followed [illegible] to reach the needed sound engineering basis. Both the Board and the public have already asked what is the NRC Staff response to the report's recommendations and will want to know what significant information is developed in carrying out these recommendations. For these reasons I believe all three of the guidelines provided by OELD apply and would be the basis for reopening the hearing on the DGB.

? [illegible] Potential Hearing Consideration. The Task Group report in many [illegible] discusses the controversial finite element analysis [illegible] by the Applicant [illegible]

[illegible] App. III, pgs. 9 and 14). In the Dec. 6 through 10, 1982 hearing sessions this issue was extensively discussed and reflected significant differences in professional opinions that has left the hearing record unclear and unresolved. The statements in the Task Group report on this controversial subject are very specific and clear "that this model (the Applicant's) will yield unconservative estimates of stresses." (App. III, pg. 9, 2nd par.) and "We therefore conclude that this approach to compute settlement stresses is inappropriate."

[illegible] report, it is our opinion that this analysis will result in unconservative predictions of stresses due to settlements. As such, it is considered to be an inappropriate analysis." (App. III, pg. 14, 2nd par.).

B. Applicable OELD Guidelines. Guideline Nos. 1, 2 and 3.

C. Basis for Identifying Issue As Potential Hearing Consideration. In my [illegible]

[illegible] this [illegible] appropriate would [illegible]

[illegible] identified concern [illegible] (Oct. 24, 1983 memo [illegible] Paton on [illegible] Proposed Findings, pg. [illegible] with the results [illegible] also impacted by [illegible] report. Although the Task Group in App. III, [illegible] the value of the [illegible] because of the apparent linear assumption of settlement data points made in the study, the report by the Group reflects an influence of the NSWC results by referencing the important conclusion by the NSWC study - that very high stresses are calculated in areas of the DGB where no cracks now exist. (See Group Report, pgs. 8 and 20 item 1; App. III [illegible]. 14 and 15). This NSWC conclusion is seriously questioned when comparison is made of the computed areas of high stress with areas of recorded cracking (See enclosure tables to Oct. 24, 1983 memo). When [illegible] areas of recorded cracking [illegible] that [illegible]

B. Applicable OELD Guidelines - Guidelines Nos. 1, 2 and 3.

C. Basis for Identifying Issue As Potential Hearing Consideration. Both the Task Group report and the present hearing record offer the conclusion by the NSWC study that cracks do not appear in areas of [illegible]

[illegible] Board's attention. It is quite likely that the Board would place significant reliance on the NSWC conclusion, if left uncorrected, in reaching its decision with respect to the safety of the DGB. For these reasons I feel it should be brought to the Board's attention.

5. There are less important considerations affected by the information within the Independent Task Group report that would not require reopening of the DGB hearing, but which would be helpful to the Board if addressed, since they are related to previous testimony. These items are:

[illegible] III, p. 8. The [illegible]

[illegible]

III, p. 12. The [illegible] [illegible] the very [illegible] settlement [illegible] the DGB

III pps. 12 and 13. The need to improve the accuracy of [illegible] settlement monitoring at the DGB and to require better [illegible] monitoring crack growth with reliable strain gages.

Enclosure 4

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

NOV 18 1983

MEMORANDUM FOR: George Lear, Chief
Structural and Geotechnical Engineering Branch

[illegible]

Structural Engineering Section B
[illegible]
[illegible] of Engineering

FROM: [illegible], Structural Engineer
[illegible] Engineering Section B
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: EVALUATION OF EVIDENCE ON DIESEL GENERATOR BUILDING - [illegible] PROJECT FOR DETERMINATION OF NEED TO REOPEN HEARINGS

[P]ursuant to your request of November 8, 1983, for my evaluation of any new [e]vidence related to the structural adequacy of the Diesel Generator Building [(]DGB), I have evaluated the report by the NRR Task Group dated October 21, 1983, for the test conditions provided by your management (Enclosure 1) and expanded by the staff attorney (Enclosure 2).

[illegible]

[illegible] hearing of December, 1982. In addition, the NRC legal staff [illegible] of the questions raised by the Region III-IE inspector as well as the answers provided by all concerned parties. Indeed the NRR Task Group Report of October 21, 1982, documents the conclusions, discussions, and specific answers to the questions raised by Region III-IE inspector. The NRR Task Group report includes their findings, those of their consultant staff from Brookhaven National Laboratory (BNL), as well as the replies by NRR Structural and Geotechnical staff and their consultants to the questions [illegible]

[illegible]

Recognizing the fact that my recommendations on the subject of reopening the hearing for the DGB are needed for the final decision making, I will identify the important facts stated by the Task Group and state if they constitute, from the structural engineering point of view, new evidence or if they impact on the previous conclusions reached by the structural engineering staff. The major points are the following:

Dupe ~~8406120594~~

1. The Task Group used the same facts and evidence used by the review staff in their evaluation of the DGB.

[illegible] maintained and [illegible] requirements fulfilled."

[illegible] the most reasonable estimate of [illegible] based on the crack width data. However, the [illegible] in this area need to be completely [illegible]

[illegible] The Task Group stated [illegible] that a more accurate and reliable crack [illegible] and that sufficient stress margins for Action Level and specific repairs be established for Alert Level of crack width[illegible]. Also, they recommended a general repair program prior to plant operation.

[illegible]e first two items are self-explanatory and from a structural engineering [illegible]nical point of view should be the major reasons that no additional [illegible]s are required to establish the structural adequacy of the DGB. The [illegible] item asks for the documentation of the calculations used in the [illegible]ation of the conservative stress values utilizing the crack width data. The approach has been discussed, the results have been documented [illegible] requested documentation [illegible]

[illegible] The resulting stress values can be easily verified with the stress results identified in the written and oral testimony of the applicant and the staff. I do not consider this documentation to be new evidence because the facts do not change. The fourth item recommends a modification to the monitoring program previously proposed by the applicant and accepted by the staff and a general repair program. The Task Group does not provide specific approaches that would fulfill these recommendations. BNL report recommends the extensive use of Whitmore strain gages in place of the [illegible]

[illegible] Levels. The Task Group was aware of the BNL recommendation related to the Whitmore strain gages, but did not make such firm recommendation. The above stated facts lead me to the conclusion that the Task Group is leaving the structural review staff and the applicant with the task of resolving these concerns.

I conclude from my review of the Task Group report that the NRC staff needs to start discussions with the applicant concerning the documentation of the rebar stresses as determined from all available crack-width data, the [illegible] of the strain gages proposed by BNL, and [illegible]

[illegible] applicant has contracted with Portland Cement Association (PCA) to [illegible] [illegible] problems identified by the monitoring [illegible] of this independent monitoring and evaluation [illegible] acceptance of the monitoring requirements.

I understand the fact that some people may not fully understand the structural engineering technical aspects of this case and may consider [illegible] availability of any new document as solid ground for reopening the hearings on the DGB. However, based on the fact that no new evidence was uncovered in the preparation of the conclusions of the Task Group, that the structural adequacy of the DGB was assured, and that no specific detailed recommendations were made other than generic suggestions which the staff can request the applicant to resolve and then inform the board [illegible] recommend, from the structural engineering technical point [illegible] reopen the hearing on the structural safety of the DGB.

Frank Rinaldi, Structural Engineer
Structural Engineering Section [illegible]
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosures:
As stated

cc: R. Vollmer
J. Knight
T. Novak
T. Sullivan
E. Adensam
D. Hood
W. Paton
P. Kuo
L. Heller
J. Kane
G. Harstead
J. Matra
F. Rinaldi

Test to apply in deciding whether to recommend that the hearing be reopened.

[illegible] evidence that [illegible] the evidence of record?

[illegible] hat [illegible]

[illegible]

[illegible] have been said if the information had been available [illegible]

[illegible] testimony was given?

- The issue is one of "fairness to the board". If our feeling is that the evidence would not change our conclusions but that the board nevertheless, should have the benefit of reviewing this new evidence to reach its conclusions, then we should recommend for reopening the record.

ENCLOSURE 1

Are the facts or expert opinions in the DGB Task Report that are

[illegible]

[illegible]

[illegible] with respect to the structural [illegible]

[illegible]

11/83

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

November 22, 1983

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: [redacted]rector
Division of Licensing

THRU: Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

FROM: Darl S. Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

SUBJECT: RECOMMENDATION FOR SUPPLEMENTAL BOARD NOTIFICATION REGARDING MIDLAND DIESEL GENERATOR BUILDING

Board Notification 83-165 dated October 26, 1983, transmitted the report of a special task group on the re-evaluation of the structural design and construction adequacy of the Midland Diesel Generator Building (DGB). The re-evaluation had been prompted by the concern of Dr. Landsman in BN 83-109. Also, BN 83-153 dated October 11, 1983, had transmitted a reply to an inquiry by NRR's Director of the Division of Engineering as to whether or not any member of that Division or NRC consultant shared Dr. Landsman's specific technical concerns.

Review of the task group's report by others, and the NRC's internal process of soliciting comments on the Applicant's Proposed Findings of Fact and Conclusions of Law on Remedial Soils Issues, have resulted in recent comments on the DGB which are material and relevant to issues before the Board. The comments further indicate the views of NRR members and consultants regarding Dr. Landsman's concerns as expressed in BN 83-153. Because of the contents of the task group's report, but also, in part, because of these supplemental comments, the NRC staff stated during the Midland OM-OL hearing session of November 19, 1983, it would advise the Board by December 1, 1983, of its position on the need to reopen the record on the special task group's re-review of the DGB. The staff also noted during the November session that if it takes the position that the record need not be re-opened, it will file responsive findings with respect to the DGB on December 9, 1983. As part of this decision process, Messrs. J. Kane and F. Rinaldi were requested to provide comments on the task group's report and to provide their recommendation as to whether of not the hearing should be reopened. Both replied November 18, 1983. I recommend that the Board be notified of these supplemental comments relative to the DGB. These are discussed below.

Dupe

I. Comments of Joseph Kane on Applicant's Findings

The task group's report, in part, discussed the results of an interview with Mr. J. Kane:

> "With regard to the structural analyses using actual settlement data, Mr. Kane observed 70-80% of the cracks to be in areas where the analyses indicated areas of high stress. Mr. Kane has documented his concerns in memos dated August 2, 1983, and are included in Attachments 1 and 2." [page AII-3].

In Attachment 1 of the task group's report, page 2, Mr. Kane noted he personally had serious problems and questions with a report documenting an analysis performed by an NRC consultant, the U.S. Naval Surface Weapons Center (NSWC), and explained why he had not pursued his concerns at that time. He acknowledged that the staff position does not rely on the results or conclusions of the NSWC study.

In Attachment 2 of the task group's report, second paragraph, Mr. Kane questions why total settlements were used in the NSWC study to compute maximum stresses and movements in checking for areas of cracking. Mr. Kane noted the need to clarify this with NSWC and re-examine computed stresses and movements with available crack mapping. He also noted that in several of the walls there does appear to be correlation of cracks with high stress areas and that this should be discussed with NSWC.

Supplemental information regarding the above concerns in BN 83-165 is contained in a memorandum from G. Lear dated October 14, 1983, which transmits to OELD the Geotechnical Engineering review comments on the applicant's proposed findings of fact and conclusions of law regarding technical aspects of the OM-OL proceeding. The comments were prepared by J. Kane. On page 12 (Enclosure 1) Mr. Kane notes the results of his examination of the results of the NSWC report and attaches a table showing the results of his comparison from which he concludes that in the majority of locations, cracks do appear in the identified areas of high stress. Mr. Kane notes the need to resolve this difference with NSWC, and that if his conclusions are correct, "both the applicant's findings and the hearing record need to be corrected in order for the Board to make the proper findings."

I recommend that Enclosure 1 be forwarded to the Midland Board for supplemental information to BN 83-165 and BN 83-153, even though the staff did not rely on the NSWC study nor the applicant's analyses, for its conclusion regarding the adequacy of the DGB. The information is potentially relevant since the concern, if valid, would be contrary to other information on the record, which if relied upon by the Board, could lead to improper findings or cause the issue to be viewed in a different light. Specifically:

The NSWC report (Consumers Power Company Exhibit 30) concluded, in part, that:

> "the analyses show that other areas [other than at the duct bank 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." [Statments in brackets and underlining added.]

and that:

> "2. The measured settlement values imposed on the analytical models resulted in very high stresses (over ten times yield) in areas where no cracks now exist. Thus indicating that this settlement value more than likely was not seen by this structure."

Similar statements are made in the hearing by J. Matra of NSWC (Tr. pp. 11094 - 11127) and K. Wiedner (Tr. p. 10815).

II. Comments by U.S. Army Corps of Engineers

Mr. G. Lear's memorandum of November 16, 1983 (Enclosure 2) transmits to LB #4 an October 28, 1983, coverletter from the Corps. of Engineers (COE) with two memoranda containing the comments of H. N. Singh. Mr. Singh's comments further explain why "the Corps is not in a position to certify the adequacy of the structure." Mr. Singh expresses numerous differences with the Applicants proposed findings of fact, and presents significant conclusions of his own. For example, Mr. Singh finds "surcharging has created major structural distress in different parts of the building," ... "The Applicant's decision to cast concrete [to complete construction of the DGB] during the surcharge does not comply with the sound construction practices." ... "There has been considerable warping of the structure during and subsequent to the removal of the surcharge" ... "numerous cracks which have developed due to the settlement have been ignored for the purpose of stress evaluation." ... "The soil spring constant used in the analysis is not appropriate" ... "It is clear from the east wall that all the cracks which are inclined and have developed after the release of the duct banks are shear cracks" ... "Obviously, all of the Applicant's analyses are erroneous. If the structure can not be correctly analyzed, that is not a justification to declare it structurally adequate."

Enclosure 2 is also relevant to the Board because as a composit document, it may cause the Board to view the Corps' position on the DGB in a different light.

III. Comments of J. Kane on Task Group's Report and Recommendations to Reopen Hearing

In Enclosure 3, Mr. J. Kane notes numerous conflicts between hearing testimony and the Task Group's report. Paragraph 4C of Enclosure 3 states that an incorrect conclusion has not yet been brought to the Board's attention. Mr. Kane presents several reasons why the hearing should be reopended on the DGB. Enclosure 3 speaks for itself as to why it is material and relevant to the issues before the Board. Accordingly, the Board should be notified of this document.

IV. Evaluation of F. Rinaldi on need to Reopen Hearing

In Enclosure 4, Mr. Rinaldi, using the same criteria as Mr. Kane in III above, reaches the contrasting view that the hearing record need not be reopended on the DGB. The issue of whether the Task Group's report provides a sufficient basis to reopen the hearing is material and relevant to issues before the Board. Hence, Mr. Rinaldi's views should be forwarded to the Board.

Darl S. Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

Enclosure 1

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

Hood

OCT 14 1983

MEMORANDUM FOR: William D. Paton, Attorney
Office of the Executive Legal Director

FROM: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: GEOTECHNICAL ENGINEERING REVIEW COMMENTS ON THE APPLICANT'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW - MIDLAND PLANT

We have enclosed the final phase of geotechnical engineering input on Midland's Finding of Fact in response to OELD request. Comments 1 through 23 were previously provided to you in my memos of September 27, 1983 and September 30, 1983. The enclosed comments cover our review of the Applicant's Findings on the Borated Water Storage Tanks, Diesel Fuel Oil Tanks, Underground Piping, Liquefaction and Dewatering, Slope Stability of Baffle and Perimeter Dikes and the Diesel Generator Building.

The enclosed comments were prepared by Joseph Kane (28153) who may be contacted if you wish to further discuss the comments.

Lyman W. Heller
for George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

cc: w/attachment
R. Vollmer
J. Knight
T. Sullivan
E. Adensam
G. Lear
P. Kuo
L. Heller
D. Hood
N. Wright
M. Wilcove
R. Gonzales
F. Rinaldi
J. Kimball
H. Singh, COE
J. Kane

Dupe
~~8310200429XA~~

actual Finding discussions. Because of the above effects we feel major revisions to the Applicant's Findings are needed in order to adequately reflect the Staff's SER positions and conclusions in the NRC Findings.

Diesel Generator Building

61. (Page 134, Par. 166). In this paragraph the Applicant's Findings cite the results of the Naval Surface Weapon Center (NSWC) study which ultimately concludes that when the measured settlement values are imposed on the analytical models of the DGB, very high stresses result in areas where no cracks now exist. In response to this study conclusion, we have examined the results of the NSWC report. As indicated in the attached tables where we have compared the areas of high stress computed by the NSWC with areas of recorded cracking (visible signs of potential structural distress) our conclusions in this review indicate that in the majority of locations cracks do appear in the identified areas of high stress. Because the NSWC conclusions are so significantly different from our conclusions we feel it is necessary to resolve this difference with the NSWC. If our conclusions are correct we feel both the Applicant's Findings and the hearing record need to be corrected in order for the Board to make the proper Findings.

Comparison of Computed High Stress Areas with Recorded Cracked Areas

WEST CENTER WALL

NSWC Figure	Computed High Stress Areas	Period of Measured Settlement	Observations of J. Kane in Comparison of Cracked Areas with High Stress Area: Fig. 14-2 Mapping December 1978	Figs. 28-2 and 28-3 Mapping Dec 1978; Sept 1979 to Jan 1980	Fig. 49 Mapping July 1981	Conclusions on Comparison
31	On south side (1) below El. 650	3/28/78 to 8/15/78 (presurcharge)	*No cracks shown on 12/78 Map	Crack observed in 9/79 is recorded in this area and is identified as crack due to structural displacement	Same crack observed in 9/79 is again recorded in 7/81.	Cracks do appear in all NSWC identified areas of high stress when incremental settlements for a given time frame are imposed and the latest crack mapping (July 1981) is used.
32	On north side (2) below El 650	3/28/78 to 8/15/78 (presurcharge)	*Crack shown in 12/78 Map	No cracks shown on 9/79 Map	Cracks shown in 7/81 Mapping	
33	On north side (3) above El 634.	8/78 to 1/79 (presurcharge)	*Cracks shown in 12/78 Map	No cracks shown on 9/79 Map	Cracks shown in 7/81 Mapping and slight extension of 12/78 mapped cracks.	*If comparision is limitec to available maps closest to dates of measured settlement, then cracks appear in 4 out of the 6 locations (shown by asterisks) of high stresses. The fact that cracks were observed in 12/78, not observed in 9/79 but reappear in same locations in 7/81 could mean the cracks were missed in 9/79.
35	On north side (2) below El 650	8/78 to 1/79 (presurcharge)	*Crack shown in 12/78 Map	No cracks shown on 9/79 Map	Cracks shown in 7/81 Mapping	
37	On north side (3) above El 634	1/79 to 8/79 (Surcharge Period)	Fig 14-2 Mapping not applicable as it predates this period of settlement	*No cracks shown on 9/79 Mapp	Cracks shown in 7/81 mapping and slightly extend 12/78 mapped cracks.	
39	On south side (4) above El 634	1/79 to 8/79 (Surcharge Period)	Fig. 14-2 Mapping not applicable.	*Crack shown in 9/79 map and is identified as structural displacement crack.	Same crack observed in 9/79 is again recorded in 7/81.	

Comparison of Computed High Stress Areas with Recorded Cracked Areas

CENTER WALL

NSWC Figure	Computed High Stress Areas	Period of Measured Settlement	Observations of J. Kane in Comparison of Cracked Areas with High Stress Area: Fig. 14-2 Mapping December 1978	Figs. 28-2 and 28-3 Mapping Dec. 1978; Sept 1979 to Jan 1980	Fig. 49 Mapping July 1981	Conclusions on Comparis
31	On north side (1) above El. 634	3/28/78 to 8/15/78 (presurcharge)	Cracks shown in 12/78 Map	Cracks shown and increase from 12/78 to 9/79	Cracks shown in 7/81 Mapping	Cracks do appear in 5 out of the 6 locations where NSWC has computed areas of high stress and on crack maps with dates closest to the periods of measured settlements.
32	On north side (2) below El. 650	3/28/78 to 8/15/78 (presurcharge)	Cracks shown in 12/78 Map	Cracks shown and increase from 12/78 to 9/79.	Crack shown in 7/81 Mapping	
33	On north side (1) above El. 634	8/78 to 1/79 (presurcharge)	Cracks shown in 12/78 Map	Cracks shown and increase from 12/78 to 9/79.	Cracks shown in 7/81 Mapping	
35	On north side (1) above El. 634	8/78 to 1/79 (presurcharge)	Cracks shown in 12/78 Map	Cracks shown and increase from 12/78 to 9/79.	Cracks shown in 7/81 Mapping	
37	On north side (1) above El. 634	1/79 to 8/79 (Surcharge Period)	Fig. 14-2 Mapping not applicable as it predates this period of settlements	Cracks shown and increase from 12/78 to 9/79	Cracks shown in 7/81 Mapping	
39	On south side (3) above El. 634	1/79 to 8/79 (Surcharge Period)	Fig. 14-2 Mapping not applicable	No cracks shown on 9/79 Map	No cracks shown on 7/81 Map	

Comparison of Computed High Stress Areas with Recorded Cracked Areas

EAST CENTER WALL

NSWC Figure	Computed High Stress Areas	Period of* Measured Settlement	Observations of J. Kane in Comparision of Cracked Areas with High Stress Areas: Fig. 14-2 Mapping December 1978	Figs. 28-2 and 28-3 Mapping Dec. 1978; Sept. 1979 to Jan 1980	Fig. 49 Mapping July 1981	Conclusions on Comparison
31	On south side below El 663 (not reasonable since wall is built only to El 656 at this time).	→	→	→	→	Location of high stress is unreasonable for this stage of construction. No comparison therefore can be made.
32	On north side ① below El. 650	3/28/78 to 8/15/78 (presurcharge)	*Cracks shown in 12/78	No cracks shown in 9/79 Map	Cracks shown in 7/81 Mapping	Cracks do appear in all NSWC identified areas of high stress when incremental settlements for a given time frame are imposed and the latest crack mapping (July 1981) is used.
33	On north side ② above El. 634	8/78 to 1/79 (presurcharge)	*Cracks shown in 12/78 Map	No cracks shown in 9/79 Map	Cracks shown in 7/81 Mapping	
35	On south side ③ above El. 640	8/78 to 1/79 (presurcharge)	*Cracks appear very close to this location in 12/78 Map	Crack shown in 12/78 Map	Crack shown in 7/81 mapping	*If comparison is limited to available maps closest to dates of measured settlements, then cracks appear in 3 out of the 5 locations (shown by asterisks) of high stresses.
37	On north side ④ above El 640	1/79 to 8/79 (surcharge period)	Fig. 14-2 Mapping not applicable as it predates this period of settlement	*No cracks shown in 9/79 Map	Cracks shown in 7/81 mapping	
39	On south side ⑤ above El. 634	1/79 to 8/79 (Surcharge Period)	Fig. 14-2 Mapping not applicable.	*Crack shown in 12/78 Map but not in 9/79 Map	Crack shown in 7/81 Mapping	

Enclosure 2

Room 116B

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

NOV 16 1983

MEMORANDUM FOR: Elinor Adensam, Chief
Licensing Branch No. 4
Division of Licensing

FROM: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: CORPS OF ENGINEERS MEMORANDA ON DIESEL GENERATOR BUILDING - MIDLAND PLANT

We have recently received the attached letter from P. McCallister, Chief, Engineering Division, U.S. Army Corps of Engineers which is dated October 28, 1983 and includes two enclosures that pertain to the Diesel Generator Building at the Midland plant. The enclosures were originated by the Corps reviewer for the Midland project, Mr. Hari N. Singh.

The October 28, 1983 letter and two enclosures are being forwarded to DL for your information and appropriate licensing action.

We plan to address the items identified in the two enclosures to the October 28, 1983 letter, where they are appropriate, in our future input to NRC Findings of Fact for the Diesel Generator Building.

George Lear

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

Attachments:
As stated

cc: w/o attachments
R. Vollmer
D. Eisenhut
J. Knight

w/attachments
G. Lear
L. Heller
P. Kuo
[redacted]
F. Rinaldi
J. Kane

Dupe
~~8312010449XA~~

50-329
50-330

DEPARTMENT OF THE ARMY

DETROIT DISTRICT, CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231

REPLY TO
ATTENTION OF

28 OCT

Design Branch

SUBJECT: Two Memoranda Concerning the Midland Nuclear Power Plant

Mr. George Lear
U.S. Nuclear Regulatory Commission
Chief, Hydrologic and Geotechnical Engr Br
Division of Engineering
Mail Stop P-214
Washington, D. C. 20555

Dear Mr. Lear:

Attached are two memoranda providing Corps of Engineers comments regarding the recent controversy over the structural adequacy of the Diesel Generator Building (D.G.B.). These memoranda are Midland Nuclear Power Plant, Midland, Michigan dated 28 September 1983 and Applicant's Proposed Finding of Fact and Conclusions of Law on Remedial Soils Issues-Midland Nuclear Power Plant, Midland, Michigan.

Sincerely,

Enclosures

G. Emore for
P. McCallister, P. E.
Chief, Engineering Division

XE02
1/1

NCDED-G 28 September 1983

SUBJECT: Midland Nuclear Power Plant, Midland, Michigan

TO: File

FROM: H.N. Singh

1. The controversy over the structural adequacy of the Diesel Generator Building (DGB) of the Midland Nuclear Power Plant led the formation of an Independent Review Committee of four experts by the Nuclear Regulatory Commission.

2. Pursuant to an interagency agreement between the U.S. Army Corps of Engineers (the Corps) and the U.S. Nuclear Regulatory Commission (NRC), which became effective in September 1979, we have reviewed the geotechnical aspects of the Midland Nuclear Power Plant, and have concluded that the DGB has not been correctly analysed (H.N. Singh's testimony of 10 December 1982 before the U.S. Atomic Safety Licensing Board, ASLB). Therefore, the Corps is not in a position to certify the adequacy of the structure.

3. The NRC geotechnical experts have also concluded that the effects of the foundation settlement have not been considered in the analyses, therefore, the structural analyses performed by the Consumers Power Company (CPCO) are not appropriate. Dr. R. B. Landsman of the NRC Region III office has testified to this aspect before the Congressman Udall's subcommitte, and before the ASLB. Mr. J. D. Kane, Principal geotechnical Engineer of the NRC also expressed his concern before the ASLB hearing on 10 December 1982.

4. On 8 September 1983, I was called upon by the newly formed Independent Review Committee to apprise the committee of the Corps' concerns regarding the DGB.

5. I informed the Committee that the details of my concerns are provided in my testimony of 10 December 1982 before the ASLB, and in the Corps' report of 7 July 1980, and 16 April 1981. An abstract of the Corps' concerns are:

a. The CPCO has not considered the effect of differential settlement of the DGB in structural analyses.

b. The DGB has numerous cracks on its walls. These cracks have reduced the rigidity of the structure, therefore, the effects of cracking must be considered in structural analysis.

c. CPCO method of computing stresses in the reinforcing bars on the basis of the crack width is not appropriate.

6. A list of concerns resulting from the review of the CPCO's "Proposed Findings of Fact and Conclusions of Law in the Midland Proceeding" is inclosed.

H N Singh.

H. N. Singh, PESE
Lead Reviewer
Midland Nuclear Power Plant

NCDED-G

SUBJECT: Applicant's Proposed Findings of Fact and Conclusions of Law on Remedial Soils Issues - Midland Nuclear Plant, Midland, Michigan

The Corps of Engineers has reviewed the subject report. The following are the comments:

1. Para. 91: The main reason for uneven settlement of the Diesel Generator Building (DGB) is variable soil stiffness resulting from poorly compacted soil. No doubt, the duct banks did contribute to unequal settlement in the beginning, but there has been significant uneven settlement subsequent to their release from the walls in December, 1978.

2. Para. 92: The major cracks in the east wall of the DGB developed subsequent to the release of the duct banks from the building. The number of cracks prior to the release of the duct banks are shown in Attachment #2 of the original testimony of H. N. Singh. This attachment shows only 10 cracks on the east wall, but today there are 16 cracks on the wall.

3. Para. 92: The settlement of the D.G.B. after the release of the duct banks is not uniform as claimed by the Applicant in the last sentence of this paragraph. As shown in Attachment No.-2 (Fig-2) of the testimony of Mr. H. N. Singh, there has been considerable differential settlement after the release of the duct banks.

4. Para. 93: The settlement of the D.G.B. during the surcharge has created many cracks, (Singh's original testimony Q-9). On the east wall, the number of cracks increased from 10 to 16. Therefore, the surcharge did reduced the structural integrity of the D.G.B. The Applicant has not considered the settlement in his structural analyses (Singh testified before ASLD on 10 Dec 1982 to this aspect), and has not been able to demonstrate the adequacy of the D.G.B.

5. Para. 95: Partially saturated soil will not consolidate as saturated clay as claimed by the Applicant in this paragraph. The Corps of Engineers' concern as to this matter was communicated to the Applicant through the Corps' report of 7 July 1980 para. 63(a).

6. Para. 96,97, 98: We do not understand the intent of providing the contents of these three pargraphs. The matter described is well-known. Every soil engineer knows when primary consolidation is completed, and the secondary portion of consolidation continues as a straight line when plotted on logarithimic time scale.

7. Para. 99: Surcharging of a completed or partially completed structure is not a well established and widely accepted technique as claimed by the Applicant in this paragraph. A number of precedents described in Dr. Peck's testimony are nothing but surcharging of foundations; the portions of structures which are

affected by the differential settlement were not completed. The case of the D.G.B. is entirely different, where almost entire structure was completed during the surcharge. Therefore, surcharging has created major structural distress in different parts of the building.

8. Para. 102: The surcharge did not produce adequate stresses in the foundation soils to negate the effect of future loads (dewatering etc.) on the settlement. This has been substantiated by the excessive measured settlement after the plant area was dewatered to elevations less than 595.

9. Para. 103: It is not a sound engineering practice to cast concrete, when the structure is moving (settling). The Applicant's decision to cast concrete during the surcharge does not comply with the sound construction practices.

10. The piezometer readings and the shape of the consolidation curves did not confirm that all the excessive pore pressures were dissipated. The reasons are given in the Corps of Engineers report of 16 April 1981 (Question Nol 40).

11. Para. 106: To limit the accuracy of survey instruments (transit) to 1/8" is too high to be realistic. The normal measuring devices in leveling instruments can read up to 1/1000 of a foot, therefore, it appears that Applicant's settlement measuring method was not appropriate. Further, the error in measurement can be either plus or minus resulting in uncertainty in the measured settlement. In such case, to insure safety of the structure, it is reasonable to use higher values of settlement. The Applicant's method of computing settlement and creating error band of 1/4", and neglecting the differential settlement for computing stresses are not appropriate.

12. Para. 107: It is not known how the observations of the borros anchors would improve the precision of the data obtained. The data from borros anchors are more susceptible to errors than the reading on the markers which were located at the fixed points on the walls of the D.G.B.

13. Para. 112: Although, the pond level was raised to elevation 627.00, there is no evidence that water level below the D.G.B. rose above elevation 622.0 (Corps' report of 16 April 1981, see piezometer 12, 17, 23, 25, 29, 34, 36, 40, and 43).

14. Para. 114: The primary consolidation under the D.G.B. was not completed at all the points (Singh testified before ASLB on 10 Dec 1982 on this aspect) as claimed by the Applicant.

15. Para. 117: The foundation of the D.G.B. did not remain in plane after the removal of the surcharge. There has been considerable warping of the structure during and subsequent to the removal of the surcharge (see Singh's original testimony).

16. Para. 121: The reduction in stresses due to the surcharge removal did not exceed the stresses due to the added loads. For example the dewatering has added so much stress in excess of the surcharge stress that the foundation soils started showing primary consolidation.

17. Para. 125: The settlement due to the dewatering is primary settlement. I don't know when and how Dr. Peck added this settlement to the secondary settlement. It should be the part of the primary settlement. Part of this might be compensated by the additional settlement for continuing the surcharge load which has been included in the total predicted settlement. But definitely it has not been included in the secondary settlement.

18. Para. 130: There is no justification for correcting the measured settlement the way the Applicant has done. Applicant has consistently made unjustified corrections to reduce the differential settlement in the structure. If there are errors in survey, there is possibility that corrections might increase the settlement. But the Applicant's corrections have always reduced the settlement.

19. Para. 131: Dr. Peck's conclusion that piezometer observations are prone to anomalies is correct. But in the case of Midland Plant, a substantial number of piezometers consistently showed that pore pressures under the D.G.B. have not been completely dissipated. Hence taking advantage of anomalies to justify an incorrect result is not appropriate.

20. Para. 132: Dr. Peck's calculations of permeability are based on many questionable assumptions. Therefore, there is no merit in the values of the permeability calculated.

21. Para. 135: Dr. Peck's conclusion in para. 135 is not appropriate. In case of future cracks, a redistribution of stresses will take place, and the soil which was bridged by the structure before cracking will be subjected to more loading, causing additional settlement and more stresses in the structure.

22. Para. 138: I do not know whether Licensing Board has agreed with Peck's and Hendron's conclusions.

23. Para. 147: Dr. Peck's and Hendron's conclusion that the structural integrity of the structure has not been impaired is not correct. Mr. Singh has already shown in his original testimony that number of cracks on the east wall has increased from 10 to 16 after the surcharge. The curvature of the structure has considerably increased after the surcharge. This is a clear indication that stresses in the structure had increased to such a level due to the surcharge that numerous new cracks developed. Further the analysis of the D.G.B. structure due to settlement is incorrect. Differential settlement of the structure has not been considered in the evaluation of the stresses. Also numerous cracks which have developed due to the settlement have been ignored for the purpose of stress evaluation.

24. Para. 150, 151: The soil spring constant used in the analysis is not appropriate. Bechtel did not consider the correct values of spring constant.

NCDED-G
SUBJECT: Applicant's Proposed Findings of Fact and Conclusions of Law on Remedial Soils Issues - Midland Nuclear Plant, Midland, Michigan

25. Para. 154: It is clear from the east wall that all the cracks which are inclined and have developed after the release of the duct banks are shear cracks. These cracks have bent towards south, indicating shear stree due to excessive settlement at the southeast corner.

26. Para. 166. The error band created by the Applicant is not justified. The ASLB has been informed by Mr. Singh and Mr. Kane on 10 December 1982 regarding this fact.

27. Para. 168: Dr. Corley was wrong in making the statement that there is no evidence in the structure of any other hard spot. I do not know what is the basis of his conclusion. There are evidences of large cracks on the east wall which occurred after the release of the duct banks. This clearly establishes that these large shear cracks have occurred following the settlement of the southeast corner. Further, settlement patterns developed after the release of the duct banks clearly indicate that there are many soft spots under the D.G.B. Further, the variation made in the spring constant over a 15' length was not adequate to reflect the softness of the large area under the foundation.

28. Para. 169: No cracks have been considered in the analysis.

29. Para. 170: If the Applicant can not analyse the structure correctly, that does not mean that he will perform incorrect analysis to justify the adequacy of the structure. Obviously, all of the Applicant's analyses are erroneous. If the structure can not be correctly analyzed, that is not a justification to declare it structurally adequate.

Hn Singh.

H. N. SINGH, P.E.S.E.
NCDED-G
Lead Reviewer
Midland Nuclear Plant

Enclosure 3

D. Hood
116

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

NOV 18 1983

MEMORANDUM FOR: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

THRU: Lyman W. Heller, Leader
Geotechnical Engineering Section
Structural and Geotechnical Engineering Branch
Division of Engineering

FROM: Joseph Kane, Sr. Geotechnical Engineer
Geotechnical Engineering Section
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: COMMENTS ON OCTOBER 21, 1983 REPORT BY INDEPENDENT TASK GROUP REVIEW OF THE DGB AT THE MIDLAND PLANT

In response to your verbal request, I have enclosed my review comments on the October 21, 1983 report by the Independent Task Group which was formed to evaluate the concerns expressed by R. B. Landsman of Region III for the Diesel Generator Building.

It is my understanding that my review comments will ultimately be considered in OELD deliberations as to whether it is necessary for NRC to request reopening of the ASLB hearings on the DGB. The general guidelines provided by OELD relative to their decision which I have used in identifying the potential hearing considerations are the following:

1. Does the issue which I have identified in the Independent Task Group report provide new evidence that affects or modifies the hearing record evidence?

2. Are the facts or expert opinions which are expressed in the Independent Task Group Report significant and different from the facts or expert opinions that are now in evidence before the Licensing Board which could affect a conclusion with respect to the structural adequacy of the DGB?

3. Although the information from the Independent Task Group report does not change the Staff conclusion with respect to the DGB - in "fairness to the Board" should the Board have the benefit of reviewing the evidence in the report in order to reach its conclusion?

Dupe ~~8312070026XA~~

On the basis of my review of the Independent Task Group report and my comparison with the guideline provided by OELD, I have provided my comments in Enclosure 1.

Joseph Kane, Senior Geotechnical Engineer
Geotechnical Engineering Section
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosure:
As stated

cc: w/enclosure
R. Vollmer
J. Knight
T. Novak
L. Heller
P. Kuo
T. Sullivan
E. Adensam
D. Hood
W. Paton, OELD
M. Wilcove, OELD
F. Rinaldi
H. Singh, COE
J. Kane

Subject: Review Comments on October 21, 1983 Report by Independent Task Group on the DGB
Plant: Midland Plant Units 1 and 2, 50-329/330
Prepared by: Joseph Kane, NRR, DE, SGEB

1. A. Potential Hearing Consideration - There are statements in the Independent Task Group report on the completeness and accuracy of available settlement data and history that are in conflict with the previous testimony of reviewers from the NRC geotechnical engineering staff and the Corps of Engineers. The specific areas of the report are:

   a. Group Report, Pg. 6. "a complete and accurate settlement history does not exist."

   b. Group Report, Pg. 12. "there are no such detailed settlement measurements available, especially for the early stages of construction."

   c. Group Report, Pg. 15. "Given the unavailability of the data necessary to complete the input to the analysis by the staff's consultant. the previously stated staff position is reasonable."

   d. Group Report, Pg. 20. "However, such settlement history for the DGB does not exist."

   e. Group Report, Pg. 21. "Inconsistencies in the documentation of the settlement history needs to be resolved."

   f. Appendix III, Pg. 5. "However, it should be mentioned that the exact settlement history at the various settlement markers at the DGB is open to question." (Reasons for this statement are subsequently given).

   g. Appendix III, Pg. 7. "These analyses, though different in detail, lead to the similar conclusion that the settlement measurements were (and continue to be) in significant error."

   h. Appendix III, Pg. 8. "The first period (where measured settlements are being used to compute stresses) spans from the beginning of construction through August 1978 at which time construction was halted."

   i. Appendix III, Pg. 17. "However, it is recommended that the anomalies in the documentation of the settlement history be resolved" (Last paragraph of App. III, Section 2.2).

   These nine statements are in conflict with SSER No. 2, pg. 2-33 and the testimony of J. Kane and H. Singh during the week of December 6 - 10, 1982.

B. Applicable OELD Guidelines - Guidelines Nos. 1, 2 and 3

C. Basis for Identifying Issue As Potential Hearing Consideration - Because the nine identified statements in the Independent Task Group report raise questions with respect to the completeness and accuracy of the DGB settlement history and because this is in conflict with previous Staff testimony, the hearing record has become unclear and confusing. Also item i. in the above identified statements appropriately recommends that these anomalies be resolved. In my opinion all three of the guidelines identified by OELD would apply when considering the need to reopen the hearings in order to straighten out the hearing record on this issue.

2. A. Potential Hearing Consideration. At this particular time there are questions and significant doubts as to the defensibility of NRC position in concluding there is reasonable assurance that the structural integrity of the DGB will be maintained and its functional requirement fulfilled (See October 21, 1983 memo from P. T. Kuo to J. P. Knight, pg. 1; Group Report, pg. 21, Conclusion no. 5; App. III, pg. 17, Conclusion no. 6). The questions and doubts result from the following items in the Independent Task Group report:

a. The report in several locations identifies the need for the Applicant and the NRC staff to properly document the information and calculations for crack width approach for all DGB walls in order for the stresses that are induced by settlements to be known and evaluated. (See October 21, 1983 memo, pg. 2, item 3; Group Report, pgs. 16 and 21, item 2; App. III, pgs. 11, 16, 17 item 2).

b. Closely related to this issue is the report's acknowledgement that the crack method approach is questionable where relatively few cracks occurred (App. III, pg. 11) and the absence of written justification in the FSAR for using this approach for structures like the DGB (App. III, pg. 16).

c. In addition the report in several locations points out the inadequacies of the present crack monitoring program and the need for improvement (Group Report, pgs. 17 and 21 item 4; App. III, pgs. 13, 16 and 17) and the need to establish action levels (Oct. 21, 1983 memo, pg. 2 item 5; App III, pgs. 16 and 17 item 4).

d. The NRC Staff position on DGB acceptability uses the crack width approach to estimate settlement induced stresses and this position is heavily dependent on the accuracy of available crack maps. In several locations in the Task Group report, the reliability and accuracy of presently available crack maps are questioned and the Group report cites concern that cracking in the DGB has not stabilized and the cracks are growing (See Oct. 21, 1983 memo, pg. 2 item 4; App. III pgs. 6, 7, 13 and 17 item 3). In my opinion it will be necessary to obtain and use more recent and accurate crack maps of the DGB before the recommendation of the Task Group can be followed for establishing crack width levels that will reflect a sufficient stress margin available to resist critical load combinations (October 21, 1983 memo, pg. 2 item 5).

B. Applicable OELD Guidelines. Guideline Nos. 1, 2 and 3.

C. Basis for Identifying Issue As Potential Hearing Consideration. For the NRC staff to have a reasonable and defensible position in judging the adequacy of the DGB there is a need to have a good data basis. The Task Group report, as indicated by the above comments, correctly points out that at this time we do not have that basis. The report provides some specific recommendations that should be followed in order to reach the needed sound engineering basis. Both the Board and the public have already asked what is the NRC Staff response to the report's recommendatiors and will want to know what significant information is developed in carrying out these recommendations. For these reasons I believe all three of the guidelines provided by OELD apply and would be the basis for reopening the hearing on the DGB.

3. A. Potential Hearing Consideration. The Task Group report in many locations discusses the controversial finite element analysis completed by the Applicant where the measured/predicted displacements were "straight lined" which essentially disregards any effect of differential settlement. (See Group Report, pgs. 7, ?0 item 1; App. III, pgs. 9 and 14). In the Dec. 6 through 10, 1982 hearing sessions this issue was extensively discussed and reflected significant differences in professional opinions that has left the hearing record unclear and unresolved. The statements in the Task Group report on this controversial subject are very specific and clear "that this model (the Applicant's) will yield unconservative estimates of stresses." (App. III, pg. 9, 2nd par.) and "We therefore conclude that this approach to compute settlement stresses is inappropriate." (App III, pg. 9) and 'The straight line representation of the settlements along the north and south wall for the analysis reported in 2.4.1 is said to be in error. As indicated in that section of this report, it is our opinion that this analysis will result in unconservative predictions of stresses due to settlements. As such, it is considered to be an inappropriate analysis." (App. III, pg. 14, 2nd par.).

B. Applicable OELD Guidelines. Guideline Nos. 1, 2 and 3.

C. Basis for Identifying Issue As Potential Hearing Consideration. In my opinion the presently conflicting evidence before the Board on this issue is significantly impacted by the Task Group's findings. I believe the clear engineering explanation provided in the report's statements on why this analytical approach is not appropriate would be helpful to the Board in assisting them to reach a decision on this issue.

4. A. Potential Hearing Consideration. A previously identified concern expressed by J. Kane (Oct. 24, 1983 memo, G. Lear to W. Paton on the Applicant's Proposed Findings, pg. 12, item 61) with the results of the Naval Surface Weapon Center (NSWC) study is also impacted by the Task Group's report. Although the Task Group in App. III, pg. 10 questions the value of the NSWC conclusions because of the apparent linear assumption of settlement data points made in the study, the report by the Group reflects an influence of the NSWC results by referencing the important conclusion by the NSWC study - that very high stresses are calculated in areas of the DGB where no cracks now exist. (See Group Report, pgs. 8 and 20 item 1; App. III pgs. 14 and 15). This NSWC conclusion is seriously questioned when a comparison is made of the computed areas of high stress with areas of recorded cracking (See enclosure tables to Oct. 24, 1983 memo). When the internal walls of the DGB are evaluated for computed areas of high stress with areas of recorded cracking, it can be shown that cracks appear in 94 percent of the locations where the NSWC study has computed high stresses.

B. Applicable OELD Guidelines - Guidelines Nos. 1, 2 and 3.

C. Basis for Identifying Issue As Potential Hearing Consideration. Both the Task Group report and the present hearing record offer the conclusion by the NSWC study that cracks do not appear in areas of computed high stress, thereby indicating that the settlement values more than likely were not seen by the structure. This NSWC conclusion is incorrect and this issue has not yet been brought to the Board's attention. It is quite likely that the Board would place significant reliance on the NSWC conclusion, if left uncorrected, in reaching its decision with respect to the safety of the DGB. For these reasons I feel it should be brought to the Board's attention.

5. There are less important considerations affected by the information within the Independent Task Group report, that would not require reopening of the DGB hearing, but which would be helpful to the Board if addressed, since they are related to previous testimony. These items are:

   a. Group Report, pgs. 3 and 4. The implication that surcharging the completed DGB structure relieved it of stress.

   b. App. III, pg. 5. The questionable significance of the piezometer data during surcharging.

   c. App. III, pg. 12. The statement that serious structural distress was caused by the very large settlements at the DGB.

   d. App. III pgs. 12 and 13. The need to improve the accuracy of future settlement monitoring at the DGB and to require better methods for monitoring crack growth with reliable strain gages.

Enclosure 4

D. Hood
116

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

NOV 18 1983

MEMORANDUM FOR: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

THRU: Pao-Tsin Kuo, Leader
Structural Engineering Section B
Structural and Geotechnical Engineering Branch
Division of Engineering

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

SUBJECT: EVALUATION OF EVIDENCE ON DIESEL GENERATOR BUILDING - MIDLAND PROJECT FOR DETERMINATION OF NEED TO REOPEN HEARINGS

Pursuant to your request of November 8, 1983, for my evaluation of any new evidence related to the structural adequacy of the Diesel Generator Building (DGB), I have evaluated the report by the NRR Task Group dated October 21, 1983, for the test conditions provided by your management (Enclosure 1) and expanded by the staff attorney (Enclosure 2).

Foremost, I like to state that the NRC staff decision to reopen the hearings on the DGB lies on the NRC legal staff. The NRC legal staff is aware of the official staff position and personal technical positions of staff members and consultants, as stated in written and oral testimony during the ASLB hearing of December, 1982. In addition, the NRC legal staff is aware of the questions raised by the Region III-IE inspector as well as the answers provided by all concerned parties. Indeed the NRR Task Group Report of October 21, 1982, documents the conclusions, discussions, and specific answers to the questions raised by Region III-IE inspector. The NRR Task Group report includes their findings, those of their consultant staff from Brookhaven National Laboratory (BNL), as well as the replies by NRR Structural and Geotechnical staff and their consultants to the questions raised by the Region III-IE inspector. Please note that errata has been pointed out to the Task Group. The need for corrections has been acknowledged by the Task Group and errata pages have been issued.

Recognizing the fact that my recommendations on the subject of reopening the hearing for the DGB are needed for the final decision making, I will identify the important facts stated by the Task Group and state if they constitute, from the structural engineering point of view, new evidence or if they impact on the previous conclusions reached by the structural engineering staff. The major points are the following:

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1. The Task Group used the same facts and evidence used by the review staff in their evaluation of the DGB.

2. The Task Group reached the same bottom line conclusion, "that there is reasonable assurance that the structural integrity of the DGB will be maintained and its functional requirements fulfilled."

3. The Task Group concluded that, "The most reasonable estimate of stress due to settlement is based on the crack width data. However, the calculations that have been done in this area need to be completely documented."

4. The Task Group stated, "That a more accurate and reliable crack monitoring program be established," and that sufficient stress margins for Action Level and specific repairs be established for Alert Level of crack/s width/s. Also, they recommended a general repair program prior to plant operation.

The first two items are self-explanatory and from a structural engineering technical point of view should be the major reasons that no additional hearings are required to establish the structural adequacy of the DGB. The third item asks for the documentation of the calculations used in the determination of the conservative stress values utilizing the crack width data. The approach has been discussed, the results have been documented, and the data used for the calculations has been identified. Therefore the requested documentation will consist of nothing more than presenting the information related to the assumptions made, formula used, input data, calculations, and results. The actual calculations require basic skills and engineering judgment. The resulting stress values can be easily verified with the stress results identified in the written and oral testimony of the applicant and the staff. I do not consider this documentation to be new evidence because the facts do not change. The fourth item recommends a modification to the monitoring program previously proposed by the applicant and accepted by the staff and a general repair program. The Task Group does not provide specific approaches that would fulfill these recommendations. BNL report recommends the extensive use of Whitmore strain gages in place of the three crack monitoring windows currently accepted by the staff, but recommends the same general approaches as the Task Group for requirements on the general repairs and the requirements on the Alert and Action Levels. The Task Group was aware of the BNL recommendation related to the Whitmore strain gages, but did not make such firm recommendation. The above stated facts lead me to the conclusion that the Task Group is leaving the structural review staff and the applicant with the task of resolving these concerns.

I conclude from my review of the Task Group report that the NRC staff needs to start discussions with the applicant concerning the documentation of the rebar stresses as determined from all available crack-width data, the usefulness and effectiveness of the strain gages proposed by BNL, and if more specific actions should be established now, or as results of meetings with the applicant after the alert and/or action levels are reached. The applicant has contracted with Portland Cement Association (PCA) to review and evaluate all field data (cracks and deflections) to evaluate potential and specific problems identified by the monitoring program. The staff was relying on this independent monitoring and evaluation by PCA in the acceptance of the monitoring requirements.

I understand the fact that some people may not fully understand the structural engineering technical aspects of this case and may consider the availability of any new document as solid ground for reopening the hearings on the DGB. However, based on the fact that no new evidence was uncovered in the preparation of the conclusions of the Task Group, that the structural adequacy of the DGB was assured, and that no specific detailed recommendations were made other than generic suggestions which the staff can request the applicant to resolve and then inform the board of the resolutions; I do not recommend, from the structural engineering technical point of view, to reopen the hearing on the structural safety of the DGB.

Frank Rinaldi

Frank Rinaldi, Structural Engineer
Structural Engineering Section B
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosures:
As stated

cc: R. Vollmer
J. Knight
T. Novak
T. Sullivan
E. Adensam
D. Hood
W. Paton
P. Kuo
L. Heller
J. Kane
G. Harstead
J. Matra
F. Rinaldi

Test to apply in deciding whether to recommend that the hearing be reopened.

- Is there new evidence that modifies the evidence of record? For example, does the new evidence affect what was said by the witnesses (any or all) in such a way that something different would have been said if the information had been available before the testimony was given?

- The issue is one of "fairness to the board". If our feeling is that the evidence would not change our conclusions but that the board nevertheless, should have the benefit of reviewing this new evidence to reach its conclusions, then we should recommend for reopening the record.

ENCLOSURE 1

Are the facts or expert opinions in the DGB Task Report that are different from facts or expert opinions now in evidence before the Licensing Board. (The facts and expert opinions referred to are significant facts and expert opinions, i. e. - facts and expert opinions that could effect a conclusion with respect to the structural adequacy of the Diesel Generator Building)

ENCLOSURE 2

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

November 21, 1983

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: The Atomic Safety and Licensing Board for the Midland Plant, Units 1 and 2

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: BOARD NOTIFICATION REGARDING MIDLAND AUXILIARY BUILDING UNDERPINNING (BN 83-174)

This Notification is provided in accordance with NRC procedures regarding Board Notifications and is deemed to provide new information material and relevant to safety issues in the OM-OL proceeding. On September 14 and 15, 1983, the NRC and its consultants audited revised calculations for the design adequacy of the Midland Auxiliary Building reflecting the results of an underpinning pier load test. The test results had indicated that the soil modulus for the base of the underpinning should be 1500 KSF rather than the 3000 KSF used in the original analysis; thus, Bechtel revised its structural analysis using ½" of settlement rather than ¼". The audit meeting was summarized by R. Warnick's letter of October 5, 1983, and copies were provided to the ASLB and hearing parties. During the course of this audit, the NRC received additional information which calls into question the validity of the assumptions upon which the staff's acceptance of the underpinning design was based. The additional information is reflected in paragraphs d, e and g of R. W. Warnick's memorandum of October 11, 1983 (Enclosure 1). The information concerns (1) the manner in which differential settlement has been applied in the applicant's structural stress calculations, (2) the absence of limits for upward movement of the structure during jacking operations, (3) the acceptability of the actual measured upward movement due to jacking, and (4) the extent to which settlement stresses can be jacked out of the completed structure.

Paragraph d of Enclosure 1 notes that the stress calculations for ¼" of differential settlement at the southern edge of the Control Tower results from a settlement gradient that begins at the center of the main Auxiliary Building, rather than a point at the northern edge of the Control Tower. Application of the ¼" gradient over this longer distance is inconsistent and non conservative with respect to the prior review performed by the staff which led to acceptance of the ¼" differential settlement in Supplement 2 to the SER, page 2-40. The staff is presently evaluating the effects of this recent information and believes a solution can be reached by establishing a future differential settlement limit in the Technical Specifications that will be based on field monitoring records. The limit to be established will assure the integrity of the involved structures.

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Paragraphs e and g of Enclosure 1 call into question 1) what should be the upward movements of the structures during jacking operations and 2) whether or not the stresses due to settlements prior to and during underpinning construction can be completely jacked out of the completed structure. With respect to the upward movements, the staff understands that the east EPA has been jacked to 91 mils of upward movement and the west EPA has been jacked to 70 mils. Upward movement in excess of 30 mils has not been reviewed by the staff. On the issue of stresses due to settlement, and underpinning operations, the allowable jacking loads are limited by a concern for redistribution of stresses following upward movement of the structures. The applicant's analysis, relied upon by the staff, assumed no significant residual stress due to earlier settlements for the completed underpinned structure and, therefore, may not be sufficiently conservative. We understand that Region III has verbally imposed a hold on further jacking in excess of that previously reviewed by the NRC staff pending establishment of allowable jacking limits.

The issues associated with this and other information from the September design audit are presently being reviewed by NRR in accordance with R. Warnick's request by Enclosure 1. The staff's response to Enclosure 1, once available, will be provided to the Board.

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Attachment:
R. Warnick memo dated October 11, 1983.

cc: See next page

DISTRIBUTION LIST FOR BOARD NOTIFICATION

Midland Units 1&2,
Docket Nos. 50-329/330

Charles Bechhoefer, Esq.
Ms. Lynne Bernabei
Lee L. Bishop, Esq.
James E. Brunner, Esq.
Dr. John H. Buck
Myron M. Cherry, P.C.
Dr. Frederick P. Cowan
T. J. Creswell
Steve J. Galder, P.E.
Dr. Jerry Harbour
Mr. Wayne Hearn
Mr. James R. Kates
Frank J. Kelley, Esq.
Christine N. Kohl, Esq.
Mr. Howard A. Levin
Mr. Wendell H. Marshall
Michael I. Miller, Esq.
Thomas S. Moore, Esq.
Mr. Paul Rau
Ms. Mary Sinclair
Ms. Barbara Stamiris
Frederick C. Williams, Esq.

Atomic Safety and Licensing Board Panel
Atomic Safety and Licensing Appeal Panel
Docketing and Service Section
Document Management Branch

ACRS Members

Dr. Robert C. Axtmann
Mr. Myer Bender
Dr. Max W. Carbon
Mr. Jesse C. Ebersole
Mr. Harold Etherington
Dr. William Kerr
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Dr. J. Carson Mark
Mr. William M. Mathis
Dr. Dade W. Moeller
Dr. Milton S. Plesset
Mr. Jeremiah J. Ray
Dr. David Okrent
Dr. Paul C. Shewmon
Dr. Chester P. Siess
Mr. David A. Ward

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Enviornmental Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission, Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

ATTN: Clyde Herrick
Frenklin Research Center
20th & Race Streets
Philidelphia, Pennsylvania 19103

Mr. Patrick Bassett
Energy Division
Norwest Bank Minneapolis, N.A.
8th and Marquetts
Minneapolis, MN 55479

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

OCT 1 1 1983

MEMORANDUM FOR: D. G. Eisenhut, Director, Division of Licensing, NRR

FROM: R. F. Warnick, Director, Office of Special Cases

SUBJECT: NRC AUXILIARY BUILDING AUDIT

On September 14 and 15, 1983, an NRC team comprised of Messrs. J. Kane and F. Rinaldi of NRR; Mr. R. Landsman of RIII and Consultants S. Poulous and G. Harstead, audited the licensee reanalysis of the Midland Auxiliary Building. This audit was performed at the Bechtel Office in Ann Arbor, Michigan. As a result of the audit, the team identified several design concerns and issues requiring resolution. These are referred to the Office of Nuclear Reactor Regulation for action as appropriate.

a. The design of the remedial soils slab fix at Elev. 659 (i.e. the eye bars) was performed to ACI 318 and not to ACI 349. The acceptability of the licensee's decision to use ACI 318 in lieu of ACI 349 needs to be evaluated.

b. In view of the critical nature of the eye bars, the question arose as to the need for some type of monitoring on this fix (i.e. strain gages) due to the anticipated settlement over the life of the plant. Do monitoring requirements need to be imposed?

c. Because of the anticipated differential settlement expected to occur during the life of the plant, the control tower will be pulling away from the main auxiliary building. Has the mechanical branch determined that equipment between the two buildings can withstand this elongation?

d. The licensee performed an analysis on differential settlement of the buildings that was different from that which the NRC anticipated. The staff expected the differential settlement to be measured between the edge of the main auxiliary building and the edge of the control tower. In reality, the licensee performed an analysis using the center of the main auxiliary building as one point instead of the edge. Thus, for the requested 0.25" differential settlement analysis, the actual value was 0.17", and for the requested 0.50" differential, the actual value was 0.24". Is the licensee's analysis acceptable to NRR?

e. There appears to be a lot of confusion as to what upward building movements the licensee and NRC staff should allow during underpinning. What are the allowable upward movements during jacking operations?

f. The licensee stated that existing structures were analyzed according to ACI 318 as agreed to with NRR. The SSER #2 states that the buildings have been checked against ACI 349. Is this acceptable to NRR?

XA

XA Copy Has Been Sent to PDR

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g. The analysis of the existing structures has been performed by assuming that the existing settlement stresses will be removed during the permanent underpinning jacking. The audit team feels that the existing stresses cannot be jacked out in their entirety and must be included in the final analysis of the building. What is the NRC position in regards to including existing settlement stresses in the analysis?

Should you or members of your staff need additional information, please feel free to contact R. Landsman (388-5587).

RFWarnick

R. F. Warnick, Director
Office of Special Cases

cc: J. C. Stone, IE
E. G. Adensam, NRR
J. D. Kane, NRR
F. Rinaldi, NRR

13/B3

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MMiller

NOV 30 1983

Docket Nos.: 50-329
and 50-330

MEMORANDUM FOR: Darrell G. Eisenhut, Director
Division of Licensing

THRU: Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

FROM: Elinor G. Adensam, Branch Chief
Licensing Branch No. 4
Division of Licensing

SUBJECT: RE-OPENING THE HEARING AT MIDLAND ON THE DIESEL GENERATOR BUILDING

As indicated to you in my note of November 25, 1983, we told the Board at the last hearing session that by December 1, 1983, we would advise them whether or not we would move to re-open the hearing on the Diesel Generator Building. Based on our review of the criteria used (attached) by DE and provided by OELD, we would like to recommend that Division of Licensing support Vollmer's finding that the hearing be re-opened.

Your prompt consideration of this recommendation would be appreciated as we do need to respond to OELD promptly and we need to resolve any differences that may arise if you do not concur.

Elinor G. Adensam, Branch Chief
Licensing Branch No. 4
Division of Licensing

Attachment:
As stated

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

NOV 30 1983

Docket Nos.: 50-329
and 50-330

MEMORANDUM FOR: Darrell G. Eisenhut, Director
Division of Licensing

THRU: Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

FROM: Elinor G. Adensam, Branch Chief
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Division of Licensing

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Elinor G. Adensam

Elinor G. Adensam, Branch Chief
Licensing Branch No. 4
Division of Licensing

Attachment:
As stated

Test to apply in deciding whether to recommend that the hearing be reopened.

- Is there new evidence that modifies the evidence of record? For example, does the new evidence affect what was said by the witnesses (any or all) in such a way that something different would have been said if the information had been available before the testimony was given?

- The issue is one of "fairness to the board". If our feeling is that the evidence would not change our conclusions but that the board nevertheless, should have the benefit of reviewing this new evidence to reach <u>its</u> conclusions then we should recommend for reopening the record.

- Are the facts or expert opinions in the DGB Task Report that are different from facts or expert opinions now in evidence before the Licensing Board? (The facts and expert opinions referred to are significant facts and expert opinions, i.e., facts and expert opinions that could affect a conclusion with respect to the structural adequacy of the Diesel Generator Building.)

Midland
Aug 24-25, 1983
14/B3

MEETING SUMMARY DISTRIBUTION

November 1, 1983

Docket No(s): 50-329/330
NRC/PDR
Local PDR
NSIC
PRC System
LB #4 r/f
Attorney, OELD
E. Adensam
Project Manager MMiller/DHood
Licensing Assistant MDuncan

NRC Participants:

P. T. Kuo
M. Miller

bcc: Applicant & Service List

8311100111

November 1, 1983

Docket Nos: 50-329
and 50-330

APPLICANT: Consumers Power Company

FACILITY: Midland, Units 1 and 2

SUBJECT: SUMMARY OF TASK FORCE VISIT ON THE MIDLAND DIESEL GENERATOR BUILDING

On August 24 and 25, 1983, a task force consisting of NRC staff and its consultants from Brookhaven National Laboratory, visited Ann Arbor and the Midland site to obtain information related to rereview of the diesel generator building (DGB). The participants are listed in Enclosure 1.

The August 24, 1983, meeting was held in Ann Arbor and provided background information to the task force. Consumers and Bechtel representatives discussed design and construction of the DGB including the building's settlement. The remedial program was explained with detailed discussion of the surcharge, dewatering, and settlement monitoring efforts. The final meeting topic was the structural reanalysis performed on the DGB, particularly including details of the finite element analysis. CPCo consultants addressed cracking effects and concluded that the DGB cracks have no effect on the strength of the building. The agenda and meeting slides are provided as Enclosures 2 and 3, respectively. The Diesel Generator Building Executive Summary, distributed at the meeting, is included as Enclosure 4.

Late August 24, and August 25 was spent viewing the actual cracks in the building. Also, the applicant's crack maps were used by the task force to better see the crack pattern of the building.

/S/
Melanie A. Miller, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

DL:LB #4	DL:LB #4
MMiller/hmc	EAdensam
10/1 /83	10/1 /83

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PARTICIPANTS

DGB TASK FORCE

AUGUST 24 AND 25, 1983

NRC

P. T. Kuo*
M. Miller*

Brookhaven

A. Philippacopoulos*
C. Miller*
C. Costantino*
M. Reich*

Structural Mechanics Assoc.

R. Kennedy

Portland Cement Assoc.

G. Corley

TERA Corp.

H. Levin
J. Martore

Consumers

J. Schaub*
J. Mooney*
T. Thiruvengadam
K. Razdam
N. Ramanujam
E. Koepke*
F. Villalta
D. Budzik
M. Capicchioni**

Bechtel

N. Swanberg
M. Sozen
P. Shunmugavel
S. Afifi
T. Kumbier
D. Reeves
C. Dirnbauer
B. McConnell
D. Nims
G. Tuveson

*Attended both meeting and site visit
**Attended site visit only

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

November 1, 1983

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

APPLICANT: Consumers Power Company

FACILITY: Midland, Units 1 and ?

SUBJECT: SUMMARY OF TASK FORCE VISIT ON THE MIDLAND DIESEL GENERATOR BUILDING

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Melanie A. Miller

Melanie A. Miller, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

MIDLAND

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Michael I. Miller, Esq.
Ronald G. Zamarin, Esq.
Alan S. Farnell, Esq.
Isham, Lincoln & Beale
Three First National Plaza, 51st floor
Chicago, Illinois 60602

James E. Brunner, Esq.
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

Ms. Mary Sinclair
5711 Summerset Drive
Midland, Michigan 48640

Stewart H. Freeman
Assistant Attorney General
State of Michigan Environmental Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Wendell Marshall
Route 10
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Cherry & Flynn
Suite 3700
Three First National Plaza
Chicago, Illinois 60602

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

Mr. Steve Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Ms. Barbara Stamiris
5795 N. River
Freeland, Michigan 48623

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission, Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

cc: Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Mr. Howard Levin, Project Manager
TERA Corporation
7101 Wisconsin Avenue
Bethesda, Maryland 20814

Ms. Lynne Bernabei
Government Accountability Project
1901 Q Street, N.W.
Washington, D. C. 20009

Supplemental page to the Midland OM, OL Service List

cc: Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

Charles Bechhoefer, Esq.
Atomic Safety & Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Frederick P. Cowan
Apt. B-125
6125 N. Verde Trail
Boca Raton, Florida 33433

Jerry Harbour, Esq.
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Geotechnical Engineers, Inc.
ATTN: Dr. Steve J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

PARTICIPANTS

DGB TASK FORCE

AUGUST 24 AND 25, 1983

NRC

P. T. Kuo*
M. Miller*

Brookhaven

A. Philippacopoulos*
C. Miller*
C. Costantino*
M. Reich*

Structural Mechanics Assoc.

R. Kennedy

Portland Cement Assoc.

G. Corley

TERA Corp.

H. Levin
J. Martore

Consumers

J. Schaub*
J. Mooney*
T. Thiruvengadam
K. Razdam
N. Ramanujam
E. Koepke*
F. Villalta
D. Budzik
M. Capicchioni**

Bechtel

N. Swanberg
M. Sozen
P. Shunmugavel
S. Afifi
T. Kumbier
D. Reeves
C. Dirnbauer
B. McConnell
D. Nims
G. Tuveson

*Attended both meeting and site visit
**Attended site visit only

AGENDA

Enclosure 2

NRC PRESENTATION ON DIESEL GENERATOR BUILDING
August 24, 1983
Ann Arbor, Michigan

I. Background

A. Site Plan

B. Construction Milestones

C. General Layout of Diesel Generator Building

D. Original Design

II. Diesel Generator Building Construction History

A. Construction Sequence

B. Building Settlement

III. Remedial Program

A. Boring Program

B. Surcharge Program

C. Results of Remedial Program

IV. Structural Reanalysis

A. Analytical Techniques

B. Settlement Input

C. Imposed Loadings

D. Analytical Results

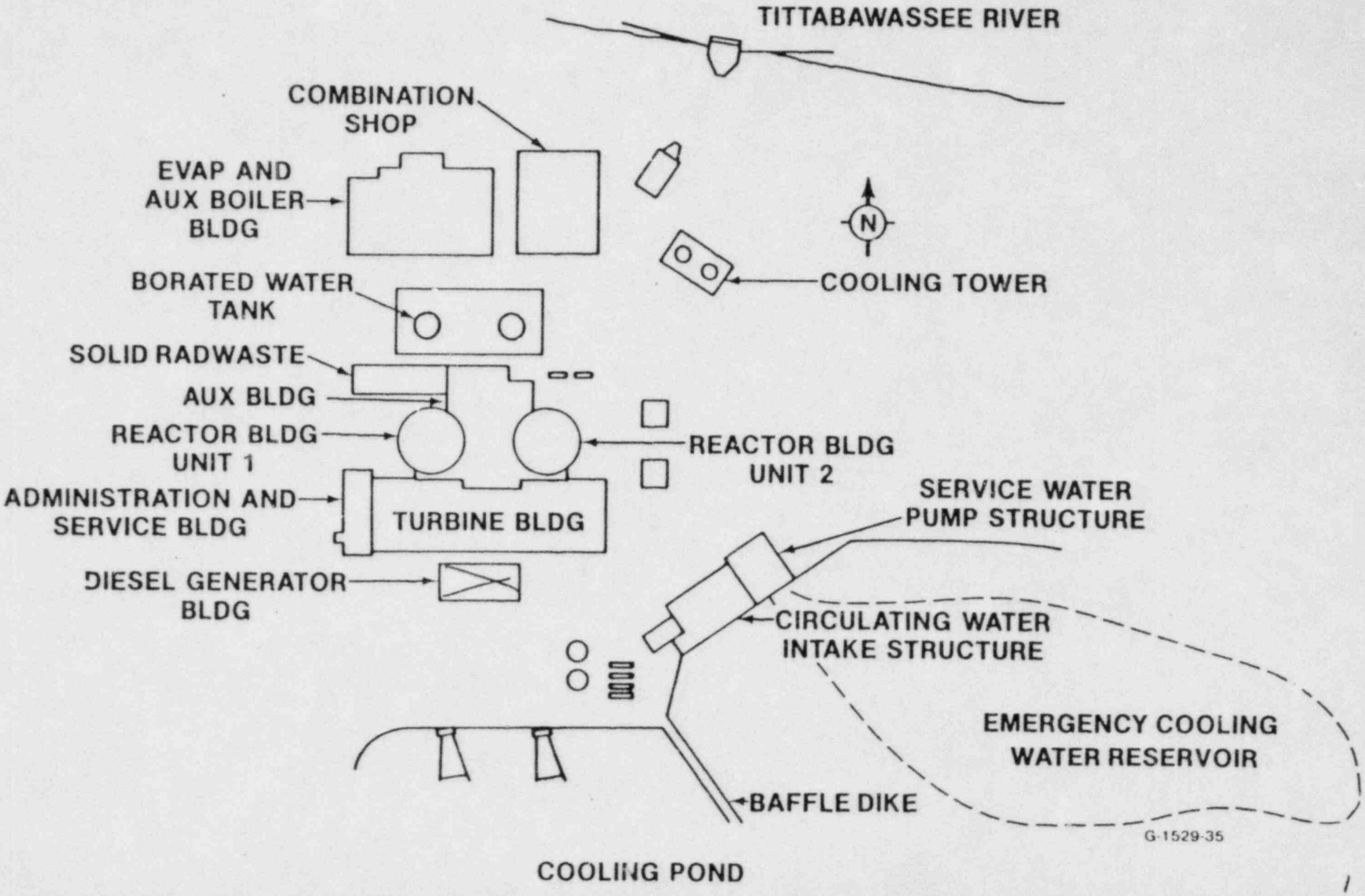
E. Effects of Cracking

F. Seismic Margin Review

V. Summary

ENCLOSURE 3

MIDLAND SITE PLAN



1

DIESEL GENERATOR BUILDING

- FOUNDED ON 30-FEET OF FILL

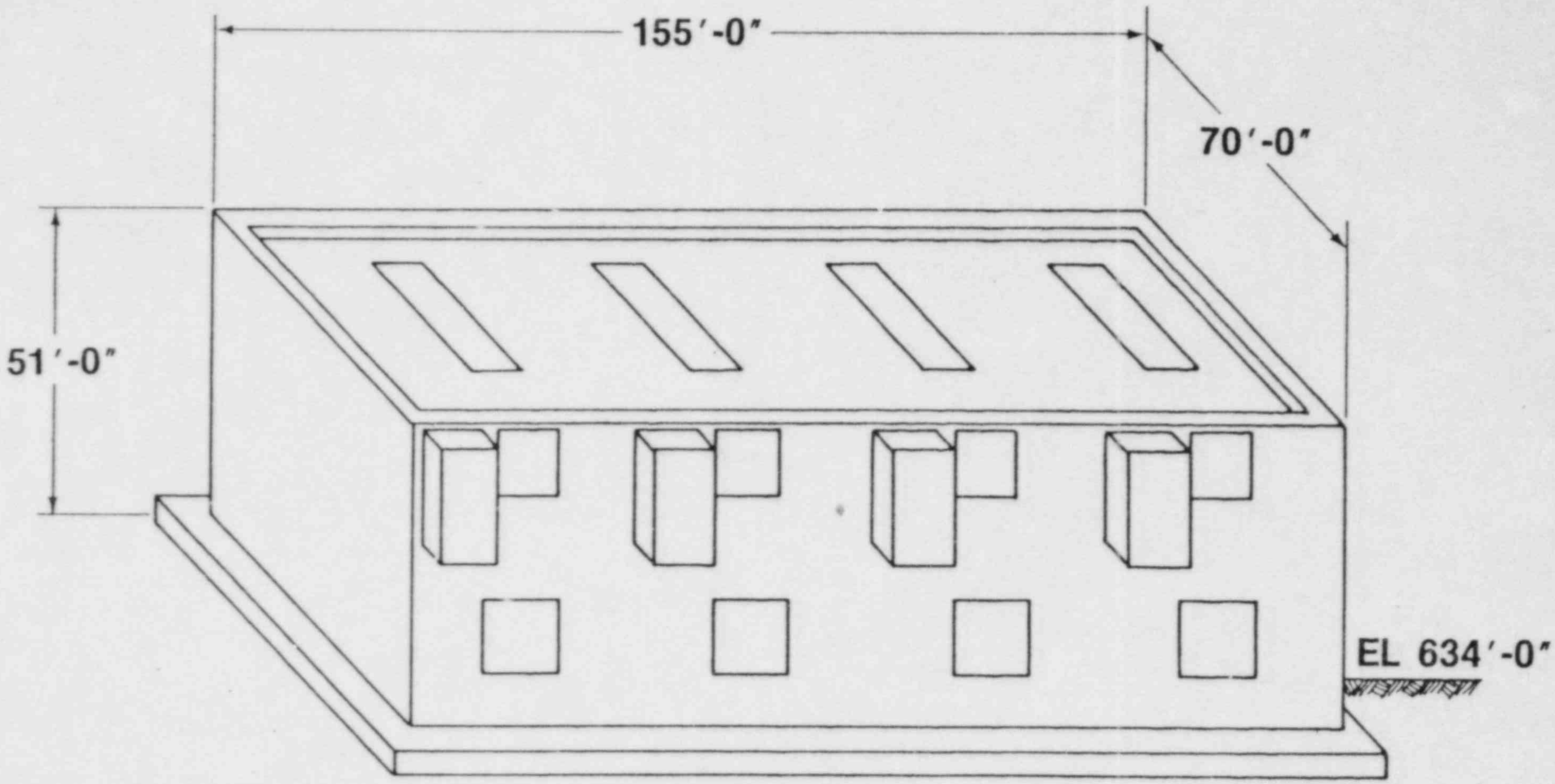
- FILL PLACEMENT FROM 1975 TO 1977

- CONSTRUCTION FROM SUMMER 1977 TO SPRING 1979

Tittabawassee 595

elevation of cooling pond 627

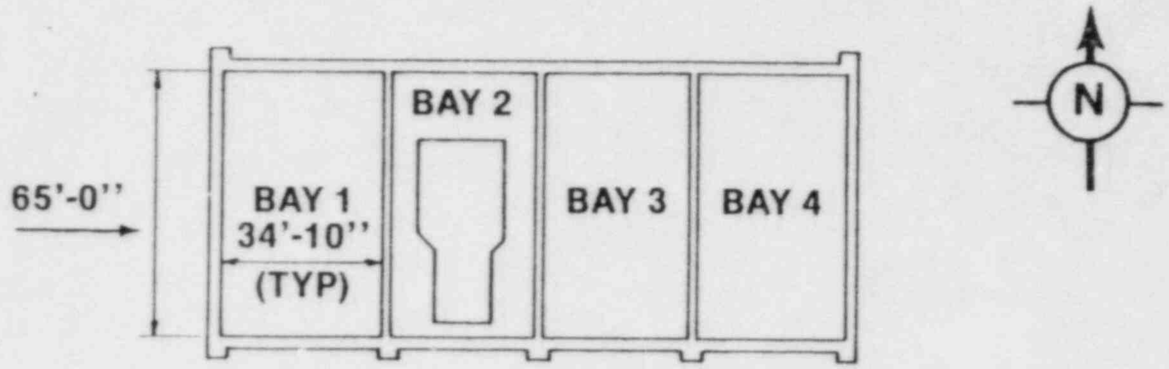
DIESEL GENERATOR BUILDING



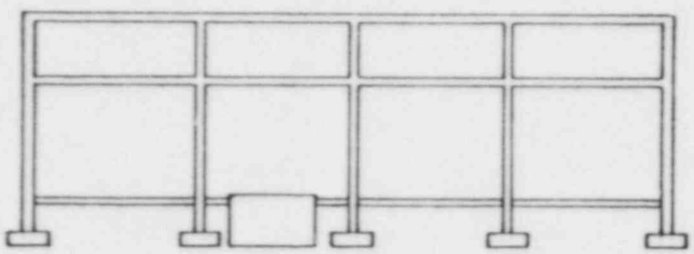
MIDLAND UNITS 1 AND 2
AUGUST 1983

30-G-3063-01

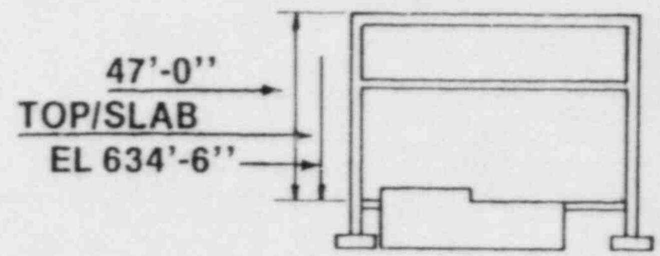
DIESEL GENERATOR BUILDING



PLAN



SECTION (Looking North)



SECTION (Looking West)

G-1534-59

DIESEL GENERATOR BUILDING
SIZE

- LENGTH = 155'-0" (outside face to outside face of walls)
- WIDTH = 70'-0" (same)
- HEIGHT = 47'-6" (above grade)
  = 51'-0" (above top of foundation)
- EXTERIOR WALL THICKNESS = 30"
- INTERIOR WALL THICKNESS = 18"
- ROOF THICKNESS (slab) = 18"
- FLOOR THICKNESS (slab) = 21"
- FOUNDATION THICKNESS = 30"

G-1530-06

DIESEL GENERATOR BUILDING
MATERIALS

- CONCRETE STRENGTH

  $f_c' = 4{,}000$ psi (walls, foundation, and floor)
  $= 5{,}000$ psi (roof)

- REINFORCING STEEL STRENGTH

  $f_y = 60{,}000$ psi

- STRUCTURAL STEEL — ASTM A 36

G-1530-07

DIESEL GENERATOR BUILDING

CODES AND STANDARDS

- AMERICAN CONCRETE INSTITUTE ACI-318, 1971 CODE
- AMERICAN INSTITUTE OF STEEL CONSTRUCTION, AISC 1969 EDITION

G-1530-08

DIESEL GENERATOR BUILDING
LOADS

- NORMAL OPERATION
  - Concrete

    $U = 1.4D + 1.7L$

    $U = 1.25\ (D + L + E)$

    $U = 1.25\ (D + L + W)$

    $U = 1.4\ (D + L + E)$ (for shear wall only)

    $U = 0.9D + 1.25E$

    $U = 0.9D + 1.25W$
  - Structural Steel

    $D + L$

    $D + L + E$

    $D + L + W$

DIESEL GENERATOR BUILDING
LOADS (cont'd)

- ACCIDENT CONDITIONS
  - Concrete
    $U = 1.0 (D + L + E')$
    $U = 1.0 (D + L + W')$
  - Structural Steel
    $D + L + E'$
    $D + L + W'$

Tornado wind loads include missile effects when applicable

G-1530-10

DIESEL GENERATOR BUILDING
TORNADO ANALYSIS

- V_M = 360 MPH
- R_M 150′-0″
- VELOCITY PRESSURE = 332 PSF
- DIFFERENTIAL BURSTING PRESSURE = 3 PSI = 432 PSF

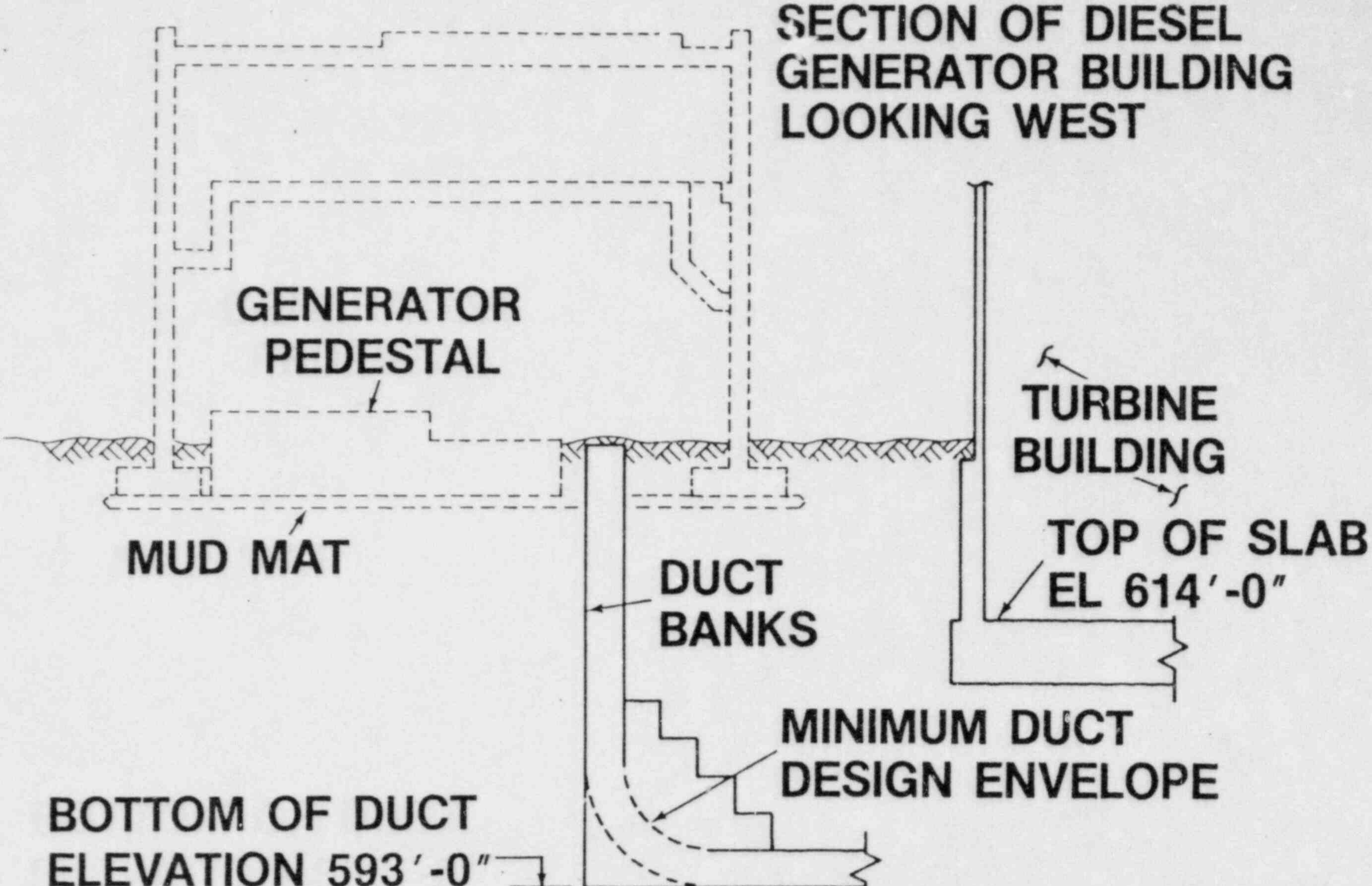
DIESEL GENERATOR BUILDING

ANALYSIS TECHNIQUE

- WALLS
  - North Wall
    - Computer analysis
    - Plate analysis
  - All Other Walls
    - Moment distribution
    - Plate analysis
- FLOOR AND ROOF
  - Moment Distribution - Slab on Steel Beams
  - Plate Analysis (roof only)
- GROUND SLAB
  - Computer Analysis, Finite Element Method
- DIESEL GENERATOR FOUNDATION
  - Manual Analysis
- BUILDING FOUNDATIONS
  - Statics and Moment Distribution

G-1530-13

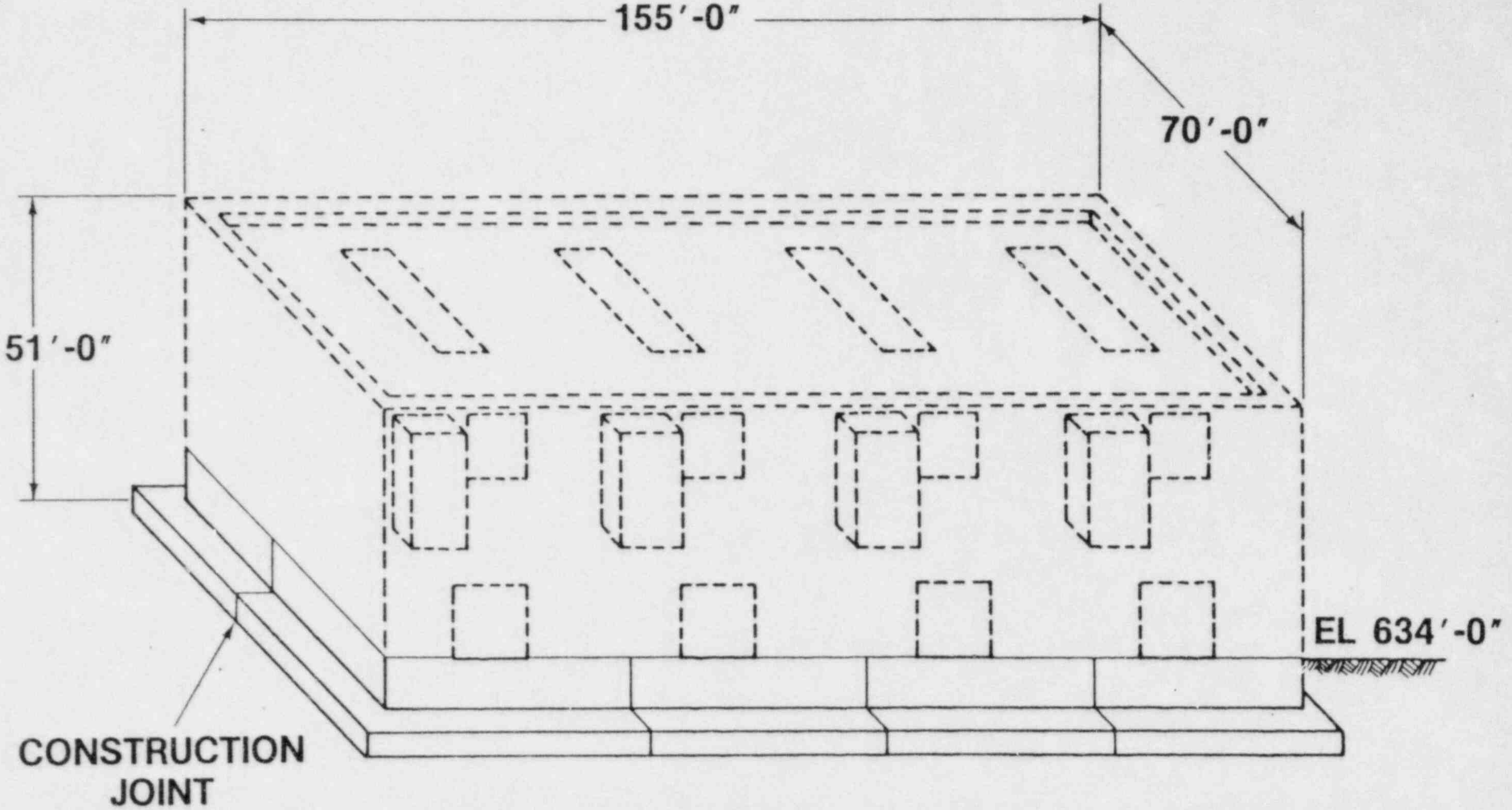
DIESEL GENERATOR BUILDING
DUCT BANK ELEVATION



MIDLAND UNITS 1 AND 2
AUGUST 1983

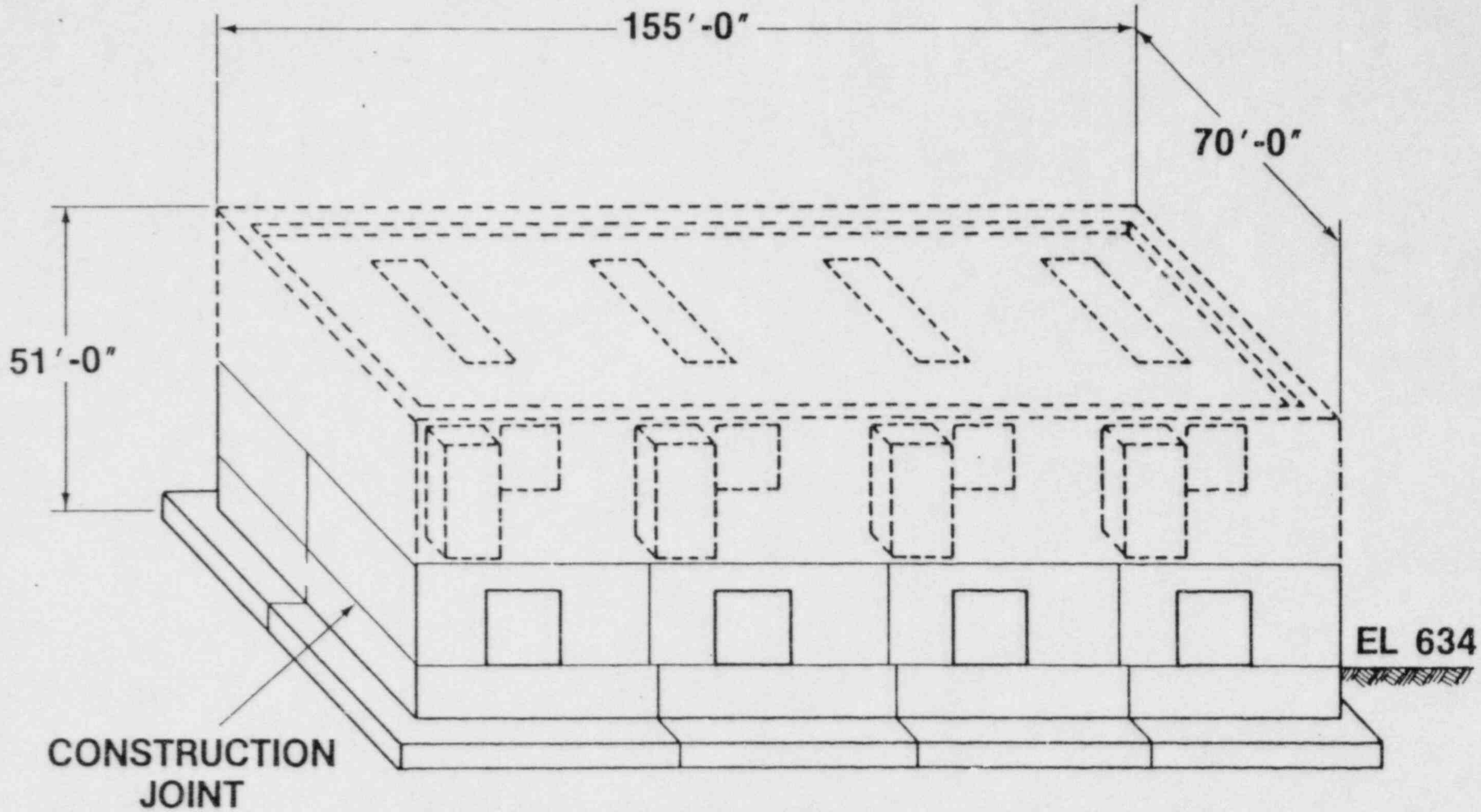
30-G-3063-04

DIESEL GENERATOR BUILDING



FEBRUARY 1978

DIESEL GENERATOR BUILDING

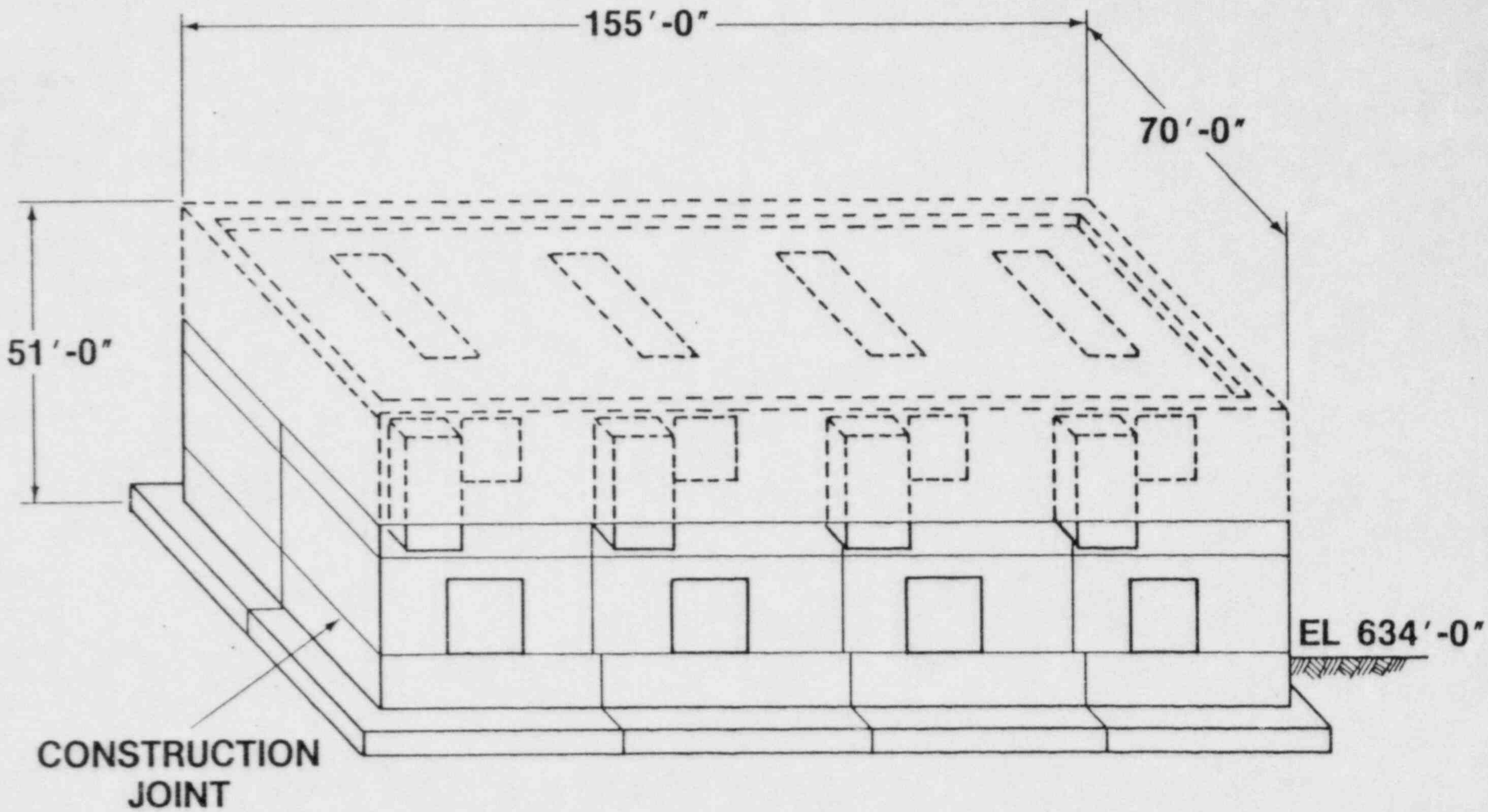


APRIL 1978

MIDLAND UNITS 1 AND 2
AUGUST 1983

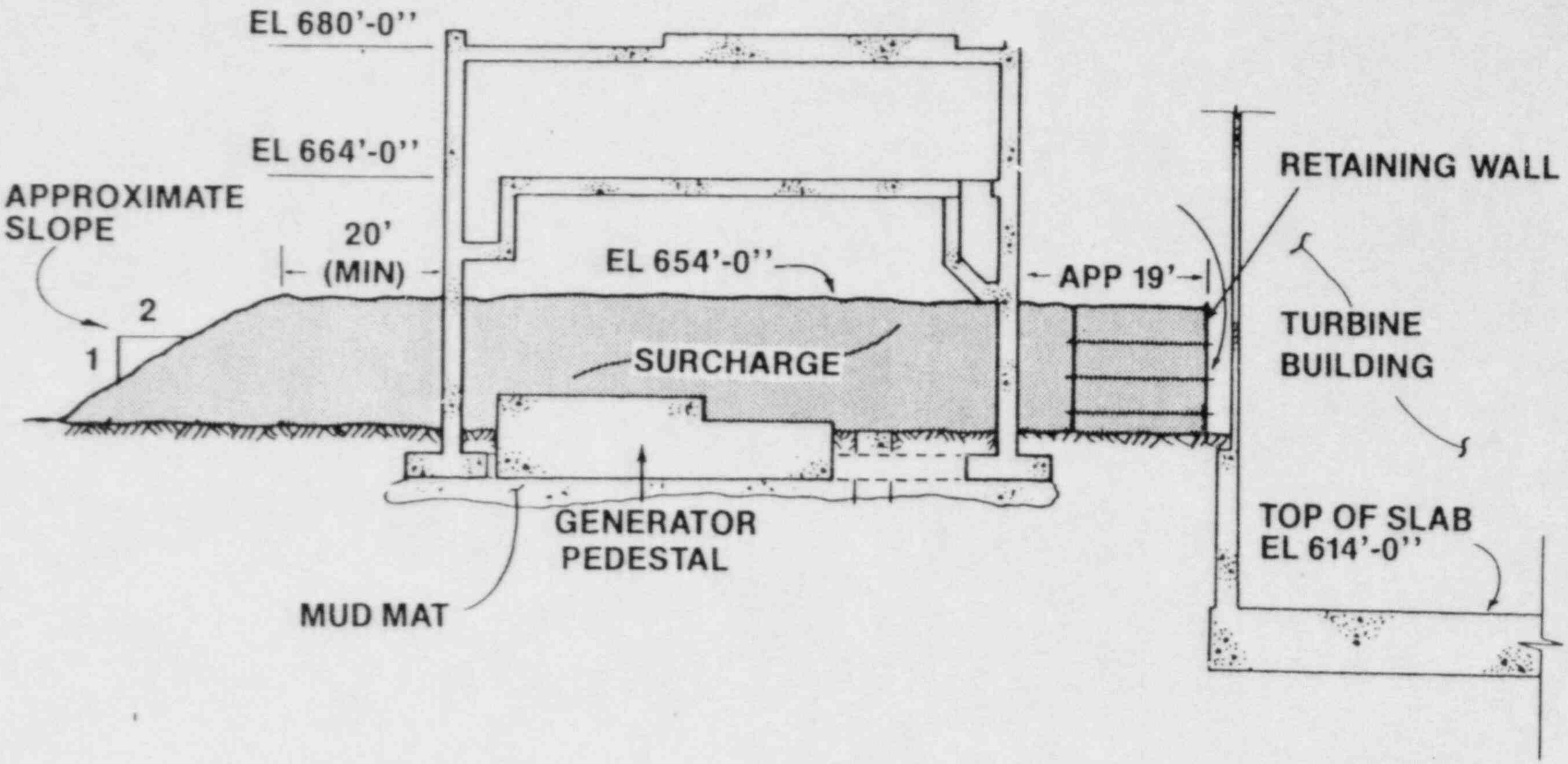
30-G-3063-06

DIESEL GENERATOR BUILDING



AUGUST 1978

DIESEL GENERATOR BUILDING

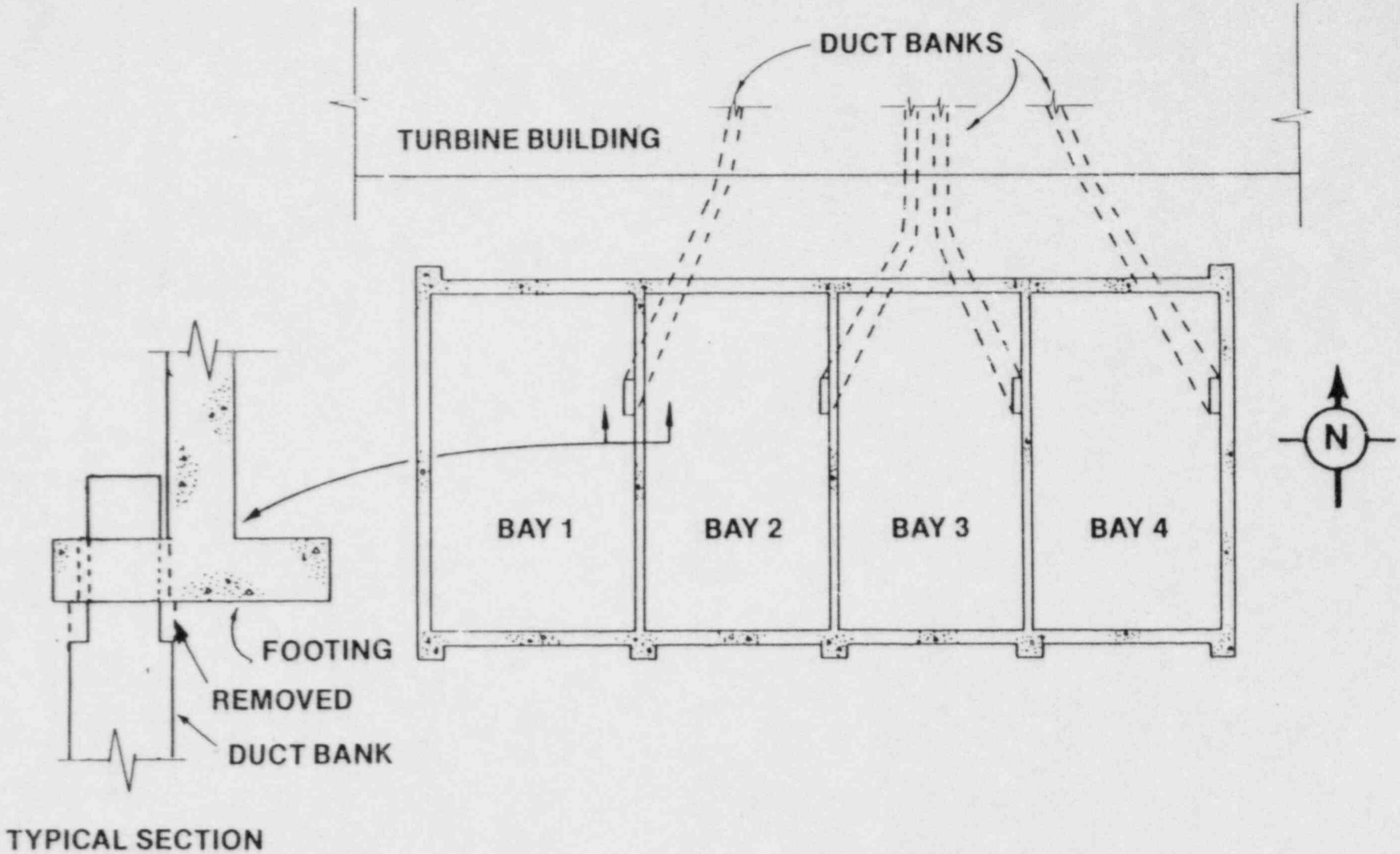


MIDLAND UNITS 1 AND 2
DIESEL GENERATOR BUILDING 2/3/82

G-1948-10

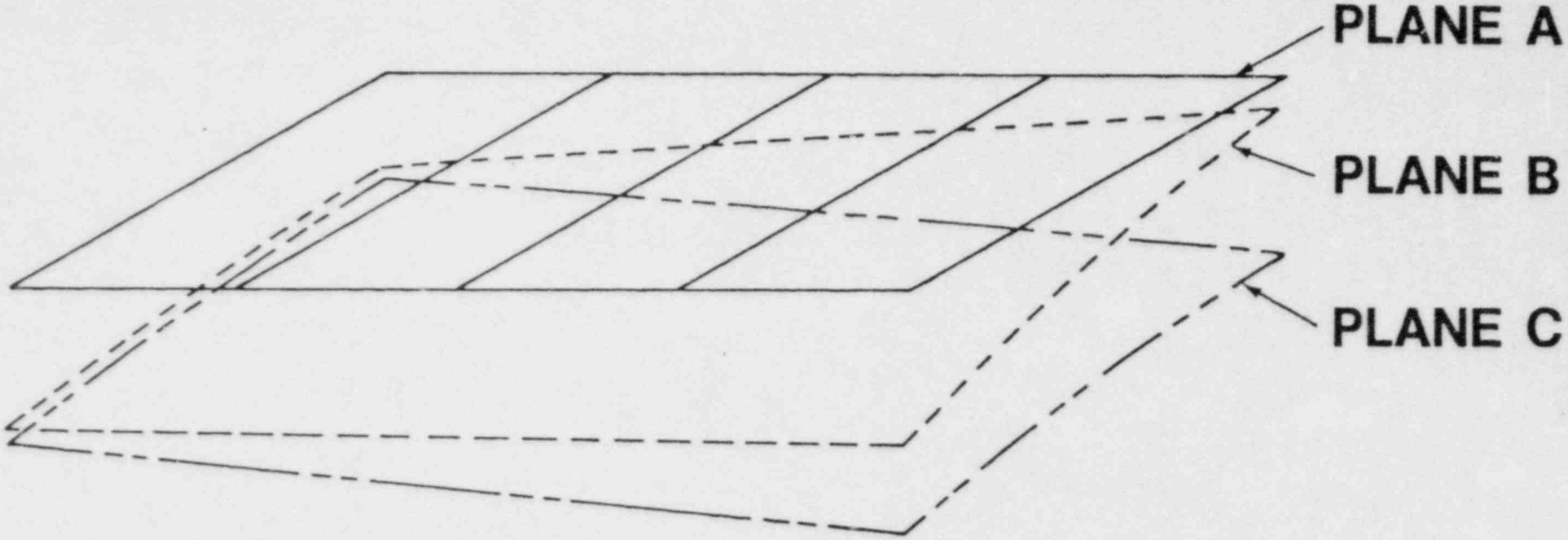
16

DIESEL GENERATOR BUILDING
DUCT BANK LAYOUT



DIESEL GENERATOR BUILDING

TREND OF MEASURED SETTLEMENT



Plane A Nominal reference plane

Plane B Settlement plot as of 11/16/78 before cutting duct banks loose

Plane C Settlement plot as of 12/28/78 approximately a month after cutting duct banks

REMEDIAL PROGRAM

I EXPLORATION

II EVALUATION OF OPTIONS AND DECISION TO SURCHARGE

III PERMANENT DEWATERING

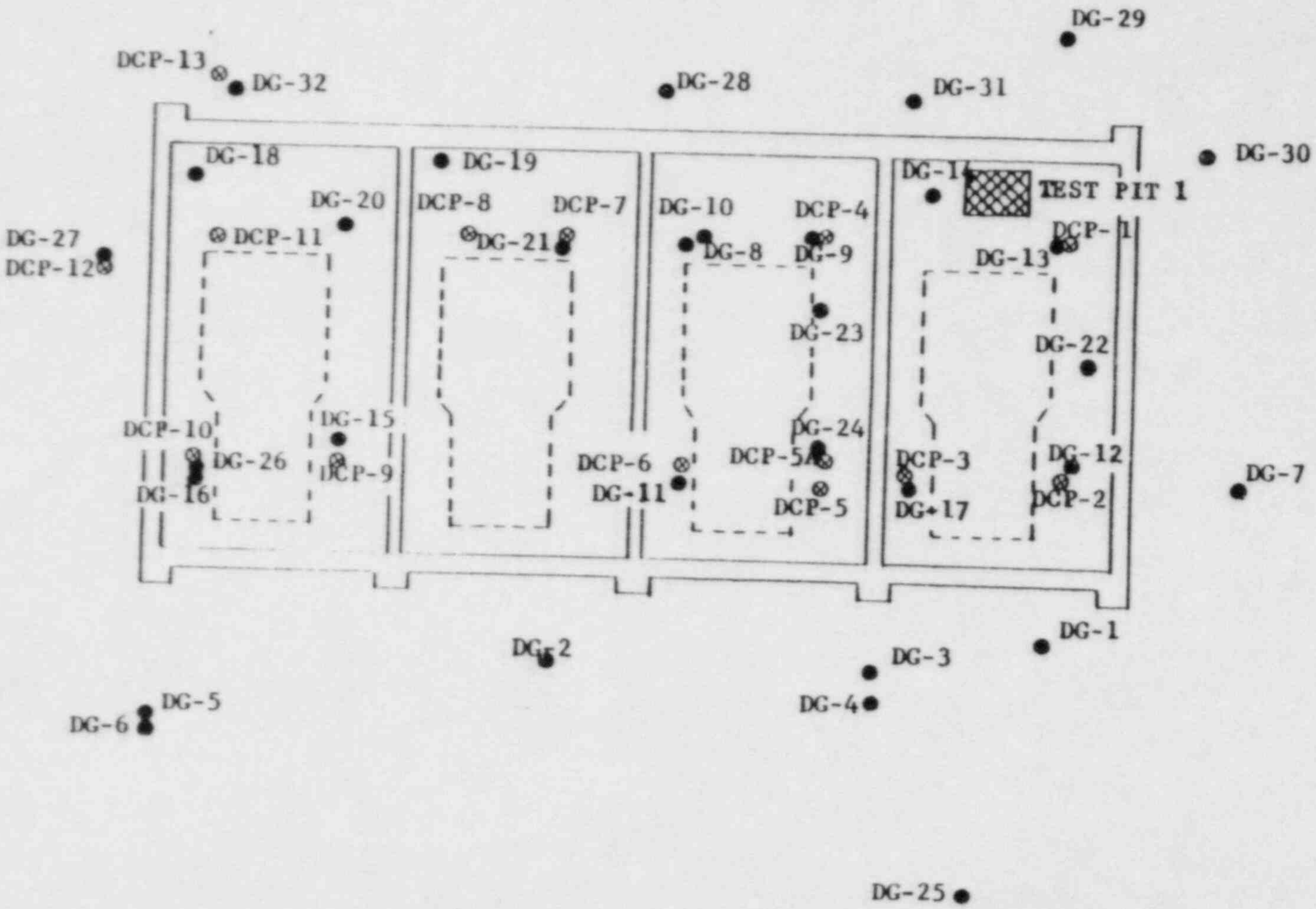
IV RESULTS

V FUTURE MONITORING

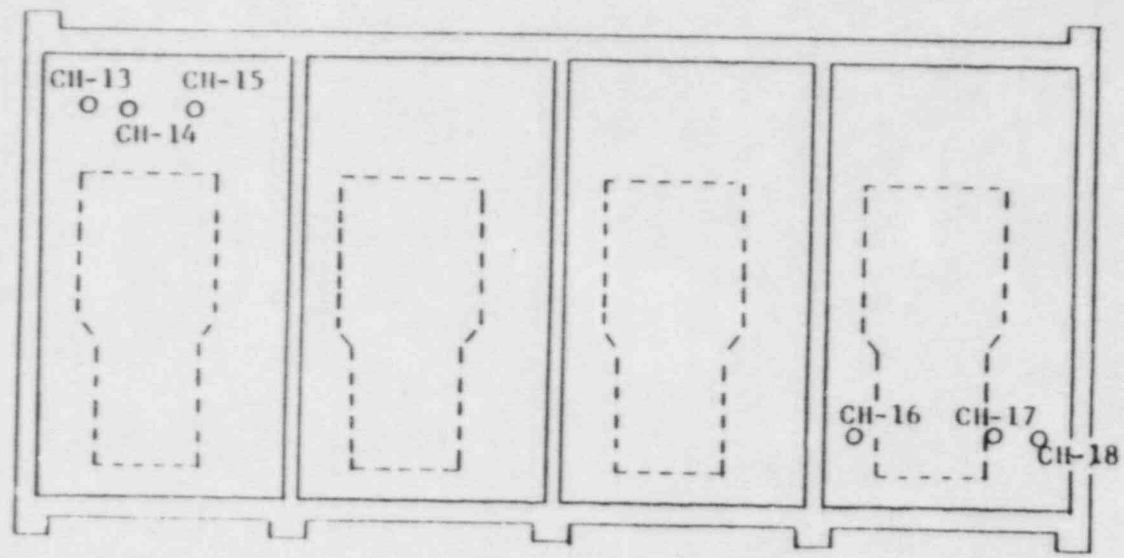
I. EXPLORATION PROGRAM

- BEFORE SURCHARGE
  - 32 Borings
  - 14 Dutch Cone Soundings
  - Laboratory Testing

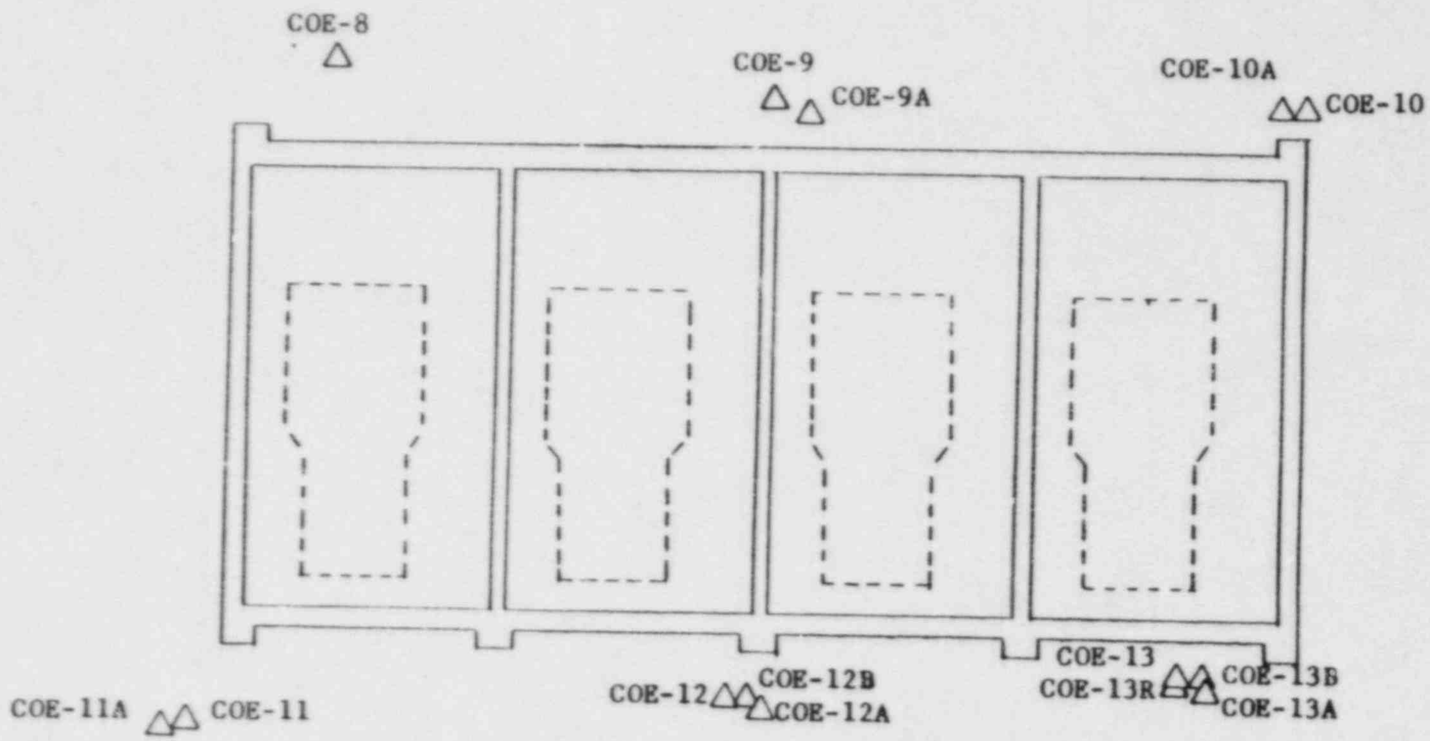
- AFTER SURCHARGE
  - 6 Borings With Cross-Hole Shear Wave Velocity Tests
  - 11 Borings With Undisturbed Sampling
  - Laboratory Testing



BORING LOCATION PLAN
DG SERIES, DCP SERIES AND TEST PIT 1



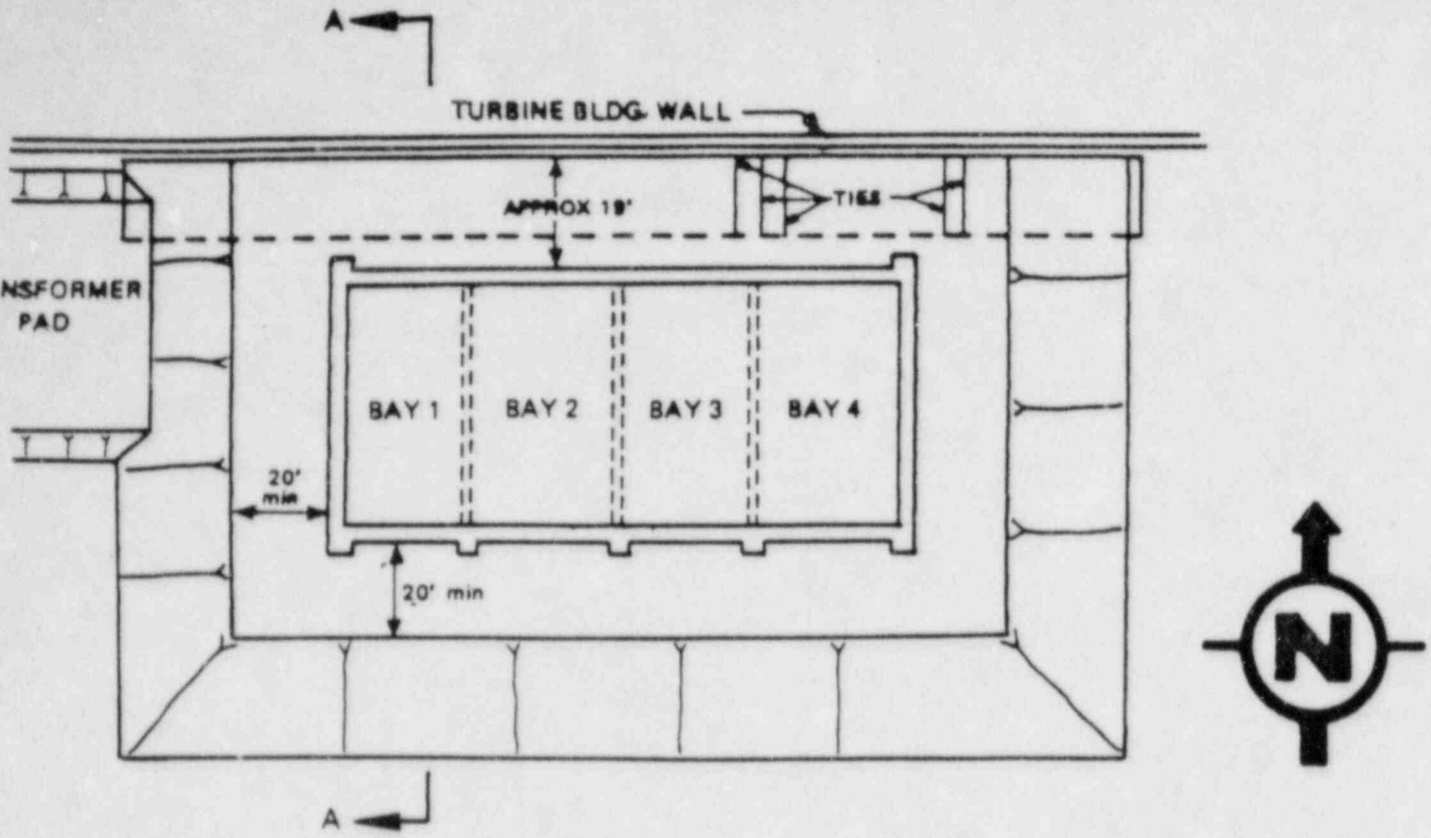
BORING LOCATION PLAN
CH SERIES



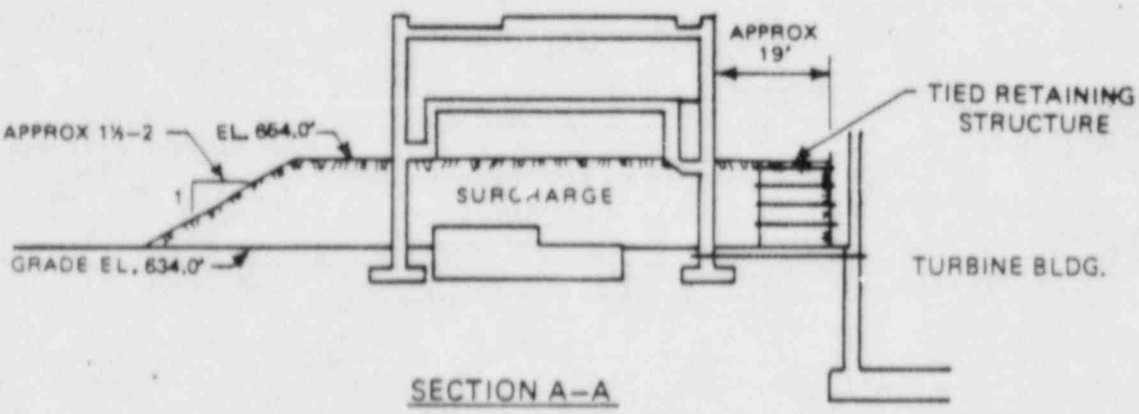
BORING LOCATION PLAN
COE SERIES

II. SURCHARGE PROGRAM

- PURPOSE
- GEOMETRY
- INSTRUMENTATION



PLAN

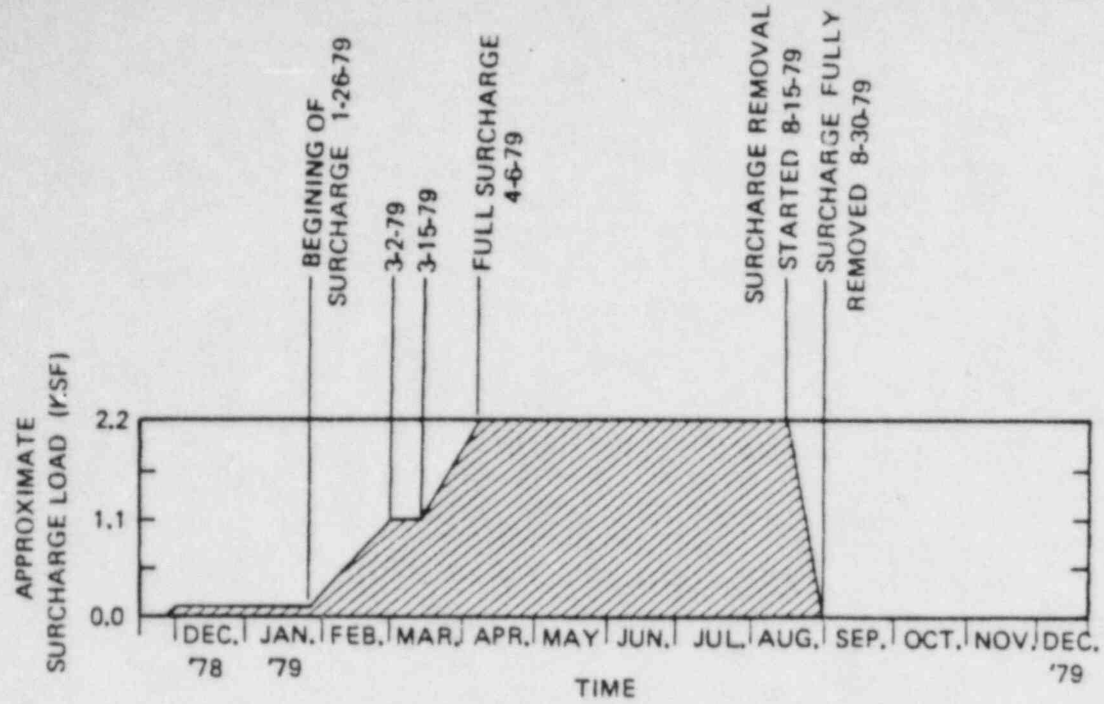


SECTION A-A

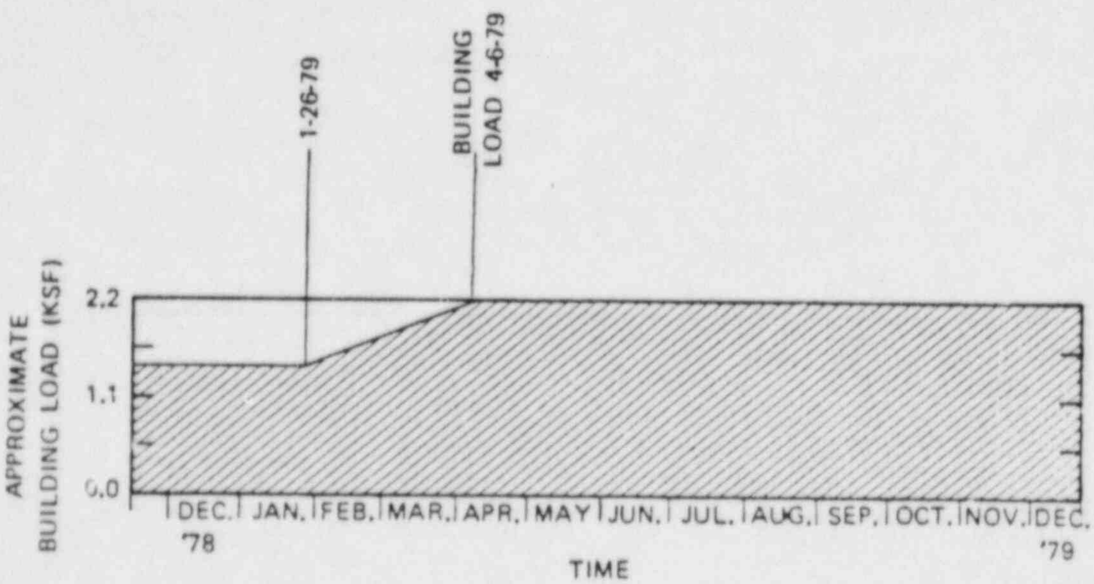
0 50

SCALE IN FEET

GENERAL LAYOUT OF
SURCHARGE LOAD
DIESEL GENERATOR BUILDING

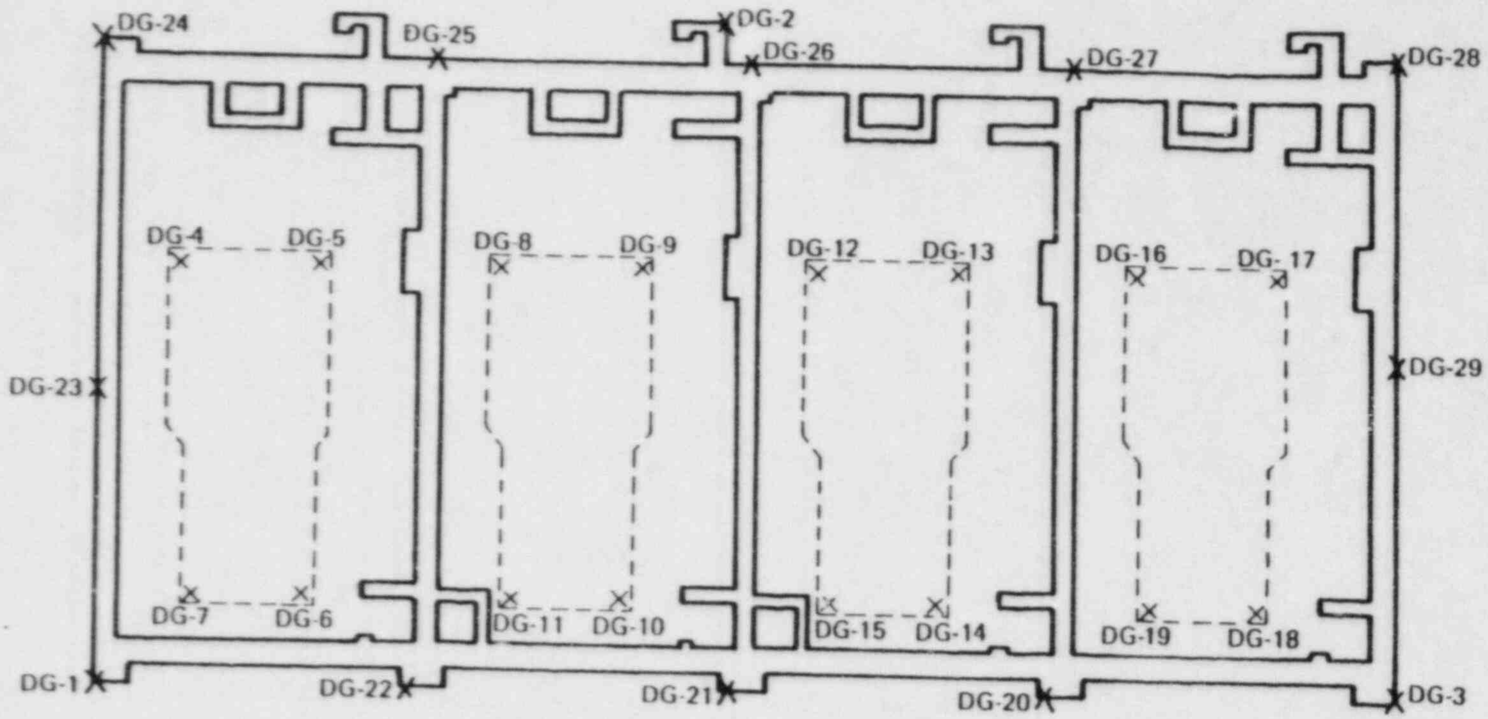


(A) IDEALIZED SURCHARGE LOAD HISTORY



(B) IDEALIZED STATIC BUILDING LOAD HISTORY

DIESEL GENERATOR BUILDING
IDEALIZED SURCHARGE AND
BUILDING LOAD HISTORIES



DIESEL GENERATOR BUILDING

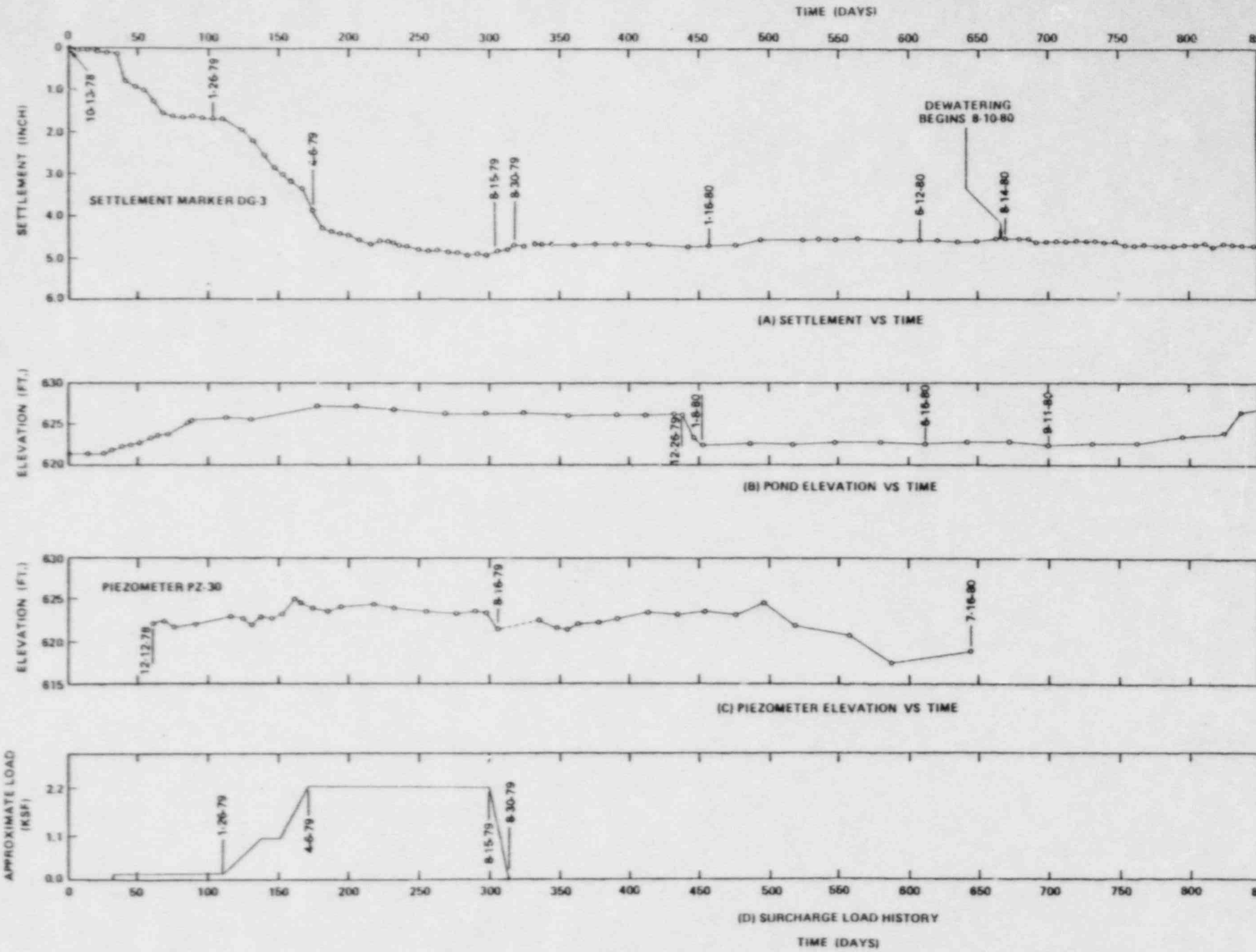
LOCATION OF BUILDING SETTLEMENT MARKERS

9

III. PERMANENT DEWATERING

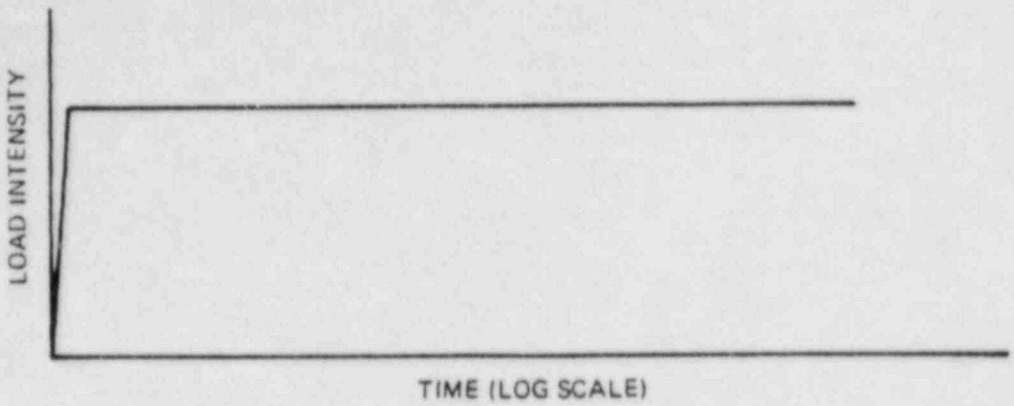
IV. RESULTS OF REMEDIAL PROGRAM

- SETTLEMENTS
  - Predictions
  - Observations
- FOUNDATION MATERIAL PROPERTIES
  - Settlement Calculations
  - Bearing Capacity
  - Dynamic Properties
  - Surcharge Effectiveness

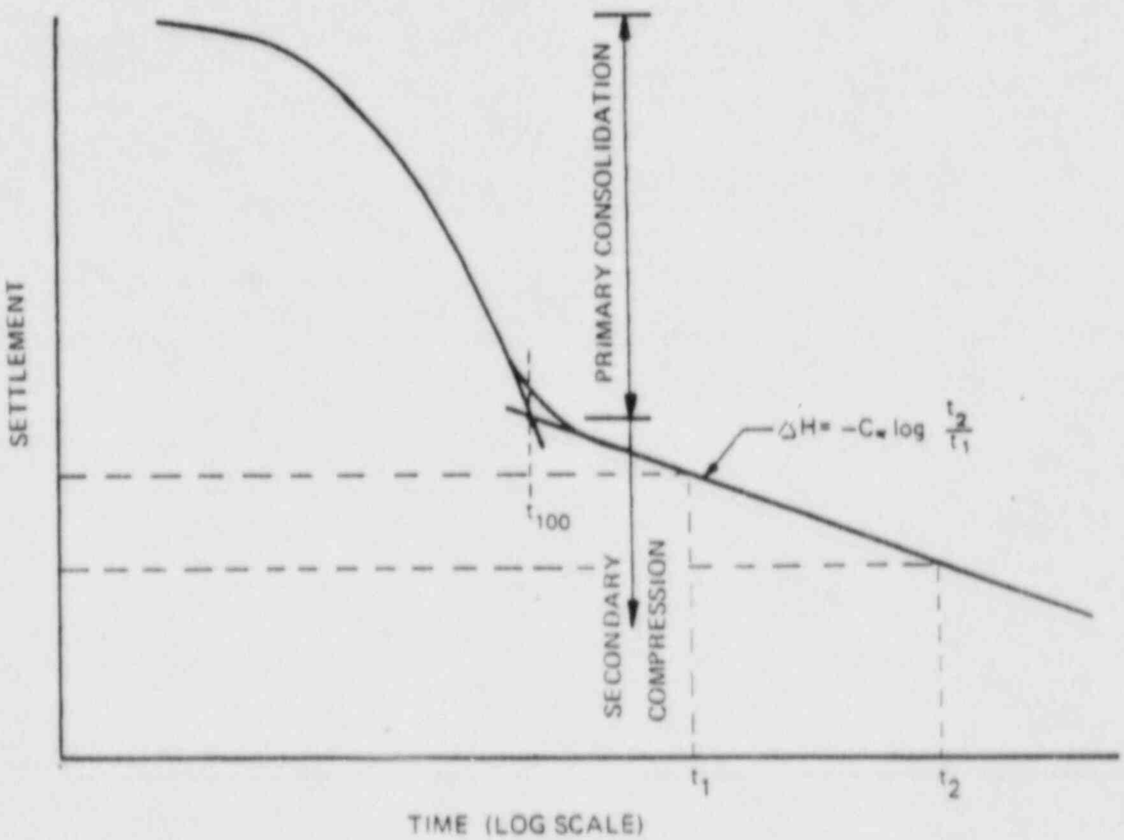


DIESEL GENERATOR BUILDING
TYPICAL SETTLEMENT, COOLING POND LEVEL,
PIEZOMETER LEVEL AND SURCHARGE LOAD HISTORY

12

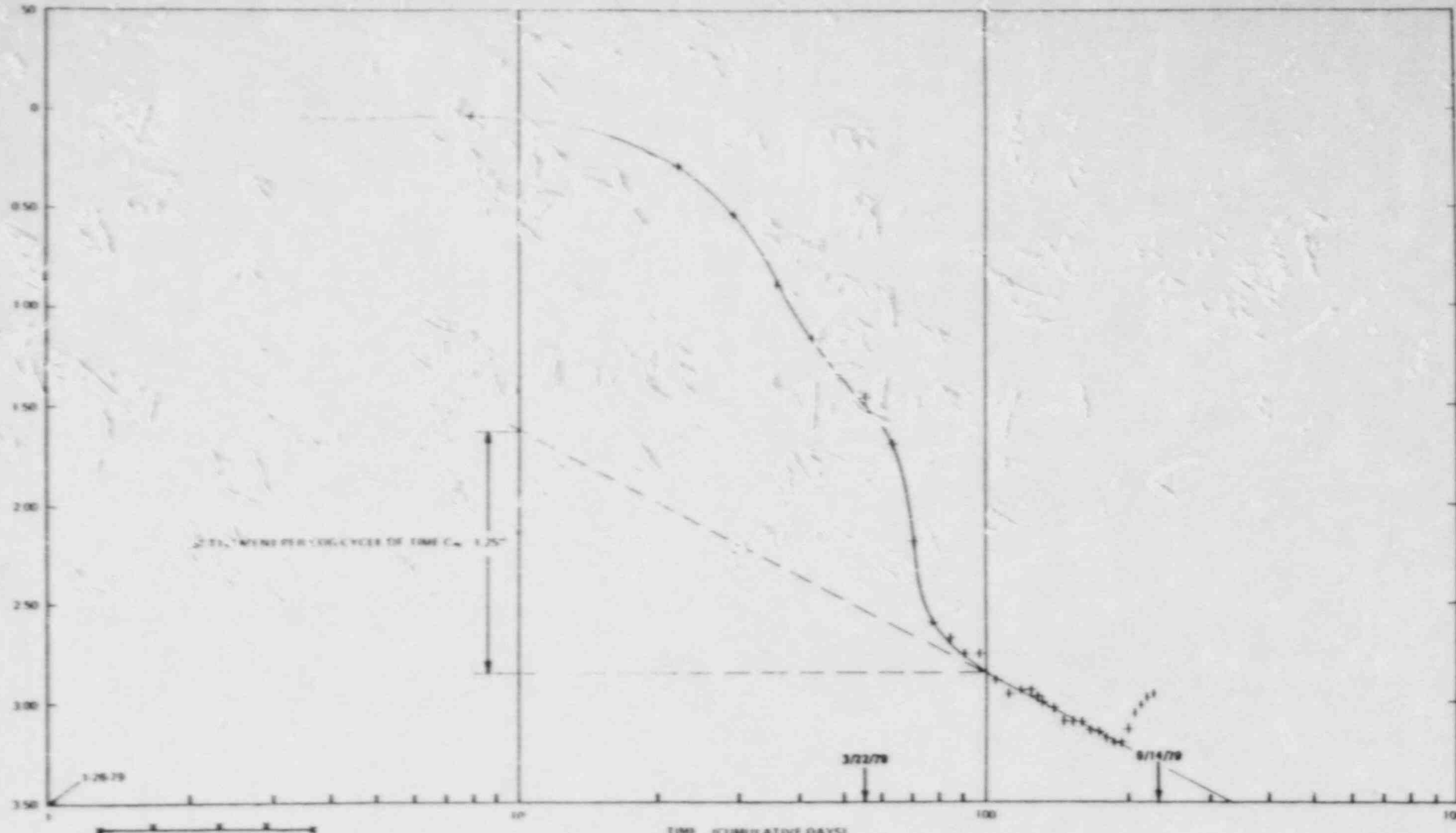


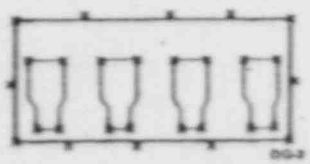
(A) LOAD HISTORY



(B) TIME - SETTLEMENT CURVE

TYPICAL LABORATORY LOAD HISTORY
AND TIME - SETTLEMENT PLOTS



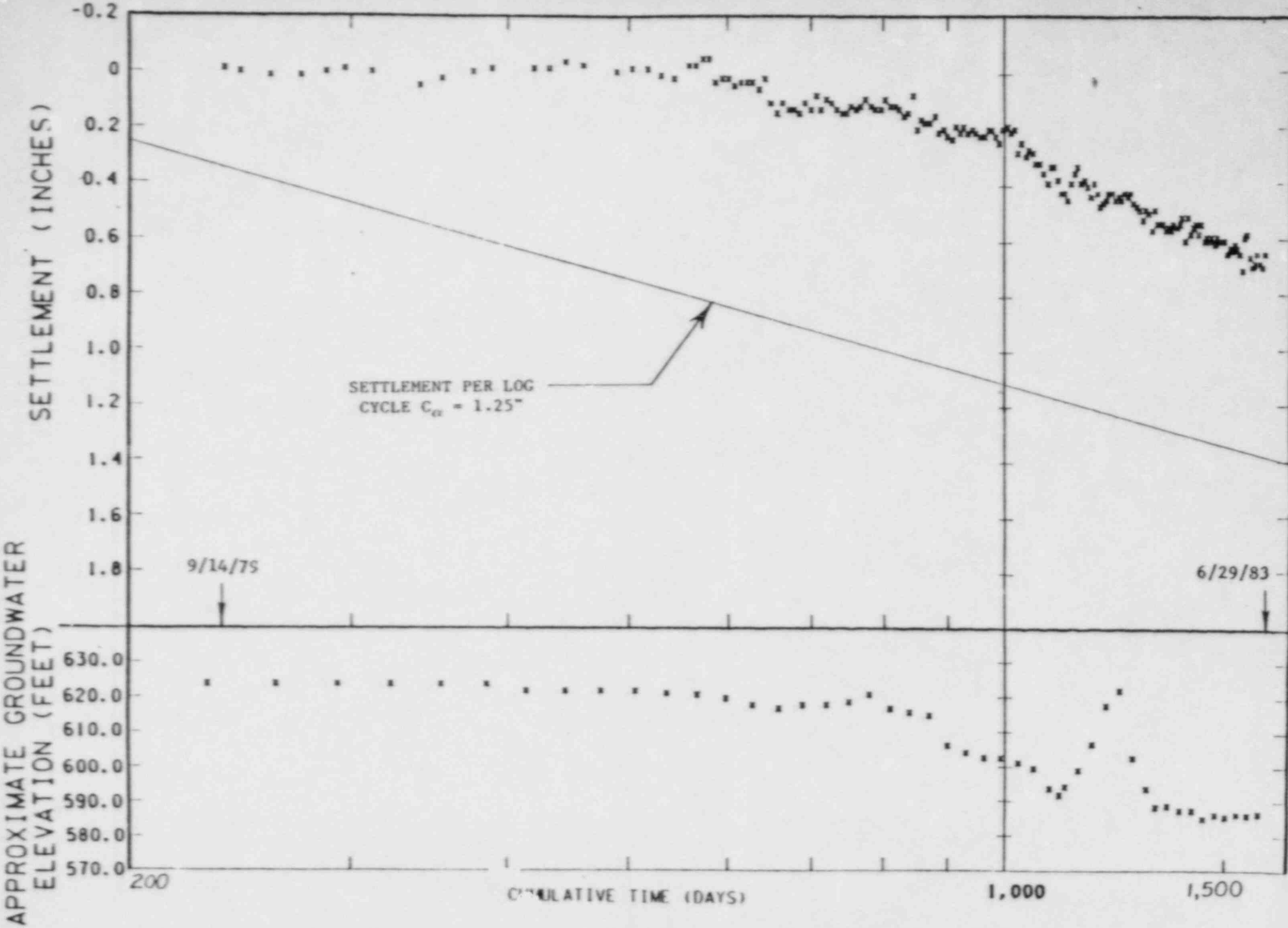


SETTLEMENT MARKER LOCATION PLAN
DIESEL GENERATOR BUILDING
(NOT TO SCALE)

NOTE

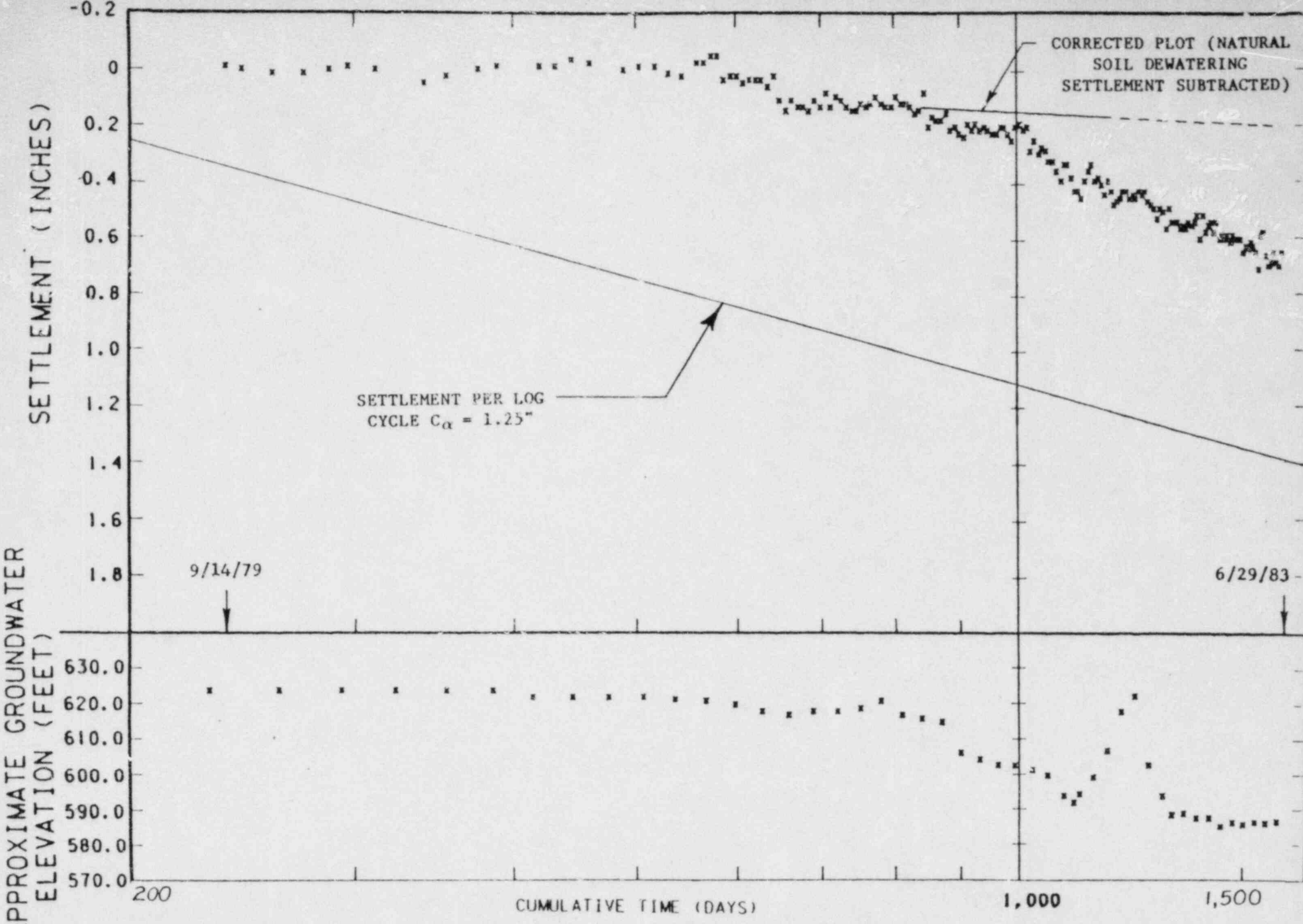
The permanent marker could not be monitored from 3-22-79 to 9-14-79 due to surcharge. Temporary markers at elevation 664'-0" ± were used during this period to estimate the settlement of the permanent marker. On 9-14-79 the settlement was again based directly upon the permanent marker.

SETTLEMENT vs. LOGARITHM OF TIME
FROM 1/26/79 TO 9/14/79
MARKER DG-3



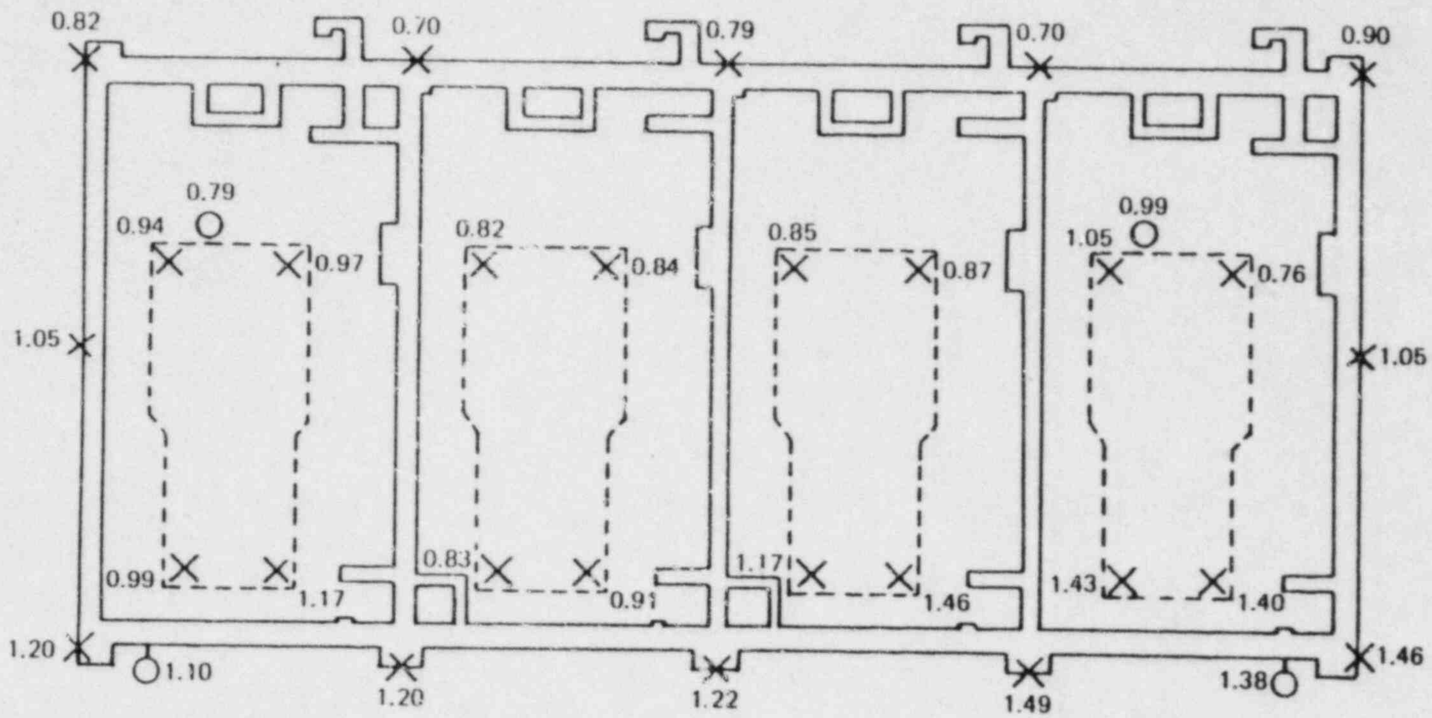
SETTLEMENT vs. LOGARITHM OF TIME SINCE 9/14/79
MARKER DG-3

15



SETTLEMENT vs. LOGARITHM OF TIME SINCE 9/14/79
SHOWING CORRECTED SLOPE
MARKER DG-3

DIESEL GENERATOR BUILDING



LEGEND

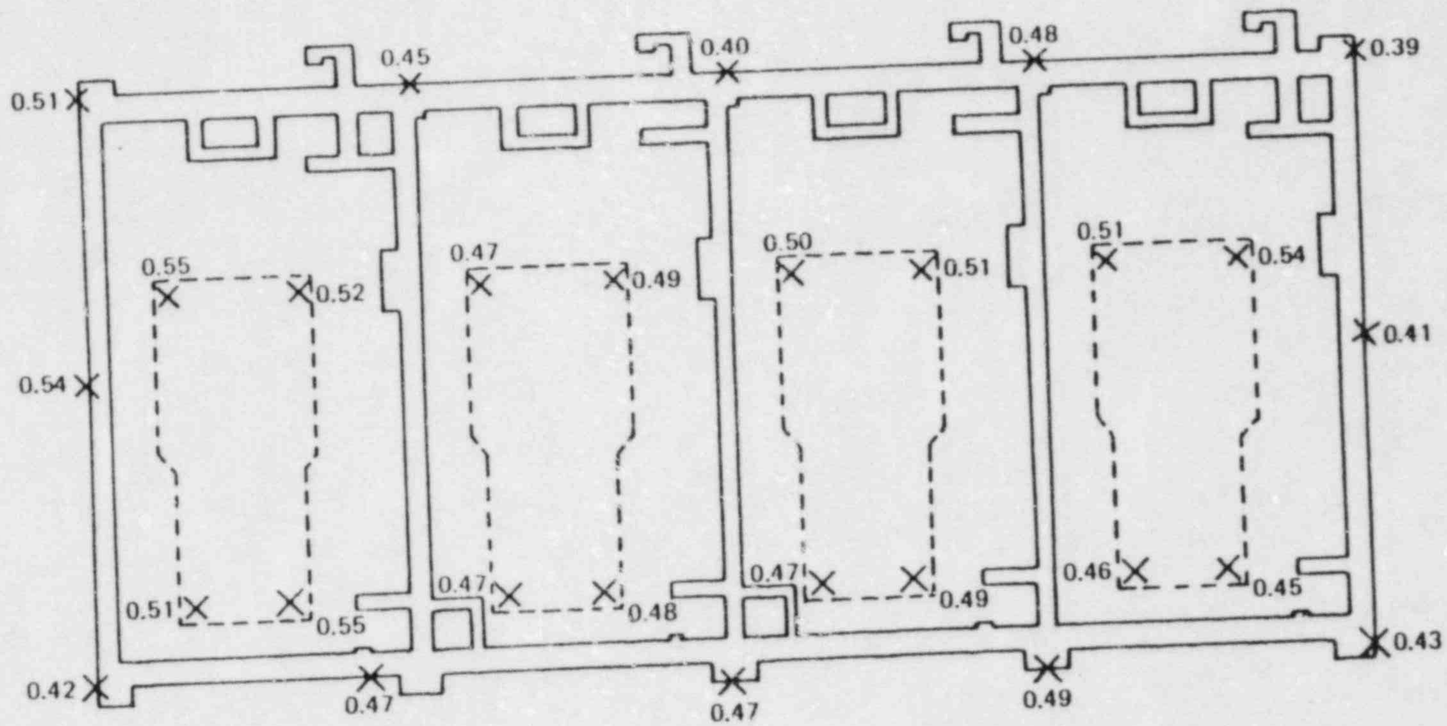
○ —— DEEP BORROS ANCHOR

╳ —— BUILDING / PEDESTAL SETTLEMENT MARKER

1.20 —— SETTLEMENT IN INCHES

DIESEL GENERATOR BUILDING
ESTIMATED SECONDARY COMPRESSION
SETTLEMENTS FROM 12/31/81 TO 12/31/2025
ASSUMING SURCHARGE REMAINS

DIESEL GENERATOR BUILDING



LEGEND

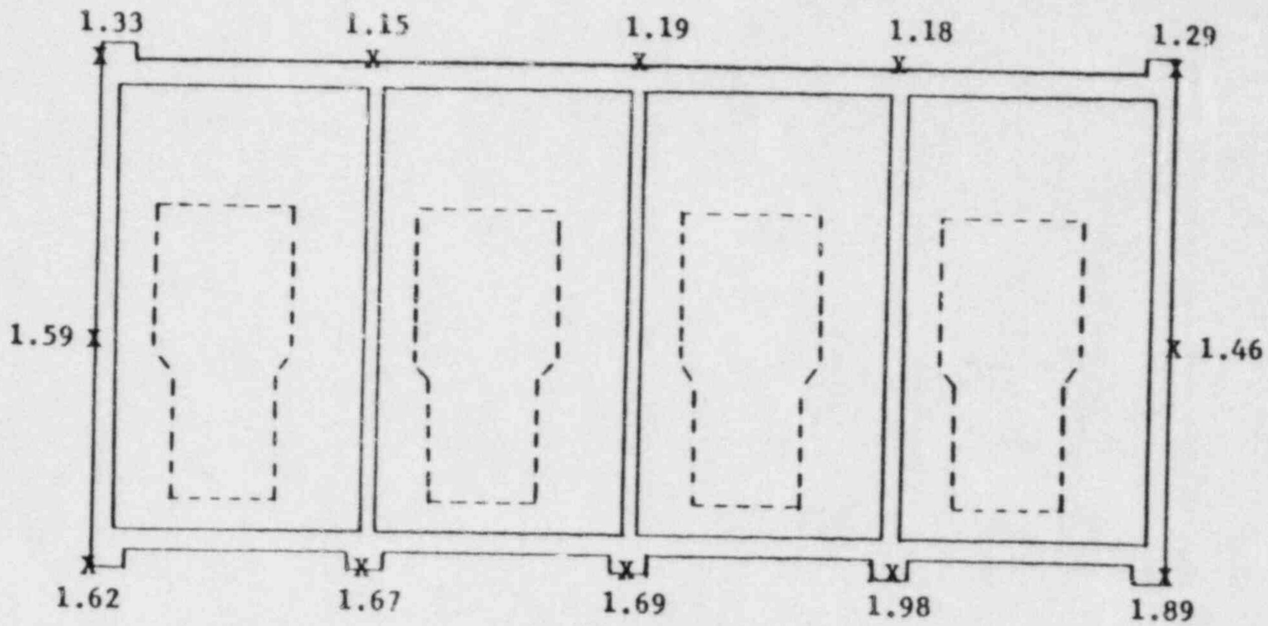
X ——— BUILDING / PEDESTAL SETTLEMENT MARKER

0.42 ——— MEASURED SETTLEMENT BETWEEN 9/14/79 AND 12/31/81.

DIESEL GENERATOR BUILDING
MEASURED SETTLEMENT FROM
9/14/79 TO 12/31/81

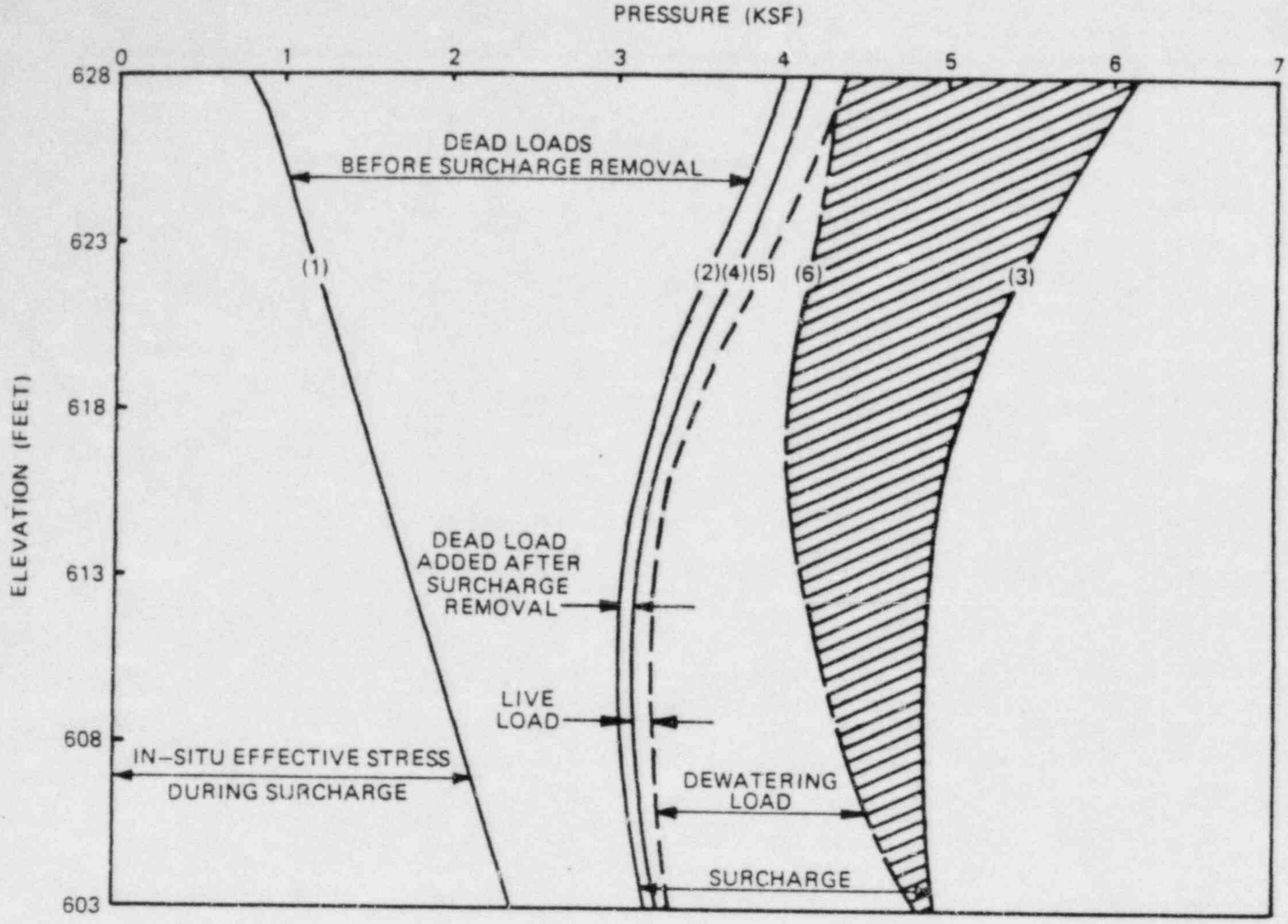
18

DIESEL GENERATOR BUILDING



SUM OF MEASURED SETTLEMENT
FROM 9/14/79 to 12/31/81 AND PREDICTED
SETTLEMENT FROM 12/31/81 TO 12/31/2025
(GROUNDWATER ELEVATION TO 595')

(19



EXPLANATIONS

(1) In-situ effective overburden pressure (GWT at 627).

(2) Total effective pressure before surcharge removal due to In-situ effective overburden pressure and structural dead loads present during surcharge.

(3) Total effective pressure at the end of surcharge due to In-situ effective overburden pressure, structural dead loads, and surcharge loads.

(4) Total effective pressure due to In-situ effective overburden pressure and total structural dead loads (loads present during surcharge plus dead loads added after surcharge removal).

(5) Total effective pressure due to In-situ effective overburden pressure, total structural dead loads, and expected live loads.

(6) Total effective pressure during the life of plant operation due to In-situ effective overburden pressure, structural dead loads, dewatering loads, and expected live loads.

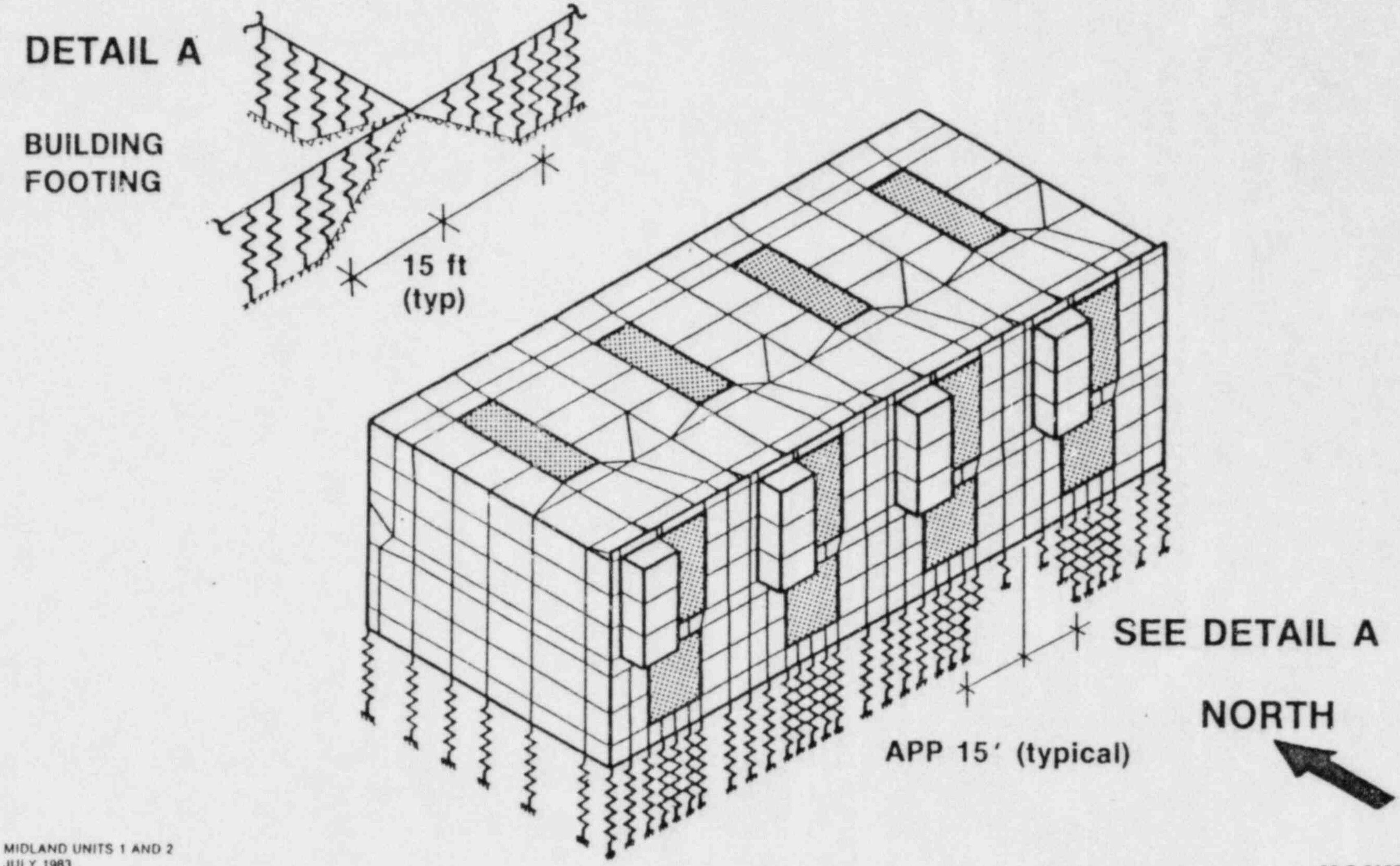
COMPARISON OF EFFECTIVE STRESS
BEFORE AND AFTER SURCHARGE
SOUTHWEST CORNER
DIESEL GENERATOR BUILDING

V. SETTLEMENT MONITORING

- PRESENT
- FUTURE

DIESEL GENERATOR BUILDING

FINITE ELEMENT MODEL FOR ZERO SPRING CONDITION

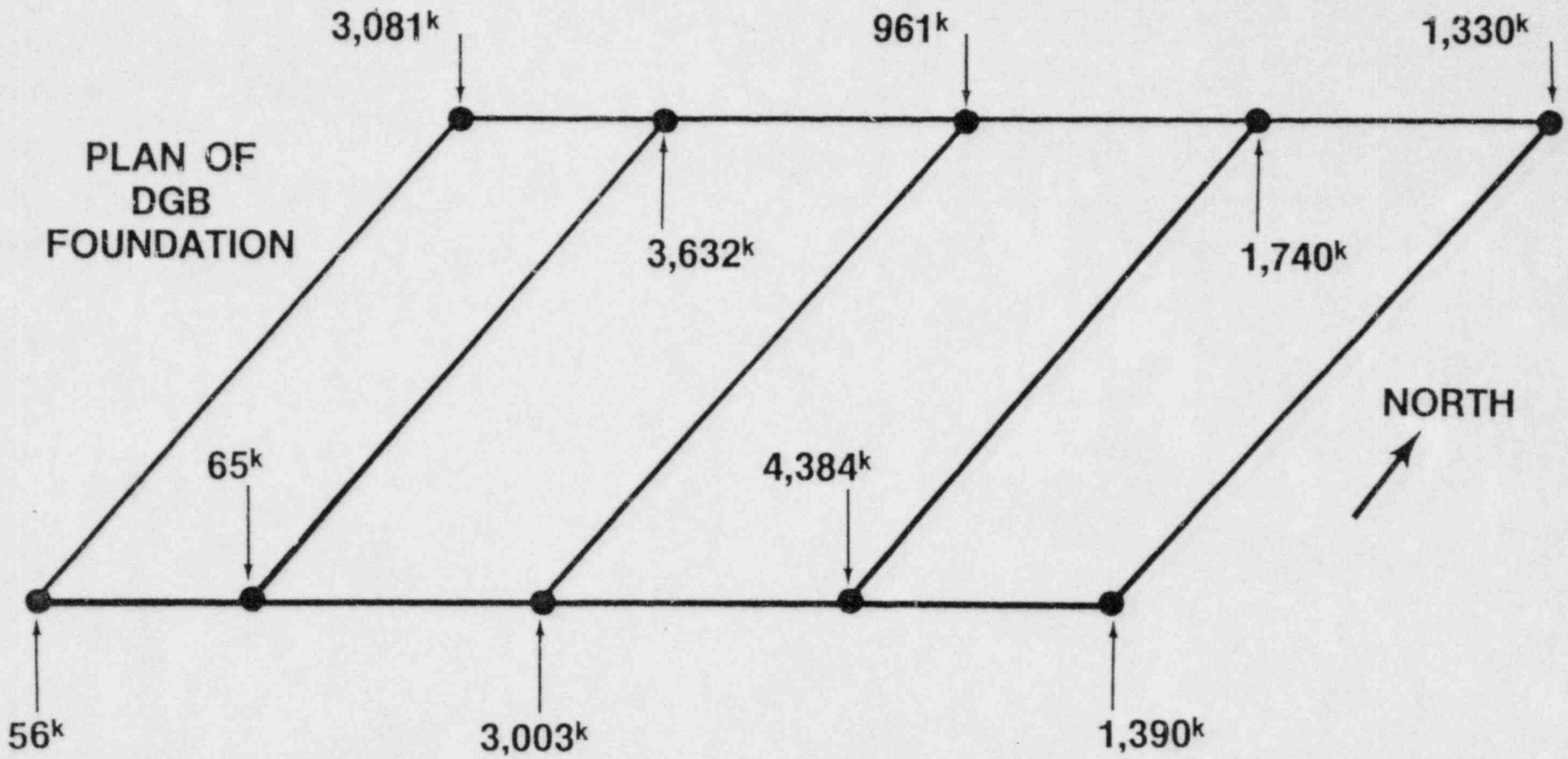


MIDLAND UNITS 1 AND 2
JULY 1983

30-G-3057-31

DIESEL GENERATOR BUILDING

FORCES REQUIRED TO DEFORM BUILDING TO GEOTECH'S 40-YEAR ESTIMATES



MIDLAND UNITS 1 AND 2
JULY 1983

30-G-3057-32

DIESEL GENERATOR BUILDING

KEY ISSUES

1. DISTORTION OF BUILDING DUE TO SETTLEMENT
   - MEASURED
   - PREDICTED

2. CONCRETE CRACKS
   - DUE TO HANG-UP ON DUCT BANKS
   - OTHER CRACKING

3. STRUCTURAL REANALYSIS
   - ACCEPTANCE CRITERIA
   - ADDITIONAL ANALYSES
   - CONSERVATISM

DIESEL GENERATOR BUILDING
MATHEMATICAL MODEL
ELEVATION LOOKING WEST

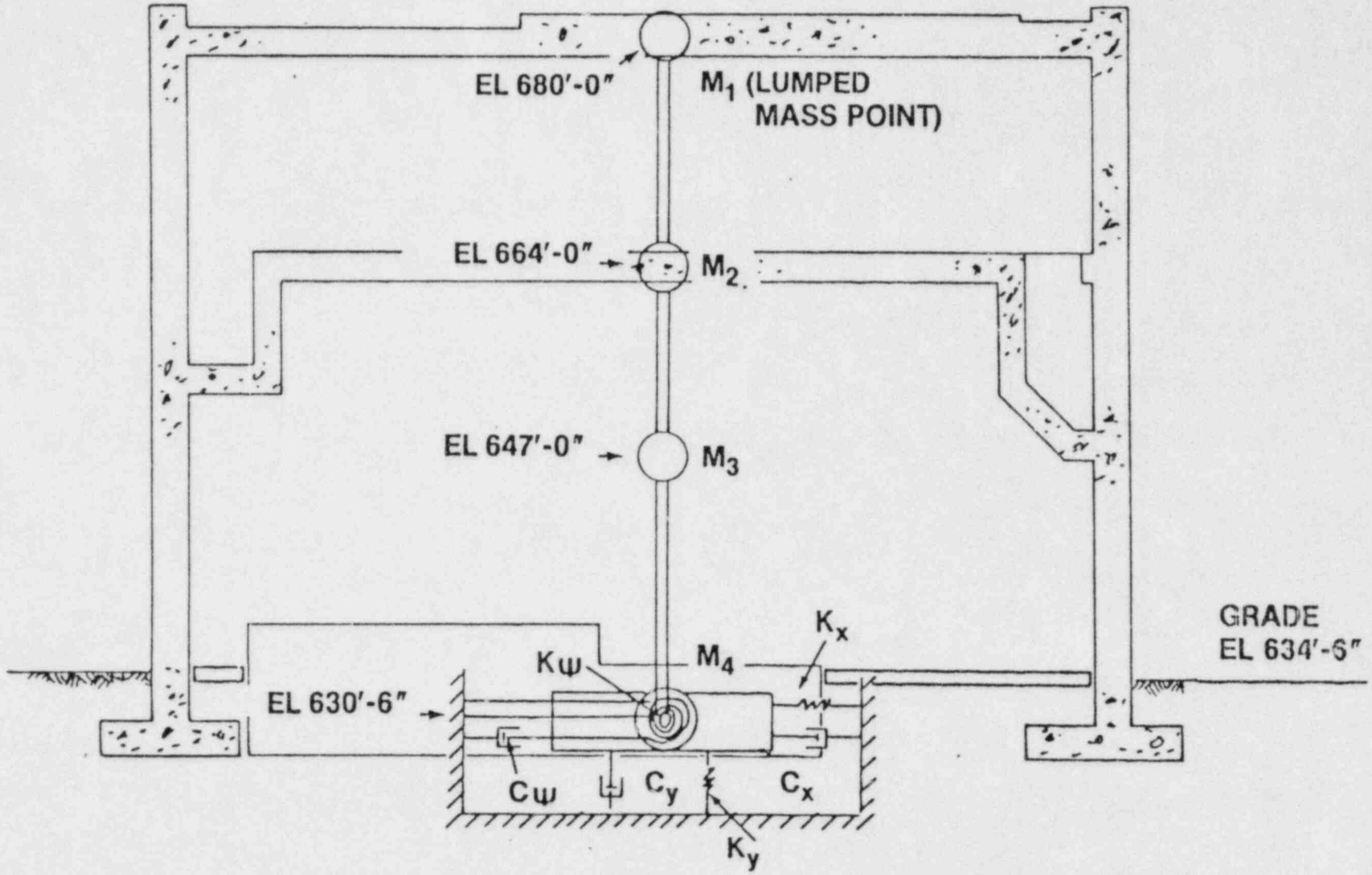


FIGURE 9

88-G-2643-13

TABLE 2

MASS PROPERTIES OF DIESEL GENERATOR BUILDING

For Horizontal Earthquake:

Elevation	Node	Mass (kips)	Mass Moment of Inertia (K-FT^2) North-South Earthquake	Mass Moment of Inertia (K-FT^2) East-West Earthquake
680'-0"	1 (M1)	5,338	2.8955×10^6	1.2247×10^7
664'-0"	2 (M2)	7,642	4.5120×10^6	1.8476×10^7
647'-0"	3 (M3)	4,185	2.9140×10^6	1.0012×10^7
630'-6"	4 (M4)	12,155	3.0670×10^6	1.0528×10^7
		Σ = 29,320	$\Sigma = 1.3388 \times 10^7$	$\Sigma = 5.1263 \times 10^7$

For Vertical Earthquake:

Elevation	Node	Mass* (kips)
680'-0"	1 (M1)	5,338
664'-0"	2 (M2)	7,642
647'-0"	3 (M3)	4,185
630'-6"	4 (M4)	4,274
		Σ = 21,439

*In weight units

TABLE 3

MEMBER PROPERTIES OF DIESEL GENERATOR BUILDING

Beam	North-South Earthquake Effective Shear Area (ft^2)	North-South Earthquake Moment of Inertia (ft^4)	East-West Earthquake Effective Shear Area (ft^2)	East-West Earthquake Moment of Inertia (ft^4)
1	799.4	1.143×10^6	863.1	3.926×10^6
2	799.4	1.143×10^6	863.1	3.926×10^6
3	799.4	1.143×10^6	863.1	3.926×10^6

TABLE 4

SOIL SPRING AND DAMPERS FOR DIESEL GENERATOR BUILDING
NORTH-SOUTH EARTHQUAKE

V_S (ft/sec)	ρ (pcf)	G (ksf)	E (ksf)	ν	K_X (k/ft)	K_ψ (k-ft/rad)	C_X (k-sec/rad)	C_ψ (k-sec-ft/rad)
471	115.6*	7,965.0	2,310.0	0.45	2.491×10^5	6.3614×10^8	17,603	2.1234×10^7
500	125.0	971.0	2,719.0	0.40	2.9451×10^5	7.1052×10^8	19,561	2.2391×10^7
666	115.6*	1,593.0	4,618.0	0.45	4.9805×10^5	1.2719×10^9	24,892	3.0023×10^7
796	115.6*	2,275.0	6,598.0	0.45	7.1150×10^5	1.8170×10^9	29,750	3.5882×10^7
816	115.6*	2,390.0	5,931.0	0.45	7.4746×10^5	1.9087×10^9	30,493	3.6779×10^7

*Values from weighted average method

TABLE 5

SOIL SPRING AND DAMPERS FOR DIESEL GENERATOR BUILDING
EAST-WEST EARTHQUAKE

V_s (ft/sec)	ρ (psf)	G (ksf)	E (ksf)	ν	K_x (k/ft)	K_ψ (K-ft/rad)	C_x (k-sec/rad)	C_ψ (K-sec-ft/rad)
471	115.6	796.5	2,310.0	0.45	2.4623×10^5	1.3006×10^9	18,887	4.54×10^7
500	125.0	971.0	2,719.0	0.40	2.9130×10^5	1.4524×10^9	21,022	4.76×10^7
666	115.6	1,593.0	4,618.0	0.45	4.9237×10^5	2.6000×10^9	26,706	6.4182×10^7
796	115.6	2,275.0	6,598.0	0.45	7.0338×10^5	3.7150×10^9	31,920	7.6723×10^7
816	115.6	2,390.0	6,931.0	0.45	7.3894×10^5	3.9025×10^9	32,717	7.846×10^7

TABLE 6

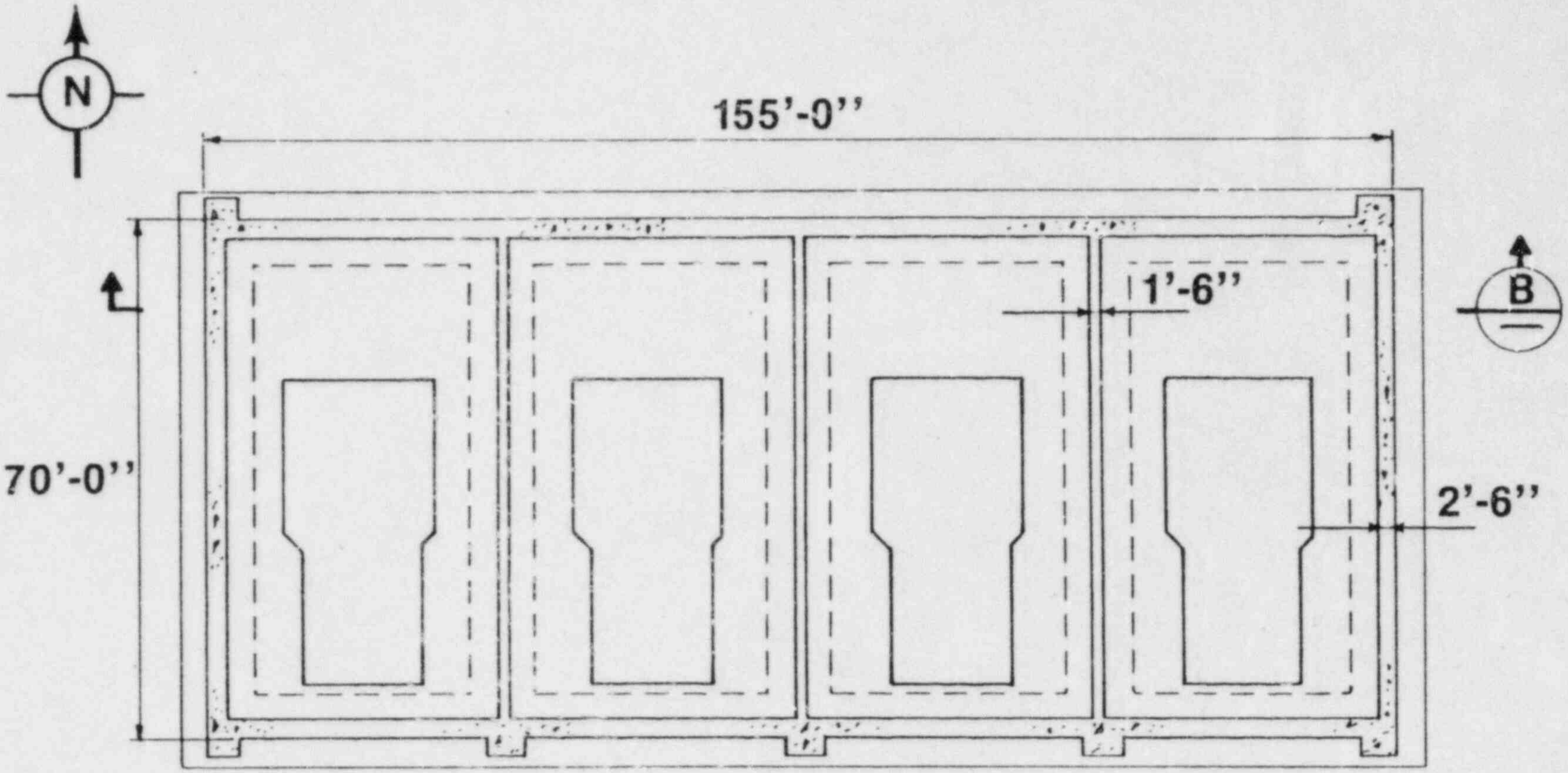
SOIL SPRING AND DAMPERS FOR DIESEL GENERATOR BUILDING VERTICAL EATHQUAKE

V_S (ft/sec)	ρ (pcf)	G (ksf)	E (ksf)	ν	Ky (K/ft)	Cy (K-sec/ft)
471	115.6	796.5	2,310.0	0.45	3.3349×10^5	25,638
500	125.0	971.0	2,609.0	0.40	3.7247×10^5	26,979
666	115.60	1,593.0	4,618.0	0.45	6.6676×10^5	36,251
796	115.60	2,275.0	6,598.0	0.45	9.5232×10^5	43,303
816	115.60	2,390.0	6,931.0	0.45	1.0007×10^6	44,410

DIESEL GENERATOR BUILDING
STRUCTURAL REANALYSIS

- BEHAVIOR
- LOADS AND LOAD COMBINATIONS
- MATERIALS
- ALLOWABLES
- SEISMIC MODEL
- FINITE ELEMENT MODEL
- EVALUATION AND RESULTS
- CONCLUSION

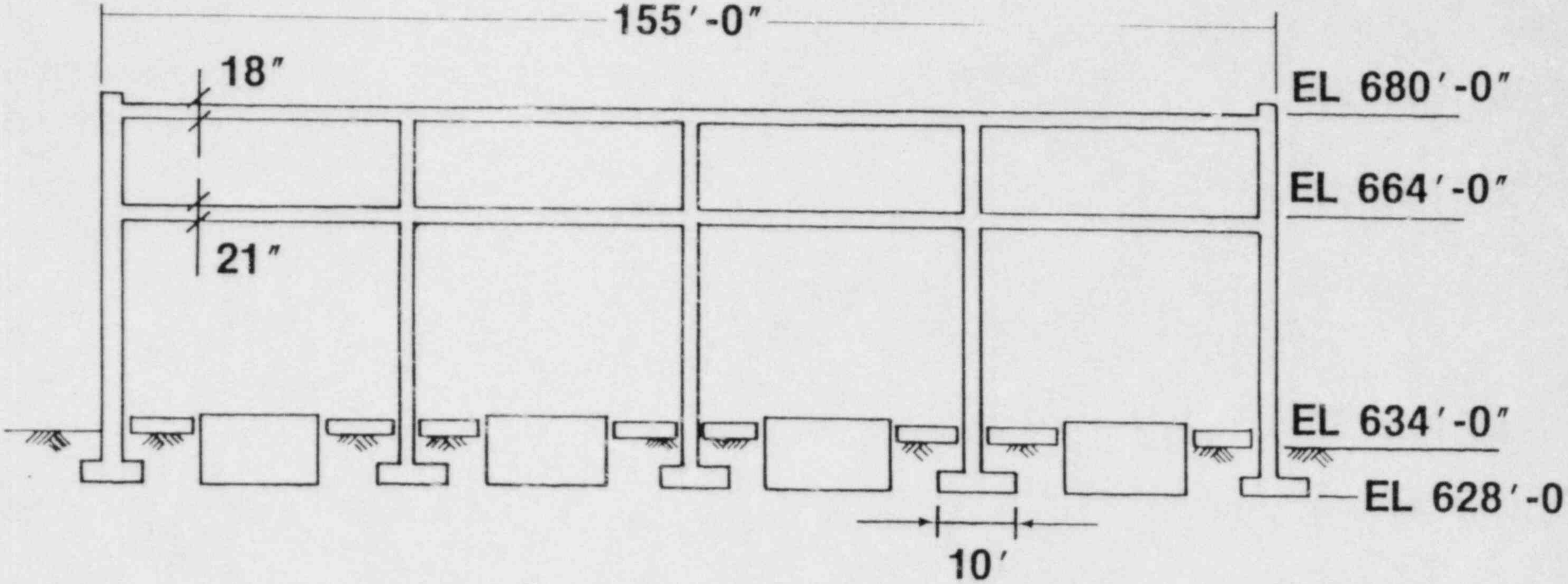
DIESEL GENERATOR BUILDING
FLOOR PLAN AT EL 634'-6"



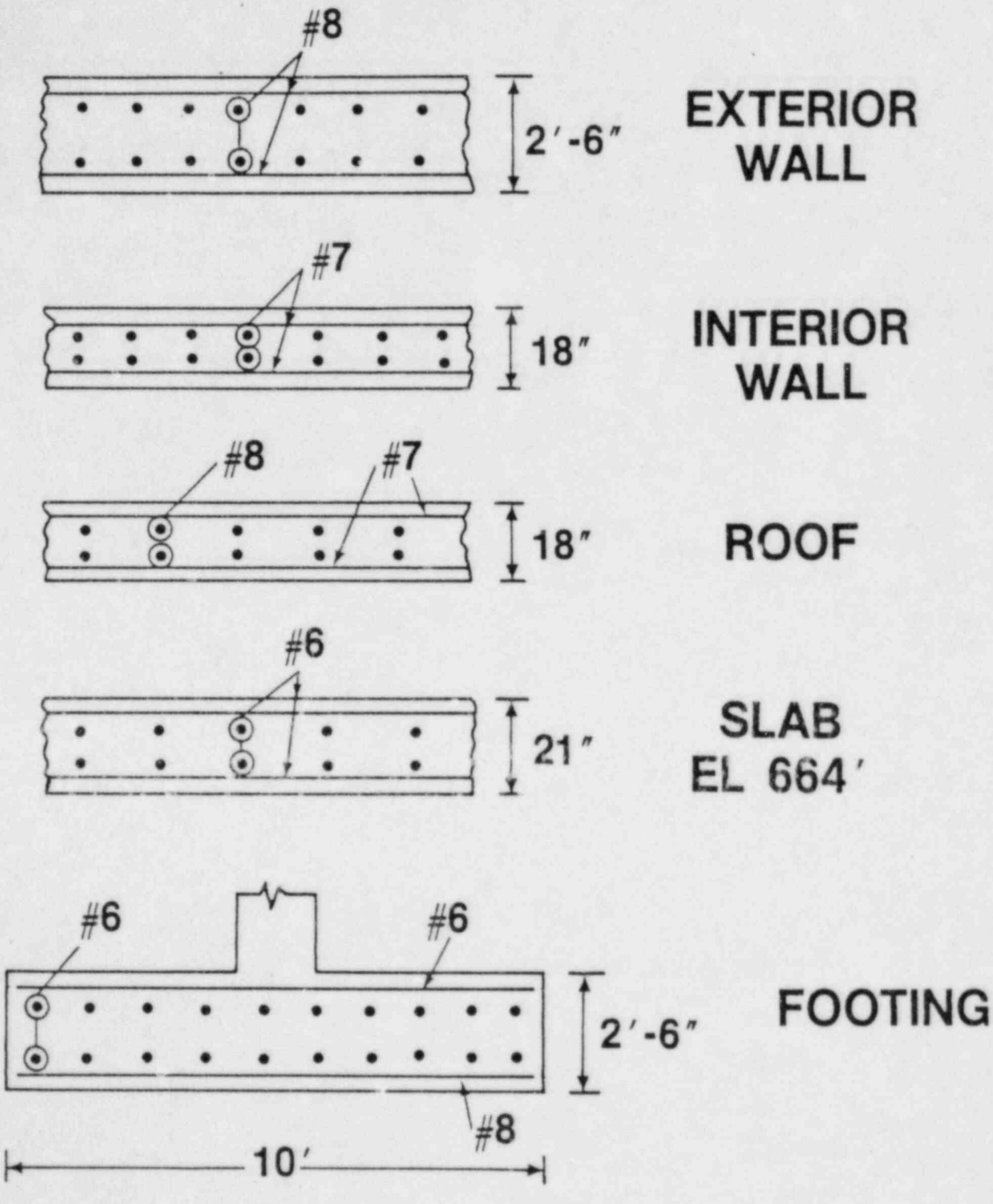
MIDLAND UNITS 1 AND 2
JULY 1983

G-3057-02

DIESEL GENERATOR BUILDING
SECTION B



DIESEL GENERATOR BUILDING
REINFORCEMENT



DIESEL GENERATOR BUILDING
MAJOR LOADS

- DEAD LOAD AND LIVE LOADS
- EARTHQUAKE
- TORNADO
- SETTLEMENT
- TEMPERATURE

DIESEL GENERATOR BUILDING
LOAD COMBINATIONS

- PSAR
- QUESTION 15
- ACI 349

CRITICAL LOAD COMBINATIONS

$$1.4\ (D + T) + 1.7\ L + 1.9\ E + T_0$$

$$D + T + L + W' + T_0$$

$$D + T + L + E' + T_0$$

DIESEL GENERATOR BUILDING
MATERIALS

- CONCRETE

  $f'_c = 4000$ PSI

  $f'_c = 5000$ PSI

- REINFORCEMENT

  GRADE 60

- STRUCTURAL STEEL A-36

- SOIL STIFFNESS

DIESEL GENERATOR BUILDING
DESIGN CRITERIA

- ACI 318 AND 349

  f_s = 54 KSI = .9 F_y

  ε_u = 0.003

- AISC 1969

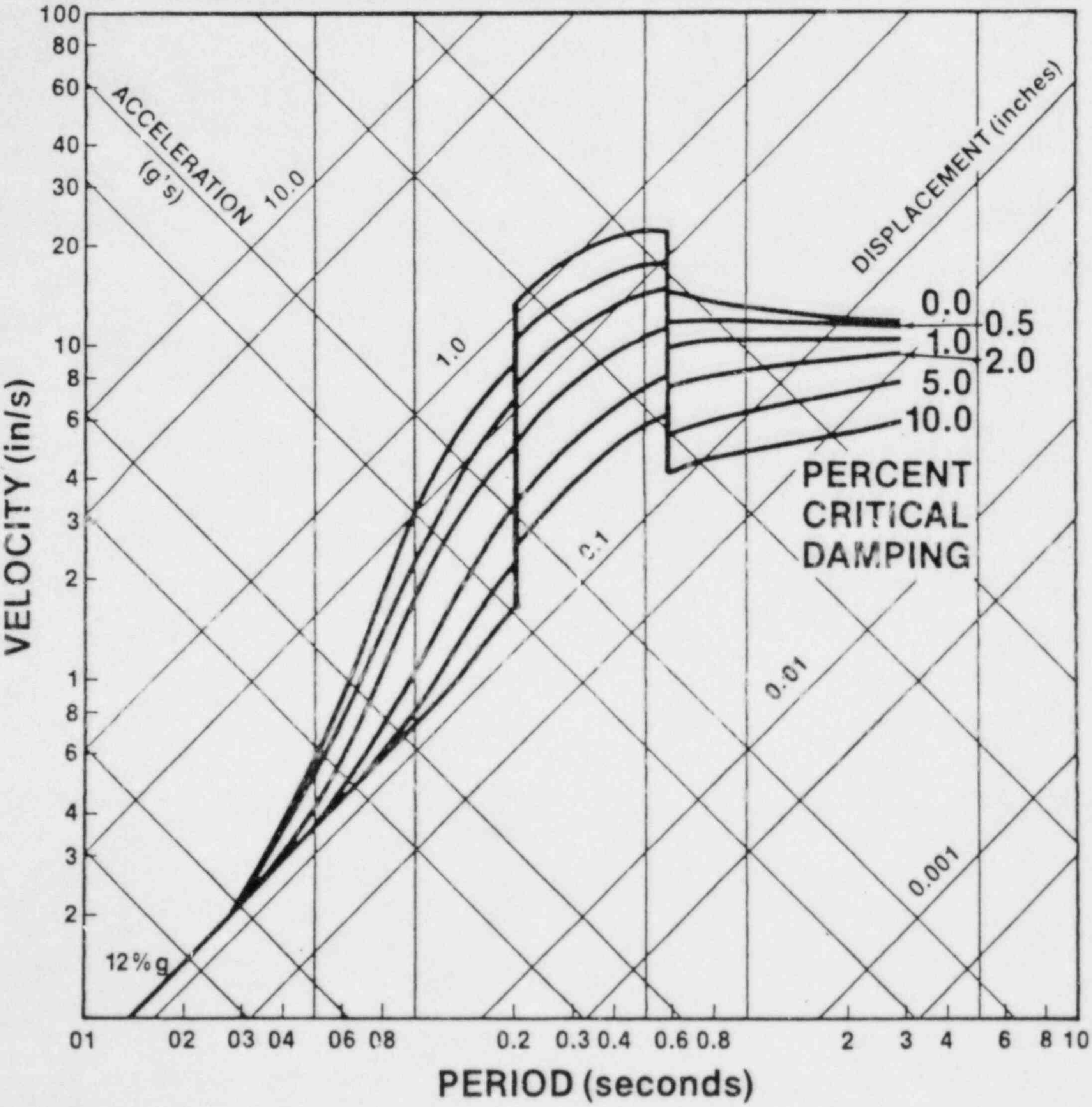
- BEARING

  4.67 KSF (STATIC)

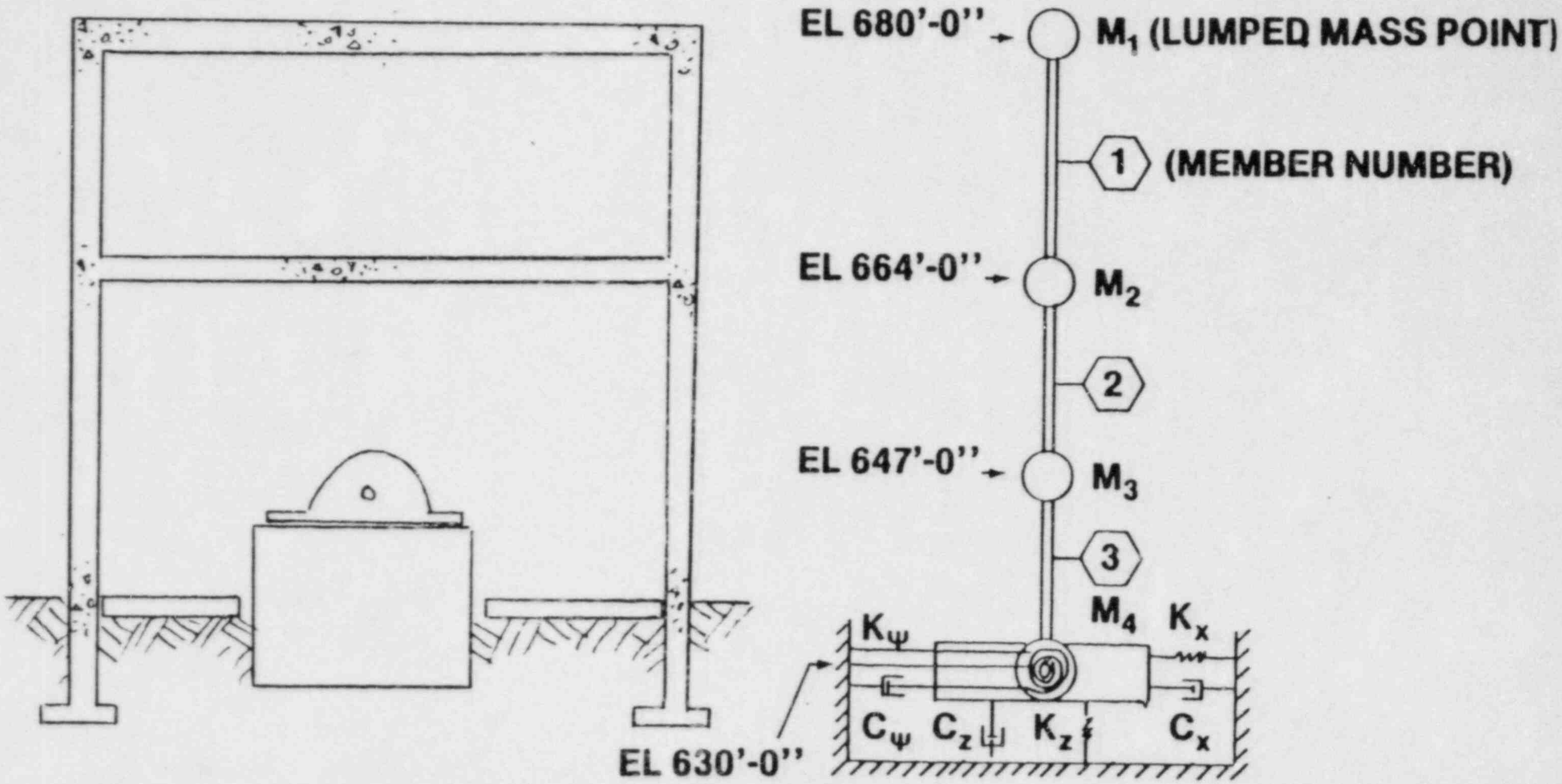
  7KSF (STATIC AND DYNAMIC)

5

DIESEL GENERATOR BUILDING
HORIZONTAL DESIGN RESPONSE SPECTRA - SSE



DIESEL GENERATOR BUILDING
SEISMIC MODEL



DIESEL GENERATOR BUILDING
SEISMIC ANALYSIS

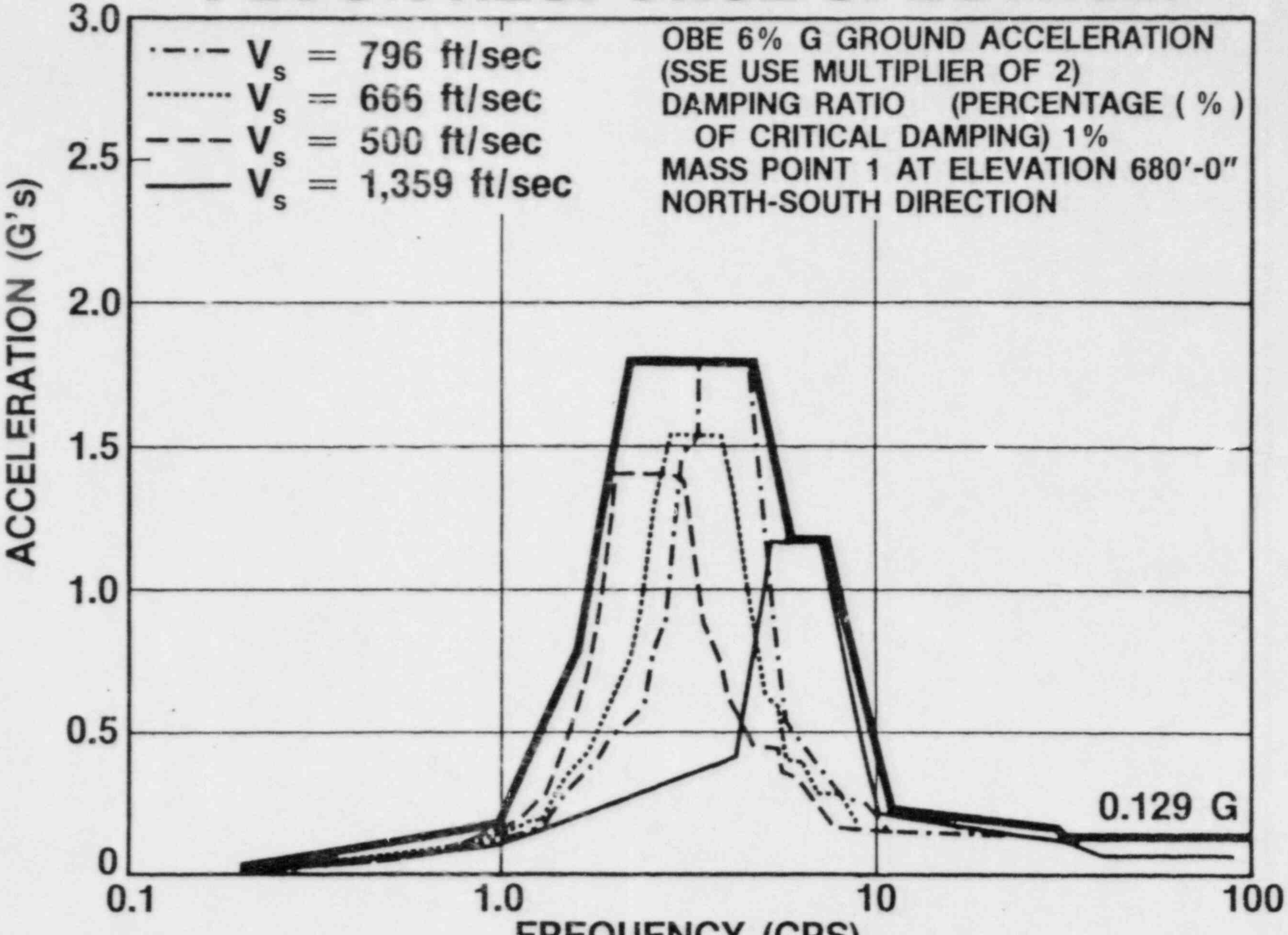
SOIL DYNAMIC PROPERTIES	ORIGINAL	SPECIAL 10 CFR 50.54	WEIGHTED AVERAGE	FSAR NOMINAL
V_S (FPS)	1,359	500	796	666
G (KSF)	7,750	971	2,275	1,593
μ	0.42	0.40	0.45	0.45
ρ (PCF)	135	125	115.6	115.6

DIESEL GENERATOR BUILDING
SEISMIC

ANALYSIS

- TIME-HISTORY
- RESPONSE SPECTRUM

DIESEL GENERATOR BUILDING
FLOOR RESPONSE SPECTRUM



MIDLAND UNITS 1 AND 2
JULY 1983

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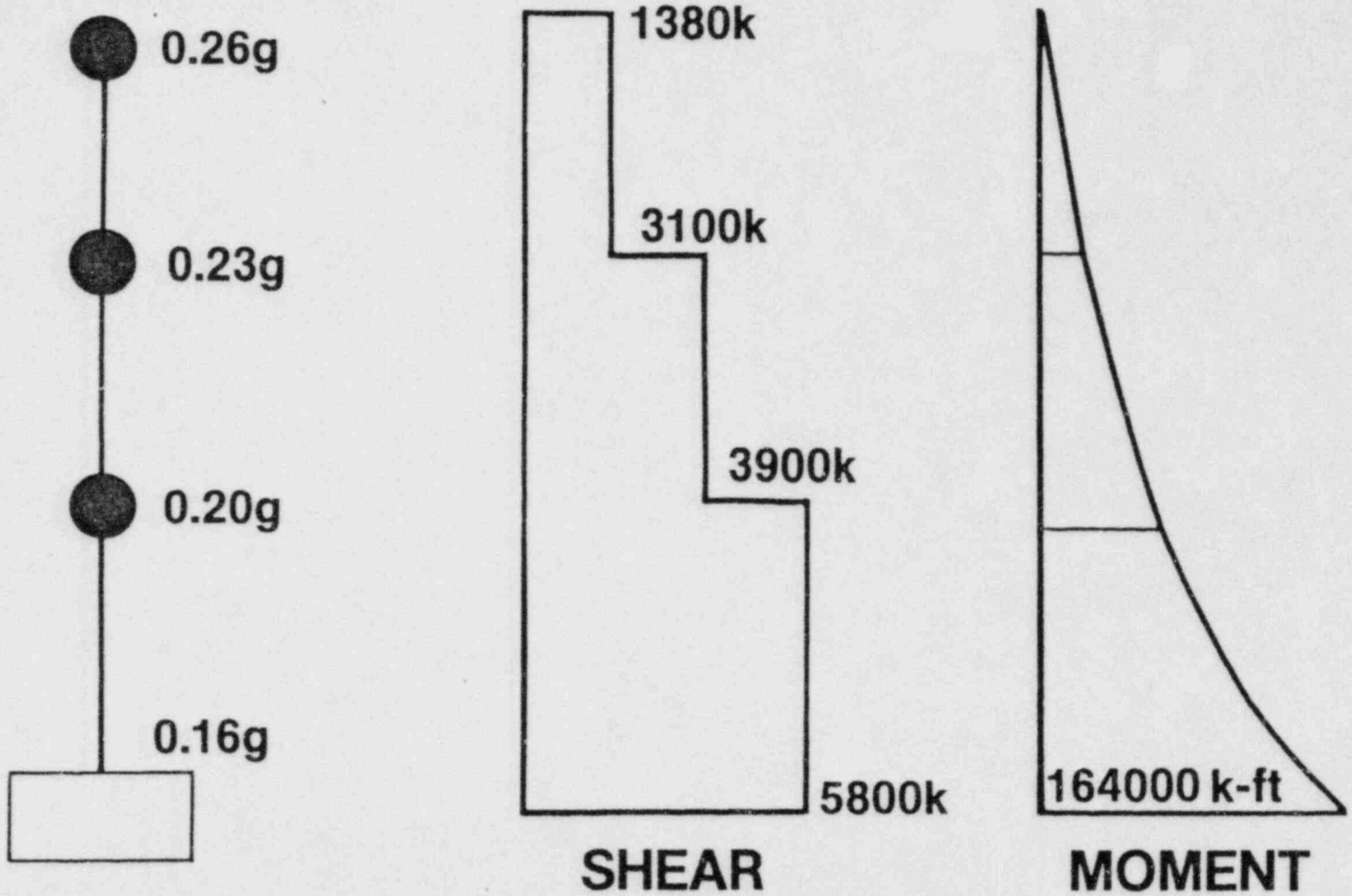
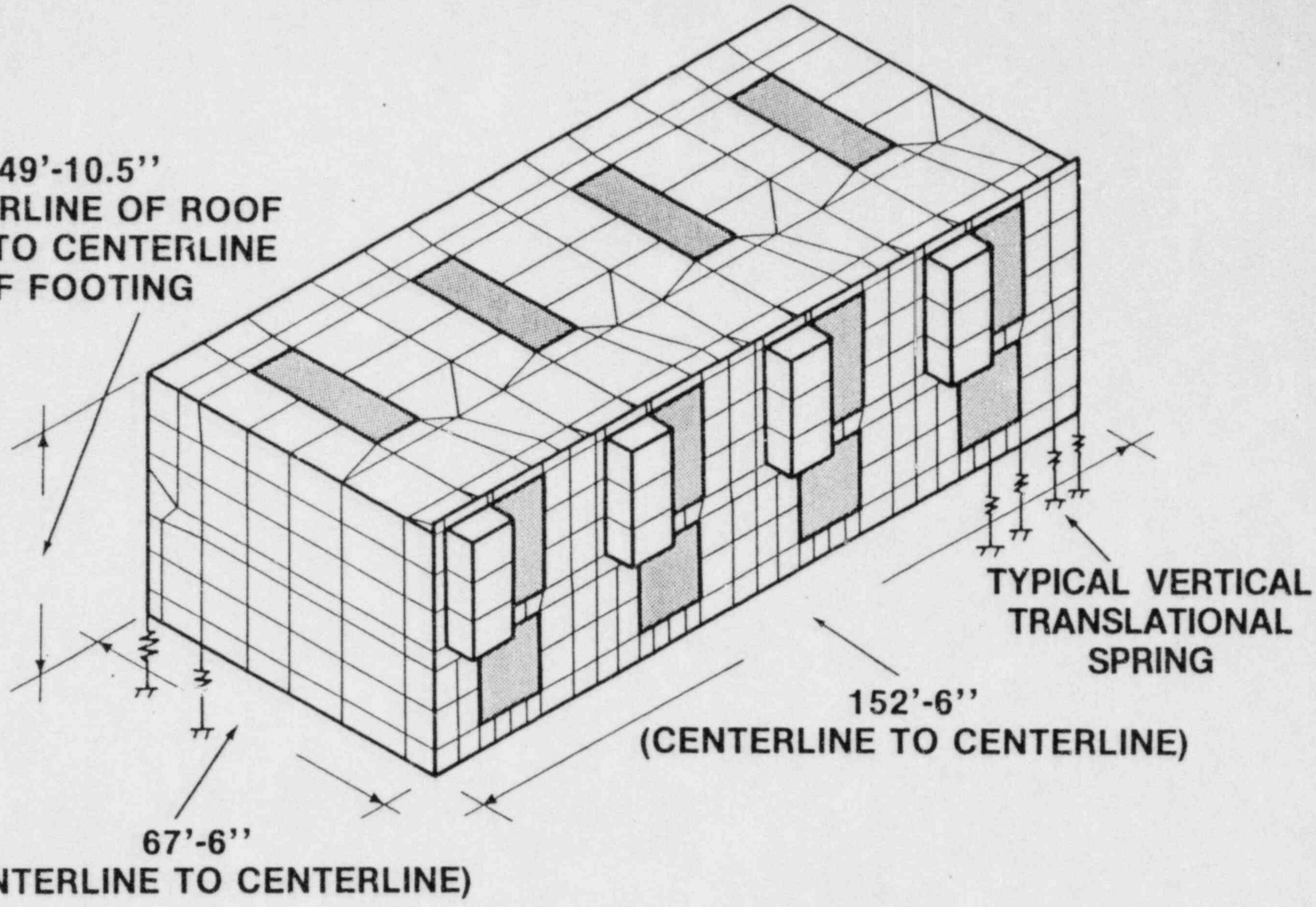
DIESEL GENERATOR BUILDING
SEISMIC ANALYSIS

RESULTS



North-South Earthquake (SSE)

DIESEL GENERATOR BUILDING
FINITE ELEMENT MODEL



DIESEL GENERATOR BUILDING
FINITE ELEMENT ANALYSIS

PLATE ELEMENTS	901
BEAM ELEMENTS	141
BOUNDARY ELEMENTS	252
TOTAL	1,294
NODES	853

BSAP PROGRAM

LINEAR ELASTIC STATIC ANALYSIS

DIESEL GENERATOR BUILDING
FINITE ELEMENT ANALYSIS

- DEAD LOAD — GRAVITY
- LIVE LOAD — PRESSURE
- EARTHQUAKE — ACCELERATIONS
- TORNADO — PRESSURE, CONCENTRATED LOADS
- SETTLEMENT — SOIL SPRINGS

DIESEL GENERATOR BUILDING

FINITE ELEMENT ANALYSIS

- SOIL SPRINGS (BOUNDARY ELEMENTS)

  No Settlements (Approximately 16,000 KSF/Ft)

  Short Term Loading (Seismic)

  Long Term Loading (Settlement)

DIESEL GENERATOR BUILDING
SETTLEMENT

MEASURED/PREDICTED	NW	SE	ERROR BAND
A) 3/78 - 8/78	1.19″	1.99″	± 1/8″
B) 8/78 - 1/79	0.77″	2.21″	± 1/8″
C) 1/79 - 8/79	1.50″	3.24″	± (1/8 + 0.1)
D) 9/79 - 12/2025	1.33″	1.89″	± 0.2″
	4.78″	9.33″	

DIESEL GENERATOR BUILDING

ERROR IN SETTLEMENT VALUES

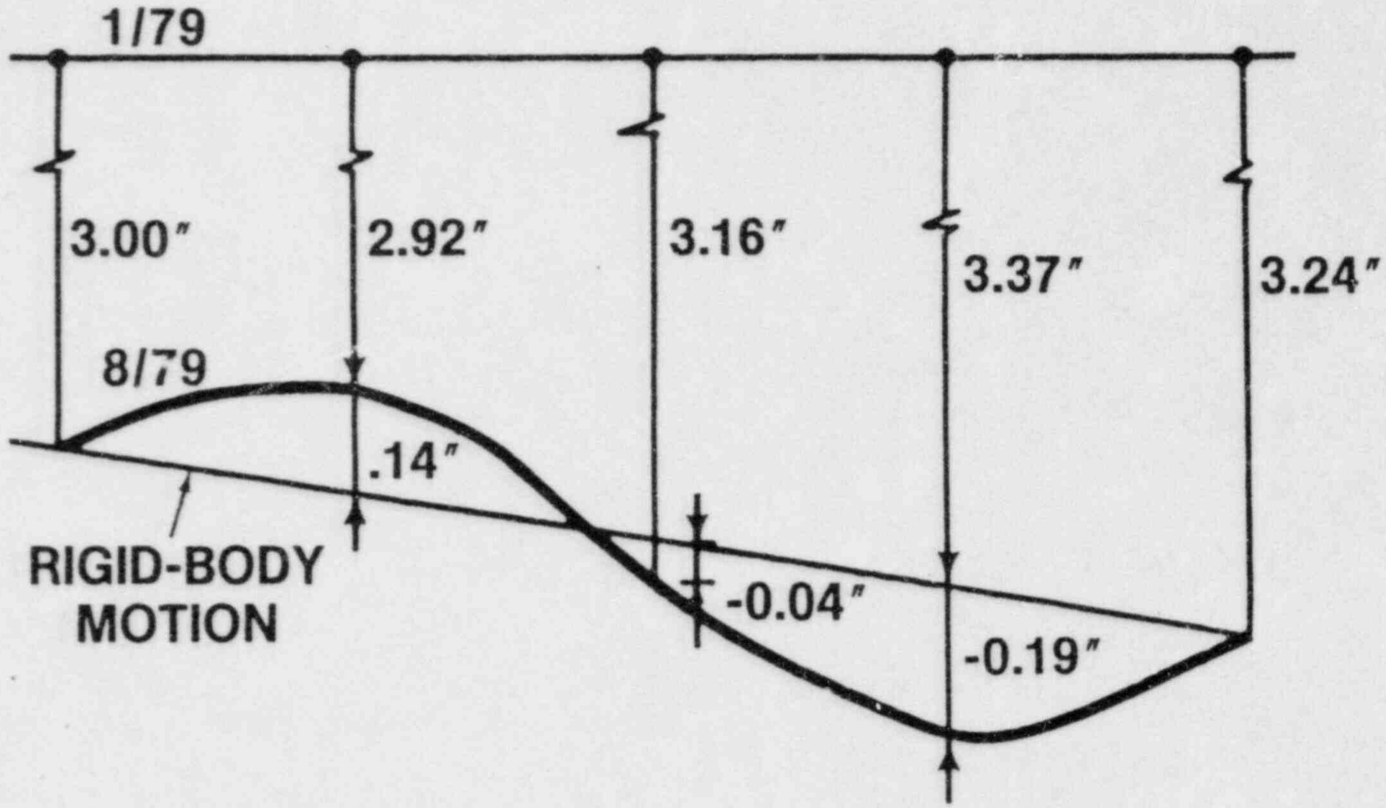
- PRECISION OF SURVEY INSTRUMENTS
- READING AND RECORDING ERRORS
- SYSTEMATIC ERRORS

(SCRIBE MARK → MARKER
SUBSTITUTED MARKER → MARKER)

- EXTRAPOLATION ERRORS

TOTAL ERROR = ± (1/8 + 0.1″)

DIESEL GENERATOR BUILDING
MEASURED SETTLEMENT ALONG SOUTH WALL



MIDLAND UNITS 1 AND 2
JULY 1983

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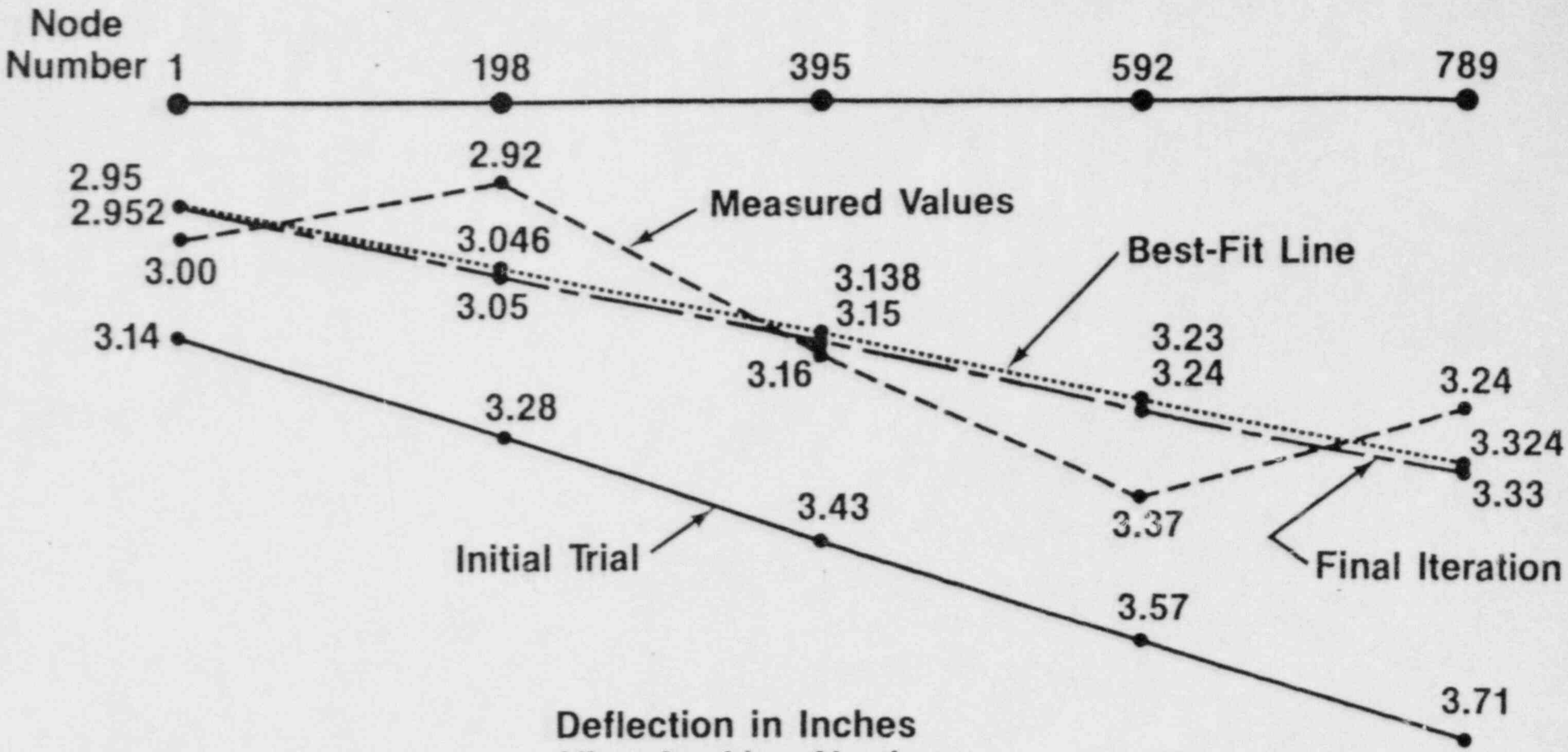
DIESEL GENERATOR BUILDING

SOUTH WALL SETTLEMENT — SURCHARGE CONDITION



Deflection in Inches
View Looking North

$$K_{i+1} = K_i \frac{\Delta I}{\Delta BF}$$

MIDLAND UNITS 1 AND 2
JULY 1983

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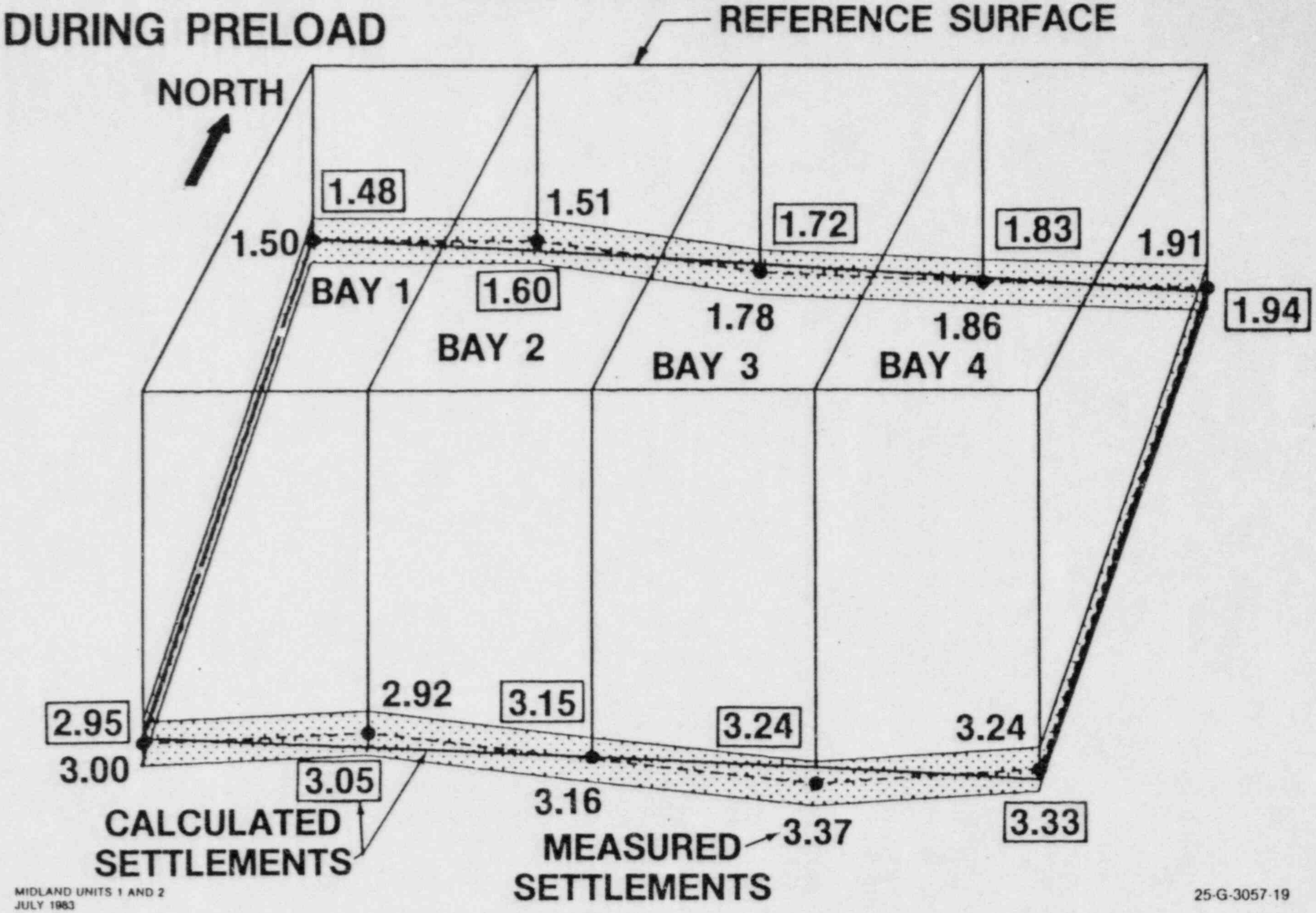
DIESEL GENERATOR BUILDING
SETTLEMENT



MIDLAND UNITS 1 AND 2
JULY 1983

25-G-3057-19

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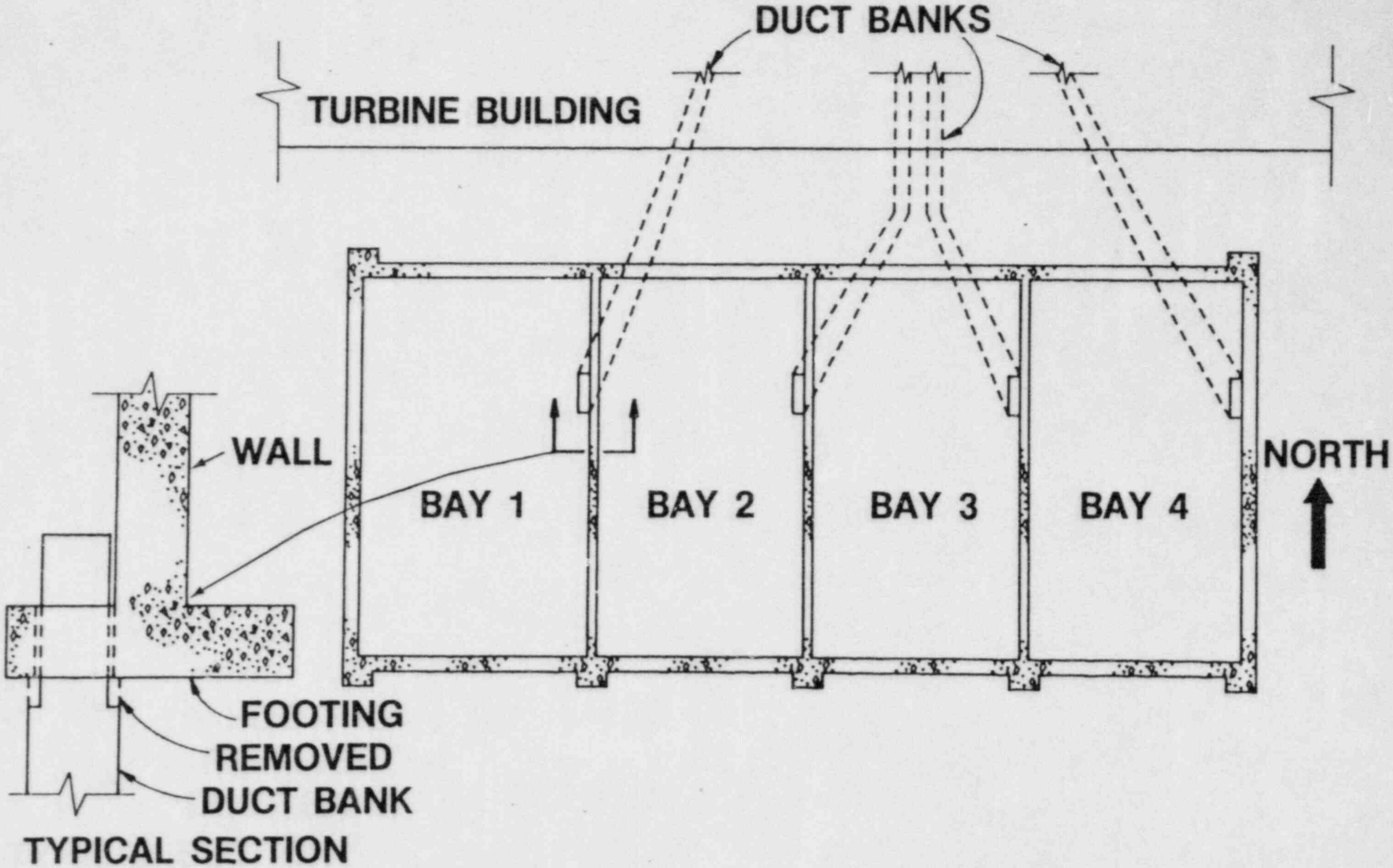
DIESEL GENERATOR BUILDING
DUCT BANK LAYOUT



MIDLAND UNITS 1 AND 2
JULY 1983

27-G-3057-26

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DIESEL GENERATOR BUILDING
ANALYSIS

- CONCRETE WALLS AND SLABS
  - Axial Load + Moment — OPTCON
    - (Thermal Gradient)
  - Out of Plane Shear
- SPREAD FOOTING
  - Bending and Shear
  - Bearing Pressure

DIESEL GENERATOR BUILDING

MAXIMUM STRESSES IN REINFORCEMENT (KSI)

LOCATION	STRESS	ALLOWABLE	LOADING
South Shield Wall in Bay 2	47	54	$(D + T + L + E' + To)$
South Wall	34	54	$1.4(D + T) + 1.7(L) + 1.9(E)$
Footing	37	54	$1.4(D + T) + 1.7(L) + 1.9(E)$
Slab @ 664′	34	54	$1.4(D) + 1.7(L)$
Roof Slab	45	54	$(D + W_T)$

DIESEL GENERATOR BUILDING

TYPICAL STRESSES IN REINFORCEMENT (KSI)

	MIDLAND POSITION		ACI 349	
LOCATION	STRESS	LOADING	STRESS	LOADING
Exterior Wall	14	FSAR Tornado	15	Tornado
Interior Wall	11	FSAR Tornado	16	Tornado
Roof Slab	45	FSAR Tornado	45	Tornado
Slab @ El 664′	34	Dead & Live	34	Dead & Live
Footing	35	FSAR Tornado	37	Seismic

DIESEL GENERATOR BUILDING
CONCRETE STRESSES (PSI)

TYPE	LOCATION	LOADING	STRESS	ALLOWABLE
Flexural Compression	Roof	Tornado	1560	3400
Shear (Out-of-Plane)	Exterior Wall	Tornado	45	126
Shear	Slab @ 664′	Dead & Live	79	126
Shear	Roof Slab	Tornado	36	141
Shear	Footing	Dead & Live	47	126

DIESEL GENERATOR BUILDING

STRUCTURAL REANALYSIS

CONCLUSION

- DGB MEETS ACI 318 AND ACI 349 CODES
- CONSERVATISM

  Elastic Analysis

  Peak Stress

  Tornado

DIESEL GENERATOR BUILDING

- **ADDITIONAL ANALYSIS**
- **MONITORING**
  - Settlement
  - Cracks
- **CRACK REPAIR**

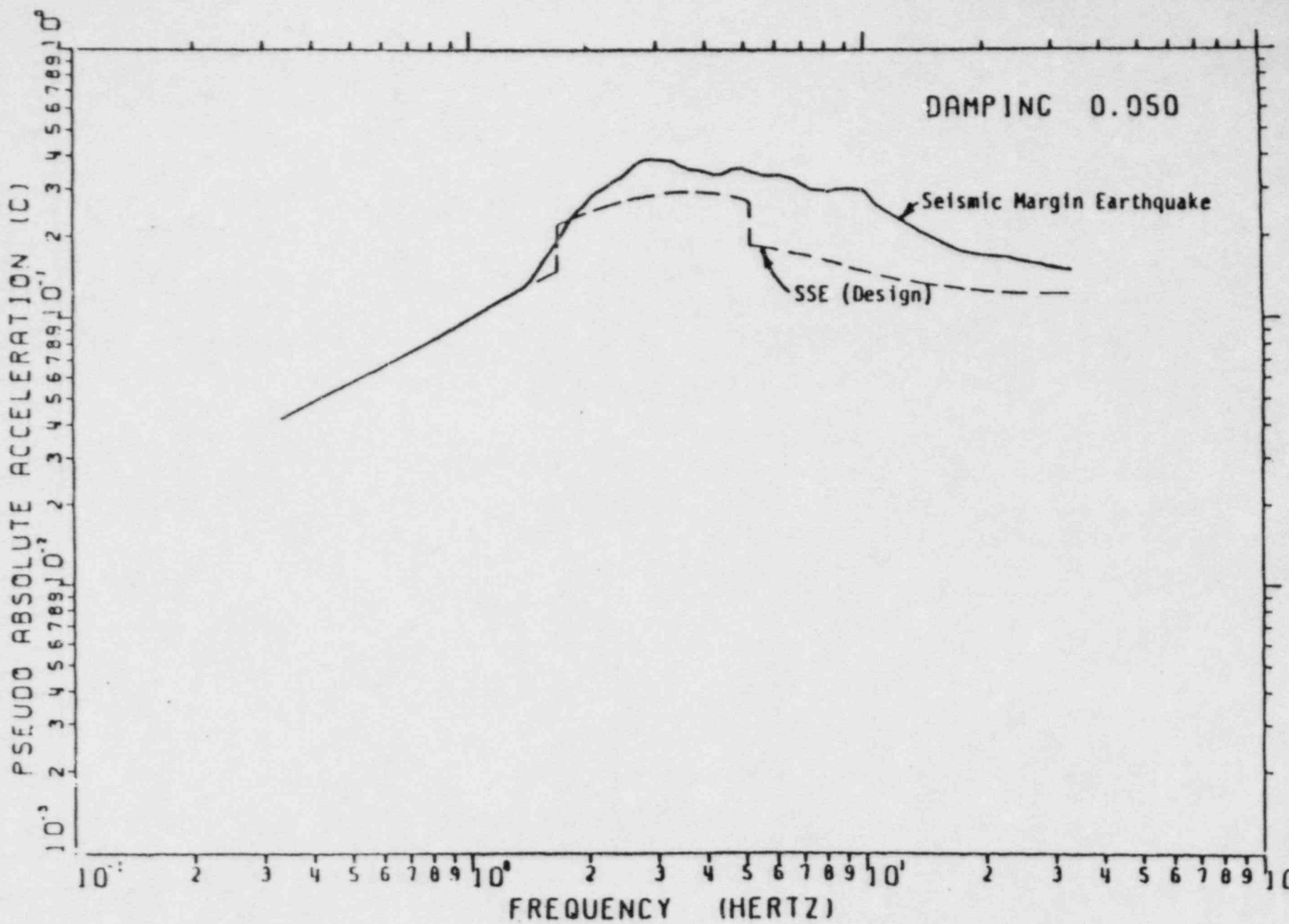

FIGURE I-2-4. COMPARISON OF SME AND FSAR (SSE) TOP OF FILL RESPONSE SPECTRA

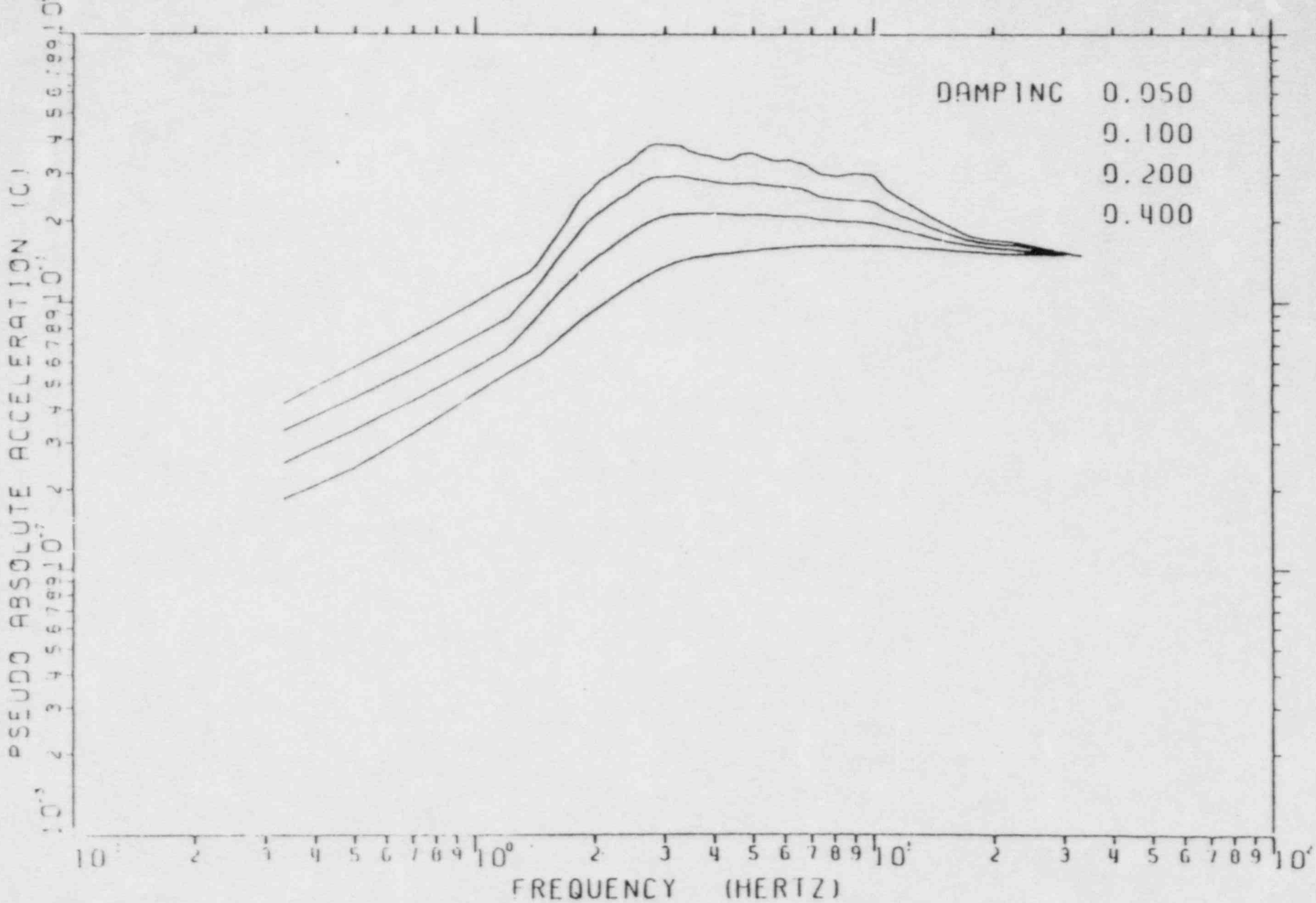

FIGURE I-2-2. SEISMIC MARGIN EARTHQUAKE TOP OF FILL ENVELOPE RESPONSE SPECTRA

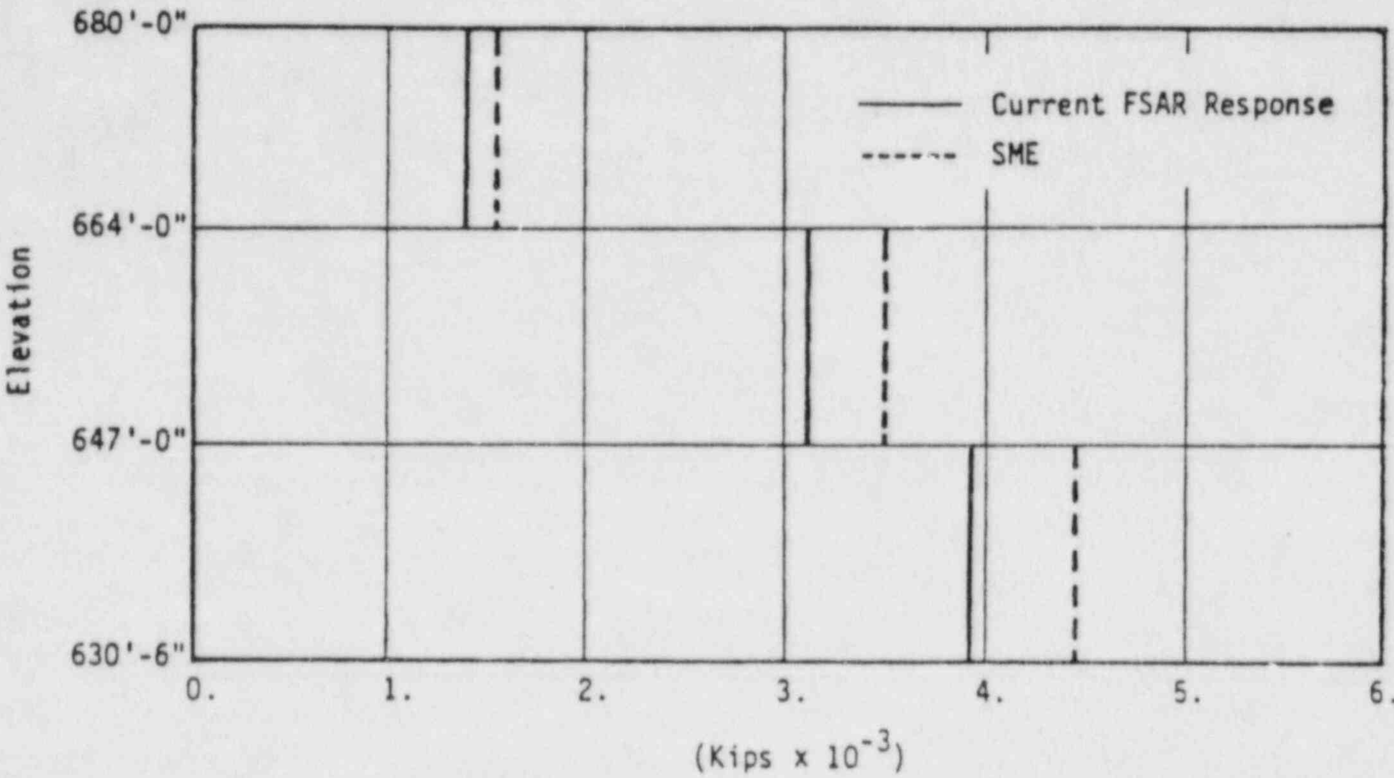

FIGURE V-3-9. DIESEL GENERATOR BUILDING N-S SHEAR COMPARISON

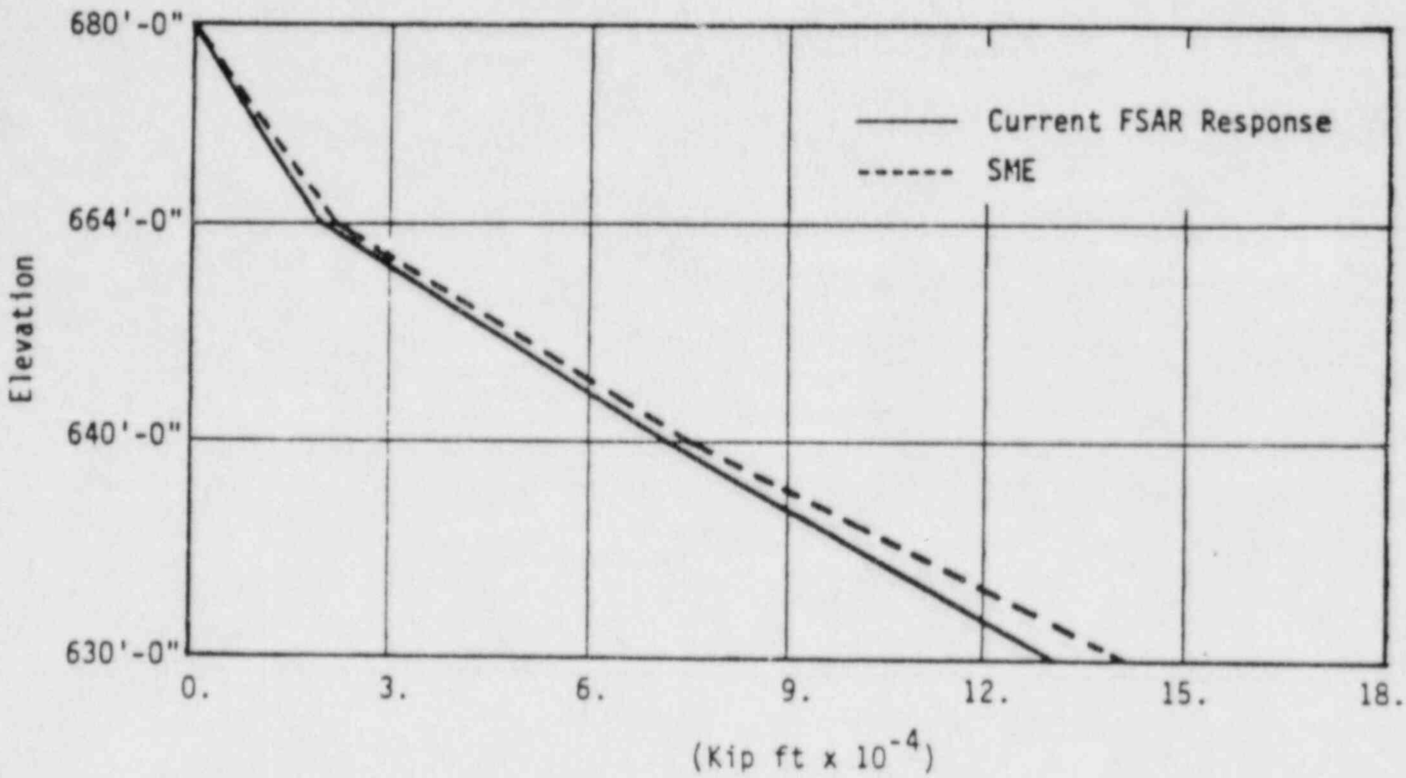

FIGURE V-3-8. DIESEL GENERATOR BUILDING MOMENT ABOUT N-S AXIS COMPARISON

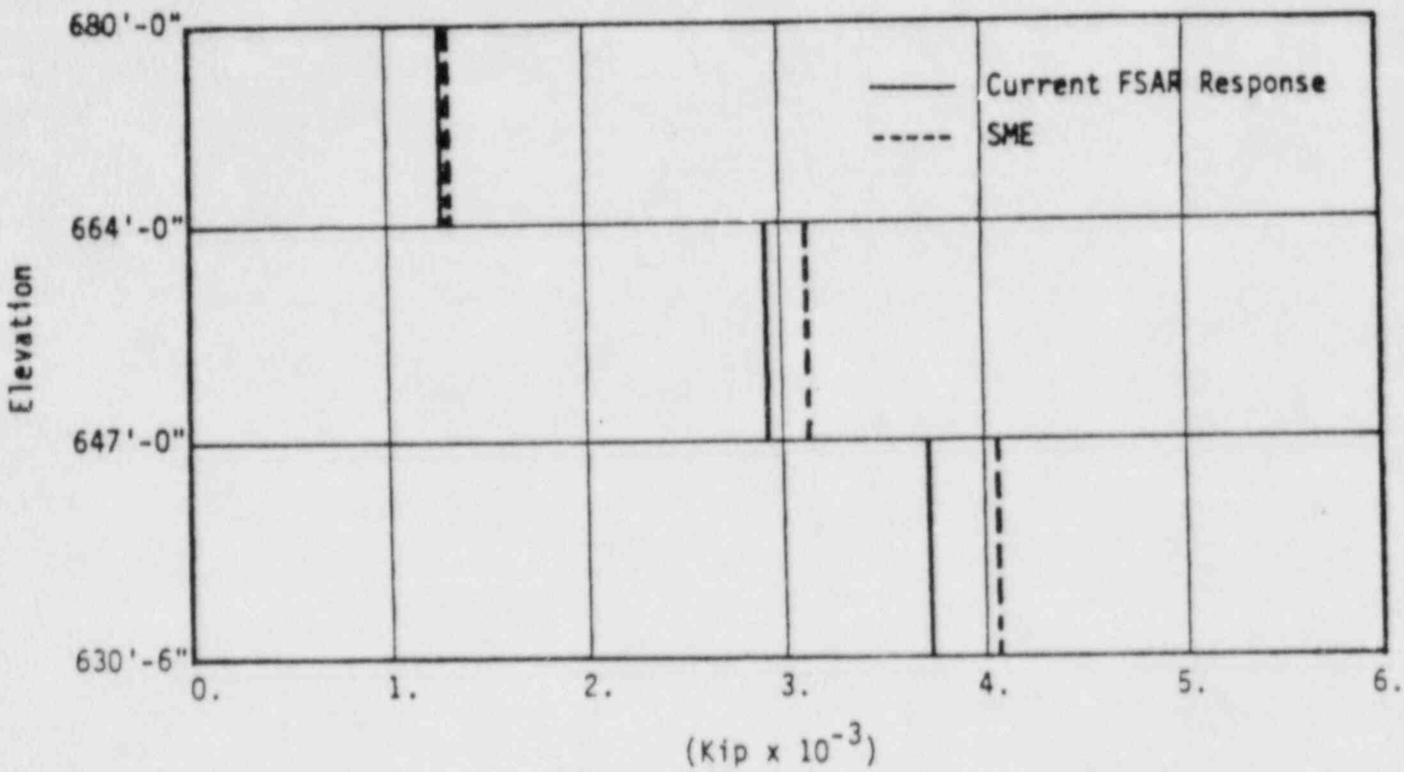

FIGURE V-3-7. DIESEL GENERATOR BUILDING E-W SHEAR COMPARISON

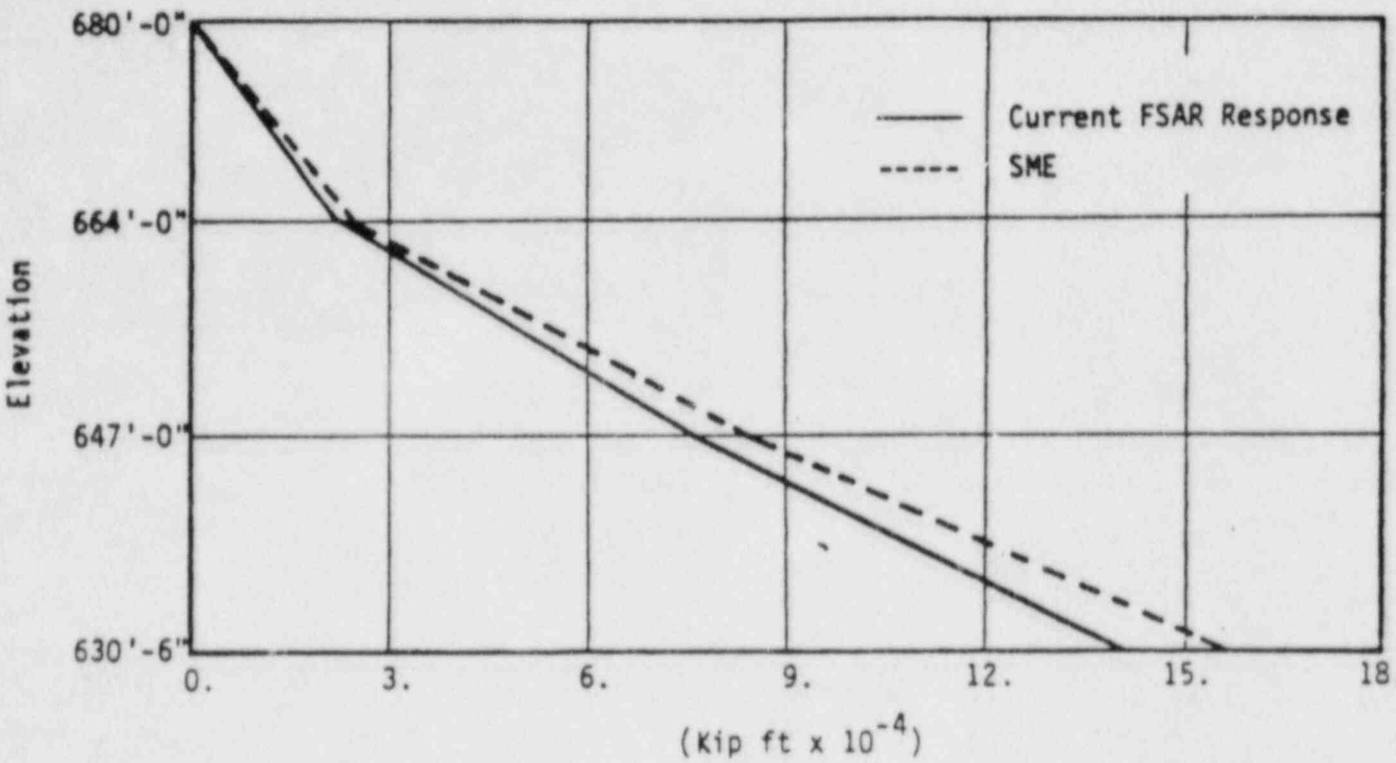

FIGURE V-3-6. DIESEL GENERATOR BUILDING MOMENT ABOUT E-W AXIS COMPARISON

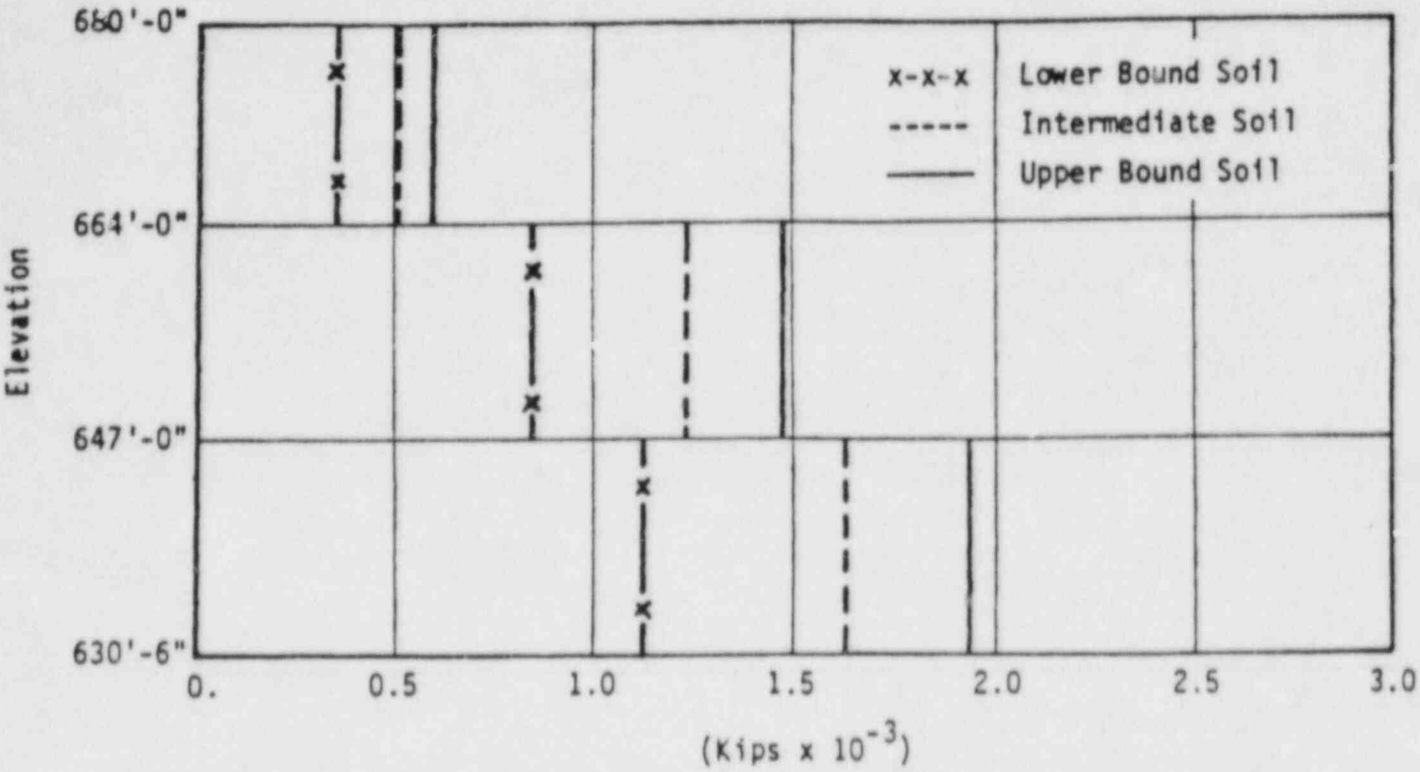

FIGURE V-3-5. DIESEL GENERATOR BUILDING AXIAL FORCE

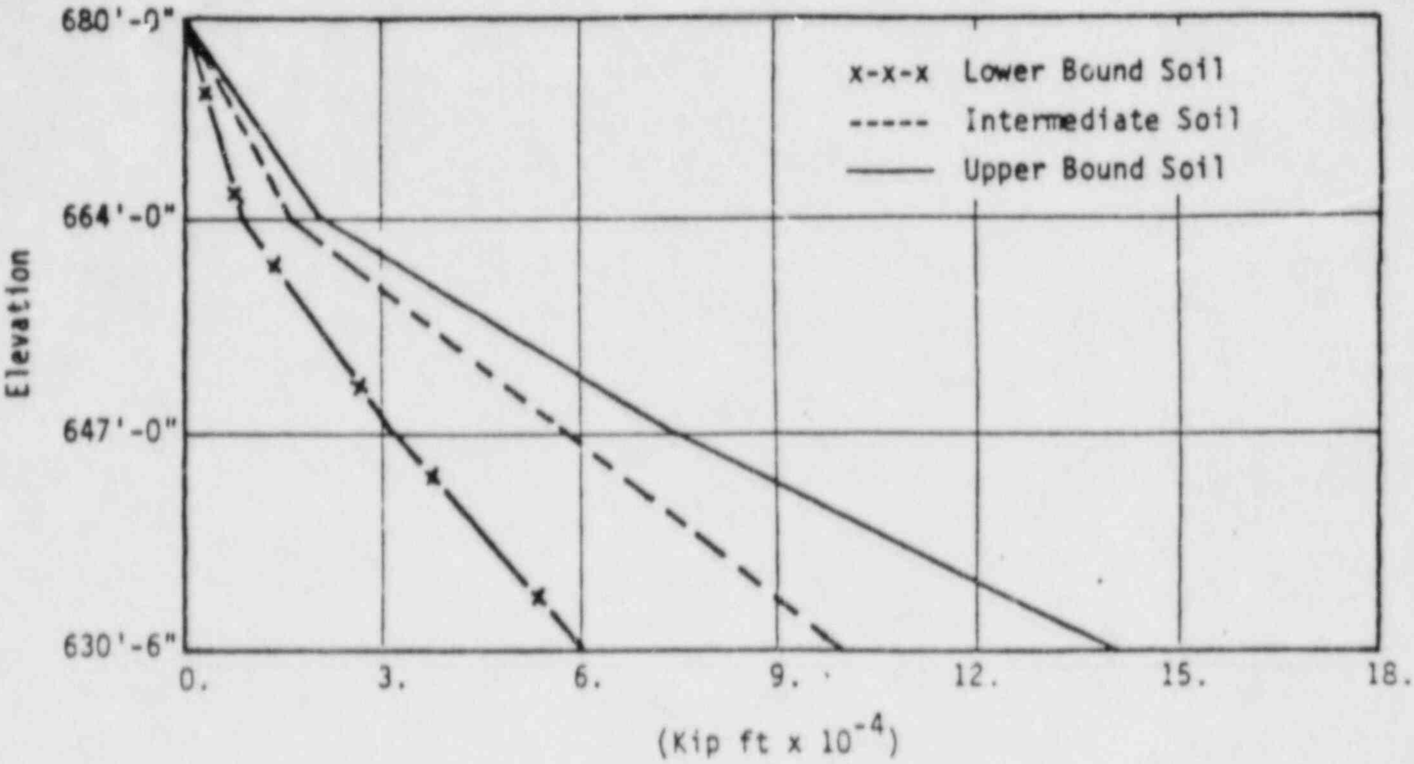

FIGURE V-3-3. DIESEL GENERATOR BUILDING MOMENT ABOUT N-S AXIS

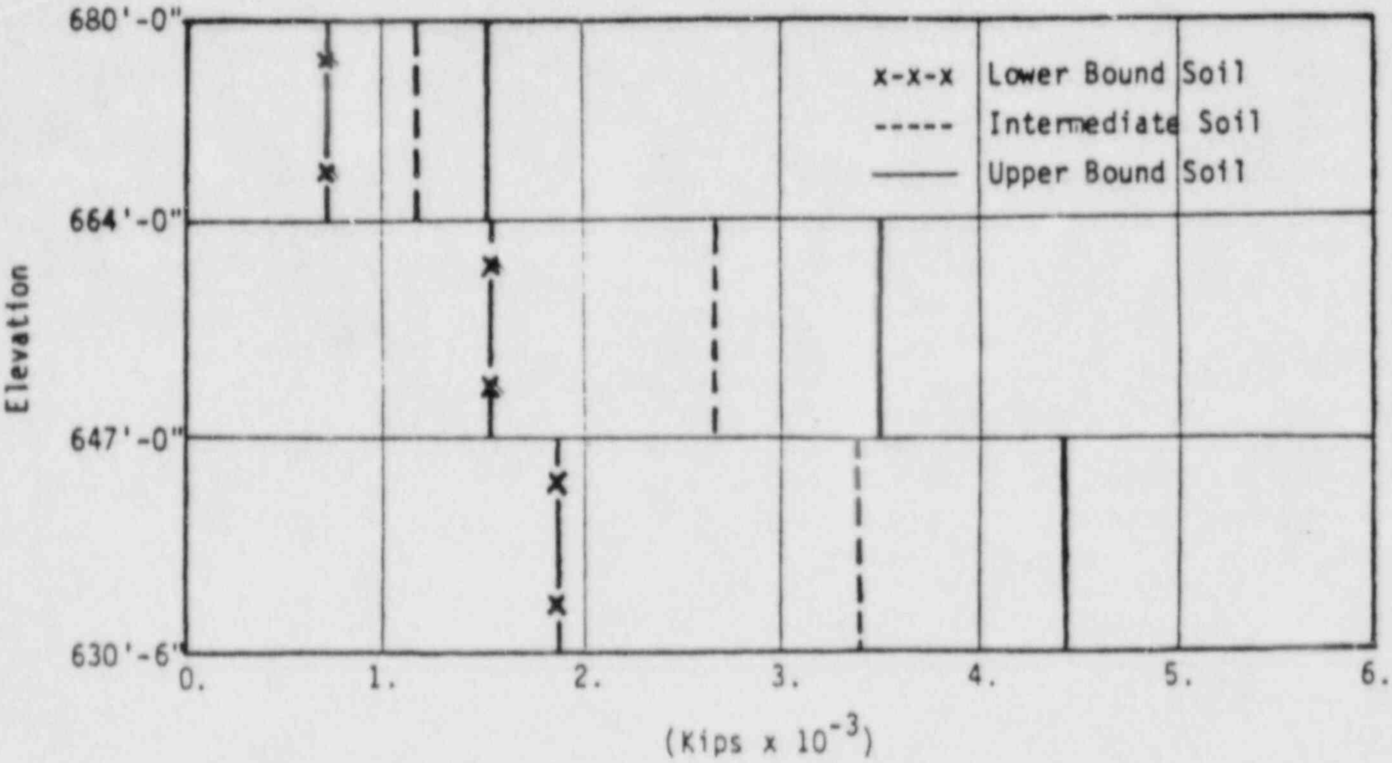

FIGURE V-3-1. DIESEL GENERATOR BUILDING N-S SHEAR

Elevation	Material	Properties		Moduli
634				
628				
	Fill	W_s = 120 pcf		G_{max} = 1.2 x 10^6 psf
		ν = 0.42		G_{ms} = 1.87 x 10^6 psf
		V_s = 570 fps		G_{SME} = 0.75 x 10^6 psf
615				
	Fill	W_s = 120 pcf		G_{max} = 2.7 x 10^6 psf
		ν = 0.42		G_{ms} = 3.28 x 10^6 psf
		V_s = 850 fps		G_{SME} = 1.7 x 10^6 psf
596				
	Glacial Till	W_s = 135 pcf		G_{max} = 22.2 x 10^6 psf
		ν = 0.42		
		V_s = 2300 fps		G_{SME} = 17.3 x 10^6 psf
463				
	Glacial Till	W_s = 135 pcf		G_{max} = 37.8 x 10^6 psf
		ν = 0.42		
		V_s = 3000 fps		G_{SME} = 32.5 x 10^6 psf
363				
	Dense Cohesionless Material	W_s = 135 pcf		G_{max} = 37.8 x 10^6 psf
		ν = 0.34		
		V_s = 3000 fps		G_{SME} = 40.3 x 10^6 psf
263				
	Bedrock	W_s = 150 pcf	V_s = 5000 fps	
		ν = 0.33		

FIGURE V-1-4. UPPER BOUND LAYERED SOIL PROFILE BASED ON STIFF SITE DATA

Elevation

634

628

Fill — W_s = 120 pcf, ν = 0.42, V_s = 490 fps; G_{max} = 0.9 x 10^6 psf, G_{ms} = 1.40 x 10^6 psf, G_{SME} = 0.30 x 10^6 psf

615

Fill — W_s = 120 pcf, ν = 0.42, V_s = 730 fps; G_{max} = 2.0 x 10^6 psf, G_{ms} = 2.50 x 10^6 psf, G_{SME} = 0.70 x 10^6 psf

603

Fill — W_s = 120 pcf, ν = 0.42, V_s = 850 fps; G_{max} = 2.7 x 10^6 psf, G_{ms} = 3.16 x 10^6 psf, G_{SME} = 0.85 x 10^6 psf

596

Glacial Till — W_s = 135, ν = 0.47, V_s = 1290 fps; G_{max} = 7.0 x 10^6 psf, G_{SME} = 1.2 x 10^6 psf

550

Glacial Till — W_s = 135 pcf, ν = 0.47, V_s = 1690 fps; G_{max} = 12 x 10^6 psf, G_{SME} = 2.5 x 10^6 psf

410

Dense Cohesionless Material — W_s = 135 pcf, ν = 0.34

- V_s = 2540 fps, G_{max} = 27 x 10^6 psf, G_{SME} = 10.7 x 10^6 psf } Elevation 410
- V_s = 2970 fps, G_{max} = 37 x 10^6 psf, G_{SME} = 15.1 x 10^6 psf } Elevation 260

260

Bedrock — W_s = 150 pcf, V_s = 5000, ν = 0.33

FIGURE V-1-3. LOWER BOUND LAYERED SOIL PROFILE BASED ON SOFT SITE DATA

Enclosure 4

August 24, 1983

MIDLAND PLANT UNITS 1 AND 2
DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

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MIDLAND PLANT UNITS 1 AND 2

DIESEL GENERATOR BUILDING

EXECUTIVE SUMMARY

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TABLE OF CONTENTS (Continued)

MIDLAND PLANT UNITS 1 AND 2
DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

I. BACKGROUND

A. GENERAL

A construction permit for Midland Plant Units 1 and 2 was issued by the Atomic Energy Commission on December 15, 1972. Soils-related problems were first identified in July 1978 when the settlement monitoring program detected excessive settlement of the diesel generator building (DGB). The DGB has a shallow foundation and is located at the southern end of the main power block as shown in the site plan (Figure ES-1). The building had settled more than was predicted for this stage of construction. Shortly thereafter, the applicant verbally reported the matter to the NRC site inspector, and formally reported it under 10 CFR 50.55(e) in September 1978.

B. LAYOUT

The DGB is a two-story, reinforced-concrete structure with three crosswalls that divide the structure into four cells; each cell contains a diesel generator unit. The building is supported on continuous footings that are founded at el 628' and rests on fill that extends down to approximately el 603'. Plan dimensions of the DGB are approximately 155' x 70' with a total internal height of approximately 44 feet as shown in Figure ES-2. Each diesel generator rests on a 6'-6"-thick, reinforced-concrete pedestal that is not structurally connected to the building foundation.

C. ORIGINAL DESIGN

1. Philosophies

The DGB is a Seismic Category I, safety-related structure designed to protect the diesel generators and associated equipment and to protect this equipment from extreme environmental conditions such as seismic events and tornado and wind loads. As a result of these requirements, a box-type, reinforced-concrete structure with thick walls and roof was chosen. The building is supported by strip or continuous footings. The diesel generators, supported on separate foundations, isolate the building from any potential vibration problem.

2. Structural Systems

In general, conventional and standard calculations were used to analyze and design the various components of the structural system. Computer analysis using the finite-element method was used in some cases such as the floating slab at grade and north walls with complex openings. A lumped-mass computer model supported by soil springs was used to generate seismic response spectra. The seismic forces used in the static analysis and design of the structural components were based on the appropriate acceleration values selected from the response spectra.

All walls were designed as shear walls to resist seismic forces. The exterior walls and roof were also designed to resist impact loads due to tornado-generated missiles as well as pressure loads caused by tornado depressurization. Interior concrete floors are supported by steel beams that carry the vertical loads. The concrete floors and roof were also designed to act as diaphragms to distribute the horizontal loads imposed on the structure. The continuous wall footings (strip foundation) were designed to transmit the building loads to the soil foundation. The floor slabs at grade are independent from the structure and the diesel generator foundations and were designed as floating slabs supported by compacted backfill. The diesel generator foundations are large, reinforced-concrete blocks independent of the structure and are designed to carry the various loads transmitted by the diesel generators.

3. Conservatisms

The DGB is a two-story box structure with a configuration that is inherently strong to resist the applied loads. In addition, the exterior walls and roof are very thick in order to prevent local penetration from postulated tornado-generated missiles. Thus, the structure has a great deal of reserve strength to resist stresses caused by a seismic event and extreme wind loads.

II. DIESEL GENERATOR BUILDING CONSTRUCTION HISTORY

The DGB has a shallow foundation and was constructed in an area of the plant where approximately 25 feet of compacted backfill was placed under the foundation over the natural material at the site. In this area, the majority of the fill was placed between 1975 and 1977. The actual foundation construction of the DGB began in October 1977 and was completed in January 1978. The building walls were constructed up to grade (el 635') between December 1977 and February 1978. The next 19-foot-high section of walls was built between March and April 1978. The diesel generator pedestal foundations were constructed between January and March 1978. The installation of the construction scribe marks to aid construction activities began in March 1978 and was completed in May 1978, and the settlement markers were installed between May and November 1978. In early July 1978, survey settlement records using the scribe marks were begun. During July 1978, when the building was approximately 60% complete, the settlement monitoring program detected settlements of 3.5 inches at the point of greatest settlement, compared to the design predictions of 3 inches for the 40 years of expected plant operation. It appeared that the building was settling due to the consolidation of the underlying fill and was being partially supported along the north portion by four electrical duct banks acting as vertical piers resting on the natural soil below the fill. Shortly thereafter, the applicant verbally reported the matter to the NRC site inspector, and formally reported it under 10 CFR 50.55(e) in September 1978.

Construction of the DGB was voluntarily stopped in August 1978 and a soil boring program was initiated to determine the quality of the backfill under the foundation. Drs. R.B. Peck and A.J. Hendron, Jr. were retained as consultants to advise on the selection and the execution of any remedial action.

The exploration program confirmed that the fill did not meet the specified compaction requirements and that it consisted of both cohesive soil and granular soil. Lean concrete was also used locally as backfill. The fill ranged from very soft to very stiff for cohesive soil and from very loose to dense for granular soil. At the time of the exploration, the groundwater level ranged from el 616' to el 622', and the cooling pond, located about 275 feet south of the building, had a water level at approximately el 622'.

On the basis of the consultants' recommendations and after a review of various alternatives, it was decided to surcharge the DGB and the surrounding area to accelerate settlement and consolidate the fill material. During November 1978, the duct banks (see Figure ES-2A) entering the DGB were isolated from the building so additional settlement due to surcharging and the additional deadweight of the structure to be constructed would not overstress these areas. Construction of the building was also resumed in November 1978 with the remainder of the concrete work on the building being essentially completed by the end of March 1979. Before the surcharge program began in January 1979, the utilities entering the DGB were isolated from the DGB so that settlement during surcharging would not overstress these areas. The utilities were reconnected after the surcharge program was completed in August 1979.

III. REMEDIAL PROGRAM

A. SURCHARGE PROGRAM

The purpose of the surcharge was to accelerate the settlement so that future settlement under the operating loads would be within tolerable limits. Furthermore, this procedure would permit a reliable estimate of the future settlement. Before the surcharge was placed, soil instrumentation was installed (see Table ES-1). The instrumentation was directed at monitoring settlement and pore water pressure in the fill.

Surcharging consisted of placing 20 feet of sand above grade (el 634') with the geometry shown in Figure ES-3. The surcharge was added in two principal increments as shown by the idealized load history in Figure ES-4. Surcharging was effectively begun on January 26, 1979. Approximately 94% of the structure dead load had been applied by the time the surcharge reached maximum level. During this time, the cooling pond level was raised to el 627'. Removal of the surcharge started August 15, 1979, when it had been determined by the applicant and its consultants that primary consolidation of the soil had been achieved and that future settlement could be reliably predicted.

B. PERMANENT DEWATERING SYSTEM

The results of the exploration showed some loose sands were present under the DGB. The surcharge was not expected to improve the sand densities sufficiently to preclude liquefaction during seismic events. Therefore, a permanent dewatering system was designed to maintain water level below el 610' in the area of the DGB. Elevation 610' was selected in accordance with a liquefaction evaluation based on the method published by Seed (see Reference 1). Standard penetration values and relative density data obtained from various investigations were used in this analysis. The study employed a conservative upper-bound acceleration value of 0.19 g, which is larger than the 0.12 g Midland SSE.

C. SETTLEMENT PREDICTIONS

1. <u>Settlement Predictions Based on Surcharge Program</u>

Figure ES-4 contains a typical plot of settlement versus time for a point on the DGB, along with piezometer elevations, cooling pond elevations, and the idealized surcharge load history. The settlement data points for the period before surcharge removal have been replotted as settlement versus the logarithm of time as shown in Figure ES-5. The data after surcharge removal are shown on the semi-log plot of Figure ES-6. Figure ES-5 shows the typical consolidation behavior with primary consolidation completed and the secondary consolidation, with a typical straight line settlement versus log time relation beginning approximately 100 days from the start of surcharge placement. This behavior permitted extrapolations to be made to forecast the building settlement during its service life under the conservative assumption that the surcharge remains in place for 40 years. Results of this extrapolation are shown in Figure ES-7.

Upon surcharge removal, the building showed a rebound of about 0.2 inch. Following the rebound in August 1979 and until the start of dewatering in September 1980, the building showed a maximum settlement of about 0.1 inch. This is less than the range of 0.2 to 0.5 inch, which was predicted on the basis of the previously mentioned straight-line extrapolation.

Following the start of dewatering activities in September 1980 up to December 31, 1981, the building settled 0.4 to 0.5 inch (see Figure ES-8) primarily due to lowering the groundwater table from approximately el 620' to el 595'. Between December 31, 1981, and June 1983, the building settled an additional 0.3 inch primarily due to further lowering of the groundwater table to approximately el 587'. As shown in Figure ES-6, these settlements display relatively steep slopes on the settlement-versus-log-time plot. However, when these data are compared with the observed settlements of the two Borros anchors BA-8 and BA-53 (see Figure ES-9) embedded in the natural soil below the structures, it is seen that most of the observed settlement of the building was due to deep settlement of the underlying natural soil caused by dewatering. When the uniform, deep-seated settlement of the natural soil (below el 603') due to dewatering is subtracted from the total building settlement, the resulting backfill settlement-versus-log-time plot (see Figure ES-10) displays a slope less than the one used for secondary consolidation settlement prediction. Therefore, the predictions of secondary consolidation settlement given in Figure ES-7 are conservative. Furthermore, any future dewatering settlements should be small because future drawdown would exceed the present magnitude by only small amounts.

Concern about liquefaction of the loose sand portions of the backfill is eliminated by permanent groundwater lowering. The settlement of the unsaturated sand because of ground shaking caused by earthquakes (shakedown settlement) was calculated on the basis of the approach described by Silver and Seed (Reference 2) and the recommendations on multidirectional shaking by Pyke, Seed, and Chan (Reference 3). The estimated shakedown settlement is approximately 1/4 to 1/2 inch for ground acceleration up to 0.19 g. The north side of the building will settle the maximum of 1/4 to 1/2 inch during the 0.19 g earthquake, whereas the south side will settle a negligible amount because there is a smaller thickness of sand under the south side of the DGB. Thus, the building will tend to rotate slightly toward the north during seismic shaking. To date, it has tended to rotate south during static settlement under the surcharge load due to the higher percentage of clay under the south side of the building.

2. Settlement Predictions Based on Laboratory Data

At the request of the NRC, 11 soil borings were drilled in the DGB area during April and May 1981 as a part of additional soil investigation. Details of this investigation program were coordinated with the NRC staff and its consultants, the Army Corps of Engineers.

One-dimensional consolidation tests were performed on the samples obtained after removal of surcharge to provide an estimate of maximum past consolidation pressure. The maximum past consolidation pressures interpreted from the laboratory tests showed a scatter predictable for consolidation laboratory tests on heterogeneous fill. The data showed some of the interpreted maximum past consolidation pressures to be lower than would have been expected after surcharging; a greater number were higher. On the basis of this information, a settlement analysis was made to estimate future primary consolidation under the DGB loading. On the basis of a review of the results of this analysis and the measured and predicted settlements, the applicant and the NRC agreed that it is sufficiently conservative to represent future settlement in the structural analysis by the sums of the values in Figures ES-7 and ES-8.

D. FOUNDATION MATERIAL PROPERTIES

1. Bearing Capacity

The results of the strength tests on cohesive soils obtained after surcharging provided shear strength parameters required for evaluation of the factors of safety against bearing capacity failure under static and seismic conditions. The factor of safety against a static bearing capacity failure is greater than 5, compared to the minimum acceptable value of 3. The factor of safety against a bearing capacity failure for combined static and earthquake loads consistent with a safe shutdown earthquake (SSE) of 0.12 g is greater than 2.6. The factor of safety was shown to be equal to 2.4 for an SSE whose dynamic forces are based on a 0.12 g earthquake increased by 50%. The minimum acceptable factor of safety is 2.0 for combined static and earthquake loading.

2. Dynamic Properties of Backfill

Seismic cross-hole testing was performed at two locations within the DGB during November and December 1979 to determine the shear wave velocity of the fill for seismic analysis. The measured shear wave velocities are given in Figure ES-11. The data showed the shear wave velocity can be represented by a value of 500 ft/sec from ground surface to el 615' and by a value of 850 ft/sec from el 615' to el 600'. These numbers were used to determine the shear wave velocity value used in the seismic analysis of the DGB.

E. SURCHARGE EFFECTIVENESS

Figure ES-12 presents a comparison between the pressures that existed during surcharge and those expected during the operating life of the structure. This comparison shows that at all depths in the fill, the pressures that existed during surcharge exceeded those that are expected while the structure is operational. Furthermore, all settlement-versus-log-time plots show that secondary consolidation has been reached. Therefore, the settlements predicted on the assumption that the surcharge remains in place for 40 years (see Figure ES-7) are conservative based on the fact that all loads added after surcharge removal, including those due to permanent dewatering, will be less than the surcharge loading at all depths.

F. SETTLEMENT MONITORING

The settlement of the diesel generator building will be monitored during plant operation. Survey measurements will be taken at least every 90 days during the first year of plant operation. Survey frequency for subsequent years will be established after evaluating measurements taken during the first year. Allowable total settlements, which are based on the predicted values, have been established for each of the settlement markers on the structure and pedestals. If 80% of the allowable settlement (settlement action limit) is reached, survey frequency will be increased to at least once every 60 days and an engineering evaluation will be performed. If the allowable settlements are exceeded, the plant will be shut down until the structure's safety can be established.

IV. STRUCTURAL REANALYSIS

A structural reanalysis was performed on the DGB to determine the settlement and surcharging effects on the building.

A. DESIGN CRITERIA

The DGB is predominately made from 4,000 psi concrete (except the roof slab, which is 5,000 psi concrete) reinforced with Grade 60 steel bars. The building was originally designed for the ACI code allowables.

The load combinations employed for the original analysis and design of the DGB are provided in FSAR Subsection 3.8.6.3. The original FSAR load combinations did not contain a settlement effects term (T). Four additional load combinations were established and committed to be considered. These additional combinations consider the effects of differential settlement in combination with long-term operating conditions and with either wind load or OBE. Table ES-2 provides the load combinations listed in FSAR Subsection 3.8.6.3 and the four additional load combinations.

The following loads are considered in the reanalysis:

1. Dead loads (D)

2. Effects of settlement combined with creep, shrinkage, and temperature (T)

3. Live Loads (L)

4. Wind loads (W)

5. Tornado loads (W')

6. OBE loads (E)

7. SSE loads (E')

8. Thermal effects (T_o)

B. ANALYSIS

1. Models

The structural reanalysis uses two different mathematical models of the DGB: a dynamic lumped-mass model, and a static finite-element model.

The dynamic lumped-mass model is a one-dimensional, stick-type, lumped-mass model using beam elements to represent the structural stiffness, and spring and damper elements to represent the impedance functions for the foundation medium. The model was used to determine the overall seismic behavior of the DGB. The impedance functions were based on the dynamic soil properties. To account for the uncertainties in the foundation soil properties, impedance functions were varied considerably and the resulting seismic responses were enveloped.

The finite-element model is a mathematical model that reduces the DGB to an interrelated system of finite elements. The building is defined by a set of 853 nodal points and 1,294 elements. Of these elements, 901 are plate elements representing walls and slabs, 141 are beam elements representing the footings, and 252 are boundary elements representing the foundation soil. Horizontal and vertical translational springs are used to simulate the boundary condition. Figure ES-13 illustrates an isometric view of the finite-element model.

2. Load Representation

The dead load is represented in the finite-element model by the acceleration due to gravity. The live load is represented by pressures applied to plate elements modeling the floors. Wind loads are represented by pressures on plate elements and concentrated nodal loads. Seismic loads are represented by accelerations and settlement effects are represented by the soil springs explained below.

3. Soils Springs

a) Short-Term Load Analysis

The overall translational soil impedances from the dynamic model are used to calculate soil springs in the finite-element analysis for short-term loads (i.e., wind, tornado, and seismic).

b) Analysis Without Settlement Effects

The analytical model for dead load and live load case without settlement effects was constructed by using large values for the soil springs.

c) Analysis for Settlement Effects

For long-term loadings with settlement effects, the structural reanalysis addresses four distinct time periods. A unique set of measured or estimated settlement values that corresponds to each of the following periods are used:

1) March 28, 1978, to August 15, 1978

The first scribe mark was placed on the structure on March 28, 1978. August 15, 1978, represents the closest survey date before halting DGB construction. The structure was partially completed to 26 feet (el 656'-6") above the top of the foundation. A long-hand analysis was used for calculating stresses.

2) August 15, 1978, to January 5, 1979

The duct banks were separated from the structure, and DGB construction activities resumed during this period. January 5, 1979, is the last survey date before the start of surcharge activities.

The structure was constructed to el 662'-0" and was analyzed using finite-element methods.

3) January 5, 1979, to August 3, 1979

Surcharge activities occurred within and around the structure during this period. August 3, 1979, is the last survey date available before the start of surcharge removal. During this period, the structure was completed and analyzed using finite-element methods.

4) Forty-year settlement

This period is composed of the following:

a. Actual measured settlements from September 1979 to December 1981 - These settlements are small when compared with the predicted settlements and are mainly due to dewatering.

b. Predicted secondary consolidation from December 1981 to December 2025 - These values, based on the conservative assumption that the surcharge remains in place over the life of the plant, exceed the settlement that will actually occur.

To determine forces resulting from settlement, an analysis was performed separately for each of the above four cases. The analysis was iterative in nature to produce a deflection profile of the spread footing foundation that best approximates the settlement profile for the time period being considered.

Figure ES-14 summarizes the actual and estimated settlements employed in the settlement analysis. Figures ES-15, ES-16, and ES-17 give individual isometric presentations of measured and predicted settlements and also show settlement values resulting from the finite-element analysis of the DGB model for periods 2, 3, and 4. The comparison shows good correlation between values resulting from the finite-element model and the measured/predicted settlement values. Because of the high stiffness of the structure compared to the underlying soil, the building will mainly undergo rigid body motion. Differences between calculated and measured/predicted settlements are small and within the accuracy of the survey. The accuracy of the surveys and of the predictions of future settlements are presented as an error band on Figures ES-15, ES-16, and ES-17. It can be seen that practically all the differences between the calculated and the measured/predicted settlements lie within these error bands.

4. Analysis of Survey Data

An analysis of the survey data reveals that the data are not accurate enough to reflect the exact changes in the structural shape due to the settlement.

The results of a review of this survey data can be summarized as follows:

a) The difference between consecutive measurements at a building location reveals both positive and negative values. The negative values indicate that the structure moved up or a potential inaccuracy in measurement existed. Because the structure cannot easily move up against its own weight, it is likely that a negative value indicates an inaccuracy in measurement.

b) Review of relative displacements of the north and south walls show that the data vary irregularly. It cannot be concluded from these data that the structure developed differential settlement in the period considered.

c) Angle Variation Analysis

During the settlement period considered, random changes in algebraic sign exists for the vertical angle formed by three markers along the south wall of the DGB. Therefore, it can be concluded that the settlement of the structure during this period was mainly rigid body motion.

d) Warpage Analysis

The warpage across the structure was found to vary with time between positive and negative values. It can be concluded that the survey data are not sufficiently accurate to prove that the structure has developed differential settlement (warpage) across the corners.

Summarizing, the survey data analysis concludes that the existing data were not accurate enough for direct use in structural analysis and need to be modified, error bands were established to be between 0.125 inch and 0.225 inch for the four settlement periods. By smoothing the settlement vs time curves to compensate for the survey inaccuracies, the data reflect that the structure was experiencing mainly rigid body motion in the period during which settlement was measured.

C. STRUCTURAL EVALUATIONS AND RESULTS

The concrete walls and slabs were evaluated using the OPTCON program. This program calculated the stresses in the concrete and reinforcement of a given section that is subjected to axial load, bending moment, and thermal gradient. The shear stresses in various parts of the building (walls, slabs, and footing) were evaluated using hand calculations from the Bechtel Structural Analysis Program (BSAP) results. The DGB was found to meet the structural design criteria as defined earlier.

The critical load combinations are those that include either the tornado load case (W'), the OBE load case (E), or the settlement effect (T), specifically:

$1.0D + 1.0L + 1.0W' + 1.0T_o$

$1.0D + 1.0T + 1.0L + 1.0E$

$1.4D + 1.4T$

In a majority of the locations in the DGB, the tornado load combinations produce the highest stress levels.

D. ADDITIONAL STRUCTURAL ANALYSES

For comparison only, an additional analysis of the DGB was evaluated for the more stringent load combinations of ACI 349 as supplemented by Regulatory Guide 1.142 (Table ES-3) and found to be adequate.

Another informational finite-element analysis of the DGB has been performed. In this analysis, the 40-year settlement values were imposed onto the structure directly, rather than adjusting the soil springs to an approximate settlement profile as explained earlier. Because the settlement profile is not a smooth curve, the results of the finite-element analysis indicate that the allowable stress levels would be exceeded by a large margin in a vast portion of the structure. Furthermore, the analysis illustrates that additional forces beyond the structural dead load are required to deflect the structure into this shape. In other words, either the soil must be capable of developing tension to pull the structure down or dead load in excess of the existing building dead load must be supplied at the appropriate points to deform the structure to comply with the settlement profile. This analysis therefore demonstrates that the settlement profile cannot realistically be applied directly to the structure.

An analysis was also performed to investigate the structure's ability to span any soft soil condition. This analysis consisted of employing a soil spring value of zero at the junction of the south wall and the interior wall separating bays 3 and 4. Soil spring values were then linearly varied in the north as well as the east-west directions so that they returned to their original 40-year value within a distance of approximately 15 feet from the zero spring. It can be concluded from this analysis that the DGB can successfully span the assumed soft soil spot introduced without significantly increasing the stress levels.

E. EFFECTS OF CONCRETE CRACKS

A set of electrical duct banks located beneath the building foundation initially acted to restrain the even movement of the structure during fill settlement. A systematic crack pattern was observed in walls resting on the duct banks. Cracks in walls that do not rest on duct banks are attributable to the effect of restrained volume changes during curing and drying of the concrete. Cracks were first mapped after the duct banks were separated from the DGB and prior to surcharge placement. Another crack mapping of the DGB was performed after surcharge removal to acertain the effect of surcharge.

The concrete cracks within the DGB were formally addressed in the response to Question 29 of the NRC Requests Regarding Plant Fill. In this response, the cause and significance of the concrete cracks in all structures were presented. Subsequently, during the NRC structural technical audit of April 1981, further discussion was held concerning the effects of the cracks and the additional stresses resulting from the concrete cracks. To evaluate the additional stresses associated with the concrete cracking, a number of analytical approaches have been used and the results forwarded to the NRC in the response to Question 40 of the NRC Requests Regarding Plant Fill. These results indicated that because these stresses are strain-induced secondary stresses, they do not affect the ultimate strength capacity of the cracked member.

In response to an NRC request for a nonlinear, finite-element analysis to evaluate the effects of cracks on the integrity of the DGB, an additional computer analysis of the DGB was performed. This analysis was performed using a finite-element program, Automated Dynamic Incremental Nonlinear Analysis (ADINA), which is a three-dimensional, nonlinear program capable of considering concrete crushing, cracking, crack widening, and reinforcement yielding. The east wall of the DGB was selected for the ADINA analysis. A crack was modeled into the east wall, and the ADINA analysis was performed for two governing load combinations. The analysis indicated that the effect of concrete cracks was localized and minor in nature. The results of this ADINA analysis were submitted to the NRC, followed by meetings with the NRC staff to discuss these results.

To address additional staff concerns, further evaluation of the existing concrete cracks was performed by two consultants, Dr. Mete Sozen of the University of Illinois and Dr. W. Gene Corley of Portland Cement Association. The consultants agree that the DGB is capable of withstanding the loads it was initially designed for, despite the existence of concrete cracks. A report addressing the evaluation of cracks by the consultants has been presented to the NRC staff; three meetings have subsequently been held to discuss the report on cracks.

Also, reports on a crack repair program by Portland Cement Association for all cracks in all structures have been submitted to the NRC. Based on these reports, all exterior cracks ~~greater than 10 mils~~ 20 mils and greater in width, and all accessible interior cracks ~~greater than 10 mils~~ 20 mils and greater in width will be repaired. Also, a monitoring program will be implemented which will consist of monitoring DGB cracks once every year during the first 5 years of plant operation and at 5-year intervals thereafter. Specific acceptance criteria (i.e., alert limits and action limits) on crack width and crack width increases are also specified.

F. SEISMIC MARGIN REVIEW

As part of the seismic margin review (SMR) conducted for Midland, the DGB's ability to withstand seismic excitation was investigated. The evaluation was conducted using new seismic response loads developed for the seismic margin earthquake (SME) together with normal operating design loads. The seismic loads were developed using a site-specific earthquake for Midland as well as new soil-structure interaction parameters which reflect the site layering characteristics. Margins against code-allowable values were calculated for selected elements throughout the structure.

The seismic excitation of the structure was specified in terms of site-specific response spectra developed for the top-of-fill location. These spectra have a peak ground acceleration of approximately 0.15 g. The vertical component was specified as two-thirds of horizontal.

A seismic analysis was performed using the lumped-mass model explained earlier.

Overall seismic loads determined by the response spectrum analyses were distributed to the resisting structural elements by the rigid diaphragm approximation. This method is appropriate for the concrete shear wall and diaphragm system of the DGB. Seismic shears and overturning moments were distributed to the individual walls in proportion to their relative rigidities. Seismic loads acting on the diaphragms were determined using information available from the load distributions to the individual walls. The shear walls and diaphragms were evaluated for seismic loads combined with loads due to normal operating conditions predicted by static analyses.

Capacities for the shear walls were developed in accordance with the ultimate strength design provisions contained in ACI 349-80. Shear walls were checked for their ability to resist in-plane shears and overturning moments. Margin factors were determined for the selected walls based on comparisons of the loads due to seismic and normal operating conditions and the code ultimate strength capacities. The selected walls were found to be governed by overturning moment. The lowest code margin calculated was found to be 1.8. The SME must be increased by at least a factor of 2.2 before the code margin for any wall would be exceeded.

Diaphragm capacities were determined using ACI 349-80 criteria developed for shear walls. The diaphragms evaluated were found to be governed by shear. The lowest code margin for the diaphragms was found to be 2.0. For any diaphragm to reach code capacity, the SME must be increased by a factor of 2.1.

Code margins for the selected structural elements were all conservatively based on minimum specified material strengths and maximum seismic load cases. Reductions in loads to account for inelastic energy dissipation were not used for the DGB. All code margins were determined to be greater than unity. Before code capacity is reached for any DGB element investigated, the SME must be increased by 2.1. It can, therefore, be concluded that the DGB has more than sufficient structural capacity to resist the SME based on code criteria and significantly higher capacity before failure is expected.

V. CONCLUSIONS

The original design of the DGB, based on its overall geometry and layout, produced a structure with a great deal of reserve strength. The settlements during early stages of construction and during the surcharge program did not cause any unusual distress or significant loss of structural strength. The remedial program of surcharging the area with 20 feet of sand has caused the fill to now be under secondary consolidation. Future settlement can be conservatively predicted and will not be excessive. It has been shown through the soil exploration program that the fill material under the DGB does have sufficient reserve in bearing capacity to resist all the imposed loads with the proper safety factor. This area of the site is being permanently dewatered to eliminate any potential for liquefaction that could occur in the sand backfill below the DGB during a seismic event.

The DGB has been structurally reanalyzed for the various phases of construction and the 40-year life of the plant considering the critical load combinations using finite-element computer methods. This analysis includes soil-structure interaction and takes into account the settlement history and the predicted settlement of the structure. On the basis of this analysis, the structure has been shown to meet the design criteria with a significant reserve in strength. In addition, a settlement monitoring program will be maintained on the structure and in the event the actual settlement is greater than 80% of the allowable values, the structure will be reevaluated.

There has been some minor structure cracking during construction and surcharge loading of the area. It has been shown through analysis and evaluation by the consultants that the cracking has not impaired the ultimate strength of the structure. A crack monitoring program will be maintained and in the event that cracks should approach the allowable crack width limits, the structure will be reevaluated.

The SMR of the DGB has revealed that the building has more than sufficient structural capacity to resist the SME.

Thus, it can be concluded that the DGB has the reserve strength to resist all the imposed loading combinations, including settlement, has sufficient margin to resist a larger earthquake, and has sufficient monitoring to ensure that the structure will continue to safely perform its function.

REFERENCES

1. H.B. Seed, "Soil Liquefaction and Cyclic Mobility Evaluation for Level Ground During Earthquakes," Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, Vol 105, No. GT2 (February 1979), Pages 201 through 255

2. M.L. Silver and H.B. Seed, The Behavior of Sands Under Seismic Loading Conditions, Earthquake Engineering Research Center, College of Engineering, University of California, Berkeley, California, December 1969

3. R. Pyke, B. Seed, and K.C. Chan, "Settlements of Sands under Multidirectional Shaking," Journal of Geotechnical Engineering Division, GT4, April 1975, Pages 379 through 397

TABLE ES-1

DIESEL GENERATOR BUILDING INSTRUMENTATION

Type	Number
Building Settlement Markers	28
Settlement Plates	52
Borros Anchors	60
Deep Borros Anchors	4
Sondex Gages	5
Piezometers	48

TABLE ES-2

LOADS AND LOAD COMBINATIONS FOR CONCRETE STRUCTURES OTHER THAN THE CONTAINMENT BUILDING FROM THE FSAR AND QUESTION 15 OF RESPONSES TO NRC REQUESTS REGARDING PLANT FILL

Responses to NRC Requests Regarding Plant Fill, Question 15

a. Service Load Condition

$U = 1.05D + 1.28L + 1.05T$ (1)

$U = 1.4D + 1.4T$ (2)

b. Severe Environmental Condition

$U = 1.0D + 1.0L + 1.0W + 1.0T$ (3)

$U = 1.0D + 1.0L + 1.0E + 1.0T$ (4)

FSAR Subsection 3.8.6.3

a. Normal Load Condition

$U = 1.4D + 1.7L$ (5)

b. Severe Environmental Condition

$U = 1.25 (D + L + H_O + E) + 1.0T_O$ (6)

$U = 1.25 (D + L + H_O + W) + 1.0T_O$ (7)

$U = 0.9D + 1.25 (H_O + E) + 1.0T_O$ (8)

$U = 0.9D + 1.25 (H_O + W) + 1.0T_O$ (9)

c. Shear Walls and Moment Resisting Frames

$U = 1.4 (D + L + E) + 1.0T_O + 1.25H_O$ (10)

$U = 0.9D + 1.25E + 1.0T_O + 1.25H_O$ (11)

d. Structural Elements Carrying Mainly Earthquake Forces, Such as Equipment Supports

$U = 1.0D + 1.0L + 1.8E + 1.0T_O + 1.25H_O$ (12)

Table ES-2 (continued)

e. Extreme Environmental and Accident Conditions

$$U = 1.05D + 1.05L + 1.25E + 1.0T_A + 1.0H_A + 1.0R \quad (13)$$

$$U = 0.95D + 1.25E + 1.0T_A + 1.0HA_A + 1.0R \quad (14)$$

$$U = 1.0D + 1.0L + 1.0E' + 1.0T_O + 1.25H_O + 1.0R \quad (15)$$

$$U = 1.0D + 1.0L + 1.0E' + 1.0T_A + 1.0H_A + 1.0R \quad (16)$$

$$U = 1.0D + 1.0L + 1.0B + 1.0T_O + 1.25H_O \quad (17)$$

$$U = 1.0D + 1.0L + 1.0T_O + 1.25H_O + 1.0W' \quad (18)$$

where

B = hydrostatic forces due to the probable maximum flood (PMF)

D = dead loads of structures and equipment and other permanent, load-contributing stress

E = operating basis earthquake (OBE)

E' = safe shutdown earthquake load (SSE)

H_O = force on structure caused by thermal expansion of pipes under operating conditions

H_A = force on structure caused by thermal expansion of pipes under accident conditions

L = conventional floor and roof live loads (includes moveable equipment loads or other loads which vary in intensity)

R = local force, pressure on structure, or penetration caused by rupture of pipe

T = effects of differential settlement, creep, shrinkage, and temperature

T_O = thermal effects during normal operating conditions

T_A = total thermal effects which may occur during a design accident

U = required strength to resist design loads or their related internal moments and forces

W = design wind load

W' = tornado wind loads, excluding missile effects, if applicable (refer to Subsection 2.2.3.5)

TABLE ES-3

LOADS AND LOAD COMBINATIONS FOR
COMPARISON ANALYSIS REQUESTED IN
QUESTION 26 OF NRC REQUESTS
REGARDING PLANT FILL

ACI 349 as Supplemented by Regulatory Guide 1.142

a. Normal Load Condition

$U = 1.4 (D + T) + 1.7L + 1.7R_O$

$U = 0.75 [1.4 (D + T) + 1.7L + 1.7T_O + 1.7R_O]$

b. Severe Environmental Condition

$U = 1.4 (D + T) + 1.4F + 1.7L + 1.7H + 1.9E_O + 1.7R_O$

$U = 1.4 (D + T) + 1.4F + 1.7L + 1.7H + 1.7W + 1.7R_O$

$U = 0.75 [1.4 (D + T) + 1.4F + 1.7L + 1.7H + 1.9E_O + 1.7T_O + 1.7R_O]$

$U = 0.75 [1.4 (D + T) + 1.4F + 1.7L + 1.7H + 1.7W + 1.7T_O + 1.7R_O]$

c. Extreme Environmental Conditions

$U = (D + T) + F + L + H + T_O + R_O + W_T$

$U = (D + T) + F + L + H + T_O + R_O + E_{SS}$

d. Abnormal Load Conditions

$U = (D + T) + F + L + H + T_A + R_A + 1.5P_A$

$U = (D + T) + F + L + H + T_A + R_A + 1.25P_A + 1.0(Y_R + Y_J + Y_M) + 1.25E_O$

$U = (D + T) + F + L + H + T_A + R_A + 1.0P_A + 1.0(Y_R + Y_J + Y_M) + 1.0E_{SS}$

where

Normal loads are those loads encountered during normal plant operation and shutdown, and include:

T = settlement loads

Table ES-3 (continued)

D = dead loads or their related internal moments and forces

L = applicable live loads or their related internal moments and forces

F = lateral and vertical pressure of liquids or their related internal moments and forces

H = lateral earth pressure or its related internal moments and forces

T_O = thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady-state condition

R_O = maximum pipe and equipment reactions if not included in the above loads

Severe environmental loads are those loads that could infrequently be encountered during the plant life and include:

E_O = loads generated by the operating basis earthquake (OBE)

W = loads generated by the operating basis wind (OBW) specified for the plant

Extreme environmental loads are those loads which are credible but highly improbable, and include:

E_{SS} = loads generated by the safe shutdown earthquake (SSE)

W_T = loads generated by the design tornado specified for the plant

Abnormal loads are those loads generated by a postulated high-energy pipe break accident and include:

P_A = maximum differential pressure load generated by a postulated break

T_A = thermal loads under accident conditions generated by a postulated break and including T_O

R_A = pipe and equipment reactions under accident conditions generated by a postulated break and including R_O

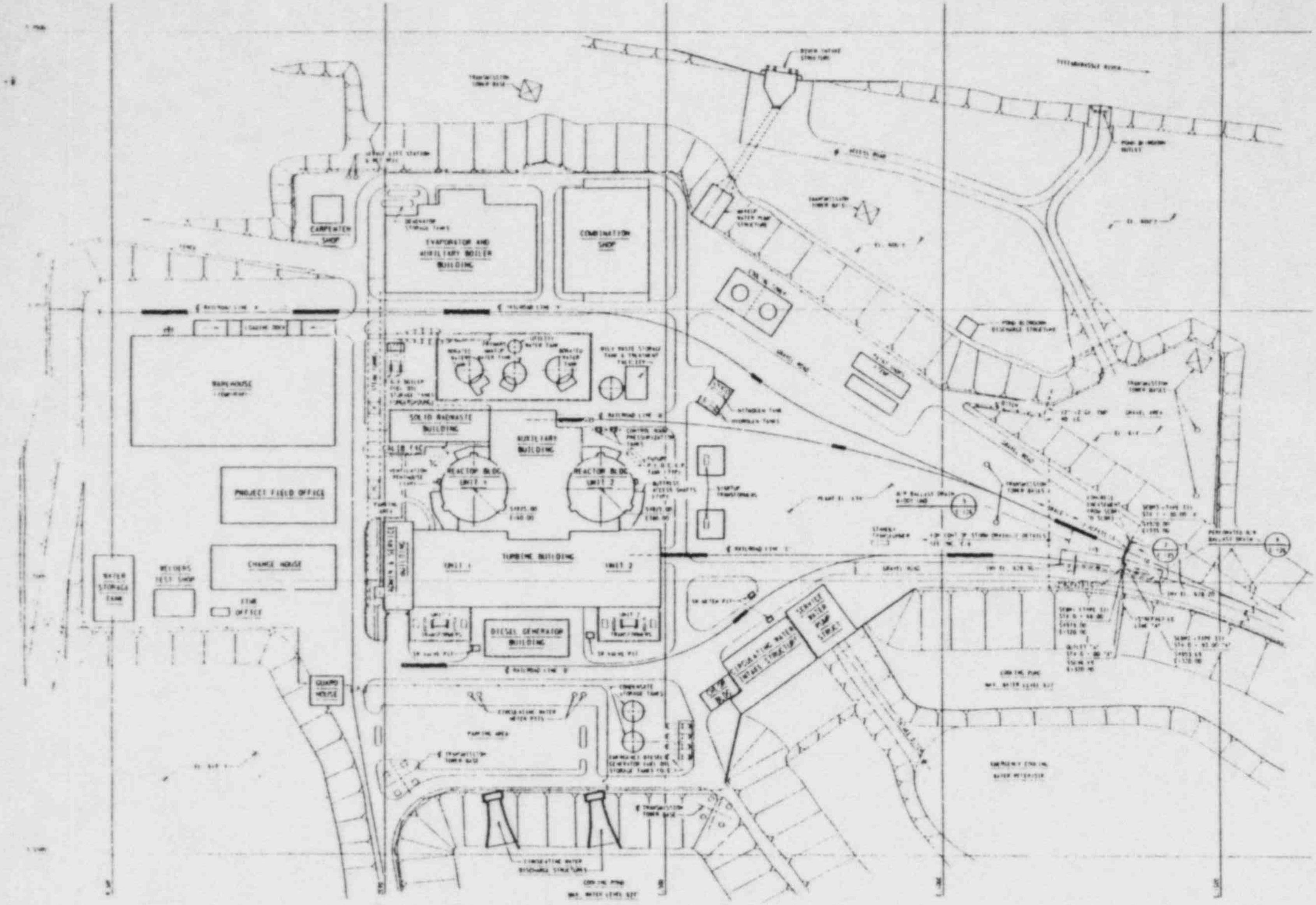
U = required strength to resist design loads or their related internal moments and forces

Y_R = loads on the structure generated by the reaction on the broken high-energy pipe during a postulated break

Table ES-3 (continued)

Y_J = jet impingement load on a structure generated by a postulated break

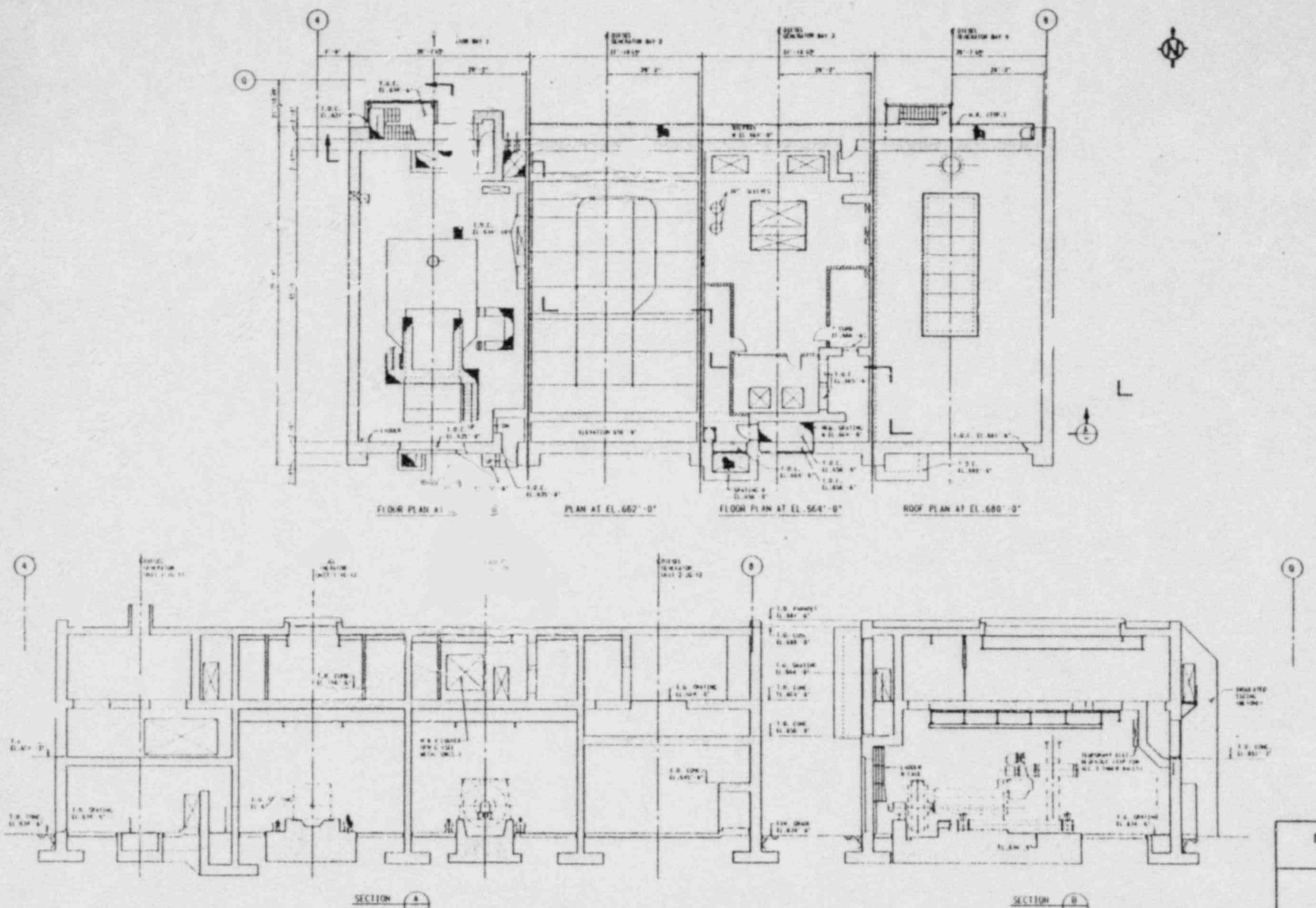
Y_M = missile impact load on a structure generated by or during a postulated break, such as pipe whipping



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

SITE PLAN OF MIDLAND
UNITS 1 AND 2 POWER PLANT

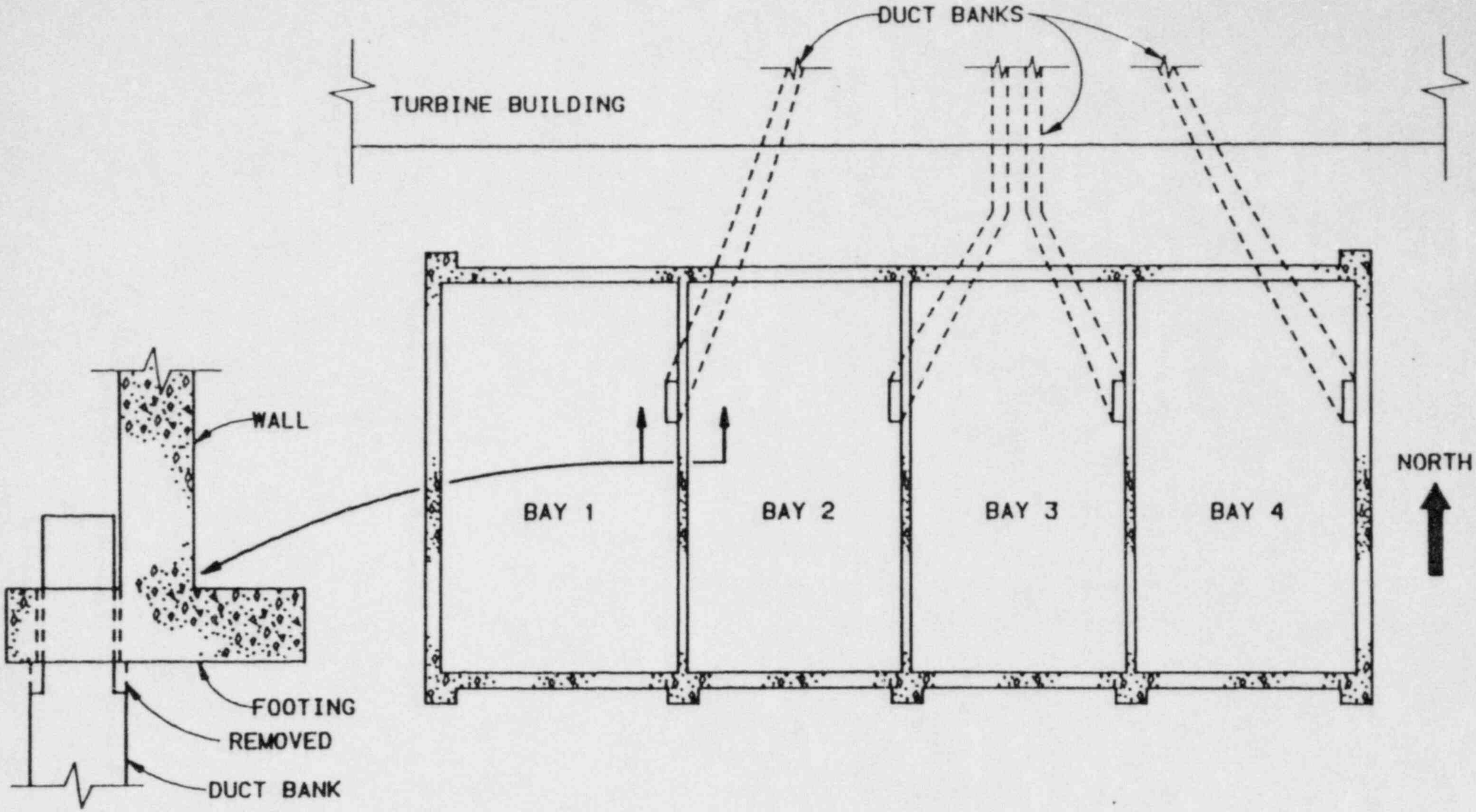
FIGURE ES-1



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

PLAN VIEW AND SECTIONS

FIGURE ES-2

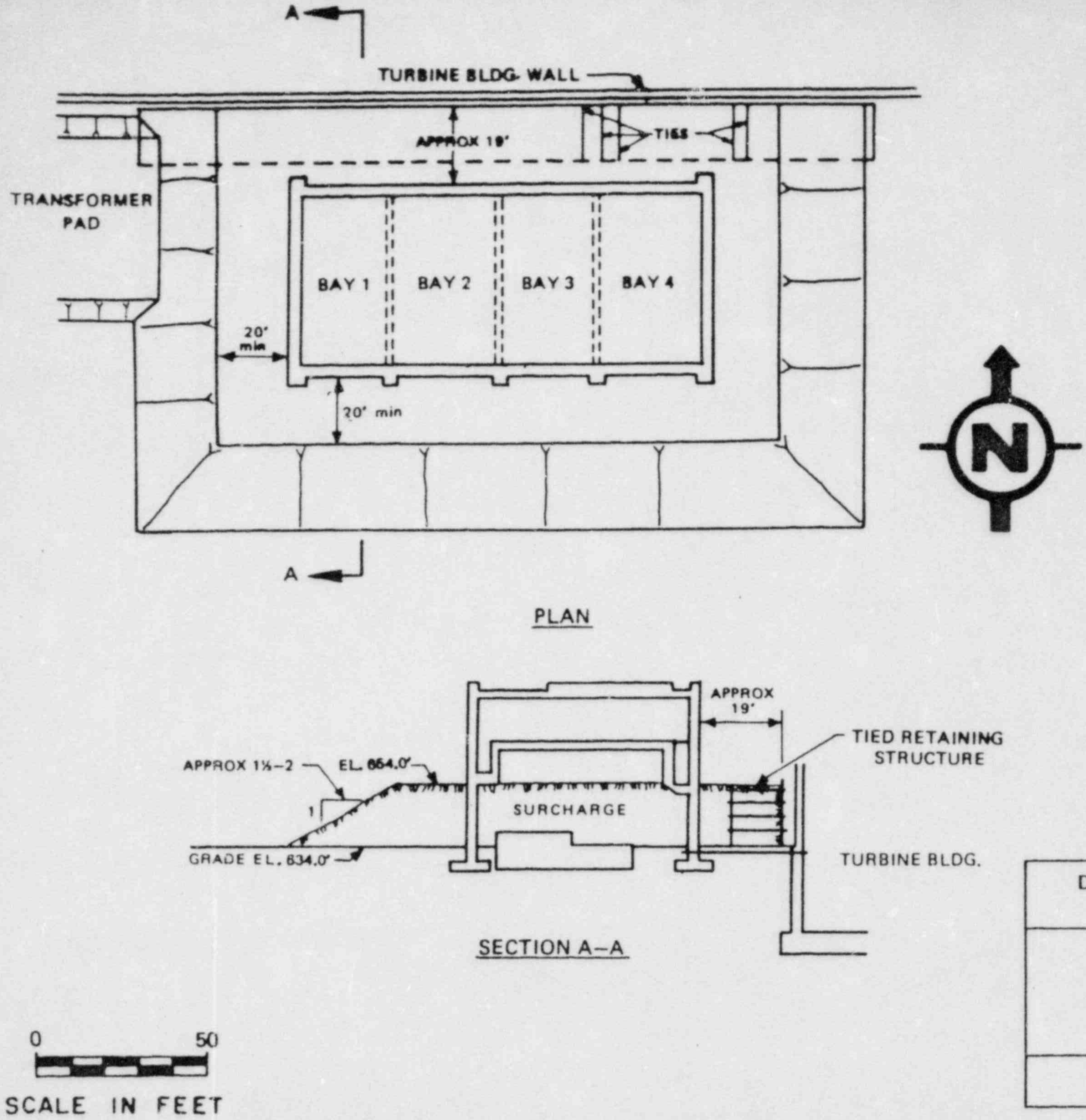


TYPICAL SECTION

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

DUCT BANK LAYOUT

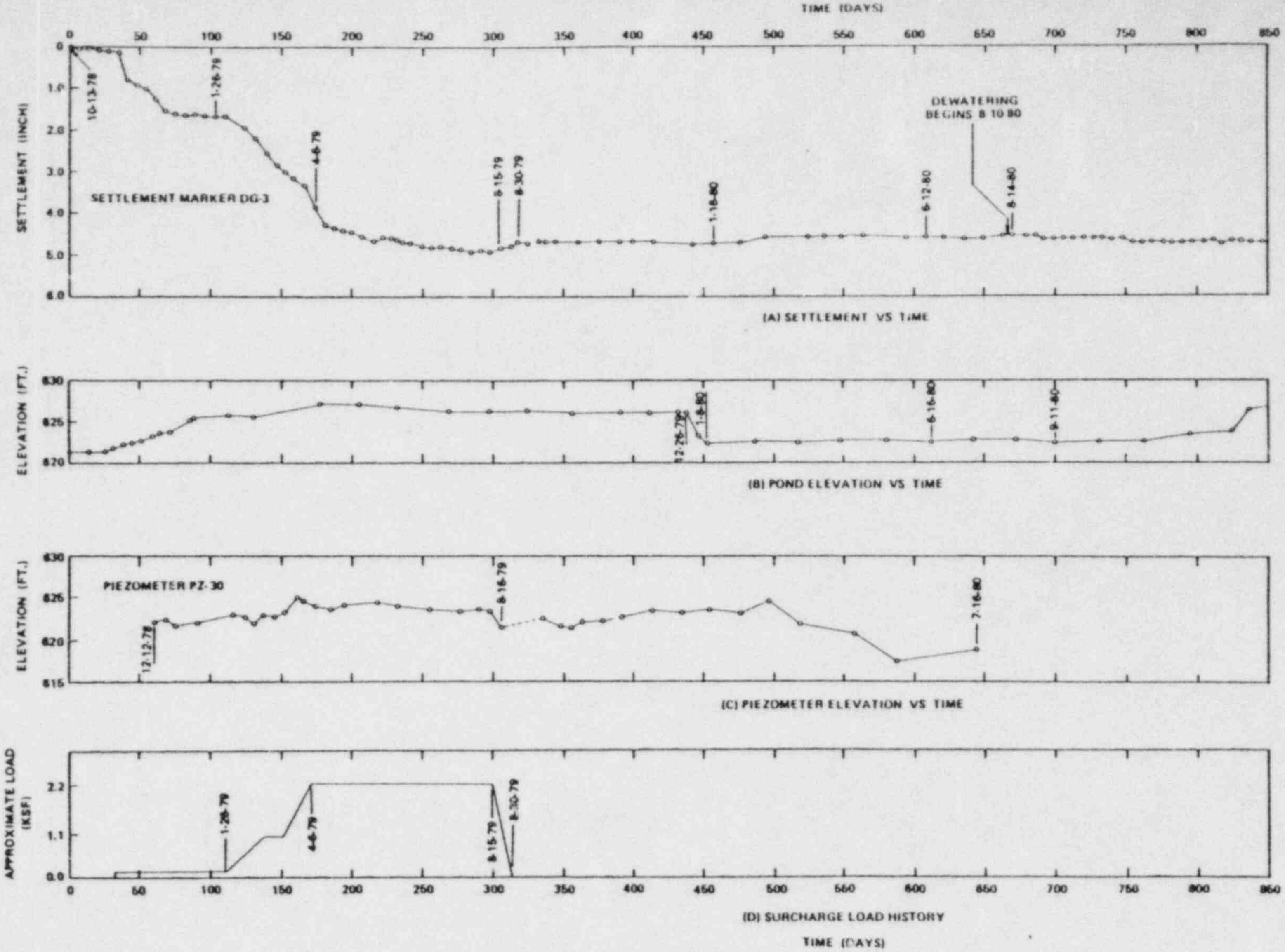
FIGURE ES-2A



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

GENERAL LAYOUT OF SURCHARGE LOAD

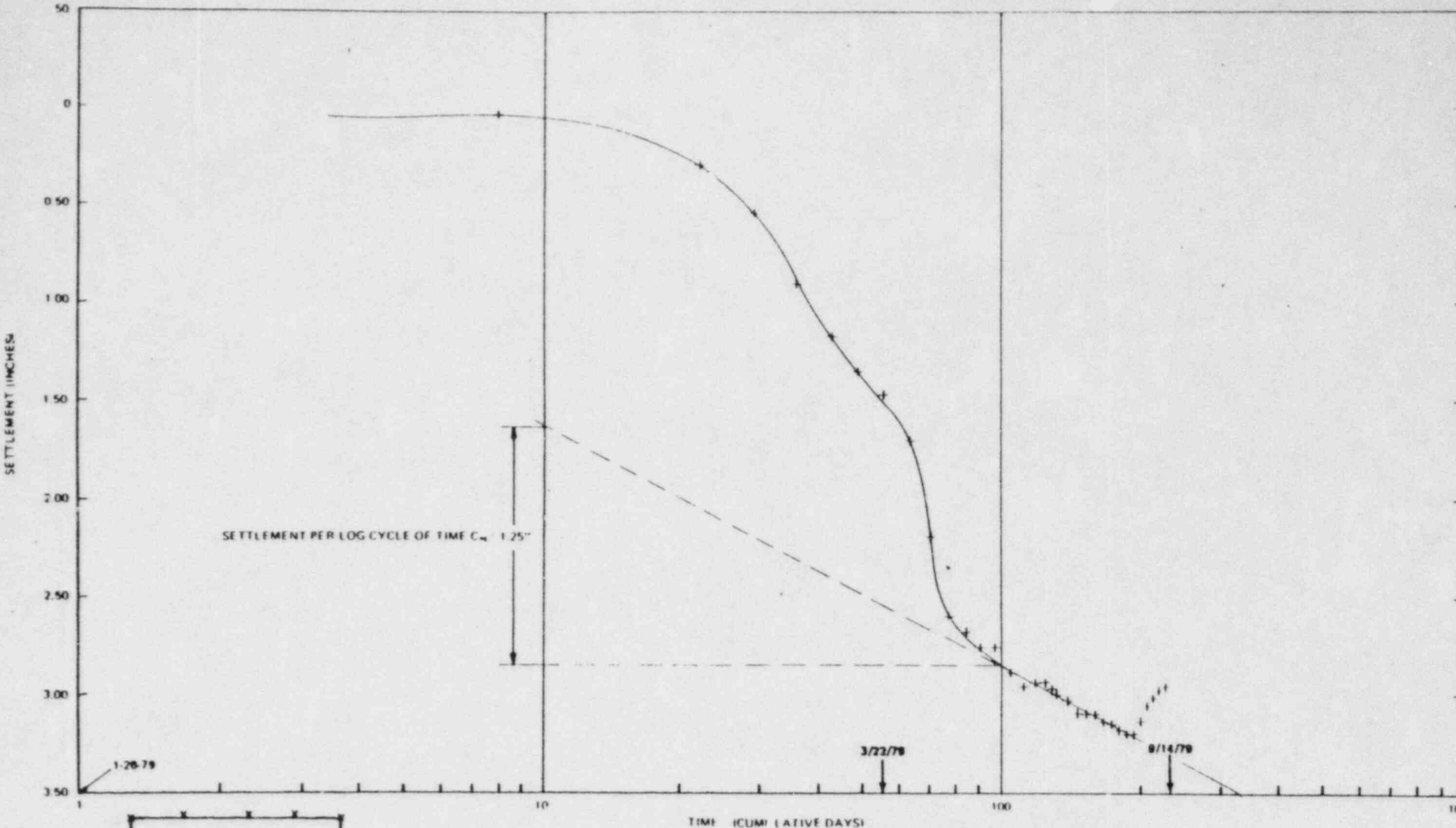
FIGURE ES-3

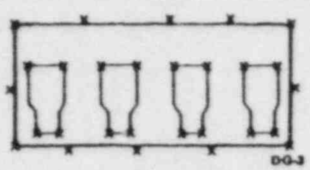


DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

TYPICAL SETTLEMENT, COOLING POND LEVEL, PIEZOMETER LEVEL AND SURCHARGE LOAD HISTORY

FIGURE ES-4





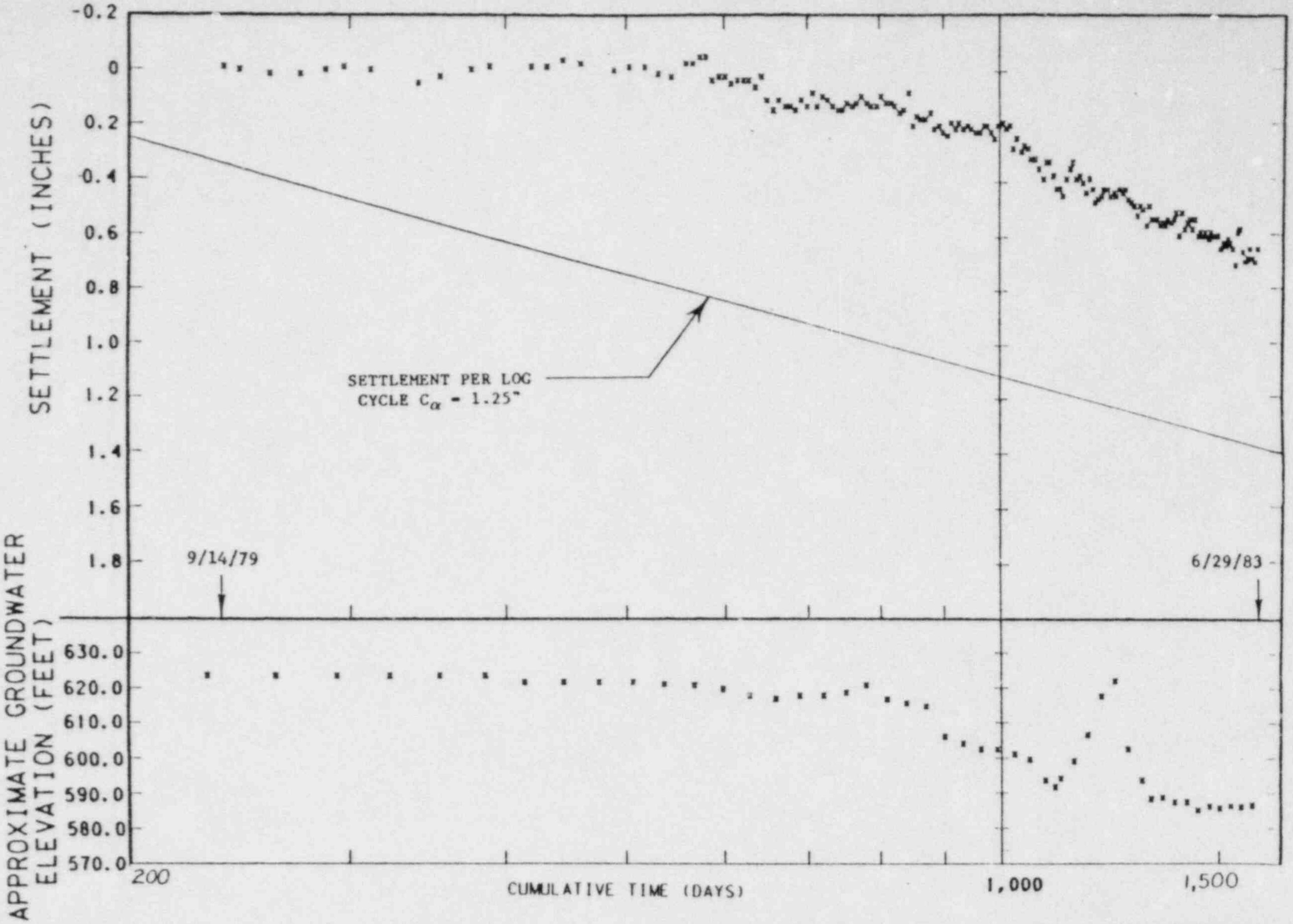
SETTLEMENT MARKER LOCATION PLAN
DIESEL GENERATOR BUILDING
(NOT TO SCALE)

NOTE:
The permanent marker could not be monitored from 3-22-79 to 9-14-79 due to surcharge. Temporary markers at elevation 664'-0" ± were used during this period to estimate the settlement of the permanent markers. On 9-14-79 the settlement was again based directly upon the permanent markers.

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

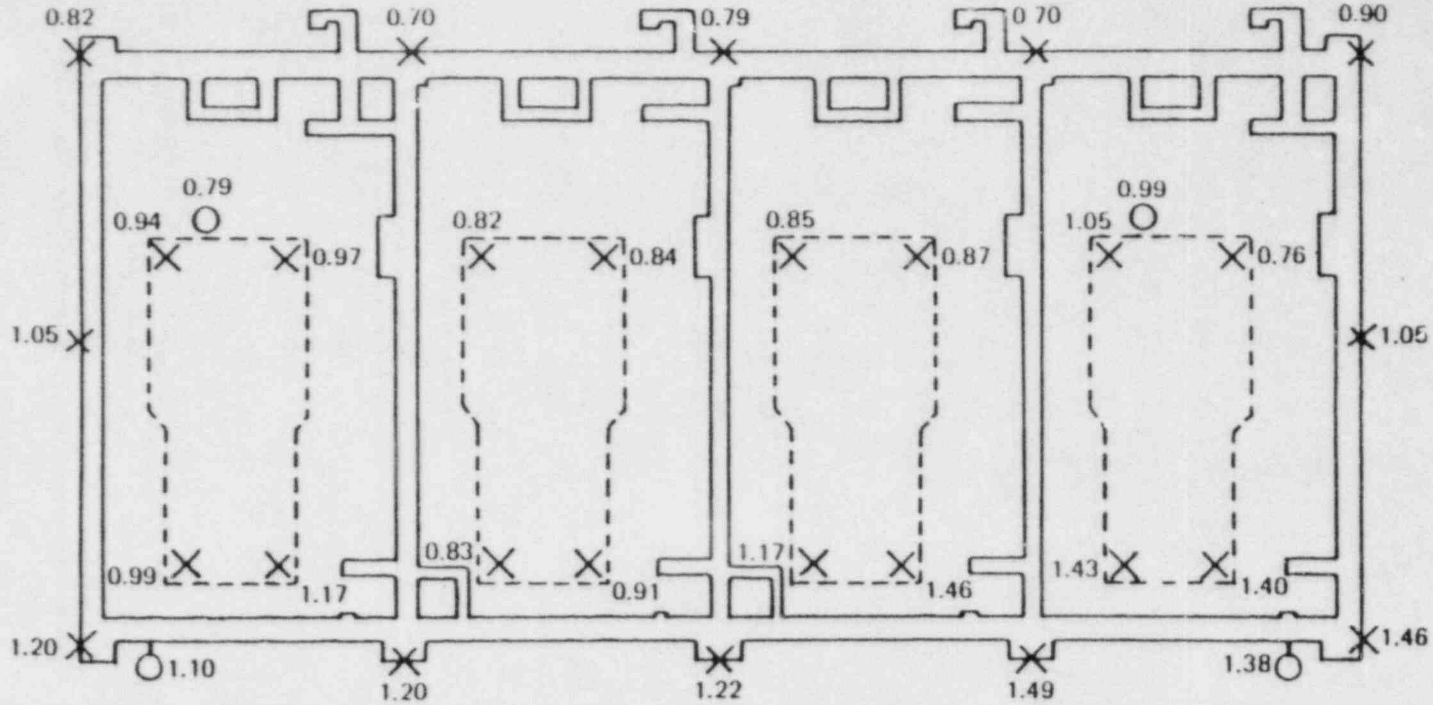
SETTLEMENT VS. LOGARITHM OF TIME FROM 1/26/79 TO 9/14/79
MARKER DG-3

FIGURE ES-5



DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY
SETTLEMENT VS. LOGARITHM OF TIME SINCE 9/14/79 MARKER DG-3
FIGURE ES-6

DIESEL GENERATOR BUILDING



LEGEND

○ —— DEEP BORROS ANCHOR

X —— BUILDING / PEDESTAL SETTLEMENT MARKER

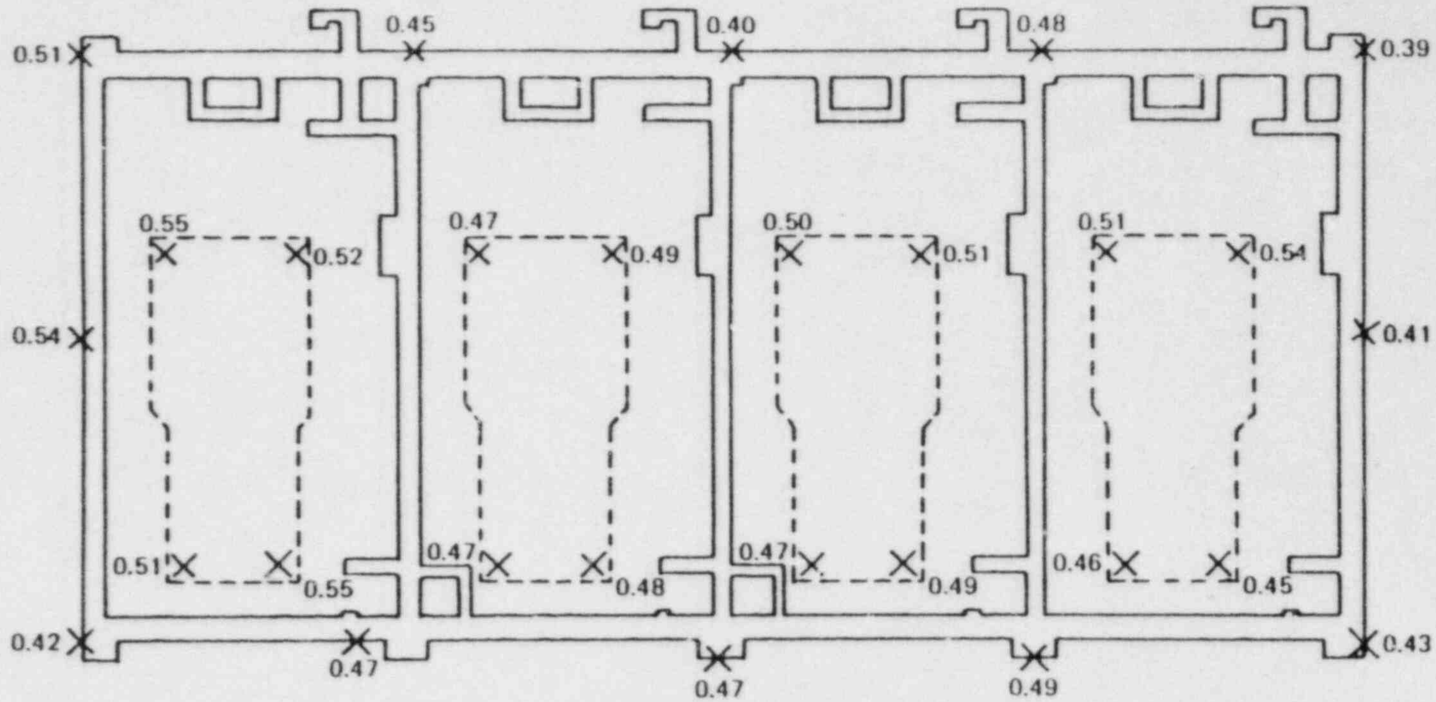
1.20 —— SETTLEMENT IN INCHES

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

ESTIMATED SECONDARY
COMPRESSION SETTLEMENTS FROM
12/31/81 TO 12/31/2025
ASSUMING SURCHARGE REMAINS

FIGURE ES-7

DIESEL GENERATOR BUILDING



LEGEND

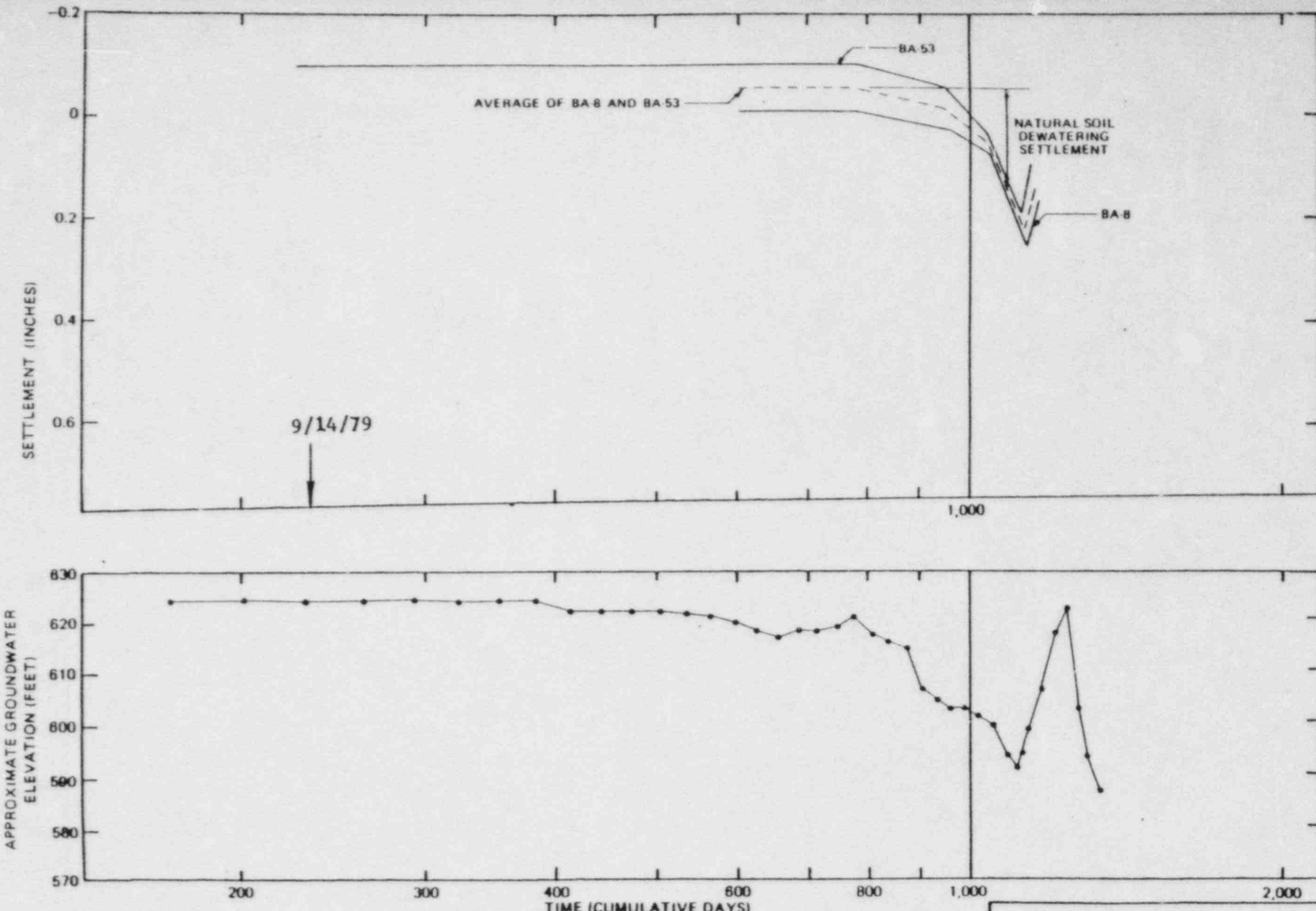
X ——— BUILDING / PEDESTAL SETTLEMENT MARKER

0.42 ——— MEASURED SETTLEMENT BETWEEN 9/14/79 AND 12/31/81.

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

MEASURED SETTLEMENT FROM
9/14/79 TO 12/31/81

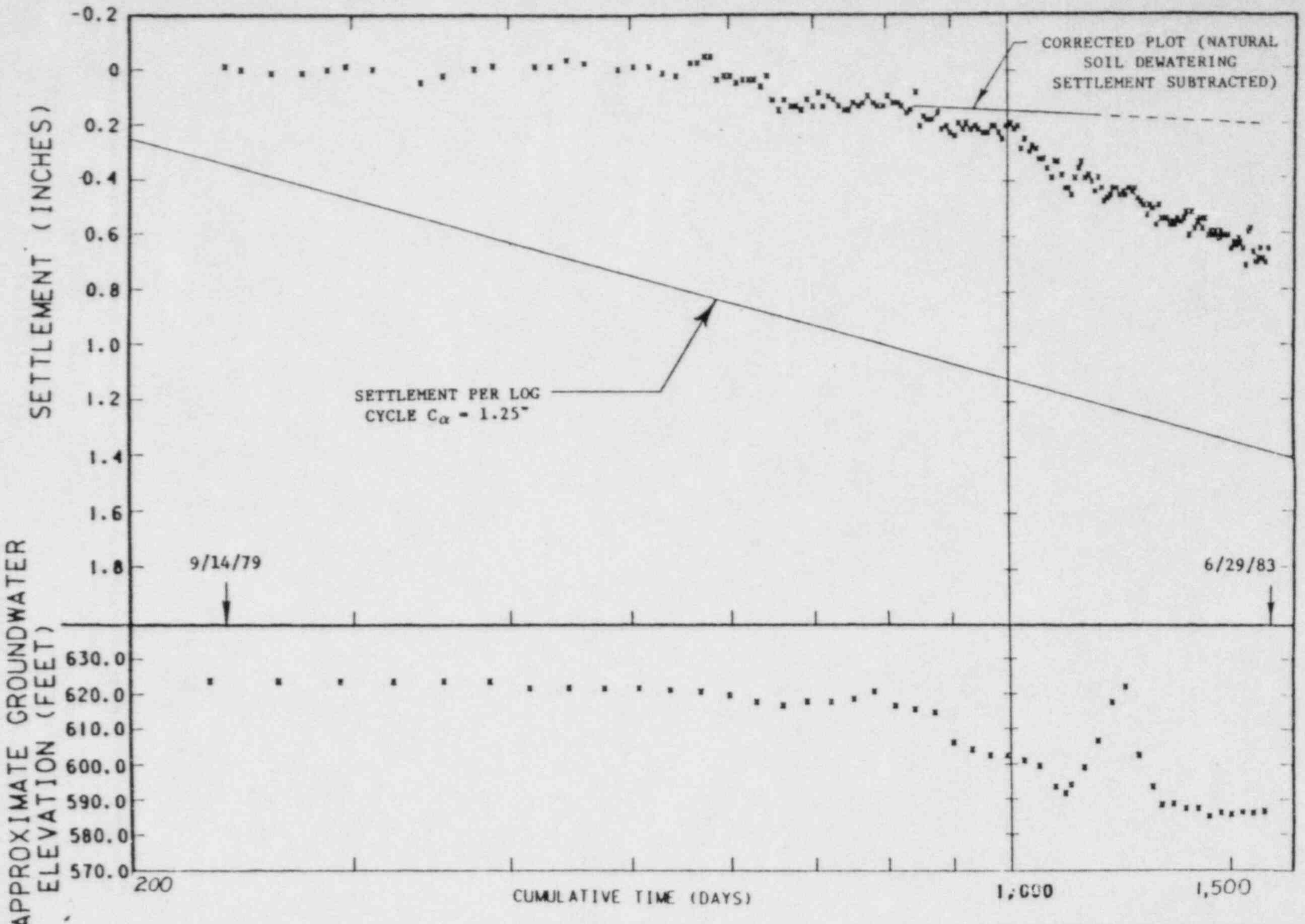
FIGURE ES-8



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

AVERAGE SETTLEMENT AFTER
SURCHARGE REMOVAL
BA-8 AND BA-53

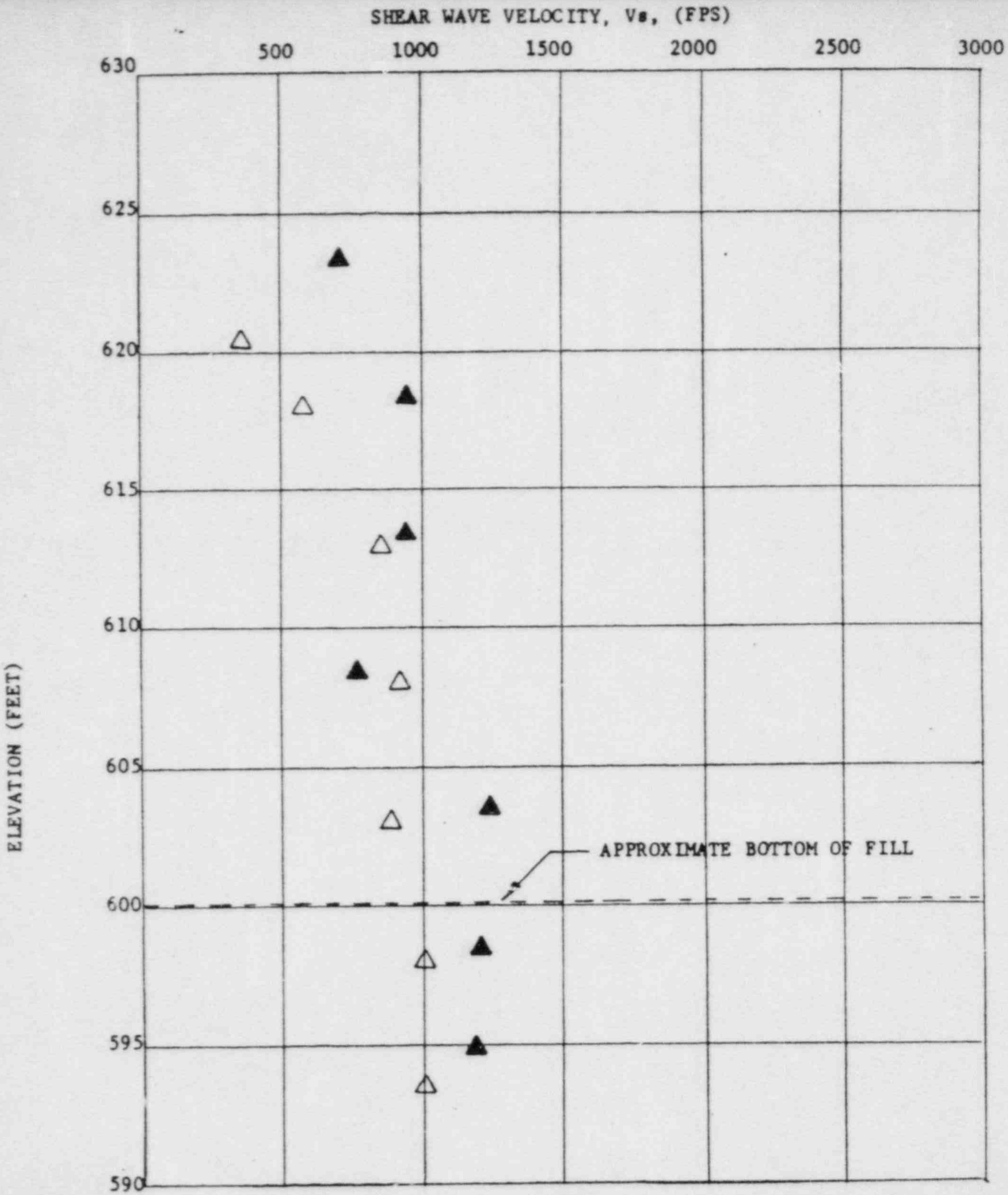
FIGURE ES-9



DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY

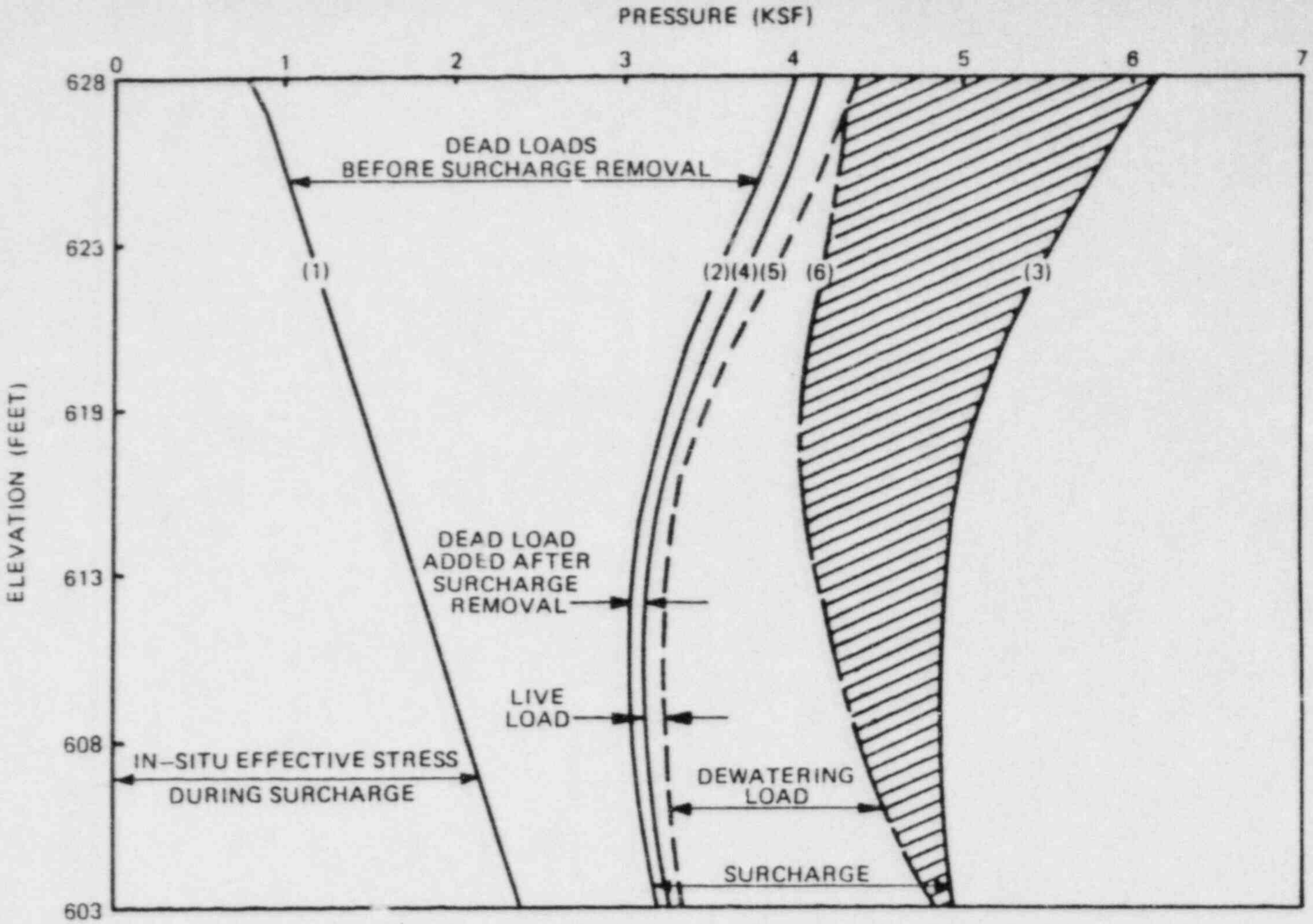
SETTLEMENT VS. LOGARITHM OF TIME SINCE 9/14/79 SHOWING CORRECTED SLOPE MARKER DG-3

FIGURE ES-10



NOTE:
Open and closed symbols represent tests at different locations.

DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY
SHEAR WAVE VELOCITY PROFILE
FIGURE ES-11



EXPLANATIONS

(1) In-situ effective overburden pressure (GWT at 627).

(2) Total effective pressure before surcharge removal due to In-situ effective overburden pressure and structural dead loads present during surcharge.

(3) Total effective pressure at the end of surcharge due to In-situ effective overburden pressure, structural dead loads, and surcharge loads.

(4) Total effective pressure due to In-situ effective overburden pressure and total structural dead loads (loads present during surcharge plus dead loads added after surcharge removal).

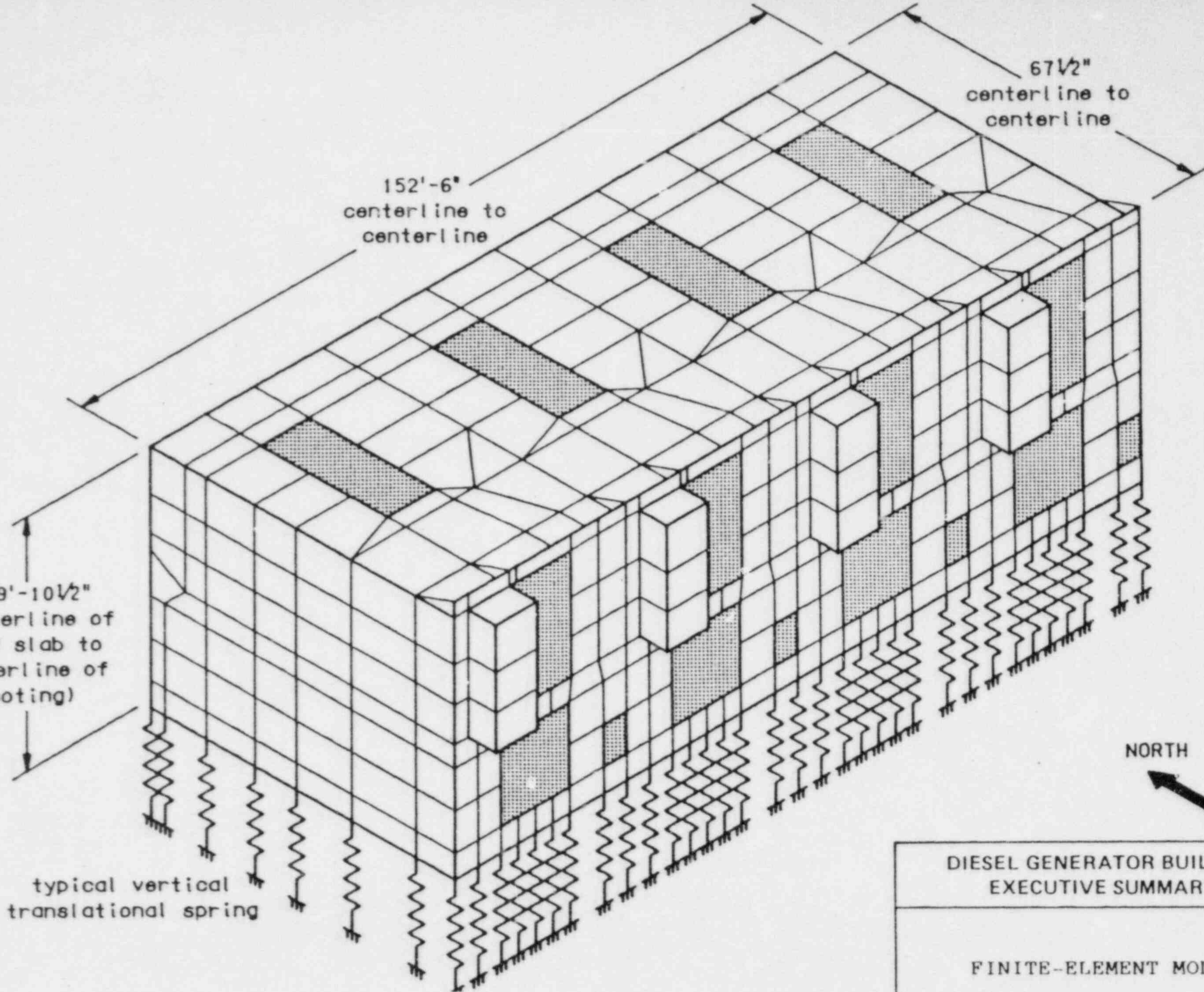
(5) Total effective pressure due to In-situ effective overburden pressure, total structural dead loads, and expected live loads.

(6) Total effective pressure during the life of plant operation due to In-situ effective overburden pressure, structural dead loads, dewatering loads, and expected live loads.

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

COMPARISON OF EFFECTIVE STRESS BEFORE AND AFTER SURCHARGE SOUTHWEST CORNER

FIGURE ES-12



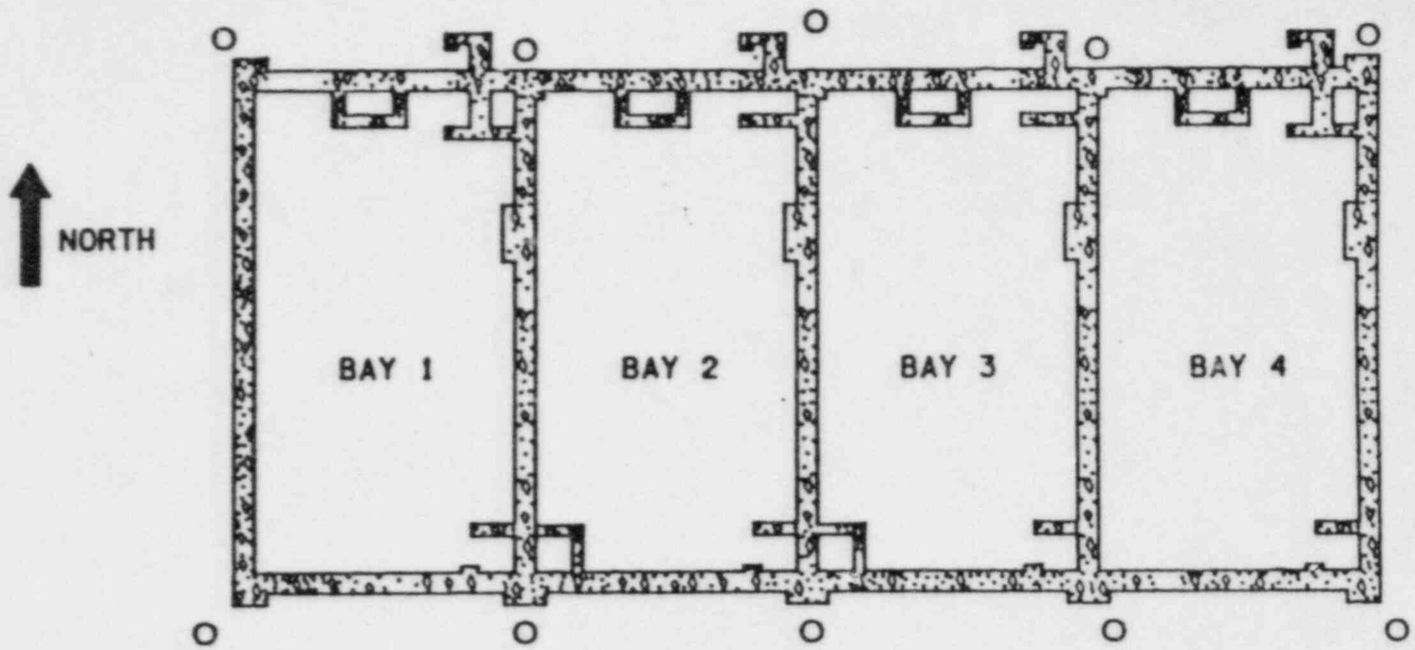
(for ease of presentation, only vertical translational springs have been depicted)

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

FINITE-ELEMENT MODEL

FIGURE ES-13

LINE A	1.19	1.02	0.90	0.85	0.76
LINE B	0.77	1.09	1.54	1.98	2.41
LINE C	1.50	1.51	1.78	1.86	1.91
LINE D	1.33	1.15	1.19	1.18	1.29
TOTAL	4.79	4.77	5.41	5.87	6.37



LINE A	1.67	1.42	1.28	1.44	1.99
LINE B	1.14	1.12	1.46	1.92	2.21
LINE C	3.00	2.92	3.16	3.37	3.24
LINE D	1.62	1.67	1.69	1.98	1.89
TOTAL	7.43	7.13	7.59	8.71	9.33

LEGEND

O —— DIESEL GENERATOR BUILDING SETTLEMENT MARKER

SETTLEMENT IN INCHES FOR

PRE-SURCHARGE PERIOD (3/78-8/78)............LINE A

PRE-SURCHARGE PERIOD (8/78-1/79)............LINE B

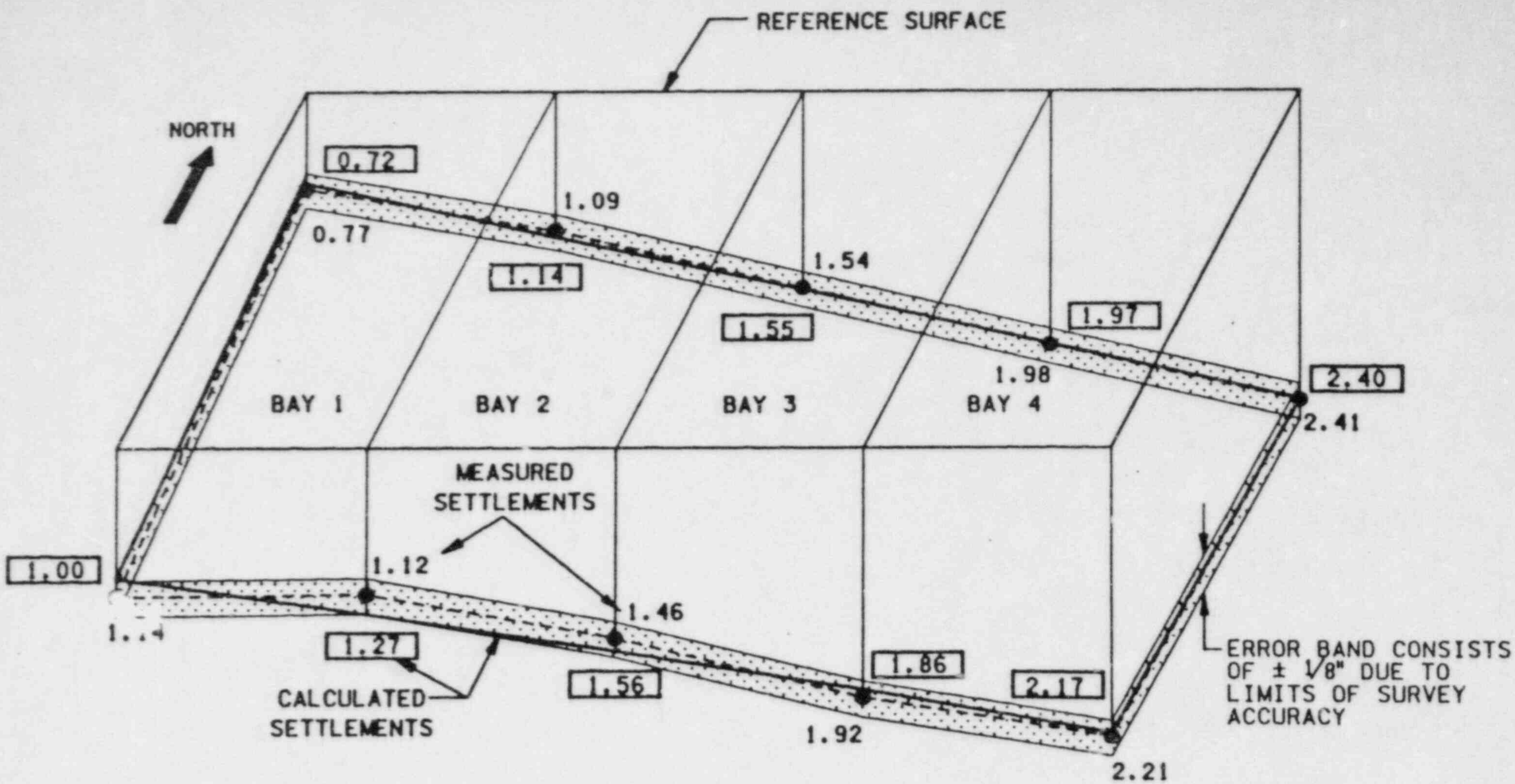
SURCHARGE PERIOD (1/79-8/79) ....LINE C

POST SURCHARGE PERIOD (9/79-12/2025) ....LINE D
ASSUMING SURCHARGE REMAINS IN PLACE

DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

SUMMARY OF ACTUAL AND ESTIMATED SETTLEMENTS

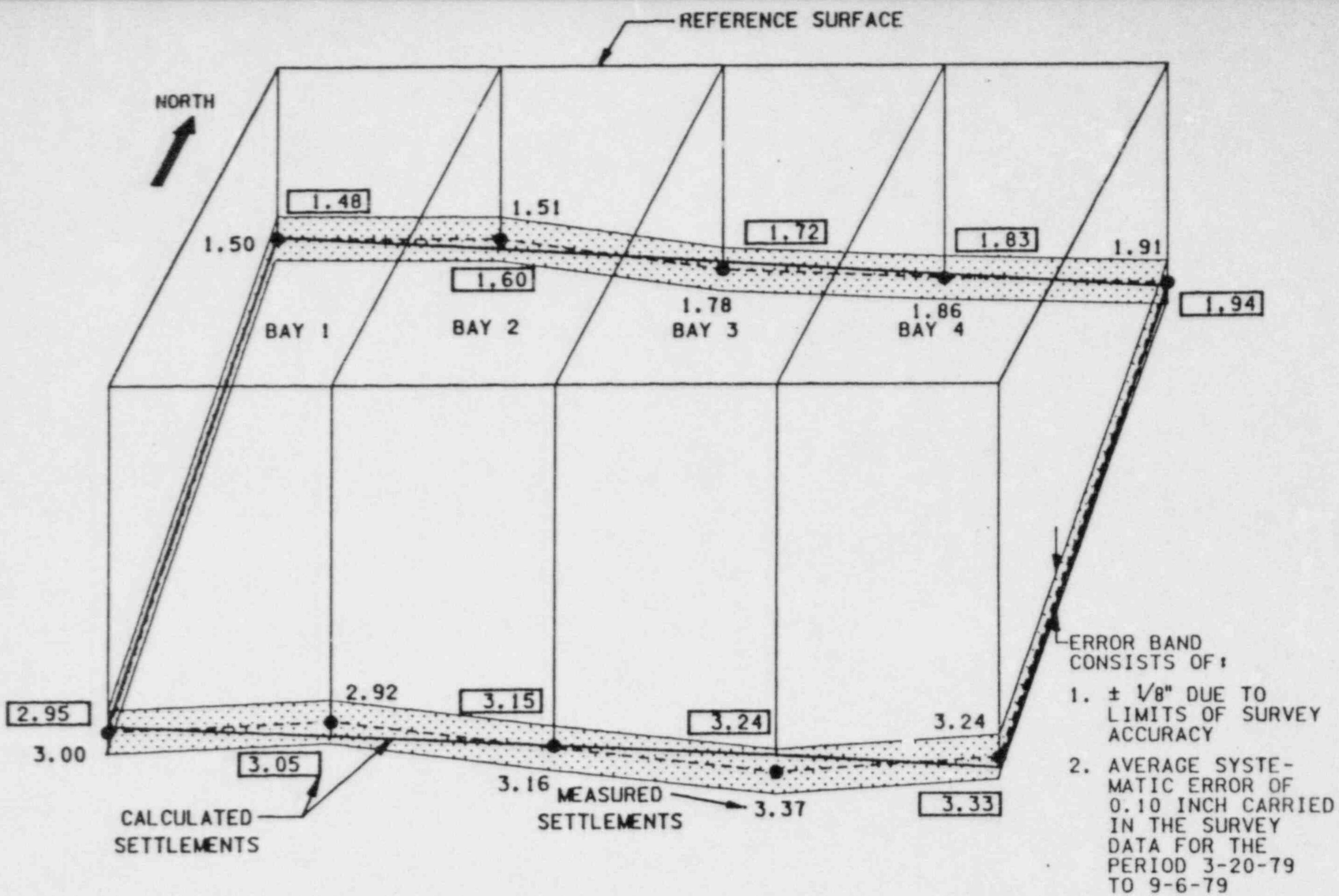
FIGURE ES-14



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

COMPARISON OF SETTLEMENT VALUES
PRE-SURCHARGE PERIOD
AUGUST 1978 - JANUARY 1979

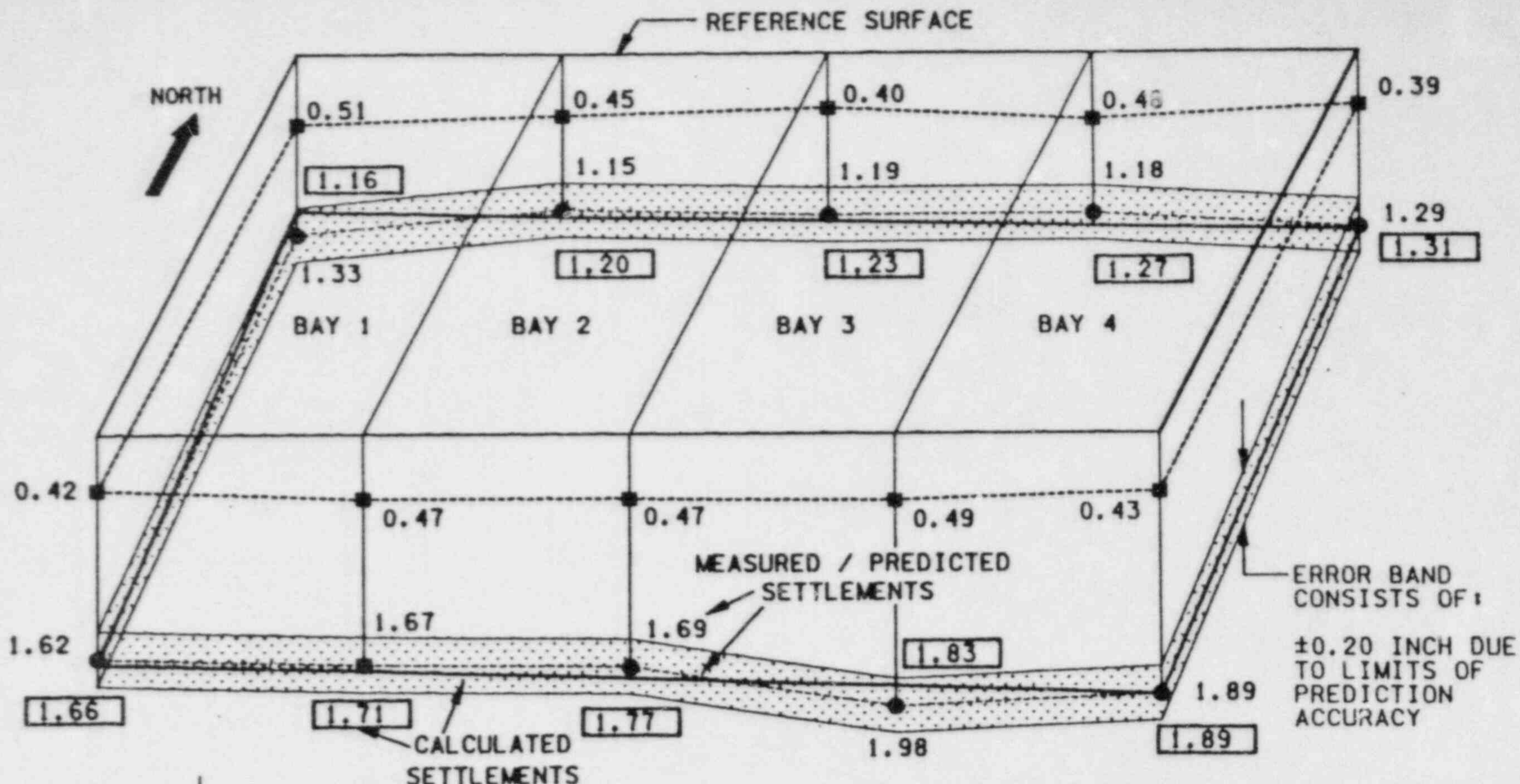
FIGURE ES-15



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

COMPARISON OF SETTLEMENT VALUES
SURCHARGE PERIOD
JANUARY 1979 - AUGUST 1979

FIGURE ES-16



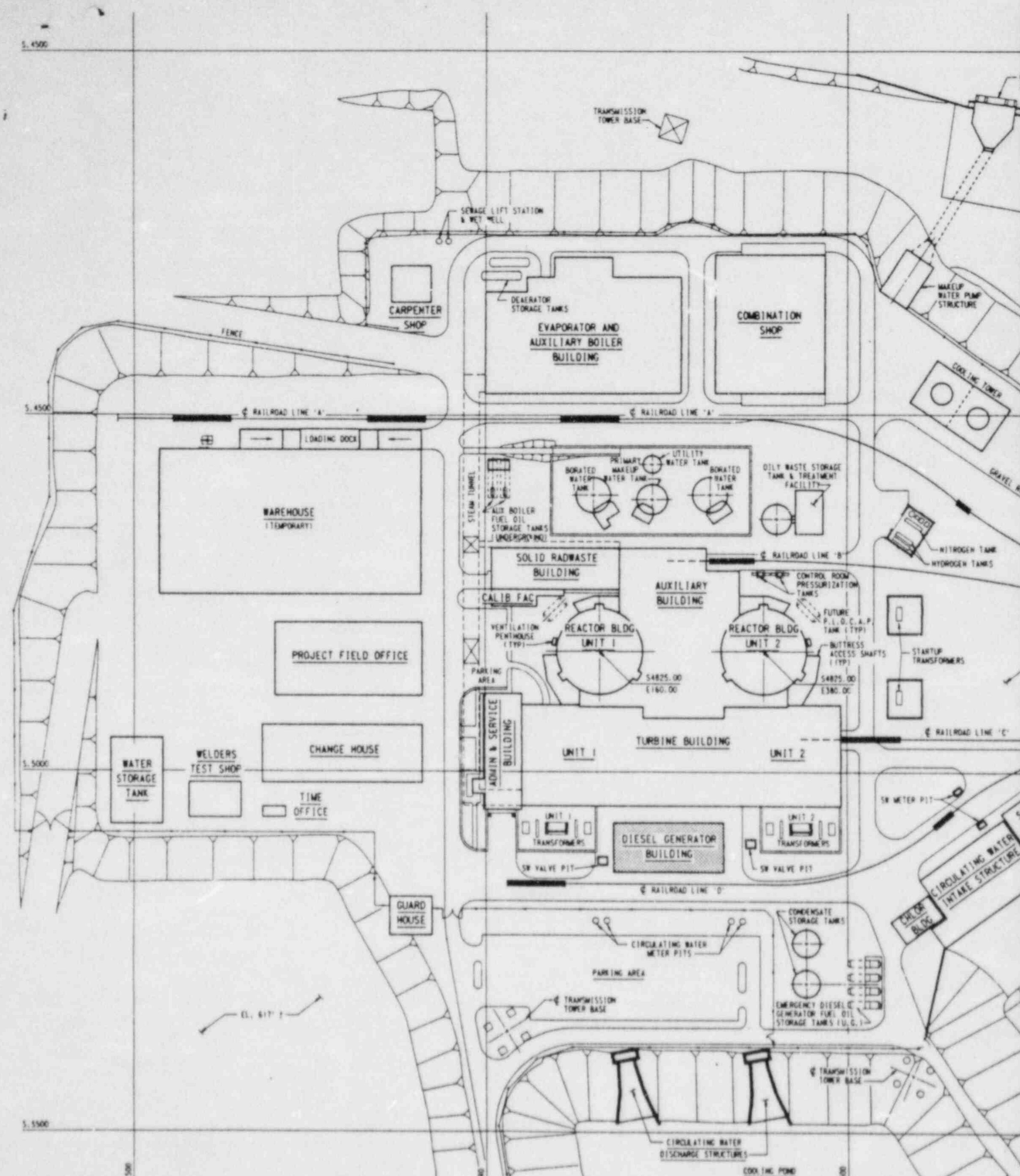
ACTUAL MEASURED SETTLEMENT FROM SEPT.14, 1979 TO DEC.31, 1981. THESE INCLUDE EFFECT OF DEWATERING TO APPROXIMATELY EL. 595', AND REPRESENT MOVEMENT OF THE STRUCTURE DUE TO SETTLEMENT OF THE FILL AND NATURAL SOIL BELOW.

ACTUAL MEASURED SETTLEMENTS FROM SEPT.14, 1979 TO DEC.31, 1981 PLUS ESTIMATED SECONDARY COMPRESSION SETTLEMENT FROM DEC.31, 1981 TO DEC.31, 2025 ASSUMING SURCHARGE REMAINS IN PLACE.

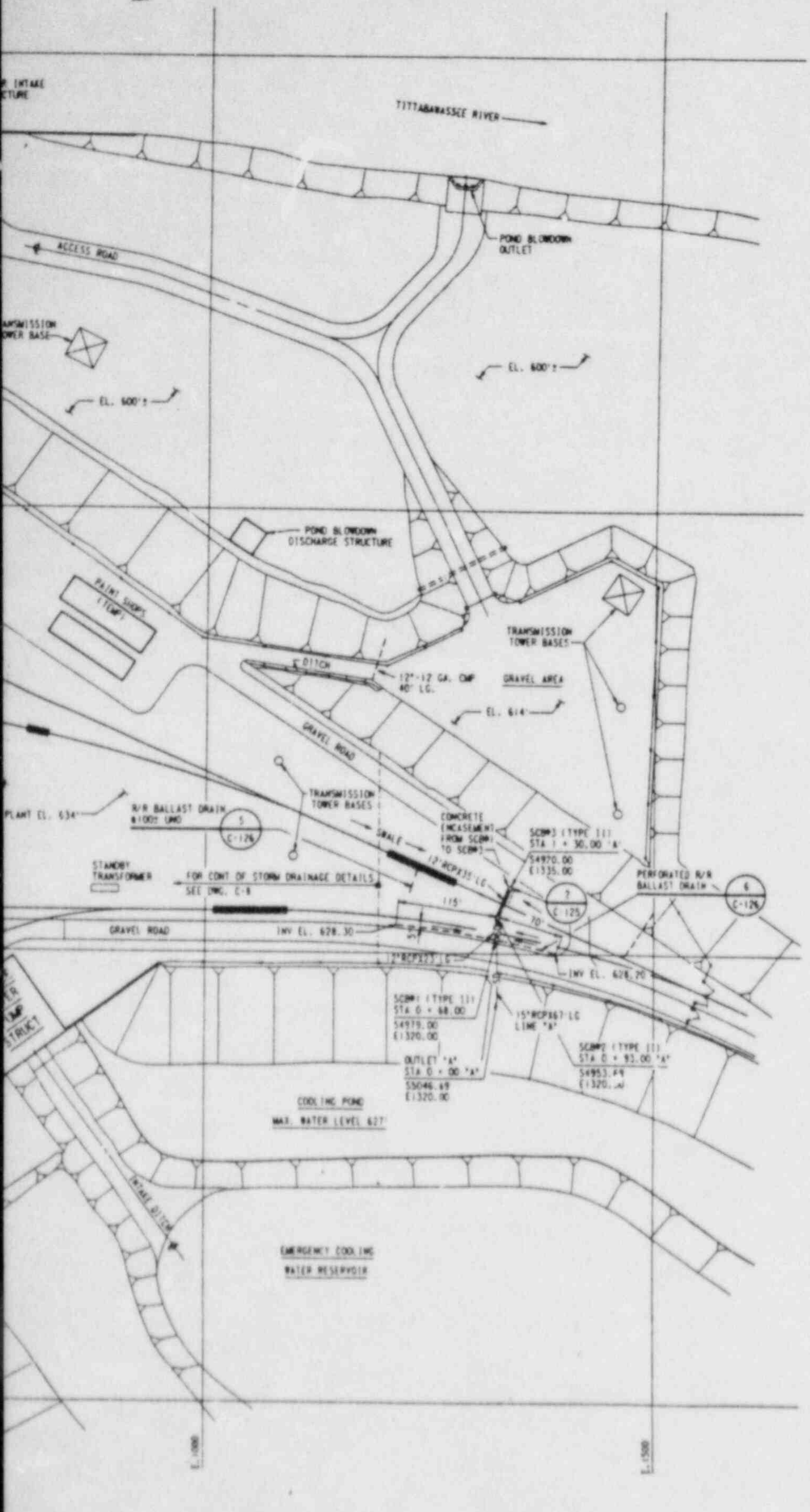
DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

COMPARISON OF SETTLEMENT VALUES
POST-SURCHARGE PERIOD
SEPTEMBER 1979 - DECEMBER 2025

FIGURE ES-17



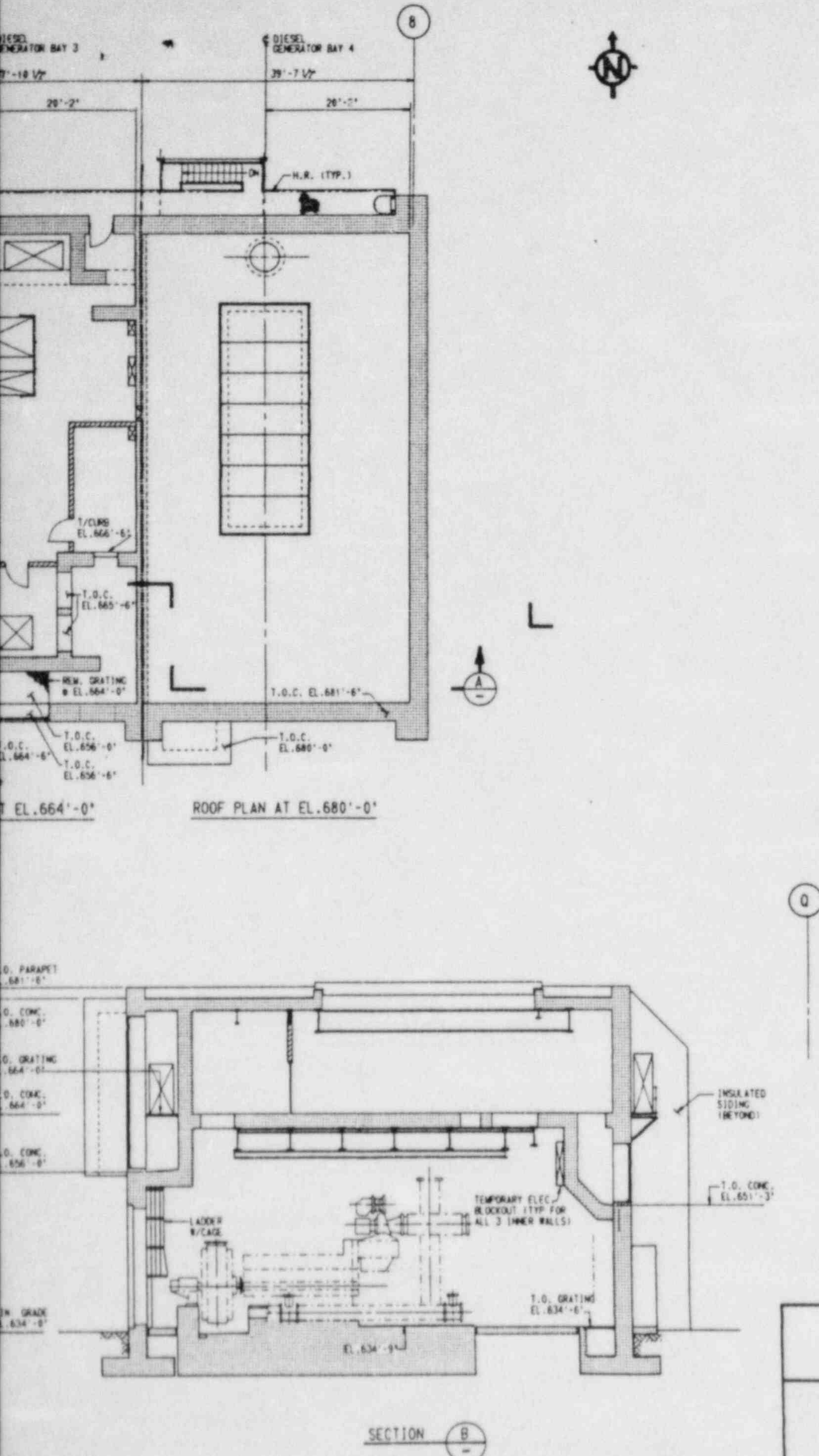
TRANSMISSION TOWER BASE
SEWAGE LIFT STATION & WET WELL
CARPENTER SHOP
DEAERATOR STORAGE TANKS
EVAPORATOR AND AUXILIARY BOILER BUILDING
COMBINATION SHOP
MAKEUP WATER PUMP STRUCTURE
FENCE
COOLING TOWER
S. 4500
℄ RAILROAD LINE 'A'
LOADING DOCK
WAREHOUSE (TEMPORARY)
STEAM TUNNEL
BORATED WATER TANK
PRIMARY MAKEUP WATER TANK
UTILITY WATER TANK
OILY WASTE STORAGE TANK & TREATMENT FACILITY
AUX BOILER FUEL OIL STORAGE TANKS (UNDERGROUND)
SOLID RADWASTE BUILDING
℄ RAILROAD LINE 'B'
NITROGEN TANK
HYDROGEN TANKS
CONTROL ROOM PRESSURIZATION TANKS
AUXILIARY BUILDING
CALIB FAC
FUTURE P.I.O.C.A.P. TANK (TYP)
VENTILATION PENTHOUSE (TYP)
REACTOR BLDG UNIT 1
REACTOR BLDG UNIT 2
BUTTRESS ACCESS SHAFTS (TYP)
STARTUP TRANSFORMERS
PROJECT FIELD OFFICE
PARKING AREA
S4825.00 E160.00
S4825.00 E380.00
ADMIN & SERVICE BUILDING
TURBINE BUILDING
UNIT 1
UNIT 2
℄ RAILROAD LINE 'C'
CHANGE HOUSE
S. 5000
WATER STORAGE TANK
WELDERS TEST SHOP
TIME OFFICE
SW METER PIT
UNIT 1 TRANSFORMERS
DIESEL GENERATOR BUILDING
UNIT 2 TRANSFORMERS
SW VALVE PIT
SW VALVE PIT
CIRCULATING WATER INTAKE STRUCTURE
℄ RAILROAD LINE 'D'
GUARD HOUSE
CHLOR BLDG
CONDENSATE STORAGE TANKS
CIRCULATING WATER METER PITS
PARKING AREA
EL. 617' ±
℄ TRANSMISSION TOWER BASE
EMERGENCY DIESEL GENERATOR FUEL OIL STORAGE TANKS (U.G.)
℄ TRANSMISSION TOWER BASE
S. 5500
CIRCULATING WATER DISCHARGE STRUCTURES
COOLING POND
MAX. WATER LEVEL 627'
W. 500
ZERO
E. 500



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

SITE PLAN OF MIDLAND
UNITS 1 AND 2 POWER PLANT

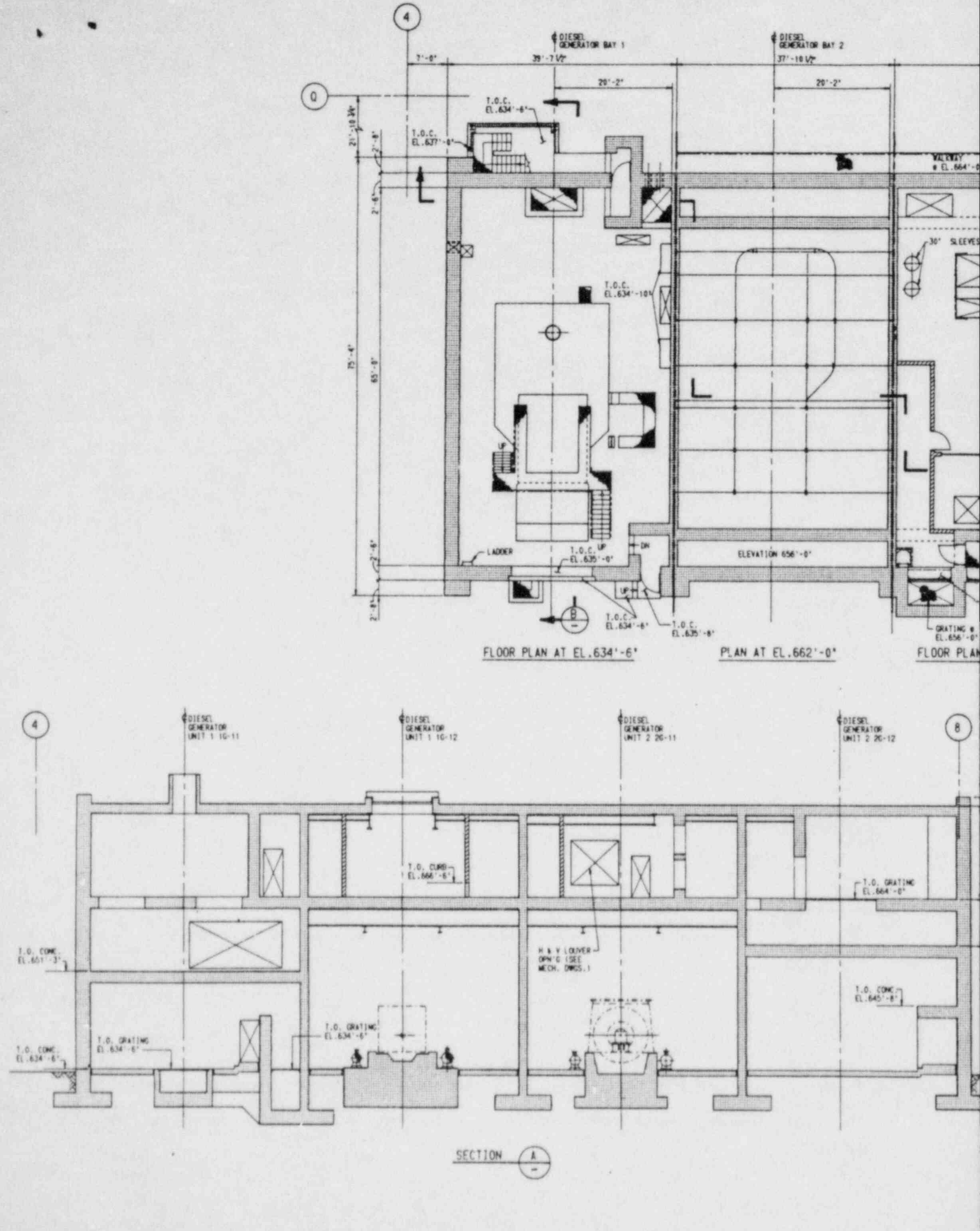
FIGURE ES-1



DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

PLAN VIEW AND SECTIONS

FIGURE ES-2



DIESEL GENERATOR BAY 1
DIESEL GENERATOR BAY 2
T.O.C. EL.634'-6"
T.O.C. EL.637'-0"
T.O.C. EL.634'-10¼
LADDER
T.O.C. EL.635'-0"
ELEVATION 656'-0"
30" SLEEVES
FLOOR PLAN AT EL.634'-6"
PLAN AT EL.662'-0"
FLOOR PLAN
DIESEL GENERATOR UNIT 1 1G-11
DIESEL GENERATOR UNIT 1 1G-12
DIESEL GENERATOR UNIT 2 2G-11
DIESEL GENERATOR UNIT 2 2G-12
T.O. CURB EL.666'-6"
T.O. GRATING EL.664'-0"
H & V LOUVER OPN'G (SEE MECH. DWGS.)
T.O. CONC. EL.645'-8"
T.O. GRATING EL.634'-6"
T.O. CONC. EL.634'-6"
SECTION A

10/26/83

Document Name:
SUMMARY - MIDLAND 8/24&25/83

Requestor's ID:
HELEN

Author's Name:
MMiller

Document Comments:
Summary of task force visit on the Midland DGB

Docket Nos: 50-329
and 50-330

APPLICANT: Consumers Power Company

FACILITY: Midland, Units 1 and 2

SUBJECT: SUMMARY OF TASK FORCE VISIT ON THE MIDLAND DIESEL GENERATOR BUILDING

On August 24 and 25, 1983, a task force consisting of NRC staff and its consultants from Brookhaven National Laboratory, visited Ann Arbor and the Midland site to obtain information related to rereview of the diesel generator building (DGB). The participants are listed in Enclosure 1.

The August 24, 1983, meeting was held in Ann Arbor and provided background information to the task force. Consumers and Bechtel representatives discussed design and construction of the DGB including the building's settlement. The remedial program was explained with detailed discussion of the surcharge, dewatering, and settlement monitoring efforts. The final meeting topic was the strucutal reanalysis performed on the DGB, particularly including details of the finite element analysis. CPCo consultants addressed cracking effects and concluded that the DGB cracks have no effect on the strength of the building. The agenda and meeting slides are provided as Enclosure 2 and 3, respectively. The Diesel Generator Building Executive Summary, distributed at the meeting, is included as Enclosure 4.

Late August 24, and August 25 was spent viewing the actual cracks in the building. Also, the applicant's crack maps were used by the task force to better see the crack pattern of the building.

Melanie A. Miller, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

DL:LB #4	DL:LB #4
MMiller/hmc	EAdensam
10/ /83	10/ /83

PARTICIPANTS

DGB TASK FORCE

AUGUST 24 AND 25, 1983

NRC

P. T. Kuo*
M. Miller*

Brookhaven

A. Philippacopoulos*
C. Miller*
C. Costantino*
M. Reich*

Seismic Margin Associates

R. Kennedy

Portland Cement Assoc.

G. Corley

TERA Corp.

H. Levin
J. Martore

Consumers

J. Schaub*
J. Mooney*
T. Thiruvengadam
K. Razdam
N. Ramanijam
E. Koepke*
F. Villalta
D. Budzik
M. Capicchioni**

Bechtel

N. Swanberg
M. Sozen
P. Shunmugavel
S. Afifi
T. Kumbier
D. Reeves
C. Dirnbauer
B. McConnell
D. Nims
G. Tuvenson

*Attended both meeting and site visit
**Attended site visit only

15/83

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

October 26, 1983

MEMORANDUM FOR: The Atomic Safety and Licensing Board for the Midland Plant, Units 1 & 2

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: TRANSMITTAL OF REPORT ON RE-REVIEW OF THE MIDLAND DIESEL GENERATOR BUILDING (BN 83-165)

By earlier Board Notifications 83-109, 83-142 and 83-153, the NRC has described its plan to address the concerns of Dr. Ross Landsman of Region III regarding the structural adequacy of the Midland Diesel Generator Building (DGB). The plan included the preparation of a report on the adequacy of the DGB by a team of NRC structural engineers and consultants. That report, and an accompanying cover letter by the team head, Dr. P. T. Kuo, is enclosed (Enclosure 1) for your information.

Enclosure 2 provides the applicant's results of a modified finite-element analysis of the DGB which was requested by the review team on September 12, 1983, but which was not provided to a schedule consistent with issuance of Enclosure 1. The modified analysis is discussed in Section 2.4.2 to Appendix III of Enclosure 1.

The NRC is currently reviewing Enclosures 1 and 2 to determine its impact, if any, on existing staff positions. The staff plans to prepare a response to Congress relative to the concerns expressed by Dr. Landsman before the Subcommittee on Interior and Insular Affairs on June 16, 1983. The effort is proceeding on a high priority basis. Results will be reported as they become available.

/S/
Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosures:
As Stated

cc: See next page

DL:LB #4	LA:DL:LB #4	DL:LB #4	AD:L:DL
DHood/hmc	MDuncan	EAdensam	TNovak
10/25/83	10/25/83	10/25/83	10/26/83

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MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Enviornmental Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission, Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

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

October 26, 1983

Docket Nos: 50-329 OM, OL
and 50-330 OM, OL

MEMORANDUM FOR: The Atomic Safety and Licensing Board for the Midland Plant, Units 1 & 2

FROM: Thomas M. Novak, Assistant Director for Licensing
Division of Licensing

SUBJECT: TRANSMITTAL OF REPORT ON RE-REVIEW OF THE MIDLAND DIESEL GENERATOR BUILDING (BN 83-165)

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Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosures:
As Stated

cc: See next page

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Docket Nos. 50-329/330

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Dr. Chester P. Siess
Mr. David A. Ward

MIDLAND (For BNs)

Mr. J. W. Cook
Vice President
Consumers Power Company
1945 West Parnall Road
Jackson, Michigan 49201

cc: Stewart H. Freeman
Assistant Attorney General
State of Michigan Enviornmental
Protection Division
720 Law Building
Lansing, Michigan 48913

Mr. Paul Rau
Midland Daily News
124 McDonald Street
Midland, Michigan 48640

Mr. R. B. Borsum
Nuclear Power Generation Division
Babcock & Wilcox
7910 Woodmont Avenue, Suite 220
Bethesda, Maryland 20814

Mr. Don van Farrowe, Chief
Division of Radiological Health
Department of Public Health
P.O. Box 33035
Lansing, Michigan 48909

U.S. Nuclear Regulatory Commission
Resident Inspectors Office
Route 7
Midland, Michigan 48640

Mr. Paul A. Perry, Secretary
Consumers Power Company
212 W. Michigan Avenue
Jackson, Michigan 49201

Mr. Walt Apley
c/o Mr. Max Clausen
Battelle Pacific North West Labs (PNWL)
Battelle Blvd.
SIGMA IV Building
Richland, Washington 99352

Mr. I. Charak, Manager
NRC Assistance Project
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

James G. Keppler, Regional Administrator
U.S. Nuclear Regulatory Commission,
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Mr. Ron Callen
Michigan Public Service Commission
6545 Mercantile Way
P.O. Box 30221
Lansing, Michigan 48909

Geotechnical Engineers, Inc.
ATTN: Dr. Steven J. Poulos
1017 Main Street
Winchester, Massachusetts 01890

Billie Pirner Garde
Director, Citizens Clinic
for Accountable Government
Government Accountability Project
Institute for Policy Studies
1901 Que Street, N.W.
Washington, D. C. 20009

Commander, Naval Surface Weapons Center
ATTN: P. C. Huang
White Oak
Silver Spring, Maryland 20910

Mr. L. J. Auge, Manager
Facility Design Engineering
Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, California 91304

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

Enclosure 1

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

OCT 21 1983

MEMORANDUM FOR: James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

FROM: Pao-Tsin Kuo, Section Leader
Structural Engineering Section B
Structural and Geotechnical Engineering Branch
Division of Engineering, ONRR

SUBJECT: REPORT ON THE REVIEW OF THE DIESEL GENERATOR BUILDING AT MIDLAND

References:

1. Memo from R. F. Wanick, Region III to D. G. Eisenhut NRR/DE, "Evaluation of Dr. Landsman's Concerns Regarding the Diesel Generator Building at Midland," dated July 21, 1983.

2. Memo from R. H. Vollmer, DE to D. G. Eisenhut, DL "Evaluation of Dr. Landsman's Concerns Regarding Diesel Generator Building at Midland," dated July 21, 1983.

Pursuant to Reference 2 above, a task group, consisting of three members of the Structural Engineering staff and a consultant team of Brookhaven National Laboratory, was formed to re-evaluate the structural design and construction adequacy of the Midland Diesel Generator Building (DGB). The group, headed by P. T. Kuo, reviewed the design review documents and the construction reports; physically inspected the building; interviewed concerned individuals, including Dr. Landsman; and prepared a final report on the adequacy of the Midland NPP Diesel Generator Building. The final report on the adequacy of the Midland DGB is enclosed.

The task group's conclusions and recommendations are summarized as follows:

1. The settlement data indicate that the fill under the DGB is well into the secondary consolidation phase so that large additional settlements are not anticipated;

2. It is judged that there is reasonable assurance that the structural integrity of the DGB will be maintained and its functional requirement fulfilled. However, it is difficult to show that the stresses in the DGB can meet the criteria of the FSAR. The stresses due to settlement were either underestimated or overestimated by the Applicant's previous analyses;

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3. The most reasonable estimate of stresses due to settlement is based on the crack width data. However, the calculations that have been done in this area need to be completely documented;

4. There is evidence that the number of cracks in the DGB is continuing to grow. It is essential that a more accurate and reliable crack monitoring program be established; and

5. The monitoring program should specify an upset crack width level that would reflect a sufficient stress margin available to resist critical load combinations. The monitoring program should mandate structural repairs if the Alert Limit (in crack width) were exceeded.

Pao-Tsin Kuo, Section Leader
Structural Engineering Section B
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosure:
As stated

cc: H. Denton
D. Eisenhut
R. Vollmer
G. Lear
E. Adensam
D. Hood
N. Romney
C. Tan
R. Landsman, R III
F. Rinaldi
J. Kane

CONTACTS: C. P. Tan, SGEB
x28424

N. D. Romney, SGEB
x28987

REPORT ON THE REVIEW OF THE DIESEL GENERATOR BUILDING AT MIDLAND

OCTOBER, 1983

BY

Dr. Chen P. Tan
Mr. Norman D. Romney
Dr. Pao-Tsin Kuo, Task Group Leader

Structural Engineering Section B
Structural and Geotechnical Engineering Branch
Division of Engineering, ONRR

Assisted By:

Professor Charles Miller
Professor Carl Costantino
Dr. A. J. Philippacopoulos
Dr. Morris Reich

Brookhaven National Laboratory

TABLE OF CONTENTS

1. INTRODUCTION

The Diesel Generator Building (DGB) at the Midland Nuclear Power Plant (NPP) is a reinforced concrete structure which has undergone excessive unequal settlement since its construction. The concrete walls of the DGB have been more extensively cracked than usually expected of such a concrete structure. On the basis of review and evaluation of the Applicant's (Consumer Power Co.) various analytical studies, remedial measures taken, and the commitments made and of the staff's own assessments, the original structural engineering staff reviewer came to the conclusion that the DGB was acceptable. However, an NRC regional inspector disagrees with the conclusion as to the acceptability of the DGB and has expressed his concerns in a hearing before a Congressional Government Oversight Committee.

In the wake of this controversy, the Division of Engineering (DE) formed an independent Task Group to re-review the structural adequacy of the DGB. The Task Group consists of three members from the structural engineering staff and a consultant team from Brookhaven National Laboratory. The consultant team provides expertise in both structural and geotechnical engineering. The charter of the group and its composition, the names of the Staff, and its consultants involved are included in Appendix I to this report. The Charter of this Task Group has three elements that are interwoven and do not lend themselves to neat separation. The Task Group was charged:

(1) to re-evaluate the structural design and construction adequacy of the DGB as accepted by the structural engineering staff reviewer

(2) to assess the concerns as indicated by comments from other NRC personnel, and

(3) to make recommendations to resolve any lingering concerns.

It is acknowledged that the Task Group has had outstanding cooperation from the Applicant, the structural engineering staff reviewer and its consultants, the geotechnical engineering staff reviewer and its consultant, and NRC Region III Inspector, in either group's on-site inspection, interviews, or design audit in Applicant's A/E office. It is this cooperation that enables the Task Group to assemble all the necessary information and facts in a short period of time. The chronology of the group's various activities and persons contacted are presented in Appendix II to this report.

An independent report written by Brookhaven National Laboratory is included in Appendix III of this report.

2. DESCRIPTION OF THE DGB AND ITS PROBLEMS

The DGB is a two-story, box-type reinforced-concrete (RC) structure with three cross walls that divide the structure into four cells, each of which contains a diesel generator unit. The building is supported on continuous RC footings 10' - 0" wide and 2' - 6" thick founded at plant elevation 628' and resting on a fill that extends down to approximately elevation 603'. The building has exterior wall thickness of 30", roof slab and interior wall thickness of 18". Plan dimensions of DGB are 155' x 70 with a total internal height of approximately 44'. Each diesel generator rests on a 6'-6" thick, RC pedestal that is not structurally connected to the building foundation. Figure 1 shows the general layout of the DGB.

The DGB as implied by its name is a building which houses the diesel generators and is classified as a seismic Category I structure. As such it is designed against the effects of extreme environmental conditions such as seismic load and tornado wind load. The latter includes a wind pressure, a differential pressure and tornado missile impact. The use of thick exterior walls and roof slab is basically a result of the consideration of the effects of the tornado missile impact load.

When the building was approximately 60% complete, unusual settlement and cracking of concrete walls were observed. The building was settling due to the consolidation of the underlying fill while it was partially supported along the north portion by four electrical duct banks acting as vertical piers resting on natural soil below the fill. A soil boring program to determine the quality of the backfill under the foundation discovered that the fill was uncontrolled and improperly compacted. The fill consisted of both cohesive soil, granular soil and lean concrete. The fill ranged from very soft to very stiff for cohesive soil and from very loose to dense for granular soil. At the time of the soil exploration, the groundwater level was observed to be ranging from elev. 616' to 622' and the cooling pond, located about 275 feet south of the building, had a water level at approximately elev. 622'.

In view of the condition of the DGB as described above, it was apparent that corrective measures must be taken to relieve the DGB from its distress. The remedial actions taken by the Applicant can be summarized as follows:

(A) Separate the DGB from the duct banks - The duct banks entering the DGB were isolated from the building, thus relieving the building from the effects of the rigid supports.

(B) Surcharge the DGB and the surrounding area - The purpose of the surcharge was to accelerate the settlement and consolidate the fill material so that future settlement under the operating loads would be within tolerable limits.

(C) Install a permanent dewatering system - The purpose of the permanent dewatering system is to maintain water level below elev. 610' in the area of DGB, thus minimizing the potential of liquefaction of the loose sands contained in the fill.

The effects of the remedial measures taken can be observed from the amount of settlement which the DGB has gone through as indicated in Figure 2 and also from the crack sizes and crack patterns of the walls as shown in Figure 3. Details of both settlement and cracking issues are discussed in the following sections.

3. SETTLEMENT AND CRACKING ISSUES

As a result of the remedial actions taken by the Applicant, it appears that the settlement of the DGB has mostly stabilized. However the fact still remains that the building has undergone unusual settlement and its walls have experienced extensive cracking. It has given rise to the concern of the DGB's structural capability to fulfill the function of protecting the safety-related equipment located therein as originally designed. In order to alleviate this concern and to assure that the structural integrity is preserved, the Applicant undertook a number of structural re-analyses using the FSAR criteria and the ACI 349 criteria and taking the settlement and cracking into consideration. On the basis of the results of the re-analyses, the Applicant concluded as follows:

(a) The settlements during early stages of construction and during the surcharge did not cause any unusual distress or significant loss of structural strength. As a result of surcharging, future settlement can be conservatively predicted and will not be excessive. The installation of the permanent dewatering system has eliminated any potential for liquefaction of the sand backfill below the DGB during a seismic event.

(b) Cracking of the walls during construction and surcharging has not impaired the ultimate strength of the structure.

(c) The building will be re-evaluated for its structural adequacy when the allowable limit for the cracking width is exceeded under the established monitoring program, thus insuring its safety function.

The structural engineering staff reviewer and its consultants with findings of their own independent assessments in essence concurred with the Applicant's conclusions. However, the geotechnical engineering staff reviewer and its consultant together with the Region III inspector disagreed.

A major point of contention was that the Applicant's analyses linearized the unequal settlements and thus the effect of unequal settlements has not properly been considered. The Region III inspector also contended that, because actual cracking of the concrete walls was not considered in the Applicant's analyses, the rebar stresses as calculated by the Applicant were not representative of the stress for the loading combinations considered.

In what follows the Task Group shall present its major observations of the analyses performed by the Applicant and by the consultants to the structural engineering staff, the issues raised, and its assessment of the Applicant's conclusion on the DGB structural integrity.

4. STRUCTURAL RE-ANALYSES

In the preceding section, it is indicated that the Applicant has made a number of structural re-analyses and used the results of the re-analyses to justify the DGB structural adequacy, and that there have been concerns expressed as to the appropriateness of the re-analyses. The essential elements of the applicant's re-analyses are succinctly summarized.

Settlement Analyses

Settlement of the DGB is time-dependent and load-dependent, but a complete and accurate settlement history does not exist. On the basis of the availability of the measured or estimated settlement values at various stages of construction, four cases of settlement analyses were performed by the Applicant as listed in Table 1, with the corresponding settlement values shown in Figure 2. With the exception of Case 1A which was analyzed by long hand computation and by idealizing the partially completed DGB as a series of individual beams, the other three cases were analyzed by computer through the discretion of the DGB into a number of finite elements as exemplified in Figure 4. Case 1A was accomplished by passing deflection curve through any three measured neighboring settlement points and selecting the one with the largest curvature for moment computation, and eventually, stress determination. This calculation indicated that the measured displacements would result in a maximum rebar stress of 11 ksi. For the other three settlement cases, individual finite-element models were used. For settlement Case 1B, the finite-element model represents the structure as built to el. 662 f 0 in.

For settlement Cases 2A and 2B, the finite-element model represents a fully completed structure. For Cases 1B, 2A, and 2B, springs were typically calculated at each nodal point along the foundation by dividing the structural load represented at the selected point by the measured or predicted settlement at that point. The finite-element analysis of each case then involved several iterations in which the soil springs were varied until the deflected shape of the DGB, as calculated by the model, approximated the "best fit" settlements. The resulting deflections of the DGB from these analyses as shown in Figures 5 and 6 are not in conformance with the measured values and are almost linearly related. The magnitude of stresses would depend on the final cycle of iteration selected and would bear no relationship to the actual stresses resulting from settlement. Other analyses performed by the Applicant consisted of (1) using zero and near zero soil springs to simulate the soft soil condition, and (2) considering the DGB to be simply supported. The purpose of these analyses was to study if the DGB has the capability of bridging voids and soft spots in the soil.

In an attempt to provide more insight into the problem the consultant to the structural engineering staff was requested to make an independent analysis by using the measured settlement values at 12 locations as input. It was found that the DGB should have cracked extensively and yielded to failure. However, the cracking condition as exhibited by the DGB does not bear out the conclusion of the analysis. It was, therefore, concluded by the staff's consultant that the DGB did not experience the settlement as measured and that the analysis did not reflect the actual settlement history of the DGB.

Cracking Analysis

Cracks in reinforced concrete (RC) members may be caused by the conditions of hardening or curing of the concrete (its shrinkage) or by excessive stresses in the materials (induced by too heavy loads, settlement of the footings and/or changes in temperature). Cracks due to excessive stresses appear most frequent in the tension zones and are seldom encountered in the compression zone of concrete members. Cracks in the RC walls of the DGB are caused by a combination of shrinkage, unequal settlement and temperature changes.

Drying shrinkage and thermal contraction cause shallow cracks at surface.As soon as the cracks are formed the tensile strain is relieved. In the case of cracks due to unequal settlement the tensile strain is to be resisted by the reinforcing steel. The purpose of the cracking analysis is to determine the rebar stresses from the measured crack width. First, the Applicant made an analysis of a single through crack in a subsection of the east wall of the DGB by using the Automatic Dynamic Incremental Non-linear Analysis (ADINA) computer program. The purpose of this analysis was to evaluate the ultimate capacity of a concrete section containing a single crack. As such, the results of the analysis are of only limited value in assessing the effects of the cracks. As a further attempt to resolve the concern on cracking, the Applicant sought the opinion of Professor M. A. Sozen of the University of Illinois. On the basis of the crack patterns and crack-size, Prof. Sozen estimated the stresses in the rebar across the cracks to be in the range of 20 to 30 ksi.

The structural engineering staff reviewer also made his own assessment by combining the rebar stresses estimated from crack widths with stresses resulting from the Applicant's analyses for other operating loads. It showed that the resultant stress was within the acceptance criteria (Tr. 11086).

In order to assure the structural integrity of the DGB, the Applicant has proposed a crack monitoring and evaluation program to be used during the life of the DGB, in addition to an initial repair program. Specific acceptance criteria (i.e. alert limits and action limits) for crack width and crack width increases have been specified by the structural engineering staff reviewer and agreed to by the Applicant.

5. VIEWS ON THE ISSUES RAISED

The four concerns as raised by Region III inspector, Dr. R. B. Landsman, are directly quoted from his memorandum to R. F. Warnick, Director, Chief of Special Cases of NRC Region III, dated July 19, 1983, as follows.

I. Concern:

"My first concern deals with the finite element analysis that Consumers Power Company (CPCo) used to show that the building is structurally sound. Their model of the building assumed a very rigid structure without any cracks. The building has numerous cracks, reducing the rigidity of the structure. The effects of these cracks have not been taken into account in the analysis. CPCo's interpretation of the settlement data as a straight line approximation always stems from their position that the building is too rigid to deform as indicated by actual settlement readings. The settlement of the building occurred over a period of time during different phases of construction. It is this time dependent effect that was also not used in their model. Even CPCo expert Dr. Corely testified at the ASLB hearings that the analysis should have "taken into account cracking and time dependent effects" in order to give correct results. Finally, the staff's official position, as stated by Dr. Schauer, on CPCo's analysis was, "The staff takes no position with regard to that analysis."

Comment:

The first part of this concern is that the cracks have not been considered in the Applicant's analyses. As indicated in previous discussion, cracks in the walls of the DGB are due to a combination of shrinkage, unequal settlement and temperature changes. Ordinary drying shrinkage and temperature change cracks are generally surface cracks. As soon as the cracks are formed, the tensile strain is relieved. Cracks due to differential settlement are generally through cracks across the wall thickness and, therefore,reduce the stiffness of the structural members. Structural engineers involved in reinforced concrete design are well aware of this fact. In order to take cracking of structural members into consideration, structural engineers first assume these members are uncracked and perform the structural analyses to obtain the moments, shears and axial forces required for the design of member sections. In designing the members concrete is then assumed to be cracked and does not take tension. Such a procedure of analysis and design is a standard practice and is, in fact, recommended by the ACI 318-77 code.

The second part of this concern is that the actually measured settlements have not been used in the Applicant's analyses. From the settlement data available it is obvious that settlement was continuing with the progress of construction with the maximum attained after the removal of the duct bank restraints and at the end of surcharging. In the early stages of construction the components such as the continuous strip footings, and wall portions forming the lower part of the DGB were most likely very flexible, and deflected in conformance with the settlement without creating any excessive stresses in the as-built portion of the DGB. There might be cracks in some of the components of this portion of the DGB due to shrinkage and/or displacement of the green concrete as a result of settlement. In order to adequately consider effects of settlement over the period of time during different phases of construction, the analytical models would have to be different for different phases of construction and to be meaningful there should be settlement measurements corresponding to each phase. However, there are no such detailed settlement measurements available, especially for the early stages of construction. The settlement measurements which are available correspond to those in the later stages of DGB construction, that is, when the as-built portions of the DGB are relatively rigid. The Applicant performed three separate finite element analyses for which measured and/or predicted settlement values are available. The measured and/or predicted settlement values are used as data points in linearizing the settlement. The differences between the measured/predicted settlement values and the resulting linearized values have been discounted as survey inaccuracies. This is basically equivalent to assuming that the north and south walls underwent rigid body motions. The computed stresses from this model are due to racking only. The stresses obtained in the process of linearizing the settlements, therefore, do not represent the actual settlement stresses.

The use of survey inaccuracies to discount the differences between the measured/predicted settlements and the linearized values is not convincing in view of the fact that all the settlements have not occurred after the completion of the DGB construction.

The third part of this concern is that the time dependent effect has not been considered in the Applicant's analyses. The Applicant has considered the four stages of construction, therefore the time factor has been taken into consideration but in a very gross manner. As indicated in the preceding comment in order to assess accurately the stresses in the walls of the DGB, detailed information on wall cracks (time-dependent) and on settlement values (also time-dependent) would be required for each step in the construction. There is no detailed information on either the cracks or the settlement values to cover the whole time span of construction. Basically this portion of the concern is inherent in the above two portions of the concern.

The fourth portion of the concern is that the structural engineering staff reviewer has taken no position with respect to the Applicant's analysis. From the preceding comments it is obvious that the adequacy of the Applicant's settlement analysis is questionable and it cannot be relied on to reach any conclusion. The structural engineering staff reviewer took a practical approach by ignoring the analysis, and resorted to the solution through crack analysis.

II. Concern:

"My second concern deals with the acceptance of the diesel generator building in the SSER #2 which was subject to the results of an analysis to be performed by the NRC consultants using the actual settlement values. The consultants testified at the ASLB hearing that this analysis gave unacceptable results and this portion of the SSER should be stricken. They are basing their unacceptable results and comments on their finding of very high stresses obtained in areas where no cracks exist. Therefore, the actual settlement values are not accurate enough (are in error) to be used in an analysis. The consultants, as well as CPCo, ran a linear analysis (structure always in the elastic range) instead of a plastic analysis which would allow a redistribution of loads in the structure. Therefore, supposed areas of high stress, where cracks are not located, may not exist due to redistribution of loads. Finally, the staff's official position, as stated by Mr. Rinaldi, on this analysis as performed by the consultants, was that the actual settlement values could not be relied upon to determine if the diesel generator building meets regulatory requirements."

Comment:

The first portion of concern is that the structural engineering staff reviewer disregarded the results of an analysis done by its consultants on the basis of the actual settlement values. This portion of the concern is in essence the same as the first concern. It is indicated in the comment on the first concern that the settlement was continuing with the progress of construction. When the strip footing concrete was placed, settlement started. Since the footing is a comparatively thin slab, it would likely deform with the settlement without creating excessive stresses. With the build-up of the walls, settlement increases and rigidity also increases. When the intermediate floor slab and the roof slab were completed, the complete structure became a very rigid structure and any settlement should be nearly linear unless there were weak sections across the building. To analyze the completed DGB on the basis of the settlement values which were accumulated during the construction and after its completion would result in exceedingly high stresses which are not representative of the actual values.

The second portion of this concern is that the staff has not used plastic analysis. It is suggested, that in order to conform to the measured settlement values a plastic analysis should be made to allow redistribution of loads in the structure. This observation is valid providing that rebar in the walls and slabs of the DGB have undergone yielding and plastic hinges have formed. It is the judgment of this Task

Group that, without the knowledge of accurate geometry of the DGB at the various phases of settlement, a non-linear model accounting for plastic effects would not be meaningful.

The third portion of this concern is the staff's official position that the results of the analysis by the staff's consultants on the basis of actual settlement measurements cannot be relied upon to determine if the DGB meets regulatory requirements. From the preceding comments, one cannot accurately calculate the stresses in the completed DGB without settlement data from the initial phase of construction. Given the unavailability of the data necessary to complete the input to the analysis by the staff's consultant, the previously stated staff position is reasonable.

III. Concern:

"My third concern deals with the fact that we are not following normal engineering practice in accepting the building by using a crack analysis approach because there is no practical method available today to analyze a complex structure with cracks in it. The basis of this concern is that there are no formulas available that can estimate stresses in a complex stress field like those which exist in this building. Thus, the evaluation of the structure based on the staff's crack analysis using empirical unproven formulas to determine the rebar stresses is unacceptable."

Comment:

This concern is related to the use of crack analysis to accept the DGB. Contrary to the concern expressed there are computational tools available to relate crack width to rebar stresses, but in effecting the analyses one still has to make some major simplifying assumptions which requires the judgment of the analyst. The results of such analyses in most likelihood will not be exactly the same as what actually exists. In the case of DGB the estimation of rebar stresses from the sizes of cracks is admittedly an approximation. However, it is the judgment of the Task Group that this is the only practical approach available to evaluate the DGB rebar stresses.

In evaluating the rebar stresses estimated from crack widths the following, as a minimum, needs to be considered and documented by the Applicant: whether or not the cracks are through the wall thickness; the sizes and locations of the cracks; whether or not the cracks are growing in width and/or length; whether or not the number of cracks are increasing; and whether the estimated rebar stresses due to settlement are less than the allowable values after accounting for load combinations is made.

IV. Concern:

"My fourth concern deals with the staff accepting the building by relying on a crack monitoring program to evaluate the stresses during the service life of the building. If cracks exceed certain levels, recommendations will be made for maintaining the structural integrity of the building. The basis for my concern deals with the lack of crack size criteria and the lack of formulated corrective action to be taken when the allowed crack sizes are exceeded."

Comment:

This concern questions the staff's acceptance of the DGB on the basis of a crack monitoring program which is not well defined in crack size criteria and in corrective action. The DGB is designed for combinations of dead, live, tornado and earthquake loads, and therefore it is expected to be able to resist these loads and their loading combinations with adequate margins of safety as designed. However, as a result of settlement which was not considered in the original design, the margins of safety have been reduced to some extent and there is some uncertainty as to its capability to resist the design loads. The purpose of monitoring the cracks is to insure that if there is any change in the condition of the structure it will be observed and appropriate actions can be taken, if necessary. The structural engineering staff reviewer has specified and the Applicant has agreed to the crack size criteria and the corrective action to be taken when the allowed sizes are exceeded. The Task Group is of the opinion that, while the approach is reasonable, details of the program should be further examined and improved. It should also be noted that the crack monitoring program should be in complement with a settlement monitoring program, since any assessment based on either of the two monitoring programs alone may be misleading.

6. AN ASSESSMENT OF THE DGB

Before assessing the structural adequacy of the DGB, let us examine general characteristics of structures in their capability to adapt to the settlement of the foundation soil. Structures may be classified as highly flexible, practically flexible, highly rigid and practically rigid on the basis of their deformability with respect to the settlement of the foundation soil.

Highly flexible structures follow the displacement of the foundation soil surface at all points. An example of such a structure is an earth embankment. Non-uniform (differential) settlements do not give rise to any complications in the deformation of such a structure.

Highly rigid structures either have a uniform settlement when subjected to a symmetrical load with symmetrical distribution of the soil compliance, or else tilt without bending. As an example of this are grain elevators, factory chimneys (smoke stacks), blast furnaces, etc. These structures level out the settlements, i.e., they perform in conjunction with the soil bearing material. It is because of re-distribution of the pressure by the structure that differential settlement effect of the supporting material diminishes.

Practically rigid structures, which include most buildings and many engineering structures (multispan trestles and bridges with continuous structural members, reservoirs, storage tanks, etc.), cannot closely follow the foundation soil deformations at all points and, because of differential settlement, are subject to bending. Such structures level out only in part the non-uniform settlements of the foundation soil surface. This results in the development of additional forces in the supporting members of the structures, which are usually disregarded in the course of their designing. Hence the possible development of cracks in such members.

Practically flexible structures largely follow the displacements of the soil surface, i.e., they bend (such as low single-story buildings), but over short sections they are capable of levelling out to a certain extent the differential settlement. This results in the emergence of usually insignificant additional forces in the supporting members. In the event of highly non-uniform settlements these forces can cause the development of cracks and fractures.

On the basis of above classification and because of the box-type construction with heavy reinforced concrete walls and slabs, the completed DGB can be considered as a highly rigid structure. However, in the process of construction, the as-built portions of the DGB at different stages of construction can be considered to vary from highly flexible, practically flexible, practically rigid to highly rigid. It is believed that most of the settlement and settlement cracks appeared at the various stages of construction. However, the cracks have not been carefully studied and mapped at each stage of construction so that a reasonable correlation of the cracks with all the causes can be established. Only the cracks which were mapped in January 1980 have been identified as shrinkage and/or settlement cracks. Most of the cracks which have been identified to be due to unequal settlement are the cracks in the cross-walls, the movement of which was restrained by the duct banks.

The DGB design, as indicated by Applicant's analyses, is controlled by the tornado wind. Under such a load, especially the postulated internal pressure, the full strength of the walls will be mobilized, and there will be a redistribution of the load, if there exist localized high stress areas. This will also be true if the seismic loads are considered. One can make such judgments on the basis of the observation that the DGB is a highly redundant structure. The structural elements are not columns and beams. They are heavy reinforced concrete walls and slabs. With necessary repair work to be done and with adequate monitoring programs, there is reasonable assurance that the structural integrity of the DGB will be maintained and its functional requirement will be fulfilled.

7. CONCLUSIONS AND RECOMMENDATION

Most of our conclusions have been expressed in our comments to the concerns they may be summarized as follows:

1. Analyses of the DGB either by linearizing the settlements or by applying the settlements as measured render unrealistic results. The stresses due to settlement are either underestimated or overestimated. A realistic analysis would be one which simulates the stage-by-stage construction of the DGB, and uses the actual and more detailed settlement measurements at each stage. However, such settlement history for the DGB does not exist. For this reason, the Task Group believes that a rigorous analysis to compute rebar stresses is unattainable.

2. The estimation of rebar stresses from the crack width is admittedly an approximation. The estimated stresses of 20 to 30 ksi appear to be reasonable. However to be convincing a detailed procedure of crack analysis should be documented and provided.

3. Inconsistences in the documentation of the settlement history needs to be resolved. For example, the Midland Units 1 and 2 Executive Summary dated August, 1983 states that for the July 1978 period, the maximum settlements recorded were 3.5 inches while Figure ES-14 of the same document indicates a maximum of 1.99 inches for the same period.

4. The current monitoring program is inadequate to deduce future distress. Thus, an adequate monitoring program for both settlement and cracks should be developed and implemented to assure that the structural integrity of the DGB should be maintained during the life of the plant.

5. On the basis of the overall evaluation, it is nevertheless felt that the DGB in its current state can fulfill its functional requirement .

6. It is recommended that a repair program be developed and implemented.

TABLE 1

DIESEL GENERATOR BUILDING

SETTLEMENT CASES

CASE	TIME PERIOD	PERIOD	PORTION OF BLDG COMPLETE
1A	3/78 - 8/78	PRE-SURCHARGE	WALLS TO ELEV 654'
1B	8/78 - 1/79	PRE-SURCHARGE	WALLS TO ELEV 662' (BELOW MEZZANINE SLAB)
2A	1/79 - 8/79	SURCHARGE	COMPLETE BUILDING
2B	9/79 - 12/2025	40 YEAR	COMPLETE BUILDING

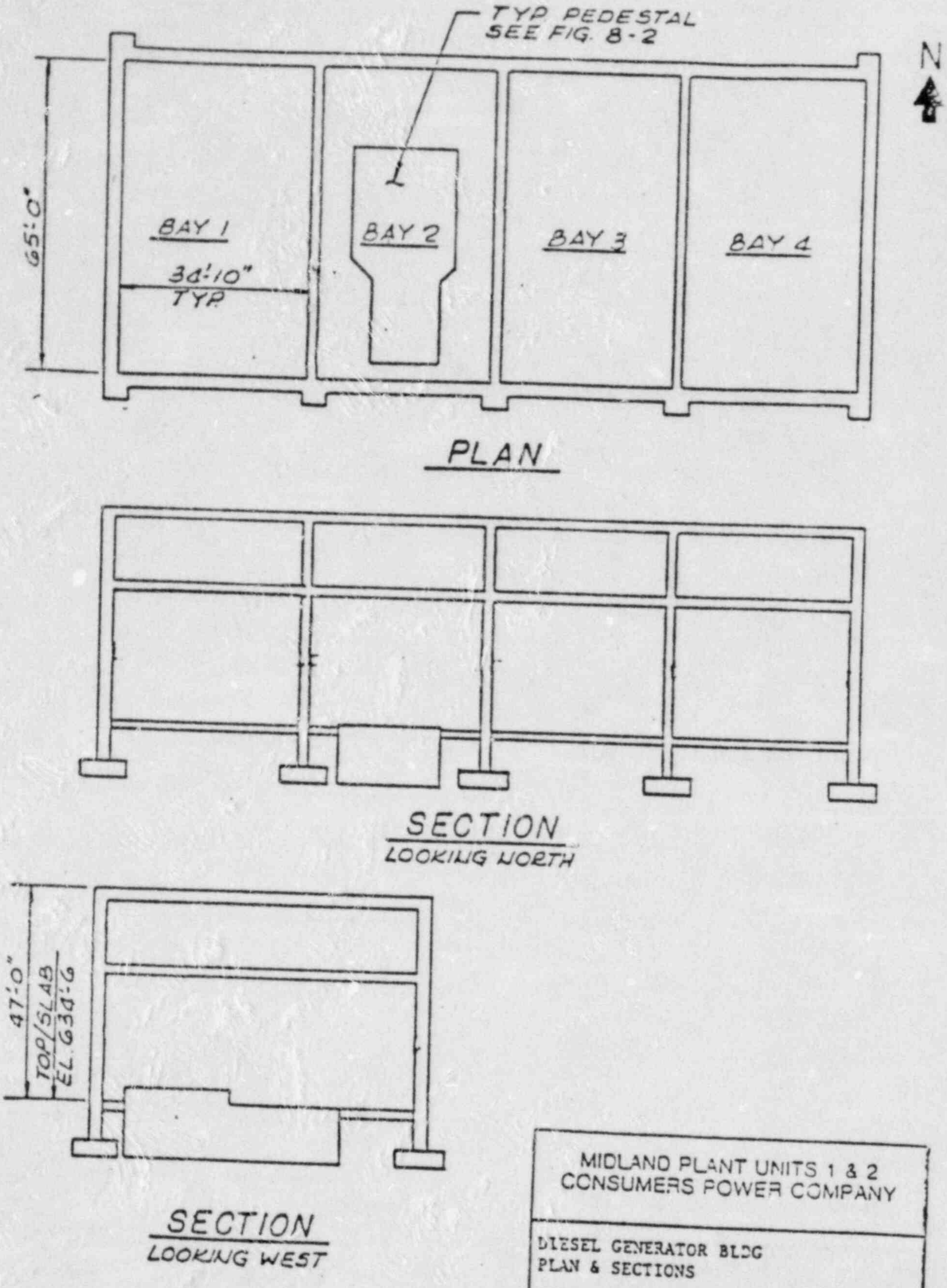


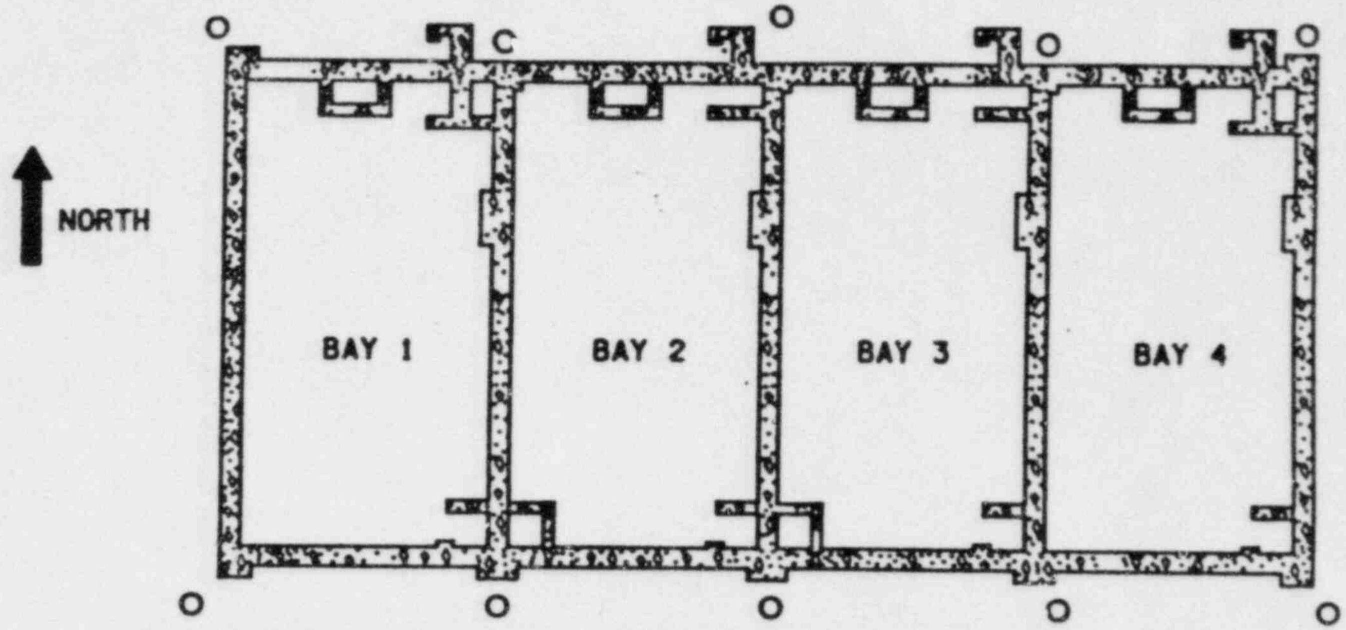
FIGURE 1

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

DIESEL GENERATOR BLDG
PLAN & SECTIONS

FIGURE ________ DATE. 4/24/79

LINE A	1.19	1.02	0.90	0.85	0.76
LINE B	0.77	1.09	1.54	1.98	2.41
LINE C	1.50	1.51	1.78	1.86	1.91
LINE D	1.33	1.15	1.19	1.18	1.29
TOTAL	4.79	4.77	5.41	5.87	6.37



LINE A	1.67	1.42	1.28	1.44	1.99
LINE B	1.14	1.12	1.46	1.92	2.21
LINE C	3.00	2.92	3.16	3.37	3.24
LINE D	1.62	1.67	1.69	1.98	1.89
TOTAL	7.43	7.13	7.59	8.71	9.33

LEGEND

O —— DIESEL GENERATOR BUILDING SETTLEMENT MARKER

SETTLEMENT IN INCHES FOR

PRE-SURCHARGE PERIOD (3/78-8/78)............LINE A

PRE-SURCHARGE PERIOD (8/78-1/79)............LINE B

SURCHARGE PERIOD (1/79-8/79) ....LINE C

POST SURCHARGE PERIOD (9/79-12/2025) ....LINE D

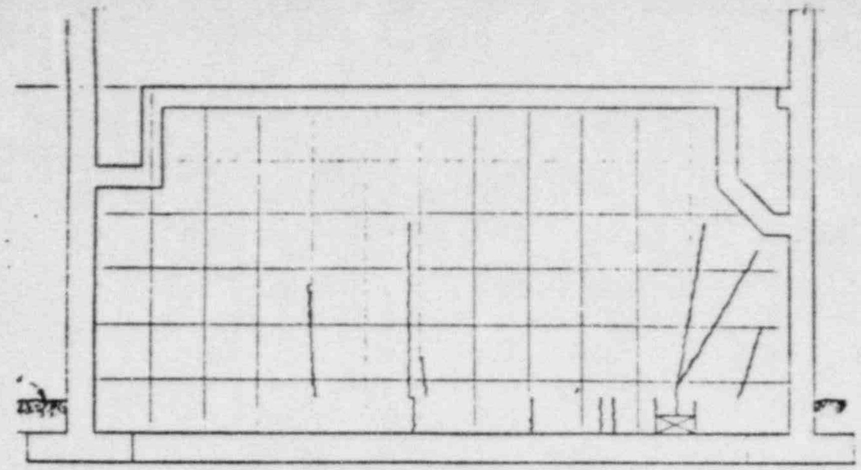
ASSUMING SURCHARGE REMAINS IN PLACE

FIGURE 2

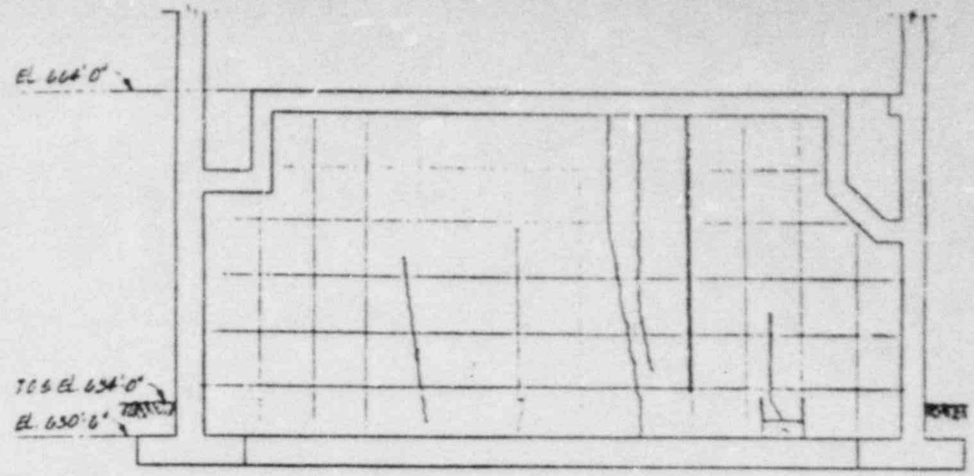
DIESEL GENERATOR BUILDING
EXECUTIVE SUMMARY

SUMMARY OF ACTUAL AND ESTIMATED SETTLEMENTS

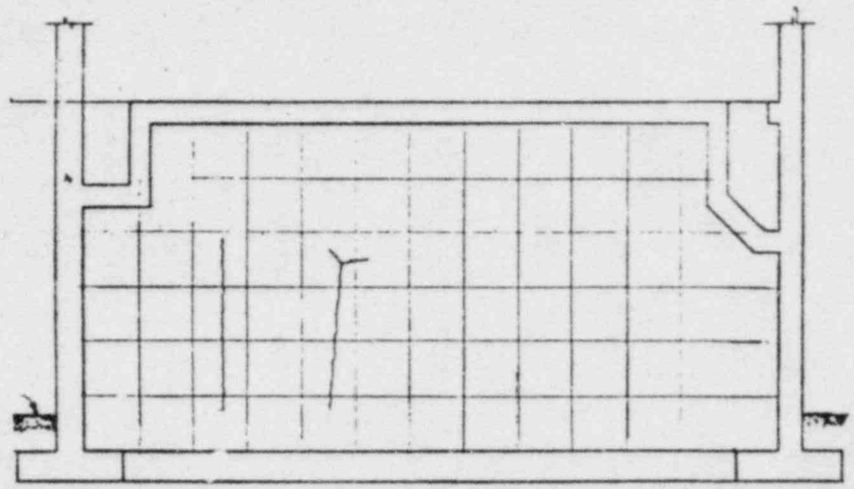
FIGURE ES-14



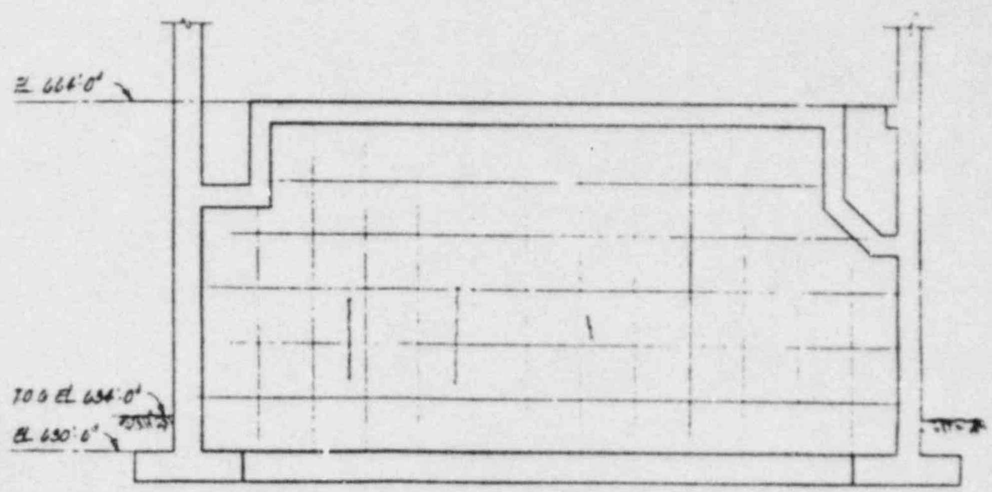
WEST CENTE[illegible] WALL-EAST SIDE
LOOKING WEST



WEST CENTER WALL-WEST SIDE
LOOKING WEST

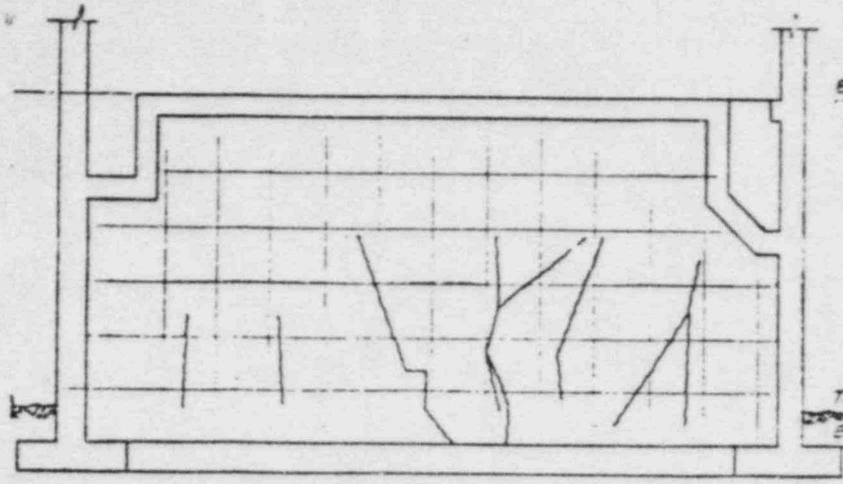


WEST WALL-EAST SIDE
LOOKING WEST

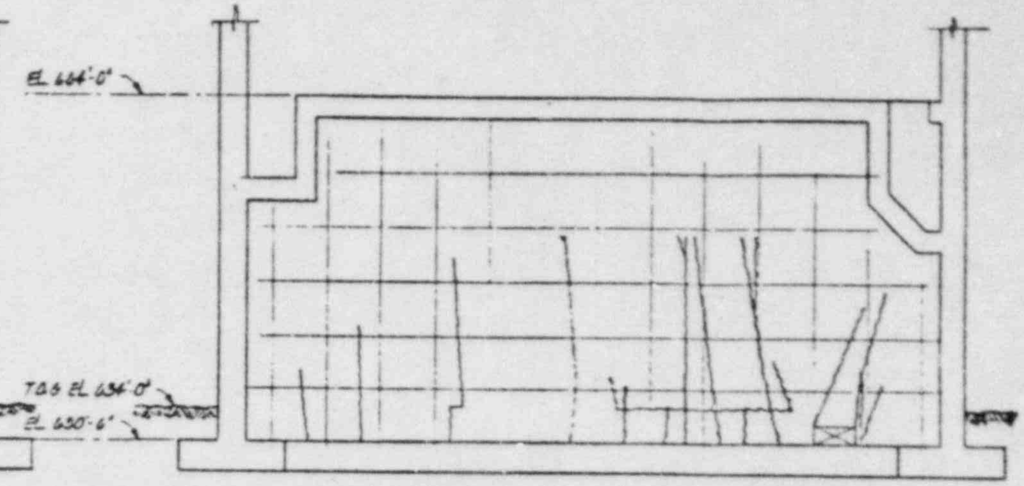


WEST WALL-WEST SIDE
LOOKING WEST

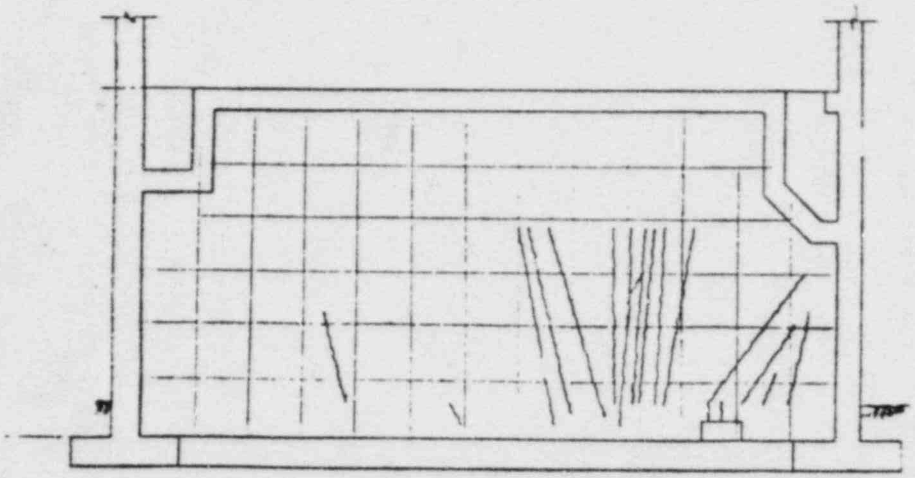
FIGURE 3 - A - 1



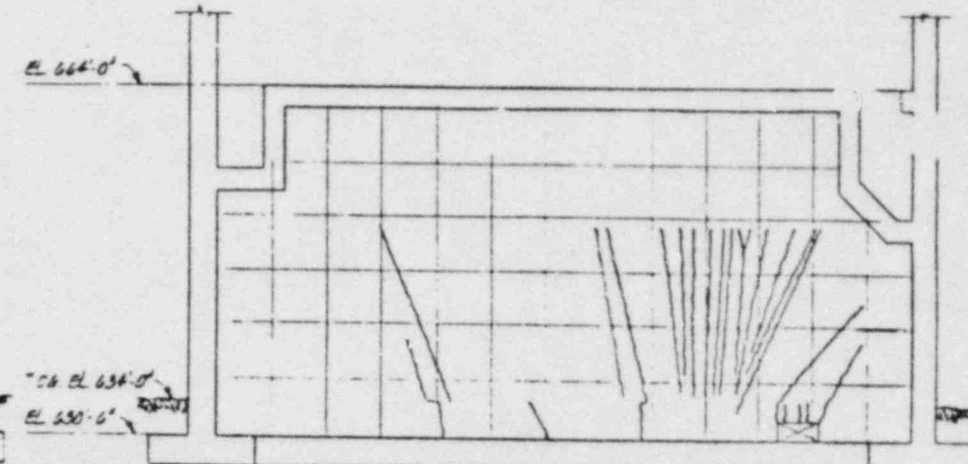
EAST WALL-WEST SIDE
LOOKING WEST



EAST CENTER WALL-EAST SIDE
LOOKING WEST

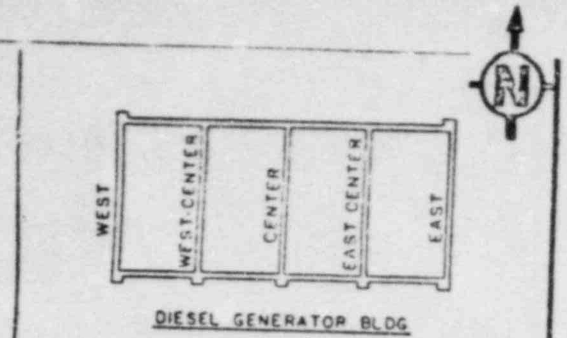


CENTER WALL-EAST SIDE
LOOKING WEST



CENTER WALL-WEST SIDE
LOOKING WEST

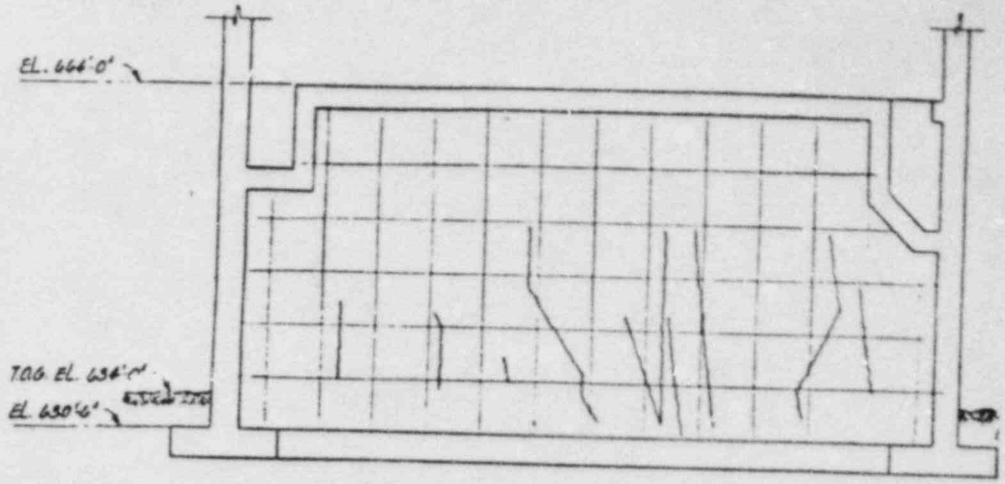
FIGURE 3 A - 2



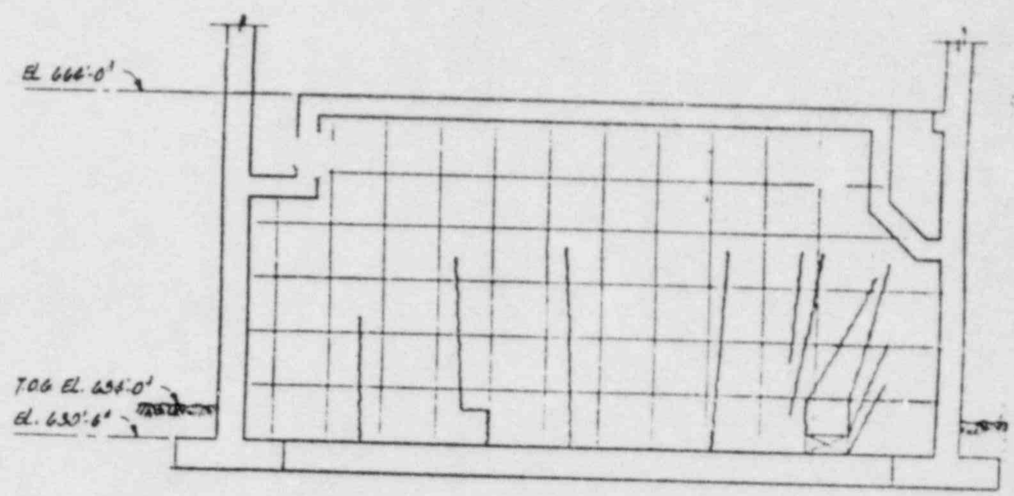
KEY PLAN

NOTES

1. CRACK SHOWN WERE MAPPED PRIOR TO PLACING THE PRELOAD (12-13-78 TO 12-18-78).
2. NORTH & SOUTH WERE NOT MAPPED SINCE NO SIGNIFICANT CRACKS WERE OBSERVED.
3. IN GENERAL, ALL CRACKS WERE HAIRLINE WITH SOME CRACKS WITH A THICKNESS OF 28 MILS AS OF 2-2-79.

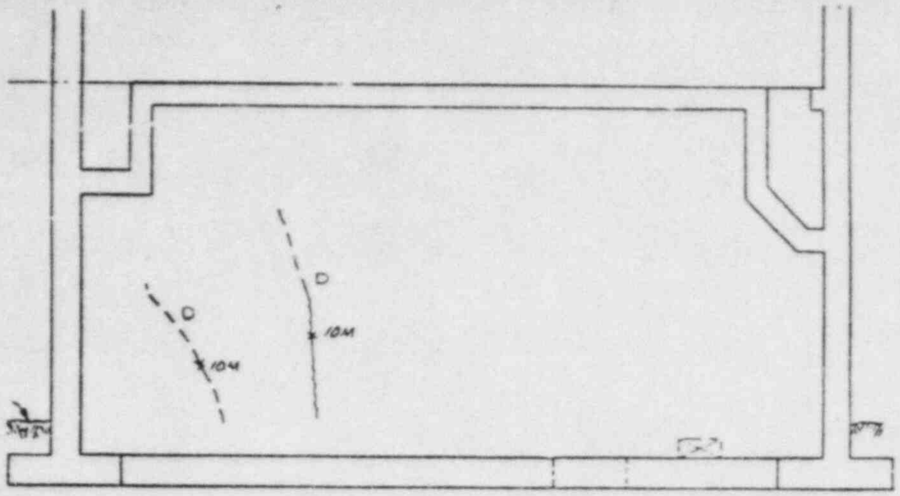


EAST WALL-EAST SIDE
LOOKING WEST

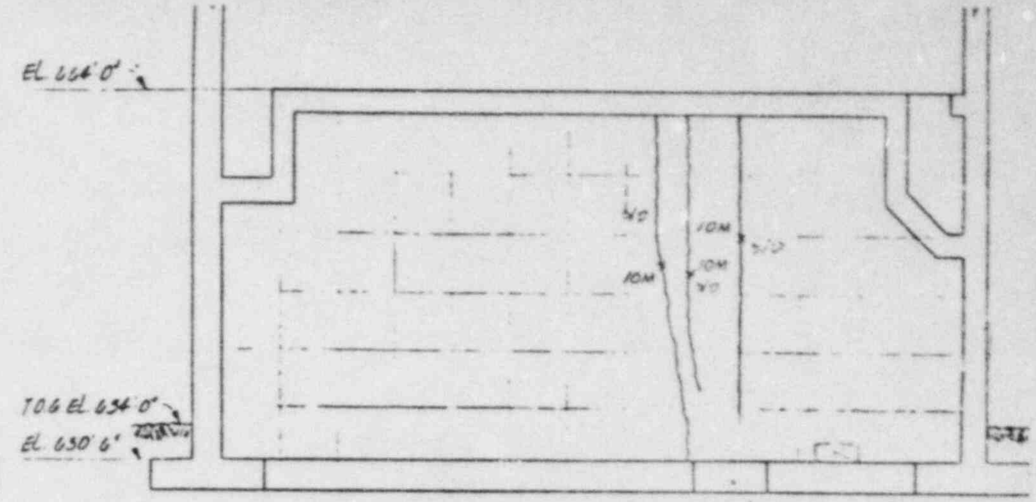


EAST CENTER WALL-WEST SIDE
LOOKING WEST

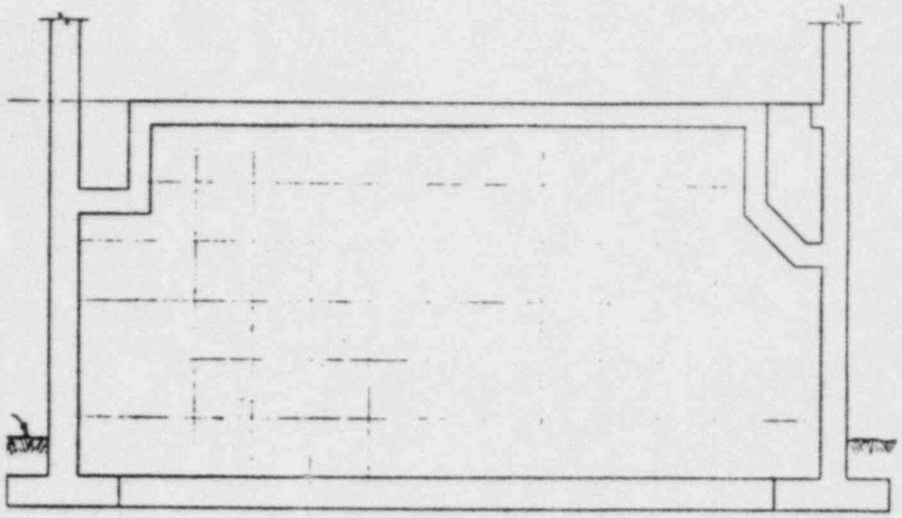
FIGURE 3 A - 3



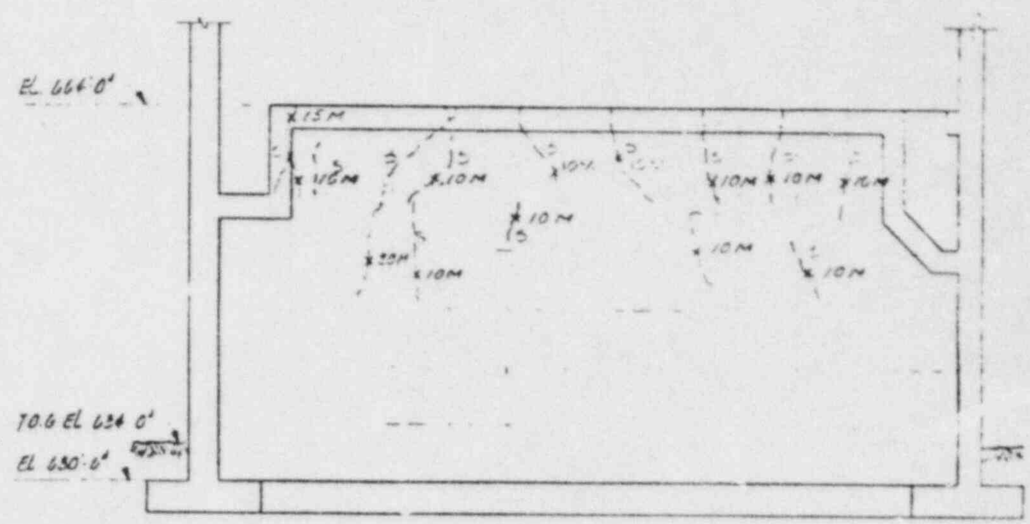
WEST CENTER WALL-EAST SIDE
LOOKING WEST



WEST CENTER WALL-WEST SIDE
LOOKING WEST

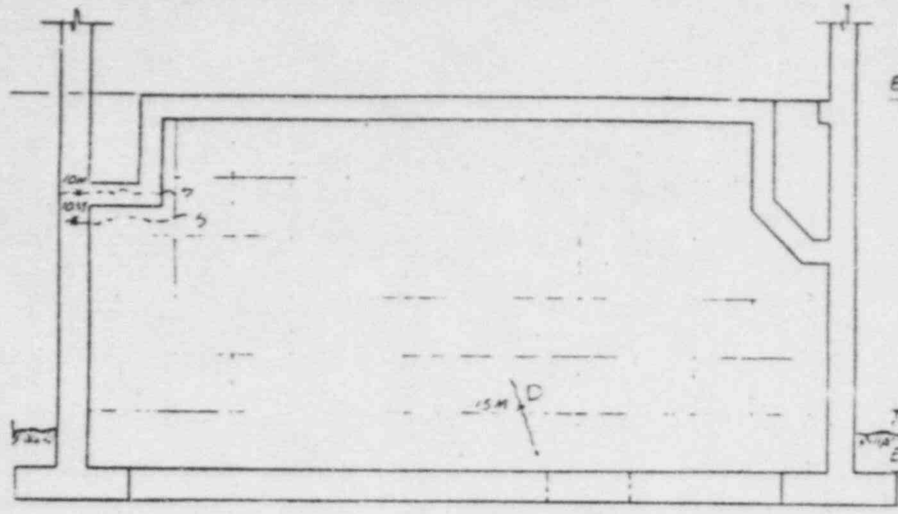


WEST WALL-EAST SIDE
LOOKING WEST

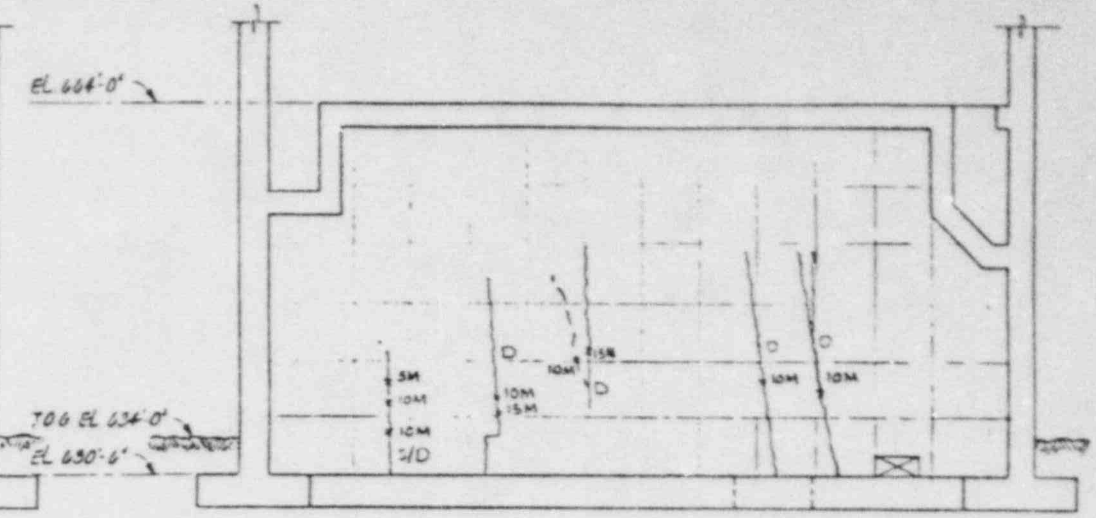


WEST WALL-WEST SIDE
LOOKING WEST

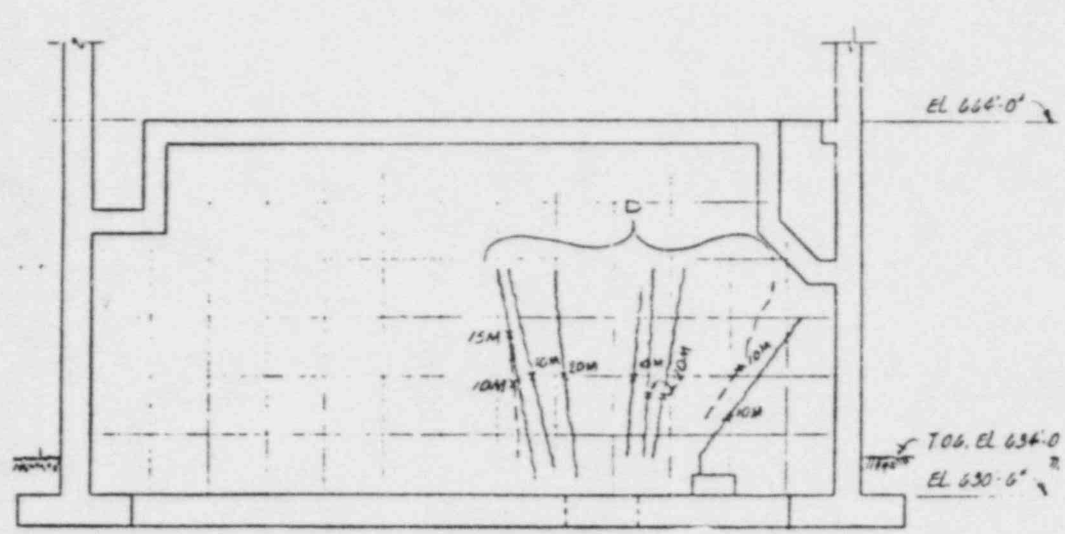
FIGURE 3 B - 1



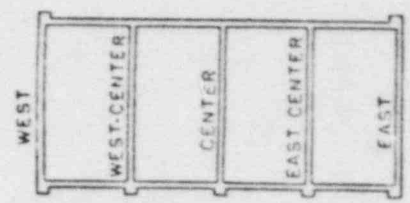
EAST WALL - EAST SIDE
LOOKING WEST



EAST CENTER WALL - EAST SIDE
LOOKING WEST



CENTER WALL - EAST SIDE
LOOKING WEST



DIESEL GENERATOR BLDG
KEY PLAN

NOTES

1. IN GENERAL ALL CRACKS MAPPED IN DEC 1978 WERE HAIRLINE. SOME CRACKS HAD A THICKNESS OF 28 MILS AS OF 7-7-79.

2. FOR CRACK MAPPING OF WALLS FROM EL. 664'-0" TO EL 681'-6" SEE FIG. 3B-3

3. CRACKS LESS THAN 10 MILLS IN SIZE ARE NOT SHOWN.

FIGURE 3 B - 2

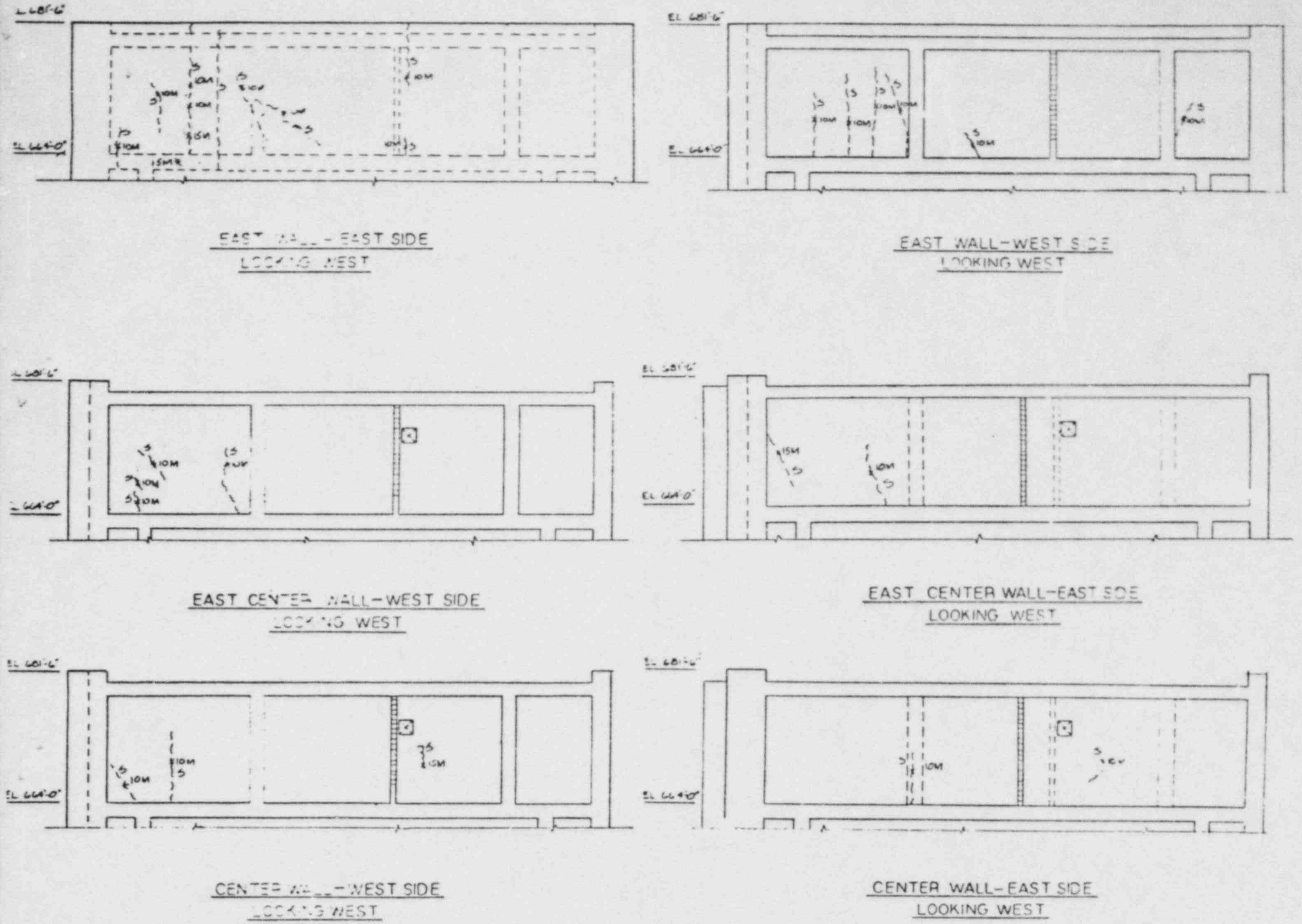
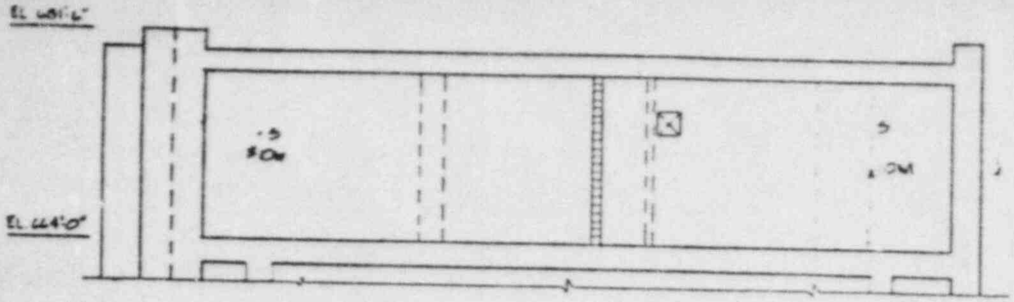
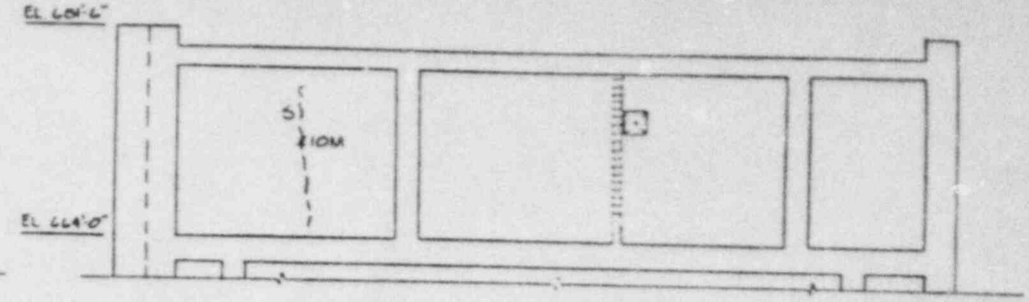

EL 681'-6"
EL 664'-0"
EAST WALL - EAST SIDE
LOOKING WEST
EAST WALL-WEST SIDE
LOOKING WEST
EAST CENTER WALL-WEST SIDE
LOOKING WEST
EAST CENTER WALL-EAST SIDE
LOOKING WEST
CENTER WALL-WEST SIDE
LOOKING WEST
CENTER WALL-EAST SIDE
LOOKING WEST

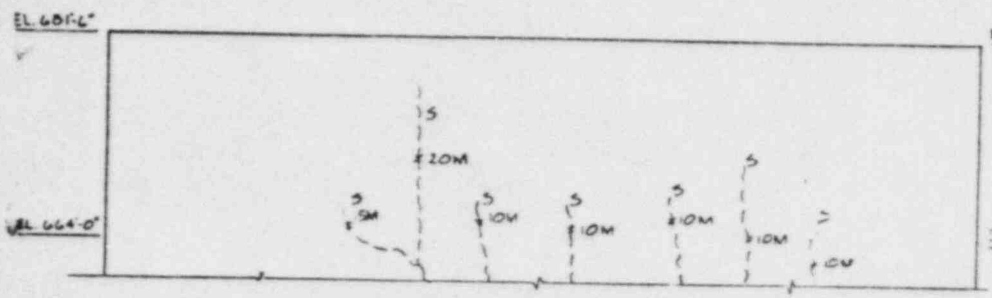
FIGURE 3 B - 3



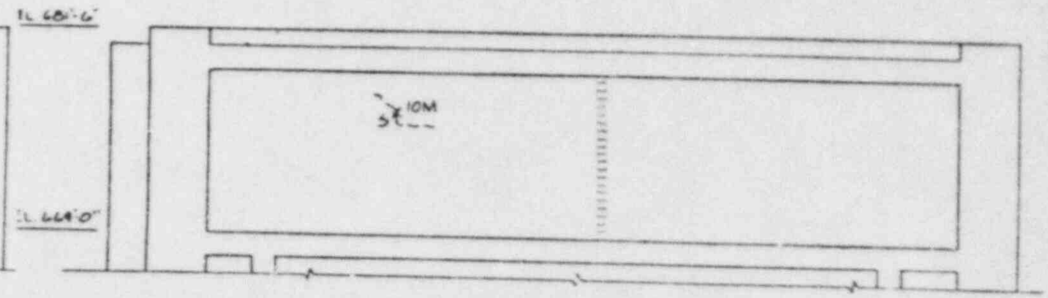
WEST CENTER WALL - EAST SIDE
LOOKING WEST



WEST CENTER WALL - WEST SIDE
LOOKING WEST



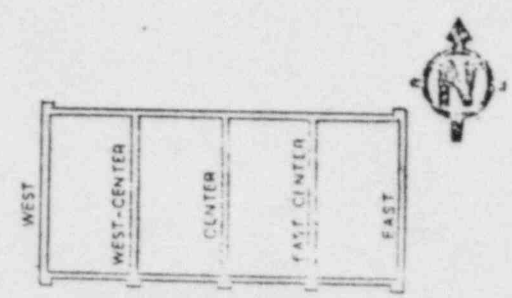
WEST WALL - WEST SIDE
LOOKING WEST



WEST WALL - EAST SIDE
LOOKING WEST

NOTES

1. CRACKS SHOWN WERE MAPPED ON JAN. 1980.
2. SEE FIG 28-2 FOR TYPICAL CONSTRUCTION SEQUENCE.
3. SEE FIG 28-2 FOR CRACK MAPPING OF WALLS FROM [illegible] ON 630'-6" TO 664'-0".
4. SEE FIG 28-2 FOR [illegible] NOTES AND LEGEND



DIESEL GENERATOR BLDG
KEY PLAN

FIGURE 3 3 - 4

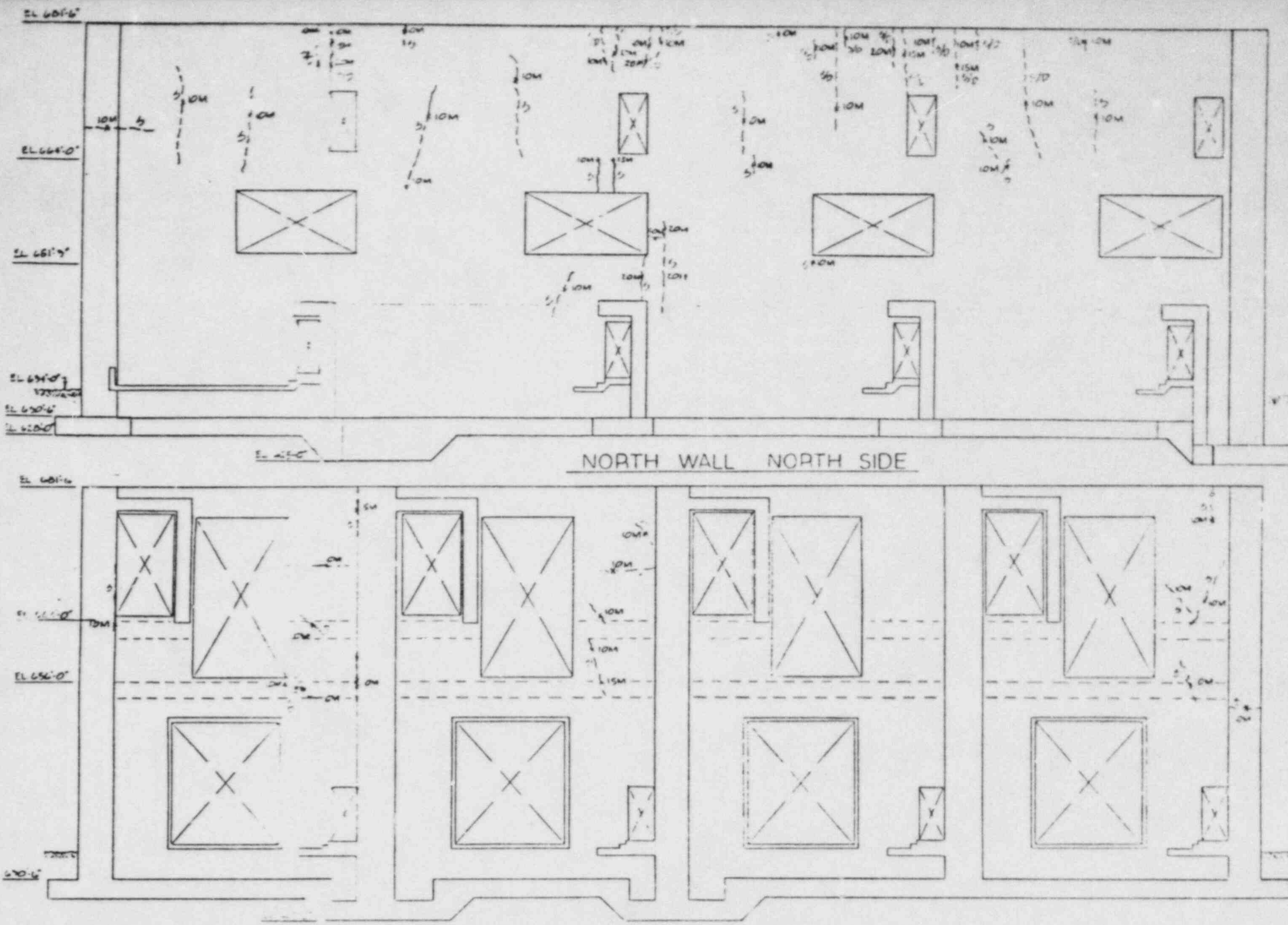


FIGURE 3 B - 5

LOOKING NORTH

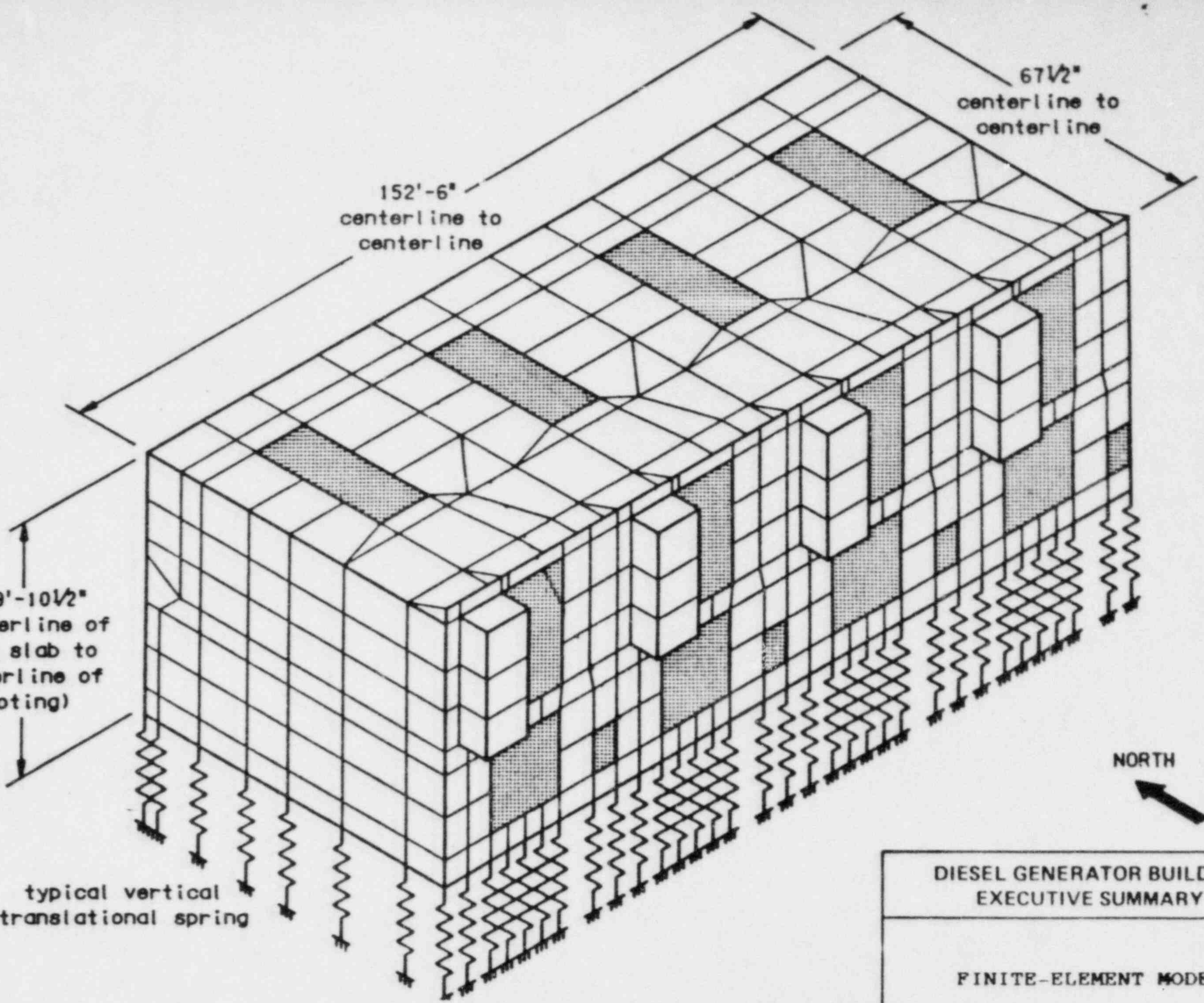


FIGURE 4

DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY
FINITE-ELEMENT MODEL
FIGURE ES-13

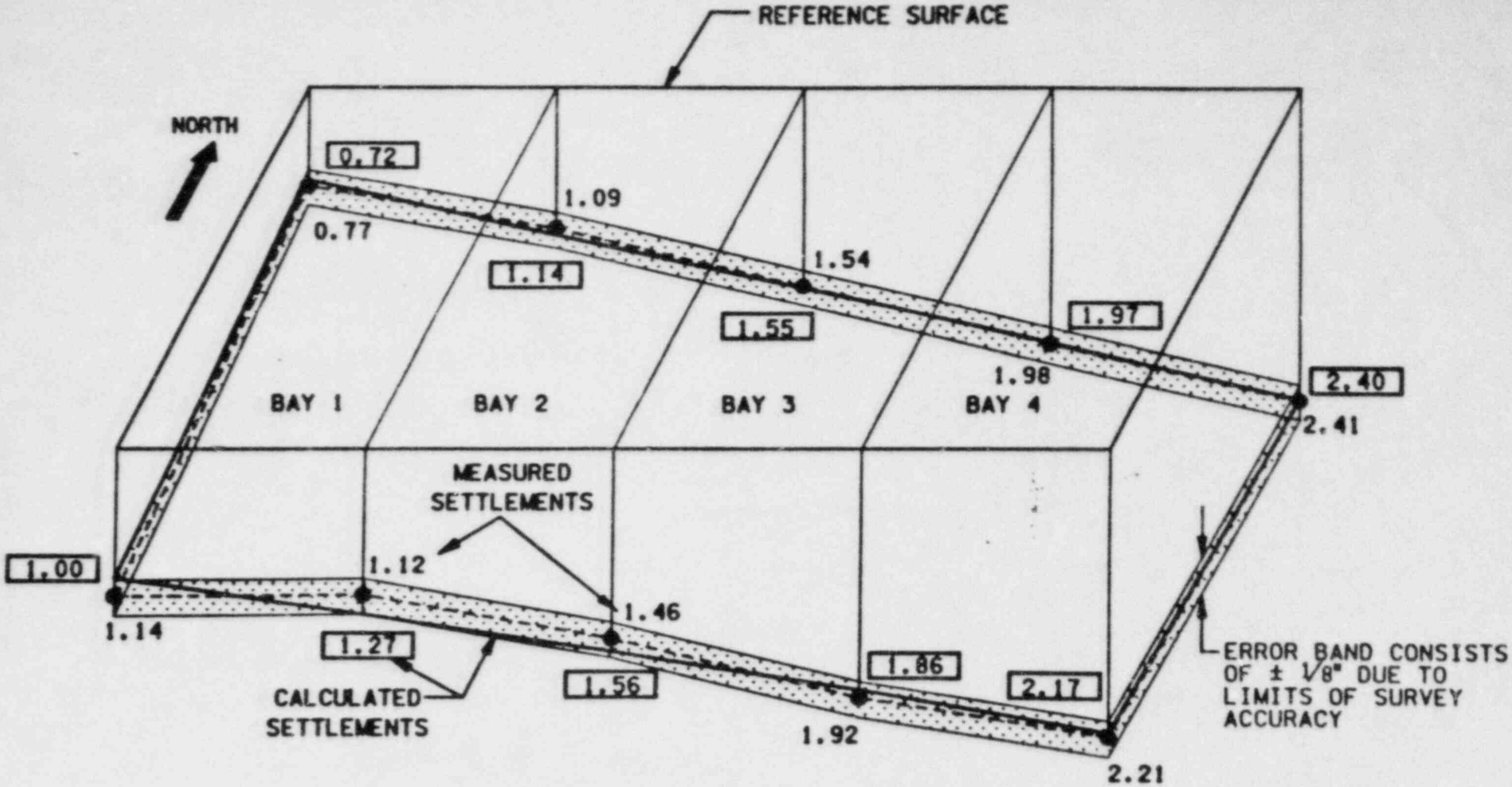


FIGURE 5

DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY
COMPARISON OF SETTLEMENT VALUES PRE-SURCHARGE PERIOD AUGUST 1978 - JANUARY 1979
FIGURE ES-15

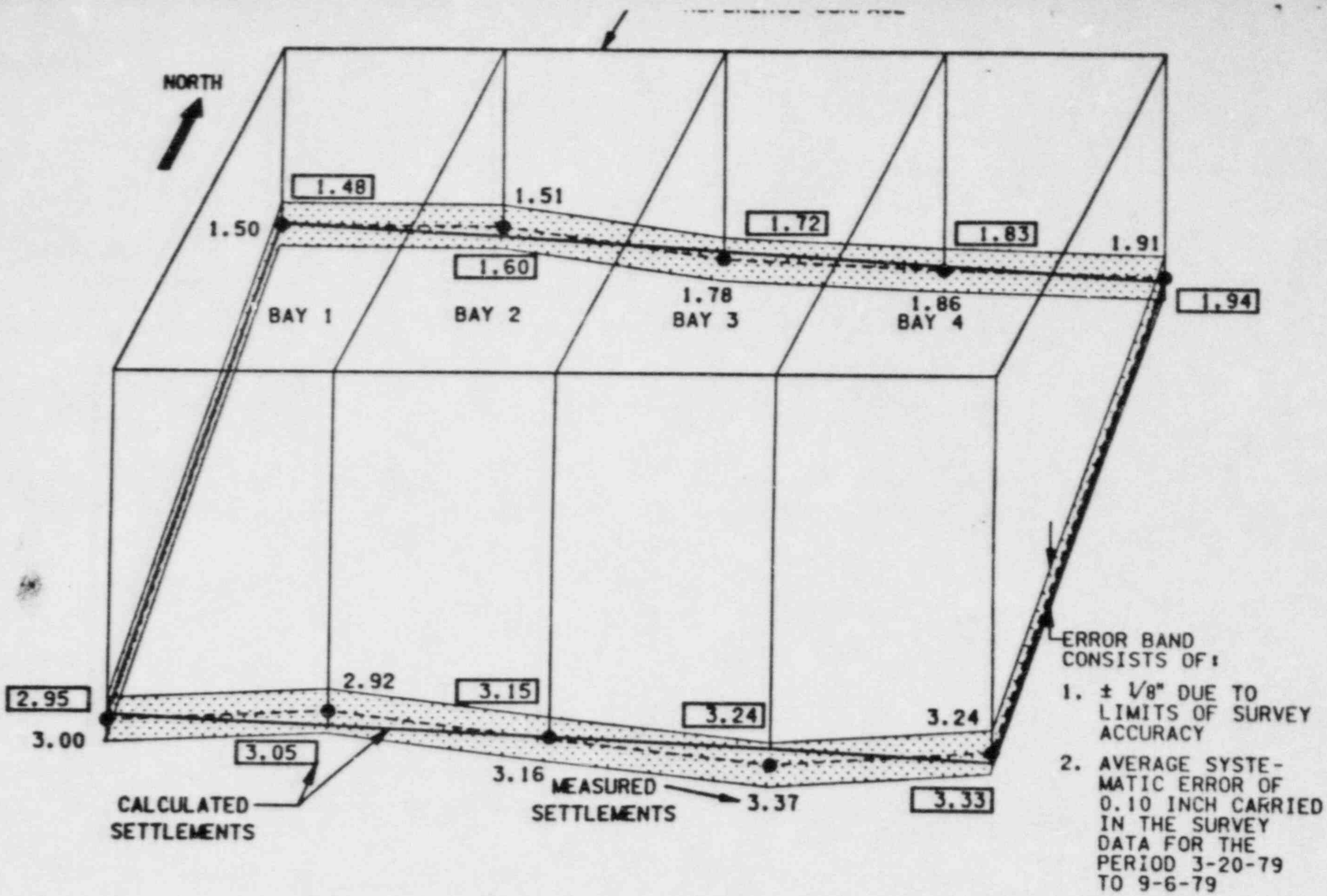
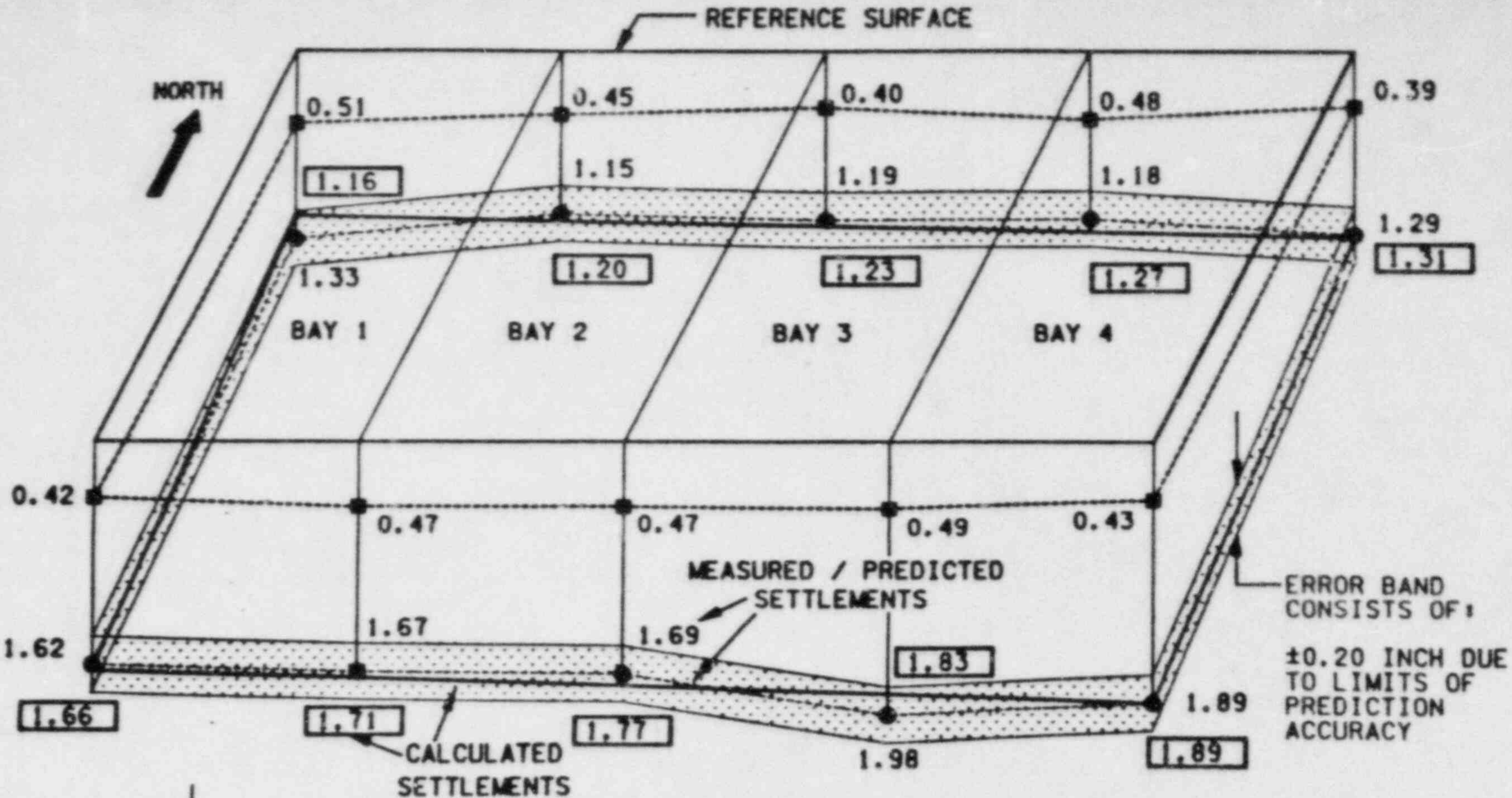


FIGURE 6

DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY

COMPARISON OF SETTLEMENT VALUES
SURCHARGE PERIOD
JANUARY 1979 - AUGUST 1979

FIGURE ES-16



ACTUAL MEASURED SETTLEMENT FROM SEPT.14, 1979 TO DEC.31, 1981. THESE INCLUDE EFFECT OF DEWATERING TO APPROXIMATELY EL. 595', AND REPRESENT MOVEMENT OF THE STRUCTURE DUE TO SETTLEMENT OF THE FILL AND NATURAL SOIL BELOW.

ACTUAL MEASURED SETTLEMENTS FROM SEPT.14, 1979 TO DEC.31, 1981 PLUS ESTIMATED SECONDARY COMPRESSION SETTLEMENT FROM DEC.31, 1981 TO DEC.31, 2025 ASSUMING SURCHARGE REMAINS IN PLACE.

FIGURE 7

DIESEL GENERATOR BUILDING EXECUTIVE SUMMARY
COMPARISON OF SETTLEMENT VALUES POST-SURCHARGE PERIOD SEPTEMBER 1979 - DECEMBER 2025
FIGURE ES-17

APPENDIX I

COMPOSITION OF TASK GROUP

NRC Staff: Task Group Leader	Dr. Pao-Tsin Kuo, Section Leader Structural Engineering Section B Structural and Geotechnical Engineering Branch
	Dr. Chen P.Tan, Structural Engineer Structural Engineering Section B Structural and Geotechnical Engineering Branch
	Mr. Norman D. Romney, Structural Engineer Structural Engineering Section B Structural and Geotechnical Engineering Branch
NRC Consultants:	Dr. A. J. Philippacopoulos, Associate Scientist Structural Analysis Division Brookhaven National Laboratory (BNL)
	Dr. Charles A. Miller, Senior Consultant Structural Analysis Division Brookhaven National Laboratory
	Dr. Carl J. Costantino, Senior Consultant Structural Analysis Division Brookhaven National Laboratory

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

AUG 8 1983

MEMORANDUM FOR: C. P. Tan
Norman Romney
Structural Engineering Section B
Structural and Geotechnical Engineering Branch, DE

THRU: George Lear, Chief
Structural and Geotechnical Engineering Branch, DE GL 8/5/83

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

SUBJECT: EVALUATION OF LANDSMAN'S CONCERNS REGARDING DIESEL GENERATOR BUILDING AT MIDLAND

Reference: Memorandum from R. H. Vollmer to D. G. Eisenhut, dated July 21, 1983

Per the enclosed memo from R. H. Vollmer to D. Eisenhut, a task group to re-evaluate the structural design and construction adequacy of the Midland Diesel Generator Building has been formed and I have been designated as the leader of the group. You are assigned as members of this group. The mission of the group is described in the enclosure.

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

Enclosure: As stated

cc: w/o enclosure
R. H. Vollmer
J. P. Knight
G. Lear

Dupe ~~8308150338~~ XA

ENCLOSURE

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

JUL 2 1 1983

MEMORANDUM FOR: Darrell G. Eisenhut, Director
Division of Licensing

FROM: Richard H. Vollmer, Director
Division of Engineering

SUBJECT: EVALUATION OF LANDSMAN'S CONCERNS REGARDING DIESEL GENERATOR BUILDING AT MIDLAND

Responding to your memorandum, subject as above dated June 27, 1983, J. Knight, Assistant Director for Components & Structures Engineering, has formed a task group to re-evaluate the structural design and construction adequacy of the Midland Diesel Generator Building. The group, headed by Dr. P. T. Kuo, will review the design review documents and the construction reports; physically inspect the building; search out and interview concerned individuals, including Mr. Landsman; and prepare a final report on the adequacy of the Midland NPP Diesel Generator Building. The particulars of the groups' composition and charter are developed in more detail in the attached document. Note that we intend to use a consultant in a capacity to critique our findings on Mr. Landsman's concerns. The consultant's views will be provided in our report.

Richard H. Vollmer, Director
Division of Engineering

cc: H. Denton
J. Knight
J. Keppler
T. Novak
E. Adensam
G. Lear
P. Kuo
F. Rinaldi
D. Hood

Dupe ~~8307290161~~XA

IMPLEMENTATION CONCEPT

REVIEW OF THE MIDLAND NPP

DIESEL GENERATOR BUILDING

1. MISSION

A review will be conducted as to the structural adequacy of the Midland NPP diesel generator building. All information available from NRC regional inspectors in this matter will be obtained and the impact of that information will be fully considered in the review.

2. BACKGROUND

The NRC structural engineering staff (headquarters) has reviewed the Midland NPP diesel generator building's engineering design and construction and has indicated that the building is structurally adequate to resist its design loads. However, during hearings before a NRC Congressional Oversite Committee, the structural adequacy of the Midland NPP diesel generator building was questioned by an NRC employee, Mr. Ross Landsman, a Region III site inspector for the Midland project. It is considered prudent that a review be undertaken by a technical group to assure that Mr. Landsman's concerns are fully heard and carefully evaluated so that the adequacy of the diesel generator building may be further assured.

3. ORGANIZATION

The review group is composed of four technical members -

a group leader, two team members from the structural review staff and a structural consultant. The consultant will be asked to provide his critique of Landsman's concerns and our findings directly into the final report.

4. SUPPORT

The NRC structural review staff will provide the background technical studies, reports, and other review materials that formed the basis for their review and technical conclusions. The NRC project staff for the Midland NPP will provide general administrative arrangements to facilitate the review. Region III will provide a complete listing of Mr. Landsman's concerns.

5. SCOPE OF EFFORT

The efforts of the review group may include but will not be limited to 1) review of all pertinent technical materials, 2) on-site inspection of the diesel generator building, 3) on-site interviews with all inspection personnel that have information to contribute and 4) preparation of a technical report summarizing their activities, considerations and findings. The report will include, as a separate attachment, the opinion of the consultant group member.

6. TIMING

Review activities should be completed NLT 30 working days after receipt of a written statement of Mr. Landsman's concerns and the final report will be due to the Director, DE NLT 15 working days after completion of the review.

7. DESIRED PRODUCT

The desired final report of the review is a report that discusses each of Mr. Landsman's concerns, as well as any other concerns that might be offered during the review, and provide a basis for acceptance or rejection of each concern. A technical review of the adequacy of the diesel generator building should then be presented that is reflective of the groups' final recommendations in this matter in light of new information furnished by Mr. Landsman and others.

APPENDIX II

SUMMARY OF MEETINGS

August Meeting with Applicant and Site Visit

On August 24, 1983 members of the Task Group met with Bechtel and Consumers Power Co. staff in the Bechtel, Ann Arbor, Michigan offices. At this meeting, presentations were made by the applicant and their consultants to provide background on the history of the DGB construction original design philosophy and the analyses done to demonstrate the adequacy of the structure following settlement.

On the evening of August 24 and during the morning of August 25, 1983 the members of the Task Group visited the Midland site to observe the DGB. The Task Group members observed the cracks in the DGB and held discussions with construction personnel to determine the sequence of concrete placement during construction of the DGB. At the site crack maps of the DGB were provided by the Applicant.

Task Group Interviews With Original Reviewers

On September 8, 1983 the Task Group met individually with the original NRC staff reviewers responsible for the Geotechnical and Structural Engineering evaluation of the Midland DGB. The persons interviewed were: Dr. Harry Singh of the U.S. Army Corps of Engineers, Chicago (geotechnical engineering consultant); Mr. Joseph Kane of the Geotechnical Engineering Section, SGEB; Dr. Lyman Heller, Geotechnical Engineering Section Leader, SGEB; Mr. Frank Rinaldi, Structural Engineering Section B, SGEB, Mr. John Matra, Naval Surface Weapons Center, (structural engineering consultant); and Dr. Gunnar Harstead, Harstead Associates (structural engineering consultant. The purpose of the interviews was to gain an understanding and/or clarification of the concerns each reviewer had regarding the Midland DGB.

Dr. Harry Singh was retained by the Geotechnical Engineering Section after discovery of the soils problems existing at the Midland site. Dr. Singh was concerned that the structural analysis of the DGB did not take into account the settlement data as measured. Dr. Singh was concerned with the appropriateness of using crack widths to evaluate rebar stress due to settlement; although he did recommend that the cracks should be monitored as a measure of the DGB's structural adequacy. Generally, Dr. Singh expressed his opinion that the cracks in the DGB were much more extensive than one sees in normal concrete work. Dr. Singh is of the opinion that the DGB is in secondary settlement and that future long term settlement would be about 1-1/4 inches over 30-40 years.

The primary concern of Mr. Joseph Kane involved the Applicant's assumption of a straight line, rigid body motion in the structural evaluation of the effects of settlement on the DGB. Mr. Kane was of the opinion that the settlement values measured by the applicant are appropriate to use in the structural analysis because the building did settle as the soil conditions would have indicated (i.e., nonuniform). Furthermore, Mr. Kane was not concerned about the accuracy of the settlement data because they are the best data available from the Applicant and were more appropriate to use than to assume straight line settlement. With regard to the structural analyses using actual settlement data, Mr. Kane observed 70-80% of the cracks to be in areas where the analyses indicated areas of high stress. Mr. Kane has documented his concerns in memos dated August 2, 1983 and are included in Attachments 1 and 2.

Dr. Lyman Heller met with the Task Group to express his concurrence with the concerns expressed by Mr. Kane. Dr. Heller also offered an explanation as to why cracks were observed in areas where the analyses of the DGB indicated low stresses. The explanation offered was that the settlement of the concrete forms (i.e., yielding) during the pour created discontinuities in the finished concrete which served as preferred paths for the development of cracks.

Dr. Gunnar Harstead, Mr. John Matra and Mr. Frank Rinaldi were interviewed together. Mr. Rinaldi, Mr. Matra and Dr. Harstead maintained that use of the measured settlements would be inappropriate given the accuracy between survey measurements of + or - 1/8". Such inaccuracies in the survey data would result in unrealistic concrete stresses. Mr. Matra discussed the finite element models he prepared and executed for various stages of construction using the settlement measurements as inputs.

He indicated that there was not sufficient settlement data points to make a reasonable stress analysis. To obtain the required input, Mr. Matra stated that he linearly interpolated between the measured settlement data points. As expected there was extremely high stress in areas where no cracks in concrete were observed. Both Dr. Harstead and Mr. Matra mentioned that stresses depended on higher order derivatives. These higher order derivatives cannot be determined accurately from the five measured data points. Mr. Rinaldi indicated the most appropriate method of estimating rebar stresses due to settlement was to estimate stresses from crack widths. This method produced rebar stresses of about 5 ksi which when added to the stresses from the controlling load cases was less than the 54 ksi allowable. Mr. Rinaldi described the crack monitoring program the Applicant agreed to (0.05 /10' as alert limit and 0.06" or 0.020"/10' as action limit). Finally, Mr. Rinaldi and Mr. Matra indicated that the controlling load case for the DGB was tornado depressurization which assumed the DGB to be unvented which is conservative considering the building is vented. Mr. Rinaldi documented his response to Landsman's concerns in a memo in Attachment 3.

Task Group Audit of Design Calculation

The Task Group visited the Bechtel, Ann Arbor, Michigan offices on September 12 and 13, 1983. The purpose of the visit was to conduct an audit of the structural design calculations of the Midland DGB.

On Monday, September 12, 1983 the NRC Task Group reviewed the following DGB calculations:

- concrete/rebar stresses using settlement data by Karl Wiedner;
- straight line (rigid body) settlement by Karl Wiedner;
- concrete/rebar stresses assuming the DGB is supported at four points;
- stress totals from all load combinations;
- finite element modal for DGB.

On Tuesday, September 13, 1983, the NRC Task Group discussed with Dr. Mete Sozen the calculations he did on rebar stresses estimated from concrete crack widths. Dr. Sozen had made calculations estimating rebar stresses from crack widths for the center cross wall only. A call was made to Mr. Rinaldi in Bethesda to verify how he made his calculations on the other walls. Mr. Rinaldi indicated he did the same type of analysis using Dr. Sozen's approach for other walls. However, Mr. Rinaldi did not document the details of his analysis.

Landsman Interview

The Task Group interviewed Dr. Landsman on September 13, 1983 for about 3 hours. Dr. Landsman discussed each of his concerns at length. During the interview, potential resolution of the problem of the DGB cracks was discussed. DR. Landsman agreed that stresses determined from analysis of crack widths would be acceptable, provided that:

(1) these calculations were sufficiently documented; and
(2) an acceptable crack monitoring program was specified and implemented.

A copy of Dr. Landsman's memo of July 19, 1983 documenting his concerns on the Midland Diesel Generator Building is included as Appendix IV.

APPENDIX III

Review of Diesel Generator Building at Midland Plant

by

C.A. Miller and C.J. Costantino

Structural Analysis Division
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, NY 11973

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Dupe

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1.0 INTRODUCTION

This report describes a study undertaken by Brookhaven National Laboratory (BNL) to evaluate the extent to which settlement cracks observed in the Diesel Generator Building (DGB) at the Midland Nuclear Power Plant impact on the ability of the building to satisfy design requirements. Dr. R.B Landsman, of Region III, has raised questions regarding this safety issue (Ref. 1). The specific objective of this study is to assess the significance of his comments and to prepare a written response.

This objective was achieved by reviewing the existing pertinent work (published reports, testimony and analytical studies), and by interviewing key personnel so that a correct interpretation of the work performed could be made. Additional calculations were specifically omitted from the scope of this study. All of the conclusions drawn in this report are based on an assessment of calculations and studies performed by others.

The study described herein was carried out during the period of August through September 1983. On August 4, a meeting was held at NRC to discuss the problem and to obtain some of the pertinent literature. Some of this literature was carried back to BNL while other documents were mailed to NRC during the following week. Appendix A contains a listing of all reports used during the program. On August 24, a meeting was held at Bechtel Corporation offices in Ann Arbor, Michigan. Presentations were made by Bechtel and Consumers Power staff summarizing the work performed by project personnel to demonstrate the adequacy of the DGB. Their consultant's (Dr. M. Sozen of the University of Illinois and Dr. G. Corley of Construction Technology Laboratories) also discussed their work. An inspection of the DGB was held on the evening of August 24 and during the morning of August 25. At this inspection, the cracks were observed although no new detailed crack maps were made. Discussions were held with construction personnel to determine the sequence of concrete placement.

Further interviews were held at NRC on September 8. Individual interviews were held with Dr. Harry Singh (soils consultant for NRC from the Army Corps of Engineers), Joseph Kane (NRC staff), and Lyman Heller (NRC staff).

A combined interview was also conducted with Frank Rinaldi (NRC staff), John Matra (structural consultant for NRC from Naval Special Weapons Center), and Dr. Gunnar Haarstead (structural consultant for NRC). The purpose c' these interviews was to explore the role each played in the design and analysis of the DGB and to learn of their concerns regarding the adequacy of the DGB.

An audit of the DGB calculations by the task group was held at Bechtel's Ann Arbor offices on September 12 and 13. Dr. Sozen was present on September 13. The following items were reviewed in detail during this audit: numerical models used by Bechtel to calculate stresses in the DGB due to settlement; the magnitude of stresses due to the various load cases; the method of determining stresses from crack data; the accuracy of the survey methods used to monitor settlments; and the concrete pour data. A meeting was held with Dr. Landsman of Region III on September 13, at which time his specific concerns raised in Ref. 1 were discussed.

This report is organized as follows. An evaluation of the literature is presented in Section 2 of the report. Section 3 contains BNL's assessment of the adequacy of the DGB, while specific responses to Dr. Landsman's concerns are given in Section 4. Conclusions are listed in Section 5.

2.0 EVALUATION OF PERTINENT WORK

The material on the DGB which was reviewed during the course of this study is divided into six categories; namely, historical description of the structure and its settelment behavior; developed crack patterns; structural analyses to evaluate settelment stresses; treatment of other loads and stresses; and survey data. The material in each category is described and evaluated in this section of the report.

2.1 History of Structure

The DGB is a reinforced concrete shear wall building consisting of five cross walls connecting a north and south wall. The interior walls are 18" thick while the exterior walls are 30" thick. The structure is 155' by 70' in plan and is 51' high with an intermediate floor slab located 35' above the foundation. Wall footings are located under each of the walls, the footings being 10' wide and 30" deep. The building is founded on about 30' of various fills overlying the natural glacial till.

The fill was placed from 1975 through 1977 with construction of the DGB begun in October 1977. Concrete was placed in 6 lifts as follows:

October	1977	-	to Elev. 630.5 (foundation)
December	1977	-	to Elev. 635.0
March	1978	-	to Elev. 654.0
August	1978	-	to Elev. 662.0
December	1978	-	to Elev. 664.0
February	1979	-	to Elev. 678.3

Within each lift the pours were generally made from east to west. Construction joints occur in the middle of the cross walls and at the west end of each bay for the north and south walls.

Large settlements and cracks in the concrete were noticed while the lift going to Elev. 662 was being poured. Construction was halted while the problem was being studied. It was concluded that the large settlement was due to poor compaction of the fill material. This settlement caused the structure to "hang up" on the duct banks which penetrate the footings on the cross walls. The duct banks were cut loose from the DGB foundation in November 1978 and construction of the building restarted. In January 1979, 20' of sand surcharge was placed on the site to consolidate the fill. This remained in place until August 1979. In September 1980, a permanent dewatering system was installed to maintain the water table below Elev. 610.

2.2 Settlement History

The DGB is founded on approximately 30' of fill material, underlain by a very stiff glacial till about 190 feet thick. A dense sand layer about 140' thick lies below the till, which is in turn underlain by bedrock. The majority of the fill was placed at the site between 1975 and 1977, with actual foundation construction completed by January 1978. During July 1978, settlements of the order of 3.5 inches (Ref. 7) were noted which were greater than the original 40 year predicted settlements. Apparently consolidation of the fill was taking place as structural dead loads were applied. In addition, the four electrical duct banks under the structural crosswalls were acting as hard points to the foundation since they were in turn being supported by the stiff natural soils below the fill. This caused rotation of the building about the duct banks.

Construction was halted during August 1978, a soil boring program undertaken to determine the problem with the fill and Drs. R.B. Peck and A.J. Hendron retained to advise on the remedial action. The exploratory program consisted of 32 borings (with no undisturbed sampling) and 14 Dutch cone penetrometers. These confirmed that the fill had been improperly placed (in an extremely variable density state) and consisted of varying amounts of cohesive as well as granular backfill. Lean concrete was also encountered in the backfill. The thickness of silty clay backfill was found to be greater under the south-east side of the building leading to the generally larger settlements on this side.

A surcharge program was implemented to attempt to consolidate the fill more uniformly. In addition, the duct banks were cut loose from the foundation in November 1978 to eliminate the foundation hard points. Surcharging began in January 1979 and remained in place until August 1979, when it was determined that primary consolidation had been completed. Instrumentation (primarily settlement plates and Borros anchors) placed in the fill was used to arrive at this conclusion. It should be noted that the consolidation test results, obtained from undisturbed samples taken after completion of the surcharge program, did not confirm this conclusion. Data was sufficiently scattered to indicate that the fill may not be uniformly consolidated. Unfortunately, the boring program conducted after the surcharge program was completed, did not include cone penetrometer soundings for comparison with the readings taken before the surcharge was applied.

At the completion of the surcharge program, it was decided that since loose sands still existed in the fill, a permanent dewatering system would be installed to preclude the potential for soil liquefaction during a seismic event. This dewatering caused additional settlements to be developed at the site, but apparently these were related to deep seated consolidation of the natural soils under the fill, and would be more uniform than the settlements caused by the fill consolidation.

It is questionable whether the piezometer data was of any significance in analyzing the excess pore pressure condition developed in the fill during the consolidation process. The readings indicate generally very low pore pressures, about 1/20 the magnitude of the applied surcharge pressures. It is not clear in fact whether the fill was ever fully saturated at the time of the surcharge program.

Peak settlements anticipated at the end of 2025 (actual settlements to date plus secondary settlements from now till then) are specified in Ref. 7 to vary from 4.79 inches (under the NW corner) to 9.33 inches (under the SE corner). However, it should be mentioned that the exact settlement history at the various settlement markers at the DGB is open to question. For example, it is mentioned in Ref. 7 that the maximum settlements in August 1978 were about 3.5 inches. Yet the data used in the stress analyses for the presurcharge period (Figures ES-14 of Ref. 7) indicates peak settlements of only 1.99 inches. It was stated at one of the Bechtel presentations that prior to cutting the duct banks loose from the footing, footings along the North wall actually lifted off from the soil, with the DGB rotating about the duct banks. There is no indication of this behavior in any of the settlement data used in the computations. Ref. 8 lists the settlement increment from 8/79 to 12/2025 to be 2.36 inches under the SE corner of the building. For the same period Ref. 7 lists this data as 1.89 inches. Thus some inconsistencies appear to exist in the various documents.

2.3 Crack Patterns

After it was determined that settlement was a problem, Bechtel initiated a program to monitor cracks in the structure. In general cracks were visually observed and an optical comparator used to determine crack width. Crack widths greater than 10 mils were of specific interest as this corresponds to reinforcing stresses of about 10 ksi. Crack maps were prepared based on surveys conducted during December 1978, September 1979, February 1980 and July 1981. Dr. Corely observed the cracking in January 1982 (Ref. 6) and confirmed that the general pattern of cracks agreed with the July 1981 Bechtel crack maps. He prepared a detailed crack map for the center interior wall. A comparison of this center wall map (Fig. 4.21 of Ref. 6) with that prepared by Bechtel in July 1981 (Fig. 4.17) indicates that more cracking had occurred although the widths of the cracks appear to be about the same.

Cracks were observed during the BNL inspection of the plant on August 25, 1983 and some photographs taken. In general the pattern of cracks appears to be similar to the previously mapped cracks. However cracks, which had not been shown on any of the Bechtel cracks maps, were noted in both the north and south walls. These additional cracks are in the lower level (up to Elev. 664) and run at 45 degree angles to the horizontal up to the cross walls.

The first crack maps prepared from the December 1978 survey indicate vertical cracks in the cross walls which begin near the bottom of the wall and run up to Elev. 664 (this was the top of the concrete pour at the time the settlement problem was first noticed). The pattern of cracking is more severe in the east side of the building. This crack pattern is compatible with the model that assumes the cracks result from flexural stresses caused by the building "hanging up on the duct banks". No crack maps were prepared for the north or south walls.

Th second set of crack maps were prepared from the September 1979 survey. In general, many of the cracks which occurred in the east wall prior to placing the surcharge do not appear on these maps. The east center and center walls show the same type of crack patterns as shown on the first crack maps except for the appearance of additional cracks. These maps also show cracks in the upper level of the building. These cracks occur near the south side of the building in the cross walls. The cracks tend to be vertical with some inclination of the cracks near the south wall. Some cracks are indicated in these maps for the south wall. Primary cracking occurs in the east side of the wall and are concentrated in the upper portion of the wall. The north wall is shown to be more severely cracked than the south wall and contains mostly vertical cracks in the upper part of the wall. The cracks appear to be centered about the three interior walls.

The third set of crack maps were prepared from the July 1981 survey. These maps indicate the same type of cracking as before although the cross wall now contain more cracking near the north side of the building than was evident before. The west wall contains many more cracks than were shown previously. These cracks run from the Elev. 664 level down to the base of the structure.

It appears that many of the cracks which have occurred may be attributed to the building resting on the duct banks. Other cracks have occurred, however, which were most likely caused by differential settlement of the wall footings. Comparison of successive crack observations generally indicates that more cracks are occurring, but that the maximum size of the cracks is still about 20 mils.

2.4 Structural Analyses

The various analyses which have been used to evaluate stresses in the DGB are discussed in this section. The first analysis described is the method used by Bechtel to estimate stresses due to settlement for use in its load combination study. This analysis makes use of the straight line approximations to the profiles of the settlements of the north and south walls. The second and third analyses described are the Bechtel and Matra studies, which attempt to use the actual measured settlements to estimate settlement stresses. These analyses, though different in detail, lead to the similar conclusion that the settlement measurements were (and continue to be) in significant error. The fourth analysis describes a cruder model which attempts to approximate an upper bound to settlement stresses by looking at the crack measurements. The first three analyses are bas d on detailed finite element models, while the fourth is based on crack patterns and crack widths.

2.4.1 Bechtel's Computation of Settlement Stresses (Ref. 2)

Since the building settlements occurred when the structure was in various stages of construction, the settlement stresses were evaluated for four different time periods. The first period spans from the beginning of construction through August 1978 at which time construction was halted. The second time period extends from August 1978 to January 1979 during which the duct banks were cut loose from the structure and construction resumed. The third time period extends from January 1979 to August 1979 during which time the surcharge was placed. The last time period extends to the year 2025 and includes measured settlements from August 1979 to December 1981 as well as the predicted settlements over the forty year life of the structure.

The actual measured settlements were used to calculate stresses for the first period. Stresses were calculated in each of the walls by determining the arc of a circle which fit any three adjacent measured displacements. The radius of the arc was then used to find the resulting bending moment in the wall, and the moment used to calculate stress. The maximum stress in each of the walls was assumed to exist over the entire wall. The stress in the south wall was 11.3 ksi; the east wall 6.6 ksi; and all other walls 2 ksi.

The increments in stress which occurred during each of the other three time periods were evaluated using a finite element model of the DGB. This model was constructed and run on the Bechtel version of SAP (BSAP). The building was defined with 853 nodal points. Plate elements were used to model the walls, and beam elements used for the footings. Eighty-four (84) boundary elements were used to model the vertical soil stiffness (equivalent to the coefficient of subgrade reaction). An iterative process was then used to determine the stiffness of these boundary elements. A best fit straight line was first fit through the measured settlements for the north wall and another straight line fit to the data for the south wall. It was shown that the measured displacements departure from the best fit straight lines is within the tolerance of the survey data. Dead load reactions were next estimated at each of the 84 boundary elements. The stiffness of any soil element was then determined as the ratio of the dead load reaction to the displacement of the best fit straight line. The BSAP program was run and the reaction found at each of these boundary elements. A new stiffness was then calculated as the ratio of the reaction to the displacement of the best fit straight line. This process was continued for several iterations.

It is our opinion that this model will yield unconservative estimates of stresses. If the iteration process were successfully completed, the deformation of the north and south walls will be straight lines. The only stresses that would be computed would then occur due to racking of the structure caused by the difference in the north and south wall straight lnes. It should be clear that if a best fit plane could be passed through all the settlement points under both the north and south walls, no stresses would be computed anywhere in the building. The stresses computed by this approach are a function of which iterative cycle is used to define to soil spring parameters, and bears no resemblance to the actual soil conditions at the site. There is no reason to expect that the soil stiffness should vary from point to point as shown by the analyses. We therefore conclude that this approach to compute settlement stresses is inappropriate.

2.4.2 Bechtel's Analysis Using Measured Settlements (Ref. 3)

This analysis was performed using the same finite element model described above. This time however, the known survey displacement data was input to the program at the ten (10) wall intersection points. The settlements used were the displacement increments measured for the fourth time period described above. At the remaining 74 boundary element points, the structure was allowed to deform as required to maintain equilibrium (forces equal zero). It was found that computed stresses were very high in those elements adjacent to the wall intersection, but fall off rapidly away from these points. This indicates that the analysis overly penalizes the structure by imposing large concentrated forces at the wall intersections. In fact, at some points, the soil is required to pull the structure downward to match these known displacements.

A modified analysis was performed by Bechtel at the suggestion of the task group. Rather than input only the ten known displacements, a smoothed curve was generated which matched the known settlement data, but eliminated the sharp profile changes developed in the analysis described above. A best fit polynomial was passed through both the north and south wall settlements, and displacements computed at all boundary element points of the finite element model. Comparative plots of wall profiles indicate that this approach would still yield high stresses.

2.4.3 Matra's Analysis Using Measured Settlements (Ref. 4)

The analysis performed by Matra is similar in intent to that described above. Differences between the two are as follows. First, this finite element analysis was performed for all four time periods described in Section 2.4.1. Three separate finite element models were used to define the DGB at various stages of construction. For each problem analyzed, the known settlement data at the wall intersection points was input to the models. The report does not specifically state what input was used at the remaining boundary element points between the wall intersection. However, at the interview, Matra stated that a linear displacement profile was assumed between these points. The stress results of the analyses are similar to those described above for the Bechtel study, with similar conclusions reached. In fact, it can be anticipated that the Matra stress calculations would be even higher than the corresponding Bechtel results due to the linear assumption between data points. If in fact this was done, the conclusions reached in that report would be of little value since such high bending stresses would be generated at these discontinuities.

2.4.4 Estimation of Stresses from Crack Data (Ref. 5)

Sozen considered the problem of predicting reinforcement stresses from a knowledge of the crack patterns. He observed that the usual problem is to predict crack width based upon a given reinforcement stress. When these methods are applied to the DGB center wall, a 20 ksi steel stress is consistent with a crack width of 20 mils. He also adds the crack widths for a series of cracks in the center wall and equates this to the total elongation in the reinforcement. Using an estimated gage length over which this elongation occurred he obtains an estimated stress of 24 ksi, and indicates a probable range of 20-30 ksi considering the uncertainties of the method. (This was presented by Sozen at the August 24 meeting). It is likely that these stress values would be reduced with time. A major cause of cracking was the hard points provided by the duct banks. When these were cut free, one would expect the stresses induced by the uneven support to be relieved. Creep in the concrete would also tend to relieve the settlement-induced stresses.

Rinaldi (pg. 11086 of the testimony) reported at the interview of September 8, that he calculated stresses using Sozen's method in each of the 5 cross walls, as well as the north and south walls. He then added these stresses to the maximum stress reported in each of the walls by Bechtel. The resultant maximum reinforcement stress was found to be less than 54 ksi (the allowable limit). It was noted that the Bechtel stresses already included settlement stresses (to an unknown degree however) from the analyses described in 2.4.1. The crack-based estimates of settlement stresses were added to the maximum of the Bechtel stresses without regard to where they occurred. While this is a conservative approach, there is no documentation of the computations. It should be noted that there would be some question in the application of this method on those walls where relatively few cracks occurred.

2.5 Stress Totals

The finite element model described in 2.4.1 was used to calculate wall forces from all loadings except for the seismic loading. A lumped mass model was used to determine forces resulting from the seismic loading. These forces were then combined according to the load combinations required in ACI 318 and ACI 349. Critical elements were then identified in each of the walls and Bechtel's program OPTCON used to evaluate reinforcement stresses. OPTCON determines the reinforcement stress resulting from out-of-plane bending moment plus in-plane shear loading. The shear capacity of the concrete is deducted from the total shear load with the difference assumed to be carried by the reinforcement. The following are peak reinforcement stresses reported by Bechtel for the critical load cases: north wall - 22 ksi; south wall - 34 ksi; west wall - 29 ksi; east wall - 23 ksi; and interior walls - 20 ksi. The allowable steel streess is 54 ksi.

2.6 Survey Data

Bechtel reports that the accuracy of the survey data describing the DGB settlements is 1/8" until the surcharge was removed and 1/16" since that time. Standard survey techniques and equipment were used.

3.0 ASSESSMENT OF THE DIESEL GENERATOR BUILDING

The DGB has undergone very large settlements which have undoubtedly caused serious structural distress. This distress is manifested in the cracks which have occurred in the building. The purpose of this section of the report is to give an opinion as to (1) whether the building is structurally sound and (2) whether the building still meets the criteria as stated in the FSAR.

An important issue is whether the major part of the settlement has occurred. The settlement data indicate that settlements are well into the secondary consolidation phase so that large additional settlements would not be anticipated. This leads to confidence that predictions of the adequacy of the structure based on settlements which have taken place to date should hold for the life of the structure. Certainly settlements should be monitored and the problem reconsidered should more than the anticpated additional settlements occur. Relative settlements of points on the structure of .005" are significant. The accuracy of the settlement measurements should be refined to reflect this requirement.

While significant cracking has occurred in the structure, it would appear that there is little evidence to indicate that the structure is unsound. The structure is very massive and is not subjected to large loadings. Even the tornado and seismic loadings do not introduce large stresses and usually these stresses occur at locations that are not critical locations for the settlement stresses.

It is difficult to show that the stresses in the DGB meet the criteria of the FSAR. Bechtel's straight line analysis (see 2.4.1) is based on the claim that the settlement survey data is not sufficiently accurate to calculate structural stresses. The adjustment they make to account for this inaccuracy gives results that are likely unconservative. If conservative assumptions are made then the calculated stresses are too large to satisfy the criteria and not consistent with the crack patterns observed in the structure (see 2.4.2). It is doubtful whether any analysis could now be developed which would provide more realistic estimates of settlement stresses with the required degree of confidence.

The most likely source for obtaining reasonable estimates of settlement stresses are the crack studies (see 2.4.4). However, these studies must be documented much more completely than has been done to date. It is imperative that significantly better methods be used to monitor crack growth than is currently being considered. Whitemore strain gages should be used extensively. Plugs are attached to the concrete on a 2" gage. An instrument is then used to measure the distance between the plugs. Accuracies of .0001" is routine. Such gages would give a good picture of the overall behavior of the cracks. It should be noted that the repair of cracks would not interfere with the use of these instruments. No special "windows" need to be maintained during the crack repair program. This program of crack monitoring is also important because there is some indication that cracks in the DGB have not stabilized and that the number of cracks may in fact be increasing.

4.0 RESPONSE TO CONCERNS OF R.B. LANDSMAN

The Region III inspector has raised four concerns (Ref. 1) regarding the adequacy of the DGB. Each of these is addressed in the following.

Concern 1: FINITE ELEMENT ANALYSIS

The first concern deals with the Bechtel finite element models (see 2.4.1 and 2.4.2) of the DGB used to evaluate stresses due to settlement. There are four objections made to the models.

Concern is raised with regard to the use of uncracked section properties while the concrete is known to be cracked. All concrete structures are cracked and it is standard practice (specifically permitted in the ACI code) to determine forces in concrete structures based on gross section properties (i.e., neglect the cracks in the concrete and the reinforcement). If cracked section properties were used then the stresses calculated by Bechtel (2.4.1) would have been smaller. Therefore neglecting cracks in this analysis is a conservative approximation. On the other hand, the analysis reported in 2.4.2 was used to show that the measured settlements result in stresses which are so high that much more severe cracking would be expected than was observed. It was then argued that the measured values must be in error. If cracked sections were assumed for this analysis the calculated stresses would have been smaller, but probably still not consistent with the observed crack patterns.

The straight line representation of the settlements along the north and south wall for the analysis reported in 2.4.1 is said to be in error. As indicated in that section of this report, it is our opinion that this analysis will result in unconservative predictions of stresses due to settlements. As such, it is considered to be an inappropriate analysis.

The third part of this concern raises questions regarding the time effects of the settlements. Bechtel does calculate stresses for different phases of the settlement. The structure was changing during the significant settlement period. Construction was still in progress during the largest settlements. Therefore the structural geometry changed as did the concrete properties (while maturing). The Bechtel models did not account for these changes. This would have been conservative for the calculation of stresses, but would result in lower stresses in the analyses performed using the measured settlements as input.

The fourth objection deals with the claim that the NRC staff did not approve of the Bechtel analysis. It appears that this is the case and the intention of the staff was to use settlement stress data based on an analysis of the cracks rather than the finite element analyses.

Concern 2: RELIABILITY OF MEASURED SETTLEMENT VALUES

The analyses reported in 2.4.2 and 2.4.3 were used to show that stresses computed from structural models subjected to the measured settlements are very high and would indicate cracking in the structure where no cracks are observed. The objection is raised that a linear model was used and that a non-linear model accounting for plastic effects would result in a redistribution of stresses and the same conclusion may not apply. This observation is true, but by itself would not change the conclusions drawn from these analyses.

As stated above, however, there are other factors which when coupled with this objection may result in a different conclusion. The other important factors are: the assumed shape of the settlement between the measured points; and the differing geometry of the DGB when the various phases of settlement occurred.

Concern 3: STRESSES DETERMINED FROM CRACK SIZES

If the finite element analyses are not reliable then one alternative approach is to find settlement stresses from a study of the crack sizes. The objection raised is that this approach is not consistent with normal engineering practice and that there are no equations available to evaluate stresses from crack data when the stress fields are as complex as occur in the DGB. It is true that this would not be standard practice, but "non-standard" analyses may be used provided they are sufficiently documented and shown to give results that are conservative.

An approach that could predict approximate settlement stresses in the DGB could probably be used to demonstrate its adequacy. This is true for two reasons. First, stresses in the structure due to other loadings are rather low and there is a large reserve for settlement stresses. Second, if large settlement stresses and local yielding of the reinforcement occurs, the resulting deformations of the structure will reduce the settlement induced loadings.

The documentation of the crack analyses used to determine stresses is not sufficient. There is no calculation on record which calculates stresses in all of the walls using this method. There is also no written justification showing that the method may be used for structures like the DGB.

Concern 4: CRACK MONITORING

This concern deals with the lack of a good crack monitoring system and specification of action to be taken if the cracks exceed certain limits. As stated in Section 3.0, it is our opinion that the planned crack monitoring system is not adequate. More reliable gages (e.g., Whitemore Strain Gages) should be placed in areas where cracking is now evident. These gages can be used even after crack repairs are made.

Two limits are now defined in the current crack monitoring program. If the crack width reaches .05" (Action Limit) a meeting will be held to evaluate what steps to take when the cracks reach the next limit. The next upset limit is set at .06" (Alert Limit). It is our opinion that the form of this plan is adequate, but that the specific threshold numbers must be based on a resolution of the current settlement stresses. A safety margin must be left for the other potential loading events, such as tornado or seismic loads, with the remaining allowable stress allocated to future potential settelments.

Once this limit was reached the only solution would be to make a structural repair. The exact form of this repair would depend on the location and extent of the crack which exceeded the limit. The planned response could not specify the nature of the repair, but could indicate that an exceedance of the Alert Limit would result in a structural repair rather than performing additional analyses.

5.0 CONCLUSIONS

Based on the review of the studies performed to demonstrate the adequacy of the DGB, the following conclusions are drawn:

1. The settlement data indicates that primary consolidation of the fill is completed. However, it is recommended that the anomolies in the documentation of the settlement history be resolved. (See last paragraph of Section 2.2).

2. It is unlikely that a satisfactory stress analysis can be performed based on the measured settlement data. It is recommended that settlement stresses be estimated from the crack width data. The existing work that has been done in this area must be completely documented.

3. It appears that the number of cracks in the DGB are continuing to increase. It is essential that a better crack monitoring program be established as outlined in Section 3.0.

4. The upset crack width levels specified in the crack monitoring program should be chosen so that a sufficient stress margin is available to resist the critical load combinations.

5. If the Alert Limit (in crack width) were exceeded, specific structural repairs should be mandated.

6. While significant cracking has occurred in the DGB, it is our opinion that the structure will continue to fulfill its functional requirement. This conclusion is based on the fact that stresses induced in the structure by all other extreme loadings are small.

REFERENCES

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2. Bechtel Calculation No. DQ-52.0 (Q), Rev. 2.

3. Bechtel Calculation No. DQ-52.7 (Q) - Finite Element Calculation of Settlement Stresses Using Actual Displacements.

4. Structural Reanalysis of Diesel Generator Building Utilizing Actual Measured Deflections as Load Input, by John Matra, Naval Surface Weapons Center.

5. Evaluation of the Effect on Structural Strength of Cracks in the Walls of the Diesel Generator Building Midland Plant Units 1 and 2, by Mete Sosen, February 11, 1982.

6. Effects of Cracks on Serviceability of Structures at Midland Plant, by W.G. Corely, A.E. Fiorato, and D.C. Stark, April 19, 1982.

7. Executive Summary, Diesel Generator Building, Midland Plants Units 1 and 2, August 1983.

8. Letter from CPCo to NRR dated October 21, 1981; Enclosure 1, Tech. Report, Structural Stresses Induced by Differential Settlement of the DGB.

APPENDIX A: SOURCE MATERIAL FOR STUDY

<u>Site Specific Response Spectra</u> Midland Plant Units 1 & 2
Addendum to Part 1
Response Spectra--Orginal Ground Surface
Jan 81 Weston Geophysical Corp

<u>Site Specific Response Spectra</u> Midland Plant Units 1 & 2 Part II
Response Spectra Applicable for the top of fill material at the plant site
April 81 Weston Geophysical Corp

<u>Site Specific Response Spectra</u> Midland Plant Units 1 & 2 Part III
Seismic Hazard Analysis
Feb 81 Weston Geophysical Corp

<u>Soil Boring and Testing Program</u> Midland Plant Units 1 & 2
Test Results Foundation Soils
Auxiliary Building
Woodward-Clyde Consultants Aug 81
Docket Nos. 50-329,50-330

<u>Test Results</u> Perimeter and Baffle Dike Areas Soil Boring and Testing Program
Volume II Supporting Data July 81
Docket Nos. 50-329,50-330

<u>Test Results</u> Perimeter and Baffle Dike Areas Soil Boring and Testing Program
Volume I
Woodward-Clyde Consultants July 81
Docket Nos. 50-329,50,330

<u>Estimates of Maximum Past Consolidation Pressure of Cohesive Fill Materials</u>
Diesel Generator Building
July 81 Woodward-Clyde Consultants
Docket Nos. 50-329,50-330

<u>USA/NRC Before The Atomic Safety and Licensing Board</u> 12/7/82
testimony of; Frank Rinaldi
John Matra
Gunnar Harstead
with respect to the Structural Adequacy of The Diesel Generator Building at Midland

<u>Official Transcript Proceedings Before NRC Atomic Safety and Licensing Board</u>
DKT/CASE No. 50-329,50-330 OL & OM
12/10/82 pages 11008 through 11228

Evaluation Report for Concrete Cracks in the Diesel Generator Building
Consumers Power Company 2/16/82

Evaluation of the Effect on Structural Strength of Cracks in the Walls of the Diesel Generator Building Mete A. Sozen 2/11/82

Relationship of Observed Concrete Crack Widths and Spacing to Reinforcement Residual Stresses Consumers Power Company 6/14/82

Observed Cracks in Walls of Midland Plant Structures 6/14/82
Corley and Fiorato
Portland Cement Association

Safety Evaluation Report related to the operation of Midland Plant
Docket Nos. 50-329 and 50-330
Consumers Power Company
USNRC 5/82

Effects of Cracks on Serviceability of Concrete Structures and Repair of Cracks
Consumers Power Company 4/30/82

Effects of Cracks on Serviceability of Structures at Midland Plant
Corley, Fiorato, Stark
Portland Cement Association

Summary of Sept. 8, 1981 Meeting on Seismic Input Parameters Midland Plant
USNRC 12/3/81

USA/NRC Before the Atomic Safety and Licensing Board 50-329,50-330
testimony of Jeffrey K. Kimball 9/29/81

NRC Atomic Safety and Licensing Board 50-329 OM,OL 50-330 OM,OL
witnesses; Johnson
Burke
Corley
Sozen
Gould

NRC Before the Atomic Safety and Licensing Board (no date)
NRC staff testimony of Joseph Kane
on Stamiris Contention 4.B
Docket Nos. 50-329 OM,OL 50-330 OM,OL

Safety Evaluation Report related to the operation of Midland Plant October 82
Docket Nos. 50-329 50-330
USNRC NUREG-0793 Supplement No. 2

Safety Evaluation Report related to the operation of Midland Plant June 82
Docket Nos. 50-329 50-330
USNRC NUREG-0793 Supplement No. 1

NRC Atomic Safety and Licensing Board 9/29/81

Applicant's Brief on Compatibility
of Site Specific Response Spectra
Approach with 10 CRF part 100 Appendix A

Safety Evaluation Report related to the operation of Midland Plant May 82

Docket Nos. 50-329 50-330
NUREG-0793

Response to the NRC Staff request for Settlement Related Analyses for the Diesel Generator Building 6/1/82

Consumers

Technical Report Structural Stresses Induced by Differential Settlement of the Diesel Gererator Building

Consumers Power Company

Test Results of Soil Boring and Testing Program for Diesel Generator Building

Docket Nos. 50-329 50-330 7/31/81
Consumers Power Company

Final Results of Soil Boring and Testing Program for Perimeter and Baffle Dike Areas 7/27/81

Docket Nos. 50-329 50-330
Consumers Power Company

NRC Atomic Safety and Licensing Board Docket Nos. 50-329 OM,OM 50-330 OM,OL

Witnesses; Hood 12/3/81
Kane
Singh
Rinaldi

NRC Atomic Safety and Licensing Board Docket Nos. 50-329 OM,OL 50-330 OM,OL

Witnesses; Kennedy 2/17/82
Campbell
Kane
Hood
Singh
Rinaldi
Matra

CSE Input to the Midland SER Supplement Aug. 82

Geotechnical, structural, mechanical and hydrologic inputs for the Midland Ser Supplement

Transcript of Proceedings USA/NRC 1/6/81

Deposition of Frank Rinaldi

Transcript of Proceedings USA/NRC 1/9/81

Deposition of Pao C. Huang

Transcript of Proceedings USA/NRC Docket Nos. 50-329 OM, OL 50-330 OM,OL

Deposition of John P. Matra 1/7/81

USA/NRC Before the Atomic Safety and Licensing Board Docket Nos. 50-329 OM-OL
50-330 OM-OL

NRC Staff Brief in Support of the use of a Site Specific Response Spectra to comply with the Requirements if 10 CFR Part 100, Appendix A 9/29/81

USA/NRC Before the Atomic Safety and Licensing Board Docket Nos. 50-329 OM-OL
50-330 OM-OL

Testimony of Dr. Paul F. Hadala with Respect to the Study of Amplication of Earthquake Induced Ground Motions and the Stability of the Cooling Pond Dike Slopes Under Earthquake Loading 9/29/81

USA/NRC Before the Atomic Safety and Licensing Board Docket Nos. 50-329 OM,OL
50-330 OM,OL

Witnesses; Boos
Hendron
Hanson

Testimony of Ralph B. Peck before the Atomic Safety and Licensing Board, in the the matter of Consumers Power Company (Midland Plant, Units 1 and 2), Docket Nos. 50-329 OM, 50-330 OM, 50-329 OL, 50-330 OL, notarized Nov. 3, 1982.

Letter from CPCo to H.R. Denton dated June 14, 1982 with Enclosure "Response to the NRC Staff Request for Additional Information Required for Completion of Staff Review of Soils Remedial Workd dated June 14, 1982.

Summary of August 17, 1982 Meeting on Soils-Related Construction Release, dated September 7, 1982, by Darl Hood.

"Structural Reanalysis of Diesel Generator Building Utilizing Actual Measured Deflections as Input", by John Matra.

Letter from CPCo to H.R. Denton dated October 21, 1981 with Enclosures:
"Structural Stresses Induced by Differential Settlement of DGB",
"Subgrade Modulus & Spring Constant Values for DGB Structural Analysis",
"Bearing Capacity Evaluation of DGB Foundation"
"Logterm Monitoring of Settlement for DGB",
"Relative Density and Shakedown Settelment of Sand under DGB",
"Estimates fo Relative Density of granular Fill Materials, DGB",
"Review and Control of Facility Chagnes to DGB",
"DGB Bearing Pressaure due to Equipment and Commodities",

Report form Woodward-Clyde to CPCo dated June 10, 1981, "Preliminary Test Results, Soil Boring & Testing Program, Perimeter and Baffle Dike Areas",

"Seismic Margin Review, Midland Energy Center Project": Volumne 1, Methodology and Criteria, dated February 1983, Volume V, Diesel Generator Building, dated July 1983, prepared for CPCo by Structural Mechanics Associates.

Applicant's Propsed Findings of Facts and Conclusions of Law on Remedial Soils Issue

Docket Nos. 50-329-OM
50-330-OM
50-329-OL
50-330-OL

Testimony of Karl Weidner for the Midland Plant Diesel Generator Building September 8, 1982

Docket Nos. 50-329-OL
50-330-OL
50-329-OM
50-330-OM

Find Report on the ADINA Concrete Cracki-g Analysis for the Diesel Generator Building by Gygna Energy Services, September 16, 1981

ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

JUL 1 8 1983

MEMORANDUM FOR: R. F. Warnick, Director, Office of Special Cases

THRU: J. J. Harrison, Chief, Section 2, Midland

FROM: R. B. Landsman, Reactor Inspector

SUBJECT: DIESEL GENERATOR BUILDING CONCERNS AT MIDLAND

At the recent hearing before Congressman Udall's subcommittee, I expressed my concern regarding the structural adequacy of the diesel generator building because of numerous structural cracks that have occurred throughout the building over the years. I also expressed the same concern during the recent ASLB hearings. Mr. Eisenhut has requested me to document the basis of my concerns about the building so an independent review group can analyze them.

My first concern deals with the finite element analysis that Consumers Power Company (CPCo) used to show that the building is structurally sound. Their model of the building assumed a very rigid structure without any cracks. The building has numerous cracks, reducing the rigidity of the structure. The effects of these cracks have not been taken into account in the analysis. CPCo's interpretation of the settlement data as a straight line approximation always stems from their position that the building is too rigid to deform as indicated by actual settlement readings. The settlement of the building occurred over a period of time during different phases of construction. It is this time dependent effect that was also not used in their model. Even CPCo expert Dr. Corely testified at the ASLB hearings that the analysis should have "taken into account cracking and time dependent effects" in order to give correct results. Finally, the staff's official position, as stated by Dr. Schauer, on CPCo's analysis was, "The staff takes no position with regard to that analysis."

My second concern deals with the acceptance of the diesel generator building in the SSER #2 which was subject to the results of an analysis to be performed by the NRC consultants using the actual settlement values. The consultants testified at the ASLB hearing that this analysis gave unacceptable results and this portion of the SSER should be stricken. They are basing their unacceptable results and comments on their finding of

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very high stresses obtained in areas where no cracks exist. Therefore, the actual settlement values are not accurate enough (are in error) to be used in an analysis. The consultants, as well as CPCo, ran a linear analysis (structure always in the elastic range) instead of a plastic analysis which would allow a redistribution of loads in the structure. Therefore, supposed areas of high stress, where cracks are not located, may not exist due to redistribution of loads. Finally, the staff's official position, as stated by Mr. Rinaldi, on this analysis as performed by the consultants, was that the actual settlement values could not be relied upon to determine if the diesel generator building meets regulatory requirements.

My third concern deals with the fact that we are not following normal engineering practice in accepting the building by using a crack analysis approach because there is no practical method available today to analyze a complex structure with cracks in it. The basis of this concern is that there are no formulas available that can estimate stresses in a complex stress field like those which exist in this building. Thus, the evaluation of the structure based on the staff's crack analysis using empirical unproven formulas to determine the rebar stresses is unacceptable.

My fourth concern deals with the staff accepting the building by relying on a crack monitoring program to evaluate the stresses during the service life of the building. If cracks exceed certain levels, recommendations will be made for maintaining the structural integrity of the building. The basis for my concern deals with the lack of crack size criteria and the lack of formulated corrective action to be taken when the allowed crack sizes are exceeded.

These concerns which I have just enumerated are also shared by members of Mr. Vollmer's engineering staff, as well as their consultant. These concerns were documented in the ASLB hearing transcripts of December 10, 1982, prior to my ever expressing my concerns before the ASLB hearing or Congressman Udall's subcommittee.

In summary, since it is impossible to analyze this severely cracked structure to the total staff's approval, I recommend some remedial structural fixes be undertaken to ensure the structural integrity of the building to provide an adequate margin of safety.

Ross B. Landsman

Ross B. Landsman
Reactor Inspector

cc: DMB/Document Control Desk (RIDS)

ATTACHMENT 1

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

MEMORANDUM FOR: George Lear, Chief
Structural and Geotechnical Engineering Branch
Division of Engineering

THRU: Lyman Heller, Leader
Geotechnical Engineering Section
Structural and Geotechnical Engineering Branch
Division of Engineering

FROM: Joseph Kane, Senior Geotechnical Engineer
Geotechnical Engineering Section
Structural and Geotechnical Engineering Branch
Division of Engineering

SUBJECT: REVIEW OF REGION III REACTOR INSPECTOR'S CONCERNS REGARDING THE DIESEL GENERATOR BUILDING AT MIDLAND

In response to your verbal request of July 27, 1983 I am providing my comments on the July 19, 1983 memorandum prepared by R. B. Landsman on his concerns for the Diesel Generator Building. Since many of the concerns covered in the July 19, 1983 memorandum had previously been expressed in the ASLB hearing sessions of December 6-10, 1983, I have attempted to identify the specific transcript pages where these issues were discussed. Hopefully this listing of transcript pages will permit the interested reviewer in recognizing and evaluating the similarities and differences with both my previously expressed views and those of GES Consultant, the U.S. Army Corps of Engineers, and those views now provided by Dr. Landsman.

Joseph D. Kane

Joseph D. Kane, Senior Geotechnical Engineer
Geotechnical Engineering Section
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosure:
As stated

cc: See page 2

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cc: w/enclosure
R. Vollmer
J. Knight
G. Lear
P. Kuo
L. Heller
E. Adensam
T. Sullivan
D. Hood
F. Rinaldi
H. Singh, COE
R. Landsman, Region III
J. Harrison, Region III
W. Paton, OELD
J. Kane

Review Comments of

Joseph Kane

Diesel Generator Building Concerns

at Midland

Reference - July 19, 1983 Memorandum, From R. B. Landsman thru J. J. Harrison to R. F. Warnick, Subject: Diesel Generator Building Concerns at Midland.

1. First Concern - The problems and limitations inherent in the finite element analysis completed by CPC because of the effects of cracks and CPC interpretation of settlement data.

   Comment: To the best of my understanding and recollection the statements expressed in this first concern are accurate. I am in agreement with these statements except for the sentence "It is this time dependent effect that was also not used in their model." It is not clear to me what is intended by "time dependent effect". If it means the effect of cracking that resulted because of settlements, then I would agree with the statement. If it implies that time dependent settlements were not considered, then I believe the statement is in error.

   Pertinent Transcript Pages - December 10, 1982, Pages 11173 to 11203.

2. Second Concern - Problems with analysis performed by NRC Consultant, the U.S. Naval Surface Weapons Center, and statement that this analysis gave unacceptable results.

Comment: In my opinion it was very unfortunate that the study by NSWC was not provided to the NRC Staff who are affected by the study results in sufficient time to permit a full internal NRC review with opportunity for calm and deliberate discussions on its contents before this document was introduced by the Applicant into evidence before the ASLB. I personally have serious problems and questions with the NSWC report. I have not pursued my concerns with the NSWC report for two reasons. First, I was under the impression that all review issues related to the DGB had been fully addressed at the December 6 through 10, 1982 ASLB Hearing session and secondly, my understanding of the procedure used by NRC Structural Engineering Section to arrive at its conclusion as to the magnitude of the stresses induced by settlement (the crack analysis approach) does not rely on the results or conclusions of the NSWC study.

With respect to Dr. Landsman's stated second concern, I essentially am in agreement with his statements except I do not understand what is meant by the words "and this portion of the SSER should be stricken" which appears in the second sentence.

3. Third Concern - Crack analysis approach used by the Staff is not normal engineering practice.

Comment: In response to examination questions from both OELD and ASLB, both Mr. Singh and I gave our views on the crack analysis approach. An important conclusion reached by Dr. Landsman, which is different from my position, is that the Staff's crack analysis to determine rebar stresses is unacceptable. I believe a review of the transcript records will clearly show that I did not make this conclusion on unacceptability because I feel it is outside my area of responsibility and expertise.

Pertinent Transcript Pages - December 10, 1982, Pages 11187 to 11201.

4. Fourth Concern - Problems with relying on the crack monitoring program to evaluate stresses during the service life of the DGB.

Comment: The hearing transcripts will show that neither H. Singh or myself was questioned on the acceptability of the crack monitoring program for the Diesel Generator Building. The discussions that did occur in the hearings were provided by CPC consultants and NRC Structural Engineering Section. It is my impression that technical specification details still need to be resolved with the Applicant on the crack monitoring program for the DGB. Some of the details to be resolved would include the actual method to be used in measuring the cracks and the requirements for jointly coordinating and evaluating both settlement and crack readings. I share the same concern as Mr. Landsman on the "lack of formulated corrective action to be taken when the allowed crack sizes are exceeded." In addition to Mr. Landsman's concern I have problems with the following aspects of the crack monitoring program which were worked out by NRC Structural Engineering Section and the Applicant.

a. The criteria on crack widths permitted under both the alert and action limits (December 10, 1982 transcript, page 11069) are not sufficiently restrictive to prevent potential sections of the DGB from experiencing cracks where tensile stresses in the reinforcing steel would be well above the allowable stress.

b. It is not clear what is intended by the wording "summation of the increase in all the crack widths...." as it pertains to both the alert and action limits. Are the crack widths identified in transcript page 11069 to be the increases that are permitted? Increase over what existing width and date?

c. A crack monitoring program may elect to select certain wall sections for more careful measurement of cracks but it should not fail to require reasonable surveillance on other portions of the structure. My understanding of the agreed upon monitoring program for the DGB is that it is limited to localized areas on the faces of three selected walls.

d. The decision to require crack monitorirg at a frequency of once in five years after yearly monitoring for the first five years should not be made at this time. The decision to significantly increase the required monitoring interval should be withheld until the initial data and trends are known and evaluated.

ATTACHMENT 2

[illegible] 8/2/83
[illegible]
[illegible]

Comments on J. Matra's Study - Structural Reanalysis of DGB

The time frames for the phases of construction (e.g. pre-surcharge, during surcharge, etc.) have been selected for the convenience of major construction phases or events and to more accurately estimate the DGB's stiffness at these specific times when the effects of settlement are evaluated.

It is not clear why total settlements (Figs. 29, 34, 36, 38, 40 and 42) are being used to compute max. stresses and moments. It is my understanding that computed stresses and moments are only appropriate for the various time frames where the specific settlement increment for that time frame has been used. The comments provided in Tables 2, 3, 4, and 5 should not be comparing stresses and moments based on total settlements when checking for areas of cracking. Need to clarify this with NSWC and reexamine computed stresses and moments with available crack mapping. On several of the walls (See Table notes) there does appear to be correlation of cracks with high stress areas. Discuss w/ NSWC.

Tables 3 and 4 provide results of NSWC on various floor and roof elevations. Since crack maps for floors and roof are not provided in the NSWC, is it intended to check study results of stresses and moments against existing cracks by a site inspection or request for additional mapping?

Tables 5 and 6 when addressing the settlements on Figs 4 and 43 in causing high stresses and moments should recognize the settlements are predicted to the year 2025. The major portion of these settlements have yet to occur, therefore, a check for cracking due to these settlements can not be made at this time.

(over)

The elements in the F.E. analysis appear to be approx. 20' in length. What effect does this 20' length have on the results of the analysis (location of high stresses and strains) recognizing that it is assumed the strain is constant over this length. Could check by using smaller elements, e.g. 5' lengths.

Explanation for "out of plane" moment?

Explanation on how allowable axial load and allowable out of plane moment were established (e.g. Table 2) for the 30" wide wall that has reinforcing of # 8 bars, 12" O.C. in both H & V directions

Following discussions with NSWC, is there a need to set up site inspection to check areas of high stress and moment with visually observed areas of cracking

ATTACHMENT 3

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

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

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

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

Enclosed please find the initial response to R. Landsman's 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.

Frank Rinaldi

Frank Rinaldi, Structural Engineer
Structural Engineering Section B
Structural and Geotechnical
Engineering Branch
Division of Engineering

Enclosure: As stated

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

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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

INTRODUCTION:

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, therby 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.-6 inch-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 inch thick, with their base at el. 628 ft. The walls rise from an elevation of 628 ft. (bottom of footing) to el. 690 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 summarize 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, Franz Schauer, John Matra, and Gunnar Harstead and all oral correction introduced by the same witnesses. The adequacy of the DGB is based upon many analyses, reviews, and monitoring requirements which address normal loads, settlement loads and postulated environmental loads. Due to the fact that available measured and predicted settlement data is not sufficiently refined to calculate structural component's stress by the use of a finite element analyses, the following quotations summarize the structural staff position for acceptance of the DGB:

(a) The NRC Staff believes the actual measured settlement values are the best characterization of settlement at the Midland site.

(b) The NRC Staff has not fully relied on these settlement values in any analyses to ascertain the acceptability of the DGB to withstand its design load over the lifetime of the plant. Instead, the Staff has looked at the current condition of the structure to estimate stresses due to settlement. To these it added stresses due to other design loads which are not presently on the structure but which have to be considered. The staff relied on Applicant's finite element analysis only for the latter stresses.

(c) The NRC Staff finds the DGB to be structurally acceptable.

(d) The NRC Staff is requiring a program of surveillance of the structure and for its foundation to ensure the continued safety of the structure.

(e) The NRC Staff takes no postion with respect to the acceptability of Applicant's finite element analysis of the DGB (as applicable to settlement effects).

(f) The NRC Staff's acceptance of the DGB is subject to the outcome of Seismic Margin Review.

Summary of Landsman's Concerns:

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 official 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 integrity and provide adequate margins of safety.

<u>Reply to Landsman's Concern:</u>

FIRST CONCERN

Part (a) In the design of reinforced concrete structures, the composite of concrete and rebars is modelled as 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 both the expected cracks and the stiffness of reinforcing bars which are compensating effects in the calculation of stiffness. Also, a reduced stiffness 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 what they considered the best practical approach to determine 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". Bending moments are proportional to the second derivative of displacement with respect to length and shear is proportional to the third 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 judgment must be exercised in the formulation of the models and in the evaluation of the results.

The applicant performed many of the 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 directly 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 state that the use of the straight line or other representation using the available settlement data cannot produce credible results.Therefore, the staff did develop a conservative estimate of the state of stress of the structure based on the crack-evaluation and added these results to the stress levels for the environmental loads as per code requirements. However, we like to point out that several loads (DL, LL, T) were added twice. Also, the controlling load combination is the one with the tornado load. The applicant did not account for venting of the structure in their analysis, but the drawings and site visits indicated that considerable venting is provided. We like to point out that these two factors add a great deal of conservatism to the results. In addition, the effects of future settlement was considered in the applicant analysis, but the staff will rely on the monitoring program.

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 has less effect 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 cculd 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 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 judgment needs to be exercized.

Second Concern

Part (a) The summary report of 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 duct 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 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 in selecting a crack monitoring point for the service life of the DGB (a location of high stress as per 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 for non-settlement loads. 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 inconsistent with the mechanism of redistribution of stresses.

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 were 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. The proposed crack monitoring will provide controls over potential future crack-patterns.

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. These stresses were conservatively added to total stresses developed by the applicant.

The structural analyses of the DGB were performed by the applicant considering all load 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 applicant's structural consultants and our structural staff and their consultants have performed several evaluations of the DGB without finding any unresolved concerns.

Fourth Concern

The DGB was not accepted by the staff soley 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. It contains specific requirements for Alert and Action levels for the monitoring of single and collective crack widths.

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.

Gunnar Harstead, Consultant
Structural & Geotechnical
Engineering Branch

John Matra, Consultant
Structural & Geotechnical
Engineering Branch

Frank Rinaldi, Structural Engineer
Midland Project,
Structural & Geotechnical
Engineering Branch

Enclosure 2

Consumers Power Company

General Offices: 1945 West Parnall Road, Jackson, MI 49201 • (517) 788-0550

October 14, 1983

Harold R Denton
Office of Nuclear Reactor Regulation
U S Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND ENERGY CENTER
MIDLAND DOCKET NOS 50-329, 50-330
ADDITIONAL INFORMATION REQUESTED BY NRC STAFF
AT THE TECHNICAL AUDIT OF THE DIESEL GENERATOR BUILDING
FILE: B3.0.3 SERIAL: 25867

This letter transmits to the NRC Staff the information requested at the September 12, 1983 Technical Audit of the Diesel Generator Building (DGB) in Ann Arbor, Michigan. The information provides a comparison of rebar stresses resulting from two analyses in which the forty-year estimated settlements (Settlement Case 2B) were performed on a finite-element model of the DGB. The model and the referenced settlement case were previously discussed by Mr Karl Wiedner at the Atomic Safety and Licensing Board (ASLB) hearing held on December 8 & 9, 1982.

Table 1 gives the stresses for settlements imposed at 10 boundary nodes around the DGB foundation; specifically, 5 nodes on the south wall, and 5 nodes on the north wall. These nodes are located at the intersection of cross walls with north and south walls. This analysis was performed for information purposes only and was carried out during April of 1982.

Table 2 gives stresses for the same settlement case as above, however, this time, settlement values were imposed at 66 boundary nodes around the DGB foundation. The settlement values were obtained by fitting smooth fourth-order polynomial curves through the same settlement values for the 10 node points on the north and south walls stated above. Likewise, this analysis was performed for information purposes only and at the suggestion of the NRC Staff during the aforementioned audit.

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OC1083-0055A-MP04

Tabulated rebar stresses for the majority of the elements for both cases are considerably in excess of the allowable value (54 ksi). For the elements with maximum stress values in the the same category the rebar stress values obtained from the second analysis (Table II) are consistently higher than those obtained from the first analysis (Table I).

RJE/MFC/bjw

CC RJCook, Midland Resident Inspector
JGKeppler, Administrator, Region III
DHood, NRC
FRinaldi, NRC
PTKuo, NRC
GLear, NRC
GHarsted, Consultant
JMatra, NSWC
MReich, BNL
CMiller, BNL
CConstancino, BNL
JKane, NRC
RLandsman, Region III

CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 25867 Dated October 14, 1983

At the request of the Commission and pursuant to the Atomic Energy Acts of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits information requested by the NRC during the DGB audit held on September 12, 1983.

CONSUMERS POWER COMPANY

By /s/ R J Erhardt
R J Erhardt
Executive Manager - Midland Project

Sworn and subscribed before me this 17th day of October.

/s/ Alva C Robinson
Notary Public
Jackson County, Michigan

My Commission Expires October 1, 1986.

TABLE 1

128860 DIESEL GENERATOR BUILDING

Displacements imposed at 10 points around the bldg.

TABULATION OF MAX REBAR STRESSES FOR IMPOSING GEOTECHS 40-YEAR DISPLACEMENTS.

Settlement Case 2B

CATEGORY	ELEMENT	LOAD CASE	DIR'N	AXIAL K/Ft	MOMENT K-Ft/Ft	SHEAR K/Ft	GRAD	REBAR STRESS	CONC STRESS
WEST WALL	43	1	VER	267.573	-19.318	95.990	0	170*	0.000
INTERIOR WALL	640	1	VER	136.897	0.529	-66.791	0	115*	0.000
EAST WALL	895	1	VERT	161.973	17.367	43.310	0	101.913	0.000
NORTH WALL	102	1	VERT	186.210	-25.266	-73.447	0	120*	0.000
SOUTH WALL	689	1	HOR.	276.129	17.415	122.949	0	175*	0.000
SLAB @ 664'-0"	377	1	E-W	31.358	2.387	-11.755	0	38.629	0.000
ROOF @ 680'-0"	358	1	E-W	65.495	1.268	28.860	0	42.500	0.000
SHIELD WALL NORTH	196	1	HOR.	29.455	8.453	21.334	0	15.859	0.000
SHIELD WALL (S) ABOVE EL 664'-0"	610	1	VER	69.375	6.764	45.297	0	73.379	0.000
SHIELD WALL (S) BELOW EL 664'-0"	631	1	HOR	86.690	78.147	49.568	0	73*	0.000
INTERNAL SHIELD WALL	398	1	HOR.	0.864	0.190	1.853	0	5.766	0.000
BOX MISSILE SHIELD	739	1	VERT	32.054	0.626	-18.679	0	37.360	0.000

REFERENCE BSAP OUTPUT, CALC NO. DQ-52.1-C1(Q)

REFERENCE OPTCON OUTPUT, CALC. NO. DQ-52.1-C2(Q)

* Stresses based on axial load only

TABLE 2

129860

DIESEL GENERATOR BUILDING

Displacements imposed at 66 points around the bldg

Tabulation of Max Rebar Stresses for Enforced 40 yr settlements from 4th order curve.

(Settlement Case 2B)

DGB STRUCTURAL CATEGORY	ELEMENT NO.	LOAD CASE	REBAR DIR'N	AXIAL FORCE (K/FT)	BENDING MOMENT (FT-K/FT)	SHEAR FORCE (K/FT)	TEMP GRAD. (°F)	REBAR STRESS (KSI)	CONC. STRESS (KSI)
WEST WALL	36	1	Vert	201.627	-16.246	-84.206	0	173.036	0
INTERIOR WALL	641	1	Vert	107.829	4.259	-47.798	0	114.301	0
EAST WALL	895	1	Vert	467.989	34.162	88.293	0	244.564	0
NORTH WALL	766	1	Vert	408.619	-34.272	81.767	0	266.747	0
SOUTH WALL	716	1	Vert	416.466	9.614	-37.377	0	258.916	0
SLAB @ 664'-0"	178	1	E-W	60.995	2.283	1.152	0	72.177	0
ROOF @ 680'-0"	791	1	N-S	77.936	4.567	9.503	0	70.442	0
SHIELD WALL NORTH	839	1	Vert	58.894	12.754	-4.308	0	29.617	0
SHIELD WALL SOUTH ABOVE 664'0"	610	1	Vert	92.365	8.273	61.632	0	108.295	0
SHIELD WALL SOUTH BELOW 664'0"	631	1	Horiz.	119.811	95.726	70.239	0	230.620	0
INTERNAL SHIELD WALL	398	1	Horiz	6.888	.255	4.905	0	8.147	0
BOX MISSILE SHIELD	739	1	Vert	47.516	1.782	-16.187	0	56.657	0

Reference BSAP output DQ-52.12-C1(Q), Rev 0

Reference OPTCON output DQ-52.12-C2(Q), Rev 0