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

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Knight
Miller
~~Heller~~
Kane

JUN 8 1981

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

MEMORANDUM FOR: H. Denton, NRR
J. Carter, NRR
D. Eisenhut, DL
R. Purple, DL
DL Assistant Directors
S. Hanauer, HFS
R. Vollmer, DE
R. Mattson, DSI
T. Murley, DST
J. Sniezek, IE
J. Olshinski, ORAB

THRU: E. Adensam, Acting Chief
Licensing Branch #4
Division of Licensing

FROM: D. Hood, Project Manager
Licensing Branch #4
Division of Licensing

SUBJECT: DAILY HIGHLIGHT - MIDLAND PLANT UNITS 1 & 2

On June 8, 1981, Consumers Power Company (CPCo) and NRC filed a stipulation with respect to quality assurance aspects of the hearing on Midland soils settlement, scheduled to begin July 7, 1981. The hearing was requested by CPCo following a December 6, 1979 Order Modifying Construction Permits which was issued, in part, because of a quality assurance breakdown with respect to soil construction activities. The December 6, 1979 Order would prohibit certain soils construction activities pending issuance of an amendment to the construction permits. By the stipulation, CPCo agrees (1) not to contest the Staff's conclusion that a breakdown in quality assurance with respect to soils placement existed when the December 6, 1979 Order was issued, and (2) this breakdown constituted an adequate basis for issuance of the December 6, 1979 Order. The stipulation also acknowledges the NRCs recent findings that the current quality assurance program satisfies all requisite NRC criteria, and that as a result of revisions in the quality assurance program, the improved implementation of that program, and other factors, the NRC has reasonable assurance that quality assurance and quality control programs will be appropriately implemented with respect to future soils construction activities including remedial actions taken as a result of inadequate soil placement.

Darl Hood
Darl Hood, Project Manager
Licensing Branch #4
Division of Licensing

8408140526 840718
PDR FOIA
RICE84-96 PDR

J. Kane
Rec'd 8/26/80

22/B4

August 21, 1980

Ms. Barbara Stamiris
5795 North River Road
Freeland, Michigan 48623

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

Dear Ms. Stamiris:

Per your request of Messrs. William Paton and Darl Hood of the NRC last week, enclosed please find copies of the nonconformance reports and the quality action requests referenced in paragraph 4 in Appendix A of the December 6, 1979 Order Modifying Construction Permits for the Midland plant. The two related audit reports you mentioned are also enclosed.

Sincerely,

Steven C. Goldberg
Counsel for NRC Staff

Enclosures:
  Action Request No. SD-40
  Nonconformance Report Nos. QF-29, QF-52, QF-68, QF-120, QF-130
    QF-147, QF-172, QF-174, QF-199, QF-203
  Audit Report Nos. 77-21 and 77-22

cc w/enc.:
- Frank J. Kelley, Esq.
- Myron M. Cherry, Esq.
- Ms. Mary Sinclair
- Michael I. Miller, Esq.
- Grant J. Merritt, Esq.
- Judd L. Bacon, Esq.
- Mr. Steve Gadler
- Wendell H. Marshall
- Michael A. Race
- Ms. Sandra D. Reist
- Ms. Sharon K. Warren
- Patrick A. Race
- George C. Wilson, Sr.
- Ms. Carol Gilbert
- William A. Thibodeau
- Terry R. Miller

Internal Distribution:
- NRC Central
- OELD-FF (2)
- Shapar/Engelhardt
- Christenbury/Scinto
- Olmstead/Karman
- Paton/Chron (2)
- Goldberg/Chron
- Jones
- D. Hood -116-C
- IJLee - 147

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5

OFFICE ▶	OELD J					
SURNAME ▶	SCGoldberg:eat					
DATE ▶	8/21/80					

QUALITY ACTION REQUEST

From:
G. L. Richardson Site QA Job 7220 ①

To: J. F. Newgen/
G. P. Connolly ②

Control Document ref.: 7220-C-210 ③

QAR Ident. No.: SD-40 ④

Action Requested: ⑤

Section 13.0 of specification 7220-C-210, Rev. 4 provides the requirements for Q-listed backfill in the plant area. Section 13.6 states that the moisture control in this area shall be in accordance with Section 12.6 of the same specification. Section 12.6 states in part: "The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above optimum moisture content". . ."

"Tests done in accordance with para. 12.5 will indicate the degree of moistening or aerating necessary to comply with para. 12.5.1. After placement of loose material on the embankment fill, the moisture content shall be further adjusted as necessary to bring such material within the moisture content limits required) OVER

Signature: Gary L. Richardson ⑥

Date: 7/22/77 ⑦

Reply Requested by: 1&3) 7/25/77 2) 8/19/77 ⑧

Reply: ⑨

RECEIVED
JUL 22 1977
QUALITY CONTROL
BECHTEL JOB 7220
dp

ROUTE TO
QC 0/7220
INIT.
A. PFQCE
CIVIL
ELECT.
PIPING
MECH.
WELDING
RECEIVING
OPEN TOPS
☐ YES ☑ NO
DATE

Signature: ⑩ Date:

Action Verified: ⑪

⑫ Date: ⑬

WHITE — Return to sender CANARY — Addressee's file PINK — Sender's file

BPC 20977
G1701549-05

for compaction."

> "Rolling of any section of embankment containing material too wet or too dry to obtain the required compaction shall be delayed until the moisture content of the material is brought to within the required limits or the material shall be removed and replaced with suitable material. . ."

Contrary to the above: The field does not take moisture control tests prior to and during placement of the backfill, but rather rely on the moisture results taken from the in-place soil density tests.

Recommended Corrective Action

1) A system for testing the soil for moisture content prior to compaction should be developed and implemented by Bechtal and the subcontractor. QC should make any necessary revisions to the QCI.

2) Recognizing that the soil has been tested for moisture content after compaction and meets the requirements of the specification it is not necessary to identify these materials as nonconforming. However Project Engineering should be apprized of the past testing methods. In addition it is recommended that engineering concur with the interpretation that moisture contents taken after compaction are for determining dry densities and should not be used for specified moisture control.

3) Assure responsible personnel are aware of the testing system.

ey
lager
. Hills

This Copy For
S. H. Howell
W. E. Kessler(2)
W. F. Holub
File

Nonconformance No QF29

File 16.3.6
Issue Date October 14, 1974
Project Midland 1 & 2

File Title NCR's on Bechtel Quality Control

This Nonconformance Report is Issued to:

Mr. J. P. Connolly
Bechtel Project Field Quality Control Engineer

who is responsible for correction action.

Prepared By Date 10-14-74
Reviewed By Date [illegible]
Written Reply Required By Date 10-24-74
Action Required By Date 11-14-74

Nonconformance Description and Supporting Details: Specification C-211 Rev. 0 and SCN No. C-211-4001, 5.6.2 states "Material delivered to the jobsite for use as structural backfill shall be visually inspected, and tested in accordance with ASTM C-117 and C-136 by the contractors representative once per day when material is being delivered." Structural backfill material was delivered on thirty (30) days in August and September, but the QC File only has test reports for one (1) of the thirty (30) days. U.S. Testing File only has test reports for eleven (11) of the thirty (30) days.

AEC Reportable Yes ☐ No ☒ See Procedure 9 - Reporting of Deficiencies to AEC
AEC Notified on ________ By ________ Method ________

Recommended Corrective Action (If Appropriate): (1) Evaluate the structural backfill aterial in place and in the stockpile with additional tests. (2) Locate the missing test eports. (3) Correct the problem of U.S. Testing not being notified of in coming structural backfill material.

[1] Corrective Action To Be Taken: (1) Evaluate the structural backfill material in the stockpile with additional tests. (2) Locate the missing test reports. (3) Correct the problem of U.S. Testing not being notified of incoming structural backfill material.

[1] Underlying Cause of Nonconformance: The underlying cause of this nonconformance is Bechtel Quality Control was not being fully informed of material deliveries, therefore U.S. Testing was not being informed by Bechtel Quality Control.

(Corrective Action Implemented and Nonconformance Closed) Confirmed By Donald E. Horn
Date February 12, 1975

(1) Bechtel NCR 198 was initiated. 26 additional samples were taken from the stockpile. Bechtel Project Engineering's Disposition is to "use as is" s d on the results of the additional samples. (2) The ten missing reports were found and aced in the QC File (3) A memorandum from E. E. Felton directing that Quality Control be tified of all incoming shipments of structural backfill material was issued on October 29, 74.

[1] To Be Provided by Addressee.

3/15/74

Attachment A

**Reissued January 19, 1976

Route To	This Copy For
FMSouthworth	SHHowell
HWSlager	GSKeeley (2)
CQHills	TCCooke
	JMilandin
	WFHolub
	GLRichardson
	Subject File

Consumers Power

Nonconformance Report No QF-52

File 16.3.6
Issue Date August 7, 1975**
Project Midland 1 & 2
File Title NCR's on Bechtel Quality Control

This Nonconformance Report is Issued To:

Mr. J. P. Connolly
Bechtel Project Field Quality Control Engineer

who is responsible for corrective action.

Prepared By Donald E. Horn Date 8-7-75
Approved By Date 8/7/75
Written Reply Requested By Date 9-5-75
Corrective Action Requested By Date 9-5-75

Nonconformance Description and Supporting Details: (1) Specification C-210 Rev. 4 Section 13.6 for plant area backfill and berm backfill states "Moisture control of the plant area and berm materials shall conform to section 12.6". Under section 12.6, 12.6.1 states in part that "the water content during compaction shall not be more than two percentage points below optimum moisture content and shall not be more than two percentage points above optimum moisture content". Contrary to this requirement, test no. MD202 for plant area fill located 14' east of 8.7 line and 36' north of A line at elevation 594.5 had a moisture content 2.9 below optimum moisture content. Approximately 7 feet of material has been placed over this failing material.

(Contd)

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______

Recommended Corrective Action: (1) Receive a Project Engineering evaluation on the acceptability of the material in question or remove the material. (2) U.S. Testing should have training sessions to take corrective action to preclude repetition. (3) Quality Control should have training sessions to take corrective action to preclude repetition. The written replies to these items is requested with the Project Engineering evaluation.

[1] Corrective Action Taken: (1) Project Engineering has evaluated and accepted the in place material with low moisture content based on a satisfactory compaction test result. (2) United States Testing and Bechtel Quality Control have each had training sessions re-emphasizing the acceptance criteria for soil tests.

[1] Verification of Corrective Action Required Yes ☒ No ☐

[1] Method of Verification: Reviewed Bechtel NCR #324 covering item (1) of this NCR (QF-52) and the Project Engineering disposition. Also reviewed letter FQCL-049 dated 8-13-75* that states U.S. Testing and Bechtel Quality Control have each had training sessions to re-emphasize the acceptance criteria for soil tests.

[1] Nonconformance Closure Confirmed By Donald E. Horn
Date 8-14-75

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[1] To be completed at time of closure by Consumers Power QA Services.

*Corrected, previously stated 8-7-75. Donald E. Horn 1-19-76

Nonconformance Report No QF-52 (Contd)

Nonconformance Description and Supporting Details: (Contd)

(2) This failing test was shown on the compacted fill density test report form QC-C1 as passing by U.S. Testing in the remarks column.

(3) On the back of the QC-C1 form, in the FIM, it states the entry information. For Block no. 3 the entry information states "to be signed and dated by the QC Engineer signifying the form has been reviewed for completeness and correctness". Contrary to this requirement, the Quality Control Engineer had signed on the compacted fill density test report the acceptance of MD202 which had actually failed.

Attachment A

Route To	This Copy For
FMSouthworth	SHHowell
HWSlager	GSKeeley
CQHills	TCCooke
	JMilandin
	WFHolub
	CLRichardson
	Subject File

Consumers Power

Nonconformance
Report No QF-68

File 16.3.6
Issue Date October 17, 1975
Project Midland 1 & 2
File Title NCR's on Bechtel Quality Control

This Nonconformance Report is Issued To:

J. P. Connolly
Bechtel Project Field Quality Control
Engineer

who is responsible for corrective action.

Prepared By Donald E. Horn Date 10-17-75
Approved By Date [illegible]/17/[illegible]
Written Reply Requested By Date 11-17-7
Corrective Action Requested By Date 11-17-7

Nonconformance Description and Supporting Details: Specification C-210 Revision 4, section 13.7 states in part "All backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by modified Proctor method..." Contrary to this requirement, the compaction test MD142 taken in the West Plant Dike had been calculated using the wrong maximum laboratory dry density for Bechtel Modified Proctor, resulting in a 96% compaction which is passing. Using the correct maximum laboratory dry density results in 92% compaction which is failing.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______

Recommended Corrective Action:

See Attachment A.

[1]Corrective Action Taken:

See Attachment A.

[1]Verification of Corrective Action Required Yes ☒ No ☐

[1]Method of Verification: (1) Compared 17 Bechtel Modified Proctors to Field Work Sheets. (2) Reviewed revised reports for correctness. (3) Reviewed U.S. Testing's system for checking tests against a Master Proctor List and a Master Log Book.

[1]Nonconformance Closure Confirmed By Donald E. Horn
Date 11-21-75

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[1] To be completed at time of closure by Consumers Power QA Services.

File 16.3.6
Issue Date October 17, 1975
Project Midland 1 & 2
File Title NCR's on Bechtel
Quality Control

Attachment A
Nonconformance Report No QF-68

Recommended Corrective Action:

(1) Review all Bechtel Modified Proctors (BMP) and Field Work Sheets used by U.S. Testing to assure the maximum laboratory dry densities and optimum moisture contents on the BMP's agree with the Field Work Sheets.

(2) If there is a discrepancy between the maximum laboratory dry densities and/or the optimum moisture contents, review all compacted Fill Density Test Reports that used the maximum laboratory dry densities and/or optimum moisture contents in error.

(3) Resubmit all test reports that used the maximum laboratory dry densities and/or optimum moisture contents in error.

(4) Receive a Project Engineering evaluation on the acceptability of the failing test MD142 and any failing tests that are found during the review.

(5) Take corrective action to preclude these occurrences.

The written reply to these items is requested with the Project Engineering evaluation.

Corrective Action Taken:

(1) A complete comparison of all Bechtel Modified Proctors to Field Work Sheets was performed by United States Testing.

(2) Three additional discrepancies were found during this review. A total of twelve Field Tests were affected by the discrepancies.

(3) Revised reports have been submitted for the twelve Field Tests.

(4) Failing test MD142 has been cleared by passing test MD160. None of the twelve Field Tests were found failing after corrections had been made. A Project Engineering evaluation was not necessary.

(5) U.S. Testing has devised a system for checking tests against a Master Proctor List and a Master Log Book.

Attachment A

Route To	This Copy For
FMSouthworth	SHHowell
HWSlager	GSKeeley
CQHills	TCCooke
	JMilandin
	JMKlacking
	GLRichardson
	Subject File

Consumers Power

Nonconformance Report No QF-120

File 16.3.4 & 16.3.6
Issue Date September 21, 1976
Project Midland 1 & 2

File Title NCR's on Bechtel Construction & Quality Control

This Nonconformance Report is Issued To:
J. P. Connolly
Bechtel Project Field Quality Control Engineer
J. F. Newgen
Bechtel Project Superintendent
who is responsible for corrective action.

Prepared By Donald E. Horn Date 9-21-76
Approved By DRKeating Date 9-21-76
Written Reply Requested By Date 10-8-76
Corrective Action Requested By Date 10-8-76

Nonconformance Description and Supporting Details: Specification C-210, Revision 4 sections 12.5.2, 12.5.3 and 12.5.4 state in part that (1) The uncompacted lift thickness of soil placement shall be not more than 12 inches. (2) In areas not accessible to roller equipment, the material shall be placed in lifts not to exceed 4 inches in uncompacted thickness. Contrary to these requirements, (1) soil was placed between manhole #5 and #6 above the Sanitary Sewer in the West Plant Dike in an uncompacted lift thickness varying between 9 and 14 inches, (2) in an area not accessible to roller equipment, soil was placed between manhole #4 and #5 above the Sanitary Sewer in the West Plant Dike in uncompacted lift thickness of 6 inches. The material was removed down to the required lift thicknesses and compacted, prior to continued work in this area.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
No Hold Tags Applied.

Recommended Corrective Action:

(1) Determine why the original uncompacted lift thicknesses exceeded the maximum lift thicknesses.

(2) Take corrective action to preclude repetition.

[1]Corrective Action Taken:

(1) This was the result of insufficient monitoring of the placing crews and the work was done in accordance to the note on Detail 6 of Drawing C-130, Rev. 3 which is in conflict with Specification C-210.

(2) A Training Session was given to the Laborer General Foreman and Laborer Foreman and Drawing Change Notice No. 5 to Drawing C-130, Rev. 3 corrected the conflict between Drawing C-130, Rev. 3 and Specification C-210.

[1]Verification of Corrective Action Required Yes ☒ No ☐

[1]Method of Verification:

Reviewed Training Session BT94, letters BCCC-2068 and FQCL-114, and DCN No. 5 on Drawing C-130, Rev. 3.

[1]Nonconformance Closure Confirmed By Donald E. Horn
Date 11-9-76

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[1]To be completed at time of closure by Consumers Power QA Services.

Attachment A

Route To	This Copy For
BWMarguglio HWSlager JHMaclaren	SHHowell GSKeeley TCCooke JMilandin JMKlacking GLRichardson Subject File

Consumers Power

Nonconformance Report No QF-130

File 16.3.6
Issue Date October 18, 1976
Project Midland 1 & 2
File Title NCR's on Bechtel Quality Control

This Nonconformance Report is Issued To:

J. P. Connolly
Bechtel Project Field Quality
Control Engineer

who is responsible for corrective action.

Prepared By Donald E. Horn Date 10-18-76
Approved By Date 10/18/76
Written Reply Requested By Date 11-1-76
Corrective Action Requested By Date 11-8-76

Nonconformance Description and Supporting Details:
Field Inspection Plan C-210-4-55 Rev. 0 for Placing Plant Area Backfill, North of "A" line, "4.55" to "8.7" line, elevation 610' ± to 634.5, under section 2.20 Activity/Task for "Placement" item 1 states "Zone 1, 1A, 2 and 3 material placed in uncompacted lifts not exceeding 12 inches. Areas not accessible to roller equipment, the material placed in uncompacted lifts not exceeding 4 inches".

Contrary to this Activity/Task, Quality Control Engineers have observed material placed in approximate 12 inch uncompacted lifts where roller equipment was not used to compact the material.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
No Hold Tags Applied

Recommended Corrective Action:
(1) Review other C-210-4 Field Inspection Plans for similar problems.
(2) Determine the cause of the nonconformance above and similar problems in (1) above, if any found.
(3) Take corrective action to preclude repetition.

[1] **Corrective Action Taken:**
(1) All closed C-210-4 Field Inspection Plans have been reviewed and similar situations as described in QF-130 existed (i.e., that 12 inch lifts were placed in areas where roller equipment was not used).
(2) Cause of nonconformance was misinterpretation of specification requirements.
(3) To preclude repetition QCI C-1.02 will be used to inspect compacted backfill and a training/discussion session was held on 2/22/77.

[1] **Verification of Corrective Action Required** Yes ☒ No ☐

[1] **Method of Verification:**

Reviewed letter FQCL-142.

[1] **Nonconformance Closure Confirmed By** Donald E. Horn
Date 3-3-77

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[1] To be completed at time of closure by Consumers Power QA Services.

Attachment A

Route To	This Copy For
BWMarguglio HWSlager JHMaclaren WRBird	SHHowell GSKeeley TCCooke JMilandin JMKlacking GLRichardson Subject File

Consumers Power

Nonconformance Report No QF-147

File 16.3.4 & 16.3.6
Issue Date February 2, 1977
Project Midland 1 & 2

File Title NCR's on Bechtel Construction and Bechtel Quality Control

This Nonconformance Report is Issued To:
Mr. J. F. Newgen
Bechtel Project Superintendent

Mr. J. P. Connolly
Bechtel Project Field Quality Control Engineer
who is responsible for corrective action.

Prepared By Donald E. Horn Date 2-2-77
Approved By Date 2/2/77
Written Reply Requested By Date 2-14-77
Corrective Action Requested By Date 3-15-77

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ee
QF-29
T 14, 1974

Nonconformance Description and Supporting Details: (1) Specification C-211 Revision 3 section 5.6.2 states "Material delivered to the jobsite for use as structural backfill shall be visually inspected, and tested in accordance with ASTM C-136 (and C-117 when required by the Field Engineer) by the Contractor's representative once per day when material is being delivered". (2) Project QC Instruction No. 7220/C-1.02 Compacted Backfill Revision 0 section 2.3 D states in part "The following tests shall be taken at the specified frequencies: 4. During each day's delivery of structural backfill material, a minimum of one representative sample tested in accordance with ASTM C-136 (and ASTM C-117 as determined by Field Engineering) to the gradation requirements specified, prior to placement". (Contd)

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
Bechtel applied hold tags to the structural backfill stockpile.

Recommended Corrective Action:

See attachment.

[1] **Corrective Action Taken:**

See attachment.

[1] **Verification of Corrective Action Required** Yes ☒ No ☐

[1] **Method of Verification:**
Verified review of structural backfill deliveries for October and November, 1976 for lack of testing on February 9, 1977. Reviewed letters FQCL-140 and BCCC-2373, Training File BT-117 and NCR's 686 and 698.

[1] **Nonconformance Closure Confirmed By** Donald E. Horn
Date 6-10-77

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[1] To be completed at time of closure by Consumers Power QA Services.

Attachment to Report No QF-147

Nonconformance Description and Supporting Details: (Contd)

Contrary to (1) and (2) above, structural backfill delivered on December 1, 1976, December 14, 1976 and January 11, 1977 was not tested for gradation requirements.

Recommended Corrective Action:

(1) Review October and November structural backfill delivered in 1976 for similar lack of testing.

(2) Receive a Project Engineering evaluation on the material lacking gradation tests including any found in the review in (1) above.

(3) This same problem of structural backfill material lacking gradation tests was identified in CPCo NCR QF-29 issued October 14, 1974. The corrective action to preclude repetition for this NCR was a memorandum from the Project Superintendent directing that Quality Control be notified of all incoming shipments of structural backfill material was issued. Recently, Bechtel QA identified this same problem in QADR SD-6 issued October 21, 1976. The corrective action to preclude repetition for this QADR was to use the following system:

a) Each day's delivery of structural backfill is stockpiled separately.

b) On the following day the responsible field engineer verifies that the material was tested and is acceptable.

c) If the material wasn't tested, a test will be taken at this time or if the material is acceptable, it will be placed in the acceptable pile.

It is evident that the corrective action taken for NCR QF-29 and QADR SD-6 is not adequate.

Determine the underlying cause(s) and propose further corrective action to preclude repetition.

1 Corrective Action Taken:

(1) Shipments of structural backfill delivered in October and November, 1976 have been reviewed. NCR's 686 and 698 have been written identifying the lack of testing in this NCR and in the review of October and November, 1976 delivery tickets.

(2) Project Engineering has evaluated the materials lacking gradation tests in NCR's 686 and 698 and has dispositioned it "use as is".

File 16.3.4 & 16.3.6
Issue Date February 2, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel Construction and Bechtel Quality Control

Attachment to Report No QF-147

[1]Corrective Action Taken: (Contd)

(3) Starting Friday, February 4, 1977 incoming structural backfill was controlled in accordance with the Quality Control Receipt Inspection Program.

In addition, a training session was held on February 10, 1977 on the control of Q-list backfill sand to preclude repetition.

Attachment A

** Reissued July 19, 1977 to indicate time nonconformances occurred.

Route To

/RBird (Third)
OESkaggs (Second)
BWMarguglio (First)

This Copy For

GLBarclay
JLCooke
RHermeston
SHHowell
DRJohnson
GSKeeley
JMKlacking
PAMartinez
JMilandin
JF Newgen

Consumers Power

Nonconformance Report No OF-172

File 16.3.4, 16.3.6
Issue Date July 8, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel Construction & Quality Control

This Nonconformance Report is Issued To:

G. L. Richardson
Bechtel Project Field Quality Assurance Engineer

who is responsible for corrective action.

Prepared By Date 7-8-77
Approved By Date 7/8/77
Written Reply Requested By Date 7-25-77
Corrective Action Requested By Date 8-26-77

Nonconformance Description and Supporting Details:

SEE ATTACHMENT

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
"No hold tags applied"

Recommended Corrective Action:

Have Project Engineering evaluate the acceptability of these materials and determine what action is needed to correct these problems if the material is unacceptable.

[1] **Corrective Action Taken:**
Project Engineering evaluated the nonconforming conditions and determined these materials acceptable.
Percent compaction for MD 342 in North East Dike was incorrect and has been revised identifying the correct (passing) result.

[1] **Verification of Corrective Action Required** Yes ☒ No ☐

[1] **Method of Verification:**
Reviewed the revised North East Dike test MD 342, IOM R. L. Castleberry to G. L. Richardson dated 8/31/77, Bechtel QA Letter GLR-9-77-317, CPCo Letter 151FQA77, IOM R. L. Castleberry to G. L. Richardson dated 10/4/77 and Bechtel QA Letter GLR-10-77-390.

[1] **Nonconformance Closure Confirmed By** Donald E. Horn
Date 10-11-77

[1] To be completed at time of closure by Consumers Power QA Services.

File: 16.3.4, 16.3.6
Date: July 8, 1977 ** July 19, 1977
Project: Midland 1 & 2
Title: NCR's on Bechtel Construction &
Quality Control

Attachment to Report No QF-172

During a review of test reports for partial cooling ponds and dikes turnover, the following were found:

Specification C-210, Revision 4, Section 13.6 states:

> "Moisture control of the plant area and berm material shall conform to Section 12.6.

Section 12.6.1 states in part:

> "The water content during compaction shall not be more than 2 percentage points below optimum moisture content ..."

Contrary to this requirement, test report MD 359 for the North East Dike Station 29+00 5'R ℄ Zone 2 @ elevation 622 had moisture content of 2.8 percent below optimum moisture content. This test had been marked P - for pass, when actually the test failed.

Specification C-210, Revision 4, Section 13.7 states in part:

> "All backfill in the plant area and berm shall be compacted to not less than 95 per cent of maximum density as determined by modified Proctor method (ASTM 1557, Method D)..."

Contrary to this requirement, test reports for the North East Dike MD 342 Station 30+00,℄ Zone 2 @ elevation 622 had 94.5 percent compaction; MD 354 Station 31+00, 100'R of ℄ sand drain Zone 2 @ elevation 622 had 93.7 percent compaction; and MD 356 Station 29+00, 100'R of ℄ of sand drain Zone 2 @ elevation 622 had 92.2 percent compaction. Test MD 342 had been marked P - for pass, when actually the test failed. Tests MD 354 and MD 356 had been marked F - for fail and accepted by 4 roller passes. The 4 roller passes are not the acceptance criteria in this area.

** Test MD 342 was taken May 25, 1974, Tests MD 354 and MD 356 were taken May 28, 1974, and Test MD 359 was taken May 30, 1974.

Attachment A

**Reissued July 19, 1977 to indicate time nonconformances occurred.

Route To	This Copy For
Bird (Third)	WLBarclay
Skaggs (Second)	TCCooke
WMarguglio (First)	RHermeston
	SHHowell
	DRJohnson
	GSKeeley
	JMKlacking
	PAMartinez
	JMilandin
	JFNewgen

Consumers Power

Nonconformance
Report No QF-174

File 16.3.4, 16.3.6
Issue Date July 15, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel Construction & Quality Control

This Nonconformance Report is Issued To:

G. L. Richardson
Bechtel Project Field Quality
Assurance Engineer
who is responsible for corrective action.

Prepared By Date 7-15-77
Approved By RB Walling Date 7-15-77
Written Reply Requested By Date 8-19-77
Corrective Action Requested By Date 9-2-77

Nonconformance Description and Supporting Details:

See Attachment.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
No hold tags applied

Recommended Corrective Action:

Have Project Engineering evaluate the acceptability of these materials and determine what action is needed to correct these problems if the material is unacceptable.

[1]Corrective Action Taken:

Project Engineering evaluated the nonconforming conditions and determined these materials acceptable.

[1]Verification of Corrective Action Required Yes ☒ No ☐

[1]Method of Verification:

Reviewed IOM R. L. Castleberry to G. L. Richardson dated 8/31/77, Bechtel QA Letter GLR-9-77-317, CPCo Letter 151FQA77, IOM R. L. Castleberry to G. L. Richardson dated 10/4/77 and Bechtel QA Letter GLR-10-77-390.

[1]Nonconformance Closure Confirmed By Ronald E. Horn
Date 10-11-77

5

[1]To be completed at time of closure by Consumers Power QA Services.

File: 16.3.[illegible] 16.3.6
Date: July [illegible], 1977 ** July 19, 1977
Project: Midland 1 & 2
Title: NCR's on Bechtel Construction and
Quality Control

Attachment to Report No QF-174

Nonconformance Description and Supporting Details

During a review of test reports for partial cooling ponds **and dikes turnover**, the following was found:

Specification C-210, Revision 2, Section 12.5.2 states in part:

> "Zone 1 and Zone 1A material shall be placed in the embankment fill as shown on the Drawings or as required..."

Table 12-1 in this specification states in part:

> "Zone 1 Impervious Fill - Not less than 20% passing No. 200 sieve..."

Contrary to these requirements, tests 115 in North Plant Dike and MD 359 and MD 358 in North East Dike had soil classification Zone 1 (BMP 114) which has 5.2% passing No. 200 sieve. Test MD 830 in North East Dike had soil classification Zone 1 (BMP 139) which has 3.4% passing No. 200 sieve.

** Test 115 was taken May 28, 1974, Tests MD 358 and MD 359 were taken May 30, 1974 and Test MD 830 was taken August 8, 1974.

Attachment A

Route To	This Copy For
RBird (last)	WLBarclay
BWMarguglio (first)	TCCooke
DATaggart (second)	RHermeston
	SHHowell
	DRJohnson
	GSKeeley
	JMKlacking
	PAMartinez
	JMilandin

Consumers Power

Nonconformance Report No 0F-199

File 16.3.4 & 16.3.6
Issue Date November 4, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel Construction and Quality Control

This Nonconformance Report is Issued To:

G. L. Richardson
Bechtel Lead QAE

Who is responsible for corrective action.

Prepared By Donald E. Horn Date 11-4-77
Approved By Date 11/7/77
Written Reply Requested By Date 11-23-77
Corrective Action Requested By Date 12-15-77

Nonconformance Description and Supporting Details:

See attachment.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No ______
No Hold Tags Applied

Recommended Corrective Action:

See attachment.

[1]Corrective Action Taken:

See attachment.

[1]Verification of Corrective Action Required Yes ☐ No ☐

[1]Method of Verification:

[1]Nonconformance Closure Confirmed By ____________
Date ____________

[1] To be completed at time of closure by Consumers Power QA Services.

File 16.3.4 & 16.3.6
Issue Date November 4, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel
Construction and Quality Control

Attachment to NCR QF-199

Nonconformance Description and Supporting Details:

Specification C-210, Revision 5 Section 12.6.1 states in part, "The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above moisture content..."

Specification C-210, Revision 5 Section 13.7.1 states, "All cohesive backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by ASTM D 1557, Method D".

Specification C-210, Revision 5 Section 13.7.2 states in part, "All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049..."

Part 1

Contrary to these requirements, the following tests had been passed using incorrect testing data. Using the correct testing data, the tests fail.

North Plant Dike

MD 290 (sampled 7-16-74) shows optimum moisture content 11.6. It should have been 9.5. Using the correct optimum moisture content of 9.5%, the actual moisture content is 2.2% above optimum moisture content.

MD 360 (sampled 7-31-74) shows optimum moisture content as 21.4. It should have been 15.2. This also shows maximum lab dry density as 103.2. It should have been 115.1. Using the correct optimum moisture content of 15.2%, the actual moisture content is 5.4% above optimum moisture content. Also using the correct maximum lab dry density of 115.1, the correct percent of maximum density is 86.4%.

MD 377 (sampled 8-6-74) shows optimum moisture content as 18.0. It should have been 15.2. Using the correct optimum moisture content of 15.2%, the actual moisture content is 4.5% above optimum moisture content.

Structural Backfill

MDR 621 (sampled 10-14-76) shows minimum dry lab density as 94.2. It should have been 112.2. Using the correct minimum dry lab density of 112.2, the correct percent of relative density is 41.5.

Part 2

Also contrary to these requirements, the following tests had failing results and did not indicate being cleared by passing tests or had been marked passing.

5

Attachment to NCR QF-199

Nonconformance Description and Supporting Details:

Part 2 (Contd)

North Plant Dike

MD 142 (sampled 5-30-74) shows optimum moisture content 8.0, moisture content 10.3. This test failed but it is shown as passing.

MD 143 (sampled 5-30-74) shows optimum moisture content 13.8, moisture content 11.4. This failed but it is shown as passing.

West Plant Dike

MD 227 (sampled 10-6-75) failed moisture but has not been cleared.

Plant Area Fill

Test No.	Date Sampled	Compaction	Moisture	
			Actual	Optimum
MD 1311	5-03-77	61.6% of Relative Density		
1326	5-10-77		18.5%	15.2%
1328	5-10-77		12.2%	15.2%
1412	6-07-77		10.4%	15.2%

Structural Backfill

MDR 621	10-14-76	78.0% of Relative Density
671	11-12-76	74.8% of Relative Density
672	11-23-76	75.4% of Relative Density
685	11-24-76	56.2% of Relative Density
686	11-24-76	70.9% of Relative Density
691	11-24-76	62.0% of Relative Density

Recommended Corrective Action:

(1) Determine if there are passing tests in the same area to clear these failing tests.

(2) If these failing tests cannot be cleared by passing tests in the same area, present these findings to Bechtel Project Engineering so Project Engineering can determine what additional tests, reviews, etc. are needed to justify the material these tests represent. Have Project Engineering justify the material these failing tests represent.

(3) Determine the underlying cause(s) and take corrective action to preclude repetition.

File 16.3.4 & 16.3.6
Issue Date November 4, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel
Construction and Quality Control

Attachment to NCR QF-199
(Contd)

[1]Corrective Action Taken:

Part 1

(1) Bechtel QC has determined that none of the above failing tests have passing tests in the same area to clear them.

(2) North Plant Dike MD 290 and MD 377 have been identified on Bechtel NCR 1005. North Plant Dike MD 360 and Structural Backfill MDR 621 density problems have been identified on Bechtel NCR 1004. North Plant Dike MD 360 moisture problem has been identified on revised NCR 1005.

Part 2

(1) Bechtel QC has determined that none of the above failing tests have passing tests in the same area to clear them.

(2) North Plant Dike MD 142 and MD 143, West Plant Dike MD 227 and Plant Area Fill MD 1326, 1328 and 1412 have been identified on Bechtel NCR 1005. Structural Backfill MDR 621, 671, 672, 685, and 686 have been identified on Bechtel NCR 1004. Plant Area Fill MD 1311 has been identified on revised NCR 1004.

(3) Corrective action has been taken as of the last of July 1977 by Bechtel QC and U.S. Testing to more adequately clear failing tests. Therefore, the corrective action to preclude repetition for not clearing failing tests need not be addressed.

Attachment A

Route To	This Copy For
	WLBarclay WRBird TCCooke RLHermeston SHHowell DRJohnson GSKeeley JPKlacking BWMarguglio LAMartinez JMilandin JFNewgen DATaggart

Consumers Power

Nonconformance Report No QF-203

File 16.3.4 & 16.3.6
Issue Date November 22, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel Construction and Quality Control

This Nonconformance Report is Issued To:

G. L. Richardson
Bechtel Lead QAE

who is responsible for corrective action.

Prepared By Donald E. Horn Date 11-22-77
Approved By Date 11/22/77
Written Reply Requested By Date 12/16/77
Corrective Action Requested By Date 12/30/77

Nonconformance Description and Supporting Details:

See attachment.

AEC Reportable Yes ☐ No ☒ See Procedure 9 (For Nuclear Projects Only)

Stop Work Necessary Yes ☐ No ☒ See Procedure 16 - Stop Work No _____

No Hold Tags Applied

Recommended Corrective Action:

See attachment.

[1] **Corrective Action Taken:**

See attachment.

[1] **Verification of Corrective Action Required** Yes ☒ No ☐

[1] **Method of Verification:**

Reviewed letters GLR-12-77-517, GLR-1-78-001 and GLR-01-78-040 from G. L. Richardson to J. L. Corley; letters 216FQA77 and 6FQA78 from J. L. Corley to G. L. Richardson; letters 0-1621 and 0-1651 from J. Newgen to G. Richardson; Bechtel QC Training Session QCFM-4250; and NCR's 1055 and 1094.

[1] **Nonconformance Closure Confirmed By** Donald E. Horn
Date 3-3-78

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[1] To be completed at time of closure by Consumers Power QA Services.

Attachment to NCR No QF-203

Nonconformance Description and Supporting Details:

Project Quality Control Instruction R-1.00, "Material Receiving Instruction" Section 5.2 of Revision 3 and Section 5.1 of Revision 5 states in part, "Requirements for the sampling and testing and the acceptance criteria reference documents shall be noted on the applicable IR" and Section 5.4 of Revision 3 and 5.3 of Revision 5 states, "Review any required user's test data reports to verify that they have been satisfactorily completed".

Part A

QCIR No. R-1.00-1560 for Zone 4A Fine Backfill references User's Test Report No. 0630 and the acceptance criteria as:

Sieve Size	% Passing
1"	100
3/4"	90-100
1/2"	75-90
3/8"	60-85
#200	7-15

Contrary to the above, User's Test Report No. 0630 references 75-100% passing as the acceptance criteria for the 1/2" sieve, consequently 94% passed the 1/2" sieve and it was accepted when actually it failed.

Part B

QCIR No. R-1.00-2105 for Zone 4A Fine Backfill references User's Test Report No. 1036 and the acceptance criteria as:

Sieve Size	% Passing
1"	100
3/4"	90-100
1/2"	75-90
3/8"	60-85
#200	7-15

Contrary to the above, User's Test Report No. 1036 indicated 81% passing the 1/2" sieve and accepted, this should have indicated 91% passing the 1/2" sieve and failed.

Attachment to NCR No QF-203

Nonconformance Description and Supporting Details: (Contd)

Part C

QCIR No. R-1.00-1836 for Zone 4A Fine Backfill references User's Test Report No. 0836 and the acceptance criteria as:

Sieve Size	% Passing
1"	100
3/4"	90-100
1/2"	75-90
3/8"	60-85
#200	12-20

Contrary to the above, User's Test Report No. 0836 had 11% passing the #200 sieve and it was accepted.

Recommended Corrective Action:

Part A & B

1. Present these findings to Bechtel Project Engineering so Project Engineering can determine what additional tests, reviews, etc. are needed to justify the material these tests represent. Have Project Engineering determine the acceptability of the material these failing tests represent.
2. Determine the underlying cause(s) for these discrepancies and take corrective action to preclude repetition in other areas.

Part C

1. An evaluation of this material is not needed because the acceptance criteria as given on QCIR No. R-1.00-1836 was 12-20% passing the No. 200 sieve. It should have been 7-20%, therefore, the test result of 11% is passing.
2. Determine the underlying cause(s) for QC not rejecting the Zone 4A Fine Backfill per the QCIR No. R-1.00-1836 acceptance criteria of 12-20% passing the No. 200 sieve. Review the interface between the material receiving QCE's and the test lab QCE's to determine if there is a breakdown in communicating the inspection criteria for materials being received. Take corrective action to preclude repetition.

File 16.3.4 & 16.3.6
Issue Date November 22, 1977
Project Midland 1 & 2
File Title NCR's on Bechtel
Construction and Quality Control

Attachment to NCR No QF-203

[1]Corrective Action Taken:

Part A & B

1. NCR-1094 was written to identify the nonconforming material in Part A. Project Engineering dispositioned this material "Use-As-Is". NCR-1055 was written to identify the nonconforming material in Part B. Field Engineering has dispositioned this material "Reject For Q-Use". This material was only used in Non-Q Areas.

2. The underlying cause of these conditions was improper review of the test reports by Quality Control. To prevent this condition from recurring, a training session was held with cognizant individuals in attendance.

Part C

1. Based on response given in Part A of letter 0-1621 from J. Newgen to G. Richardson, it was necessary for Field Engineering to justify the more stringent requirements and the use of this material when it did not meet these requirements. The justification was given by Field Engineering.

2. The underlying cause of this condition was that the Civil QC Engineer identified the different gradation requirements on the QCIR and failed to bring it to the attention of the QC Receiving Engineer. To preclude repetition, the cognizant QC engineers in both disciplines were reminded that close interfacing is a necessity.

CONSUMERS POWER COMPANY
RECEIVED
FEB 1 1978
FIELD QUALITY ASSURANCE
MIDLAND, MICHIGAN

Bechtel Power Corporation

Post Office Box 2167
Midland, Michigan 48640

January 31, 1978

JLC
DRK
RGW
PRK
GS
FILE

Consumers Power Company
P. O. Box 1963
Midland, MI 48640

Attention: J. L. Corley

Job 7220 Midland Project
CPCo NCR QF-203 Final
GLR-01-78-040

Dear Mr. Corley:

Ref: 1) Letter J. Corley to G. Richardson, 216FQA77, dated 12/23/77

The following is in response to the above subject nonconformance report which identified problems on user tests for backfill material.

For the material identified in Part A of the subject finding, NCR-1094 was written. This NCR has been dispositioned by Project Engineering as Use-As-Is, and is now closed.

For the material identified in Part B of the subject finding, NCR-1055 was written. This NCR is closed as previously addressed in letter GLR-01-78-001.

For the material identified in Part C of the subject finding the field has provided justification as to why FMRs had stricter requirements than those given by Project Engineering. In letter ~~0-1621~~, dated 1/17/78, Field Engineering stated in part:
0-1651 BML 2/2/78

> The reason for specifying a 12-20% range of aggregate passing through a #200 sieve, when Specification C-210, Rev. 5 and Dwg. C-130, Rev. 6 allowed a range of 7-20%, was strictly for commercial reasons. The vendor said he had a supply of "12-20% material". When this material actually turned out to be 11%, it was still acceptable for use in accordance with our specification and drawing.

This concludes our action on the subject nonconformance report. Should you desire additional information, do not hesitate to bring it to my attention.

Very truly yours,

G. L. Richardson

G. L. Richardson
LEAD QUALITY ASSURANCE ENGINEER

GLR/JGH/sw

Bechtel Power Corporation

Interoffice Memorandum

G. L. Richardson

File No.

Job 7220 Midland Project
FMR Preparation
0-1651

Date January 17, 1973

From J. F. Newgen

Construction

Of Midland, MI

At Ext

References: 1) Ltr. Richardson to Newgen, GLR-12-77-532, dated 12-23-77 (I 8840)
2) Ltr. Corley to Richardson, 216FQA77, dated 12-23-77

This memo is in response to reference 1 and is numbered similarly.

1. Our reason for specifying a 12-20% range of aggregate passing through a number 200 sieve, when Specification C-210, Rev. 5 allowed a range of 7-20%, was strictly for commercial reasons. The vendor said he had a supply of "12-20% material". When this material actually turned out to be 11%, it was still acceptable for use in accordance with our Specification. The only "error" was in dispositioning NCR QF-203 by revising the FMR, rather than noting to "use as is".

2. The intent of our previous response to blank signature blocks on FMR's CY-3171, Rev's 1 & 2, was to point out the following:

   a. Revisions to FMR's for commercial purposes do not fall under the QA program.

   b. Paragraph 3.10.2 of the IJI-1, Rev. 1 limits the necessity of the approval process of FMR revisions to those which address specification changes.

   c. Commercial changes to FMR's are not governed by FPG-3.000.

3. We disagree that a generic problem currently exists in the approval completeness of FMR's. The PFE and APFE's have indicated the frequency of signature omission is neglegible, on "Q" FMR's. Those which have lacked signatures were returned when discovered.

4. The PFE and APFE's have intensified their surveillance of "Q" FMR's to assure the requirements of FPG-8.000 are implemented.

J. F. Newgen

JFN/LFS/re

WLBarclay
WRBird
SHHowell
JMKlacking
BWMarguglio
JFNewgen
GLRichardson
QA SUBJ FILE

Consumers Power Company

QUALITY ASSURANCE PROGRAM

REPORT NO F-77-32

DATE October 3-7, 1977

PLANT: Midland UNIT 1 & 2

SUBJECT OF AUDIT: Soil Placement Records

I. AUDIT SCOPE

The purpose of this record review audit is to verify the documentation associated with the placement of Structural Backfill, North Plant Dike, West Plant Dike, and Plant Area Fill conforms to the specifications and to expedite dike turnover.

II. AUDITORS

***D. A. Blumenthal, CPCo QAE (IE&TV) - Team Member
**D. E. Horn, CPCo QAE Civil Supervisor - Team Leader

III. PERSONNEL CONTACTED

**Ben Cheek, Bechtel Lead Civil Quality Control Engineer
*Keith Berk, Bechtel QCE (QC Vault)
*Pat Guiette, Bechtel QCE (QC Vault)
*Mary Kerridge, Bechtel QC Documentation Clerk
*Jim Miller, Bechtel QC Documentation Lead
*Tom Lieb, Bechtel QCE (Civil)
****Daryl Osborn, Bechtel Assistant Lead Civil QCE
*John Speltz, U.S. Testing Lab Chief

IV. SUMMARY OF AUDIT

A. A Pre-Audit Conference was held on August 31, 1977 in Ben Cheek's office with those in attendance as noted in Sections II and III above. The audit scope was the only item discussed. The audit scope originally was to observe soil placement, however, due to heavy rains and no soil placement in "Q" areas, the audit scope was changed to that given in Section I.

B. The audit was performed on soil reports North Plant Dike MD 72 (5-23-74) through MD 514 (9-21-74), West Plant Dike MD 25 (9-12-74) through MD 307 (9-27-76), Structural Backfill MDR 611 (10-7-76) through MDR 1121 (8-11-77), Plant Area Fill MD 1122 (10-7-76) through MD 1854 (8-12-77) and gradation reports for structural backfill material received February 4, 1977 through August 31, 1977 to assure failing tests have been cleared by passing tests; correct optimum moisture contents, maximum and minimum dry lab densities have been used; the test results were properly evaluated for acceptance; and test reports could be located in the Quality Control Documentation Vault using the attached checklist.

C. The findings associated with this audit are noted in Section V.

*Contacted during Audit
**Attended Pre-Audit Conference and Post-Audit Conference
***Attended Post-Audit Conference
****Contacted during Audit and attended Post-Audit Conference

BY Donald E. Horn DATE 11-4-77
Donald A. Blumenthal 11/4/77
Reviewed by

FILE: [illegible].4.3.4 & 18.4.3.6
DATE: October 3-7, 1977
PLANT: Midland UNIT 1 & 2
SUBJECT OF AUDIT: Soil Placement Records

AUDIT REPORT NO F-77-32

IV. SUMMARY OF AUDIT (Contd)

D. Future audits will be run the same, when scheduled.

E. A Post-Audit Conference was held on October 11, 1977 in Ben Cheek's office with those in attendance as noted in Sections II and III above. The audit findings were presented to those in attendance by D. A. Blumenthal and D. E. Horn. Bechtel QC understood and agreed with the findings and recommended corrective action.

V. CLOSED OUT FINDINGS

Finding 1

West Plant Dike

MD-276 and 277 (sampled 9-15-76), 278 (sampled 9-16-76), and 285 (sampled 9-17-76) have NA in the optimum moisture content column.

North Plant Dike

MD-92 (sampled 5-25-74) shows maximum dry lab density 110.6. It should have been 103.4.

MD-93 (sampled 5-25-74) shows maximum dry lab desnity 110.6. It should have been 103.4.

MD-109 (sampled 5-28-74) shows maximum dry lab density 103.4. It should have been 115.1.

MD-119 (sampled 5-28-74) shows maximum dry lab density 127.2. It should have been 128.0.

MD-155 (sampled 6-4-74) shows optimum moisture content 18.8. It should have been 18.4.

MD-195 (sampled 6-24-74) shows optimum moisture content 11.0. It should have been 11.6.

MD-223 (sampled 6-25-74) shows optimum moisture content 10.3. It should have been 11.6.

MD-224 (sampled 6-25-74) shows optimum moisture content 13.5. It should have been 13.0.

MD-257 (sampled 7-11-74) shows optimum moisture content 9.8. It should have been 10.4. This also shows maximum dry lab density 126.8. It should have been 127.4.

AUDIT REPORT NO F-77-32

V. CLOSED OUT FINDINGS

Finding 1

Plant Area Fill (Contd)

MD-1420 (sampled 6-8-77) gives optimum moisture content of 9.8. It should have been 8.6. It also gives maximum dry lab density of 127.3. It should have been 132.9.

MD-1521 (sampled 6-17-77) gives maximum dry lab density of 117.0. It should have been 117.1.

Corrective Action Requested: Recalculate the test results using the proper values and determine the acceptability of the corrected test results.

Corrective Action Taken: The test results were recalculated and corrections made. The above errors did not change the acceptance of these tests even though they did change the test results.

Corrective action verified October 25-26, 1977.

For further corrective action see Section VI "Open Findings" Finding 1.

Finding 2

Specification C-210, Revision 5 Section 12.6.1 states in part, "The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above optimum moisture content..."

Specification C-210, Revision 5 Section 13.7.1 states, "All cohesive backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by ASTM D 1557, Method D".

Specification C-210, Revision 5 Section 13.7.2 states in part, "All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049..."

Contrary to these requirements, the following tests had failing results and did not indicate being cleared by passing tests.

DATE: October 3-7, 1977
PLANT: Midland UNIT 1 & 2
SUBJECT OF AUDIT: Soil Placement Records

AUDIT REPORT NO F-77-32

V. CLOSED OUT FINDINGS

Finding 2 (Contd)

Plant Area Fill

Test No.	Date Sampled	Compaction	Moisture Actual	Moisture Optimum
MD 1153 ✓	10-21-76	61.6% of Relative Density		
1155 ✓	10-21-76	73.5% of Relative Density		
1191 ✓	11-03-76	74.6% of Relative Density		
1194 ✓	11-02-76	75.4% of Relative Density		
"Q" { 1317	5-09-77		18.0%	15.2%
1318	5-09-77		11.5%	15.2%
1319	5-09-77		11.7%	15.2%
1320	5-09-77		12.2%	15.2%
1321 ✓	5-09-77	94.0% of Maximum Density		
1337 ✓	5-17-77		12.4%	15.2%
1388 ✓	6-02-77		9.8%	15.2%
1393 ✓	6-03-77		11.1%	13.4%
1398 ✓	6-03-77		11.2%	13.4%
1404 ✓	6-03-77		10.2%	13.4%
1415 ✓	6-07-77		9.9%	13.4%
1498 ✓	6-15-77	88.2% of Maximum Density	14.5%	10.0%
1509 ✓	6-16-77		12.9%	15.2%

North Plant Dike

MD 418	8-14-74		17.2%	20.0%

Structural Backfill

MDR 620	10-13-76	72.3% of Relative Density
625 ✓	10-12-76	51.5% of Relative Density
629	10-20-76	79.2% of Relative Density
632	10-20-76	73.5% of Relative Density
637	10-21-76	76.3% of Relative Density
663 ✓	11-11-76	53.0% of Relative Density
664 ✓	11-11-76	72.3% of Relative Density
667 ✓	11-11-76	67.5% of Relative Density
673	11-23-76	33.9% of Relative Density
679	11-23-76	71.8% of Relative Density
680 ✓	11-23-76	60.0% of Relative Density
682 ✓	11-24-76	70.6% of Relative Density
688 ✓	11-24-76	~~77.1% of~~ Relative Density
700	1-13-77	75.0% of Relative Density
701	1-13-77	68.1% of Relative Density
721 ✓	3-14-77	60.0% of Relative Density

FILE: .4.3.4 & 18.4.3.6
DATE: October 3-7, 1977
PLANT: Midland UNIT 1 & 2
SUBJECT OF AUDIT: Soil Placement Records

AUDIT REPORT NO F-77-32

V. CLOSED OUT FINDINGS

Finding 2

Structural Backfill (Contd)

Test No.	Date Sampled	Compaction	Moisture Actual	Moisture Optimum
MDR 734✓	3-17-77	34.0% of Relative Density		
736✓	3-18-77	79.0% of Relative Density		
737✓	3-18-77	41.9% of Relative Density		
738✓	3-18-77	72.4% of Relative Density		
739	3-18-77	70.6% of Relative Density		
740✓	3-18-77	69.3% of Relative Density		
741✓	3-21-77	77.8% of Relative Density		
744✓	3-21-77	56.2% of Relative Density		
746✓	3-21-77	54.9% of Relative Density		
757✓	3-23-77	68.7% of Relative Density		
767	3-29-77	54.3% of Relative Density		
768✓	3-30-77	66.9% of Relative Density		
770–	3-30-77	65.0% of Relative Density		
785✓	4-07-77	69.3% of Relative Density		
799✓	4-12-77	78.8% of Relative Density		
826✓	4-19-77	70.4% of Relative Density		
843✓	4-28-77	66.8% of Relative Density		
845✓	4-29-77	70.4% of Relative Density		
854	5-09-77	67.4% of Relative Density		
861	5-10-77	76.3% of Relative Density		
862	5-10-77	74.0% of Relative Density		
889✓	5-13-77	56.5% of Relative Density		
914✓	5-24-77		9.0%	11.8%
922✓	5-26-77	75.7% of Relative Density		
925✓	5-27-77		11.4%	15.2%
938✓	6-08-77	56.5% of Relative Density		
940✓	6-08-77	78.6% of Relative Density		
993✓	6-25-77	60.2% of Relative Density		
998✓	6-25-77	77.4% of Relative Density		

Corrective Action Requested: Determine if there are passing tests in the same area to clear these failing tests.

Corrective Action Taken: Test reports Plant Area Fill MD 1317-1320; North Plant Dike MD 418; and Structural Backfill MDR 620, 629, 632, 637, 673, 679, 700, 701, 757, 767, 768 ~~and 770~~ have been cleared by passing tests and Structural Backfill represented by MDR 854, 861 and 862 was removed.

Corrective Action Verified October 26, 1977.

V. CLOSED OUT FINDINGS

Finding 2 (Contd)

Corrective Action Taken: Test reports Plant Area Fill MD 1153, 1155, 1191, 1194, 1321, 1337, 1388, 1393, 1398, 1404, 1415, 1498, 1509 and Structural Backfill MDR 625, 663, 664, 667, 680, 682, 688, 721, 734, 736-741, 744, 746, 757, 768, 770, 785, 799, 826, 843, 845, 889, 914, 922, 925, 938, 940, 993 and 998 are in a "Non-Q" area and have been given to CPCo Project Management Organization (Field) for resolution in letter 186FQA77.

For further corrective action see Section VI "Open Findings" Finding 2.

Finding 3

Relative Density Reports 59 and 61 were missing from the QC Vault.

Corrective Action Requested: Obtain copies of these reports and place them in the QC Vault.

Corrective Action Taken: Copies have been obtained and placed in the QC Document Vault.

Corrective action verified October 26, 1977.

VI. OPEN FINDINGS

Finding 1

Specification C-210, Revision 5 Section 12.6.1 states in part, "The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above moisture content..."

Specification C-210, Revision 5 Section 13.7.1 states, "All cohesive backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by ASTM D 1557, Method D".

Specification C-210, Revision 5 Section 13.7.2 states in part, "All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049..."

Contrary to these requirements, the following tests had been passed using incorrect testing data. ~~Using~~ the correct testing data, the tests fail.

FILE: .4.3.4 & 18.4.3.6
DATE: October 3-7, 1977
PLANT: Midland UNIT 1 & 2
SUBJECT OF AUDIT: Soil Placement Records

AUDIT REPORT NO F-77-32

VI. OPEN FINDINGS

Finding 1 (Contd)

North Plant Dike

MD 290 (sampled 7-16-74) shows optimum moisture content 11.6. It should be 9.5. Using the correct optimum moisture content of 9.5%, the actual moisture content is 2.2% above optimum moisture content.

MD 360 (sampled 7-31-74) shows optimum moisture content as 21.4. It should be 15.2. This also shows maximum lab dry density as 103.2. It should be 115.1. Using the correct optimum moisture content of 15.2%, the actual moisture content is 5.4% above optimum moisture content. Also using the correct maximum lab dry density of 115.1, the correct percent of maximum density is 86.4%.

MD 377 (sampled 8-6-74) shows optimum moisture content as 18.0. It should be 15.2. Using the correct optimum moisture content of 15.2%, the actual moisture content is 4.5% above optimum moisture content.

Structural Backfill

MDR 621 (sampled 10-14-76) shows minimum dry lab density as 94.2. It should be 112.2. Using the correct minimum dry lab density of 112.2, the correct percent of relative density is 41.5.

Corrective Action Requested:

(1) Determine if there are passing tests in the same area to clear these failing tests.

(2) If these failing tests cannot be cleared by passing tests in the same area, present these findings to Bechtel Project Engineering so Project Engineering can determine what additional tests, reviews, etc. are needed to justify the material these tests represent. Have Project Engineering justify the material these failing tests represent.

(3) Determine the underlying cause(s) and take corrective action to preclude repetition.

Corrective Action Taken:

(1) North Plant Dike MD 290 and MD 377 have been identified on Bechtel NCR 1005. North Plant Dike MD 360 and Structural Backfill MDR 621 density problems have been identified on Bechtel NCR 1004.

Corrective action verified October 26, 1977.

North Plant Dike MD 360 moisture problem has been identified on revised NCR 1005.

Corrective action verified October 28, 1977.

VI. OPEN FINDINGS

Finding 1 (Contd)

NCR QF-199 has been written to resolve the corrective action still open.

Finding 2

Specification C-210, Revision 5 Section 12.6.1 states in part, "The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above optimum moisture content..."

Specification C-210, Revision 5 Section 13.7.1 states, "All cohesive backfill in the plant area and the berm shall be compacted to not less than 95 percent of maximum density as determined by ASTM D 1557, Method D".

Specification C-210, Revision 5 Section 13.7.2 states in part, "All cohesionless backfill in the plant area and the berm shall be compacted to not less than 80 percent of relative density as determined by ASTM D 2049".

Contrary to these requirements, the following tests had failing results and did not indicate being cleared by passing tests or had been marked passing.

North Plant Dike

MD 142 (sampled 5-30-74) shows optimum moisture content 8.0, moisture content 10.3. This test failed but it is shown as passing.

MD 143 (sampled 5-30-74) shows optimum moisture content 13.8, moisture content 11.4. This failed but it is shown as passing.

West Plant Dike

MD 227 (sampled 10-6-75) failed moisture but has not been cleared.

Plant Area Fill

Test No.	Date Sampled	Compaction	Moisture	
			Actual	Optimum
MD 1311	5-03-77	61.6% of Relative Density		
1326	5-10-77		18.5%	15.2%
1328	5-10-77		12.2%	15.2%
1412	6-07-77		10.4%	15.2%

VI. OPEN FINDINGS

Finding 2 (Contd)

Structural Backfill

Test No.	Date Sampled	Compaction	Moisture Actual	Moisture Optimum
MDR 621	10-14-76	78.0% of Relative Density		
671	11-12-76	74.8% of Relative Density		
672	11-23-76	75.4% of Relative Density		
685	11-24-76	56.2% of Relative Density		
686	11-24-76	70.9% of Relative Density		
691	11-24-76	62.0% of Relative Density		

Corrective Action Requested:

(1) Determine if there are passing tests in the same area to clear these failing tests.

(2) If these failing tests cannot be cleared by passing tests in the same area, present these findings to Bechtel Project Engineering so Project Engineering can determine what additional tests, reviews, etc. are needed to justify the material these tests represent. Have Project Engineering justify the material these failing tests represent.

(3) Determine the underlying cause(s) and take corrective action to preclude repetition.

Corrective Action Taken:

(1) Bechtel QC has determined that none of the above have passing tests in the same area to clear the failing tests.

(2) North Plant Dike MD 142 and MD 143, West Plant Dike MD 227 and Plant Area Fill MD 1326, 1328 and 1412 have been identified on Bechtel NCR 1005. Structural Backfill MDR 621, 671, 672, 685, and 686 have been identified on Bechtel NCR 1004.

(3) Corrective action has been taken as of the last of July, 1977 by Bechtel QC and U.S. Testing to more adequately clear failing tests. Therefore, the corrective action to preclude repetition for not clearing failing tests need ~~not be~~ addressed.

Corrective action ~~verified~~ October 26, 1977

Plant Area Fill MD 1311 has been identified on revised NCR 1004.

Corrective action verified November 1, 1977.

NCR QF-199 has been written to resolve the corrective action still open.

VI. OPEN FINDINGS (Contd)

Finding 3

Specification C-211 Revision 3 Section 5.6.2 states in part, "Material delivered to the jobsite for use as structural backfill shall be visually inspected, and tested in accordance with ASTM C-136..."

ASTM C136-71 Section 4.2 states in part, "In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weigh more than 4g/in.^{2} of sieving surface.

Note 2 - This amounts to 200g for the usual 8 in. (203-mm) diameter sieve".

To preclude repetition to NCR QF-152 (the same deficiency as this), U.S. Testing developed a new gradation form that has check points that include documenting that the 200 gram material limit on any individual 8 inch sieve has not been exceeded. In addition, a training session was held on February 21, 1977.

Project Quality Control Instruction No. SC-1.05 "Material Testing Services and Concrete Production" Rev. 3 Section 2.7.2 Reports, Item A states, "Perform a daily review of the subcontractor's jobsite inspection and test reports for acceptability, completeness, and the laboratory chief's signature for concrete, steel, and soils. Sign and date on the report verifying the acceptable status".

Contrary to these requirements:

Structural Backfill Log Number	Date Sampled	Amount Retained
G- 270	1-13-77	#40 Sieve - 225.2g
0364	4-27-77	#10 Sieve - 217.1g
0417	5-11-77	#10 Sieve - 221.4g
0431	5-16-77	#10 Sieve - 260.1g
0451	5-18-77	#10 Sieve - 211.7g
0505	6-02-77	#200 Sieve - 228.0g
0704	7-18-77	#10 Sieve - 249.5g

Corrective Action Requested:

(1) Present these findings to Bechtel Project Engineering and obtain engineering rationale from Bechtel Project Engineering as to the acceptability of the material these tests represent.

(2) Evidently the corrective action taken in NCR QF-152 was not adequate. Determine the underlying cause(s) and take further corrective action to preclude repetition.

AUDIT REPORT NO F-77-32

VI. OPEN FINDINGS

Finding 3 (Contd)

Corrective Action Taken:

(1) These findings have been identified on Bechtel NCR 1006.

Corrective action verified October 26, 1977.

NCR QF-195 has been written to resolve the corrective action still open.

VII. NONCONFORMANCE REPORTS

QF-195
QF-199

WRBird J[illegible]holly
JMKlacking
JFNewgen
GLRichardson
HWSlager

QA SUBJ FILE

Power Company
QUALITY ASSURANCE PROGRAM

REPORT NO F-77-21

DATE: May 23, & June [illegible], 10, 197

PLANT: Midland UNIT 1 & 2

SUBJECT OF AUDIT: Soils Placement and Inspection

I. AUDIT SCOPE

The purpose of this audit is to verify that soils placement and inspection are being accomplished in accordance with Bechtel's procedures, specifications and codes.

II. AUDITOR

G. B. Johnson, CPCo Field Quality Assurance Engineer (Civil)

III. PERSONNEL CONTACTED

**Ben Cheek, Bechtel Lead Civil Quality Control Engineer
*Daryle Osborn, Bechtel Quality Control Engineer (Civil)

IV. SUMMARY OF AUDIT

A. A Pre-Audit Conference was held on May 23, 1977 at Daryle Osborn's desk with those in attendance as noted in Sections II and III above. The audit scope was the only item discussed.

B. The audit was performed on the placement and inspection of zone 2 material in the plant area South of the Turbine Building at elevations 620' - 622'. The backfilling operation was centered around plant coordinates S 5070 and E 360. The attached checklist was used.

C. The soils placement and inspection seemed adequate except as described in Section V of this report.

D. Future audits will be run the same, when scheduled.

E. A Post-Audit Conference was held on June 16, 1977 in Ben Cheek's office with those in attendance as noted in Sections II and III above. The Post-Audit Conference consisted of telling Ben Cheek and Daryle Osborn that the results of this audit were adequate except for Findings #1 & #2 in Section V.

CLOSED OUT

V. FINDINGS

Finding #1

Bechtel Specification 7220-C-210, Rev. 4, Section 12.6.1, states in part:

> The water content during compaction shall not be more than 2 percentage points below optimum moisture content and shall not be more than 2 percentage points above optimum moisture content. . . .

*Attended Pre-Audit Conference and Post-Audit Conference
**Attended Post Audit Conference

BY Gary B. Johnson DATE 5 July 77 SHEET 1 OF 3

[illegible] 1-25-78

File: .4.3.4, 13.4.3.
Date: May 25, & June 8, 9, 10, 1977
Plant: Midland 1 & 2
Subject of Audit: Soils Placement and Inspection

Report No F-77-21

CLOSED OUT

V. FINDINGS

Finding #1 (Contd)

Contrary to These Requirements:

> Backfill was placed on a lift which was determined to be greater than 2% below optimum moisture content (Plant Backfill Test #1352, optimum 15.2%, actual 12.8%). When questioned, the Foreman directing the soils work stated that he would continue backfilling since satisfactory compaction had been obtained.

Recommended Corrective Action:

1. The Foreman directing the soils work should be instructed as to the required moisture content limits.
2. Bechtel QC should determine if a re-test had been accomplished on the lift in question. If a re-test had not been accomplished, it will be necessary to obtain one. If the affected material is found to be nonconforming, an evaluation will have to be made as to the acceptability of the in-place material by Project Engineering.

Corrective Action Taken:

1. Bechtel QC informed the foreman directing the soils work of the required moisture content limits and what to do if a failing test occurs.
2. A retest was taken in the area and the retest passed (Plant Backfill Test 1414).

Finding #2

Bechtel Specification C-208, Rev. 10, Table 9-1, states in part:

> Field Densities and Moisture Contents will be taken at the frequency of one test per every 500 cubic yards of fill.

Contrary to These Requirements:

> During the audit it was discovered that the Foreman directing the soils work believed that the required frequency for testing of field density and moisture content was one test per 1000 cubic yards of fill.

Recommended Corrective Action:

1. The foreman directing the soils work should be instructed as to the correct test frequency requirements.

Plant: [illegible]dland 1 & 2
Subject of Audit: Soils Placement and Inspection

Report No F-77-21

CLOSED OUT
V. FINDINGS

Finding #2 (Contd)

Recommended Corrective Action: (Contd)

2. Bechtel QC should determine if the 1/500 cy test frequency has been exceeded. If the test frequency has been exceeded, an evaluation will have to be made as to the acceptability of the in-place material by Project Engineering.

Corrective Action Taken:

1. Bechtel QC informed the foreman directing the soils work of the correct test frequency requirements.
2. Bechtel QC made an evaluation concerning the frequency of testing in the affected area. It was determined that between 5/13/77 and 6/17/77, 18,200 cy of random backfill was placed South and East of the Turbine Building. 57 tests were taken on this material which results in an overall test frequency of 320 cy/test. The majority of this 18,200 cy was placed in a NON-Q area.

VI. NONCONFORMANCE REPORTS

None

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.Kane
Advance copy was
rec'd @ Oct 1, 1981
Meeting w/CPCo

Consumers
Power
Company

James W Cook
*Vice President - Projects, Engineering
and Construction*

General Offices: 1945 West Parnell Road, Jackson, MI 49201 • (517) 788-0453

September 30, 1981

RECEIVED
OCT 22 1981
U.S. NUCLEAR REGULATORY COMMISSION

Harold R Denton, Director
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND PROJECT
DOCKET NOS 50-329, 50-330
SUBMITTAL OF THE AUXILIARY BUILDING
DYNAMIC MODEL, SERVICE WATER PUMP
STRUCTURE DYNAMIC MODEL AND DESCRIPTION OF SOILS
SETTLEMENT REMEDIAL FIX FOR THE AUXILIARY BUILDING
FILE 0485.16, B3.0.1 SERIAL 14110
REFERENCES: (1) JWCook Letter to HRDenton, Serial 11625 Dated March 23, 1981
(2) JWCook Letter to HRDenton, Serial 13738 Dated August 26, 1981
ENCLOSURES: (1) Service Water Pump Structure Seismic Model
(2) Auxiliary Building Seismic Model
(3) Technical Report on Underpinning the Auxiliary Building and Feedwater Isolation Valve Pits

In our previous correspondence of August 26, 1981 (Reference 2) construction permit level design information relating to the remedial actions for the service water pump structure was provided to the staff. Enclosed are twenty-five (25) copies of the report (Enclosure 1) entitled "Service Water Pump Structure Seismic Model" which is based upon the design information already forwarded to the NRC. In addition, we are providing twenty-five (25) copies each of two reports, Enclosures 2 and 3. Enclosure 2 describes the seismic model for the auxiliary building for computing the building response to seismic loading as well as to generate instructure response spectra. Enclosure 3 represents the construction permit level of design information for the auxiliary building remedial actions. All three of the enclosed documents are provided to complete commitments contained in the "Statement of Agreement" from the ASLB Prehearing Conference Order of May 5, 1981.

The seismic model reports for the service water pump structure and the auxiliary building include the following information: (1) model description, (2) soil-structure interaction considerations; (3) the dynamic model properties; and (4) fundamental frequencies and mode shapes. The auxiliary building model includes full underpinning of the control tower and electrical penetration areas, integrally tied to the main auxiliary building at Column Line H. The service water pump structure model includes full underpinning of the northern

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S 1/25

portion of the building originally supported by the fill. The models reflect the underpinning currently planned and, therefore, are subject to possible revision after the final building structural analysis and NRC staff review is completed. We believe that the enclosed reports combined with our scheduled meeting with the staff during the week of September 30, 1981 provides sufficient information to permit the NRC to review and provide its concurrence with the proposed remedial actions. Your expeditious review and approval would be most appreciated to support the hearings and construction of the remedial work.

for JW Cook

JWC/RLT/bh

CC Atomic Safety and Licensing Appeal Board, w/o
   CBechhoefer, ASLB, w/o
   MMCherry, Esq, w/o
   RJCook, Midland Resident Inspector, w/o
   RSDecker, ASLB, w/o
   DHood, NRC, w/a (2)
   DFJudd, B&W, w/o
   JDKane, NRC, w/a
   FJKelley, Esq, w/o
   RBLandsman, NRC Region III, w/a
   WHMarshall, w/o
   WOtto, US Army Corps of Engineers, w/a
   WDPaton, Esq, w/o
   FRinaldi, NRC, w/a
   HSingh, Army Corps of Engineers, w/a
   BStamiris, w/o
   FPCowan, w/o

BCC RCBauman/TRThiruvengadam, P-14-400, w/a
WRBird, P-14-418A, w/a
JEBrunner, M-1079, w/a
AJBoos, Bechtel, w/a
WJCloutier, P-24-611, w/a
BDhar, Bechtel, w/a
BFHenley, P-14-100, w/a
RWHuston, Washington, w/a
GSKeeley, P-14-113B, w/a
DBMiller, Midland, w/a
MIMiller, IL&B, w/a
KBRazdan, P-13-220, w/a
JARutgers, Bechtel, w/a
SLSobkowski, Bechtel, w/a
TJSullivan/DMBudzik, P-24-517, w/o
NRC Correspondence File, w/a

1/B5

J. Kane
Rec'd 10/1/81
in meeting w/ CPCo

TECHNICAL REPORT ON UNDERPINNING
THE AUXILIARY BUILDING AND FEEDWATER ISOLATION VALVE PITS
FOR
MIDLAND PLANT UNITS 1 AND 2
CONSUMERS POWER COMPANY
DOCKET NUMBERS 50-329 AND 50-330

Encl. 3 to Sept. 30, [illegible] Dent[illegible])

~~8110220353~~ 28 pp.

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MIDLAND PLANT UNITS 1 AND 2 TECHNICAL REPORT ON UNDERPINNING THE AUXILIARY BUILDING AND FEEDWATER ISOLATION VALVE PITS

TABLE OF CONTENTS

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TABLE OF CONTENTS (continued)

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TABLE OF CONTENTS (continued)

FIGURES

MIDLAND PLANT UNITS 1 AND 2
TECHNICAL REPORT ON UNDERPINNING THE AUXILIARY BUILDING AND FEEDWATER ISOLATION VALVE PITS

1.0 INTRODUCTION

This report describes the design and construction requirements of the remedial action for the auxiliary building and feedwater isolation valve pits (FIVPs) necessitated by the settlement potential of the plant fill underlying the structure.

2.0 PRESENT CONDITION

The auxiliary building is located between the two containment buildings (Figure 1). The auxiliary building contains the control room, access control room, cable spreading rooms, engineered safeguard systems, switchgear equipment, and the facilities for fuel handling, storage, and shipment. The physical characteristics of the building are diverse because of its many functions. Exterior walls, the spent fuel pool, and some of the interior walls are constructed of reinforced concrete. The reinforced concrete floor and roof slabs are supported by walls, steel beams, and columns. (See FSAR Figures 3.8-51 through 3.8-54)

The FIVPs are symmetrically located at the sides of each containment building and are adjacent to the auxiliary building, electrical penetration area, turbine building, and the buttress access shaft. Each pit is C-shaped with the open end in contact with, but structurally separate from, the containment building. Primarily, the pits enclose the Seismic Category I feedwater pipe isolation valves.

Parts of the auxiliary building are founded on plant area fill: the railroad bay on the north side, the eletrical penetration areas for Units 1 and 2, and the control tower on the south side. The rest of the auxiliary building is founded on natural soil. The FIVPs for both Units 1 and 2 are founded on plant fill. Figures 1 and 2 show the layout of the auxiliary building foundation, including the areas of plant fill.

After discovering settlement of the plant fill under the diesel generator building, an investigation of the plant fill revealed some areas of inadequately compacted fill under the electrical penetration areas and FIVPs.

3.0 REMEDIAL ACTION

To adequately support the structure under all design load conditions, a continuous underpinning wall resting on undisturbed natural material is provided under the control tower and the electrical penetration area exterior walls. A similar wall is provided under the FIVPs. The underpinning wall provides the necessary vertical and horizontal support to the affected part of the structure. To ensure adequate load transfer, the existing

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structure is jacked against the underpinning walls (see Figures 3, 4, and 5).

4.0 DESIGN FEATURES

The details of the underpinning are provided in Figures 3, 4, and 5. The design features with appropriate dimensions are described as follows. The proposed underpinning for the Unit 1 and 2 penetration areas is a 6-foot thick, reinforced concrete wall that is 38 feet high and is belled out to 10 feet thick to limit bearing pressures to the allowable values. The underpinning walls under the control tower are 6 feet thick, 47 feet high, and are belled out to 14 feet thick. Similarly, the underpinning walls under the FIVPs are 4 feet thick, 38 feet high, and are belled out to 6 feet thick (see Figures 3, 4, and 5 for details). The walls are constructed to act as a continuous member under the perimeter of the structures. The entire wall system will be founded on undisturbed natural material. The allowable bearing pressures for the undisturbed natural material are based on safety factors of 2 for dynamic loading and 3 for static loading.

What is it? How established? How long will it be held

Design jacking force is applied to the existing structure to provide adequate load transfer from the structure to the underpinning. The jacking force is determined so the structure is not unduly stressed under dead load and live load conditions. These jacking forces are transmitted from the structure through the permanent underpinning wall to the bearing stratum. Preliminary details of jacking forces are shown in Figures 3, 4, and 5.

Give details

Dowels connect the underpinning walls and the existing structure at the vertical and horizontal interfaces. The dowels are designed to transfer shear and tension forces between the structure and the underpinning wall.

In addition to the conventional lap splices, Fox Howlett mechanical, tapered thread splices may be used for reinforcing the underpinning walls. These tapered thread splices shall conform to the requirements of Section III, Division 2 of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, 1980 Edition, 1980 and 1981 Summer Addenda.

5.0 CONSTRUCTION

This section addresses construction groundwater control, building post-tensioning, temporary supports, construction details, instrumentation, load transfer, load sensing, and corrective measures.

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5.1 CONSTRUCTION GROUNDWATER CONTROL

To construct the underpinning, the FIVPs and electrical penetration and control tower areas are dewatered.

The construction groundwater control consists of three parts:

a. Permanent wells to maintain the groundwater at el 595

Q.4 b. A frozen earth cutoff membrane to prevent recharge to the underpinning area

c. Supplemental internal predrainage wells to remove the residual water within the cutoff wall

The soil particle monitoring acceptance criteria for the permanent wells have been accepted by the NRC staff. The acceptance criteria for the supplemental internal predrainage wells is that the effluent has less than 10 ppm of soil particles larger than 0.05 millimeters. For further details regarding construction groundwater control, refer to Appendix B.

Q.3 —.005 mm for long term pumping

5.2 BUILDING POST-TENSIONING

Q.5 Construction site dewatering removes the buyoyancy force under the FIVPs and electrical penetration areas. To compensate for this effect, an existing temporary post-tensioning system applies a compressive force to the upper part of the east-west walls of the electrical penetration areas as shown in Figure 7. The post-tensioning system will be removed after initial jacking loads are applied under the penetration areas.

5.3 TEMPORARY SUPPORTS

Presently, the FIVPs are temporarily supported as shown in Figure 8 by rock bolts and tension rods from the steel grillage beams spanning the buttress access shaft and the turbine building walls. These temporary supports will be removed after the valve pits are underpinned.

5.4 CONSTRUCTION DETAILS

Refer to Appendix C for construction details.

5.5 INSTRUMENTATION, LOAD TRANSFER, LOAD SENSING, AND CORRECTIVE MEASURES

Instrumentation is provided to detect building and pier movements during construction, permanent load transfer, and corrective measures. The details are given in Appendix D.

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5.6 ACCEPTANCE CRITERIA FOR BEARING STRATUM

The quality of the clay till as bearing material will be initially assessed by using the WES penetrometer (Type CN 973). This device consists of a hand-held, cone penetrometer with a shaft whose area is equal to precisely 1/2 sq in. and whose bottom end is tapered with a 30° cone. A load is applied through a proving ring at the top with a dial gage which reads as pressure intensity in the full cross-section of the shaft. That is, the dial gage reading gives the pressure applied through the shaft to the soil in psi, which is exactly double the force applied through the proving ring. The maximum foce that can be placed through the proving ring is 150 pounds total or 300 psi in the shaft cross-section.

Q.6 The correlations presented in this appendix relate pressure read by the proving ring in psi and penetration of the pointed cone with bearing capacity for a strip footing. The failure bearing capacity factors utilized are nine times shear strength for the cone, 5.7 for the strip footing, a safety factor of 3, and assume a $\phi = 0$ soil.

The cone will be painted in 1/4-inch wide bands with high visibility colors. Several readings will be taken of the force required to make penetrations of the cone to various depths in the soil. From this, using the calibration curves (see Figure 9), the bearing quality of the subgrade can be evaluated. This helps the resident geotechnical engineer judge by his visual inspection when the underpinning excavation has reached clay till of the bearing quality described in Subsection 7.2.1.

Q.7 More decisive information is expected to be obtained from the application of jacking loads to the individual piers for the temporary support of the two penetration structures. Settlement of these piers will be measured by a dial gage as the jacking load is applied in stages. From the observed load and settlement values, an equivalent soil modulus will be computed utilizing the conventional relationships in elastic theory. This modulus value will then be applied to a confirming analysis of the permanent underpinning wall to ensure that the combination of final bearing pressure bearing area and embedment will limit settlement to tolerable values for the structure.

6.0 MONITORING REQUIREMENTS

Q.8 During construction, the underpinning of the existing structure is monitored for settlement and crack propogation, and the existing structure is monitored for differential settlement. The long-term surveillance program of the building after the underpinning is constructed is being evaluated.

1/B5

6.1 SETTLEMENTS

6.1.1 Monitoring Structures

The elevations of settlement markers attached to the structure are measured and recorded according to a schedule based on construction procedures. Based on these readings, the absolute and differential settlement values are calculated. The acceptance criteria for the absolute settlement values are established based on the requirements of various interconnected piping systems and geotechnical considerations. The acceptance criteria for the differential settlement are based on the structure's ability to withstand the loading due to differential settlement in combination with stresses from other loads. The acceptance criteria for the differential and absolute settlement and the frequency of measurement will be established before the Q.9 start of the underpinning work.

6.1.2 Monitoring Underpinning

During jacking operations, the underpinning will be monitored for Q.9.a movements. The procedure for this monitoring is being developed. An acceptance criteria for this movement will be established before beginning underpinning, based on the expected loads due to jacking and geotechnical properties of the foundation material.

6.2 CRACKS

Existing or new cracks appearing during the underpinning construction will be monitored. Because of the sequence of construction procedures, it is not anticipated that existing cracks will significantly widen or that significant new cracks will appear. However, any new structural cracks or changes in existing structural cracks exceeding 0.01 inch will be evaluated Q.10 and if any crack widths reach 0.03 inch, construction in the affected area will be modified or suspended until the reasons for excessive cracking are established and appropriate remedial measures are implemented.

6.3 CONSTRUCTION GROUNDWATER

Q.6 Groundwater measurements will be taken at the existing observation wells and/or piezometers located outside and within the influence of the freeze wall. Measurements will be taken at least daily after the freeze wall is installed. Instrumentation to monitor ground temperature and the rate of frost penetration will also be installed (such as thermistors; multi-sensor, copper, constantan thermocouples, flouroscene frost penetration markers, etc). These systems will be monitored closely during freezing of the elements and on a routine basis during the underpinning. Each freeze unit and coolant pipe distribution

JK
— Identify items
Indicate GWT
which would
allow start of
underpinning
& level required
evaluation on
[illegible]
[illegible]

1/B5

system will be visually inspected periodically during underpinning operations.

7.0 ANALYSIS AND DESIGN

The auxiliary building and FIVPs were originally designed in accordance with Final Safety Analysis Report (FSAR) requirements for Seismic Category I structures. A preliminary analysis of the underpinned structure is in progress. The seismic loads used in this analysis were obtained from a preliminary seismic analysis of the auxiliary building. These loads incorporate the effects of the underpinning.

7.1 DESCRIPTION OF ANALYTICAL MODELS

A description of the mathematical seismic model is being submitted separately to the NRC. A description of the static, three-dimensional, finite element model of the structure is given in Appendix A.

7.2 SOIL PARAMETERS

7.2.1 Bearing Capacity

The present approach to selecting allowable bearing pressures on the various underpinning elements is based on FSAR shear strength data as modified by the recent exploration and testing by Woodward-Clyde and Consultants (WCC). Strength test data (Reference 1) are summarized in the Consumers Power Company letter (Reference 2) of September 22, 1981, to the NRC.

The allowable bearing capacity commitment in FSAR Subsection 2.5.4.10.1 for the foundation design requires a safety factor of 3 against dead load plus sustained live load and a safety factor of 2 for the above loads plus the seismic load. For the strip footing, which represents the mode of load application for the continuous underpinning piers, the bearing capacity factor (Nc) in Ø = 0 foundation soil ranges between 6 and 7 depending on the depth of embedment in the natural soils. Q10a Choosing a bearing capacity factor (Nc) of 6 and the average shear strength (Su) of 6.6 ksf for a typical condition where embedment equals half the width of the underpinning piers, an ultimate bearing capacity can be calculated. This ultimate bearing capacity equals Nc x Su, which is approximately 40 ksf. The allowable bearing pressure under sustained loads thus equals 40/3 or 13.3 ksf. The ultimate bearing capacity under sustained loads using an undrained shear strength of 6 ksf from FSAR Figure 2.5-33 is 36 ksf resulting in an allowable bearing capacity of 36/3 or 12 ksf. Similarly, the corresponding allowable bearing capacity values for the seismic condition are 20 ksf and 18 ksf using the average shear strength based on WCC tests and the design values presented in FSAR Figure 2.5-33. It

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is evident from the foregoing discussion that the allowable bearing capacity based on the average shear strength obtained from the tests are higher than the conservative values based on FSAR shear strength data.

Support of both temporary and permanent underpinning elements will be in undisturbed, unweathered, clay till whose suitability will be judged by the procedures outlined in Section 5.6. The bearing characteristics of the underpinning units can be summarized as follows based on currently available loading information.

Unit	Applied Bearing Pressure (ksf)	Safety Factor	Approximate Elevation of Bearing
Temporary piers for penetration building	20	2.0	562 to 568
Permanent wall for penetration building	6.8	5 to 6	571
Permanent wall for control tower	8.8	4 to 4-1/2	562

Note: Bearing pressure is for dead load, sustained live load, and net weight of the underpinning elements. In case of dead, live, and seismic loads, the allowable bearing capacity will be 20 ksf, giving a safety factor of 2 based on the recent WCC investigation.

Distinctly conservative bearing pressures have been chosen for the permanent underpinning design because of the necessity of providing essentially unyielding support after the lock-off of the jacking load. The test jacking of the individual piers for temporary underpinning is expected to demonstrate the suitability of the load condition of the permanent units. The higher bearing pressures applied to the temporary piers will be judged satisfactory if the settlement rate reaches a straight line trend on a semi-log time plot approximately 2 days after the jacking load reaches a peak value, and the final rate of settlement does not exceed the criteria given in Appendix D. Q.11

7.2.2 Soil Deformation Modulus

Undrained E values were studied by WCC, employing controlled rebound-reload cycles in the undrained triaxial tests. Four such Q.12 tests yielded a median value of secant modulus of elasticity of about 3,500 ksf, roughly 500 times the median undrained shear strength. This corresponds closely to the equivalent undrained E value interpreted from the Dames and Moore tests between el 560 to 580. The E value which can be computed from the actual observed settlement in the latter stages of the reactor construction are somewhat larger than the laboratory test values and range from about 5,000 to 6,000 ksf.

This is expected because the large size of the reactor foundation stresses the clay till to a great depth, generally in excess of 100 feet below the reactor bearing level. This engages till with high residual, horizontal stress whose effective E value probably increases with depth in the same manner.

—[illegible] [illegible] [illegible] Tower 14

For the underpinning units whose narrow dimension in plan is only 10 feet, the seat of settlement is much shallower than that of the reactor structures. Consequently, the E value selected should be closer to the laboratory test values than to the interpreted E value for the reactor. We have conservatively selected an E value of 3,000 ksf for the analysis presented in Subsection 7.2.2 to compute the anticipated settlement of the underpinning units. The E value used in the dynamic analysis is presented in Auxiliary Building Seismic Model (Reference 4).

7.2.3 Settlement of Underpinning Units

Employing an E value of 3,000 ksf, preliminary estimates of settlement were made for each of the three underpinning units described in Subsection 7.2.1. The methods of analysis are based on simple theory of elasticity and summarized in NAVFAC Design Manual DM-7 (Reference 3), which include the influence of size and shape of the loaded area and depth of embedment of the piers or walls within the clay till bearing stratum. The settlement values tabulated below include time-delayed movements, which occur slowly in the form of secondary compression. These latter values are expected to be about one-fifth of the total computed settlement.

Figs 11-3 & 11-9

		Preliminary Estimated Settlement		
Unit	Applied Bearing Pressure (ksf)	Total (in.)	During Jacking (in.)	After Jacking (Long Term) (in.)
Temporary piers for penetration building	20	1.0	0.8	0.2 (1 yr ±)
Load transfer points for temporary load to reactor footing	2,300 k and 3,000 k	0.3	0.2	0.1 (1 yr ±)

See Fig. 10 of App. C

Q. 13a
-how established?
effect on reactor [illegible] [illegible]

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Unit	Applied Bearing Pressure (ksf)	Preliminary Estimated Settlement: Total (in.)	During Jacking (in.)	After Jacking (Long Term) (in.)
Permanent wall for penetration building	6.8	0.6	0.4	0.2 (40 yr)
Permanent wall for control tower	8.8	0.9	0.6	0.3 (40 yr)

In general, it is anticipated that the jacking load for permanent underpinning would be applied in stages over several days and the peak value maintained for 90 days after reaching the peak. Satisfactory completion of the jacking is expected to be indicated by a final straight line trend on a semi-log plot of settlement versus time. We have conservatively selected an E value of 3,000 ksf for the analysis presented in Subsection 7.2.2 to compute the anticipated settlement of the underpinning. The settlement increment in the last 30 days of sustained load should not exceed 0.05 inch, and not more than 0.01 inch in the final 10 days of the jacking period.

7.2.4 Differential Settlement Between Existing Walls and Underpinning

?.7.2.3

Of the estimated settlements listed in Subsection 7.2.2, only those occurring after lock-off of the jacking loads will be involved in creating differential settlements within the auxiliary building structural frame. The purpose of the final jacking operation is to ensure that all but the very gradually occurring time-delayed settlement is completed while the structure is maintained in an undeflected position. Thus, the settlement of particular interest is the long-term value for the south underpinning wall of the control tower, which is estimated as somewhat less than 1/4 inch. Differential settlement between the control tower area and the penetration areas will be less than 1/4 inch. This will be compared to the predicted settlement of the nonunderpinned block of the auxiliary building. The respective values will be employed in the analysis of the effects of the predicted settlement pattern.

7.3 DESIGN CRITERIA AND APPLICABLE CODES

The underpinning structure is designed as a Seismic Category I structure in accordance with FSAR Section 3.8.

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7.4 CONSTRUCTION CONDITION

7.4.1 Structural Behavior

During construction, the control tower and the penetration areas will be supported by a combination of jacking loads and the existing material. As construction proceeds, the soil support will be replaced by the jacking loads. This will be simulated by appropriate boundary conditions in the finite element model.

7.4.2 Boundary Conditions

For boundary conditions, refer to Appendix A.

7.4.3 Loads and Load Combinations

Dead load, live load, external hydropressures, soil pressures, wind loads, and jacking loads will be investigated. The structure will also be checked for sliding and overturning.

7.4.4 Acceptance Criteria

The acceptance criteria for the temporary condition will be in accordance with American Concrete Institute (ACI) 318-71 except that a stress increase factor of 1.33 for the structure will be used.

7.5 PERMANENT CONDITION

7.5.1 Structure Behavior

The vertical loads of the control tower, electrical penetration areas, and FIVPs are transmitted to the foundation medium through the underpinning wall bearing area. The lateral forces due to seismic and tornado loads in the east-west direction for the control tower and penetration areas will be transferred to the foundation medium by the combined action of the east-west walls of the control tower and penetration areas and the underpinning walls underneath. The lateral forces in the north-south direction will be transferred through the underpinning to the north-south walls in the main auxiliary building. To ensure this action, the underpinning walls are connected to the existing main auxiliary building structure by dowels capable of transferring all direct loads as described in Section 4.0.

The lateral forces for the FIVPs will be carried by the box-shaped underpinning walls.

7.5.2 Boundary Conditions

For the boundary conditions of the finite element model used in the analysis, refer to Appendix A.

7.5.3 Loads and Load Combinations

The underpinning structure rests entirely on undisturbed natural material. The preliminary analysis of the underpinned structure utilizes the same load combinations used in the original design. However, each load combination is modified by adding the jacking load (P_L). For each load combination, the jacking load is evaluated with two load factors: a value of 1.0, and the load factor associated with the dead load for that load combination.

For the design of the underpinning and the connections to the existing structure, the safe shutdown earthquake (SSE) (0.12g) forces were increased by 50% to provide for a possible future increase in this load. The 50% increase was applied to the seismic response of the structure corresponding to the analytical model with the mean soil properties. The existing structure was checked for a 0.12g SSE.

The long-term settlement of the underpinning wall after it is connected to the existing structure will be calculated. The calculation is based on properties of the supporting soil. The long-term settlement effects will be considered in the final analysis of the structure. To provide for these effects, the final analysis is governed by four additional load combinations. These load combinations are discussed in the response to Question 15 of the NRC Requests Regarding Plant Fill (September 1979) and were used in the diesel generator building reanalysis. The load combinations are modified by the additional jacking load.

Table 1 lists 26 load combinations that have been modified for jacking loads. For the preliminary analysis of the underpinned auxiliary building and FIVPs, the following load combination is most critical:

$$U = 1.0D + 1.0L + 1.0E' + 1.0T_o + 1.25H_o + 1.0R + P_L$$

where

U = ultimate load capacity

D = dead loads

L = live loads

E' = safe shutdown earthquake

T_o = thermal effects during normal operating conditions

H_o = force on structure due to thermal expansion of pipes under operating conditions

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R = local force or pressure on structure or penetration cause by rupture of any one pipe

P_L = load on structure due to jacking preload

In addition to this load combination, the underpinned structure was checked for stability using the load combinations specified in FSAR Subsection 3.8.6.3.4.

A complete analysis of the underpinned structure, using all applicable load combinations, will be made when the final seismic loads become available.

7.5.4 Structural Acceptance Criteria

The acceptance criteria for analyzing the underpinned structure are in accordance with FSAR Subsection 3.8.6.5. For factors of safety against sliding and overturning, refer to FSAR Table 3.8-23.

7.5.5 Additional NRC Requirements

For information purposes, an analysis of the critical sections of the underpinned structure will be made conforming to the provisions of ACI 349-76 as supplemented by NRC Regulatory Guide 1.142.

8.0 QUALITY ASSURANCE REQUIREMENT

This project work is a combination of Q-listed and non-Q-listed work. Construction of permanent structures, such as the underpinning wall and the connectors, is Q-listed, as well as any other activity or structure necessary to protect the auxiliary building and FIVPs. Construction of temporary structures such as the access shafts and tunnels is non-Q-listed. A detailed quality plan shall be prepared by Bechtel to identify those specific activities which are required to have a safety "Q" quality program applied with the major quality program elements for these activities.

R. Landsman

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REFERENCES

1. Woodward-Clyde and Consultants Test Reports
2. Consumers Power Company letter to the NRC, September 22, 1981
3. NAVFAC Design Manual DM-7
4. Bechtel Power Corporation, Auxiliary Building Seismic Model, Rev 3, September 28, 1981

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Midland Plant Units 1 and 2
Underpinning the Auxiliary Building
and Feedwater Isolation Valve Pits

TABLE 1

LOAD EQUATIONS FOR THE AUXILIARY BUILDING MODIFIED TO INCLUDE PRELOAD

Responses to NFC Requests Regarding Plant Fill, Question 15

(See Note 2)

a. Normal Operating Condition:

$$U = 1.05D + 1.28L + 1.05T + P_L \qquad (1)$$

$$U = 1.4D + 1.4T + P_L \qquad (2)$$

b. Severe Environmental Condition:

$$U = 1.0D + 1.0L + 1.0W + 1.0T + P_L \qquad (3)$$

$$U = 1.0D + 1.0L + 1.0E + 1.0T + P_L \qquad (4)$$

Loading Under Normal Conditions

a. Concrete:

$$U = 1.4D + 1.7L + P_L \qquad (5)$$

$$U = 1.25\ (D + L + H_o + E) + 1.0T_o + P_L \qquad (6)$$

$$U = 1.25\ (D + L + H_o + W) + 1.0T_o + P_L \qquad (7)$$

$$U = 0.9D + 1.25\ (H_o + E) + 1.0T_o + P_L \qquad (8)$$

$$U = 0.9D + 1.25\ (H_o + W) + 1.0T_o + P_L \qquad (9)$$

For ductile moment resisting concrete frames and for shear walls

$$U = 1.4\ (D + L + E) + 1.0T_o + 1.25H_o + P_L \qquad (10)$$

$$U = 0.9D + 1.25E + 1.0T_o + 1.25H_o + P_L \qquad (11)$$

Structural Elements Carrying Mainly Earthquake Forces, Such as Equipment Supports

$$U = 1.0D + 1.0L + 1.8E + 1.0T_o + 1.25H_o + P_L \qquad (12)$$

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TABLE 1 (continued)

b. Structural Steel:

$D + L + D_L$ (stress limit = f_s) (13)

$D + L + T_O + H_O + E + P_L$ (stress limit = $1.25f_s$) (14)

$D + L + T_O + H_O + W + P_L$ (stress limit = $1.33f_s$) (15)

In addition, for structural elements carrying mainly earthquake forces, such as struts and bracing:

$D + L + T_O + H_O + E + P_L$ (stress limit = f_s) (16)

Loading Under Accident Conditions

a. Concrete:

$U = 1.05D + 1.05L + 1.25E + 1.0T_A + 1.0H_A + 1.0R + 1.05P_L$ (17)

$U = 0.95D + 1.25E + 1.0T_A + 1.0H_A + 1.0R + 0.95P_L$ (18)

$U = 1.0D + 1.0L + 1.0E' + 1.0T_O + 1.25H_O + 1.0R + P_L$ (19)

$U = 1.0D + 1.0L + 1.0E' + 1.0T_O + 1.0H_O + 1.0R + P_L$ (20)

$U = 1.0D + 1.0L + 1.0B + 1.0T_O + 1.25H_O + P_L$ (21)

$U = 1.0D + 1.0L + 1.0T_O + 1.25H_O + 1.0W' + P_L$ (22)

b. Structural Steel:

$D + R + T + H_O + E' + P_L$ (stress limit = $1.5f_s$) (23)

$D + L + R + T_A + H_A + E' + P_L$ (stress limit = $1.5f_s$) (24)

$D + L + B + T_O + H_O + P_L$ (stress limit - $1.5f_s$) (25)

$D + L + T_O + H_O + W' + P_L$ (stress limit = $1.5f_s$) (26)

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TABLE 1 (continued)

where

U = required strength to resist design loads or their related internal moments and forces

For the ultimate load capacity of a concrete section, U is calculated in accordance with American Concrete Institute (ACI) 318-71.

F = specified minimum yield strength for structural steel

f_s = allowable stress for structural steel; f_s is calculated in accordance with the American Institute of Steel Construction (AISC) Code, 1963 Edition for design calculations initiated prior to February 1, 1973.

f_s is calculated in accordance with the AISC, 1969 Edition, with Supplements 1, 2, and 3 for design calculations initiated after February 1, 1973.

D = dead loads

L = live loads

P_L = load on structure due to jacking preload

R = local force or pressure on structure or penetration caused by rupture of any one pipe

T = effects of differential settlements, creep, shrinkage, and temperature

T_0 = thermal effects during normal operating conditions

H_0 = force on structure due to thermal expansion of pipes under operating conditions

T_A = total thermal effects which may occur during a design accident other than H

H_A = force on structure due to thermal expansion of pipes under accident condition

E = operating basis earthquake (OBE)

E' = safe shutdown earthquake load (SSE)

B = hydrostatic forces due to the postulated maximum flood (PMF) elevation of 635.5 feet

W = design wind load

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TABLE 1 (continued)

W' = tornado wind loads, including missile effects and differential pressure

ϕ = capacity reduction factor

The capacity redunction factor (ϕ) provides for the possibility that small adverse variations in material strengths, workmanship, dimensions, control, and degree of supervision, although individually within required tolerances and the limits of good practice, occasionally may combine to result in undercapacity.

OTES:

. In the load equations, the following factors are used:

ϕ = 0.90 for reinforced concrete in flexure

ϕ = 0.75 for spirally reinforced concrete compression members

ϕ = 0.70 for tied compression members

ϕ = 0.90 for fabricated structural steel

ϕ = 0.90 for reinforced steel in direct tension

ϕ = 0.90 for welded or mechanical splices of reinforcing steel

. Unity load factor is shown for P_L. An alternative load factor to be considered in all load combinations is the load factor associated with dead load (D) in that loading combination.

or load combinations 23-26:

aximum allowable stress in bending and tension is 0.9 F_Y.
aximum allowable stress in shear is 0.5 F_Y.

or these load combinations, the maximum allowable stress except or local areas that do not affect overall stability is limited o 0.9 F_Y for bending, bearing, and tension and 0.5 F_Y for shear. he time phasing between loads is used where applicable to atisfy the above equations.

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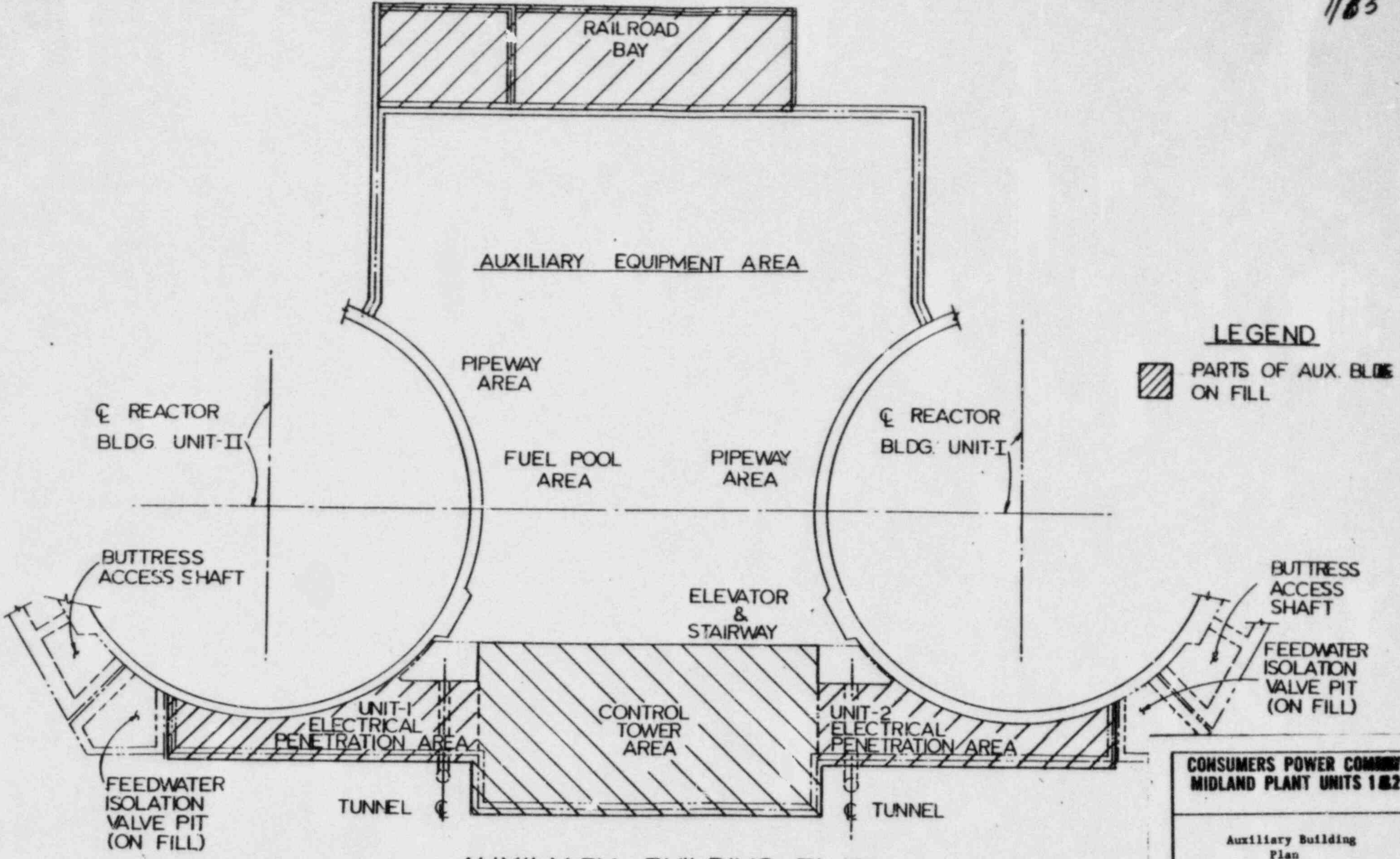
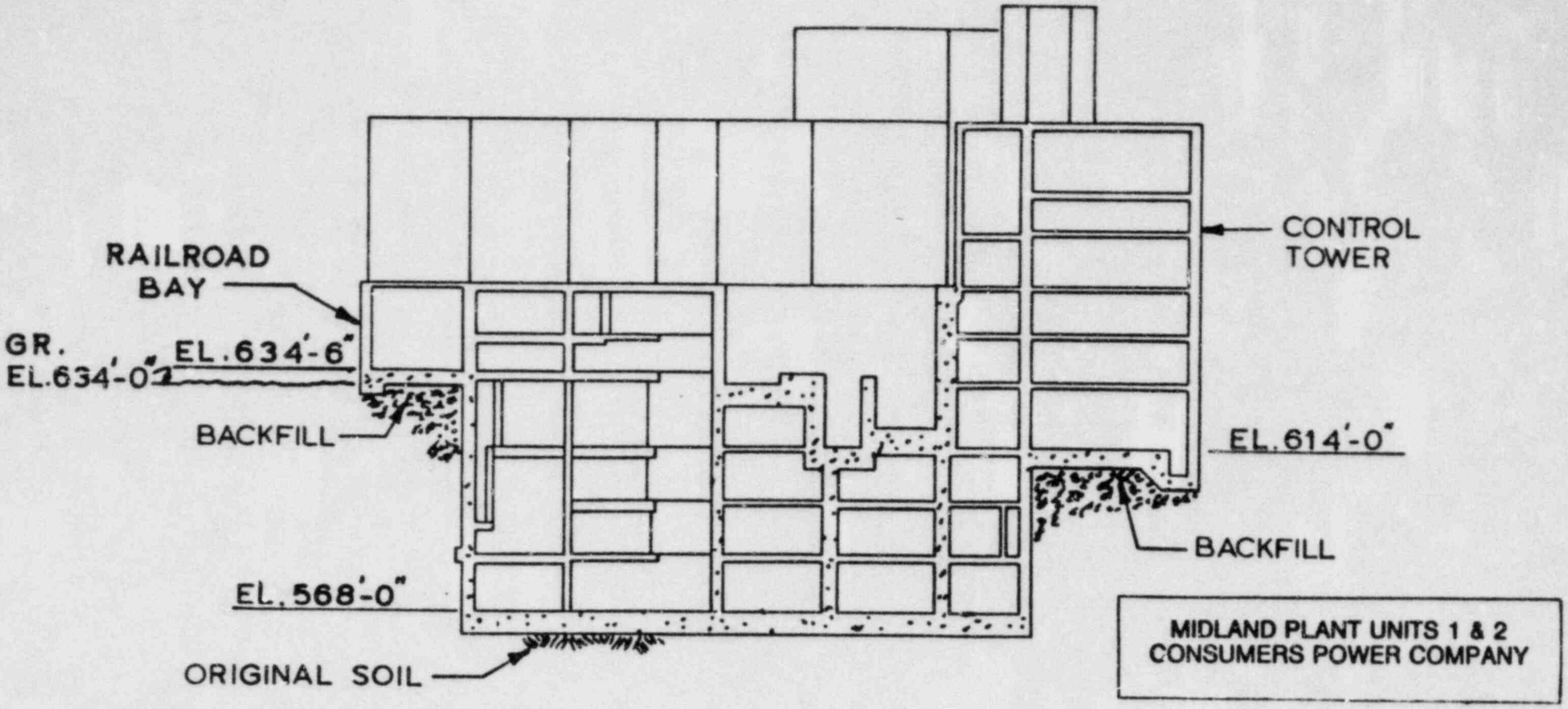


AUXILIARY BUILDING PLAN

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1&2

Auxiliary Building
Plan

FIGURE 1



TYPICAL SECTION (LOOKING EAST)

AUXILIARY BUILDING

SECTIONS

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

Auxiliary Building
Sectione

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FIGURE 2

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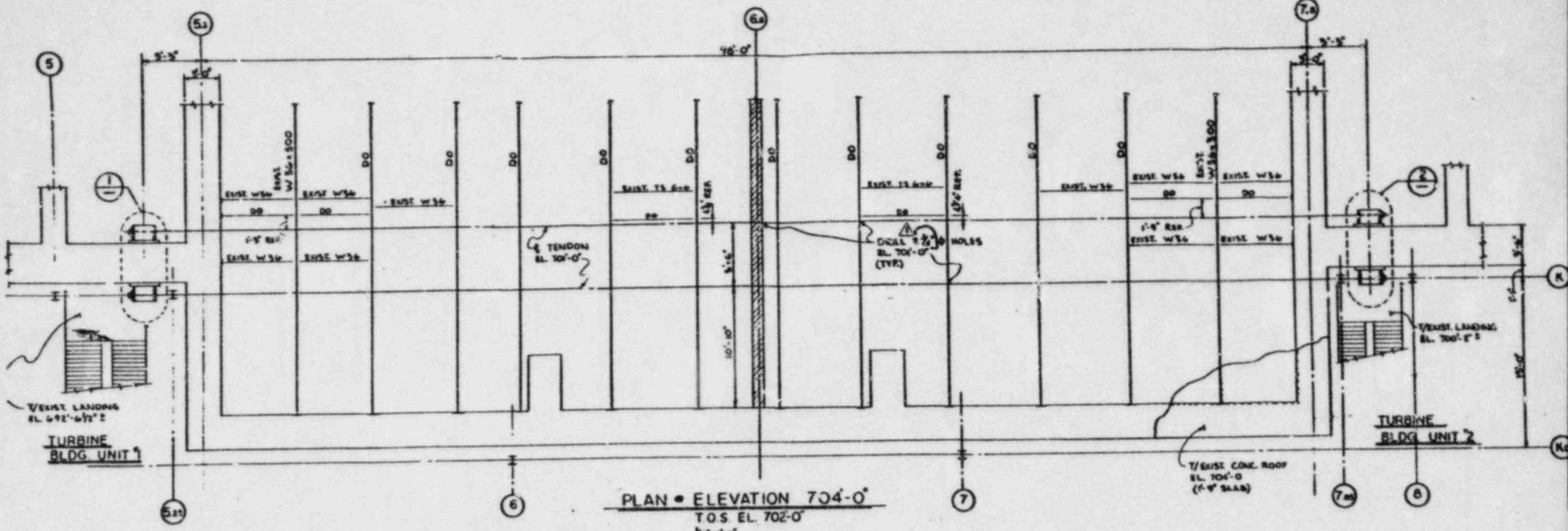


PLAN • ELEVATION 704'-0"
T.O.S. EL. 702'-0"
1/4"=1'-0"

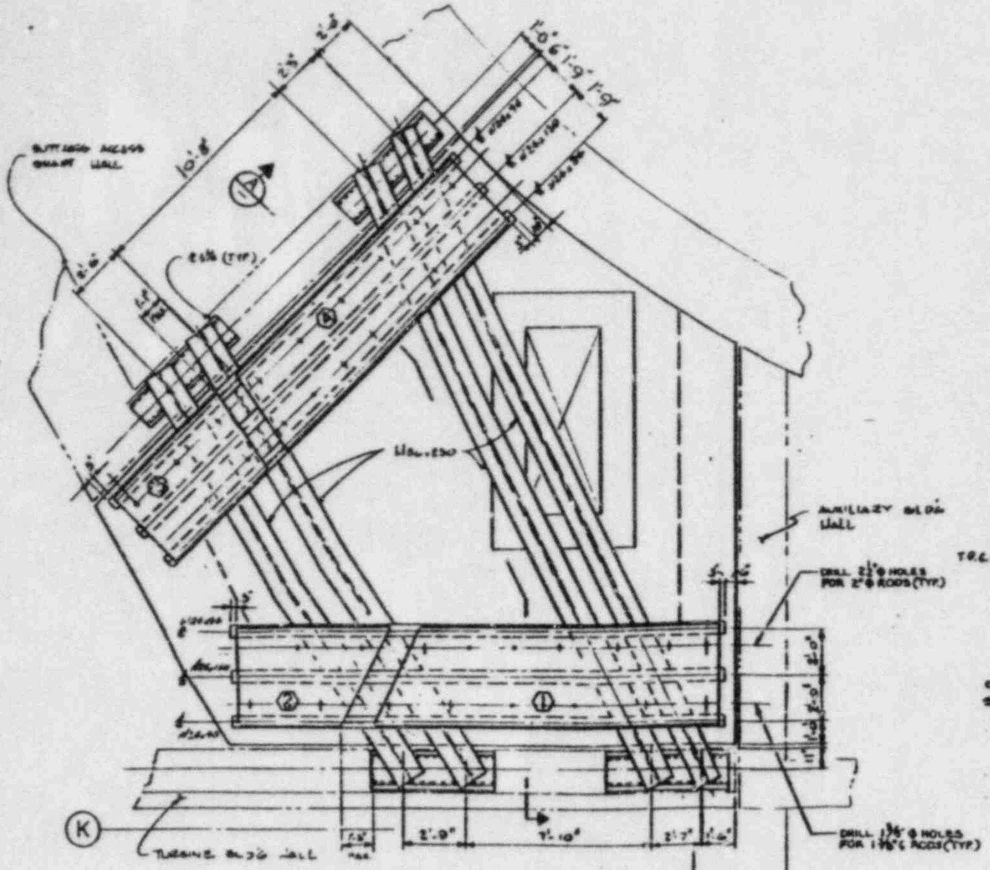
TEMPORARY SUPPORT AT CONTROL TOWER

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

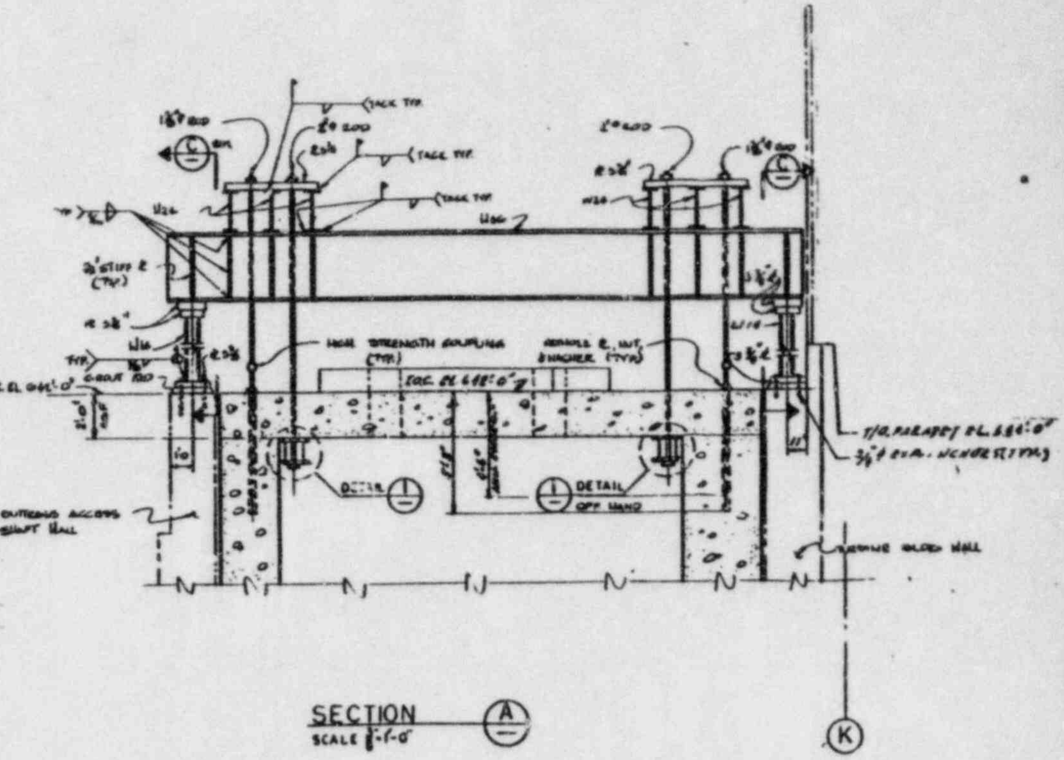
Temporary Support
at Control Tower

FIGURE 7

1/B5



PLAN AT EL 651'-0'
SCALE ¼"=1'-0"   ○-E NO.-SEE TABLE II ABOVE



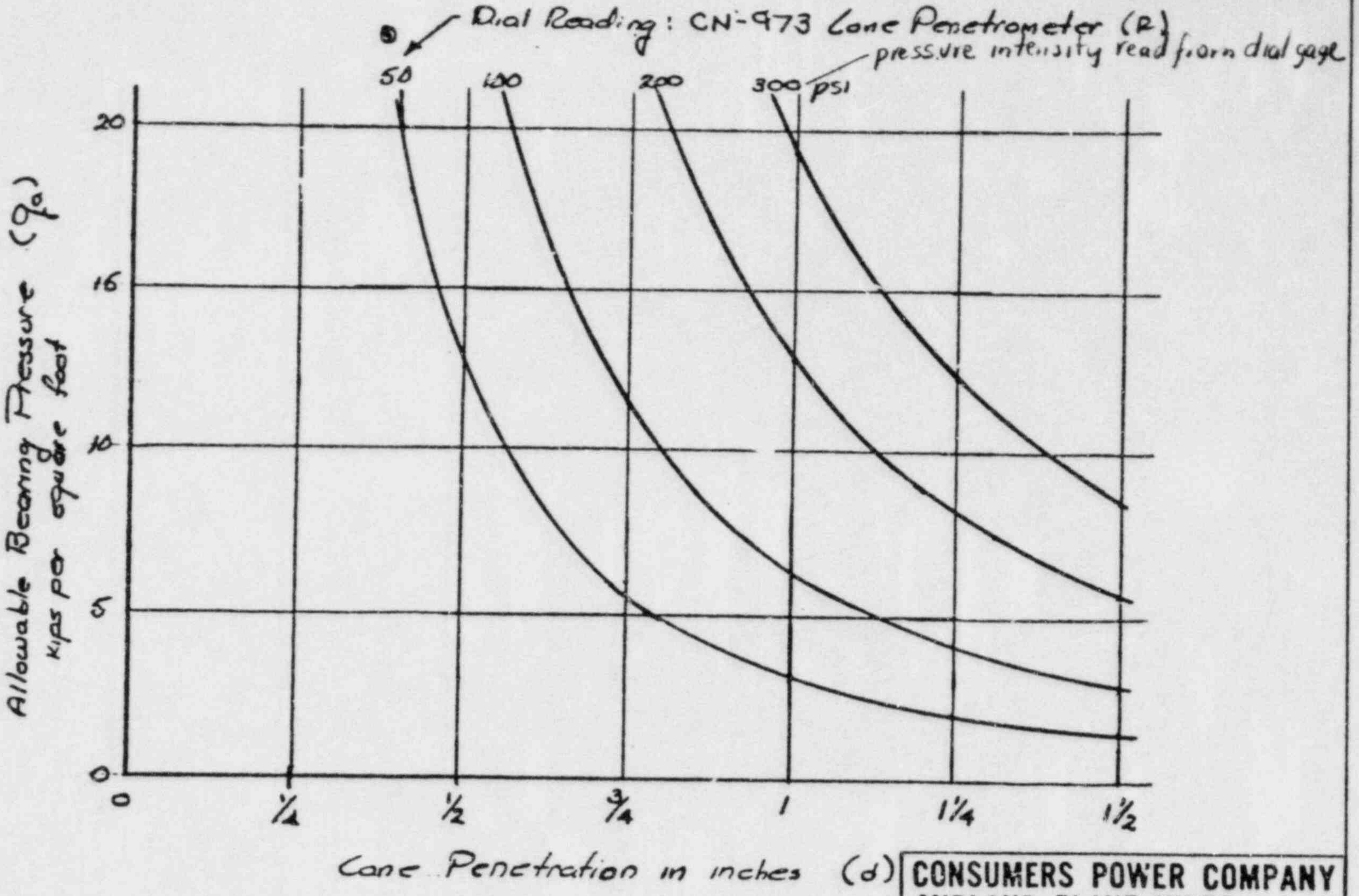
SECTION A
SCALE ¼"=1'-0"

TEMPORARY SUPPORT FOR FEEDWATER ISOLATION VALVE CHAMBER

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

Temporary Support
for Feedwater Isolation
Valve Chamber

FIGURE 8



CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

PENETROMETER CALIBRATION CURVES

Figure 9

11/4/81
Handout from
J. Gould

MEMORANDUM

TO: OFFICE

FROM: JAMES P. GOULD

RE: BECHTEL MIDLAND PLANT
USE OF WES PENETROMETER FOR
EVALUATION OF UNDERPINNING BEARING CAPACITY
JOB NO. 5464

DATE: AUGUST 31, 1981

Urged to provide a means of quantitative evaluation of bearing capacity for underpinning piers, we suggested the WES penetrometer. This device was intended merely to supplement judgements made by an experienced resident engineer. However, it seems to have taken on the status of a quality control tool and this memorandum is to clarify the relationship between load applied to the penetrometer and interpreted bearing capacity. The device consists of a hand-held cone penetrometer with a shaft whose area is equal to precisely one-half square inch and whose bottom end is tapered with a 30-degree cone. Load is applied through a proving ring at the top with a dial gauge which reads as pressure intensity in the full cross-section of the shaft. That is, the dial gauge reading gives the pressure applied through the shaft to the soil in pounds per square inch, which is thus exactly double the force applied through the proving ring. The maximum force that can be placed through the proving ring is 150 pounds total or 300 pounds per square inch in the shaft cross-section.

We have devised the attached correlations relating pressure read by the proving ring in pounds per square inch and penetration of the pointed cone with bearing capacity for a strip footing. The failure bearing capacity factors utilized are nine times shear strength for the cone, 5.7 for the strip footing, a safety factor of 3, and assumes a $\phi = 0$ soil.

It is suggested that the cone be painted in quarter-inch wide bands with some high visibility colors and that several readings be taken of the force required to make penetrations of the cone to various depths in the soil. From this, using the calibration curves attached, a <u>crude</u> evaluation of the bearing quality of the subgrade can be attempted. It may be appropriate to alter the statement included in the specification to the effect that, "the subgrade bearing quality will be evaluated at intervals utilizing the WES CN-973 Cone Penetrometer with calibration curves supplied by the Contractor".

It is cautioned that no such device can take the place of an experienced and qualified resident engineer and should be used only as an aid to his judgement.

James P. Gould

James P. Gould

JPG:pag
ATT.

Sheet No. 1 Of 5

MUESER, RUTLEDGE, JOHNSTON & DESIMONE
CONSULTING ENGINEERS
FOR Bechtel - Midland, Mich.

File 5464
Made By DHB Date 8-27-81
Checked By HSL Date 8-30-81

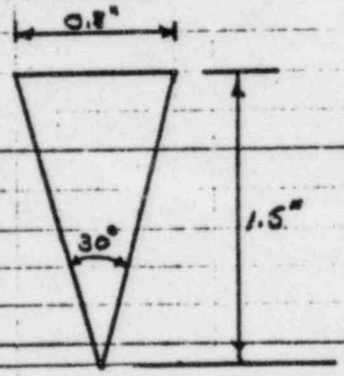
FORM 3

BEARING CAPACITY FROM CONE PENETROMETER

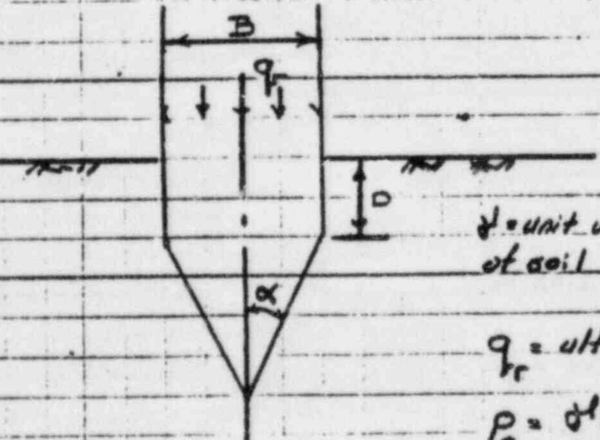
CN-973 Cone Penetrometer:

Dial reads 0-300 pounds per square inch. This is 0 to 150 lbs. load as base area of cone is 0.5 in²

Cone dimensions:



Reference: G.G. Meyerhof: "The Ultimate Bearing Capacity of Wedge-shaped Foundations", Paris 1961, Vol. II, p. 105.



For cone penetrating $\phi = 0$ material:

$$q_r = C N_{cr} + p_o N_{qr}$$

γ = unit weight of soil

q_r = ultimate bearing pressure

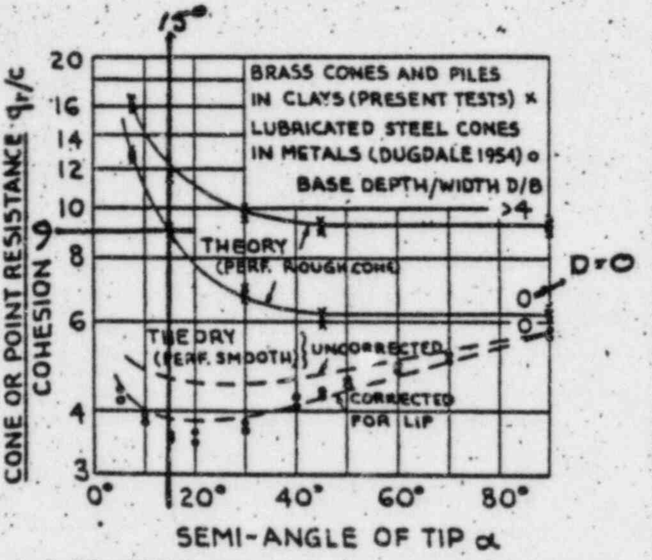
$p_o = \gamma D$

N_{cr} & N_{qr} are bearing capacity factors

In our case D = 0; thus

$$q_r = C N_{cr}$$

From Meyerhof:



(a) CONE RESISTANCE AND POINT RESISTANCE OF PILES IN CLAYS

For $\alpha = 15°$, $N_{cr} = 9$

Thus, for CN-973 Cone Penetrometer:

$$q_r = 9c \quad \text{or} \quad c = \frac{q_r}{9}$$

Ultimate bearing capacity of strip footing $= q_{ult} = 5.7c$

$$q_{u.t} = 5.7 \times \frac{q_r}{9} = 0.6\, q_r$$

Assuming Safety Factor = 3; allowable bearing pressure: q_a

$$q_a = \frac{1}{3} q_{ult} = 0.2\, q_r$$

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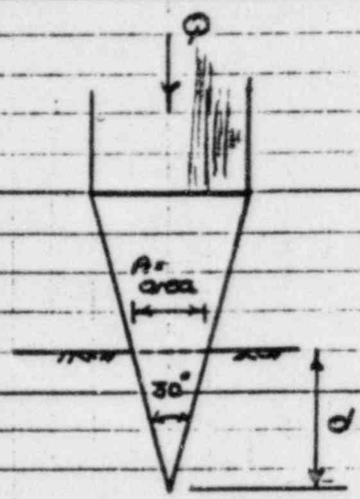
CONSULTING ENGINEERS
FOR Bechtel- Midland, Mich.

FORM 3

SHEET No. 3 OF 5
FILE 5464
MADE BY PHE DATE 8-27-81
CHECKED BY HSL DATE 8-30-81



Say: R= CN-973 dial reading

Thus, load $Q = 0.5R$ (lb.)

$A = \pi\,(d \tan 15°)^2$

$q_r = \frac{Q}{A} = \frac{0.5\,R}{\pi (d \tan 15°)^2}$ [in psi if d in inches]

$q_a = 0.2\,q_r = \frac{0.10\,R}{\pi (d \tan 15°)^2}$ (psi)

1 psi = 144 psf = 0.144 ksf

$\therefore\ q_a = \frac{0.0144\,R}{\pi (d \tan 15°)^2} = \frac{0.064\,R}{d^2}$ ✓ [ksf w/ d in inches]

Say R= 300 (limit of guage)

d (inches)	qa (ksf) for R= 300	200	100	50
0.25	307 (306)	205 (204)	102 ✓	51 ✓
0.50	77 ✓	51 ✓	26 ✓	13 ✓
0.75	34 ✓	23 ✓	11 ✓	6 ✓
1.00	19 ✓	13 ✓	6 ✓	3 ✓
1.25	12 ✓	8 ✓	4 ✓	2 ✓
1.50	9 ✓	6 ✓	3 ✓	1 ✓

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Sheet No. 4 Of 5
File 5464
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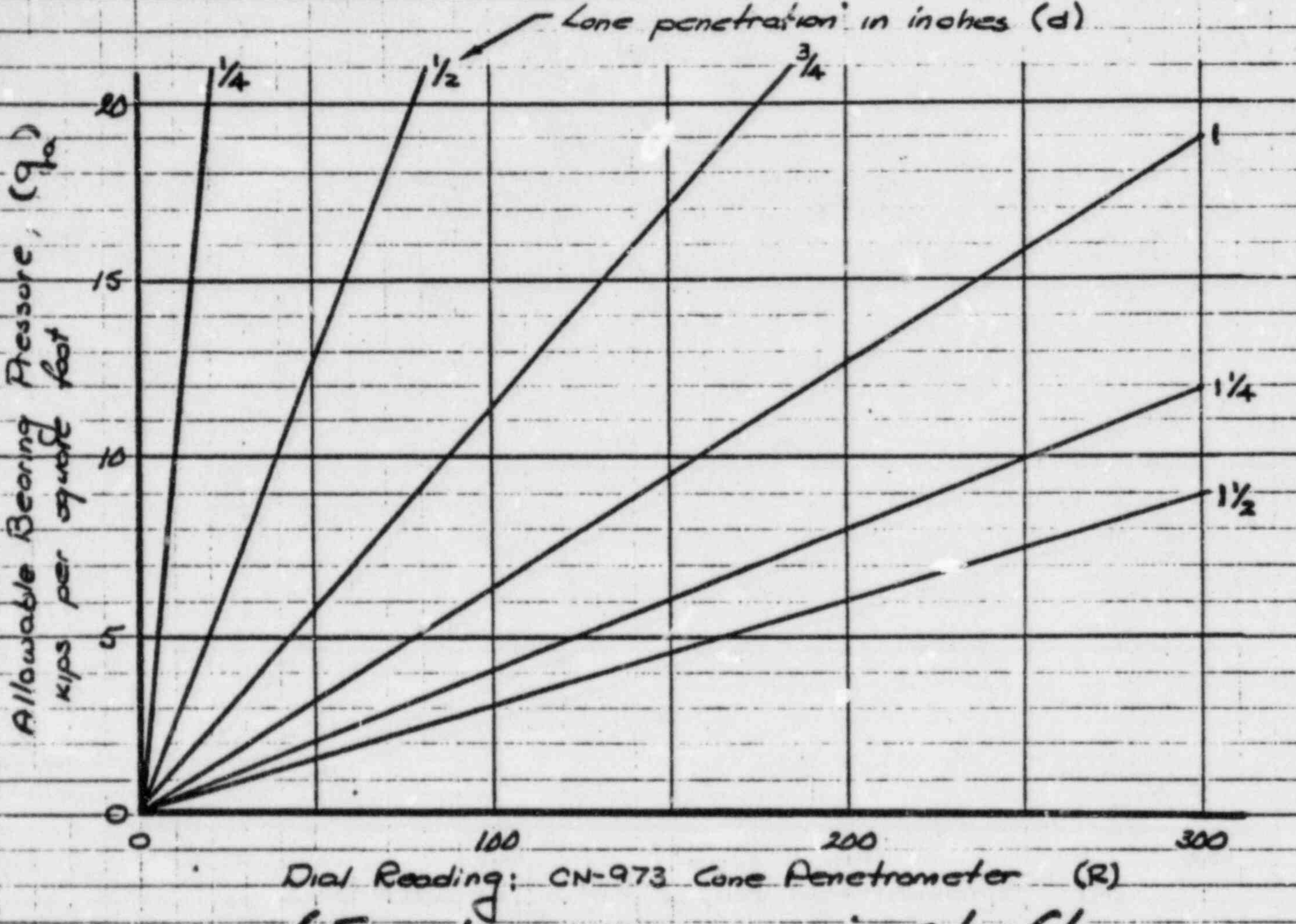
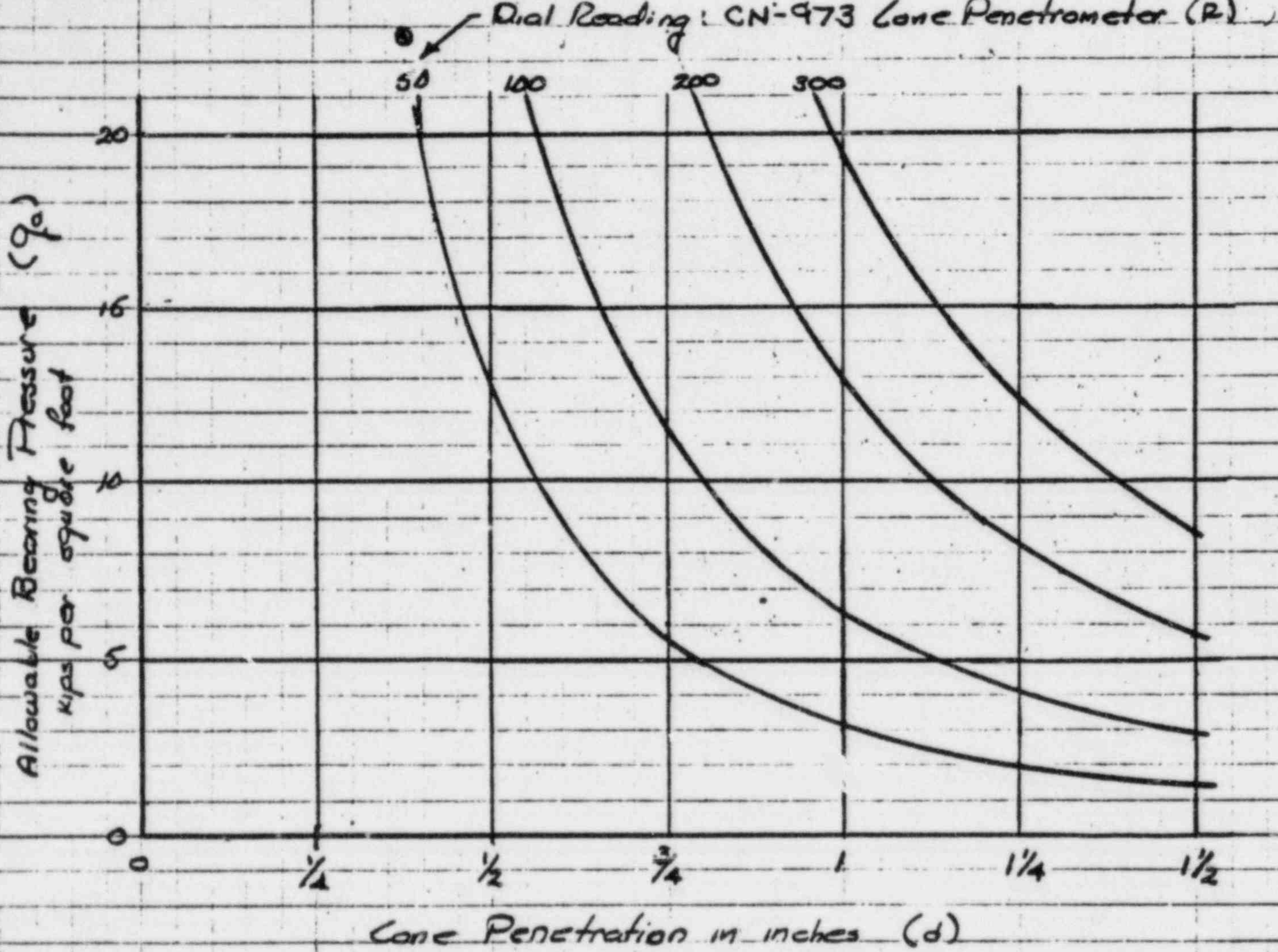


(Equals pressure in shaft cross-section in psi)
= double applied load in pounds

FORM 2

FOR Bechtel - Midland, Mich.

SHEET No. 5 OF 5
FILE 5464
MADE BY CHE DATE 8-27-81
CHECKED BY KSL DATE 8-30-81



1/B5

APPENDIX A

THREE-DIMENSIONAL FINITE ELEMENT MODELS OF THE AUXILIARY BUILDING

1.0 FINITE ELEMENT MODELS

The superstructure and underpinning of the auxiliary building are analyzed by the finite element method using the Bechtel Structural Analysis Program (BSAP). The structure is analyzed for four conditions with four different finite element models. The modeled conditions are: construction sequence of the proposed underpinning, long-term loading without connecting the underpinning to the building, long-term loading with full connection between the underpinning and building, and short-term loading with full connection between the underpinning and building.

Q.14

The models consist primarily of plate elements. Beam elements are used to represent columns, minor concrete elements, and major steel components of the structure. The nodal mesh is intensified in the areas south of column line G to better represent the detail of the structure in the area significantly affected by underpinning (see Figures A-1 through A-6). The soil subbase is represented by boundary springs placed under the foundation areas. The spring constants are based on appropriate soil response predictions as dictated by the load duration.

[illegible]

The underpinning is modeled as a continuation of the main shear walls in the control tower and the auxiliary building wings and extends the full length under these areas.

The unique characteristics of each model are briefly described below.

1.1 CONSTRUCTION MODEL

The construction sequence model is used to investigate the construction sequence as the existing soil support of the structure is sequentially replaced by jacking loads. Several variations of this model are utilized. The only difference between variations is the total number of boundary springs which are replaced by jacking loads.

The underpinning structure is not present on this model.

The spring constants for the boundary springs reflect the soil properties prior to underpinning.

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The load cases applied to the model are: dead load, live load, jacking loads, external hydropressures, soil pressures, and wind loads.

1.2 MODELS FOR LONG-TERM LOADS

1.2.1 Underpinning and Structure Disconnected

This model is used to investigate the effects of long-term loads with the underpinning disconnected from the superstructure. This model represents the construction stage when the superstructure and underpinning are separated by a series of hydraulic jacks with the jacks totally supporting the underpinned areas. Structural interaction is produced by placing upward jacking loads on the superstructure and placing equal and opposite loads on the underpinning.

The boundary springs have spring constants based on the predicted soil response to long-term loads.

The load cases applied to the model are: dead load, live load, external hydropressures, soil pressures, settlement, jacking loads, and wind loads.

1.2.2 Underpinning and Structure Connected

This model is used to investigate the effects of long-term loads with the underpinning fully connected to the superstructure.

The boundary springs have spring constants based on the predicted soil response to long-term loads.

The load cases applied to the model are differential settlement loads.

1.3 MODEL FOR SHORT-TERM LOADS

This model is used to investigate the effects of short-term loads with the underpinning fully attached to the superstructure.

The spring constants for the boundary springs are based on the predicted soil response to short-term loads.

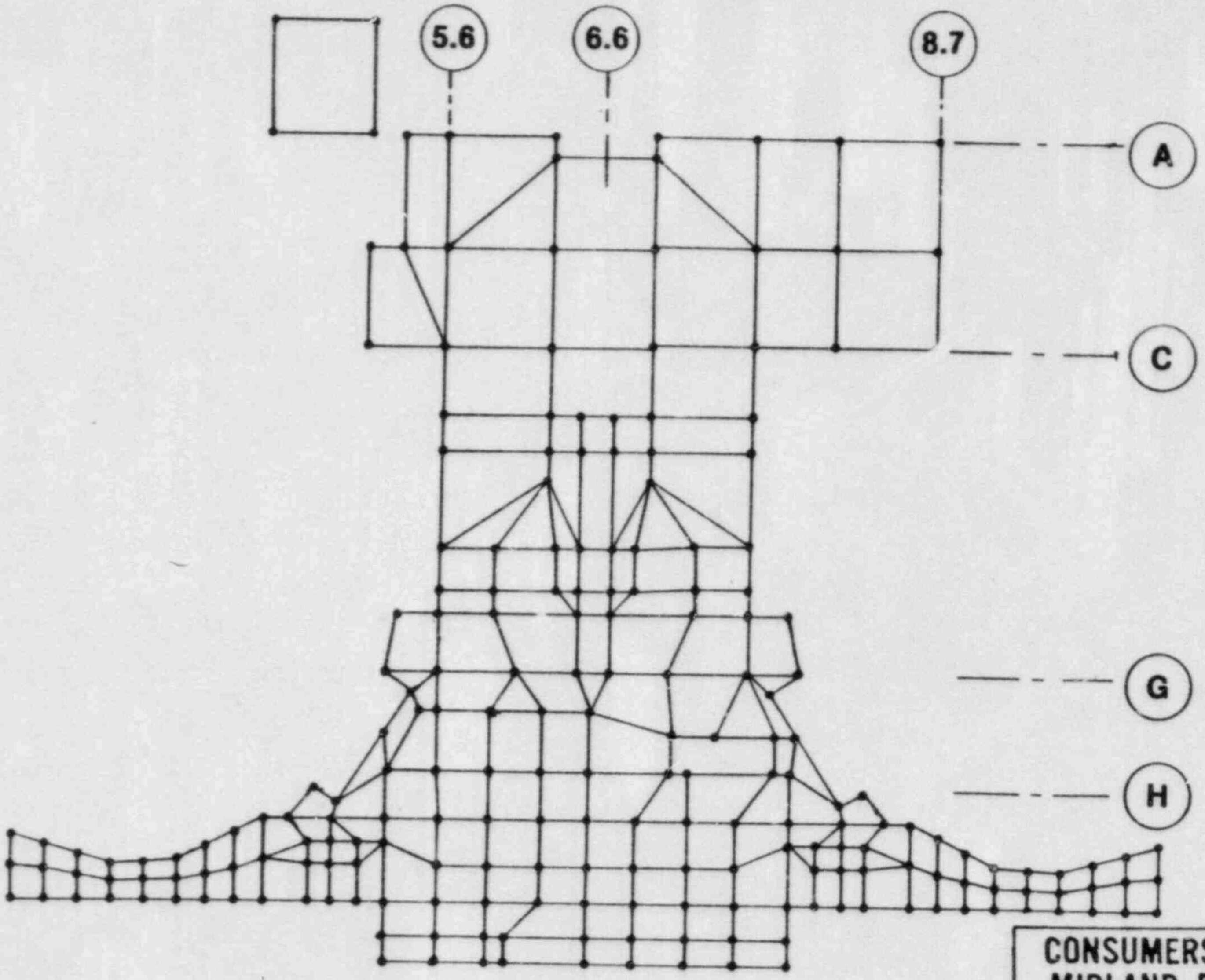
The load cases applied to the model are: east-west earthquake, north-south earthquake, vertical earthquake, tornado, and pipe rupture loads.

1/05

2.0 ANALYSIS

The results of these analyses are then factored and added in specific combinations in order to investigate the load combinations listed in Table 1 of the Technical Report on Underpinning the Auxiliary Building and Feedwater Isolation Valve Pits. These combinations are then used to evaluate structural adequacy of the structure and underpinning.

AUXILIARY BUILDING UNDERPINNING
NODAL MESH AT ELEVATION 614'
PLAN VIEW



1/85

MIDLAND UNITS 1 AND 2
AUXILIARY BLDG 9/22/81

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

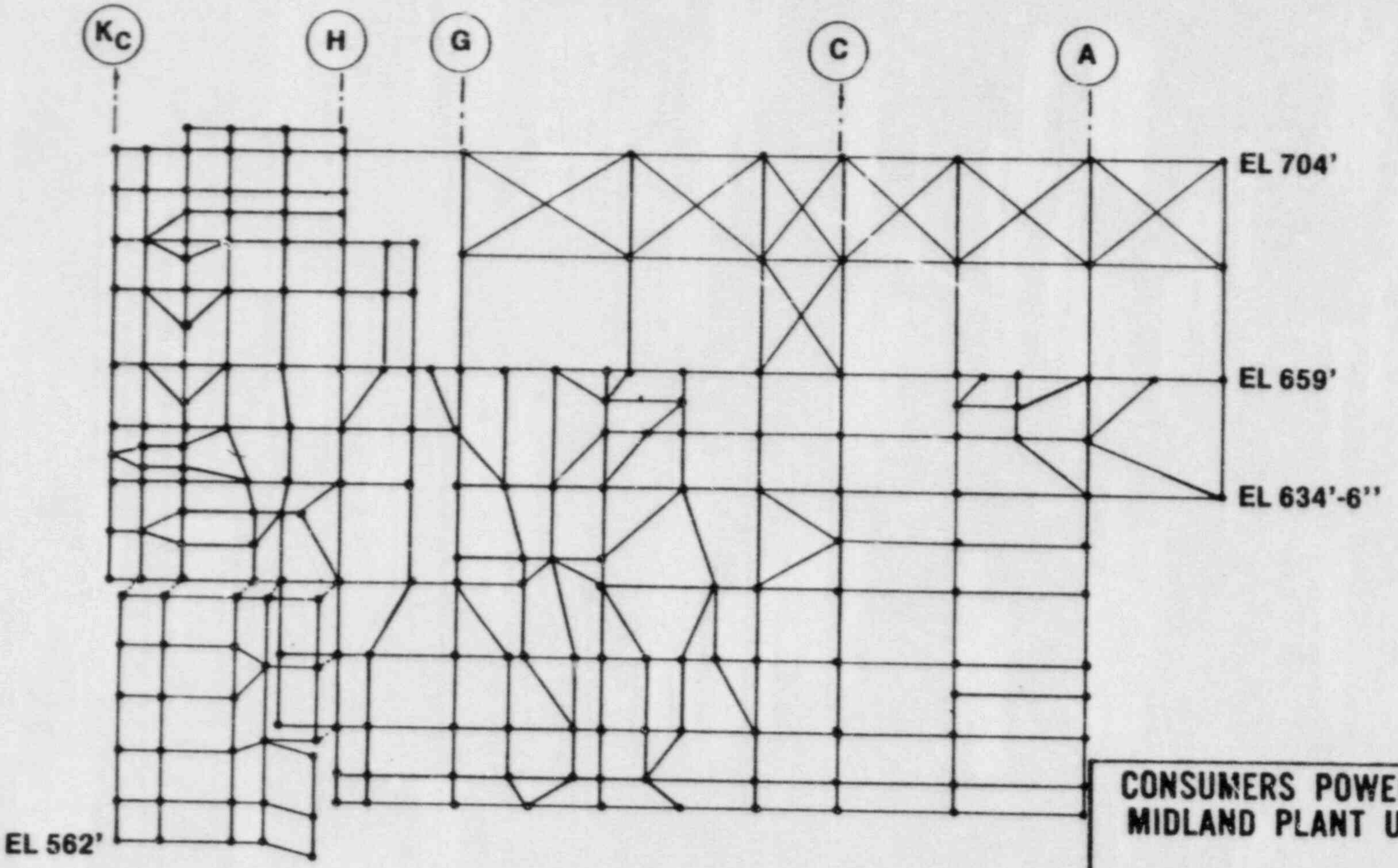
NODAL MESH AT EL. 614'

Fig. A-1

AUXILIARY BUILDING UNDERPINNING

NODAL MESH AT COLUMN LINE 5.6

ELEVATION VIEW



MIDLAND UNITS 1 AND 2
AUXILIARY BLDG 9/22/81

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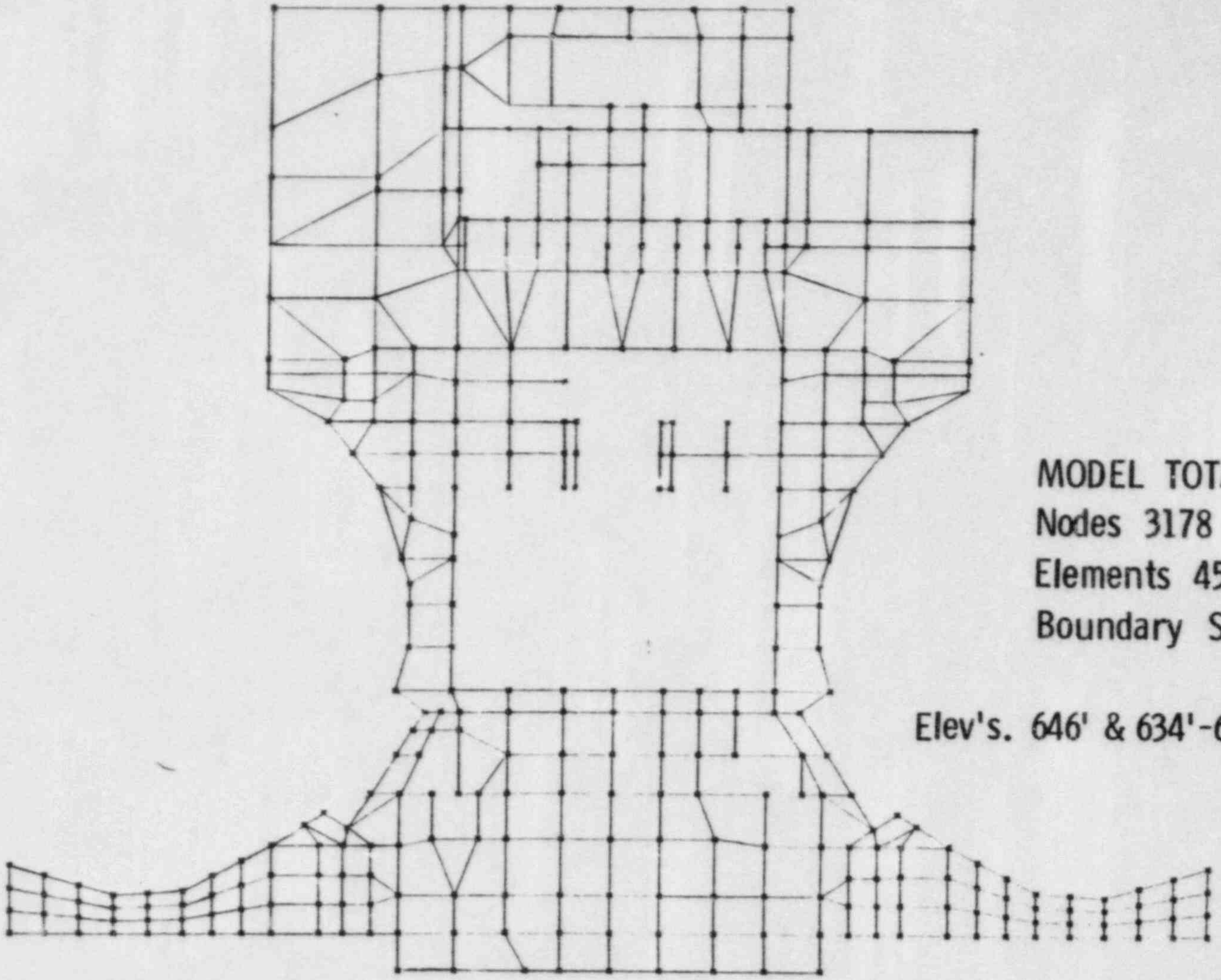
NODAL MESH AT
COL. LINE 5.6

Fig. A-2



MODEL TOTALS :
Nodes 3178
Elements 4500
Boundary Springs 600

Elev's. 646' & 634'-6" similar

AUXILIARY BUILDING UNDERPINNING MODEL
NODAL MESH AT EL. 659'

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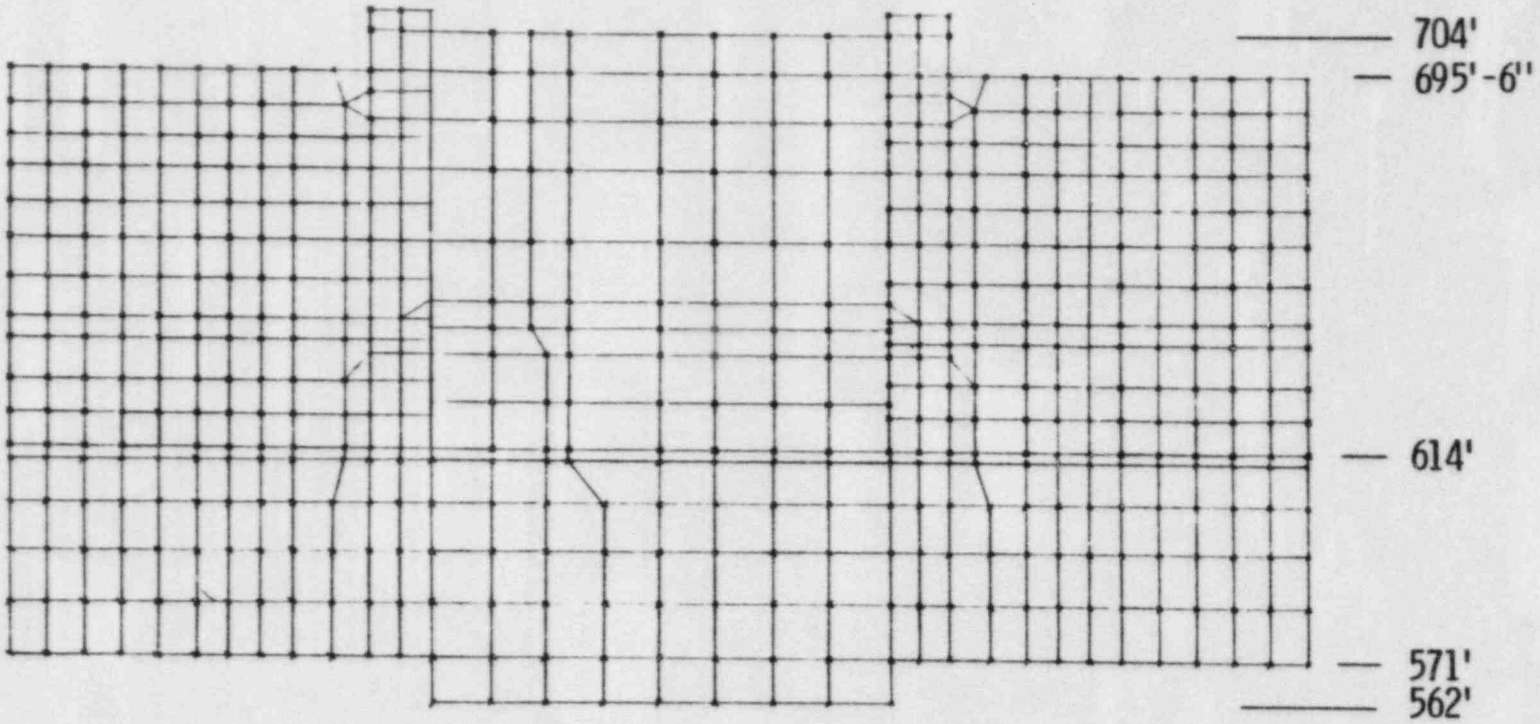
NODAL MESH AT EL. 659'

Figure A-3



ELEVATION VIEW OF NODAL MESH
FOR COL. LINES K & K_C

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ELEV. VIEW AT COL. LINES
K & K_c

Figure A-4

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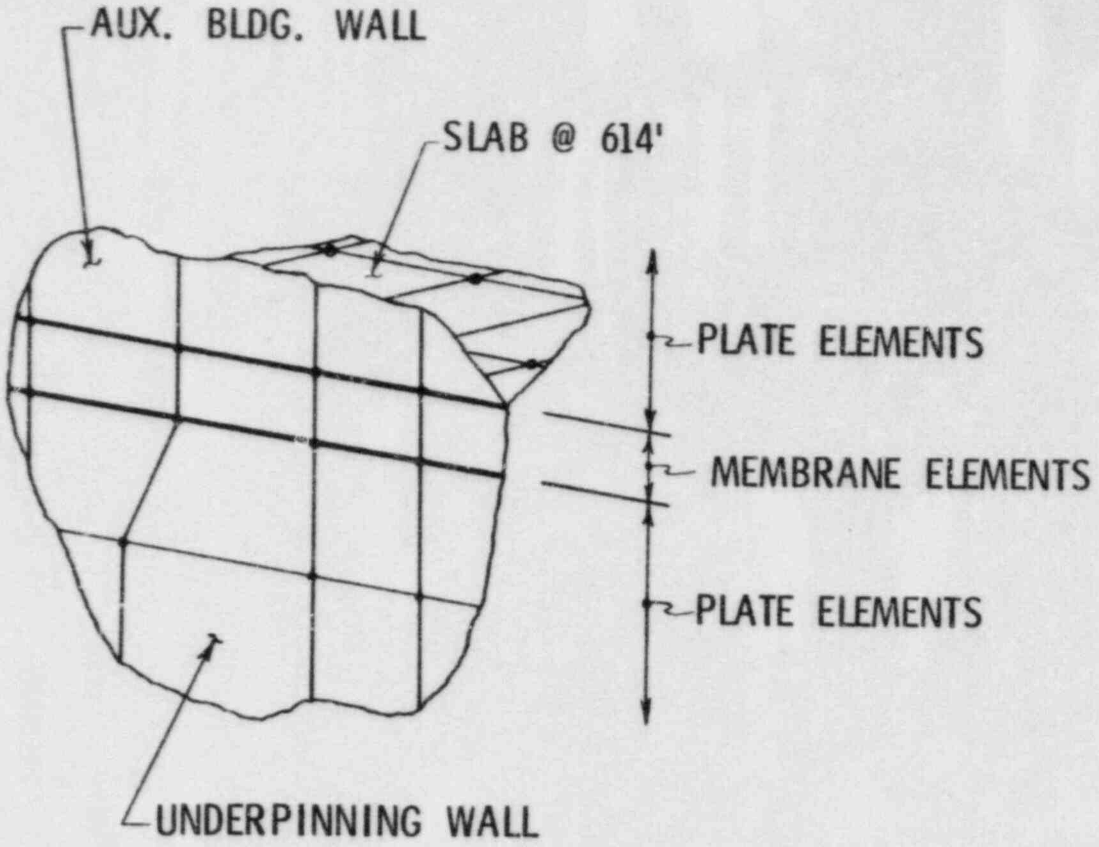

UNDERPINNING CONNECTION DETAIL

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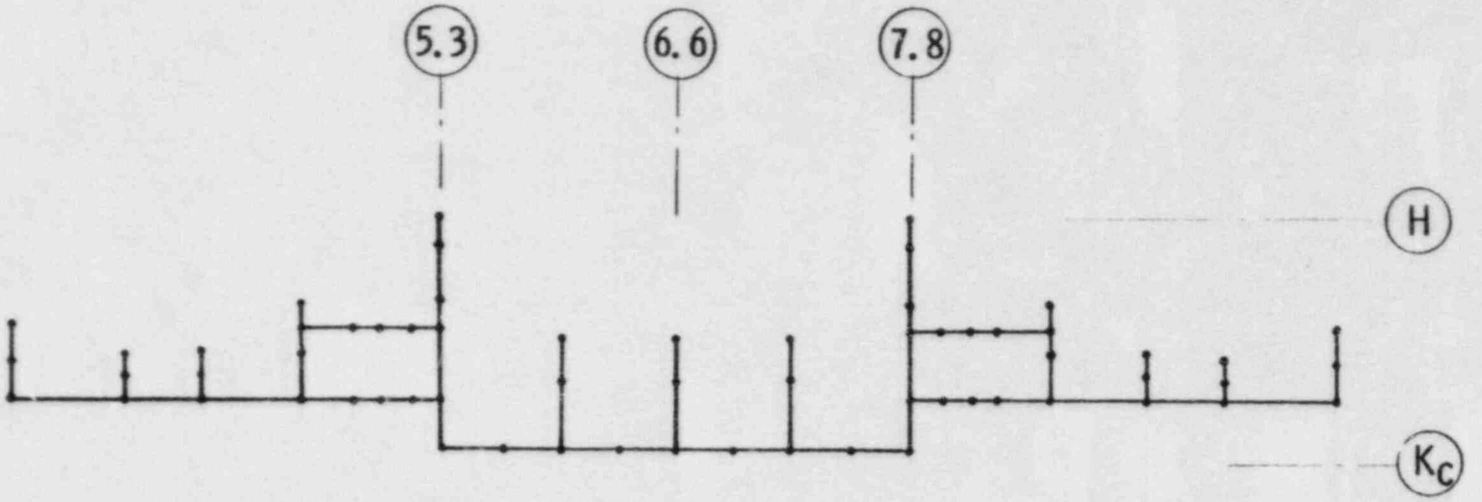
UNDERPINNING CONNECTION TO
STRUCTURE

Figure A-5

1185



UNDERPINNING MODEL PLAN VIEW

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PLAN VIEW OF UNDERPINNING MODEL

Figure A-6

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APPENDIX B

GROUNDWATER CONTROL

Underpinning the auxiliary building requires excavating approximately 9,000 cubic yards of material from underneath the structure and replacing that material with structural concrete and backfill.

The geohydrological environment in which this excavation is to be performed consists of approximately 40% undisturbed natural clay, 10% unreinforced concrete, and 50% heterogeneous fill. The heterogeneous fill contains free water. To perform the underpinning work safely and within a reasonably predictable period of time, the free water must be controlled so that it does not produce significant settlement of the immediate and surrounding structures or significantly impede progress of the underpinning work.

One well known groundwater control technique is predrainage. Presently, 20 permanent plant dewatering wells are being installed to intercept the seepage from the cooling pond. A predrainage system is also in place at the site of the planned excavation. This predrainage system has a demonstrated capability for lowering the existing groundwater from approximately el 627' to el 595. El 595 is a maximum of 10 feet below the bottom of the structures where the underpinning excavation is to be performed. Ultimately, the underpinning excavation will reach el 562, or 33 feet below the level dewatered by the existing predrainage system.

The existing predrainage system is currently recharged at a rate of approximately 60 gpm, which is expected to decrease with the installation and operation of the permanent dewatering wells. The recharge is occurring at unknown locations around 380 feet of the 700-foot perimeter of the planned excavation. The perimeter of this excavation is not accessible from the existing ground surface except for a distance of approximately 40 linear feet in an area located between the isolation valve pits and the turbine building. The majority of the existing predrainage eductor system is located in this area There are several other predrainage points which are located in the immediate vicinity of the planned excavation. These predrainage points are located in presently inaccessible areas in the basement of the turbine building.

Such a predrainage system will permit access shafts to be excavated from the ground surface to approximately el 600 and will permit approximately 7 feet of material to be excavated underneath the existing structures. Thus, this predrainage system will provide safe access to the area to be excavated for underpinning.

1/B5

The present plans for excavating approximately 9,000 cubic yards of material for underpinning requires that shafts be sunk from el 600 to 571 or 562, depending on the shaft location. The present plan for sinking the shafts is to hand excavate the material and place lagging to support the surrounding material as the shaft is progressed vertically. Such a construction method can only be safely performed with very minor water seepage into the shaft excavation. Thus, it is essential that groundwater inflows be substantially reduced to a predictable volume and location.

The configuration and location of the geohydrological environment is defined by the initial excavation for the site as shown in Figure B-1, which shows a large open cut excavation from the original ground surface elevations of approximately 605 to 615 to an ultimate depth at el 562. This original excavation has been filled with structures and backfill. The reactors and portions of the auxiliary building are founded on natural clay and form an essentially impervious barrier over their length. The rest of the structures and the manmade fill do not cut off groundwater movement. The cooling pond water elevation is approximately 627 and constitutes the major charging source of the fills and natural sands located below all the structures except the reactors and a portion of the auxiliary building, which are founded on clay.

The proposed underpinning is located at the deepest level of the original general site excavation. It is bounded by the impermeable reactor and auxiliary building on one side, and by the steep side slopes on the general site excavation on the other.

The location of the groundwater recharging conduits is unknown, although it is known that the conduits do not pass through or under the reactor and a portion of the auxiliary building. Because of this, a groundwater control plan that intercepts or cuts off recharge water must be of a nonspecific nature in that it must function over the entire potential recharge zone.

Q.15 The frozen earth membrane method has been selected as a groundwater cutoff (interception) plan for the following reasons.

a. Proof of its continuity is easily monitored.

b. Its extent can be discriminately controlled at specific locations by the input of coolant.

c. Spacing of the freeze pipes can be readily adjusted to deal with interferences and yet continuity of the membrane can be ensured.

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d. Its vertical extent can be varied after intial installation.

e. Membrane formation times are predictable.

f. When its function is completed, it is totally degradable and will permit groundwaters to behave as if the system has never been used. Thus it would not interfere with or jeopardize the expected performance of the permanent dewatering system.

The preliminary plan location for installing the frozen earth membrane is shown in Figure B-2. This location was chosen for the following reasons.

a. It does not interfere with the planned groundwater recharge program particularly as it relates to the diesel generator building.

b. It is the most efficient method of intercepting, or cutting off, recharge water in open and accessible areas.

c. It removes the coolant circulating lines from trafficked areas.

d. It is close to the deep well system and will benefit from the deep well dewatering.

El 610 has been preliminarily selected as the membrane crest height (as shown in Figure B-3) for the following reasons.

a. It forms a barrier in the granular (SP class) soil materials, which are suspected of being a major recharge aquifer.

b. It minimizes operational energy costs.

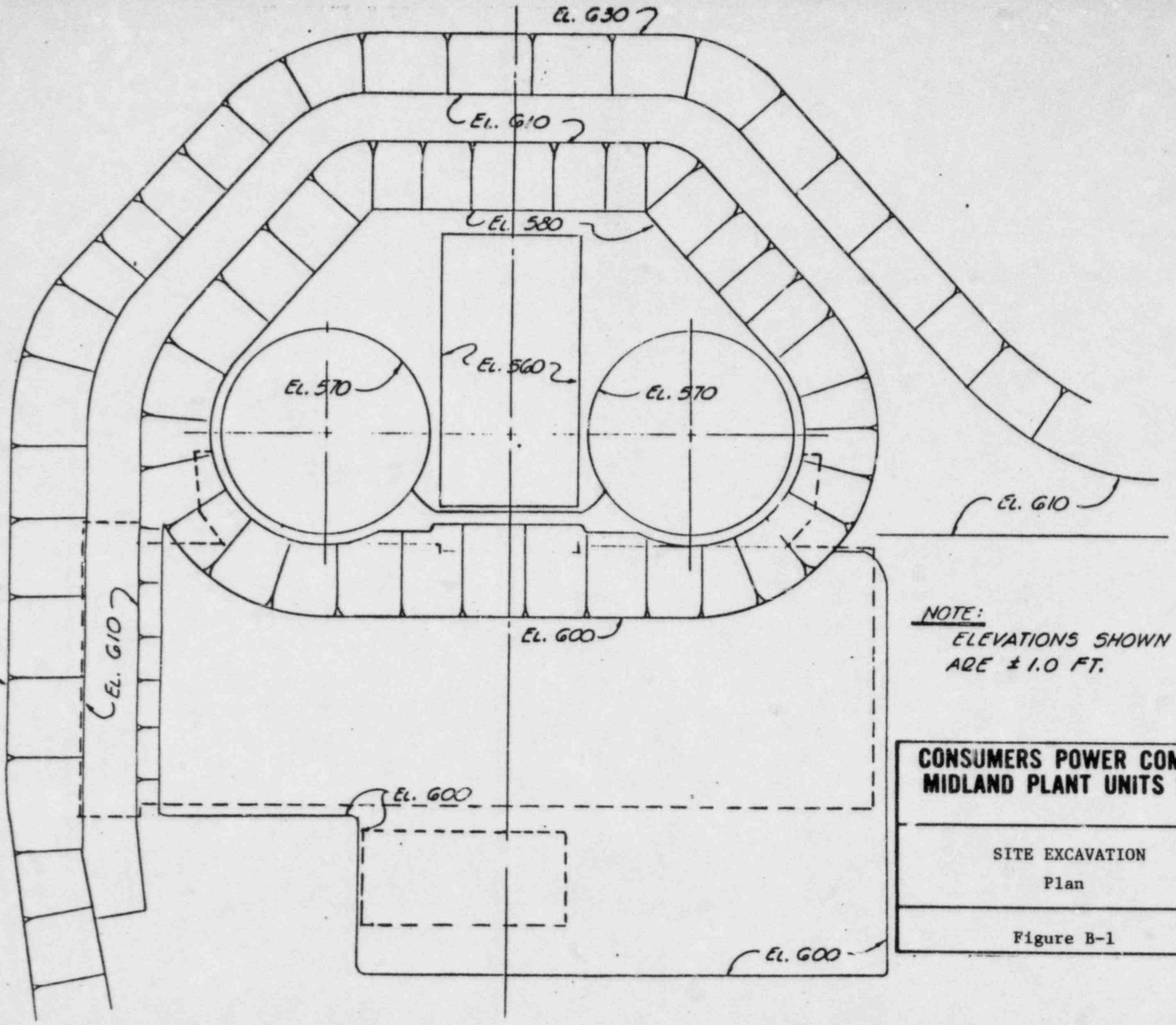
c. It allows for maximum benefit from the drawdown effect of the planned predrainage system when it becomes operational.

Attached Figures:

B-1 Site Excavation - Plan

B-2 Frozen Earth Membrane - Proposed Location

B-3 Frozen Earth Membrane - Typical Section



NOTE:
ELEVATIONS SHOWN
ARE ± 1.0 FT.

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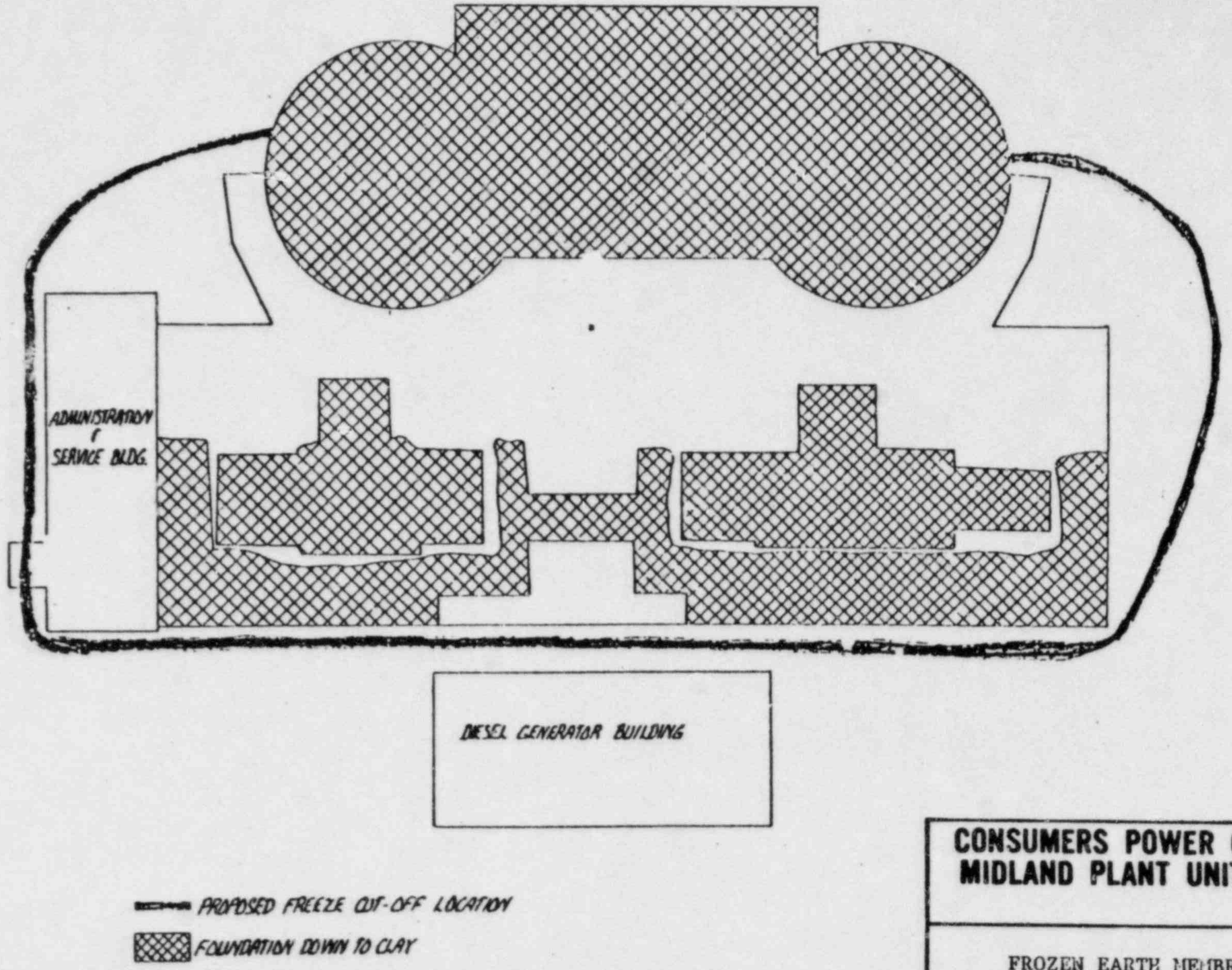
SITE EXCAVATION
Plan

Figure B-1

11B5



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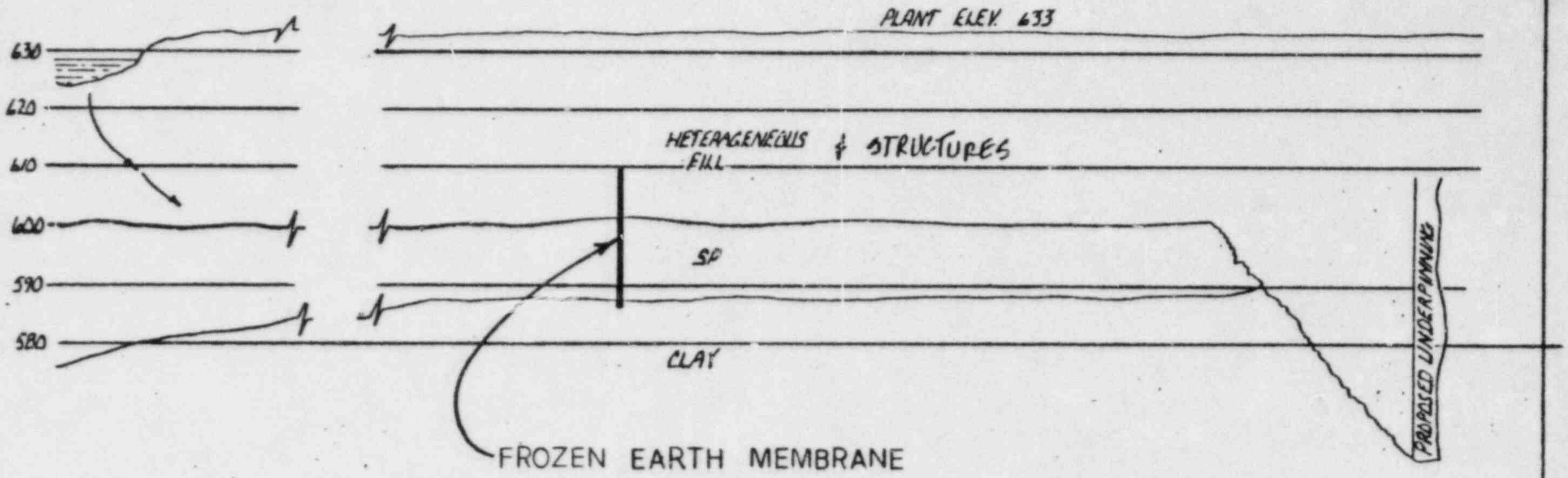
FROZEN EARTH MEMBRANE

Proposed Location

Figure B-2



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FROZEN EARTH MEMBRANE

Typical Section

Figure B-3

1/B5

MIDLAND PLANT UNITS 1 and 2
UNDERPINNING OF THE AUXILIARY BUILDING
AND FEEDWATER ISOLATION VALVE PITS

APPENDIX C

CONSTRUCTION DETAILS

The material presented herein is based on preliminary analysis and concepts, and must be checked in detail and adjustments made accordingly.

The objective of the underpinning construction plan is to complete the underpinning work in such a manner that there will be no intolerable stresses or strains imposed on the existing Auxiliary Building or Feedwater Isolation Valve Pits.

The strategy which will be employed to serve this objective is to reduce potentially high levels of existing stress or strain prior to removing any significant portion of the existing subgrade support for the structure.

The tactics which will be employed are as follows:

a. Use temporary support to reduce potentially high levels of existing stress or strain.

b. Install initial support at locations which require the minimum disturbance at the existing subgrade support.

c. Activate currently unused existing structure strength characteristics to effect reduction of potentially high levels of existing stress or strain.

The areas in the existing structure which have the potential for having the highest level of stress or strain that may be approaching an intolerable limit are, in order of priority:

a. The junction between the control tower and the wings in the general area of Column Lines 5.3 or 7.8. See Fig C-1

b. The junction between the control tower and the main Auxiliary Building, in the general area of Column Row H. See Fig C-1

With respect to Item (a) above, the potentially high stress is tension in the upper portion of the junction.

With respect to Item (b) above, the potentially high stress is either tension in the upper portion of the junction or shear across the junction.

Both junctions have not exhibited intolerable stresses or strains when buoyant support of approximately 1.3 ksf was lost due to temporary dewatering. Both the wings and control tower structures behaved as cantilevers when the buoyant support was removed. The settlement measurements indicate that the control tower behaved more as a rigid body than the wing when the buoyant support was removed.

Where is settlement data that supports this statement

In addition to the aforementioned structural considerations, the construction plan must address the existing subsurface conditions. The most noteworthy subsurface conditions are as follows:

a. The soil immediately under the wings is in an indeterminate state of compactness.

b. Underlying the soil immediately under the wing is a layer of unreinforced concrete which averages six feet in thickness and bears on natural clay.

c. The soil immediately under the control tower is an adequate state of compactness. It is underlain by layers of concrete varying in thickness from 1 to 2 feet, except in the vicinity of the utility tunnels where the concrete which bears on natural clay is as much as 15 feet thick.

The permanent underpinning must be founded on undisturbed natural clay. This means that unless it can be proven that the clay in contact with the concrete is in an undisturbed state, approximately 1,000 cubic yards of concrete must be demolished and excavated.

E# 215

The detailed preliminary underpinning construction plan which best copes with the existing conditions and meets the objective is developed below and shown in graphic form in Appendix C, Figures 1 through 13. The construction plan incorporates protective construction for the Turbine Building and Buttress Access Shafts, which is shown in the graphic exhibits and explained at the end of this section.

MIDLAND PLANT UNITS 1 and 2
UNDERPINNING OF THE AUXILIARY BUILDING
AND FEEDWATER ISOLATION VALVE PITS

This work assumes that Turbine Bldg. underpinning is already underway - See Fig. C-2 @ location "R" & "N"

A. Auxiliary Building and Feedwater Isolation Valve Pits Underpinning

1. Install temporary support at the open end of both wings Fig. C-1 location M

Q.16
Q.17

a. Locate the bearing support for the temporary support so that it minimizes the amount of concrete to be removed.

data? for temp is 20 ksf (pg. 7) @ location M

b. Provide sufficient bearing capacity to develop that maximum structural capacity of the existing structure when the existing subgrade support is neglected.

Q.17
Q.18

c. Load test large temporary support pier founded in undisturbed clay.

d. Preload temporary support to an amount yet to be determined, which will reduce potentially high levels of tension stresses near the top of the wings in the vicinity of Column Lines 5.3 and 7.8. The preload will also have the effect of establishing the wing structure as a propped cantilever and thus remove any doubt as to the structural behavior of the wings.

e. Perform all the aforementioned work prior to the removal of any subgrade support from under the control tower or the wings except for the outermost 8 feet.

f. If the subgrade under the wing was supporting the structure to some degree prior to preloading of the temporary support, some amount of the structure load supported by the subgrade may be transferred to the control tower when the temporary support is preloaded.

Since none of the subgrade under the control tower has been disturbed, this is the best time to transfer load to that area. (The control tower subgrade is not only undisturbed, but it is also in its original state of confinement.)

Q.18

Tolerance will be established by analysis

Since the preload on the temporary support at the end of the wings will be introduced incrementally, the behavior of the control tower structure can be monitored. If the control tower cannot tolerate part or all of the load imposed by the wing preload, then the preload will be stopped at that point and pits will be installed under the control tower to supplement the control tower capacity so that the full preload from the wings can be distributed. If this situation were to arise, no further excavation from under the wings would occur until the full wing preload were in place.

Q.19 - Q.20

2. Start installation of permanent support at control tower using pit method.
   a. Preload to an amount yet to be determined which will reduce potentially high levels of stress in the vicinity of Column Row H.
   b. Adjust preload at wings to bring temporary support load to predetermined amount.
3. Install temporary support at middle of wings and continue installing permanent support under the control tower.
   a. Provide sufficient bearing capacity so that the temporary support is capable of supporting the wing as a propped cantilever without failing and without structure support from the previously installed temporary support.
   b. Load test large temporary support founded in undisturbed clay.
   c. Preload middle temporary support to an amount yet to be determined, but which results in it assuming a major portion of any load previously shifted from the wing to the control tower.

Q.20 Q.21

Q.21 Q.22

Q.23

4. Install last temporary support under wing and continue installing permanent support under the control tower.

5. Start mass excavation and lagging for support of excavation under wings. See Fig C-5
for wall show in Sect. C, Fig. 5 between the three temp. supports

6. Complete permanent support under control tower. Figs C-7 & C-8, C-9
does this include the center support?

7. Excavate to electric ducts under control tower and temporarily support same.

8. Excavate and install lagging for support of excavation under control tower. (? towards reactor)

9. Install bracing for support of excavation as required.

10. Perform concrete demolition as required under wings and develop tunnel under existing pipeway.

11. Complete demolition and excavation under control tower.

12. Construct permanent underpinning under valve pits, wings and control tower at Column Lines 5.3 and 7.8, and complete permanent underpinning under control tower along Column Row K.C.

13. Install permanent load transfer and long term load test jacking equipment and start backfill of mass excavation and removal of support of excavation under wings.

Q.22 Q.24

14. Good for only wings Perform long term load test. Load magnitude - how established Settlement acceptance criteria
on the entire wing wall under EPA - possible because of 3 temp. supports

15. Complete long term load test, transfer structure load to permanent underpinning.

16. Grout dowels between permanent underpinning and existing structure.

17. Remove temporary support upon completion of load transfer.

18. Complete backfill as required.

19. Backfill access shaft.

B. Turbine Building and Buttress Access Shaft Protective Construction

2.16

1. Underpin Turbine Building where it is loaded from the feedwater isolation valve pit temporary support reaction, in the vicinity of Column Row K and Column Lines 2.5-3.0 and 10.0-10.5.

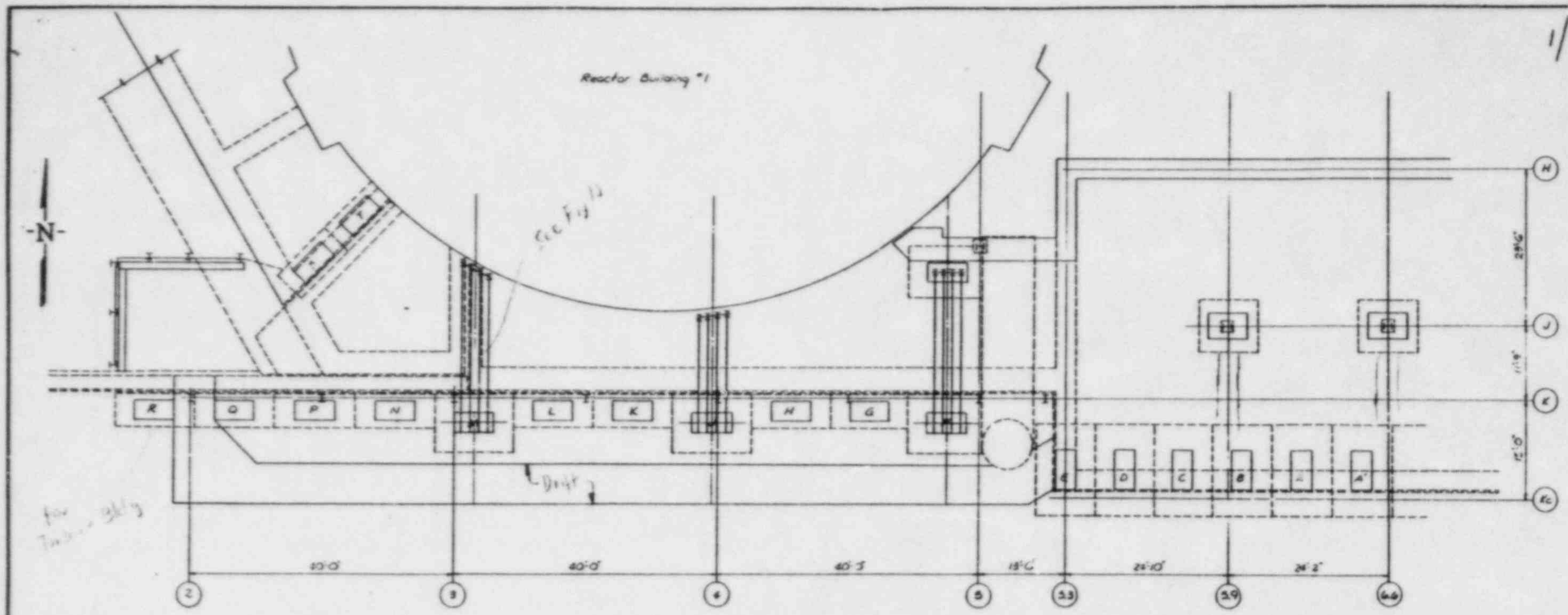
2. Underpin Buttress Access Shafts.

3. Underpin Turbine Building as shown in Exhibit 1, but Auxiliary Building sequence of work always controls priority and sequence of work.

MIDLAND PLANT UNITS 1 and 2
UNDERPINNING OF THE AUXILIARY BUILDING
AND FEEDWATER ISOLATION VALVE PITS

LIST OF FIGURES

1/B5

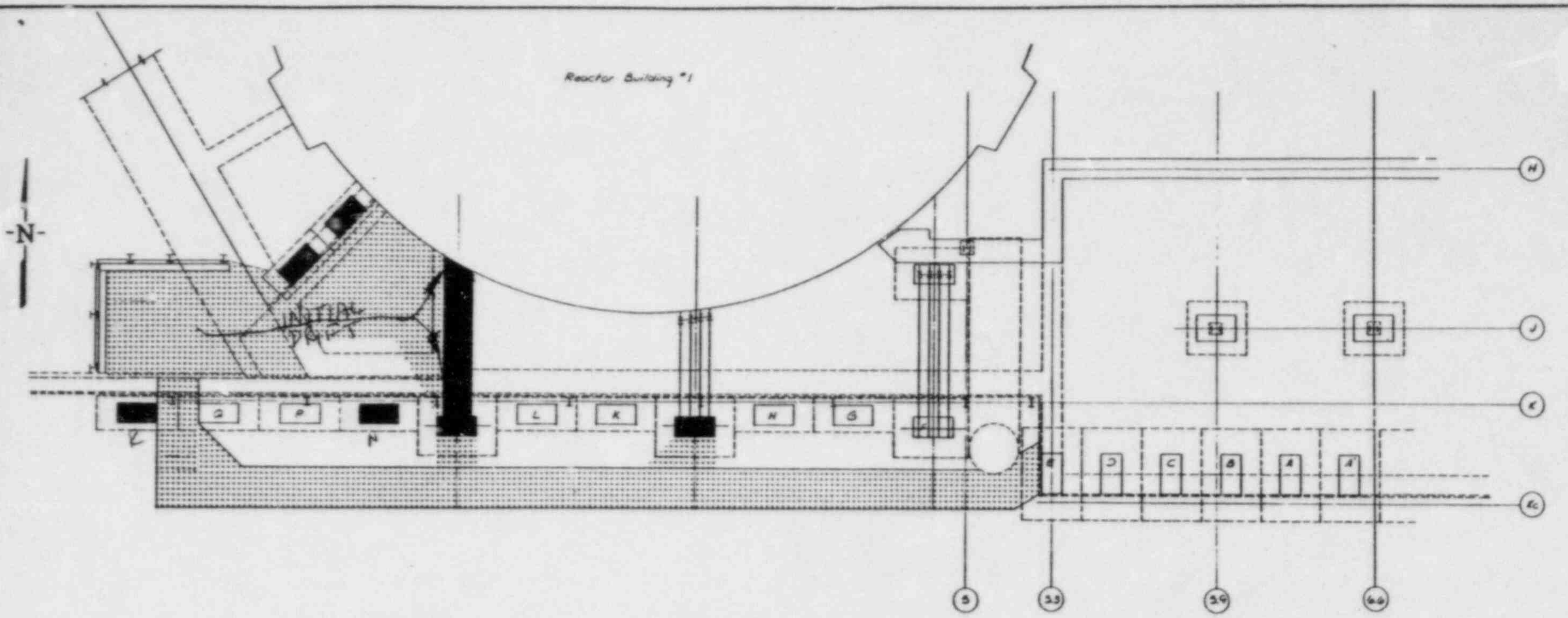


GENERAL PLAN
(WEST SIDE)

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING
GENERAL PLAN

APPENDIX C FIGURE 1



GENERAL PLAN
(WEST SIDE)

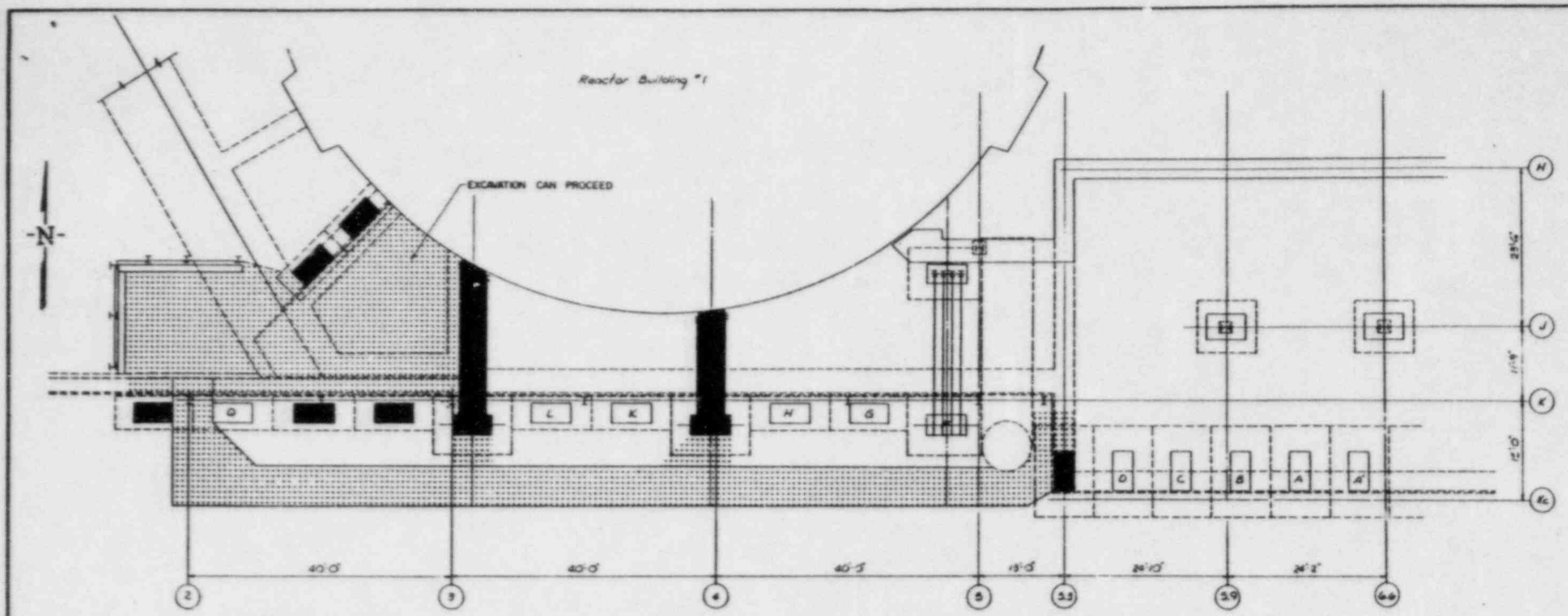
▨ -AREA OPEN FOR ACCESS
■ -AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 13 WEEKS

APPENDIX C FIGURE 2



GENERAL PLAN
(WEST SIDE)

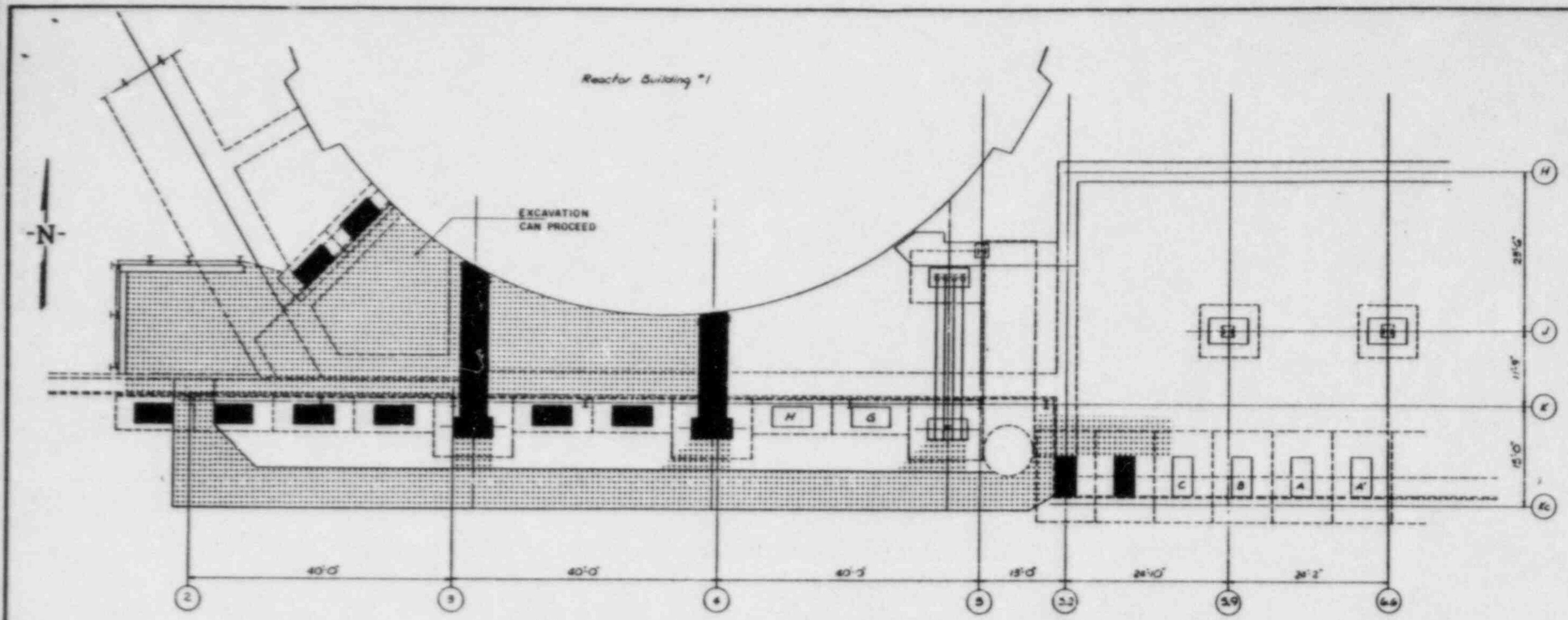
▨ -AREA OPEN FOR ACCESS
■ -AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 16 WEEKS

APPENDIX C FIGURE 3



GENERAL PLAN
(WEST SIDE)

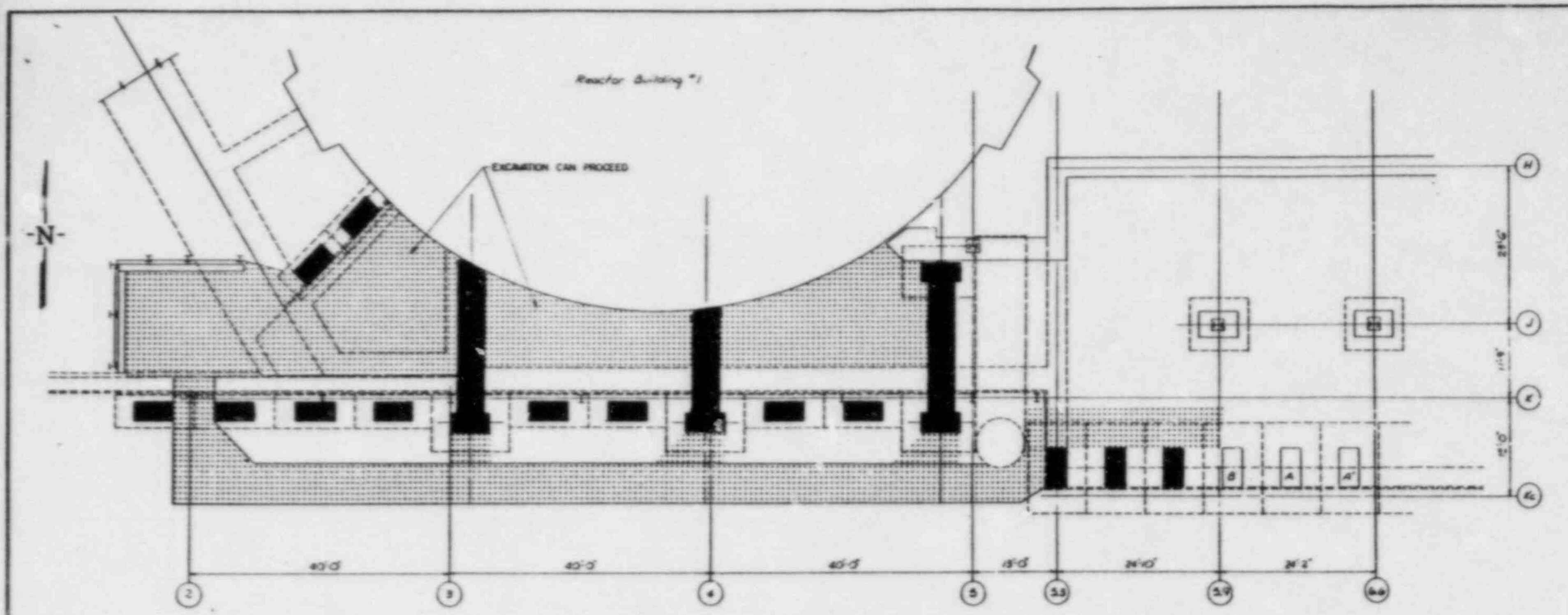
▨ - AREA OPEN FOR ACCESS
■ - AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 19 WEEKS

APPENDIX C FIGURE 4



GENERAL PLAN
(WEST SIDE)

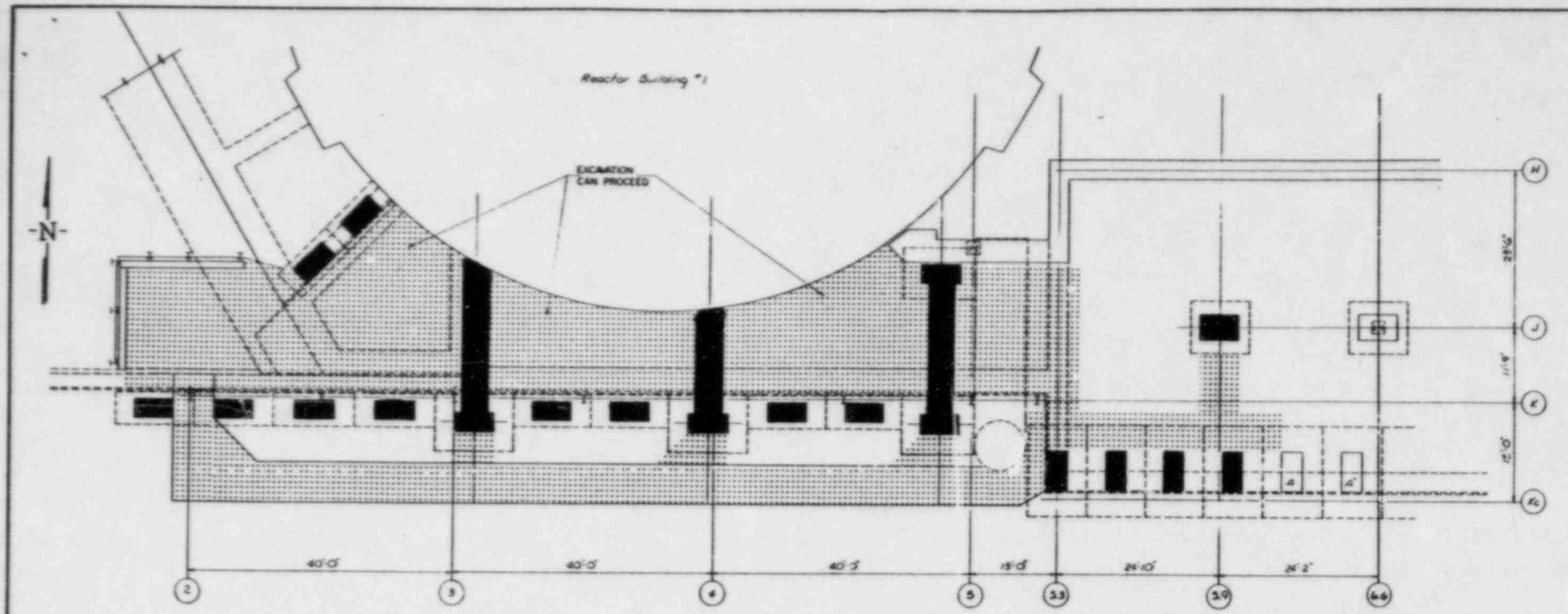
▨ - AREA OPEN FOR ACCESS
■ - AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 22 WEEKS

APPENDIX C FIGURE 5



GENERAL PLAN
(WEST SIDE)

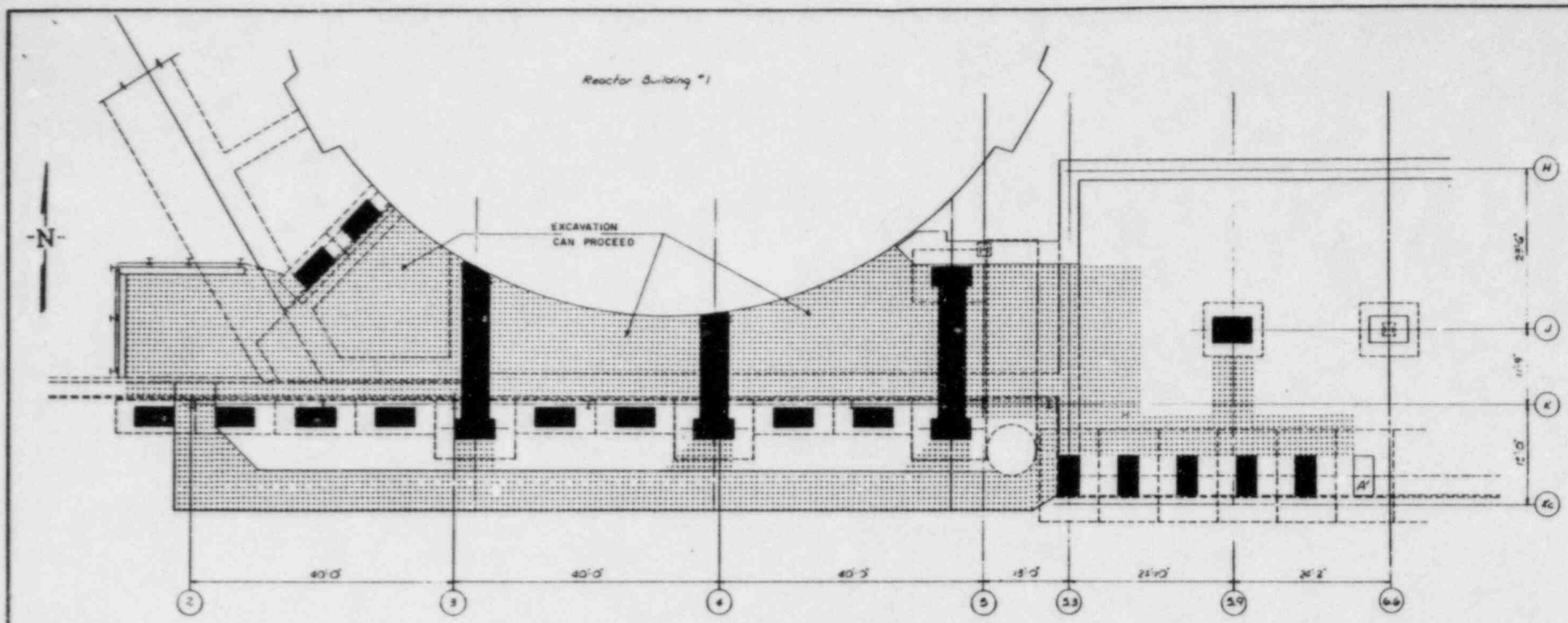
▨ -AREA OPEN FOR ACCESS
■ -AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 25 WEEKS

APPENDIX C FIGURE 6



GENERAL PLAN
(WEST SIDE)

▨ -AREA OPEN FOR ACCESS

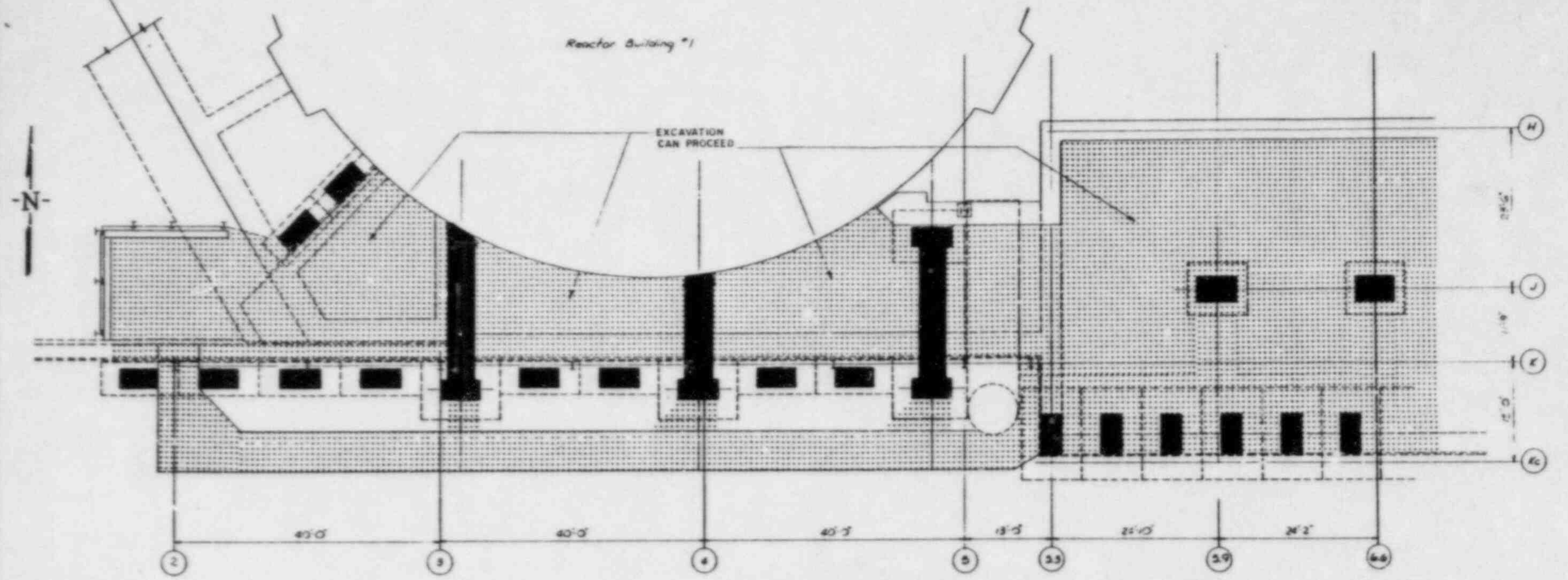
■ -AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 28 WEEKS

APPENDIX C FIGURE 7



GENERAL PLAN
(WEST SIDE)

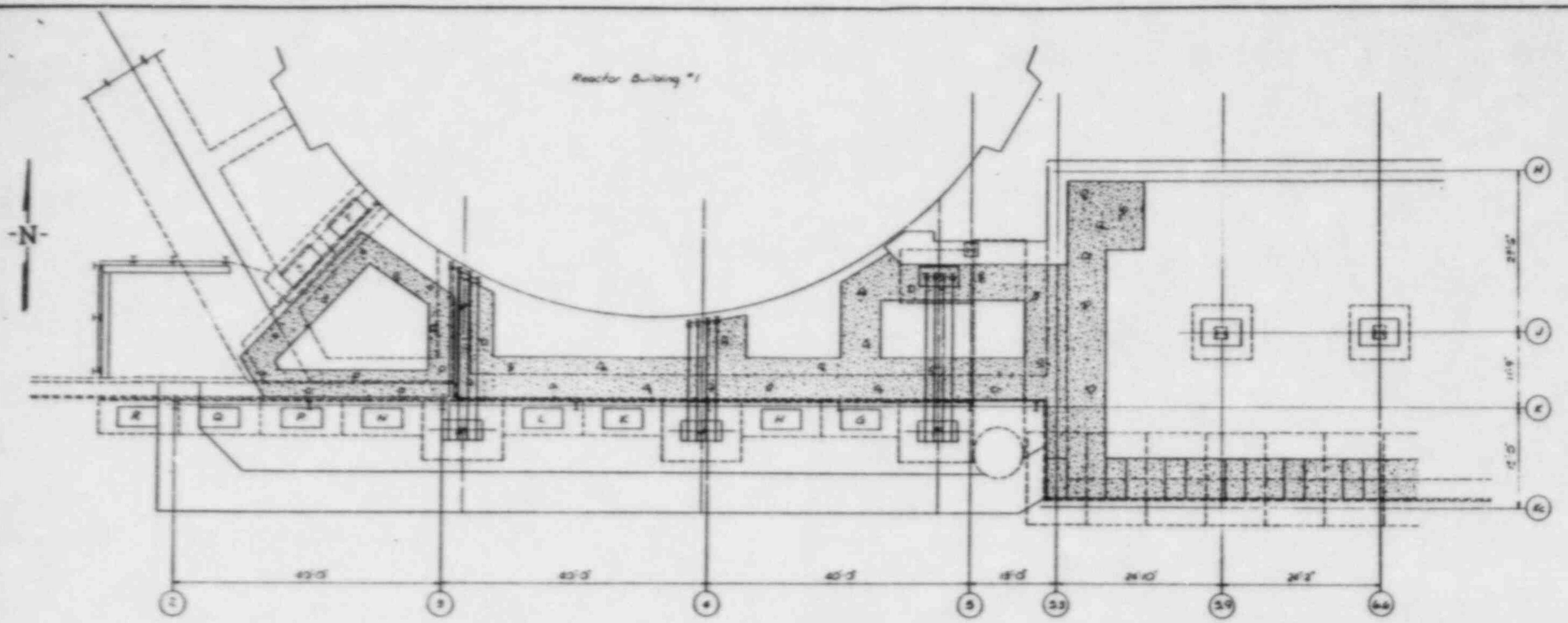
▨ - AREA OPEN FOR ACCESS
■ - AREA OF COMPLETED CONSTRUCTION

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

CONSTRUCTION AFTER 31 WEEKS

APPENDIX C FIGURE 8



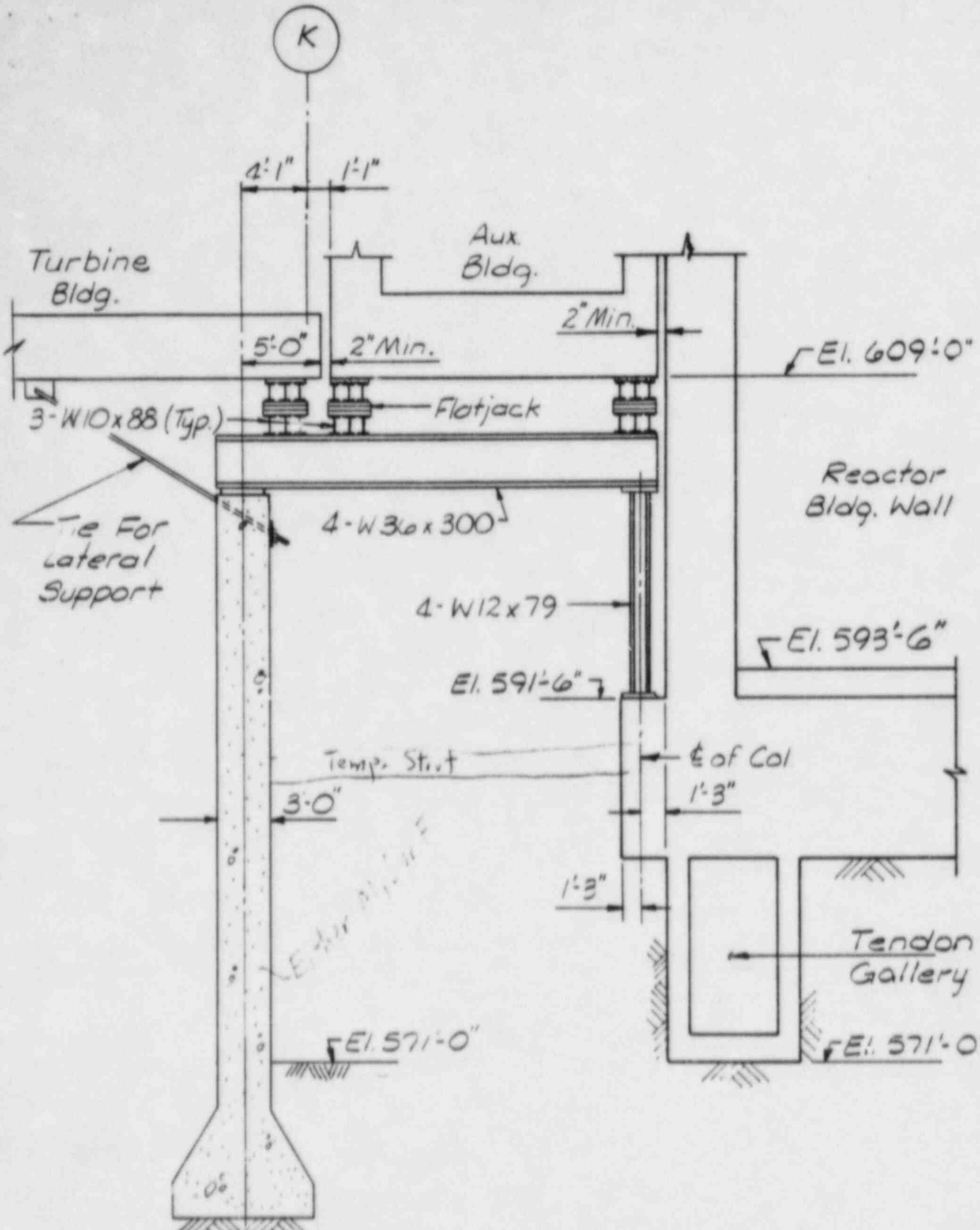
GENERAL PLAN
(WEST SIDE)

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

CONCEPT DRAWING
UNDERPINNING AUXILIARY BUILDING

PERMANENT UNDERPINNING

APPENDIX C FIGURE 9

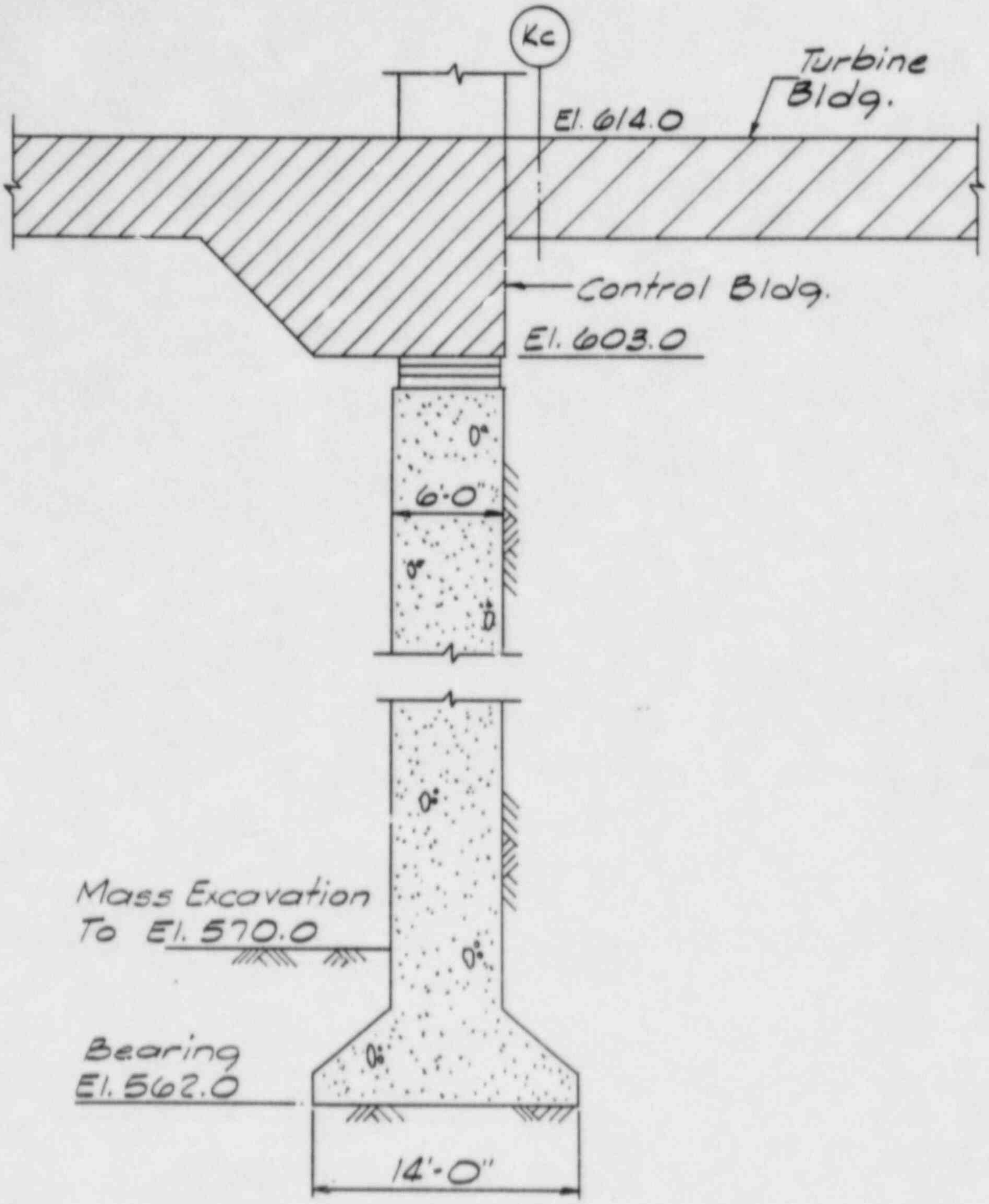


SECTION AT CONTROL TOWER WINGS

CONSUMER POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

UNDERPINNING AUXILIARY BUILDING

FIGURE 10

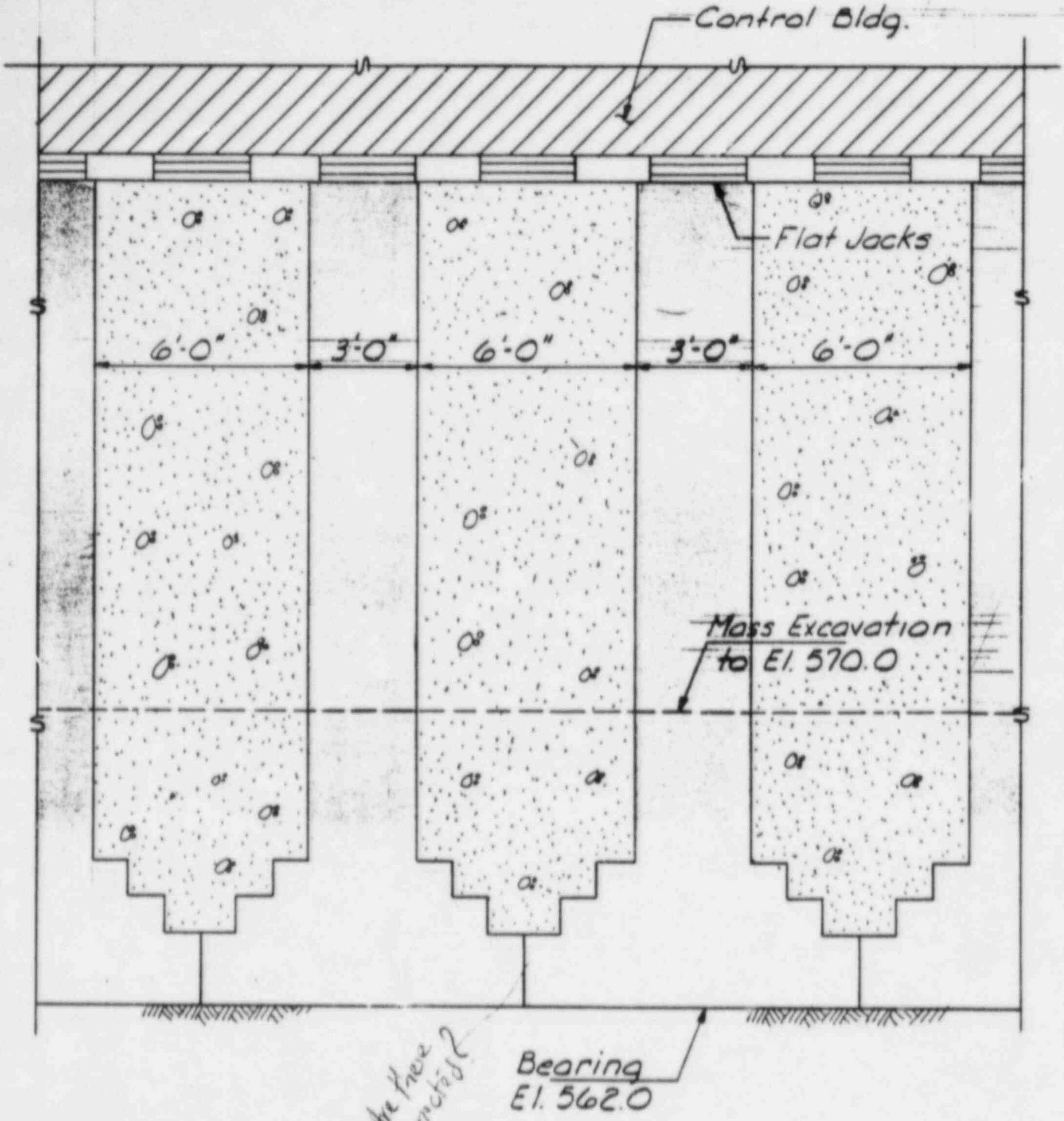


SECTION AT CONTROL TOWER

CONSUMER POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

UNDERPINNING AUXILIARY BUILDING

FIGURE 11



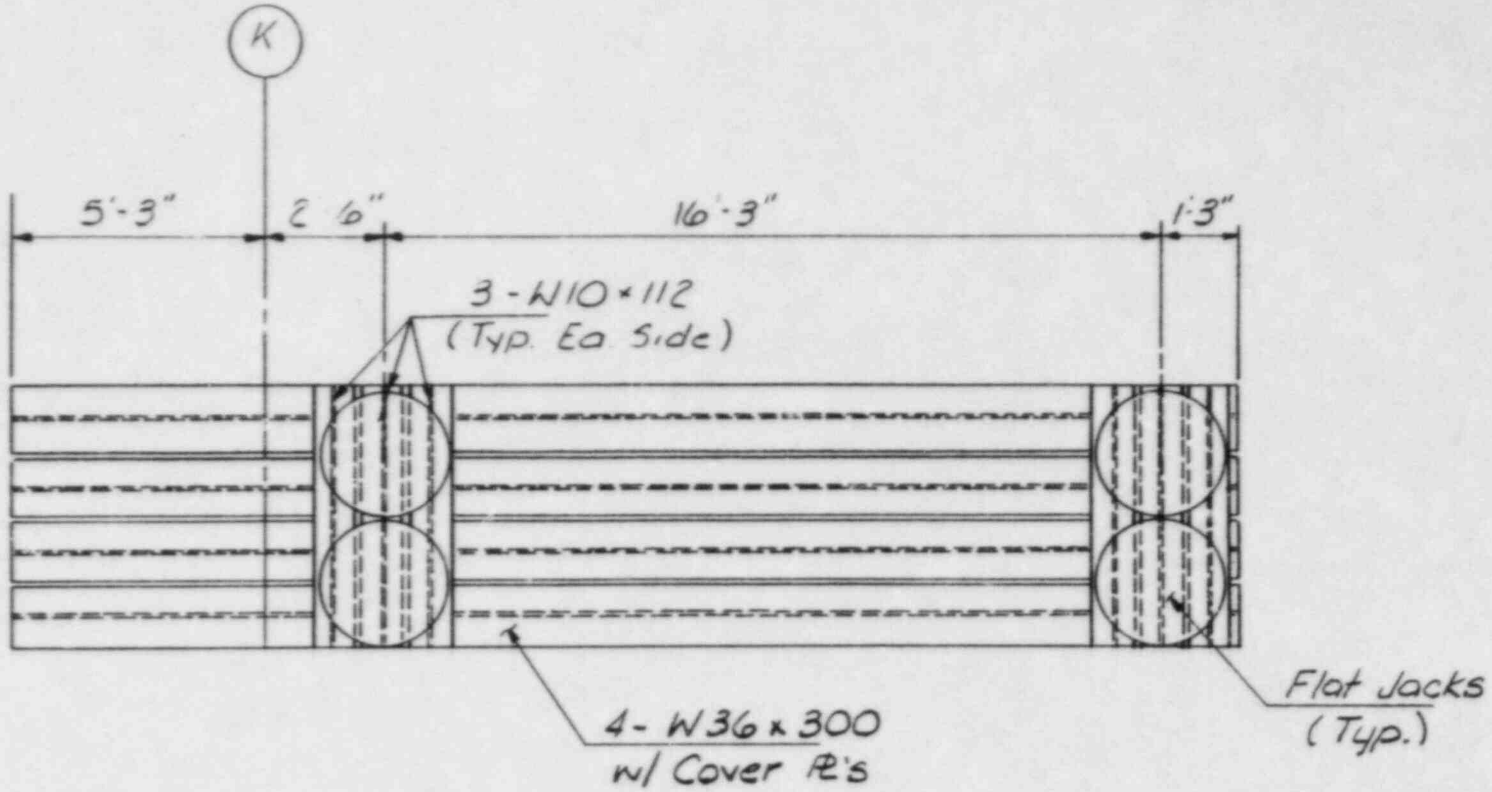
Are these connected?

ELEV. – UNDERPINNING FOR CONTROL TOWER

CONSUMER POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

UNDERPINNING AUXILIARY BUILDING

FIGURE 12



PLAN VIEW - TRANSFER BEAMS & JACKS

CONSUMER POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

UNDERPINNING AUXILIARY BUILDING

FIGURE 13

1/85

Midland Plant Units 1 and 2
Underpinning the Auxiliary Building
and Feedwater Isolation Valve Pits

APPENDIX D

INSTRUMENTATION, LOAD TRANSFER, LOAD SENSING, AND CORRECTIVE MEASURES

1.0 INSTRUMENTATION

Underpinning the auxiliary building requires excavating approximately 9,000 cubic yards of material from underneath the structure and replacing that material with structural concrete.

The structural integrity of the auxiliary building or adjacent structures must be maintained while performing the underpinning work. To maintain the structural integrity of the structure, it is necessary to control structural stresses below predetermined levels. Allowable stresses can be correlated to allowable strains which are manifested in structure movement. Q23 Q.25

The underpinning methods that are planned require that the structure be undermined in small, discrete units and that these units be replaced with load bearing units of greater capacity than the unit that was removed. Discrete units are removed and replaced progressively, according to a predetermined plan, in a manner that will maintain the stresses in the structure below allowable limits.

Nonetheless, the existing backfill may not assume the subgrade reaction exactly according to the predetermined plan. Consequently, there is a possibility that the removal/replacement method could induce structure movement. Because of the size of any removal/replacement relative to the total structure, any single removal/replacement will not induce significant structure movement. However, the progressive nature of the work could cause an accumulated movement, which if unchecked or undetected, could lead to overstressing beyond tolerable limits.

The key to preventing intolerable stress is threefold:

a. A systematic and accurate method for detecting structure movement

Q.19 b. A plan for arresting structure movement before these movements reach intolerable levels what are the intolerable levels?

c. A method for monitoring and assessing structure movement and load data, which results in placing a protective plan into effect. This method should constrain unwarranted concern or unnecessary remedial work.

1/135

This instrumentation plan provides the first key to preventing intolerable stress: a systematic and accurate method for detecting structure movement.

Because the structure is relatively rigid, measurable differential structure movement could produce high stress growth. Therefore, the measurement system must be highly sensitive to real movements. Similarly, measurement points must be located where they will have the highest degree of magnification proportional to real stress (i.e., the free end of the cantilever).

Q.24
Q.26

Thus, two systems for detecting vertical and horizontal movement have been designed to meet this objective. Both systems are based on two layers of measurements. The first layer is for detecting movement of the reactor building, auxiliary building, and turbine building with respect to a fixed datum or vertical plane. The second layer is for detecting relative movement of each of the structures with respect to each other. A two-layer system is required because of the precision of instrumentation hardware.

~~Q.24~~
Q.25

The only exception to this is that a fixed base datum (deep seated bench mark), high-precision system will be used to measure movement of the free end of the wings and control tower. The location of these measurement points is shown in Figure D-1. The precision of the instrumentation is ±0.002 inch; accuracy is ±0.005 inch.

Ask for [illegible] view w/ details

All other vertical detection of movement points rely on a two-layer system. The precision of the instrumentation of the first layer (relative base) is ±0.005. The precision of the second layer (fixed base reference) is ±0.06 inch. Because the first-layer system depends on the second level, the absolute accuracy of the first-level system is approximately ±0.07 inch. Because of direct reading and high precision, the benefit of the second-level system is that data from the system is readily available for sensing differential movement, for developing trends, and for triggering nonroutine readings of the absolute system. The location of the relative base and absolute base reference points is shown in Figure D-1.

Q25
Q28

Relative horizontal movement will be detected at all vertical measurement locations at all three levels. Relative horizontal movement instrumentation will consist of Ames dials and mechanical micrometers.

[illegible]

The absolute horizontal movement detection system will be installed at three locations on top of the auxiliary building. One point will be on the top of the elevator shaft, just north of column row H along column line 6.6. The other two points will be at column lines 3 and 10, approximately 9 feet north of column

[illegible]

row K. The reference points for these points will be the base of the elevator shaft and targets near existing ground level at the exterior walls of the auxiliary building at column lines 3 and 10. The exterior targets will be referenced to a monumented double center horizontal alignment system which projects east and west at existing ground level. The reference points at the roof level will be projected to the base reference points by plumbing. The absolute system will have a precision of ±0.1 inch.

[illegible] movement

2.0 LOAD TRANSFER AND LOAD SENSING

Section 1.0 listed three key features of a successful program to prevent distress in the structures being underpinned. The second feature of that program is compensation for structure movements and their consequent stresses. This section addresses that issue.

does this mean "long term"

Q.26
Q.27

The structures being underpinned are not continually supported on hydraulically actuated jacks. Therefore, in practice, hydraulic pressure data (translated into force) cannot be used for measuring load over a period of time. Hydraulic pressure (translated into force) is used only for transferring load from the structure to the underpinning. The amount of hydraulic force is based on the calculated amount of support the underpinning element must provide at the time of the load transfer. Hydraulic pressure is used because the load transfer is dynamic and requires elongating the jack until equilibrium is established between the structure and the underpinning element.

steel plate

Q.27
Q.30

Once the dynamic aspect of load transfer is completed, a rigid structural element is inserted between the structure and the underpinning element. The rigid element is closed by driving matched pairs of steel wedges. However, prior to driving the wedges and deactivating the jacks, it is necessary to ensure that short-term, time-dependent effects are not occurring. Therefore, the jack/hydraulic system is maintained for 1 hour. If the relative position of the structure with respect to the underpinning element changes by more than 0.01 inch, or the hydraulic pressure dissipates by more than 10%, the process is repeated until the aforementioned criteria are satisfied.

original jacked position

Ask for view that shows how these measurements will be made

As the underpinning work progresses, the load previously transferred to the underpinning elements will most likely change.

Changes in loads on either the newly installed underpinning or the existing and remaining subgrade can cause total or differential settlement of the structure. Differential settlements induce stresses in the structure. These stresses may or may not be significant, depending on their magnitude, algebraic sign, and location.

1/B5

The causes of load change that are easiest to deal with are related to the newly installed underpinning, because there is access to the point of applied load. This problem will be addressed later in this discussion.

The more difficult cause relates to the existing and remaining subgrade reaction, because the subgrade is not accessible.

The transfer of structure loads to and from this area is accomplished from remote locations. The exercise of remote load control primarily depends on three construction procedures:

a. The installation sequence, location, and capacity of the underpinning

b. The amount of calendar time consumed performing the sequential work

c. The method and rate of dewatering

Q 13
~~Q~~.31

Any or all of these construction procedures can be varied in the planning stage or during construction. In both the planning stage and construction, these procedures can be modeled so critical structural stresses can be determined and an underpinning construction procedure can be developed which prevents intolerable structural stresses.

The construction plan for the underpinning work is to initially install the maximum allowable support at the end of the wings and transform the wing structure to a propped cantilever with a fixed end at the control tower. This procedure immediately eliminates the need for remote load sensing in the wing areas and the variability in modeling the least known subgrade reaction. It also significantly reduces the area in which remote load sensing is required, while simultaneously simplifying the structure modeling for determining critical stresses.

Q.23
Same as
~~Q~~.25
~~2Q~~.31
Q.28

The sensing of load in the control tower area, while and after the propped cantilever configuration is working, is based on precise measurements of control tower displacements (movements). Deep seated bench marks at column line/row H x 7.2 and K_c x 7.2 in combination with a deep plumb line at H x 7.2 will be capable of measuring increments of structure movement well below critical strain levels.

what are these? how established?

By sensing loads at the underpinning support points at the ends of the wings and structure displacements at the control tower, fewer variables will be used to develop the structural model.

If the model data indicate that the boundary conditions and resultant critical stresses for the second stage of underpinning

11B5

are close to the preplanned conditions, underpinning will proceed as planned. If not, it will be necessary to modify or change the underpinning plan.

Q.29
~~Q.32~~

Load sensing at the location of the underpinning will be measured by concrete stress meters installed in each underpinning element and verified by hydraulic jack lift-off tests as necessary. Relative movement of the underpinning element base relative to the structure will also be measured by tell tale devices. — Section Details

Q.29
~~Q.33~~

Predetermined points which provide the greatest allowable vertical movement (the free ends of the wing and control tower cantilevers) will be measured directly by mechanical devices (Ames dials and mechanical micrometers) attached to deep seated bench marks. All other data for detecting vertical movement will be obtained.

3.0 CORRECTIVE MEASURES

Section 1.0 outlined a three-fold program for preventing intolerable stresses. This section address the third step of the program: A method for monitoring and assessing structure movement and load data, which results in placing a protective plan into effect.

Q.30
Q.34

A. Frequency of Monitoring

1. Detection of Movement - Routine

a) High-precision system, cantilever free ends and relative base system

What is plotted? Vert. movement vs. time?

1) Read and plot each point once every 8 hours

2) Evaluation of data by onsite geotechnical engineer once daily — Will intolerable levels be identified for when action should be taken?

b. Fixed datum reference points

1) Read and plot each point once every week

2) Evaluation of data by onsite geotechnical engineer once every week

3) Evaluation by engineering once every month

c) Underpinning load data

1/B5

        1) Read and plot each point once every 8 hours What is plotted?

        2) Evaluation of data by onsite geotechnical engineer once daily Action levels?

2. Horizontal Detection of Movement - Routine

    a) High-precision system

        1) Read and plot each point once a week What is plotted

        2) Evaluation of data by onsite geotechnical engineer once each week — Action levels

    b) Fixed base system

        1) Read and plot each point once a month

        2) Evaluation of data by onsite geotechnical engineer once each month

3. Vertical Detection of Movement - Nonroutine

    If evaluation of either the high-precision, fixed datum reference, or underpinning load data reveals movements that exceed predetermined amounts for a particular stage of underpinning, the fixed datum reference points which reflect activity shall be read once every 24 hours and the high-precision points shall be read 9 times a day. — what are these amounts

B. Plan of Action

1. If the evaluation of the underpinning load data and the high-precision vertical movement system indicates trends which would lead to an intolerable level, the onsite geotechnical engineer will institute nonroutine procedures cited in Section A.3 above and with the subcontractor will make adjustments to the underpinning construction plan to arrest the movements. — what is this level? how established — what levels would permit resumption of work

2. If the evaluation of the fixed datum reference data gathered under Section A.1.b or B.1 reveals movements in excess of a predetermined amount, the onsite geotechnical engineer with the subcontractor will make adjustments to the underpinning construction plan to arrest the movements and report the findings, data, and corrective actions to engineering. Engineering shall evaluate the

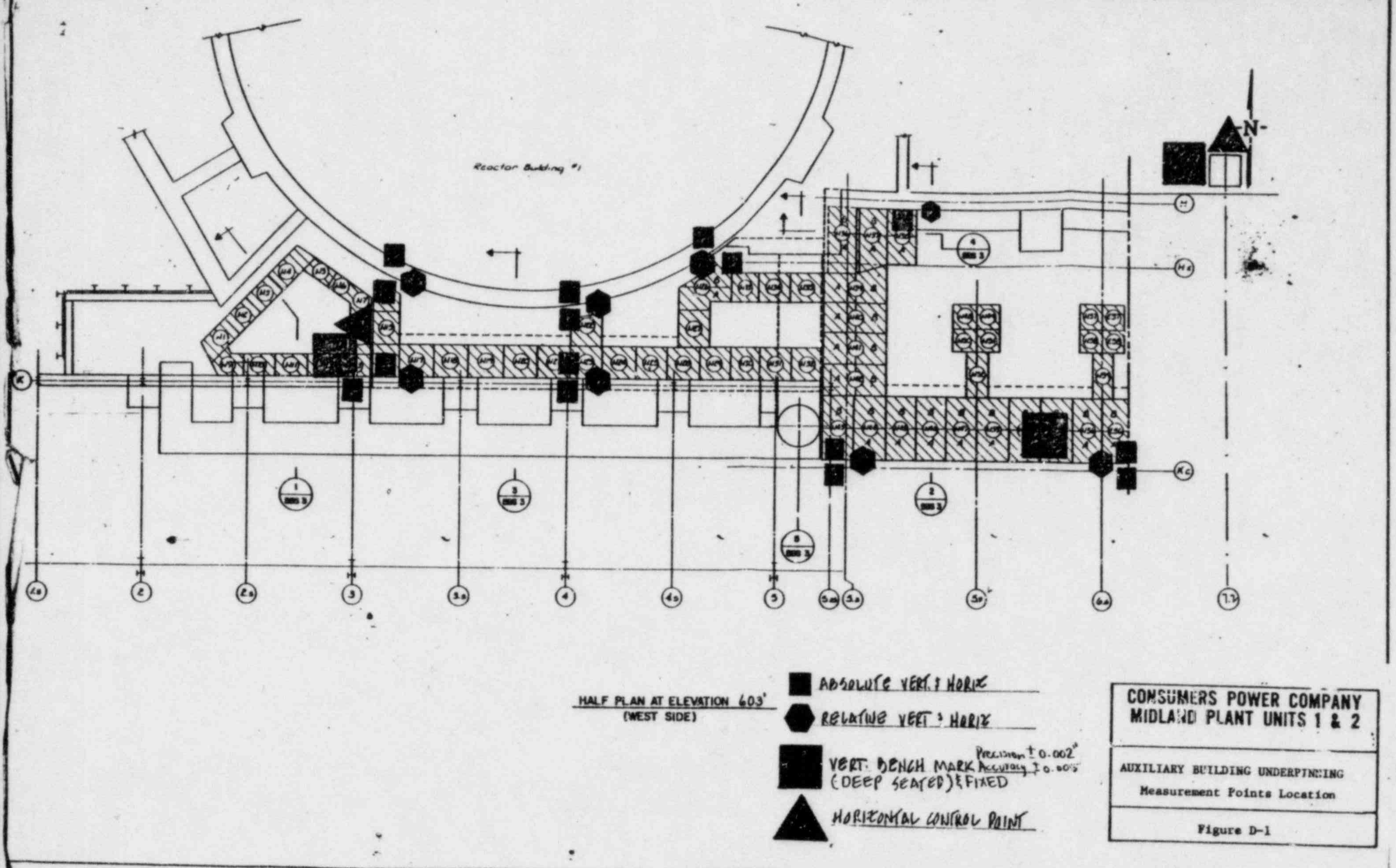
1/B5

information furnished by the onsite geotechnical engineer and determine if other changes in the underpinning construction plan are required, and if construction must be partially or totally stopped.

Attached Figures:

D-1 Auxiliary Building Underpinning - Measurement Points Location

1/B5



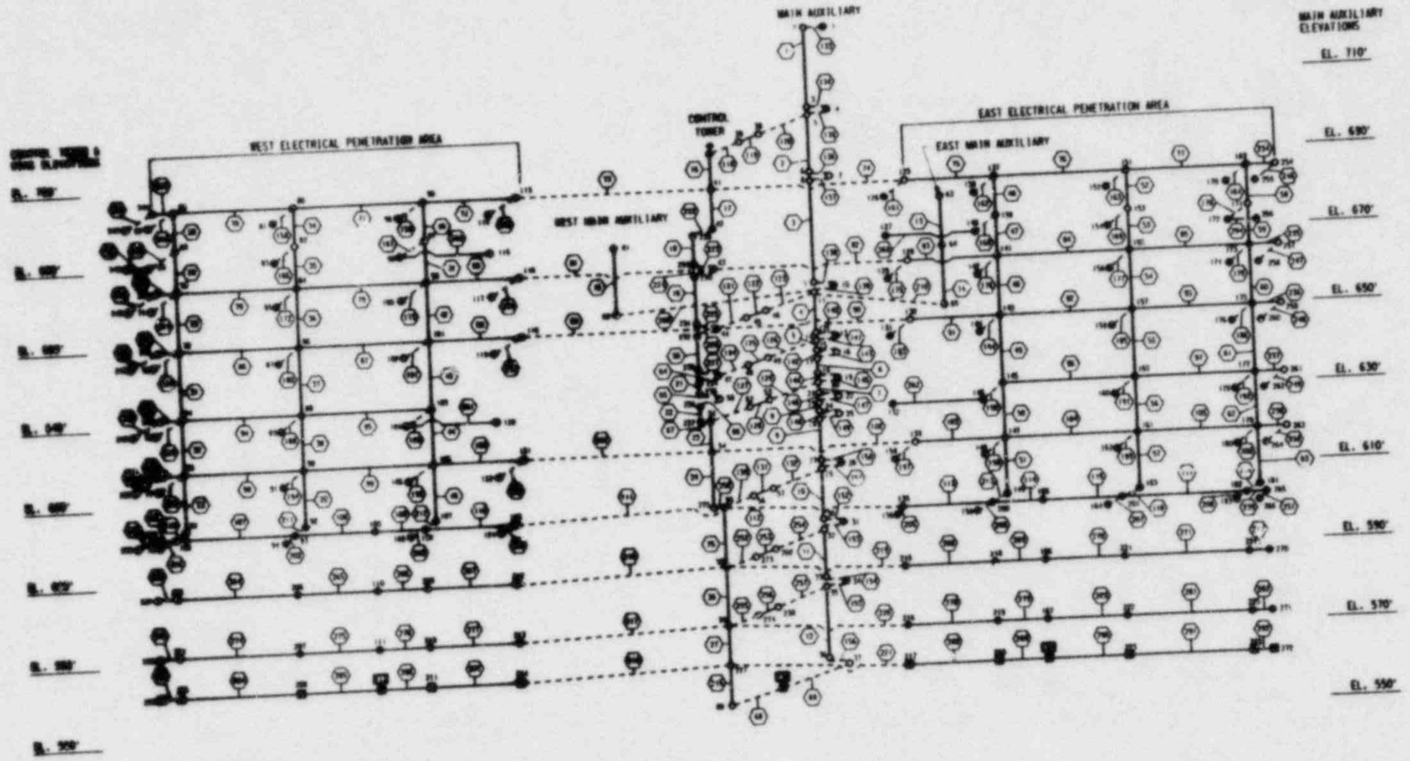
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 & 2

AUXILIARY BUILDING UNDERPINNING
Measurement Points Location

Figure D-1

SIZE E

AUXILIARY BUILDING SEISMIC MODEL

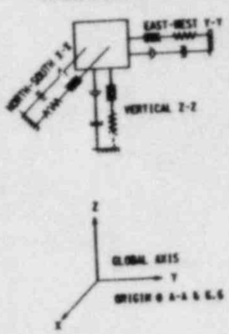


LEGEND

- ● MASS POINT NODE NUMBER
- ○ STATIC POINT NODE NUMBER
- ⑤ BEAM ELEMENT NUMBER
- --- RIGID ELEMENT
- ■ FOUNDATION MASS POINTS

184 TO 197,240,176 ARE
DUMMY NODE POINTS
FOR LOCAL AXIS DEFINITION ONLY

TYPICAL FOUNDATION POINT



BECHTEL
[illegible]

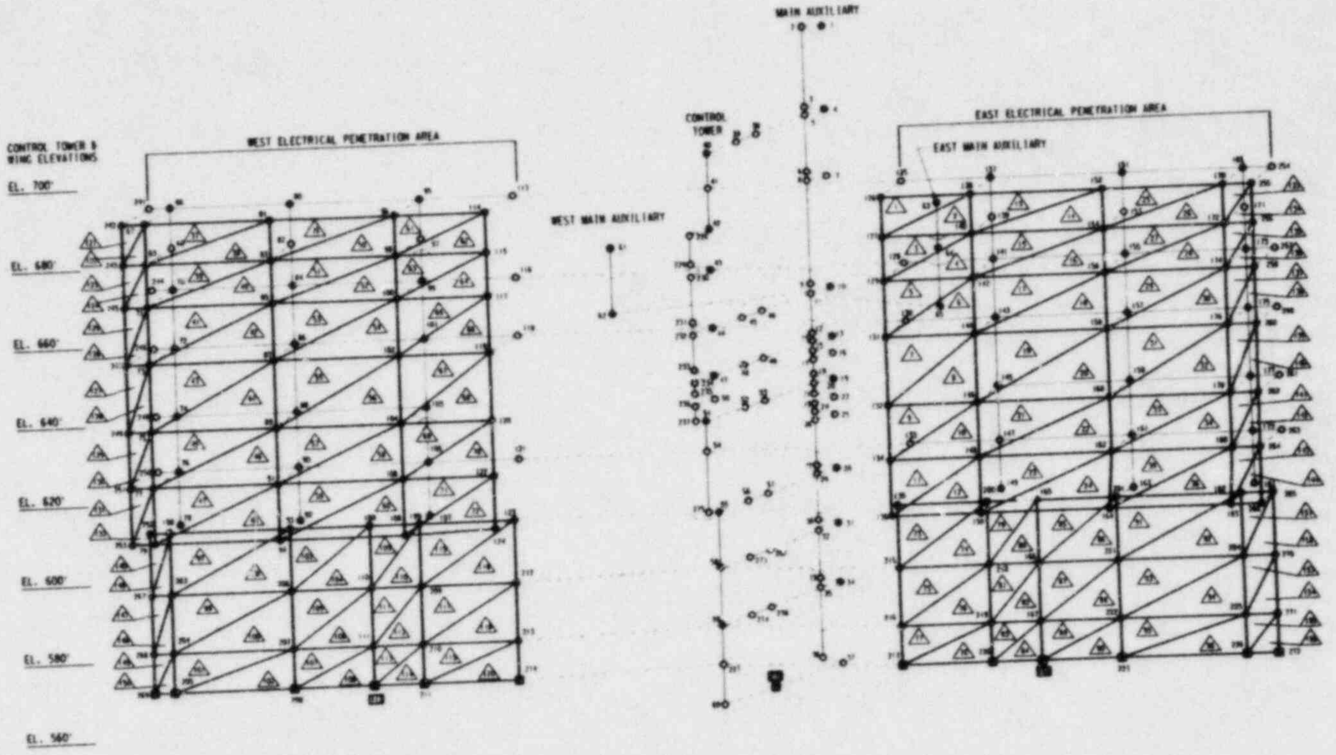
MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

AUXILIARY BUILDING
3-D SEISMIC MODEL
NODE LAYOUT

JOB NO.	DRAWING NO.	REV.
7220	FIGURE 5	

SIZE E

AUXILIARY BUILDING SEISMIC MODEL

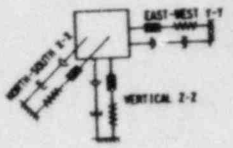


LEGEND

- ● MASS POINT NODE NUMBER
- ○ STATIC POINT NODE NUMBER
- ① BEAM ELEMENT NUMBER
- △ PLATE ELEMENT NUMBER
- --- RIGID ELEMENT
- ■ FOUNDATION MASS POINTS

184 TO 197,240,176 ARE
DUMMY NODE POINTS
FOR LOCAL AXIS DEFINITION ONLY

TYPICAL FOUNDATION POINT



BECHTEL
[illegible]

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY

AUXILIARY BUILDING
3-D SEISMIC MODEL
PLATE LAYOUT

JOB NO.	DRAWING NO.	REV.
7220	FIGURE 6	

J Kane

1|B5

AUXILIARY BUILDING SEISMIC MODEL
REVISION 3

FOR

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY
SEPTEMBER 28, 1981

Encl. 2 to Sept. 30, 1981 letter (Cook to Denton)

8110220349

CONTENTS

FIGURES

APPENDIX

AUXILIARY BUILDING SEISMIC MODEL

1. MODEL DESCRIPTION

The model described herein will be used to evaluate overall building response to seismic loadings as well as to generate in-structure response spectra. The responses developed from this model will provide input to other static analyses to develop forces in the individual structural elements. The building is represented by a three-dimensional lumped-mass stick model (with additional detail in the electrical penetration areas) which preserves the physical geometry of the various building components (see Figures 1 and 4). The layout of elements within the model enables all structural elements north of column line G to be lumped to one stick (main auxiliary building), and all structural elements south of column line H, excluding the electrical penetration wing areas, to be lumped to another stick (control tower) (see Figures 2 and 3). The remaining six sticks, in conjunction with a series of plate elements, are used to represent the electrical penetration areas (east and west wing areas).

The existing connection between the main auxiliary building and control tower sticks (between H and G lines) is represented by a series of beam elements at the floor elevations. The stiffness for these connecting beam elements reflects both the floor properties and any interconnecting shear walls between column lines G and H. Rigid beam elements are used as connection members between column line H and the center line of the control tower stick, and between column line G and the center line of the main auxiliary stick to reflect the actual geometry between the two sticks. The wing areas are made up of a major vertical wall with several intermediate cross walls; therefore, a series of plate elements have been used to represent the south wall along with three sticks per wing to reflect the intermediate cross walls. The plate elements are connected to the wing sticks by a series of rigid beams to maintain the geometry of the wing area. The individual wing sticks are connected by horizontal beam elements whose stiffness represents the existing floor properties. The wing stick nearest the control tower is connected to the control stick by rigid beam elements, representing the geometric distance to the control tower stick. In all cases, the individual sticks have been located at the calculated center of shear resistance.

The mass associated with the main auxiliary and control tower has been lumped at the major floor elevations (see Figures 5 and 6). The mass includes concrete, steel, blockwalls, major equipment and 25% of the floor design live loading. The center of mass was established for each floor level and the eccentricity between the center of mass and center of rigidity is included in the model. For the wing areas the mass associated with each plate element has been lumped in accordance with the plate thicknesses and the remaining mass associated with each wing lumped at the floor elevations along the six sticks.

The proposed underpinning design underneath the control tower has been accounted for in the section proprties of the control tower stick below el 614'. The underpinning wall layout is connected to the existing column line H wall to make up the extention of the control tower stick to el 562'. This portion of the control tower stick is also connected to the main auxiliary stick by beam elements representing the floor properties and interconnecting shear walls in the same manner as the higher elevations. The mass associated with this portion of the control tower stick includes both the concrete and any effective entrapped soil.

The wing area underpinning is represented by a series of plate elements having section properties equivalent to the underpinning concrete sections. The wing underpinning plates are connected to the structural wing sticks and plates by rigid beams to maintain the geometric location and continuity of stiffness between the underpinning and existing structure. The underpinning plates are connected to the control tower stick by rigid beams to reflect the geometry. The mass associated with the wing underpinning has been lumped to the nodes connecting the plate elements. This mass includes the actual concrete volume and the effective entrapped soil.

It should be noted that the properties used for the underpinning portion of the model reflect the design as of August 1981. Should some modification of the design occur which causes significant changes in the present analysis, these design changes will have to be reflected in the model.

Basic Modeling Assumptions:

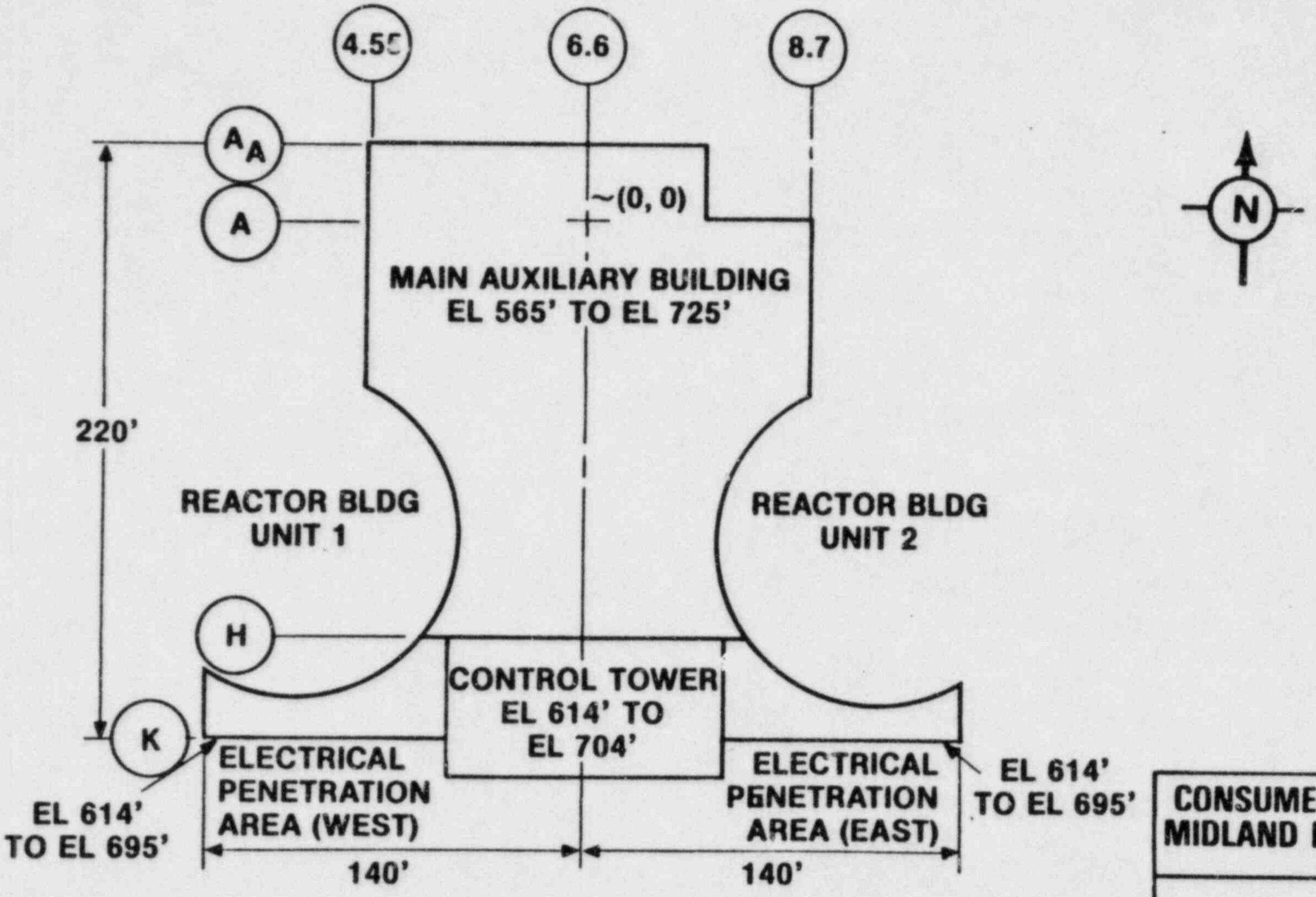
1. Torsional effects will be considered in the dynamic analysis.

2. Model properties are based on gross concrete properties.

3. Soil-structure interaction will be represented by equivalent soil spring constants and damping coefficients based on elastic half-space theory.

4. The effect of surrounding structures is negligible.

AUXILIARY BUILDING
SCHEMATIC PLAN



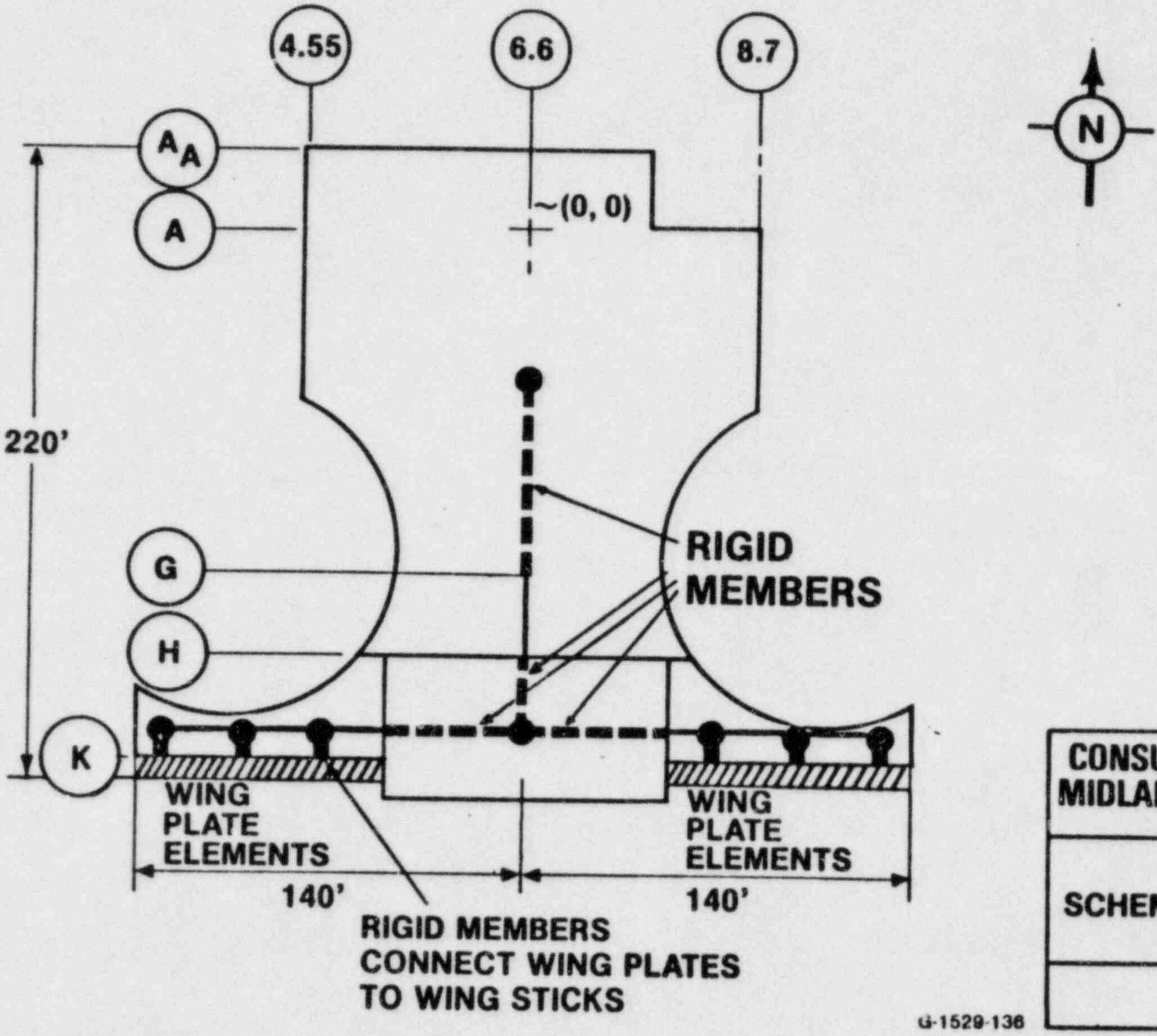
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SCHEMATIC PLAN

FIGURE 1

G-1529-135

AUXILIARY BUILDING
SCHEMATIC PLAN
(With Conceptual Seismic Model)



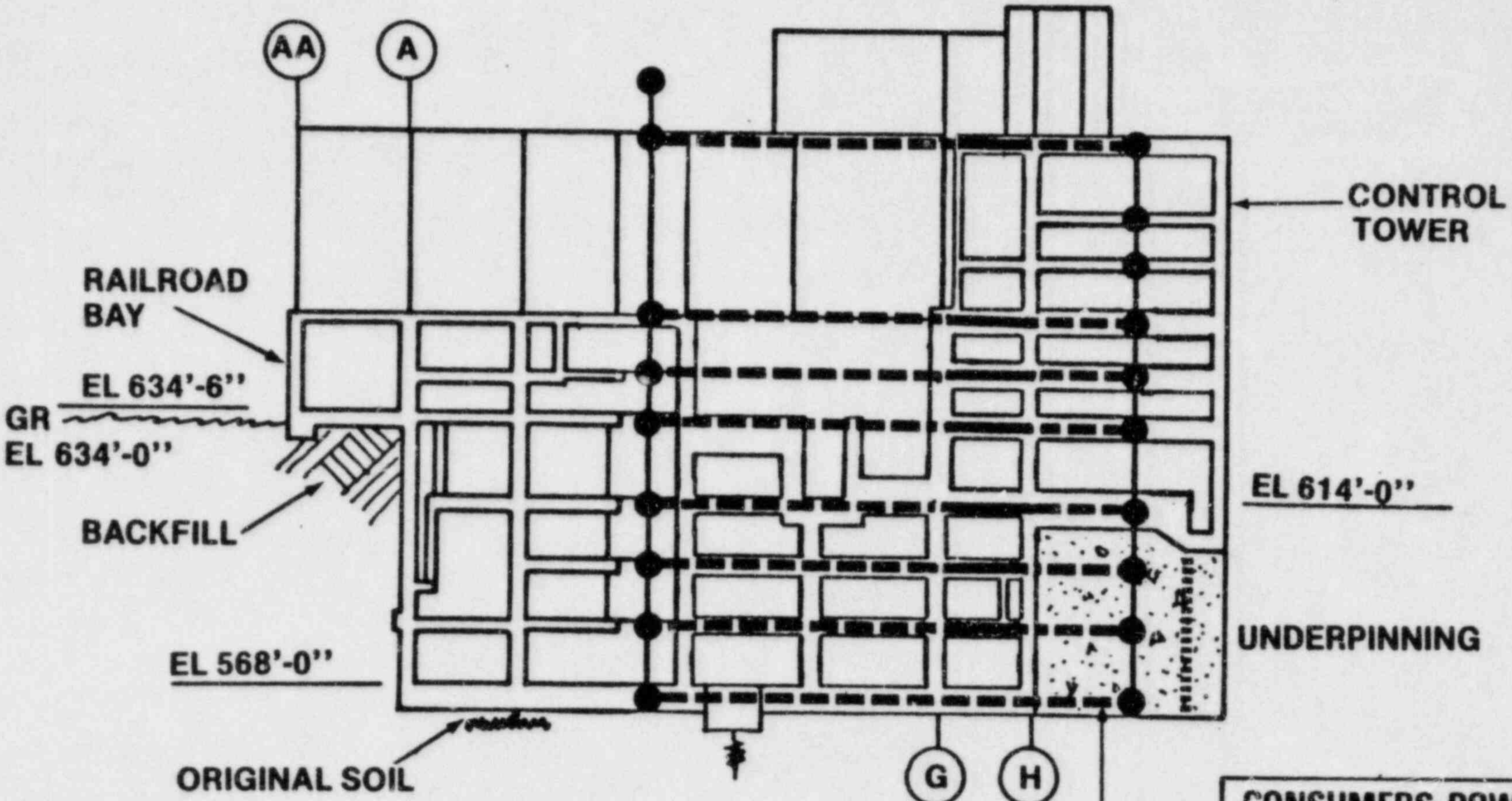
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SCHEMATIC PLAN WITH MODEL

FIGURE 2

G-1529-136

AUXILIARY BUILDING
TYPICAL SECTION LOOKING EAST
(With Conceptual Seismic Model)



HORIZONTAL MEMBERS SHOWN ARE RIGID EXCEPT BETWEEN LINES G & H

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SECTION WITH MODEL

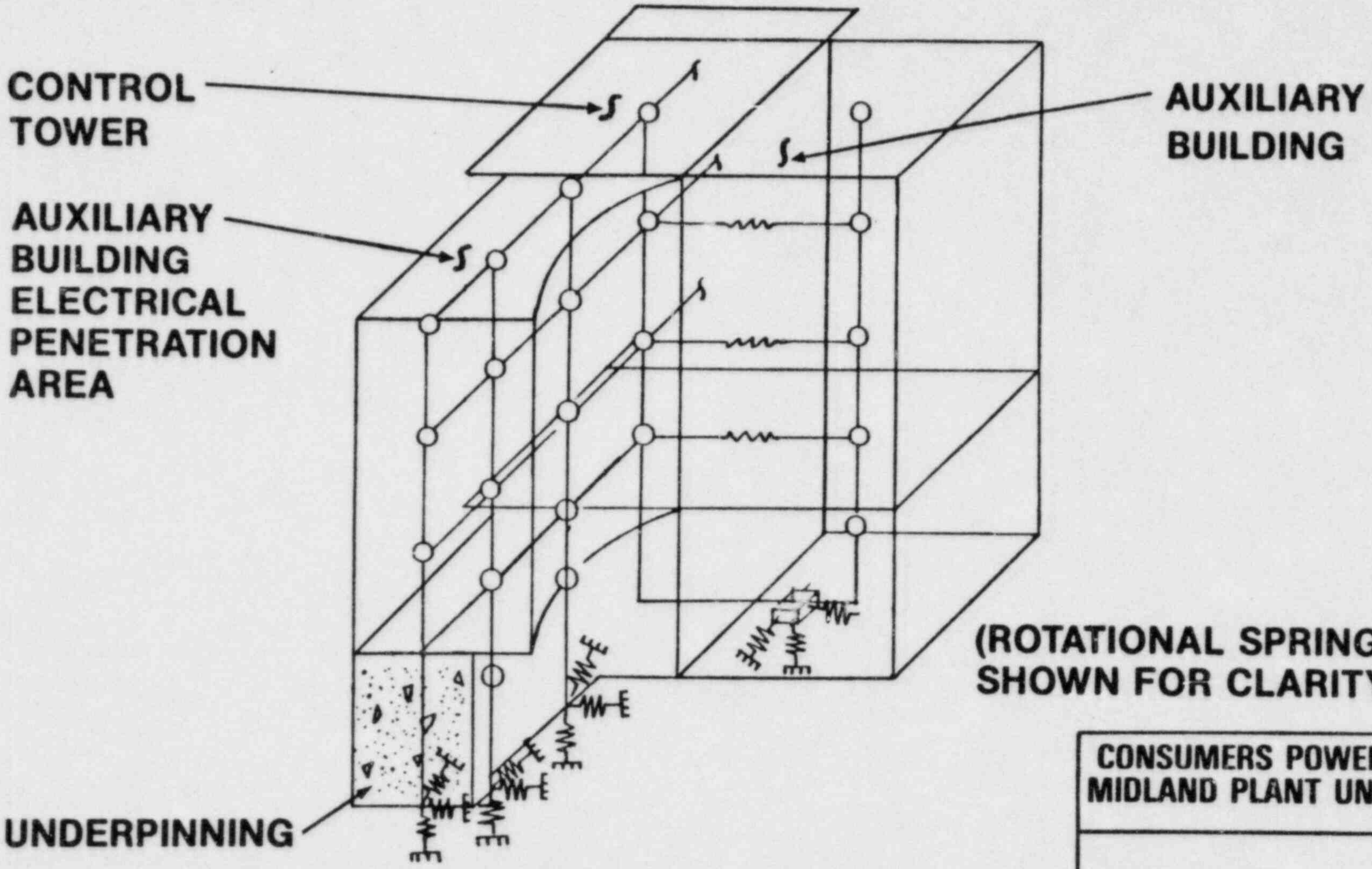
FIGURE 3

MIDLAND UNITS 1 AND 2
BLC 9/8/81

G-1529-134

AUXILIARY BUILDING

(With Conceptual Seismic Model)



(ROTATIONAL SPRINGS NOT SHOWN FOR CLARITY)

CONSUMERS POWER COMPANY MIDLAND PLANT UNITS 1 AND 2
ROUGH 3-D MODEL
FIGURE 4

2. REVIEW INFORMATION

A. AREAS OF DEVIATION FROM FSAR CRITERIA (REVISION 36)

1. Subsection 3.7.1.2

   The modified Taft time-history has been adjusted to envelop the horizontal site design response spectra (for the 2% and greater dampings) in Figures 3.7-1 and 3.7-2 with the 50% increase described in Subsection 3.7.1.1.

2. Section 3.7.1.3

   Soil material damping has been accounted for in the present analysis.

3. Subsection 3.7.1.4

   Soil fill material under auxiliary will be incorporated

4. Section 3.7.2.1

   Reference is made to the impedance functions as being those directly calculated from BC-TOP-4A, Revision 3, Table 3.2. Embedment considerations will be included.

   The computer programs referenced in this section does not include BSAP-DYNAM. Verification will be included in Appendix 3C, for BSAP-DYNAM.

5. Subsection 3.7.2.3

   A three-dimensional model is being used which considers torsional effects.

6. Subsections 2.5.4.7 and 3.7.2.4

   The consideration of embedment will be addressed in these subsections and the assumptions that exist concerning embedment will be deleted. A summary of soil properties used will be included.

7. Subsection 3.7.2.9

   The effect of parameter variation on in-structure floor response spectra will be at least equal to ±15%. The actual numerical value will be determined in accordance with Regulatory Guide 1.122.

8. Subsection 3.7.2.11

   Dynamic torsional effects have been considered.

9. Subsection 3.7.2.15

   Embedment effects will be considered.

10. The following figures and tables will be changed to reflect the new analysis data.

Tables	Figures	
3.7-1	3.7-3	3.7-4
3.7-2	3.7-5	3.7-6
3.7-3	3.7-7	3.7-8
	3.7-10	3.7-43
	3.7-11	3.7-44
	3.7-33	3.7-45
	3.7-34	3.7-46
	3.7-35	3.7-47
	3.7-36	3.7-48
	3.7-37	3.7-49
	3.7-38	3.7-50
	3.7-39	3.7-51
	3.7-40	3.7-52
	3.7-41	3.7-53
	3.7.42	

B. COMMITTMENTS FOR FSAR REVISIONS

1. BSAP-DYNAM (CE 207) will be added to Appendix 3C.

2. An addition will be made to the FSAR addressing soil-sructure interaction with embedment.

3. The method presented for the consideration of torsional response will be revised to reflect the inclusion of this effect in the revised seismic model.

4. The use of soil material damping as well as radiation damping will be addressed in the discussion of critical damping.

5. Techniques for broadening in-structure response spectra curves will be included.

C. OVERVIEW OF HOW THE REVISED MODEL HANDLES DYNAMIC EXCITATION

The BSAP computer program enables solutions for simultaneous excitation of all base points by the input forcing function along a single principal direction. The principal direction solutions are then combined.

D. MIDLAND SEISMIC ANALYSIS CRITERIA

1. Soil Properties:

    a. Till Material Properties

    A nominal soil dynamic modulus of elasticity of 22,000 ksf and a Poisson's ratio of 0.42 is used as uniform foundation media properties to compute the soil impedance functions for both the SSE and OBE.

    b. Fill material properties are based on 10 CFR 50.54(f) investigations by Bechtel.

2. Analyses are based upon the FSAR 0.12g SSE design spectra and damping.

3. The seismic analysis and evaluation of the structure and components considers the following:

    a. Variation of ± 50% in the dynamic modulus of elasticity of the till is used to develop upper bound building forces.

    b. Dynamic torsion is considered in the seismic analysis.

    c. Embedment effects are considered.

d. The impedance functions are represented by the equivalent spring stiffnesses and radiation damping coefficients specified in Table 3-2 of BC-TOP-4-A, (see Table A-1).

e. Soil material damping (3% of critical damping) will be added directly to the radiation damping calculated.

f. Response spectra calculated using nominal soil properties will be widened by at least ± 15% according to Regulatory Guide 1.122.

g. Any computed composite modal damping exceeding 10% of critical will be limited to a maximum of 10% of critical except for those modes clearly associated with rigid body translation or rotation (BC-TOP-4A, Section 3.3.1, Rev 3).

3. SOIL-STRUCTURE INTERACTION TECHNIQUE

Soil structure interaction has been accounted for by using a lumped parameter representation. Impedance coefficients representing the foundation media were derived based on elastic half-space theory. These impedance coefficients have been adjusted for embedment conditions.

A. GENERAL ASSUMPTIONS AND METHODOLOGY

The elastic half-space impedance parameters (prior to embedment considerations) were evaluated based on soil properties obtained using a weighted average of the soil properties under the railroad bay with the soil under the remainder of the building. The weighting technique was based on area for translational motion and on moment of inertia for rocking motions. The horizontal and torsional impedance parameters were based on the entire area enclosed within the foundation perimeter, while the vertical and rocking impedance parameters were based on the foundation contact area only. The total foundation area assumed for each impedance parameter calculation was then transformed into equivalent rectangles and circular areas (maintaining equivalent areas for translation and equivalent moment of inertias for rocking) with foundation soil properties based on the weighted averages. Finally these weighted soil properties and equivalent areas were used to develop the elastic half space impedance coefficients as outlined in BC-TOP-4A, Table 3.2. The global translational springs were then uniformly proportioned for a major set of springs at the control tower and main auxiliary building base and a series of springs along each wing foundation. The series of springs distributed along the wings were developed by distributing the global translational springs to the various foundation points based on the tributary area of each. The rotational spring at the main auxiliary building and control tower base was reduced to maintain equivalent stiffness to offset the additional rocking restraint imposed by the wing area springs. The radiation damping values were assigned to the main auxiliary and control tower foundation with soil material damping added at all spring locations. (A soil material damping ratio of 3% was used. This value was conservatively selected from Figure 2-4 of BC-TOP-4A, Rev 3). The effect of embedment was considered in the form of multipliers

$G = \frac{E}{2(1+\nu)} = \frac{22,000 \text{ kip}/ft^2}{2(1+0.42)} = 7746$

to the calculated elastic half space spring constants and damping coefficients. A more detailed discussion of how the embedment multipliers were developed is described in Appendix A.

B. SOILS DATA

Strain Range - general site range of 10^{-2} to 10^{-3}%; FSAR Subsection 2.5.4.7

FSAR pg. 2.5-93
$E = 22 \times 10^6$ lb/ft^2
$E = 22,000$ KSF
for strain in range of 10^{-2} to 10^{-3}

Properties of Material Below Main Building Foundation Grade: (E = 22,000 ksf ± 50% as recommended by Dames and Moore: FSAR Subsection 2.5.4.7)

see FSAR pg. 2.5-92 for natural soils

where

$\nu = 0.42$

$\rho = 135$ pcf

G = 7,746 ksf (nominal)

$G = \rho V_s^2 = \frac{135 \text{ lb/ft}^3}{32.2 \text{ ft/sec}^2} \times \overline{2300}^2 \text{ ft}^2/\text{sec}^2$

G = 22,179 KSF

(This is @ strain of 10^{-4}% where V_s is measured)

Average properties of material below the railroad bay portion of the main auxiliary building (north of column line A):

See FSAR pg. 2.5-95

where

$\nu = 0.40$

$\rho = 120$ pcf

G = 2,165 ksf*

Average properties of fill material along the sides of the auxiliary building used to develop the effect of embedment:

North side

where

G = 2,495 ksf**

East, West, and South sides

where

G = 1,728 ksf**

*The shear modulus of fill has been degraded to earthquake strain levels by the Seed and Idriss curves from BC-TOP-4A, Revision 3, Figures 2-3 and 2-5.

**Only the averaged shear modulus is required for the side soil in the embedment calculations.

C. RESULTS OF LUMPED-PARAMETER REPRESENTATION FOR THE FOUNDATION MEDIA

The equivalent half-space soil spring constants and damping coefficients developed without the effect of embedment have been tabulated below.

GLOBAL SOIL SPRING CONSTANTS AND DAMPING COEFFICIENTS WITHOUT THE EFFECT OF EMBEDMENT

Motion	Spring Constant	Radiation Damping Coefficient
Translational		
North-South	Kxx = 3.7E6 k/ft	Cxx = 1.7E5 $\frac{\text{k-sec}}{\text{ft}}$
East-West	Kyy = 3.7E6 k/ft	Cyy = 1.7E5 $\frac{\text{k-sec}}{\text{ft}}$
Vertical	Kzz = 4.8E6 k/ft	Czz = 3.0E5 $\frac{\text{k-sec}}{\text{ft}}$
Rotational		
East-West	Kψxx = 3.1E10 $\frac{\text{k-ft}}{\text{rad}}$	Cψxx = 5.2E8 $\frac{\text{k-ft-sec}}{\text{rad}}$
North-South	Kψyy = 4.8E10 $\frac{\text{k-ft}}{\text{rad}}$	Cψyy = 1.1E9 $\frac{\text{k-ft-sec}}{\text{rad}}$
Torsion	Kψzz = 4.7E10 $\frac{\text{k-ft}}{\text{rad}}$	Cψzz = 3.4E9 $\frac{\text{k-ft-sec}}{\text{rad}}$

Kxx = translational soil stiffness in x-direction
Kψxx = rotational soil stiffness about x-x axis

The translational springs constants are distributed to the discrete foundation locations (one under the main auxiliary building and control tower (node 239) and six each under the wing areas (nodes 112, 168, 205, 226, 208, 211, 214, 217, 220, 223, 269, and 272) weighing the distribution by tributary area (refer to Figure 5 for node locations). The table below represents the spring constants and damping coeffients calculated for each node as well as the embedment multipliers used.

DISTRIBUTED SOIL SPRING CONSTANTS AND DAMPING COEFFICIENTS WITH THE EFFECT OF EMBEDMENT

Node No.	Direction of Impedance Parameter	Spring Constant(1)	Radiation Damping Coefficient or Material Damping(1)	Embedment Factor Spring/ Damp	Final Spring Constant(2)	Final Damping Ratio or Coefficient(2)
	XX(4)	4.3E4	3%	1.10/NA	4.7E4	3%
214	YY	4.4E4	3%	1.08/NA	4.7E4	3%
217	ZZ	6.0E4	3%	1.07/NA	6.4E4	3%
	ψYY(5&8)	1.0E7	3%	1.07/NA	1.1E7	3%
	XX	4.6E4	3%	1.10/NA	5.1E4	3%
211	YY	4.7E4	3%	1.08/NA	5.1E4	3%
220	ZZ	6.5E4	3%	1.07/NA	6.9E4	3%
	ψYY	1.1E7	3%	1.07/NA	1.2E7	3%
	XX	1.2E4	3%	1.10/NA	1.3E4	3%
112	YY	1.2E4	3%	1.08/NA	1.3E4	3%
168	ZZ	1.7E4	3%	1.07/NA	1.8E4	3%
	ψYY	2.9E6	3%	1.07/NA	3.1E6	3%
	XX	2.6E4	3%	1.10/NA	2.8E4	3%
208	YY	2.6E4	3%	1.08/NA	2.8E4	3%
223	ZZ	3.6E4	3%	1.07/NA	3.9E4	3%
	ψYY	6.2E6	3%	1.07/NA	6.6E6	3%
	XX	2.3E4	3%	1.10/NA	2.5E4	3%
205	YY	2.3E4	3%	1.08/NA	2.5E4	3%
226	ZZ	3.1E4	3%	1.07/NA	3.4E4	3%
	ψYY	5.4E6	3%	1.07/NA	5.8E6	3%
269	XX	5.6E3	3%	1.10/NA	6.1E3	3%
272	YY	5.7E3	3%	1.08/NA	6.1E3	3%
	ZZ	7.8E3	3%	1.07/NA	8.3E3	3%
	ψYY	1.3E6	3%	1.07/NA	1.4E6	3%
	XX	3.4E6	1.7E5(6)	1.10/1.21	3.7E6	2.0E5
	YY	3.4E6	1.7E5	1.08/1.18	3.7E6	2.0E5
239(3)	ZZ	4.3E6	3.0E5	1.07/1.09	4.6E6	3.3E5
	ψXX	3.1E10	5.2E8(7)	1.15/1.28	3.2E10	7.0E8
	ψYY	4.8E10	1.1E9	1.23/1.46	5.4E10	1.6E9
	ψZZ	4.7E10	3.4E9	1.19/1.32	5.0E10	4.2E9

---

(1) Without embedment

(2) With embedment

(3) Effect of 3% soil material damping is also included in final embedded damping coefficient

(4) Translational spring constants in units of k/ft

(5) Rotational spring constants in units of k-ft/rad

(6) Translational damping coefficients in units of k-sec/ft

(7) Rotational damping coefficients in units of $\frac{\text{k-ft-sec}}{\text{rad}}$

(8) The east-west rotational spring constant (Kψxx) and torsional spring constant (Kψzz) have been lumped to node 239

D. SAMPLE CALCULATION OF TRANSLATIONAL SPRING

The following represents the calculation of the translational spring constant using the equivalent building foundation in the north-south direction at point 239. (See Appendix A for method.)

From Appendix A, two methods are available for generating this value. (see Table A-1)

1. Method 1 - Equivalent Circular Base

$$Kxx_{Global} = \frac{32\ (1-\nu)\ GR}{7-8\nu} \qquad R = \sqrt{\frac{A}{\pi}}$$

$$= \frac{32\ (1-0.42)\ (7{,}155)\ (102.3)}{7-8\ (.42)}$$

$$= 3.73E6\ k/ft$$

2. Method 2 - Equivalent Rectangular Base

This method assumes that the foundation area can be represented by a rectangle whose one dimension is equal to the gross north south foundation length and the other dimension based on the total area.

$$Kxx_{Global} \approx 2(1 + \nu)\ G\beta \times \sqrt{BC}$$

$$= 2(1+0.42)\ (7155)\ (0.98)\ \sqrt{234 \times 140.6}$$

$$= 3.61\ E6\ k/ft$$

Spring constant used is equal to average of two methods

$$Kxx_{Global} = \frac{3.73\ E6 + 3.61\ E6}{2}$$

$$= 3.67\ E6\ k/ft$$

The global Kxx is then distributed to the various local foundations based on tributary areas:

$$Kxx_{239} = 3.67E6\ k/ft \times \frac{\text{Area (239)}}{\text{Area total foundation}}$$

$$= 3.67E6\ k/ft \times \frac{30{,}121\ ft^2}{32{,}905\ ft^2} = 3.36E6\ k/ft$$

Then the embedment multiplier can be found by Equation A-1 from Appendix A (individual terms will be evaluated in the calculations to follow)

$$K'_{ii} = K_{ii} \ [1 + (\alpha_{ii} - 1) \times \frac{G1}{G2} \times f] = K_{ii} \ E_k$$

Where E_k is the embedment multiplier.

$a_o = \frac{\omega R}{V_s}$ (Equation A-8)

Using an initial estimate of $\omega = 2.8$ cps x 2π based on previous analysis of this structure (two-dimensional model) and $R = \sqrt{A/\pi}$ where the area is the foundation area of the embedded portion (total foundation area - railroad bay foundation area)

The value of V_s is also required;

$$V_s = \sqrt{G/\rho} = \sqrt{\frac{7,746 \ (32.2)}{.135}} = 1,359 \text{ fps}$$

The use of these soil properties is justified because the base is founded entirely in the Dames and Moore material.

$$a_o = \frac{2.8 \times 2\pi \times 96.3}{1,359} = 1.25$$

The h/r ratio of side embedment is found based on the assumption that side soil on the north side of the building is effective only up to the bottom of the railroad bay (el 630.5').

$$\frac{h}{R} = \frac{630.5 - 562}{96.3} = 0.71$$

For the south side of the building, the embedment soil is assumed effective only to the bottom of the turbine building foundation (el 611').

$$\frac{h}{R} = \frac{611 - 562}{96.3} = .51$$

Then using Figure A-2

For $\frac{h}{R} = .71; \ a_o = 1.25$

$\alpha_{xx} = 1.90$

$\frac{h}{R} = .51; \ a_o = 1.25$

$\alpha_{xx} = 1.67$

The 'f' factor, the reduction factor for partial perimetrical embedment, is determined from Figure A-12 based on the following assumptions:

Recognizing the conservatism involved in using the completely free condition (see Figure A-12, Appendix A) the best estimate of the actual conditions would be the use of the recommended curve for establishing 'f'.

Additionally to take into account the differential embedment depths assumed around the perimeter of the building the angular section (Θ) defined in Figure A-12 is reduced to account for the varied depths.

Recall the various embedments depths

North side - 630.5 - 562 = 68.5 ft
East, West, South sides - 611 - 562 = 49 ft

Therefore for northern motion

$$\left(\frac{68.5}{4} + \frac{49 \times 3}{4}\right) \times \left(\frac{360°}{68.5}\right) = 280° \text{ Welded Contact}$$

For southern motion the 360° welded contact condition is assumed since at least 49 ft is available on all sides.

Then based on Figure A-12

For northern motion, with

$\Theta = 280°$, recommended curve
$f = .38$

For southern motion, with

$\Theta = 360°$; recommended curve
$f = .50$

Finally the G1/G2 ratio of side shear modulus to foundation shear modulus is established.

For north side of building

$$\frac{G1}{G2} = \frac{2,495}{7,746} = 0.32$$

For south side of building

$$\frac{G1}{G2} = \frac{1,728}{7,746} = 0.22$$

Therefore, from Equation A-1

$$E_{kn} = [1 + (1.9-1) \times (.32) \times (.38)] = 1.11$$

$$E_{ks} = [1 + (1.67-1) \times (.22) \times (.50)] = 1.08$$

And taking the average of these two directions (since the spring must act in two directions in the model)

$$E_{kn-s} = \frac{1.11 + 1.08}{2} = 1.10$$

Finally

$$K'_{xx_{n-s_{239}}} = 3.36E6 \times 1.10$$
$$= 3.7E6 \text{ k/ft}$$

E. CALCULATION OF COMPOSITE MODAL DAMPING

A pseudo-fixed base modal analysis utilizing the strain energy approach to develop composite structural modal damping was run with the main auxiliary building and control tower foundation restrained and the wings having the flexibility of the soil as calculated. The pseudo fixed base results are then used as input to BSAP-DYNAM (CE 207) to develop the soil-structure interaction composite modal damping analysis. The technique used in CE 207 matches the rigorous and normal mode solutions of the transfer function simultaneously at all the natural frequencies within the frequency range of interest. The technique follows the work mentioned in Reference 1, but has been extended based on References 2 and 3 for three dimensional use.

F. REFERENCES

1. Tsai, N.C., (1972) "Soil-Structure Interaction During Earthquake," Technical Report, Power and Industrial Division, Bechtel Corporation, San Francisco, California.

2. Ibrahim, A.M. and Hadjian, A.H., (1975) "The Composite Damping Matrix Matrix for a Three Dimensional Soil-Structure System," 2nd ASCE Specialty Conference on Structural Design of Nuclear Plant facilities, pp. 932, New Orleans.

3. Atalik, T.S., (1980) "Equivalent Interaction Modal Damping," Proceedings, 7th World Conference on Earthquake Engineering, August, Istanbul, Turkey

4. DYNAMIC MODEL PROPERTIES

Nodal Coordinates	Pages 4-2 to 4-7
Element Properties	Pages 4-8 to 4-21, Page 4-29
Boundary Conditions	Pages 4-22 to 4-24
Nodal Masses	Pages 4-25 to 4-28

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BSAP  AUXILIARY BUILD SEISMIC  ANALYSIS FLEXIBLE BASE                                                  090881
CE800D15
    C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S  . . .  UNITS OF ( L )

  NODE       . . BOUNDARY CONDITION CODES . .          . . NODE COORDINATES . .                              NODAL
 NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)       X(N)       Y(N)       Z(N)                           SYSTEM
(NOTE 1)                (NOTE 2)                               (NOTE 3)                                      (NOTE 4)
     1     0      0      0      0      0      0      125.850     -.620    724.880                           GLOBAL
     2     0      0      0      0      0      0      131.040      .770    724.880                           GLOBAL
     3     0      0      0      0      0      0      131.040      .770    704.000                           GLOBAL
     4     0      0      0      0      0      0       89.550      .000    704.000                           GLOBAL
     5     0      0      0      0      0      0       65.390      .000    704.000                           GLOBAL
     6     0      0      0      0      0      0       65.390      .000    687.000                           GLOBAL
     7     0      0      0      0      0      0       65.490      .000    687.000                           GLOBAL
     8     0      0      0      0      0      0       65.390      .000    687.000                           GLOBAL
     9     0      0      0      0      0      0       65.390      .000    659.000                           GLOBAL
    10     0      0      0      0      0      0       45.860     -.640    659.000                           GLOBAL
    11     0      0      0      0      0      0       59.970    -2.210    659.000                           GLOBAL
    12     0      0      0      0      0      0       59.970    -2.210    646.000                           GLOBAL
    13     0      0      0      0      0      0       61.440    -1.270    646.000                           GLOBAL
    14     0      0      0      0      0      0       58.710    -3.610    646.000                           GLOBAL
    15     0      0      0      0      0      0       58.710    -3.610    642.580                           GLOBAL
    16     0      0      0      0      0      0       58.810    -3.610    642.580                           GLOBAL
    17     0      0      0      0      0      0       58.710    -3.610    642.580                           GLOBAL
    18     0      0      0      0      0      0       58.710    -3.610    634.500                           GLOBAL
    19     0      0      0      0      0      0       50.050    -5.180    634.500                           GLOBAL
    20     0      0      0      0      0      0       60.580    -7.540    634.500                           GLOBAL
    21     0      0      0      0      0      0       60.580    -7.540    632.500                           GLOBAL
    22     0      0      0      0      0      0       60.680    -7.540    632.500                           GLOBAL
    23     0      0      0      0      0      0       60.580    -7.540    632.500                           GLOBAL
    24     0      0      0      0      0      0       60.580    -7.540    628.500                           GLOBAL
    25     0      0      0      0      0      0       60.680    -7.540    628.500                           GLOBAL
    26     0      0      0      0      0      0       60.580    -7.540    628.500                           GLOBAL
    27     0      0      0      0      0      0       60.580    -7.540    614.000                           GLOBAL
    28     0      0      0      0      0      0       60.880     -.760    614.000                           GLOBAL
    29     0      0      0      0      0      0       61.320      .000    614.000                           GLOBAL
    30     0      0      0      0      0      0       61.320      .000    599.000                           GLOBAL
    31     0      0      0      0      0      0       62.850     -.260    599.000                           GLOBAL
    32     0      0      0      0      0      0       60.860     -.490    599.000                           GLOBAL
    33     0      0      0      0      0      0       60.860     -.490    584.000                           GLOBAL
    34     0      0      0      0      0      0       55.730      .360    584.000                           GLOBAL
    35     0      0      0      0      0      0       74.460      .000    584.000                           GLOBAL
    36     0      0      0      0      0      0       74.460      .000    565.000                           GLOBAL
    37     0      0      0      0      0      0       71.470     -.040    565.000                           GLOBAL
    38     0      0      0      0      0      0      132.500     -.540    704.000                           GLOBAL
    39     0      0      0      0      0      0      155.000     -.720    704.000                           GLOBAL
    40     0      0      0      0      0      0      173.410     -.870    704.000                           GLOBAL
    41     0      0      0      0      0      0      173.410     -.870    695.000                           GLOBAL
    42     0      0      0      0      0      0      173.410     -.870    685.000                           GLOBAL
    43     0      0      0      0      0      0      173.840    -1.670    674.500                           GLOBAL
    44     0      0      0      0      0      0      175.680     -.860    659.000                           GLOBAL
    45     0      0      0      0      0      0      155.000    -1.100    659.000                           GLOBAL
    46     0      0      0      0      0      0      132.500    -1.360    659.000                           GLOBAL
    47     0      0      0      0      0      0      177.220     -.720    646.000                           GLOBAL
    48     0      0      0      0      0      0      155.000    -1.260    646.000                           GLOBAL
    49     0      0      0      0      0      0      132.500    -1.810    646.000                           GLOBAL
    50     0      0      0      0      0      0      153.640     -.720    642.580                           GLOBAL
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NOTES: See page 4-7.

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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                        090881
CE800D15
   C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S . . . UNITS OF ( L )

  NODE       . BOUNDARY CONDITION CODES . .         . . NODE COORDINATES . .                                 NODAL
NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)       X(N)       Y(N)       Z(N)                           SYSTEM
(NOTE 1)                (NOTE 2)                                (NOTE 3)                                     (NOTE 4)
    51      0      0      0      0      0      0    179.480     -.210    634.500                            GLOBAL
    52      0      0      0      0      0      0    155.000    -1.720    634.500                            GLOBAL
    53      0      0      0      0      0      0    132.500    -3.100    634.500                            GLOBAL
    54      0      0      0      0      0      0    179.480     -.210    628.500                            GLOBAL
    55      0      0      0      0      0      0    185.770      .000    614.000                            GLOBAL
    56      0      0      0      0      0      0    155.000      .000    614.000                            GLOBAL
    57      0      0      0      0      0      0    132.500      .000    614.000                            GLOBAL
    58      0      0      0      0      0      0    185.770      .000    599.000                            GLOBAL
    59      0      0      0      0      0      0    185.770      .000    584.000                            GLOBAL
    60      0      0      0      0      0      0    185.770      .000    564.000                            GLOBAL
    61      0      0      0      0      0      0     17.980   -64.030    687.000                            GLOBAL
    62      0      0      0      0      0      0     17.980   -64.030    659.000                            GLOBAL
    63      0      0      0      0      0      0     28.120    65.240    687.000                            GLOBAL
    64      0      0      0      0      0      0     28.120    65.240    673.500                            GLOBAL
    65      0      0      0      0      0      0     28.120    65.240    659.000                            GLOBAL
    66      0      0      0      0      0      0    175.800  -133.800    695.000                            GLOBAL
    67      0      0      0      0      0      0    187.400  -133.800    695.000                            GLOBAL
    68      0      0      0      0      0      0    175.800  -133.800    685.000                            GLOBAL
    69      0      0      0      0      0      0    187.400  -133.800    685.000                            GLOBAL
    70      0      0      0      0      0      0    175.800  -133.800    674.500                            GLOBAL
    71      0      0      0      0      0      0    187.400  -133.800    674.500                            GLOBAL
    72      0      0      0      0      0      0    175.800  -133.800    659.000                            GLOBAL
    73      0      0      0      0      0      0    187.400  -133.800    659.000                            GLOBAL
    74      0      0      0      0      0      0    175.800  -133.800    642.580                            GLOBAL
    75      0      0      0      0      0      0    187.400  -133.800    642.580                            GLOBAL
    76      0      0      0      0      0      0    175.800  -133.800    628.500                            GLOBAL
    77      0      0      0      0      0      0    187.400  -133.800    628.500                            GLOBAL
    78      0      0      0      0      0      0    175.800  -133.800    614.000                            GLOBAL
    79      0      0      0      0      0      0    187.400  -133.800    614.000                            GLOBAL
    80      0      0      0      0      0      0    175.800  -103.400    695.000                            GLOBAL
    81      0      0      0      0      0      0    187.400  -103.400    695.000                            GLOBAL
    82      0      0      0      0      0      0    175.800  -103.400    685.000                            GLOBAL
    83      0      0      0      0      0      0    187.400  -103.400    685.000                            GLOBAL
    84      0      0      0      0      0      0    175.800  -103.400    674.500                            GLOBAL
    85      0      0      0      0      0      0    187.400  -103.400    674.500                            GLOBAL
    86      0      0      0      0      0      0    175.800  -103.400    659.000                            GLOBAL
    87      0      0      0      0      0      0    187.400  -103.400    659.000                            GLOBAL
    88      0      0      0      0      0      0    175.800  -103.400    642.580                            GLOBAL
    89      0      0      0      0      0      0    187.400  -103.400    642.580                            GLOBAL
    90      0      0      0      0      0      0    175.800  -103.400    628.500                            GLOBAL
    91      0      0      0      0      0      0    187.400  -103.400    628.500                            GLOBAL
    92      0      0      0      0      0      0    175.800  -103.400    614.000                            GLOBAL
    93      0      0      0      0      0      0    181.250  -103.400    614.000                            GLOBAL
    94      0      0      0      0      0      0    187.400  -103.400    614.000                            GLOBAL
    95      0      0      0      0      0      0    175.800   -71.300    695.000                            GLOBAL
    96      0      0      0      0      0      0    187.400   -71.300    695.000                            GLOBAL
    97      0      0      0      0      0      0    175.800   -71.300    685.000                            GLOBAL
    98      0      0      0      0      0      0    187.400   -71.300    685.000                            GLOBAL
    99      0      0      0      0      0      0    175.800   -71.300    674.500                            GLOBAL
   100      0      0      0      0      0      0    187.400   -71.300    674.500                            GLOBAL
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NOTES: See page 4-7.

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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                    090881
CE800D15
    C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S  . . .  UNITS OF ( L )

  NODE        . . BOUNDARY CONDITION CODES . .           . . NODE COORDINATES . .                          NODAL
 NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)       X(N)       Y(N)       Z(N)                        SYSTEM
 (NOTE 1)               (NOTE 2)                                  (NOTE 3)                                (NOTE 4)
   101     0      0      0      0      0      0      175.800    -71.300    659.000                       GLOBAL
   102     0      0      0      0      0      0      187.400    -71.300    659.000                       GLOBAL
   103     0      0      0      0      0      0      175.800    -71.300    642.580                       GLOBAL
   104     0      0      0      0      0      0      187.400    -71.300    642.580                       GLOBAL
   105     0      0      0      0      0      0      175.800    -71.300    628.500                       GLOBAL
   106     0      0      0      0      0      0      187.400    -71.300    628.500                       GLOBAL
   107     0      0      0      0      0      0      175.800    -71.300    614.000                       GLOBAL
   108     0      0      0      0      0      0      187.400    -71.300    614.000                       GLOBAL
   109     0      0      0      0      0      0      181.250    -87.500    614.000                       GLOBAL
   110     0      0      0      0      0      0      181.250    -87.500    599.000                       GLOBAL
   111     0      0      0      0      0      0      181.250    -87.500    584.000                       GLOBAL
   112     0      0      0      0      0      0      181.250    -87.500    573.000                       GLOBAL
   113     0      0      0      0      0      0      175.800    -49.000    695.000                       GLOBAL
   114     0      0      0      0      0      0      187.400    -49.000    695.000                       GLOBAL
   115     0      0      0      0      0      0      187.400    -49.000    685.000                       GLOBAL
   116     0      0      0      0      0      0      175.800    -49.000    674.500                       GLOBAL
   117     0      0      0      0      0      0      187.400    -49.000    674.500                       GLOBAL
   118     0      0      0      0      0      0      175.800    -49.000    659.000                       GLOBAL
   119     0      0      0      0      0      0      187.400    -49.000    659.000                       GLOBAL
   120     0      0      0      0      0      0      187.400    -49.000    642.580                       GLOBAL
   121     0      0      0      0      0      0      175.800    -49.000    628.500                       GLOBAL
   122     0      0      0      0      0      0      187.400    -49.000    628.500                       GLOBAL
   123     0      0      0      0      0      0      181.250    -49.000    614.000                       GLOBAL
   124     0      0      0      0      0      0      187.400    -49.000    614.000                       GLOBAL
   125     0      0      0      0      0      0      175.800     49.000    695.000                       GLOBAL
   126     0      0      0      0      0      0      187.400     49.000    695.000                       GLOBAL
   127     0      0      0      0      0      0      187.400     49.000    685.000                       GLOBAL
   128     0      0      0      0      0      0      175.800     49.000    674.500                       GLOBAL
   129     0      0      0      0      0      0      187.400     49.000    674.500                       GLOBAL
   130     0      0      0      0      0      0      175.800     49.000    659.000                       GLOBAL
   131     0      0      0      0      0      0      187.400     49.000    659.000                       GLOBAL
   132     0      0      0      0      0      0      187.400     49.000    642.580                       GLOBAL
   133     0      0      0      0      0      0      175.800     49.000    628.500                       GLOBAL
   134     0      0      0      0      0      0      187.400     49.000    628.500                       GLOBAL
   135     0      0      0      0      0      0      181.250     53.500    614.000                       GLOBAL
   136     0      0      0      0      0      0      187.400     49.000    614.000                       GLOBAL
   137     0      0      0      0      0      0      175.800     71.300    695.000                       GLOBAL
   138     0      0      0      0      0      0      187.400     71.300    695.000                       GLOBAL
   139     0      0      0      0      0      0      175.800     71.300    685.000                       GLOBAL
   140     0      0      0      0      0      0      187.400     71.300    685.000                       GLOBAL
   141     0      0      0      0      0      0      175.800     71.300    674.500                       GLOBAL
   142     0      0      0      0      0      0      187.400     71.300    674.500                       GLOBAL
   143     0      0      0      0      0      0      175.800     71.300    659.000                       GLOBAL
   144     0      0      0      0      0      0      187.400     71.300    659.000                       GLOBAL
   145     0      0      0      0      0      0      175.800     71.300    642.580                       GLOBAL
   146     0      0      0      0      0      0      187.400     71.300    642.580                       GLOBAL
   147     0      0      0      0      0      0      175.800     71.300    628.500                       GLOBAL
   148     0      0      0      0      0      0      187.400     71.300    628.500                       GLOBAL
   149     0      0      0      0      0      0      175.800     71.300    614.000                       GLOBAL
   150     0      0      0      0      0      0      187.400     71.300    614.000                       GLOBAL
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NOTES: See page 4-7.

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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                   090881
CEBOOD15
   C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S . . .  UNITS OF ( L )

  NODE      . . BOUNDARY CONDITION CODES . .               . . NODE COORDINATES . .                          NODAL
 NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)      X(N)        Y(N)       Z(N)                          SYSTEM
 (NOTE 1)                (NOTE 2)                                (NOTE 3)                                   (NOTE 4)
    151     0      0      0      0      0      0    175.800     103.400    695.000                          GLOBAL
    152     0      0      0      0      0      0    187.400     103.400    695.000                          GLOBAL
    153     0      0      0      0      0      0    175.800     103.400    685.000                          GLOBAL
    154     0      0      0      0      0      0    187.400     103.400    685.000                          GLOBAL
    155     0      0      0      0      0      0    175.800     103.400    674.500                          GLOBAL
    156     0      0      0      0      0      0    187.400     103.400    674.500                          GLOBAL
    157     0      0      0      0      0      0    175.800     103.400    659.000                          GLOBAL
    158     0      0      0      0      0      0    187.400     103.400    659.000                          GLOBAL
    159     0      0      0      0      0      0    175.800     103.400    642.580                          GLOBAL
    160     0      0      0      0      0      0    187.400     103.400    642.580                          GLOBAL
    161     0      0      0      0      0      0    175.800     103.400    628.500                          GLOBAL
    162     0      0      0      0      0      0    187.400     103.400    628.500                          GLOBAL
    163     0      0      0      0      0      0    175.800     103.400    614.000                          GLOBAL
    164     0      0      0      0      0      0    187.400     103.400    614.000                          GLOBAL
    165     0      0      0      0      0      0    181.250      87.500    614.000                          GLOBAL
    166     0      0      0      0      0      0    181.250      87.500    599.000                          GLOBAL
    167     0      0      0      0      0      0    181.250      87.500    584.000                          GLOBAL
    168     0      0      0      0      0      0    181.250      87.500    573.000                          GLOBAL
    169     0      0      0      0      0      0    175.800     133.800    695.000                          GLOBAL
    170     0      0      0      0      0      0    187.400     133.800    695.000                          GLOBAL
    171     0      0      0      0      0      0    175.800     133.800    685.000                          GLOBAL
    172     0      0      0      0      0      0    187.400     133.800    685.000                          GLOBAL
    173     0      0      0      0      0      0    175.800     133.800    674.500                          GLOBAL
    174     0      0      0      0      0      0    187.400     133.800    674.500                          GLOBAL
    175     0      0      0      0      0      0    175.800     133.800    659.000                          GLOBAL
    176     0      0      0      0      0      0    187.400     133.800    659.000                          GLOBAL
    177     0      0      0      0      0      0    175.800     133.800    642.580                          GLOBAL
    178     0      0      0      0      0      0    187.400     133.800    642.580                          GLOBAL
    179     0      0      0      0      0      0    175.800     133.800    628.500                          GLOBAL
    180     0      0      0      0      0      0    187.400     133.800    628.500                          GLOBAL
    181     0      0      0      0      0      0    175.800     133.800    614.000                          GLOBAL
    182     0      0      0      0      0      0    181.250     133.800    614.000                          GLOBAL
    183     0      0      0      0      0      0    187.400     133.800    614.000                          GLOBAL
    184     1      1      1      1      1      1     25.000     -64.030    687.000                          GLOBAL
    185     1      1      1      1      1      1    150.000        .700    724.830                          GLOBAL
    186     1      1      1      1      1      1     70.000        .000    704.000                          GLOBAL
    187     1      1      1      1      1      1    160.000      -3.020    685.000                          GLOBAL
    188     1      1      1      1      1      1     70.000      -2.210    659.000                          GLOBAL
    189     1      1      1      1      1      1     70.000      -3.610    646.000                          GLOBAL
    190     1      1      1      1      1      1    160.000      -4.370    674.500                          GLOBAL
    191     1      1      1      1      1      1     70.000      -7.540    634.500                          GLOBAL
    192     1      1      1      1      1      1    160.000      -2.500    659.000                          GLOBAL
    193     1      1      1      1      1      1    160.000      -2.850    642.580                          GLOBAL
    194     1      1      1      1      1      1    185.000       -.210    634.500                          GLOBAL
    195     1      1      1      1      1      1     70.000       -.490    599.000                          GLOBAL
    196     1      1      1      1      1      1     80.000        .000    584.000                          GLOBAL
    197     1      1      1      1      1      1     35.000      65.240    687.000                          GLOBAL
    198     0      0      0      0      0      0    181.250    -133.800    614.000                          GLOBAL
    199     0      0      0      0      0      0    181.250     -81.500    614.000                          GLOBAL
    200     0      0      0      0      0      0    181.250      81.500    614.000                          GLOBAL
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NOTES: See page 4-7.

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BSAP  AUXILIARY BUILD SEISMIC  ANALYSIS FLEXIBLE BASE                                                             090881
CE8000D15
    COMPLETE  CARTESIAN  NODAL  COORDINATES . . .  UNITS OF ( L )

  NODE     . . BOUNDARY CONDITION CODES . .              . . NODE COORDINATES . .                                   NODAL
NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)       X(N)       Y(N)       Z(N)                                   SYSTEM
(NOTE 1)                (NOTE 2)                                 (NOTE 3)                                          (NOTE 4)
   201      0      0      0      0      0      0    181.250    103.400    614.000                                   GLOBAL
   202      0      0      0      0      0      0    132.500      -.210    599.000                                   GLOBAL
   203      0      0      0      0      0      0    181.250   -133.800    599.000                                   GLOBAL
   204      0      0      0      0      0      0    181.250   -133.800    584.000                                   GLOBAL
   205      0      0      0      0      0      0    181.250   -133.800    573.000                                   GLOBAL
   206      0      0      0      0      0      0    181.250   -103.400    599.000                                   GLOBAL
   207      0      0      0      0      0      0    181.250   -103.400    584.000                                   GLOBAL
   208      0      0      0      0      0      0    181.250   -103.400    573.000                                   GLOBAL
   209      0      0      0      0      0      0    181.250    -81.500    599.000                                   GLOBAL
   210      0      0      0      0      0      0    181.250    -81.500    584.000                                   GLOBAL
   211      0      0      0      0      0      0    181.250    -81.500    573.000                                   GLOBAL
   212      0      0      0      0      0      0    181.250    -53.500    599.000                                   GLOBAL
   213      0      0      0      0      0      0    181.250    -53.500    584.000                                   GLOBAL
   214      0      0      0      0      0      0    181.250    -53.500    573.000                                   GLOBAL
   215      0      0      0      0      0      0    181.250     53.500    599.000                                   GLOBAL
   216      0      0      0      0      0      0    181.250     53.500    584.000                                   GLOBAL
   217      0      0      0      0      0      0    181.250     53.500    573.000                                   GLOBAL
   218      0      0      0      0      0      0    181.250     81.500    599.000                                   GLOBAL
   219      0      0      0      0      0      0    181.250     81.500    584.000                                   GLOBAL
   220      0      0      0      0      0      0    181.250     81.500    573.000                                   GLOBAL
   221      0      0      0      0      0      0    181.250    103.400    599.000                                   GLOBAL
   222      0      0      0      0      0      0    181.250    103.400    584.000                                   GLOBAL
   223      0      0      0      0      0      0    181.250    103.400    573.000                                   GLOBAL
   224      0      0      0      0      0      0    181.250    133.800    599.000                                   GLOBAL
   225      0      0      0      0      0      0    181.250    133.800    584.000                                   GLOBAL
   226      0      0      0      0      0      0    181.250    133.800    573.000                                   GLOBAL
   227      0      0      0      0      0      0    185.770       .000    573.000                                   GLOBAL
   228      0      0      0      0      0      0    150.910     -3.020    685.000                                   GLOBAL
   229      0      0      0      0      0      0    150.910     -3.020    674.500                                   GLOBAL
   230      0      0      0      0      0      0    150.770     -4.370    674.500                                   GLOBAL
   231      0      0      0      0      0      0    150.770     -4.370    659.000                                   GLOBAL
   232      0      0      0      0      0      0    154.200     -2.500    659.000                                   GLOBAL
   233      0      0      0      0      0      0    154.200     -2.500    646.000                                   GLOBAL
   234      0      0      0      0      0      0    154.050     -2.850    646.000                                   GLOBAL
   235      0      0      0      0      0      0    154.050     -2.850    642.580                                   GLOBAL
   236      0      0      0      0      0      0    154.050     -2.850    642.580                                   GLOBAL
   237      0      0      0      0      0      0    154.050     -2.850    634.500                                   GLOBAL
   238      0      0      0      0      0      0    132.500       .000    584.000                                   GLOBAL
   239      0      0      0      0      0      0     81.640     -2.310    565.000                                   GLOBAL
   240      1      1      1      1      1      1    175.000      -.870    695.000                                   GLOBAL
   241      0      0      0      0      0      0    175.800   -140.000    695.000                                   GLOBAL
   242      0      0      0      0      0      0    187.400   -140.000    695.000                                   GLOBAL
   243      0      0      0      0      0      0    187.400   -140.000    685.000                                   GLOBAL
   244      0      0      0      0      0      0    175.800   -140.000    674.500                                   GLOBAL
   245      0      0      0      0      0      0    187.400   -140.000    674.500                                   GLOBAL
   246      0      0      0      0      0      0    175.800   -140.000    659.000                                   GLOBAL
   247      0      0      0      0      0      0    187.400   -140.000    659.000                                   GLOBAL
   248      0      0      0      0      0      0    175.800   -140.000    642.580                                   GLOBAL
   249      0      0      0      0      0      0    187.400   -140.000    642.580                                   GLOBAL
   250      0      0      0      0      0      0    175.800   -140.000    628.500                                   GLOBAL
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NOTES: See page 4-7.

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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                          090881
CE8000015
     C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S          UNITS OF ( L )

  NODE          BOUNDARY CONDITION CODES                      NODE COORDINATES                                   NODAL
 NUMBER  ID(X)   ID(Y)   ID(Z) ID(XX) ID(YY) ID(ZZ)      X(N)        Y(N)        Z(N)                            SYSTEM
(NOTE 1)                   (NOTE 2)                               (NOTE 3)                                       (NOTE 4)
    251     0       0       0      0      0      0     187.400   -140.000     628.500                           GLOBAL
    252     0       0       0      0      0      0     181.250   -140.000     614.000                           GLOBAL
    253     0       0       0      0      0      0     187.400   -140.000     614.000                           GLOBAL
    254     0       0       0      0      0      0     175.800    140.000     695.000                           GLOBAL
    255     0       0       0      0      0      0     187.400    140.000     695.000                           GLOBAL
    256     0       0       0      0      0      0     187.400    140.000     685.000                           GLOBAL
    257     0       0       0      0      0      0     175.800    140.000     674.500                           GLOBAL
    258     0       0       0      0      0      0     187.400    140.000     674.500                           GLOBAL
    259     0       0       0      0      0      0     175.800    140.000     659.000                           GLOBAL
    260     0       0       0      0      0      0     187.400    140.000     659.000                           GLOBAL
    261     0       0       0      0      0      0     175.800    140.000     642.580                           GLOBAL
    262     0       0       0      0      0      0     187.400    140.000     642.580                           GLOBAL
    263     0       0       0      0      0      0     175.800    140.000     628.500                           GLOBAL
    264     0       0       0      0      0      0     187.400    140.000     628.500                           GLOBAL
    265     0       0       0      0      0      0     181.250    140.000     614.000                           GLOBAL
    266     0       0       0      0      0      0     187.400    140.000     614.000                           GLOBAL
    267     0       0       0      0      0      0     181.250   -140.000     599.000                           GLOBAL
    268     0       0       0      0      0      0     181.250   -140.000     584.000                           GLOBAL
    269     0       0       0      0      0      0     181.250   -140.000     573.000                           GLOBAL
    270     0       0       0      0      0      0     181.250    140.000     599.000                           GLOBAL
    271     0       0       0      0      0      0     181.250    140.000     584.000                           GLOBAL
    272     0       0       0      0      0      0     181.250    140.000     573.000                           GLOBAL
    273     0       0       0      0      0      0     155.000      -.120     599.000                           GLOBAL
    274     0       0       0      0      0      0     155.000       .000     584.000                           GLOBAL
    275     0       0       0      0      0      0     179.480      -.210     614.000                           GLOBAL
    276     1       1       1      1      1      1     190.000       .000     614.000                           GLOBAL
```

NOTES: 1. NODE NUMBER: The nodes are shown schematically in Figure 5.

2. BOUNDARY CONDITIONS: Zero (0) or blank indicates an active (free) degree of freedom. One (1) indicates a fixed degree of freedom.

3. NODE COORDINATES: Distances (ft.) from the origin of the nodal system.

4. NODAL SYSTEM: Defines the local coordinate system for nodal input. The word GLOBAL indicates that the global cartesian coordinate system is used. The origin of the system is shown in Figure 1. The orientation of the system is shown in Figure 5.

```
T A B L E   O F   B E A M   M A T E R I A L   P R O P E R T I E S

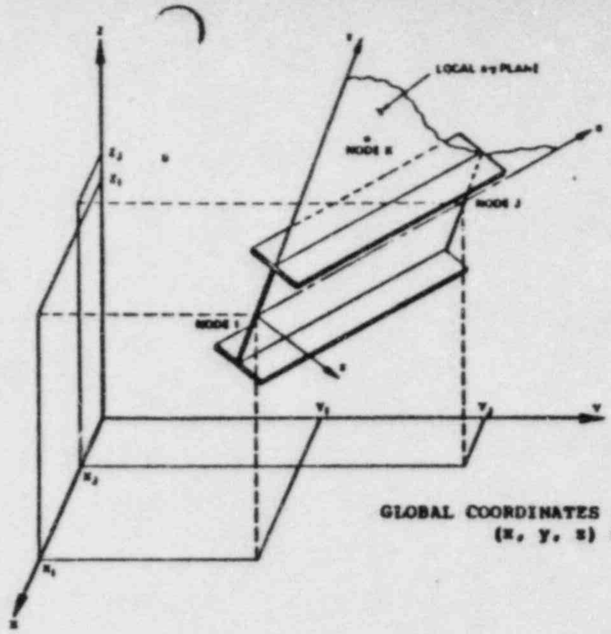
MATERIAL      YOUNG'S        POISSON'S
  NUMBER      MODULUS            RATIO
 (NOTE 1)     (NOTE 2)        (NOTE 3)
        1   4176000.00           .3000
        2    617300.00           .2500
```

NOTES: 1. MATERIAL NUMBER: Beam element material property set number. Refer to pages 4-11 thru 4-16. In this analysis, MATL. NO. 1 is structural steel and MATL. NO. 2 is concrete.

2. YOUNG'S MODULUS: Expressed in (k/ft^2).

3. POISSON'S RATIO: Dimensionless.

BSAP AUXILIARY BUILD SEISMIC ANALYSIS FLEXIBLE BASE 090881
CE800D15



GLOBAL COORDINATES (X, Y, Z) AND LOCAL COORDINATES
(x, y, z) SYSTEMS OF BEAM ELEMENT

TABLE OF BEAM SECTION PROPERTIES

BEAM TYPE NUMBER (NOTE 1)	CROSS SECTIONAL AREA (NOTE 2)	EFFECTIVE SHEAR AREAS (NOTE 3) LOCAL Y-AXIS A(XY)	EFFECTIVE SHEAR AREAS (NOTE 3) LOCAL Z-AXIS A(XZ)	MOMENTS OF INERTIA (NOTE 4) LOCAL X-AXIS (TORSIONAL) (NOTE 5)	MOMENTS OF INERTIA (NOTE 4) LOCAL Y-AXIS I(Y)	MOMENTS OF INERTIA (NOTE 4) LOCAL Z-AXIS I(Z)
1	37.1500	1.14100	3.15200	5311.00	13076.0	35797 0
2	14.3000	1.78600	1.37000	13134 0	20696.0	38990 0
3	3751.00	1357.00	2510.00	.468000+07	.606568+07	.249672+07
4	3280 00	1196.00	2131.00	.432000+07	.585676+07	.199513+07
5	3751 00	1638.00	2290.00	.107000+08	.843339+07	.102095+08
6	3763.00	1569.00	2194.00	.100000+08	.827528+07	.785805+07
7	3659.00	1690.00	2005.00	.101000+08	.824491+07	.854041+07
8	2388.00	1102.00	1402.00	.420000+07	.229961+07	.457543+07
9	475.000	244.000	232.000	110000.	88222.0	247301.
10	587.000	353.000	234.000	253000.	140440.	619900.
11	998.000	340.000	688.000	.113000+07	.120802+07	601167.
12	1019.00	376.000	340.000	.120000+07	.126399+07	596137.
13	1051.00	396.000	382.000	.112000+07	.130397+07	629416.
14	909.000	335.000	301.000	.106000+07	.127748+07	462712.
15	850.000	333.000	276.000	.102000+07	.123221+07	445634.
16	952 000	408.000	575.000	910000.	.125161+07	425552.
17	2982 00	1206.00	2019 00	.130000+07	.417269+07	763641.
18	31.0000	25.8200	.000000	41.3000	10.0000	621.000
19	83.3000	38.9200	30.4400	181.500	3353.00	1137.00
20	19.0000	15.8300	.000000	25.3300	6.00000	143.000
21	9.00000	7.50000	.000000	12.0000	3.00000	15.2000
22	8.00000	6.66000	.000000	10.7000	2.70000	10.7000
23	60.2800	.000000	50.2100	80.4000	4563.00	20.0000
24	68.0000	44.9800	11.6600	90.7000	750.000	5623.00
25	.100000+00	.000000	.000000	.100000+00	.100000+00	.100000+00
26	62.5000	.000000	52.0600	130.200	3255.00	32.6000
27	28.0000	23.3200	.000000	37.3300	9.33000	457.000
28	24.5000	20.4100	.000000	25.0000	6.25000	400.000
29	109.740	26.9500	64.4700	163.500	10671.0	1308.50
30	19.0800	16.2200	.000000	17.2900	4.87000	221.000

NOTES: See page 4-10.

```
BSAP  AUXILIARY BUILD SEISMIC  ANALYSIS FLEXIBLE BASE                                                            090881
CE800015
 T A B L E   O F   B E A M   S E C T I O N   P R O P E R T I E S

   BEAM           CROSS        EFFECTIVE SHEAR AREAS                       MOMENTS OF INERTIA  (NOTE 4)
   TYPE        SECTIONAL    LOCAL Y-AXIS   LOCAL Z-AXIS   LOCAL X-AXIS   LOCAL Y-AXIS   LOCAL Z-AXIS
  NUMBER            AREA          A(XY)          A(XZ)   (TORSIONAL)            I(Y)           I(Z)
 (NOTE 1)        (NOTE 2)              (NOTE 3)           (NOTE 5)
     31      .100000+11     .000000        .000000       .100000+11     .100000+11     .100000+11
     32      24.7500        21.0000        .000000       23.0000        6.32000        541.500
     33      59.9000        50.9000        .000000       61.4000        15.2800        8698.00
     34      61.4000        52.2000        .000000       62.7000        15.6800        6605.00
     35      12.8300        10.9000        .000000       13.3300        1.67000        130.800
     36      25.6000        21.8000        .000000       25.4000        16.4100        465.000
     37      120.200        102.200        .000000       458.800        123.600        17123.0
     38      10.5000        8.92000        .000000       3.50000        .880000        114.500
     39      13.1500        11.1800        .000000       4.38000        1.10000        211.900
     40      21.0000        17.8500        .000000       24.5000        7.00000        229.000
     41      26.3000        22.4000        .000000       31.3000        9.77000        424.000
     42      64.2000        54.6000        .000000       85.6000        21.4000        8820.00
     43      105.400        87.8000        87.8000       19250.0        906.500        2487.50
     44      86.8000        72.3000        72.3000       16283.0        180.950        2522.80
     45      103.300        86.1000        86.1000       16283.0        215.200        3675.00
     46      84.2000        .000000        40.3000       .100000+00     694.000        .100000+00
     47      174.900        196.600        76.9000       226.000        210706.        68950.0
     48      38.9000        20.8000        58.8000       51.8000        42071.0        480.400
     49      74.3000        27.3000        47.0000       42.9000        39888.0        1216.00
     50      132.200        43.4000        58.8000       81.3000        117457.        2076.00
     51      2951.00        1430.00        1892.00       .140000+07     .359681+07     767245.
     52      137.100        40.8000        71.6000       109.400        123323.        1224.00
     53      167.400        62.6000        80.1000       194.200        181945.        1778.00
     54      108.300        29.8500        60.3900       226.000        9310.00        2351.00
     55      3089.00        1334.00        2127.00       .131000+07     .419258+07     825488.
     56      3203.00        1430.00        2144.00       .163000+07     .375115+07     905292.
     57      110.000        110.000        110.000       7079.00        6932.00        147.000
     58      40.0000        40.0000        40.0000       386.000        333.000        53.0000
     59      40.0000        40.0000        40.0000       1477.00        1391.00        86.0000
```

NOTES:

1. BEAM TYPE NUMBER: Beam element cross-section property set number. Refer to SECT. NO. on pages 4-11 thru 4-16.

2. CROSS SECTIONAL AREA: Expressed in (ft.^{2}).

3. EFFECTIVE SHEAR AREAS: Expressed in (ft.^{2}).

4. MOMENTS OF INERTIA: Expressed in (ft.^{4}).

5. LOCAL X-AXIS (TORSIONAL): Torsional resistance.

```
BSAP  AUXILIARY BUILD SEISMIC ANALYSIS FLEXIBLE BASE                                   090881
CE800D15

T A B U L A T I O N   O F   D A T A   I N P U T   F O R   B E A M   E L E M E N T S . . .

   ELEMENT            NODE   NODE    REF    MATL     SECT      END-CODES
   NUMBER              -I     -J      -K     NO       NO       -I      -J
                      - -(NOTE 1)- -      (NOTE 2)  (NOTE 3)   (NOTE 4)
         1              2      3     185      1        1        0       0
         2              5      6     186      1        2        0       0
         3              8      9     186      1        2        0       0
         4             11     12     188      2        3        0       0
         5             14     15     189      2        4        0       0
         6             17     18     189      2        4        0       0
         7             20     21     191      2        5        0       0
         8             23     24     191      2        5        0       0
         9             26     27     191      2        5        0       0
        10             29     30     186      2        6        0       0
        11             32     33     195      2        7        0       0
        12             35     36     196      2        8        0       0
        13             63     64     197      2        9        0       0
        14             64     65     197      2        9        0       0
        15             61     62     184      2       10        0       0
        16             40     41     240      2       11        0       0
        17             41     42     240      2       11        0       0
        18            228    229     187      2       12        0       0
        19            230    231     190      2       13        0       0
        20            232    233     192      2       14        0       0
        21            234    235     193      2       15        0       0
        22            236    237     193      2       15        0       0
        23             51     54     194      2       16        0       0
        24             54    275     194      2       16        0       0
        25             55     58     276      2       17        0       0
        26             58     59     276      2       55        0       0
        27             59    227     276      2       56        0       0
        28             66     68      69      2       18        0       0
        29             68     70      71      2       18        0       0
        30             70     72      73      2       18        0       0
        31             72     74      75      2       18        0       0
        32             74     76      77      2       18        0       0
        33             76     78      79      2       19        0       0
        34             80     82      83      2       20        0       0
        35             82     84      85      2       20        0       0
        36             84     86      87      2       21        0       0
        37             86     88      89      2       22        0       0
        38             88     90      91      2       21        0       0
        39             90     92      93      2       23        0       0
        40             95     97      98      2       24        0       0
        41             97     99     100      2       25        0       0
        42             99    101     102      2       26        0       0
        43            101    103     104      2       27        0       0
        44            103    105     106      2       28        0       0
        45            105    107     108      2       29        0       0
        46            137    139     140      2       24        0       0
        47            139    141     142      2       25        0       0
        48            141    143     144      2       54        0       0
        49            143    145     146      2       27        0       0
        50            145    147     148      2       28        0       0
```

NOTES: See page 4-16.

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BSAP  AUXILIARY BUILD  SEISMIC ANALYSIS FLEXIBLE BASE                                              090881
CE800D15

T A B U L A T I O N   O F   D A T A   I N P U T   F O R   B E A M   E L E M E N T S . . .

      ELEMENT               NODE    NODE     REF     MATL     SECT     END-CODES
      NUMBER                 -I      -J       -K      NO       NO       -I      -J
                             - -(NOTE 1)- -        (NOTE 2) (NOTE 3)   (NOTE 4)
          51                 147     149     150       2       29        0       0
          52                 151     153     154       2       20        0       0
          53                 153     155     156       2       20        0       0
          54                 155     157     158       2       21        0       0
          55                 157     159     160       2       22        0       0
          56                 159     161     162       2       21        0       0
          57                 161     163     164       2       23        0       0
          58                 169     171     172       2       18        0       0
          59                 171     173     174       2       18        0       0
          60                 173     175     176       2       18        0       0
          61                 175     177     178       2       18        0       0
          62                 177     179     180       2       18        0       0
          63                 179     181     182       2       19        0       0
          64                 234      47     235       2       31        0       0
          65                 235      50     234       2       31        0       0
          66                 236      50     237       2       31        0       0
          67                 237      51     236       2       31        0       0
          68                  60     239     227       2       31        0       0
          69                 239      37     227       2       31        0       0
          70                  66      80      67       2       30        0       0
          71                  80      95      67       2       32        0       0
          72                  95     113      67       2       33        0       0
          73                 113      41      67       2       31        0       0
          74                  41     125      67       2       31        0       0
          75                 125     137      67       2       33        0       0
          76                 137     151      67       2       32        0       0
          77                 151     169      67       2       30        0       0
          78                  70      84      71       2       30        0       0
          79                  84      99      71       2       32        0       0
          80                  99     116      71       2       34        0       0
          81                 116      43      71       2       31        0       0
          82                  43     128      71       2       31        0       0
          83                 128     141      71       2       34        0       0
          84                 141     155      71       2       32        0       0
          85                 155     173      71       2       30        0       0
          86                  72      86      73       2       35        0       0
          87                  86     101      73       2       36        0       0
          88                 101     118      73       2       37        0       0
          89                 118      44      73       2       31        0       0
          90                  44     130      73       2       31        0       0
          91                 130     143      73       2       37        0       0
          92                 143     157      73       2       36        0       0
          93                 157     175      73       2       35        0       0
          94                  74      88      75       2       38        0       0
          95                  88     103      75       2       39        0       0
          96                 145     159      75       2       39        0       0
          97                 159     177      75       2       38        0       0
          98                  76      90      77       2       40        0       0
          99                  90     105      77       2       41        0       0
         100                 105     121      77       2       42        0       0
```

NOTES: See page 4-16.

TABULATION OF DATA INPUT FOR BEAM ELEMENTS

ELEMENT NUMBER	NODE -I	NODE -J	REF -K	MATL NO	SECT NO	END CODES -I	END CODES -J
	- -(NOTE 1)- -			(NOTE 2)	(NOTE 3)	(NOTE 4)	
101	121	54	77	2	31	0	0
102	54	133	77	2	31	0	0
103	133	147	77	2	42	0	0
104	147	161	77	2	41	0	0
105	161	179	77	2	40	0	0
106	78	198	76	2	31	0	0
107	198	93	79	2	43	0	0
108	93	109	79	2	44	0	0
109	109	199	79	2	44	0	0
110	199	123	79	2	45	0	0
111	123	55	124	2	31	0	0
112	55	135	136	2	31	0	0
113	135	200	79	2	45	0	0
114	200	165	79	2	44	0	0
115	165	201	79	2	44	0	0
116	163	201	161	2	31	0	0
117	201	182	79	2	43	0	0
118	40	39	41	2	31	0	0
119	39	38	41	2	46	0	0
120	38	5	41	2	31	0	0
121	44	45	233	2	31	0	0
122	45	46	12	2	47	0	0
123	46	11	233	2	31	0	0
124	47	48	235	2	31	0	0
125	48	49	15	2	48	0	0
126	49	14	235	2	31	0	0
127	51	52	54	2	31	0	0
128	52	53	54	2	49	0	0
129	53	20	54	2	31	0	0
130	55	56	60	2	31	0	0
131	56	57	60	2	50	0	0
132	57	29	60	2	31	0	0
133	1	2	3	2	31	0	0
134	4	3	2	2	31	0	0
135	4	5	6	2	31	0	0
136	7	6	5	2	31	0	0
137	7	8	9	2	31	0	0
138	10	9	8	2	31	0	0
139	10	11	12	2	31	0	0
140	13	12	11	2	31	0	0
141	13	14	15	2	31	0	0
142	16	15	14	2	31	0	0
143	16	17	18	2	31	0	0
144	19	18	17	2	31	0	0
145	19	20	21	2	31	0	0
146	22	21	20	2	31	0	0
147	22	23	24	2	31	0	0
148	25	24	23	2	31	0	0
149	25	26	27	2	31	0	0
150	28	27	26	2	31	0	0

NOTES: See page 4-16.

TABULATION OF DATA INPUT FOR BEAM ELEMENTS

```
ELEMENT       NODE   NODE    REF    MATL     SECT      END-CODES
NUMBER          -I     -J     -K     NO       NO       -I      -J
                 - -(NOTE 1)- -   (NOTE 2) (NOTE 3)    (NOTE 4)
   151          28     29     30      2       31        0       0
   152          31     30     29      2       31        0       0
   153          31     32     33      2       31        0       0
   154          34     33     32      2       31        0       0
   155          34     35     36      2       31        0       0
   156          37     36     35      2       31        0       0
   157          66     67     68      2       31        0       0
   158          80     81     82      2       31        0       0
   159          95     96     97      2       31        0       0
   160         113    114    116      2       31        0       0
   161         125    126    128      2       31        0       0
   162         137    138    139      2       31        0       0
   163         151    152    153      2       31        0       0
   164         169    170    171      2       31        0       0
   165          68     69     70      2       31        0       0
   166          82     83     84      2       31        0       0
   167          97     98     99      2       31        0       0
   168         139    140    141      2       31        0       0
   169         153    154    155      2       31        0       0
   170         171    172    173      2       31        0       0
   171          70     71     72      2       31        0       0
   172          84     85     86      2       31        0       0
   173          99    100    101      2       31        0       0
   174         116    117    118      2       31        0       0
   175         128    129    130      2       31        0       0
   176         141    142    143      2       31        0       0
   177         155    156    157      2       31        0       0
   178         173    174    175      2       31        0       0
   179          72     73     74      2       31        0       0
   180          86     87     88      2       31        0       0
   181         101    102    103      2       31        0       0
   182         118    119    121      2       31        0       0
   183         130    131    133      2       31        0       0
   184         143    144    145      2       31        0       0
   185         157    158    159      2       31        0       0
   186         175    176    177      2       31        0       0
   187          74     75     76      2       31        0       0
   188          88     89     90      2       31        0       0
   189         103    104    105      2       31        0       0
   190         145    146    147      2       31        0       0
   191         159    160    161      2       31        0       0
   192         177    178    179      2       31        0       0
   193          76     77     78      2       31        0       0
   194          90     91     92      2       31        0       0
   195         105    106    107      2       31        0       0
   196         121    122    123      2       31        0       0
   197         133    134    135      2       31        0       0
   198         147    148    149      2       31        0       0
   199         161    162    163      2       31        0       0
   200         179    180    181      2       31        0       0
```

NOTES: See page 4-16.

TABULATION OF DATA INPUT FOR BEAM ELEMENTS

ELEMENT NUMBER	NODE -I	NODE -J	REF -K	MATL NO	SECT NO	END-CODES -I	END-CODES -J
	- -(NOTE 1)- -			(NOTE 2)	(NOTE 3)	(NOTE 4)	
201	198	79	76	2	31	0	0
202	93	94	90	2	31	0	0
203	199	108	105	2	31	0	0
204	123	124	121	2	31	0	0
205	135	136	133	2	31	0	0
206	200	150	147	2	31	0	0
207	201	164	161	2	31	0	0
208	182	183	179	2	31	0	0
209	62	11	61	2	31	0	0
210	11	65	63	2	31	0	0
211	92	93	90	2	31	0	0
212	107	199	105	2	31	0	0
213	149	200	147	2	31	0	0
214	181	182	179	2	31	0	0
215	227	60	276	2	51	0	0
216	212	58	123	2	31	0	0
217	213	59	123	2	31	0	0
218	214	227	123	2	31	0	0
219	58	215	55	2	31	0	0
220	59	216	55	2	31	0	0
221	227	217	55	2	31	0	0
222	42	228	229	2	31	0	0
223	43	229	228	2	31	0	0
224	43	230	231	2	31	0	0
225	44	231	230	2	31	0	0
226	44	232	233	2	31	0	0
227	47	233	232	2	31	0	0
228	66	241	67	2	30	0	0
229	70	244	71	2	30	0	0
230	72	246	73	2	35	0	0
231	74	248	75	2	38	0	0
232	76	250	77	2	40	0	0
233	198	252	79	2	43	0	0
234	254	169	170	2	30	0	0
235	257	173	174	2	30	0	0
236	259	175	176	2	35	0	0
237	261	177	178	2	38	0	0
238	263	179	180	2	40	0	0
239	265	182	183	2	43	0	0
240	241	242	66	2	31	0	0
241	244	245	70	2	31	0	0
242	246	247	72	2	31	0	0
243	248	249	74	2	31	0	0
244	250	251	76	2	31	0	0
245	252	253	198	2	31	0	0
246	254	255	169	2	31	0	0
247	257	258	173	2	31	0	0
248	259	260	175	2	31	0	0
249	261	262	177	2	31	0	0
250	263	264	179	2	31	0	0

NOTES: See page 4-16.

TABULATION OF DATA INPUT FOR BEAM ELEMENTS . . .

ELEMENT NUMBER	NODE -I	NODE -J	REF -K	MATL NO	SECT NO	END-CODES -I	END-CODES -J
	- -(NOTE 1)- -			(NOTE 2)	(NOTE 3)	(NOTE 4)	
251	265	266	182	2	31	0	0
252	58	273	55	2	31	0	0
253	273	202	55	2	52	0	0
254	202	32	55	2	31	0	0
255	59	274	55	2	31	0	0
256	274	238	55	2	53	0	0
257	238	35	55	2	31	0	0
258	275	55	54	2	31	0	0
259	98	115	97	2	25	0	0
260	127	140	139	2	25	0	0
261	104	120	103	2	25	0	0
262	132	146	145	2	25	0	0
263	267	203	198	2	25	0	0
264	203	206	198	2	25	0	0
265	206	110	198	2	25	0	0
266	110	209	198	2	25	0	0
267	209	212	198	2	25	0	0
268	215	218	198	2	25	0	0
269	218	166	198	2	25	0	0
270	166	221	198	2	25	0	0
271	221	224	198	2	25	0	0
272	224	270	198	2	25	0	0
273	268	204	198	2	25	0	0
274	204	207	198	2	25	0	0
275	207	111	198	2	25	0	0
276	111	210	198	2	25	0	0
277	210	213	198	2	25	0	0
278	216	219	198	2	25	0	0
279	219	167	198	2	25	0	0
280	167	222	198	2	25	0	0
281	222	225	198	2	25	0	0
282	225	271	198	2	25	0	0
283	269	205	198	2	59	0	0
284	205	208	198	2	58	0	0
285	208	112	198	2	58	0	0
286	112	211	198	2	58	0	0
287	211	214	198	2	57	0	0
288	217	220	198	2	57	0	0
289	220	166	198	2	58	0	0
290	168	223	198	2	58	0	0
291	223	226	198	2	58	0	0
292	226	272	198	2	59	0	0
293	243	69	68	2	25	0	0
294	172	256	171	2	25	0	0

NOTES: 1. NODE-I NODE-J REF-K: Node numbers which define the location and orientation of the beam element. Refer to the local coordinate system schematic on page 4-9.

2. MATL. NO.: Beam element material property set number. Refer to page 4-8.

3. SECT. NO.: Beam element cross-section property set number. Refer to BEAM TYPE NUMBER on pages 4-9 and 4-10.

4. END CODES: Member end release codes. Zero (0) indicates that the element is restrained by the stiffness of other elements at the I^{th} or J^{th} node.

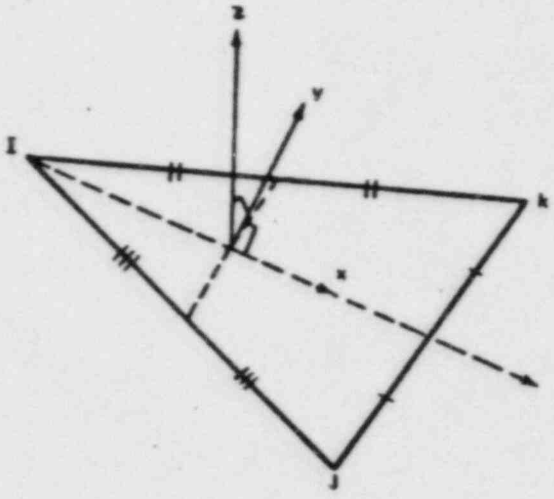
TABLE OF TRIANGULAR ELEMENT MATERIAL PROPERTIES . . . (NOTE 1)

MATERIAL NUMBER (NOTE 2)	YOUNG*S MODULUS (NOTE 3)	POISSON*S RATIO (NOTE 4)
1	617300.00	.2500

NOTES:

1. **TRIANGULAR ELEMENTS:** BSAP's Simple Plate Elements are used to simulate the south wall of the wing areas.
2. **MATERIAL NUMBER:** Triangular element material property set number. Refer to pages 4-18 thru 4-21. In this analysis, MATL. NO. 1 is concrete.
3. **YOUNG'S MODULUS:** Expressed in (k/ft^2).
4. **POISSON'S RATIO:** Dimensionless.

DEFINITION OF DEFAULT LOCAL AXIS SYSTEM



TABULATION OF DATA INPUT FOR TRIANGULAR THIN SHELL ELEMENTS (NOTE 1)

```
 ELEMENT  ELEMENT         NODE  NODE  NODE   MATL    ELEMENT    REF  RESTR
   TYPE   NUMBER           -I    -J    -K     NO.   THICKNESS  PLANE  FLAG
 (NOTE 2)                 - -(NOTE 3)- -   (NOTE 4)  (NOTE 5) (NOTE 6) (NOTE 7)

COMBINED       1           126   127   138     1       3.500      0     1
COMBINED       2           127   140   138     1       3.500      0     1
COMBINED       3           127   129   140     1       3.500      0     1
COMBINED       4           129   142   140     1       3.500      0     1
COMBINED       5           129   131   142     1       3.500      0     1
COMBINED       6           131   144   142     1       3.500      0     1
COMBINED       7           131   132   144     1       3.500      0     1
COMBINED       8           132   146   144     1       3.500      0     1
COMBINED       9           132   134   146     1       3.500      0     1
COMBINED      10           134   148   146     1       3.500      0     1
COMBINED      11           134   136   148     1       3.500      0     1
COMBINED      12           136   150   148     1       3.500      0     1
COMBINED      13           138   140   152     1       3.500      0     1
COMBINED      14           140   154   152     1       3.500      0     1
COMBINED      15           140   142   154     1       3.500      0     1
COMBINED      16           142   156   154     1       3.500      0     1
COMBINED      17           142   144   156     1       3.500      0     1
COMBINED      18           144   158   156     1       3.500      0     1
COMBINED      19           144   146   158     1       3.500      0     1
COMBINED      20           146   160   158     1       3.500      0     1
COMBINED      21           146   148   160     1       3.500      0     1
COMBINED      22           148   162   160     1       3.500      0     1
COMBINED      23           148   150   162     1       3.500      0     1
COMBINED      24           150   164   162     1       3.500      0     1
COMBINED      25           152   154   170     1       3.500      0     1
COMBINED      26           154   172   170     1       3.500      0     1
COMBINED      27           154   156   172     1       3.500      0     1
COMBINED      28           156   174   172     1       3.500      0     1
COMBINED      29           156   158   174     1       3.500      0     1
COMBINED      30           158   176   174     1       3.500      0     1
COMBINED      31           158   160   176     1       3.500      0     1
COMBINED      32           160   178   176     1       3.500      0     1
COMBINED      33           160   162   178     1       3.500      0     1
COMBINED      34           162   180   178     1       3.500      0     1
COMBINED      35           162   164   180     1       3.500      0     1
COMBINED      36           164   183   180     1       3.500      0     1
COMBINED      37            67    69    81     1       3.500      0     1
COMBINED      38            69    83    81     1       3.500      0     1
COMBINED      39            69    71    83     1       3.500      0     1
COMBINED      40            71    85    83     1       3.500      0     1
COMBINED      41            71    73    85     1       3.500      0     1
COMBINED      42            73    87    85     1       3.500      0     1
COMBINED      43            73    75    87     1       3.500      0     1
COMBINED      44            75    89    87     1       3.500      0     1
COMBINED      45            75    77    89     1       3.500      0     1
COMBINED      46            77    91    89     1       3.500      0     1
COMBINED      47            77    79    91     1       3.500      0     1
COMBINED      48            79    94    91     1       3.500      0     1
COMBINED      49            81    83    96     1       3.500      0     1
COMBINED      50            83    98    96     1       3.500      0     1
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NOTES: See page 4-21.

BSAP AUXILIARY BUILD SEISMIC ANALYSIS FLEXIBLE BASE 090881
CE800D15

TABULATION OF DATA INPUT FOR TRIANGULAR THIN SHELL ELEMENTS (NOTE 1)

ELEMENT TYPE (NOTE 2)	ELEMENT NUMBER	NODE -I	NODE -J	NODE -K	MATL NO. (NOTE 4)	ELEMENT THICKNESS (NOTE 5)	REF PLANE (NOTE 6)	RESTR FLAG (NOTE 7)
		- -(NOTE 3)- -						
COMBINED	51	83	85	98	1	3.500	0	1
COMBINED	52	85	100	98	1	3.500	0	1
COMBINED	53	85	87	100	1	3.500	0	1
COMBINED	54	87	102	100	1	3.500	0	1
COMBINED	55	87	89	102	1	3.500	0	1
COMBINED	56	89	104	102	1	3.500	0	1
COMBINED	57	89	91	104	1	3.500	0	1
COMBINED	58	91	106	104	1	3.500	0	1
COMBINED	59	91	94	106	1	3.500	0	1
COMBINED	60	94	108	106	1	3.500	0	1
COMBINED	61	96	98	114	1	3.500	0	1
COMBINED	62	98	115	114	1	3.500	0	1
COMBINED	63	98	100	115	1	3.500	0	1
COMBINED	64	100	117	115	1	3.500	0	1
COMBINED	65	100	102	117	1	3.500	0	1
COMBINED	66	102	119	117	1	3.500	0	1
COMBINED	67	102	104	119	1	3.500	0	1
COMBINED	68	104	120	119	1	3.500	0	1
COMBINED	69	104	106	120	1	3.500	0	1
COMBINED	70	106	122	120	1	3.500	0	1
COMBINED	71	106	108	122	1	3.500	0	1
COMBINED	72	108	124	122	1	21.000	0	1
COMBINED	73	135	215	200	1	21.000	0	1
COMBINED	74	215	218	200	1	21.000	0	1
COMBINED	75	215	216	218	1	21.000	0	1
COMBINED	76	216	219	218	1	21.000	0	1
COMBINED	77	216	217	219	1	21.000	0	1
COMBINED	78	217	220	219	1	21.000	0	1
COMBINED	79	200	218	165	1	6.000	0	1
COMBINED	80	218	166	165	1	6.000	0	1
COMBINED	81	218	219	166	1	6.000	0	1
COMBINED	82	219	167	166	1	6.000	0	1
COMBINED	83	219	220	167	1	6.000	0	1
COMBINED	84	220	168	167	1	6.000	0	1
COMBINED	85	165	166	201	1	6.000	0	1
COMBINED	86	166	221	201	1	6.000	0	1
COMBINED	87	166	167	221	1	6.000	0	1
COMBINED	88	167	222	221	1	6.000	0	1
COMBINED	89	167	168	222	1	6.000	0	1
COMBINED	90	168	223	222	1	6.000	0	1
COMBINED	91	201	221	182	1	6.000	0	1
COMBINED	92	221	224	182	1	6.000	0	1
COMBINED	93	221	222	224	1	6.000	0	1
COMBINED	94	222	225	224	1	6.000	0	1
COMBINED	95	222	223	225	1	6.000	0	1
COMBINED	96	223	226	225	1	6.000	0	1
COMBINED	97	198	203	93	1	6.000	0	1
COMBINED	98	203	206	93	1	6.000	0	1
COMBINED	99	203	204	206	1	6.000	0	1
COMBINED	100	204	207	206	1	6.000	0	1

NOTES: See page 4-21.

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BSAP  AUXILIARY BUILD SEISMIC ANALYSIS FLEXIBLE BASE                                                              090881
CE800D15
TABULATION OF DATA INPUT FOR TRIANGULAR THIN SHELL ELEMENTS (NOTE 1)

  ELEMENT   ELEMENT          NODE  NODE  NODE   MAIL    ELEMENT      REF   RESTR
     TYPE    NUMBER            -I    -J    -K    NO    THICKNESS   PLANE   FLAG
  (NOTE 2)
                             - -(NOTE 3)- -   (NOTE 4)  (NOTE 5)  (NOTE 6) (NOTE 7)

  COMBINED      101           204   205   207     1        6.000      0      1
  COMBINED      102           205   208   207     1        6.000      0      1
  COMBINED      103            93   206   109     1        6.000      0      1
  COMBINED      104           206   110   109     1        6.000      0      1
  COMBINED      105           206   207   110     1        6.000      0      1
  COMBINED      106           207   111   110     1        6.000      0      1
  COMBINED      107           207   208   111     1        6.000      0      1
  COMBINED      108           208   112   111     1        6.000      0      1
  COMBINED      109           109   110   199     1        6.000      0      1
  COMBINED      110           110   209   199     1        6.000      0      1
  COMBINED      111           110   111   209     1        6.000      0      1
  COMBINED      112           111   210   209     1        6.000      0      1
  COMBINED      113           111   112   210     1        6.000      0      1
  COMBINED      114           112   211   210     1        6.000      0      1
  COMBINED      115           199   209   123     1       21.000      0      1
  COMBINED      116           209   212   123     1       21.000      0      1
  COMBINED      117           209   210   212     1       21.000      0      1
  COMBINED      118           210   213   212     1       21.000      0      1
  COMBINED      119           210   211   213     1       21.000      0      1
  COMBINED      120           211   214   213     1       21.000      0      1
  COMBINED      121           242   243    67     1        3.500      0      1
  COMBINED      122           243    69    67     1        3.500      0      1
  COMBINED      123           243   245    69     1        3.500      0      1
  COMBINED      124           245    71    69     1        3.500      0      1
  COMBINED      125           245   247    71     1        3.500      0      1
  COMBINED      126           247    73    71     1        3.500      0      1
  COMBINED      127           247   249    73     1        3.500      0      1
  COMBINED      128           249    75    73     1        3.500      0      1
  COMBINED      129           249   251    75     1        3.500      0      1
  COMBINED      130           251    77    75     1        3.500      0      1
  COMBINED      131           251   253    77     1        3.500      0      1
  COMBINED      132           253    79    77     1        3.500      0      1
  COMBINED      133           170   172   255     1        3.500      0      1
  COMBINED      134           172   256   255     1        3.500      0      1
  COMBINED      135           172   174   256     1        3.500      0      1
  COMBINED      136           174   258   256     1        3.500      0      1
  COMBINED      137           174   176   258     1        3.500      0      1
  COMBINED      138           176   260   258     1        3.500      0      1
  COMBINED      139           176   178   260     1        3.500      0      1
  COMBINED      140           178   262   260     1        3.500      0      1
  COMBINED      141           178   180   262     1        3.500      0      1
  COMBINED      142           180   264   262     1        3.500      0      1
  COMBINED      143           180   183   264     1        3.500      0      1
  COMBINED      144           183   266   264     1        3.500      0      1
  COMBINED      145           252   267   198     1       14.100      0      1
  COMBINED      146           267   203   198     1       14.100      0      1
  COMBINED      147           267   268   203     1       14.100      0      1
  COMBINED      148           268   204   203     1       14.100      0      1
  COMBINED      149           268   269   204     1       14.100      0      1
  COMBINED      150           269   205   204     1       14.100      0      1
```

NOTES: See page 4-21.

TABULATION OF DATA INPUT FOR TRIANGULAR THIN SHELL ELEMENTS (NOTE 1)

ELEMENT TYPE	ELEMENT NUMBER	NODE -I	NODE -J	NODE -K	MATL NO.	ELEMENT THICKNESS	REF PLANE	RESTR FLAG
(NOTE 2)		- -(NOTE 3)- -			(NOTE 4)	(NOTE 5)	(NOTE 6)	(NOTE 7)
COMBINED	151	182	224	265	1	14.100	0	1
COMBINED	152	224	270	265	1	14.100	0	1
COMBINED	153	224	225	270	1	14.100	0	1
COMBINED	154	225	271	270	1	14.100	0	1
COMBINED	155	225	226	271	1	14.100	0	1
COMBINED	156	226	272	271	1	14.100	0	1

NOTES:

1. **TRIANGULAR ELEMENTS:** BSAP's Simple Plate Elements are used to simulate the south wall of the wing areas.
2. **ELEMENT TYPE:** Indicates whether the element has membrane and/or bending properties. The word COMBINED indicates that the element has both properties.
3. **NODE-I NODE-J NODE-K:** Node numbers which define the location and orientation of the triangular element. Refer to the local coordinate system schematic on page 4-17.
4. **MATL. NO.:** Triangular element material property set number. Refer to page 4-17.
5. **ELEMENT THICKNESS:** Expressed in (ft.).
6. **REF. PLANE:** A BSAP option used to define the local axis system for triangular elements. Zero (0) indicates that the default local axis system is in use. Refer to the local coordinate system schematic on page 4-17.
7. **RESTR. FLAG:** Flag to restrain in-plane rotation of the triangular elements. One (1) indicates that a restraint is added at each node.

```
T A B L E   O F   V E C T O R   D I R E C T I O N   C O S I N E S          (NOTE 1)

VECTOR   X-COEFFICIENT   Y-COEFFICIENT   Z-COEFFICIENT
NUMBER            A(X)            B(Y)            C(Z)

     1         1.00000          .00000          .00000
     2          .00000         1.00000          .00000
     3          .00000          .00000         1.00000
```

NOTES: 1. VECTOR DIRECTION COSINES: Defines the local x axis of boundary elements in terms of the global coordinate system. For example, a value of one (1) in the x coefficient column indicates that the local x direction coincides with the global x direction. The boundary element springs act in or about the local x axes of the elements.

For this analysis:

REF. VECTOR	SPRING ACTS IN GLOBAL
1	X
2	Y
3	Z

BSAP AUXILIARY BUILD SEISMIC ANALYSIS FLEXIBLE BASE 090881
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TABULATION OF DATA INPUT FOR BOUNDARY ELEMENTS . . .

ELEMENT NUMBER	ELEMENT IDTAG	END-N (NOTE 1)	REF VECTOR (NOTE 2)	DISPLACEMENT CODE (NOTE 3)	ROTATION CODE (NOTE 4)	DISP SPRING STIFFNESS (NOTE 5)	ROTNL SPRING STIFFNESS (NOTE 6)
1		112	1	1	0	1.34000+04	.00000
2		112	2	1	0	1.34000+04	.00000
3		112	3	1	0	1.82000+04	.00000
4		112	2	0	1	.00000	3.12000+06
5		168	1	1	0	1.34000+04	.00000
6		168	2	1	0	1.34000+04	.00000
7		168	3	1	0	1.82000+04	.00000
8		168	2	0	1	.00000	3.12000+06
9		269	3	1	0	8.29000+03	.00000
10		269	2	0	1	.00000	1.42000+06
11		272	1	1	0	6.13000+03	.00000
12		272	2	1	0	6.11000+03	.00000
13		272	3	1	0	8.29000+03	.00000
14		272	2	0	1	.00000	1.42000+06
15		214	1	1	0	4.72000+04	.00000
16		214	2	1	0	4.71000+04	.00000
17		214	3	1	0	6.40000+04	.00000
18		214	2	0	1	.00000	1.10000+07
19		217	1	1	0	4.72000+04	.00000
20		217	2	1	0	4.71000+04	.00000
21		217	3	1	0	6.40000+04	.00000
22		217	2	0	1	.00000	1.10000+07
23		211	1	1	0	5.09000+04	.00000
24		211	2	1	0	5.08000+04	.00000
25		211	3	1	0	6.90000+04	.00000
26		211	2	0	1	.00000	1.19000+07
27		220	1	1	0	5.09000+04	.00000
28		220	2	1	0	5.08000+04	.00000
29		220	3	1	0	6.90000+04	.00000
30		220	2	0	1	.00000	1.19000+07
31		208	1	1	0	2.84000+04	.00000
32		208	2	1	0	2.83000+04	.00000
33		208	3	1	0	3.85000+04	.00000
34		208	2	0	1	.00000	6.62000+06
35		223	1	1	0	2.84000+04	.00000
36		223	2	1	0	2.83000+04	.00000
37		223	3	1	0	3.85000+04	.00000
38		223	2	0	1	.00000	6.62000+06
39		205	1	1	0	2.48000+04	.00000
40		205	2	1	0	2.47000+04	.00000
41		205	3	1	0	3.36000+04	.00000
42		205	2	0	1	.00000	5.78000+06
43		226	1	1	0	2.48000+04	.00000
44		226	2	1	0	2.47000+04	.00000
45		226	3	1	0	3.36000+04	.00000
46		226	2	0	1	.00000	5.78000+06
47		269	1	1	0	6.13000+03	.00000
48		269	2	1	0	6.11000+03	.00000
49		239	1	1	0	3.70000+06	.00000
50		239	2	1	0	3.68000+06	.00000

NOTES: See page 4-24.

```
BSAP  AUXILIARY BUILD SEISMIC  ANALYSIS FLEXIBLE BASE                                                          090881
CE800015
TABULATION  OF  DATA  INPUT  FOR  BOUNDARY  ELEMENTS

   ELEMENT  ELEMENT                              REF  DISPLACEMENT     ROTATION  DISP SPRING  ROTNL SPRING
   NUMBER    IDTAG    END-N                      VECTOR        CODE        CODE    STIFFNESS     STIFFNESS
                     (NOTE 1)                   (NOTE 2)   (NOTE 3)    (NOTE 4)    (NOTE 5)      (NOTE 6)

       51              239                          3          1           0    4.62000+06      .00000
       52              239                          1          0           1     .00000       3.23000+10
       53              239                          2          0           1     .00000       5.43000+10
       54              239                          3          0           1     .00000       4.94000+10
```

NOTES:

1. END-N: The node at which the boundary element is placed.
2. REF. VECTOR: Vector direction cosine number. Refer to VECTOR NUMBER on page 4-22.
3. DISPLACEMENT CODE: Flag for translational stiffness. One (1) indicates a translational spring stiffness.
4. ROTATION CODE: Flag for rotational stiffness. One (1) indicates a rotational spring stiffness.
5. DISP. SPRING STIFFNESS: Expressed in (k/ft).
6. ROTNL. SPRING STIFFNESS: Expressed in (k*ft/rad).

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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                              090881
CE800015
 G L O B A L  ( X, Y, Z )  N O D A L   M A S S E S   .   .   . (NOTE 1)
                                                                - - - (NOTE 4) - - -
NODE         X-MASS          Y-MASS          Z-MASS        X-ROTNL MASS     Y-ROTNL MASS     Z-ROTNL MASS
 NO.     (F*(T**2)/L)    (F*(T**2)/L)    (F*(T**2)/L)    (F*L*(T**2))     (F*L*(T**2))     (F*L*(T**2))
               - - - - - (NOTE 2) - - - - -                         - - - - - (NOTE 3) - - - - -

   1      .4207830+02     .4207830+02     .4207830+02     .0000000         .0000000         .6188900+05
   4      .1355649+03     .1355649+03     .1355649+03     .0000000         .0000000         .2288960+06
  10      .3283538+03     .3283538+03     .3283538+03     .0000000         .0000000         .1592320+07
  13      .4446367+03     .4446367+03     .4446367+03     .0000000         .0000000         .2111690+07
  19      .7012117+03     .7012117+03     .7012117+03     .0000000         .0000000         .3483200+07
  28      .6402557+03     .6402557+03     .6402557+03     .0000000         .0000000         .2960720+07
  31      .4040201+03     .4040201+03     .4040201+03     .0000000         .0000000         .1691840+07
  34      .6133853+03     .6133853+03     .6133853+03     .0000000         .0000000         .2466230+07
  40      .1020080+03     .1020080+03     .1020080+03     .0000000         .0000000         .1511460+06
  42      .1290961+03     .1290961+03     .1290961+03     .0000000         .0000000         .1977960+06
  43      .1197661+03     .1197661+03     .1197661+03     .0000000         .0000000         .1847340+06
  44      .1230627+03     .1230627+03     .1230627+03     .0000000         .0000000         .1819350+06
  47      .1029410+03     .1029410+03     .1029410+03     .0000000         .0000000         .1495910+06
  51      .1453614+03     .1453614+03     .1453614+03     .0000000         .0000000         .1956190+06
  55      .3249017+03     .3249017+03     .3249017+03     .0000000         .0000000         .4416200+06
  58      .3690948+03     .3690948+03     .2293625+03     .0000000         .0000000         .3763100+06
  59      .4194146+03     .4194146+03     .2836942+03     .0000000         .0000000         .4447300+06
  61      .8418770+02     .8418770+02     .8418770+02     .0000000         .0000000         .9174500+05
  62      .4182950+02     .4182950+02     .4182950+02     .0000000         .0000000         .5131500+05
  63      .4201610+02     .4201610+02     .4201610+02     .0000000         .0000000         .2537760+05
  64      .4111420+02     .4111420+02     .4111420+02     .0000000         .0000000         .2587520+05
  65      .1738490+02     .1738490+02     .1738490+02     .0000000         .0000000         .1172470+05
  66      .3110000+01     .3110000+01     .3110000+01     .0000000         .0000000         .1016970+05
  67      .1542560+01     .1542560+01     .1542560+01     .0000000         .0000000         .0000000
  69      .3162870+01     .3162870+01     .3162870+01     .0000000         .0000000         .0000000
  70      .4291800+01     .4291800+01     .4291800+01     .0000000         .0000000         .1262660+05
  71      .4011900+01     .4011900+01     .4011900+01     .0000000         .0000000         .0000000
  72      .3514300+01     .3514300+01     .3514300+01     .0000000         .0000000         .1427490+05
  73      .4926240+01     .4926240+01     .4926240+01     .0000000         .0000000         .0000000
  74      .3172200+01     .3172200+01     .3172200+01     .0000000         .0000000         .7868300+04
  75      .4708540+01     .4708540+01     .4708540+01     .0000000         .0000000         .0000000
  76      .5193700+01     .5193700+01     .5193700+01     .0000000         .0000000         .1178690+05
  77      .4413090+01     .4413090+01     .4413090+01     .0000000         .0000000         .0000000
  78      .2873640+01     .2873640+01     .2873640+01     .0000000         .0000000         .2005950+05
  79      .2239200+01     .2239200+01     .2239200+01     .0000000         .0000000         .0000000
  80      .3657360+01     .3657360+01     .3657360+01     .0000000         .0000000         .1016970+05
  81      .2634170+01     .2634170+01     .2634170+01     .0000000         .0000000         .0000000
  83      .5402070+01     .5402070+01     .5402070+01     .0000000         .0000000         .0000000
  84      .4105200+01     .4105200+01     .4105200+01     .0000000         .0000000         .1262660+05
  85      .6854440+01     .6854440+01     .6854440+01     .0000000         .0000000         .0000000
  86      .2830100+01     .2830100+01     .2830100+01     .0000000         .0000000         .1427490+05
  87      .8415660+01     .8415660+01     .8415660+01     .0000000         .0000000         .0000000
  88      .2425800+01     .2425800+01     .2425800+01     .0000000         .0000000         .7868300+04
  89      .8042460+01     .8042460+01     .8042460+01     .0000000         .0000000         .0000000
  90      .5722400+01     .5722400+01     .5722400+01     .0000000         .0000000         .1178690+05
  91      .7535530+01     .7535530+01     .7535530+01     .0000000         .0000000         .0000000
  92      .2550200+01     .2550200+01     .2550200+01     .0000000         .0000000         .2005950+05
  93      .3203300+01     .3203300+01     .3203300+01     .0000000         .0000000         .0000000
  94      .3822190+01     .3822190+01     .3822190+01     .0000000         .0000000         .0000000
  95      .2043270+02     .2043270+02     .2043270+02     .0000000         .0000000         .1016970+05

NOTES:  See page 4-28.
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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                         090881
CE800015
 G L O B A L  ( X, Y, Z )  N O D A L   M A S S E S            (NOTE 1)
                                                         - - - (NOTE 4) - - -
NODE        X-MASS          Y-MASS          Z-MASS       X-ROTNL MASS     Y-ROTNL MASS     Z-ROTNL MASS
 NO.     (F*(T**2)/L)    (F*(T**2)/L)    (F*(T**2)/L)    (F*L*(T**2))     (F*L*(T**2))     (F*L*(T**2))
               - - - - - (NOTE 2) - - - - -                      - - - - - (NOTE 3) - - - - -

  96     .2292070+01     .2292070+01     .2292070+01      .0000000         .0000000         .0000000
  98     .4702320+01     .4702320+01     .4702320+01      .0000000         .0000000         .0000000
  99     .1365290+02     .1365290+02     .1365290+02      .0000000         .0000000         .1262660+05
 100     .5968090+01     .5968090+01     .5968090+01      .0000000         .0000000         .0000000
 101     .2469340+02     .2469340+02     .2469340+02      .0000000         .0000000         .1427490+05
 102     .7327160+01     .7327160+01     .7327160+01      .0000000         .0000000         .0000000
 103     .2021500+01     .2021500+01     .2021500+01      .0000000         .0000000         .7868300+04
 104     .7000610+01     .7000610+01     .7000610+01      .0000000         .0000000         .0000000
 105     .1819350+02     .1819350+02     .1819350+02      .0000000         .0000000         .1178690+05
 106     .6558990+01     .6558990+01     .6558990+01      .0000000         .0000000         .0000000
 107     .4260700+01     .4260700+01     .4260700+01      .0000000         .0000000         .2005950+05
 108     .3327700+01     .3327700+01     .3327700+01      .0000000         .0000000         .0000000
 109     .1586100+01     .1586100+01     .1586100+01      .0000000         .0000000         .0000000
 110     .3949700+01     .3949700+01     .3949700+01      .0000000         .0000000         .0000000
 111     .4105200+01     .4105200+01     .4105200+01      .0000000         .0000000         .0000000
 112     .3203300+01     .3203300+01     .3203300+01      .0000000         .0000000         .0000000
 114     .9392200+00     .9392200+00     .9392200+00      .0000000         .0000000         .0000000
 115     .1928200+01     .1928200+01     .1928200+01      .0000000         .0000000         .0000000
 117     .2447570+01     .2447570+01     .2447570+01      .0000000         .0000000         .0000000
 119     .3004260+01     .3004260+01     .3004260+01      .0000000         .0000000         .0000000
 120     .2870530+01     .2870530+01     .2870530+01      .0000000         .0000000         .0000000
 122     .2690150+01     .2690150+01     .2690150+01      .0000000         .0000000         .0000000
 123     .6002300+01     .6002300+01     .6002300+01      .0000000         .0000000         .0000000
 124     .1365290+01     .1365290+01     .1365290+01      .0000000         .0000000         .0000000
 126     .9392200+00     .9392200+00     .9392200+00      .0000000         .0000000         .0000000
 127     .1928200+01     .1928200+01     .1928200+01      .0000000         .0000000         .0000000
 129     .2447570+01     .2447570+01     .2447570+01      .0000000         .0000000         .0000000
 131     .3004260+01     .3004260+01     .3004260+01      .0000000         .0000000         .0000000
 132     .2870530+01     .2870530+01     .2870530+01      .0000000         .0000000         .0000000
 134     .2690150+01     .2690150+01     .2690150+01      .0000000         .0000000         .0000000
 135     .6002300+01     .6002300+01     .6002300+01      .0000000         .0000000         .0000000
 136     .1365290+01     .1365290+01     .1365290+01      .0000000         .0000000         .0000000
 137     .2055710+02     .2055710+02     .2055710+02      .0000000         .0000000         .1016970+05
 138     .2292070+01     .2292070+01     .2292070+01      .0000000         .0000000         .0000000
 140     .4702320+01     .4702320+01     .4702320+01      .0000000         .0000000         .0000000
 141     .1570550+02     .157055C+02     .1570550+02      .0000000         .0000000         .1290650+05
 142     .5968090+01     .5968090+01     .5968090+01      .0000000         .0000000         .0000000
 143     .2537760+02     .2537760+02     .2537760+02      .0000000         .0000000         .1443040+05
 144     .7327160+01     .7327160+01     .7327160+01      .0000000         .0000000         .0000000
 145     .2021500+01     .2021500+01     .2021500+01      .0000000         .0000000         .7868300+04
 146     .7000610+01     .7000610+01     .7000610+01      .0000000         .0000000         .0000000
 147     .1819350+02     .1819350+02     .1819350+02      .0000000         .0000000         .1178690+05
 148     .6558990+01     .6558990+01     .6558990+01      .0000000         .0000000         .0000000
 149     .4260700+01     .4260700+01     .4260700+01      .0000000         .0000000         .2005950+05
 150     .3327700+01     .3327700+01     .3327700+01      .0000000         .0000000         .0000000
 151     .3657360+01     .3657360+01     .3657360+01      .0000000         .0000000         .1016970+05
 152     .2634170+01     .2634170+01     .2634170+01      .0000000         .0000000         .0000000
 154     .5402070+01     .5402070+01     .5402070+01      .0000000         .0000000         .0000000
 155     .4105200+01     .4105200+01     .4105200+01      .0000000         .0000000         .1290650+05
 156     .6854440+01     .6854440+01     .6854440+01      .0000000         .0000000         .0000000

NOTES:  See page 4-28.
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BSAP  AUXILIARY BUILD  SEISMIC  ANALYSIS FLEXIBLE BASE                                                          090881
CE800D15
 G L O B A L  ( X, Y, Z )  N O D A L   M A S S E S        (NOTE 1)
                                                        - - - (NOTE 4) - - -
 NODE         X-MASS          Y-MASS          Z-MASS       X-ROTNL MASS     Y-ROTNL MASS     Z-ROTNL MASS
  NO.     (F*(T**2)/L)    (F*(T**2)/L)    (F*(T**2)/L)     (F*L*(T**2))     (F*L*(T**2))     (F*L*(T**2))
                - - - - - (NOTE 2) - - - - -                      - - - - - (NOTE 3) - - - - -

  157     .2830100+01     .2830100+01     .2830100+01       .0000000         .0000000        .1443040+05
  158     .8415660+01     .8415660+01     .8415660+01       .0000000         .0000000        .0000000
  159     .2425800+01     .2425800+01     .2425800+01       .0000000         .0000000        .7868300+04
  160     .8042460+01     .8042460+01     .8042460+01       .0000000         .0000000        .0000000
  161     .5722400+01     .5722400+01     .5722400+01       .0000000         .0000000        .1178690+05
  162     .7535530+01     .7535530+01     .7535530+01       .0000000         .0000000        .0000000
  163     .2550200+01     .2550200+01     .2550200+01       .0000000         .0000000        .2005950+05
  164     .3822190+01     .3822190+01     .3822190+01       .0000000         .0000000        .0000000
  165     .1586100+01     .1586100+01     .1586100+01       .0000000         .0000000        .0000000
  166     .3949700+01     .3949700+01     .3949700+01       .0000000         .0000000        .0000000
  167     .4105200+01     .4105200+01     .4105200+01       .0000000         .0000000        .0000000
  168     .3203300+01     .3203300+01     .3203300+01       .0000000         .0000000        .0000000
  169     .3110000+01     .3110000+01     .3110000+01       .0000000         .0000000        .1016970+05
  170     .1542560+01     .1542560+01     .1542560+01       .0000000         .0000000        .0000000
  172     .3162870+01     .3162870+01     .3162870+01       .0000000         .0000000        .0000000
  173     .4291800+01     .4291800+01     .4291800+01       .0000000         .0000000        .1290650+05
  174     .4011900+01     .4011900+01     .4011900+01       .0000000         .0000000        .0000000
  175     .3514300+01     .3514300+01     .3514300+01       .0000000         .0000000        .1443040+05
  176     .4926240+01     .4926240+01     .4926240+01       .0000000         .0000000        .0000000
  177     .3172200+01     .3172200+01     .3172200+01       .0000000         .0000000        .7868300+04
  178     .4708540+01     .4708540+01     .4708540+01       .0000000         .0000000        .0000000
  179     .3638700+01     .3638700+01     .3638700+01       .0000000         .0000000        .1178690+05
  180     .4413090+01     .4413090+01     .4413090+01       .0000000         .0000000        .0000000
  181     .2873640+01     .2873640+01     .2873640+01       .0000000         .0000000        .2005950+05
  182     .3265500+01     .3265500+01     .3265500+01       .0000000         .0000000        .0000000
  183     .2239200+01     .2239200+01     .2239200+01       .0000000         .0000000        .0000000
  198     .3265500+01     .3265500+01     .3265500+01       .0000000         .0000000        .0000000
  199     .6935300+01     .6935300+01     .6935300+01       .0000000         .0000000        .0000000
  200     .6935300+01     .6935300+01     .6935300+01       .0000000         .0000000        .0000000
  201     .3203300+01     .3203300+01     .3203300+01       .0000000         .0000000        .0000000
  203     .8148200+01     .8148200+01     .8148200+01       .0000000         .0000000        .1542560+05
  204     .8459200+01     .8459200+01     .8459200+01       .0000000         .0000000        .1337300+05
  205     .6173350+01     .6173350+01     .6173350+01       .0000000         .0000000        .8925700+04
  206     .7961600+01     .7961600+01     .7961600+01       .0000000         .0000000        .1542560+05
  207     .8272600+01     .8272600+01     .8272600+01       .0000000         .0000000        .1337300+05
  208     .6468800+01     .6468800+01     .6468800+01       .0000000         .0000000        .8925700+04
  209     .1735380+02     .1735380+02     .1735380+02       .0000000         .0000000        .1542560+05
  210     .1803800+02     .1803800+02     .1803800+02       .0000000         .0000000        .1337300+05
  211     .1299980+02     .1299980+02     .1299980+02       .0000000         .0000000        .8925700+04
  212     .1502130+02     .1502130+02     .1502130+02       .0000000         .0000000        .0000000
  213     .1558110+02     .1558110+02     .1558110+02       .0000000         .0000000        .0000000
  214     .1153810+02     .1153810+02     .1153810+02       .0000000         .0000000        .0000000
  215     .1502130+02     .1502130+02     .1502130+02       .0000000         .0000000        .0000000
  216     .1558110+02     .1558110+02     .1558110+02       .0000000         .0000000        .0000000
  217     .1153810+02     .1153810+02     .1153810+02       .0000000         .0000000        .0000000
  218     .1735380+02     .1735380+02     .1735380+02       .0000000         .0000000        .1542560+05
  219     .1803800+02     .1803800+02     .1803800+02       .0000000         .0000000        .1337300+05
  220     .1299980+02     .1299980+02     .1299980+02       .0000000         .0000000        .8925700+04
  221     .7961600+01     .7961600+01     .7961600+01       .0000000         .0000000        .1542560+05
  222     .8272600+01     .8272600+01     .8272600+01       .0000000         .0000000        .1337300+05

NOTES:  See page 4-28.
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BSAP  AUXILIARY BUILD SEISMIC  ANALYSIS FLEXIBLE BASE                                           050881
CE800015
 G L O B A L  ( X, Y, Z )  N O D A L   M A S S E S  . (NOTE 1)
                                                          - - - (NOTE 4) - - -
NODE          X-MASS          Y-MASS           Z-MASS     X-ROTNL MASS    Y-ROTNL MASS     Z-ROTNL MASS
 NO      (F*(T**2)/L)    (F*(T**2)/L)     (F*(T**2)/L)   (F*L*(T**2))    (F*L*(T**2))     (F*L*(T**2))
                - - - - - (NOTE 2) - - - - -                    - - - - - (NOTE 3) - - - - -

 223      .6468800+01     .6468800+01     .6468800+01      .0000000        .0000000        .8925700+04
 224      .8148200+01     .8148200+01     .8148200+01      .0000000        .0000000        .1542560+05
 225      .8459200+01     .8459200+01     .8459200+01      .0000000        .0000000        .1337300+05
 226      .6173350+01     .6173350+01     .6173350+01      .0000000        .0000000        .8925700+04
 239      .1040015+04     .1040015+04     .9401841+03      .9889800+07     .1132040+08     .3887500+07
 242      .2612400+00     .2612400+00     .2612400+00      .0000000        .0000000        .0000000
 243      .5349200+00     .5349200+00     .5349200+00      .0000000        .0000000        .0000000
 245      .6779800+00     .6779800+00     .6779800+00      .0000000        .0000000        .0000000
 247      .8334800+00     .8334800+00     .8334800+00      .0000000        .0000000        .0000000
 249      .7961600+00     .7961600+00     .7961600+00      .0000000        .0000000        .0000000
 251      .7495100+00     .7495100+00     .7495100+00      .0000000        .0000000        .0000000
 252      .1057400+01     .1057400+01     .1057400+01      .0000000        .0000000        .0000000
 253      .3794200+00     .3794200+00     .3794200+00      .0000000        .0000000        .0000000
 255      .2612400+00     .2612400+00     .2612400+00      .0000000        .0000000        .0000000
 256      .5349200+00     .5349200+00     .5349200+00      .0000000        .0000000        .0000000
 258      .6779800+00     .6779800+00     .6779800+00      .0000000        .0000000        .0000000
 260      .8334800+00     .8334800+00     .8334800+00      .0000000        .0000000        .0000000
 262      .7961600+00     .7961600+00     .7961600+00      .0000000        .0000000        .0000000
 264      .7495100+00     .7495100+00     .7495100+00      .0000000        .0000000        .0000000
 265      .1057400+01     .1057400+01     .1057400+01      .0000000        .0000000        .0000000
 266      .3794200+00     .3794200+00     .3794200+00      .0000000        .0000000        .0000000
 267      .2643500+01     .2643500+01     .2643500+01      .0000000        .0000000        .0000000
 268      .2736800+01     .2736800+01     .2736800+01      .0000000        .0000000        .0000000
 269      .1694950+01     .1694950+01     .1694950+01      .0000000        .0000000        .0000000
 270      .2643500+01     .2643500+01     .2643500+01      .0000000        .0000000        .0000000
 271      .2736800+01     .2736800+01     .2736800+01      .0000000        .0000000        .0000000
 272      .1694950+01     .1694950+01     .1694950+01      .0000000        .0000000        .0000000
```

NOTES: 1. NODAL MASSES: A non-zero entry indicates a dynamic degree of freedom at that node.

2. X Y Z MASS: Expressed in ($k*sec^2/ft$).

3. X Y Z ROTNL. MASS: Expressed in ($k*ft*sec^2$).

4. X Y ROTNL. MASS: The rocking mass is lumped to the main foundation, i.e., NODE NO. 239.

DAMPING DATA

FIRST ELEMENT (NOTE 1)	LAST ELEMENT (NOTE 2)	ELEMENT TYPE	% CRIT. DAMPING (NOTE 3)	REPRESENTING
1	3	BEAM	.02	Structural Steel Beam Elements
4	294	BEAM	.03	Concrete Beam Elements
1	156	SIMP	.03	Concrete Plate Elements
1	48	BOUND	.03	Soil Spring Elements With 3% Material Damping

NOTES: 1. FIRST ELEMENT: The first element in the generated series.

2. LAST ELEMENT: The last element in the generated series.

3. % CRITICAL DAMPING: Material damping expressed as a ratio of critical damping. Values are according to Midland Units 1 and 2 Final Safety Analysis Report Response to Regulatory Guide 1.61.

5.0 RESULTS

TABLE 1

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 ........... SUMMARY TABLES FOR BASE MOTION ALONG EACH AXIS (ACTING INDEPENDENTLY) ...........
MODE  OMEGA     FN       T    GENL         PARTICIPATION FACTORS                         MODAL MASSES                    CUMULATIVE MASS(PERCENT)
     (RAD/S)   (CPS)   (SEC)  MASS        X          Y          Z          X          Y          Z          X        Y
                                                                                                            
  1   17.55    2.79   .3579  1.00       .053     77.165     -.410       .003   5954.492       .168       .0     81.9       .0
  2   18.33    2.92   .3429  1.00     78.185     -.187    -5.025   6112.942       .035     25.252     84.1     81.9       .4
  3   23.04    3.67   .2727  1.00     -1.916     1.992      .401      3.670      3.967       .161     84.2     82.0       .4
  4   25.97    4.13   .2420  1.00     -4.253      .300    26.138     18.092       .090    683.170     84.4     82.0     10.3
  5   26.27    4.18   .2392  1.00     -9.317     -.607   -78.119     86.798       .369   6102.547     85.6     82.0     98.8
  6   28.19    4.49   .2229  1.00       .400     1.064      .905       .160      1.131       .819     85.6     82.0     98.8
  7   30.49    4.85   .2061  1.00      -.201   -21.202      .355       .040    449.540       .126     85.6     88.2     98.8
  8   33.71    5.36   .1864  1.00       .292     -.304      .087       .085       .092       .008     85.6     88.2     98.8
  9   34.34    5.47   .1830  1.00    -11.049      .010      .054    122.075       .000       .003     87.3     88.2     98.8
 10   37.57    5.98   .1673  1.00    -28.852    -1.292     7.373    832.412      1.669     54.359     98.7     88.2     99.6
 11   39.68    6.32   .1583  1.00     -1.008    28.248     -.429      1.016    797.977       .184     98.8     99.2     99.6
 12   43.94    6.99   .1430  1.00     -6.033      .535     3.247     36.403       .286     10.540     99.3     99.2     99.8
 13   51.43    8.19   .1222  1.00       .305    -3.156      .065       .093      9.961       .004     99.3     99.3     99.8
 14   52.39    8.34   .1199  1.00      -.060      .361     -.106       .004       .130       .011     99.3     99.3     99.8
 15   52.50    8.36   .1197  1.00     -1.050      .175     -.219      1.103       .031       .048     99.3     99.3     99.8

                                                         SUMMATIONS   7214.896   7219.769   6877.399

                                                         TOTAL MASS   7267.939   7267.939   6892.656
```

TABLE 2

SUMMARY TABLE - MODE NUMBER 1

```
BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 M O D E   N U M B E R    1
     FREQUENCY ***************************          2.79380449 CPS
     PERIOD ******************************           .35793485 SEC
     EIGENVALUE **************************         .17553991+02 RAD/SEC
     PARTICIPATION FACTOR ( X ) *********         .53137844-01
     PARTICIPATION FACTOR ( Y ) *********         .77165352+02
     PARTICIPATION FACTOR ( Z ) *********        -.40964501+00

E I G E N V E C T O R   I N   G L O B A L  ( X , Y , Z )  R E F E R E N C E   S Y S T E M . . .

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
 NUMBER

     1     4.00804-05       2.61687-02      -1.21677-04      -7.64838-05       4.32995-07      -6.22980-05
     2     1.26675-04       2.58454-02      -2.30237-04      -7.64838-05       4.32995-07      -6.22980-05
     3     1.20834-04       2.28584-02      -2.30025-04      -7.51302-05       4.30209-07      -5.50812-05
     4     7.84210-05       2.51437-02      -1.54325-04      -7.51301-05       4.30210-07      -5.50812-05
     5     7.84210-05       2.64745-02      -1.43931-04      -7.51300-05       4.30209-07      -5.50813-05
     6     5.59141-05       2.14061-02      -1.41724-04      -7.29126-05       4.02728-07      -3.22964-05
     7     5.59141-05       2.14029-02      -1.41765-04      -7.29126-05       4.02728-07      -3.22964-05
     8     5.59141-05       2.14061-02      -1.41724-04      -7.29126-05       4.02728-07      -3.22964-05
     9     1.99850-05       1.32553-02      -1.38110-04      -6.56932-05       3.47396-07       5.23211-06
    10     2.33336-05       1.31531-02      -8.92818-05      -6.56930-05       3.47400-07       5.23218-06
    11     3.15482-05       1.32269-02       8.95433-06      -6.56928-05       3.47388-07       5.23225-06
    12     2.60106-05       1.23033-02       9.01791-06      -6.53826-05       3.17189-07       5.44835-06
    13     2.08892-05       1.23113-02      -5.29080-05      -6.53826-05       3.17209-07       5.44836-06
    14     3.36384-05       1.22964-02       1.00953-04      -6.53825-05       3.17253-07       5.44837-06
    15     3.20611-05       1.20385-02       1.00987-04      -6.52684-05       3.06109-07       5.41154-06
    16     3.20611-05       1.20390-02       1.00956-04      -6.52684-05       3.06109-07       5.41154-06
    17     3.20611-05       1.20385-02       1.00987-04      -6.52684-05       3.06109-07       5.41154-06
    18     2.84914-05       1.14311-02       1.01067-04      -6.49309-05       2.78114-07       5.32453-06
    19     3.68509-05       1.13850-02       2.05417-04      -6.49303-05       2.78172-07       5.32448-06
    20     4.94166-05       1.14410-02       3.55723-04      -6.49295-05       2.78066-07       5.32444-06
    21     4.84556-05       1.12837-02       3.55706-04      -6.48603-05       2.76382-07       5.33861-06
    22     4.84556-05       1.12843-02       3.55678-04      -6.48603-05       2.76381-07       5.33861-06
    23     4.84556-05       1.12837-02       3.55706-04      -6.48603-05       2.76381-07       5.33861-06
    24     4.65439-05       1.09696-02       3.55672-04      -6.47039-05       2.72856-07       5.36693-06
    25     4.65439-05       1.09701-02       3.55644-04      -6.47039-05       2.72856-07       5.36693-06
    26     4.65439-05       1.09696-02       3.55672-04      -6.47039-05       2.72855-07       5.36693-06
    27     3.97420-05       9.83732-03       3.55548-04      -6.39366-05       2.58325-07       5.46959-06
    28     2.65812-06       9.83897-03      -7.80188-05      -6.39363-05       2.58330-07       5.46962-06
    29    -1.49879-06       9.84137-03      -1.26724-04      -6.39362-05       2.58359-07       5.46962-06
    30    -7.13046-06       8.62576-03      -1.26716-04      -6.27509-05       2.34453-07       5.64404-06
    31    -5.66300-06       8.63440-03      -1.10760-04      -6.27506-05       2.34421-07       5.64405-06
    32    -4.36487-06       8.62316-03      -9.58608-05      -6.27502-05       2.34445-07       5.64406-06
    33    -8.57414-06       7.37425-03      -9.57596-05      -6.11160-05       2.10747-07       5.79006-06
    34    -1.34957-05       7.34454-03      -1.46627-04      -6.11147-05       2.10610-07       5.79006-06
    35    -1.14113-05       7.45299-03      -1.28570-04      -6.11099-05       2.10530-07       5.79029-06
    36    -1.54746-05       5.72841-03      -1.28021-04      -5.11161-05       1.57841-07       9.16627-06
    37    -1.51079-05       5.70100-03      -1.25505-04      -5.11151-05       1.57846-07       9.16635-06
    38     4.86770-05       2.27780-02      -1.32232-04      -7.51300-05       4.30209-07      -5.50817-05
    39     1.48181-05       1.82220-02      -1.28495-04      -6.41208-05      -3.88934-08       6.97632-06
    40     1.58645-05       1.83504-02      -1.18161-04      -6.41208-05      -3.88934-08       6.97637-06
    41     1.60328-05       1.76955-02      -1.18102-04      -6.40408-05      -3.88747-08       7.86198-06
    42     1.67933-05       1.69643-02      -1.17968-04      -6.38714-05      -4.05368-08       8.84739-06
    43     2.57245-05       1.60019-02      -6.58398-05      -6.34385-05      -4.98135-08       8.02568-06
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Table 2 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 M O D E   N U M B E R   1

E I G E N V E C T O R   I N   G L O B A L  ( X , Y , Z )  R E F E R E N C E   S Y S T E M . . .

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION      Z-ROTATION
NUMBER

   44      2.18135-05      1.45833-02      -1.16559-04     -6.25396-05      1.38167-08      6.81802-06
   45      2.34498-05      1.44423-02      -1.01263-04     -6.25396-05      1.38202-08      6.81803-06
   46      2.71005-05      1.36064-02      -7.20807-05     -6.56928-05      3.47389-07      5.23268-06
   47      2.36639-05      1.32873-02      -1.27023-04     -6.16758-05      7.57507-08      5.74464-06
   48      2.67660-05      1.31596-02      -9.20352-05     -6.16758-05      7.57508-08      5.74465-06
   49      2.38312-05      1.26984-02      -4.01455-05     -6.53825-05      3.17254-07      5.44849-06
   50      2.51302-05      1.27952-02      -1.25001-04     -6.13383-05      9.25758-08      5.28430-06
   51      2.62158-05      1.20662-02      -1.58349-04     -6.03631-05      1.35455-07      4.19675-06
   52      3.25529-05      1.19635-02      -6.38845-05     -6.03631-05      1.35456-07      4.19676-06
   53      2.57760-05      1.18340-02       4.74378-05     -6.49295-05      2.78068-07      5.32444-06
   54      2.82647-05      1.15612-02      -1.59088-04     -5.94777-05      1.26260-07      5.21976-06
   55     -1.05490-05      1.03347-02      -1.59468-04     -5.76046-05     -1.02741-07      6.33355-06
   56     -1.05490-05      1.01398-02      -1.62629-04     -5.76046-05     -1.02740-07      6.33352-06
   57     -1.49879-06      1.02307-02      -1.45114-04     -6.39362-05      2.58361-07      5.46957-06
   58     -1.35379-05      9.23936-03      -1.48776-04     -5.68322-05      6.78784-08      6.69390-06
   59     -1.43670-05      8.12862-03      -1.47179-04     -5.52646-05      1.14335-07      7.03582-06
   60     -1.56412-05      6.69803-03      -1.45547-04     -5.11386-05      1.57010-07      9.17223-06
   61      3.67975-04      1.50690-02       4.09288-03     -6.74607-05      3.57121-07      5.29926-06
   62      3.55000-04      1.30072-02       4.08468-03     -6.56931-05      3.47342-07      5.23211-06
   63     -3.14760-04      1.50746-02      -4.41920-03     -6.74431-05      3.34171-07      5.29733-06
   64     -3.18369-04      1.41195-02      -4.41657-03     -6.71166-05      3.36604-07      5.27674-06
   65     -3.21363-04      1.30603-02      -4.41097-03     -6.56930-05      3.47413-07      5.23217-06
   66      1.40808-04      1.79368-02       9.77114-03     -8.59733-05     -1.13869-05     -1.09075-05
   67      1.40808-04      1.78102-02       9.90322-03     -8.59733-05     -1.13869-05     -1.09075-05
   68      2.47126-04      1.70536-02       9.76511-03     -8.95111-05     -1.17142-05     -7.87555-06
   69      2.47126-04      1.69622-02       9.90099-03     -8.95111-05     -1.17142-05     -7.87555-06
   70      3.63577-04      1.61210-02       9.75542-03     -8.73033-05     -1.22567-05     -5.12620-06
   71      3.63577-04      1.60615-02       9.89760-03     -8.73033-05     -1.22567-05     -5.12620-06
   72      5.57105-04      1.46912-02       9.72597-03     -9.27258-05     -1.35391-05      8.92563-07
   73      5.57105-04      1.47015-02       9.88302-03     -9.27258-05     -1.35391-05      8.92563-07
   74      7.87585-04      1.31178-02       9.68051-03     -9.69027-05     -1.41803-05      9.76627-06
   75      7.87585-04      1.32311-02       9.84500-03     -9.69027-05     -1.41803-05      9.76627-06
   76      9.89225-04      1.17740-02       9.63030-03     -8.73222-05     -1.37350-05      1.63105-05
   77      9.89225-04      1.19632-02       9.78963-03     -8.73222-05     -1.37350-05      1.63105-05
   78      1.15272-03      1.04880-02       9.60087-03     -8.66433-05     -1.02570-05      1.67217-05
   79      1.15272-03      1.06820-02       9.71986-03     -8.66433-05     -1.02570-05      1.67217-05
   80      4.73481-04      1.78748-02       7.33771-03     -8.20024-05      1.18475-06     -7.18537-06
   81      4.73481-04      1.77914-02       7.32397-03     -8.20024-05      1.18475-06     -7.18537-06
   82      4.68809-04      1.70120-02       7.33090-03     -8.90542-05      7.62775-07     -5.07475-06
   83      4.68809-04      1.69532-02       7.32206-03     -8.90542-05      7.62775-07     -5.07475-06
   84      4.66624-04      1.60826-02       7.32460-03     -8.60799-05      9.29771-07     -2.54573-06
   85      4.66624-04      1.60531-02       7.31382-03     -8.60799-05      9.29771-07     -2.54573-06
   86      4.74967-04      1.46538-02       7.28365-03     -8.33665-05     -3.71716-07      2.09523-06
   87      4.74967-04      1.46782-02       7.28797-03     -8.33665-05     -3.71716-07      2.09523-06
   88      5.03146-04      1.30873-02       7.17235-03     -9.58895-05     -5.74722-06      8.33565-06
   89      5.03146-04      1.31840-02       7.23902-03     -9.58895-05     -5.74722-06      8.33565-06
   90      6.01069-04      1.17409-02       7.01736-03     -8.86689-05     -1.36226-05      1.31178-05
   91      6.01069-04      1.18931-02       7.17538-03     -8.86689-05     -1.36226-05      1.31178-05
   92      7.08825-04      1.04555-02       6.97248-03     -8.86859-05     -1.02667-05      1.41594-05
   93      7.08825-04      1.05327-02       7.02843-03     -8.86859-05     -1.02667-05      1.41594-05
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Table 2 (continued)

BSAP AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
MODE NUMBER 1

EIGENVECTOR IN GLOBAL (X, Y, Z) REFERENCE SYSTEM . . .

NODE NUMBER	X-DISPLACEMENT	Y-DISPLACEMENT	Z-DISPLACEMENT	X-RCTATION	Y-ROTATION	Z-ROTATION
144	-4.30475-04	1.46786-02	-4.98098-03	-9.13111-05	-2.40916-06	5.13295-06
145	-3.66718-04	1.30603-02	-4.91828-03	-1.06268-04	6.92957-07	4.53905-06
146	-3.66718-04	1.31129-02	-4.92631-03	-1.06268-04	6.92957-07	4.53905-06
147	-3.77783-04	1.16058-02	-4.78314-03	-6.74717-05	6.53103-06	1.22809-05
148	-3.77783-04	1.17482-02	-4.85890-03	-6.74717-05	6.53103-06	1.22809-05
149	-4.37273-04	1.04114-02	-4.73354-03	-6.31277-05	4.21733-06	6.77301-06
150	-4.37273-04	1.04899-02	-4.78246-03	-6.31277-05	4.21734-06	6.77301-06
151	-5.28757-04	1.78656-02	-7.66605-03	-8.30279-05	-1.03299-06	-4.67915-06
152	-5.28757-04	1.78114-02	-7.65407-03	-8.30279-05	-1.03299-06	-4.67915-06
153	-5.26575-04	1.69947-02	-7.65979-03	-8.88452-05	-8.14112-07	-2.06538-06
154	-5.26575-04	1.69707-02	-7.65035-03	-8.88452-05	-8.14112-07	-2.06538-06
155	-5.28813-04	1.60768-02	-7.65515-03	-8.51503-05	-1.15541-06	-5.97077-07
156	-5.28813-04	1.60699-02	-7.64175-03	-8.51503-05	-1.15541-06	-5.97077-07
157	-5.29784-04	1.46575-02	-7.61571-03	-8.32714-05	-1.83256-07	3.15402-06
158	-5.29784-04	1.46941-02	-7.61358-03	-8.32714-05	-1.83256-07	3.15402-06
159	-5.54021-04	1.30958-02	-7.50012-03	-9.56415-05	4.93253-06	8.86998-06
160	-5.54021-04	1.31987-02	-7.55734-03	-9.56415-05	4.93253-06	8.86998-06
161	-6.62042-04	1.17514-02	-7.34293-03	-8.90731-05	1.22719-05	1.37725-05
162	-6.62042-04	1.19112-02	-7.48525-03	-8.90731-05	1.22719-05	1.37725-05
163	-7.74477-04	1.04585-02	-7.29499-03	-8.90267-05	9.54413-06	1.54568-05
164	-7.74477-04	1.06378-02	-7.40571-03	-8.90267-05	9.54413-06	1.54568-05
165	-5.55534-04	1.04821-02	-5.88777-03	-8.55844-05	5.57747-06	9.88227-06
166	-6.15622-04	9.26400-03	-5.86645-03	-8.52020-05	3.32940-06	1.12930-05
167	-6.45350-04	8.05007-03	-5.83920-03	-8.49537-05	1.38612-06	8.63396-06
168	-6.49970-04	7.11441-03	-5.82807-03	-8.41456-05	-6.29089-07	5.93145-06
169	-3.00841-04	1.79254-02	-1.01072-02	-8.53231-05	1.11404-05	-7.79809-06
170	-3.00841-04	1.78349-02	-1.02364-02	-8.53231-05	1.11404-05	-7.79809-06
171	-4.05640-04	1.70493-02	-1.01010-02	-8.92181-05	1.15595-05	-5.51219-06
172	-4.05640-04	1.69853-02	-1.02351-02	-8.92181-05	1.15595-05	-5.51219-06
173	-5.18884-04	1.61141-02	-1.00911-02	-8.76885-05	1.20954-05	-2.61216-06
174	-5.18884-04	1.60838-02	-1.02314-02	-8.76885-05	1.20954-05	-2.61216-06
175	-7.00534-04	1.46852-02	-1.00611-02	-9.27272-05	1.30885-05	3.23360-06
176	-7.00534-04	1.47227-02	-1.02130-02	-9.27272-05	1.30885-05	3.23360-06
177	-9.18797-04	1.31161-02	-1.00142-02	-9.62381-05	1.33665-05	1.16289-05
178	-9.18797-04	1.32510-02	-1.01692-02	-9.62381-05	1.33665-05	1.16289-05
179	-1.11578-03	1.17819-02	-9.96344-03	-8.77142-05	1.26286-05	1.71687-05
180	-1.11578-03	1.19810-02	-1.01099-02	-8.77142-05	1.26286-05	1.71687-05
181	-1.26822-03	1.04927-02	-9.93481-03	-8.71433-05	9.40530-06	1.74302-05
182	-1.26822-03	1.05877-02	-9.98607-03	-8.71433-05	9.40530-06	1.74302-05
183	-1.26822-03	1.06949-02	-1.00439-02	-8.71433-05	9.40530-06	1.74302-05
184	.00000	.00000	.00000	.00000	.00000	.00000
185	.00000	.00000	.00000	.00000	.00000	.00000
186	.00000	.00000	.00000	.00000	.00000	.00000
187	.00000	.00000	.00000	.00000	.00000	.00000
188	.00000	.00000	.00000	.00000	.00000	.00000
189	.00000	.00000	.00000	.00000	.00000	.00000
190	.00000	.00000	.00000	.00000	.00000	.00000
191	.00000	.00000	.00000	.00000	.00000	.00000
192	.00000	.00000	.00000	.00000	.00000	.00000
193	.00000	.00000	.00000	.00000	.00000	.00000

Table 2 (continued)

BSAP AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
MODE NUMBER 1

EIGENVECTOR IN GLOBAL (X, Y, Z) REFERENCE SYSTEM . . .

NODE NUMBER	X-DISPLACEMENT	Y-DISPLACEMENT	Z-DISPLACEMENT	X-ROTATION	Y-ROTATION	Z-ROTATION
194	.00000	.00000	.00000	.00000	.00000	.00000
195	.00000	.00000	.00000	.00000	.00000	.00000
196	.00000	.00000	.00000	.00000	.00000	.00000
197	.00000	.00000	.00000	.00000	.00000	.00000
198	1.15272-03	1.05791-02	9.65677-03	-8.66433-05	-1.02570-05	1.67217-05
199	4.93203-04	1.04230-02	5.09978-03	-6.14742-05	-4.05202-06	4.75646-06
200	-5.06357-04	1.04483-02	-5.40043-03	-6.31277-05	4.21734-06	6.77301-06
201	-7.74477-04	1.05427-02	-7.34701-03	-8.90267-05	9.54413-06	1.54568-05
202	-5.94517-06	9.02750-03	-1.30227-04	-6.27502-05	2.34445-07	5.64405-06
203	1.22424-03	9.30096-03	9.60509-03	-8.65692-05	1.96964-07	1.68919-05
204	1.17235-03	7.99080-03	9.55333-03	-8.85224-05	6.24544-06	1.69678-05
205	1.09657-03	6.99485-03	9.51642-03	-8.96068-05	7.45548-06	1.62321-05
206	7.81486-04	3.27158-03	6.95107-03	-8.94839-05	-6.04786-07	1.40471-05
207	7.66469-04	8.01152-03	6.89941-03	-8.75890-05	2.82190-06	1.09492-05
208	7.36069-04	7.05209-03	6.87252-03	-8.60609-05	2.90029-06	8.61173-06
209	5.40962-04	9.26470-03	5.04648-03	-8.33103-05	-2.60360-06	6.06636-06
210	5.79513-04	8.08621-03	5.00583-03	-8.56625-05	-2.67393-06	6.90772-06
211	6.06637-04	7.19658-03	4.98212-03	-9.00963-05	-2.52640-06	7.42605-06
212	3.44586-04	9.20910-03	2.89206-03	-5.68323-05	6.76743-08	6.69392-06
213	3.62050-04	8.09682-03	2.80999-03	-5.52645-05	1.14161-07	7.03582-06
214	3.72045-04	7.28255-03	2.72307-03	-5.36067-05	1.53073-07	7.21496-06
215	-3.71663-04	9.20910-03	-3.18898-03	-5.68321-05	6.80681-08	6.69393-06
216	-3.90784-04	8.09682-03	-3.10332-03	-5.52645-05	1.14516-07	7.03585-06
217	-3.99961-04	7.28255-03	-3.01283-03	-5.36066-05	1.53174-07	7.21494-06
218	-5.58710-04	9.26318-03	-5.36186-03	-8.43301-05	3.16928-06	7.60329-06
219	-5.94395-04	8.07797-03	-5.33092-03	-8.58473-05	2.25609-06	7.79963-06
220	-6.11247-04	7.16052-03	-5.32372-03	-9.00670-05	1.34721-06	7.80626-06
221	-8.35709-04	9.27621-03	-7.27887-03	-8.96261-05	-7.71610-07	1.53052-05
222	-8.05545-04	8.00357-03	-7.22970-03	-8.81671-05	-4.68678-06	1.24458-05
223	-7.58273-04	7.03327-03	-7.20266-03	-8.70460-05	-5.24379-06	1.00567-05
224	-1.32688-03	9.29575-03	-9.93886-03	-8.71475-05	-1.31185-06	1.73653-05
225	-1.26049-03	7.97852-03	-9.89507-03	-8.87417-05	-7.32607-06	1.71065-05
226	-1.17344-03	6.98016-03	-9.86103-03	-8.98439-05	-8.31200-06	1.64583-05
227	-1.39584-05	7.31516-03	-1.45574-04	-5.36063-05	1.53113-07	7.21511-06
228	3.58153-05	1.67652-02	1.84435-05	-6.38712-05	-4.05269-08	8.84739-06
229	3.65592-05	1.58179-02	1.86601-05	-6.34389-05	-4.98272-08	8.02567-06
230	4.73939-05	1.58167-02	1.04295-04	-6.34382-05	-4.97915-08	8.02571-06
231	4.57446-05	1.44134-02	1.03300-04	-6.25403-05	1.37562-08	6.81798-06
232	3.29951-05	1.44368-02	-1.36971-05	-6.25393-05	1.38322-08	6.81805-06
233	3.38893-05	1.31550-02	-1.54963-05	-6.16765-05	7.57185-08	5.74460-06
234	3.59000-05	1.31542-02	6.10108-06	-6.16752-05	7.57885-08	5.74464-06
235	3.63858-05	1.27974-02	5.61157-06	-6.13383-05	9.25824-08	5.28431-06
236	3.63858-05	1.27974-02	5.61151-06	-6.13383-05	9.25692-08	5.28429-06
237	3.72951-05	1.19595-02	4.45501-06	-6.03642-05	1.35387-07	4.19674-06
238	-1.14113-05	7.78906-03	-1.40790-04	-6.11099-05	2.10530-07	5.79034-06
239	5.70005-06	5.79422-03	-1.10803-05	-5.11115-05	1.57369-07	9.16670-06
240	.00000	.00000	.00000	.00000	.00000	.00000
241	7.48771-05	1.79368-02	1.02974-02	-8.43287-05	-1.15968-05	-1.08030-05
242	7.48771-05	1.78115-02	1.04319-02	-8.43287-05	-1.15968-05	-1.08030-05
243	1.95928-04	1.69626-02	1.04321-02	-8.37474-05	-1.31677-05	-7.92841-06

Table 2 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 MODE   NUMBER    1

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
NUMBER

   244     3.32157-04       1.61209-02       1.02706-02      -8.09847-05      -1.41976-05      -5.04246-06
   245     3.32157-04       1.60624-02       1.04353-02      -8.09847-05      -1.41976-05      -5.04246-06
   246     5.64873-04       1.46913-02       1.02371-02      -7.73101-05      -1.65316-05       1.11418-06
   247     5.64873-04       1.47042-02       1.04289-02      -7.73101-05      -1.65316-05       1.11418-06
   248     8.49848-04       1.31184-02       1.01928-02      -7.54966-05      -1.75009-05       1.01899-05
   249     8.49848-04       1.32366-02       1.03958-02      -7.54966-05      -1.75009-05       1.01899-05
   250     1.08824-03       1.17751-02       1.01664-02      -8.60345-05      -1.47718-05       1.69291-05
   251     1.08824-03       1.19715-02       1.03377-02      -8.60345-05      -1.47718-05       1.69291-05
   252     1.25785-03       1.05820-02       1.01855-02      -8.59672-05      -1.03166-05       1.72367-05
   253     1.25785-03       1.06880-02       1.02490-02      -8.59672-05      -1.03166-05       1.72367-05
   254    -2.55949-04       1.79254-02      -1.06314-02      -8.41627-05       1.16070-05      -7.63391-06
   255    -2.55949-04       1.78369-02      -1.07660-02      -8.41627-05       1.16070-05      -7.63391-06
   256    -3.73625-04       1.69864-02      -1.07670-02      -8.40705-05       1.29432-05      -5.56681-06
   257    -5.05644-04       1.61142-02      -1.06099-02      -8.16904-05       1.37471-05      -2.50597-06
   258    -5.05644-04       1.60851-02      -1.07694-02      -8.16904-05       1.37471-05      -2.50597-06
   259    -7.23130-04       1.46852-02      -1.05786-02      -7.88394-05       1.55803-05       3.47609-06
   260    -7.23130-04       1.47255-02      -1.07594-02      -7.88394-05       1.55803-05       3.47609-06
   261    -9.90060-04       1.31162-02      -1.05339-02      -7.76357-05       1.61368-05       1.20589-05
   262    -9.90060-04       1.32561-02      -1.07211-02      -7.76357-05       1.61368-05       1.20589-05
   263    -1.21979-03       1.17831-02      -1.04963-02      -8.50634-05       1.41793-05       1.76088-05
   264    -1.21979-03       1.19873-02      -1.06608-02      -8.50634-05       1.41793-05       1.76088-05
   265    -1.37833-03       1.05915-02      -1.05204-02      -8.66635-05       9.38128-06       1.80190-05
   266    -1.37833-03       1.07024-02      -1.05781-02      -8.66635-05       9.38128-06       1.80190-05
   267     1.33050-03       9.30551-03       1.01424-02      -8.67146-05       2.01821-07       1.76122-05
   268     1.27778-03       7.99532-03       1.01045-02      -8.90801-05       6.38362-06       1.73445-05
   269     1.19874-03       6.99682-03       1.00751-02      -9.01418-05       7.65280-06       1.65902-05
   270    -1.43686-03       9.30038-03      -1.04804-02      -8.74376-05      -1.34073-06       1.81229-05
   271    -1.36793-03       7.98180-03      -1.04475-02      -8.92761-05      -7.60077-06       1.75237-05
   272    -1.27730-03       6.98010-03      -1.04212-02      -9.03809-05      -8.52328-06       1.67383-05
   273    -1.27347-05       9.03339-03      -1.39867-04      -5.68322-05       6.78785-08       6.69387-06
   274    -1.43670-05       7.91213-03      -1.43661-04      -5.52646-05       1.14335-07       7.03579-06
   275    -9.21898-06       1.02949-02      -1.48017-04      -5.76049-05      -1.02743-07       6.33352-06
   276       .00000           .00000           .00000           .00000           .00000           .00000

        SUMMARY  OF  MIN/MAX  NODAL  DISPLACEMENTS

           X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION

NODE MIN        270              37              258              103              349               1
   VALUE   -.0014368560     .0057010001     -.0107694088     -.0001068390     -.0000175009     -.0000622980

NODE MAX        257               5              245              239              262              270
   VALUE    .0013305033     .0264744839      .0104352737     -.0000511115      .0000161368      .0000181229
```
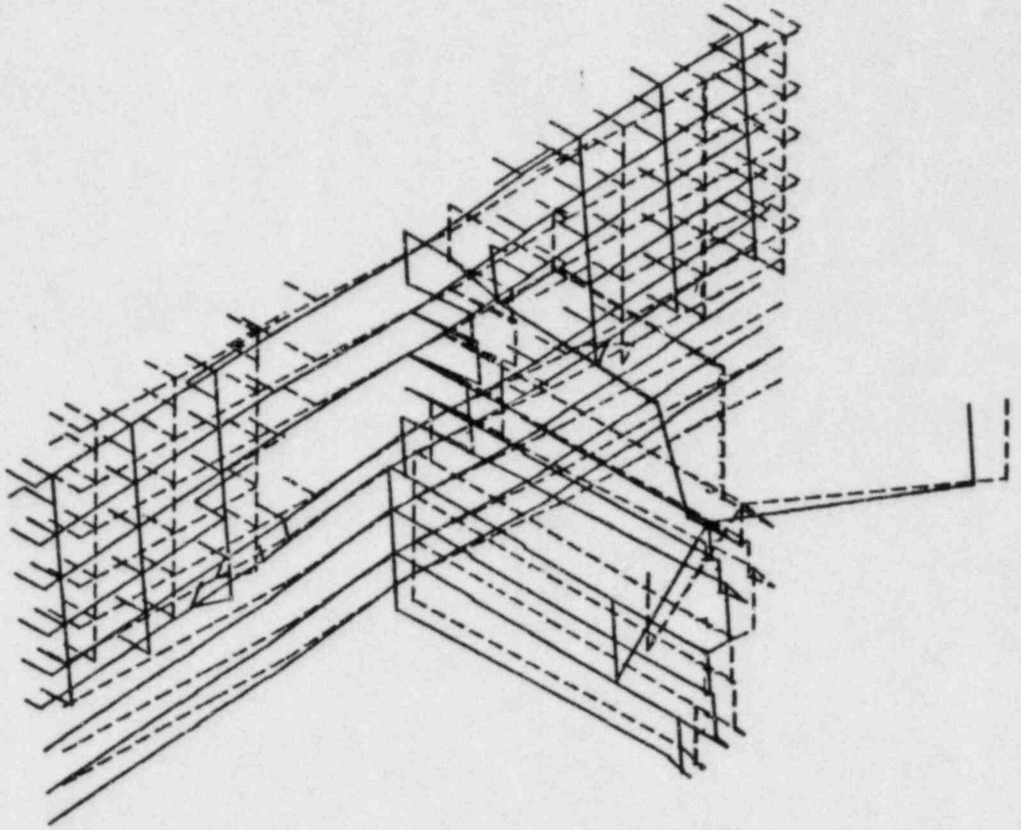
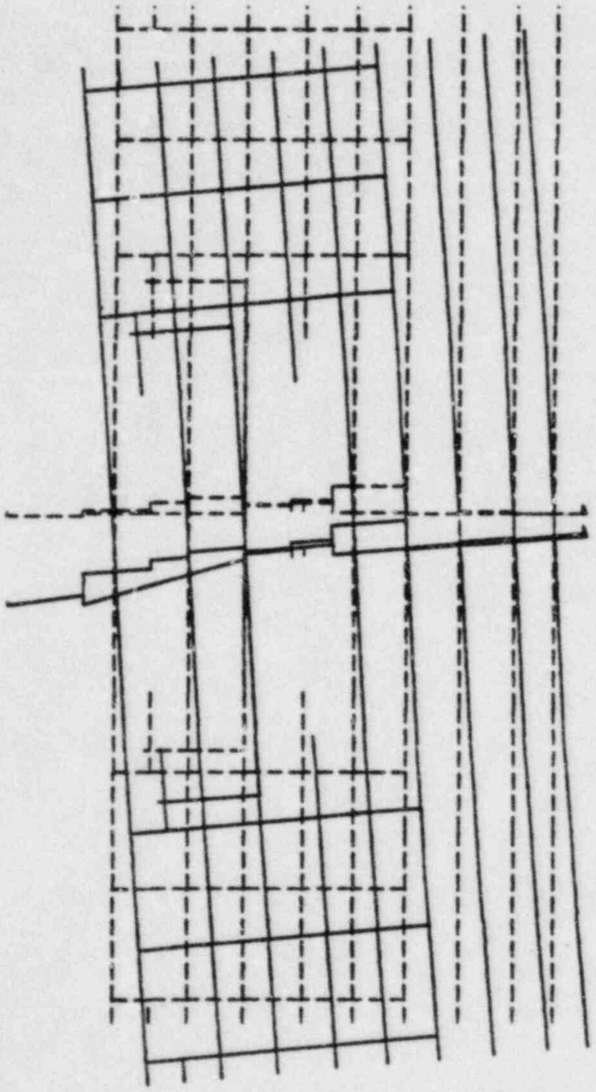

COMPUTER PLOT OF MODE NUMBER 1



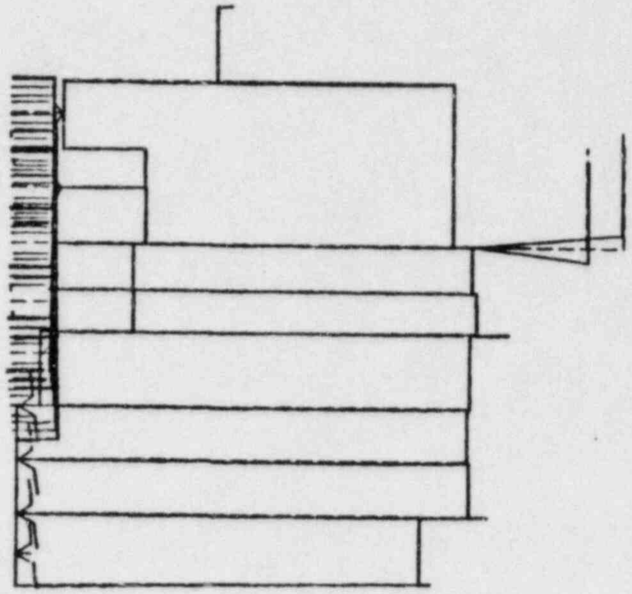
AUXILIARY BUILDING SIESMIC ANALYSIS FLEXIBLE BASE
MODE SHAPES FROM A 45 DEGREE VIEW

[illegible] 045N10 000481 PLOT SET 1 FRAME NO. 1 DISP/MODE NO 1

COMPUTER PLOT OF MODE NUMBER 1



COMPUTER PLOT OF MODE NUMBER 1



FLEX BASE MODE SHAPES VIEW FROM Y DIRECTION

POST AUX BLDG SEISMIC ANALYSIS MODE SHAPE PLOTTING

CER0086 94FF10 000881 PLOT SET 1 FRAME NO. 1 DISP/MODE NO. 1

TABLE 3

SUMMARY TABLE - MODE NUMBER 2

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 MODE  NUMBER    2
    FREQUENCY ***************************           2.91660221 CPS
    PERIOD ******************************            .34286472 SEC
    EIGENVALUE **************************          .18325552+02 RAD/SEC
    PARTICIPATION FACTOR ( X ) *********           .78185304+02
    PARTICIPATION FACTOR ( Y ) *********          -.18675554+00
    PARTICIPATION FACTOR ( Z ) *********          -.50250896+01

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
 NUMBER

     1      2.39789-02       8.90426-05      -2.11316-03      -5.32807-07       4.87243-05      -2.08773-06
     2      2.39819-02       7.82073-05      -2.36678-03      -5.32807-07       4.87243-05      -2.08774-06
     3      1.91072-02       7.08754-05      -2.36276-03      -5.40623-07       4.82519-05      -3.11840-06
     4      1.91048-02       2.00258-04      -3.60371-04      -5.40625-07       4.82518-05      -3.11840-06
     5      1.91048-02       2.75599-04       8.05393-04      -5.40625-07       4.82518-05      -3.11840-06
     6      1.68826-02       1.96364-04       8.18533-04      -5.23905-07       4.70728-05      -2.67565-06
     7      1.68826-02       1.96096-04       8.13826-04      -5.23905-07       4.70728-05      -2.67565-06
     8      1.68826-02       1.96364-04       8.18533-04      -5.23905-07       4.70728-05      -2.67565-06
     9      1.32776-02       6.79360-05       8.40296-04      -4.30418-07       4.42094-05      -1.94641-06
    10      1.32763-02       1.05949-04       1.70398-03      -4.30417-07       4.42093-05      -1.94641-06
    11      1.32733-02       7.84856-05       1.08086-03      -4.30407-07       4.42093-05      -1.94640-06
    12      1.24637-02       7.07528-05       1.06498-03      -4.25351-07       4.47617-05      -1.80289-06
    13      1.24654-02       6.81025-05       9.98776-04      -4.25344-07       4.47618-05      -1.80289-06
    14      1.24611-02       7.30244-05       1.12197-03      -4.25331-07       4.47618-05      -1.80288-06
    15      1.22150-02       7.06030-05       1.11665-03      -4.27484-07       4.48487-05      -1.71628-06
    16      1.22150-02       7.04313-05       1.11217-03      -4.27484-07       4.48487-05      -1.71628-06
    17      1.22150-02       7.06030-05       1.11665-03      -4.27484-07       4.48487-05      -1.71628-06
    18      1.16333-02       6.48599-05       1.10409-03      -4.30667-07       4.47516-05      -1.51169-06
    19      1.16309-02       7.79510-05       1.49231-03      -4.30691-07       4.47515-05      -1.51164-06
    20      1.16273-02       6.20338-05       1.02210-03      -4.30712-07       4.47514-05      -1.51155-06
    21      1.14856-02       6.05150-05       1.01882-03      -4.36582-07       4.47374-05      -1.46019-06
    22      1.14856-02       6.03690-05       1.01435-03      -4.36583-07       4.47374-05      -1.46018-06
    23      1.14856-02       6.05150-05       1.01882-03      -4.36584-07       4.47374-05      -1.46018-06
    24      1.12021-02       5.74428-05       1.01228-03      -4.47900-07       4.46893-05      -1.35746-06
    25      1.12021-02       5.73070-05       1.00781-03      -4.47901-07       4.46893-05      -1.35746-06
    26      1.12021-02       5.74428-05       1.01228-03      -4.47901-07       4.46893-05      -1.35745-06
    27      1.01775-02       4.59533-05       9.88558-04      -4.84179-07       4.42898-05      -9.85067-07
    28      1.01841-02       4.56578-05       9.71988-04      -4.84196-07       4.42892-05      -9.85032-07
    29      1.01849-02       4.52243-05       9.52133-04      -4.84217-07       4.42891-05      -9.85033-07
    30      9.09202-03       3.38985-05       9.23382-04      -4.30664-07       4.33584-05      -1.03892-06
    31      9.09175-03       3.23089-05       8.57155-04      -4.30628-07       4.33583-05      -1.03892-06
    32      9.09151-03       3.43764-05       9.43537-04      -4.30636-07       4.33582-05      -1.03892-06
    33      8.05053-03       2.47173-05       9.11036-04      -3.77525-07       4.21068-05      -1.04192-06
    34      8.05141-03       3.00624-05       1.12672-03      -3.77378-07       4.21064-05      -1.04192-06
    35      8.05104-03       1.05469-05       3.38221-04      -3.77162-07       4.21047-05      -1.04194-06
    36      6.49751-03       1.07981-06       2.67529-04      -8.13452-08       3.75447-05      -1.08704-06
    37      6.49747-03       4.33006-06       3.79790-04      -8.13251-08       3.75444-05      -1.08704-06
    38      1.91031-02       6.63223-05      -2.43249-03      -5.40625-07       4.82518-05      -3.11841-06
    39      1.86818-02      -7.59714-05      -2.22615-03      -2.07200-07       7.73708-05      -6.26690-06
    40      1.86809-02      -1.91345-04      -3.65052-03      -2.07200-07       7.73708-05      -6.26690-06
    41      1.78124-02      -1.92932-04      -3.64869-03      -2.07485-07       7.71951-05      -6.24982-06
    42      1.67889-02      -1.95739-04      -3.65225-03      -2.21518-07       7.66272-05      -6.05305-06
    43      1.56615-02      -1.91353-04      -3.65639-03      -2.36485-07       7.53325-05      -5.62847-06
```

Table 3 (continued)

BSAP AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASF
CEROOD15
MODE NUMBER 2

EIGENVECTOR IN GLOBAL (X, Y, Z) REFERENCE SYSTEM . . .

NODE NUMBER	X-DISPLACEMENT	Y-DISPLACEMENT	Z-DISPLACEMENT	X-ROTATION	Y-ROTATION	Z-ROTATION
44	1.39357-02	-1.82235-04	-3.71869-03	-2.67129-07	7.20250-05	-4.50573-06
45	1.39346-02	-8.90566-05	-2.22915-03	-2.67124-07	7.20247-05	-4.50568-06
46	1.32749-02	-6.26922-05	-2.12596-03	-4.30398-07	4.42085-05	-1.94655-06
47	1.26705-02	-1.75108-04	-3.72899-03	-2.26872-07	6.98541-05	-4.34457-06
48	1.26681-02	-7.85722-05	-2.17671-03	-2.26872-07	6.98541-05	-4.34455-06
49	1.24644-02	-6.00106-05	-2.18176-03	-4.25329-07	4.47617-05	-1.80290-06
50	1.23332-02	-6.74899-05	-2.06595-03	-2.13421-07	6.90190-05	-4.32145-06
51	1.15511-02	-1.65362-04	-3.75072-03	-1.88899-07	6.66409-05	-4.26682-06
52	1.15447-02	-6.09107-05	-2.11906-03	-1.88897-07	6.66409-05	-4.26681-06
53	1.16340-02	-4.66775-05	-2.19833-03	-4.30702-07	4.47513-05	-1.51157-06
54	1.09654-02	-1.60539-04	-3.72053-03	-2.34213-07	6.60503-05	-4.57225-06
55	9.76232-03	-1.39863-04	-4.04877-03	2.31880-07	6.29112-05	-1.24197-06
56	9.76232-03	-1.01647-04	-2.11299-03	2.31880-07	6.29111-05	-1.24197-06
57	1.01849-02	-2.48914-05	-2.20035-03	-4.84217-07	4.42888-05	-9.85060-07
58	8.73210-03	-1.33117-04	-4.01300-03	1.47611-07	5.94388-05	-6.34240-07
59	7.74824-03	-1.26058-04	-3.97254-03	7.11300-08	5.29595-05	-6.52606-07
60	6.45996-03	-1.20011-04	-3.91215-03	-7.97765-08	3.75563-05	-1.08720-06
61	1.45306-02	1.75075-04	2.97031-03	-4.52741-07	4.46304-05	-1.97343-06
62	1.31530-02	1.60209-04	2.96382-03	-4.30360-07	4.42096-05	-1.94618-06
63	1.47996-02	1.54502-04	2.46490-03	-4.50070-07	4.48802-05	-1.97305-06
64	1.41475-02	1.47928-04	2.46330-03	-4.46422-07	4.47556-05	-1.96469-06
65	1.34046-02	1.40483-04	2.45990-03	-4.30435-07	4.42095-05	-1.94660-06
66	2.64665-02	-1.37574-03	-2.54453-03	-3.50364-06	1.67357-04	1.46277-04
67	2.64665-02	3.21072-04	-4.48587-03	-3.50364-06	1.67357-04	1.46277-04
68	2.48345-02	-1.36174-03	-2.53862-03	8.19980-06	1.68834-04	1.39925-04
69	2.48345-02	2.61391-04	-4.49710-03	8.19980-06	1.68834-04	1.39925-04
70	2.30709-02	-1.26652-03	-2.52989-03	1.37833-06	1.71238-04	1.29326-04
71	2.30709-02	2.33664-04	-4.51625-03	1.37833-06	1.71238-04	1.29326-04
72	2.04126-02	-1.18347-03	-2.53002-03	4.57782-06	1.73697-04	1.17319-04
73	2.04126-02	1.77428-04	-4.54491-03	4.57782-06	1.73697-04	1.17319-04
74	1.75093-02	-9.62457-04	-2.56960-03	1.99876-05	1.72156-04	9.48973-05
75	1.75093-02	1.38351-04	-4.56661-03	1.99876-05	1.72156-04	9.48973-05
76	1.50327-02	-6.62413-04	-2.65377-03	4.49127-06	1.65082-04	7.10435-05
77	1.50327-02	1.61692-04	-4.56872-03	4.49127-06	1.65082-04	7.10435-05
78	1.26283-02	-5.17437-04	-2.71304-03	2.20848-06	1.57184-04	6.16781-05
79	1.26283-02	1.98030-04	-4.53637-03	2.20848-06	1.57184-04	6.16781-05
80	2.17132-02	-1.08136-03	-2.88347-03	-7.95892-06	1.39730-04	1.13339-04
81	2.17132-02	2.33374-04	-4.50434-03	-7.95892-06	1.39730-04	1.13339-04
82	2.03736-02	-1.07895-03	-2.86959-03	8.08621-06	1.42461-04	1.07167-04
83	2.03736-02	1.64193-04	-4.52214-03	8.08621-06	1.42461-04	1.07167-04
84	1.89309-02	-9.89808-04	-2.85378-03	1.43265-06	1.44626-04	9.75475-05
85	1.89309-02	1.41742-04	-4.53144-03	1.43265-06	1.44626-04	9.75475-05
86	1.68102-02	-8.65656-04	-2.84613-03	-9.79543-06	1.45504-04	8.31920-05
87	1.68102-02	9.93721-05	-4.53398-03	-9.79543-06	1.45504-04	8.31920-05
88	1.46131-02	-7.79314-04	-2.88950-03	1.15687-05	1.40837-04	7.25043-05
89	1.46131-02	6.17353-05	-4.52322-03	1.15687-05	1.40837-04	7.25043-05
90	1.27106-02	-5.63147-04	-2.96278-03	4.54031-06	1.32466-04	5.72976-05
91	1.27106-02	1.01505-04	-4.49938-03	4.54031-06	1.32466-04	5.72976-05
92	1.08230-02	-4.51801-04	-3.00386-03	2.94810-06	1.25547-04	5.11078-05
93	1.08230-02	-1.73263-04	-3.68809-03	2.94809-06	1.25547-04	5.11078-05

Table 3 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CEBOCD15
 M O D E   N U M B E R    2

E I G E N V E C T O R   I N   G L O B A L  ( X , Y , Z )  R E F E R E N C E   S Y S T E M . . .

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION      Z-ROTATION
NUMBER

    94      1.08230-02       1.41050-04      -4.46020-03      2.94809-06      1.25547-04      5.11078-05
    95      1.81306-02      -3.58078-04      -3.23087-03     -1.88722-06      1.15449-04      2.29666-05
    96      1.81306-02      -9.16661-05      -4.57008-03     -1.88722-06      1.15449-04      2.29666-05
    97      1.70232-02      -3.47969-04      -3.22984-03     -1.14162-06      1.16306-04      2.15606-05
    98      1.70232-02      -9.78663-05      -4.57899-03     -1.14162-06      1.16306-04      2.15606-05
    99      1.58224-02      -3.51094-04      -3.25014-03      2.63877-06      1.13442-04      2.03751-05
   100      1.58224-02      -1.14742-04      -4.57207-03      2.63877-06      1.13442-04      2.03751-05
   101      1.41001-02      -2.73870-04      -3.27788-03      1.12882-06      1.08452-04      1.24398-05
   102      1.41001-02      -1.29568-04      -4.53592-03      1.12882-06      1.08452-04      1.24398-05
   103      1.24206-02      -5.11555-04      -3.29820-03      1.52883-06      1.00677-04      3.41311-05
   104      1.24206-02      -1.15634-04      -4.46606-03      1.52883-06      1.00677-04      3.41311-05
   105      1.10546-02      -2.20580-04      -3.34955-03     -6.04616-06      8.99155-05      1.12566-05
   106      1.10546-02      -9.00037-05      -4.39257-03     -6.04616-06      8.99155-05      1.12566-05
   107      9.75812-03      -2.34094-04      -3.36277-03     -7.53120-06      8.39762-05      1.34682-05
   108      9.75812-03      -7.78624-05      -4.33689-03     -7.53121-06      8.39762-05      1.34682-05
   109      1.00471-02      -1.60900-04      -3.71679-03     -4.19424-06      9.54108-05      2.94769-05
   110      8.69910-03      -1.57129-04      -3.71056-03     -3.00151-06      8.74723-05      9.72693-06
   111      7.36173-03      -1.56632-04      -3.69372-03     -3.14931-06      8.83386-05     -1.96909-05
   112      6.38422-03      -1.64972-04      -3.67619-03     -3.46066-06      8.59750-05     -4.13103-05
   113      1.75116-02      -2.07869-04      -3.82320-03     -2.07516-07      7.71951-05     -6.24968-06
   114      1.75116-02      -2.80365-04      -4.71866-03     -2.07516-07      7.71951-05     -6.24968-06
   115      1.64868-02      -2.06739-04      -4.67861-03     -6.13053-06      1.25763-04      5.24230-06
   116      1.53951-02      -2.02385-04      -3.79285-03     -2.36516-07      7.53325-05     -5.62838-06
   117      1.53951-02      -2.67674-04      -4.66670-03     -2.36516-07      7.53325-05     -5.62838-06
   118      1.37188-02      -1.82775-04      -3.71447-03     -2.67154-07      7.20250-05     -4.50551-06
   119      1.37188-02      -2.35039-04      -4.54996-03     -2.67154-07      7.20250-05     -4.50551-06
   120      1.21071-02      -1.45083-04      -4.37476-03      5.37653-06      1.19636-04     -4.65126-06
   121      1.07423-02      -1.43713-04      -3.46604-03     -2.34296-07      6.60504-05     -4.57244-06
   122      1.07423-02      -1.96753-04      -4.23222-03     -2.34296-07      6.60504-05     -4.57244-06
   123      9.70146-03      -1.34249-04      -3.77577-03      2.32070-07      6.29120-05     -1.24208-06
   124      9.70146-03      -1.41887-04      -4.16268-03      2.32070-07      6.29120-05     -1.24207-06
   125      1.81241-02      -2.07869-04      -3.84353-03     -2.07450-07      7.71951-05     -6.24999-06
   126      1.81241-02      -2.80369-04      -4.73899-03     -2.07450-07      7.71951-05     -6.24999-06
   127      1.70107-02      -3.39939-04      -4.71708-03      7.44217-06      1.12456-04     -1.07111-05
   128      1.59467-02      -2.02385-04      -3.81602-03     -2.36452-07      7.53324-05     -5.62857-06
   129      1.59467-02      -2.67676-04      -4.68988-03     -2.36452-07      7.53325-05     -5.62857-06
   130      1.41604-02      -1.82775-04      -3.74065-03     -2.67108-07      7.20250-05     -4.50599-06
   131      1.41604-02      -2.35045-04      -4.57614-03     -2.67108-07      7.20250-05     -4.50599-06
   132      1.24376-02      -2.89539-04      -4.43401-03     -2.26174-06      1.07538-04     -3.93063-06
   133      1.11904-02      -1.43714-04      -3.48900-03     -2.34260-07      6.60504-05     -4.57230-06
   134      1.11904-02      -1.96752-04      -4.25518-03     -2.34260-07      6.60504-05     -4.57230-06
   135      9.82875-03      -1.34250-04      -3.75200-03      2.31863-07      6.29116-05     -1.24170-06
   136      9.82317-03      -1.41886-04      -4.13995-03      2.31863-07      6.29116-05     -1.24170-06
   137      1.91820-02      -2.36576-05      -3.28669-03      5.94704-06      1.09736-04     -4.00562-05
   138      1.91820-02      -4.88309-04      -4.55963-03      5.94704-06      1.09735-04     -4.00562-05
   139      1.80078-02       1.22516-05      -3.28749-03      5.33561-06      1.10283-04     -4.09358-05
   140      1.80078-02      -4.62604-04      -4.56678-03      5.33561-06      1.10283-04     -4.09358-05
   141      1.67707-02      -3.08223-05      -3.28188-03     -1.08050-06      1.10516-04     -3.30677-05
   142      1.67707-02      -4.14408-04      -4.56387-03     -1.08050-06      1.10516-04     -3.30677-05
   143      1.48927-02      -8.27236-05      -3.28944-03     -5.24497-07      1.07257-04     -2.38819-05
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Table 3 (continued)

BSAP AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CEBOOD15
MODE NUMBER 2

EIGENVECTOR IN GLOBAL (X, Y, Z) REFERENCE SYSTEM ...

NODE NUMBER	X-DISPLACEMENT	Y-DISPLACEMENT	Z-DISPLACEMENT	X-ROTATION	Y-ROTATION	Z-ROTATION
144	1.48927-02	-3.59754-04	-4.53362-03	-5.24497-07	1.07257-04	-2.38819-05
145	1.30813-02	2.43122-04	-3.30136-03	1.46576-07	1.00448-04	-4.90202-05
146	1.30313-02	-3.25513-04	-4.46655-03	1.46576-07	1.00448-04	-4.90202-05
147	1.16511-02	-8.99223-05	-3.28611-03	9.75828-06	9.80258-05	-1.88477-05
148	1.16511-02	-3.08556-04	-4.42321-03	9.75828-06	9.80258-05	-1.88477-05
149	1.01283-02	-2.12817-05	-3 29349-03	1.12312-05	9.46059-05	-2.38587-05
150	1.01283-02	-2.98043-04	-4.39092-03	1.12312-05	9.46059-05	-2.38587-05
151	2.35497-02	7.67545-04	-2.91679-03	1.08036-05	1.31072-04	-1.37894-04
152	2.35497-02	-8.32029-04	-4.43723-03	1.08036-05	1.31072-04	-1.37894-04
153	2.21268-02	7.77496-04	-2.89913-03	-7.84744-06	1.33619-04	-1.30744-04
154	2.21268-02	-7.39130-04	-4.44910-03	-7.84744-06	1.33619-04	-1.30744-04
155	2.05997-02	6.99028-04	-2.88079-03	1.54592-06	1.36164-04	-1.20105-04
156	2.05997-02	-6.94192-04	-4.46029-03	1.54592-06	1.36164-04	-1.20105-04
157	1.82481-02	5.99859-04	-2.86218-03	1.07586-05	1.38132-04	-1.04805-04
158	1.82481-02	-6.15877-04	-4.46451-03	1.07586-05	1.38132-04	-1.04805-04
159	1.58328-02	5.16674-04	-2.80446-03	-1.25909-05	1.42414-04	-9.09427-05
160	1.58328-02	-5.38262-04	-4.45646-03	-1.25909-05	1.42414-04	-9.09427-05
161	1.37122-02	2.76626-04	-2.81000-03	-1.42486-06	1.41121-04	-7.10537-05
162	1.37122-02	-5.47597-04	-4.44700-03	-1.42486-06	1.41121-04	-7.10537-05
163	1.15765-02	2.11937-04	-2.83720-03	1.26389-07	1.36597-04	-6.59234-05
164	1.15765-02	-5.52774-04	-4.42172-03	1.26390-07	1.36597-04	-6.59234-05
165	1.05955-02	-1.52279-04	-3.65153-03	6.78347-06	1.05989-04	-4.15933-05
166	9.06017-03	-1.21789-04	-3.64642-03	5.63193-06	9.62619-05	-1.90596-05
167	7.64637-03	-9.08712-05	-3.62989-03	5.63007-06	9.24896-05	1.50370-05
168	6.67105-03	-5.63084-05	-3.61089-03	5.75128-06	8.85238-05	4.72297-05
169	2.93791-02	1.08207-03	-2.26633-03	1.08508-05	1.80031-04	-1.72832-04
170	2.93791-02	-9.22782-04	-4.35469-03	1.08508-05	1.80031-04	-1.72832-04
171	2.75783-02	1.12045-03	-2.25561-03	-6.10477-06	1.82206-04	-1.68891-04
172	2.75783-02	-8.38693-04	-4.36920-03	-6.10477-06	1.82206-04	-1.68891-04
173	2.56269-02	1.03168-03	-2.24157-03	6.55429-07	1.85331-04	-1.57199-04
174	2.56269-02	-7.91832-04	-4.39141-03	6.55429-07	1.85331-04	-1.57199-04
175	2.26629-02	9.64642-04	-2.23657-03	-4.63757-06	1.88459-04	-1.43758-04
176	2.26629-02	-7.02947-04	-4.42269-03	-4.63757-06	1.88459-04	-1.43758-04
177	1.94191-02	7.01425-04	-2.27139-03	-2.26321-05	1.88121-04	-1.14937-04
178	1.94191-02	-6.31839-04	-4.45359-03	-2.26321-05	1.88121-04	-1.14937-04
179	1.66513-02	3.89767-04	-2.36724-03	-8.80318-07	1.80132-04	-8.77232-05
180	1.66513-02	-6.27822-04	-4.45678-03	-8.80318-07	1.80132-04	-8.77232-05
181	1.40039-02	3.05161-04	-2.43523-03	1.11239-06	1.71564-04	-8.08247-05
182	1.40039-02	-1.35333-04	-3.37025-03	1.11239-06	1.71564-04	-8.08247-05
183	1.40039-02	-6.32405-04	-4.42537-03	1.11239-06	1.71564-04	-8.08247-05
184	.00000	.00000	.00000	.00000	.00000	.00000
185	.00000	.00000	.00000	.00000	.00000	.00000
186	.00000	.00000	.00000	.00000	.00000	.00000
187	.00000	.00000	.00000	.00000	.00000	.00000
188	.00000	.00000	.00000	.00000	.00000	.00000
189	.00000	.00000	.00000	.00000	.00000	.00000
190	.00000	.00000	.00000	.00000	.00000	.00000
191	.00000	.00000	.00000	.00000	.00000	.00000
192	.00000	.00000	.00000	.00000	.00000	.00000
193	.00000	.00000	.00000	.00000	.00000	.00000

Table 3 (continued)

BSAP AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CEBOOD15
MODE NUMBER 2

EIGENVECTOR IN GLOBAL (X, Y, Z) REFERENCE SYSTEM . . .

NODE NUMBER	X-DISPLACEMENT	Y-DISPLACEMENT	Z-DISPLACEMENT	X-ROTATION	Y-ROTATION	Z-ROTATION
194	.00000	.00000	.00000	.00000	.00000	.00000
195	.00000	.00000	.00000	.00000	.00000	.00000
196	.00000	.00000	.00000	.00000	.00000	.00000
197	.00000	.00000	.00000	.00000	.00000	.00000
198	1.26283-02	-1.81291-04	-3.56969-03	2.20848-06	1.57184-04	6.16781-05
199	9.89550-03	-1.60692-04	-3.74362-03	-7.53121-06	8.39762-05	1.34682-05
200	1.03717-02	-1.51312-04	-3.69454-03	1.12312-05	9.46059-05	-2.38587-05
201	1.15765-02	-1.47345-04	-3.58165-03	1.26390-07	1.36597-04	-6.59234-05
202	9.09180-03	-4.00521-05	-2.16278-03	-4.30635-07	4.33580-05	-1.03893-06
203	1.01312-02	-1.87984-04	-3.57128-03	-1.36621-06	1.75766-04	5.23193-05
204	7.44452-03	-2.01203-04	-3.56088-03	-1.49571-06	1.82929-04	4.00888-05
205	5.46918-03	-2.15222-04	-3.54748-03	-1.35486-06	1.77597-04	2.67956-05
206	8.97316-03	-1.70928-04	-3.66834-03	-3.03979-06	1.29847-04	2.17572-05
207	7.04686-03	-1.77963-04	-3.64740-03	-3.04405-06	1.32490-04	-1.30362-05
208	5.66796-03	-1.92368-04	-3.62961-03	-2.93198-06	1.16408-04	-3.60052-05
209	8.67175-03	-1.50999-04	-3.72894-03	-2.78195-06	7.93241-05	3.31314-06
210	7.45752-03	-1.47127-04	-3.71231-03	-2.77117-06	8.10032-05	-8.37504-06
211	6.58303-03	-1.50439-04	-3.69778-03	-2.69040-06	7.72568-05	-1.80102-05
212	8.69817-03	-1.30249-04	-3.75223-03	1.47670-07	5.94398-05	-6.34484-07
213	7.71331-03	-1.23107-04	-3.73697-03	7.11893-08	5.29605-05	-6.52888-07
214	7.05672-03	-1.17927-04	-3.72995-03	2.30567-09	4.63405-05	-8.74036-07
215	8.76603-03	-1.30251-04	-3.73644-03	1.47548-07	5.94396-05	-6.33980-07
216	7.78314-03	-1.23109-04	-3.72936-03	7.10658-08	5.29605-05	-6.52259-07
217	7.15034-03	-1.17921-04	-3.72970-03	2.35341-09	4.63405-05	-8.75765-07
218	8.97695-03	-1.25705-04	-3.68012-03	5.13864-06	8.90758-05	-7.03259-06
219	7.70569-03	-1.02230-04	-3.66288-03	5.09603-06	8.16181-05	7.35448-06
220	6.86915-03	-7.50123-05	-3.64559-03	5.13770-06	7.26959-05	1.68617-05
221	9.51134-03	-1.06856-04	-3.56183-03	5.88352-06	1.41960-04	-3.75133-05
222	7.42809-03	-6.37811-05	-3.54079-03	5.91915-06	1.43725-04	4.11903-06
223	5.95041-03	-2.09782-05	-3.52206-03	5.80114-06	1.31163-04	3.17073-05
224	1.12826-02	-9.33219-05	-3.37411-03	4.00823-06	1.92057-04	-6.96820-05
225	8.36214-03	-4.13264-05	-3.36482-03	4.27054-06	1.97370-04	-5.65346-05
226	6.23735-03	3.19007-06	-3.35217-03	4.09695-06	1.88878-04	-4.20764-05
227	7.10350-03	-1.21879-04	-3.93929-03	2.32217-09	4.63399-05	-8.74897-07
228	1.67759-02	-5.95455-05	-1.92767-03	-2.21544-07	7.66271-05	-6.05302-06
229	1.56539-02	-6.22918-05	-1.92869-03	-2.36456-07	7.53327-05	-5.62850-06
230	1.56463-02	-6.15049-05	-1.91783-03	-2.36536-07	7.53322-05	-5.62841-06
231	1.39199-02	-6.99962-05	-1.92360-03	-2.67022-07	7.20255-05	-4.50579-06
232	1.39283-02	-8.54515-05	-2.17115-03	-2.67122-07	7.20250-05	-4.50573-06
233	1.26627-02	-7.50965-05	-2.12054-03	-2.26856-07	6.98543-05	-4.34457-06
234	1.26612-02	-7.44446-05	-2.10998-03	-2.26884-07	6.98540-05	-4.34457-06
235	1.23240-02	-6.92617-05	-2.09379-03	-2.13428-07	6.90190-05	-4.32145-06
236	1.23240-02	-6.92617-05	-2.09379-03	-2.13414-07	6.90189-05	-4.32145-06
237	1.15398-02	-5.68573-05	-2.05554-03	-1.88846-07	6.66412-05	-4.26681-06
238	8.05104-03	-4.99273-05	-2.10553-03	-3.77162-07	4.21046-05	-1.04194-06
239	6.49500-03	-6.72509-06	-1.84486-06	-8.08280-08	3.75429-05	-1.08702-06
240	.00000	.00000	.00000	.00000	.00000	.00000
241	2.73762-02	-1.37632-03	-2.52255-03	-3.56510-06	1.67369-04	1.46284-04
242	2.73762-02	3.20578-04	-4.46403-03	-3.56510-06	1.67369-04	1.46284-04
243	2.57032-02	2.65854-04	-4.47506-03	-9.45324-06	1.73719-04	1.38217-04

Table 3 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CEBOOD15
 MODE  NUMBER  2

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION      Z-ROTATION
NUMBER

   244      2.38786-02      -1.26715-03      -2.45781-03     -1.81280-05      1.75878-04      1.29590-04
   245      2.38786-02       2.36096-04      -4.49799-03     -1.81280-05      1.75878-04      1.29590-04
   246      2.11339-02      -1.18316-03      -2.42431-03     -2.78651-05      1.81334-04      1.17583-04
   247      2.11339-02       1.80801-04      -4.52778-03     -2.78651-05      1.81334-04      1.17583-04
   248      1.80846-02      -9.61852-04      -2.43504-03     -4.25494-05      1.83258-04      9.50753-05
   249      1.80846-02       1.41022-04      -4.56084-03     -4.25494-05      1.83258-04      9.50753-05
   250      1.54722-02      -6.63604-04      -2.58404-03     -1.91170-05      1.71671-04      7.10399-05
   251      1.54722-02       1.60459-04      -4.57543-03     -1.91170-05      1.71671-04      7.10399-05
   252      1.30042-02      -1.82487-04      -3.57340-03      1.40719-06      1.58913-04      6.15055-05
   253      1.30042-02       1.95772-04      -4.55071-03      1.40719-06      1.58913-04      6.15055-05
   254      3.04496-02       1.08267-03      -2.20427-03      9.58947-06      1.82247-04     -1.72833-04
   255      3.04496-02      -9.22201-04      -4.31834-03      9.58947-06      1.82247-04     -1.72833-04
   256      2.85166-02      -8.43657-04      -4.33548-03      1.12121-05      1.86446-04     -1.66569-04
   257      2.66100-02       1.03267-03      -2.15245-03      2.12357-05      1.90325-04     -1.57538-04
   258      2.66100-02      -7.94767-04      -4.36021-03      2.12357-05      1.90325-04     -1.57538-04
   259      2.35572-02       9.64182-04      -2.12175-03      3.00975-05      1.95892-04     -1.43972-04
   260      2.35572-02      -7.05895-04      -4.39410-03      3.00975-05      1.95892-04     -1.43972-04
   261      2.01485-02       6.99488-04      -2.11791-03      4.84466-05      1.99789-04     -1.15012-04
   262      2.01485-02      -6.34655-04      -4.43546-03      4.84466-05      1.99789-04     -1.15012-04
   263      1.72229-02       3.88696-04      -2.24239-03      3.06451-05      1.90343-04     -8.75061-05
   264      1.72229-02      -6.26375-04      -4.45037-03      3.06451-05      1.90343-04     -8.75061-05
   265      1.44971-02      -1.35551-04      -3.35759-03      1.57489-06      1.73870-04     -8.06876-05
   266      1.44971-02      -6.31779-04      -4.42689-03      1.57489-06      1.73870-04     -8.06876-05
   267      1.04555-02      -1.88132-04      -3.56602-03     -5.89993-07      1.80312-04      5.30716-05
   268      7.69100-03      -2.02587-04      -3.55372-03     -9.85286-07      1.88394-04      3.98201-05
   269      5.65207-03      -2.16316-04      -3.54084-03     -1.05387-06      1.81726-04      2.92329-05
   270      1.17154-02      -9.25357-05      -3.35316-03      3.06507-06      1.96833-04     -7.05234-05
   271      8.71037-03      -3.95392-05      -3.34080-03      3.67808-06      2.03778-04     -5.65977-05
   272      6.51195-03       4.15905-06      -3.32875-03      3.75869-06      1.93807-04     -4.38477-05
   273      8.73203-03      -1.13601-04      -2.18407-03      1.47611-07      5.94387-05     -6.34253-07
   274      7.74824-03      -1.05977-04      -2.34298-03      7.11300-08      5.29594-05     -6.52620-07
   275      9.76206-03      -1.32051-04      -3.65310-03      2.31826-07      6.29112-05     -1.24202-06
   276          .00000           .00000           .00000          .00000          .00000          .00000

      SUMMARY  OF  MIN/MAX  NODAL  DISPLACEMENTS

           X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION      Z-ROTATION

NODE MIN       205              241              126              249             239             255
   VALUE   .0054691828     -.0013763202     -.0047389926     -.0000425494     .0000375429    -.0001728334

NODE MAX       254              171               61              261             271             242
   VALUE   .0304496427      .0011204463      .0029703120      .0000484466     .0002037776     .0001462843
```
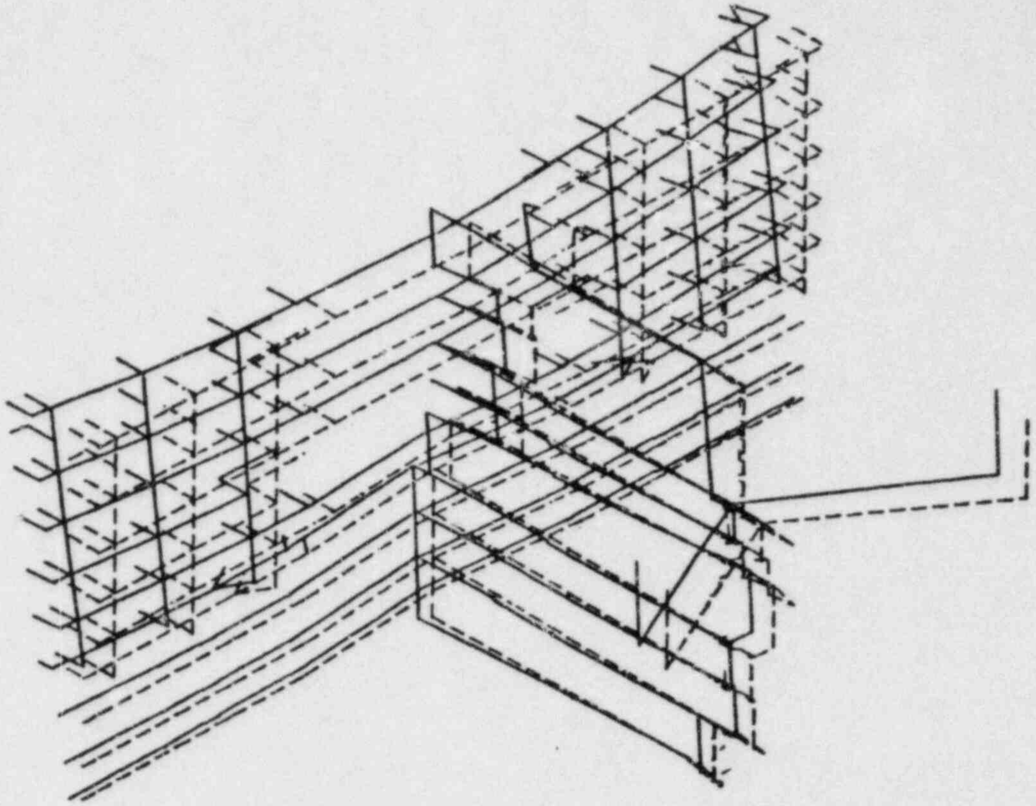
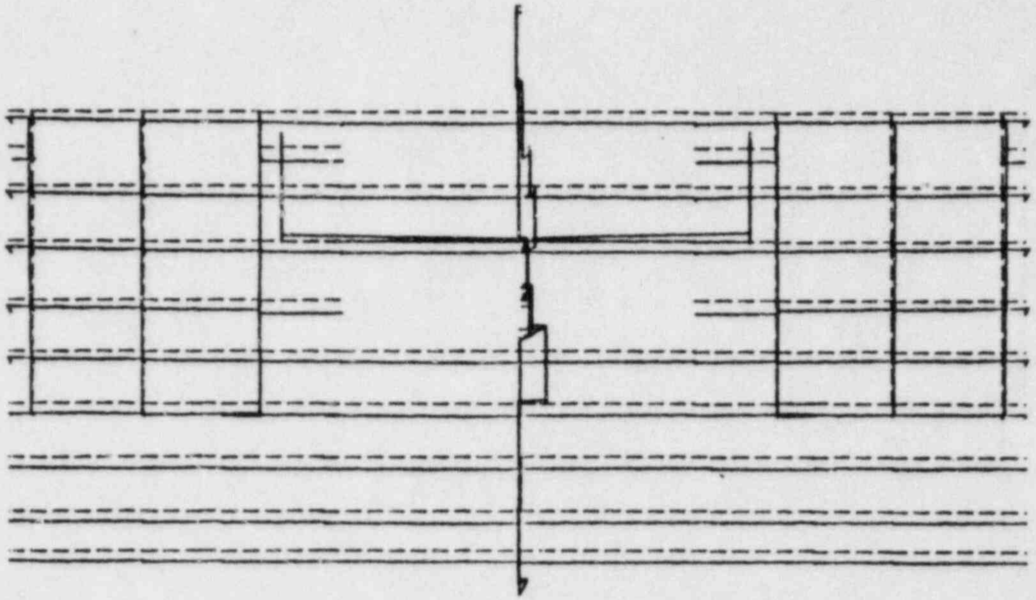

COMPUTER PLOT OF MODE NUMBER 2



AUXILIARY BUILDING SIESMIC ANALYSIS FLEXIBLE BASE
MODE SHAPES FROM A 45 DEGREE VIEW

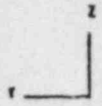
[illegible] 045N19 090481 PLOT SET 1 FRAME NO. 2 DISP/MODE NO. 2

COMPUTER PLOT OF MODE NUMBER 2



FLEX BASE MODE SHAPES VIEW FROM X DIRECTION

POST AUX BLDG SEISMIC ANALYSIS MODE SHAPE PLOTTING



[illegible] 046F36 090881 PLOT SET 1 FRAME NO. 2 DISP/MODE NO. 2

COMPUTER PLOT OF MODE NUMBER 2

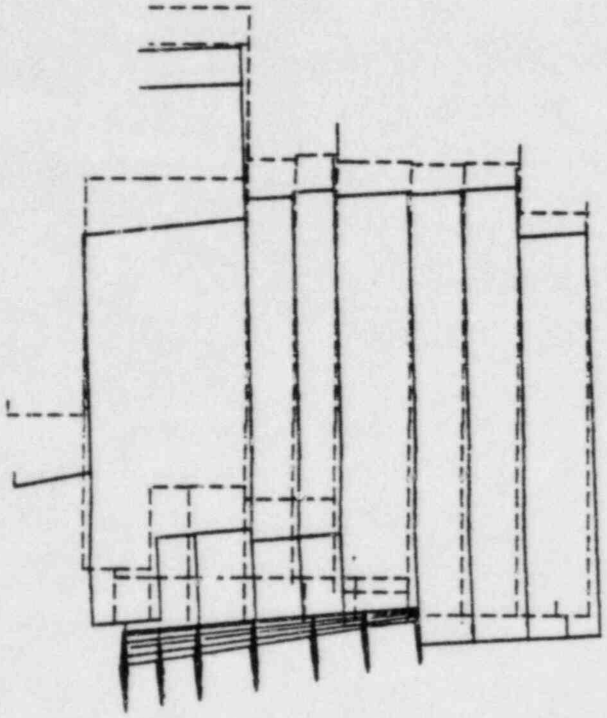


TABLE 4

SUMMARY TABLE - MODE NUMBER 5

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 M O D E   N U M B E R    5
     FREQUENCY **************************            4.18062764 CPS
     PERIOD *****************************             .23919853 SEC
     EIGENVALUE *************************           .26267658+02 RAD/SEC
     PARTICIPATION FACTOR ( X ) *********          -.93165681+01
     PARTICIPATION FACTOR ( Y ) *********          -.60726168+00
     PARTICIPATION FACTOR ( Z ) *********          -.78118798+02

E I G E N V E C T O R   I N   G L O B A L  ( X . Y . Z )  R E F E R E N C E   S Y S T E M . . .

  NODE    X-DISPLACEMENT    Y-DISPLACEMENT    Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
 NUMBER

     1      -1.95268-03      -1.32096-04      -1.37014-02      6.33583-07      1.96533-05      7.60456-06
     2      -1.96325-03      -9.26284-05      -1.38025-02      6.33583-07      1.96533-05      7.60456-06
     3      -1.73136-03      -6.74052-05      -1.37490-02      4.04389-07      2.00250-05      6.95189-06
     4      -1.72600-03      -3.55839-04      -1.29184-02      4.04380-07      2.00249-05      6.95189-06
     5      -1.72600-03      -5.23797-04      -1.24346-02      4.04377-07      2.00248-05      6.95189-06
     6      -1.81557-03      -3.95904-04      -1.19774-02      3.13743-07      1.46199-05      5.29620-06
     7      -1.81557-03      -3.95374-04      -1.19788-02      3.13743-07      1.46199-05      5.29620-06
     8      -1.81557-03      -3.95904-04      -1.19774-02      3.13743-07      1.46199-05      5.29620-06
     9      -1.76443-03      -1.91327-04      -1.12259-02      5.00934-08      5.85138-06      2.56918-06
    10      -1.76279-03      -2.41504-04      -1.11117-02      5.00790-08      5.85117-06      2.56917-06
    11      -1.75876-03      -2.05253-04      -1.11943-02      5.01174-08      5.85104-06      2.56916-06
    12      -1.80885-03      -2.02572-04      -1.11572-02      4.40962-08      5.73281-06      2.45677-06
    13      -1.81116-03      -1.98961-04      -1.11656-02      4.40920-08      5.73280-06      2.45677-06
    14      -1.80541-03      -2.05668-04      -1.11500-02      4.40895-08      5.73279-06      2.45676-06
    15      -1.81137-03      -2.04485-04      -1.11330-02      5.80305-08      5.65014-06      2.40609-06
    16      -1.81137-03      -2.04244-04      -1.11336-02      5.80310-08      5.65014-06      2.40609-06
    17      -1.81137-03      -2.04485-04      -1.11330-02      5.80316-08      5.65014-06      2.40609-06
    18      -1.82448-03      -2.01509-04      -1.10928-02      8.89765-08      5.49883-06      2.28637-06
    19      -1.82089-03      -2.21309-04      -1.10453-02      8.90272-08      5.49874-06      2.28635-06
    20      -1.81550-03      -1.97234-04      -1.11034-02      8.92414-08      5.49867-06      2.28630-06
    21      -1.81728-03      -1.96125-04      -1.10900-02      1.14457-07      5.51498-06      2.26420-06
    22      -1.81728-03      -1.95899-04      -1.10906-02      1.14460-07      5.51498-06      2.26420-06
    23      -1.81728-03      -1.96125-04      -1.10900-02      1.14462-07      5.51499-06      2.26420-06
    24      -1.82094-03      -1.93759-04      -1.10632-02      1.64304-07      5.55116-06      2.21998-06
    25      -1.82094-03      -1.93537-04      -1.10638-02      1.64306-07      5.55116-06      2.21998-06
    26      -1.82094-03      -1.93759-04      -1.10632-02      1.64309-07      5.55117-06      2.21998-06
    27      -1.83565-03      -1.83546-04      -1.09661-02      3.38398-07      5.72205-06      2.05970-06
    28      -1.84961-03      -1.82929-04      -1.09655-02      3.38414-07      5.72230-06      2.05967-06
    29      -1.85118-03      -1.82022-04      -1.09678-02      3.38413-07      5.72232-06      2.05967-06
    30      -1.85713-03      -1.70245-04      -1.08357-02      1.55936-07      6.05943-06      1.94234-06
    31      -1.85663-03      -1.67273-04      -1.08450-02      1.55889-07      6.05947-06      1.94234-06
    32      -1.85618-03      -1.71138-04      -1.08330-02      1.55851-07      6.05952-06      1.94233-06
    33      -1.87295-03      -1.60480-04      -1.06766-02     -9.02062-09      6.39928-06      1.80965-06
    34      -1.87449-03      -1.69763-04      -1.06437-02     -9.17745-09      6.39936-06      1.80964-06
    35      -1.87384-03      -1.35870-04      -1.07636-02     -9.75750-09      6.40021-06      1.80956-06
    36      -1.85395-03      -1.23583-04      -1.04007-02     -9.72584-07      1.01517-05      1.29620-06
    37      -1.85390-03      -1.27459-04      -1.03703-02     -9.72669-07      1.01520-05      1.29619-06
    38      -1.72225-03      -5.72552-05      -1.37787-02      4.04377-07      2.00248-05      6.95190-06
    39      -1.64119-03       1.49976-04      -1.22457-02     -2.09246-06      7.14956-06      2.39262-06
    40      -1.64083-03       1.94024-04      -1.23770-02     -2.09246-06      7.14956-06      2.39261-06
    41      -1.67321-03       1.75600-04      -1.23643-02     -2.09288-06      7.18228-06      2.35992-06
    42      -1.70772-03       1.55932-04      -1.23550-02     -2.08992-06      7.41566-06      2.37702-06
    43      -1.72614-03       1.35608-04      -1.23123-02     -2.04051-06      6.70707-06      2.35208-06
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Table 4 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE8OOD15
 MODE  NUMBER   5

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT       X-ROTATION        Y-ROTATION        Z-ROTATION
NUMBER

    44     -1.75275-03       1.12341-04      -1.22274-02      -1.89677-06       5.20151-06       2.45013-06
    45     -1.75216-03       6.16719-05      -1.21193-02      -1.89677-06       5.20157-06       2.45013-06
    46     -1.76094-03      -1.89111-05      -1.16187-02       5.01124-08       5.85146-06       2.56916-06
    47     -1.77713-03       9.28458-05      -1.21124-02      -1.79084-06       2.67212-06       2.48397-06
    48     -1.77578-03       3.76520-05      -1.20520-02      -1.79084-06       2.67212-06       2.48397-06
    49     -1.80983-03      -2.43835-05      -1.15730-02       4.40888-08       5.73282-06       2.45676-06
    50     -1.77067-03       2.80800-05      -1.20261-02      -1.74954-06       1.74211-06       2.48240-06
    51     -1.74424-03       7.80575-05      -1.19618-02      -1.65185-06      -3.97984-07       2.47870-06
    52     -1.74050-03       1.73789-05      -1.19690-02      -1.65185-06      -3.97975-07       2.47870-06
    53     -1.82565-03      -3.28023-05      -1.14985-02       8.92385-08       5.49872-06       2.28630-06
    54     -1.70199-03       6.79631-05      -1.19136-02      -1.65267-06       3.58133-08       2.50261-06
    55     -1.69695-03       1.01439-04      -1.18053-02      -1.03788-06       1.67565-06       1.01092-06
    56     -1.69695-03       7.03322-05      -1.17537-02      -1.03788-06       1.67566-06       1.01094-06
    57     -1.85118-03      -3.54154-05      -1.13751-02       3.38413-07       5.72238-06       2.05965-06
    58     -1.72077-03       7.15940-05      -1.17411-02      -1.03548-06       3.47207-06       1.30133-06
    59     -1.78810-03       4.63836-05      -1.16643-02      -1.02441-06       5.71499-06       1.47075-06
    60     -1.86411-03       1.97335-05      -1.15316-02      -9.73722-07       1.01625-05       1.29644-06
    61     -1.46508-03      -3.25292-04      -1.10012-02       1.35881-07       5.76356-06       2.64415-06
    62     -1.59993-03      -3.13131-04      -1.09518-02       5.04642-08       5.85075-06       2.56912-06
    63     -1.80875-03      -2.96300-04      -1.10507-02       1.27659-07       5.67957-06       2.64187-06
    64     -1.87382-03      -2.92617-04      -1.10359-02       1.13290-07       5.71087-06       2.61888-06
    65     -1.93205-03      -2.87082-04      -1.10046-02       4.98267-08       5.85083-06       2.56922-06
    66      1.26042-02      -2.04271-03      -1.28394-02      -9.29982-06      -3.80102-05       2.85873-04
    67      1.26042-02       1.27342-03      -1.23985-02      -9.29982-06      -3.80102-05       2.85873-04
    68      1.30571-02      -2.28854-03      -1.28167-02      -2.26589-05      -3.37142-05       3.00992-04
    69      1.30571-02       1.20297-03      -1.24256-02      -2.26589-05      -3.37141-05       3.00992-04
    70      1.34567-02      -2.38156-03      -1.27789-02      -7.79121-07      -2.74870-05       3.12320-04
    71      1.34567-02       1.24135-03      -1.24601-02      -7.79121-07      -2.74870-05       3.12320-04
    72      1.39837-02      -2.79339-03      -1.26740-02      -1.64428-05      -1.31987-05       3.49745-04
    73      1.39837-02       1.26366-03      -1.25209-02      -1.64428-05      -1.31987-05       3.49745-04
    74      1.41767-02      -2.87254-03      -1.25163-02       4.17551-06       6.32208-06       3.64180-04
    75      1.41767-02       1.35194-03      -1.25897-02       4.17551-06       6.32208-06       3.64180-04
    76      1.40209-02      -2.80918-03      -1.23496-02       8.08515-06       2.51645-05       3.84007-04
    77      1.40209-02       1.64530-03      -1.26415-02       8.08515-06       2.51645-05       3.84007-04
    78      1.36858-02      -2.80672-03      -1.22802-02       1.07886-05       3.33878-05       4.22985-04
    79      1.36858-02       2.09991-03      -1.26675-02       1.07886-05       3.33878-05       4.22985-04
    80      3.84595-03      -1.29287-03      -1.23292-02      -7.12403-06      -5.12858-06       1.96213-04
    81      3.84595-03       9.83207-04      -1.22697-02      -7.12403-06      -5.12858-06       1.96213-04
    82      4.01374-03      -1.44692-03      -1.22918-02      -1.35139-05       7.77817-07       2.04509-04
    83      4.01374-03       9.25384-04      -1.23008-02      -1.35139-05       7.77818-07       2.04509-04
    84      4.12652-03      -1.48356-03      -1.22485-02       3.89320-06       5.58464-06       2.09016-04
    85      4.12652-03       9.41026-04      -1.23133-02       3.89320-06       5.58464-06       2.09016-04
    86      4.15955-03      -1.53284-03      -1.21075-02      -9.23867-06       1.75473-05       2.14727-04
    87      4.15955-03       9.57985-04      -1.23110-02      -9.23867-06       1.75473-05       2.14727-04
    88      4.03929-03      -1.83010-03      -1.19212-02      -4.15015-06       3.21535-05       2.41961-04
    89      4.03929-03       9.76648-04      -1.22942-02      -4.15015-06       3.21535-05       2.41961-04
    90      3.53315-03      -1.75535-03      -1.17967-02       3.86683-06       4.03251-05       2.49910-04
    91      3.53315-03       1.14361-03      -1.22645-02       3.86683-06       4.03251-05       2.49910-04
    92      2.87753-03      -1.76231-03      -1.18218-02       6.16176-06       3.63498-05       2.67811-04
    93      2.87753-03      -3.02743-04      -1.20199-02       6.16176-06       3.63498-05       2.67811-04
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Table 4 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 MODE  NUMBER   5

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION       Z-ROTATION
NUMBER

    94     2.87753-03       1.34429-03      -1.22435-02      6.16176-06      3.63498-05      2.67811-04
    95    -1.20485-03      -8.72768-06      -1.25325-02     -8.69016-07     -2.10597-05      3.12289-05
    96    -1.20485-03       3.53527-04      -1.22883-02     -8.69016-07     -2.10597-05      3.12289-05
    97    -1.04189-03      -2.96604-05      -1.25165-02     -1.19042-06     -1.96148-05      3.77538-05
    98    -1.04189-03       4.08283-04      -1.22889-02     -1.19042-06     -1.96148-05      3.77538-05
    99    -9.87653-04      -1.11370-04      -1.22614-02      6.19329-06      1.00573-06      4.22917-05
   100    -9.87653-04       3.79214-04      -1.22731-02      6.19329-06      1.00573-06      4.22917-05
   101    -1.04223-03      -9.92263-06      -1.22574-02      5.94502-06     -2.78625-06      3.08150-05
   102    -1.04223-03       3.47531-04      -1.22251-02      5.94502-06     -2.78625-06      3.08150-05
   103    -1.15557-03      -8.08559-04      -1.21095-02     -6.05681-06      2.13023-06      1.02613-04
   104    -1.15557-03       3.81746-04      -1.21343-02     -6.05681-06      2.13023-06      1.02613-04
   105    -1.12620-03      -1.21778-04      -1.19814-02     -2.03649-05      6.58316-06      3.83878-05
   106    -1.12620-03       3.23521-04      -1.20577-02     -2.03649-05      6.58316-06      3.83878-05
   107    -1.31337-03      -2.71932-04      -1.19187-02     -2.36102-05      1.15710-05      4.13385-05
   108    -1.31337-03       2.07595-04      -1.20529-02     -2.36102-05      1.15710-05      4.13385-05
   109    -4.00082-04      -1.19695-04      -1.17533-02      9.17610-06      1.91818-05      1.14035-04
   110    -7.33955-04      -4.53251-05      -1.17212-02      8.21830-06      2.27757-05      1.02336-04
   111    -1.03168-03       1.44656-05      -1.16725-02      8.81257-06      1.52029-05      7.49955-05
   112    -1.23137-03       7.06714-05      -1.16334-02      9.07971-06      2.14303-05      5.80764-05
   113    -1.55962-03       1.81240-04      -1.22807-02     -2.09291-06      7.18224-06      2.35998-06
   114    -1.55962-03       2.08616-04      -1.23640-02     -2.09291-06      7.18224-06      2.35998-06
   115    -1.60758-03       2.72034-04      -1.23289-02     -2.09053-06      6.57460-06      1.05206-05
   116    -1.61482-03       1.40218-04      -1.22289-02     -2.04053-06      6.70706-06      2.35219-06
   117    -1.61482-03       1.67503-04      -1.23067-02     -2.04053-06      6.70706-06      2.35219-06
   118    -1.63479-03       1.12635-04      -1.21367-02     -1.89678-06      5.20150-06      2.45034-06
   119    -1.63479-03       1.41059-04      -1.21970-02     -1.89678-06      5.20150-06      2.45035-06
   120    -1.72013-03       2.73313-04      -1.20096-02      1.14101-05     -2.82012-05     -2.14105-05
   121    -1.57988-03       5.87530-05      -1.18328-02     -1.65275-06      3.55918-08      2.50281-06
   122    -1.57988-03       8.77857-05      -1.18332-02     -1.65275-06      3.55736-08      2.50282-06
   123    -1.64741-03       9.68689-05      -1.17469-02     -1.03777-06      1.67576-06      1.01108-06
   124    -1.64741-03       1.03087-04      -1.17572-02     -1.03777-06      1.67577-06      1.01108-06
   125    -1.79089-03       1.81240-04      -1.24856-02     -2.09285-06      7.18224-06      2.35984-06
   126    -1.79089-03       2.08614-04      -1.25691-02     -2.09285-06      7.18224-06      2.35984-06
   127    -1.83424-03       1.03697-04      -1.25450-02     -1.55846-06      1.15323-05     -3.04779-06
   128    -1.84532-03       1.40218-04      -1.24289-02     -2.04050-06      6.70705-06      2.35194-06
   129    -1.84532-03       1.67500-04      -1.25067-02     -2.04050-06      6.70705-06      2.35194-06
   130    -1.87490-03       1.12635-04      -1.23226-02     -1.89678-06      5.20150-06      2.44991-06
   131    -1.87490-03       1.41053-04      -1.23829-02     -1.89678-06      5.20150-06      2.44990-06
   132    -1.95269-03      -6.07317-05      -1.22385-02     -1.55923-05      3.62410-06      3.10247-05
   133    -1.82514-03       5.87537-05      -1.19948-02     -1.65276-06      3.58883-08      2.50249-06
   134    -1.82514-03       8.77826-05      -1.19952-02     -1.65276-06      3.58914-08      2.50249-06
   135    -1.75103-03       9.68701-05      -1.18533-02     -1.03785-06      1.67561-06      1.01058-06
   136    -1.74648-03       1.03085-04      -1.18589-02     -1.03785-06      1.67561-06      1.01058-06
   137    -1.48465-03       3.87779-04      -1.29449-02     -3.98741-06     -3.13371-05     -3.07079-05
   138    -1.48465-03       3.15667-05      -1.25814-02     -3.98741-06     -3.13371-05     -3.07080-05
   139    -1.28743-03       3.66278-04      -1.29327-02     -3.50762-06     -2.91774-05     -3.63065-05
   140    -1.28743-03      -5.48780-05      -1.25942-02     -3.50762-06     -2.91774-05     -3.63065-05
   141    -1.25992-03       4.06309-04      -1.26162-02     -1.04576-05     -2.71491-06     -3.91054-05
   142    -1.25992-03      -4.73131-05      -1.25848-02     -1.04576-05     -2.71491-06     -3.91054-05
   143    -1.37499-03       2.43526-04      -1.26013-02     -1.04329-05     -4.33919-06     -2.71499-05
```

Table 4 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CEROOD15
 MODE  NUMBER   5

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT       X-ROTATION       Y-ROTATION        Z-ROTATION
NUMBER

   144     -1.37499-03      -7.14130-05      -1.25509-02      -1.04329-05      -4.33919-06      -2.71499-05
   145     -1.51094-03       1.03701-03      -1.24776-02       1.49937-06      -1.59617-06      -1.02613-04
   146     -1.51094-03      -1.53304-04      -1.24591-02       1.49937-06      -1.59617-06      -1.02613-04
   147     -1.45366-03       2.68765-04      -1.23144-02       2.83115-05       7.95538-06      -3.70417-05
   148     -1.45366-03      -1.60918-04      -1.24067-02       2.83115-05       7.95538-06      -3.70417-05
   149     -1.61760-03       5.29469-04      -1.22562-02       3.18113-05       1.17694-05      -5.79529-05
   150     -1.61760-03      -1.42786-04      -1.23928-02       3.18113-05       1.17694-05      -5.79529-05
   151      3.81360-03       1.71656-03      -1.30221-02       2.16798-06      -3.31247-05      -2.03978-04
   152      3.81360-03      -6.49580-04      -1.26379-02       2.16798-06      -3.31247-05      -2.03978-04
   153      4.05350-03       1.83924-03      -1.29907-02       1.28920-05      -2.86606-05      -2.11348-04
   154      4.05350-03      -6.12396-04      -1.26582-02       1.28920-05      -2.86606-05      -2.11348-04
   155      4.22785-03       1.88028-03      -1.29523-02      -4.76520-06      -2.40446-05      -2.18841-04
   156      4.22785-03      -6.58280-04      -1.26734-02      -4.76520-06      -2.40446-05      -2.18841-04
   157      4.23862-03       1.93048-03      -1.27889-02       1.84859-06      -9.41297-06      -2.28984-04
   158      4.23862-03      -7.25735-04      -1.26797-02       1.84859-06      -9.41297-06      -2.28984-04
   159      4.15106-03       2.17970-03      -1.24475-02      -1.23186-06       1.81216-05      -2.56109-04
   160      4.15106-03      -7.91166-04      -1.26577-02      -1.23186-06       1.81216-05      -2.56109-04
   161      3.65984-03       1.99706-03      -1.22431-02      -6.87387-06       3.43245-05      -2.58178-04
   162      3.65984-03      -9.97803-04      -1.26412-02      -6.87387-06       3.43245-05      -2.58178-04
   163      3.02502-03       1.97086-03      -1.22367-02      -9.51442-06       3.34596-05      -2.75506-04
   164      3.02502-03      -1.22502-03      -1.26248-02      -9.51442-06       3.34596-05      -2.75506-04
   165     -4.44757-04       2.93968-04      -1.20433-02      -1.58322-05       1.81834-05      -1.28051-04
   166     -8.45922-04       1.58972-04      -1.20095-02      -1.42776-05       2.08680-05      -1.06882-04
   167     -1.17663-03       3.95765-05      -1.19597-02      -1.39187-05       1.93880-05      -8.46371-05
   168     -1.42414-03      -7.14339-05      -1.19201-02      -1.30326-05       2.90570-05      -6.59372-05
   169      1.29686-02       2.42536-03      -1.34697-02       1.55103-05      -5.56634-05      -2.88413-04
   170      1.29686-02      -9.20239-04      -1.28240-02       1.55103-05      -5.56634-05      -2.88413-04
   171      1.35107-02       2.74332-03      -1.34410-02       2.74968-05      -5.10610-05      -3.12393-04
   172      1.35107-02      -8.80438-04      -1.28487-02       2.74968-05      -5.10610-05      -3.12393-04
   173      1.39900-02       2.85605-03      -1.33962-02       2.54723-06      -4.38222-05      -3.28859-04
   174      1.39900-02      -9.58712-04      -1.28879-02       2.54723-06      -4.38222-05      -3.28859-04
   175      1.45887-02       3.30359-03      -1.32788-02       1.43971-05      -2.87709-05      -3.74012-04
   176      1.45887-02      -1.03494-03      -1.29451-02       1.43971-05      -2.87709-05      -3.74012-04
   177      1.48230-02       3.28440-03      -1.30848-02      -1.15126-05      -4.77930-06      -3.85325-04
   178      1.48230-02      -1.18537-03      -1.30294-02      -1.15126-05      -4.77930-06      -3.85325-04
   179      1.46739-02       3.12921-03      -1.28990-02      -1.19213-05       1.73930-05      -4.01863-04
   180      1.46739-02      -1.53240-03      -1.31007-02      -1.19213-05       1.73930-05      -4.01863-04
   181      1.43278-02       3.07558-03      -1.28242-02      -1.47998-05       3.04299-05      -4.41035-04
   182      1.43278-02       6.71939-04      -1.29901-02      -1.47998-05       3.04299-05      -4.41035-04
   183      1.43278-02      -2.04043-03      -1.31772-02      -1.47998-05       3.04299-05      -4.41035-04
   184       .00000           .00000           .00000           .00000           .00000           .00000
   185       .00000           .00000           .00000           .00000           .00000           .00000
   186       .00000           .00000           .00000           .00000           .00000           .00000
   187       .00000           .00000           .00000           .00000           .00000           .00000
   188       .00000           .00000           .00000           .00000           .00000           .00000
   189       .00000           .00000           .00000           .00000           .00000           .00000
   190       .00000           .00000           .00000           .00000           .00000           .00000
   191       .00000           .00000           .00000           .00000           .00000           .00000
   192       .00000           .00000           .00000           .00000           .00000           .00000
   193       .00000           .00000           .00000           .00000           .00000           .00000
```

Table 4 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 MODE  NUMBER   5

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
NUMBER

   194       .00000           .00000           .00000           .00000           .00000           .00000
   195       .00000           .00000           .00000           .00000           .00000           .00000
   196       .00000           .00000           .00000           .00000           .00000           .00000
   197       .00000           .00000           .00000           .00000           .00000           .00000
   198   1.36858-02      -5.01451-04      -1.24621-02       1.07886-05       3.33878-05       4.22985-04
   199  -8.91720-04      -4.66370-05      -1.17409-02      -2.36102-05       1.15710-05       4.13385-05
   200  -1.02648-03       2.13625-04      -1.19959-02       3.18113-05       1.17694-05      -5.79529-05
   201   3.02502-03       4.69349-04      -1.24190-02      -9.51442-06       3.34596-05      -2.75506-04
   202  -1.85673-03      -3.19911-05      -1.12670-02       1.55651-07       6.05956-06       1.94232-06
   203   1.30365-02      -2.36340-04      -1.23926-02       1.60730-05       5.93923-05       4.50559-04
   204   1.19394-02      -1.96209-05      -1.23240-02       1.54683-05       8.69236-05       4.65224-04
   205   1.09470-02       1.37495-04      -1.22748-02       1.58075-05       9.30250-05       4.59720-04
   206   2.23475-03      -1.18711-04      -1.19302-02       1.53235-05       4.98493-05       2.73618-04
   207   1.48626-03       1.53909-05      -1.18612-02       1.39786-05       4.88168-05       2.47676-04
   208   9.45524-04       1.25318-04      -1.18127-02       1.32090-05       4.99432-05       2.24597-04
   209  -1.12245-03      -1.56973-05      -1.16859-02       4.13461-06       1.53047-05       3.08982-05
   210  -1.31832-03       1.19140-05      -1.16285-02       5.98608-06       1.11877-05       2.21865-05
   211  -1.43486-03       3.97119-05      -1.15853-02       6.17952-06       9.77395-06       1.86524-05
   212  -1.65114-03       6.57112-05      -1.16701-02      -1.03547-06       3.47186-06       1.30165-06
   213  -1.70941-03       3.97353-05      -1.15837-02      -1.02443-06       5.71473-06       1.47093-06
   214  -1.77522-03       2.23738-05      -1.15104-02      -9.90532-07       7.64607-06       1.59558-06
   215  -1.79038-03       6.57128-05      -1.17809-02      -1.03548-06       3.47185-06       1.30104-06
   216  -1.86677-03       3.97363-05      -1.16933-02      -1.02439-06       5.71469-06       1.47053-06
   217  -1.94599-03       2.23715-05      -1.16164-02      -9.90868-07       7.64600-06       1.59638-06
   218  -1.28993-03       1.35097-04      -1.19389-02      -1.00629-05       1.29117-05      -3.67955-05
   219  -1.51575-03       4.91153-05      -1.18862-02      -1.11436-05       1.15667-05      -2.54671-05
   220  -1.66661-03      -3.62805-05      -1.18528-02      -1.14478-05       1.40569-05      -2.11268-05
   221   2.29708-03       2.37915-04      -1.23209-02      -2.14312-05       5.44585-05      -2.85546-04
   222   1.52626-03       3.69103-05      -1.22460-02      -2.03326-05       6.18859-05      -2.67192-04
   223   9.01701-04      -1.29670-04      -1.21973-02      -1.98804-05       6.79211-05      -2.47211-04
   224   1.37109-02       3.44891-04      -1.29291-02      -2.02424-05       5.75959-05      -4.69504-04
   225   1.26793-02       6.21259-05      -1.28701-02      -1.98452-05       8.43808-05      -4.80514-04
   226   1.17228-02      -1.46816-04      -1.28239-02      -2.03107-05       8.96383-05      -4.75317-04
   227  -1.86059-03       2.95864-05      -1.15979-02      -9.90712-07       7.64620-06       1.59594-06
   228  -1.70261-03       1.02450-04      -1.21837-02      -2.08991-06       7.41563-06       2.37702-06
   229  -1.72297-03       8.16748-05      -1.21558-02      -2.04054-06       6.70708-06       2.35208-06
   230  -1.71979-03       8.13454-05      -1.21521-02      -2.04048-06       6.70703-06       2.35209-06
   231  -1.74415-03       5.13080-05      -1.20911-02      -1.89680-06       5.20151-06       2.45012-06
   232  -1.74873-03       5.97118-05      -1.21125-02      -1.89675-06       5.20141-06       2.45013-06
   233  -1.77270-03       3.56649-05      -1.20477-02      -1.79086-06       2.67220-06       2.48397-06
   234  -1.77183-03       3.52922-05      -1.20466-02      -1.79080-06       2.67199-06       2.48397-06
   235  -1.76539-03       2.90978-05      -1.20231-02      -1.74955-06       1.74218-06       2.48240-06
   236  -1.76539-03       2.90978-05      -1.20231-02      -1.74953-06       1.74205-06       2.48240-06
   237  -1.73770-03       1.50241-05      -1.19675-02      -1.65188-06      -3.97879-07       2.47870-06
   238  -1.87384-03      -3.08434-05      -1.11351-02      -9.75755-09       6.40025-06       1.80954-06
   239  -1.85095-03      -1.14277-04      -1.04714-02      -9.73189-07       1.01532-05       1.29614-06
   240       .00000           .00000           .00000           .00000           .00000           .00000
   241   1.44023-02      -2.04505-03      -1.28886-02       1.65469-05      -4.28281-05       2.86117-04
   242   1.44023-02       1.27391-03      -1.23918-02       1.65469-05      -4.28281-05       2.86117-04
   243   1.49252-02       1.21481-03      -1.24237-02       1.08618-05      -4.52171-05       2.95999-04
```

Table 4 (continued)

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BSAP  AUXILIARY BUILD SIESMIC ANALYSIS FLEXIBLE BASE
CE800D15
 MODE   NUMBER    5

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM . . .

  NODE    X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT        X-ROTATION        Y-ROTATION         Z-ROTATION
NUMBER

   244       1.54254-02      -2.38525-03      -1.29533-02        4.25670-05       -4.11790-05        3.13137-04
   245       1.54254-02       1.24715-03      -1.24756-02        4.25670-05       -4.11790-05        3.13137-04
   246       1.61562-02      -2.79072-03      -1.28121-02        4.16326-05       -2.24490-05        3.50280-04
   247       1.61562-02       1.27252-03      -1.25517-02        4.16326-05       -2.24490-05        3.50280-04
   248       1.64540-02      -2.87427-03      -1.26699-02        3.50775-05       -9.07465-08        3.65404-04
   249       1.64540-02       1.36442-03      -1.26689-02        3.50775-05       -9.07465-08        3.65404-04
   250       1.64356-02      -2.81367-03      -1.26520-02        6.91234-05        1.03838-05        3.84854-04
   251       1.64356-02       1.65063-03      -1.27724-02        6.91234-05        1.03838-05        3.84854-04
   252       1.63507-02      -5.08136-04      -1.25597-02        1.32460-05        3.03641-05        4.27986-04
   253       1.63507-02       2.12398-03      -1.27464-02        1.32460-05        3.03641-05        4.27986-04
   254       1.47758-02       2.42795-03      -1.35023-02       -1.56544-05       -5.77529-05       -2.88401-04
   255       1.47758-02      -9.17498-04      -1.28324-02       -1.56544-05       -5.77529-05       -2.88401-04
   256       1.54350-02      -8.91863-04      -1.28729-02       -1.95954-05       -6.63965-05       -3.10647-04
   257       1.60450-02       2.85911-03      -1.35692-02       -4.31261-05       -5.56935-05       -3.29544-04
   258       1.60450-02      -9.63600-04      -1.29232-02       -4.31261-05       -5.56935-05       -3.29544-04
   259       1.68852-02       3.30096-03      -1.34760-02       -5.48957-05       -4.10024-05       -3.74283-04
   260       1.68852-02      -1.04072-03      -1.30003-02       -5.48957-05       -4.10024-05       -3.74283-04
   261       1.72286-02       3.28610-03      -1.32533-02       -3.50126-05       -1.01390-05       -3.86709-04
   262       1.72286-02      -1.19973-03      -1.31357-02       -3.50126-05       -1.01390-05       -3.86709-04
   263       1.71977-02       3.14277-03      -1.31997-02       -6.67912-05        5.18629-06       -4.05249-04
   264       1.71977-02      -1.55811-03      -1.32598-02       -6.67912-05        5.18629-06       -4.05249-04
   265       1.70941-02       6.78799-04      -1.31132-02       -1.73204-05        2.67349-05       -4.45069-04
   266       1.70941-02      -2.05837-03      -1.32777-02       -1.73204-05        2.67349-05       -4.45069-04
   267       1.58197-02      -2.45471-04      -1.24938-02        1.64482-05        5.11370-05        4.48945-04
   268       1.48084-02      -2.60464-05      -1.24193-02        1.53138-05        8.42930-05        4.63889-04
   269       1.38078-02       1.33526-04      -1.23723-02        1.57203-05        9.40331-05        4.61832-04
   270       1.66039-02       3.51899-04      -1.30562-02       -2.06293-05        4.92861-05       -4.68479-04
   271       1.56445-02       6.87793-05      -1.29918-02       -1.95268-05        8.19800-05       -4.79251-04
   272       1.46800-02      -1.43448-04      -1.29489-02       -2.01504-05        9.03400-05       -4.76964-04
   273      -1.72061-03       3.15522-05      -1.16342-02       -1.03548-06        3.47208-06        1.30134-06
   274      -1.78810-03       1.12860-06      -1.14885-02       -1.02441-06        5.71500-06        1.47075-06
   275      -1.69674-03       9.50798-05      -1.17946-02       -1.03796-06        1.67560-06        1.01095-06
   276        .00000           .00000           .00000             .00000            .00000             .00000

        SUMMARY  OF  MIN/MAX  NODAL  DISPLACEMENTS

           X-DISPLACEMENT  Y-DISPLACEMENT  Z-DISPLACEMENT     X-ROTATION      Y-ROTATION        Z-ROTATION

NODE MIN         2              248             2              263             256               225
   VALUE   -.0019632473    -.0028742667    -.0138025013    -.0000667912    -.0000663965     -.0004805137

NODE MAX        262             175             37             251             269               204
   VALUE    .0172286111     .0033035949    -.0103703431     .0000691234     .0000940331      .0004652242
```
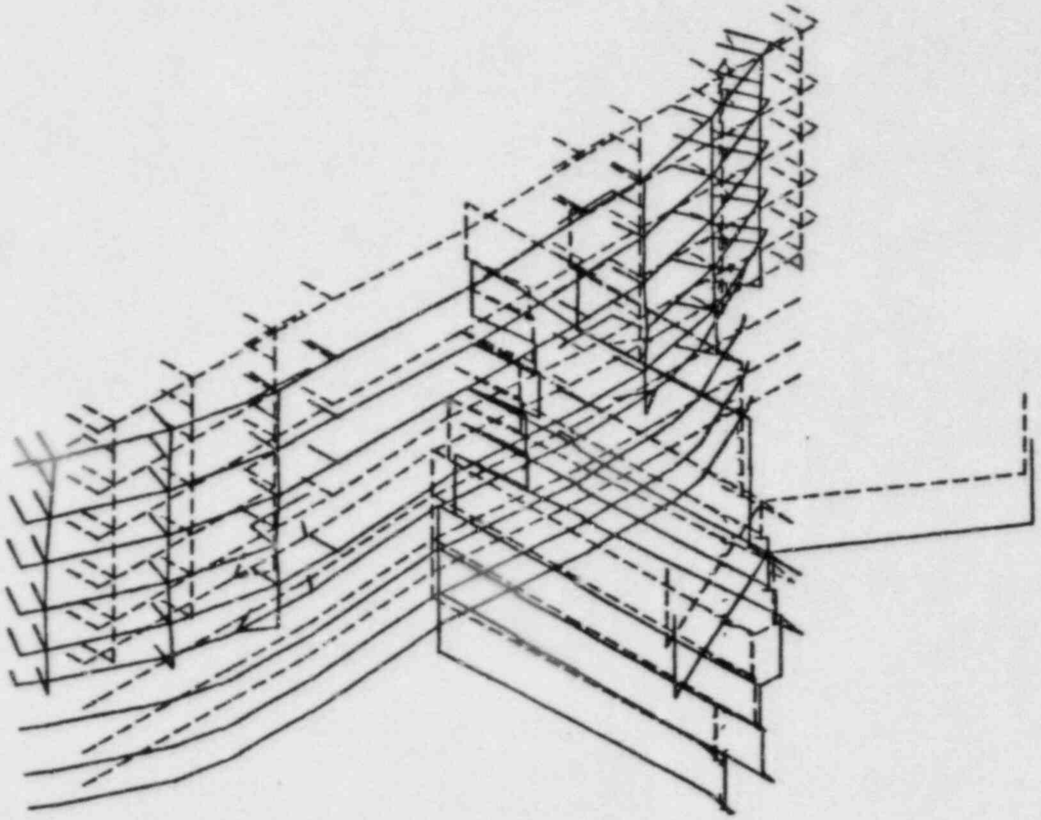
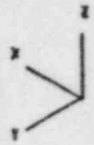

COMPUTER PLOT OF MODE NUMBER 5



AUXILIARY BUILDING SIESMIC ANALYSIS FLEXIBLE BASE
MODE SHAPES FROM A 45 DEGREE VIEW



[illegible] 045N19 090481 PLOT SET 1 FRAME NO. 5 DISP/MODE NO. 5

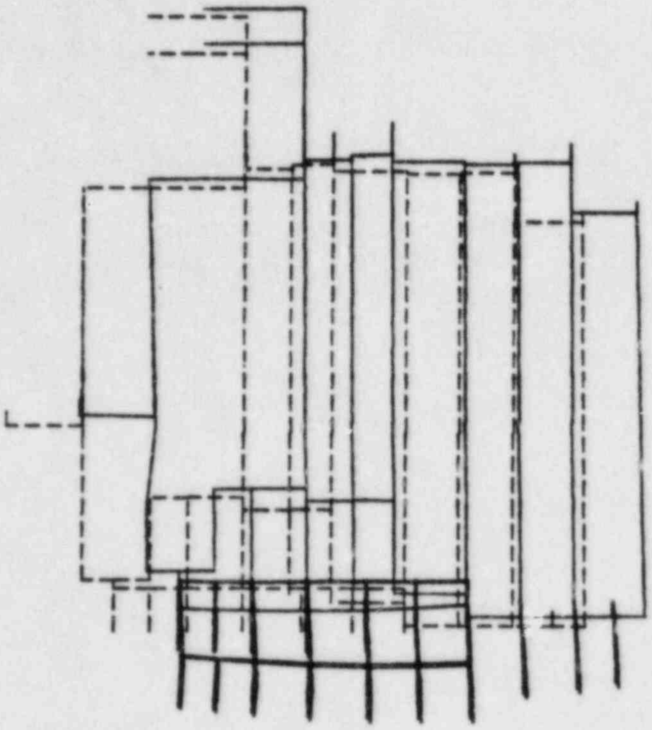
COMPUTER PLOT OF MODE NUMBER 5

FLEX BASE MODE SHAPES   VIEW FROM X DIRECTION

POST   AUX BLDG SEISMIC ANALYSIS MODE SHAPE PLOTTING

[illegible]   04DEC80   090881   PLOT SET   1 FRAME NO.   5   DISP/MODE NO.   5

COMPUTER PLOT OF MODE NUMBER 5



APPENDIX A

SOIL-STRUCTURE INTERACTION TECHNIQUE TO INCORPORATE EMBEDMENT EFFECTS

The auxiliary building structural model has been coupled with the supporting soil to account for soil-structure interaction. The method used to account for this interaction was a lumped-parameter representation.

1.0 LUMPED-PARAMETER REPRESENTATION

In using the lumped-parameter representation, the dynamic characteristics of the foundation are represented by the foundation impedances. In general, the foundation impedances are functions of the basemat geometry, embedment depth, and elastic properties of the foundation medium, and forcing frequencies.

Figure A-13 shows a schematic lumped parameter model of the structure-foundation system, with the equivalent foundation springs, k_x and K_ψ, and radiation dampers, c_x and c_ψ, representing the foundation impedances for horizontal seismic excitation. The foundation is represented by k_z and c_z for vertical motion, and k_t and c_t for torsion.

As concluded by Tsai et al (1974); Richart et al (1970); and Parmelee et al (1976), when the material below the base slab elevation may be considered uniform to a great depth, the impedance functions for the surface foundation can be adequately represented by frequency-independent expressions. In this case, Table 3-2 (a), (b), and (c) of BC-TOP-4A, Revision 3 (see Table A-1) present the simplest approximation to obtain the frequency-independent impedances for rigid surface circular and rectangular foundations based on the findings of Whitman and Richart (1967).

When frequency-independent impedances are used, it is sufficient to represent this coupled system by normal modes of the soil-structure system. The determination of the composite modal damping is accomplished by requiring that the dynamic amplification functions of selected structural responses of both the coupled and uncoupled systems match each other at the natural frequencies as described by Tsai (1972).

2.0 IMPEDANCE FUNCTIONS FOR EMBEDDED STRUCTURES

Embedment increases both damping and stiffness of the soil-structure systems. This increase is considered as a factor larger than one affecting the impedance values obtained for the same foundation resting on a half-space located at the elevation of the bottom of the basemat.

The first step in the solution consists of determining the values of k_{ii} and c_{ii}, the impedance coefficients of the foundation without embedment effects (see Table A-1). Then, the impedance coefficients including embedment effects are given by:

$$k'_{ii} = k_{ii} \left[1 + (\alpha_{ii} - 1) \frac{G_1}{G_2} f \right] \qquad \text{(A-1)}$$

$$c'_{ii} = c_{ii} \left[1 + (\beta_{ii} - 1) \frac{G_1}{G_2} f \right] \qquad \text{(A-2)}$$

The coefficients α_{ii} and β_{ii} represent the effects of full embedment and complete lateral perimeter contact as developed in Section 2.3. Corrections required to account for differences in soil properties between the side soil (G_1) and the soil beneath the foundation (G_2) are made by multiplying the embedment effects by the ratio G_1/G_2. The impedance functions calculated by Equations A-1 and A-2 are referred to the centroid of the foundation.

The possibility of having only a partial perimetrical section of a structure being embedded is considered by multiplying the embedment effects by a factor, f, which is equal to or less than unity (see Section 2.2). The factor f is obtained from Figure A-12.

As embedment increases, the coupling between translational and rocking impedances becomes important and must be considered in the analysis (see Section 2.1).

2.1 IMPEDANCES FOR CYLINDRICAL FOUNDATIONS IN ELASTIC HALF-SPACE

This appendix provides curves derived from Apsel (1979) for circular foundations normalized to the corresponding impedances for the equivalent surface foundations. The curves have been drawn for a family of dimensionless frequencies given by

$$a_o = \frac{\omega R}{V_s} \qquad \text{(A-8)}$$

where ω is the forcing function frequency, R is the radius of the foundation and, V_s is the shear wave velocity of the half-space. The abscissa of the curves is the embedment ratio h/R where h is the depth of embedment. Refer to Figure A-1 for nomenclature. The normalized impedances are given in Figures A-2 through A-9. These impedances refer to the centroid of the foundation.

As embedment increases, the coupling effect between horizontal translation and rocking becomes significant and should be included in the solution. Figures A-10 and A-11 give these coupling terms. Unlike the previous curves, these are given in absolute terms. No normalization is introduced.

If the formulation used in the solution of a particular case permits handling of these off-diagonal terms, the coupling effects are incorporated directly. However, if off-diagonal terms cannot be handled, the stiffness matrix as defined in Equation A-3 can be converted into a diagonal matrix by defining a point at a height H_c above the bottom of the foundation for which the cross coupling terms will vanish. This particular point is normally referred to as the center of resistance. Because the overall contribution of the damping (imaginary part) cross coupling term is small compared to the stiffness cross coupling effect, as demonstrated by Kausel and Roesset (1975), only the stiffness characteristics are considered in determining H_c. The force-displacement relationship of the foundation is given by:

$$\begin{Bmatrix} F \\ M \end{Bmatrix} = \begin{bmatrix} k_x & k_{x\psi} \\ k_{\psi x} & k\psi \end{bmatrix} \begin{Bmatrix} u \\ \psi \end{Bmatrix} \qquad \text{(A-3)}$$

where

F = horizontal force applied at the foundation

M = rocking moment applied at the foundation

u = horizontal translation

ψ = rotation of the foundation

Defining F*, M*, u*, and ψ* the corresponding parameters at the center of resistance, the following relations exist between the two coordinate systems:

$$u^* = u + \psi H_c \qquad \text{and } \psi^* = \psi \qquad \text{(A-4)}$$

$$F^* = F \qquad \text{and } M^* = M - FH_c \qquad \text{(A-5)}$$

Substituting the above into Equation A-3

$$\begin{Bmatrix} F^* \\ M^* \end{Bmatrix} = \begin{bmatrix} k^* & 0 \\ 0 & k^*_\psi \end{bmatrix} \begin{Bmatrix} u^* \\ \psi \end{Bmatrix} \qquad \text{(A-6)}$$

The following parameters are defined:

$$H_c = \frac{k'_{x\psi}}{k'_x} \qquad k_x = k^*_x = k'_x \qquad \text{(A-7)}$$

and

$$k^*_\psi = k_\psi - \frac{k^{2'}_{x\psi}}{k'_x}$$

(Primed values from Appendix A, Section 2.3)

The damping matrix consistent with Equation A-3 should also be transferred to the degrees of freedom at the center of resistance and only the terms on the diagonal used. With the foundation impedances specified, the structure-foundation system is formulated by coupling the fixed base structure with the foundation medium through the basemat.

Coupling between translational and rocking impedances while important as embedment increases has been found to be negligible for the axuiliary building.

2.2 CORRECTION FOR PARTIAL EMBEDMENT

The analytical solution provided in Section 2.3 is based on the common assumption that the cylinder is fully welded to the surrounding soil. This assumption is not that different from the case of the surface foundation. However, considering the fact that the dead load of the structure itself tends to ensure complete contact at the horizontal interface between soil and structure, such an assumption for the case of the sides cannot be made. During oscillations of the structure, separation of the side of the structure from the surrounding soil is almost certain. If the assumption is made that the soil is effective only in compression, then the contribution of the lateral reactions to the impedances obtained analytically should be halved.

Another consideration is the fact that because of the proximity of nuclear plant structures, almost all structures are only partially embedded along their perimeters. Furthermore, some structures are completely surrounded by others and thus, in fact, are surface structures located in a hole with no contact at the sides. Figure A-12 depicts all these possibilities. Considering only the full 360° perimetral embedment condition, the factor f for the welded case equals 1.0 and Kausel et al (1975) provide data for the completely free case. It is not surprising that these latter results are not zero, because the structure,even though free, has to move against the depth, d, of surcharge through its base. The vertical and rocking factor (.15) is less than that of the horizontal (.40), because these cause predominantly local deformations. The variation of these reduction factors (1.0, .40, and .15) for perimetral embedment less than 360° has not been studied. Obviously though, they should vary from zero to their maximum values. A linear variation is assumed.

Field test results (Barneich et al, 1974) for 180° perimetral embedment are shown in Figure A-12. Extrapolation of these points linearly to 360° gives f = 0.5 for the horizontal and 0.64 for the vertical and rocking. The value f = 0.5 for the horizontal matches the case where the soil is assumed not to resist tension. Considering the same property for the soil (no tension), it is expected that the vertical and rocking give results larger than 0.5. Whether 0.64 is the correct factor is difficult to determine.

Intuitive reasoning and field data suggest that the dashed lines are, at the present time, the best that is available to consider embedment effects for real soils. The fully welded condition is unrealizable, but constitutes an upper bound.

2.3 PROCEDURE TO EVALUATE IMPEDANCES FOR EMBEDDED FOUNDATIONS

The following step-by-step procedure is followed to obtain impedance coefficients to be used in a frequency-independent soil-structure interaction analysis for embedded structures. The reference to frequency-independent analysis is to the solution procedure. The goal is made to select impedance coefficients that are compatible with the fundamental frequency of the soil-structure system.

1. If the foundation is cylindrical, proceed to step 2. If it is rectangular, first find an equivalent radius (R) of a disk with equal area to the rectangle. The question of equivalence between a rectangular and a cylindrical structure with regard to embedment effects, although conceivably could be an important issue, in the present context, is not a critical concern because

the equivalence criteria is used only to find a ratio by which the surface impedances have to be modified (Equations A-1 and A-2).

Because most rectangular structures have aspect ratios of less than 2.0, any choice of the equivalence parameter, be it equal contact area, equal base area or equal moment of inertia of the base, would not result in very dissimilar equivalent radii. To avoid confusion, the area equivalence is chosen such that $R = \sqrt{\frac{A}{\pi}}$.

2. Obtain the soil-structure system frequency ω in rad/sec.

3. Calculate a_o according to Equation (A-8) and determine h/R.

$$a_o = \frac{\omega R}{V_s} \tag{A-8}$$

4. Find all values of α_{ii} and β_{ii} per curves, Figures A-2 through A-9.

5. Simplify any layering into G_1 and G_2 as shown in Figure A-1.

6. Establish the characteristics of the foundation regarding "welding" conditions and the existence of backfill on the perimeter of the foundation (both represented by the coefficient f as in Figure A-12.)

7. Determine the impedance coefficients k'_{ii} and c'_{ii} from Equations (A-1) and (A-2).

8. Find the coupling coefficients $k_{x\psi}$ and $c_{x\psi}$ from curves, Figures A-10 and A-11.

9. Evaluate stiffness and damping coefficients from expressions (A-10) to (A-25) which are based on the force-displacement relationship given in Equation (A-9).

Shear modulus (G) in Equations (A-9) to (A-25) relate to the level at which the foundation rests. This corresponds to G_2 in Figure A-1.

$$\begin{Bmatrix} P'_x \\ M'_\psi/R \\ \\ P'_v \\ M'_t/R \end{Bmatrix} = GR \begin{bmatrix} k'_{xx}+ia_o c'_{xx} & k_{x\psi}+ia_o c_{x\psi} & 0 & 0 \\ k_{\psi x}+ia_o c_{\psi x} & k'_{\psi\psi}\, ia_o c'_{\psi\psi} & 0 & 0 \\ \\ 0 & 0 & k'_{vv}+ia_o c'_{vv} & 0 \\ 0 & 0 & 0 & k'_{tt}+ia_o c'_{tt} \end{bmatrix} \begin{Bmatrix} u'_x \\ \psi' R \\ \\ u'_v \\ \delta' R \end{Bmatrix} \tag{A-9}$$

Horizontal:

$$P'_x = (k'_x+i\omega c'_x)u'_x + (k'_{x\psi}+i\omega c'_{x\psi})\psi' \tag{A-10}$$

$$k'_x = GRk'_{xx} \tag{A-11}$$

$$c'_x = \frac{GR(a_o c'_{xx})}{\omega} = \frac{GR^2}{V_s}\ c'_{xx} \tag{A-12}$$

$$k'_{x\psi} = GR^2 k_{x\psi} \tag{A-13}$$

$$c'_{x\psi} = \frac{GR^2 a_o c_{x\psi}}{\omega} = \frac{GR^3}{V_s}\ c_{x\psi} \tag{A-14}$$

Rocking:

$$M'_\psi = (k'_{\psi x}+i\omega c'_{\psi x})u'_x+(k'_\psi+i\omega c'_\psi)\psi' \tag{A-15}$$

$$k'_\psi = GR^3 k'_{\psi\psi} \tag{A-16}$$

$$c'_\psi = \frac{GR^3 a_o c'_{\psi\psi}}{\omega} = \frac{GR^4}{V_s}\ c'_{\psi\psi} \tag{A-17}$$

$$k'_{\psi x} = k'_{x\psi} \tag{A-18}$$

$$c'_{\psi x} = c'_{x\psi} \tag{A-19}$$

Vertical:

$$P'_v = (k'_v + i\omega c'_v)u'_v \tag{A-20}$$

$$k'_v = GRk'_{vv} \tag{A-21}$$

$$c'_v = \frac{GRa_o c'_{vv}}{\omega} = \frac{GR^2}{V_s} c'_{vv} \tag{A-22}$$

Torsion:

$$M'_t = (k'_t + \omega c'_t)\delta' \tag{A-23}$$

$$k'_t = GR^3 k'_{tt} \tag{A-24}$$

$$c'_t + \frac{GR^3 a_o c'_{tt}}{\omega} = \frac{GR^4}{V_s} c'_{tt} \tag{A-25}$$

3.0 REFERENCES

Apsel, R.J., (1979) "Dynamic Green's Functions for Layered Media and applications to Boundary Value Problems," Ph.D Thesis, University of California, San Diego.

Barneich, J.A., Johns, D.H., and McNeill, R.L., (1974) "Soil-Structure Interaction Parameters for Aseismic Design of Nuclear Power Stations," Preprint 2182, ASCE National Meeting on Water Resources Engineering, January 21-25.

Kausel, E. and Roesset, J.M., (1975) "Dynamic Stiffness of Circular Foundations," Journal of Engineering Mechanics Division, ASCE, Vol. 101, No. EM6, Proc. Paper 11800, pp. 771-785.

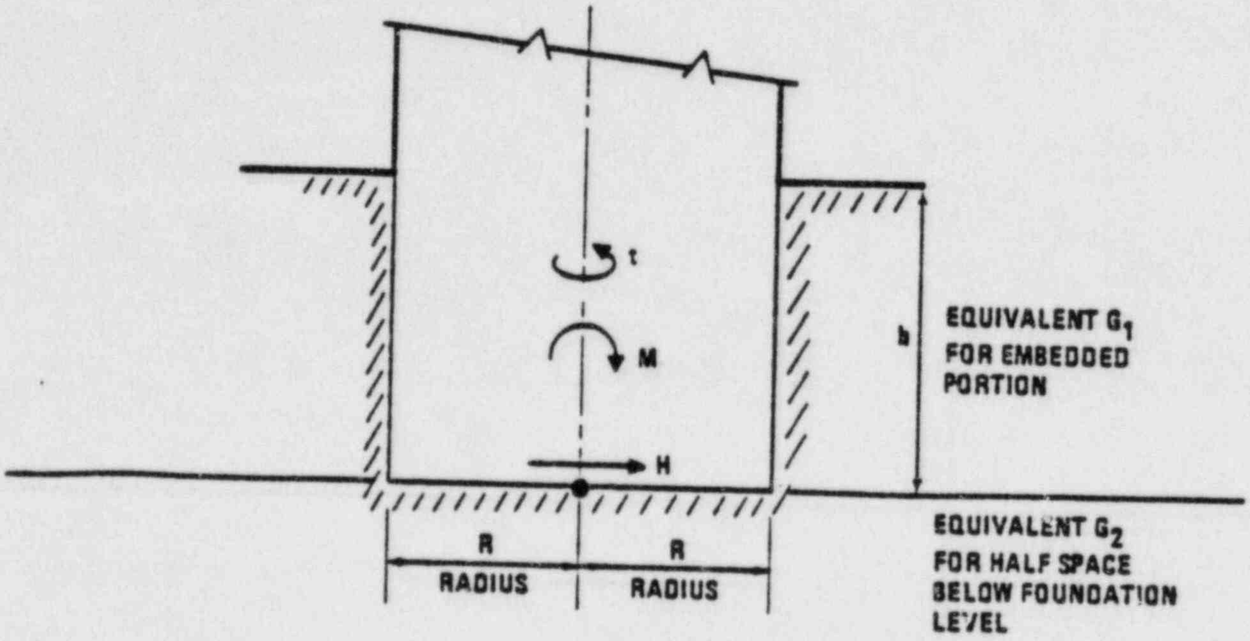


Figure A-1 NOMENCLATURE AND POSITIVE SIGNS

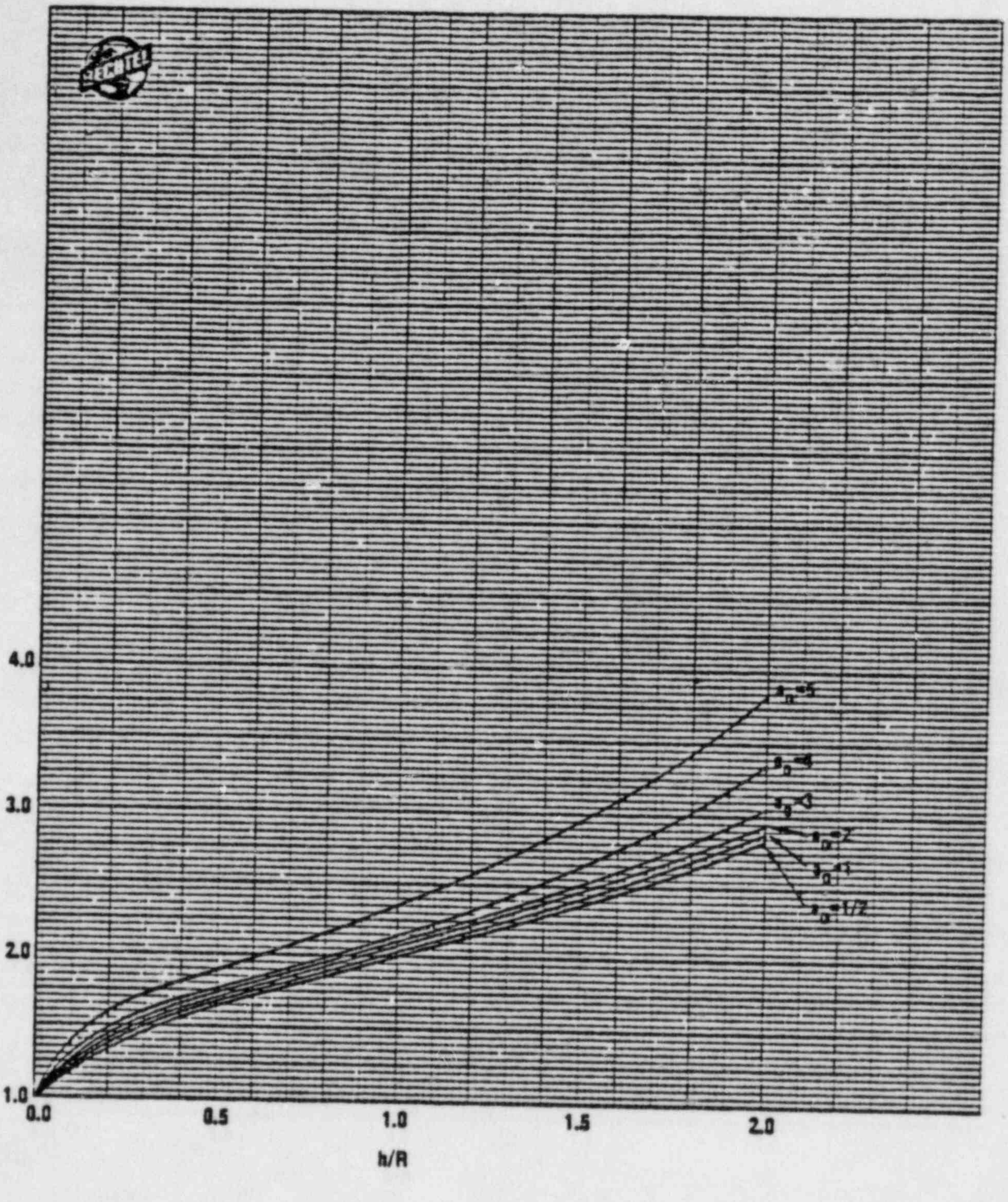


Figure A-2 NORMALIZED EMBEDMENT STIFFNESS COEFFICIENT, α_{xx}

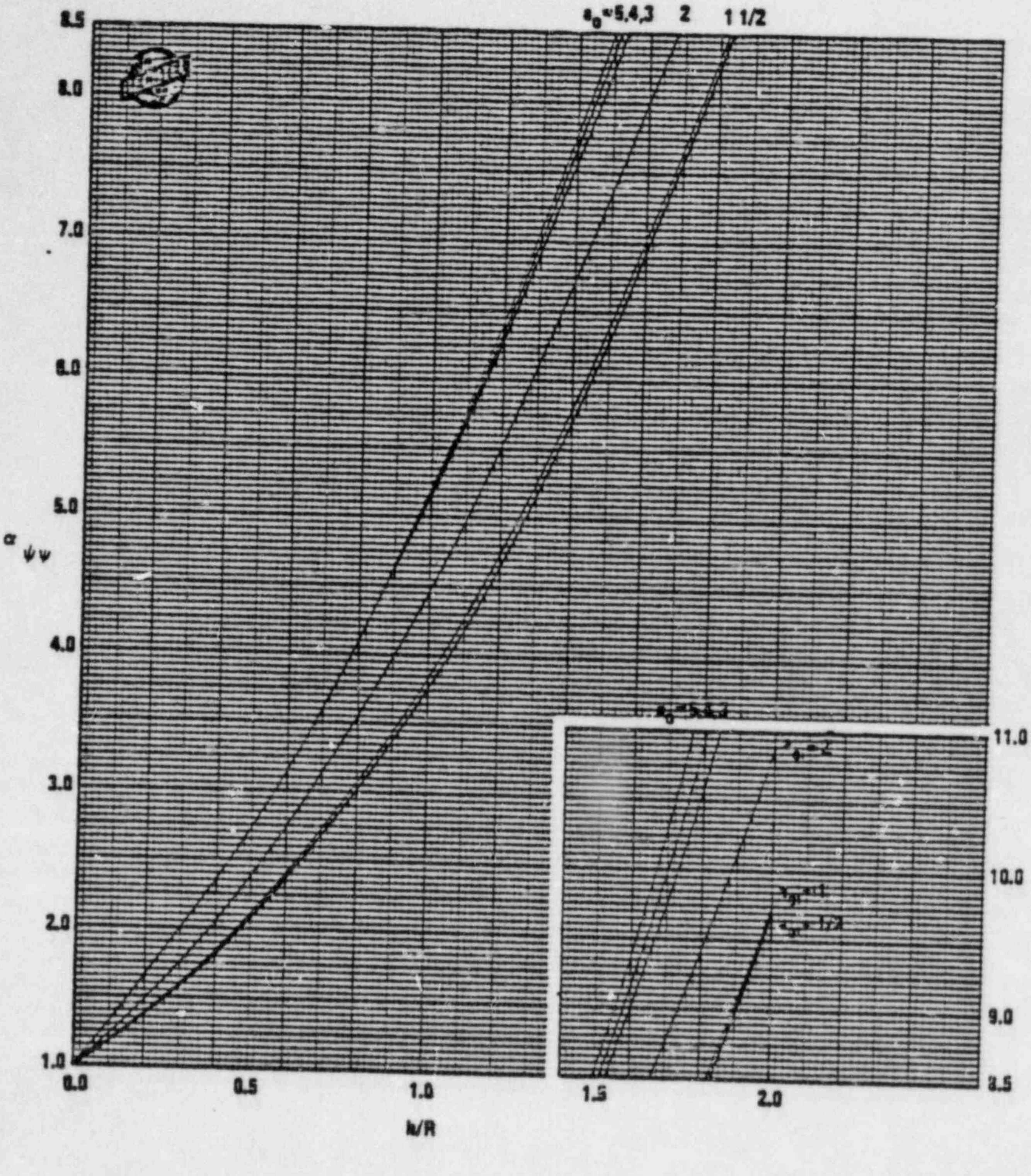


Figure A-3 NORMALIZED EMBEDMENT STIFFNESS COEFFICIENT, $\alpha_{\psi\psi}$

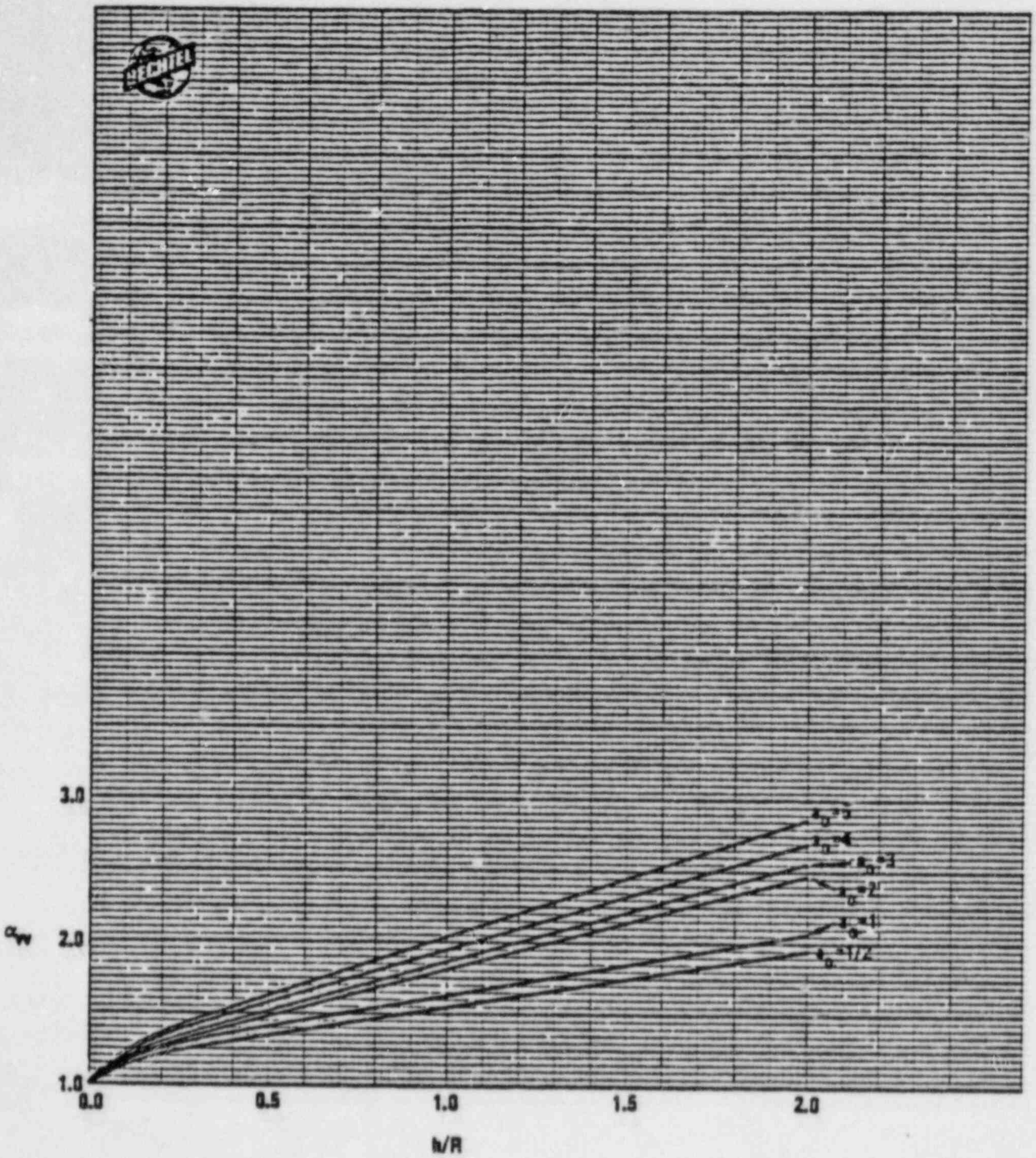


Figure A-4 NORMALIZED EMBEDMENT STIFFNESS COEFFICIENT, α_{vv}

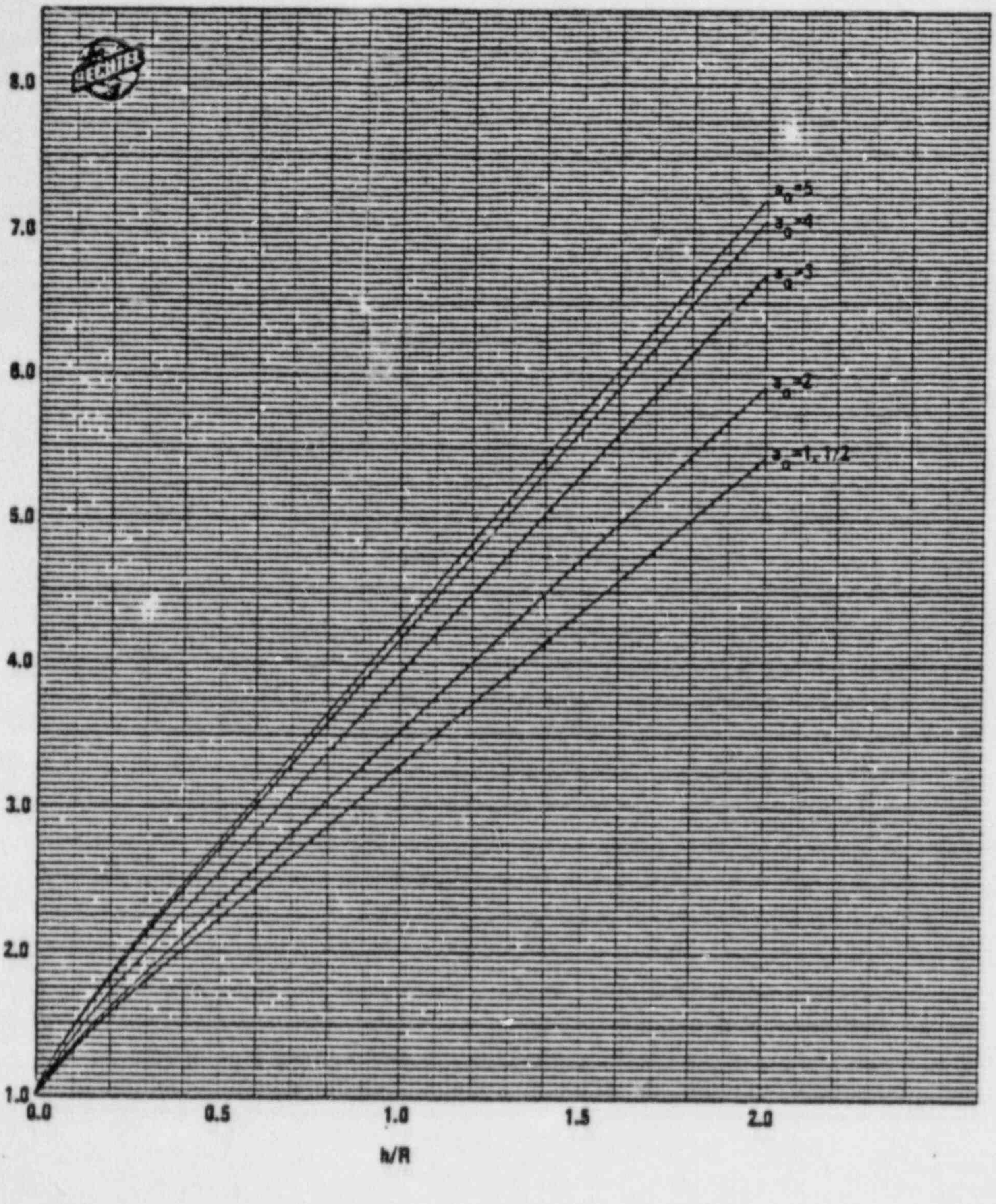


Figure A-5 NORMALIZED EMBEDMENT STIFFNESS COEFFICIENT, α_{tt}

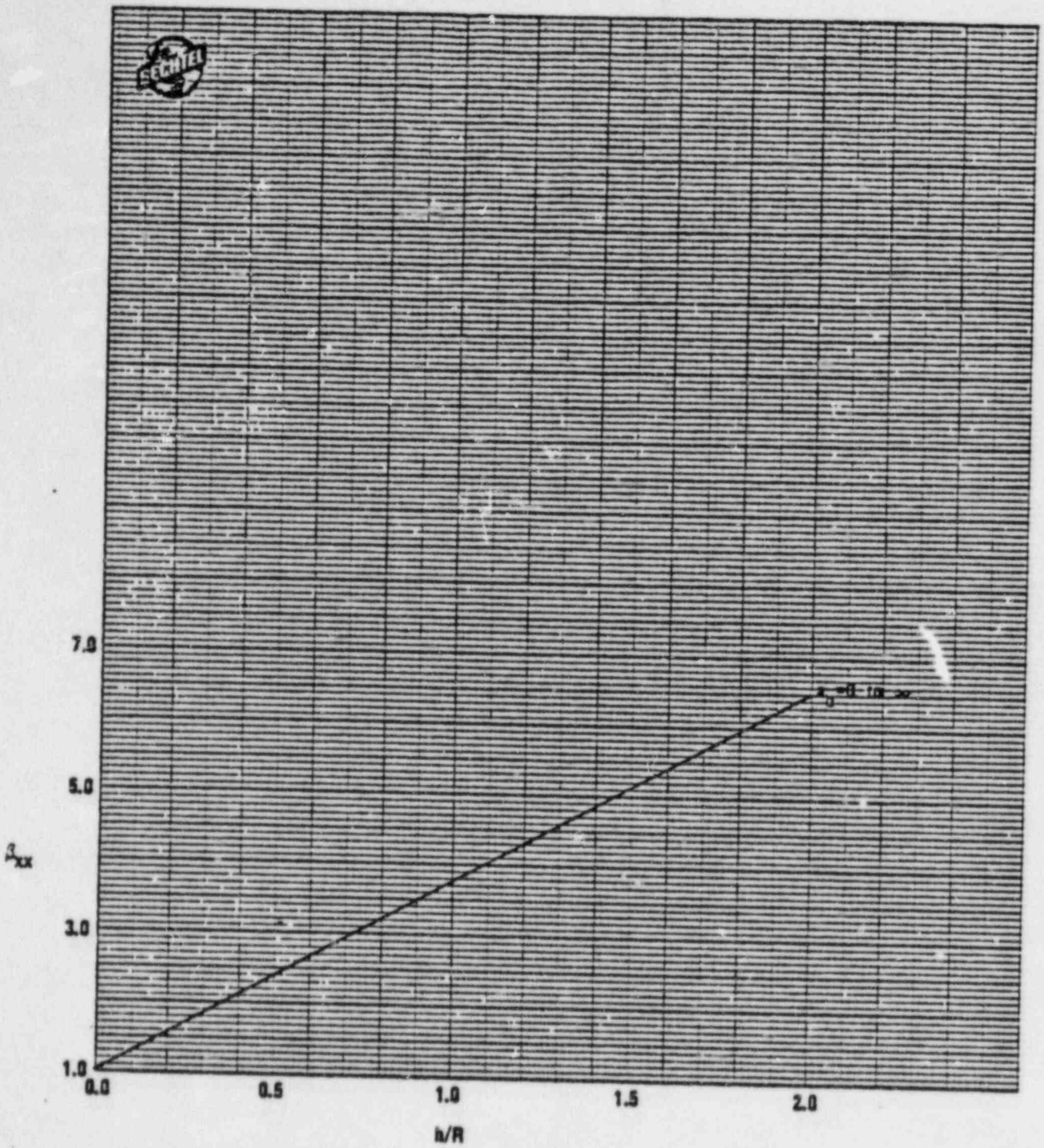


Figure A-6 NORMALIZED EMBEDMENT DAMPING COEFFICIENT, β_{xx}

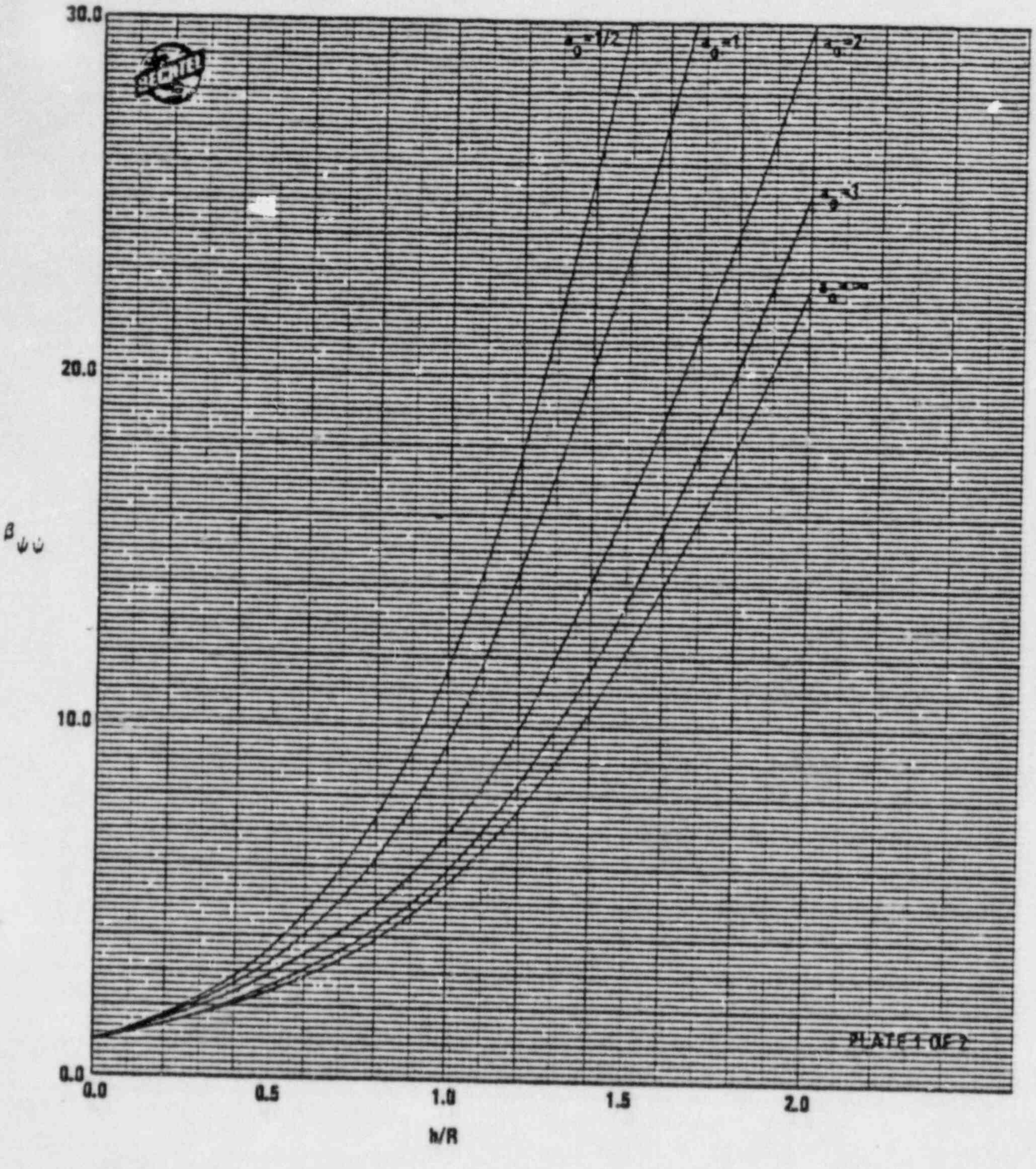


Figure A-7NORMALIZED EMBEDMENT DAMPING COEFFICIENT, $\beta_{\psi\psi}$

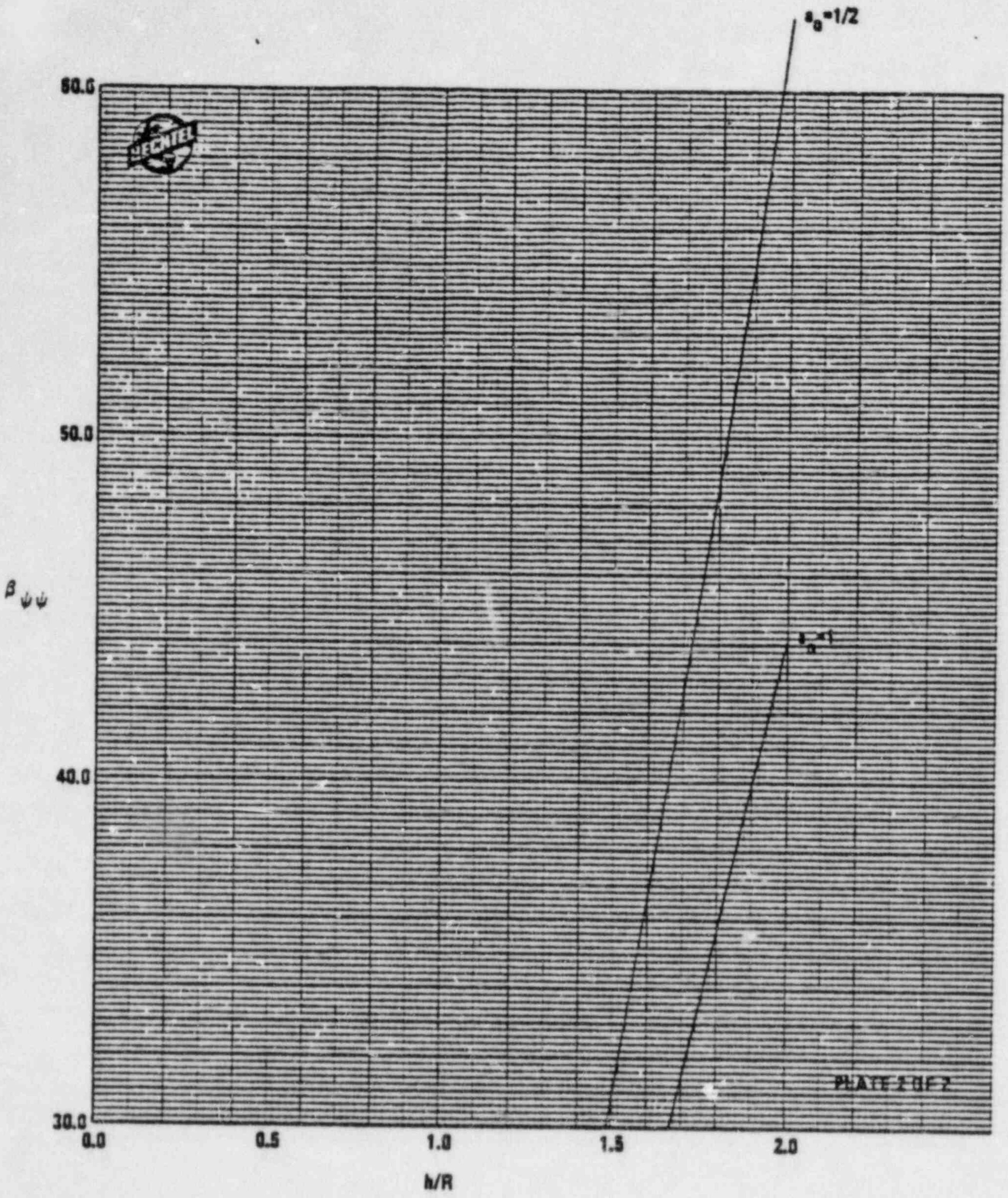


Figure A-7 NORMALIZED EMBEDMENT DAMPING COEFFICIENT, $\beta_{\psi\psi}$

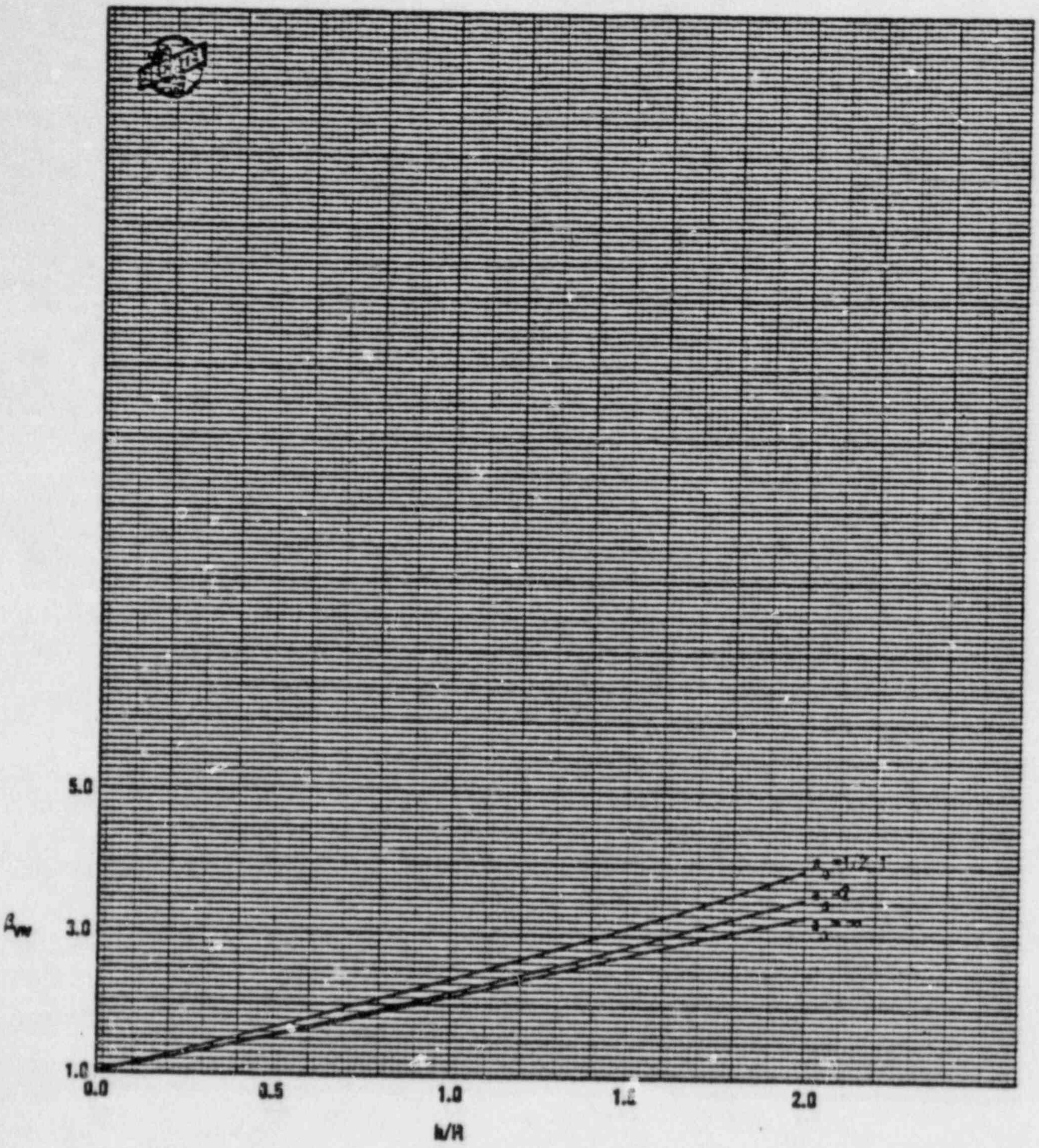


Figure A-8 NORMALIZED EMBEDMENT DAMPING COEFFICIENT, β_{vv}

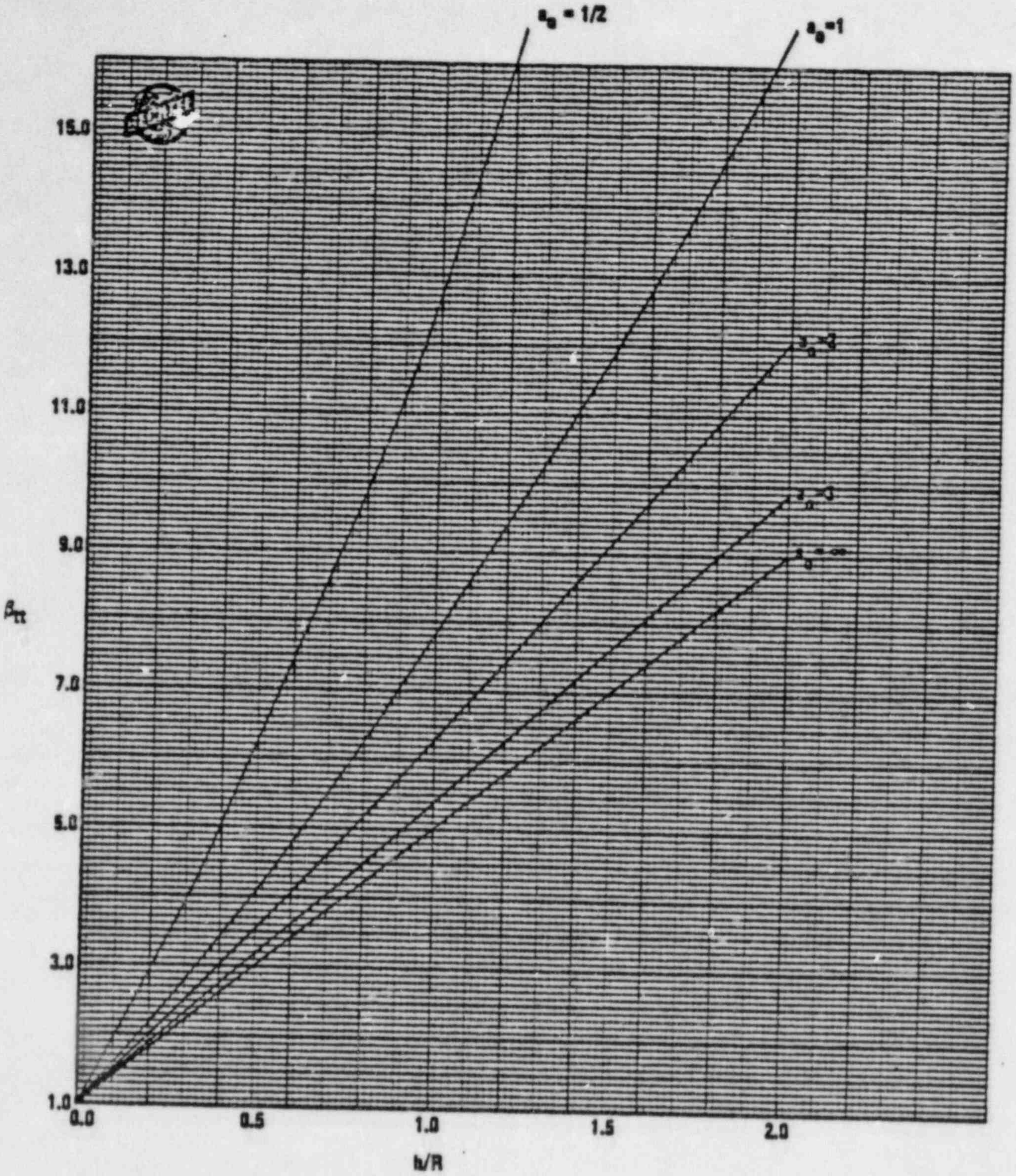


Figure A-9 NORMALIZED EMBEDMENT DAMPING COEFFICIENT, β_{tt}

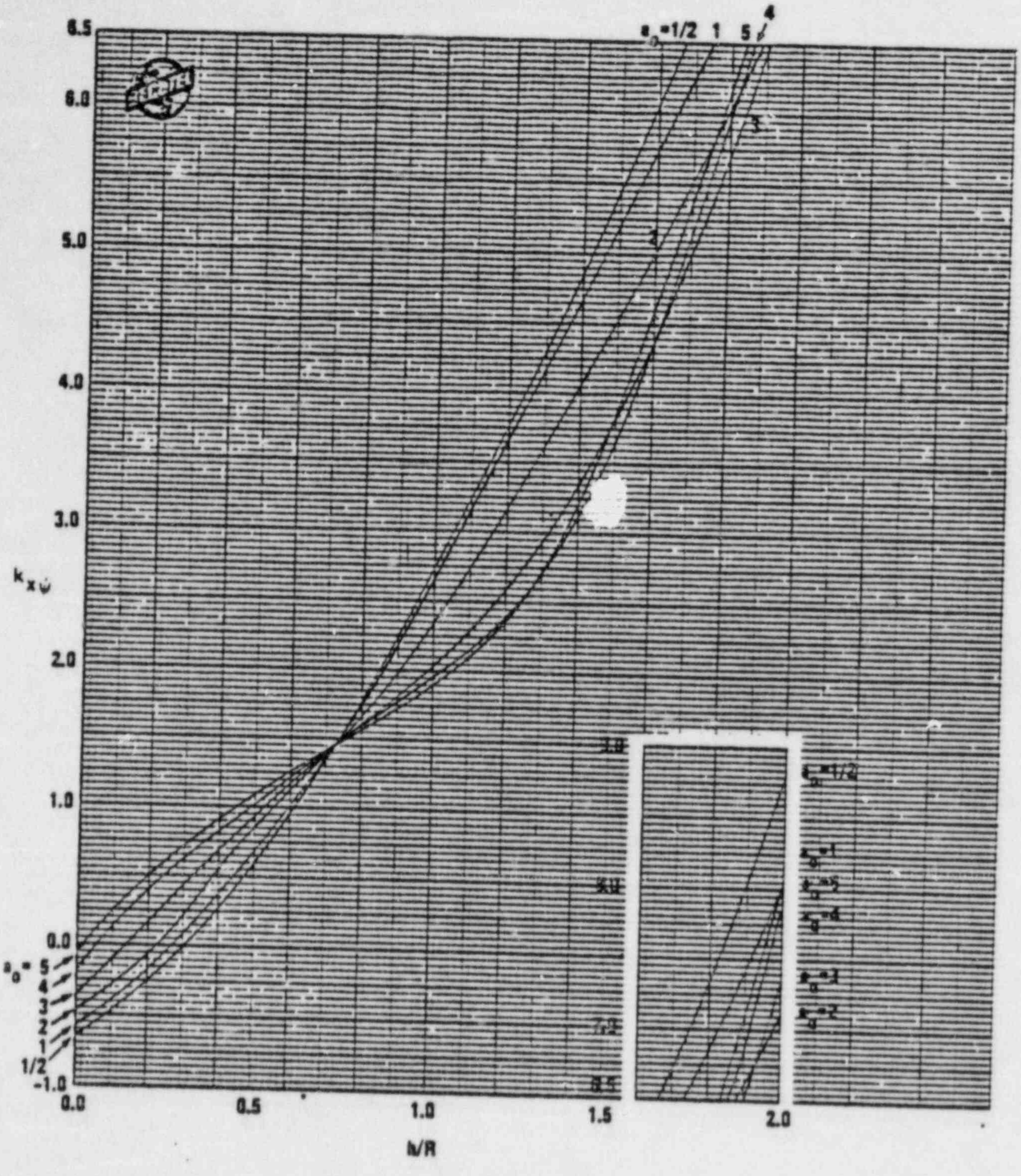


Figure A-10 STIFFNESS COEFFICIENT, $k_{x\psi}$

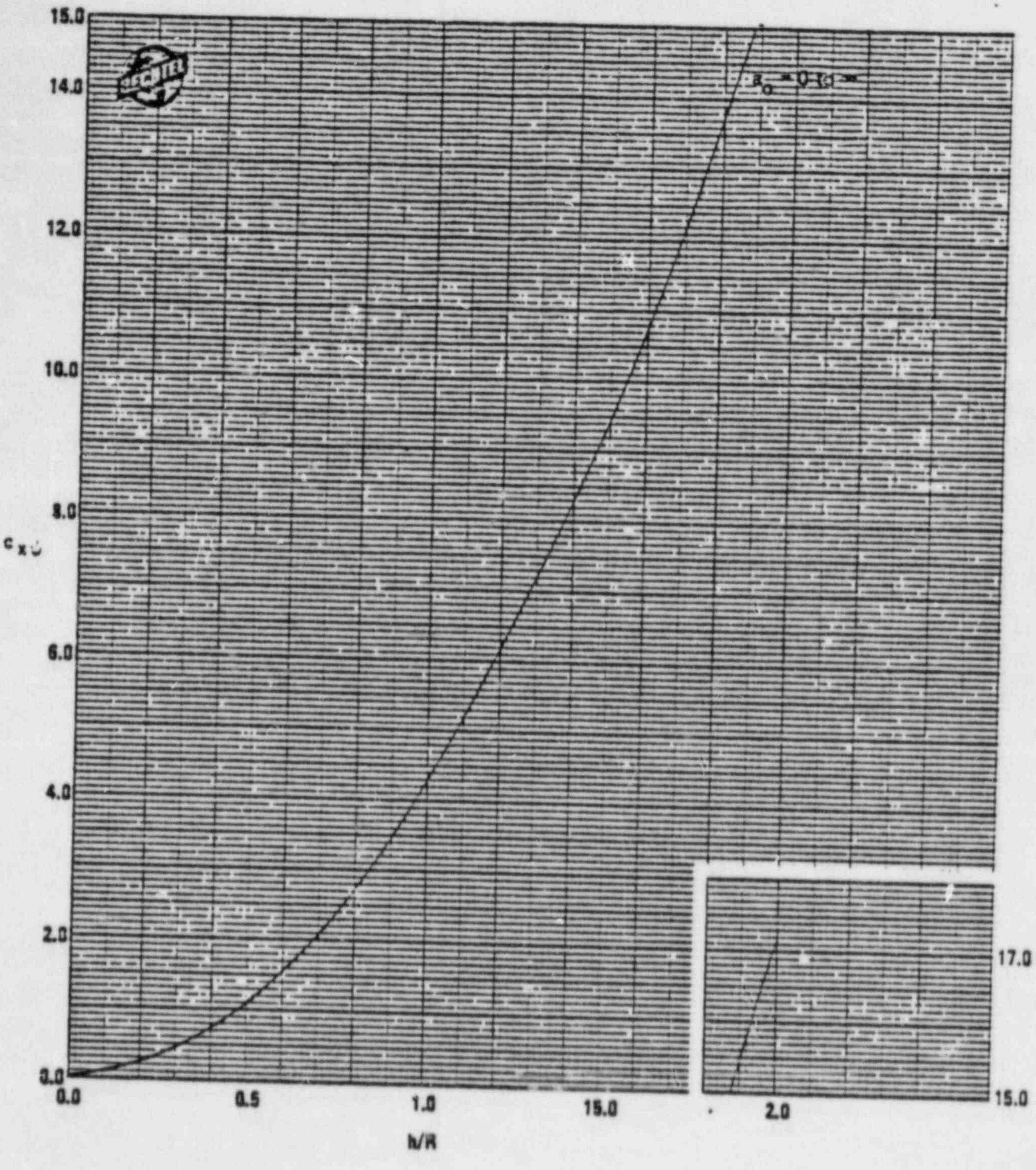


Figure A-1 DAMPING COEFFICIENT, $c_{x\psi}$

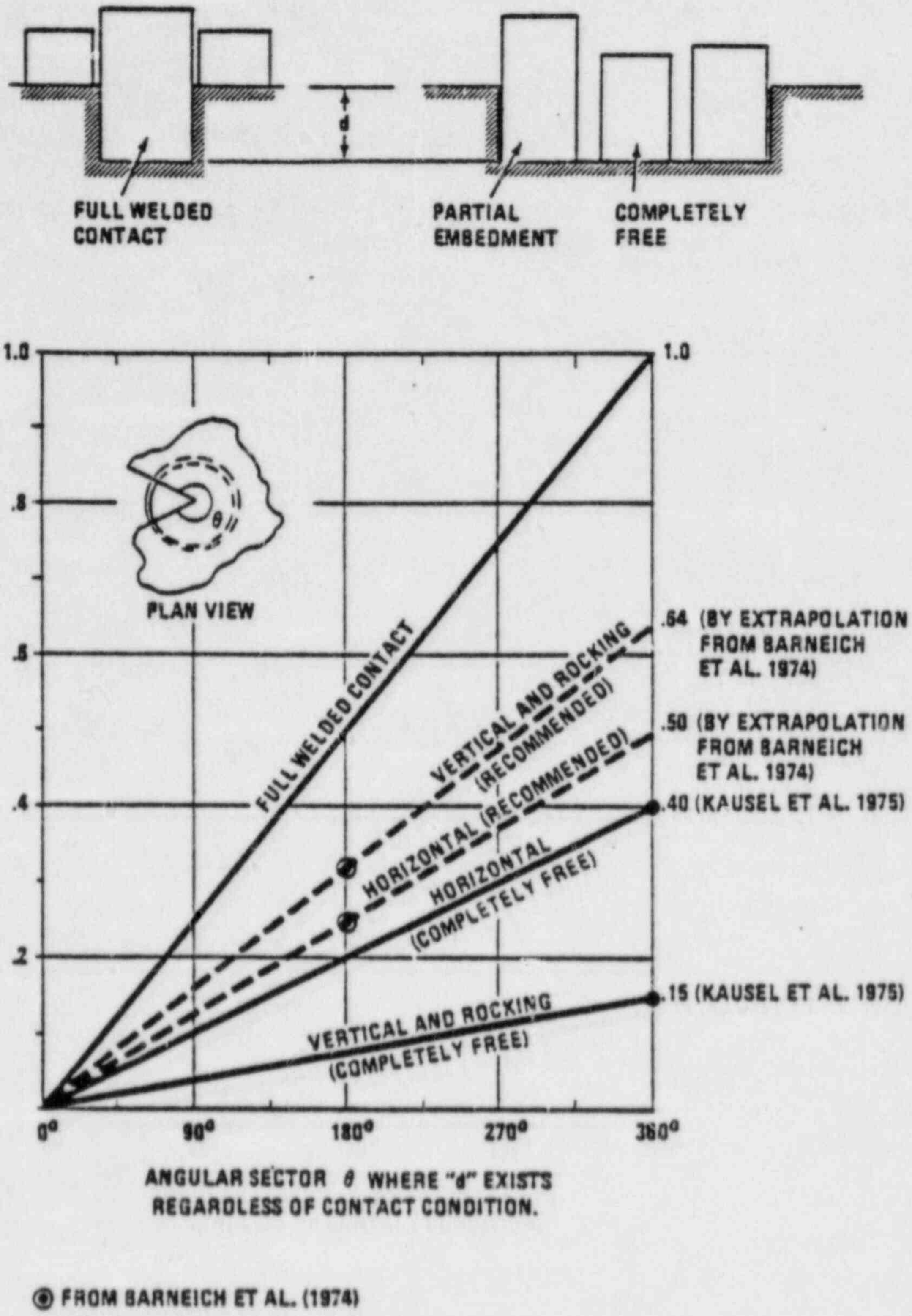


Figure A-12 EMBEDDED FOUNDATIONS. IMPEDANCE CORRECTION FACTOR *f* FOR SHALLOW EMBEDMENT.

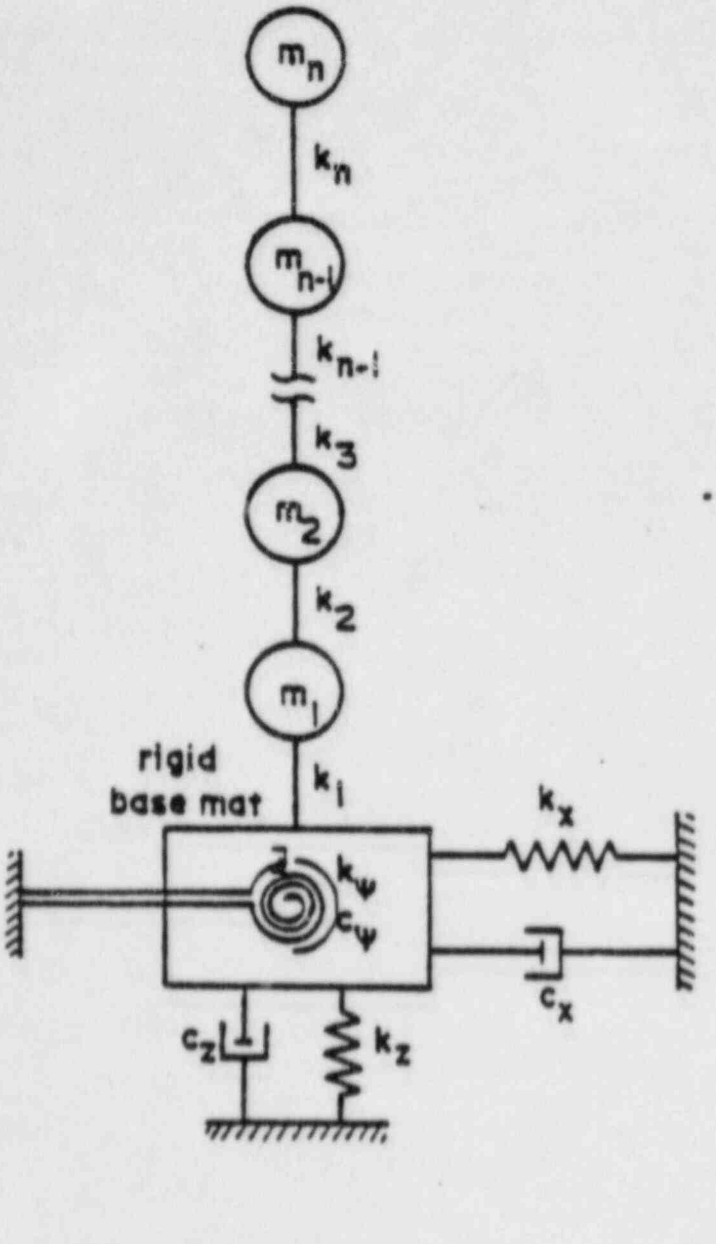


Figure A-13 A Lumped Mass Model of Structure-Foundation System

Table A-1*

LUMPED REPRESENTATION OF STRUCTURE-FOUNDATION INTERACTION

(a) Circular Base

Motion	Equivalent Spring Constant	Equivalent Damping Coefficient
Horizontal	$k_x = \frac{32(1-\nu)GR}{7-8\nu} = k_{ii}GR$	$c_x = 0.576k_x R \sqrt{\rho/G}$
Rocking	$k_\psi = \frac{8GR^3}{3(1-\nu)} = k_{\psi\psi}GR^3$	$c_\psi = \frac{0.30}{1+B} k_\psi R \sqrt{\rho/G}$
Vertical	$k_z = \frac{4GR}{1-\nu} = k_{zz}GR$	$c_z = 0.85k_z R \sqrt{\rho/G}$
Torsion	$k_t = 16\ GR^3/3 = k_{tt}GR^3$	$c_t = \frac{\sqrt{k_t I_t}}{1+2I_t/\rho R^5}$

where

ν = Poisson's ratio of foundation medium

G = shear modulus of foundation medium

R = radius of the circular basemat

ρ = mass density of foundation medium

$B_\psi = \frac{3(1-\nu)I_o}{8\rho R^5}$

I_o = total mass moment of inertia of structure and basemat about the rocking axis at the base

I_t = polar mass moment of inertia and structure and basemat

*Taken from BC-TOP-4A, Rev 3 Table 3.2

Table A-1 (Continued)

(b) Rectangular Base

Motion	Equivalent Spring Constant	Equivalent Damping Coefficient
Horizontal	$k_x = 2(1+\nu)G\beta_x\sqrt{BC}$	Use the formulae for circular base having an equivalent radius R defined by Table A-1(c).
Rocking	$k_\psi = \frac{G}{1-\nu}\beta_\psi\ B^2C$	
Vertical	$k_z = \frac{G}{1-\nu}\ \beta_z\ \sqrt{BC}$	
Torsion	Use Table A-1(a) for $R = \sqrt[4]{BC(B^2+C^2)/6\pi}$	

where

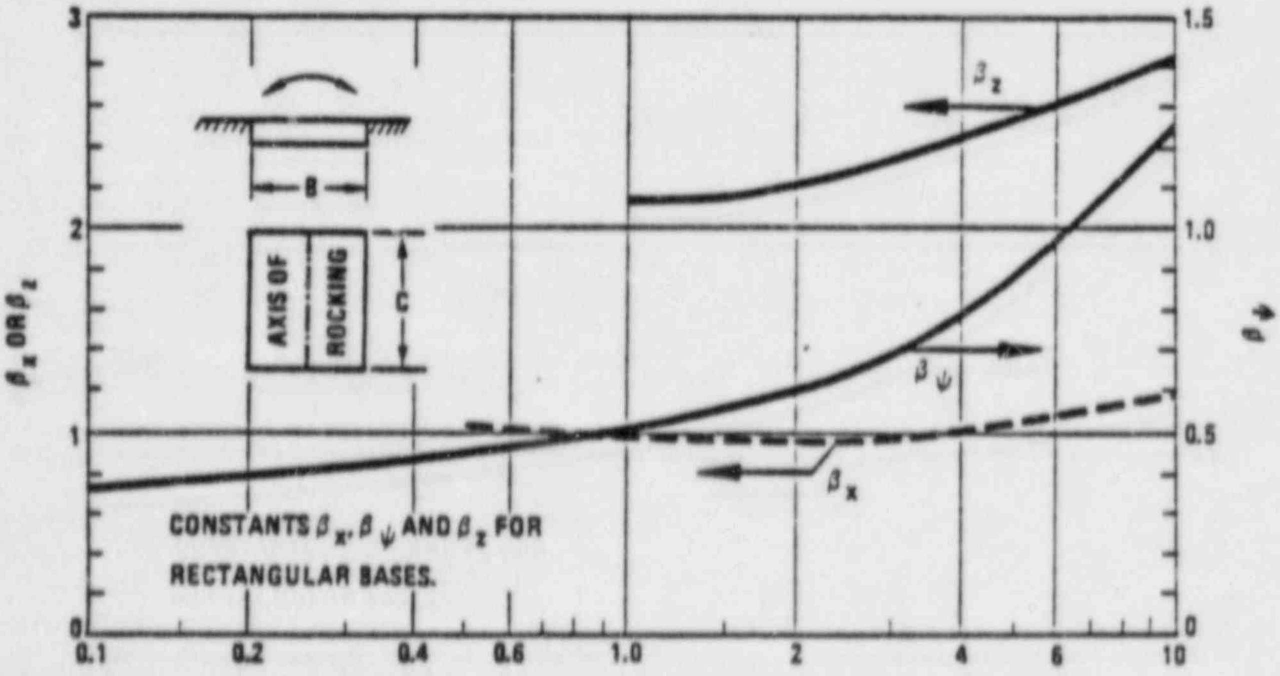
ν = Poisson's ratio of foundation medium

G = shear modulus of foundation medium

B = width of the basemat in the plane of horizontal excitation

C = length of the basemat perpendicular to the plane of horizontal excitation

$\beta_x, \beta_\psi, \beta_z$ = constants that are functions of the dimensional ratio, B/C and are given below



CONSTANTS β_x, β_ψ AND β_z FOR RECTANGULAR BASES.

Table A-1 (Continued)

(c) Equivalent Radius for Rectangular Base

For a rectangular base having a dimension of B x C (B = width of base in the plane of horizontal vibration), the equivalent radius R is taken to be the smallest of the parameters R_x, R_ψ and R_z defined below:

$$R_x = \frac{(1+\nu)(7-8\nu)\beta_x\sqrt{BC}}{16(1-\nu)}$$

$$R_\psi = \sqrt[3]{3\beta_\psi\ B^2C/8}$$

$$R_z = \frac{\beta z\sqrt{BC}}{4}$$

The parameters β_x, β_ψ, and β_z are determined in Table A-1(b).

(After Whitman and Richart, 1967).

J. Kane
1|B5

SERVICE WATER PUMP STRUCTURE
SEISMIC MODEL
REVISION 1

FOR

MIDLAND PLANT UNITS 1 & 2
CONSUMERS POWER COMPANY
SEPTEMBER 28, 1981

Encl. 1 to Sept 30, 1981 letter (Cook to Denton)

8110220344 35pp.

CONTENTS

FIGURES

SERVICE WATER PUMP STRUCTURE SEISMIC MODEL

1. MODEL DESCRIPTION

The model described herein will be used to evaluate the overall building response to seismic loadings as well as to generate in-structure response spectra. The responses developed from this model will provide input to other static analyses to develop forces in the individual structural elements. The building is represented by a three-dimensional lumped-mass stick model using beam elements (Figures 1 through 4). The individual sticks have been located at the calculated center of shear resistance.

The mass of the structure is lumped at the major floor elevations (see Figure 5). The mass includes concrete, steel, blockwalls, major equipment, water within building, entrapped soil, and 25% of the floor design live loading. The center of mass was established for each floor level and the eccentricity between the center of mass and center of rigidity is included in the model. Rigid beam elements are used to connect the center of stiffness and center of mass.

The proposed underpinning design underneath the northern portion of the building has been accounted for in the section properties below el 620'. The underpinning wall layout is connected to the existing wall to make up the extention of the stick to el 587'. It should be noted that the properties used for the underpinning portion of the model reflect the design described in a letter from J.W. Cook to H.R. Denton, Serial 13738, August 26, 1981, with the enclosure, Midland Unit 1 and 2 Technical Report on Underpinning the Service Water Pump Structure.

Basic Modeling Assumptions:

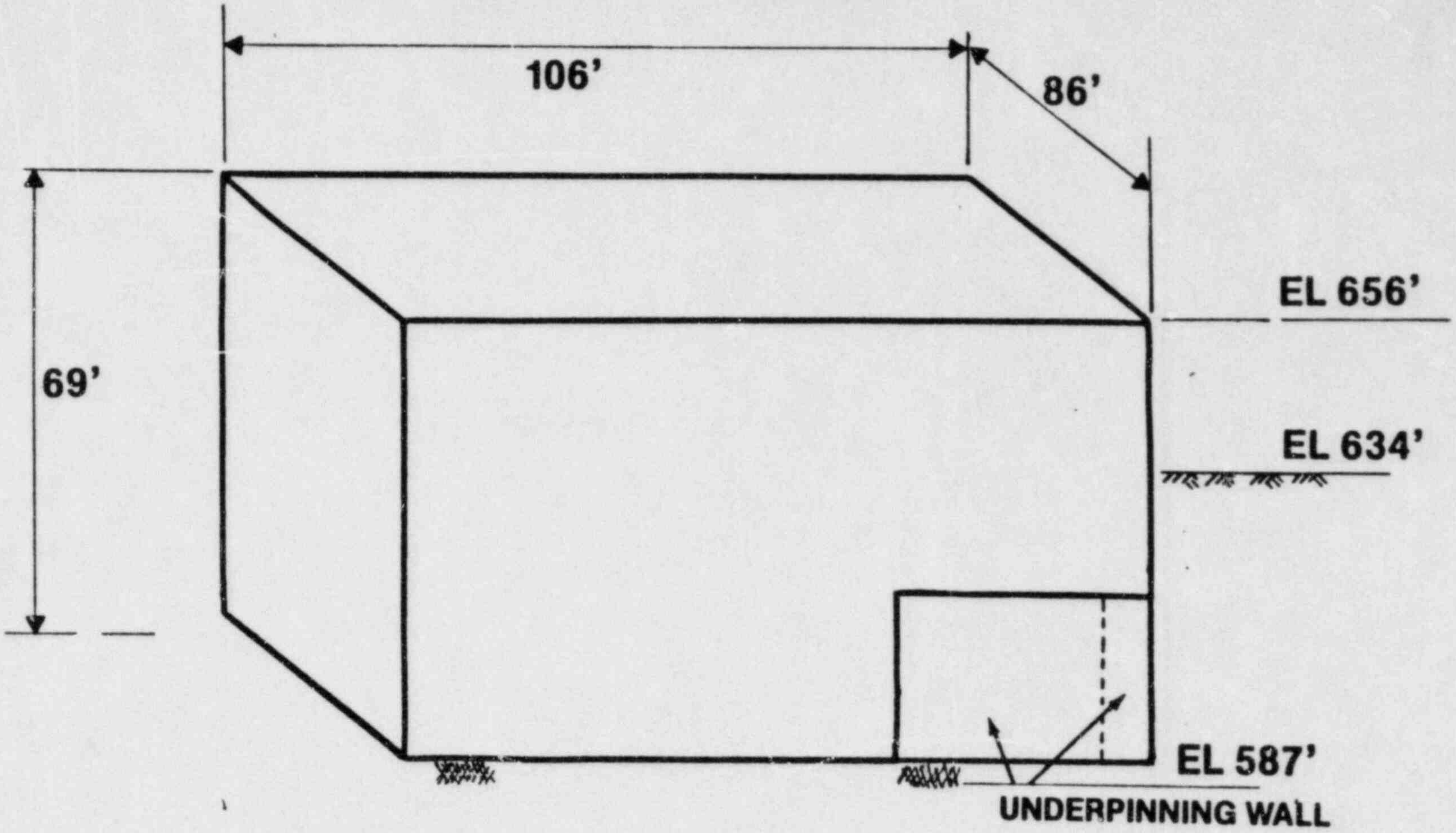
1. Torsional effects due to structural eccentricities and one empty pump bay are considered in the dynamic analysis.

2. Model properties are based on gross concrete properties.

3. Soil-structure interaction will be represented by equivalent spring constants and damping coefficients based on elastic half-space theory.

4. The effect of surrounding structures is negligible.

SERVICE WATER PUMP STRUCTURE

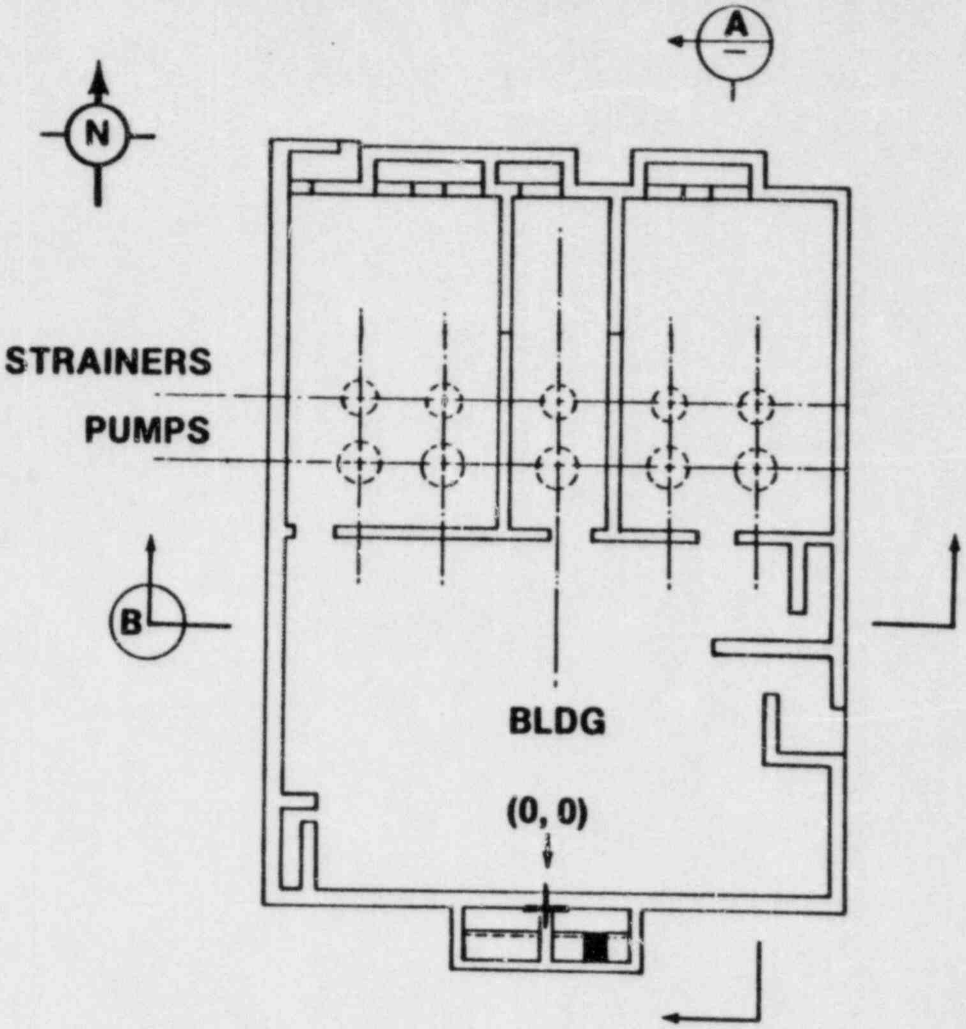


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SERVICE WATER
PUMP STRUCTURE
SCHEMATIC VIEW

FIGURE 1

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

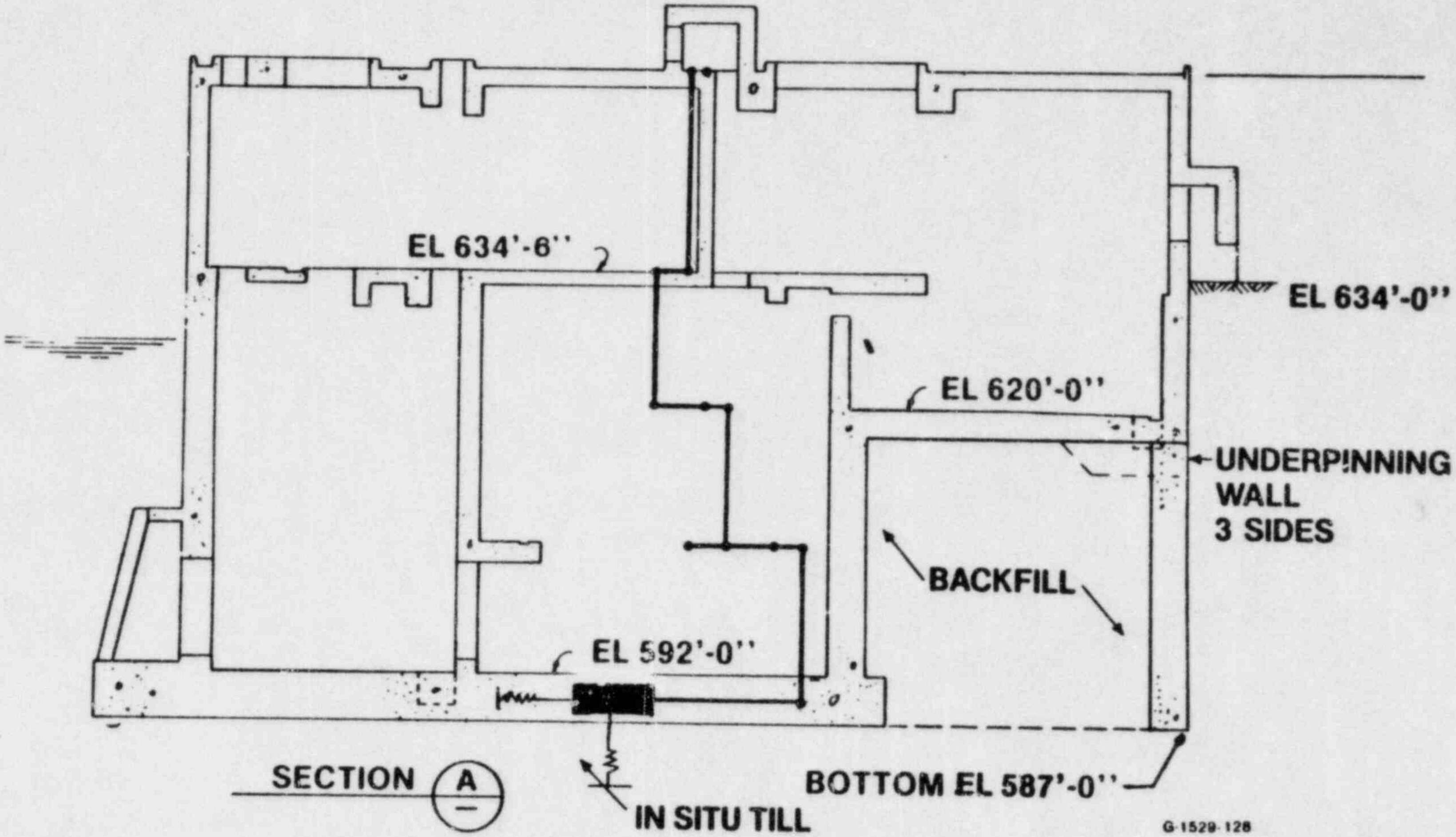


CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SERVICE WATER
PUMP STRUCTURE
PLAN

FIGURE 2

SERVICE WATER PUMP STRUCTURE
SECTION A



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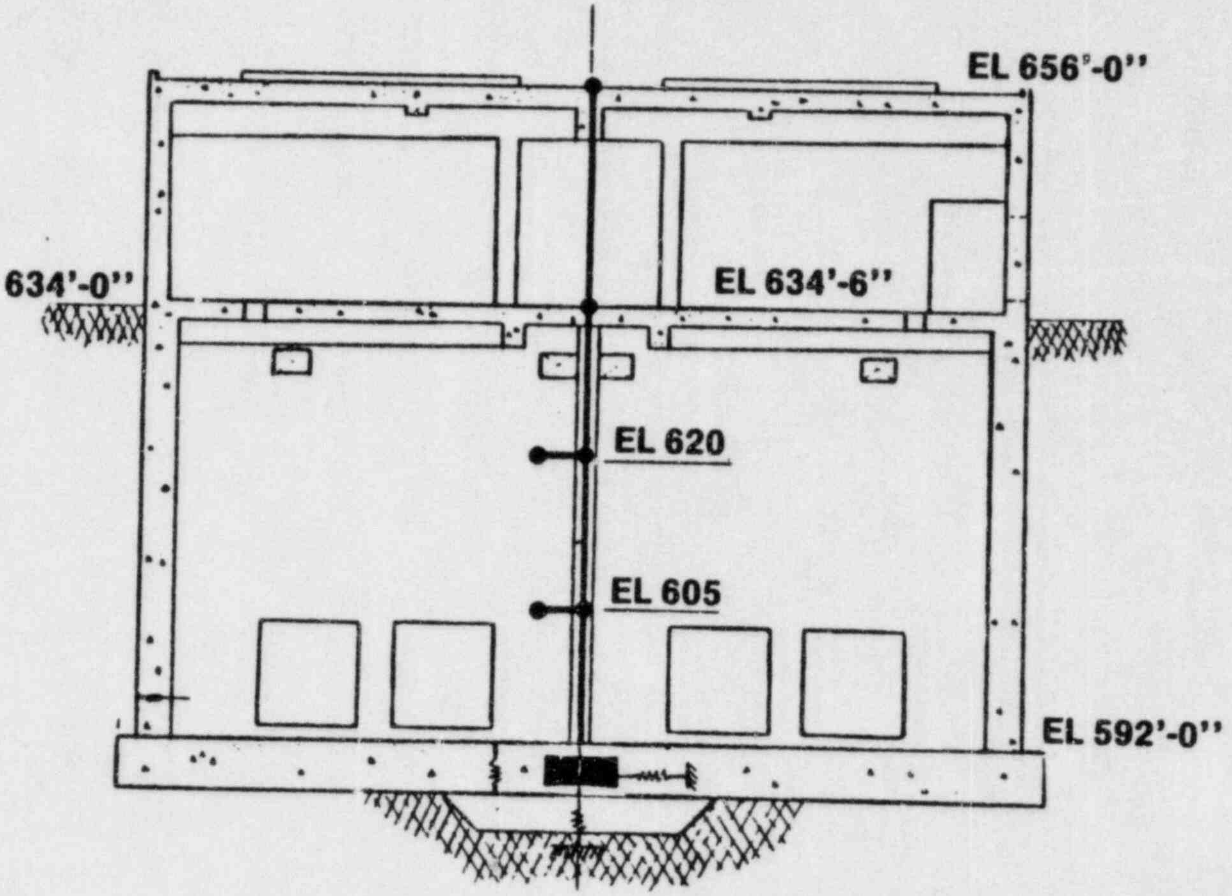
MIDLAND PLANT UNITS 1 AND 2

SERVICE WATER
PUMP STRUCTURE
NORTH-SOUTH SECTION

FIGURE 3

SERVICE WATER PUMP STRUCTURE
SECTION B



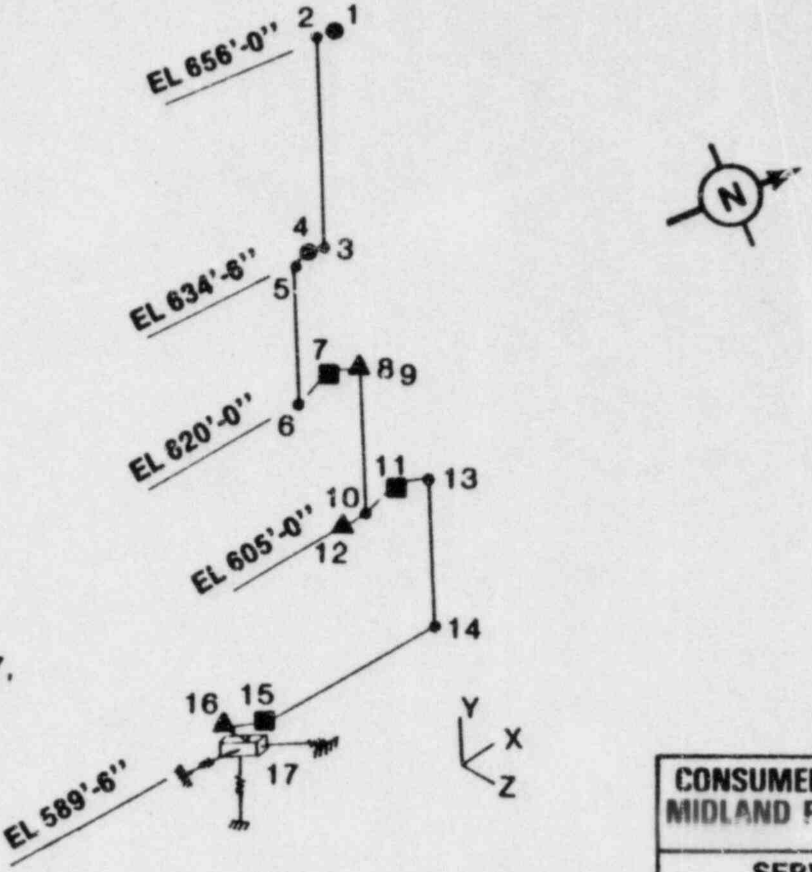
CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SERVICE WATER
PUMP STURCTURE
EAST-WEST VIEW

FIGURE 4

LEGEND

- • Node locations
- ● Mass for all 3 degrees of freedom
- ■ Mass for two horizontal degrees of freedom
- ▲ Mass for vertical degree of freedom
- Base location. Damper rotational springs not shown for clarity



NOTES:

1. The mass of the water is lumped at mass points 7, 11, and 15 horizontally and at mass point 16 vertically.
2. The mass of the fill entrapped within the underpinning walls is lumped at mass points 7, 11, and 15 for the two horizontal degrees of freedom only.

CONSUMERS POWER COMPANY
MIDLAND PLANT UNITS 1 AND 2

SERVICE WATER
PUMP STRUCTURE
NODE LAYOUT

FIGURE 5

G-1858-01

5. Sloshing water effects are negligible.

2. REVIEW INFORMATION

A. AREAS OF DEVIATION FROM FSAR CRITERIA (REVISION 36)

1. Subsection 3.7.1.2

   The modified Taft time-history has been adjusted to envelop the horizontal site design response spectra (for the 2% and greater dampings) in Figures 3.7-1 and 3.7-2 with the 50% increase described in Subsection 3.7.1.1.

2. Section 3.7.1.3

   Soil material damping has been accounted for in the present analysis.

3. Section 3.7.2.1

   Reference is made to the impedance functions as being those directly calculated from BC-TOP-4A, Revision 3, Table 3.2. Embedment considerations will be included.

   The computer programs referenced in this section does not include BSAP-DYNAM. Verification will be included in Appendix 3C, for BSAP-DYNAM.

4. Subsection 3.7.2.3

   A three-dimensional model is being used which considers torsional effects.

5. Subsections 3.7.2.4 and 2.5.4.7

   The consideration of embedment will be addressed in these sections and the assumptions that exist concerning embedment will be deleted. A summary of soil properties used will be included.

6. Subsection 3.7.2.9

   The effect of parameter variation on in-structure floor response spectra will be at least equal to ±15%.

7. Subsection 3.7.2.11

   Dynamic torsional effects have been considered.

8. Subsection 3.7.2.15

   Embedment effects will be considered.

9. The following figures will be changed.

   Figures

   3.7-3 3.7-4
   3.7-5 3.7-6
   3.7-7 3.7-8

B. COMMITTMENTS FOR FSAR REVISIONS

1. BSAP-DYNAM (CE 207) will be added to Appendix 3C.

2. An addition will be made to the FSAR addressing soil-structure interaction with embedment.

3. The method presented for the consideration of torsional response will be revised to reflect the inclusion of this effect in the revised seismic model.

4. The use of soil material damping as well as radiation damping will be addressed in the discussion of critical damping.

5. Techniques for broadening in-structure response spectra curves will be included.

C. OVERVIEW OF HOW THE REVISED MODEL HANDLES DYNAMIC EXCITATION

The BSAP computer program enables excitation of the base by the input forcing function along each of the three principle directions. These single-direction solutions are then combined.

D. MIDLAND SEISMIC ANALYSIS CRITERIA

1. Soil Properties

- a. Till Material Properties

  A nominal soil dynamic modulus of elasticity of 22,000 ksf and a Poisson's ratio of 0.42 is used as uniform foundation media properties to compute the soil impedance functions for both the SSE and OBE.

- b. Fill material properties are based on 10 CFR 50.54(f) investigations by Bechtel.

2. Analyses are based upon the FSAR's 0.12 g SSE design spectra and damping.

3. The seismic analysis and evaluation of the structure considers the following:

   - a. Variation of ±50% in the dynamic modulus of elasticity of the till is used to develop upper bound building forces.

   - b. Dynamic torsion is considered in the seismic analysis.

   - c. Embedment effects are considered.

   - d. The impedance functions are represented by the equivalent spring stiffnesses and radiation damping coefficients specified in Table 3-2 of BC-TOP-4-A, Revision 3.

   - e. Soil material damping (3% of critical damping) will be added directly to the radiation damping calculated.

   - f. Response spectra calculated using nominal soil properties will be widened by at least ± 15% according to Regulatory Guide 1.122.

   - g. Any computed composite modal damping exceeding 10% of critical will be limited to a maximum of 10% of critical except for those modes clearly associated with rigid body translation or rotation (BC-TOP-4A, Section 3.3.1, Revision 3).

3. SOIL-STRUCTURE INTERACTION TECHNIQUE

Soil-structure interaction has been counted for by using a lumped-parameter representation. Impedance coefficients representing the foundation media were derived based on elastic half-space the [illegible] These impedance coefficients have been adjusted [illegible] embedment conditions.

A. GENERAL ASSUMPTIONS AND METHODOLOGY

The elastic half-space impedance coefficients were calculated in accordance with BC-TOP-4A, Revision 3. The effect of embedment was considered in the form of multipliers to the calculated elastic half-space spring constants and damping coefficients. A detailed discussion of how the embedment multipliers were developed is described in Appendix A of the Auxiliary Building Seismic Model Report. The foundation consists of the foundation mat at el 587'-0" and the underpinning walls. The foundation contact area was transformed into equivalent rectangles (maintaining equivalent areas for translation and equivalent moment of inertias for rocking). The horizontal and torsional spring constants and damping coefficients were based on the entire foundation mat, fill, and underpinning walls area. The vertical and rocking spring constants and damping coefficients were based on the foundation contact area at el 587 (foundation mat and underpinning walls). Additionally, 3% soil material damping was applied at the base point in all six degrees of freedom. (This value was conservatively selected from Figure 2-4 of BC-TOP-4A, Revision 3). All soil spring constants and damping coefficients were located at the centroid of the foundation contact area (foundation mat and underpinning walls).

B. SOILS DATA

Strain Range - general site range of 10^{-2} to 10^{-3}%, FSAR Subsection 2.5.4.7

Properties of Material Below Foundation: (E = 22,000 ksf ± 50% as recommended by Dames and Moore: FSAR Subsection 2.5.4.7)

where

$\nu = 0.42$

$\rho = 135$ pcf

G = 7.8E3 ksf (nominal)

Average properties of fill material along the sides of the service water pump structure used to develop embedment effect:

where

G = 1.4E3 ksf*

*The shear modulus of fill has been degraded to earthquake strain levels by the Seed and Idriss curves from BC-TOP-4A, Revision 3, Figures 2-3 and 2-5. Only the averaged shear modulus is required for the side soil in the embedment calculations.

C. RESULTS OF LUMPED-PARAMETER REPRESENTATION FOR THE FOUNDATION MEDIA

The equivalent half-space soil spring constants and damping coefficients developed with and without the effect of embedment have been tabulated below.

SOIL SPRING CONSTANTS AND DAMPING COEFFICIENTS

WITHOUT THE EFFECT OF EMBEDMENT

Motion	Spring Constant	Radiation Damping Coefficient
Translational		
North-South	Kxx = 2.0E6 k/ft	Cxx = 4.3E4 $\frac{\text{k-sec}}{\text{ft}}$
East-West	Kzz = 2.1E6 k/ft	Czz = 4.6E4 $\frac{\text{k-sec}}{\text{ft}}$
Vertical	Kyy = 2.5E6 k/ft	Cyy = 6.6E4 $\frac{\text{k-sec}}{\text{ft}}$
Rotational		
East-West	Kψzz = 5.0E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψxx = 4.1E7 $\frac{\text{k-ft-sec}}{\text{rad}}$
North-South	Kψxx = 4.6E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψzz = 3.7E7 $\frac{\text{k-ft-sec}}{\text{rad}}$
Torsion	Kψyy = 6.8E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψyy = 3.8E7 $\frac{\text{k-ft-sec}}{\text{rad}}$

SOIL SPRING CONSTANTS AND DAMPING COEFFICIENTS

WITH THE EFFECT OF EMBEDMENT

Motion	Spring Constant	Radiation Damping Coefficient
Translational		
North-South	Kxx = 2.1E6 k/ft	Cxx = 5.1E4 $\frac{\text{k-sec}}{\text{ft}}$
East-West	Kzz = 2.2E6 k/ft	Czz = 5.4E4 $\frac{\text{k-sec}}{\text{ft}}$
Vertical	Kyy = 2.6E6 k/ft	Cyy = 7.9E4 $\frac{\text{k-sec}}{\text{ft}}$
Rotational		
North-South	Kψzz = 6.6E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψxx = 2.1E8 $\frac{\text{k-ft-sec}}{\text{rad}}$
East-West	Kψzz = 6.0E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψzz = 1.7E8 $\frac{\text{k-ft-sec}}{\text{rad}}$
Torsion	Kψyy = 7.1E9 $\frac{\text{k-ft}}{\text{rad}}$	Cψyy = 4.8E7 $\frac{\text{k-ft-sec}}{\text{rad}}$

Kxx = translational soil stiffness in x-direction
Kψxx = rotational soil stiffness about x-x axis

D. CALCULATION OF COMPOSITE MODAL DAMPING

A fixed-base modal analysis utilizing the strain energy approach was used to develop composite structural modal damping. The fixed-base modal results are then used as input to BSAP-DYNAM (CE 207) to develop the soil-structure interaction composite modal damping analysis. The technique used in CE 207 matches the rigorous and normal mode solutions of the transfer function simultaneously at all the natural frequencies within the frequency range of interest. The technique follows the work mentioned in Reference 1, but has been extended based on References 2 and 3 for three-dimensional use.

E. REFERENCES

1. Tsai, N.C., (1972) Soil-Structure Interaction During Earthquake, Technical Report, Power and Industrial Division, Bechtel Corporation, San Francisco, California

2. Ibrahim, A.M. and Hadjian, A.H., *The Composite Damping Matrix Matrix for a Three Dimensional Soil-Structure System*, 2nd ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities, pp. 932, New Orleans (1975)

3. Atalik, T.S., *Equivalent Interaction Modal Damping*, Proceedings, 7th World Conference on Earthquake Engineering, August, Istanbul, Turkey (1980)

4. DYNAMIC MODEL PROPERTIES

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D                                  091681
CE800D15
    C O M P L E T E   C A R T E S I A N   N O D A L   C O O R D I N A T E S . . .  UNITS OF ( L )

  NODE      . . BOUNDARY CONDITION CODES . .            . . NODE COORDINATES . .                              NODAL
 NUMBER  ID(X)  ID(Y)  ID(Z) ID(XX) ID(YY) ID(ZZ)        X(N)      Y(N)       Z(N)                          SYSTEM
(NOTE 1)                   (NOTE 2)                              (NOTE 3)                                  (NOTE 4)
      1    0      0      0      0      0      0       54.400   656.000      .000                           GLOBAL
      2    0      0      0      0      0      0       53.310   656.000      .000                           GLOBAL
      3    0      0      0      0      0      0       53.310   634.500      .000                           GLOBAL
      4    0      0      0      0      0      0       50.900   634.500      .000                           GLOBAL
      5    0      0      0      0      0      0       49.540   634.500      .000                           GLOBAL
      6    0      0      0      0      0      0       49.540   620.000      .000                           GLOBAL
      7    0      0      0      0      0      0       54.940   620.000    -1.880                           GLOBAL
      8    0      0      0      0      0      0       57.330   620.000      .000                           GLOBAL
      9    0      0      0      0      0      0       57.150   620.000      .000                           GLOBAL
     10    0      0      0      0      0      0       57.150   605.000      .000                           GLOBAL
     11    0      0      0      0      0      0       62.440   605.000    -1.530                           GLOBAL
     12    0      0      0      0      0      0       54.380   605.000      .000                           GLOBAL
     13    0      0      0      0      0      0       65.180   605.000      .000                           GLOBAL
     14    0      0      0      0      0      0       65.180   589.500      .000                           GLOBAL
     15    0      0      0      0      0      0       45.520   589.500     -.520                           GLOBAL
     16    0      0      0      0      0      0       42.180   589.500    -2.910                           GLOBAL
     17    0      0      0      0      0      0       43.020   589.500      .000                           GLOBAL
```

NOTES: 1. NODE NUMBER: The nodes are shown schematically in Figure 5.

2. BOUNDARY CONDITIONS: Zero (0) or blank indicates an active (free) degree of freedom. One (1) indicates a fixed degree of freedom.

3. NODE COORDINATES: Distances (ft.) from the origin of the nodal system.

4. NODAL SYSTEM: Defines the local coordinate system for nodal input. The word GLOBAL indicates that the global cartesian coordinate system is used. The origin of the system is shown in Figure 2. The orientation of the system is shown in Figure 5.

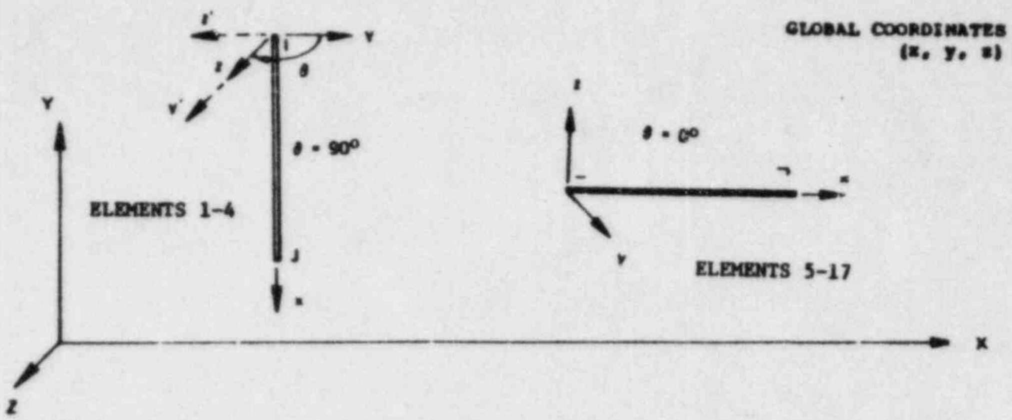
TABLE OF BEAM MATERIAL PROPERTIES

MATERIAL NUMBER (NOTE 1)	YOUNG*S MODULUS (NOTE 2)	POISSON*S RATIO (NOTE 3)
1	552000.00	.2500

NOTES: 1. MATERIAL NUMBER: Beam element material property set number. Refer to page 4-5. In this analysis, MATL. NO. 1 is concrete.

2. YOUNG'S MODULUS: Expressed in (k/ft^2).

3. POISSON'S RATIO: Dimensionless.



GLOBAL COORDINATES (X, Y, Z) AND LOCAL COORDINATES
(x, y, z) SYSTEMS OF BEAM ELEMENT

TABLE OF BEAM SECTION PROPERTIES...

BEAM TYPE NUMBER (NOTE 1)	CROSS SECTIONAL AREA (NOTE 2)	EFFECTIVE SHEAR AREAS (NOTE 3)		MOMENTS OF INERTIA (NOTE 4)		
		LOCAL Y-AXIS A(XY)	LOCAL Z-AXIS A(XZ)	LOCAL X-AXIS (TORSIONAL) (NOTE 5)	LOCAL Y-AXIS I(Y)	LOCAL Z-AXIS I(Z)
1	977.100	580.800	469.500	.157830+07	964757.	.140512+07
2	1609.80	872.200	773.800	.244040+07	.151322+07	.215014+07
3	1886.50	888.800	1044.70	.292700+07	.181533+07	.255706+07
4	1822.76	917.400	1044.70	.248660+07	.181991+07	.245394+07
5	.200000+07	.200000+07	.200000+07	.100000+09	.100000+09	.100000+09

NOTES:

1. BEAM TYPE NUMBER: Beam element cross-section property set number. Refer to SECT. NO. on page 4-5.
2. CROSS SECTIONAL AREA: Expressed in (ft.^{2}).
3. EFFECTIVE SHEAR AREAS: Expressed in (ft.^{2}).
4. MOMENTS OF INERTIA: Expressed in (ft.^{4}).
5. LOCAL X-AXIS (TORSIONAL): Torsional resistance.

TABULATION OF DATA INPUT FOR BEAM ELEMENTS . . .

ELEMENT NUMBER	NODE -I	NODE -J	REF -K	MATL NO	SECT NO	END-CODES -I	-J	THETA ANGLE
	- -(NOTE 1)- -			(NOTE 2)	(NOTE 3)	(NOTE 4)		
1	2	3	-1	1	1	0	0	90.00
2	5	6	-1	1	2	0	0	90.00
3	9	10	-1	1	3	0	0	90.00
4	13	14	-1	1	4	0	0	90.00
5	1	2	-1	1	5	0	0	.00
6	3	4	-1	1	5	0	0	.00
7	4	5	-1	1	5	0	0	.00
8	6	7	-1	1	5	0	0	.00
9	7	9	-1	1	5	0	0	.00
10	9	8	-1	1	5	0	0	.00
11	10	11	-1	1	5	0	0	.00
12	12	10	-1	1	5	0	0	.00
13	11	13	-1	1	5	0	0	.00
14	14	15	-1	1	5	0	0	.00
15	15	16	-1	1	5	0	0	.00
16	16	17	-1	1	5	0	0	.00

NOTES: 1. NODE-I NODE-J REF-K: Node numbers which define the location and orientation of the beam element. A value of negative one (-1) in the REF-K column indicates that the Theta Angle method is used to define the local axis system.

2. MATL. NO.: Beam element material property set number. Refer to page 4-3.

3. SECT. NO.: Beam element cross-section property set number. Refer to BEAM TYPE NUMBER on page 4-4.

4. END CODES: Member end release codes. Zero (0) indicates that the element is restrained by the stiffness of other elements at the Ith or Jth node.

5. THETA ANGLE: When REF-K is equal to negative one (-1), then the local axis system of the beam element is defined by an angle called the Theta Angle. The Theta Angle is defined as follows:

> The angle θ is determined as right-hand rotation about the x axis required to bring the local y axis from its actual position into a plane parallel to the global x-z plane with the local z axis (in the rotated position) projecting positively onto the global y axis.
>
> For the beam element parallel to the global y axis, the local y axis is always in a plane parallel to the global x-z plane. In that case, the following definition applies: Angle θ is the right-hand rotation about the local x axis required to make the local y axis parallel to, and have a positive projection on, the global z axis.

Refer to the schematic on page 4-4.

```
 COMPOSITE MODAL DAMPING DATA


   FIRST   LAST       ELEMENT          % CRIT.                                   REPRESENTING
  ELEMENT ELEMENT      TYPE           DAMPING
 (NOTE 1) (NOTE 2)                     (NOTE 3)
     1       17        BEAM              .03                                     Concrete Beam Elements



  NOTES:  1. FIRST ELEMENT: The first element in the generated series.

          2. LAST ELEMENT: The last element in the generated series.

          3. % CRITICAL DAMPING: Material damping expressed as a ratio of critical damping.
             Values are according to Midland Units 1 and 2 Final Safety Analysis Report
             Response to Regulatory Guide 1.61.
```

```
    T A B L E   O F   V E C T O R   D I R E C T I O N   C O S I N E S . . .   (NOTE 1)

   VECTOR  X-COEFFICIENT   Y-COEFFICIENT   Z-COEFFICIENT
   NUMBER           A(X)            B(Y)            C(Z)

        1        1.00000          .00000          .00000
        2         .00000         1.00000          .00000
        3         .00000          .00000         1.00000
```

NOTES: 1. VECTOR DIRECTION COSINES: Defines the local x axis of boundary elements in terms of the global coordinate system. For example, a value of one (1) in the x coefficient column indicates that the local x direction coincides with the global x direction. The boundary element springs act in or about the local x axes of the elements.

For this analysis:

REF. VECTOR	SPRING ACTS IN GLOBAL
1	X
2	Y
3	Z

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D                         091681
CE800D15
T A B U L A T I O N   O F   D A T A   I N P U T   F O R   B O U N D A R Y   E L E M E N T S . . .

      ELEMENT                                              REF  DISPLACEMENT      ROTATION   DISP SPRING  ROTNL SPRING
       NUMBER            END-N                            VECTOR         CODE          CODE    STIFFNESS     STIFFNESS
                        (NOTE 1)                         (NOTE 2)      (NOTE 3)     (NOTE 4)   (NOTE 5)      (NOTE 6)
            1              17                                1             1             0   2.08970+06       .00000
            2              17                                3             0             1     .00000     6.56700+09
            3              17                                2             1             0   2.55700+06       .00000
            4              17                                3             1             0   2.15560+06       .00000
            5              17                                1             0             1     .00000     6.04200+09
            6              17                                2             0             1     .00000     7.07400+09
```

NOTES:

1. END-N: The node at which the boundary element is placed.

2. REF. VECTOR: Vector direction cosine number. Refer to VECTOR NUMBER on page 4-7 .

3. DISPLACEMENT CODE: Flag for translational stiffness. One (1) indicates a translational spring stiffness. Zero (0) indicates no translational spring stiffness.

4. ROTATION CODE: Flag for rotational stiffness. One (1) indicates a rotational spring stiffness. Zero (0) indicates no rotational spring stiffness.

5. DISP. SPRING STIFFNESS: Expressed in (k/ft).

6. ROTNL. SPRING STIFFNESS: Expressed in (k*ft/rad).

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D                                091681
CE800D15
G L O B A L  ( X, Y, Z )  N O D A L   M A S S E S . . . (NOTE 1)
                                                          (NOTE 4)                                (NOTE 4)
NODE      X-MASS          Y-MASS          Z-MASS       X-ROTNL MASS     Y-ROTNL MASS      Z-ROTNL MASS
 NO.   (F*(T**2)/L)    (F*(T**2)/L)    (F*(T**2)/L)    (F*L*(T**2))     (F*L*(T**2))      (F*L*(T**2))
                - - - - - (NOTE 2) - - - - -
                                                            - - - - - (NOTE 3) - - - - -
   1   .1561439+03     .1561439+03     .1561439+03     .0000000         .2927640+06       .0000000
   4   .2159925+03     .2159925+03     .2159925+03     .0000000         .4166400+06       .0000000
   7   .3473364+03     .0000000        .3473364+03     .0000000         .5836990+06       .0000000
   8   .0000000        .1750570+03     .0000000        .0000000         .0000000          .0000000
  11   .3984771+03     .0000000        .3984771+03     .0000000         .6466290+06       .0000000
  12   .0000000        .1462301+03     .0000000        .0000000         .0000000          .0000000
  15   .4079879+03     .0000000        .4079879+03     .0000000         .5741200+06       .0000000
  16   .0000000        .5387397+03     .0000000        .0000000         .0000000          .0000000
  17   .0000000        .0000000        .0000000        .1231940+07      .0000000          .9244200+06
```

NOTES:

1. NODAL MASSES: A non-zero entry indicates a dynamic degree of freedom at that node.

2. X Y Z MASS: Expressed in $(k*sec^2/ft)$.

3. X Y Z ROTNL. MASS: Expressed in $(k*ft*sec^2)$.

4. X Z ROTNL. MASS: The rocking mass is lumped to the main foundation, i.e., NODE NO. 17.

5.0 RESULTS

TABLE 1

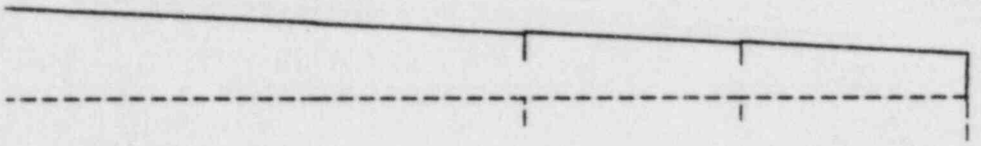
```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D
CE800D15
                  .......... SUMMARY TABLES FOR BASE MOTION ALONG EACH AXIS (ACTING INDEPENDENTLY) ..........

MODE  OMEGA      FN       T      GENL          PARTICIPATION FACTORS                          MODAL MASSES                  CUMULATIVE MASS(PERCENT)
     (RAD/S)   (CPS)    (SEC)    MASS          X            Y            Z            X            Y            Z            X         Y         Z


   1   30.28    4.82   .2075    1.00       2.287         .441       36.406        5.229         .194     1325.373         .3        .0      86.9
   2   30.87    4.91   .2035    1.00      37.130       -2.450       -2.241     1378.663        6.001        5.024       90.7        .5      87.2
   3   44.62    7.10   .1408    1.00       3.698       34.803        -.907       13.673     1211.276         .823       91.6      98.8      87.2
   4   48.40    7.70   .1298    1.00       -.260         .484       -2.646         .068         .235        7.002       91.6      98.8      87.7
   5   64.15   10.21   .0979    1.00        .535         .732       13.521         .286         .536      182.813       91.6      98.9      99.7
   6   69.97   11.14   .0898    1.00     -11.175        3.569         .416      124.874       12.736         .173       99.8      99.9      99.7
   7  150.01   23.87   .0419    1.00        .052        -.036        1.389         .003         .001        1.930       99.8      99.9      99.8
   8  166.40   26.48   .0378    1.00      -1.178        -.708         .057        1.387         .501         .003       99.9      99.9      99.8
   9  177.21   28.20   .0355    1.00        .061         .021        1.152         .004         .000        1.327       99.9      99.9      99.9
  10  214.39   34.12   .0293    1.00       -.627        -.027         .976         .393         .001         .953       99.9      99.9     100.0

                                                                SUMMATIONS     1524.580     1231.481     1525.422

                                                                TOTAL MASS     1525.938     1232.163     1525.938
```

TABLE 2

SUMMARY TABLE - MODE NUMBER 1

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D
CEBOOD15
 MODE  NUMBER  1
    FREQUENCY ***************************           4.81934447 CPS
    PERIOD *****************************             .20749710 SEC
    EIGENVALUE *************************           .30230834+02 RAD/SEC
    PARTICIPATION FACTOR ( X ) *********           .22867183+01
    PARTICIPATION FACTOR ( Y ) *********           .44094389+00
    PARTICIPATION FACTOR ( Z ) *********           .36405667+02

EIGENVECTOR  IN  GLOBAL (X,Y,Z) REFERENCE  SYSTEM ...

  NODE    X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
NUMBER

     1      2.06700-03      4.57682-05      3.61942-02      2.27103-04      -8.04116-05      -1.14827-05
     2      2.06700-03      5.82842-05      3.61065-02      2.27103-04      -8.04111-05      -1.14827-05
     3      1.77114-03      5.80230-05      3.01652-02      2.24854-04      -7.87309-05      -1.13947-05
     4      1.77114-03      8.54838-05      2.99754-02      2.24842-04      -7.87294-05      -1.13944-05
     5      1.77114-03      1.00980-04      2.98683-02      2.24835-04      -7.87275-05      -1.13942-05
     6      1.55807-03      1.00597-04      2.56854-02      2.21502-04      -7.64423-05      -1.12599-05
     7      1.70174-03      4.56195-04      2.60980-02      2.21435-04      -7.64367-05      -1.12448-05
     8      1.55808-03      1.30339-05      2.62806-02      2.21409-04      -7.64344-05      -1.12541-05
     9      1.55808-03      1.50596-05      2.62668-02      2.21409-04      -7.64344-05      -1.12541-05
    10      1.30015-03      1.46912-05      2.17237-02      2.15147-04      -7.58804-05      -1.09908-05
    11      1.41620-03      2.85690-04      2.21249-02      2.15011-04      -7.58832-05      -1.09645-05
    12      1.30015-03      4.51357-05      2.15135-02      2.15147-04      -7.58804-05      -1.09908-05
    13      1.30014-03     -7.32929-05      2.23326-02      2.14944-04      -7.58873-05      -1.09823-05
    14      1.00315-03     -7.37801-05      1.72366-02      2.02950-04      -7.89511-05      -1.04424-05
    15      1.04419-03      2.36747-04      1.56835-02      2.02069-04      -7.88935-05      -1.04350-05
    16      1.23278-03      7.54449-04      1.54198-02      2.01925-04      -7.88544-05      -1.04806-05
    17      1.00338-03      1.58121-04      1.54859-02      2.01866-04      -7.88232-05      -1.04945-05

        SUMMARY  OF  MIN/MAX  NODAL  DISPLACEMENTS

          X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION      Y-ROTATION      Z-ROTATION

NODE MIN        14               14               16               17               1               2
   VALUE   .0010031516     -.0000737801      .0154197768      .0002018660    -.0000804116    -.0000114827

NODE MAX         1               16                1                2              12              15
   VALUE   .0020670041      .0007544492      .0361941882      .0002271035    -.0000758804    -.0000104350
```

COMPUTER PLOT OF
MODE NUMBER 1



COMPUTER PLOT OF MODE NUMBER 1

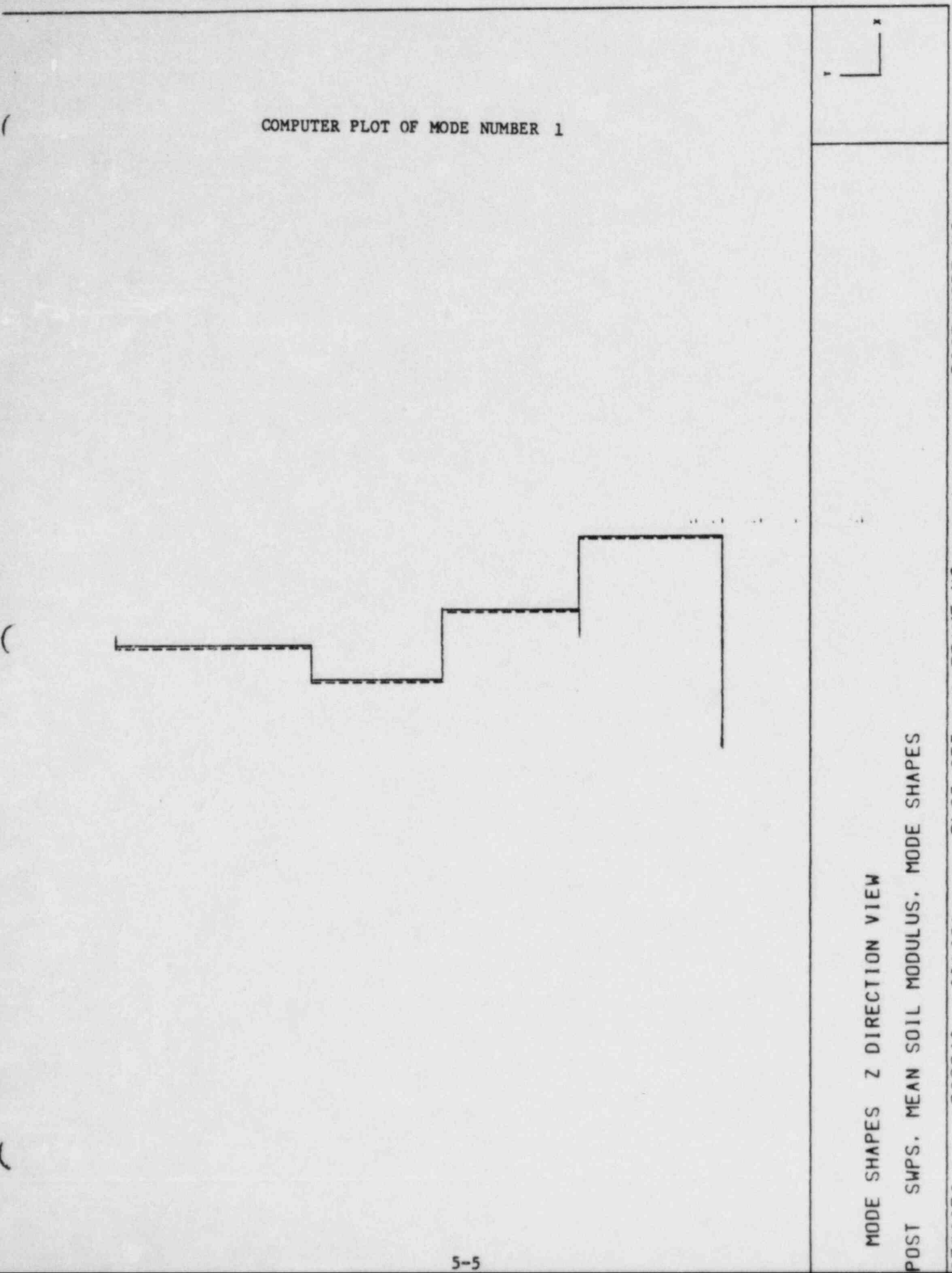


TABLE 3

SUMMARY TABLE - MODE NUMBER 2

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D
CEBOOD15
 M O D E   N U M B E R   2
     FREQUENCY **************************           4.91383860 CPS
     PERIOD *****************************            .20350689 SEC
     EIGENVALUE *************************          .30874558+02 RAD/SEC
     PARTICIPATION FACTOR ( X ) *********          .37130354+02
     PARTICIPATION FACTOR ( Y ) *********         -.24496340+01
     PARTICIPATION FACTOR ( Z ) *********         -.22413303+01

E I G E N V E C T O R   I N   G L O B A L  ( X , Y , Z )  R E F E R E N C E   S Y S T E M . . .

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION
 NUMBER

    1       3.57092-02     -3.01749-03      -2.28969-03      -1.51670-05      -5.00523-06      -2.04295-04
    2       3.57091-02     -2.79481-03      -2.29514-03      -1.51670-05      -5.00520-06      -2.04295-04
    3       3.04372-02     -2.77691-03      -1.89943-03      -1.50191-05      -4.94194-06      -2.02697-04
    4       3.04372-02     -2.28841-03      -1.91134-03      -1.50183-05      -4.94192-06      -2.02692-04
    5       3.04372-02     -2.01275-03      -1.91806-03      -1.50179-05      -4.94188-06      -2.02690-04
    6       2.66415-02     -1.99773-03      -1.63934-03      -1.47983-05      -4.91044-06      -2.00233-04
    7       2.66507-02     -3.10672-03      -1.61285-03      -1.48078-05      -4.91125-06      -2.00200-04
    8       2.66413-02     -3.55733-03      -1.60106-03      -1.47952-05      -4.91090-06      -2.00175-04
    9       2.66413-02     -3.52130-03      -1.60195-03      -1.47952-05      -4.91090-06      -2.00175-04
   10       2.21093-02     -3.49949-03      -1.30027-03      -1.43838-05      -4.27825-06      -1.95593-04
   11       2.21157-02     -4.55601-03      -1.27767-03      -1.43984-05      -4.27675-06      -1.95530-04
   12       2.21093-02     -2.95770-03      -1.31212-03      -1.43838-05      -4.27825-06      -1.95593-04
   13       2.21091-02     -5.06967-03      -1.26589-03      -1.43734-05      -4.27505-06      -1.95485-04
   14       1.69384-02     -5.04000-03      -9.30773-04      -1.35928-05      -2.74320-06      -1.86435-04
   15       1.69393-02     -1.38525-03      -9.84473-04      -1.35215-05      -2.73267-06      -1.86066-04
   16       1.69456-02     -7.96214-04      -9.93494-04      -1.34567-05      -2.73562-06      -1.85945-04
   17       1.69374-02     -9.13213-04      -9.91150-04      -1.34298-05      -2.73743-06      -1.85805-04

        S U M M A R Y   O F   M I N / M A X   N O D A L   D I S P L A C E M E N T S

              X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT      X-ROTATION       Y-ROTATION       Z-ROTATION

NODE MIN            17               13               2                2                1                1
   VALUE     .0169373965     -.0050696733     -.0022951420     -.0000151670     -.0000050052     -.0002042949

NODE MAX             1               16               14               17               15               17
   VALUE     .0357091522     -.0007962140     -.0009307726     -.0000134298     -.0000027327     -.0001858048
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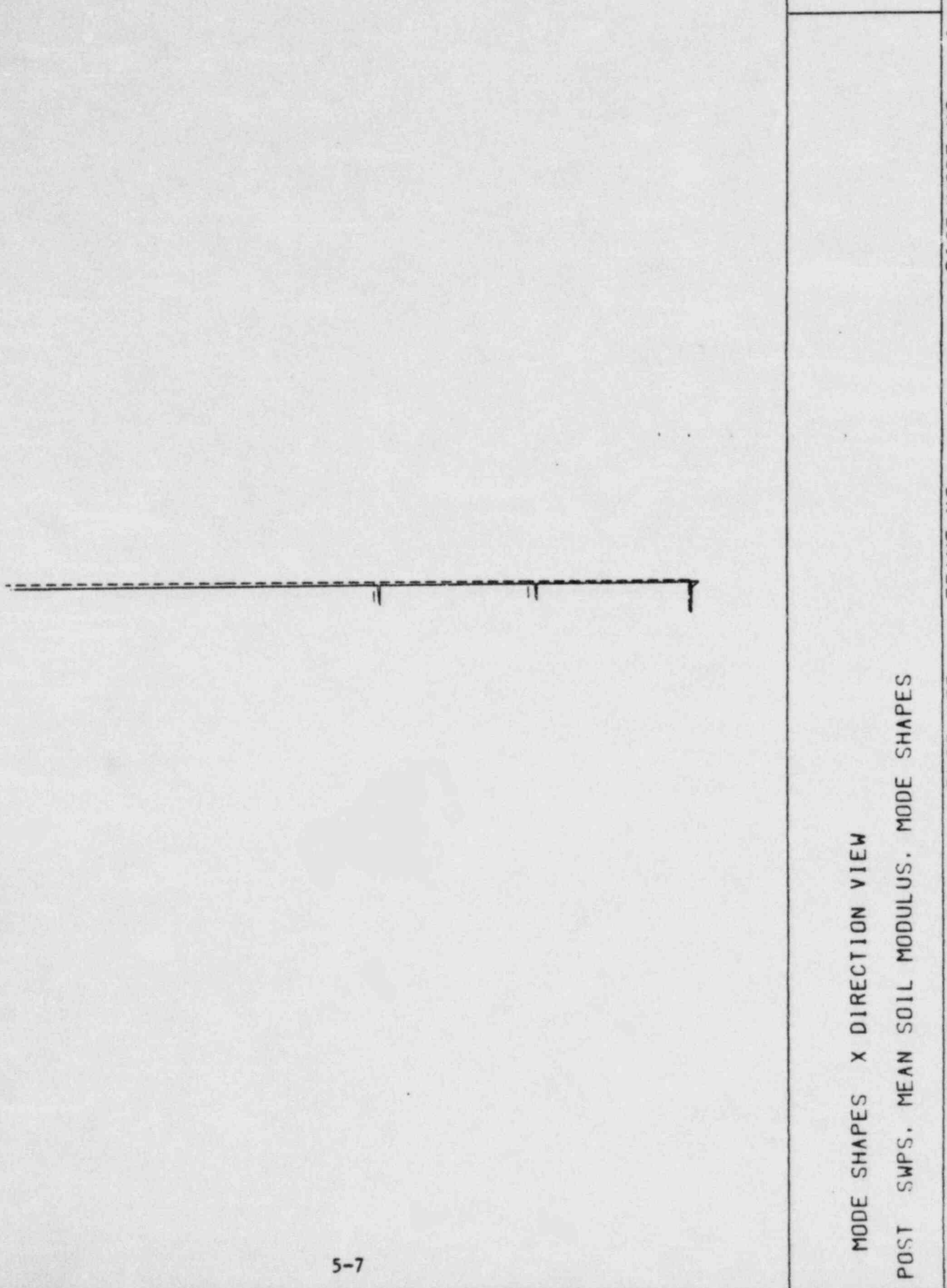
COMPUTER PLOT OF MODE NUMBER 2



COMPUTER PLOT OF MODE NUMBER 2

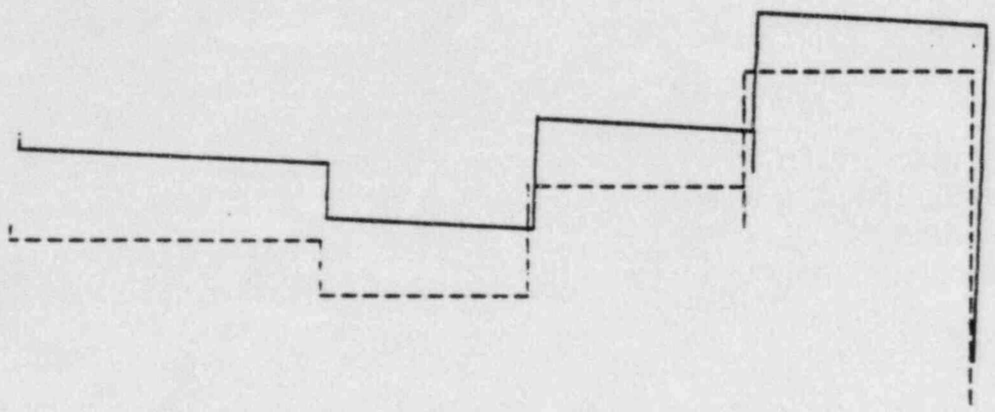


TABLE 4
SUMMARY TABLE - MODE NUMBER 3

```
BSAP MIDLAND UNITS 1&2 (7220) SERVICE WATER PUMP STRUCTURE SEISMIC ANAL-3D
CE800D15
 M O D E   N U M B E R   3
    FREQUENCY ***************************           7.10129634 CPS
    PERIOD ******************************            .14081936 SEC
    EIGENVALUE **************************          .44618761+02 RAD/SEC
    PARTICIPATION FACTOR ( X ) **********          .36977178+01
    PARTICIPATION FACTOR ( Y ) **********          .34803395+02
    PARTICIPATION FACTOR ( Z ) **********         -.90714707+00


E I G E N V E C T O R   I N   G L O B A L  ( X , Y , Z )  R E F E R E N C E   S Y S T E M  . . .

  NODE   X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT        X-ROTATION         Y-ROTATION         Z-ROTATION
 NUMBER

     1     2.00339-04       2.97133-02       4.16588-05         1.60427-05         9.04899-06         5.80358-05
     2     2.00339-04       2.96501-02       5.15221-05         1.60427-05         9.04888-06         5.80357-05
     3     1.43480-03       2.92819-02      -2.96042-04         1.60371-05         8.72436-06         5.77752-05
     4     1.43480-03       2.91426-02      -2.75017-04         1.60371-05         8.72414-06         5.77743-05
     5     1.43480-03       2.90639-02      -2.63152-04         1.60371-05         8.72383-06         5.77732-05
     6     2.21629-03       2.87087-02      -4.86781-04         1.60455-05         8.38454-06         5.70931-05
     7     2.20053-03       2.90469-02      -5.32054-04         1.60504-05         8.38320-06         5.70930-05
     8     2.21627-03       2.91531-02      -5.52082-04         1.60560-05         8.38212-06         5.71017-05
     9     2.21627-03       2.91428-02      -5.50573-04         1.60560-05         8.38212-06         5.71017-05
    10     2.91447-03       2.86829-02      -7.61047-04         1.61278-05         7.96725-06         5.84788-05
    11     2.90227-03       2.90165-02      -8.03188-04         1.61261-05         7.96542-06         5.85079-05
    12     2.91447-03       2.85209-02      -7.38978-04         1.61278-05         7.96725-06         5.84782-05
    13     2.91443-03       2.91519-02      -8.24996-04         1.61468-05         7.96406-06         5.85430-05
    14     3.52297-03       2.85321-02      -1.00234-03         1.64083-05         7.42596-06         6.45739-05
    15     3.51903-03       2.72683-02      -8.56390-04         1.64428-05         7.41486-06         6.46338-05
    16     3.50127-03       2.70914-02      -8.31599-04         1.64411-05         7.41013-06         6.46056-05
    17     3.52277-03       2.70973-02      -8.37808-04         1.64364-05         7.40663-06         6.45627-05


        S U M M A R Y   O F   M I N / M A X   N O D A L   D I S P L A C E M E N T S

              X-DISPLACEMENT   Y-DISPLACEMENT   Z-DISPLACEMENT       X-ROTATION       Y-ROTATION        Z-ROTATION

NODE MIN             2               16               14                 5                17                 7
   VALUE      .0002003388      .0270913562     -.0010023417       .0000160371       .0000074066       .0000570930

NODE MAX            14                1                2                15                 1                15
   VALUE      .0035229688      .0297133425      .0000515221       .0000164428       .0000090490       .0000646338
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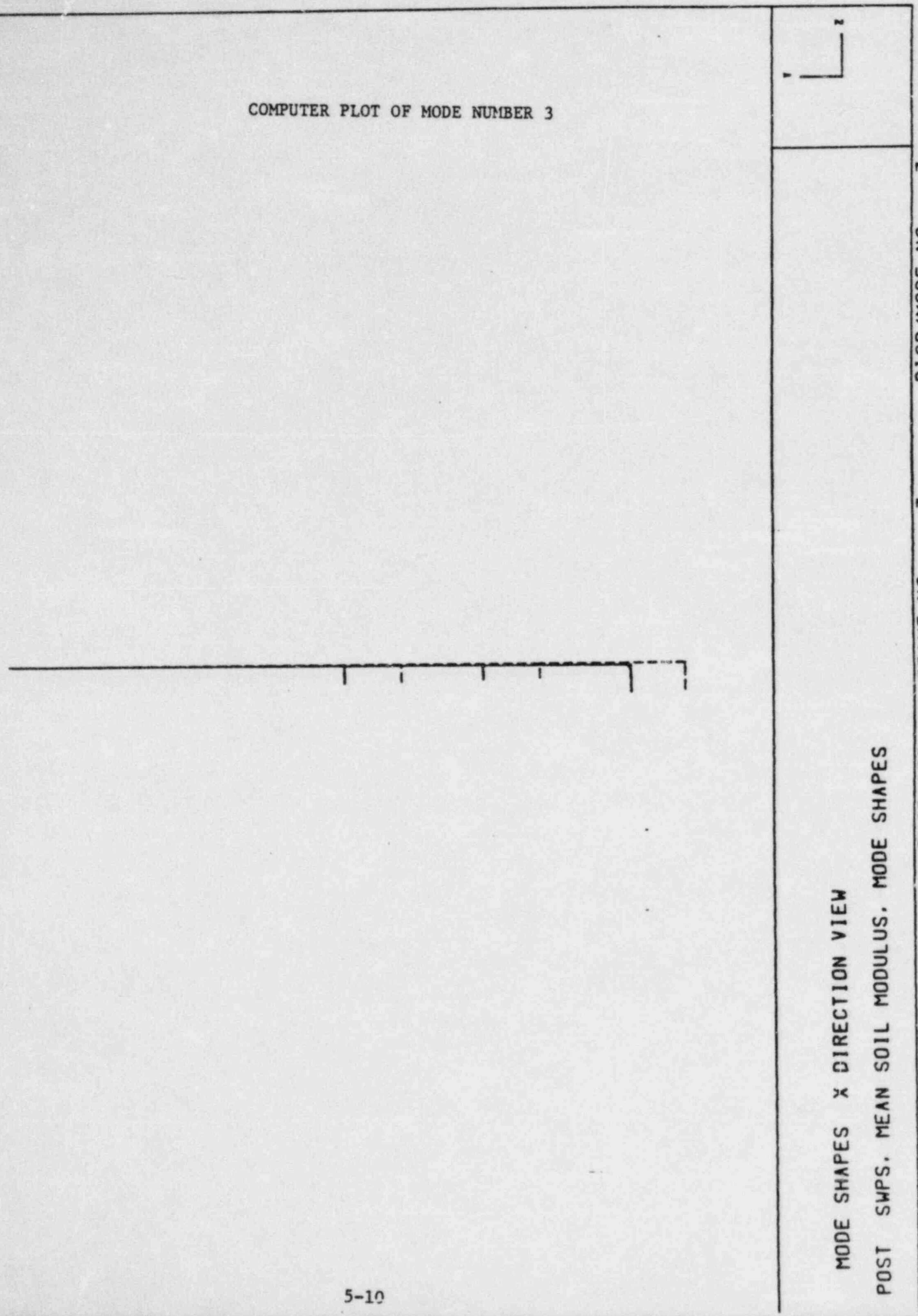
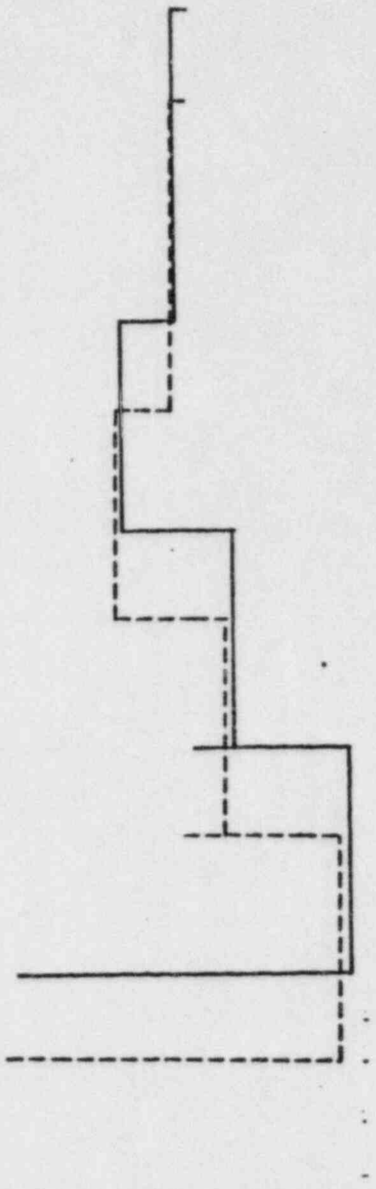
COMPUTER PLOT OF MODE NUMBER 3



COMPUTER PLOT OF MODE NUMBER 3



MODE SHAPES Z DIRECTION VIEW

POST SWPS. MEAN SOIL MODULUS. MODE SHAPES

028046 0916[illegible] PLOT SET 1 FRAME NO. 3 DISP/MODE NO

J Kane

2/85

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

DEC 16 1981

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

FROM: Darl Hood, Project Manager
Licensing Branch #4
Division of Licensing

SUBJECT: CORRECTIONS TO LICENSING CONDITIONS FOR AUXILIARY BUILDING AND FW PIT UNDERPINNING - MIDLAND UNITS 1 & 2

The attached Table A.20 from "Testimony of Darl Hood, Joseph Kane and Hari Singh concerning the Remedial Underpinning of the Auxiliary Building Area" is marked to reflect changes made during the OM-OL hearing on 12/03/81.

During the hearing Mr. Ted Johnson of Bechtel committed on behalf of the applicant to abide by the conditions of Table A.20, as amended, and not to procede with the construction milestones in Table A.20 without staff approval.

The ASLB asked to be notified by NRR in the event that:

(1) Appeals reaching the Director of NRR should result in an impasse or

(2) Consumers Power should decide to proceed with any of the construction milestones in Table A.20 without first receiving NRC approval.

The ASLB clarified that its desire to be notified did not include dates in the Table for supplying information or dates for starting construction. The staff stated that these dates were not intended to be licensing conditions, per se.

Darl Hood

Darl Hood, Project Manager
Licensing Branch #4
Division of Licensing

Enclosure:
As stated

cc: G.Lear
W. Paton
J. Keppler
[redacted]
F. Rinaldi
R. Landsman
R. Tedesco
D. Eisenhut
R. Hernan

~~8201180593~~ 8pp.

Table A.20

Construction Milestone	Date Information Available for Staff Review	Requested Starting Date of Construction Milestone
1. Install Vertical Access Shaft to El. 609 and Complete Freeze Wall Installation.	No submittal required	12/29/81

Proposed Special License Condition: None

Construction Milestone	Date Information Available for Staff Review	Requested Starting Date of Construction Milestone
2. Activate Freezing of Soil along Freeze Wall Alignment	12/15/81	2/1/82

Proposed Special License Conditions:

2a. Provide documentation demonstrating the Freeze Wall, when activiated, will not adversely affect seismic Category I structures, conduits and pipes by causing ground heave or resettlement upon unfreezing.

2b. Provide a plan, with established criteria and basis, for field monitoring of the effects of the Freeze Wall. The required plan will include a commitment to monitor both vertical and lateral movements at a minimum of four locations where safety related structures and utilities could potentially be affected. This plan is to be provided by 1/15/82.

2c. Provide responses for questions 3 and 4 identified in Attachment 21 ~~except for Questions 9, 18, 20, 25, 28 and 30~~.

2d. Provide responses for review concerns identified in answers to questions 14 and 17 of this testimony.

COE considers question 14 & 17 of testimony to be resolved.

Construction Milestone	Date Information Available for Staff Review	Requested Starting Date of Construction Milestone
3. Extend Vertical Access Shaft below El. 609 and begin to remove soil foundation support from beneath Feedwater Isolation Valve Pit.	1/15/82	2/15/82

Proposed Special License Conditions:

3a. Provide design analysis for temporarily supporting the Feedwater Isolation Valve Pits (FIVP) on beams extending from the Buttress Access Shaft to the Turbine Building. The design will identify actual loads and displacements and demonstrate the adequacy and safety of the temporary support system.

3b. Provide an acceptable monitoring program with criteria for avoiding adverse impact on FIVP.

3c. Provide responses to questions 5, 8, 10, 11, 12, 13, 24, 26, 27 and 29 identified in Attachment 21.

4. Begin drift excavation beneath the Turbine Building.	1/15/82	2/15/82

Proposed Special License Conditions:

4a. Provide design analysis (including supporting calculations, drawings and specifications) which evaluates the anticipated undermining and temporary construction loading on the Turbine Building at this stage. The analysis will be required to demonstrate an acceptable margin of safety for the Turbine Building to safely carry the imposed temporary construction loads so as to avoid adverse impact on the adjacent Auxiliary Building.

4b. Provide an acceptable monitoring program for affected Category I structures, conduits and pipes with criteria and basis for this construction stage. Criteria basis should describe how movements to be measured are related to code allowable stresses and allowable strains.

4c. Provide documentation demonstrating the adequacy of the final permanent support system along the north side of the Turbine Building in safely providing long-term support for the Turbine Building without adversely impacting the Auxiliary Building.

4d. Provide responses for questions 9, 14, 15, 25 and 30 which are identified in Attachment 21.

Construction Milestone	Date Information Available for Staff Review	Requested Starting Date of Construction Milestone
5. Begin removal of soil foundation support from beneath Auxiliary Building.	2/1/82	4/1/82

Proposed Special License Conditions:

5a. Provide design analysis (including supporting calculations, drawings and specifications) which evaluates the temporary support system for the Auxiliary Building at appropriate sequential stages of excavation and jacking. The design analysis will be required to demonstrate acceptable margins of safety at the various stages of temporary construction.

5b. Provide an acceptable monitoring program with criteria and basis for temporary conditions of loading at this stage of construction.

5c. Provide responses for questions 6, 7, 12, 18, 19, 20, 21, 22, 23 and 28 which are identified in Attachment 21.

SEB

5d. Provide design analysis (including supporting calculations, drawings and specifications) demonstrating the adequacy of the installed temporary post-tensioning system.

5e. Provide an engineering evaluation of all cracks (existing and new) and propose a plan for the detailed evaluation of through cracks.

6. Begin construction of permanent underpinning wall.	5/17/82	11/1/82

Proposed Special License Conditions:

6a. Provide design analysis (including supporting calculations, drawings and specifications) which evaluates the permanent underpinning structure. The design analysis will be required to address all load combinations including stability under seismic loading.

6b. Provide results of the evaluation of through cracks.

6c. Provide an acceptable monitoring program with criteria and basis for long-term plant operation condition.

6d. Provide responses for questions 1 and 2 which are identified in Attachment 21.

ATTACHMENT 21

RECORD OF TELEPHONE CONVERSATIONS

Date: October 30, 1981

Project: Midland 50-330

Recorded by: Joseph D. Kane

Talked With:	CPCo	Bechtel	NRC	COE
	D. Budzik G. Keeley	A. Boos N. Swanberg	R. Landsman F. Rinaldi D. Hood J. Kane	H. Singh

Route To: For Information

G. Lear
L. Heller
D. Hood
W. Paton
F. Rinaldi
R. Landsman, I&E, Region III
H. Singh, COE, Chicago
J. Kane

Main Subject of Call: Remedial Underpinning of Auxiliary Building and Feedwater Isolation Valve Pits

Items Discussed:

1. Enclosure 3 to CPCo September 30, 1981 submittal from J. W. Cook to H. R. Denton entitled "Technical Report on Underpinning the Auxiliary Building and Feedwater Isolation Valve Pits". During the October 30, 1981 conference call CPCo was requested to respond to the following questions which had been developed in the COE/NRC review of Enclosure 3, relative to geotechnical engineering aspects in underpinning the Auxiliary Building.

LIC. CONDITION NO. 6d.

Q.1. (Pg. 2, Sect. 4, 2nd Para.) Please define "design jacking force," how established and the duration that it will be held?

No. 6d.

Q.2. (Pg. 2, Sect. 4, 3rd Para.) Discuss and provide detail of dowel connection. (Diameter, how distributed along wall, length of embedment, etc).

No. 2.c.
Meeting of 1/20/82
(Ann Arbor)

Q.3. (Pg. 3, Sect. 5.1, last para) The agreed upon acceptance criteria for soil particle monitoring during dewatering requires 0.005 mm and not 0.05 mm. Correction by CPCo required.

License Condition

No.2.C. Meeting of 1/26/82 (Ann Arbor)

Q.4. (Pg. 3, Sect. 5.1, Para. b) Installing the frozen cutoff membrane will cause expansion and possibly increase the soil voids. When ultimately unfrozen, what is the effect (e.g., further settlement) on safety related structures, conduits and piping. Provide discussion on the basic system of the frozen membrane [size and spacing of holes to be drilled, method for pumping brine into foundation layers, range of temperatures that are critical to wall stability which are to be monitored, decomissioning (e.g., grouting, etc)].

No.3.C. Audit Jan 18-19, 1982

Q.5. — HGEB considers resolved - Check w/ SEB

(Pg. 3, Sect. 5.2) Clarify the procedure to be used in post tensioning the Electrical Penetration Area. Where will the buoyancy force be transmitted to the foundation and in what manner?

No.5.C. AUDIT 2/1 to 2/5/82

Q.6. (Pg. 4, Sect. 5.6, 2nd Para.) Please explain the meaning of "failure bearing capacity factors" and the basis for "the nine times the shear strength for the cone"?

No.5.C. AUDIT 2/1 to 2/5/82

Q.7. (Pg. 4, Sect. 5.b, 4th Para.) How will the equivalent soil modulus be determined? What is the depth that the measured settlement will be distributed over and what is the area to be used in determining the stress?

No.3.C. Audit Jan 18-19, 1982

Q.8. — HGEB considers resolved w/ CPC - Check w/ I&E for their plans to VERIFY base line mapping

(Pg. 4, Sect. 6) Presently, this paragraph implies that crack monitoring will not be performed on the existing structure. Please correct. Before remedial underpinning begins an accurate and up-to-date record of cracks should be developed for those safety related structures which could potentially be affected by the underpinning operations. This background record should be verified by I&E inspection and could serve as the basis for evaluating any changes in cracks due to underpinning operations.

No.4.d. AUDIT 1/18/82 to 1/19/82 and later MAY 1982 AUDIT

Q.9. (Pg. 5, Sect 6.1.1 and 6.1.2) When will the acceptance criteria for the differential and absolute settlement be provided to the NRC?

No.3.C. AUDIT 1/18 & 19/82 SEB Issue

Q.10. (Pg. 5, Sect. 6.2) Provide the basis for establishing the crack width of 0.03 inch. Appendix D should also address crack monitoring requirements during underpinning (frequency of reading, format for presenting observations, action levels etc).

No.3.C. Audit Jan 18-19, 1982

Q.11. — HGEB considers resolved

(Pg. 6, Sect. 7.2.1, last Para.) Provide discussion why the drained shear strength is not required to be considered in analyzing for adequate bearing capacity. Also in the last paragraph in Section 7.2.1, Pg. 7 indicate the basis for the 2 days and what would be required if the settlement rate does not reach a straight line trend in 2 days.

No.3.C. Audit Jan 18-19, 1982

Q.12. (Pg. 7, Sect. 7.2.2) Where are the WCC controlled rebound-reload cycle soil test results? What is the corresponding stress level with a secant modulus of elasticity equal to 3500 KSF?

— HGEB considers resolved

No.3c. Q.13. (Pg. 8, Sect 7.2.3, 1st Para.) The estimates of settlement using the referenced NAVFAC DM-7 do not include secondary consolidation. What secondary consolidation would be indicated if the consolidation test results using the appropriate load increment were used? Compare this estimate with valves for permanent wall conditions "after jacking, long term". Please provide basis for the three estimated settlement valves for "Load transfer points for temporary load to reactor footing" at the bottom of pg. 8 and discuss any effects of this settlement on the reactor and pipe connections.

Audit June 8-11, '82 -

No.4d. Q.14. (Pg A-1, Sect. 1, 2nd Par.) Please indicate how the soil spring constants were established for long term loads.

Audit June 8-11, '82 -

No.4d. Q.15. (Pg C-2, last Par. and Pg. C-6, Par. B) What are the protective construction measures planned for the Turbine Building and Buttress Access Shafts and when will they be placed? Please provide discussion on the sequence of operations to complete the drift beneath the Turbine Building and show sectional views of this work with respect to the Turbine Building foundations and affected piping and conduits.

Audit June 8-11, '82 -

No Q.16. (Pg C-3, Par. A.1.a) Please explain what is meant by minimizing the amount of concrete to be removed.

RESOLVED

No.5.c. Q.17. (Pg. C-3, Par. A.1.c. and A.1.d) What is the magnitude of the load for testing the temporary support pier and how was it established and how will it be applied? Is the EPA foundation slab capable of supporting this load at this time?

Audit 4/1 to 4/5 '82

No.5.c. Q.18. (Pg. C-4, Sect. A.1.f., 1st complete para.) Provide discussion on monitoring of the control tower behavior at this time. What criteria will be used to decide if preload should be stopped and support capacity should be added to the control tower?

Audit 4/1 to 4/5 '82

No.5.c. Q.19. (Pg. C-4, Sect. A.2.) What are the reasons why the three temporary supports under the EPA should not be completed before the permanent support at the control tower is initiated?

Audit 4/1 to 4/5 '82

No.5.c. Q.20. (Pg. C-4, Sect. A.3.a) Questions are raised as to whether the EPA structure can withstand the overhang condition which results if the initial temporary supports is assumed to fail. What is the basis and need for this extreme assumption? Is the EPA structure capable of withstanding this loading condition?

Audit 4/1 to 4/5 '82

No.5.c. Q.21. (Pg. C-4, Sect A.3.b and A.3.c) The distinction between 3.b and 3.c is unclear. What is the magnitude of the load for testing and how established? Is there a problem with the EPA foundation slab providing a sufficient reaction load?

Audit 4/1 to 4/5 '82

No.5.c. Q.22. (Pg. C-5, Sect. 14 and 15) It appears the operations described in these items are intended only for the wings and not the control tower. How is the load test and load transfer for the control tower to be completed. For the long term load test on the wings, what is the load magnitude and how was it established? What is the final

Audit [illegible]

sequence of operations in transferring the structure load to the permanent underpinning.

No.5.C. Q.23. (Pg. D-1, Sect 1.0, 2nd Par) Describe the procedure that relates allowable stresses and allowable strains with structure movements that are being monitored.
Audit [illegible]

HGEB considers resolved

No.3.C. Q.24. (Pg D-2, Sect. 1, 3rd Par.) Please clarify the distinction between the first and second layer systems for detecting structure movement.
Audit [illegible]

No.4.d. Q.25. (Pg D-2, Sect. 1, 4th, 6th, and 7th Para.) Please provide elevations and sectional views with typical details for the deep seated bench mark and the instrumentation for monitoring relative horizontal movement and absolute horizontal movement.
Audit [illegible]

HGEB considers resolved

No.3.C. Q.26. (Pg. D.3, Sect. 2, 2nd Par.) Please clarify the explanation why the hydraulic pressure data cannot be used to measure load.
Audit [illegible]

No.3.C. Q.27. (Pg. D-3, Sect. 2, 3rd Par.) Provide sectional view of set up for measuring difference in relative position. How does this procedure address the possibility of both the underpinning element and structure settling? Provide the basis for maintaining the jack/hydraulic system for 1 hour and for establishing the 0.01 inch movement.
Audit [illegible]

No.5.C. Q.28. (Pg. D-4, Sect. 2, 4th Para.) When will the modeling and critical structural stresses and strains be determined and furnished to the NRC?
Audit Feb 1-5 1982

No.3.C. Q.29. (Pg D-5, Sect. 2, 2nd and 3rd Para.) Provide sketch and locations with typical details of instrumentation for measuring concrete stress, tell tale devices and predetermined points for monitoring vertical movement.
Audit [illegible]

No.4.d. Q.30. (Pgs. D-5 and D-6, Sect. 3, Par. 3A.1, 3A.2, 3A.3) For the various types of monitoring described in these paragraphs provide an example of the forms to be used for plotting the recorded data. What are the predetermined levels of movements which would require adjustments and/or action by the onsite geotechnical engineer. Identify any specific instrumentation which would be continued to be read during plant operation and which eventually will be addressed by a Technical Specification.
Audit [illegible]

2. Consumers was notified that the above questions do not contain the COE/NRC review comments on the laboratory test results for foundation soils beneath the Auxiliary Building. The COE/NRC comments on the test results will be furnished at a later date following CPCo submittal of the Part II lab test report which is expected to be submitted to the NRC the week of November 2, 1981.

3. Consumers indicated the questions asked in the conference call of October 30, 1981 would be addressed as far as possible in the upcoming meeting with NRC in Bethesda on November 4, 1981.

Related to Barbara Stamiris Request 4.(b)
Is in Public Document Room Files

3/85

February 24, 1983

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

APPLICANT: Consumers Power Company

FACILITY: Midland Plant, Units 1 and 2

SUBJECT: TELEPHONE DISCUSSION ON UNDERPINNING CONSTRUCTION OF THE TURBINE AND AUXILIARY BUILDINGS

On February 8, 1983, Mr. Joseph Kane of the NRC participated in a telephone discussion with members of Consumers Power Company (CPCo) and Bechtel regarding the sequence of loading proposed for underpinning pier W11 to be located beneath the west end of the Midland Turbine Building . The call also included a follow-up discussion of settlement records for deep-seated benchmarks associated with the Auxiliary Building underpinning (see telephone summary dated January 19, 1983). CPCo's plans for underpinning are described in Supplement #2 of the Safety Evaluation Report (NUREG-0793, October 1982).

Enclosure 1 is a record of this telephone conversation.

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

Enclosure:
As stated

cc: See next page

~~8303030389~~ 3pp.

OFFICE ▶	DL:LB #4	DL:LB #4					
SURNAME ▶	DHood/hmc DH	EAdensam					
DATE ▶	2/23/83	2/24/83					

NRC FORM 318 (10-80) NRCM 0240

OFFICIAL RECORD COPY

RECORD OF TELEPHONE CONVERSATION

DATE: February 8, 1983 @ 2:00 pm

PROJECT: Midland

RECORDED BY: Joseph D. Kane

TALKED WITH:

CPC

R. Wheeler
R. Ramanujam
K. Razdan
J. Anderson

Bechtel

J. Darby
E. Cwikl
M. Lewis
M. Das Gupta
C. Hund
R. Adler

NRC

J. Kane

ROUTE TO:

J. Knight
G. Lear
L. Heller
D. Hood

H. Singh, COE
S. Poulos, GEI
R. Landsman, Region III
J. Kane

MAIN SUBJECT OF CALL: To discuss loading sequence for pier load test and background settlement readings

ITEMS DISCUSSED:

This call had been arranged by R. Ramanujam of CPC to discuss the pier load test procedure (for Pier W11) and the background settlement data up to January 13, 1983.

1. R. Ramanujam of Consumers Power Co. indicated that the loading sequence they are planning to use in the pier load test (Pier W11) is as follows:

   - Load increments equal to 25% & 50% of max. design load.
   - Unload at increments of 40%, 30%, 20% and 10%.
   - Reload in increments of 20%, 30%, 40%, 50%, 65%, 80%, 90%, 100%, 105%, 110%, 115%, 120%, 125% and 130%.

   The staff indicated their acceptance of this loading sequence and recommended that initially a 5% of max. design load be placed for seating of load and that the maximum load be incrementally reduced from 130% to 120% before stopping at 110%. This recommendation was accepted by CPC.

2. With respect to the underpinning monitoring data that had been provided to Region III for the time period of 8/23/82 to 1/13/83, the Staff made the following comments based on previous discussions with its consultant, Geotechnical Engineers, Inc.

    a. Recommend that standard graph paper (K&E 46-2610) be used which has space for 6-month period on the 11-inch side of the 8-1/2 x 11 inch paper.

    b. NRC staff no longer requests the plotting of data on semi-log paper.

    c. All data (vertical movement, thermocouple and <u>outside</u> temperatures, extensometer and strain data) should be plotted on the same type of graph paper which has a similar time scale.

    d. A plot of settlement (plotted downward) which has been temperature correctedis sufficient. It is not considered necessary to plot the before correction settlement curve.

    e. A smaller vertical scale (e.g., 1 inch = 40 mils or 1 inch=100 mils) would be preferable to avoid being misled about the significance of the settlement data.

    d. A location plan (preferably on 8-1/2 x 11 inches) that indicates outline of structures and instrument locations would be helpful when evaluating data. The locations where outside temperatures are being measured should be identified. A north-south trending sectional view that plots instruments at proper elevation levels and distances would also be helpful in evaluating the vertical movement data.

3. The NRC staff recommends that temperature corrections be continued to be made for all settlement instrument locations. Documentation for exceptions to this procedure should be provided if CPC feels temperature corrections are not required. The documentation should use actual recorded data to justify position.