JOHN A. BLUME AND ASSOCIATES, ENGINEERS

# MONTICELLO REACTOR PRESSURE VESSEL SEISMIC ANALYSIS

## CROSS SECTIONAL AREAS & MOMENT OF INERTIA (CONT.)

## IV PEDESTAL WALL

### A. SECTIONS (NO OPENINGS)

$$A = 0.785(25.167^2 - 17.167^2) + 0.785(17.375^2 - 17.167^2) \times \frac{3945600}{432000} = 317.26 \text{ ft.}^2$$

$$I = 0.049(25.167^4 - 17.167^4) + 0.049(17.375^4 - 17.167^4) \times 9.14 = 17{,}321. \text{ ft.}^4$$

### B. SECTIONS (OPENINGS FOR PIPES)

$$A = 0.785(25.167^2 - 17.167^2) - 2 \times 4.0(3.75 + 3.25) + 0.785(17.375^2 - 17.167^2) \times 9.14 = 261.26 \text{ ft.}^2$$

$$I = 0.049(25.167^4 - 17.167^4) - \frac{2 \times 4.0}{12}(3.75^3 + 3.25^3) - 2 \times 4.0(3.75 + 3.25)\left(\frac{21.167}{2}\right)^2 + 0.049(17.375^4 - 17.167^4) \times 9.14 = 10{,}991. \text{ ft.}^4$$

### C. SECTIONS (OPENINGS FOR PERSONNEL)

$$A = 0.785(25.167^2 - 17.167^2) - 4.0 \times 2.5 + 0.785(17.375^2 - 17.167^2) \times 9.14 = 307.26 \text{ ft.}^2$$

$$I = 0.049(25.167^4 - 17.167^4) - 4\frac{(2.5)^3}{12} - 4.0 \times 2.5\left(\frac{21.167}{2}\right)^2 + 0.049(17.375^4 - 17.167^4) \times 9.14 = 16{,}196. \text{ ft.}^4$$

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

# MONTICELLO REACTOR PRESSURE VESSEL SEISMIC ANALYSIS

## MODULI OF ELASTICITY

### A. REACTOR PRESSURE VESSEL

$E = 26.0 \times 10^6$ psi @ 550°F $= 37.44 \times 10^5$ K/ft.²

$\nu = 0.26 \sim 0.27$

USE $\nu = 0.265$

$G = \dfrac{E}{2(1+\nu)} = 0.395E = 14.789 \times 10^5$ K/ft.²

### B. SKIRT

$E = 27.4 \times 10^6$ psi @ 300°F $= 39.456 \times 10^5$ K/ft.²

$G = 0.395E = 15.585 \times 10^5$ K/ft.²

### C. STRUCTURAL STEEL

$E = 30 \times 10^6$ psi $= 43.20 \times 10^5$ K/ft.²

$G = 0.4E = 17.28 \times 10^5$ K/ft.²

### D. CONCRETE

$E = 3 \times 10^6$ psi $= 4.32 \times 10^5$ K/ft.²

$G = 0.4E = 1.728 \times 10^5$ K/ft.²

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MONTICELLO REACTOR PRESSURE VESSEL SEISMIC ANALYSIS

SUMMARY OF SPRING FORCES

| FORCE \ LOADING CONDITION | SEISMIC | JET LOAD 256.0$^K$ @ EL.999'-0" | JET LOAD 664.0$^K$ @ EL.961'-11" |
|---|---|---|---|
| BETWEEN RPV AND SHIELD STABILIZER | 67.0$^K$ | 172.0$^K$ | 126.9$^K$ |
| BETWEEN SHIELD AND BUILDING | 106.1$^K$ | 198.7$^K$ | 191.6$^K$ |

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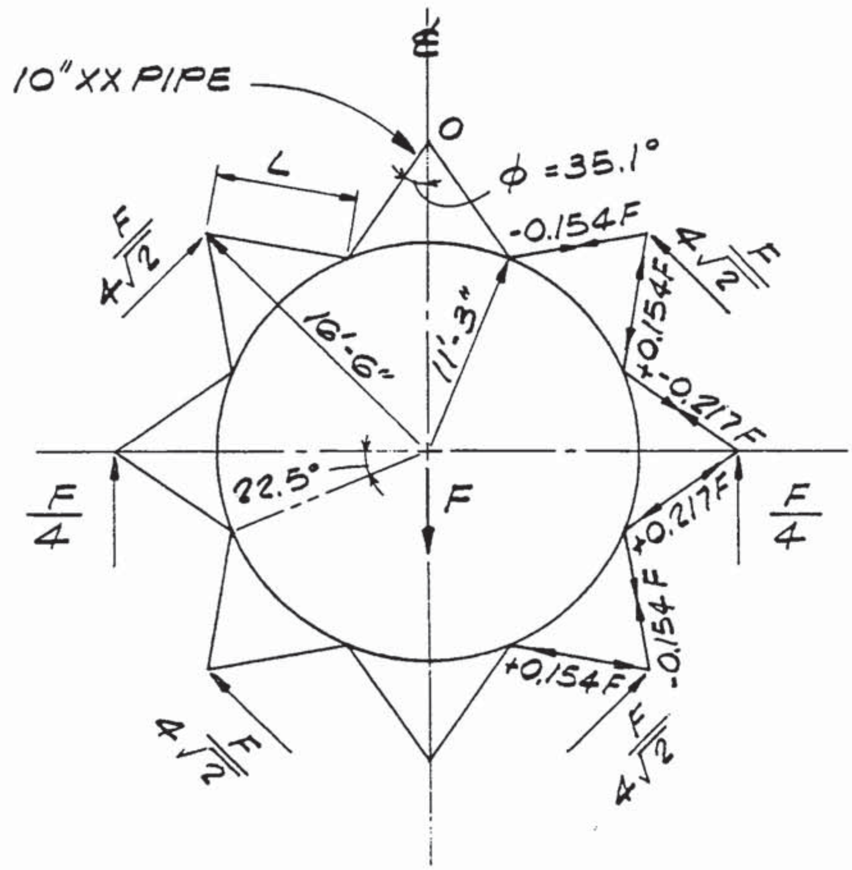
# MONTICELLO REACTOR PRESSURE VESSEL SEISMIC ANALYSIS

## SPRING CONSTANT (CONT'D)

### B. TRUSS LOADS




\+ DENOTES TENSION

\- DENOTES COMPRESSION

$$L = (16.5^2 + 11.25^2 - 2 \times 16.5 \times 11.25 \cos 22.5°)^{1/2} = 7.483 \text{ FT.}$$

$$\sin\phi = \frac{11.25}{7.483} \sin 22.5° = 0.5753, \quad \phi = 35.1°$$

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MONTICELLO REACTOR PRESSURE VESSEL

SEISMIC ANALYSIS

SPRING CONSTANT (CONT'D)

$$\delta = \frac{FL}{AE} \Sigma u^2$$

$F = 1^K$

$L = 7.483$ FT

$E = 30 \times 10^6$ LB/IN² $= 4,320,000$ K/FT²

A OF 10" XXS PIPE $= 0.2127$ FT²

$$\Sigma u^2 = 4(\bar{0}^2 + 0.2172^2 + 2 \times 0.1536^2) = 0.3774$$

DISPLACEMENT $\delta = \frac{1 \times 7.483 \times 0.3774}{4,320,000 \times 0.2127} = 3.074 \times 10^{-6}$ FT

SPRING CONSTANT

$F = K\delta$

$1 = K\delta$

$K = \frac{1}{\delta} = 325,330$ K/FT

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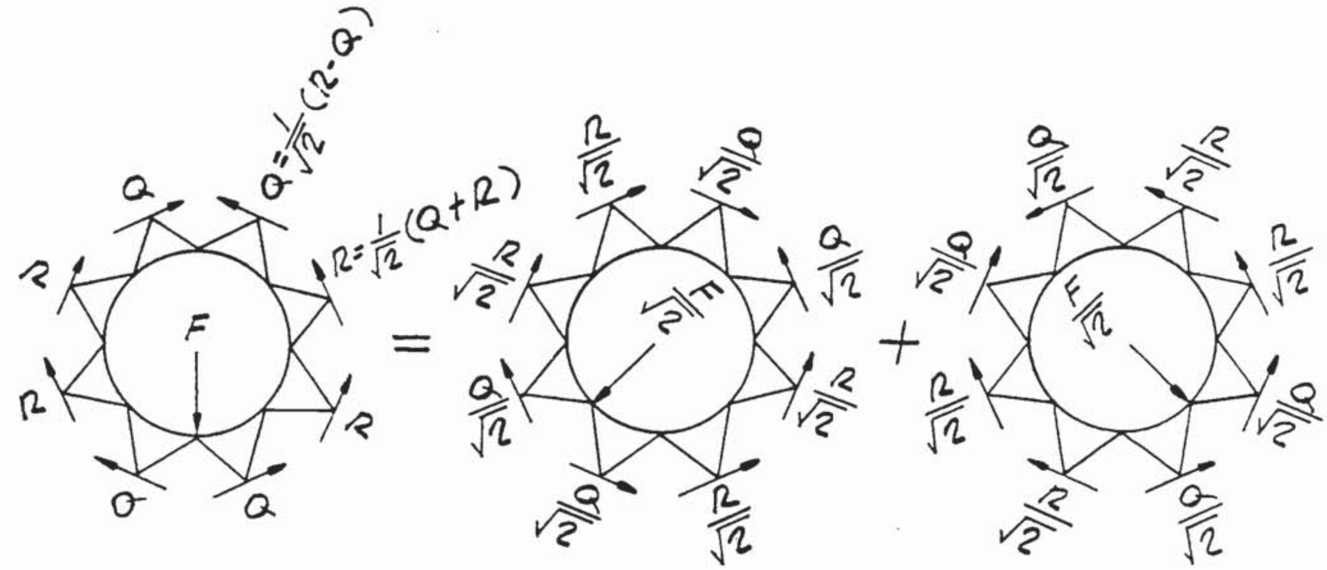
MONTICELLO REACTOR PRESSURE VESSEL SEISMIC ANALYSIS

SPRING CONSTANT (CONT'D)

CASE II (ARBITRARY FORCE F)

A. TANGENTIAL REACTIONS




NOTE: THE NATURE OF SYMMETRY & ANTISYMMETRY

$$\begin{cases} \Sigma F = F_1 + F_2 \\ R = \frac{1}{\sqrt{2}}(Q+R) \\ \Sigma V = 0, \text{ GIVES} \\ F = 4(R \cos \pi/8 + Q \sin \pi/8) \end{cases}$$

SOLUTION : $\begin{cases} Q = 0.0955\ F \\ R = 0.231\ F \end{cases}$

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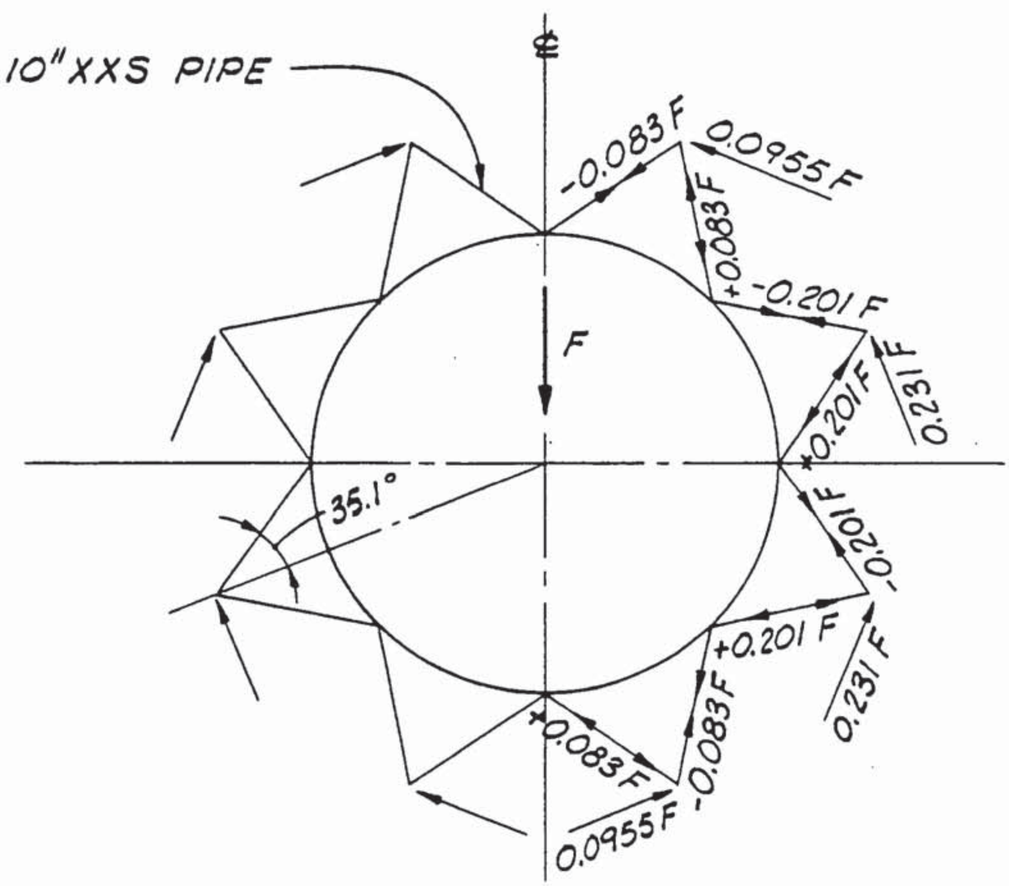
MONTICELLO REACTOR PRESSURE VESSEL

SEISMIC ANALYSIS

SPRING CONSTANT (CONT'D)

B. TRUSS LOADS




+ DENOTES TENSION

− DENOTES COMPRESSION

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MONTICELLO REACTOR PRESSURE VESSEL
SEISMIC ANALYSIS

SPRING CONSTANT (CONT'D)

$$\delta = \frac{FL}{AE} \Sigma u^2$$

$$L = 7.483 \text{ FT}$$

$$F = 1^K$$

$$A = 0.2127 \text{ FT}^2$$

$$E = 30 \times 10^6 \text{ LBS/IN}^2 = 4,320,000 \text{ K/FT}^2$$

$$\Sigma u^2 = 8(\overline{0.083}^2 + \overline{0.201}^2) = 0.3777$$

DISPLACEMENT $\delta = \frac{1 \times 7.483 \times 0.3777}{4,320,000 \times 0.2127} = 3.0757 \times 10^{-6}$ FT

SPRING CONSTANT $K = \frac{1}{\delta} = 325,129$ K/FT

GENERAL ELECTRIC COMPANY
Atomic Power Equipment Department

# MONTICELLO NUCLEAR GENERATION PLANT

## Report on the Earthquake Analysis of the Control Room

JOHN A. BLUME & ASSOCIATES, ENGINEERS
SAN FRANCISCO

JOHN A. BLUME & ASSOCIATES. ENGINEERS
HOWARD STREET • SAN FRANCISCO, CALIFORNIA

November 22, 1968

General Electric Company
Atomic Power Equipment Department
175 Curtner Avenue
San Jose, California 95125

ATTENTION: Mr. R. B. Gile
MC-750

SUBJECT : Monticello Nuclear Generation Plant - Unit 1
Control Room Earthquake Analysis

Gentlemen:

Transmitted herewith is the subject report based on the information furnished us by Bechtel Corporation, General Electric Company, and as listed in the References.

The analysis consists of an investigation of the coupled flexural dynamic response and the rocking dynamic response of the subject building. The results of the analysis are presented in this report, and are based on the building drawings listed in the References. These drawings should be reviewed to determine if any substantial changes in the building's structural properties have been made to warrant a further earthquake analysis.

Very truly yours,

JOHN A. BLUME & ASSOCIATES, ENGINEERS

R. T. Yokoyama
Assistant Vice President

RTY/vdr

# MONTICELLO NUCLEAR GENERATION PLANT-UNIT 1
# CONTROL ROOM
# EARTHQUAKE ANALYSIS

## CONTENTS

# MONTICELLO NUCLEAR GENERATION PLANT-UNIT 1
# CONTROL ROOM
# EARTHQUAKE ANALYSIS

## INTRODUCTION

The purpose of this report is to summarize the results of the seismic investigation of the Monticello Nuclear Generation Plant Control Room. Based upon the recommended earthquake design criteria established for the Plant, design envelopes of maximum acceleration, displacement, shear and overturning moment versus height of the building have been developed for both directions and are herein presented.

## DESIGN CRITERIA

Based upon data developed by John A. Blume & Associates, Engineers (Reference 2), the design earthquake used in this analysis is the North 69° West component of the July 1952 Taft earthquake, normalized to a maximum ground acceleration of 0.06 gravity.

## BUILDING DESCRIPTION

The control room is a separate, multistory structure located on the south side of the turbine building and adjacent to the east side of the reactor building. Both concrete block and reinforced concrete are used in wall construction throughout the structure. The reinforced concrete walls resist both vertical and lateral loads. Walls of concrete block resist lateral loading, and resistance to vertical loading in these areas is provided by use of steel columns and framing.

## METHOD OF ANALYSIS

For the dynamic response analysis, the equivalent mass system shown on Sheet No. 1 was selected to approximate the building. Masses were lumped at the floor levels indicated, and each represents the mass of concrete and steel at these floor levels and the tributary mass of the concrete and steel between them.

The average area and moment of inertia of the concrete and concrete block walls between floors were used to determine the stiffness characteristics.

References 7, 10, and 11 present the data associated with the granular material which supports the reactor building. These values are as follows:

$E_{dyn}$ = 78,500 pounds per square inch.

$G$ = 29,500 pounds per square inch.

$\mu$ = 0.33 (dimensionless).

$\rho$ = 135 pounds per cubic foot.

Using these given field determined values the following rotational and lateral foundation spring supports were determined using Equation (212) from Reference 3 and Equation (1-4-5) from Reference 9:

For earthquake in N-S direction:

$K_{rot}$ = 285,000,000 kip - feet per radian.

For earthquake in E-W direction:

$K_{rot}$ = 165,000,000 kip - feet per radian.

For earthquake in N-S & E-W directions

$K_G$ = 628,000 kips per foot

The natural periods and mode shapes and the dynamic response of the equivalent lumped mass system were determined with the aid of an IBM 1130 digital computer. The first three modes were considered, with the damping value assigned as 5 percent for each mode.

ANALYTICAL PROCEDURE

Periods and Mode Shapes

The natural periods of vibration and mode shapes of the mathematical model are given by Equation (1).

$$\left[\underline{K} - W_n^{\ 2}\ \underline{M}\right] \underline{\Phi}_n = \underline{0} \quad \text{--------------------------------} \quad (1)$$

where:

$\underline{K}$ = Stiffness matrix (see Remarks on the Computer Program)

$W_n$ = Natural circular frequency for the $n^{\underline{th}}$ mode

$\underline{M}$ = Mass matrix

$\underline{\Phi}_n$ = Mode shape matrix for the $n^{\underline{th}}$ mode

$\underline{0}$ = Zero matrix

By use of a computer program the $W_n$ value and the $\underline{\Phi}_n$ matrix for the $n^{\underline{th}}$ mode are obtained.

## Generalized Acceleration and Displacement Response

The generalized displacement response of the structure, once the period and mode shapes have been determined, is given by the following equation:

$$\underline{\ddot{Y}_n(t)} + 2W_n\lambda_n\ \underline{\dot{Y}_n(t)} + W_n^2\ \underline{Y_n(t)} = R_n\ M_n^{-1}\ \underline{\ddot{U}_g(t)} \quad \text{---------} \quad (2)$$

where:

$\underline{Y_n(t)}$ = Generalized displacement response for the $n^{\underline{th}}$ mode

$$= \frac{R_n}{M_n W_n} \int_0^t \ddot{U}_g\ (\tau)\ e^{-\lambda_n W_n (t-\tau)}\ \text{Sin}\left[W_n\ (t-\tau)\right] d\tau \quad \text{--} \quad (3)$$

$M_n$ = Generalized mass for the $n^{\underline{th}}$ mode

$$= \underline{\Phi}_n^T \cdot \underline{M} \cdot \underline{\Phi}_n$$

$\underline{\ddot{U}_g(t)}$ = Earthquake ground acceleration

$\lambda_n$ = Damping for the $n^{\underline{th}}$ mode - taken as 5 percent for all modes

$d\tau$ = Integration interval used in the step-by-step solution of the Duhamel Integral

From the Generalized displacement response the time-history of displacements is found according to Equation (4).

$$\underline{v}(t) = \underline{\Phi}\ \underline{Y}(t) \qquad (4)$$

where:

$\underline{\Phi} = \left[\underline{\Phi}_1\ \underline{\Phi}_2\ \text{--------}\ \underline{\Phi}_m\right]$, m = Number of modes considered

$$\underline{Y}(t) = \begin{bmatrix} Y_1(t) \\ Y_2(t) \\ \vdots \\ Y_m(t) \end{bmatrix}$$

$\underline{v}(t)$ = Displacement - time-history matrix

The solution for generalized acceleration response is identical to the above, except that Equation (2) is solved for acceleration, from which the relative acceleration - time-history matrix is calculated. To this is added the ground acceleration, resulting in the absolute acceleration - time-history.

Once displacement and acceleration - time-histories have been established, the time-histories of shears and moments are determined. These records are then enveloped to determine the maximum values which are then graphically presented in the report and used by the designer.

## Remarks on the Computer Program

1) The computer program used in this analysis was specially designed to solve the dynamic response of structures subjected to

arbitrary ground motions. Since the program was written to cover as many structural configurations as possible, the structural member input data for the program, except for the foundation spring, is in the form of member moments of inertia, areas, and effective shear areas. The effects of axial deformations and shear deformations are included in the calculation of the stiffness matrix.

2) The computer retains the response of each mass for each individual mode at each increment of time, and the total response for each increment of time is obtained by adding together the responses of each mass point for each mode at a particular instant of time. This results in an exact combination of mode participation without the necessity of using approximate methods such as the root-mean-square method.

3) Individual elements in the stiffness matrix are designated $K_{ij}$ and are stored in the computer such that the i value designates the row number and the j value the column number. $K_{ij}$ is determined by applying a unit displacement at the $j^{th}$ point while restraining the other points against displacement, and finding the corresponding reaction at the $i^{th}$ point. In this manner the foundation spring is included in the stiffness matrix. This procedure couples the foundation spring and elastic springs of the structural system.

4) The general computer techniques used in this analysis are taken from References 5, 6, and 8. However, the referenced techniques have been extensively modified and expanded by John A. Blume & Associates, Engineers to increase their versatility and capability. A simplified block diagram of the computer program is shown on Plate A, and the input and output are indicated in Tables A and B respectively.

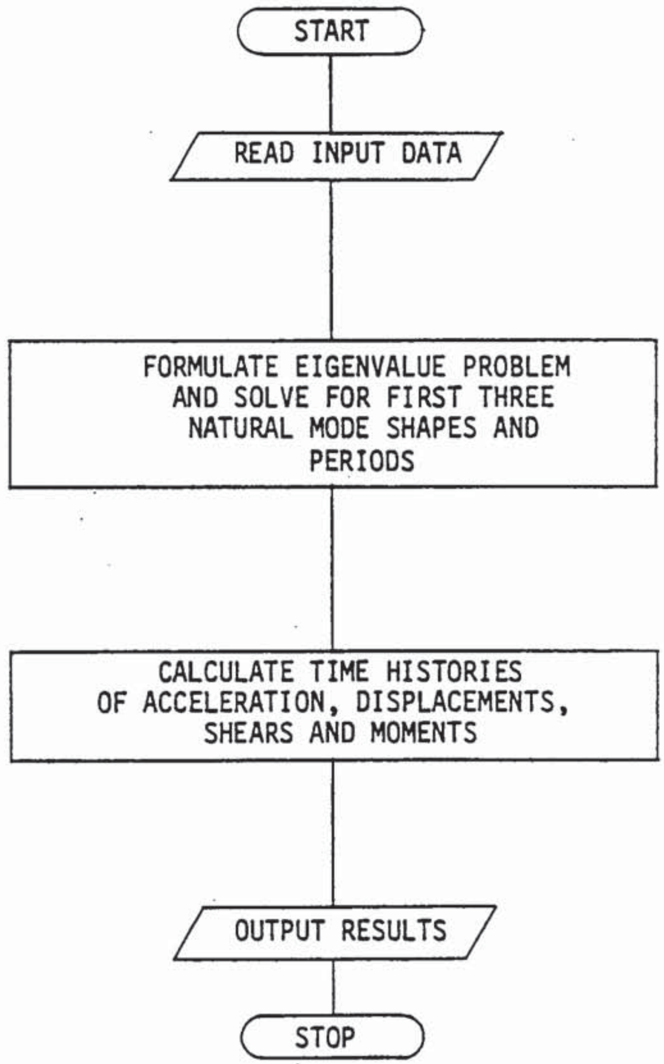


PLATE A

FLOW DIAGRAM OF COMPUTER PROGRAM

# TABLE A

## INPUT DATA

1. Geometry of Model
   a) Vertical distances between mass points
   b) Mass point identification
      ie: Mass 1
      Mass 2
      Etc.

2. Section and Foundation Properties
   a) Moments of inertia of columns
   b) Areas of columns
   c) Shear areas of columns
   d) Foundation spring constants, $K_g$, $K_s$

3. Weights and Masses
   a) Weight of each mass point
   b) Mass of each mass point

4. Input Earthquake Data
   a) Input earthquake - time in seconds and acceleration in gravity units.
   b) Time length of earthquake record used - 10.0 seconds.

TABLE B

OUTPUT RESULTS

1. Maximum displacement of each mass point.
2. Maximum absolute accelerations of each mass point.
3. Maximum shears at each mass point.
4. Maximum overturning moments at each mass point.
5. Period of vibration of each mode calculated.

## DISCUSSION OF RESULTS

### Absolute Acceleration

The curves shown on Sheets 2 and 6 give an envelope of the maximum absolute accelerations with respect to height. These curves can be used for the seismic design of equipment elements rigidly attached to the subject building, but the moment, shear, and displacement curves presented should be used in the design of the building.

### Shears, Moments, and Displacements

The maximum envelopes of building design shears, moments, and displacements are presented graphically on Sheets 3, 4, 5, 7, 8, and 9. The displacement values plotted are relative to the base. These curves should be used in the seismic design of the building.

### Periods of Vibration

| Direction of Earthquake | First Mode (Seconds) | Second Mode (Seconds) | Third Mode (Seconds) |
|---|---|---|---|
| North-South | 0.21 | 0.085 | 0.026 |
| East-West | 0.244 | 0.090 | 0.031 |

### Recommendations

It is recommended that the subject structure be designed to resist the seismic shears and moments presented herein without the usual increase in stress for short term loadings. In addition, the structure should be reviewed to assure that it can resist twice the seismic shears and moments presented herein without hindering the ability of the plant to safely shut down. In addition to the horizontal accelerations, a vertical building (and equipment) acceleration of 0.04 gravity, acting simultaneously with the horizontal accelerations is recommended for design.

# MONTICELLO NUCLEAR GENERATION PLANT

## CONTROL ROOM

## EARTHQUAKE ANALYSIS

## REFERENCES


1. Design Drawings

   BECHTEL Drawings

   C-19, Rev. 1, dated June 14, 1968
   C-460, Rev. 2; C-461, Rev. 3; C-462, Rev. 1, dated July 17, 1968
   C-463, Rev. 2; C-466, Rev. 2; C-468, Rev. 1, dated July 17, 1968
   C-465, Rev. 1; C-467, Rev. 1, dated April 18, 1968
   C-470, Rev. 2, dated May 10, 1968
   C-471, Rev. 2, dated July 25, 1968
   C-472, Rev. 2, dated July 25, 1968

2. Monticello Nuclear Generation Plant Recommended Earthquake Criteria, John A. Blume & Associates, Engineers, July 15, 1966.

3. Theory of Elasticity, Timoshenko and Goodier, Second Edition, McGraw Hill Company, 1951.

4. Nuclear Geoplosics, Stanford Research Institute, Defense Atomic Support Agency, Part Two, Mechanical Properties of Earth Materials, May 1962.

5. Use of Modern Computers in Structural Analysis, R. W. Clough, Journal of the Structural Division of the American Society of Civil Engineers, ST 3, May 1958.

6. Structural Analysis of Multistory Buildings, R. W. Clough, Ian P. King, and Edward L. Wilson, Journal of the Structural Division of the American Society of Civil Engineers, ST 3, June 1964.

7. Monticello Nuclear Generation Plant Earthquake Analysis of the Reactor Building, John A. Blume & Associates, Engineers, July 18, 1967.

8. Dynamic Effects of Earthquakes, R. W. Clough, Transactions of the American Society of Civil Engineers, Paper No. 3252.

9. Dynamics of Bases and Foundations, D. D. Barkan, McGraw Hill Company, 1962.

10. Report of Foundation Investigation - Proposed Nuclear Power Plant-Unit Number 1, Monticello, Minnesota, by Dames & Moore, dated July 27, 1966 (including Supplements 1 through 5)

REFERENCES (cont'd)

11. Report-Dynamic Response Data Investigation - Proposed Nuclear Power Plant, Monticello, Minnesota, by Dames & Moore, dated July 7, 1966.

# MONTICELLO NUCLEAR GENERATION PLANT-UNIT 1
## CONTROL ROOM
## EARTHQUAKE ANALYSIS

LIST OF FIGURES — SHEET NO.



LIST OF PROPERTIES

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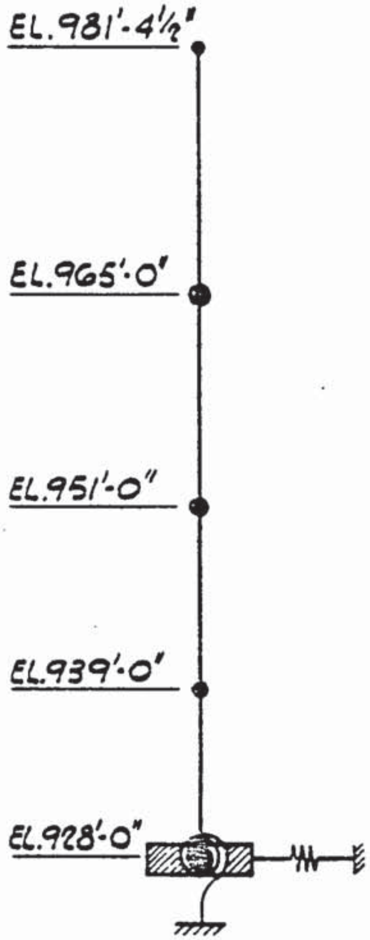
# MONTICELLO CONTROL ROOM
# SEISMIC ANALYSIS
## MATHEMATICAL MODEL




| | EARTHQUAKE IN N-S DIRECTION | | EARTHQUAKE IN E-W DIRECTION | |
|---|---|---|---|---|
| WEIGHT(K) | $\bar{A}$ ($FT^2$) | I ($FT^4$) | $\bar{A}$ ($FT^2$) | I ($FT^4$) |
| 734.8 | | | | |
| | 187 | 33,566 | 95 | 24,971 |
| 1848.8 | | | | |
| | 142 | 78,682 | 137 | 71,575 |
| 1502.0 | | | | |
| | 133 | 77,050 | 137 | 65,950 |
| 1220.0 | | | | |
| | 217 | 110,643 | 134 | 66,139 |
| 3970.6 | $A_{BASE}$ = 3340 | $I_{BASE}$ = 1,235,000 | $A_{BASE}$ = 3340 | $I_{BASE}$ = 710,000 |

SHEET NO. 1

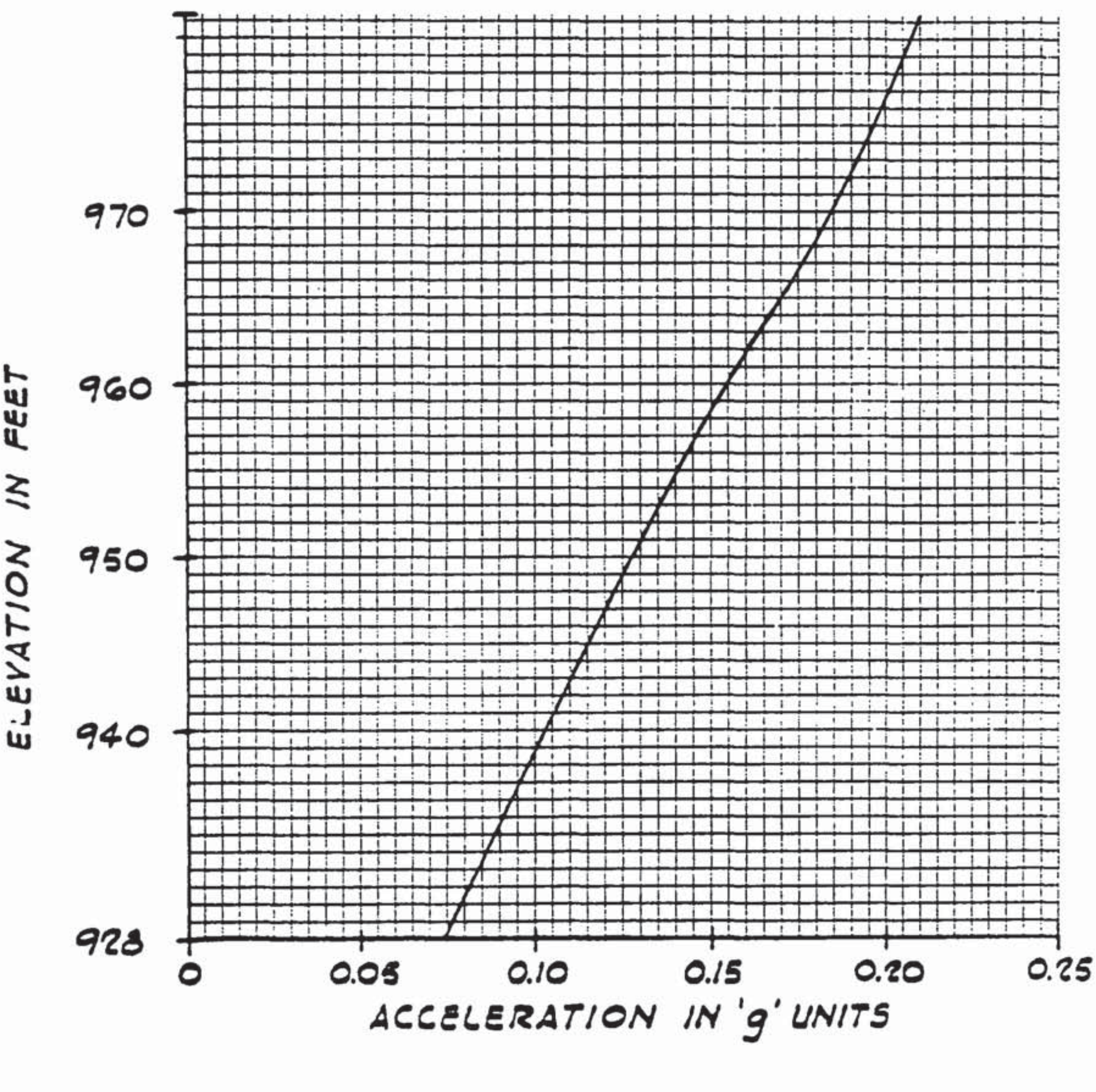
JOHN A. BLUME AND ASSOCIATES, ENGINEERS

# MONTICELLO CONTROL ROOM

## SEISMIC ANALYSIS

## ACCELERATION DIAGRAM

## NORTH - SOUTH DIRECTION




SHEET NO. 2

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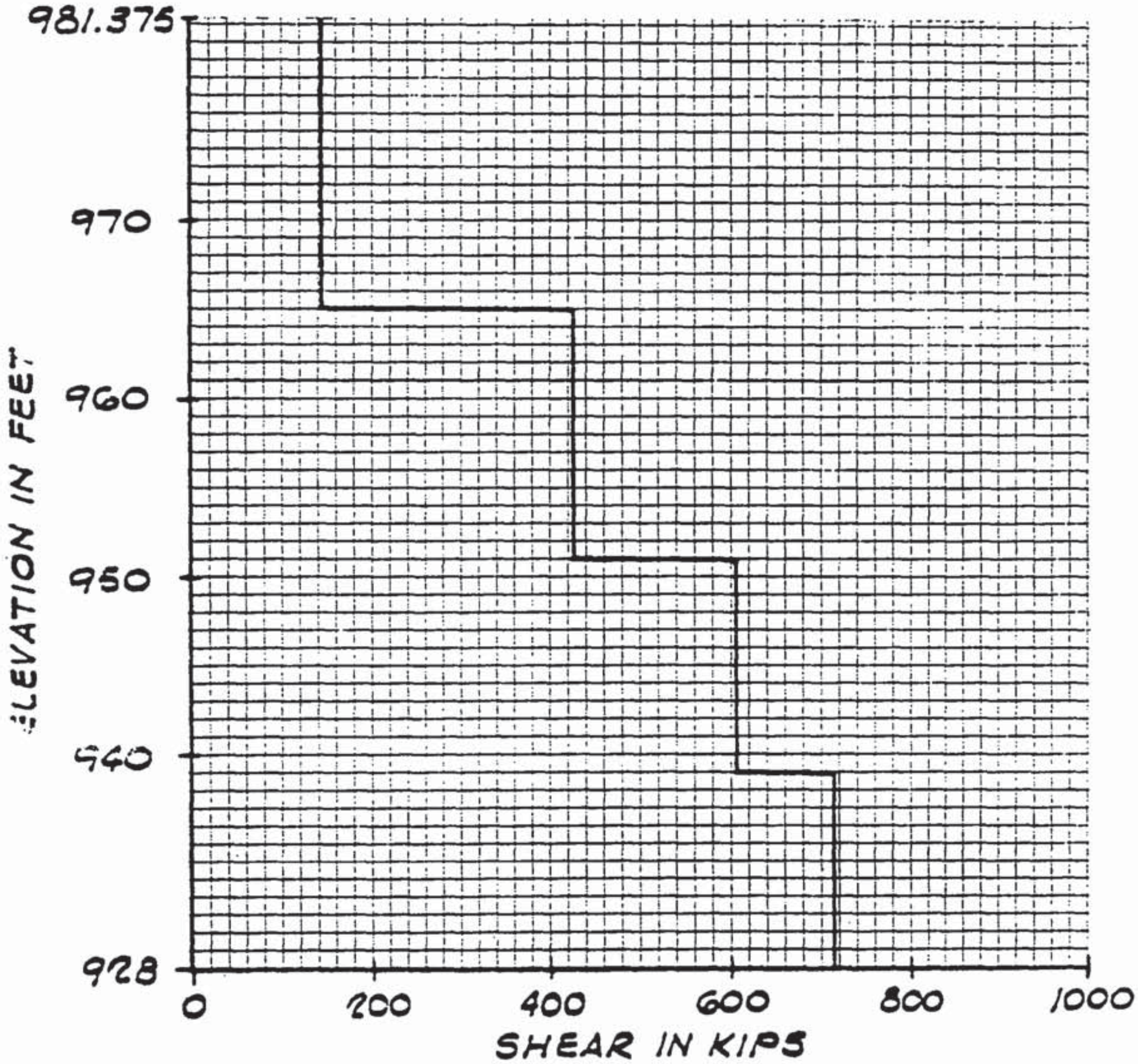
# MONTICELLO CONTROL ROOM
## SEISMIC ANALYSIS
## SHEAR DIAGRAM
## NORTH-SOUTH DIRECTION




SHEET NO. 3

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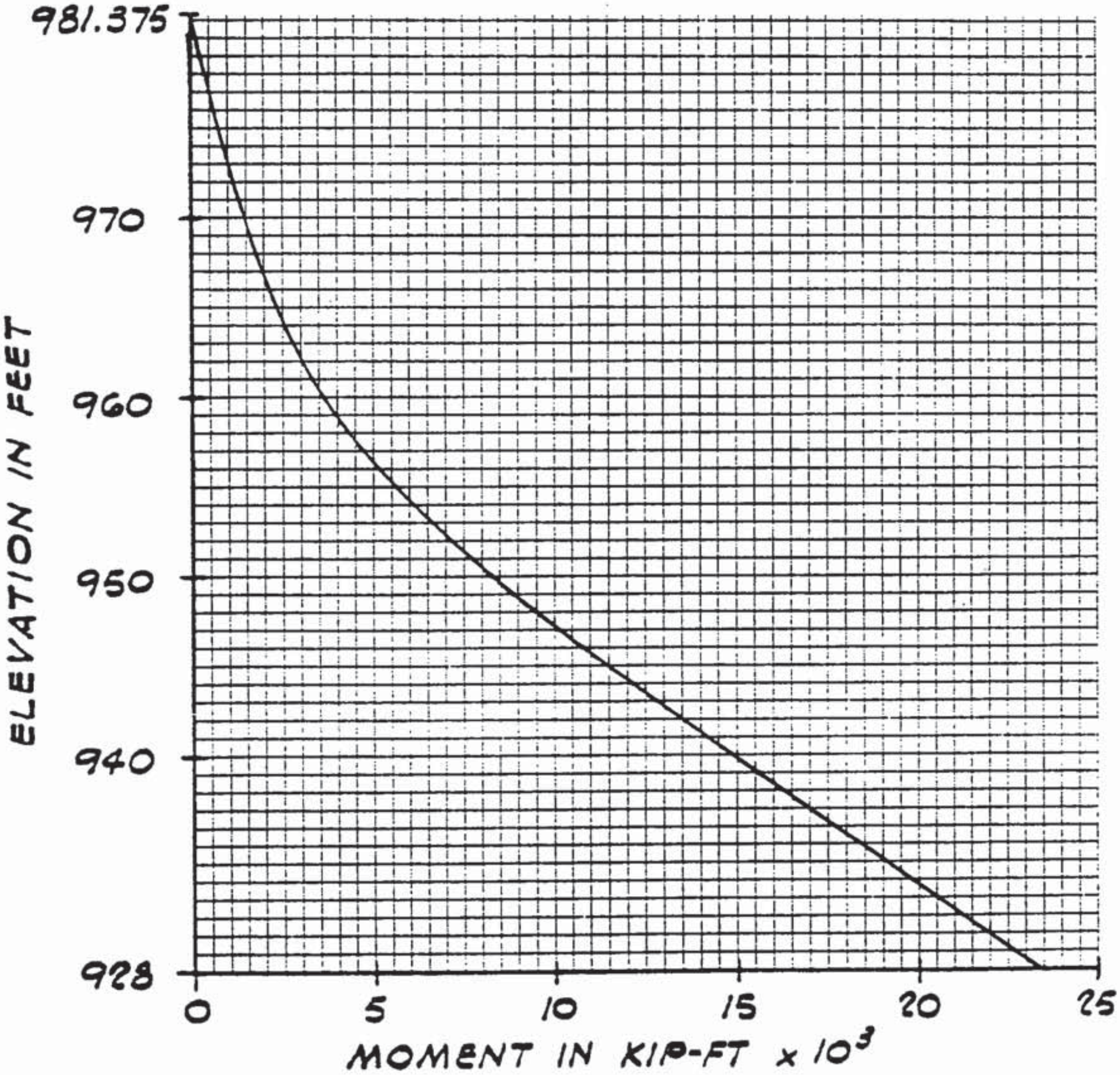
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

MOMENT DIAGRAM

NORTH-SOUTH DIRECTION



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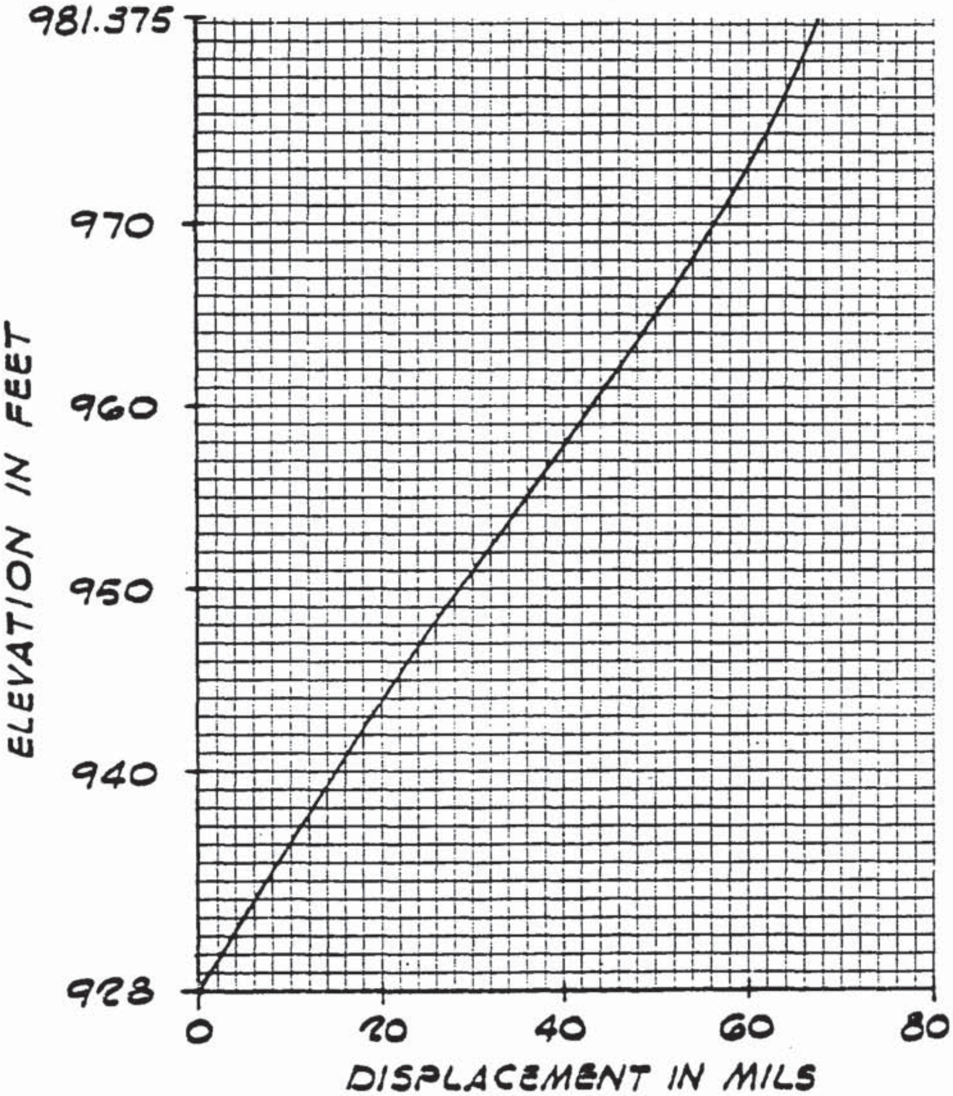
# MONTICELLO CONTROL ROOM
## SEISMIC ANALYSIS
## DISPLACEMENT DIAGRAM
## NORTH-SOUTH DIRECTION



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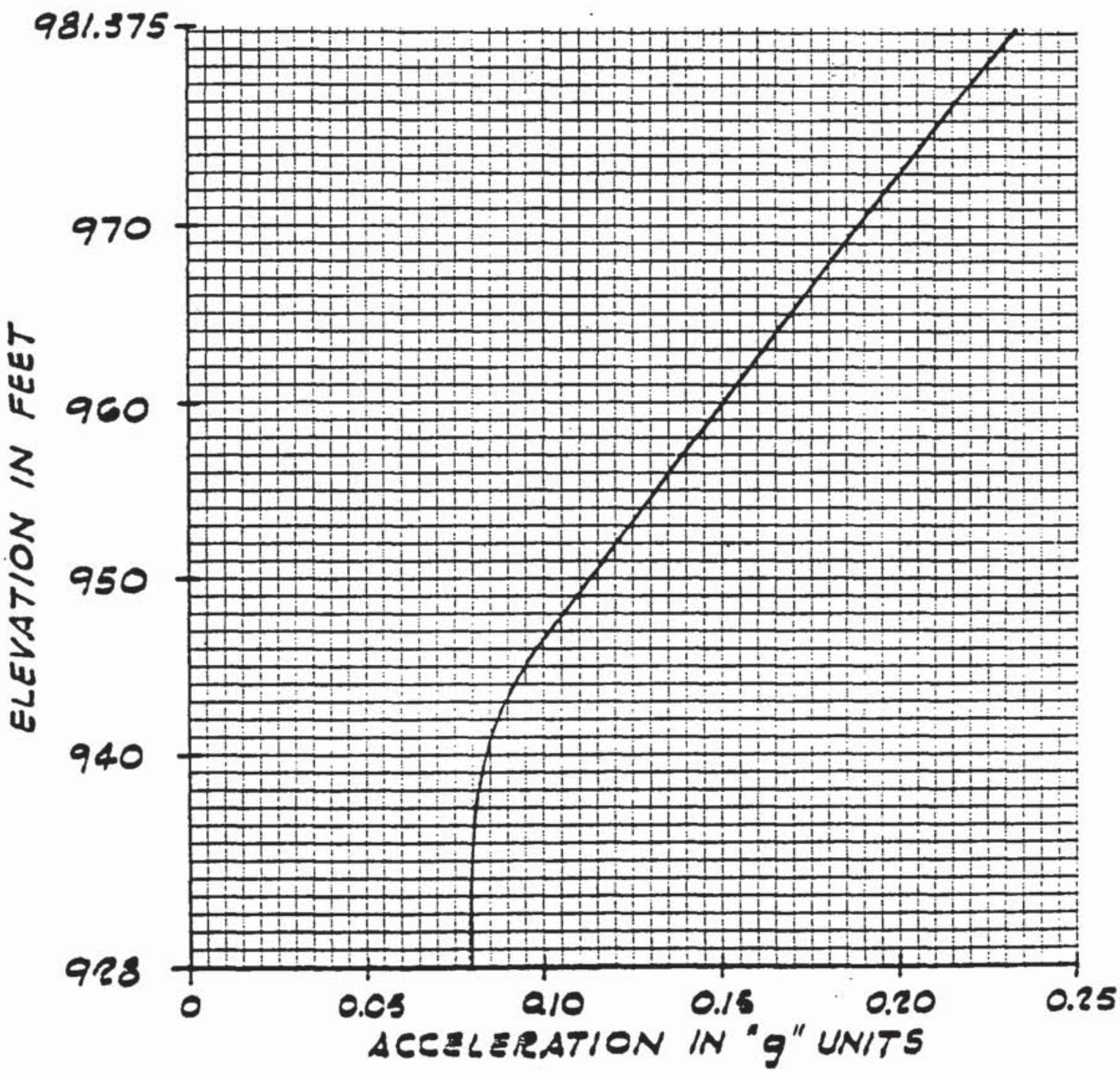
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

ACCELERATION DIAGRAM

EAST-WEST DIRECTION




SHEET NO. 6

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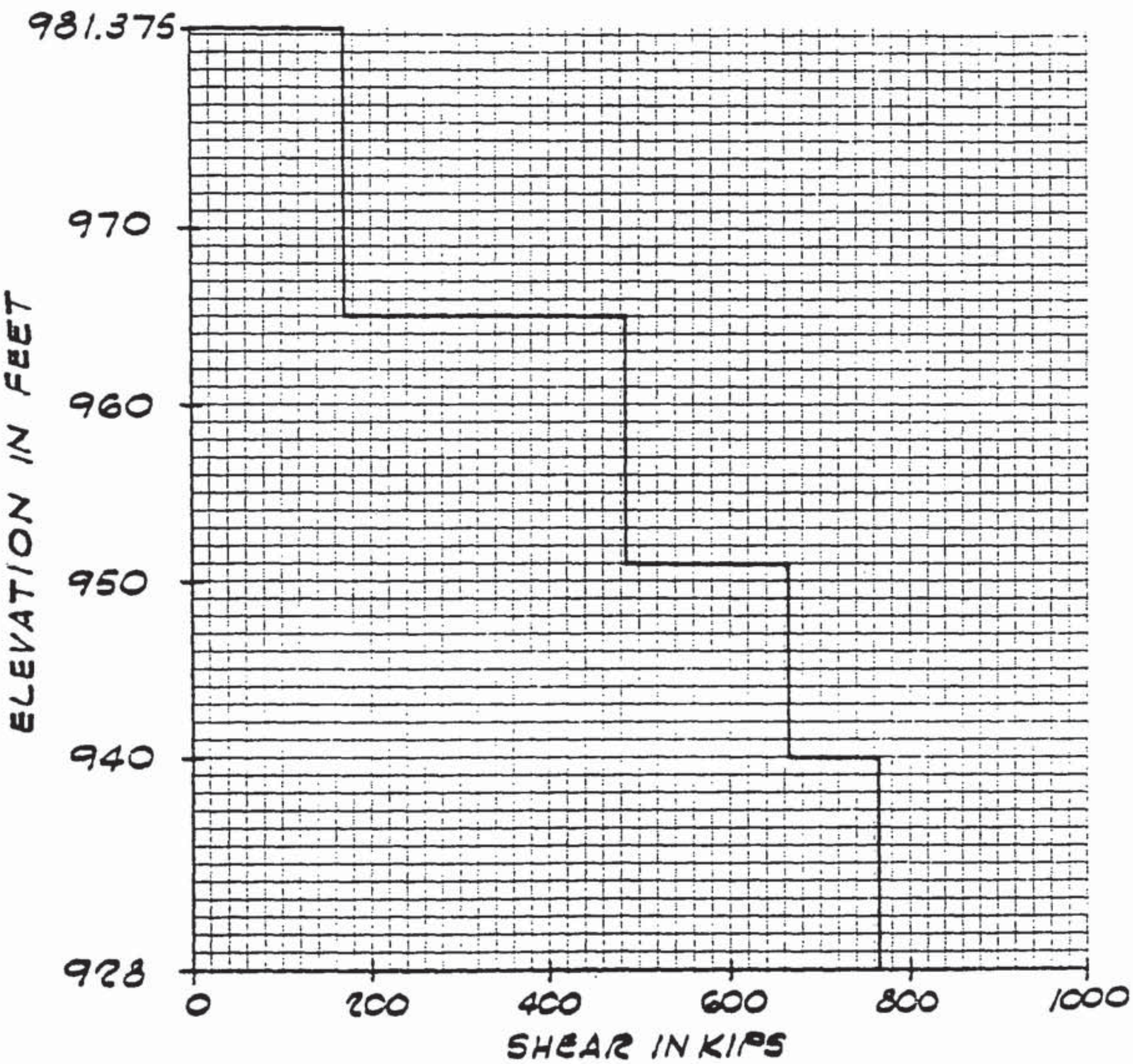
# MONTICELLO CONTROL ROOM
## SEISMIC ANALYSIS
## SHEAR DIAGRAM
## EAST-WEST DIRECTION



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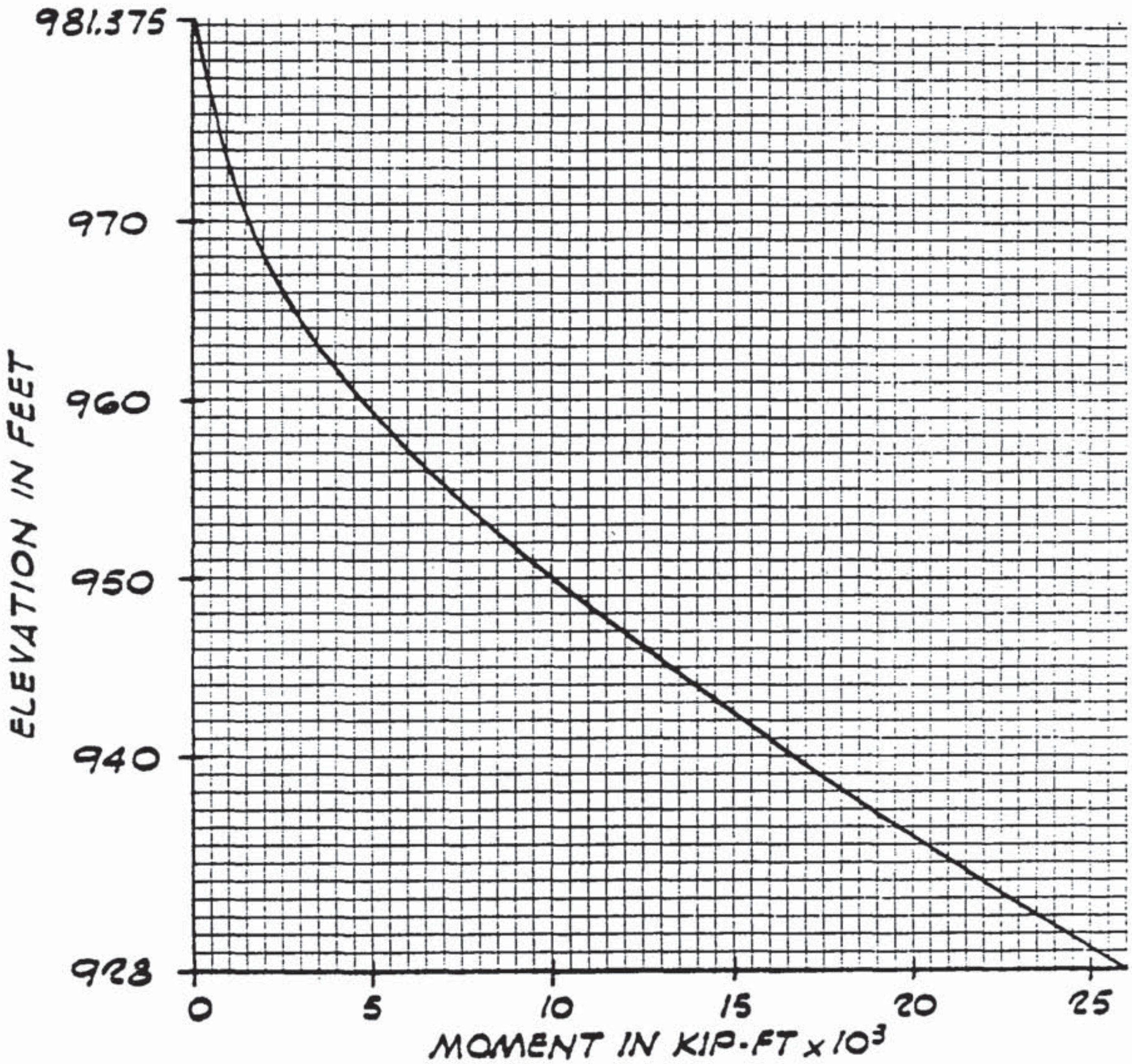
# MONTICELLO CONTROL ROOM
# SEISMIC ANALYSIS
# MOMENT DIAGRAM
# EAST-WEST DIRECTION



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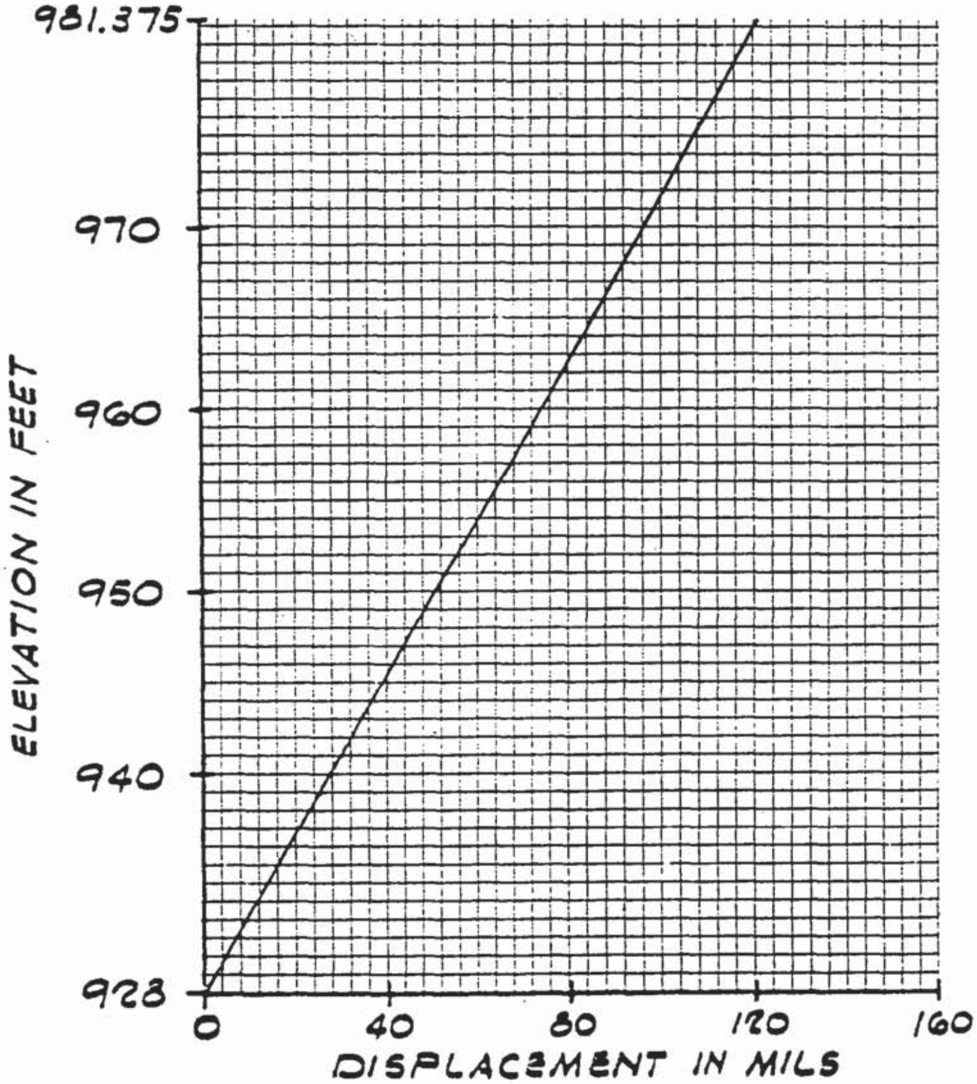
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

DISPLACEMENT DIAGRAM

EAST-WEST DIRECTION



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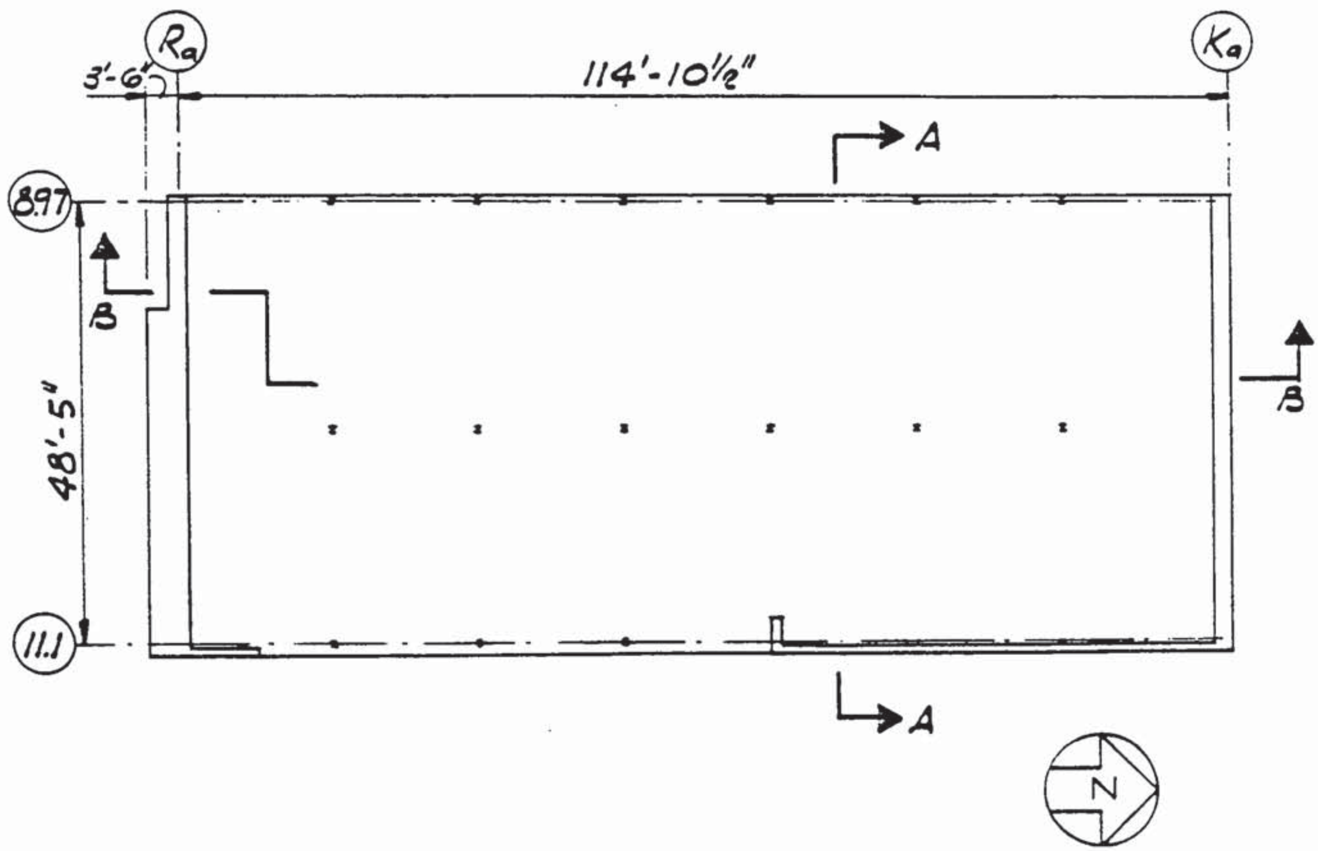
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

ROOF PLAN @ EL. 981'-4½"



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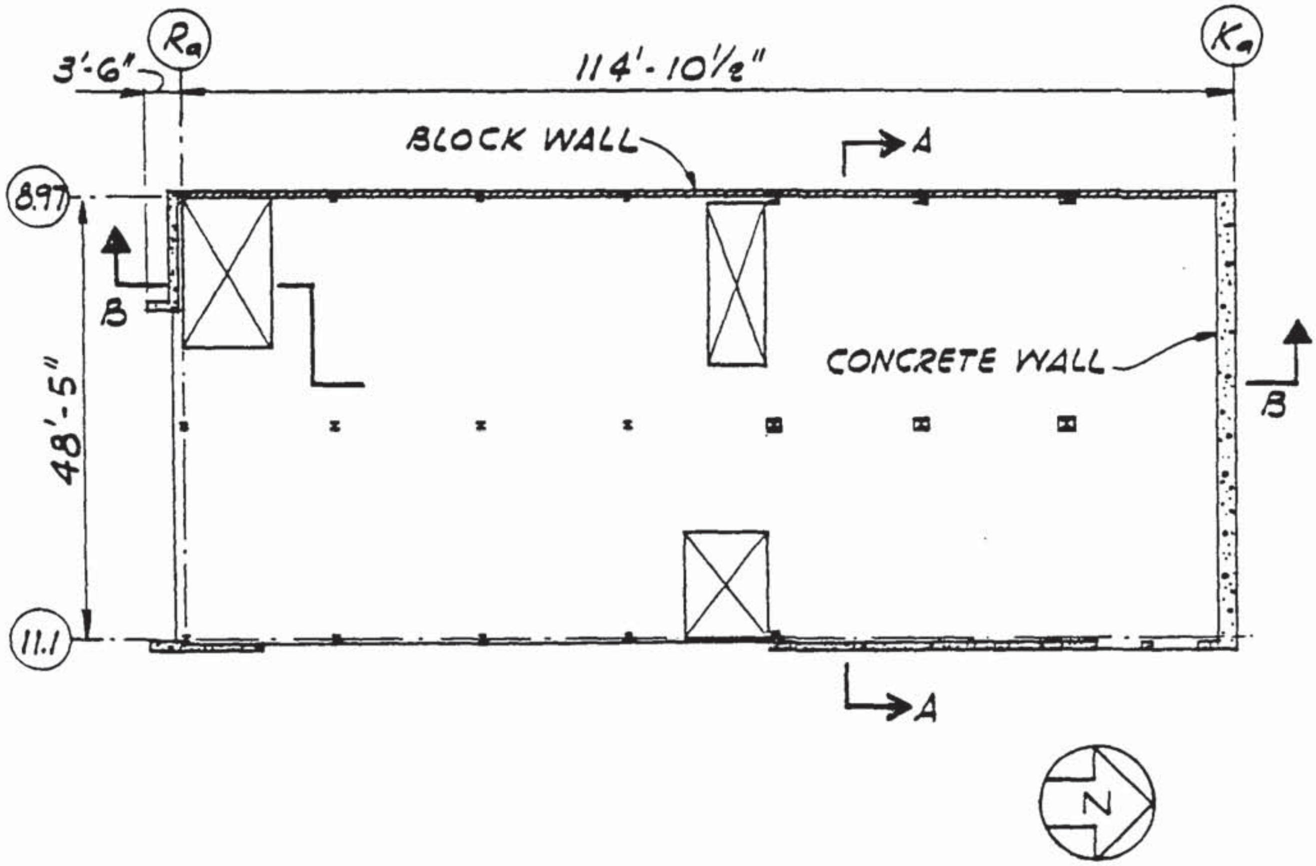
# MONTICELLO CONTROL ROOM
# SEISMIC ANALYSIS
# FLOOR PLAN @ EL. 965'-0"



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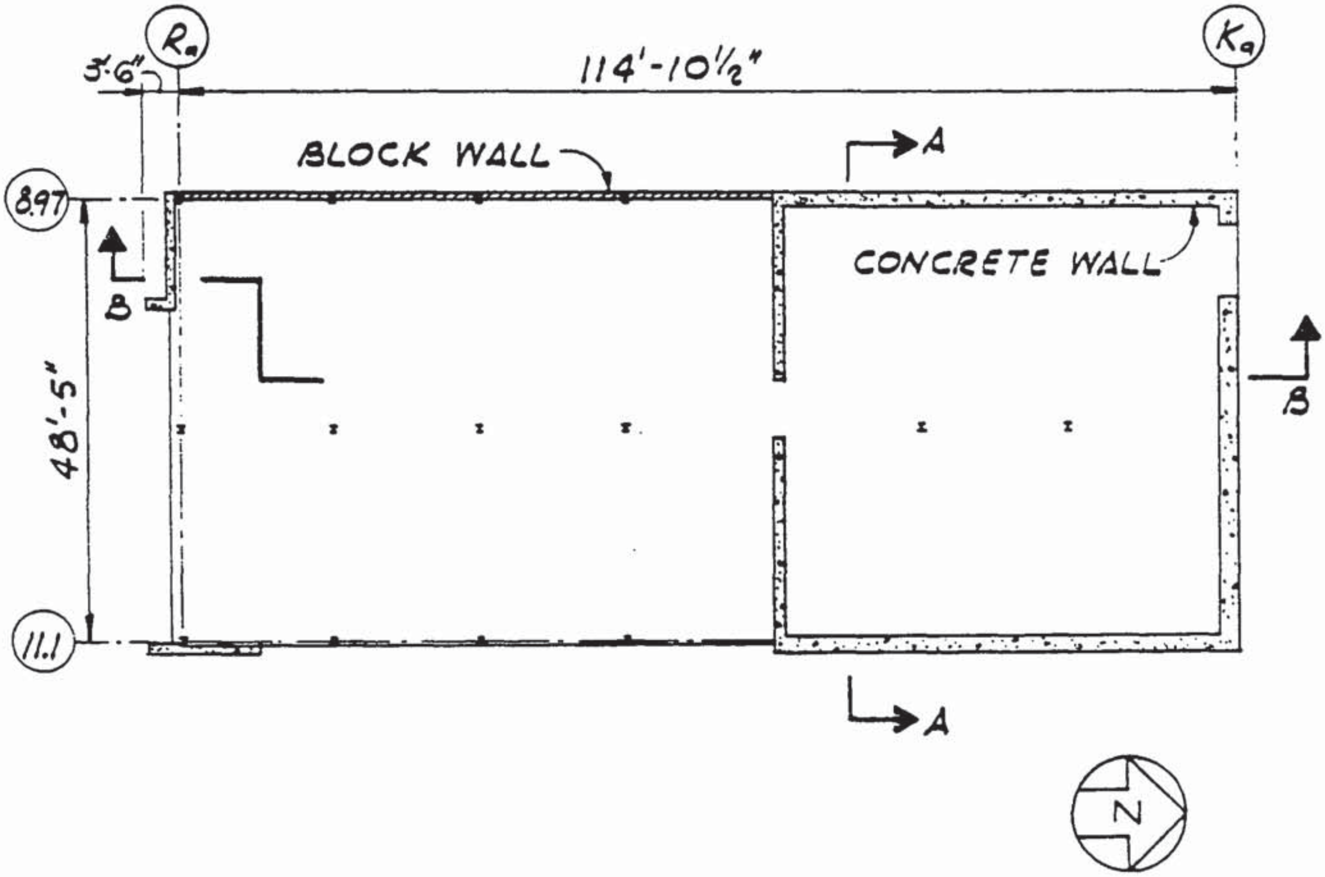
# MONTICELLO CONTROL ROOM

## SEISMIC ANALYSIS

## FLOOR PLAN @ EL. 951'-0"

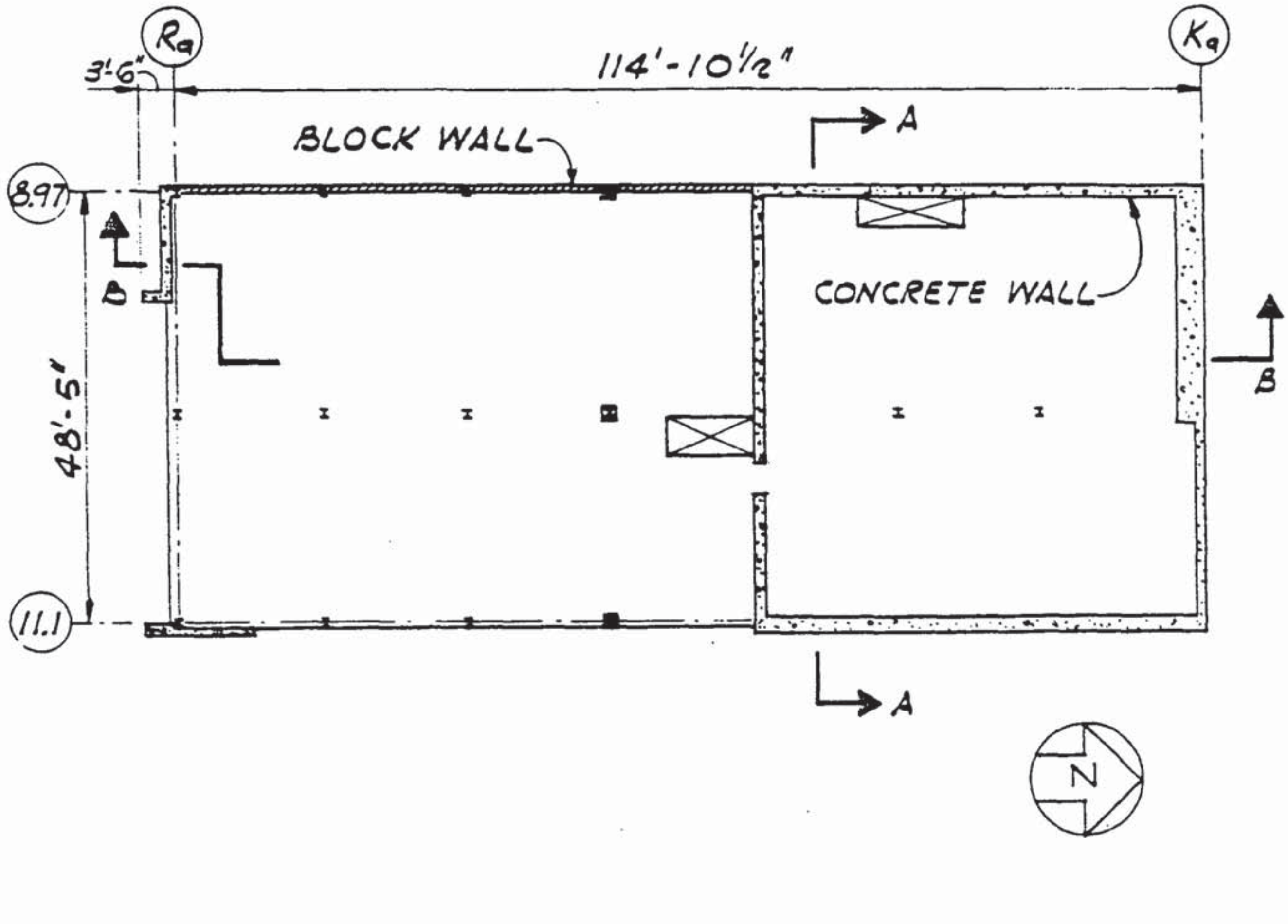


JOHN A. BLUME AND ASSOCIATES, ENGINEERS

MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

FLOOR PLAN @ EL. 939'-0"



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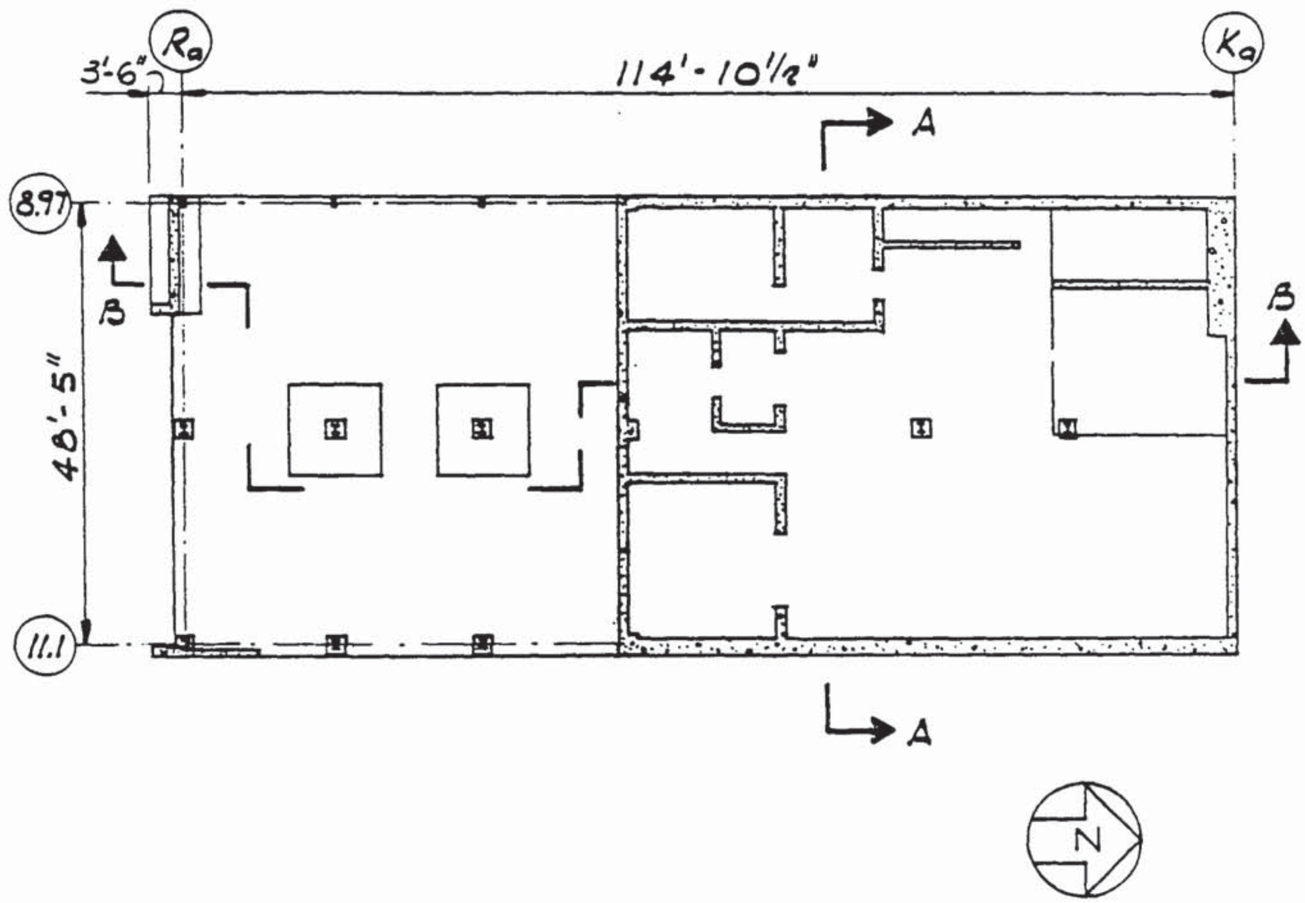
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

FLOOR PLAN @ EL. 928'-0"

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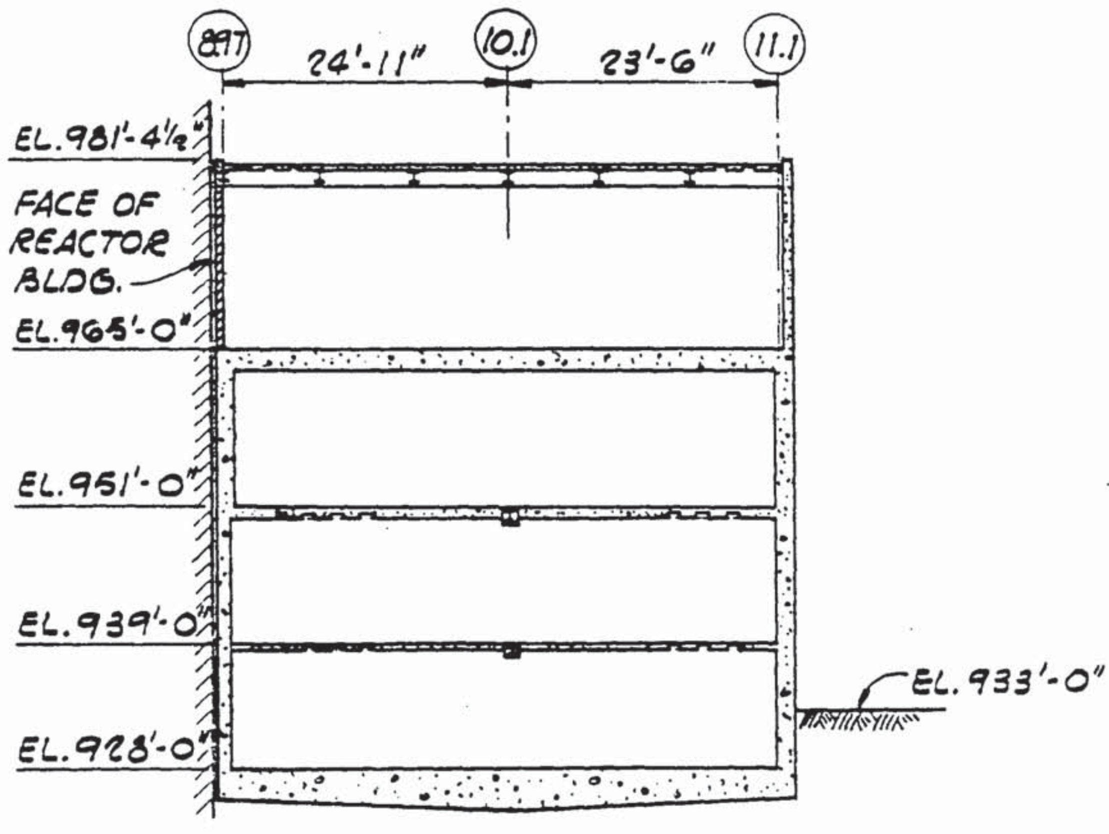
MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

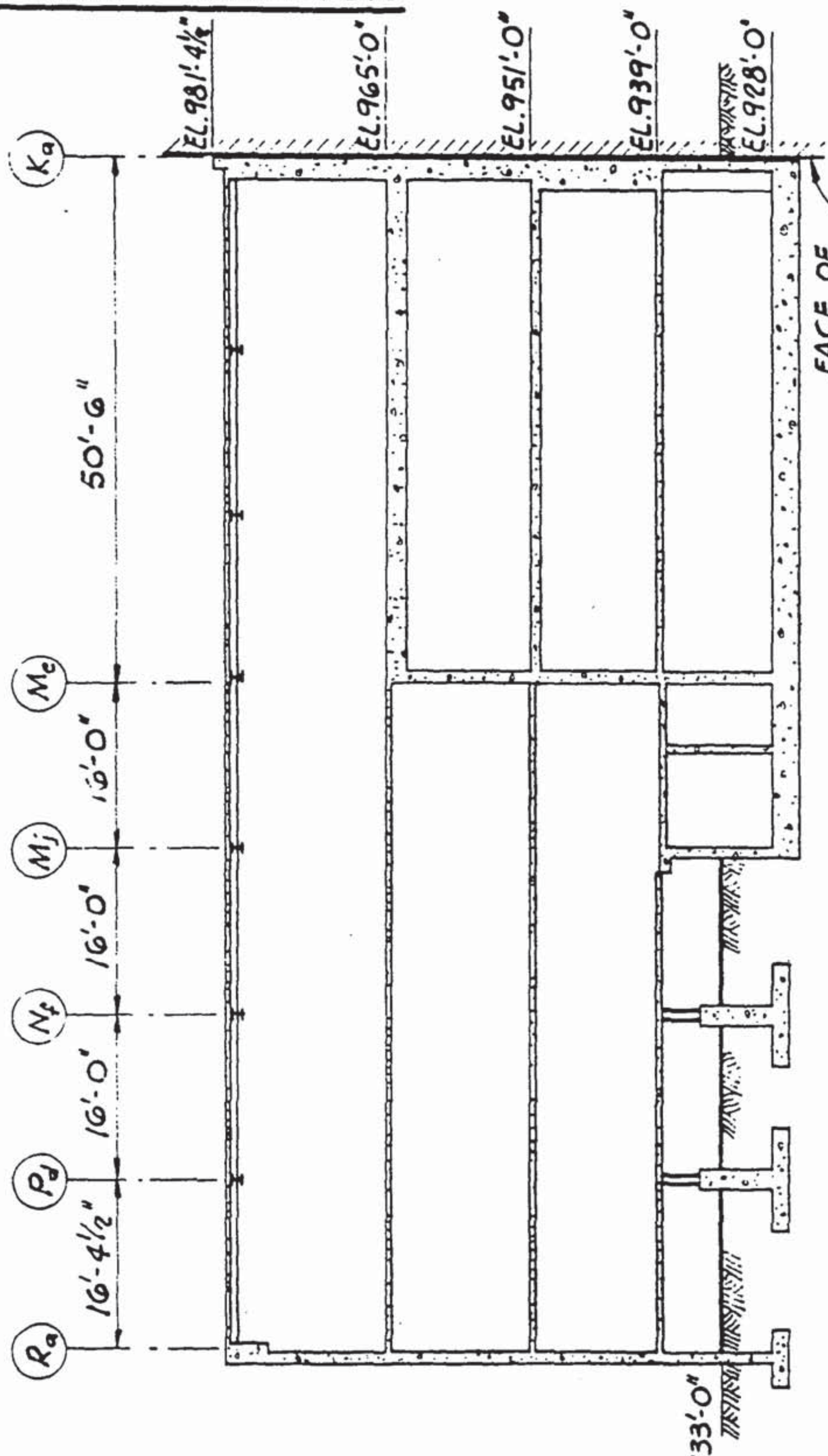



SECTION A-A

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS




SECTION B-B

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

## MONTICELLO CONTROL ROOM
## SEISMIC ANALYSIS
## LUMPED WEIGHTS

### WEIGHT 1 @ EL. 981'-4½"

| | |
|---|---|
| SNOW LOAD: 0.015 x 50.3 x 114.88 | = 87.0$^K$ |
| METAL ROOF + BEAMS + PURLINS: 0.010 x 50.3 x 114.88 | = 57.8 |
| CONCRETE DECK: 0.15 x 0.3 x 50.3 x 114.88 | = 260.4 |
| ½ WALLS BELOW: 0.15 x 8.19 x (2 x 50.3 + 1 x 15.1 + 0.833 x 48.5 + 1 x 11.75 + 0.833 x 11.75) + 0.15 x (1.25 x 38.4 x 3 + 0.875 x 11.5 x 4 + 0.67 x 2.25 x 112.38) + 0.065 x 5.94 x 112.38 + 0.02 x 8.19 x (36.25 + 56) | = 330.0 |
| DEDUCT OPENINGS: 0.15 x 0.833 x 40 | = −5.0 |
| ½ COLS. BELOW: 8.19 x (.039 x 6 + .045 x 3 + .033 x 6) | = 4.6 |
| | 734.8 |

### WEIGHT 2 @ EL. 965'-0"

| | |
|---|---|
| CONCRETE SLAB: 0.15 x 2 x 47.5 x 48.4 | = 689.0$^K$ |
| METAL DECK W/ CONCRETE SLAB: 0.048 (64.5 x 48.4 - 10 x 16.3 - 6 x 18.2 - 9.1 x 11.63) | = 131.9 |
| ½ WALLS ABOVE & BELOW: 0.15 x 15.19 x (2 x 50.3 + 1 x 15.1 + 0.833 x 49.5 + 0.833 x 11.75) + 0.15 (1.5 x 48.6 x 8 + 0.75 x 49.5 x 7 + 1.5 x 8 x 5.5 + 1 x 7 x 47.4) + 0.065 x (112.88 x 15.19 + 64.75 x 8) + 0.02 x (36.25 x 15.19 + 56 x 15.19) + 0.043 x 26 x 11.5 | = 752.0 |
| ½ COLS. ABOVE & BELOW: 15.19 x (0.036 x 6 + 0.039 x 3) | = 5.1 |
| STEEL FLOOR FRAMING: 0.0086 x 64.4 x 50.3 | = 27.8 |
| EQUIPMENT: 0.06 x 47.5 x 48.4 + 0.04 (64.5 x 48.4 - 10 x 16.3 - 6 x 18.2 - 9.1 x 11.63) | = 248.0 |
| DEDUCT FOR OPENINGS IN WALLS: 0.15 x 0.833 x 40 | = −5.0 |
| | 1848.8 |

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

LUMPED WEIGHTS CONT'D.

WEIGHT 3 @ EL. 951'-0"

| | |
|---|---|
| CONCRETE SLAB : 0.15 x 1 x 47.5 x 48.4 | = 344.5$^K$ |
| METAL DECK W/ CONCRETE SLAB : 0.048 (64.5 x 48.4 -10x16.3 - 6x18.2 - 9.1 x 11.63) | = 131.9 |
| 1/2 WALLS ABOVE & BELOW : 0.15 (2 x 50.3 x 7 + 1 x 23.88 x 6 + 3 x 26.6 x 6 + 1 x 47.4 x 13 + 1 x 15.1 x 13 + 0.833 x 16 x 4 + 0.875 x 15.75 x 10 + 1 x 50.5 x 6 + 1.75 x 50.5 x 7 + 1.625 x 49.5 x 13 + 1 x 11.75 x 13) + 0.02 x (36.25 x 7 + 20.5 x 6 + 56 x 3) + 0.065 x (64.38 x 13) + 0.043 x (26 x 14) | = 745.4 |
| 1/2 COLS. ABOVE & BELOW : 13 x (.078 + .045) x 4 | = 6.9 |
| STEEL FLOOR FRAMING : 0.0085 x 50.3 x 114.88 | = 49.0 |
| EQUIPMENT : 0.060 x 47.5 x 48.4 + 0.040 (64.5 x 48.4 - 10 x 16.3 - 6 x 18.2 - 9.1 x 11.63) | = 248.0 |
| DEDUCT FOR OPENINGS IN WALLS : 0.15 x (2 x 7 x 8 + 1 x 6.38 x 7) | = -23.7 |
| | 1502.0 |

WEIGHT 4 @ EL. 939'-0"

| | |
|---|---|
| CONCRETE SLAB : 0.15 x (1 x 9 x 17 + 0.75 x 13 x 11 + 0.67 x 6 x 4) | = 41.5$^K$ |
| METAL DECK W/ CONCRETE SLAB : 0.048 x (48 x 47.5 - 320 - 56) + 0.048 x 48.83 x 48.38 + 0.07 x 14 x 17 + 0.061 x (33 x 16 - 40) | = 258.8 |
| 1/2 EXTERIOR WALLS ABOVE & BELOW : 0.15 x [(1 x 20.3 + 3 x 26.6 + 1 x 47.5 + 1.625 x 49.5) x 6 + (1 x 35.13 + 3 x 14.17 + 0.833 x 49.2 + 1 x 64.5) x 5.5 + 0.833 x 55 x 4 + 1 x 15.1 x 13 + 1 x 11.75 x 11.5 + 0.833 x 17 x 1.625] + 0.02 x (36.25 x 7 + 20.5 x 6) + 0.065 x (64.38 x 6 + 56 x 4.17) | = 482.5 |
| 1/2 INTERIOR WALLS BELOW : 0.15 x 1 x 177.5 x 5 + 0.15 x 0.67 x 45 x 5 | = 154.0 |
| LANDING : 0.15 x (0.67 x 9 x 15.75 + 0.54 x 11.75 x 7) | 20.9 |
| 1/2 COLS. ABOVE & BELOW : 10.16 x (0.039 x 6 + 0.045 x 3) | = 3.8 |
| STEEL FLOOR FRAMING : 0.0078 x 50.3 x 114.8 | = 45.0 |
| EQUIPMENT : 0.04 x (47.5 x 48.4 + 64.5 x 48.4 - 3.5 x 11.5 - 4.5 x 9.5) | = 213.5 |
| | 1220.0 |

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# MONTICELLO CONTROL ROOM

## SEISMIC ANALYSIS

## LUMPED WEIGHTS CONT'D.

### WEIGHT 5 @ EL. 928'-0"

| | |
|---|---|
| CONCRETE MAT: $0.15 \times \left(\frac{2.5+3.5}{2}\right) \times 50.3 \times 67.5$ | = 1530.0 |
| CONCRETE SLAB @ EL. 933'-0": $0.15 \times 1/6 \times 47.38 \times 48$ | = 56.8 |
| FOOTINGS: $0.15 \times (1.5 \times 42.54 \times 5.42 + 1.5 \times 50.88 \times 5 + 1.5 \times 50.88 \times 4.83 + 1.5 \times 10 \times 10 \times 2)$ | = 209.4 |
| 1/2 EXTERIOR WALLS ABOVE & BELOW: $0.15 \times 5.5 \times (1 \times 99.6 + 0.833 \times 100.18 + 1.5 \times 47.38 + 1.625 \times 66.5 + 2 \times 2 \times 5.5 + 3 \times 15.1)$ | = 339.4 |
| 1/2 INTERIOR WALLS ABOVE: | = 154.0 |
| 1/2 CONCRETE COLS. ABOVE: $0.15 \times 2 \times 1 \times 5.5 \times 3$ | = 5.0 |
| EARTH FILL: $48 \times 47.38 \times 4.8 \times 0.135$ | = 1472.0 |
| EQUIPMENT: $0.060 \times 50.3 \times 67.5$ | = 204.0 |
| | 3970.6 |

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MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

SECTION PROPERTIES

ELEV. 981'-4½" TO ELEV. 965'-0"

EQ IN N-S DIR.

$$I_{E-W} = \frac{0.833(50.5)^3}{12} + 8(2)(2)(24.25)^2 + \frac{1}{6}\frac{(8)(18.0)^3}{12}$$

$$+ 8(2)(2)(8.25)^2 + \frac{1}{6}\frac{(8)(15)^3}{12} \times 6 + 8(1)(1)(8.8)^2 + \frac{0.833(11.75)^3}{12}$$

$$= 33{,}566.1 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(0.833 \times 50.5 + 0.833 \times 11.75) + \frac{1}{6}(8 \times 18 + 8 \times 15 \times 6)$$

$$= 187.2 \text{ FT}^2$$

EQ IN E-W DIR.

$$I_{N-S} = \frac{2(50.3)^3}{12} + 8(0.67 \times 0.67 \times \tfrac{1}{6}) \times 25.2^2 + 8(0.833$$

$$\times 0.833) \times 24.0^2 + \frac{1(13)^3}{12}$$

$$= 24{,}971.2 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}[2(50.3) + 1(13)]$$

$$= 94.7 \text{ FT}^2$$

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MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

SECTION PROPERTIES

ELEV. 965'-0" TO ELEV. 951'-0"

EQ IN N-S DIR.

$$I_{E-W} = \frac{1.625(50.5)^3}{12} + 8\times1\times1\times(24.75)^2 + 8\times2\times2\times(24.25)^2$$

$$+ \frac{1.25(50.5)^3}{12} + 8\times1\times1\times(24.75)^2 + 8\times2\times2\times(24.5)^2$$

$$= 78,682.4 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(1.625\times50.5 + 1.25\times50.5 + 0.833\times11.75)$$

$$+\frac{1}{6}\left(8\times16\times\frac{1}{6}\times4\right)$$

$$= 141.7 \text{ FT}^2$$

EQ IN E-W DIR.

$$I_{N-S} = \frac{2(50.3)^3}{12} + 8\times1.625\times1.625\times(23.9)^2 + 8\times1.25$$

$$\times1.25\times(25.0)^2 + \frac{1(50.3)^3}{12} + 8\times1.625\times1.625$$

$$\times(23.9)^2 + 8\times1.25\times1.25\times(25.0)^2$$

$$= 71,574.5 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(2\times50.3 + 1\times50.3 + 1\times13)$$

$$= 136.6 \text{ FT}^2$$

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MONTICELLO CONTROL ROOM

SEISMIC ANALYSIS

SECTION PROPERTIES

ELEV. 951'-0" TO ELEV. 939'-0"

EQ IN N-S DIR.

$$I_{E-W} = \frac{1.625(50.5)^3}{12} + 8 \times 2 \times 2 \times (24.75)^2 + 8 \times 1 \times 1 \times (24.75)^2$$

$$+ \frac{1(50.5)^3}{12} + 8 \times 2 \times 2 \times (24.75)^2 + 8 \times 1 \times 1 \times (24.75)^2$$

$$= 77{,}050.3 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(1.625 \times 50.5 + 1 \times 50.5 + 0.833 \times 12)$$

$$+ \frac{1}{6}\left(8 \times 16 \times \frac{1}{6} \times 4\right)$$

$$= 133.0 \text{ FT}^2$$

EQ IN E-W DIR.

$$I_{N-S} = \frac{2(50.3)^3}{12} + 8 \times 1.625 \times 1.625 \times (23.9)^2 + 8 \times 1 \times 1 \times (25)^2$$

$$+ \frac{1(50.3)^3}{12} + 8 \times 1.625 \times 1.625 \times (23.9)^2 + 8 \times 1 \times 1 \times (25)^2$$

$$= 65{,}949.5 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(2 \times 50.3 + 1 \times 50.3 + 1 \times 13)$$

$$= 136.6 \text{ FT}^2$$

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# MONTICELLO CONTROL ROOM
## SEISMIC ANALYSIS
## SECTION PROPERTIES
## ELEV. 939'-0" TO ELEV. 928'-0"

EQ IN N-S DIR.

$$I_{E-W} = \frac{1.625(66.5)^3}{12} + 8 \times 1.5 \times 1.5 \times (32.5)^2 + 8 \times 1.17 \times 1.17 \times (32.5)^2$$

$$+ \frac{1.17 \times (66.5)^3}{12} + 8 \times 1.5 \times 1.5 \times (32.5)^2 + 8 \times 1.17 \times 1.17 \times (32.5)^2$$

$$= 110{,}643.0 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(1.625 \times 66.5 + 1.17 \times 66.5 + 1 \times 17 + 0.67 \times 16 + 1 \times 29 + 1 \times 18)$$

$$= 217.15 \text{ FT}^2$$

EQ IN E-W DIR.

$$I_{N-S} = \frac{1.5(50.3)^3}{12} + 8 \times 1.17 \times 1.17 \times (25.0)^2 + 8 \times 1.625 \times 1.625 \times (23.9)^2$$

$$+ \frac{1.17(50.3)^3}{12} + 8 \times 1.17 \times 1.17 \times (25.0)^2 + 8 \times 1.625 \times 1.625 \times (23.9)^2$$

$$= 66{,}138.8 \text{ FT}^4$$

$$\bar{A} = \frac{5}{6}(1.5 \times 50.3 + 1.17 \times 50.3 + 1 \times 27)$$

$$= 134.4 \text{ FT}^2$$

H. J. SEXTON & ASSOCIATES, ENGINEERS
SAN FRANCISCO • MENLO PARK, CALIFORNIA

IN REPLY REFER TO:
552 MISSION STREET
SAN FRANCISCO, 94105
(415) 781-8914

May 27, 1968

General Electric Company
Atomic Power Equipment Department
175 Curtner Avenue
San Jose, California 95125

ATTENTION: Mr. Ralph B. Gile

SUBJECT: Monticello Nuclear Generation Plant-Earthquake Analysis 20 Inch Suction Header

Gentlemen:

Transmitted herewith is our report on the subject analysis. In accordance with your instructions, we have performed this analysis to determine the forces, moments and stresses produced by the design earthquake for the subject facility.

Very truly yours,

H. J. Sexton & Associates, Engineers

E. J. Keith

E. J. Keith
Associate

EJK/pb
Encl.

# REPORT ON THE DYNAMIC EARTHQUAKE ANALYSIS OF THE 20 INCH SUCTION HEADER FOR THE MONTICELLO NUCLEAR GENERATION PLANT

This report, prepared for the General Electric Company, presents the results of a dynamic earthquake analysis of the 20 Inch Suction Header for the Monticello Nuclear Generation Plant. A typical segment of this pipe was analysed for the two directions of horizontal earthquake motion parallel to the primary axes of the reactor building. The results are presented for each case including coordinates, forces, moments, support reactions and stresses at all critical points along the pipe. Displacements are not presented since the results indicate that these displacements are negligibly small, being less than three mils maximum.

## DESCRIPTION OF 20 INCH HEADER



The 20 inch suction header consists of a 20 inch outside diameter steel pipe having a wall thickness of 3/8-inch. The header is a 16-segmented closed loop connected to the pressure suppression chamber by four 20 inch tees and 24 pairs of one-half inch by two and one-half inch pin-connected struts. The entire closed loop lies in a horizontal plane at Elevation 902'-3" and is centered about the vertical centerline of the pressure suppression chamber. Figures 1 and 2 show the plan and details of the header and its connections to the suppression chamber. Page 6 summarizes the pertinent properties of the header.

## ANALYTICAL CRITERIA

The analysis was based on the following data included in the Plant's Design and Analysis Report:

1. Design Earthquake

   North 69$^{o}$ West component of the 1952 Taft, California Earthquake normalized to 0.06 gravity. Safe shutdown is at twice the design earthquake.

2. Damping Factors

   Critical Piping------------------------0.5%

Only the results for the Design Earthquake are presented herein. To obtain the results for the safe shutdown, multiply the results presented by a factor of 2.0.

## METHOD OF ANALYSIS

A typical representative segment of pipe was idealized as a mathematical model consisting of lumped masses separated by elastic members. Lumped masses were located at critical points as required to adequately represent the typical segment of pipe. Using elastic properties of the pipe between successive mass points the flexibility matrix of the modeled three-dimensional pipe system was determined. The flexibility calculations included the effects of torsional, bending, shear and axial deformations. Comments on the adequacy of the model's boundry conditions and resonance effects are presented later in this report. 2

After the flexibility and mass matricies of the mathematical model were obtained, the frequencies and mode shapes for the first three modes of vibration were determined. Normally, after the frequency has been determined for each mode, the spectral acceleration is read from the appropriate support point response spectra and the response displacement is calculated. In this case, however, the period of vibration of the first mode of the header is only 0.03 seconds and is so small the header may be treated as a rigid system supported on a rigid suppression chamber. ( The first mode period of the pressure suppression chamber is 0.04 seconds ). Therefore, the header was analysed as if it were loaded with a uniform equivalent static coefficient equal to the response acceleration of the suppression chamber times a factor of 1.33 to account for the effects of higher modes in the header and the minor magnification that could be produced from interaction between the suppression chamber and the header. The resulting uniform static coefficient of 0.20 was used in the horizontal direction and was assumed to act simultaneously with a uniform static coefficient of 0.05 in the vertical direction. Since the stresses resulting from this loading are very small, no further refinement of analysis was deemed justified.

## COMPUTATION OF STRESSES

The values of forces and moments given in this report are for both member coordinate and global coordinate systems and the particular system used is so noted on the sheets containing the results. Using the results given for the member coordinate system, the pipe stresses are determined in accordance with Reference 2.

## DESCRIPTION OF COMPUTER PROGRAM

All of the calculations were performed with the aid of an IBM 360/65 digital computer. The computer program employed was written specifically for the analysis of three dimensional piping systems.

The input data for this program consists of the coordinates of all joints, pipe diameter, pipe wall thickness, pipe weight per foot, modulus of elasticity and boundary conditions. The computer calculates the pipe stiffness matrix, force transformation matrix, mode shapes, frequencies, inertia forces, internal forces, displacements and support reactions.

## DISCUSSION OF RESULTS

The results presented herein are in the form of coordinates, internal forces and moments in global and member coordinates, support reactions and stresses. These results are given for two different horizontal directions of earthquake acting simultaneously with the vertical direction of earthquake. 3

The following table summarizes the maxima of certain selected parameters:

| | |
|---|---|
| Maximum stress--------------------------- | 329 psi (at tee) |
| Maximum deflection------------------------ | 3 mils |
| Maximum moments acting at end of tee section in member coordinate system: | |
| Bending ------------------------- | 4.86 kip-feet |
| Torsion ------------------------- | 4.86 kip-feet |

Maximum forces acting at
end of tee section in member
coordinate system:
Shear -------------------------- 2.44 kips
Axial -------------------------- 2.44 kips
Maximum stresses acting
on tee at connection to
suppression chamber ----------------- 820 psi
Maximum force in
horizontal strut ---------------------- 0.415 kips
Maximum stress in
horizontal strut ---------------------- 330 psi
Allowable stress in
horizontal strut --------------------- 11,260 psi
Allowable bolt force in
horizontal strut --------------------- 8.84 kips

It should be pointed out that the above results are for seismic conditions alone. Dead load and thermal conditions have not been considered. In order to check the vertical strut it was necessary to find the force in the strut due to dead load. This was found to be 2.54 kips. The strut force due to seismic effects was found to be 0.12 kips. Thus, the total vertical strut force is 2.66 kips which produces a maximum stress of 3.15 ksi. This is less than the allowable tensile stress of 20 ksi. The strut support system and connecting bolts are therefore adequate for the seismic plus dead load condition.

## COMMENTS ON ASSUMPTIONS

This analysis is based on the assumption that the header segments may 4
be considered rigid at their connection to the 20-inch tee sections. While this assumption is not strictly true, it leads to the conclusion that the period of vibration of the header is extremely short and the earthquake induced stresses are very small compared to the allowable stresses. Even if the tee sections provided only partial restraint they would not increase the period of vibration of the header by more than about fifty per-cent, thus producing a period of vibration of the header of only 0.045 seconds, still very small. Furthermore, even if the period was 0.045 seconds and the header was subjected to magnification factors greater than those assumed in this analysis, the current calculated stresses are so low that there is ample margin for such magnifications. Therefore, it is our opinion that the results presented herein are adequate and should be used for the design of the 20-inch suction header and its supports.

# LIST OF FIGURES

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Weights and Properties

| | |
|---|---|
| 1. Outside diameter of pipe | 20.0 inches |
| 2. Wall thickness of pipe | 3/8 inches |
| 3. Weight of pipe per foot | 78.6 lbs. |
| 4. Weight of contents per foot | 126 lbs. |
| 5. Modulus of elasticity | 4,032,000 ksf. |

6

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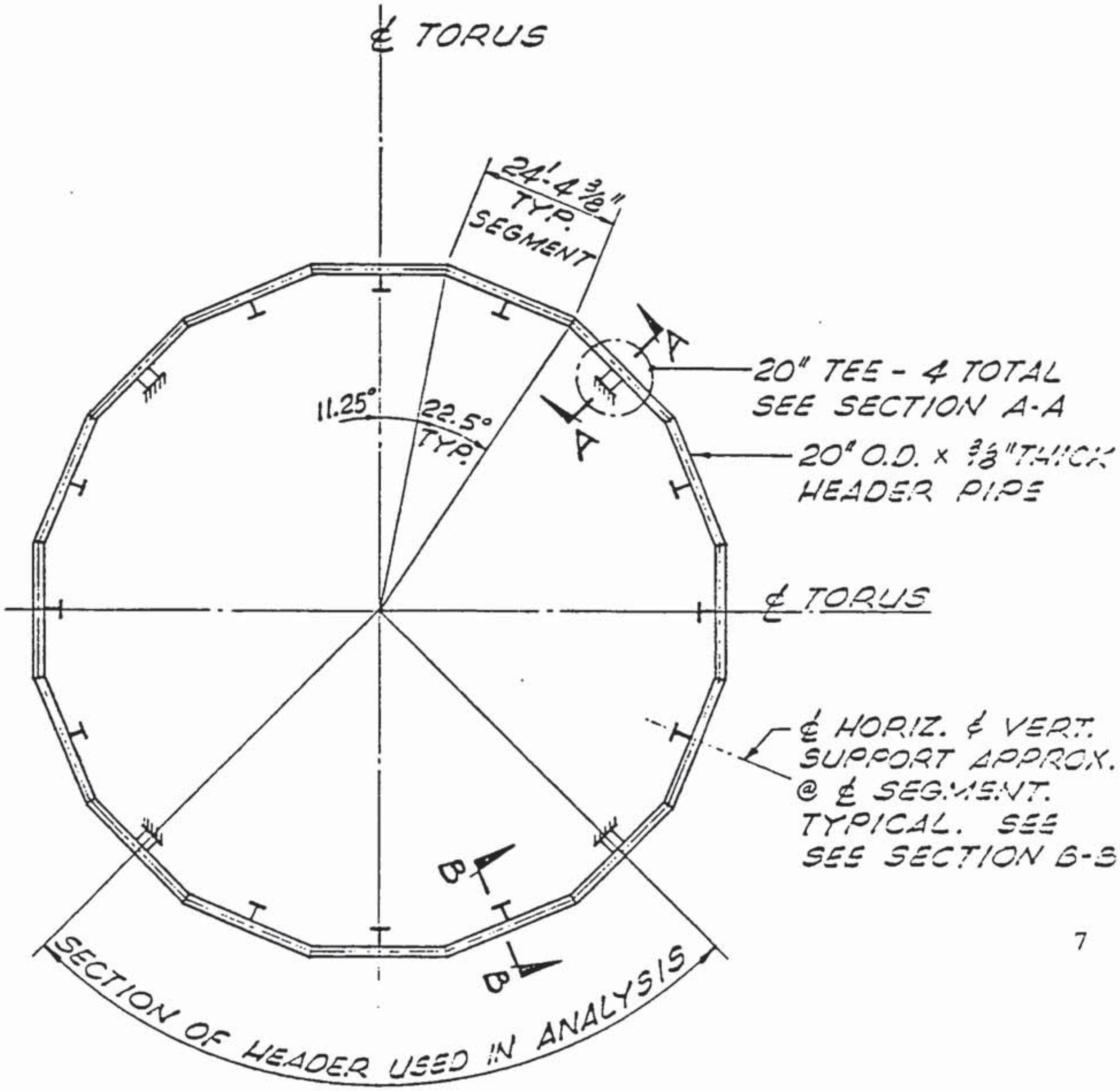
MONTICELLO NUCLEAR GENERATION PLANT






PLAN OF 20 INCH HEADER

FIGURE 1

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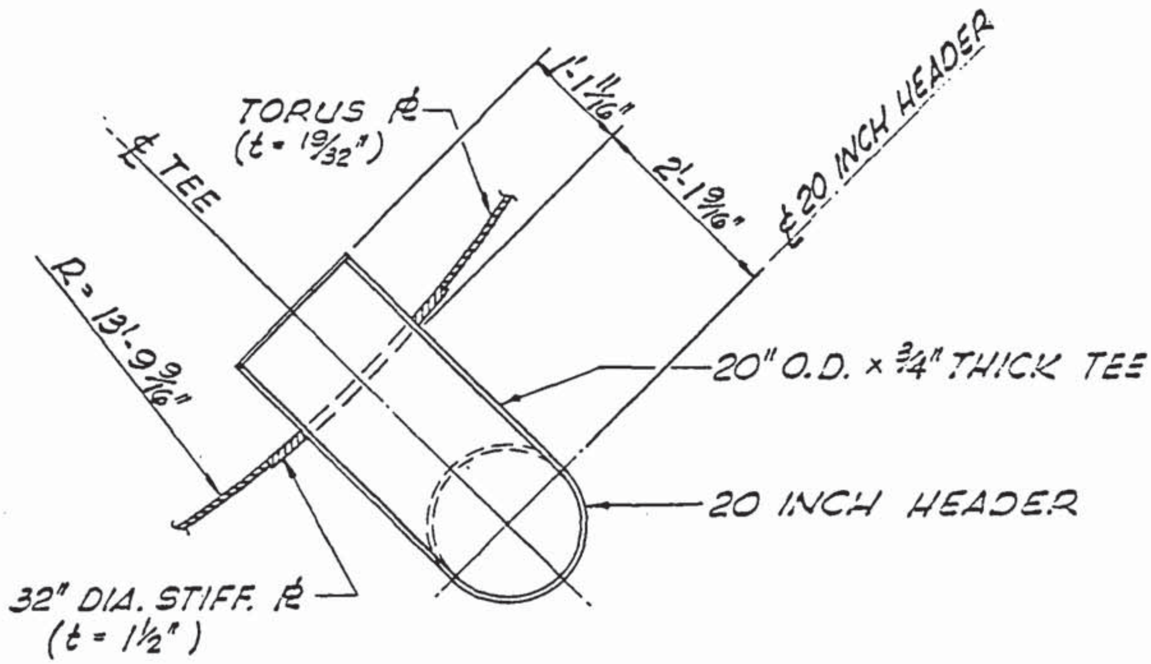
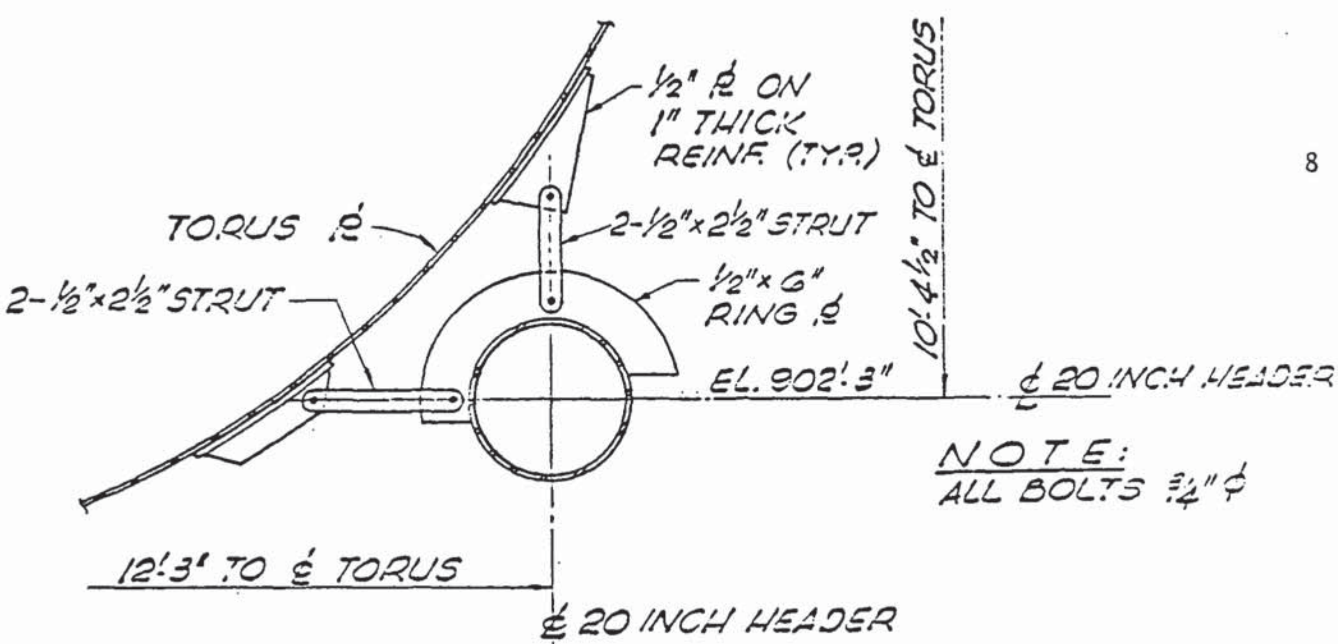



SECTION A-A




SECTION B-B

FIGURE 2

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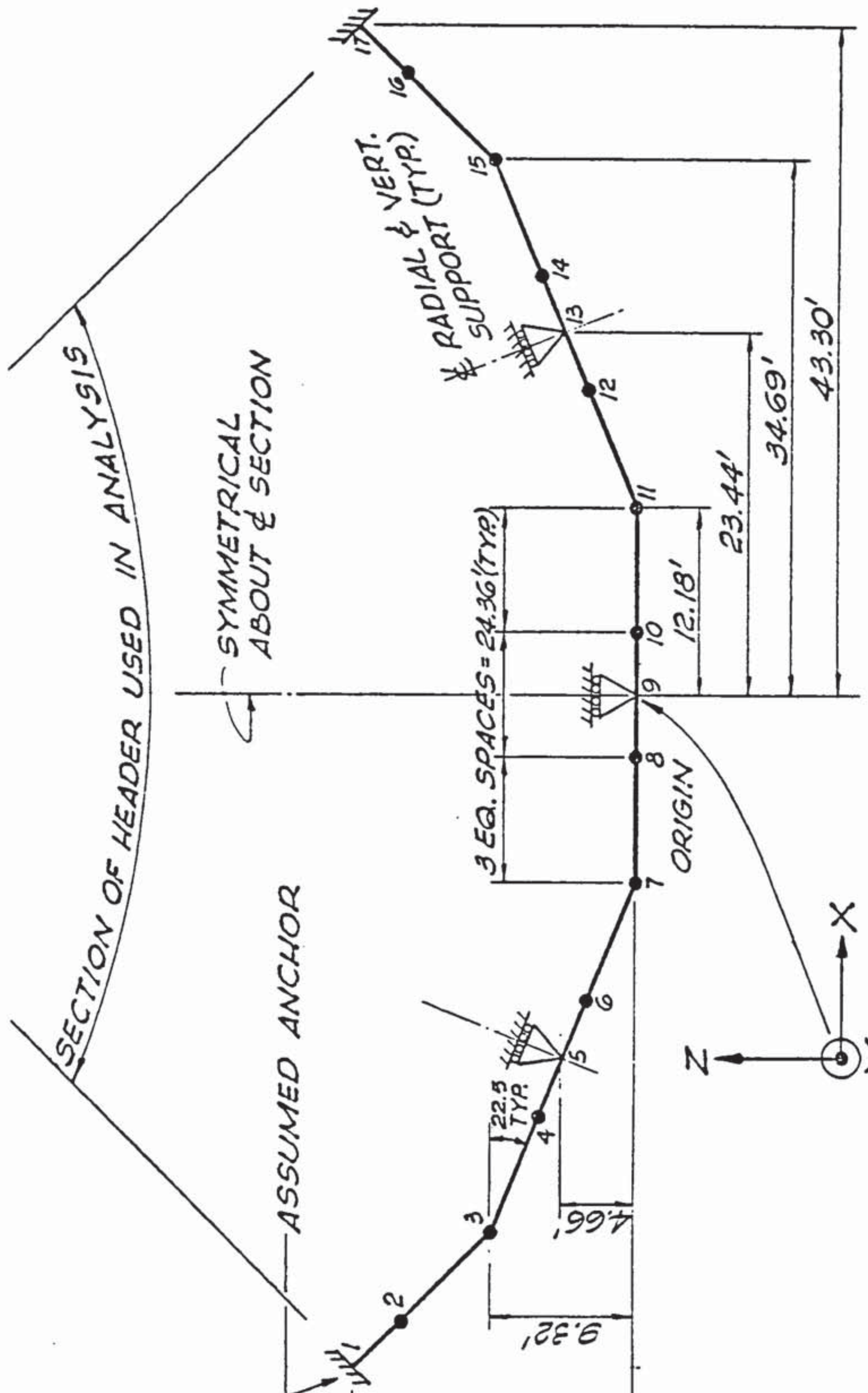


SCALE: 3/32" = 1'-0"

MATHEMATICAL MODEL

FIGURE 3

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Coordinates of Joints

| Joint | X<br>Feet | Y<br>Feet | Z<br>Feet |
|---|---|---|---|
| 1 | -43.30 | 0.00 | 17.93 |
| 2 | -40.43 | 0.00 | 15.06 |
| 3 | -34.69 | 0.00 | 9.32 |
| 4 | -27.19 | 0.00 | 6.21 |
| 5 | -23.44 | 0.00 | 4.66 |
| 6 | -19.68 | 0.00 | 3.11 |
| 7 | -12.18 | 0.00 | 0.00 |
| 8 | -4.16 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 |
| 10 | 4.16 | 0.00 | 0.00 |
| 11 | 12.18 | 0.00 | 0.00 |
| 12 | 19.68 | 0.00 | 3.11 |
| 13 | 23.44 | 0.00 | 4.66 |
| 14 | 27.19 | 0.00 | 6.21 |
| 15 | 34.69 | 0.00 | 9.32 |
| 16 | 40.43 | 0.00 | 15.06 |
| 17 | 43.30 | 0.00 | 17.93 |

10

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Combined X and Y Direction Earthquake

Forces at Joints (Global Coordinates)

| Joint | X Direction Kips | Y Direction Kips | Z Direction Kips |
|---|---|---|---|
| 1 | 1.52 | 0.08 | 0.78 |
| 2 | 1.52 | 0.08 | 0.78 |
| 3 | 1.36 | 0.05 | 0.78 |
| 4 | 1.02 | 0.13 | 0.79 |
| 5 | 0.99 | 0.13 | 0.79 |
| 6 | 0.99 | 0.12 | 0.07 |
| 7 | 0.67 | 0.05 | 0.07 |
| 8 | 0.33 | 0.13 | 0.07 |
| 9 | 0.00 | 0.13 | 0.07 |
| 10 | 0.33 | 0.13 | 0.07 |
| 11 | 0.67 | 0.05 | 0.07 |
| 12 | 0.99 | 0.12 | 0.07 |
| 13 | 0.99 | 0.13 | 0.79 |
| 14 | 1.02 | 0.13 | 0.79 |
| 15 | 1.36 | 0.05 | 0.78 |
| 16 | 1.52 | 0.08 | 0.78 |
| 17 | 1.52 | 0.08 | 0.78 |

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Combined X and Y Direction Earthquake

Moments at Joints (Global Coordinates)

| Joint | X Direction Kip-Feet | Y Direction Kip-Feet | Z Direction Kip-Feet |
|---|---|---|---|
| 1 | 0.44 | 2.99 | 0.18 |
| 2 | 0.20 | 0.86 | 0.05 |
| 3 | 0.02 | 2.46 | 0.29 |
| 4 | 0.11 | 0.20 | 0.04 |
| 5 | 0.31 | 2.06 | 0.49 |
| 6 | 0.12 | 0.77 | 0.05 |
| 7 | 0.00 | 0.81 | 0.23 |
| 8 | 0.00 | 0.27 | 0.12 |
| 9 | 0.00 | 0.00 | 0.65 |
| 10 | 0.00 | 0.27 | 0.12 |
| 11 | 0.00 | 0.81 | 0.23 |
| 12 | 0.12 | 0.77 | 0.05 |
| 13 | 0.39 | 2.06 | 0.49 |
| 14 | 0.11 | 0.20 | 0.04 |
| 15 | 0.02 | 2.46 | 0.29 |
| 16 | 0.20 | 0.86 | 0.05 |
| 17 | 0.44 | 2.99 | 0.18 |

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Combined X and Y Direction Earthquake

Forces at Joints (Member Coordinates)

| Joint | Axial Kips | Shear Y Kips | Shear Z Kips |
|---|---|---|---|
| 1 | 1.64 | 0.08 | 0.53 |
| 2 | 1.64 | 0.08 | 0.53 |
| 3 | 1.52 | 0.05 | 0.42 |
| 4 | 1.25 | 0.13 | 0.46 |
| 5 | 0.94 | 0.13 | 0.46 |
| 6 | 0.94 | 0.12 | 0.32 |
| 7 | 0.64 | 0.05 | 0.20 |
| 8 | 0.33 | 0.13 | 0.07 |
| 9 | 0.00 | 0.13 | 0.07 |
| 10 | 0.33 | 0.13 | 0.07 |
| 11 | 0.64 | 0.05 | 0.20 |
| 12 | 0.94 | 0.12 | 0.32 |
| 13 | 0.94 | 0.13 | 0.46 |
| 14 | 1.25 | 0.13 | 0.46 |
| 15 | 1.52 | 0.05 | 0.42 |
| 16 | 1.64 | 0.08 | 0.53 |
| 17 | 1.64 | 0.08 | 0.53 |

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Combined X and Y Direction Earthquake

Moments at Joints (Member Coordinates)

| Joint | Torsional Kip-Feet | Bending Y Kip-Feet | Bending Z Kip-Feet |
|---|---|---|---|
| 1 | 0.19 | 3.00 | 0.44 |
| 2 | 0.19 | 0.85 | 0.11 |
| 3 | 0.19 | 2.46 | 0.27 |
| 4 | 0.09 | 0.21 | 0.08 |
| 5 | 0.09 | 2.06 | 0.60 |
| 6 | 0.09 | 0.77 | 0.10 |
| 7 | 0.09 | 0.80 | 0.23 |
| 8 | 0.00 | 0.27 | 0.12 |
| 9 | 0.00 | 0.00 | 0.65 |
| 10 | 0.00 | 0.27 | 0.12 |
| 11 | 0.09 | 0.80 | 0.23 |
| 12 | 0.09 | 0.77 | 0.10 |
| 13 | 0.09 | 2.06 | 0.60 |
| 14 | 0.09 | 0.21 | 0.08 |
| 15 | 0.19 | 2.46 | 0.27 |
| 16 | 0.19 | 0.85 | 0.11 |
| 17 | 0.19 | 3.00 | 0.44 |

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Pipe Support Reactions (Global Coordinates)

Forces at Points 5 and 13

| | |
|---|---|
| X Direction | 0.29 kips |
| Y Direction | 0.25 kips |
| Z Direction | 0.72 kips |

Forces at Point 9

| | |
|---|---|
| X Direction | 0.00 kips |
| Y Direction | 0.26 kips |
| Z Direction | 0.00 kips |

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Combined X and Y Direction Earthquake

Stresses at Joints

| Joint | Stress Kips/Sq. In |
|---|---|
| 1 | 0.329 |
| 2 | 0.095 |
| 3 | 0.269 |
| 4 | 0.026 |
| 5 | 0.232 |
| 6 | 0.090 |
| 7 | 0.091 |
| 8 | 0.033 |
| 9 | 0.070 |
| 10 | 0.033 |
| 11 | 0.091 |
| 12 | 0.090 |
| 13 | 0.232 |
| 14 | 0.026 |
| 15 | 0.269 |
| 16 | 0.095 |
| 17 | 0.329 |

MONTICELLO NUCLEAR GENERATION PLANT

20 Inch Header

Combined Z and Y Direction Earthquake

Forces at Joints (Global Coordinates)

| Joint | X Direction Kips | Y Direction Kips | Z Direction Kips |
|---|---|---|---|
| 1 | 0.74 | 0.08 | 0.83 |
| 2 | 0.74 | 0.08 | 0.83 |
| 3 | 0.74 | 0.05 | 0.67 |
| 4 | 0.74 | 0.13 | 0.34 |
| 5 | 0.74 | 0.13 | 0.58 |
| 6 | 0.53 | 0.12 | 0.58 |
| 7 | 0.50 | 0.05 | 0.25 |
| 8 | 0.50 | 0.13 | 0.41 |
| 9 | 0.50 | 0.13 | 0.41 |
| 10 | 0.50 | 0.13 | 0.41 |
| 11 | 0.50 | 0.05 | 0.25 |
| 12 | 0.53 | 0.12 | 0.58 |
| 13 | 0.74 | 0.13 | 0.58 |
| 14 | 0.74 | 0.13 | 0.34 |
| 15 | 0.74 | 0.05 | 0.67 |
| 16 | 0.74 | 0.08 | 0.83 |
| 17 | 0.74 | 0.08 | 0.83 |