STONE & WEBSTER ENGINEERING CORPORATION

CLIENT & PROJECT	PAGE 1 OF 35
PRIVATE FUEL STORAGE FACILITY-PRIVATE FUEL STORAGE, LLC	PLUS 54 PGS OF ATTACHMENTS

CALCULATION TITLE	QA CATEGORY (X)
SEISMIC ANALYSIS OF CANISTER TRANSFER BUILDING	X I - NUCLEAR SAFETY RELATED ___ II ___ III ___ OTHER

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
05996.02	**STRUCTURAL**	**SC-5**	**NA**	**300B**

APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	REV. NO. OR NEW CALC. NO	SUPERSEDES CALC. NO. OR REV. NO.	CONFIRMATION REQUIRED (X) YES	NO
B E Ebbeson B.E. EBBESON 6/23/98 S Chen 7/9/98	Anthony Grant 7/9/98 S Chen 7/9/98 Bruce E. Ebbeson 7/9/98	Mahendra J. Shah (*) 7/13/98	0	NA	X p. 5	

* IDV CHECKLIST IN FILE Q2.9

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STONE & WEBSTER ENGINEERING

CALCULATION SHEET	J.O./W.O./CALCULATION NO. 05996.02-SC-5	REVISION 0	PAGE 2
PREPARER/DATE B.E. EBBESON 6-18-98	REVIEWER/CHECKER/DATE S Chen 7/9/98	INDEPENDENT REVIEWER MJS 7/13/98	
SUBJECT/TITLE Seismic Analysis of Canister Transfer Building		QA CATEGORY/CODE CLASS I	

TABLE OF CONTENTS AND HISTORICAL DATA

(Revisions, Additions, Deletions, Etc.)

HISTORICAL DATA - REVISION 0

Page No.	Description
None	Original Issue

OBJECTIVE:

The purpose of this calculation is to perform the seismic analysis of the Canister Transfer Building, in order to develop amplified response spectra for use in the seismic qualification of equipment and subsystems, and to obtain building accelerations for use in the design of the structure.

CALCULATION METHOD :

The SWEC computer program FRIDAY (Ref. 2) is used to perform the analysis. Input to this program consist of a lumped mass model of the building, which is developed in this calculation, soil impedance functions, which were developed in calculation 05996.02-SC-4 (Ref. 1), and ground acceleration time histories, which were developed in calculation 05996.02-SC-3 (Ref. 4). The method of soil-structure interaction analysis is the impedance method, as described in ASCE 4-86 (Reference 3). The program FRIDAY performs the analysis using the complex frequency response method. Results are obtained for the nominal, upper bound and lower bound soil cases, and results are enveloped.

ASSUMPTIONS:

1. The structural model is developed from preliminary drawings 05996.01-EM-1-D, 05996.01-EM-2-D, and 05996.01-EM-3-D, 05996.01-EA-8-C, 05996.01-EA-9-C and 05996.01-EA-12-B. No information is provided pertaining to the thickness of walls, slabs and beams. Therefore, based on preliminary calculations, the base mat is assumed to be 5' thick, the major walls are assumed to be 2' thick, and the roof slab is assumed to be 1' thick supported on 6'x3' beams.

2. The bridge crane is assumed to weigh 700 kips.

3. The soil properties provided in the design criteria are assumed to be the best estimate values. The shear modulus of all layers is increased by 50 % and reduced by 33 % to account for uncertainties. Results of these soil cases are enveloped for design purposes.

4. Soil material damping values given in the design criteria are used. Due to the high ground acceleration, the soil strains are assumed to be greater than the limit given in ASCE4-86 (ref. 3, sect. 3.3.2.3)

5. The cut-off frequency used in the FRIDAY analysis is 15 hz. A test case was run using a cut-off frequency of 20 hz and results did not change significantly.

6. Translational accelerations at points away from the center of mass caused by rotation are considered insignificant.

7. Section 3.4.2.3 of ASCE4-86 (ref. 3) allows a 15 % reduction in the ARS peak amplitude. Due to the uncertainties discussed above, this reduction was not included.

8. Damping in the structure is taken to be 7 % of critical. This assumes that the stresses in the structure will exceed 50 % of ultimate strength.

SOURCES OF DATA AND EQUATIONS:

See the next page for a list of references used in this calculation.

CONCLUSION:

The seismic analysis of the Canister Transfer Building has been completed and the results appear to be reasonable. Results are contained on the computer runs (microfiche), and response spectra have been enveloped and plotted, as shown on pages 15 - 29. Results at El. 170' and El. 100' have been peak broadened and are shown on pages 30-35. The analysis is based on a preliminary configuration of the building, and may require adjustment if the building configuration changes substantially.
CONFIRMATION REQUIRED

References:

1. Calculation 05996.02-SC-4, Rev. 0, 'Development of Soil Impedance Functions for Canister Transfer Building'
2. SWEC Computer Program FRIDAY, ST-243, Version 02, Level 01.
3. ASCE 4, 'Standard for Seismic Analysis of Safety-Related Nuclear Structures',. 1986, American Society of Civil Engineers.
4. Calculation 05996.02-SC-3, Rev. 0, 'Development of PFSF Artificial Time Histories'
5. SWEC Computer Program MASS, ST-237, Version 00, Level 01.
6. SWEC Computer Program RIG3, ST- 248, Version 01, Level 00.
7. SWEC Computer Program RIG4, ST- 249, Version 01, Level 00.
8. Computer Program GTSTRUDL, Version 9701 NT, Completion No. 3570, April 1997.
9. Private Fuel Storage Facility Design Criteria, Revision 2, June 20, 1997, Stone & Webster Engineering Corporation, Denver, Colorado.

PART 1 MODEL DEVELOPMENT

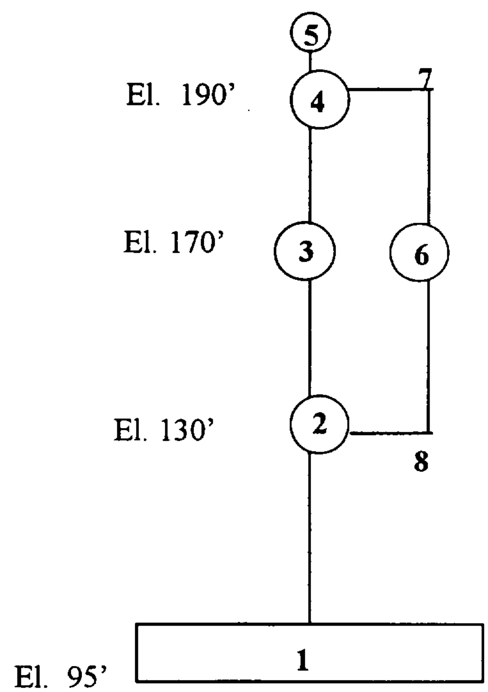
A lumped mass model of the building will be developed. A sketch of the model is shown on the following page. A node will be included at El. 95'-0", which is the bottom of the base mat. The mass properties at this node will consist of the contributions from the base mat, the major walls between El. 100'-0" and El 115'-0', and some of the interior partition walls. An allowance (5 %) will be made for miscellaneous equipment. A second node will be included at El. 130'-0", which will include the roofs at El. 130'-0", main walls between El. 115'-0" and El. 130'-0", walls between El. 130'-0" and el. 150'-0", and interior partition walls.

At the crane elevation, approximately El. 170'-0", two nodes will be included. Since the only shear walls in the East-West direction are on column lines 1, 8, and 11, the out-of plane response of the North-South wall may cause increased response at locations away from the E-W shear walls, especially when the crane is located in the middle of the building. To account for this, a mass point including a portion of the mass in the E-W direction is separated from the rest of the building, and is connected to the nodes at El. 130' and 190' with member selected such that the frequency in the E-W direction matches the out-of-plane stiffness of the N-S walls. In the N-S and vertical directions, the effect of the crane on the building response is not significant, therefore, the total mass between El. 150' and 180' will be included in the other mass point at E. 170'. See pages 9 and 10, and also Attachment C for details of crane model.

The top node of the model is at El. 190'-0", and includes the roof and walls between El. 180' and El. 190'. At the roof El. 190', the roof spans 65 feet from north to south walls. It is relatively flexible in the vertical direction compared to the walls. Therefore, a mass point is added to the stick model to account for this effect. The effective mass and member properties are selected such that it simulates the roof frequency. For detail of roof model, see Attachment C.

Mass properties and the center of mass for each node point are calculated using the SWEC computer program MASS (Ref. 5). Attachment A provides sketches showing attribute masses for each mass point location from walls, roof and mat, as well as computer input and output.

The stiffness of the members between nodes is representative of the walls between elevations. Hand calculations are used to develop the properties of these walls (i.e. area, shear areas, moments of inertia, torsional constant, and center of rigidity). Using these properties, the SWEC program RIG3 (Ref. 6) is used to develop a member stiffness matrix between El. 95'-0' and the center of mass at El. 130'-0". The SWEC program RIG4 (Ref. 7) was used to develop the stiffness matrices between the other nodes. The programs RIG3 and RIG4 account for the difference in location of the center of mass of the structure and the location of the center of rigidity. Attachment B provides calculation of member properties and computer input and output.

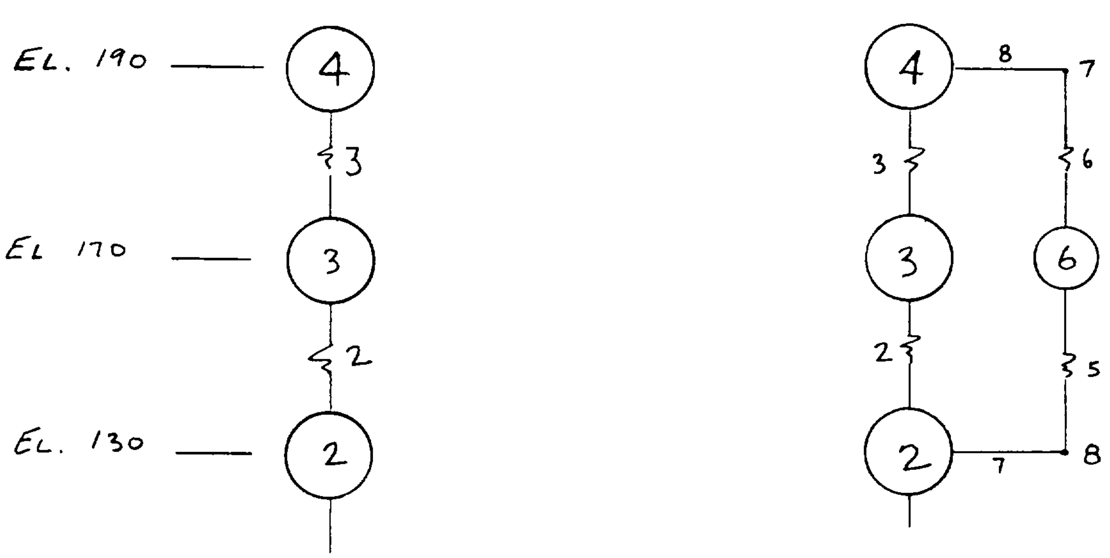


Canister Transfer Building Stick Model

MODEL OF CRANE & WALL

THE 700 K CRANE, WHEN IN A POSITION AWAY FROM E-W SHEAR WALLS, MAY CAUSE OUT-OF-PLANE BENDING OF THE WALLS IN N-S DIRECTION. THE FREQUENCY AND EFFECTIVE MASS OF THE WALL IS ESTIMATED IN ATTACHMENT C.

TO INCORPORATE THIS EFFECT INTO THE STICK MODEL, THE E-W MASS AT EL. 170' WILL BE DIVIDED INTO TWO PORTIONS, THE PORTION WHICH IS ASSUMED TO MOVE WITH THE SHEAR WALLS, AND THE PORTION WHICH MOVES OUT-OF-PLANE.



THE TOTAL MASS AT EL. 170. IS 274.2 (FROM 'MASS' RUN) PLUS $700/32.2$ (CRANE) = 295.9 $\frac{K\text{-}SEC^2}{FT}$

THE MASS ASSIGNED TO JOINT 6 IS 142.2 $\frac{K\text{-}SEC^2}{FT}$

THE REMAINING E-W MASS AT JOINT 3 IS 295.9 - 142.2 = 153.7 $\frac{K\text{-}SEC^2}{FT}$. JOINT 6 WILL BE ASSIGNED SMALL INERTIA VALUES IN THE OTHER DEGREES OF FREEDOM.

JOINTS 7 & 8 WILL BE INTRODUCED TO ALLOW MEMBERS 5 & 6 TO BE ORIENTED VERTICALLY. THEY WILL BE ASSIGNED SMALL INERTIA VALUES.

MEMBERS 7 & 8 ARE ASSIGNED LARGE SECTIONAL PROPERTIES TO SIMULATE RIGID LINKS

MEMBERS 5 & 6 WILL BE ASSIGNED A MOMENT OF INERTIA OF 213.8 FT^4 (ABOUT LOCAL Y AXIS) TO MATCH THE FREQUENCY IN THE E-W DIRECTION. OTHER PROPERTIES (AX, IX & IZ) WILL BE MADE LARGE ENOUGH TO MAKE THE MASS AT JOINT 6 RIGID, BUT SMALL IN COMPARISON TO THE PROPERTIES OF MEMBERS 2 & 3, SO THAT NO SIGNIFICANT STIFFNESS BETWEEN EL. 130' & 190' WILL BE INTRODUCED.

PART 2 COMPUTER ANALYSIS

Computer program FRIDAY is used to generate response spectra for mass points at El. 100', 130', 170', and 190' plus roof. Three computer runs, nominal soil case, upper bound and lower bound soil cases are performed. The results are given in microfiches in Attachment D. The output from three computer runs are enveloped, which are plotted and attached in this calculation. For use in the crane specification, the response spectra at El. 170' and El. 100' have been peak broadened, and are attached.

The major input to the program is described below:

IMPEDANCE FUNCTIONS

The soil impedance functions were developed in calculation 05996.02-SC-4 (ref. 1). However, since the latest revision to the seismic analysis program FRIDAY (ref. 2), the output from 'REFUND' is no longer directly usable in FRIDAY. Consequently, the data had to be reformatted. The information was retrieved from mainframe disk files, reformatted, and stored on new disk files. The data set names of the original and modified files are:

Nominal soil case — 'FRIDAY' Input

STRUCTRL.BEE.NOMINAL ⟶ STRUCTRL.BEE.BASEY

Upper bound soil case

STRUCTRL.BEE.UPPER ⟶ STRUCTRL.BEE.BASEZ

Lower bound soil case

STRUCTRL.BEE.LOWER ⟶ STRUCTRL.BEE.BASEX

Note:

Inadvertently, the echo print of the impedance functions was not included in the FRIDAY analysis. The checker reviewed the input disk files to confirm that the input to FRIDAY is consistent with the output from REFUND (ref. 1).

GROUND TIME HISTORIES

The ground acceleration time histories were developed in calc. 05996.02-SC-3, and stored under disk file name "STUCTRL.AEG.REFUND", which are used as input to FRIDAY program.

MASS PROPERTIES AND STIFFNESS MATRIX

The masses, centroid of masses, and mass moment of inertia are output from MASS program, given in Attachment A. The stiffness matrices are output from RIG3 and RIG4 programs given in Attachment B.

RESPONSE SPECTRA FREQUENCIES

The response spectrum from computer output is calculated for 80 frequencies at various increments. These increments are verified to ensure that they meet the requirement of ASCE4-86 (ref. 3), and are shown on the following pages.

Computer Log

Input to and output from the computer program MASS (ST-237) are contained in Attachment A. Input to and output from the computer programs RIG3 (ST-248) and RIG4 (ST-249) are contained in Attachment B. Input to and output from the PC based computer program GTSTRUDL (ref. 8) are contained in Attachment C.

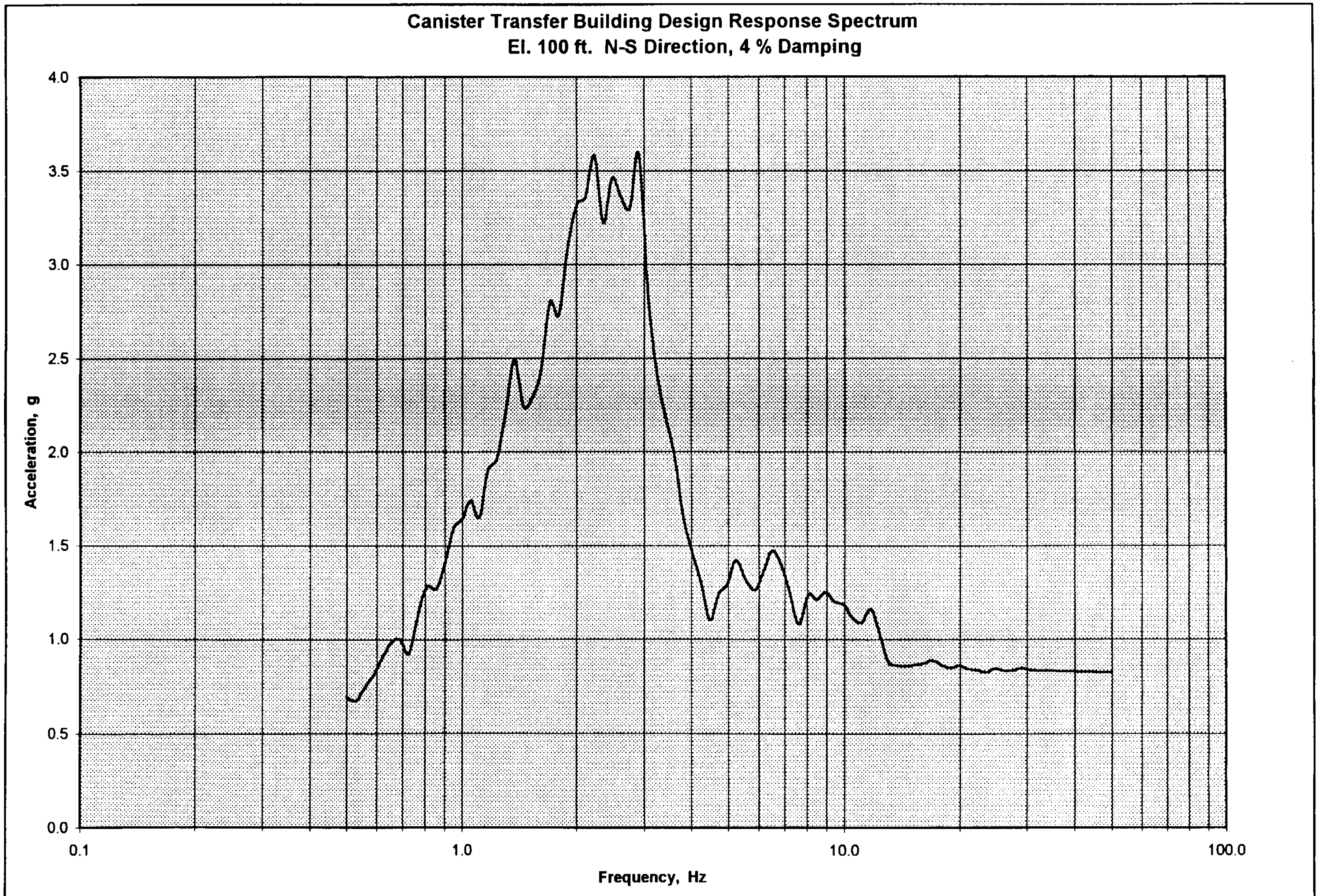
Attachment D is microfiche of the three analyses using the program FRIDAY (ST-243). The three analyses are:

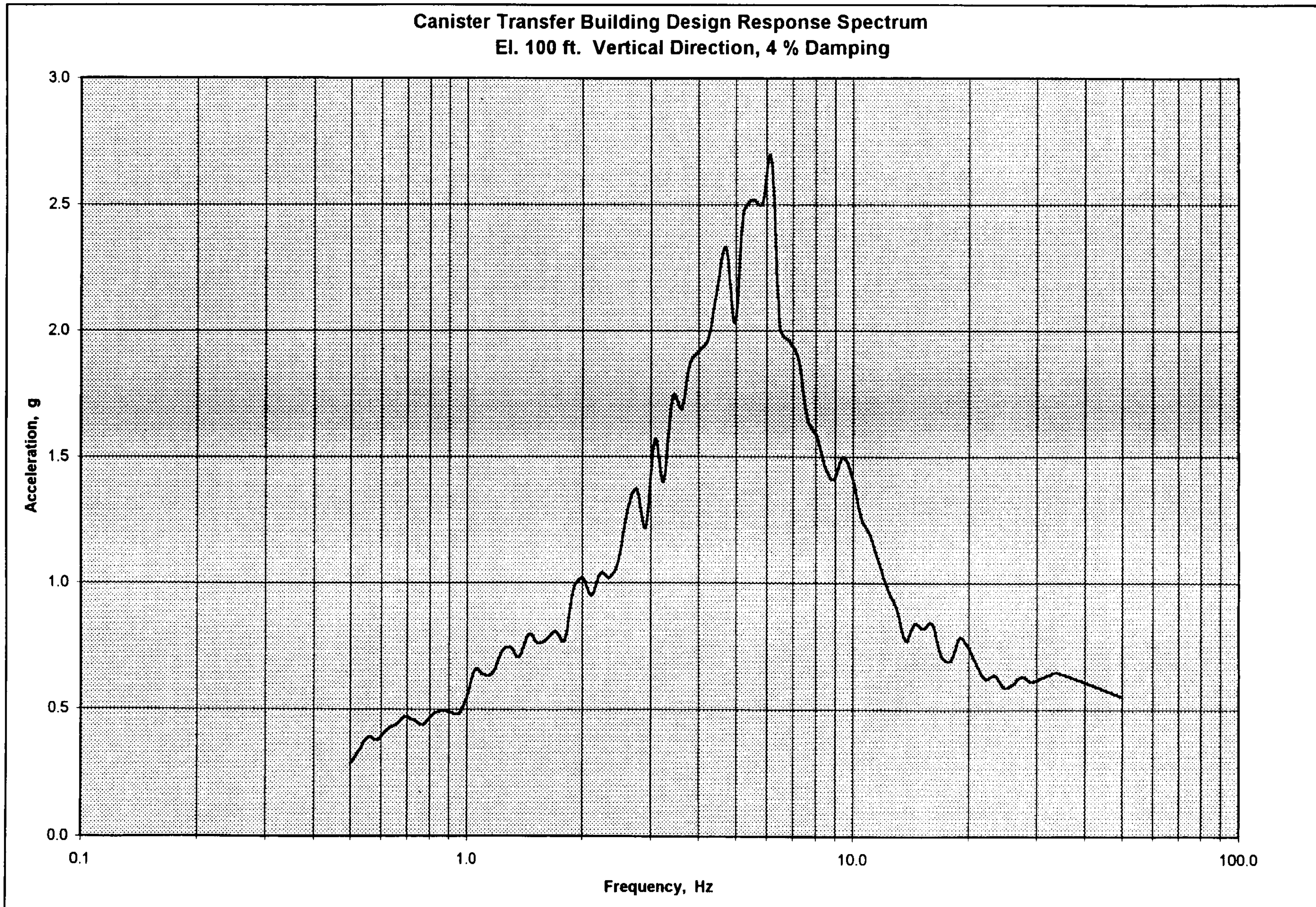
Job No.	Date	Description
1912	6/26/98	Nominal soil case
1991	6/26/98	Lower bound soil case
1998	6/26/98	Upper bound soil case

Frequency Increment Verification from Friday Output

Frequencies Table 3400-1 Hz	Frequency Increments Hz	Frequencies Calculated Hz	Calculated Freq. Increments Hz	Comparison to req. increments	Periods Calculated second
0.5	0.1	0.500	0.027	less than 0.1 hz	2.00000
0.6		0.527	0.029		1.89597
0.7		0.556	0.031		1.79745
0.8		0.587	0.032		1.70386
0.9		0.619	0.034		1.61523
1		0.653	0.036		1.53122
1.1		0.689	0.038		1.45157
1.2		0.727	0.040		1.37607
1.3		0.767	0.042		1.30449
1.4		0.809	0.044		1.23664
1.5		0.853	0.047		1.17231
1.6	0.1	0.900	0.049		1.11134
1.8	0.2	0.949	0.052		1.05353
2		1.001	0.055		0.99873
2.2		1.056	0.058		0.94678
2.4		1.114	0.061		0.89753
2.6		1.175	0.064		0.85085
2.8	0.2	1.240	0.068		0.80659
3.1	0.3	1.308	0.072		0.76464
3.4		1.380	0.076		0.72487
3.7		1.455	0.080		0.68716
4	0.3	1.535	0.084		0.65142
4.5	0.5	1.619	0.089	less than 0.1 hz	0.61753
5		1.708	0.094	less than 0.2 hz	0.58541
5.5		1.802	0.099		0.55496
6		1.901	0.104		0.52610
6.5		2.005	0.110		0.49873
7		2.115	0.116		0.47279
7.5		2.231	0.122		0.44820
8		2.354	0.129		0.42489
8.5		2.483	0.136		0.40279
9	0.5	2.619	0.144		0.38183
10	1	2.763	0.152	less than 0.2 hz	0.36197
11		2.914	0.160	less than 0.3 hz	0.34315
12		3.074	0.169		0.32530
13		3.243	0.178		0.30838
14		3.421	0.188		0.29234
15		3.608	0.198		0.27713
16	1	3.806	0.209		0.26272
18	2	4.015	0.220	less than 0.3 hz	0.24905
20		4.235	0.232	less than 0.5 hz	0.23610

Frequencies Table 3400-1 Hz	Frequency Increments Hz	Frequencies Calculated Hz	Calculated Freq. Increments Hz	Comparison to req. increments	Periods Calculated second
22	2	4.468	0.245	less than 0.5 hz	0.22382
25	3	4.713	0.258		0.21217
28		4.972	0.273		0.20114
31		5.244	0.288		0.19068
34	3	5.532	0.303		0.18076
		5.836	0.320		0.17136
		6.156	0.338		0.16244
		6.494	0.356		0.15399
		6.850	0.376		0.14598
		7.226	0.397		0.13839
		7.623	0.418		0.13119
		8.041	0.441		0.12437
		8.482	0.465		0.11790
		8.947	0.491	less than 0.5 hz	0.11177
		9.438	0.518	less than 1 hz	0.10595
		9.956	0.546		0.10044
		10.502	0.577		0.09522
		11.079	0.607		0.09026
		11.686	0.641		0.08557
		12.327	0.676		0.08112
		13.004	0.714		0.07690
		13.717	0.752		0.07290
		14.470	0.795		0.06911
		15.265	0.838		0.06551
		16.103	0.884	less than 1 hz	0.06210
		16.987	0.931	less than 2 hz	0.05887
		17.918	0.982		0.05581
		18.900	1.036		0.05291
		19.936	1.094		0.05016
		21.030	1.157		0.04755
		22.188	1.215	less than 2 hz	0.04507
		23.403	1.283	less than 3 hz	0.04273
		24.685	1.356		0.04051
		26.042	1.431		0.03840
		27.473	1.505		0.03640
		28.977	1.595		0.03451
		30.572	1.676		0.03271
		32.248	1.766		0.03101
		34.014		less than 3 hz	0.02940


Canister Transfer Building Design Response Spectrum
El. 100 ft. N-S Direction, 4 % Damping
Acceleration, g
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 100 ft. Vertical Direction, 4 % Damping
Acceleration, g
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2.0
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1.0
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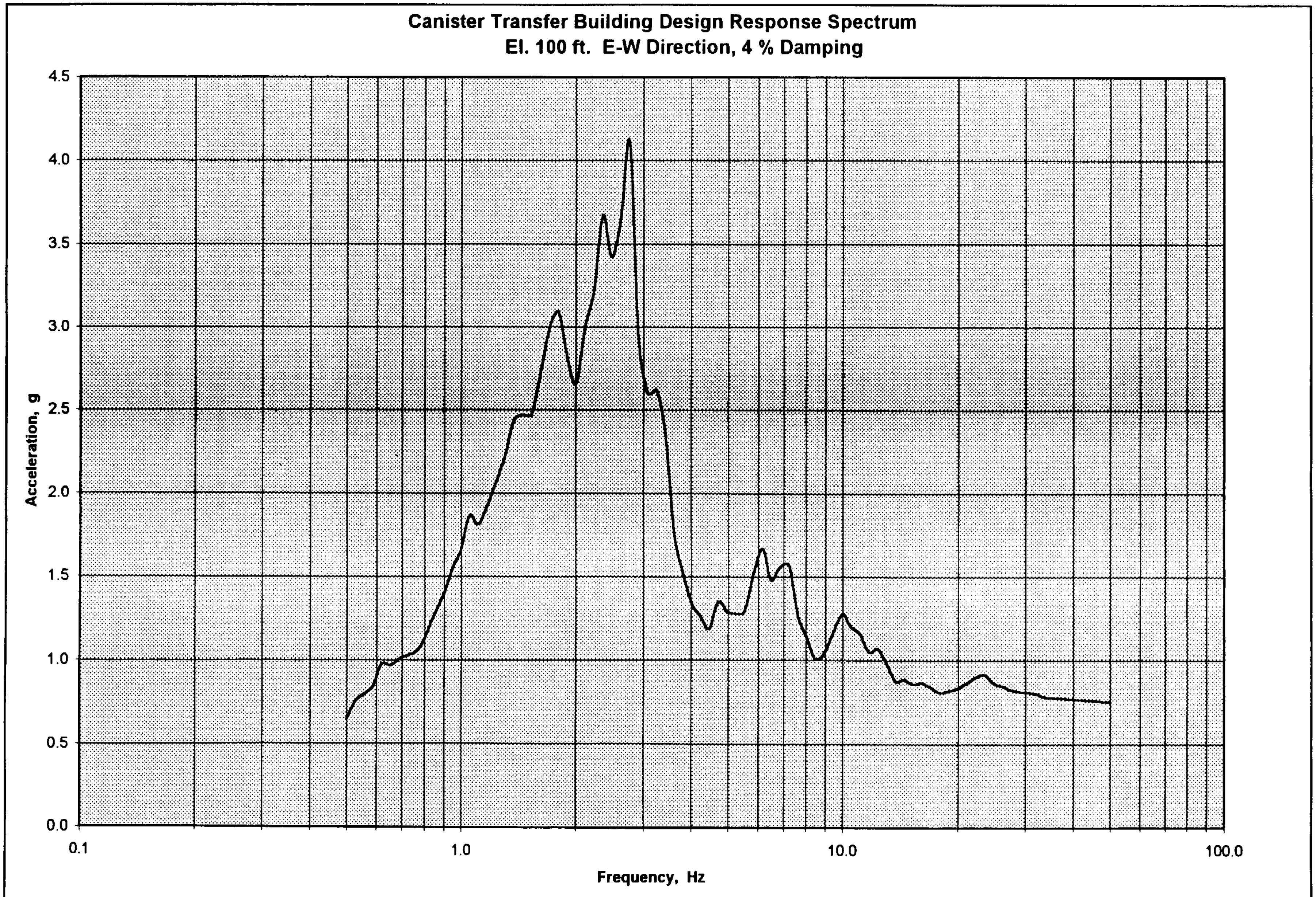
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 100 ft. E-W Direction, 4 % Damping
Acceleration, g
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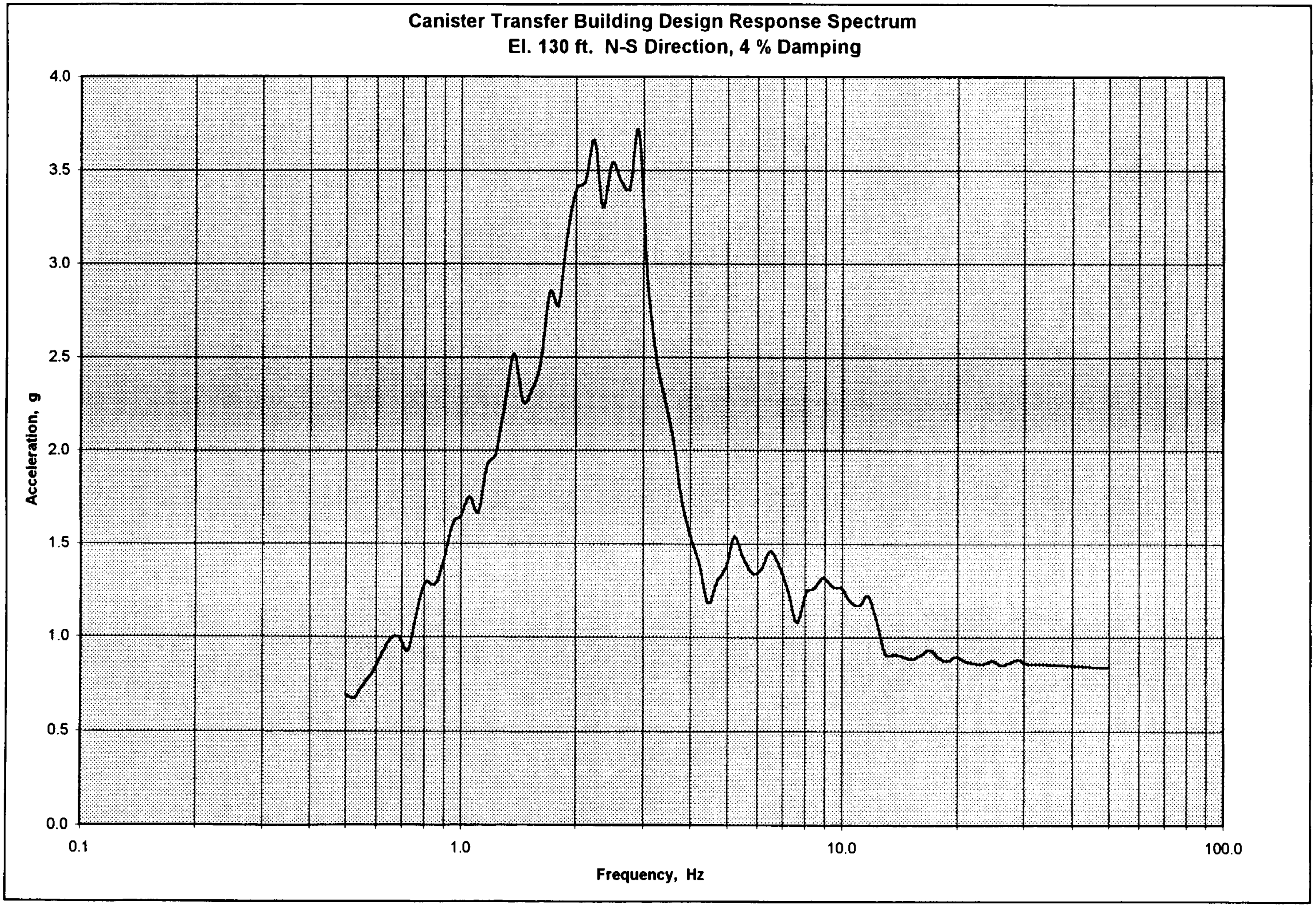
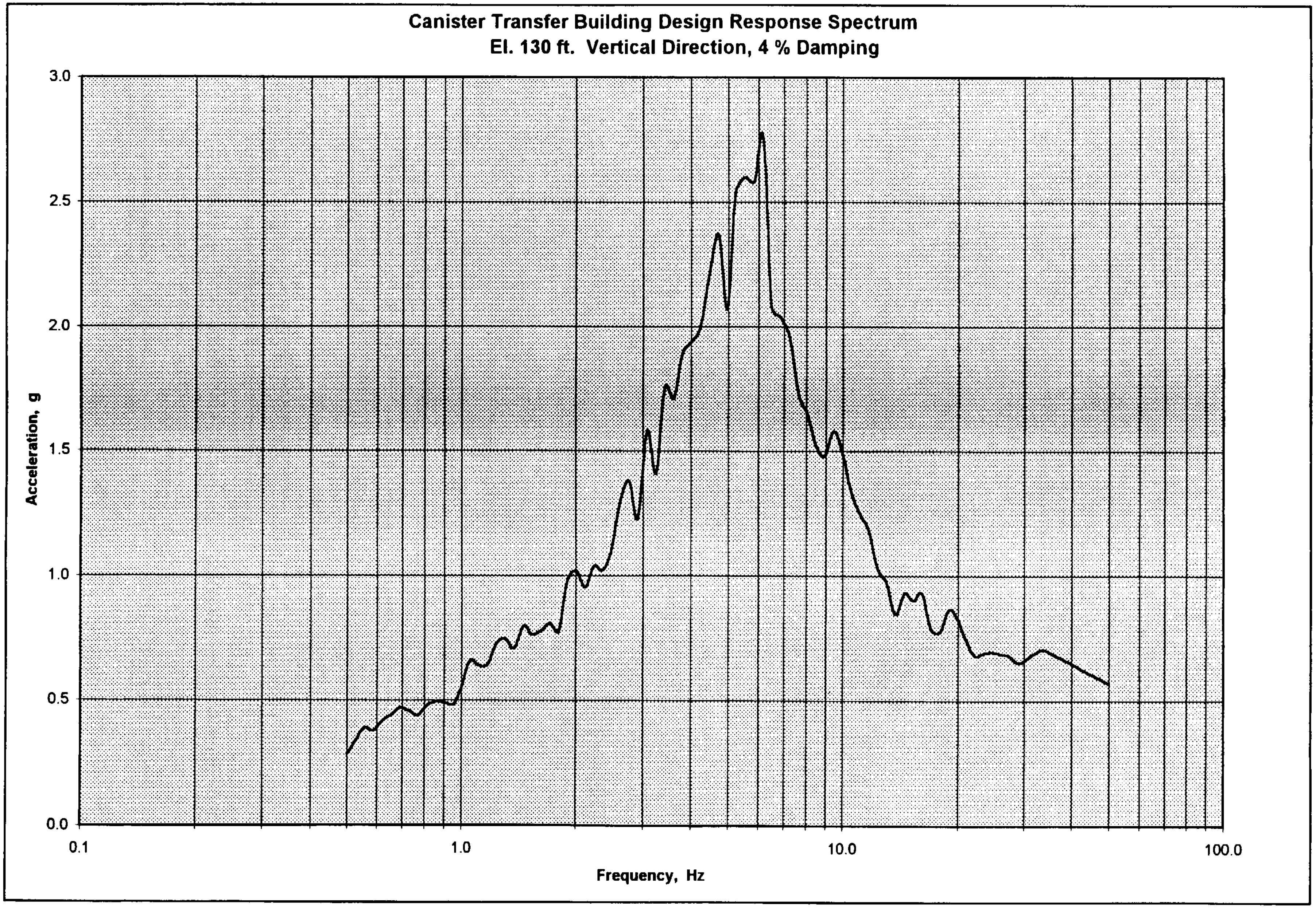
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 130 ft. N-S Direction, 4 % Damping
Acceleration, g
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 130 ft. Vertical Direction, 4 % Damping
Acceleration, g
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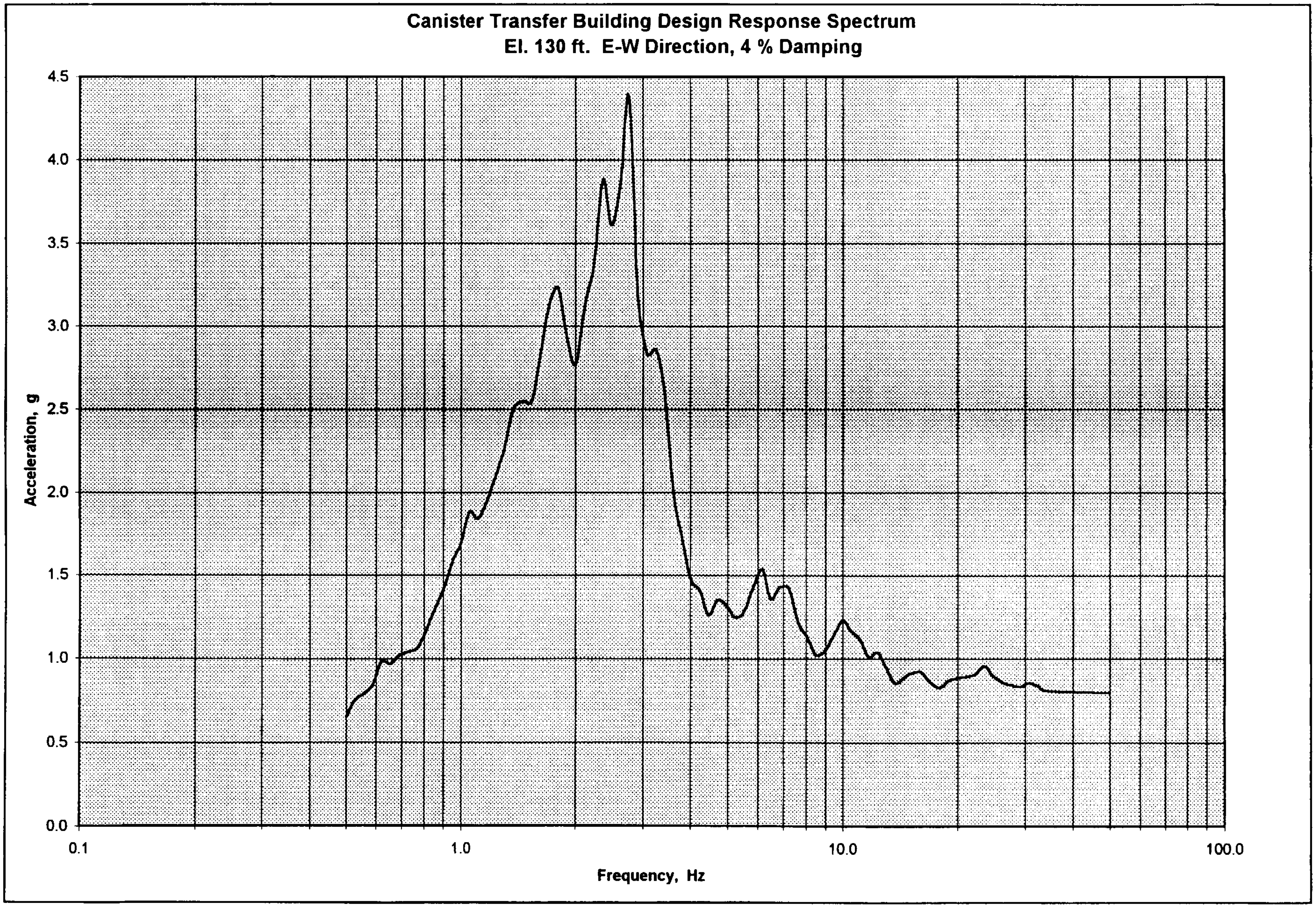
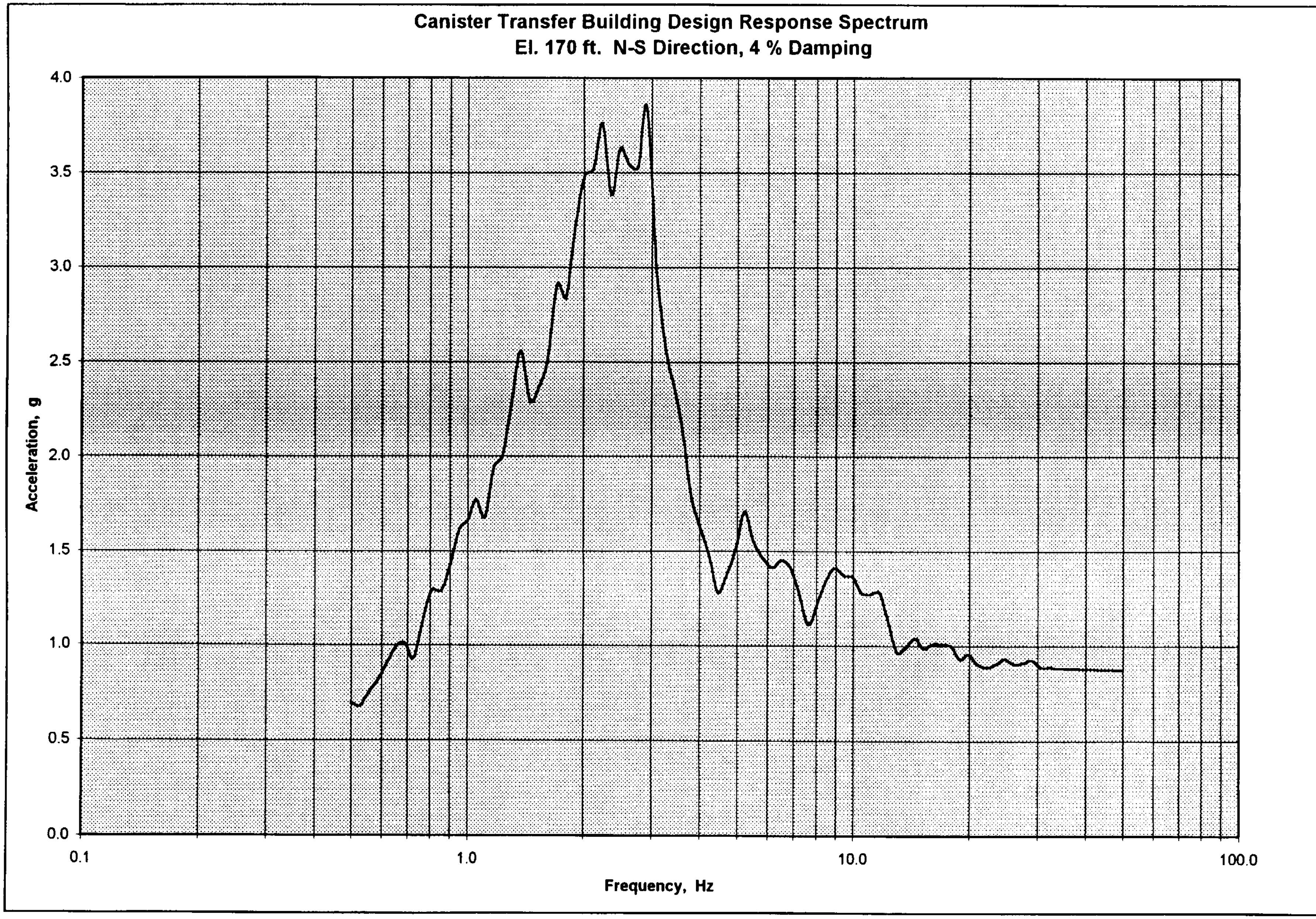
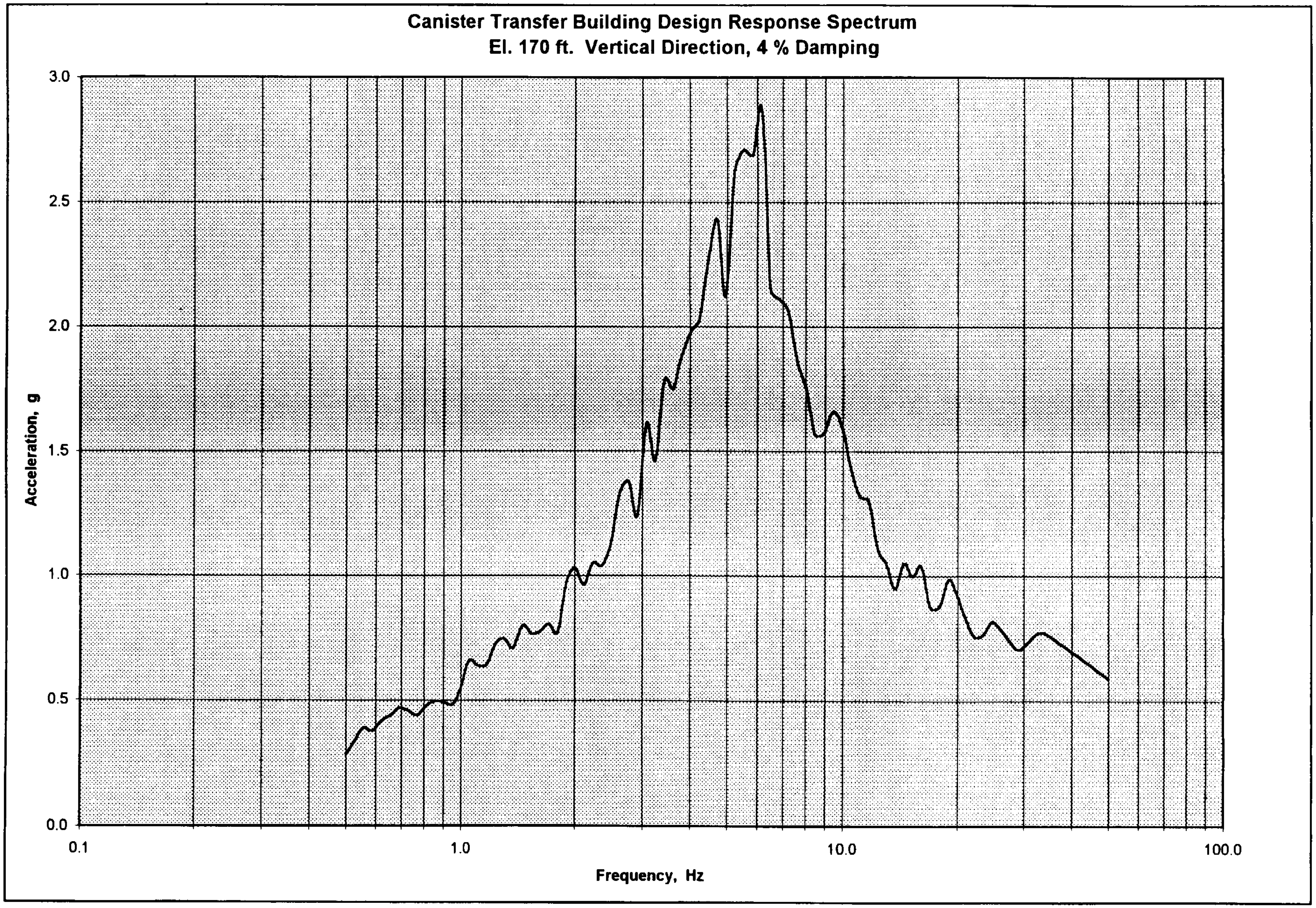
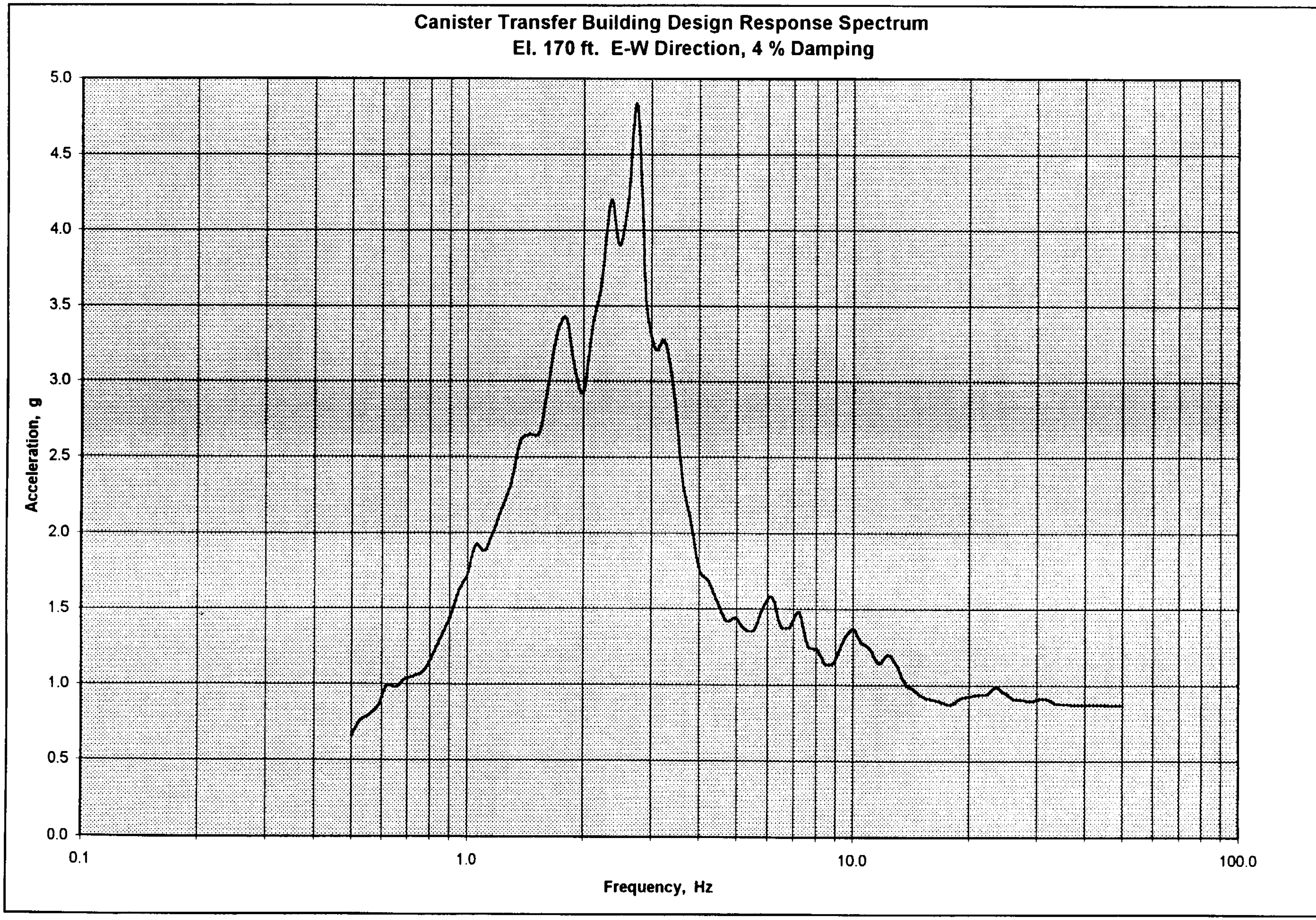
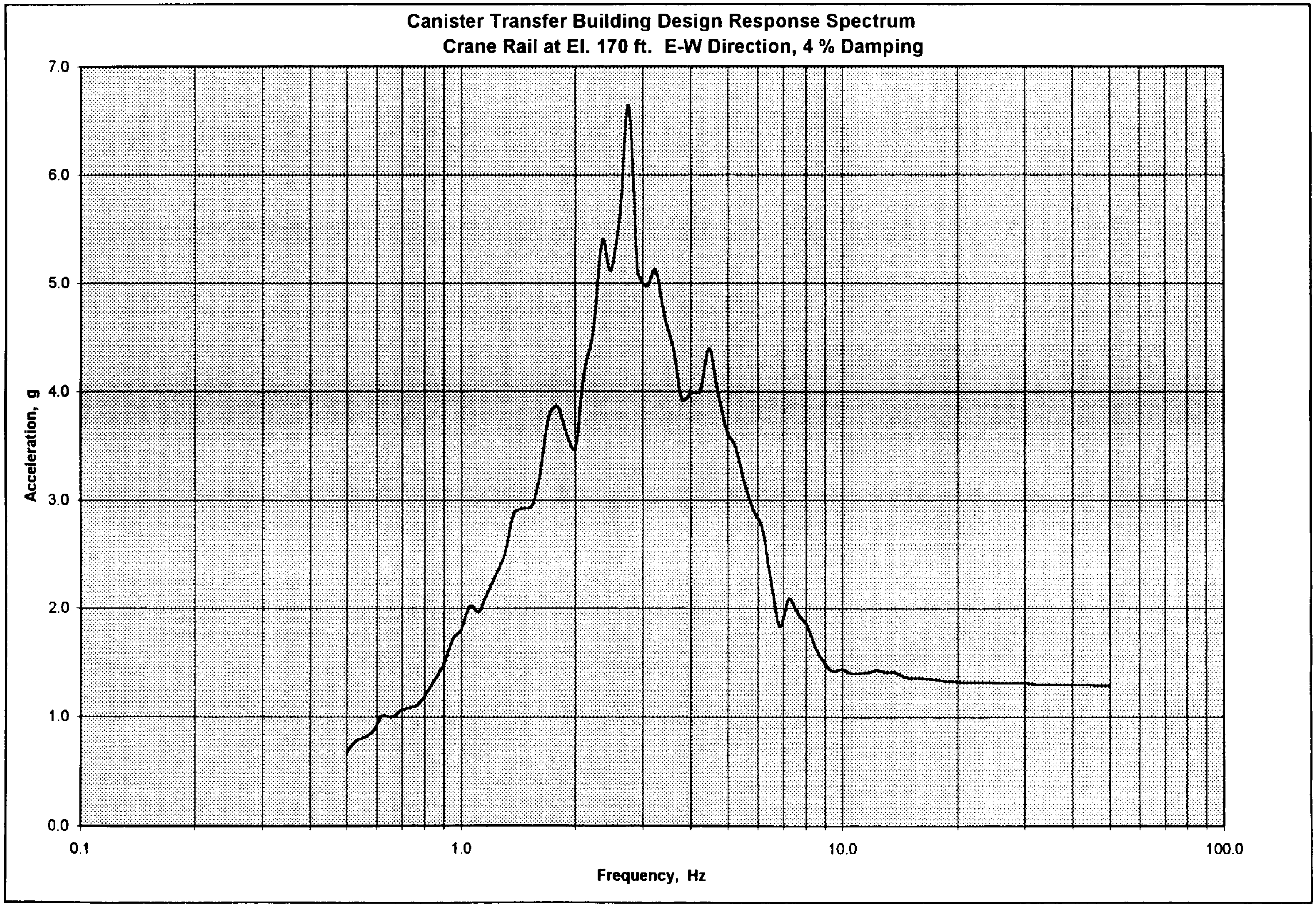
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

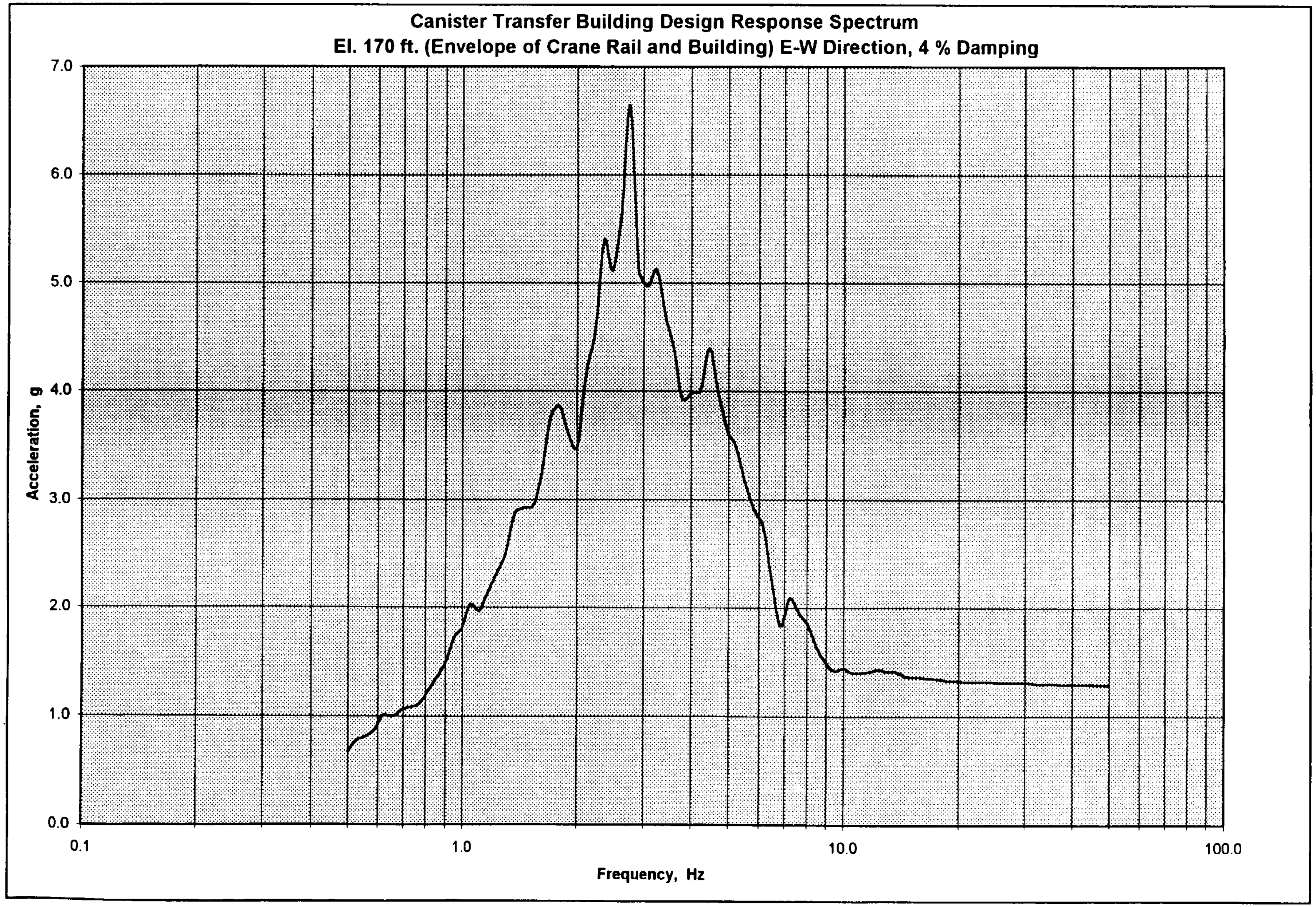

Canister Transfer Building Design Response Spectrum
El. 130 ft. E-W Direction, 4 % Damping
Acceleration, g
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

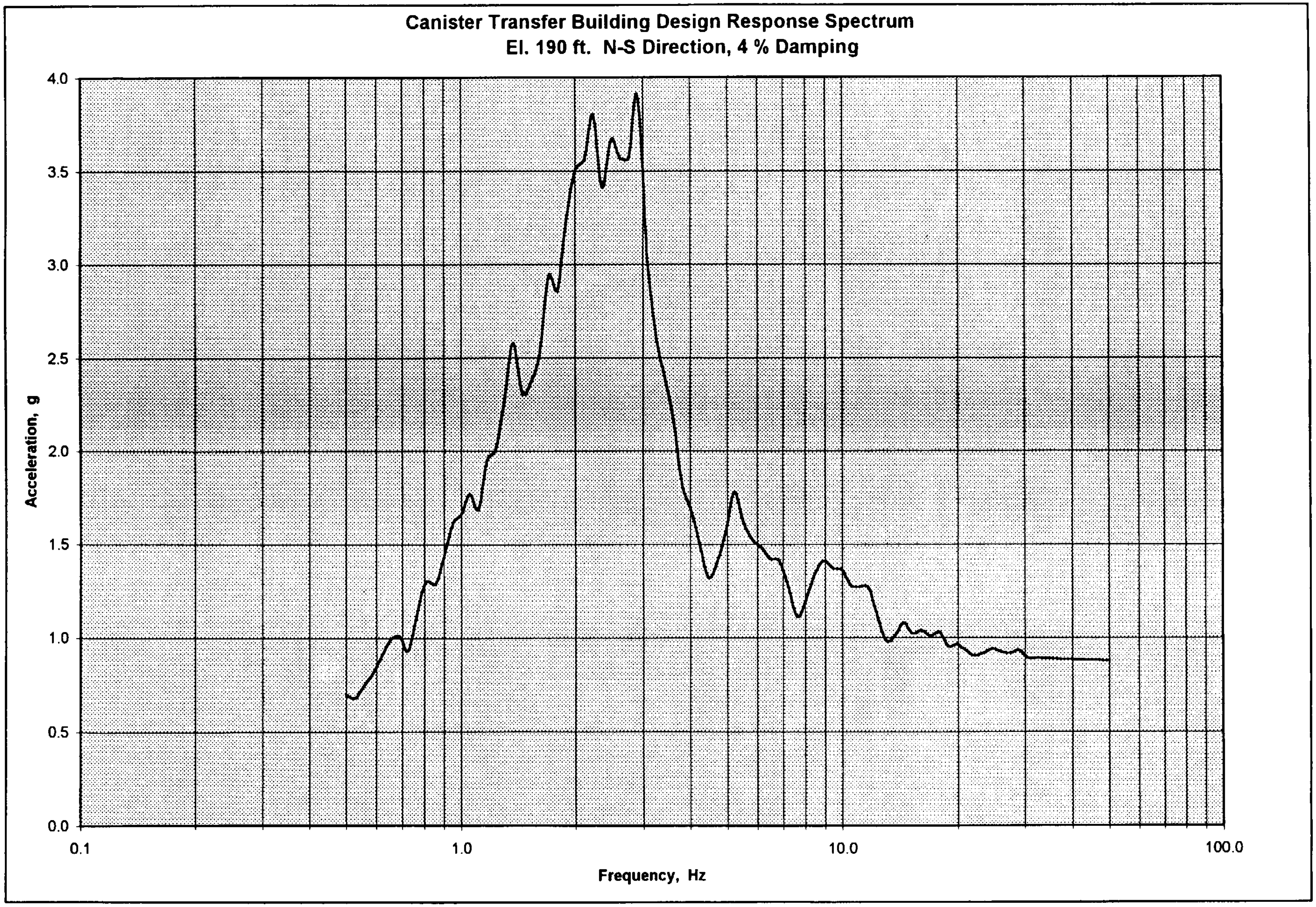

Canister Transfer Building Design Response Spectrum
El. 170 ft. N-S Direction, 4 % Damping
Acceleration, g
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

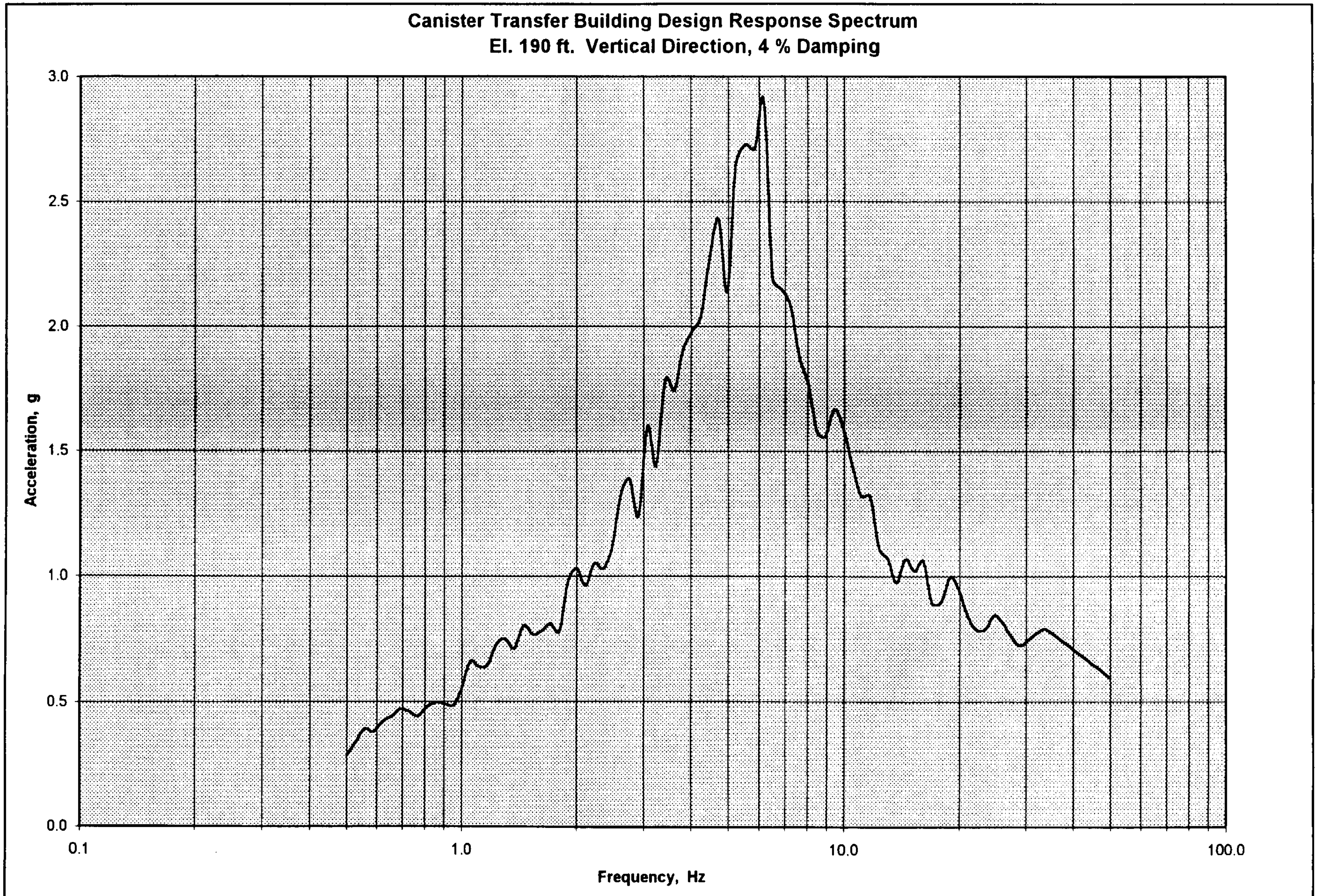

Canister Transfer Building Design Response Spectrum
El. 170 ft. Vertical Direction, 4 % Damping
Acceleration, g
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

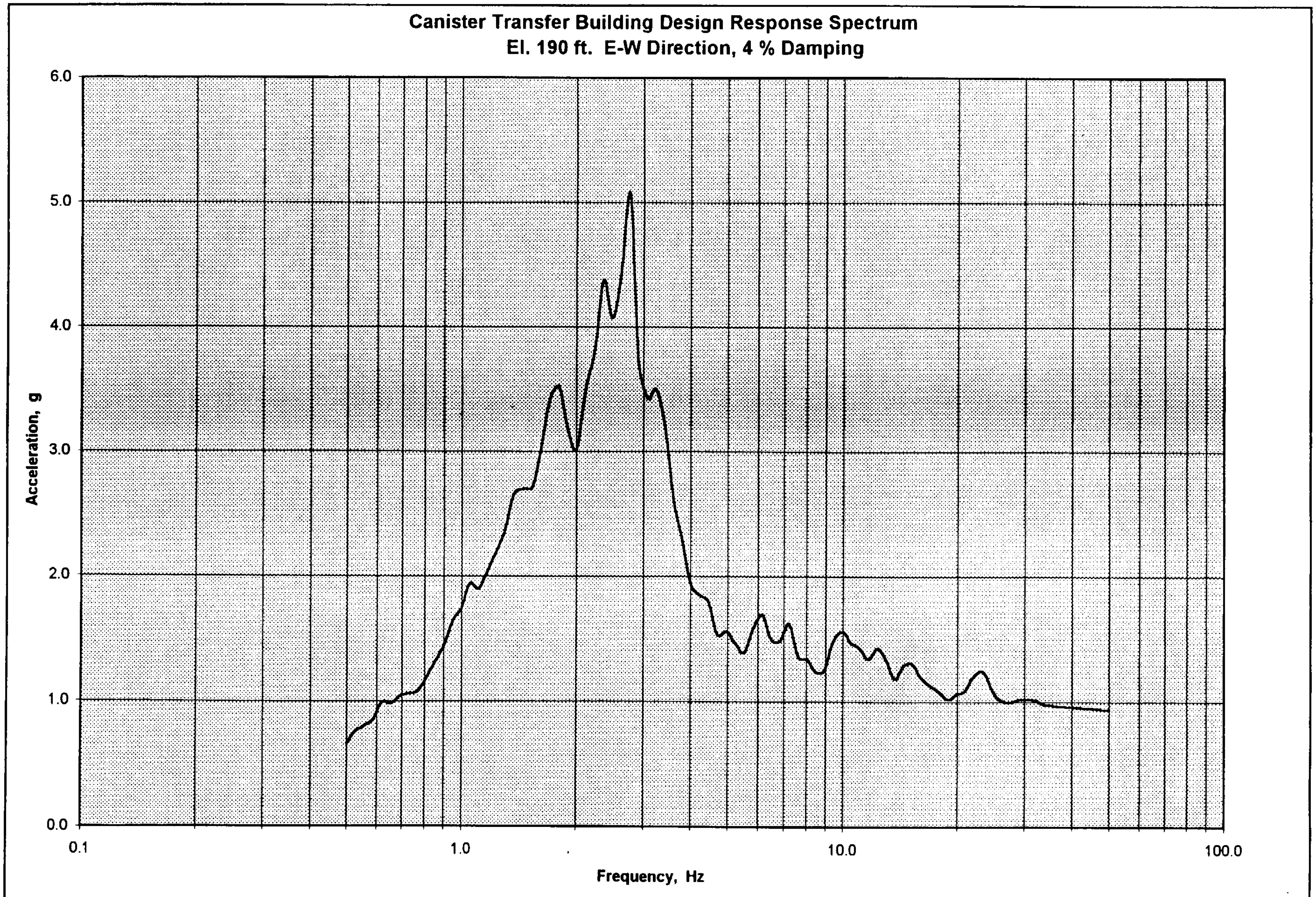

Canister Transfer Building Design Response Spectrum
El. 170 ft. E-W Direction, 4 % Damping
Acceleration, g
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

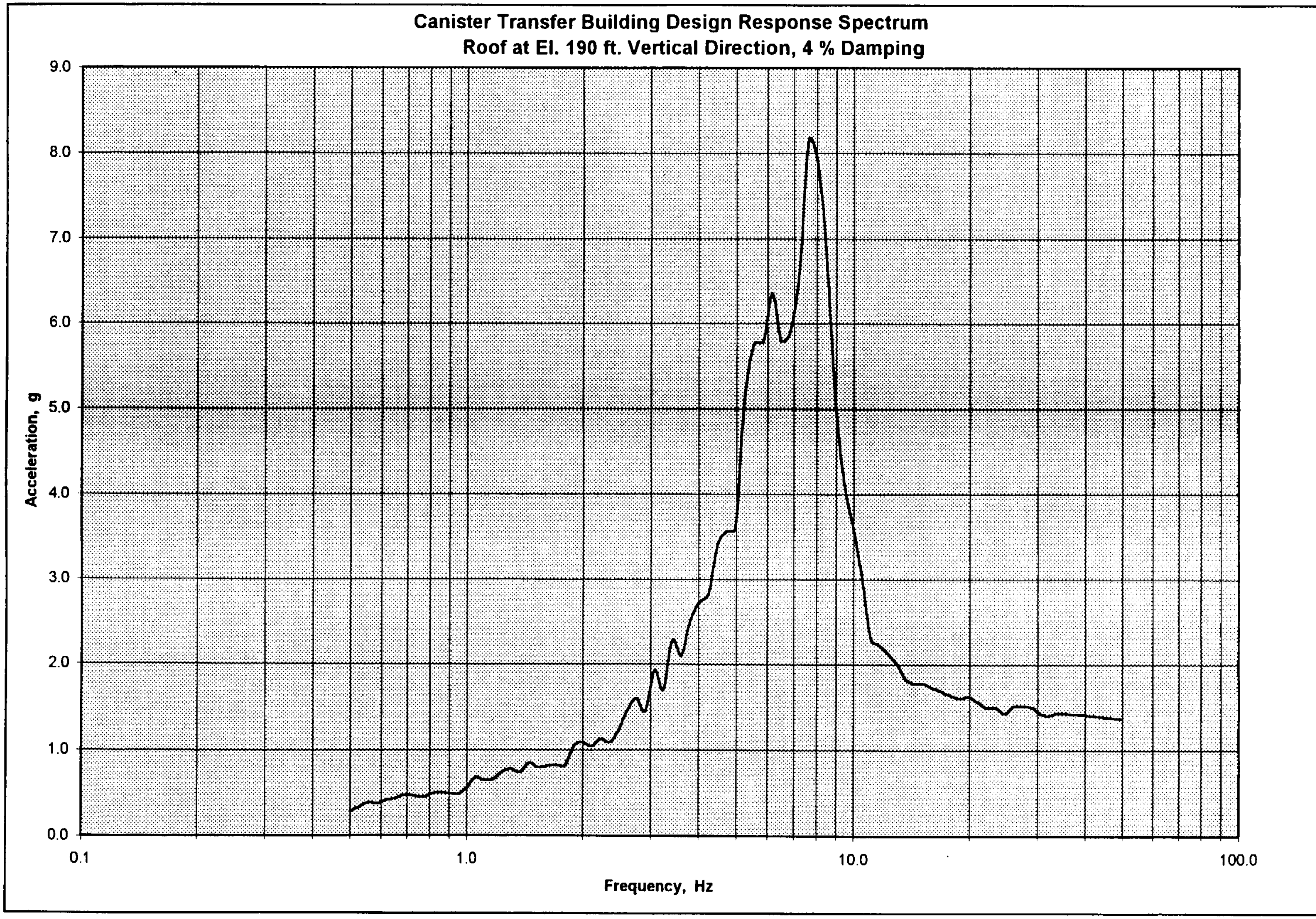

Canister Transfer Building Design Response Spectrum
Crane Rail at El. 170 ft. E-W Direction, 4 % Damping
Acceleration, g
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

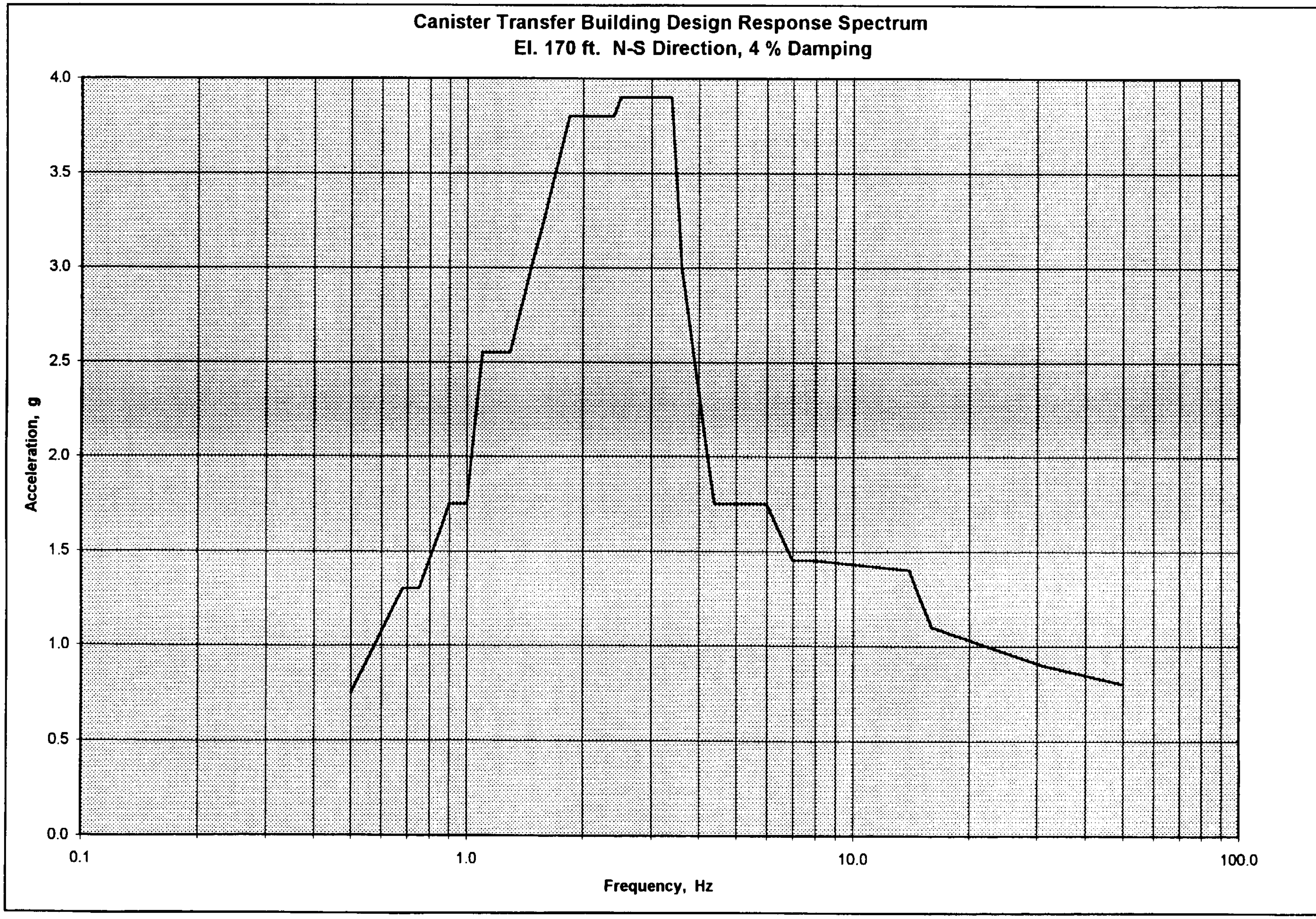

Canister Transfer Building Design Response Spectrum
El. 170 ft. (Envelope of Crane Rail and Building) E-W Direction, 4 % Damping
Acceleration, g
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

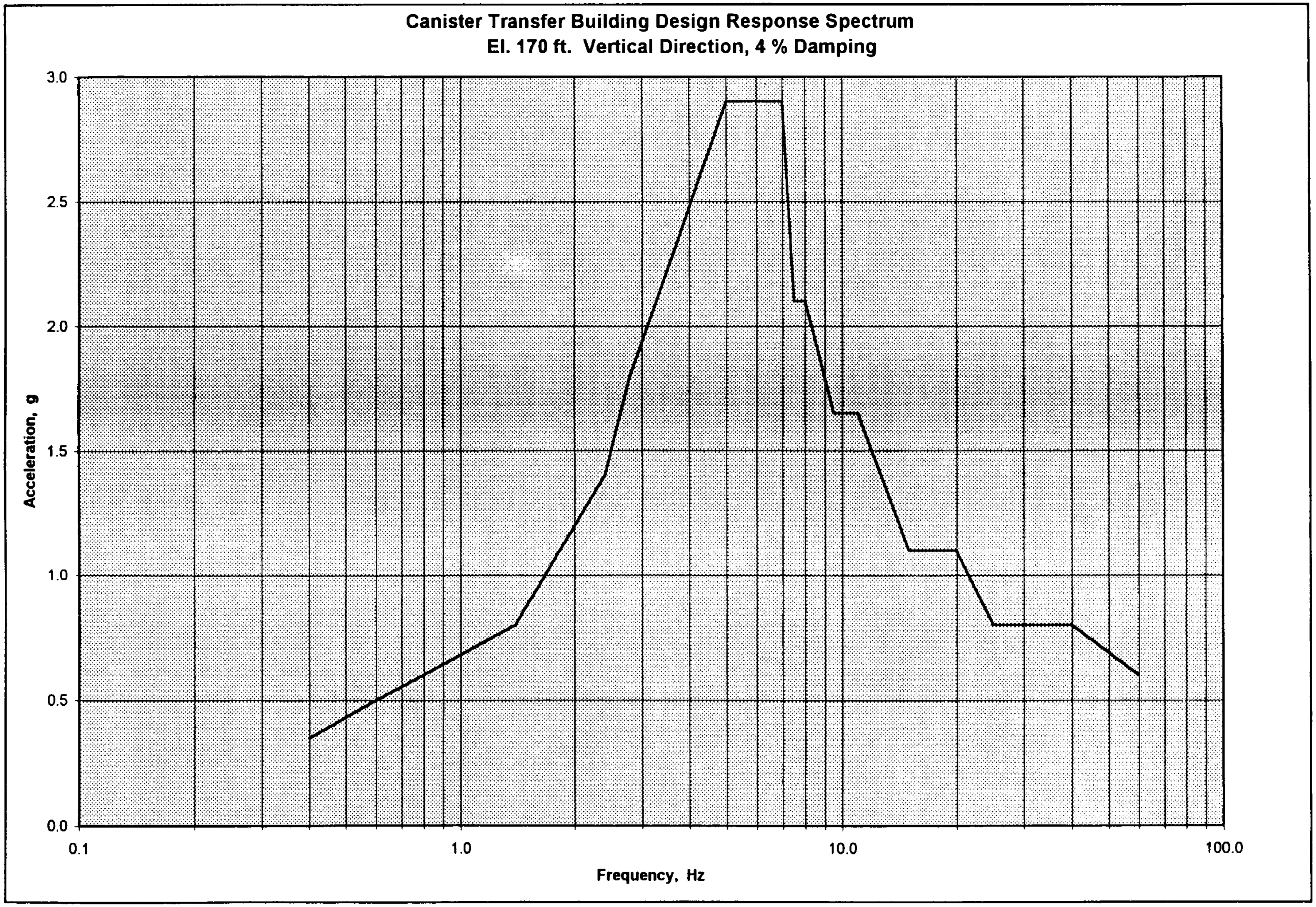

Canister Transfer Building Design Response Spectrum
El. 190 ft. N-S Direction, 4 % Damping
Acceleration, g
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

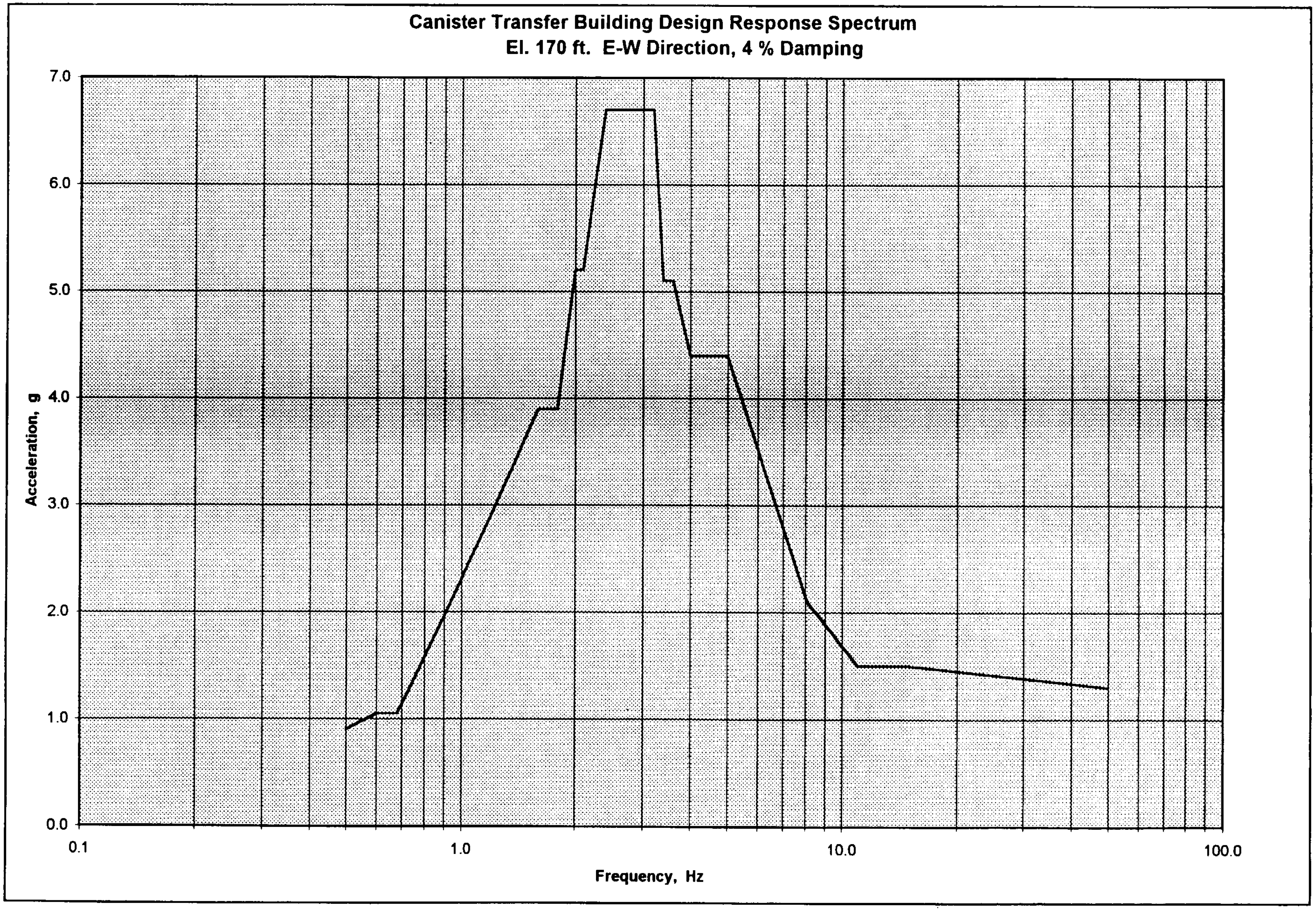

Canister Transfer Building Design Response Spectrum
El. 190 ft. Vertical Direction, 4 % Damping
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Acceleration, g
0.1
1.0
10.0
100.0
Frequency, Hz

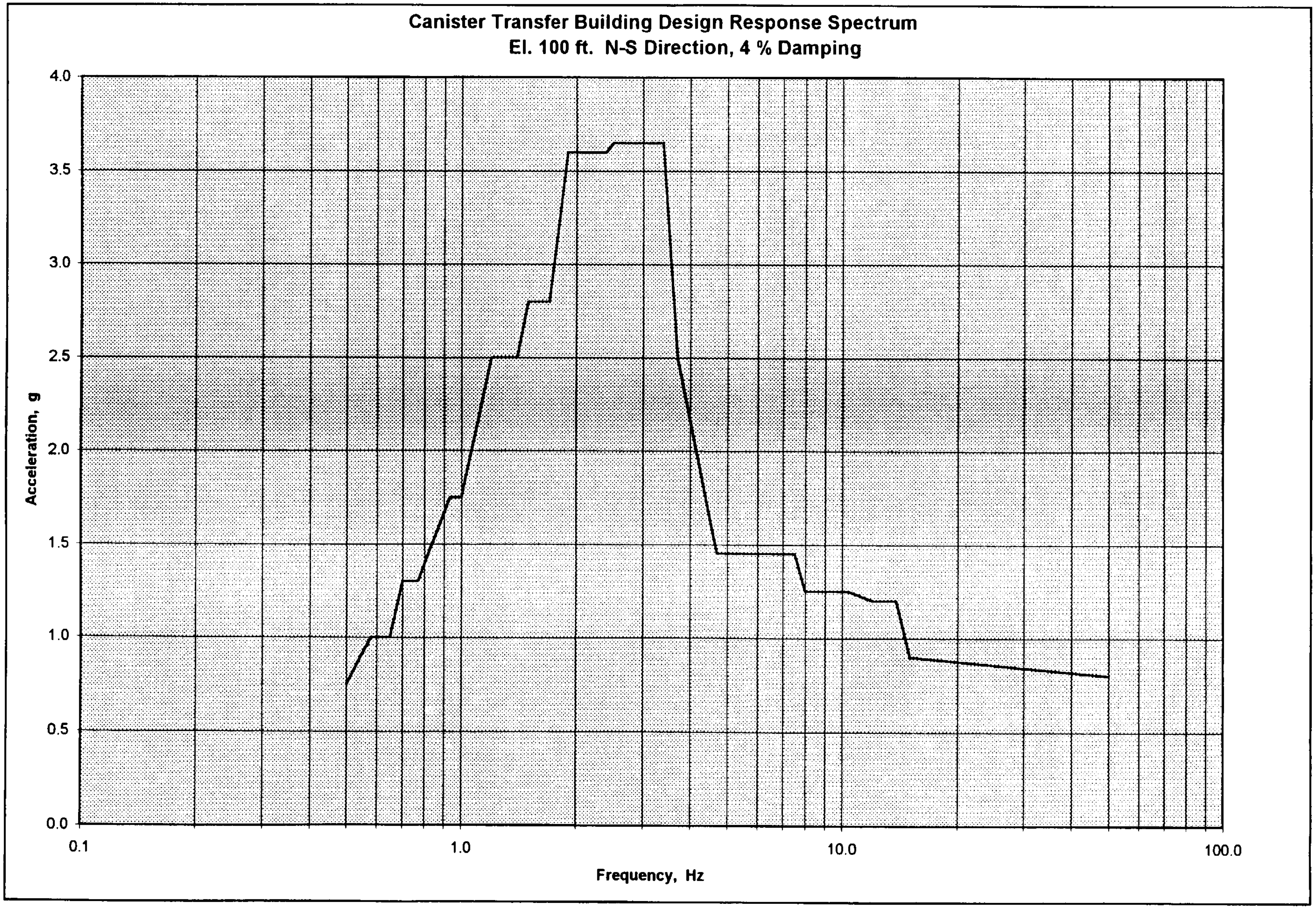

Canister Transfer Building Design Response Spectrum
El. 190 ft. E-W Direction, 4 % Damping
Acceleration, g
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0.1
1.0
10.0
100.0
Frequency, Hz

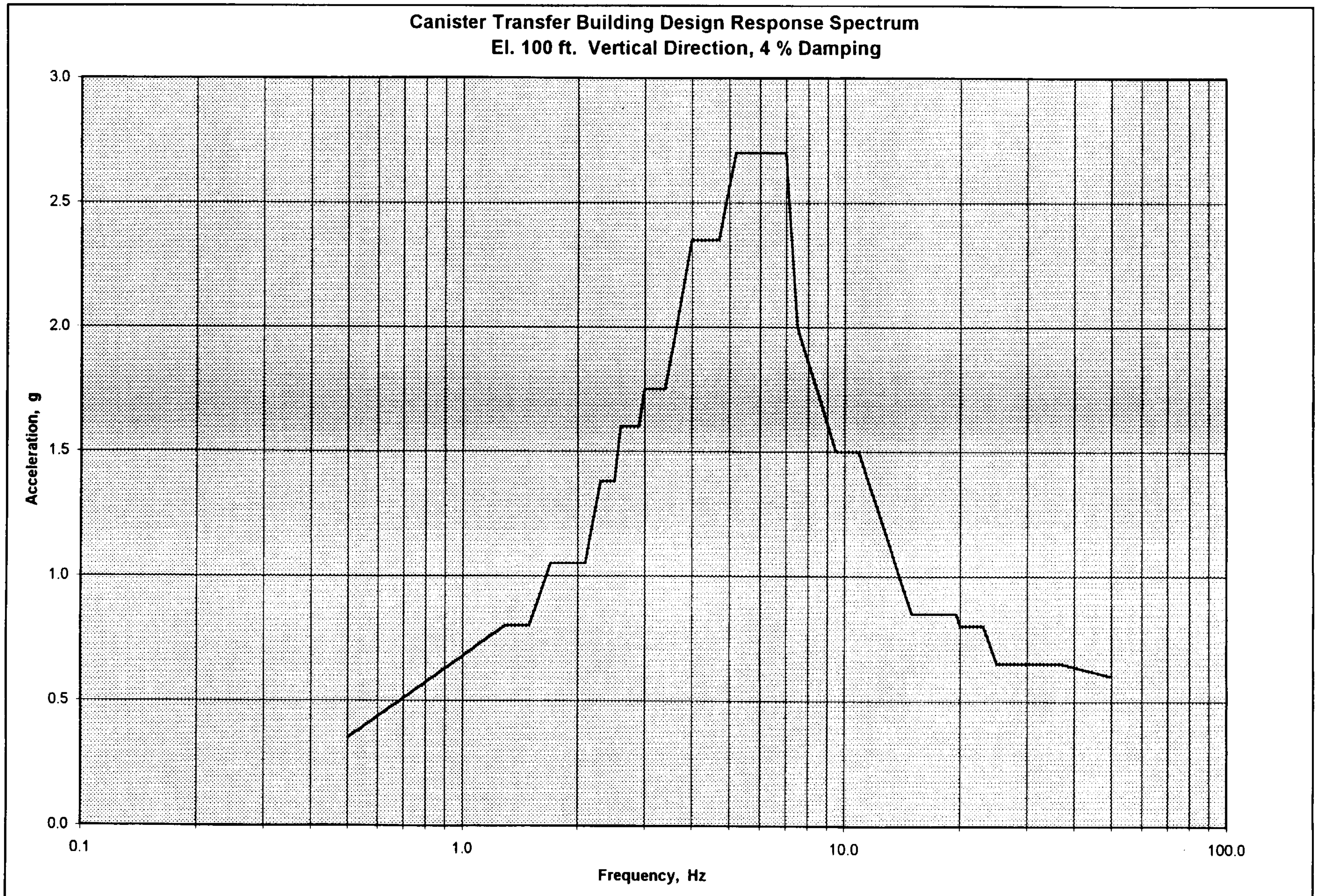

Canister Transfer Building Design Response Spectrum
Roof at El. 190 ft. Vertical Direction, 4 % Damping
Acceleration, g
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

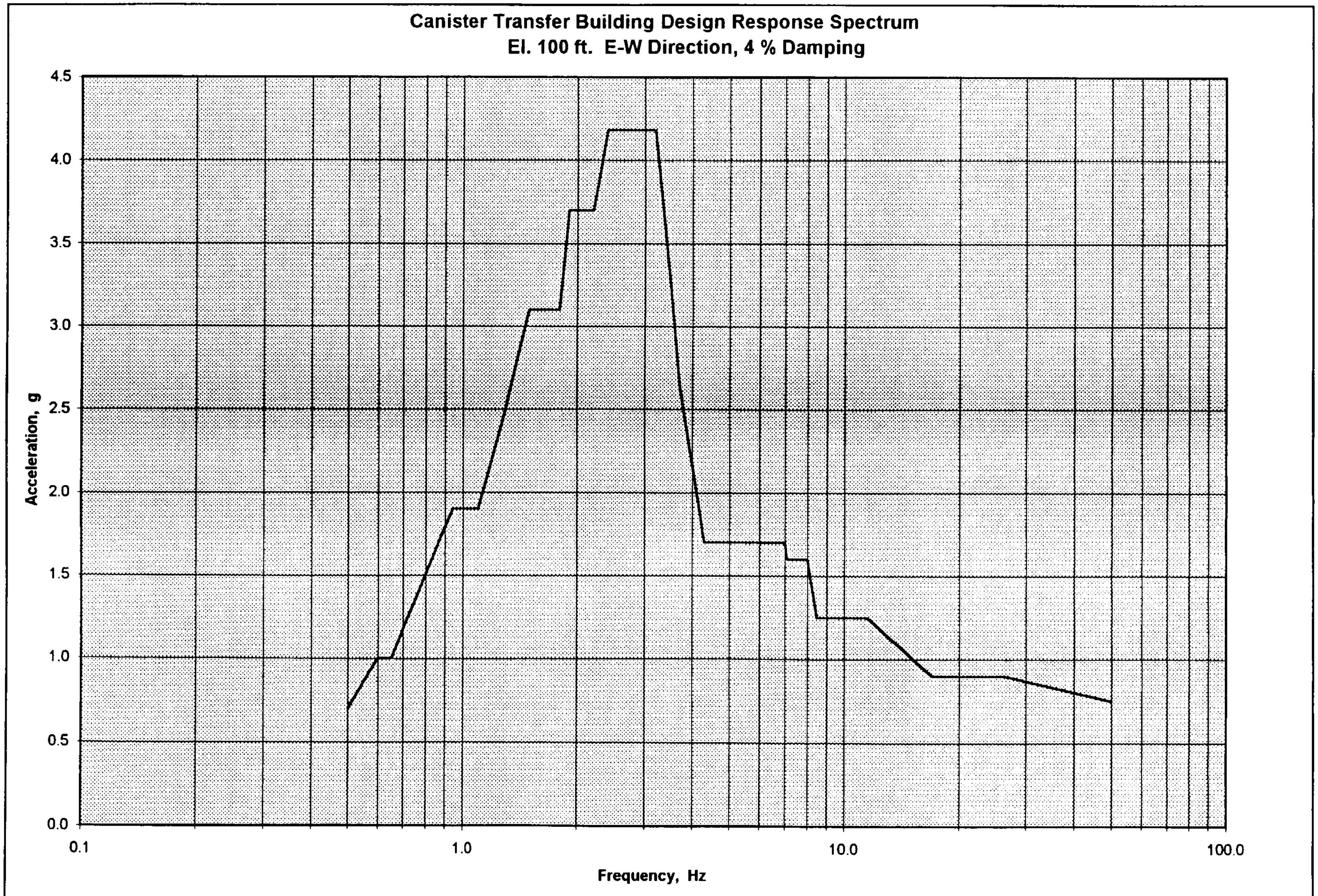

Canister Transfer Building Design Response Spectrum
El. 170 ft. N-S Direction, 4 % Damping
Acceleration, g
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 170 ft. Vertical Direction, 4 % Damping
Acceleration, g
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 170 ft. E-W Direction, 4 % Damping
Acceleration, g
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 100 ft. N-S Direction, 4 % Damping
Acceleration, g
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz


Canister Transfer Building Design Response Spectrum
El. 100 ft. Vertical Direction, 4 % Damping
Acceleration, g
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

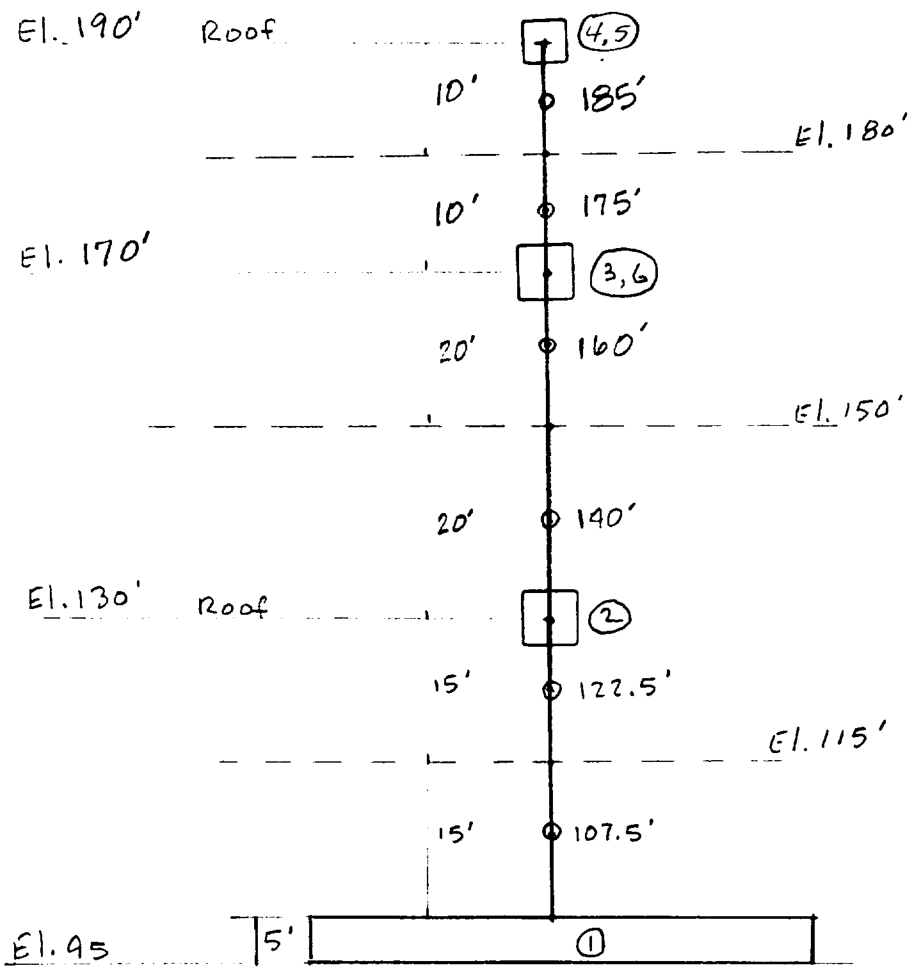

Canister Transfer Building Design Response Spectrum
El. 100 ft. E-W Direction, 4 % Damping
Acceleration, g
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1.0
10.0
100.0
Frequency, Hz

Attachment A Building Masses

The building masses are distributed at elevations 100', 130' 170' and 190'. The masses, centroid of masses, and mass moment of inertia are calculated at each elevation using SWEC computer program MASS. The attributed masses to each mass point location from walls, roofs and mat are shown on the attached sketches. The computer input and output are also attached.

Notice that the origin of the coordinate system is located on the north side of the building at the intersection of column lines 1 and D. The x axis points toward south and y axis toward east. The z axis points vertically upward.

Estimate Building Mass



CALCULATION SHEET STONE & WEBSTER ENGINEERING CORPORATION

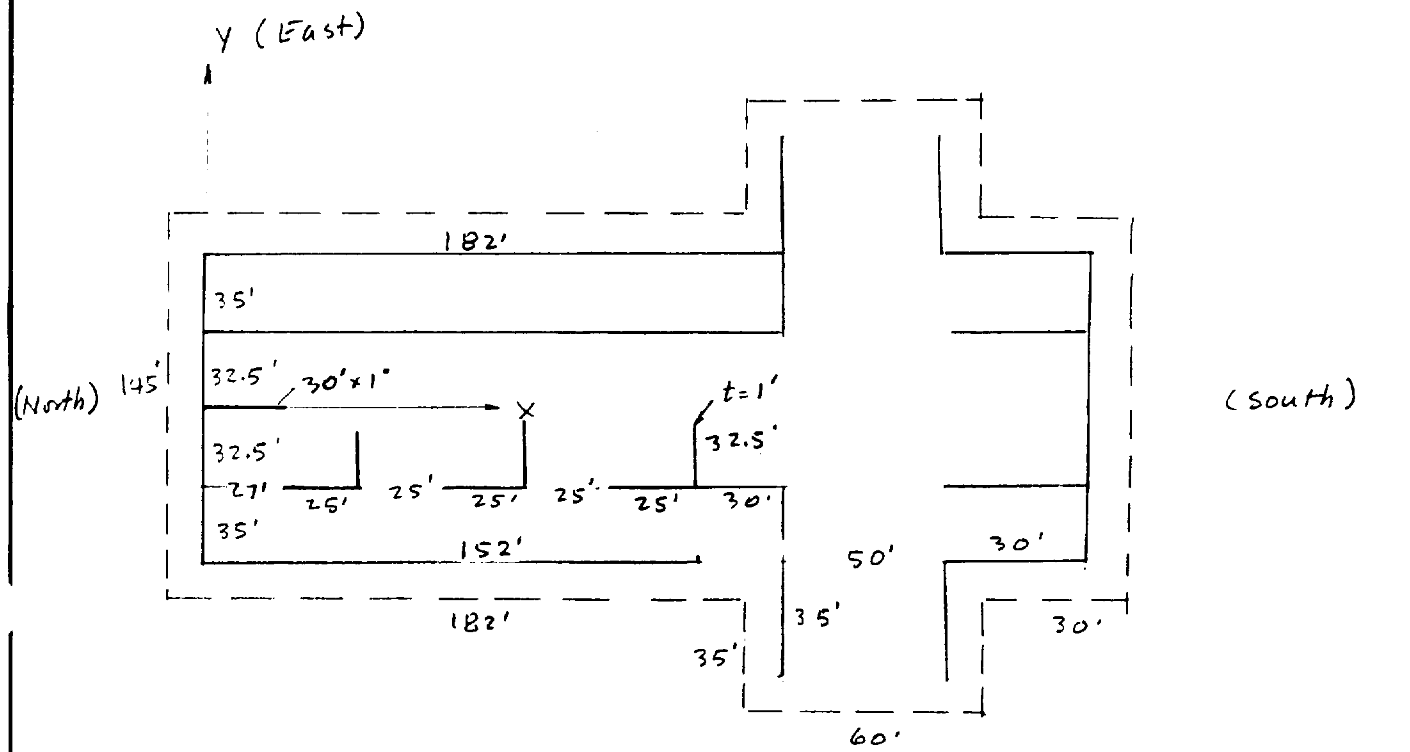
▲5010.61

J.O./W.O./CALCULATION NO.	REVISION	PAGE
0599602-SC-5	0	A-3

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	A. Grant 6/22/98	MJL 7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB SEISMIC ANALYSIS	I

Masses @ El. 100'



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CALCULATION SHEET

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J.O./W.O./CALCULATION NO.	REVISION	PAGE
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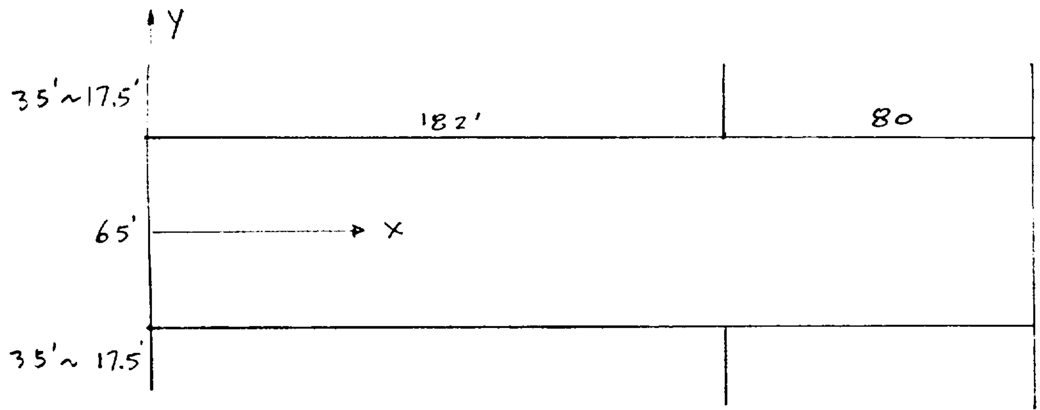
S Chen 6/22/98	A. Grant 6/22/98	7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB SEISMIC ANALYSIS	I

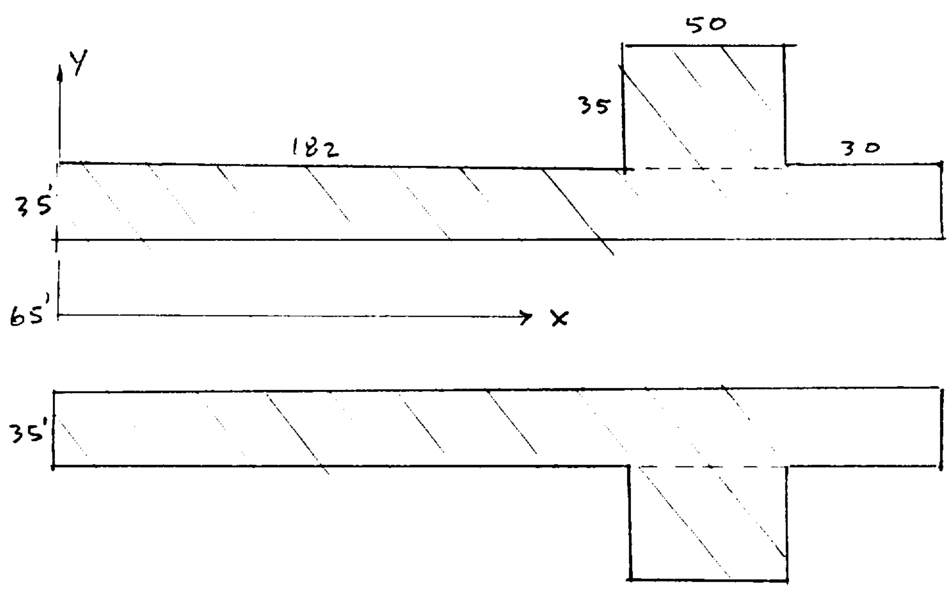
Masses @ El. 130'

Walls (El. 130' - 150')



walls (El. 115' - El. 130') Same as walls from El. 100' - 115'

Roof @ El. 130'



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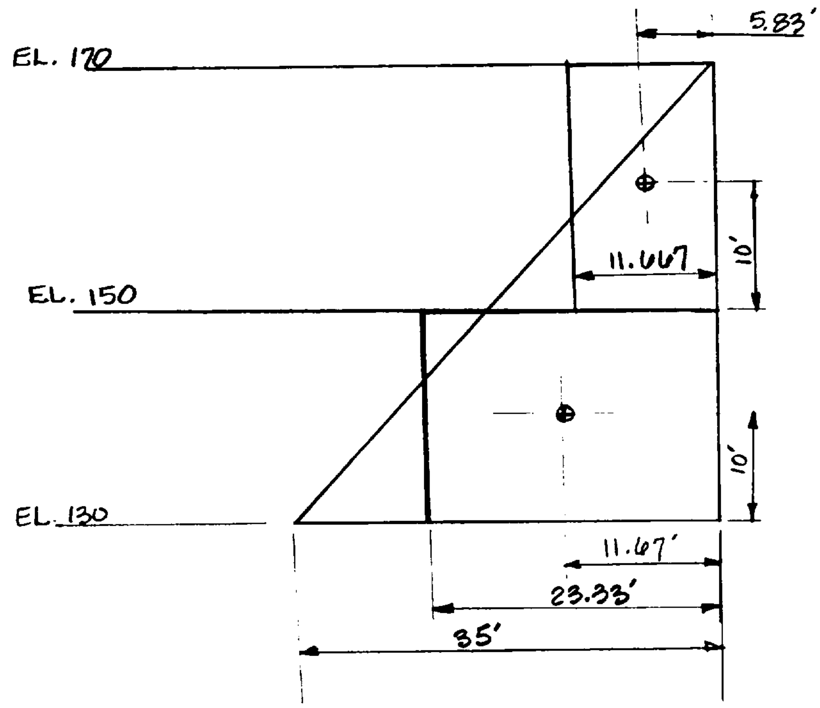
PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	[signature] 6/22/98	[initials] 9/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB SEISMIC ANALYSIS	I



TRIANGULAR WALLS MODELED AS RECTANGULAR @ col. lines 1, 8 & 11.

LOWER RECTANGLE BASE DIMENSION:

$2/3 \times 35' = 23.33'$

UPPER RECTANGLE BASE DIMENSION:

$1/3 \times 35' = 11.667'$

ATTACHMENT A

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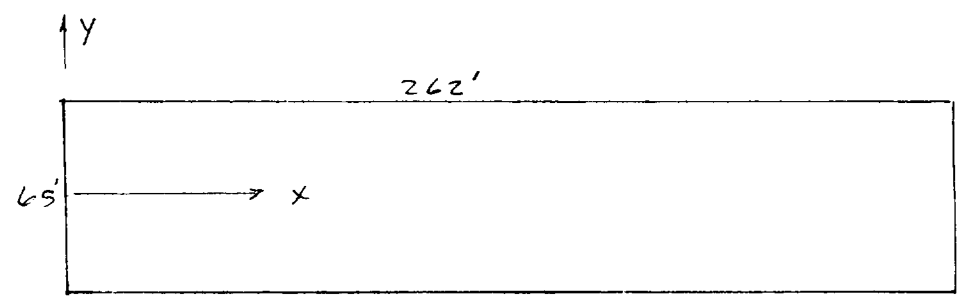
Masses @ El. 170'

Walls (El. 170'- 180')

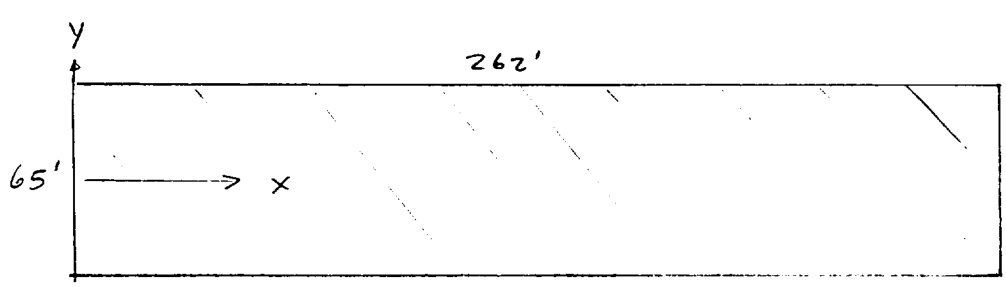


Walls (El. 150' ~ 170') same as walls from El. 130' - 150', except for the wing walls, which become 11.667' wide in lieu of 23.33'

Masses @ El. 190'

Walls El 180' - 190' Same as walls from El. 170' - 180'

Roof @ El 190'



STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲5010.61

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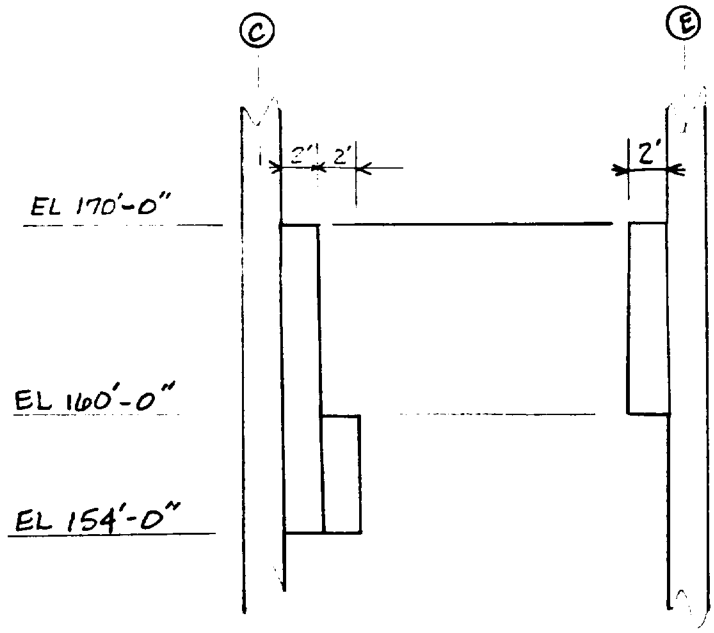
PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	A. Grant 6/22/98	[signature] 7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB SEISMIC ANALYSIS	I



MODEL OF BUILT UP WALL SECTONS FOR CRANE RAILS

ATTACHMENT A

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```
INPU23ECMOS        .0, LEVEL-01 77.301  08.57.37
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 100.
 15.       152.      2.        76.       -67.5     107.5
 15.       182.      2.        91.        67.5     107.5
 15.       182.      2.        91.        32.5     107.5
 15.        30.      2.        247.      -67.5     107.5
 15.        30.      2.        247.      -32.5     107.5
 15.        30.      2.        247.       67.5     107.5
 15.        30.      2.        247.       32.5     107.5
 15.        25.      2.        39.5      -32.5     107.5
 15.        25.      2.        89.5      -32.5     107.5
 15.        55.      2.        154.5     -32.5     107.5
 15.        30.      1.        15.        0.       107.5
9999.
 15.       135.      2.        0.         0.       107.5
 15.        70.      2.        182.      -67.5     107.5
 15.        70.      2.        182.       67.5     107.5
 15.        35.      2.        232.      -85.      107.5
 15.        35.      2.        232.       85.      107.5
 15.       135.      2.        262.       0.       107.5
 15.        32.5     1.         52.      -16.25    107.5
 15.        32.5     1.        102.      -16.25    107.5
 15.        32.5     1.        152.      -16.25    107.5
9999.
9999.
9999.
 182.      145.      5.        86.        0.       97.5      0.
  60.      215.      5.        207.       0.       97.5      0.
  30.      145.      5.        252.       0.       97.5      0.
9999.
9999.
9999.
9999.
 137.22    0.0       95.0      0.0
9999.
```

SKULL VALLEY CTB MASS EL. 100.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
15.000	152.000	2.000	76.000	-67.500	107.500
15.000	182.000	2.000	91.000	67.500	107.500
15.000	182.000	2.000	91.000	32.500	107.500
15.000	30.000	2.000	247.000	-67.500	107.500
15.000	30.000	2.000	247.000	-32.500	107.500
15.000	30.000	2.000	247.000	67.500	107.500
15.000	30.000	2.000	247.000	32.500	107.500
15.000	25.000	2.000	39.500	-32.500	107.500
15.000	25.000	2.000	89.500	-32.500	107.500
15.000	55.000	2.000	154.500	-32.500	107.500
15.000	30.000	1.000	15.000	0.0	107.500

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
15.000	135.000	2.000	0.0	0.0	107.500
15.000	70.000	2.000	182.000	-67.500	107.500
15.000	70.000	2.000	182.000	67.500	107.500
15.000	35.000	2.000	232.000	-85.000	107.500
15.000	35.000	2.000	232.000	85.000	107.500
15.000	135.000	2.000	262.000	0.0	107.500
15.000	32.500	1.000	52.000	-16.250	107.500
15.000	32.500	1.000	102.000	-16.250	107.500
15.000	32.500	1.000	152.000	-16.250	107.500

RECT. FLOORS AND MAT

LX	LY	T	X0	Y0	Z0	ALFA
182.000	145.000	5.000	86.000	0.0	97.500	0.0
60.000	215.000	5.000	207.000	0.0	97.500	0.0
30.000	145.000	5.000	252.000	0.0	97.500	0.0

X0= 137.22 Y0= 0.44 Z0= 99.00 M= 1197.12

MASS MOMENTS OF INERTIA:

ORIGIN
IX= 14699297.0 IY= 41952976.0 IZ= 33144240.0 IXY= 58002.62

CENTROID
IX= 2965834.00 IY= 7679117.00 IZ= 10603392.0 IXY= -13694.37

BASE
IX= 14699069.0 IY= 19412352.0 IZ= 10603392.0 IXY= -13694.37

PRINCIPAL AXIS OF INERTIA AT -0.17 DEGREES:

A
9
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IX·	_965793.00	IY=	7679156.00	IZ=	10603392.0	IXY=	J.01

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 137.220 0.0 95.000 0.0

IX=	2985227.00	IY=	7698282.00	IZ=	10603620.0	IXY=	-13694.87

```
IBPU23ECMAS'        u0, LEVEL-01 77.301  08.57.37
          1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 130.
 15.        152.      2.        76.        -67.5      122.5
 15.        182.      2.        91.         67.5      122.5
 15.        182.      2.        91.         32.5      122.5
 15.         30.      2.        247.       -67.5      122.5
 15.         30.      2.        247.       -32.5      122.5
 15.         30.      2.        247.        67.5      122.5
 15.         30.      2.        247.        32.5      122.5
 15.         25.      2.        39.5       -32.5      122.5
 15.         25.      2.        89.5       -32.5      122.5
 15.         55.      2.        154.5      -32.5      122.5
 15.         30.      1.        15.         0         122.5
 20.        262.      2.        131.       -32.5      140.
 20.        262.      2.        131.        32.5      140.
9999.
 15.        135.      2.        0.          0.        122.5
 15.         70.      2.        182.       -67.5      122.5
 15.         70.      2.        182.        67.5      122.5
 15.         35.      2.        232.       -85.       122.5
 15.         35.      2.        232.        85.       122.5
 15.        135.      2.        262.        0.        122.5
 15.        32.5      1.        52.        -16.25     122.5
 15.        32.5      1.        102.       -16.25     122.5
 15.        32.5      1.        152.       -16.25     122.5
 20.        111.6     2.        0.          0.        140.
 20.        111.6     2.        262.        0.        140.
 20.         23.3     2.        182.       -44.17     140.
 20.         23.3     2.        182.        44.17     140.
9999.
9999.
9999.
 262.        35.      1.5       131.       -50.       130.          0.
  50.        35.      1.5       207.       -85.       130.          0.
 262.        35.      1.5       131.        50.       130.          0.
  50.        35.      1.5       207.        85.       130.          0.
9999.
9999.
9999.
9999.
 135.8       1.09     130.0      0.
9999.
```

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SKULL VALLEY CTB MASS EL. 130.

WALLS IN X DIRECTION

H	L	T	XO	YO	ZO
15.000	152.000	2.000	76.000	-67.500	122.500
15.000	182.000	2.000	91.000	67.500	122.500
15.000	182.000	2.000	91.000	32.500	122.500
15.000	30.000	2.000	247.000	-67.500	122.500
15.000	30.000	2.000	247.000	-32.500	122.500
15.000	30.000	2.000	247.000	67.500	122.500
15.000	30.000	2.000	247.000	32.500	122.500
15.000	25.000	2.000	39.500	-32.500	122.500
15.000	25.000	2.000	89.500	-32.500	122.500
15.000	55.000	2.000	154.500	-32.500	122.500
15.000	30.000	1.000	15.000	0.0	122.500
20.000	262.000	2.000	131.000	-32.500	140.000
20.000	262.000	2.000	131.000	32.500	140.000

WALLS IN Y DIRECTION

H	L	T	XO	YO	ZO
15.000	135.000	2.000	0.0	0.0	122.500
15.000	70.000	2.000	182.000	-67.500	122.500
15.000	70.000	2.000	182.000	67.500	122.500
15.000	35.000	2.000	232.000	-85.000	122.500
15.000	35.000	2.000	232.000	85.000	122.500
15.000	135.000	2.000	262.000	0.0	122.500
15.000	32.500	1.000	52.000	-16.250	122.500
15.000	32.500	1.000	102.000	-16.250	122.500
15.000	32.500	1.000	152.000	-16.250	122.500
20.000	111.600	2.000	0.0	0.0	140.000
20.000	111.600	2.000	262.000	0.0	140.000
20.000	23.300	2.000	182.000	-44.170	140.000
20.000	23.300	2.000	182.000	44.170	140.000

RECT. FLOORS AND MAT

LX	LY	T	XO	YO	ZO	ALFA
262.000	35.000	1.500	131.000	-50.000	130.000	0.0
50.000	35.000	1.500	207.000	-85.000	130.000	0.0
262.000	35.000	1.500	131.000	50.000	130.000	0.0
50.000	35.000	1.500	207.000	85.000	130.000	0.0

XO= 135.80 YO= 1.09 ZO= 130.28 M= 480.51

MASS MOMENTS OF INERTIA:

ORIGIN

IX= 9396519.00 IY= 20655984.0 IZ= 13675669.0 IXY= 58002.62

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CENTROID

I.	1240707.00	IY=	3639097.00	IZ=	4813459.00	IXY=	.3.69

BASE

IX=	9395950.00	IY=	11794340.0	IZ=	4813459.00	IXY=	-12953.69

PRINCIPAL AXIS OF INERTIA AT -0.31 DEGREES:

IX=	1240636.00	IY=	3639166.00	IZ=	4813459.00	IXY=	-0.02

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 135.800 1.090 130.000 0.0

IX=	1240743.00	IY=	3639133.00	IZ=	4813459.00	IXY=	-12953.69

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IBPU23ECMAS[illegible]  [illegible]0, LEVEL-01 77.301  08.57.37
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 170.
 20.       262.      2.        131.       -32.5      160.
 20.       262.      2.        131.        32.5      160.
 10.       262.      2.        131.       -32.5      175.
 10.       262.      2.        131.        32.5      175.
 16.       262.      2.        131.       -30.5      162.
 6.        262.      2.        131.       -28.5      157.
 10.       262.      2.        131.        30.5      165.
 9999.
 20.        88.34    2.        0.          0.        160.
 20.        88.34    2.        262.        0.        160.
 20.        11.67    2.        182.       -38.33     160.
 20.        11.67    2.        182.        38.33     160.
 10.        65.      2.        0.          0.        175.
 10.        65.      2.        262.        0.        175.
9999.
9999.
9999.
9999.
9999.
9999.
9999.
 131.81     -3.15    170.0      0.
9999.
```

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SKULL VALLEY CTB MASS EL. 170.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
20.000	262.000	2.000	131.000	-32.500	160.000
20.000	262.000	2.000	131.000	32.500	160.000
10.000	262.000	2.000	131.000	-32.500	175.000
10.000	262.000	2.000	131.000	32.500	175.000
16.000	262.000	2.000	131.000	-30.500	162.000
6.000	262.000	2.000	131.000	-28.500	157.000
10.000	262.000	2.000	131.000	30.500	165.000

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
20.000	88.340	2.000	0.0	0.0	160.000
20.000	88.340	2.000	262.000	0.0	160.000
20.000	11.670	2.000	182.000	-38.330	160.000
20.000	11.670	2.000	182.000	38.330	160.000
10.000	65.000	2.000	0.0	0.0	175.000
10.000	65.000	2.000	262.000	0.0	175.000

X0= 131.81 Y0= -3.15 Z0= 163.91 M= 274.21

MASS MOMENTS OF INERTIA:

ORIGIN

IX= 7641304.00 IY= 14217809.0 IZ= 7092625.00 IXY= -113303.87

CENTROID

IX= 271852.00 IY= 2087037.00 IZ= 2325849.00 IXY= 700.50

BASE

IX= 7638575.00 IY= 9453760.00 IZ= 2325849.00 IXY= 700.50

PRINCIPAL AXIS OF INERTIA AT 0.02 DEGREES:

IX= 271851.62 IY= 2087036.00 IZ= 2325849.00 IXY= 0.00

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 131.810 -3.150 170.000 0.0

IX= 282033.31 IY= 2097218.00 IZ= 2325849.00 IXY= 700.50

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```
IBPUZ3ECHASS      J0, LEVEL-01 77.301  08.57.37
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 190.
 10.       262.      2.         131.      -32.5      185.
 10.       262.      2.         131.       32.5      185.
9999.
 10.        65.      2.         0.         0.        185.
 10.        65.      2.         262.       0.        185.
9999.
9999.
9999.
 262.       65.      2.0        131.       0.        190.        0.
9999.
9999.
9999.
9999.
 131.0       0.      190.0       0.
9999.
```

ATTACHMENT A

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SKULL VALLEY CTB MASS EL. 190.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
10.000	262.000	2.000	131.000	-32.500	185.000
10.000	262.000	2.000	131.000	32.500	185.000

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
10.000	65.000	2.000	0.0	0.0	185.000
10.000	65.000	2.000	262.000	0.0	185.000

RECT. FLOORS AND MAT

LX	LY	T	X0	Y0	Z0	ALFA
262.000	65.000	2.000	131.000	0.0	190.000	0.0

X0= 131.00 Y0= 0.0 Z0= 188.61 M= 219.80

MASS MOMENTS OF INERTIA:

ORIGIN								
IX=	7932831.00	IY=	12989052.0	IZ=	5279849.00	IXY=	0.0	
CENTROID								
IX=	113480.00	IY=	1397702.00	IZ=	1507850.00	IXY=	0.0	
BASE								
IX=	7932831.00	IY=	9217053.00	IZ=	1507850.00	IXY=	0.0	

PRINCIPAL AXIS OF INERTIA AT 0.0 DEGREES:

IX= 113480.00 IY= 1397702.00 IZ= 1507850.00 IXY= 0.0

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 131.000 0.0 190.000 0.0

IX= 113903.06 IY= 1398125.00 IZ= 1507850.00 IXY= 0.0

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Attachment B Building Stiffness

The building stiffness for members between mass points is calculated manually. The calculations include cross section areas, moment of inertia, and center of rigidity. To account for the eccentric of the center of rigidity from the mass centroid, the stiffness matrix is calculated using SWEC program RIG3 and RIG4. The results are given in Attachment

Notice that the origin of the coordinate system used in RIG3 and RIG4 is located on the south side of the building at the intersection of column lines 11 and D. The x axis points toward north and z axis toward east, with y axis being vertical. This system is consistent with the coordinate system used in FRIDAY program. The properties from the output of MASS program are adjusted to match this coordinate system.

CALCULATION SHEET

▲5010.61

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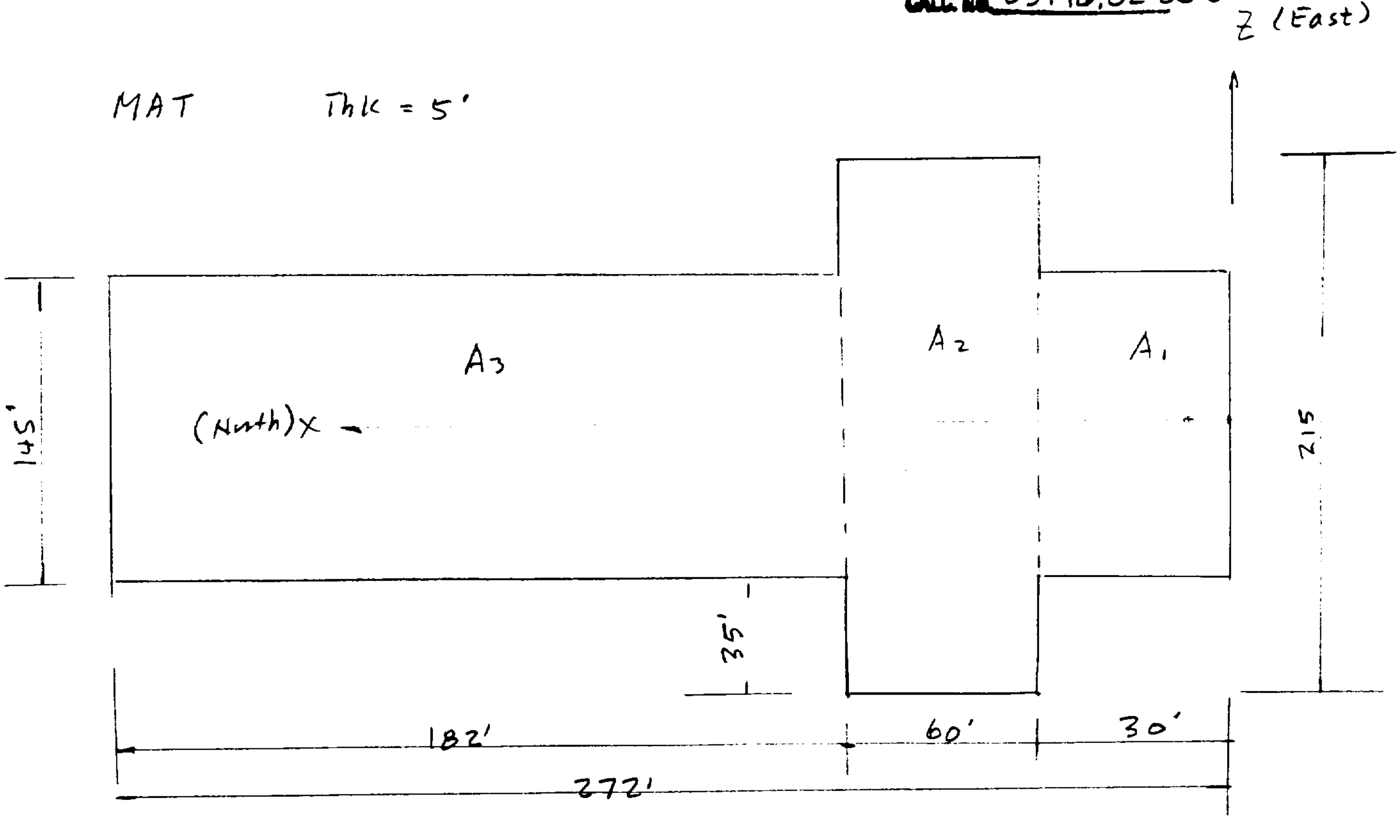
Estimate Bldg stiffness

MAT Thk = 5'



$A_1 = 145(30) = 4350 \ ft^2$

$A_2 = 215(60) = 12,900$

$A_3 = 145(182) = 26,390$

$43,640$

$$\bar{X} = \frac{4350 \times 15 + 12,900 \times 60 + 26,390(181)}{43,640} = 128.7'$$

(123.7' from origin of Bldg)

$W = (43,640)(5)(.15) = 32,730 \ K$

Note: For calculation of stiffness matrices (using RIG3 & RIG4), Youngs modulus of 519000 KSF & Shear modulus of 216000 KSF are used, corresponding to $f_c' = 4000$ psi (Ref 9)

ATTACHMENT B
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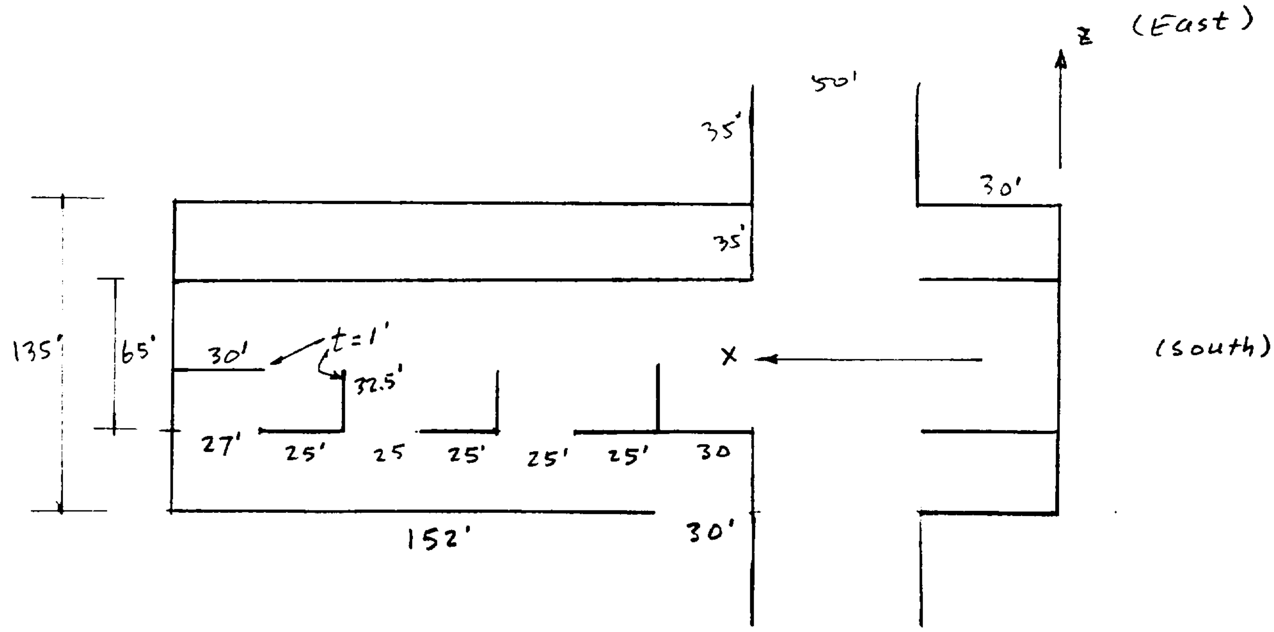
Major Walls El 100' – El. 130'

Vertical Direction



Area		X	Z	A x	A z
182 x 2 =	364	171'	67.5	62244	24,570
30 x 2 =	60	15	67.5	900	4,050
182 x 2 =	364	171	32.5	62244	11,830
30 x 2 =	60	15	32.5	900	1,950
30 x 1 =	30	247	0	7,410	0
25 x 2 =	50	222.5	-32.5	11,125	-1,625
25 x 2 =	50	172.5	-32.5	8625	-1625
55 x 2 =	110	107.5	-32.5	11825	-3575
30 x 2 =	60	15	-32.5	900	-1950
152 x 2 =	304	186	-67.5	56544	-20,520
30 x 2 =	60	15	-67.5	900	-4,050

Area	x	z	Ax	Az
2×35×2 = 140	30	0	4,200	0
135×2 = 270	262	0	70,740	0
2×70×2 = 280	80	0	22,400	0
135×2 = 270	0	0	0	0
32.5×1 = 32.5	210	-16.25	6825	-528
32.5×1 = 32.5	160	-16.25	5200	-528
32.5×1 = 32.5	110	-16.25	3,575	-528
A = 2569.5			336,557	7471

$\bar{x} = 336{,}557 / A = 130.98'$

$\bar{z} = 7471 / A = 2.91'$

I_y = Approximated by a hollow rectangle of 135′ × 262′ with wall thickness of 2′

$$I_y = \frac{4A^2t}{u} = \frac{4(135 \times 262)^2(2)}{2(135+262)} = 126 \times 10^5 \text{ ft}^4$$

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CTB SEISMIC ANALYSIS	I

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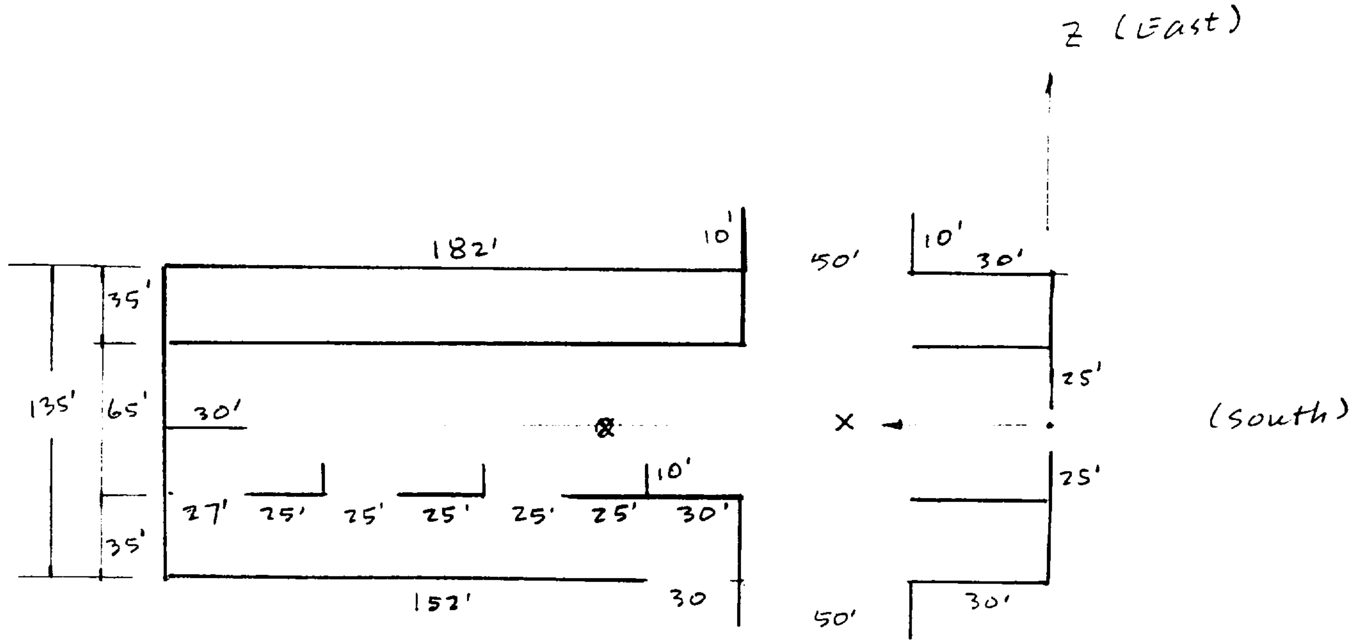
Major Walls El. 100' - 130'

N-S Direction



	Area	X	AX
A_{N-S}	135' x 2' = 270 ft^2	262'	70,740
	2 (45)(2) = 180	80'	14,400
	2 (10)(2) = 40	30'	1,200
	2 (60)(2) = 240	0	0
	10 x 1 = 10	210	2100
	10 x 1 = 10	160	1600
	10 x 1 = 10	111	1110
	2 x 182 x 2 = 728	171	124,488
	4 x 30 x 2 = 240	15	3,600
	30 x 1 = 30	247	7,410
	25 x 2 = 50	222.5	11,125
	25 x 2 = 50	172.5	8,625
	55 x 2 = 110	107.5	11,825
	152 x 2 = 304	186	56,544
	2,272 ft^2		314,767

$\bar{X}$ = 138.5'

Walls @ 100' - 130'

N-S Direction

$I_{EW} = I_Z$

$270 \times (262 - 138.5)^2 = 41.18 \times 10^5$

$180 \times (138.5 - 80)^2 = 6.16 \times 10^5$

$40 \times (138.5 - 30)^2 = 4.71 \times 10^5$

$240 \times 138.5^2 = 46.04$

$10 \ (210 - 138.5)^2 = .51$

$10 \ (160 - 138.5)^2 = .05$

$10 \ (138.5 - 111)^2 = .08$

$2 \times \frac{1}{12} 2 (182)^3 + 728 (171 - 138.5)^2 = 27.78$

$4 \times \frac{1}{12} 2 (30)^3 + 240 (138.5 - 15)^2 = 36.79$

$\frac{1}{12}(1)(30)^3 + 30 (247 - 138.5)^2 = 3.55$

$\frac{1}{12}(2)(25)^3 + 50 (222.5 - 138.5)^2 = 3.55$

$\frac{1}{12}(2)(25)^3 + 50 (172.5 - 138.5)^2 = 0.60$

$\frac{1}{12}(2)(55)^3 + 110 (138.5 - 107.5)^2 = 1.33$

$\frac{1}{12}(2)(152)^3 + 304 (186 - 138.5)^2 = 12.71$

185.04×10^5

Center of rigidity – $\bar{Z}$ (Note)

A	Z	AZ
182 × 2 = 364	67.5	24570
182 × 2 = 364	32.5	11,830
30 × 1 = 30	0	0
105 × 2 = 210	-32.5	-6,825
152 × 2 = 304	-67.5	-20,520
4 × 30 × 2 = 240	0	0
1512		9055

$\bar{Z} = 5.99' \approx 6.0'$

Note: only N-S shear walls are included, since E-W walls have negligible effect in resisting shear force in N-S direction.

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STONE & WEBSTER ENGINEERING CORPORATION

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CTB SEISMIC ANALYSIS	I

Walls El. 100' - 130'

E-W Direction

ATTACHMENT B

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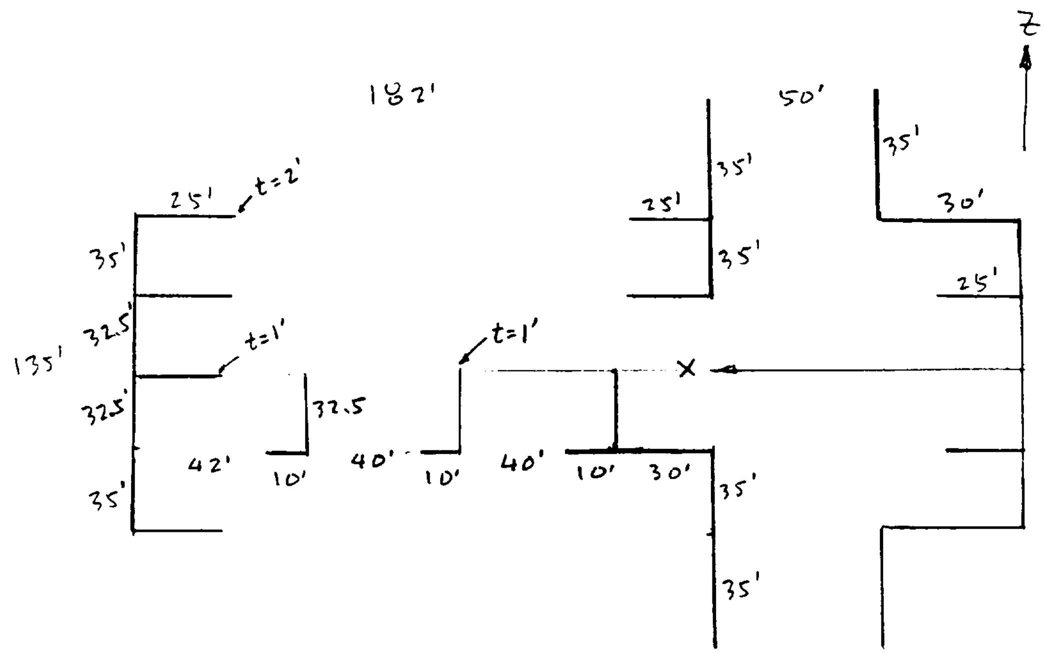

Walls

El. 100' - 130' E-W Direction

A_{EW}	z	A z
80×2 = 160	67.5'	10,800
75×2 = 150	32.5	4875
30×1 = 30	0	0
85×2 = 170	-32.5	-5,525
55×2 = 110	-67.5	-7,425
2×135×2 = 540	0	0
3×32.5×1 = 97.5	-16.25	-1,584
70×2 = 140	67.5	
70×2 = 140	-67.5	
35×2 = 70	85	
35×2 = 70	-85	
A_{EW} = 1677.5		1141

$\bar{z} = 0.68'$

El. 100' - 130' E-W Direction

$I_{NS} = I_x$

$$160 \times (67.5 - 0.68)^2 = 7.14 \times 10^5$$
$$160 \times (32.5 - 0.68)^2 = 1.62 \times 10^5$$
$$30 \times 0.68^2 = 0.00$$
$$170 \times (-32.5 - 0.68)^2 = 1.87$$
$$110 \times (-67.5 - 0.68)^2 = 5.11$$
$$2 \times \frac{1}{12} 2 (135)^3 + 540 (0.68)^2 = 8.20$$
$$3 \times \frac{1}{12}(1)(32.5)^3 + 97.5 (16.25 + 0.68)^2 = 0.37$$
$$\frac{1}{12}(2)(70)^3 + 140 (67.5 - 0.68)^2 = 6.82$$
$$\frac{1}{12}(2)(70)^3 + 140 (67.5 + 0.68)^2 = 7.08$$
$$\frac{1}{12}(2)(35)^3 + 70 (85 - 0.68)^2 = 5.05$$
$$\frac{1}{12}(2)(35)^3 + 70 (85 + 0.68)^2 = 5.21$$

$48.47 \times 10^5 \ ft^4$

Center of Rigidity $\bar{x}$ (Note)

A		x	Ax
135×2	= 270	262	70,740
32.5×1	= 32.5	210	6,825
32.5×1	= 32.5	160	5,200
32.5×1	= 32.5	110	3,575
2×70×2	= 280	80	22,400
2×35×2	= 140	30	4200
135×2	= 170	0	0
	957.5		112,940

Note:

Only E-W shearwalls are included, since N-S walls have negligible effect in resisting shear force in E-W direction.

$\bar{x} = 117.95' \sim 118'$

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CTB SEISMIC ANALYSIS	I

Walls El. 130' – 170'

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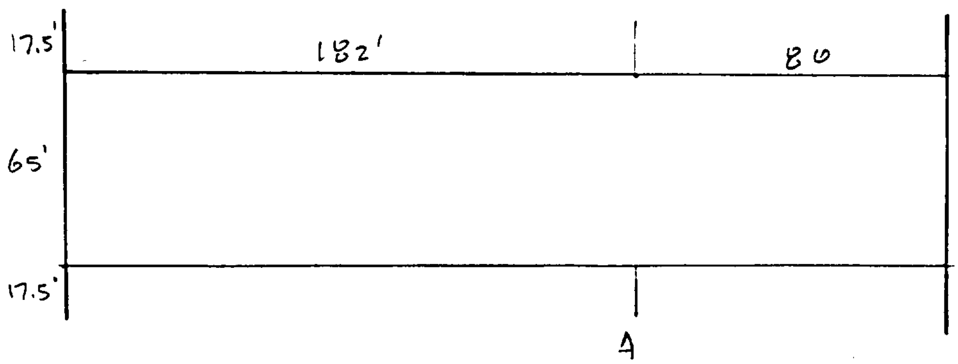
Vertical



Area	$2 \times 65 \times 2$	=	260 ft^2
	$6 \times 17.5 \times 2$	=	210
	$2 \times 262 \times 2$	=	1048
			1518 ft^2

I_{vert} (torsional stiffness)

Approximated by a hollow rectangle of 65' × 262' with wall thickness of 2'

$$I_y = \frac{4A^2t}{U} = \frac{4(65 \times 262)^2 \times 2}{2(65+262)} = 35.5 \times 10^5 \ ft^4$$

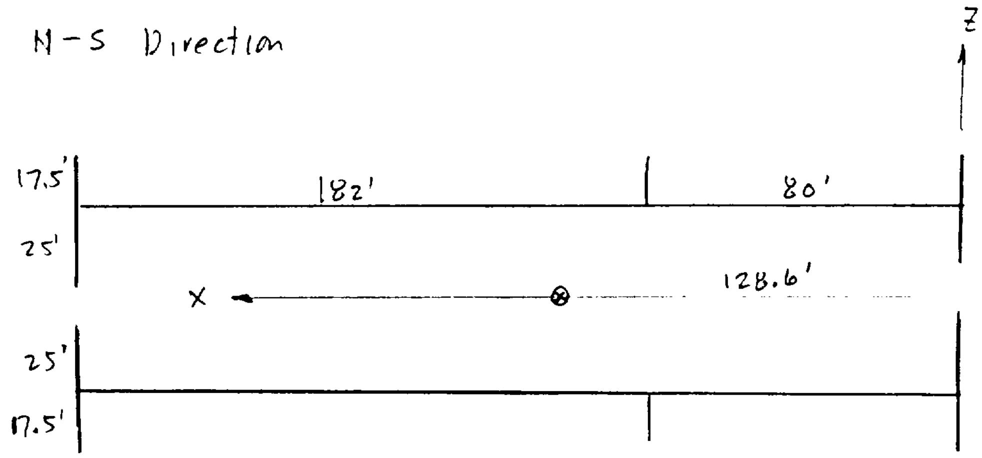
Vertical Center of rigidity

A	x	Ax
$100 \times 2 = 200$	262	52,400
$35 \times 2 = 70$	80	5,600
$100 \times 2 = 200$	0	0
$2 \times 262 \times 2 = 1048$	131	137,288
1518		195,288

$\left(\bar{X} = 128.65', \ \bar{Z} = 0\right)$

Walls El. 130' - 170'

N-S Direction



Area					
85 × 2	= 170 ft²	×	262	=	44,540
2 × 17.5 × 2	= 70	×	80	=	5,600
85 × 2	= 170	×	0	=	0
2 × 262 × 2	= 1048	×	131	=	137,288
	1458 ft²				187,428 / 1458 = $\bar{X}$ = 128.6'

I_{zc}

$$170(262-128.6)^2 = 30.25\times10^5$$

$$70(128.6-80)^2 = 1.65\times10^5$$

$$170(128.6)^2 = 28.11\times10^5$$

$$2\times\frac{1}{12}(2)(262)^3+1048(131-128.6)^2 = 60.01\times10^5$$

$$I_{zc} = 120\times10^5\ \text{ft}^4$$

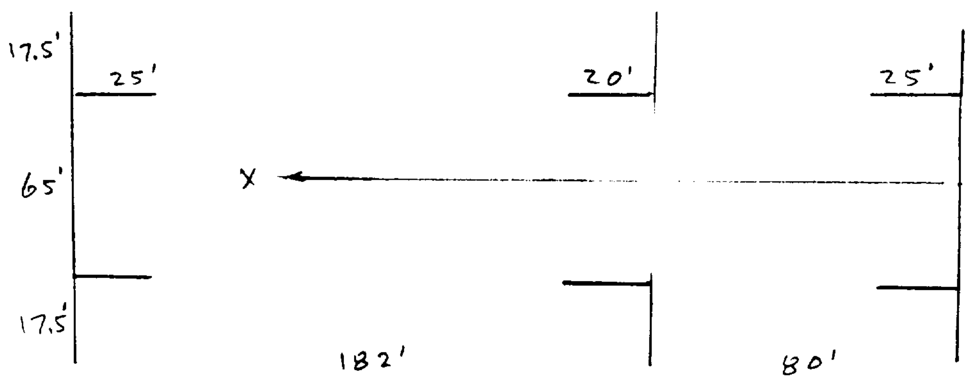
Center of rigidity

$\bar{Z} = 0$

Walls El. 130' – 170'

E-W Direction

z



A_{EW}

2 × 100 × 2	=	400	ft²
1 × 35 × 2	=	70	
2 × (25 + 20 + 25)(2)	=	280	
		750	ft²

I_x

$$2 \times \frac{1}{12}(2)(100)^3 = 3.33 \times 10^5$$

$$280\,(32.5)^2 = 2.96 \times 10^5$$

$$2 \times \frac{1}{12}(2)(17.5)^3 + 70\,(41.25)^2 = 1.21 \times 10^5$$

$$7.5 \times 10^5$$

Center of Rigidity $\bar{x}$

A	x	Ax
100 × 2 = 200	262	52,400
2 × 17.5 × 2 = 70	80	5,600
100 × 2 = 200	0	0
470		58,000

$\bar{x} = 123.4'$

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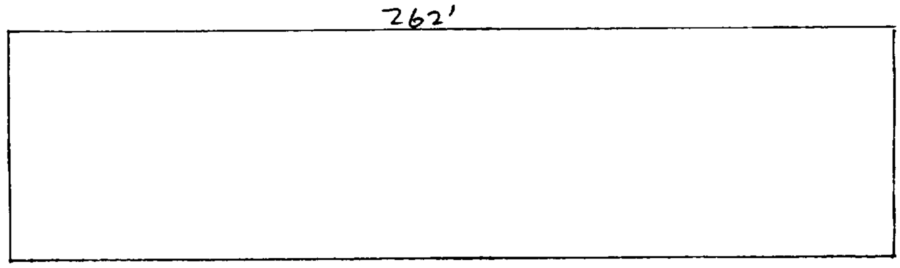
Walls El 170' - 190'

Vertical Direction



A_{vert} = $2 \times 65 \times 2 = 260$ ft²

$2 \times 262 \times 2 = 1048$

1308 ft²

Centroid

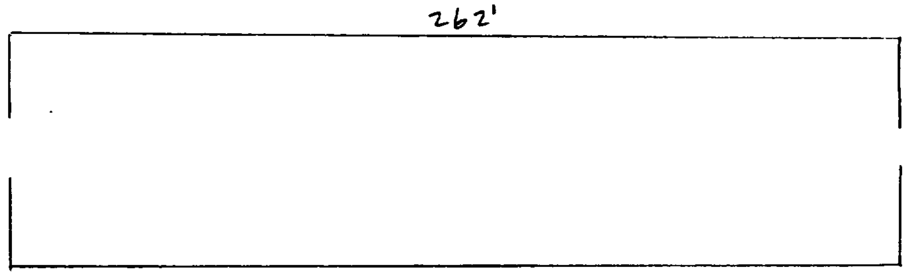
x = 131

z = 0

$I_{vert} = I_y$

$$\frac{4(65 \times 262)^2 \times 2}{2(65+262)} = 35.5 \times 10^5 \text{ ft}^4$$

N-S Direction



A_{NS} $2 \times 50 \times 2 = 200$ ft²) 1248 ft²

$2 \times 262 \times 2 = 1048$

$I_{EW} = I_z$ $200 \times 131^2 = 34.32 \times 10^5$

$2 \times \frac{1}{12}(2)(262)^3 = 59.94 \times 10^5$

94.3×10^5 ft⁴

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Walls El. 170' - 190'

E-W Direction

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A_{EW}

$$2 \times 65 \times 2 = 260 \text{ ft}^2$$

$$4 \times 25 \times 2 = 200$$

$$460 \text{ ft}^2$$

$I_{NS} = I_x$

$$2 \times \frac{1}{12}(2)(65)^3 = 0.92 \times 10^5$$

$$200\,(32.5)^2 = 2.11 \times 10^5$$

$$3.03 \times 10^5 \text{ ft}^4$$

Center of Rigidity

$\bar{x} = 131$

$\bar{z} = 0$

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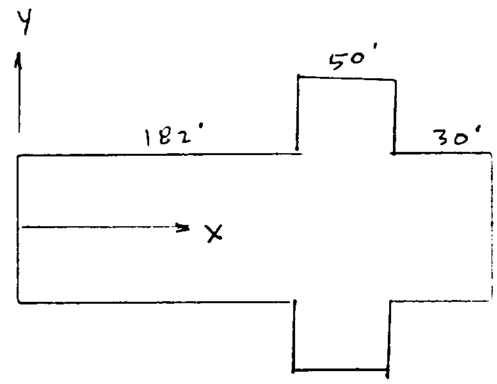
CTB SEISMIC ANALYSIS	

Mass centroids in

Mass Coordinate system

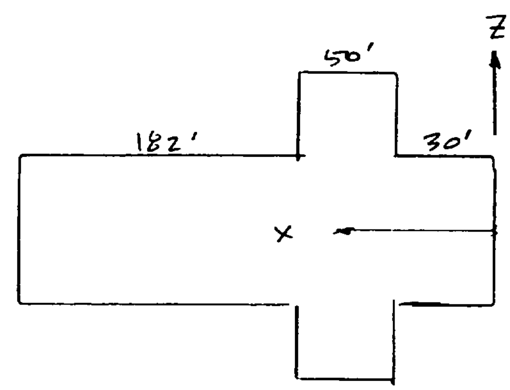
El.	X	Y	Z	Mass k-slug
190'	131.00'	0'	188.31'	180.10
170'	131.81	-3.15'	163.91	274.21
130'	135.8	1.09	130.28	480.16
100'	137.22	0.44	99.00	1197.12
				2131.59



Mass centroids in

Rigidity Coordinate system

El.	X	Y	Z
190'	131'	188.31	0
170'	130.19'	163.91	-3.15'
130'	126.2'	130.28	1.09'
100'	124.78'	99.0	0.44'



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S■P048ER■G3          01 LEVEL-00 77.116  13.52.36
          1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
 STIFFNESS MATRIX OF WALLS BETWEEN MAT AND EL. 130 FT.                   1  0
 123.7      0.0        95.0       100.
 126.2      1.09       130.0
 2569.5     2272.      1677.5     12600000. 4847000. 18500000.   519000. 216000.
 118.0      6.0
 130.98     2.91
 0.
```

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STIFFNESS MATRIX OF WALLS BETWEEN MAT AND EL. 130 FT.

```
0.256950D+04 0.227200D+04 0.167750D+04 0.126000D+08 0.484700D+07 0.185000D+08 0.519000D+06 0.216000D+06
0.118000D+03 0.600000D+01
0.130980D+03 0.291000D+01
0.123700D+03 0.0          0.950000D+02
0.126200D+03 0.109000D+01 0.130000D+03
0.100000D+03
0.0
```

THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.442782D+08	0.223456D+07	-0.123721D+06	0.969133D+07	-0.118669D+08	0.244603D+09
0.223456D+07	0.157757D+08	0.158775D+07	-0.113611D+09	0.141971D+08	-0.215673D+09
-0.123721D+06	0.158775D+07	0.126433D+08	0.429291D+08	0.193569D+09	-0.238884D+08
0.969133D+07	-0.113611D+09	0.429291D+08	0.919781D+11	-0.166106D+10	0.843702D+10
-0.118669D+08	0.141971D+08	0.193569D+09	-0.166106D+10	0.124367D+12	-0.865518D+11
0.244603D+09	-0.215673D+09	-0.238884D+08	0.843702D+10	-0.865518D+11	0.286993D+12

```
SMP049ERIG4         01 LEVEL-00 77.116  14.20.02
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
 STIFFNESS MATRIX OF WALLS BETWEEN EL.130 AND EL.170 FT                   1  0
 126.2     1.09      130.
 130.19    -3.15     170.0
 1518.     1458.     750.       3550000.  750000. 12000000.   519000. 216000.
 123.4     0.0
 128.65    0.0
 0.
 STIFFNESS MATRIX OF WALLS BETWEEN EL.170 AND EL.190 FT                   1  0
 130.19    -3.15     170.0
 131.0     0.0       190.0
 1308.     1248.     460.       3550000.  303000.  9430000.   519000. 216000.
 131.0     0.0
 131.0     0.0
 0.
```

ATTACHMENT B

PAGE 18

CALC. NO. 05996.02-SC-5

(Rev. 0)

STIFFNESS MATRIX OF WALLS BETWEEN EL.130 AND EL.170 FT

```
0.151800D+04 0.145800D+04 0.750000D+03 0.355000D+07 0.750000D+06 0.120000D+08 0.519000D+06 0.216000D+06
0.123400D+03 0.0
0.128650D+03 0.0
0.126200D+03 0.109000D+01 0.130000D+03
0.130190D+03-0.315000D+01 0.170000D+03
0.0
```

THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.194058D+08	0.199380D+07	0.286348D+06	-0.403485D+07	0.256292D+08	-0.488385D+08
0.199380D+07	0.599809D+07	-0.196730D+07	0.729139D+07	-0.357257D+08	-0.122469D+09
0.286348D+06	-0.196730D+07	0.594967D+07	0.182824D+08	0.122908D+09	0.397605D+08
-0.403485D+07	0.729139D+07	0.182824D+08	0.206752D+11	-0.930863D+10	-0.106391D+11
0.256292D+08	-0.357257D+08	0.122908D+09	-0.930863D+10	0.882959D+11	0.728033D+11
-0.488385D+08	-0.122469D+09	0.397605D+08	-0.106391D+11	0.728033D+11	0.807898D+11

STIFFNESS MATRIX OF WALLS BETWEEN EL.170 AND EL.190 FT

```
0.130800D+04 0.124800D+04 0.460000D+03 0.355000D+07 0.303000D+06 0.943000D+07 0.519000D+06 0.216000D+06
0.131000D+03 0.0
0.131000D+03 0.0
0.130190D+03-0.315000D+01 0.170000D+03
0.131000D+03 0.0          0.190000D+03
0.0
```

THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.332072D+08	0.452240D+07	-0.332494D+06	0.533703D+06	-0.328183D+07	0.866489D+07
0.452240D+07	0.613363D+07	0.204456D+07	-0.328183D+07	0.201805D+08	-0.532818D+08
-0.332494D+06	0.204456D+07	0.129210D+08	-0.207402D+08	0.127535D+09	-0.207142D+08
0.533703D+06	-0.328183D+07	-0.207402D+08	0.433119D+11	-0.305731D+11	0.920281D+10
-0.328183D+07	0.201805D+08	0.127535D+09	-0.305731D+11	0.226339D+12	-0.565896D+11
0.866489D+07	-0.532818D+08	-0.207142D+08	0.920281D+10	-0.565896D+11	0.230922D+11

ATTACHMENT B
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Attachment C Crane and Roof Model

The crane rail is approximately on El. 170'. The north and south walls supporting the crane is relatively flexible in the E-W direction, and may cause increased response especially when the crane is located in the middle of the building. The effective mass and member properties of the walls are calculated to simulate the crane frequency in the E-W direction. GTSTRUDL program is used for the frequency estimation.

The roof at El. 190 ft. spans 65 ft. from the north wall to the south wall. It is relatively flexible in the vertical direction compared to the walls. To account for this effect, a mass point 5 is added to the stick model. The frequency and effective mass of the roof are estimated.

CALCULATION SHEET

▲5010 61

STONE & WEBSTER ENGINEERING CORPORATION

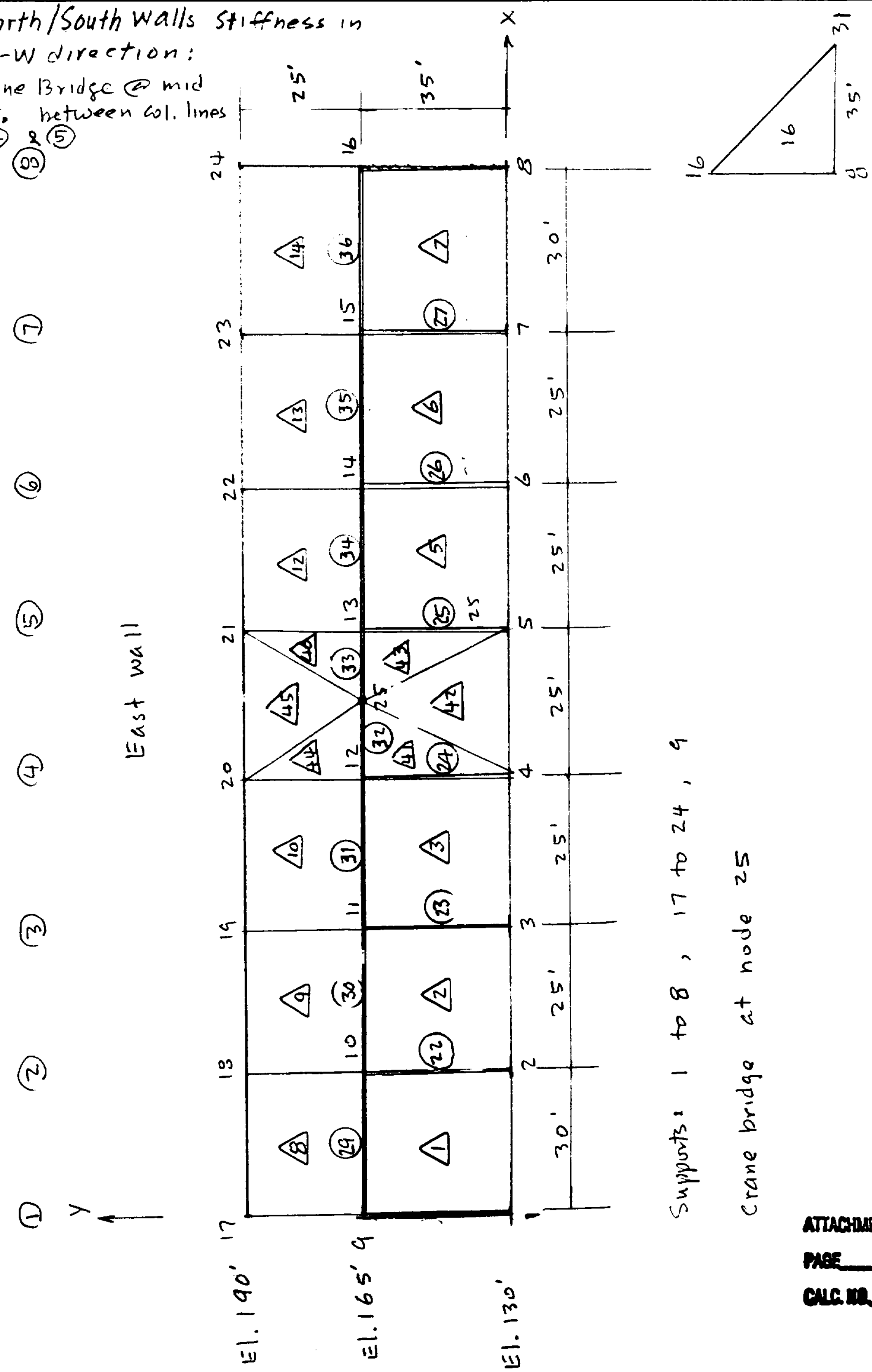
J.O./W.O./CALCULATION NO.	REVISION	PAGE
	C	C-2

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	B. Ebben 6/25/98	7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB Seismic Analysis	I

North/South Walls Stiffness in E-W direction:

Crane Bridge @ mid pt. between col. lines ④ & ⑤



ATTACHMENT C

PAGE 2

CALC. NO. 05996.02-SC-5

CALCULATION SHEET

▲5010.61

J.O./W.O./CALCULATION NO.	REVISION	PAGE
	0	C-3

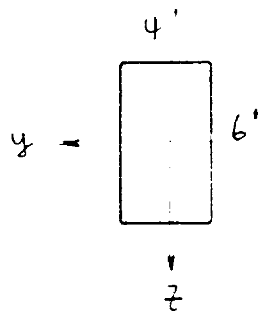
PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	B. Elduso 6/25/98	MGL 7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CTB SEISMIC ANALYSIS	I

Member properties

wall thickness ≈ 2'

22 TO 27



$A = 24 \text{ ft}^2$

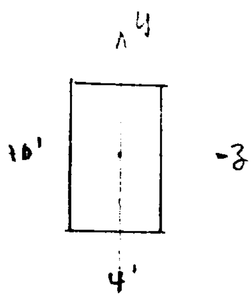
$I_x = \frac{1}{3}(6)(4)^3 = 128 \text{ ft}^4$

$I_y = \frac{1}{12}(4)(6)^3 = 72$

$I_z = \frac{1}{12}(6)(4)^3 = 32$

Note: Dimensions are based on preliminary design and are subject to change

29 TO 36



$A = 40$

$I_x = \frac{1}{3}(10)(4)^3 = 213.3$

$I_y = \frac{1}{12}(10)(4)^3 = 53.3$

$I_z = \frac{1}{12}(4)(10)^3 = 333.3$

Crane Bridge

Estimated total weight = 700K

Half of the wt to E. wall and other half to W. wall

Frequency in EW Direction

$W = 350K \qquad f \approx 5 \text{ Hz}$

(See Attached Computer output)

ATTACHMENT C

PAGE 3

CALC. NO. 05996.02-SC-5

CALCULATION SHEET

STONE & WEBSTER ENGINEERING CORPORATION

▲5010.61

J.O./W.O./CALCULATION NO.	REVISION	PAGE
		C-4

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	B. Ebbeson 6/25/98	[signature] 7/13/98

SUBJECT / TITLE	QA CATEGORY / CODE CLASS
CTB Seismic Analysis	

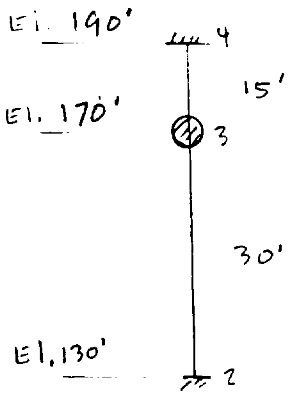
Estimate of Wall Stiffness

Bridge Crane @ mid pt between column Lines (4) & (5)

Frequency in E W Direction

$f = 5.0$ Hz

$W = 2290$ K (see * below)



$$\Delta = \frac{P a^3 b^3}{3 E I L^3}$$

$$K = \frac{P}{\Delta} = \frac{3 E I L^3}{a^3 b^3}$$

$$= \frac{3 \times 519{,}000\ I\ (60)^3}{(20 \times 40)^3}$$

$$= 656.9\ I$$

$$f = \frac{1}{2\pi}\sqrt{\frac{Kg}{W}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{656.9 I \times 32.2}{2290}} = 5 \text{ Hz}$$

$I = 106.9\ ft^4$

For East and West walls together

$I_{NS} = 106.9 \times 2 = 213.8\ ft^4$

$M_{EW} = (2290 \times 2)/32.2 = 142.2$ kslug (4580^K)

* Attribute weight

Wall	$(35' \times 125' \times 2') \times 0.15$	=	1313^K
Beam	$2 \times 10 \times 125 \times .15$	=	375^K
col.	$6(4 \times 4 \times 17.5) \times .15$	=	252
Bridge			350
			2290^K

ATTACHMENT C

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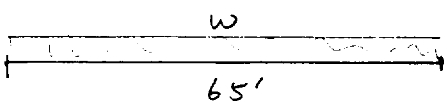
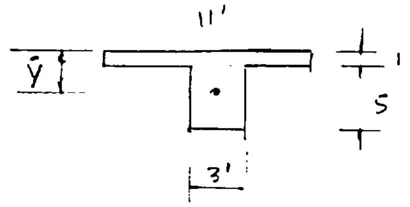
Roof Stiffness El. 190'





cross section / bay

Area 11 × 1 = 11 × 0.5 = 5.5

5 × 3 = 15 × 3.5 = 52.5

26 58 $\bar{y} = 58/26 = 2.23'$

$I = \frac{1}{12}(11)(1)^3 = 0.92$

$11(2.23-0.5)^2 = 32.92$

$\frac{1}{12}(3)(5)^3 = 31.25$

$15 \times (3.5-2.23)^2 = 24.19$

$89.3\ ft^4$

Pinned - Ends

$\Delta = \frac{5wL^4}{384EI}$ $K = \frac{wL}{\Delta} = \frac{384}{5}\frac{EI}{L^3}$

Fixed - Ends

$\Delta = \frac{wL^4}{384EI}$ $K = 384\frac{EI}{L^3}$

Approximate by using average value

$K = \frac{1}{2}\left(384 + \frac{384}{5}\right)\frac{EI}{L^3} \approx 230\frac{EI}{L^3}$

E = 519000 ksf

L = 65'

K = 38,800 k/ft per bay 9 bays total

$K_{Total} = K \times 9 = 349,000$ k/ft

Roof – Spring weight

$A = (65-8)(262-14) = 14{,}136 \text{ ft}^2$

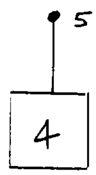
Assume 300 psf

$Wt = 14{,}136 \times .300 = 4241 \text{ K}$

$f = \frac{1}{2\pi}\sqrt{\frac{Kg}{W}} = \frac{1}{2\pi}\left(\frac{349{,}000 \times 32.2}{4241}\right)^{1/2} \approx 8.2 \text{ Hz}$

(say 8 Hz)

Add mass point to simulate roof response



Assume 1' length 1/3 of Roof Mass

$$M_y \text{ at } 5 = \frac{1}{3}(262')(65')(2')\left(\frac{.15}{32.2}\right) = 52.9 \ \frac{K\text{-}SEC^2}{FT}$$

$$M_y \text{ at } 4 = 219.8 - 52.9 = 166.9 \ \frac{K\text{-}SEC^2}{FT}$$

Properties of Member

$$K = \frac{AE}{L} = \frac{A\,(519000)}{1} = 519000\,A$$

$$f = \frac{1}{2\pi}\sqrt{K/m} = 8.\ H_z$$

$$K/m = (16\pi)^2$$

$$519000\,A = (16\pi)^2 (m) = 133658.$$

$$A = .258 \ ft^2$$

```
# Fri Jun 19 14:05:07 1998


1GTICES/C-NP 2.5.0 MD-NT 2.0, January 1995.
 Proprietary to Georgia Tech Research Corporation, U.S.A.

Reading password file C:\Program Files\GTSTRUDL\Gtaccess.dat
 CI-i-audfile, Command AUDIT file FILE1405.aud has been activated.

 *** G T S T R U D L ***
   RELEASE DATE          VERSION              COMPLETION NO.
   April  1997           9701 NT                   3570

 **** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
 **** ASSUMED TO BE    INCH    POUND    RADIAN    FAHRENHEIT   SECOND

 (     1} > CINPUT 'wall.dat'
 (     2} > STRUDL 'GTWALL' 'CANISTER WALL SUPPORTING CRANE BRIDGE, 700k'


**********************************************************************
*                                                                    *
*   ******                             G T S T R U D L               *
*  ********                                                          *
*  **    **                                                          *
*  **               *****   ******  *****   **  **   *****   **      *
*  **  *********** ******   ******  ******  **  **   ******  **      *
*  **  *********** **          **    **  **  **  **   **  **  **      *
*  **    ****      *****       **    ******  **  **   **  **  **      *
*  **********       *****      **    *****   **  **   **  **  **      *
*   ****** **          **      **    ** **   **  **   **  **  **      *
*          **      ******      **    **  **  ******   ******  ****** *
*          **      *****       **    **  **   ****    *****   ****** *
*          **                                                        *
*          **                  OWNED BY AND PROPRIETARY TO THE       *
*          **                  GEORGIA TECH RESEARCH CORPORATION     *
*                                                                    *
*  RELEASE DATE         VERSION             COMPLETION NO.           *
*  April  1997          9701 NT                 3570                 *
*                                                                    *
**********************************************************************


 **** ACTIVE UNITS -  LENGTH   WEIGHT   ANGLE    TEMPERATURE   TIME
 **** ASSUMED TO BE    INCH    POUND    RADIAN    FAHRENHEIT   SECOND
```

ATTACHMENT C
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```
{    3} > $ INPUT FILE C:\TEMP\WALL.DAT
{    4} > UNIT FT KIPS
{    5} > CONSTANTS
{    6} > MATERIAL CONCRETE ALL
{    7} > $E 519000. ALL
{    8} > $G 216000. ALL
{    9} > JOINT COORDINATES
{   10} > 1  0.   0.   0.
{   11} > 2  30.   0.   0.
{   12} > 3  55.   0.   0.
{   13} > 4  80.   0.   0.
{   14} > 5  105. 0.   0.
{   15} > 6  130. 0. 0.
{   16} > 7  155. 0. 0.
{   17} > 8  185. 0. 0.
{   18} > 9  0.    35. 0.
{   19} > 10 30.   35. 0.
{   20} > 11 55.   35. 0.
{   21} > 12 80.   35. 0.
{   22} > 13 105. 35. 0.
{   23} > 14 130. 35. 0.
{   24} > 15 155. 35. 0.
{   25} > 16 185. 35. 0.
{   26} > 17 0.    60. 0.
{   27} > 18 30.   60. 0.
{   28} > 19 55.   60. 0.
{   29} > 20 80.   60. 0.
{   30} > 21 105. 60. 0.
{   31} > 22 130. 60. 0.
{   32} > 23 155. 60. 0.
{   33} > 24 185. 60. 0.
{   34} > 25 92.5 35. 0.
{   35} > 30  0.   0.   -35.
{   36} > 31 185. 0.   -35.
{   37} > $
{   38} > STATUS SUPPORT  1 TO 8 9 17 TO 24  31
{   39} > $ JOINT RELEASES
{   40} > $ MOM X Y Z KFX 3.5 KFZ 3.5 KFY 135.7
{   41} > type plate
{   42} > ELEMENT INCIDENCES
{   43} > 1      1    2     10    9
{   44} > 2      2    3     11    10
{   45} > 3      3    4     12    11
{   46} > 5      5    6     14    13
{   47} > 6      6    7     15    14
{   48} > 7      7    8     16    15
{   49} > 8      9    10    18    17
{   50} > 9      10   11    19    18
{   51} > 10     11   12    20    19
{   52} > 12     13   14    22    21
{   53} > 13     14   15    23    22
{   54} > 14     15   16    24    23
{   55} > 16     8    16    31
{   56} > $
{   57} > 41   25   12    4
{   58} > 42   4     5    25
{   59} > 43   13   25    5
{   60} > 44   12   25    20
{   61} > 45   21   20    25
{   62} > 46   25   13    21
{   63} > ELEMENT PROPERTIES
{   64} > 1 TO 3  5 to 10  12 to 14 TYPE 'SBCR' thi 2.
{   65} > 16  41 to 46 TYPE 'SBCT' THI 2.
{   66} > $
{   67} > TYPE SPACE FRAME
{   68} > MEMBER INCIDENCES
{   69} > 22   2    10
{   70} > 23   3    11
{   71} > 24   4    12
{   72} > 25   5    13
```

```
(   73) > 26    6    14
(   74) > 27    7    15
(   75) > 29    9    10
(   76) > 30   10    11
(   77) > 31   11    12
(   78) > 32   12    25
(   79) > 33   25    13
(   80) > 34   13    14
(   81) > 35   14    15
(   82) > 36   15    16
(   83) > MEMBER PROPERTIES PRISMATIC
(   84) > 22 TO 27 AX 24.  AY 24. AZ 24. IX 128. IY 72. IZ 32.
(   85) > 29 TO 36 AX  40. AY 40.  AZ 40. IX 213.3 IY 53.3 IZ 333.3
(   86) > INERTIA OF NODES LUMPED
(   87) > DYNAMIC DEGREES OF FREEDOM STATIC CONDENSATION
(   88) > NODES 10 TO 15  25  TRANS X Y Z
(   89) > INERTIA OF JOINTS WEIGHT GRAVITY 32.2
(   90) > 25 TRANS ALL 350.
(   91) > UNITS CYCLES
(   92) > EIGEN PARAM
(   93) > FREQUENCY SPECS 0. TO 60.
(   94) > DYNAMIC ANALYSIS EIGENVALUE
**** STRUDL ERROR 2.05 - NO MEMBERS INCIDENT ON JOINT 30


BANDWIDTH INFORMATION BEFORE RENUMBERING.


THE MAXIMUM BANDWIDTH IS    5 AND OCCURS AT JOINT 25
THE AVERAGE BANDWIDTH IS                         1.250
THE STANDARD DEVIATION OF THE BANDWIDTH IS       1.479
                                            ----------
                                                 2.729
                                            ==========


BANDWIDTH INFORMATION AFTER  RENUMBERING.


THE MAXIMUM BANDWIDTH IS    1 AND OCCURS AT JOINT 11
THE AVERAGE BANDWIDTH IS                         0.875
THE STANDARD DEVIATION OF THE BANDWIDTH IS       0.331
                                            ----------
                                                 1.206
                                            ==========
TIME FOR CONSISTENCY CHECKS FOR     33 MEMBERS      0.24 SECONDS
TIME FOR BANDWIDTH REDUCTION                        0.16 SECONDS
TIME TO GENERATE      33 ELEMENT STIF. MATRICES     0.80 SECONDS
TIME TO ASSEMBLE THE STIFFNESS MATRIX               0.11 SECONDS
TIME TO PROCESS      26 JOINTS                      0.00 SECONDS
TIME TO GENERATE REDUCED STIFFNESS MATRIX           0.00 SECONDS
TIME TO ASSEMBLE LUMPED MASS MATRIX                 0.01 SECONDS
TIME FOR CONDENSATION                               0.25 SECONDS
TIME TO TRANSFORM EIGENPROBLEM                      0.02 SECONDS
TIME FOR TRIDIAGONALIZATION                         0.01 SECONDS
TIME TO COMPUTE EIGENVALUES                         0.00 SECONDS
TIME TO COMPUTE EIGENVECTORS                        0.01 SECONDS
TIME TO TRANSFORM EIGENVECTORS                      0.00 SECONDS
TIME TO TRANSFORM EIGENVECTORS TO JOINTS            0.01 SECONDS

*************************
* EIGEN-SOLUTION CHECKS *
*************************


MODE------EIGENVALUE-------FREQUENCY-------FREQUENCY--------PERIOD--------ESTIMATED---/
        ((RAD/SEC)**2)     (RAD/SEC)       (CYC/SEC)       (SEC/CYC)       ACCURACY

   1     9.975079D+02    3.158335D+01    5.026646D+00    1.989398D-01    1.062414D-12
```

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2	1.464538D+03	3.826928D+01	6.090745D+00	1.641835D-01	4.002918D-13
3	1.785999D+03	4.226109D+01	6.726061D+00	1.486754D-01	1.921985D-13
4	3.521294D+03	5.934049D+01	9.444332D+00	1.058836D-01	5.290019D-13
5	4.780845D+03	6.914365D+01	1.100455D+01	9.087147D-02	7.872588D-13
6	9.749758D+03	9.874086D+01	1.571510D+01	6.363308D-02	2.270714D-13
7	2.789175D+04	1.670082D+02	2.658019D+01	3.762201D-02	1.196749D-13
8	5.697114D+04	2.386863D+02	3.798810D+01	2.632403D-02	6.741605D-14
9	1.035535D+05	3.217972D+02	5.121562D+01	1.952529D-02	2.213112D-14
10	1.160862D+05	3.407142D+02	5.422635D+01	1.844122D-02	2.333997D-15

```
------------------
ORTHOGONALITY CHECK
------------------


WITH RESPECT TO MASS
--------------------

OFF DIAGONALS:   MAXIMUM =   0.2026E-14
                 MINIMUM =   0.3469E-17
                    MEAN =   0.2087E-15

    DIAGONALS:   MAXIMUM =   0.1000E+01
                 MINIMUM =   0.1000E+01
                    MEAN =   0.1000E+01



WITH RESPECT TO STIFFNESS
-------------------------

OFF DIAGONALS:   MAXIMUM =   0.4502E-10
                 MINIMUM =   0.2511E-12
                    MEAN =   0.1101E-10

    DIAGONALS:   MAXIMUM =   0.1161E+06
                 MINIMUM =   0.9975E+03
                    MEAN =   0.3268E+05


*********************************
* END OF EIGEN-SOLUTION CHECKS *
*********************************

TIME TO CHECK EIGENSOLUTION                        0.15 SECONDS
{   95} > LIST DYNAMIC EIGENVALUES 10
1

   *****************************
   *RESULTS OF LATEST ANALYSES*
   *****************************


    PROBLEM - GTWALL    TITLE - CANISTER WALL SUPPORTING CRANE BRIDGE, 700k


    ACTIVE UNITS   FEET KIP   CYC   DEGF SEC



    EIGENVALUES
```

ATTACHMENT C
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MODE	EIGENVALUE ((RAD/SEC)**2)	FREQUENCY (RAD/SEC)	FREQUENCY (CYC/SEC)	PERIOD (SEC/CYC)	STATUS
1	9.975079D+02	3.158335D+01	5.026646D+00	1.989398D-01	ACTIVE
2	1.464538D+03	3.826928D+01	6.090745D+00	1.641835D-01	ACTIVE
3	1.785999D+03	4.226109D+01	6.726061D+00	1.486754D-01	ACTIVE
4	3.521294D+03	5.934049D+01	9.444332D+00	1.058836D-01	ACTIVE
5	4.780845D+03	6.914365D+01	1.100455D+01	9.087147D-02	ACTIVE
6	9.749758D+03	9.874086D+01	1.571510D+01	6.363308D-02	ACTIVE
7	2.789175D+04	1.670082D+02	2.658019D+01	3.762201D-02	ACTIVE
8	5.697114D+04	2.386863D+02	3.798810D+01	2.632403D-02	ACTIVE
9	1.035535D+05	3.217972D+02	5.121562D+01	1.952529D-02	ACTIVE
10	1.160862D+05	3.407142D+02	5.422635D+01	1.844122D-02	ACTIVE

{ 96} > LIST DYNAMIC EIGENVECTORS 3

1

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - GTWALL TITLE - CANISTER WALL SUPPORTING CRANE BRIDGE, 700k

ACTIVE UNITS FEET KIP CYC DEGF SEC

EIGENVECTORS (UNITS: INCHES & RADIANS)

MODE 1

JOINT		TRANS X-TRANS	TRANS Y-TRANS	TRANS Z-TRANS	ROTATION X-ROTATION	ROTATION Y-ROTATION	ROTATION Z-ROTATION
JOINT 1	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 2	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 3	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 4	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 5	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 6	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 7	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 8	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 9	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 10	GLOBAL	0.3152067E-06	0.5055406E-09	0.1279556	0.2496921E-03	-0.6573644E-03	- 0.3328968E-10
JOINT 11	GLOBAL	0.7355391E-06	0.8739647E-09	0.4247128	0.7165046E-03	-0.1256158E-02	- 0.7162801E-10
JOINT 12	GLOBAL	0.1510372E-05	-0.2779439E-08	0.8691610	0.1303834E-02	-0.1349448E-02	- 0.2076020E-09
JOINT 13	GLOBAL	0.2656841E-05	-0.5301807E-07	0.8765918	0.1316845E-02	0.1295988E-02	- 0.1583972E-08
JOINT 14	GLOBAL	0.5404836E-05	0.5262303E-06	0.4531357	0.7629231E-03	0.1179652E-02	0.1461604E-07
JOINT 15	GLOBAL	0.1076693E-04	-0.3029634E-05	0.1763181	0.3270830E-03	0.6329282E-03	- 0.1239195E-06

JOINT 16	GLOBAL	0.2444925E-04	0.3731995E-05	-0.8709873E-03	0.9677662E-04	0.3995075E-03	0.6803201E-06
JOINT 17	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 18	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 19	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 20	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 21	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 22	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 23	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 24	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 25	GLOBAL	0.1997945E-05	-0.1040615E-07	1.000000	0.8143339E-03	-0.2347835E-04	-0.1154166E-09
JOINT 30	GLOBAL						
JOINT 31	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00		0.0000000E+00	0.0000000E+00

MODE 2

JOINT		/----------TRANS----------		//----------	----------ROTATION----------		---------/
		X-TRANS	Y-TRANS	Z-TRANS	X-ROTATION	Y-ROTATION	Z-ROTATION
JOINT 1	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 2	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 3	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 4	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 5	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 6	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 7	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 8	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 9	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 10	GLOBAL	-0.2595524E-05	-0.4170096E-08	0.3411265	0.5170298E-03	-0.1063834E-02	0.2742776E-09
JOINT 11	GLOBAL	-0.6045194E-05	-0.7173206E-08	0.5370231	0.7841634E-03	-0.3928116E-04	0.5892636E-09
JOINT 12	GLOBAL	-0.1238374E-04	0.2259684E-07	0.3600305	0.4847893E-03	0.1046068E-02	0.1699369E-08
JOINT 13	GLOBAL	-0.2171149E-04	0.4279163E-06	-0.1671854	-0.3069399E-03	0.2345668E-02	0.1278421E-07
JOINT 14	GLOBAL	-0.4400672E-04	-0.4259381E-05	-0.8980998	-0.1323209E-02	0.1655359E-02	-0.1179068E-06
JOINT 15	GLOBAL	-0.8740596E-04	0.2454757E-04	-1.000000	-0.1439381E-02	-0.1216233E-02	0.1001326E-05
JOINT 16	GLOBAL	-0.1978387E-03	-0.3015359E-04	-0.1111913E-01	-0.3579779E-03	-0.3227761E-02	-0.5496836E-05
JOINT 17	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 18	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 19	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 20	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 21	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 22	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 23	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 24	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 25	GLOBAL	-0.1636225E-04	0.8442717E-07	0.1517853	0.3893935E-04	0.1735126E-02	0.9301182E-09
JOINT 30	GLOBAL						
JOINT 31	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00		0.0000000E+00	0.0000000E+00

MODE 3

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JOINT		/---TRANS--- X-TRANS	Y-TRANS	Z-TRANS	//---ROTATION--- X-ROTATION	Y-ROTATION	Z-ROTATION
JOINT 1	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 2	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 3	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 4	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 5	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 6	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 7	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 8	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 9	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
JOINT 10	GLOBAL	0.1764572E-05	0.2838469E-08	0.9706511	0.1369904E-02	-0.2250598E-02	- 0.1865428E-09
JOINT 11	GLOBAL	0.4104458E-05	0.4865829E-08	1.000000	0.1418263E-02	0.2113805E-02	- 0.4003538E-09
JOINT 12	GLOBAL	0.8394253E-05	-0.1522682E-07	-0.3691772E-01	0.9707836E-04	0.3104518E-02	- 0.1150607E-08
JOINT 13	GLOBAL	0.1468330E-04	-0.2869189E-06	-0.3808675	-0.3879022E-03	-0.1021650E-02	- 0.8571930E-08
JOINT 14	GLOBAL	0.2968614E-04	0.2861556E-05	0.2290462	0.3374705E-03	-0.2052298E-02	0.7902869E-07
JOINT 15	GLOBAL	0.5884169E-04	-0.1650343E-04	0.6000141	0.8039090E-03	0.1648855E-03	- 0.6719321E-06
JOINT 16	GLOBAL	0.1328877E-03	0.2023310E-04	0.1046168E-01	0.1865651E-03	0.2165759E-02	0.3688395E-05
JOINT 17	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 18	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 19	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 20	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 21	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 22	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 23	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 24	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	
JOINT 25	GLOBAL	0.1108212E-04	-0.5681137E-07	-0.3855992	-0.3798510E-04	0.1154401E-02	- 0.6229744E-09
JOINT 30	GLOBAL						
JOINT 31	GLOBAL	0.0000000E+00	0.0000000E+00	0.0000000E+00		0.0000000E+00	0.0000000E+00

{ 97} > PRINT DYNAMIC DATA

1**

* PROBLEM DATA FROM INTERNAL STORAGE *

****

JOB ID - GTWALL JOB TITLE - CANISTER WALL SUPPORTING CRANE BRIDGE, 700k

ACTIVE UNITS -	LENGTH	WEIGHT	ANGLE	TEMPERATURE	TIME
	FEET	KIP	CYC	DEGF	SEC

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DYNAMIC STRUCTURAL DATA

======================

ATTACHMENT C

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(REV. 0)

DYNAMIC DEGREES OF FREEDOM

0**** CONDENSATION METHOD: STATIC

0 JOINT	TRANSLATION	ROTATION
10	X Y Z	
11	X Y Z	
12	X Y Z	
13	X Y Z	
14	X Y Z	
15	X Y Z	
25	X Y Z	

JOINT INERTIAS

0**** INERTIA OF JOINTS LUMPED HAS BEEN SPECIFIED
0**** EFFECTIVE FRACTIONAL MEMBER LENGTH FOR MASS MOMENT OF INERTIA TERMS IS 0.100E-01
0**** JOINT INERTIAS ARE IN THE CURRENT WEIGHT UNITS
0**** ACCELERATION OF GRAVITY = 32.20000

OJOINT	TRANS X	TRANS Y	TRANS Z	ROTAT X	ROTAT Y	ROTAT Z	DAMPING
25	350.00	350.00	350.00	0.00000E+00	0.00000E+00	0.00000E+00	
0.00000E+00							

MODAL DAMPING RATIOS

0**** MODAL DAMPING RATIOS HAVE NOT BEEN SPECIFIED

MEMBER ADDED MASS

MEMBER	SYSTEM	EFFECTIVE DIRECTIONS	TYPE	LOCATION ALONG MEMBER START	END	MASS VALUE
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DYNAMIC PARAMETERS

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ONUMBER OF DYNAMIC DEGREES-OF-FREEDOM = 21
ONUMBER OF CONDENSED DEGREES-OF-FREEDOM = 27
OEIGENPROBLEM SOLUTION TECHNIQUE: TRIDIAGONALIZATION
OMAXIMUM FREQUENCY= 60.00000
OCOMPUTE RIGID BODY MODES: NO
OEIGENVALUE TOLERANCE= 8.4294E-08
OEIGENVECTOR TOLERANCE= 8.4294E-08
OAVERAGE HALF BAND WIDTH OF THE STIFFNESS MATRIX= 10

0***
 * END OF DATA FROM INTERNAL STORAGE *
 ****

{ 98} > LIST DYNAMIC MASS SUMMARY
1

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******************************
*RESULTS OF LATEST ANALYSES*
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PROBLEM - GTWALL   TITLE - CANISTER WALL SUPPORTING CRANE BRIDGE, 700k

ACTIVE UNITS FEET KIP CYC DEGF SEC

GLOBAL AXIS	CENTER OF MASS COORDINATE	TOTAL MASS	TOTAL WEIGHT	MASS MOMENT OF INERTIA
X	92.50000	94.80829	3052.827	0.0000000E+00
Y	35.00000	94.80829	3052.827	156773.7
Z	0.0000000E+00	94.80829	3052.827	156773.7

{ 99} > finish

1

---------------------- RUN-TIME PERFORMANCE SUMMARY ----------------------

CPU Time 00:00:07.04 Elapsed Time 0 00:00:07   On Fri Jun 19 14:05:14 1998

COMPUTER RUNS

for

Calculation No. 05996.02 STRUCTURAL-SC-5

DEVELOPMENT OF SOIL IMPEDANCE FUNCTIONS FOR CANISTER TRANSFER BUILDING