Private Fuel Storage, L.L.C.

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John L. Donnell, P.E., Project Director

April 13, 2001

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

CALCULATION PACKAGE SUBMITTAL
DOCKET NO. 72-22 / TAC NO. L22462
PRIVATE FUEL STORAGE FACILITY
PRIVATE FUEL STORAGE L.L.C.

Enclosed for your use please find the following calculations for the Private Fuel Storage Facility (PFSF):

- Calculation No. 05996.02 – SC – 4, Revision 2, entitled "Development of Soil Impedance Functions for Canister Transfer Building"
- Calculation No. 05996.02 – SC - 5, Revision 2, entitled "Seismic Analysis of Canister Transfer Building"
- Calculation No. 05996.02 – SC - 10, Revision 1, entitled "Seismic Restraints for Spent Fuel Handling Casks"
- Calculation No. 05996.02 – UR(D) - 008, Revision 1, entitled "Dose Rate Calculations at PFSF Locations Potentially Accessible to Wildlife and Estimates of Annual Doses to Individual Animals"
- Calculation No. 05996.02 – G(B) - 04, Revision 7, entitled "Stability Analysis of Storage Pads"
- Calculation No. 05996.02 – G(B) - 13, Revision 4, entitled "Stability Analysis of the Canister Transfer Building Supported on a Mat Foundation"

These calculations were revised to incorporate the new PFSF design ground motions as discussed in License Amendment #22. If you have any questions regarding this submittal, please contact me at 303-741-7009.

Sincerely,

John L. Donnell
Project Director
Private Fuel Storage L.L.C.

Enclosure

NMSS01 public

cc:
Mark Delligatti-1/1
John Parkyn-1/0
Jay Silberg-1/0
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Richard E. Condit-1/0
John Paul Kennedy-1/0
Joro Walker-1/0
Utah Document File (D. Bird)-1/1

STONE & WEBSTER ENGINEERING CORPORATION

CLIENT & PROJECT	PAGE 1 OF 18
PRIVATE FUEL STORAGE FACILITY – PRIVATE FUEL STORAGE, LLC	PLUS 6 OF ATTACHMENTS

CALCULATION TITLE

Development of Soil Impedance Functions for Canister Transfer Building

QA CATEGORY (X)

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-4**	**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	CONFIRMATION REQUIRED (X) NO
B.Ebbeson	S.Chen	F.Ogden	0	N/A		X
AJ.Cokonis Alex J. Cokonis 8/19/99	B.Ebbeson Bruce E. Ebbeson 8/19/99	B.Ebbeson Bruce E. Ebbeson 8/19/99	1	REV. 0		X
Bruce E. Ebbeson 3/19/01	JOHN J PIERRO John J Pierro 3/21/01	JOHN J PIERRO John J Pierro 3/21/01	2	Rev. 1		X

DISTRIBUTION

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STONE & WEBSTER ENGINEERING

CALCULATION SHEET

J.O./W.O./CALCULATION NO.	REVISION	PAGE
05996.02-SC-4	2	2

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER
B. E. Ebbeson 3/19/01	J. Pierro 3/20/01	J. Pierro 3/20/01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
Development of Soil Impedance Functions for Canister Transfer Building	I

TABLE OF CONTENTS

HISTORICAL DATA - REVISIONS

Revision	Description
0	Original Issue
1	Revised soil properties for 2000 year earthquake, per ref. 5 calculation.
2	Revised soil properties for larger 2000 year earthquake per ref. 5 calculation. Revised mat dimensions to accommodate larger accelerations.

OBJECTIVE:

The purpose of this calculation is to develop soil impedance functions to simulate the stiffness and damping effects provided by the soil beneath the Skull Valley Canister Transfer Building. These results will be used in the seismic analysis of the Canister Transfer Building, which will be performed in calculation 05996.02-SC-5 (Ref. 1). Revision 2 of this calculation incorporates the new soil properties from Ref. 5, intended for the evaluation of the 2000 year earthquake, and a change in the mat dimensions.

CALCULATION METHOD & ASSUMPTIONS:

The SWEC computer program REFUND (Ref. 2) is used to calculate the impedance functions. This program assumes that the building foundation is a rigid rectangular mat on the surface of a layered soil column. The building mat will be 5 feet thick, and the assumption of a rigid mat is consistent with ASCE 4-86. The soil properties used in the analysis are obtained from Geometrix calculation G(PO18)-2, Ref. 5, for best estimate, low range and high range cases. Resulting impedance functions, in the form of stiffness and damping matrices are contained in the computer output, and also stored on disk files for reformatting for use in the seismic analysis. Plots of the impedance functions for the nominal soil case were developed for information, and are shown on pages 13-18.

SOURCES OF DATA AND EQUATIONS:

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

CONCLUSION:

The soil impedance functions, in the form of stiffness and damping matrices, have been developed and are suitable for use in the seismic analysis.

The impedance functions have been stored on the SWEC mainframe computer system with the following data set names:

STRUCTRL.BEE.STIFFU5W	(High range soil case)
STRUCTRL.BEE.STIFFB5W	(Best estimate soil case)
STRUCTRL.BEE.STIFFL5W	(Low range soil case)

References:

1. SWEC calculation No. 05996.02-SC-5, Rev. 2. 'Seismic Analysis of Canister Transfer building' 2

2. SWEC Computer program "REFUND", ST-232, Version 0, Level 1.

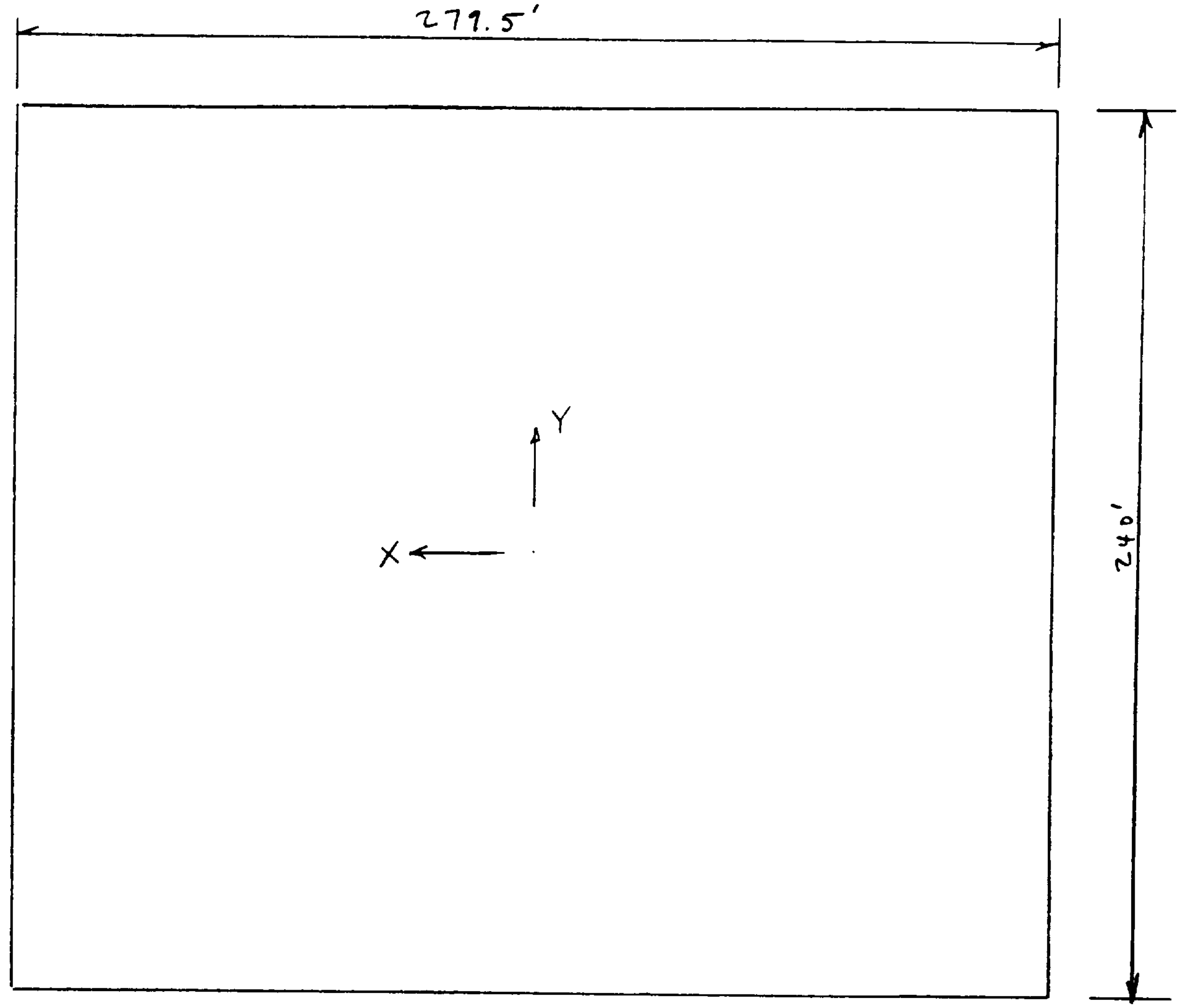
3. ASCE-4, Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures, 1986, ASCE.

4. Private Fuel Storage Facility Design Criteria, Revision 2, June 20, 1997, Stone & Webster engineering Corporation, Denver, Colorado.

5. Geometrix Consultants Inc. Calculation 05996.02-G(PO18)-2 (Rev. 1) 2

ANALYSIS

A. DIMENSIONS OF BASE MAT



USE 21 SEGMENTS IN THE X DIRECTION AND 17 SEGMENTS IN THE Y DIRECTION

INTENTIONALLY BLANK 2

INTENTIONALLY BLANK 2

B. SOIL PROPERTIES

Properties will be taken from Table 1 of Ref. 5. (see Attachment A). Assuming that the top 5 feet will be excavated for the foundation, the top 5 feet will be excluded. From examining the values in Table 1, 9 macro-layers will represent the sub-grade to 300 ft (350 feet for the lower range case), where the model will stop due to the high shear wave velocity.

Best Estimate Soil Properties

Macro-layer	Sub-layers	Thickness ft.	Density, Ksf	Shear Wave Velocity, fps.	ν Poisson's Ratio	Damping
1	2	5	.080	415	.422	.0478
2	1	2	.080	622	.339	.0360
3	2	6	.100	779	.306	.0229
4	2	8	.094	760	.307	.0301
5	2	9	.115	818	.341	.0621
6	3	15	.115	956	.367	.0613
7	4	40	.120	1716	.329	.0174
8	3	35	.135	2900	.250	.0432
9	9	175	.145	2900	.250	.0432

2

High Range Soil Properties

Macro-layer	Sub-layers	Thickness ft.	Density, Ksf	Shear Wave Velocity, fps.	ν Poisson's Ratio	Damping
1	2	5	.080	557	.403	.0348
2	1	2	.080	807	.312	.0269
3	2	6	.100	983	.289	.0182
4	2	8	.094	973	.281	.0231
5	2	9	.115	1053	.319	.0507
6	3	15	.115	1488	.329	.0404
7	4	40	.120	2481	.318	.0121
8	3	35	.135	4101	.250	.0428
9	9	175	.145	4101	.250	.0428

Low Range Soil Properties						
Macro-layer	**Sub-layers**	**Thickness ft.**	**Density, Ksf**	**Shear Wave Velocity, fps.**	**ν Poisson's Ratio**	**Damping**
1	2	5	.080	298	.442	.0657
2	1	2	.080	622	.339	.0360
3	2	6	.100	610	.327	.0297
4	2	8	.094	593	.330	.0373
5	2	9	.115	614	.372	.0809
6	3	15	.115	565	.414	.0982
7	4	40	.120	1191	.337	.0218
8	3	35	.135	2051	.250	.0397
9	9	225	.145	2051	.250	.0397

2

Frequency interval:

Use 0.5 Hz interval from 0 to 14.0 Hz and 1.0 Hz from 15 Hz to 25 Hz.

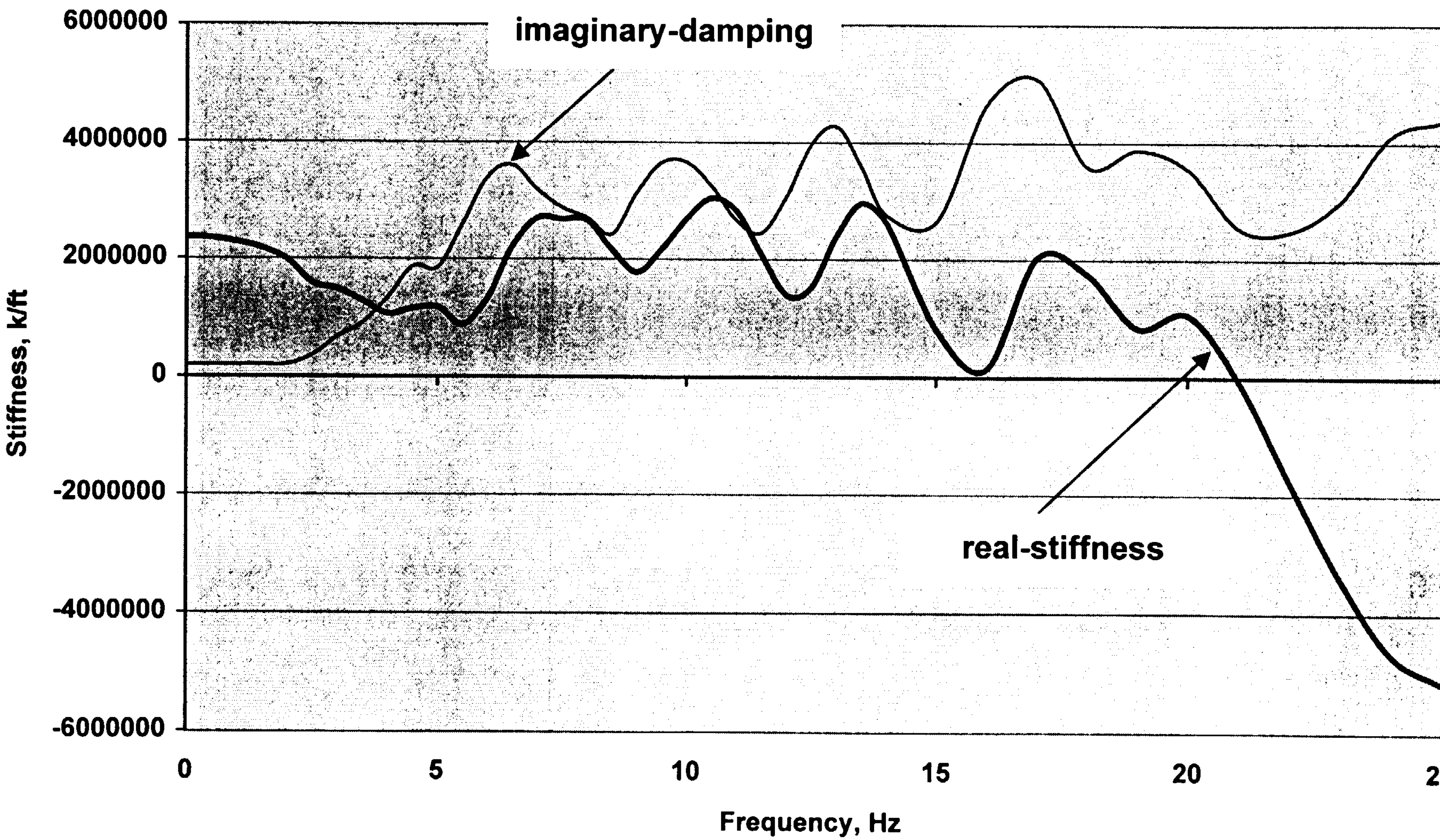
Coordinate System:

For REFUND input X is the N-S direction and Y is the E-W direction. Output is in the convention of X being the N-S direction, Z being the E-W direction and Y being vertical, which is consistent with the seismic analysis sign convention.

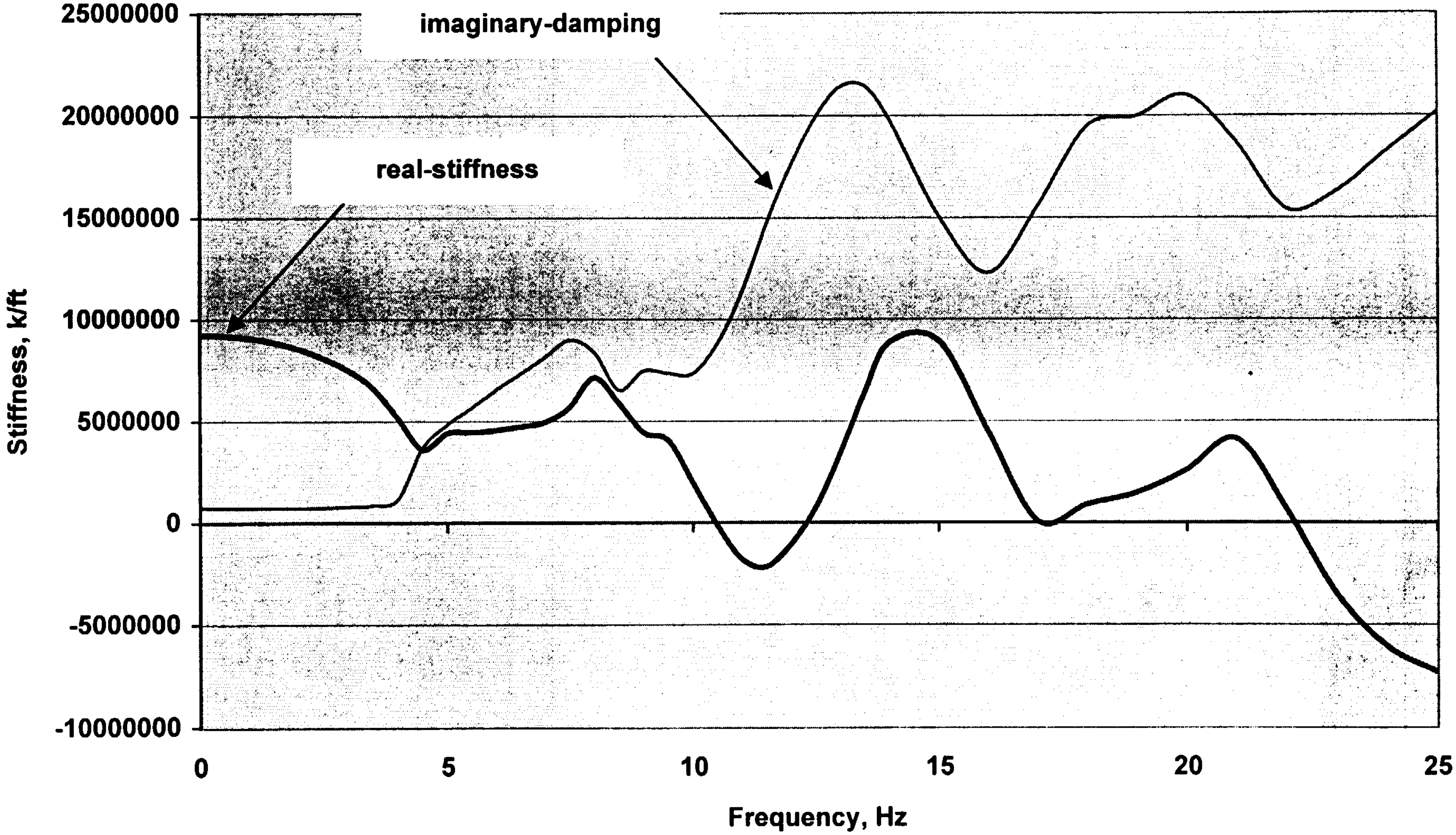
Computer Log

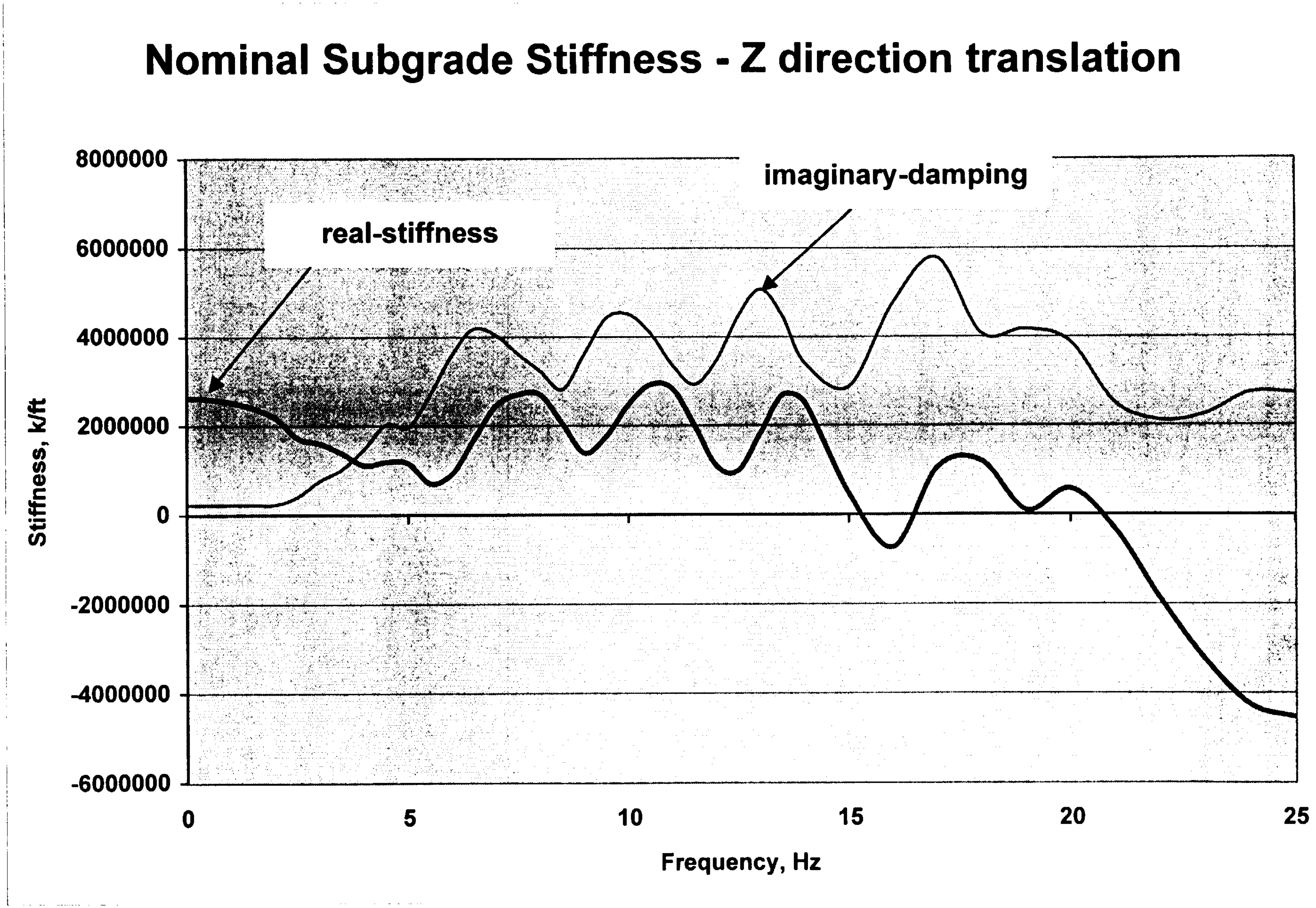
Program name	Library ref. No.	Ver./Level	Job Number	Run date	Diskette location	Comments
REFUND	ST-232	00/01	4126	3/17/01	page 12	Best estimate soil case.
REFUND	ST-232	00/01	4116	3/17/01	page 12	High range soil case.
REFUND	ST-232	00/01	4117	3/17/01	page 12	Low range soil case.

Nominal Subgrade Stiffness - X direction translation



Nominal Subgrade Stiffness - Y direction translation




Nominal Subgrade Stiffness - Z direction translation
imaginary-damping
real-stiffness
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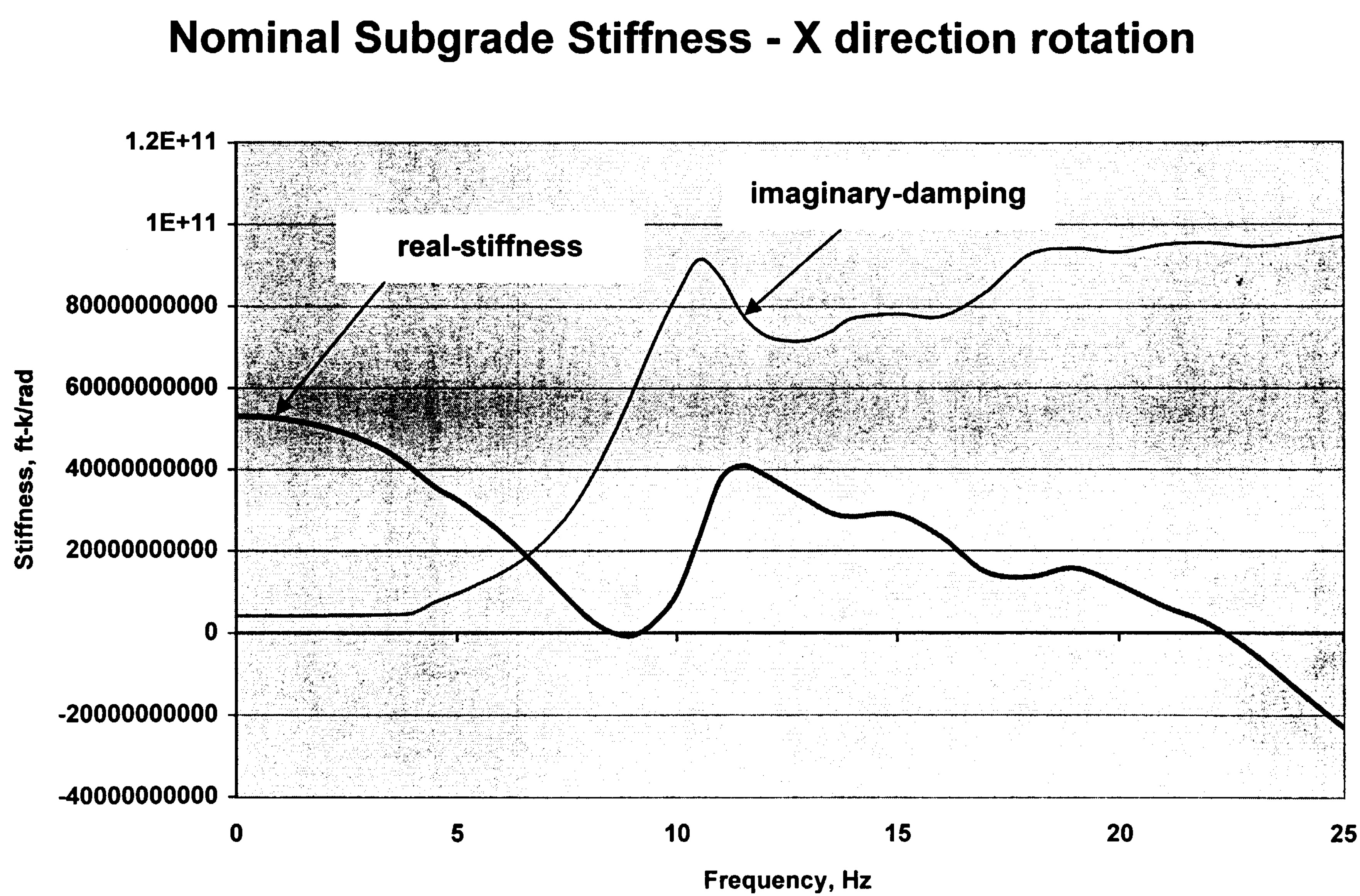
6000000
4000000
2000000
0
-2000000
-4000000
-6000000
Stiffness, k/ft
0
5
10
15
20
25
Frequency, Hz


Nominal Subgrade Stiffness - X direction rotation
imaginary-damping
real-stiffness
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1E+11
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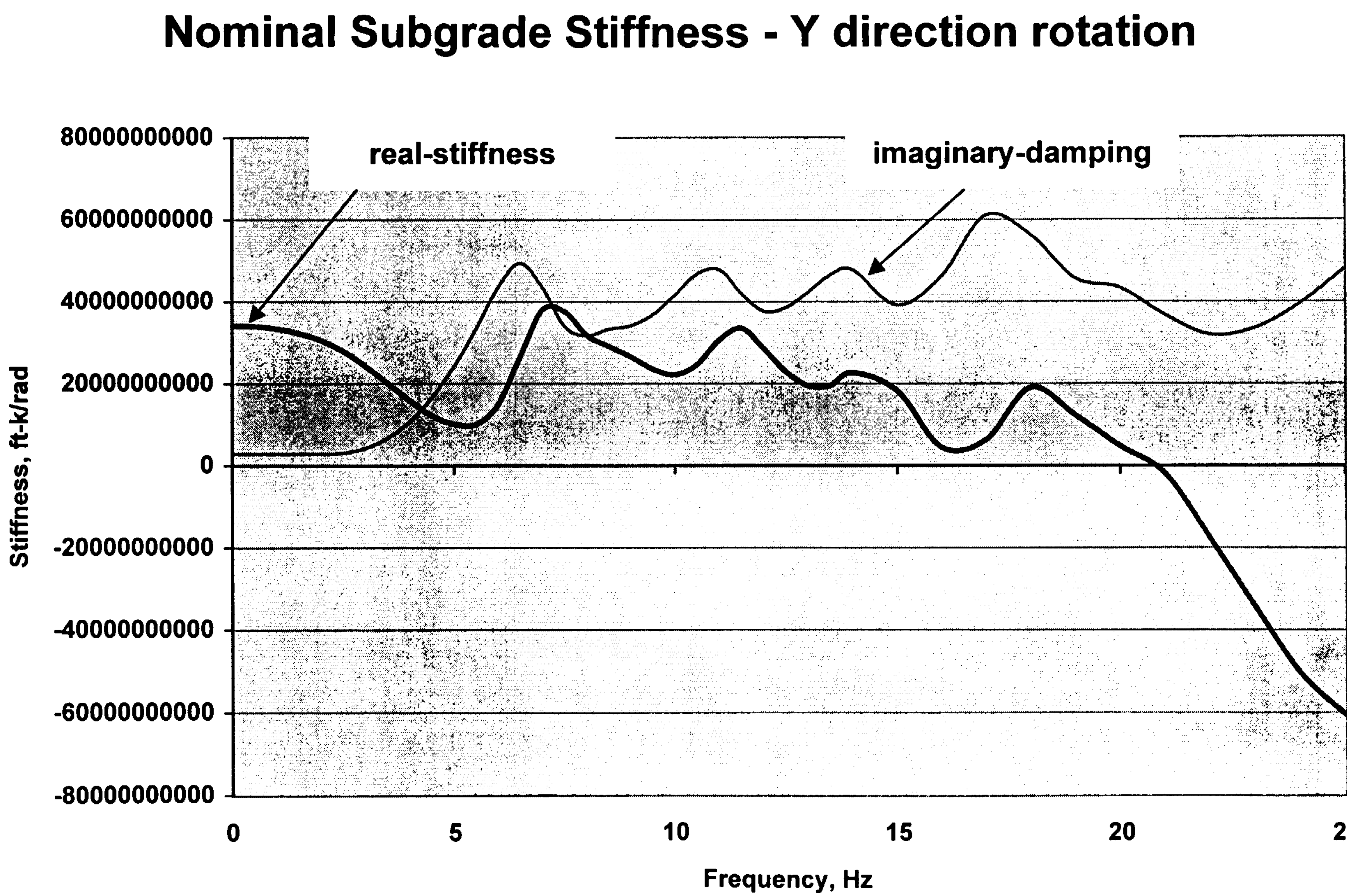
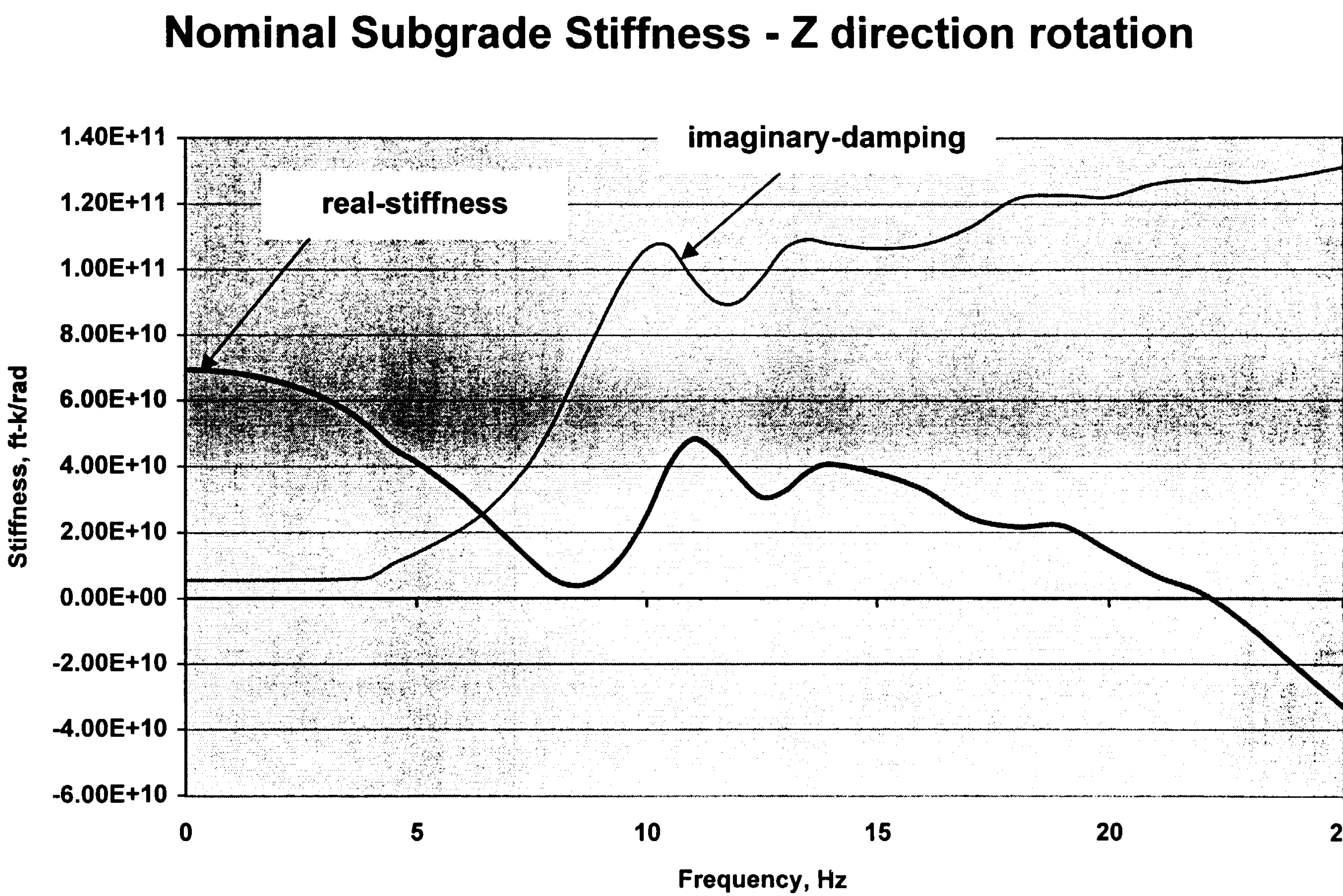
60000000000
40000000000
20000000000
0
-20000000000
-40000000000
Stiffness, ft-k/rad
0
5
10
15
20
25
Frequency, Hz



Nominal Subgrade Stiffness - Y direction rotation
real-stiffness
imaginary-damping
80000000000
60000000000
40000000000
20000000000
0
-20000000000
-40000000000
-60000000000
-80000000000
Stiffness, ft-k/rad
0
5
10
15
20
25
Frequency, Hz


Nominal Subgrade Stiffness - Z direction rotation
imaginary-damping
real-stiffness
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1.20E+11
1.00E+11
8.00E+10
6.00E+10
4.00E+10
2.00E+10
0.00E+00
-2.00E+10
-4.00E+10
-6.00E+10
Stiffness, ft-k/rad
0
5
10
15
20
25
Frequency, Hz

ATTACHMENT A.
DYNAMIC SOIL PROPERTIES

Table 1
Dynamic Soil Properties for SASSI Model

High Range Properties

Shake Layers	Depth Top (ft)	Depth Bottom (ft)	Density (pcf)	Wave Velocity Vs (fps)	Wave Velocity Vp (fps)	Damping Ratio Shear (%)	Damping Ratio Compress. (%)	Poisson's Ratio
1-2	0	5	100	2120	3380	0.91	0.91	0.176
3-4	5	10	80	557	1385	3.48	3.48	0.403
5	10	12	80	807	1543	2.69	2.69	0.312
6-7	12	18	100	983	1803	1.82	1.82	0.289
8-9	18	26	94	973	1764	2.31	2.31	0.281
10-12	26	35	115	1053	2042	5.07	5.07	0.319
13-15	35	50	115	1488	2949	4.04	4.04	0.329
16-23	50	90	120	2481	4808	1.21	1.21	0.318
24-26	90	125	135	4101	7104	4.28	4.28	0.250
27-35	125	300	145	4101	7104	4.28	4.28	0.250
36-39	300	500	145	5657	9798	3.10	3.10	0.250
40-41	500	700	145	6398	11155	2.53	2.53	0.255
	700		170	6398	11155	2.16	1.00	0.255

Best Estimate Properties

Shake Layers	Depth Top (ft)	Depth Bottom (ft)	Density (pcf)	Wave Velocity Vs (fps)	Wave Velocity Vp (fps)	Damping Ratio Shear (%)	Damping Ratio Compress (%)	Poisson's Ratio
1-2	0	5	100	1497	2390	0.94	0.94	0.177
3-4	5	10	80	415	1131	4.78	4.78	0.422
5	10	12	80	622	1260	3.60	3.60	0.339
6-7	12	18	100	779	1472	2.29	2.29	0.306
8-9	18	26	94	760	1440	3.01	3.01	0.307
10-12	26	35	115	818	1667	6.21	6.21	0.341
13-15	35	50	115	956	2085	6.13	6.13	0.367
16-23	50	90	120	1716	3400	1.74	1.74	0.329
24-26	90	125	135	2900	5023	4.32	4.32	0.250
27-35	125	300	145	2900	5023	4.32	4.32	0.250
36-39	300	500	145	3450	5976	3.67	3.67	0.250
40-41	500	700	145	3950	6842	3.33	3.33	0.250
	700		170	6398	11155	1.76	1.00	0.255

Low Range Properties

Shake Layers	Depth Top (ft)	Depth Bottom (ft)	Density (pcf)	Wave Velocity Vs (fps)	Wave Velocity Vp (fps)	Damping Ratio Shear (%)	Damping Ratio Compress (%)	Poisson's Ratio
1-2	0	5	100	1053	1690	1.08	1.08	0.183
3-4	5	10	80	298	923	6.57	6.57	0.442
5	10	12	80	622	1260	3.60	3.60	0.339
6-7	12	18	100	610	1202	2.97	2.97	0.327
8-9	18	26	94	593	1176	3.73	3.73	0.330
10-12	26	35	115	614	1361	8.09	8.09	0.372
13-15	35	50	115	565	1474	9.82	9.82	0.414
16-23	50	90	120	1191	2404	2.18	2.18	0.337
24-26	90	125	135	2051	3552	3.97	3.97	0.250
27-35	125	300	145	2051	3552	3.97	3.97	0.250
36-39	300	500	145	2051	3552	3.97	3.97	0.250
40-41	500	700	145	2051	3552	3.97	3.97	0.250
	700		170	6398	11155	2.16	1.00	0.255

ATTACHMENT B,
DEVELOPMENT OF POISSON'S RATIO

No longer required (Poisson's ratio provided in Reference 5). 2

ATTACHMENT C. REFUND INPUT FILES

A. UPPER BOUND FILE

```
//LUNGMAN JOB (0556,06),EBBESON,MSGLEVEL=1
/*JOBPARM     R=600K,TIME=5,LINES=100
//GO EXEC PGM=REFUND,REGION=4000K,TIME=30
//STEPLIB DD DISP=SHR,DSN=STRUCTRL.PROGLIB
//FT08F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=1177,BLKSIZE=1181),
// SPACE=(1181,(15,2),,CONTIG,ROUND)
//FT09F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=3464,BLKSIZE=3468),
// SPACE=(3468,(50,5),,CONTIG,ROUND)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=1177,BLKSIZE=1181),
// SPACE=(1181,(15,2),,CONTIG,ROUND)
//SYSDUMP DD SYSOUT=A
//FT06F001 DD DUMMY
//FT07F001 DD DSN=STRUCTRL.BEE.STIFFU5W,
//    DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000),
//    DISP=(NEW,CATLG),UNIT=DISK,SPACE=(8000,(20,10,))
//GO.FT05F001 DD SPACE=(TRK,(50,50)),DCB=OBJECT,UNIT=DISK
//GO.FT55F001 DD *
START
SKULL VALLEY CTB UPPER BOUND 5' RECTANGULAR MAT
RECT
   21    17  279.5     240.
    9
    2         5.      .080         557.              .403       .0348
    1         2.      .080         807.              .312       .0269
    2         6.      .100         983.              .289       .0182
    2         8.      .094         973.              .281       .0231
    2         9.      .115         1053.             .319       .0507
    3        15.      .115         1488.             .329       .0404
    4        40.      .120         2481.             .318       .0121
    3        35.      .135         4101.             .250       .0428
    9       175.      .145         4101.             .250       .0428
    2
   29       .50        0.0
   11       1.0        15.
/*
```

B. LOWER BOUND FILE

```
//LUNGMAN JOB (0556,06),EBBESON,MSGLEVEL=1
/*JOBPARM     R=600K,TIME=5,LINES=100
//GO EXEC PGM=REFUND,REGION=4000K,TIME=30
//STEPLIB DD DISP=SHR,DSN=STRUCTRL.PROGLIB
//FT08F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=1177,BLKSIZE=1181),
// SPACE=(1181,(15,2),,CONTIG,ROUND)
//FT09F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=3464,BLKSIZE=3468),
// SPACE=(3468,(50,5),,CONTIG,ROUND)
//FT10F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=1177,BLKSIZE=1181),
// SPACE=(1181,(15,2),,CONTIG,ROUND)
//SYSDUMP DD SYSOUT=A
//FT06F001 DD DUMMY
//FT07F001 DD DSN=STRUCTRL.BEE.STIFFL5W,
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000),
//     DISP=(NEW,CATLG),UNIT=DISK,SPACE=(8000,(20,10,))
//GO.FT05F001 DD SPACE=(TRK,(50,50)),DCB=OBJECT,UNIT=DISK
//GO.FT55F001 DD *
START
SKULL VALLEY CTB LOWER BOUND '5 RECTANGULAR MAT
RECT
   21   17 279.5      240.
    9
    2        5.     .080         298.                .442       .0657
    1        2.     .080         622.                .339       .0360
    2        6.     .100         610.                .327       .0297
    2        8.     .094         593.                .330       .0373
    2        9.     .115         614.                .372       .0809
    3       15.     .115         565.                .414       .0982
    4       40.     .120         1191.               .337       .0218
    3       35.     .135         2051.               .250       .0397
   10      225.     .145         2051.               .250       .0397
    2
   29       .50      0.0
   11       1.0      15.
/*
```

2

2

C. BEST ESTIMATE FILE

```
//LUNGMAN JOB (0556,06),EBBESON,MSGLEVEL=1
/*JOBPARM     R=600K,TIME=5,LINES=100
//GO EXEC PGM=REFUND,REGION=4000K,TIME=30
//STEPLIB DD DISP=SHR,DSN=STRUCTRL.PROGLIB
//FT08F001 DD UNIT=DISK,DCB=(RECFM=VBS,LRECL=1177,BLKSIZE=1181),
// SPACE=(1181,(15,2),,CONTIG,ROUND)
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// SPACE=(3468,(50,5),,CONTIG,ROUND)
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// SPACE=(1181,(15,2),,CONTIG,ROUND)
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//FT06F001 DD DUMMY
//FT07F001 DD DSN=STRUCTRL.BEE.STIFFB5W,
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000),
//     DISP=(NEW,CATLG),UNIT=DISK,SPACE=(8000,(20,10,))
//GO.FT05F001 DD SPACE=(TRK,(50,50)),DCB=OBJECT,UNIT=DISK
//GO.FT55F001 DD *
START
SKULL VALLEY CTB BEST ESTIMATE 5' RECTANGULAR MAT
RECT
   21   17 279.5      240.
    9
    2        5.     .080         415.              .422       .0478
    1        2.     .080         622.              .339       .0360
    2        6.     .100         779.              .306       .0229
    2        8.     .094         760.              .307       .0301
    2        9.     .115         818.              .341       .0621
    3       15.     .115         956.              .367       .0613
    4       40.     .120         1716.             .329       .0174
    3       35.     .135         2900.             .250       .0432
    9      175.     .145         2900.             .250       .0432
    2
   29      .50      0.0
   11      1.0      15.
/*
```

2

2

STONE & WEBSTER ENGINEERING

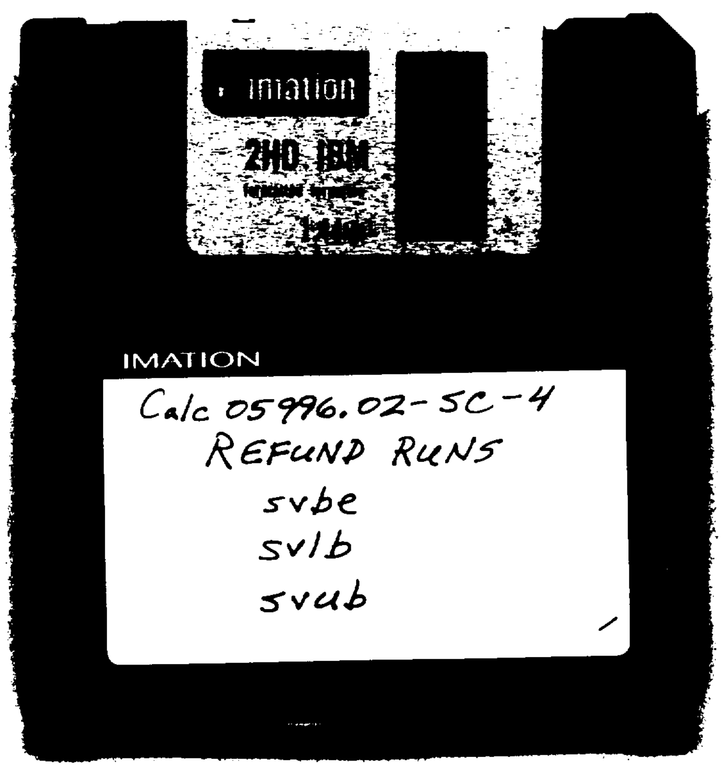
CALCULATION SHEET

J.O./W.O./CALCULATION NO.	REVISION	PAGE
05996.02-SC-4	2	12

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER
B. E. Ebbeson 3/19/01	J. Pierro 3/20/01	J. Pierro 3/20/01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
Development of Soil Impedance Functions for Canister Transfer Building	I

DISKETTE



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PRIVATE FUEL STORAGE FACILITY-PRIVATE FUEL STORAGE, LLC	PLUS ~~64~~ ~~57~~ 73 PGS OF ATTACHMENTS (2)
CALCULATION TITLE: **SEISMIC ANALYSIS OF CANISTER TRANSFER BUILDING**	QA CATEGORY (X): X I - NUCLEAR SAFETY RELATED; ___ II ___ III ___ OTHER

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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 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	
B. E. Ebbeson 8/28/99	D. M. Bonner 8/31/99	D. M. Bonner 8/31/99	1	0	X p.5	
B. E. Ebbeson 4-2-01	[illegible] 4/2/01; John J Pierro 4/4/01	John J Pierro 4/4/01	2	1	X p.5	

* IDV CHECKLIST - IN FILE Q2.9

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STONE & WEBSTER ENGINEERING

CALCULATION SHEET

J.O./W.O./CALCULATION NO.	REVISION	PAGE
05996.02-SC-5	2	2

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER
B.E. EBBESON 3/23/01	J. PIERRO 3/26/01	J. PIERRO 3/26/01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
Seismic Analysis of Canister Transfer Building	I

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2

2

HISTORICAL DATA - REVISION 0

Page No.	Description
None	Original Issue

HISTORICAL DATA - REVISION 1

Revision 1 of this calculation is issued to incorporate revised soil properties and to reflect the 2000 year return period design spectra.

Page No.	Description
2, 4, 6, 10, 11, 12, A-5, A-7, C-3, C-4	Revised pages
15-35 A-11 thru A-15 B-15 thru B-20 C-8 thru C-16 D-1	Replaced pages
36, 37, C-17, C-18, E-1	Added pages

HISTORICAL DATA - REVISION 2

Revision 2 of this calculation is issued to incorporate a larger earthquake ground motion, associated revised soil properties, and configuration changes to the building, including enlarging the mat.

Page No.	Description
2, 4, 5, 6, 8, 9, 10, 11, 12	Revised pages
15 - 37	Replaced pages
Attachments A - D	Revised attachment
Attachment E	Replaced attachment
Attachment F	Added attachment

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-G(PO-18)-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 best estimate, low range and high range soil cases, and results are enveloped.

ASSUMPTIONS:

1. The structural model developed in Revision 1 of this calculation needs to be revised due to changes made to the building configuration. This calculation develops a new model which reflects a new configuration. Results of this analysis will be used to verify the design. Since the results of this calculation may affect the final design, there may be minor changes made to the building configuration in the future. However, it is anticipated that any changes will be minor and will have little effect on results. 2

2. The bridge crane is assumed to weigh 310 kips and the semi-gantry crane to weigh 222 kips. This is based on the original design of the crane, and may change when the crane design is updated. 2

3. Not used

4. Soil material damping values given in Reference 10 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 25.0 Hz. This meets the requirements of ASCE 4-86 (Reference 3, sect. 3.3.3.5). 2

6. Not used.

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 (Attachment D), and response spectra have been enveloped and plotted, as shown on pages 15 - 30. Results at El. 170' and El. 100' have been peak broadened and are shown on pages 31-36. The analysis is based on a preliminary configuration of the building (Ref. 13), and may require adjustment if the building configuration changes substantially. **CONFIRMATION REQUIRED** (2)

References:

1. Calculation 05996.02-SC-4, Rev. 2, 'Development of Soil Impedance Functions for Canister Transfer Building' (2)

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-G(P018)-3, Rev. 1, 'Development of Time Histories for 2000 Year Return Period Design Spectra' (2)

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 9801 NT, Completion No. 3716, March 1998. (1)

9. Private Fuel Storage Facility Design Criteria, Revision 2, June 20, 1997, Stone & Webster Engineering Corporation, Denver, Colorado.

10. Calculation 05996.02-G(P018)-2, Rev. 1, 'Soil and Foundation Parameters for Dynamic Soil-Structure Interaction Analyses, 2000 Year Return Period Design Ground Motions'

11. Computer Program SECPROP3, ST-244, Version 00, Level 00. (2)

12. Biggs, John M., "Introduction to Structural Dynamics", 1964.

12. Conceptual Drawings 0599602-CEA-401B, 402B, and 403C

14. Computer Program TIMHIS6, ST-239, Version 01, Level 01.

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.

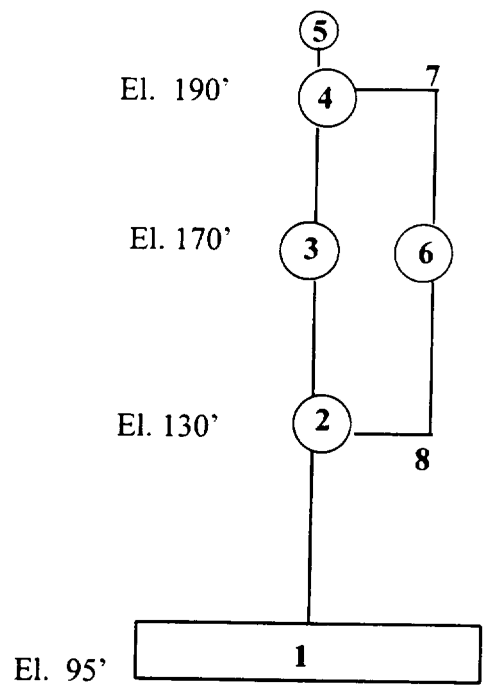
At the crane elevation, approximately El. 170'-0", two nodes will be included. Since the only shear walls in the East-West direction are on column lines 1, 8, and 11, the out-of plane response of the North-South wall may cause increased response at locations away from the E-W shear walls, especially 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 El. 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.

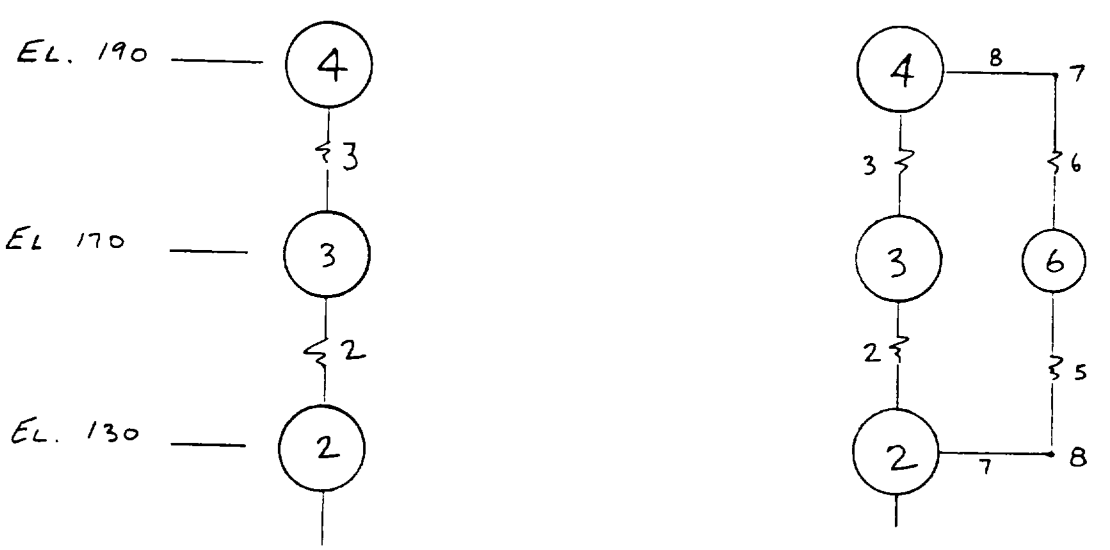
Four additional nodes were added at Elevation 170'-0" at the extremities of the building to capture the contributions to the response caused by rocking and torsion. They are not shown on the sketch below, but are described in Attachment F. (2)



Canister Transfer Building Stick Model

MODEL OF CRANE & WALL

THE TWO CRANES, 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. △2



CALCULATION SHEET STONE & WEBSTER ENGINEERING CORPORATION

▲5010 61

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05996.02-SC-5	-	10

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
B Allison 6/23/98	S Chen 7/6/98	[illegible] 7/13/98

SUBJECT/TITLE: SEISMIC ANALYSIS OF CANISTER TRANSFER BLDG.

QA CATEGORY/CODE CLASS: I

THE TOTAL MASS AT EL. 170. IS 287.8 (FROM 'MASS' RUN) PLUS 532/32.2 (CRANES) = 304.3 $\frac{K-SEC^2}{FT}$

△2 THE MASS ASSIGNED TO JOINT 6 IS 134.0 $\frac{K-SEC^2}{FT}$

THE REMAINING E-W MASS AT JOINT 3 IS 304.3 - 134.0 = 170.3 $\frac{K-SEC^2}{FT}$. 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

△2 INERTIA OF 72.5 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'

△2 WILL BE INTRODUCED. (SEE ATTACHMENT C)

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, best estimate soil case, low range and high range soil cases are performed. The results are contained on text files on the diskette included as 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 the same disk files. The data set names of these files are:

Best Estimate soil case

STRUCTRL.BEE.STIFFB5W

Low Range soil case

STRUCTRL.BEE.STIFFL5W

High Range soil case

STRUCTRL.BEE.STIFFU5W

GROUND TIME HISTORIES

The ground acceleration time histories were developed in Reference 4 and were transmitted via e-mail. They were retrieved and stored under disk file name "STUCTRL.BEE(ATHREVIS)", which are used as input to FRIDAY program. The FRIDAY limits the number of time points to 4000 (20 seconds for a time interval of .005 seconds), so only the first 20 seconds of the time histories were used. This will have negligible effect on results (see Attachment E).

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 SECPROP3 (ST-244), RIG3 (ST-248) and RIG4 (ST-249) are contained in Attachment B. 2

Attachment D contains text files of the three analyses using the program FRIDAY (ST-243), two GT-STRUDL analyses used to develop the crane model (see Attachment C), a TIMHIS6 (ST-239) analysis to verify the ground time histories (Attachment E), and a FRIDAY run to verify the modeling of the crane girder (Attachment C). The analyses are:

File Name	Date	Description
fr-svbe	3/17/01	Best Estimate soil case
fr-svlb	3/17/01	Low Range soil case
fr-svub	3/17/01	High Range soil case
WALLFINE.OUT	3/12/01	Wall Finite Element Analysis
WALLFLEX.OUT	3/22/01	Verification of Wall Model
TIMHIS6	4/02/01	Verification of Time Histories
Dif6	3/17/01	Verification of Crane

2

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SUBJECT/TITLE Seismic Analysis of Canister Transfer Building		QA CATEGORY/CODE CLASS I	

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

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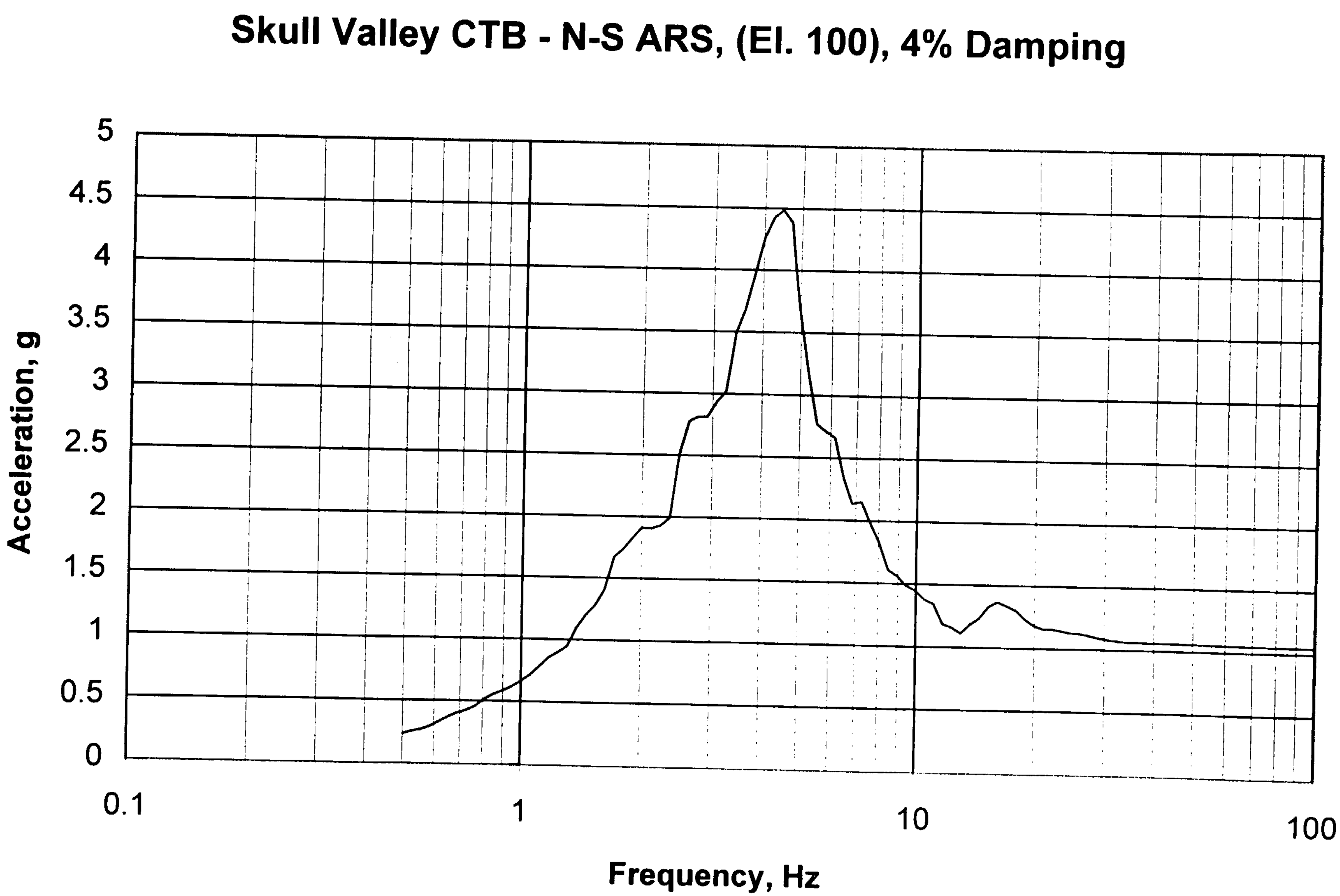
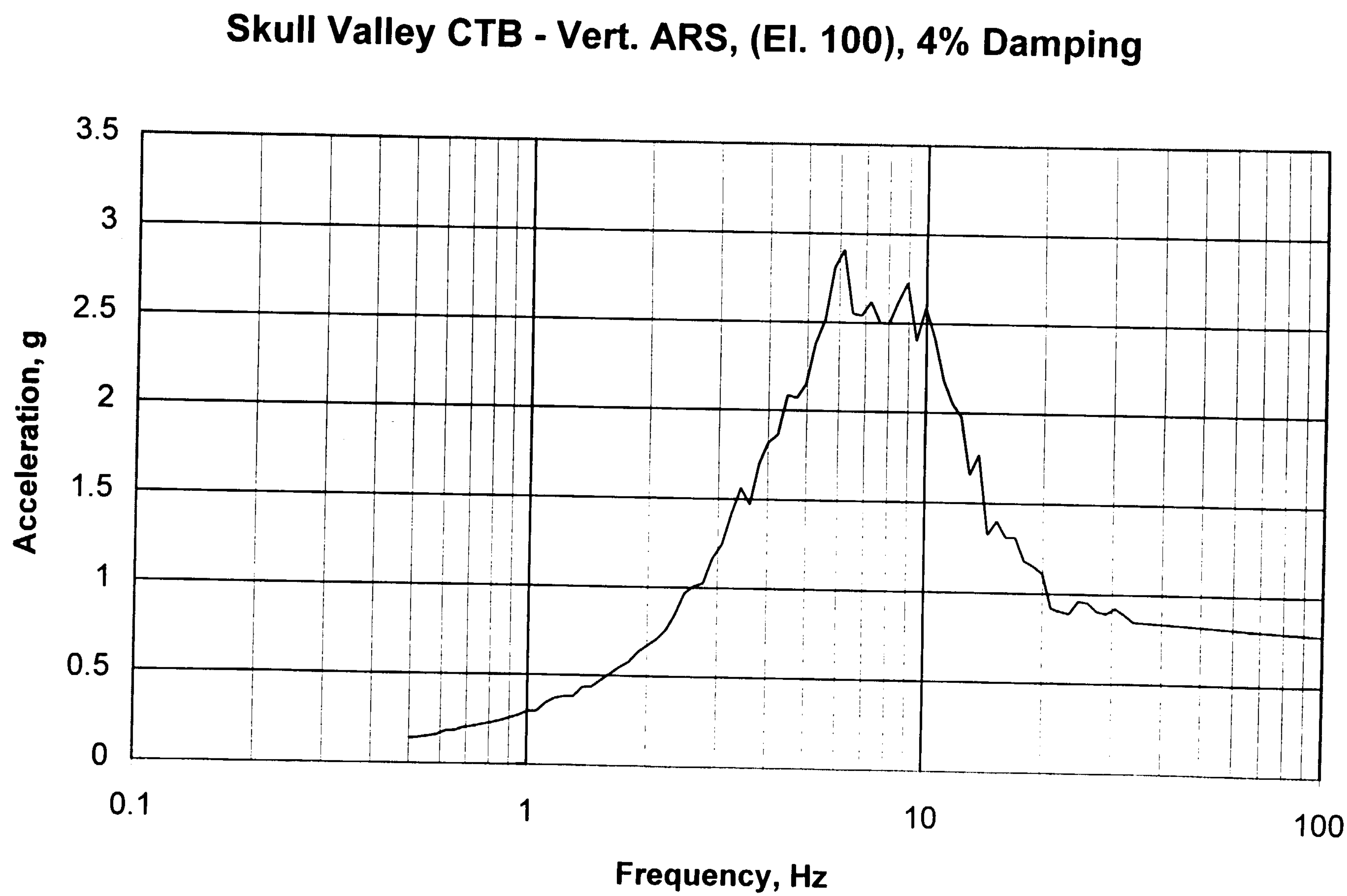
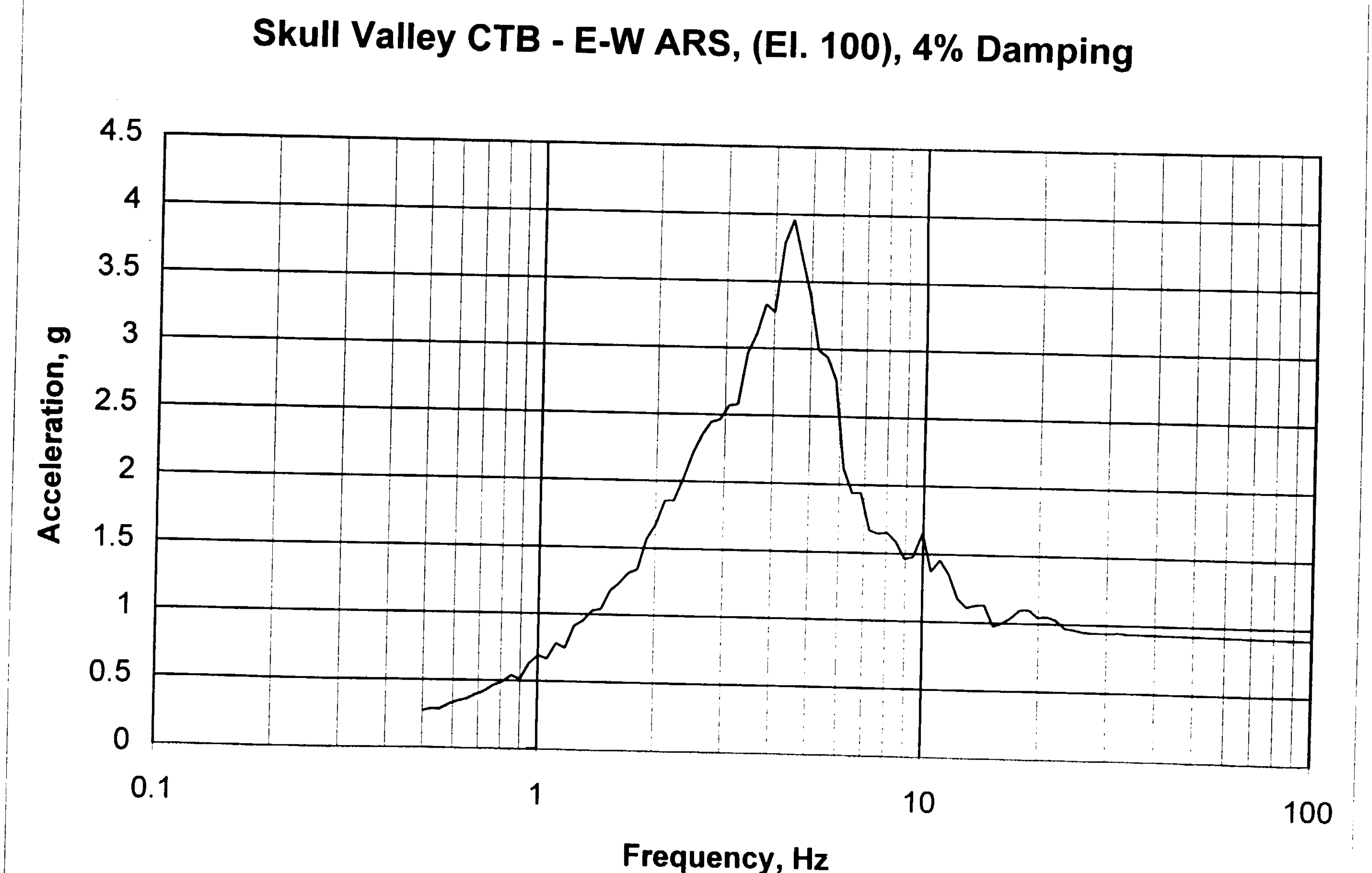
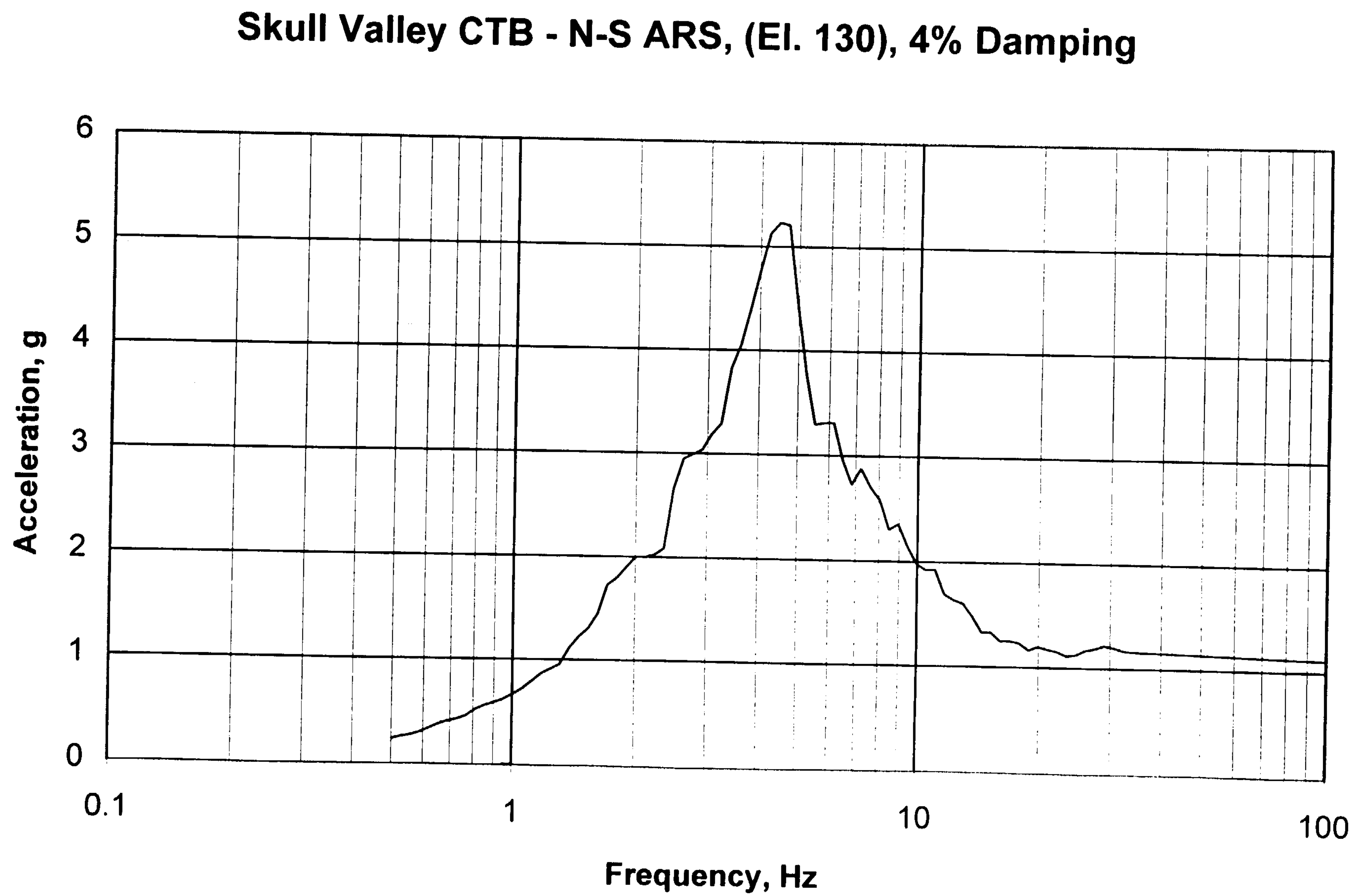
PREPARER/DATE B.E. EBBESON 6-18-98	REVIEWER/CHECKER/DATE S Chen 7/9/98	INDEPENDENT REVIEWER [signature] 7/13/98	
SUBJECT/TITLE Seismic Analysis of Canister Transfer Building		QA CATEGORY/CODE CLASS I	

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

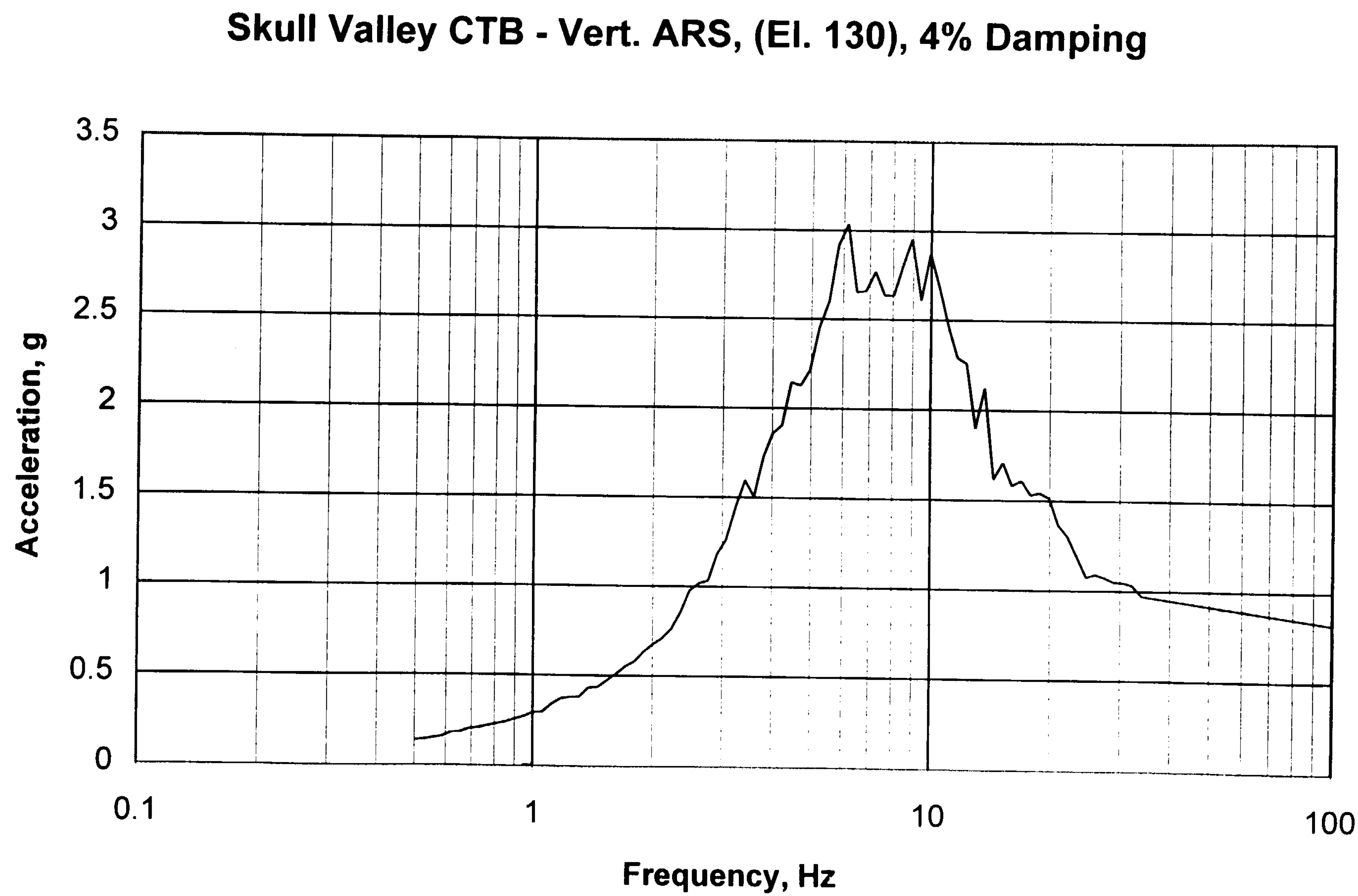

Skull Valley CTB - N-S ARS, (El. 100), 4% Damping
Acceleration, g
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
Frequency, Hz

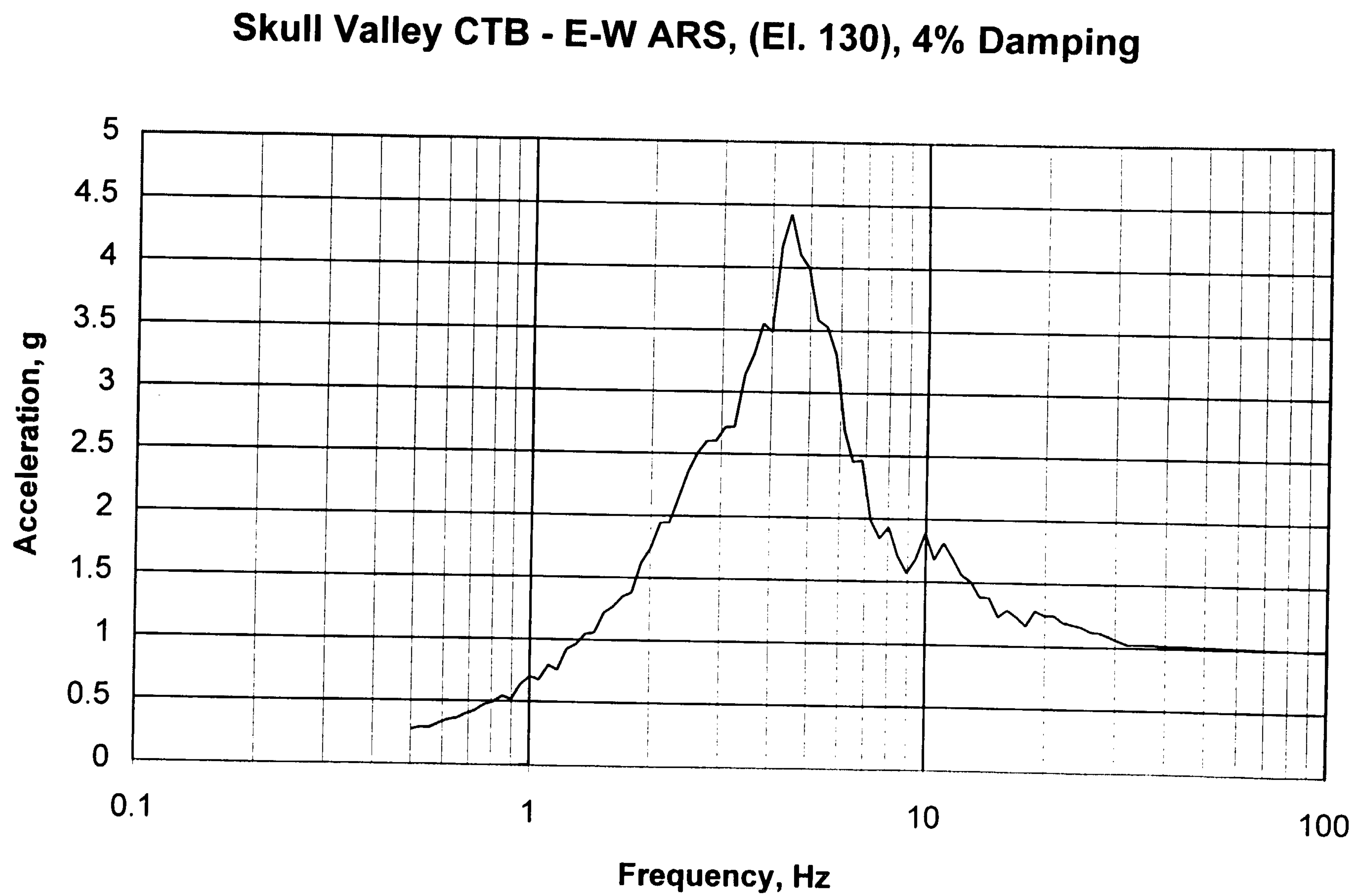

Skull Valley CTB - Vert. ARS, (El. 100), 4% Damping
3.5
3
2.5
2
1.5
1
0.5
0
Acceleration, g
0.1
1
10
100
Frequency, Hz

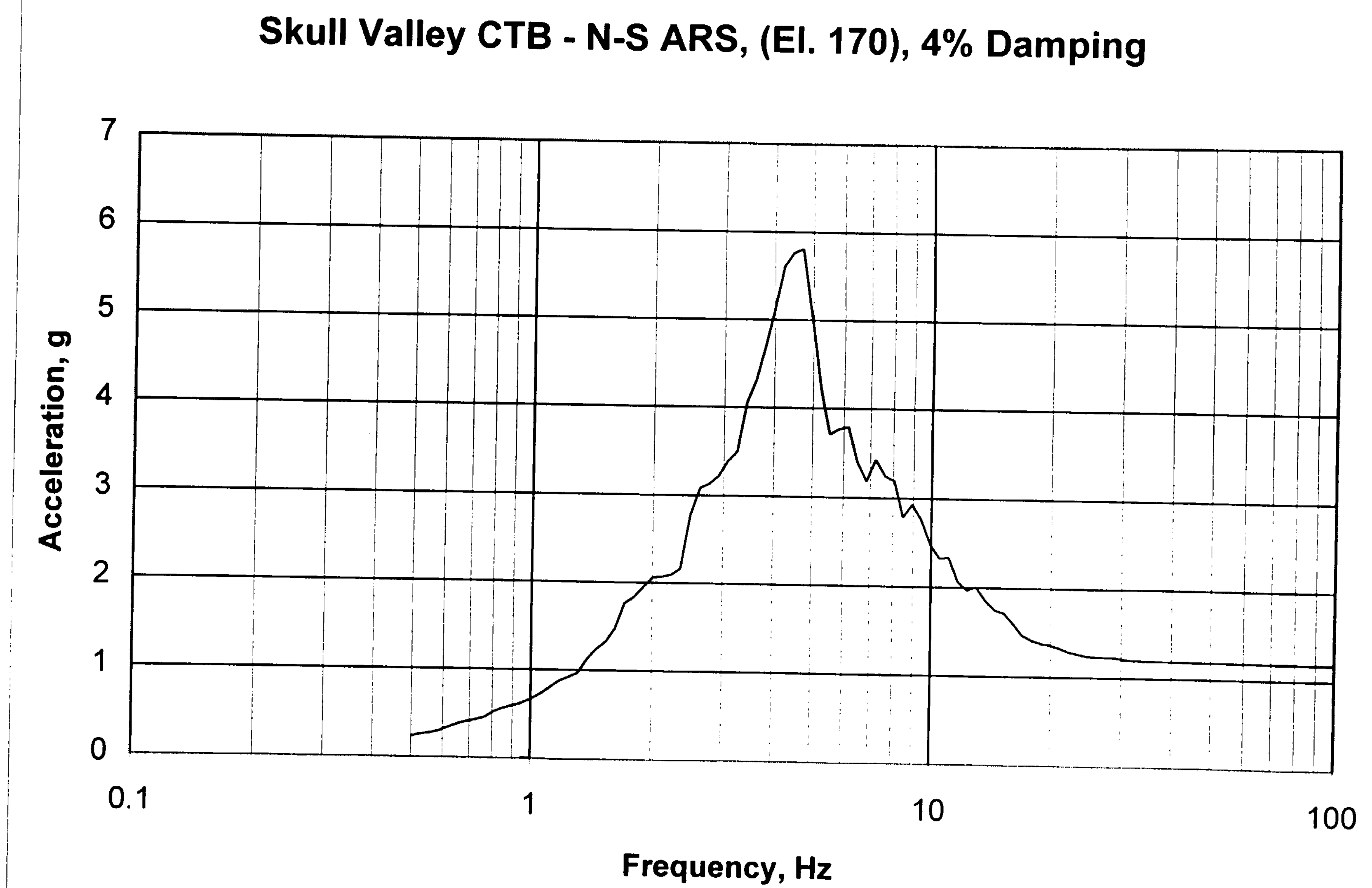

Skull Valley CTB - E-W ARS, (El. 100), 4% Damping
Acceleration, g
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0.1
1
10
100
Frequency, Hz



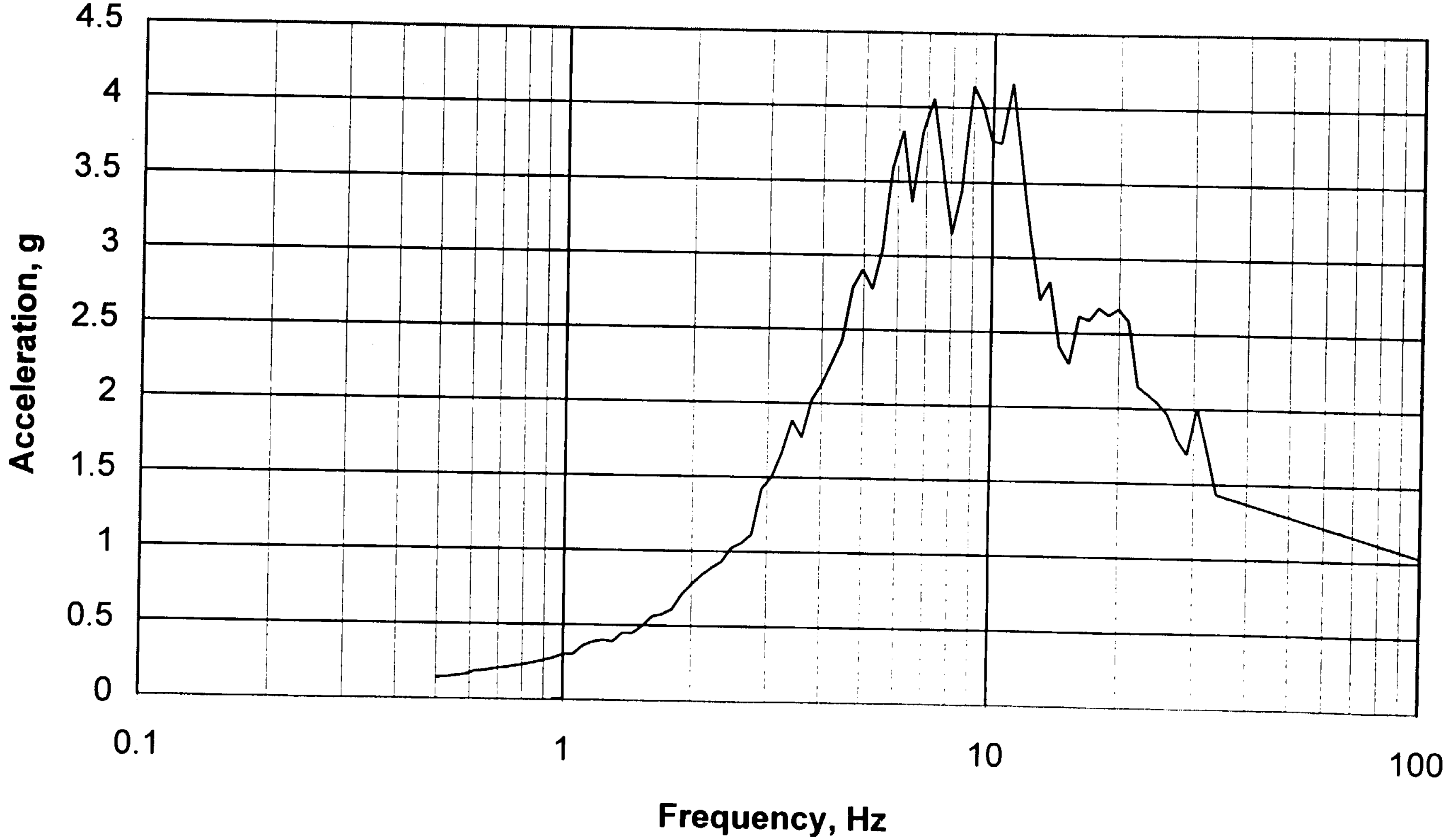
Skull Valley CTB - N-S ARS, (El. 130), 4% Damping
Acceleration, g
0
1
2
3
4
5
6
0.1
1
10
100
Frequency, Hz

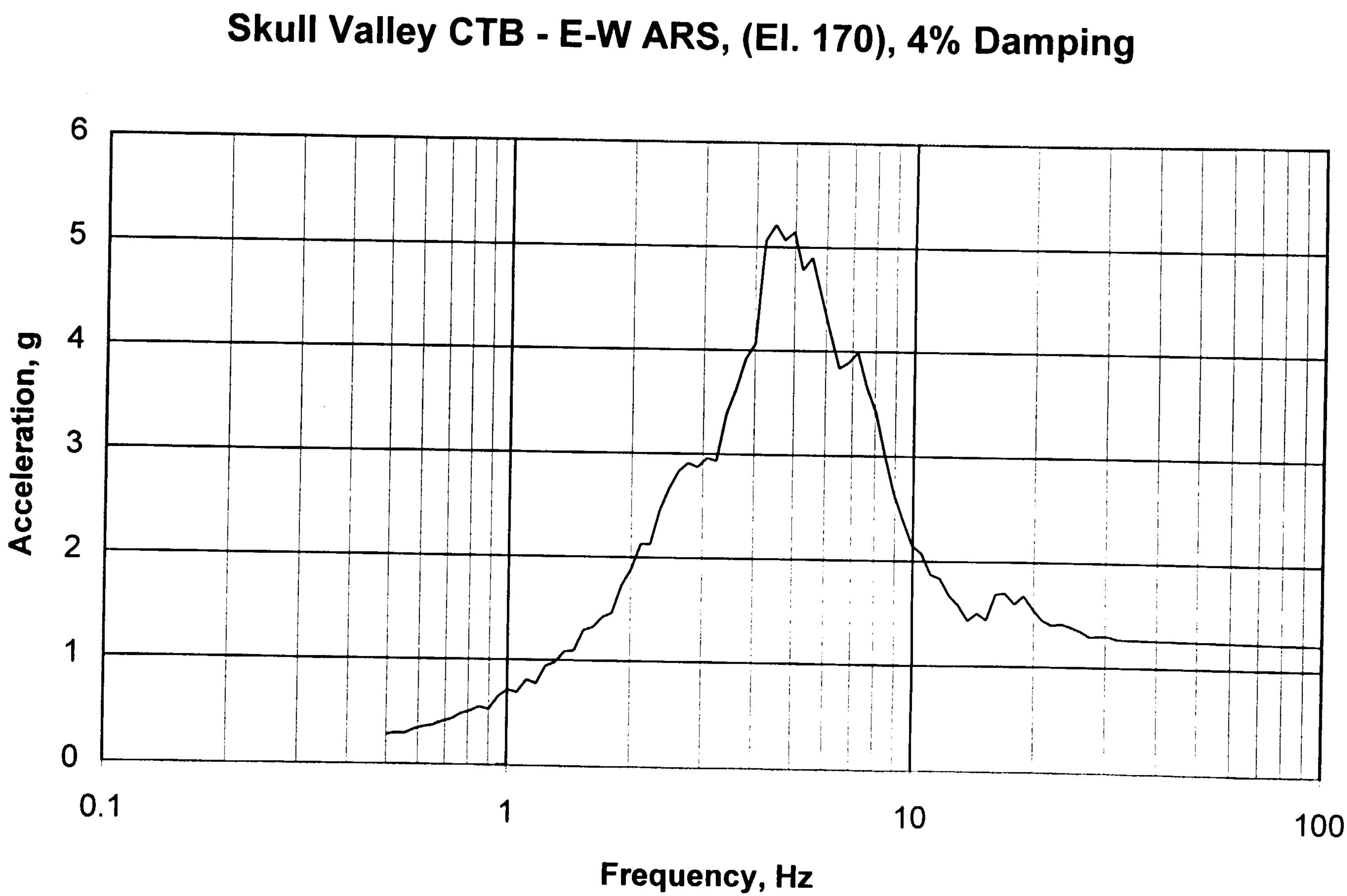

Skull Valley CTB - Vert. ARS, (El. 130), 4% Damping
3.5
3
2.5
2
1.5
1
0.5
0
Acceleration, g
0.1
1
10
100
Frequency, Hz


Skull Valley CTB - E-W ARS, (El. 130), 4% Damping
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Acceleration, g
0.1
1
10
100
Frequency, Hz

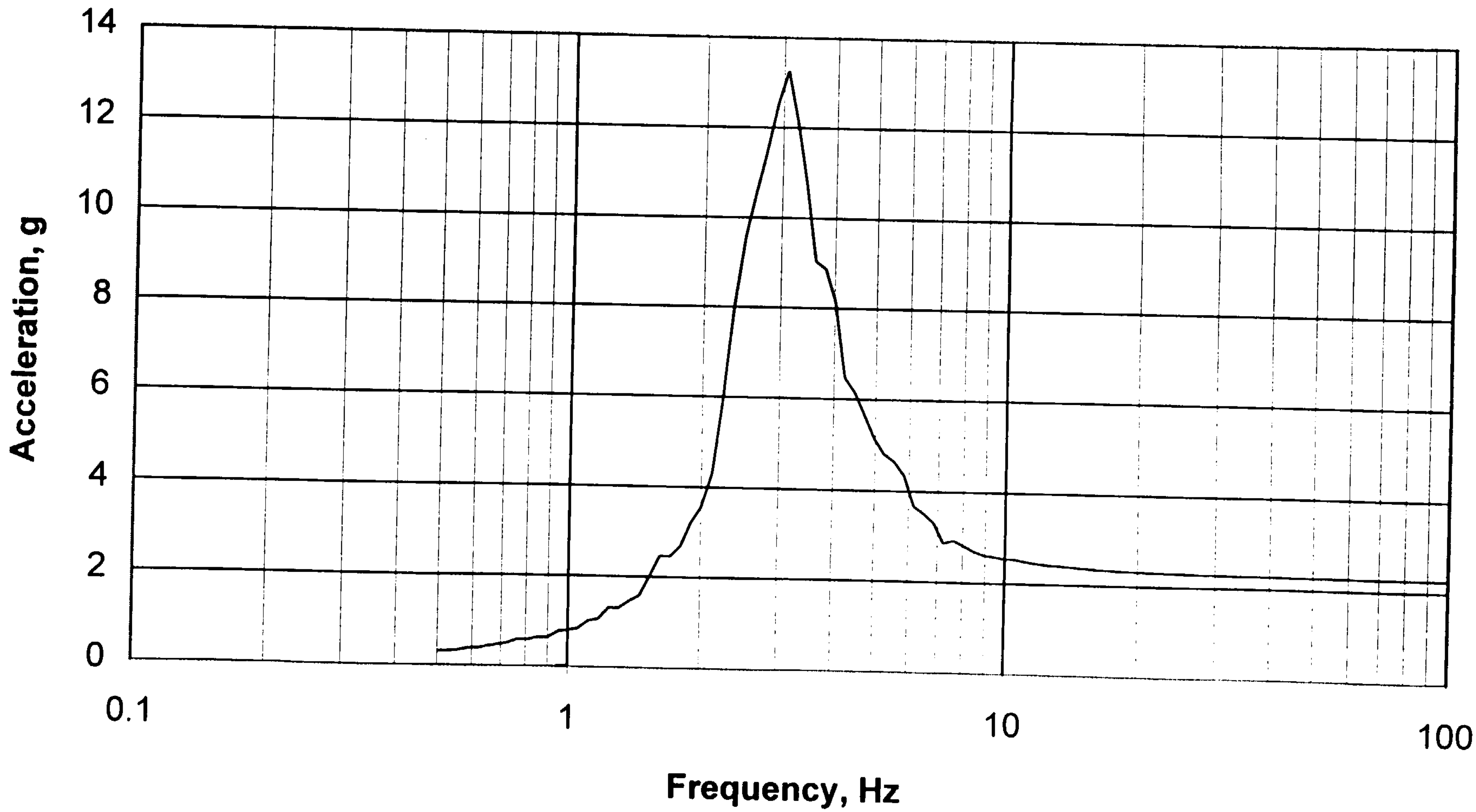

Skull Valley CTB - N-S ARS, (El. 170), 4% Damping
Acceleration, g
7
6
5
4
3
2
1
0
0.1
1
10
100
Frequency, Hz

Skull Valley CTB - Vert. ARS, (El. 170), 4% Damping

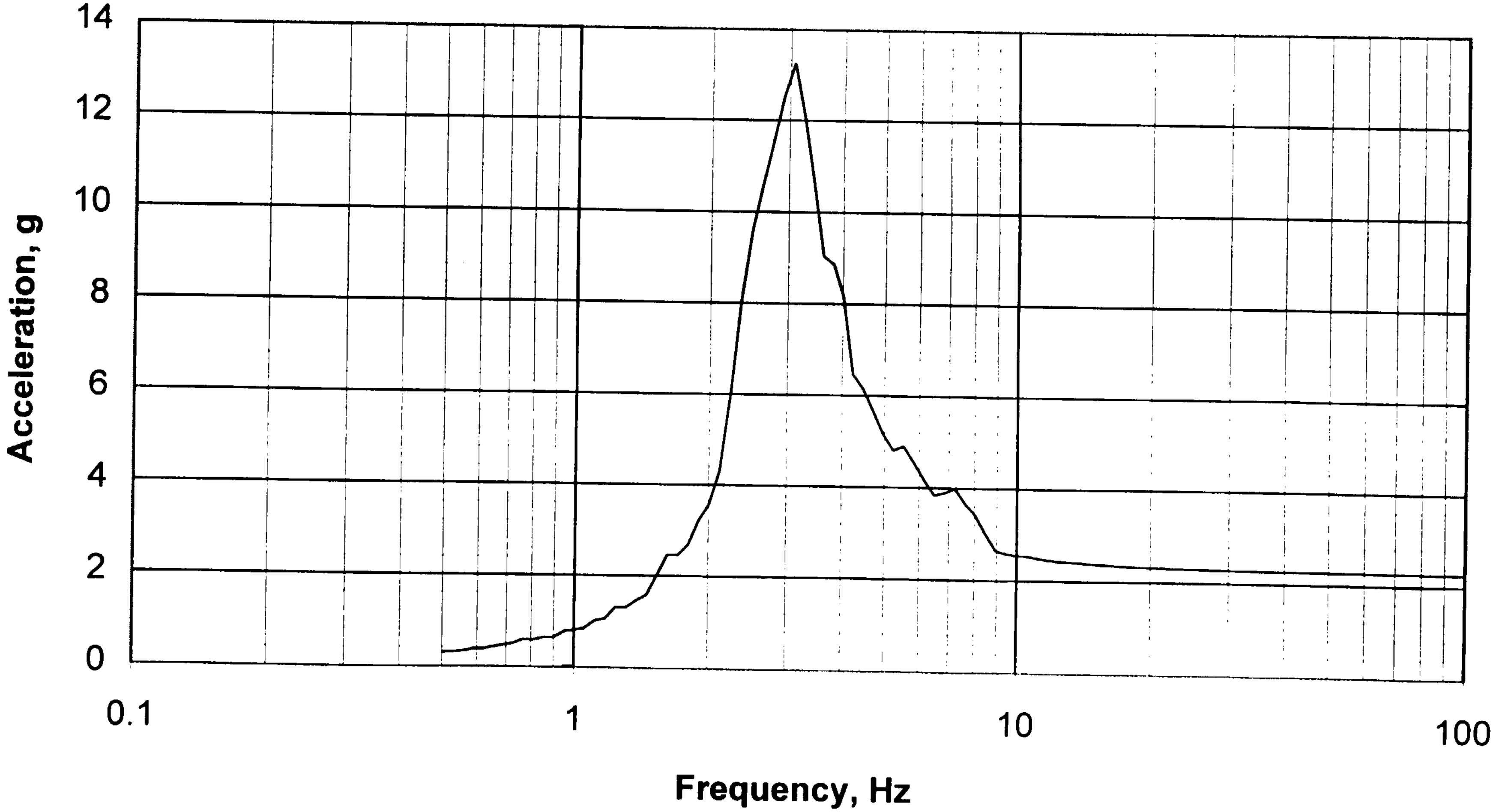



Skull Valley CTB - E-W ARS, (El. 170), 4% Damping
6
5
4
3
2
1
0
0.1
1
10
100
Acceleration, g
Frequency, Hz

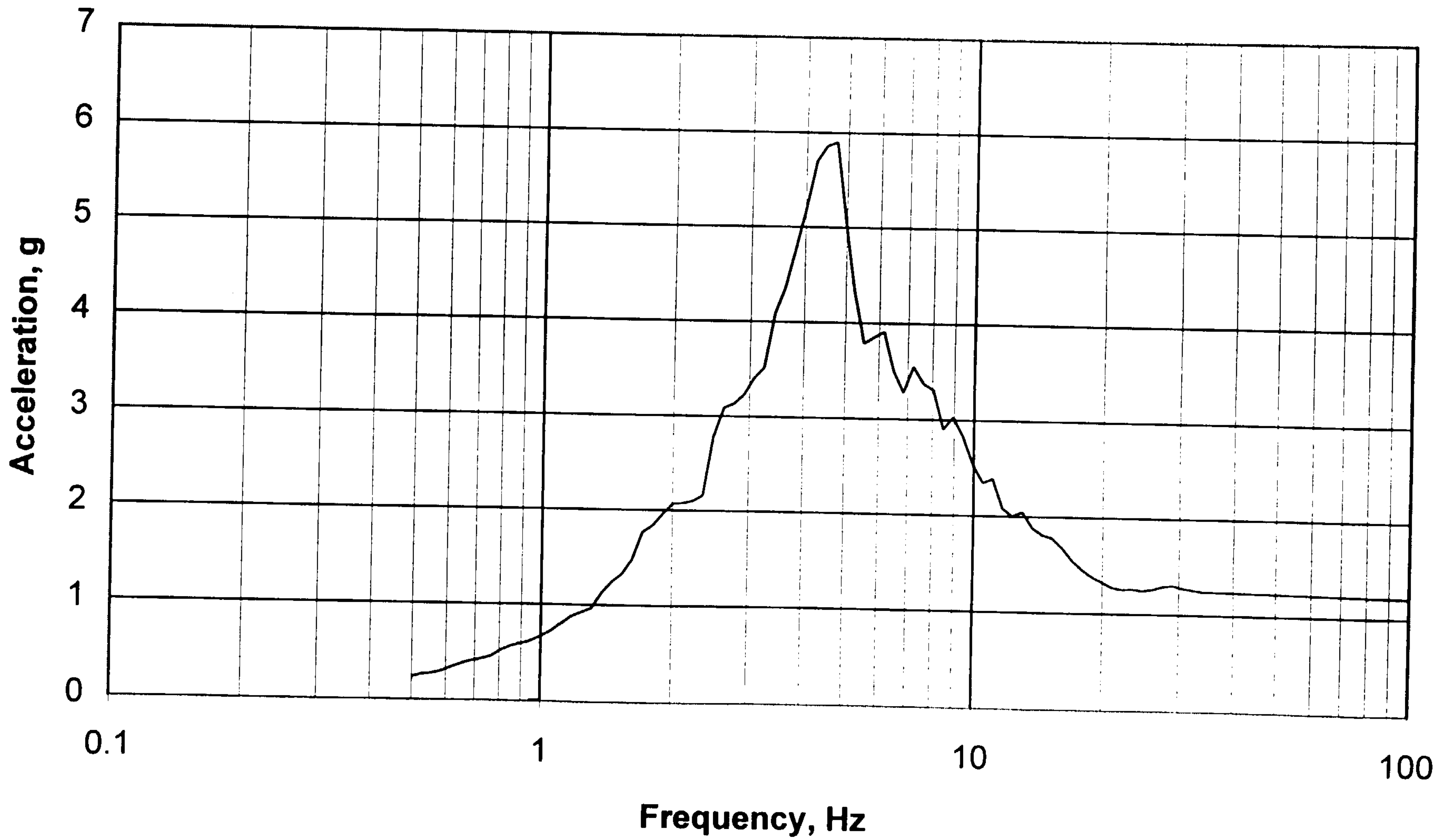
Skull Valley CTB - E-W ARS, (Crane Rail at El. 170), 4% Damping

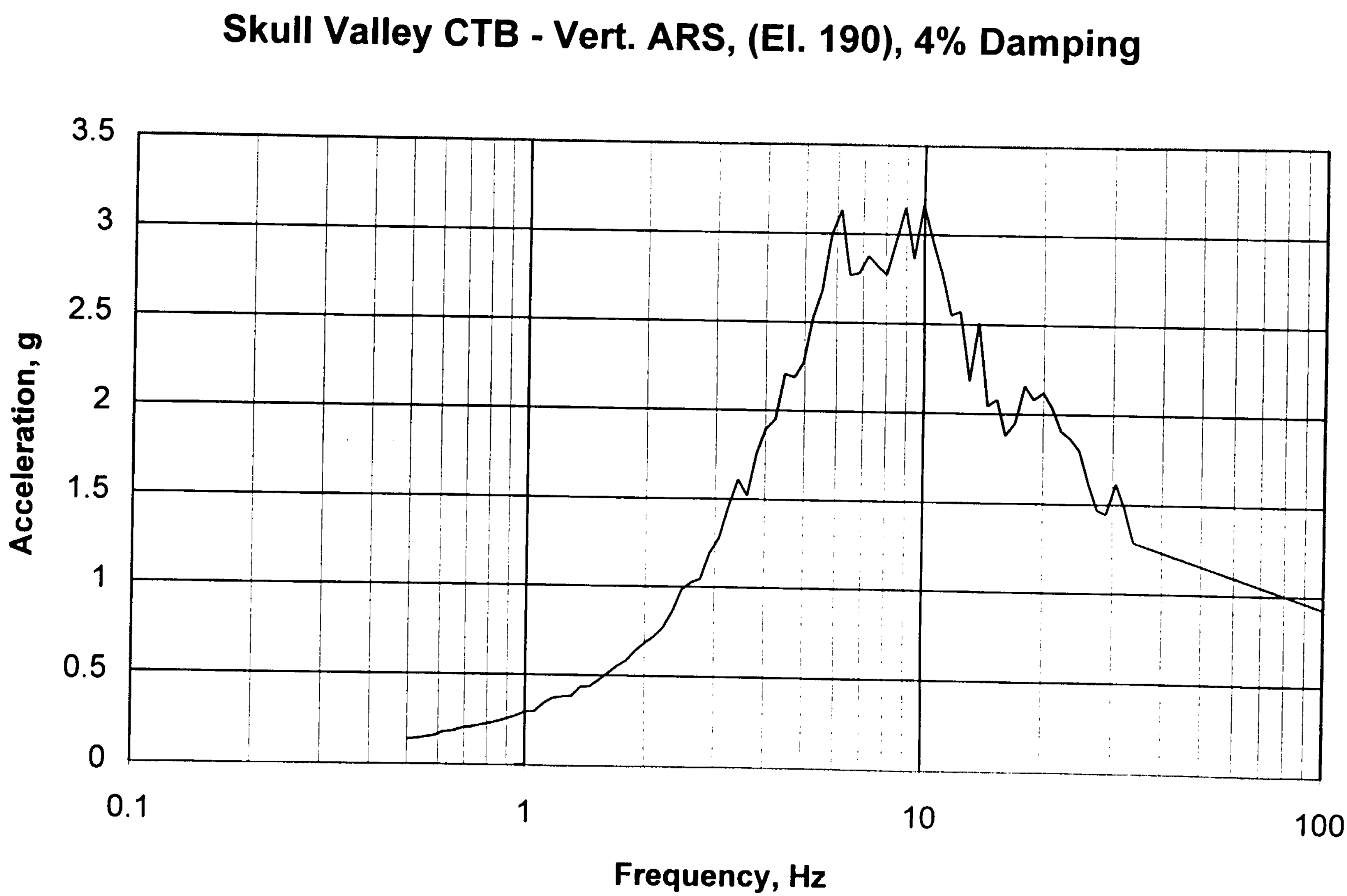


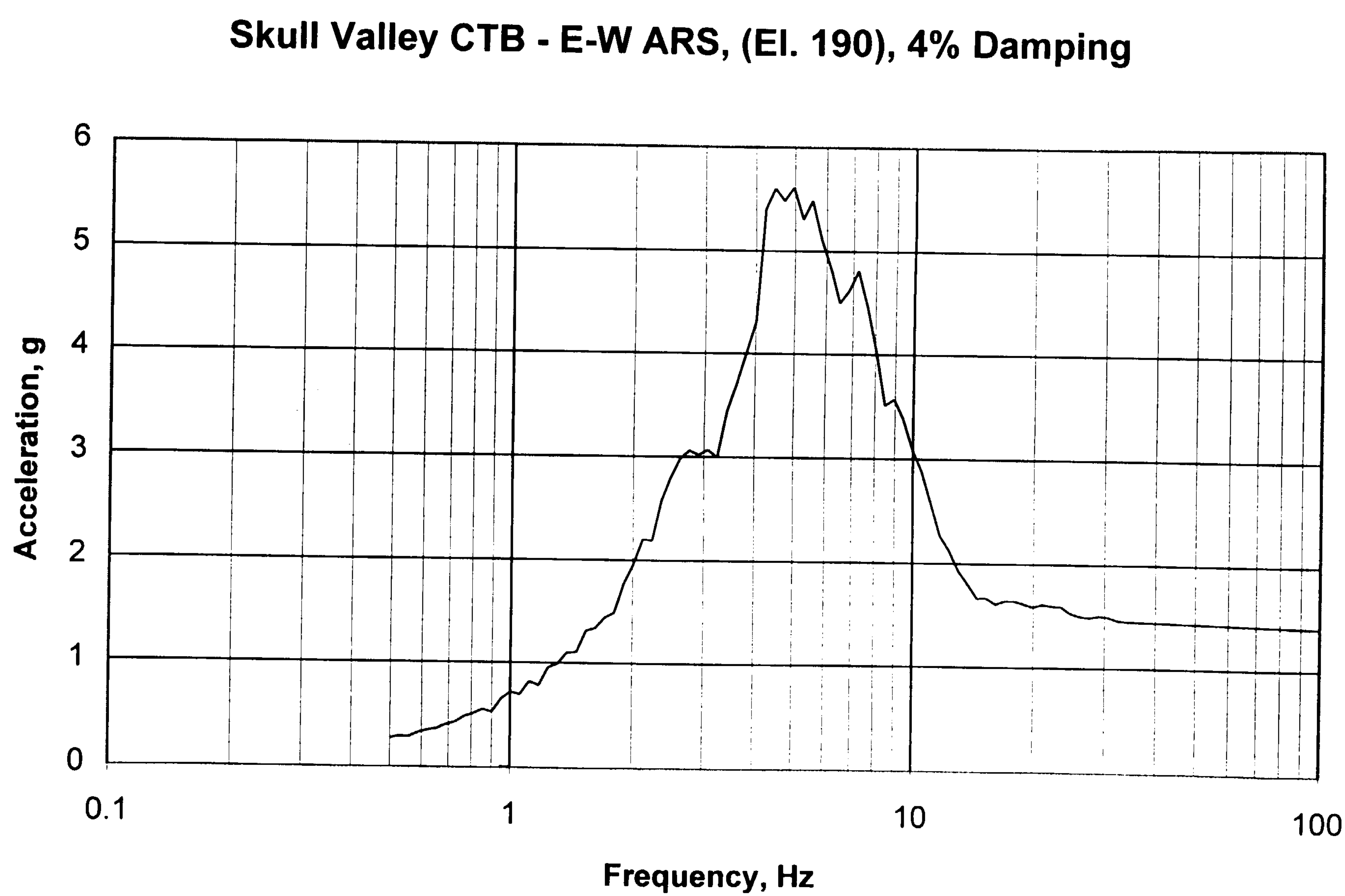
Skull Valley CTB - E-W ARS, (El. 170), 4% Damping
(Envelope of Crane Rail and Building)



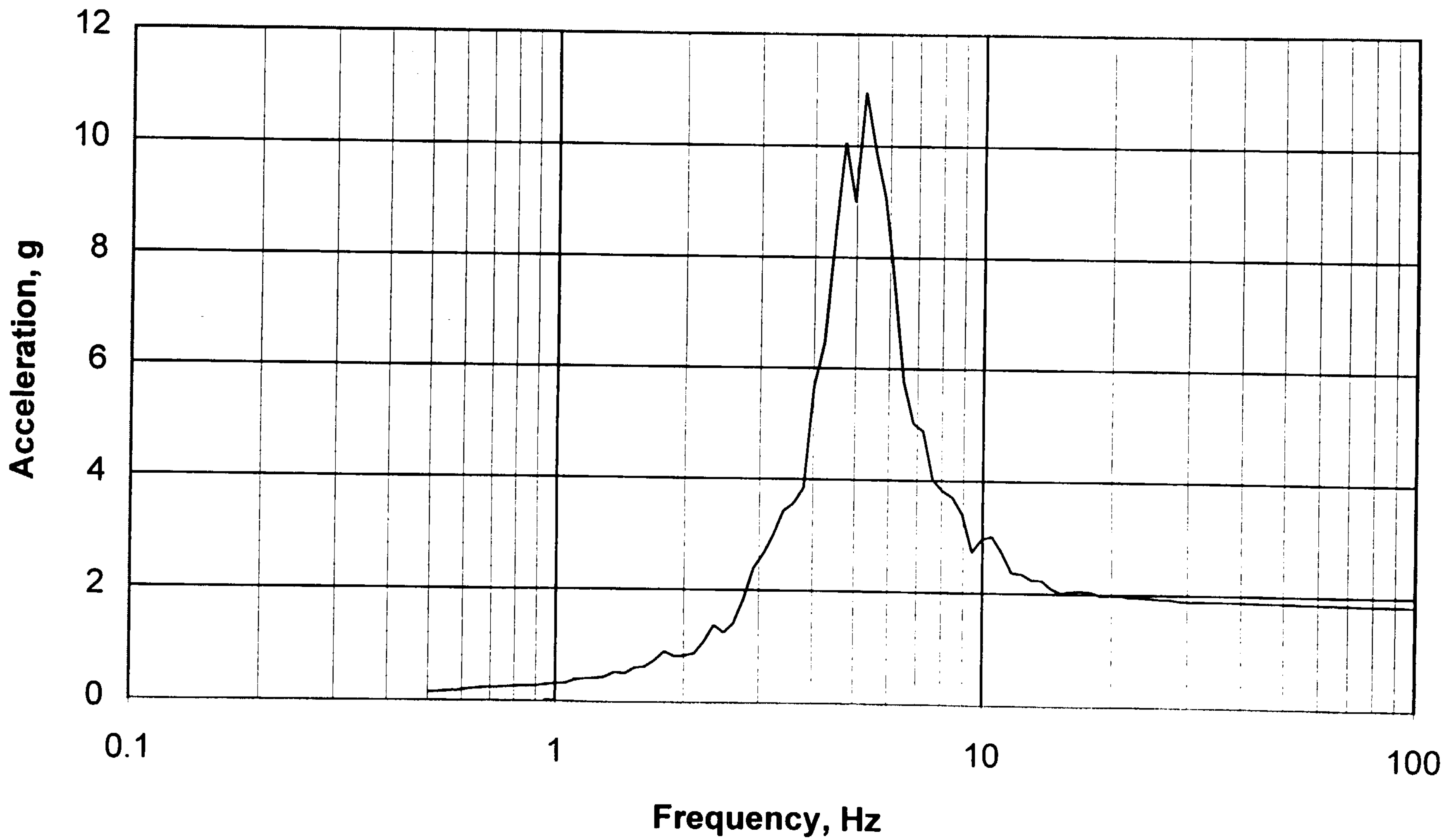
Skull Valley CTB - N-S ARS, (El. 190), 4% Damping



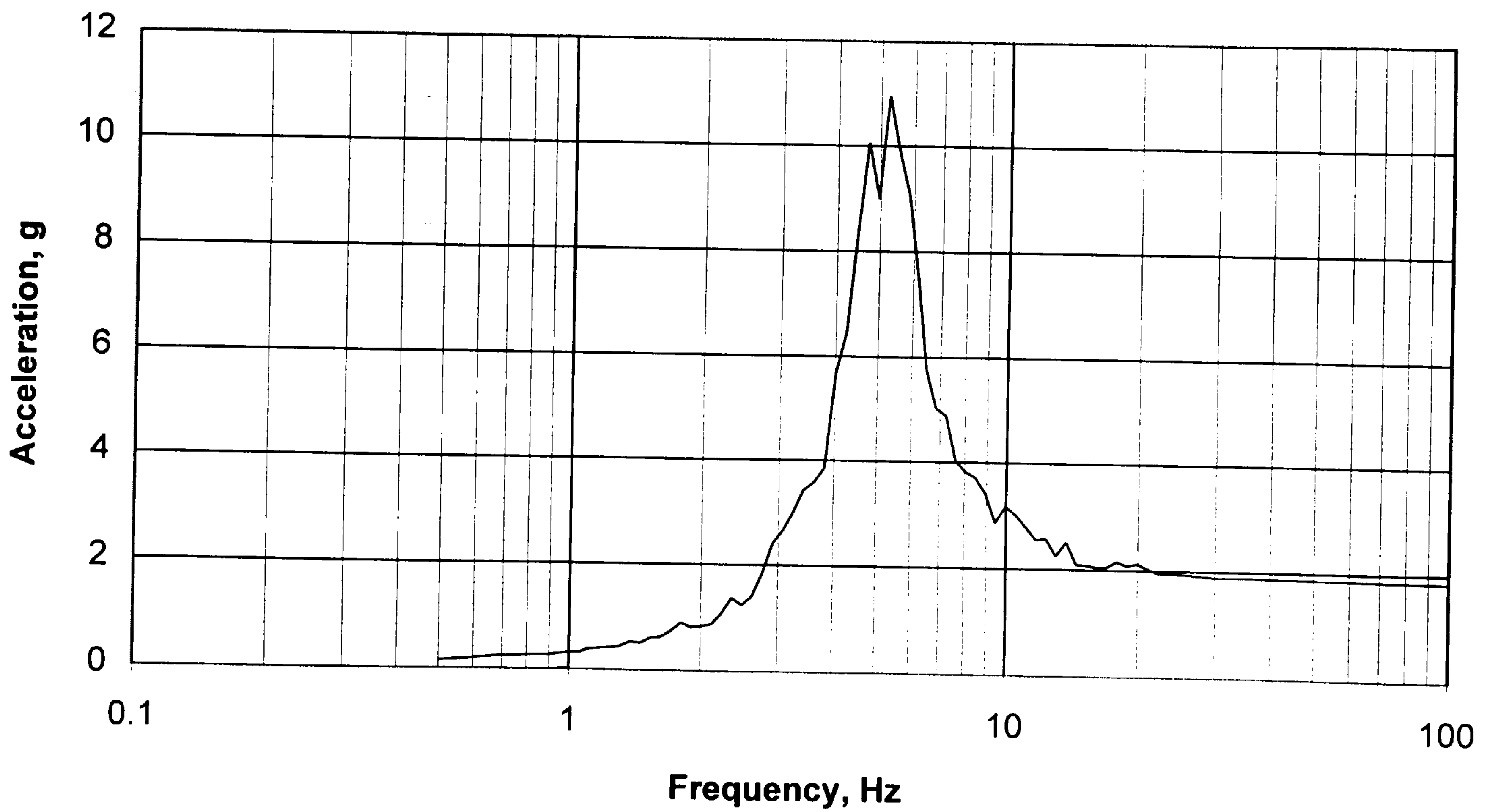

Skull Valley CTB - Vert. ARS, (El. 190), 4% Damping
3.5
3
2.5
2
1.5
1
0.5
0
Acceleration, g
0.1
1
10
100
Frequency, Hz

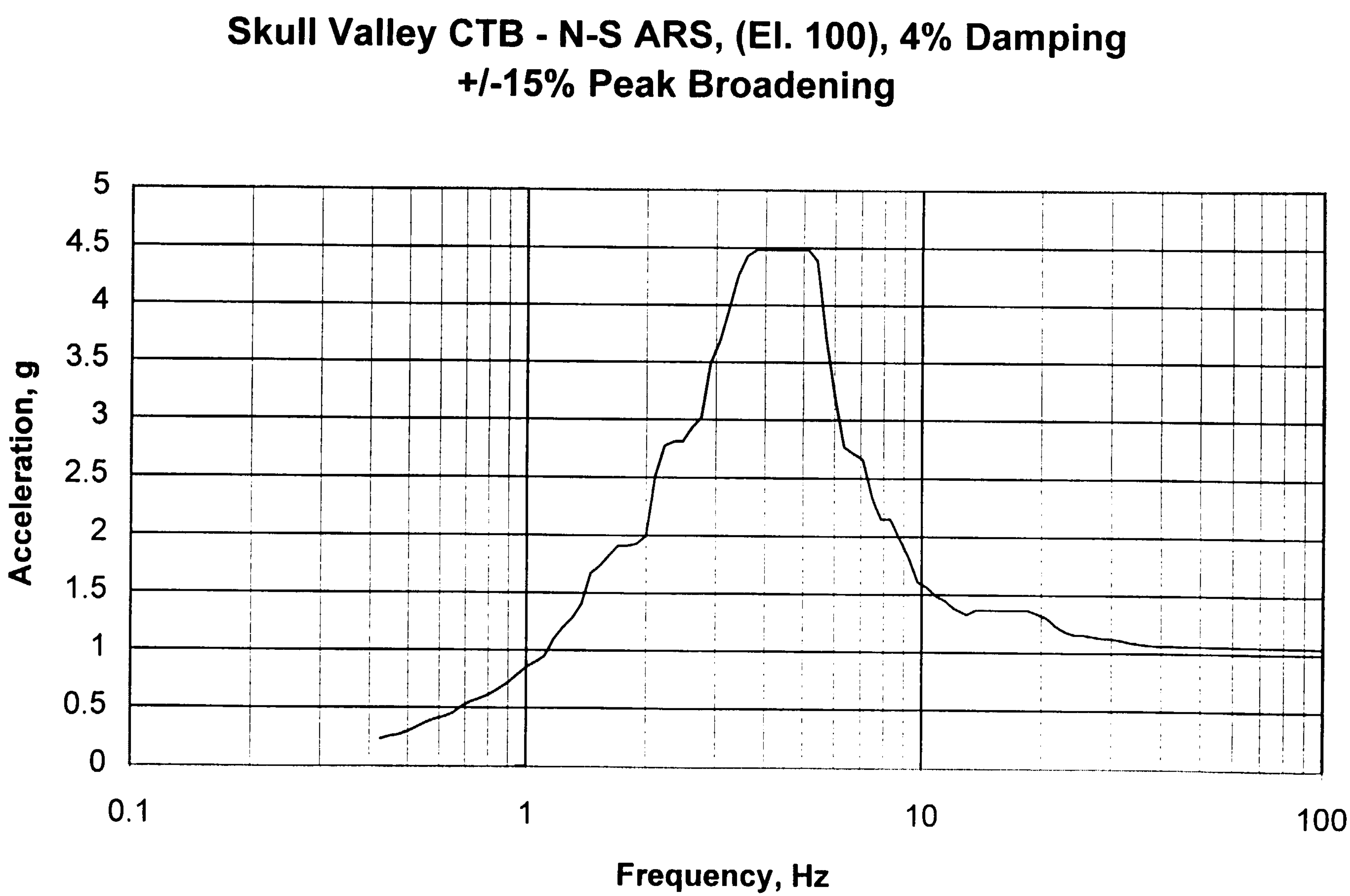

Skull Valley CTB - E-W ARS, (El. 190), 4% Damping
6
5
4
3
2
1
0
Acceleration, g
0.1
1
10
100
Frequency, Hz

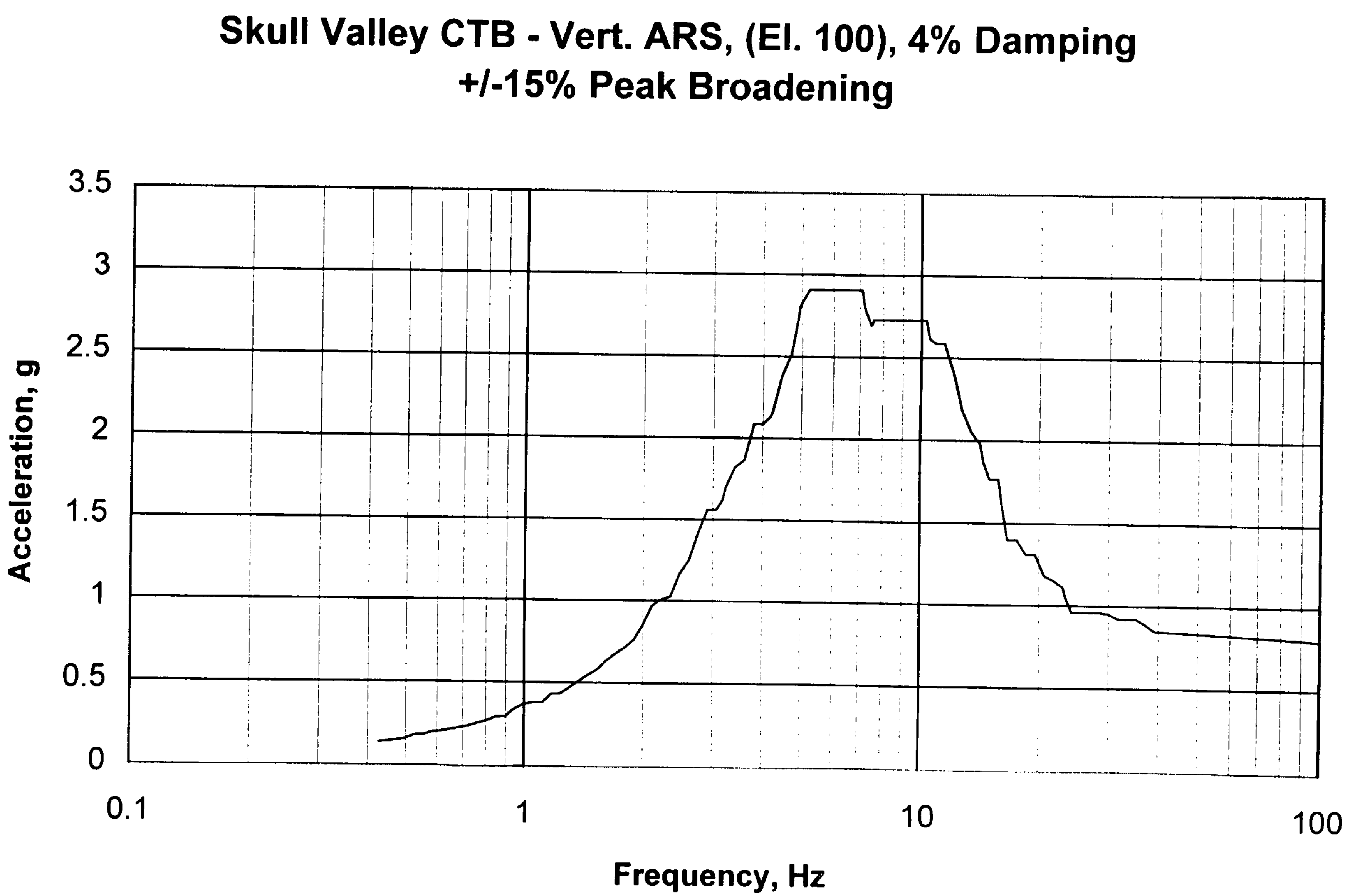
Skull Valley CTB - Vert. ARS, (Roof at El. 190), 4% Damping



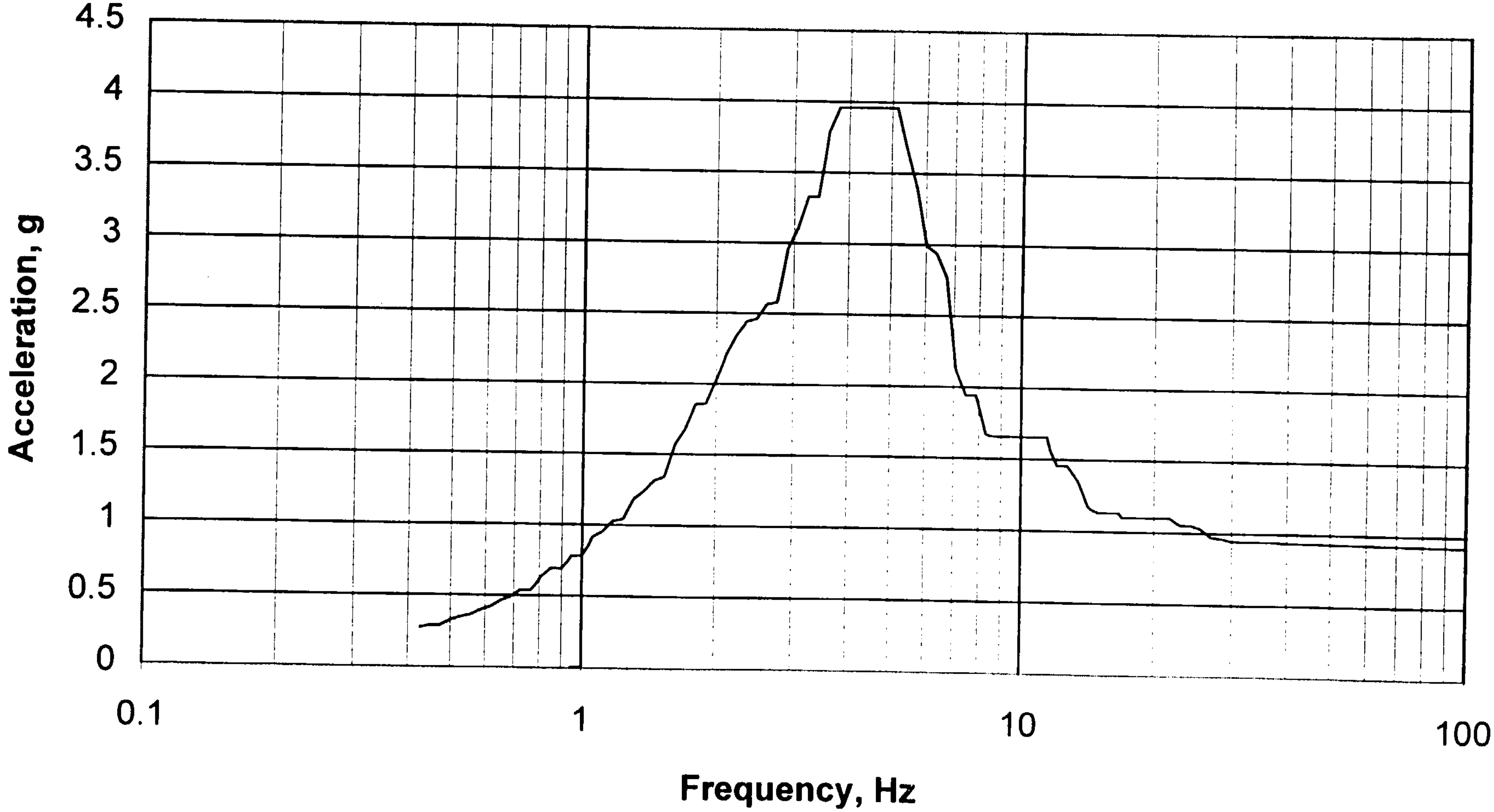
Skull Valley CTB - Vert. ARS, (El. 190), 4% Damping
(Envelope of Roof and Building)

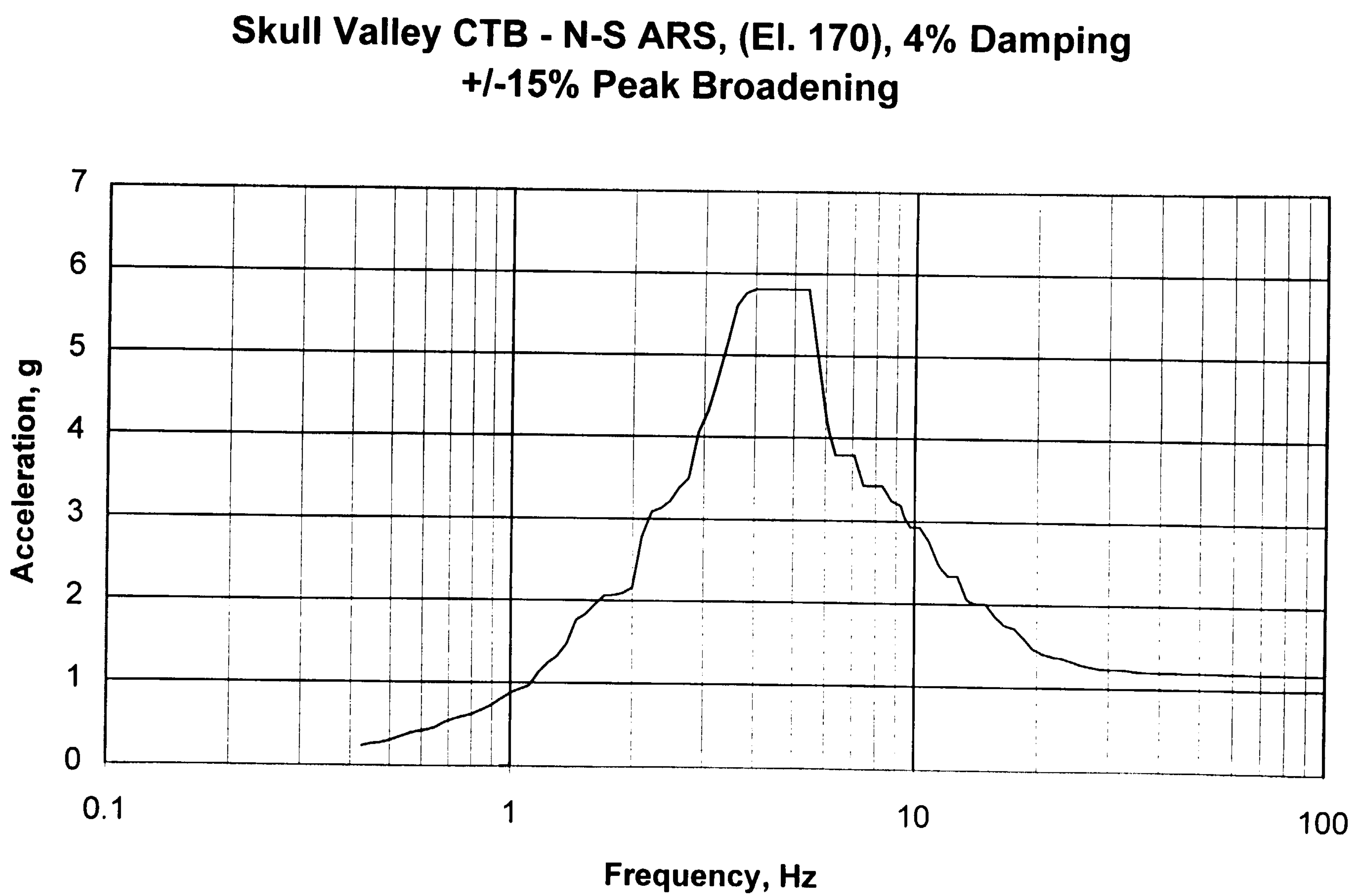


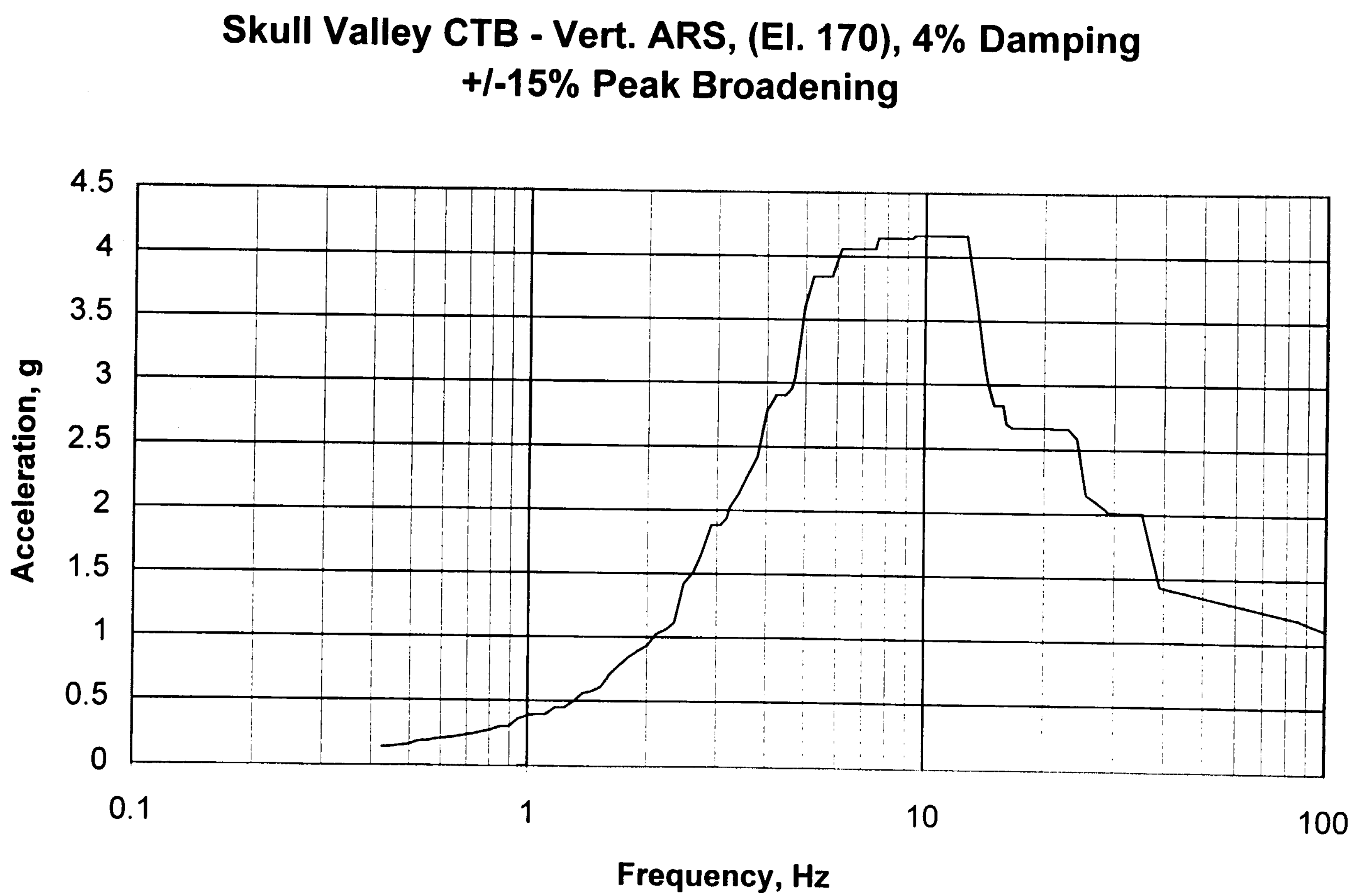

Skull Valley CTB - N-S ARS, (El. 100), 4% Damping
+/-15% Peak Broadening
Acceleration, g
Frequency, Hz
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100


Skull Valley CTB - Vert. ARS, (El. 100), 4% Damping
+/-15% Peak Broadening
Acceleration, g
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
Frequency, Hz

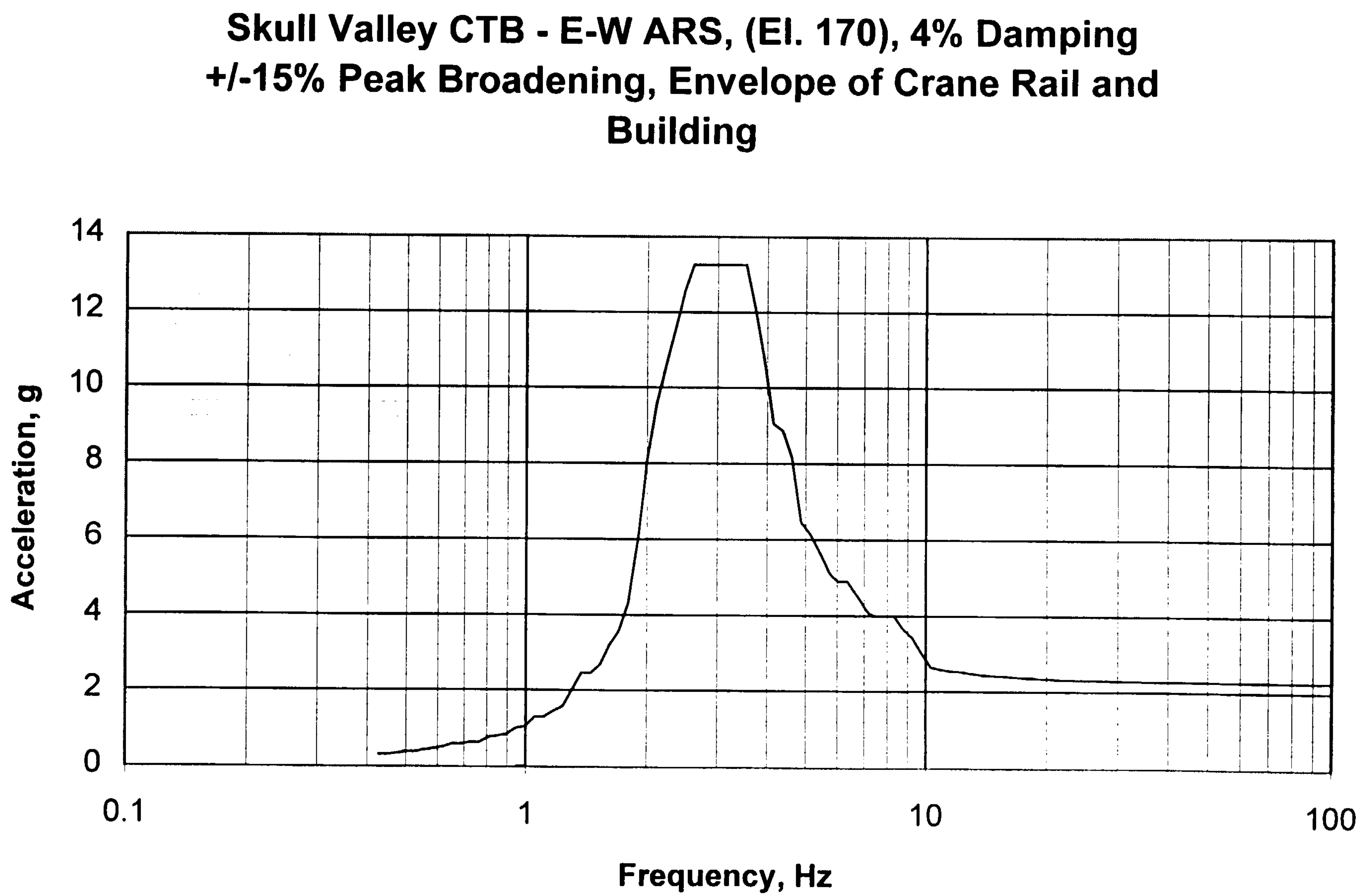
Skull Valley CTB - E-W ARS, (El. 100), 4% Damping +/-15% Peak Broadening




Skull Valley CTB - N-S ARS, (El. 170), 4% Damping
+/-15% Peak Broadening
Acceleration, g
0
1
2
3
4
5
6
7
0.1
1
10
100
Frequency, Hz



Skull Valley CTB - Vert. ARS, (El. 170), 4% Damping
+/-15% Peak Broadening
Acceleration, g
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
Frequency, Hz


Skull Valley CTB - E-W ARS, (El. 170), 4% Damping
+/-15% Peak Broadening, Envelope of Crane Rail and
Building
14
12
10
8
6
4
2
0
Acceleration, g
0.1
1
10
100
Frequency, Hz

SLIDING AND UPPLIFT FORCES

For use in the stability analysis (Calculation 05996.02-G(B)-13, Rev. 2), horizontal and vertical forces are tabulated. Since the accelerations are highest for the upper bound soil case, only these need to be tabulated.

JT.	EL.	MASS X	MASS Y	MASS Z	AX	AY	AZ	SHEAR X	UPLIFT	SHEAR Z
1	95	1908.0	1908.0	1908.0	1.047	0.783	0.920	1997.7	1493.8	1755.4
2	130	420.4	420.4	420.4	1.111	0.821	0.994	467.0	345.2	418.0
3	170	304.3	304.3	170.3	1.778	0.913	1.185	541.0	277.9	201.8
4	190	144.7	117.1	144.7	1.215	0.928	1.408	175.8	108.6	203.7
5	190	1.0	27.6	1.0		1.840		0.0	50.8	0.0
6	170	1.0	1.0	134.0			2.166	0.0	0.0	290.2
		WEIGHT	89381				TOTAL	102346	73228	92299

Additionally, overturning moments due to rotational acceleration are required for the overturning evaluation. They have been extracted from the FRIDAY output and are summarized below.

About N-S axis:

JT	IX	RX	OTMX
1	8552600	0.000951	261609
2	997726	0.001598	51284
3	298016	0.012023	115267
4	88173	0.013245	37570
TOTAL			465729

About E-W axis:

JT	IZ	RZ	OTMZ
1	12949775	0.001385	576775
2	3461796	0.001667	185591
3	2223390	0.002296	164246
4	1009564	0.002393	77709
TOTAL			1004322

Note: Total moments are in ft-kips.

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.

CALCULATION SHEET STONE & WEBSTER ENGINEERING CORPORATION

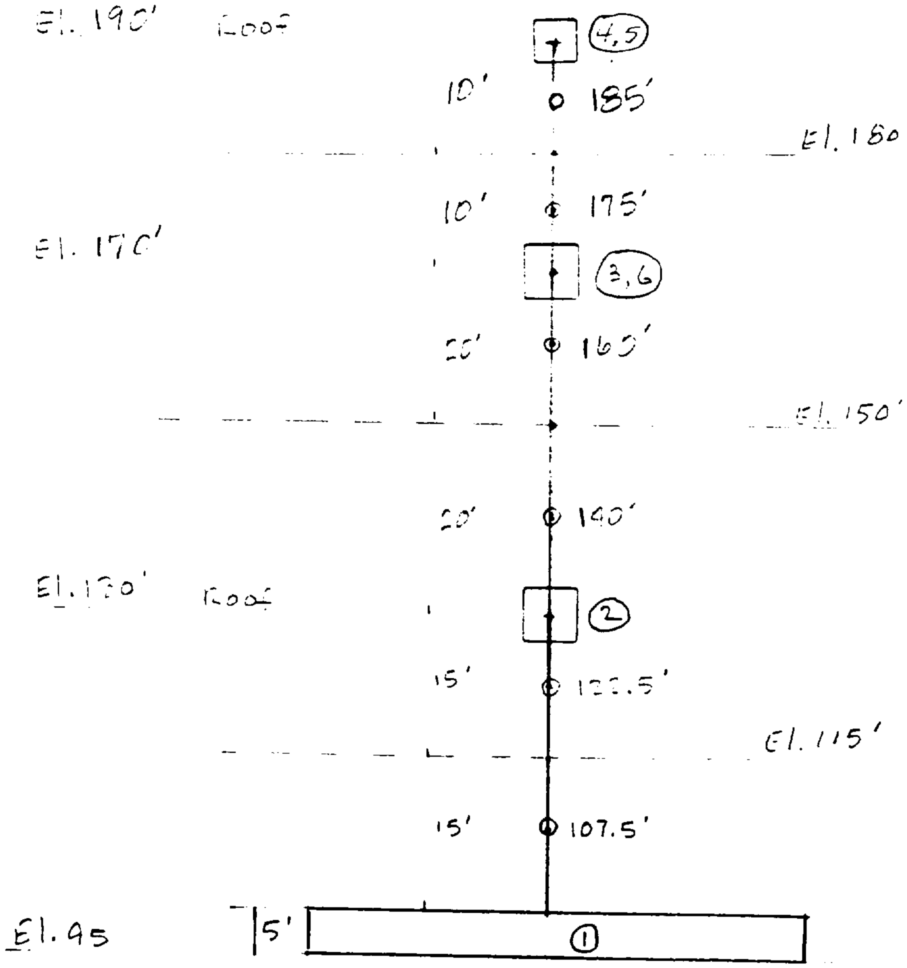
▲5010.61

J.O./W.O./CALCULATION NO.	REVISION	PAGE
05996.02-SC-5	0	A-2

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
S Chen 6/22/98	Anthony Grant 6/22/98	[illegible] 7/13/98

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
Seismic Analysis	I

Estimate Building Mass



ATTACHMENT A
PAGE 2
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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
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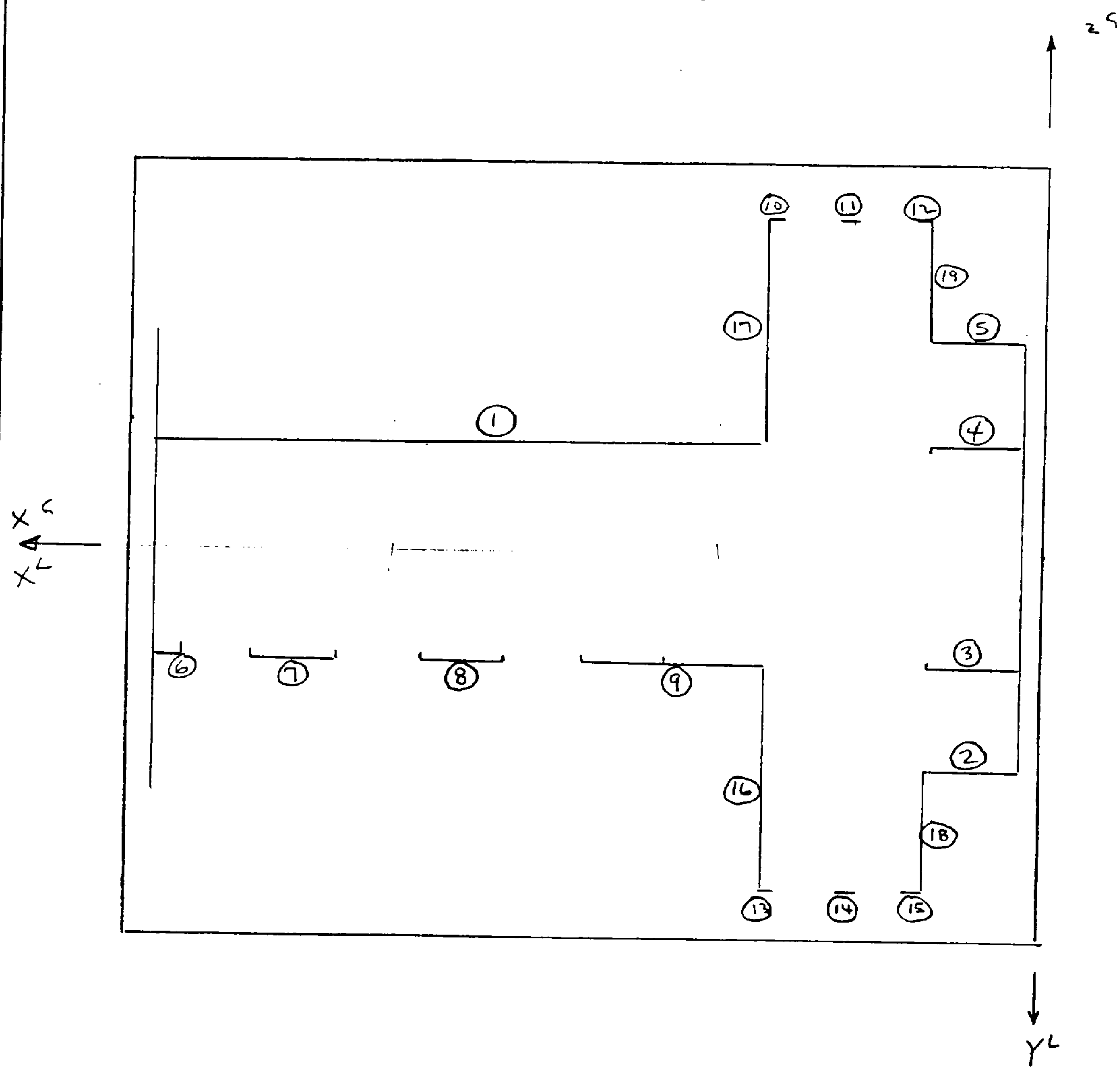
05996.02		SC-5		

MASS AT EL. 100. MAJOR WALLS



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CALCULATION SHEET

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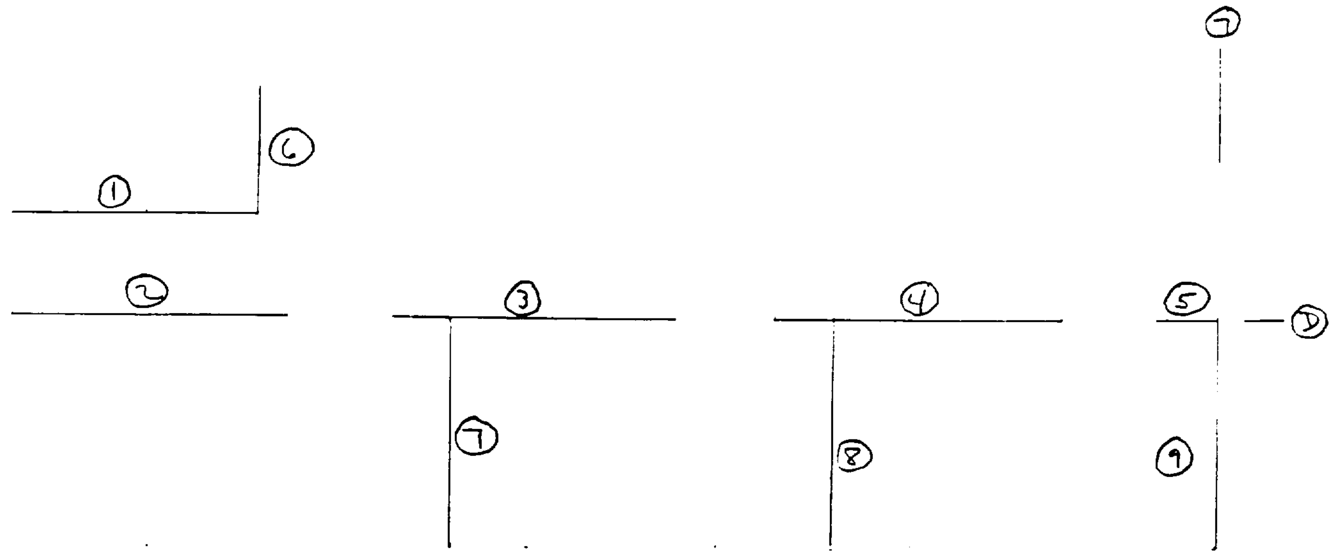
05996.02		SC-5		

1' THICK WALLS



WALLS 1-6 DO NOT ATTACH TO EL. 130, AND ALL THEIR MASS IS INCLUDED AT JOINT 1. WALLS 7-9 DO NOT ATTACH DIRECTLY TO EL. 130, BUT ATTACH TO THE WALL ON COL. LINE C, WHICH ATTACHES TO THE TRANSPORTER AISLE ROOF AT EL. 130. ACCORDINGLY THE BOTTOM 20' WILL BE INCLUDED WITH JOINT 1, AND THE TOP 10' WITH JOINT 2.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
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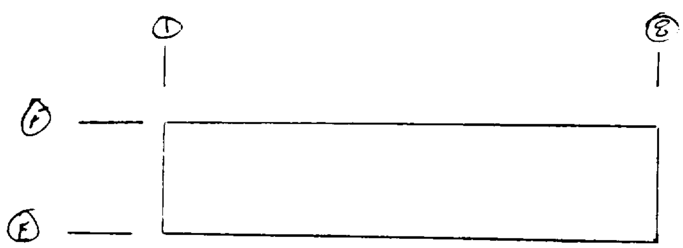
MASS PROPERTIES EL. 100'-0"

EXTRA MASS TO ACCOUNT FOR L.L. & MISC.

A. Office & Equip Area Assume 50 psf

Equivalent thickness of concrete $= \frac{50}{150} = .33$



$LX = 187.5'$

$LY = 35'$

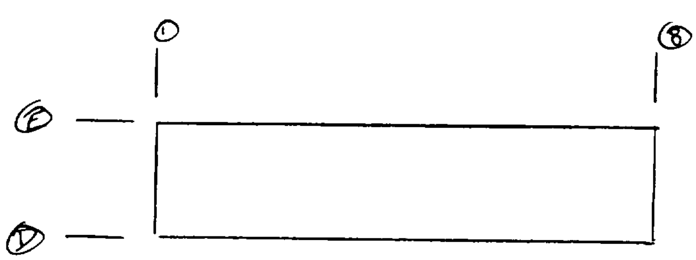
$T = .33'$

$X_0 = 179.75$

$Y_0 = -50$

$Z_0 = 100$

B. CRANE Aisle - Assume 50 psf ($T = .33'$)



$LX = 187.5'$

$LY = 32.5'$

$T = .33'$

$X_0 = 179.75'$

$Y_0 = -16.25'$

$Z_0 = 100'$

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
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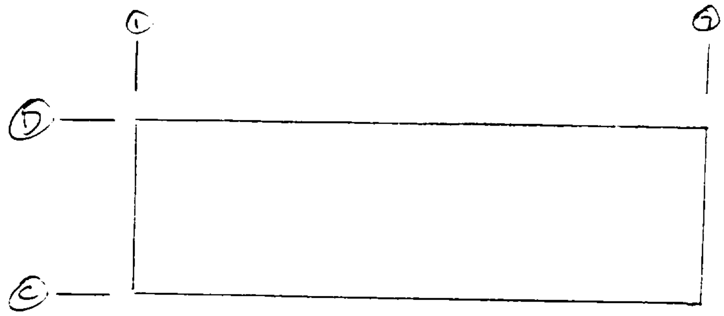
C. TRANSFER CELLS (Assume 200 psf) T = 1.33'



LX = 157.5'

LY = 32.5'

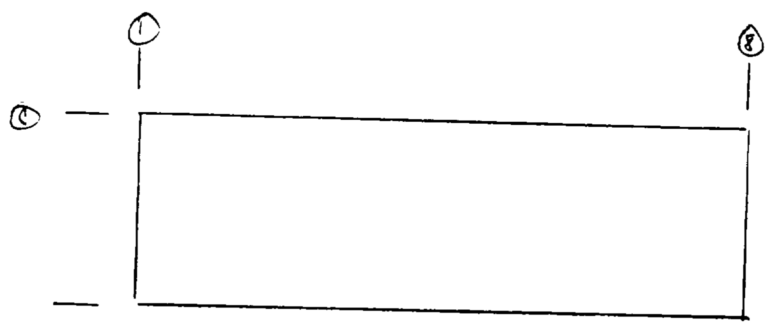
T = 1.33'

X_0 = 194.75'

Y_0 = 16.25'

Z_0 = 100.

D. TRANSPORTER AISLE Assume 150 psf (T = 1')



LX = 187.5'

LY = 42'

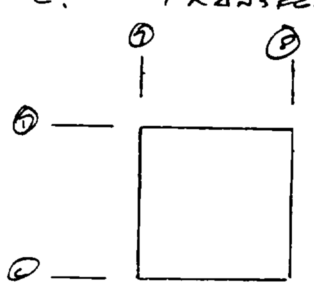
T = 1'

X_0 = 179.75'

Y_0 53.5'

Z_0 = 100'

E. TRANSFER EQUIP LAYDOWN AREA Assume 50 psf

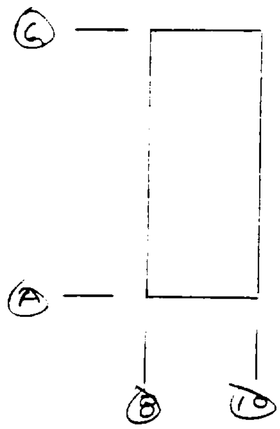


LX = 30' X_0 = 101'

LY = 32.5' Y_0 = 16.25'

T = .33' Z_0 = 100'

F. LOAD/UNLOAD BAY (ASSUME 150 psf)



LX = 50'

LY = 205'

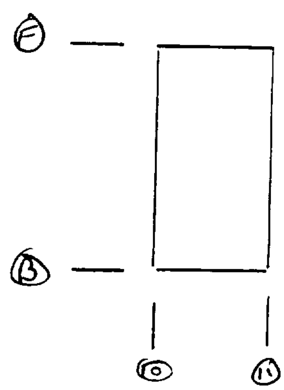
T = 1'

X_o = 61'

Y_o = 0

Z_o = 100'

G LAYDOWN AREAS ASSUME 50 psf



LX = 30'

LY = 135'

T = .33'

X_o = 21.

Y_o = 0

Z_o = 100'

STONE & WEBSTER, INC.
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CALCULATION IDENTIFICATION NUMBER				PAGE A-8
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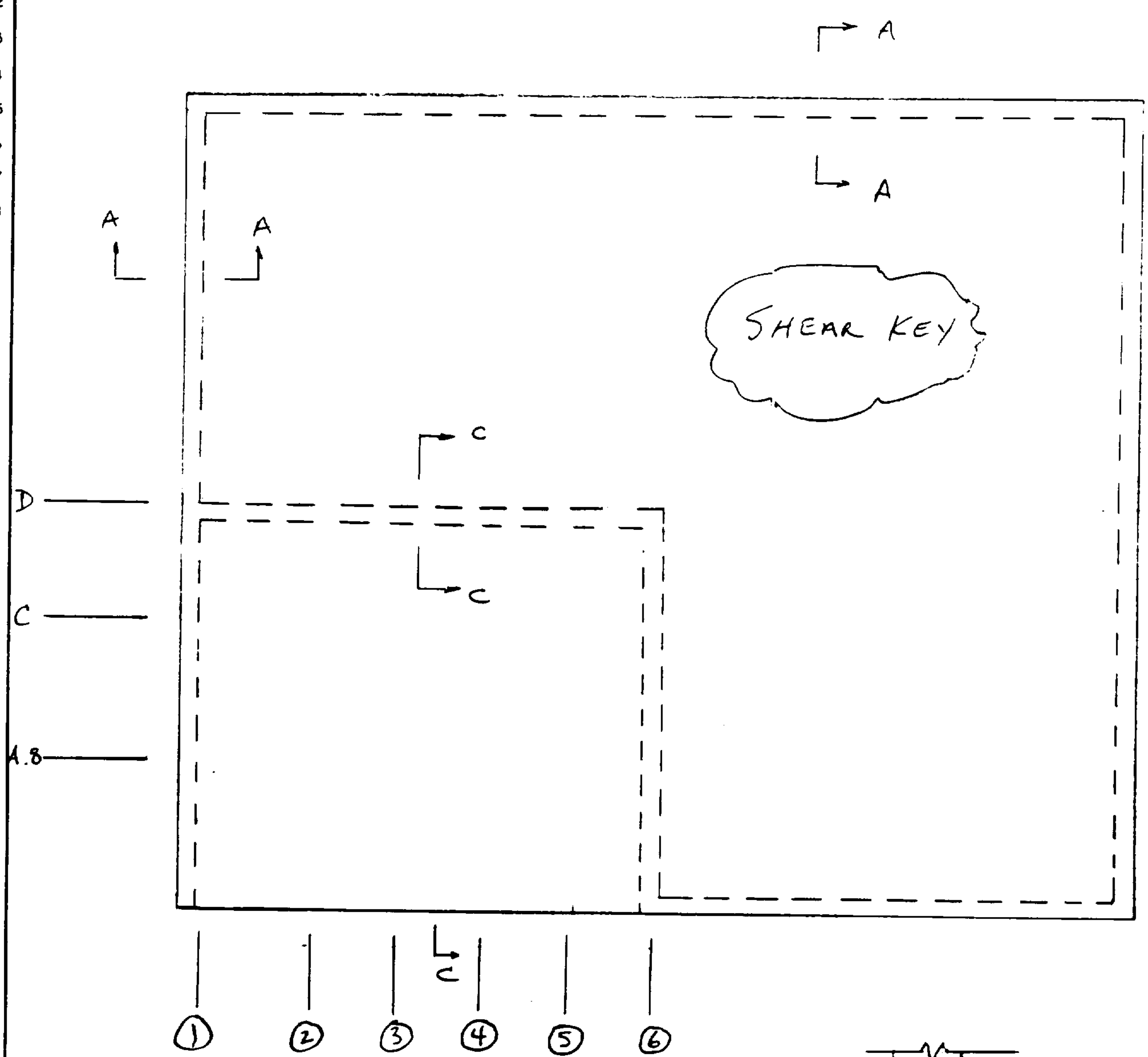
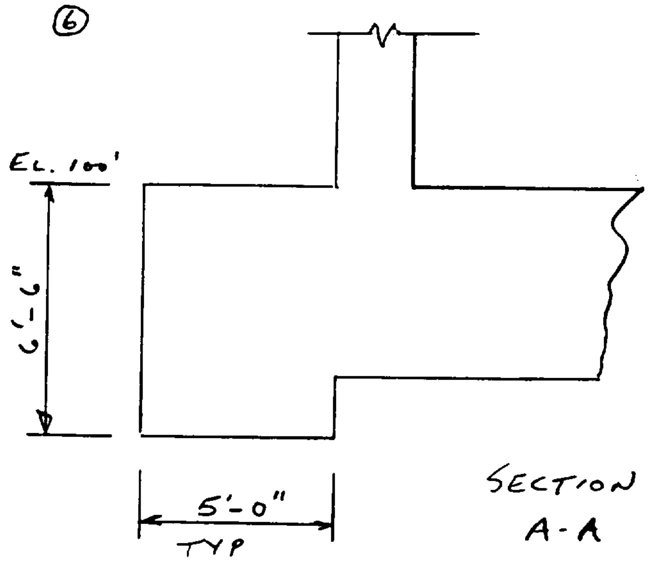
05996.02		SC-5		



Note: The shear key is entered into 'MASS' as walls 1.5' HIGH AND 5' THICK



SECTION A-A

ST-237 MASS VERS-00, LEVEL-01 77.301 08.57.37

Calc. 0596.02-SC-5

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```
INPUT ECHO
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 100.
 15.       187.5     2.        179.75    -32.5     107.5
 15.        30.      2.         21.       67.5     107.5
 15.        30.      2.         21.       32.5     107.5
 15.        30.      2.         21.      -32.5     107.5
 15.        30.      2.         21.      -67.5     107.5
 15.         8.      2.        268.5      32.5     107.5
 15.        28.      2.        228.5      32.5     107.5
 15.        28.      2.        178.5      32.5     107.5
 15.        56.5     2.        114.25     32.5     107.5
 15.         3.5     2.         84.25   -102.5     107.5
 15.         7.0     2.         61.0    -102.5     107.5
 15.         3.5     2.         37.75   -102.5     107.5
 15.         3.5     2.         84.25    102.5     107.5
 15.         7.0     2.         61.0     102.5     107.5
 15.         3.5     2.         37.75    102.5     107.5
 12.        33.      1.        256.      -14.      106.
 30.        36.      1.        254.5      0.       115.
 30.        37.      1.        205.       0.       115.
 30.        37.      1.        155.       0.       115.
 30.         7.5     1.        119.75     0.       115.
 1.5       279.5     5.        139.75   -117.5      94.25
 1.5       136.      5.        206.5      2.5      94.25
 1.5       143.5     5.         61.      117.5      94.25
9999.
 15.       144.5     2.        273.5      3.5      107.5
 15.        70.0     2.         86.0     67.5      107.5
 15.        70.0     2.         86.0    -67.5      107.5
 15.        35.0     2.         36.      85.       107.5
 15.        35.0     2.         36.     -85.       107.5
 15.       135.0     2.          6.       0.       107.5
 12.         8.      1.        240.     -26.5      106.
 20.        32.5     1.        216.      16.25     110.
 20.        32.5     1.        166.      16.25     110.
 20.        32.5     1.        116.      16.25     110.
 1.5       235.      5.        277.       2.5       94.25
 1.5       110.      5.        141.      60.0       94.25
 1.5       230.      5.          2.5      0.        94.25
9999.
9999.
9999.
279.5      240.      5.        139.75     0.        97.5
 32.        17.       .5       256.5    -23.       111.75
187.5       35.       .33      179.75   -50.       100.
187.5       32.5      .33      179.75   -16.25     100.
157.5       32.5     1.33      194.75    16.25     100.
187.5       42.      1.00      179.75    53.5      100.
 30.        32.5      .33      101.      16.25     100.
 50.       205.      1.0        61.       0.       100.
 30.       135.       .33       21.       0.       100.
```

Calc. 0596.02-SC-5

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INPUT ECHO

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
9999.                                                                             51
9999.                                                                             52
9999.                                                                             53
9999.                                                                             54
 139.75      0.0       95.0      0.                                               55
9999.                                                                             56
```

Calc. 0596.02-5C-5

SKULL VALLEY CTB MASS EL. 100.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
15.000	187.500	2.000	179.750	-32.500	107.500
15.000	30.000	2.000	21.000	67.500	107.500
15.000	30.000	2.000	21.000	32.500	107.500
15.000	30.000	2.000	21.000	-32.500	107.500
15.000	30.000	2.000	21.000	-67.500	107.500
15.000	8.000	2.000	268.500	32.500	107.500
15.000	28.000	2.000	228.500	32.500	107.500
15.000	28.000	2.000	178.500	32.500	107.500
15.000	56.500	2.000	114.250	32.500	107.500
15.000	3.500	2.000	84.250	-102.500	107.500
15.000	7.000	2.000	61.000	-102.500	107.500
15.000	3.500	2.000	37.750	-102.500	107.500
15.000	3.500	2.000	84.250	102.500	107.500
15.000	7.000	2.000	61.000	102.500	107.500
15.000	3.500	2.000	37.750	102.500	107.500
12.000	33.000	1.000	256.000	-14.000	106.000
30.000	36.000	1.000	254.500	0.0	115.000
30.000	37.000	1.000	205.000	0.0	115.000
30.000	37.000	1.000	155.000	0.0	115.000
30.000	7.500	1.000	119.750	0.0	115.000
1.500	279.500	5.000	139.750	-117.500	94.250
1.500	136.000	5.000	206.500	2.500	94.250
1.500	143.500	5.000	61.000	117.500	94.250

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
15.000	144.500	2.000	273.500	3.500	107.500
15.000	70.000	2.000	86.000	67.500	107.500
15.000	70.000	2.000	86.000	-67.500	107.500
15.000	35.000	2.000	36.000	85.000	107.500
15.000	35.000	2.000	36.000	-85.000	107.500
15.000	135.000	2.000	6.000	0.0	107.500
12.000	8.000	1.000	240.000	-26.500	106.000
20.000	32.500	1.000	216.000	16.250	110.000
20.000	32.500	1.000	166.000	16.250	110.000
20.000	32.500	1.000	116.000	16.250	110.000
1.500	235.000	5.000	277.000	2.500	94.250
1.500	110.000	5.000	141.000	60.000	94.250
1.500	230.000	5.000	2.500	0.0	94.250

RECT. FLOORS AND MAT

LX	LY	T	X0	Y0	Z0	ALFA
279.500	240.000	5.000	139.750	0.0	97.500	0.0
32.000	17.000	0.500	256.500	-23.000	111.750	0.0

0599.02-SC-5

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187.500	35.000	0.330	179.750	-50.000	100.000	0.0
187.500	32.500	0.330	179.750	-16.250	100.000	0.0
157.500	32.500	1.330	194.750	16.250	100.000	0.0
187.500	42.000	1.000	179.750	53.500	100.000	0.0
30.000	32.500	0.330	101.000	16.250	100.000	0.0
50.000	205.000	1.000	61.000	0.0	100.000	0.0
30.000	135.000	0.330	21.000	0.0	100.000	0.0

X0= 138.86 Y0= 0.73 Z0= 98.54 M= 1908.34

MASS MOMENTS OF INERTIA:

ORIGIN

IX= 27060144.0 IY= 68252464.0 IZ= 58196240.0 IXY= 218679.81

CENTROID

IX= 8527616.00 IY= 12924304.0 IZ= 21398544.0 IXY= 24434.87

BASE

IX= 27059104.0 IY= 31455792.0 IZ= 21398544.0 IXY= 24434.87

PRINCIPAL AXIS OF INERTIA AT 0.32 DEGREES:

IX= 8527479.00 IY= 12924438.0 IZ= 21398544.0 IXY= 0.05

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 139.750 0.0 95.000 0.0

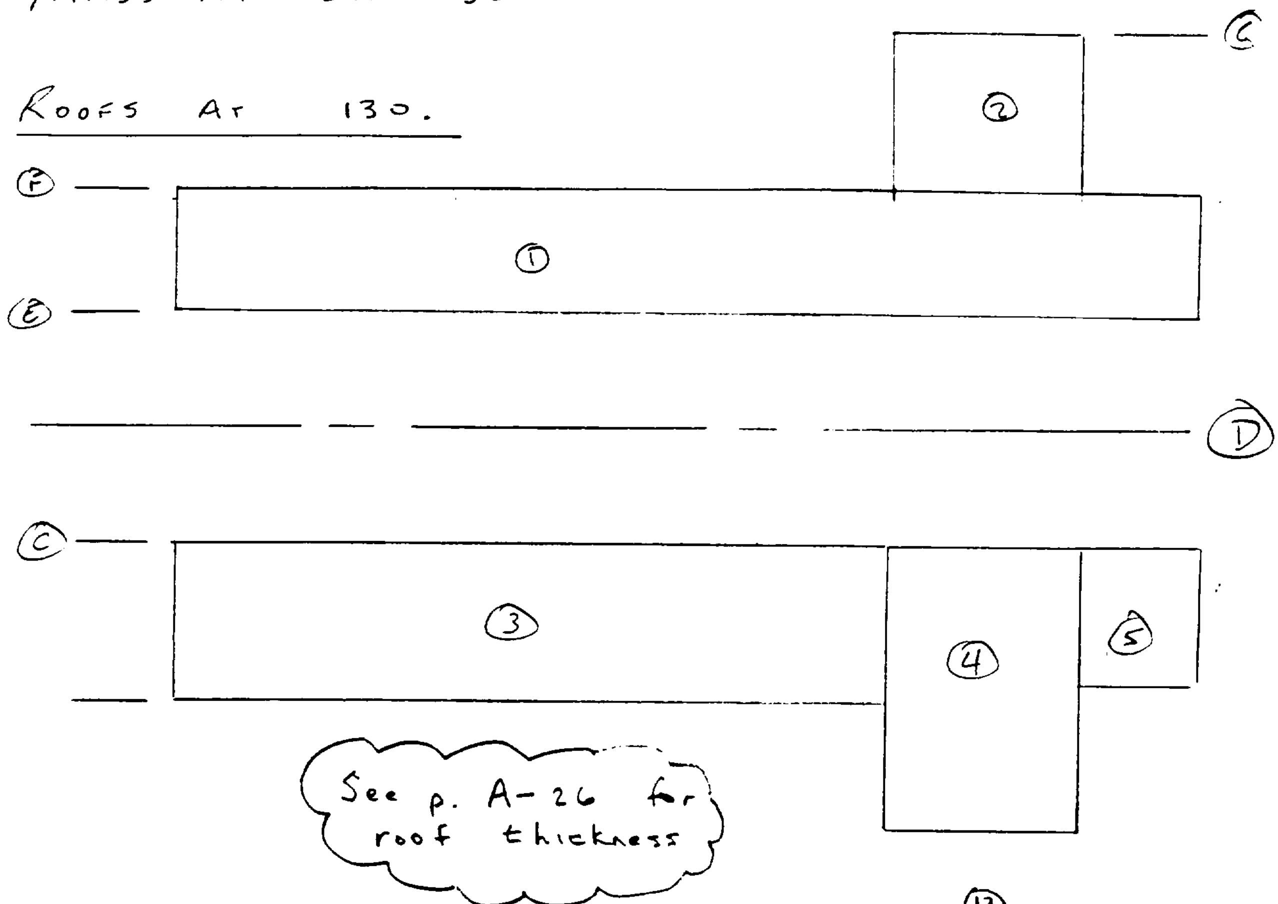
IX= 8552600.00 IY= 12949775.0 IZ= 21401072.0 IXY= 23189.40

Calc. 0596.02-SC-5

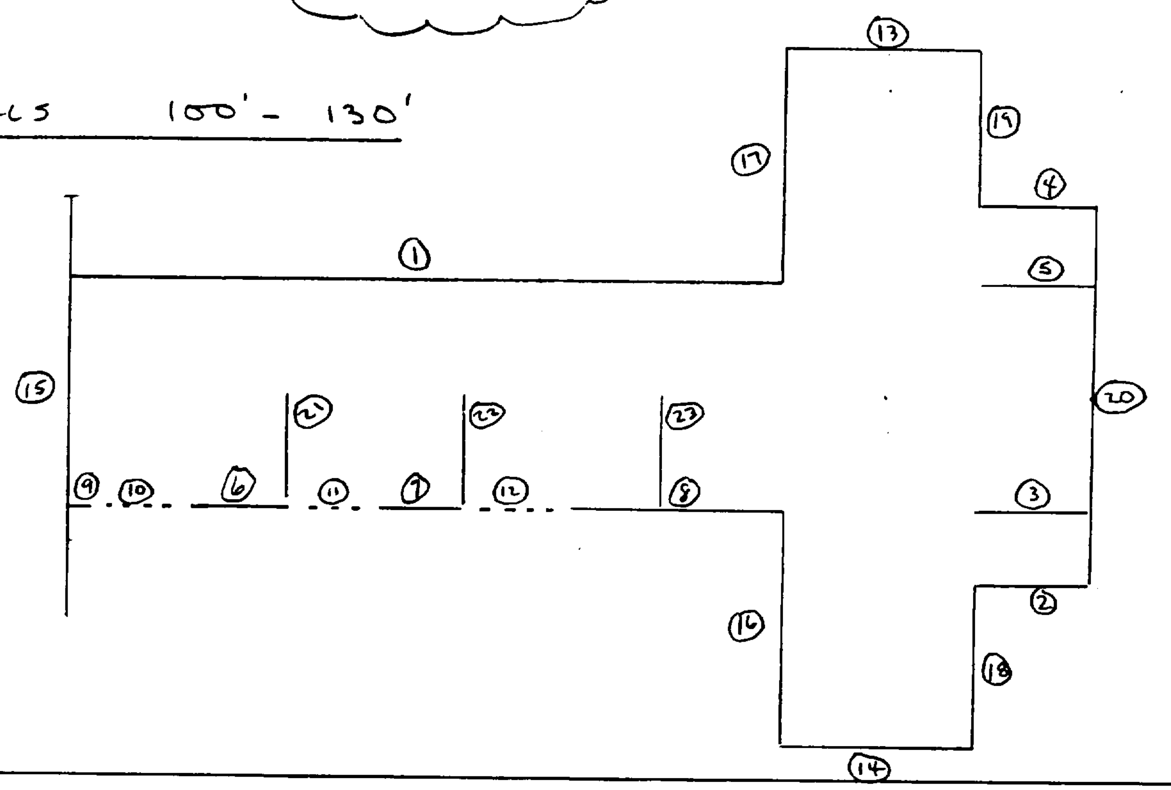
CALCULATION IDENTIFICATION NUMBER				PAGE A-14
J.O. OR W.O. NO. 05996.02	DIVISION & GROUP	CALCULATION NO. SC-5	OPTIONAL TASK CODE	

MASS AT El. 130

ROOFS AT 130.



WALLS 100' - 130'



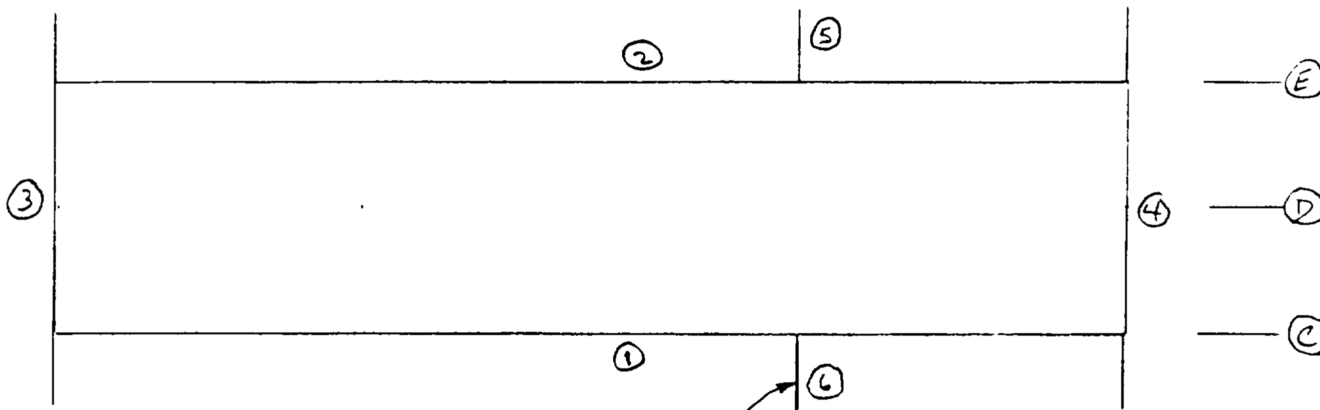
STONE & WEBSTER, INC.
CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				PAGE A-15
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
05996.02		SC-5		

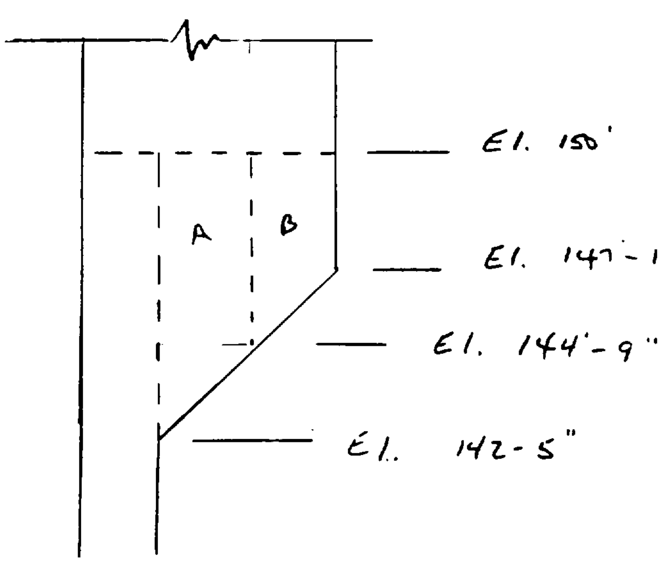
CHECKED [initials]

WALLS 130' - 170'



See p. A-16

CRANE SUPPORTS (Col. Line C only)



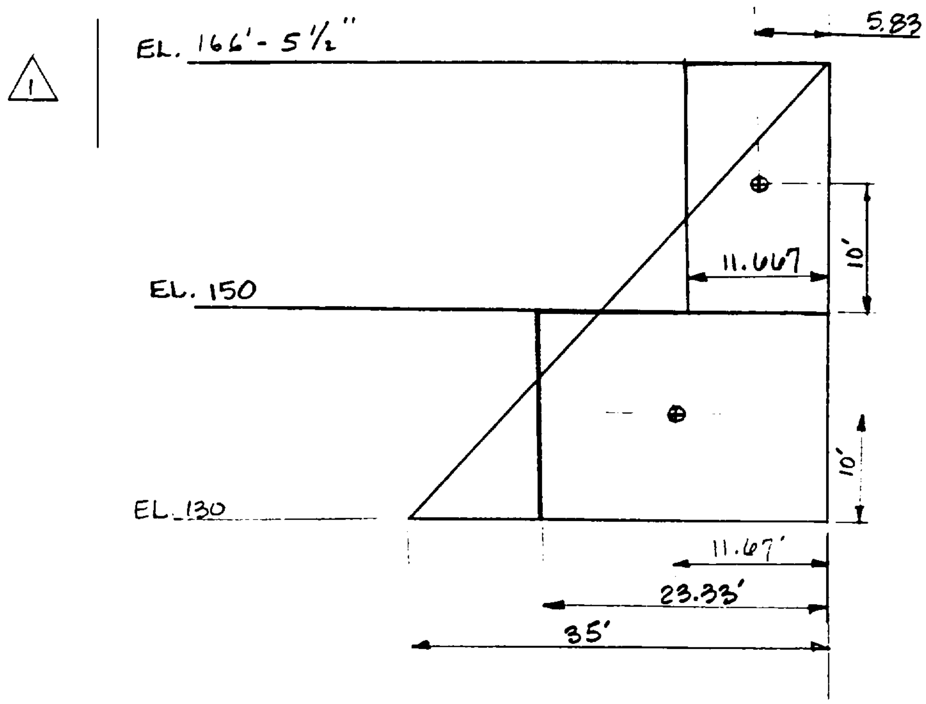
Piece A

Height ≈ 6.4'

Piece B

Height ≈ 4.1'

Note: The heights of walls A & B were entered into 'MASS' As 5' & 3', respectively. Insignificant effect on results



TRIANGULAR WALLS MODELED AS RECTANGULAR @ col. lines 1, 6 & 11.

LOWER RECTANGLE BASE DIMENSION:

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

UPPER RECTANGLE BASE DIMENSION:

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

ST-237 MASS VERS-00, LEVEL-01 77.301 08.57.37

Calc. 0596.02-SC-5

```
INPUT ECHO
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 130.
  15.       187.5      2.        179.75    -32.5      122.5
  15.        30.       2.         21.       67.5      122.5
  15.        30.       2.         21.       32.5      122.5
  15.        30.       2.         21.      -67.5      122.5
  15.        30.       2.         21.      -32.5      122.5
  15.        25.       2.        228.5      32.5      122.5
  15.        25.       2.        178.5      32.5      122.5
  15.        55.       2.        113.5      32.5      122.5
  15.         8.       2.        268.5      32.5      122.5
   6.        22.       2.        253.5      32.5      127.0
   6.        22.       2.        203.5      32.5      127.0
   6.        22.       2.        153.5      32.5      127.0
   7.        50.       2.         61.     -102.5      126.5
   7.        50.       2.         61.      102.5      126.5
  20.       267.5      2.        139.75     32.5      140.
  20.       267.5      2.        139.75    -32.5      140.
   5.       187.5      2.33      179.5     30.33      147.5
   3.       187.5      2.33      179.5     28.00      148.5
9999.
  15.       144.5      2.        273.5       3.5      122.5
  15.        70.0      2.         86.0      67.5      122.5
  15.        70.0      2.         86.0     -67.5      122.5
  15.        35.0      2.         36.       85.       122.5
  15.        35.0      2.         36.      -85.       122.5
  15.       135.0      2.          6.        0.       122.5
  10.        32.5      1.        216.       16.25     120.
  10.        32.5      1.        166.       16.25     120.
  10.        32.5      1.        116.       16.25     120.
  20.       111.6      2.        273.5       0.       140.
  20.       111.6      2.          6.        0.       140.
  20.        23.3      2.         86.       44.17     140.
  20.        23.3      2.         86.      -44.17     140.
9999.
9999.
9999.
267.5        35.       1.02      139.75    -50.       130.
 50.         35.       1.02       61.      -85.       130.
187.5        42.       1.02      179.75     53.5      130.
 50.         70.       1.02       61.       67.5      130.
 30.         35.       1.02       21.       50.0      130.
9999.
9999.
9999.
9999.
 131.46      2.02     130.0        0.
9999.
```

Calc. 05996.02-SC-5

A-18

SKULL VALLEY CTB MASS EL. 130.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
15.000	187.500	2.000	179.750	-32.500	122.500
15.000	30.000	2.000	21.000	67.500	122.500
15.000	30.000	2.000	21.000	32.500	122.500
15.000	30.000	2.000	21.000	-67.500	122.500
15.000	30.000	2.000	21.000	-32.500	122.500
15.000	25.000	2.000	228.500	32.500	122.500
15.000	25.000	2.000	178.500	32.500	122.500
15.000	55.000	2.000	113.500	32.500	122.500
15.000	8.000	2.000	268.500	32.500	122.500
6.000	22.000	2.000	253.500	32.500	127.000
6.000	22.000	2.000	203.500	32.500	127.000
6.000	22.000	2.000	153.500	32.500	127.000
7.000	50.000	2.000	61.000	-102.500	126.500
7.000	50.000	2.000	61.000	102.500	126.500
20.000	267.500	2.000	139.750	32.500	140.000
20.000	267.500	2.000	139.750	-32.500	140.000
5.000	187.500	2.330	179.500	30.330	147.500
3.000	187.500	2.330	179.500	28.000	148.500

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
15.000	144.500	2.000	273.500	3.500	122.500
15.000	70.000	2.000	86.000	67.500	122.500
15.000	70.000	2.000	86.000	-67.500	122.500
15.000	35.000	2.000	36.000	85.000	122.500
15.000	35.000	2.000	36.000	-85.000	122.500
15.000	135.000	2.000	6.000	0.0	122.500
10.000	32.500	1.000	216.000	16.250	120.000
10.000	32.500	1.000	166.000	16.250	120.000
10.000	32.500	1.000	116.000	16.250	120.000
20.000	111.600	2.000	273.500	0.0	140.000
20.000	111.600	2.000	6.000	0.0	140.000
20.000	23.300	2.000	86.000	44.170	140.000
20.000	23.300	2.000	86.000	-44.170	140.000

RECT. FLOORS AND MAT

LX	LY	T	X0	Y0	Z0	ALFA
267.500	35.000	1.020	139.750	-50.000	130.000	0.0
50.000	35.000	1.020	61.000	-85.000	130.000	0.0
187.500	42.000	1.020	179.750	53.500	130.000	0.0
50.000	70.000	1.020	61.000	67.500	130.000	0.0
30.000	35.000	1.020	21.000	50.000	130.000	0.0

X0= 131.46 Y0= 2.02 Z0= 131.80 M= 420.40

Calc. 0596.02-SC-5

MASS MOMENTS OF INERTIA:

ORIGIN

IX=	8301387.00	IY=	18028576.0	IZ=	11655240.0	IXY=	153047.31

CENTROID

IX=	996358.00	IY=	3460428.00	IZ=	4388691.00	IXY=	41418.06

BASE

IX=	8299671.00	IY=	10763741.0	IZ=	4388691.00	IXY=	41418.06

PRINCIPAL AXIS OF INERTIA AT 0.96 DEGREES:

IX=	995661.87	IY=	3461123.00	IZ=	4388691.00	IXY=	0.02

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 131.460 2.020 130.000 0.0

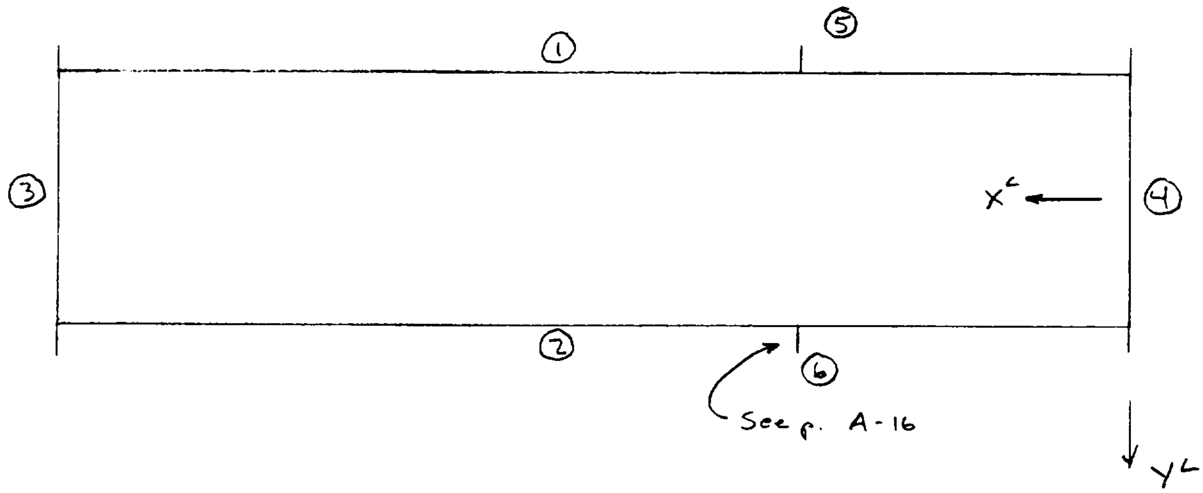
IX=	997726.19	IY=	3461796.00	IZ=	4388691.00	IXY=	41418.06

Calc. 05996.02-SC-5

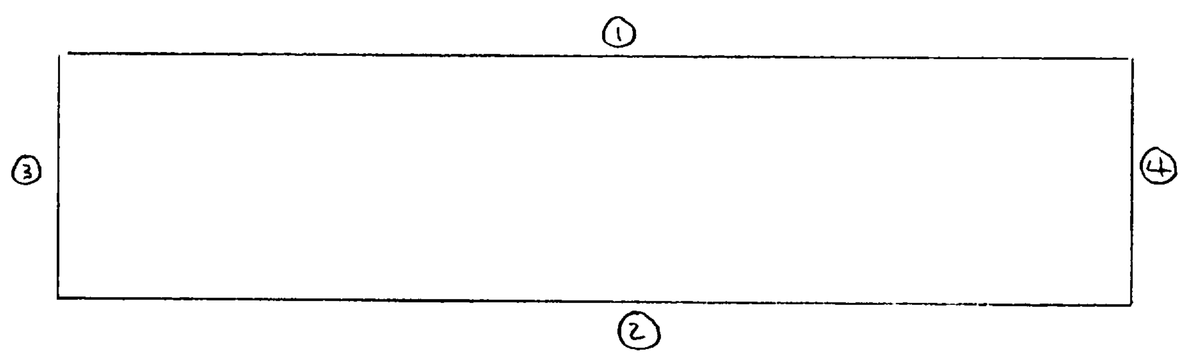
CHECK [illegible]

MASS AT EL. 170'-0"

WALLS BELOW 170'

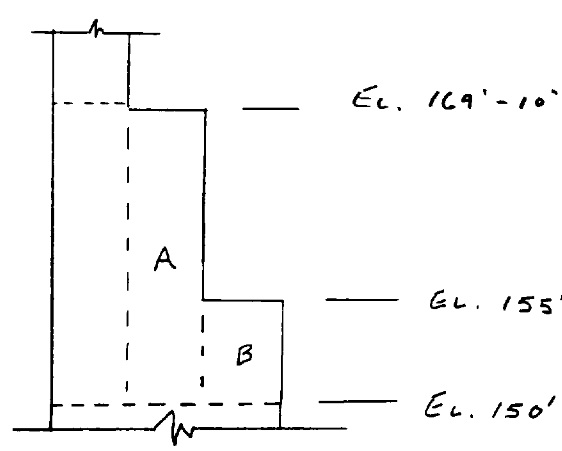


WALLS ABOVE 170'



CRANE SUPPORTS

COLUMN LINE C



STONE & WEBSTER, INC.
CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE A-22
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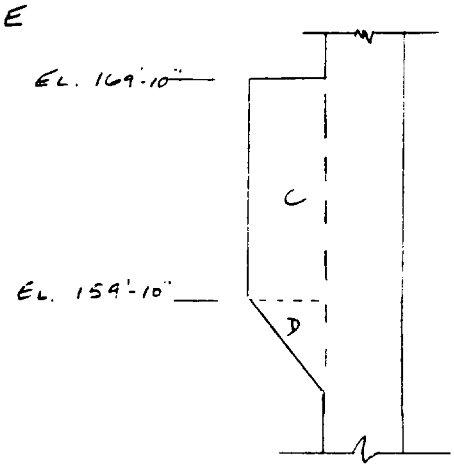
CHECKED HC

COL. LINE E



NOTE: PORTION 'D' ABOVE WAS NOT INCLUDED IN THE 'MASS' RUN. INSIGNIFICANT EFFECT ON RESULTS

INPUT ECHO

```
          1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 170.
 20.       267.5     2.        139.75    -32.5     160.
 20.       267.5     2.        139.75     32.5     160.
 10.       267.5     2.        139.75    -32.5     175.
 10.       267.5     2.        139.75     32.5     175.
 20.       187.5     2.33      179.75     30.33    160.
 5.        187.5     2.33      179.75     28.00    152.5
 10.       267.5     2.33      139.75    -30.33    165.
 10.        80.      2.33       46.       30.33    165.
9999.
 20.       88.34     2.        273.5      0.       160.
 20.       88.34     2.          6.       0.       160.
 20.       11.67     2.         86.     -38.33     158.229
 20.       11.67     2.         86.      38.33     158.229
 10.       65.       2.        273.5      0.       175.
 10.       65.       2.          6.       0.       175.
9999.
9999.
9999.
9999.
9999.
9999.
9999.
 143.18      3.14     170.0      0.
9999.
```

Calc. 05996.02-SC-5

CHECKED

A-23

SKULL VALLEY CTB MASS EL. 170.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
20.000	267.500	2.000	139.750	-32.500	160.000
20.000	267.500	2.000	139.750	32.500	160.000
10.000	267.500	2.000	139.750	-32.500	175.000
10.000	267.500	2.000	139.750	32.500	175.000
20.000	187.500	2.330	179.750	30.330	160.000
5.000	187.500	2.330	179.750	28.000	152.500
10.000	267.500	2.330	139.750	-30.330	165.000
10.000	80.000	2.330	46.000	30.330	165.000

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
20.000	88.340	2.000	273.500	0.0	160.000
20.000	88.340	2.000	6.000	0.0	160.000
20.000	11.670	2.000	86.000	-38.330	158.229
20.000	11.670	2.000	86.000	38.330	158.229
10.000	65.000	2.000	273.500	0.0	175.000
10.000	65.000	2.000	6.000	0.0	175.000

X0= 143.18 Y0= 3.14 Z0= 163.60 M= 287.78

MASS MOMENTS OF INERTIA:

ORIGIN

IX= 7991119.00 IY= 15813635.0 IZ= 8363549.00 IXY= 162316.50

CENTROID

IX= 286215.00 IY= 2211589.00 IZ= 2460740.00 IXY= 33019.44

BASE

IX= 7988285.00 IY= 9913659.00 IZ= 2460740.00 IXY= 33019.44

PRINCIPAL AXIS OF INERTIA AT 0.98 DEGREES:

IX= 285648.87 IY= 2212154.00 IZ= 2460740.00 IXY= 0.01

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 143.180 3.140 170.000 0.0

IX= 298016.44 IY= 2223390.00 IZ= 2460740.00 IXY= 33019.43

Calc. 05996.02-SC-5

STONE & WEBSTER ENGINEERING CORPORATION

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J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE A-25
05996.02		SC-5		

CHECKED WL.

MASS OF CRANE:

FROM PRELIMINARY DESIGNS, THE WEIGHT OF THE GANTRY CRANE IS 310 K, AND THE SEMI-GANTRY 222 K (TEL-CON WITH WAYNE LEWIS)

ALTHOUGH SOME OF THE WEIGHT OF THE SEMI-GANTRY CRANE WILL ACT AT EL 100, THE MASS OF BOTH CRANES WILL BE INCLUDED AT EL. 170'

$$M = \frac{310 + 222}{32.17} = 16.5 \quad \frac{K\text{-}SEC^2}{FT}$$

TOTAL MASS AT EL. 170 =

$$287.8 + 16.5 = 304.3 \quad \frac{K\text{-}SEC^2}{FT}$$

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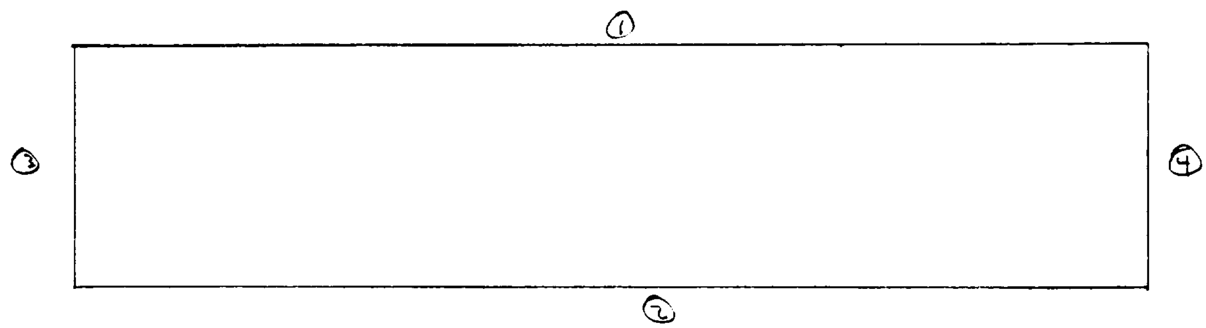
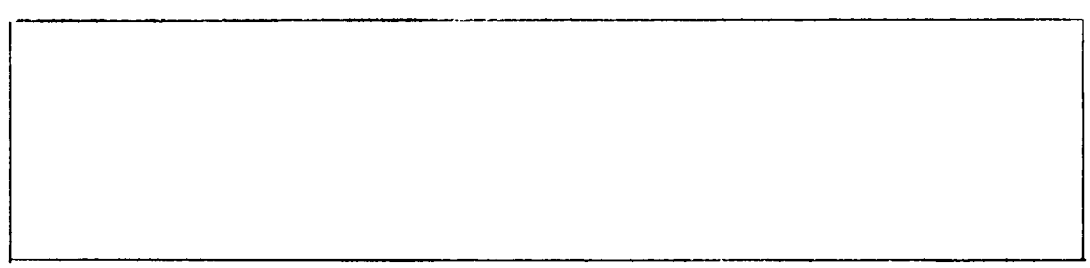
CHECKED [initials]

MASS AT EL. 190'-0"

WALLS BELOW 190



ROOF AT 190



EQUIVALENT THICKNESS OF ROOF

Assume 9½" SLAB $w = \frac{9.5}{12}(150) = 119$ psf

Steel BEAM & GIRDERS = 25 psf

Assume 10 psf for LL & EQUIP 10 psf

Equivalent Conc. Thick $= \frac{119 + 25 + 10}{150} = 1.02'$

```
INPUT ECHO
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY CTB  MASS EL. 190.
 10.       267.5     2.        139.75    -32.5     185.
 10.       267.5     2.        139.75     32.5     185.
9999.
 10.       65.       2.        273.5      0.       185.
 10.       65.       2.          6.       0.       185.
9999.
9999.
9999.
267.5      65.       1.02       139.75    0.        190.
9999.
9999.
9999.
9999.
 139.75      0.00    190.0      0.
9999.
```

Calc. 05996.02-SC-5

CHECKED

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SKULL VALLEY CTB MASS EL. 190.

WALLS IN X DIRECTION

H	L	T	X0	Y0	Z0
10.000	267.500	2.000	139.750	-32.500	185.000
10.000	267.500	2.000	139.750	32.500	185.000

WALLS IN Y DIRECTION

H	L	T	X0	Y0	Z0
10.000	65.000	2.000	273.500	0.0	185.000
10.000	65.000	2.000	6.000	0.0	185.000

RECT. FLOORS AND MAT

LX	LY	T	X0	Y0	Z0	ALFA
267.500	65.000	1.020	139.750	0.0	190.000	0.0

X0= 139.75 Y0= 0.0 Z0= 187.86 M= 144.71

MASS MOMENTS OF INERTIA:

ORIGIN

IX= 5194331.00 IY= 8941891.00 IZ= 3919755.00 IXY= 0.0

CENTROID

IX= 87509.00 IY= 1008900.00 IZ= 1093586.00 IXY= 0.0

BASE

IX= 5194331.00 IY= 6115722.00 IZ= 1093586.00 IXY= 0.0

PRINCIPAL AXIS OF INERTIA AT 0.0 DEGREES:

IX= 87509.00 IY= 1008900.00 IZ= 1093586.00 IXY= 0.0

MASS PROPERTIES ABOUT THE NEW AXIS SYSTEM 139.750 0.0 190.000 0.0

IX= 88173.44 IY= 1009564.44 IZ= 1093586.00 IXY= 0.0

Calc. 05996.02-SC-5

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STONE & WEBSTER, INC.
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▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE A-29
05996.02		SC-5		

CHECKED NO

TOTAL MASS OF BUILDING

NODE 1	1908.34
NODE 2	420.40
NODE 3	304.3
NODE 4	144.71
TOTAL	2778.

WEIGHT = 2778 (32.17) = 89368 KIPS

SINCE THE MODEL INCLUDES SOME LIVE LOAD, CRANES, AND STEEL BEAMS, THE CONCRETE WEIGHT IS ESTIMATED AS 95% OF THE TOTAL

CONCRETE WT. = .95 (89368) = 84900 KIPS

CONCRETE VOL. = $\frac{84,900}{.15}$ = 566,000 CF = 20,963 cu. yds

Estimate concrete volume as

21,000 cu yds ± 5%

ATTACHMENT B BUILDING STIFFNESS

The building stiffness for members between mass points is determined by first calculating the area properties (area, shear areas, torsional constant, moments of inertia, center of area, and center of rigidity) of the walls between the elevations. For the walls between El. 100'-0" and El. 130'-0" (member 1) these properties are calculated using the SWEC computer program SECPROP3. For the walls between El. 130'-0" and El. 170-0" and those between El. 170'-0" and El. 190'-0" (members 2 and 3, respectively), hand calculations are used.

Once the area properties are known, a member stiffness matrix, in the FRIDAY local coordinate system, is developed using the SWEC computer programs RIG3 (member 1) and RIG4 (members 2 and 3). These matrices provide the stiffness between the center of mass of the mass point above and the mass point below, and account for the misalignment the center of rigidity and the centers of mass.

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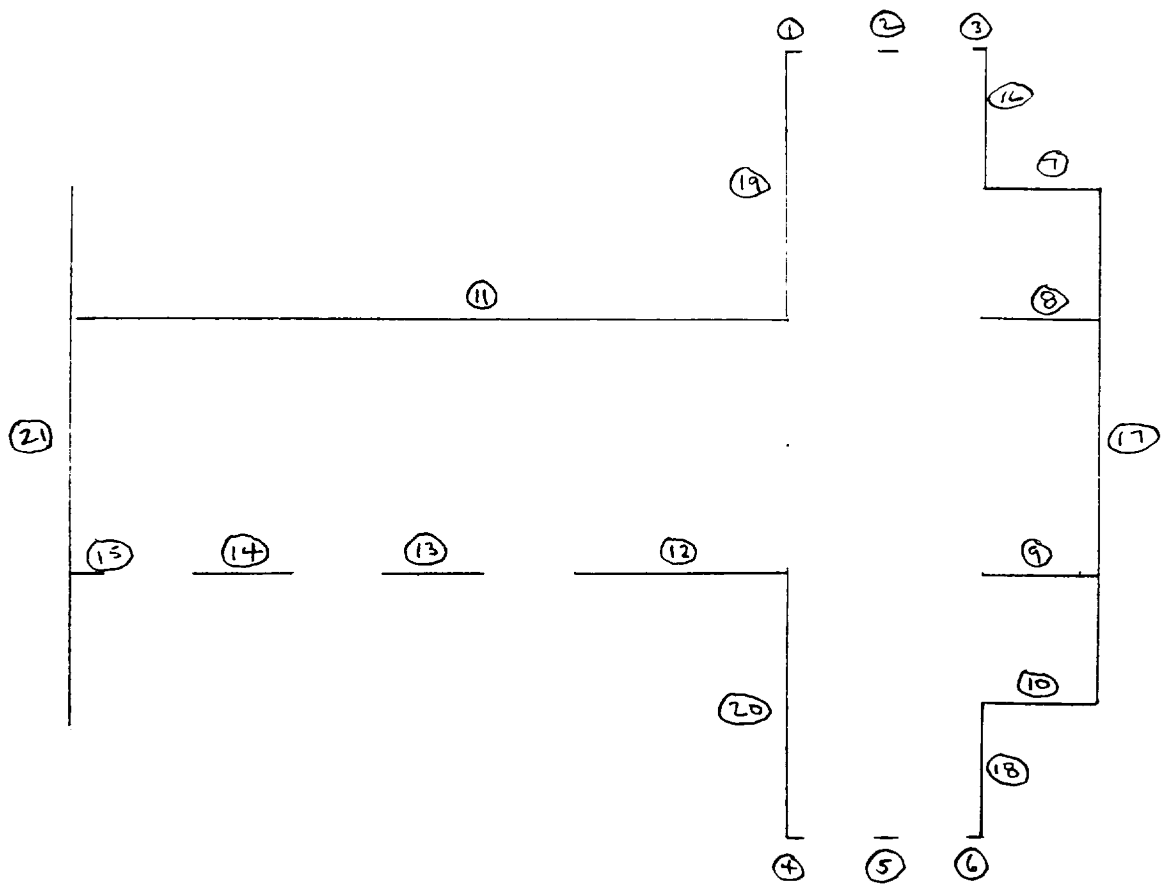
CALCULATION IDENTIFICATION NUMBER				PAGE B-7
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	

STIFFNESS PROPERTIES 100 - 130



THE 'SECPROP3' RUN FOR THIS CONFIGURATION IS ON PAGES B-6 THROUGH B-8. RESULTING AREA, SHEAR AREAS, TORSIONAL CONSTANT, AREA CENTER AND CENTER OF RIGIDITY ARE USED. FOR BENDING STIFFNESS, THE MODELS ARE MODIFIED TO ACCOUNT FOR SHEAR LAG (SECTION 3.1.8.3 OF REF. 3). MODELS FOR BENDING IN THE N-S AND E-W DIRECTIONS FOLLOW.

STONE & WEBSTER ENGINEERING CORPORATION

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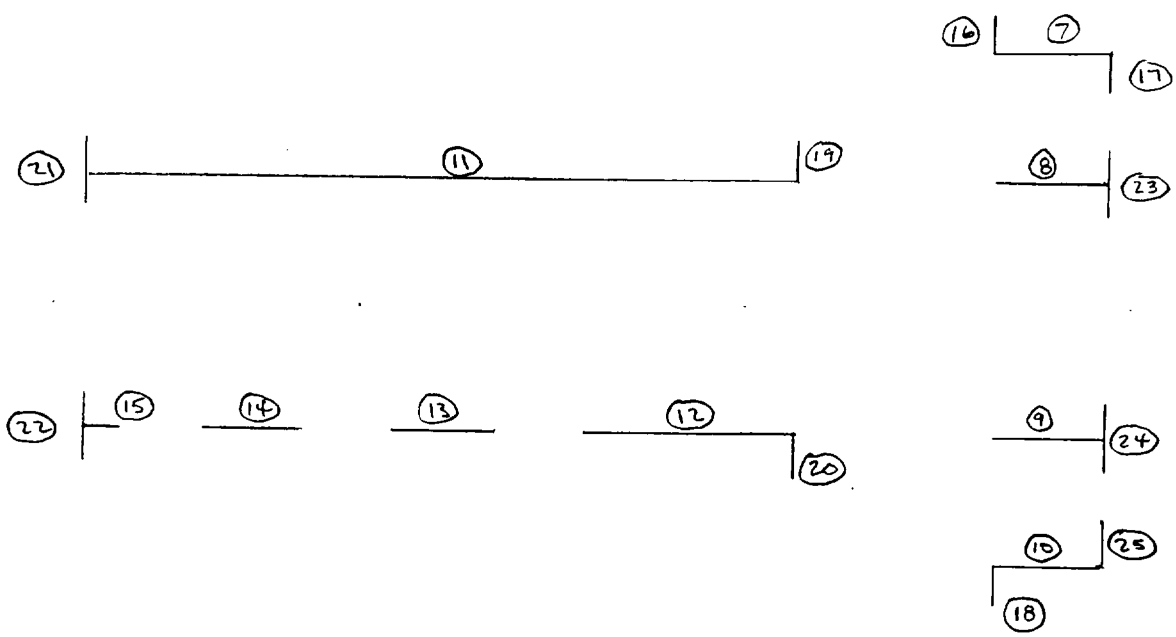
CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE B-3

A. N-S DIRECTION



SEE PAGES B-9 THROUGH B-11. ONLY THE VALUE OF IY FROM THIS MODEL WAS USED.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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CALCULATION IDENTIFICATION NUMBER				
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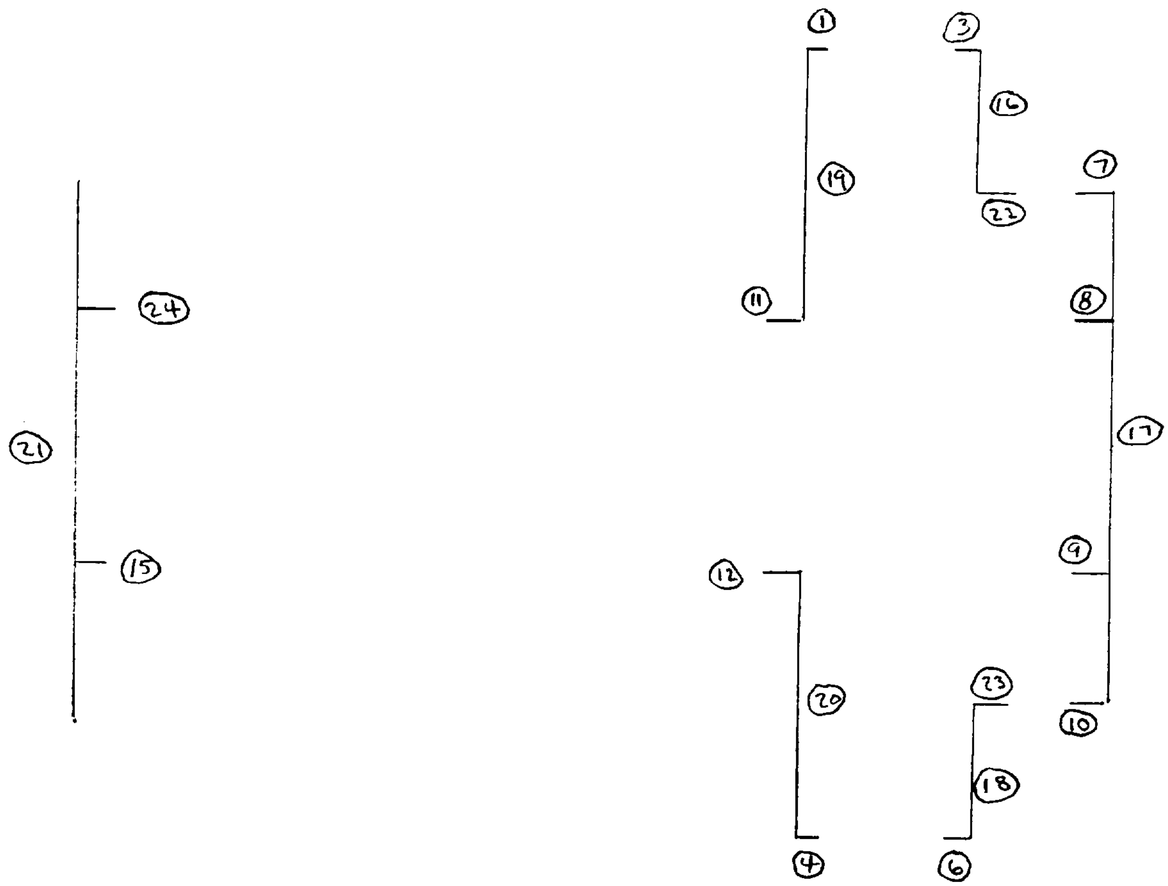
B. E-W DIRECTION



SEE PAGES B-12 THROUGH B-14. ONLY THE VALUE OF IX FROM THIS MODEL IS USED.

SUMMARY OF PROPERTIES

AREA	1888	FT^2
SHEAR AREA X_G	762	FT^2
SHEAR AREA Z_G	812	FT^2
I ABOUT X_G	4.09×10^6	FT^4
I ABOUT Z_G	9.86×10^6	FT^4
TORSIONAL CONST.	10.2×10^6	FT^4
X_G C.G.	119.08'	
Z_G C.G.	1.75'	
X_G C.R.	113.86'	
Z_G C.R.	8.11'	

THESE PROPERTIES ARE USED AS INPUT TO RIG3, TO GET THE STIFFNESS MATRIX FOR MEMBER 1. SEE PAGES B-15 THROUGH B-17 FOR THE INPUT AND OUTPUT. USING 4000 psi CONCRETE A POISSON'S RATIO OF .17

$$E = 57\sqrt{4000} = 3605 \text{ KSI} = 519\,000. \text{ KSF}$$

$$G = \frac{519{,}000}{2(1+.17)} = 222{,}000 \text{ KSF}$$

ST-244 SECPROP3 VERS-00 LEVEL-00 OCT 1992
Date of run: 03/06/2001 Time: 15:37:46.22

Skull Valley CTB Member 1 - SECPROP3

X1	Y1	X2	Y2	T	MASS/L
8.600E+01	1.025E+02	8.250E+01	1.025E+02	2.000E+00	2.795E-01
6.450E+01	1.025E+02	5.750E+01	1.025E+02	2.000E+00	2.795E-01
3.950E+01	1.025E+02	3.600E+01	1.025E+02	2.000E+00	2.795E-01
8.600E+01	-1.025E+02	8.250E+01	-1.025E+02	2.000E+00	2.795E-01
6.450E+01	-1.025E+02	5.750E+01	-1.025E+02	2.000E+00	2.795E-01
3.950E+01	-1.025E+02	3.600E+01	-1.025E+02	2.000E+00	2.795E-01
3.600E+01	6.750E+01	6.000E+00	6.750E+01	2.000E+00	2.795E-01
3.600E+01	3.250E+01	6.000E+00	3.250E+01	2.000E+00	2.795E-01
3.600E+01	-3.250E+01	6.000E+00	-3.250E+01	2.000E+00	2.795E-01
6.000E+00	-6.750E+01	3.600E+01	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	3.250E+01	2.735E+02	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-3.250E+01	1.425E+02	-3.250E+01	2.000E+00	2.795E-01
1.645E+02	-3.250E+01	1.925E+02	-3.250E+01	2.000E+00	2.795E-01
2.145E+02	-3.250E+01	2.425E+02	-3.250E+01	2.000E+00	2.795E-01
2.645E+02	-3.250E+01	2.735E+02	-3.250E+01	2.000E+00	2.795E-01
3.600E+01	1.025E+02	3.600E+01	6.750E+01	2.000E+00	2.795E-01
6.000E+00	6.750E+01	6.000E+00	-6.750E+01	2.000E+00	2.795E-01
3.600E+01	-1.025E+02	3.600E+01	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	1.025E+02	8.600E+01	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-1.025E+02	8.600E+01	-3.250E+01	2.000E+00	2.795E-01
2.735E+02	6.750E+01	2.735E+02	-7.450E+01	2.000E+00	2.795E-01

TOTAL ELEMENT 21 HEIGHT OF WALLS 30.00 C. WEIGHT OF MAT .15

******AREA******

TOTAL AREA OR MASS 1.8880000E+03

X-CG 1.1907865E+02 Y-CG 1.7457627E+00

IX-CG 5.2157943E+06 IY-CG 1.7820447E+07 IXY-CG 2.0867275E+05

INCLINATION OF PRINCIPAL AXIS 1.6549170E-02 RADIANS

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 5.2123406E+06 IY-P 1.7823901E+07

ADDITIONAL AREA PROPERTIES

COORDINATES OF CENTER OF RIGIDITY

XC 1.1385628E+02 YC 8.1090328E+00

SHEAR AREAS

AX 7.6166664E+02 AY 8.1166663E+02

SHEAR AREAS ABOUT PRINCIPAL AXES

AXP 7.7499413E+02 AYP 8.2415986E+02

TORSIONAL CONSTANT IS BASED UPON BENDING AND SHEAR
STIFFNESSES OF INDIVIDUAL ELEMENTS

TORSIONAL CONSTANT 1.0156574E+07

****** MASS ******

TOTAL AREA OR MASS 2.6385093E+02

X-CG 1.1907865E+02 Y-CG 1.7457627E+00

IX-CG 7.2891534E+05 IY-CG 2.4904351E+06 IXY-CG 2.9162341E+04

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 7.2843268E+05 IY-P 2.4909178E+06

LENGTHS OF ELEMENTS

3.500E+00 7.000E+00 3.500E+00 3.500E+00 7.000E+00 3.500E+00 3.000E+01
3.000E+01

3.000E+01 3.000E+01 1.875E+02 5.650E+01 2.800E+01 2.800E+01 9.000E+00
3.500E+01

1.350E+02 3.500E+01 7.000E+01 7.000E+01 1.420E+02

ELEMENT SHEAR AREA ALONG X

5.833333E+00 1.166667E+01 5.833333E+00 5.833333E+00 1.166667E+01
5.833333E+00

5.000000E+01 5.000000E+01 5.000000E+01 5.000000E+01 3.125000E+02
9.416666E+01

4.666666E+01 4.666666E+01 1.500000E+01 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00

ELEMENT SHEAR AREA ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 5.833333E+01 2.250000E+02
5.833333E+01

1.166667E+02 1.166667E+02 2.366667E+02

ELEMENT TORSION COEFF ALONG X

5.421257E-05 1.084251E-04 5.421257E-05 6.352726E-05 1.270545E-04
6.352726E-05

2.923770E-04 1.200748E-04 1.999150E-04 3.722172E-04 7.504673E-04
3.765066E-04

1.865873E-04 1.865873E-04 5.997450E-05 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00

ELEMENT TORSION COEFF ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 4.471603E-04 2.389355E-03
4.471603E-04

3.199799E-04 3.199799E-04 3.719989E-03

ST-244 SECPROP3 VERS-00 LEVEL-00 OCT 1992
Date of run: 03/15/2001 Time: 14:22:12.01

Skull Valley CTB Member 1N - SECPROP3

X1	Y1	X2	Y2	T	MASS/L
3.600E+01	6.750E+01	6.000E+00	6.750E+01	2.000E+00	2.795E-01
3.600E+01	3.250E+01	6.000E+00	3.250E+01	2.000E+00	2.795E-01
3.600E+01	-3.250E+01	6.000E+00	-3.250E+01	2.000E+00	2.795E-01
3.600E+01	-6.750E+01	6.000E+00	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	3.250E+01	2.735E+02	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-3.250E+01	1.425E+02	-3.250E+01	2.000E+00	2.795E-01
1.645E+02	-3.250E+01	1.925E+02	-3.250E+01	2.000E+00	2.795E-01
2.145E+02	-3.250E+01	2.425E+02	-3.250E+01	2.000E+00	2.795E-01
2.645E+02	-3.250E+01	2.735E+02	-3.250E+01	2.000E+00	2.795E-01
3.600E+01	7.750E+01	3.600E+01	6.750E+01	2.000E+00	2.795E-01
6.000E+00	6.750E+01	6.000E+00	5.750E+01	2.000E+00	2.795E-01
3.600E+01	-7.750E+01	3.600E+01	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	4.250E+01	8.600E+01	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-4.250E+01	8 600E+01	-3.250E+01	2.000E+00	2.795E-01
2.735E+02	2.250E+01	2.735E+02	4.250E+01	2.000E+00	2.795E-01
2.735E+02	-2.250E+01	2.735E+02	-4.250E+01	2.000E+00	2.795E-01
6.000E+00	2.250E+01	6.000E+00	4.250E+01	2.000E+00	2.795E-01
6.000E+00	-2.250E+01	6.000E+00	-4.250E+01	2.000E+00	2.795E-01
6.000E+00	-5.750E+01	6.000E+00	-6.750E+01	2.000E+00	2.795E-01

TOTAL ELEMENT 19 HEIGHT OF WALLS 30.00 C. WEIGHT OF MAT .15

******AREA******

TOTAL AREA OR MASS 1.1380000E+03

X-CG 1.2343629E+02 Y-CG 3.7697715E+00

IX-CG 1.9084595E+06 IY-CG 9.8590272E+06 IXY-CG 3.4347331E+05

INCLINATION OF PRINCIPAL AXIS 4.3094080E-02 RADIANS

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 1.8936487E+06 IY-P 9.8738381E+06

ADDITIONAL AREA PROPERTIES

COORDINATES OF CENTER OF RIGIDITY

XC 1.1600000E+02 YC 8.1624453E+00

SHEAR AREAS

AX 7.1499997E+02 AY 2.3333332E+02

SHEAR AREAS ABOUT PRINCIPAL AXES

AXP 7.2438833E+02 AYP 2.6391943E+02

TORSIONAL CONSTANT IS BASED UPON BENDING AND SHEAR
STIFFNESSES OF INDIVIDUAL ELEMENTS

TORSIONAL CONSTANT 2.4052715E+06

****** MASS ******

TOTAL AREA OR MASS 1.5903726E+02

X-CG 1.2343629E+02 Y-CG 3.7697715E+00

IX-CG 2.6671017E+05 IY-CG 1.3778143E+06 IXY-CG 4.8000927E+04

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 2.6464034E+05 IY-P 1.3798842E+06

LENGTHS OF ELEMENTS

3.000E+01 3.000E+01 3.000E+01 3.000E+01 1.875E+02 5.650E+01 2.800E+01
2.800E+01

9.000E+00 1.000E+01 1.000E+01 1.000E+01 1.000E+01 1.000E+01 2.000E+01
2.000E+01

2.000E+01 2.000E+01 1.000E+01

ELEMENT SHEAR AREA ALONG X

5.000000E+01 5.000000E+01 5.000000E+01 5.000000E+01 3.125000E+02
9.416666E+01

4.666666E+01 4.666666E+01 1.500000E+01 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00

ELEMENT SHEAR AREA ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 1.666667E+01 1.666667E+01
1.666667E+01

1.666667E+01 1.666667E+01 3.333333E+01 3.333333E+01 3.333333E+01
3.333333E+01

1.666667E+01

ELEMENT TORSION COEFF ALONG X

1.233490E-03 5.059211E-04 8.452776E-04 1.572846E-03 3.162007E-03
1.591940E-03

7.889258E-04 7.889258E-04 2.535833E-04 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00

ELEMENT TORSION COEFF ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 5.543379E-04 7.622147E-04
5.543379E-04

2.078767E-04 2.078767E-04 2.182706E-03 2.182706E-03 1.524429E-03
1.524429E-03

7.622147E-04

ST-244 SECPROP3 VERS-00 LEVEL-00 OCT 1992
Date of run: 03/07/2001 Time: 08:24:16.31

Skull Valley CTB Member 1 - SECPROP3

X1	Y1	X2	Y2	T	MASS/L
8.600E+01	1.025E+02	8.250E+01	1.025E+02	2.000E+00	2.795E-01
3.950E+01	1.025E+02	3.600E+01	1.025E+02	2.000E+00	2.795E-01
8.600E+01	-1.025E+02	8.250E+01	-1.025E+02	2.000E+00	2.795E-01
3.950E+01	-1.025E+02	3.600E+01	-1.025E+02	2.000E+00	2.795E-01
1.600E+01	6.750E+01	6.000E+00	6.750E+01	2.000E+00	2.795E-01
1.600E+01	3.250E+01	6.000E+00	3.250E+01	2.000E+00	2.795E-01
1.600E+01	-3.250E+01	6.000E+00	-3.250E+01	2.000E+00	2.795E-01
1.600E+01	-6.750E+01	6.000E+00	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	3.250E+01	9.600E+01	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-3.250E+01	9.600E+01	-3.250E+01	2.000E+00	2.795E-01
2.645E+02	-3.250E+01	2.735E+02	-3.250E+01	2.000E+00	2.795E-01
3.600E+01	1.025E+02	3.600E+01	6.750E+01	2.000E+00	2.795E-01
6.000E+00	6.750E+01	6.000E+00	-6.750E+01	2.000E+00	2.795E-01
3.600E+01	-1.025E+02	3.600E+01	-6.750E+01	2.000E+00	2.795E-01
8.600E+01	1.025E+02	8.600E+01	3.250E+01	2.000E+00	2.795E-01
8.600E+01	-1.025E+02	8.600E+01	-3.250E+01	2.000E+00	2.795E-01
2.735E+02	6.750E+01	2.735E+02	-7.450E+01	2.000E+00	2.795E-01
3.600E+01	6.750E+01	2.600E+01	6.750E+01	2.000E+00	2.795E-01
3.600E+01	-6.750E+01	2.600E+01	-6.750E+01	2.000E+00	2.795E-01
2.735E+02	3.250E+01	2.635E+02	3.250E+01	2.000E+00	2.795E-01

TOTAL ELEMENT 20 HEIGHT OF WALLS 30.00 C. WEIGHT OF MAT .15

******AREA******

TOTAL AREA OR MASS 1.2000000E+03

X-CG 1.0507833E+02 Y-CG -7.7416667E-01

IX-CG 4.0892998E+06 IY-CG 1.3501133E+07 IXY-CG -1.5708123E+05

INCLINATION OF PRINCIPAL AXIS -1.6683564E-02 RADIANS

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 4.0866789E+06 IY-P 1.3503754E+07

ADDITIONAL AREA PROPERTIES

COORDINATES OF CENTER OF RIGIDITY

XC 1.1385628E+02 YC 7.6773048E-01

SHEAR AREAS

AX 1.8833333E+02 AY 8.1166663E+02

SHEAR AREAS ABOUT PRINCIPAL AXES

AXP 2.0184798E+02 AYP 8.1469560E+02

TORSIONAL CONSTANT IS BASED UPON BENDING AND SHEAR
STIFFNESSES OF INDIVIDUAL ELEMENTS

TORSIONAL CONSTANT 9.3540726E+06

****** MASS ******

TOTAL AREA OR MASS 1.6770186E+02

X-CG 1.0507833E+02 Y-CG -7.7416667E-01

IX-CG 5.7148598E+05 IY-CG 1.8868043E+06 IXY-CG -2.1952345E+04

PROPERTIES ABOUT PRINCIPAL AXES

IX-P 5.7111971E+05 IY-P 1.8871706E+06

LENGTHS OF ELEMENTS

3.500E+00 3.500E+00 3.500E+00 3.500E+00 1.000E+01 1.000E+01 1.000E+01
1.000E+01

1.000E+01 1.000E+01 9.000E+00 3.500E+01 1.350E+02 3.500E+01 7.000E+01
7.000E+01

1.420E+02 1.000E+01 1.000E+01 1.000E+01

ELEMENT SHEAR AREA ALONG X

5.833333E+00 5.833333E+00 5.833333E+00 5.833333E+00 1.666667E+01
1.666667E+01

1.666667E+01 1.666667E+01 1.666667E+01 1.666667E+01 1.500000E+01
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
1.666667E+01

1.666667E+01 1.666667E+01

ELEMENT SHEAR AREA ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
5.833333E+01

2.250000E+02 5.833333E+01 1.166667E+02 1.166667E+02 2.366667E+02
0.000000E+00

0.000000E+00 0.000000E+00

ELEMENT TORSION COEFF ALONG X

6.344169E-05 6.344169E-05 6.439923E-05 6.439923E-05 1.189006E-04
5.653913E-05

5.927495E-05 1.216364E-04 5.653913E-05 5.927495E-05 5.334745E-05
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
1.189006E-04

1.216364E-04 5.653913E-05

ELEMENT TORSION COEFF ALONG Y

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00

0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00 0.000000E+00
4.855229E-04

2.594342E-03 4.855229E-04 3.474315E-04 3.474315E-04 4.039133E-03
0.000000E+00

0.000000E+00 0.000000E+00

ST-248 RIG3, VERS-01 LEVEL-00 77.116 13.52.36

Calc. 05996.02-SC-5

INPUT ECHO

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SKULL VALLEY STIFFNESS MATRIX FOR MEMBER 1
139.75         0.00    95.0      100.
131.46        -2.02   130.
1888.       762.       812.     10200000.  4090000. 9860000.  519000.     222000.
113.86      8.11
119.08      1.75
0.0
```

Calc. 05996.02-SC-5

SKULL VALLEY STIFFNESS MATRIX FOR MEMBER 1

```
0.188800D+04 0.762000D+03 0.812000D+03 0.102000D+08 0.409000D+07 0.986000D+07 0.519000D+06 0.222000D+06
0.113860D+03 0.811000D+01
0.119080D+03 0.175000D+01
0.139750D+03 0.0          0.950000D+02
0.131460D+03-0.202000D+01 0.130000D+03
0.100000D+03
0.0
```

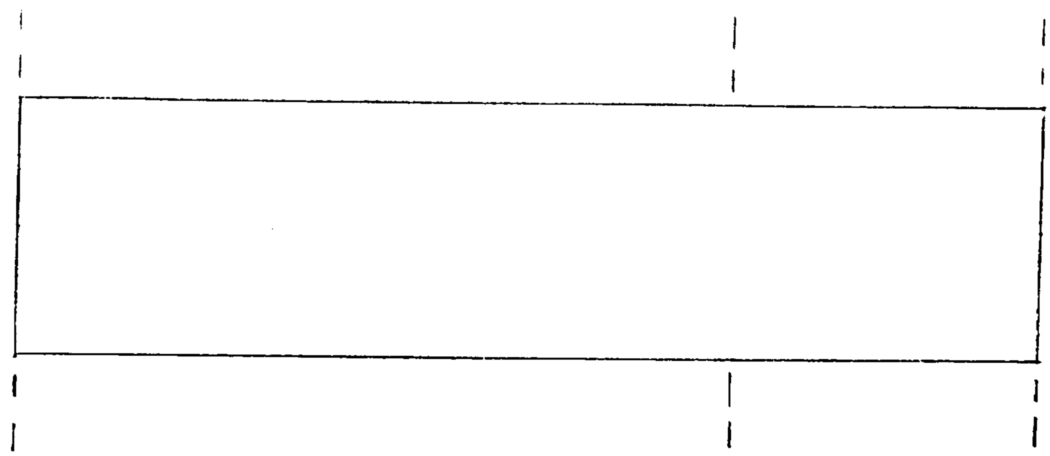
THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.311467D+08	0.621718D+07	0.188449D+05	0.310274D+08	-0.207510D+09	0.373418D+09
0.621718D+07	0.715991D+07	-0.773006D+05	0.880930D+08	-0.322208D+08	0.389131D+07
0.188449D+05	-0.773006D+05	0.595138D+07	-0.107231D+09	0.657436D+08	0.119347D+07
0.310274D+08	0.880930D+08	-0.107231D+09	0.785859D+11	-0.145706D+10	0.483252D+10
-0.207510D+09	-0.322208D+08	0.657436D+08	-0.145706D+10	0.784314D+11	-0.249042D+11
0.373418D+09	0.389131D+07	0.119347D+07	0.483252D+10	-0.249042D+11	0.170304D+12

Calc. 05996.02-SC-5

CHECKED MWD

STIFFNESS OF WALLS - EL. 130' - 170'



ASSUMPTIONS

- Ignore pilasters
- Wing walls will be considered using average length & resist only E-W shear

AREA = 2 (2')(267.5' + 65') = 1330 ft²

Shear area in N-S direction =

$$2 \times 267.5' \times 2' = 1070.\ ft^2$$

Shear area in E-W direction =

$$2 \times 65' \times 2' + 6 \times \frac{35'}{2} \times 2' = 470\ ft^2$$

CHECKED WL

VERTICAL C.R. (AT CENTER OF BOX)

$$X = 6 + \frac{267.5}{2} = 139.75'$$

$$Z = 0'$$

HORIZONTAL C.R.

$$X = \frac{\left(\left(65 + 2\left(\frac{35}{2}\right)\right)(6') + 2\left(\frac{35}{2}\right)(86') + \left(65 + 2\left(\frac{35}{2}\right)\right)(273.5)\right)2'}{470'} =$$

$$131.74'$$

$$Z = 0$$

TORSIONAL CONSTANT (BOX SECTION)

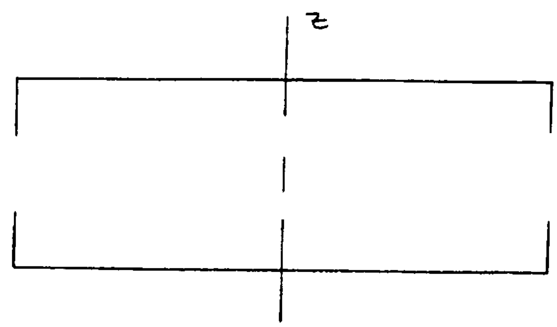
$$J = \frac{2(2')(2')(267.5)^2(65)^2}{2(267.5 + 65)} = 3.64 \times 10^6$$

MOMENTS OF INERTIA - CONSIDER WALLS HAVING A HEIGHT OF 60' (130' TO 190')

$$H/3 = 60/3 = 20'$$ USE 20' FLANGES

CHECKED WC

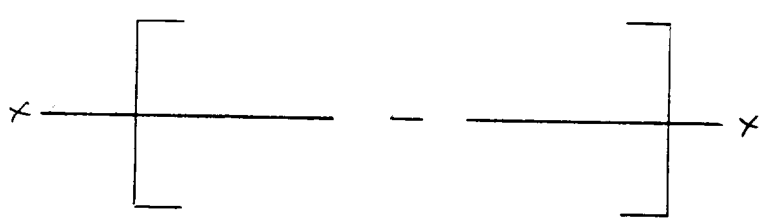
N-S DIRECTION



$$I_z = 2\left(\frac{1}{12}(2')(267.5)^3 + 2(20' \times 2')\left(\frac{267.5}{2}\right)^2\right) =$$

$$9.24 \times 10^6 \ FT^4$$

E-W DIRECTION



$$I_x = 2\left(\frac{1}{12}(2')(65)^3 + 2(20' \times 2')\left(\frac{65}{2}\right)^2\right) =$$

$$2.61 \times 10^5 \ FT^4$$

THESE PROPERTIES ARE USED AS INPUT TO 'RIG4' TO GET THE STIFFNESS MATRIX FOR MEMBER 2.

SEE PAGES B-21 THROUGH B-23 FOR INPUT/OUTPUT.

ST-249 RIG4, VERS-01 LEVEL-00 77.116 14.20.02

Calc. 05796.02-SC-5

Checked [illegible]

B-21

INPUT ECHO

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
STIFFNESS MATRIX FOR MEMBER 2
131.46     -2.02     130.
143.18     -3.14     170.
1330.      1070.     470.     3640000.  261000.   9240000.    519000.   222000.
131.74     0.0
139.75     0.0
0.0
```

Calc. 05996.02-SC-5

Checked

STIFFNESS MATRIX FOR MEMBER 2

```
0.133000D+04 0.107000D+04 0.470000D+03 0.364000D+07 0.261000D+06 0.924000D+07 0.519000D+06 0.222000D+06
0.131740D+03 0.0
0.139750D+03 0.0
0.131460D+03-0.202000D+01 0.130000D+03
0.143180D+03-0.314000D+01 0.170000D+03
0.0
```

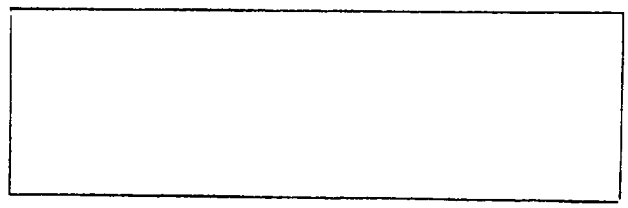
THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.163487D+08	0.308498D+07	0.944947D+05	-0.932156D+07	0.475361D+08	-0.283346D+08
0.308498D+07	0.677557D+07	-0.321045D+06	-0.166397D+08	0.262831D+07	-0.130669D+09
0.944947D+05	-0.321045D+06	0.239753D+07	0.139943D+08	0.541036D+08	0.669325D+07
-0.932156D+07	-0.166397D+08	0.139943D+08	0.190601D+11	0.455493D+10	-0.279788D+10
0.475361D+08	0.262831D+07	0.541036D+08	0.455493D+10	0.704467D+10	0.106296D+11
-0.283346D+08	-0.130669D+09	0.669325D+07	-0.279788D+10	0.106296D+11	0.121420D+12

Calc. 0596.02-SC-5

CHECKED [initials]

STIFFNESS OF WALLS 170' - 190'



SHEAR AREA

$A = 2(2')(267.5' + 65') = 1330\ ft^2$

N-S $2 \times 2' \times 267.5' = 1070\ ft^2$

E-W $2 \times 65' \times 2' = 260\ ft^2$

I_x, I_z, J SAME AS 130'-170'

$I_z = 9.24 \times 10^6\ FT^4$

$I_x = 2.61 \times 10^5\ FT^4$

$J = 3.64 \times 10^6\ FT^4$

VERTICAL & HORIZONTAL C.R. AT

$X = 139.75'$

$Z = 0$

THESE PROPERTIES ARE USED AS INPUT TO 'RIG4' TO GET THE STIFFNESS MATRIX FOR MEMBER 3. SEE PAGES B-25 THROUGH B-27 FOR INPUT/OUTPUT.

ST-249 RIG4, VERS-01 LEVEL-00 77.116 14.20.02

Calc. 05996.02-SC-5

B-25

```
INPUT ECHO
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
STIFFNESS MATRIX FOR MEMBER 3
143.18     -3.14      170.
139.75      0.00      190.
1330.      1070.      260.      3640000.  261000.   9240000.    519000.   222000.
139.75     0.0
139.75     0.0
0.0
```

Calc 0596.02-SC-5

B-26

STIFFNESS MATRIX FOR MEMBER 3

```
0.133000D+04 0.107000D+04 0.260000D+03 0.364000D+07 0.261000D+06 0.924000D+07 0.519000D+06 0.222000D+06
0.139750D+03 0.0
0.139750D+03 0.0
0.143180D+03-0.314000D+01 0.170000D+03
0.139750D+03 0.0          0.190000D+03
0.0
```

THE LOCAL STIFFNESS MATRIX OF THE EQUIVALENT MEMBER

0.331408D+08	0.590397D+07	0.101649D+07	-0.230203D+07	0.990076D+07	0.175480D+08
0.590397D+07	0.912125D+07	-0.437178D+07	0.990076D+07	-0.425819D+08	-0.754719D+08
0.101649D+07	-0.437178D+07	0.695449D+07	-0.157498D+08	0.677380D+08	0.448840D+08
-0.230203D+07	0.990076D+07	-0.157498D+08	0.441636D+11	-0.161694D+11	-0.263833D+11
0.990076D+07	-0.425819D+08	0.677380D+08	-0.161694D+11	0.109947D+12	0.113471D+12
0.175480D+08	-0.754719D+08	0.448840D+08	-0.263833D+11	0.113471D+12	0.134315D+12

Calc. 0596.02-SC-5

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.

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CRANE

MASS POINT 6 REPRESENTS A PORTION OF THE N-S WALLS ON COLUMN LINES C & E ALLOW MOVEMENT IN THE E-W DIRECTION INDEP-ENDENLY OF MASS POINT 3. JOINTS 7 & 8 ARE FICTITIOUS POINTS WHICH ARE INTRODUCED TO ENSURE THAT MEMBERS 5 & 6 ARE ORIENTED IN THE VERTICAL DIRECTION, AND ARE GIVEN A VERY SMALL AMOUNT OF MASS. MEMBERS 7 & 8 ARE FICTITIOUS RIGID MEMBERS. THE EFFECTIVE MASS IN THE Z DIRECTION AND THE PROPERTIES OF MEMBERS 5 & 6 WILL BE SELECTED SUCH THAT FREQUENCY OF THE SYSTEM BETWEEN JOINTS 7 & 8 MATCHES THE FREQUENCY OF THE WALL IN THE E-W DIRECTION. THE FREQUENCY OF THE WALL IS ESTIMATED BY MAKING A FINITE ELEMENT MODEL OF THE WALL BETWEEN ELEVATION 130 AND ELEVATION 190. THE ROOFS AT EL. 130 AND 190 ARE ASSUMED TO PROVIDE SUPPORT FOR THE WALL (PINNED BOUNDARY CONDITIONS). SEE PAGE C-4 FOR A SKETCH OF THE MODEL.

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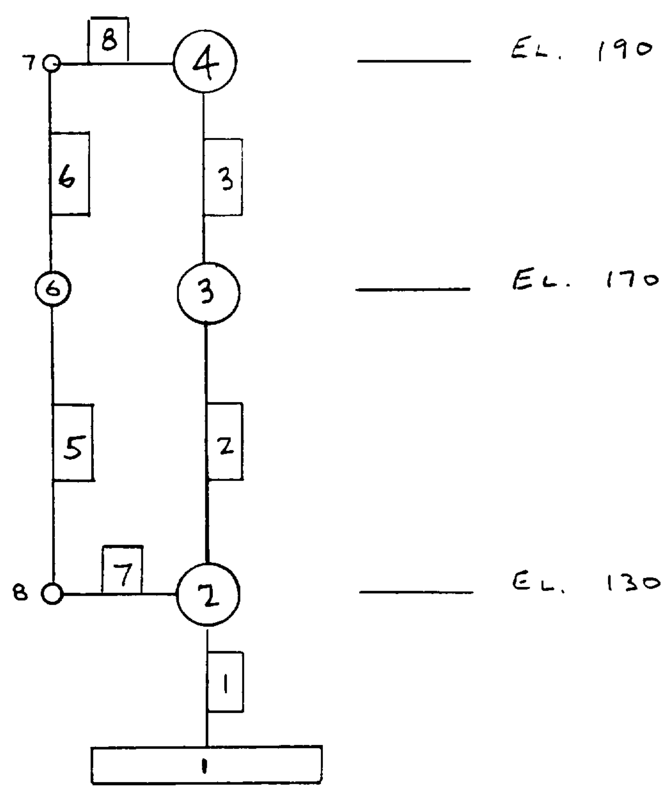
SINCE THE CRANE IS SUPPORTED AT APPROXIMATE ELEVATION 170, AND THE WALLS ON COLUMN LINES C & E ARE RELATIVELY FLEXIBLE IN THE E-W (OUT-OF-PLANE) DIRECTION, THE ACCELERATIONS IN THE E-W DIRECTION AT EL. 170 MAY BE AMPLIFIED. TO SIMULATE THIS, AN ADDITIONAL DEGREE OF FREEDOM WILL BE ADDED TO THE MODEL, AS SHOWN BELOW.



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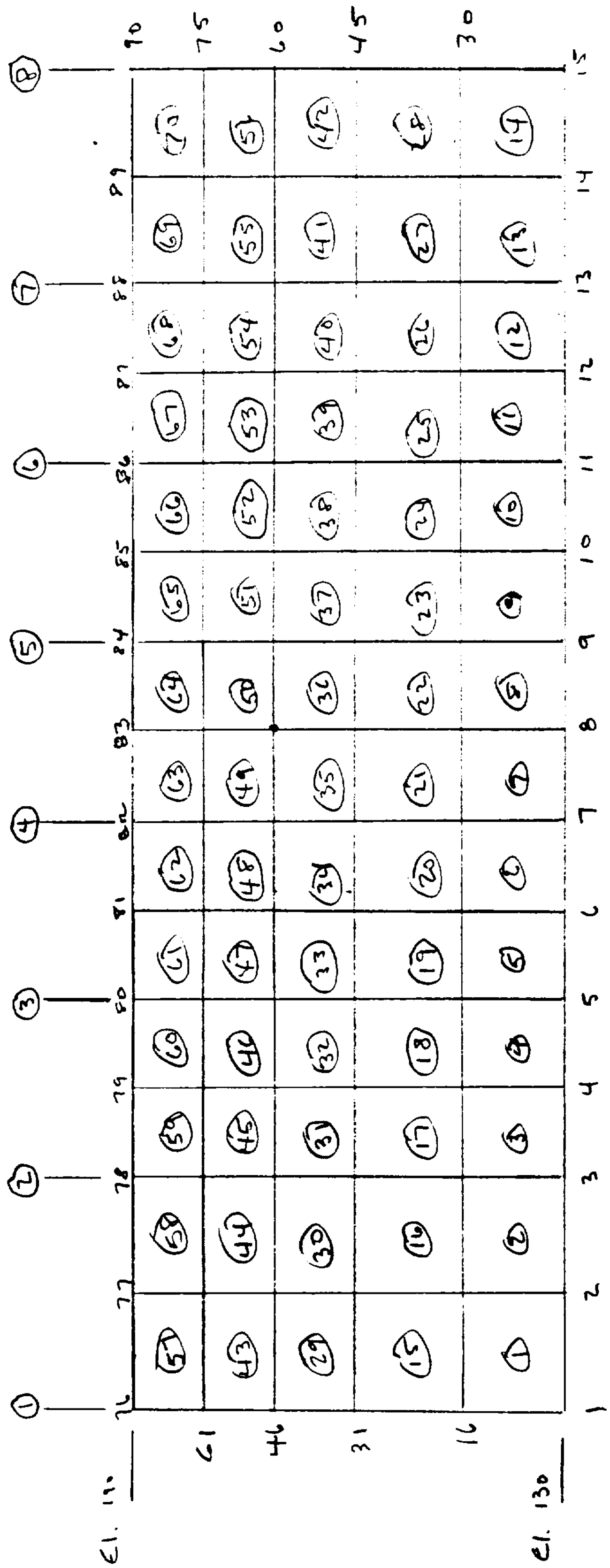

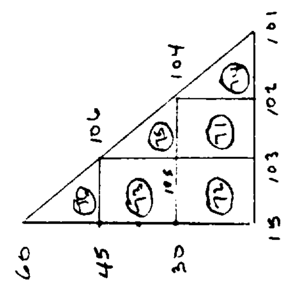

THE OUTPUT FILE IS ON THE DISKETTE IN ATTACHMENT D WITH THE NAME WALLFINE.OUT

MODEL OF WALL

EFFECTIVE MASS OF WALL:

TO APPROXIMATE THE EFFECTIVE MASS OF THE WALL, THE WALL WILL BE CONSIDERED AS A SLAB. THE TOTAL WEIGHT IS

WALL $187' \times 60' \times 2' \times .15 = 3375$ K

HORIZONTAL BEAM $187.5' \times 10' \times 2.33' \times .15 = 655$ K

PILASTERS $6 \times 35' \times 3' \times 2' \times .15 = 189$ K

TOTAL $= 3375 + 655 + 189 = 4219.$ K

THE MASS FACTOR FOR A SIMPLY SUPPORTED BEAM WITH UNIFORM MASS DISTRIBUTION IS .50 (Biggs, p. 209). FOR A 2-WAY SLAB WITH SIMPLE SUPPORTS AND AN ASPECT RATIO OF 0.5 IS 0.41 (Biggs, p. 213). USE A VALUE OF 0.45

$W_e = 0.45\,(4219) = 1899$ K

ADDING CRANE $W_e = 1899 + 255 = 2154$ K

FOR 2 WALLS, $W_e = 2\,(2154) = 4308$ K

MASS $= 4308/32.2 = 134.$ $K\text{-}SEC^2/FT$

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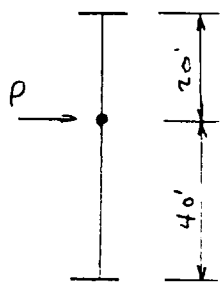
STIFFNESS = 656.9 I (See below)



$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{656.9\ I}{134}}$$

FOR A FREQUENCY OF 3 Hz *

$$\Delta = \frac{P a^3 b^3}{3EIL^2}$$

$$3 = \frac{1}{2\pi}\sqrt{\frac{656.9\ I}{134}}$$

$K = P/\Delta =$

656.9 I

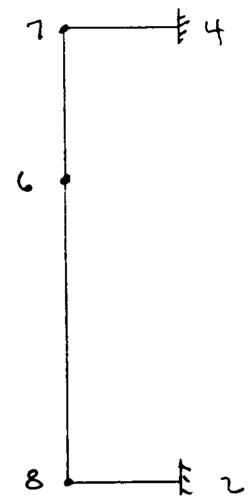
(for E = 519,000)

$$I = 72.5\ FT^4$$

TO DEMONSTRATE THAT THE MODEL HAS A FREQUENCY OF 3 Hz,* SIMPLE GT STRUDL MODEL WITH THESE PROPERTIES WILL BE CREATED AND NATURAL FREQUENCIES CALCULATED

* THE FUNDAMENTAL FREQUENCY FROM THE GT STRUDL ANALYSIS IS 3.28 Hz. THIS IS PROBABLY AN OVERESTIMATE SINCE THE CONCRETE WAS ASSUMED TO BE COMPLETELY UNCRACKED AND THE ROOFS AT EL. 130' AND 190' WERE ASSUMED TO COMPLETELY RESTRAIN HORIZONTAL MOVEMENT. 3 Hz IS A REALISTIC FREQUENCY.

TO DEMONSTRATE THE FREQUENCY OF THE WALL AS MODELLED IN 'FRIDAY' DOES HAVE A FREQUENCY OF 3 Hz, THE PORTION OF THE MODEL BETWEEN JOINTS 2 ¢ 4 WILL BE EXTRACTED AND CONVERTED TO GT-STRUDL, WITH EXACTLY THE SAME PROPERTIES.



THIS ANALYSIS IS INCLUDED ON THE DISKETTE IN ATTACHMENT D (FILENAME WALLFLEX.OUT) AND SHOWS THAT THE FREQUENCY IS 2.99 Hz

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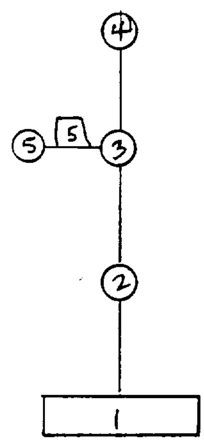
AN ALTERNATE METHOD OF SIMULATING THE FLEXIBILITY OF THE WALL IS TO ATTACH THE ADDED DEGREE OF FREEDOM TO NODE 3 (RATHER THAN BETWEEN 2 & 4), AS SHOWN



IF (5) IS GIVEN COORDINATES SUCH THAT IT IS 1' EAST OF (3), THE STIFFNESS OF THE MEMBER [5] IS $K = \frac{AE}{L} = 519{,}000\ A$

WITH A MASS OF 134 $\frac{K\text{-}SEC^2}{FT}$ AND FREQUENCY OF 3 H_3

$$3 = \frac{1}{2\pi}\sqrt{\frac{519{,}000A}{134.}}$$

$$A = .0917\ ft^2$$

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COMPARING RESULTS FOR THE UPPER BOUND SOIL CASE (SEE OUTPUT FILES STRUCTEL.FRIDAY.SVUB AND STRUCTEL.FRIDAY.DIF6)

	ORIGINAL MODEL	ALTERNATE MODEL
ZPA AT NODE 3	1.1852	1.1812
PEAK AT NODE 3	5.1402	5.1330
ZPA AT NODE 6	2.1657	2.1150
PEAK AT NODE 6	11.9760	11.7305

THE RESULTS ARE VERY SIMILAR. EITHER WAY OF MODELLING IS REASONABLE

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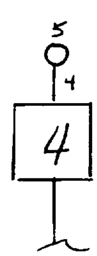
ROOF

A SINGLE MASS POINT WILL BE ADDED AT JOINT 4 TO SIMULATE THE FLEXIBILITY OF THE ROOF. THE VERTICAL FREQUENCY WAS CALCULATED TO BE APPROXIMATELY 3.34 Hz; HOWEVER, THAT ANALYSIS CONSIDERED THE CONCRETE TO CONTRIBUTE NO STIFFNESS (ONLY THE ROOF BEAMS AND GIRDERS WERE MODELLED). HENCE, THE FREQUENCY MAY BE SOMEWHAT HIGHER. SINCE TEST RUNS SHOW THAT ACCELERATIONS DECREASE AS FREQUENCY DECREASES, THE ROOF WILL CONSERVATIVELY BE ASSIGNED A FREQUENCY OF 5. Hz



MEMBER 4 WILL BE ASSIGNED A CROSS-SECTIONAL AREA SUCH THAT THE VERTICAL FREQUENCY IS 5 Hz.

IT WILL BE RIGID IN OTHER DIRECTIONS

CHECKED WQ

PROPERTIES FOR ROOF (EL. 190)

MASS OF ROOF =

$$(1.02)\left(\frac{.15}{32.17}\right)(65')(267.5') =$$

$$82.7 \ \frac{K\text{-}SEC^2}{FT}$$

$$\text{EFFECTIVE MASS} \approx \frac{M}{3} = \frac{82.7}{3} = 27.6$$

FOR 1' LENGTH, AND FREQ OF 5 Hz

$$\left(\frac{\frac{AE}{L}}{m}\right)^{1/2} = 2\pi(5) = 10\pi$$

$$A = \left(27.6/519{,}000\right)(10\pi)^2 = .0525'$$

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J.O./W.O./CALCULATION NO.	REVISION	PAGE
05996.02-SC-5	2	D-1

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER
B.E. EBBESON 3/23/01	J. PIERRO 3/26/01	J. PIERRO 3/26/01

SUBJECT/TITLE	QA CATEGORY/CODE CLASS
Seismic Analysis of Canister Transfer Building	I

ATTACHMENT D

DISKETTE

ATTACHMENT E

The ground motion time histories provided by Geomatrix (Reference 4) have a time step of .005 seconds and a duration of 30 seconds. Since FRIDAY limits the number of time points to 4000, the entire time history cannot be used. Looking at plots of the time histories on pages 25-27 of Reference 4, it can be seen that the motion dies out after 20 seconds, so using only the first 20 seconds should capture the peak response. To verify this, the response spectra (5% damping) of the shortened time histories will be calculated using the SWEC program TIMHIS6 (Reference 14), and compared to the response spectra of the full 30 second time histories. found in Table 1 of Reference 4. Results are tabulated below:

PERIOD	X-30	X-20	Y-30	Y-20	Z-30	Z-20
0.0294	0.7868	0.7867	0.9963	0.9963	0.7693	0.7694
0.0323	0.8099	0.8102	1.0002	1.0022	0.7798	0.7813
0.0357	0.8695	0.8693	1.0489	1.0589	0.8413	0.8416
0.0400	0.9308	0.9308	1.1927	1.1978	0.9047	0.9152
0.0455	1.0219	1.0222	1.3559	1.3546	0.9832	0.9844
0.0500	1.0801	1.0800	1.4401	1.4401	1.0302	1.0302
0.0556	1.1210	1.1212	1.5065	1.5070	1.0666	1.0687
0.0588	1.1881	1.1883	1.5170	1.5171	1.1294	1.1291
0.0625	1.2105	1.2105	1.5596	1.5596	1.2124	1.2124
0.0667	1.2382	1.2385	1.6182	1.6182	1.2999	1.2998
0.0690	1.2245	1.2243	1.5925	1.5929	1.2776	1.2772
0.0714	1.2691	1.2680	1.7030	1.6989	1.2762	1.2761
0.0741	1.3404	1.3407	1.7886	1.7880	1.2743	1.2741
0.0769	1.3893	1.3891	1.6991	1.6990	1.3132	1.3128
0.0800	1.3661	1.3661	1.8698	1.8698	1.3631	1.3631
0.0833	1.3328	1.3329	1.8125	1.8136	1.4245	1.4236
0.0870	1.4830	1.4860	1.7709	1.7720	1.4481	1.4487
0.0909	1.5693	1.5693	1.8407	1.8405	1.4492	1.4489
0.0952	1.5737	1.5730	1.9695	1.9683	1.5847	1.5843
0.1000	1.6065	1.6064	2.0001	2.0001	1.5845	1.5845
0.1050	1.7273	1.7171	1.7436	1.7288	1.6962	1.6912
0.1110	1.7998	1.7993	1.9413	1.9430	1.7439	1.7403
0.1180	1.6992	1.7007	1.7284	1.7028	1.7185	1.7006
0.1250	1.8682	1.8682	1.7955	1.7954	1.8473	1.8472
0.1290	1.8817	1.8818	1.7664	1.7666	1.8304	1.8313
0.1330	1.9008	1.8982	1.7938	1.7881	1.7716	1.7502
0.1380	1.9507	1.9513	1.8559	1.8556	1.8099	1.8089
0.1430	1.8875	1.8847	1.7319	1.7247	1.8904	1.8950
0.1480	1.9549	1.9543	1.5736	1.5734	2.0152	2.0155
0.1540	1.8994	1.9030	1.5643	1.5680	1.9722	1.9740
0.1600	2.0562	2.0562	1.7947	1.7947	2.0439	2.0438
0.1670	2.1056	2.1038	1.6199	1.6032	2.0864	2.0824
0.1740	1.9970	1.9950	1.7125	1.7115	2.0622	2.0644
0.1820	1.9581	1.9605	1.6032	1.6000	2.1106	2.1092
0.1900	2.1339	2.1244	1.5118	1.5187	2.0593	2.0591

0.2000	2.1885	2.1884	1.4795	1.4794	2.1413	2.1412
0.2080	2.0774	2.0831	1.5549	1.5559	2.1528	2.1528
0.2170	2.0982	2.0978	1.3899	1.4000	2.1120	2.1150
0.2270	2.0881	2.0893	1.3899	1.3905	2.0137	2.0195
0.2380	1.9540	1.9559	1.3167	1.3171	2.0442	2.0442
0.2500	1.9103	1.9102	1.2611	1.2611	1.8328	1.8326
0.2630	1.9085	1.9092	1.1598	1.1608	1.9148	1.9151
0.2780	1.8595	1.8585	1.1110	1.1132	1.8686	1.8684
0.2900	1.8132	1.8117	1.1363	1.1358	1.8736	1.8737
0.3030	1.7713	1.7713	1.0490	1.0493	1.8050	1.8053
0.3170	1.7434	1.7454	0.9634	0.9637	1.6473	1.6500
0.3330	1.6716	1.6726	0.9390	0.9394	1.6106	1.6087
0.3450	1.6425	1.6419	0.8834	0.8818	1.6184	1.6180
0.3570	1.6148	1.6151	0.7530	0.7531	1.5977	1.5979
0.3700	1.5671	1.5690	0.8026	0.8011	1.5348	1.5369
0.3850	1.4797	1.4761	0.8032	0.8023	1.4377	1.4349
0.4000	1.3377	1.3376	0.7662	0.7661	1.2975	1.2973
0.4170	1.3655	1.3649	0.6619	0.6593	1.3238	1.3246
0.4350	1.3172	1.3167	0.6440	0.6439	1.2949	1.2934
0.4550	1.2969	1.2960	0.6089	0.6078	1.1725	1.1719
0.4760	1.2419	1.2422	0.5997	0.5997	1.1466	1.1472
0.5000	1.1760	1.1759	0.5671	0.5671	1.0783	1.0781
0.5260	1.1630	1.1629	0.5339	0.5346	1.0515	1.0519
0.5660	1.1260	1.1250	0.4732	0.4733	0.8856	0.8862
0.5880	1.0321	1.0331	0.4600	0.4603	0.9198	0.9193
0.6250	0.9293	0.9291	0.4269	0.4269	0.8890	0.8889
0.6670	0.9430	0.9424	0.3903	0.3899	0.7393	0.7368
0.7140	0.8583	0.8587	0.3900	0.3900	0.7858	0.7863
0.7690	0.7748	0.7748	0.3095	0.3091	0.7524	0.7522
0.8330	0.7134	0.7135	0.3362	0.3362	0.6480	0.6488
0.9090	0.6366	0.6366	0.2806	0.2807	0.5838	0.5836
1.0000	0.5670	0.5669	0.2651	0.2650	0.5851	0.5849
1.1110	0.5092	0.5092	0.2384	0.2384	0.4485	0.4485
1.2500	0.4472	0.4471	0.2041	0.2040	0.4175	0.4174
1.4290	0.3794	0.3788	0.1862	0.1859	0.3604	0.3597
1.6670	0.2826	0.2813	0.1439	0.1442	0.3084	0.3073
2.0000	0.2089	0.2088	0.1274	0.1274	0.2500	0.2499
2.5000	0.1423	0.1422	0.0985	0.0984	0.2020	0.2019
3.3330	0.0917	0.0917	0.0714	0.0714	0.1466	0.1466
5.0000	0.0535	0.0535	0.0451	0.0450	0.0861	0.0859

NOTE: X-30, Y-30, and Z-30 are the values from Table 1 of Reference 4, for the Fault-parallel, Vertical and Fault-normal time histories, respectively.

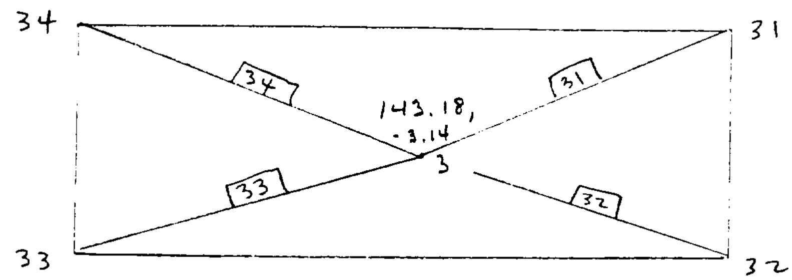
X-20, Y-20 and Z-20 are the values from TIMHIS6 (see Attachment D) for the time histories shortened to 20 seconds.

As can be seen, the values correspond well. Minor differences are due in part to rounding of the numerical value of the period. Examining the results for periods which correspond to even

frequencies which have no rounding (e.g .05 sec, .08 sec, .10 sec) the results match almost exactly. It can be concluded that no accuracy is lost by shortening the time histories to 20 seconds.

ATTACHMENT F

ADD JOINTS TO GET TORSIONAL AND ROCKING CONTRIBUTIONS



31	6.0	170.	32.5
32	6.0	170.	-32.5
33	273.5	170.	-32.5
34	273.5	170	32.5

ASSIGN MASS OF 1

RIGID MEMBERS

LONGEST MEMBER $= (137.18^2 + 35.14^2)^{1/2} = 141.73'$

SET I & A FOR f = 100.

$$\left(\frac{AE}{L}\right)^{1/2} = 2\pi\,(100)$$

$$A = \frac{141.73}{519{,}000}\,(4\pi^2)(10000)$$

$$A = 107.8\ ft^2$$

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$$\left(\frac{3EI}{L^3}\right)^{1/2} = 2\pi\ (100)$$

$$I = \frac{141.73^3}{3(519,000)}\ (4\pi^2)(10000) = .722 \times 10^6\ ft^4$$

Use A: 200 ft^2

I: 5,000,000 ft^4

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CLIENT & PROJECT	PAGE 1 OF 25
PRIVATE FUEL STORAGE FACILITY – PRIVATE FUEL STORAGE, LLC	PLUS 17 OF ATTACHMENTS
CALCULATION TITLE **Seismic Restraints for Spent Fuel Handling Casks**	QA CATEGORY (X) 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-10**	**NA**	**NA**

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	CONFIRMATION REQUIRED (X) NO
O.Bilgin O.Bilgin/9-1-99	AJ.Cokonis Alex Cokonis 9/1/99	D.M.Bonner D.M.Bonner 9/1/99	0	N/A	X Page 6	
O.Bilgin O.Bilgin/4-4-01	D.M.Bonner D.M.Bonner 4/4/01	D.M.Bonner D.M.Bonner 4/4/01	1	0	pages 6 & 10	

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HISTORICAL DATA REVISION

REVISION No.	PAGE AFFECTED	DESCRIPTION
Rev. 0	ALL	Original
Rev. 1	Revised pages 1, 2, 3, 6, 8 through 25, A-3, A-4, A-6, A-8, A-9, A-10. Added pages C-1 through C-4, and D-1, D-2.	Acceleration values, and location of casks with respect to column line C are revised.

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PURPOSE/OBJECTIVE

This calculation documents the design of seismic restraints for the spent fuel casks during the transfer of the fuel from the shipping cask to the storage cask inside the canister transfer building.

SUMMARY OF RESULTS

The shipping casks, transfer casks and the storage casks are tied to the building columns on column row "C" by rigid struts, as shown in Figure 1. The rear brackets of the struts are attached to the plate and rod anchorages built into the reinforced concrete columns, as detailed in the Design Description. The adequacy of the columns and walls including strut loads will be addressed in the next revision of Reference 1.

The design of the connection between the struts and the casks will be completed pending the selection of the vendor and finalization of the cask designs

DESIGN INPUT/METHOD

The design input and criteria are based on the SAR (Reference 2). The struts are qualified to the ASME Code, Subsection NF, Class 2 (Reference 3). The design of the column anchorage is based on the AISC Manual (Reference 4). The seismic acceleration value is obtained from Reference 5. The dimensions, weights and the center of gravity are based on the vendor data provided in Attachment A, and the building arrangement and structural details are based on the Reference 6 drawings. The linear elastic theory is used for the method of analysis.

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ASSUMPTIONS

1. The finalized design of the casks will result in weights enveloped by the values obtained from Attachment C.
2. The location of the casks is as shown in Figure 1. Casks are located 13'-0" from ℄ of Column Row C (see TEL-CON in Attachment B).
3. Sufficient reinforcement can be provided by cask manufacturer at the lug/bracket locations on the cask shells where the struts are attached. (Confirmation req'd.)
4. Although the vendor catalog (Ref. 7) reflects insufficient capacity for the struts, the vendor will accommodate the required capacities on special order. See Attach. D.
5. Only two of the three transfer cells may be loaded concurrently during the fuel transfer activities (see Attachment B).
6. A preliminary analysis of the building structure has been performed, and results indicate that the walls and columns can resist

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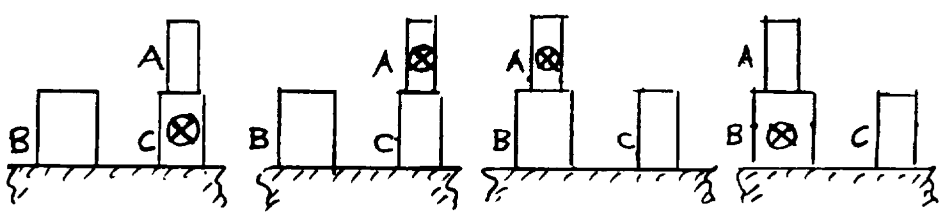
ASSUMPTIONS (cont'd.)

the loads from the struts. Final documentation will be included in Calculation 05996.02-SC-6 (Rev.1) and 05996.02-SC-7 (Rev.1). (Confirmation required).

DESIGN DESCRIPTION

The fuel is transported into the building inside the shipping cask (item C). The transfer cask (item A), which is placed on top of the shipping cask, is loaded with the fuel before it is transferred to the storage cask (item B), as shown in the sketch below.



[⊗ Denotes fuel load]

Step 1 step 2 step 3 step 4

Any two of the three fuel transfer cells may contain fuel loads concurrently (see Attach. B), with each bay loaded in any of the 4 conditions (steps 1 through 4 shown above). The casks are temporarily attached to the columns on Col. Row C by rigid struts, as shown in Figure 1.

The location and position of the casks are shown on Reference Drawings (6D, 6E, 6F, 6G). The critical loading condition for the building walls and columns occurs when Cell 2 is in the transfer phase of step 2, and Cell 3 has the loading of Step 3. This loading condition is shown in Figure 2 (pg. 15) along with the cask weights and the strut loads. The row of casks are located 13'-0" East of column row C, and at the center of each column bay in the North-South direction. The 13'-0" distance to to column row C is longer than minimum distance of 12'-0" which provides safe commodity clearances (see Attach. B). ⚠1

The struts are located approximately at the center-of-gravity elevation of each cask and they tie the casks to the columns during the fuel transfer activities (see Figure 1).

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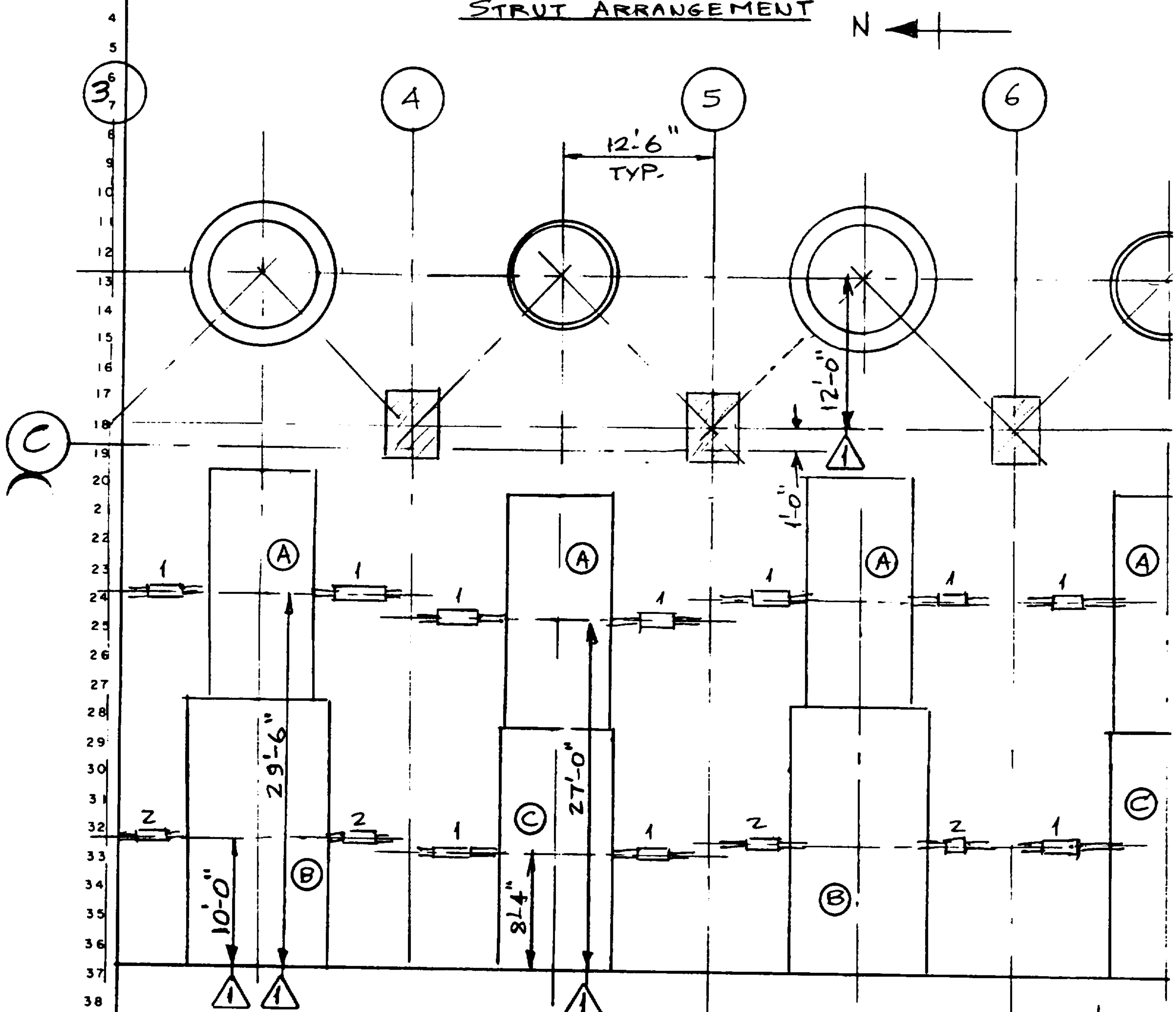
FIGURE 1
STRUT ARRANGEMENT



Strut TYPE 1 on Casks A & C (similar to 2100-200 of Ref. 7)

Strut TYPE 2 on Casks B (similar to 2100-200 of Ref. 7)

Rear end brackets for TYPE 1 & TYPE 2 (Part 2003-200 of Ref. 7)

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REFERENCES

1. Calculation No. 05996.02-SC-7, Rev. 0, "Design of Reinforcing Steel for Canister Transfer Building".
2. Safety Analysis Report (SAR), Rev. 17, "Private Fuel Storage Facility". ⚠1
3. ASME Boiler and Pressure Vessel Code, Division 1, Subsection NF, "Component Supports", 1992 edition.
4. AISC Manual of Steel Construction, 9th edition.
5. Calculation No. 05996.02-SC-5, Rev. 1, "Seismic Analysis of Canister Transfer Building". ⚠1
6. Drawings:
   A - No. 059602-EA-401 A-0 (Confirmation Required)
   B - No. 059602-EC-421 A-0 (Confirmation Required) ⚠1
   C - No. 059602-EC-422 A-0 (Confirmation Required)

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REFERENCES (cont'd.)

7. Bergen-Paterson Pipe Support Corp. Catalog :
No. 77 NFR, 1977, Rev. 3 for Part 2100 Strut
No. 77 NFR, 1977, Rev. 1 for Part 2003 Bracket

⚠1

ANALYSIS

The cask weights and approximate c.g. heights given in Attachments C and A, respectively are tabulated in Table 1, and used conservatively as the bases for the design loads and dimensional configurations. ⚠1

TABLE 1

ENVELOPED DATA FROM VENDORS

Cask Type	Design Data	Empty	Full
A	Vendor/Model	HI-STORM	HI-STORM
	Weight (kips)	152.6	239.8
	c.g. (inch)	~88	~93
B	Vendor/Model	HI-STORM	HI-STORM
	Weight (kips)	268.3	355.6
	c.g. (inch)	~117	~118
C	Vendor/Model	HI-STORM	HI-STORM
	Weight (kips)	153.0	240.2
	c.g. (inch)	~102	~100

⚠1

The seismic loads on the struts are based on 1.1108 g. acceleration values obtained from Reference 5. No uplift is postulated since the vertical g-value is smaller than 1.0. ⚠1

The full weight of each cask is used to derive the horizontal design loads on the struts and the connections.

	Enveloped Weight		g-Value		Strut Load
Casks A (FULL)	239.8^k	×	1.1108	=	266.4^k
Cask B (FULL)	355.6^k	×	1.1108	=	395.0^k
Cask C (FULL)	240.2^k	×	1.1108	=	266.8^k
Cask B (EMPTY)	268.3^k	×	1.1108	=	298.0^k
Cask C (EMPTY)	153.0^k	×	1.1108	=	170.0^k

⚠1

The maximum strut loads, based on full cask weights, are shown in Figure 3 for casks A, B & C in Cell 2, as typical for all three cells.

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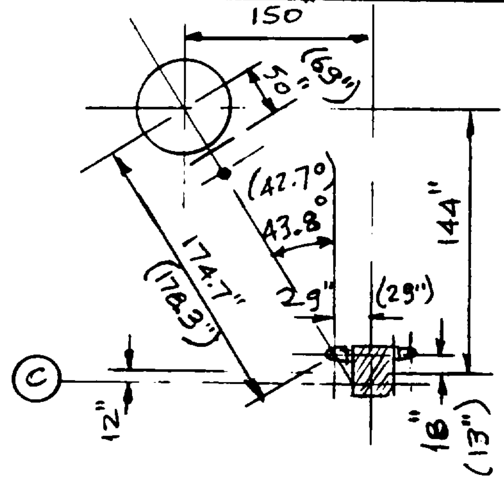
Strut Lengths

94.625" Φ Transfer Cask & (132½" Φ storage Cask)



( ) - Dimensions are for 132½" storage Cask

TYPE 1 Strut (94.625" Φ Cask)

Similar to Ref. 7, Part 2100 - Size 200 with Level D capacity ≥ 266.8 kips.

Pin to pin = 174.7 − 50 − 11. = 113.7"
= 9'-5 5/8"

TYPE 2 Strut (132½" Φ Cask)

Similar to Ref. 7, Part 2100 - Size 200 with Level D capacity ≥ 395 kips. ⚠

Pin-to-pin = 178.3" − 69" − 11" = 98.3"
= 8'-2¼"

Pin-to-pin dimensions vary according to cask diameter and actual installed location.

(*) TYPE 1 Strut : 9'-5 5/8" ± 5"

TYPE 2 Strut : 8'-2¼" ± 5"

(*) TYPE 1 strut can also accommodate 92" to 96" shipping casks since the total pin-to-pin dimension is provided with ± 5" tolerance (see Attach. D).

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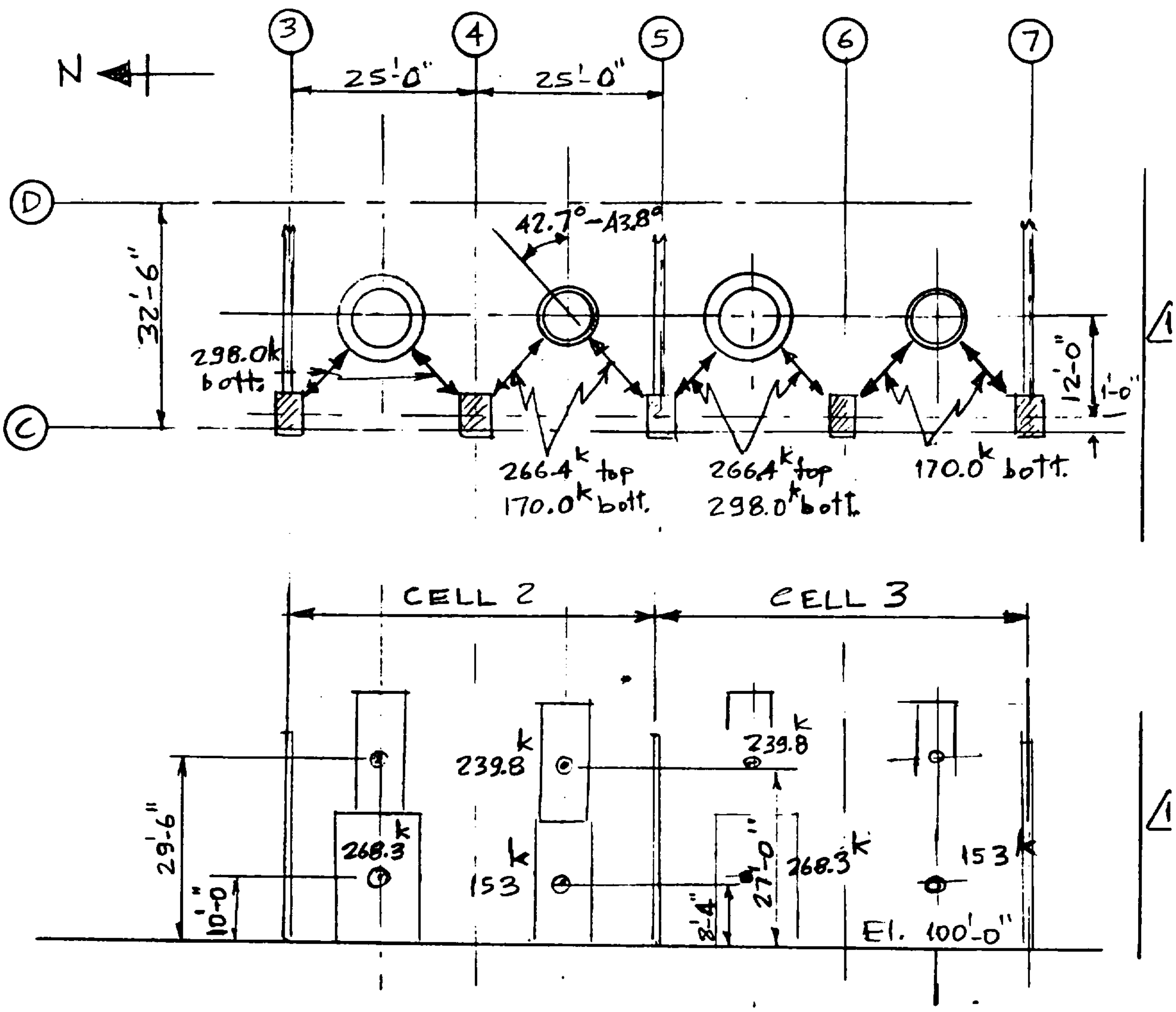
FIGURE 2
CRITICAL COLUMN LOADS



The critical loading on the columns occurs when the top casks are full, and the bottom casks are empty.

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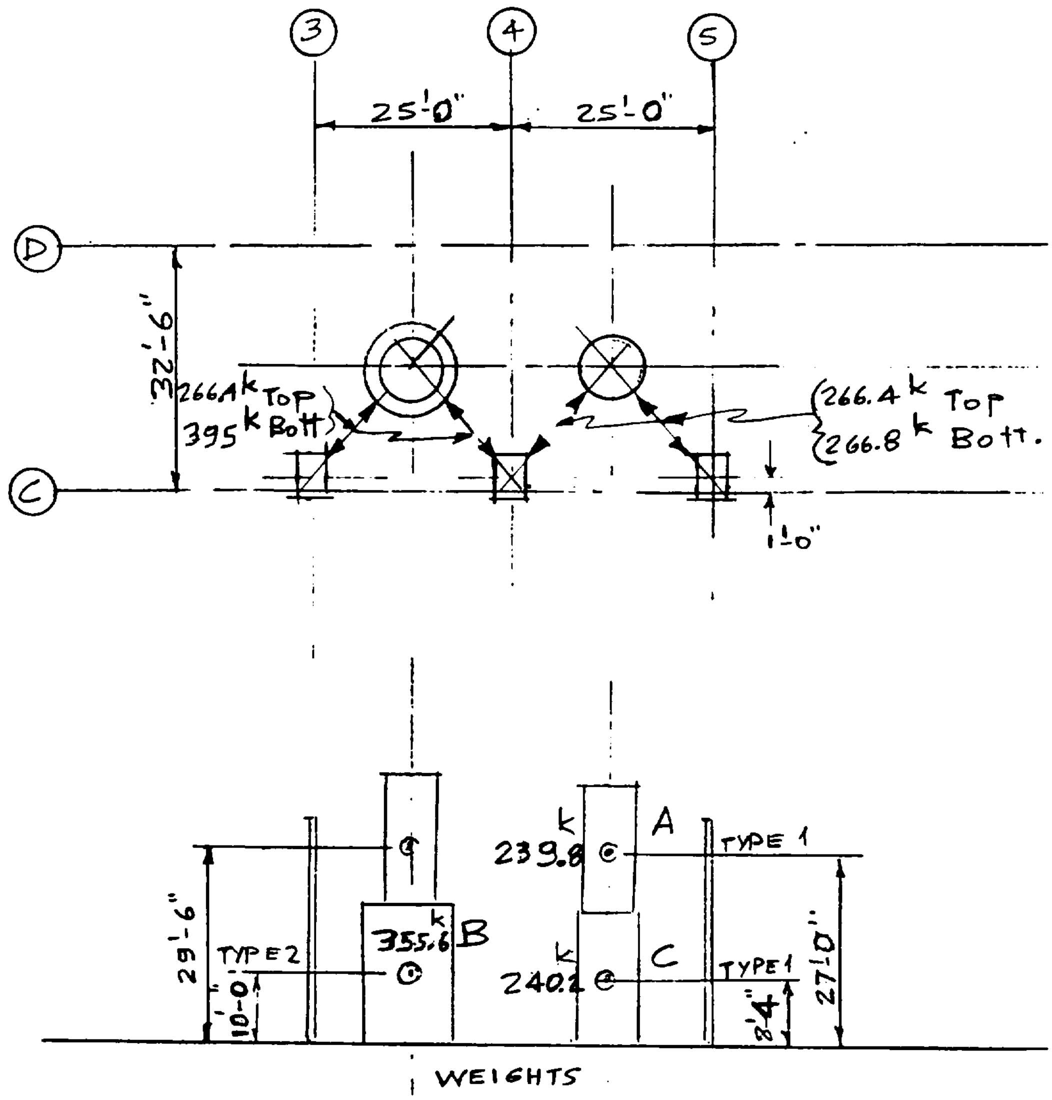
FIGURE 3

MAXIMUM STRUT LOADS (FULL CASKS)



Max. Pin-to-pin lengths of TYPE 1 and TYPE 2 struts are shown in Figures 4 and 5, respectively.

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FIGURE 4
TYPE 1 STRUT Length

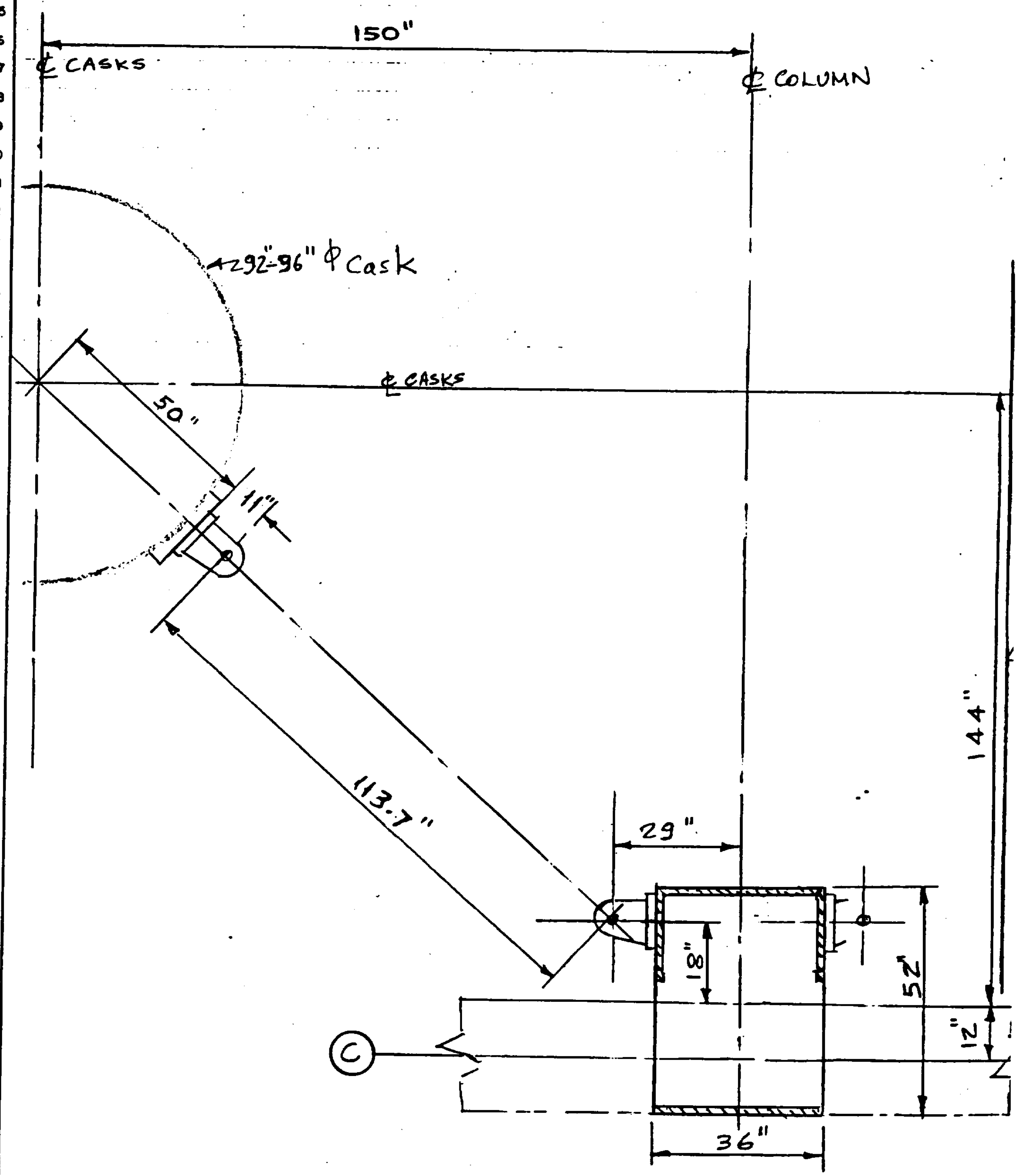

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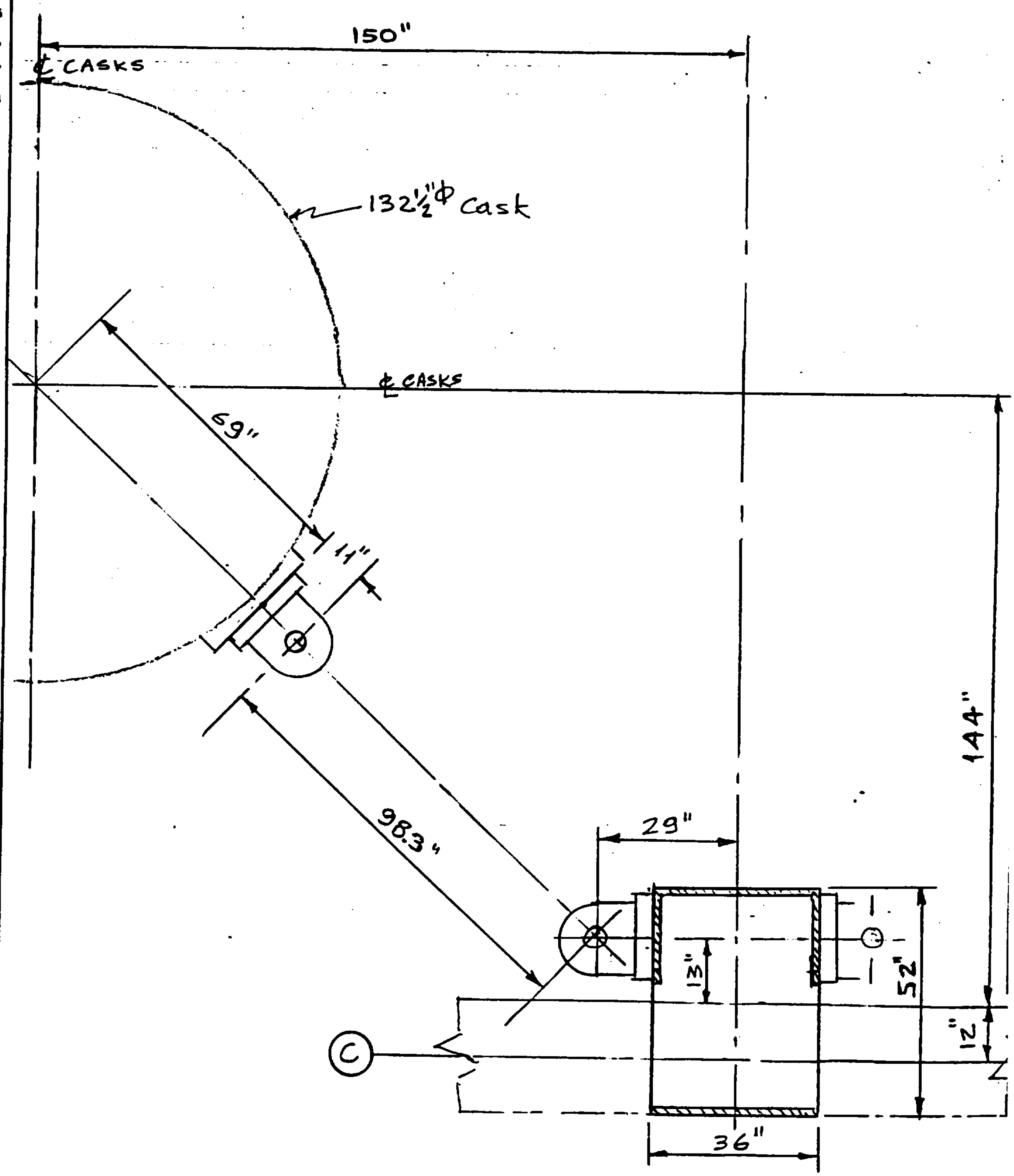
FIGURE 5
TYPE 2 STRUT Length



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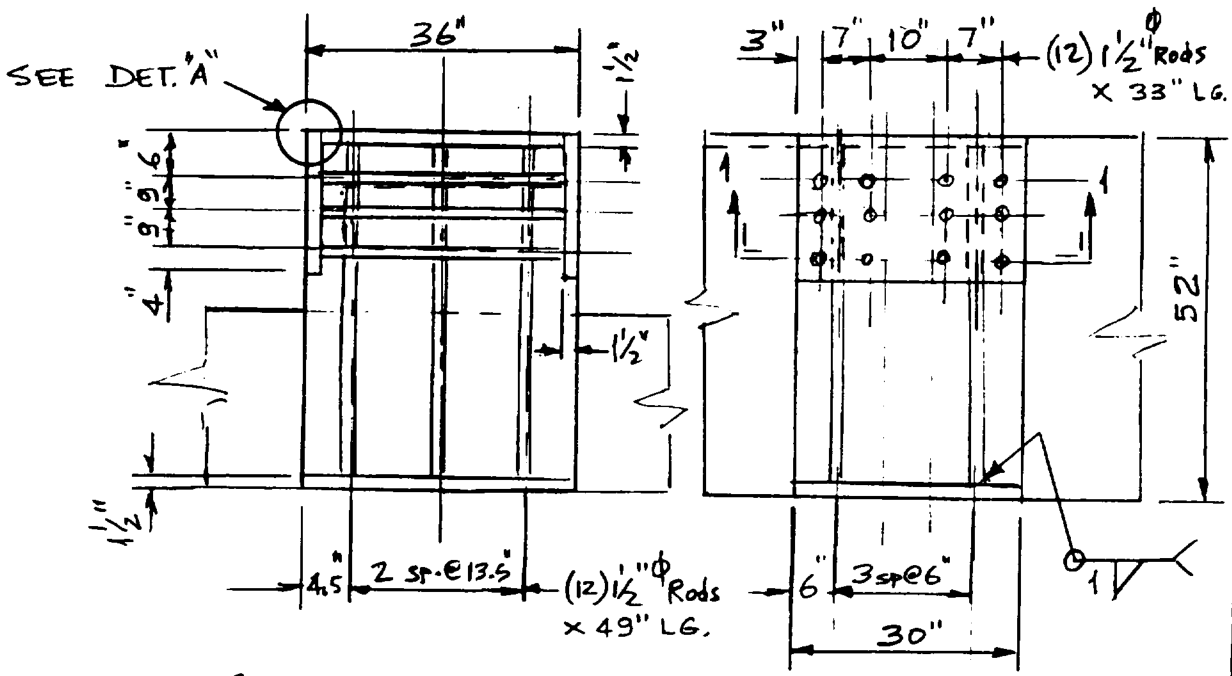
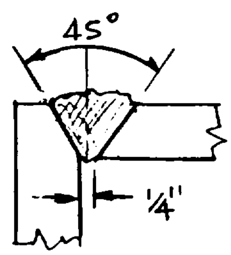
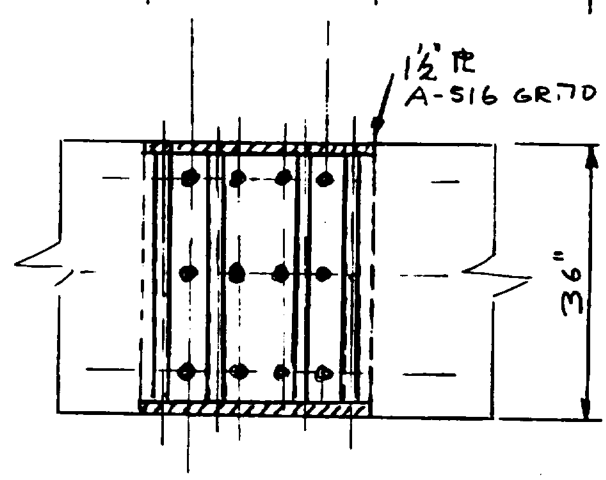
COLUMN ANCHOR



1



DETAIL "A"



SECTION "1-1"

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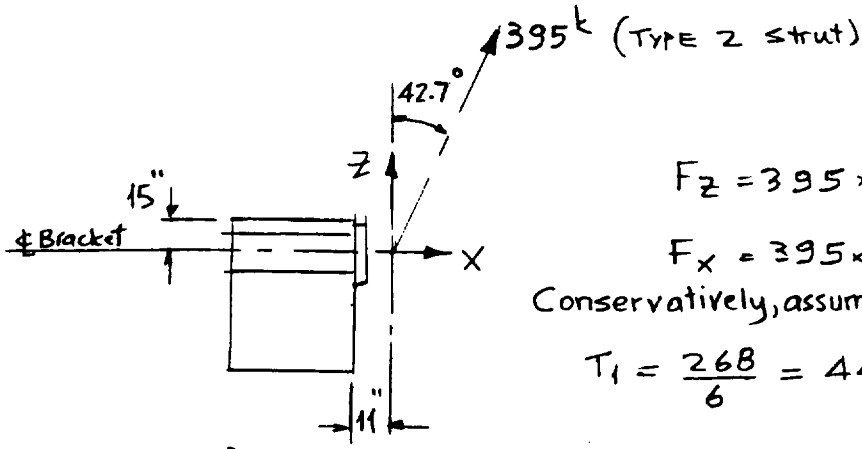
ANCHOR RODS

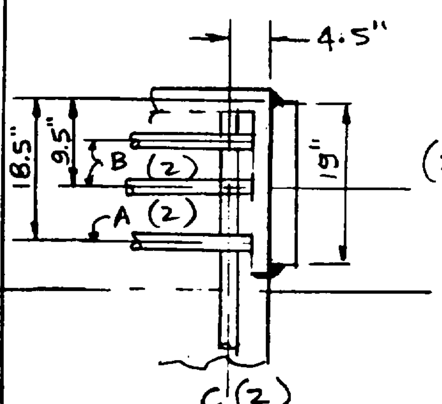


$F_Z = 395 \times \cos 42.7° = 290^k$

$F_X = 395 \times \sin 42.7° = 268^k$

Conservatively, assume only 6 bolts are effective.

$T_1 = \frac{268}{6} = 44.7^k$



$M_y = 11 \times 290 = 3190$ in-k

$\Sigma r^2 = (9.5)^2 + (18.5)^2 = 362.5 \text{ in}^2$ ⚠1

(2) "A" Rods, $T_2 = \frac{3190 \times 18.5}{362.5 \times 2} = 81.4$ k

Rod material A193 B7, or equivalent.

Using $S_y = 105$ ksi

Allow. $F_t = 0.9 \times 105 = 94.5$ ksi

The maximum load on rod "A",

$T_1 + T_2 = 44.7 + 81.4 = 126.1^k$

$f_t = \frac{126.1}{1.77} = 71.24 \text{ ksi} < 94.5 \text{ ksi}$

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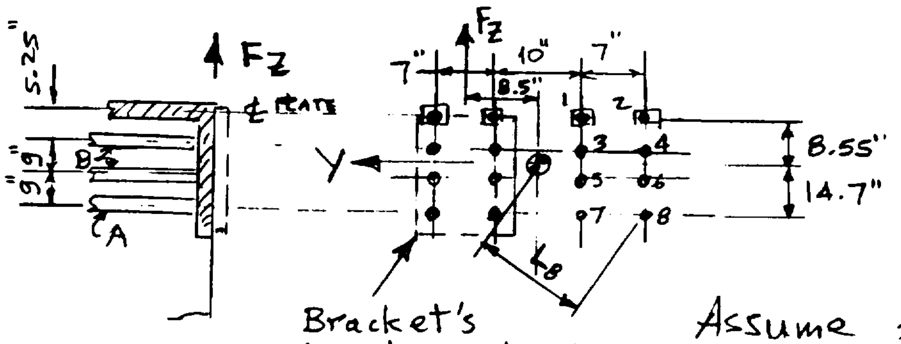
Shear Load on Rods "A" and B:



Bracket's worst case location, off-center

Assume 2× Rod area as the effective area of 1½" PL for the distibution of Fz.

c.g. from Rod "A" $= \frac{1}{5A}(9\times1A + 18\times1A + 23.25\times2A) = 14.7"$

L = distance from c.g. to Areas 1 through 8.

$L_1 = [(5)^2 + (8.55)^2]^{1/2} = 9.90"$, $L_2 = [(12)^2 + (8.55)^2]^{1/2} = 14.73"$

$L_3 = [(5)^2 + (3.3)^2]^{1/2} = 6.0"$, $L_4 = [(12)^2 + (3.3)^2]^{1/2} = 12.45"$, $L_5 = [(5.7)^2 + (5)^2]^{1/2} = 7.58"$ ⚠1

$L_6 = [(5.7)^2 + (12)^2]^{1/2} = 13.28"$, $L_7 = [(14.7)^2 + (5)^2]^{1/2} = 15.53"$, $L_8 = [(12)^2 + (14.7)^2]^{1/2} = 18.98"$

$I_R = \Sigma(2L_1^2 + 2L_2^2 + L_3^2 + L_4^2 + L_5^2 + L_6^2 + L_7^2 + L_8^2) = 1656\ in^2$

$M = 290 \times 8.5 = 2465$ in-k

due to M, max. shear load in Rod #8 $= \frac{2465\times18.98}{2\times1656} = 14.13^k$

due to Fz, shear/bolt $= \frac{290}{20} = 14.5^k$

In z-direction, due to M, $F_{mz} = \frac{12}{18.98}\times14.13 = 8.93^k$

Total shear in z-direction $= 14.5 + 8.93 = 23.43^k$

In y-direction, due to M, $F_{my} = \frac{14.7}{18.98}\times14.13 = 10.94^k$

Max. shear load, $S = [(23.43)^2 + (10.94)^2]^{1/2} = 25.86^k$

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Based on the ratio of normal allowable stresses from the AISC Code, with Tension = 0.6 Sy, & Shear = 0.4Sy,

Shear stress allow. $= \frac{0.4}{0.6} \times 94.5 = 63$ ksi

Shear stress $= \frac{25.86}{1.77} = 14.61$ ksi

Conservatively, based on a linear interaction between tension and shear, (typically it is non-linear),

$$\frac{T}{T_A} + \frac{S}{S_A} = \frac{71.24}{94.5} + \frac{14.61}{63} = 0.986$$

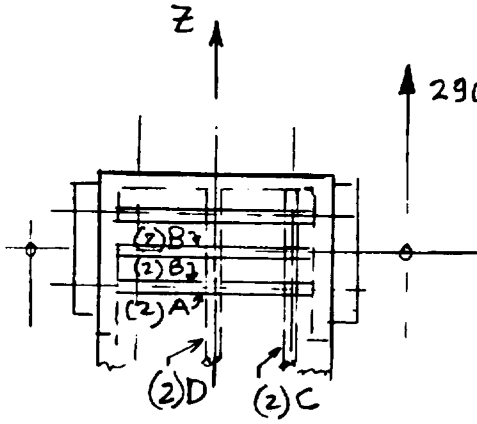
Considering the conservatism involved in the analytical assumptions, the actual interaction ratio is lower than calculated above. ⚠1

Shear stress in 1½" thick plate,

$$f_V = \frac{2465 \times 14.73 \times 2}{2 \times 1656 \times 1.77} = 12.39 \text{ ksi}$$

Allow. shear stress $F_V = 0.4 \times 1.33 \times 38 = 20.2$ ksi for A-516 GR70 Mat'l.

ANCHOR RODS (cont'd.)



The maximum F_Z load on one bracket is 290 kips.

Rod area (1½" φ) $A_s = 1.77\ in^2$

$$f_t = \frac{290}{2 \times 1.77} = 81.9\ ksi,$$

assuming 2 rods each end (Rod C) take the total load in tension, and conservatively considering the "A" and "B" rods ineffective.

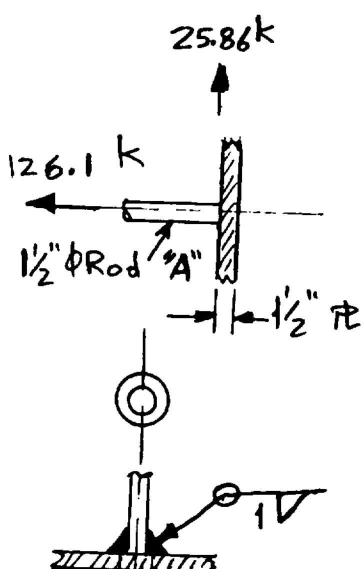
81.9 ksi < 94.5 ksi

The highest load is in rod "A":

Tension, T = 126.1 k

Shear, S = 25.86 k

Based on E70XX electrode,



$$\text{Req'd. Weld Area} = \frac{[(126.1)^2 + (25.86)^2]^{1/2}}{21.0 \times 1.33} = 4.6\ in^2$$

$$\text{Req'd. } w_R = \frac{4.6}{\pi \times 2.17 \times 0.707} = 0.954''$$

1" fillet weld is adequate.

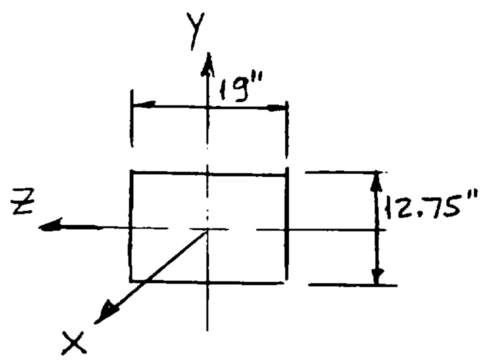
$$d = 1.5 + 2 \times \frac{1.0}{3} = 2.17''$$

for 1" fillet weld

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 24
05996.02	structural	05996.02-SC-10	N/A	

Size 200 Strut Bracket

TYPE 1 strut



$A = 2\,(19 + 12.75) = 63.5$ in

$Z_Y = \frac{19}{3}(19 + 3\times 12.75) = 362.6\ in^2$

$F_X = 266.8 \times \sin 43.8^\circ = 184.7^k$

$F_Z = 266.8 \times \cos 43.8^\circ = 192.6^k$

$M_Y = 11 \times 192.6 = 2118.6$ in-k

Unit weld force, $f = \left[\left(\frac{184.7}{63.5} + \frac{2118.6}{362.6}\right)^2 + \left(\frac{192.6}{63.5}\right)^2\right]^{1/2}$

$= 9.262$ k/in

Req'd. $w_R = \frac{9.262}{0.707 \times 21 \times 1.33} = 0.47''$

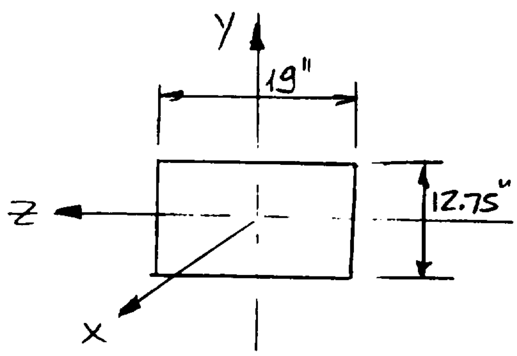
use 3/4" fillet weld

⚠1

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 25
05996.02	Structural	05996.02-SC-10	N/A	

Size 200 Strut Bracket

TYPE 2 Strut



$A = 2(19 + 12.75) = 63.5$ in

$Z_y = \frac{19}{3}(19 + 3 \times 12.75) = 362.6$ in^2

FROM PG. 20:

$F_x = 268^k$, $F_z = 290^k$

$M_y = 11 \times 290 = 3190$ in-k

Unit weld force, $f = \left[\left(\frac{268}{63.5} + \frac{3190}{362.6}\right)^2 + \left(\frac{290}{63.5}\right)^2\right]^{1/2}$

$= 13.80$ k/in

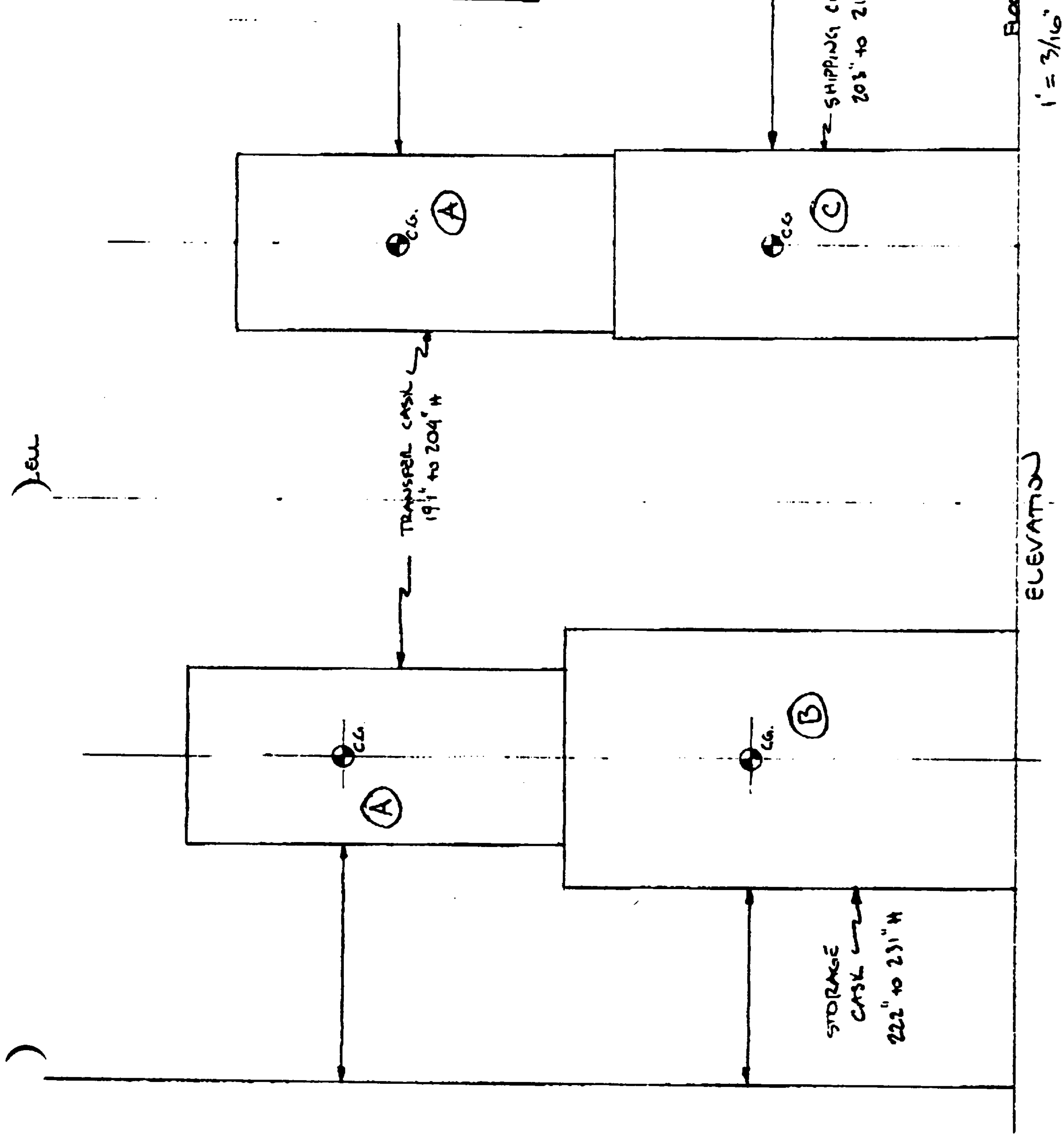
Reqd. $w_R = \frac{13.80}{0.707 \times 21.0 \times 1.33} = 0.70$ in

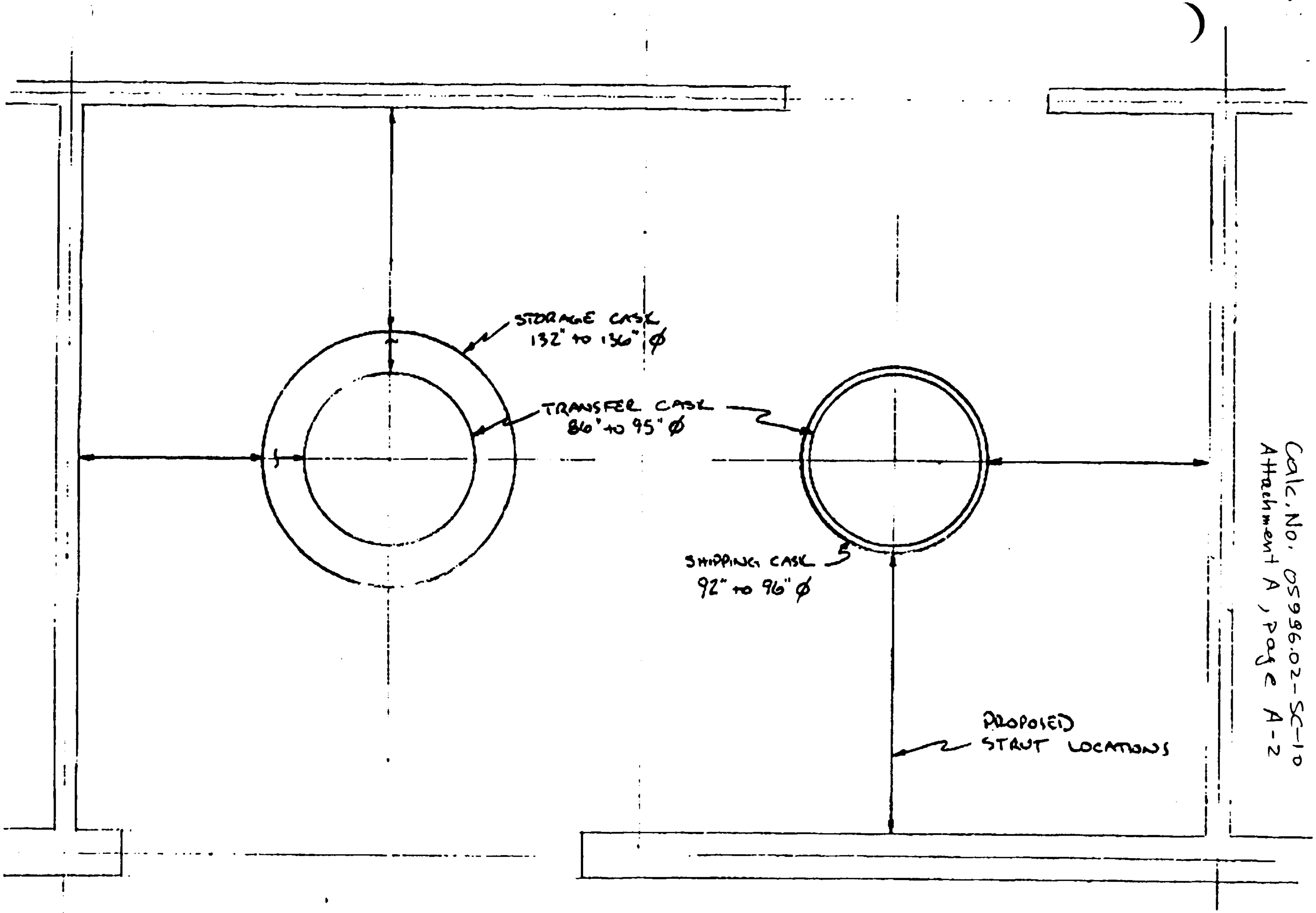
use 3/4" fillet weld

⚠1

Calc. No. 05996.02-SC-10
Attachment A, page A-1/A-10

Post-it® Fax Note 7671	Date 8/9/99 8-11-99	# of pages ▶ 69
To Bruce Ebbeson	From Wayne Lewis	
Co./Dept.	Co.	
Phone #	Phone #	
Fax # 3171	Fax #	





CTB CELL

1' = 3/16" SCALE

Calc. No. 05996.02-SC-10
Attachment A, Page A-2

Holtec

Calc. No. 05996.02-SC-10
Attachment A, page A-3

Table 3.2.2

125-TON HI-TRAC TRANSFER CASK WEIGHT DATA

ITEM	WEIGHT (lb)†		
	Component	Assembly	Bounding Weight††
125-Ton HI-TRAC Transfer Cask with Pool Lid		142,988	143,500
· Pool Lid · Top Lid	12,031 2,730		12,500 2,750
125-Ton HI-TRAC Transfer Cask with Transfer Lid		152,636	153,000
· Transfer Lid · Top Lid	21,679 2,730		22,000 2,750
MPC-24			
· Without SNF · Fully loaded with SNF		39,667 79,987	 80,000
125-Ton HI-TRAC with Pool Lid with loaded MPC-24		222,975	223,500
(A) PWR → 125-Ton HI-TRAC with Transfer Lid w/ loaded MPC-24		232,623	233,000
MPC-68			
· Without SNF · Fully loaded with SNF		39,641 87,241	 90,000
125-Ton HI-TRAC with Pool Lid with loaded MPC-68		230,229	233,500
(A) BWR → 125-Ton HI-TRAC with Transfer Lid w/ loaded MPC-68		239,877	243,000

See Attach. C for final weights. | △1

† All calculated weights are rounded up to the nearest pound

†† Bounding weights or calculated weights may be used for analytical calculations, as appropriate, to insure conservatism in the results.

Holtec

Calc. No. 05996.02-SC-10
Attachment A, page A-4

Table 3.2.1

HI-STORM 100 OVERPACK WEIGHT DATA

Item	WEIGHT (lb)† Component (lb.)	Assembly (lb.)	Bounding Weight†† (lb.)
Overpack		268,334	270,000
· Overpack top lid	21,638		23,000
MPC-24			
· Without SNF		39,667	
· Fully loaded with SNF		79,987	90,000
(B) PWR → Storage cask → Overpack with fully loaded MPC-24		348,321	360,000
MPC-68			
· Without SNF		39,641	
· Fully loaded with SNF		87,241	90,000
(B) BWR → Storage cask → Overpack with fully loaded MPC-68		355,575	360,000
Overpack with minimum weight MPC without SNF		307,975	303,000 (Lower Bound)

See Attach. C for final weights △1

† All calculated weights are rounded up to the nearest pound

†† Bounding weights or calculated weights may be used for analytical calculations, as appropriate, to ensure conservatism in the results.

Table 3.2.3

CENTERS OF GRAVITY OF HI-STORM 100 CONFIGURATIONS

Component	Height of CG Above Datum, inches
HI-STORM 100 Overpack empty	116.8
125-Ton HI-TRAC with Pool Lid empty	90.51
125-Ton HI-TRAC with Transfer Lid empty	88.19
MPC-24 Empty (See Note 2.)	108.9
MPC-68 Empty (See Note 2.)	109.9
PWR (B) → MPC-24 with Fuel in Overpack	118.39
BWR (B) → MPC-68 with Fuel in Overpack	118.38
125-Ton HI-TRAC w/Pool Lid and MPC-24 w/fuel	93.88
125-Ton HI-TRAC w/Pool Lid and MPC-68 w/fuel	93.95
PWR (A) → 125-Ton HI-TRAC w/Transfer Lid and MPC-24 w/fuel	91.66
BWR (A) → 125-Ton HI-TRAC w/Transfer Lid and MPC-68 w/fuel	92.34
100-Ton HI-TRAC w/Pool Lid Empty	85.57
100-Ton HI-TRAC w/Transfer Lid Empty	85.73
100-Ton HI-TRAC w/Pool Lid and MPC-24 w/fuel	90.31
100-Ton HI-TRAC w/Pool Lid and MPC-68 w/fuel	90.54
100-Ton HI-TRAC w/Transfer Lid and MPC-24 w/fuel	91.24
100-Ton HI-TRAC w/Transfer Lid and MPC-68 w/fuel	91.92

Note:

1. The datum used for calculations involving the overpack is the bottom of the overpack baseplate. The datum used for calculations involving the HI-TRAC is the bottom of the pool lid or transfer lid.

2. The datum used for calculations involving only the MPC is the bottom of the MPC baseplate.

Calc. No. 05996.02-SC-10
Attachment A, page A-6

Holtec

Table 3.2.1

HI-STAR 100 WEIGHT DATA†

Item	CALCULATED WEIGHT (lb) Component	Assembly
➤ Overpack		153,710
• Overpack closure plate	7,984	
➤ MPC-24		
• Fuel basket	17,045	
• Without SNF		39,667
• Fully loaded with SNF		79,987
➤ Overpack with loaded MPC-24 (SHIPPING CASK)		233,697
➤ MPC-68		
• Fuel basket	15,263	
• Without SNF		39,641
• Fully loaded with SNF		87,241
➤ Overpack with fully loaded MPC-68 (SHIPPING CASK)		240,951
➤ Overpack with minimum weight MPC without SNF (Value listed is lower bound to actual minimum weight of 193351 lb.)		189,000

(C) PWR → Overpack with loaded MPC-24
(C) BWR → Overpack with fully loaded MPC-68

See Attach. C for final weights ⚠1

† All calculated weights are rounded to the nearest pound.

Calc. No. 05996.02-SC-10
Attachment A, page A-7

Holtec

Table 3.2.2

CENTERS OF GRAVITY OF HI-STAR 100 CONFIGURATIONS

Component	Height of CG Above Datum†, inches
Overpack empty	99.7
MPC-24 empty	108.9
MPC-68 empty	109.9
MPC-24 with fuel in overpack	101.8
MPC-68 with fuel in overpack	101.8

† The datum used for calculations involving the overpack is the bottom of the overpack bottom plate. The datum used for calculations involving the MPC only is the bottom of MPC baseplate (see Figure 3.2.1).

TABLE 3.2-1
TranStor™ SYSTEM WEIGHTS AND CENTERS OF GRAVITY

ITEM DESCRIPTION	WEIGHT (lbs)		CENTER OF GRAVITY (inches above bottom)	
	PWR	BWR	PWR	BWR
• Storage Cask Lid	1,235	1,235	N/A	N/A
• Basket Structural Lid	2,730	2,730	N/A	N/A
• Basket Shield Lid	7,350	7,350	N/A	N/A
• Transfer Cask Lid	400	400	N/A	N/A
• Basket (Empty, w/o Lids)	29,215	31,250	88.3	89.0
• Basket (Loaded w/Water and Shield Lid)	87,840	94,075	93.5	96.9
• Basket (Loaded, dry, w/Lids)	77,760	84,020	97.5	100.8
• Storage Cask (Empty, w/o Lid)	222,200	222,200	109.4	109.4
• Storage Cask & Basket (Empty, w/o Lids)	252,790	254,825	110.5	110.6
(B) • Storage Cask & Basket (Loaded, w/Lids) Canister	297,200	307,600	113.9	113.9
• Transfer Cask (Empty w/o Lid)	126,230	126,230	90.6	90.6
• Transfer Cask with Basket (Empty, w/o Shield Lid)	156,100	158,100	92.8	92.8
• Transfer Cask with Basket (Loaded, w/ water and Lid)	212,400	222,000	97.9	98.1
(A) • Transfer Cask with Basket (Loaded, dry, w/ Lids) Canister	200,430	210,850	99.0	99.2

See Attach. C for final weights ⚠1

TABLE 2.2-1
TRANSTOR™ SYSTEM COMPONENTS USED FOR SHIPPING
WEIGHTS AND CENTERS OF GRAVITY - BWR

Component Description	BWR Basket 175 inch Cavity Height		BWR Basket 180 inch Cavity Height	
	Weight (kips)	Center of Gravity (inches above bottom of item)	Weight (kips)	Center of Gravity (inches above bottom of item)
Basket (total - including Structural Lid)	40.5	110.2	41.3	112.8
Basket Structural Lid	2.73	N/A	2.73	N/A
Basket with Fuel	83.2	98.2	84.0	100.9
Water	13.0	N/A	13.5	N/A
Cask (without Closure Lid)	152.4	96.7	152.4	96.7
Cask (with Closure Lid & Spacer where applicable)	160.9	102.7	159.8	101.8
Impact Limiters	34	N/A	34	N/A
Contents (Fuel)	42.7	N/A	42.7	N/A
Lifting Yoke	4.5	N/A	4.5	N/A
Under the Hook Weight[1]	248.5	100.0	249.8	101.9
Transport Weight	278	N/A	279.3	N/A

[1] Assumes that at least 225 gallons of water (1870 lb) are pumped out of the cask at the pool surface to get within 125 ton (250,000 lb) crane capacity for wet loading. This water is in addition to water removed from the top of basket shield lid.

C BWR

See Attach. C for final weights 1

Calc. No. 05996.02-SC-10
Attachment A, page A-10/A

TABLE 2.2-2
TRANSTOR™ SYSTEM COMPONENTS USED FOR SHIPPING WEIGHTS AND CENTERS OF GRAVITY - PWR

Component Description	PWR Basket 170 in. Cavity Height		PWR Basket 175 in. Cavity Height		PWR Basket 180 in. Cavity Height	
	Weight (kips)	Center of Gravity (inches above bottom of item)	Weight (kips)	Center of Gravity (inches above bottom of item)	Weight (kips)	Center of Gravity (inches above bottom of item)
Basket (total – including Structural Lid)	37.7	108.2	37.4	109.0	39.3	113.5
Basket Structural Lid	2.73	N/A	2.73	N/A	2.73	N/A
Basket with Fuel	77.6	95.9	77.8	97.5	73.6	102.2
Water	12.9	N/A	13.5	N/A	14.6	N/A
Cask (without Closure Lid)	152.4	96.7	152.4	96.7	152.4	96.7
Cask (with Closure Lid & Spacer)	161.2	102.6	160.9	102.5	159.8	102.0
Impact Limiters	34	N/A	34	N/A	34	N/A
Contents (Fuel & Control Component Envelop)	39.8	N/A	40.3	N/A	34.3	N/A
Lifting Yoke	4.50	N/A	4.50	N/A	4.50	N/A
Under the Hook Weight	244.7	99.1	245.5	99.6	243.2	101.0
Transport Weight	274.2	N/A	275	N/A	272.2	N/A

(C) PwR

See Attach. C for final weights ⚠1

TEL-CON NOTE

J.O NO. 05996.02

TIME: 1:30 PM DATE: 8/18/99

	NAME	COMPANY
FROM:	O. Bilgin	SWEC-Cherry Hill
TO:	W. Lewis	SWEC-Denver

TOPIC: Seismic restraints for spent fuel casks in Canister Transfer Building

Question from O. Bilgin: How close can the casks be located to Colum Row "C" in the East-West direction without interference with other equipment in the Canister Transfer Building? And in which Transfer Cells will the transfer activities occur simultaneously?

Response from W. Lewis: Casks can be located 12'-0" from column Row "C" without interferences, and the transfer activities can occur in any 2 cells simultaneously.

Calc. No. 05996.02-SC-10
Attachment C, page C-1

TABLE 3.6-1
(Sheet 1 of 5)

SUMMARY OF PFSF DESIGN CRITERIA

DESIGN PARAMETERS	DESIGN CONDITIONS	APPLICABLE CRITERIA AND CODES
GENERAL		
PFSF Design Life	40 years	PFSF Specifications
Storage Capacity	40,000 MTU of commercial spent fuel	PFSF Specifications
Number of Casks	approximately 4,000 casks	PFSF Specifications
SPENT FUEL SPECIFICATIONS		
Type of Fuel	See Appendix B of HI-STORM C. of C. See Table 3.1-3 (Sheet 2 of 2)	Reference 34 TranStor SAR
Fuel Characteristics	See Appendix B of HI-STORM C. of C. See Table 3.1-3 (Sheet 2 of 2)	Reference 34 TranStor SAR
STORAGE SYSTEM CHARACTERISTICS		
Canister Capacity	HI-STORM 24 PWR assemblies/canister 68 BWR assemblies/canister TranStor 24 PWR assemblies/canister 61 BWR assemblies/canister	HI-STORM SAR, Section 1.1 TranStor SAR, Section 1.1
Weights (maximum)	HI-STORM Storage Cask - 268,334 lbs. Loaded Canister - 87,241 lbs. Transfer Cask - 152,636 lbs. Shipping Cask - 153,080 lbs. TranStor Storage Cask - 222,200 lbs. Loaded Canister - 84,020 lbs. Transfer Cask - 126,230 lbs. Shipping Cask - 160,900 lbs.	HI-STORM SAR, Table 3.2.1 " HI-STORM SAR, Table 3.2.2 Shipping SAR, Table 2.2.1 TranStor SAR, Table 3.2-1 " " Shipping SAR, Table 2.2-1

Calc. No. 05996.02 - SC-10
Attachment C, page C-2

TABLE 4.2-1

PHYSICAL CHARACTERISTICS OF THE HI-STORM CANISTER

PARAMETER	VALUE
Outside Diameter	68.38 inches
Length, maximum	190.5 inches
Capacity	24 PWR assemblies 68 BWR assemblies
Maximum Heat Load	20.88 kW for PWR canister (MPC-24) 21.52 kW for BWR canister (MPC-68)
Material of Construction	Stainless steel
Weight, maximum (loaded with spent fuel)	79,987 lb (MPC-24) 87,241 lb (MPC-68)
Internal Atmosphere	Helium

Calc. No. 05996.02 – SC-10
Attachment C, page C-3

TABLE 4.2-2

PHYSICAL CHARACTERISTICS OF THE HI-STORM STORAGE CASK

PARAMETER	VALUE
Height	~~231~~239.~~2~~5 inches
Outside Diameter	132.5 inches
Capacity	1 loaded canister
Max. Radiation Dose Rate[1] 1 meter from surface: Side Top On contact with surface: Side Top Top vents Bottom vents	 17 mrem/hr 2 mrem/hr 35 mrem/hr 5 mrem/hr 9 mrem/hr 15 mrem/hr
Material of Construction	Concrete (core and lid) Steel (liner and shell)
Weight, maximum	268,334 lb (empty) 348,321 lb (with loaded MPC-24) 355,575 lb (with loaded MPC-68)
Service Life	>100 years

1. Dose rate is based on HI-STORM design basis zircaloy clad fuel for normal conditions.

Calc. No. 05996.02-SC-10
Attachment C, page C-4/C-4

TABLE 4.7-1

PHYSICAL CHARACTERISTICS OF THE HI-TRAC TRANSFER CASK

PARAMETER	VALUE
Inside Diameter	68.75 inches
Outside Diameter	94.625 inches
Height	~~203~~201.50 inches
Materials of Construction	Steel (inner and outer shell) Lead (gamma shield) Water (neutron absorber)
Weight (empty)	152,636 lb
Maximum Working Dose Rate[1] (1 meter from surface) Side	42 mrem/hr

1. Dose rates are based on HI-TRAC design basis zircaloy clad fuel for normal conditions.

Calc. No. 05996.02-SC-10
Attachment D, page D-1

BERGEN-POWER PIPE SUPPORTS

P.O. BOX 4011 - 225 Merrimac Street, Woburn, MA 01888

Fax Cover Sheet

DATE: Friday, March 30, 2001

TO: Ozzie Bilkin
Stone & Webster Eng. Corp.
PHONE: 865-482-3629
FAX: 856-482-3171

FROM: Bill Dunleavy
PHONE: 781-935-9550
FAX: 781-938-0026

RE: Rigids Strut Faulted Loads
Skull Valley Fuel Storage Facility

CC: A. Shumilla

Number of pages including cover sheet: (1)

Message:

Confirming our telcon our part 2100-200 can be modified to suit the loads given in your fax. We would need to increase the weld sizes at the Paddle and the Pipe and the paddle material would need to be changed. One of the welds currently has a capacity of 293,110 lb. faulted and the other is 364,293 lb.. The paddle has a faulted limit of 344,925 lb. using A-36 Material we would have to substitute a stronger material as there is little room to increase the size. The rear bracket Part 2003-200 has a faulted capacity of 376,000 at 90 degrees, the supports in this design are at 45 degrees which would allow some increase in load. We would be interested in providing you a quote for the 18 type I and 6 type II struts on this project.

Our Load Qualifications are based on the 7-1-77 issue of NF.

If we can be of further assistance please call.

Regards,

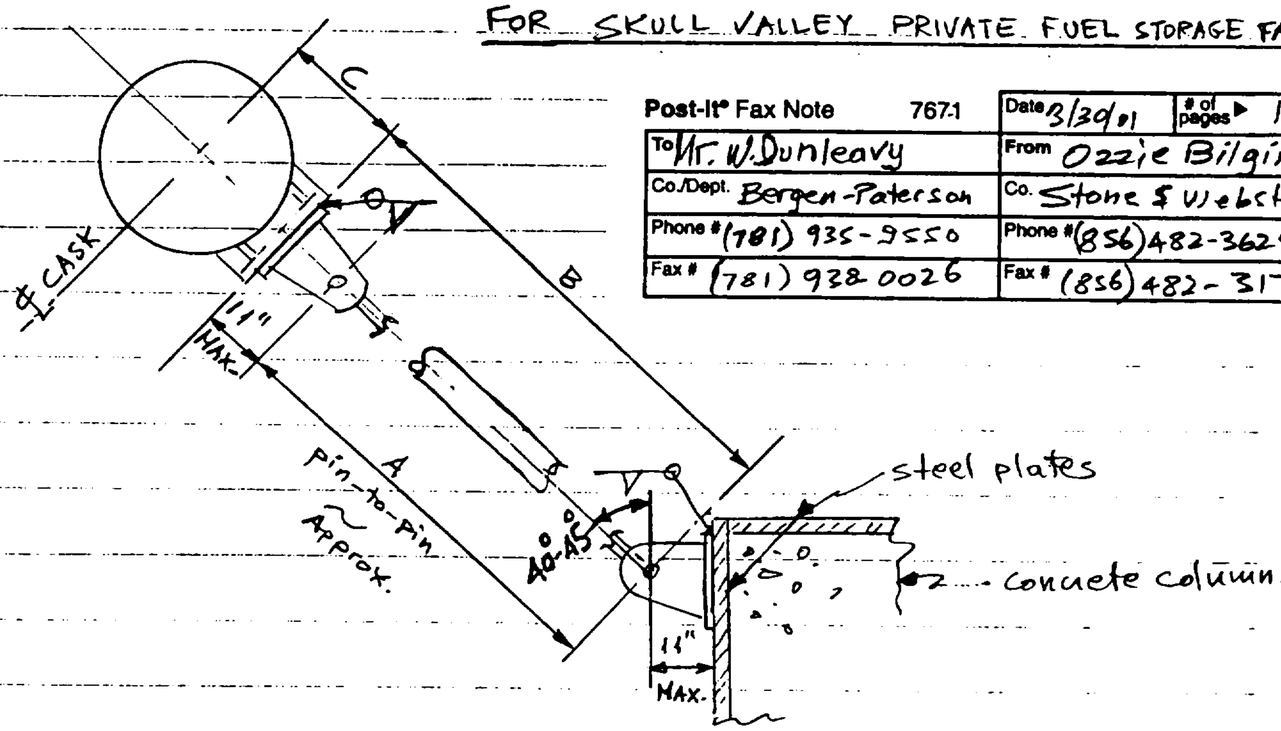
Wm B. Dunleavy

William B. Dunleavy
Engineering Supervisor

STRUTS FOR SPENT FUEL CASKS

FOR SKULL VALLEY PRIVATE FUEL STORAGE FACI[L]

Post-It® Fax Note 7671	Date 3/30/01 # of pages ▶ 1
To Mr. W. Dunleavy	From Ozzie Bilgin
Co./Dept. Bergen-Paterson	Co. Stone & Webster
Phone # (781) 935-9550	Phone # (856) 482-3629
Fax # (781) 938 0026	Fax # (856) 482-3171



	A	B	C	LOAD (FAULTED)	CASK TYPE
TYPE I	~115"	~126"	50" ± 3"	270 k.	TRANSFER or SHIPPIN[G]
TYPE II	~98"	~109"	69" ± 3"	400 k.	STORAGE

Struts are to be qualified to ASME III NF Class 2 1992 Code for Level D "FAULTED" condition.

Note: It is important that 11 in. dimension for the rear end brackets not be exceeded.

Tolerance: ± 2½" each end (Total = ± 5")

O. Bilgin (SWEC)
3/30/01
Ph: (856) 482-3629
Fax (856)-482-3171