ATTACHMENT A

INDIAN POINT UNIT 2

PROCEDURE AND CRITERIA UTILIZED TO GENERATE IN-STRUCTURE RESPONSE SPECTRA

Consolidated Edison Company of New York, Inc.

September 1992

ATTACHMENT A

SUMMARY OF SEISMIC IN-STRUCTURE
RESPONSE SPECTRA

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT UNIT NO. 2
DOCKET NO. 50-247
SEPTEMBER, 1992

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1.0 Introduction

The purpose of this report is to present detailed information on the procedures and criteria used to generate the In-Structure Response Spectra (ISRS) for the Indian Point Unit 2 Nuclear Generating Station (IP2). The report has been prepared to comply with the requirements of the Nuclear Regulatory Commission (NRC) as specified in the May 22, 1992 letter, "Supplement 1 to Generic Letter (GL) 87-02 that transmits Supplemental Safety Evaluation Report (SSER) No. 2 on the SQUG Generic Implementation procedure (GIP), Revision 2, as corrected on February 14, 1992".

2.0 Seismic Design Basis

The peak ground acceleration (PGA) corresponding to the Operating Basis Earthquake (OBE), and the Safe Shutdown Earthquake (SSE) are shown below:

Earthquake	Horizontal Acceleration (g)	Vertical Acceleration (g)
OBE	0.10	0.05
SSE	0.15	0.10

Housner ground response spectra [1] anchored to the peak acceleration of the OBE and SSE were used in the design. Figures 1 and 2 show the horizontal design spectra for the OBE and SSE, respectively.

The SSE ground acceleration value for Indian Point was confirmed in NRC licensing proceedings conducted from 1975 through 1977 [2]. Specifically, based on the seismic hazard as determined in the licensing proceedings, the NRC found that "[t]he ground acceleration value used for the design of Indian Point Units 2 and 3 should remain at 0.15g" [2, page 6].

Note that the terms Maximum Potential Earthquake and Design Basis Earthquake (DBE) are used synonymously in the Updated Final Safety Analysis Report (UFSAR) [3], and refer to the SSE.

3.0 Time History Analyses

The generation of ISRS for the IP2 structures was performed through dynamic analyses of multi-degree of freedom elastic models subjected to seismic motions represented by appropriate time histories compatible with the design basis SSE Housner ground response spectra anchored to 0.15g. The ISRS were obtained from the time history response of the building floors. The dynamic analyses for IP2 structures were originally performed by Westinghouse Electric Corporation, and subsequently supplemented by other consultants like URS/Blume & Associates and Harstead Engineering Associates.

The vertical floor response spectra are equal to two-thirds of the horizontal floor response spectra.

The damping values used in the design of the structures, systems and components are given in Table 1.

4.0 Soil-Structure Interaction

The structures at IP2 are founded on competent rock. Therefore, for design of IP2 structures, soil-structure interaction was not considered. Structures were considered to be fixed at the base. The design ground response spectra for IP2 were applied at the foundation levels for all structures.

5.0 In-Structure Response Spectra

Appendices A to G of this report provide the pertinent information with regard to the conservative design ISRS of IP2 structures where the majority of the safe shutdown equipment are located. Each appendix covers a particular structure. The information provided include:

- Building description
- Building dynamic model
- Building dynamic characteristics (natural frequencies, mode shapes and participation factors)
- ISRS at important floor levels of the building
- Total amplification factors at important floor levels of the building

6.0 Total Amplification Factors

Two Total Amplification Factors (TAF_1 and TAF_2) were calculated for the structures where equipment is to be verified using the ISRS. The TAF values are defined as the Peak Floor Acceleration (PFA) of a building floor divided by:

1. The corresponding floor Zero Period Acceleration (ZPA),

$$TAF_1 = PFA/ZPA$$

2. The Peak Ground Acceleration

$$TAF_2 = PFA/PGA$$

These values are tabulated in the appendices and are given for different floor elevations. It is concluded from the review of the TAF values that there is significant amplification in a number of instances.

The IP2 ISRS may be used as one of the options provided in the GIP for resolution of USI A-46. Alternatively, Con Edison will use other options provided in the GIP, as appropriate, depending on the building, the location of equipment in the building, and the equipment characteristics.

7.0 References

1. "Design of Nuclear Power Reactors Against Earthquakes", Proceedings of the Second World Conference on Earthquake Engineering, Vol. I, Japan, 1960.

2. Nuclear Regulatory Commission, "Matter of Consolidated Edison and Power Authority of the State of New York", 6NRC 547,550 (1977), ALAB-436

3. Consolidated Edison Company of New York, Inc., "Indian Point Nuclear Generating Unit No. 2", Updated Final Safety Analysis Report.

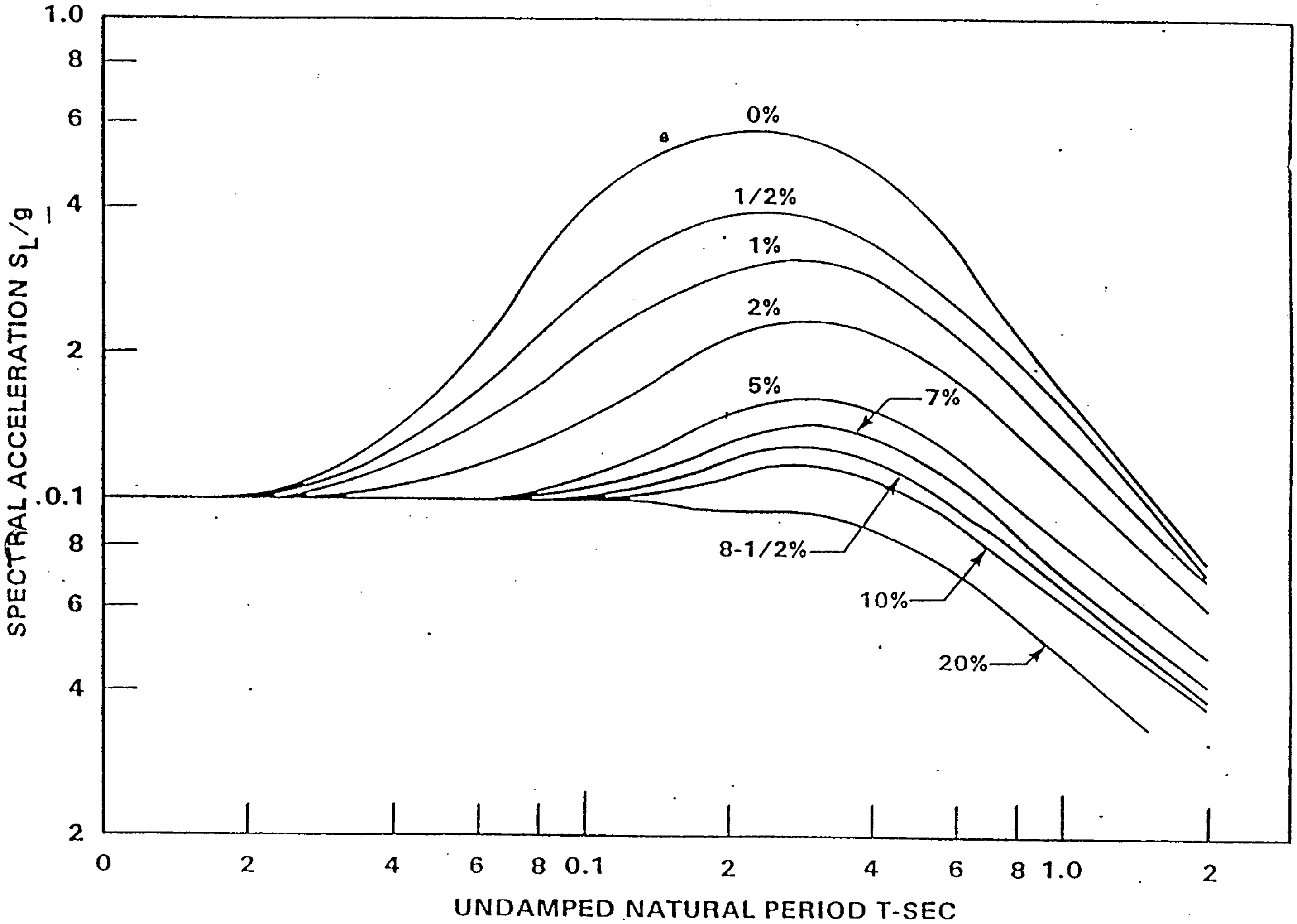


Figure 1
Horizontal Seismic Design Spectra For The Operating Basis Earthquake (OBE)

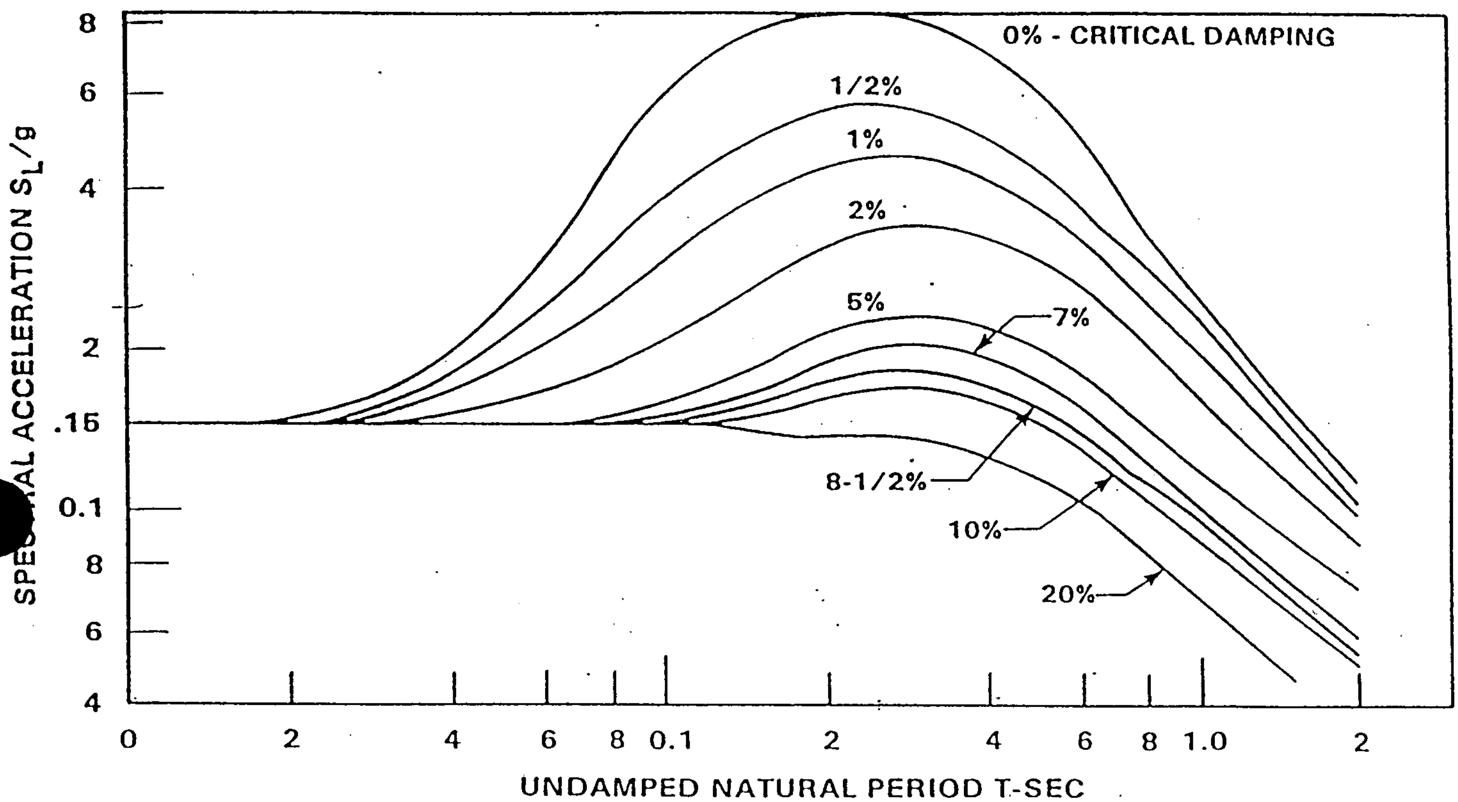


Figure 2
Horizontal Seismic Design Spectra For The Safe Shutdown Earthquake (SSE)

Component	% of Critical Damping
Containment Structure	2.0
Concrete Support Structure of Reactor Vessel	2.0
Steel Assemblies:	
Bolted or Riveted	2.5
Welded	1.0
Vital Piping Systems	0.5
Concrete Structures Above Ground:	
Shear Wall	5.0
Rigid Frame	5.0

Table 1
Damping Values

APPENDIX A

Containment Structure

A.1 Structure Description

The Containment Structure is a reinforced concrete structure with a 4'-6" vertical cylindrical wall, flat base, and a 3'-6" hemispherical dome. A welded steel liner with a minimum thickness if 1/4 inch is attached to the inside of the concrete shell. The cylindral wall measures 148 feet from the liner at the base to the springline of the dome and has an inside diameter of 135 feet. The foundation is a nine foot thick reinforced concrete mat, founded on bedrock. A bottom liner plate is located on top of the foundation mat. This bottom liner plate is covered with 2 feet of concrete which forms the floor of containment. The liner plate is anchored to the concrete shell by means of Nelson studs, such as to become integral with the concrete shell under all loading conditions. A plan and section of the Containment Structure is shown in Figures A.1 and A.2, respectively.

The Inner Containment Structure has a separate dynamic model from that of the Containment Structure and is outlined in Appendix B.

A.2 Dynamic Model

The ISRS for the Containment Structure were generated by Westinghouse Electric Corporation (Westinghouse) using an 11-node lumped mass model, as shown in Figure A.3. This model was used for the generation of ISRS in both horizontal directions due to the symmetric nature of the Containment Structure. The forcing function used to obtain the Containment Structure ISRS was the 1952 Taft Earthquake, N69W component normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used for the Containment Structure response was 2%, consistent with the IP2 UFSAR, as shown in Table 1.

A.3 Dynamic Parameters

The dynamic properties of the Containment Structure (frequencies, mode shapes, and participation factors) are provided in Table A.1, associated with the significant modes of response. Amplification factors TAF_1, and TAF_2 (Section 6.0) associated with each of the model mass points are provided in Table A.2.

A.4 In-Structure Response Spectra

Representative SSE floor response spectra associated with important elevations of the Containment Structure for 5% equipment damping are shown in Figures A.4 and A.5.

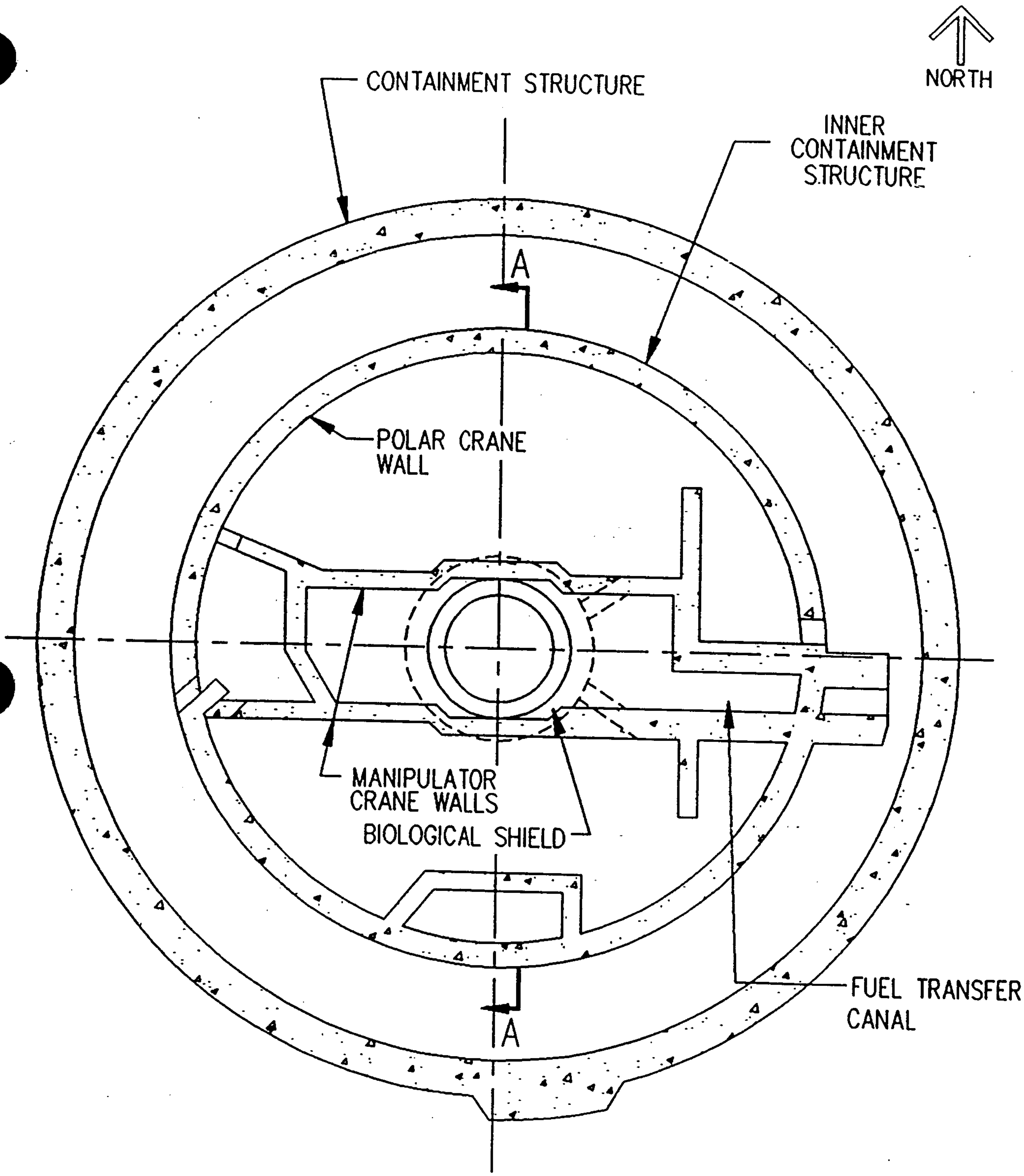


Figure A.1
Containment Structure
Plan of Structure

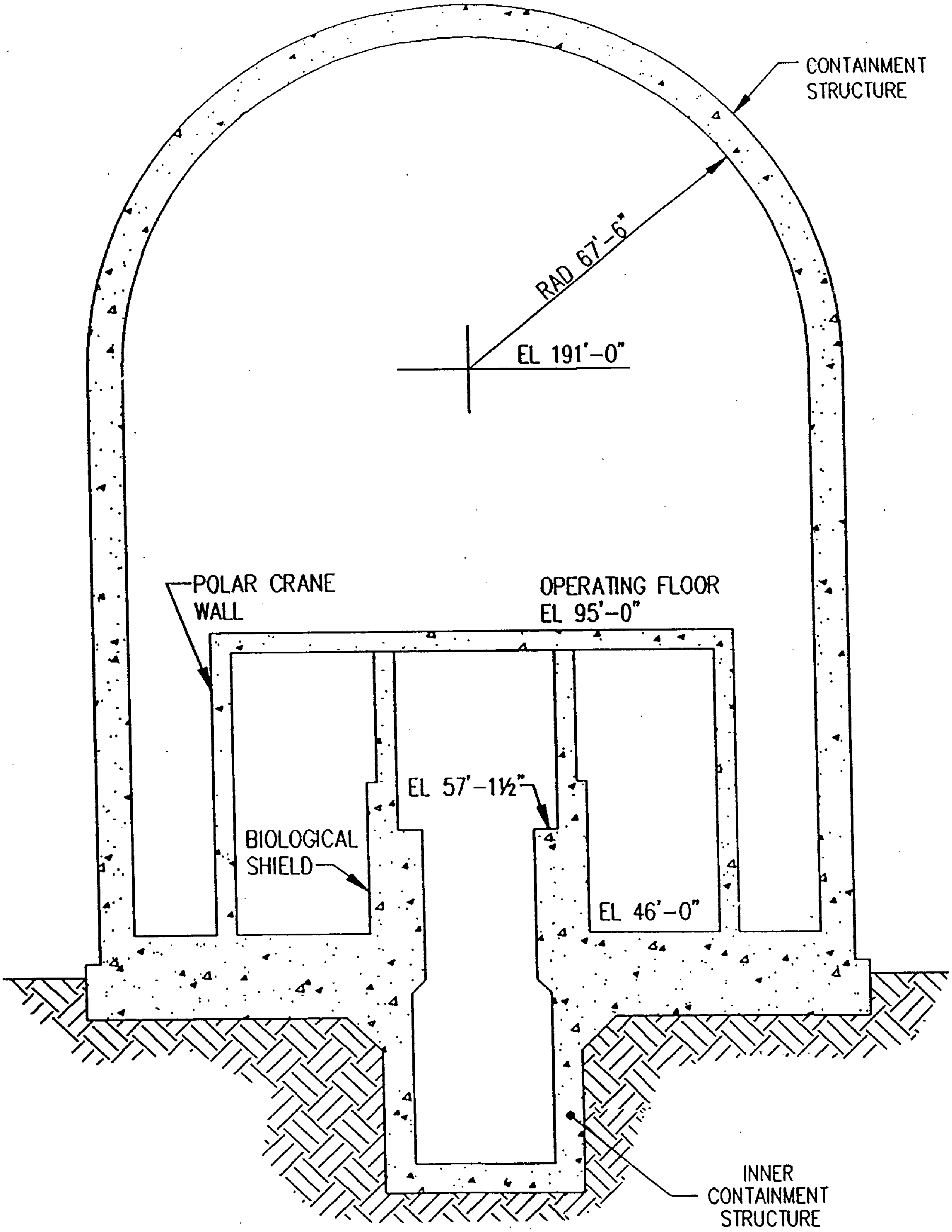


Figure A.2
Containment Structure
Section A-A Through Structure

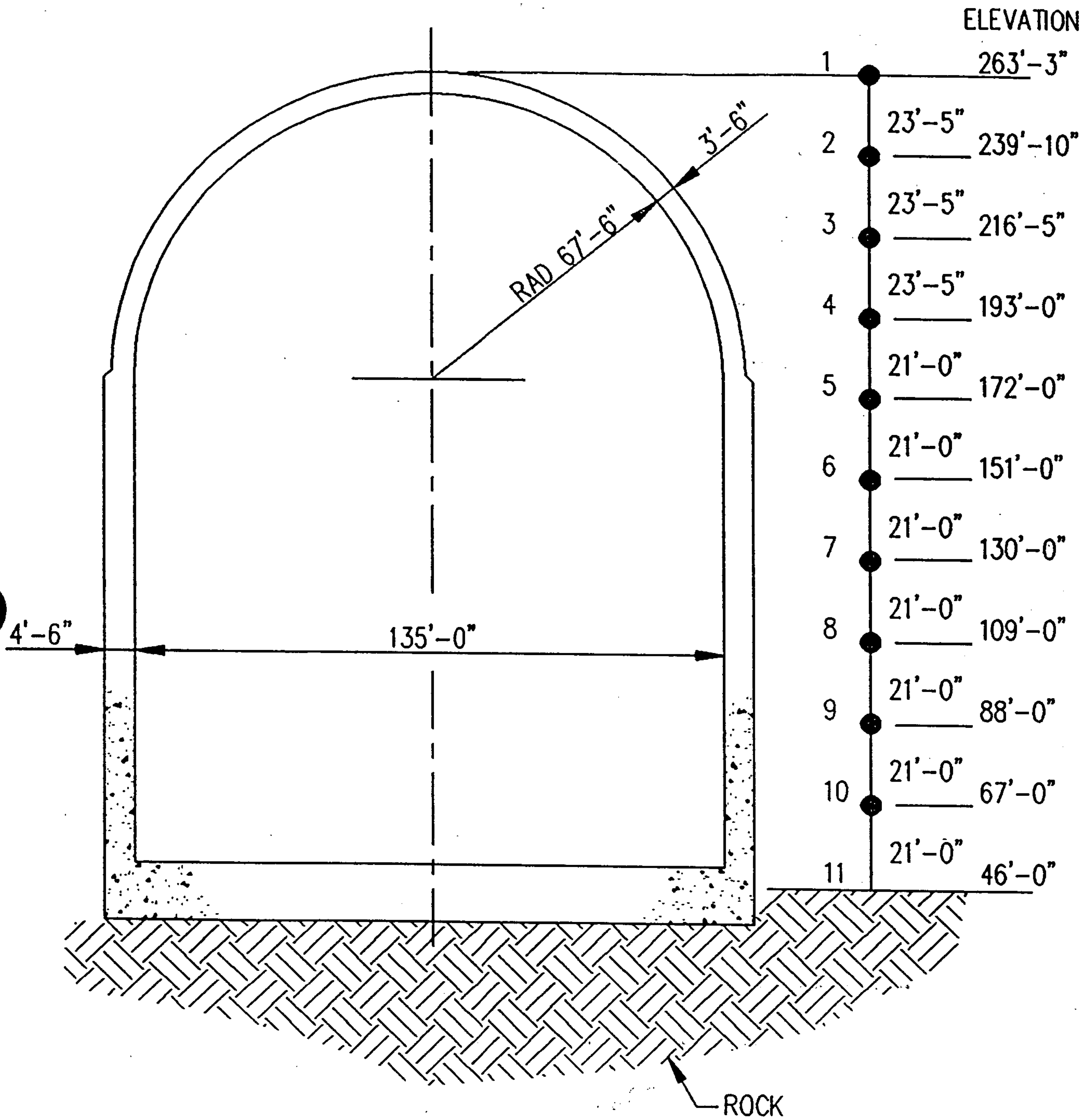


Figure A.3
Containment Structure
Horizontal Lumped Mass Model

Mass Point \ Mode (Frequency, Part. Factor)	1 4.19 1.45	2 11.91 0.64	3 22.38 0.12	4 24.10 0.30	5 34.34 0.21	6 39.0 0.0
1	1.00	-1.00	-0.07	1.00	-1.00	0.84
2	0.91	-0.63	0.58	0.66	-0.16	-0.73
3	0.80	-0.20	0.88	0.01	0.70	-0.72
4	0.68	0.24	0.70	-0.58	0.62	0.66
5	0.58	0.54	0.33	-0.67	-0.07	1.00
6	0.47	0.74	-0.22	-0.42	-0.70	0.21
7	0.36	0.83	-0.73	0.05	-0.64	-0.69
8	0.26	0.78	-1.00	0.48	0.07	-0.59
9	0.16	0.60	-0.91	0.65	0.73	0.29
10	0.07	0.33	-0.52	0.46	0.70	0.69

Table A.1
Containment Structure
Dynamic Characteristics

DIRECTION: North - South or East - West								
Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
1	263.25	217	184	4.500	0.552	0.15	8.15	30.00
2	239.83	194	161	4.245	0.493	0.15	8.61	28.30
3	216.42	170	137	3.807	0.471	0.15	8.08	25.38
4	193.00	147	114	3.000	0.343	0.15	8.75	20.00
5	172.00	126	93	2.700	0.275	0.15	9.82	18.00
6	151.00	105	72	2.307	0.239	0.15	9.65	15.38
7	130.00	84	51	1.800	0.207	0.15	8.70	12.00
*			40				8.03	10.32
8	109.00	63	30	1.320	0.178	0.15	7.42	8.80

Where, Per Section 6.0: TAF_1 = PFA/ZPA
TAF_2 = PFA/PGA
*, TAF_1 & TAF_2 interpolated at 40' above grade reference point.

Table A.2
Containment Structure
Total Amplification Factors

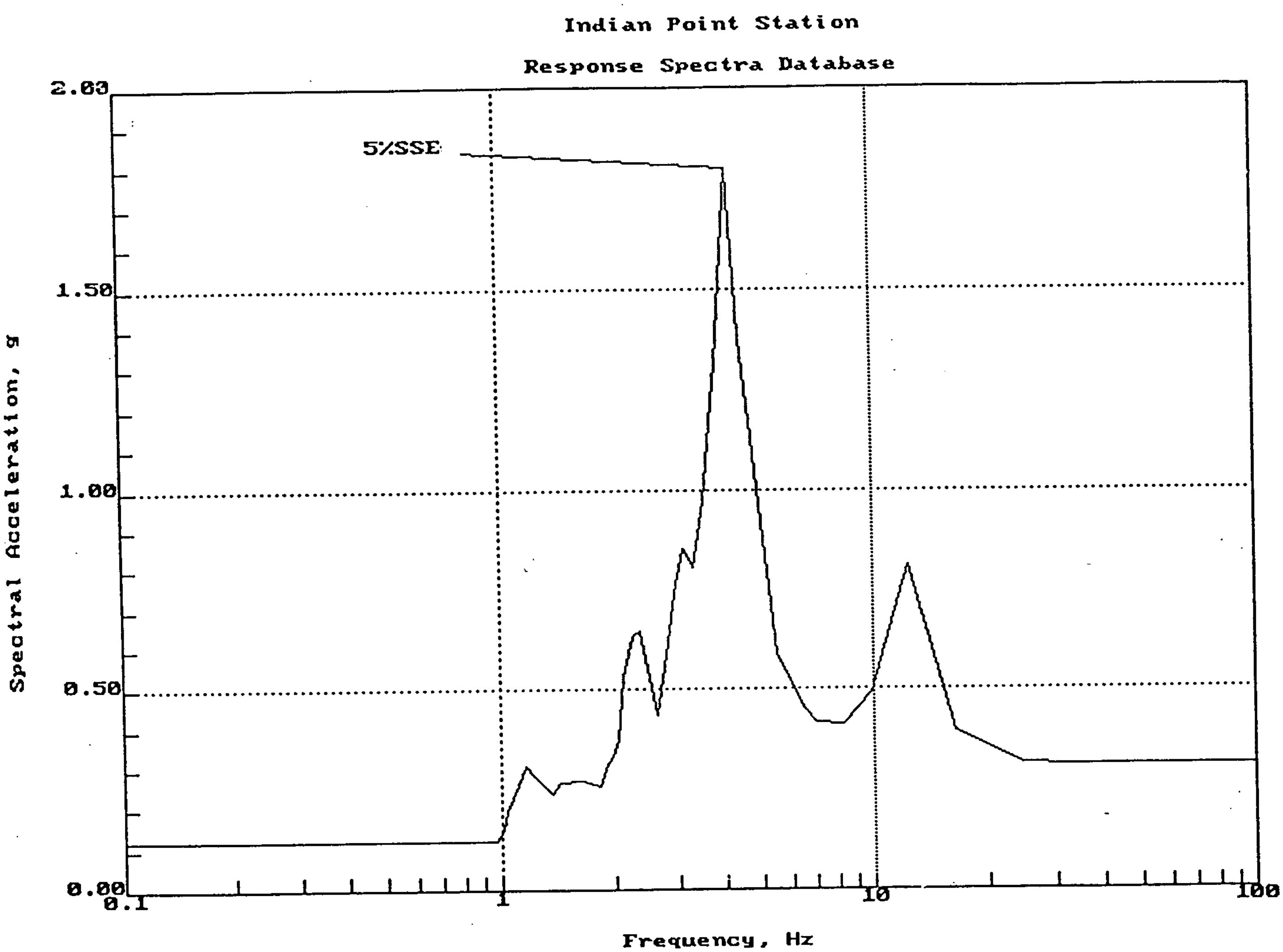


Figure A.4
Containment Structure
Horizontal In-Structure Response Spectra
Elevation 130'

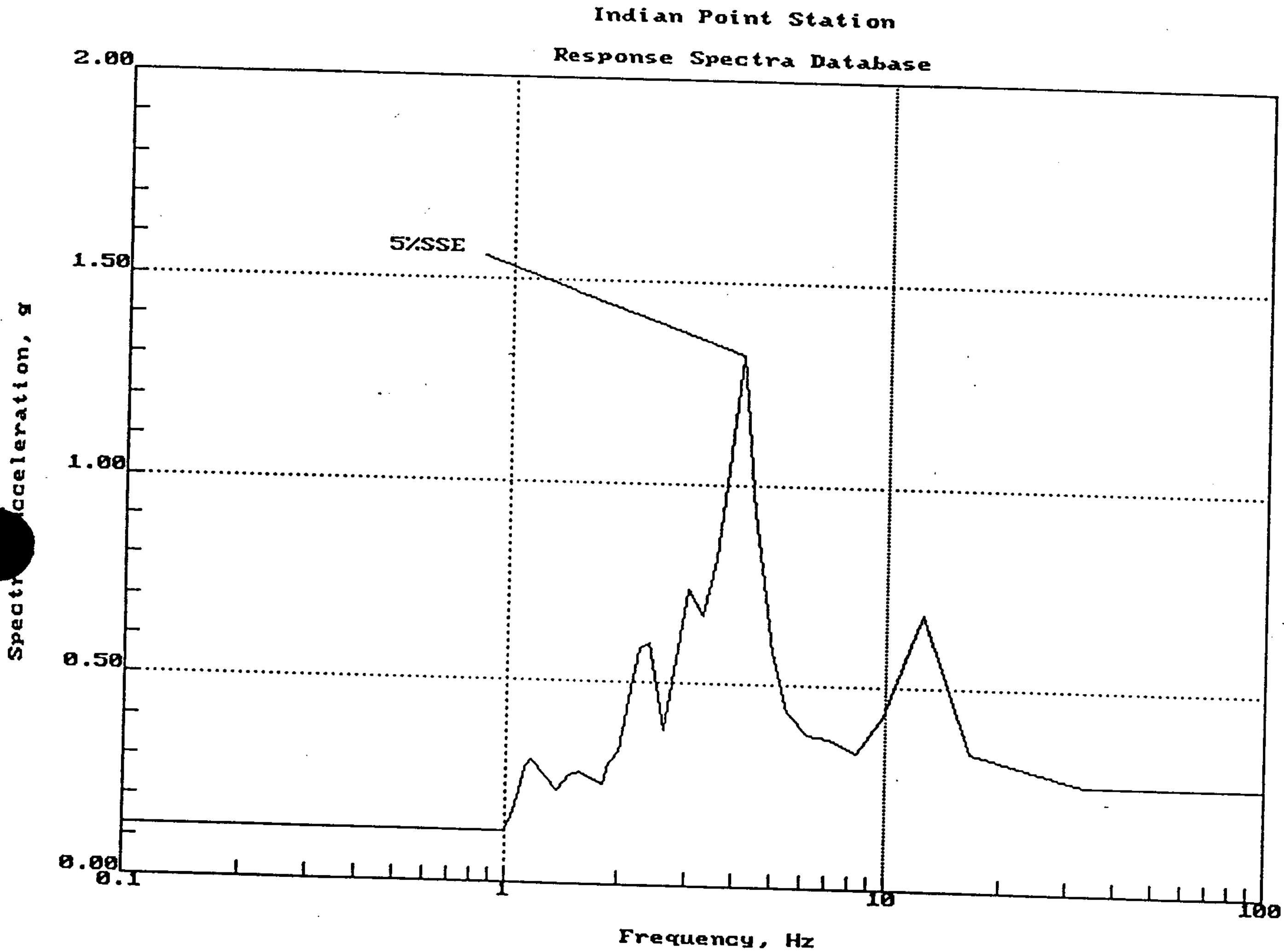


Figure A.5
Containment Structure
Horizontal In-Structure Response Spectra
Elevation 109'

APPENDIX B

Inner Containment Structure

B.1 Structure Description

The Inner Containment Structure is a reinforced concrete structure supported on the Containment Structure mat. This structure includes, the reactor cavity, the fuel transfer canal, and miscellaneous concrete and steel for floors and stairs. All internal structures are supported by the containment floor mat. A three feet thick concrete wall surrounds the reactor coolant components and supports the polar crane. A two foot thick reinforced concrete and iron grate floor at the 95' elevation forms the operating floor for the building. A plan and section through the Containment Structure showing the Inner Containment Structure are shown in Figures B.1 and B.2, respectively.

B.2 Dynamic Model

The ISRS for the Inner Containment Structure were generated by Westinghouse Electric Corporation using a 9-node lumped mass model shown in Figure B.3. This model is based on the section through the structure in the North-South direction, as indicated in Section A-A of Figure B.1. This model (i.e., a North-South model) is also used for determining response in the East-West direction. The stiffness of the Inner-Containment Structure in the East-West direction is significantly higher than in the North-South direction. Thus, the use of the model for determining East-West response is conservative. The forcing function used to obtain the Inner Containment Structure ISRS design response spectra was the 1952 Taft Earthquake, N69W component normalized to 0.15g for the Safe Shutdown Earthquake. Similar to the Containment Structure, the structural damping used for the IP2 Inner Containment Structure response was 2%, consistent with the IP2 UFSAR, as shown in Table 1.

B.3 Dynamic Parameters

The dynamic properties of the Inner Containment Structure (frequencies, mode shapes, and participation factors) are provided in Table B.1, associated with the significant modes of response of the structure. Amplification factors TAF_1 and TAF_2 (Section 6.0) associated with each of the Inner Containment Structure model mass points are provided in Table B.2.

B.4 In-Structure Response Spectra

Representative SSE floor response spectra associated with the important elevation of the Inner Containment Structure for 5% equipment damping is shown in Figure B.4.

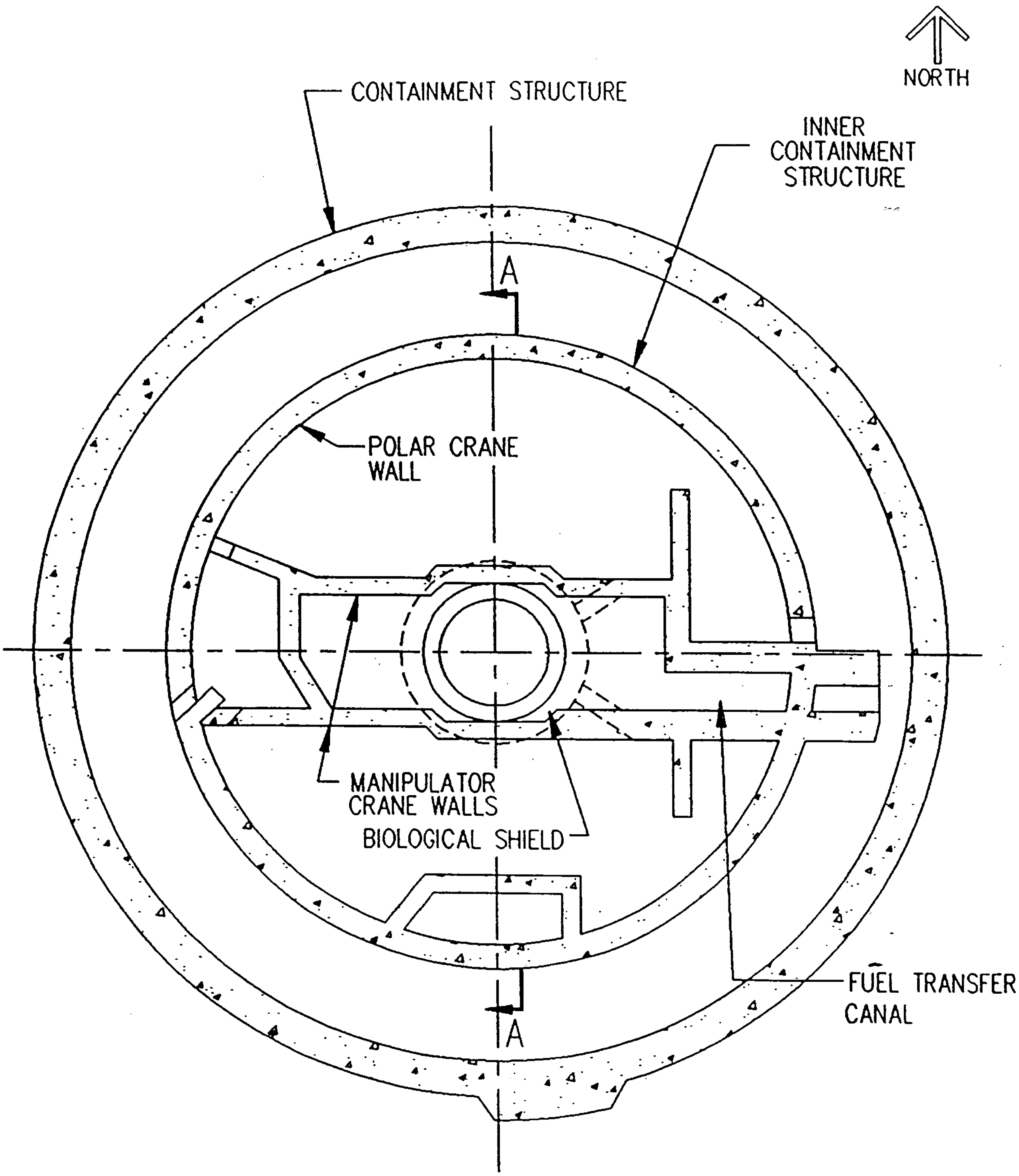


Figure B.1
Inner Containment Structure
Plan of Structure

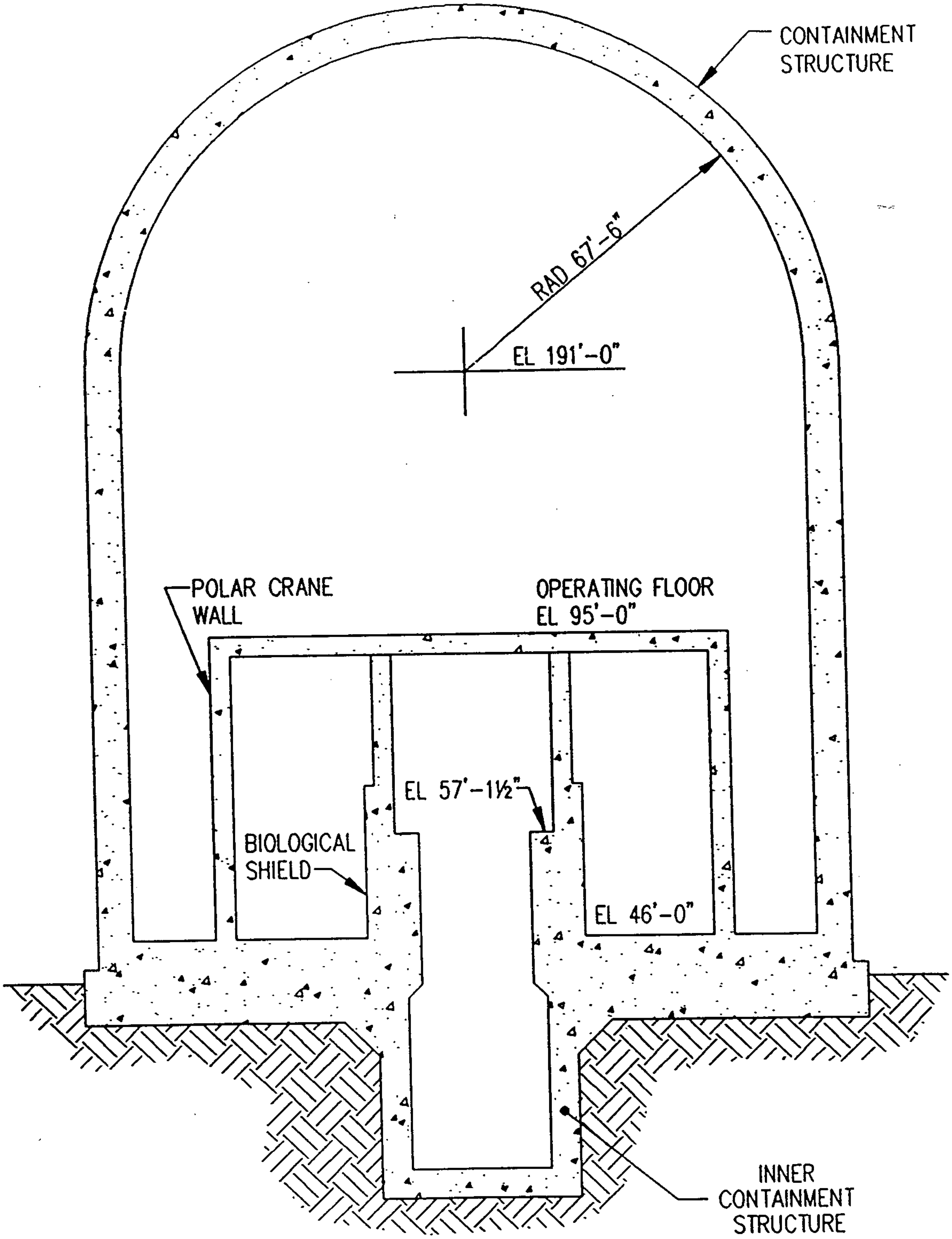


Figure B.2
Inner Containment Structure
Section A-A Through Structure

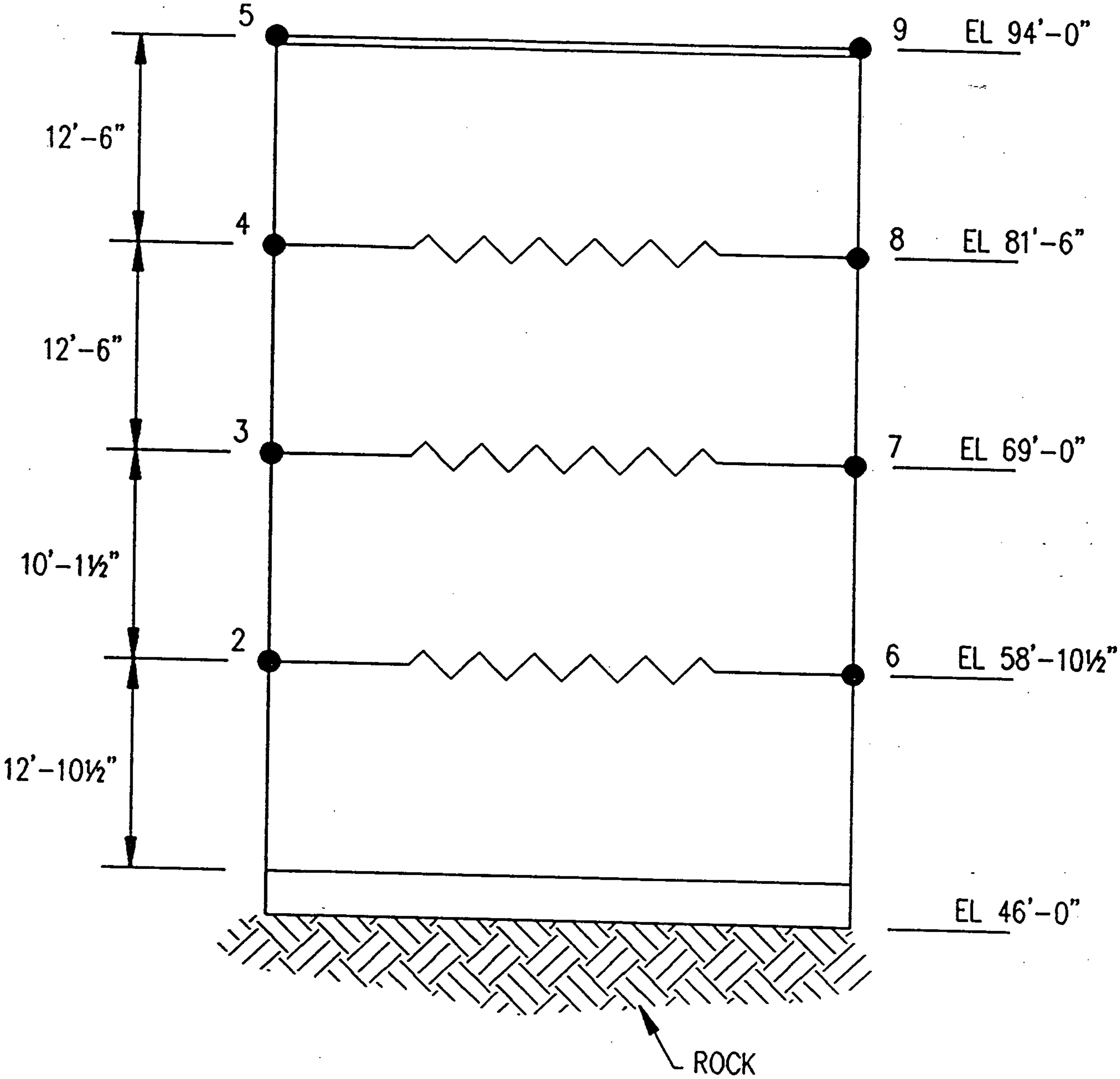


Figure B.3
Inner Containment Structure
Horizontal Lumped Mass Model
(North-South Direction)

Frequency / Part. Factor / Mass Point	Mode		
	1 18.64 1.24	2 43.97 0.37	3 46.79 0.04
2	0.28	0.28	-0.52
3	0.51	0.25	-0.76
4	0.79	-0.04	-0.74
5	1.00	-0.47	-0.41
6	0.20	0.68	0.62
7	0.40	1.00	0.95
8	0.81	0.89	1.00
9	1.00	-0.47	-0.41

Table B.1
Inner Containment Structure
Dynamic Characteristics

DIRECTION: North - South or East - West								
Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
5 or 9	94.00	48	15	0.651	0.246	0.15	2.65	4.34

Where, Per Section 6.0: $TAF_1 = PFA/ZPA$
$TAF_2 = PFA/PGA$

Table B.2
Inner Containment Structure
Total Amplification Factors

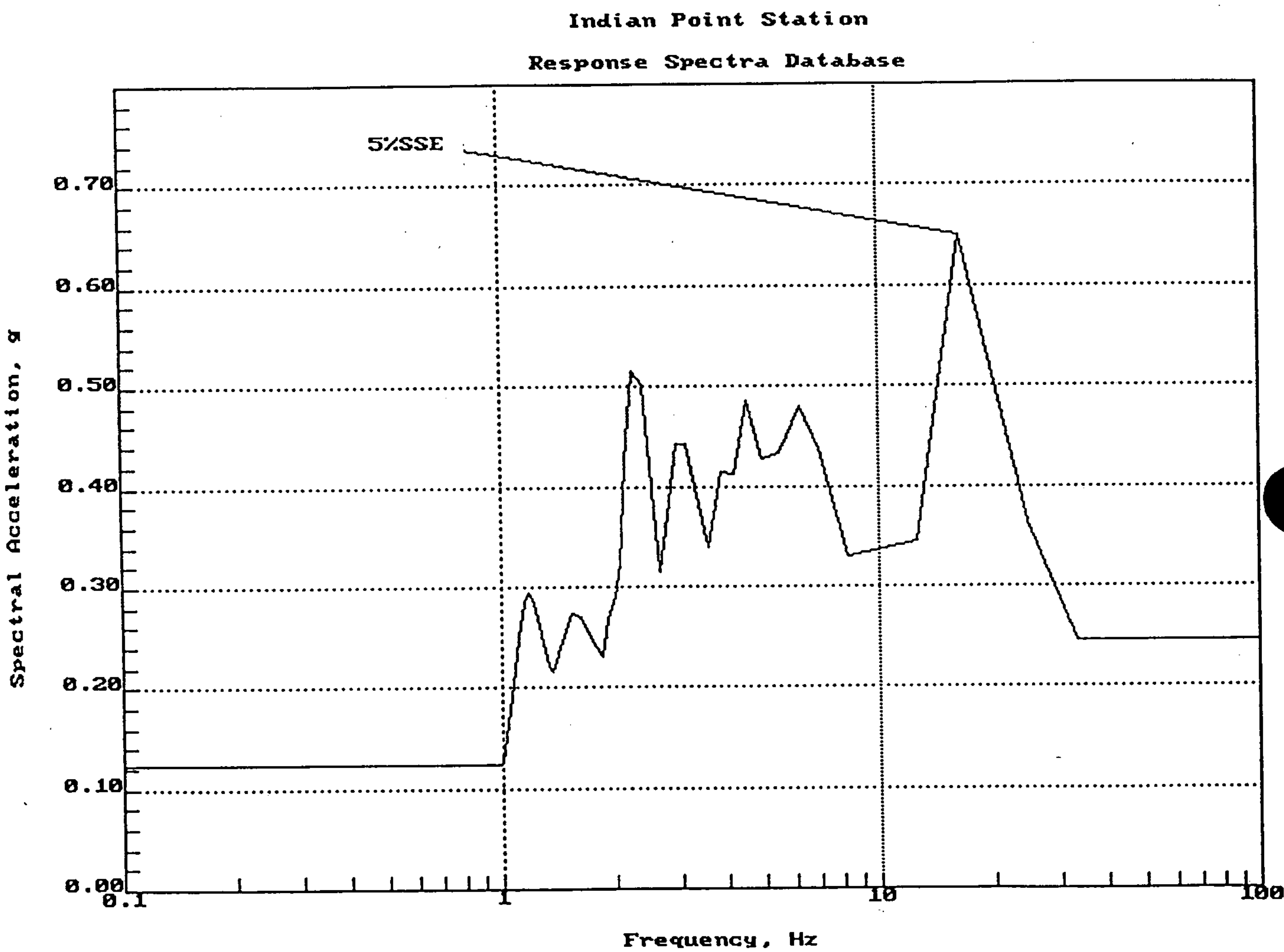


Figure B.4
Inner Containment Structure
Horizontal In-Structure Response Spectra
Elevation 94'

APPENDIX C

Control Building

C.1 Structure Description

The Control Building is a three-story steel framed structure, and is an extension of the Unit 1 control room. The structure is founded on rock at elevation 16'-0". Floor slabs are composite type construction, concrete over steel beams. Insulated metal-sandwich panels form the exterior on the north side of the building. Control Building floor plan is shown in Figure C.1, with building sections through the structure shown in Figures C.2 and C.3.

C.2 Dynamic Model

The design response spectra for the Control Building were generated by Westinghouse Electric Corporation using a 9-node lumped mass model, as shown in Figure C.4, and URS/Blume and Associates (Blume), using a three dimensional frame model as shown in Figure C.5. The forcing function used by Westinghouse was the 1952 Taft Earthquake, N69W component normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used was 2.5% for bolted steel structures as per the IP2 UFSAR, as shown in Table 1.0. The forcing function for the Blume model was a synthetic time history normalized to 0.15g with a structural damping of 2.5%.

The Westinghouse 9-node lumped mass model, Figure C.4 is used to predict response in the North-South direction. However, in the East-West direction the model has similar characteristics and is thus used both for the prediction of North-South and East-West responses.

The Blume model, Figure C.5 consists of a 3-dimensional frame model.

C.3 Dynamic Parameters

The dynamic parameters of the Control Building (frequencies, mode shapes and participation factors) are shown in Table C.1 for the Westinghouse dynamic model and (frequencies, mode shapes) for the Blume dynamic model.

Based upon a review of the two sets of ISRS, the Westinghouse model predicts a higher response than the Blume model. This is because the Westinghouse analysis uses the 1952 Taft

Earthquake which in the 1 to 5 Hz frequency range is more conservative than the synthetic input used in the Blume analysis. Given the detailed model and the reasonable spectrum used in the Blume analysis, the ISRS generated from this dynamic analysis will be utilized for the prediction of floor response. Associated amplification factors, TAF_1 and TAF_2 (Section 6.0) for the Blume model are provided in Table C.2.

C.4 In-Structure Response Spectra

Representative SSE floor response spectra associated with important elevations of the Control Building for 5% equipment damping are shown in Figures C.6 and C.7.

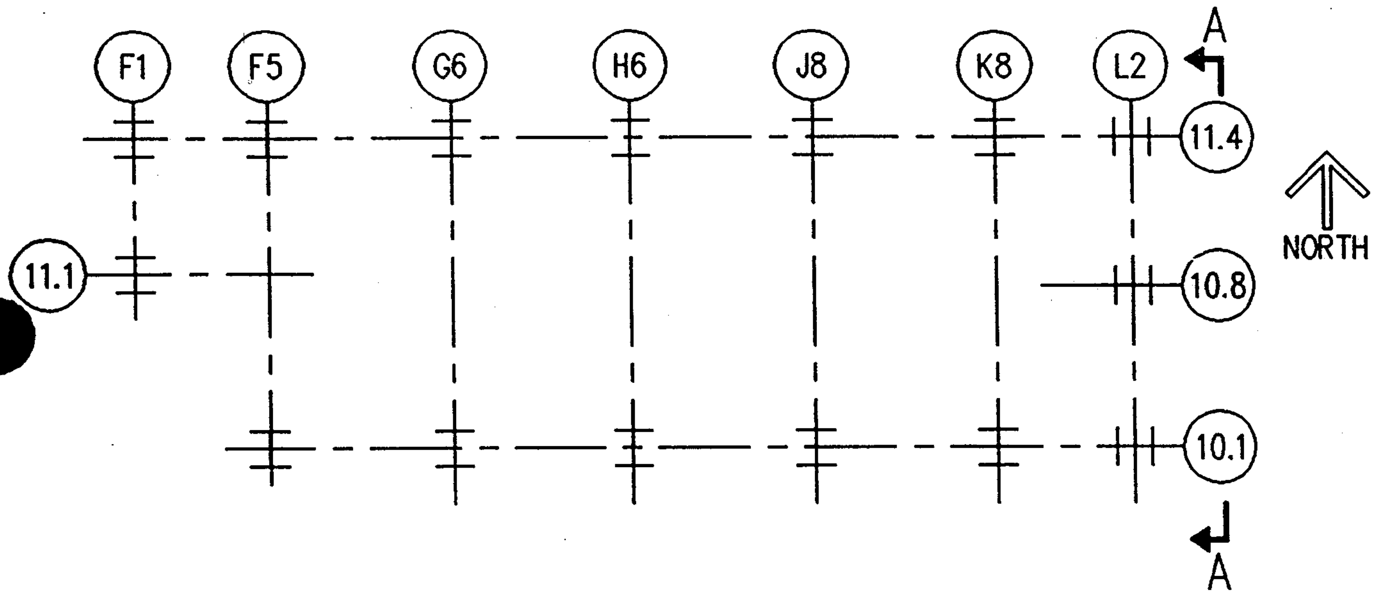


Figure C.1
Control Building
Plan of Structure

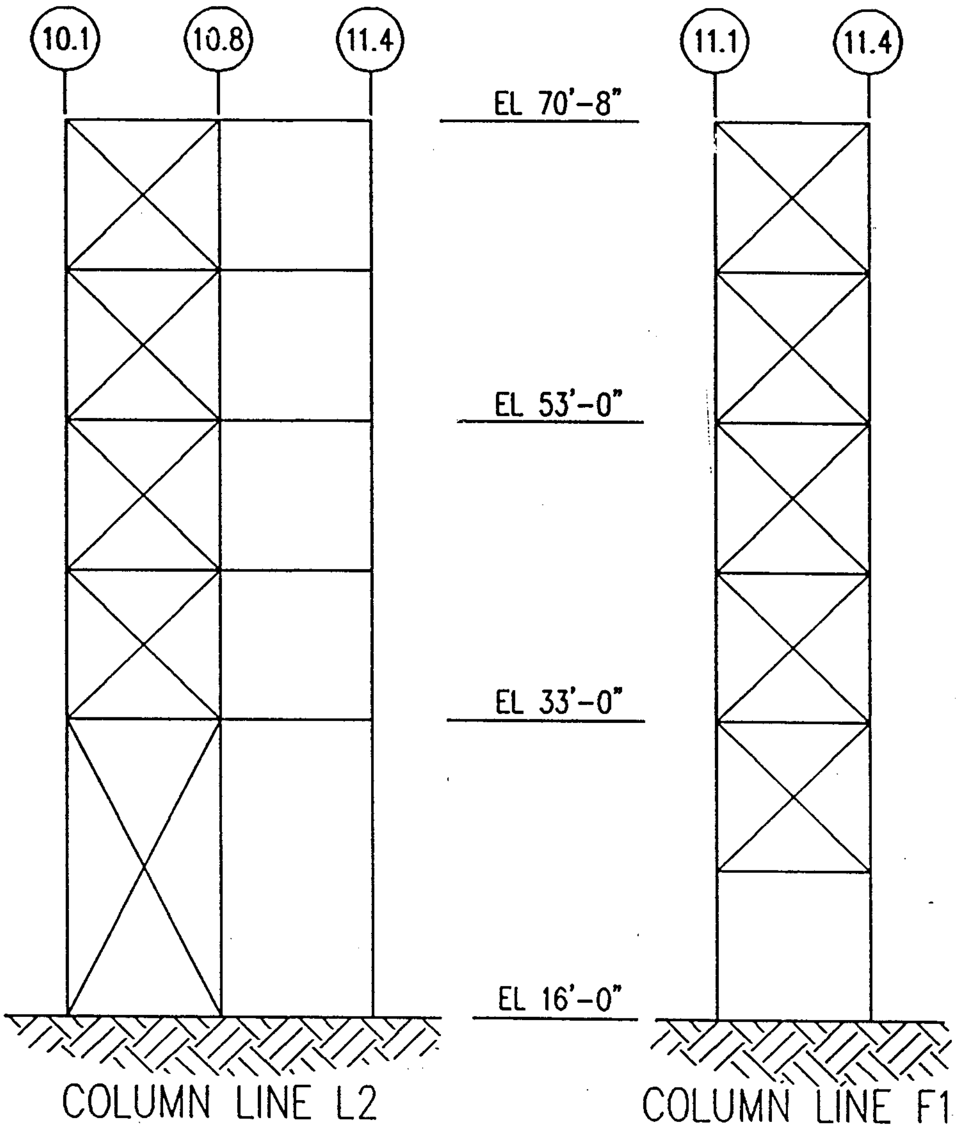
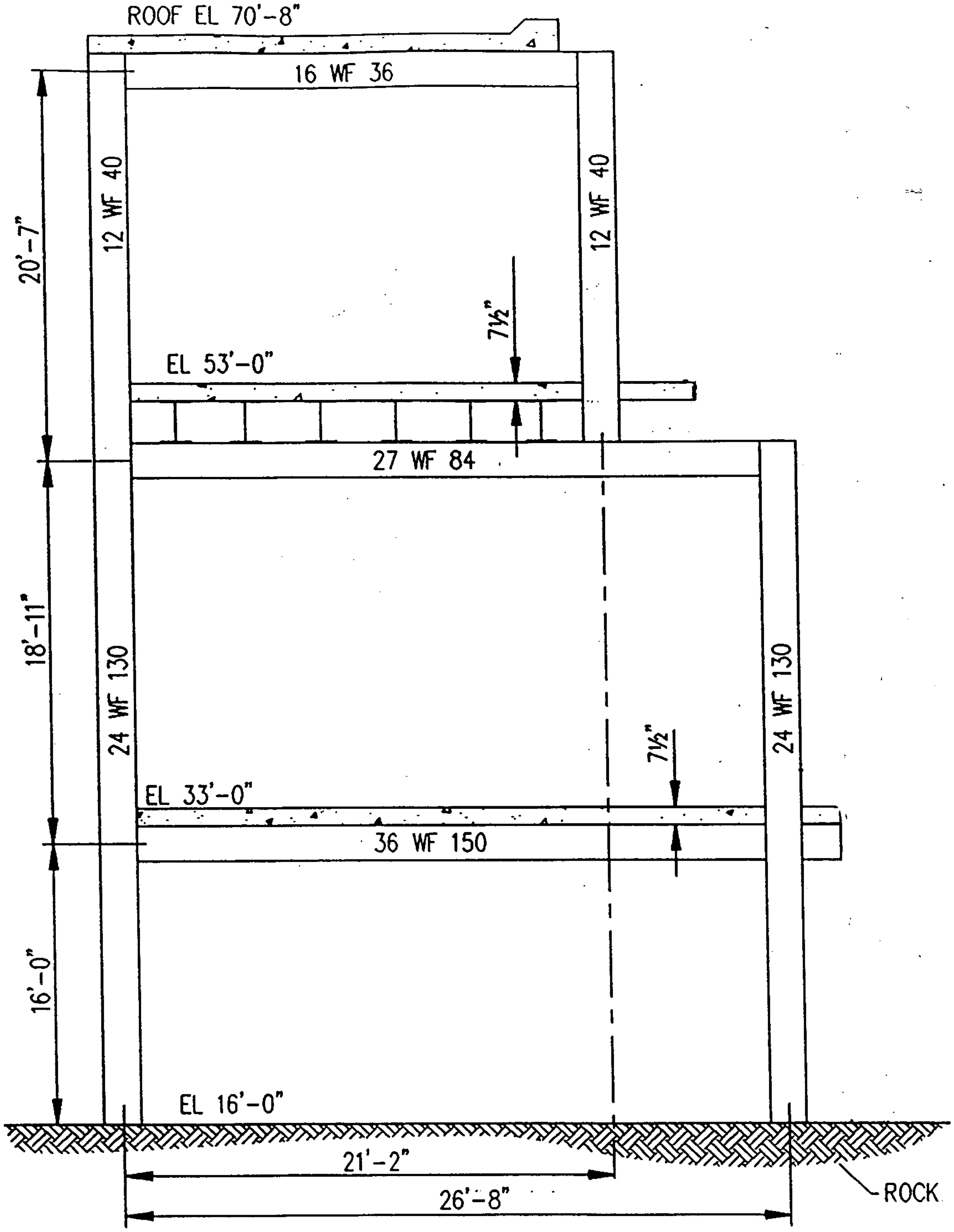


Figure C.2
Control Building
Section A-A Through Structure



ELEVATION LOOKING EAST

Figure C.3
Control Building
Section Through Structure

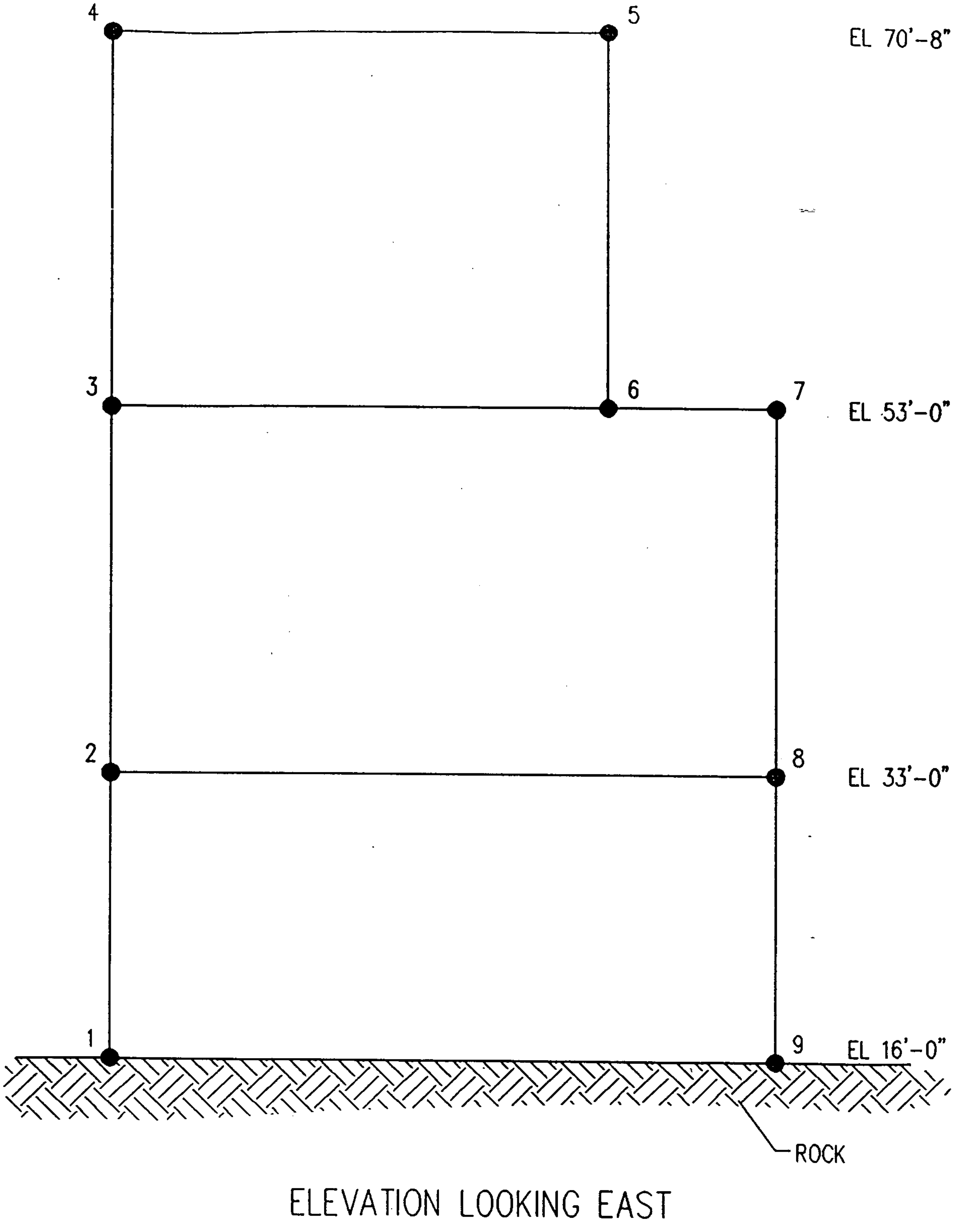


Figure C.4
Control Building
Westinghouse Lumped Mass Model

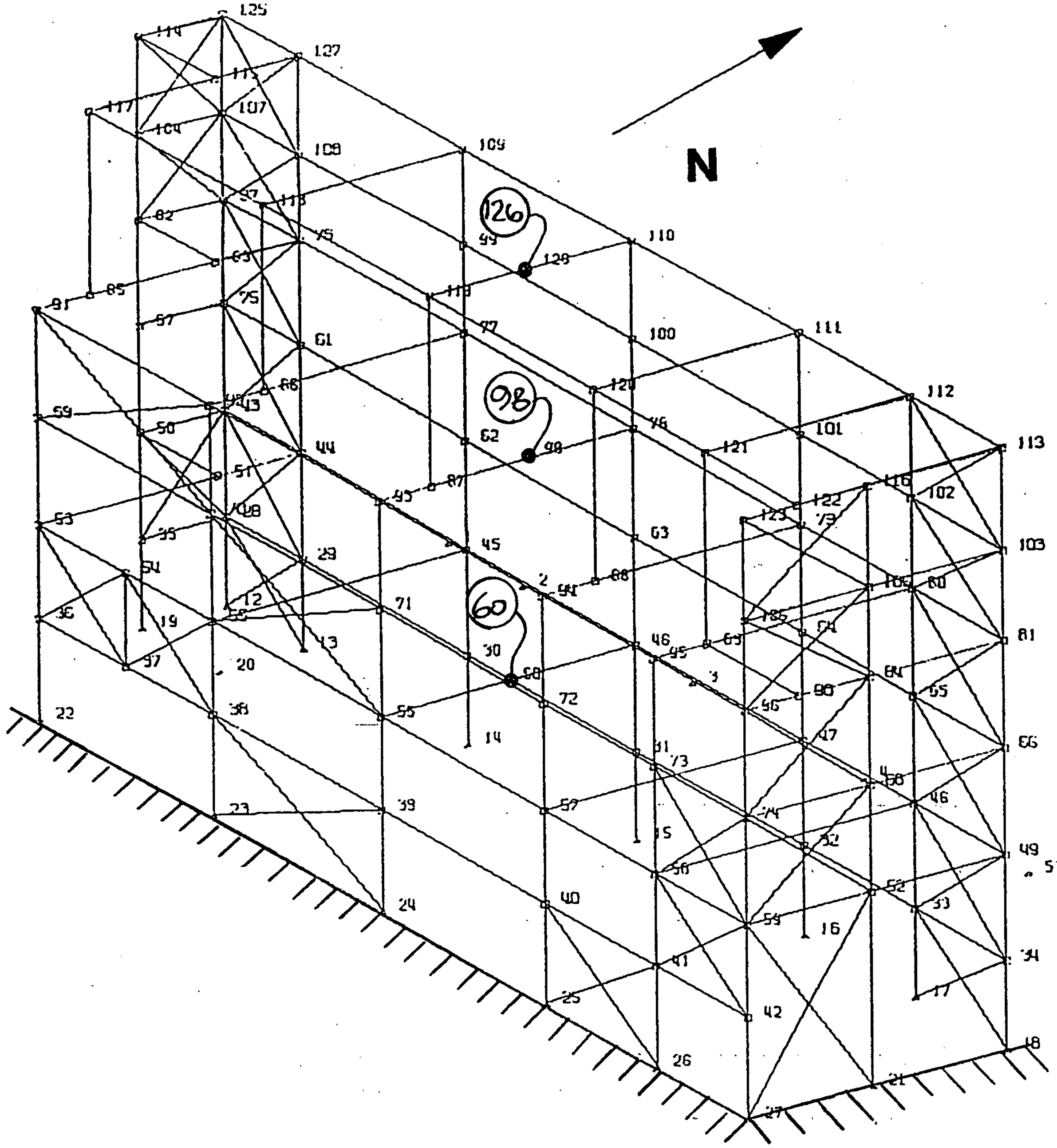


Figure C.5
Control Building
Blume Lumped Mass Model

Westinghouse Dynamic Model

Frequency / Part. Factor / Mass Point	Mode 1	Mode 2	Mode 3
Frequency	1.61	2.46	4.64
Part. Factor	2.37	1.51	0.43
2	0.13	0.17	1.00
3	0.36	0.34	-0.86
4	1.00	-1.00	0.33

Table C.1
Control Building
Westinghouse Dynamic Characteristics

East-West Direction

Frequency / Mass Point	Mode 1 1.57	Mode 2 3.48	Mode 3 4.42
60	0.18	0.36	0.56
98	0.63	0.19	-0.64
126	1.00	-1.00	1.00

North-South Direction

Frequency / Mass Point	Mode 1 1.81	Mode 2 4.15	Mode 3 5.77
60	0.26	0.27	1.00
98	0.70	0.16	-1.00
126	1.00	-1.00	1.00

Table C.1 (Cont.)
Control Building
URS/Blume Dynamic Characteristics

Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
DIRECTION: North - South								
	53	37	37	2.150	0.443	0.150	4.85	14.33
	33	17	17	1.160	0.302	0.15	3.84	7.73
DIRECTION: East - West								
	53	37	37	1.100	0.242	0.15	4.55	7.33
	33	17	17	1.150	0.203	0.15	5.67	7.67

Where, Per Section 6.0: TAF_1 = PFA/ZPA
TAF_2 = PFA/PGA

Table C.2
Control Building
Total Amplification Factors

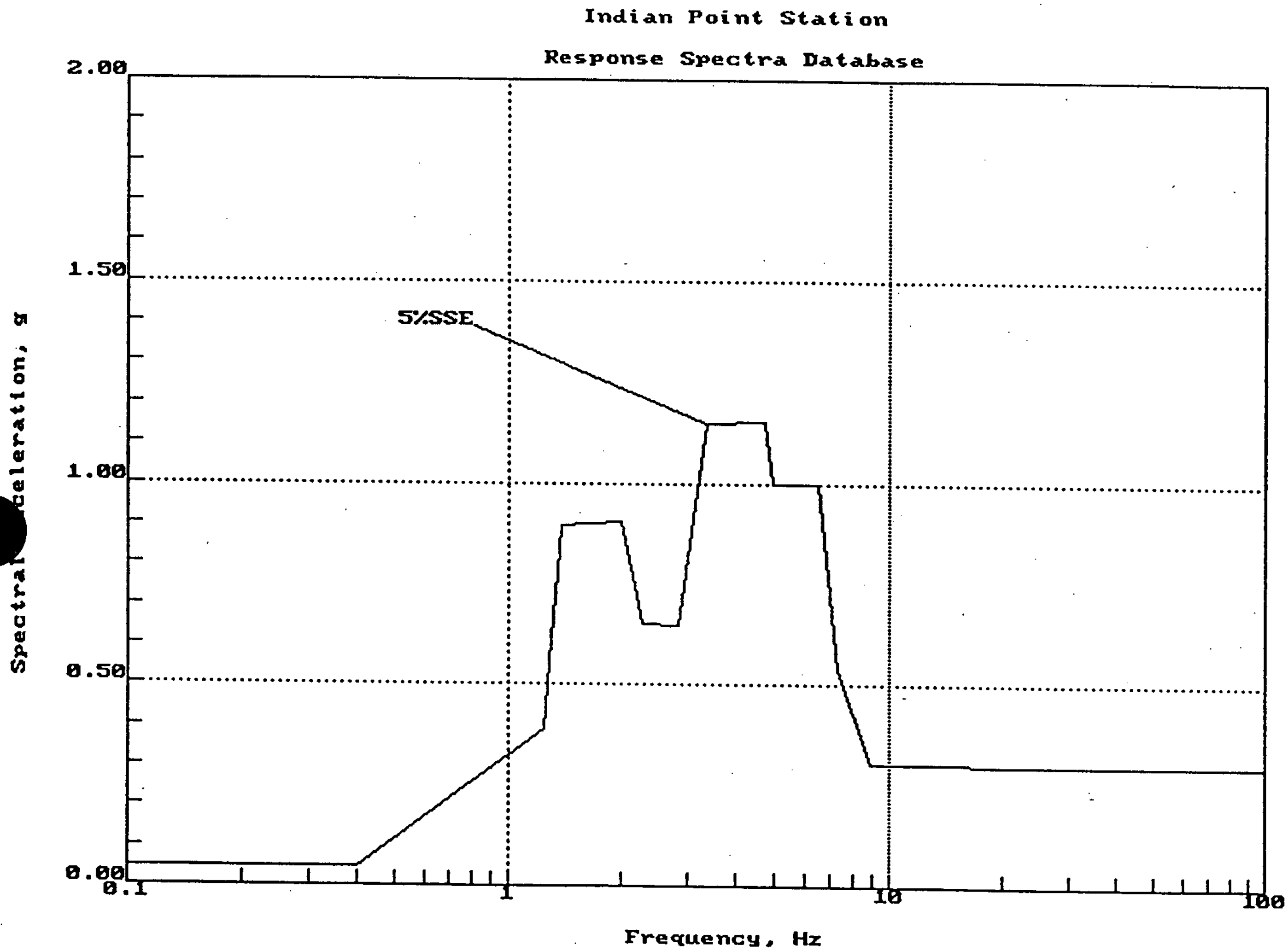


Figure C.6
Control Building
North-South In-Structure Response Spectra
Elevation 33'

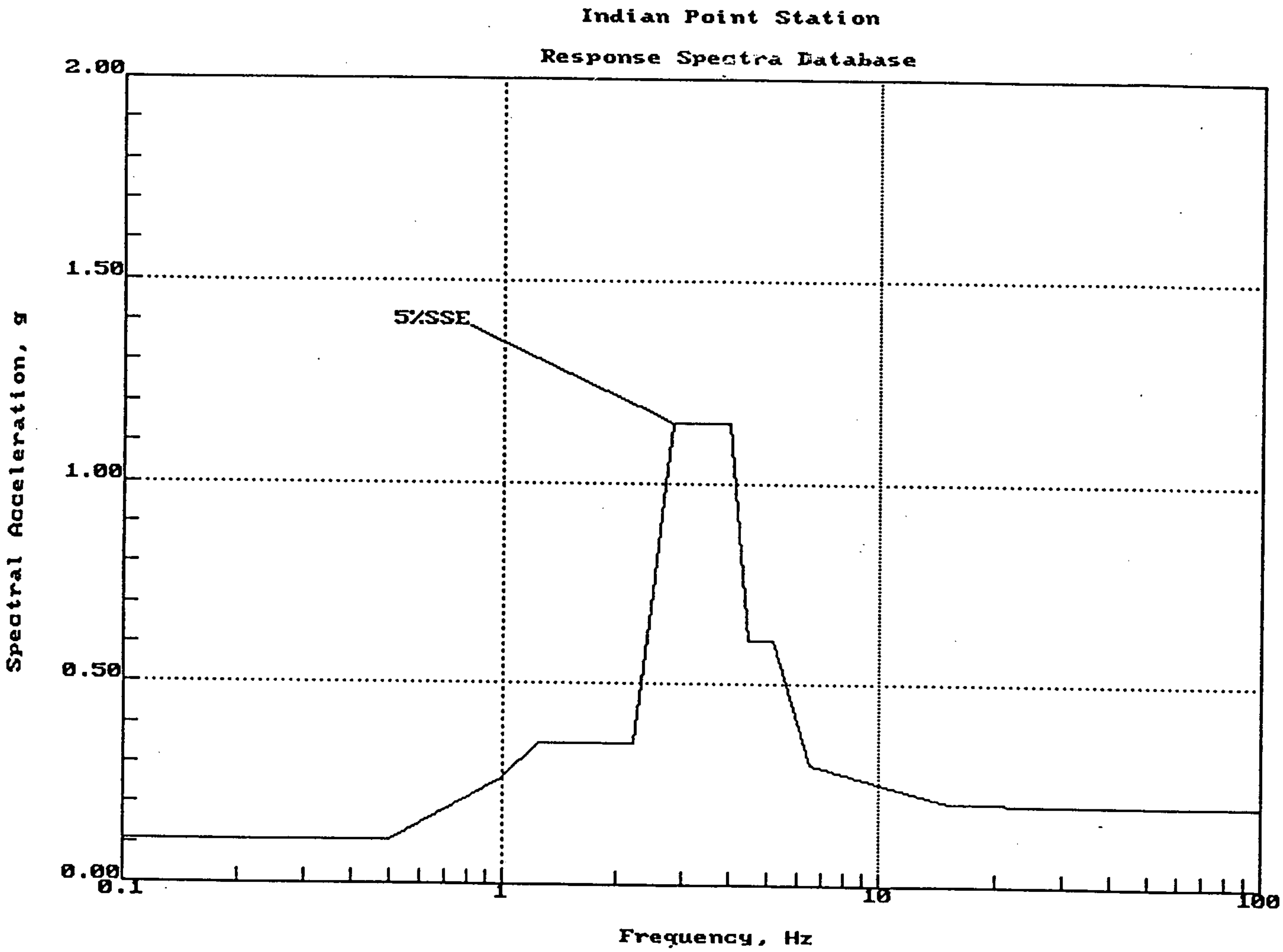


Figure C.7
Control Building
East-West In-Structure Response Spectra
Elevation 33'

APPENDIX D

Fan House

D.1 Structure Description

The Fan House is a reinforced concrete structure, which is adjacent, but separate from, the Containment Structure. The structure is founded on rock at elevation 47 feet. The structure is bounded on the east side by the Fuel Storage Building and by the Containment Structure on the North-West side. Plan and section views of the Fan House structure are shown in Figures D.1 and D.2.

D.2 Dynamic Model

ISRS are not available for the IP2 Fan House, however, ISRS are available for the IP3 Fan House. A review of the IP2 and IP3 Fan House structures shows that the two structures are similar. This similarity enables the use of the IP3 spectra for the IP2 structure. The ISRS for the IP3 Fan House were developed by Westinghouse, using an 18-node lumped mass model, as shown in Figure D.3. This model was used to determine both North-South and East-West responses. The forcing function used to obtain the design response spectra was a synthetic time history normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used for the IP3 Fan House was 5%, which is consistent with the IP2 UFSAR for shear wall or rigid frame construction as shown in Table 1.

D.3 Dynamic Parameters

The dynamic properties of the Fan House (frequencies, modes shapes and participation factors) are provided in Tables D.1 and D.2 associated with the significant building response in the North-South and East-West directions, respectively. Amplification factors TAF_1 and TAF_2 (Section 6.0) associated with each of the Fan House model mass points are provided in Table D.2.

D.4 In-Structure Response Spectra

Representative SSE ISRS associated with important elevations of the Fan House for 5% equipment damping are shown in Figures D.4 and D.5.

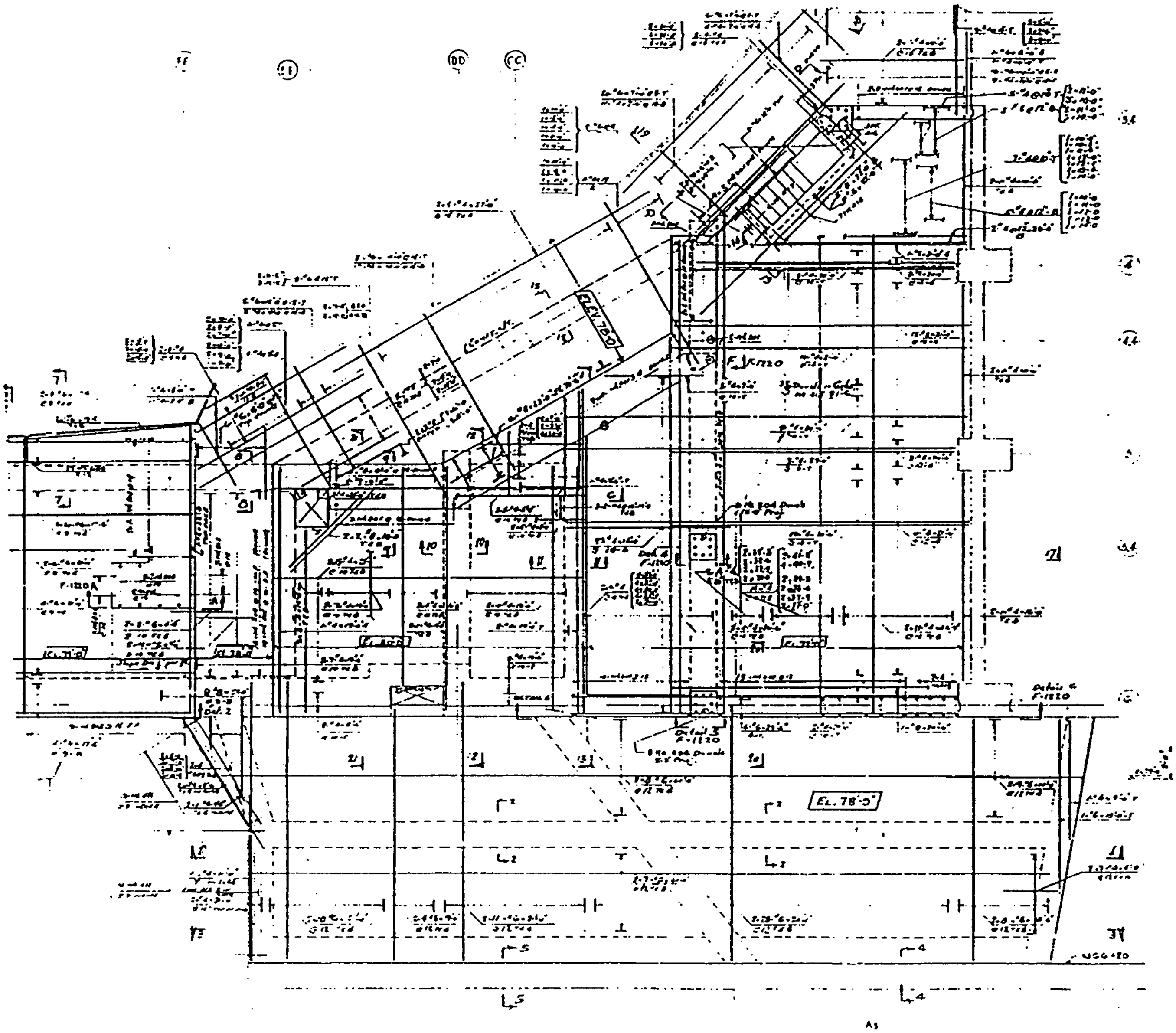


Figure D.1
Fan House
Plan of Structure

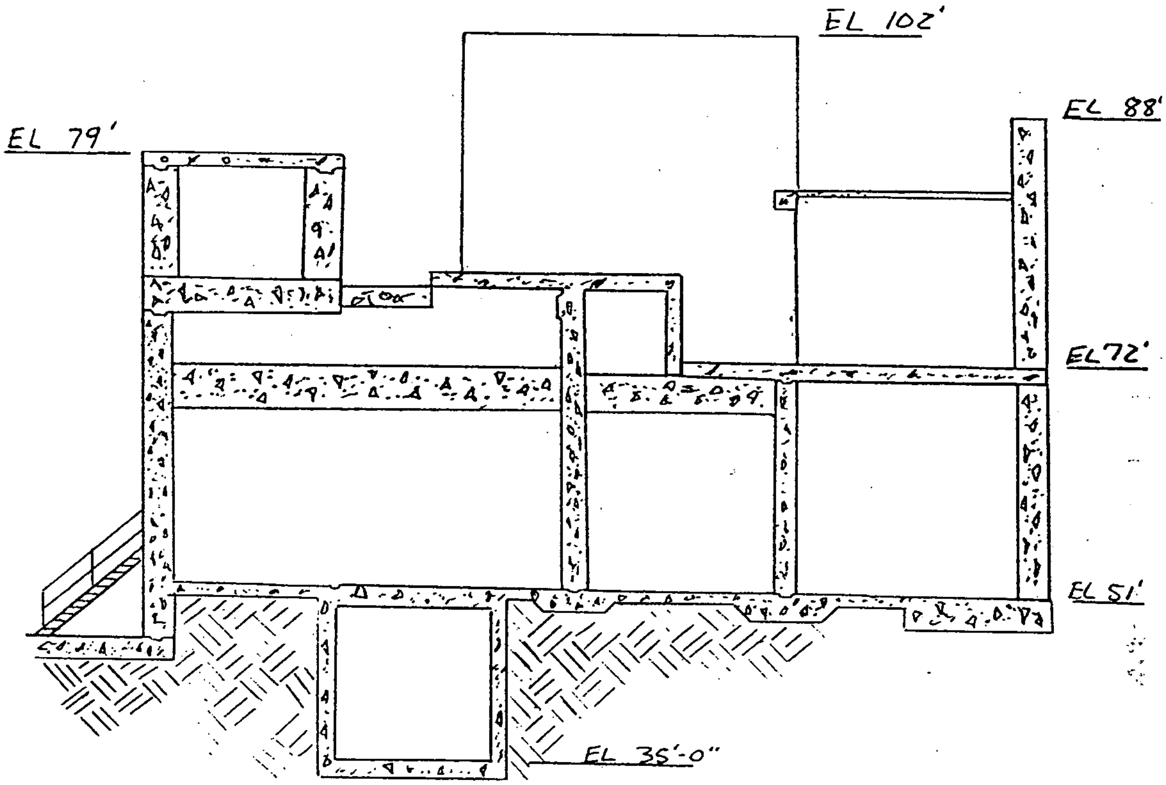


Figure D.2
Fan House
Section of Structure

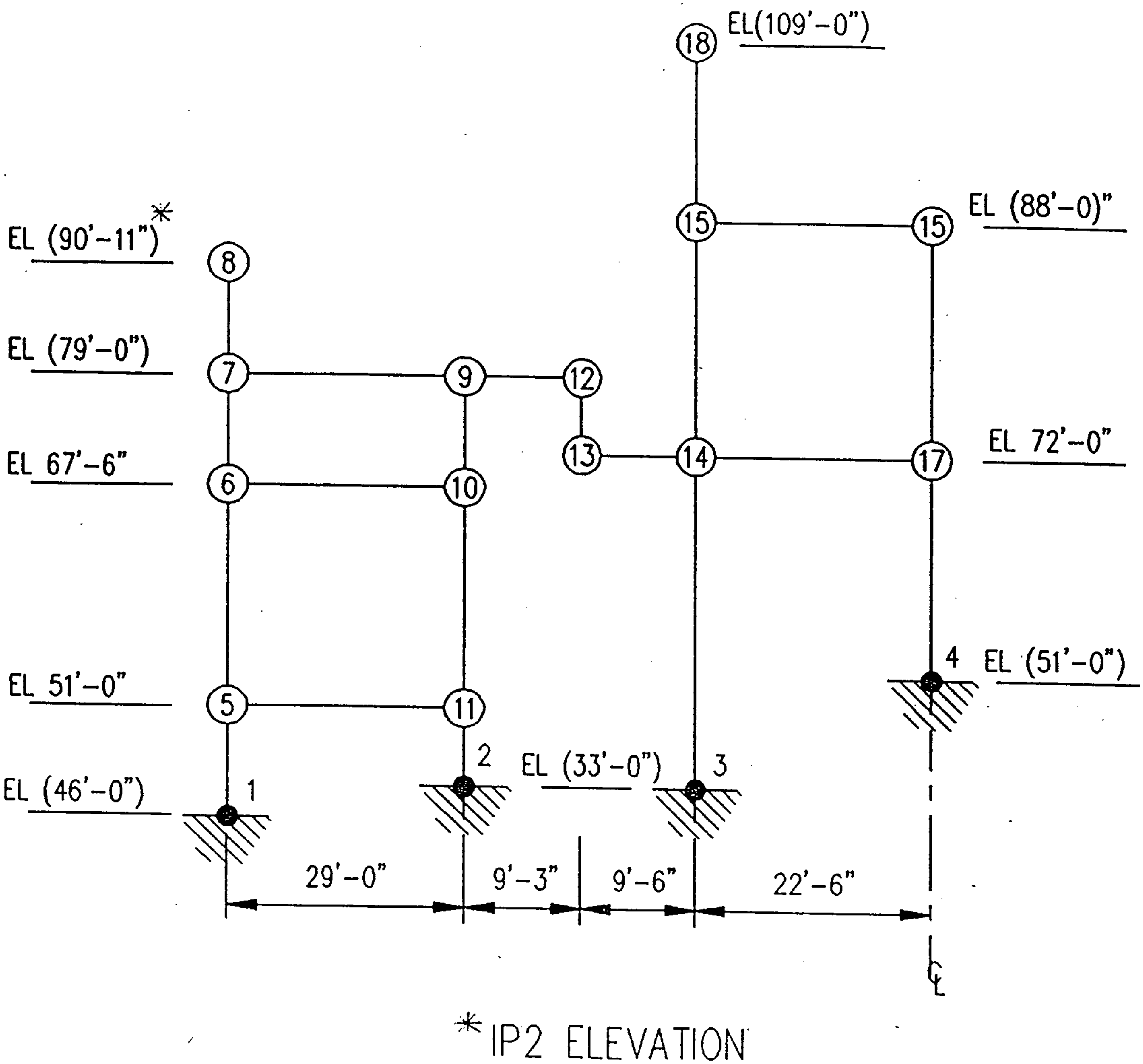


Figure D.3
Fan House
Dynamic Model

North-South Direction

	Mode				
Frequency / Part. Factor / Mass Point	1 2.74 0.30	2 8.19 1.30	3 11.57 1.20	4 11.76 0.40	5 21.34 -0.60
5	0.000	-0.006	0.209	0.105	-0.002
6	0.000	-0.014	0.549	0.273	-0.014
7	-0.001	-0.020	0.832	0.406	-0.040
8	-0.001	-0.020	1.000	0.487	-0.053
9	-0.001	0.426	0.541	-0.473	-0.231
10	0.011	0.261	0.326	-0.303	-1.000
11	0.068	0.033	0.042	-0.039	-0.221
12	0.001	0.574	0.393	-0.683	-0.171
13	0.017	0.480	0.135	-0.267	-0.241
14	0.012	0.336	0.061	-0.129	-0.096
15	0.040	0.657	-0.090	0.120	0.418
16	0.001	0.008	-0.010	0.160	-0.079
17	0.000	0.004	-0.006	0.008	-0.028
18	1.000	1.000	-0.586	1.000	-0.244

Table D.1
Fan House
Dynamic Characteristics
North-South Direction

East-West Direction

Mass Point \ Frequency, Part. Factor	Mode 1	Mode 2	Mode 3	Mode 4
Frequency	4.20	6.93	8.39	13.20
Part. Factor	-0.40	0.96	1.40	0.58
5	0.008	0.064	0.152	0.463
6	0.014	0.108	0.253	0.707
7	0.017	0.136	0.318	0.860
8	0.019	0.152	0.357	1.000
9	0.021	0.153	0.336	0.643
10	0.015	0.117	0.267	0.642
11	0.006	0.049	0.116	0.352
12	0.022	0.156	0.337	0.571
13	0.024	0.157	0.315	0.139
14	0.025	0.160	0.315	0.062
15	0.075	0.399	0.593	-0.890
16	0.069	0.399	0.615	-0.983
17	0.024	0.146	0.261	-0.212
18	-1.000	1.000	-1.000	0.180

Table D.2
Fan House
Dynamic Characteristics
East-West Direction

Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
DIRECTION: North - South								
8	90.92	45	45[1]		0.170	0.15	4.89	5.55
15-16	88.00	42	42[1]	1.079	0.260	0.15	4.15	7.19
*			40				4.18	6.67
7-9-12	79.00	33	33	0.728	0.170	0.15	4.28	4.85
13-14-17	72.00	28	28	0.815	0.160	0.15	5.09	5.43
6-10	67.50	21	21	0.549	0.150	0.15	3.66	3.66
DIRECTION: East - West								
8	90.92	45	45[1]	0.679	0.170	0.15	3.99	4.53
15-16	88.00	42	42[1]	1.207	0.260	0.15	4.64	8.05
*			40				4.44	7.20
7-9-12	79.00	33	33	0.632	0.170	0.15	3.72	4.21
13-14-17	72.00	28	28	0.653	0.160	0.15	4.08	4.35
6-10	67.5	21	21	0.547	0.150	0.15	3.65	3.65

Where, Per Section 6.0: TAF_1 = PFA/ZPA
TAF_2 = PFA/PGA
*, TAF_1 & TAF_2 interpolated at 40' above grade reference point.

Note: 1. Elevations reflect IP2 which differ slightly from IP3 elevation used in dynamic model, see Figure D.3.

Table D.3
Fan House
Total Amplification Factors

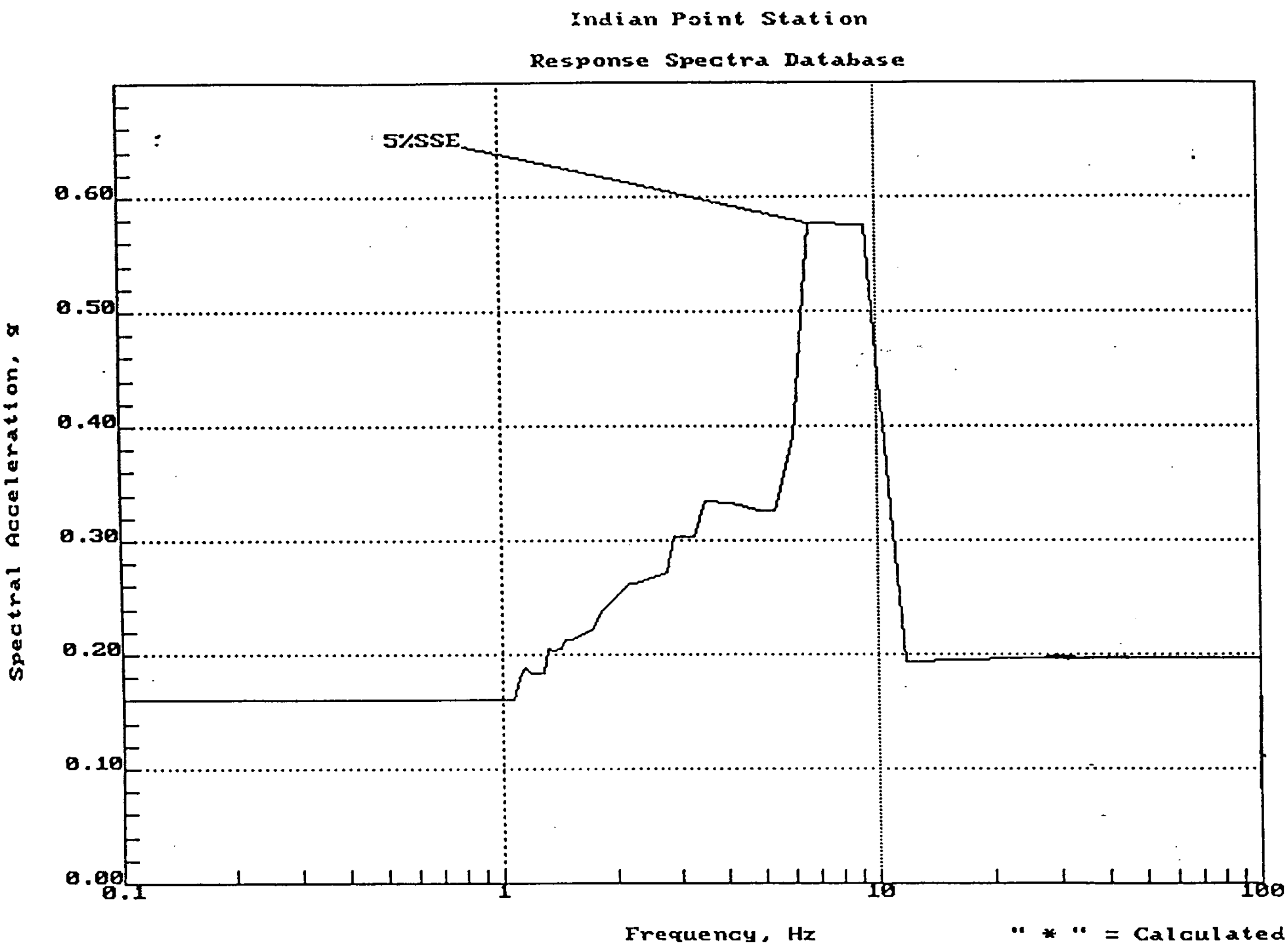


Figure D.4
Fan House
North-South In-Structure Response Spectra
Elevation 67' (Node 10)

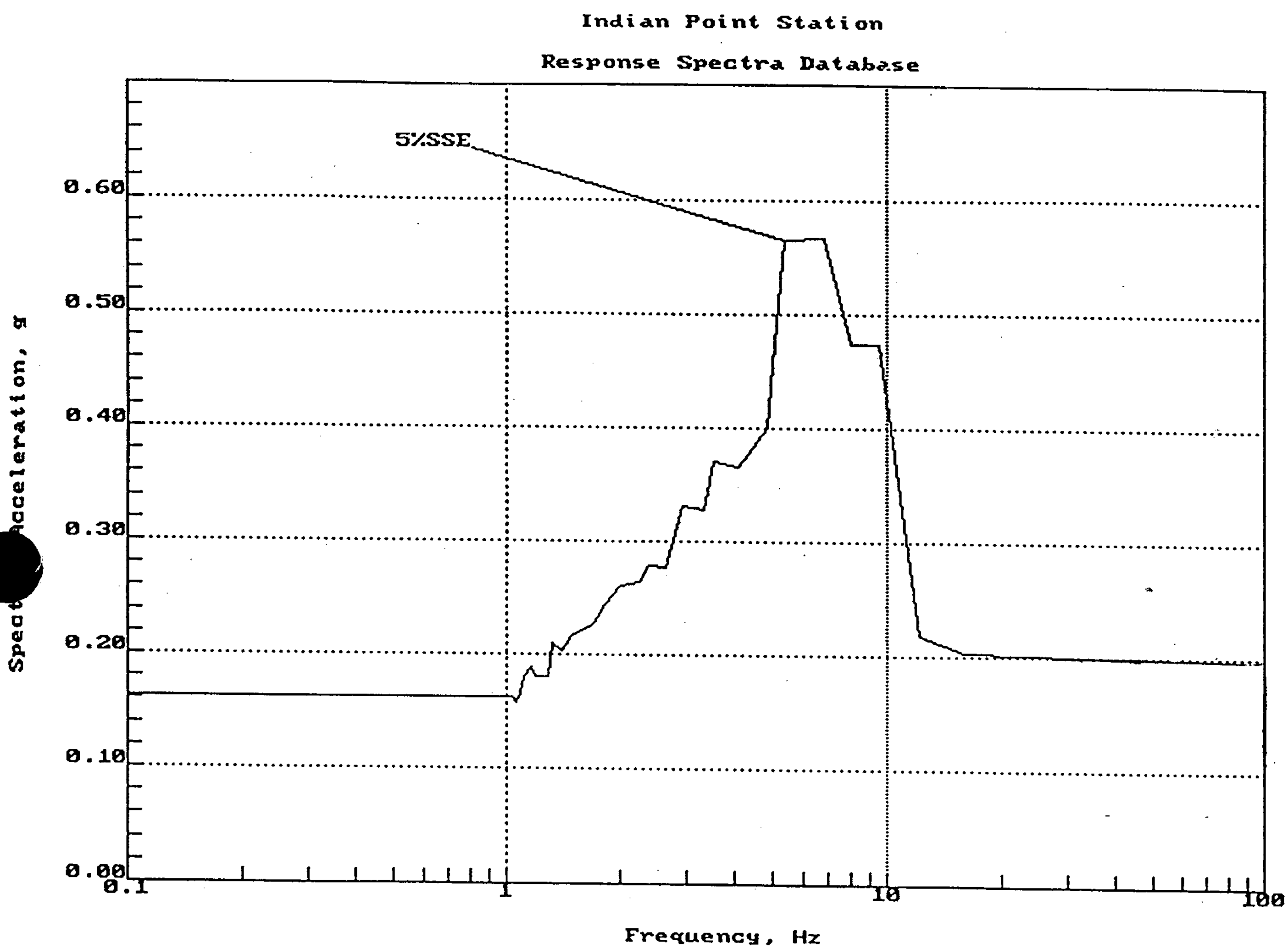


Figure D.5
Fan House
East-West In-Structure Response Spectra
Elevation 67' (Node 10)

APPENDIX E

Intake Structure

E.1 Structure Description

The Intake Structure is a massive reinforced concrete structure, consisting of separate concrete cells. The intake structure is built below grade at the Hudson River bank. The structure roof is at elevation 15'. The structure is open to the river on the west side. The base of the structure is founded on rock at elevation -27 feet. Section and plan views for the Intake Structure are shown in Figure E.1 and E.2.

E.2 Dynamic Model

ISRS are not available for the IP2 Intake Structure, however, ISRS are available for the IP3 Intake Structure. A review of the IP2 and IP3 Intake Structures shows that the two structures are similar. This similarity enables the use of the IP3 spectra for the IP2 structure. The IP3 Intake Structure dynamic analysis was performed by Westinghouse using a 3 node lumped mass model, as shown in Figure E.3. The forcing function used to obtain the design response spectra was a synthetic time history normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used for the IP3 Intake Structure was 5%, consistent with the IP2 UFSAR for concrete structure shear wall or rigid frame construction as shown in Table 1.

E.3 Dynamic Parameters

The dynamic properties of the Intake Structure (frequencies, mode shapes, and participation factors) are provided in Table E.1, associated with the significant modes of response for both horizontal directions. Amplification factors TAF_1 and TAF_2 (Section 6.0) associated with each of the Intake Structure model mass points are shown in Table E.2.

E.4 In-Structure Response Spectra

Representative SSE floor response spectra associated with important elevations of the Intake Structure for 5% equipment damping are shown in Figures E.4 and E.5.

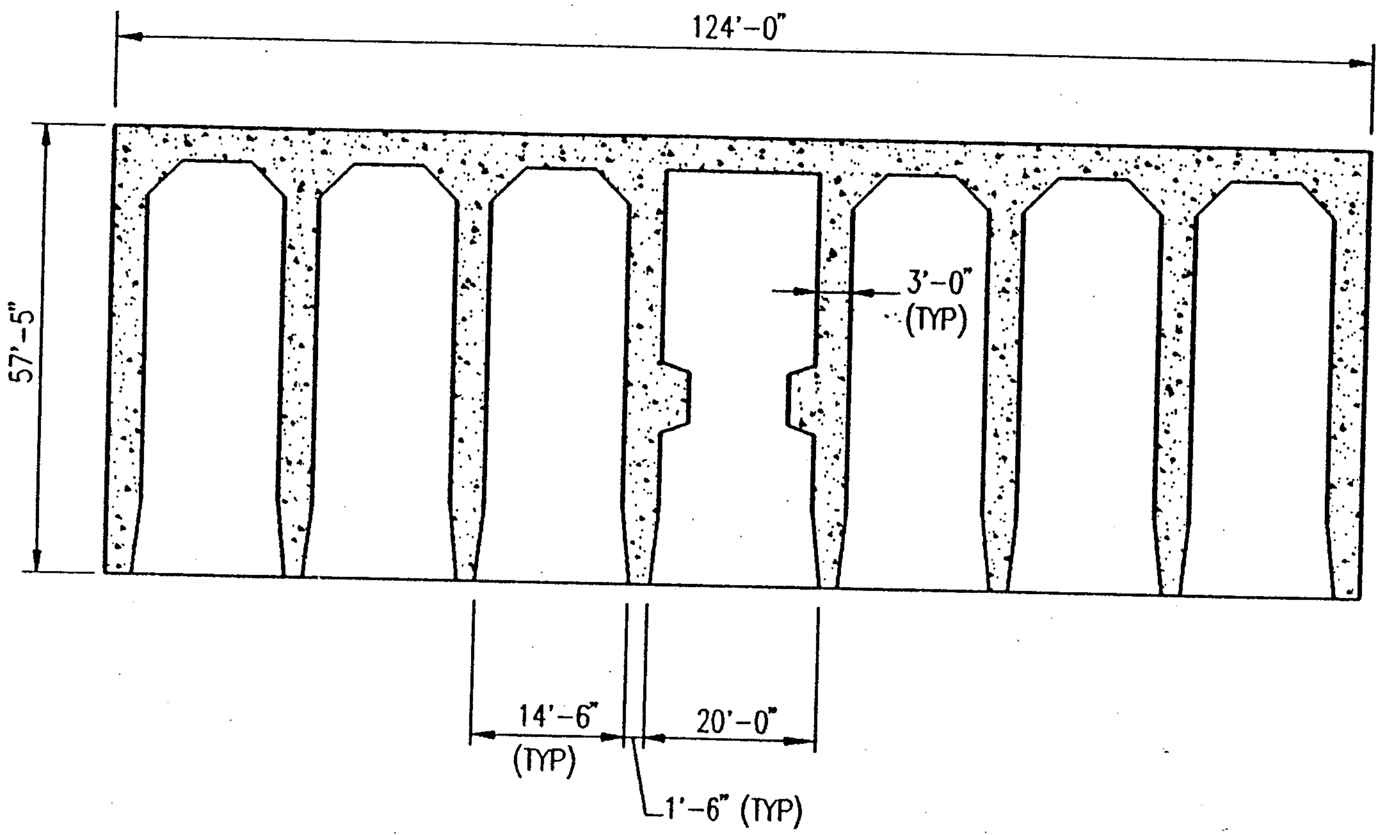


Figure E.1
Intake Structure
Plan of Structure

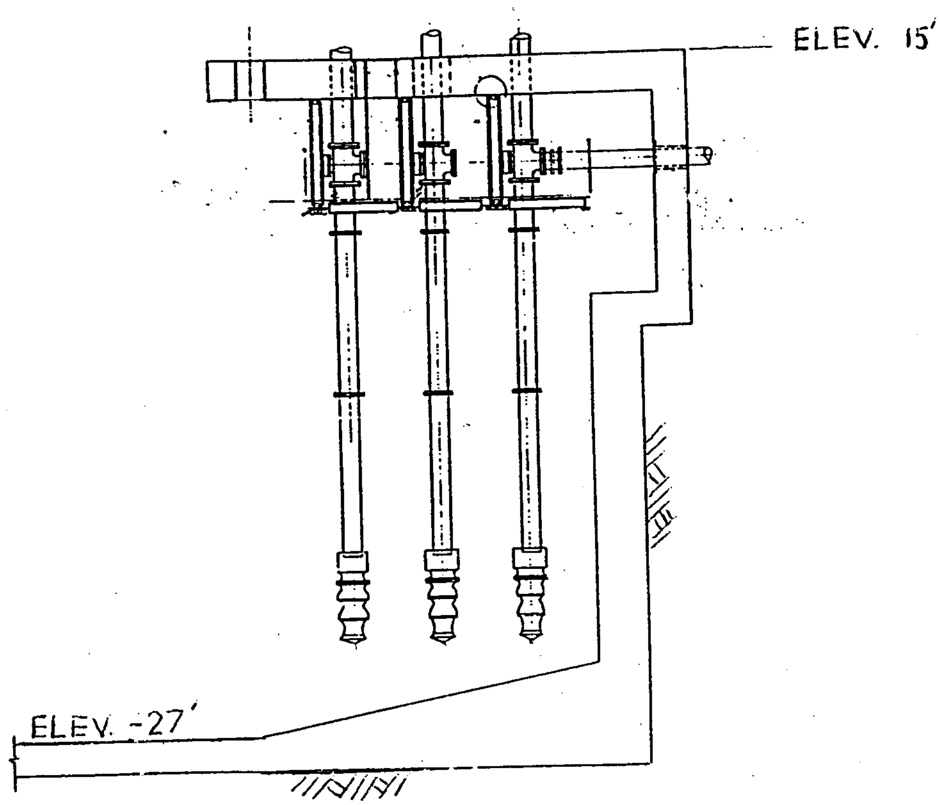


Figure E.2
Intake Structure
Section of Structure

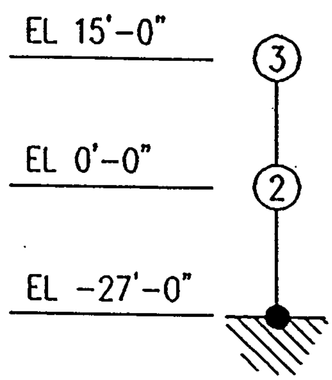


Figure E.3
Intake Structure
Horizontal Lumped Mass Model

North-South Direction

Mass Point \ Mode: Frequency / Part. Factor	1 12.29 1.05	2 19.11 0.07	3 46.89 0.08
1	0.000	0.000	0.000
2	0.826	1.000	0.868
3	1.000	0.439	-1.000

East-West Direction

Mass Point \ Mode: Frequency / Part. Factor	1 18.40 1.10	2 49.84 0.23
1	0.000	0.000
2	0.682	1.000
3	1.000	-0.309

Table E.1
Intake Structure
Dynamic Characteristics

DIRECTION: North - South								
Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
3	15.00	42	0	0.549	0.200	0.15	2.75	3.66
2	0.00	27	-15	0.492	0.180	0.15	2.73	3.28
DIRECTION: East - West								
3	15.00	42	0	0.537	0.190	0.15	2.83	3.58
2	0.00	27	-15	0.401	0.180	01.5	2.23	2.67

Where, Per Section 6.0: $TAF_1 = PFA/ZPA$
$TAF_2 = PFA/PGA$

Table E.2
Intake Structure
Total Amplification Factors

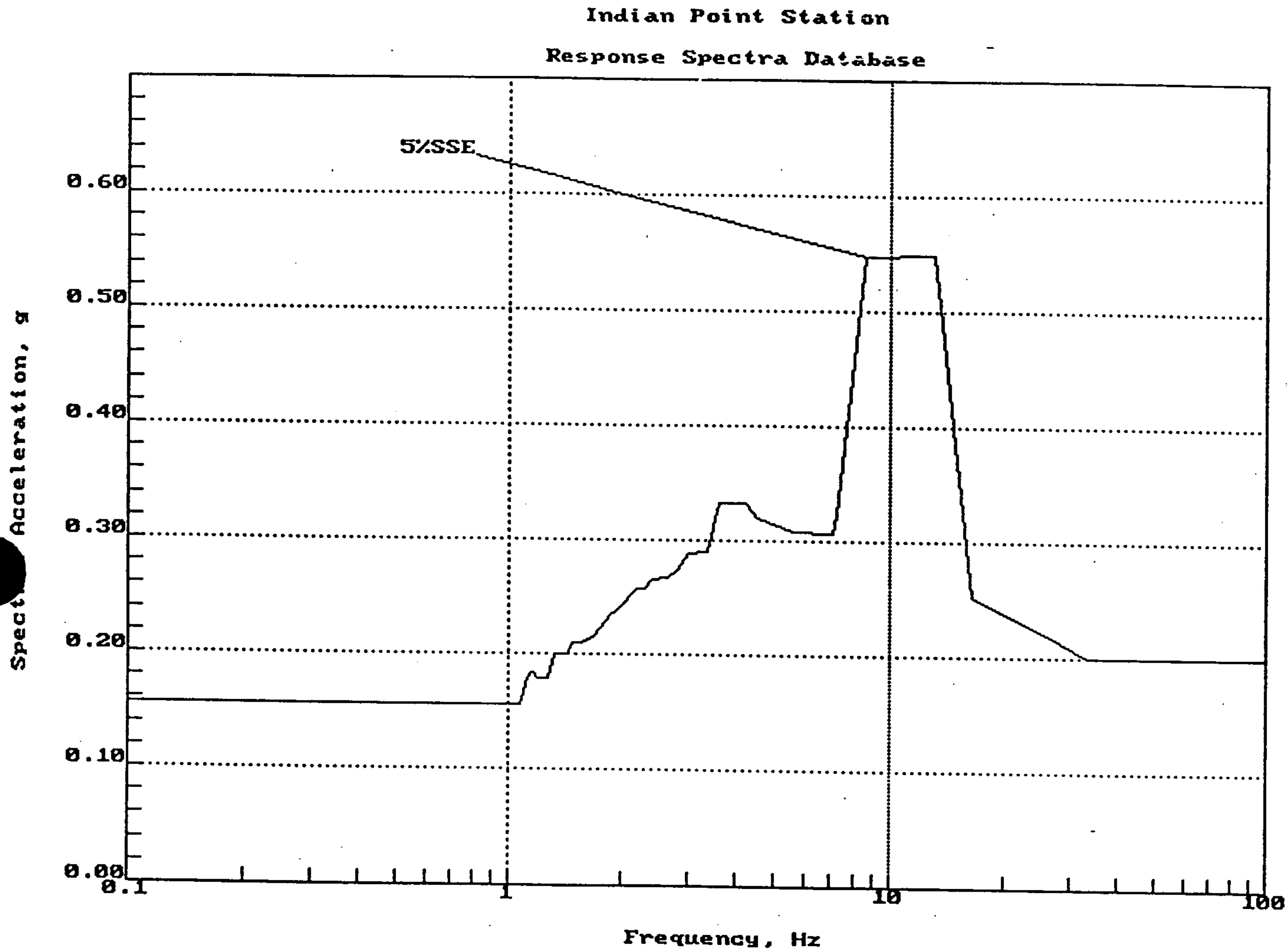


Figure E.4
North-South Intake Structure
North-South In-Structure Response Spectra
Elevation 15'-0"

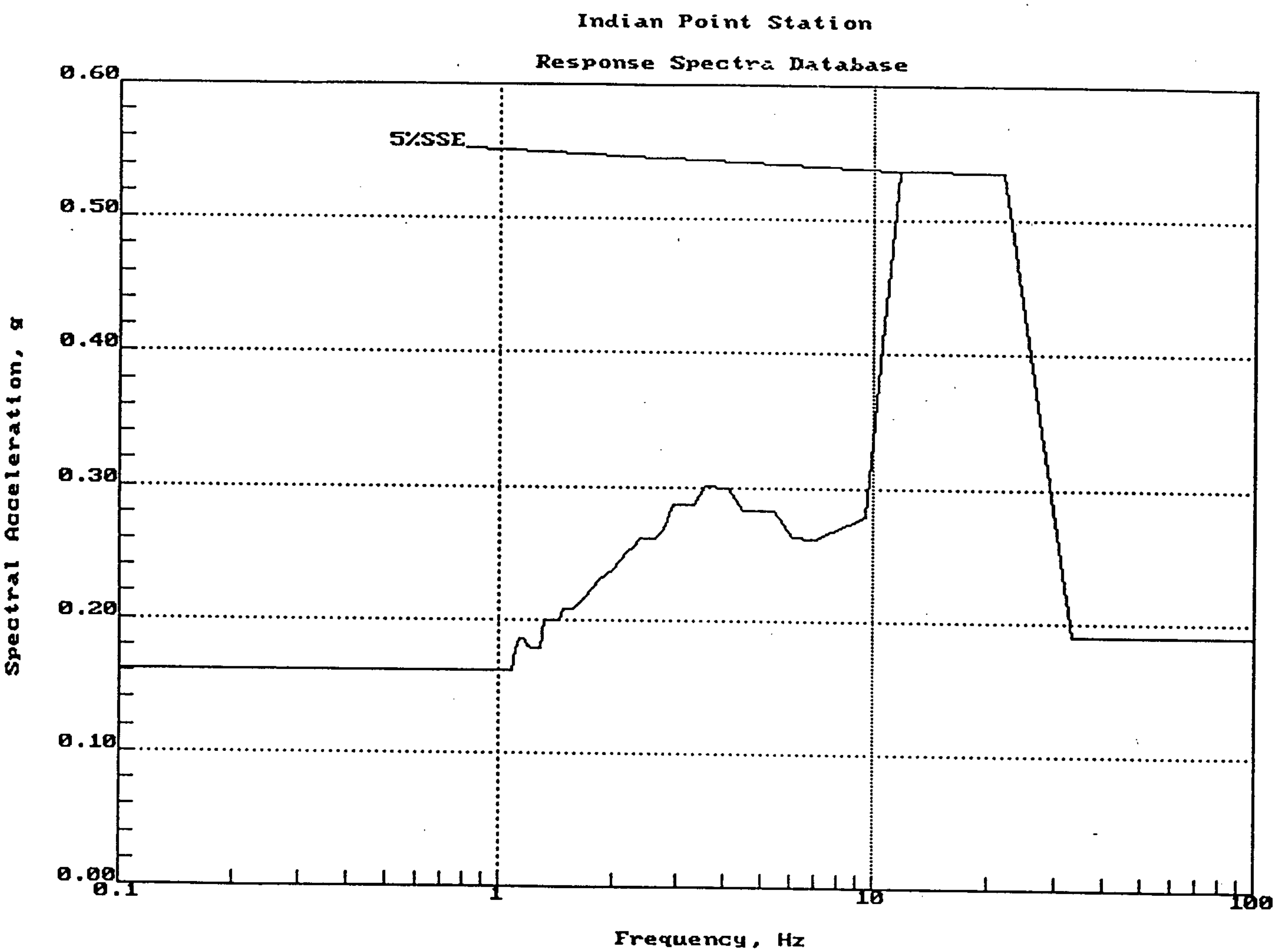


Figure E.5
East-West Intake Structure
East-West In-Structure Response Spectra
Elevation 15'-0"

APPENDIX F

Primary Auxiliary Building

F.1 Structure Description

The Primary Auxiliary Building is a reinforced concrete structure with steel framing and metal siding on the East and West ends constructed on variable levels from elevation 15' to elevation 80'. The building is founded on rock. Generalized Primary Auxiliary Building plan and sections are shown in Figures F.1, F.2 and F.3.

F.2 Dynamic Model

Design response spectra for the Primary Auxiliary Building were generated by two vendors, Westinghouse and Harstead. The dynamic models developed by Westinghouse and Harstead vary in complexity and size.

Westinghouse separated the Primary Auxiliary Building into three decoupled dynamic models; Left End (West), Center, and right (East side bay at Column Line 6-6). These dynamic models are shown in Figures F.4, F.5 and F.6. The forcing function used by Westinghouse was the 1952 Taft Earthquake, N69W component normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used was 5% for concrete structures above ground as per the IP2 UFSAR as shown in Table 1, except for the Column Line 6-6 model, which utilized a damping factor of 2.5% applicable for bolted steel structures.

Harstead developed models for the Primary Auxiliary Building in the East-West and North-South directions (Figures F.7 and F.8). The forcing function for the Harstead model was a synthetic time history normalized to 0.15g. The structural damping was set to 2.5% for bolted steel structures, consistent with the East side of the structure, and conservative for the concrete portions of the building.

F.3 Comparison of Vendor Spectra Sets

As the dynamic models used by Westinghouse and Harstead differ in complexity and size, the Harstead to Westinghouse comparison consists of a comparison of the input time histories, and a comparison of the generated ISRS.

The comparison of the input time histories used by Westinghouse and Harstead, shows that both the Taft and the synthetic ground response spectra envelope the Housner site spectra at 2.5% and 5% structural damping. At the natural frequencies of the Harstead model the margin between the synthetic time history and the Housner response spectra is greater, than the Taft margin for the applicable frequencies of the Westinghouse models.

The comparison of the ISRS spectra sets shows that the Harstead spectra are generally comparable or more conservative than the Westinghouse spectra, except for the Column Line 6-6 spectra. This is because of the uncoupling of the steel and concrete structures in the Westinghouse analysis. Typically, a more flexible steel structure will have a greater response than a concrete, or a concrete and steel structure. Thus, by uncoupling the steel and concrete structures for the Primary Auxiliary Building, Westinghouse incorporated an additional margin in the model for Column Line 6-6.

Based on the discussion above it is concluded that the Westinghouse dynamic analysis for the Primary Auxiliary Building is acceptable, and consistent with the original design basis. However, the Harstead generated response spectra is more realistic given the single dynamic model in comparison to Westinghouse's decoulped three dynamic models. The Harstead model has included both directions of response, and are generally conservative in comparison to the Westinghouse model. As such, Con Edison has selected to utilize the Harstead spectra for the A-46 program.

F.4 Dynamic Parameters

The dynamic properties of the Primary Auxiliary Building (frequencies, mode shapes, and participation factors) are provided in Table F.1, associated with the significant modes of response for both horizontal directions. Amplification factors TAF_1 and TAF_2 (Section 6.0) associated with each of the Primary Auxiliary Building model mass points are shown in Table F.2.

F.5 In-Structure Response Spectra

Representative SSE floor response spectra associated with important elevations of the Primary Auxiliary Building structure for 5% equipment damping are shown in Figures F.9 and F.10.

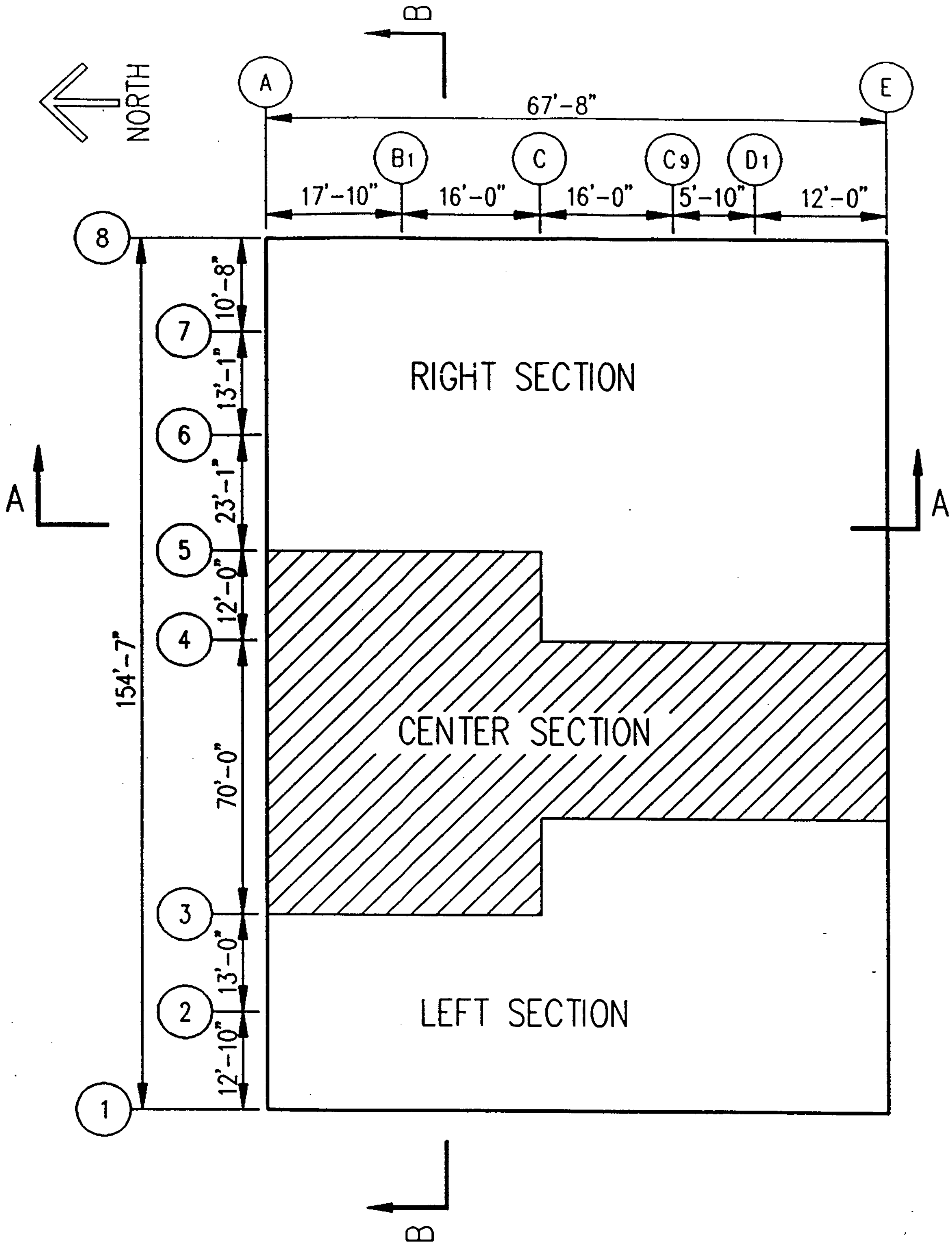


Figure F.1
Primary Auxiliary Building
Plan of Structure

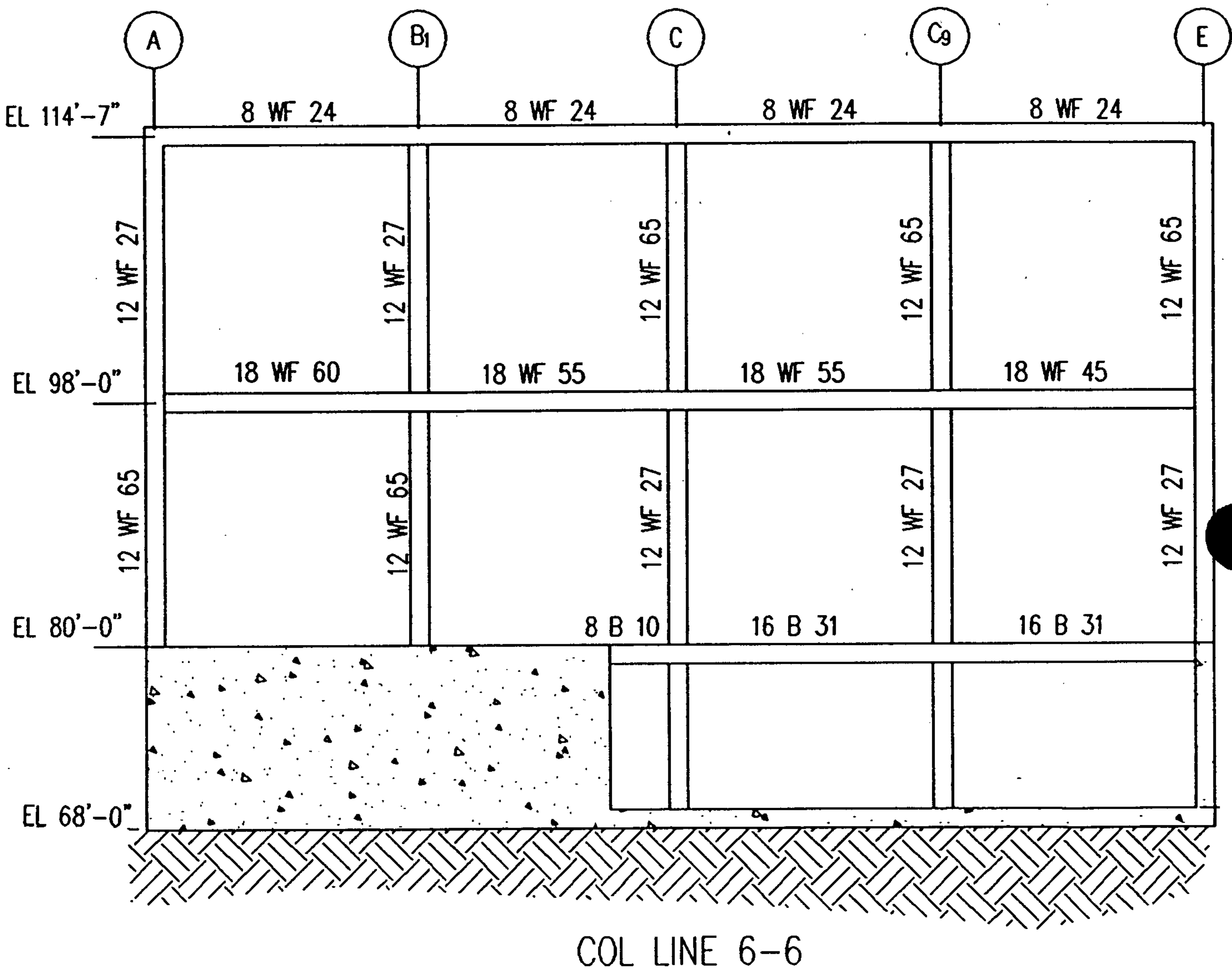


Figure F.2
Primary Auxiliary Building
Section A-A Through Structure

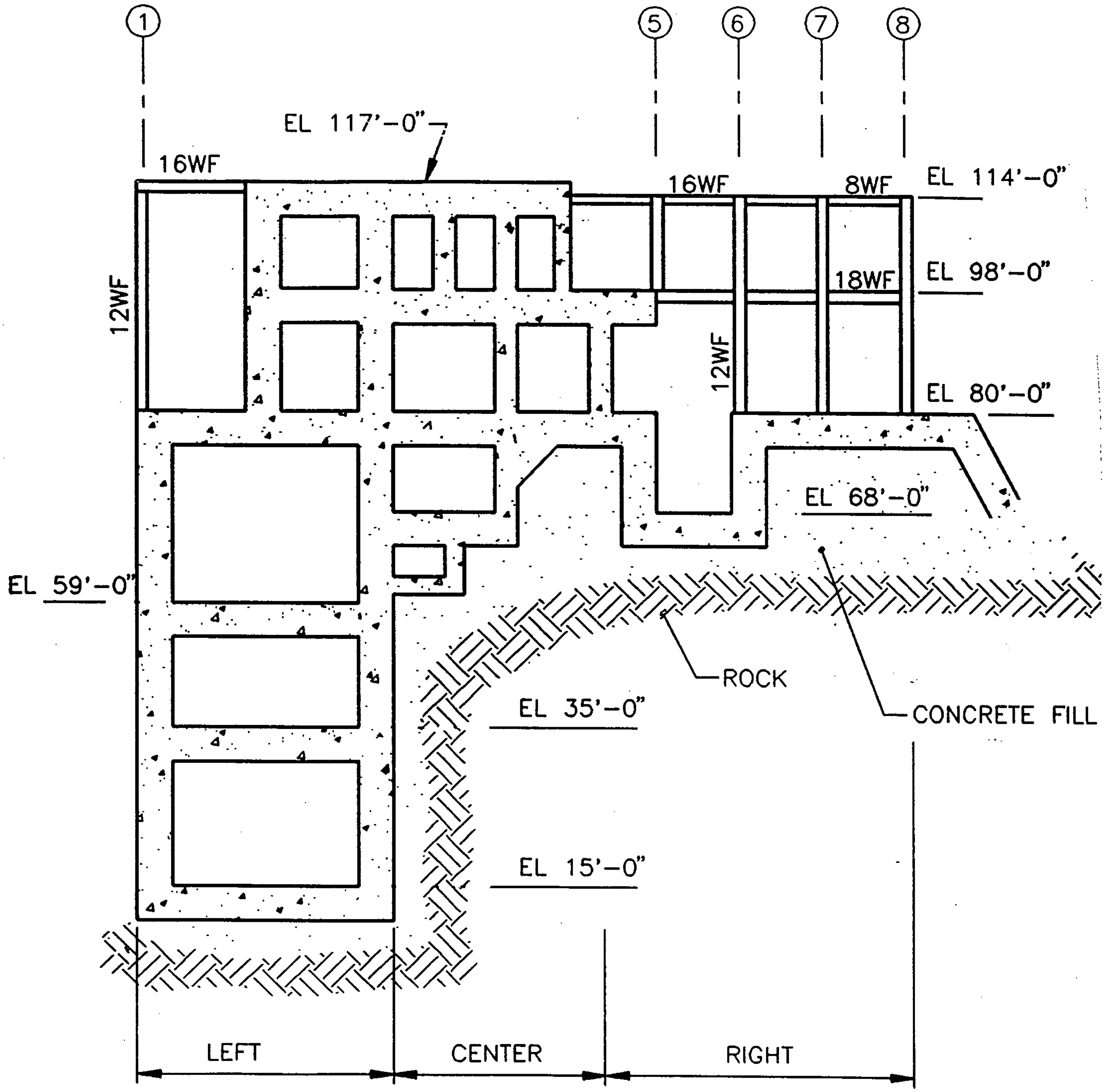


Figure F.3
Primary Auxiliary Building
Section B-B Through Structure

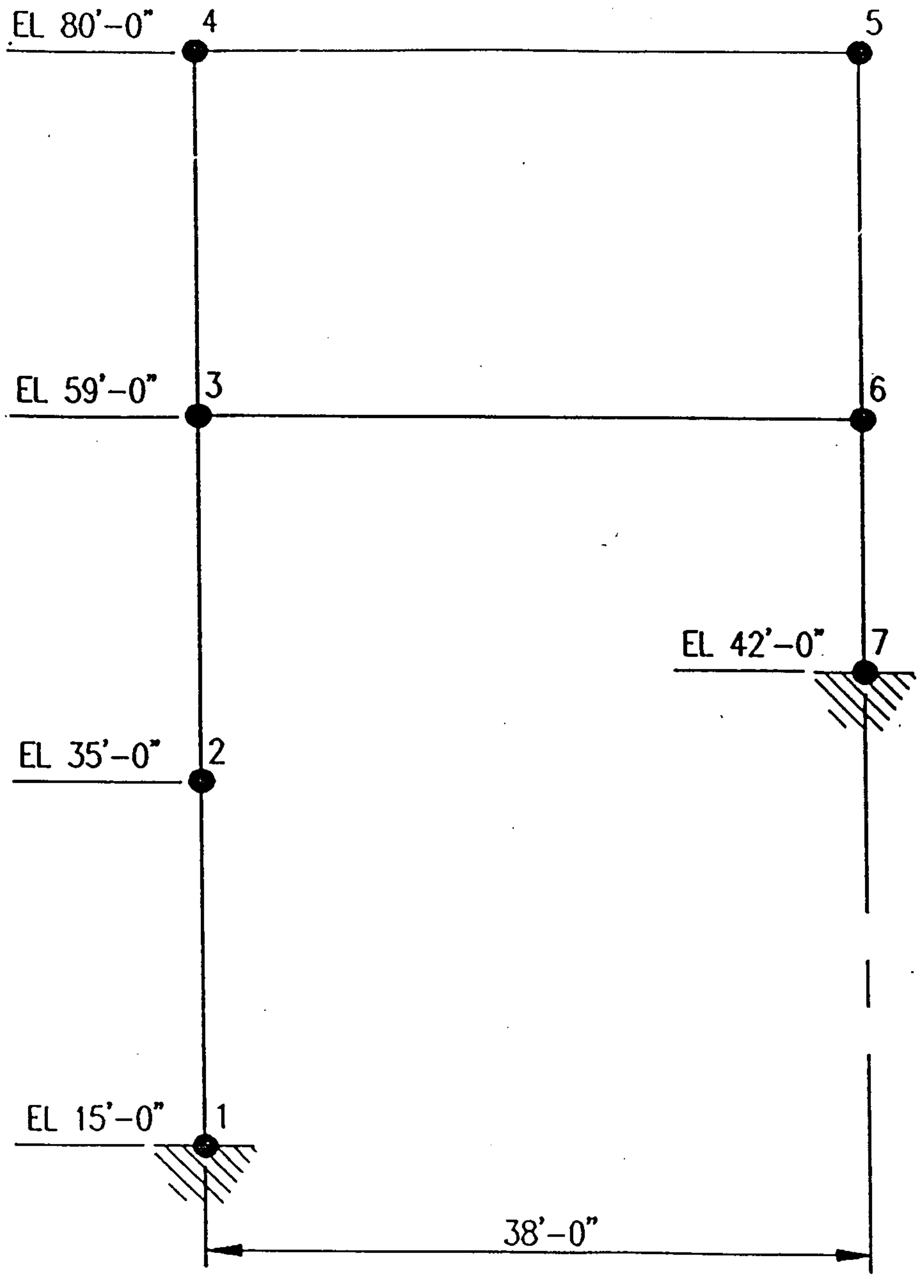


Figure F.4
Primary Auxiliary Building
Horizontal Lumped Mass Model
Westinghouse - Left End (West)

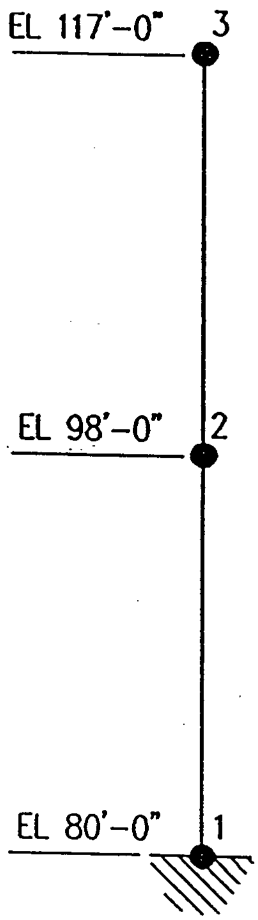


Figure F.5
Primary Auxiliary Building
Horizontal Lumped Mass Model
Westinghouse - Center

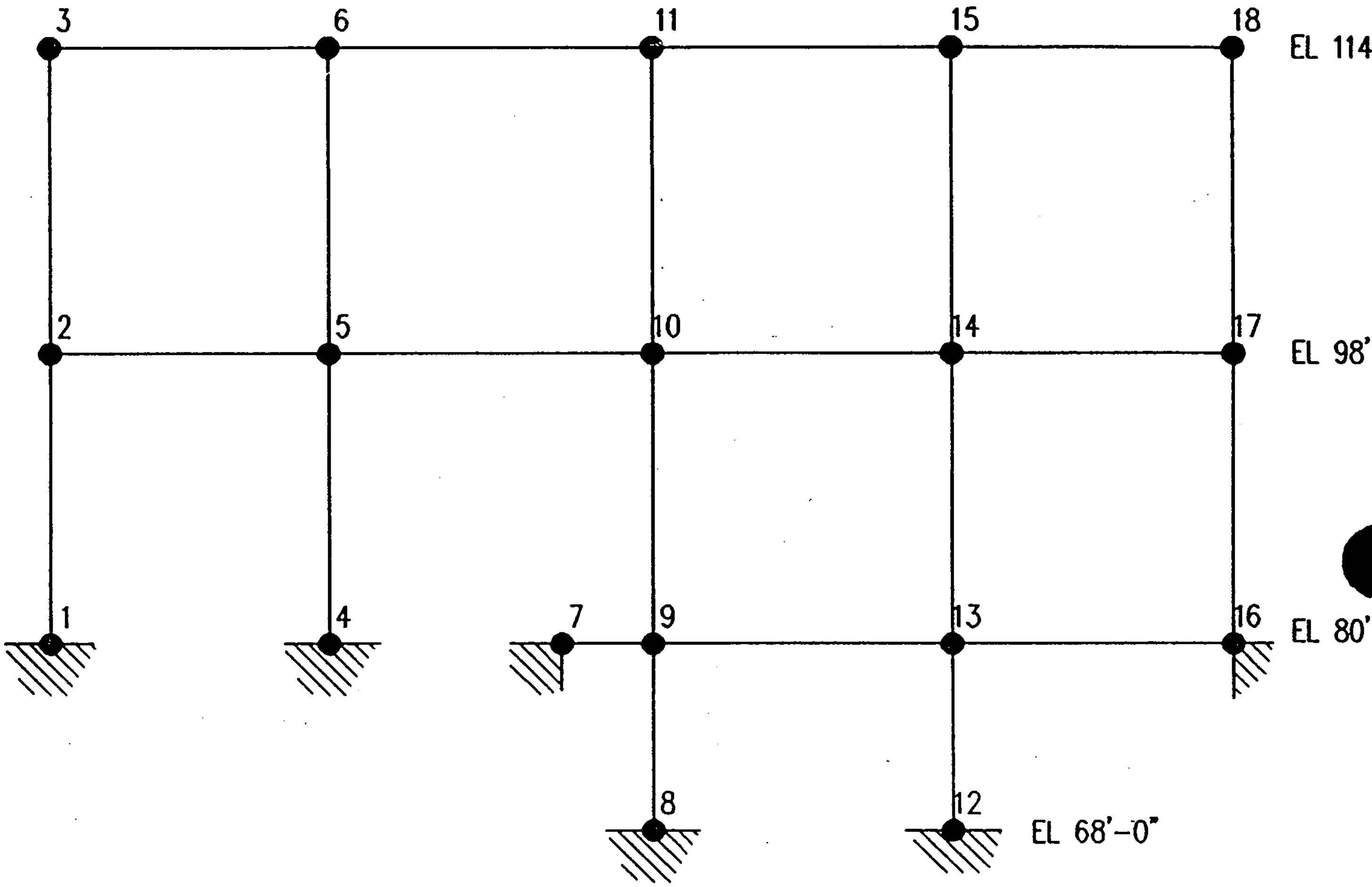


Figure F.6
Primary Auxiliary Building
Horizontal Lumped Mass Model
Westinghouse - Column Line 6-6

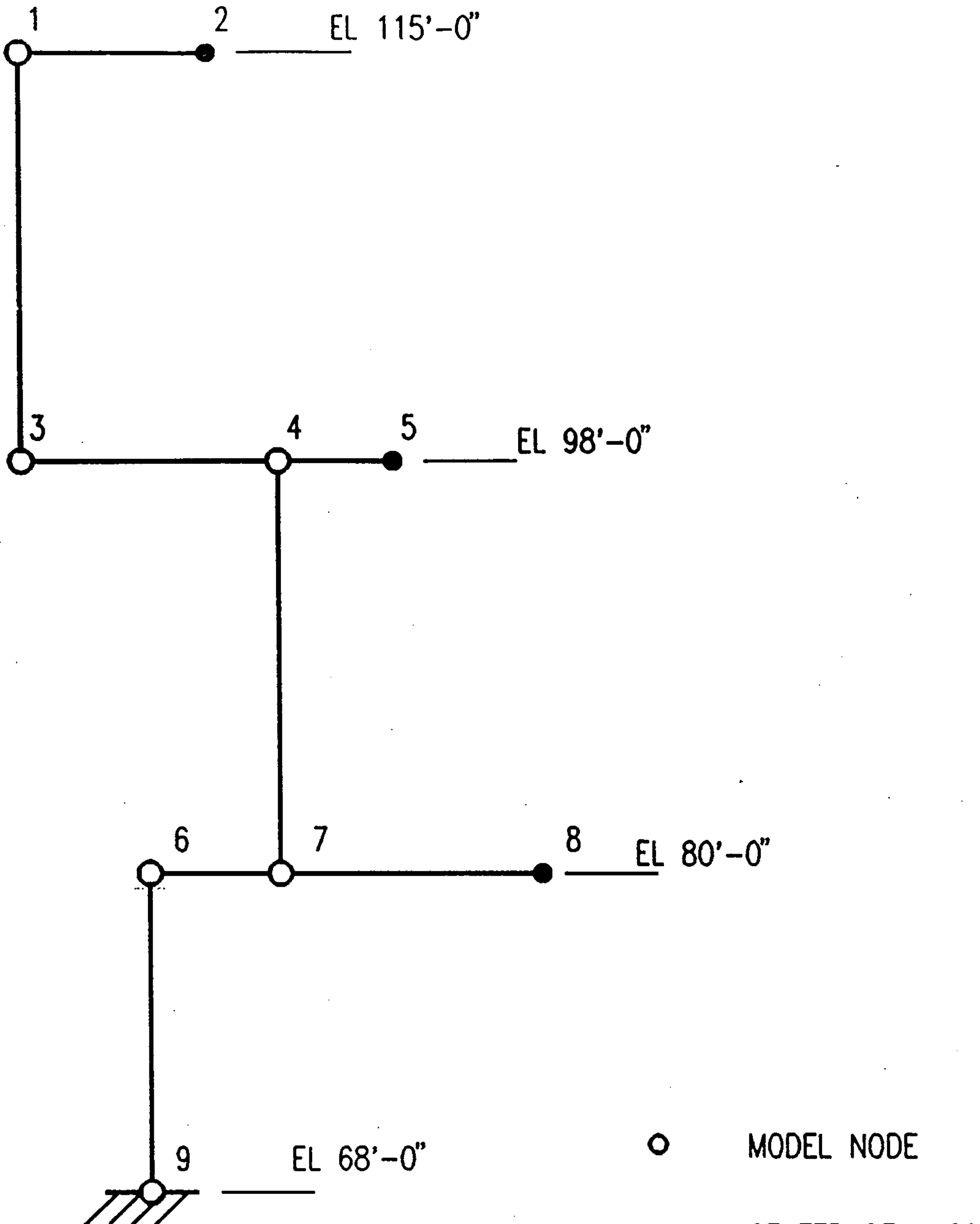


Figure F.7
Primary Auxiliary Building.
Horizontal Lumped Mass Model
Harstead - North-South

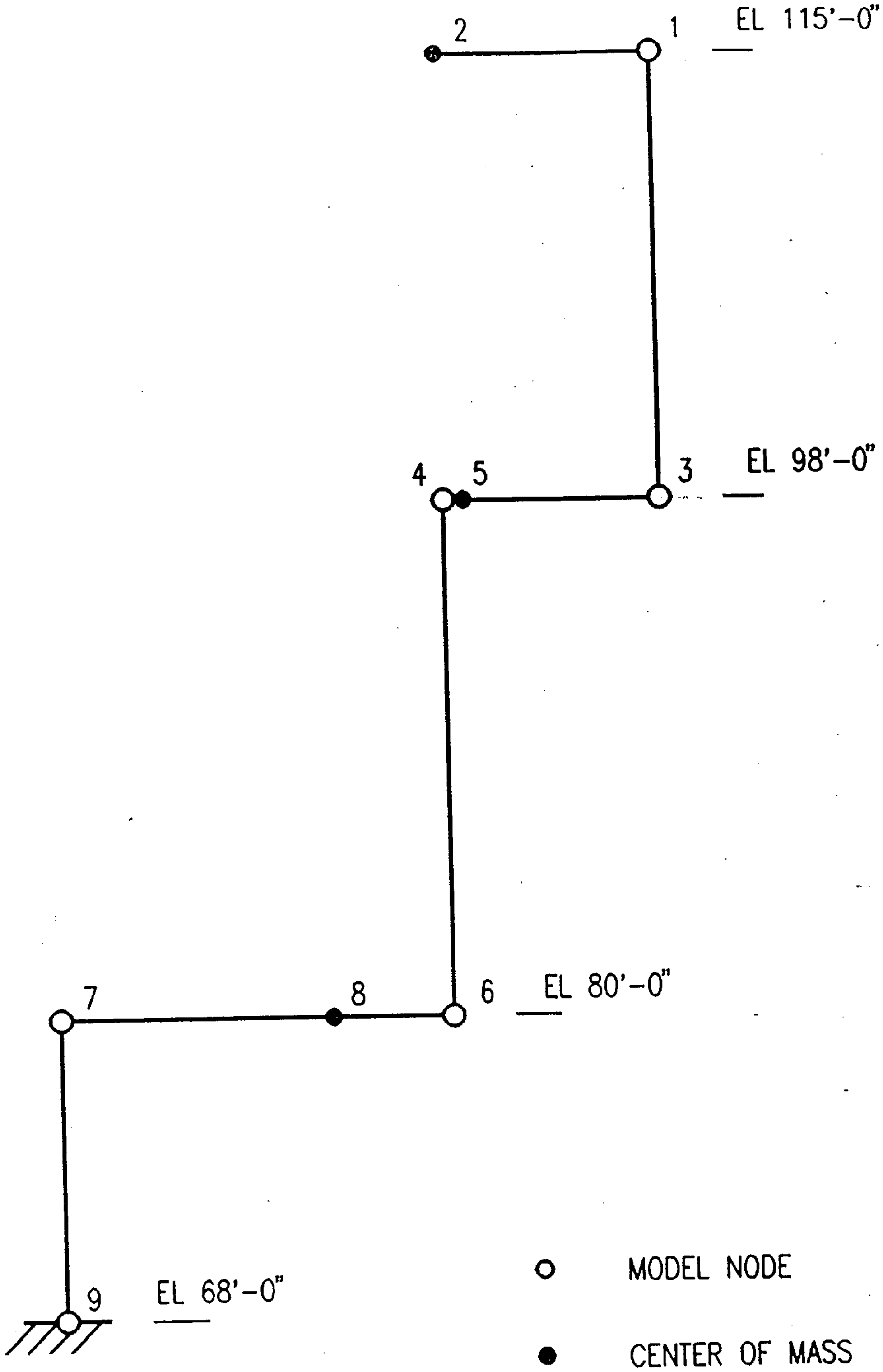


Figure F.8
Primary Auxiliary Building
Horizontal Lumped Mass Model
Harstead - East-West

North-South Direction

Frequency / Part. Factor / Mass Point	Mode 1	Mode 2	Mode 3
Frequency	13.46	30.77	40.88
Part. Factor	1.42	-0.62	0.19
2	1.00	1.00	1.00
5	0.74	-0.22	-0.95
8	0.28	-0.77	0.64

East-West Direction

Frequency / Part. Factor / Mass Point	Mode 1	Mode 2	Mode 3
Frequency	15.75	36.87	51.30
Part. Factor	1.40	-0.54	0.14
2	1.00	1.00	1.00
5	0.77	-0.11	-0.95
8	0.38	-0.73	0.56

Table F.1
Primary Auxiliary Building
Dynamic Characteristics

DIRECTION: North - South								
Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
1-2	15	44	44	1.292	0.287	70.15	4.50	8.61
*		40	40				4.38	8.09
3-4-5	98	27	27	0.957	0.240	0.15	3.99	6.38
6-7-8	80	9	9	0.449	0.170	0.15	2.64	2.99
DIRECTION: East - West								
1-2	115	44	44	1.161	0.314	0.15	3.70	7.74
*		40	40				3.74	7.28
3-4-5	98	27	27	0.867	0.224	0.15	3.87	5.78
6-7-8	80	9	9	0.491	0.200	0.15	2.46	3.27

Where, Per Section 6.0: TAF_1 = PFA/ZPA
TAF_2 = PFA/PGA
* TAF_1 & TAF_2 interpolated at 40' above grade reference point.

Table F.2
Primary Auxiliary Building
Total Amplification Factors

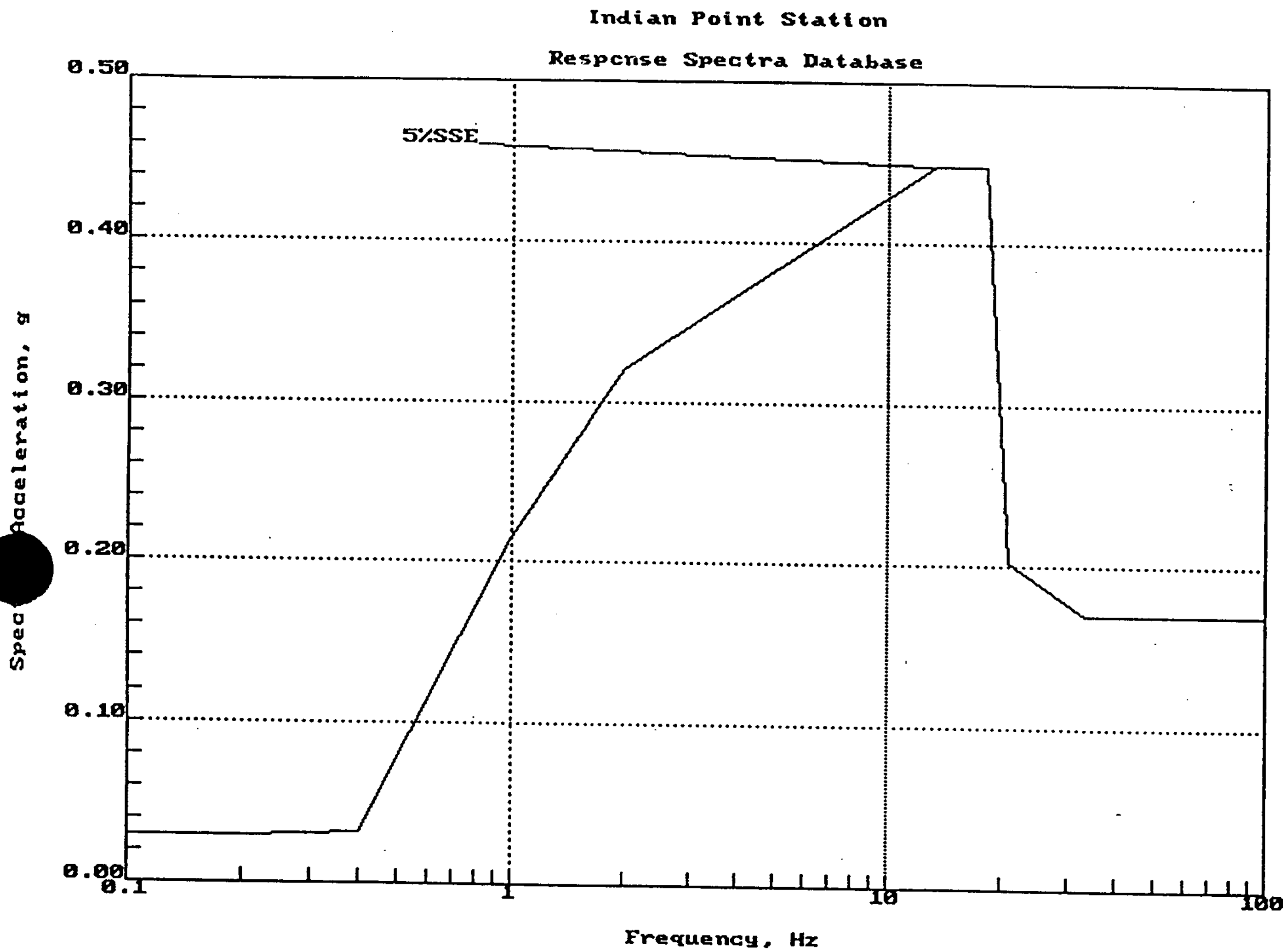


Figure F.9
Primary Auxiliary Building
North-South In-Structure Response Spectra
Elevation 80'

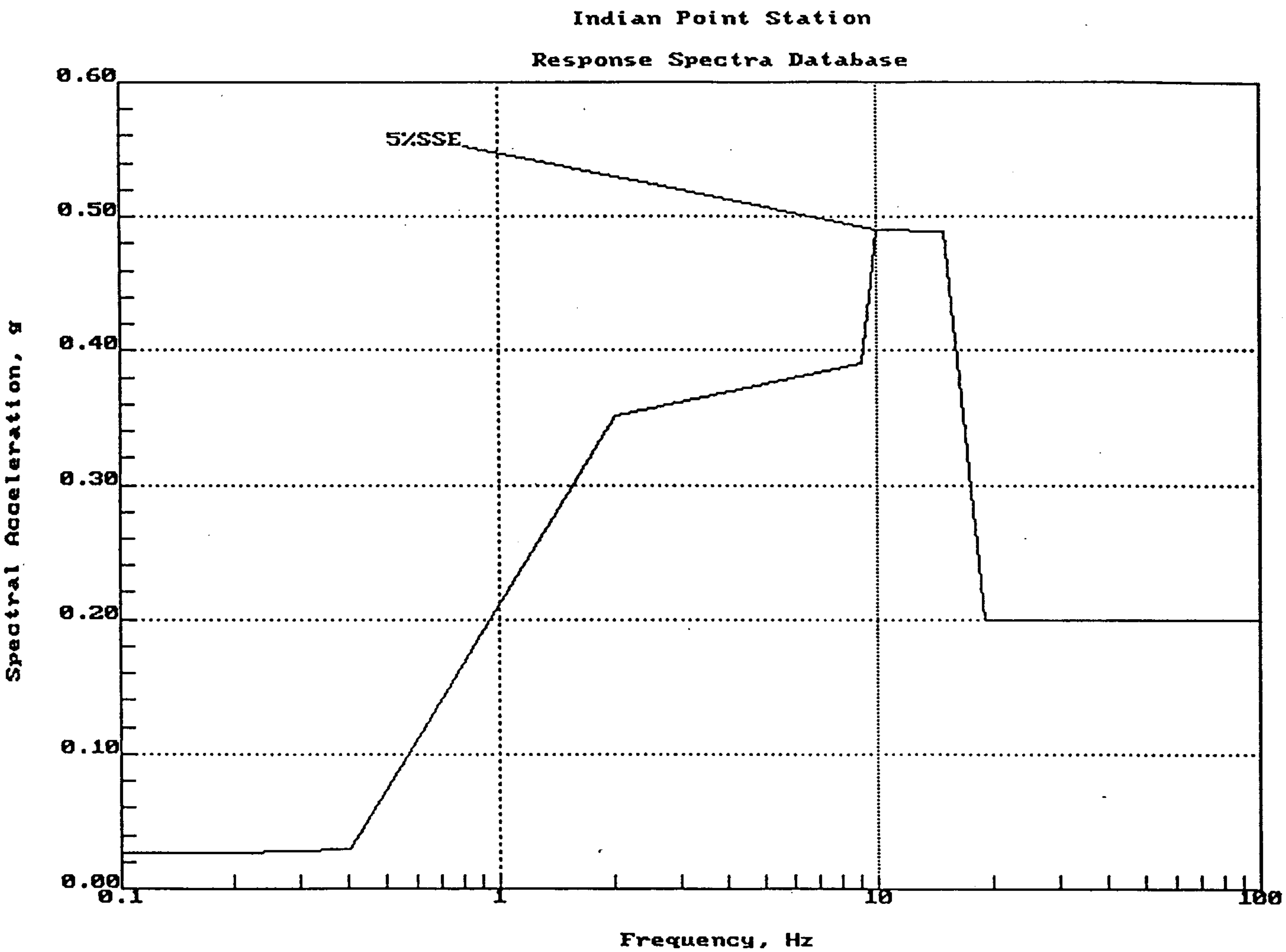


Figure F.10
Primary Auxiliary Building
East-West In-Structure Response Spectra
Elevation 80'

APPENDIX G

Shield Wall

G.1 Structure Description

The Shield Wall is a 4' thick reinforced concrete wall founded on bedrock. The Shield Wall is located inside the Auxiliary Feedwater Pump Building on the West side of the Containment Structure, and is founded on rock at elevation 6 feet. The Shield Wall supports concrete floors which span between the wall and a concrete fill foundation on the rock base at elevation 18', 32' and 43'. The structure is as shown in Figures G.1 and G.2.

G.2 Dynamic Model

ISRS are not available for the IP2 Shield Wall, however, ISRS are available for the IP3 Shield Wall. A review of the IP2 and IP3 shield walls indicate that the two structures are similar. This similarity enables the use of the IP3 spectra for the IP2 structure. The IP3 Shield Wall dynamic analysis was performed by Westinghouse using a 21-node lumped mass model, as shown in Figure G.3. The forcing function used to obtain the design response spectra was a synthetic time history normalized to 0.15g for the Safe Shutdown Earthquake. The structural damping used for the IP3 Shield Wall was 5%, consistent with the IP2 UFSAR for shear wall or rigid frame construction as shown in Table 1.

G.3 Dynamic Parameters

The dynamic properties of the Shield Wall (frequencies, mode shapes, and participation factors) are provided in Tables G.1 and G.2, associated with the significant modes of response for both horizontal directions. Amplification factors TAF_1 and TAF_2 (Section 6.0) associated with each of the Shield Wall model mass points are shown in Table G.3.

G.4 In-Structure Response Spectra

Representative SSE floor response spectra associated with important elevations of the Shield Wall structure for 5% equipment damping are shown in Figures G.5 and G.6.

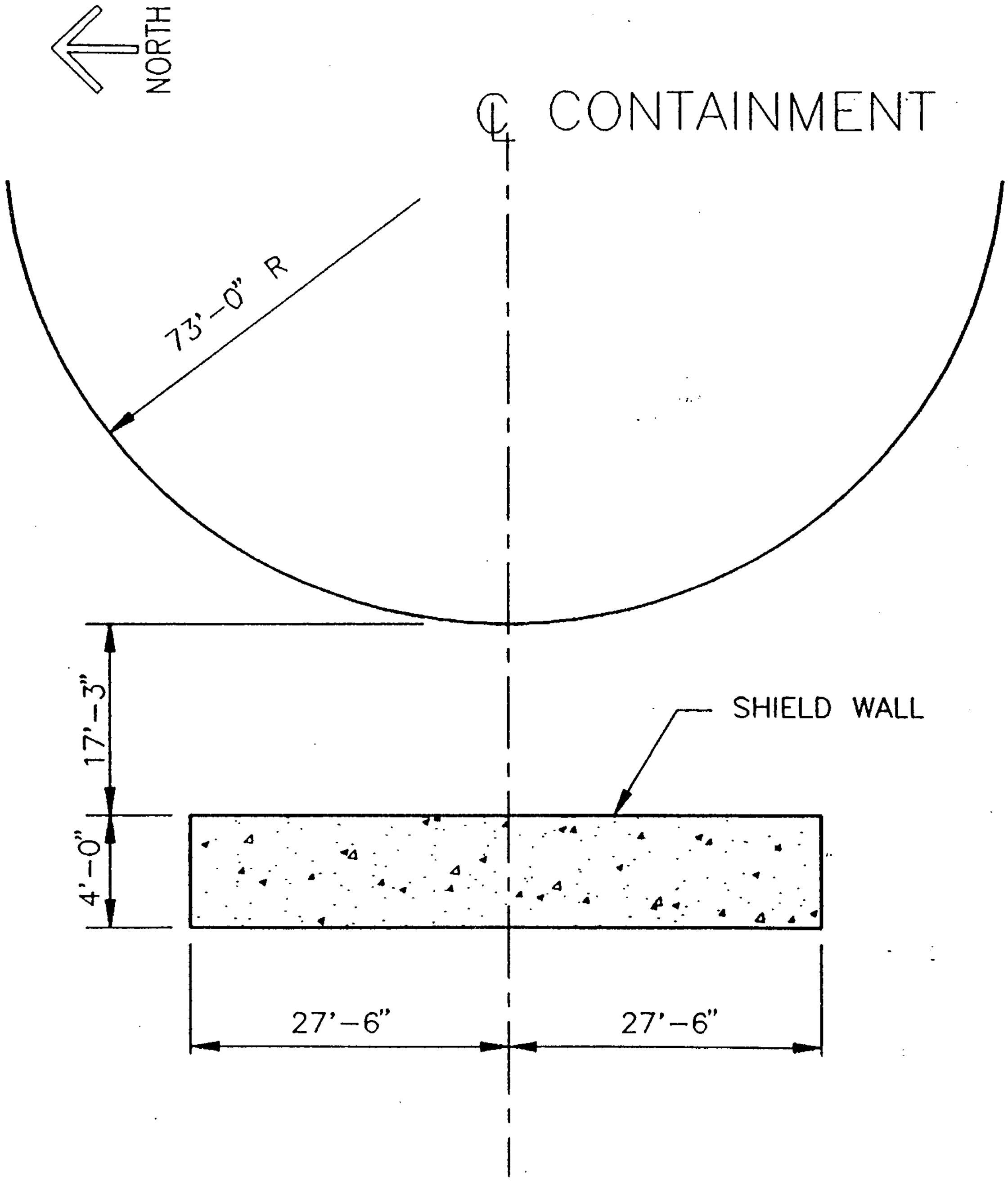


Figure G.1
Shield Wall
Plan of Structure

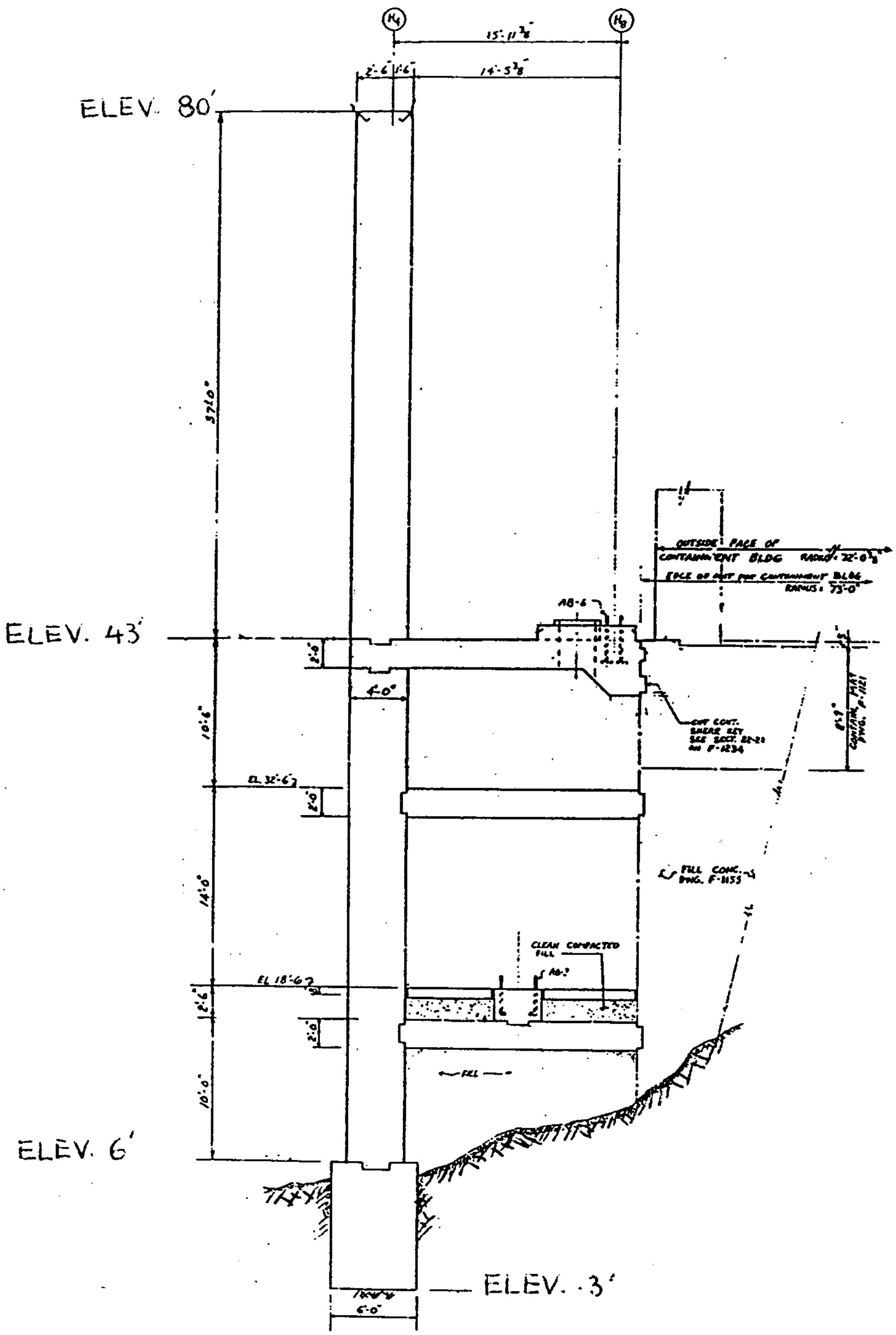


Figure G.2
Shield Wall
Section of Structure

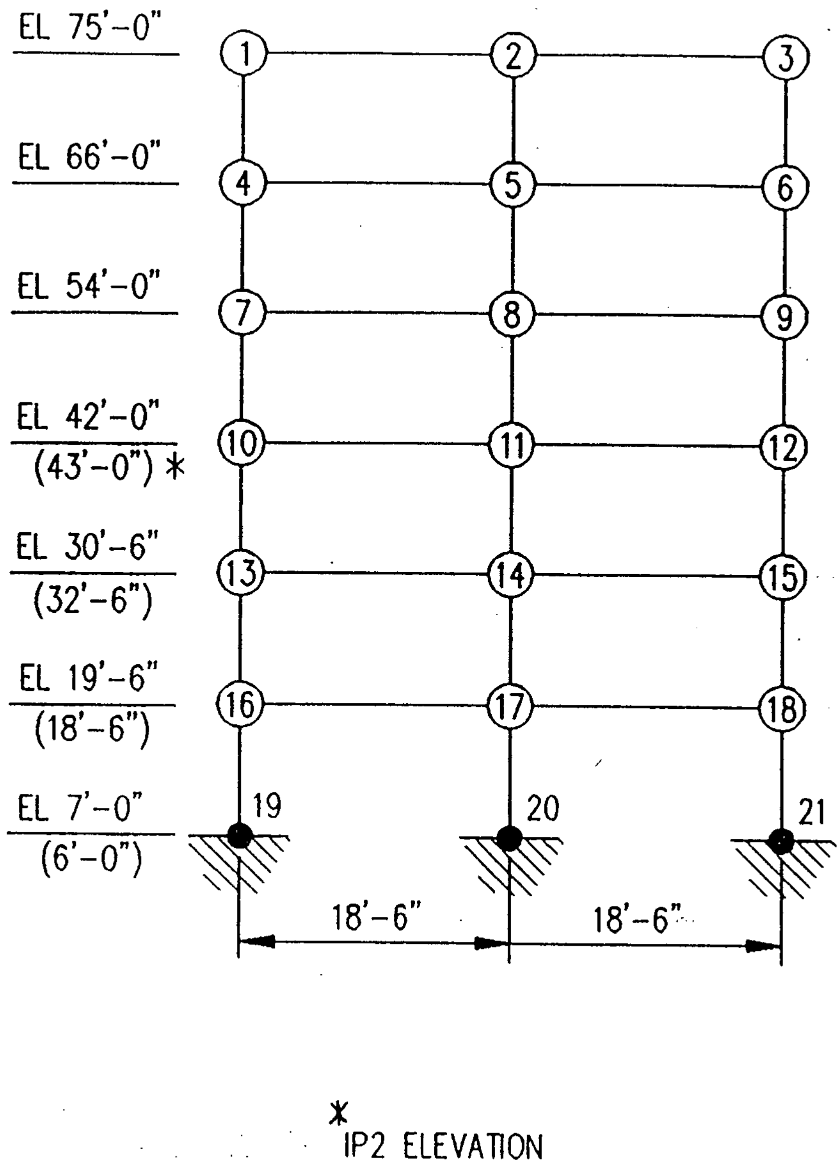


Figure G.3
Shield Wall
Horizontal Lumped Mass Model

North-South Plane Model

	Mode	
Frequency / Part. Factor / Mass Point	1 14.95 1.23	2 52.18 0.34
1	1.000	-1.000
2	0.993	-0.921
3	1.000	-1.000
4	0.735	-0.172
5	0.734	-0.172
6	0.735	-0.172
7	0.447	0.582
8	0.447	0.567
9	0.447	0.582
10	0.175	0.804
11	0.176	0.791
12	0.175	0.804
13	0.048	0.700
14	0.050	0.691
15	0.048	0.700
16	0.004	0.424
17	0.004	0.420
18	0.004	0.424

Table G.1
Shield Wall
Dynamic Characteristics

East-West Grid Model

Mass Point \ Frequency, Part. Factor	Mode 1 3.35 1.35	Mode 2 7.74 0.00	Mode 3 17.02 0.00	Mode 4 19.26 0.49
1	1.000	-1.000	-0.500	-0.909
2	1.000	0.000	1.000	-0.909
3	1.000	1.000	-0.500	-0.909
4	0.584	-0.691	-0.387	0.768
5	0.584	0.000	0.774	0.768
6	0.584	0.691	-0.387	0.768
7	0.224	-0.332	-0.215	1.000
8	0.224	0.000	0.429	1.000
9	0.224	0.332	-0.215	1.000
10	0.011	-0.030	-0.027	0.120
11	0.011	0.000	0.054	0.120
12	0.011	0.030	-0.027	0.120
13	-0.008	0.009	0.002	-0.041
14	-0.008	0.000	0.005	-0.041
15	-0.008	-0.009	0.002	-0.041
16	-0.001	0.003	0.000	-0.021
17	-0.001	0.000	-0.001	-0.021
18	-0.001	-0.003	0.000	-0.021

Table G.2
Shield Wall
Dynamic Characteristics

Mass Point	Elevation (Ft)	Elevation (Ft) Above		PFA (g)	ZPA (g)	PGA (g)	TAF_1	TAF_2
		Basement	Grade					
DIRECTION: North - South								
1-2-3	78	72	60	0.526	0.242	0.15	2.17	3.51
4-5-6	66	60	48	0.381	0.292	0.15	1.30	2.54
*		52	40				1.39	2.21
7-8-9	54	48	36	0.306	0.214	0.15	1.43	2.04
10-11-12	42	36	24	0.296	0.153	0.15	1.93	1.97
DIRECTION: East - West								
1-2-3	78	72	60	1.354	0.409	0.15	3.07	8.36
4-5-6	66	60	48	0.775	0.264	0.15	2.94	5.17
*		52	40				1.89	3.66
7-8-9	54	48	36	0.437	0.244	0.15	1.79	2.91
10-11-12	42	36	24	0.288	0.194	0.15	1.48	1.92

Where, Per Section 6.0: $TAF_1 = PFA/ZPA$
$TAF_2 = PFA/PGA$
* TAF_1 & TAF_2 interpolated at 40' above grade reference point.

Table G.3
Shield Wall
Total Amplification Factors

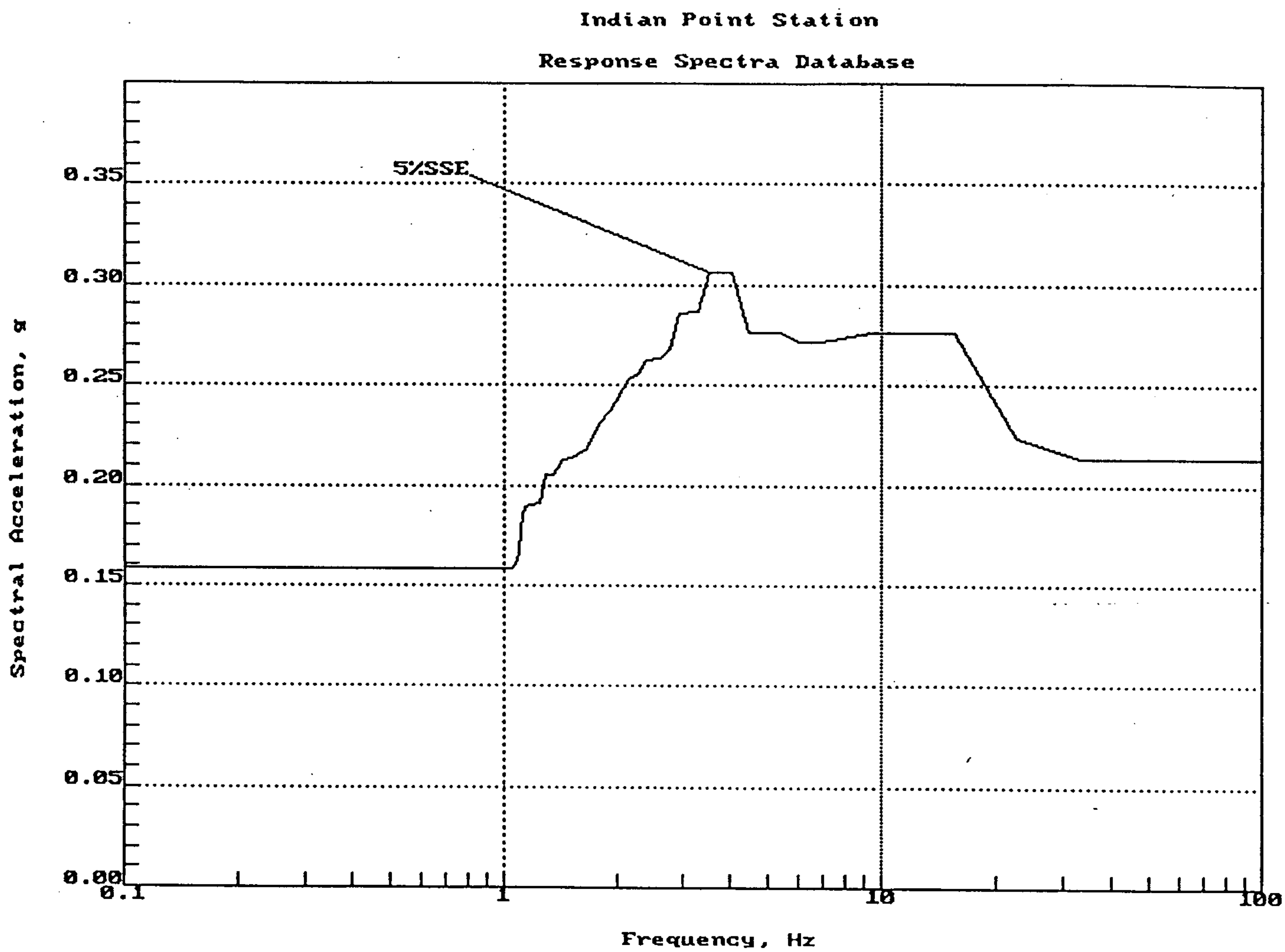


Figure G.5
Shield Wall
North-South In-Structure Response Spectra
Elevation 54'

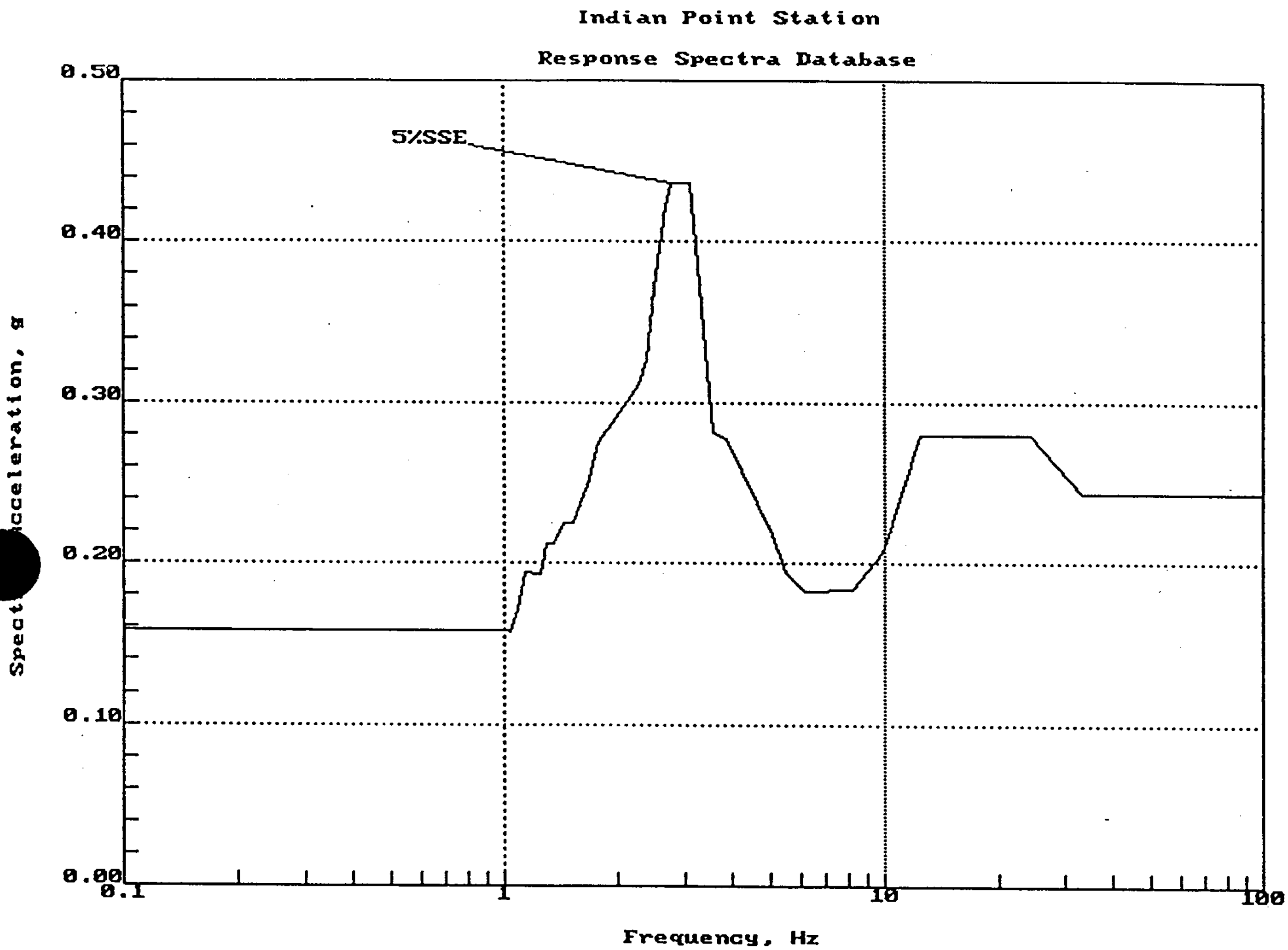


Figure G.6
Shield Wall
East-West In-Structure Response Spectra
Elevation 54'