ATTACHMENT 1

GINNA STATION

Seismic Upgrading Program

Auxiliary Structures Seismic Analysis

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1.0 INTRODUCTION

Included in this report are descriptions of the analytical procedures and criteria used for the seismic analysis of the auxiliary structures of the Robert Emmett Ginna Nuclear Power Station Unit No. 1 located in Rochester, New York. The primary purpose of the present dynamic analysis was to generate floor response spectra and maximum floor displacements at the mass points of the structural model for use in equipment qualification and upgrading of selected piping systems of the existing plant facilities. These maximum floor displacements and floor response curves are presented in this report.

The structures analyzed consisted of the following buildings: Auxiliary Building, Service Building, Turbine Building, Diesel Generator Building, Control Building, and Intermediate Building (with Facade). These buildings are all structurally interconnected and the seismic analysis procedure employed considered them as several smaller structures interconnected to form a large structure.

There are several differences in this seismic analysis compared to previous analyses of the same structures. First, in previous analyses, only the Auxiliary Building, Intermediate Building and Control Building were considered. Also, each of these structures was analyzed as an independent structure with no connection to the adjacent buildings, which is unlike the physical situation. In the current analysis, all of the structures listed previously were considered from a stiffness and mass standpoint in the combined structural model although floor response curves were not generated for all buildings. The other major difference for this seismic analysis versus previous analyses was that here the

eccentricity between the center of the mass and the center of stiffness of the wall and column elements was accounted for in the mathematical model where appropriate.

The results of the analysis are presented as floor response spectra in the form of linear-linear acceleration versus frequency plots for both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). The curves are for different magnitudes of equipment damping and are presented for various floor elevations in each building except the service building. Curves are given based on both the actual generated floor response data and on using a broad band approach to modifying that data. Curves are given in each of three mutually perpendicular directions at each response location. Also given is a tabulation of the maximum relative floor displacements and maximum floor accelerations at the same locations.

The floor response locations are at the center of mass of each floor or response location elevation except in the Intermediate Building where several response locations per elevation were selected. For horizontal responses at other locations at a particular elevation, the conservative procedure described in Chapter 6 may be used. The more precise approach would be to generate floor response curves at specific locations on a floor when required. Also, the vertical responses presented herein for all buildings except the Intermediate Building assume rigid floor diaphragms but they do account for vertical amplification by considering the vertical stiffness of the structure. Since rigid diaphragms were not assumed for the Intermediate Building, the vertical response at floor response locations in this building reflect only the stiffness of the column at the particular floor response location. To include the effects of a flexible floor system at those points where rigid diaphragms were assumed, the floor response spectra can be generated in a two step approach for the specified location when required.

2.0 ANALYSIS PROCEDURE AND CRITERIA

2.1 Analysis Procedure

The seismic analysis procedure involved the use of the linear elastic finite element program STARDYNE. This program is publicly recognized and verified by Gilbert Associates. The static portion of the program was used to model the stiffness of the structures and compute mode shapes and natural frequencies. The dynamic portion, which employs the modal superposition method, was used to accept the three-directional ground motion input and, using all modes with frequencies less than 33 Hertz and several above that value, produce a time history response. This time history analysis was used to obtain maximum floor displacement, velocity and acceleration. This was followed by computation of the acceleration floor response curves for the response in each of the three translational directions at each nodal point using the results of the time history analysis. The locations of the floor response points are given in Table 2-1. A description of the mathematical model used in the analysis of the combined structure as well as a further description of the analysis procedure are given in a later section.

2.2 Criteria

The floor response spectra and maximum relative displacements presented herein are for both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). The structural ground time history input consisted of the simultaneous application of time histories at each base support location in each of the three mutually perpendicular directions, two horizontal and one vertical. The

horizontal earthquakes are input along the plant E-W and N-S axes . These correspond to the X and Y axes of the model. The coefficient of correlation for any two of these time histories is less than 0.12. The response spectra of each input time history meets the requirements of the U.S. Nuclear Regulatory Commission Regulatory Guide 1.60 for design response spectra. These time histories reflect a maximum ground acceleration of 0.08g for OBE and 0.20g for SSE. These selected maximum ground seismic acceleration values for the plant are based upon plant site geologic investigations and seismologic recommendations. The response spectra curve of the artificial time history envelopes the USNRC Regulatory Guide 1.60 curves as shown in Figures 2.1 to 2.3 for 10% damping for the H1, H2, and V directions, respectively.

The structural damping values used (as a percent of critical damping) were those given by USNRC Regulatory Guide 1.61 for each of the two earthquakes. The values used for each material are shown below:

	OBE	SSE
Bolted Steel Structures	4	7
Reinforced Concrete	4	7
Soil Springs	4	7

In addition to mode shapes and natural frequencies obtained from the static portion of STARDYNE, the material damping values above were used to calculate a composite modal damping value for each mode. This composite modal damping value was then used for the appropriate mode as input to the time history analysis.

Floor response curves at the designated locations were produced by

following USNRC Regulatory Guide 1.122. The values of equipment damping (in percent) used for each design earthquake are shown below:

OBE	SSE
1	2
2	3
4	4
	7

[illegible]

3.0 DESCRIPTION OF STRUCTURES

The plant buildings are located in a relatively level meadow area with finished grade elevation approximately 270'-0". The major plant structures are supported on the Queenston Formation bed rock (red sandstone) or atop natural or compacted granular soils immediately above the bed rock. The Queenston Formation is generally found at a depth of 30 to 40 feet below natural grade.

3.1 Auxiliary Building

The Auxiliary Building is located south of the Containment Building and founded on rock. The bottom of foundation mat elevation is 233'-8", with the deepest foundation for decay heat removal area at elevation 217'-0" with sump at elevation 214'-0". Rock elevation in this area is approximately at elevation 236'-0". The west end of the superstructure of the Auxiliary Building is connected with a portion of the Service Building, and on the northwest with the Intermediate Building. However, the foundation of the Auxiliary Building is independent of these building foundations. The basement floor is at elevation 235'-8". The intermediate and operating floors are of reinforced concrete supported on reinforced concrete walls and are at elevation 251'-0" and 271'-0" respectively. The superstructure is braced structural steel framing with high and low roof at elevation 328'-0" and 312'-0", approximately. High roof area has an overhead crane, with the top of the crane rail at elevation 310'-9".

3.2 Intermediate Building

The Intermediate Building is located on the north and west of Containment Building, and is founded on rock. The west end has a

[illegible]

retaining wall where the floor at elevation 253'-6" is supported. The bottom of the retaining wall footing is at elevation 233'-6". Rock elevation in this area is approximately at elevation 239'-0". Foundations for interior columns are on individual column footings and embedded a minimum of 2'-0" in solid rock. The basement floor slab is reinforced concrete and is at elevation 253'-8". The upper floors are reinforced concrete supported on structural steel framing. The floors on the north of the Containment Building are at elevations 278'-4", 298'-4", and 315'-4" with the structural steel framed roof at elevation 336'-4". The southwest floors are at elevation 271'-0" and 293'-0" with the structural steel framed roof at elevation 318'-0".

3.3 Control Building

The Control Building is located adjacent to the southeast corner of the Turbine Building and is supported by a mat foundation. The foundation of the Control Building is supported on the natural compacted granular material. The rock elevation in this area is approximately at elevation 240'-0". Bottom elevation of the deepest portion of the foundation mat is at elevation 245'-4", with a structural slab supported at elevation 250'-6" with a thickened slab for column footings. The Control Building has reinforced concrete walls on the south and west sides up to the roof elevation, while the concrete wall on the east side is up to grade level. The basement slab is at elevation 253'-8". The intermediate floors are reinforced concrete, supported on structural steel framing systems and are at elevations 271'-0" and 289'-6". The roof is reinforced concrete supported on a structural steel truss and is at elevation 310'-4".

3.4 Diesel Generator Building

The Diesel Generator Building is located beyond the northeast corner of the Turbine Building and is supported on strip and spread footings at elevation 243'-0". The rock elevation in this area is at elevation 240'-0". The foundation structures are supported on the natural compacted granular material. The Diesel Generator Building has reinforced concrete walls on all four sides. The basement floor is a reinforced concrete slab at an elevation of 253'-8". The roof is structural steel framing with decking and is at elevation 275'-10".

3.5 Turbine Building

The Turbine Building is located north of the Intermediate Building and is supported by a combination of perimeter grade beams and a structural mat. The mat foundation of the turbine generator is independent of the surrounding Turbine Building foundations. The Turbine Building foundation is supported on the natural compacted granular material which overlays the natural rock. Rock elevation in this area is approximately at elevation 239'-0". The bottom of the perimeter column foundation mat varies from elevation 245'-3" on the south side along the Intermediate Building to approximately 246'-9". The bottom of the turbine generator foundation mat is at elevation 243'-0". The circulating water discharge tunnel is supported at elevation 242'-2". Where condensate pumps are located, the entire area is filled with lean concrete having a bottom elevation of 229'-8". Area between the turbine generator foundation and the perimeter column mat foundation is supported on compacted granular material with the bottom of mat at elevation approximately 251'-6". The basement floor is reinforced concrete and is at elevation 253'-6". The

mezzanine and operating floors are reinforced concrete and are supported on structural steel framing at elevation 271'-0" and 289'-6" respectively. The superstructure is a braced structural steel frame, with the roof at elevation 356'-11 3/4". The building has an overhead crane, $125^T/25^T$ capacity, with the top of the crane rail at elevation 330'-0".

3.6 Service Building

The Service Building is located on the west side of the Intermediate Building and is founded on compacted soil. The bottom of the mat is approximately at elevation 252'-8" with a localized thickened mat for column footings. The deepest foundation for the sump is at elevation 247'-3". Natural compacted granular soil is approximately at elevation 255'-0". The mat is supported on the east side by a retaining wall on column line 3 with the Intermediate Building. The basement floor is reinforced concrete and is at elevation 253'-8". The main floor slab is reinforced concrete supported on structural steel framing and is at elevation 271'-0". The roof is composed of structural steel framing with decking at elevation 287'-4". The superstructure is a structural steel framing system with exterior block walls all around.

4.0 MATHEMATICAL MODEL

In order to analyze seismically the Ginna Nuclear Power Station auxiliary structures, the structures were modeled mathematically with respect to stiffness and mass. This modeling was done in such a way that the behavior of the model under simulated seismic loading adequately represented that which would be experienced by the actual structures under an actual seismic event. The model was then analyzed using the dynamic analysis portions of program STARDYNE.

The procedure involved defining the stiffness and mass characteristics of each of the buildings except the Intermediate Building via a simplified model. Each of these simplified models was then combined with an elastic model of the Intermediate Building to form the combined model of the auxiliary structures which was used for the dynamic analysis. The following sections detail the specifics of the mathematical model.

4.1 Auxiliary Building

4.1.1 Stiffness Modeling

The stiffnesses of the steel framed elevations of the Auxiliary Building were modeled in detail using elastic beam elements to represent the columns, beams, and bracing. All large columns of the Auxiliary Building were represented in the model with the exception of columns shared in common with the Intermediate Building and Facade structure. These columns were modeled in the Intermediate Building model. The column bases were modeled as having pinned boundary conditions since the base plate anchor bolts are located between the column flanges close to the web. The end conditions of beams were modeled as being pinned

since the connections have no moment capacity.

The frame cross bracing also contributes to the lateral stiffness of the steel structure. In reality, due to its slenderness, the bracing has only strength while in tension and essentially no compressive strength. However, the linear elastic analysis used in this study required the bracing members to be equally effective in both tension and compression. In order to effectively utilize the linear elastic finite element computer program to simulate this non-linear behavior, the axial stiffness of each brace was reduced by fifty percent when the brace was designed for tension. When the brace was designed for both tension and compression, the full value of axial stiffness was utilized. The connection details at the ends of the braces were not considered important because of the relatively small flexural properties of the braces. However, the braces were modeled having pinned end conditions.

The roofs and the concrete floor slab were assumed to behave as rigid diaphragms and were modeled using rigid links.

The two (2) concrete elevations of the Auxiliary Building were modeled as vertical elastic beams approximating the equivalent stiffness properties of the reinforced concrete walls. The elastic beams were located at the center of stiffness of the walls. The floors were considered to behave as rigid diaphragms.

4.1.2 Mass Modeling

A lumped mass approach was used to model the Auxiliary Building

weight. The masses of the upper roof, lower roof, concrete slab, and walls were calculated by hand and located at the mass centroid of each elevation. Rigid links were used to attach the masses to the structural model. Rotational mass moment of inertias were also calculated and lumped at the mass centroids. The linear and rotational masses of major equipment were included.

4.1.3 Seismic Model

The steel framing was analyzed using the STARDYNE finite element program. By using a Guyan reduction, the detailed steel framing finite element model was reduced to a seismic model having 3 nodes (the mass centroids), each node having six (6) degrees of freedom. Associated with each node were stiffnesses and masses related to each of the six degrees of freedom. Thus, the model properly reflects the torsional, vertical, rocking and translational behavior due to the inclusion of the six degrees of freedom. The stiffness matrix obtained by static condensation includes the effect of possible torsional motion due to the eccentricity of the center of stiffness with respect to the mass centroids. This reduced three node model representing the steel framed elevations together with the elastic beam model of the two lower concrete elevations was combined later with the other buildings into an overall dynamic model of the auxiliary structures shown in Fig. 4.1.

Since the structure is founded on rock having a shear wave velocity of 7200 feet per second, the base of the model was considered to be fixed against both rotation and displacement.

4.2 Service Building

4.2.1 Stiffness Modeling

The stiffness of the steel framing of the Service Building was modeled in detail using elastic beam elements to represent the columns and beams and with plate bending elements representing the reinforced concrete walls. All main columns of the Service Building were represented in the model with the exception of the columns which were shared with the Intermediate Building, the Auxiliary Building, and the Turbine Building. These columns were modeled in the appropriate building model. All column bases, except one, were modeled as having pinned boundary conditions since the base plate anchor bolts are located between the column flanges close to the web, providing very little moment resistance capability. The roofs and floor slabs were assumed to behave as rigid diaphragms and were modeled using rigid links.

4.2.2 Mass Modeling

The linear and rotational masses of the roofs, floor slabs, walls, columns and footings were calculated by hand and lumped at the mass centroid of each floor. Horizontal rigid links were used to attach the masses to the structural model. One-half of the floor slab design uniform live load was considered in the weight at each elevation of the Service Building to account for wall partitions and live load of a permanent nature.

4.2.3 Seismic Model

The Service Building structure was analyzed with the STARDYNE finite element program using the Guyan reduction method to condense the structure to a 3 node model with each node having

stiffness defined in each of the six degrees of freedom. This reduced model was then saved for use in the auxiliary structure combined model.

The reduced model of the Service Building, shown as part of Fig. 4.1, included soil springs since the structure is not founded upon rock. The spring constants for all six degrees of freedom are presented in Table 4-1 and represent the average of upper and lower bound computed soil spring constants. These spring constants were derived based on the actual site soil conditions.

4.3 Turbine Building

4.3.1 Stiffness Modeling

The stiffness of the steel framing of the Turbine Building was modeled in detail using elastic beam elements to represent the columns, beams and bracing. All Turbine Building columns were represented in the model with the exception of the columns shared with the Intermediate Building and Facade structure, which were modeled in the Intermediate Building model. The column bases were modeled as having pinned boundary conditions. This was done because the angles connecting the columns to the base plates are considered flexible. The end conditions of the beams were modeled as being pinned because the beam connections are shear connections.

The frame cross bracing also contributes to the lateral stiffness of the steel structure and was modeled as described in the stiffness modeling of the Auxiliary Building.

[illegible]

The corrugated steel pressurization walls were not considered to provide lateral stiffness to the Turbine Building due to the small thickness and the corrugations of the metal siding. However, the stiffness of the armor plate between the Turbine and Control Buildings was represented in the model by plate bending elements.

The roof and concrete floor slabs were assumed to behave as rigid diaphragms and are modeled using rigid links.

4.3.2 Mass Modeling

The linear and rotational masses of the slabs, roof, walls, columns, footings and major equipment were calculated by hand and lumped at the mass centroid of each floor elevation or response location. Rigid links were used to attach the masses to the structural model.

coordinates!

4.3.3 Seismic Model

The Turbine Building structure was analyzed with the STARDYNE finite element program using the Guyan reduction method to condense the structure to a 6 node model with each node having six (6) degrees of freedom. This reduced model was then saved for use in the auxiliary structures combined model.

The reduced model of the Turbine Building, shown as part of Fig. 4.2, includes soil springs since the structure is not founded upon rock. The spring constants for all six degrees of freedom are presented in Table 4-1 and represent the average of upper and lower bound computed soil spring constants.

4.4 Control Building

4.4.1 Stiffness Modeling

The stiffness of the Control Building was modeled using three vertical elastic beams representing the stiffness properties of the concrete shear walls of the structure. The beam elements are located at the respective centers of stiffness of the walls which they model.

4.4.2 Mass Modeling

The linear and rotational masses of the roof, floor slabs, walls, footings and major equipment were calculated by hand and lumped at the mass centroid of each elevation. Rigid links were used in the model to connect the member ends above and below a floor to each other and to connect the center of mass to the end of the elastic member below that particular floor at each elevation so that eccentricity of mass from the center of stiffness could be accounted for.

4.4.3 Seismic Model

The model of the Control Building showing the three vertical members and the four lumped masses and presented in Fig. 4.2, includes soil springs applied at the base since the structure is not founded upon rock. The spring constants for all six degrees of freedom are presented in Table 4-1 and represent stiffnesses derived from the actual site soil conditions.

4.5 Diesel Generator Building

4.5.1 Stiffness Modeling

The stiffness of the Diesel Generator Building was modeled using two vertical elastic beams representing the stiffness properties

of the concrete shear walls of the structure. The beam elements are located at the respective centers of stiffness of the walls which they model.

4.5.2 Mass Modeling

The linear and rotational masses of the roof, floor slabs, walls, footings and major equipment were calculated by hand and lumped at the mass centroid of each elevation. Rigid links were used in the model to connect the member ends above and below a floor to each other and to connect the center of mass to the end of the elastic member below that particular floor at each elevation in order to model the eccentricity of mass from center of twist.

4.5.3 Seismic Model

The model of the Diesel Generator Building showing the two vertical members and the three lumped masses and presented in Fig. 4.2 ., includes soil springs applied at the base since the structure is not founded upon rock. The soil spring constants for all six degrees of freedom are presented in Table 4-1 and represent the average of upper and lower bound computed soil spring stiffnesses.

4.6 Intermediate Building and Facade Structure

4.6.1 Stiffness Modeling

The stiffness of the steel framed elevations and the concrete retaining wall of the Intermediate Building and Facade Structure were modeled in detail using elastic beam elements to represent the columns, beams, and bracing and with plate bending elements to represent the retaining walls. The column bases were modeled as having either pinned or fixed boundary conditions depending upon the column base plate detail. If the anchor bolts are

located close to the web of the column, the boundary conditions were considered to be pinned. If the anchor bolts are located close to the edge of the base plate, the boundary conditions were considered to be fixed. The ends of the beam elements which represent the columns were modeled as hinge or moment connections depending upon the splice detail on the design or fabrication drawings. The end conditions of the beams in the model were pinned since the beam connections are shear connections.

The frame cross bracing also contributes to the lateral stiffness of the steel structure and was modeled as described in the stiffness modeling the Auxiliary Building. The many roof and floor members were modeled elastically with several beams that have the properties of the floor and roof framing members they represent if the elevation is comprised of structural steel. For floors composed of concrete slabs and concrete beams formed monolithically, elastic beams with properties of the floor slab and beam were used to model the floors. The stiffness of the horizontal trusses located in the Facade Structure were modeled using individual beam elements which have the same flexural stiffness as the truss.

Unlike the other building structures, this detailed model of the Intermediate Building was not reduced to a simplified model via Guyan reduction.

4.6.2 Mass Modeling

The linear masses of the slabs, steel framing and walls were calculated by hand and distributed to the nodes on the elastic model located at the various floor elevations.

4.7 Combined Seismic Model

Since the Intermediate Building and Facade Structure is the central

building of the R. E. Ginna Nuclear Power Station, the simplified models of the Auxiliary, Service, Turbine, Control, and Diesel Generator Buildings were rigidly connected to the model of the Intermediate Building and Facade Structure. By modeling the Intermediate Building wall and floor systems elastically, the elastic interaction among the buildings could be included. The Auxiliary Building model was connected to the Intermediate Building and Facade Structure at elevations 253'-0", 271'-0", 315'-0", and 327'-0". The Service Building model was connected to the Intermediate Building and Facade Structure at elevations 253'-0", 271'-0", and 289'-0". The Turbine Building model was connected to the Intermediate Building and Facade Structure at elevations 253'-0", 271'-0", 289'-0", 315'-0", 327'-0", and 357'-0". The Control Building model was rigidly connected to the Turbine Building model at elevations 253'-0", 271'-0", 289'-0", and 315'-0". The Diesel Generator Building model was rigidly connected to the Turbine Building model at elevations 253'-0" and 271'-0". For connections of the various buildings to the Intermediate Building, several rigid beams were attached to the mass point on the particular building and these beams were then attached to several nodes on the side of the Intermediate Building facing that particular structure. For attachment of the Diesel Generator and Control Buildings to the Turbine Building, one rigid link attached the mass point on each of these smaller buildings to a mass point at the same elevation on the Turbine Building.

In this combined model, the base of the Intermediate Building and

Facade Structure was considered to be fixed against both rotation and displacement since the structure is founded on rock.

This combined model of all the structures, shown in Fig. 4.1 and Fig. 4.2, was used for the entire seismic analysis. The seismic analysis was performed using the free vibration and dynamic analysis routines available in program STARDYNE. The procedure was to first obtain mode shapes, natural frequencies, and composite modal damping values via a free vibration analysis with only those modes having frequencies below 33 Hertz and those above 33 Hertz having significant participation factors being included in any further analysis. This was followed by a time history analysis using only those particular modes. The results of the time history analysis were then used to generate floor response spectra at desired locations.

A total of 413 dynamic degrees of freedom were present in the combined seismic model. Based upon the results of the free vibration analysis, there were 98 modes with natural frequencies less than 33 Hertz. Modes 109, 110, 138, and 141 with natural frequencies of 34.7, 34.9, 45.4, and 46.4 Hertz respectively were included with the 98 modes below 33 Hertz in the time history analysis.

5.0 FLOOR RESPONSE SPECTRA

The floor response locations are at the center of mass of each floor or response location elevation for the Auxiliary Building, Turbine Building, Diesel Generator Building, and Control Building. The floor response locations in the Intermediate Building are at the nodes which produce the maximum responses.

The floor response spectra curves for various locations of the auxiliary structures are given in Appendix A. The curves present the response relationship of acceleration versus frequency for both OBE and SSE in three directions at each node. Curves for several equipment damping values are given on each figure. Curves are presented for both the actual and the broad band response. Also shown on the curves is the Zero Period Acceleration (ZPA).

The response spectra were obtained following the guidelines of USNRC Regulatory Guide 1.122. The frequency interval used in computation of the spectra was that recommended in that publication. The procedure of obtaining the broad band curves from the narrow band response spectra by broadening the peaks by ±15 percent was also derived from that regulatory guide. The purpose of the broadening is to account for uncertainties in the structural frequencies due to undertainties in such parameters as the material properties of the structure and soil, damping values and the approximations in the structural modeling used in the seismic analysis.

6.0 MAXIMUM RELATIVE FLOOR DISPLACEMENT AND MAXIMUM FLOOR ACCELERATION

6.1 Maximum Relative Floor Displacement

Tabulated in Tables 6-1 and 6-2 are the maximum relative floor displacements for each of the response locations in each of the three directions for OBE and SSE. The relative displacement is defined as the displacement of a point relative to the ground displacement.

6.2 Maximum Floor Acceleration

Presented in Tables 6-3 and 6-4 are the maximum OBE and SSE floor acceleration for each of the response locations. The accelerations are given in the three translational directions as well as the torsional direction for each node on the interior structure.

6.3 Torsion Effect

The procedure to compute the maximum linear acceleration at any point on a floor on the interior structure is by the equation

$$a_{ij} = a_{mj} + r_i \ddot{\theta}_m$$

where

a_{ij} = maximum linear acceleration at point i in direction j

a_{mj} = maximum linear acceleration at mass center in direction j

r_i = distance in feet from mass center to point i along a line perpendicular to direction j

$\ddot{\theta}_m$ = maximum torsional acceleration about mass point

BUILDING	NODE	X*	Y	Z
Auxiliary	402	116.89	-14.97	253.00
	403	110.20	-18.11	271.00
	404	178.50	- 9.08	315.00
	405	86.09	-16.91	327.00
Control	581	233.16	109.12	253.00
	582	230.12	109.19	271.00
	583	223.60	109.40	289.00
	584	229.24	110.27	308.00
Diesel Generator	590	212.08	283.78	253.00
	591	221.61	283.17	271.00
Turbine	601	127.06	196.50	253.00
	602	142.52	185.30	271.00
	603	128.13	195.41	289.00

TABLE 2-1A

AUXILIARY STRUCTURES FLOOR RESPONSE LOCATIONS (FT)

* Coordinate origin is at the intersection of column lines 3 and N
+X is East, +Y is North, +Z is Vertical

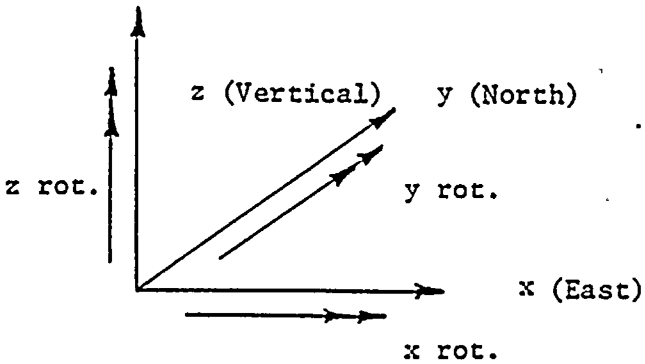
BUILDING	NODE	X*	Y	Z
Intermediate	47	0.00	133.50	271.00
	48	0.00	109.25	271.00
	83	18.08	122.83	271.00
	145	125.10	133.50	298.00
	161	8.75	110.50	298.00
	163	18.08	122.83	298.00
	172	0.00	0.00	315.00
	203	18.08	122.83	315.00
	243	0.00	85.00	336.00
	260	125.10	133.50	336.00

TABLE 2-1B

AUXILIARY STRUCTURES FLOOR RESPONSE LOCATIONS (FT)

* Coordinate origin is at the intersection of column lines 3 and N
+X is East, +Y is North, +Z is Vertical

Direction (DOF)*	Turbine Building	Service Building	Diesel Generator Building	Control Building
Vertical (z)	30.5×10^6	20.0×10^6	2.5×10^6	6.36×10^6
Horizontal (x, y)	5.0×10^6	4.25×10^6	2.0×10^6	2.34×10^6
Rocking (x rot.)	5.75×10^{10}	14.5×10^{10}	2.0×10^9	1.36×10^9
Rocking (y rot.)	18.5×10^{10}	1.75×10^{10}	8.0×10^9	3.19×10^9
Torsional (z rot.)	13.0×10^{10}	8.0×10^{10}	4.25×10^9	3.11×10^{10}



* The sketch above shows the directions of the six degrees of freedom (DOF).

TABLE 4-1
SOIL SPRINGS (KIPS/FT., FT.-KIPS/RADIAN)

BLDG	NODE	ELEV	X	Y	Z	Z ROTATION X 10^{-3}
Aux	402	253'-0"	.0021	.0027	.0003	.0087
	403	271'-0"	.0034	.0042	.0005	.0349
	404	315'-0"	.6521	.5256	.0152	.4782
	405	327'-0"	.6385	.5090	.0097	.2913
Control	581	253'-0"	.0098	.0069	.0017	.0014
	582	271'-0"	.0442	.0146	.0035	.0154
	583	289'-0"	.0685	.0372	.0052	.0693
	584	308'-0"	.0848	.0681	.0066	.2246
Diesel Generator	590	253'-0"	.0097	.0072	.0019	.0019
	591	271'-0"	.0199	.0142	.0025	.0154
Turbine	601	253'-0"	.0091	.0070	.0012	.0013
	602	271'-0"	.0301	.0211	.0034	.0155
	603	289'-0"	.0980	.0907	.0057	.0692

TABLE 6-1A

MAXIMUM RELATIVE DISPLACEMENT (INCHES, RADIANS) UNDER OBE

BLDG	NODE	ELEV	X	Y	Z	Z ROTATION X 10^{-3}
Inter.	47	271'-0"	.0397	.0420	.0057	.0155
	48	271'-0"	.0827	.0385	.0043	.0427
	83	271'-0"	.0503	.0368	.0269	.0421
	145	298'-0"	.1854	.1549	.0062	.1271
	161	298'-0"	.1927	.3209	.0371	.1629
	163	298'-0"	.1911	.3022	.0478	.1543
	172	315'-0"	.5499	.6092	.0189	.2185
	203	315'-0"	.0994	.5428	.0547	.2335
	243	336'-0"	.3805	.8019	.0903	.4098
	260	336'-0"	.3888	.3471	.0082	.2601

TABLE 6-1B

MAXIMUM RELATIVE DISPLACEMENT (INCHES, RADIANS) UNDER OBE

BLDG	NODE	ELEV	X	Y	Z	Z ROTATION X 10^{-3}
Aux	402	253'-0"	.0046	.0063	.0007	.0162
	403	271'-0"	.0077	.0099	.0011	.0681
	404	315'-0"	1.2076	.9738	.0288	.8003
	405	327'-0"	1.2761	.9624	.0220	.5526
Control	581	253'-0"	.0222	.0157	.0038	.0027
	582	271'-0"	.0950	.0336	.0077	.0328
	583	289'-0"	.1423	.0789	.0114	.1368
	584	308'-0"	.1713	.1390	.0143	.4430
Diesel Generator	590	253'-0"	.0205	.0165	.0038	.0035
	591	271'-0"	.0426	.0326	.0051	.0328
Turbine	601	253'-0"	.0199	.0163	.0029	.0024
	602	271'-0"	.0650	.0471	.0080	.0330
	603	289'-0"	.1903	.1809	.0132	.1367

TABLE 6-2A

MAXIMUM RELATIVE DISPLACEMENT (INCHES, RADIANS) UNDER SSE

BLDG	NODE	ELEV	X	Y	Z	Z ROTATION X 10^{-3}
Inter.	47	271'-0"	.0855	.0896	.0134	.0331
	48	271'-0"	.1646	.0768	.0097	.0841
	83	271'-0"	.1086	.0770	.0569	.0857
	145	289'-0"	.3590	.2963	.0148	.2179
	161	298'-0"	.3773	.6122	.0701	.2988
	163	289'-0"	.3725	.5776	.0994	.2921
	172	315'-0"	1.088	1.2042	.0416	.4171
	203	315'-0"	.2015	1.0447	.1139	.4605
	243	336'-0"	.7133	1.5600	.1508	.7920
	260	336'-0"	.7205	.6186	.0196	.5130

TABLE 6-2B

MAXIMUM RELATIVE DISPLACEMENT (INCHES, RADIANS) UNDER SSE

BLDG	NODE	ELEV	X	Y	Z	Torsion X 10^{-2}
Aux	402	253'-0"	.1055	.1115	.0908	.0787
	403	271'-0"	.1239	.1287	.0912	.1742
	404	315'-0"	.4728	.4370	.1537	.5981
	405	327'-0"	.4962	.3556	.1665	.4257
Control	581	253'-0"	.1266	.1279	.0972	.0227
	582	271'-0"	.1836	.1717	.1068	.0934
	583	289'-0"	.2469	.2530	.1210	.1225
	584	308'-0"	.2916	.4948	.1381	.2732
Diesel Generator	590	253'-0"	.1415	.1269	.0975	.0292
	591	271'-0"	.2095	.1661	.1005	.0844
Turbine	601	253'-0"	.1310	.1314	.0973	.0216
	602	271'-0"	.1713	.1698	.1135	.0932
	603	289'-0"	.2376	.2026	.1391	.1228

units g?

TABLE 6-3A

MAXIMUM FLOOR ACCELERATIONS (g) UNDER OBE

BLDG	NODE	ELEV	X	Y	Z	Torsion X 10^{-2}
Inter.	47	271'-0"	.1703	.2523	.1396	.0929
	48	271'-0"	.2635	.1758	.1217	.1830
	83	271'-0"	.1878	.2119	.1791	.4121
	145	298'-0"	.5677	.5155	.1551	.6677
	161	298'-0"	.5378	.2448	.3070	.4028
	163	298'-0"	.5630	.2167	.2478	.3387
	172	315'-0"	.5600	.4763	.2324	.2763
	203	315'-0"	.3065	.4078	.2882	.3509
	243	336'-0"	.9421	.6080	.9292	.9784
	260	336'-0"	.4136	.8415	.1983	1.3634

TABLE 6-3B

MAXIMUM FLOOR ACCELERATIONS (g) UNDER OBE

BLDG	NODE	ELEV	X	Y	Z	Torsion X 10^{-2}
Aux	402	253'-0"	.2488	.2678	.2267	.1252
	403	271'-0"	.2754	.3019	.2272	.3225
	404	315'-0"	.8671	.7498	.3629	.8457
	405	327'-0"	.9288	.6333	.3841	.6835
Control	581	253'-0"	.2762	.3141	.2408	.0447
	582	271'-0"	.4106	.3563	.2601	.1648
	583	289'-0"	.5111	.5145	.2961	.2399
	584	308'-0"	.5477	.8926	.3325	.4940
Diesel Generator	590	253'-0"	.3100	.3088	.2424	.0579
	591	271'-0"	.3995	.3534	.2470	.1474
Turbine	601	253'-0"	.2843	.3212	.2417	.0424
	602	271'-0"	.3489	.3808	.2754	.1642
	603	289'-0"	.4903	.4046	.3330	.2417

TABLE 6-4A

MAXIMUM FLOOR ACCELERATIONS (g) UNDER SSE

BLDG	NODE	ELEV	X	Y	Z	Torsion X 10^{-2}
Inter.	47	271'-0"	.3874	.5577	.3256	.1640
	48	271'-0"	.5238	.3781	.2800	.3336
	83	271'-0"	.4236	.4757	.3809	.7224
	145	298'-0"	1.0315	.8766	.3600	1.1492
	161	298'-0"	.9992	.4379	.6325	.6884
	163	298'-0"	1.0329	.4273	.5169	.5163
	172	315'-0"	1.0794	.8347	.5002	.4335
	203	315'-0"	.5675	.7598	.5685	.5554
	243	336'-0"	1.5211	1.0591	1.0589	1.4605
	260	336'-0"	.7348	1.2809	.4489	1.8564

TABLE 6-4B

MAXIMUM FLOOR ACCELERATIONS (g) UNDER SSE

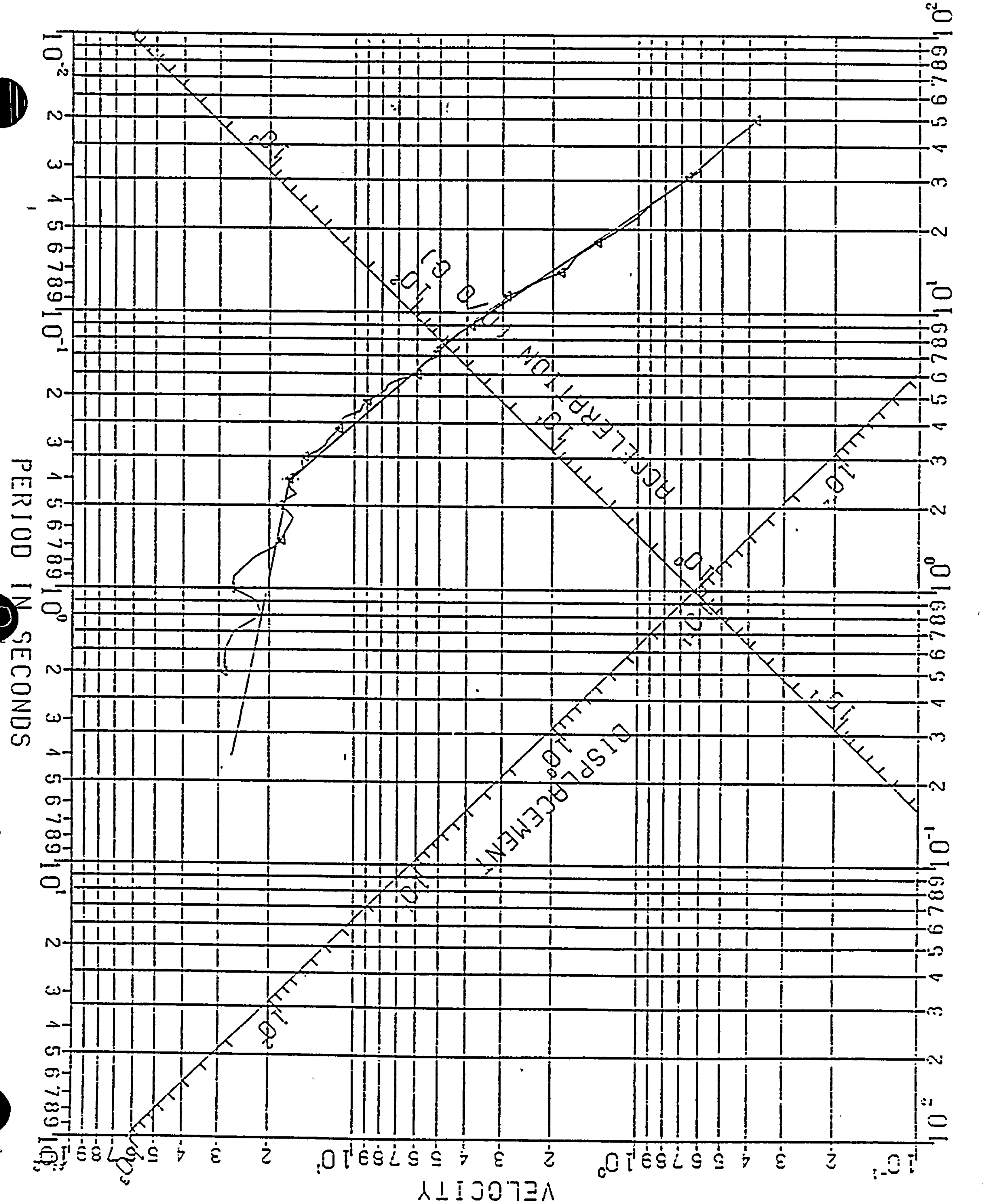


Fig. 2.1 Ground Response Spectrum - H1 Direction (10% Damping)

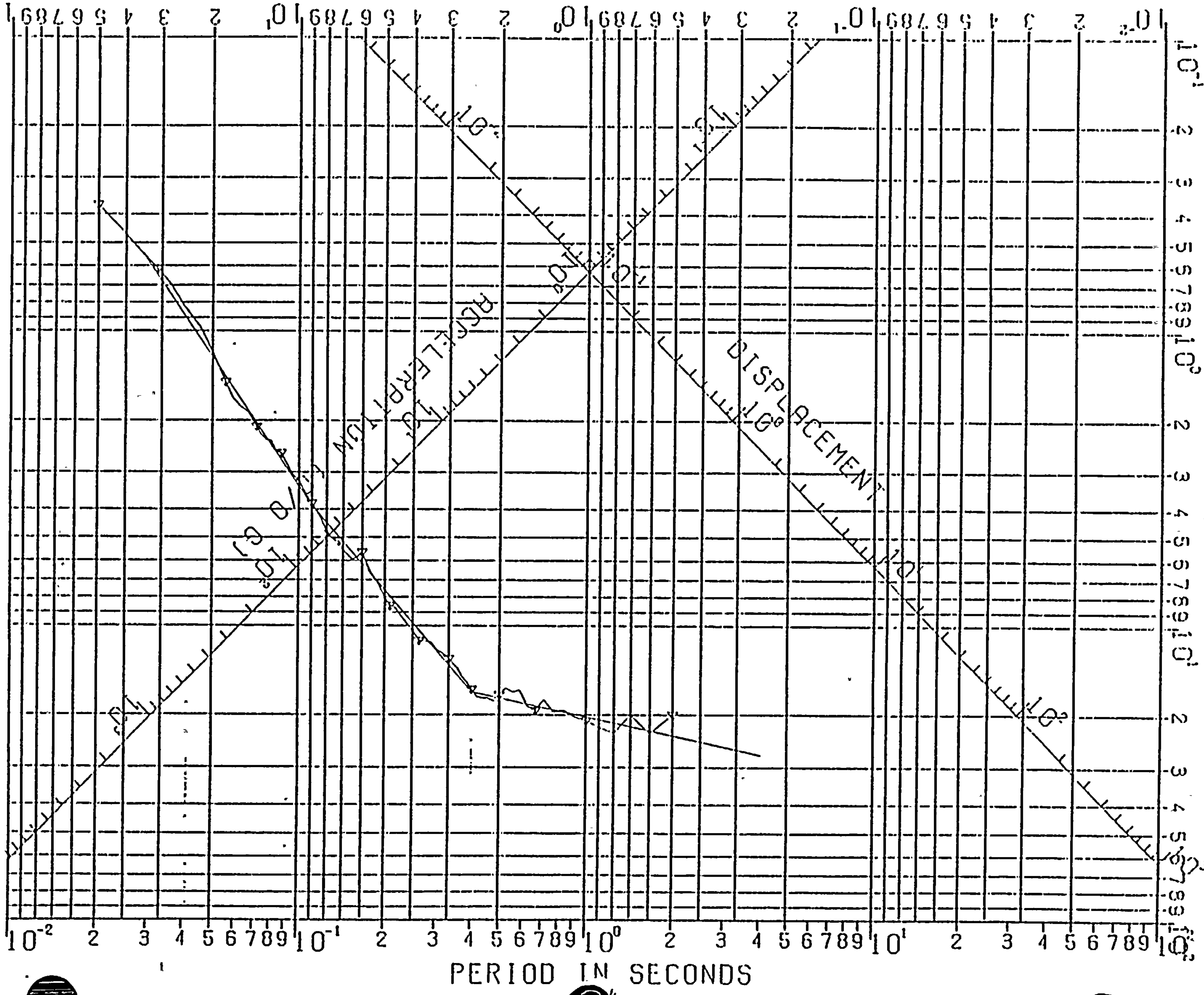


Fig. 2.2 Ground Response Spectrum - H2 Direction (10% Damping)

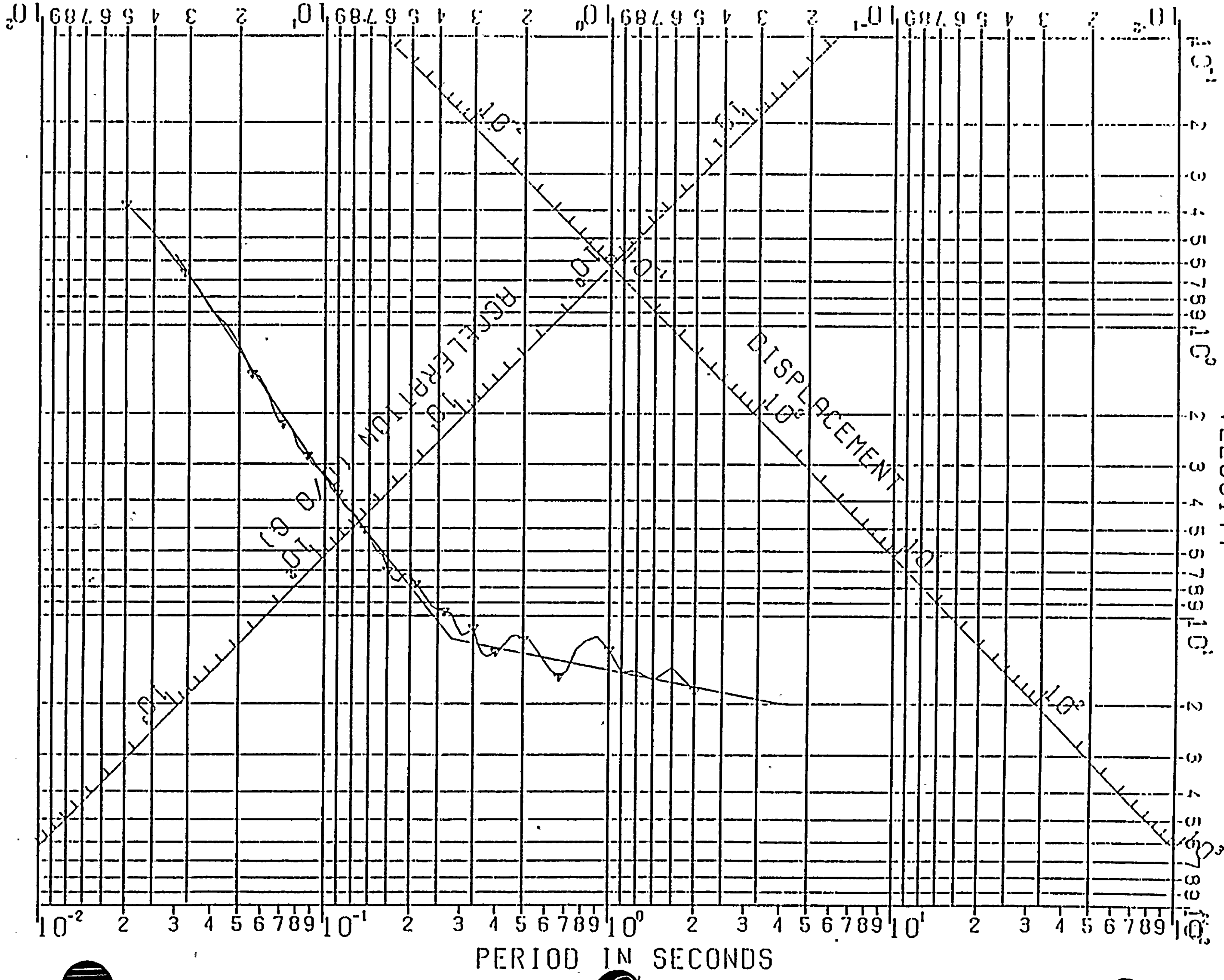


Fig. 2.3 Ground Response Spectrum - V Direction (10% Damping)

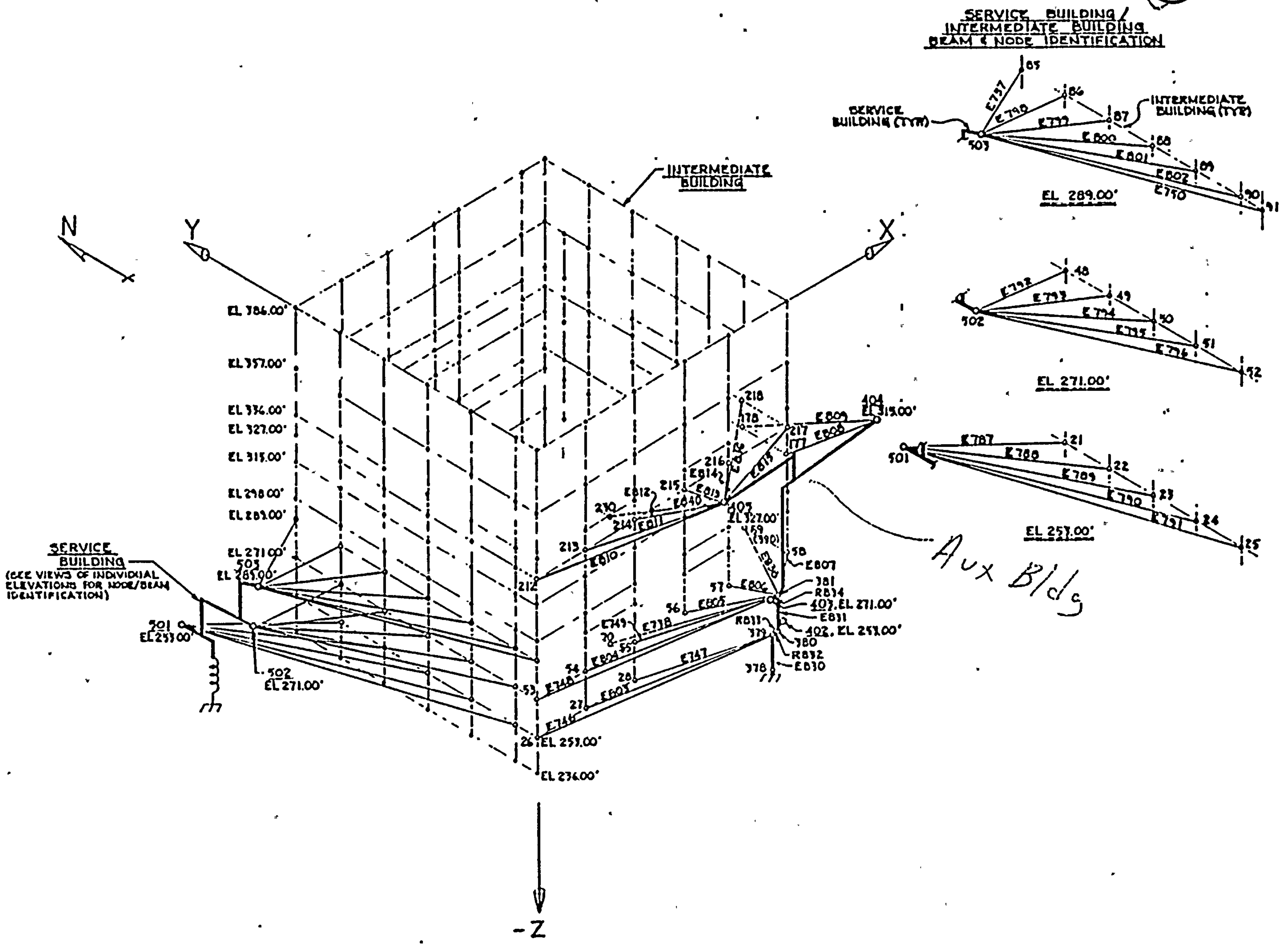
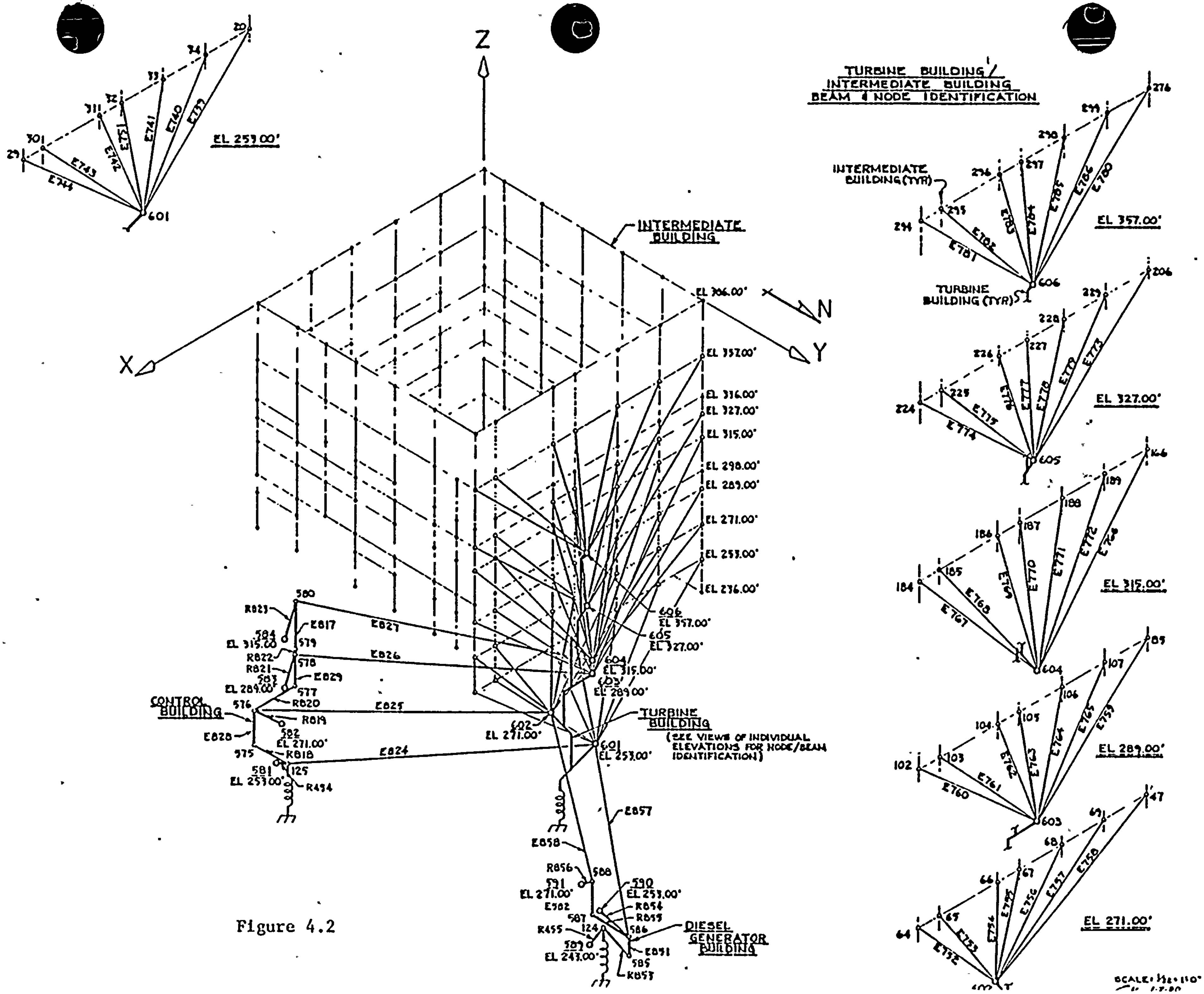

SERVICE BUILDING / INTERMEDIATE BUILDING BEAM & NODE IDENTIFICATION
SERVICE BUILDING (TYP)
INTERMEDIATE BUILDING (TYP)
EL 289.00'
EL 271.00'
EL 253.00'
INTERMEDIATE BUILDING
SERVICE BUILDING
(SEE VIEWS OF INDIVIDUAL ELEVATIONS FOR NODE/BEAM IDENTIFICATION)
N
Y
X
-Z
EL 386.00'
EL 357.00'
EL 336.00'
EL 327.00'
EL 315.00'
EL 298.00'
EL 283.00'
EL 271.00'
EL 285.00'
EL 253.00'
EL 236.00'
Aux Bldg
SCALE: 1/32"=1'0"

Figure 4.1



TURBINE BUILDING/
INTERMEDIATE BUILDING
BEAM & NODE IDENTIFICATION
Z
X
Y
N
INTERMEDIATE BUILDING
INTERMEDIATE BUILDING (TYP.)
TURBINE BUILDING (TYP.)
CONTROL BUILDING
TURBINE BUILDING
(SEE VIEWS OF INDIVIDUAL ELEVATIONS FOR NODE/BEAM IDENTIFICATION)
DIESEL GENERATOR BUILDING
EL 253.00'
EL 357.00'
EL 327.00'
EL 315.00'
EL 289.00'
EL 271.00'
EL 306.00'
EL 336.00'
EL 298.00'
EL 236.00'
EL 243.00'

Figure 4.2

CALCULATION COVER SHEET

IMPELL CORPORATION

CALCULATION NUMBER: 9550-1

TITLE: DEVELOPMENT & VERIFICATION OF SLICE PROGRAM

CLIENT: ROCHESTER GAS & ELECTRIC CORPORATION

PROJECT: SEISMIC EVALUATION OF F-LINE USING A SLICE METHODOLOGY

JOB NUMBER: 0950-050-1683

SUMMARY DESCRIPTION:

THIS CALCULATION DOCUMENTS THE DEVELOPMENT AND VERIFICATION OF "SLICE", VERSION 1.0, A PROJECT SPECIFIC PROGRAM THAT EXTRACTS FROM THE RESULTS OF DYNAMIC ANALYSIS ONLY THOSE MODES WHICH CONTRIBUTE TO THE RESPONSE OF THE SELECTED SLICE OF BRACED FRAME. THE MODE SELECTION CRITERIA IS BASED ON THE CONSIDERATION OF A MODE SIGNIFICANCE FACTOR. IN-PLANE HORIZONTAL FLOOR DISPLACEMENTS DUE TO GROUND SPECTRA IN BOTH HORIZONTAL DIRECTIONS ARE THEN CALCULATED FOR EACH MODE WHICH MAY THEN BE INPUT AS STATIC LOAD CASES TO THE DETAILED MODEL OF THE SLICE FOR SEISMIC EVALUATION.

REVISION	REVISION DESCRIPTION	APPROVED	DATE
0	ORGINAL ISSUE	[signature]	12-2-88

Effective 06/88

TABLE OF CONTENTS

ATTACHMENT:

A. SOURCE CODE: SLICE7.FOR (12 PAGES)

B. INPUT FILE: SLICE-F.DAT (4 PAGES)

C. OUTPUT FILE: SLICE-F.OUT (40 PAGES)

					RG & E		
					SLICE PROGRAM		
					IMPELL CORPORATION	JOB NO 0950-050-1683	PAGE 2
0	[illegible]	9/17/88	A.V	9/22/88		CALC NO 9550-1	OF 22
REV	BY	DATE	CHECKED	DATE			

1. PURPOSE

"SLICE", VERSION 1.0, IS A PROJECT SPECIFIC PROGRAM THAT EXTRACTS FROM THE RESULTS OF DYNAMIC ANALYSIS ONLY THOSE MODES WHICH CONTRIBUTE TO THE RESPONSE OF THE SELECTED SLICE OF BRACED FRAME. THE MODE SELECTION CRITERIA WILL BE BASED ON THE CONSIDERATION OF A MODE SIGNIFICANCE FACTOR. IN-PLANE HORIZONTAL FLOOR DISPLACEMENTS DUE TO GROUND SPECTRA INPUT IN BOTH IN-PLANE AND OUT-OF-PLANE HORIZONTAL DIRECTIONS ARE THEN CALCULATED FOR EACH MODE SELECTED. THE GROUND SPECTRA WILL BE THE REGULATORY GUIDE 1.60 SPECTRA WITH DAMPING VALUES AT 0.5, 2, 5, 7 OR 10 PER CENT OF THE CRITICAL DAMPING.

THE OUTPUT DISPLACEMENTS OF THIS PROGRAM MAY THEN BE USED AS INPUT AS STATIC LOAD CASES TO THE DETAILED MODEL OF THE SLICE FOR SEISMIC EVALUATION.

"SLICE", VERSION 1.0 WAS WRITTEN IN FORTRAN LANGUAGE AND WAS COMPILED BY USING MICROSOFT FORTRAN OPTIMIZING COMPILER, VERSION 4.00. IT MAY BE RUN ON AN IBM PC/XT/AT COMPUTER OR ITS COMPATIBLES.

2. METHOD

THE SLICE METHOD WAS DEVELOPED BY GORDON S. BJORKMAN IN A PROPOSAL TO RG&E (REF. 1), WHICH USES THE RESULTS FROM THE EXISTING DYNAMIC MODEL OF THE ENTIRE STRUCTURE AND APPLIES THOSE RESULTS AS STATIC LOAD CASES TO ONLY THOSE STRUCTURAL SYSTEMS (SLICES) WHICH IS BELIEVED AS NECESSARY TO BE EVALUATED.

TO UTILIZE THE SLICE METHODOLOGY. IT IS NOT NECESSARY TO USE ALL MODES TO OBTAIN AN ACCURATE SOLUTION FOR THE SLICE. ONLY THOSE MODES WHICH CONTRIBUTE TO THE RESPONSE OF THE SELECTED SLICE ARE REQUIRED.

THE MODE SELECTION CRITERIA TO BE USED FOR THE SLICE EVALUATION WILL BE BASED ON THE MAGNITUDE OF A MODE SIGNIFICANCE FACTOR (MSF). THE MSF OF A MODE IS DEFINED AS THE PRODUCT OF THREE QUANTITIES :

METHOD

1. THE MAXIMUM STORY SHEAR STRAIN WITHIN THE SLICE, WHICH IS THE DIFFERENCE OF IN-PLANE HORIZONTAL NORMALIZED MODAL TRANSLATIONS BETWEEN THE UPPER AND LOWER FLOORS OF THE SUBJECT STORY, DIVIDED BY THE STORY HEIGHT. (SEE FIGURE ON PAGE 6)
2. THE SRSS OF THE TWO HORIZONTAL DIRECTION MODAL PARTICIPATION FACTORS.
3. THE SPECTRA DISPLACEMENT, WHICH IS THE SPECTRA ACCELERATION, DIVIDED BY THE CIRCULAR FREQUENCY SQUARED.

THE ABOVE DEFINITION OF MSF MAY BE EXPRESSED AS:

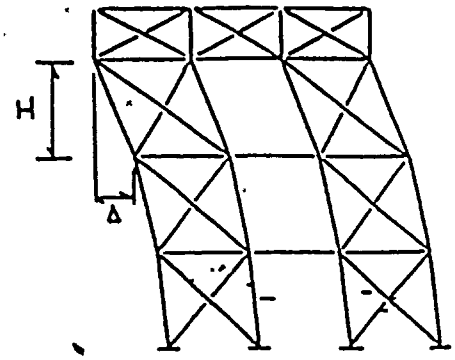
$$MSF = (SSS) \times \sqrt{(PFX)^2 + (PFY)^2} \times \frac{S_A}{(2\pi f)^2}$$

WHERE

SSS = STORY SHEAR STRAIN (SEE FIG. ON PAGE 6)
PFX = MODAL PARTICIPATION FACTOR IN X-DIRECTION
PFY = MODAL PARTICIPATION FACTOR IN Y-DIRECTION
f = MODE FREQUENCY
S_A = SPECTRA ACCELERATION

METHOD

$$SSS = \frac{\Delta}{H}$$



NOTE THAT THE PRODUCT OF $\sqrt{(PFX)^2 + (PFY)^2}$ AND $\frac{S_A}{(2\pi f)^2}$ IS CALLED "MODE COEFFICIENT" IN THE ANSYS PROGRAM (*), WHICH IS A QUANTITY PERTAINING TO THE ENTIRE DYNAMIC MODEL TAKEN AS A WHOLE FOR THE MODE CONSIDERED. PHYSICALLY IT IS THE SRSS COMBINATION OF THE DISPLACEMENT RESPONSE OF A MODE DUE TO EACH DIRECTION OF HORIZONTAL GROUND MOTION SPECTRA INPUT.

NOTE: * IN ANSYS PROGRAM, MODE COEFFICIENT IS CALCULATED INDEPENDENTLY FOR EACH OF THE THREE GLOBAL DIRECTIONS.

					RG & E
					SLICE PROGRAM
0	[illegible]	12/2/88	A.V	12/2/88	IMPELL CORPORATION — JOB NO 0950-050-1683 — CALC NO 9550-1 — PAGE 6 OF 22
REV	BY	DATE	CHECKED	DATE	

THE ACTUAL MODES SELECTED WILL BE DETERMINED BY A SPECIFIED MSF RATIO. FOR A PARTICULAR STORY, AN n-MODE MSF RATIO IS DEFINED AS THE RATIO OF THE SRSS OF THE MSF OF n-MODES WITH HIGHEST MSF TO THE SRSS OF THE MSF OF ALL MODES. FOR INSTANCE, SUPPOSE THAT MODE NUMBERS 1, 4 AND 8 ARE THE THREE MODES WITH HIGHEST MSF IN A PARTICULAR STORY, THE 3-MODE MSF RATIO IS THEN

$$\text{MSF RATIO} = \frac{\sqrt{(MSF)_1^2 + (MSF)_4^2 + (MSF)_8^2}}{\sqrt{\sum_{i=1}^{N} (MSF)_i^2}}$$

WHERE $(MSF)_i$ IS THE MSF OF THE i-TH MODE OF THAT STORY AND N IS THE NUMBER OF TOTAL MODES. FOR AN MSF RATIO OF 0.90 FOR ALL FLOORS, IT MEANS THAT THE ACTUAL MODES WHICH WILL THEN BE USED IN THE SLICE EVALUATION ARE THOSE WHICH GIVE A COMBINED MSF EQUAL TO OR BETTER THAN 90% OF THE TOTAL MSF FOR ALL MODES.

FOR EACH MODE SELECTED, THE IN-PLANE HORIZONTAL DISPLACEMENT AT EACH FLOOR IS THEN CALCULATED WHICH IS THE PRODUCT OF :

1. IN-PLANE HORIZONTAL MODAL TRANSLATION

2. MODE COEFFICIENT

INPUT FORMAT (CONT'D)

4. ZPA, GMULT

ZPA = PEAK GROUND ACCELERATION EXPRESSED IN G, USUALLY 0.2

GMULT = G MULTIPLIER. IF 32.2 IS ENTERED, THE FINAL FLOOR DISPLACEMENT WILL BE IN "FT". IF 386.4 IS ENTERED, THE RESULTS WILL BE IN "INCHES".

5. MSF RATIO

SEE PAGES 6 AND 7 FOR EXPLANATION OF THE MSF RATIO. THIS RATIO SHOULD BE IN THE RANGE OF 0.90 THRU 0.99, WITH INCREMENT 0.01

6. NODE, ELEVATION

NODE = NODE NUMBER IN THE DYNAMIC MODEL FROM WHICH THE DYNAMIC OUTPUT DATA ARE OBTAINED

ELEV. = ELEVATION OF THE NODE

NOTE THAT THE NODE AND ELEVATION ARE TO BE STARTED WITH THE FLOOR AT THE LOWEST ELEVATION.

INPUT FORMAT (CONT'D)

REPEAT (6) A TOTAL OF "NFLOOR" LINES

7. MODE, FREQ, PFX, PFY

MODE = MODE NUMBER

FREQ = FREQUENCY IN HERTZ

PFX = MODAL PARTICIPATION FACTOR IN X-DIR.

PFY = MODAL PARTICIPATION FACTOR IN Y-DIR.

NOTE THAT IF THE GLOBAL Z-AXIS IS NOT IN VERTICAL DIRECTION, THEN, PFX AND PFY ARE SIMPLY THE MODAL PARTICIPATION FACTORS IN THE FIRST AND THE SECOND HORIZONTAL DIRECTIONS.

REPEAT (7) A TOTAL OF "NMODE" LINES.

8. MODE, PHIX(1), PHIX(2), ..., PHIX(NFLOOR)

MODE = MODE NUMBER

PHIX(I) = MODE SHAPE AT THE I-TH FLOOR. IT IS THE HORIZONTAL TRANSLATION IN THE PLANE OF THE FRAME.

NOTE THAT THE SEQUENCE OF MODE NUMBERS IN (7) AND (8) SHOULD BE IN CONSISTENT ORDER.

REPEAT (8) A TOTAL OF "NMODE" LINES.

4. PROGRAM LIMITATIONS.

1. MAXIMUM NUMBER OF MODES = 200
2. MAXIMUM NUMBER OF FLOORS = 10
3. MAXIMUM NUMBER OF DAMPING VALUES = 5
4. DAMPING VALUES, EXPRESSED IN PER CENT OF CRITICAL DAMPING, MUST BE ENTERED AS ONE OR MORE OF THE VALUES: 0.5, 2., 5., 7. OR 10. FOR INSTANCE, A VALUE OF 7.3 WILL NOT BE ACCEPTED.
5. THE CUT-OFF MSF RATIO MUST BE IN THE RANGE OF 0.90 THROUGH 0.99, WITH INCREMENT 0.01. THEREFORE, A RATIO OF 0.95 IS ACCEPTABLE BUT 0.956 IS NOT.
6. IN ITEMS (7) AND (8) OF THE INPUT FORMAT, THE SEQUENCE OF MODE NUMBERS MUST BE IN CONSISTENT ORDER.

THE PROGRAM WILL PRINT AN ERROR MESSAGE FOR ANY VIOLATION OF THE ABOVE LIMITATIONS AND TERMINATES THE RUN.

5. PROGRAM COMPILATION AND HARDWARE REQUIREMENTS

"SLICE" PROGRAM WAS WRITTEN IN FORTRAN LANGUGE AND WAS COMPILED BY USING MICROSOFT FORTRAN OPTIMIZING COMPILER, VERSION 4.00 (REF. 2), ON IBM AT-COMPUTER. THE EXECUTABLE FILE "SLICE7.EXE" REQUIRES 168,348 BYTES OF MEMORY. IT MAY BE RUN ON ANY IBM PC, XT, AT OR COMPATIBLES.

6. PROGRAM EXECUTION

TO RUN THE SLICE PROGRAM, AN INPUT FILE WHICH IS PREPARED IN ACCORDANCE WITH THE INPUT FORMAT OF SECTION 3 SHOULD BE NAMED AS "FILE5", WITHOUT EXTENSION.

WITH "FILE5" AND THE EXECUTABLE FILE "SLICE7.EXE" IN THE CURRENT DIRECTORY, SIMPLY TYPE

SLICE7

AND THE OUTPUT FILE WILL BE OBTAINED AS "FILE6"