Attachment 2

Report Number C-NPP-SEP 9/95

USER'S MANUAL

CREST

A Computer Program for Coupled Response Spectrum Analysis of Secondary Systems

Interfaced with PIPESTRESS

By

Ajaya Kumar Gupta
Professor and Director

Jing-Wen Jaw
Former Research Assistant

Abhinav Gupta
Research Engineer

July 1995

Center for Nuclear Power Plant
Structures, Equipment and Piping

North Carolina State University
Raleigh, NC 27695-7908

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ABSTRACT

The CREST program performs a coupled seismic analysis of piping (secondary) systems in conjunction with a piping analysis program. We have interfaced CREST with the piping analysis program PIPESTRESS. The CREST program accounts for the interaction between primary and the secondary systems and uses the response spectrum input specified at the base of the primary system directly, without converting it into either a compatible time history or a power spectral density function. CREST represents a new method of analysis which is computationally efficient and theoretically elegant. It eliminates many uncertainties associated with conventional methods of analysis and gives accurate response values.

ACKNOWLEDGEMENT

Development of CREST has been progressing at North Carolina State University since 1982, mostly as unsponsored research. Sargent and Lundy provided support for a part of the initial development. Recent enhancements in the program have been partially supported by the Center for Nuclear Power Plant Structures, Equipment and Piping, which came into existence in 1991. The authors (and not the supporting companies) are solely responsible for the information presented in the report.

CENTER FOR NUCLEAR POWER PLANT STRUCTURES, EQUIPMENT AND PIPING

There are some one hundred nuclear power generating units in the United States and four hundred worldwide. Nuclear power plants have been the safest and ecologically friendliest among all competing sources of energy. However, nuclear power is no longer the cheap source of energy it was expected to be.

Technology can help bring down the cost of operating existing plants and of building new plants to make nuclear power competitive. It is with this knowledge that we have embarked on establishing the Center at North Carolina State University. Our goal is to become a premier university-based research and professional organization for nuclear power plant structures, equipment and piping.

We have already developed sophisticated engineering tools that can save millions of dollars in the lifetime of an existing plant. We believe that the engineering tools need not be complicated nor cumbersome. Often, the more sophisticated the technology is, the simpler and more elegant the solutions are. This report is an example of our effort.

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Introduction

CREST is a computer program developed at North Carolina State University for the evaluation of seismic response of the secondary systems, such as piping and other equipment. "CREST" is an acronym which stands for **C**-oupled **RE**-sponse spectrum analysis of **S**-econdary sys-**T**ems. This title essentially describes the main features of the program. More details regarding the capabilities of CREST are described below.

The conventional practice of calculating seismic response is to perform the analysis of the primary structure (building) and the secondary systems (piping and equipment) separately. Earthquake input to the primary system is defined in terms of a design response spectrum. An acceleration time history compatible with the design response spectrum is developed (a non-unique process) and primary system is analyzed to obtain the acceleration histories at the desired floors. Floor time histories are used for generating the corresponding instructure response spectrum (IRS). The instructure response spectra are used as input at the supports of secondary systems. Further, in case of multiple supports, an envelope spectrum (a source of conservatism) is obtained from the individual support IRS. The enveloped spectrum in then used as an input at all the supports of secondary system. For multiply supported secondary systems, an alternate practice is to evaluate the responses due to individual support IRS and combine them using absolute sum (which is also conservative). In these two methods the effect of relative support motion is incorporated by a separate worst-case static analysis (additional source of conservatism) and combined with the dynamic response by square root of sum of squares (SRSS) rule. In the above methods, mass interaction between the secondary and primary system is ignored, which may significantly reduce the response of the secondary system in modes with resonant frequencies. All together the conventional methods calculate the secondary system response that is excessively conservative.

The most important feature of CREST is that it gives the coupled response of the secondary systems. It accounts for the interaction between primary and the secondary systems. The interaction between the two systems is a reality, and as such CREST gives more accurate response values than would be given by any other analysis procedure in which the secondary system is uncoupled. An equally important feature of CREST is that it directly uses the response spectrum input at the base of the primary system without converting it into a compatible time history or a power spectral density function, either directly or indirectly. Therefore, it eliminates the uncertainties associated with the analysis procedures that convert the response spectrum input at the base of the main structure into other forms. In this respect, the accuracy of the CREST calculated response is the same as one would expect from the well established and accepted response spectrum method.

The computer program CREST has eliminated the need for intermediate step of having to calculate the floor response spectra. The coupled analysis does not have to make any assumptions about the multiply supported secondary systems. The correlation between the inputs at various secondary system supports is automatically accounted for. Such artificial steps as having to envelope the floor response spectra at various secondary system supports are eliminated. Also, the need for a separate static analysis of the secondary system using support displacements is eliminated; the separate static analysis must not be performed when using CREST. CREST has thus eliminated unnecessary conservatisms associated with having to envelope the floor response spectra and the additional static analysis.

The program requires that the secondary system be light relative to the primary system. We have successfully analyzed sample secondary systems which when coupled with the primary system, changed the uncoupled frequency of the primary system by $\pm$ 10%. When using this measure, we found that some of the mass ratios were as high as 0.25. We expect that CREST should give the response of a secondary system

accurately when the change in the uncoupled frequencies of the **significant** primary system modes is within ± 10%. Further, the ± 10% limit in change is not sacred, it is the limit we used in our sample problems.

The secondary system can apply static constraints to the primary system. An effect of such constraints is the increase in frequencies of the coupled system over those of the uncoupled primary system alone. The CREST program is capable of accounting for this and related effects of the static constraints.

The theoretical background of the program is described in references [2, 1, 3]. A summary is provided here. When the secondary system is light relative to the primary system, the coupled mode shapes, frequencies and damping values can be obtained using a perturbation technique. The perturbation technique is one of the ways of performing modal synthesis. In a conventional modal synthesis method, one may have to perform an eigenvalue analysis using the transformed coupled matrices. In the perturbation technique, it is assumed that the change in the uncoupled modal properties is small. This change is called "perturbation". The perturbation can be calculated quite efficiently and accurately using approximate methods, such as those used in CREST. Since the objective is to calculate the response of the secondary system, it is reasonable to assume that the necessary inertia, damping and stiffness properties of the secondary system are specified for the CREST program. The uncoupled mode shapes and frequencies of the significant secondary system modes are also assumed to be specified. Only limited information about the primary system is required. We need to specify the frequencies and the participation factors of the significant modes of the uncoupled primary system. In addition, the corresponding mode shape parameters for the connecting DOF only need be specified. This information is sufficient to perform the modal synthesis of the coupled system using the perturbation or any other technique. The modal properties of both the primary and secondary system are required for significant modes up to the rigid frequency only.

The effect of higher frequency residual modes is appropriately accounted for by using the residual modal vectors as explained in reference [1].

In most practical cases, the primary and secondary systems have different damping values. It is assumed that each system is individually classically damped. Even then, the coupled system becomes nonclassically damped because the two systems have different damping values. The eigenvectors (mode shapes) and the eigenvalues of a nonclassically damped system are complex, which the CREST program calculates. The complex eigenvalue for any mode gives the real frequency and the corresponding real damping value. This damping value for any mode of the coupled system is between the damping values of the constituent primary and secondary systems.

For calculating the response of the coupled system, we evaluate two real response vectors for each complex mode shape (and its conjugate). In the response spectrum method, this requires the knowledge of the conventional input response spectrum plus another response spectrum. The conventional response spectrum is based on the maximum relative displacement of the SDOF oscillator; therefore we call it the **relative displacement response spectrum**. We denote the displacement response spectrum by S^d. The response spectrum values can be represented in the units of displacement (D), velocity (V) or acceleration (A). We represent the unit of the spectrum by the capital letter subscripts D, V or A. We recall the well known relationship

$$S_A^d = \omega S_V^d = \omega^2 S_D^d \tag{1}$$

where ω is the circular frequency. The other response spectrum is based upon maximum relative velocity, and we call it the **relative velocity response spectrum**, S^v. The velocity response spectrum can also be represented in the units of displacement, velocity or acceleration. The relative velocity spectra in the three units have the same relationship, as do the relative displacement spectra; viz.,

$$S_A^v = \omega S_V^v = \omega^2 S_D^v \tag{2}$$

In the intermediate frequency range, the two spectra are approximately equal when represented in the same unit. In the lower and higher frequency range, it is not so. The relative displacement spectra is higher in the high frequency range and the relative velocity spectra is higher in the low frequency region. The available design spectra at the base of the primary structure is the relative displacement spectra. The relative velocity spectra is usually not available. We have developed empirical relationships between the relative velocity and the relative displacement spectra which are included in the CREST program. The program input requires the displacement spectra only. The relative velocity spectra is evaluated from the relative displacement spectra using the empirical relationships.

In the response spectrum analysis of classically damped systems, the mode combination is performed by a double sum technique which uses the correlation between various modes. The situation is slightly more complicated in the case of nonclassically damped systems. Now each mode has a response vector related to the displacement spectrum, and another to the velocity spectrum. To combine these vectors for all the modes, a triple-double sum is employed. One double sum uses the same correlation matrix as the conventional response spectrum method. Another double sum accounts for the correlation between the velocity spectrum-based responses. The third double sum represents the cross-correlation between the displacement and velocity spectra-based responses.

Piping Analysis Using CREST

The computer program CREST can be used to perform the coupled analysis of piping systems when interfaced with a piping analysis program. The flow chart in fig.1 completely describes the exchange of information between CREST and a piping program. As can be seen from the chart, the secondary system (piping) is modeled using the piping program. The piping program then calls CREST as a subprogram to evaluate the coupled modal displacements. CREST requires an additional input file that contains the control data, the primary-secondary system connectivity data, the modal properties of the uncoupled primary system and the design response spectra at the base of primary system. The coupled modal displacements evaluated by CREST are used by the piping program to evaluate coupled modal responses in terms of member forces, support reactions and pipe stresses. The coupled modal responses are then appropriately combined in CREST using the mode combination procedure given in reference [3].

The piping analysis program that is currently being used with CREST is the commercial program PIPESTRESS []. The source code of PIPESTRESS was provided by DST Computer Services which was then installed on DEC and SUN workstations. CREST and PIPESTRESS were made to interact through a Master Program. Since the purpose of interfacing CREST and PIPESTRESS was to perform research on coupled analysis of real piping systems, a simplified interfacing was performed and is shown in Fig. 2. In this interface, the piping system is modeled on PIPESTRESS and the conventional response spectrum analysis is performed. A restart file is created as an output of PIPESTRESS run. The restart file contains the nodal and element data, the mass and stiffness properties, unit solutions and properties for each mode of the piping system. A "level" number is specified for each support in the PIPESTRESS input file. PIPESTRESS creates unit solutions for piping responses when any level

displaces by unity in the three global directions. The total number of such unit solutions are, therefore, equal to three times the total number of support levels. Fu rther, three residual vectors are associated with each level, one in each of the three global directions. PIPESTRESS generates unit solutions for each such residual vector also. The Master Program reads the necessary information from the PIPESTRESS restart file. The Master Program requires additional input related to the uncoupled primary system properties, primary-secondary connectivity data and the response spectra at the base of primary system. A detailed explanation of this input file is given later. The master program then calls CREST to evaluate the coupled modal responses in terms of displacements, member forces and support reactions. The coupled modal responses are combined using the mode combination procedure described in reference [3].

Input Files for CREST

In order to run the Master Program for CREST/ PIPESTRESS, the user needs to input the names of three files that CREST asks for interactively. The two of these files are the input files and the third is the output file. The first file is a restart file generated by PIPESTRESS. As stated earlier, the secondary system (piping) is modeled on PIPESTRESS and an uncoupled analysis performed. This run of PIPESTRESS generates a restart file. The user of CREST should input the name of this restart file when CREST asks for PIPESTRESS restart file. CREST then asks for CREST input file. This file contains the primary-secondary connectivity data, the uncoupled modal properties of primary system and the response spectra at the base of primary system. The user needs to prepare this file using the input format given in this manual. Next CREST asks for the name of the output file that would be created by the program (CREST).

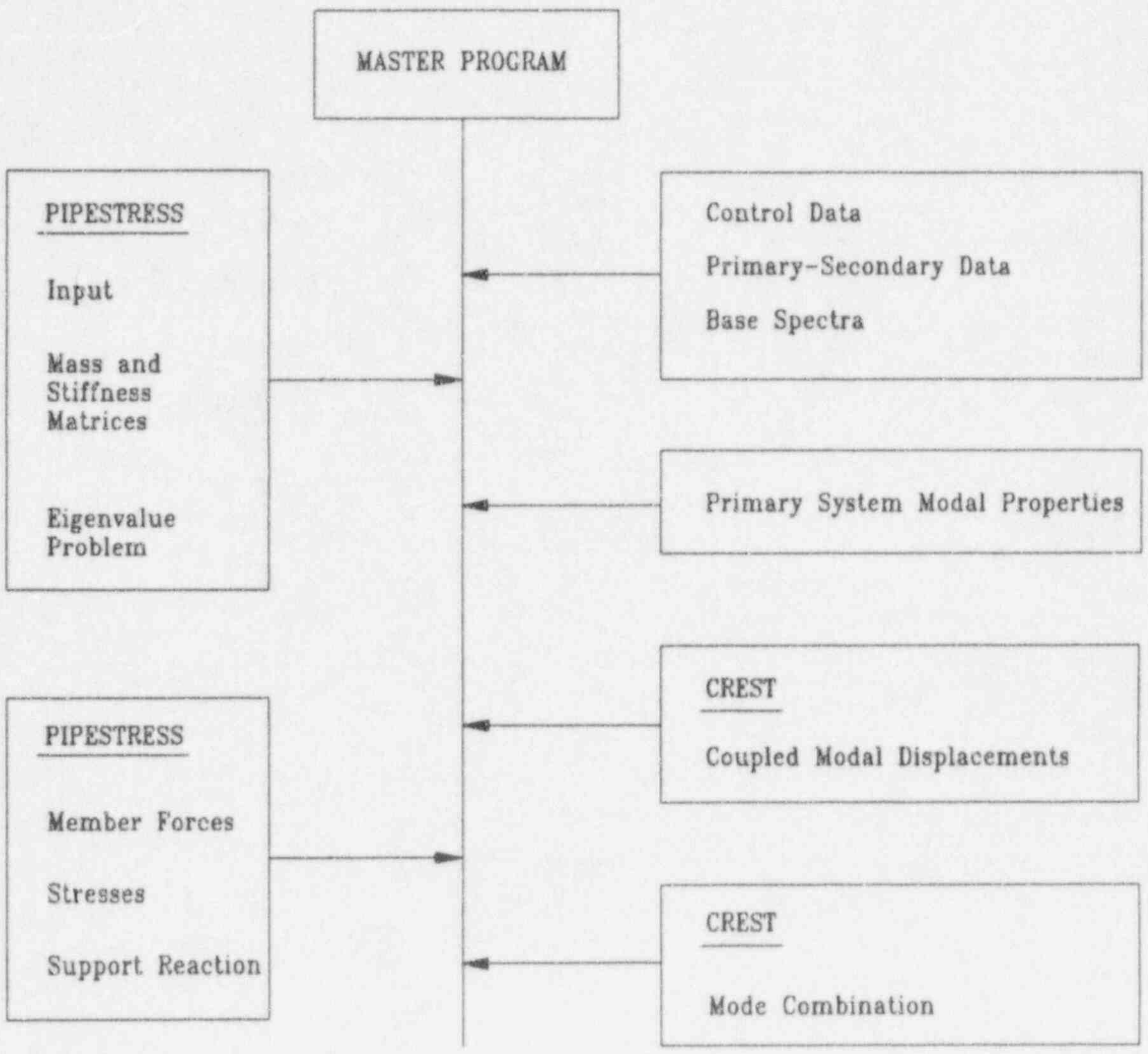

Figure 1: Interaction of CREST with a Piping Program

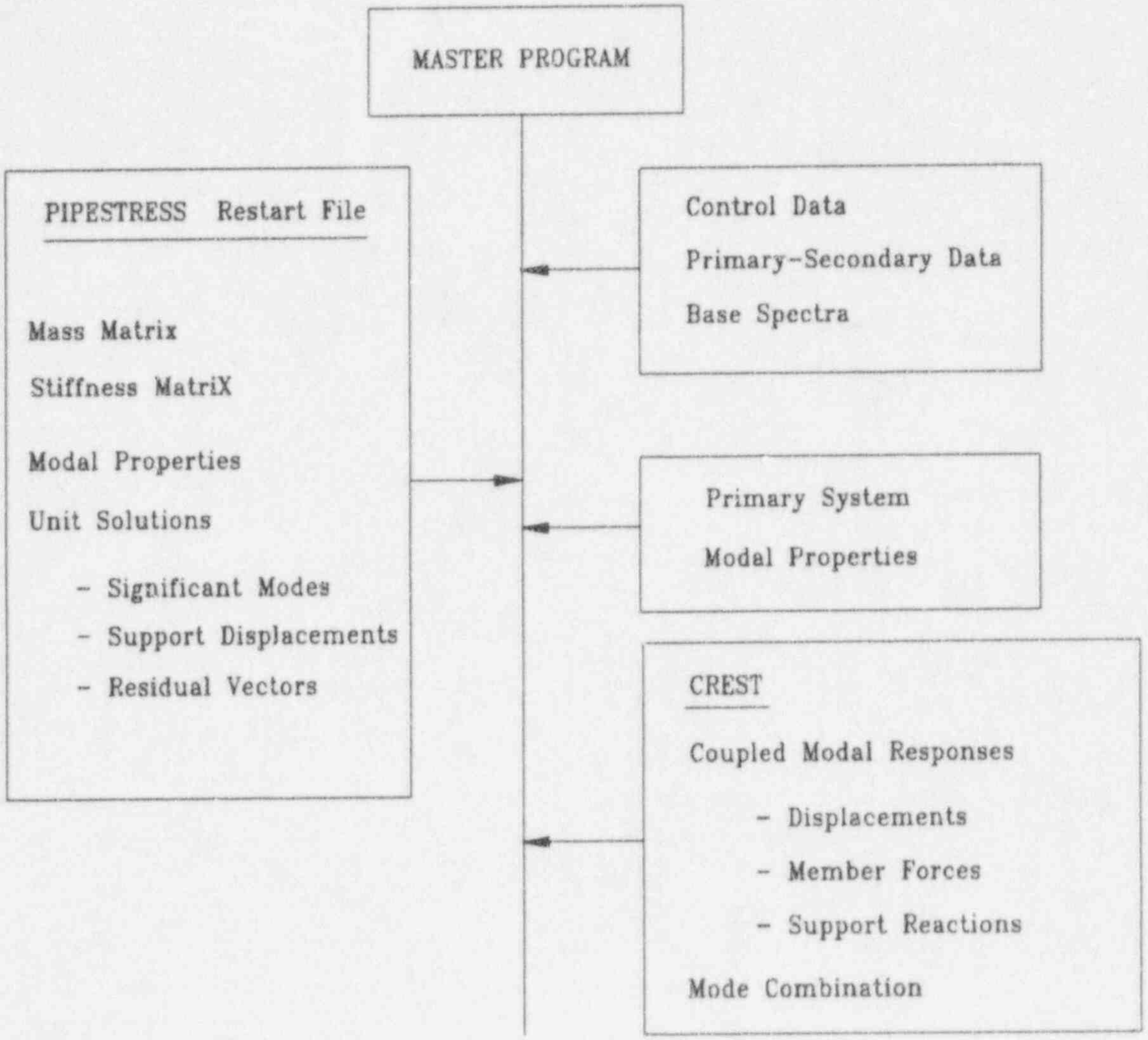

Figure 2: Flow Chart for Interaction of CREST and PIPESTRESS

Table 1: **FREE FORMAT INPUT DATA FOR MASTER PROGRAM**

Variable	Entry
Card I - Heading Card	
TITLE	Alphanumeric information to be printed out as heading
Card II - Master Control Card	
NP	Number of primary system DOF[1]
NC	Number of primary system connecting DOF
NA	Number of anchors in piping system
NPM	Number of uncoupled primary system modes[2]
NSM	Number of uncoupled secondary system modes[2]
NORMP	Normalization index for primary system mode shape input EQ.0, unnormalized EQ.1, normalized
NORMS	Normalization index for secondary system mode shape input EQ.0, unnormalized EQ.1, normalized
NONZP	Number of nonzero elements in the lower triangular primary system stiffness matrix[1]
IPRINT	Output type indicator EQ.0, limited output EQ.1, detailed output printed
IPRINTS	Output type indicator for response spectrum values EQ.0, limited output EQ.1, detailed output printed

Card II - Master Control Card (Contd.)

KRESP	Flag for evaluation of primary system residual modes[3] EQ.0, do not evaluate EQ.1, evaluate
KRESS	Flag for evaluation of secondary system residual modes[4] EQ.0, do not evaluate EQ.1, evaluate
KFLG	Flag to indicate global direction of input spectra EQ.1, global X direction EQ.2, global Y direction EQ.3, global Z direction

Card III - Control Card for CREST subroutine

NITER	Maximum number of iterations allowed for coupled frequency calculations If EQ.0, default is 50
NCURVE	Number of response spectrum curves input at the base of primary system
MXLP	Maximum number of input spectrum definitions points; max. of NLP(NCURVE)
TOL	Convergence tolerance in the calculation of coupled frequencies. If EQ.0, default 1.0E-6
FR	Rigid frequency for the input response spectra, Hz.
SFTR	Scale factor to be applied to the input spectral values
ET	Tolerance value used in the evaluation of modal correlation coefficients

Card IV - Uncoupled Primary System Critical Damping Ratios XIP(NPM) — Damping ratios for modes 1 to NPM Add as many cards as necessary for all the NPM modes
Card V - Uncoupled Secondary System Critical Damping Ratios XIS(NSM) — Damping ratios for modes 1 to NSM Add as many cards as necessary for all the NSM modes
Card VI - Primary System Connecting DOF IEL(NC,1) — Primary system DOF numbers connected to secondary system Add as many cards as necessary for NC DOF
Card VII - Piping support DOF IEL(NC,2) — Support DOF numbers at various levels to which piping is connected[5] Add as many cards as necessary for NC DOF
Card VIII - Secondary System Stiffness Matrix for Connected DOF SKCC(NC,NC) — Stiffness matrix containing support stiffnesses at each connecting DOF[6] Add as many cards as necessary for NC DOF Start a new card for each of the NC DOF

Card IX - PIPESTRESS node numbers for piping anchors

IAL(NA)	Node numbers of anchors for piping model in PIPESTRESS

Add as many cards as necessary for NA anchors

Card X - Uncoupled primary system frequencies, Hz

WP(NPM)	Frequencies for modes 1 to NPM

Add as many cards as necessary for NPM modes

Card XI - Uncoupled primary system mode shapes (KRESP=0)

PHIC(NC,NPM)	Primary system mode shapes at connecting DOF only for NPM modes[7]

This card is required only when KRESP=0.
When KRESP≠0, skip this card
Add as many cards as necessary for NPM modes
Start a new card for each of the NC DOF

Card XII - Uncoupled primary system participation factor (KRESP=0)

GAMAP(NPM)	Participation factor for each of the NPM modes[8]

This card is required only when KRESP=0
When KRESP≠0, skip this card
Add as many cards as necessary for NPM modes

Card XIII - Uncoupled primary system mode shapes (KRESP≠0)

PHI(NP,NPM)	Primary system mode shapes for NPM modes[7]

This card is required only when KRESP≠0
When KRESP=0, skip this card
Add as many cards as necessary for NPM modes
Start a new card for each of the NP DOF

Card XIV - Lumped masses for primary system DOF (KRESP≠0)

DM(NP)	Lumped masses for NP DOF

This card is required only when KRESP≠0
When KRESP=0, skip this card
Add as many cards as necessary for NP DOF

Card XV - Stiffness matrix for primary system (KRESP≠0)

SP(NONZP)	Lower triangular part of the primary system stiffness matrix[9]

This card is required only when KRESP≠0
When KRESP=0, skip this card
Add as many cards as necessary for NP DOF

Card XVI - Address of diagonals of primary system stiffness matrix (KRESP≠0)

JDP(NP)	Address of diagonal elements of the lower triangular part of primary system stiffness matrix[9]

This card is required only when KRESP≠0
When KRESP=0, skip this card
Add as many cards as necessary for NP DOF

Card XVII - Base influence vector for primary system

UBP(NP)	Influence vector for primary system DOF[10]

This card is required only when KRESP≠0
When KRESP=0, skip this card
Add as many cards as necessary for NP DOF

Card XVIII - Base response spectra[11]

A. Card 1	
NLP(1)	Number of definition points for curve 1
SDAMP(1)	Critical damping ratio for curve 1
B. Card 2	
FSAD(1,1)	Frequency at point 1, curve 1, Hz
FSAD(2,1)	Spectral acceleration at point 1, curve 1
FSAD(1,2)	Frequency at point 2, curve 1, Hz
FSAD(2,2)	Spectral acceleration at point 2, curve 1
	⋮
FSAD(1,NLP)	Frequency at point NLP, curve 1, Hz
FSAD(2,NLP)	Spectral acceleration at point NLP, curve 1

Provide necessary number of cards for curve 1
Repeat the set of Card 1 and Card(s) 2 for all NCURVE curves

NOTES

1. For the case KRESP=0, the user should input nonzero integer values for NP and NONZP.

2. Only significant and non-rigid primary and secondary system modes need to be considered.

3. Primary system residual mode is evaluated using the procedure defined in reference [4]. The residual modal vector can be easily calculated using a static analysis program by solving the equation

$$[K_p]\{U_o\} = [M_p]\{U_{bo}\}, \quad \{U_{bo}\} = \{U_{bp}\} - \sum_{i=1}^{np} \{\phi_{pi}\}\gamma_{pi} \tag{3}$$

where γ_{pi} is the participation factor and $\{\phi_{pi}\}$ the mass normalized mode shape vector in the i^{th} uncoupled primary system mode; np the number of significant non rigid primary system modes; and $\{U_{bp}\}$ the static displacement vector of the primary system when the base undergoes a unit displacement in the direction of the earthquake. The solution of the above equation yields an eigenvector $\{\phi_o\}$, which is then normalized such that $\{\phi_o\}^T[M_p]\{\phi_o\} = 1$. We can also evaluate a fictitious frequency corresponding to the residual mode by

$$\omega_o^2 = \{\phi_o\}^T[K_p]\{\phi_o\} \tag{4}$$

This modal vector and the corresponding fictitious frequency ω_o are then inut into CREST along with other modal vectors and frequencies. When the above procedure is followed, the variable KRESP is set equal to zero. Alternatively, the residual vector can be calculated in CREST, by inputing the mass and stiffness matrices, the static displacement vector $\{U_{bp}\}$ and the complete modal vectors $\{\phi_{pi}\}$ (Other than for calculating the residual mode vector, CREST

needs the modal vectors corresponding to the connecting degrees of freedom only). In this alternate method, the variable KRESP is set equal to 1.

4. High frequency modes (missing mass) of the secondary system can significantly affect the coupled response. The missing mass effect of the secondary system can be accurately accounted for by making KRESS=1. When all the modes of secondary sytem are included, the user should set KRESS=0.

5. The array SKCC(NC,NC) is input to evaluate the static constraining effect of the secondary system. Its elements contain the stiffness of the piping supports used in PIPESTRESS.

6. Each piping support in PIPESTRESS has a level number associated with it. PIPESTRESS generates unit solutions for support displacements and residual vector associated with each level. At any given level there are three such sets of unit solutions, one in each of the three global directions. The total number of such solutions are therefore equal to three times the total number of levels. Since piping is connected to the building at NC DOF only, IEL(NC,2) contains the row of numbers that helps in identifying the particular unit solutions needed in the coupled analysis.

7. The PHI(NP,NPM) array contains one modal vector for each uncoupled primary system mode. Each vector includes the elements of the corresponding uncoupled primary modal vector for NP DOF. The complete primary system modal vectors are normalized such that $\{\phi_{pi}\}^T[M_p]\{\phi_{pi}\} = 1$. PHIC(NC,NPM) is a submatrix of PHI(NP,NPM) and contains the elements of the corresponding uncoupled primary modal vector associated with the connected DOF only.

8. The elements of GAMAP(NPM) are calculated from the following equation:

$$\gamma_{pi} = \{\phi_{pi}\}^T [M_p] \{U_{bp}\} \tag{5}$$

where $\{\phi_{pi}\}$, $[M_p]$ and $\{U_{bp}\}$ are defined above.

9. SP(NONZP) contains the lower triangle part of the primary system stiffness matrix. The elements are stored row-wise starting from first non-zero element in each row. NONZP is the total number of non-zero elements in SP. The addresses of the diagonal elements in SP are stored in the array JDP.

10. UBP(NP) is the primary system displacement vector when the base of the primary system is displayed by unity in the direction of the earthquake.

11. A total of NCURVE spectral acceleration curves are specified at the base of the primary system, one for each damping value, SDAMP. The number of points defined on each curve NLP can be different from curve to curve. MXLP is the maximum of NLP values for all the curves. The FSAD(KN,MXLP) array is arranged as follows :

$$\begin{bmatrix} f_{1,1} & f_{1,2} & \cdots & f_{1,MXLP} \\ S_{A1,1} & S_{A1,2} & \cdots & S_{A1,MXLP} \\ \vdots & \vdots & & \vdots \\ f_{i,1} & f_{i,2} & \cdots & f_{i,MXLP} \\ S_{Ai,1} & S_{Ai,2} & \cdots & S_{Ai,MXLP} \\ \vdots & \vdots & & \vdots \\ f_{NCURVE,1} & f_{NCURVE,2} & \cdots & f_{NCURVE,MXLP} \\ S_{ANCURVE,1} & S_{ANCURVE,2} & \cdots & S_{ANCURVE,MXLP} \end{bmatrix} \begin{matrix} \}1^{st} curve \\ \\ \}i^{th} curve \\ \\ \}NCURVE^{th} curve \end{matrix}$$

Each curve has two rows. The first row defines the frequencies in Hz, and the second row defines the spectral accelerations. The spectral accelerations should have the same length unit as used in the rest of the analysis. For example, if the length unit is ft., the S_A unit should be ft./sec^2.

Sample Problem

A 4-DOF secondary system coupled to a 6-DOF primary system is analyzed. The secondary system is connected to the primary system at DOF numbers 2 and 6. The primary system was subjected to the El Centro (S00E, 1940) ground motion. This problem is identical to Case-1 given in reference [1]. Fig. 3 illustrates the coupled system and also gives the mass and stiffness properties of the two uncoupled systems. To perform the coupled analysis, the secondary system was modeled on PIPESTRESS. The PIPESTRESS input file for this analysis is given later in this section. The frequencies and damping ratios of the uncoupled primary and secondary system modes are given in table 2. The restart file from the PIPESTRESS run was then used by the Master Program for the CREST/ PIPESTRESS interface along with the additional input file required by CREST. The additional input file required by CREST is also given later in this section. This input file is based on the input format described in this manual. The coupled analysis results are given here in the form of output file obtained from the CREST run. Two different sets of analysis were performed on this system. First, all the modes of primary and secondary system were considered in the analysis. Second, the two highest modes of secondary system are truncated and their effect is included in the analysis using the residual modal vectors evaluated inside CREST. The two modes of secondary system that were truncated have frequencies higher than the rigid frequency (20.5 Hz.) of El Centro ground motion response spectra. The input and output files for the two sets of analysis are attached here.

The secondary system is modeled on PIPESTRESS using the element "Internal Spring". This element has six DOF at each node. In order to model one DOF at each node, the remaining five DOF at each node are restrained. As stated earlier, each restrain in PIPESTRESS is assigned a level number. This makes the total number

Table 2: Frequencies and Damping Ratios for Uncoupled Systems

Primary System			Secondary System		
Mode No.	Freq. (Hz.)	Damping Ratio	Mode No.	Freq. (Hz.)	Damping Ratio
1	2.10148	0.07	1	9.83625	0.02
2	6.18237	0.07	2	18.71025	0.02
3	9.90389	0.07	3	25.751	0.02
4	13.04991	0.07	4	30.27286	0.02
5	15.43755	0.07			
6	16.92772	0.07			

of levels equal to six. However, we need the unit solutions for only the connecting DOF and therefore use the appropriate numbers in IEL(NC,2). As explained earlier, a response spectrum analysis of the piping system is performed using PIPESTRESS to obtain the unit solutions needed in the coupled analysis (and not to calculate the uncoupled response PIPESTRESS gives). This analysis needs the floor spectrum input at each level that does not affect the unit solutions. Dummy spectra with constant unit values at all frequencies are input. Since, the secondary system supports are modeled using spring stiffnesses in PIPESTRESS, the SKCC matrix therefore consists of the default anchor stiffness values of PIPESTRESS. The secondary system responses in terms of nodal displacements and spring forces from the two sets of analyses are given in tables 3 and 4. These response values are also compared to those obtained from the time history analysis of the coupled system. As can be seen from these tables, the coupled analysis results are in good agreement with the time history analysis results.

Table 3: Comparison of Nodal Displacements (inches) for Secondary System

Node no.	CREST / PIPESTRESS		TIME HISTORY
	Including all modes	Truncated modes; Including missing mass	
1	1.281	1.277	1.289
2	1.498	1.493	1.498
3	1.688	1.682	1.682
4	1.849	1.842	1.838

Table 4: Comparison of Spring Forces (kips) for Secondary System

Element no.	CREST / PIPESTRESS		TIME HISTORY
	Including all modes	Truncated modes; Including missing mass	
1	240.4	239.7	239.9
2	217.6	217.0	214.8
3	191.0	190.3	185.9
4	161.3	160.6	155.6
5	128.8	128.2	124.1

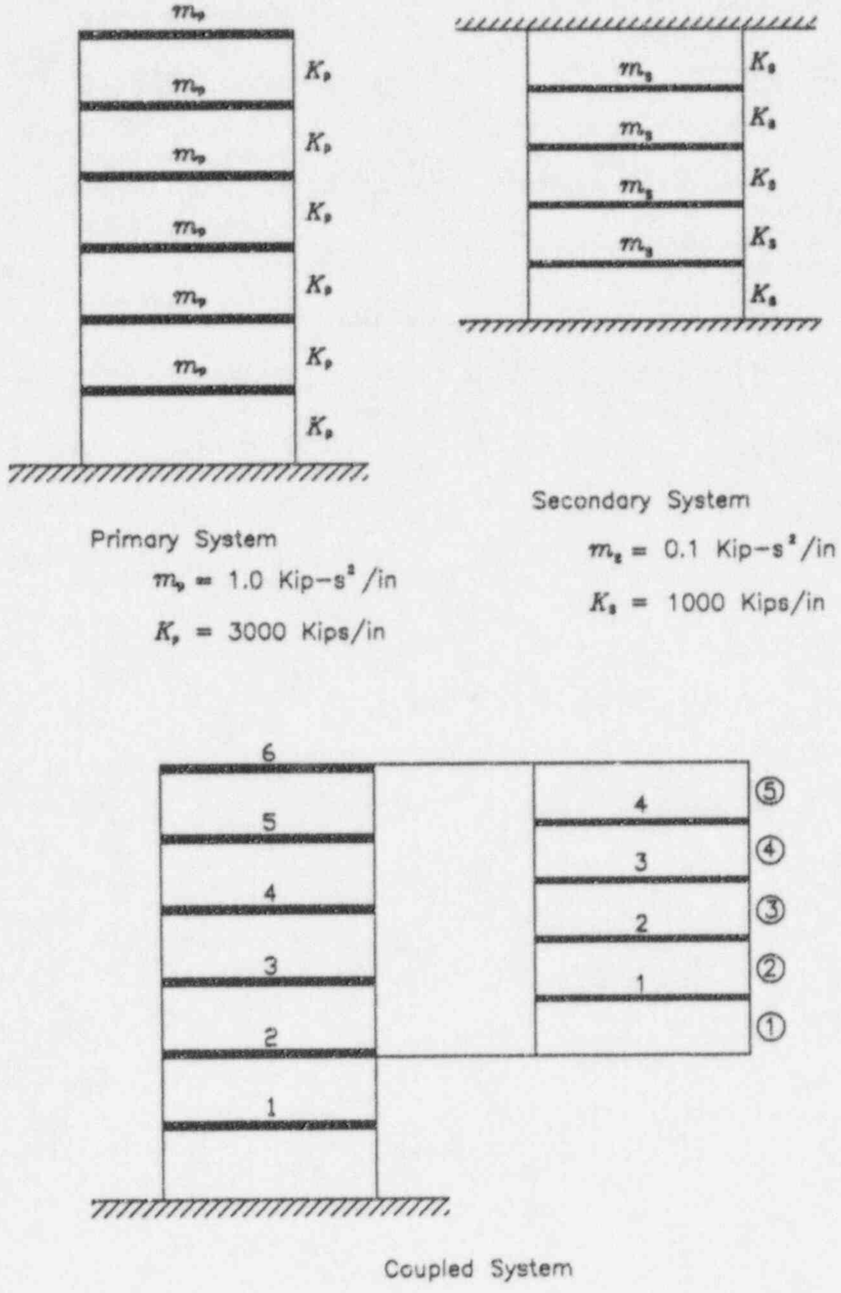

Figure 3: Primary, Secondary and Coupled Systems for Case 1

References

[1] A. Gupta and A. K. Gupta. Recent Improvements in the CREST-IRS Program. Report C-NPP-SEP 7/93, Center for Nuclear Power Plant Structures, Equipments and Piping, Department of Civil Engineering, North Carolina State University, Raleigh, NC, 1993.

[2] A. K. Gupta. *Response Spectrum Method In Seismic Analysis and Design of Structures.* CRC Press, Inc., Boca Raton, FL, 1992.

[3] H. A. Megahed and A. K. Gupta. Research on Coupled Seismic Response of Secondary Systems. In *Current Issues Related to Nuclear Power Plant Structures, Equipment and Piping*, Proceedings of Fourth Symposium, Orlando, Fl, 1992.

[4] H. A. Megahed and A. K. Gupta. Topics in Seismic Response of Nonclassically Damped Systems. Report C-NPP-SEP 2/92, Research Program on Nuclear Power Plant Structures, Equipments and Piping, Department of Civil Engineering, North Carolina State University, Raleigh, NC, 1992.

```
IDEN JB=1111 IU=1 OU=1 PL=/PIPESTRESS INPUT FILE/
TITL SU=1 CV=2 TI=/CASE-1, 4-DOF PROBLEM/
FREQ FR=33 LO=1 MX=4 TI=/INCLUDING ALL MODES /
RCAS CA=1 EV=1 TY=1 SU=3 LO=1 FX=1 FY=1 FZ=1
RSEC CA=2 EV=1 SU=1 FX=1 FY=1 FZ=1
SPEC EV=1 ME=1 FP=0 SH=0
     LV=1 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=2 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=3 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=4 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=5 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=6 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
MATL CD=3 EC=28.0 SC=75 SH=75 KL=1
ANCH PT=1 LV=1
SPRS PT=2 DX=1.0 AZ=1000.0
LUMP PT=2 MA=38.64
RSUP PT=2 DY=1 LV=2
RSUP PT=2 DZ=1 LV=2
ROTR PT=2 RX=1
ROTR PT=2 RY=1
ROTR PT=2 RZ=1
SPRS PT=3 DX=1.0 AZ=1000.0
LUMP PT=3 MA=38.64
RSUP PT=3 DY=1 LV=3
RSUP PT=3 DZ=1 LV=3
ROTR PT=3 RX=1
ROTR PT=3 RY=1
ROTR PT=3 RZ=1
SPRS PT=4 DX=1.0 AZ=1000.0
LUMP PT=4 MA=38.64
RSUP PT=4 DY=1 LV=4
RSUP PT=4 DZ=1 LV=4
ROTR PT=4 RX=1
ROTR PT=4 RY=1
ROTR PT=4 RZ=1
SPRS PT=5 DX=1.0 AZ=1000.0
LUMP PT=5 MA=38.64
RSUP PT=5 DY=1 LV=5
RSUP PT=5 DZ=1 LV=5
ROTR PT=5 RX=1
ROTR PT=5 RY=1
ROTR PT=5 RZ=1
SPRS PT=6 DX=1.0 AZ=1000.0
ANCH PT=6 LV=6
ENDP
```

```
CREST/ PIPESTRESS RUN FOR CASE-1, WITH ALL THE S.S. MODES
    6    2    2    6    4    1    0  11  1    1    0    0   1
  900   10   10     1.0E-6       20.5      386.4 0.10
      0.07        0.07        0.07        0.07        0.07       0.07
      0.02        0.02        0.02        0.02
    2    6
    1   16
100000000. 0.0
0.0       100000000.
1 6
2.10148200 6.18237000 9.9038940 13.0499100 15.4375500 16.9277200
 -0.25778    -0.55066    0.36783    0.13275     0.51865  0.45651
-0.55066   0.51865    . 0.45651     0.36783    -0.25778  0.13275
 -0.2284E+01 -0.7313E+00  0.4018E+00 -0.2457E+00 -0.1456E+00  0.6836E-01
   10  0.020089
 2.1291.2220 6.5500.8379 8.9410.718911.1560.715613.2270.534515.3120.6440
16.9800.514619.3090.515525.9200.439530.3200.4303
   10  0.020570
 2.1291.2127 6.5500.8284 8.9410.715011.1560.711113.2270.533415.3120.6403
16.9800.513619.3090.513825.9200.437630.3200.4285
   10  0.025668
 2.1291.1228 6.5500.7413 8.9410.678211.1560.668913.2270.520215.3120.6033
16.9800.503619.3090.497425.9200.418530.3200.4137
   10  0.038864
 2.1290.9478 6.5500.6178 8.9410.608711.1560.591713.2270.483915.3120.5476
16.9800.484919.3090.467825.9200.380330.3200.387
   10  0.047920
 2.1290.8611 6.5500.5556 8.9410.578511.1560.559513.2270.463315.3120.5251
16 9800.471719.3090.452325.9200.364630.3200.3754
   10  0.064194
 2.1290.7464 6.5500.4921 8.9410.537511.1560.519413.2270.457315.3120.4935
16.9800.458219.3090.431625.9200.358930.3200.3621
   10  0.064384
 2.1290.7453 6.5500.4918 8.9410.537111.1560.519113.2270.457315.3120.4932
16.9800.458019.3090.431425.9200.358930.3200.3620
   10  0.065102
 2.1290.7412 6.5500.4907 8.9410.535611.1560.517613.2270.457015.3120.4920
16.9800.457419.3090.430625.9200.358730.3200.3615
   10  0.067043
 2.1290.7302 6.5500.4876 8.9410.531511.1560.513713.2270.456115.3120.4889
16.9800.455819.3090.428725.9200.358130.3200.3604
   10  0.068084
 2.1290.7245 6.5500.4862 8.9410.529411.1560.511713.2270.455615.3120.4872
16.9800.454919.3090.427625.9200.357830.3200.3598
```

```
CREST/ PIPESTRESS RUN FOR CASE-1, WITH ALL THE S.S. MODES

  NUMBER OF PRIMARY DOF              NP=    6
  NUMBER OF CONNECTING DOP           NC=    2
  NUMBER OF PIPING ANCHORS           NA=    2
  NUMBER OF PRIMARY MODES           NPM=    6
  NUMBER OF SECONDARY MODES         NSM=    4
  NORMALIZATION INDEX FOR P.S.    NORMP=    1
  NORMALIZATION INDEX FOR S.S.    NORMS=    0
  OUTPUT TYPE INDICATOR          IPRINT=    1
  OUTPUT TYPE INDICATOR         IPRINTS=    1
  PRIMARY RESIDUAL MODE KEY       KRESP=    0
  SECONDARY RESIDUAL MODE KEY     KRESS=    0
  NUMBER OF NONZERO IN PRIMARY SYSTEM STIFFNESS MATRIX       NONZP=   11
  GLOBAL EARTHQUAKE DIRECTION  X=1  Y=2(VERTICAL)  Z=3       KFLG=    1

  NUMBER OF ITERATIONS           NITER=  900
  NUMBER OF SPECTRA CURVES      NCURVE=   10
  NUMBER OF SPECTRUM POINTS       NXLP=   10
  ITERATION TOLERANCE              TOL=  0.1000E-05
  RIGID FREQUENCY                   FR=  20.500
  SPECTRUM FACTOR                 SFTR= 386.400
  CORRELATION TOLERANCE             ET=   0.100

  TOTAL STORAGE REQUIRED  =      27023
  ACTUAL PROVIDED STORAGE  = 550000000

  PRIMARY DAMPING RATIOS

  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01

  SECONDARY DAMPING RATIOS

  0.2000E-01  0.2000E-01  0.2000E-01  0.2000E-01

  CONNECTING DOF # OF PRIMARY SYSTEM

   2   6

  CONNECTING DOF # OF PIPING SUPPORTS

   1   16

  STIFFNESS OF CONNECTING DOF OF S.S.

  0.1000E+09  0.0000E+00  0.0000E+00  0.1000E+09

  NODE # OF PIPING ANCHORS

   1   6

  MASS OF EACH SECONDARY DOF

  0.2588E-08  0.2588E-08  0.2588E-08  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2588E-08  0.2588E-08  0.2588E-08  0.0000E+00  0.0000E+00  0.0000E+00

  ADDRESS OF DIAGONAL ELEMENTS IN S.S. STIFFNESS MATRIX (JDG MATRIX)

    1    3    6   10   15   21   28   36   45   55   66   78   85   93  102  112
  123  135  142  150  159  169  180  192  199  207  216  226  237  249  256  264
  273  283  294  306

  LOWER TRIANGULAR STIFFNESS MATRIX OF SECONDARY SYSTEM

  0.1000E+09  0.0000E+00  0.1000E+09  0.0000E+00  0.0000E+00  0.1000E+05
  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.9996E+10  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.9996E+10 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.2000E+04  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+11
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11
 -0.1000E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+04  0.0000E+00 -0.1000E-03  0.0000E+00  0.0000E+00  0.0000E+00
```



```
 -0.1200E-02  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00 -0.1000E-03
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+11 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.2000E+04  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+11
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11
 -0.1000E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+04  0.0000E+00 -0.1000E-03  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00 -0.1000E-03
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+11 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+09  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+09
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+09  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.9996E+10  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10

  SECONDARY FREQUENCIES (HZ)

   9.8362088  18.7097518  25.7517959  30.2730820

  STATIC DEFORMATION SHAPE OF S.S. FOR P.S. CONNECTING DOF        2

  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.8000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.6000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E-05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

  STATIC DEFORMATION SHAPE OF S.S. FOR P.S. CONNECTING DOF        6

  0.2000E-05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.6000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.8000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

  UNNORMALIZED MODE SHAPE OF SECONDARY SYSTEM

  0.6180E-05  0.1000E-04  0.1000E-04 -0.6180E-05
 -0.8759E-31  0.7474E-24  0.1115E-26  0.1288E-20
 -0.4080E-31  0.4754E-24 -0.7232E-27 -0.1860E-21
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4899E-32 -0.5707E-25  0.8682E-28  0.2233E-22
 -0.1051E-31  0.8972E-25  0.1339E-27  0.1547E-21
  0.6180E+00  0.1000E+01  0.1000E+01 -0.6180E+00
 -0.8759E-19  0.7474E-12  0.1115E-14  0.1288E-08
 -0.4080E-19  0.4754E-12 -0.7232E-15 -0.1860E-09
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.5770E-31  0.1577E-20 -0.1458E-23  0.2630E-21
 -0.4160E-27 -0.1577E-20  0.2921E-23  0.1822E-20
  0.1000E+01  0.6181E+00 -0.6180E+00  0.1000E+01
 -0.1254E-19  0.1070E-11 -0.7769E-15 -0.1420E-08
 -0.6100E-19 -0.2997E-11 -0.8044E-15  0.2692E-08
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4159E-27 -0.9855E-22 -0.2919E-23 -0.3454E-21
 -0.5198E-28 -0.3154E-20  0.4378E-23  0.4230E-17
  0.1000E+01 -0.6179E+00 -0.6180E+00 -0.1000E+01
 -0.5963E-19  0.5151E-12  0.9987E-15  0.2244E-08
  0.1023E-19 -0.3489E-12 -0.8497E-15  0.3299E-08
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.8548E-32 -0.1578E-20 -0.2919E-23 -0.1692E-16
  0.2079E-27 -0.1578E-20  0.2131E-27 -0.4230E-17
  0.6180E+00 -0.9999E+00  0.1000E+01  0.6180E+00
  0.6302E-19 -0.7852E-12  0.5184E-15 -0.1254E-08
 -0.9885E-19 -0.7367E-14  0.5795E-16 -0.4316E-09
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1309E-31  0.2461E-22  0.1823E-24  0.1058E-17
  0.1472E-31  0.4733E-20 -0.1460E-23 -0.4230E-17
  0.6180E-05 -0.9999E-05  0.1000E-04  0.6180E-05
  0.6303E-31 -0.7851E-24  0.5184E-27 -0.1254E-20
 -0.9885E-31 -0.7366E-26  0.5794E-28 -0.4315E-21
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2999E-37 -0.8723E-30  0.1576E-31  0.1796E-35
 -0.2032E-35  0.7951E-28 -0.1169E-31 -0.2750E-24

  NORMALIZED MODE SHAPE OF SECONDARY SYSTEM

  0.1176E-04  0.1902E-04  0.1902E-04 -0.1176E-04
 -0.1666E-30  0.1422E-23  0.2121E-26  0.2451E-20
 -0.7762E-31  0.9042E-24 -0.1376E-26 -0.3538E-21
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.9318E-32 -0.1086E-24  0.1651E-27  0.4247E-22
 -0.2000E-31  0.1707E-24  0.2547E-27  0.2942E-21
  0.1176E+01  0.1902E+01  0.1902E+01 -0.1176E+01
 -0.1666E-18  0.1422E-11  0.2121E-14  0.2451E-08
 -0.7762E-19  0.9042E-12 -0.1376E-14 -0.3538E-09
```

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1098E-30	0.3000E-20	-0.2774E-23	0.5002E-21
-0.7913E-27	-0.2999E-20	0.5555E-23	0.3466E-20
0.1902E+01	0.1176E+01	-0.1176E+01	0.1902E+01
-0.2386E-19	0.2036E-11	-0.1478E-14	-0.2702E-08
-0.1160E-18	-0.5700E-13	-0.1530E-14	0.5121E-08
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.7911E-27	-0.3875E-21	-0.5552E-23	-0.6566E-21
-0.9887E-28	-0.6002E-20	0.8128E-23	0.9045E-17
0.1902E+01	-0.1175E+01	-0.1176E+01	-0.1902E+01
-0.1134E-18	0.9798E-12	0.1900E-14	0.4268E-08
0.1946E-19	-0.6637E-12	-0.1616E-14	0.6275E-08
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
-0.1626E-31	-0.3001E-20	-0.5552E-23	-0.3218E-16
0.3955E-27	-0.3001E-20	0.4053E-27	-0.8045E-17
0.1176E+01	-0.1902E+01	0.1902E+01	0.1176E+01
0.1199E-18	-0.1493E-11	0.9861E-15	-0.2385E-09
-0.1890E-18	-0.1401E-13	0.1102E-15	-0.8210E-09
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.2490E-31	0.4682E-22	0.3468E-24	0.2012E-17
0.2800E-31	0.9003E-20	-0.2776E-23	-0.8047E-17
0.1176E-04	-0.1902E-04	0.1902E-04	0.1176E-04
0.1199E-30	-0.1493E-23	0.9861E-27	-0.2385E-20
-0.1880E-30	-0.1401E-25	0.1102E-27	-0.8208E-21
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.5704E-37	-0.1659E-29	0.2998E-31	0.3416E-25
-0.3865E-35	0.1512E-27	-0.2207E-31	-0.5231E-24

PRIMARY FREQUENCIES (HZ)

2.1034820 6.1823700 9.9038940 13.0499100 15.4375500 16.9277200

MODE SHAPE OF P.S. AT CONNECTING DOF 2

-0.2578E+00 -0.5507E+00 0.3678E+00 0.1328E+00 0.5187E+00 0.4565E+00

MODE SHAPE OF P.S. AT CONNECTING DOF 6

-0.5507E+00 0.5187E+00 0.4565E+00 0.3678E+00 -0.2578E+00 0.1328E+00

BASE INFLUENCE VECTOR FOR S.S.---UBS

0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.1000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PARTICIPATION FACTOR FOR P.S.---GAMAP

-0.2284E+01 -0.7315E+00 0.4018E+00 -0.2457E+03 -0.1456E+05 0.4834E-01

INPUT SPECTRUM CURVE NUMBARS = 1

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.20089E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.1222E+01
2	0.6550E+01	0.8379E+00
3	0.8941E+01	0.7189E+00
4	0.1116E+02	0.7156E+00
5	0.1323E+02	0.5345E+00
6	0.1531E+02	0.6440E+00
7	0.1698E+02	0.5146E+00
8	0.1931E+02	0.5155E+00
9	0.2592E+02	0.4395E+00
10	0.3032E+02	0.4303E+00

INPUT SPECTRUM CURVE NUMBER = 2

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.20570E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.1213E+01
2	0.6550E+01	0.8284E+00
3	0.8941E+01	0.7150E+00
4	0.1116E+02	0.7111E+00
5	0.1323E+02	0.5334E+00
6	0.1531E+02	0.6403E+00
7	0.1698E+02	0.5136E+00
8	0.1931E+02	0.5138E+00
9	0.2592E+02	0.4376E+00
10	0.3032E+02	0.4285E+00

INPUT SPECTRUM CURVE NUMBER = 3

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.25668E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.1123E+01
2	0.6550E+01	0.7413E+00
3	0.8941E+01	0.6782E+00
4	0.1116E+02	0.6659E+00
5	0.1323E+02	0.5202E+00
6	0.1531E+02	0.6033E+00
7	0.1698E+02	0.5036E+00

8	0.1931E+02	0.4974E+00
9	0.2592E+02	0.4185E+00
10	0.3032E+02	0.4137E+00

INPUT SPECTRUM CURVE NUMBER = 4

NUMBEP OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = L.38968E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.9478E+00
2	0.6550E+01	0.6178E+00
3	0.8941E+01	0.6087E+00
4	0.1116E+02	0.5917E+00
5	0.1323E+02	0.4839E+00
6	0.1531E+02	0.5476E+00
7	0.1690E+02	5.4849E+00
8	0.1931E+02	0.4678E+00
9	0.2592E+02	0.3803E+00
10	0.3032E+02	0.3870E+00

INPUT SPECTRUM CURVE NUMBER = 5

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.47920E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.8611E+00
2	0.6550E+01	0.5556E+06
3	0.8941E+01	0.5785E+00
4	0.1116E+02	0.5595E+00
5	0 .323E+02	0.4633E+00
6	0.1531E+02	0.5251E+00
7	0.1698E+02	0.4717E+00
8	0.1931E+02	0.4523E+00
9	0.2592E+02	0.3646E+00
10	0.3032E+02	0.3754E+00

INPUT SPECTRUM CURVE NUMBER = 6

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64194E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2729E+01	0.7464E+00
2	0.6550E+01	0.4921E+00
3	0.8941E+01	0.5575E+00
4	0.1116E+02	0.5190E+00
5	0.1323E+02	0.4573E+00
6	0.1531E+02	0.4935E+00
7	0.1698E+02	0.4582E+00
8	0.1931E+02	0.4316E+00
9	0.2592E+02	0.3589E+00
10	0.3032E+02	0.3621E+00

INPUT SPECTRUM CURVE NUMBER = 7

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64384E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.212 E+01	0.7453E+00
2	0.6550E+01	0.4918E+00
3	0.8941E+01	0.5371E+00
4	0.1116E+02	0.5191E+00
5	0.1323E+02	0.4573E+00
6	0.1531E+02	0.4932E+00
7	0.1698E+02	0.4580E+00
8	0.1931E+02	0.4314E+00
9	0.2592E+02	0.3589E+00
10	0.3032E+02	0.3620E+00

INPUT SPECTRUM CURVE NUMBER = 8

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.65102E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.7412E+00
2	0.6550E+01	0.4907E+00
3	0.8941E+01	0.5356E+00
4	0.1116E+02	0.5176E+00
5	0.1323E+02	0.4570E+00
6	0.1531E+02	0.4920E+00
7	0.1698E+02	0.4574E+00
8	0.1931E+02	0.4306E+00
9	0.2592E+02	0.3587E+00
10	0.3032E+02	0.3615E+00

INPUT SPECTRUM CURVE NUMBER = 9

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.67043E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.7302E+00

2	0.6550E+01	0.4876E+00
3	0.8941E+01	0.5315E+00
4	0.1116E+02	0.5137E+00
5	0.1323E+02	0.4561E+00
6	0.1531E+02	0.4889E+00
7	0.1698E+02	0.4558E+00
8	0.1931E+02	0.4287E+00
9	0.2592E+02	0.3581E+00
10	0.3032E+02	0.3604E+00

INPUT SPECTRUM CURVE NUMBER = 16

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.68084E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.7245E+00
2	0.6550E+01	0.4862E+00
3	0.8941E+01	0.5294E+00
4	0.1116E+02	0.5117E+00
5	0.1323E+02	0.4556E+00
6	0.1531E+02	0.4872E+00
7	0.1698E+02	0.4549E+00
8	0.1931E+02	0.4276E+00
9	0.2592E+02	0.3579E+00
10	0.3032E+02	0.3598E+00

A COMPUTER PROGRAM FOR

COUPLED RESPONSE SPECTRUM ANPLYSIS OF SECONDARY SYSTEMS

" C R E S T "

DEVELOPED BY

AJAYA KUMAR GUPTA
JING-WEN JAW ABHINAV GUPTA

NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

REVISION-1.0

PARTICIPATION FACTOR FOR S.S.---GAMAS
0.6155E+00 0.5509E-04 0.1453E+00 -0.3661E-08

MASS RATIOS

PRIMARY SYSTEM MODE 1
0.6191E-01 0.1623E-02 0.3450E-02 0.9056E-04

PRIMARY SYSTEM MODE 2
0.9706E-04 0.2166E-01 0.5409E-05 0.1207E-02

PRIMARY SYSTEM MODE 3
0.6437E-01 0.1484E-03 0.3587E-02 0.8302E-05

PRIMARY SYSTEM MODE 4
0.2374E-01 0.1046E-02 0.1323E-02 0.5834E-04

PRIMARY SYSTEM MODE 5
0.6446E-02 0.1142E-01 0.3592E-03 0.6364E-03

PRIMARY SYSTEM MODE 6
0.3289E-01 0.1987E-02 0.1833E-02 0.1107E-03

C O U P L E D F R E Q U E N C I E S A N D M O D E S H A P E S E X T R A C T I O N

NUMBER OF ITERATIONS TO BE APPLIED FOR COUPLED FREQUENCIES EXTRACTION NITER = 900

CONVERGENCE TOLERANCE FOR COUPLED FREQUENCIES TOL = 0.10000E-05

COUPLED MODE	FREQUENCY (HZ)	DAMPING RATIO (%)
1	0.21291E+01	0.64394E+01
2	0.65495E+01	0.64194E+01
3	0.89327E+01	0.42667E+01
4	0.11156E+02	0.47920E+01
5	0.13227E+02	0.67975E+01
6	0.15312E+02	0.65101E+01
7	0.16980E+02	0.67040E+01
8	0.19309E+02	0.25670E+01
9	0.25920E+02	0.20570E+01
10	0.30310E+02	0.20089E+01

UNIT DISPLACEMENT & UNIT VELOCITY*W RESPONSE

COUPLED MODE NO. 1

1	0.64571E+00	0.10810E-02
2	0.12297E+01	-0.11230E-02
3	0.33033E-06	-0.41562E-07
4	0.22961E-24	-0.29932E-25
5	-0.34315E-25	0.44725E-26
6	0.00000E+00	0.00000E+00
7	0.41195E-26	-0.53692E-27
8	0.27565E-25	-0.35931E-26
9	0.33033E-01	-0.41563E-02
10	0.22961E-12	-0.29932E-13
11	-0.34315E-13	0.44725E-14
12	0.00000E+00	0.00000E+00
13	-0.31166E-23	0.40393E-24
14	0.34924E-23	-0.45291E-24
15	0.51822E-01	-0.65274E-02
16	-0.25691E-12	0.32488E-13
17	0.48295E-12	-0.62555E-13
18	0.00000E+00	0.00000E+00
19	0.13040E-24	-0.16874E-25
20	0.76500E-21	-0.99718E-22
21	0.53941E-01	-0.68019E-02
22	0.40148E-12	-0.52335E-13
23	0.59240E-12	-0.77222E-13
24	0.00000E+00	0.00000E+00
25	-0.30318E-20	0.39521E-21
26	-0.75548E-21	0.98484E-22
27	0.37264E-01	-0.47048E-02
28	-0.22338E-12	0.29120E-13
29	-0.77404E-13	0.10090E-13
30	0.00000E+00	0.00000E+00
31	0.18971E-21	-0.24730E-22
32	-0.76829E-21	0.10014E-21
33	0.37263E-06	-0.47047E-07
34	-0.22337E-24	0.29118E-25
35	-0.77385E-25	0.10088E-25
36	0.00000E+00	0.00000E+00
37	0.32231E-29	-0.42014E-30
38	-0.49485E-28	0.64505E-29

COUPLED MODE NO. 2

1	0.31884E+00	-0.92082E-02
2	-0.32116E+00	0.62400E-02
3	0.23670E-06	-0.45415E-07
4	-0.24783E-23	0.37152E-24
5	0.37135E-24	-0.55734E-25
6	0.00000E+00	0.00000E+00
7	-0.44580E-25	0.66908E-26
8	-0.29751E-24	0.44600E-25
9	0.23671E-01	-0.45415E-02
10	-0.24783E-11	0.37152E-12
11	0.37135E-12	-0.55734E-13
12	0.00000E+00	0.00000E+00
13	0.36269E-22	-0.56135E-23
14	-0.40299E-22	0.62176E-23
15	0.11164E-01	-0.31019E-02
16	0.27761E-11	-0.41630E-12
17	-0.52154E-11	0.78202E-12
18	0.00000E+00	0.00000E+00
19	-0.16291E-23	0.25532E-24
20	-0.82664E-20	0.12398E-20
21	-0.13786E-01	0.77654E-03
22	-0.43346E-11	0.64989E-12
23	-0.63979E-11	0.95936E-12
24	0.00000E+00	0.00000E+00
25	0.32737E-19	-0.49085E-20
26	0.81558E-20	-0.12227E-20
27	-0.25362E-01	0.30329E-02
28	0.24109E-11	-0.36142E-12
29	0.83586E-12	-0.12537E-12
30	0.00000E+00	0.00000E+00
31	-0.20486E-20	0.30718E-21
32	0.83046E-20	-0.12457E-20
33	-0.25362E-06	0.30128E-07
34	0.24108E-23	-0.36140E-24
35	0.83566E-24	-0.12530E-24
36	0.00000E+00	0.00000E+00
37	-0.34807E-28	0.52191E-29
38	0.53451E-27	-0.80155E-28

COUPLED MODE NO. 3

1	0.46321E-02	0.65865E-02
2	0.43029E-02	0.64884E-02
3	0.19227E-06	0.14911E-06
4	-0.25415E-26	-0.53430E-27
5	0.38208E-27	0.80223E-28
6	0.00000E+00	0.00000E+00
7	-0.45867E-28	-0.96306E-29
8	-0.30510E-27	-0.64141E-28
9	0.19227E-01	0.14911E-01
10	-0.25415E-14	-0.53430E-15
11	0.38208E-15	0.80223E-16
12	0.00000E+00	0.00000E+00
13	0.45608E-25	0.82775E-26
14	-0.44479E-25	-0.88181E-26
15	0.30657E-01	0.23602E-01
16	0.28514E-14	0.59956E-15
17	-0.53527E-14	-0.11259E-14
18	0.00000E+00	0.00000E+00
19	-0.24398E-26	-0.10674E-26
20	-0.84901E-23	-0.17849E-23
21	0.30628E-01	0.23596E-01
22	-0.44471E-14	-0.93512E-15
23	-0.65670E-14	-0.13813E-14
24	0.00000E+00	0.00000E+00
25	0.33593E-22	0.70646E-23
26	0.83664E-23	0.17594E-23
27	0.19172E-01	0.14900E-01

28	0.24726E-14	0.52012E-15
29	0.85782E-15	0.18042E-15
30	0.00000E+00	0.00000E+00
31	-0.21024E-23	-0.44213E-24
32	0.85336E-23	0.17945E-23
33	0.19172E-06	0.14899E-06
34	0.24725E-26	0.52009E-27
35	0.85762E-27	0.18038E-27
36	0.00000E+00	0.00000E+00
37	-0.35720E-31	-0.75096E-32
38	0.54874E-30	0.11541E-30

COUPLED MODE NO. 4

1	0.91637E-01	-0.15338E-01
2	0.13897E+00	-0.17405E-01
3	-0.36640E-05	-0.12053E-06
4	0.58485E-24	-0.80437E-25
5	-0.88386E-25	0.12228E-25
6	0.00000E+00	0.00000E+00
7	0.10611E-25	-0.14679E-26
8	0.70210E-25	-0.96564E-26
9	-0.36640E+00	-0.12053E-01
10	0.58485E-12	-0.80437E-13
11	-0.88386E-13	0.12228E-13
12	0.00000E+00	0.00000E+00
13	-0.10585E-22	0.16505E-23
14	0.11552E-22	-0.17840E-23
15	-0.60139E+00	-0.16777E-01
16	-0.65756E-12	0.90668E-13
17	0.12328E-11	-0.16974E-12
18	0.00000E+00	0.00000E+00
19	0.48900E-24	-0.77146E-25
20	0.19580E-20	-0.26998E-21
21	-0.59192E+00	-0.17955E-01
22	0.10239E-11	-0.14092E-12
23	0.15127E-11	-0.20832E-12
24	0.00000E+00	0.00000E+00
25	-0.77360E-20	0.10650E-20
26	-0.19258E-20	0.26496E-21
27	-0.35227E+00	-0.14242E-01
28	-0.56887E-12	0.78231E-13
29	-0.19756E-12	0.27201E-13
30	0.00000E+00	0.00000E+00
31	0.48421E-21	-0.66667E-22
32	-0.19690E-20	0.27168E-21
33	-0.35227E-05	-0.14242E-06
34	-0.56884E-24	0.78228E-25
35	-0.19752E-24	0.27195E-25
36	0.00000E+00	0.00000E+00
37	0.82285E-29	-0.11331E-29
38	-0.12644E-27	0.17420E-28

COUPLED MODE NO. 5

1	-0.29279E-01	-0.66334E-03
2	-0.88352E-01	-0.21329E-02
3	0.10272E-05	0.95018E-07
4	-0.11007E-23	0.13307E-24
5	0.16780E-24	-0.20902E-25
6	0.00000E+00	0.00000E+00
7	-0.20144E-25	0.25092E-26
8	-0.13214E-24	0.15974E-25
9	0.10272E+00	0.95019E-02
10	-0.11007E-11	0.13307E-12
11	0.16780E-12	-0.20902E-13
12	0.00000E+00	0.00000E+00
13	0.23659E-22	-0.45501E-23
14	-0.25662E-22	0.47690E-23
15	0.16225E+00	0.16753E-01
16	0.12423E-11	-0.15218E-12
17	-0.23242E-11	0.28265E-12
18	0.00000E+00	0.00000E+00
19	-0.11894E-23	0.24748E-24
20	-0.36990E-20	0.45310E-21
21	0.14511E+00	0.20130E-01
22	-0.19290E-11	0.23404E-12
23	-0.28527E-11	0.34725E-12
24	0.00000E+00	0.00000E+00
25	0.14580E-19	-0.17713E-20
26	0.36266E-20	-0.43935E-21
27	0.71125E-01	0.15435E-01
28	0.10705E-11	-0.12935E-12
29	0.37243E-12	-0.45281E-13
30	0.00000E+00	0.00000E+00
31	-0.91278E-21	0.11097E-21
32	0.37237E-20	-0.45775E-21
33	0.71124E-06	0.15435E-06
34	0.10705E-23	-0.12935E-24
35	0.37234E-24	-0.45270E-25
36	0.00000E+00	0.00000E+00
37	-0.15514E-28	0.18875E-29
38	0.23857E-27	-0.29094E-28

COUPLED MODE NO. 6

1	-0.78160E-01	0.78314E-03
2	0.29161E-01	0.21743E-02
3	-0.29584E-06	0.15984E-06
4	0.28949E-23	-0.38425E-24
5	-0.44970E-24	0.64426E-25
6	0.00000E+00	0.00000E+00
7	0.53986E-25	-0.77343E-26
8	0.34753E-24	-0.46129E-25
9	-0.29584E-01	0.15984E-01
10	0.28949E-11	-0.38425E-12
11	-0.44970E-12	0.64426E-13
12	0.00000E+00	0.00000E+00

13	-0.85422E-22	0.24141E-22
14	0.90146E-22	-0.24775E-22
15	0.19385E-01	0.80482E-03
16	-0.32945E-11	0.45268E-12
17	0.61356E-11	-0.82733E-12
18	0.00000E+00	0.00000E+00
19	0.45994E-23	-0.14100E-23
20	0.98091E-20	-0.13476E-20
21	0.82249E-01	-0.10322E-01
22	0.50848E-11	-0.68131E-12
23	0.75352E-11	-0.10186E-11
24	0.00000E+00	0.00000E+00
25	-0.38465E-19	0.51726E-20
26	-0.95507E-20	0.12748E-20
27	0.82322E-01	-0.15113E-01
28	-0.28147E-11	0.37314E-12
29	-0.98101E-12	0.13245E-12
30	0.00000E+00	0.00000E+00
31	0.24091E-20	-0.32458E-21
32	-0.93969E-20	0.13720E-20
33	0.82321E-06	-0.15113E-06
34	-0.28145E-23	0.37312E-24
35	-0.98278E-24	0.13242E-24
36	0.00000E+00	0.00000E+00
37	0.40966E-28	-0.55293E-29
38	-0.63089E-27	0.85682E-28

COUPLED MODE NO. 7

1	0.30069E-01	0.36569E-03
2	0.14861E-01	-0.42199E-02
3	-0.18697E-07	-0.41178E-07
4	-0.56722E-24	-0.76161E-25
5	0.92146E-25	0.85716E-26
6	0.00000E+00	0.00000E+00
7	-0.11062E-25	-0.10290E-26
8	-0.68093E-25	-0.91430E-26
9	-0.18697E-02	-0.41178E-02
10	-0.56722E-12	-0.76161E-13
11	0.92146E-13	0.85716E-14
12	0.00000E+00	0.00000E+00
13	0.27642E-22	-0.65656E-23
14	-0.28567E-22	0.64435E-23
15	-0.31924E-01	0.27473E-03
16	0.65862E-12	0.76085E-13
17	-0.12132E-11	-0.15252E-12
18	0.00000E+00	0.00000E+00
19	-0.15931E-23	0.43283E-24
20	-0.19608E-20	-0.22671E-21
21	-0.52784E-01	0.55236E-02
22	-0.10017E-11	-0.12938E-12
23	-0.14921E-11	-0.18559E-12
24	0.00000E+00	0.00000E+00
25	0.75917E-20	0.96591E-21
26	0.18774E-20	0.24637E-21
27	-0.37637E-01	0.41214E-02
28	0.55110E-12	0.74270E-13
29	0.19429E-12	0.24503E-13
30	0.00000E+00	0.00000E+00
31	-0.47611E-21	-0.60087E-22
32	0.19889E-20	0.22020E-21
33	-0.37637E-06	0.41214E-07
34	0.55107E-24	0.74367E-25
35	0.19424E-24	0.24497E-25
36	0.00000E+00	0.00000E+00
37	-0.81048E-29	-0.10147E-29
38	0.12527E-27	0.15262E-28

COUPLED MODE NO. 8

1	-0.31799E-03	0.96043E-03
2	0.27843E-03	-0.57660E-03
3	0.35029E-07	-0.62604E-07
4	0.31538E-25	-0.89924E-25
5	-0.25095E-26	0.93748E-26
6	0.00000E+00	0.00000E+00
7	0.30126E-27	-0.11254E-26
8	0.37861E-26	-0.10795E-25
9	0.35030E-02	-0.62605E-02
10	0.31538E-13	-0.89924E-13
11	-0.25095E-14	0.93748E-14
12	0.00000E+00	0.00000E+00
13	0.55304E-23	-0.97680E-23
14	-0.54833E-23	0.96277E-23
15	-0.22183E-02	-0.42317E-02
16	-0.28130E-13	0.87416E-13
17	0.60322E-13	-0.17805E-12
18	0.00000E+00	0.00000E+00
19	-0.35296E-24	0.91196E-24
20	0.83893E-21	-0.26052E-21
21	-0.21563E-02	0.35424E-02
22	0.52172E-13	-0.15175E-12
23	0.72821E-13	-0.21624E-12
24	0.00000E+00	0.00000E+00
25	-0.38530E-21	0.11300E-20
26	-0.10046E-21	0.28978E-21
27	-0.34749E-02	0.60222E-02
28	-0.30900E-13	0.87886E-13
29	-0.97136E-14	0.28631E-13
30	0.00000E+00	0.00000E+00
31	0.23832E-22	-0.70194E-22
32	-0.78373E-22	0.25081E-21
33	-0.34749E-07	0.60222E-07
34	-0.30898E-25	0.87881E-25
35	-0.97113E-26	0.28614E-25
36	0.00000E+00	0.00000E+00
37	0.40004E-30	-0.11836E-29
38	-0.58938E-29	0.17715E-28

COUPLED MODE NO 9

1	0.37019E-03	-0.20025E-03
2	0.32005E-03	-0.15851E-03
3	-0.78335E-07	0.34653E-07
4	-0.10763E-25	0.94276E-26
5	0.15421E-26	-0.13492E-26
6	0.00000E+00	0.00000E+00
7	-0.18512E-27	0.16197E-27
8	-0.12921E-26	0.11318E-26
9	-0.78335E-02	0.34654E-02
10	-0.10763E-13	0.94274E-14
11	0.15421E-14	-0.13492E-14
12	0.00000E+00	0.00000E+00
13	-0.34016E-25	0.33826E-25
14	0.56387E-26	-0.13733E-25
15	0.41538E-02	-0.17624E-02
16	0.11810E-13	-0.10347E-13
17	-0.22432E-13	0.19651E-13
18	0.00000E+00	0.00000E+00
19	0.37506E-25	-0.14424E-25
20	-0.35185E-22	0.30820E-22
21	0.42040E-02	-0.18057E-02
22	-0.18717E-13	0.16398E-13
23	-0.27467E-13	0.24072E-13
24	0.00000E+00	0.00000E+00
25	0.14103E-21	-0.12357E-21
26	0.35280E-22	-0.30915E-22
27	-0.77896E-02	0.34278E-02
28	0.10466E-13	-0.91725E-14
29	0.35955E-14	-0.31510E-14
30	0.00000E+00	0.00000E+00
31	-0.88159E-23	0.77248E-23
32	0.35127E-22	-0.30779E-22
33	-0.77895E-07	0.34278E-07
34	0.10465E-25	-0.91721E-26
35	0.35948E-26	-0.31503E-26
36	0.00000E+00	0.00000E+00
37	-0.14971E-30	0.13114E-30
38	0.22885E-29	-0.20058E-29

COUPLED MODE NO 10

1	0.73800E-04	-0.16243E-04
2	-0.66584E-04	0.12914E-04
3	-0.22315E-07	0.34730E-08
4	-0.45151E-23	-0.69001E-24
5	-0.65181E-24	0.99612E-25
6	0.00000E+00	0.00000E+00
7	0.78248E-25	-0.11958E-25
8	0.54203E-24	-0.82834E-25
9	-0.22315E-02	0.34730E-03
10	0.45151E-11	-0.69001E-12
11	-0.65181E-13	0.99612E-13
12	0.00000E+00	0.00000E+00
13	0.82819E-24	-0.11997E-24
14	0.64782E-23	-0.99660E-24
15	0.34653E-02	-0.52620E-03
16	-0.49773E-11	0.76065E-12
17	0.94343E-11	-0.14418E-11
18	0.00000E+00	0.00000E+00
19	-0.12045E-23	0.18365E-24
20	0.14822E-19	-0.22652E-20
21	-0.34703E-02	0.52853E-03
22	0.78638E-11	-0.12017E-11
23	0.11560E-10	-0.17666E-11
24	0.00000E+00	0.00000E+00
25	-0.59293E-19	0.90613E-20
26	-0.14822E-19	0.22651E-20
27	0.22186E-02	-0.34112E-03
28	-0.43949E-11	0.67163E-12
29	-0.15125E-11	0.23115E-12
30	0.00000E+00	0.00000E+00
31	0.37074E-20	-0.56657E-21
32	-0.14825E-19	0.22656E-20
33	0.22105E-07	-0.34111E-08
34	-0.43947E-23	0.67159E-24
35	-0.15122E-23	0.23109E-24
36	0.00000E+00	0.00000E+00
37	0.62934E-28	-0.96177E-29
38	-0.96367E-27	0.14727E-27

B A S E R E S P O N S E S P E C T R A D A T A

TOTAL NUMBER OF INPUT SPECTRUM CURVE = 10

MAXIMUM NUMBER OF DEFINITION POINTS IN INPUT SPECTRUM CURVES = 15

SPECTRUM SCALE FACTOR = 0.38640E+03

RIGID FREQUENCY = 0.20500E+02

SPECTRUM PARAMETERS

CURVE NO 1 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 1

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.20089E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1222E+01	0.1222E+01
2	0.6550E+01	0.8379E+00	0.7934E+00
3	0.8941E+01	0.7189E+00	0.6039E+00
4	0.1116E+02	0.7156E+00	0.5209E+00
5	0.1323E+02	0.5345E+00	0.3261E+00
6	0.1531E+02	0.6440E+00	0.3025E+00
7	0.1698E+02	0.5146E+00	0.1662E+00
8	0.1931E+02	0.5155E+00	0.1364E+00
9	0.2592E+02	0.4395E+00	0.8661E-01
10	0.3032E+02	0.4303E+00	0.7249E-01

SPECTRUM PARAMETERS

CURVE NO 2 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 2

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR TH'S CURVE = 0.20570E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1213E+01	0.1213E+01
2	0.6550E+01	0.8284E+00	0.7838E+00
3	0.8941E+01	0.7150E+00	0.5995E+00
4	0.1116E+02	0.7111E+00	0.5163E+00
5	0.1323E+02	0.5334E+00	0.3245E+00
6	0.1531E+02	0.6403E+00	0.3000E+00
7	0.1698E+02	0.5136E+00	0.1658E+00
8	0.1931E+02	0.5139E+00	0.1359E+00
9	0.2592E+02	0.4376E+00	0.8623E-01
10	0.3032E+02	0.4285E+00	0.7219E-01

SPECTRUM PARAMETERS

CURVE NO 3 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 3

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.25668E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1123E+01	0.1123E+01
2	0.6550E+01	0.7413E+00	0.6960E+00
3	0.8941E+01	0.6782E+00	0.5584E+00
4	0.1116E+02	0.6689E+00	0.4737E+00
5	0.1323E+02	0.5202E+00	0.3076E+00
6	0.1531E+02	0.6013E+00	0.2754E+00
7	0.1698E+02	0.5036E+00	0.1614E+00
8	0.1931E+02	0.4974E+00	0.1316E+00
9	0.2592E+02	0.4185E+00	0.8247E-01
10	0.3032E+02	0.4137E+00	0.6969E-01

SPECTRUM PARAMETERS

CURVE NO 4 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 4

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.38862E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.9478E+00	0.9478E+00
2	0.6550E+01	0.6178E+00	0.5709E+00
3	0.8941E+01	0.6087E+00	0.4824E+00
4	0.1116E+02	0.5917E+00	0.3976E+00
5	0.1323E+02	0.4839E+00	0.2697E+00
6	0.1531E+02	0.5476E+00	0.2372E+00
7	0.1698E+02	0.4809E+00	0.1533E+00
8	0.1931E+02	0.4678E+00	0.1237E+00
9	0.2592E+02	0.3803E+00	0.7494E-01
10	0.3032E+02	0.3870E+00	0.6520E-01

SPECTRUM PARAMETERS

CURVE NO 5 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 5

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.47930E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.8611E+00	0.8611E+00
2	0.6550E+01	0.5556E+00	0.5088E+00
3	0.8941E+01	0.5785E+00	0.4487E+00
4	0.1116E+02	0.5595E+00	0.3649E+00
5	0.1323E+02	0.4633E+00	0.2497E+00
6	0.1531E+02	0.5251E+00	0.2209E+00
7	0.1698E+02	0.4717E+00	0.1490E+00
8	0.1931E+02	0.4523E+00	0.1196E+00
9	0.2592E+02	0.3646E+00	0.7105E-01
10	0.3032E+02	0.3754E+00	0.6324E-01

SPECTRUM PARAMETERS

CURVE NO 6 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 6

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64194E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7464E+00	0.7464E+00
2	0.6550E+01	0.4921E+00	0.4446E+00
3	0.8941E+01	0.5375E+00	0.4033E+00
4	0.1116E+02	0.5194E+00	0.3234E+00
5	0.1323E+02	0.4573E+00	0.2340E+00
6	0.1531E+02	0.4935E+00	0.1986E+00
7	0.1698E+02	0.4582E+00	0.1424E+00
8	0.1931E+02	0.4316E+00	0.1142E+00
9	0.2592E+02	0.3589E+00	0.7073E-01
10	0.3032E+02	0.3621E+00	0.6100E-01

SPECTRUM PARAMETERS

CURVE NO 7 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 7

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64384E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7453E+00	0.7453E+00
2	0.6550E+01	0.4918E+00	0.4443E+00
3	0.8941E+01	0.5371E+00	0.4029E+00
4	0.1116E+02	0.5191E+00	0.3231E+00
5	0.1323E+02	0.4573E+00	0.2339E+00
6	0.1531E+02	0.4932E+00	0.1984E+00
7	0.1698E+02	0.4580E+00	0.1423E+00
8	0.1931E+02	0.4314E+00	0.1141E+00
9	0.2592E+02	0.3549E+00	0.7073E-01
10	0.3032E+02	0.3620E+00	0.6098E-01

SPECTRUM PARAMETERS

CURVE NO 8 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 8

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.65102E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7412E+00	0.7412E+00
2	0.6550E+01	0.4907E+00	0.4431E+00
3	0.8941E+01	0.5356E+00	0.4012E+00
4	0.1116E+02	0.5176E+00	0.3216E+00
5	0.1323E+02	0.4570E+00	0.2333E+00
6	0.1531E+02	0.4920E+00	0.1976E+00
7	0.1698E+02	0.4574E+00	0.1420E+00
8	0.1931E+02	0.4306E+00	0.1139E+00
9	0.2592E+02	0.3597E+00	0.7069E-01
10	0.3032E+02	0.3615E+00	0.6090E-01

SPECTRUM PARAMETERS

CURVE NO 9 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 9

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.67043E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7302E+00	0.7469E+00
2	0.6550E+01	0.4876E+00	0.4395E+00
3	0.8941E+01	0.5315E+00	0.3968E+00
4	0.1116E+02	0.5137E+00	0.3175E+00
5	0.1323E+02	0.4561E+00	0.2315E+00
6	0.1531E+02	0.4889E+00	0.1954E+00
7	0.1698E+02	0.4558E+00	0.1418E+00
8	0.1931E+02	0.4287E+00	0.1134E+00
9	0.2592E+02	0.3581E+00	0.7057E-01
10	0.3032E+02	0.3604E+00	0.6071E-01

SPECTRUM PARAMETERS

CURVE NO 10 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FH = 5.10786

INPUT SPECTRUM CURVE NUMBER = 10

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.68094E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7245E+00	0.7245E+00
2	0.6550E+01	0.4862E+00	0.4380E+00
3	0.8941E+01	0.5294E+00	0.3944E+00
4	0.1116E+02	0.5117E+00	0.3155E+00
5	0.1323E+02	0.4556E+00	0.2306E+00
6	0.1531E+02	0.4872E+00	0.1942E+00
7	0.1698E+02	0.4549E+00	0.1410E+00
8	0.1931E+02	0.4276E+00	0.1131E+00
9	0.2592E+02	0.3578E+00	0.7051E-01
10	0.3532E+02	0.3598E+00	0.6061E-01

INTERPOLATED SPECTRAL ACCELERATIONS FOR CORRESPONDING FREQUENCIES & DAMPING RATIOS

FREQUENCY (HZ)	DAMPING RATIO (%)	SPECTRAL ACCELERATIONS SAD	SAV
0.21291E+01	0.64384E+01	0.7453E+00	0.7453E+00
0.65495E+01	0.64194E+01	0.4921E+00	0.4446E+00
0.89327E+01	0.42667E+01	0.5960E+00	0.4695E+00
0.11156E+02	0.47920E+01	0.5595E+00	0.3649E+00
0.13227E+02	0.67975E+01	0.4557E+00	0.2307E+00
0.15312E+02	0.65101E+01	0.4920E+00	0.1976E+00
0.16980E+02	0.67040E+01	0.4558E+00	0.1414E+00
0.19309E+02	0.25670E+01	0.4974E+00	0.1316E+00
0.25920E+02	0.20570E+01	0.4376E+00	0.8623E-01
0.30310E+02	0.20089E+01	0.4303E+00	0.7252E-01

DISPLACEMENT RESPONSE UD (FROM SD)

```
   MODE NO.    1
 0.1039E+01  0.1979E+01  0.1039E+01  0.3695E-24 -0.5522E-25  0.0000E+00
 0.6629E-26  0.4436E-25  0.1280E+01  0.3695E-12 -0.5522E-13  0.0000E+00
-0.5015E-23  0.5620E-23  0.1498E+01 -0.4134E-12  0.7772E-12  0.0000E+00
 0.2098E-24  0.1231E-20  0.1690E+01  [illegible]  0.9533E-12  0.0000E+00
-0.4979E-20 -0.1216E-20  0.1851E+01 -0.3595E-12 -0.1244E-12  0.0000E+00
 0.3053E-21 -0.1216E-20  0.1979E+01 -0.3595E-24 -0.1245E-24  0.0000E+00
 [illegible] -0.7963E-28
   MODE NO.    2
 0.3580E-01 -0.3606E-01  0.3580E-01 -0.2783E-24  0.4170E-25  0.0000E+00
-0.5006E-26  0.3341E-25  0.2409E-01 -0.2783E-12  0.4170E-13  0.0000E+00
 0.4073E-23 -0.8525E-23  0.8310E-02  0.3117E-12 -0.5856E-12  0.0000E+00
-0.1829E-24 -0.9282E-21 -0.8865E-02 -0.4867E-12 -0.7184E-12  0.0000E+00
 0.3676E-20  0.9150E-21 -0.2454E-01  0.2707E-12  0.9386E-13  0.0000E+00
-0.2300E-21  0.9325E-21 -0.3606E-01  0.2707E-24  0.9383E-25  0.0000E+00
-0.2908E-29  0.6082E-28
   MODE NO.    3
 0.3386E-03  0.3146E-03  0.3397E-03 -0.1858E-27  0.2793E-28  0.0000E+00
-0.3353E-29 -0.2230E-28  0.1739E-02 -0.1858E-15  0.2793E-16  0.0000E+00
 0.2969E-26 -0.3252E-26  0.2570E-02  0.2085E-15 -0.3913E-15  0.0000E+00
-0.1784E-27 -0.6207E-24  0.2563E-02 -0.3251E-15 -0.4801E-15  0.0000E+00
 0.7456E-23  0.6116E-24  0.1721E-02  0.1808E-15  0.6271E-16  0.0000E+00
-0.1527E-24  0.6239E-24  0.3146E-03  0.1808E-27  0.6270E-28  0.0000E+00
-0.2611E-32  0.4012E-31
   MODE NO.    4
 0.4032E-02  0.6115E-02  0.4032E-02  0.2573E-25 -0.3889E-26  0.0000E+00
 0.4669E-27  0.3089E-26 -0.1167E-01  0.2573E-13 -0.3889E-14  0.0000E+00
-0.4659E-24  0.5083E-24 -0.2160E-01 -0.2893E-13  0.5424E-13  0.0000E+00
 0.2152E-25  0.8615E-22 -0.2085E-01  0.4505E-13  0.6656E-13  0.0000E+00
-0.3404E-21 -0.8473E-22 -0.9802E-02 -0.2503E-13 -0.8693E-14  0.0000E+00
 0.2131E-22 -0.8664E-22  0.6114E-02 -0.2503E-25 -0.8691E-26  0.0000E+00
 0.3621E-30 -0.5564E-29
   MODE NO.    5
-0.7464E-03 -0.2252E-02 -0.7464E-03 -0.2806E-25  0.4278E-26  0.0000E+00
-0.5135E-27 -0.3369E-26  0.1571E-02 -0.2806E-13  0.4278E-14  0.0000E+00
 0.6063E-24 -0.6542E-24  0.2787E-02  0.3167E-13 -0.5925E-13  0.0000E+00
-0.3032E-25 -0.9430E-22  0.2049E-02 -0.4918E-13 -0.7272E-13  0.0000E+00
 0.3717E-21  0.9245E-22 -0.1300E-03  0.2729E-13  0.9495E-14  0.0000E+00
-0.2327E-22  0.9433E-22 -0.2252E-02  0.2729E-25  0.9492E-26  0.0000E+00
-0.3955E-30  0.6082E-29
   MODE NO.    6
-0.1605E-02  0.5990E-03 -0.1605E-02  0.5946E-25 -0.9237E-26  0.0000E+00
 0.1109E-26  0.7138E-26 -0.1772E-02  0.5946E-13 -0.9237E-14  0.0000E+00
-0.1755E-23  0.1852E-23 -0.3255E-03 -0.6767E-13  0.1260E-12  0.0000E+00
 0.9447E-25  0.2015E-21  0.1407E-02  0.1044E-12  0.1546E-12  0.0000E+00
-0.7901E-21 -0.1962E-21  0.1849E-02 -0.5781E-13 -0.2019E-13  0.0000E+00
 0.4948E-22 -0.2033E-21  0.5990E-03 -0.5781E-25 -0.2019E-25  0.0000E+00
 0.8414E-30 -0.1296E-28
   MODE NO.    7
 0.4653E-03  0.2300E-03  0.4653E-03 -0.8777E-26  0.1426E-26  0.0000E+00
-0.1712E-27 -0.1054E-26  0.3893E-03 -0.8777E-14  0.1426E-14  0.0000E+00
 0.4277E-24 -0.4421E-24 -0.1228E-03  0.1019E-13 -0.1877E-13  0.0000E+00
-0.2485E-25 -0.3034E-22 -0.4927E-03 -0.1550E-13 -0.2209E-13  0.0000E+00
 0.1175E-21  0.2905E-22 -0.3054E-03  0.8528E-14  0.3006E-14  0.0000E+00
-0.7367E-23  0.3078E-22  0.2300E-03  0.8527E-26  0.3006E-26  0.0000E+00
-0.1254E-30  0.1938E-29
   MODE NO.    8
-0.4152E-05  0.3636E-05 -0.4152E-05  0.4118E-27 -0.3277E-28  0.0000E+00
 0.3934E-29  0.4944E-28  0.4315E-04  0.4118E-15 -0.3277E-16  0.0000E+00
 0.7222E-25 -0.7159E-25  0.2793E-04 -0.3673E-15  0.7877E-15  0.0000E+00
-0.4609E-26  0.1095E-23 -0.2764E-04  0.6813E-15  0.9509E-15  0.0000E+00
-0.5031E-23 -0.1312E-23 -0.4330E-04 -0.4035E-15 -0.1266E-15  0.0000E+00
 0.3112E-24 -0.1023E-23  0.3635E-05 -0.4035E-27 -0.1268E-27  0.0000E+00
 0.5224E-32 -0.7696E-31
   MODE NO.    9
 0.2360E-05  0.2040E-05  0.2359E-05 -0.6861E-28  0.9831E-29  0.0000E+00
-0.1180E-29 -0.8237E-29 -0.4765E-04 -0.6861E-16  0.9831E-17  0.0000E+00
-0.2169E-27  0.3595E-28  0.2871E-04  0.7529E-16 -0.1429E-15  0.0000E+00
 0.1754E-27 -0.2243E-24  0.2897E-04 -0.1193E-15 -0.1751E-15  0.0000E+00
 0.8990E-24  0.2249E-24 -0.4755E-04  0.6672E-16  0.2292E-16  0.0000E+00
-0.5620E-25  0.2239E-24  0.2040E-05  0.6672E-28  0.2292E-28  0.0000E+00
-0.9544E-33  0.1459E-31
   MODE NO.   10
 0.3383E-06 -0.3052E-06  0.3382E-06  0.2070E-25 -0.2988E-26  0.0000E+00
 0.3587E-27  0.2485E-26 -0.1002E-04  0.2070E-13 -0.2988E-14  0.0000E+00
 0.3797E-26  0.2970E-25  0.1597E-04 -0.2282E-13  0.4325E-13  0.0000E+00
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-0.5522E-26  0.6795E-22 -0.1596E-04  0.3605E-13  0.5300E-13  0.0000E+00
-0.2718E-21 -0.6795E-22  0.9994E-05 -0.2015E-13 -0.6934E-14  0.0000E+00
 0.1700E-22 -0.6796E-22 -0.3051E-06 -0.2015E-25 -0.6932E-26  0.0000E+00
 0.2805E-30 -0.4418E-29

 DISPLACEMENT RESPONSE UV (FROM SV)

   MODE NO.     1
 0.1740E-02 -0.1807E-02  0.1740E-02 -0.4817E-25  0.7197E-26  0.0000E+00
-0.8640E-27 -0.5782E-26 -0.5658E-02 -0.4817E-13  0.7197E-14  0.0000E+00
 0.6500E-24 -0.7288E-24 -0.1018E-01  0.5389E-13 -0.1013E-12  0.0000E+00
-0.2715E-25 -0.1605E-21 -0.1133E-01 -0.8422E-13 -0.1243E-12  0.0000E+00
 0.6360E-21  0.1585E-21 -0.8669E-02  0.4686E-13  0.1624E-13  0.0000E+00
-0.3980E-22  0.1612E-21 -0.1807E-02  0.4686E-25  0.1623E-25  0.0000E+00
-0.6761E-30  0.1038E-28
   MODE NO.     2
-0.9423E-03  0.6331E-03 -0.9423E-03  0.3769E-25 -0.5654E-26  0.0000E+00
 0.6788E-27  0.4525E-26 -0.1068E-02  0.3769E-13 -0.5654E-14  0.0000E+00
-0.5695E-24  0.6308E-24 -0.6269E-03 -0.4224E-13  0.7934E-13  0.0000E+00
 0.2590E-25  0.1258E-21  0.8170E-04  0.6593E-13  0.9733E-13  0.0000E+00
-0.4980E-21 -0.1240E-21  0.6257E-03 -0.3667E-13 -0.1272E-13  0.0000E+00
 0.3116E-22 -0.1264E-21  0.6.31E-03 -0.3667E-25 -0.1271E-25  0.0000E+00
 0.5295E-30 -0.8132E-29
   MODE NO.     3
 0.3785E-03  0.3728E-03  0.3785E-03 -0.3070E-28  0.4610E-29  0.0000E+00
-0.5534E-30 -0.3686E-29  0.1234E-02 -0.3070E-16  0.4610E-17  0.0000E+00
 0.4756E-27 -0.5067E-27  0.1732E-02  0.3445E-16 -0.6470E-16  0.0000E+00
-0.6135E-28 -0.1026E-24  0.1731E-02 -0.5373E-16 -0.7937E-16  0.0000E+00
 0.4060E-24  0.1011E-24  0.1230E-02  0.2989E-16  0.1037E-16  0.0000E+00
-0.2541E-25  0.1031E-24  0.3729E-03  0.2989E-28  0.1037E-28  0.0000E+00
-0.4315E-33  0.6632E-32
   MODE NO.     4
-0.4401E-03 -0.4994E-03 -0.4401E-03 -0.2308E-26  0.3509E-27  0.0000E+00
-0.4212E-28 -0.2771E-27 -0.7978E-03 -0.2308E-14  0.3509E-15  0.0000E+00
 0.4736E-25 -0.5119E-25 -0.9453E-03  0.2602E-14 -0.4871E-14  0.0000E+00
-0.2214E-26 -0.7747E-23 -0.9909E-03 -0.4044E-14 -0.5978E-14  0.0000E+00
 0.3056E-22  0.7603E-23 -0.8962E-03  0.2245E-14  0.7805E-15  0.0000E+00
-0.1913E-23  0.7796E-23 -0.4994E-03  0.2245E-26  0.7804E-27  0.0000E+00
-0.3251E-31  0.4999E-30
   MODE NO.     5
-0.8561E-05 -0.2753E-04 -0.8560E-05  0.1717E-26 -0.2698E-27  0.0000E+00
 0.3238E-28  0.2062E-27  0.1103E-03  0.1717E-14 -0.2698E-15  0.0000E+00
-0.5872E-25  0.6155E-25  0.2001E-03 -0.1964E-14  0.3648E-14  0.0000E+00
 0.3194E-26  0.5848E-23  0.2398E-03  0.3020E-14  0.4482E-14  0.0000E+00
-0.2286E-22 -0.5670E-23  0.1755E-03 -0.1669E-14 -0.5844E-15  0.0000E+00
 0.1432E-23 -0.5908E-23 -0.2752E-04 -0.1669E-26 -0.5842E-27  0.0000E+00
 0.2436E-31 -0.3755E-30
   MODE NO.     6
 0.6460E-05  0.1793E-04  0.6461E-05 -0.3169E-26  0.5314E-27  0.0000E+00
-0.6380E-28 -0.3805E-27  0.1406E-03 -0.3169E-14  0.5314E-15  0.0000E+00
 0.1991E-24 -0.2044E-24  0.7743E-04  0.3734E-14 -0.6824E-14  0.0000E+00
-0.1163E-25 -0.1112E-22 -0.7180E-04 -0.5620E-14 -0.8401E-14  0.0000E+00
 0.4267E-22  0.1052E-22 -0.1090E-03  0.3078E-14  0.1093E-14  0.0000E+00
-0.2677E-23  0.1132E-22  0.1793E-04  0.3078E-26  0.1092E-26  0.0000E+00
-0.4561E-31  0.7067E-30
   MODE NO.     7
 0.1755E-05 -0.2026E-04  0.1755E-05 -0.3656E-27  0.4115E-28  0.0000E+00
-0.4940E-29 -0.4389E-28 -0.2242E-04 -0.3656E-15  0.4115E-16  0.0000E+00
-0.3152E-25  0.3093E-25 -0.5731E-05  0.3653E-15 -0.7322E-15  0.0000E+00
 0.2078E-26 -0.1088E-23  0.1506E-04 -0.6211E-15 -0.8909E-15  0.0000E+00
 0.4637E-23  0.1183E-23  0.3930E-05  0.3570E-15  0.1176E-15  0.0000E+00
-0.2885E-24  0.1057E-23 -0.2026E-04  0.3570E-27  0.1176E-27  0.0000E+00
-0.4871E-32  0.7326E-31
   MODE NO.     8
 0.3318E-05 -0.1999E-05  0.3317E-05 -0.3106E-27  0.3238E-28  0.0000E+00
-0.3888E-29 -0.3729E-28 -0.1937E-04 -0.3106E-15  0.3238E-16  0.0000E+00
-0.3374E-25  0.3326E-25 -0.1343E-04  0.3020E-15 -0.6151E-15  0.0000E+00
 0.2183E-26 -0.8999E-24  0.1236E-04 -0.5242E-15 -0.7470E-15  0.0000E+00
 0.3903E-23  0.1001E-23  0.1987E-04  0.3036E-15  0.9887E-16  0.0000E+00
-0.2425E-24  0.8664E-24 -0.1999E-05  0.3036E-27  0.9885E-28  0.0000E+00
-0.4089E-32  0.6119E-31
   MODE NO.     9
-0.3516E-06 -0.1991E-06 -0.2515E-06  0.1184E-28 -0.1695E-29  0.0000E+00
 0.2035E-30  0.1422E-29  0.4112E-05  0.1184E-16 -0.1695E-17  0.0000E+00
 0.4249E-28 -0.1731E-28 -0.2445E-05 -0.1300E-16  0.2469E-16  0.0000E+00
-0.1812E-28  0.3873E-25 -0.2489E-05  0.2060E-16  0.3624E-16  0.0000E+00
-0.1552E-24 -0.3884E-25  0.4097E-05 -0.1152E-16 -0.3958E-17  0.0000E+00
 0.9704E-26 -0.3867E-25 -0.1991E-06 -0.1152E-28 -0.3958E-29  0.0000E+00
 0.1647E-33 -0.2520E-32
   MODE NO.    10
-0.1255E-07  0.9977E-08 -0.1255E-07 -0.5331E-27  0.7696E-28  0.0000E+00
-0.9238E-29 -0.6399E-28  0.2603E-06 -0.5331E-15  0.7696E-16  0.0000E+00
-0.9269E-28 -0.7699E-27 -0.4101E-06  0.5876E-15 -0.1114E-14  0.0000E+00
 0.1419E-27 -0.1750E-23  0.4093E-06 -0.9284E-15 -0.1365E-14  0.0000E+00
 0.7000E-23  0.1750E-23 -0.2581E-06  0.5189E-15  0.1786E-15  0.0000E+00
-0.4377E-24  0.1750E-23  0.9974E-08  0.5189E-27  0.1785E-27  0.0000E+00
-0.7430E-32  0.1338E-30

 CORRELATION EPSD

   MODE NO.     1
 0.1000E+01  0.6964E-01  0.7323E-01  0.8279E-01  0.9150E-01  0.9471E-01
 0.9694E-01  0.9709E-01  0.9709E-01  0.9709E-01
   MODE NO.     2
 0.6964E-01  0.1000E+01  0.5615E+00  0.5975E+00  0.6485E+00  0.6687E+00
 0.6834E+00  0.6846E+00  0.6846E+00  0.6846E+00
   MODE NO.     3
 0.7323E-01  0.5615E+00  0.1000E+01  0.6920E+00  0.7230E+00  0.7391E+00
 0.7535E+00  0.7542E+00  0.7542E+00  0.7542E+00
   MODE NO.     4
 0.8279E-01  0.5975E+00  0.6920E+00  0.1000E+01  0.8566E+00  0.8428E+00
 0.8530E+00  0.8527E+00  0.8527E+00  0.8527E+00
   MODE NO.     5
 0.9150E-01  0.6485E+00  0.7230E+00  0.8566E+00  0.1000E+01  0.9462E+00
 0.9383E+00  0.9349E+00  0.9349E+00  0.9349E+00
   MODE NO.     6
 0.9471E-01  0.6687E+00  0.7391E+00  0.8428E+00  0.9462E+00  0.1000E+01
 0.9801E+00  0.9715E+00  0.9715E+00  0.9715E+00
   MODE NO.     7
 0.9694E-01  0.6834E+00  0.7535E+00  0.8530E+00  0.9383E+00  0.9801E+00
 0.1000E+01  0.9968E+00  0.9968E+00  0.9968E+00
   MODE NO.     8
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```
 0.9709E-01  0.6846E+00  0.7542E+00  0.8527E+00  0.9349E+00  0.9715E+00
 0.9968E+00  0.1000E+01  0.1000E+01  0.1000E+01
   MODE NO.     9
 0.9709E-01  0.6846E+00  0.7542E+00  0.8527E+00  0.9349E+00  0.9715E+00
 0.9968E+00  0.1000E+01  0.1000E+01  0.1000E+01
   MODE NO.    10
 0.9709E-01  0.6846E+00  0.7542E+00  0.8527E+00  0.9349E+00  0.9715E+00
 0.9968E+00  0.1000E+01  0.1000E+01  0.1000E+01

 CORRELATION EPSV

   MODE NO.     1
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   MODE NO.     2
 0.0000E+00  0.1000E+01  0.1361E+00  0.1135E+00  0.1469E+00  0.1661E+00
 0.1814E+00  0.1864E+00  0.2360E+00  0.2360E+00
   MODE NO.     3
 0.0000E+00  0.1361E+00  0.1000E+01  0.2589E+00  0.2429E+00  0.2436E+00
 0.2645E+00  0.2717E+00  0.3440E+00  0.3440E+00
   MODE NO.     4
 0.0000E+00  0.1135E+00  0.2589E+00  0.1000E+01  0.4995E+00  0.3878E+00
 0.3883E+00  0.3800E+00  0.4812E+00  0.4812E+00
   MODE NO.     5
 0.0000E+00  0.1469E+00  0.2429E+00  0.4995E+00  0.1000E+01  0.6738E+00
 0.5720E+00  0.4953E+00  0.6226E+00  0.6226E+00
   MODE NO.     6
 0.0000E+00  0.1661E+00  0.2436E+00  0.3878E+00  0.6738E+00  0.1000E+01
 0.8148E+00  0.5890E+00  0.7038E+00  0.7038E+00
   MODE NO.     7
 0.0000E+00  0.1814E+00  0.2645E+00  0.3883E+00  0.5720E+00  0.8148E+00
 0.1000E+01  0.7107E+00  0.7687E+00  0.7687E+00
   MODE NO.     8
 0.0000E+00  0.1864E+00  0.2717E+00  0.3800E+00  0.4953E+00  0.5890E+00
 0.7107E+00  0.1000E+01  0.7898E+00  0.7898E+00
   MODE NO.     9
 0.0000E+00  0.2360E+00  0.3440E+00  0.4812E+00  0.6226E+00  0.7038E+00
 0.7687E+00  0.7898E+00  0.1000E+01  0.1000E+01
   MODE NO.    10
 0.0000E+00  0.2360E+00  0.3440E+00  0.4812E+00  0.6226E+00  0.7038E+00
 0.7687E+00  0.7898E+00  0.1000E+01  0.1000E+01

 CORRELATION MU (FOR CROSS TERM OF RD AND RV)

   MODE NO.     1
 0.0000E+00  0.5255E-01  0.2312E-01  0.2133E-01  0.2414E-01  0.2021E-01
 0.1817E-01  0.6759E-02  0.0000E+00  0.0000E+00
   MODE NO.     2
-0.5255E-01  0.0000E+00  0.1662E+00  0.8799E-01  0.6697E-01  0.4484E-01
 0.3442E-01  0.1302E-01  0.0000E+00  0.0000E+00
   MODE NO.     3
-0.2312E-01 -0.1662E+00  0.0000E+00  0.1780E+00  0.1074E+00  0.6612E-01
 0.4844E-01  0.1905E-01  0.0000E+00  0.0000E+00
   MODE NO.     4
-0.2133E-01 -0.8799E-01 -0.1780E+00  0.0000E+00  0.1731E+00  0.9844E-01
 0.6711E-01  0.2625E-01  0.0000E+00  0.0000E+00
   MODE NO.     5
-0.2414E-01 -0.6697E-01 -0.1074E+00 -0.1731E+00  0.0000E+00  0.1159E+00
 0.8209E-01  0.3295E-01  0.0000E+00  0.0000E+00
   MODE NO.     6
-0.2021E-01 -0.4484E-01 -0.6612E-01 -0.9844E-01 -0.1159E+00  0.0000E+00
 0.7008E-01  0.3695E-01  0.0000E+00  0.0000E+00
   MODE NO.     7
-0.1817E-01 -0.3442E-01 -0.4844E-01 -0.6711E-01 -0.8209E-01 -0.7008E-01
 0.0000E+00  0.1882E-01  0.0000E+00  0.0000E+00
   MODE NO.     8
-0.6759E-02 -0.1302E-01 -0.1905E-01 -0.2625E-01 -0.3295E-01 -0.3695E-01
-0.1882E-01  0.0000E+00  0.0000E+00  0.0000E+00
   MODE NO.     9
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   MODE NO.    10
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 COMBINED VALUES OF COUPLED MODAL DISPLACEMENTS

 DISPLACEMENTS AT PRIMARY SYSTEM CONNETING DOF

 DOF #      DISPLACEMENT

  2         0.1042E+01

  6         0.1977E+01

 DISPLACEMENTS AT SECONDARY SYSTEM DOF

 NODE      DX          DY          DZ         ROT-X       ROT-Y       ROT-Z

  1    0.1042E+01  0.4361E-24  0.6523E-25  0.0000E+00  0.7831E-26  0.5236E-25
  2    0.1281E+01  0.4361E-12  0.6523E-13  0.0000E+00  0.6059E-23  0.6770E-23
  3    0.1498E+01  0.4882E-12  0.9175E-12  0.0000E+00  0.2599E-24  0.1454E-20
  4    0.1688E+01  0.7627E-12  0.1125E-11  0.0000E+00  0.5760E-20  0.1435E-20
  5    0.1849E+01  0.4243E-12  0.1470E-12  0.0000E+00  0.3604E-21  0.1460E-20
  6    0.1977E+01  0.4243E-24  0.1470E-24  0.0000E+00  0.6123E-29  0.9402E-28

 COMBINED VALUES OF COUPLED MEMBER FORCES

 NODE      FX          FY          FZ          MX          MY          MZ
```

1	0.2404E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.2404E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.2176E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.2176E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.1910E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.1910E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.1613E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	0.1613E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	0.1288E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	0.1288E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

COMBINED VALUES OF COUPLED SUPPORT REACTIONS

TYPE	NODE	SUPPORT REACTION
FX	1	0.2404E+03
FY	2	0.2195E-08
FZ	2	0.3169E-09
FY	3	0.2420E-08
FZ	3	0.4587E-08
FY	4	0.3823E-08
FZ	4	0.5620E-08
FY	5	0.2137E-08
FZ	5	0.7354E-09
FX	6	0.1288E+03

```
IDEN JB=1111 IU=1 OU=1 PL=/PIPESTRESS INPUT FILE/
TITL SU=1 CV=2 TI=/CASE-1, 4-DOF PROBLEM/
FREQ FR=33 LO=1 MX=2 TI=/TRUNCATED MODES /
RCAS CA=1 EV=1 TY=1 SU=3 LO=0 FX=1 FY=1 FZ=1
RSEC CA=2 EV=1 SU=1 FX=1 FY=1 FZ=1
SPEC EV=1 ME=1 FP=0 SH=0
     LV=1 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=2 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=3 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=4 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=5 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
     LV=6 DX=1 DY=1 DZ=1
          DI=X
              1.0/1.0  50.0/1.0
          DI=Y
              1.0/1.0  50.0/1.0
          DI=Z
              1.0/1.0  50.0/1.0
MATL CD=3 EC=28.0 SC=75 SH=75 KL=1
ANCH PT=1 LV=1
SPRS PT=2 DX=1.0 AZ=1000.0
LUMP PT=2 MA=38.64
RSUP PT=2 DY=1 LV=2
RSUP PT=2 DZ=1 LV=2
ROTR PT=2 RX=1
ROTR PT=2 RY=1
ROTR PT=2 RZ=1
SPRS PT=3 DX=1.0 AZ=1000.0
LUMP PT=3 MA=38.64
RSUP PT=3 DY=1 LV=3
RSUP PT=3 DZ=1 LV=3
ROTR PT=3 RX=1
ROTR PT=3 RY=1
ROTR PT=3 RZ=1
SPRS PT=4 DX=1.0 AZ=1000.0
LUMP PT=4 MA=38.64
RSUP PT=4 DY=1 LV=4
RSUP PT=4 DZ=1 LV=4
ROTR PT=4 RX=1
ROTR PT=4 RY=1
ROTR PT=4 RZ=1
SPRS PT=5 DX=1.0 AZ=1000.0
LUMP PT=5 MA=38.64
RSUP PT=5 DY=1 LV=5
RSUP PT=5 DZ=1 LV=5
ROTR PT=5 RX=1
ROTR PT=5 RY=1
ROTR PT=5 RZ=1
SPRS PT=6 DX=1.0 AZ=1000.0
ANCH PT=6 LV=6
ENDP
```

```
CREST/ PIPESTRESS RUN FOR CASE-1, TRUNCATED MODES OF S.S.
    6     2     2     6     2     1     0  11  1    1    0    1   1
  900   10    10     1.0E-6        20.5       386.4 0.10
      0.07        0.07        0.07        0.07        0.07       0.07
      0.02        0.02
    2     6
    1    16
100000000. 0.0
0.0        100000000.
1 6
2.10148200 6.18237000 9.9038940 13.0499100 15.4375500 16.9277200
 -0.25778    -0.55066     0.36783     0.13275      0.51865  0.45651
-0.55066    0.51865      0.45651      0.36783     -0.25778  0.13275
 -0.2284E+01 -0.7313E+00  0.4018E+00 -0.2457E+00 -0.1456E+00  0.6836E-01
   10  0.020089
 2.1291.2220 6.5500.8379 8.9410.718911.1560.715613.2270.534515.3120.6440
16.9800.514619.3090.515525.9200.439530.3200.4303
   10  0.020570
 2.1291.2127 6.5500.8284 8.9410.715011.1560.711113.2270.533415.3120.6403
16.9800.513619.3090.513825.9200.437630.3200.4285
   10  0.025668
 2.1291.1228 6.5500.7413 8.9410.678211.1560.668913.2270.520215.3120.6033
16.9800.503619.3090.497425.9200.418530.3200.4137
   10  0.038864
 2.1290.9478 6.5500.6178 8.9410.608711.1560.591713.2270.483915.3120.5476
16.9800.484919.3090.467825.9200.380330.3200.387
   10  0.047920
 2.1290.8611 6.5500.5556 8.9410.578511.1560.559513.2270.463315.3120.5251
16.9800.471719.3090.452325.9200.364630.3200.3754
   10  0.064194
 2.1290.7464 6.5500.4921 8.9410.537511.1560.519413.2270.457315.3120.4935
16.9800.458219.3090.431625.9200.358930.3200.3621
   10  0.064384
 2.1290.7453 6.5500.4918 8.9410.537111.1560.519113.2270.457315.3120.4932
16.9800.458019.3090.431425.9200.358930.3200.3620
   10  0.065102
 2.1290.7412 6.5500.4907 8.9410.535611.1560.517613.2270.457015.3120.4920
16.9800.457419.3090.430625.9200.358730.3200.3615
   10  0.067043
 2.1290.7302 6.5500.4876 8.9410.531511.1560.513713.2270.456115.3120.4889
16.9800.455819.3090.428725.9200.358130.3200.3604
   10  0.068084
 2.1290.7245 6.5500.4862 8.9410.529411.1560.511713.2270.455615.3120.4872
16.9800.454919.3090.427625.9200.357830.3200.3598
```

```
CREST/ PIPESTRESS RUN FOR CASE-1, TRUNCATED MODES OF S.S.

  NUMBER OF PRIMARY DOF                 NP=    6
  NUMBER OF CONNECTING DOF              NC=    2
  NUMBER OF PIPING ANCHORS              NA=    2
  NUMBER OF PRIMARY MODES              NPM=    6
  NUMBER OF SECONDARY MODES            NSM=    2
  NORMALIZATION INDEX FOR P.S.       NORMP=    1
  NORMALIZATION INDEX FOR S.S.       NORMS=    0
  OUTPUT TYPE INDICATOR             IPRINT=    1
  OUTPUT TYPE INDICATOR            IPRINTS=    1
  PRIMARY RESIDUAL MODE KEY          KRESP=    0
  SECONDARY RESIDUAL MODE KEY        KRESS=    1
  NUMBER OF NONZERO IN PRIMARY SYSTEM STIFFNESS MATRIX       NONZP=   11
  GLOBAL EARTHQUAKE DIRECTION  X=1  Y=2(VERTICAL)  Z=3       KFLG=    1

  NUMBER OF ITERATIONS              NITER=  900
  NUMBER OF SPECTRA CURVES         NCURVE=   10
  NUMBER OF SPECTRUM POINTS          MXLP=   10
  ITERATION TOLERANCE                 TOL=  0.1000E-05
  RIGID FREQUENCY                      FR=  20.500
  SPECTRUM FACTOR                    SFTR= 386.400
  CORRELATION TOLERANCE                ET=   0.100

  TOTAL STORAGE REQUIRED  =      22209
  ACTUAL PROVIDED STORAGE  = 550000000

  PRIMARY DAMPING RATIOS

  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01  0.7000E-01

  SECONDARY DAMPING RATIOS

  0.2000E-01  0.2000E-01

  CONECTING DOF # OF PRIMARY SYSTEM

    2    6

  CONECTING DOF # OF PIPING SUPPORTS

    1   16

  STIFFNESS OF CONNECTING DOF OF S.S.

  0.1000E+09  0.0000E+00  0.0000E+00  0.1000E+09

  NODE # OF PIPING ANCHORS

    1    6

  MASS OF EACH SECONDARY DOF

  0.2588E-08  0.2588E-08  0.2588E-08  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+00  0.1000E+00  0.1000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2588E-08  0.2588E-08  0.2588E-08  0.0000E+00  0.0000E+00  0.0000E+00

  ADDRESS OF DIAGONAL ELEMENTS IN S.S. STIFFNESS MATRIX (JDG MATRIX)

    1    3    6   10   15   21   28   36   45   55   66   78   85   93  102  112
  123  135  142  150  159  169  180  192  199  207  216  226  237  249  256  264
  273  283  294  306

  LOWER TRIANGULAR STIFFNESS MATRIX OF SECONDARY SYSTEM

  0.1000E+09  0.0000E+00  0.1000E+09  0.0000E+00  0.0000E+00  0.1000E+09
  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.9996E+10  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.9996E+10 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.2000E+04  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+11
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11
 -0.1000E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+04  0.0000E+00 -0.1000E-03  0.0000E+00  0.0000E+00  0.0000E+00
```



```
 -0.1200E-02  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00 -0.1000E-03
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+11 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.2000E+04  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+11
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11
 -0.1000E+04  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+04  0.0000E+00 -0.1000E-03  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.5000E+04  0.0000E+00  0.0000E+00 -0.1000E-03
  0.0000E+00  0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.5000E+04
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.1000E+11  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+11 -0.1000E+04  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+09  0.0000E+00 -0.1000E-03
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02  0.0000E+00  0.1000E+09
  0.0000E+00  0.0000E+00 -0.1000E-03  0.0000E+00  0.1200E-02  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+09  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1200E-02  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.9996E+10  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00 -0.1200E-02
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.9996E+10

  SECONDARY FREQUENCIES (HZ)

   9.8362808  18.7097518

  STATIC DEFORMATION SHAPE OF S.S. FOR P.S. CONNECTING DOF        2

  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.8000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.6000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E-05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

  STATIC DEFORMATION SHAPE OF S.S. FOR P.S. CONNECTING DOF        6

  0.2000E-05  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.2000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.4000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.6000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.8000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

  UNNORMALIZED MODE SHAPE OF SECONDARY SYSTEM

  0.6180E-05  0.1000E-04
 -0.8759E-31  0.7474E-24
 -0.4080E-31  0.4754E-24
  0.0000E+00  0.0000E+00
  0.4899E-32 -0.5707E-25
 -0.1051E-31  0.8972E-25
  0.6180E+00  0.1000E+01
 -0.8759E-19  0.7474E-12
 -0.4080E-19  0.4754E-12
  0.0000E+00  0.0000E+00
  0.5770E-31  0.1577E-20
 -0.4160E-27 -0.1577E-20
  0.1000E+01  0.6181E+00
 -0.1254E-19  0.1070E-11
 -0.6100E-19 -0.2997E-13
  0.0000E+00  0.0000E+00
  0.4159E-27 -0.9855E-22
 -0.5198E-28 -0.3156E-20
  0.1000E+01 -0.6179E+00
 -0.5963E-19  0.5151E-12
  0.1023E-19 -0.3489E-12
  0.0000E+00  0.0000E+00
 -0.8548E-32 -0.1578E-20
  0.2079E-27 -0.1578E-20
  0.6180E+00 -0.9999E+00
  0.6302E-19 -0.7852E-12
 -0.9885E-19 -0.7367E-14
  0.0000E+00  0.0000E+00
  0.1309E-31  0.2461E-22
  0.1472E-31  0.4733E-20
  0.6180E-05 -0.9999E-05
  0.6303E-31 -0.7951E-24
 -0.9885E-31 -0.7366E-26
  0.0000E+00  0.0000E+00
  0.2999E-37 -0.8723E-30
 -0.2032E-35  0.7951E-28

  NORMALIZED MODE SHAPE OF SECONDARY SYSTEM

  0.1176E-04  0.1902E-04
 -0.1666E-30  0.1422E-23
 -0.7762E-31  0.9042E-24
  0.0000E+00  0.0000E+00
  0.9319E-32 -0.1086E-24
 -0.2000E-31  0.1707E-24
  0.1176E+01  0.1902E+01
 -0.1666E-18  0.1422E-11
 -0.7762E-19  0.9042E-12
```

```
 0.0000E+00  0.0000E+00
 0.1093E-30  0.3000E-20
-0.7913E-27 -0.2999E-20
 0.1902E+01  0.1176E+01
-0.2386E-19  0.2736E-11
-0.1160E-18 -0.5700E-11
 0.0000E+00  0.0000E+00
 0.7911E-27 -0.1875E-21
-0.9887E-28 -0.6002E-20
 0.1902E+01 -0.1175E+01
-0.1134E-18  0.9798E-12
 0.1946E-19 -0.6637E-12
 0.0000E+00  0.0000E+00
-0.1626E-31 -0.3001E-20
 0.3955E-27 -0.3001E-20
 0.1176E+01 -0.1902E+01
 0.1199E-18 -0.1493E-11
-0.1880E-18 -0.1401E-13
 0.0000E+00  0.0000E+00
 0.2490E-31  0.4882E-22
 0.2800E-31  0.9003E-20
 0.1176E-04 -0.1902E-01
 0.1199E-30 -0.1493E-23
-0.1860E-30 -0.1401E-25
 0.0000E+00  0.0000E+00
 0.5704E-37 -0.1659E-29
-0.3865E-15  0.1512E-27

PRIMARY FREQUENCIES (HZ)

 2.1014820   6.1823700   9.9018940  13.0499100  15.4375500  16.9277200

MODE SHAPE OF P.S. AT CONNECTING DOF        2

-0.2578E+00 -0.5507E+00  0.3678E+00  0.1328E+00  0.5187E+00  0.4565E+00

MODE SHAPE OF P.S. AT CONNECTING DOF        6

-0.5507E+00  0.5187E+00  0.4565E+00  0.3678E+00 -0.2578E+00  0.1328E+00

BASE INFLUENCE VECTOR FOR S.S.---UBS

 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

PARTICIPATION FACTOR FOR P.S.---GAMAP

-0.2284E+01 -0.7313E+00  0.4018E+00 -0.2457E+00 -0.1456E+00  0.6836E-01

INPUT SPECTRUM CURVE NUMBER =  1

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.20089E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.1222E+01
        2     0.6550E+01      0.8379E+00
        3     0.8941E+01      0.7189E+00
        4     0.1116E+02      [illegible]6E+00
        5     0.1323E+02      [illegible]5E+00
        6     0.1531E+02      0.6[illegible]0E+00
        7     0.1698E+02      0.5166E+00
        8     0.1931E+02      0.5155E+00
        9     0.2592E+02      0.4395E+00
       10     0.3032E+02      0.4303E+00

INPUT SPECTRUM CURVE NUMBER =  2

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.20570E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.1213E+01
        2     0.6550E+01      0.8284E+00
        3     0.8941E+01      0.7150E+00
        4     0.1116E+02      0.7111E+00
        5     0.1323E+02      0.5334E+00
        6     0.1531E+02      0.6403E+00
        7     0.1698E+02      0.5136E+00
        8     0.1931E+02      0.5138E+00
        9     0.2592E+02      0.4376E+00
       10     0.3032E+02      0.4285E+00

INPUT SPECTRUM CURVE NUMBER =  3

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.25668E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.1123E+01
        2     0.6550E+01      0.7413E+00
        3     0.8941E+01      0.6782E+00
        4     0.1116E+02      0.6689E+00
        5     0.1323E+02      0.5202E+00
        6     0.1531E+02      0.6033E+00
        7     0.1698E+02      0.5036E+00
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        8     0.1931E+02      0.4974E+00
        9     0.2592E+02      0.4185E+00
       10     0.3032E+02      0.4137E+00

INPUT SPECTRUM CURVE NUMBER =  4

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.38864E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.9478E+00
        2     0.6550E+01      0.6178E+00
        3     0.8941E+01      0.6087E+00
        4     0.1116E+02      0.5917E+00
        5     0.1323E+02      0.4839E+00
        6     0.1531E+02      0.5476E+00
        7     0.1698E+02      0.4849E+00
        8     0.1931E+02      0.4578E+00
        9     0.2592E+02      0.3803E+00
       10     0.3032E+02      0.3870E+00

INPUT SPECTRUM CURVE NUMBER =  5

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.47920E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.8611E+00
        2     0.6550E+01      0.5556E+00
        3     0.8941E+01      0.5785E+00
        4     0.1116E+02      0.5595E+00
        5     0.1323E+02      0.4632E+00
        6     0.1531E+02      0.5251E+00
        7     0.1698E+02      0.4717E+00
        8     0.1931E+02      0.4523E+00
        9     0.2592E+02      0.3646E+00
       10     0.3032E+02      0.3754E+00

INPUT SPECTRUM CURVE NUMBER =  6

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.64194E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.7464E+00
        2     0.6550E+01      0.4921E+00
        3     0.8941E+01      0.5375E+00
        4     0.1116E+02      0.5194E+00
        5     0.1323E+02      0.4573E+00
        6     0.1531E+02      0.4935E+00
        7     0.1698E+02      0.4582E+00
        8     0.1931E+02      0.4316E+00
        9     0.2592E+02      0.3589E+00
       10     0.3032E+02      0.3621E+00

INPUT SPECTRUM CURVE NUMBER =  7

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.64385E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.7453E+00
        2     0.6550E+01      0.4918E+00
        3     0.8941E+01      0.5371E+00
        4     0.1116E+02      0.5191E+00
        5     0.1323E+02      0.4573E+00
        6     0.1531E+02      0.4912E+00
        7     0.1698E+02      0.4580E+00
        8     0.1931E+02      0.4314E+00
        9     0.2592E+02      0.3587E+00
       10     0.3032E+02      0.3620E+00

INPUT SPECTRUM CURVE NUMBER =  8

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.65102E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.7412E+00
        2     0.6550E+01      0.4907E+00
        3     0.8941E+01      0.5356E+00
        4     0.1116E+02      0.5176E+00
        5     0.1323E+02      0.4570E+00
        6     0.1531E+02      0.4920E+00
        7     0.1698E+02      0.4574E+00
        8     0.1931E+02      0.4306E+00
        9     0.2592E+02      0.3587E+00
       10     0.3032E+02      0.3615E+00

INPUT SPECTRUM CURVE NUMBER =  9

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.67043E-01

     INPUT      FREQUENCY    INPUT SPECTRAL
     POINT        (HZ)        ACCELERATION
        1     0.2129E+01      0.7302E+00
```

2	0.6550E+01	0.4076E+00
3	0.8941E+01	0.5315E+00
4	0.1116E+02	0.5137E+00
5	0.1323E+02	0.4561E+00
6	0.1531E+02	0.4889E+00
7	0.1698E+02	0.4558E+00
8	0.1931E+02	0.4287E+00
9	0.2592E+02	0.3581E+00
10	0.3032E+02	0.3604E+00

INPUT SPECTRUM CURVE NUMBER = 10

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.68084E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION
1	0.2129E+01	0.7245E+00
2	0.6550E+01	0.4862E+00
3	0.8941E+01	0.5294E+00
4	0.1116E+02	0.5117E+00
5	0.1323E+02	0.4556E+00
6	0.1531E+02	0.4872E+00
7	0.1698E+02	0.4529E+00
8	0.1931E+02	0.4276E+00
9	0.2592E+02	0.3578E+00
10	0.3032E+02	0.3598E+00

A COMPUTER PROGRAM FOR

COUPLED RESPONSE SPECTRUM ANALYSIS OF SECONDARY SYSTEMS

" C R E S T "

DEVELOPED BY

AJAYA KUMAR GUPTA
JING-WEN JAW ABHINAV GUPTA

NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

REVISION-1.0

PARTICIPATION FACTOR FOR S.S ---GAMAS
0.6155E+00 0.5509E-04

MASS RATIOS

PRIMARY SYSTEM MODE 1
0.6191E-01 0.1623E-02

PRIMARY SYSTEM MODE 2
0.9706E-04 0.2165E-01

PRIMARY SYSTEM MODE 3
0.6437E-01 0.1484E-03

PRIMARY SYSTEM MODE 4
0.2374E-01 0.1046E-02

PRIMARY SYSTEM MODE 5
0.6446E-02 0.1142E-01

PRIMARY SYSTEM MODE 6
0.3289E-01 0.1987E-02

C O U P L E D F R E Q U E N C I E S A N D M O D E S H A P E S E X T R A C T I O N

NUMBER OF ITERATIONS TO BE APPLIED FOR COUPLED FREQUENCIES EXTRACTION NITER = 900

CONVERGENCE TOLERANCE FOR COUPLED FREQUENCIES TOL = 0.10000E-05

COUPLED MODE	FREQUENCY (HZ)	DAMPING RATIO (%)
1	0.21326E+01	0.64491E+01
2	0.65535E+01	0.64237E+01
3	0.89326E+01	0.42568E+01
4	0.11170E+02	0.48247E+01
5	0.13238E+02	0.68083E+01
6	0.15321E+02	0.65151E+01
7	0.17007E+02	0.67222E+01
8	0.19309E+02	0.25666E+01

UNIT DISPLACEMENT & UNIT VELOCITY*W RESPONSE

COUPLED MODE NO. 1

1	0.44640E+00	0.11702E-02

2	0.12311E+01	-0.94790E-03
3	0.33169E-06	-0.39657E-07
4	0.26322E-28	0.18970E-27
5	0.16742E-28	0.12071E-27
6	0.00000E+00	0.00000E+00
7	-0.20098E-29	-0.14490E-28
8	0.31599E-29	0.22782E-28
9	0.33170E-01	-0.39658E-02
10	0.26322E-16	0.18970E-15
11	0.16742E-16	0.12071E-15
12	0.00000E+00	0.00000E+00
13	-0.62636E-23	0.42266E-24
14	0.95313E-23	-0.41657E-24
15	0.52073E-01	-0.66796E-02
16	0.37699E-16	0.27180E-15
17	-0.10555E-17	-0.76082E-17
18	0.00000E+00	0.00000E+00
19	0.59573E-24	-0.26040E-25
20	-0.18185E-24	-0.83595E-24
21	0.54193E-01	-0.70010E-02
22	0.18142E-16	0.13080E-15
23	-0.12289E-16	-0.88599E-16
24	0.00000E+00	0.00000E+00
25	0.12708E-22	-0.41926E-24
26	-0.64454E-23	-0.41314E-24
27	0.37425E-01	-0.44888E-02
28	-0.27652E-16	-0.19936E-15
29	-0.25970E-18	-0.18699E-17
30	0.00000E+00	0.00000E+00
31	-0.25104E-24	0.63155E-26
32	-0.12798E-22	0.12299E-23
33	0.37425E-06	-0.44887E-07
34	-0.27146E-28	-0.19936E-27
35	-0.26268E-30	-0.18698E-29
36	0.00000E+00	0.00000E+00
37	0.56838E-32	-0.22205E-33
38	0.55278E-31	0.21014E-31

COUPLED MODE NO. 2

1	0.31748E+00	-0.91006E-02
2	-0.31973E+00	0.60447E-02
3	0.23569E-06	-0.43784E-07
4	0.29803E-26	-0.23190E-26
5	0.13231E-26	-0.14750E-26
6	0.00000E+00	0.00000E+00
7	-0.15884E-27	0.17707E-27
8	0.24973E-27	-0.27839E-27
9	0.23569E-01	-0.43784E-02
10	0.29803E-14	-0.23190E-14
11	0.13231E-14	-0.14750E-14
12	0.00000E+00	0.00000E+00
13	0.67525E-22	-0.61912E-23
14	-0.52160E-22	0.59503E-23
15	0.11239E-01	-0.33475E-02
16	0.29794E-14	-0.33213E-14
17	-0.83403E-16	0.92971E-16
18	0.00000E+00	0.00000E+00
19	-0.32600E-27	0.37191E-24
20	-0.10410E-21	0.12203E-22
21	-0.13810E-01	0.10002E-02
22	0.14337E-14	-0.15983E-14
23	-0.97119E-15	0.10826E-14
24	0.00000E+00	0.00000E+00
25	-0.59901E-22	0.60994E-23
26	-0.36576E-22	0.58097E-23
27	-0.25215E-01	0.28521E-02
28	-0.21853E-14	0.24361E-14
29	-0.20504E-16	0.22857E-16
30	0.00000E+00	0.00000E+00
31	0.33402E-24	-0.79156E-25
32	0.94699E-22	-0.16545E-22
33	-0.25215E-06	0.28521E-07
34	-0.21876E-26	0.24361E-26
35	-0.20504E-28	0.22856E-28
36	0.00000E+00	0.00000E+00
37	-0.58327E-32	0.27062E-32
38	0.24709E-29	-0.30441E-30

COUPLED MODE NO. 3

1	0.45953E-02	0.63990E-02
2	0.42739E-02	0.63044E-02
3	0.18921E-06	0.14397E-06
4	0.85353E-29	0.50647E-29
5	0.54293E-29	0.32216E-29
6	0.00000E+00	0.00000E+00
7	-0.65177E-30	-0.38675E-30
8	0.10247E-29	0.60801E-30
9	0.18932E-01	0.14397E-01
10	0.85353E-17	0.50647E-17
11	0.54292E-17	0.32216E-17
12	0.00000E+00	0.00000E+00
13	0.62021E-25	0.41465E-26
14	0.34739E-24	0.56382E-24
15	0.30258E-01	0.22818E-01
16	0.12227E-16	0.72556E-17
17	-0.34388E-18	-0.20414E-18
18	0.00000E+00	0.00000E+00
19	0.21725E-25	0.25249E-25
20	-0.89992E-24	-0.11567E-23
21	0.30229E-01	0.22811E-01
22	0.58827E-17	0.34907E-17
23	-0.39856E-17	-0.23650E-17
24	0.00000E+00	0.00000E+00
25	0.54135E-24	0.84992E-24
26	-0.83788E-24	-0.11506E-23
27	0.18869E-01	0.14387E-01
28	-0.89673E-17	-0.53210E-17
29	-0.86727E-19	-0.51597E-19

30	0.00000E+00	0.00000E+00
31	-0.18223E-25	-0.26622E-25
32	-0.28760E-24	-0.54484E-24
33	0.18869E-06	0.14387E-06
34	-0.89462E-29	-0.52885E-29
35	-0.86984E-31	-0.51967E-31
36	0.00000E+00	0.00000E+00
37	0.41693E-33	0.60918E-33
38	0.25511E-31	0.33371E-31

COUPLED MODE NO. 4

1	0.92753E-01	-0.15313E-01
2	0.14034E+00	-0.17321E-01
3	-0.36821E-05	-0.11946E-06
4	-0.16467E-26	0.63301E-27
5	-0.10474E-26	0.40262E-27
6	0.00000E+00	0.00000E+00
7	0.12573E-27	-0.48334E-28
8	-0.19768E-27	0.75991E-28
9	-0.36822E+00	-0.11946E-01
10	-0.16467E-14	0.63301E-15
11	-0.10474E-14	0.40262E-15
12	0.00000E+00	0.00000E+00
13	-0.17803E-23	0.20019E-23
14	0.30689E-22	-0.41331E-23
15	-0.60165E+00	-0.18534E-01
16	-0.23585E-14	0.90660E-15
17	0.66069E-16	-0.25379E-16
18	0.00000E+00	0.00000E+00
19	0.19178E-23	-0.25833E-24
20	-0.41634E-23	0.90884E-24
21	-0.59402E+00	-0.19809E-01
22	-0.11349E-14	0.43628E-15
23	0.76879E-15	-0.29553E-15
24	0.00000E+00	0.00000E+00
25	0.40634E-22	-0.53624E-23
26	-0.21968E-22	0.29112E-23
27	-0.75400E+00	-0.14096E-01
28	0.17299E-14	-0.66499E-15
29	0.16307E-16	-0.62398E-17
30	0.00000E+00	0.00000E+00
31	-0.88218E-24	0.13117E-24
32	-0.45303E-22	0.71625E-23
33	-0.35600E-05	-0.14096E-06
34	0.17313E-26	-0.66511E-27
35	0.16296E-28	-0.62379E-29
36	0.00000E+00	0.00000E+00
37	0.20323E-31	-0.32441E-32
38	0.26029E-30	-0.41434E-31

COUPLED MODE NO. 5

1	-0.29446E-01	-0.69833E-03
2	-0.89025E-01	-0.22107E-02
3	0.10477E-05	0.87712E-07
4	0.56031E-26	-0.23498E-26
5	0.35638E-26	-0.14940E-26
6	0.00000E+00	0.00000E+00
7	-0.42783E-27	0.17935E-27
8	0.67264E-27	-0.28197E-27
9	0.10477E+00	0.87713E-02
10	0.56031E-14	-0.23488E-14
11	0.35638E-14	-0.14940E-14
12	0.00000E+00	0.00000E+00
13	0.36361E-22	-0.43340E-23
14	-0.62064E-22	0.41976E-23
15	0.16232E+00	0.17334E-01
16	0.80249E-14	-0.33641E-14
17	-0.22466E-15	0.94170E-16
18	0.00000E+00	0.00000E+00
19	-0.26290E-23	0.26237E-24
20	-0.37349E-22	0.95507E-23
21	0.14465E+00	0.21006E-01
22	0.38618E-14	-0.16189E-14
23	-0.26159E-14	0.10966E-14
24	0.00000E+00	0.00000E+00
25	-0.50917E-22	0.39811E-23
26	-0.98337E-24	0.52149E-23
27	0.72984E-01	0.14630E-01
28	-0.58862E-14	0.24675E-14
29	-0.55255E-16	0.23149E-16
30	0.00000E+00	0.00000E+00
31	0.83537E-24	-0.61204E-25
32	0.78845E-22	-0.13765E-22
33	0.72983E-06	0.14630E-06
34	-0.58875E-26	0.24674E-26
35	-0.55245E-28	0.23148E-28
36	0.00000E+00	0.00000E+00
37	-0.20434E-31	0.23991E-32
38	0.79573E-30	-0.24426E-30

COUPLED MODE NO. 6

1	-0.78340E-01	0.89029E-03
2	0.29227E-01	0.21680E-02
3	-0.28230E-06	0.15269E-06
4	-0.26934E-25	0.11806E-25
5	-0.17131E-25	0.75088E-26
6	0.00000E+00	0.00000E+00
7	0.20566E-26	-0.90142E-27
8	-0.32334E-26	0.14172E-26
9	-0.28230E-01	0.15270E-01
10	-0.26934E-13	0.11806E-13
11	-0.17131E-13	0.75088E-14
12	0.00000E+00	0.00000E+00
13	-0.11484E-21	0.24215E-22
14	0.94163E-22	-0.23978E-22

15	0.17925E-01	0.88456E-02
16	-0.38575E-13	0.16908E-13
17	0.10798E-14	-0.47332E-15
18	0.00000E+00	0.00000E+00
19	0.58854E-23	-0.14987E-23
20	0.21438E-21	-0.49595E-22
21	0.82320E-01	-0.10440E-01
22	-0.18543E-13	0.81366E-14
23	0.12574E-13	-0.55116E-14
24	0.00000E+00	0.00000E+00
25	0.98016E-23	-0.23708E-22
26	0.99520E-22	-0.25371E-22
27	0.93546E-01	-0.15844E-01
28	0.28295E-13	-0.12402E-13
29	0.26547E-15	-0.11636E-15
30	0.00000E+00	0.00000E+00
31	-0.82479E-24	0.38702E-24
32	-0.23892E-21	0.73464E-22
33	0.83546E-06	-0.15844E-06
34	0.28295E-25	-0.12401E-25
35	0.26546E-27	-0.11636E-27
36	0.00000E+00	0.00000E+00
37	0.27516E-31	-0.13309E-31
38	-0.53101E-29	0.12543E-29

COUPLED MODE NO. 7

1	0.29753E-01	0.29627E-03
2	0.14696E-01	-0.42509E-02
3	-0.35832E-07	-0.31364E-07
4	0.10836E-25	-0.39641E-26
5	0.68920E-26	-0.25213E-26
6	0.00000E+00	0.00000E+00
7	-0.82737E-27	0.30268E-27
8	0.13008E-26	-0.47588E-27
9	-0.35832E-02	-0.31365E-02
10	0.10836E-13	-0.39641E-14
11	0.68920E-14	-0.25213E-14
12	0.00000E+00	0.00000E+00
13	0.32631E-22	-0.53060E-23
14	-0.22999E-22	0.54065E-23
15	-0.30024E-01	-0.40861E-03
16	0.15519E-13	-0.56774E-14
17	-0.43442E-15	0.15893E-15
18	0.00000E+00	0.00000E+00
19	-0.14375E-23	0.33794E-24
20	-0.75001E-22	0.11402E-22
21	-0.51287E-01	0.51002E-02
22	0.74681E-14	-0.27321E-14
23	-0.50598E-14	0.18507E-14
24	0.00000E+00	0.00000E+00
25	-0.20585E-22	0.47161E-23
26	-0.42359E-22	0.80532E-23
27	-0.39265E-01	0.53771E-02
28	-0.11363E-13	0.41443E-14
29	-0.10679E-15	0.39071E-16
30	0.00000E+00	0.00000E+00
31	0.58096E-25	-0.87552E-25
32	0.73984E-22	-0.20513E-22
33	-0.39264E-06	0.53771E-07
34	-0.11383E-25	0.41640E-26
35	-0.10679E-27	0.39069E-28
36	0.00000E+00	0.00000E+00
37	-0.53655E-32	0.37705E-32
38	0.19197E-29	-0.34979E-30

COUPLED MODE NO. 8

1	-0.29647E-03	0.90863E-03
2	0.26042E-03	-0.54763E-03
3	0.32872E-07	-0.59805E-07
4	0.25694E-26	-0.46783E-26
5	0.16342E-26	-0.29756E-26
6	0.00000E+00	0.00000E+00
7	-0.19619E-27	0.35721E-27
8	0.30845E-27	-0.56162E-27
9	0.32872E-02	-0.59805E-02
10	0.25694E-14	-0.46783E-14
11	0.16342E-14	-0.29756E-14
12	0.00000E+00	0.00000E+00
13	0.49432E-23	-0.86225E-23
14	-0.50463E-23	0.90011E-23
15	0.20705E-02	-0.39582E-02
16	0.36799E-14	-0.67003E-14
17	-0.10301E-15	0.18756E-15
18	0.00000E+00	0.00000E+00
19	-0.31666E-24	0.56260E-24
20	-0.10110E-22	0.17712E-22
21	-0.20149E-02	0.33511E-02
22	0.17709E-14	-0.32244E-14
23	-0.11995E-14	0.21841E-14
24	0.00000E+00	0.00000E+00
25	-0.50152E-23	0.88928E-23
26	-0.51648E-23	0.90859E-23
27	-0.32605E-02	0.56828E-02
28	-0.26992E-14	0.49146E-14
29	-0.25325E-16	0.46112E-16
30	0.00000E+00	0.00000E+00
31	0.82967E-25	-0.15239E-24
32	0.15662E-22	-0.28091E-22
33	-0.32605E-07	0.56828E-07
34	-0.26991E-26	0.49144E-26
35	-0.25324E-28	0.46110E-28
36	0.00000E+00	0.00000E+00
37	-0.29815E-32	0.54755E-32
38	0.25582E-30	-0.44872E-30

BASE RESPONSE SPECTRA DATA

TOTAL NUMBER OF INPUT SPECTRUM CURVE = 10

MAXIMUM NUMBER OF DEFINITION POINTS IN INPUT SPECTRUM CURVES = 10

SPECTRUM SCALE FACTOR = 0.38640E+03

RIGID FREQUENCY = 0.20500E+02

SPECTRUM PARAMETERS

CURVE NO 1 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 1

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.20009E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1222E+01	0.1222E+01
2	0.6550E+01	0.8379E+00	0.7934E+00
3	0.8941E+01	0.7189E+00	0.6039E+00
4	0.1116E+02	0.7156E+00	0.5209E+00
5	0.1323E+02	0.5345E+00	0.3261E+00
6	0.1531E+02	0.6440E+00	0.3025E+00
7	0.1698E+02	0.5146E+00	0.1662E+00
8	0.1931E+02	0.5155E+00	0.1364E+00
9	0.2592E+02	0.4395E+00	0.8661E-01
10	0.3032E+02	0.4303E+00	0.7149E-01

SPECTRUM PARAMETERS

CURVE NO 2 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 2

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.20570E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1213E+01	0.1213E+01
2	0.6550E+01	0.8284E+00	0.7836E+00
3	0.8941E+01	0.7150E+00	0.5995E+00
4	0.1116E+02	0.7111E+00	0.5163E+00
5	0.1323E+02	0.5334E+00	0.3245E+00
6	0.1531E+02	0.6403E+00	0.3000E+00
7	0.1698E+02	0.5136E+00	0.1658E+00
8	0.1931E+02	0.5138E+00	0.1359E+00
9	0.2592E+02	0.4376E+00	0.8623E-01
10	0.3032E+02	0.4285E+00	0.7219E-01

SPECTRUM PARAMETERS

CURVE NO 3 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 3

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.25668E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.1123E+01	0.1123E+01
2	0.6550E+01	0.7413E+00	0.6960E+00
3	0.8941E+01	0.6782E+00	0.5564E+00
4	0.1116E+02	0.6689E+00	0.4737E+00
5	0.1323E+02	0.5202E+00	0.3076E+00
6	0.1531E+02	0.6033E+00	0.2754E+00
7	0.1698E+02	0.5036E+00	0.1614E+00
8	0.1931E+02	0.4974E+00	0.1316E+00
9	0.2592E+02	0.4185E+00	0.8247E-01
10	0.3032E+02	0.4137E+00	0.6969E-01

SPECTRUM PARAMETERS

CURVE NO 4 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 4

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.38864E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.9478E+00	0.9479E+00
2	0.6550E+01	0.6178E+00	0.5709E+00
3	0.8941E+01	0.6087E+00	0.4824E+00
4	0.1116E+02	0.5917E+00	0.3976E+00
5	0.1323E+02	0.4839E+00	0.2697E+00
6	0.1531E+02	0.5476E+00	0.2372E+00
7	0.1698E+02	0.4849E+00	0.1533E+00
8	0.1931E+02	0.4678E+00	0.1237E+00
9	0.2592E+02	0.3803E+00	0.7494E-01
10	0.3032E+02	0.3870E+00	0.6520E-01

SPECTRUM PARAMETERS

CURVE NO 5 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 5

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.47920E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.8611E+00	0.8611E+00
2	0.6550E+01	0.5556E+00	0.5088E+00
3	0.8941E+01	0.5785E+00	0.4487E+00
4	0.1116E+02	0.5595E+00	0.3649E+00
5	0.1323E+02	0.4633E+00	0.2497E+00
6	0.1531E+02	0.5251E+00	0.2209E+00
7	0.1698E+02	0.4717E+00	0.1480E+00
8	0.1931E+02	0.4523E+00	0.1196E+00
9	0.2592E+02	0.3646E+00	0.7185E-01
10	0.3032E+02	0.3754E+00	0.6324E-01

SPECTRUM PARAMETERS

CURVE NO 6 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 6

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64194E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7264E+00	0.7464E+00
2	0.6550E+01	0.4921E+00	0.4446E+00
3	0.8941E+01	0.5375E+00	0.4033E+00
4	0.1116E+02	0.5194E+00	0.3234E+00
5	0.1323E+02	0.4573E+00	0.2340E+00
6	0.1531E+02	0.4935E+00	0.1986E+00
7	0.1698E+02	0.4582E+00	0.1424E+00
8	0.1931E+02	0.4316E+00	0.1142E+00
9	0.2592E+02	0.3589E+00	0.7073E-01
10	0.3032E+02	0.3621E+00	0.6100E-01

SPECTRUM PARAMETERS

CURVE NO 7 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 7

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.64384E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7453E+00	0.7453E+00
2	0.6550E+01	0.4918E+00	0.4443E+00
3	0.8941E+01	0.5371E+00	0.4029E+00
4	0.1116E+02	0.5191E+00	0.3231E+00
5	0.1323E+02	0.4573E+00	0.2339E+00
6	0.1531E+02	0.4932E+00	0.1984E+00
7	0.1698E+02	0.4580E+00	0.1423E+00
8	0.1931E+02	0.4314E+00	0.1141E+00
9	0.2592E+02	0.3589E+00	0.7073E-01
10	0.3032E+02	0.3620E+00	0.6099E-01

SPECTRUM PARAMETERS

CURVE NO 8 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 8

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE = 0.65102E-01

INPUT POINT	FREQUENCY (HZ)	INPUT SPECTRAL ACCELERATION	CALCULATED VELOCITY SPECTRAL ACCELERATION
1	0.2129E+01	0.7412E+00	0.7412E+00
2	0.6550E+01	0.4907E+00	0.4431E+00
3	0.8941E+01	0.5356E+00	0.4012E+00
4	0.1116E+02	0.5176E+00	0.3216E+00
5	0.1323E+02	0.4570E+00	0.2333E+00
6	0.1531E+02	0.4920E+00	0.1976E+00
7	0.1698E+02	0.4574E+00	0.1420E+00
8	0.1931E+02	0.4306E+00	0.1139E+00
9	0.2592E+02	0.3587E+00	0.7059E-01
10	0.3032E+02	0.3615E+00	0.6090E-01

SPECTRUM PARAMETERS

CURVE NO 9 F1 = 1.83094 F2 = 17.22000 FL = 2.12900 FN = 5.10786

INPUT SPECTRUM CURVE NUMBER = 9

NUMBER OF DEFINITION POINTS = 10

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DAMPING RATIO FOR THIS CURVE =    0.47043E-01

     INPUT     FREQUENCY    INPUT SPECTRAL    CALCULATED VELOCITY
     POINT       (HZ)       ACCELERATION      SPECTRAL ACCELERATION

        1     0.2129E+01     0.7302E+00           0.7469E+00
        2     0.6550E+01     0.4876E+00           0.4396E+00
        3     0.8941E+01     0.5315E+00           0.3948E+00
        4     0.1116E+02     0.5137E+00           0.3175E+00
        5     0.1323E+02     0.4561E+00           0.2315E+00
        6     0.1531E+02     0.4889E+00           0.1954E+00
        7     0.1698E+02     0.4558E+00           0.1414E+00
        8     0.1931E+02     0.4287E+00           0.1134E+00
        9     0.2592E+02     0.3581E+00           0.7057E-01
       10     0.3032E+02     0.3604E+00           0.6071E-01

  SPECTRUM PARAMETERS

  CURVE NO  10  F1 =  1.83094  F2 = 17.22000  FL =  2.12900  FM =  5.10786

INPUT SPECTRUM CURVE NUMBER = 10

NUMBER OF DEFINITION POINTS = 10

DAMPING RATIO FOR THIS CURVE =    0.68064E-01

     INPUT     FREQUENCY    INPUT SPECTRAL    CALCULATED VELOCITY
     POINT       (HZ)       ACCELERATION      SPECTRAL ACCELERATION

        1     0.2129E+01     0.7245E+00           0.7245E+00
        2     0.6550E+01     0.4862E+00           0.4380E+00
        3     0.8941E+01     0.5294E+00           0.3944E+00
        4     0.1116E+02     0.5117E+00           0.3155E+00
        5     0.1323E+02     0.4556E+00           0.2306E+00
        6     0.1531E+02     0.4872E+00           0.1942E+00
        7     0.1698E+02     0.4549E+00           0.1410E+00
        8     0.1931E+02     0.4276E+00           0.1131E+00
        9     0.2592E+02     0.3579E+00           0.7051E-01
       10     0.3032E+02     0.3598E+00           0.6061E-01

INTERPOLATED SPECTRAL ACCELERATIONS FOR CORRESPONDING FREQUENCIES & DAMPING RATIOS

    FREQUENCY     DAMPING RATIO          SPECTRAL ACCELERATIONS
      (HZ)            (%)                  SAD          SAV

   0.21326E+01     0.64491E+01         0.7442E+00    0.7441E+00
   0.65535E+01     0.64237E+01         0.4921E+00    0.4445E+00
   0.89326E+01     0.42566E+01         0.5963E+00    0.4608E+00
   0.11170E+02     0.48247E+01         0.5579E+00    0.3630E+00
   0.13230E+02     0.68083E+01         0.6558E+00    0.2303E+00
   0.15321E+02     0.65151E+01         0.4917E+00    0.1971E+00
   0.17007E+02     0.67222E+01         0.4553E+00    0.1409E+00
   0.19309E+02     0.25666E+01         0.4974E+00    0.1316E+00

DISPLACEMENT RESPONSE UD (FROM SD)

   MODE NO.    1
 0.1035E+01  0.1972E+01  0.1035E+01  0.4216E-28  0.2681E-28  0.0000E+00
-0.3219E-29  0.5061E-29  0.1276E+01  0.4216E-16  0.2681E-16  0.0000E+00
-0.1003E-22  0.1527E-22  0.1493E+01  0.6038E-16 -0.1690E-17  0.0000E+00
 0.9541E-24 -0.2913E-24  0.1684E+01  0.2906E-16 -0.1968E-16  0.0000E+00
-0.2035E-22 -0.1032E-22  0.1844E+01 -0.4429E-16 -0.4159E-18  0.0000E+00
-0.4021E-24 -0.2050E-22  0.1972E+01 -0.4348E-28 -0.4207E-30  0.0000E+00
 0.8783E-32  0.8853E-31
   MODE NO.    2
 0.3560E-01 -0.3586E-01  0.3560E-01  0.2333E-27  0.1484E-27  0.0000E+00
-0.1781E-28  0.2801E-28  0.2396E-01  0.2333E-15  0.1484E-15  0.0000E+00
 0.7573E-23 -0.5850E-23  0.8281E-02  0.3341E-15 -0.9353E-17  0.0000E+00
-0.3656E-24 -0.1167E-22 -0.8821E-02  0.1608E-15 -0.1089E-15  0.0000E+00
-0.6718E-23 -0.4102E-23 -0.2439E-01 -0.2451E-15 -0.2299E-17  0.0000E+00
 0.3755E-25  0.1062E-22 -0.3586E-01 -0.2453E-27 -0.2300E-29  0.0000E+00
-0.6541E-33  0.2771E-30
   MODE NO.    3
 0.3361E-03  0.3126E-03  0.3362E-03  0.6244E-30  0.3971E-30  0.0000E+00
-0.4768E-31  0.7495E-31  0.1716E-02  0.6244E-18  0.3971E-18  0.0000E+00
 0.4537E-26  0.2541E-25  0.2540E-02  0.8944E-18 -0.2518E-19  0.0000E+00
 0.1589E-26 -0.6583E-25  0.2533E-02  0.4303E-18 -0.2916E-18  0.0000E+00
 0.3960E-25 -0.6129E-25  0.1698E-02 -0.6560E-18 -0.6344E-20  0.0000E+00
-0.1333E-26 -0.2105E-25  0.3126E-03 -0.6544E-30 -0.6363E-32  0.0000E+00
 0.3050E-34  0.1866E-32
   MODE NO.    4
 0.4059E-02  0.6142E-02  0.4059E-02 -0.7207E-28 -0.4584E-28  0.0000E+00
 0.5503E-29 -0.8652E-29 -0.1164E-01 -0.7207E-16 -0.4584E-16  0.0000E+00
-0.7792E-24  0.1343E-23 -0.2144E-01 -0.1032E-15  0.2892E-17  0.0000E+00
 0.8394E-25 -0.1822E-24 -0.2069E-01 -0.4967E-16  0.3365E-16  0.0000E+00
 0.1778E-23 -0.9614E-24 -0.9758E-02  0.7571E-16  0.7137E-18  0.0000E+00
-0.3861E-25 -0.1983E-23  0.6142E-02  0.7577E-28  0.7132E-30  0.0000E+00
 0.8895E-33  0.1139E-31
   MODE NO.    5
-0.7495E-03 -0.2266E-02 -0.7495E-03  0.1426E-27  0.9071E-28  0.0000E+00
-0.1089E-25  0.1712E-28  0.1614E-02  0.1426E-15  0.9071E-16  0.0000E+00
 0.9255E-24 -0.1071E-23  0.2776E-02  0.2043E-15 -0.5719E-17  0.0000E+00
-0.6692E-25 -0.9507E-24  0.2023E-02  0.9830E-16 -0.6659E-16  0.0000E+00
-0.1296E-23 -0.2503E-25 -0.1050E-03 -0.1498E-15 -0.1406E-17  0.0000E+00
 0.2126E-25  0.2007E-23 -0.2266E-03 -0.1499E-27 -0.1406E-29  0.0000E+00
-0.5201E-33  0.2025E-31
   MODE NO.    6
-0.1606E-03  0.5992E-03 -0.1606E-02 -0.5522E-27 -0.3512E-27  0.0000E+00
 0.4216E-28 -0.6629E-28 -0.1744E-02 -0.5522E-15 -0.3512E-15  0.0000E+00
-0.2354E-23  0.1931E-23 -0.3565E-03 -0.7909E-15  0.2214E-16  0.0000E+00
 0.1207E-24  0.4395E-23  0.1403E-02 -0.3806E-15  0.2578E-15  0.0000E+00
 0.2010E-23  0.2040E-23  0.1871E-02  0.5801E-15  0.5443E-17  0.0000E+00
-0.1691E-25 -0.4898E-23  0.5992E-03  0.5801E-27  0.5442E-29  0.0000E+00
 0.5441E-33 -0.1089E-30
   MODE NO.    7
 0.4504E-03  0.2264E-03  0.4504E-03  0.1669E-27  0.1062E-27  0.0000E+00
-0.1275E-28  0.2004E-28  0.3568E-03  0.1669E-15  0.1062E-15  0.0000E+00
 0.5026E-24 -0.3543E-24 -0.9696E-04  0.2391E-15 -0.6693E-17  0.0000E+00
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-0.2215E-25 -0.1156E-23 -0.4710E-03  0.1151E-15 -0.7794E-16  0.0000E+00
-0.3171E-24 -0.6526E-24 -0.3321E-03 -0.1754E-15 -0.1645E-17  0.0000E+00
 0.8951E-27  0.1140E-23  0.2254E-03 -0.1754E-27 -0.1645E-29  0.0000E+00
-0.8267E-34  0.2958E-31
   MODE NO.    8
-0.3871E-05  0.3401E-05 -0.3871E-05  0.3355E-28  0.2134E-28  0.0000E+00
-0.2562E-29  0.4028E-29  0.4051E-04  0.3355E-16  0.2134E-16  0.0000E+00
 0.6455E-25 -0.6616E-25  0.2608E-04  0.4805E-16 -0.1345E-17  0.0000E+00
-0.4135E-26 -0.1320E-24 -0.2582E-04  0.2312E-16 -0.1566E-16  0.0000E+00
-0.6549E-25 -0.6744E-25 -0.4063E-04 -0.3525E-16 -0.3307E-18  0.0000E+00
 0.1083E-26  0.2045E-24  0.3400E-05 -0.3525E-28 -0.3307E-30  0.0000E+00
-0.3893E-34  0.3341E-32

  DISPLACEMENT RESPONSE UV (FROM SV)

   MODE NO.    1
 0.1874E-02 -0.1518E-02  0.1874E-02  0.3039E-27  0.1933E-27  0.0000E+00
-0.2320E-28  0.3646E-28 -0.5155E-02  0.3039E-15  0.1933E-15  0.0000E+00
 0.6768E-24 -0.6671E-24 -0.1018E-01  0.4352E-15 -0.1218E-16  0.0000E+00
-0.4170E-25 -0.1239E-23 -0.1137E-01  0.2095E-15 -0.1419E-15  0.0000E+00
-0.6714E-24 -0.6616E-24 -0.8028E-02 -0.3192E-15 -0.2994E-17  0.0000E+00
 0.1011E-25  0.1970E-23 -0.1518E-02 -0.3192E-27 -0.2994E-29  0.0000E+00
-0.3556E-35  0.3365E-31
   MODE NO.    2
-0.9218E-03  0.6123E-03 -0.9218E-03 -0.2349E-27 -0.1494E-27  0.0000E+00
 0.1793E-28 -0.2820E-28 -0.1058E-02 -0.2349E-15 -0.1494E-15  0.0000E+00
-0.6474E-24  0.6027E-24 -0.6472E-03 -0.3264E-15  0.9617E-17  0.0000E+00
 0.3767E-25  0.1236E-23  0.9995E-04 -0.3619E-15  0.1097E-15  0.0000E+00
 0.6178E-24  0.5885E-24  0.5944E-03  0.2468E-15  0.2315E-17  0.0000E+00
-0.8018E-26 -0.1676E-23  0.6123E-03  0.2468E-27  0.2315E-29  0.0000E+00
 0.2741E-33 -0.3083E-31
   MODE NO.    3
 0.3680E-03  0.3626E-03  0.3680E-03  0.2913E-30  0.1853E-30  0.0000E+00
-0.2224E-31  0.3497E-31  0.1195E-02  0.2913E-18  0.1853E-18  0.0000E+00
 0.3535E-27  0.3243E-25  0.1678E-02  0.4173E-18 -0.1174E-19  0.0000E+00
 0.2027E-26 -0.6652E-25  0.1677E-02  0.2008E-18 -0.1360E-18  0.0000E+00
 0.4888E-25 -0.6617E-25  0.1192E-02 -0.3060E-18 -0.2967E-20  0.0000E+00
-0.1533E-26 -0.3133E-25  0.3626E-03 -0.3041E-30 -0.2989E-32  0.0000E+00
 0.3503E-34  0.1919E-32
   MODE NO.    4
-0.4361E-03 -0.4933E-03 -0.4361E-03  0.1803E-28  0.1147E-28  0.0000E+00
-0.1376E-29  0.2164E-29 -0.7877E-03  0.1803E-16  0.1147E-16  0.0000E+00
 0.5701E-25 -0.1177E-24 -0.9068E-03  0.2582E-16 -0.7228E-18  0.0000E+00
-0.7357E-26  0.2588E-25 -0.1075E-02  0.1242E-16 -0.8416E-17  0.0000E+00
-0.1527E-24  0.8291E-25 -0.8833E-03 -0.1894E-16 -0.1777E-18  0.0000E+00
 0.3735E-26  0.2040E-24 -0.4933E-03 -0.1894E-28 -0.1776E-30  0.0000E+00
-0.9238E-34 -0.1180E-32
   MODE NO.    5
-0.8983E-05 -0.2844E-04 -0.8982E-05 -0.3021E-28 -0.1922E-28  0.0000E+00
 0.2307E-29 -0.3627E-29  0.9996E-04 -0.3021E-16 -0.1922E-16  0.0000E+00
-0.5575E-25  0.5400E-25  0.2063E-03 -0.4327E-16  0.1211E-17  0.0000E+00
 0.3375E-26  0.1229E-24  0.2496E-03 -0.2082E-16  0.1411E-16  0.0000E+00
 0.5121E-25  0.6706E-25  0.1637E-03  0.3174E-16  0.2978E-18  0.0000E+00
-0.7883E-27 -0.1773E-24 -0.2844E-04  0.3174E-28  0.2978E-30  0.0000E+00
 0.3086E-34 -0.3142E-32
   MODE NO.    6
 0.7317E-05  0.1765E-04  0.7319E-05  0.9703E-28  0.6172E-28  0.0000E+00
-0.7409E-29  0.1165E-28  0.1349E-03  0.9703E-16  0.6172E-16  0.0000E+00
 0.1990E-24 -0.1971E-24  0.8416E-04  0.1390E-15 -0.3890E-17  0.0000E+00
-0.1232E-25 -0.4076E-24 -0.7229E-04  0.6688E-16 -0.4530E-16  0.0000E+00
-0.1949E-24 -0.2085E-24 -0.1146E-03 -0.1019E-15 -0.9564E-18  0.0000E+00
 0.3017E-26  0.6038E-24  0.1765E-04 -0.1019E-27 -0.9564E-30  0.0000E+00
-0.1094E-33  0.1051E-31
   MODE NO.    7
 0.1413E-05 -0.2027E-04  0.1413E-05 -0.1891E-28 -0.1203E-28  0.0000E+00
 0.1444E-29 -0.2270E-29 -0.1788E-04 -0.1891E-16 -0.1203E-16  0.0000E+00
-0.2531E-25  0.2579E-25 -0.9211E-05 -0.2708E-16  0.7580E-18  0.0000E+00
 0.1632E-26  0.6392E-25  0.1273E-04 -0.1303E-16  0.0827E-17  0.0000E+00
 0.2249E-25  0.3860E-25  0.9799E-05  0.1986E-16  0.1864E-18  0.0000E+00
-0.4176E-27 -0.9784E-25 -0.2027E-04  0.1986E-28  0.1863E-30  0.0000E+00
 0.1798E-34 -0.1668E-32
   MODE NO.    8
 0.3139E-05 -0.1892E-05  0.3139E-05 -0.1616E-28 -0.1028E-28  0.0000E+00
 0.1234E-29 -0.1940E-29 -0.1853E-04 -0.1616E-16 -0.1028E-16  0.0000E+00
-0.2979E-25  0.3109E-25 -0.1255E-04 -0.2315E-16  0.6479E-18  0.0000E+00
 0.1943E-26  0.6119E-25  0.1170E-04 -0.1114E-16  0.7545E-17  0.0000E+00
 0.3072E-25  0.3139E-25  0.1875E-04  0.1698E-16  0.1593E-18  0.0000E+00
-0.5264E-27 -0.9704E-25 -0.1892E-05  0.1698E-28  0.1593E-30  0.0000E+00
 0.1892E-34 -0.1550E-32

  CORRELATION EPSD

   MODE NO.    1
 0.1000E+01  0.7046E-01  0.7403E-01  0.8392E-01  0.9257E-01  0.9581E-01
 0.9808E-01  0.9820E-01
   MODE NO.    2
 0.7046E-01  0.1000E+01  0.5617E+00  0.5986E+00  0.6491E+00  0.6692E+00
 0.6840E+00  0.6849E+00
   MODE NO.    3
 0.7403E-01  0.5617E+00  0.1000E+01  0.6922E+00  0.7229E+00  0.7389E+00
 0.7533E+00  0.7539E+00
   MODE NO.    4
 0.8384E-01  0.5986E+00  0.6922E+00  0.1000E+01  0.8581E+00  0.8440E+00
 0.8543E+00  0.8538E+00
   MODE NO.    5
 0.9257E-01  0.6491E+00  0.7229E+00  0.8581E+00  0.1000E+01  0.9466E+00
 0.9386E+00  0.9353E+00
   MODE NO.    6
 0.9581E-01  0.6692E+00  0.7389E+00  0.8440E+00  0.9466E+00  0.1000E+01
 0.9799E+00  0.9717E+00
   MODE NO.    7
 0.9808E-01  0.6840E+00  0.7533E+00  0.8543E+00  0.9386E+00  0.9799E+00
 0.1000E+01  0.9972E+00
   MODE NO.    8
 0.9820E-01  0.6849E+00  0.7539E+00  0.8538E+00  0.9353E+00  0.9717E+00
 0.9972E+00  0.1000E+01

  CORRELATION EPSV

   MODE NO.    1
 0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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 0.0000E+00  0.0000E+00
   MODE NO.     2
 0.0000E+00  0.1000E+01  0.1363E+00  0.1141E+00  0.1473E+00  0.1665E+00
 0.1820E+00  0.1867E+00
   MODE NO.     3
 0.0000E+00  0.1363E+00  0.1000E+01  0.2586E+00  0.2427E+00  0.2434E+00
 0.2646E+00  0.2715E+00
   MODE NO.     4
 0.0000E+00  0.1141E+00  0.2586E+00  0.1000E+01  0.5023E+00  0.3897E+00
 0.1903E+00  0.3813E+00
   MODE NO.     5
 0.0000E+00  0.1473E+00  0.2427E+00  0.5023E+00  0.1000E+01  0.6751E+00
 0.5729E+00  0.4960E+00
   MODE NO.     6
 0.0000E+00  0.1665E+00  0.2434E+00  0.3897E+00  0.6751E+00  0.1000E+01
 0.8135E+00  0.5896E+00
   MODE NO.     7
 0.0000E+00  0.1820E+00  0.2646E+00  0.3903E+00  0.5729E+00  0.8135E+00
 0.1000E+01  0.7136E+00
   MODE NO.     8
 0.0000E+00  0.1867E+00  0.2715E+00  0.3813E+00  0.4960E+00  0.5896E+00
 0.7136E+00  0.1000E+01

 CORRELATION MD (FOR CROSS TERM OF SD AND RV)

   MODE NO.     1
 0.0000E+00  0.5267E-01  0.2314E-01  0.2144E-01  0.2416E-01  0.2022E-01
 0.1817E-01  0.6761E-02
   MODE NO.     2
-0.5267E-01  0.0000E+00  0.1664E+00  0.8810E-01  0.6694E-01  0.4482E-01
 0.3434E-01  0.1303E-01
   MODE NO.     3
-0.2314E-01 -0.1664E+00  0.0000E+00  0.1774E+00  0.1071E+00  0.6598E-01
 0.4824E-01  0.1905E-01
   MODE NO.     4
-0.2144E-01 -0.8810E-01 -0.1774E+00  0.0000E+00  0.1729E+00  0.9848E-01
 0.6692E-01  0.2630E-01
   MODE NO.     5
-0.2416E-01 -0.6694E-01 -0.1071E+00 -0.1729E+00  0.0000E+00  0.1156E+00
 0.8143E-01  0.3298E-01
   MODE NO.     6
-0.2022E-01 -0.4482E-01 -0.6598E-01 -0.9848E-01 -0.1156E+00  0.0000E+00
 0.6978E-01  0.3693E-01
   MODE NO.     7
-0.1817E-01 -0.3434E-01 -0.4824E-01 -0.6652E-01 -0.8143E-01 -0.6978E-01
 0.0000E+00  0.1776E-01
   MODE NO.     8
-0.6761E-02 -0.1303E-01 -0.1905E-01 -0.2630E-01 -0.3298E-01 -0.3693E-01
-0.1776E-01  0.0000E+00
```

COMBINED VALUES OF COUPLED MODAL DISPLACEMENTS

DISPLACEMENTS AT PRIMARY SYSTEM CONNETING DOF

DOF #	DISPLACEMENT
2	0.1039E+01
6	0.1970E+01

DISPLACEMENTS AT SECONDARY SYSTEM DOF

NODE	DX	DY	DZ	ROT-X	ROT-Y	ROT-Z
1	0.1039E+01	0.4668E-27	0.2969E-27	0.0000E+00	0.3565E-28	0.5604E-28
2	0.1277E+01	0.4668E-15	0.2969E-15	0.0000E+00	0.1180E-22	0.1587E-22
3	0.1493E+01	0.6696E-15	0.1872E-16	0.0000E+00	0.9917E-24	0.1677E-22
4	0.1682E+01	0.3218E-15	0.2179E-15	0.0000E+00	0.2091E-22	0.1130E-22
5	0.1842E+01	0.4904E-15	0.4601E-17	0.0000E+00	0.4043E-24	0.2220E-22
6	0.1970E+01	0.4904E-27	0.4601E-29	0.0000E+00	0.8863E-32	0.2763E-30

COMBINED VALUES OF COUPLED MEMEBER FORCES

NODE	FX	FY	FZ	MX	MY	MZ
1	0.2397E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.2397E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.2170E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.2170E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.1903E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.1903E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.1606E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	0.1606E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	0.1282E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	0.1282E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

COMBINED VALUES OF COUPLED SUPPORT REACTIONS

TYPE	NODE	SUPPORT REACTION
FX	1	0.2397E+03
FX	6	0.1282E+03

Coupled Piping System Analysis Using CREST

1 Theoretical Concepts

1. Conceptually, we model the building (primary system) and the piping (secondary system) as a single structure (coupled system). Because the building and the piping damping values are different, the coupled system becomes nonclassically damped even though the two uncoupled systems are assumed to be classically damped.

2. Displacement vector of the coupled system is transformed in terms of the undamped modal vectors of the two uncoupled systems (reference [2], article 6.2). The effect of missing mass is accounted for by using residual vectors for both the building and the piping (reference [1]).

3. Since the coupled system is nonclassically damped, it can not be analyzed using the undamped mode shapes of the (coupled) system. (That would lead to nonzero off-diagonal terms in the transformed damping matrix).

4. The eigenvectors and eigenvalues of a nonclassically damped system are complex. Complex eigenvalues represent the frequency and the damping of the coupled system. Complex eigenvectors can be represented in terms of two real modal vectors. The relative displacement vector of the coupled system can be represented in terms of the sum of these vectors multiplied by the relative displacement and velocity of the equivalent single degree of freedom systems. (For classically damped system the modal vector that multiplies with relative velocity is identically equal to zero. The resulting response is the same as that calculated using the conventional modal superposition method; reference [2], article 5.2). The process of evaluating the complex modal properties of the coupled system using the modal properties of the uncoupled systems is called modal synthesis. Since, the mass of the piping is much smaller than that of the building, an efficient modal synthesis procedure is used in which the effect of higher order mass ratio terms is ignored (reference [2], article 6.3).

5. In the response spectrum method for nonclassically damped systems, the relative displacement and velocity are replaced by respective maximum values. These maximum

values define two response spectra. One is based on the maximum relative displacement values, and is same as the spectrum used in the conventional analysis. The other is bases on the maximum relative velocity. Both these spectra can be represented in displacement, velocity and acceleration units by appropriately multiplying or dividing the spectral values by the circular frequency (ω, radians/ sec; reference [2], article 5.3) .

6. The relative velocity spectrum is almost equal to the relative displacement spectrum (when represented in the same units) in the intermediate frequency range. In high frequency range, relative velocity spectral values become progressively small compared with the corresponding relative displacement values as the frequency increases. In low frequency range the reverse is the case (reference [2], Fig.5.1).

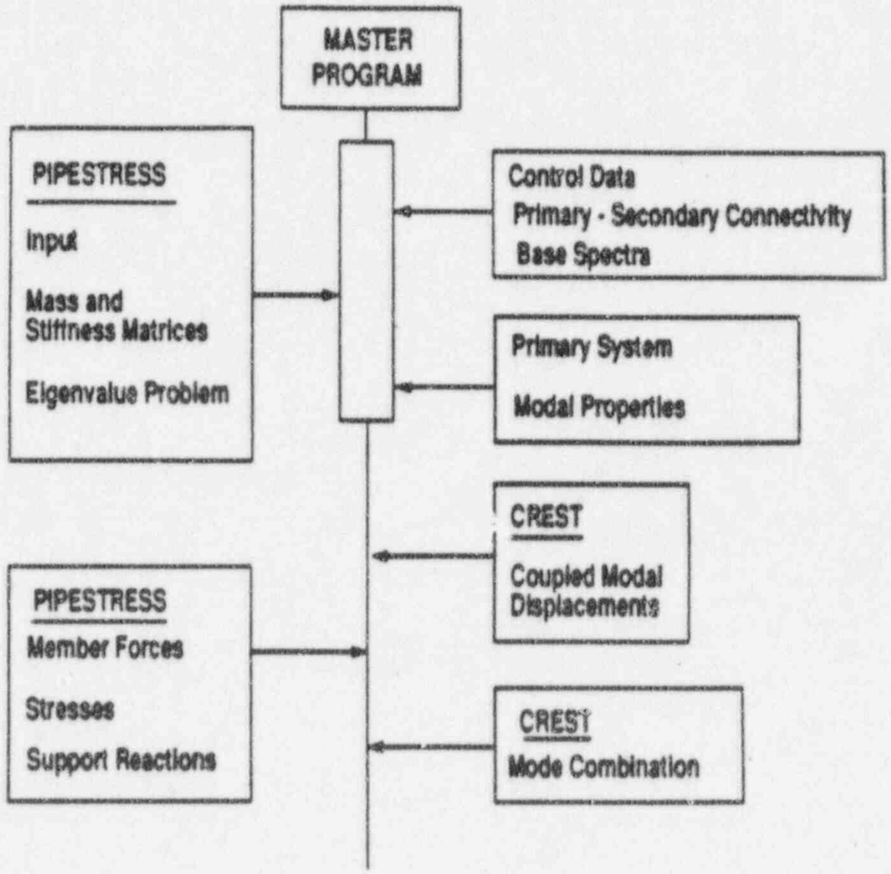
7. The relative velocity spectrum can be evaluated in the same way as the relative displacement spectrum is. However, the current design spectra are exclusively relative displacement based. An empirical method (based on a study with several actual ground motion records) is used to estimate the relative velocity spectrum from a relative displacement spectrum (reference [3]).

8. Two sets of maximum response values are calculated for each mode of the coupled system based on the relative displacement and velocity spectra, respectively. These maximum values are combined using a theoretically developed rule that requires three sets of correlation coefficients. The rule is similar to that used for the conventional response spectrum analysis. Expressions for the correlation coefficients are evaluated by emperically modifying (based on several earthquake motion responses) the theoretically derived formulas(reference [3]).

2 Flow Chart

1. The computer program CREST together with a piping analysis program can be used to perform coupled seismic analysis of piping systems. The piping analysis program used for the coupled analysis of SM piping is PIPESTRESS. The flow chart describes the flow of information between CREST and PIPESTRESS. This flow chart describes a conceptual relationship between the CREST and any piping analysis program. The uncoupled modal properties, mass matrix and the stiffness matrix of the piping system are obtained from PIPESTRESS. This information along with the uncoupled modal

properties of the supporting structure and the response spectra at the base of the structure are used by CREST to evaluate the coupled modal properties and displacements. The coupled modal displacements are then used by PIPESTRESS to give the coupled modal responses in terms of member forces, support reactions and pipe stresses. The modal responses are combined using the appropriate mode combination procedure in CREST.



Generalized Flow Chart for Interaction of CREST and PIPESTRESS

References

[1] A. Gupta and A. K. Gupta. Coupled Analysis of Piping Systems Including the Effect of High Frequency Modes. Report C-NPP-SEP 9/94, Center for Nuclear Power Plant Structures, Equipments and Piping, Department of Civil Engineering, North Carolina State University, Raleigh, NC, 1994.

[2] A. K. Gupta. *Response Spectrum Method In Seismic Analysis and Design of Structures.* CRC Press, Inc., Boca Raton, FL, 1992.

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