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3D-BASIS-M:
Nonlinear Dynamic Analysis of Multiple Building Base Isolated Structures

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Technical Report NCEER-91-0014

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NOTICE

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16. Abstract (Limit: 200 words)

Over the last few years, a special purpose computer program, named 3D-BASIS, has been developed for the dynamic analysis of base isolated building structures. This program was described in NCEER Reports 89-0019 and 91-0005. In this report, 3D-BASIS is extended to the case of multiple buildings with a common isolation basemat, while retaining other features of 3D-BASIS. The program is called 3D-BASIS-M and its development and verification are presented herein. Also included in this report are the User's Guide (Appendix A), Input-Output printout of a case study considered in the report (Appendix B), and the source code (Appendix C) for easy reference.

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PREFACE

The National Center for Earthquake Engineering Research (NCEER) is devoted to the expansion and dissemination of knowledge about earthquakes, the improvement of earthquake-resistant design, and the implementation of seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures and lifelines that are found in zones of moderate to high seismicity throughout the United States.

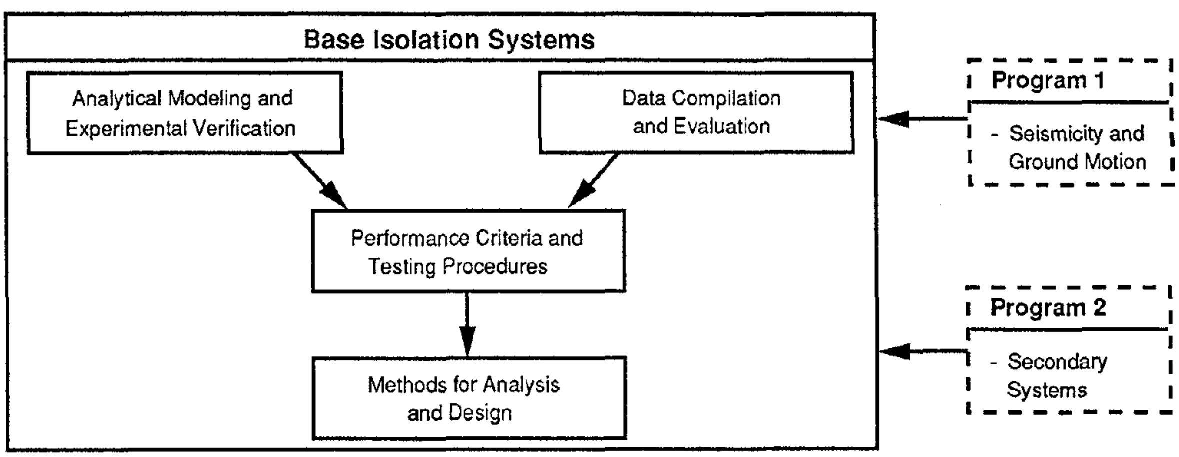
NCEER's research is being carried out in an integrated and coordinated manner following a structured program. The current research program comprises four main areas:

- Existing and New Structures
- Secondary and Protective Systems
- Lifeline Systems
- Disaster Research and Planning

This technical report pertains to Program 2, Secondary and Protective Systems, and more specifically, to protective systems. Protective Systems are devices or systems which, when incorporated into a structure, help to improve the structure's ability to withstand seismic or other environmental loads. These systems can be passive, such as base isolators or viscoelastic dampers; or active, such as active tendons or active mass dampers; or combined passive-active systems.

Passive protective systems constitute one of the important areas of research. Current research activities, as shown schematically in the figure below, include the following:

1. Compilation and evaluation of available data.
2. Development of comprehensive analytical models.
3. Development of performance criteria and standardized testing procedures.
4. Development of simplified, code-type methods for analysis and design.



Over the last few years, a special purpose computer program, named 3D-BASIS, has been developed for the dynamic analysis of base isolated building structures. This program was described in NCEER Reports 89-0019 and 91-0005. In this report, 3D-BASIS is extended to the case of multiple buildings with a common isolation basemat, while retaining other features of 3D-BASIS. The program is called 3D-BASIS-M and its development and verification are presented herein. Also included in this report are the User's Guide (Appendix A), Input-Output printout of a case study considered in the report (Appendix B), and the source code (Appendix C) for easy reference.

ABSTRACT

During the last few years research effort has been devoted to the development of analytical tools for the prediction of the nonlinear seismic response of base isolated structures. Two computer programs emerged out of these research efforts, both capable of analyzing base isolated structures consisting of a single building superstructure.

In cases, however, of long buildings the superstructure may consist of several buildings separated by narrow thermal joints. In these cases, neighboring bearings of adjacent superstructure parts are connected together at their tops to form a large isolation basemat. The isolated structure consists of several buildings on a common basemat with the isolation system below. This situation can not be analyzed with the existing computer programs which are capable of analyzing only a single building superstructure.

One of the aforementioned computer programs is 3D-BASIS which was developed at the State University of New York at Buffalo. An extension of this program which is capable of analyzing multiple building isolated structures has been developed and is described herein. The new program is called 3D-BASIS-M.

This report describes the development and verification of program 3D-BASIS-M. Furthermore, a case study is presented which demonstrates the usefulness of the new computer program.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1

INTRODUCTION

In the last few years, seismic isolation has become an accepted design technique for buildings and bridges (Kelly 1986, Kelly 1988, Buckle et al. 1990). There are two basic types of isolation systems, one typified by elastomeric bearings and the other typified by sliding bearings. Furthermore, combinations of sliding and elastomeric systems and helical steel spring-viscous damper systems have been proposed. Several applications of isolation systems in buildings and bridges have been reported (Kelly 1986, Kelly 1988, Buckle et al. 1990, Makris et al. 1991, Constantinou et al. 1991).

Most isolation systems exhibit strong nonlinear behavior. Furthermore, their force-deflection properties depend on the axial load, bilateral load and rate of loading. Under these conditions, the recently developed requirements for isolated structures (Structural Engineers Association of California 1990) require that dynamic time history analysis be performed for the isolated structure. The analysis should account for the spatial distribution of isolator units, torsion in the structure and the aforementioned force-deflection characteristics of the isolator units.

Existing general purpose nonlinear dynamic analysis programs like DRAIN-2D (Kanaan et al. 1973) and ANSR (Mondkar et al. 1975) can be used in the dynamic analysis of base-isolated structures. These programs are limited to elements exhibiting bilinear hysteretic behavior and can not accurately model sliding bearings. Furthermore, these programs require detailed modeling which is time consuming and not necessary in the analysis of base isolated structures. Special purpose programs for the analysis of base isolated structures have been developed. Program NPAD (Way et al. 1988) has plasticity based nonlinear elements that can be used to model certain types of elastomeric bearings. Program 3D-BASIS (Nagarajaiah et al. 1989, Nagarajaiah et al. 1991) utilizes viscoplasticity based elements that can model a wide range of isolation devices, including elastomeric and sliding bearings. Both programs represent the superstructure by a condensed, three-degrees-of-freedom per floor model. They are limited to the case of a single building on the top of a rigid basemat with the isolation system below.

A situation in which the aforementioned programs can not be used is that of multiple buildings on a common isolation basemat with the isolation system below. This situation occurs in long buildings which are separated by thermal joints. When isolated, the parts of the building are built on separate isolation basemats with the top of neighboring bearings of adjacent parts connected by common steel plates. This results in a complex of several buildings on a common rigid isolation basemat. This type of construction prevents impact of the adjacent parts at the isolation basemat level.

The torsional characteristics of the combined isolation systems of the various parts that form the complex are significantly different than those of the individual parts. The distance of corner bearings from the center of resistance of the combined system is much larger than that of individual parts when unconnected. Thus when the combined system is set into torsional motion, the corner bearings may experience inelastic deformations much earlier than when the individual parts are not connected together. Furthermore, the motion experienced by each of the various parts of the combined system is different. This coupled with the possibility of significantly different dynamic characteristics of each of the buildings above the common basemat may result in out-of-phase motion with possible impact of adjacent parts above the basemat.

To evaluate these possible effects it is necessary to analyze the complete system. Analysis of the individual parts as being unconnected from the rest may result in underestimation of the forces and displacements experienced by the system and may give insufficient information for assessing the possibility of impact of adjacent parts. The above considerations motivated the development of an extended version of computer program 3D-BASIS which is capable of analyzing multiple buildings on a common isolation basemat. The program is called 3D-BASIS-M and its development and verification is presented herein. Furthermore, the program is used in the analysis of a multiple building isolated structure and the results demonstrate the significance of the aforementioned effects and the usefulness of the computer program.

SECTION 2

OVERVIEW OF PROGRAM 3D-BASIS

Program 3D-BASIS (Nagarajaiah et al. 1989, Nagarajaiah et al. 1991) was developed as a public domain special purpose program for the dynamic analysis of base isolated building structures. The basic features of program 3D-BASIS are:

1. Elastic superstructure,
2. Detailed modeling of the isolation system with spatial distribution of isolation elements,
3. Library of isolation elements which include elastomeric and sliding bearing elements with bidirectional interaction effects and rate loading effects,
4. Time domain solution algorithm for very stiff differential equations, and
5. Bidirectional excitation.

These features are maintained in the extended 3D-BASIS-M program.

2.1 Superstructure Modeling

The superstructure is assumed to be remain elastic at all times. Coupled lateral-torsional response is accounted for by maintaining three degrees of freedom per floor, that is two translational and one rotational degrees of freedom. Two options exists in modeling the superstructure :

a. Shear type representation in which the stiffness matrix of the superstructure is internally constructed by the program. It is assumed that the centers of mass of all floors lie on a common vertical axis, floors are rigid and walls and columns are inextensible.

b. Full three dimensional representation in which the dynamic characteristics of the superstructure are determined by other computer programs (e.g. ETABS, Wilson et al. 1975) and imported to program 3D-BASIS. In this way, the extensibility of the vertical elements, arbitrary location of centers of mass and floor flexibility may be implicitly accounted for. Still, however, the model for dynamic analysis maintains three degrees of freedom per floor.

In both options, the data needed for dynamic analysis are the mass and the moment of inertia of each floor, frequencies, mode shapes and associated damping ratios for a number of modes. A minimum of three modes of vibration of the superstructure need to be considered.

2.2 Isolation System Modeling

The isolation system is modeled with spatial distribution and explicit nonlinear force-displacement characteristics of individual isolation devices. The isolation devices are considered rigid in the vertical direction and individual devices are assumed to have negligible resistance to torsion.

Program 3D-BASIS has the following elements for modeling the behavior of an isolation system:

1. Linear Elastic element.

2. Linear viscous element.

3. Hysteretic element for elastomeric bearings and steel dampers.

4. Hysteretic element for sliding bearings.

2.2.1 Linear Elastic Element

This element can be used to approximately simulate the behavior of elastomeric bearings along with the viscous element. All linear elastic devices of the isolation system are combined in a single element having the combined properties of the devices. These are the translational stiffnesses, K_x and K_y and the rotational stiffness, K_r, with respect to the center of mass of the base. Furthermore, eccentricities e_x^B and e_y^B of the center of resistance of the isolation system to the center of mass of the base need to be specified.

The forces exerted at the center of mass of the base by the linear elastic element are given by the following equations (with reference to figure 2.1)

$$F_x = K_x(u_x^B - e_y^B u_r^B) \tag{2.1}$$

$$F_y = K_y(u_y^B + e_x^B u_r^B) \tag{2.2}$$

$$T = K_r u_r^B + K_y e_x^B u_y^B - K_x e_y^B u_x^B \tag{2.3}$$

2.2.2 Linear Viscous Element

The linear viscous element is used to simulated the combined viscous properties of the isolation devices. All linear viscous devices are combined in a single viscous element having translational damping coefficients C_x and C_y and rotational damping coefficient C_r. Furthermore, eccentricities e_x^C and e_y^C are defined in a manner similar to those of the linear elastic element. The forces exerted by the linear viscous element at the center of mass of the base are given by :

$$F_x = C_x(\dot{u}_x^B - e_y^C \dot{u}_r^B) \tag{2.4}$$

$$F_y = C_y(\dot{u}_y^B + e_x^C \dot{u}_r^B) \tag{2.5}$$

$$T = C_r\dot{u}_r^B + C_y e_x^B \dot{u}_y^B - C_x e_y^B \dot{u}_x^B \tag{2.6}$$

2.2.3. Biaxial Hysteretic Element for Elastomeric Bearings and Steel Dampers

The forces along the orthogonal directions which are mobilized during motion of elastomeric bearings or steel dampers are described by :

$$F_x = \alpha\frac{F^y}{Y}U_x + (1-\alpha)F^y Z_x, \qquad F_y = \alpha\frac{F^y}{Y}U_y + (1-\alpha)F^y Z_y \tag{2.7}$$

in which, α is the post-yielding to pre-yielding stiffness ratio, F^y is the yield force and Y is the yield displacement. Z_x and Z_y are dimensionless variables governed by the following system of differential equations which was proposed by Park et al. 1986 :

$$\begin{Bmatrix} \dot{Z}_x & Y \\ \dot{Z}_y & Y \end{Bmatrix} = \begin{Bmatrix} A & \dot{U}_x \\ A & \dot{U}_y \end{Bmatrix} - \begin{pmatrix} Z_x^2(\gamma Sgn(\dot{U}_x Z_x)+\beta) & Z_x Z_y(\gamma Sgn(\dot{U}_y Z_y)+\beta) \\ Z_x Z_y(\gamma Sgn(\dot{U}_x Z_x)+\beta) & Z_y^2(\gamma Sgn(\dot{U}_y Z_y)+\beta) \end{pmatrix} \begin{Bmatrix} \dot{U}_x \\ \dot{U}_y \end{Bmatrix} \tag{2.8}$$

in which A, γ and β are dimensionless quantities that control the shape of the hysteresis loop. Furthermore, U_x, U_y and $\dot{U}_x, \dot{U}_y$ represent the displacements and velocities that occur at the isolation element.

Constantinou et al. 1990 have shown that when motion commences and displacements exceed the yield displacement, equation 2.8 has the following solution provided that $A/(\beta+\gamma)=1$:

$$Z_x = \cos\theta, \qquad Z_y = \sin\theta \tag{2.9}$$

where θ is the angle specifying the instantaneous direction of motion

$$\theta = \tan^{-1}(\dot{U}_y/\dot{U}_x) \tag{2.10}$$

Equations 2.7 and 2.9 indicate that the interaction curve of the element is circular. To demonstrate this, consider motion along an angle θ with respect to the X-axis so that $U_x = U\cos\theta$ and $U_y = U\sin\theta$. By substituting equations 2.9 into equations 2.7 , it is easily shown that the resultant of mobilized forces is independent of θ and given by

$$F = (F_x^2 + F_y^2)^{1/2} = \left\{ (1-\alpha)^2 F^{y^2} + \alpha^2 \frac{F^{y^2}}{Y^2} U^2 + 2\alpha(1-\alpha)\frac{F^{y^2} U}{Y} \right\}^{1/2} \tag{2.11}$$

Equation 2.11 clearly describes a circle. At the lower limit of inelastic behavior, i.e. $U=Y$, equation 2.11 reduces to $F=F^y$ which demonstrates that the yield force of the element is equal to F^y in all directions. This desirable property is possible only when $A/(\beta+\gamma)=1$ (Constantinou et al. 1990). In particular, $A=1$ and $\beta=0.1$ and $\gamma=0.9$ are suggested.

2.2.4. Biaxial Element for Sliding Bearings

For sliding bearings, the mobilized forces are described by the equations (Constantinou et al. 1990)

$$F_x = \mu_s N Z_x, \quad F_y = \mu_s N Z_y \tag{2.12}$$

in which N is the vertical load carried by the bearing and μ_s is the coefficient of sliding friction which depends on the bearing pressure, direction of motion as specified by angle θ (equation 2.10) and the instantaneous velocity of sliding $\dot{U}$

$$\dot{U} = (\dot{U}_x^2 + \dot{U}_Y^2)^{1/2} \tag{2.13}$$

The conditions of separation and reattachment and biaxial interaction are accounted for by variables Z_x and Z_y in equation 2.8.

The coefficient of sliding friction is modeled by the following equation suggested by Constantinou et al. 1990 :

$$\mu_s = f_{\max} - \Delta f \exp(-a \mid \dot{U} \mid) \tag{2.14}$$

in which, $f_{\max}$ is the maximum value of the coefficient of friction and Δf is the difference between the maximum and minimum (at $\dot{U}=0$) values of the coefficient of friction. Furthermore, a is a parameter which controls the variation of the coefficient of friction with velocity. Values of parameters $f_{\max}$, Δf and a for interfaces used in sliding bearings have been reported in Constantinou et al 1990 and Mokha et al. 1991. In general, parameters $f_{\max}$, Δf and a are functions of bearing pressure and angle θ, though the dependency on θ is usually not important.

2.2.5. Uniaxial Model for Elastomeric Bearings, Steel Dampers and Sliding Bearings

The biaxial interaction achieved in the models of equations 2.7 to 2.10 and 2.12 to 2.14 may be neglected by replacing the off-diagonal elements in equation 2.8 by zeroes. This results in two uniaxial independent elements having either sliding or smooth hysteretic behavior in the two orthogonal directions.

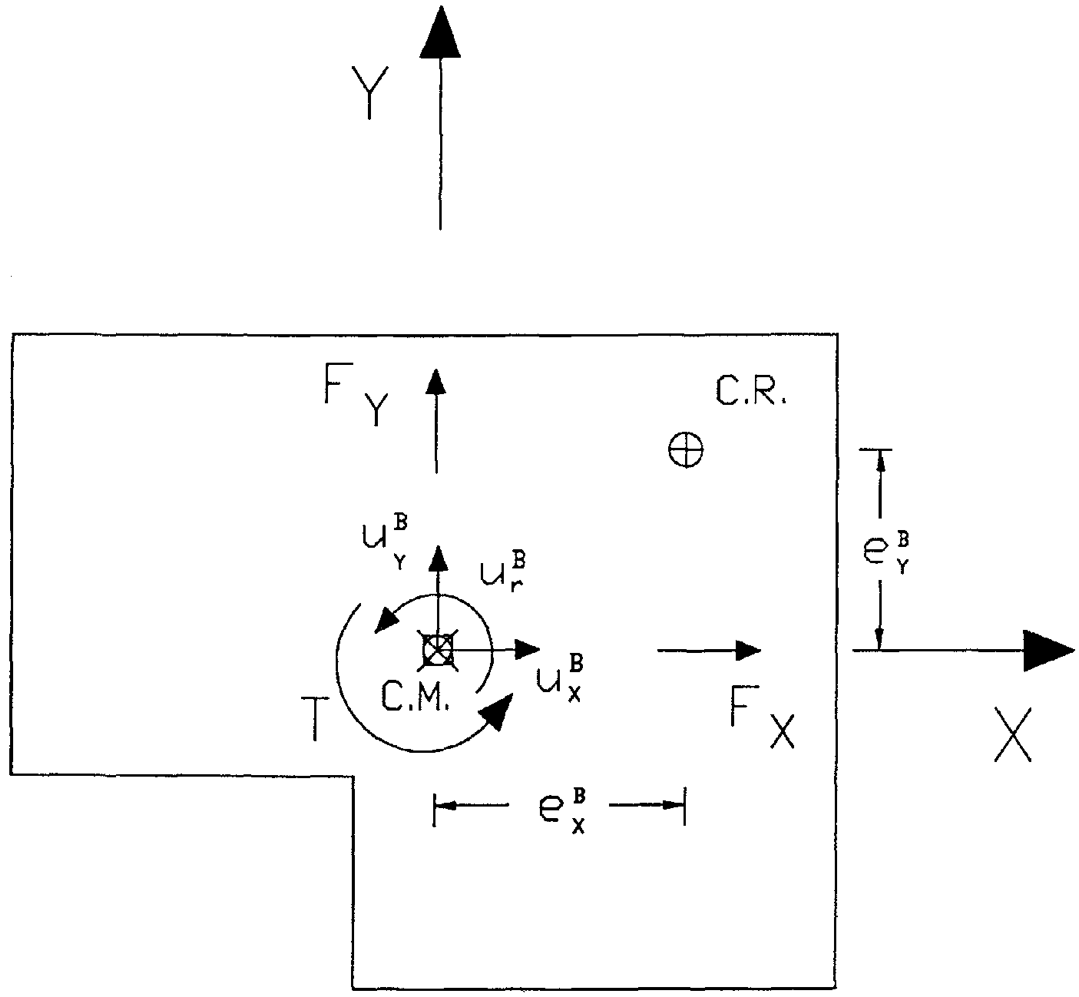


FIGURE 2-1 Displacements and Forces at the Center of Mass of a Rigid Diaphragm.

SECTION 3

PROGRAM 3D-BASIS-M

Program 3D-BASIS-M is an extension of program 3D-BASIS for the dynamic analysis of base isolated structures with multiple building superstructures on a common isolation system. This section concentrates on the development of the equations of motion of the multiple superstructure isolated system and the method of solution.

3.1 Superstructure and Isolation System Configuration

The model used in the analysis of the system (superstructure and isolation system) has been discussed in Section 2 when program 3D-BASIS was overviewed. The same options available in 3D-BASIS are adopted in program 3D-BASIS-M. The basic assumptions considered in modeling the system are :

1. Each floor has three degrees of freedom. These are the X and Y translations and rotation about the center of mass of each floor. These degrees of freedom are attached to the center of mass of each floor.
2. There exists a rigid slab at the level that connects all the isolation elements. The three degrees of freedom at the base are attached to the center of mass of the base.
3. Since three degrees of freedom per floor are required in the three-dimensional representation of the superstructure, the number of modes required for modal reduction is always a multiple of three. The minimum number of modes required is three.

The degrees of freedom of the floors and base and the configuration of a multiple building isolated structure are illustrated in Figures 3-1 and 3-2. A global reference axis is attached to the center of mass of the base (Figure 3-1). The coordinates of the center of mass of each floor of each superstructure are measured with respect to the reference axis. The center of resistance of each floor is located at distances e_{xj} and e_{yj} (eccentricities) with respect to the center of mass of the floor (Figure 3-2). All degrees of freedom (two translations and one rotation at each floor and base) are attached to the centers of mass as shown in Figures 3-1 and 3-2. Displacements and rotations of each floor are measured with respect to the base, whereas those of the base are measured with respect to the ground as shown in Figure 3-3.

As in program 3D-BASIS, the extended 3D-BASIS-M program has two options for the representation of the superstructure. In the first option, each superstructure is represented by a shear building representation. In this representation, the stiffness characteristics of each story of each superstructure are represented by the story translational stiffnesses, rotational stiffness and eccentricities of the story center of resistance with respect to the center of mass of the floor (see Figure 3-2). Furthermore, and only for the shear type representation, it is assumed that the centers of mass of the all floors of each superstructure lie on a common vertical axis. This common vertical axis is located at distances X_j and Y_j with respect to the global reference axis which is located at the center of mass of the base (see Figures 3-1 and 3-2). Of course, the shear representation implies that the floors and the base are rigid and all vertical elements are inextensible.

In the second option, all restrictions of the shear type representation other than that of rigid floor and base are relaxed. A complete three dimensional model of each superstructure is developed externally to program 3D-BASIS-M using appropriate computer programs (e.g. ETABS, Wilson et al. 1975). The dynamic characteristics of each superstructure in terms of frequencies and mode shapes are extracted and imported to program 3D-BASIS-M.

Modeling of the isolation system in program 3D-BASIS-M is identical to that in program 3D-BASIS. Spatial distribution and biaxial interaction effects are included.

3.2 Analytical Model and Equations of Motion

A multiple building base isolated structure and the coordinates (displacements) used in the basic formulation is shown in Figure 3-3. $\mathbf{u}^i_j$ is the relative displacement vector of the center of mass of floor (j) of superstructure (i) with respect to the base, $\mathbf{u}_b$ is the relative displacement vector of the center of mass of the base with respect to the ground and $\mathbf{u}_g$ is the ground displacement vector. Each one of the these vectors has translational X, Y components and rotation about the vertical axis.

The equations of motion of the part of the structure above the base (supertstructures) are :

$$\mathbf{M}_{N_b\times N_b}\ddot{\mathbf{u}}_{N_b\times 1}+\mathbf{C}_{N_b\times N_b}\dot{\mathbf{u}}_{N_b\times 1}+\mathbf{K}_{N_b\times N_b}\mathbf{u}_{N_b\times 1}=-\mathbf{M}_{N_b\times N_b}\mathbf{R}_{N_b\times 3}\{\ddot{\mathbf{u}}_b+\ddot{\mathbf{u}}_g\}_{3\times 1} \tag{3.1}$$

In the above equations **M**, **C** and **K** are the combined mass, damping and stiffness matrices of the superstructure buildings, **u** is the combined displacement vector relative to the base and **R** is a transformation matrix which transfers the base ($\ddot{\mathbf{u}}_b$) and ground ($\ddot{\mathbf{u}}_g$) acceleration vectors from the center of mass of the base to the center of mass of each floor of each superstructure building. The subscripts in equation 3.1 denote the dimension of the matrices. $\mathbf{N_b}$ is the number of degrees of freedom in the part above the base. It is equal to the total number of degrees of freedom minus the three degrees of freedom of the base. In extended form, equations 3.1 are expressed as

$$\begin{pmatrix} \mathbf{m}^1 & 0 & 0 & 0 & 0 \\ 0 & .. & 0 & 0 & 0 \\ 0 & 0 & \mathbf{m}^i & 0 & 0 \\ 0 & 0 & 0 & .. & 0 \\ 0 & 0 & 0 & 0 & \mathbf{m}^{ns} \end{pmatrix} \begin{Bmatrix} \ddot{\mathbf{u}}^1 \\ .. \\ \ddot{\mathbf{u}}^i \\ .. \\ \ddot{\mathbf{u}}^{ns} \end{Bmatrix} + \begin{pmatrix} \mathbf{c}^1 & 0 & 0 & 0 & 0 \\ 0 & .. & 0 & 0 & 0 \\ 0 & 0 & \mathbf{c}^i & 0 & 0 \\ 0 & 0 & 0 & .. & 0 \\ 0 & 0 & 0 & 0 & \mathbf{c}^{ns} \end{pmatrix} \begin{Bmatrix} \dot{\mathbf{u}}^1 \\ .. \\ \dot{\mathbf{u}}^i \\ .. \\ \dot{\mathbf{u}}^{ns} \end{Bmatrix}$$

$$+ \begin{pmatrix} \mathbf{k}^1 & 0 & 0 & 0 & 0 \\ 0 & .. & 0 & 0 & 0 \\ 0 & 0 & \mathbf{k}^i & 0 & 0 \\ 0 & 0 & 0 & .. & 0 \\ 0 & 0 & 0 & 0 & \mathbf{k}^{ns} \end{pmatrix} \begin{Bmatrix} \mathbf{u}^1 \\ .. \\ \mathbf{u}^i \\ .. \\ \mathbf{u}^{ns} \end{Bmatrix} = -\begin{pmatrix} \mathbf{m}^1 & 0 & 0 & 0 & 0 \\ 0 & .. & 0 & 0 & 0 \\ 0 & 0 & \mathbf{m}^i & 0 & 0 \\ 0 & 0 & 0 & .. & 0 \\ 0 & 0 & 0 & 0 & \mathbf{m}^{ns} \end{pmatrix} \begin{Bmatrix} \mathbf{r}^1 \\ .. \\ \mathbf{r}^i \\ .. \\ \mathbf{r}^{ns} \end{Bmatrix} [\ddot{\mathbf{u}}_b + \ddot{\mathbf{u}}_g] \tag{3.2}$$

In equations 3.2, $\mathbf{m}^i$, $\mathbf{c}^i$, and $\mathbf{k}^i$ and the mass, damping and stiffness matrices of superstructure (i). These matrices are of dimensions $3nf^i$ where nf^i is the number of floors in superstructure (i). It should be noted that matrices $\mathbf{m}^i$ are diagonal and contain the mass and mass moment of inertia of each floor. The range of index (i) varies between one and ns, the number of superstructures. $\mathbf{u}^i$ is the displacement vector of superstructure (i) relative to the base. Further, $\mathbf{r}^i$ is the transformation matrix which transfers the base and ground acceleration vectors from the center of mass of the base to the center of mass of each floor of superstructure (i) :

$$\mathbf{r}^i = \begin{pmatrix} \mathbf{R}_{nf^i} \\ .. \\ \mathbf{R}_{j^i} \\ .. \\ \mathbf{R}_1 \end{pmatrix} \tag{3.3}$$

where

$$\mathbf{R}_{j^i} = \begin{pmatrix} 1 & 0 & -Y_j \\ 0 & 1 & X_j \\ 0 & 0 & 1 \end{pmatrix} \tag{3.4}$$

in which $\mathbf{X}_j$, $\mathbf{Y}_j$ are the distances to the center of mass of floor (j) of superstructure (i) from the center of mass of the base (see Figure 3-2).

The equilibrium equation of dynamic equilibrium of the base is:

$$\mathbf{R}^T_{3\times N_b}\mathbf{M}_{N_b\times N_b}\{\ddot{\mathbf{u}}_{N_b\times 1}+\mathbf{R}_{N_b\times 3}\{\ddot{\mathbf{u}}_b+\ddot{\mathbf{u}}_g\}_{3\times 1}\}+\mathbf{M}_{b_{3\times 3}}\{\ddot{\mathbf{u}}_b+\ddot{\mathbf{u}}_g\}_{3\times 1}+\mathbf{C}_{b_{3\times 3}}\{\dot{\mathbf{u}}_b\}_{3\times 1}+\mathbf{K}_{b_{3\times 3}}\{\mathbf{u}_b\}_{3\times 1}+\{\mathbf{f}_N\}_{3\times 1}=0 \tag{3.5}$$

in which $\mathbf{M}_b$ is the mass matrix of the base, $\mathbf{C}_b$ is the resultant damping matrix of viscous elements of the isolation system, $\mathbf{K}_b$ is the resultant stiffness matrix of elastic elements of the isolation system at the center of mass of the base and $\mathbf{f}_N$ is a vector containing the forces mobilized in the nonlinear elements of the isolation system.

Employing modal reduction :

$$\mathbf{u}^i_{3nf^i}=\Phi^i_{3nf^i\times ne^i}\mathbf{Y}^i_{ne^i\times 1} \tag{3.6}$$

where Φ^i is the orthonormal modal matrix relative to the mass matrix of superstructure (i), $\mathbf{Y}^i$ is the modal displacement vector of superstructure (i) relative to the base and ne^i is the number of eigenvectors of superstructure (i) retained in the analysis.

Combining equations 3.2 to 3.6, the following equation is derived

$$\begin{pmatrix} \mathbf{I} & \Phi^T\mathbf{M}\mathbf{R} \\ \mathbf{R}^T\mathbf{M}\Phi & \mathbf{R}^T\mathbf{M}\mathbf{R}+\mathbf{M}_b \end{pmatrix}_{(M_b+3)\times(M_b+3)}\begin{Bmatrix}\ddot{\mathbf{Y}} \\ \ddot{\mathbf{u}}_b\end{Bmatrix}_{(M_b+3)\times 1}+\begin{pmatrix} 2\xi\omega & \mathbf{0} \\ \mathbf{0} & \mathbf{C}_b \end{pmatrix}_{(M_b+3)\times(M_b+3)}\begin{Bmatrix}\dot{\mathbf{Y}} \\ \dot{\mathbf{u}}_b\end{Bmatrix}_{(M_b+3)\times 1}$$

$$+\begin{pmatrix} \omega^2 & \mathbf{0} \\ \mathbf{0} & \mathbf{K}_b \end{pmatrix}_{(M_b+3)\times(M_b+3)}\begin{Bmatrix}\mathbf{Y} \\ \mathbf{u}_b\end{Bmatrix}_{(M_b+3)\times 1}+\begin{Bmatrix}\mathbf{0} \\ \mathbf{f}_N\end{Bmatrix}_{(M_b+3)\times 1}=-\begin{Bmatrix}\Phi^T\ \mathbf{M}\ \mathbf{R} \\ \mathbf{R}^T\ \mathbf{M}\ \mathbf{R}\ +\ \mathbf{M}_b\end{Bmatrix}_{(M_b+3)\times 3}\{\ddot{\mathbf{u}}_g\}_{3\times 1} \tag{3.7}$$

in which M_b is the total number of eigenvectors for all superstructures retained in the analysis, and ξ and ω are the matrices of modal damping and eigenvalues for all eigenvectors of all superstructures, respectively. Furthermore, **I** denotes an identity matrix and **0** denotes a null matrix.

Equation 3.7 may be written as :

$$\tilde{M}\ddot{\tilde{y}}_t+\tilde{C}\dot{\tilde{y}}_t+\tilde{K}\tilde{y}_t+f_t=\tilde{P}_t \tag{3.8}$$

in which subscript t denotes that the equation is valid at time t. Extending equation 3.8 to time $t+\Delta t$, where Δt is the time step, we have

$$\tilde{M}\ddot{\tilde{y}}_{t+\Delta t}+\tilde{C}\dot{\tilde{y}}_{t+\Delta t}+\tilde{K}\tilde{y}_{t+\Delta t}+f_{t+\Delta t}=\tilde{P}_{t+\Delta t} \tag{3.9}$$

Taking the difference between equations 3.8 and 3.9 gives the incremental equation of equilibrium

$$\tilde{M}\Delta\ddot{\tilde{y}}_{t+\Delta t}+\tilde{C}\Delta\dot{\tilde{y}}_{t+\Delta t}+\tilde{K}\Delta\tilde{y}_{t+\Delta t}+\Delta f_{t+\Delta t}=\tilde{P}_{t+\Delta t}-\tilde{M}\ddot{\tilde{y}}_t-\tilde{C}\dot{\tilde{y}}_t-\tilde{K}\tilde{Y}_t-f_t \tag{3.10}$$

Accordingly, the response of the multiple building superstructure and base is represented by the modal coordinate vectors $\ddot{\tilde{y}}_t$, $\dot{\tilde{y}}_t$ and $\tilde{y}_t$.

3.3 Method of Solution

The modified Newton-Raphson solution procedure with tangent stiffness representation is widely used in nonlinear dynamic analysis programs and rapidly converges to the correct solution when the nonlinearities of the system are mild. However the method fails to converge when the nonlinearities are severe (Stricklin et al.

1971, Stricklin et al. 1977). Additional studies by Nagarajaiah et al. 1989 reported the failure of this method to converge when nonlinearities stemmed from sliding isolation devices.

The pseudo-force method is used in the present study as originally adopted in the program 3D-BASIS by Nagarajaiah et al. 1989. This method has been used for nonlinear dynamic analysis of shells by Stricklin et al. 1971 and by Darbre and Wolf 1988 for soil structure interaction problems. More details and the advantages of this method in the analysis of base isolated structures have been presented by Nagarajaiah et al. 1989, 1990a, 1990b and 1991. In the pseudo-force method, the incremental nonlinear force vector $\Delta f_{t+\Delta t}$ in equation 3.10 is unknown. It is, thus brought on the right hand side of equation 3.10 and treated as pseudo-force vector.

3.4 Solution Algorithm

The differential equations of motion are integrated in the incremental form of equations 3.10. The solution involves two stages :

(i) Solution of the equations of motion using the unconditionally stable (for both positive and negative tangent stiffness - Cheng 1988) Newmark's constant-average-acceleration method (Newmark 1959).

(ii) Solution of the differential equations governing the nonlinear behavior of the isolation elements using an unconditionally stable semi-implicit Runge-Kutta method suitable for stiff differential equations (Rosenbrock 1964). The solution algorithm of the pseudo force method with iteration is presented in Table 3-I.

3.4.2 Varying Time Step for Accuracy

The solution algorithm has the option of using a constant time step or variable time step. The time step is reduced from Δt_{slip} (time step at high velocity) to a fraction of its value at low velocities to maintain accuracy in sliding isolated structures. The time step is reduced based on the magnitude of the resultant velocity at the center of mass of the base :

$$\Delta t_{stick}=\Delta t_{slip}\left[1-\exp\left(-\frac{\dot{u}^2}{\alpha}\right)\right] \tag{3.11}$$

in which, $\dot{u}$ is the resultant velocity at the center of mass of the base, Δt_{stick} is the reduced time step when the base velocity is low ($\Delta t_{slip} > \Delta t_{stick} > \Delta t_{slip}/nl$, nl is an integer to introduce the desired reduction) and α is a constant to define the range of velocity over which the reduction takes place. It is important to note that the reduction in the time step is not continuous as indicated by equation 3.11 but rather at discrete intervals of velocity. This procedure is adopted for computational efficiency.

TABLE 3-1 SOLUTION ALGORITHM

A. Initial Conditions:

1. Form stiffness matrix $\tilde{\mathbf{K}}$, mass matrix $\tilde{\mathbf{M}}$, and damping matrix $\tilde{\mathbf{C}}$. Initialize $\tilde{\mathbf{u}}_0$, $\dot{\tilde{\mathbf{u}}}_0$ and $\ddot{\tilde{\mathbf{u}}}_0$.
2. Select time step Δt, set parameters $\delta=0.25$ and $\theta=0.5$, and calculate the integration constants:

$$a_1=\frac{1}{\delta(\Delta t)^2};\quad a_2=\frac{1}{\delta\Delta t};\quad a_3=\frac{1}{2\delta};\quad a_4=\frac{\theta}{\delta\Delta t};\quad a_5=\frac{\theta}{\delta};\quad a_6=\Delta t(\frac{\theta}{2\delta}-1)$$

3. Form the effective stiffness matrix $\mathbf{K}^*=a_1\tilde{\mathbf{M}}+a_4\tilde{\mathbf{C}}+\tilde{\mathbf{K}}$
4. Triangularize $\mathbf{K}^*$ using Gaussian elimination (only if the time step is different from the previous step).

B. Iteration at each time step:

1. Assume the pseudo-force $\Delta f^i_{t+\Delta t}$ = 0 in iteration i = 1.
2. Calculate the effective load vector at time $t+\Delta t$:

$$\mathbf{P}^*_{t+\Delta t}=\Delta\tilde{\mathbf{P}}_{t+\Delta t}-\Delta f^i_{t+\Delta t}+\tilde{\mathbf{M}}(a_2\dot{\tilde{\mathbf{u}}}_t+a_3\ddot{\tilde{\mathbf{u}}}_t)+\tilde{\mathbf{c}}(a_5\dot{\tilde{\mathbf{u}}}_t+a_6\ddot{\tilde{\mathbf{u}}}_t)$$

$$\Delta\tilde{\mathbf{P}}_{t+\Delta t}=\tilde{\mathbf{P}}_{t+\Delta t}-(\tilde{\mathbf{M}}\ddot{\tilde{\mathbf{u}}}_t+\tilde{\mathbf{C}}\dot{\tilde{\mathbf{u}}}_t+\tilde{\mathbf{K}}\tilde{\mathbf{u}}_t+\mathbf{f}_t)$$

3. Solve for displacements at time $t+\Delta t$: $\mathbf{K}^*\Delta\mathbf{u}^i_{t+\Delta t}=\mathbf{P}^*_{t+\Delta t}$

4. Update the state of motion at time $t+\Delta t$:

$$\ddot{\tilde{\mathbf{u}}}_{t+\Delta t}=\ddot{\tilde{\mathbf{u}}}_t+a_1\Delta\tilde{\mathbf{u}}^i_{t+\Delta t}-a_2\dot{\tilde{\mathbf{u}}}_t-a_3\ddot{\tilde{\mathbf{u}}}_t;\quad \dot{\tilde{\mathbf{u}}}_{t+\Delta t}=\dot{\tilde{\mathbf{u}}}_t+a_4\Delta\tilde{\mathbf{u}}^i_{t+\Delta t}-a_5\dot{\tilde{\mathbf{u}}}_t-a_6\ddot{\tilde{\mathbf{u}}}_t;\quad \tilde{\mathbf{u}}_{t+\Delta t}=\tilde{\mathbf{u}}_t+\Delta\tilde{\mathbf{u}}^i_{t+\Delta t}$$

5. Compute the state of motion at each bearing and solve for the nonlinear force at each bearing using semi-implicit Runge-Kutta method.
6. Compute the resultant nonlinear force vector at the center of mass of the base $\Delta f^{i+1}_{t+\Delta t}$.
7. Compute

$$Error=\frac{\|\Delta f^{i+1}_{t+\Delta t}-\Delta f^i_{t+\Delta t}\|}{Ref.\mathrm{Max}.Moment}$$

Where $\|.\|$ is the euclidean norm

8. If Error $\geq$ tolerance, further iteration is needed, iterate starting form step B-1 and use $\Delta f^{i+1}_{t+\Delta t}$ as the pseudo-force and the state of motion at time t, $\tilde{\mathbf{u}}_t$, $\dot{\tilde{\mathbf{u}}}_t$ and $\ddot{\tilde{\mathbf{u}}}_t$.
9. If Error $\leq$ tolerance, no further iteration is needed, update the nonlinear force vector:

$$\mathbf{f}_{t+\Delta t}=\mathbf{f}_t+\Delta\mathbf{f}^{i+1}_{t+\Delta t}$$

reset time step if necessary, go to step B-1 if the time step is not reset or go to A-2 if the time step is reset.

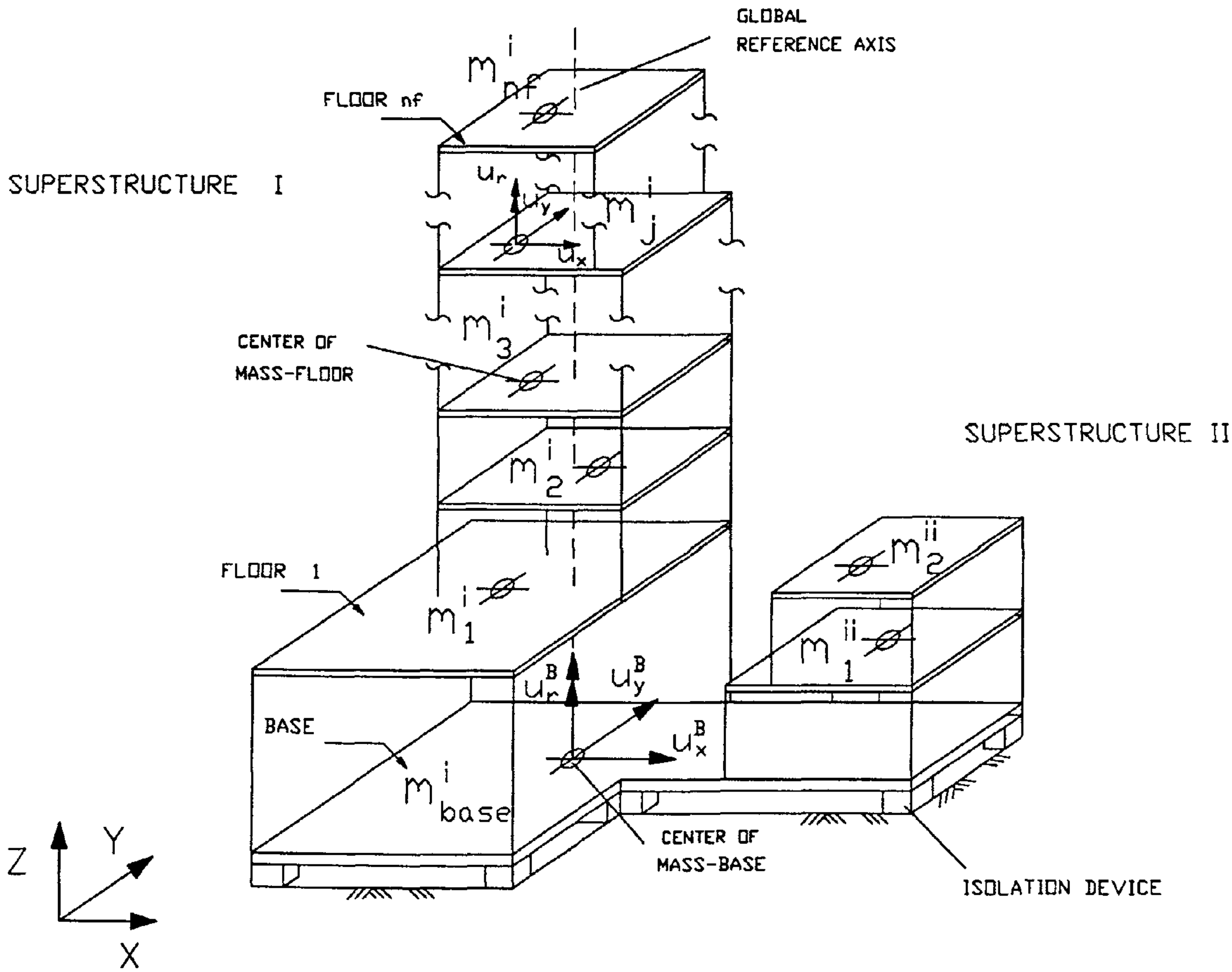
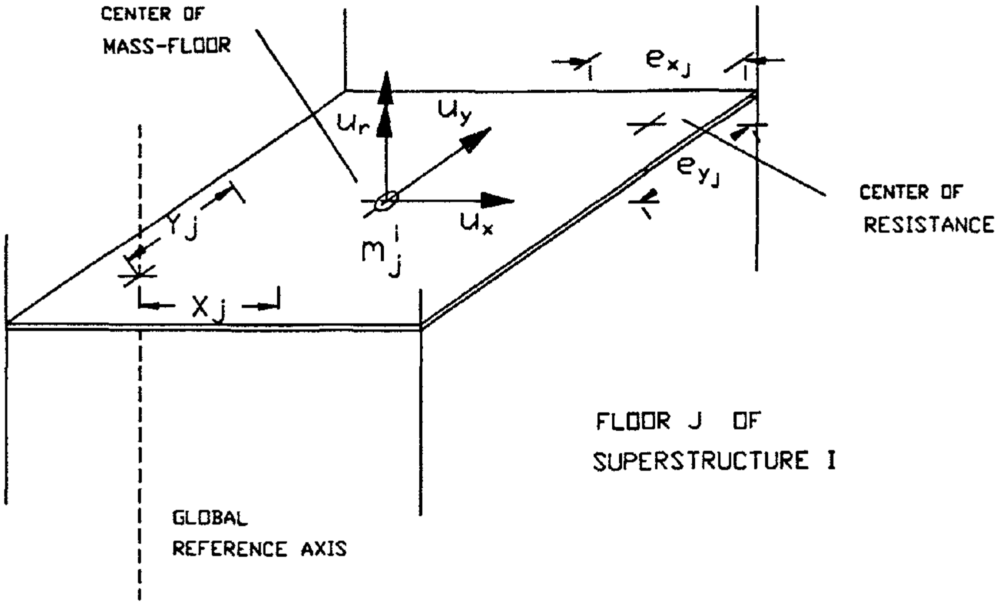
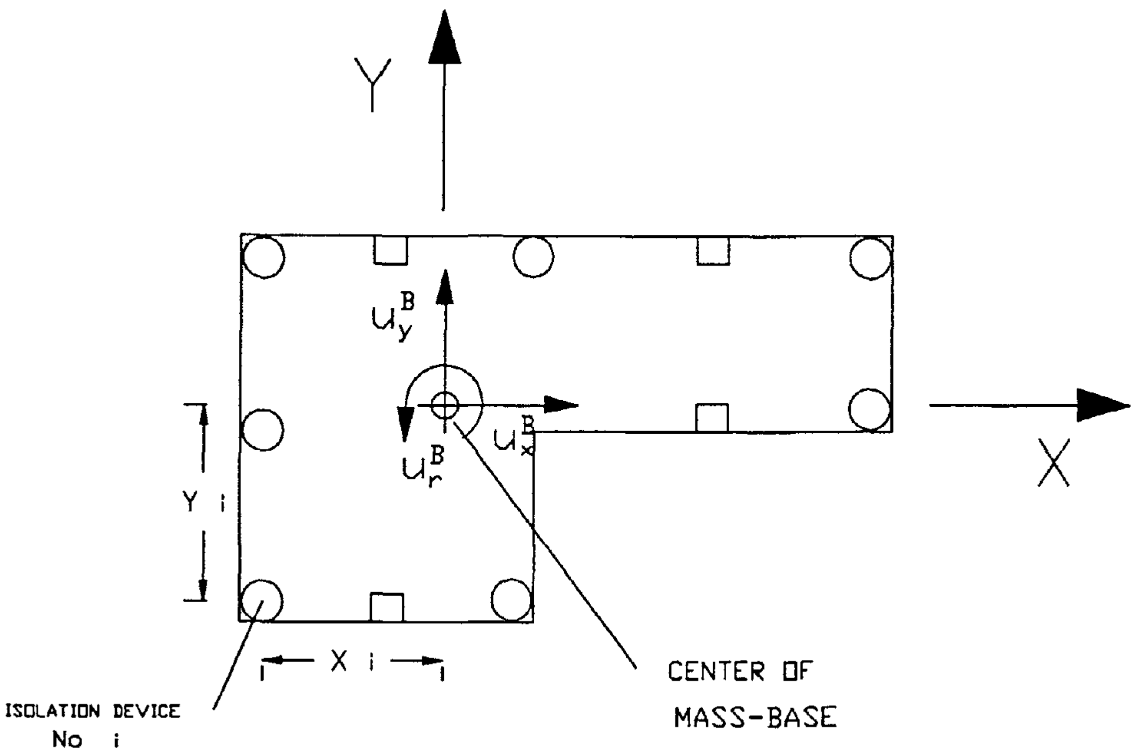


FIGURE 3-1 Multiple Building Isolated Structure.



(a)



(b)

FIGURE 3-2 Degrees of Freedom and Details of a Typical Floor and Base : (a) Isometric View of Floor j of Superstructure i; (b) Plan of Base.

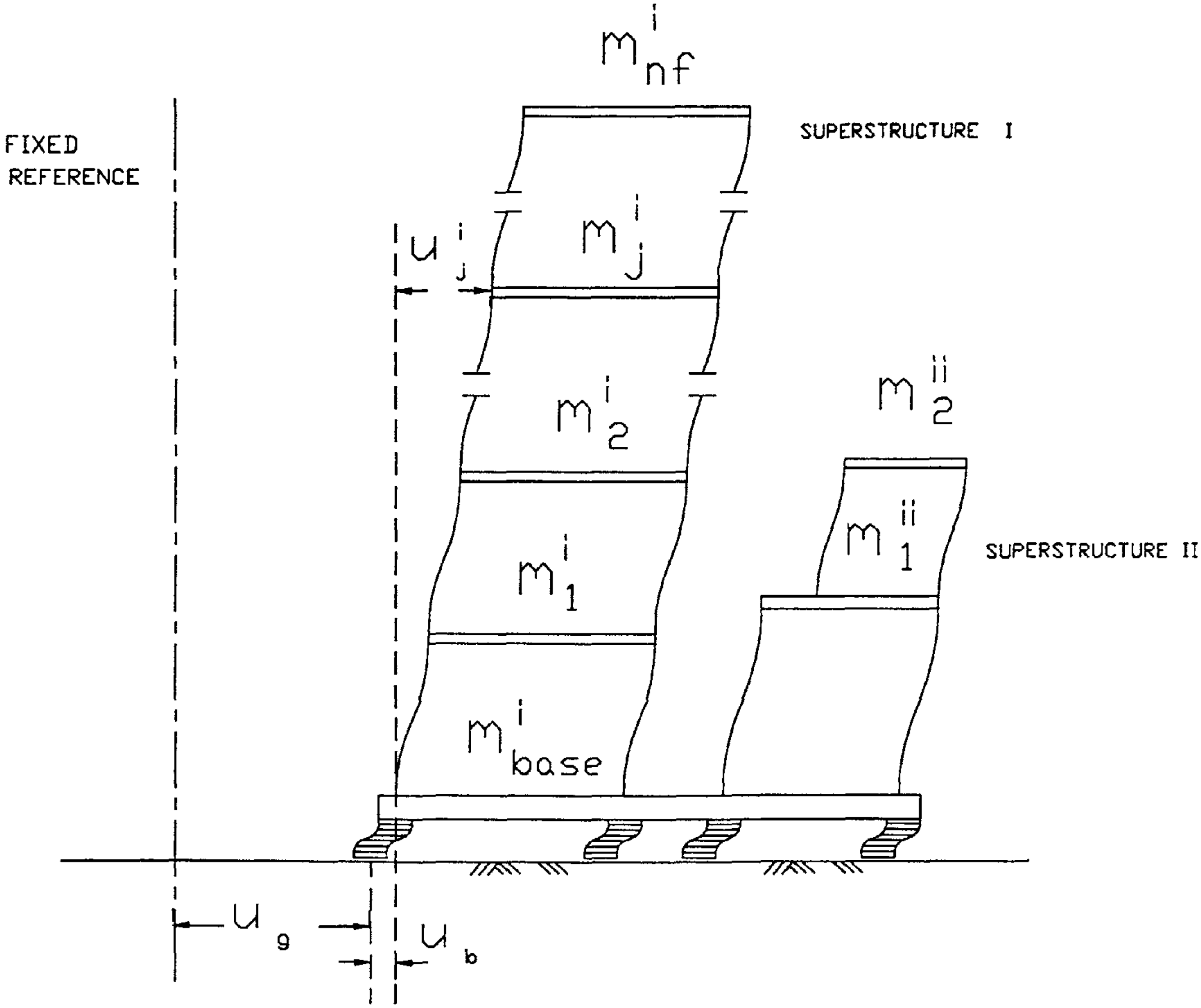


FIGURE 3-3 Displacement Coordinates of Isolated Structure.

SECTION 4

NUMERICAL VERIFICATIONS

Many existing computer programs can be used to model base isolated structures when the isolation system consists of elements exhibiting bilinear behavior. Examples of these programs are DRAIN-2D (Kannan et al. 1975) and ANSR (Mondkar et al. 1975) among others. All these programs are for general purpose nonlinear analysis. They require detailed modeling which is time consuming and not necessary in the analysis of base isolated structures. Furthermore, these programs can not accurately handle special devices used in base isolation such as sliding bearings. Accordingly the tools available to verify the 3D-BASIS-M program are limited.

Extensive verifications of program 3D-BASIS has been carried out by Nagarajaiah et al. 1989 , 1990b by comparison to results of DRAIN-2D, ANSR, ANSYS, GTSTRUDL and DNA-3D. Furthermore, 3D-BASIS has been verified by comparison to experimental results and to results of rigorous mathematical solutions.

In this study, verifications of the program 3D-BASIS-M are conducted by comparison to results of DRAIN-2D and ANSR. Simple structural systems are considered which meet the limitations of the previously mentioned programs and also satisfy to the maximum the needs of verifications.

First program DRAIN-2D was used to verify 3D-BASIS-M in unidirectional, uniaxial response assuming linear elastic behavior of the isolation system. Additionally, inelastic analyses were carried out assuming bilinear force displacement relationship of the isolation system. Comparisons of displacement and acceleration time histories are presented.

Further verification tests were undertaken using program ANSR with three dimensional structural systems undergoing coupled lateral and torsional response of the superstructures and having bilinear behavior at the isolation system.

4.1 Comparisons to DRAIN-2D

4.1.1 Superstructure Configuration

The structural system considered consists of two two-story identical superstructures, shown in Figure 4-1, supported by a rigid basemat. The two superstructures have equal floor dimensions L= 480 in (12192 mm), equal floor weight W= 240 Kips (1070.2 kN) and equal height between floors H= 180 in (4572 mm). The base has 960 in X 480 in dimensions and weight W_b= 480 Kips (2140.4 kN).

The mass at the floor levels of the buildings is uniformly distributed so that the centers of mass of both floors of each building lie on the same vertical axis on which the geometric centers of each floor are located. The center of mass of the base coincides with the geometric center of the base (uniform distributed mass). The stiffness at each level of the two superstructures is 1027.60 Kip/in (180.4 kN/mm) in each lateral direction. No eccentricities between centers of mass and centers of rigidity at each floor of the superstructures are assumed. The fixed base period of each superstructure is 0.25 secs in both principal directions. When a linear elastic isolation system is considered, no damping in the structure is taken into account whereas when the isolation system assumed to be nonlinear, viscous damping in the structure of 2% of critical in each of the superstructure modes is considered.

4.1.2 Isolation System Configuration

The isolation system consists of eight identical bearings placed directly below the eight columns of the two-part superstructure. In the case of elastic behavior of the isolation system, the total horizontal stiffness of the eight bearings is K= 36.8 Kip/in (6.46 kN/mm). This results in a rigid body mode period of 2 secs in both orthogonal directions. Damping in the isolation system is assumed to be 2% of critical in both directions.

In the case of nonlinear behavior of the isolation system, the eight bearings have a combined force-displacement relation which is bilinear with initial stiffness of 239.2 Kip/in (41.99 kN/mm), post-yielding stiffness of 36.8 Kip/in (6.46 kN/mm) and yield strength of 85.09 Kips (379.42 kN). This amounts to 0.059 times the total weight of the isolated system. The excitation is represented by the first 15 seconds of the 1940 El Centro earthquake (component S00E) applied in the X direction.

Figures 4-2 and 4-3 compare time histories of displacements and structure and base shear as calculated by programs 3D-BASIS-M and DRAIN-2D in the case of the linear isolation system. The calculated responses are identical.

Figures 4-4 and 4-5 compare responses calculated by the two programs in the case of the nonlinear isolation system. Small differences in the base shear and base displacement between the results of the two programs are observed. They are caused by differences in modeling bilinear behavior in the two programs (truly bilinear in DRAIN-2D versus smooth bilinear in 3D-BASIS-M). This difference is illustrated in the hysteresis loop of the isolation system which is shown in Figure 4-6.

4.2 Comparisons to ANSR

4.2.1 Superstructure Configuration

The superstructure consists of three one-story buildings placed on a rigid L-shaped isolated base. Each building has plan dimensions L X L where L= 480 in (12192 mm) and story height H= 180 in (4572 mm). The weight of each building is W= 240 Kips (1070.2 kN) and is represented by four equal concentrated masses at the four corners of the floor. The center of mass coincides with the geometric center of the floor but the center of rigidity is offsetted from the center of mass by 0.1 L in both directions as a result of nonuniform distribution of stiffness as illustrated in Figure 4-7. The total stiffness in both lateral directions is 272.58 Kip/in (47.58 kN/mm) and the torsional stiffness at the center of mass is 31401193 Kip-in (3547682 kN-m). These properties results in the following fixed base periods of each building : $T_1 = 0.335\,\text{sec}$, $T_2 = 0.299\,\text{sec}$, $T_3 = 0.274\,\text{sec}$. In the analysis with 3D-BASIS-M, viscous damping of 2% of critical was assumed in each vibration mode of each superstructure building. In the ANSR model, an appropriate mass proportional damping coefficient was used to simulate the damping considered in the 3D-BASIS-M model.

4.2.2 Isolation System Configuration

The isolation system is placed below the rigid L-shaped basemat and consists of twelve isolation bearings (four below each building at corners). Dimensions and the configuration of the system are shown in Figures 4-7 and 4-8. The separation (gap) between the three buildings, s , was selected to be 12 in (304.8 mm) Furthermore, the weight of the L-shaped basemat was assumed to be equal to that of the three buildings (3X240=720 Kips or 3203 kN) and is represented by twelve equal concentrated masses each one at the location of each column of the buildings as showed in the Figure 4-7.

Each isolation bearing has bilinear behavior and is modeled by two nonlinear springs placed along directions X and Y as illustrated in Figure 4-7. Each of the bearings in building I and III has initial stiffness of 17.8 Kip/in (3.12 kN/mm), post-yielding stiffness of 2.74 Kip/in (0.48 kN/mm) and yield strength of 6.6 Kips (29.36 kN). Each of the bearings in building II has initial stiffness of 10.79 Kip/in (1.89 kN/mm), post-yielding stiffness of 1.66 Kip/in (0.29 kN/mm) and yield strength of 4 Kips (17.79 kN). The uneven distribution of stiffness results in an eccentrically placed center of rigidity (based on the initial bearing stiffnesses) with eccentricities e_x= 50 in (1270 mm) and e_y= 25 in (635 mm) as shown in Figure 4-8. These eccentricities amount to 5% and 2.5% of the plan dimensions of the complex, respectively.

It should be noted that the combined yield strength of the bearings is 0.048 times the weight of the complex and that the ratio of combined initial stiffness to combined post-yielding stiffness of the bearings is 6.5. These parameters are typical of lead-rubber bearings (Dynamic Isolation Syatems, 1983). Based on a 6 in (152.4 mm) isolation system displacement (which represents the displacement for a ground motion having characteristics of the ATC 0.4g S2 spectrum [SEAOC 1990]), the period of the isolated complex is about 2 secs (based on the effective stiffness at 6 in displacement).

For modeling the complex (isolation system and superstructure) in ANSR, three dimensional truss elements were used. The masses were considered to be concentrated at the nodes as shown in Figure 4-7. The plane rigidity of the floors was modeled using two linear truss elements with very large area forming an X bracing. Diagonal truss elements with an appropriate value for area were used in each face of the buildings to simulate the lateral stiffness. Uniaxial bilinear elements were used to model the isolators in both 3D-BASIS-M and ANSR. In ANSR, the bilinear elements exhibited truly bilinear behavior with sharp transition from initial to post-yielding stiffness at yield point. In 3D-BASIS-M the transition is smooth.

Bidirectional earthquake excitation was imposed with components S00E and S90W of the 1940 El Centro motion applied along directions X and Y, respectively. Computed corner bearing and interstory displacement histories by the two programs are compared in Figures 4-9 to 4-12. The responses compare well and the observed differences are attributed to differences in the two models in describing damping in the system and in representing bilinear behavior.

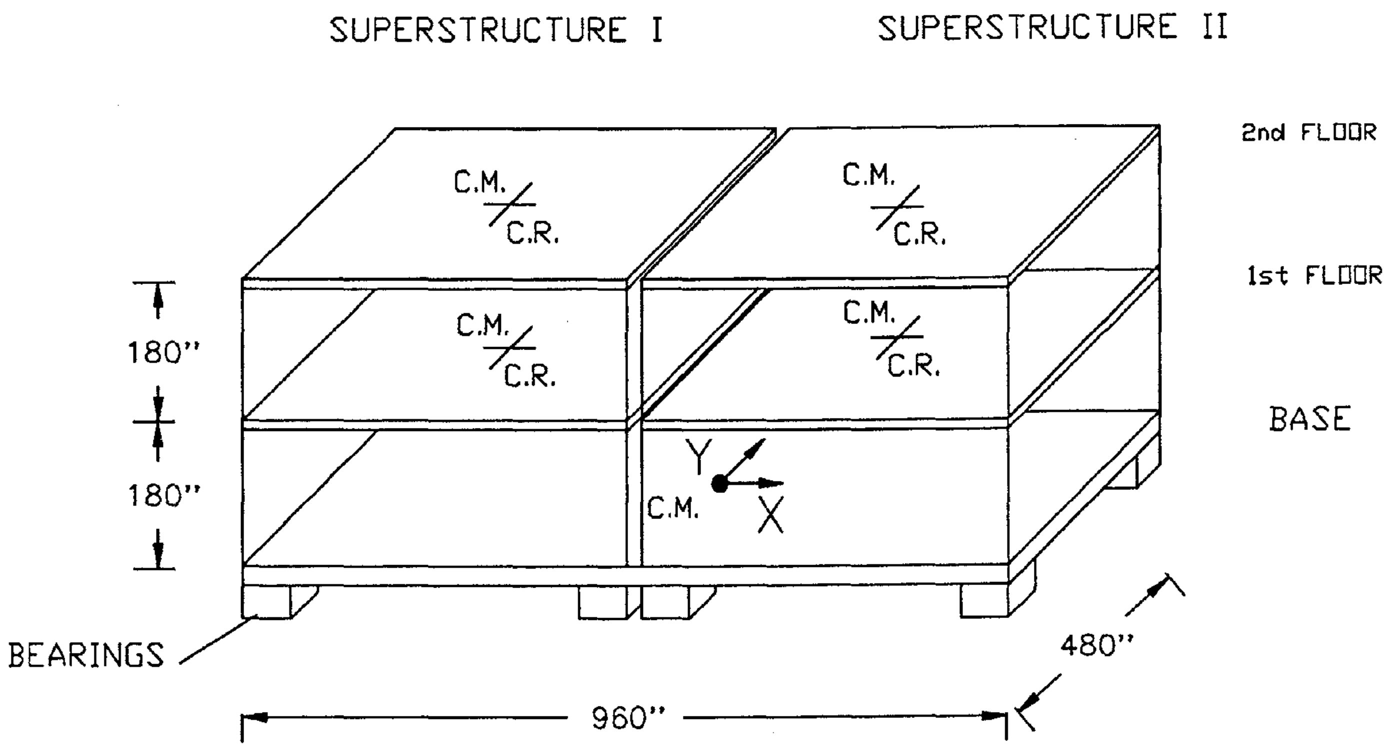


FIGURE 4-1 Multiple Building Isolated Structure used in Comparison Study to Program DRAIN-2D (1 in = 25.4 mm).

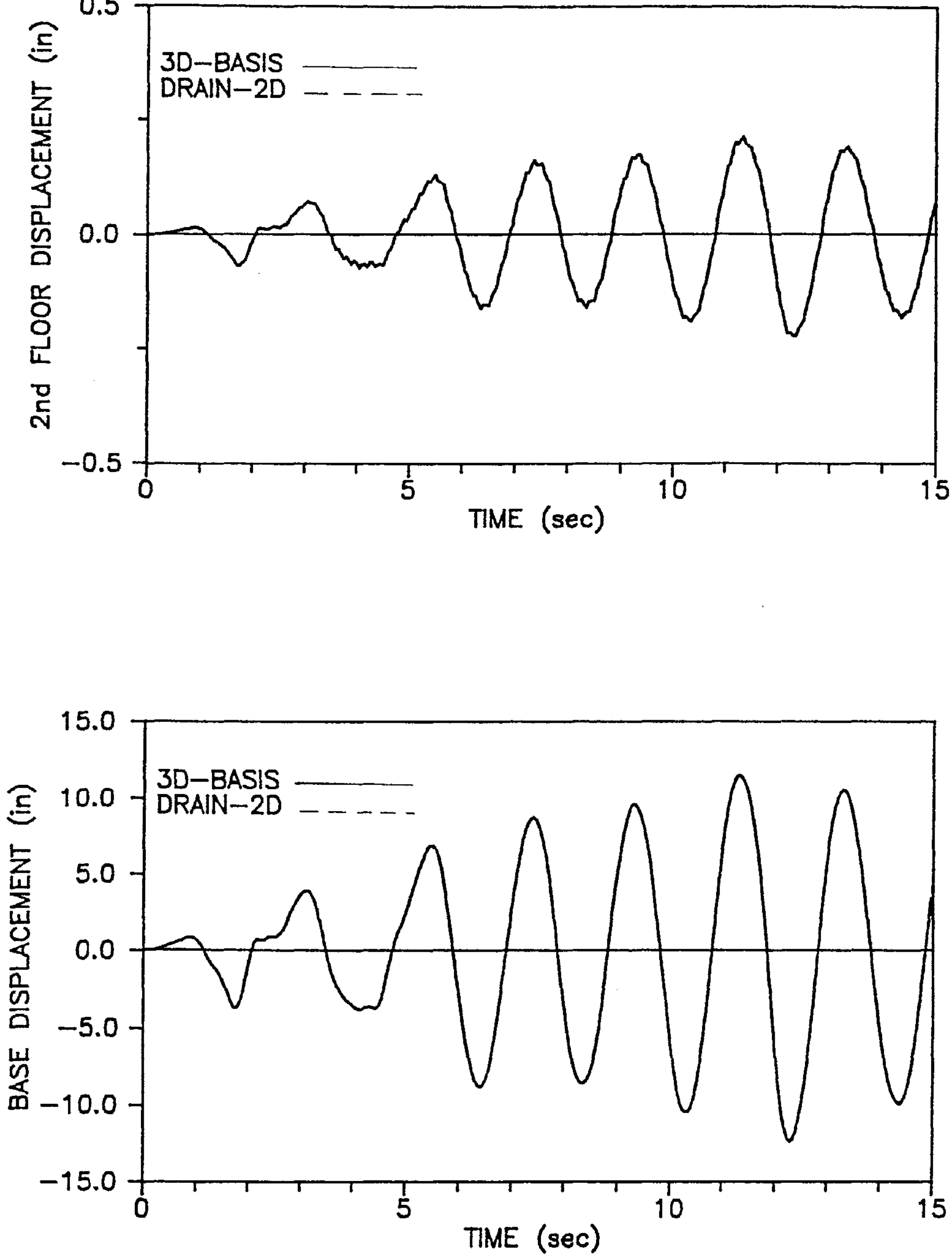
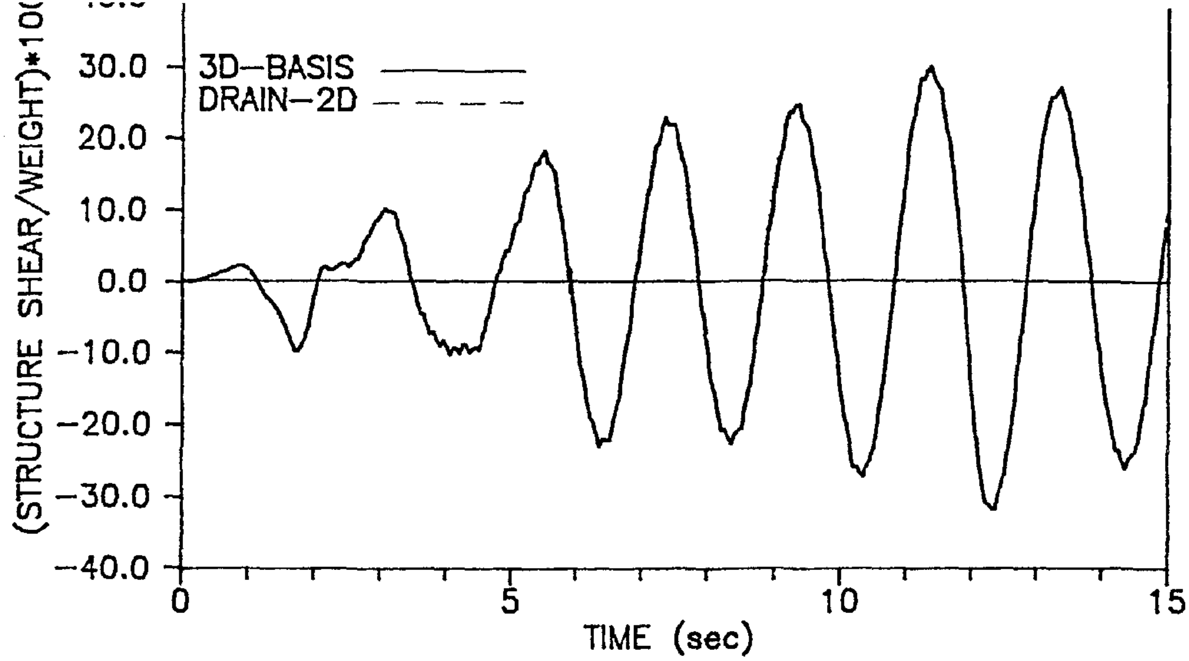


FIGURE 4-2 Displacement Response of Structure with Linear Elastic Isolation System Subjected to 1940 EL-CENTRO S00E Earthquake along the Longitudinal Direction (X); (a) Second Floor Displacement relative to Base; (b) Base Displacement (1 in = 25.4 mm).



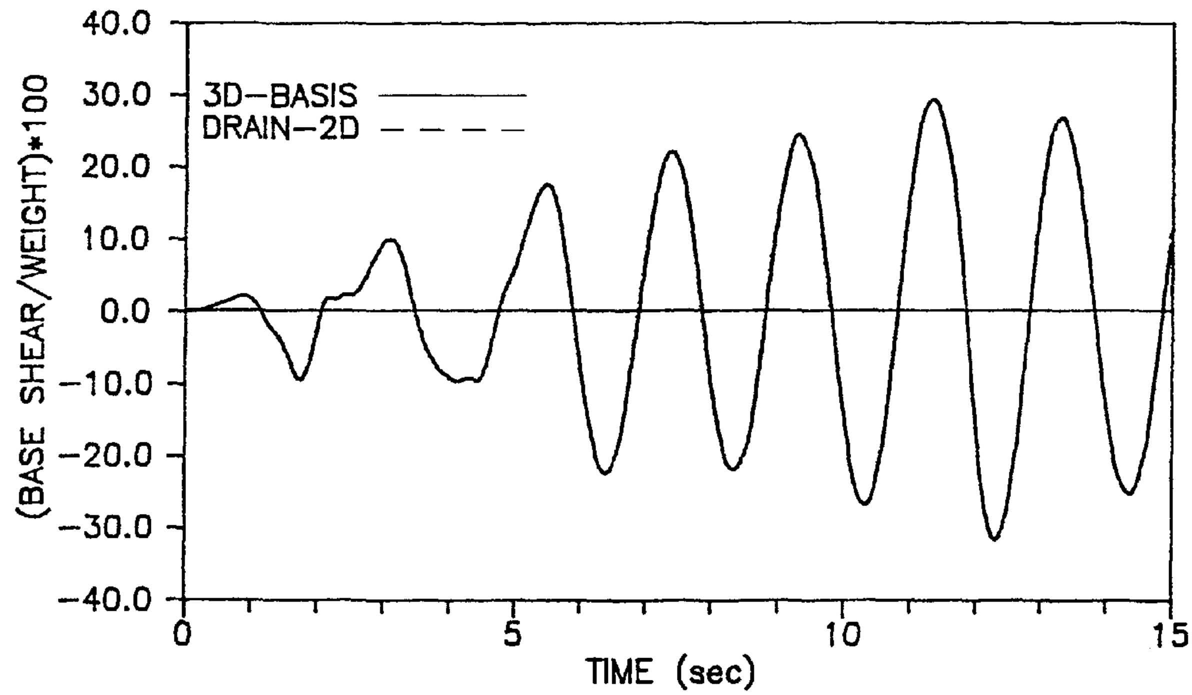
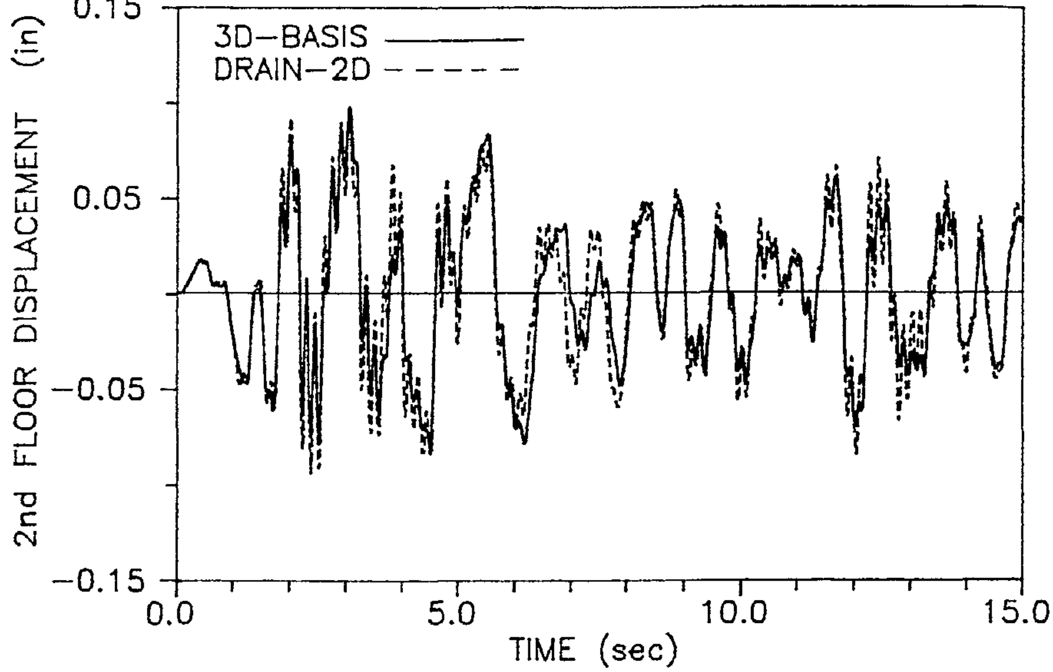


FIGURE 4-3 (a) Structural Shear and (b) Base Shear response, of Structure with Linear Elastic Isolation System Subjected to 1940 EL-CENTRO S00E Earthquake along the Longitudinal Direction (X).



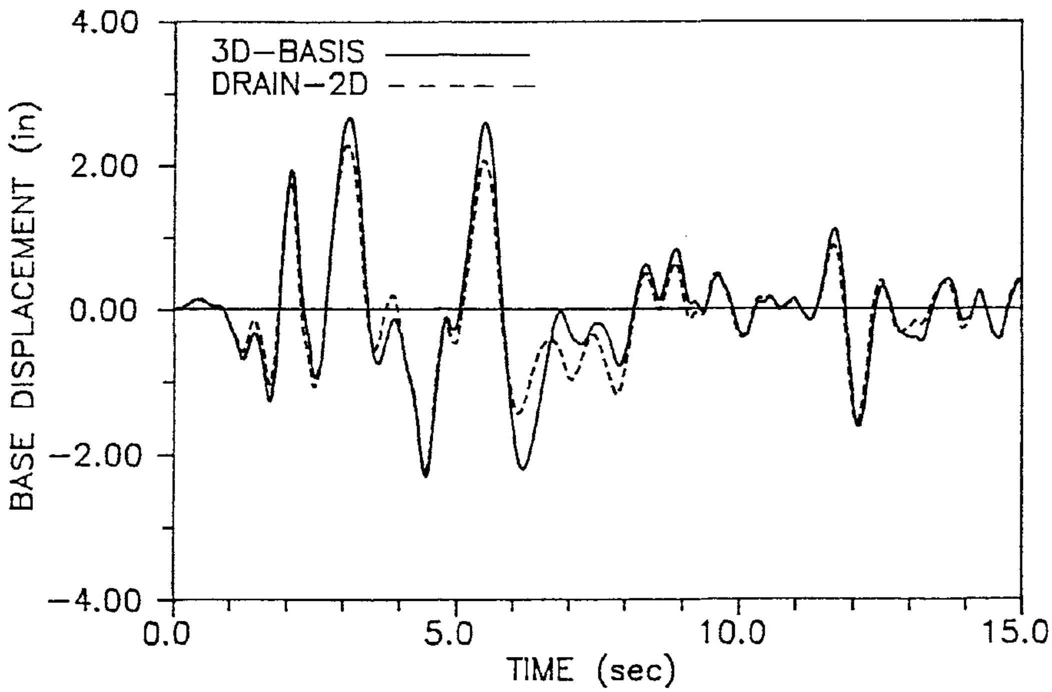
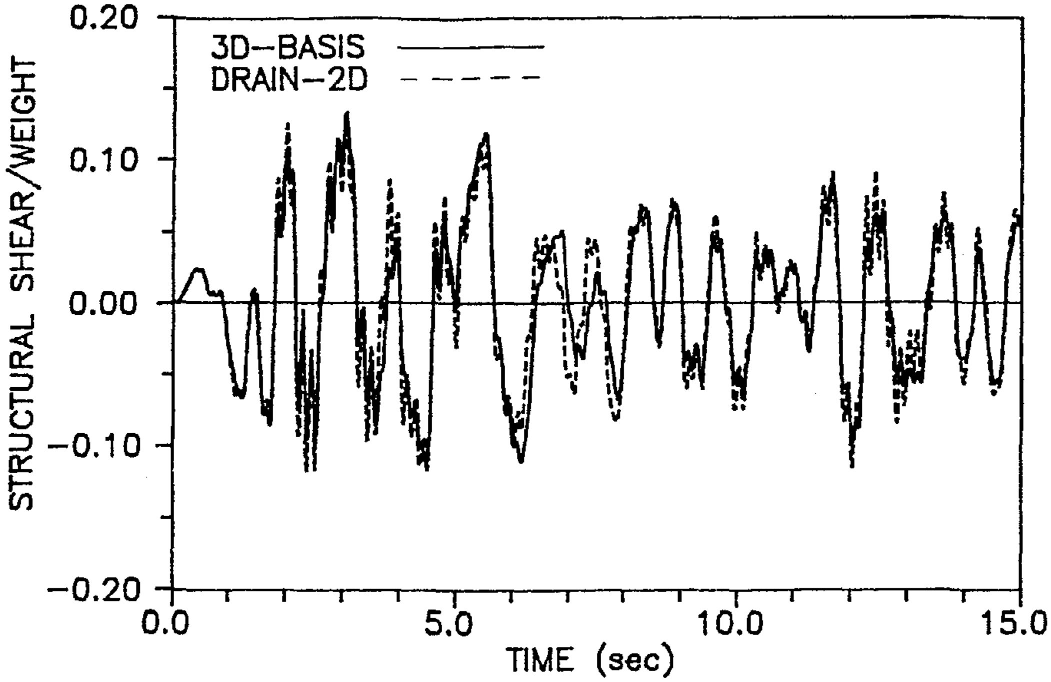


FIGURE 4-4 Displacement response of Structure with Bilinear Isolation System Subjected to 1940 EL-CENTRO S00E Earthquake along the Longitudinal Direction (X); (a) Second Floor Displacement relative to Base; (b) Base Displacement (1 in = 25.4 mm).



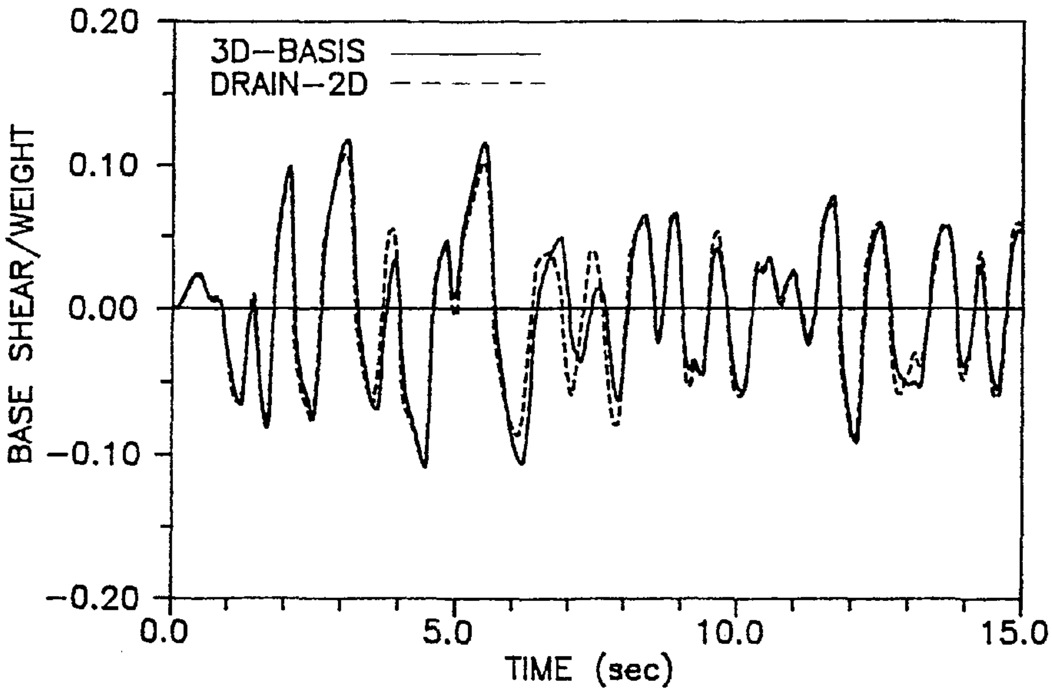


FIGURE 4-5 (a) Structural Shear and (b) Base Shear Response, of Structure with Bilinear Isolation System Subjected to 1940 EL-CENTRO S00E Earthquake along the Longitudinal Direction (X).

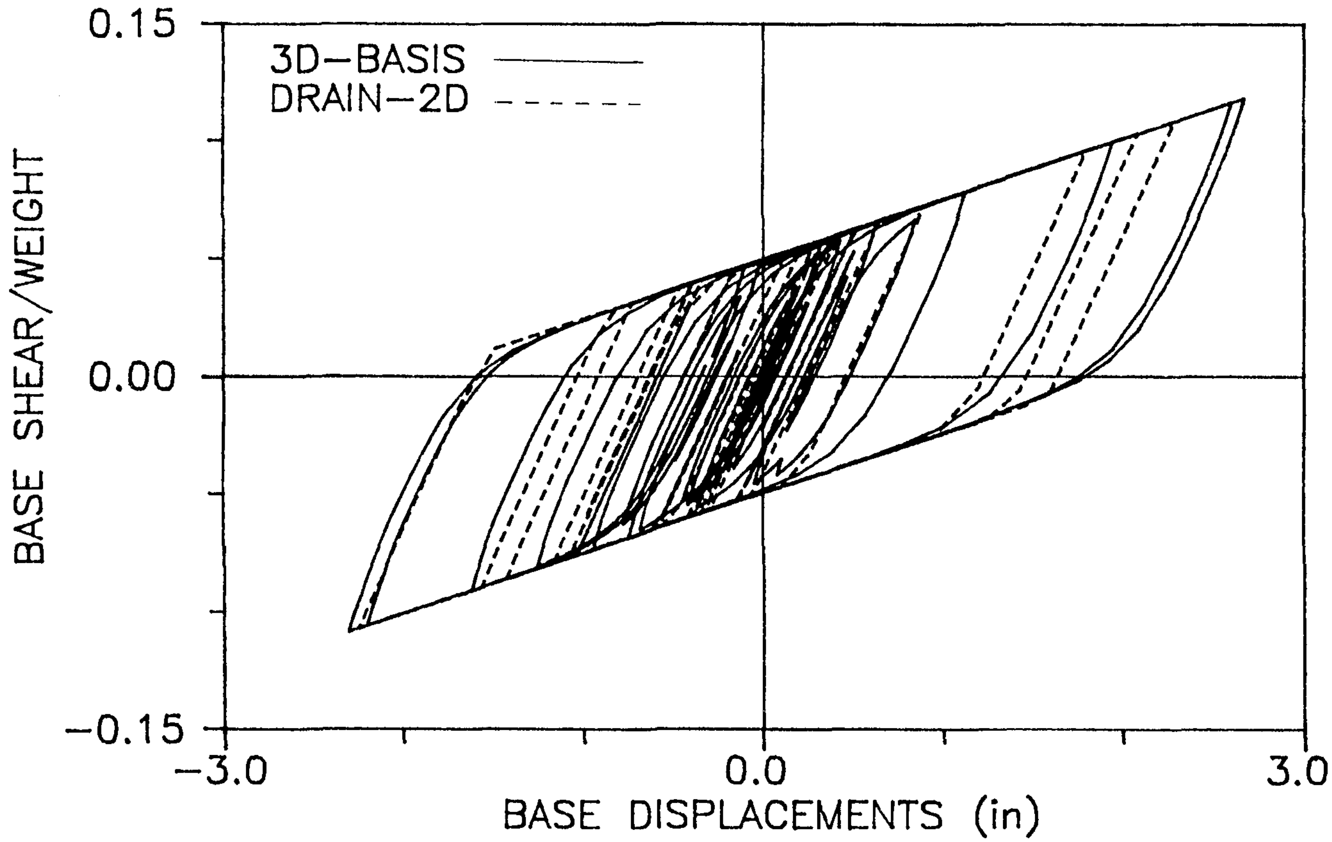


FIGURE 4-6 Force-Displacement Loop of Isolation System (1 in = 25.4 mm).

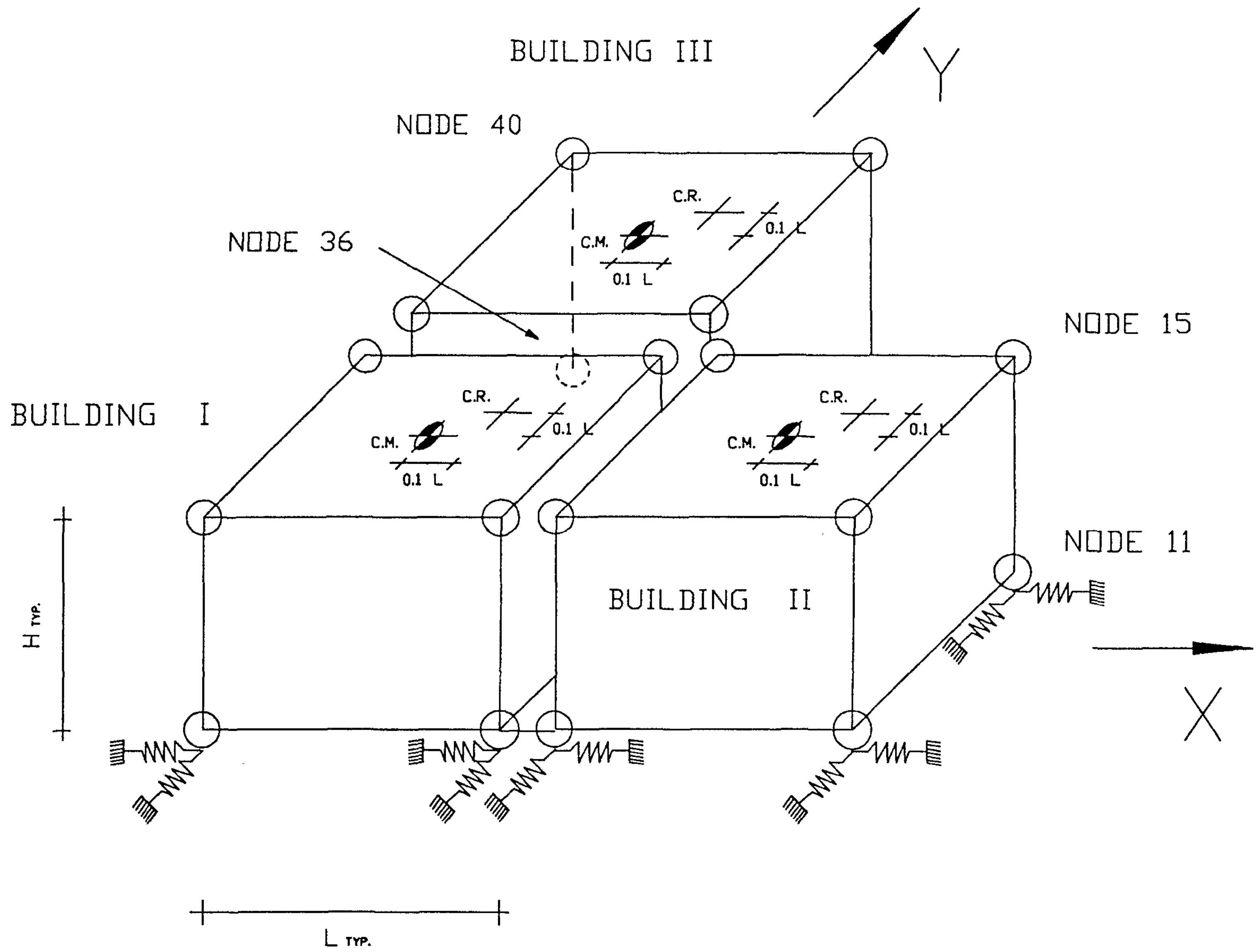


FIGURE 4-7 ANSR Model of Isolated Structure.

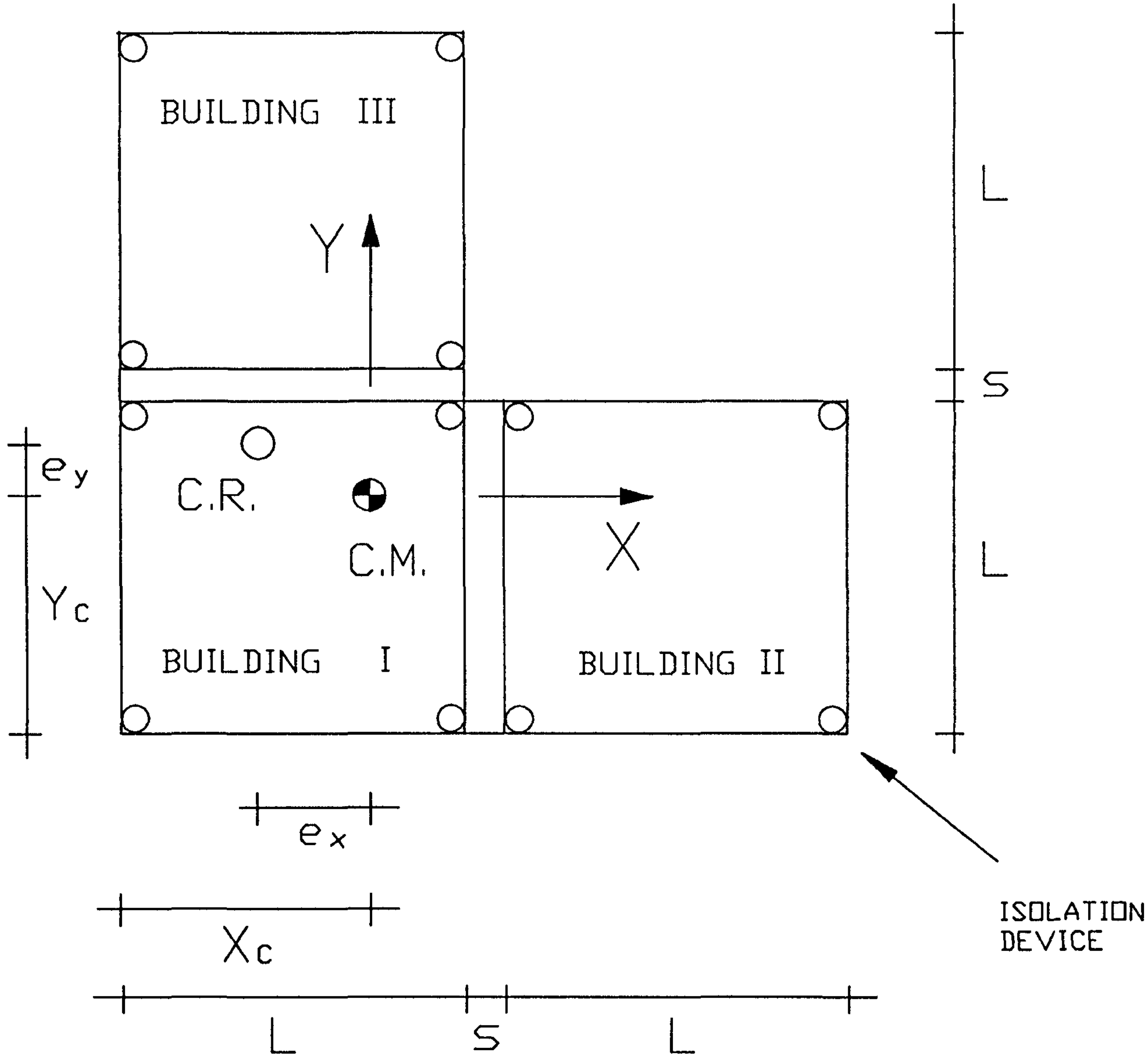


FIGURE 4-8 Isolation System Configuration.

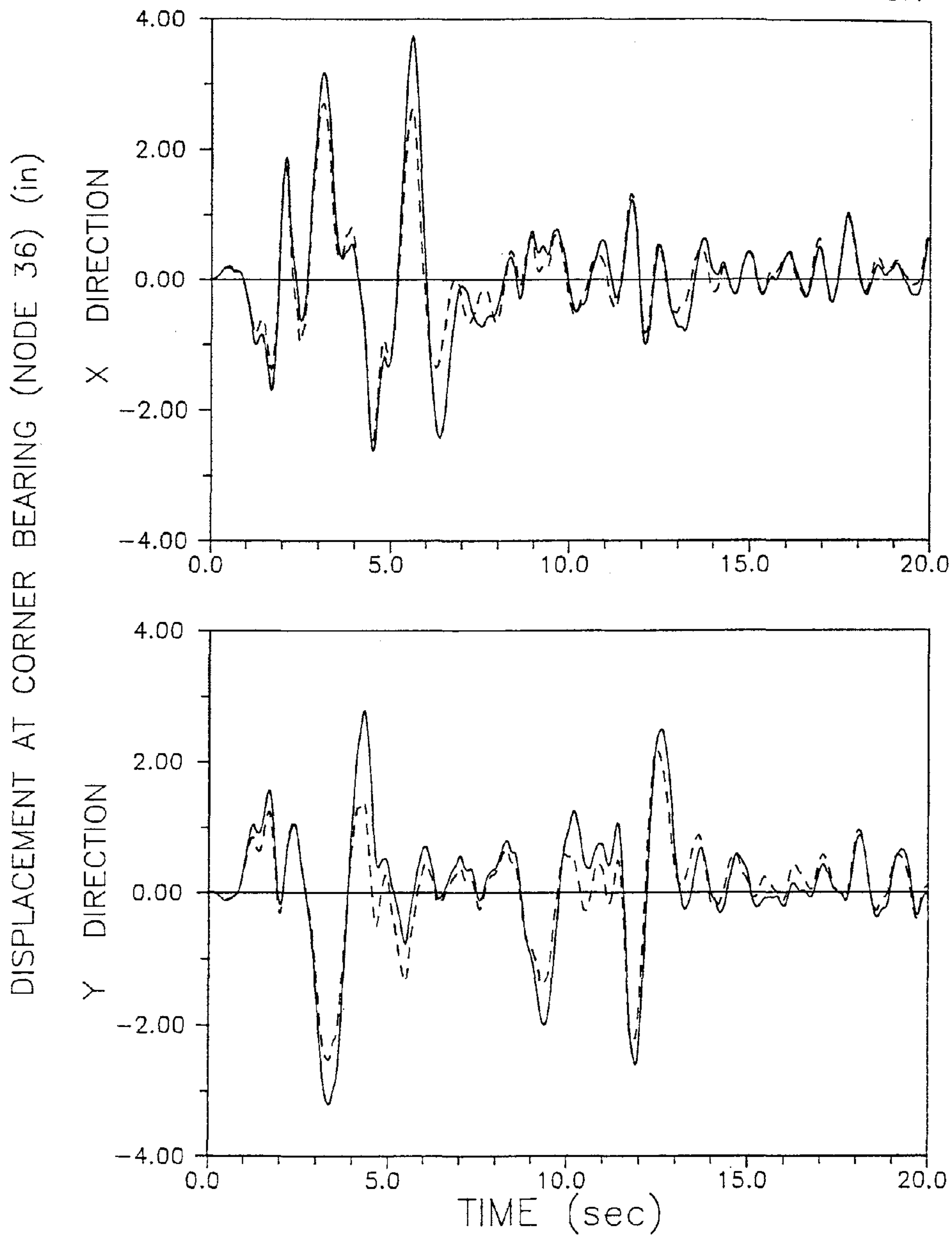


FIGURE 4-9 Comparison of Bearing Displacements (Node 36) of Multiple Building Isolated Structure under Bidirectional Excitation (1 in = 25.4 mm).

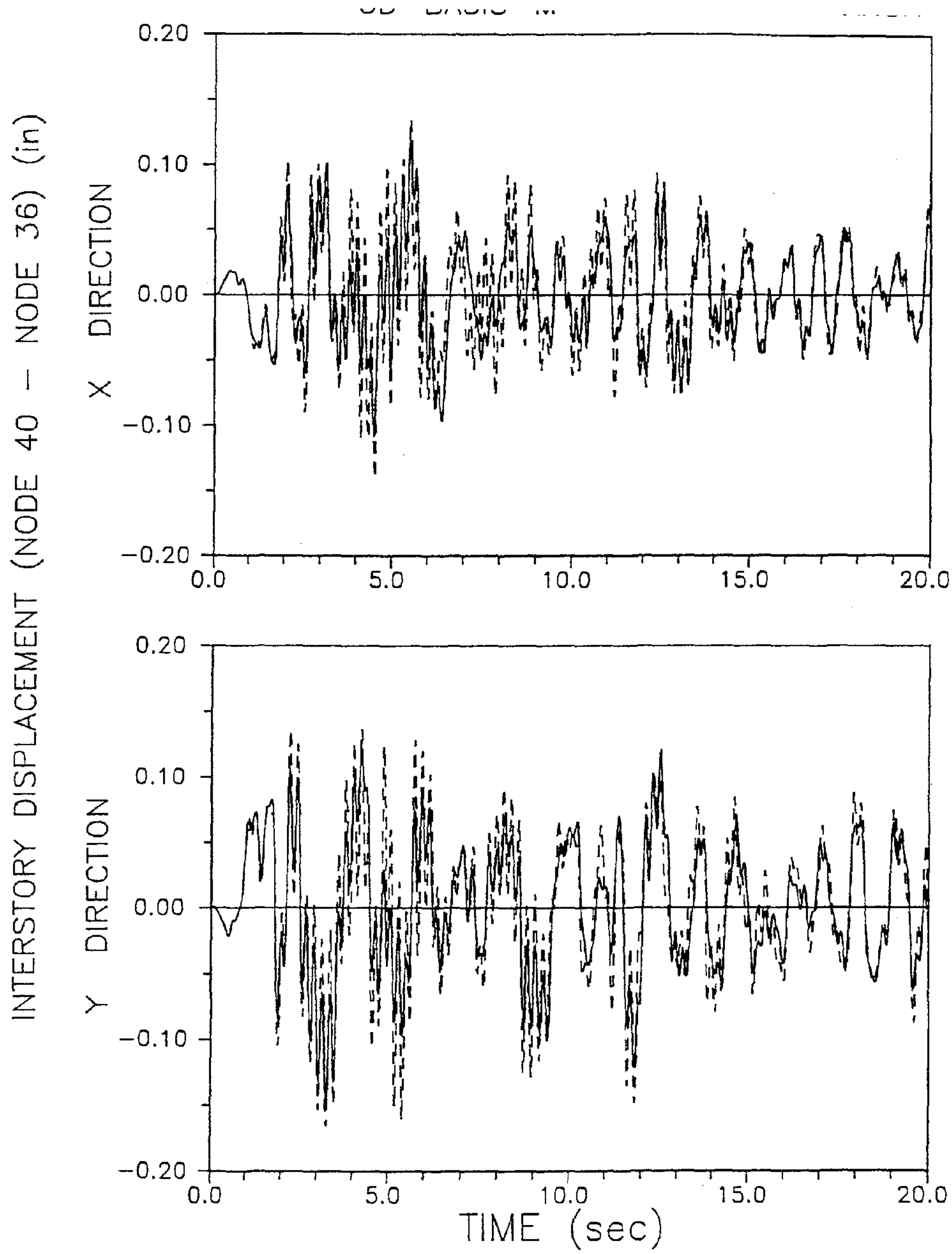


FIGURE 4-10 Comparison of Interstory Displacements (Node 40 - Node 36) of Multiple Building Isolated Structure under Bidirectional Excitation (1 in = 25.4 mm).

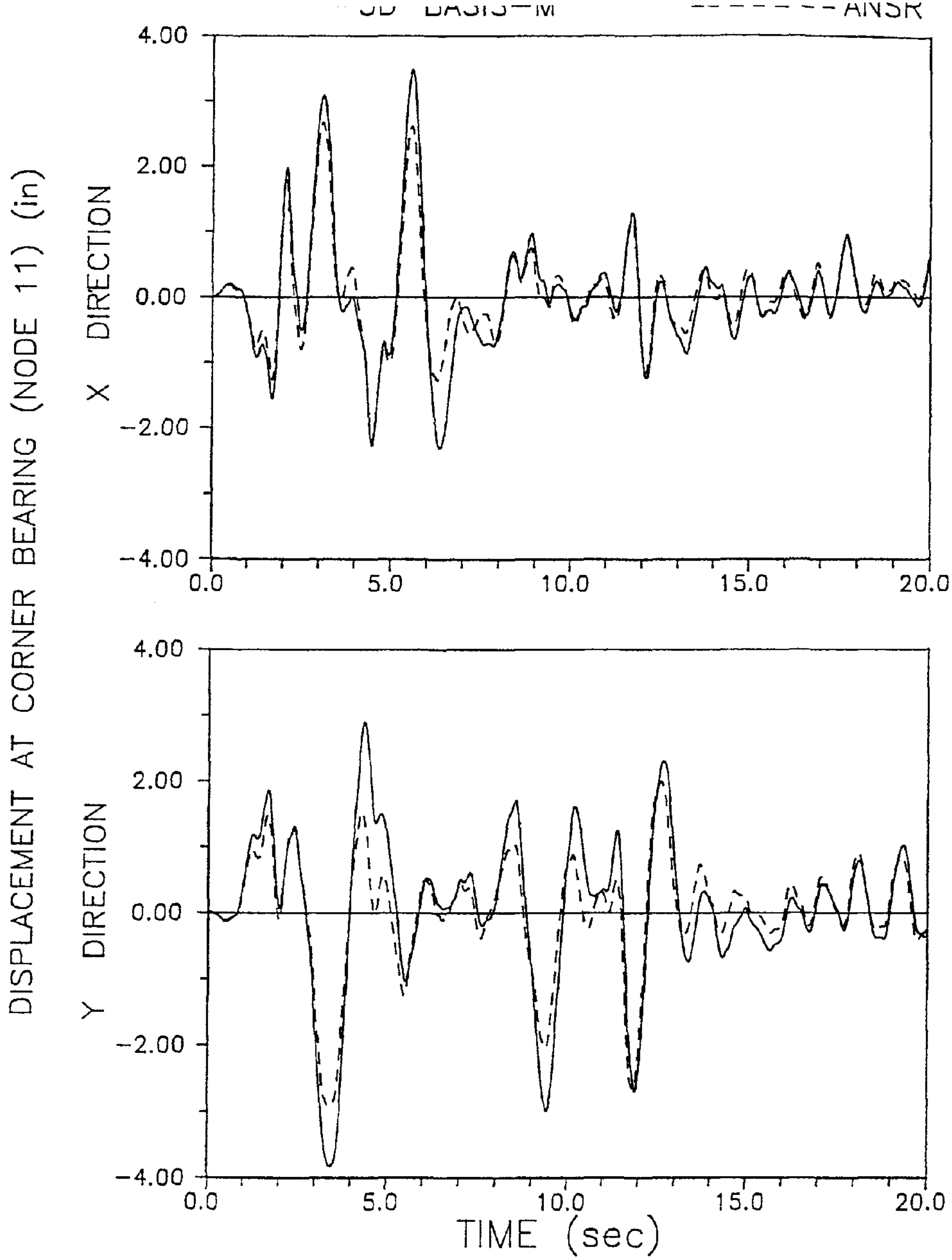


FIGURE 4-11 Comparison of Bearing Displacements (Node 11) of Multiple Building Isolated Structure under Bidirectional Excitation (1 in = 25.4 mm).

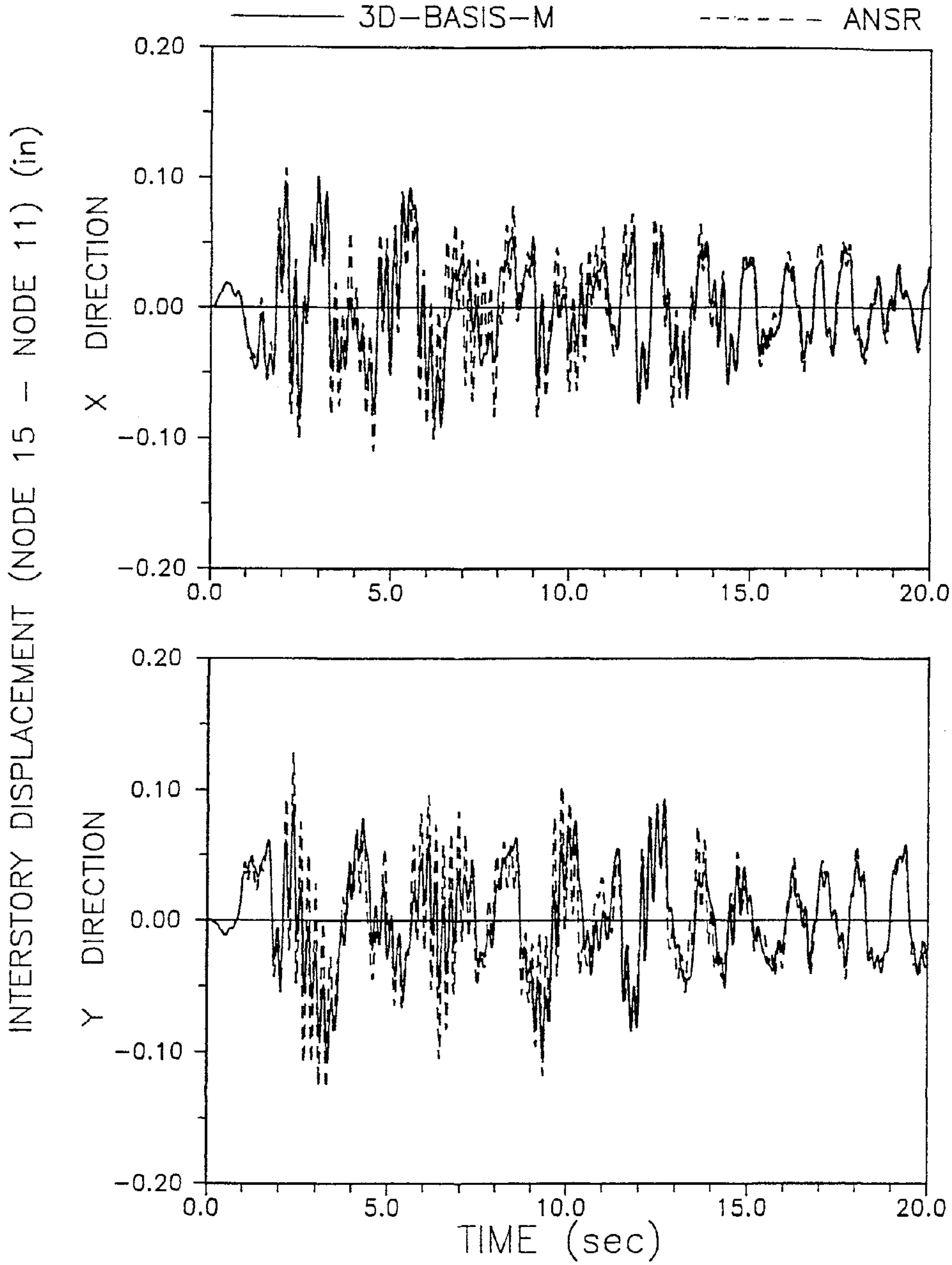


FIGURE 4-12 Comparison of Interstory Displacements (Node 15 - Node 11) of Multiple Building Isolated Structure under Bidirectional Excitation (1 in = 25.4 mm).

SECTION 5

A CASE STUDY

The General State Hospital of Mesologgi, Greece is a new facility consisting of five buildings. Four of the buildings are to be seismically isolated and the fifth is to be constructed with a conventional fixed base. The four isolated parts sit on a common large T-shaped base with the isolation system below (Figure 5-1). Above the common base the four buildings are separated by a 0.05 m thermal gap. Two alternative isolation systems were developed for this structure, one of which consisted of lead-rubber bearings.

This study looks into the differences of the response which arise when one part (PART III) of the complex is analyzed as separate building and when is analyzed considering the interaction with the other parts of the complex.

5.1 Description of Facility

The Mesologgi hospital complex consists of four isolated 6-story buildings (parts I to IV) and one non-isolated 4-story building. The layout is shown in Figure 5-1 . The four isolated parts form a T-shape in plan with dimensions of approximately 76 m X 57 m. Part III has plan dimensions 10.8 m X 29.7 m. The four isolated buildings are separated by a 0.05 m thermal gap. However, the basemats of the four buildings are connected together at the isolation system level forming a large T-shaped isolation basemat.

The buildings are to be constructed of reinforced concrete. The structural system consists of doubly reinforced slabs supported by reinforced concrete columns and beams. The lateral force resisting system consists of the slabs behaving as rigid diaphragms, concrete shear walls and infill brick shear panels. The total seismic weight of the complex including superstructure (buildings) and basemat is W_{tot}= 174.4 MN (39100.2 Kips). The seismic weight of part III (superstructure plus basemat) is W_{III}= 37.6 MN (8438.3 Kips).

The dynamic characteristics of each of the four superstructures of the complex are presented in Table 5-I in terms of the periods of free vibration. These periods, the corresponding mode shapes and damping ratios (assumed to be 5% of critical in each mode) represented input to program 3D-BASIS-M. The periods and mode shapes were calculated in a detailed model of each part using program ETABS (Wilson et al. 1975). In the model, the stiffening effects of brick walls were included so that the calculated fundamental period of each part was consistent with empirical values. Each of the four superstructures could remain elastic for a structural shear force (1^{st} floor shear) of 0.23 times the seismic weight and interstory drift of 0.2% of the story height.

Lead rubber bearings are placed at 153 locations under each column and at the ends of each shear wall. Thirty two of these bearings are placed below part III. Four types of elastomeric bearings are used. Three of these types have cylindrical lead plug in the center and one type is without lead core. The properties of each type of bearing are presented in Table 5-II and the location of each bearing is shown in Figure 5-2 with reference to Table 5-III.

Nonlinear dynamic time history analyses of the entire complex and of part III alone were performed using program 3D-BASIS-M. The 1971 San Fernando motion (Record No. 211, component NS), was scaled so that its 5% damped spectrum was compatible with the site specific response spectrum. Figure 5-3 shows the scaled ground acceleration record and a comparison of its spectrum to the site specific response spectrum. The motion was applied in the X direction of the complex. As shown in Figure 5-2, part III is placed at considerable distance from the center of the mass of the entire complex. Its corner columns are at a distance of 34.34 m from the center of mass. For this part, the application of excitation in the X direction represents the worst loading condition. When part III is analyzed alone, its center of mass coincides with its geometric center and the corner columns are at distance of 14.85 m away of the center of mass.

A summary of the response of part III when analyzed as part of the complex and when analyzed alone is presented in Table 5-IV. The table includes the peak floor accelerations at the center of mass of each floor, the peak corner column drift ratio at all stories, the peak structural shear over superstructure weight (W_{III}) ratio and the peak corner bearing displacements. Figures 5-4 and 5-5 present time histories of some calculated response quantities.

Bearing displacements in the two analyses are almost the same. However, floor accelerations, interstory drifts and the structural shear of part III are larger in the analysis of the entire complex than in the analysis of part III alone. The underestimation of these response quantities in the analysis of part III alone amounts to about 20% of the values calculated in the analysis of the entire complex. Such deviation is significant and demonstrates the importance of interaction between adjacent buildings supported by a common isolation system.

Next an attempt is presented to explain the observed differences in the response of the part III when analyzed alone and when analyzed as part of the complex. We note that part III has large eccentricities between the center of resistance and the center of mass of each floor. These eccentricities are primarily along the X direction, in which they assume values of more than 10% of the building's long dimension. In the Y direction, eccentricities are almost non existent.

When part III is analyzed alone and excitation is applied in the X direction (see Figure 5-6), the isolated part responds primarily in the X direction with insignificant motion in the y direction. This is due to the almost zero eccentricities in the Y direction. When part III is analyzed as part of the complex and excitation is applied in X direction (see Figure 5-6), the rotation of the T-shaped common basemat introduces a sizeable motion in the Y direction of part III. This is caused by the significant distance of the center of mass of part III from the center of mass of the common basemat which is 19.64 m (see Figure 5-6). Figure 5-7 shows the distribution with height of acceleration in the Y direction of part III. When part III is analyzed alone, this acceleration is almost zero. When part III is analyzed as part of the complex, this acceleration reaches values of about 15% of the acceleration in X direction (see also results of Table 5-IV). The acceleration that develops in the Y direction when coupled with the sizable eccentricities in that direction results in substantial rotation of the part with accordingly more floor acceleration and interstory drift.

BUILDING	PERIOD		
	T_1 (sec)	T_2 (sec)	T_3 (sec)
PART I	0.45	0.34	0.26
PART II	0.42	0.26	0.17
PART III	0.44	0.26	0.24
PART IV	0.34	0.30	0.20

TABLE 5-I Period of Vibration of Parts of Isolated Complex.

BEARING TYPE	A	B	C	D
DIMENSIONS (mm)	380 X 380	460 X 460	540 X540	530 X 530
BEARING HEIGHT (mm)	220	220	220	220
LEAD CORE DIAMETER (mm)	70	100	90	0
No. OF RUBBER LAYERS	13	13	13	13
RUBBER LAYER THICKNESS (mm)	9.53	9.53	9.53	9.53
YIELD FORCE (kN)	35.71	75.83	57.98	1.15
YIELD DISPLACEMENT (mm)	5.23	7.06	4.35	1
POST YIELDING STIFFNESS (kN/mm)	1.05	1.66	2.05	1.15

TABLE 5-II Properties of Lead Rubber Bearings.

No	BUILDING	BEARING TYPE	No	BUILDING	BEARING TYPE	No	BUILDING	BEARING TYPE
1	I	C	61	II	B	121	IV	D
2	I	C	62	II	C	122	IV	A
3	I	A	63	II	B	123	IV	A
4	I	B	64	II	C	124	IV	D
5	I	C	65	II	C	125	IV	C
6	I	B	66	II	A	126	IV	A
7	I	B	67	III	A	127	IV	A
8	I	C	68	III	A	128	IV	C
9	I	A	69	III	C	129	IV	C
10	I	C	70	III	C	130	IV	A
11	I	B	71	III	A	131	IV	D
12	I	C	72	III	C	132	IV	C
13	I	A	73	III	A	133	IV	C
14	I	C	74	III	A	134	IV	D
15	I	B	75	III	C	135	IV	D
16	I	B	76	III	A	136	IV	A
17	I	B	77	III	A	137	IV	D
18	I	C	78	III	C	138	IV	D
19	I	B	79	III	A	139	IV	C
20	I	C	80	III	A	140	IV	C
21	I	C	81	III	C	141	IV	C
22	I	C	82	III	A	142	IV	C
23	II	C	83	III	A	143	IV	C
24	II	C	84	III	C	144	IV	C
25	II	A	85	III	A	145	IV	D
26	II	A	86	III	A	146	IV	D
27	II	A	87	III	C	147	IV	A
28	II	B	88	III	A	148	IV	A
29	II	C	89	III	A	149	IV	A
30	II	B	90	III	B	150	IV	A
31	II	B	91	III	A	151	IV	C
32	II	C	92	III	A	152	IV	C
33	II	B	93	III	B	153	IV	C
34	II	B	94	III	B			
35	II	C	95	III	C			
36	II	A	96	III	C			
37	II	B	97	III	A			
38	II	C	98	III	A			
39	II	A	99	IV	A			
40	II	B	100	IV	C			
41	II	C	101	IV	C			
42	II	B	102	IV	A			
43	II	B	103	IV	C			
44	II	C	104	IV	C			
45	II	C	105	IV	A			
46	II	C	106	IV	A			
47	II	A	107	IV	A			
48	II	C	108	IV	C			
49	II	C	109	IV	A			
50	II	C	110	IV	A			
51	II	A	111	IV	A			
52	II	B	112	IV	A			
53	II	C	113	IV	D			
54	II	C	114	IV	D			
55	II	B	115	IV	D			
56	II	C	116	IV	A			
57	II	A	117	IV	A			
58	II	B	118	IV	A			
59	II	C	119	IV	A			
60	II	A	120	IV	C			

TABLE 5-III Location and Type of Isolation Bearings (with reference to Table 5-II and Figure 5-2).

		COMPLEX		INDIVIDUAL	
DIRECTION OF GROUND MOTION		X		X	
RESPONSE DIRECTION		X	Y	X	Y
(STRUCTURE SHEAR)/(WEIGHT)		0.236	0.023	0.181	0.001
PEAK FLOOR ACCELERATION AT C.M. (g)	6	0.284	0.044	0.228	0.003
	5	0.261	0.038	0.206	0.002
	4	0.248	0.026	0.189	0.001
	3	0.233	0.022	0.186	0.001
	2	0.216	0.015	0.194	0.002
	1	0.205	0.012	0.197	0.001
PEAK INTERSTORY DRIFT RATIO AT CORNER COLUMN (%)	6	0.122	0.012	0.097	0.010
	5	0.128	0.013	0.102	0.011
	4	0.129	0.012	0.102	0.010
	3	0.126	0.013	0.098	0.009
	2	0.100	0.012	0.079	0.009
	1	0.050	0.005	0.039	0.003
CORNER BEARING PEAK DISPLACEMENT (m)	67	0.128	0.003	0.133	0.003
	70	0.128	0.002	0.133	0.003
	95	0.128	0.003	0.131	0.003
	98	0.128	0.002	0.131	0.003

COMPLEX : Analysis of Entire Complex.

INDIVIDUAL : Analysis of Part III Alone

TABLE 5-IV Maximum Response of Part III of Mesologgi Hospital Complex.

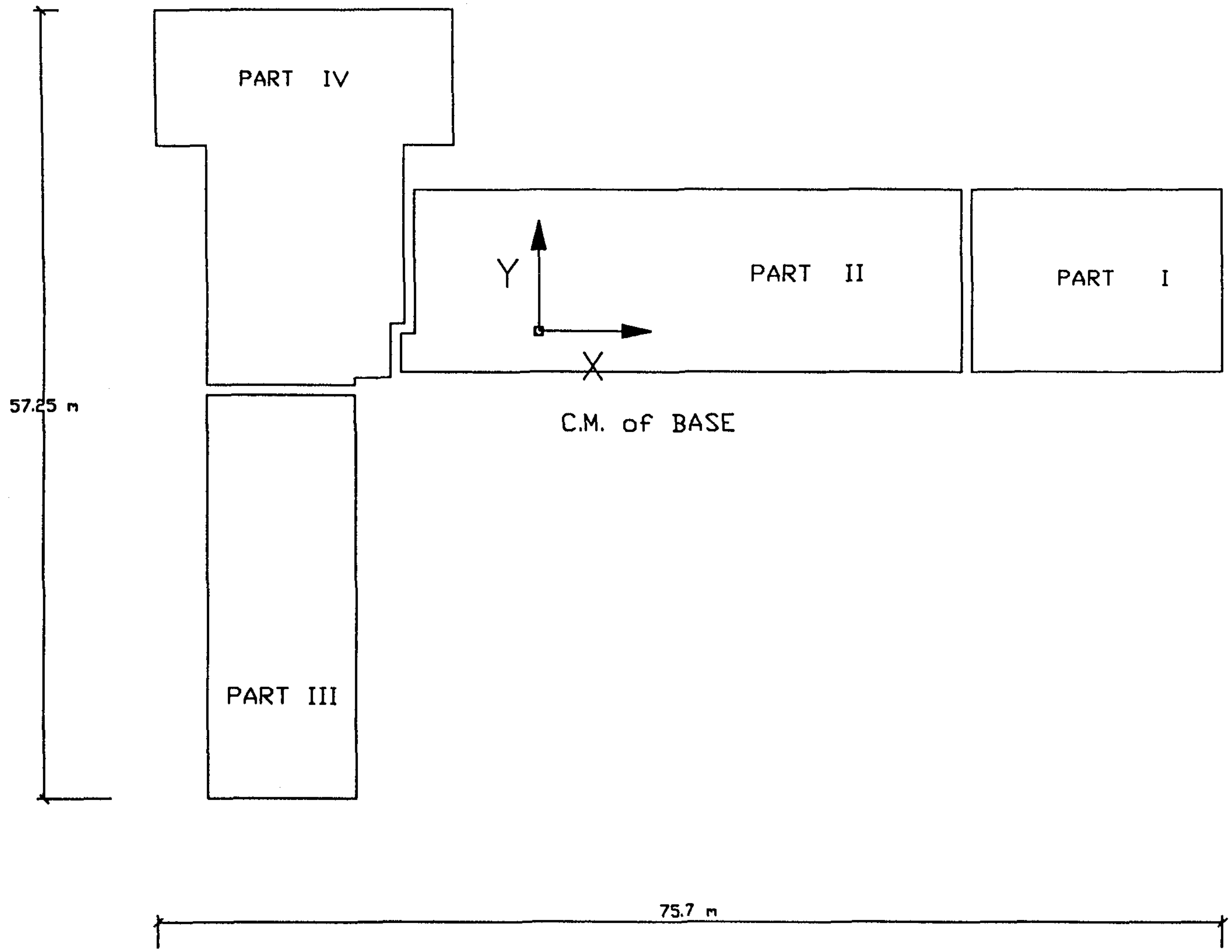


FIGURE 5-1 Layout of Mesologgi Hospital Complex.

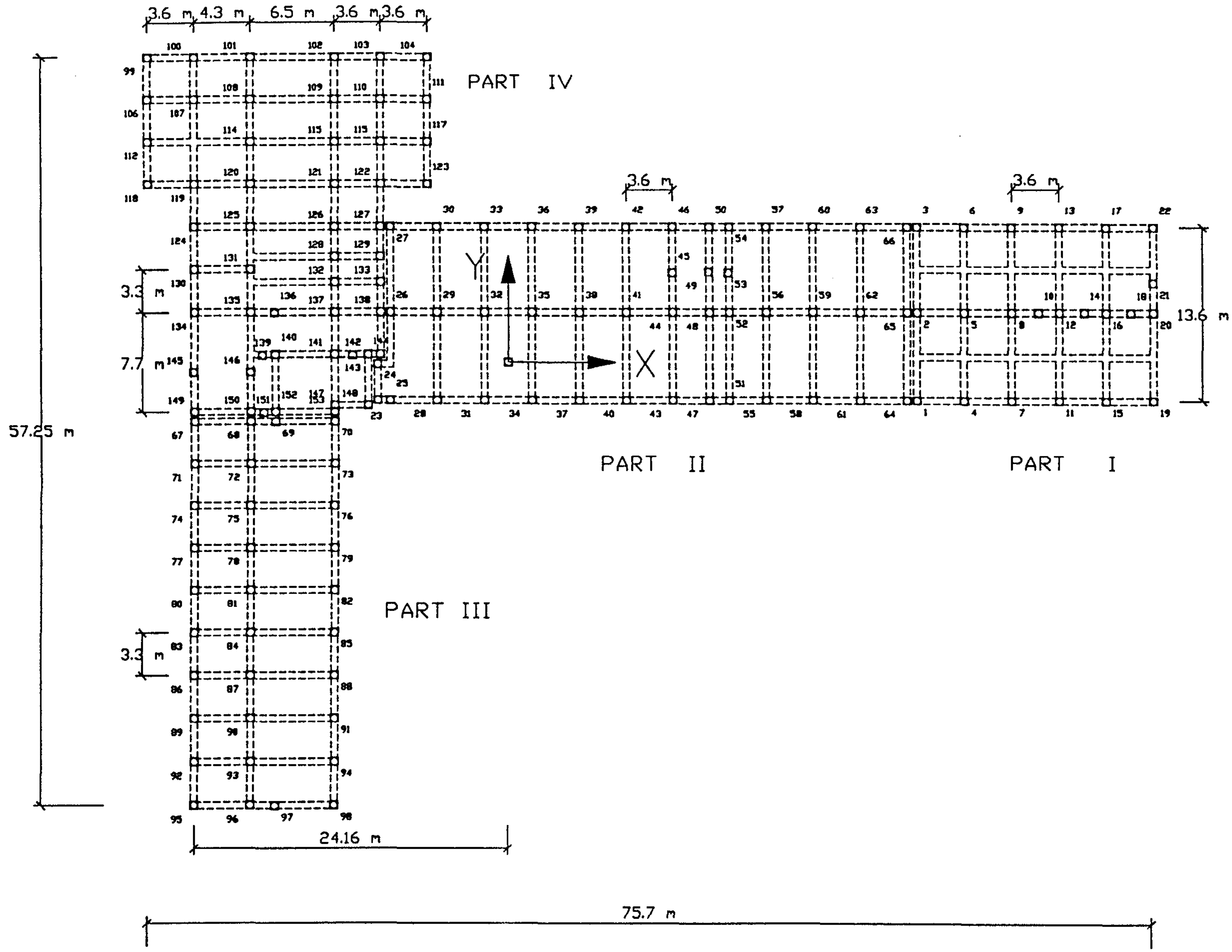


FIGURE 5-2 Bearing Locations of Mesologgi Hospital Complex.

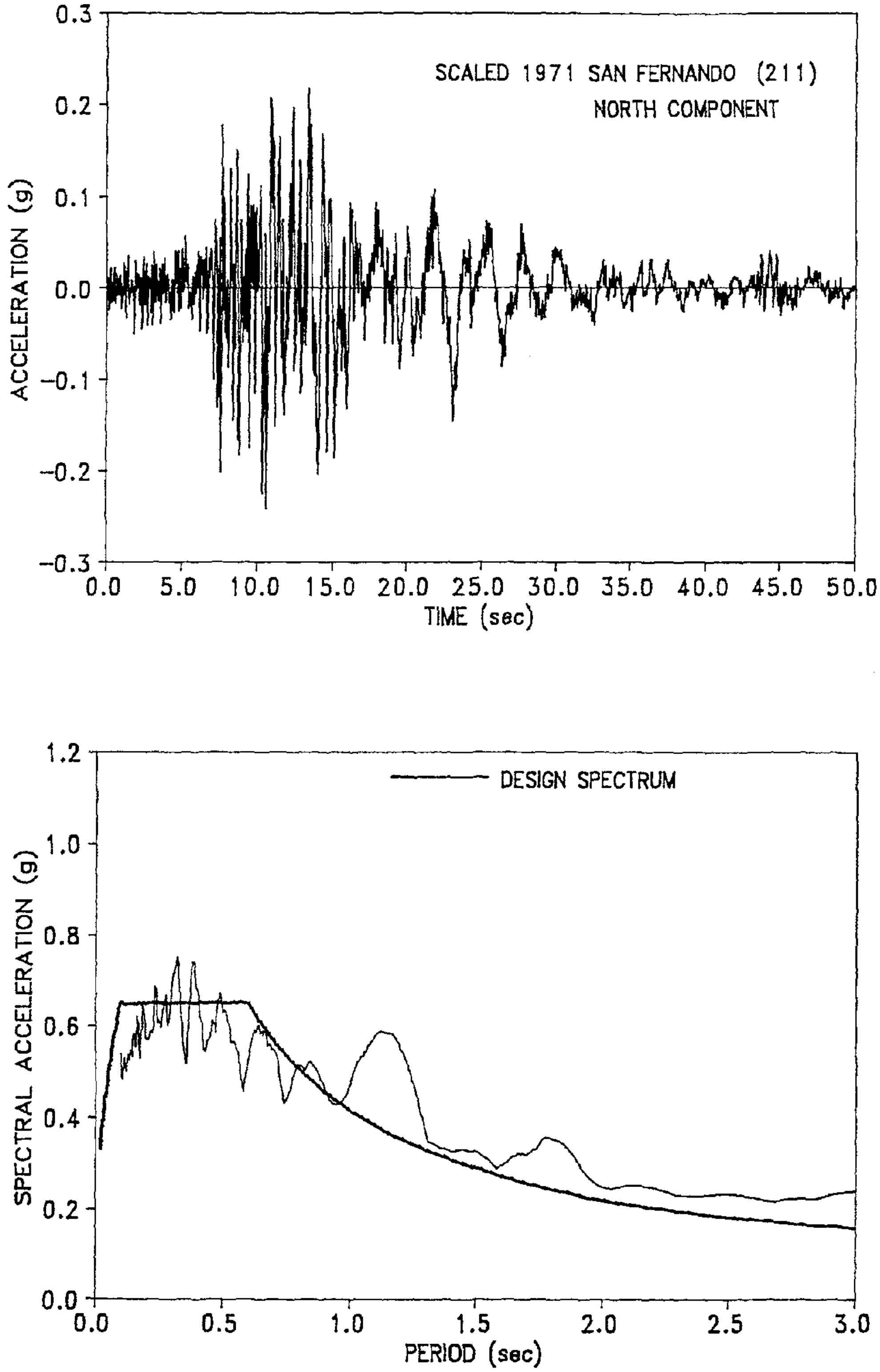


FIGURE 5-3 Acceleration Record of input Motion and Response Spectrum.

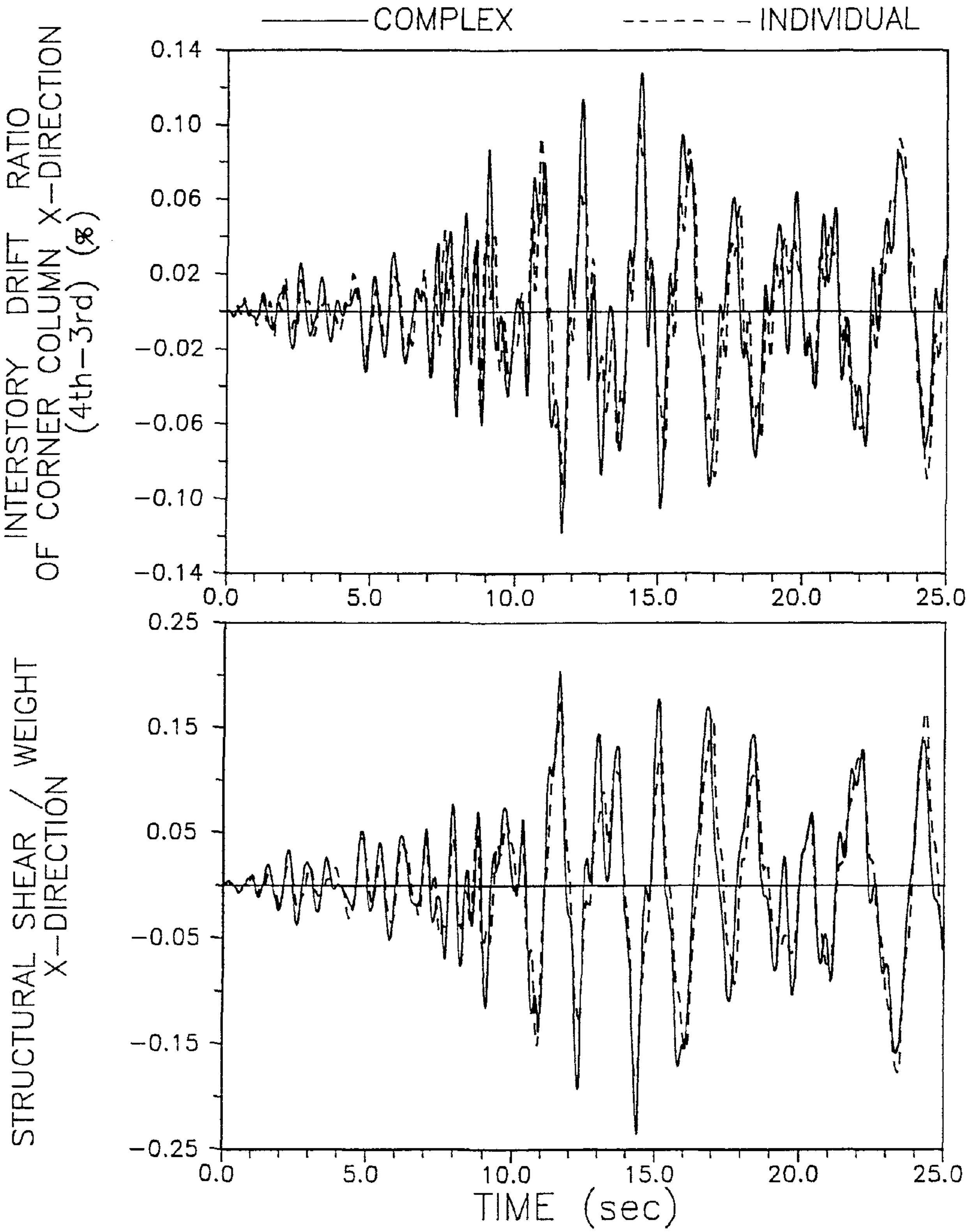


FIGURE 5-4 (a) Interstory Drift Ratio History of Corner Column of Part III (above bearing No 67) and (b) Structural Shear History of Part III of Mesologgi Hospital Complex.

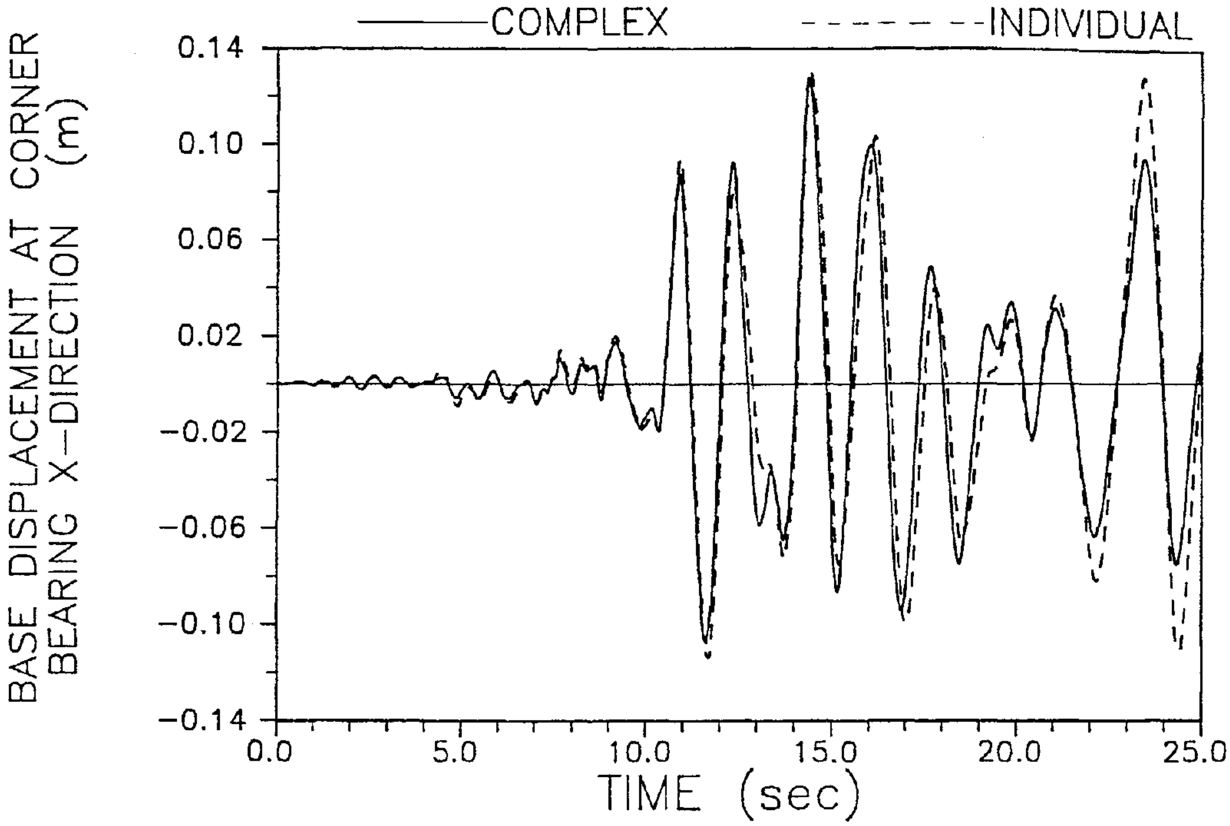


FIGURE 5-5 Base Displacement History of Corner Bearing of Part III (bearing No 67) of Mesologgi Hospital Complex.

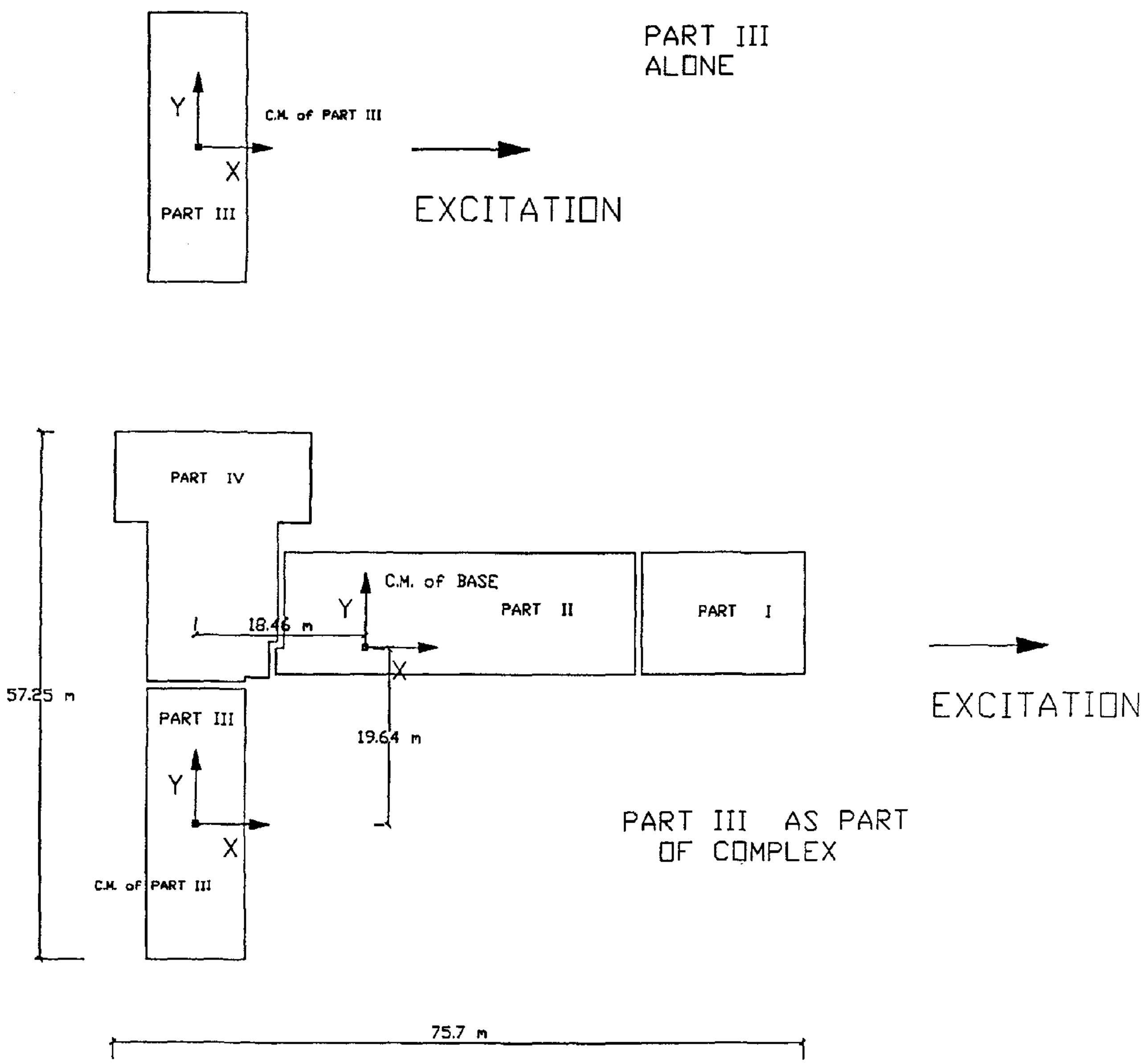


FIGURE 5-6 Part III Alone and Part III as Part of Complex.

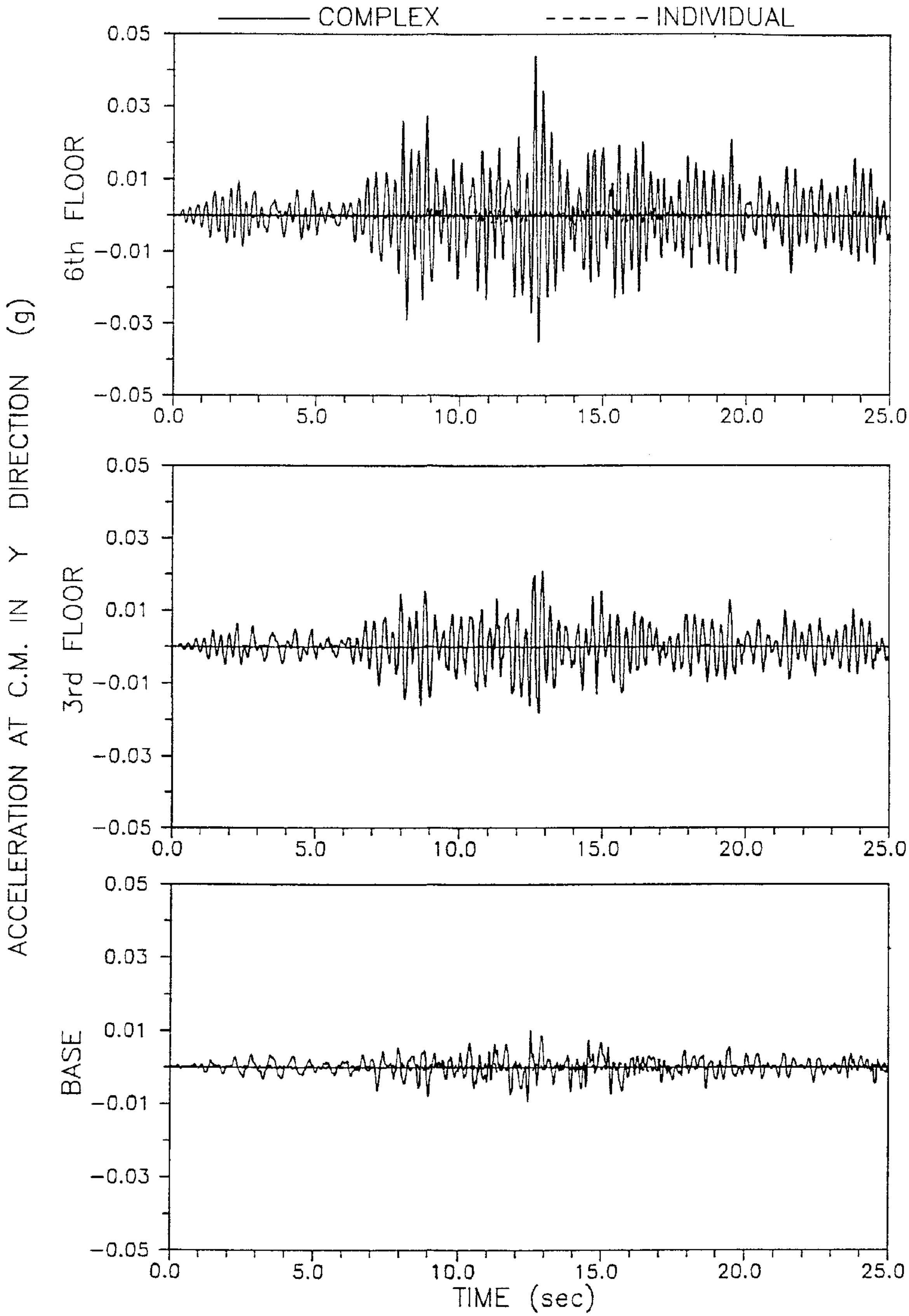


FIGURE 5-7 Acceleration Response in Y Direction of Part III.

SECTION 6

CONCLUSIONS

A computer program, called 3D-BASIS-M has been developed which is capable of performing dynamic nonlinear analysis of isolated structures consisting of several building superstructures which are connected together at the isolation system level. This situation arises in long buildings which need to be separated by narrow thermal joints.

The developed computer program is an extension of program 3D-BASIS which was developed for the analysis of isolated structures consisting of a single building superstructure. The basic features of program 3D-BASIS-M are:

a. Elastic Superstructure,

b. Spatial distribution of isolation elements,

c. Nonlinear behavior of isolation devices, and

d. Solution algorithm capable of handling severe nonlinearities like those in sliding bearings.

Computer program 3D-BASIS-M was verified by comparison of its results to results obtained by general purpose analysis programs such as DRAIN-2D and ANSR. These computer programs are widely used but are restricted only to elements exhibiting bilinear hysteretic behavior. In contrast, program 3D-BASIS-M is also capable of analyzing systems with sliding elements which exhibit severe nonlinear behavior.

The usefulness of program 3D-BASIS-M has been demonstrated in a case study of an isolated hospital complex consisting of four 6-story buildings on a common isolation basemat with 153 lead-rubber isolation bearings. The seismic response of one of the four buildings of the complex was analyzed

a. As part of the complex and considering the interaction with the adjacent buildings, and

b. As individual building and neglecting the interaction with the adjacent buildings.

A comparison of the computed responses in the two models revealed that the neglect of interaction with adjacent parts could result in substantial underestimation of story shears and interstory drifts of the isolated building.

SECTION 7

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APPENDIX A

3D-BASIS-M PROGRAM USER'S GUIDE

A.1 INPUT FORMAT FOR 3D-BASIS-M

Input file name is 3DBASISM.DAT and the output file is 3DBASISM.OUT. Free format is used to read all input data. Earthquake records are to be given in files WAVEX.DAT and/or WAVEY.DAT. Dynamic arrays are used. Double precision is used in the program for accuracy. Common block size has been set to 100,000 and should be changed if the need arises. All values are to be input unless mentioned otherwise. No blank cards are to be input.

A.2 PROBLEM TITLE

One card

TITLE	TITLE up to 80 characters

A.3 UNITS

One card

LENGTH,MASS,RTIME

LENGTH = Basic unit of length
up to 20 characters

MASS = Basic unit of mass
up to 20 characters

RTIME = Basic unit of time
up to 20 characters

A.4 CONTROL PARAMETERS

A.4.1 Control Parameters - Entire structure

One card

ISEV,NB,NP,INP

ISEV = 1 for option 1 - Data for Stiffness of the superstructures to be input.

ISEV = 2 for option 2 - Eigenvalues and eigenvectors of the superstructures (for fixed base condition) to be input.

NB = Number of superstructures on the common base.

NP = Number of bearings. (If NP<4 then NP set = 4)

INP = Number of bearings at which output is desired.

Notes: 1. For explanation of the option 1 and the option 2 refer to section 3.1.

2. Number of bearings refers to the total number of bearings which could be a combination of linear elastic, viscous, smooth bilinear or sliding bearings.

A.4.2 Control Parameters - Superstructures

NB cards

NF(I),NE(I),I=1,NB

NF(I) = Number of floors of superstructure I excluding base. (If NF<1 then NF set = 1)

NE(I) = Number of eigenvalues of superstructure I
to be retained in the analysis.
(If NE<3 then NE set = 3)

Notes: 1. Number of eigenvectors to be retained in the analysis should be in groups of three - the minimum being one set of three modes.

A.4.3 Control Parameters - Integration

one card
TSI,TOL,FMNORM,MAXMI,KVSTEP

TSI = Time step of integration.
Default = TSR (refer to A.4.5)

TOL = Tolerance for the nonlinear force vector computation. Recommended value =0.001.

FMNORM = Reference moment for convergence.

MAXMI = Maximum number of iterations within a time step.

KVSTEP = Index for time step variation.

KVSTEP = 1 for constant time step.
KVSTEP = 2 for variable time step.

Note: 1. The time step of integration cannot exceed the time step of earthquake record.

2. If MAXMI is exceeded the program is terminated with an error message.

3. Compute an estimate of FMNORM by multiplying the expected base shear by one half the maximum base dimension.

A.4.4 Control Parameters - Newmark's Method

One card

GAM,BET

GAM = Parameter which produces numerical damping within a time step.
(Recommended value = 0.5)

BET = Parameter which controls the variation of acceleration within a time step.
(Recommended value = 0.25)

A.4.5 Control Parameters - Earthquake Input

One card

INDGACC,TSR,LOR,XTH,ULF

INDGACC = 1 for a single earthquake record at an angle of incidence XTH.

INDGACC = 2 for two independent earthquake records along the X and Y axes.

TSR = Time step of earthquake record(s).

LOR = Length of earthquake record(s) (Number of data in earthquake record)

XTH = Angle of incidence of the earthquake with respect to the X axis in anticlockwise direction (for INDGACC=1).

ULF = Load factor.

Notes: 1. Two options are available for the earthquake record input:

a. INDGACC = 1 refers to a single earthquake record input at any angle of incidence XTH. Input only one earthquake record (read through a single file WAVEX.DAT). Refer to D.2 for wave input information.

b. INDGACC = 2 refers to two independent earthquake records input in the X and Y directions, e.g. El Centro N-S along the X direction and El Centro E-W along the Y direction. Input two independent earthquake records in the X and Y directions (read through two files WAVEX.DAT and WAVEY.DAT). Refer to D.2 and D.3 for wave input information.

2. The time step of earthquake record and the length of earthquake record has to be the same in both X and Y directions for INDGACC = 2.

3. Load factor is applied to the earthquake records in both the X and Y directions.

B.1 SUPERSTRUCTURE DATA

Go to B.2 for option 1 - three dimensional shear building representation of superstructure.

Go to B.3 for option 2 - full three dimensional representation of the superstructure. Eigenvalue analysis has to be done prior to the 3D-BASIS-M analysis using computer program ETABS.

Note: 1. The same type of group, B2 or B3, must be given for all superstructures (the same option, either 1 or 2, must be used for all superstructures).

2. The data must be supplied in the following sequence: B2 or B3, B4, B5, B6 and B7 for superstructure No. 1, then repeat for superstructure No. 2, etc. for a total of NB superstructures.

B.2 Shear Stiffness Data for Three Dimensional Shear Building (ISEV = 1)

B.2.1 Shear Stiffness - X Direction (Input only if ISEV = 1)

NF cards

SX(I),I=1,NF SX(I) = Shear stiffness of story I in the X direction.

Note: 1. Shear stiffness of each story in the X direction starting from the top story to the first story. One card is used for each story.

B.2.2 Shear stiffness in the Y Direction (Input only if ISEV = 1)

NF cards

SY(I),I=1,NF SY(I) = Shear stiffness of story I in the Y direction.

Note: 1. Shear stiffness of each story in the Y direction starting from the top story to the first story.

B.2.3 Torsional stiffness in the θ Direction (Input only if ISEV = 1)

NF cards

ST(I),I=1,NF ST(I) = Torsional stiffness of story I in the θ direction about the center of mass of the floor.

Note: 1. Torsional stiffness of each story in the θ direction starting from the top story to the first story.

B.2.4 Eccentricity Data - X Direction (Input only if ISEV = 1)

NF cards

EX(I),I=1,NF EX(I) = Eccentricity of center of resistance from the center of mass of the floor I. Default = 0.0001.

B.2.5 Eccentricity Data - Y direction (Input only if ISEV = 1)

NF cards

EY(I),I=1,NF EY(I) = Eccentricity of center of resistance from the center of mass of the floor I. Default = 0.0001.

Note: 1. The case of zero eccentricity in both the X and Y directions cannot be solved correctly by the eigensolver in the program, hence if both the eccentricties are zero, a default value of 0.0001 is used.

B.3 Eigenvalues and Eigenvectors for Fully Three Dimensional Building (ISEV = 2)

B.3.1 Eigenvalues (Input only if ISEV = 2)

NE cards
W(I),I=1,NE   W(I) = Eigenvalue of I^{th} mode.

Note: 1. Input from the first mode to the NE mode.

B.3.2 Eigenvectors (Input only if ISEV =2)

NE cards
E(3*NF,I),I=1,NE
E(3*NF,I) = Eigenvector of I^{th} mode.

Note: 1. Input from the first mode to the NE mode.

B.4 Superstructure Mass Data

B.4.1 Translational Mass

NF Cards
CMX(I),I=1,NF CMX(I) = Translational mass at floor I.

Note: 1. Input from the top floor to the first floor.

B.4.2 Rotational Mass (Mass Moment of Inertia)

NF Cards
CMT(I),I=1,NF CMT(I) = Mass moment of inertia of floor I about the center of mass of the floor.

Note: 1. Input from the top floor to the first floor.

B.5 Superstructure Damping Data

NE Cards

DR(I),I=1,NE DR(I) = Damping ratio corresponding to mode I.

Note: 1. Input from the first mode to the NE mode.

B.6 Distance to the Center of Mass of the Floor

NF cards

XN(I),YN(I),I=1,NF

XN(I) = Distance of the center of mass of the floor I from the center of mass of the base in the X direction.

YN(I) = Distance of the center of mass of the floor I from the center of mass of the base in the Y direction.

(If ISEV = 1 then XN(I) and YN(I) set 0)

Note: 1. Input from the top floor to the first floor.

B.7 Height of the Base and Different Floors

NF+1 cards

H(I),I=1,NF+1 H(I) = Height from the ground to the floor I.

Note: 1. Input from the top floor to the base.

C.1 ISOLATION SYSTEM DATA

C.2 Stiffness Data for Linear Elastic Isolation System

One card
SXE,SYE,STE,EXE,EYE

SXE = Resultant stiffness of linear elastic isolation system in the X direction.

SYE = Resultant stiffness of linear elastic isolation system in the Y direction.

STE = Resultant tortional stiffness of linear elastic isolation system in the θ direction about the center of mass of the base.

EXE = Eccentricity of the center of resistance of the linear elastic isolation system in the X direction from the center of mass of the base.

EYE = Eccentricity of the center of resistance of the linear elastic isolation system in the Y direction from the center of mass of the base.

Note: 1. Data for linear elastic elements can also be input individually (refer to C.5.1).

C.3 Mass Data of the Base

One Card

CMXB,CMTB — CMXB = Mass of the base in the translational direction.

CMTB = Mass moment of inertia of the base about the center of mass of the base.

C.4 Global Damping Data

One card

CBX,CBY,CBT,ECX,ECY

CBX = Resultant global damping coefficient in the X direction.

CBY = Resultant global damping coefficient in the Y direction.

CBT = Resultant global damping coefficient in the θ direction about the center of mass of the base.

ECX = Eccentricity of the center of global damping of the isolation system in the X direction from the center of mass of the base.

ECY = Eccentricity of the center of global damping of the isolation system in the Y direction from the center of mass of the base.

Note: 1. Data for viscous elements can also be input individually (refer to C.5.2).

C.5 Isolation Element Data

The isolation element data are input in the following sequence:

1. Coordinates of isolation elements with respect to the center of mass of the base. One card containing the X and Y coordinates of each isolation element is used. The first card in the sequence corresponds to element No. 1, the second to element No. 2, etc. up to element No. NP.

2. The second set of data for the isolation elements consists of two cards for isolation element. The first card identifies the type of element and the second specifies its mechanical properties. Two cards are used for isolation element No. 1, then another two for element No. 2, etc. up to No. NP. The first of the two cards for each element always contains two integer numbers. These numbers are stored in array INELEM(NP,2) which has NP rows and two columns. The card containing these two numbers will be identified in the sequel as INELEM(K,I:J)
where K refers to the isolation element number (1 to NP), I is the first number and J is the second number. I denotes whether the element is uniaxial (unidirectional) or biaxial (bidirectional). J denotes the type of element :

I = 1 for uniaxial element in the X direction

I = 2 for uniaxial element in the Y direction

I = 3 for biaxial element

J = 1 for linear elastic element

J = 2 for viscous element

J = 3 for hysteretic element for elastomeric bearings/steel dampers

J = 4 for hysteretic element for sliding bearings

Note: 1. Uniaxial element refers to the element in which biaxial interaction between the forces in the X and Y directions is neglected rendering the interaction surface to be square, instead of the circular interaction surface for the biaxial case.

C.5.1 Linear Elastic Element

One card

INELEM(K,1:2) INELEM(K,1) can be either 1,2 or 3

INELEM(K,2) = 1

(Refer to C.5 for further details).

One card

PS(K,1),PS(K,2)

PS(K,1) = Shear stiffness in the X direction for biaxial element or uniaxial element in the X direction (leave blank if the uniaxial element is in the Y direction only.

PS(K,2) = Shear stiffness in the Y direction for biaxial element or uniaxial

element in the Y direction
(leave blank if the uniaxial element
is in the X direction only.

Note: 1. Biaxial element means elestic stiffness in both X and Y directions (no interaction between forces in X and Y direction).

C.5.2 Viscous Element

One card

INELEM(K,1:2) INELEM(K,1) can be either 1,2 or 3
INELEM(K,2) = 2
(Refer to C.5 for further details).

One card

PC(K,1),PC(K,2)

PC(K,1) = Damping coefficient in the X direction for biaxial element or uniaxial element in the X direction
(leave blank if the uniaxial element is in the Y direction only.

PC(K,2) = Damping coefficient in the Y direction for biaxial element or uniaxial element in the Y direction
(leave blank if the uniaxial element is in the X direction only.

Note: 1. Biaxial element means elestic stiffness in both X and Y directions (no interaction between forces in X and Y direction).

C.5.3 Hysteretic Element for Elastomeric Bearings/Steel Dampers

One card

INELEM(K,1:2) INELEM(K,1) can be either 1,2 or 3

INELEM(K,2) = 3

(Refer to C.5 for further details).

One card

ALP(K,I),YF(K,I),YD(K,I),I=1,2

ALP(K,1) = Post-to-preyielding stffness ratio;
YF(K,1) = Yield force;
YD(K,1) = Yield displacement;
in the X direction
for biaxial element or uniaxial element in the X direction
(leave blank if the uniaxial element is in the Y direction only.

ALP(K,2) = Post-to-preyielding stffness ratio;
YF(K,2) = Yield force;
YD(K,2) = Yield displacement;
in the Y direction
for biaxial element or uniaxial element in the Y direction
(leave blank if the uniaxial element is in the X direction only.

C.5.4 Hysteretic Element for Sliding Bearings

One card

INELEM(K,1:2) INELEM(K,1) can be either 1,2 or 3
INELEM(K,2) = 4
(Refer to C.5 for further details).

One card

(FMAX(K,I),DF(K,I),PA(K,I),YD(K,I),I=1,2),FN(K)

FMAX(K,1) = Maximum coefficient of sliding friction;
DF(K,1) = Difference between the maximum and minimum coefficient of sliding friction;
PA(K,1) = Constant which controls the transition of coefficient of sliding friction from maximum to minimum value;
YD(K,1) = Yield displacement; in the X direction for biaxial element or uniaxial element in the X direction (leave blank if the uniaxial element is in the Y direction only.

FMAX(K,2) = Maximum coefficient of sliding friction;
DF(K,2) = Difference between the maximum and minimum coefficient of sliding friction;
PA(K,2) = Constant which controls the transition of coefficient of sliding friction from maximum to minimum value;

YD(K,2) = Yield displacement;
in the Y direction
for biaxial element or uniaxial
element in the Y direction
(leave blank if the uniaxial element
is in the X direction only.

FN(K) = Initial normal force at the
sliding interface.

C.6 Coordinates of Bearings

NP Cards

XP(NP),YP(NP),I=1,NP

XP(I) = X Coordinate of isolation
element I from the center of mass
of the base.

YP(I) = Y Coordinate of isolation
element I from the center of mass
of the base.

D.1 EARTHQUAKE DATA

D.2 Unidirectional Earthquake Record

File:WAVEX.DAT

LOR cards

X(I),I=1,LOR X(I) = Unidirectional acceleration component.

Note: 1. If INDGACC as specified in A.4.4 is 1, then the input will be assumed at an angle XTH specified in A.4.4. If INDGACC as specified in A.4.4 is 2, then X(LOR) is considered to be the X component of the bidirectional earthquake.

D.3 Earthquake Record in the Y Direction for the Bidirectional Earthquake

File:WAVEY.DAT (Input only if INDGACC = 2)

LOR cards

Y(I),I=1,LOR Y(I) = Acceleration component in the Y direction.

E.1 OUTPUT DATA

E.2 Output Parameters

One card
LTMH,KPD,IPROF

LTMH = 1 for both the time history and peak response output.
LTMH = 0 for only peak response output.

KPD = No. of time steps before the next response quantity is output.

IPROF = 1 for accelerations-displacements profiles output.
IPROF = 0 for no accelerations-displacements profiles output.

E.3 Isolator output

INP cards
IP(I),I=1,INP

IP(I) = Bearing number of bearings I at which the force and displacement response is desired.

E.4 Interstory drift output

The following set of cards must be imported as many times as the number of superstructures NB.

One card

ICOR(I),I=1,NB

ICOR(I) = Number of column lines of superstructure I at which the interstory drift is desired.

ICOR(I) cards

CORDX(K),CORDY(K),K=1,ICOR(I)

CORDX(K) = X coordinate of the column line at which the interstory drift is desired.

CORDY(K) = Y coordinate of the column line at which the interstory drift is desired.

Note: 1. Maximum number of columns at which drift output may be requested is limited to six for each superstructure (maximum value for ICOR(I) is six)

2. The coordinates of the column lines are with respect to the reference axis at the center of mass of the base.

APPENDIX B

3D-BASIS-M INPUT/OUTPUT EXAMPLE

Input and output (for option LTMH=0 -only peak response output) for the case study of section 5 are presented.

Input file was file 3DBASISM.DAT. Furthermore, file WAVEX.DAT contained the ground acceleration record. Output file was 3DBASISM.OUT.

```
MESSOLOGI HOSPITAL 153 LEAD RUBBER ISOLATORS                              TITLE
    meters    tons*sec*sec/meters      sec                                UNITS
2 4 153 16
6 6
6 6                                                                       CONTROL PARAMETERS - STRUCTURE
6 6
6 6
0.005 10 1 200 1                                                          CONTROL PARAMETERS - INTEGRATION
0.5 0.25                                                                  DATA FOR NEWMARK'S METHOD
0.1 0.9                                                                   DATA IN HYSTERETIC MODEL (ALWAYS THE SAME)
1 0.025 1000 0 9.81                                                       CONTROL PARAMETERS - E'QUAKE INPUT
193.59
340.812
574.62                                                                    EIGENVALUES (ω^2 in rad/sec)
2255.21
2733.61
5011.075
  0.0059400 -0.1169470  0.0030560  0.0052590 -0.0900270  0.0021540
  0.0044570 -0.0616990  0.0012660  0.0033550 -0.0358980  0.0004420           1st MODE
  0.0020290 -0.0133070 -0.0002110  0.0008180 -0.0053770 -0.0000910
 -0.1020630 -0.0045800  0.0036720 -0.0883190 -0.0025260  0.0029060
 -0.0697160 -0.0005760  0.0020700 -0.0483690  0.0008070  0.0012510
 -0.0281440  0.0015950  0.0005060 -0.0134670  0.0006270  0.0002090
  0.0201900  0.0118200  0.0163630  0.0184390  0.0140890  0.0132730
  0.0150020  0.0151130  0.0096800  0.0107110  0.0152290  0.0061400
  0.0071300  0.0127030  0.0027690  0.0037950  0.0058720  0.0012590        MODE SHAPES STARTING
 -0.0113810  0.0847690  0.0003110 -0.0025530 -0.0021180  0.0016620        FROM 1st AND ENTERED
  0.0059750 -0.0736540  0.0023900  0.0110500 -0.0953630  0.0018520        IN ROW FORMAT          DATA FOR SUPERSTRUCTURE
  0.0102320 -0.0555710 -0.0003560  0.0054310 -0.0275380 -0.0002520                                       No. 1
  0.0878400  0.0102410 -0.0013280  0.0228490 -0.0015030  0.0003040                                    (OPTION 2)
 -0.0464610 -0.0106300  0.0015890 -0.0860050 -0.0117000  0.0019500
 -0.0759720 -0.0041250  0.0010390 -0.0428490 -0.0022080  0.0004800
  0.0080520 -0.0006750  0.0130530  0.0053480  0.0133640  0.0010460
 -0.0024000  0.0135210 -0.0096130 -0.0095510 -0.0050210 -0.0136230
 -0.0112180 -0.0327510 -0.0088540 -0.0073750 -0.0204980 -0.0047870
     33.737     33.737     33.737     37.123     39.652     34.594      MASSES
   1476.889   1476.889   1476.889   1625.117   1735.886   1514.442      MASS MOMENT OF INERTIA
0.05 0.05 0.05 0.05 0.05 0.05                                             DAMPING RATIOS
39.09 2.31
39.09 2.31
39.09 2.31                                                                ECCENTRICITIES
39.09 2.31
39.09 2.31
39.09 2.31
21.3 18.1 14.9 11.7 7.9 4.7 1                                             HEIGHTS
219.35
569.81
1447.225
4358.106
8789.97
10307.88
  0.0022470 -0.0786390  0.0023540  0.0017130 -0.0618930  0.0019890
  0.0010660 -0.0450550  0.0015400  0.0007120 -0.0297010  0.0010910
  0.0003850 -0.0139630  0.0005870  0.0000420 -0.0047610  0.0002050
  0.0013700  0.0349520  0.0065920  0.0010590  0.0249580  0.0051310
```

DATA FOR SUPERSTRUCTURE
No. 2
(OPTION 2)

```
  0.0004100  0.0161930  0.0035440  0.0002410  0.0080670  0.0020950
  0.0001790  0.0019200  0.0007860 -0.0000640  0.0006310  0.0002920
  0.0798050  0.0009410 -0.0001280  0.0673120  0.0011170 -0.0001070
  0.0497480  0.0012050 -0.0001070  0.0345410  0.0011130 -0.0000800
  0.0182970  0.0007000 -0.0000280  0.0093690  0.0002830 -0.0000070
 -0.0081190  0.0559460 -0.0049860  0.0001920  0.0032420  0.0002520
  0.0050230 -0.0263750  0.0023680  0.0057680 -0.0417910  0.0032440
  0.0039630 -0.0360460  0.0025000  0.0013790 -0.0172400  0.0011670
  0.0192590  0.0410440  0.0044310  0.0033380  0.0102040 -0.0007190
 -0.0104240 -0.0285480 -0.0029080 -0.0138900 -0.0471280 -0.0032650
 -0.0103810 -0.0393060 -0.0017720 -0.0054230 -0.0206570 -0.0008110
 -0.0705630  0.0048180  0.0015790 -0.0189940  0.0018560 -0.0001710
  0.0389010 -0.0048150 -0.0008760  0.0582890 -0.0075250 -0.0010950
  0.0480160 -0.0056680 -0.0007330  0.0286740 -0.0029390 -0.0003680
     55.118     75.060     76.877     81.483     84.187     73.192
   8359.707  11384.150  11659.783  12657.450  13077.691  11144.315
0.05 0.05 0.05 0.05 0.05 0.05
10.24  1.66
10.24  1.66
10.24  1.66
9.99   1.61
9.99   1.61
9.99   2.14
21.3 18.1 14.9 11.7 7.9 4.7 1
199.61
569.82
677.79
3737.93
3949.42
10262.74
 -0.0979990 -0.0008600  0.0026840 -0.0798740 -0.0009340  0.0021660
 -0.0609280 -0.0010950  0.0016370 -0.0421690 -0.0011820  0.0011260
 -0.0213180 -0.0009150  0.0005640 -0.0077810 -0.0003180  0.0001890
  0.0067760 -0.0925420  0.0022150  0.0056870 -0.0834900  0.0018540
  0.0044340 -0.0603760  0.0014630  0.0031860 -0.0447500  0.0010680
  0.0017050 -0.0223330  0.0005640  0.0007560 -0.0112200  0.0002220
  0.0225330  0.0225500  0.0099260  0.0194600  0.0202460  0.0081950
  0.0156760  0.0135440  0.0063380  0.0116470  0.0091420  0.0044930
  0.0063020  0.0027960  0.0023210  0.0029810  0.0017520  0.0008930
  0.0874160  0.0028910 -0.0017140  0.0212520  0.0013760 -0.0002480
 -0.0389100 -0.0011330  0.0009670 -0.0739850 -0.0020730  0.0015610
 -0.0700880 -0.0031680  0.0013030 -0.0371560 -0.0017960  0.0005760
  0.0033330 -0.0878610  0.0004180  0.0007020 -0.0341390  0.0002500
 -0.0016320  0.0536870  0.0000650 -0.0029760  0.0784270 -0.0000770
 -0.0029080  0.0565070 -0.0001630 -0.0015400  0.0328610 -0.0001180
  0.0088020  0.0138880  0.0090140  0.0073030 -0.0026890  0.0023810
  0.0001150 -0.0163620 -0.0037930 -0.0103980 -0.0085920 -0.0074340
 -0.0193390  0.0191360 -0.0072820 -0.0153570  0.0149140 -0.0040380
     33.079     51.824     45.565     53.607     52.727     50.036
   2963.309   4642.417   4081.713   4802.204   4593.430   4359.010
0.05 0.05 0.05 0.05 0.05 0.05
-18.32 -20.29
-18.32 -20.29
-18.32 -20.29
-18.32 -20.29
```

DATA FOR SUPERSTRUCTURE
No. 3
(OPTION 2)

DATA FOR SUPERSTRUCTURE
No. 4
(OPTION 2)

```
-18.33 -19.64
-18.33 -19.64
21.3 18.1 14.9 11.7 7.9 4.7 1
337.69
449.71
968.27
2861.76
5191.42
8360.33
  0.0249770 -0.0787770  0.0003940  0.0199800 -0.0674090  0.0003570
  0.0148300 -0.0522180  0.0003210  0.0094920 -0.0380740  0.0002520
  0.0047160 -0.0208060  0.0001190  0.0017680 -0.0090370  0.0000360
  0.0842820  0.0246590  0.0012730  0.0671660  0.0203170  0.0011060
  0.0496650  0.0146630  0.0009370  0.0319040  0.0103920  0.0007350
  0.0156770  0.0060810  0.0004330  0.0061440  0.0028470  0.0001540
 -0.0137810  0.0061910  0.0097190 -0.0098150  0.0021540  0.0078340
 -0.0055700 -0.0021330  0.0058390 -0.0090220 -0.0061120  0.0039430
 -0.0035400 -0.0028680  0.0019620 -0.0017270 -0.0011550  0.0008280
  0.0046120 -0.0819690  0.0002600  0.0010210 -0.0180560  0.0005730
 -0.0022210  0.0469630  0.0007450 -0.0049410  0.0565230  0.0006080
 -0.0038680  0.0458250  0.0003450 -0.0017890  0.0255400  0.0001550
 -0.0651600 -0.0059210  0.0031330 -0.0119000 -0.0021020  0.0008490
  0.0347680  0.0030240 -0.0012060  0.0626600  0.0048330 -0.0022650
  0.0516010  0.0041900 -0.0016320  0.0264870  0.0029060 -0.0007830
 -0.0237520 -0.0225450 -0.0067790 -0.0037340  0.0223480 -0.0015390
  0.0139000  0.0312050  0.0029920  0.0149610 -0.0071390  0.0053870
  0.0167250 -0.0336670  0.0047250  0.0101780 -0.0263260  0.0025170
     56.373     56.373     67.428     85.003     74.834     73.283
   4321.655   4321.655   5169.205   7837.712   6930.497   6791.275
0.05 0.05 0.05 0.05 0.05 0.05
-18.19  9.33
-18.19  9.33
-18.19  9.33
-16.90 10.34
-16.95 10.50
-16.83 10.49
21.3 18.1 14.9 11.7 7.9 4.7 1
0,0,0,0,0                    GLOBAL ELASTIC STIFFNESSES AT CENTER OF MASS OF BASE
453.24,291323.2              MASS AND MASS MOMENT OF INERTIA OF BASE
0,0,0,0,0                    GLOBAL DAMPING COEFFICIENTS AT CENTER OF MASS OF BASE
```

COORDINATES OF ISOLATION ELEMENTS

```
      29.94       -4.59
      29.94        2.26
      29.94        8.91
      33.39       -4.59
      33.39        2.26
      33.39        8.91
      36.99       -4.59
      36.99        2.26
      36.99        8.91
      39.39        2.26
      40.59       -4.59
      40.59        2.26
      40.59        8.91
      41.79        2.26
      44.19       -4.59
```

44.19	2.26
44.19	8.91
45.49	2.26
47.79	-4.59
47.79	2.26
47.79	4.36
47.79	8.91
-10.61	-4.29
-10.61	-1.19
-9.71	-4.59
-9.71	2.01
-9.71	8.91
-5.96	-4.59
-5.96	2.01
-5.96	8.91
-2.36	-4.59
-2.36	2.01
-2.36	8.91
1.24	-4.59
1.24	2.01
1.24	8.91
4.84	-4.59
4.84	2.01
4.84	8.91
8.44	-4.59
8.44	2.01
8.44	8.91
12.04	-4.59
12.04	2.01
12.04	5.31
12.04	8.91
14.34	-4.59
14.34	2.01
14.34	5.31
14.34	8.91
16.74	-4.59
16.74	2.01
16.74	5.31
16.74	8.91
19.24	-4.59
19.24	2.01
19.24	8.91
22.84	-4.59
22.84	2.01
22.84	8.91
26.44	-4.59
26.44	2.01
26.44	8.91
29.89	-4.59
29.89	2.01
29.89	8.91
-24.16	-4.64
-19.86	-4.64
-17.51	-4.64
-13.06	-4.64

-24.16	-7.79
-19.86	-7.79
-13.06	-7.79
-24.16	-11.09
-19.86	-11.09
-13.06	-11.09
-24.16	-14.39
-19.86	-14.39
-13.06	-14.39
-24.16	-17.69
-19.86	-17.69
-13.06	-17.69
-24.16	-20.99
-19.86	-20.99
-13.06	-20.99
-24.16	-24.29
-13.06	-24.29
-19.86	-25.69
-24.16	-27.59
-19.86	-27.59
-13.06	-27.59
-24.16	-30.89
-19.86	-30.89
-13.06	-30.89
-24.16	-34.34
-19.86	-34.34
-16.81	-34.34
-13.06	-34.34
-27.76	23.06
-25.26	23.06
-19.86	23.06
-15.36	23.06
-13.36	23.06
-9.76	23.06
-6.31	23.06
-27.76	19.61
-24.16	19.61
-19.86	19.61
-13.36	19.61
-9.76	19.61
-6.31	19.61
-27.76	16.31
-24.16	16.31
-19.86	16.31
-13.36	16.31
-9.76	16.31
-6.31	16.31
-27.76	13.01
-24.16	13.01
-19.86	13.01
-13.36	13.01
-9.76	13.01
-6.31	13.01
-24.16	9.71
-19.86	9.71

```
-13.36      9.71
 -9.76      9.71
-13.36      7.66
 -9.76      7.66
-24.16      6.41
-19.86      6.41
-13.36      4.76
 -9.76      4.76
-24.16      3.11
-19.86      3.11
-17.66      3.11
-13.36      3.11
 -9.76      3.11
-17.66      0.01
-17.11      0.01
-13.36      0.01
-12.71      0.01
-11.61      0.01
-10.66      0.01
-24.16     -1.29
-19.86     -1.29
-13.36     -3.29
-10.66     -3.29
-24.16     -4.59
-19.86     -4.59
-17.66     -4.59
-17.11     -4.59
-13.36     -4.59
   3    3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3                                                       ]---- ELEMENT No. 2
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3                                                             ELEMENT No. 3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3    3                                                             ELEMENT No. 4
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
   3    3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
   3    3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
   3    3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3    3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
   3    3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3    3
```

TYPE AND MECHANICAL PROPERTIES
OF ISOLATION ELEMENTS

```
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
  3     3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
  3     3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
  3     3
0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
  3     3
0.153800   0.153800   7.732000   7.732000   0.007061   0.007061
  3     3
0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
```

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   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.153800    0.153800    7.732000    7.732000    0.007061    0.007061
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.144070    0.144070    5.909000    5.909000    0.004353    0.004353
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
0.146500    0.146500    3.640000    3.640000    0.005232    0.005232
   3     3
```

0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
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0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
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0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
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0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
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0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
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0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.153800	0.153800	7.732000	7.732000	0.007061	0.007061
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.153800	0.153800	7.732000	7.732000	0.007061	0.007061
3 3					
0.153800	0.153800	7.732000	7.732000	0.007061	0.007061
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353

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   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 1.000000   1.000000 117.216003 117.216003   1.000000   1.000000
   3     3
 1.000000   1.000000 117.216003 117.216003   1.000000   1.000000
   3     3
 1.000000   1.000000 117.216003 117.216003   1.000000   1.000000
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3     3
 1.000000   1.000000 117.216003 117.216003   1.000000   1.000000
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
 0.146500   0.146500   3.640000   3.640000   0.005232   0.005232
   3     3
```

1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
1.000000	1.000000	117.216003	117.216003	1.000000	1.000000
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.146500	0.146500	3.640000	3.640000	0.005232	0.005232
3 3					
0.144070	0.144070	5.909000	5.909000	0.004353	0.004353

```
   3    3
  0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
   3    3
  0.144070   0.144070   5.909000   5.909000   0.004353   0.004353
0 5 1                                                              OUTPUT PARAMETERS
1 3 19 22 25 27 64 66 67 70 95 98 105 99 148 149                  ISOLATOR OUTPUT
3
47.94,9.01
29.94,-4.59                                                        SUPERSTRUCTURE No.1
39.09,2.31
3
29.89,9.01
-9.71,-4.59                                                        SUPERSTRUCTURE No.2
9.96,2.14
3                                                                              INTERSTORY DRIFT OUTPUT
-24.16,-34.34
-13.36,-4.64
-18.46,-19.64
2                                                                  2 COLUMN LINES
-27.76,23.06
-13.36,-4.59                                                       COORDINATES OF 2 COLUMN LINES
```

B.2 OUTPUT FILE (3DBASISM.OUT)

```
******************************************************************


PROGRAM   3D-BASIS-M...... A GENERAL PROGRAM FOR THE NONLINEAR
          DYNAMIC ANALYSIS OF THREE DIMENSIONAL BASE ISOLATED
          MULTIPLE BUILDING STRUCTURES

DEVELOPED BY...P. C. TSOPELAS, S. NAGARAJAIAH,
               M. C. CONSTANTINOU AND A. M. REINHORN
               DEPARTMENT OF CIVIL ENGINEERING
               STATE UNIV. OF NEW YORK AT BUFFALO

               VAX VERSION, APRIL 1991


NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
STATE UNIVERSITY OF NEW YORK, BUFFALO


******************************************************************



MESSOLOGI HOSPITAL 153 LEAD RUBBER ISOLATORS



UNITS
LENGTH :     meters    tons*s
MASS   : ec*sec/meters      s
TIME   : ec



**************INPUT DATA***************



***************** CONTROL PARAMETERS ***************



NO. OF BUILDINGS........................=           4
NO. OF ISOLATORS........................=         153
INDEX FOR  SUPERSTRUCTURE STIFFNESS DATA=           2
```

```
  INDEX = 1 FOR 3D SHEAR BUILDING  REPRES.
  INDEX = 2 FOR FULL 3D REPRESENTATION
NUMBER OF ISOLATORS, OUTPUT IS DESIRED...=         16

TIME STEP OF INTEGRATION (NEWMARK)......=     0.00500
INDEX FOR TYPE OF TIME STEP.............=           1

  INDEX = 1 FOR CONSTANT TIME STEP
  INDEX = 2 FOR VARIABLE TIME STEP

GAMA FOR NEWMARKS  METHOD...............=     0.50000
BETA FOR NEWMARKS  METHOD...............=     0.25000
TOLERANCE FOR FORCE COMPUTATION.........=    10.00000
REFERENCE MOMENT OF CONVERGENCE.........=     1.00000
MAX NUMBER OF ITERATIONS WITHIN T.S.....=         200
BETA FOR WENS MODEL ....................=     0.10000
GAMA FOR WENS MODEL ....................=     0.90000

INDEX FOR GROUND MOTION INPUT...........=           1

  INDEX = 1 FOR UNIDIRECTIONAL INPUT
  INDEX = 2 FOR BIDIRECTIONAL INPUT

TIME STEP OF RECORD ....................=     0.02500
LENGTH OF RECORD........................=        1000
LOAD FACTOR.............................=     9.81000
ANGLE OF EARTHQUAKE INCIDENCE...........=     0.00000


************* SUPERSTRUCTURE DATA ************


SUPERSTRUCTURE  :  1

.....STIFFNESS DATA.........

EIGENVALUES AND EIGENVECTORS (FULL THREE DIMENSIONAL REPRESENTATION)....

MODE NUMBER     EIGENVALUE         PERIOD

      1          193.590000       0.451584
      2          340.812000       0.340347
      3          574.620000       0.262114
      4         2255.210000       0.132308
      5         2733.610000       0.120174
```

6	5011.075000	0.088759

MODE SHAPES

LEVEL		1	2	3	4	5	6
6	X	0.0059400	-0.1020630	0.0201900	-0.0113810	0.0878400	0.0080520
6	Y	-0.1169470	-0.0045800	0.0118200	0.0847690	0.0102410	-0.0006750
6	R	0.0030560	0.0036720	0.0163630	0.0003110	-0.0013280	0.0130530
5	X	0.0052590	-0.0883190	0.0184390	-0.0025530	0.0228490	0.0053480
5	Y	-0.0900270	-0.0025260	0.0140890	-0.0021180	-0.0015030	0.0133640
5	R	0.0021540	0.0029060	0.0132730	0.0016620	0.0003040	0.0010460
4	X	0.0044570	-0.0697160	0.0150020	0.0059750	-0.0464610	-0.0024000
4	Y	-0.0616990	-0.0005760	0.0151130	-0.0736540	-0.0106300	0.0135210
4	R	0.0012660	0.0020700	0.0096800	0.0023900	0.0015890	-0.0096130
3	X	0.0033550	-0.0483690	0.0107110	0.0110500	-0.0860050	-0.0095510
3	Y	-0.0358980	0.0008070	0.0152290	-0.0953630	-0.0117000	-0.0050210
3	R	0.0004420	0.0012510	0.0061400	0.0018520	0.0019500	-0.0136230
2	X	0.0020290	-0.0281440	0.0071300	0.0102320	-0.0759720	-0.0112180
2	Y	-0.0133070	0.0015950	0.0127030	-0.0555710	-0.0041250	-0.0327510
2	R	-0.0002110	0.0005060	0.0027690	-0.0003560	0.0010390	-0.0088540
1	X	0.0008180	-0.0134670	0.0037950	0.0054310	-0.0428490	-0.0073750
1	Y	-0.0053770	0.0006270	0.0058720	-0.0275380	-0.0022080	-0.0204980
1	R	-0.0000910	0.0002090	0.0012590	-0.0002520	0.0004800	-0.0047870

SUPERSTRUCTURE MASS..........

LEVEL	TRANSL. MASS	ROTATIONAL MASS	ECCENT X	ECCENT Y
6	33.73700	1476.88900	39.09000	2.31000
5	33.73700	1476.88900	39.09000	2.31000
4	33.73700	1476.88900	39.09000	2.31000
3	37.12300	1625.11700	39.09000	2.31000
2	39.65200	1735.88600	39.09000	2.31000
1	34.59400	1514.44200	39.09000	2.31000

SUPERSTRUCTURE DAMPING.......

MODE SHAPE	DAMPING RATIO
1	0.05000
2	0.05000
3	0.05000
4	0.05000
5	0.05000
6	0.05000

HEIGHT.........

LEVEL	HEIGHT
6	21.300
5	18.100
4	14.900
3	11.700
2	7.900
1	4.700
0	1.000

SUPERSTRUCTURE : 2

.....STIFFNESS DATA.........

EIGENVALUES AND EIGENVECTORS (FULL THREE DIMENSIONAL REPRESENTATION)....

MODE NUMBER	EIGENVALUE	PERIOD
1	219.350000	0.424239
2	569.810000	0.263218
3	1447.225000	0.165163
4	4358.106000	0.095177
5	8789.970000	0.067017
6	10307.880000	0.061886

MODE SHAPES

LEVEL		1	2	3	4	5	6
6	X	0.0022470	0.0013700	0.0798050	-0.0081190	0.0192590	-0.0705630
6	Y	-0.0786390	0.0349520	0.0009410	0.0559460	0.0410440	0.0048180
6	R	0.0023540	0.0065920	-0.0001280	-0.0049860	0.0044310	0.0015790

5	X	0.0017130	0.0010590	0.0673120	0.0001920	0.0033380	-0.0189940
5	Y	-0.0618930	0.0249580	0.0011170	0.0032420	0.0102040	0.0018560
5	R	0.0019890	0.0051310	-0.0001070	0.0002520	-0.0007190	-0.0001710
4	X	0.0010660	0.0004100	0.0497480	0.0050230	-0.0104240	0.0389010
4	Y	-0.0450550	0.0161930	0.0012050	-0.0263750	-0.0285480	-0.0048150
4	R	0.0015400	0.0035440	-0.0001070	0.0023680	-0.0029080	-0.0008760
3	X	0.0007120	0.0002410	0.0345410	0.0057680	-0.0138900	0.0582890
3	Y	-0.0297010	0.0080670	0.0011130	-0.0417910	-0.0471280	-0.0075250
3	R	0.0010910	0.0020950	-0.0000800	0.0032440	-0.0032650	-0.0010950
2	X	0.0003850	0.0001790	0.0182970	0.0039630	-0.0103810	0.0480160
2	Y	-0.0139630	0.0019200	0.0007000	-0.0360460	-0.0393060	-0.0056680
2	R	0.0005870	0.0007860	-0.0000280	0.0025000	-0.0017720	-0.0007330
1	X	0.0000420	-0.0000640	0.0093690	0.0013790	-0.0054230	0.0286740
1	Y	-0.0047610	0.0006310	0.0002830	-0.0172400	-0.0206570	-0.0029390
1	R	0.0002050	0.0002920	-0.0000070	0.0011670	-0.0008110	-0.0003680

SUPERSTRUCTURE MASS...........

LEVEL	TRANSL. MASS	ROTATIONAL MASS	ECCENT X	ECCENT Y
6	55.11800	8359.70700	10.24000	1.66000
5	75.06000	11384.15000	10.24000	1.66000
4	76.87700	11659.78300	10.24000	1.66000
3	81.48300	12657.45000	9.99000	1.61000
2	84.18700	13077.69100	9.99000	1.61000
1	73.19200	11144.31500	9.99000	2.14000

SUPERSTRUCTURE DAMPING.......

MODE SHAPE	DAMPING RATIO
1	0.05000
2	0.05000
3	0.05000
4	0.05000
5	0.05000
6	0.05000

HEIGHT.........

LEVEL	HEIGHT
6	21.300
5	18.100
4	14.900
3	11.700
2	7.900
1	4.700
0	1.000

SUPERSTRUCTURE : 3

.....STIFFNESS DATA.........

EIGENVALUES AND EIGENVECTORS (FULL THREE DIMENSIONAL REPRESENTATION)....

MODE NUMBER	EIGENVALUE	PERIOD
1	199.610000	0.444722
2	569.820000	0.263215
3	677.790000	0.241342
4	3737.930000	0.102770
5	3949.420000	0.099980
6	10262.740000	0.062022

MODE SHAPES

LEVEL		1	2	3	4	5	6
6	X	-0.0979990	0.0067760	0.0225330	0.0874160	0.0033330	0.0088020
6	Y	-0.0008600	-0.0925420	0.0225500	0.0028910	-0.0878610	0.0138880
6	R	0.0026840	0.0022150	0.0099260	-0.0017140	0.0004180	0.0090140
5	X	-0.0798740	0.0056870	0.0194600	0.0212520	0.0007020	0.0073030
5	Y	-0.0009340	-0.0834900	0.0202460	0.0013760	-0.0341390	-0.0026890
5	R	0.0021660	0.0018540	0.0081950	-0.0002480	0.0002500	0.0023810
4	X	-0.0609280	0.0044340	0.0156760	-0.0389100	-0.0016320	0.0001150
4	Y	-0.0010950	-0.0603760	0.0135440	-0.0011330	0.0536870	-0.0163620
4	R	0.0016370	0.0014630	0.0063380	0.0009670	0.0000650	-0.0037930

3	X	-0.0421690	0.0031860	0.0116470	-0.0739850	-0.0029760	-0.0103980
3	Y	-0.0011820	-0.0447500	0.0091420	-0.0020730	0.0784270	-0.0085920
3	R	0.0011260	0.0010680	0.0044930	0.0015610	-0.0000770	-0.0074340
2	X	-0.0213180	0.0017050	0.0063020	-0.0700880	-0.0029080	-0.0193390
2	Y	-0.0009150	-0.0223330	0.0027960	-0.0031680	0.0565070	0.0191360
2	R	0.0005640	0.0005640	0.0023210	0.0013030	-0.0001630	-0.0072820
1	X	-0.0077810	0.0007560	0.0029810	-0.0371560	-0.0015400	-0.0153570
1	Y	-0.0003180	-0.0112200	0.0017520	-0.0017960	0.0328610	0.0149140
1	R	0.0001890	0.0002220	0.0008930	0.0005760	-0.0001180	-0.0040380

SUPERSTRUCTURE MASS..........

LEVEL	TRANSL. MASS	ROTATIONAL MASS	ECCENT X	ECCENT Y
6	33.07900	2963.30900	-18.32000	-20.29000
5	51.82400	4642.41700	-18.32000	-20.29000
4	45.56500	4081.71300	-18.32000	-20.29000
3	53.60700	4802.20400	-18.32000	-20.29000
2	52.72700	4593.43000	-18.33000	-19.64000
1	50.03600	4359.01000	-18.33000	-19.64000

SUPERSTRUCTURE DAMPING.......

MODE SHAPE	DAMPING RATIO
1	0.05000
2	0.05000
3	0.05000
4	0.05000
5	0.05000
6	0.05000

HEIGHT.........

LEVEL	HEIGHT
6	21.300
5	18.100
4	14.900
3	11.700
2	7.900
1	4.700
0	1.000

SUPERSTRUCTURE : 4

.....STIFFNESS DATA.........

EIGENVALUES AND EIGENVECTORS (FULL THREE DIMENSIONAL REPRESENTATION)....

MODE NUMBER	EIGENVALUE	PERIOD
1	337.690000	0.341917
2	449.710000	0.296288
3	968.270000	0.201921
4	2861.760000	0.117453
5	5191.420000	0.087204
6	8360.330000	0.068718

MODE SHAPES

LEVEL		1	2	3	4	5	6
6	X	0.0249770	0.0842820	-0.0137810	0.0046120	-0.0651600	-0.0237520
6	Y	-0.0787770	0.0246590	0.0061910	-0.0819690	-0.0059210	-0.0225450
6	R	0.0003940	0.0012730	0.0097190	0.0002600	0.0031330	-0.0067790
5	X	0.0199800	0.0671660	-0.0098150	0.0010210	-0.0119000	-0.0037340
5	Y	-0.0674090	0.0203170	0.0021540	-0.0180560	-0.0021020	0.0223480
5	R	0.0003570	0.0011060	0.0078340	0.0005730	0.0008490	-0.0015390
4	X	0.0148300	0.0496650	-0.0055700	-0.0022210	0.0347680	0.0139000
4	Y	-0.0522180	0.0146630	-0.0021330	0.0469630	0.0030240	0.0312050
4	R	0.0003210	0.0009370	0.0058390	0.0007450	-0.0012060	0.0029920
3	X	0.0094920	0.0319040	-0.0090220	-0.0049410	0.0626600	0.0149610
3	Y	-0.0380740	0.0103920	-0.0061120	0.0565230	0.0048330	-0.0071390
3	R	0.0002520	0.0007350	0.0039430	0.0006080	-0.0022650	0.0053870
2	X	0.0047160	0.0156770	-0.0035400	-0.0038680	0.0516010	0.0167250
2	Y	-0.0208060	0.0060810	-0.0028680	0.0458250	0.0041900	-0.0336670
2	R	0.0001190	0.0004330	0.0019620	0.0003450	-0.0016320	0.0047250

```
1  X    0.0017680 0.0061440-0.0017270-0.0017890 0.0264870 0.0101780

1  Y   -0.0090370 0.0028470-0.0011550 0.0255400 0.0029060-0.0263260

1  R    0.0000360 0.0001540 0.0008280 0.0001550-0.0007830 0.0025170
```

SUPERSTRUCTURE MASS..........

LEVEL	TRANSL. MASS	ROTATIONAL MASS	ECCENT X	ECCENT Y
6	56.37300	4321.65500	-18.19000	9.33000
5	56.37300	4321.65500	-18.19000	9.33000
4	67.42800	5169.20500	-18.19000	9.33000
3	85.00300	7837.71200	-16.90000	10.34000
2	74.83400	6930.49700	-16.95000	10.50000
1	73.28300	6791.27500	-16.83000	10.49000

SUPERSTRUCTURE DAMPING.......

MODE SHAPE	DAMPING RATIO
1	0.05000
2	0.05000
3	0.05000
4	0.05000
5	0.05000
6	0.05000

HEIGHT.........

LEVEL	HEIGHT
6	21.300
5	18.100
4	14.900
3	11.700
2	7.900
1	4.700
0	1.000

************* ISOLATION SYSTEM DATA ************

STIFFNESS DATA FOR LINEAR-ELASTIC ISOLATION SYSTEM......

STIFFNESS OF LINEAR-ELASTIC SYS. IN X DIR. =	0.00000
STIFFNESS OF LINEAR ELASTIC SYS. IN Y DIR. =	0.00000
STIFFNESS OF LINEAR ELASTIC SYS. IN R DIR. =	0.00000
ECCENT. IN X DIR. FROM CEN. OF MASS......=	0.00000
ECCENT. IN Y DIR. FROM CEN. OF MASS......=	0.00000

MASS AT THE CENTER OF MASS OF THE BASE ....

	TRANSL. MASS	ROTATIONAL MASS
MASS	453.24000	291323.20000

GLOBAL ISOLATION DAMPING AT THE CENTER OF MASS OF THE BASE.....

	X	Y	R	ECX	ECY
DAMPING	0.00000	0.00000	0.00000	0.00000	0.00000

ISOLATORS LOCATION INFORMATION.........

ISOLATOR	X	Y
1	29.9400	-4.5900
2	29.9400	2.2600
3	29.9400	8.9100
4	33.3900	-4.5900
5	33.3900	2.2600
6	33.3900	8.9100
7	36.9900	-4.5900
8	36.9900	2.2600
9	36.9900	8.9100
10	39.3900	2.2600
11	40.5900	-4.5900
12	40.5900	2.2600
13	40.5900	8.9100
14	41.7900	2.2600
15	44.1900	-4.5900
16	44.1900	2.2600
17	44.1900	8.9100
18	45.4900	2.2600
19	47.7900	-4.5900
20	47.7900	2.2600
21	47.7900	4.3600
22	47.7900	8.9100
23	-10.6100	-4.2900
24	-10.6100	-1.1900
25	-9.7100	-4.5900
26	-9.7100	2.0100
27	-9.7100	8.9100
28	-5.9600	-4.5900
29	-5.9600	2.0100
30	-5.9600	8.9100
31	-2.3600	-4.5900
32	-2.3600	2.0100

33	-2.3600	8.9100
34	1.2400	-4.5900
35	1.2400	2.0100
36	1.2400	8.9100
37	4.8400	-4.5900
38	4.8400	2.0100
39	4.8400	8.9100
40	8.4400	-4.5900
41	8.4400	2.0100
42	8.4400	8.9100
43	12.0400	-4.5900
44	12.0400	2.0100
45	12.0400	5.3100
46	12.0400	8.9100
47	14.3400	-4.5900
48	14.3400	2.0100
49	14.3400	5.3100
50	14.3400	8.9100
51	16.7400	-4.5900
52	16.7400	2.0100
53	16.7400	5.3100
54	16.7400	8.9100
55	19.2400	-4.5900
56	19.2400	2.0100
57	19.2400	8.9100
58	22.8400	-4.5900
59	22.8400	2.0100
60	22.8400	8.9100
61	26.4400	-4.5900
62	26.4400	2.0100
63	26.4400	8.9100
64	29.8900	-4.5900
65	29.8900	2.0100
66	29.8900	8.9100
67	-24.1600	-4.6400
68	-19.8600	-4.6400
69	-17.5100	-4.6400
70	-13.0600	-4.6400
71	-24.1600	-7.7900
72	-19.8600	-7.7900
73	-13.0600	-7.7900
74	-24.1600	-11.0900
75	-19.8600	-11.0900
76	-13.0600	-11.0900
77	-24.1600	-14.3900
78	-19.8600	-14.3900
79	-13.0600	-14.3900
80	-24.1600	-17.6900
81	-19.8600	-17.6900
82	-13.0600	-17.6900
83	-24.1600	-20.9900
84	-19.8600	-20.9900

85	-13.0600	-20.9900
86	-24.1600	-24.2900
87	-13.0600	-24.2900
88	-19.8600	-25.6900
89	-24.1600	-27.5900
90	-19.8600	-27.5900
91	-13.0600	-27.5900
92	-24.1600	-30.8900
93	-19.8600	-30.8900
94	-13.0600	-30.8900
95	-24.1600	-34.3400
96	-19.8600	-34.3400
97	-16.8100	-34.3400
98	-13.0600	-34.3400
99	-27.7600	23.0600
100	-25.2600	23.0600
101	-19.8600	23.0600
102	-15.3600	23.0600
103	-13.3600	23.0600
104	-9.7600	23.0600
105	-6.3100	23.0600
106	-27.7600	19.6100
107	-24.1600	19.6100
108	-19.8600	19.6100
109	-13.3600	19.6100
110	-9.7600	19.6100
111	-6.3100	19.6100
112	-27.7600	16.3100
113	-24.1600	16.3100
114	-19.8600	16.3100
115	-13.3600	16.3100
116	-9.7600	16.3100
117	-6.3100	16.3100
118	-27.7600	13.0100
119	-24.1600	13.0100
120	-19.8600	13.0100
121	-13.3600	13.0100
122	-9.7600	13.0100
123	-6.3100	13.0100
124	-24.1600	9.7100
125	-19.8600	9.7100
126	-13.3600	9.7100
127	-9.7600	9.7100
128	-13.3600	7.6600
129	-9.7600	7.6600
130	-24.1600	6.4100
131	-19.8600	6.4100
132	-13.3600	4.7600
133	-9.7600	4.7600
134	-24.1600	3.1100
135	-19.8600	3.1100
136	-17.6600	3.1100

137	-13.3600	3.1100
138	-9.7600	3.1100
139	-17.6600	0.0100
140	-17.1100	0.0100
141	-13.3600	0.0100
142	-12.7100	0.0100
143	-11.6100	0.0100
144	-10.6600	0.0100
145	-24.1600	-1.2900
146	-19.8600	-1.2900
147	-13.3600	-3.2900
148	-10.6600	-3.2900
149	-24.1600	-4.5900
150	-19.8600	-4.5900
151	-17.6600	-4.5900
152	-17.1100	-4.5900
153	-13.3600	-4.5900

ELASTOMERIC/DAMPER FORCE-DISPLACEMENT LOOP PARAMETERS........

ISOLATOR	ALPFA X	ALPFA Y	YIELD FORCE X	YIELD FORCE Y	YIELD DISPL. X	YIELD DISPL. Y
1	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
2	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
3	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
4	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
5	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
6	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
7	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
8	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
9	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
10	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
11	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
12	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
13	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
14	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
15	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
16	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
17	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
18	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
19	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
20	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
21	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
22	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
23	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
24	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
25	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
26	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
27	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
28	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
29	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
30	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706

31	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
32	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
33	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
34	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
35	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
36	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
37	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
38	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
39	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
40	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
41	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
42	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
43	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
44	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
45	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
46	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
47	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
48	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
49	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
50	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
51	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
52	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
53	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
54	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
55	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
56	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
57	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
58	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
59	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
60	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
61	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
62	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
63	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
64	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
65	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
66	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
67	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
68	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
69	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
70	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
71	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
72	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
73	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
74	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
75	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
76	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
77	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
78	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
79	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
80	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
81	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
82	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523

83	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
84	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
85	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
86	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
87	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
88	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
89	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
90	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
91	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
92	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
93	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
94	0.15380	0.15380	7.73200	7.73200	0.00706	0.00706
95	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
96	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
97	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
98	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
99	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
100	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
101	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
102	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
103	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
104	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
105	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
106	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
107	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
108	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
109	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
110	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
111	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
112	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
113	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
114	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
115	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
116	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
117	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
118	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
119	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
120	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
121	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
122	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
123	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
124	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
125	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
126	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
127	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
128	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
129	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
130	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
131	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
132	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
133	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
134	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000

135	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
136	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
137	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
138	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
139	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
140	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
141	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
142	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
143	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
144	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
145	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
146	1.00000	1.00000	117.21600	117.21600	1.00000	1.00000
147	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
148	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
149	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
150	0.14650	0.14650	3.64000	3.64000	0.00523	0.00523
151	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
152	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435
153	0.14407	0.14407	5.90900	5.90900	0.00435	0.00435

************ OUTPUT PARAMETERS *************

TIME HISTORY OPTION ....= 0

INDEX = 0 FOR NO TIME HISTORY OUTPUT
INDEX = 1 FOR TIME HISTORY OUTPUT

NO. OF TIME STEPS AT WHICH TIME HISTORY
OUTPUT IS DESIRED ....= 5
ACCELERATION-DISPLACEMENTS PROFILES OPTION..= 1

INDEX = 0 FOR NO PROFILES OUTPUT
INDEX = 1 FOR PROFILES OUTPUT

FORCE-DISPLACEMENT TIME HISTORY DESIRED
AT ISOLATORS NUMBERED..................=

1	3	19	22	25
27	64	66	67	70
95	98	105	99	148
149				

**************FORCE PROFILES***********

MAX OVERTURNING MOMENT X DIRECTION

SUPR/STURE	TIME	OVERTURNING MOMENT
1	14.290	-5049.9151

MAX STRUCTURAL SHEAR X DIRECTION

TIME	MAX STUCTURAL SHEAR
14.315	-417.9692

FLOOR	INERTIA FORCES
6	-70.7577
5	-69.0901
4	-66.9498
3	-71.1398
2	-73.5982
1	-62.8294
BASE	-805.6050

SUPR/STURE	TIME	OVERTURNING MOMENT
2	14.315	-10408.3328

FLOOR	INERTIA FORCES
6	-114.1117
5	-153.0787
4	-153.4787
3	-159.7224
2	-161.8267
1	-139.2515
BASE	-850.0250

SUPR/STURE	TIME	OVERTURNING MOMENT
3	14.385	-8026.7552

FLOOR	INERTIA FORCES
6	-88.3071
5	-132.2717
4	-110.4490
3	-122.3726
2	-110.7431
1	-98.2488
BASE	-859.2719

SUPR/STURE	TIME	OVERTURNING MOMENT
4	14.250	-8975.7181

FLOOR	INERTIA FORCES
6	-115.3485
5	-110.9392
4	-127.2347
3	-152.5816
2	-128.2771
1	-121.8337
BASE	-737.6673

MAX OVERTURNING MOMENT Y DIRECTION

INERTIA FORCES	
-66.8693	
-67.0944	
-67.1545	
-73.4090	
-77.1927	
-66.2492	
-850.0250	FORCE AT C.M. OF ENTIRE BA

TIME	MAX STUCTURAL SHEAR
14.325	-883.2470

INERTIA FORCES	
-112.6149	
-151.7777	
-153.2136	
-160.4467	
-163.7213	
-141.4728	
-867.2863	FORCE AT C.M. OF ENTIRE BA

TIME	MAX STUCTURAL SHEAR
14.380	-663.4785

INERTIA FORCES	
-88.2339	
-131.9044	
-109.9995	
-122.0694	
-111.3769	
-99.8945	
-885.2861	FORCE AT C.M. OF ENTIRE BA

TIME	MAX STUCTURAL SHEAR
14.385	-779.3185

INERTIA FORCES	
-99.3478	
-102.8898	
-126.9458	
-164.0635	
-144.9387	
-141.1329	
-859.2719	FORCE AT C.M. OF ENTIRE BA

MAX STRUCTURAL SHEAR Y DIRECTION

SUPR/STURE	TIME	OVERTURNING MOMENT	TIME	MAX STUCTURAL SHEAR	
1	9.135	1002.1089	9.130	61.2199	
FLOOR		INERTIA FORCES		INERTIA FORCES	
6		21.9919		21.8895	
5		17.1035		16.9263	
4		11.8541		11.6598	
3		7.5518		7.4672	
2		2.4149		2.6573	
1		0.2606		0.6198	
BASE		-4.9300		-4.0576	FORCE AT C.M. OF ENTIRE BA

SUPR/STURE	TIME	OVERTURNING MOMENT	TIME	MAX STUCTURAL SHEAR	
2	11.625	-664.7666	11.020	42.3123	
FLOOR		INERTIA FORCES		INERTIA FORCES	
6		-14.6984		11.3954	
5		-14.3086		11.9918	
4		-8.6881		8.9234	
3		-3.4055		6.0344	
2		2.4655		2.8588	
1		4.9944		1.1085	
BASE		33.9000		-1.4948	FORCE AT C.M. OF ENTIRE BA

SUPR/STURE	TIME	OVERTURNING MOMENT	TIME	MAX STUCTURAL SHEAR	
3	12.600	933.9941	12.605	63.5190	
FLOOR		INERTIA FORCES		INERTIA FORCES	
6		14.3767		14.2948	
5		19.4589		19.3882	
4		11.3364		11.3584	
3		9.6147		9.6775	
2		5.3969		5.5112	
1		3.1645		3.2889	
BASE		3.8913		3.0973	FORCE AT C.M. OF ENTIRE BA

SUPR/STURE	TIME	OVERTURNING MOMENT	TIME	MAX STUCTURAL SHEAR	
4	9.310	1242.3959	9.310	84.2086	
FLOOR		INERTIA FORCES		INERTIA FORCES	
6		22.5868		22.5868	
5		18.8328		18.8328	
4		16.8195		16.8195	
3		15.4860		15.4860	
2		7.3633		7.3633	
1		3.1202		3.1202	
BASE		8.2407		8.2407	FORCE AT C.M. OF ENTIRE BA

MAX. RELATIVE DISPLACEMENTS AT CENTER OF MASS OF LEVELS
(WITH RESPECT TO THE BASE)

SUPERSTRUCTURE : 1

LEVEL	TIME	DISPL X	TIME	DISPL Y	TIME	ROTATION
6	14.285	0.7262E-02	9.350	0.3339E-02	10.885	-.1879E-03
5	14.290	0.6479E-02	9.350	0.2526E-02	10.880	-.1480E-03
4	14.295	0.5354E-02	9.145	-.1718E-02	10.880	-.1051E-03
3	14.300	0.3921E-02	9.145	-.9917E-03	10.880	-.6273E-04
2	14.310	0.2389E-02	9.145	-.3575E-03	14.275	-.2566E-04
1	14.310	0.1170E-02	9.140	-.1429E-03	14.280	-.1000E-04

SUPERSTRUCTURE : 2

LEVEL	TIME	DISPL X	TIME	DISPL Y	TIME	ROTATION
6	14.315	0.1929E-02	11.640	0.1179E-02	11.275	-.5453E-04
5	14.315	0.1696E-02	11.640	0.9214E-03	11.275	-.4435E-04
4	14.320	0.1341E-02	11.640	0.6604E-03	11.275	-.3231E-04
3	14.320	0.9836E-03	11.640	0.4266E-03	11.275	-.2107E-04
2	14.320	0.5498E-03	11.640	0.1952E-03	9.695	-.1007E-04
1	14.325	0.2862E-03	11.640	0.6472E-04	9.695	-.3590E-05

SUPERSTRUCTURE : 3

LEVEL	TIME	DISPL X	TIME	DISPL Y	TIME	ROTATION
6	14.395	0.1681E-01	12.605	-.7473E-03	11.665	0.3438E-03
5	14.395	0.1390E-01	12.605	-.6769E-03	11.665	0.2783E-03
4	14.395	0.1082E-01	12.605	-.5019E-03	11.665	0.2114E-03
3	14.395	0.7677E-02	12.605	-.3851E-03	11.665	0.1460E-03
2	14.390	0.4014E-02	12.605	-.2073E-03	11.665	0.7341E-04
1	14.390	0.1521E-02	12.605	-.9831E-04	11.665	0.2390E-04

SUPERSTRUCTURE : 4

LEVEL	TIME	DISPL X	TIME	DISPL Y	TIME	ROTATION
6	14.245	0.6444E-02	10.880	-.1482E-02	10.810	0.8619E-04
5	14.250	0.5256E-02	10.880	-.1278E-02	10.810	0.7402E-04
4	14.250	0.4017E-02	10.880	-.1021E-02	10.810	0.6217E-04
3	14.250	0.2720E-02	10.875	-.7498E-03	10.810	0.4826E-04
2	14.255	0.1400E-02	10.880	-.4047E-03	10.805	0.2819E-04
1	14.255	0.5680E-03	10.880	-.1699E-03	10.805	0.9553E-05

MAX. DISPLACEMENTS AT CENTER OF MASS OF BASE

LEVEL	TIME	DISPL X	TIME	DISPL Y	TIME	ROTATION

BASE 14.375 0.1284E+00 12.155 0.4911E-03 14.960 0.1008E-03

.MAXIMUM INTERSTORY DRIFT RATIOS' FOR EACH SUPERSTRUCTURE

SUPERSTRUCTURE : 1

COORDINATES OF COLUMN LINES WITH RESPECT TO MASS CENTER OF BASE

C/L : 1	X COOR :	47.940
	Y COOR :	9.010
C/L : 2	X COOR :	29.940
	Y COOR :	-4.590
C/L : 3	X COOR :	39.090
	Y COOR :	2.310

COLUMN LINES

	1				2				3			
LEVEL	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR
6	14.275	0.3149E-03	15.120	0.1654E-03	14.430	0.2182E-03	9.345	0.3718E-03	14.275	0.2467E-03	9.350	0.2544E-03
5	14.275	0.4298E-03	15.125	0.1794E-03	14.425	0.3153E-03	9.345	0.3857E-03	14.275	0.3549E-03	9.350	0.2640E-03
4	14.275	0.5261E-03	15.125	0.1738E-03	14.405	0.4035E-03	9.345	0.3499E-03	14.280	0.4510E-03	9.350	0.2342E-03
3	14.280	0.4626E-03	15.130	0.1367E-03	14.395	0.3688E-03	9.345	0.2477E-03	14.290	0.4041E-03	9.150	0.1670E-03
2	14.295	0.4123E-03	15.135	0.9229E-04	14.335	0.3516E-03	9.345	0.6911E-04	14.305	0.3810E-03	9.145	0.6714E-04
1	14.300	0.3328E-03	15.135	0.4942E-04	14.335	0.3011E-03	9.345	0.4022E-04	14.310	0.3163E-03	9.140	0.3862E-04

SUPERSTRUCTURE : 2

COORDINATES OF COLUMN LINES WITH RESPECT TO MASS CENTER OF BASE

C/L : 1	X COOR :	29.890
	Y COOR :	9.010
C/L : 2	X COOR :	-9.710
	Y COOR :	-4.590
C/L : 3	X COOR :	9.960
	Y COOR :	2.140

COLUMN LINES

	1				2				3			
LEVEL	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR
6	14.410	0.7739E-04	15.040	0.8230E-04	14.305	0.8205E-04	9.865	0.1145E-03	14.310	0.7222E-04	11.635	0.8101E-04
5	14.410	0.1095E-03	15.040	0.7714E-04	14.310	0.1240E-03	11.665	0.1272E-03	14.315	0.1102E-03	11.635	0.8210E-04
4	14.400	0.1094E-03	15.040	0.6969E-04	14.310	0.1235E-03	9.690	0.1198E-03	14.315	0.1112E-03	11.635	0.7480E-04
3	14.395	0.1104E-03	15.040	0.5226E-04	14.315	0.1233E-03	9.690	0.1019E-03	14.320	0.1134E-03	11.640	0.6095E-04
2	14.390	0.7570E-04	11.005	0.2058E-04	14.315	0.8941E-04	11.655	0.7626E-04	14.320	0.8137E-04	11.640	0.4082E-04
1	14.385	0.7366E-04	11.005	0.1014E-04	14.320	0.8133E-04	11.655	0.3449E-04	14.325	0.7736E-04	11.640	0.1752E-04

SUPERSTRUCTURE : 3

COORDINATES OF COLUMN LINES WITH RESPECT TO MASS CENTER OF BASE

C/L : 1	X COOR	:	-24.160
	Y COOR	:	-34.340
C/L : 2	X COOR	:	-13.360
	Y COOR	:	-4.640
C/L : 3	X COOR	:	-18.460
	Y COOR	:	-19.640

COLUMN LINES

	1				2				3			
LEVEL	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR
6	14.395	0.6330E-03	11.670	0.1183E-03	14.410	0.1221E-02	14.450	0.1124E-03	14.405	0.9229E-03	12.605	0.2314E-04
5	14.395	0.6820E-03	11.670	0.1246E-03	14.410	0.1279E-02	14.455	0.1297E-03	14.400	0.9760E-03	12.605	0.5584E-04
4	14.390	0.7082E-03	11.665	0.1233E-03	14.405	0.1289E-02	14.455	0.1151E-03	14.400	0.9949E-03	12.605	0.3762E-04
3	14.390	0.7226E-03	11.665	0.1334E-03	14.400	0.1260E-02	14.460	0.9494E-04	14.395	0.9879E-03	12.605	0.4793E-04
2	14.390	0.5633E-03	11.665	0.1214E-03	14.395	0.1001E-02	12.335	0.5761E-04	14.390	0.7793E-03	12.600	0.3486E-04
1	14.385	0.3260E-03	11.670	0.5411E-04	14.395	0.4980E-03	13.050	0.2873E-04	14.390	0.4110E-03	12.605	0.2694E-04

SUPERSTRUCTURE : 4

COORDINATES OF COLUMN LINES WITH RESPECT TO MASS CENTER OF BASE

C/L : 1	X COOR	:	-27.760
	Y COOR	:	23.060
C/L : 2	X COOR	:	-13.360
	Y COOR	:	-4.590

COLUMN LINES

	1				2							
LEVEL	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR	TIME	X DIR	TIME	Y DIR
6	14.430	0.3443E-03	10.860	0.7863E-04	10.810	0.4273E-03	11.050	0.6180E-04				
5	14.425	0.3618E-03	10.865	0.9170E-04	10.810	0.4403E-03	11.050	0.7941E-04				
4	14.420	0.3540E-03	10.865	0.9159E-04	10.810	0.4517E-03	10.900	0.7568E-04				
3	14.395	0.3059E-03	10.845	0.1279E-03	10.810	0.4137E-03	10.885	0.8345E-04				
2	14.385	0.2082E-03	10.845	0.1167E-03	14.240	0.3376E-03	10.885	0.6298E-04				
1	14.375	0.1372E-03	10.855	0.6103E-04	14.240	0.1850E-03	10.885	0.4285E-04				

MAXIMUM BEARING DISPLACEMENTS

	MAX DISPL X			MAX DISPL Y		
ISOLATOR	TIME	X DIRECT	Y DIRECT	TIME	X DIRECT	Y DIRECT
1	14.375	0.1283E+00	-.3511E-03	14.955	-.4758E-01	0.2737E-02
3	14.375	0.1285E+00	-.3511E-03	14.955	-.4894E-01	0.2737E-02
19	14.375	0.1283E+00	-.6441E-03	14.955	-.4758E-01	0.4536E-02
22	14.375	0.1285E+00	-.6441E-03	14.955	-.4894E-01	0.4536E-02
25	14.375	0.1283E+00	0.2997E-03	12.925	-.4620E-01	-.1307E-02
27	14.375	0.1285E+00	0.2997E-03	12.925	-.4745E-01	-.1307E-02
64	14.375	0.1283E+00	-.3503E-03	14.955	-.4758E-01	0.2732E-02
66	14.375	0.1285E+00	-.3503E-03	14.955	-.4894E-01	0.2732E-02

67	14.375	0.1283E+00	0.5369E-03	14.970	-.5306E-01	-.2722E-02
70	14.375	0.1283E+00	0.3547E-03	12.930	-.4730E-01	-.1616E-02
95	14.375	0.1278E+00	0.5369E-03	14.970	-.5007E-01	-.2722E-02
98	14.375	0.1278E+00	0.3547E-03	12.930	-.4457E-01	-.1616E-02
105	14.375	0.1288E+00	0.2439E-03	12.170	0.6979E-01	0.9952E-03
99	14.375	0.1288E+00	0.5960E-03	14.970	-.5585E-01	-.3085E-02
148	14.375	0.1283E+00	0.3153E-03	12.925	-.4632E-01	-.1395E-02
149	14.375	0.1283E+00	0.5369E-03	14.970	-.5307E-01	-.2722E-02

MAX. TOTAL ACCELERATIONS AT CENTER OF MASS OF LEVELS

SUPERSTRUCTURE : 1

LEVEL	TIME	ACCEL X	TIME	ACCEL Y	TIME	ACCEL R
6	14.270	-.2148E+01	9.340	-.7256E+00	10.735	-.6269E-01
5	14.275	-.2062E+01	9.335	-.5278E+00	10.730	-.4900E-01
4	14.305	-.1994E+01	9.140	0.3540E+00	10.725	-.3416E-01
3	14.325	-.1985E+01	11.245	-.2254E+00	10.575	0.2175E-01
2	14.345	-.1983E+01	8.660	0.1754E+00	12.545	-.1108E-01
1	14.355	-.1988E+01	11.500	-.1644E+00	12.545	-.6311E-02

SUPERSTRUCTURE : 2

LEVEL	TIME	ACCEL X	TIME	ACCEL Y	TIME	ACCEL R
6	14.310	-.2075E+01	11.630	-.2687E+00	11.140	-.2490E-01
5	14.310	-.2041E+01	11.625	-.1906E+00	11.135	-.1954E-01
4	14.315	-.1996E+01	11.025	0.1178E+00	11.130	-.1394E-01
3	14.345	-.1975E+01	11.030	0.7571E-01	11.120	-.9134E-02
2	14.360	-.1985E+01	10.820	-.6294E-01	10.975	0.5018E-02
1	14.360	-.1991E+01	11.510	-.7872E-01	9.020	0.4031E-02

SUPERSTRUCTURE : 3

LEVEL	TIME	ACCEL X	TIME	ACCEL Y	TIME	ACCEL R
6	14.430	-.2778E+01	12.600	0.4346E+00	14.625	-.6817E-01
5	14.395	-.2559E+01	12.600	0.3755E+00	14.625	-.5375E-01
4	14.395	-.2434E+01	12.605	0.2493E+00	14.635	-.3983E-01
3	14.390	-.2285E+01	12.915	0.2084E+00	11.050	0.2764E-01
2	14.375	-.2116E+01	12.915	0.1482E+00	11.195	-.1528E-01
1	14.370	-.2010E+01	12.915	0.1157E+00	9.040	0.7039E-02

SUPERSTRUCTURE : 4

LEVEL	TIME	ACCEL X	TIME	ACCEL Y	TIME	ACCEL R
6	14.435	-.2275E+01	11.055	-.4229E+00	10.665	0.3270E-01
5	14.425	-.2003E+01	9.305	0.3342E+00	10.665	0.2770E-01
4	14.400	-.1922E+01	11.030	-.2530E+00	10.670	0.2282E-01

3	14.390	-.1931E+01	9.310	0.1822E+00	10.675	0.1773E-01
2	14.365	-.1970E+01	11.025	-.1078E+00	10.800	-.1072E-01
1	14.360	-.2000E+01	12.520	0.9240E-01	10.940	0.5925E-02

MAX. ACCELERATIONS AT CENTER OF MASS OF BASE

LEVEL	TIME	ACCEL X	TIME	ACCEL Y	TIME	ACCEL R
BASE	14.365	-.1990E+01	11.640	0.8113E-01	14.975	-.3785E-02

.MAXIMUM STRUCTURAL SHEARS.........

SUPERST. No	TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
1	14.315	-.4180E+03	9.130	0.6122E+02	10.730	-.2671E+03
2	14.325	-.8832E+03	11.020	0.4231E+02	11.125	-.7654E+03
3	14.380	-.6635E+03	12.605	0.6352E+02	14.635	-.8229E+03
4	14.385	-.7793E+03	9.310	0.8421E+02	10.670	0.6221E+03

.MAXIMUM BASE SHEARS...........

TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
14.375	0.3615E+04	11.635	-.3173E+02	14.975	0.1093E+04

.MAXIMUM STORY SHEARS.............

SUPERSTRUCTURE : 1

LEVEL	TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
6	14.270	-.7248E+02	9.340	-.2448E+02	10.735	-.9259E+02
5	14.270	-.1420E+03	9.340	-.4229E+02	10.735	-.1648E+03
4	14.275	-.2080E+03	9.335	-.5310E+02	10.730	-.2151E+03
3	14.285	-.2780E+03	9.140	0.5866E+02	10.730	-.2479E+03
2	14.305	-.3524E+03	9.135	0.6092E+02	10.730	-.2619E+03
1	14.315	-.4180E+03	9.130	0.6122E+02	10.730	-.2671E+03

SUPERSTRUCTURE : 2

LEVEL	TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
6	14.310	-.1144E+03	11.630	-.1481E+02	11.140	-.2082E+03
5	14.310	-.2675E+03	11.630	-.2912E+02	11.140	-.4291E+03
4	14.310	-.4208E+03	11.625	-.3770E+02	11.135	-.5893E+03
3	14.315	-.5804E+03	11.625	-.4110E+02	11.135	-.6965E+03
2	14.320	-.7425E+03	11.025	0.4142E+02	11.130	-.7468E+03
1	14.325	-.8832E+03	11.020	0.4231E+02	11.125	-.7654E+03

SUPERSTRUCTURE : 3

LEVEL	TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
6	14.430	-.9191E+02	12.600	0.1438E+02	14.625	-.2020E+03
5	14.420	-.2218E+03	12.600	0.3384E+02	14.625	-.4516E+03
4	14.395	-.3318E+03	12.600	0.4517E+02	14.625	-.6117E+03
3	14.390	-.4541E+03	12.600	0.5479E+02	14.630	-.7400E+03
2	14.385	-.5641E+03	12.605	0.6023E+02	14.630	-.8007E+03
1	14.380	-.6635E+03	12.605	0.6352E+02	14.635	-.8229E+03

SUPERSTRUCTURE : 4

LEVEL	TIME	FORCE X	TIME	FORCE Y	TIME	Z MOMENT
6	14.435	-.1283E+03	11.055	-.2384E+02	10.665	0.1413E+03
5	14.430	-.2401E+03	11.055	-.4245E+02	10.665	0.2610E+03
4	14.425	-.3585E+03	9.305	0.5828E+02	10.665	0.3780E+03
3	14.405	-.5071E+03	9.305	0.7376E+02	10.670	0.5144E+03
2	14.395	-.6422E+03	9.310	0.8109E+02	10.670	0.5871E+03
1	14.385	-.7793E+03	9.310	0.8421E+02	10.670	0.6221E+03

PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT AT TIME OF MAX BASE DISPLACEMENTS

MAXIMUM BASE DISPLACEMENT IN X DIRECTION
TIME : 14.375

SUPERSTRUCTURE : 1

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0068	-1.8623	-0.0009	0.0602
5	0.0061	-1.8832	-0.0008	0.0736
4	0.0051	-1.9090	-0.0006	0.0857
3	0.0038	-1.9360	-0.0004	0.0901

2	0.0023	-1.9594	-0.0002	0.0868
1	0.0011	-1.9738	-0.0001	0.0915
BASE	0.1284	-1.9855	-0.0005	0.0946

SUPERSTRUCTURE : 2

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0018	-1.9026	-0.0006	0.0938
5	0.0016	-1.9204	-0.0005	0.0833
4	0.0013	-1.9435	-0.0004	0.0727
3	0.0010	-1.9596	-0.0002	0.0610
2	0.0005	-1.9731	-0.0001	0.0489
1	0.0003	-1.9800	0.0000	0.0423
BASE	0.1284	-1.9852	0.0000	0.0381

SUPERSTRUCTURE : 3

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0166	-2.6573	0.0003	-0.1294
5	0.0137	-2.5356	0.0003	-0.1182
4	0.0107	-2.4057	0.0003	-0.0889
3	0.0076	-2.2723	0.0002	-0.0700
2	0.0040	-2.1164	0.0002	-0.0418
1	0.0015	-2.0095	0.0001	-0.0290
BASE	0.1281	-1.9429	0.0004	-0.0170

SUPERSTRUCTURE : 4

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0059	-1.6998	-0.0001	-0.1052
5	0.0048	-1.7726	-0.0001	-0.0977
4	0.0037	-1.8444	-0.0002	-0.0859
3	0.0026	-1.9186	-0.0001	-0.0687
2	0.0013	-1.9669	-0.0001	-0.0423
1	0.0006	-1.9903	0.0000	-0.0256
BASE	0.1286	-2.0014	0.0004	-0.0140

MAXIMUM BASE DISPLACEMENT IN Y DIRECTION
TIME : 12.155

SUPERSTRUCTURE : 1

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0049	-1.4596	0.0004	-0.1099
5	0.0044	-1.4074	0.0003	-0.0831
4	0.0036	-1.3437	0.0001	-0.0539
3	0.0026	-1.2819	0.0000	-0.0213
2	0.0016	-1.2353	0.0000	0.0129
1	0.0008	-1.2103	0.0000	0.0124
BASE	0.0631	-1.1917	-0.0026	0.0112

SUPERSTRUCTURE : 2

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0012	-1.2860	-0.0003	0.0359
5	0.0010	-1.2740	-0.0002	0.0274
4	0.0008	-1.2555	-0.0002	0.0167
3	0.0006	-1.2378	-0.0001	0.0064
2	0.0003	-1.2169	-0.0001	-0.0057
1	0.0002	-1.2047	0.0000	-0.0149
BASE	0.0631	-1.1915	-0.0003	-0.0198

SUPERSTRUCTURE : 3

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0050	-0.6553	0.0004	-0.1968
5	0.0042	-0.7472	0.0003	-0.1799
4	0.0034	-0.8445	0.0003	-0.1398
3	0.0024	-0.9419	0.0002	-0.1140
2	0.0013	-1.0530	0.0001	-0.0814
1	0.0005	-1.1249	0.0001	-0.0657
BASE	0.0613	-1.1682	0.0019	-0.0500

SUPERSTRUCTURE : 4

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0037	-1.0345	-0.0010	0.2422
5	0.0030	-1.0685	-0.0008	0.1991
4	0.0023	-1.1030	-0.0007	0.1420
3	0.0016	-1.1386	-0.0005	0.0919
2	0.0008	-1.1705	-0.0003	0.0305
1	0.0003	-1.1885	-0.0001	-0.0131
BASE	0.0637	-1.2004	0.0018	-0.0484

PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT AT TIME OF MAX ACCELERATION IN EACH BUILDING

SUPERSTRUCTURE : 1

MAX ACCELERATION IN X DIRECTION
TIME : 14.270

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0072	-2.1485	-0.0003	0.0071
5	0.0064	-2.0604	-0.0003	0.0021

4	0.0053	-1.9528	-0.0003	-0.0019
3	0.0039	-1.8501	-0.0002	0.0015
2	0.0023	-1.7758	-0.0001	0.0132
1	0.0011	-1.7363	0.0000	0.0085
BASE	0.1114	-1.7071	-0.0008	0.0063

MAX ACCELERATION IN Y DIRECTION
TIME : 9.340

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0013	-0.3494	0.0033	-0.7256
5	0.0011	-0.3303	0.0025	-0.5278
4	0.0009	-0.2976	0.0017	-0.3201
3	0.0006	-0.2465	0.0009	-0.1292
2	0.0004	-0.1816	0.0003	0.0393
1	0.0002	-0.1271	0.0001	0.0894
BASE	0.0121	-0.0707	-0.0006	0.1233

SUPERSTRUCTURE : 2

MAX ACCELERATION IN X DIRECTION
TIME : 14.310

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0019	-2.0748	-0.0006	0.0575
5	0.0017	-2.0409	-0.0005	0.0478
4	0.0013	-1.9933	-0.0003	0.0382
3	0.0010	-1.9526	-0.0002	0.0297
2	0.0005	-1.9091	-0.0001	0.0206
1	0.0003	-1.8860	0.0000	0.0135
BASE	0.1220	-1.8609	0.0000	0.0102

MAX ACCELERATION IN Y DIRECTION
TIME : 11.630

LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0016	1.5918	0.0012	-0.2687
5	-0.0014	1.6111	0.0009	-0.1906
4	-0.0011	1.6304	0.0007	-0.1111
3	-0.0008	1.6328	0.0004	-0.0386
2	-0.0005	1.6208	0.0002	0.0333
1	-0.0002	1.6067	0.0001	0.0723
BASE	-0.1088	1.5902	0.0000	0.0923

SUPERSTRUCTURE : 3

MAX ACCELERATION IN X DIRECTION
TIME : 14.430

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0161	-2.7785	0.0000	0.0541
5	0.0133	-2.4771	0.0000	0.0525
4	0.0103	-2.1630	0.0001	0.0411
3	0.0072	-1.8606	0.0001	0.0282
2	0.0037	-1.5410	0.0001	0.0104
1	0.0014	-1.3491	0.0000	0.0092
BASE	0.1237	-1.2479	0.0001	0.0077

MAX ACCELERATION IN Y DIRECTION
TIME : 12.600

LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0035	0.7317	-0.0007	0.4346
5	-0.0028	0.5384	-0.0007	0.3755
4	-0.0021	0.3401	-0.0005	0.2488
3	-0.0014	0.1525	-0.0004	0.1794
2	-0.0007	-0.0386	-0.0002	0.1024
1	-0.0002	-0.1521	-0.0001	0.0632
BASE	0.0362	-0.2085	-0.0006	0.0307

SUPERSTRUCTURE : 4

MAX ACCELERATION IN X DIRECTION
TIME : 14.435

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0063	-2.2753	0.0001	-0.2221
5	0.0051	-1.9802	0.0000	-0.1527
4	0.0038	-1.6926	0.0000	-0.0862
3	0.0026	-1.4414	0.0000	-0.0664
2	0.0013	-1.2706	0.0000	-0.0484
1	0.0005	-1.2045	0.0000	-0.0242
BASE	0.1230	-1.1816	0.0001	0.0034

MAX ACCELERATION IN Y DIRECTION
TIME : 11.055

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0010	-0.3198	0.0011	-0.4229
5	0.0008	-0.2890	0.0009	-0.3301
4	0.0006	-0.2648	0.0007	-0.2249
3	0.0004	-0.2474	0.0005	-0.1549
2	0.0002	-0.2741	0.0003	-0.0839
1	0.0001	-0.3050	0.0001	-0.0325
BASE	0.0569	-0.3349	-0.0002	0.0085

PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT AT TIME OF MAX STRUCT SHEAR IN EACH BUILDING

SUPERSTRUCTURE : 1

MAX STRUC SHEAR IN X DIRECTION
TIME : 14.315

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0071	-1.9821	-0.0004	-0.0413
5	0.0064	-1.9887	-0.0004	0.0067
4	0.0053	-1.9905	-0.0003	0.0529
3	0.0039	-1.9775	-0.0003	0.0866
2	0.0024	-1.9468	-0.0002	0.1027
1	0.0012	-1.9150	-0.0001	0.0980
BASE	0.1230	-1.8816	-0.0008	0.0916

MAX STRUC SHEAR IN Y DIRECTION
TIME : 9.130

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0001	0.2689	-0.0032	0.6488
5	0.0001	0.0885	-0.0024	0.5017
4	0.0002	-0.1356	-0.0017	0.3456
3	0.0003	-0.3475	-0.0010	0.2011
2	0.0002	-0.4936	-0.0003	0.0670
1	0.0001	-0.5700	-0.0001	0.0179
BASE	0.0168	-0.6288	-0.0004	-0.0193

SUPERSTRUCTURE : 2

MAX STRUC SHEAR IN X DIRECTION

TIME : 14.325

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0019	-2.0432	-0.0006	0.0630
5	0.0017	-2.0221	-0.0005	0.0561
4	0.0013	-1.9930	-0.0003	0.0486
3	0.0010	-1.9691	-0.0002	0.0414
2	0.0005	-1.9447	-0.0001	0.0332
1	0.0003	-1.9329	0.0000	0.0264
BASE	0.1246	-1.9196	0.0000	0.0230

MAX STRUC SHEAR IN Y DIRECTION
TIME : 11.020

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0000	0.2800	-0.0007	0.2067
5	0.0000	0.1310	-0.0005	0.1598
4	0.0000	-0.0727	-0.0004	0.1161
3	0.0000	-0.2351	-0.0002	0.0741
2	0.0000	-0.3952	-0.0001	0.0340
1	0.0000	-0.4781	0.0000	0.0151
BASE	0.0681	-0.5609	0.0002	0.0052

SUPERSTRUCTURE : 3

MAX STRUC SHEAR IN X DIRECTION
TIME : 14.380

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0167	-2.6674	0.0003	-0.1203
5	0.0138	-2.5452	0.0003	-0.1088
4	0.0108	-2.4141	0.0002	-0.0790
3	0.0076	-2.2771	0.0002	-0.0600
2	0.0040	-2.1123	0.0001	-0.0323
1	0.0015	-1.9965	0.0001	-0.0201
BASE	0.1280	-1.9224	0.0004	-0.0090

MAX STRUC SHEAR IN Y DIRECTION
TIME : 12.605

LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0033	0.6468	-0.0007	0.4321
5	-0.0027	0.4990	-0.0007	0.3741
4	-0.0020	0.3445	-0.0005	0.2493

3	-0.0014	0.1893	-0.0004	0.1805
2	-0.0007	0.0151	-0.0002	0.1045
1	-0.0002	-0.1013	-0.0001	0.0657
BASE	0.0350	-0.1676	-0.0006	0.0332

SUPERSTRUCTURE : 4

MAX STRUC SHEAR IN X DIRECTION
TIME : 14.385

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0060	-1.7623	-0.0001	-0.1389
5	0.0049	-1.8252	-0.0001	-0.1277
4	0.0038	-1.8827	-0.0001	-0.1050
3	0.0026	-1.9301	-0.0001	-0.0750
2	0.0014	-1.9368	0.0000	-0.0365
1	0.0006	-1.9259	0.0000	-0.0148
BASE	0.1283	-1.9090	0.0004	-0.0012

MAX STRUC SHEAR IN Y DIRECTION
TIME : 9.310

LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0013	-0.3166	-0.0013	0.4007
5	0.0011	-0.3269	-0.0011	0.3341
4	0.0008	-0.3326	-0.0009	0.2494
3	0.0006	-0.3235	-0.0006	0.1822
2	0.0003	-0.2978	-0.0003	0.0984
1	0.0001	-0.2703	-0.0001	0.0426
BASE	0.0137	-0.2473	0.0001	0.0011

PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT AT TIME OF MAX BASE SHEARS

MAXIMUM BASE SHEAR IN X DIRECTION
TIME : 14.375

SUPERSTRUCTURE : 1

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0068	-1.8623	-0.0009	0.0602

5	0.0061	-1.8832	-0.0008	0.0736
4	0.0051	-1.9090	-0.0006	0.0857
3	0.0038	-1.9360	-0.0004	0.0901
2	0.0023	-1.9594	-0.0002	0.0868
1	0.0011	-1.9738	-0.0001	0.0915
BASE	0.1284	-1.9855	-0.0005	0.0946

SUPERSTRUCTURE : 2

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0018	-1.9026	-0.0006	0.0938
5	0.0016	-1.9204	-0.0005	0.0833
4	0.0013	-1.9435	-0.0004	0.0727
3	0.0010	-1.9596	-0.0002	0.0610
2	0.0005	-1.9731	-0.0001	0.0489
1	0.0003	-1.9800	0.0000	0.0423
BASE	0.1284	-1.9852	0.0000	0.0381

SUPERSTRUCTURE : 3

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0166	-2.6573	0.0003	-0.1294
5	0.0137	-2.5356	0.0003	-0.1182
4	0.0107	-2.4057	0.0003	-0.0889
3	0.0076	-2.2723	0.0002	-0.0700
2	0.0040	-2.1164	0.0002	-0.0418
1	0.0015	-2.0095	0.0001	-0.0290
BASE	0.1281	-1.9429	0.0004	-0.0170

SUPERSTRUCTURE : 4

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	0.0059	-1.6998	-0.0001	-0.1052
5	0.0048	-1.7726	-0.0001	-0.0977
4	0.0037	-1.8444	-0.0002	-0.0859
3	0.0026	-1.9186	-0.0001	-0.0687
2	0.0013	-1.9669	-0.0001	-0.0423
1	0.0006	-1.9903	0.0000	-0.0256
BASE	0.1286	-2.0014	0.0004	-0.0140

MAXIMUM BASE SHEAR IN Y DIRECTION
TIME : 11.635

SUPERSTRUCTURE : 1

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0063	1.8378	0.0018	-0.3643
5	-0.0056	1.8093	0.0014	-0.2424
4	-0.0047	1.7675	0.0010	-0.1163
3	-0.0034	1.7104	0.0006	-0.0056
2	-0.0021	1.6458	0.0002	0.0841

1	-0.0010	1.5922	0.0001	0.1141
BASE	-0.1086	1.5413	0.0008	0.1322

SUPERSTRUCTURE : 2

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0015	1.5560	0.0012	-0.2684
5	-0.0014	1.5841	0.0009	-0.1887
4	-0.0011	1.6115	0.0007	-0.1076
3	-0.0008	1.6129	0.0004	-0.0346
2	-0.0004	1.5918	0.0002	0.0366
1	-0.0002	1.5691	0.0001	0.0748
BASE	-0.1086	1.5416	0.0000	0.0936

SUPERSTRUCTURE : 3

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0147	2.3213	-0.0002	0.0854
5	-0.0122	2.2232	-0.0002	0.0872
4	-0.0095	2.1146	-0.0002	0.0869
3	-0.0067	1.9875	-0.0002	0.0834
2	-0.0035	1.8099	-0.0001	0.0723
1	-0.0013	1.6680	-0.0001	0.0620
BASE	-0.1080	1.5705	-0.0008	0.0560

SUPERSTRUCTURE : 4

	X		Y	
LEVEL	DISP	ACCEL	DISP	ACCEL
6	-0.0062	1.9282	0.0002	0.0445
5	-0.0051	1.8940	0.0002	0.0539
4	-0.0039	1.8502	0.0002	0.0561
3	-0.0026	1.7757	0.0002	0.0503
2	-0.0014	1.6754	0.0001	0.0513
1	-0.0006	1.5944	0.0000	0.0549
BASE	-0.1088	1.5305	-0.0007	0.0580

APPENDIX C

3D-BASIS-M SOURCE CODE

```
C     ********************************************************************
C
C       PROGRAM  3D-BASIS-M...... A GENERAL PROGRAM FOR THE NONLINEAR
C                DYNAMIC ANALYSIS OF THREE DIMENSIONAL BASE ISOLATED
C                MULTIPLE BUILDING STRUCTURES
C
C       DEVELOPED BY...P. C. TSOPELAS, S. NAGARAJAIAH,
C                      M. C. CONSTANTINOU AND A. M. REINHORN
C                      DEPARTMENT OF CIVIL ENGINEERING
C                      STATE UNIV. OF NEW YORK AT BUFFALO
C
C                      VAX VERSION, APRIL 1991
C
C
C     NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH, BUFFALO
C     STATE UNIVERSITY OF NEW YORK, BUFFALO
C
C     ********************************************************************
C
C     NO RESPONSIBILITY IS ASSUMED BY THE AUTHORS OR BY THE UNIVERSITY
C     AT BUFFALO FOR ANY ERRORS, MISTAKES, OR MISREPRESENTATIONS
C     THAT MAY OCCUR FROM THE USE OF THIS COMPUTER PROGRAM.  ALL
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C
C     PUBLIC DISTRIBUTION OF THIS PROGRAM THROUGH NCEER WAS MADE POSSI-
C     BLE BY THE AUTHORS AND THE NATIONAL SCIENCE FOUNDATION WITH THE
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C     PURCHASER UNDERSTANDS THE RESTRICTIONS ON THE USE AND DISTRIBU-
C     TION OF THE PROGRAM.  THE FEE PAID TO NCEER REPRESENTS A CHARGE
C     FOR DUPLICATION, MAILING, AND DOCUMENTATION.  THE LEGAL OWNERSHIP
C     OF THE PROGRAM REMAINS WITH THE DEVELOPERS.
C
C     IF THIS PROGRAM HAS GIVEN YOU NEW ANALYSIS CAPABILITY RESULTING
C     IN INDIRECT PROFITS, YOU MAY WISH TO SUPPORT FURTHER WORK IN THIS
C     AREA BY GIVING AN UNRESTRICTED GRANT TO THE AUTHORS UNIVERSITY.
C
C**********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)

      CHARACTER *80 BBASE
      CHARACTER *20 LENGTH,MASS,RTIME
      CHARACTER *4 IS(10)

      COMMON /STEP    /TSI,TSR
      COMMON /GENBASE /ISEV,LOR
      COMMON /PRINT   /LTMH,IPROF,KPD,KPF,INP
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /GENERAL1/A(100000)
      COMMON /GENERAL2/IA(10000)

      OPEN (UNIT=5,FILE='3DBASISM.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=7,FILE='3DBASISM.OUT',STATUS='NEW')
      OPEN (UNIT=8,STATUS='SCRATCH',FORM='UNFORMATTED')
      OPEN (UNIT=9,STATUS='SCRATCH',FORM='UNFORMATTED')
      OPEN (UNIT=10,STATUS='SCRATCH',FORM='UNFORMATTED')
      OPEN (UNIT=13,STATUS='SCRATCH',FORM='UNFORMATTED')
      OPEN (UNIT=14,STATUS='SCRATCH',FORM='UNFORMATTED')
      OPEN (UNIT=15,FILE='WAVEX.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=16,FILE='WAVEY.DAT',STATUS='UNKNOWN')
      OPEN (UNIT=17,STATUS='SCRATCH',FORM='UNFORMATTED')

      REWIND 5
      REWIND 7
      REWIND 8
      REWIND 9
      REWIND 10
```

```
      REWIND 14
      REWIND 15
      REWIND 16
      REWIND 17
C
C
      MA =100000
      MA1= 10000
C
C
      READ(5,1000) BBASE
      READ(5,'(3A20)') LENGTH,MASS,RTIME
      READ(5,*) ISEV,NB,NP,INP
      WRITE(7,3000)
      WRITE(7,'(///6X,A80//)') BBASE
      WRITE(7,2001) LENGTH,MASS,RTIME
      K1=1
      K2=K1+NB
      K3=K2+NB
      CALL READ1 ( IA(1) , IA(K2) )
      L 1=1
      L 2=L 1 + MNE
      L 3=L 2 + NFE
      L 4=L 3 + MNF
      L 5=L 4 + MNF
      L 6=L 5 + (MNF+NB)
      L 7=L 6 + NP*2
      L 8=L 7 + NP*2
      L 9=L 8 + NP*2
      L10=L 9 + NP*2
      L11=L10 + NP*2
      L12=L11 + NP*2
      L13=L12 + NP*2
      L14=L13 + NP*2
      L15=L14 + NP
      L16=L15 + NP
      L17=L16 + NP
      L18=L17 + NB*6
      L19=L18 + NB*6
      L20=L19 + LOR
      L21=L20 + LOR
      L22=L21 + (MNE+3)*(MNE+3)
      L23=L22 + (3*MNF+3)*(3*MNF+3)
      L24=L23 + (MNE+3)*(MNE+3)
      L25=L24 + MXF
      L26=L25 + MXF
      L27=L26 + MXF
      L28=L27 + 3*MXF
      L29=L28 + (3*MXF)*(3*MXF)
      L30=L29 + 3*MXF
      L31=L30 + (3*MXF)*(3*MXF)
      L32=L31 + MXF
      L33=L32 + MXF
      L34=L33 + MXF
      L35=L34 + MXF
      L36=L35 + MXF
      K 1=1
      K 4=K 3 + NP*2
      K 5=K 4 + INP
      K 6=K 5 + NB
C
C
```

```
C
C
C-----INITIALIZE CM,C MATRICES-------
C
      N1=(3*MNF+3)*(3*MNF+3)
      DO 80 J=1,N1
      A(L22-1+J)=0.0
   80 CONTINUE
      N1=(MNE+3)*(MNE+3)
      DO 90 J=N1
      A(L23-1+J)=0.0
   90 CONTINUE

      WRITE (7,500)

      N1=0
      N2=0
      DO 100 I=1,NB

      NF1=IA(I)
      NE1=IA(K2-1+I)

      CALL READ2
     +(                A(L 3),A(L 4),A(L 5)
     + ,A(L 6),A(L 7),A(L 8),A(L 9),A(L10)
     + ,A(L11),A(L12),A(L13),A(L14),A(L15)
     + ,A(L16),A(L17),A(L18),A(L19),A(L20)
     + ,                      A(L24),A(L25)
     + ,A(L26),A(L27),A(L28),A(L29)
     + ,A(L31),A(L32),A(L33),A(L34),A(L35)
     + ,                 IA(K 3),IA(K 4),IA(K 5)
     + ,NF1,NE1,I)

      IF(ISEV.EQ.1)THEN

       L37=L36 + (MXF)*(MXF)
       L38=L37 + (MXF)*(MXF)
       L39=L38 + (MXF)*(MXF)
       L40=L39 + (MXF)*(MXF)
       L41=L40 + (MXF)*(MXF)

       CALL STIFF1
     + (                              A(L30)
     +  ,A(L31),A(L32),A(L33),A(L34),A(L35)
     +  ,A(L36),A(L37),A(L38),A(L39),A(L40)
     +  ,NF1,I)

       L32=L31 + (3*MXF)*(3*MXF)

       CALL MASSA
     + (       A(L22),        A(L24),A(L25)
     +  ,A(L26)
     +  ,A(L31)
     +  ,NF1,I)

       CALL JACOBI(A(L30),A(L31),A(L28),A(L27),3*NF1,7,30,3*MXF)

      ELSE IF(ISEV.EQ.2)THEN

       CALL MASSB
     + (       A(L22),        A(L24),A(L25)
     +  ,A(L26)
     +  ,NF1,I)

      END IF
C
C    STORE EIGEN-VECTORS - VALUES IN ONE DIMENS ARRAY
C
      N1=N1+NE1
      N2=N2+3*NF1*NE1

```

```
          CALL DAMP
         +( A(L 7),A(L15),A(L16)
         + ,A(L23),A(L27),A(L29)
         + ,IA(K 3)
         + ,NE1,I)

   100     CONTINUE
C
           IF(LTMH.EQ.1) THEN
            DO 150 I=1,NB
            ISK=50+I
            ISK1=1000+I
            WRITE(IS(I),'(I4)') ISK1
            OPEN(UNIT=ISK,FILE=IS(I),STATUS='NEW')
C
            WRITE(ISK,1001) I
    150     CONTINUE
C
          ENDIF
C
          L25=L24 + (MNE+3)*(MNE+3)
          L26=L25 + (MNE+3)*(MNE+3)
          L27=L26 + (3*MNF+3)*3
          L28=L27 + (3*MNF+3)*(MNE+3)
          L29=L28 + (MNE+3)
          L30=L29 + (MNE+3)

          L31=L30 + (MNE+3)
          L32=L31 + (MNE+3)
          L33=L32 + (MNE+3)*2
          L34=L33 + (MNE+3)
          L35=L34 + (MNE+3)
          L36=L35 + (MNE+3)
          L37=L36 + (MNE+3)
          L38=L37 + (MNE+3)
          L39=L38 + (MNE+3)
          L40=L39 + (3*MNF+3)

          L41=L40 + NP
          L42=L41 + NP
          L43=L42 + NP
          L44=L43 + NP
          L45=L44 + NP
          L46=L45 + NP
          L47=L46 + NP
          L48=L47 + NP
          L49=L48 + NP
          L50=L49 + NP

          L51=L50 + NP
          L52=L51 + NP
          L53=L52 + NP
          L54=L53 + (MNE+3)*(3*MNF+3)
          L55=L54 + (3*MNF+3)*1
          L56=L55 + (MNE+3)*(3*MNF+3)
          L57=L56 + (MNE+3)*3
          L58=L57 + (3*MNF+3)
          L59=L58 + (3*MNF+3)
          L60=L59 + (3*MNF+3)

          L61=L60 + (3*MNF+3)
          L62=L61 + MNF*3
          L63=L62 + MNF*3
          L64=L63 + NB*3
          L65=L64 + NB*3
          L66=L65 + NB*3
          L67=L66 + 2*NB*2
          L68=L67 + 2*(3*MNF+3)*5
          L69=L68 + 2*(3*MNF+3)*5
          L70=L69 + 2*NB*2
```

```
      L72=L71 + NB*3*2
      L73=L72 + NB*3*2
      L74=L73 + NB*3*2

      L75=L74 + (NB*MXF*6)*6

      L76=L75 + INP
      L77=L76 + INP
      L78=L77 + INP
      L79=L78 + INP
      L80=L79 + INP

      L81=L80 + INP

      L82=L81 + NB*2
      L83=L82 + NB*2
      L84=L83 + MNF+NB
      L85=L84 + MNF+NB
      L86=L85 + NB
      L87=L86 + NB
C
      CALL CHECK(L87,MA,2)
C
        CALL SOLUTION
     +( A(L 1),A(L 2),A(L 3),A(L 4),A(L 5)
     + ,A(L 6),       A(L 8),A(L 9),A(L10)
     + ,A(L11),A(L12),A(L13),A(L14),A(L15)
     + ,A(L16),A(L17),A(L18),A(L19),A(L20)
     + ,A(L21),A(L22),A(L23),A(L24),A(L25)
     + ,A(L26),A(L27),A(L28),A(L29),A(L30)
     + ,A(L31),A(L32),A(L33),A(L34),A(L35)
     + ,A(L36),A(L37),A(L38),A(L39),A(L40)
     + ,A(L41),A(L42),A(L43),A(L44),A(L45)
     + ,A(L46),A(L47),A(L48),A(L49),A(L50)
     + ,A(L51),A(L52),A(L53),A(L54),A(L55)
     + ,A(L56),A(L57),A(L58),A(L59),A(L60)
     + ,A(L61),A(L62),A(L63),A(L64),A(L65)
     + ,A(L66),A(L67),A(L68),A(L69),A(L70)
     + ,A(L71),A(L72),A(L73),A(L74),A(L75)
     + ,A(L76),A(L77),A(L78),A(L79),A(L80)
     + ,A(L81),A(L82),A(L83),A(L84),A(L85)
     + ,A(L86)
     + ,IA(  1),IA(K 2),IA(K 3),IA(K 4),IA(K 5))

       CLOSE (UNIT=5)
       CLOSE (UNIT=7)
       CLOSE (UNIT=8,STATUS='DELETE')
       CLOSE (UNIT=9,STATUS='DELETE')
       CLOSE (UNIT=10,STATUS='DELETE')
       CLOSE (UNIT=13,STATUS='DELETE')
       CLOSE (UNIT=14,STATUS='DELETE')
       CLOSE (UNIT=15)
       CLOSE (UNIT=16)

       STOP
C
 500  FORMAT(/////6X,'************* SUPERSTRUCTURE DATA ************')
 1000 FORMAT (A80)
 1001 FORMAT(//6X,'SUPERSTRUCTURE : ',I2,//
     +        2X,' TIME',1X,'LEVEL',3X,'ACCEL  X',3X,'ACCEL  Y',
     +        3X,'DISPL  X',3X,'DISPL  Y',3X,'ROTATION'/)
 2001 FORMAT(//6X,'UNITS'/
     +,         6X,'LENGTH :',1X,A20/
     +,         6X,'MASS   :',1X,A20/
     +,         6X,'TIME   :',1X,A20//)
 3000 FORMAT(//6X,'************************************'
     +,'********************************'/,6X,
     +' '/,6X,
     +' '/,6X,
     +'PROGRAM  3D-BASIS-M...... A GENERAL PROGRAM FOR THE',
```

```
     +'          DYNAMIC ANALYSIS OF THREE DIMENSIONAL BASE ISOLATED'/,6X,
     +'          MULTIPLE BUILDING STRUCTURES'/,6X,
     +' '/,6X,
     +'DEVELOPED BY...P. C. TSOPELAS, S. NAGARAJAIAH,'/,6X,
     +'                M. C. CONSTANTINOU AND A. M. REINHORN'/,6X,
     +'                DEPARTMENT OF CIVIL ENGINEERING '/,6X,
     +'                STATE UNIV. OF NEW YORK AT BUFFALO'/,6X,
     +' '/,6X,
     +'                VAX VERSION, APRIL 1991'/,6X,
     +' '/,6X,
     +' '/,6X,
     +'NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH'/,6X,
     +'STATE UNIVERSITY OF NEW YORK, BUFFALO'/,6X,
     +' '/,6X,
     +' '/,6X,
     +'***********************************'
     +,'*******************************')
       END

C****************************************************   CHECK   ********

      SUBROUTINE CHECK(I,MAXA,M)

C***********************************************************************
C     SUBROUTINE FOR CHECKING THE USAGE OF MASTER ARRAY.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
C
      IF(I.LT.MAXA)THEN
       IF (M.EQ.1) WRITE(*,110)I
       IF (M.EQ.2) WRITE(*,100)I
      ELSE
       IF (M.EQ.1) WRITE(*,210)MAXA
       IF (M.EQ.2) WRITE(*,200)MAXA
      END IF
      RETURN
  110   FORMAT (//6X,'POINTER WITHIN MASTER ARRAY  " IA "',
     +            2X,'MAX STORAGE',I10)
  100   FORMAT (//6X,'POINTER WITHIN MASTER ARRAY  " A "',
     +            2X,'MAX STORAGE',I10)
  210   FORMAT (//6X,'POINTER OUT OF BOUNDS OF MASTER ARRAY  " IA "',
     +  12X,'MAX STORAGE REQUIRED',I10)
  200   FORMAT (//6X,'POINTER OUT OF BOUNDS OF MASTER ARRAY  " A "',
     +  12X,'MAX STORAGE REQUIRED',I10)
      END

C****************************************************   STORE   ********

      SUBROUTINE STORE (W1,E1,W,E,M1,N1,M2,N2)

C***********************************************************************
C     SUBROUTINE FOR STORING EIGENVALUES AND EIGENVECTORS.
C     DEVELOPED  BY.....................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      DIMENSION W1(MNE),E1(NFE)
      DIMENSION W(3*MXF),E(3*MXF,3*MXF)
C
      DO 110 J=1,M1
      W1(N1-M1+J)=W(J)
  110 CONTINUE

      DO 120 K=1,M1
      DO 120 J=1,3*M2
```

```
      ET(N3)=E(J,K)
  120 CONTINUE
C
      RETURN
      END

C*****************************************************    READ1    ********

      SUBROUTINE READ1(NF,NE)

C************************************************************************
C     SUBROUTINE TO READ CONTROL PARAMETERS.
C     DEVELOPED BY.......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY.......................PANAGIOTIS TSOPELAS....APR 1991
C
C************************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /GENBASE /ISEV,LOR
      COMMON /PRINT   /LTMH,IPROF,KPD,KPF,INP
      COMMON /HYS1    /WBET,WGAM
      COMMON /INT     /FMNORM,BET,GAM,TOL
      COMMON /LOAD1   /XTH,IDAT,TIME,PTSR,ULF,INDGACC
      DIMENSION NF(NB),NE(NB)
C
      MNF=0
      MNE=0
      NFE=0
      DO 10 I=1,NB
      READ(5,*) NF(I),NE(I)
      MNF=MNF+NF(I)
      MNE=MNE+NE(I)
      NFE=NFE+3*NF(I)*NE(I)
   10 CONTINUE
      MXF=0
      DO 20 I=1,NB
      IF(NF(I).GT.MXF) MXF=NF(I)
   20 CONTINUE

      READ (5,*)TSI,TOL,FMNORM,MAXMI,KVSTEP
      READ (5,*)GAM,BET
      READ (5,*)WBET,WGAM
      READ (5,*)INDGACC,TSR,LOR,XTH,ULF

      IF(TSI.GT.TSR)TSI=TSR

      WRITE (7,1)

      WRITE(7,100) NB,NP,ISEV,INP,TSI,KVSTEP,GAM,BET,TOL,FMNORM,
     +              MAXMI,WBET,WGAM,INDGACC,TSR,LOR,ULF,XTH
C
      RETURN
 1    FORMAT(//6X,'**************INPUT DATA***************',/
     +///6X,'**************** CONTROL PARAMETERS ***************',//)

100   FORMAT(///6X,'NO. OF BUILDINGS........................= ',I12,/
     +          6X,'NO. OF ISOLATORS........................= ',I12,/
     +          6X,'INDEX FOR  SUPERSTRUCTURE STIFFNESS DATA= ',I12,//
     +          6X,'  INDEX = 1 FOR 3D SHEAR BUILDING  REPRES.',/
     +          6X,'  INDEX = 2 FOR FULL 3D REPRESENTATION    ',/
     +          6X,'NUMBER OF ISOLATORS, OUTPUT IS DESIRED...= ',I12,//

     +          6X,'TIME STEP OF INTEGRATION (NEWMARK)......= ',F12.5,/
     +          6X,'INDEX FOR TYPE OF TIME STEP.............= ',I12,//
     +          6X,'  INDEX = 1 FOR CONSTANT TIME STEP        ',/
     +          6X,'  INDEX = 2 FOR VARIABLE TIME STEP        ',//
     +          6X,'GAMA FOR NEWMARKS  METHOD...............= ',F12.5,/
     +          6X,'BETA FOR NEWMARKS  METHOD...............= ',F12.5,/
     +          6X,'TOLERANCE FOR FORCE COMPUTATION.........= ',F12.5,/
```

```
     +          6X,'BETA FOR WENS MODEL ....................= ',F12.5,/
     +          6X,'GAMA FOR WENS MODEL ....................= ',F12.5,//

     +          6X,'INDEX FOR GROUND MOTION INPUT...........= ',I12,//
     +          6X,'  INDEX = 1 FOR UNIDIRECTIONAL INPUT      ',/
     +          6X,'  INDEX = 2 FOR BIDIRECTIONAL INPUT       ',//
     +          6X,'TIME STEP OF RECORD ....................= ',F12.5,/
     +          6X,'LENGTH OF RECORD........................= ',I12,/
     +          6X,'LOAD FACTOR.............................= ',F12.5,/
     +          6X,'ANGLE OF EARTHQUAKE INCIDENCE...........= ',F12.5//)
       END

C***********************************************     READ2    ********

      SUBROUTINE READ2
     + (                 XN, YN,    H
     + ,  PS,    PC,    ALP, YF,   YD
     + ,FMAX,    DF,     PA, FN,   XP
     + ,   YP,CORDX, CORDY,  X,    Y
     + ,                     CMX,  CMY
     + , CMR,     W,      E, DR
     + ,  SX,    SY,     ST, EX,   EY
     + ,             INELEM, IP,ICOR
     + ,NF,NE,I)

C*********************************************************************
C     SUBROUTINE TO READ THE INPUT DATA.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C*********************************************************************

C
C          !!!!!!!!!! BE AWARE !!!!!!!!!!!
C       DO NOT USE  ' I '  AS INDEX  IN THIS SUBROUTINE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /GENBASE /ISEV,LOR
      COMMON /STIFF   /SXE,SYE,STE,EXE,EYE
      COMMON /MASS1   /CMXB,CMYB,CMRB
      COMMON /DAMP1   /CBX,CBY,CBT,ECX,ECY
      COMMON /INT     /FMNORM,BET,GAM,TOL
      COMMON /LOAD1   /XTH,IDAT,TIME,PTSR,ULF,INDGACC
      COMMON /PRINT   /LTMH,IPROF,KPD,KPF,INP
      COMMON /DIREC   /DRIN(3),DRIN1(4)
      CHARACTER*1 DRIN
      CHARACTER*2 DRIN1
      DIMENSION ALP(NP,2),YF(NP,2),YD(NP,2),FMAX(NP,2)
     +   ,DF(NP,2),PA(NP,2),FN(NP),XP(NP),YP(NP)
     +   ,SX(MXF),SY(MXF),ST(MXF),EX(MXF),EY(MXF)
     +   ,W(3*MXF),E(3*MXF,3*MXF),INELEM(NP,2)
     +   ,CMX(MXF),CMY(MXF),CMR(MXF),XN(MNF),YN(MNF),H(MNF+NB)
     +   ,DR(3*MXF),PC(NP,2),PS(NP,2),X(LOR),Y(LOR),IP(INP)
      DIMENSION ICOR(NB),CORDX(NB,6),CORDY(NB,6)
C
      PI=4.DO*DATAN(1.DO)

      DRIN(1)='X'
      DRIN(2)='Y'
      DRIN(3)='R'

      DRIN1(1)='Dx'
      DRIN1(2)='Dy'
      DRIN1(3)='Fx'
      DRIN1(4)='Fy'

      DO 7 K=1,3*MXF
      DO 5 J=1,3*MXF
```

```
C-------ISEV=1
C-------STIFFNESS DATA FOR 3D SHEAR BUILDING REPRESENTATION
C-------BEGIN WITH THE TOP FLOOR AND END WITH THE FIRST FLOOR

         WRITE(7,1029) I
         WRITE(7,1030)

        IF (ISEV.EQ.1)THEN

        WRITE(7,1031)
        READ(5,*)(SX(NF+1-J),J=1,NF)

        READ(5,*)(SY(NF+1-J),J=1,NF)

C-------STIFFNESS AT THE CENTER OF MASS

        READ(5,*)(ST(NF+1-J),J=1,NF)

        READ(5,*)(EX(NF+1-J),J=1,NF)

        READ(5,*)(EY(NF+1-J),J=1,NF)

        DO 3 J=1,NF
        IF(EX(NF+1-J).EQ.0.0.AND.EY(NF+1-J).EQ.0.0) EX(NF+1-J)=1.D-5
    3   CONTINUE

        DO 150 J=1,NF
  150   WRITE(7,2031) NF+1-J,SX(NF+1-J),SY(NF+1-J),ST(NF+1-J),
     +                EX(NF+1-J),EY(NF+1-J)

C-------ISEV=2
C-------EIGENVALUES AND EIGENVECTORS FOR FULL THREE DIMENSIONAL BUILDING

        ELSE IF(ISEV.EQ.2)THEN

        READ(5,*)(W(J),J=1,NE)

         WRITE(7,1032)

         WRITE(7,1033)(J,W(J),2*PI/DSQRT(W(J)),J=1,NE)

        READ(5,*)((E(K,J),K=1,3*NF),J=1,NE)

         DO 152 L=1,NE,6
         IH=L+5
         IF(IH.GT.NE) IH=NE
         WRITE(7,2033) (J,J=L,IH)
         DO 152 N=1,NF
         LN=NF+1-N
         NN=3*(N-1)
         DO 152 J=1,3
  152    WRITE(7,2034) LN,DRIN(J),(E(NN+J,K),K=L,IH)

        END IF

C-------MASSES AT SUPERSTRUCTURES LEVELS
C-------BEGIN WITH THE TOP FLOOR AND END WITH THE FIRST FLOOR

        READ(5,*)(CMX(NF+1-J),J=1,NF)

         DO 8 J=1,NF
  8      CMY(NF+1-J)=CMX(NF+1-J)

C-------MASS AT THE CENTER OF MASS

        READ(5,*)(CMR(NF+1-J),J=1,NF)

        IF(I.EQ.1)N1=0
        IF(I.EQ.1)N2=0
```

```
C-------MODAL DAMPING RATIOS FOR THE SUPERSTRUCTURE

      READ(5,*)(DR(J),J=1,NE)

C-------LOCATION OF THE CENTER OF MASS OF THE FLOOR WITH RESPECT TO
C-------THE CENTER OF MASS OF THE BASE IN X AND Y DIRECTION

      READ(5,*)(XN(N1+1-J),YN(N1+1-J),J=1,NF)

       WRITE(7,1050)
       DO 170 J=1,NF
170    WRITE(7,2050) NF+1-J,CMX(NF+1-J),CMR(NF+1-J),
     +               XN(N1+1-J),YN(N1+1-J)

       WRITE(7,1080)
       DO 180 J=1,NE
 180   WRITE(7,2080) J,DR(J)

C-------HEIGHT TO FLOORS FROM THE GROUND

      READ(5,*)(H(N2+1-J),J=1,NF+1)

      WRITE(7,1060)
      DO 175 J=1,NF+1
175   WRITE(7,2060) NF+1-J,H(N2+1-J)

     IF(I.EQ.NB) THEN

C-------STIFFNESS DATA OF LINEAR ELASTIC ISOLATION SYSTEM

      READ(5,*)SXE,SYE,STE,EXE,EYE

       WRITE (7,600)

       WRITE(7,1040)
       WRITE(7,2040) SXE,SYE,STE,EXE,EYE

C-------MASS DATA OF BASE

      READ(5,*)CMXB,CMRB

       CMYB=CMXB

       WRITE(7,1070)
       WRITE(7,2070) CMXB,CMRB

C-------GLOBAL DAMPING COEFFICIENTS AT THE BASE

      READ(5,*)CBX,CBY,CBT,ECX,ECY

       WRITE(7,1071)
       WRITE(7,2071) CBX,CBY,CBT,ECX,ECY

C-------CORDINATES OF ISOLATORS

      READ(5,*)(XP(J),YP(J),J=1,NP)

       WRITE(7,1020)
       DO 140 J=1,NP
140    WRITE(7,2020) J,XP(J),YP(J)

C-------DATA FOR ISOLATION ELEMENTS

       DO 20 K=1,NP

       READ(5,*)(INELEM(K,J),J=1,2)

       IF(INELEM(K,2).EQ.2)GO TO 10
       IF(INELEM(K,2).EQ.3)GO TO 11
```

```
C-------DATA FOR LINEAR ELASTIC ELEMENTS

        IF(INELEM(K,1).EQ.1)THEN
        READ(5,*) PS(K,1)
        PS(K,2)=0.0

        ELSE IF(INELEM(K,1).EQ.2)THEN
        READ(5,*) PS(K,2)
        PS(K,1)=0.0

        ELSE IF(INELEM(K,1).EQ.3)THEN
        READ(5,*) (PS(K,J),J=1,2)

        END IF

        GO TO 20

C-------DATA FOR VISCOUS ELEMENTS

   10   IF(INELEM(K,1).EQ.1)THEN
        READ(5,*) PC(K,1)
        PC(K,2)=0.0

        ELSE IF(INELEM(K,1).EQ.2)THEN
        READ(5,*) PC(K,2)
        PC(K,1)=0.0

        ELSE IF(INELEM(K,1).EQ.3)THEN
        READ(5,*) (PC(K,J),J=1,2)

        END IF

        GO TO 20

C-------DATA FOR ELASTOMERIC BEARINGS

   11   IF(INELEM(K,1).EQ.1)THEN
        READ(5,*)ALP(K,1),YF(K,1),YD(K,1)
        ALP(K,2)=0.0
        YF(K,2)=0.0
        YD(K,2)=0.0

        ELSE IF(INELEM(K,1).EQ.2)THEN
        READ(5,*)ALP(K,2),YF(K,2),YD(K,2)
        ALP(K,1)=0.0
        YF(K,1)=0.0
        YD(K,1)=0.0

        ELSE IF(INELEM(K,1).EQ.3)THEN
        READ(5,*)(ALP(K,J),J=1,2),(YF(K,J),J=1,2),(YD(K,J),J=1,2)

        END IF

        GO TO 20

C-------DATA FOR SLIDING BEARINGS

   12   IF(INELEM(K,1).EQ.1)THEN
        READ(5,*)FMAX(K,1),DF(K,1),PA(K,1),YD(K,1),FN(K)
        FMAX(K,2)=0.0
        DF(K,2)=0.0
        PA(K,2)=0.0
        YD(K,2)=0.0

        ELSE IF(INELEM(K,1).EQ.2)THEN
        READ(5,*)FMAX(K,2),DF(K,2),PA(K,2),YD(K,2),FN(K)
        FMAX(K,1)=0.0
        DF(K,1)=0.0
        PA(K,1)=0.0
        YD(K,1)=0.0
```

```
          READ(5,*)(FMAX(K,J),J=1,2),(DF(K,J),J=1,2),
     +             (PA(K,J),J=1,2),(YD(K,J),J=1,2),FN(K)

          END IF

          GO TO 20

 20       CONTINUE

          DO 50 K=1,NP
          DO 40 J=1,2
          IF(YD(K,J).EQ.0.0)THEN
          YD(K,J)=0.000001
          END IF
 40       CONTINUE
 50       CONTINUE

          K=0
          DO 300 IK=1,NP
          IF(INELEM(IK,2).NE.1) GO TO 300
          IF(K.EQ.0)THEN
          WRITE(7,3500)
          END IF
          WRITE(7,3501) IK,(PS(IK,J),J=1,2)
          K=1
300       CONTINUE

          K=0
          DO 301 IK=1,NP
          IF(INELEM(IK,2).NE.2) GO TO 301
          IF(K.EQ.0)THEN
          WRITE(7,3600)
          END IF
          WRITE(7,3601) IK,(PC(IK,J),J=1,2)
          K=1
301       CONTINUE

          K=0
          DO 110 IK=1,NP
          IF(INELEM(IK,2).NE.3) GO TO 110
          IF(K.EQ.0)THEN
          WRITE(7,1000)
          END IF
          WRITE(7,2000) IK,(ALP(IK,J),J=1,2),(YF(IK,J),J=1,2),
     +    (YD(IK,J),J=1,2)
          K=1
110       CONTINUE

          K=0
          DO 120 IK=1,NP
          IF(INELEM(IK,2).NE.4) GO TO 120
          IF(K.EQ.0)THEN
          WRITE(7,1010)
          END IF
          WRITE(7,2010) IK,(FMAX(IK,J),J=1,2),(DF(IK,J),J=1,2),
     +                    (PA(IK,J),J=1,2),(YD(IK,J),J=1,2),FN(IK)
          K=1
120       CONTINUE

C-------EARTHQUAKE - ACCELEROGRAM

          READ(15,*)(X(K),K=1,LOR)

C-------EARTHQUAKE - ACCELEROGRAM IN Y DIRECTION IF
C-------BIDIRECTIONAL EXCITATION IS DESIRED

          IF(INDGACC.EQ.2)THEN
          READ(16,*)(Y(K),K=1,LOR)
          END IF
```

```
      READ(5,*) LTMH,KPD,IPROF

      KPF=KPD

      READ(5,*) (IP(J),J=1,INP)

      WRITE (7,700)

      WRITE(7,3000) LTMH,KPD,IPROF,(IP(J),J=1,INP)

C-HOW MANY COLUMN LINES OF EACH BUILDING NEED TO KNOW THE DRIFTS
C-AND THE COORDINATES OF THESE LINES WITH RESPECT TO THE C.M. OF
C-THE BASE

      DO 210 K=1,NB
      READ(5,*) ICOR(K)
      READ(5,*) (CORDX(K,J),CORDY(K,J),J=1,ICOR(K))
  210 CONTINUE

      ENDIF

      RETURN
 600 FORMAT(///6X,'************* ISOLATION SYSTEM DATA ************')
 700 FORMAT(//6X,'************ OUTPUT PARAMETERS *************')
 1000 FORMAT(//6X,'ELASTOMERIC/DAMPER FORCE
     +-DISPLACEMENT LOOP PARAMETERS........'/,
     +  6X,'ISOLATOR',9X,'ALPFA X',9X,'ALPFA Y',3X,'YIELD FORCE X',
     +  3X,'YIELD FORCE Y',2X,'YIELD DISPL. X',2X,'YIELD DISPL. Y'/)
 2000 FORMAT(6X,I5,3X,6(1X,F15.5))
 1010 FORMAT(//6X,'SLIDING BEARING PARAMETERS.......'/,
     +  6X,'ISOLATOR',3X,'FMAX  X',3X,'FMAX  Y',6X,'DF X',
     +  6X,'DF Y',6X,'PA X',6X,'PA Y',2X,'YIELD DISPL. X',
     +  2X,'YIELD DISPL. Y',4X,'NORMAL FORCE'/)
 2010 FORMAT(6X,I5,3X,4(1X,F9.5),2(1X,F9.3),3(1X,F15.5))
 1020 FORMAT(//6X,'ISOLATORS LOCATION INFORMATION.........'/
     +          ,6X,'ISOLATOR',5X,'X',10X,'Y'/)
 2020 FORMAT(6X,I5,4X,F10.4,1X,F10.4)
 1029 FORMAT(///6X,'SUPERSTRUCTURE  :',1X,I2)
 1030 FORMAT(//6X,'.....STIFFNESS DATA........')
 1031 FORMAT(/6X,' STIFFNESS (THREE DIMENSIONAL SHEAR BUILDING) ....'/,
     +         6X,'LEVEL',11X,'STIFF  X ',11X,'STIFF  Y ',
     +        11X,'STIFF  R ',5X,'ECCENT  X ',5X,'ECCENT  Y '/)
 2031 FORMAT(6X,I5,3F20.5,2F15.5)
 1032 FORMAT(/6X,'EIGENVALUES AND EIGENVECTORS (FULL
     + THREE DIMENSIONAL REPRESENTATION)....')
 1033 FORMAT(/6X,'MODE NUMBER',5X,'EIGENVALUE',9X,'PERIOD'//,
     +          (6X,I7,7X,F12.6,3X,F12.6))
 1040 FORMAT(//6X,'STIFFNESS DATA FOR LINEAR-ELASTIC',
     +               ' ISOLATION SYSTEM......'/)
 2033   FORMAT(//6X,'MODE SHAPES'/,
     +            6X,'LEVEL',8X,6(5X,I1,4X))
 2034   FORMAT(/6X,I5,2X,A1,2X,12F10.7)
 2040 FORMAT(6X,'STIFFNESS OF LINEAR-ELASTIC SYS. IN X DIR. = ',F20.5,/
     +         6X,'STIFFNESS OF LINEAR ELASTIC SYS. IN Y DIR. = ',F20.5,/
     +         6X,'STIFFNESS OF LINEAR ELASTIC SYS. IN R DIR. = ',F20.5,/
     +         6X,'ECCENT. IN  X  DIR. FROM CEN. OF MASS......= ',F20.5,/
     +         6X,'ECCENT. IN  Y  DIR. FROM CEN. OF MASS......= ',F20.5//)
 1050 FORMAT(//6X,'SUPERSTRUCTURE MASS..........'/
     +           ,6X,'LEVEL',11X,'TRANSL. MASS',5X,
     +           'ROTATIONAL MASS',8X,'ECCENT  X ',5X,'ECCENT  Y '/)
 2050 FORMAT(6X,I5,3F20.5,2F15.5)
 1060 FORMAT(//6X,'HEIGHT.........'/,
     +           6X,'LEVEL',8X,'HEIGHT'/)
 2060 FORMAT(6X,I5,4X,F10.3)
 1070 FORMAT(//6X,
     +               'MASS AT THE CENTER OF MASS OF THE BASE ....'/,
     +           6X,12X,'TRANSL. MASS    ',
     +                    'ROTATIONAL MASS '/)
 2070 FORMAT(6X,'MASS      ',3F15.5,/)
 1071 FORMAT(//6X,'GLOBAL ISOLATION DAMPING AT THE CENTER
```

```
     +                 '          R          ','       ECX      ',
     +                 '          ECY        ')
 2071 FORMAT(/6X,'DAMPING   ',5F15.5/)
 1080 FORMAT(//6X,'SUPERSTRUCTURE DAMPING.......'/,
     +          6X,'MODE SHAPE',5X,'DAMPING RATIO'/)
 2080 FORMAT(6X,I5,8X,F15.5)
 1090 FORMAT(//6X,'LOCAL ISOLATOR DAMPING AT EACH
     + INDIVIDUAL BEARING....'
     +        /,6X,'BEARING',2X,'DAMPING COEFF.'/)
 2090 FORMAT(6X,I5,3X,F15.5)
 1092 FORMAT(//6X,'.INITIAL CONDITIONS.........',/
     +          6X,7X,9X,'DISPLACEMENTS',8X,10X,'VELOCITIES',10X,
     +             9X,'ACCELERATIONS',8X,/
     +          6X,'FLOOR',2X,3(6X,'X',5X,6X,'Y',5X,6X,'R',5X)/)
 2092 FORMAT(6X,I5,2X,9F12.4)
 3000 FORMAT
     +(//6X,'TIME HISTORY OPTION ........................= ',I12,//
     +   6X,' INDEX = 0 FOR NO TIME HISTORY OUTPUT',/
     +   6X,' INDEX = 1 FOR TIME HISTORY OUTPUT',//
     +   6X,'NO. OF TIME STEPS AT WHICH TIME HISTORY',/
     +   6X,'OUTPUT IS DESIRED ..........................= ',I12,/


     +   6X,'ACCELERATION-DISPLACEMENTS PROFILES OPTION..= ',I12,//
     +   6X,' INDEX = 0 FOR NO PROFILES OUTPUT',/
     +   6X,' INDEX = 1 FOR PROFILES OUTPUT',//

     +   6X,'FORCE-DISPLACEMENT TIME HISTORY DESIRED',/
     +   6X,'AT ISOLATORS NUMBERED...................= ',/
     +       (45X,5(I4,1X)))
 3050 FORMAT(//6X,'COORDINATES OF 2 POINTS AT WHICH INTERSTORY DRIFTS
     + ARE DESIRED',/6X,'FLOOR',5X,'X. CORD. PT.1',4X,
     + 'Y. CORD. PT.2',2X,'X. CORD. PT.2',3X,'Y. CORD. PT.2',/)
 3100 FORMAT(6X,I4,5X,4(F12.6,3X))
 3500 FORMAT(//6X,'LINEAR ELASTIC ELEMENT PARAMETERS........'/,
     +          6X,'ISOLATOR',8X,'STIFFNESS  X',8X,'STIFFNESS  Y')
 3501 FORMAT(6X,I5,3X,2F20.5)
 3600 FORMAT(//6X,'VISCOUS ELEMENT PARAMETERS........'/,
     +          6X,'ISOLATOR',8X,'DAMP-COEF  X',8X,'DAMP-COEF  Y')
 3601 FORMAT(6X,I5,3X,2F20.5)
       END

C****************************************************   STIFF1   *******

      SUBROUTINE STIFF1
     +(            STIFF
     + , SX, SY, ST,  EX,   EY
     + ,SGX,SGY,SGT,SGXT, SGYT
     + ,NF,I)

C**********************************************************************
C     SUBROUTINE FOR ASSEMBLING THE STIFFNESS MATRIX FOR THE
C     SUPERSTRUCTURE, FOR THE FIRST OPTION - THREE DIMENSIONAL
C     SHEAR BUILDING.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C**********************************************************************

C
C         !!!!!!!!!! BE AWARE !!!!!!!!!!!
C      DO NOT USE  ' I '  AS INDEX  IN THIS SUBROUTINE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STIFF   /SXE,SYE,STE,EXE,EYE

      DIMENSION SX(MXF),SY(MXF),ST(MXF),EX(MXF),EY(MXF),SGX(MXF,MXF)
     +         ,SGY(MXF,MXF),SGT(MXF,MXF),SGXT(MXF,MXF),SGYT(MXF,MXF)
     +         ,STIFF(3*MXF,3*MXF)
```

```
      DO 15 K=1,NF
      SGX(J,K)=0.0
      SGY(J,K)=0.0
      SGT(J,K)=0.0
      SGXT(J,K)=0.0
      SGYT(J,K)=0.0
   15  CONTINUE
   20  CONTINUE

C      FORM NF*NF STIFFNESS MATRIX PARTITIONS

      SGX(1,1)=SX(NF)
      SGX(1,2)=-SX(NF)
      SGY(1,1)=SY(NF)
      SGY(1,2)=-SY(NF)
      SGT(1,1)=ST(NF)
      SGT(1,2)=-ST(NF)
      SGXT(1,1)=-SX(NF)*EY(NF)
      SGXT(1,2)=SX(NF)*EY(NF)
      SGYT(1,1)=SY(NF)*EX(NF)
      SGYT(1,2)=-SY(NF)*EX(NF)

      DO 35 J=2,NF
      JJ=NF+1-J
      SGX(J,J)=SX(JJ)+SX(JJ+1)
      SGY(J,J)=SY(JJ)+SY(JJ+1)
      SGT(J,J)=ST(JJ)+ST(JJ+1)
      SGXT(J,J)=-(SX(JJ+1)*EY(JJ+1)+SX(JJ)*EY(JJ))
      SGYT(J,J)=(SY(JJ+1)*EX(JJ+1)+SY(JJ)*EX(JJ))

      IF (J.GT.NF-1)GO TO 35
      SGX(J,J+1)=-SX(JJ)
      SGY(J,J+1)=-SY(JJ)
      SGT(J,J+1)=-ST(JJ)
      SGXT(J,J+1)=SX(JJ)*EY(JJ)
      SGYT(J,J+1)=-SY(JJ)*EX(JJ)
   35 CONTINUE

      DO 50 J=1,3*NF
      DO 45 K=1,3*NF
      STIFF(J,K)=0.0
   45 CONTINUE
   50 CONTINUE

      DO 60 J=1,NF
      J1=3*(J-1)+1

      J2=J1+1
      J3=J1+2

      STIFF(J1,J1)=SGX(J,J)
      STIFF(J2,J2)=SGY(J,J)
      STIFF(J3,J3)=SGT(J,J)
      STIFF(J1,J3)=SGXT(J,J)
      STIFF(J2,J3)=SGYT(J,J)

      IF (J3.GE.3*NF)GO TO 60

      STIFF(J1,J3+1)=SGX(J,J+1)
      STIFF(J1,J3+3)=SGXT(J,J+1)
      STIFF(J2,J3+2)=SGY(J,J+1)
      STIFF(J2,J3+3)=SGYT(J,J+1)
      STIFF(J3,J3+1)=SGXT(J,J+1)
      STIFF(J3,J3+2)=SGYT(J,J+1)
      STIFF(J3,J3+3)=SGT(J,J+1)

   60  CONTINUE

       DO 70 J=1,3*NF
       DO 70 K=1,3*NF
```

```
C
      RETURN
      END

C****************************************************   MASSA   ********

      SUBROUTINE MASSA
     + (        CM,   CMX,CMY
     +  ,   CMR
     +  ,TEMP2
     +  ,NF,I)

C***********************************************************************
C     SUBROUTINE FOR ASSEMBLING THE DIAGONAL LUMPED MASS MATRIX FOR
C     EACH SUPERSTRUCTURE AND THE DIAGONAL MASS MATRIX FOR THE WHOLE
C     STRUCTURE, FOR THE FIRST OPTION - THREE DIMENSIONAL SHEAR BUILDING.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

C
C          !!!!!!!!!! BE AWARE !!!!!!!!!!!
C       DO NOT USE  ' I '  AS INDEX  IN THIS SUBROUTINE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /MASS1   /CMXB,CMYB,CMRB
      DIMENSION  CM(3*MNF+3,3*MNF+3),CMX(MXF),CMY(MXF),CMR(MXF)
     +        ,TEMP2(3*MXF,3*MXF)
C
      DO 20 J=1,3*MXF
      DO 20 K=1,3*MXF
      TEMP2(J,K)=0.0
   20 CONTINUE

      DO 30 J=1,NF
      JJ=NF+1-J
      J1=3*(J-1)+1
      J2=J1+1
      J3=J1+2

      TEMP2(J1,J1)=CMX(JJ)
      TEMP2(J2,J2)=CMY(JJ)
      TEMP2(J3,J3)=CMR(JJ)
   30 CONTINUE

      IF(I.EQ.1) N1=0

      N1=N1+NF
      DO 40 J=1,NF
      J1=3*(N1-NF)+3*(J-1)+1
      J2=J1+1
      J3=J1+2
      CM(J1,J1)=CMX(NF+1-J)
      CM(J2,J2)=CMY(NF+1-J)
      CM(J3,J3)=CMR(NF+1-J)
   40 CONTINUE

      IF(I.EQ.NB) THEN
       CM(3*MNF+1,3*MNF+1)=CMXB
       CM(3*MNF+2,3*MNF+2)=CMYB
       CM(3*MNF+3,3*MNF+3)=CMRB
      ENDIF
C
      RETURN
      END

C****************************************************   MASSB   ********
```

```
      SUBROUTINE MASSB
     + (        CM,   CMX,CMY
     +  ,   CMR
     +   ,NF,I)

C***********************************************************************
C     SUBROUTINE FOR ASSEMBLING THE DIAGONAL LUMPED MASS MATRIX FOR
C     THE WHOLE STRUCTURE, FOR THE SECOND OPTION - FULLY THREE
C     DIMENSIONAL BUILDING.
C     DEVELOPED BY.......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

C
C           !!!!!!!!!! BE AWARE !!!!!!!!!!!
C       DO NOT USE  ' I '  AS INDEX  IN THIS SUBROUTINE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /MASS1   /CMXB,CMYB,CMRB
      DIMENSION  CM(3*MNF+3,3*MNF+3),CMX(MXF),CMY(MXF),CMR(MXF)
C
      IF(I.EQ.1) N1=0

      N1=N1+NF
      DO 40 J=1,NF
      J1=3*(N1-NF)+3*(J-1)+1
      J2=J1+1
      J3=J1+2
      CM(J1,J1)=CMX(NF+1-J)
      CM(J2,J2)=CMY(NF+1-J)
      CM(J3,J3)=CMR(NF+1-J)
   40 CONTINUE

      IF(I.EQ.NB) THEN
       CM(3*MNF+1,3*MNF+1)=CMXB
       CM(3*MNF+2,3*MNF+2)=CMYB
       CM(3*MNF+3,3*MNF+3)=CMRB
      ENDIF
C
      RETURN
      END

C*****************************************************      DAMP    ********

      SUBROUTINE DAMP
     +( PC,XP,YP
     + , C, W,DR
     + ,INELEM
     + ,NE,I)

C***********************************************************************
C     SUBROUTINE FOR ASSEMBLING THE MODAL DAMPING MATRIX FOR
C     THE WHOLE STRUCTURE AND THE DAMPING AT THE BASE (CONSIDERED TO BE
C     EITHER LOCAL DAMPING OF INDIVIDUAL BEARING ASSEMBLED EXPLICITLY
C     OR GLOBAL DAMPING OF BASE).
C     DEVELOPED BY.......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY.......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

C
C           !!!!!!!!!! BE AWARE !!!!!!!!!!!
C       DO NOT USE  ' I '  AS INDEX  IN THIS SUBROUTINE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /DAMP1   /CBX,CBY,CBT,ECX,ECY

```

```
C
      IF(I.EQ.1) N1=0
      N1=N1+NE

      DO 30 J=1,NE
      C(N1-NE+J,N1-NE+J)=2*DR(J)*DSQRT(W(J))
   30 CONTINUE

      IF(I.EQ.NB) THEN

       J1=MNE+1
       J2=MNE+2
       J3=MNE+3

      CXYT=CBX+CBY+CBT

      IF(CXYT.EQ.0) GO TO 35

       C(J1,J1)=CBX
       C(J2,J2)=CBY
       C(J3,J3)=CBT
       C(J1,J3)=-CBX*ECY
       C(J2,J3)=CBY*ECX

   35 CONTINUE


      SUM1=0.
      SUM2=0.
      NUMBEL=0

      DO 40 K=1,NP

      IF(INELEM(K,2).NE.1) GO TO 40

      SUM1=SUM1+PC(K,1)
      SUM2=SUM2+PC(K,2)

      NUMBEL=NUMBEL+1
   40 CONTINUE

      IF(NUMBEL.GT.0)THEN
      C(J1,J1)=SUM1
      C(J2,J2)=SUM2
      ENDIF

       DO 50 K=1,NP

      IF(INELEM(K,2).NE.1) GO TO 50

       C(J3,J3)=C(J3,J3)+PC(K,2)*XP(K)**2+PC(K,1)*YP(K)**2
       C(J1,J3)=C(J1,J3)-PC(K,1)*YP(K)
       C(J2,J3)=C(J2,J3)+PC(K,2)*XP(K)
  50   CONTINUE

       C(J3,J1)=C(J1,J3)
       C(J3,J2)=C(J2,J3)

      ENDIF
C
      RETURN
      END

C*****************************************************   TRANSF   ********

      SUBROUTINE TRANSF(T,E1,R,XN,YN,NF,NE)

C************************************************************************
C     SUBROUTINE FOR ASSEMBLING THE TRANSFORMATION MATRIX.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
```

```
C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      DIMENSION  E1(NFE),T(3*MNF+3,MNE+3),R(3*MNF+3,3)
     +           ,NF(NB),NE(NB),XN(MNF),YN(MNF)
C
      DO 20 J=1,3*MNF+3
      DO 10 K=1,3+MNE
      T(J,K)=0.0
   10 CONTINUE
      DO 15 JK=1,3
      R(J,JK)=0.0
   15 CONTINUE
   20 CONTINUE

      N1=0
      DO 100 I=1,NB
      N1=N1+NF(I)
      DO 110 J=1,NF(I)

      J1=3*N1-3*NF(I)+3*(J-1)+1
      J2=J1+1
      J3=J1+2

      R(J1,1)=1
      R(J2,2)=1
      R(J3,3)=1
      R(J1,3)=-YN(N1+1-J)
      R(J2,3)=+XN(N1+1-J)

  110 CONTINUE
  100 CONTINUE
C
      R(3*MNF+1,1)=1
      R(3*MNF+2,2)=1
      R(3*MNF+3,3)=1
C
      N1=0
      N2=0
      N3=0
      DO 40 I=1,NB
      DO 45 J=1,NE(I)
      DO 50 K=1,3*NF(I)
      I1=N3+3*NF(I)*(J-1)+K
      T(N1+K,N2+J)=E1(I1)
  50  CONTINUE
  45  CONTINUE
      N1=N1+3*NF(I)
      N2=N2+NE(I)
      N3=N3+3*NF(I)*NE(I)
  40  CONTINUE

      DO 70 J=1,3*MNF+3
      DO 60 K=1,3
      T(J,MNE+K)=R(J,K)
   60 CONTINUE
   70 CONTINUE
C
      RETURN
      END

C*******************************************************     STIFF2    *******

      SUBROUTINE STIFF2(W1,PS,XP,YP,SE,INELEM)

C***********************************************************************
C     SUBROUTINE FOR ASSEMBLING THE REDUCED STIFFNESS MATRIX
C     USING THE EIGENVALUES.
```

```
C
C*************************************************************************
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /STIFF   /SXE,SYE,STE,EXE,EYE
      DIMENSION W1(MNE),PS(NP,2),SE(MNE+3,MNE+3),INELEM(NP,2)
      DIMENSION XP(NP),YP(NP)
C
      DO 10 J=1,MNE+3
      DO 10 K=1,MNE+3
      SE(J,K)=0.0
   10 CONTINUE
      DO 30 J=1,MNE
      SE(J,J)=W1(J)
   30 CONTINUE
      J1=MNE+1
      J2=MNE+2
      J3=MNE+3
      SXYT=SXE+SYE+STE
      IF(SXYT.EQ.0) GO TO 35
      SE(J1,J1)=SXE
      SE(J2,J2)=SYE
      SE(J3,J3)=STE
      SE(J1,J3)=-SXE*EYE
      SE(J2,J3)=SYE*EXE
   35 CONTINUE
      SUM1=0.
      SUM2=0.
      NUMBEL=0
      DO 40 K=1,NP
      IF(INELEM(K,2).NE.1) GO TO 40
      SUM1=SUM1+PS(K,1)
      SUM2=SUM2+PS(K,2)
      NUMBEL=NUMBEL+1
   40 CONTINUE
      IF(NUMBEL.GT.0)THEN
      SE(J1,J1)=SUM1
      SE(J2,J2)=SUM2
      ENDIF
      DO 50 K=1,NP
      IF(INELEM(K,2).NE.1) GO TO 50
      SE(J3,J3)=SE(J3,J3)+PS(K,2)*XP(K)**2+PS(K,1)*YP(K)**2
      SE(J1,J3)=SE(J1,J3)-PS(K,1)*YP(K)
      SE(J2,J3)=SE(J2,J3)+PS(K,2)*XP(K)
   50 CONTINUE
      SE(J3,J1)=SE(J1,J3)
      SE(J3,J2)=SE(J2,J3)
C
      RETURN
      END
C****************************************************   SOLUTION   *****
```

```
     +(     W1,     E1,     XN,     YN,      H
     + ,    PS,            ALP,     YF,     YD
     + ,  FMAX,     DF,     PA,     FN,     XP
     + ,    YP,  CORDX,  CORDY,      X,      Y
     + ,    SE,     CM,      C,     SK,    CMT
     + ,     R,      T,      A,     AC,      V
     + ,    VC,      D,    DDE,   DELF,    PTU
     + ,    FH,    RTS,     PT,      F,     FX
     + ,    FY,    FXP,    FYP,     ZX,     ZY
     + ,   ZXP,    ZYP,   FNXY,FXTEMP,FYTEMP
     + ,ZXTEMP,ZYTEMP,  TEMP1,  TEMP3,TEMP31
     + ,TEMP32,  DMAX,  AMAXF,  DTIME,ATIMEF
     + ,  SUMF,  SUMFT,   SUMB,  SMMBT,   SMMB
     + ,    C2,   PACC,   PDEF,    C2T,   BAS1
     + ,  BAS2,   BAS3,   BAS4,      B,     DX
     + ,    DY,    DXY,    DYX,    DXT,    DYT
     + ,  OVMX,   OVMY,    OAX,    OAY,   OVXT
     + ,  OVYT
     + ,    NF,     NE,INELEM,     IP,   ICOR )

C***********************************************************************
C     SUBROUTINE FOR SOLUTION OF THE EQUATIONS OF MOTION AND OUTPUT OF
C     TIME HISTORY RESULTS AND/OR PEAK RESPONSE VALUES.
C     DEVELOPED BY......................SATISH NAGARAJAIAH.....OCT 1990
C     MODIFIED  BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /STEP     /TSI,TSR
      COMMON /GENBASE  /ISEV,LOR
      COMMON /PRINT    /LTMH,IPROF,KPD,KPF,INP
      COMMON /MAIN     /NB,NP,MNF,MNE,NFE,MXF
      COMMON /HYS1     /WBET,WGAM
      COMMON /STIFF    /SXE,SYE,STE,EXE,EYE
      COMMON /MASS1    /CMXB,CMYB,CMRB
      COMMON /DAMP1    /CBX,CBY,CBT,ECX,ECY
      COMMON /INT      /FMNORM,BET,GAM,TOL
      COMMON /LOAD1    /XTH,IDAT,TIME,PTSR,ULF,INDGACC
      COMMON /DIREC    /DRIN(3),DRIN1(4)
      CHARACTER*1 DRIN
      CHARACTER*2 DRIN1
      DIMENSION ALP(NP,2),YF(NP,2),YD(NP,2),FMAX(NP,2),DF(NP,2)
     +   ,PS(NP,2),PA(NP,2),FN(NP),XP(NP),YP(NP)
     +   ,W1(MNE),E1(NFE)
     +   ,XN(MNF),YN(MNF),H(MNF+NB)
     +   ,X(LOR),Y(LOR)
     +   ,NF(NB),NE(NB),INELEM(NP,2)
C
     +   ,CMT(MNE+3,MNE+3),C(MNE+3,MNE+3),SE(MNE+3,MNE+3)
     +   ,T(3*MNF+3,MNE+3),R(3*MNF+3,3),CM(3*MNF+3,3*MNF+3)
     +   ,SK(MNE+3,MNE+3)
C
     +   ,A(MNE+3),V(MNE+3),AC(MNE+3),VC(MNE+3)
     +   ,D(MNE+3,2),DDE(MNE+3)
C
     +   ,PTU(MNE+3),FH(MNE+3),RTS(MNE+3),PT(MNE+3)
C
     +   ,TEMP1(MNE+3,3*MNF+3),TEMP3(3*MNF+3,1)
     +   ,TEMP31(MNE+3,3*MNF+3),TEMP32(MNE+3,3)
C
     +   ,FX(NP),FY(NP),FXP(NP),FYP(NP),FXTEMP(NP),FYTEMP(NP)
     +   ,ZX(NP),ZY(NP),ZXP(NP),ZYP(NP),ZXTEMP(NP),ZYTEMP(NP)
     +   ,FNXY(NP),F(3*MNF+3)
     +   ,DELF(MNE+3)
C
        DIMENSION ANC(3),VNC(3),FHTEMP(3),ERR(3)
     +   ,AB(3),DB(3),VN(3),AN(3),ANP(3),VNP(3),DN(3,2),UG(3,1)
C
C-- ARRAYS FOR THE PRINT OUT
```

```
     + ,SUMF(MNF,3),SUMFT(MNF,3),SUMB(NB,3),SMMBT(NB,3),SMMB(NB,3)
C
     +,IP(INP),C1(2,2),C2(2,NB,2),C1T(2,2),C2T(2,NB,2)
     +,PACC(2,3*MNF+3,5),PDEF(2,3*MNF+3,5),BAS1(NB,3,2),BAS2(NB,3,2)
     +,BAS3(NB,3,2),BAS4(NB,3,2)
C
     + ,B(NB*MXF*6*6)
     + ,DX(INP),DY(INP),DXY(INP),DYX(INP),DXT(INP),DYT(INP)
C
      DIMENSION ICOR(NB),CORDX(NB,6),CORDY(NB,6)
C
C--ARRAYS FOR OVERTERNING MOMENTS--
      DIMENSION OVMX(NB,2),OVMY(NB,2),OAX(MNF+NB),OAY(MNF+NB)
     + ,OVXT(NB),OVYT(NB)
C
     + ,TIMPR(2)
C
        IF(LTMH.EQ.1) THEN
         OPEN(UNIT=50,FILE='BASE',STATUS='NEW')
         IF(INP.GT.O) THEN
         WRITE(50,1002) (IP(I),I=1,INP)
         ENDIF
       ENDIF

        DO 360 I=1,MNE+3
        A(I)=0.0
        V(I)=0.0
  360   CONTINUE

        DO 361 I=1,NP
        FXP(I)=0
        FYP(I)=0
        ZXP(I)=0
  361   ZYP(I)=0

        DO 370 I=1,3
        VN(I)=0.0
        AN(I)=0.0
        ANP(I)=0.0
        VNP(I)=0.0
  370   CONTINUE

        DO 378 I=1,3
        DO 375 J=1,2
        DN(I,J)=0.0
  375   CONTINUE
  378   CONTINUE

        DO 390 I=1,MNE+3
        DO 380 J=1,2
        D(I,J)=0.0
  380   CONTINUE
  390   CONTINUE

        DO 391 I=1,3*MNF+3
  391   DMAX(I)=0.0

        DO 392 I=1,3*MNF+3
  392   AMAXF(I)=0.0

        DO 393 I=1,3
        DO 393 J=1,2
  393   BMAXF(I,J)=0.0

        DO 394 I=1,MNE+3
  394   FH(I)=0.0

        DO 395 I=1,NP
        ZX(I)=0
  395   ZY(I)=0
```

```
      TIME=0.0
      PTSR=TSR
      KPRINT=1
      KPRINT1=1
      PRINT=0
      PRINT1=0
      TSIT=TSI
      KPDT=KPD
      KPFT=KPF
      J1=3*MNF+3
      J2=MNE+3
      CALL TRANSF(T,E1,R,XN,YN,NF,NE)
      CALL TMULT(T,CM,TEMP1,J1,J2,J1)
      CALL MULT(TEMP1,T,CMT,J2,J1,J2)
      CALL STIFF2(W1,PS,XP,YP,SE,INELEM)
      IT=1
50    IF (TIME.GT.(LOR-1)*TSR) GO TO 2000
      DUM=V(MNE+1)**2+V(MNE+2)**2
      VEL=DSQRT(DUM)
      DISP=DSQRT(DN(1,1)**2+DN(2,1)**2)
      TSIP=TSI
      TSI=TSIT
      IF (KVSTEP.EQ.2) THEN
      IF (VEL.LE.20 .AND. VEL.GT.15)THEN
      TSI=TSIT*0.875
      ELSE IF( VEL.LE.15 .AND. VEL.GT.10)THEN
      TSI=TSIT*0.75
      ELSE IF( VEL.LE.10 .AND. VEL.GT.5 )THEN
      TSI=TSIT*0.625
      ELSE IF( VEL.LE. 5 .AND. VEL.GT.0 )THEN
      TSI=TSIT*0.5
      END IF
      ELSE IF (KVSTEP.EQ.1)THEN
      TSI=TSIT
      END IF
      IF(IT.LE.2)GO TO 55
      IF(TSI.EQ.TSIP)GO TO 60
55    CONTINUE
      DT=TSI
      A1=1/(BET*(DT**2))
      A2=1/(BET*DT)
      A3=1/(2*BET)
      A4=GAM/(BET*DT)
      A5=GAM/BET
      A6=DT*(GAM/(2*BET)-1)
      J1=MNE+3
      DO 100 I=1,J1
      DO 90  J=1,J1
      SK(I,J)=A1*CMT(I,J)+A4*C(I,J)+SE(I,J)
 90   CONTINUE
100   CONTINUE
 60   CONTINUE
      ITER=0
```

```
      J1=MNE+3

      CALL LOAD(TEMP31,TEMP32,T,R,CM,Y,X,UG,PTU,IT)

      DO 452 I=1,MNE+3
452   DELF(I)=0.0

451   CONTINUE

      DO 470 I=1,MNE+3
      DUM=0.0
      DO 460 J=1,MNE+3
460   DUM=DUM-CMT(I,J)*A(J)-C(I,J)*V(J)-SE(I,J)*D(J,1)
      RTS(I)=PTU(I)+DUM-FH(I)-DELF(I)
470   CONTINUE

      DO 550 I=1,MNE+3
      DUM=0.0
      DO 500 J=1,MNE+3
      DUM=DUM+CMT(I,J)*(A2*V(J)+A3*A(J))+C(I,J)*(A5*V(J)+A6*A(J))
500   CONTINUE
      PT(I)=RTS(I)+DUM
550   CONTINUE

      IF(IT.LE.2.OR.TSI.NE.TSIP)THEN

      CALL GAUSS(SK,PT,MNE+3,MNE+3,1,1)

      END IF

      CALL GAUSS(SK,PT,MNE+3,MNE+3,1,2)
      CALL GAUSS(SK,PT,MNE+3,MNE+3,1,3)

      DO 920 I=1,MNE+3
920   DDE(I)=PT(I)

      DO 950 I=1,MNE+3
      D(I,2)=D(I,1)+DDE(I)
      AC(I)=A(I)+A1*DDE(I)-A2*V(I)-A3*A(I)
      VC(I)=V(I)+A4*DDE(I)-A5*V(I)-A6*A(I)
 950  CONTINUE

      DO 1000 I=1,3
      II=MNE+I
      DN(I,2)=D(II,2)
      ANC(I)=AC(II)
      VNC(I)=VC(II)
1000  CONTINUE

      DO 1050 I=1,NP
      FXP(I)=FX(I)
      FYP(I)=FY(I)
      ZXP(I)=ZX(I)
      ZYP(I)=ZY(I)
1050  CONTINUE

      CALL BEARING(ERR,FN,FXP,FYP,XP,YP,DN,VNC,VN,ANC,AN,FH,
     + IT,ZXP,ZYP,FNXY,ALP,YF,YD,FMAX,DF,PA,INELEM,DELF)

      SUM=0.0
      SUM1=0.0
      DO 1250 I=1,3
      SUM=SUM+ERR(I)**2
1250  CONTINUE
      RTOL=DSQRT(SUM)/FMNORM

      ITER=0
      IF(RTOL.GT.TOL)ITER=1
      ITER1=ITER1+ITER
              IF (ITER1.GT.200)THEN
```

```
      END IF

      IF (ITER.EQ.1)GO TO 451

      DO 1400 I=1,NP
      FX(I)=FXP(I)
      FY(I)=FYP(I)
      ZX(I)=ZXP(I)
 1400 ZY(I)=ZYP(I)

      DO 1800 I=1,MNE+3 ,
      A(I)=AC(I)
      V(I)=VC(I)
 1800 D(I,1)=D(I,2)

      DO 1846 I=1,MNE+3
 1846 FH(I)=FH(I)+DELF(I)

 1847 DO 1850 I=1,3
      ANP(I)=AN(I)
      VNP(I)=VN(I)
      DN(I,1)=DN(I,2)
      AN(I)=ANC(I)
      VN(I)=VNC(I)
 1850 CONTINUE

      IF(DABS(VEL).LE.30)THEN
      KPF=TSIT/TSI*KPFT
      KPD=TSIT/TSI*KPDT
      ELSE IF(DABS(VEL).GT.20)THEN
      KPF=KPFT
      KPD=KPDT
      END IF

      DO 1870 I=1,3*MNF
      SUM=0.0
      DO 1860 J=1,MNE
      SUM=SUM+T(I,J)*D(J,2)
 1860 CONTINUE
      TEMP3(I,1)=SUM
 1870 CONTINUE
      TEMP3(3*MNF+1,1)=D(MNE+1,2)
      TEMP3(3*MNF+2,1)=D(MNE+2,2)
      TEMP3(3*MNF+3,1)=D(MNE+3,2)

C--MAX BEARINGS DISPLACEMENTS

      IF(INP.GT.0)THEN
      DO 1875 I=1,INP
       DISX=DN(1,1)-DN(3,1)*YP(IP(I))
       DISY=DN(2,1)+DN(3,1)*XP(IP(I))
        IF(DABS(DISX).GT.DABS(DX(I))) THEN
         DX(I)=DISX
         DXY(I)=DISY
         DXT(I)=TIME
        ENDIF
        IF(DABS(DISY).GT.DABS(DY(I))) THEN
         DY(I)=DISY
         DYX(I)=DISX
         DYT(I)=TIME
        ENDIF
 1875 CONTINUE
      ENDIF

C --WRITE BEARINGS DISPLACEMENTS AND FORCES (TIME HISTORIES)---

      IF(LTMH.EQ.1) THEN
      IF(INP.GT.0) THEN
      IF(IT.EQ.KPRINT)THEN
      WRITE(50,8001) TIME,DRIN1(1),(DN(1,1)-DN(3,1)*YP(IP(J)),J=1,INP)
```

```
         WRITE(50,8002)      DRIN1(3),(FX(IP(J)),J=1,INP)
         WRITE(50,8002)      DRIN1(4),(FY(IP(J)),J=1,INP)
         ENDIF
         ENDIF
         ENDIF

C--MAX DISPLACEMENTS----

         DO 1880 I=1,3*MNF+3
         IF (DABS(TEMP3(I,1)).GT.DABS(DMAX(I)))THEN
         DMAX(I)=TEMP3(I,1)
         DTIME(I)=TIME
         ENDIF
 1880    CONTINUE

C--ESTIMATION OF DRIFTS FOR EACH BUILDING

        L 1=1
        L 2=L 1 + NB*MXF*6
        L 3=L 2 + NB*MXF*6
        L 4=L 3 + NB*MXF*6
        L 5=L 4 + NB*MXF*6
        L 6=L 5 + NB*MXF*6
        L 7=L 6 + NB*MXF*6

        CALL DRIFTS(TIME,TEMP3,XN,YN,NF,H,ICOR,CORDX,CORDY,
     +   B(L1),B(L2),B(L3),B(L4),B(L5),B(L6),0)

C--TEMPORARILY RETAIN THE DEFLECTIONS IN  'F ' ARRAY---

         DO 1885 I=1,3*MNF+3
         F(I)=TEMP3(I,1)
 1885    CONTINUE

C-------ACCELERATION COMPUTATION

         CALL MULT(T,A,TEMP3,3*MNF+3,MNE+3,1)

         DO 1895 I=1,3*MNF+3
         SUM=0.0
         DO 1890 J=1,3
         SUM=SUM+R(I,J)*UG(J,1)*ULF
 1890    CONTINUE
         TEMP3(I,1)=TEMP3(I,1)+SUM
 1895    CONTINUE

C-- ACCELERATIONS IN ' TEMP3 ' ARRAY AT THIS POINT
C---MAX ACCELERATIONS--
         DO 1915 I=1,3*MNF+3
         IF(DABS(TEMP3(I,1)).GT.DABS(AMAXF(I)))THEN
         AMAXF(I)=TEMP3(I,1)
         ATIMEF(I)=TIME
         ENDIF
 1915    CONTINUE
C
        IF(LTMH.EQ.1) THEN
C
C---------------------------PRINT DEFLECTIONS AND ACCELERATIONS------
        CALL WDEFAC(TIME,F,TEMP3,NF,IT,KPRINT,PRINT,0)
C-------------------------------------------------------------------

        ENDIF

C--PROFILES FOR MAX BASE DISPLACEMENTS---

        IF(IPROF.EQ.1) THEN

         DO 1916 I=1,2
          IF(DABS(F(3*MNF+I)).GT.DABS(C1(I,1)))THEN
           DO 1917 J=1,3*MNF+3
            PACC(I,J,1)=TEMP3(J,1)
```

```
 1917     CONTINUE
          C1(I,1)=F(3*MNF+I)
          C1T(I,1)=TIME
         ENDIF
 1916   CONTINUE

C--PROFILES FOR MAX ACCEL IN EACH BUILDING----

      N1=0
      DO 1918 K=1,NB
      DO 1919 I=1,2
       IF(DABS(TEMP3(N1+I,1)).GT.DABS(C2(I,K,1)))THEN
        BAS1(K,1,I)=TEMP3(3*MNF+1,1)
        BAS1(K,2,I)=TEMP3(3*MNF+2,1)
        BAS1(K,3,I)=TEMP3(3*MNF+3,1)
        BAS3(K,1,I)=F(3*MNF+1)
        BAS3(K,2,I)=F(3*MNF+2)
        BAS3(K,3,I)=F(3*MNF+3)
        DO 1921 J=1,3*NF(K)
         PACC(I,N1+J,2)=TEMP3(N1+J,1)
         PDEF(I,N1+J,2)=F(N1+J)
 1921   CONTINUE
        C2(I,K,1)=TEMP3(N1+I,1)
        C2T(I,K,1)=TIME
       ENDIF
 1919 CONTINUE
      N1=N1+3*NF(K)
 1918 CONTINUE

       ENDIF

C--NOW KEEP THE DEFLECTIONS IN THE TEMP1 ARRAY

        DO 1925 I=1,3*MNF+3
        TEMP1(1,I)=F(I)
 1925   CONTINUE

C-------FORCE COMPUTATION

        DO 1930 I=1,3*MNF+3
        SUM=0.0
        DO 1920 J=1,3*MNF+3
        SUM=SUM+CM(I,J)*TEMP3(J,1)
 1920   CONTINUE
        F(I)=SUM
 1930   CONTINUE

C       MAXIMUM FORCES AT FLOORS

        DAMPF1=CBX*VN(1)
        DAMPF2=CBY*VN(2)
        DAMPF3=CBT*VN(3)
C       FISI1=DAMPF1+SXE*D(MNE+1,2)+FH(MNE+1)+F(3*MNF+1)
C       FISI2=DAMPF2+SYE*D(MNE+2,2)+FH(MNE+2)+F(3*MNF+2)
C       FISI3=DAMPF3+STE*D(MNE+3,2)+FH(MNE+3)+F(3*MNF+3)
C
C--CALCULATE OVERTURNING MOMENTS
C--ABOVE BASE AT THE LEVEL OF FIRST STOREY
C       OVMX=0.0
C       OVMY=0.0
C
        N1=0
        N2=0
        DO 1950 K=1,NB
        OVMX(K,1)=.0
        OVMY(K,1)=.0
        N2=N2+NF(K)+1
        DO 1951 J=1,NF(K)
        OVMX(K,1)=OVMX(K,1)+F(N1+3*(J-1)+1)*(H(N2+1-J)-H(N2-NF(K)))
        OVMY(K,1)=OVMY(K,1)+F(N1+3*(J-1)+2)*(H(N2+1-J)-H(N2-NF(K)))
 1951   CONTINUE
```

```
 1955 ALENX=ALEN
      ALENY=ALEN
      DO 1957 I=1,NP
C     FNXY(I)=FN(I)+OVMX*XP(I)/(ALENX*DABS(XP(I)))
C    + +OVMY*YP(I)/(ALENY*DABS(YP(I)))
      FNXY(I)=FN(I)
 1957 CONTINUE
 1950 CONTINUE

      N1=0
      N2=0
      DO 1952 K=1,NB
       IF(DABS(OVMX(K,1)).GT.DABS(OVMX(K,2)))THEN
        OVMX(K,2)=OVMX(K,1)
        OVXT(K)=TIME
        DO 1953 I=1,NF(K)
        OAX(N2+I)=F(N1+3*(I-1)+1)
 1953   CONTINUE
        OAX(N2+NF(K)+1)=F(3*MNF+1)
       ENDIF
       IF(DABS(OVMY(K,1)).GT.DABS(OVMY(K,2)))THEN
        OVMY(K,2)=OVMY(K,1)
        OVYT(K)=TIME
        DO 1954 I=1,NF(K)
        OAY(N2+I)=F(N1+3*(I-1)+2)
 1954   CONTINUE
        OAY(N2+NF(K)+1)=F(3*MNF+2)
       ENDIF
       N1=N1+3*NF(K)
       N2=N2+NF(K)+1
 1952  CONTINUE

C     BASE SHEAR (STRUCTURE LEVEL)

      SUM4=0.0
      SUM5=0.0
      SUM6=0.0
      N1=0

      DO 1960 I=1,NB

      DO 1962 J=1,3
 1962 SUMB(I,J)=0.0
      SUM1=0.0
      SUM2=0.0
      SUM3=0.0

      N1=N1+3*NF(I)

      DO 1964 K=1,NF(I)

      J1=N1-3*NF(I)+3*(K-1)
      SUM1=SUM1+F(J1+1)
      SUM2=SUM2+F(J1+2)
      SUM3=SUM3+F(J1+3)
      IF(DABS(SUM1).GT.DABS(SUMF(N1/3-NF(I)+K,1))) THEN
        SUMF(N1/3-NF(I)+K,1)=SUM1
        SUMFT(N1/3-NF(I)+K,1)=TIME
      ENDIF
      IF(DABS(SUM2).GT.DABS(SUMF(N1/3-NF(I)+K,2))) THEN
        SUMF(N1/3-NF(I)+K,2)=SUM2
        SUMFT(N1/3-NF(I)+K,2)=TIME
      ENDIF
      IF(DABS(SUM3).GT.DABS(SUMF(N1/3-NF(I)+K,3))) THEN
        SUMF(N1/3-NF(I)+K,3)=SUM3
        SUMFT(N1/3-NF(I)+K,3)=TIME
      ENDIF
 1964 CONTINUE

      SUMB(I,1)=SUM1
```

```
             SUMB(I,3)=SUM3

             IF(DABS(SUM1).GT.DABS(SMMB(I,1))) THEN
               SMMB(I,1)=SUM1
               SMMBT(I,1)=TIME
             ENDIF
             IF(DABS(SUM2).GT.DABS(SMMB(I,2))) THEN
               SMMB(I,2)=SUM2
               SMMBT(I,2)=TIME
             ENDIF
             IF(DABS(SUM3).GT.DABS(SMMB(I,3))) THEN
               SMMB(I,3)=SUM3
               SMMBT(I,3)=TIME
             ENDIF

             SUM4=SUM4+SUM1
             SUM5=SUM5+SUM2
             SUM6=SUM6+SUM2

 1960        CONTINUE

C--PROFILES FOR MAX STRUCTURAL SHEAR IN EACH BUILDING----

            IF(IPROF.EQ.1) THEN
           N1=0
           DO 1965 K=1,NB
           DO 1966 I=1,2
            IF(DABS(SUMB(K,I)).GT.DABS(C2(I,K,2)))THEN
             BAS2(K,1,I)=TEMP3(3*MNF+1,1)
             BAS2(K,2,I)=TEMP3(3*MNF+2,1)
             BAS2(K,3,I)=TEMP3(3*MNF+3,1)
             BAS4(K,1,I)=TEMP1(1,3*MNF+1)
             BAS4(K,2,I)=TEMP1(1,3*MNF+2)
             BAS4(K,3,I)=TEMP1(1,3*MNF+3)
             DO 1967 J=1,3*NF(K)
              PACC(I,N1+J,3)=TEMP3(N1+J,1)
              PDEF(I,N1+J,3)=TEMP1(1,N1+J)
 1967        CONTINUE
             C2(I,K,2)=SUMB(K,I)
             C2T(I,K,2)=TIME
            ENDIF
 1966      CONTINUE
           N1=N1+3*NF(K)
 1965      CONTINUE

            ENDIF

C            BASE SHEAR (BEARINGS LEVEL)

             FISI1=-(SUM4+F(3*MNF+1))
             FISI2=-(SUM5+F(3*MNF+2))
             FISI3=-(SUM6+F(3*MNF+3))

             IF(DABS(FISI1).GT.DABS(BMAXF(1,1))) THEN
              BMAXF(1,1)=FISI1
              BMAXF(1,2)=TIME
             ENDIF
             IF(DABS(FISI2).GT.DABS(BMAXF(2,1))) THEN
              BMAXF(2,1)=FISI2
              BMAXF(2,2)=TIME
             ENDIF
             IF(DABS(FISI3).GT.DABS(BMAXF(3,1))) THEN
              BMAXF(3,1)=FISI3
              BMAXF(3,2)=TIME
             ENDIF

C--PROFILES FOR MAX BASE SHEARS---

            IF(IPROF.EQ.1) THEN

             DO 1970 I=1,2
```

```
             PACC(I,J,4)=TEMP3(J,1)
             PDEF(I,J,4)=TEMP1(1,J)
  1971      CONTINUE
            C1(I,2)=BMAXF(I,1)
            C1T(I,2)=TIME
           ENDIF
  1970    CONTINUE

         ENDIF

        IF (LTMH.EQ.1)THEN

C------------------------------PRINT FORCES AT FLOORS LEVEL----------
        CALL WFORC(TIME,SUMB,FISI1,FISI2,FISI3,NF,IT,
     +             KPRINT1,PRINT1,0)
C--------------------------------------------------------------------

        ENDIF
          IT=IT+1
          GO TO 50

  2000    CONTINUE

C----WRITE FORCE PROFILES FOR MAX OVERTURNING MOMENTS
C---------------AND MAX STRUCTURAL SHEARS

         N1=0
         N2=0
         WRITE(7,10001)
         DO 1956 K=1,NB
         N2=N2+NF(K)+1
         WRITE(7,10002) K,OVXT(K),OVMX(K,2),C2T(1,K,2),SUMF(N2-K,1)
         WRITE(7,10004) (NF(K)+1-J,OAX(N2-(NF(K)+1)+J)
     +,PACC(1,N1+3*(J-1)+1,3)*CM(N1+3*(J-1)+1,N1+3*(J-1)+1)
     +,J=1,NF(K))
         WRITE(7,10005) '    BASE    ',OAX(N2)
     +                 ,BAS2(K,1,1)*CM(3*MNF+1,3*MNF+1)
     +                 ,'FORCE AT C.M. OF ENTIRE BASE'
          N1=N1+3*NF(K)
 1956    CONTINUE

         N1=0
         N2=0
         WRITE(7,10003)
         DO 1958 K=1,NB
         N2=N2+NF(K)+1
         WRITE(7,10002) K,OVYT(K),OVMY(K,2),C2T(2,K,2),SUMF(N2-K,2)
         WRITE(7,10004) (NF(K)+1-J,OAY(N2-(NF(K)+1)+J)
     +,PACC(2,N1+3*(J-1)+2,3)*CM(N1+3*(J-1)+2,N1+3*(J-1)+2)
     +,J=1,NF(K))
         WRITE(7,10005) '    BASE    ',OAY(N2)
     +                 ,BAS2(K,2,2)*CM(3*MNF+2,3*MNF+2)
     +                 ,'FORCE AT C.M. OF ENTIRE BASE'
          N1=N1+3*NF(K)
 1958    CONTINUE

        IF (LTMH.EQ.1)THEN

         CALL WDEFAC(TIME,F,TEMP3,NF,IT,KPRINT,PRINT,1)

         CALL WFORC(TIME,SUMB,FISI1,FISI2,FISI3,NF,IT,
     +              KPRINT1,PRINT1,1)

        ENDIF

C--WRITE MAX DISPL---

          WRITE(7,7010)
          N1=0
          N2=0
```

```
         WRITE(7,7011) I
         DO 1985 J=1,NF(I)
         N2=N1+3*(J-1)
         WRITE(7,7050)NF(I)+1-J,(DTIME(N2+K),DMAX(N2+K),K=1,3)
 1985    CONTINUE
         N1=N1+3*NF(I)
 1980    CONTINUE

         WRITE(7,7051) ' BASE',(DTIME(3*MNF+K),DMAX(3*MNF+K),K=1,3)

C--WRITE DRIFTS FOR EACH BUILDING--

       CALL DRIFTS(TIME,TEMP3,XN,YN,NF,H,ICOR,CORDX,CORDY,
     +   B(L1),B(L2),B(L3),B(L4),B(L5),B(L6),1)

C-WRITE MAX BEARINGS DISPLACEMENTS-----

         IF(INP.GT.0)THEN
        WRITE(7,8500)
        DO 2010 I=1,INP
        WRITE(7,8501) IP(I),DXT(I),DX(I),DXY(I),DYT(I),DYX(I),DY(I)
 2010   CONTINUE
         ENDIF

C--WRITE MAX ACCEL--

         WRITE(7,7060)
         N1=0
         N2=0
         DO 1990 I=1,NB
         WRITE(7,7061) I
         DO 1995 J=1,NF(I)
         N2=N1+3*(J-1)
         WRITE(7,7070)NF(I)+1-J,(ATIMEF(N2+K),AMAXF(N2+K),K=1,3)
 1995    CONTINUE
         N1=N1+3*NF(I)
 1990    CONTINUE

       WRITE(7,7071) ' BASE',(ATIMEF(3*MNF+K),AMAXF(3*MNF+K),K=1,3)

C--WRITE MAXIMUM STRUCTURAL SHEARS----

         WRITE(7,9100)
         DO 2570 I=1,NB
         WRITE(7,9101) I,(SMMBT(I,K),SMMB(I,K),K=1,3)
 2570    CONTINUE

C--WRITE MAX BASE SHEARS---

         WRITE(7,6999)
         WRITE(7,7100)(BMAXF(I,2),BMAXF(I,1),I=1,3)

C--WRITE MAXIMUM STORY SHEARS--

         WRITE(7,9000)
         N2=0
         DO 2550 I=1,NB
         WRITE(7,9001) I
         DO 2560 J=1,NF(I)
         WRITE(7,9002)NF(I)+1-J,(SUMFT(N2+J,K),SUMF(N2+J,K),K=1,3)
 2560    CONTINUE
         N2=N2+NF(I)
 2550    CONTINUE

C----WRITE PROFILES FOR TIME WHERE MAX BASE DISPLACEMENT OCCURS

CTHE BASE DISPL AND  ACCEL  ARE IN THE POINT
C  WHERE THE C.M. OF FIRST FLOOR IS

        IF(IPROF.EQ.1) THEN

```

```
      DO 2500 I=1,2
      IF(I.EQ.1) WRITE(7,8600)  C1T(I,1)
      IF(I.EQ.2) WRITE(7,8601)  C1T(I,1)
      N1=0
      N2=0
      DO 2510 K=1,NB
      N2=N2+NF(K)
      WRITE(7,8602) K
      DO 2511 J=1,NF(K)
      WRITE(7,8603) NF(K)+1-J,PDEF(I,N1+3*(J-1)+1,1)
     + ,PACC(I,N1+3*(J-1)+1,1),PDEF(I,N1+3*(J-1)+2,1)
     + ,PACC(I,N1+3*(J-1)+2,1)
      IF(J.EQ.NF(K)) WRITE(7,8604) ' BASE'
     + ,PDEF(I,3*MNF+1,1)-PDEF(I,3*MNF+3,1)*YN(N2+1-J)
     + ,(PACC(I,3*MNF+1,1)-PACC(I,3*MNF+3,1)*YN(N2+1-J))
     + ,PDEF(I,3*MNF+2,1)+PDEF(I,3*MNF+3,1)*XN(N2+1-J)
     + ,(PACC(I,3*MNF+2,1)+PACC(I,3*MNF+3,1)*XN(N2+1-J))
 2511 CONTINUE
      N1=N1+3*NF(K)
 2510 CONTINUE
 2500 CONTINUE

C--WRITE PROFILES FOR MAX ACCELERATION IN EACH BUILDING--
C
CTHE BASE DISPL AND  ACCEL  ARE IN THE POINT
C  WHERE THE C.M. OF FIRST FLOOR IS

      WRITE(7,8699)
      N1=0
      N2=0
      DO 2520 K=1,NB
      N2=N2+NF(K)
      WRITE(7,8700) K
      DO 2521 I=1,2
      IF(I.EQ.1) WRITE(7,8701)  C2T(I,K,1)
      IF(I.EQ.2) WRITE(7,8702)  C2T(I,K,1)
      WRITE(7,8703)
      DO 2522 J=1,NF(K)
      WRITE(7,8603) NF(K)+1-J,PDEF(I,N1+3*(J-1)+1,2)
     + ,PACC(I,N1+3*(J-1)+1,2),PDEF(I,N1+3*(J-1)+2,2)
     + ,PACC(I,N1+3*(J-1)+2,2)
      IF(J.EQ.NF(K)) WRITE(7,8604) ' BASE'
     + ,BAS3(K,1,I)-BAS3(K,3,I)*YN(N2+1-J)
     + ,(BAS1(K,1,I)-BAS1(K,3,I)*YN(N2+1-J))
     + ,BAS3(K,2,I)+BAS3(K,3,I)*XN(N2+1-J)
     + ,(BAS1(K,2,I)+BAS1(K,3,I)*XN(N2+1-J))
 2522 CONTINUE
 2521 CONTINUE
      N1=N1+3*NF(K)
 2520 CONTINUE

C--WRITE PROFILES FOR MAX ACCELERATION IN EACH BUILDING--
C
CTHE BASE DISPL AND  ACCEL  ARE IN THE POINT
C  WHERE THE C.M. OF FIRST FLOOR IS

      WRITE(7,8799)
      N1=0
      N2=0
      DO 2530 K=1,NB
      N2=N2+NF(K)
      WRITE(7,8700) K
      DO 2531 I=1,2
      IF(I.EQ.1) WRITE(7,8801)  C2T(I,K,2)
      IF(I.EQ.2) WRITE(7,8802)  C2T(I,K,2)
      WRITE(7,8703)
      DO 2532 J=1,NF(K)
      WRITE(7,8603) NF(K)+1-J,PDEF(I,N1+3*(J-1)+1,3)
     + ,PACC(I,N1+3*(J-1)+1,3),PDEF(I,N1+3*(J-1)+2,3)
     + ,PACC(I,N1+3*(J-1)+2,3)
      IF(J.EQ.NF(K)) WRITE(7,8604) ' BASE'
```

```
     +    ,(BAS2(K,1,I)-BAS2(K,3,I)*YN(N2+1-J))
     +    ,BAS4(K,2,I)+BAS4(K,3,I)*XN(N2+1-J)
     +    ,(BAS2(K,2,I)+BAS2(K,3,I)*XN(N2+1-J))
 2532   CONTINUE
 2531   CONTINUE
        N1=N1+3*NF(K)
 2530   CONTINUE

C--WRITE PROFILES FOR MAX BASE SHEARS----
C
CTHE BASE DISPL AND  ACCEL  ARE IN THE POINT
C  WHERE THE C.M. OF FIRST FLOOR IS

      WRITE(7,8899)
      DO 2540 I=1,2
      IF(I.EQ.1) WRITE(7,8900)  C1T(I,2)
      IF(I.EQ.2) WRITE(7,8901)  C1T(I,2)
      N1=0
      N2=0
      DO 2541 K=1,NB
      N2=N2+NF(K)
      WRITE(7,8602) K
      DO 2542 J=1,NF(K)
      WRITE(7,8603) NF(K)+1-J,PDEF(I,N1+3*(J-1)+1,4)
     +,PACC(I,N1+3*(J-1)+1,4),PDEF(I,N1+3*(J-1)+2,4)
     +,PACC(I,N1+3*(J-1)+2,4)
      IF(J.EQ.NF(K)) WRITE(7,8604) ' BASE'
     +  ,PDEF(I,3*MNF+1,4)-PDEF(I,3*MNF+3,4)*YN(N2+1-J)
     +  ,(PACC(I,3*MNF+1,4)-PACC(I,3*MNF+3,4)*YN(N2+1-J))
     +  ,PDEF(I,3*MNF+2,4)+PDEF(I,3*MNF+3,4)*XN(N2+1-J)
     + ,(PACC(I,3*MNF+2,4)+PACC(I,3*MNF+3,4)*XN(N2+1-J))
 2542  CONTINUE
       N1=N1+3*NF(K)
 2541  CONTINUE
 2540  CONTINUE

      ENDIF

 2101 CONTINUE
C
      RETURN
 1002 FORMAT(////6X,'ISOLATORS TIME HISTORIES................'//,
     +            2X,' TIME',1X,2X,10(1X,4X,I2,4X))
 5000 FORMAT (/6X,'INST.STIFF',3X,'FORCE',3X,'DISPL',3X,'Z',3X,'VEL')
 5010 FORMAT (11X,5(E15.7,1X))
 6000 FORMAT(/6X,'DISPLACEMENT...AT...FLOOR DEGREE OF FREEDOM'
     + ,/11X,'TIME',7X,6(I3,7X))
 6002 FORMAT(6X,F6.3,1X,6(E10.4,1X))
 7000 FORMAT(/6X,'FORCE...AT...FLOOR DEGREE OF FREEDOM',/
     + 15X,'(FINAL THREE DEGREES OF FREEDOM REPRESENT BASE SHEAR',/
     + 15X,'  - AT THE TOP OF THE BASE',/
     + 11X,'TIME',7X,6(I3,7X))
 7001 FORMAT(/6X,'FORCE AT STRUCTURES LEVEL')
 7002 FORMAT(1X,F5.2,1X,12(E9.3,1X))
 7080 FORMAT(6X,'MAX. FORCE  2ND COLUMN AT BEARING LEVEL')
 7090 FORMAT(6X,'MAX. RESULTANT  DISP, FORCE AND PERM DISP')
 7200 FORMAT(6X,'FORCE IN X AND Y DIR AT PA: ',I5)
 7300 FORMAT(6X,F12.6,6X,9(E12.6,1X))
 7400 FORMAT(/6X,'BASE SHEARS'/
     +        6X,'TIME',3X,'X DIRECTION',1X,'Y DIRECTION',
     +        1X,'R DIRECTION')
 7401 FORMAT(6X,F6.3,1X,6(E10.4,2X))
C
 6999 FORMAT(//////6X,'.MAXIMUM BASE SHEARS...........',
     +        /6X,' TIME ',1X,' FORCE  X ',
     +  1X,' TIME ',1X,' FORCE  Y ',1X,' TIME ',1X,'Z  MOMENT ')
 7100 FORMAT(3(6X,F6.3,1X,E10.4))
 7010 FORMAT(//6X,'MAX. RELATIVE DISPLACEMENTS AT ',
     +'CENTER OF MASS OF LEVELS',
     +        /6X,'
     +'(WITH RESPECT TO THE BASE)')
```

```
     +          /6X,'LEVEL',1X,' TIME ',1X,' DISPL  X ',
     +       1X,' TIME ',1X,' DISPL  Y ',1X,' TIME ',1X,' ROTATION '/)
 7050 FORMAT(6X,1X,I2,2X,3(1X,F6.3,1X,E10.4))
 7051 FORMAT(//6X,'MAX. DISPLACEMENTS AT CENTER OF MASS OF BASE',
     +          /6X,'LEVEL',1X,' TIME ',1X,' DISPL  X ',
     +       1X,' TIME ',1X,' DISPL  Y ',1X,' TIME ',1X,' ROTATION ',
     +          /6X,A5,3(1X,F6.3,1X,E10.4))
 7060 FORMAT(//6X,'MAX. TOTAL ACCELERATIONS AT ',
     +'CENTER OF MASS OF LEVELS')
 7061 FORMAT(//6X,'SUPERSTRUCTURE : ',I2,
     +          /6X,'LEVEL',1X,' TIME ',1X,' ACCEL  X ',
     +      1X,' TIME ',1X,' ACCEL  Y ',1X,' TIME ',1X,' ACCEL  R '/)
 7070 FORMAT(6X,1X,I2,2X,3(1X,F6.3,1X,E10.4))
 7071 FORMAT(//6X,'MAX. ACCELERATIONS AT CENTER OF MASS OF BASE',
     +          /6X,'LEVEL',1X,' TIME ',1X,' ACCEL  X ',
     +       1X,' TIME ',1X,' ACCEL  Y ',1X,' TIME ',1X,' ACCEL  R ',
     +          /6X,A5,3(1X,F6.3,1X,E10.4))
 8001 FORMAT(1X,F6.3,1X,A2,1X,10(E10.4,1X))
 8002 FORMAT(1X,5X,  2X,A2,1X,10(E10.4,1X))
 8500 FORMAT(///6X,'MAXIMUM BEARING DISPLACEMENTS'/
     +          ,/6X,8X,1X,7X,'MAX DISPL    X ',8X,5X
     +                       ,7X,'MAX DISPL    Y '
     + ,/6X,'ISOLATOR',1X,2(' TIME ',1X,' X  DIRECT'
     + , 1X,' Y  DIRECT',5X))
 8501 FORMAT(6X,I5,3X,1X,2(F6.3,1X,E10.4,1X,E10.4,5X))
 8599 FORMAT
     +(//////6X,'PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT'
     +          ,' AT TIME OF MAX BASE DISPLACEMENTS')
 8600 FORMAT(///6X,'MAXIMUM BASE DISPLACEMENT IN  X  DIRECTION',
     +           /6X,'TIME :',1X,F6.3)
 8601 FORMAT(///6X,'MAXIMUM BASE DISPLACEMENT IN  Y  DIRECTION',
     +           /6X,'TIME :',1X,F6.3)
 8602 FORMAT(/6X,'SUPERSTRUCTURE :',1X,I2,
     +         /6X,5X,      1X,10X,'X',10X,2X,10X,'Y',
     +         /6X,'LEVEL',1X,2('   DISP    ',1X,'   ACCEL   ',2X))
 8603 FORMAT(6X,I3,2X,1X,2(F10.4,1X,F10.4,2X))
 8604 FORMAT(6X,A5,1X,2(F10.4,1X,F10.4,2X))
 8699 FORMAT
     +(//////6X,' PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT'
     +          ,' AT TIME OF MAX ACCELERATION IN EACH BUILDING')
 8700 FORMAT(//6X,'SUPERSTRUCTURE :',1X,I2)
 8701 FORMAT(//6X,' MAX ACCELERATION IN  X  DIRECTION',
     +          /6X,'  TIME :',1X,F6.3)
 8702 FORMAT(//6X,' MAX ACCELERATION IN  Y  DIRECTION',
     +          /6X,'  TIME :',1X,F6.3)
 8703 FORMAT(//6X,'LEVEL',1X,2('   DISP    ',1X,'   ACCEL   ',2X))
 8799 FORMAT
     +(//////6X,'PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT'
     +          ,' AT TIME OF MAX STRUCT SHEAR IN EACH BUILDING')
 8801 FORMAT(//6X,' MAX STRUC SHEAR IN  X  DIRECTION',
     +          /6X,'  TIME :',1X,F6.3)
 8802 FORMAT(//6X,' MAX STRUC SHEAR IN  Y  DIRECTION',
     +          /6X,'  TIME :',1X,F6.3)
 8899 FORMAT
     +(///////6X,'PROFILES OF TOTAL ACCELERATION AND DISPLACEMENT'
     +            ,' AT TIME OF MAX BASE SHEARS')
 8900 FORMAT(//6X,'MAXIMUM BASE SHEAR IN  X  DIRECTION',
     +          /6X,'TIME :',1X,F6.3)
 8901 FORMAT(//6X,'MAXIMUM BASE SHEAR IN  Y  DIRECTION',
     +          /6X,'TIME :',1X,F6.3)
 9000 FORMAT(///////6X,'.MAXIMUM STORY SHEARS.............')
 9001 FORMAT(//6X,'SUPERSTRUCTURE : ',1X,I2,
     +          /6X,'LEVEL',1X,' TIME ',1X,' FORCE  X ',
     +  1X,' TIME ',1X,' FORCE  Y ',1X,' TIME ',1X,' Z  MOMENT'/)
 9002 FORMAT(6X,1X,I2,2X,3(1X,F6.3,1X,E10.4))
 9100 FORMAT(///////6X,'.MAXIMUM STRUCTURAL SHEARS.........',
     +          //6X,'SUPERST. No',1X,' TIME ',
     +1X,' FORCE  X ',1X,' TIME ',1X,' FORCE  Y ',
     +1X,' TIME ',1X,' Z  MOMENT')
 9101 FORMAT(6X,4X,I2,5X,3(1X,F6.3,1X,E10.4))
10001 FORMAT(///1X,30X,'**************FORCE PROFILES***********'
```

```
     +        ,' MAX STRUCTURAL SHEAR X DIRECTION')
10002 FORMAT( /1X,'SUPR/STURE',1X,' TIME ',1X,'  OVERTURNING MOMENT'
     +             ,34X,' TIME ',1X,' MAX STUCTURAL SHEAR'
     +        ,/1X,I6,5X,F6.3,1X,F20.4,34X,F6.3,1X,F20.4)
10003 FORMAT(///10X,' MAX OVERTURNING MOMENT  Y  DIRECTION',30X
     +        ,' MAX STRUCTURAL SHEAR Y DIRECTION')
10004 FORMAT(//1X,'   FLOOR  ',1X,6X,1X,'  INERTIA   FORCES  '
     +        ,34X,6X,1X,'  INERTIA  FORCES'
     +        ,/(1X,I6,5X,6X,1X,F20.4,34X,6X,1X,F20.4))
10005  FORMAT(1X,A10,1X,6X,1X,F20.4,34X,6X,1X,F20.4,2X,A28)
      END

C*****************************************************   DRIFTS   *******

      SUBROUTINE DRIFTS (TIME,DEF,XN,YN,NF,H,ICOR,CORDX,CORDY,
     +                   AXD,AYD,PXD,PYD,PXDT,PYDT,INDEX)

C***********************************************************************
C     SUBROUTINE FOR CALCULATING AND PRINTING INTERSTORY DRIFT RATIOS.
C     DEVELOPED BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      DIMENSION DEF(3*MNF+3),NF(NB),XN(MNF),YN(MNF),H(MNF+NB)
      DIMENSION ICOR(NB),CORDX(NB,6),CORDY(NB,6)
      DIMENSION AXD(NB,MXF,6),AYD(NB,MXF,6),
     +          PXD(NB,MXF,6),PYD(NB,MXF,6),
     +          PXDT(NB,MXF,6),PYDT(NB,MXF,6)

      IF(INDEX)  5,5,10

    5 CONTINUE
      N1=0
      N2=0
      DO 100 I=1,NB
      N2=N2+NF(I)
      DO 110 J=1,NF(I)
      DO 120 L=1,ICOR(I)
      IF(J.EQ.NF(I)) THEN
       AXD(I,J,L)=DABS((DEF(N1+3*(J-1)+1)-
     +                DEF(N1+3*J)*(CORDY(I,L)-YN(N2+1-J))))
       AYD(I,J,L)=DABS((DEF(N1+3*(J-1)+2)+
     +                DEF(N1+3*J)*(CORDX(I,L)-XN(N2+1-J))))
      ELSE
       AXD(I,J,L)=DABS((DEF(N1+3*(J-1)+1)-
     +                DEF(N1+3*J)*(CORDY(I,L)-YN(N2+1-J)))
     +             -(DEF(N1+3*J+1)-
     +                DEF(N1+3*(J+1))*(CORDY(I,L)-YN(N2+1-(J+1)))))
       AYD(I,J,L)=DABS((DEF(N1+3*(J-1)+2)+
     +                DEF(N1+3*J)*(CORDX(I,L)-XN(N2+1-J)))
     +             -(DEF(N1+3*J+2)+
     +                DEF(N1+3*(J+1))*(CORDX(I,L)-XN(N2+1-(J+1)))))
      ENDIF

  120 CONTINUE
  110 CONTINUE
      N1=N1+3*NF(I)
  100 CONTINUE

      DO 200 I=1,NB
      DO 210 J=1,NF(I)
      DO 220 L=1,ICOR(I)
      IF (AXD(I,J,L).GT.PXD(I,J,L))THEN
       PXD(I,J,L)=AXD(I,J,L)
       PXDT(I,J,L)=TIME
      ENDIF
      IF (AYD(I,J,L).GT.PYD(I,J,L))THEN
       PYD(I,J,L)=AYD(I,J,L)
       PYDT(I,J,L)=TIME
      ENDIF
```

```
  210 CONTINUE
  200 CONTINUE

      GO TO 20

   10 CONTINUE

      N1=0
      WRITE(7,1000)
      DO 300 I=1,NB
      WRITE(7,1010) I
      WRITE(7,1011) ((L,CORDX(I,L),CORDY(I,L)),L=1,ICOR(I))
      KS2=1
  400 KS3=KS2+2
      KS4=ICOR(I)
      IF(KS3.LE.ICOR(I))KS4=KS3

      WRITE(7,1020)(L,L=KS2,KS4)
      WRITE(7,1021)
      N1=N1+NF(I)+1
      DO 310 J=1,NF(I)
      WRITE(7,1030) NF(I)+1-J
     + ,(PXDT(I,J,L),PXD(I,J,L)/(H(N1+1-J)-H(N1+1-(J+1)))
     +  ,PYDT(I,J,L),PYD(I,J,L)/(H(N1+1-J)-H(N1+1-(J+1))),L=KS2,KS4)
  310 CONTINUE

      KS2=KS2+3
      IF(ICOR(I).GT.KS3) GOTO 400
  300 CONTINUE

   20 CONTINUE

      RETURN
 1000 FORMAT(//////6X,'.MAXIMUM INTERSTORY DRIFT RATIOS'
     +' FOR EACH SUPERSTRUCTURE'//)
 1010 FORMAT(/6X,'SUPERSTRUCTURE :',1X,I2)
 1011 FORMAT(/6X,'COORDINATES OF COLUMN LINES'
     +           ' WITH RESPECT TO MASS CENTER OF BASE',
     +      /(6X,'C/L : ',I1,1X,' X COOR :',F10.3,
     +        /6X,7X,          1X,' Y COOR :',F10.3))
 1020 FORMAT(/6X,'COLUMN LINES',
     +         /6X,3(15X,I1,14X))
 1021 FORMAT(6X,'LEVEL',
     +        3(1X,'  TIME',5X,'X  DIR',1X,'  TIME',5X,'Y  DIR'))
 1030 FORMAT(6X,1X,I2,2X,6(1X,F6.3,1X,E10.4))
      END

C**************************************************   WFORC  *********

      SUBROUTINE WFORC(TIME,SUMB,FISI1,FISI2,FISI3,NF,IT,
     +                 KPRINT1,PRINT1,INDEX)

C*******************************************************************
C     SUBROUTINE FOR PRINTING FORCE OUTPUT.
C     DEVELOPED BY........................PANAGIOTIS TSOPELAS....APR 1991
C
C*******************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /PRINT   /LTMH,IPROF,KPD,KPF,INP
      COMMON /DIREC   /DRIN(3),DRIN1(4)
      CHARACTER*1 DRIN
      CHARACTER*2 DRIN1
      DIMENSION NF(NB),SUMB(NB,3)
C
C----------------------
      MNF3=3*MNF+3
C----------------------

      IF(INDEX)  5,5,10
```

```
    5  CONTINUE
        IF (IT.EQ.KPRINT1)THEN
C---------WRITE 30+.. STRUCTURES BASE SHEARS------
         KS1=0
         KS2=1
 1985    KS3=KS2+9
         KS4=NB
         IF(KS3.LE.NB)KS4=KS3
         WRITE(30+KS1)TIME,KS2,KS4
       +             ,(SUMB(I,1),SUMB(I,2),SUMB(I,3),I=KS2,KS4)
         KS2=KS2+10
         KS1=KS1+1
         IF(NB.GT.KS3)GO TO  1985
C---------WRITE 40 BASE SHEARS---------------
         WRITE (40)TIME,FISI1,FISI2,FISI3
         KPRINT1=KPRINT1+KPF
         PRINT1=PRINT1+1
        ENDIF
        GO TO 20
   10   CONTINUE
        KS1=0
        KS2=1
 2100   KS3=KS2+9
        KS4=NB
        IF(KS3.LE.NB)KS4=KS3
        WRITE (50,7000)KS2,(KS2+I,I=1,9)
        REWIND (30+KS1)
        DO 2250 II=1,PRINT1
        READ (30+KS1) TIME,KS2,KS4
       +             ,(SUMB(I,1),SUMB(I,2),SUMB(I,3),I=KS2,KS4)
        WRITE (50,7002)TIME,DRIN(1),(SUMB(I,1),I=KS2,KS4)
        WRITE (50,7003)     DRIN(2),(SUMB(I,2),I=KS2,KS4)
        WRITE (50,7003)     DRIN(3),(SUMB(I,3),I=KS2,KS4)
 2250   CONTINUE
        KS2=KS2+10
        KS1=KS1+1
        IF(NB.GT.KS3)GO TO  2100
        REWIND(40)
        WRITE(50,7400)
        DO 2400 II=1,PRINT1
        READ  (40)      TIME,FISI1,FISI2,FISI3
        WRITE (50,7401) TIME,FISI1,FISI2,FISI3
 2400   CONTINUE
  20    CONTINUE
        RETURN
 7000   FORMAT(//6X,'FORCE AT STRUCTURES LEVEL (STRUCTURAL SHEARS)',/
       +           2X,' TIME',1X,'DIRC',1X,10(4X,I2,4X,1X))
 7002   FORMAT(1X,F6.3,1X,2X,A1,1X,1X,10(E10.4,1X))
 7003   FORMAT(1X,6X  ,1X,2X,A1,1X,1X,10(E10.4,1X))
 7400   FORMAT(//6X,'FORCE AT BASE LEVEL (BASE SHEAR)'/
       +          2X,' TIME',5X,'X DIRECTION',5X,'Y DIRECTION',
       +          5X,'R DIRECTION')
 7401   FORMAT(1X,F6.3,6X,3(E10.4,6X))
        END
C**************************************************    WDEFAC   ********
```

```
      SUBROUTINE WDEFAC(TIME,DF,AC,NF,IT,KPRINT,PRINT,INDEX)

C***********************************************************************
C     SUBROUTINE FOR PRINTING DISPLACEMENT AND ACCELERATION OUTPUT.
C     DEVELOPED BY......................PANAGIOTIS TSOPELAS....APR 1991
C
C***********************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /PRINT   /LTMH,IPROF,KPD,KPF,INP
      DIMENSION DF(3*MNF+3),NF(NB),AC(3*MNF+3)
C-----------------------------
      MNF3=3*MNF+3
C-----------------------------

      IF(INDEX)  5,5,10

    5 CONTINUE

      IF(IT.EQ.KPRINT)THEN

       N1=0
       N2=0
       DO 110 I=1,NB
       ISK=50+I
       DO 120 J=1,NF(I)
       N2=N1+3*(J-1)
       IF(J.EQ.1) THEN
        WRITE(ISK,1002) TIME,NF(I)+1-J,
     +                  (AC(N2+K),K=1,2),(DF(N2+K),K=1,3)
       ELSE
        WRITE(ISK,1003)      NF(I)+1-J,
     +                  (AC(N2+K),K=1,2),(DF(N2+K),K=1,3)
       ENDIF
  120  CONTINUE
       N1=N1+3*NF(I)
  110  CONTINUE

       WRITE(20)TIME,(AC(MNF3-(3-I)),I=1,2),(DF(MNF3-(3-I)),I=1,3)

       KPRINT=KPRINT+KPD
       PRINT=PRINT+1

      END IF

      GO TO 20

   10 CONTINUE

      WRITE(50,6000)
      REWIND (20)
      DO 2002 II=1,PRINT
      READ(20)TIME,(AC(I),I=1,2),(DF(I),I=1,3)
 2002 WRITE (50,6002) TIME,(AC(I),I=1,2),(DF(I),I=1,3)

   20 CONTINUE

      RETURN
 1002 FORMAT(1X,F6.3,1X,I3,3X,2(E10.4,1X),3(E10.4,1X))
 1003 FORMAT(1X,6X  ,1X,I3,3X,2(E10.4,1X),3(E10.4,1X))
 6000 FORMAT(///6X,'BASE ACCELERATIONS AND DISPLACEMENTS...AT...C.M.'
     +        /2X,' TIME',3X,'ACCEL  X',3X,'ACCEL  Y',
     +         3X,'DISPL  X',3X,'DISPL  Y',3X,'ROTATION'/)
 6002 FORMAT(1X,F6.3,1X,5(E10.4,1X))
      END

C****************************************************   BEARING    ******

      SUBROUTINE BEARING(ERR,FN,FX,FY,XP,YP,DN,VN,VNP,AN,ANP,FH,IT
     + ,ZX,ZY,FNXY,ALP,YF,YD,FMAX,DF,PA,INELEM,DELF)
```

```
C***********************************************************************
C      SUBROUTINE FOR STATE DETERMINATION AT BEARINGS.
C      DEVELOPED BY......................SATISH NAGARAJAIAH....OCT 1990
C
C***********************************************************************

       IMPLICIT REAL*8(A-H,O-Z)
       COMMON /MAIN     /NB,NP,MNF,MNE,NFE,MXF
       COMMON /STEP     /TSI,TSR
       COMMON /HYS1     /WBET,WGAM
       DIMENSION FX(NP),FY(NP),TP(3,3),
     + TEMP1(3,2),TEMP2(3,1),TEMP3(3,1),TEMP4(3,1),TEMP5(3,1),
     + XP(NP),YP(NP),DN(3,2),VN(3),VNP(3),AN(3),ANP(3),
     + FH(MNE+3),ZX(NP),ZY(NP),INELEM(NP,2),
     + PKI(2),FR(2),ERR(3),FN(NP),FNXY(NP),DELF(MNE+3)
     + ,ALP(NP,2),YF(NP,2),YD(NP,2),FMAX(NP,2),DF(NP,2),PA(NP,2)
C
      DO 20 I=1,3
      DO 10 J=1,3
      TP(I,J)=0.0
   10 CONTINUE
   20 CONTINUE

      DO 100 I=1,NP

      IF(INELEM(I,2).LE.2) GO TO 100

      J=1
      TP(1,1)=1
      TP(2,2)=1
      TP(3,3)=1
      TP(3,1)=-YP(I)
      TP(3,2)=XP(I)
      CALL TMULT(TP,DN,TEMP1,3,3,2)
      CALL TMULT(TP,VN,TEMP2,3,3,1)
      CALL TMULT(TP,VNP,TEMP3 ,3,3,1)
      CALL TMULT(TP,AN,TEMP4,3,3,1)
      CALL TMULT(TP,ANP,TEMP5 ,3,3,1)

      IF(IT.EQ.1)THEN
      FR(1)=0
      FR(2)=0
      ELSE
      FR(1)=FX(I)
      FR(2)=FY(I)
      END IF

      CALL HYS(IT,PKI,TEMP1,TEMP2,TEMP3,TEMP4,TEMP5,FR,I,ZX,ZY
     + ,FN,FNXY,ALP,YF,YD,FMAX,DF,PA,INELEM)

      FX(I)=FR(1)
      FY(I)=FR(2)
  100 CONTINUE

      DUM1=0.0
      DUM2=0.0
      DUM3=0.0
      DO 200 I=1,NP
      DUM1=DUM1+FX(I)
      DUM2=DUM2+FY(I)
      DUM3=DUM3+FY(I)*XP(I)-FX(I)*YP(I)
  200 CONTINUE

      DELF1=DUM1-FH(MNE+1)
      DELF2=DUM2-FH(MNE+2)
      DELF3=DUM3-FH(MNE+3)

      ERR(1)=DELF1-DELF(MNE+1)
      ERR(2)=DELF2-DELF(MNE+2)
      ERR(3)=DELF3-DELF(MNE+3)
```

```
      DELF(MNE+2)=DELF2
      DELF(MNE+3)=DELF3
C
      RETURN
      END

C***************************************************    LOAD    *********

      SUBROUTINE LOAD(TEMP1,TEMP2,T,R,CM,Y,X,UG,PTU,IT)

C*************************************************************************
C     SUBROUTINE TO FORM THE REDUCED LOAD VECTOR USING THE SPECIFIED
C     GROUND ACCELERATION VECTOR.
C     DEVELOPED BY.......................SATISH NAGARAJAIAH....OCT 1990
C
C*************************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /GENBASE /ISEV,LOR
      COMMON /LOAD1   /XTH,IDAT,TIME,PTSR,ULF,INDGACC
      DIMENSION TEMP1(MNE+3,3*MNF+3),TEMP2(MNE+3,3),T(3*MNF+3,MNE+3)
     +  ,R(3*MNF+3,3),CM(3*MNF+3,3*MNF+3),Y(LOR),UG(3,1),PTU(MNE+3)
     +  ,X(LOR)
C
   70 TIME=TIME+TSI

      IF(TIME.GT.(LOR-1)*TSR)GO TO 100

   80 IF(TIME.LE.PTSR)GO TO 90
      IDAT=IDAT+1
      PTSR=PTSR+TSR
      GO TO 80

   90 IF(INDGACC.EQ.1)THEN
       UG(1,1)=DCOS(XTH)*(X(IDAT)+(X(IDAT-1)-X(IDAT))*(PTSR-TIME)/TSR)
       UG(2,1)=DSIN(XTH)*(X(IDAT)+(X(IDAT-1)-X(IDAT))*(PTSR-TIME)/TSR)
      ELSE IF(INDGACC.EQ.2)THEN
       UG(1,1)=(X(IDAT)+(X(IDAT-1)-X(IDAT))*(PTSR-TIME)/TSR)
       UG(2,1)=(Y(IDAT)+(Y(IDAT-1)-Y(IDAT))*(PTSR-TIME)/TSR)
      END IF
      UG(3,1)=0.0

  100 CONTINUE

      J1=3*MNF+3
      J2=MNE+3

      CALL TMULT(T,CM,TEMP1,J1,J2,J1)
      CALL MULT(TEMP1,R,TEMP2,J2,J1,3)

      DO 200 I=1,MNE+3
      SUM=0.0
      DO 150 K=1,3
      SUM=SUM+TEMP2(I,K)*UG(K,1)*ULF
  150 CONTINUE
      PTU(I)=-SUM
  200 CONTINUE
C
      RETURN
      END


C********************************************************** HYS *****

      SUBROUTINE HYS(IT,PKI,DN,VN,VNP,AN,ANP,FXY,I,ZXX,ZYY
     +  ,FN,FNXY,ALP,YF,YD,FMAX,DF,PA,INELEM)

C********************************************************************
C
```

```
C
C*********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MAIN    /NB,NP,MNF,MNE,NFE,MXF
      COMMON /STEP    /TSI,TSR
      COMMON /CON1    /A1,A2,A3,A4,A5
      COMMON /CON2    /B1,B2,B3,B4,B5
      COMMON /PARA    /C1,C2,GAMA,BETA,Y(2)
      COMMON /HYS1    /WBET,WGAM

        DIMENSION DN(3,2),VN(3),VNP(3),AN(3),ANP(3),FN(NP),FNXY(NP)
     +  ,ZXX(NP),ZYY(NP),FXY(2),PKI(2),DA(2),VRK(2),ARK(2),Z(2)
     +  ,ALP(NP,2),YF(NP,2),YD(NP,2),FMAX(NP,2),DF(NP,2),PA(NP,2)
     +  ,INELEM(NP,2)

        DIMENSION AJI(2,2),ZX(2),ZY(2),ZP(2,2),RK(2),RL(2)
     +  ,V(2,2)

      DATA C1,C2 / 0.788675134595, -1.15470053838 /

        GAMA=0.9
        BETA=0.1


        Y(1)=YD(I,1)
        Y(2)=YD(I,2)


        V1=(VNP(1)+VN(1))/2
        V2=(VNP(2)+VN(2))/2

        V(1,1)=V1
        V(2,1)=V2

        V(1,2)=V1
        V(2,2)=V2

        IF(INELEM(I,1).EQ.3)THEN

        CALL BIAXIAL(I,V,ZXX,ZYY,NP)

        END IF

        IF(INELEM(I,1).EQ.1)THEN

        YD1=Y(1)
        ZXY=ZXX(I)
        CALL UNIAXIAL(V1,ZXY,YD1)
        ZXX(I)=ZXY
        ZYY(I)=0.0

        ELSE IF(INELEM(I,1).EQ.2)THEN

        YD2=Y(2)
        ZXY=ZYY(I)
        CALL UNIAXIAL(V2,ZXY,YD2)
        ZYY(I)=ZXY
        ZXX(I)=0.0

        END IF

        IF(INELEM(I,2).EQ.3)THEN

        FXY(1)=ALP(I,1)*YF(I,1)/YD(I,1)*DN(1,2)+(1-ALP(I,1))
     +  *YF(I,1)*ZXX(I)
        FXY(2)=ALP(I,2)*YF(I,2)/YD(I,2)*DN(2,2)+(1-ALP(I,2))
     +  *YF(I,2)*ZYY(I)

        IF(INELEM(I,1).EQ.1)THEN
```

```
      ELSE IF(INELEM(I,1).EQ.2)THEN

      FXY(1)=0

      END IF

      END IF


      IF(INELEM(I,2).EQ.4)THEN

      IF(INELEM(I,1).EQ.1.OR.INELEM(I,1).EQ.2)THEN

      FMEW1=FMAX(I,1)-DF(I,1)*DEXP(-PA(I,1)*DABS(VN(1)))
      FMEW2=FMAX(I,2)-DF(I,2)*DEXP(-PA(I,2)*DABS(VN(2)))

      ELSE IF(INELEM(I,1).EQ.3)THEN

      VELC=DSQRT(VN(1)**2+VN(2)**2)
      FMEW1=FMAX(I,1)-DF(I,1)*DEXP(-PA(I,1)*DABS(VELC))
      FMEW2=FMAX(I,2)-DF(I,2)*DEXP(-PA(I,2)*DABS(VELC))

      END IF

      FXY(1)=FMEW1*FNXY(I)*ZXX(I)
      FXY(2)=FMEW2*FNXY(I)*ZYY(I)

      END IF



C***************************************************BIAXIAL***********

      SUBROUTINE BIAXIAL(I,V,ZXX,ZYY,NP)

C*******************************************************************
C
C     SUBROUTINE TO CALCULATE THE HYSTERETIC PARAMETERS
C     DEVELOPED BY................SATISH NAGARAJAIAH....OCT 1990
C
C*******************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /STEP/ TSI,TSR
      COMMON /CON1/A1,A2,A3,A4,A5
      COMMON /CON2/B1,B2,B3,B4,B5
      COMMON /PARA/C1,C2,GAMA,BETA,Y(2)
      DIMENSION  ZXX(NP),ZYY(NP)
      DIMENSION AJI(2,2),ZX(2),ZY(2),Z(2),ZP(2,2),RK(2),RL(2)
     + ,V(2,2)
C
      T=TSI
      ZX(1)=ZXX(I)
      ZY(1)=ZYY(I)

      CALL CONST(V(1,1),V(2,1),ZX(1),ZY(1))

      AJI(1,1)=1+C1*T*(2*B2*ZY(1)+2*B3*ZY(1)+B4*ZX(1)+B5*ZX(1))
      AJI(2,2)=1+C1*T*(2*A2*ZX(1)+2*A3*ZX(1)+A4*ZY(1)+A5*ZY(1))
      AJI(1,2)=-C1*T*(A4*ZX(1)+A5*ZX(1))
      AJI(2,1)=-C1*T*(B4*ZY(1)+B5*ZY(1))

      DAJI=AJI(1,1)*AJI(2,2)-AJI(1,2)*AJI(2,1)

      DO 40 II=1,2
      DO 30 JJ=1,2
   30 AJI(II,JJ)=AJI(II,JJ)/DAJI
   40 CONTINUE

```

```
     +                    -A4*ZX(1)*ZY(1)-A5*ZX(1)*ZY(1)

      ZP(2,1)= B1-B2*ZY(1)**2-B3*ZY(1)**2
     +                    -B4*ZX(1)*ZY(1)-B5*ZX(1)*ZY(1)


      DO 80 II=1,2
      SUM=0
      DO 60 JJ=1,2
   60 SUM=SUM+AJI(II,JJ)*ZP(JJ,1)*T
      RK(II)=SUM
   80 CONTINUE

      ZX(2)=ZX(1)+C2*RK(1)
      ZY(2)=ZY(1)+C2*RK(2)


      CALL CONST(V(1,2),V(2,2),ZX(2),ZY(2))

      ZP(1,2)= A1-A2*ZX(2)**2-A3*ZX(2)**2
     +                    -A4*ZX(2)*ZY(2)-A5*ZX(2)*ZY(2)

      ZP(2,2)= B1-B2*ZY(2)**2-B3*ZY(2)**2
     +                    -B4*ZX(2)*ZY(2)-B5*ZX(2)*ZY(2)

      DO 120 II=1,2
      SUM=0
      DO 100 JJ=1,2
  100 SUM=SUM+AJI(II,JJ)*ZP(JJ,2)*T
      RL(II)=SUM
  120 CONTINUE

      ZX(1)=ZX(1)+0.75*RK(1)+0.25*RL(1)
      ZY(1)=ZY(1)+0.75*RK(2)+0.25*RL(2)

      ZXX(I)=ZX(1)
      ZYY(I)=ZY(1)


      RETURN
      END

C***********************************************UNIAXIAL************

      SUBROUTINE UNIAXIAL(V1,ZX1,YD)

C*****************************************************************
C
C     SUBROUTINE TO CALCULATE THE HYSTERETIC PARAMETERS
C     DEVELOPED BY................SATISH NAGARAJAIAH....OCT 1990
C
C*****************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /STEP/ TSI,TSR
      COMMON /PARA/C1,C2,GAMA,BETA,Y(2)
      COMMON /CONU1/A1,A2,A3

      DIMENSION ZX(2),ZP(1,2)

      NETA=2
      T=TSI
      ZX(1)=ZX1

      CALL CONSTU(V1,ZX(1),YD,GAMA,BETA)

      ZP(1,1)= A1-A2*ZX(1)**NETA-A3*ZX(1)**NETA

      AJI1=1+T*C1*NETA*ZX(1)**(NETA-1)*(A2+A3)

      AJI=1/AJI1
```

```
      ZX(2)=ZX(1)+C2*RK

      CALL CONSTU(V1,ZX(2),YD,GAMA,BETA)

      ZP(1,2)= A1-A2*ZX(2)**NETA-A3*ZX(2)**NETA

      RL=AJI*ZP(1,2)*T

      ZX(1)=ZX(1)+0.75*RK+0.25*RL


      ZX1=ZX(1)

      RETURN
      END

C*************************************************** CONST *********

      SUBROUTINE CONST(VX,VY,ZX,ZY)

C*******************************************************************
C
C     SUBROUTINE TO CALCULATE THE HYSTERETIC PARAMETERS
C     DEVELOPED BY...............SATISH NAGARAJAIAH....OCT 1990
C
C*******************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /CON1/A1,A2,A3,A4,A5
      COMMON /CON2/B1,B2,B3,B4,B5
      COMMON /PARA/C1,C2,GAMA,BETA,Y(2)

      ONE=1
      SIGNX=DSIGN(ONE,VX*ZX)

      ONE=1
      SIGNY=DSIGN(ONE,VY*ZY)


      A1=VX/Y(1)

      A2=GAMA*VX*SIGNX/Y(1)

      A3=BETA*VX/Y(1)

      A4=GAMA*VY*SIGNY/Y(1)

      A5=BETA*VY/Y(1)

      B1=VY/Y(2)

      B2=GAMA*VY*SIGNY/Y(2)

      B3=BETA*VY/Y(2)

      B4=GAMA*VX*SIGNX/Y(2)

      B5=BETA*VX/Y(2)

      RETURN
      END

C**********************************************CONSTU***************

      SUBROUTINE CONSTU(VX,ZX,YD,GAMA,BETA)

C*******************************************************************
C
C     SUBROUTINE TO CALCULATE THE HYSTERETIC PARAMETERS
```

```
C
C*********************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /CONU1/A1,A2,A3

      ONE=1
      SIGNX=DSIGN(ONE,VX*ZX)


      A1=VX/YD

      A2=GAMA*VX*SIGNX/YD

      A3=BETA*VX/YD

      RETURN
      END


C******************************************************   MAX   ********

      SUBROUTINE MAX(A,B,MN)

C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(MN),B(MN)
      DO 10 I=1,MN
      IF(DABS(A(I)).GT.DABS(B(I)))B(I)=A(I)
   10 CONTINUE
      RETURN
      END

C******************************************************   MULT   *******

      SUBROUTINE MULT(A,B,C,NR,NT,NC)

C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(NR,NT),B(NT,NC),C(NR,NC)
C
      DO 200 I=1,NR
      DO 200 J=1,NC
       X=0.0
      DO 100 K=1,NT
  100 X=X+A(I,K)*B(K,J)
  200 C(I,J)=X
      RETURN
      END

C******************************************************   TMULT   ******

      SUBROUTINE  TMULT(A,B,C,NT,NR,NC)

C***********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(NT,NR),B(NT,NC),C(NR,NC)
C
      DO 200 I=1,NR
      DO 200 J=1,NC
       X=0.0
      DO 100 K=1,NT
  100 X=X+A(K,I)*B(K,J)
  200 C(I,J)=X
C
      RETURN
      END
```

```
      SUBROUTINE TRANSP(A,AT,NR,NC)

C*********************************************************************

      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(NR,NC),AT(NC,NR)
C
      DO 100 I=1,NR
      DO 100 J=1,NC
  100 AT(J,I)=A(I,J)

      RETURN
      END

C***************************************************  GAUSS   ******

      SUBROUTINE GAUSS(A,B,NEQ,LEQ,LL,M)

C*********************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
C-----SYMMETRICAL EQUATION SOLVER---------------
C      M = 0 TRIANGULARIZATION AND SOLUTION
C      M = 1 TRIANGULARIZATION ONLY
C      M = 2 FORWARD REDUCTION ONLY
C      M = 3 BACKSUBSTITUTION ONLY
      DIMENSION A(NEQ,NEQ),B(NEQ,LL)
C----------------------------------------------
      IF(M.EQ.3) GO TO 800
      IF(M.EQ.2) GO TO 500
C---- TRIANGULARIZATION -----------------------
      DO 400 N=1,LEQ
      IF(N.EQ.NEQ) GO TO 400
C
      D = A(N,N)
      IF(D.NE.0.0) GO TO 100
      WRITE(6,2000) N
      STOP
C
  100 N1 = N + 1
C
      DO 300 J=N1,NEQ
      IF(A(N,J).EQ.0.0) GO TO 300
      A(N,J) = A(N,J)/D
C
      DO 200 I=J,NEQ
      A(I,J) = A(I,J) - A(I,N)*A(N,J)
  200 A(J,I) = A(I,J)
C
  300 CONTINUE
C
  400 CONTINUE
C
      IF(NEQ.NE.1) A(NEQ,1) = LEQ
      IF(M.EQ.1) RETURN
C-----FORWARD REDUCTION -------------
  500 IF(NEQ.NE.1) LEQ = A(NEQ,1)
      DO 700 N=1,LEQ
C
      IF(N.EQ.NEQ) GO TO 650
      N1 = N + 1
C
      DO 600 L=1,LL
      DO 600 I=N1,NEQ
  600 B(I,L) = B(I,L) - A(N,I)*B(N,L)
C
  650 DO 675 L=1,LL
  675 B(N,L) = B(N,L)/A(N,N)
C
  700 CONTINUE
```

```
C-----BACK-SUBSTITUTION
  800 N = NEQ
      IF(NEQ.NE.1) LEQ = A(NEQ,1)
      IF(LEQ.NE.NEQ) N = LEQ + 1
  810 N1 = N
      N  = N - 1
      IF(N.EQ.0) RETURN
C
      DO 900 L=1,LL
      DO 900 J=N1,NEQ
  900 B(N,L) = B(N,L) - A(N,J)*B(J,L)
      GO TO 810
C-------------------------------------------------------------
 2000 FORMAT(/' * ERROR * *DIAGONAL TERM OF EQUATION ',I4,' = ZERO')
      END

C*******************************************************   JACOBI   *****

             SUBROUTINE JACOBI (A,B,X,E,N,NFIG,NSMAX,N1)

C**********************************************************************

C-----------------------------------------------------------
C     SUBROUTINE SOLVES EIGENVALUE PROBLEM  AX = BXE  WHERE
C     A AND B ARE N X N SYMMETRIC MATRICES
C     E IS A DIAGONAL MATRIX OF EIGENVALUES STORED AS A COLUMN
C     X IS A N X N MATRIX OF EIGENVECTORS
C     NSMAX IS THE MAXIMUM NUMBER OF SWEEPS TO BE PERFORMED
C     NFIG IS THE NUMBER OF SIGNIFICANT FIGURES TO BE OBTAINED
C-------------------------------------------------------------
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(N1,N1),B(N1,N1),X(N1,N1),E(N1)
C-----INITIALIZATION--------------------------------
      NT = 0
      NN = N-1
      RTOL = 0.1**(2*NFIG)
      EPS  = 0.01
      DO 30 I=1,N
      DO 20 J=1,N
   20 X(I,J) = 0.
   30 X(I,I) = 1.
      IF(N.EQ.1) GO TO 820
C-----SWEEP OFF-DIAGONAL TERMS FOR POSSIBLE REDUCTION---
      DO 800 M=1,NSMAX
      YMAX = 0.0
      DO 700 J=1,NN
      JJ = J + 1
      DO 700 K=JJ,N
C-----COMPARE WITH THRESHOLD VALUE----------------
      IF(A(K,K).LE.0.0) GO TO 1000
      IF(B(K,K).LE.0.0) GO TO 1000
      EA = DABS( (A(J,K)/A(J,J))*(A(J,K)/A(K,K)) )
      EB = DABS( (B(J,K)/B(J,J))*(B(J,K)/B(K,K)) )
      Y = EA + EB
      IF(Y.GT.YMAX) YMAX = Y
      IF(Y.LT.EPS) GO TO 700
C-----CALCULATE TRANSFORMATIONS TERMS-------------
      IF(B(J,J).LE.0.0) GO TO 1000
      IF(A(J,J).LE.0.0) GO TO 1000
      Y  = B(K,K)/A(K,K) - B(J,J)/A(J,J)
      AK = B(J,K)/A(J,J) - (B(K,K)/A(J,J))*(A(J,K)/A(K,K))
      AJ = B(J,K)/A(K,K) - (B(J,J)/A(J,J))*(A(J,K)/A(K,K))
      D1 = Y/2.
      D2 = Y**2 + 4.*AK*AJ
      IF(D2.LT.0.0) GO TO 700
      D2 = DSQRT(D2)/2.
      Z  = D1 + D2
      IF(D1.LT.0.0) Z = D1 - D2
      IF(DABS(Z).GT.0.00001*(Y)) GO TO 80
   70 CA = 0.0
      CG = -A(J,K)/A(K,K)
```

```
   80 IF(Z.EQ.0.0) GO TO 1000
      CA = AK/Z
      CG = -AJ/Z
C-----ZERO TERMS A(J,K) AND B(J,K)----------------
   90 DO 100 I=1,N
      IF(I.EQ.J.OR.I.EQ.K) GO TO 100
      A(J,I) = A(I,J) + CG*A(I,K)
      A(K,I) = A(I,K) + CA*A(I,J)
      A(I,J) = A(J,I)
      A(I,K) = A(K,I)
      B(J,I) = B(I,J) + CG*B(I,K)
      B(K,I) = B(I,K) + CA*B(I,J)
      B(I,J) = B(J,I)
      B(I,K) = B(K,I)
  100 CONTINUE
      AK = A(K,K)
      BK = B(K,K)
      A(K,K) = AK + CA*(A(J,K) + A(J,K) + CA*A(J,J))
      B(K,K) = BK + CA*(B(J,K) + B(J,K) + CA*B(J,J))
      A(J,J) = A(J,J) + CG*(A(J,K) + A(J,K) + CG*AK)
      B(J,J) = B(J,J) + CG*(B(J,K) + B(J,K) + CG*BK)
      A(J,K) = 0.
      B(J,K) = 0.
      A(K,J) = 0.0
      B(K,J) = 0.0
C-----TRANSFORM EIGENVECTORS----------------------
      DO 200 I=1,N
      XJ = X(I,J)
      XK = X(I,K)
      X(I,J) = XJ + CG*XK
  200 X(I,K) = XK + CA*XJ
      NT = NT + 1
  700 CONTINUE
      IF(YMAX.LT.RTOL) GO TO 820
      EPS = 0.10*YMAX**3
      IF(YMAX.GT.1.0) EPS = 0.01
  800 CONTINUE
C-----SCALE EIGEN VECTORS ----------------------
  820 DO 845 J=1,N
      IF(B(J,J).LE.0.0) GO TO 845
      E(J) = A(J,J)/B(J,J)
      BB   = DSQRT(B(J,J))
      IF(BB.EQ.0.0) GO TO 1000
      DO 840 K=1,N
  840 X(K,J) = X(K,J)/BB
      IF(NN.EQ.0) RETURN
  845 CONTINUE
C-----ORDER EIGENVALUES AND EIGENVECTORS ---------
      DO 900 I=1,NN
      JL = I+1
      HT = E(I)
      IM = I
      DO 850 J=JL,N
      IF(HT.LT.E(J)) GO TO 850
      HT = E(J)
      IM = J
  850 CONTINUE
      E(IM) = E(I)
      E(I)  = HT
      DO 900 J=1,N
      HT = X(J,I)
      X(J,I)  = X(J,IM)
  900 X(J,IM) = HT
       CALL MTP1(X,E,N1,N1)
C        CALL MATPRT(X,N1,N1,N,N)
C        CALL MATPRT(E,N1,1,N,1)
C
      RETURN
C
 1000 WRITE(6,3000)
      WRITE(6,3000)
```

```
      GO TO 820
C-------------------------------------------------------------------
      END

C*****************************************************    MTP1    *******

      SUBROUTINE MTP1(A,B,IISIZE,JJSIZE)

C*********************************************************************

      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /DIREC   /DRIN(3),DRIN1(4)
      CHARACTER*1 DRIN
      CHARACTER*2 DRIN1
      DIMENSION A(IISIZE,JJSIZE),B(JJSIZE)
C
      PI=4.DO*DATAN(1.DO)

      WRITE(7,1032)
      WRITE(7,1033)(J,B(J),2.DO*PI/DSQRT(B(J)),J=1,JJSIZE)

      DO 154 L=1,JJSIZE,6
      IH=L+5
      IF(IH.GT.JJSIZE) IH=JJSIZE
      WRITE(7,2033) (J,J=L,IH)
      DO 153 N=1,IISIZE/3
      LN=IISIZE+1-N
      NN=3*(N-1)
      DO 152 J=1,3
      WRITE(7,2034) LN,DRIN(J),(A(NN+J,K),K=L,IH)
  152 CONTINUE
  153 CONTINUE
  154 CONTINUE
C
      RETURN
 1032 FORMAT(/6X,'EIGENVALUES AND EIGENVECTORS (3D SHEAR
     + BUILDING REPRESENTATION)....')
 1033 FORMAT(/6X,'MODE NUMBER',5X,'EIGENVALUE',9X,'PERIOD'//,
     +         (6X,I7,7X,E12.6,3X,E12.6))
 2033 FORMAT(//6X,'MODE SHAPES'/,
     +              6X,'LEVEL',8X,6(5X,I2,4X))
 2034 FORMAT(/6X,I5,2X,A1,2X,12F10.7)
      END

C*****************************************************    MATPRT    *****

       SUBROUTINE MATPRT(A,IISIZE,JJSIZE,ISIZE,JSIZE)

C*********************************************************************

       IMPLICIT REAL*8 (A-H,O-Z)
       INTEGER RTCOL
       DIMENSION A(IISIZE,JJSIZE)
C
       NPAGES=(JSIZE-1)/9+1
       DO 20 I=1,NPAGES
        LTCOL=9*(I-1)+1
        RTCOL=9*I
       IF (RTCOL.GT.JSIZE)RTCOL=JSIZE
        WRITE (7,50) (K,K=LTCOL,RTCOL)
       DO 10 J=1,ISIZE
        WRITE (7,60)J,(A(J,K),K=LTCOL,RTCOL)
   10       CONTINUE
   20       CONTINUE
   50        FORMAT (/6X,'COLUMN:',I4,3X,9(I10,3X),//,
     +                   6X,'  ROW',/)
   60        FORMAT (6X,'ROW',I3,1X,1P9G13.5)
C
       RETURN
       END
```

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LIST OF TECHNICAL REPORTS

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NCEER-87-0003 "Experimentation Using the Earthquake Simulation Facilities at University at Buffalo," by A.M. Reinhorn and R.L. Ketter, to be published.

NCEER-87-0004 "The System Characteristics and Performance of a Shaking Table," by J.S. Hwang, K.C. Chang and G.C. Lee, 6/1/87, (PB88-134259/AS). This report is available only through NTIS (see address given above).

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