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SARCF USER'S GUIDE
SEISMIC ANALYSIS OF REINFORCED CONCRETE FRAMES

by

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A computer program for the automatic damage controlled design of reinforced concrete frames is described. The program is an extension of DRAIN-2D with various enhancements, such as an improved model for RC frame elements, automatic generation of random earthquakes, a new damage model, and an automated damage-controlled design. The current version covers only beam and beam-column elements. It is intended to implement other structural element types in future program versions.

This report reviews a few important aspects of the program, some of them retained from DRAIN-2D, such as basic structural analysis assumptions and the step-by-step solution of the nonlinear equations of motion. The frame element and damage model are described in some detail, as are the basis for the automated damage-controlled design procedure. Several examples illustrate the use and capabilities of the program.

Appendices contain the user's manual and the complete source listing of the program.

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PREFACE

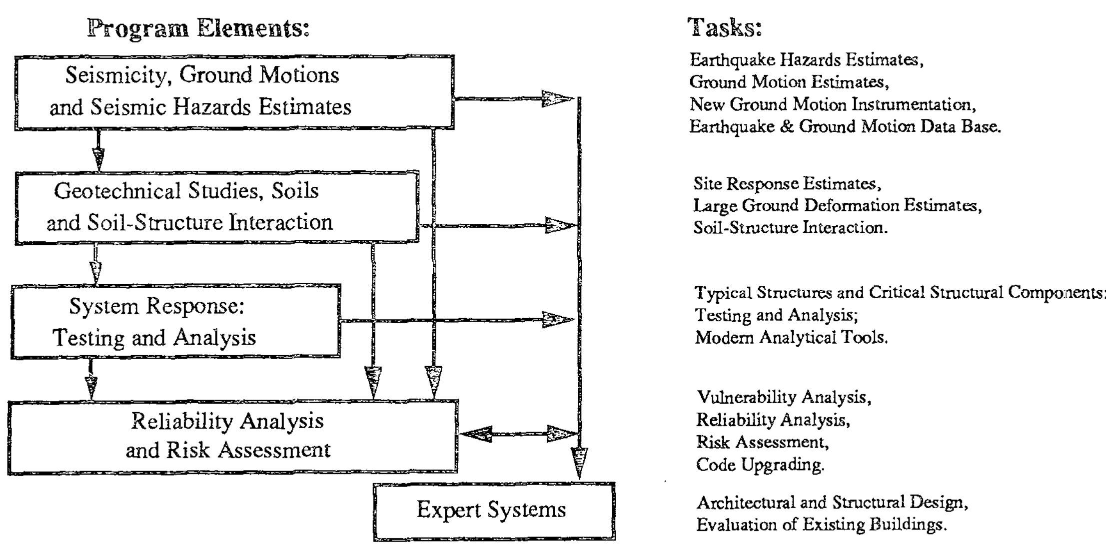
The National Center for Earthquake Engineering Research (NCEER) is devoted to the expansion and dissemination of knowledge about earthquakes, the improvement of earthquake-resistant design, and the implementation of seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis 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 1, Existing and New Structures, and more specifically to system response investigations.

The long term goal of research in Existing and New Structures is to develop seismic hazard mitigation procedures through rational probabilistic risk assessment for damage or collapse of structures, mainly existing buildings, in regions of moderate to high seismicity. The work relies on improved definitions of seismicity and site response, experimental and analytical evaluations of systems response, and more accurate assessment of risk factors. This technology will be incorporated in expert systems tools and improved code formats for existing and new structures. Methods of retrofit will also be developed. When this work is completed, it should be possible to characterize and quantify societal impact of seismic risk in various geographical regions and large municipalities. Toward this goal, the program has been divided into five components, as shown in the figure below:



System response investigations constitute one of the important areas of research in Existing and New Structures. Current research activities include the following:

1. Testing and analysis of lightly reinforced concrete structures, and other structural components common in the eastern United States such as semi-rigid connections and flexible diaphragms.
2. Development of modern, dynamic analysis tools.
3. Investigation of innovative computing techniques that include the use of interactive computer graphics, advanced engineering workstations and supercomputing.

The ultimate goal of projects in this area is to provide an estimate of the seismic hazard of existing buildings which were not designed for earthquakes and to provide information on typical weak structural systems, such as lightly reinforced concrete elements and steel frames with semi-rigid connections. An additional goal of these projects is the development of modern analytical tools for the nonlinear dynamic analysis of complex structures.

The systems response area is, in part, concerned with the design and analysis of structures using sophisticated computer programs. This report describes improved models for the analysis and design of reinforced concrete frames and for damage estimation. These can be used to assess the expected distribution of damage throughout the frame. The program can help to estimate the response of reinforced concrete frames and in damage assessment. The program and the new models are described in detail and a listing of the program is provided.

ABSTRACT

A computer program for the automatic damage controlled design of reinforced concrete frames is described. The program is an extension of DRAIN-2D with various enhancements, such as an improved model for RC frame elements, automatic generation of random earthquakes, a new damage model, and an automated damage-controlled design. The current version covers only beam and beam-column elements. It is intended to implement other structural element types in future program versions.

This report reviews a few important aspects of the program, some of them retained from DRAIN-2D, such as basic structural analysis assumptions and the step-by-step solution of the nonlinear equations of motion. The frame element and damage model are described in some detail, as are the basis for the automated damage-controlled design procedure. Several examples illustrate the use and capabilities of the program.

Appendices contain the user's manual and the complete source listing of the program.

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1. Introduction

Modern seismic design of concrete buildings relies on the energy dissipation of structural components through large inelastic deformations. A consistent design approach thus requires a rational assessment of the reliability of a given design subjected to a hypothetical seismic event of specified intensity. As long as the structural response is limited to linear elastic behavior, standard methods of structural analysis suffice for this task, and very approximate techniques have proven adequate for most practical purposes.

If inelastic frame action is taken into account, accurate response analyses are considerably more difficult. Even though grossly simplified analysis methods have been proposed for design purposes (9), their application to actual structures is not straightforward, and their accuracy varies widely. Thus, more refined mathematical models and analysis techniques are needed for unusual situations. They also can be used for calibration purposes in cases where data from physical experiments are not available.

It is the purpose of this report to document SARCF, a computer program for seismic analysis of reinforced concrete frames, which has been partially developed at Columbia University. It contains a refined mathematical model for reinforced concrete frame elements, which can simulate the strength and stiffness degradation observed in laboratory experiments under strong load reversals. The large computational effort required for full-scale nonlinear seismic analyses will preclude the use of this program in the day-to-day operations of a design firm, but its claim to high accuracy commends it for special and comparative purposes.

A significant feature of the program is its automted damage-controlled design procedure. It incorporates a set of design rules, with which it can perform iterations on a preliminary design entered by the user, until a uniform damage distribution of specified value is achieved. Thus the least amount of damage and high reliability of the frame for a seismic event of given intensity is assured.

The program is based on the well-known structural analysis program DRAIN-2D (8). Over the years, the following major modifications and enhancements have been added to the program.

1) The Roufaiel-Meyer frame element model (11,12), with enhancements due to Chung (4,5), was incorporated to replace the element models supplied with the standard DRAIN-2D version.

2) At any time during a dynamic time history analysis it is possible to interrupt the analysis to compute mode shapes and natural frequencies using the current tangent stiffness of the frame.

3) At each time step during the dynamic time history analysis, a damage index is computed for both ends of each element in the frame.

4) Whereas DRAIN-2D expects the user to supply a ground motion time history and performs only one time history analysis per run, SARCF may also generate an arbitrary number of artificial ground motion histories upon demand, using Monte Carlo simulation.

5) The program can perform a static analysis for gravity loads before executing the dynamic time history analysis. Thus the problem of nonlinear superposition is solved correctly.

6) Following the analysis of a frame structure for a specified number of ground motions, the program computes mean value and standard deviation of all element damage indices.

7) The program contains a number of design rules which it utilizes to modify the given frame such that the damage distribution becomes as uniform and as low as specified by the user.

The next chapter summarizes some of the important theoretical aspects of the original DRAIN-2D program, especially the numerical method used to solve the nonlinear equations of dynamic motion. Also the eigenvalue solver and artificial ground motion generator will be reviewed briefly.

Chapter 3 contains summary descriptions of the hysteresis model for RC frame elements, as well as of our damage index. The automated damage-controlled design procedure is described in chapter 4. The examples in chapter 5 illustrate the various capabilities and the use of the program. The user's guide in Appendix A contains detailed input specifications as well as instructions for preparing the data file and executing the program. The complete Fortran source listing of the program is given in Appendix B.

2. Nonlinear Dynamic Frame Analysis

This chapter summarizes some of the theoretical background for nonlinear dynamic analysis of frames. Much of this material is based on program DRAIN-2D (8). The eigenvalue solver utilizes the determinant search algorithm of the well-known SAP4 program (3).

2.1 Basic Assumptions

For analysis, a structure can be idealized as a finite number of nodes, or joints, interconnected by a finite number of deformable elements, or members. The nodes may have finite dimensions, but are commonly idealized as points. The elements may in general be one-, two- or three-dimensional, but in the present version of the program only one-dimensional or line elements are incorporated. Loads may be applied to the nodes or to the elements.

The analysis is based on the following assumptions:

1) The input structure is idealized as a plane frame. Out-of-plane motion is ignored.
2) Each member is treated as a massless prismatic line member represented by its centroidal axis, and all the mass in the structure is assumed to be lumped at the corresponding nodes.
3) The $P-\Delta$ effect is taken into account by adding geometric stiffness to the column stiffness, using the axial forces produced by the static loads.
4) Axial and shear deformations of the frame are ignored.
5) The idealized frame is assumed to be fixed at the base of the first story columns on a rigid foundation.

Based on the above assumptions, the equilibrium equations to be solved at any stage of the analysis can be obtained as described in the next section. They are solved by an efficient algorithm based on the Gaussian elimination method. The structure stiffness is stored in a compacted form to optimize the use of core storage, and during the elimination operation virtually all unnecessary arithmetic operations are avoided. The initial elastic stiffness is stored separately in the case that the automated design option is exercised.

2.2 Solution of Equations of Motion

Basic analysis procedures are the same as those for DRAIN-2D (8). That is, member forces are computed for each load increment, and the tangent stiffness matrix is updated to account for changes in any of the element stiffnesses. The equations of motion to be solved at any stage of the analysis are written as

$$[M]\{\Delta\ddot{u}\} + [C_t]\{\Delta\dot{u}\} + [K_t]\{\Delta u\} = \{\Delta p\} \tag{2.1}$$

where

$[K_t]$: current tangent stiffness matrix

$[M]$: mass matrix

$[C_t]$: current damping matrix

$\{\Delta p\} = -[M]\{I\}\{\Delta\ddot{u}_g\}$
: load increment due to earthquake excitation

$\{I\}$: modal influence vector

$\Delta\ddot{u}_g$: earthquake ground acceleration increment

The above system of equations is solved using the constant acceleration method (2). That is, using velocity and acceleration at the previous time step, the finite increments are

$$\begin{aligned} \{\Delta\ddot{u}\} &= \frac{4}{\Delta t^2}\{\Delta u\} - \frac{4}{\Delta t}\{\dot{u}_o\} - 2\{\ddot{u}_o\} \\ \{\Delta\dot{u}\} &= \frac{2}{\Delta t}\{\Delta u\} - 2\{\dot{u}_o\} \end{aligned} \tag{2.2}$$

where the subscript "o" refers to the previous time step. The damping matrix is assumed to be a linear combination of mass and stiffness proportional components, known as Rayleigh damping,

$$[C_t] = \alpha[M] + \beta[K_t] \tag{2.3}$$

Substitution of Eqs (2.2) and (2.3) into Eq (2.1) gives

$$\begin{aligned}\left(\frac{4}{\Delta t^2} + \frac{2\alpha}{\Delta t}\right)[M]\{\Delta u\} + [K_t]\left(1 + \frac{2\beta}{\Delta t}\right)\{\Delta u\} - 2\beta[K_t]\{\dot{u}_o\} \\ = \{\Delta p\} + [M]\{2\ddot{u}_o + \frac{4}{\Delta t}\dot{u}_o + 2\alpha\dot{u}_o\}\end{aligned} \tag{2.4}$$

To avoid the need to compute the product $\beta[K_t]\{2\dot{u}_o\}$, Wilson (16) suggested the following transformation.

$$\{\Delta x\} = \{\Delta u\} + \beta\{\Delta\dot{u}\} = \left(1 + \frac{2\beta}{\Delta t}\right)\{\Delta u\} - 2\beta\{\dot{u}_o\} \tag{2.5}$$

Using Eq (2.5), Eq (2.4) becomes

$$[\gamma M + K_t]\{\Delta x\} = \{\Delta p\} + [M]\{2\ddot{u}_o + \frac{4}{\Delta t}\dot{u}_o + 2\alpha\dot{u}_o\} \tag{2.6}$$

where

$$\gamma = \frac{\left(\frac{4}{\Delta t^2} + \frac{2\alpha}{\Delta t}\right)}{\left(1 + \frac{2\beta}{\Delta t}\right)}$$

After the solution of Eq (2.6) for $\{\Delta x\}$, the nodal displacement increments, $\{\Delta u\}$, are obtained from Eq (2.5).

The proportionality factors α and β of Eq (2.3) can be determined by specifying damping ratios, λ_1 and λ_2, for any two modes of vibration, say the first and second modes. The set of two simultaneous equations used to obtain α and β is

$$\lambda_n = \frac{\alpha}{2\omega_n} + \frac{\beta\omega_n}{2} \quad ; \quad n = 1,2 \tag{2.7}$$

where λ_n indicates the proportion of critical damping in the n-th mode and ω_n denotes the circular frequency of the n-th mode.

2.3 Generation of Artificial Earthquakes

For nonlinear dynamic analysis of structures, the representation of earthquake ground motions as a stationary random process is of limited use because of the time dependency of the mean peak acceleration envelope and the duration of strong ground motion. Artificial ground acceleration histories, $\ddot{x}(t)$, can be generated by multiplying an envelope function, $s(t)$, and a stationary Gaussian process, $g(t)$. The envelope is here assumed to be either of a trapezoidal form or an exponential function, Fig 2.1 (14),

$$s(t) = \frac{e^{-\alpha t} - e^{-\beta t}}{e^{-\alpha t_n} - e^{-\beta t_n}} \qquad t > 0 \tag{2.8}$$

where α and β are positive constants and $t_n = \frac{1}{\alpha-\beta} ln\left(\frac{\alpha}{\beta}\right)$ with $\alpha > \beta$. A Gaussian process, $g(t)$, can be obtained by using the well-known Kanai-Tajimi spectrum as the power spectral density function,

$$S(\omega) = S_o \times \frac{1 + 4\varsigma_g^2(\frac{\omega}{\omega_g})^2}{[1-(\frac{\omega}{\omega_g})^2]^2 + 4\varsigma_g^2(\frac{\omega}{\omega_g})^2} \tag{2.9}$$

where ω_g is the characteristic ground frequency, ς_g is the predominant damping coefficient, S_o is the intensity of Gaussian white noise over the range $-\infty < \omega < \infty$. The Gaussian process, $g(t)$, can be generated by using Monte Carlo technique (15),

$$g(t) = \sqrt{2}\sum_{k=1}^{N}\sqrt{G(\omega_k)\Delta\omega}\cdot cos(\omega_k t - \phi_k) \tag{2.10}$$

where ϕ_k is the random phase angle, uniformly distributed between 0 and 2π. $\omega_k = k\Delta\omega$, and $\omega_u = N\Delta\omega$ is the upper cut-off frequency. $G(\omega_k) = 2S(\omega_k)$ is the one-sided power spectrum. To generate an artificial earthquake, Shinozuka (13) suggested the following relationship between the intensity, S_o, and the peak ground acceleration, PGA. With

$$\sigma_g^2 = E\left[\ddot{x}_g^2\right] = \int S(\omega)\ d\omega = \frac{S_o \pi \omega_g (1 + 4\varsigma_g^2)}{2\varsigma_g} \tag{2.11}$$

the peak ground acceleration can be written as

$$PGA = \alpha_g S_o^{\frac{1}{2}} \tag{2.12}$$

where $\alpha_g = p_g \left[\pi \omega_g (\frac{1}{2\varsigma_g} + 2\varsigma_g)\right]^{\frac{1}{2}}$, and p_g denotes the peak factor, empirically assumed to be 3.0 in this study.

Because of the random nature of earthquake acceleration histories, structure response quantities (such as damage indices) are more meaningful if formed as averages for an ensemble of responses, rather than responses to individual input functions. In order to determine the minimum number of sample functions necessary to give useful mean responses, the running mean values of damage indices for certain structural elements of a frame can be computed as functions of the number of sample earthquake input histories (6). The number of sample functions to be generated is input by the user.

2.4 Eigenvalue Solver

The eigenvalue solver is based on the determinant search algorithm and has been adopted with minor modifications from the SAP4 program (3). The theoretical background has been described in detail by Bathe (2).

The user has the option of computing the natural frequencies and mode shapes, by interrupting a time history analysis at any point to solve the eigenvalue problem

$$[K_t]\{\phi_i\} = \omega_i^2 [M]\{\phi_i\} \tag{2.13}$$

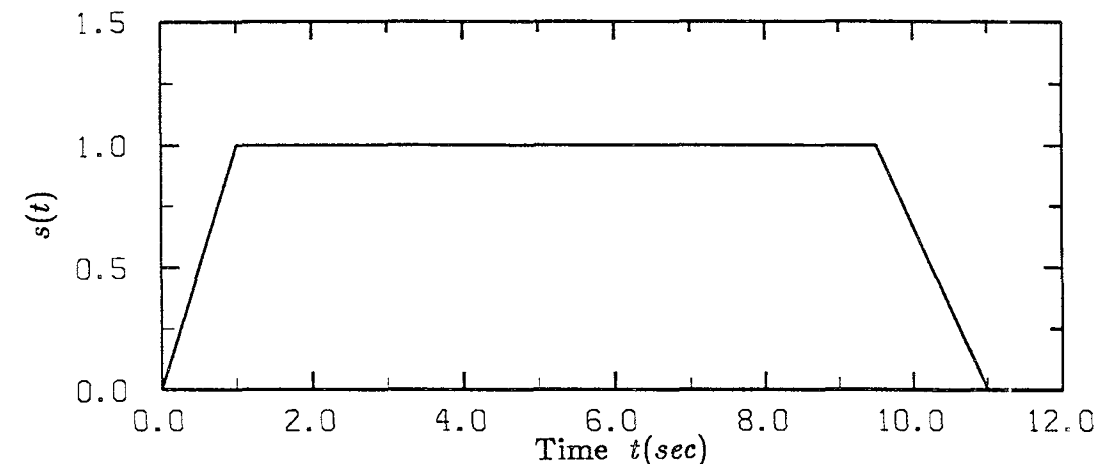
where

$[K_t]$: current tangent stiffness matrix

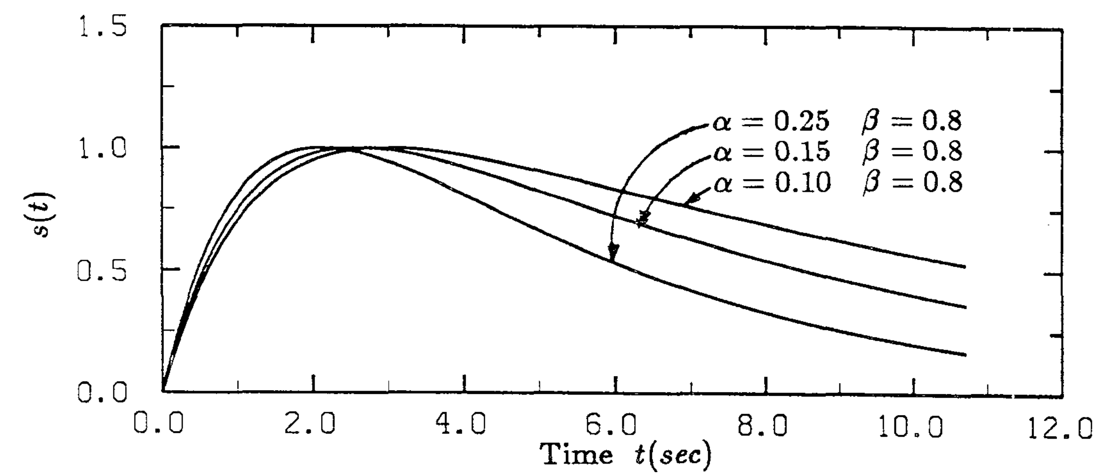
$[M]$: mass matrix

$\{\phi_i\}$: i–th modal vector

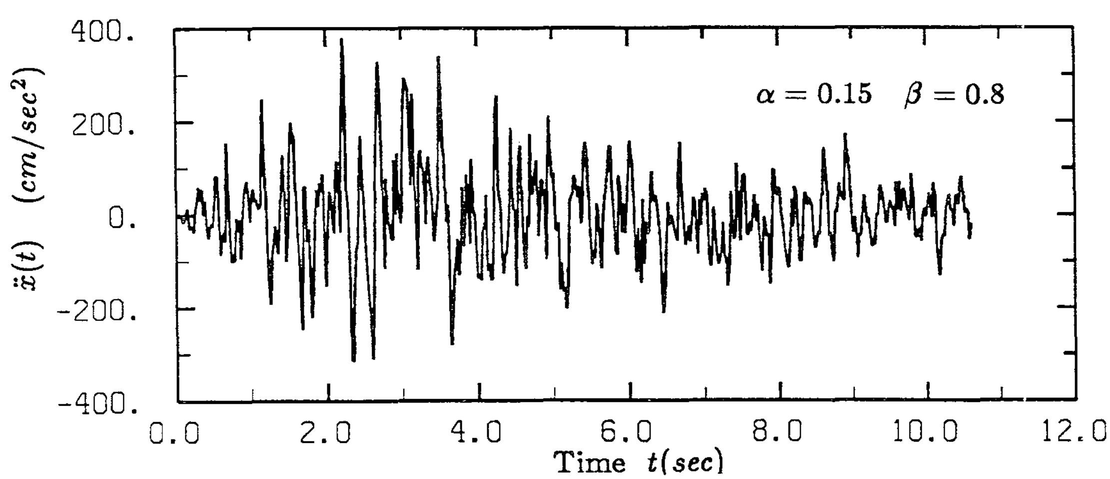
ω_i : the natural frequency corresponding to i–th mode



a) Trapezoidal Envelope Function



b) Exponential Envelope Function



c) Nonstationary Ground Motion Based on Exponential Envelope Function

Fig. 2.1 – Generation of Artificial Earthquakes

3. Frame Element and Damage Index

This chapter describes the reinforced concrete frame element model of SARCF. Originally proposed by Roufaiel and Meyer (11,12), several aspects of the model have been refined by Chung (4,5), particularly for the representation of stiffness and strength degradation. This model takes into account the finite size of the plastic regions and realistically simulates the experimental hysteretic behavior under cyclic load. In addition, the computer program contains a new damage model as an objective measure of strength deterioration.

3.1 Primary Moment-Curvature Curve

The primary moment-curvature curve relates moment to curvature under monotonically increasing loading. If the stress-strain laws for steel and concrete are specified and the cross-sectional dimensions are known, it is relatively straightforward to compute the moment associated with any specified curvature (4).

First, the neutral axis has to be positioned for a given moment or curvature, based on the corresponding concrete or tensile steel strain. The complete moment-curvature is obtained by increasing the concrete strain or steel strain in small increments from zero until any one of the possible failure modes is reached, and at each step computing the neutral axis position, the curvature and the bending moment. This analysis is based on the following assumptions:

1) The stress-strain curves of reinforcing steel and concrete are idealized as shown in Figs A.2 and A.3;
2) The tensile strength of concrete is ignored;
3) Plane sections remain plane after deformation;
4) The axial force, if any, is acting at the plastic centroid of the section.

3.2 Hysteresis Model

Under load reversals, the stiffness of a RC member experiences a progressive reduction due to cracking of the concrete and bond deterioration of the steel-concrete interface. In a Takeda-type model, a set of rules is specified, with which it is possible to characterize the hysteretic behavior more realistically than either with a simple bilinear or degrading bilinear formulation. The model of Roufaiel and Meyer utilizes such a set of rules and therefore has been adopted herein, together with certain improvements to better represent stiffness and strength degradation, Fig 3.1.

The hysteresis response can be characterized by five different types of branches:

1) Elastic loading and unloading: If the maximum moment does not exceed the yield moment M_y, the moment-curvature relationship is given by

$$\Delta M = (EI)_1 \Delta\phi \tag{3.1}$$

where $(EI)_1 = (EI)_e$ is the initial elastic sectional stiffness.

2) Inelastic loading: If the moment exceeds the yield moment and is still increasing, the moment-curvature relationship is given by

$$\Delta M = (EI)_2 \Delta\phi \tag{3.2}$$

where $(EI)_2 = p(EI)_e = \frac{M_u^+ - M_y^+}{\phi_u^+ - \phi_y^+}$.

3) Inelastic unloading: If the moment decreases after the yield moment has been exceeded, the moment-curvature relationship becomes

$$\Delta M = (EI)_3 \Delta\phi \tag{3.3}$$

where $(EI)_3 = \frac{M_x^+}{\phi_x^+ - \phi_r^+}$. The "+" superscript denotes loading in the positive sense. Likewise, a "−" superscript stands for loading in the negative sense.

4) Inelastic reloading during closing of cracks: In a reversed load cycle, previously opened cracks tend to close, leading to an increase in stiffness and

a characteristic "pinched" shape of the moment-curvature curve. This effect is a function of the shear span. If the absolute value of the moment increases but is still less than a certain "crack-closing moment", M_p^+, the moment-curvature relationship is in this case

$$\Delta M \; = \; (EI)_4 \Delta\phi \tag{3.4}$$

where $(EI)_4 = \frac{M_p^+}{\phi_p^+ \; - \; \phi_r^-}$.

5) Inelastic reloading after closing of cracks: Once the absolute value of the moment exceeds the "crack-closing moment", M_p^+, and is still increasing, then the moment-curvature relationship is

$$\Delta M \; = \; (EI)_5 \Delta\phi \tag{3.5}$$

where $(EI)_5 = \frac{\overline{M}_x^+ - M_p^+}{\overline{\phi}_x^+ \; - \; \phi_p^+}$.

For further details see Ref (4). It should be emphasized that this model, unlike most other models, does not depend on the program user's input of either stiffness or strength degradation parameters. These parameters are determined internally from the basic material and section properties that are input.

3.3 Tangent Stiffness Matrix

To compute the tangent stiffness matrix of a general frame member, the element is subdivided into three regions, Fig 3.2:

1) an inelastic region of length x_i at node i, having the average stiffness $(\overline{EI})_i$,

2) an inelastic region of length x_j at node j, having the average stiffness $(\overline{EI})_j$, and

3) an elastic region of length $L - x_i - x_j$ with the initial stiffness $(EI)_e$.

For the six planar degrees of freedom identified in Fig 3.2, the tangent stiffness of this frame element can be written as

$$[K_e] = \begin{bmatrix} k_{11} & 0 & 0 & k_{14} & 0 & 0 \\ & k_{22} & k_{23} & 0 & k_{25} & k_{26} \\ & & k_{33} & 0 & k_{35} & k_{36} \\ & & & k_{44} & 0 & 0 \\ & & sym. & & k_{55} & k_{56} \\ & & & & & k_{66} \end{bmatrix}$$

The coefficients, $k_{11} = k_{44} = -k_{14} = \frac{EA}{L}$, are assumed to remain constant. k_{33}, k_{36}, and k_{66} are obtained from their flexibility counterparts, which in turn can be computed by integrating the moment-curvature expressions over the entire length of the member.

Denoting by

$$\begin{aligned} Q_i &= \frac{(EI)_e}{(\overline{EI})_i} \\ Q_j &= \frac{(EI)_e}{(\overline{EI})_j} \end{aligned} \tag{3.6}$$

the stiffness ratios for the end regions i and j, the flexibility coefficients are given by Roufaiel (12).

$$\begin{aligned} f_{ii} &= \frac{1}{3(EI)_e L^2}\left[(Q_j-1)x_j^3 - (Q_i-1)(L-x_i)^3 + Q_i L^3\right] \\ f_{jj} &= \frac{1}{3(EI)_e L^2}\left[(Q_i-1)x_i^3 - (Q_j-1)(L-x_j)^3 + Q_j L^3\right] \\ f_{ij} &= \frac{1}{3(EI)_e L^2}\left[(Q_j-1)x_j^2(1.5L-x_j) + (Q_i-1)x_i^2(1.5L-x_i) + \frac{L^3}{2}\right] \end{aligned} \tag{3.7}$$

The corresponding stiffness coefficients follow as

$$\begin{aligned} k_{33} &= \frac{f_{jj}}{f_{ii}f_{jj} - f_{ij}^2} \\ k_{66} &= \frac{f_{ii}}{f_{ii}f_{jj} - f_{ij}^2} \\ k_{36} &= -\frac{f_{ij}}{f_{ii}f_{jj} - f_{ij}^2} \end{aligned} \tag{3.8}$$

The remaining coefficients follow from statics

$$
\begin{aligned}
k_{23} &= -k_{35} = \frac{(k_{33} + k_{36})}{L} \\
k_{26} - k_{56} &= \frac{(k_{36} + k_{66})}{L} \\
k_{22} &= k_{55} = -k_{25} = \frac{(k_{33} + 2 \times k_{36} + k_{66})}{L^2}
\end{aligned}
\tag{3.9}
$$

The length x_i and stiffness ratio Q_i of the plastic region at node i depend on the current branch of the moment-curvature diagram. For elastic loading or unloading, we have

$$
\begin{aligned}
x_i &= 0.0 \\
Q_i^1 &= 1.0
\end{aligned}
\tag{3.10}
$$

For inelastic loading (see branch 2 in Fig 3.1), the length of the plastic region is determined by

$$x_i = \frac{M_i - M_y}{M_i + M_j}\, L \tag{3.11}$$

because bending moments are assumed to vary linearly along the beam length. The stiffness ratio within the plastic region is assumed to be constant over the length x_i and equal to the value at node i, i.e.

$$Q_i^2 = \frac{(EI)_e}{(EI)_2} \tag{3.12}$$

Upon inelastic unloading, x_i remains the maximum plastic region length reached in any previous inelastic loading cycle. But now the stiffness varies over the length of the plastic region, and for an accurate analysis, it would be necessary to compute the stiffnesses at all sections. This would be a time-consuming task and require considerable computer storage. In order to simplify this task, an empirical averaging process is used.

Directly at node i the stiffness has to be equal to $(EI)_3$, while at the border line between plastic and elastic regions it is $(EI)_e$. We approximate the variable stiffness by an average value, assumed to be constant over the length of the plastic region and given by

$$(\overline{EI})_3 = (EI)_3 \frac{(EI)_e}{c(EI)_e + (1-c)(EI)_3} \tag{3.13}$$

where c is an empirical constant, for which values between 0.5 and 0.75 have been found to give most accurate results. In the present analysis a value of 0.5 is used.

The stiffness ratio for the plastic region at node i during inelastic unloading follows as

$$Q_i^3 = \frac{(EI)_e}{(\overline{EI})_3} = c\left(\frac{(EI)_e}{(EI)_3} - 1\right) + 1 \tag{3.14}$$

Similarly, the stiffness ratios during inelastic reloading(branches 4 and 5 in Fig 3.1) are

$$\begin{aligned} Q_i^4 &= \frac{(EI)_e}{(\overline{EI})_4} = c\left(\frac{(EI)_e}{(EI)_4} - 1\right) + 1 \\ Q_i^5 &= \frac{(EI)_e}{(\overline{EI})_5} = c\left(\frac{(EI)_e}{(EI)_5} - 1\right) + 1 \end{aligned} \tag{3.15}$$

3.4 Nodal Damage Index

This damage index, D_e, quantifies the damage of a member section in a plastic hinge. It takes into consideration the nonlinear relationship between maximum displacement and dissipated energy, the strength deterioration rate and the number of load cycles to failure. The damage index is expressed in the form of a modified Miner's Rule. It contains damage modifiers, which reflect the effect of the loading history, and it considers the fact that RC members typically respond differently to positive and negative moments:

$$D_e = \sum_i \left(\alpha_i^+ \frac{n_i^+}{N_i^+} + \alpha_i^- \frac{n_i^-}{N_i^-}\right) \tag{3.16}$$

where

i : indicator of different displacement or curvature levels

$N_i = \dfrac{M_i - M_{fi}}{\Delta M_i}$: number of cycles up to curvature level i to cause failure

ΔM_i : strength drop in one load cycle up to curvature level i, Fig 3.3

n_i : number of cycles up to curvature level i actually applied

α_i : damage modifier

$+, -$: indicator of loading sense

$(M_i - M_{fi})$ denotes the total strength drop at curvature level i. The strength drop in a single load cycle up to curvature level i, ΔM_i (Fig 3.3), is given by

$$\Delta M_i = \left(\frac{\phi_i - \phi_f}{\phi_f - \phi_y}\right)^{\omega} \Delta M_f \qquad (3.17)$$

The loading history effect is captured by including the damage modifier α_i, which, for positive moment loading, is defined as

$$\alpha_i^+ = \frac{\frac{1}{n_i^+}\sum_{j=1}^{n_i^+} k_{ij}^+}{\overline{k_i}^+} \cdot \frac{\phi_i^+ + \phi_{i-1}^+}{2\phi_i^+} \qquad (3.18)$$

where

$$k_{ij}^+ = \frac{M_{ij}^+}{\phi_i^+} \qquad (3.19)$$

is the stiffness during the j-th cycle up to load level i, Fig 3.4, and

$$\overline{k_i}^+ = \frac{1}{N_i^+}\sum_{j=1}^{N_i^+} k_{ij}^+ \qquad (3.20)$$

is the average stiffness during N_i^+ cycles up to load level i. Denoting with

$$M_{ij}^+ = M_{i1}^+ - (j-1)\Delta M_i^+ \qquad (3.21)$$

the moment reached after j cycles up to load level i, Fig 3.4, the damage modifier α_i^+ can be expressed as

$$\alpha_i^+ = \frac{M_{i1}^+ - \frac{1}{2}\left(n_i^+ - 1\right)\Delta M_i^+}{M_{i1}^+ - \frac{1}{2}\left(N_i^+ - 1\right)\Delta M_i^+} \cdot \frac{\phi_i^+ + \phi_{i-1}^+}{2\phi_i^+} \qquad (3.22)$$

As Fig 3.4 illustrates, the energy that can be dissipated during a single cycle up to a given load level i decreases in successive cycles. That means the damage increments also decrease. In a constant-amplitude loading sequence, the first load cycle will cause more damage than the last one. As a result, the α_i-factor decreases as load cycling proceeds. This has been considered by incorporating the stiffness ratio into the damage modifier. The factor $\frac{\phi_i^+ + \phi_{i-1}^+}{2\phi_i^+}$ has been introduced to normalize the damage increments in the case of changing load amplitudes. For negative loading, "+" superscripts are replaced by "−" superscripts. For further details refer to Refs (4,6).

3.5 Structural Damage Index

A structural damage index can be composed of individual story damage indices (10), each of which is a weighted average of the damage indices of all potential plastic hinges in the story under consideration,

$$D_{S_k} = \frac{\sum_{i=1}^{n_k} D_i^k \cdot E_i^k}{\sum_{i=1}^{n_k} E_i^k} \tag{3.23}$$

where D_{S_k} and D_i^k denote the damage index for k-th story and for joint i in story k, respectively. n_k is the number of potential plastic hinges in the k-th story ($2 \times$ number of elements in story k). E_i^k is the energy dissipated in joint i of story k. Then, the structural damage index, D_g, can be defined as,

$$D_g = \sum_{k=1}^{N} D_{S_k} I_k \tag{3.24}$$

where N is the total number of stories. $I_k = \frac{N+1-k}{N}$ is the weighting factor for story k, which expresses the greater importance of the lower stories of a building ($I_k = 1$ for $k = 1$).

By combining the detailed damage information of an entire frame into a single number (D_g), too much information is lost to make this single structural damage index a useful estimator of the structure's residual strength and capacity to withstand further loading. However, for other purposes such as insurance risk evaluations this kind of single number may be of use. Any rational evaluation of a structure's reliability appears to be meaningful only if the mechanical deterioration process of all significant structural members are accurately accounted for.

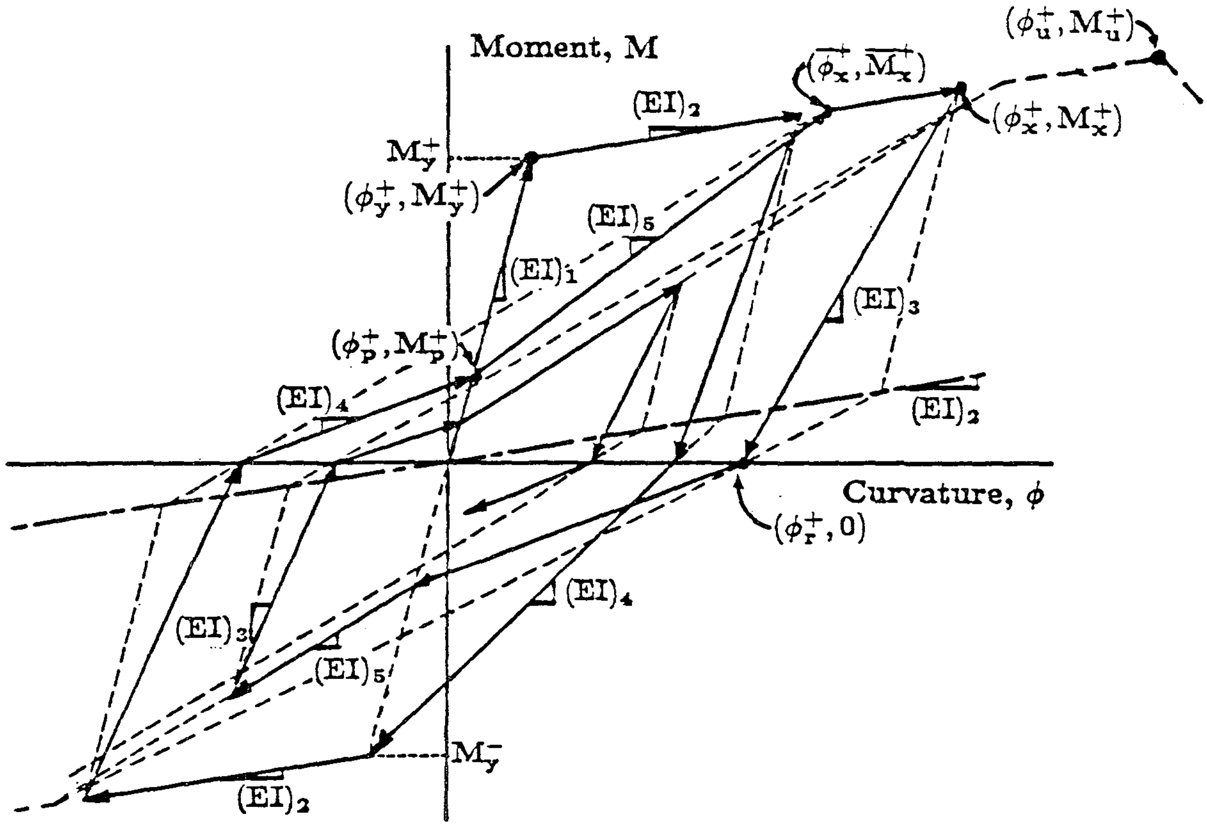


Fig. 3.1 – Typical Hysteretic Moment-Curvature Relationship

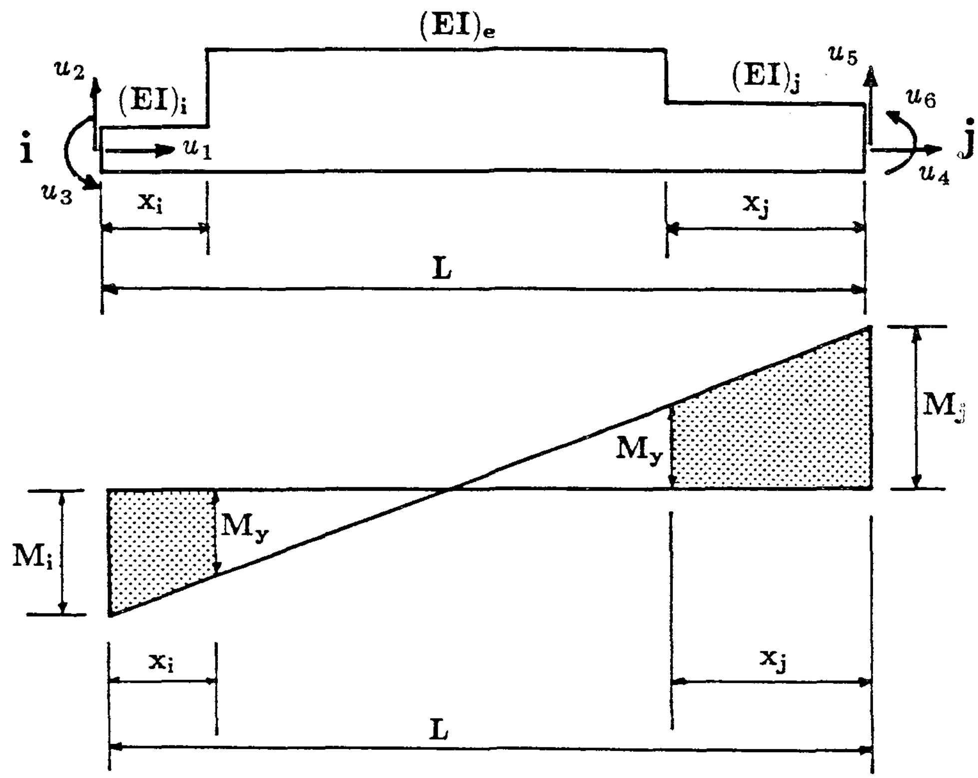


Fig. 3.2 – Member Size Model

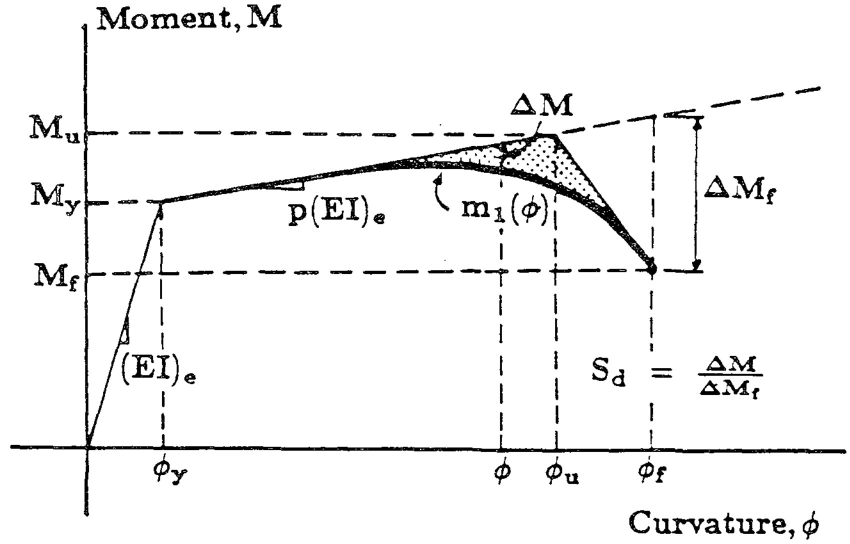


Fig. 3.3 – Strength Degradation Curve

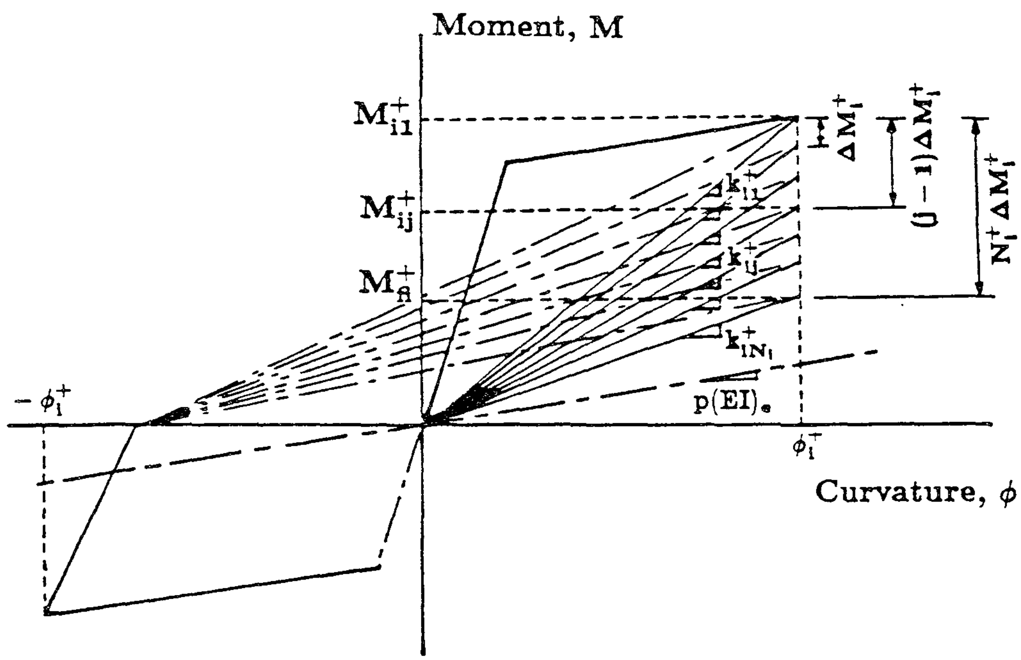


Fig. 3.4 – Strength Drop Due to Cyclic Loading

4. Automatic Design Procedure

The automatic design method of Fig 4.1 is based on a thorough study of the effects of three important design variables, the longitudinal reinforcement, the confinement steel, and member depth. Design rules derived from a large number of numerical studies allow an iterative improvement of a preliminary design until the distribution of damage indices has reached a user-specified degree of uniformity, Ref (6). The rationale for this design philosophy is that a structure, which is shown to dissipate energy uniformly in its main components, can be expected to survive an earthquake of given intensity with the least amount of damage possible.

The key components of the design procedure are, 1) an algorithm to evaluate the computed damage distribution by comparing it with user-specified acceptance criteria; 2) a set of design rules which permit the automatic modification of the structure such that improved performance is guaranteed.

The damage acceptance algorithm contains the following components:

1) Damage (and plastic hinges) in columns is unacceptable, as required by the strong-column weak-beam concept. Specifically, a column damage index greater than the user-specified allowable index shall be flagged as unacceptable in any column except at the base of the first story.
2) The mean value of all beam damage indices shall not exceed a user-specified acceptance level, allowing for a small prescribed tolerance.
3) The damage index of any beam element shall not deviate from the mean value computed for all beams by more than a user-specified allowance. Thus, individual beam elements may be flagged as having too much or too little damage.

If the damage index of at least one frame member is unacceptable, corrective action has to be taken, i.e. the design will have to be modified such that an improved performance in a reanalysis is guaranteed and convergence towards an acceptable design is assured.

Structural designers normally rely on their experience when designing a structure to withstand seismic loads. They can fall back on both knowledge of rational principles of structural theory and intuition. The design task is complicated by the fact that a typical reinforced concrete frame is a highly redundant structure with intricate load-resistant mechanisms. In addition, the random nature of the earthquake loading makes the design task more difficult.

By performing numerous numerical parameter studies, we accumulated a store of experience with a certain regular building frame that structural engineers would possibly gain in years of practice. The rules summarized below, which are contained in program SARCF, are considered to form a useful starting point for an automatic design procedure.

1) For any beam element which showed an unacceptable level of damage in the preliminary analysis, the longitudinal steel will be increased (or decreased) by 5%,

$$\Delta A_s^1 = 0.05 \times A_s \times \mathrm{SIGN}[D - D_{all}] \tag{4.1}$$

where A_s is the original amount of steel, D is the amount of damage determined in the preliminary analysis, and D_{all} is the allowable damage index of the beam element. The steel increments (reductions) of Eq (4.1) are only trial amounts introduced to determine in a first design iteration the influence of these changes.

2) In a subsequent design iteration "i" , the amount of steel in any beam with unacceptable damage is changed according to,

$$\Delta A_s^i = \Delta A_s^{i-1} \times \frac{D^i - D_{all}}{D^{i-1} - D^i} \tag{4.2}$$

where ΔA_s^i denotes the additional(or deductible) amount of longitudinal steel for the element in question, ΔA_s^{i-1} denotes the steel increased (or decreased) for the previous iteration, D^i and D^{i-1} represent damage values in the (i)th and (i-1)th iteration, respectively.

3) To adhere to the strong-column weak-beam concept, any column with unacceptable damage has to satisfy the requirement, $M_y^{col} \geq 1.25 \times M_y^{beam}$, where M_y^{col} is the yield moment of the column considered, and M_y^{beam} is the yield moment of the beam framing into the same joint. There are four categories of joints; 1) one beam and one column meeting at a joint, 2) one beam and two columns, 3) two beams and one column, in which case M_y^{beam} is the sum of the absolute value of the two beam yield moments, and 4) two beams and two columns. In the last case, M_y^{beam} is the average of the two beam yield moments. Then, the reinforcing steel of each column will be linearly increased(or decreased) by the amount,

$$\Delta A_s^i = \Delta A_s^{col} \times \frac{M_y^i - M_y^{i-1}}{\Delta M_y^{col}} \tag{4.3}$$

where the superscript indicates the iteration number. ΔM_y^{col} denotes the increment of the yield moment of the column when the longitudinal steel of the corresponding column is increased by ΔA_s^{col}. Since only one reinforcing steel area is used for the entire column, the more critical joint (top or bottom) controls.

4) At any section of an element, the longitudinal steel ratio ρ shall not be less than the minimum required by the ACI 318-83 Code (1), and shall not be greater than the maximum permitted by the ACI 318-83 Code (1), $\rho \leq \rho_{max} = \frac{3}{4}\rho_b + \rho'$ where ρ_b is the balanced steel and ρ' is the compression steel. For any element which does not satisfy the above steel requirements, the member depth will be

reduced(or increased) by:

$$\Delta d = \frac{A_s}{b \cdot (\rho_{min} - \rho)} \quad \left(\text{or} \quad \Delta \mathrm{d} = \frac{\mathrm{A_s}}{\mathrm{b} \cdot (\rho - \rho_{\max})} \right) \tag{4.4}$$

where b is the width of the element section in question.

The steel ratios of all beams with unacceptable damage indices are either increased or decreased simultaneously. Thus, full use of the superposition principle is made. Design rule 4 is subjected to practical constraints, which at this time are not yet fully implemented. This design procedure assures that concentrations of heavy damage in some vulnerable structural members are avoided. Such local damage concentrations have led to many collapses in recent earthquakes. It is also felt that by keeping the damage in a frame uniform, an optimum response to an earthquake of given intensity is achieved.

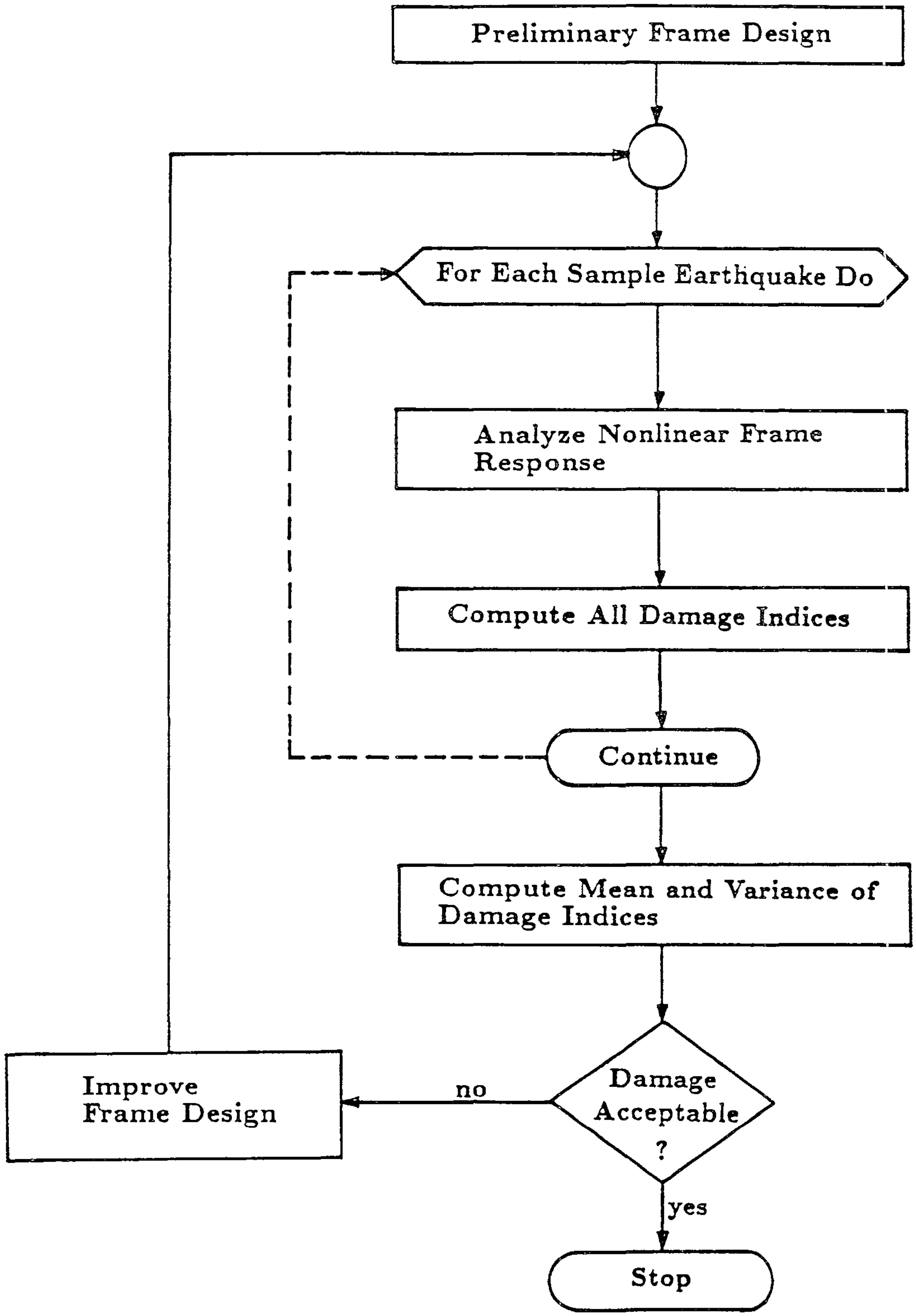


Fig. 4.1 – Automatic Design Method

5. Examples

This chapter presents four examples to demonstrate the usage of the different analysis and design options of program SARCF. Two examples utilize deterministically specified earthquake ground motions, whereas in the third example the ground accelerations are generated artificially, using an envelope function of the exponential type. In addition, one example of an automatic design is presented herein. Detailed input data and some basic output are included with further explanations.

5.1 Deterministic Analysis of Four-Story Three-Bay Frame

This example illustrates the input for one-half of a four-story and three-bay building frame, by making use of symmetry, Fig 5.1. The nonlinear response to the El Centro North-South earthquake is to be computed. In addition, the fundamental natural frequency and the damage indices are requested. The input data are listed in Table 5.1. The printout of the fundamental natural frequency and corresponding mode shape is listed in Table 5.3, and the maximum story displacements are plotted in Fig 5.3.

5.2 Deterministic Analysis of Irregular Frame

The input data for the building frame shown in Fig 5.2 are listed in Table 5.2. As in example 1, the nonlinear response, fundamental natural frequency and the damage indices are to be computed for the El Centro North-South earthquake. The output damage indices are listed in Table 5.4.

5.3 Random Vibration Analysis of Four-Story Three-Bay Frame

Input data for this example are almost the same as those for the first example, except that ten artificial earthquake ground motions are now to be generated. After the ten analyses, mean and standard deviation of beam damage indices will be computed. The output damage information is given in Table 5.5 and plotted in Fig 5.4. The input data for this case are identical to those for example 2 of Table 5.1, except that lines 1 and 2 read now:

```
1       START     RANDOM VIBRATION ANALYSIS FOR FOUR STORY - THREE BAY FRAME
2           1    1    0   -1
```

and line 78 through line 147 are replaced by

```
78          0    0       12000.010            1.00        1.0        1.0        0.0     300.0
79         10    1   1.5 11.5 13.0  386.4000    28.2743 0.6 300.0  3.0  1.0
80        512    0    0     0INPUT ARTIFICIAL GROUND MOTIONS
81          1    0
82          0  400  400  400
83       STOP
```

This input specifies the necessary information for the generation of random artificial earthquakes.

5.4 Automatic Design Example

The automatic design procedure is to be applied to the frame of Fig 5.1. Design iterations are to continue until the average damage values of all beams have reached user-specified values. The input data for this case are identical to those for example 3, except that lines 1 and 2 read now:

```
1       START     AUTOMATIC DESIGN ANALYSIS FOR FOUR STORY - THREE BAY FRAME
2           1    1    1   -1
```

and line 83 is replaced by

```
83          0   20       0.15        0.05        0.10        0.01
84       STOP
```

This input specifies a target mean value of 0.15 for the beam damage indices, with tolerance 0.05, and maximum deviation of 0.1. For columns, the maximum allowable damage index is specified to be 0.01. The damage indices obtained after 13 design iterations are plotted in Fig 5.5. A maximum of 20 iterations was allowed.

Table 5.1 — Input Data for Deterministic Analysis of Four-Story Three-Bay Frame

```
Line No.                     Input Data

   1     START     HALF OF FOUR STORY - THREE BAY FRAME
   2        0    1    0   -1
   3        4    3   14    6    3    2    4    8    2    0    1       30000
   4      10.0        480.0
   5      2240.0      480.0
   6      3360.0      480.0
   7     12360.0      120.0
   8      130.0         0.0
   9     14240.0        0.0
  10        1   13    3    3
  11        2   14    3    3
  12        3   12    2    3
  13       13    1    1    1   14    1
  14        3    0    1    0   12    3
  15        1    3    1    2    3
  16        1    3    4    5    6
  17        1    3    7    8    9
  18        1    3   10   11   12
  19       10  0.067638  0.067638       0.0    0    0  1.
  20       11  0.135276  0.135276       0.0    0    0  1.
  21        7  0.070280  0.070280       0.0    0    0  1.
  22        8  0.140560  0.140560       0.0    0    0  1.
  23        4  0.068366  0.068366       0.0    0    0  1.
  24        5  0.136732  0.136732       0.0    0    0  1.
  25        1  0.074081  0.074081       0.0    0    0  1.
  26        2  0.148163  0.148163       0.0    0    0  1.
  27       0.075     0.004        0.0       0.0
  28        1    8    1    2    4    5    0    0
  29        1    29000.000        0.01     60.00       0.100
  30        1       4.0     0.0030   0.024
  31        2       4.0     0.0030   0.030
  32       -1      20.0      12.00      2.00      2.280 1.50
  33       -2      20.0      12.00      2.00      2.622 1.50
  34       -3      22.0      12.00      2.00      2.622 1.50
  35       -4      22.0      12.00      2.00      2.736 1.50
  36        1       7.5       -7.5      0.0        0.0
  37        2       7.5       -9.0      0.0        0.0
  38        3       9.0       -9.0      0.0        0.0
  39        4       7.5        0.0      0.0        0.0
  40        5       9.0        0.0      0.0        0.0
  41        1    1    2    0    1    1    1    1    0    0    0    0    0  0.0  0.0    0  0.0
  42       -2    2    3    0    1    1    1    4    0    0    0    0    0  0.0  0.0    0  0.0
  43        3    4    5    0    1    1    2    1    0    0    0    0    0  0.0  0.0    0  0.0
  44       -4    5    6    0    1    1    2    4    0    0    0    0    0  0.0  0.0    0  0.0
  45        5    7    8    0    2    1    3    2    0    0    0    0    0  0.0  0.0    0  0.0
  46       -6    8    9    0    2    1    3    5    0    0    0    0    0  0.0  0.0    0  0.0
  47        7   10   11    0    2    1    4    3    0    0    0    0    0  0.0  0.0    0  0.0
  48       -8   11   12    0    2    1    4    5    0    0    0    0    0  0.0  0.0    0  0.0
  49        2    8    1    3    4    4    8    0
  50        1    29000.000        0.01     60.00    0.100
  51        1       4.0     0.0030   0.012
  52        2       4.0     0.0030   0.010
  53        3       4.0     0.0030   0.008
  54       -1      15.0      12.00     1.50       1.800 1.50
  55       -2      15.0      12.00     1.50       2.850 1.50
  56       -3      18.0      15.00     1.875      2.850 1.50
  57       -4      18.0      15.00     1.875      2.964 1.50
  58        1       0.0        0.0    -11.0        0.0
  59        2       0.0        0.0    -11.0       11.0
  60        3       0.0        0.0    -10.0       11.0
  61        4       0.0        0.0    -10.0       10.0
  62        1    0  26.833        0.0       0.0  -26.833       0.0       0.0
  63        2    0  53.667        0.0       0.0  -53.667       0.0       0.0
  64        3    0  53.250        0.0       0.0  -53.250       0.0       0.0
  65        4    0 106.500        0.0       0.0 -106.500       0.0       0.0
```

```
      5    0  80.250          0.0        0.0  -80.250         0.0        0.0
      6    0 160.500          0.0        0.0 -160.500         0.0        0.0
      7    0 107.563          0.0        0.0 -107.563         0.0        0.0
      8    0 215.125          0.0        0.0 -215.125         0.0        0.0
      1    1     4     0     1     1     1     4     0     0     0     1     0   1.0   0.0     0   0.0
      2    2     5     0     1     1     1     4     0     0     0     2     0   1.0   0.0     0   0.0
      3    4     7     0     1     1     1     3     0     0     0     3     0   1.0   0.0     0   0.0
      4    5     8     0     2     1     2     3     0     0     0     4     0   1.0   0.0     0   0.0
      5    7    10     0     2     1     2     2     0     0     0     5     0   1.0   0.0     0   0.0
      6    8    11     0     3     1     3     2     0     0     0     6     0   1.0   0.0     0   0.0
      7   10    13     0     3     1     3     1     0     0     0     7     0   1.0   0.0     0   0.0
      8   11    14     0     3     1     4     1     0     0     0     8     0   1.0   0.0     0   0.0
      0    0         7680.010         38.64           1.0         1.0         0.0     300.0
    384    0     0     0    El CENTRO NORTH-SOUTH EARTHQUAKES
  0.000  0.000 0.020 -0.014 0.040 -0.110 0.060 -0.103 0.080 -0.090 0.100 -0.097
  0.120 -0.122 0.140 -0.145 0.160 -0.130 0.180 -0.112 0.200 -0.087 0.220 -0.087
  0.240 -0.133 0.260 -0.179 0.280 -0.198 0.300 -0.165 0.320 -0.147 0.340 -0.110
  0.360 -0.084 0.380 -0.043 0.400 -0.067 0.420 -0.133 0.440 -0.194 0.460 -0.200
  0.480 -0.067 0.500  0.031 0.520  0.144 0.540 -0.050 0.560 -0.130 0.580 -0.147
  0.600 -0.207 0.620 -0.265 0.640 -0.331 0.660 -0.312 0.680 -0.175 0.700 -0.201
  0.720 -0.166 0.740 -0.167 0.760 -0.068 0.780  0.026 0.800  0.153 0.820  0.240
  0.840  0.257 0.860  0.342 0.880  0.472 0.900  0.501 0.920  0.427 0.940  0.366
  0.960  0.276 0.980  0.239 1.000  0.345 1.020  0.420 1.040  0.540 1.060  0.651
  1.080  0.746 1.100  0.664 1.120  0.610 1.140  0.408 1.160  0.408 1.180  0.064
  1.200 -0.525 1.220 -0.802 1.240 -0.614 1.260 -0.493 1.280 -0.255 1.300 -0.060
  1.320  0.137 1.340  0.314 1.360  0.508 1.380  0.723 1.400  1.014 1.420  1.242
  1.440  1.558 1.460  1.476 1.480  1.177 1.500  0.953 1.520  0.909 1.540  0.943
  1.560  0.855 1.580  0.918 1.600  1.012 1.620  1.232 1.640  0.334 1.660 -1.503
  1.680 -2.105 1.700 -2.027 1.720 -2.072 1.740 -1.850 1.760 -1.758 1.780 -1.785
  1.800 -1.786 1.820 -1.839 1.840 -1.661 1.860 -1.372 1.880 -1.108 1.900 -0.797
  1.920 -0.437 1.940 -0.017 1.960  0.367 1.980  0.800 2.000  1.186 2.020  1.628
  2.040  1.997 2.060  2.458 2.080  2.781 2.100  3.093 2.120  3.260 2.140  3.482
  2.160  2.874 2.180  2.368 2.200 -1.221 2.220 -2.418 2.240 -1.671 2.260 -1.900
  2.280 -1.116 2.300 -0.767 2.320 -0.176 2.340  0.115 2.360  0.543 2.380  0.912
  2.400  1.208 2.420  1.790 2.440  0.587 2.460 -2.681 2.480 -1.576 2.500 -1.762
  2.520 -1.031 2.540 -0.590 2.560  0.241 2.580 -0.683 2.600 -2.017 2.620 -1.672
  2.640 -1.717 2.660 -1.509 2.680 -1.254 2.700 -1.020 2.720 -0.765 2.740 -0.533
  2.760 -0.276 2.780 -0.045 2.800  0.192 2.820 -0.097 2.840 -0.441 2.860 -0.854
  2.880 -0.969 2.900 -0.730 2.920 -0.610 2.940 -0.340 2.960 -0.110 2.980  0.188

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

  6.000  0.590 6.020  0.260 6.040 -0.042 6.060 -0.436 6.080 -0.136 6.100  0.097
  6.120  0.234 6.140 -0.131 6.160 -0.051 6.180  0.082 6.200  0.214 6.220  0.387
  6.240  0.520 6.260  0.160 6.280 -0.033 6.300 -0.113 6.320  0.005 6.340  0.077
  6.360  0.036 6.380 -0.097 6.400 -0.037 6.420 -0.016 6.440  0.039 6.460  0.087
  6.480 -0.057 6.500 -0.310 6.520 -0.429 6.540 -0.249 6.560 -0.240 6.580 -0.180
  6.600 -0.131 6.620 -0.018 6.640  0.207 6.660 -0.110 6.680 -0.093 6.700 -0.035
  6.720 -0.108 6.740 -0.113 6.760 -0.101 6.780 -0.002 6.800  0.074 6.820  0.239
  6.840  0.362 6.860  0.718 6.880  0.794 6.900  0.187 6.920 -0.268 6.940 -0.126
  6.960 -0.043 6.980  0.162 7.000  0.049 7.020 -0.223 7.040 -0.476 7.060 -0.436
  7.080 -0.220 7.100 -0.044 7.120  0.162 7.140  0.326 7.160  0.427 7.180  0.125
  7.200 -0.163 7.220 -0.208 7.240 -0.084 7.260 -0.210 7.280 -0.140 7.300 -0.056
  7.320  0.054 7.340  0.137 7.360  0.271 7.380  0.236 7.400  0.081 7.420 -0.008
  7.440  0.204 7.460  0.443 7.480  0.501 7.500  0.195 7.520  0.094 7.540 -0.022
  7.560 -0.021 7.580  0.053 7.600  0.095 7.620  0.260 7.640  0.375 7.660  0.535
      1    0
      0  400   400   400
      0    0     0     0     0     0     0     0     0     0     0     0     0
 STOP
```

Table 5.2 – Input Data for Deterministic Analysis of Irregular Frame

Line No.	Input Data
1	START NONSYMMMERIC FOUR-STORY FRAME
2	0 1 0 -1
3	4 0 19 10 4 1 4 7 2 0 0 30000
4	4 3 2 1
5	10. 480.
6	2240. 480.
7	30. 360.
8	5480. 360.
9	60. 240.
10	9720. 240.
11	100. 120.
12	14960. 120.
13	150. 0.
14	19960. 0.
15	3 5 1 1
16	6 9 2 1
17	10 14 3 1
18	15 19 3 1
19	15 1 1 1 19 1
20	1 2 1 2
21	1 3 3 4 5
22	1 4 6 7 8 9
23	1 5 10 11 12 13 14
24	1 0.072733 0.072733 0.0 2 0 1.
25	3 0.069094 0.069094 0.0 5 2 1.
26	4 0.138188 0.138188 0.0 0 0 1.
27	6 0.071251 0.071251 0.0 9 3 1.
28	7 0.142501 0.142501 0.0 8 0 1.
29	10 0.068474 0.068474 0.0 14 4 1.
30	11 0.136948 0.136948 0.0 13 1 1.
31	0.075 0.004 0.0 0.0
32	1 10 1 2 4 2 0 0
33	1 29000.000 0.01 60.00 0.100
34	1 4.0 0.0030 0.024
35	2 4.0 0.0030 0.030
36	-1 18.0 12.00 2.00 1.596 1.50
37	-2 20.0 12.00 2.00 2.400 1.50
38	-3 22.0 12.00 2.00 2.622 1.50
39	-4 22.0 12.00 2.00 2.736 1.50
40	1 7.5 -7.5 0.0 0.0
41	2 9.0 -9.0 0.0 0.0
42	1 1 2 0 1 1 1 1 0 0 0 0 0 0.0 0.0 0 0.0
43	2 3 4 0 1 1 2 2 0 0 0 0 0 0.0 0.0 0 0.0
44	3 4 5 0 1 1 2 2 0 0 0 0 0 0.0 0.0 0 0.0
45	4 6 7 0 2 1 3 2 0 0 0 0 0 0.0 0.0 0 0.0
46	5 7 8 0 2 1 3 2 0 0 0 0 0 0.0 0.0 0 0.0
47	6 8 9 0 2 1 3 2 0 0 0 0 0 0.0 0.0 0 0.0
48	7 10 11 0 2 1 4 2 0 0 0 0 0 0.0 0.0 0 0.0
49	8 11 12 0 2 1 4 2 0 0 0 0 0 0.0 0.0 0 0.0
50	9 12 13 0 2 1 4 2 0 0 0 0 0 0.0 0.0 0 0.0
51	10 13 14 0 2 1 4 2 0 0 0 0 0 0.0 0.0 0 0.0
52	2 14 1 3 4 4 7 0
53	1 29000.000 0.01 60.00 0.100
54	1 4.0 0.0030 0.012
55	2 4.0 0.0030 0.010
56	3 4.0 0.0030 0.008
57	-1 15.0 12.00 1.50 2.160 1.50
58	-2 18.0 12.00 1.875 2.993 1.50
59	-3 18.0 15.00 1.875 3.135 1.50
60	-4 18.0 15.00 1.875 3.260 1.50
61	1 0.0 0.0 -11.0 0.0
62	2 0.0 0.0 -11.0 11.0
63	3 0.0 0.0 -10.0 11.0
64	4 0.0 0.0 -9.00 10.0
65	1 0 26.250 0.0 0.0 -26.250 0.0 0.0

```
     2    0  52.792          0.0         0.0  -52.792          0.0         0.0
     3    0 105.583          0.0         0.0 -105.583          0.0         0.0
     4    0  80.229          0.0         0.0  -80.229          0.0         0.0
     5    0 160.458          0.0         0.0 -160.458          0.0         0.0
     6    0 107.854          0.0         0.0 -107.854          0.0         0.0
     7    0 215.708          0.0         0.0 -215.708          0.0         0.0
     1    1    3    0    1    1    1    4    0    0    0    1    0  1.0  0.0    0  0.0
     2    2    4    0    1    1    1    4    0    0    0    1    0  1.0  0.0    0  0.0
     3    3    6    0    1    1    2    3    0    0    0    2    0  1.0  0.0    0  0.0
     4    4    7    0    2    1    3    3    0    0    0    3    0  1.0  0.0    0  0.0
     5    5    8    0    1    1    2    3    0    0    0    2    0  1.0  0.0    0  0.0
     6    6   10    0    2    1    3    2    0    0    0    4    0  1.0  0.0    0  0.0
     7    7   11    0    2    1    4    2    0    0    0    5    0  1.0  0.0    0  0.0
     8    8   12    0    2    1    4    2    0    0    0    5    0  1.0  0.0    0  0.0
     9    9   13    0    2    1    3    2    0    0    0    4    0  1.0  0.0    0  0.0
    10   10   15    0    2    1    3    1    0    0    0    6    0  1.0  0.0    0  0.0
    11   11   16    0    3    1    4    1    0    0    0    7    0  1.0  0.0    0  0.0
    12   12   17    0    3    1    4    1    0    0    0    7    0  1.0  0.0    0  0.0
    13   13   18    0    3    1    4    1    0    0    0    7    0  1.0  0.0    0  0.0
    14   14   19    0    2    1    3    1    0    0    0    6    0  1.0  0.0    0  0.0
     0    0        7680.010          38.64          1.0          1.0        0.0     300.0
   384    0    0    0   El CENTRO NORTH-SOUTH EARTHQUAKES
 0.000  0.000 0.020 -0.014 0.040 -0.110 0.060 -0.103 0.080 -0.090 0.100 -0.097
 0.120 -0.122 0.140 -0.145 0.160 -0.130 0.180 -0.112 0.200 -0.087 0.220 -0.087
 0.240 -0.133 0.260 -0.179 0.280 -0.198 0.300 -0.165 0.320 -0.147 0.340 -0.110
 0.360 -0.084 0.380 -0.043 0.400 -0.067 0.420 -0.133 0.440 -0.194 0.460 -0.200
 0.480 -0.067 0.500  0.031 0.520  0.144 0.540 -0.050 0.560 -0.130 0.580 -0.147
 0.600 -0.207 0.620 -0.265 0.640 -0.331 0.660 -0.312 0.680 -0.175 0.700 -0.201
 0.720 -0.166 0.740 -0.167 0.760 -0.068 0.780  0.026 0.800  0.153 0.820  0.240
 0.840  0.257 0.860  0.342 0.880  0.472 0.900  0.501 0.920  0.427 0.940  0.366
 0.960  0.276 0.980  0.239 1.000  0.345 1.020  0.420 1.040  0.540 1.060  0.651
 1.080  0.746 1.100  0.664 1.120  0.610 1.140  0.408 1.160  0.408 1.180  0.064
 1.200 -0.525 1.220 -0.802 1.240 -0.614 1.260 -0.493 1.280 -0.255 1.300 -0.060
 1.320  0.137 1.340  0.314 1.360  0.508 1.380  0.723 1.400  1.014 1.420  1.242
 1.440  1.558 1.460  1.476 1.480  1.177 1.500  0.953 1.520  0.909 1.540  0.943
 1.560  0.855 1.580  0.918 1.600  1.012 1.620  1.232 1.640  0.334 1.660 -1.503
 1.680 -2.105 1.700 -2.027 1.720 -2.072 1.740 -1.850 1.760 -1.758 1.780 -1.785
 1.800 -1.786 1.820 -1.839 1.840 -1.661 1.860 -1.372 1.880 -1.108 1.900 -0.797
 1.920 -0.437 1.940 -0.017 1.960  0.367 1.980  0.800 2.000  1.186 2.020  1.628
 2.040  1.997 2.060  2.458 2.080  2.781 2.100  3.093 2.120  3.260 2.140  3.482
 2.160  2.874 2.180  2.368 2.200 -1.221 2.220 -2.418 2.240 -1.671 2.260 -1.900

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

 6.000  0.590 6.020  0.260 6.040 -0.042 6.060 -0.436 6.080 -0.136 6.100  0.097
 6.120  0.234 6.140 -0.131 6.160 -0.051 6.180  0.082 6.200  0.214 6.220  0.387
 6.240  0.520 6.260  0.160 6.280 -0.033 6.300 -0.113 6.320  0.005 6.340  0.077
 6.360  0.036 6.380 -0.097 6.400 -0.037 6.420 -0.016 6.440  0.039 6.460  0.087
 6.480 -0.057 6.500 -0.310 6.520 -0.429 6.540 -0.249 6.560 -0.240 6.580 -0.180
 6.600 -0.131 6.620 -0.018 6.640  0.207 6.660 -0.110 6.680 -0.093 6.700 -0.035
 6.720 -0.108 6.740 -0.113 6.760 -0.101 6.780 -0.002 6.800  0.074 6.820  0.239
 6.840  0.362 6.860  0.718 6.880  0.794 6.900  0.187 6.920 -0.268 6.940 -0.126
 6.960 -0.043 6.980  0.162 7.000  0.049 7.020 -0.223 7.040 -0.476 7.060 -0.436
 7.080 -0.220 7.100 -0.044 7.120  0.162 7.140  0.326 7.160  0.427 7.180  0.125
 7.200 -0.163 7.220 -0.208 7.240 -0.084 7.260 -0.210 7.280 -0.140 7.300 -0.056
 7.320  0.054 7.340  0.137 7.360  0.271 7.380  0.236 7.400  0.081 7.420 -0.008
 7.440  0.204 7.460  0.443 7.480  0.501 7.500  0.195 7.520  0.094 7.540 -0.022
 7.560 -0.021 7.580  0.053 7.600  0.095 7.620  0.260 7.640  0.375 7.660  0.535
     1    0
     0  400  400  400
     0    0    0    0    0    0    0    0    0    0    0    0    0
STOP
```

Table 5.3 – Example 1, Output for Fundamental Natural Frequency and Mode Shape

FIRST NATUARAL FREQUENCY = 0.11419E+01 (Hz)

FIRST MODE SHAPE:

NODE	X	Y	R
1	0.1000E+01	0.7361E-02	-0.9242E-03
2	0.1000E+01	-0.5171E-03	-0.5822E-03
3	0.1000E+01	0.0000E+00	0.3562E-03
4	0.7871E+00	0.6929E-02	-0.1621E-02
5	0.7871E+00	-0.4371E-03	-0.1326E-02
6	0.7871E+00	0.0000E+00	0.8012E-03
7	0.4948E+00	0.5548E-02	-0.1700E-02
8	0.4948E+00	-0.2984E-03	-0.1579E-02
9	0.4948E+00	0.0000E+00	0.9858E-03
10	0.2125E+00	0.3095E-02	-0.1829E-02
11	0.2125E+00	-0.1970E-03	-0.1536E-02
12	0.2125E+00	0.0000E+00	0.9574E-03
13	0.0000E+00	0.0000E+00	0.0000E+00
14	0.0000E+00	0.0000E+00	0.0000E+00

Table 5.4 – Example 2, Output for Damage Indices

NODAL DAMAGE INDICES TIME = 7.690

DAMAGE INDICES FOR BEAM ELEMENT : GROUP 1

ELEMENT NO.	NODE NO	DAMAGE INDICES AT I	NODE NO	DAMAGE INDICES AT J
1	1	0.0160	2	0.0150
2	3	0.0069	4	0.0046
3	4	0.0109	5	0.0118
4	6	0.0046	7	0.0036
5	7	0.0033	8	0.0032
6	8	0.0110	9	0.0069
7	10	0.0067	11	0.0008
8	11	0.0007	12	0.0007
9	12	0.0007	13	0.0007
10	13	0.0004	14	0.0003

DAMAGE INDICES FOR BEAM-COLUMN ELEMENT : GROUP 2

ELEMENT NO.	NODE NO	DAMAGE INDICES AT I	NODE NO	DAMAGE INDICES AT J
1	1	0.0000	3	0.0154
2	2	0.0000	4	0.0371
3	3	0.0000	6	0.0000
4	4	0.0000	7	0.0076
5	5	0.0000	8	0.0136
6	6	0.0000	10	0.0000
7	7	0.0000	11	0.0000
8	8	0.0000	12	0.0000
9	9	0.0000	13	0.0155
10	10	0.0000	15	0.0095
11	11	0.0000	16	0.0109
12	12	0.0000	17	0.0143
13	13	0.0000	18	0.0234
14	14	0.0000	19	0.0408

*** STORY DAMAGE INDEX ***

FLOOR	BEAM	COLUMN	STORY
4	0.01553	0.02908	0.02400
3	0.00883	0.01061	0.00956
2	0.00587	0.01509	0.00831
1	0.00290	0.02156	0.01866

GLOBAL DAMAGE = 0.03567

Table 5.5 – Example 3, Output of Statistics of All Element Damage Indices

STATISTICS FOR DAMAGE INDICES

BEAM ELEMENTS GROUP 1

ELEM NO.	NODE NO	NODE NO	NO. OF EARTHQUAKE	MEAN VALUE AT I	MEAN VALUE AT J	STAND DEV AT I	STAND DEV AT J	VARIANCE AT I	VARIANCE AT J	MAXIMUM AT I	MAXIMUM AT J	MINIMUM AT I	MINIMUM AT J
1	1	2	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	3	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	4	5	10	0.0231	0.0012	0.0171	0.0015	0.0003	0.0000	0.0608	0.0048	0.0004	0.0000
4	5	6	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	7	8	10	0.0987	0.0727	0.0422	0.0380	0.0018	0.0014	0.1682	0.1268	0.0277	0.0238
6	8	9	10	0.1895	0.0000	0.1144	0.0000	0.0131	0.0000	0.4071	0.0000	0.0305	0.0000
7	10	11	10	0.1880	0.1557	0.0924	0.0837	0.0085	0.0070	0.4012	0.3637	0.0688	0.0614
8	11	12	10	0.2812	0.0000	0.1516	0.0000	0.0230	0.0000	0.5057	0.0000	0.0934	0.0000

BEAM-COLUMN ELEMENTS GROUP 2

ELEM NO.	NODE NO	NODE NO	NO. OF EARTHQUAKE	MEAN VALUE AT I	MEAN VALUE AT J	STAND DEV AT I	STAND DEV AT J	VARIANCE AT I	VARIANCE AT J	MAXIMUM AT I	MAXIMUM AT J	MINIMUM AT I	MINIMUM AT J
1	1	4	10	0.0546	0.0215	0.0516	0.0271	0.0027	0.0007	0.1376	0.0826	0.0000	0.0000
2	2	5	10	0.1443	0.1042	0.0989	0.1103	0.0098	0.0122	0.3083	0.3637	0.0298	0.0004
3	4	7	10	0.0803	0.0169	0.0561	0.0186	0.0032	0.0003	0.1956	0.0550	0.0152	0.0000
4	5	8	10	0.1652	0.0390	0.0796	0.0417	0.0063	0.0017	0.2933	0.1465	0.0545	0.0049
5	7	10	10	0.0066	0.0000	0.0141	0.0000	0.0002	0.0000	0.0480	0.0000	0.0000	0.0000
6	8	11	10	0.0562	0.0136	0.0374	0.0156	0.0014	0.0002	0.1140	0.0532	0.0035	0.0000
7	10	13	10	0.0000	0.1793	0.0000	0.0895	0.0000	0.0080	0.0000	0.3489	0.0000	0.0652
8	11	14	10	0.0004	0.1592	0.0011	0.0742	0.0000	0.0055	0.0036	0.3212	0.0000	0.0674

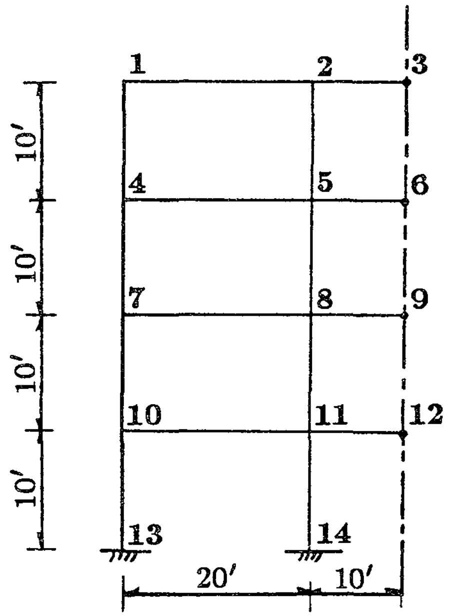


Fig. 5.1 – Half of Four-Stroy Three-Bay Building Frame

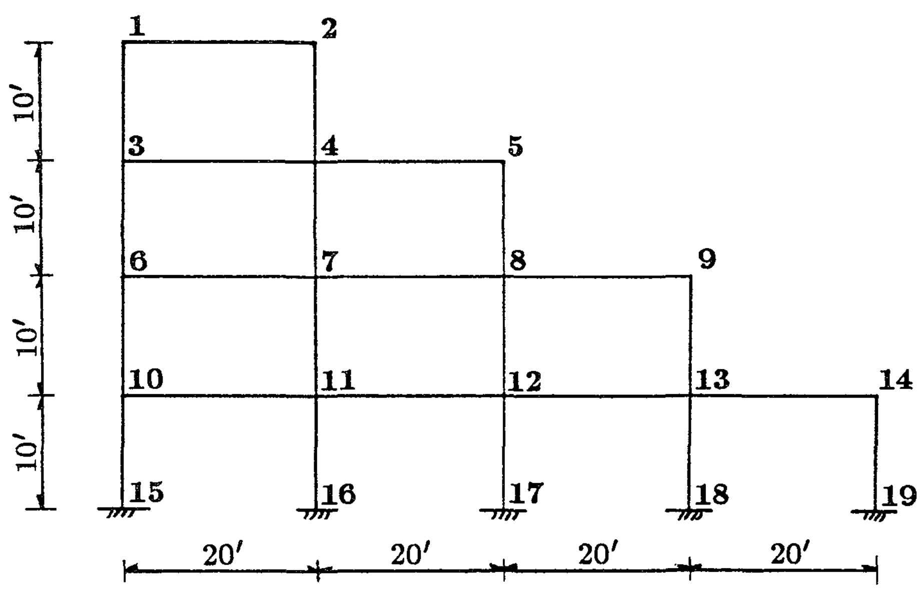


Fig. 5.2 – Nonsymmetric Building Frame

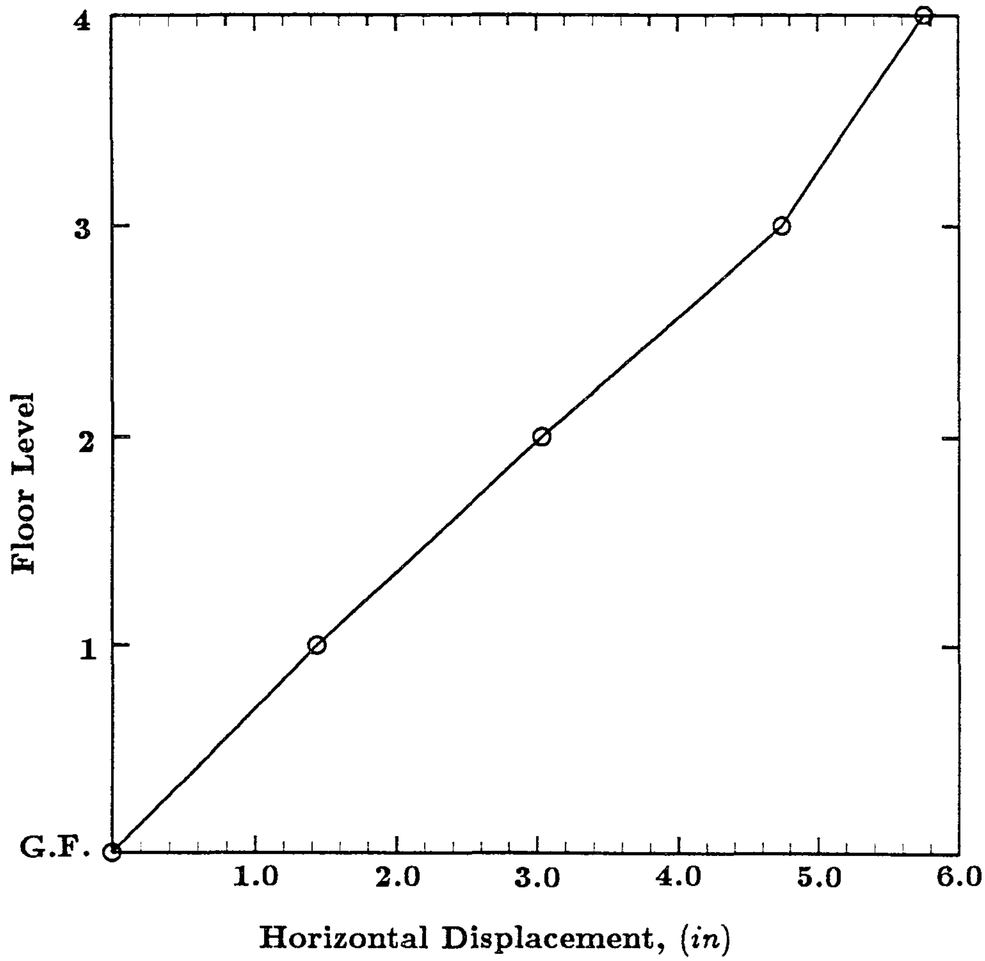
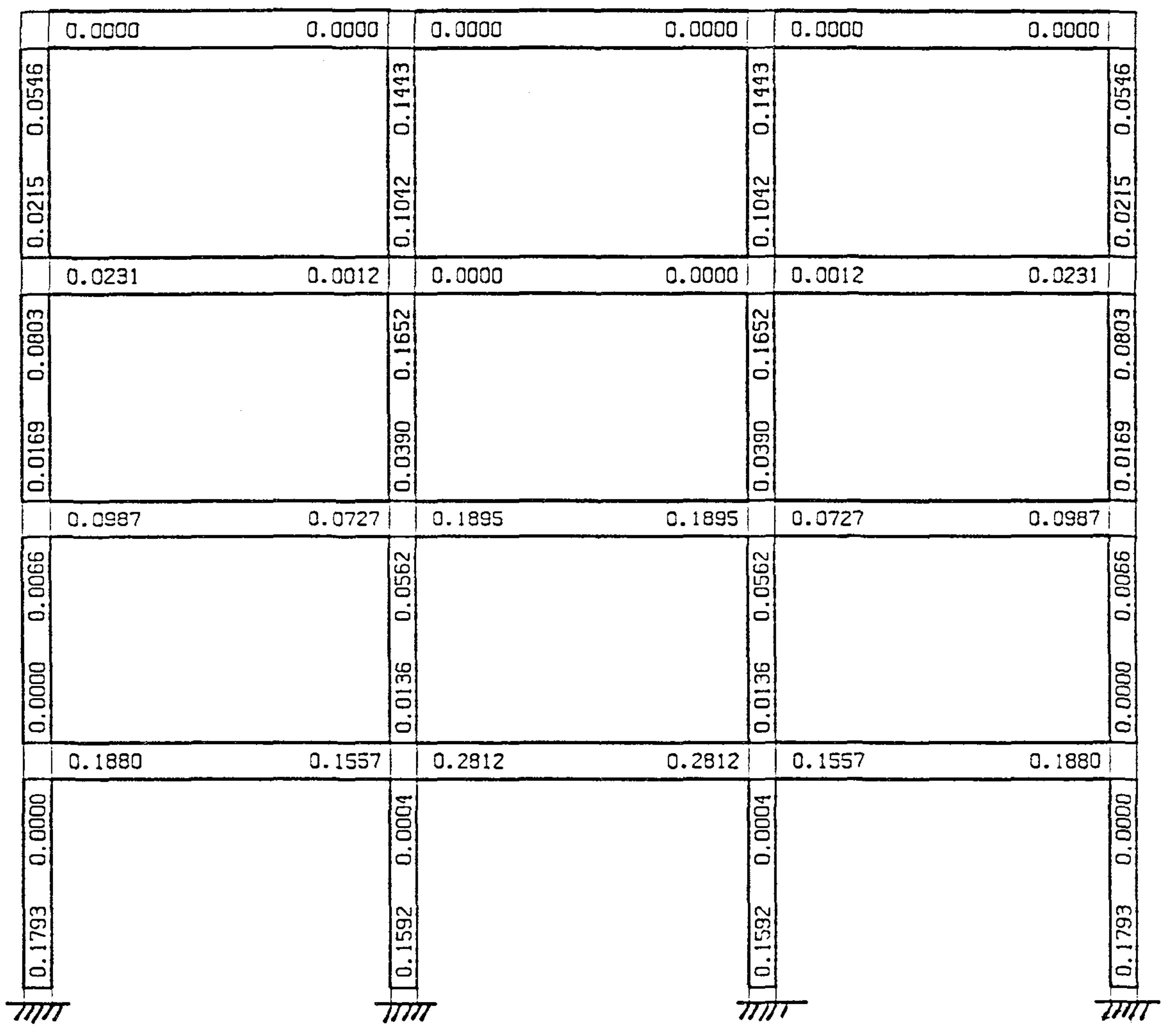


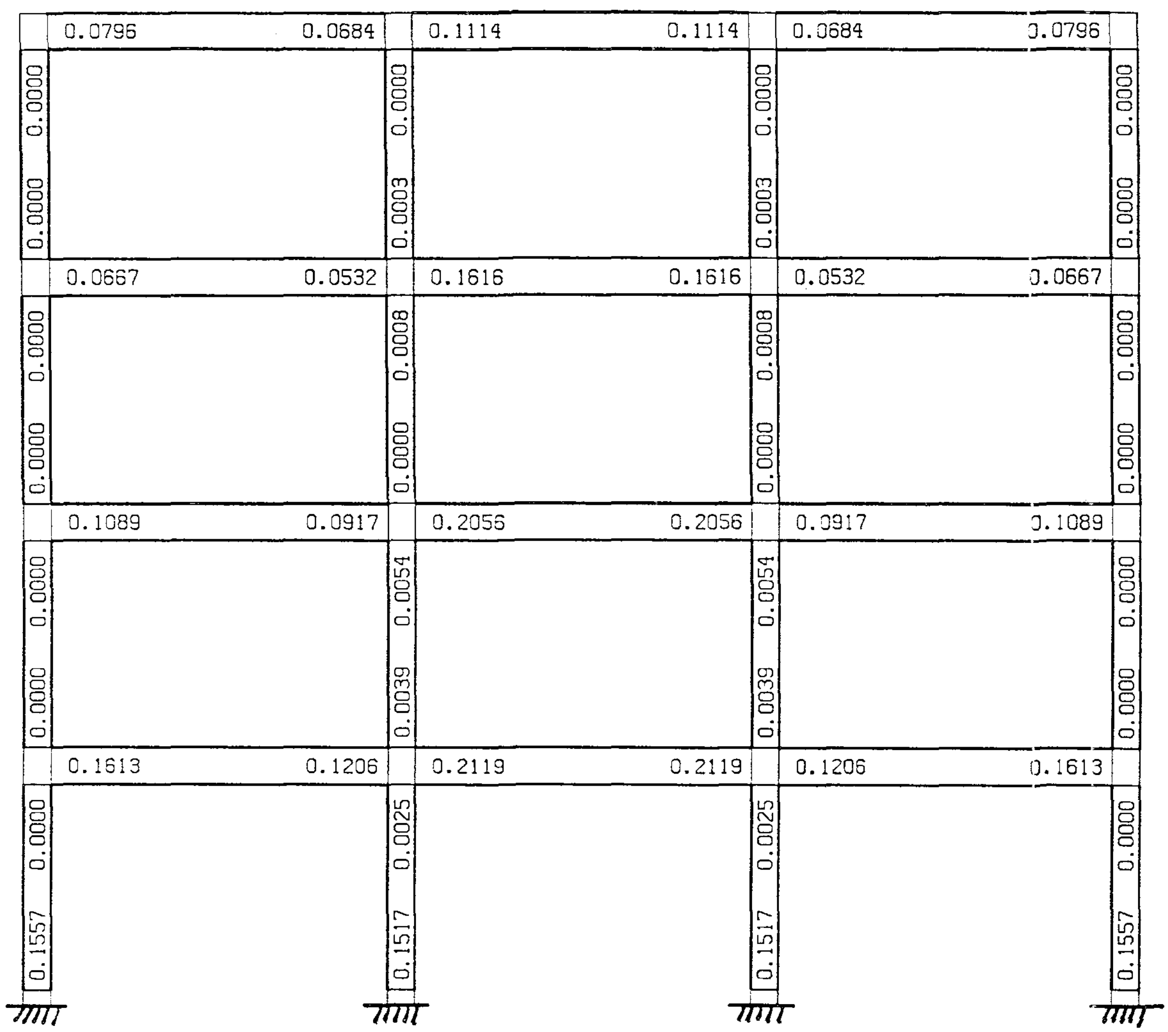
Fig. 5.3 – Maximum Horizontal Floor Displacements



Mean Damage of All Beams : $\overline{D} = 0.084$

Standard Deviation of All Beams : $\sigma_D = 0.094$

Fig. 5.4 – Mean Damage Indices for Example Office Building



Mean Damage of All Beams : $\overline{D} = 0.120$

Standard Deviation of All Beams : $\sigma_D = 0.051$

Fig. 5.5 – Mean Damage Indices for Example Office Building After 13 Design Iterations

6. References

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15) Shinozuka, M. and Wai, P., "Digital Simulation of Short-Crested Sea Surface Elevations," Journal of Ship Research, Vol. 23, No. 1, March 1979.

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Appendix – A

SARCF User's Guide

Appendix A – SARCF User's Guide

The purpose of program SARCF ("Seismic Analysis of Reinforced Concrete Frames") is to compute nonlinear responses of reinforced concrete frames subject to deterministic and/or randomly generated earthquake ground motions, including expected damage values, with an option to perform automatic design iterations until a user-specified damage distribution has been achieved.

This program has been written in Fortran-77 for VAX/VMS computer systems and for the Sun3 micro-computer system. It is a derivative of DRAIN-2D, a general purpose computer program for dynamic analysis of inelastic plane structures, with various enhancements. At the present, the program can handle only reinforced concrete frames made up of beam and beam-column elements. Input data are entered in a batch mode consisting of 7 items arranged in the following sequence.

1) "START" card and analysis control data.
2) Structure information.
3) Element information.
4) Load information.
    * Static load information.
    * Earthquake data, either deterministic or randomly generated.
5) Analysis information.
    * Eigenvalue information (optional).
    * Damage index information (optional).
    * Automatic design procedure (optional).
6) Output specifications.
7) "STOP" card.

Static loads may be applied to the structure prior to the application of the dynamic loading, but the response to such static loads must remain elastic.

The present program version makes limited use of fixed dimension statements, so that some important input variables are subject to upper limits. These restrictions are clearly indicated in the input specifications below. However, because of the use of PARAMETER statements, it is relatively easy to relax any one of these capacity restrictions if necessary.

1. Description of Problem

1.1 START Card (A5,3X,18A4)

Provide a single card with the following information:

Columns 1 - 5 : Enter the word "START".

6 - 80 : Designate the title of this problem.

1.2 Analysis Control Data (4I5)

Provide a single card with the following control data:

Columns 1 - 5 : Code for type of earthquake data ("KEARTH").

1 : for randomly generated earthquake data.

0 : for deterministic earthquake data.

6 - 10 : Code for damage index ("KDAMAGE").

1 : compute damage indices.

0 : do not compute damage indices.

11 - 15 : Code for an automatic design analysis. ("KAUTO")

1 : perform automatic design.

0 : do not perform automatic design.

16 - 20 : Data checking code ("KDATA"). This code specifies two items of information: 1) whether to perform a complete analysis or only a data check run; 2) whether to store all element data in core or on a scratch file with the result of increased peripheral processing cost.

1 : data check run only.

0 : complete analysis execution, with element data stored on a

scratch file.

-1 : complete analysis execution, with element data stored in core.

2. Structure Information

All data necessary to describe the structure are to be supplied in the order and format as described below. Some data have to be input specifically, while others will default to previously defined values. Consistent units have to be used throughout. If the automatic design option is exercised, then only U.S. customary units (foot, pound and kips) are permitted.

2.1 Structural Geometry Control Card (11I5,I10)

Columns 1 - 5 : Number of stories ("NSTORY").

6 - 10 : Number of bays ("NBAY").

If the number of bays is the same for each story, enter this number here. If it is variable, enter zero here and specify the numbers of bays in Section 2.2 below.

11 - 15 : Number of nodes ("NJTS").

(e.g. (NBAY+1)$\times$ NSTORY)

16 - 20 : Number of control nodes, of which x and y coordinates are to be specified ("NCONJT"). See Section 2.3.A.

21 - 25 : Number of node generation commands ("NCDJT").

See Section 2.3.B.

26 - 30 : Number of zero displacements commands ("NCDDOF").

See Section 2.4.

31 - 35 : Number of identical displacements commands ("NCDDIS").

See Section 2.5.

36 - 40 : Number of lumped mass commands ("NCDMS").

See Section 2.6.

41 - 45 : Number of different element groups in structure ("NELGR").

46 - 50 : Structure stiffness storage code ("KODST"). A duplicate structure stiffness matrix is always retained and periodically updated and stored in core, if sufficient memory is available, else it is stored on a scratch file. Whether the stiffness duplicate can fit into core or not can be determined in a data check run (KDATA = 1, see Section 1.2) by setting KODST = 0.

0 : store stiffness duplicate in core.

1 : store stiffness duplicate on scratch file.

51 - 55 : Symmetry option code ("KSYM").

1 : only left half of structure is modeled.

0 : no use of symmetry is made.

-1 : only right half of structure is modeled.

56 - 65 : Blank COMMON length to be allocated.

Enter the number of double-precision words. The length of blank COMMON to be allocated depends on the size of the problem and is difficult to compute by hand. This important information is provided in a data check run (KDATA = 1, Section 1.2). The current program defaults to COMMON A(50000). If this memory allocation turns out to be insufficient, the main program of SARCF has to be recompiled with an appropriately increased COMMON allocation.

2.2 Number of Bays (16I5)

Omit if the structure has the same number of bays in each story, i.e. if a non-zero value for NBAY was entered in Section 2.1. If the number of bays varies, enter for each story the actual number of bays, starting with the ground story and preceding to the top.

If the number of stories exceeds 16, use two or more cards, as needed.

2.3 Node Generation Cards

The node generation cards allow the omission of input data for frames which exhibit some regularity. For example, if all story heights are equal, it suffices to specify the coordinates of only the top and bottom nodes (defined as "control nodes") and to prompt the automatic generation of the coordinates for all nodes inbetween. Note that all control nodes are to be defined first, one node per card, followed by all node generation commands, with one command per card.

Node numbers can be assigned in any arbitrary sequence. However, if use of the automatic design option is made, nodes have to be numbered sequentially, starting from the top story as shown in Fig A.1. If no use of the node generation option is made, enter all nodes as "control nodes".

2.3.A Control Node Cards (I5,2F10.0)

Columns 1 - 5 : Node number.

6 - 15 : X coordinate of node.

16 - 25 : Y coordinate of node.

2.3.B Node Generation Commands(4I5)

Omit if NCDJT = 0. (See Section 2.1)

Columns 1 - 5 : First node number in the line of nodes.

6 - 10 : Last node number in the line of nodes.

11 - 15 : Number of nodes to be generated along the line.

16 - 20 : Node number increment between any two successive nodes.

Default value = 1.

2.4 Zero Displacements Commands (6I5)

These commands allow the specification of a series of nodes having identical boundary conditions, identified by the code

1 : For fixed boundary condition.

0 : For free boundary condition.

Enter NCDDOF cards, with one command per card. See Section 2.1.

Columns 1 - 5 : First node number in series.

6 - 10 : Code for X displacements.

11 - 15 : Code for Y displacements.

16 - 20 : Code for rotations.

21 - 25 : Last node number in series. Leave blank for a single node.

26 - 30 : Node number increment between any two successive nodes in series. Default = 1.

2.5 Identical Displacements Commands (16I5)

One command for each card. Omit if NCDDIS = 0. See Section 2.1.

Columns 1 - 5 : Displacement code:

1 : For X displacement.

2 : For Y displacement.

3 : For rotation.

6 - 10 : Number of nodes having identical displacement (Maximum =14).

11 - 15 : First node.

16 - 20 : Second node etc.

List up to 14 nodes in this card. If there are more than 14 nodes with identical displacement, two or more commands will be used, with the nodes in increasing order in each command. The smallest node number has to appear on each command card.

2.6 Lumped Mass Commands (I5,3F10.0,2I5,F10.0)

One command for each card. Omit if NCDMS = 0. See Section 2.1.

Columns 1 - 5 : First node number in series.

6 - 15 : Mass associated with X displacement.

16 - 25 : Mass associated with Y displacement.

26 - 35 : Rotary inertia.

36 - 40 : Last node number in series. Leave blank for a single node.

41 - 45 : Node number difference between any two successive nodes in series. Default = 1.

46 - 55 : Scale factor by which input masses are to be divided ("SCALE"). Default value is the one specified in the preceding command, so that the same factor applies to all subsequent commands until it changes again. Thus, it needs to be specified at least for the first command. If masses are input as weights, enter the gravity constant for SCALE. For example, a 100 *kip* weight (or $\frac{100}{386.4} = 0.2588\ k - sec^2/in$ mass) may be input as a mass "100.", with scale factor "386.4".

2.7 Damping Information (4F10.0)

Four different types of damping may be specified singly or in combination.

Columns 1 - 10 : Mass proportional damping factor, α.

11 - 20 : Tangent stiffness proportional damping factor, β.

21 - 30 : Original stiffness proportional damping factor, β_o.

31 - 40 : Structural damping factor, δ.

Note : Use of structural damping may be problematic, especially for inelastic structures. A possible cause is that the damping forces tend to accentuate small oscillations in numerical computations. From past experience, the following values give realistic results: $\alpha = 0.07$, $\beta = 0.004$, $\beta_o = 0$ and $\delta = 0$.

3. Element Information

Only frame elements with or without axial force are incorporated in the current program version. That is, there are two different element types, beam-columns and beams. All elements of a frame must be divided into groups. All elements in any one group must be of the same type, and typically all elements of the same type will be included in a single group. However, elements of the same type may be subdivided into more than one group if desired. The number of groups, NELGR, was specified in Section 2.1.

If the automated design option is not exercised, element groups may be input in any convenient sequence. Otherwise, the beam element group has to be input before the beam-column element group. In any case, the elements within a group must be numbered in sequence. In addition, in the automatic design option, elements are to be sequentially numbered from the top story as shown in Fig A.1.

Each group needs all the following data.

3.1 Group Control Information (8I5)

Columns 1 - 5 : Group type number.

1 : for beam element.

2 : for beam-column element.

6 - 10 : Number of elements in this group ("NMEM").

11 - 15 : Number of different reinforcing steel types ("NSTL").

See Section 3.2.

16 - 20 : Number of different concrete types ("NCON").

See Section 3.3.

21 - 25 : Number of different cross section types ("NSEC").

See Section 3.4.

26 - 30 : Number of different end eccentricity types ("NECC"). See Section 3.5.

31 - 35 : Number of different fixed-end forces patterns ("NFEF"). See Section 3.6.

36 - 40 : Number of different initial element force patterns ("NINT"). See Section 3.7.

3.2 Reinforcing Steel Types (I5,F15.4,F10.4,F10.2,F10.5)

Supply NSTL cards (see Section 3.1), one for each different reinforcing steel. See Fig A.2 for definitions. Assign each type a number, starting with 1, up to maximum 6.

Columns 1 - 5 : Type number.

6 - 20 : Young's modulus, E_s.

21 - 30 : Strain hardening ratio, as a fraction of Young's modulus, P_s.

31 - 40 : Yield stress, f_{sy}.

41 - 50 : Ultimate strain, ϵ_{su}.

3.3 Concrete Types (I5,3F10.4)

Supply NCON cards (see Section 3.1), one for each different concrete type. See Fig A.3 for definitions. Assign each type a number, starting with 1, up to maximum 9.

Columns 1 - 5 : Type number.

6 - 15 : Uniaxial concrete strength, f_c'.

16 - 25 : Strain at maximum stress, ϵ_o.

26 - 35 : Confinement steel ratio, ρ''.

3.4 Cross Section Types (I5,4F10.4,F5.2,3F10.4)

Supply NSEC cards (see Section 3.1), one for each different cross section. See Fig A.4 for definitions. Assign each type a number, starting with 1, up to maximum 9. Input negative type number for the section which is symmetrical about horizontal axis.

Columns 1 - 5 : Type number (Negative for symmetrical section).

6 - 15 : Height of cross section ("HT").

16 - 25 : Bottom width of cross section ("BB").

26 - 35 : Distance from the bottom face to the centroid of bottom reinforcing steel ("DCB").

36 - 45 : Area of bottom reinforcing steel ("ASB").

46 - 50 : Strength degradation parameter, ω.

This parameter depends on various factors, such as the longitudinal steel ratio, the confinement ratio, the axial force. Values between 1.5 and 2.0 have been found to lead to realistic results.

51 - 60 : Top width of cross section ("BT").

Leave blank or zero for symmetrical section.

61 - 70 : Distance from the top face to the centroid of top reinforcing steel ("DCT").

Leave blank or zero for symmetrical section.

71 - 80 : Area of top reinforcing steel ("AST").

Leave blank or zero for symmetrical section.

3.5 End Eccentricities (I5,4F10.4)

Plastic hinges may form near the faces of a connection rather than inside a beam-column joint. This behavior can be modeled with rigid links connecting nodes with the respective element ends, as shown in Fig A.5.

Supply NECC cards (see Section 3.1), one for each different kind of eccentricity with which members are attached to a node. Omit if NECC = 0. All eccentricities are measured from the node to the element end. Assign each different eccentricity type a number, starting with 1, up to maximum 15.

Columns 1 - 5 : Type number.

6 - 15 : X_i = X eccentricity at end i.

16 - 25 : X_j = X eccentricity at end j.

26 - 35 : Y_i = Y eccentricity at end i.

36 - 45 : Y_j = Y eccentricity at end j.

3.6 Fixed-End Force Patterns (2I5,7F10.0)

Static loads applied along the lengths of beams and beam-column elements may be taken into account by specifying fixed-end forces as shown in Fig A.6. These forces are those which must act on the element ends to prevent end displacements. The sign convention for these forces is as shown in Fig A.6.

Supply NFEF cards (see Section 3.1), one for each different fixed-end force pattern. Omit if NFEF = 0. Assign each different fixed-end force pattern a number, starting with 1, up to maximum 35.

Columns 1 - 5 : Pattern number.

6 - 10 : Coordinate system code.

0 : Forces refer to element coordinate system, (Fig A.6.a).

1 : Forces refer to global coordinate system, (Fig A.6.b).

11 - 20 : Fixed end force, F_{x_i}.

21 - 30 : Fixed end force, F_{y_i}.

31 - 40 : Fixed end moment, M_i.

41 - 50 : Fixed end force, F_{x_j}.

51 - 60 : Fixed end force, F_{y_j}.

61 - 70 : Fixed end moment, M_j.

71 - 80 : Live load reduction factor. The fixed-end forces specified for each element may account for the live load reduction as permitted, e.g. by the Uniform Building Code for members with large tributary areas. For dead loads, however, this reduction factor is ignored.

3.7 Initial Element Force Patterns (I5,6F10.0)

For structures for which static analyses are carried out separately, initial member forces such as those due to prestress may be specified by use of initial element force patterns. These forces are converted internally to nodal loads, using the same sign convention as indicated for fixed-end force patterns. The geometric stiffness, if used, is based on the initial axial force plus any axial force due to static loading, and may be included for the dynamic loading, if required.

Supply NINT cards (see Section 3.1), one for each different initial element force pattern. Omit if NINT = 0. Assign each different initial element force pattern a number, starting with 1, up to maximum 30.

Columns	1 - 5	: Pattern number.
	6 - 15	: Initial axial force, F_{x_i}.
	16 - 25	: Initial shear force, F_{y_i}.
	26 - 35	: Initial moment, M_i.
	36 - 45	: Initial axial force, F_{x_j}.
	46 - 55	: Initial shear force, F_{y_j}.
	56 - 65	: Initial moment, M_j.

3.8 Element Generation Commands (8I5,5I4,2F5.0,I5,F5.0)

For structures with similar elements, the program can automatically generate data for repetitive elements. Provided all data for a sequence of elements are identical (except node numbers), only two cards, one for the first and one for the last element in the sequence (the "key elements") need to be provided. In the printout of the element data, generated elements are identified by an asterisk at the beginning of the printed line.

Assign a sequential number for all the elements in the same group, starting with 1, up to NMEM (See Section 3.1). Supply one card for each key element in increasing numerical order of the assigned element number.

Columns 1 - 5 : Element number. If KSYM is not equal to zero, input a negative element number for the beam element, which is located at the symmetrical axis. For example, input -2 , -4 and -6 for element No. ②, ④ and ⑥ in Figs. A.1.b) or A.1.c), respectively.

6 - 10 : Node number at element end i.

11 - 15 : Node number at element end j.

16 - 20 : Node number increment for element generation.
Default = 1.

21 - 25 : Concrete type number.

26 - 30 : Steel type number.

31 - 35 : Cross section type number.

36 - 40 : End eccentricity type number. Leave blank or input zero if there is no end eccentricity.

41 - 44 : Geometric stiffness code.

1 : include geometric stiffness.

0 : ignore geometric stiffness.

45 - 48 : Time history output code. If a time history of element results is not required for the element covered by this command, input zero or leave blank. If a time history printout, at the intervals specified in Section 6.1, is required, input 1.

49 - 52 : Code for the output of hysteretic curve. If hysteretic response information for this element is not required, input zero or leave blank. If such information is required, input node number at element end "*i*" or "*j*", of this element.

53 - 56 : Fixed-end force pattern number for static dead loads on element. Leave blank or input zero if there are no dead loads.

57 - 60 : Fixed-end force pattern number for static live loads on element.

Leave blank or input zero if there are no live loads.

61 - 65 : Scale factor to be applied to fixed-end forces due to static dead loads.

66 - 70 : Scale factor to be applied to fixed-end forces due to static live loads.

71 - 75 : Initial force pattern number. Leave blank or input zero if there are no initial forces.

76 - 80 : Scale factor to be applied to initial element forces.

4. Load Information

Static loads may be applied to the structure prior to the application of the dynamic loading, but the response to static load must remain elastic. For a deterministic analysis, ground acceleration data are to be input in the format described in Section 4.4.B. If random earthquake data are to be generated, only the data described in Section 4.1 are to be entered.

4.1 Load Control Data (2I5,1I10,6F10.0)

Columns 1 - 5 : Static load code ("KSTAT").

1 : Static loads are to be applied prior to dynamic loads.

0 : No static loads are to be included in the analysis.

6 - 10 : Number of commands specifying static loads applied directly at the nodes ("NCDLD"). See Section 4.2.

Leave blank or input zero if there are no static loads.

11 - 20 : Number of integration time steps to be considered in the dynamic analysis ("NSTEPS").

21 - 30 : Integration time step, Δt ("DT").

31 - 40 : Scale factor to be applied to the ground X-accelerations ("FACAXH").

41 - 50 : Scale factor to be applied to the time coordinates of the X-acceleration record ("FACAMH").

51 - 60 : Scale factor to be applied to the ground Y-accelerations ("FACAXV").

61 - 70 : Scale factor to be applied to the time coordinates of the Y-acceleration record ("FACAMV").

71 - 80 : Absolute value of the maximum displacement response permitted ("DISMAX"). The specification of such a displacement limit presumes that exceedance of this limit corresponds to failure, at which point the execution is terminated. Default = 10^5.

4.2 Commands for Static Nodal Loads (I5,3F10.0,2I5)

These commands allow the specification of a series of loads having the same static nodal loads with the sign convention of Fig A.6. Omit if there are no static loads applied directly at nodes. One command for each card.

Columns 1 - 5 : First node number in series.

6 - 15 : Load in X direction.

16 - 25 : Load in Y direction.

26 - 35 : Moment.

36 - 40 : Last node number in series. Leave blank or zero for a single node.

41 - 45 : Node number difference between any two successive nodes in series. Default = 1.

Note : A loaded node may appear in two or more commands if desired, for example, if it is a part of two series. In such a case, the total load applied at the node will be the sum of the load from the separate commands.

4.3 Data for Randomly Generated Earthquakes (2I5,3F5.2,2F10.4,F5.4,2F5.0)

Omit this card if KEARTH = 0 (See Section 1.2), i.e. for a deterministic analysis, and proceed to Section 4.4.

Columns 1 - 5 : Number of artificial earthquakes to be generated ("NEAR").

6 - 10 : Code for envelope function type (See Fig 2.1).

1 : for trapezoidal envelope.

2 : for exponential envelope.

11 - 15 : Initial peak time, t_1, for the trapezoidal envelope function; coefficient α, for the exponential envelope function.

16 - 20 : Last peak time, t_2, for the trapezoidal envelope function; coefficient β, for the exponential envelope function.

21 - 25 : Strong motion duration, t_3, for the trapezoidal envelope function, but leave blank or input zero for the exponential envelope function.

26 - 35 : Intensity factor for the input spectrum, S_o. For this program, the one-sided Kanai-Tajimi spectrum is used, Fig. A.7.

36 - 45 : Characteristic dominant frequency, ω_g.

46 - 50 : Characteristic dominant damping ratio, τ_g.

51 - 55 : Upper cut-off frequency, ω_u.

56 - 60 : Peak factor for the earthquake simulation, p_g.

Note : For firm soil conditions, the following parameter values are recommended: for $1g$ peak acceleration data, $S_o = 0.6378(ft^2/sec^3)$; $\omega_g = 9\pi(rad/sec)$; $\tau_g = 0.6$; $\omega_u = 300(rad/sec)$ for one-sided Kanai-Tajimi spectrum, and $p_g = 3.0$. For $0.1g$ peak acceleration earthquake, only the S_o value changes to $0.006378(ft^2/sec^3)$. For further information see Ref. 13.

4.4 Deterministic Acceleration Records

Omit this set of data if KEARTH = 1, i.e. for randomly generated earthquakes.

4.4.A Control Information (4I5,10A4)

Columns 1 - 5 : Number of time-acceleration pairs defining ground motion in X direction (NPTH). Input zero or leave blank for no ground motion in this direction.

6 - 10 : Number of time-acceleration pairs defining ground motion in Y direction (NPTV). Input zero or leave blank for no ground motion in this direction.

11 - 15 : Code for echo printing accelerations as input. Leave blank or zero for no output.

1 : print.

0 : do not print.

16 - 20 : Code for echo printing accelerations as interpolated at intervals of Δt.

1 : print.

0 : do not print.

21 - 60 : Title to identify acceleration record.

4.4.B Ground Acceleration Time History in X-Direction (6(F6.3,F7.3))

Omit if NPTH = 0. Otherwise, enter 6 pairs of time and acceleration records per card. The first time-acceleration pair has to be (0.0,0.0). Note that both the accelerations and time coordinates may be scaled if desired. See Section 4.1.

4.4.C Ground Acceleration Time History in Y-Direction (6(F6.3,F7.3))

Omit if NPTV = 0. Otherwise, enter 6 pairs of time and acceleration records per card. The first time-acceleration pair has to be (0.0,0.0). Note that both the accelerations and time coordinates may be scaled if desired. See Section 4.1.

5. Analysis Information

5.1 Control Information for Eigenvalue Analysis(2I5)

Columns 1 - 5 : Code for natural frequencies.

1 : compute natural frequencies at specified time intervals.

0 : do not compute natural frequencies.

6 - 10 : Time intervals, at which natural frequencies are to be computed, expressed as a multiple of the time step, Δt.

5.2 Control Information for Damage Indices (4I5)

Omit this card if KDAMAGE = 0 in Section 1.2. Otherwise, all nodal damage indices as well as global and story damage indices may be obtained at selected time intervals. If KDAMAGE = 1, all damage indices will be automatically computed at the end of the time history analysis.

Columns 1 - 5 : Code for time history of damage index.

1 : compute and print time history of damage indices.

0 : do not compute.

6 - 10 : Time interval for nodal damage indices to be computed, expressed as a multiple of the time step, Δt.

11 - 15 : Time interval for story damage indices to be computed, expressed as a multiple of the time step, Δt.

16 - 20 : Time interval for structural damage indices to be computed, expressed as a multiple of the time step, Δt.

5.3 Data for Automatic Design Procedure (5X,1I5,4F10.5)

Omit this card if KAUTO = 0 in Section 1.2.

Columns 6 - 10 : Maximum number of automatic design iterations.

11 - 20 : Target mean value of beam damage indices.

21 - 30 : Tolerance by which the actual mean may deviate from the target mean value.

31 - 40 : Maximum tolerable deviation of individual beam damage indices from the actual mean value.

41 - 50 : Allowable damage index for beam-columns.

6. Time History Output Specifications

Omit all the cards for this section if KEARTH = 1, i.e. for randomly generated earthquake data. However, envelope values of all nodal displacements and element results are automatically printed at the end of the computation for each randomly generated earthquake, except if the specified maximum displacement has been exceeded.

For the deterministic earthquake data, i.e. KEARTH = 0, printed time histories of selected nodal displacements and element results at selected time intervals may be obtained if desired. Similarly, envelope values of all nodal displacements and element results are printed at the end of the computation if the specified maximum displacement was not exceeded. Intermediate result envelopes are also printed at selected time intervals.

6.1 Control Information (6I5)

Columns 1 - 5 : Time interval for printout of nodal displacement time histories, expressed as a multiple of a time step Δt. Leave blank for no printout. The nodes for which time histories are required are specified in Sections 6.2, 6.3 and 6.4.

6 - 10 : Time interval for printout of time histories of element results, expressed as a multiple of the time step Δt. Leave blank for no printout. The elements for which time histories are required are specified in Section 3.8.

11 - 15 : Time interval for intermediate printout of envelope values, expressed as a multiple of the time step Δt. Leave blank for no intermediate printout. Envelope values are automatically printed at the end of the response period.

16 - 20 : Number of nodes (NHOUT) for which X displacement time histories are required.

21 - 25 : Number of nodes (NVOUT) for which Y displacement time histories

are required.

26 - 30 : Number of nodes (NROUT) for which rotation time histories are required.

6.2 List of Nodes for X-Displacement Time Histories (10I5)

As many cards as needed to specify NHOUT node numbers, with up to 10 nodes per card. Omit if NHOUT = 0.

6.3 List of Nodes for Y-Displacement Time Histories (10I5)

As many cards as needed to specify NVOUT node numbers, with up to 10 nodes per card. Omit if NVOUT = 0.

6.4 List of Nodes for Rotation Time Histories (10I5)

As many cards as needed to specify NROUT node numbers, with up to 10 nodes per card. Omit if NROUT = 0.

7. Termination

One card (A4) to terminate the complete data.

Columns 1 - 4 : Print the word "STOP".

8. Installation and Execution

SARCF is written in Fortran-77 language for VAX/VMS computer systems. All the calculations need to be performed in double precision. Otherwise, truncation errors would cause excessive errors in the solution and numerical instabilities. This program has also been installed with relatively little additional effort on SUN3 micro-computer systems. It can be installed on most small or large computers as well.

The SARCF source consists of about 6000 statements, listed in Appendix B, and is organized in a number of "base" subroutines. These subroutines read and print the structure and loading data, assemble the structure stiffness and loading, compute the displacement histories of the structure, eigenvalues, the statistics of damage indices and perform automatic design modifications of a preliminary frame design. It is in particular noted that SARCF calls some IMSL subroutines to generate random earthquakes (Ref. 7). Because the IMSL library is proprietary, these subroutines are not listed in the Appendix B. These subroutines are

FFTCC, GGUD and GGUBFS

and are called in lines 1022, 1052 and 1082 of the listing in Appendix B.

A typical procedure to execute SARCF on the VAX 780 under a VMS system or to execute the program on the SUN3 micro-computer, is listed below:

For VAX 780

```
$ assign Datafile for$read
$ assign Outputfile for$print
$ for sarcf
$ lin sarcf
$ run sarcf
```

For SUN3

```
% f77 -ffpa -O -o sarcf.exe sarcf.f
% sarcf.exe <Datafile >Outputfile
```

After executing SARCF, the following output or scratch files will be generated on the for002.dat : scratch file for element information.

for007.dat : scratch file for element information only if the automatic design is required.

for008.dat : scratch file for time history of horizontal or vertical displacement if required (see Section 6.2 and 6.3).

for009.dat : scratch file for time history of rotational displacement if required (see Section 6.4).

for012.dat : scratch file for element stiffness information only if natural frequencies are required.

for013.dat : scratch file for element lumped mass information only if natural frequencies are required.

for016.dat : output file of the hysteretic curve information only for the element required (see Section 3.8).

for020.dat : output file of time history of damage indices if damage analysis is required.

for033.dat : output file of mean value of all the element damage indices only if random earthquake analysis is required.

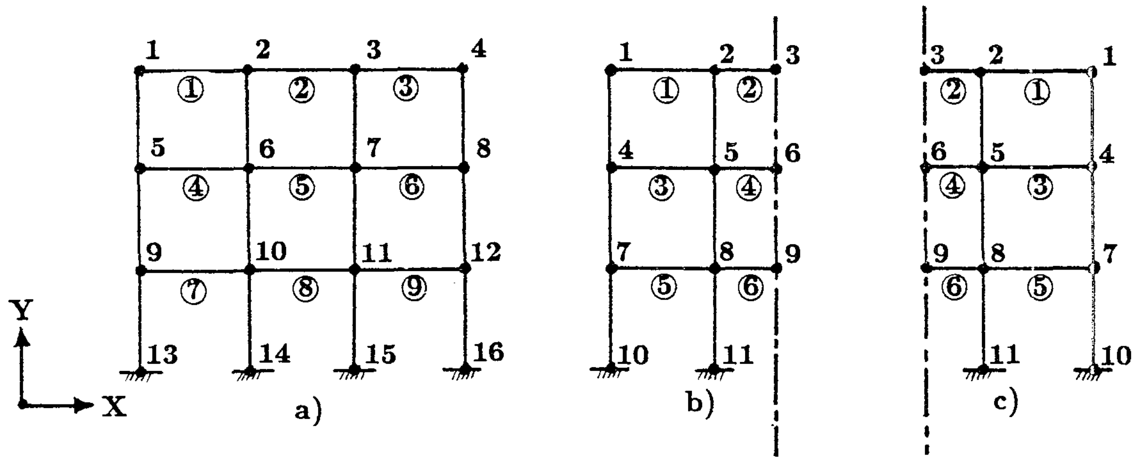

Fig. A.1 – Node and Beam Element Numbering Sequence
(Mandatory if the Automatic Design Option is Required.)

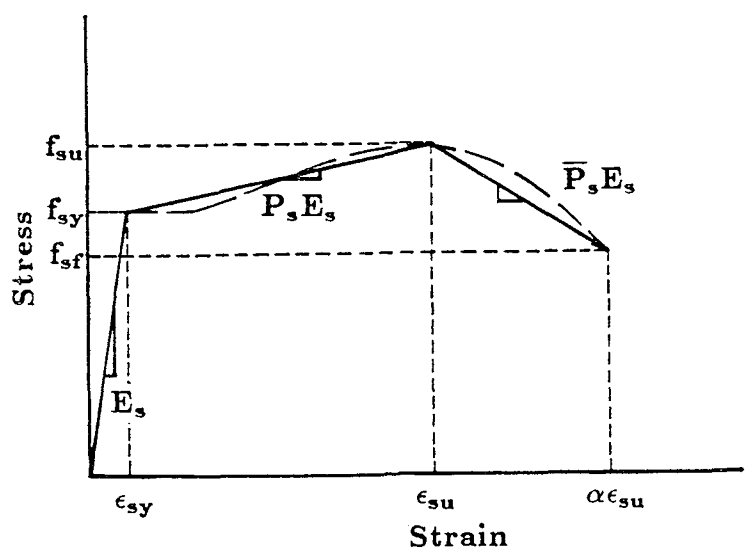

Fig. A.2 – Stress-Strain Curve for Reinforcing Steel

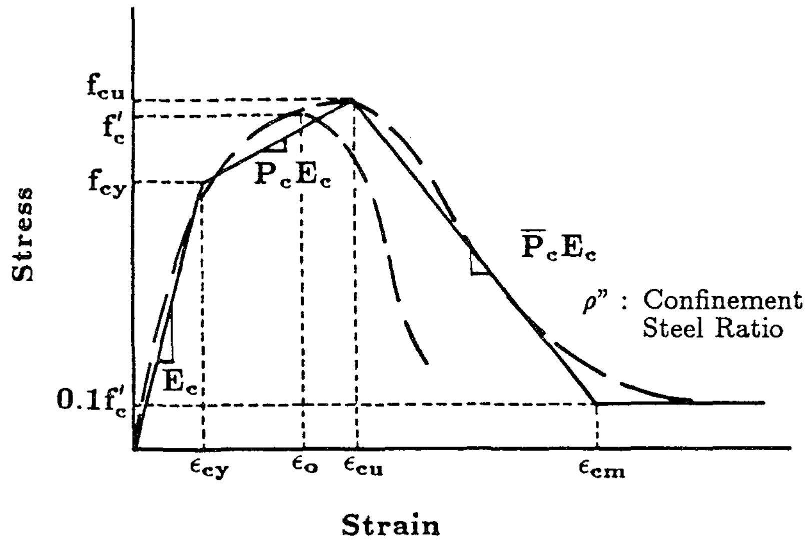

Fig. A.3 – Stress-Strain Curve for Concrete

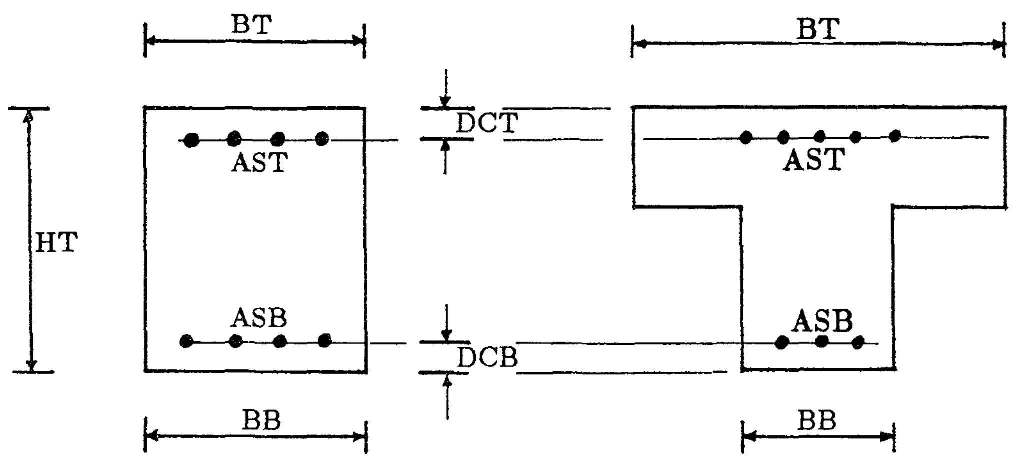

Fig. A.4 – Idealized Concrete Cross Sections

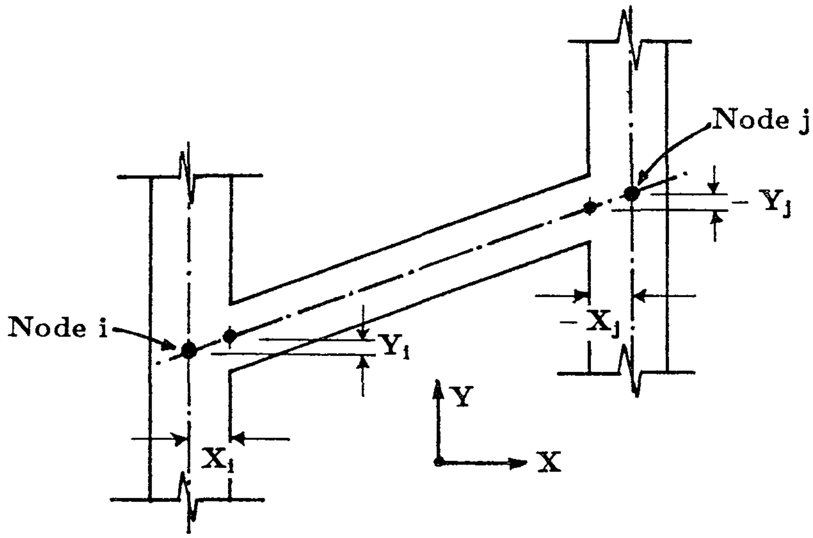

Fig. A.5 – End Eccentricities of Frame Element

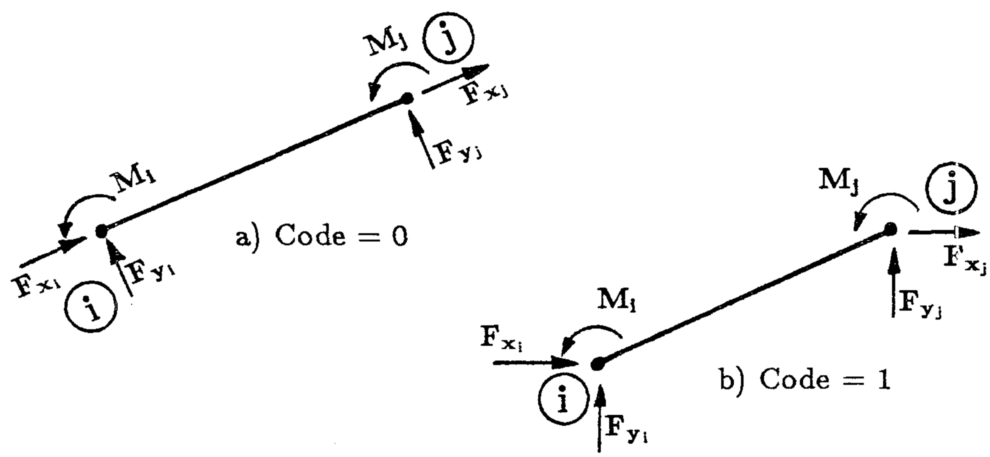

Fig. A.6 – Fixed End Forces and Initial Forces Pattern

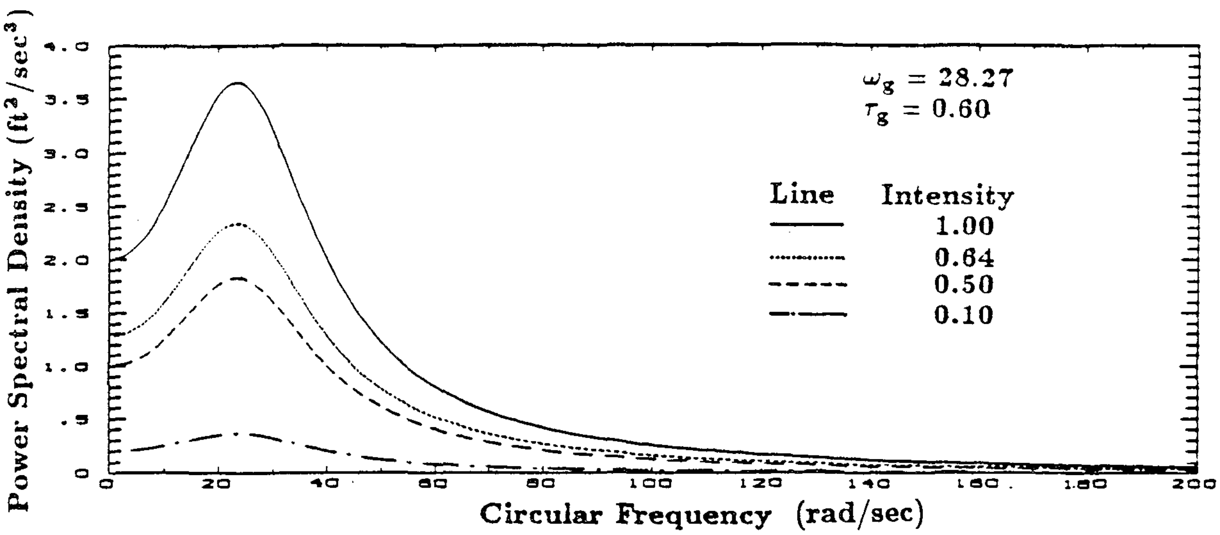

Fig. A.7 – One-Sided Kanai Tajimi Spectrum

Appendix – B

(Fortran Source Listing of Program SARCF)

Please contact NCEER for the magnetic tape of program source file.

```
C     ****************************************************************** MAIN   1
C     ****************************************************************** MAIN   2
C     *                      SEISMIC ANALYSIS                            MAIN   3
C     *                             OF                                   MAIN   4
C     *                  REINFORCED CONCRETE FRAMES                      MAIN   5
C     *                          ( SARCF )                               MAIN   6
C     *                                                                  MAIN   7
C     *                     YOUNG SOO CHUNG, PH.D.                       MAIN   8
C     *                       RESEARCH ASSOCIATE                         MAIN   9
C     *                                                                  MAIN   9
C     *                                                                  MAIN   9
C     * DEPARTMENT OF CIVIL ENGINEERING AND OPERATIONS RESEARCH          MAIN  10
C     *                      PRINCETON UNIVERSITY                        MAIN  11
C     *                                                                  MAIN  12
C     *                               DATED ON NOVEMBER 1, 1988          MAIN  13
C     *                                                                  MAIN  14
C     *                                                                  MAIN  15
C     ****************************************************************** MAIN  16
C     ****************************************************************** MAIN  17
      IMPLICIT REAL*8(A-H,O-Z)                                           MAIN  18
C                                                                        MAIN  19
C     SET STORAGE CAPACITY AND CALL DRAIN                                MAIN  20
C                                                                        MAIN  21
      COMMON A(50000)                                                    MAIN  22
      NNTST=5000                                                         MAIN  23
C                                                                        MAIN  24
      CALL SARCF(A,NNTST)                                                MAIN  25
C                                                                        MAIN  26
      STOP                                                               MAIN  27
      END                                                                MAIN  28
C     *******************************************************************MAIN  29
      SUBROUTINE SARCF (A,NNTST)                                         SARCF  1
      IMPLICIT REAL*8(A-H,O-Z)                                           SARCF  2
C                                                                        SARCF  3
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY      SARCF  4
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)      SARCF  5
     1              ,FCONT(3),NUMEM(10)                                  SARCF  6
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,        SARCF  7
     1             C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA    SARCF  8
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IEAR,NEAR,SARCF  9
     1    KSYM,KSYMD                                                     SARCF 10
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA,NF17           SARCF 11
      COMMON/OUTN/ IPJ,IPE,KNTJ,KNTE,NHOUT,NVOUT,NROUT                   SARCF 12
      COMMON/WORK/HED1(18),KFORM1(2),TITLE1(10),W1(1571)                 SARCF 13
      COMMON/WORK1/ HED(18),KFORM(2),TITLE(10)                           SARCF 14
      COMMON/THIST/ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE    SARCF 15
      COMMON/INFEL/ IMEM,IMEMD,KST,KSTD,LM(1),LMD(1),DUM(212)            SARCF 16
      COMMON/THISTJ/ITHPJ,NF5,NSTHJ,ISJ                                  SARCF 17
      COMMON/THISTR/ITHPR,NF6,NSTHR,NHR,NVR,LRH1(50),LRH2(50),LRV1(50),  SARCF 18
     1       LRV2(50)                                                    SARCF 19
      COMMON/EQUAKE/DSEED,PGA,WG,TAU,UWG,PG,IEVL,KIEVL,ENA,ENB,ENC       SARCF 20
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,     SARCF 21
     1GLDAM                                                              SARCF 22
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,     SARCF 23
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV               SARCF 24
C                                                                        SARCF 25
      PARAMETER (NQKE=20,NELN=40,NELG=2)                                 SARCF 26
      DIMENSION NIBAY(NELN/3),STIN(6,NELN),CONIN(9,NELN),SECIN(9,NELN),  SARCF 27
     1ITY(3,NELN),YBM(2,NELG,NELN),RHOM(2,NELG,NELN),DDIN(2,NELN),       SARCF 28
     2DMY(2,NELN),DCAVG(NELN),DBAVG(NELN),DEDIF(NELN),PDEDIF(NELN),      SARCF 29
     3IECHK(NELN),ICOR(NELN),IICHK(NELN),DD1(NQKE),DD2(NQKE),DA(NELN),   SARCF 30
     4NOD(2*NELN),DDAM(NQKE,2*NELN),STHYS(NELG,NELN/3),                  SARCF 31
     5STDAM(NELG,NELN/3),STRDAM(NELN/3),STRHYS(NELN/3),ELDAM(NELG,NELN),SARCF 32
     6ELHYS(NELG,NELN),IR(NQKE),S(2*NELN),IP(5*NELN),KIP(5*NELN),        SARCF 33
     7PR(5*NELN),PPR(2,5*NELN)                                           SARCF 34
C                                                                        SARCF 35
      DIMENSION A(1)                                                     SARCF 36
      DIMENSION CHEK(2),HDAT(3,3),HSTF(2,2),SLOD(2,2)                    SARCF 37
      DATA CHEK/5HSTART,5HSTOP /                                         SARCF 38
      DATA HDAT/8HEXECUTE ,8H        ,8H        ,                        SARCF 39
     1          8HDATA CHE,8HCKING ON,8HLY      ,                        SARCF 40
     2          8HEXECUTE ,8HIF SINGL,8HE BLOCK /                        SARCF 41
      DATA HSTF/8HSTORED I,8HN CORE  ,                                   SARCF 42
     1          8HSTORED O,8HN TAPE  /                                   SARCF 43
      DATA SLOD/8HLOADS AP,8HPLIED   ,                                   SARCF 44
     1          8HLOADS IG,8HNORED   /                                   SARCF 45
C                                                                        SARCF 46
C     START AND TITLE CARD                                               SARCF 47
C                                                                        SARCF 48
   20 FORMAT (A5,3X,18A4)                                                SARCF 49
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```
   10 READ 20, OPER,HED                                                 SARCF 50
      IF (OPER.EQ.CHEK(2)) CALL EXIT                                    SARCF 51
      IF (OPER.NE.CHEK(1)) GO TO 10                                     SARCF 52
      PRINT 30, HED                                                     SARCF 53
   30 FORMAT (9H1ERDARCS ,59X,4H1986//72(1H*)//1X,18A4//72(1H*))        SARCF 54
      READ 25, KEARTH,KDAMAGE,KAUTO,KDATA                               SARCF 55
   25 FORMAT (4I5)                                                      SARCF 56
C                                                                       SARCF 57
      NF1=1                                                             SARCF 58
      NF2=2                                                             SARCF 59
      NF3=3                                                             SARCF 60
      NF4=4                                                             SARCF 61
      NF5=8                                                             SARCF 62
      NF6=9                                                             SARCF 63
      NF7=10                                                            SARCF 64
      NF17=7                                                            SARCF 65
      REWIND NF17                                                       SARCF 66
      REWIND NF1                                                        SARCF 67
      REWIND NF2                                                        SARCF 68
      REWIND NF3                                                        SARCF 69
C                                                                       SARCF 70
C     CONTROL CARD                                                      SARCF 71
C                                                                       SARCF 72
      READ 40, NSTORY,NBAY,NJTS,NCONJT,NCDJT,NCDDOF,NCDDIS,NCDMS,NELGR, SARCF 73
     1KDOST,KSYM,NTST                                                   SARCF 74
   40 FORMAT (11I5,I10)                                                 SARCF 75
      IF(NELGR .LE. NELG) GO TO 42                                      SARCF 76
      PRINT 43, NELGR                                                   SARCF 77
   43 FORMAT('INCREASE THE PARAMETER, NELG, FOR NUMBER OF ELEMENT GROUP SARCF 78
     1, I.E. INPUT NELG >= ',I3)                                        SARCF 79
      GO TO 999                                                         SARCF 80
   42 IF(NBAY .EQ. 0) READ 41, (NIBAY(I),I=1,NSTORY)                    SARCF 81
   41 FORMAT(16I5)                                                      SARCF 82
C                                                                       SARCF 83
      IF (NTST.EQ.0) NTST=NNTST                                         SARCF 84
      I=1                                                               SARCF 85
      IF (KDATA.GT.0) I=2                                               SARCF 86
      IF (KDATA.LT.0) I=3                                               SARCF 87
      J=1                                                               SARCF 88
      IF (KODST.NE.0) J=2                                               SARCF 89
      PRINT 50, NJTS,NCONJT,NCDJT,NCDDOF,NCDDIS,NCDMS,NELGR,KDATA,(HDAT(SARCF 90
     1K,I),K=1,3),KODST,(HSTF(K,J),K=1,2),NTST                          SARCF 91
   50 FORMAT (////                                                      SARCF 92
     1 41H TOTAL NUMBER OF NODES                   =I5//                SARCF 93
     2 41H NO. OF CONTROL NODES                    =I5/                 SARCF 94
     3 41H NO. OF NODE GENERATION COMMANDS         =I5//                SARCF 95
     4 41H NO. OF ZERO DISPLACEMENT COMMANDS       =I5/                 SARCF 96
     5 41H NO. OF IDENTICAL DISPLACEMENT COMMANDS  =I5//                SARCF 97
     6 41H NO. OF MASS GENERATION COMMANDS         =I5//                SARCF 98
     7 41H NO. OF ELEMENT GROUPS                   =I5///               SARCF 99
     8 41H DATA CHECKING CODE                      =I5,6X,3A8/          SARCF100
     9 41H STRUCTURE STIFFNESS STORAGE CODE        =I5,6X,2A8///        SARCF101
     9 41H BLANK COMMON TO BE ASSUMED              =I10)                SARCF102
C                                                                       SARCF103
      KID=1                                                             SARCF104
      KX=KID+3*NJTS                                                     SARCF105
      KY=KX+NJTS                                                        SARCF106
C                                                                       SARCF107
C     NODE COORDINATES, ETC                                             SARCF108
C                                                                       SARCF109
      CALL INJTS (A(KX),A(KY),A(KID),NJTS,NCONJT,NCDJT,NCDDOF,NCDDIS)   SARCF110
C                                                                       SARCF111
C     MASS DATA                                                         SARCF112
C                                                                       SARCF113
      KFM=KY+NJTS                                                       SARCF114
      KEQM=KFM+NEQ+1                                                    SARCF115
      KD=KEQM+NEQ+1                                                     SARCF116
      KDDS=KD+NEQ+1                                                     SARCF117
      KM=KDDS+NEQ+1                                                     SARCF118
      NEQK=KD+NEQ                                                       SARCF119
      DO 72 I=KDDS,KM-1                                                 SARCF120
72    A(I)=0.0                                                          SARCF121
C                                                                       SARCF122
      CALL INMASS (A(KFM),A(KEQM),A(KID),NCDMS,NJTS)                    SARCF123
C                                                                       SARCF124
C     DATA FOR DAMPING COEFFICIENTS                                     SARCF125
C                                                                       SARCF126
      READ 11,ALPHA,BETA,BETAO,DELTA                                    SARCF127
   11 FORMAT(4E10.0)                                                    SARCF128
      PRINT 21, ALPHA,BETA,BETAO,DELTA                                  SARCF129
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   21 FORMAT( 21H1DAMPING COEFFICIENTS   ////                           SARCF130
     1         5X,39HMASS PROPORTION, ALPHA                =F12.6//     SARCF131
     2         5X,39HTANGENT STIFFNESS PROPORTION, BETA    =F12.6//     SARCF132
     3         5X,39HORIGINAL STIFFNESS PROPORTION, BETA-O =F12.6//     SARCF133
     4         5X,39HSTRUCTURAL DAMPING, DELTA             =F12.6)      SARCF134
C                                                                       SARCF135
C     ELEMENT DATA                                                      SARCF136
C                                                                       SARCF137
      CALL INELEM (A(KID),A(KX),A(KY),A(KM),NJTS,NELTOT,ITY,STIN,CONIN, SARCF138
     1SECIN,DDIN,RHOM,YBM,NELG,NELN,IP,KIP,PR,PPR,DMY)                  SARCF139
C                                                                       SARCF140
C     LOAD CONTROL DATA                                                 SARCF141
C                                                                       SARCF142
      READ 61, KSTAT,NCDLD,NSTEPS,DT,FACAXH,FACTMH,FACAXV,FACTMV,DISMAX SARCF143
   61 FORMAT (2I5,1I10,6F10.0)                                          SARCF144
      KSTAT=0                                                           SARCF145
      IF (FACTMV.EQ.0.) FACTMV=1.                                       SARCF146
      IF (DISMAX.EQ.0.) DISMAX=100000.                                  SARCF147
C                                                                       SARCF148
C     COEFFICIENTS FOR EQUATION OF MOTION                               SARCF149
C                                                                       SARCF150
      CALL CONSTANT                                                     SARCF151
C                                                                       SARCF152
C     STATIC NODAL LOADS                                                SARCF153
C                                                                       SARCF154
      CALL INEXLD (A(KDDS),A(KID),NCDLD,NJTS,A(KEQM))                   SARCF155
C                                                                       SARCF156
C     INPUT INFORMATION FOR EARTHQUAKE                                  SARCF157
C                                                                       SARCF158
      IF(KEARTH.EQ.1) GO TO 64                                          SARCF159
C                                                                       SARCF160
C     INPUT INFORMATION FOR DETERMINISTIC EARTHQUAKE                    SARCF161
C                                                                       SARCF162
      J=1                                                               SARCF163
      IF(KSTAT.EQ.0)J=2                                                 SARCF164
      PRINT 71, KSTAT,(SLOD(K,J),K=1,2),NCDLD,NSTEPS,DT,FACAXH,FACTMH,FASARCF165
     1CAXV,FACTMV,DISMAX                                                SARCF166
   71 FORMAT (32H STATIC LOAD CONTROL INFORMATION  ///                  SARCF167
     1        29H STATIC LOAD CODE             =I5,1X,2A8//             SARCF168
     2        29H NO. OF NODAL LOAD COMMANDS =I5//////                  SARCF169
     1        31H1EARTHQUAKE CONTROL INFORMATION  ///                   SARCF170
     1        32H DETERMINISTIC EARTHQUAKE       /                      SARCF171
     2        32H NO. OF INTEGRATION TIME STEPS =I5/                    SARCF172
     3        32H INTEGRATION STEP SIZE         =F9.4///                SARCF173
     4        40H MAGNIFICATION FACTORS FOR X EARTHQUAKE    /           SARCF174
     5        18X, 14HACCELERATION =, F9.2, /                           SARCF175
     6        18X, 14HTIME         =, F9.2, //                          SARCF176
     7        40H MAGNIFICATION FACTORS FOR Y EARTHQUAKE    /           SARCF177
     8        18X, 14HACCELERATION =, F9.2, /                           SARCF178
     9        18X, 14HTIME         =, F9.2 , ///                        SARCF179
     9        32H MAX. PERMISSIBLE DISPLACEMENT =F10.2)                 SARCF180
      GO TO 125                                                         SARCF181
C                                                                       SARCF182
C     INPUT INFORMATION FOR ARTIFICIAL EARTHQUAKE                       SARCF183
C                                                                       SARCF184
   64 READ 126, NEAR,IEVL,ENA,ENB,ENC,PGA,WG,TAU,UWG,PG                 SARCF185
  126 FORMAT(2I5,3F5.2,2F10.4,F5.4,2F5.0)                               SARCF186
C                                                                       SARCF187
      J=1                                                               SARCF188
      IF(KSTAT.EQ.0)J=2                                                 SARCF189
      PRINT 73, KSTAT,(SLOD(K,J),K=1,2),NCDLD,NEAR,NSTEPS,DT,FACAXH,FACTSARCF190
     1MH,FACAXV,FACTMV,DISMAX                                           SARCF191
   73 FORMAT (32H STATIC LOAD CONTROL INFORMATION  ///                  SARCF192
     1        29H STATIC LOAD CODE             =I5,1X,2A8//             SARCF193
     2        29H NO. OF NODAL LOAD COMMANDS =I5//////                  SARCF194
     1        31H1EARTHQUAKE CONTROL INFORMATION///                     SARCF195
     1        32H NO. OF INPUT EARTHQUAKE       =I5/                    SARCF196
     2        32H NO. OF INTEGRATION TIME STEPS =I5/                    SARCF197
     3        32H INTEGRATION STEP SIZE         =F9.4///                SARCF198
     4        40H MAGNIFICATION FACTORS FOR X EARTHQUAKE    /           SARCF199
     5        18X, 14HACCELERATION =, F9.2, /                           SARCF200
     6        18X, 14HTIME         =, F9.2, //                          SARCF201
     7        40H MAGNIFICATION FACTORS FOR Y EARTHQUAKE    /           SARCF202
     8        18X, 14HACCELERATION =, F9.2, /                           SARCF203
     9        18X, 14HTIME         =, F9.2 , ///                        SARCF204
     9        32H MAX. PERMISSIBLE DISPLACEMENT =F10.2)                 SARCF205
C                                                                       SARCF206
      IF(NEAR .LE. NQKE) GO TO 122                                      SARCF207
      PRINT 123, NEAR                                                   SARCF208
  123 FORMAT('INCREASE THE PARAMETER, NQKE, FOR NUMBER OF RANDOM EARTHQUSARCF209
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     1AKE, I.E. INPUT NQKE >=',I5)                                      SARCF210
      GO TO 999                                                         SARCF211
  122 IF(IEVL .EQ. 1) PRINT 127, PGA,WG,TAU,UWG,PG,ENA,ENB,ENC          SARCF212
  127 FORMAT(35HARTIFICIAL EARTHQUAKE INFORMATIONS ///                  SARCF213
     1       43HKANAI-TAJIMI SPECTRAL DENSITY FUNCTION WITH//           SARCF214
     2    5X,25HINTENSITY FOR SPECTRUM  =F8.4,'  (FT**2/SC**3)'//       SARCF215
     3    5X,25HDOMINANT FREQUENCY      =F8.4,'  (RAD/SECOND)'//        SARCF216
     4    5X,25HDOMINANT DAMAPING RATIO =F8.4,//                        SARCF217
     5    5X,25HUPPER CUT-OFF FREQUENCY =F10.2,'  (RAD/SECOND)'//       SARCF218
     6    5X,25HPEAK FACTOR             =F10.2,//                       SARCF219
     7       35HTRAPEZOIDAL ENVELOPE FUNCTION WITH ///                  SARCF220
     8    5X,25HINITIAL PEAK TIME       =F8.4,'  (FT**2/SC**3)'//       SARCF221
     9    5X,25HLAST PEAK TIME          =F8.4,//                        SARCF222
     9    5X,25HSTRONG MOTION DURATION  =F8.4,///)                      SARCF223
C                                                                       SARCF224
      IF(IEVL .EQ. 2) PRINT 128, PGA,WG,TAU,UWG,PG,ENA,ENB              SARCF225
  128 FORMAT(35HARTIFICIAL EARTHQUAKE INFORMATIONS ///                  SARCF226
     1       43HKANAI-TAJIMI SPECTRAL DENSITY FUNCTION WITH//           SARCF227
     2    5X,25HINTENSITY FOR SPECTRUM  =F8.4,'  (FT**2/SC**3)'//       SARCF228
     3    5X,25HDOMINANT FREQUENCY      =F8.4,'  (RAD/SECOND)'//        SARCF229
     4    5X,25HDOMINANT DAMAPING RATIO =F8.4,//                        SARCF230
     5    5X,25HUPPER CUT-OFF FREQUENCY =F10.2,'  (RAD/SECOND)'//       SARCF231
     6    5X,25HPEAK FACTOR             =F10.2,//                       SARCF232
     7       35HEXPONENTIAL ENVELOPE FUNCTION WITH ///                  SARCF233
     8    5X,25HCOEFFICIENT FOR ALPHA   =F8.4,'  (FT**2/SC**3)'//       SARCF234
     9    5X,25HCOEFFICIENT FOR BETA    =F8.4,///)                      SARCF235
C                                                                       SARCF236
      IDSGN=0                                                           SARCF237
      ICONV=0                                                           SARCF238
      DO 92 I=1,20                                                      SARCF239
      ICOR(I)=0                                                         SARCF240
   92 IECHK(I)=0                                                        SARCF241
C                                                                       SARCF242
      IF(KEARTH .EQ. 0) GO TO 125                                       SARCF243
      CALL RANINT(NEAR,IR)                                              SARCF244
   91 IEAR=IEAR+1                                                       SARCF245
      IF(NEAR .GE. 1) DSEED=DFLOAT(IR(IEAR))                            SARCF246
C                                                                       SARCF247
C     EARTHQUAKE RECORDS                                                SARCF248
C                                                                       SARCF249
      IF(IEAR .GE. 2 .OR. IDSGN .GE. 1) GO TO 81                        SARCF250
  125 READ 90, NPTH,NPTV,KFORM,TITLE                                    SARCF251
   90 FORMAT (4I5,10A4)                                                 SARCF252
      IF(KEARTH .EQ. 1) GO TO 63                                        SARCF253
      PRINT 100, TITLE,NPTH,NPTV,KFORM                                  SARCF254
  100 FORMAT (/////32H1EARTHQUAKE ACCELERATION RECORDS,3H - ,10A4,///   SARCF255
     1              30H NO. OF X INPUT PAIRS       =, I5, /             SARCF256
     2              30H NO. OF Y INPUT PAIRS       =, I5, ///           SARCF257
     3              12H PRINT CODES   //                                SARCF258
     4              30H ACCELERATIONS AS INPUT     =, I5, /             SARCF259
     5              30H INTERPOLATED ACCELERATIONS  =, I5)              SARCF260
      GO TO 81                                                          SARCF261
C                                                                       SARCF262
   63 PRINT 101, TITLE,IEAR,NPTH,NPTV,KFORM                             SARCF263
  101 FORMAT (/////32H1EARTHQUAKE ACCELERATION RECORDS,3H - ,10A4,3HNO.,SARCF264
     1I5///                                                             SARCF265
     1              30H NO. OF X INPUT PAIRS       =, I5, /             SARCF266
     2              30H NO. OF Y INPUT PAIRS       =, I5, ///           SARCF267
     3              12H PRINT CODES   //                                SARCF268
     4              30H ACCELERATIONS AS INPUT     =, I5, /             SARCF269
     5              30H INTERPOLATED ACCELERATIONS  =, I5)              SARCF270
C                                                                       SARCF271
   81 DO 80 I=KD,NEQK                                                   SARCF272
   80 A(I)=0.0                                                          SARCF273
C                                                                       SARCF274
      IF(IEAR .GE. 2) PRINT 103,TITLE,IEAR                              SARCF275
  103 FORMAT (/////32H1EARTHQUAKE ACCELERATION RECORDS,3H - ,10A4,3HNO.,SARCF276
     1I5)                                                               SARCF277
C                                                                       SARCF278
      KTH=KM+NEQ+1                                                      SARCF279
      KGH=KTH+NPTH                                                      SARCF280
      KTV=KGH+NPTH                                                      SARCF281
      KGV=KTV+NPTV                                                      SARCF282
      KAXH=KGV+NPTV                                                     SARCF283
      KAXV=KAXH+NSTEPS                                                  SARCF284
C                                                                       SARCF285
      DO 104 I=KTH,KAXV+NSTEPS-1                                        SARCF286
  104 A(I)=0.0                                                          SARCF287
C                                                                       SARCF288
      CALL INAXL (KFORM,A(KTH),A(KGH),A(KTV),A(KGV),A(KAXH),A(KAXV),NSTESARCF289
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     1PS,DT,FACAXH,FACTMH,FACAXV,FACTMV,KEARTH,IEAR)                    SARCF290
C                                                                       SARCF291
C     ANALYSIS INFORMATION DATA                                         SARCF292
C                                                                       SARCF293
      IF(IEAR.GE.2 .OR. IDSGN.GE.1) GO TO 121                           SARCF294
C                                                                       SARCF295
C     ANALYSIS FOR FUNDAMENTAL NATURAL FREQUENCY                        SARCF296
C                                                                       SARCF297
      READ 105, KFREQ,IFREQ                                             SARCF298
  105 FORMAT(2I5)                                                       SARCF299
      IF(KFREQ .NE. 1) PRINT 106, KFREQ                                 SARCF300
  106 FORMAT(42HANALYSIS FOR FUNDAMENTAL NATURAL FREQUENCY///           SARCF301
     1     5X,35HCODE FOR ANALYSIS                     = ,I5,/          SARCF302
     2   20X,'*** DO NOT COMPUTE NATURAL FREQUENCY ',///)               SARCF303
      IF(KFREQ .EQ. 1) PRINT 107, KFREQ,IFREQ                           SARCF304
  107 FORMAT(42HANALYSIS FOR FUNDAMENTAL NATURAL FREQUENCY///           SARCF305
     1     5X,35HCODE FOR ANALYSIS                     = ,I5,/          SARCF306
     2   20X,'*** COMPUTE NATURAL FREQUENCY ',///                       SARCF307
     3   10X,35HINTERVAL FOR NATURAL FREQUENCY   = ,I5,/)               SARCF308
C                                                                       SARCF309
C     ANALYSIS FOR DAMAGE INDEX                                         SARCF310
C                                                                       SARCF311
      IF(KDAMAGE .EQ. 1) READ 129, ITDAM,NSSKIP,NNSKIP,NGSKIP           SARCF312
  129 FORMAT(4I5)                                                       SARCF313
      IF(KDAMAGE .NE. 1) PRINT 136, KDAMAGE                             SARCF314
  136 FORMAT(22H1DAMAGE INDEX ANALYSIS////                              SARCF315
     1        5X,42HCODE FOR THE DAMAGE INDEX              =,I5,///     SARCF316
     2        20X,' *** NOT PERFORM THE DAMAGE ANALYSIS ***')           SARCF317
      IF(KDAMAGE .GE. 1) PRINT 137, KDAMAGE,ITDAM,NSSKIP,NNSKIP,NGSKIP  SARCF318
  137 FORMAT(22H1DAMAGE INDEX ANALYSIS////                              SARCF319
     1        5X,42HCODE FOR THE DAMAGE INDEX              =,I5,///     SARCF320
     2        5X,42HCODE FOR TIME HISTORIES OF DAMAGE INDEX  =,I5,/     SARCF321
     3        10X,37HINTERVAL FOR NODE DAMAGE INDEX      =,I5,/         SARCF322
     4        10X,37HINTERVAL FOR STORY DAMAGE INDEX     =,I5,/         SARCF323
     5        10X,37HINTERVAL FOR GLOBAL DAMAGE INDEX    =,I5///)       SARCF324
C                                                                       SARCF325
C     ANALYSIS FOR AUTOMATIC DESIGN PROCEDURE                           SARCF326
C                                                                       SARCF327
      IF(KAUTO .EQ. 1) READ 131, KECO,NDSGN,BMAVG,BMDEV,DBALL,DCALL     SARCF328
  131 FORMAT(2I5,4F10.5)                                                SARCF329
      IF(KAUTO .NE. 1) PRINT 132, KAUTO                                 SARCF330
  132 FORMAT(35HAUTOMATIC DESIGN ANALYSIS          ///                  SARCF331
     1     5X,37HCODE FOR AUTOMATIC DESIGN ANALYSIS  =,I5,/             SARCF332
     2   20X,'*** NOT PERFORM THE AUTOMTIC DESIGN ANALYSIS',///)        SARCF333
      IF(KAUTO .EQ. 1) PRINT 133, KAUTO,NDSGN,DBALL,DCALL               SARCF334
  133 FORMAT(35HAUTOMATIC DESIGN ANALYSIS          ///                  SARCF335
     1     5X,37HCODE FOR AUTOMATIC DESIGN ANALYSIS  =,I5,/             SARCF336
     2   20X,'*** DO THE AUTOMTIC DESIGN ANALYSIS',///                  SARCF337
     35X,49HMAXIMUM ITERATION NUMBER OF AUTOMATIC DESIGN     =,I5,//    SARCF338
     45X,49HALLOWABLE MEAN VALUE OF BEAM DAMAGE INDEX       =,F10.5,//  SARCF339
     45X,49HALLOWABLE DEV FROM BEAM MEAN VALUE              =,F10.5,//  SARCF340
     45X,49HTOLERABLE DEV OF INDIVIDUAL BEAM DAMAGE INDEX   =,F10.5,//  SARCF341
     45X,49HALLOWABLE DAMAGE INDICES FOR COLUMN             =,F10.5,///)SARCF342
C                                                                       SARCF343
C     OUTPUT CONTROL DATA                                               SARCF344
C                                                                       SARCF345
      IF(KEARTH.EQ.0) READ 110, IPJ,IPE,IENV,NHOUT,NVOUT,NROUT,NHR,NVR, SARCF346
     1ITHPJ,ITHPR,ITHP,ISJ,ISE                                          SARCF347
  110 FORMAT (13I5)                                                     SARCF348
  121 IF(IPJ .LE. 0) IPJ=0                                              SARCF349
      IF(IPE .LE. 0) IPE=0                                              SARCF350
      IF(IDSGN.EQ.0 .AND. IEAR.EQ.1)                                    SARCF351
     1PRINT 120, IPJ,IPE,IENV,NHOUT,NVOUT,NROUT,NHR,NVR,ITHPJ,ITHPR,ITHPSARCF352
     2,ISJ,ISE                                                          SARCF353
  120 FORMAT (30H1TIME HISTORY OUTPUT INTERVALS //                      SARCF354
     1         5X,21H NODE DISPLACEMENTS =, I5, /                       SARCF355
     2         5X,21H ELEMENT RESULTS    =, I5, ///                     SARCF356
     3         40H OUTPUT INTERVAL FOR RESULTS ENVELOPES =,I5/////      SARCF357
     4         35H NO. OF NODES FOR X DISPL HISTORY =, I5,/             SARCF358
     5         35H NO. OF NODES FOR Y DISPL HISTORY =, I5,/             SARCF359
     6         35H NO. OF NODES FOR ROTATION HISTORY=, I5,///           SARCF360
     7         46H NO. OF PRS OF NODES FOR REL X DISPL HISTORY =,I5,/   SARCF361
     8         46H NO. OF PRS OF NODES FOR REL Y DISPL HISTORY =,I5,/// SARCF362
     9         40H CODE FOR JOINT TIME HISTORY PRINT     =, I5,/        SARCF363
     9         40H CODE FOR REL DISPL TIME HISTORY PRINT =,I5,/         SARCF364
     9         40H CODE FOR ELEMENT TIME HISTORY PRINT   =, I5///       SARCF365
     9         48H CODE FOR SAVING DISPL TIME HISTORIES ON TAPE  =,I5,/ SARCF366
     9         48H CODE FOR SAVING ELEMENT TIME HISTORIES ON TAPE=,I5)  SARCF367
C                                                                       SARCF368
      NSTH=0                                                            SARCF369
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      NSTHR=0                                                           SARCF370
      NELTH=0                                                           SARCF371
      NSTHJ=0                                                           SARCF372
      IF (ITHPJ.GT.0) REWIND NF5                                        SARCF373
      IF (ITHPR.GT.0) REWIND NF6                                        SARCF374
      IF (ITHP.GT.0) REWIND NF4                                         SARCF375
C                                                                       SARCF376
      KJH=KAXV+NSTEPS                                                   SARCF377
      KJV=KJH+NHOUT                                                     SARCF378
      KJR=KJV+NVOUT                                                     SARCF379
      IF (IPJ.EQ.0) IPJ=-1                                              SARCF380
      IF (IPE.EQ.0) IPE=-1                                              SARCF381
C                                                                       SARCF382
      IF(KEARTH.EQ.0) CALL OUTJT (A(KJH),A(KJV),A(KJR),A(KID),NJTS)     SARCF383
C                                                                       SARCF384
      IF (NHR.EQ.0) GO TO 150                                           SARCF385
      READ 130,(LRH1(I),LRH2(I),I=1,NHR)                                SARCF386
  130 FORMAT (10I5)                                                     SARCF387
      PRINT 140, (LRH1(I),LRH2(I),I=1,NHR)                              SARCF388
  140 FORMAT (////39H PAIRS OF NODES FOR REL X DISPL HISTORY//10(3X,I4,ISARCF389
     14,1H,))                                                           SARCF390
  150 IF (NVR.EQ.0) GO TO 170                                           SARCF391
      READ 130,(LRV1(I),LRV2(I),I=1,NVR)                                SARCF392
      PRINT 160, (LRV1(I),LRV2(I),I=1,NVR)                              SARCF393
  160 FORMAT (////39H PAIRS OF NODES FOR REL Y DISPL HISTORY//10(3X,I4,ISARCF394
     14,1H,))                                                           SARCF395
  170 CONTINUE                                                          SARCF396
      IF(IEAR.GE.2 .OR. IDSGN.GE.1) CALL REINT(IEAR,IDSGN,NELG,NELN,ICORSARCF397
     1,DEDIF,PDEDIF,IICHK,DA,SECIN,STIN,CONIN,YBM,RHOM,DDIN,ITY,DMY)    SARCF398
      IF(IEAR.GE.2 .OR. IDSGN.GE.1) GO TO 171                           SARCF399
C                                                                       SARCF400
      IF(NELTOT .LE. NELN) GO TO 171                                    SARCF401
      PRINT 173, NELTOT                                                 SARCF402
  173 FORMAT('INCREASE THE PARAMETER, NELN, FOR TOTAL NUMBER OF ELEMENTSSARCF403
     1,  I.E. INPUT NELN >=',I5)                                        SARCF404
      GO TO 999                                                         SARCF405
C                                                                       SARCF406
C     COMPACT STORAGE                                                   SARCF407
C                                                                       SARCF408
  171 J=KJR+NROUT-KAXH                                                  SARCF409
      KMM=KM+NEQ                                                        SARCF410
      KAXHH=KAXH-1                                                      SARCF411
      DO 190 I=1,J                                                      SARCF412
  190 A(KMM+I)=A(KAXHH+I)                                               SARCF413
      J=KAXHH-KMM                                                       SARCF414
      KAXH=KAXH-J                                                       SARCF415
      KAXV=KAXV-J                                                       SARCF416
      KJH=KJH-J                                                         SARCF417
      KJV=KJV-J                                                         SARCF418
      KJR=KJR-J                                                         SARCF419
C                                                                       SARCF420
C     ARRAY ADDRESSES FOR REMAINING COMPUTATION                         SARCF421
C                                                                       SARCF422
      KA=KJR+NROUT                                                      SARCF423
      KAA=KA+NSTO                                                       SARCF424
      IF (KODST.NE.0) KAA=KA                                            SARCF425
      KDIS=KAA+NSTO                                                     SARCF426
      KVEL=KDIS+NEQ+1                                                   SARCF427
      KACC=KVEL+NEQ+1                                                   SARCF428
      KENP=KACC+NEQ+1                                                   SARCF429
      KENN=KENP+NEQ+1                                                   SARCF430
      KTP=KENN+NEQ+1                                                    SARCF431
      KTN=KTP+NEQ+1                                                     SARCF432
      KIAD=KTN+NEQ+1                                                    SARCF433
      KBL=KIAD+NELTOT+1                                                 SARCF434
C                                                                       SARCF435
      NAVST=NTST-KBL+1                                                  SARCF436
      LSOFAR=KBL-1                                                      SARCF437
C                                                                       SARCF438
C     INITIALIZE                                                        SARCF439
C                                                                       SARCF440
      DO 200 I=KA,KIAD                                                  SARCF441
  200 A(I)=0.                                                           SARCF442
      KNTJ=0                                                            SARCF443
      KNTE=0                                                            SARCF444
C                                                                       SARCF445
C     CONSOLIDATE ELEMENT DATA                                          SARCF446
C                                                                       SARCF447
      CALL CONSOL (A(KIAD),A(KBL),LSOFAR)                               SARCF448
C                                                                       SARCF449
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      IF (KDATA.GT.0.AND.IEAR.LT.NEAR) GO TO 91                         SARCF450
      IF (KDATA.GT.0.AND.IEAR.EQ.NEAR) GO TO 10                         SARCF451
      IF (KDATA.GE.0.OR.NBLOK.EQ.1) GO TO 220                           SARCF452
      PRINT 210                                                         SARCF453
  210 FORMAT (///42H MORE THAN ONE BLOCK, EXECUTION SUPPRESSED)         SARCF454
      GO TO 10                                                          SARCF455
C                                                                       SARCF456
C     EXECUTE                                                           SARCF457
C                                                                       SARCF458
  220 PRINT 230                                                         SARCF459
  230 FORMAT (1H1,20X,20(1H*),5X,7HRESULTS,5X,20(1H*)//////)            SARCF460
C                                                                       SARCF461
C     COMPUTE STATIC STIFFNESS                                          SARCF462
C                                                                       SARCF463
      ISTEP=0                                                           SARCF464
      KVARY=100000000                                                   SARCF465
      CALL STIFF (A(KBL),A(KAA),A(KD),A(KIAD),A(KFM),A(KVEL),A(KM),A(KBLSARCF466
     1))                                                                SARCF467
C                                                                       SARCF468
C     COMPUTE NATURAL FREQUENCIES                                       SARCF469
C                                                                       SARCF470
      IF(KFREQ.LT.1) GO TO 255                                          SARCF471
      IF(IEAR.GE.2) GO TO 255                                           SARCF472
      S(NEQ+1)=0.                                                       SARCF473
      CALL FNFQ(NEQ,A(KAA),A(KFM),A(KM),WE,S)                           SARCF474
      CALL PRTFQ(WE,S,NJTS,NEQ,A(KID))                                  SARCF475
C                                                                       SARCF476
C     STATIC LOAD EFFECTS                                               SARCF477
C                                                                       SARCF478
  255 IF (KSTAT.EQ.0) GO TO 260                                         SARCF479
      CALL RESERV (A(KA),A(KAA),A(KM),NSTO,NF3,KODST,NEQ,1,2)           SARCF480
      CALL OPTSOL (A(KA),A(KDDS),A(KM),NEQ,1,3)                         SARCF481
      CALL RESPON (A(KBL),A(KD),A(KDIS),A(KVEL),A(KACC),A(KDDS),A(KENP),SARCF482
     1A(KENN),A(KIAD),A(KJH),A(KJV),A(KJR),A(KTP),A(KTN),DISMAX,A(KBL),ASARCF483
     2(KID),NJTS,NELG,NELN,ELDAM,ELHYS,STDAM,STHYS,STRDAM,STRHYS,NIBAY) SARCF484
      IF (KSTAT.NE.-1.AND.KVARY.EQ.0) GO TO 250                         SARCF485
      IF (KVARY.NE.0) PRINT 240                                         SARCF486
  240 FORMAT (///32H ERROR - YIELD UNDER STATIC LOAD)                   SARCF487
      GO TO 10                                                          SARCF488
C                                                                       SARCF489
C     MODIFY STIFFNESS FOR GEOMETRIC AND INERTIA EFFECTS                SARCF490
C                                                                       SARCF491
  250 IF (KODST.NE.0) CALL RESERV (A(KA),A(KAA),A(KM),NSTO,NF3,KODST,NEQSARCF492
     1,JCOL,1)                                                          SARCF493
  260 IF (NSTEPS.EQ.0) GO TO 10                                         SARCF494
      ISTEP=1                                                           SARCF495
      IENVY=IENV                                                        SARCF496
      KVARY=100000000                                                   SARCF497
      CALL STIFF (A(KBL),A(KAA),A(KD),A(KIAD),A(KFM),A(KVEL),A(KM),A(KBLSARCF498
     1))                                                                SARCF499
      CALL RESERV (A(KA),A(KAA),A(KM),NSTO,NF3,KODST,NEQ,1,2)           SARCF500
      CALL OPTSOL (A(KA),A(KDDS),A(KM),NEQ,1,1)                         SARCF501
C                                                                       SARCF502
C     SOLVE, STEP BY STEP                                               SARCF503
C                                                                       SARCF504
      DO 280 ISTEP=1,NSTEPS                                             SARCF505
C                                                                       SARCF506
C     COMPUTE TIME HISTORY FOR FUNDAMENTAL NATURAL FREQUENCIES          SARCF507
C                                                                       SARCF508
      IF(KFREQ.LT.1) GO TO 271                                          SARCF509
      IF(IFREQ .EQ. 0) IFREQ=NSTEPS+1                                   SARCF510
      REM=DFLOAT(ISTEP)/DFLOAT(IFREQ)-DFLOAT(ISTEP/IFREQ)               SARCF511
      IF(REM .NE. 0.0) GO TO 271                                        SARCF512
      S(NEQ+1)=0.                                                       SARCF513
      CALL FNFQ(NEQ,A(KAA),A(KFM),A(KM),WE,S)                           SARCF514
      CALL PRTFQ(WE,S,NJTS,NEQ,A(KID))                                  SARCF515
C                                                                       SARCF516
C     MODIFY STIFFNESS IF NECESSARY                                     SARCF517
C                                                                       SARCF518
  271 IF (KVARY.EQ.0) GO TO 270                                         SARCF519
      IF (KODST.NE.0) CALL RESERV (A(KA),A(KAA),A(KM),NSTO,NF3,KODST,NEQSARCF520
     1,JCOL,1)                                                          SARCF521
      CALL STIFF (A(KBL),A(KAA),A(KD),A(KIAD),A(KFM),A(KVEL),A(KM),A(KBLSARCF522
     1))                                                                SARCF523
      CALL RESERV (A(KA),A(KAA),A(KM),NSTO,NF3,KODST,NEQ,JCOL,2)        SARCF524
      CALL OPTSOL (A(KA),A(KDDS),A(KM),NEQ,JCOL,1)                      SARCF525
C                                                                       SARCF526
C     SET UP EFFECTIVE LOAD                                             SARCF527
C                                                                       SARCF528
  270 CALL FORCE (A(KD),A(KDDS),A(KAXH),A(KAXV),A(KFM),A(KEQM),A(KVEL),ASARCF529
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     1(KACC))                                                           SARCF530
C                                                                       SARCF531
C     RESPONSE                                                          SARCF532
C                                                                       SARCF533
      CALL OPTSOL (A(KA),A(KDDS),A(KM),NEQ,JCOL,2)                      SARCF534
      CALL RESPON (A(KBL),A(KD),A(KDIS),A(KVEL),A(KACC),A(KDDS),A(KENP),SARCF535
     1A(KENN),A(KIAD),A(KJH),A(KJV),A(KJR),A(KTP),A(KTN),DISMAX,A(KBL),ASARCF536
     2(KID),NJTS,NELG,NELN,ELDAM,ELHYS,STDAM,STHYS,STRDAM,STRHYS,NIBAY) SARCF537
      IF (KSTAT.EQ.-1) GO TO 290                                        SARCF538
      IF (ISTEP.NE.IENV.OR.IENV.GE.NSTEPS) GO TO 280                    SARCF539
      CALL OUTEND (A(KBL),A(KIAD),A(KENP),A(KENN),A(KTP),A(KTN),A(KID),NSARCF540
     1JTS)                                                              SARCF541
      IF(KDAMAGE .GE. 1) CALL OUTDAM (A(KBL),A(KIAD),A(KID),NJTS,NQKE,NESARCF542
     1LG,NELN,STDAM,STRDAM,NOD,DDAM)                                    SARCF543
C       IENV=IENV+IENVY                                                 SARCF544
C                                                                       SARCF545
  280 CONTINUE                                                          SARCF546
C                                                                       SARCF547
C     PRINT FINAL ENVELOPES                                             SARCF548
C                                                                       SARCF549
  290 CALL OUTEND (A(KBL),A(KIAD),A(KENP),A(KENN),A(KTP),A(KTN),A(KID),NSARCF550
     1JTS)                                                              SARCF551
      IF(KDAMAGE .GE. 1) CALL OUTDAM (A(KBL),A(KIAD),A(KID),NJTS,NQKE,NESARCF552
     1LG,NELN,STDAM,STRDAM,NOD,DDAM)                                    SARCF553
C                                                                       SARCF554
C     PRINT REORGANISED DISPLACEMENT TIME HISTORIES                     SARCF555
C                                                                       SARCF556
      IF (ITHPJ.EQ.0) GO TO 300                                         SARCF557
      CALL THPRJ (A(KJH),A(KJV),A(KJR),NF7)                             SARCF558
C                                                                       SARCF559
C     PRINT REORGANISED RELATIVE NODE DISPLACEMENT TIME HISTORIES       SARCF560
C                                                                       SARCF561
  300 IF (ITHPR.EQ.0) GO TO 310                                         SARCF562
      CALL THPRR (NF7,ISJ)                                              SARCF563
C                                                                       SARCF564
C     PRINT REORGANISED ELEMENT TIME HISTORIES                          SARCF565
C                                                                       SARCF566
  310 IF (ITHP.EQ.0) GO TO 85                                           SARCF567
      CALL THPREL (NF4)                                                 SARCF568
   85 IF(IEAR. LT. NEAR) GO TO 91                                       SARCF569
      IF(KEARTH .EQ. 0 .OR. NEAR .EQ. 1) GO TO 10                       SARCF570
C                                                                       SARCF571
C     COMPUTE STATISTICS FOR DAMAGE INDICES                             SARCF572
C                                                                       SARCF573
      IF(NEAR .GE. 2) CALL DSTATIS(A(KX),A(KY),NJTS,NELTOT,ICHK,IDSGN,NQSARCF574
     1KE,NELN,DDAM,NIBAY,DBAVG,DCAVG,DEDIF,PDEDIF,ICOR,IICHK,IECHK,NOD,DSARCF575
     1D1,DD2)                                                           SARCF576
      IF(KAUTO .LE. 0 .OR. ICHK .EQ. 0) GO TO 10                        SARCF577
      IEAR=0                                                            SARCF578
      IDSGN=IDSGN+1                                                     SARCF579
      PRINT 350, IDSGN                                                  SARCF580
      GO TO 91                                                          SARCF581
  350 FORMAT(1H1////,15(8H*****   ),/15(8H*****   ),////,               SARCF582
     110X,'NUMBERS OF CORRECTIVE DESIGN FOR COLUMNS AND BEAMS ',1I2///) SARCF583
C                                                                       SARCF584
  999 STOP                                                              SARCF585
      END                                                               SARCF586
      SUBROUTINE INJTS (X,Y,ID,NJTS,NCONJT,NCDJT,NCDDOF,NCDDIS)         INJTS  1
      IMPLICIT REAL*8(A-H,O-Z)                                          INJTS  2
C                                                                       INJTS  3
C     SET UP JOINT COORDINATES AND ID ARRAY                             INJTS  4
C                                                                       INJTS  5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     INJTS  6
      COMMON/WORK/ KDOF(3),IJOINT(14),IDUM,W(1591)                      INJTS  7
C                                                                       INJTS  8
      DIMENSION X(1),Y(1),ID(NJTS,1)                                    INJTS  9
C                                                                       INJTS 10
C     INITIALIZE CCORDINATES                                            INJTS 11
C                                                                       INJTS 12
      DO 10 IJ=1,NJTS                                                   INJTS 13
      Y(IJ)=999999.                                                     INJTS 14
   10 X(IJ)=999999.                                                     INJTS 15
C                                                                       INJTS 16
C     CONTROL JOINT COORDINATES                                         INJTS 17
C                                                                       INJTS 18
      PRINT 20                                                          INJTS 19
   20 FORMAT (25H1CONTROL NODE COORDINATES///                           INJTS 20
     1        5H NODE, 6X, 7HX-COORD, 6X, 7HY-COORD /)                  INJTS 21
      DO 50 IJ=1,NCONJT                                                 INJTS 22
      READ 30, IJT,X(IJT),Y(IJT)                                        INJTS 23
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   30 FORMAT(I5,2F10.0)                                              INJTS 24
      PRINT 40, IJT,X(IJT),Y(IJT)                                    INJTS 25
   40 FORMAT (I5,2F13.3)                                             INJTS 26
   50 CONTINUE                                                       INJTS 27
C                                                                    INJTS 28
C     GENERATION COMMANDS                                            INJTS 29
C                                                                    INJTS 30
      PRINT 60                                                       INJTS 31
   60 FORMAT (////25H NODE GENERATION COMMANDS   /)                  INJTS 32
      IF (NCDJT.NE.0) GO TO 80                                       INJTS 33
      PRINT 70                                                       INJTS 34
   70 FORMAT (//, 5H NONE)                                           INJTS 35
      GO TO 130                                                      INJTS 36
   80 PRINT 90                                                       INJTS 37
   90 FORMAT (/, 6H FIRST, 4X, 4HLAST, 3X, 5HNO.OF, 4X, 4HNODE, 5X,  INJTS 38
     1        8HDISTANCE, /, 6H  NODE, 4X, 4HNODE, 3X, 5HNODES, 4X,  INJTS 39
     2        4HDIFF, /)                                             INJTS 40
      DO 120 IJ=1,NCDJT                                              INJTS 41
      READ 100,IJT,JJT,NJT,KDIF,PROP                                 INJTS 42
  100 FORMAT(4I5,F10.0)                                              INJTS 43
      IF (KDIF.EQ.0) KDIF=1                                          INJTS 44
      PRINT 110, IJT,JJT,NJT,KDIF,PROP                               INJTS 45
  110 FORMAT (I6, 3I8, F13.3)                                        INJTS 46
      CALL LINGEN (X,Y,IJT,JJT,NJT,KDIF,PROP)                        INJTS 47
  120 CONTINUE                                                       INJTS 48
C                                                                    INJTS 49
C     GENERATE UNSPECIFIED JOINT COORDINATES                         INJTS 50
C                                                                    INJTS 51
  130 IJ=1                                                           INJTS 52
  140 IJ=IJ+1                                                        INJTS 53
      IF (IJ.GT.NJTS) GO TO 160                                      INJTS 54
      IF (X(IJ).NE.999999.) GO TO 140                                INJTS 55
      IJT=IJ-1                                                       INJTS 56
      JJT=IJT                                                        INJTS 57
  150 JJT=JJT+1                                                      INJTS 58
      IF (JJT.GT.NJTS) GO TO 160                                     INJTS 59
      IF (X(JJT).EQ.999999.) GO TO 150                               INJTS 60
      NJT=JJT-IJT-1                                                  INJTS 61
      PROP=0.                                                        INJTS 62
      CALL LINGEN (X,Y,IJT,JJT,NJT,1,PROP)                           INJTS 63
      IJ=JJT                                                         INJTS 64
      GO TO 140                                                      INJTS 65
  160 CONTINUE                                                       INJTS 66
C                                                                    INJTS 67
      PRINT 170, (IJ,X(IJ),Y(IJ),IJ=1,NJTS)                          INJTS 68
  170 FORMAT (26H1COMPLETE NODE COORDINATES///                       INJTS 69
     1        5H NODE, 6X, 7HX-COORD, 6X, 7HY-COORD, //, (I5, 2F13.3)) INJTS 70
C                                                                    INJTS 71
C     INITIALIZE ID MATRIX                                           INJTS 72
C                                                                    INJTS 73
      DO 180 I=1,NJTS                                                INJTS 74
      DO 180 J=1,3                                                   INJTS 75
  180 ID(I,J)=0                                                      INJTS 76
C                                                                    INJTS 77
C     ZERO DISPLACEMENTS                                             INJTS 78
C                                                                    INJTS 79
      PRINT 190                                                      INJTS 80
  190 FORMAT (27H1ZERO DISPLACEMENT COMMANDS   /)                    INJTS 81
      IF (NCDDOF.NE.0) GO TO 200                                     INJTS 82
      PRINT 70                                                       INJTS 83
      GO TO 280                                                      INJTS 84
  200 PRINT 210                                                      INJTS 85
  210 FORMAT (/6H FIRST, 4X, 4H  X , 4X, 4H  Y , 4X, 4HROTN,         INJTS 86
     1        4X, 4HLAST, 4X, 4HNODE, /, 6H  NODE, 4X, 4HCODE, 4X,   INJTS 87
     2        4HCODE, 4X, 4HCODE, 4X, 4HNODE, 4X, 4HDIFF, /)         INJTS 88
      DO 270 IJ=1,NCDDOF                                             INJTS 89
      READ 220,IJT,(KDOF(J),J=1,3),JJT,KDIF                          INJTS 90
  220 FORMAT(6I5)                                                    INJTS 91
      PRINT 230, IJT,(KDOF(J),J=1,3),JJT,KDIF                        INJTS 92
  230 FORMAT (I6, 5I8)                                               INJTS 93
      DO 240 J=1,3                                                   INJTS 94
  240 ID(IJT,J)=KDOF(J)                                              INJTS 95
      IF (JJT.EQ.0) GO TO 270                                        INJTS 96
      IF (KDIF.EQ.0) KDIF=1                                          INJTS 97
      NJT=(JJT-IJT)/KDIF                                             INJTS 98
      DO 260 II=1,NJT                                                INJTS 99
      IJT=IJT+KDIF                                                   INJTS100
      DO 250 J=1,3                                                   INJTS101
  250 ID(IJT,J)=KDOF(J)                                              INJTS102
  260 CONTINUE                                                       INJTS103
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  270 CONTINUE                                                          INJTS104
C                                                                       INJTS105
C     IDENTICAL DISPLACEMENTS                                           INJTS106
C                                                                       INJTS107
  280 CONTINUE                                                          INJTS108
      PRINT 290                                                         INJTS109
  290 FORMAT (//// 28H EQUAL DISPLACEMENT COMMANDS   /)                 INJTS110
      IF (NCDDIS.NE.0) GO TO 300                                        INJTS111
      PRINT 70                                                          INJTS112
      GO TO 380                                                         INJTS113
  300 PRINT 310                                                         INJTS114
  310 FORMAT (/, 5H DISP, 3X, 5HNO.OF, /,                               INJTS115
     1           5H CODE, 3X, 5HNODES, 6X, 14H LIST OF NODES,  /)       INJTS116
      DO 370 IJ=1,NCDDIS                                                INJTS117
      READ 320,KODOF,NJT,(IJOINT(I),I=1,NJT)                            INJTS118
  320 FORMAT (16I5)                                                     INJTS119
      PRINT 330, KODOF,NJT,(IJOINT(I),I=1,NJT)                          INJTS120
  330 FORMAT (I5, I8, 6X, 14I5)                                         INJTS121
      II=IJOINT(1)                                                      INJTS122
      IF (ID(II,KODOF).LT.0) GO TO 350                                  INJTS123
      DO 340 I=2,NJT                                                    INJTS124
      IK=IJOINT(I)                                                      INJTS125
  340 ID(IK,KODOF)=-II                                                  INJTS126
      GO TO 370                                                         INJTS127
  350 DO 360 I=2,NJT                                                    INJTS128
      IK=IJOINT(I)                                                      INJTS129
  360 ID(IK,KODOF)=ID(II,KODOF)                                         INJTS130
  370 CONTINUE                                                          INJTS131
C                                                                       INJTS132
C     SET UP ID ARRAY                                                   INJTS133
C                                                                       INJTS134
  380 KOUNT=0                                                           INJTS135
      DO 410 I=1,NJTS                                                   INJTS136
      DO 410 J=1,3                                                      INJTS137
      IF (ID(I,J).NE.0) GO TO 390                                       INJTS138
      KOUNT=KOUNT+1                                                     INJTS139
      ID(I,J)=KOUNT                                                     INJTS140
      GO TO 410                                                         INJTS141
  390 IF (ID(I,J).NE.1) GO TO 400                                       INJTS142
      ID(I,J)=0                                                         INJTS143
      GO TO 410                                                         INJTS144
  400 II=-ID(I,J)                                                       INJTS145
      ID(I,J)=ID(II,J)                                                  INJTS146
  410 CONTINUE                                                          INJTS147
C                                                                       INJTS148
      PRINT 420, (I,(ID(I,J),J=1,3),I=1,NJTS)                           INJTS149
  420 FORMAT(24H1ID ARRAY (FOR INTEREST)///                             INJTS150
     1       5H NODE,7X,1HX,7X,1HY,7X,1HR//(I5,3I8))                    INJTS151
C                                                                       INJTS152
      NEQ=KOUNT                                                         INJTS153
      KOUNT=KOUNT+1                                                     INJTS154
      DO 430 I=1,NJTS                                                   INJTS155
      DO 430 J=1,3                                                      INJTS156
      IF (ID(I,J).EQ.0) ID(I,J)=KOUNT                                   INJTS157
  430 CONTINUE                                                          INJTS158
C                                                                       INJTS159
      RETURN                                                            INJTS160
      END                                                               INJTS161
      SUBROUTINE LINGEN (X,Y,IJT,JJT,NJT,KDIF,PROP)                     LINGE  1
      IMPLICIT REAL*8(A-H,O-Z)                                          LINGE  2
C                                                                       LINGE  3
C     SUBROUTINE TO GENERATE JOINTS ALONG STRAIGHT LINE                 LINGE  4
C                                                                       LINGE  5
      DIMENSION X(1),Y(1)                                               LINGE  6
C                                                                       LINGE  7
      XI=X(IJT)                                                         LINGE  8
      YI=Y(IJT)                                                         LINGE  9
      DX=X(JJT)-XI                                                      LINGE 10
      DY=Y(JJT)-YI                                                      LINGE 11
      IF (PROP.LT.1.) GO TO 10                                          LINGE 12
      PROP=PROP/DSQRT(DX**2+DY**2)                                      LINGE 13
   10 IF (PROP.EQ.0.) PROP=1./DFLOAT(NJT+1)                             LINGE 14
      DX=DX*PROP                                                        LINGE 15
      DY=DY*PROP                                                        LINGE 16
C                                                                       LINGE 17
      DO 20 IJ=1,NJT                                                    LINGE 18
      IJT=IJT+KDIF                                                      LINGE 19
      XI=XI+DX                                                          LINGE 20
      YI=YI+DY                                                          LINGE 21
      X(IJT)=XI                                                         LINGE 22
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   20 Y(IJT)=YI                                                          LINGE 23
C                                                                        LINGE 24
      RETURN                                                             LINGE 25
      END                                                                LINGE 26
      SUBROUTINE INMASS (FM,IEQFM,ID,NCDMS,NJTS)                         INMAS  1
      IMPLICIT REAL*8(A-H,O-Z)                                           INMAS  2
C                                                                        INMAS  3
C     SET UP MASS MATRIX                                                 INMAS  4
C                                                                        INMAS  5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY      INMAS  6
      COMMON/WORK/ FMAS(3),W(1597)                                       INMAS  7
C                                                                        INMAS  8
      DIMENSION FM(1),IEQFM(1),ID(NJTS,1)                                INMAS  9
C                                                                        INMAS 10
      NEQ1=NEQ+1                                                         INMAS 11
      DO 10 J=1,NEQ1                                                     INMAS 12
      IEQFM(J)=1                                                         INMAS 13
   10 FM(J)=0.                                                           INMAS 14
C                                                                        INMAS 15
      PRINT 20                                                           INMAS 16
   20 FORMAT (25H1MASS GENERATION COMMANDS///                            INMAS 17
     1        6H FIRST,8X,6H   X  ,8X,6H   Y  ,10X,4HROTN,4X,4X,4HLAST,  INMAS 18
     2        4X, 4HNODE, 4X, 9HMODIFYING/                               INMAS 19
     3        6H  NODE, 8X, 6H  MASS, 8X, 6H  MASS, 10X, 4HMASS, 4X,     INMAS 20
     4        4X, 4HNODE, 4X, 4HDIFF, 4X, 9H  FACTOR /)                  INMAS 21
      DO 90 IJ=1,NCDMS                                                   INMAS 22
C                                                                        INMAS 23
      READ 30,IJT,(FMAS(I),I=1,3),JJT,KDIF,SSCALE                        INMAS 24
   30 FORMAT(I5,3F10.0,2I5,F10.0)                                        INMAS 25
      IF (SSCALE.EQ.0.) GO TO 40                                         INMAS 26
      SCALE=SSCALE                                                       INMAS 27
   40 PRINT 50, IJT,(FMAS(I),I=1,3),JJT,KDIF,SCALE                       INMAS 28
   50 FORMAT(I6,3E14.4,4X,2I8,F13.2)                                     INMAS 29
C                                                                        INMAS 30
      DO 60 J=1,3                                                        INMAS 31
      IF (FMAS(J).EQ.0.) GO TO 60                                        INMAS 32
      IEQ=ID(IJT,J)                                                      INMAS 33
      FM(IEQ)=FM(IEQ)+FMAS(J)/SCALE                                      INMAS 34
      IEQFM(IEQ)=J+1                                                     INMAS 35
   60 CONTINUE                                                           INMAS 36
C                                                                        INMAS 37
      IF (JJT.EQ.0) GO TO 90                                             INMAS 38
      IF (KDIF.EQ.0) KDIF=1                                              INMAS 39
      NJT=(JJT-IJT)/KDIF                                                 INMAS 40
      DO 80 IK=1,NJT                                                     INMAS 41
      IJT=IJT+KDIF                                                       INMAS 42
      DO 70 J=1,3                                                        INMAS 43
      IF (FMAS(J).EQ.0.) GO TO 70                                        INMAS 44
      IEQ=ID(IJT,J)                                                      INMAS 45
      FM(IEQ)=FM(IEQ)+FMAS(J)/SCALE                                      INMAS 46
      IEQFM(IEQ)=J+1                                                     INMAS 47
   70 CONTINUE                                                           INMAS 48
   80 CONTINUE                                                           INMAS 49
C                                                                        INMAS 50
   90 CONTINUE                                                           INMAS 51
      FM(NEQ+1)=0.                                                       INMAS 52
C                                                                        INMAS 53
      PRINT 100                                                          INMAS 54
  100 FORMAT (////22H COMPLETE NODAL MASSES///                           INMAS 55
     1        5H NODE,11X, 6HX-MASS,11X, 6HY-MASS,11X, 6HR-MASS   /)     INMAS 56
C                                                                        INMAS 57
      DO 140 IJ=1,NJTS                                                   INMAS 58
      DO 120 J=1,3                                                       INMAS 59
      IEQ=ID(IJ,J)                                                       INMAS 60
      IJT=IEQFM(IEQ)                                                     INMAS 61
      IF (IJT.LE.1) GO TO 110                                            INMAS 62
      FMAS(J)=FM(IEQ)                                                    INMAS 63
      IEQFM(IEQ)=-IJT                                                    INMAS 64
      GO TO 120                                                          INMAS 65
  110 FMAS(J)=0.                                                         INMAS 66
  120 CONTINUE                                                           INMAS 67
C                                                                        INMAS 68
      PRINT 130, IJ,(FMAS(J),J=1,3)                                      INMAS 69
  130 FORMAT (I5, 3F17.6)                                                INMAS 70
C                                                                        INMAS 71
  140 CONTINUE                                                           INMAS 72
C                                                                        INMAS 73
      DO 150 J=1,NEQ                                                     INMAS 74
  150 IEQFM(J)=IABS(IEQFM(J))                                            INMAS 75
C                                                                        INMAS 76
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      RETURN                                                            INMAS 77
      END                                                               INMAS 78
      SUBROUTINE INEXLD (D,ID,NCDLD,NJTS,IEQFM)                         INEXL  1
      IMPLICIT REAL*8(A-H,O-Z)                                          INEXL  2
C                                                                       INEXL  3
C     SET UP STATIC LOADS DIRECTLY ON JOINTS                            INEXL  4
C                                                                       INEXL  5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     INEXL  6
      COMMON/WORK/ FLD(3),W(1597)                                       INEXL  7
C                                                                       INEXL  8
      DIMENSION D(1),ID(NJTS,1),IEQFM(1)                                INEXL  9
C                                                                       INEXL 10
      DO 10 I=1,NEQ                                                     INEXL 11
   10 D(I)=0.                                                           INEXL 12
      D(NEQ+1)=0.                                                       INEXL 13
      IF (NCDLD.EQ.0) RETURN                                            INEXL 14
      PRINT 20                                                          INEXL 15
   20 FORMAT(29H1STATIC NODAL LOAD GENERATION///                        INEXL 16
     1       6H FIRST,8X,6H   X  ,8X,6H   Y  ,8X,6HMOMENT,8X,4HLAST,    INEXL 17
     2       4X,4HNODE/                                                 INEXL 18
     3       6H  NODE,8X,6H  LOAD,8X,6H  LOAD,8X,6H LOAD ,8X,4HNODE,    INEXL 19
     4       4X,4HDIFF/)                                                INEXL 20
C                                                                       INEXL 21
      DO 80 IJ=1,NCDLD                                                  INEXL 22
C                                                                       INEXL 23
      READ 30,IJT,(FLD(I),I=1,3),JJT,KDIF                               INEXL 24
   30 FORMAT(I5,3F10.0,2I5)                                             INEXL 25
      PRINT 40, IJT,(FLD(I),I=1,3),JJT,KDIF                             INEXL 26
   40 FORMAT (I6, 3F14.3, 4X, 2I8)                                      INEXL 27
      DO 50 J=1,3                                                       INEXL 28
      IEQ=ID(IJT,J)                                                     INEXL 29
   50 D(IEQ)=D(IEQ)+FLD(J)                                              INEXL 30
C                                                                       INEXL 31
      IF (JJT.EQ.0) GO TO 80                                            INEXL 32
      IF (KDIF.EQ.0) KDIF=1                                             INEXL 33
      NJT=(JJT-IJT)/KDIF                                                INEXL 34
      DO 70 IK=1,NJT                                                    INEXL 35
      IJT=IJT+KDIF                                                      INEXL 36
      DO 60 J=1,3                                                       INEXL 37
      IEQ=ID(IJT,J)                                                     INEXL 38
   60 D(IEQ)=D(IEQ)+FLD(J)                                              INEXL 39
   70 CONTINUE                                                          INEXL 40
   80 CONTINUE                                                          INEXL 41
      D(NEQ+1)=0.                                                       INEXL 42
C                                                                       INEXL 43
      PRINT 90                                                          INEXL 44
   90 FORMAT(////28H COMPLETE STATIC NODAL LOADS///                     INEXL 45
     1        5H NODE, 6X, 6HX-LOAD, 6X, 6HY-LOAD, 6X, 6HMOMENT/)       INEXL 46
C                                                                       INEXL 47
      DO 130 IJ=1,NJTS                                                  INEXL 48
      DO 110 J=1,3                                                      INEXL 49
      IEQ=ID(IJ,J)                                                      INEXL 50
      IJT=IEQFM(IEQ)                                                    INEXL 51
      IF (IJT.LT.0) GO TO 100                                           INEXL 52
      FLD(J)=D(IEQ)                                                     INEXL 53
      IEQFM(IEQ)=-IJT                                                   INEXL 54
      GO TO 110                                                         INEXL 55
  100 FLD(J)=0.                                                         INEXL 56
  110 CONTINUE                                                          INEXL 57
C                                                                       INEXL 58
      PRINT 120, IJ,(FLD(J),J=1,3)                                      INEXL 59
  120 FORMAT (I5, 3F12.3)                                               INEXL 60
  130 CONTINUE                                                          INEXL 61
C                                                                       INEXL 62
      DO 140 J=1,NEQ                                                    INEXL 63
  140 IEQFM(J)=IABS(IEQFM(J))                                           INEXL 64
C                                                                       INEXL 65
      RETURN                                                            INEXL 66
      END                                                               INEXL 67
      SUBROUTINE INAXL (KFORM,TH,GH,TV,GV,GAXH,GAXV,NSTEPS,DT,FACAXH,FACINAXL  1
     1TMH,FACAXV,FACTMV,KEARTH,IEAR)                                    INAXL  2
      IMPLICIT REAL*8(A-H,O-Z)                                          INAXL  3
C                                                                       INAXL  4
C     SET UP EARTHQUAKE RECORDS                                         INAXL  5
C                                                                       INAXL  6
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     INAXL  7
      COMMON/EQUAKE/DSEED,PGA,WG,TAU,UWG,PG,IEVL,KIEVL,ENA,ENB,ENC      INAXL  8
C                                                                       INAXL  9
      DIMENSION KFORM(1),TH(1),GH(1),TV(1),GV(1),GAXH(1),GAXV(1),       INAXL 10
     1          IEQFM(1)                                                INAXL 11
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      C                                                                 INAXL 12
            DATA XPR, YPR /3H X , 3H Y /                                INAXL 13
      C                                                                 INAXL 14
            IF (NPTH.EQ.0) GO TO 80                                     INAXL 15
            IF (KEARTH.EQ.0) GO TO 20                                   INAXL 16
            CALL QUAKE(TH,GH,NPTH,FACAXH,FACTMH,IEAR)                   INAXL 17
            GO TO 35                                                    INAXL 18
         20 READ 30, (TH(I),GH(I),I=1,NPTH)                             INAXL 19
         30 FORMAT(6(F6.3,F7.3))                                        INAXL 20
         35 IF (KFORM(1).NE.0) PRINT 40, XPR,(TH(I),GH(I),I=1,NPTH)     INAXL 21
         40 FORMAT (24H1GROUND ACCELERATIONS IN, A3, 19HDIRECTION, AS INPUT///INAXL 22
           1        5(4X, 4HTIME, 7X, 5HACCEL, 3X)  //                  INAXL 23
           2        (5(F 8.3, F12.4, 3X)))                              INAXL 24
      C                                                                 INAXL 25
            DO 50 I=1,NPTH                                              INAXL 26
            GH(I)=GH(I)*FACAXH                                          INAXL 27
         50 TH(I)=TH(I)*FACTMH                                          INAXL 28
      C                                                                 INAXL 29
         55 IF (NSTEPS.LE.0) GO TO 80                                   INAXL 30
            CALL INTPOL (TH,GH,GAXH,DT,NSTEPS)                          INAXL 31
      C                                                                 INAXL 32
            IF (KFORM(2).NE.0) PRINT 60, XPR,(N,GAXH(N),N=1,NSTEPS)     INAXL 33
         60 FORMAT (24H1GROUND ACCELERATIONS IN, A3,                    INAXL 34
           1        37HDIRECTION, AS SCALED AND INTERPOLATED  ///       INAXL 35
           2        5(5H STEP, 7X, 5HACCEL, 5X)  //                     INAXL 36
           3        (5(I5, F12.3, 5X)))                                 INAXL 37
      C                                                                 INAXL 38
            GA=0.                                                       INAXL 39
            DO 70 I=1,NSTEPS                                            INAXL 40
            GAXH(I)=GAXH(I)-GA                                          INAXL 41
         70 GA=GAXH(I)+GA                                               INAXL 42
      C                                                                 INAXL 43
         80 IF (NPTV.EQ.0) GO TO 130                                    INAXL 44
            IF (KEARTH.EQ.0) GO TO 100                                  INAXL 45
            CALL QUAKE(TV,GV,NPTV,FACAXV,FACTMV,IEAR)                   INAXL 46
            GO TO 105                                                   INAXL 47
        100 READ 30, (TV(I),GV(I),I=1,NPTV)                             INAXL 48
        105 IF (KFORM(1).NE.0) PRINT 40, YPR,(TV(N),GV(N),N=1,NPTV)     INAXL 49
      C                                                                 INAXL 50
            DO 110 I=1,NPTV                                             INAXL 51
            GV(I)=GV(I)*FACAXV                                          INAXL 52
        110 TV(I)=TV(I)*FACTMV                                          INAXL 53
      C                                                                 INAXL 54
            IF (NSTEPS.LE.0) GO TO 130                                  INAXL 55
            CALL INTPOL (TV,GV,GAXV,DT,NSTEPS)                          INAXL 56
      C                                                                 INAXL 57
            IF (KFORM(2).NE.0) PRINT 60, YPR,(N,GAXV(N),N=1,NSTEPS)     INAXL 58
      C                                                                 INAXL 59
            GA=0.                                                       INAXL 60
            DO 120 I=1,NSTEPS                                           INAXL 61
            GAXV(I)=GAXV(I)-GA                                          INAXL 62
        120 GA=GAXV(I)+GA                                               INAXL 63
      C                                                                 INAXL 64
        130 RETURN                                                      INAXL 65
            END                                                         INAXL 66
            SUBROUTINE RANINT(N,IR)                                     RANIN  1
            IMPLICIT REAL*8(A-H,O-Z)                                    RANIN  2
            DIMENSION IR(1)                                             RANIN  3
      C                                                                 RANIN  4
            DSEED=123457.0D0                                            RANIN  5
            K=2147483647                                                RANIN  6
            CALL GGUD(DSEED,K,N,IR)                                     RANIN  7
            RETURN                                                      RANIN  8
            END                                                         RANIN  9
            SUBROUTINE QUAKE(T,G,N,FACA,FACB,IEAR)                      QUAKE  1
            IMPLICIT REAL*8(A-H,O-Z)                                    QUAKE  2
            COMMON/EQUAKE/DSEED,PGA,WG,TAU,UWG,PG,IEVL,KIEVL,ENA,ENB,ENC QUAKE  3
            COMPLEX*16 AGL,A(1024)                                      QUAKE  4
            DIMENSION G(N),T(N),RR(1024),WK(6294),IWK(6294)             QUAKE  5
            PARAMETER(PI=3.14159D0)                                     QUAKE  6
            EQUIVALENCE(IWK(1),WK(1))                                   QUAKE  7
      C                                                                 QUAKE  8
            EN=DFLOAT(N)                                                QUAKE  9
            DF=UWG/(2.D0*PI*EN)                                         QUAKE 10
            DT=1.D0/(DF*EN)                                             QUAKE 11
            FG=WG/(2.D0*PI)                                             QUAKE 12
      C                                                                 QUAKE 13
            SO=(PGA**2)/((PG**2)*PI*WG*(0.5/TAU+2.D0*TAU))              QUAKE 14
      C                                                                 QUAKE 15
            DO 10 I=1,N                                                 QUAKE 16
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      T(I)=DT*DFLOAT(I-1)/FACB                                          QUAKE 17
      G(I)=DF*DFLOAT((I))                                               QUAKE 18
      ALPHA=4.D0*((G(I)*FG*TAU)**2)                                     QUAKE 19
   10 G(I)=2.D0*SO*(FG**4+ALPHA)/((G(I)**2-FG**2)**2+ALPHA)             QUAKE 20
C                                                                       QUAKE 21
      CALL RANAGL(N,RR,PI,DSEED)                                        QUAKE 22
C                                                                       QUAKE 23
      DO 40 I=1,N                                                       QUAKE 24
      AGL=DCMPLX(DCOS(RR(I)),DSIN(-RR(I)))                              QUAKE 25
   40 A(I)=DSQRT(G(I)*2.D0*PI*DF)*AGL                                   QUAKE 26
C                                                                       QUAKE 27
      CALL FFTCC(A,N,IWK,WK)                                            QUAKE 28
C                                                                       QUAKE 29
      DO 50 I=1,N                                                       QUAKE 30
   50 G(I)=DREAL(DSQRT(2.D0)*A(I))                                      QUAKE 31
C                                                                       QUAKE 32
      IF(IEVL .GE. 2) GO TO 70                                          QUAKE 33
      DO 60 I=1,N                                                       QUAKE 34
      EI=DFLOAT(I-1)*DT                                                 QUAKE 35
      EG=1.D0                                                           QUAKE 36
      IF(T(I) .LE. ENA) EG=(1.D0/ENA)*EI                                QUAKE 37
      IF(T(I) .GE. ENB) EG=(1.D0/(ENC-ENB))*(ENB-EI)+1.D0               QUAKE 38
      IF(T(I) .GE. ENC) EG=0.D0                                         QUAKE 39
   60 G(I)=G(I)*EG/FACA                                                 QUAKE 40
      GO TO 90                                                          QUAKE 41
C                                                                       QUAKE 42
   70 TO=1.D0/(ENA-ENB)*DLOG(ENA/ENB)                                   QUAKE 43
      GAMMA=1.D0/(EXP(-ENA*TO)-EXP(-ENB*TO))                            QUAKE 44
      DO 80 I=1,N                                                       QUAKE 45
      EI=DFLOAT(I-1)*DT                                                 QUAKE 46
      EG=GAMMA*(EXP(-ENA*T(I))-EXP(-ENB*T(I)))                          QUAKE 47
      G(I)=G(I)*EG/FACA                                                 QUAKE 48
   80 CONTINUE                                                          QUAKE 49
C                                                                       QUAKE 50
   90 RETURN                                                            QUAKE 51
      END                                                               QUAKE 52
      SUBROUTINE RANAGL(N,RR,PI,DSEED)                                  RANAG  1
      DOUBLE PRECISION DSEED,RR(N),PI                                   RANAG  2
      REAL RAN(1024)                                                    RANAG  3
C                                                                       RANAG  4
      DO 10 I=1,N                                                       RANAG  5
   10 RAN(I)=GGUBFS(DSEED)                                              RANAG  6
C                                                                       RANAG  7
      DO 20 I=1,N                                                       RANAG  8
      RR(I)=RAN(I)*2.D0*PI                                              RANAG  9
   20 CONTINUE                                                          RANAG 10
      RETURN                                                            RANAG 11
      END                                                               RANAG 12
      SUBROUTINE INTPOL (T,G,GAX,DT,NPMAX)                              INTPO  1
      IMPLICIT REAL*8(A-H,O-Z)                                          INTPO  2
C                                                                       INTPO  3
C     INTERPOLATE EARTHQUAKE DATA                                       INTPO  4
C                                                                       INTPO  5
      DIMENSION T(1),G(1),GAX(1)                                        INTPO  6
C                                                                       INTPO  7
      N=1                                                               INTPO  8
      TIM=0.                                                            INTPO  9
      DO 30 MSTEP=1,NPMAX                                               INTPO 10
      TIM=TIM+DT                                                        INTPO 11
   10 IF (TIM.LE.T(N+1)) GO TO 20                                       INTPO 12
      N=N+1                                                             INTPO 13
      GO TO 10                                                          INTPO 14
   20 PP=(TIM-T(N))/(T(N+1)-T(N))                                       INTPO 15
   30 GAX(MSTEP)=PP*G(N+1)+(1.-PP)*G(N)                                 INTPO 16
C                                                                       INTPO 17
      RETURN                                                            INTPO 18
      END                                                               INTPO 19
      SUBROUTINE CONSTANT                                               CONST  1
      IMPLICIT REAL*8(A-H,O-Z)                                          CONST  2
C                                                                       CONST  3
C     DAMPING DATA AND INTEGRATION COEFFICIENTS                         CONST  4
C                                                                       CONST  5
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,       CONST  6
     1             C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA   CONST  7
C                                                                       CONST  8
C     COEFFICIENTS FOR CONSTANT ACCN METHOD                             CONST  9
C                                                                       CONST 10
      CON1=4./DT**2                                                     CONST 11
      CON2=2./DT                                                        CONST 12
      CON3=4./DT                                                        CONST 13
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      CON4=2.                                                           CONST 14
      CON5=0.                                                           CONST 15
C                                                                       CONST 16
      C6=1.0/(1.0+BETA*CON2)                                            CONST 17
      C1=(CON1+ALPHA*CON2)*C6                                           CONST 18
      C2=CON4+ALPHA*CON5                                                CONST 19
      C3=CON3+ALPHA*CON4                                                CONST 20
      C4=CON5*BETA*C1                                                   CONST 21
      C5=CON4*BETA*C1                                                   CONST 22
      C7=CON4*BETA*C6                                                   CONST 23
      C8=CON5*BETA*C6                                                   CONST 24
      C9=C2-C4                                                          CONST 25
      C10=C3-C5                                                         CONST 26
      C11=CON4*BETAO*C6                                                 CONST 27
      C12=CON2*BETAO*C6                                                 CONST 28
C                                                                       CONST 29
      RETURN                                                            CONST 30
      END                                                               CONST 31
      SUBROUTINE OUTJT (LJTH,LJTV,LJTR,ID,NJTS)                         OUTJT  1
      IMPLICIT REAL*8(A-H,O-Z)                                          OUTJT  2
C                                                                       OUTJT  3
C     LIST OUTPUT JOINTS FOR TIME HISTORY                               OUTJT  4
C                                                                       OUTJT  5
      COMMON/OUTN/ IPJ,IPE,KNTJ,KNTE,NHOUT,NVOUT,NROUT                  OUTJT  6
C                                                                       OUTJT  7
      DIMENSION LJTH(1),LJTV(1),LJTR(1),ID(NJTS,1)                      OUTJT  8
C                                                                       OUTJT  9
      IF (NHOUT.EQ.0) GO TO 30                                          OUTJT 10
      READ 10,(LJTH(I),I=1,NHOUT)                                       OUTJT 11
   10 FORMAT(10I5)                                                      OUTJT 12
      PRINT 20, (LJTH(I),I=1,NHOUT)                                     OUTJT 13
   20 FORMAT (//// 26H NODES FOR X DISPL HISTORY//                      OUTJT 14
     1        (5X, 20I5))                                               OUTJT 15
   30 IF (NVOUT.EQ.0) GO TO 60                                          OUTJT 16
      READ 40,(LJTV(I),I=1,NVOUT)                                       OUTJT 17
   40 FORMAT(10I5)                                                      OUTJT 18
      PRINT 50, (LJTV(I),I=1,NVOUT)                                     OUTJT 19
   50 FORMAT (//// 26H NODES FOR Y DISPL HISTORY//                      OUTJT 20
     1        (5X, 20I5))                                               OUTJT 21
   60 IF (NROUT.EQ.0) GO TO 90                                          OUTJT 22
      READ 70,(LJTR(I),I=1,NROUT)                                       OUTJT 23
   70 FORMAT(10I5)                                                      OUTJT 24
      PRINT 80, (LJTR(I),I=1,NROUT)                                     OUTJT 25
   80 FORMAT (//// 27H NODES FOR ROTATION HISTORY//                     OUTJT 26
     1        (5X, 20I5))                                               OUTJT 27
   90 RETURN                                                            OUTJT 28
      END                                                               OUTJT 29
      SUBROUTINE INELEM (ID,X,Y,M,NJTS,NELTOT,ITY,STIN,CONIN,SECIN,DDIN,INELE  1
     1RHOM,YBM,NELG,NELN,IP,KIP,PR,PPR,DMY)                             INELE  2
      IMPLICIT REAL*8(A-H,O-Z)                                          INELE  3
C                                                                       INELE  4
C     INPUT ELEMENT DATA                                                INELE  5
C                                                                       INELE  6
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     INELE  7
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     INELE  8
     1              ,FCONT(3),NUMEM(10)                                 INELE  9
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   INELE 10
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA,NF17          INELE 11
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    INELE 12
     1GLDAM                                                             INELE 13
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    INELE 14
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              INELE 15
C                                                                       INELE 16
      DIMENSION STIN(6,1),CONIN(9,1),SECIN(9,1),DDIN(2,1),YBM(2,NELG,1),INELE 17
     1ITY(3,1),RHOM(2,NELG,1),DMY(NELG,1)                               INELE 18
      DIMENSION M(1),IP(1),KIP(1),PR(1),PPR(2,1)                        INELE 19
      DIMENSION X(1),Y(1),ID(NJTS,1)                                    INELE 20
C                                                                       INELE 21
      NEQ1=NEQ+1                                                        INELE 22
      DO 10 I=1,NEQ1                                                    INELE 23
   10 M(I)=I                                                            INELE 24
C                                                                       INELE 25
C     STORE NODE COORDINATES FOR THE PLOT OF DAMAGE INDEX               INELE 26
C                                                                       INELE 27
      IF(KDAPT.EQ.0) GO TO 15                                           INELE 28
C                                                                       INELE 29
C     PRINT NUMBER OF STORY AND BAY FOR A OUTPUT OF DAMAGE INDEX        INELE 30
C                                                                       INELE 31
   15 IC=0                                                              INELE 32
      NELTOT=0                                                          INELE 33
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C                                                                       INELE 34
      CONC=0.0                                                          INELE 35
      STEEL=0.0                                                         INELE 36
      DO 140 IGR=1,NELGR                                                INELE 37
      READ 20,KCONT,FCONT                                               INELE 38
   20 FORMAT(10I5,3E10.0)                                               INELE 39
      PRINT 30, IGR                                                     INELE 40
   30 FORMAT(29H1ELEMENT SPECIFICATION, GROUP,I3//)                     INELE 41
      KEL=KCONT(1)                                                      INELE 42
      KELEM(IGR)=KEL                                                    INELE 43
      NELEM(IGR)=KCONT(2)                                               INELE 44
      NELTOT=NELTOT+KCONT(2)                                            INELE 45
C                                                                       INELE 46
      GO TO (40,50), KEL                                                INELE 47
   40 CALL INELL(KCONT,FCONT,NDOF(IGR),NINF(IGR),ID,X,Y,NJTS,CONC,STEEL,INELE 48
     1ITY,STIN,CONIN,SECIN,DDIN,RHOM,YBM,NELG,NELN,IP,KIP,PR,PPR,DMY)   INELE 49
      GO TO 140                                                         INELE 50
   50 CALL INELL(KCONT,FCONT,NDOF(IGR),NINF(IGR),ID,X,Y,NJTS,CONC,STEEL,INELE 51
     1ITY,STIN,CONIN,SECIN,DDIN,RHOM,YBM,NELG,NELN,IP,KIP,PR,PPR,DMY)   INELE 52
  140 CONTINUE                                                          INELE 53
C                                                                       INELE 54
      REWIND NF17                                                       INELE 55
      REWIND NF2                                                        INELE 56
      CALL MODIFY (M,NEQ,NSTO)                                          INELE 57
C                                                                       INELE 58
      RETURN                                                            INELE 59
      END                                                               INELE 60
      SUBROUTINE CONSOL (IAD,BL,LSOFAR)                                 CONSO  1
      IMPLICIT REAL*8(A-H,O-Z)                                          CONSO  2
C                                                                       CONSO  3
C     COMPACT ELEMENT DATA IN AVAILABLE STORAGE, INITIALIZE ARRAYS      CONSO  4
C                                                                       CONSO  5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     CONSO  6
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     CONSO  7
     1             ,FCONT(3),NUMEM(10)                                  CONSO  8
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA               CONSO  9
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   CONSO 10
C                                                                       CONSO 11
      DIMENSION IAD(1),BL(1)                                            CONSO 12
C                                                                       CONSO 13
      NBLOK=1                                                           CONSO 14
      IC=0                                                              CONSO 15
      NSELM=LSOFAR                                                      CONSO 16
C                                                                       CONSO 17
      DO 70 IGR=1,NELGR                                                 CONSO 18
      NEL=NELEM(IGR)                                                    CONSO 19
      NIN=NINF(IGR)                                                     CONSO 20
      IF (NIN.LE.NAVST) GO TO 20                                        CONSO 21
      PRINT 10                                                          CONSO 22
   10 FORMAT(40H1INSUFFICIENT STORAGE FOR SINGLE ELEMENT)               CONSO 23
      NAVST=NIN                                                         CONSO 24
   20 DO 60 IEL=1,NEL                                                   CONSO 25
      NSELM=NSELM+NIN                                                   CONSO 26
      IC=IC+1                                                           CONSO 27
      IF (IC.GT.1) GO TO 30                                             CONSO 28
      IAD(IC)=1                                                         CONSO 29
      KBB=1                                                             CONSO 30
      GO TO 40                                                          CONSO 31
   30 IAD(IC)=IAD(IC-1)+NINP                                            CONSO 32
      KBB=IAD(IC)                                                       CONSO 33
   40 IF (KBB+NIN.LE.NAVST) GO TO 50                                    CONSO 34
      CALL STORE (BL(1),NAVST,NF1,2)                                    CONSO 35
      NBLOK=NBLOK+1                                                     CONSO 36
      IAD(IC)=1                                                         CONSO 37
      KBB=1                                                             CONSO 38
   50 CALL STORE (BL(KBB),NIN,NF2,1)                                    CONSO 39
C                                                                       CONSO 40
   60 NINP=NIN                                                          CONSO 41
   70 CONTINUE                                                          CONSO 42
C                                                                       CONSO 43
      PRINT 80, LSOFAR,NBLOK,NSELM                                      CONSO 44
   80 FORMAT(21H1STORAGE REQUIREMENTS///                                CONSO 45
     1       5X,34HSTORAGE EXCLUDING ELEMENT DATA    =I6//              CONSO 46
     2       5X,34HNUMBER OF BLOCKS OF ELEMENT DATA =I6//               CONSO 47
     3       5X,34HTOTAL STORAGE IF SINGLE BLOCK    =I6)                CONSO 48
C                                                                       CONSO 49
      IF (NBLOK.GT.1) CALL STORE (BL(1),NAVST,NF1,2)                    CONSO 50
      REWIND NF1                                                        CONSO 51
      REWIND NF2                                                        CONSO 52
C                                                                       CONSO 53
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      RETURN                                                            CONSO 54
      END                                                               CONSO 55
      SUBROUTINE FINISH                                                 FINIS  1
      IMPLICIT REAL*8(A-H,O-Z)                                          FINIS  2
C                                                                       FINIS  3
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     FINIS  4
     1              ,FCONT(3),NUMEM(10)                                 FINIS  5
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   FINIS  6
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA,NF17          FINIS  7
      COMMON/INFEL/ COM(215)                                            FINIS  8
C                                                                       FINIS  9
      CALL STORE (COM,NINF(IGR),NF2,2)                                  FINIS 10
      CALL STORE (COM,NINF(IGR),NF17,2)                                 FINIS 11
C                                                                       FINIS 12
      RETURN                                                            FINIS 13
      END                                                               FINIS 14
      SUBROUTINE STORE (A,N,NF,K)                                       STORE  1
      IMPLICIT REAL*8(A-H,O-Z)                                          STORE  2
C                                                                       STORE  3
      DIMENSION A(N)                                                    STORE  4
C                                                                       STORE  5
      GO TO (10,20), K                                                  STORE  6
   10 READ (NF) A                                                       STORE  7
      RETURN                                                            STORE  8
   20 WRITE (NF) A                                                      STORE  9
C                                                                       STORE 10
      RETURN                                                            STORE 11
      END                                                               STORE 12
      SUBROUTINE BAND                                                   BAND   1
      IMPLICIT REAL*8(A-H,O-Z)                                          BAND   2
C                                                                       BAND   3
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     BAND   4
     1              ,FCONT(3),NUUMEM(10)                                BAND   5
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   BAND   6
      COMMON/INFEL/ IMEM,IMEMD,KST,KSTD,LM(1),LMD(1),DUM(212)           BAND   7
      COMMON A(1)                                                       BAND   8
C                                                                       BAND   9
      CALL SBAND (A(KM),LM,NDOF(IGR))                                   BAND  10
C                                                                       BAND  11
      RETURN                                                            BAND  12
      END                                                               BAND  13
      SUBROUTINE SBAND (M,LM,NDF)                                       SBAND  1
      IMPLICIT REAL*8(A-H,O-Z)                                          SBAND  2
C                                                                       SBAND  3
      DIMENSION M(1),LM(1)                                              SBAND  4
C                                                                       SBAND  5
      DO 10 J=1,NDF                                                     SBAND  6
      JJ=LM(J)                                                          SBAND  7
      NN=M(JJ)                                                          SBAND  8
C                                                                       SBAND  9
      DO 10 I=1,NDF                                                     SBAND 10
      II=LM(I)                                                          SBAND 11
      IF (JJ.LT.II.OR.II.GE.NN) GO TO 10                                SBAND 12
      M(JJ)=II                                                          SBAND 13
      NN=II                                                             SBAND 14
   10 CONTINUE                                                          SBAND 15
C                                                                       SBAND 16
      RETURN                                                            SBAND 17
      END                                                               SBAND 18
      SUBROUTINE MODIFY (M,NEQ,NSTO)                                    MODIF  1
      IMPLICIT REAL*8(A-H,O-Z)                                          MODIF  2
C                                                                       MODIF  3
      DIMENSION M(1)                                                    MODIF  4
C                                                                       MODIF  5
      NSTO=0                                                            MODIF  6
      DO 10 J=1,NEQ                                                     MODIF  7
      NSTO=NSTO+1+J-M(J)                                                MODIF  8
   10 M(J)=NSTO                                                         MODIF  9
C                                                                       MODIF 10
      RETURN                                                            MODIF 11
      END                                                               MODIF 12
      SUBROUTINE MULTST (A,ST,ATK,FK,NN,MM)                             MULTS  1
      IMPLICIT REAL*8(A-H,O-Z)                                          MULTS  2
C                                                                       MULTS  3
      DIMENSION FK(NN,1),A(MM,1),ST(MM,1),ATK(NN,1)                     MULTS  4
C                                                                       MULTS  5
C     FORM MATRIX PRODUCTS A(T)*ST=ATK AND ATK*A=FK                     MULTS  6
C                                                                       MULTS  7
      DO 10 I=1,NN                                                      MULTS  8
      DO 10 J=1,MM                                                      MULTS  9
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   10 ATK(I,J)=0.                                                       MULTS 10
C                                                                       MULTS 11
      DO 30 K=1,MM                                                      MULTS 12
      DO 30 I=1,NN                                                      MULTS 13
      AA=A(K,I)                                                         MULTS 14
      IF (AA.EQ.0.) GO TO 30                                            MULTS 15
      DO 20 J=1,MM                                                      MULTS 16
   20 ATK(I,J)=ATK(I,J)+AA*ST(K,J)                                      MULTS 17
   30 CONTINUE                                                          MULTS 18
C                                                                       MULTS 19
      DO 40 I=1,NN                                                      MULTS 20
      DO 40 J=1,NN                                                      MULTS 21
   40 FK(I,J)=0.                                                        MULTS 22
C                                                                       MULTS 23
      DO 60 K=1,MM                                                      MULTS 24
      DO 60 J=1,NN                                                      MULTS 25
      AA=A(K,J)                                                         MULTS 26
      IF (AA.EQ.0.) GO TO 60                                            MULTS 27
      DO 50 I=J,NN                                                      MULTS 28
   50 FK(I,J)=FK(I,J)+ATK(I,K)*AA                                       MULTS 29
   60 CONTINUE                                                          MULTS 30
C                                                                       MULTS 31
      DO 70 I=1,NN                                                      MULTS 32
      DO 70 J=I,NN                                                      MULTS 33
   70 FK(I,J)=FK(J,I)                                                   MULTS 34
C                                                                       MULTS 35
      RETURN                                                            MULTS 36
      END                                                               MULTS 37
      SUBROUTINE MULT (A,B,C,II,KK,JJ)                                  MULT   1
      IMPLICIT REAL*8(A-H,O-Z)                                          MULT   2
C                                                                       MULT   3
C     FORM MATRIX PRODUCT A*B=C                                         MULT   4
C                                                                       MULT   5
      DIMENSION A(II,1),B(KK,1),C(II,1)                                 MULT   6
C                                                                       MULT   7
      DO 10 I=1,II                                                      MULT   8
      DO 10 J=1,JJ                                                      MULT   9
   10 C(I,J)=0.                                                         MULT  10
C                                                                       MULT  11
      DO 30 I=1,II                                                      MULT  12
      DO 30 K=1,KK                                                      MULT  13
      AA=A(I,K)                                                         MULT  14
      IF (AA.EQ.0.) GO TO 30                                            MULT  15
      DO 20 J=1,JJ                                                      MULT  16
   20 C(I,J)=C(I,J)+AA*B(K,J)                                           MULT  17
   30 CONTINUE                                                          MULT  18
C                                                                       MULT  19
      RETURN                                                            MULT  20
      END                                                               MULT  21
      SUBROUTINE MULTT (A,B,C,II,KK,JJ)                                 MULTT  1
      IMPLICIT REAL*8(A-H,O-Z)                                          MULTT  2
C                                                                       MULTT  3
C     FORM MATRIX PRODUCT A(T)*B=C                                      MULTT  4
C                                                                       MULTT  5
      DIMENSION A(II,1),B(II,1),C(KK,1)                                 MULTT  6
C                                                                       MULTT  7
      DO 10 K=1,KK                                                      MULTT  8
      DO 10 J=1,JJ                                                      MULTT  9
   10 C(K,J)=0.                                                         MULTT 10
C                                                                       MULTT 11
      DO 30 K=1,KK                                                      MULTT 12
      DO 30 I=1,II                                                      MULTT 13
      AA=A(I,K)                                                         MULTT 14
      IF (AA.EQ.0.) GO TO 30                                            MULTT 15
      DO 20 J=1,JJ                                                      MULTT 16
   20 C(K,J)=C(K,J)+AA*B(I,J)                                           MULTT 17
   30 CONTINUE                                                          MULTT 18
C                                                                       MULTT 19
      RETURN                                                            MULTT 20
      END                                                               MULTT 21
      SUBROUTINE ELDIS (DDIS,VEL,LLM)                                   ELDIS  1
      IMPLICIT REAL*8(A-H,O-Z)                                          ELDIS  2
C                                                                       ELDIS  3
      COMMON/GENINF/ KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)    ELDIS  4
     1              ,FCONT(3),NUMEM(10)                                 ELDIS  5
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   ELDIS  6
      COMMON/DISVEL/ DDISE(10),VELE(10),DD(10)                          ELDIS  7
C                                                                       ELDIS  8
      DIMENSION DDIS(1),VEL(1),LLM(1)                                   ELDIS  9
C                                                                       ELDIS 10
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      NDF=NDOF(IGR)                                                     ELDIS 11
      DO 10 K=1,NDF                                                     ELDIS 12
      LL=LLM(K)                                                         ELDIS 13
      DDISE(K)=DDIS(LL)                                                 ELDIS 14
   10 VELE(K)=VEL(LL)                                                   ELDIS 15
C                                                                       ELDIS 16
      RETURN                                                            ELDIS 17
      END                                                               ELDIS 18
      SUBROUTINE SFORCE (DD)                                            SFORC  1
      IMPLICIT REAL*8(A-H,O-Z)                                          SFORC  2
C                                                                       SFORC  3
C     ADD CLAMPING FORCES TO STATIC LOAD VECTOR                         SFORC  4
C                                                                       SFORC  5
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     SFORC  6
     1             ,FCONT(3),NUMEM(10)                                  SFORC  7
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   SFORC  8
      COMMON/INFEL/ IMEM,IMEMD,KST,KSTD,LM(1),LMD(1),DUM(212)           SFORC  9
      COMMON A(1)                                                       SFORC 10
C                                                                       SFORC 11
      DIMENSION DD(1)                                                   SFORC 12
C                                                                       SFORC 13
      KDD=KDDS-1                                                        SFORC 14
      NDF=NDOF(IGR)                                                     SFORC 15
      DO 10 I=1,NDF                                                     SFORC 16
      LL=LM(I)                                                          SFORC 17
   10 A(KDD+LL)=A(KDD+LL)-DD(I)                                         SFORC 18
      RETURN                                                            SFORC 19
      END                                                               SFORC 20
      SUBROUTINE FORCE (D,DDIS,GAXH,GAXV,FM,IEQFM,VEL,ACC)              FORCE  1
      IMPLICIT REAL*8(A-H,O-Z)                                          FORCE  2
C                                                                       FORCE  3
C     SET UP DYNAMIC LOAD VECTOR FOR CURRENT STEP                       FORCE  4
C                                                                       FORCE  5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     FORCE  6
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   FORCE  7
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,       FORCE  8
     1             C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA   FORCE  9
C                                                                       FORCE 10
      DIMENSION D(1),DDIS(1),GAXH(1),GAXV(1),FM(1),IEQFM(1),VEL(1),     FORCE 11
     1          ACC(1)                                                  FORCE 12
C                                                                       FORCE 13
      DO 50 I=1,NEQ                                                     FORCE 14
      IEQ=IEQFM(I)                                                      FORCE 15
C      IF(NPTH.EQ.0 .AND. IEQ.EQ.2) IEQ=4                               FORCE 16
C      IF(NPTV.EQ.0 .AND. IEQ.EQ.3) IEQ=4                               FORCE 17
      GO TO (40,10,20,30), IEQ                                          FORCE 18
   10 D(I)=D(I)-FM(I)*GAXH(ISTEP)                                       FORCE 19
      GO TO 30                                                          FORCE 20
   20 D(I)=D(I)-FM(I)*GAXV(ISTEP)                                       FORCE 21
   30 DDIS(I)=D(I)+FM(I)*(C9*ACC(I)+C10*VEL(I))                         FORCE 22
      GO TO 50                                                          FORCE 23
   40 DDIS(I)=D(I)                                                      FORCE 24
   50 CONTINUE                                                          FORCE 25
C                                                                       FORCE 26
      RETURN                                                            FORCE 27
      END                                                               FORCE 28
      SUBROUTINE RESERV (A,AA,M,L,NF,KODST,NEQ,JCOL,K)                  RESER  1
      IMPLICIT REAL*8(A-H,O-Z)                                          RESER  2
C                                                                       RESER  3
      DIMENSION A(L),AA(L),M(NEQ)                                       RESER  4
C                                                                       RESER  5
      IF (KODST.EQ.0) GO TO 10                                          RESER  6
C                                                                       RESER  7
      CALL STORE (A,L,NF,K)                                             RESER  8
      REWIND NF                                                         RESER  9
      GO TO 60                                                          RESER 10
C                                                                       RESER 11
   10 IF (JCOL.GT.1) GO TO 30                                           RESER 12
      DO 20 I=1,L                                                       RESER 13
   20 A(I)=AA(I)                                                        RESER 14
      GO TO 60                                                          RESER 15
   30 JDP=M(JCOL-1)                                                     RESER 16
      JJ=1                                                              RESER 17
      DO 50 J=JCOL,NEQ                                                  RESER 18
      JD=M(J)                                                           RESER 19
      JH=JD-JDP                                                         RESER 20
      JDP=JD                                                            RESER 21
      NE=MINO(JH,JJ)                                                    RESER 22
      DO 40 I=1,NE                                                      RESER 23
      A(JD)=AA(JD)                                                      RESER 24
```

```
   40 JD=JD-1                                                           RESER 25
   50 JJ=JJ+1                                                           RESER 26
C                                                                       RESER 27
   60 RETURN                                                            RESER 28
      END                                                               RESER 29
      SUBROUTINE OPTSOL (A,B,NA,NEQ,JCOL,KEX)                           OPTSO  1
      IMPLICIT REAL*8(A-H,O-Z)                                          OPTSO  2
C                                                                       OPTSO  3
      DIMENSION A(1),B(NEQ),NA(NEQ)                                     OPTSO  4
C                                                                       OPTSO  5
      NEQQ=NEQ-1                                                        OPTSO  6
      GO TO (10,150,10), KEX                                            OPTSO  7
C     *****************************************************************OPTSO  8
C     REDUCE COEFFICIENT MATRIX A                                       OPTSO  9
C     *****************************************************************OPTSO 10
   10 JF=MAX0(JCOL,2)                                                   OPTSO 11
      J1=JF+1                                                           OPTSO 12
      IL=JF-1                                                           OPTSO 13
      JCL=JCOL-1                                                        OPTSO 14
      NAJP=NA(IL)                                                       OPTSO 15
      DO 140 J=JF,NEQ                                                   OPTSO 16
      NAJ=NA(J)                                                         OPTSO 17
      IF=J1-NAJ+NAJP                                                    OPTSO 18
      IF (IF.GE.J) GO TO 130                                            OPTSO 19
      IF1=MAX0(IF+1,JCOL)                                               OPTSO 20
      JK=NAJ-J                                                          OPTSO 21
      IF (IF1.GT.IL) GO TO 80                                           OPTSO 22
      JIA=JK+IF1                                                        OPTSO 23
      I1=IF1+1                                                          OPTSO 24
      KL=IF1-1                                                          OPTSO 25
      NAIP=NA(KL)                                                       OPTSO 26
      DO 70 I=IF1,IL                                                    OPTSO 27
      NAI=NA(I)                                                         OPTSO 28
      IK=NAI-I                                                          OPTSO 29
      II=I1-NAI+NAIP                                                    OPTSO 30
      IF (II.GE.I) GO TO 60                                             OPTSO 31
      KF=MAX0(II,IF)                                                    OPTSO 32
      JKA=JK+KF                                                         OPTSO 33
      IKA=IK+KF                                                         OPTSO 34
      AA=A(JIA)                                                         OPTSO 35
      IF (KF.GE.JCOL) GO TO 30                                          OPTSO 36
      DO 20 K=KF,JCL                                                    OPTSO 37
      NAK=NA(K)                                                         OPTSO 38
      AA=AA-A(JKA)*A(IKA)*A(NAK)                                        OPTSO 39
      JKA=JKA+1                                                         OPTSO 40
   20 IKA=IKA+1                                                         OPTSO 41
      IF (JCOL.GT.KL) GO TO 50                                          OPTSO 42
      KF=JCOL                                                           OPTSO 43
C                                                                       OPTSO 44
   30 DO 40 K=KF,KL                                                     OPTSO 45
      AA=AA-A(JKA)*A(IKA)                                               OPTSO 46
      JKA=JKA+1                                                         OPTSO 47
   40 IKA=IKA+1                                                         OPTSO 48
   50 A(JIA)=AA                                                         OPTSO 49
   60 JIA=JIA+1                                                         OPTSO 50
      I1=I1+1                                                           OPTSO 51
      KL=KL+1                                                           OPTSO 52
   70 NAIP=NAI                                                          OPTSO 53
C                                                                       OPTSO 54
   80 KF=IF                                                             OPTSO 55
      JKA=JK+IF                                                         OPTSO 56
      AA=A(NAJ)                                                         OPTSO 57
      IF (IF.GE.JCOL) GO TO 100                                         OPTSO 58
      DO 90 K=IF,JCL                                                    OPTSO 59
      NAI=NA(K)                                                         OPTSO 60
      AA=AA-A(NAI)*A(JKA)**2                                            OPTSO 61
   90 JKA=JKA+1                                                         OPTSO 62
      IF (JCOL.GT.IL) GO TO 120                                         OPTSO 63
      KF=JCOL                                                           OPTSO 64
C                                                                       OPTSO 65
  100 DO 110 K=KF,IL                                                    OPTSO 66
      NAI=NA(K)                                                         OPTSO 67
      CC=A(JKA)/A(NAI)                                                  OPTSO 68
      AA=AA-A(JKA)*CC                                                   OPTSO 69
      A(JKA)=CC                                                         OPTSO 70
  110 JKA=JKA+1                                                         OPTSO 71
  120 A(NAJ)=AA                                                         OPTSO 72
  130 IL=IL+1                                                           OPTSO 73
      J1=J1+1                                                           OPTSO 74
  140 NAJP=NAJ                                                          OPTSO 75
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C                                                                       OPTSO 76
      GO TO (250,250,150), KEX                                          OPTSO 77
C     ******************************************************************OPTSO 78
C     REDUCE VECTOR B AND BACK SUBSTITUTE                               OPTSO 79
C     ******************************************************************OPTSO 80
  150 DO 160 N=1,NEQQ                                                   OPTSO 81
      IF (B(N).NE.0.) GO TO 170                                         OPTSO 82
  160 CONTINUE                                                          OPTSO 83
      N=NEQQ                                                            OPTSO 84
  170 N1=N+1                                                            OPTSO 85
      I1=N1+1                                                           OPTSO 86
      KL=N                                                              OPTSO 87
      NAIP=NA(N)                                                        OPTSO 88
      DO 200 I=N1,NEQ                                                   OPTSO 89
      NAI=NA(I)                                                         OPTSO 90
      II=I1-NAI+NAIP                                                    OPTSO 91
      IF (II.GE.I) GO TO 190                                            OPTSO 92
      KF=MAX0(II,N)                                                     OPTSO 93
      IK=NAI-I                                                          OPTSO 94
      IKA=IK+KF                                                         OPTSO 95
      BB=B(I)                                                           OPTSO 96
      DO 180 K=KF,KL                                                    OPTSO 97
      BB=BB-A(IKA)*B(K)                                                 OPTSO 98
  180 IKA=IKA+1                                                         OPTSO 99
      B(I)=BB                                                           OPTSO100
  190 I1=I1+1                                                           OPTSO101
      KL=KL+1                                                           OPTSO102
  200 NAIP=NAI                                                          OPTSO103
      DO 210 I=N,NEQ                                                    OPTSO104
      NAI=NA(I)                                                         OPTSO105
  210 B(I)=B(I)/A(NAI)                                                  OPTSO106
C                                                                       OPTSO107
      J=NEQ                                                             OPTSO108
      J1=J+1                                                            OPTSO109
      KL=NEQQ                                                           OPTSO110
      NAJ=NA(NEQ)                                                       OPTSO111
      DO 240 I=1,NEQQ                                                   OPTSO112
      NAJP=NA(J-1)                                                      OPTSO113
      II=J1-NAJ+NAJP                                                    OPTSO114
      IF (II.GE.J) GO TO 230                                            OPTSO115
      JK=NAJ-J                                                          OPTSO116
      KF=II                                                             OPTSO117
      JKA=JK+KF                                                         OPTSO118
      BB=B(J)                                                           OPTSO119
      DO 220 K=KF,KL                                                    OPTSO120
      B(K)=B(K)-A(JKA)*BB                                               OPTSO121
  220 JKA=JKA+1                                                         OPTSO122
  230 J1=J1-1                                                           OPTSO123
      KL=KL-1                                                           OPTSO124
      J=J-1                                                             OPTSO125
  240 NAJ=NAJP                                                          OPTSO126
C                                                                       OPTSO127
  250 RETURN                                                            OPTSO128
      END                                                               OPTSO129
      SUBROUTINE STIFF (BL,SA,D,IAD,FM,VEL,M,IBL)                       STIFF   1
      IMPLICIT REAL*8(A-H,O-Z)                                          STIFF   2
C                                                                       STIFF   3
C     ASSEMBLE STIFFNESS MATRIX                                         STIFF   4
C                                                                       STIFF   5
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     STIFF   6
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     STIFF   7
     1             ,FCONT(3),NUMEM(10)                                  STIFF   8
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(4)   STIFF   9
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,       STIFF  10
     1             C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA   STIFF  11
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA               STIFF  12
      COMMON/INFEL/ IMEM,IMEMD,KST,KSTD,LM(1),LMD(1),DUM(212)           STIFF  13
C                                                                       STIFF  14
      DIMENSION BL(1),SA(1),IAD(1),D(1),FM(1),VEL(1),M(1),IBL(1)        STIFF  15
      DIMENSION FK(100)                                                 STIFF  16
C                                                                       STIFF  17
C     SELECT ELEMENTS IN TURN                                           STIFF  18
C                                                                       STIFF  19
      JCOL=NEQ                                                          STIFF  20
      IC=0                                                              STIFF  21
      DO 180 IGR=1,NELGR                                                STIFF  22
      NEL=NELEM(IGR)                                                    STIFF  23
      KEL=KELEM(IGR)                                                    STIFF  24
      NIN=NINF(IGR)                                                     STIFF  25
      NDF=NDOF(IGR)                                                     STIFF  26
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C                                                                       STIFF 27
      DO 170 IEL=1,NEL                                                  STIFF 28
C                                                                       STIFF 29
      IC=IC+1                                                           STIFF 30
      IF (IC.GT.KVARY) GO TO 220                                        STIFF 31
      IDD=IAD(IC)                                                       STIFF 32
      IF (NBLOK.EQ.1) GO TO 10                                          STIFF 33
      IF (IDD.EQ.1) CALL STORE (BL,NAVST,NF1,1)                         STIFF 34
C                                                                       STIFF 35
   10 IF (ISTEP.LT.2) GO TO 20                                          STIFF 36
      IF (KST.EQ.0) GO TO 170                                           STIFF 37
   20 GO TO (30,40), KEL                                                STIFF 38
   30 CALL STIF (ISTEP,NDF,NIN,BL(IDD),FK,C12)                          STIFF 39
      GO TO 130                                                         STIFF 40
   40 CALL STIF (ISTEP,NDF,NIN,BL(IDD),FK,C12)                          STIFF 41
  130 CONTINUE                                                          STIFF 42
C                                                                       STIFF 43
C     ADD ELEMENT STIFFNESS FK TO TOTAL STIFFNESS                       STIFF 44
C                                                                       STIFF 45
      DO 150 L=1,NDF                                                    STIFF 46
      LML=LM(L)                                                         STIFF 47
      IF (LML.GT.NEQ) GO TO 150                                         STIFF 48
      IF (LML.LT.JCOL) JCOL=LML                                         STIFF 49
      DO 140 K=1,NDF                                                    STIFF 50
      LMK=LM(K)                                                         STIFF 51
      IF (LMK.GT.NEQ) GO TO 140                                         STIFF 52
      IF (LMK.LT.LML) GO TO 140                                         STIFF 53
      LK=(K-1)*NDF+L                                                    STIFF 54
      JJ=M(LMK)-(LMK-LML)                                               STIFF 55
      SA(JJ)=SA(JJ)+FK(LK)                                              STIFF 56
  140 CONTINUE                                                          STIFF 57
  150 CONTINUE                                                          STIFF 58
C                                                                       STIFF 59
C     CORRECT FORCE VECTOR FOR STIFFNESS CHANGES                        STIFF 60
C                                                                       STIFF 61
      IF (BETA.EQ.0.0.OR.ISTEP.LT.2) GO TO 170                          STIFF 62
      DO 160 L=1,NDF                                                    STIFF 63
      LML=LM(L)                                                         STIFF 64
      LK=L                                                              STIFF 65
      DO 160 K=1,NDF                                                    STIFF 66
      LMK=LM(K)                                                         STIFF 67
      D(LML)=D(LML)-BETA*FK(LK)*VEL(LMK)                                STIFF 68
  160 LK=LK+NDF                                                         STIFF 69
C                                                                       STIFF 70
  170 CONTINUE                                                          STIFF 71
  180 CONTINUE                                                          STIFF 72
C                                                                       STIFF 73
C     ADD MASS DEPENDING FACTOR TO TOTAL STIFFNESS                      STIFF 74
C                                                                       STIFF 75
      IF (ISTEP.GT.1) GO TO 220                                         STIFF 76
      IF (ISTEP.EQ.0) GO TO 200                                         STIFF 77
      DO 190 I=1,NEQ                                                    STIFF 78
      II=M(I)                                                           STIFF 79
  190 SA(II)=SA(II)+C1*FM(I)                                            STIFF 80
      GO TO 220                                                         STIFF 81
C                                                                       STIFF 82
C     CHECK FOR ZEROS ON DIAGONAL                                       STIFF 83
C                                                                       STIFF 84
  200 DO 210 I=1,NEQ                                                    STIFF 85
      II=M(I)                                                           STIFF 86
      IF (SA(II).EQ.0.) SA(II)=0.000001                                 STIFF 87
  210 CONTINUE                                                          STIFF 88
C                                                                       STIFF 89
  220 KVARY=0                                                           STIFF 90
      REWIND NF1                                                        STIFF 91
C                                                                       STIFF 92
      RETURN                                                            STIFF 93
      END                                                               STIFF 94
      SUBROUTINE RESPON (BL,D,DIS,VEL,ACC,DDIS,DISENP,DISENN,IAD,LJTH,LJRESPO  1
     1TV,LJTR,TIMENP,TIMENN,DISMAX,IBL,ID,NJTS,NELG,NELN,ELDAM,ELHYS,STDRESPO  2
     2AM,STHYS,STRDAM,STRHYS,NIBAY)                                     RESPO  3
      IMPLICIT REAL*8(A-H,O-Z)                                          RESPO  4
C                                                                       RESPO  5
C     SOLVE STATE DETERMINATION PROBLEM FOR ELEMENTS                    RESPO  6
C     PRINT TIME HISTORY RESULTS                                        RESPO  7
C                                                                       RESPO  8
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     RESPO  9
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     RESPO 10
     1             ,FCONT(3),NUMEM(10)                                  RESPO 11
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(2),  RESPO 12
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     1ISYM,ISYMD                                                        RESPO 13
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,       RESPO 14
     1              C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA  RESPO 15
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA               RESPO 16
      COMMON/OUTN/ IPJ,IPE,KNTJ,KNTE,NHOUT,NVOUT,NROUT                  RESPO 17
      COMMON/DISVEL/ DDISE(10),VELE(10),DD(10)                          RESPO 18
      COMMON/INFEL/ IMEM,IMEMD,KST,KSTD,LM(1),LMD(1),DUM(212)           RESPO 19
      COMMON/WORK/POUT(1600)                                            RESPO 20
      COMMON/THIST/ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE   RESPO 21
      COMMON/THISTJ/ITHPJ,NF5,NSTHJ,ISJ                                 RESPO 22
      COMMON/THISTR/ITHPR,NF6,NSTHR,NHR,NVR,LRH1(50),LRH2(50),LRV1(50), RESPO 23
     1       LRV2(50)                                                   RESPO 24
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    RESPO 25
     1GLDAM                                                             RESPO 26
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    RESPO 27
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              RESPO 28
C                                                                       RESPO 29
      DIMENSION ELDAM(NELG,1),ELHYS(NELG,1),STHYS(NELG,1),              RESPO 30
     1STDAM(NELG,1),STRDAM(1),STRHYS(1),NIBAY(1)                        RESPO 31
      DIMENSION BL(1),D(1),DIS(1),VEL(1),ACC(1),DDIS(1),DISENP(1),      RESPO 32
     1          DISENN(1),IAD(1),TIMENP(1),TIMENN(1),LJTH(1),LJTV(1),   RESPO 33
     2          LJTR(1),IBL(1),ID(NJTS,1)                               RESPO 34
C                                                                       RESPO 35
      TIME=DT*DFLOAT(ISTEP)                                             RESPO 36
C                                                                       RESPO 37
C     STATIC DISPLACEMENTS                                              RESPO 38
C                                                                       RESPO 39
      IF (ISTEP.NE.0) GO TO 60                                          RESPO 40
      DO 10 I=1,NEQ                                                     RESPO 41
   10 DIS(I)=DIS(I)+DDIS(I)                                             RESPO 42
      PRINT 20                                                          RESPO 43
   20 FORMAT(///27H STATIC NODAL DISPLACEMENTS///5X,                    RESPO 44
     1       5H NODE,6X,7HX-DISPL,6X,7HY-DISPL,5X,8HROTATION/)          RESPO 45
      DO 40 I=1,NJTS                                                    RESPO 46
      DO 30 J=1,3                                                       RESPO 47
      IJ=ID(I,J)                                                        RESPO 48
   30 POUT(J)=DIS(IJ)                                                   RESPO 49
   40 PRINT 50, I,(POUT(J),J=1,3)                                       RESPO 50
   50 FORMAT(I10,2F13.3,F13.5)                                          RESPO 51
      GO TO 80                                                          RESPO 52
C                                                                       RESPO 53
C     DYNAMIC DISPLACEMENTS, VELOCITIES AND ACCELERATIONS               RESPO 54
C                                                                       RESPO 55
   60 KNTJ=KNTJ+1                                                       RESPO 56
      KNTE=KNTE+1                                                       RESPO 57
      DO 70 I=1,NEQ                                                     RESPO 58
      VVEL=VEL(I)                                                       RESPO 59
      AACC=ACC(I)                                                       RESPO 60
C     DDD=C6*DDIS(I)+C7*VEL(I)+C8*ACC(I)                                RESPO 61
      DDD=C6*DDIS(I)+C7*VEL(I)                                          RESPO 62
      DDIS(I)=DDD                                                       RESPO 63
      DIS(I)=DIS(I)+DDD                                                 RESPO 64
C     VEL(I)=VEL(I)+CON2*DDD-CON4*VVEL-CON5*AACC                        RESPO 65
      VEL(I)=VEL(I)+CON2*DDD-CON4*VVEL                                  RESPO 66
   70 ACC(I)=ACC(I)+CON1*DDD-CON3*VVEL-CON4*AACC                        RESPO 67
C                                                                       RESPO 68
C     CHECK FOR DISPLACEMENT ENVELOPES                                  RESPO 69
C                                                                       RESPO 70
   80 DO 100 I=1,NEQ                                                    RESPO 71
      IF (DIS(I).LT.0.) GO TO 90                                        RESPO 72
      IF (DIS(I).LE.DISENP(I)) GO TO 100                                RESPO 73
      DISENP(I)=DIS(I)                                                  RESPO 74
      TIMENP(I)=TIME                                                    RESPO 75
      GO TO 100                                                         RESPO 76
   90 IF (DIS(I).GE.DISENN(I)) GO TO 100                                RESPO 77
      DISENN(I)=DIS(I)                                                  RESPO 78
      TIMENN(I)=TIME                                                    RESPO 79
  100 CONTINUE                                                          RESPO 80
      DDIS(NEQ+1)=0.                                                    RESPO 81
C                                                                       RESPO 82
C     PRINT DISPLACEMENT TIME HISTORIES AND SAVE ON TAPE                RESPO 83
C                                                                       RESPO 84
      IF (ISTEP.EQ.0.AND.ITHPJ.GT.0) GO TO 110                          RESPO 85
      IF (KNTJ.NE.IPJ) GO TO 290                                        RESPO 86
  110 IF (NHOUT.EQ.0) GO TO 180                                         RESPO 87
      DO 120 I=1,NHOUT                                                  RESPO 88
      IJ=LJTH(I)                                                        RESPO 89
      IJ=ID(IJ,1)                                                       RESPO 90
  120 POUT(I)=DIS(IJ)                                                   RESPO 91
      IF (ITHPJ.GT.1.OR.ISTEP.EQ.0) GO TO 170                           RESPO 92
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      PRINT 130, TIME                                                   RESPO 93
  130 FORMAT (/// 34H X-DISPLACEMENTS AT NODES,  TIME =   F7.3   / )    RESPO 94
      N2=0                                                              RESPO 95
  140 N1=N2+1                                                           RESPO 96
      N2=N1+9                                                           RESPO 97
      IF (N2.GT.NHOUT) N2=NHOUT                                         RESPO 98
      PRINT 150, (LJTH(I),I=N1,N2)                                      RESPO 99
      PRINT 160, (POUT(I),I=N1,N2)                                      RESPO100
  150 FORMAT(13H NODE NO.    ,10I10)                                    RESPO101
  160 FORMAT(13H DISPLACEMENT,2X,10F10.3)                               RESPO102
      IF (N2.LT.NHOUT) GO TO 140                                        RESPO103
  170 IF (ITHPJ.LT.1) GO TO 180                                         RESPO104
      NON=NHOUT+1                                                       RESPO105
      POUT(NON)=TIME                                                    RESPO106
      CALL STORE (POUT,NON,NF5,2)                                       RESPO107
      NSTHJ=NSTHJ+1                                                     RESPO108
  180 IF (NVOUT.EQ.0) GO TO 230                                         RESPO109
      DO 190 I=1,NVOUT                                                  RESPO110
      IJ=LJTV(I)                                                        RESPO111
      IJ=ID(IJ,2)                                                       RESPO112
  190 POUT(I)=DIS(IJ)                                                   RESPO113
      IF (ITHPJ.GT.1.OR.ISTEP.EQ.0) GO TO 220                           RESPO114
      PRINT 200, TIME                                                   RESPO115
  200 FORMAT (/// 34H Y-DISPLACEMENTS AT NODES,  TIME =   F7.3   /)     RESPO116
      N2=0                                                              RESPO117
  210 N1=N2+1                                                           RESPO118
      N2=N1+9                                                           RESPO119
      IF (N2.GT.NVOUT) N2=NVOUT                                         RESPO120
      PRINT 150, (LJTV(I),I=N1,N2)                                      RESPO121
      PRINT 160, (POUT(I),I=N1,N2)                                      RESPO122
      IF (N2.LT.NVOUT) GO TO 210                                        RESPO123
  220 IF (ITHPJ.LT.1) GO TO 230                                         RESPO124
      NON=NVOUT+1                                                       RESPO125
      POUT(NON)=TIME                                                    RESPO126
      CALL STORE (POUT,NON,NF5,2)                                       RESPO127
      NSTHJ=NSTHJ+1                                                     RESPO128
  230 IF (NROUT.EQ.0) GO TO 290                                         RESPO129
      DO 240 I=1,NROUT                                                  RESPO130
      IJ=LJTR(I)                                                        RESPO131
      IJ=ID(IJ,3)                                                       RESPO132
  240 POUT(I)=DIS(IJ)                                                   RESPO133
      IF (ITHPJ.GT.1.OR.ISTEP.EQ.0) GO TO 280                           RESPO134
      PRINT 250, TIME                                                   RESPO135
  250 FORMAT (/// 28H ROTATIONS AT NODES,  TIME =   F7.3   /)           RESPO136
      N2=0                                                              RESPO137
  260 N1=N2+1                                                           RESPO138
      N2=N1+9                                                           RESPO139
      IF (N2.GT.NROUT) N2=NROUT                                         RESPO140
      PRINT 150, (LJTR(I),I=N1,N2)                                      RESPO141
      PRINT 270, (POUT(I),I=N1,N2)                                      RESPO142
  270 FORMAT(13H ROTATION    ,2X,10F10.5)                               RESPO143
      IF (N2.LT.NROUT) GO TO 260                                        RESPO144
  280 IF (ITHPJ.LT.1) GO TO 290                                         RESPO145
      NON=NROUT+1                                                       RESPO146
      POUT(NON)=TIME                                                    RESPO147
      CALL STORE (POUT,NON,NF5,2)                                       RESPO148
      NSTHJ=NSTHJ+1                                                     RESPO149
  290 CONTINUE                                                          RESPO150
C                                                                       RESPO151
C     PRINT RELATIVE DISPLACEMENTS AND SAVE ON TAPE                     RESPO152
C                                                                       RESPO153
      IF (ISTEP.EQ.0.AND.ITHPR.GT.0) GO TO 300                          RESPO154
      IF (KNTJ.NE.IPJ) GO TO 420                                        RESPO155
  300 IF (NHR.EQ.0) GO TO 370                                           RESPO156
      DO 310 I=1,NHR                                                    RESPO157
      IJ1=LRH1(I)                                                       RESPO158
      IJ2=LRH2(I)                                                       RESPO159
      IJ1=ID(IJ1,1)                                                     RESPO160
      IJ2=ID(IJ2,1)                                                     RESPO161
  310 POUT(I)=DIS(IJ1)-DIS(IJ2)                                         RESPO162
      IF (ISTEP.EQ.0.OR.ITHPR.GT.1) GO TO 360                           RESPO163
      PRINT 320, TIME                                                   RESPO164
  320 FORMAT(///46H RELATIVE X-DISPLACEMENT BETWEEN NODES, TIME =,F7.3/)RESPO165
      N2=0                                                              RESPO166
  330 N1=N2+1                                                           RESPO167
      N2=N1+9                                                           RESPO168
      IF (N2.GT.NHR) N2=NHR                                             RESPO169
      PRINT 340, (LRH1(I),LRH2(I),I=N1,N2)                              RESPO170
      PRINT 350, (POUT(I),I=N1,N2)                                      RESPO171
  340 FORMAT(11H NODE PAIRS,10(I5,2H -,I3))                             RESPO172
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  350 FORMAT(11H REL DISPL.,10F10.4)                                  RESP0173
      IF (N2.LT.NHR) GO TO 330                                        RESP0174
  360 IF (ITHPR.LT.1) GO TO 370                                       RESP0175
      NON=NHR+1                                                       RESP0176
      POUT(NON)=TIME                                                  RESP0177
      CALL STORE (POUT,NON,NF6,2)                                     RESP0178
      NSTHR=NSTHR+1                                                   RESP0179
  370 IF (NVR.EQ.0) GO TO 420                                         RESP0180
      DO 380 I=1,NVR                                                  RESP0181
      IJ1=LRV1(I)                                                     RESP0182
      IJ2=LRV2(I)                                                     RESP0183
      IJ1=ID(IJ1,2)                                                   RESP0184
      IJ2=ID(IJ2,2)                                                   RESP0185
  380 POUT(I)=DIS(IJ1)-DIS(IJ2)                                       RESP0186
      IF (ISTEP.EQ.0.OR.ITHPR.GT.1) GO TO 410                         RESP0187
      PRINT 390, TIME                                                 RESP0188
  390 FORMAT(///46H RELATIVE Y-DISPLACEMENT BETWEEN NODES, TIME =,F7.3/)RESP0189
      N2=0                                                            RESP0190
  400 N1=N2+1                                                         RESP0191
      N2=N1+9                                                         RESP0192
      IF (N2.GT.NVR) N2=NVR                                           RESP0193
      PRINT 340, (LRV1(I),LRV2(I),I=N1,N2)                            RESP0194
      PRINT 350, (POUT(I),I=N1,N2)                                    RESP0195
      IF (N2.LT.NVR) GO TO 400                                        RESP0196
  410 IF (ITHPR.LT.1) GO TO 420                                       RESP0197
      NON=NVR+1                                                       RESP0198
      POUT(NON)=TIME                                                  RESP0199
      CALL STORE (POUT,NON,NF6,2)                                     RESP0200
      NSTHR=NSTHR+1                                                   RESP0201
  420 CONTINUE                                                        RESP0202
C                                                                     RESP0203
C     CHECK FOR COLLAPSE                                              RESP0204
C                                                                     RESP0205
      DO 460 I=1,NEQ,3                                                RESP0206
      IF (DABS(DIS(I)).LT.DISMAX) GO TO 450                           RESP0207
  430 PRINT 440                                                       RESP0208
  440 FORMAT(30H1MAXIMUM DISPLACEMENT EXCEEDED)                       RESP0209
      KSTAT=-1                                                        RESP0210
      GO TO 470                                                       RESP0211
  450 IF (DABS(DIS(I+1)).GE.DISMAX) GO TO 430                         RESP0212
  460 CONTINUE                                                        RESP0213
C                                                                     RESP0214
C     INITIALIZE FORCE VECTOR                                         RESP0215
C                                                                     RESP0216
  470 DO 480 I=1,NEQ                                                  RESP0217
  480 D(I)=0.                                                         RESP0218
      D(NEQ+1)=0.                                                     RESP0219
C                                                                     RESP0220
C     STATE DETERMINATION FOR ELEMENTS                                RESP0221
C                                                                     RESP0222
      IC=0                                                            RESP0223
      KPR=0                                                           RESP0224
      IF (NBLOK.GT.1) CALL STORE (BL,NAVST,NF1,1)                     RESP0225
C                                                                     RESP0226
      DO 640 IGR=1,NELGR                                              RESP0227
      NEL=NELEM(IGR)                                                  RESP0228
      KEL=KELEM(IGR)                                                  RESP0229
      NDF=NDOF(IGR)                                                   RESP0230
      NIN=NINF(IGR)                                                   RESP0231
      IF (KNTE.EQ.IPE) KPR=IGR                                        RESP0232
      IF (ISTEP.EQ.0) KPR=-IGR                                        RESP0233
C                                                                     RESP0234
      DO 640 IEL=1,NEL                                                RESP0235
      IMEM=IEL                                                        RESP0236
      KBAL=0                                                          RESP0237
      IC=IC+1                                                         RESP0238
c     IISLP=0                                                         RESP0239
      IDD=IAD(IC)                                                     RESP0240
      IF (NBLOK.EQ.1.OR.IDD.NE.1.OR.IC.EQ.1) GO TO 490                RESP0241
      CALL STORE (BL,NAVST,NF2,2)                                     RESP0242
      CALL STORE (BL,NAVST,NF1,1)                                     RESP0243
C                                                                     RESP0244
C     ELEMENT NODAL DISPLACEMENTS AND VELOCITIES                      RESP0245
C                                                                     RESP0246
  490 CALL ELDIS (DDIS,VEL,BL(IDD+2))                                 RESP0247
C                                                                     RESP0248
C     GET RESPONSE OF EVERY ELEMENT                                   RESP0249
C                                                                     RESP0250
      GO TO (500,510), KEL                                            RESP0251
  500 CALL RESP (NDF,NIN,KBAL,KPR,BL(IDD),DDISE,DD,TIME,VELE,C11,DELTA, RESP0252
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     1ELDAM(IGR,IEL),ELHYS(IGR,IEL))                                    RESP0253
      GO TO 600                                                         RESP0254
  510 CALL RESP (NDF,NIN,KBAL,KPR,BL(IDD),DDISE,DD,TIME,VELE,C11,DELTA, RESP0255
     1ELDAM(IGR,IEL),ELHYS(IGR,IEL))                                    RESP0256
  600 CONTINUE                                                          RESP0257
C                                                                       RESP0258
C     SAVE ELEMENT TIME HISTORIES ON TAPE                               RESP0259
C                                                                       RESP0260
      IF (ISAVE.EQ.0) GO TO 610                                         RESP0261
C     CALL STORE (ITHOUT,30,NF4,2)                                      RESP0262
      CALL STORE (ITHOUT,25,NF4,2)                                      RESP0263
      NSTH=NSTH+1                                                       RESP0264
  610 CONTINUE                                                          RESP0265
C                                                                       RESP0266
C     CORRECT FOR OUT OF BALANCE FORCES, ADD DAMPING LOADS              RESP0267
C                                                                       RESP0268
      IF (KBAL.EQ.0) GO TO 630                                          RESP0269
      DO 620 K=1,NDF                                                    RESP0270
      LL=LM(K)                                                          RESP0271
  620 D(LL)=D(LL)+DD(K)                                                 RESP0272
C                                                                       RESP0273
  630 IF (KST.NE.0) KVARY=IC                                            RESP0274
  640 CONTINUE                                                          RESP0275
C                                                                       RESP0276
C     COMPUTE STORY DAMAGE INDEX                                        RESP0277
C                                                                       RESP0278
      IF(KDAMAGE.LT.1) GO TO 990                                        RESP0279
      DO 485 II=1,NSTORY                                                RESP0280
      STRHYS(II)=0.0                                                    RESP0281
      STRDAM(II)=0.0                                                    RESP0282
      DO 485 JJ=1,NELGR                                                 RESP0283
      STHYS(JJ,II)=0.0                                                  RESP0284
      STDAM(JJ,II)=0.0                                                  RESP0285
  485 CONTINUE                                                          RESP0286
C                                                                       RESP0287
      DO 660 IGR=1,NELGR                                                RESP0288
      NJ=0                                                              RESP0289
      DO 660 II=1,NSTORY                                                RESP0290
      ISTORY=NSTORY+1-II                                                RESP0291
      IF(ISYM .EQ. 0) GO TO 661                                         RESP0292
      NSYBAY=INT(NBAY/2)                                                RESP0293
      KBAY=NBAY-2*NSYBAY                                                RESP0294
      IF(NBAY.EQ.0) NSYBAY=INT(NIBAY(ISTORY)/2)                         RESP0295
      IF(NBAY.EQ.0) KBAY=NIBAY(ISTORY)-2*NSYBAY                         RESP0296
      IF(KBAY .NE. 0) NSYBAY=NSYBAY+1                                   RESP0297
      NSBAY=NSYBAY                                                      RESP0298
      IF(KBAY .EQ. 0 .AND. IGR .EQ. 2) NSBAY=NSYBAY+1                   RESP0299
      GO TO 662                                                         RESP0300
  661 NSBAY=NBAY                                                        RESP0301
      IF(IGR .EQ. 2) NSBAY=NBAY+1                                       RESP0302
      IF(NBAY .EQ. 0) NSBAY=NIBAY(ISTORY)                               RESP0303
      IF(NBAY .EQ. 0 .AND. IGR .EQ. 2) NSBAY=NSBAY+1                    RESP0304
  662 DO 670 J=1,NSBAY                                                  RESP0305
      IJ=J+NJ                                                           RESP0306
      STHYS(IGR,ISTORY)=STHYS(IGR,ISTORY)+ELHYS(IGR,IJ)                 RESP0307
      STDAM(IGR,ISTORY)=STDAM(IGR,ISTORY)+ELDAM(IGR,IJ)                 RESP0308
      STRHYS(ISTORY)=STRHYS(ISTORY)+ELHYS(IGR,IJ)                       RESP0309
      STRDAM(ISTORY)=STRDAM(ISTORY)+ELDAM(IGR,IJ)                       RESP0310
      IF(ELDAM(IGR,IJ).EQ.0.) ELDAM(IGR,IJ)=0.0                         RESP0311
      IF(ELDAM(IGR,IJ).NE.0.) ELDAM(IGR,IJ)=ELDAM(IGR,IJ)/ELHYS(IGR,IJ) RESP0312
  670 CONTINUE                                                          RESP0313
      NJ=IJ                                                             RESP0314
      IF(STDAM(IGR,ISTORY).EQ.0.) STDAM(IGR,ISTORY)=0.0                 RESP0315
      IF(STDAM(IGR,ISTORY).NE.0.) STDAM(IGR,ISTORY)=STDAM(IGR,ISTORY)/  RESP0316
     1STHYS(IGR,ISTORY)                                                 RESP0317
  660 CONTINUE                                                          RESP0318
C                                                                       RESP0319
C     COMPUTE STORY AND GLOBAL DAMAGE INDEX                             RESP0320
C                                                                       RESP0321
      GLHYS=0.0                                                         RESP0322
      GLDAM=0.0                                                         RESP0323
      DO 675 ISTORY=1,NSTORY                                            RESP0324
      STRDAM(ISTORY)=STRDAM(ISTORY)/STRHYS(ISTORY)                      RESP0325
      WEIGHT=DFLOAT(NSTORY+1-ISTORY)/DFLOAT(NSTORY)                     RESP0326
      GLHYS=GLHYS+STRHYS(ISTORY)                                        RESP0327
      GLDAM=GLDAM+STRDAM(ISTORY)*WEIGHT                                 RESP0328
  675 CONTINUE                                                          RESP0329
C                                                                       RESP0330
C     PRINT DAMAGE INDICES                                              RESP0331
C                                                                       RESP0332
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      IF(KDAMAGE.LT.1) GO TO 990                                        RESPO333
      EI=DFLOAT(ISTEP-1)                                                RESPO334
      REM1=DMOD(EI,DFLOAT(NNSKIP))                                      RESPO335
      REM2=DMOD(EI,DFLOAT(NSSKIP))                                      RESPO336
      REM3=DMOD(EI,DFLOAT(NGSKIP))                                      RESPO337
C                                                                       RESPO338
C     PRINT STORY DAMAGE INDEX IN FILE (FOR020.DAT)                     RESPO339
C                                                                       RESPO340
      IF(ISTEP.EQ.1) WRITE(20,700)                                      RESPO341
  700 FORMAT(////15X,'*****  SUMMARY OF DAMAGE INDEX  *****')           RESPO342
C                                                                       RESPO343
      IF(ISTEP .EQ. NSTEPS) GO TO 715                                   RESPO344
      IF(ITDAM.LT.1 .OR. ISTEP .EQ. 1) GO TO 990                        RESPO345
      IF(REM1.NE.0.) GO TO 810                                          RESPO346
  715 WRITE(20,710) TIME                                                RESPO347
  710 FORMAT(//2X,' AT TIME =',F7.3)                                    RESPO348
      WRITE(20,720)                                                     RESPO349
  720 FORMAT(//10X,'***  ELEMENT DAMAGE INDEX  ***')                    RESPO350
C                                                                       RESPO351
      IEL=0                                                             RESPO352
      NEEL=0                                                            RESPO353
      NEL=0                                                             RESPO354
      DO 740 II=1,NSTORY                                                RESPO355
      ISTORY=NSTORY+1-II                                                RESPO356
      WRITE(20,750) ISTORY                                              RESPO357
  750 FORMAT(/2X,'FOR STORY =',I5/)                                     RESPO358
C                                                                       RESPO359
      IF(ISYM .EQ. 0) GO TO 761                                         RESPO360
      IF(NBAY.EQ.0) NSYBAY=INT(NIBAY(ISTORY)/2)                         RESPO361
      IF(NBAY.NE.0) NSYBAY=INT(NBAY/2)                                  RESPO362
      KBAY=NBAY-2*NSYBAY                                                RESPO363
      IF(NBAY.EQ.0) KBAY=NIBAY(ISTORY)-2*NSYBAY                         RESPO364
      IF(KBAY .NE. 0) NSYBAY=NSYBAY+1                                   RESPO365
      NSBAY=NSYBAY                                                      RESPO366
      GO TO 762                                                         RESPO367
  761 NSBAY=NBAY                                                        RESPO368
      IF(NBAY .EQ. 0) NSBAY=NIBAY(ISTORY)                               RESPO369
C                                                                       RESPO370
  762 IEL=NEEL+1                                                        RESPO371
      NEEL=IEL+NSBAY-1                                                  RESPO372
      DO 740 IGR=1,NELGR                                                RESPO373
C                                                                       RESPO374
      IF(IGR .EQ. 1) GO TO 767                                          RESPO375
      IF(ISYM.NE.0 .AND. KBAY.NE.0) GO TO 767                           RESPO376
  763 IF(ISYM .EQ. 0) GO TO 764                                         RESPO377
      IF(KBAY .EQ. 0) NSBAY=NSYBAY+1                                    RESPO378
      GO TO 765                                                         RESPO379
  764 NSBAY=NBAY+1                                                      RESPO380
      IF(NBAY .EQ. 0) NSBAY=NIBAY(ISTORY)+1                             RESPO381
  765 IEL=NEL+1                                                         RESPO382
      NEL=IEL+NSBAY-1                                                   RESPO383
      WRITE(20,772) (I,I=IEL,NEL)                                       RESPO384
      WRITE(20,775) (ELDAM(2,I),I=IEL,NEL)                              RESPO385
      GO TO 740                                                         RESPO386
  767 IF(IGR .EQ. 1) WRITE(20,771) (I,I=IEL,NEEL)                       RESPO387
      IF(IGR .EQ. 2) WRITE(20,772) (I,I=IEL,NEEL)                       RESPO388
      WRITE(20,785) (ELDAM(IGR,I),I=IEL,NEEL)                           RESPO389
  740 CONTINUE                                                          RESPO390
  771 FORMAT(5X,'  BEAM  NO  ',8(5X,I3,2X))                             RESPO391
  772 FORMAT(5X,' COLUMN NO  ',8(5X,I3,2X))                             RESPO392
  775 FORMAT(5X,'  DAMAGE    ',8(F10.4)/)                               RESPO393
  785 FORMAT(5X,'  DAMAGE    ',8(F10.4))                                RESPO394
      IF(ISTEP .EQ. NSTEPS) GO TO 815                                   RESPO395
C                                                                       RESPO396
  810 IF(REM1 .NE. 0. .AND. REM2 .NE. 0.) GO TO 910                     RESPO397
  815 WRITE(20,820)                                                     RESPO398
  820 FORMAT(//2X,'***  STORY  DAMAGE INDEX   ***',                     RESPO399
     1//10X,'FLOOR',9X,'  BEAM    ',9X,'  COLUMN ',9X,'  STORY  '/)     RESPO400
      DO 830 II=1,NSTORY                                                RESPO401
      ISTORY=NSTORY+1-II                                                RESPO402
  830 WRITE(20,840) ISTORY,(STDAM(J,ISTORY),J=1,2),STRDAM(ISTORY)       RESPO403
  840 FORMAT(8X,I5,11X,F9.5,9X,F9.5,9X,F9.5)                            RESPO404
      IF(ISTEP .EQ. NSTEPS) GO TO 915                                   RESPO405
C                                                                       RESPO406
  910 IF(REM1 .NE. 0. .AND. REM2 .NE. 0. .AND. REM3 .NE. 0.) GO TO 990  RESPO407
  915 WRITE(20,920) GLDAM                                               RESPO408
  920 FORMAT(///8X,'GLOBAL DAMAGE  = ',F10.5)                           RESPO409
C                                                                       RESPO410
  990 IF (KNTJ.EQ.IPJ) KNTJ=0                                           RESPO411
      IF (KNTE.EQ.IPE) KNTE=0                                           RESPO412
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      IF (NBLOK.EQ.1) GO TO 995                                         RESPO413
      CALL STORE (BL,NAVST,NF2,2)                                       RESPO414
      REWIND NF1                                                        RESPO415
      REWIND NF2                                                        RESPO416
      NF=NF1                                                            RESPO417
      NF1=NF2                                                           RESPO418
      NF2=NF                                                            RESPO419
C                                                                       RESPO420
  995 RETURN                                                            RESPO421
      END                                                               RESPO422
      SUBROUTINE OUTEND (BL,IAD,DISENP,DISENN,TIMENP,TIMENN,ID,NJTS)    OUTEN  1
      IMPLICIT REAL*8(A-H,O-Z)                                          OUTEN  2
C                                                                       OUTEN  3
C     OUTPUT DISPLACEMENT AND FORCE ENVELOPES                           OUTEN  4
C                                                                       OUTEN  5
C                                                                       OUTEN  6
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     OUTEN  7
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)    OUTEN  8
     1              ,FCONT(3),NUMEM(10)                                 OUTEN  9
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IEAR,NEAR,OUTEN 10
     1             KSYM,KSYMD                                           OUTEN 11
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA               OUTEN 12
      COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,       OUTEN 13
     1             C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA   OUTEN 14
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    OUTEN 15
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              OUTEN 16
C                                                                       OUTEN 17
      DIMENSION BL(1),IAD(1),DISENP(1),DISENN(1),TIMENP(1),TIMENN(1),   OUTEN 18
     1          ID(NJTS,1)                                              OUTEN 19
C                                                                       OUTEN 20
C     DISPLACEMENTS                                                     OUTEN 21
C                                                                       OUTEN 22
      TIME=DT*FLOAT(ISTEP)                                              OUTEN 23
      PRINT 10, TIME                                                    OUTEN 24
   10 FORMAT (37H1NODAL DISPLACEMENT ENVELOPES, TIME =F8.3///           OUTEN 25
     1       18X, 15HX-DISPLACEMENT , 22X, 15HY-DISPLACEMENT , 28X,     OUTEN 26
     2        9HROTATION   /                                            OUTEN 27
     3        8H NODE    , 3(8HPOSITIVE, 3X, 4HTIME, 3X, 8HNEGATIVE, 3X, OUTEN 28
     4        4HTIME, 6X) / )                                           OUTEN 29
      DO 20 I=1,NJTS                                                    OUTEN 30
      II=ID(I,1)                                                        OUTEN 31
      IJ=ID(I,2)                                                        OUTEN 32
      IK=ID(I,3)                                                        OUTEN 33
   20 PRINT 30, I,DISENP(II),TIMENP(II),DISENN(II),TIMENN(II),DISENP(IJ)OUTEN 34
     1,TIMENP(IJ),DISENN(IJ),TIMENN(IJ),DISENP(IK),TIMENP(IK),DISENN(IK)OUTEN 35
     2,TIMENN(IK)                                                       OUTEN 36
   30 FORMAT(I5,2(F11.3,F7.2,F11.3,F7.2,3X),2(F11.5,F7.2))              OUTEN 37
      IF(KAUTO.EQ.1) GO TO 175                                          OUTEN 38
C                                                                       OUTEN 39
C     ELEMENT FORCES, ETC.                                              OUTEN 40
C                                                                       OUTEN 41
      IC=0                                                              OUTEN 42
      DO 160 IGR=1,NELGR                                                OUTEN 43
C                                                                       OUTEN 44
      PRINT 40, IGR,TIME                                                OUTEN 45
   40 FORMAT(33H1RESULTS ENVELOPES, ELEMENT GROUP,I3,7H TIME =F8.3//)   OUTEN 46
      KEL=KELEM(IGR)                                                    OUTEN 47
      NEL=NELEM(IGR)                                                    OUTEN 48
      NIN=NINF(IGR)                                                     OUTEN 49
C                                                                       OUTEN 50
      DO 160 IEL=1,NEL                                                  OUTEN 51
      IC=IC+1                                                           OUTEN 52
      IDD=IAD(IC)                                                       OUTEN 53
      IF (NBLOK.EQ.1) GO TO 50                                          OUTEN 54
      IF (IDD.EQ.1) CALL STORE (BL,NAVST,NF1,1)                         OUTEN 55
C                                                                       OUTEN 56
   50 GO TO (60,70), KEL                                                OUTEN 57
   60 CALL OUT (BL(IDD),NIN,IC)                                         OUTEN 58
      GO TO 160                                                         OUTEN 59
   70 CALL OUT (BL(IDD),NIN,IC)                                         OUTEN 60
  160 CONTINUE                                                          OUTEN 61
      REWIND NF1                                                        OUTEN 62
C                                                                       OUTEN 63
  175 RETURN                                                            OUTEN 64
      END                                                               OUTEN 65
      SUBROUTINE OUTDAM (BL,IAD,ID,NJTS,NQKE,NELG,NELN,STDAM,STRDAM,NOD,OUTDA  1
     1DDAM)                                                             OUTDA  2
      IMPLICIT REAL*8(A-H,O-Z)                                          OUTDA  3
C                                                                       OUTDA  4
C     OUTPUT DAMAGEINDICES                                              OUTDA  5
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      C                                                                   OUTDA  6
            COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY    OUTDA  7
            COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)   OUTDA  8
           1              ,FCONT(3),NUMEM(10)                                OUTDA  9
            COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(2), OUTDA 10
           1              ISYM,ISYMD                                         OUTDA 11
            COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA              OUTDA 12
            COMMON/DAMP/ ALPHA,BETA,DT,GAXCTE,CON1,CON2,CON3,CON4,CON5,      OUTDA 13
           1              C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,BETAO,DELTA OUTDA 14
            COMMON/WORK/POUT(1600)                                           OUTDA 15
            COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,   OUTDA 16
           1GLDAM                                                            OUTDA 17
            COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,   OUTDA 18
           1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV             OUTDA 19
      C                                                                   OUTDA 20
            DIMENSION BL(1),IAD(1),ID(NJTS,1),DDAM(NQKE,1)                   OUTDA 21
            DIMENSION STDAM(NELG,1),STRDAM(1),NOD(1)                         OUTDA 22
      C                                                                   OUTDA 23
      C     DAMAGE INDICES                                                OUTDA 24
      C                                                                   OUTDA 25
            TIME=DT*DFLOAT(ISTEP)                                            OUTDA 26
            IC=0                                                             OUTDA 27
            PRINT 40, TIME                                                   OUTDA 28
         40 FORMAT(20H1NODAL DAMAGE INDICES,7H TIME =F8.3//)                 OUTDA 29
            DO 160 IGR=1,NELGR                                               OUTDA 30
      C                                                                   OUTDA 31
            KEL=KELEM(IGR)                                                   OUTDA 32
            NEL=NELEM(IGR)                                                   OUTDA 33
            NIN=NINF(IGR)                                                    OUTDA 34
      C                                                                   OUTDA 35
            DO 160 IEL=1,NEL                                                 OUTDA 36
            IC=IC+1                                                          OUTDA 37
            IDD=IAD(IC)                                                      OUTDA 38
            IF (NBLOK.EQ.1) GO TO 50                                         OUTDA 39
            IF (IDD.EQ.1) CALL STORE (BL,NAVST,NF1,1)                        OUTDA 40
      C                                                                   OUTDA 41
         50 GO TO (60,70), KEL                                               OUTDA 42
         60 CALL OUTD (BL(IDD),NIN,IC,NQKE,NELN,NOD,DDAM)                    OUTDA 43
            GO TO 160                                                        OUTDA 44
         70 CALL OUTD (BL(IDD),NIN,IC,NQKE,NELN,NOD,DDAM)                    OUTDA 45
        160 CONTINUE                                                         OUTDA 46
      C                                                                   OUTDA 47
            PRINT 820                                                        OUTDA 48
        820 FORMAT(//2X,'***  STORY  DAMAGE INDEX   ***',                    OUTDA 49
           1//10X,'FLOOR',9X,'  BEAM   ',9X,'  COLUMN ',9X,'  STORY  '/)     OUTDA 50
            DO 830 II=1,NSTORY                                               OUTDA 51
            ISTORY=NSTORY+1-II                                               OUTDA 52
        830 PRINT 840, ISTORY,(STDAM(J,ISTORY),J=1,2),STRDAM(ISTORY)         OUTDA 53
        840 FORMAT(8X,I5,11X,F9.5,9X,F9.5,9X,F9.5)                           OUTDA 54
      C                                                                   OUTDA 55
            PRINT 920, GLDAM                                                 OUTDA 56
        920 FORMAT(///8X,'GLOBAL DAMAGE  = ',F10.5)                          OUTDA 57
      C                                                                   OUTDA 58
            REWIND NF1                                                       OUTDA 59
      C                                                                   OUTDA 60
            RETURN                                                           OUTDA 61
            END                                                              OUTDA 62
            SUBROUTINE OUTD (COMS,NINFC,IC,NQKE,NELN,NOD,DDAM)               OUTD   1
            IMPLICIT REAL*8(A-H,O-Z)                                         OUTD   2
      C                                                                   OUTD   3
            COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,  OUTD   4
           1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),         OUTD   5
           2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),  OUTD   6
           3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMx(2,2),PHx(2,2),FMp(2,2), OUTD  7
           4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),      OUTD   8
           5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,      OUTD   9
           6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),  OUTD  10
           7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,DUM(3),DAM(2),  OUTD  11
           8    REST(22)                                                     OUTD  12
            COMMON/PASS/IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IEAR,NEAR, OUTD 13
           1    ISYM,ISYMD                                                   OUTD  14
            COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,   OUTD  15
           1GLDAM                                                            OUTD  16
            COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,   OUTD  17
           1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV             OUTD  18
      C                                                                   OUTD  19
            DIMENSION COM(1),COMS(1)                                         OUTD  20
            EQUIVALENCE(IMEM,COM(1))                                         OUTD  21
      C                                                                   OUTD  22
            DIMENSION NOD(1),DDAM(NQKE,1)                                    OUTD  23
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      C                                                                 OUTD  24
      C     FINAL ENVELOPE OUTPUT, BEAM COLUMN ELEMENTS                 OUTD  25
      C                                                                 OUTD  26
            DO 10 J=1,NINFC                                             OUTD  27
         10 COM(J)=COMS(J)                                              OUTD  28
      C                                                                 OUTD  29
      C     OUTPUT FOR DAMAGE INDICES                                   OUTD  30
      C                                                                 OUTD  31
            IF(IMEM.EQ.1) PRINT 40, IGR                                 OUTD  32
         40 FORMAT(//48H DAMAGE INDICES FOR BEAM COLUMN ELEMENT : GROUP ,I15/ OUTD  33
           1       7HELEMENT,6H NODE ,6H NODE ,18H  DAMAGE INDICES   ,/    OUTD  34
           2       7H  NO.  ,6H  NO  ,6H  NO  ,18H    AT I    AT J   ,/)   OUTD  35
      C                                                                 OUTD  36
            PRINT 50, IMEM,NODI,DAM(1),NODJ,DAM(2)                      OUTD  37
         50 FORMAT(I4,2(I6,1X,F7.4,2X))                                 OUTD  38
      C                                                                 OUTD  39
      C     DATA FOR STATISITIC DAMAGE INDICES                          OUTD  40
      C                                                                 OUTD  41
            IIC=2*(IC-1)+1                                              OUTD  42
            DDAM(IEAR,IIC)=DAM(1)                                       OUTD  43
            DDAM(IEAR,IIC+1)=DAM(2)                                     OUTD  44
            NOD(IIC)=NODI                                               OUTD  45
            NOD(IIC+1)=NODJ                                             OUTD  46
      C                                                                 OUTD  47
            RETURN                                                      OUTD  48
            END                                                         OUTD  49
            SUBROUTINE DSTATIS (X,Y,NJTS,NELTOT,ICHK,IDSGN,NQKE,NELN,DDAM,NIBADSTAT   1
           1Y,DBAVG,DCAVG,DEDIF,PDEDIF,ICOR,IICHK,IECHK,NOD,DD1,DD2)     DSTAT   2
            IMPLICIT REAL*8(A-H,O-Z)                                    DSTAT   3
      C                                                                 DSTAT   4
            COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)  DSTAT   5
           1               ,FCONT(3),NUMEM(10)                          DSTAT   6
            COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY  DSTAT   7
            COMMON/PASS/IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IEAR,NEAR, DSTAT   8
           1    ISYM,ISYMD                                              DSTAT   9
            COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,   DSTAT  10
           1GLDAM                                                       DSTAT  11
            COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,   DSTAT  12
           1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV        DSTAT  13
      C                                                                 DSTAT  14
            DIMENSION X(1),Y(1),DD1(1),DD2(1),DDAM(NQKE,1),NIBAY(1),DBAVG(1), DSTAT  15
           1DCAVG(1),DEDIF(1),PDEDIF(1),ICOR(1),IICHK(1),IECHK(1),NOD(1)    DSTAT  16
      C                                                                 DSTAT  17
      C     WRITE ALL DAMAGE INDICES ON FIL'DAMAGE.DAT' FOR PLOTTING    DSTAT  18
      C                                                                 DSTAT  19
            ICHK=0                                                      DSTAT  20
            NEQK=IABS(NEAR)                                             DSTAT  21
            WRITE(33,*) NEQK                                            DSTAT  22
            WRITE(33,*) NJTS,NELTOT                                     DSTAT  23
            WRITE(34,*) NEQK                                            DSTAT  24
            WRITE(34,*) NJTS,NELTOT                                     DSTAT  25
            DO 10 I=1,NJTS                                              DSTAT  26
            WRITE(33,*) X(I),Y(I)                                       DSTAT  27
         10 WRITE(34,*) X(I),Y(I)                                       DSTAT  28
      C                                                                 DSTAT  29
            DO 11 I=1,NELTOT                                            DSTAT  30
            IF(ICOR(I).EQ.1) PDEDIF(I)=DEDIF(I)                         DSTAT  31
         11 CONTINUE                                                    DSTAT  32
      C                                                                 DSTAT  33
            PRINT 60                                                    DSTAT  34
         60 FORMAT(///30H1STATISTICS FOR DAMAGE INDICES///)             DSTAT  35
      C                                                                 DSTAT  36
            JJ=0                                                        DSTAT  37
            NB1=0                                                       DSTAT  38
            NB2=0                                                       DSTAT  39
            DBMEAN=0.0                                                  DSTAT  40
            DSUM1=0.0                                                   DSTAT  41
            DSUM2=0.0                                                   DSTAT  42
            IF(ISYM .EQ. 0) GO TO 14                                    DSTAT  43
            NSYBAY=NBAY/2                                               DSTAT  44
            KBAY=NBAY-2*NSYBAY                                          DSTAT  45
            IF(KBAY .NE. 0)  NSYBAY=NSYBAY+1                            DSTAT  46
         14 DO 15 IGR=1,NELGR                                           DSTAT  47
            IF(IGR .EQ. 1) GO TO 72                                     DSTAT  48
            IF(ISYM .EQ. 0) NUCOL=NUMEM(IGR)-NBAY                       DSTAT  49
            IF(ISYM .NE. 0 .AND. KBAY .EQ. 0) NUCOL=NUMEM(IGR)-NSYBAY-1 DSTAT  50
            IF(ISYM .NE. 0 .AND. KBAY .NE. 0) NUCOL=NUMEM(IGR)-NSYBAY   DSTAT  51
         72 PRINT 70, IGR                                               DSTAT  52
         70 FORMAT(30H BEAM COLUMN ELEMENTS GROUP   ,I5,//              DSTAT  53
           1       6H ELEM ,6H NODE ,6H NODE ,1X,10H  NO. OF  ,4X,      DSTAT  54
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     2        12H MEAN  VALUE,4X,12H STAND DEV  ,4X,12H  VARIANCE  ,4X,  DSTAT 55
     3        12H  MAXIMUM   ,4X,12H  MINIMUM   ,/                      DSTAT 56
     4        6H  NO. ,6H  NO  ,6H  NO  ,1X,10HEARTHQUAKE,2X, .          DSTAT 57
     5        12H AT I  AT J ,4X,12H AT I  AT J ,4X,12H AT I  AT J ,6X,  DSTAT 58
     6        12H AT I  AT J ,4X,12H AT I  AT J ,/)                      DSTAT 59
C                                                                        DSTAT 60
      DO 20 IEL=1,NUMEM(IGR)                                             DSTAT 61
      IF(IGR .EQ. 2) GO TO 31                                            DSTAT 62
      IREM=1                                                             DSTAT 63
      IF(ISYM.GT.0 .AND. KBAY.NE.0) IREM=IEL-NSYBAY*(IEL/NSYBAY)         DSTAT 64
      IF(ISYM.LT.0 .AND. KBAY.NE.0) IIEL=(IEL-1)/NSYBAY                  DSTAT 65
      IF(ISYM.LT.0 .AND. KBAY.NE.0) IREM=IEL-1-NSYBAY*IIEL               DSTAT 66
   31 JJ=JJ+2                                                            DSTAT 67
      DO 30 K=1,NEQK                                                     DSTAT 68
      DD1(K)=DDAM(K,JJ-1)                                                DSTAT 69
   30 DD2(K)=DDAM(K,JJ)                                                  DSTAT 70
      CALL STATIC(DD1,NEQK,DAVG1,DVAR1,DSTD1,DMX1,DMN1)                  DSTAT 71
      CALL STATIC(DD2,NEQK,DAVG2,DVAR2,DSTD2,DMX2,DMN2)                  DSTAT 72
      WRITE(33,85) IGR,NOD(JJ-1),DAVG1,NOD(JJ),DAVG2                     DSTAT 73
      PRINT 80, IEL,NOD(JJ-1),NOD(JJ),NEQK,DAVG1,DAVG2,DSTD1,            DSTAT 74
     1DSTD2,DVAR1,DVAR2,DMX1,DMX2,DMN1,DMN2                              DSTAT 75
      IF(IGR.EQ.1 .AND. IREM.EQ.0) DBAVG(IEL)=DAVG1                      DSTAT 76
      IF(IGR.EQ.1 .AND. IREM.EQ.1) DBAVG(IEL)=(DAVG1+DAVG2)/2.D0         DSTAT 77
      IF(IGR.EQ.2 .AND. IEL.LT.NUCOL) DCAVG(IEL)=DMAX1(DAVG1,DAVG2)      DSTAT 78
      IF(IGR.EQ.2 .AND. IEL.GE.NUCOL) DCAVG(IEL)=DAVG1                   DSTAT 79
      IF(IGR.EQ.2) DEDIF(IEL+NUMEM(IGR))=DCAVG(IEL)                      DSTAT 80
      IF(IGR .EQ. 1) THEN                                                DSTAT 81
      DSUM1=DSUM1+DAVG1**2                                               DSTAT 82
      DSUM2=DSUM2+DAVG2**2                                               DSTAT 83
      NB1=NB1+1                                                          DSTAT 84
      NB2=NB2+1                                                          DSTAT 85
      IF(IREM.EQ.0 .AND. ISYM.GT.0) NB2=NB2-1                            DSTAT 86
      IF(IREM.EQ.0 .AND. ISYM.LT.0) NB1=NB1-1                            DSTAT 87
      DBMEAN=DAVG1+DAVG2+DBMEAN                                          DSTAT 88
      ENDIF                                                              DSTAT 89
   20 CONTINUE                                                           DSTAT 90
      IF(IGR .EQ. 2) GO TO 15                                            DSTAT 91
      DBMEAN=DBMEAN/(NB1+NB2)                                            DSTAT 92
      DBVAR=(DSUM1+DSUM2)/(NB1+NB2)-DBMEAN**2                            DSTAT 93
      DBSTD=DSQRT(DBVAR)                                                 DSTAT 94
C                                                                        DSTAT 95
      DIFF=DABS(BMAVG-DBMEAN)                                            DSTAT 96
      DO 21 I=1,NUMEM(IGR)                                               DSTAT 97
      DEDIF(I)=DBAVG(I)-BMAVG                                            DSTAT 98
   21 CONTINUE                                                           DSTAT 99
      IF(DIFF.LE.BMDEV) GO TO 22                                         DSTAT100
C      GO TO 15                                                          DSTAT101
   22 ICONV=1                                                            DSTAT102
C                                                                        DSTAT103
   15 CONTINUE                                                           DSTAT104
   80 FORMAT(I4,2I6,4X,I5,5X,5(2(F7.4,1X)))                              DSTAT105
   85 FORMAT(I5,2(I5,2X,F7.4))                                           DSTAT106
C                                                                        DSTAT107
C     PRINT STATISTICS FOR BEAM DAMAGE INDICES                           DSTAT108
C                                                                        DSTAT109
      PRINT 71                                                           DSTAT110
   71 FORMAT(///35H1STATISTICS FOR BEAM DAMAGE INDICES///)               DSTAT111
      PRINT 74                                                           DSTAT112
   74 FORMAT(3X,'ELEMENT NO.',4X,'1',8X,'2',8X,'3',8X,'4',8X,'5',8X,'6',DSTAT113
     18X,'7',8X,'8'/)                                                    DSTAT114
      NBM=NUMEM(1)                                                       DSTAT115
      PRINT 73, (NOD(2*NJ-1),NOD(2*NJ),NJ=1,NBM),                        DSTAT116
     1(DBAVG(IEL),IEL=1,NBM),(DEDIF(IEL),IEL=1,NBM),DBMEAN,DBSTD         DSTAT117
   73 FORMAT(3X,'NODE  I / J',I4,'/',I1,3X,I4,'/',I1,3X,I4,'/',I1,3X,I4,DSTAT118
     1'/',I1,3X,I4,'/',I1,3X,I4,'/',I1,3X,I4,'/',I2,2X,I4,'/',I2,2X/     DSTAT119
     23X,' DAMAGE    ',1X,8(F8.4,1X)/                                    DSTAT120
     33X,'DIFFERENCE ',1X,8(F8.4,1X)//                                   DSTAT121
     410X,'AVERAGE VALUE = ',F8.4,10X,'STANDARD DEVIATION = ',F8.5)      DSTAT122
C                                                                        DSTAT123
C     CHECK ELEMENT DAMAGE INDICES FOR ALLOWABLE DAMAGE VALUES           DSTAT124
C                                                                        DSTAT125
      NNEL=0                                                             DSTAT126
      DO 40 IGR=1,NELGR                                                  DSTAT127
      DO 41 IEL=1,NUMEM(IGR)                                             DSTAT128
      IM=IEL+NNEL                                                        DSTAT129
      ICOR(IM)=0                                                         DSTAT130
      IICHK(IM)=0                                                        DSTAT131
      IF(ICONV .EQ. 0) GO TO 42                                          DSTAT132
      IF(IGR.EQ.1 .AND. DABS(DEDIF(IM)).LE.DBALL) GO TO 41               DSTAT133
      IF(IGR.EQ.2 .AND. DCAVG(IEL).LE.DCALL) GO TO 41                    DSTAT134
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   42 IECHK(IM)=IECHK(IM)+1                                            DSTAT135
      ICHK=1                                                           DSTAT136
      ICOR(IM)=1                                                       DSTAT137
      IF(IECHK(IM) .EQ. 1) IICHK(IM)=1                                 DSTAT138
   41 CONTINUE                                                         DSTAT139
      NNEL=NNEL+NUMEM(IGR)                                             DSTAT140
   40 CONTINUE                                                         DSTAT141
      IF(IDSGN .GE. NDSGN) ICHK=0                                      DSTAT142
C                                                                      DSTAT143
      WRITE(33,200) DS                                                 DSTAT144
C                                                                      DSTAT145
C     PLOTTING ALL THE DATA OF DAMAGE INDICES ON FILE 'DAMAGE.DAT'     DSTAT146
C                                                                      DSTAT147
      DO 140 I=1,NEQK                                                  DSTAT148
      KK=0                                                             DSTAT149
      WRITE(34,*) I                                                    DSTAT150
      DO 150 J=1,NELGR                                                 DSTAT151
      DO 150 K=1,NUMEM(J)                                              DSTAT152
      KK=KK+2                                                          DSTAT153
      WRITE(34,85) J,NOD(KK-1),DDAM(I,KK-1),NOD(KK),DDAM(I,KK)         DSTAT154
  150 CONTINUE                                                         DSTAT155
  140 WRITE(34,200) DS                                                 DSTAT156
  200 FORMAT(F10.4)                                                    DSTAT157
C                                                                      DSTAT158
      RETURN                                                           DSTAT159
      END                                                              DSTAT160
      SUBROUTINE STATIC(DD,N,DAVG,DVAR,DSTD,DMX,DMI)                   STATI  1
      IMPLICIT REAL*8(A-H,O-Z)                                         STATI  2
      DIMENSION  DD(1),DIF(1)                                          STATI  3
C                                                                      STATI  4
C     COMPUTE STATISTIC VALUES FOR DAMAGE INDICES                      STATI  5
C                                                                      STATI  6
C     ----- DAVG=MEAN VALUE OF DAMAGE INDICES AT EACH NODE             STATI  7
C     ----- DSUM =SUM OF DAMAGE INDICES AT EACH NODE                   STATI  8
C     ----- DVAR =VARIANCE AT EACH NODE                                STATI  9
C     ----- DSTD =STANDARD DEVIATION AT EACH NODE                      STATI 10
C                                                                      STATI 11
      EN=DFLOAT(N)                                                     STATI 12
      DAVG=0.D0                                                        STATI 13
      DSUM=0.D0                                                        STATI 14
      DMX=DD(1)                                                        STATI 15
      DMI=DD(1)                                                        STATI 16
      DO 10 I=1,N                                                      STATI 17
      DAVG=DAVG+DD(I)                                                  STATI 18
      DMX=DMAX1(DD(I),DMX)                                             STATI 19
      DMI=DMIN1(DD(I),DMI)                                             STATI 20
   10 DSUM=DSUM+DD(I)**2                                               STATI 21
      DAVG=DAVG/EN                                                     STATI 22
      DVAR=DSUM/EN-DAVG**2                                             STATI 23
      IF(DVAR .LT. 0.D0) DVAR=0.D0                                     STATI 24
      DSTD=DSQRT(DVAR)                                                 STATI 25
C                                                                      STATI 26
      DO 20 I=1,N                                                      STATI 27
      DIF(I)=DD(I)-DAVG                                                STATI 28
   20 CONTINUE                                                         STATI 29
      RETURN                                                           STATI 30
      END                                                              STATI 31
      SUBROUTINE THPRJ (LH,LV,LR,NF7)                                  THPRJ  1
      IMPLICIT REAL*8(A-H,O-Z)                                         THPRJ  2
C                                                                      THPRJ  3
      COMMON /OUTN/ IPJ,IPE,KNTJ,KNTE,NHOUT,NVOUT,NROUT                THPRJ  4
      COMMON /THISTJ/ ITHPJ,NF5,NSTHJ,ISJ                              THPRJ  5
C                                                                      THPRJ  6
      DIMENSION LH(1), LV(1), LR(1)                                    THPRJ  7
      DIMENSION THJD(200)                                              THPRJ  8
C                                                                      THPRJ  9
C     OUTPUT REORGANISED JOINT DISPLACEMENT TIME HISTORIES              THPRJ 10
C                                                                      THPRJ 11
      NTP=0                                                            THPRJ 12
      IF (NHOUT.GT.0) NTP=NTP+1                                        THPRJ 13
      IF (NVOUT.GT.0) NTP=NTP+1                                        THPRJ 14
      IF (NROUT.GT.0) NTP=NTP+1                                        THPRJ 15
      NSTHJ=NSTHJ/NTP                                                  THPRJ 16
      NSKJ=NTP-1                                                       THPRJ 17
      NSKIP=0                                                          THPRJ 18
      IF (NHOUT.EQ.0) GO TO 90                                         THPRJ 19
      NON=NHOUT+1                                                      THPRJ 20
      N2=0                                                             THPRJ 21
   10 N1=N2+1                                                          THPRJ 22
      N2=N1+9                                                          THPRJ 23
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      IF (NHOUT.LT.N2) N2=NHOUT                                         THPRJ 24
      REWIND NF5                                                        THPRJ 25
      DO 80 NS=1,NSTHJ                                                  THPRJ 26
      CALL STORE (THJD,NON,NF5,1)                                       THPRJ 27
      IF (NS.GT.1) GO TO 40                                             THPRJ 28
      PRINT 20, (LH(I),I=N1,N2)                                         THPRJ 29
   20 FORMAT (42H1TIME HISTORY OF X-DISPLACEMENTS AT NODES,//13H     NODTHPRJ 30
     1E NO.,10I10)                                                      THPRJ 31
      PRINT 30                                                          THPRJ 32
   30 FORMAT (9H0    TIME)                                              THPRJ 33
   40 PRINT 50, THJD(NON),(THJD(I),I=N1,N2)                             THPRJ 34
   50 FORMAT (1X,F8.3,6X,10F10.3)                                       THPRJ 35
      IF (ISJ.EQ.0) GO TO 60                                            THPRJ 36
      WRITE (99,50) THJD(NON),(THJD(I),I=N1,N2)                         THPRJ 37
   60 CONTINUE                                                          THPRJ 38
      IF (NS.EQ.NSTHJ.OR.NSKJ.EQ.0) GO TO 80                            THPRJ 39
      DO 70 N=1,NSKJ                                                    THPRJ 40
   70 READ (NF5)                                                        THPRJ 41
   80 CONTINUE                                                          THPRJ 42
      IF (N2.LT.NHOUT) GO TO 10                                         THPRJ 43
      NSKIP=NSKIP+1                                                     THPRJ 44
   90 IF (NVOUT.EQ.0) GO TO 180                                         THPRJ 45
      NON=NVOUT+1                                                       THPRJ 46
      N2=0                                                              THPRJ 47
  100 N1=N2+1                                                           THPRJ 48
      N2=N1+9                                                           THPRJ 49
      IF (NVOUT.LT.N2) N2=NVOUT                                         THPRJ 50
      REWIND NF5                                                        THPRJ 51
      IF (NSKIP.EQ.0) GO TO 120                                         THPRJ 52
      DO 110 N=1,NSKIP                                                  THPRJ 53
  110 READ (NF5)                                                        THPRJ 54
  120 DO 170 NS=1,NSTHJ                                                 THPRJ 55
      CALL STORE (THJD,NON,NF5,1)                                       THPRJ 56
      IF (NS.GT.1) GO TO 140                                            THPRJ 57
      PRINT 130, (LV(I),I=N1,N2)                                        THPRJ 58
  130 FORMAT (42H1TIME HISTORY OF Y-DISPLACEMENTS AT NODES,//13H     NODTHPRJ 59
     1E NO.,10I10)                                                      THPRJ 60
      PRINT 30                                                          THPRJ 61
  140 PRINT 50, THJD(NON),(THJD(I),I=N1,N2)                             THPRJ 62
      IF (ISJ.EQ.0) GO TO 150                                           THPRJ 63
      WRITE (99,50) THJD(NON),(THJD(I),I=N1,N2)                         THPRJ 64
  150 CONTINUE                                                          THPRJ 65
      IF (NS.EQ.NSTHJ.OR.NSKJ.EQ.0) GO TO 170                           THPRJ 66
      DO 160 N=1,NSKJ                                                   THPRJ 67
  160 READ (NF5)                                                        THPRJ 68
  170 CONTINUE                                                          THPRJ 69
      IF (N2.LT.NVOUT) GO TO 100                                        THPRJ 70
      NSKIP=NSKIP+1                                                     THPRJ 71
  180 IF (NROUT.EQ.0) GO TO 280                                         THPRJ 72
      NON=NROUT+1                                                       THPRJ 73
      N2=0                                                              THPRJ 74
  190 N1=N2+1                                                           THPRJ 75
      N2=N1+9                                                           THPRJ 76
      IF (NROUT.LT.N2) N2=NROUT                                         THPRJ 77
      REWIND NF5                                                        THPRJ 78
      IF (NSKIP.EQ.0) GO TO 210                                         THPRJ 79
      DO 200 N=1,NSKIP                                                  THPRJ 80
  200 READ (NF5)                                                        THPRJ 81
  210 DO 270 NS=1,NSTHJ                                                 THPRJ 82
      CALL STORE (THJD,NON,NF5,1)                                       THPRJ 83
      IF (NS.GT.1) GO TO 230                                            THPRJ 84
      PRINT 220, (LR(I),I=N1,N2)                                        THPRJ 85
  220 FORMAT (36H1TIME HISTORY OF ROTATIONS AT NODES,//13H     NODE NO.,THPRJ 86
     110I10)                                                            THPRJ 87
      PRINT 30                                                          THPRJ 88
  230 PRINT 240, THJD(NON),(THJD(I),I=N1,N2)                            THPRJ 89
  240 FORMAT (1X,F8.3,6X,10F10.5)                                       THPRJ 90
      IF (ISJ.EQ.0) GO TO 250                                           THPRJ 91
      WRITE (99,50) THJD(NON),(THJD(I),I=N1,N2)                         THPRJ 92
  250 CONTINUE                                                          THPRJ 93
      IF (NS.EQ.NSTHJ.OR.NSKJ.EQ.0) GO TO 270                           THPRJ 94
      DO 260 N=1,NSKJ                                                   THPRJ 95
  260 READ (NF5)                                                        THPRJ 96
      IF (N2.LT.NROUT) GO TO 190                                        THPRJ 97
  270 CONTINUE                                                          THPRJ 98
  280 CONTINUE                                                          THPRJ 99
      RETURN                                                            THPRJ100
      END                                                               THPRJ101
      SUBROUTINE THPRR (NF7,ISJ)                                        THPRR  1
      IMPLICIT REAL*8(A-H,O-Z)                                          THPRR  2
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C                                                                       THPRR   3
      COMMON /THISTR/ ITHPR,NF6,NSTHR,NHR,NVR,LRH1(50),LRH2(50),LRV1(50)THPRR   4
     1,LRV2(50)                                                         THPRR   5
C                                                                       THPRR   6
      DIMENSION REL(60)                                                 THPRR   7
C                                                                       THPRR   8
C     OUTPUT REORGANISED RELATIVE DISPLACEMENT TIME HISTORIES            THPRR   9
C                                                                       THPRR  10
      NTP=0                                                             THPRR  11
      IF (NHR.GT.0) NTP=NTP+1                                           THPRR  12
      IF (NVR.GT.0) NTP=NTP+1                                           THPRR  13
      NSTHR=NSTHR/NTP                                                   THPRR  14
      NSKJ=NTP-1                                                        THPRR  15
      NSKIP=0                                                           THPRR  16
      IF (NHR.EQ.0) GO TO 90                                            THPRR  17
      NON=NHR+1                                                         THPRR  18
      N2=0                                                              THPRR  19
   10 N1=N2+1                                                           THPRR  20
      N2=N1+9                                                           THPRR  21
      IF (NHR.LT.N2) N2=NHR                                             THPRR  22
      REWIND NF6                                                        THPRR  23
      DO 80 NS=1,NSTHR                                                  THPRR  24
      CALL STORE (REL,NON,NF6,1)                                        THPRR  25
      IF (NS.GT.1) GO TO 40                                             THPRR  26
      PRINT 20, (LRH1(I),LRH2(I),I=N1,N2)                               THPRR  27
   20 FORMAT (56H1TIME HISTORY OF RELATIVE X-DISPLACEMENTS BETWEEN NODESTHPRR  28
     1,//13H   NODE PAIRS,10(I5,2H -,I3))                               THPRR  29
      PRINT 30                                                          THPRR  30
   30 FORMAT (7H0  TIME)                                                THPRR  31
   40 PRINT 50, REL(NON),(REL(I),I=N1,N2)                               THPRR  32
   50 FORMAT (1X,F8.3,3X,10F10.4)                                       THPRR  33
      IF (ISJ.EQ.0) GO TO 60                                            THPRR  34
      WRITE (NF7) REL(NON),(REL(I),I=N1,N2)                             THPRR  35
   60 CONTINUE                                                          THPRR  36
      IF (NS.EQ.NSTHR.OR.NSKJ.EQ.0) GO TO 80                            THPRR  37
      DO 70 N=1,NSKJ                                                    THPRR  38
   70 READ (NF6)                                                        THPRR  39
   80 CONTINUE                                                          THPRR  40
      IF (N2.LT.NHR) GO TO 10                                           THPRR  41
      NSKIP=NSKIP+1                                                     THPRR  42
   90 IF (NVR.EQ.0) GO TO 170                                           THPRR  43
      NON=NVR+1                                                         THPRR  44
      N2=0                                                              THPRR  45
  100 N1=N2+1                                                           THPRR  46
      N2=N1+9                                                           THPRR  47
      IF (NVR.LT.N2) N2=NVR                                             THPRR  48
      REWIND NF6                                                        THPRR  49
      IF (NSKIP.EQ.0) GO TO 110                                         THPRR  50
      READ (NF6)                                                        THPRR  51
  110 DO 160 NS=1,NSTHR                                                 THPRR  52
      CALL STORE (REL,NON,NF6,1)                                        THPRR  53
      IF (NS.GT.1) GO TO 130                                            THPRR  54
      PRINT 120, (LRV1(I),LRV2(I),I=N1,N2)                              THPRR  55
  120 FORMAT (56H1TIME HISTORY OF RELATIVE Y-DISPLACEMENTS BETWEEN NODESTHPRR  56
     1,//13H   NODE PAIRS,10(I5,2H -,I3))                               THPRR  57
      PRINT 30                                                          THPRR  58
  130 PRINT 50, REL(NON),(REL(I),I=N1,N2)                               THPRR  59
      IF (ISJ.EQ.0) GO TO 140                                           THPRR  60
      WRITE (NF7) REL(NON),(REL(I),I=N1,N2)                             THPRR  61
  140 CONTINUE                                                          THPRR  62
      IF (NS.EQ.NSTHR.OR.NSKJ.EQ.0) GO TO 160                           THPRR  63
      DO 150 N=1,NSKJ                                                   THPRR  64
  150 READ (NF6)                                                        THPRR  65
  160 CONTINUE                                                          THPRR  66
      IF (N2.LT.NVR) GO TO 100                                          THPRR  67
  170 CONTINUE                                                          THPRR  68
      RETURN                                                            THPRR  69
      END                                                               THPRR  70
      SUBROUTINE THPREL (NF4)                                           THPRE   1
      IMPLICIT REAL*8(A-H,O-Z)                                          THPRE   2
C                                                                       THPRE   3
      COMMON /THIST/ ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE THPRE   4
C                                                                       THPRE   5
C     OUTPUT REORGANISED ELEMENT TIME HISTORIES                         THPRE   6
C                                                                       THPRE   7
      NSTH=NSTH/NELTH                                                   THPRE   8
      NSKE=NELTH-1                                                      THPRE   9
      DO 160 NE=1,NELTH                                                 THPRE  10
      REWIND NF4                                                        THPRE  11
      IF (NE.EQ.1) GO TO 20                                             THPRE  12
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      NSKIP=NE-1                                                        THPRE 13
      DO 10 N=1,NSKIP                                                   THPRE 14
   10 READ (NF4)                                                        THPRE 15
   20 DO 150 NS=1,NSTH                                                  THPRE 16
      CALL STORE (ITHOUT,25,NF4,1)                                      THPRE 17
      ITYP=ITHOUT(2)                                                    THPRE 18
      GO TO (30,40), ITYP                                               THPRE 19
   30 CALL THPR (NS)                                                    THPRE 20
      GO TO 130                                                         THPRE 21
   40 CALL THPR (NS)                                                    THPRE 22
  130 CONTINUE                                                          THPRE 23
      IF (NS.EQ.NSTH.OR.NSKE.EQ.0) GO TO 150                            THPRE 24
      DO 140 N=1,NSKE                                                   THPRE 25
  140 READ (NF4)                                                        THPRE 26
  150 CONTINUE                                                          THPRE 27
  160 CONTINUE                                                          THPRE 28
      RETURN                                                            THPRE 29
      END                                                               THPRE 30
      SUBROUTINE THPR (NS)                                              THPR   1
      IMPLICIT REAL*8(A-H,O-Z)                                          THPR   2
C                                                                       THPR   3
      COMMON /THIST/ ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE THPR   4
C                                                                       THPR   5
C     REORGANIZED TIME HISTORY OUTPUT, BEAM COLUMN ELEMENTS             THPR   6
C                                                                       THPR   7
      IF (NS.GT.1) GO TO 20                                             THPR   8
C                                                                       THPR   9
      PRINT 10, ITHOUT(1),ITHOUT(3)                                     THPR  10
   10 FORMAT(18H1RESULTS FOR GROUP,I3,                                  THPR  11
     1       35H, BEAM COLUMN ELEMENTS, ELEMENT NO.,I4///5X             THPR  12
     2       5H TIME,4X,4HNODE,3X,5HYIELD,6X,7HBENDING,7X,5HSHEAR,      THPR  13
     3       7X,5HAXIAL,12X,23HPLASTIC HINGE ROTATIONS/5X,              THPR  14
     4       5H     ,4X,4H NO.,3X,5H CODE,6X,7H MOMENT,7X,5HFORCE,      THPR  15
     5       7X,5HFORCE,8X,7HCURRENT,4X,9HACC. POS.,3X,9HACC. NEG./)    THPR  16
C                                                                       THPR  17
   20 PRINT 30, THOUT(13),ITHOUT(6),ITHOUT(4),(THOUT(I),I=1,11,2),ITHOUTTHPR  18
     1(7),ITHOUT(5),(THOUT(I),I=2,12,2)                                 THPR  19
   30 FORMAT (1H0,F8.3,I8,I7,3X,3F12.2,3X,3F12.5/9X,I8,I7,3X,3F12.2,3X,3THPR  20
     1F12.5)                                                            THPR  21
      IF (ISE.EQ.0) GO TO 40                                            THPR  22
      WRITE (NF7) THOUT(13),ITHOUT(6),ITHOUT(4),(THOUT(I),I=1,11,2),ITHOTHPR  23
     1UT(7),ITHOUT(8),(THOUT(I),I=2,12,2)                               THPR  24
   40 CONTINUE                                                          THPR  25
C                                                                       THPR  26
      RETURN                                                            THPR  27
      END                                                               THPR  28
      SUBROUTINE OUT  (COMS,NINFC,IC)                                   OUT    1
      IMPLICIT REAL*8(A-H,O-Z)                                          OUT    2
C                                                                       OUT    3
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   OUT    4
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          OUT    5
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),   OUT    6
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMx(2,2),PHx(2,2),FMp(2,2), OUT    7
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       OUT    8
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       OUT    9
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   OUT   10
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,DUM(3),DAM(2),   OUT   11
     8    REST(22)                                                      OUT   12
      COMMON/PASS/IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IEAR,NEAR, OUT   13
     1     ISYM,ISYMD                                                   OUT   14
C                                                                       OUT   15
      DIMENSION COM(1),COMS(1)                                          OUT   16
      EQUIVALENCE(IMEM,COM(1))                                          OUT   17
C                                                                       OUT   18
C     FINAL ENVELOPE OUTPUT, BEAM COLUMN ELEMENTS                       OUT   19
C                                                                       OUT   20
      DO 10 J=1,NINFC                                                   OUT   21
   10 COM(J)=COMS(J)                                                    OUT   22
C                                                                       OUT   23
      IF (IMEM.EQ.1) PRINT 20                                           OUT   24
   20 FORMAT(30H BEAM COLUMN ELEMENTS            ///                    OUT   25
     1       5H ELEM,3X,4HNODE,17X,7HBENDING,14X,5HSHEAR,14X,5HAXIAL,   OUT   26
     2       13X,8HPL HINGE,12X,9H  ACCUM  /                            OUT   27
     3       5H  NO.,3X,4H NO.,17X,7H MOMENT,3X,4HTIME,7X,5HFORCE,3X,   OUT   28
     4       4HTIME,7X,5HFORCE,3X,4HTIME,6X,8HROTATION,3X,4HTIME,       OUT   29
     5       5X,9HROTATIONS/)                                           OUT   30
C                                                                       OUT   31
      PRINT 30, IMEM,NODI,(SENP(I),TENP(I),I=1,7,2),PRACP(1),(SENN(I),TEOUT   32
     1NN(I),I=1,7,2),PRACN(1),NODJ,(SENP(I),TENP(I),I=2,8,2),PRACP(2),(SOUT   33
     2ENN(I),TENN(I),I=2,8,2),PRACN(2)                                  OUT   34
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   30 FORMAT(I4,I7,5X,8HPOSITIVE,3(F12.2,F7.3),F14.5,F7.3,F14.5/         OUT   35
     1        16X,8HNEGATIVE,3(F12.2,F7.3),F14.5,F7.3,F14.5/              OUT   36
     2        7X,I4,5X,8HPOSITIVE,3(F12.2,F7.3),F14.5,F7.3,F14.5/         OUT   37
     3        16X,8HNEGATIVE,3(F12.2,F7.3),F14.5,F7.3,F14.5/)             OUT   38
C                                                                         OUT   39
      RETURN                                                              OUT   40
      END                                                                 OUT   41
      SUBROUTINE INELL (KCONT,FCONT,NDOF,NINFC,ID,X,Y,NN,VOL,STL,ITY,     INELL  1
     1STIN,CONIN,SECIN,DDIN,RHOM,YBM,NELG,NELN,IP,KIP,PR,PPR,DMY)        INELL  2
      IMPLICIT REAL*8(A-H,O-Z)                                            INELL  3
C                                                                         INELL  4
      COMMON/GENINF/IIDUM(30),NINF(10),NDOFF(10),JJDUM(6),NUMEM(10)       INELL  5
      COMMON/PASS/IGR,KKDUM(11)                                           INELL  6
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,     INELL  7
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),            INELL  8
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),     INELL  9
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMF(2,2),PHx(2,2),FMp(2,2),   INELL 10
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),         INELL 11
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,         INELL 12
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),     INELL 13
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,    INELL 14
     8    INSLP(2,2),DAM(2),FMFI(2,2),FAC(2,2),FMDA(2,2),IDAM(2,2),       INELL 15
     9    PHDA(2,2),FMxxM(2,2)                                            INELL 16
      COMMON/WORK/GA(6,6),SFF(8),SSFF(8),DD(6),FFEF(6),FF(6),             INELL 17
     1          FEF(35,7),KDFEF(36),FINIT(30,6),ECT(15,4),STYP(7,6),      INELL 18
     2          CONYP(7,9),SECYP(14,9),W1(6),                             INELL 19
     3    ES,PS,FSY,EPSSY,EPSSU,FSU,FC,RDD,EC,PC,FCY,EPSCY,EPSCU,FCU,     INELL 20
     4    EPSCM,PCP,F,FN,FN1,PS1,PC1,PH,FM,EPSS,EPSC,EPSSD,YY,PSP,W2(2),INELL 21
     5    DPR(2),NPW(2),FACTOR,FMY(2),PY(2),PHUL(2),PHIF(2),FMU(2),       INELL 22
     6    FMIF(2),W3(740)                                                 INELL 23
      COMMON/THIST/ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE     INELL 24
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,      INELL 25
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV               INELL 26
C                                                                         INELL 27
      DIMENSION KCONT(1),ID(NN,1),X(1),Y(1),COM(1),STAR(2),YESNO(2),      INELL 28
     1KSF(2),STIN(6,1),CONIN(9,1),SECIN(9,1),DDIN(2,1),ITY(3,1),         INELL 29
     2YBM(2,NELG,1),RHOM(2,NELG,1),IP(1),KIP(1),PR(1),PPR(2,1),          INELL 30
     3DMY(NELG,1)                                                         INELL 31
C                                                                         INELL 32
      EQUIVALENCE (IMEM,COM(1))                                           INELL 33
      DATA STAR/2H  ,2H */                                                INELL 34
      DATA YESNO/4H YES,4H NO /                                           INELL 35
C                                                                         INELL 36
C     DATA INPUT, BEAM COLUMN ELEMENTS                                    INELL 37
C                                                                         INELL 38
      IF(IGR .EQ. 1) NUM=0                                                INELL 39
      NDOF=6                                                              INELL 40
      NINFC=215                                                           INELL 41
      NDOFF(IGR)=NDOF                                                     INELL 42
      NINF(IGR)=NINFC                                                     INELL 43
      NMEM=KCONT(2)                                                       INELL 44
      NUMEM(IGR)=NMEM                                                     INELL 45
      NSTL=KCONT(3)                                                       INELL 46
      NCON=KCONT(4)                                                       INELL 47
      NSEC=KCONT(5)                                                       INELL 48
      NECC=KCONT(6)                                                       INELL 49
      NFEF=KCONT(7)                                                       INELL 50
      NINT=KCONT(8)                                                       INELL 51
      IF(IGR.EQ.2) PRINT 10, (KCONT(I),I=2,8)                             INELL 52
      IF(IGR.EQ.1) PRINT 11, (KCONT(I),I=2,8)                             INELL 53
   10 FORMAT(43H BEAM COLUMN ELEMENTS (REINFORCED CONCRETE)////           INELL 54
     1        34H NO. OF ELEMENTS                 =I4/                    INELL 55
     2        34H NO. OF STEEL     TYPES          =I4/                    INELL 56
     3        34H NO. OF CONCRETE  TYPES          =I4/                    INELL 57
     4        34H NO. OF SECTION   TYPES          =I4/                    INELL 58
     5        34H NO. OF ECCENTRICITY TYPES       =I4/                    INELL 59
     6        34H NO. OF FIXED END FORCE PATTERNS =I4/                    INELL 60
     7        34H NO. OF INITIAL FORCE PATTERNS   =I4)                    INELL 61
   11 FORMAT(36H BEAM ELEMENTS (REINFORCED CONCRETE)////                  INELL 62
     1        34H NO. OF ELEMENTS                 =I4/                    INELL 63
     2        34H NO. OF STEEL     TYPES          =I4/                    INELL 64
     3        34H NO. OF CONCRETE  TYPES          =I4/                    INELL 65
     4        34H NO. OF SECTION   TYPES          =I4/                    INELL 66
     5        34H NO. OF ECCENTRICITY TYPES       =I4/                    INELL 67
     6        34H NO. OF FIXED END FORCE PATTERNS =I4/                    INELL 68
     7        34H NO. OF INITIAL FORCE PATTERNS   =I4)                    INELL 69
C                                                                         INELL 70
C     INPUT REINFORCING STEEL TYPES                                       INELL 71
C                                                                         INELL 72
      PRINT 20                                                            INELL 73
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   20 FORMAT(////24H REINFORCING STEEL TYPES//                          INELL 74
     1      20X,20H *** INPUT DATA *** ,35X,22H *** COMPUTED DATA ***//INELL 75
     2      5H TYPE,6X,7H YOUNGS,5X,9HHARDENING,6X,7H YIELD ,           INELL 76
     3      3X,9H ULTIMATE,16X,7H YIELD ,8X,9H ULTIMATE/                INELL 77
     4      5H NO. ,6X,7HMODULUS,5X,9H  RATIO  ,6X,7H STRESS,           INELL 78
     5      3X,9H  STRAIN ,16X,7H STRAIN,8X,9H  STRESS /)               INELL 79
      DO 30 N=1,NSTL                                                    INELL 80
      READ 40,I,(STYP(N,J),J=1,4)                                       INELL 81
      STYP(N,5)=STYP(N,3)/STYP(N,1)                                     INELL 82
      STYP(N,6)=STYP(N,2)*STYP(N,1)*(STYP(N,4)-STYP(N,5))+STYP(N,3)     INELL 83
   30 PRINT 50, N,(STYP(N,J),J=1,6)                                     INELL 84
   40 FORMAT (I5,E15.4,E10.4,F10.2,F10.5)                               INELL 85
   50 FORMAT (I5,2X,E13.4,E13.4,F11.2,F12.4,13X,F11.4,1X,F14.2)         INELL 86
C                                                                       INELL 87
C     INPUT CONCRETE TYPES                                              INELL 88
C                                                                       INELL 89
      PRINT 60                                                          INELL 90
   60 FORMAT(////15H CONCRETE TYPES//                                   INELL 91
     1      20X,20H *** INPUT DATA *** ,37X,22H *** COMPUTED DATA ***//INELL 92
     2      5H TYPE,6X,8HUNIAXIAL,4X,11H STRAIN AT ,6X,11HCONFINEMENT, INELL 93
     3      14X,7H  YIELD,4X,7H  YIELD,6X,8HULTIMATE,3X,8HULTIMATE,3X, INELL 94
     4      8HCRITICAL/                                                 INELL 95
     5      5H NO. ,6X,8HSTRENGTH,4X,11HMAX. STRESS,6X,11H  RATIO    , INELL 96
     6      14X,7H STRESS,4X,7H STRAIN,6X,8H STRESS ,3X,8H STRAIN ,3X, INELL 97
     7      8H STRAIN /)                                                INELL 98
      DO 70 N=1,NCON                                                    INELL 99
      READ 80 ,I,(CONYP(N,J),J=1,3)                                     INELL100
      ALPHAC=1.+10.*CONYP(N,3)                                          INELL101
      BETHAC=2.+600.*CONYP(N,3)                                         INELL102
      CONYP(N,6)=ALPHAC*CONYP(N,1)                                      INELL103
      CONYP(N,7)=ALPHAC*CONYP(N,2)                                      INELL104
      CONYP(N,4)=CONYP(N,6)*3./4.                                       INELL105
      CONYP(N,5)=CONYP(N,7)*5./12.                                      INELL106
      CONYP(N,8)=BETHAC*CONYP(N,7)                                      INELL107
   70 PRINT 90, N,(CONYP(N,J),J=1,8)                                    INELL108
   80 FORMAT (I5,7F10.4)                                                INELL109
   90 FORMAT (I5,F12.2,2X,E15.4,F15.4,12X,F10.2,F12.4,F12.2,1X,2(F11.4))INELL110
C                                                                       INELL111
C     INPUT CONCRETE CROSS SECTION TYPES                                INELL112
C                                                                       INELL113
      PRINT 100                                                         INELL114
  100 FORMAT(////29H CONCRETE CROSS SECTION TYPES//                     INELL115
     1   5H TYPE,6X,8HSECTION ,4X,8H BOTTOM ,4X,8HDISTANCE,2X,          INELL116
     2  10HBOT. STEEL,4X,10HFACTOR FOR,4X,8H  TOP   ,4X,8HDISTANCE,     INELL117
     3  3X,9HTOP STEEL,2X,10HSECTIONAL /                                INELL118
     4   5H NO. ,6X,8H HEIGHT ,4X,8H WIDTH  ,4X,8H [DCB]  ,2X,          INELL119
     5  10H  AREA    ,4X,10HMOM.  DROP,4X,8H WIDTH  ,4X,8H [DCT]  ,      INELL120
     6  3X,9H  AREA   ,2X,10H AREA     /)                               INELL121
      DO 110 N=1,NSEC                                                   INELL122
      READ 120,I,(SECYP(N,J),J=1,8)                                     INELL123
  120 FORMAT(I5,4F10.4,F5.2,3F10.4)                                     INELL124
      IF(I.LE.0)THEN                                                    INELL125
      SECYP(N,8)=SECYP(N,4)                                             INELL126
      SECYP(N,7)=SECYP(N,3)                                             INELL127
      SECYP(N,6)=SECYP(N,2)                                             INELL128
      ENDIF                                                             INELL129
      SECYP(N,9)=SECYP(N,1)*(SECYP(N,2)+SECYP(N,6))/2.                  INELL130
      PRINT 125, N,(SECYP(N,J),J=1,9)                                   INELL131
  110 IF(I.LE.0) SECYP(N,1)=-SECYP(N,1)                                 INELL132
  125 FORMAT(I5,2X,F10.2,3X,F10.2,1X,2F10.2,4X,F10.4,4X,F10.2,1X,F10.2,2INELL133
     1(2X,F10.2))                                                       INELL134
C                                                                       INELL135
C     INPUT END ECCENTRICITIES                                          INELL136
C                                                                       INELL137
      IF (NECC.EQ.0) GO TO 170                                          INELL138
      PRINT 130                                                         INELL139
  130 FORMAT(////23H END ECCENTRICITY TYPES//                           INELL140
     1      5H TYPE,6X,25HHORIZONTAL ECCENTRICITIES,5X,                 INELL141
     2      25H VERTICAL ECCENTRICITIES /                               INELL142
     3      5H  NO.,4X,25H     END I          END J ,5X,                INELL143
     4      25H     END I          END J /)                             INELL144
      DO 140 N=1,NECC                                                   INELL145
      READ 150,I,(ECT(N,J),J=1,4)                                       INELL146
  140 PRINT 160, N,(ECT(N,J),J=1,4)                                     INELL147
  150 FORMAT (I5,4F10.4)                                                INELL148
  160 FORMAT (I5,2F14.2,2X,2F14.2)                                      INELL149
C                                                                       INELL150
C     FIXED END FORCE PATTERNS                                          INELL151
C                                                                       INELL152
  170 IF (NFEF.EQ.0) GO TO 220                                          INELL153
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      PRINT 180                                                         INELL154
  180 FORMAT(////25H FIXED END FORCE PATTERNS//                         INELL155
     1       8H PATTERN,3X,4HAXIS,7X,5HAXIAL,7X,5HSHEAR,6X,6HMOMENT,    INELL156
     2       7X,5HAXIAL,7X,5HSHEAR,6X,6HMOMENT,5X,8HLL. RED./           INELL157
     3       8H   NO.  ,3X,4HCODE,7X,5HAT  I,7X,5HAT  I,6X,6H AT I ,    INELL158
     4       7X,5HAT  J,7X,5HAT  J,6X,6H AT J ,5X,8H FACTOR /)          INELL159
      DO 190 N=1,NFEF                                                   INELL160
      READ 200, I,KDFEF(N),(FEF(N,J),J=1,7)                             INELL161
  190 PRINT 210, N,KDFEF(N),(FEF(N,J),J=1,7)                            INELL162
  200 FORMAT (2I5,7F10.0)                                               INELL163
  210 FORMAT (I5,I9,F13.2,5F12.2,F12.3)                                 INELL164
C                                                                       INELL165
C     INITIAL FORCE PATTERNS                                            INELL166
C                                                                       INELL167
  220 IF (NINT.EQ.0) GO TO 270                                          INELL168
      PRINT 230                                                         INELL169
  230 FORMAT(////28H INITIAL END FORCE PATTERNS //                      INELL170
     1       8H PATTERN,7X,5HAXIAL,7X,5HSHEAR,6X,6HMOMENT,7X,5HAXIAL,   INELL171
     2       7X,5HSHEAR,6X,6HMOMENT/                                    INELL172
     3       8H   NO.  ,7X,5HAT  I,7X,5HAT  I,6X,6H AT I ,7X,5HAT  J,   INELL173
     4       7X,5HAT  J,6X,6H AT J /)                                   INELL174
      DO 240 N=1,NINT                                                   INELL175
      READ 250, I,(FINIT(N,J),J=1,6)                                    INELL176
  240 PRINT 260, N,(FINIT(N,J),J=1,6)                                   INELL177
  250 FORMAT (I5,6F10.0)                                                INELL178
  260 FORMAT (I5,3X,6F12.2)                                             INELL179
C                                                                       INELL180
C     ELEMENT SPECIFICATION                                             INELL181
C                                                                       INELL182
  270 PRINT 280                                                         INELL183
  280 FORMAT(////21H ELEMENT  INPUT  DATA//                             INELL184
     1       3X,4HELEM,2X,4HNODE,2X,4HNODE,2X,4HNODE,2X,4HCONC,2X,4HSTL INELL185
     2       ,2X,4HSECT,2X,4HECCY,2X,4HGEOM,2X,4HTIME,2X,5HHYST ,2X,    INELL186
     3       11HFEF PATTERN,2X,17HFEF SCALE FACTORS,2X,                 INELL187
     4       15HINITIAL FORCES /                                        INELL188
     5       3X,4H NO.,2X,4H  I ,2X,4H  J ,2X,4HDIFF,2X,4HTYPE,2X,4HTYPEINELL189
     6       ,2X,4HTYPE,2X,4HTYPE,2X,4HSTIF,2X,4HHIST,2X,5HCURVE,2X,    INELL190
     7       11H  DL     LL ,2X,17H    DL        LL   ,2X,              INELL191
     8       15H NO. SCALE FAC./)                                       INELL192
C                                                                       INELL193
      DO 290 J=1,215                                                    INELL194
  290 COM(J)=0.                                                         INELL195
      KST=0                                                             INELL196
C                                                                       INELL197
      IMEM=1                                                            INELL198
  310 READ 320, INNEL,INODI,INODJ,IINC,IICON,IISTL,IISEC,IIECC,IKGM,IKDTINELL199
     1,IHYS,IKFDL,IKFLL,FFDL,FFLL,IINIT,FFINIT                          INELL200
  320 FORMAT (8I5,5I4,2F5.0,I5,F5.0)                                    INELL201
C                                                                       INELL202
      IF (IABS(INNEL).GT.IMEM) GO TO 350                                INELL203
  330 INEL=INNEL                                                        INELL204
      NODI=INODI                                                        INELL205
      NODJ=INODJ                                                        INELL206
      INC=IINC                                                          INELL207
      IF (INC.EQ.0) INC=1                                               INELL208
      ICON=IICON                                                        INELL209
      ISTL=IISTL                                                        INELL210
      ISEC=IISEC                                                        INELL211
      IECC=IIECC                                                        INELL212
      KGEOM=IKGM                                                        INELL213
      KOUTDT=IKDT                                                       INELL214
      KHYST=IHYS                                                        INELL215
      YNG=YESNO(2)                                                      INELL216
      IF (KGEOM.NE.0) YNG=YESNO(1)                                      INELL217
      YNT=YESNO(2)                                                      INELL218
      IF (KOUTDT.NE.0) YNT=YESNO(1)                                     INELL219
      YNH=YESNO(2)                                                      INELL220
      IF (KHYST.NE.0) YNH=YESNO(1)                                      INELL221
      KFDL=IKFDL                                                        INELL222
      KFLL=IKFLL                                                        INELL223
      FDL=FFDL                                                          INELL224
      FLLM=FFLL                                                         INELL225
      FLLF=1.                                                           INELL226
      IF (KFLL.EQ.0) GO TO 340                                          INELL227
      FLLF=FEF(IKFLL,7)                                                 INELL228
      IF (FLLF.EQ.0.) FLLF=1.E-6                                        INELL229
  340 INIT=IINIT                                                        INELL230
      FINT=FFINIT                                                       INELL231
      ASTT=STAR(1)                                                      INELL232
      IF (IABS(INEL).NE.NMEM)   GO TO 310                               INELL233
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      GO TO 350                                                         INELL234
C                                                                       INELL235
  360 NODI=NODI+INC                                                     INELL236
      NODJ=NODJ+INC                                                     INELL237
      ASTT=STAR(2)                                                      INELL238
C                                                                       INELL239
  350 PRINT 370, ASTT,IMEM,NODI,NODJ,INC,ICON,ISTL,ISEC,IECC,YNG,YNT    INELL240
     1,YNH,KFDL,KFLL,FDL,FLLM,INIT,FINT                                 INELL241
  370 FORMAT(A2,I4,I6,4I6,2I6,3X,A4,2X,A4,2X,A4,I6,I6,F10.2,F10.2,I6,F10INELL242
     1.2)                                                               INELL243
C                                                                       INELL244
C     COUNT NUMBER OF ELEMENT TIME HISTORIES                            INELL245
C                                                                       INELL246
      IF (KOUTDT.NE.0) NELTH=NELTH+1                                    INELL247
C                                                                       INELL248
C     LOCATION MATRIX                                                   INELL249
C                                                                       INELL250
      DO 380 I=1,3                                                      INELL251
      LM(I)=ID(NODI,I)                                                  INELL252
  380 LM(I+3)=ID(NODJ,I)                                                INELL253
      CALL BAND                                                         INELL254
C                                                                       INELL255
C     ELEMENT PROPERTIES                                                INELL256
C                                                                       INELL257
      XL=X(NODJ)-X(NODI)                                                INELL258
      YL=Y(NODJ)-Y(NODI)                                                INELL259
      RFL=DSQRT(XL**2+YL**2)                                            INELL260
      IF (IECC.EQ.0) GO TO 400                                          INELL261
      DO 390 I=1,4                                                      INELL262
  390 ECC(I)=ECT(IECC,I)                                                INELL263
      XL=XL-ECC(1)+ECC(2)                                               INELL264
      YL=YL-ECC(3)+ECC(4)                                               INELL265
  400 FL=DSQRT(XL**2+YL**2)                                             INELL266
      COSA=XL/FL                                                        INELL267
      SINA=YL/FL                                                        INELL268
C                                                                       INELL269
C     DISPLACEMENT TRANSFORMATION                                       INELL270
C                                                                       INELL271
      A(1,1)=-SINA/FL                                                   INELL272
      A(1,2)=COSA/FL                                                    INELL273
      A(1,3)=1.                                                         INELL274
      A(1,4)=-A(1,1)                                                    INELL275
      A(1,5)=-A(1,2)                                                    INELL276
      A(1,6)=0.                                                         INELL277
      A(2,1)=A(1,1)                                                     INELL278
      A(2,2)=A(1,2)                                                     INELL279
      A(2,3)=0.                                                         INELL280
      A(2,4)=A(1,4)                                                     INELL281
      A(2,5)=A(1,5)                                                     INELL282
      A(2,6)=1.                                                         INELL283
      IF (IECC.EQ.0) GO TO 410                                          INELL284
      A(2,3)=(SINA*ECC(3)+COSA*ECC(1))/FL                               INELL285
      A(1,3)=1.+A(2,3)                                                  INELL286
      A(1,6)=(-SINA*ECC(4)-COSA*ECC(2))/FL                              INELL287
      A(2,6)=1.+A(1,6)                                                  INELL288
      GO TO 425                                                         INELL289
  410 ECC(1)=1.23456E10                                                 INELL290
  425 CONTINUE                                                          INELL291
C                                                                       INELL292
C     LOADS DUE TO FIXED END FORCES                                     INELL293
C                                                                       INELL294
      DO 420 I=1,6                                                      INELL295
      SFF(I)=0.                                                         INELL296
  420 SSFF(I)=0.                                                        INELL297
      IF (KFDL+KFLL.EQ.0) GO TO 510                                     INELL298
      DO 430 I=1,6                                                      INELL299
      DO 430 J=1,6                                                      INELL300
  430 GA(I,J)=0.                                                        INELL301
      GA(1,1)=COSA                                                      INELL302
      GA(1,2)=SINA                                                      INELL303
      GA(2,1)=-SINA                                                     INELL304
      GA(2,2)=COSA                                                      INELL305
      GA(3,3)=1.                                                        INELL306
      GA(4,4)=COSA                                                      INELL307
      GA(4,5)=SINA                                                      INELL308
      GA(5,4)=-SINA                                                     INELL309
      GA(5,5)=COSA                                                      INELL310
      GA(6,6)=1.                                                        INELL311
C                                                                       INELL312
      IF (KFDL.EQ.0) GO TO 470                                          INELL313
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      DO 440 I=1,6                                                    INELL314
  440 FFEF(I)=FEF(KFDL,I)*FDL                                         INELL315
      IF (KDFEF(KFDL).EQ.0) GO TO 450                                 INELL316
      CALL MULT (GA,FFEF,SFF,6,6,1)                                   INELL317
      GO TO 470                                                       INELL318
  450 DO 460 I=1,6                                                    INELL319
  460 SFF(I)=FFEF(I)                                                  INELL320
C                                                                     INELL321
  470 IF (KFLL.EQ.0) GO TO 510                                        INELL322
      DO 480 I=1,6                                                    INELL323
      FLL=FLLF*FLLM                                                   INELL324
      IF (I.EQ.3.OR.I.EQ.6) FLL=FLLM                                  INELL325
  480 FFEF(I)=FEF(KFLL,I)*FLL                                         INELL326
      IF (KDFEF(KFLL).EQ.0) GO TO 490                                 INELL327
      CALL MULT (GA,FFEF,SSFF,6,6,1)                                  INELL328
      GO TO 510                                                       INELL329
  490 DO 500 I=1,6                                                    INELL330
  500 SSFF(I)=FFEF(I)                                                 INELL331
C                                                                     INELL332
  510 DO 520 I=1,6                                                    INELL333
  520 FF(I)=SFF(I)+SSFF(I)                                            INELL334
C                                                                     INELL335
      CALL MULTT (GA,FF,DD,6,6,1)                                     INELL336
      IF (IECC.EQ.0) GO TO 530                                        INELL337
      DD(3)=DD(3)-DD(1)*ECC(3)+DD(2)*ECC(1)                           INELL338
      DD(6)=DD(6)-DD(4)*ECC(4)+DD(5)*ECC(2)                           INELL339
  530 CALL SFORCE (DD)                                                INELL340
C                                                                     INELL341
C     MODIFY TO GET INITIAL ELEMENT FORCES                            INELL342
C                                                                     INELL343
      DO 540 I=1,6                                                    INELL344
      FLL=1./FLLF                                                     INELL345
      IF (I.EQ.3.OR.I.EQ.6) FLL=1.                                    INELL346
  540 SFF(I)=SFF(I)+SSFF(I)*FLL                                       INELL347
C                                                                     INELL348
C     INITIAL FORCES                                                  INELL349
C                                                                     INELL350
  550 DO 560 I=1,6                                                    INELL351
  560 SSFF(I)=0.                                                      INELL352
      IF (INIT.EQ.0) GO TO 580                                        INELL353
      DO 570 I=1,6                                                    INELL354
      SSFF(I)=FINIT(INIT,I)*FINT                                      INELL355
  570 SFF(I)=SFF(I)+SSFF(I)                                           INELL356
C                                                                     INELL357
C     INITIALIZE ELEMENT FORCES                                       INELL358
C                                                                     INELL359
  580 BMEP(1)=SFF(3)                                                  INELL360
      BMEP(2)=SFF(6)                                                  INELL361
      FTOT(1)=SFF(1)                                                  INELL362
      FTOT(2)=SFF(4)                                                  INELL363
      SFTOT(1)=SFF(2)                                                 INELL364
      SFTOT(2)=SFF(5)                                                 INELL365
      BMTOT(1)=SFF(3)                                                 INELL366
      BMTOT(2)=SFF(6)                                                 INELL367
C                                                                     INELL368
C     INITIALIZE ENVELOPES                                            INELL369
C                                                                     INELL370
      FF(1)=SSFF(3)                                                   INELL371
      FF(2)=SSFF(6)                                                   INELL372
      FF(3)=SSFF(2)                                                   INELL373
      FF(4)=SSFF(5)                                                   INELL374
      FF(5)=SSFF(1)                                                   INELL375
      FF(6)=SSFF(4)                                                   INELL376
      DO 600 I=1,6                                                    INELL377
      IF (FF(I).LT.0.) GO TO 590                                      INELL378
      SENP(I)=FF(I)                                                   INELL379
      SENN(I)=0.                                                      INELL380
      GO TO 600                                                       INELL381
  590 SENN(I)=FF(I)                                                   INELL382
      SENP(I)=0.                                                      INELL383
  600 CONTINUE                                                        INELL384
C                                                                     INELL385
C     COMPUTE SECTION PROPERTIES                                      INELL386
C                                                                     INELL387
C     1) REINFORCING STEEL                                            INELL388
      ES=STYP(ISTL,1)                                                 INELL389
      PS=STYP(ISTL,2)                                                 INELL390
      FSY=STYP(ISTL,3)                                                INELL391
      EPSSU=STYP(ISTL,4)                                              INELL392
      EPSSY=STYP(ISTL,5)                                              INELL393
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      FSU=STYP(ISTL,6)                                                  INELL394
C     2) CONCRETE PROPERTIES                                            INELL395
      FC=CONYP(ICON,1)                                                  INELL396
      EPSCO=CONYP(ICON,2)                                               INELL397
      RDD=CONYP(ICON,3)                                                 INELL398
      FCY=CONYP(ICON,4)                                                 INELL399
      EPSCY=CONYP(ICON,5)                                               INELL400
      FCU=CONYP(ICON,6)                                                 INELL401
      EPSCU=CONYP(ICON,7)                                               INELL402
      EPSCM=CONYP(ICON,8)                                               INELL403
      SLR=CONYP(ICON,9)                                                 INELL404
C     3) DIMENSION OF SECTION                                           INELL405
      II=1                                                              INELL406
      IF(SECYP(ISEC,1).LT.0.)  II=-1                                    INELL407
      HT=SECYP(ISEC,1)                                                  INELL408
      IF(II.LE.0) HT=-HT                                                INELL409
      BB=SECYP(ISEC,2)                                                  INELL410
      DCB=SECYP(ISEC,3)                                                 INELL411
      ASB=SECYP(ISEC,4)                                                 INELL412
      OMEGA=SECYP(ISEC,5)                                               INELL413
      BT=SECYP(ISEC,6)                                                  INELL414
      DCT=SECYP(ISEC,7)                                                 INELL415
      AST=SECYP(ISEC,8)                                                 INELL416
      AT=SECYP(ISEC,9)                                                  INELL417
C                                                                       INELL418
C     SAVE ELEMENT INPUT DATA                                           INELL419
C                                                                       INELL420
      IM=NUM+IMEM                                                       INELL421
      DO 601 IN=1,6                                                     INELL422
  601 STIN(IN,IM)=STYP(ISTL,IN)                                         INELL423
      DO 602 IN=1,9                                                     INELL424
  602 CONIN(IN,IM)=CONYP(ICON,IN)                                       INELL425
      DO 603 IN=1,9                                                     INELL426
  603 SECIN(IN,IM)=SECYP(ISEC,IN)                                       INELL427
      DO 604 IN=1,2                                                     INELL428
  604 DDIN(IN,IM)=DD(IN)                                                INELL429
      ITY(1,IM)=ISTL                                                    INELL430
      ITY(2,IM)=ICON                                                    INELL431
      ITY(3,IM)=ISEC                                                    INELL432
C                                                                       INELL433
      VOL=VOL+RFL*AT                                                    INELL434
      STL=STL+RFL*(AST+ASB)                                             INELL435
      EC=FCY/EPSCY                                                      INELL436
      PC=5./21.                                                         INELL437
C                                                                       INELL438
      PCP=(FCU-0.1*FC)/((EPSCM-EPSCU)*EC)                               INELL439
      FN=ES/EC                                                          INELL440
      FN1=FN-1                                                          INELL441
      PS1=1.-PS                                                         INELL442
      PC1=1.-PC                                                         INELL443
      AS=AST+ASB                                                        INELL444
      AC=AT-AS                                                          INELL445
      DDT=HT-DCB                                                        INELL446
      DDB=HT-DCT                                                        INELL447
      AXF=DD(1)                                                         INELL448
      IF(IGR.EQ.2) AXF=-DD(2)                                           INELL449
      PSP=1.5*PS                                                        INELL450
      CALL FMPHI(SLR,AXF,HT,BT,DCT,AST,DDT,ASB,FMY1,EI1,P1,PHIU1,PHIF1,FINELL451
     1MF1,FMU1,YNX1)                                                    INELL452
      IF(II.GE.0)THEN                                                   INELL453
      CALL FMPHI(SLR,AXF,HT,BB,DCB,ASB,DDB,AST,FMY2,EI2,P2,PHIU2,PHIF2, INELL454
     1FMF2,FMU2,YNX2)                                                   INELL455
      EII=.5*(EI1+EI2)                                                  INELL456
      PP=.5*(P1*EI1+P2*EI2)/EII                                         INELL457
      FMY1=FMY1*(1.-PP*EII/EI1)/(1.-PP)                                 INELL458
      FMY2=FMY2*(1.-PP*EII/EI2)/(1.-PP)                                 INELL459
      ELSE                                                              INELL460
      EII=EI1                                                           INELL461
      PP=P1                                                             INELL462
      FMY2=FMY1                                                         INELL463
      PHIU2=PHIU1                                                       INELL464
      FMU2=FMU1                                                         INELL465
      PHIF2=PHIF1                                                       INELL466
      FMF2=FMF1                                                         INELL467
      ENDIF                                                             INELL468
      ATN=CONYP(ICON,4)*AT/HT*(DDT+DDB)/2.                              INELL469
      EA=EC*.5*(BB+BT)*HT+ES*(ASB+AST)                                  INELL470
      STR=(AS/AT)*100.D0                                                INELL471
      IF(STR.LT.0.75) STR=0.75                                          INELL472
      CFR=RDD                                                           INELL473
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      IF(CFR.GT.2.) CFR=2.                                              INELL474
      PHUL(1)=PHIU1                                                     INELL475
      PHUL(2)=-PHIU2                                                    INELL476
      FMU(1)=FMU1                                                       INELL477
      FMU(2)=-FMU2                                                      INELL478
      PHIF(1)=PHIF1                                                     INELL479
      PHIF(2)=-PHIF2                                                    INELL480
      FMIF(1)=FMF1                                                      INELL481
      FMIF(2)=-FMF2                                                     INELL482
      FMY(1)=FMY1                                                       INELL483
      FMY(2)=-FMY2                                                      INELL484
      PY(1)=AS*FSY+.85*FC*AC                                            INELL485
      PY(2)=-(6.*AC*DSQRT(FC*1000.)/1000.+FSY*AS)                       INELL486
C                                                                       INELL487
      DO 610 I=1,2                                                      INELL488
      KODY(I)=1                                                         INELL489
      XI(I)=0.                                                          INELL490
      Q(I)=1.                                                           INELL491
      DO 610 J=1,2                                                      INELL492
      EI(1,I,J)=EII                                                     INELL493
      EI(2,I,J)=PP*EII                                                  INELL494
      EI(3,I,J)=0.0                                                     INELL495
      EI(4,I,J)=0.0                                                     INELL496
  610 EI(5,I,J)=0.0                                                     INELL497
      PSH=PP                                                            INELL498
      EAL=EA/FL                                                         INELL499
      IF(INEL.LT.0) GO TO 621                                           INELL500
      SSR=FL/(2.*DDT)                                                   INELL501
      CCC=SSR                                                           INELL502
      DO 620 I=1,4                                                      INELL503
      IF(I.EQ.1.OR.I.EQ.4)CCC=FL/(2.*DDB)                               INELL504
      ALPHA=.4*CCC-.6                                                   INELL505
      IF(CCC.LT.1.50000025)ALPHA=.0000001                               INELL506
      IF(CCC.GT.4.)ALPHA=1.                                             INELL507
  620 ALPHAP(I,1)=ALPHA                                                 INELL508
      GO TO 625                                                         INELL509
  621 SSR=FL/DDT                                                        INELL510
      CCC=SSR                                                           INELL511
      DO 622 I=1,4                                                      INELL512
      IF(I.EQ.1.OR.I.EQ.4)CCC=FL/DDB                                    INELL513
      ALPHA=.4*CCC-.6                                                   INELL514
      IF(CCC.LT.1.50000025)ALPHA=.0000001                               INELL515
      IF(CCC.GT.4.)ALPHA=1.                                             INELL516
  622 ALPHAP(I,1)=ALPHA                                                 INELL517
C                                                                       INELL518
  625 DO 630 J=1,2                                                      INELL519
      DAM(J)=0.0                                                        INELL520
      DO 630 IE=1,2                                                     INELL521
      PHF(IE,J)=PHIF(J)                                                 INELL522
      FMF(IE,J)=FMIF(J)                                                 INELL523
      PHU(IE,J)=PHUL(J)                                                 INELL524
      BMIY(IE,J)=FMY(J)                                                 INELL525
  630 PHY(IE,J)=FMY(J)/EII                                              INELL526
      DO 640 I=1,4                                                      INELL527
      IDAM(I,1)=0                                                       INELL528
      INSLP(I,1)=1                                                      INELL529
      FAC(I,1)=OMEGA                                                    INELL530
      FMDA(I,1)=BMIY(I,1)                                               INELL531
      FMxxM(I,1)=BMIY(I,1)                                              INELL532
      FMxM(I,1)=BMIY(I,1)                                               INELL533
      PHDA(I,1)=PHY(I,1)                                                INELL534
      PPH1(I,1)=PHY(I,1)                                                INELL535
  640 PHxM(I,1)=PHY(I,1)                                                INELL536
C                                                                       INELL537
C     SAVE DATA FOR DAMAGE ACCEPTANCE CRITERIA                          INELL538
C                                                                       INELL539
      CC=0.85*FC*YNX1*BT                                                INELL540
      CS=FSY*AST                                                        INELL541
      RHOMAX=(CC+CS)/FSY                                                INELL542
      RHOMIN=200.0/FSY                                                  INELL543
      IF(FSY .LE. 200.0) RHOMIN=RHOMIN/1000.                            INELL544
      RHOM(1,IGR,IMEM)=RHOMIN                                           INELL545
      RHOM(2,IGR,IMEM)=RHOMAX                                           INELL546
C                                                                       INELL547
      YBM(1,IGR,NODI)=FMY(1)                                            INELL548
      YBM(2,IGR,NODJ)=FMY(1)                                            INELL549
C                                                                       INELL550
      CALL FINISH                                                       INELL551
C                                                                       INELL552
C     REARRANGE DATA FOR PRINTING INPUT DATA                            INELL553
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      C                                                                 INELL554
            IP(IMEM)=NODI                                               INELL555
            IP(IMEM+NMEM)=NODJ                                          INELL556
            IP(IMEM+2*NMEM)=ICON                                        INELL557
            IP(IMEM+3*NMEM)=ISTL                                        INELL558
            IP(IMEM+4*NMEM)=ISEC                                        INELL559
      C                                                                 INELL560
            PR(IMEM)=EII                                                INELL561
            PR(IMEM+NMEM)=STR                                           INELL562
            PR(IMEM+2*NMEM)=PP                                          INELL563
            PR(IMEM+3*NMEM)=SSR                                         INELL564
            PR(IMEM+4*NMEM)=CFR                                         INELL565
      C                                                                 INELL566
            PPR(1,IMEM)=FMY(1)                                          INELL567
            PPR(1,IMEM+NMEM)=FMU(1)                                     INELL568
            PPR(1,IMEM+2*NMEM)=FMIF(1)                                  INELL569
            PPR(1,IMEM+3*NMEM)=PHUL(1)                                  INELL570
            PPR(1,IMEM+4*NMEM)=PHIF(1)                                  INELL571
      C                                                                 INELL572
            PPR(2,IMEM)=FMY(2)                                          INELL573
            PPR(2,IMEM+NMEM)=FMU(2)                                     INELL574
            PPR(2,IMEM+2*NMEM)=FMIF(2)                                  INELL575
            PPR(2,IMEM+3*NMEM)=PHUL(2)                                  INELL576
            PPR(2,IMEM+4*NMEM)=PHIF(2)                                  INELL577
      C                                                                 INELL578
            IF(KAUTO.NE.1) GO TO 609                                    INELL579
            AST=1.1*AST                                                 INELL580
            ASB=1.1*ASB                                                 INELL581
            CALL FMPHI(SLR,AXF,HT,BT,DCT,AST,DDT,ASB,FMY1,EI1,P1,PHIU1,PHIF1,FINELL582
           1MF1,FMU1,YNX1)                                              INELL583
            DMY(IGR,IMEM)=(FMY1-FMY(1))/10                              INELL584
      C                                                                 INELL585
      C     GENERATE MISSING ELEMENTS                                   INELL586
      C                                                                 INELL587
        609 IF (IMEM.EQ.NMEM) GOTO 650                                  INELL588
            IMEM=IMEM+1                                                 INELL589
            IF (IMEM.EQ.IABS(INNEL)) GOTO 330                           INELL590
            GO TO 360                                                   INELL591
      C                                                                 INELL592
      C     PRINT COMPUTED MEMBER PROPERTIES                            INELL593
      C                                                                 INELL594
        650 DO 700 I=1,NMEM                                             INELL595
            IF(I.EQ.1) PRINT 660                                        INELL596
            PRINT 680, I,IP(I),IP(I+NMEM),IP(I+2*NMEM),IP(I+3*NMEM),    INELL597
           1IP(I+4*NMEM),PR(I),PR(I+NMEM),PR(I+2*NMEM),PR(I+3*NMEM),    INELL598
           2PR(I+4*NMEM),(PPR(J,I),J=1,2),(PPR(J,I+NMEM),J=1,2),        INELL599
           3(PPR(J,I+2*NMEM),J=1,2),PPR(1,I)/PR(I),PPR(1,I+3*NMEM),     INELL600
           4PPR(1,I+4*NMEM)                                             INELL601
        700 CONTINUE                                                    INELL602
        660 FORMAT(////36H*** COMPUTED MEMBER PROPERTIES  ***//         INELL603
           1       3HEL.,1X,4HNODE,3X,4HMATL,1X,7HYOUNG'S,3X,5HLONG.,   INELL604
           2       1X,6HHARDEN,1X,6HS/SPAN,1X,6HCONFIN,2X,13H YIELD MOMENT,4X,INELL605
           3       13HULT.  MOMENT ,4X,11HFAIL MOMENT,9X,'  CURVATURES'/,  INELL606
           5       3HNO.,1X,4H I/J,1X,8HCO/ST/SE,1X,7HMODULUS,1X,5HSTL %,  INELL607
           6       1X,6H RATIO,1X,6H RATIO,1X,6H RATIO,3X,13HPOSI.   NEGA ,3X,INELL608
           7       13HPOSI.  NEGA  ,5X,11HPOSI.  NEGA,5X,21HYIELD  MAX MO.  FAINELL609
           8IL /)                                                       INELL610
        680 FORMAT(/I2,1X,I2,'/',I2,1X,I1,'/',I1,'/',I1,1X,E9.3,1X,F5.3,1X,  INELL611
           1F6.4,1X,F5.2,1X,F6.3,2F9.2,2F9.2,1X,2F9.2,1x,2F7.4,1x,F7.4)  INELL612
            IF(IGR .GE. 1) NUM=NUM+NMEM                                 INELL613
            RETURN                                                      INELL614
            END                                                         INELL615
            SUBROUTINE FMPHI(SLR,AXF,H,B,DD,ASD,D,AS,FMY,EI,P,PHIU,PHIF,FMF,  FMPHI  1
           1FMU,YNX)                                                    FMPHI  2
            IMPLICIT REAL*8(A-H,O-Z)                                    FMPHI  3
            COMMON/INFEL/IMEM,IMEMD,DUM(214)                            FMPHI  4
            COMMON/WORK/W1(810),ES,PS,FSY,EPSSY,EPSSU,FSU,FC,RDD,EC,PC,FCY,  FMPHI  5
           1            EPSCY,EPSCU,FCU,EPSCM,PCP,F,FN,FN1,PS1,PC1,PHI,FM,  FMPHI  6
           2            EPSS,EPSC,EPSSD,Y,PSP,W2(72)                    FMPHI  7
      C                                                                 FMPHI  8
            DDD=.85*FCU*B*H                                             FMPHI  9
            DDD=(DDD*H*.5+FSY*(ASD*DD+AS*D))/(DDD+(AS+ASD)*FSY)         FMPHI 10
            DEPS=EPSSY/10.                                              FMPHI 11
            ICODE=2                                                     FMPHI 12
            DO 5 I=1,10                                                 FMPHI 13
            EPS=DFLOAT(I)*DEPS                                          FMPHI 14
            DO 10 KSD=1,2                                               FMPHI 15
            DO 10 KC=1,4                                                FMPHI 16
            CALL NUTAX(AXF,ICODE,KC,KS,KSD,IOK,EPS,H,B,DD,ASD,D,AS,DDD)  FMPHI 17
            IF(IOK.EQ.0)GO TO 20                                        FMPHI 18
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   10 CONTINUE                                                          FMPHI 19
   20 CALL MOMENT(AXF,KC,KS,KSD,H,B,DD,ASD,D,AS,DDD,ICODE)              FMPHI 20
    5 CONTINUE                                                          FMPHI 21
c   5 WRITE(30,100) Y,EPSC,EPSSD,EPSS,PHI,FM                            FMPHI 22
      PHIY=PHI                                                          FMPHI 23
      FMY=FM                                                            FMPHI 24
      FMP=FMY                                                           FMPHI 25
      FMU=FMY                                                           FMPHI 26
      YNX=Y                                                             FMPHI 27
      PEPSC=EPSC                                                        FMPHI 28
      PEPSS=EPSS                                                        FMPHI 29
C                                                                       FMPHI 30
      IULT=0                                                            FMPHI 31
      ICODE=1                                                           FMPHI 32
      EPS=EPSCM                                                         FMPHI 33
      DO 24 KSD=1,2                                                     FMPHI 34
      DO 24 KS=2,3                                                      FMPHI 35
      CALL NUTAX(AXF,ICODE,KC,KS,KSD,IOK,EPS,H,B,DD,ASD,D,AS,DDD)       FMPHI 36
      IF(IOK.EQ.0)GO TO 26                                              FMPHI 37
   24 CONTINUE                                                          FMPHI 38
   26 IF(EPSS .GT. EPSSU) GO TO 51                                      FMPHI 39
      PEPS=PEPSC                                                        FMPHI 40
      DEPS=(EPSCM-PEPSC)/20.                                            FMPHI 41
      DO 25 I=1,20                                                      FMPHI 42
      EPS=PEPS+DFLOAT(I)*DEPS                                           FMPHI 43
      IF(EPS.GT.EPSCM)EPS=EPSCM                                         FMPHI 44
      DO 30 KSD=1,2                                                     FMPHI 45
      DO 30 KS=2,3                                                      FMPHI 46
      CALL NUTAX(AXF,ICODE,KC,KS,KSD,IOK,EPS,H,B,DD,ASD,D,AS,DDD)       FMPHI 47
      IF(IOK.EQ.0)GO TO 35                                              FMPHI 48
   30 CONTINUE                                                          FMPHI 49
   35 CALL MOMENT(AXF,KC,KS,KSD,H,B,DD,ASD,D,AS,DDD,ICODE)              FMPHI 50
      IF(IULT.EQ.1) GO TO 33                                            FMPHI 51
      IF(FMP.GT.FM) THEN                                                FMPHI 52
      FMU=FMP                                                           FMPHI 53
      PHIU=PHIP                                                         FMPHI 54
      IULT=1                                                            FMPHI 55
      ELSE                                                              FMPHI 56
      ENDIF                                                             FMPHI 57
   33 PEPSS=EPSS                                                        FMPHI 58
      IF(EPSSD.GE.EPSCM) GO TO 200                                      FMPHI 59
      IF(FM.LE.0.75*FMY) GO TO 300                                      FMPHI 60
      IF(EPSS.GE.1.5*EPSSU) GO TO 400                                   FMPHI 61
      EPSSDP=EPSSD                                                      FMPHI 62
      EPSSP=EPSS                                                        FMPHI 63
      FMP=FM                                                            FMPHI 64
      PHIP=PHI                                                          FMPHI 65
      IF(EPS.GE.EPSCM) GO TO 51                                         FMPHI 66
   25 CONTINUE                                                          FMPHI 67
c     WRITE(30,100) Y,EPSC,EPSSD,EPSS,PHI,FM                            FMPHI 68
C                                                                       FMPHI 69
   51 PEPS=PEPSS                                                        FMPHI 70
      IEPS=0                                                            FMPHI 71
      DEPS=(EPSSU-PEPS)/20.                                             FMPHI 72
      EI=1.5*(PEPS/DEPS)+1                                              FMPHI 73
      NN=30+IDINT(EI)+1                                                 FMPHI 74
      IF(DEPS .LE. 0.0) DEPS=EPSSU/20.                                  FMPHI 75
      IF(DEPS .LE. 0.0) NN=100                                          FMPHI 76
      ICODE=2                                                           FMPHI 77
      DO 40 I=1,NN                                                      FMPHI 78
      EPS=PEPS+DEPS*DFLOAT(I)                                           FMPHI 79
      IF(IEPS.EQ.1) GO TO 52                                            FMPHI 80
      IF(EPS.GT.EPSSU) THEN                                             FMPHI 81
      EPS=EPSSU                                                         FMPHI 82
      IEPS=1                                                            FMPHI 83
      ELSE                                                              FMPHI 84
      ENDIF                                                             FMPHI 85
   52 DO 50 KC=1,4                                                      FMPHI 86
      DO 50 KSD=1,2                                                     FMPHI 87
      CALL NUTAX(AXF,ICODE,KC,KS,KSD,IOK,EPS,H,B,DD,ASD,D,AS,DDD)       FMPHI 88
      IF(IOK.EQ.0)GO TO 45                                              FMPHI 89
   50 CONTINUE                                                          FMPHI 90
   45 CALL MOMENT(AXF,KC,KS,KSD,H,B,DD,ASD,D,AS,DDD,ICODE)              FMPHI 91
      IF(IULT.EQ.1) GO TO 43                                            FMPHI 92
      IF(FMP.GT.FM) THEN                                                FMPHI 93
      FMU=FMP                                                           FMPHI 94
      PHIU=PHIP                                                         FMPHI 95
      IULT=1                                                            FMPHI 96
      ELSE                                                              FMPHI 97
      ENDIF                                                             FMPHI 98
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   43 IF(EPSSD.GE.EPSCM) GO TO 200                                     FMPHI 99
      IF(FM.LE.0.75*FMY) GO TO 300                                     FMPHI100
      IF(EPSS.GT.1.5*EPSSU) GO TO 400                                  FMPHI101
      EPSSDP=EPSSD                                                     FMPHI102
      EPSSP=EPSS                                                       FMPHI103
      FMP=FM                                                           FMPHI104
      PHIP=PHI                                                         FMPHI105
   40 CONTINUE                                                         FMPHI106
c  40 if(imem.eq.8)WRITE(30,100) Y,EPSC,EPSSD,EPSS,PHI,FM              FMPHI107
  200 DRA=(EPSCM-EPSSDP)/(EPSSD-EPSSDP)                                FMPHI108
      GO TO 500                                                        FMPHI109
  300 DRA=(0.75*FMY-FMP)/(FM-FMP)                                      FMPHI110
      GO TO 500                                                        FMPHI111
  400 DRA=(1.5*EPSSU-EPSSP)/(EPSS-EPSSP)                               FMPHI112
  500 FMF=FMP+DRA*(FM-FMP)                                             FMPHI113
      PHIF=PHIP+DRA*(PHI-PHIP)                                         FMPHI114
      IF(IULT.EQ.0) THEN                                               FMPHI115
      FMU=FMF                                                          FMPHI116
      PHIU=PHIF                                                        FMPHI117
      FMF=0.75*FMF                                                     FMPHI118
      PHIF=PHIF*1.5                                                    FMPHI119
      ELSE                                                             FMPHI120
      ENDIF                                                            FMPHI121
c     WRITE(30,100) Y,EPSC,EPSSD,EPSS,PHIF,FMF                         FMPHI122
      EI=FMY/PHIY                                                      FMPHI123
      P=(FMU-FMY)/((PHIU-PHIY)*EI)                                     FMPHI124
  100 FORMAT(5(F10.5,2X),F12.5)                                        FMPHI125
      RETURN                                                           FMPHI126
      END                                                              FMPHI127
      SUBROUTINE NUTAX(AXF,ICODE,KC,KS,KSD,IOK,EPS,H,B,DD,ASD,D,AS,DDD) NUTAX  1
      IMPLICIT REAL*8(A-H,O-Z)                                         NUTAX  2
      COMMON/WORK/W1(810),ES,PS,FSY,EPSSY,EPSSU,FSU,FC,RDD,EC,PC,FCY,  NUTAX  3
     1             EPSCY,EPSCU,FCU,EPSCM,PCP,F,FN,FN1,PS1,PC1,PHI,FM,  NUTAX  4
     2             EPSS,EPSC,EPSSD,Y,PSP,W2(72)                        NUTAX  5
      IOK=0                                                            NUTAX  6
      RCY=EPSCY/EPS                                                    NUTAX  7
      RCU=EPSCU/EPS                                                    NUTAX  8
      RCM=EPSCM/EPS                                                    NUTAX  9
      RSY=EPSSY/EPS                                                    NUTAX 10
      RSU=EPSSU/EPS                                                    NUTAX 11
      GO TO(10,20),ICODE                                               NUTAX 12
   10 EPSC=EPS                                                         NUTAX 13
      BETA=-AXF/(EC*EPS)                                               NUTAX 14
      GAMA=0.                                                          NUTAX 15
      KC=1                                                             NUTAX 16
      IF(EPS.GT.EPSCY)KC=2                                             NUTAX 17
      IF(EPS.GT.EPSCU)KC=3                                             NUTAX 18
      IF(EPS.GT.EPSCM) KC=4                                            NUTAX 19
      GO TO 30                                                         NUTAX 20
   20 EPSS=EPS                                                         NUTAX 21
      BETA=AXF/(EC*EPS)                                                NUTAX 22
      GAMA=AXF*D/(EC*EPS)                                              NUTAX 23
      KS=1                                                             NUTAX 24
      IF(EPS.GT.EPSSY)KS=2                                             NUTAX 25
      IF(EPS.GT.EPSSU)KS=3                                             NUTAX 26
   30 KC1=KC+4*(ICODE-1)                                               NUTAX 27
      KS1=KS+3*(ICODE-1)                                               NUTAX 28
      KSD1=KSD+2*(ICODE-1)                                             NUTAX 29
      GO TO (40,50,66,68,40,60,67,69),KC1                              NUTAX 30
   40 ALFA=0.5*B                                                       NUTAX 31
      GO TO 70                                                         NUTAX 32
   50 ALFA=0.5*B*(1-PC1*(1-RCY)**2)                                    NUTAX 33
      GO TO 70                                                         NUTAX 34
   60 ALFA=0.5*B*(1-PC1*(1+RCY)**2)                                    NUTAX 35
      BETA=BETA+B*D*PC1*(RCY+RCY*RCY)                                  NUTAX 36
      GAMA=GAMA+B*.5*PC1*(D*RCY)**2                                    NUTAX 37
      GO TO 70                                                         NUTAX 38
   66 ALFA=0.5*B*(1-PC1*(1-RCY)**2-(PC+PCP)*(1-RCU)**2)                NUTAX 39
      GO TO 70                                                         NUTAX 40
   67 ALFA=0.5*B*(1-PC1*(1+RCY)**2-(PC+PCP)*(1+RCU)**2)                NUTAX 41
      BETA=BETA+B*D*(PC1*(RCY+RCY*RCY)+(PC+PCP)*(RCU+RCU*RCU))         NUTAX 42
      GAMA=GAMA+.5*B*D*D*(PC1*RCY*RCY+(PC+PCP)*RCU*RCU)                NUTAX 43
      GO TO 70                                                         NUTAX 44
   68 ALFA=0.5*B*(1-PC1*(1-RCY)**2-(PC+PCP)*(1-RCU)**2+                NUTAX 45
     1PCP*(1-RCM)**2)                                                  NUTAX 46
      GO TO 70                                                         NUTAX 47
   69 ALFA=0.5*B*(1-PC1*(1+RCY)**2-(PC+PCP)*(1+RCU)**2+                NUTAX 48
     1PCP*(1+RCM)**2)                                                  NUTAX 49
      BETA=BETA+B*D*(PC1*(RCY+RCY*RCY)+(PC+PCP)*(RCU+RCU*RCU)-         NUTAX 50
     1PCP*(RCM+RCM*RCM))                                               NUTAX 51
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      GAMA=GAMA+.5*B*D*D*(PC1*RCY*RCY+(PC+PCP)*RCU*RCU-PCP*           NUTAX 52
     1RCM*RCM)                                                        NUTAX 53
   70 GO TO (80,90,80,100),KSD1                                       NUTAX 54
   80 BETA=BETA+FN1*ASD                                               NUTAX 55
      GAMA=GAMA+FN1*ASD*DD                                            NUTAX 56
      GO TO 110                                                       NUTAX 57
   90 BETA=BETA+FN1*RSY*ASD                                           NUTAX 58
      GO TO 110                                                       NUTAX 59
  100 BETA=BETA-FN1*RSY*ASD                                           NUTAX 60
      GAMA=GAMA-FN1*RSY*ASD*D                                         NUTAX 61
  110 GO TO(120,130,135,120,140,145),KS1                              NUTAX 62
  120 BETA=BETA+FN*AS                                                 NUTAX 63
      GAMA=GAMA+FN*AS*D                                               NUTAX 64
      GO TO 150                                                       NUTAX 65
  130 BETA=BETA+FN*AS*(1-PS1*(1+RSY))                                 NUTAX 66
      GAMA=GAMA+FN*AS*PS*D                                            NUTAX 67
      GO TO 150                                                       NUTAX 68
  135 BETA=BETA+FN*AS*(1-PS1*(1+RSY)-(PS+PSP)*(1+RSU))                NUTAX 69
      GAMA=GAMA-FN*AS*PSP*D                                           NUTAX 70
      GO TO 150                                                       NUTAX 71
  140 BETA=BETA+FN*AS*(1-PS1*(1-RSY))                                 NUTAX 72
      GAMA=GAMA+FN*AS*(PS+PS1*RSY)*D                                  NUTAX 73
      GO TO 150                                                       NUTAX 74
  145 BETA=BETA+FN*AS*(1-PS1*(1-RSY)-(PS+PSP)*(1-RSU))                NUTAX 75
      GAMA=GAMA+FN*AS*(-PSP+PS1*RSY+(PS+PSP)*RSU)*D                   NUTAX 76
  150 DM=BETA**2+4.*ALFA*GAMA                                         NUTAX 77
      IF(DM.LE.0.)GO TO 1000                                          NUTAX 78
      Y=(-BETA+DSQRT(DM))/(2.*ALFA)                                   NUTAX 79
      IF((Y.LE.0).OR.(Y.GT.H))GO TO 1000                              NUTAX 80
      GO TO(160,170),ICODE                                            NUTAX 81
  160 PHI=EPSC/Y                                                      NUTAX 82
      EPSS=PHI*(D-Y)                                                  NUTAX 83
      GO TO 180                                                       NUTAX 84
  170 PHI=EPSS/(D-Y)                                                  NUTAX 85
      EPSC=PHI*Y                                                      NUTAX 86
  180 EPSSD=PHI*(Y-DD)                                                NUTAX 87
      GO TO(190,200,205),KS                                           NUTAX 88
  190 IF(EPSS.GT.EPSSY)GO TO 1000                                     NUTAX 89
      GO TO 210                                                       NUTAX 90
  200 IF(EPSS.LT.EPSSY.OR.EPSS.GT.EPSSU)GO TO 1000                    NUTAX 91
      GO TO 210                                                       NUTAX 92
  205 IF(EPSS.LT.EPSSU)GO TO 1000                                     NUTAX 93
  210 GO TO(220,230,231,232),KC                                       NUTAX 94
  220 IF(EPSC.GT.EPSCY)GO TO 1000                                     NUTAX 95
      GO TO 240                                                       NUTAX 96
  230 IF((EPSC.LT.EPSCY).OR.(EPSC.GT.EPSCU))GO TO 1000                NUTAX 97
      GO TO 240                                                       NUTAX 98
  231 IF((EPSC.LT.EPSCU).OR.(EPSC.GT.EPSCM))GO TO 1000                NUTAX 99
      GO TO 240                                                       NUTAX100
  232 IF(EPSC.LT.EPSCM)GO TO 1000                                     NUTAX101
  240 GO TO (250,260), KSD                                            NUTAX102
  250 IF(DABS(EPSSD).GT.EPSCM) GO TO 1000                             NUTAX103
      GO TO 270                                                       NUTAX104
  260 IF(DABS(EPSSD).LT.EPSCM) GO TO 1000                             NUTAX105
  270 RETURN                                                          NUTAX106
 1000 IOK=-1                                                          NUTAX107
      RETURN                                                          NUTAX108
      END                                                             NUTAX109
      SUBROUTINE MOMENT(AXF,KC,KS,KSD,H,B,DD,ASD,D,AS,DDD,ICODE)      MOMEN   1
      IMPLICIT REAL*8(A-H,O-Z)                                        MOMEN   2
      COMMON/WORK/W1(810),ES,PS,FSY,EPSSY,EPSSU,FSU,FC,RDD,EC,PC,FCY, MOMEN   3
     1            EPSCY,EPSCU,FCU,EPSCM,PCP,F,FN,FN1,PS1,PC1,PHI,FM,  MOMEN   4
     2            EPSS,EPSC,EPSSD,Y,PSP,W2(72)                        MOMEN   5
C                                                                     MOMEN   6
      GO TO (10,20,21,22),KC                                          MOMEN   7
   10 CC=EC*.5*B*Y*EPSC                                               MOMEN   8
      FM=CC*(DDD-Y/3.)                                                MOMEN   9
      GO TO 30                                                        MOMEN  10
   20 Y1=(EPSC-EPSCY)/PHI                                             MOMEN  11
      CC1=Y*Y                                                         MOMEN  12
      CC2=Y1*Y1*PC1                                                   MOMEN  13
      CON=EC*PHI*B*.5                                                 MOMEN  14
      CC=CON*(CC1-CC2)                                                MOMEN  15
      FM=CON*(CC1*(DDD-Y/3.)-CC2*(DDD-Y1/3.))                         MOMEN  16
      GO TO 30                                                        MOMEN  17
   21 Y1=(EPSC-EPSCY)/PHI                                             MOMEN  18
      Y2=(EPSC-EPSCU)/PHI                                             MOMEN  19
      CC1=Y**2                                                        MOMEN  20
      CC2=PC1*Y1**2                                                   MOMEN  21
      CC3=(PC+PCP)*Y2**2                                              MOMEN  22
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      CON=EC*PHI*B*.5                                                   MOMEN 23
      CC=CON*(CC1-CC2-CC3)                                              MOMEN 24
      FM=CON*(CC1*(DDD-Y/3.)-CC2*(DDD-Y1/3.)-CC3*(DDD-Y2/3.))           MOMEN 25
      GO TO 30                                                          MOMEN 26
   22 Y1=(EPSC-EPSCY)/PHI                                               MOMEN 27
      Y2=(EPSC-EPSCU)/PHI                                               MOMEN 28
      Y3=(EPSC-EPSCM)/PHI                                               MOMEN 29
      CC1=Y**2                                                          MOMEN 30
      CC2=PC1*Y1**2                                                     MOMEN 31
      CC3=(PC+PCP)*Y2**2                                                MOMEN 32
      CC4=PCP*Y3**2                                                     MOMEN 33
      CON=EC*PHI*B*.5                                                   MOMEN 34
      CC=CON*(CC1-CC2-CC3+CC4)                                          MOMEN 35
      FM=CON*(CC1*(DDD-Y/3.)-CC2*(DDD-Y1/3.)-CC3*(DDD-Y2/3.)+           MOMEN 36
     1CC4*(DDD-Y3/3.))                                                  MOMEN 37
   30 FMC=FM                                                            MOMEN 38
      GO TO(40,50,55),KS                                                MOMEN 39
   40 T=ES*AS*EPSS                                                      MOMEN 40
      GO TO 60                                                          MOMEN 41
   50 T=ES*AS*(PS1*EPSSY+PS*EPSS)                                       MOMEN 42
      GO TO 60                                                          MOMEN 43
   55 T=ES*AS*(-PSP*EPSS+PS1*EPSSY+(PS+PSP)*EPSSU)                      MOMEN 44
   60 FMST=T*(D-DDD)                                                    MOMEN 45
      FM=FM+T*(D-DDD)                                                   MOMEN 46
      GO TO (80,85), KSD                                                MOMEN 47
   80 CS=FN1*EC*ASD*EPSSD                                               MOMEN 48
      GO TO 90                                                          MOMEN 49
   85 CS=FN1*EC*ASD*EPSSY                                               MOMEN 50
   90 FMSC=CS*(DDD-DD)                                                  MOMEN 51
      FM=FM+CS*(DDD-DD)                                                 MOMEN 52
      P1=CC+CS-T                                                        MOMEN 53
C     WRITE(50,300) PHI,FMC,FMST,FMSC                                   MOMEN 54
      TOL=.001                                                          MOMEN 55
      ERR=DABS(AXF-P1)                                                  MOMEN 56
      IF(ERR.LE.TOL)RETURN                                              MOMEN 57
      PRINT 200                                                         MOMEN 58
  200 FORMAT('0SOMETHING WRONG')                                        MOMEN 59
C 300 FORMAT(4F10.4)                                                    MOMEN 60
      STOP                                                              MOMEN 61
      END                                                               MOMEN 62
      SUBROUTINE STIF (MSTEP,NDOF,NINFC,COMS,FK,DFAC)                   STIF   1
      IMPLICIT REAL*8(A-H,O-Z)                                          STIF   2
C                                                                       STIF   3
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   STIF   4
     1      KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),        STIF   5
     2      KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2), STIF   6
     3      PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMx(2,2),PHx(2,2),FMp(2,2), STIF   7
     4      PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),     STIF   8
     5      PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,     STIF   9
     6      BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8), STIF  10
     7      TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD, STIF  11
     8      REST(26)                                                    STIF  12
      COMMON/WORK/ GA(6,6),PST(2,2),DST(2,2),ATK(6,2),AA(2,6),PFL,AXK,  STIF  13
     1                FFK(6,6),ELS(6,6),FAC,W(1457)                     STIF  14
C                                                                       STIF  15
      DIMENSION COM(1),COMS(1),FK(6,6)                                  STIF  16
      EQUIVALENCE(IMEM,COM(1))                                          STIF  17
C                                                                       STIF  18
C     STIFFNESS FORMULATION, BEAM COLUMN ELEMENTS                       STIF  19
C                                                                       STIF  20
      DO 10 J=3,NINFC                                                   STIF  21
   10 COM(J)=COMS(J)                                                    STIF  22
C                                                                       STIF  23
C     SAVE PREVIOUS FLEXURAL STIFFNESS                                  STIF  24
C                                                                       STIF  25
      DO 20 I=1,4                                                       STIF  26
   20 PST(I,1)=ST(I,1)                                                  STIF  27
C                                                                       STIF  28
C     CURRENT FLEXURAL STIFFNESS, ELASTO-PLASTIC PART                   STIF  29
C                                                                       STIF  30
      CALL FSTF(mstep)                                                  STIF  31
C                                                                       STIF  32
      IF (MSTEP.LT.2) GO TO 50                                          STIF  33
      DO 30 I=1,4                                                       STIF  34
   30 DST(I,1)=ST(I,1)-PST(I,1)                                         STIF  35
      CALL MULTST (A,DST,ATK,FK,6,2)                                    STIF  36
C                                                                       STIF  37
C     SAVE CURRENT FLEXURAL STIFFNESS FOR NEXT STEP                     STIF  38
C                                                                       STIF  39
  120 DO 40 I=28,31                                                     STIF  40
```

```
   40 COMS(I)=COM(I)
      DO 45 I=37,38
   45 COMS(I)=COM(I)
      RETURN
C
C     ORIGINAL STIFFNESS AT STEP 0, BETA-O CORRN AT STEP 1
C
   50 FAC=1.
      IF (MSTEP.EQ.1) FAC=DFAC
      DO 60 I=1,4
   60 DST(I,1)=ST(I,1)*FAC
      CALL MULTST (A,DST,ATK,FK,6,2)
      IF (FAC.EQ.0.) GO TO 90
      EAL=EAL*FAC
      AXK=EAL*COSA**2
      FK(1,1)=FK(1,1)+AXK
      FK(1,4)=FK(1,4)-AXK
      FK(4,4)=FK(4,4)+AXK
      AXK=EAL*SINA**2
      FK(2,2)=FK(2,2)+AXK
      FK(2,5)=FK(2,5)-AXK
      FK(5,5)=FK(5,5)+AXK
      AXK=EAL*SINA*COSA
      FK(1,2)=FK(1,2)+AXK
      FK(1,5)=FK(1,5)-AXK
      FK(2,4)=FK(2,4)-AXK
      FK(4,5)=FK(4,5)+AXK
      IF (ECC(1).EQ.1.23456E10) GO TO 70
      EC3=COSA*ECC(3)-SINA*ECC(1)
      EC4=SINA*ECC(2)-COSA*ECC(4)
      AXK=COSA*EC3*EAL
      FK(1,3)=FK(1,3)-AXK
      FK(3,4)=FK(3,4)+AXK
      AXK=SINA*EC3*EAL
      FK(2,3)=FK(2,3)-AXK
      FK(3,5)=FK(3,5)+AXK
      FK(3,3)=FK(3,3)+EAL*EC3**2
      AXK=COSA*EC4*EAL
      FK(1,6)=FK(1,6)-AXK
      FK(4,6)=FK(4,6)+AXK
      AXK=SINA*EC4*EAL
      FK(2,6)=FK(2,6)-AXK
      FK(5,6)=FK(5,6)+AXK
      FK(3,6)=FK(3,6)+EC3*EC4*EAL
      FK(6,6)=FK(6,6)+EC4**2*EAL
      EAL=EAL/FAC
   70 DO 80 I=1,6
      DO 80 J=I,6
   80 FK(J,I)=FK(I,J)
C
C     ADD GEOMETRIC STIFFNESS
C
   90 IF (MSTEP.EQ.0.OR.KGEOM.EQ.0) GO TO 120
      PFL=(COMS(134)-COMS(133))/2.
      DO 100 I=1,36
      GA(I,1)=0.
  100 ELS(I,1)=0.
      CN=PFL/30.
      C1=CN*36./FL
      C2=CN*3.
      C3=CN*4.*FL
      C4=CN*FL
      ELS(2,2)=C1
      ELS(2,3)=C2
      ELS(2,5)=-C1
      ELS(2,6)=C2
      ELS(3,3)=C3
      ELS(3,5)=-C2
      ELS(3,6)=-C4
      ELS(5,5)=C1
      ELS(5,6)=-C2
      ELS(6,6)=C3
C
      GA(1,1)=COSA
      GA(1,2)=SINA
      GA(2,1)=-SINA
      GA(2,2)=COSA
      GA(3,3)=1.
      GA(4,4)=COSA
      GA(4,5)=SINA
```

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      GA(5,4)=-SINA                                                     STIF 121
      GA(5,5)=COSA                                                      STIF 122
      GA(6,6)=1.                                                        STIF 123
C                                                                       STIF 124
      DO 105 I=1,6                                                      STIF 125
      DO 105 J=1,6                                                      STIF 126
  105 ELS(J,I)=ELS(I,J)                                                 STIF 127
C                                                                       STIF 128
      CALL MULTST (GA,ELS,ATK,FFK,6,6)                                  STIF 129
      DO 110 I=1,36                                                     STIF 130
  110 FK(I,1)=FK(I,1)+FFK(I,1)                                          STIF 131
      GO TO 120                                                         STIF 132
      END                                                               STIF 133
      SUBROUTINE FSTF (MSTEP)                                           FSTF   1
      IMPLICIT REAL*8 (A-H,O-Z)                                         FSTF   2
C                                                                       FSTF   3
C     FORM 2*2 FLEXURAL STIFFNESS                                       FSTF   4
C                                                                       FSTF   5
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   FSTF   6
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          FSTF   7
     2    KODY(2),X(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),    FSTF   8
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMx(2,2),PHx(2,2),FMp(2,2), FSTF   9
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       FSTF  10
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       FSTF  11
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   FSTF  12
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,  FSTF  13
     8    REST(26)                                                      FSTF  14
C                                                                       FSTF  15
C     USE THE CONCEPT OF PLASTIC HINGES                                 FSTF  16
C                                                                       FSTF  17
      FL2=FL**2                                                         FSTF  18
      FL3=FL**3                                                         FSTF  19
      ICI=KODY(1)                                                       FSTF  20
      ICJ=KODY(2)                                                       FSTF  21
      QI=DABS(Q(1))                                                     FSTF  22
      QJ=DABS(Q(2))                                                     FSTF  23
      FMI=BMEP(1)                                                       FSTF  24
      FMJ=BMEP(2)                                                       FSTF  25
      FMT=DABS(FMI-FMJ)                                                 FSTF  26
      GO TO (10,20,30,30,30),ICI                                        FSTF  27
   10 XI=0.                                                             FSTF  28
      GO TO 40                                                          FSTF  29
   20 IF(FMI)22,21,21                                                   FSTF  30
   21 FMYI=BMIY(1,1)                                                    FSTF  31
      XI=DABS(FMI-FMYI)/FMT*FL                                          FSTF  32
      IF(XI.GT.X(1))X(1)=XI                                             FSTF  33
      IF(XI.LE.X(1))XI=X(1)                                             FSTF  34
      GO TO 40                                                          FSTF  35
   22 FMYI=BMIY(2,1)                                                    FSTF  36
      XI=DABS(FMI-FMYI)/FMT*FL                                          FSTF  37
      IF(XI.GT.X(1))X(1)=XI                                             FSTF  38
      IF(XI.LE.X(1))XI=X(1)                                             FSTF  39
      GO TO 40                                                          FSTF  40
   30 XI=X(1)                                                           FSTF  41
   40 GO TO (50,70,60,60,60),ICJ                                        FSTF  42
   50 XJ=0.                                                             FSTF  43
      GO TO 75                                                          FSTF  44
   60 XJ=X(2)                                                           FSTF  45
      GO TO 75                                                          FSTF  46
   70 IF(FMJ)72,71,71                                                   FSTF  47
   71 FMYJ=BMIY(1,2)                                                    FSTF  48
      XJ=DABS(FMJ-FMYJ)/FMT*FL                                          FSTF  49
      IF(XJ.GE.X(2))X(2)=XJ                                             FSTF  50
      IF(XJ.LT.X(2))XJ=X(2)                                             FSTF  51
      GO TO 75                                                          FSTF  52
   72 FMYJ=BMIY(2,2)                                                    FSTF  53
      XJ=DABS(FMJ-FMYJ)/FMT*FL                                          FSTF  54
      IF(XJ.GE.X(2))X(2)=XJ                                             FSTF  55
      IF(XJ.LT.X(2))XJ=X(2)                                             FSTF  56
C  75 IF((XI+XJ).LE.FL)GO TO 80                                         FSTF  57
   75 IF(XI.GT.FL/2.) XI=FL/2.                                          FSTF  58
      IF(XJ.GT.FL/2.) XJ=FL/2.                                          FSTF  59
C      XI=FL/2.                                                         FSTF  60
C      XJ=XI                                                            FSTF  61
      X(1)=XI                                                           FSTF  62
      X(2)=XJ                                                           FSTF  63
   80 EIE=EI(1,1,1)                                                     FSTF  64
      XX=1./(3.*EIE*FL2)                                                FSTF  65
      QI1=QI-1.                                                         FSTF  66
      QJ1=QJ-1.                                                         FSTF  67
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      F11=(QJ1*XJ**3-QI1*(FL-XI)**3+QI*FL3)*XX                          FSTF  68
      F22=(QI1*XI**3-QJ1*(FL-XJ)**3+QJ*FL3)*XX                          FSTF  69
      F12=-(QJ1*XJ**2*(1.5*FL-XJ)+                                      FSTF  70
     1     QI1*XI**2*(1.5*FL-XI)+FL3*0.5)*XX                            FSTF  71
      DET=F11*F22-F12*F12                                               FSTF  72
      ST(1,1)=F22/DET                                                   FSTF  73
      ST(2,2)=F11/DET                                                   FSTF  74
      ST(1,2)=-F12/DET                                                  FSTF  75
      ST(2,1)=ST(1,2)                                                   FSTF  76
      RETURN                                                            FSTF  77
      END                                                               FSTF  78
      SUBROUTINE RESP (NDOF,NINFC,KBAL,KPR,COMS,DDISM,DD,TIME,VELM,DFAC,RESP   1
     1DELTA,ELDAM,ELHYS)                                                RESP   2
      IMPLICIT REAL*8(A-H,O-Z)                                          RESP   3
C                                                                       RESP   4
C     STATE DETERMINATION, BEAM COLUMN ELEMENTS                         RESP   5
C                                                                       RESP   6
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   RESP   7
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          RESP   8
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),   RESP   9
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMx(2,2),PHx(2,2),FMp(2,2), RESP  10
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       RESP  11
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       RESP  12
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   RESP  13
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,  RESP  14
     8    INSLP(2,2),DAM(2),FMFI(2,2),RAC(2,2),FMDA(2,2),IDAM(2,2),     RESP  15
     9    PHDA(2,2),FMxxM(2,2)                                          RESP  16
      COMMON/WORK/GA(6,6),DVR(2),DBM(2),BBMTOT(2),BML(2),DUM(6),        RESP  17
     1 BMEL(2),DVAX,DFAX,FACAC,FAC,DSF,BMIUB,BMJUB,SFUB,KT(2),          RESP  18
     2 KBL(2),W1(778),DPR(2),NPW(2),FACTOR,islop(2,2),W2(64)            RESP  19
      COMMON/THIST/ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE   RESP  20
      COMMON/PASS/ IGR,ISTEP,DUMP(4),ISYM,ISYMD                         RESP  21
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    RESP  22
     1GLDAM                                                             RESP  23
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    RESP  24
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              RESP  25
C                                                                       RESP  26
      DIMENSION COM(1),COMS(1),DDISM(1),DD(1),VELM(1),NOD(2),ISLP(2)    RESP  27
      EQUIVALENCE (IMEM,COM(1)),(NODI,NOD(1))                           RESP  28
C                                                                       RESP  29
      DO 10 J=1,NINFC                                                   RESP  30
   10 COM(J)=COMS(J)                                                    RESP  31
      IF (IMEM.EQ.1) IHED=0                                             RESP  32
C                                                                       RESP  33
C     DEFORMATION INCREMENTS                                            RESP  34
C                                                                       RESP  35
      IF (ECC(1).EQ.1.23456E10) GO TO 20                                RESP  36
      DDISM(1)=DDISM(1)-ECC(3)*DDISM(3)                                 RESP  37
      DDISM(2)=DDISM(2)+ECC(1)*DDISM(3)                                 RESP  38
      DDISM(4)=DDISM(4)-ECC(4)*DDISM(6)                                 RESP  39
      DDISM(5)=DDISM(5)+ECC(2)*DDISM(6)                                 RESP  40
   20 DVAX=COSA*(DDISM(4)-DDISM(1))+SINA*(DDISM(5)-DDISM(2))            RESP  41
      ROT=(SINA*(DDISM(4)-DDISM(1))+COSA*(DDISM(2)-DDISM(5)))/FL        RESP  42
      DVR(1)=DDISM(3)+ROT                                               RESP  43
      DVR(2)=DDISM(6)+ROT                                               RESP  44
C                                                                       RESP  45
C     AXIAL FORCE INCREMENT                                             RESP  46
C                                                                       RESP  47
      DFAX=EAL*DVAX                                                     RESP  48
      FTOT(1)=FTOT(1)-DFAX                                              RESP  49
      FTOT(2)=FTOT(2)+DFAX                                              RESP  50
C                                                                       RESP  51
C     LINEAR MOMENT INCREMENTS                                          RESP  52
C                                                                       RESP  53
      DBM(1)=ST(1,1)*DVR(1)+ST(1,2)*DVR(2)                              RESP  54
      DBM(2)=ST(1,2)*DVR(1)+ST(2,2)*DVR(2)                              RESP  55
      BML(1)=BMEP(1)+DBM(1)                                             RESP  56
      BML(2)=BMEP(2)+DBM(2)                                             RESP  57
      BMEL(1)=BMTOT(1)-BMEP(1)                                          RESP  58
      BMEL(2)=BMTOT(2)-BMEP(2)                                          RESP  59
C                                                                       RESP  60
      do 31 j=1,2                                                       RESP  61
      do 31 i=1,2                                                       RESP  62
   31 islop(i,j)=inslp(i,j)                                             RESP  63
c                                                                       RESP  64
      DO 30 I=1,2                                                       RESP  65
   30 CALL STATE(DBM(I),I,KT(I),KBL(I))                                 RESP  66
C                                                                       RESP  67
      do 32 j=1,2                                                       RESP  68
      do 32 i=1,2                                                       RESP  69
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   32 inslp(i,j)=islop(i,j)                                          RESP  70
c                                                                    RESP  71
      IF(KDAMAGE.LT.1) GO TO 37                                      RESP  72
      IF(ISLP(1).NE.1.AND.ISLP(2).NE.1) IISLP=1                      RESP  73
      ELHYS=HYS(1)+HYS(2)                                            RESP  74
      ELDAM=DAM(1)*HYS(1)+DAM(2)*HYS(2)                              RESP  75
C                                                                    RESP  76
   37 KBAL=0                                                         RESP  77
      IF(KBL(1).NE.0.AND.KBL(2).NE.0)KBAL=1                          RESP  78
C                                                                    RESP  79
C     PLASTIC HINGE ROTATION                                         RESP  80
C                                                                    RESP  81
      IF(KODY(1)-2) 40,50,60                                         RESP  82
   50 DPR(1)=DVR(1)+DVR(2)*ST(1,2)/ST(1,1)                           RESP  83
   60 DPR(1)=DVR(1)                                                  RESP  84
   40 IF(KODY(2)-2) 45,55,65                                         RESP  85
   55 DPR(2)=DVR(2)+DVR(1)*ST(1,2)/ST(2,2)                           RESP  86
   65 DPR(2)=DVR(2)                                                  RESP  87
   45 CONTINUE                                                       RESP  88
C                                                                    RESP  89
C     UPDATE ACCUMULATED PLASTIC HINGE ROTATION                      RESP  90
C                                                                    RESP  91
      DO 80 IEND=1,2                                                 RESP  92
      IF(NPW(IEND).EQ.0)GO TO 80                                     RESP  93
      DPPR=FACTOR*DPR(IEND)                                          RESP  94
      PRTOT(IEND)=PRTOT(IEND)+DPPR                                   RESP  95
      IF(DPPR.LT.0) GO TO 90                                         RESP  96
      PRACP(IEND)=PRACP(IEND)+DPPR                                   RESP  97
      GO TO 80                                                       RESP  98
   90 PRACN(IEND)=PRACN(IEND)+DPPR                                   RESP  99
      GO TO 80                                                       RESP 100
   80 CONTINUE                                                       RESP 101
C                                                                    RESP 102
C     ELASTIC AND TOTAL FORCES                                       RESP 103
C                                                                    RESP 104
      BBMTOT(1)=BMTOT(1)                                             RESP 105
      BBMTOT(2)=BMTOT(2)                                             RESP 106
      BMTOT(1)=BMEP(1)+BMEL(1)                                       RESP 107
      BMTOT(2)=BMEP(2)+BMEL(2)                                       RESP 108
      DSF=(BMTOT(1)-BBMTOT(1)+BMTOT(2)-BBMTOT(2))/FL                 RESP 109
      SFTOT(1)=SFTOT(1)+DSF                                          RESP 110
      SFTOT(2)=SFTOT(2)-DSF                                          RESP 111
C                                                                    RESP 112
C     UNBALANCED LOADS DUE TO YIELD                                  RESP 113
C                                                                    RESP 114
      BMIUB=0.                                                       RESP 115
      BMJUB=0.                                                       RESP 116
      FOUB=0.                                                        RESP 117
      IF (KBAL.EQ.0) GO TO 210                                       RESP 118
      BMIUB=BML(1)-BMEP(1)                                           RESP 119
      BMJUB=BML(2)-BMEP(2)                                           RESP 120
C                                                                    RESP 121
C     DEFORMATION RATES FOR DAMPING                                  RESP 122
C                                                                    RESP 123
  210 IF (DFAC.EQ.0.0.AND.DELTA.EQ.0.0) GO TO 240                    RESP 124
      IF (TIME.EQ.0.) GO TO 250                                      RESP 125
      KBAL=1                                                         RESP 126
      IF (ECC(1).EQ.1.23456E10) GO TO 220                            RESP 127
      VELM(1)=VELM(1)-ECC(3)*VELM(3)                                 RESP 128
      VELM(2)=VELM(2)+ECC(1)*VELM(3)                                 RESP 129
      VELM(4)=VELM(4)-ECC(4)*VELM(6)                                 RESP 130
      VELM(5)=VELM(5)+ECC(2)*VELM(6)                                 RESP 131
  220 DVAX=COSA*(VELM(4)-VELM(1))+SINA*(VELM(5)-VELM(2))             RESP 132
      ROT=(SINA*(VELM(4)-VELM(1))+COSA*(VELM(2)-VELM(5)))/FL         RESP 133
      DVR(1)=VELM(3)+ROT                                             RESP 134
      DVR(2)=VELM(6)+ROT                                             RESP 135
C                                                                    RESP 136
C     BETA-O DAMPING                                                 RESP 137
C                                                                    RESP 138
      IF (DFAC.EQ.0.) GO TO 230                                      RESP 139
      FAC=DFAC*(1./(1.-PSH))                                         RESP 140
      BMIUB=BMIUB+(ST(1,1)*DVR(1)+ST(1,2)*DVR(2))*FAC                RESP 141
      BMJUB=BMJUB+(ST(1,2)*DVR(1)+ST(2,2)*DVR(2))*FAC                RESP 142
      FOUB=EAL*DVAX*DFAC                                             RESP 143
C                                                                    RESP 144
C     STRUCTURAL DAMPING LOAD                                        RESP 145
C                                                                    RESP 146
  230 IF (DELTA.EQ.0.) GO TO 240                                     RESP 147
      SDMI=DELTA*DABS(BMTOT(1))*DSIGN(1.D0,DVR(1))                   RESP 148
      SDMJ=DELTA*DABS(BMTOT(2))*DSIGN(1.D0,DVR(2))                   RESP 149
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      SDFO=DELTA*DABS((FTOT(1)+FTOT(2))/2.D0)*DSIGN(1.D0,DVAX)          RESP 150
      BMIUB=BMIUB-SDMI+SDACT(1)                                         RESP 151
      BMJUB=BMJUB-SDMJ+SDACT(2)                                         RESP 152
      FOUB=FOUB-SDFO+SDACT(3)                                           RESP 153
      SDACT(1)=SDMI                                                     RESP 154
      SDACT(2)=SDMJ                                                     RESP 155
      SDACT(3)=SDFO                                                     RESP 156
C                                                                       RESP 157
C     SET UP UNBALANCED LOAD VECTOR                                     RESP 158
C                                                                       RESP 159
  240 IF (KBAL.EQ.0) GO TO 250                                          RESP 160
      SFUB=(BMIUB+BMJUB)/FL                                             RESP 161
      DD(1)=-SFUB*SINA-FOUB*COSA                                        RESP 162
      DD(2)=SFUB*COSA-FOUB*SINA                                         RESP 163
      DD(3)=BMIUB                                                       RESP 164
      DD(4)=-DD(1)                                                      RESP 165
      DD(5)=-DD(2)                                                      RESP 166
      DD(6)=BMJUB                                                       RESP 167
      IF (ECC(1).EQ.1.23456E10) GO TO 250                               RESP 168
      DD(3)=DD(3)-DD(1)*ECC(3)+DD(2)*ECC(1)                             RESP 169
      DD(6)=DD(6)-DD(4)*ECC(4)+DD(5)*ECC(2)                             RESP 170
C                                                                       RESP 171
C     EXTRACT ENVELOPES                                                 RESP 172
C                                                                       RESP 173
  250 DO 270 I=1,8                                                      RESP 174
      S=BMTOT(I)                                                        RESP 175
      IF (S.LE.SENP(I)) GO TO 260                                       RESP 176
      SENP(I)=S                                                         RESP 177
      TENP(I)=TIME                                                      RESP 178
  260 IF (S.GE.SENN(I)) GO TO 270                                       RESP 179
      SENN(I)=S                                                         RESP 180
      TENN(I)=TIME                                                      RESP 181
  270 CONTINUE                                                          RESP 182
C                                                                       RESP 183
C     PRINT TIME HISTORY                                                RESP 184
C                                                                       RESP 185
      ISAVE=0                                                           RESP 186
      IF (KPR.LT.0) GO TO 280                                           RESP 187
      IF (KPR.EQ.0.OR.KOUTDT.EQ.0) GO TO 350                            RESP 188
      IF (ITHP.GT.1) GO TO 320                                          RESP 189
  280 IF (IHED.NE.0) GO TO 300                                          RESP 190
      KKPR=IABS(KPR)                                                    RESP 191
      PRINT 290, KKPR,TIME                                              RESP 192
  290 FORMAT(///18H RESULTS FOR GROUP,I3,                               RESP 193
     1       30H, BEAM COLUMN ELEMENTS, TIME =,F8.3///5X,               RESP 194
     2      5H ELEM,4X,4HNODE,3X,5HYIELD,6X,7HBENDING,7X,5HSHEAR,       RESP 195
     3      7X,5HAXIAL,12X,23HPLASTIC HINGE ROTATIONS/5X,               RESP 196
     4      5H  NO.,4X,4H NO.,3X,5H CODE,6X,7H MOMENT,7X,5HFORCE,       RESP 197
     5      7X,5HFORCE,8X,7HCURRENT,4X,9HACC. POS.,3X,9HACC. NEG./)     RESP 198
      IHED=1                                                            RESP 199
  300 PRINT 310, IMEM,(NOD(I),KODY(I),BMTOT(I),SFTOT(I),FTOT(I),PRTOT(I)RESP 200
     1,PRACP(I),PRACN(I),I=1,2)                                         RESP 201
  310 FORMAT (I9,I8,I7,3X,3F12.2,3X,3F12.5/9X,I8,I7,3X,3F12.2,3X,3F12.5)RESP 202
C                                                                       RESP 203
C     SET TIME HISTORY DATA IN /THIST/                                  RESP 204
C                                                                       RESP 205
  320 IF (ITHP.LT.1.OR.KOUTDT.EQ.0) GO TO 350                           RESP 206
      KKPR=IABS(KPR)                                                    RESP 207
      ITHOUT(1)=KKPR                                                    RESP 208
      ITHOUT(2)=2                                                       RESP 209
      ITHOUT(3)=IMEM                                                    RESP 210
      ITHOUT(4)=KODY(1)                                                 RESP 211
      ITHOUT(5)=KODY(2)                                                 RESP 212
      ITHOUT(6)=NODI                                                    RESP 213
      ITHOUT(7)=NODJ                                                    RESP 214
      DO 330 I=1,8                                                      RESP 215
  330 THOUT(I)=BMTOT(I)                                                 RESP 216
      DO 340 I=1,4                                                      RESP 217
  340 THOUT(I+8)=PRACP(I)                                               RESP 218
      THOUT(13)=TIME                                                    RESP 219
      ISAVE=1                                                           RESP 220
C                                                                       RESP 221
C     SET INDICATOR FOR STIFFNESS CHANGE                                RESP 222
C                                                                       RESP 223
  350 KST=0                                                             RESP 224
      IF(KT(1).NE.0.OR.KT(2).NE.0)KST=1                                 RESP 225
C                                                                       RESP 226
C     UPDATE INFORMATION IN COMS                                        RESP 227
C                                                                       RESP 228
      COMS(2)=COM(2)                                                    RESP 229
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      DO 360 J=36,215                                                   RESP 230
  360 COMS(J)=COM(J)                                                    RESP 231
      RETURN                                                            RESP 232
      END                                                               RESP 233
      SUBROUTINE STATE (DM,IE,KSTT,KBAL)                                STATE  1
      IMPLICIT REAL*8(A-H,O-Z)                                          STATE  2
C                                                                       STATE  3
C     FIND THE CORRESPONDING STATE OF A HYSTERETIC CURVE                STATE  4
C                                                                       STATE  5
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,    STATE  6
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          STATE  7
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),   STATE  8
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMF(2,2),PHx(2,2),FMp(2,2), STATE  9
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       STATE 10
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       STATE 11
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   STATE 12
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,  STATE 13
     8    INLP(2,2),DAM(2),FMFI(2,2),FAC(2,2),FMDA(2,2),IDAM(2,2),      STATE 14
     9    PHDA(2,2),FMxxM(2,2)                                          STATE 15
      COMMON/WORK/W1(840),DPR(2),NPW(2),FACTOR,INSLP(2,2),DUM(2),ISHT,  STATE 16
     1KISHT,DFM,W(59),OMEGA                                             STATE 17
      COMMON/PASS/IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(2),   STATE 18
     1ISYM,ISYMD                                                        STATE 19
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    STATE 20
     1GLDAM                                                             STATE 21
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    STATE 22
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              STATE 23
C                                                                       STATE 24
      ISHT=0                                                            STATE 25
      ISLP=0                                                            STATE 26
      NPW(IE)=0                                                         STATE 27
      FACTOR=1.0                                                        STATE 28
      DHYS=0.0                                                          STATE 29
      ICIE=KODY(IE)                                                     STATE 30
      IT=2                                                              STATE 31
      IY=1                                                              STATE 32
      IF(BMEP(IE).LT.0.)IY=2                                            STATE 33
      IF(IY.EQ.2)IT=1                                                   STATE 34
      DPHI=DM/EI(KODY(IE),IY,IE)                                        STATE 35
      FMDM=BMEP(IE)+DM                                                  STATE 36
C                                                                       STATE 37
      GO TO(100,200,300,400,500),ICIE                                   STATE 38
  100 IF(FMDM.LT.BMIY(IE,1).AND.FMDM.GT.BMIY(IE,2)) GO TO 710           STATE 39
      NPW(IE)=1                                                         STATE 40
      KODY(IE)=2                                                        STATE 41
      IY=1                                                              STATE 42
      IT=2                                                              STATE 43
      IF(FMDM.LT.0.)IY=2                                                STATE 44
      IF(IY.EQ.2)IT=1                                                   STATE 45
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),BMIY(IE,IY),FMDM,PHI(IE),DPHSTATE 46
     1I,EI(1,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)              STATE 47
      GO TO 700                                                         STATE 48
C                                                                       STATE 49
  200 IF(BMEP(IE)*DPR(IE).LE.0.0) NPW(IE)=0                             STATE 50
      IF(BMEP(IE))202,201,201                                           STATE 51
  201 IF(DM)203,710,710                                                 STATE 52
  202 IF(DM)710,710,205                                                 STATE 53
  203 CALL SLOPE(IE)                                                    STATE 54
      IF(FMDM)230,211,211                                               STATE 55
  205 CALL SLOPE(IE)                                                    STATE 56
      IF(FMDM)211,211,230                                               STATE 57
  211 KODY(IE)=3                                                        STATE 58
      DPHI=DM/EI(KODY(IE),IY,IE)                                        STATE 59
      GO TO 700                                                         STATE 60
  230 IY=1                                                              STATE 61
      IT=2                                                              STATE 62
      IF(BMEP(IE).LT.0.)IY=2                                            STATE 63
      IF(IY.EQ.2)IT=1                                                   STATE 64
C                                                                       STATE 65
  250 IF(INSLP(IE,IY).EQ.1) GO TO 260                                   STATE 66
      KODY(IE)=4                                                        STATE 67
      IDAM(IE,IY)=2                                                     STATE 68
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),0.,FMDM,PHI(IE),DPHI,EI(3,IYSTATE 69
     1,IE),EI(4,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                       STATE 70
      IF(DABS(FMDM).LT.DABS(FMp(IE,IT))) GO TO 700                      STATE 71
      KODY(IE)=5                                                        STATE 72
      CALL OVRSHT(IMEM,IE,KODY(IE),0.,FMp(IE,IT),FMDM,PHI(IE),DPHI,EI(4,STATE 73
     1IT,IE),EI(5,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                     STATE 74
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IT))) GO TO 700                    STATE 75
      KODY(IE)=2                                                        STATE 76
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      CALL OVRSHT(IMEM,IE,KODY(IE),FMp(IE,IT),FMxxM(IE,IT),FMDM,PHI(IE),STATE 77
     1DPHI,EI(5,IT,IE),EI(2,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)          STATE 78
      GO TO 700                                                          STATE 79
  260 KODY(IE)=4                                                         STATE 80
      IDAM(IE,IY)=2                                                      STATE 81
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),0.,FMDM,PHI(IE),DPHI,EI(3,IYSTATE 82
     1,IE),EI(4,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                        STATE 83
      IF(DABS(FMDM).LT.DABS(BMIY(IE,IT))) GO TO 700                      STATE 84
      KODY(IE)=2                                                         STATE 85
      CALL OVRSHT(IMEM,IE,KODY(IE),0.,BMIY(IE,IT),FMDM,PHI(IE),DPHI,EI(4STATE 86
     1,IT,IE),EI(2,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                     STATE 87
      GO TO 700                                                          STATE 88
C                                                                        STATE 89
  300 IF(BMEP(IE)*DPR(IE).LE.0.0) NPW(IE)=0                              STATE 90
      IF(BMEP(IE))302,301,301                                            STATE 91
  301 IF(DM)303,710,304                                                  STATE 92
  302 IF(DM)304,710,306                                                  STATE 93
  303 IF(FMDM)320,710,710                                                STATE 94
  306 IF(FMDM)710,710,320                                                STATE 95
  320 IY=1                                                               STATE 96
      IT=2                                                               STATE 97
      IF(BMEP(IE).LT.0.)IY=2                                             STATE 98
      IF(IY.EQ.2)IT=1                                                    STATE 99
      IF(BMEP(IE)*PHr(IE,IY).GE.0.) GO TO 250                            STATE100
      KODY(IE)=5                                                         STATE101
      IDAM(IE,IY)=2                                                      STATE102
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),0.,FMDM,PHI(IE),DPHI,EI(3,IYSTATE103
     1,IE),EI(5,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                        STATE104
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IT))) GO TO 700                     STATE105
      KODY(IE)=2                                                         STATE106
      CALL OVRSHT(IMEM,IE,KODY(IE),0.,FMxxM(IE,IT),FMDM,PHI(IE),DPHI,EI(STATE107
     15,IT,IE),EI(2,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                    STATE108
      GO TO 700                                                          STATE109
  304 IF(DABS(FMDM).LT.DABS(FM1(IE,IY))) GO TO 710                       STATE110
      IF(BMEP(IE)*PHr(IE,IY).LT.0.) GO TO 360                            STATE111
      FF=(PH1(IE,IY)-PHY(IE,IY))*EI(2,IY,IE)+BMIY(IE,IY)                 STATE112
      IF(DABS(FMDM) .GE.  DABS(FF)) GO TO 350                            STATE113
      KODY(IE)=5                                                         STATE114
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),FM1(IE,IY),FMDM,PHI(IE),DPHISTATE115
     1,EI(3,IY,IE),EI(5,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)                STATE116
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IY))) GO TO 700                     STATE117
      KODY(IE)=2                                                         STATE118
      CALL OVRSHT(IMEM,IE,KODY(IE),FM1(IE,IY),FMxxM(IE,IY),FMDM,PHI(IE),STATE119
     1DPHI,EI(5,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)            STATE120
      GO TO 700                                                          STATE121
  350 KODY(IE)=2                                                         STATE122
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),FM1(IE,IY),FMDM,PHI(IE),DPHISTATE123
     1,EI(3,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)                STATE124
      GO TO 700                                                          STATE125
  360 KODY(IE)=4                                                         STATE126
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),FM1(IE,IY),FMDM,PHI(IE),DPHISTATE127
     1,EI(3,IY,IE),EI(4,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)                STATE128
      IF(INSLP(IE,IT).EQ.1) GO TO 370                                    STATE129
      IF(DABS(FMDM).LE.DABS(FMp(IE,IY))) GO TO 700                       STATE130
      KODY(IE)=5                                                         STATE131
      CALL OVRSHT(IMEM,IE,KODY(IE),FM1(IE,IY),FMp(IE,IY),FMDM,PHI(IE),DPSTATE132
     1HI,EI(4,IY,IE),EI(5,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)              STATE133
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IY))) GO TO 700                     STATE134
      KODY(IE)=2                                                         STATE135
      CALL OVRSHT(IMEM,IE,KODY(IE),FMp(IE,IY),FMxxM(IE,IY),FMDM,PHI(IE),STATE136
     1DPHI,EI(5,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)            STATE137
      GO TO 700                                                          STATE138
  370 IF(DABS(FMDM).LE.DABS(BMIY(IE,IY))) GO TO 700                      STATE139
      KODY(IE)=2                                                         STATE140
      CALL OVRSHT(IMEM,IE,KODY(IE),FM1(IE,IY),BMIY(IE,IY),FMDM,PHI(IE),DSTATE141
     1PHI,EI(4,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)             STATE142
      GO TO 700                                                          STATE143
C                                                                        STATE144
  400 IF(BMEP(IE)*DPR(IE).LE.0.0) NPW(IE)=0                              STATE145
      IF(BMEP(IE))402,401,401                                            STATE146
  401 IF(DM)403,710,404                                                  STATE147
  402 IF(DM)404,710,405                                                  STATE148
  403 CALL SLOPE(IE)                                                     STATE149
      IF(FMDM)450,411,411                                                STATE150
  405 CALL SLOPE(IE)                                                     STATE151
      IF(FMDM)411,411,450                                                STATE152
  411 KODY(IE)=3                                                         STATE153
      DPHI=DM/EI(KODY(IE),IY,IE)                                         STATE154
      GO TO 700                                                          STATE155
  450 IY=1                                                               STATE156
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      IT=2                                                              STATE157
      IF(BMEP(IE).LT.0.)IY=2                                            STATE158
      IF(IY.EQ.2) IT=1                                                  STATE159
      KODY(IE)=5                                                        STATE160
      IDAM(IE,IY)=2                                                     STATE161
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),0.,FMDM,PHI(IE),DPHI,EI(3,IYSTATE162
     1,IE),EI(5,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                       STATE163
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IT))) GO TO 700                    STATE164
      KODY(IE)=2                                                        STATE165
      CALL OVRSHT(IMEM,IE,KODY(IE),0.,FMxxM(IE,IT),FMDM,PHI(IE),DPHI,EI(STATE166
     15,IT,IE),EI(2,IT,IE),DHYS,NODI,NODJ,KHYST,ICIE)                   STATE167
      GO TO 700                                                         STATE168
  404 IF(INSLP(IE,IT).EQ.1) GO TO 460                                   STATE169
      IF(DABS(FMDM).LT.DABS(FMp(IE,IY))) GO TO 710                      STATE170
      KODY(IE)=5                                                        STATE171
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),FMp(IE,IY),FMDM,PHI(IE),DPHISTATE172
     1,EI(4,IY,IE),EI(5,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)               STATE173
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IY))) GO TO 700                    STATE174
      KODY(IE)=2                                                        STATE175
      CALL OVRSHT(IMEM,IE,KODY(IE),FMp(IE,IY),FMxxM(IE,IY),FMDM,PHI(IE),STATE176
     1DPHI,EI(5,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)           STATE177
      GO TO 700                                                         STATE178
  460 IF(DABS(FMDM).LT.DABS(BMIY(IE,IY))) GO TO 710                     STATE179
      KODY(IE)=2                                                        STATE180
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),BMIY(IE,IY),FMDM,PHI(IE),DPHSTATE181
     1I,EI(4,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)              STATE182
      GO TO 700                                                         STATE183
C                                                                       STATE184
  500 IF(BMEP(IE)*DPR(IE).LE.0.0) NPW(IE)=0                             STATE185
      IF(BMEP(IE))502,501,501                                           STATE186
  501 IF(DM)503,710,505                                                 STATE187
  502 IF(DM)505,710,504                                                 STATE188
  503 CALL SLOPE(IE)                                                    STATE189
      IF(FMDM)530,511,511                                               STATE190
  504 CALL SLOPE(IE)                                                    STATE191
      IF(FMDM)511,511,530                                               STATE192
  511 KODY(IE)=3                                                        STATE193
      DPHI=DM/EI(KODY(IE),IY,IE)                                        STATE194
      GO TO 700                                                         STATE195
  530 IY=1                                                              STATE196
      IT=2                                                              STATE197
      IF(BMEP(IE).LT.0.) IY=2                                           STATE198
      IF(IY.EQ.2)IT=1                                                   STATE199
      GO TO 250                                                         STATE200
  505 IY=1                                                              STATE201
      IT=2                                                              STATE202
      IF(BMEP(IE).LT.0.) IY=2                                           STATE203
      IF(IY.EQ.2)IT=1                                                   STATE204
      IF(DABS(FMDM).LT.DABS(FMxxM(IE,IY))) GO TO 710                    STATE205
      KODY(IE)=2                                                        STATE206
      CALL OVRSHT(IMEM,IE,KODY(IE),BMEP(IE),FMxxM(IE,IY),FMDM,PHI(IE),DPSTATE207
     1HI,EI(5,IY,IE),EI(2,IY,IE),DHYS,NODI,NODJ,KHYST,ICIE)             STATE208
      GO TO 700                                                         STATE209
C                                                                       STATE210
  700 KSTT=1                                                            STATE211
  710 PHI(IE)=PHI(IE)+DPHI                                              STATE212
C                                                                       STATE213
C  COMPUTE THE ACCUMULATED DAMAGE INDEX                                 STATE214
C                                                                       STATE215
      IF(KDAMAGE.LT.1) GO TO 800                                        STATE216
      IY=1                                                              STATE217
      IT=2                                                              STATE218
      IF(BMEP(IE).LT.0.) IY=2                                           STATE219
      IF(IY.EQ.2) IT=1                                                  STATE220
C  ISHT: CHECK OVERSHOOTING, I.E. IF ISHT=1, PASSED SUBROUTINE          STATE221
C                                          "OVRSHT".                    STATE222
      IF(ISHT.NE.1) DHYS=DPHI*(FMDM+BMEP(IE))/2.                        STATE223
      IF(ISHT.EQ.1) DHYS=DHYS+DPHI*DFM/2.                               STATE224
      HYS(IE)=HYS(IE)+DHYS                                              STATE225
C                                                                       STATE226
      IF(ISTEP.EQ.NSTEPS) GO TO 801                                     STATE227
      IF(DABS(FMDA(IE,IY)) .LE. DABS(FMcr))  GO TO 802                  STATE228
      IF(IDAM(IE,IY).NE.2) GO TO 800                                    STATE229
  801 OMEGA=FAC(IE,IY)                                                  STATE230
      RPHI=PHDA(IE,IY)/PHF(IE,IY)                                       STATE231
      IF((IY.EQ.1).AND.(PHDA(IE,IY).LE.PHY(IE,IY))) GO TO 802           STATE232
      IF((IY.EQ.2).AND.(PHDA(IE,IY).GE.PHY(IE,IY))) GO TO 802           STATE233
      FMcr=EI(2,IY,IE)*PHDA(IE,IY)                                      STATE234
      FMFi(IE,IY)=FMF(IE,IY)*DSQRT(2.*RPHI/(RPHI+1.0))                  STATE235
      AA=PHDA(IE,IY)-PHY(IE,IY)                                         STATE236
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      AF=PHF(IE,IY)-PHY(IE,IY)                                          STATE237
      DDFM=(AF*EI(2,IY,IE)+BMIY(IE,IY)-FMF(IE,IY))*(AA/AF)**OMEGA       STATE238
      FMi1=BMIY(IE,IY)+AA*EI(2,IY,IE)                                   STATE239
      FNi=(FMi1-FMFi(IE,IY))/DDFM+1                                     STATE240
      RATIO=(PHr(IE,IY)-PHr(IE,IT))/(2.*PHr(IE,IY))                     STATE241
      IF(RATIO.EQ.0.0) GO TO 802                                        STATE242
      DENOM=1.D0/(FMi1-(FNi-1)*DDFM/2.)*DABS(RATIO)                     STATE243
      ALPHA=FMDA(IE,IY)*DENOM                                           STATE244
      DAM(IE)=DAM(IE)+ALPHA/DINT(FNi)                                   STATE245
  802 IDAM(IE,IY)=0                                                     STATE246
C                                                                       STATE247
      IF(DABS(PHDA(IE,IY)) .LE. DABS(PHF(IE,IY))) GO TO 800             STATE248
      PRINT 930, IGR,IMEM,IE,PHDA(IE,IY),PHF(IE,IY)                     STATE249
  930 FORMAT(///'1CURVATURE EXCEEDED THE FAILURE CURVATURE'/            STATE250
     *     10X,'GROUP',5X,'MEMBER',5X,'CURVATURE',5X,'FAIL CURVATURE',/ STATE251
     *     10X,I3,7X,I3,'/',I1,6X,F9.5,5X,F10.3)                        STATE252
C                                                                       STATE253
  800 BMEP(IE)=FMDM                                                     STATE254
      IY=1                                                              STATE255
      IF(BMEP(IE).LT.0.0)IY=2                                           STATE256
      GO TO(811,812,813,814,815),KODY(IE)                               STATE257
  811 Q(IE)=1.                                                          STATE258
      GO TO 900                                                         STATE259
  812 Q(IE)=EI(1,IY,IE)/EI(2,IY,IE)                                     STATE260
      GO TO 900                                                         STATE261
  813 Q(IE)=EI(1,IY,IE)/(EI(3,IY,IE)*RD3(IY,IE))                        STATE262
      GO TO 900                                                         STATE263
  814 Q(IE)=EI(1,IY,IE)/(EI(4,IY,IE)*RD4(IY,IE))                        STATE264
      GO TO 900                                                         STATE265
  815 Q(IE)=EI(1,IY,IE)/(EI(5,IY,IE)*RD5(IY,IE))                        STATE266
  900 IF(NODI.NE.KHYST.AND.NODJ.NE.KHYST) GO TO 910                     STATE267
      WRITE(16,1111)IMEM,ISTEP,ICIE,IE,KODY(IE),BMEP(IE),               STATE268
     1PHI(IE),EI(KODY(IE),IY,IE)                                        STATE269
 1111 FORMAT(5I5,3E12.4)                                                STATE270
C                                                                       STATE271
  910 RETURN                                                            STATE272
      END                                                               STATE273
      SUBROUTINE OVRSHT (IMEM,IE,KODY,BMEP,BMY,FM,PHI,DPHI,EI1,EI2,DHYS,OVRSH   1
     1NODI,NODJ,KHYST,ICIE)                                             OVRSH   2
      IMPLICIT REAL*8(A-H,O-Z)                                          OVRSH   3
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    OVRSH   4
     1GLDAM                                                             OVRSH   5
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    OVRSH   6
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              OVRSH   7
      COMMON/WORK/W1(840),DPR(2),NPW(2),FACTOR,DUM(4),ISHT,KISHT,DFM,   OVRSH   8
     1W(60)                                                             OVRSH   9
C                                                                       OVRSH  10
C     CONSIDER OVERSHOOTING PROBLEMS                                    OVRSH  11
C                                                                       OVRSH  12
      ISHT=1                                                            OVRSH  13
      DFM=FM-BMY                                                        OVRSH  14
      DPHI=DFM/EI1                                                      OVRSH  15
      DDPHI=(BMY-BMEP)/EI1                                              OVRSH  16
      PHI=PHI+DDPHI                                                     OVRSH  17
      FM=BMY+DPHI*EI2                                                   OVRSH  18
      IF(KDAMAGE.GE.1)DHYS=DHYS+(BMY+BMEP)*DDPHI/2.                     OVRSH  19
      IF(NODI.EQ.KHYST.OR.NODJ.EQ.KHYST)WRITE(16,100)IMEM,ISTEP,ICIE,   OVRSH  20
     1IE,KODY,BMY,PHI,EI2                                               OVRSH  21
  100 FORMAT(5I5,3E12.4)                                                OVRSH  22
      RETURN                                                            OVRSH  23
      END                                                               OVRSH  24
      SUBROUTINE SLOPE(IE)                                              SLOPE   1
      IMPLICIT REAL*8(A-H,O-Z)                                          SLOPE   2
C                                                                       SLOPE   3
C     COMPUTE SLOPE OF HYSTERETIC CURVE AT EACH TIME STEP               SLOPE   4
C                                                                       SLOPE   5
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   SLOPE   6
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          SLOPE   7
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),   SLOPE   8
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),BMF(2,2),PH(2,2),FMp(2,2),  SLOPE   9
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       SLOPE  10
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       SLOPE  11
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   SLOPE  12
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,  SLOPE  13
     8    INLP(2,2),DAM(2),FMFI(2,2),FAC(2,2),FMDA(2,2),IDAM(2,2),      SLOPE  14
     9    PHDA(2,2),FMxxM(2,2)                                          SLOPE  15
      COMMON/WORK/W1(840),DPR(2),NPW(2),FACTOR,inslp(2,2),W2(63)        SLOPE  16
      COMMON/PASS/IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,DUM(1),    SLOPE  17
     1ISYM,ISYMD                                                        SLOPE  18
      COMMON/DAMAGE/KDAMAGE,ITDAM,KIDAMT,NNSKIP,NSSKIP,NGSKIP,GLHYS,    SLOPE  19
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     1GLDAM                                                             SLOPE 20
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,    SLOPE 21
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV,ICONV              SLOPE 22
C                                                                       SLOPE 23
      CC=.5                                                             SLOPE 24
      CC1=1.-CC                                                         SLOPE 25
      IULT=0                                                            SLOPE 26
      IF(BMEP(IE))20,10,10                                              SLOPE 27
   10 I1=1                                                              SLOPE 28
      I2=2                                                              SLOPE 29
      GO TO 30                                                          SLOPE 30
   20 I1=2                                                              SLOPE 31
      I2=1                                                              SLOPE 32
   30 FM1(IE,I1)=BMEP(IE)                                               SLOPE 33
      PH1(IE,I1)=PHI(IE)                                                SLOPE 34
      FMx=FMxM(IE,I2)                                                   SLOPE 35
      PHx=PHxM(IE,I2)                                                   SLOPE 36
C                                                                       SLOPE 37
      omega=fac(ie,i2)                                                  SLOPE 38
      Ps=EI(2,1,IE)/EI(1,1,IE)                                          SLOPE 39
      FMo=Ps/(1.-Ps)*(PH1(IE,I1)*EI(1,I1,IE)-FM1(IE,I1))                SLOPE 40
      PHo=1./(1.-Ps)*(PH1(IE,I1)-FM1(IE,I1)/EI(1,I1,IE))                SLOPE 41
C                                                                       SLOPE 42
      IF(IDAM(IE,I1).EQ.1) GO TO 40                                     SLOPE 43
      IF(DABS(PHx).EQ.DABS(PHY(IE,I2))) GO TO 40                        SLOPE 44
      IF(DABS(FMDA(IE,I2)).LE.DABS(PHDA(IE,I2)*EI(2,I1,IE))) GO TO 40   SLOPE 45
C                                                                       SLOPE 46
      AA=PHx-PHY(IE,I2)                                                 SLOPE 47
      AF=PHF(IE,I2)-PHY(IE,I2)                                          SLOPE 48
      DFM=(AF*EI(2,I1,IE)+BMIY(IE,I2)-BMF(IE,I2))*(AA/AF)**omega        SLOPE 49
      FMxM(IE,I2)=FMx-DFM                                               SLOPE 50
C                                                                       SLOPE 51
      STF=FMxM(IE,I2)/PHx                                               SLOPE 52
      IF(STF.LE.EI(2,I1,IE)) THEN                                       SLOPE 53
      FMx=PHx*EI(2,I1,IE)*1.0005                                        SLOPE 54
      FMxM(IE,I2)=FMx                                                   SLOPE 55
      IULT=1                                                            SLOPE 56
      ELSE                                                              SLOPE 57
      EIp=(FMxM(IE,I2)-FMo)/(PHx-PHo)                                   SLOPE 58
      EII=1/(EIp-EI(2,I1,IE))                                           SLOPE 59
      PHx=EII*(BMIY(IE,I2)-FMo-PHY(IE,I2)*EI(2,I1,IE)+PHo*EIp)          SLOPE 60
      FMx=EIp*EII*(BMIY(IE,I2)-FMo+(PHo-PHY(IE,I2))*EI(2,I1,IE))+FMo    SLOPE 61
      ENDIF                                                             SLOPE 62
C                                                                       SLOPE 63
   40 C1=(FMx-FMo)/(PHx-PHo)                                            SLOPE 64
C                                                                       SLOPE 65
      IF(DABS(FMo).GE.DABS(FM1(IE,I1)).AND.KODY(IE).EQ.5) GO TO 45      SLOPE 66
      IF((BMEP(IE)*PHo.LT.0.).OR.(IULT.EQ.1)) THEN                      SLOPE 67
   45 EI(3,I1,IE)=EI(3,I1,IE)                                           SLOPE 68
      IF(EI(3,I1,IE).EQ.0.) EI(3,I1,IE)=EI(1,I1,IE)                     SLOPE 69
      PHr(IE,I1)=PH1(IE,I1)-(FM1(IE,I1)/EI(3,I1,IE))                    SLOPE 70
      IF(PHr(IE,I1).EQ.0.0) PHr(IE,I1)=DSIGN(1.D0,PH1(IE,I1))*0.0005    SLOPE 71
      ELSE                                                              SLOPE 72
      PHr(IE,I1)=PHo-FMo/C1                                             SLOPE 73
      IF(DABS(PHr(IE,I1)).LE.DABS(PHr(IE,I2)).AND.(PHr(IE,I1)*PHr(IE,I2)SLOPE 74
     1).GT.0.0) PHr(IE,I1)=PHr(IE,I2)                                   SLOPE 75
      IF(PHr(IE,I1).EQ.0.0) PHr(IE,I1)=DSIGN(1.D0,PHo)*0.0005           SLOPE 76
      IF(FM1(IE,I1).EQ.0.0)THEN                                         SLOPE 77
      EI(3,I1,IE)=EI(3,I1,IE)                                           SLOPE 78
      PHr(IE,I1)=PH1(IE,I1)                                             SLOPE 79
      IF(PHr(IE,I1).EQ.0.0) PHr(IE,I1)=DSIGN(1.D0,PH1(IE,I1))*0.0005    SLOPE 80
      ELSE                                                              SLOPE 81
      EI(3,I1,IE)=FM1(IE,I1)/(PH1(IE,I1)-PHr(IE,I1))                    SLOPE 82
      ENDIF                                                             SLOPE 83
      ENDIF                                                             SLOPE 84
C                                                                       SLOPE 85
      RD3(I1,IE)=EI(1,I1,IE)/(CC1*EI(3,I1,IE)+CC*EI(1,I1,IE))           SLOPE 86
      IF(DABS(FMx).EQ.DABS(BMIY(IE,I2))) GO TO 60                       SLOPE 87
C                                                                       SLOPE 88
      IF(KODY(IE).EQ.4) GO TO 70                                        SLOPE 89
C                                                                       SLOPE 90
      EEI=FMx/(PHx-PHr(IE,I1))                                          SLOPE 91
      PHIn=Phr(IE,i1)*EEI/(EEI-EI(1,I2,IE))                             SLOPE 92
      FMn=EI(1,I2,IE)*PHIn                                              SLOPE 93
      ALFA=ALPHAP(IE,I2)                                                SLOPE 94
      FMp(IE,I2)=ALFA*FMn                                               SLOPE 95
      PHp(IE,I2)=ALFA*PHIn                                              SLOPE 96
C                                                                       SLOPE 97
      EI(4,I2,IE)=FMp(IE,I2)/(PHp(IE,I2)-PHr(IE,I1))                    SLOPE 98
      RD4(I2,IE)=EI(1,I2,IE)/(CC1*EI(4,I2,IE)+CC*EI(1,I2,IE))           SLOPE 99
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      EI(5,I2,IE)=(FMx-FMp(IE,I2))/(PHx-PHp(IE,I2))                     SLOPE100
      RD5(I2,IE)=EI(1,I1,IE)/(CC1*EI(5,I2,IE)+CC*EI(1,I1,IE))           SLOPE101
      GO TO 80                                                          SLOPE102
   60 EI(4,I2,IE)=FMx/(PHx-PHr(IE,I1))                                  SLOPE103
      RD4(I2,IE)=EI(1,I1,IE)/(CC1*EI(4,I2,IE)+CC*EI(1,I1,IE))           SLOPE104
      GO TO 80                                                          SLOPE105
   70 EI(5,I2,IE)=FMx/(PHx-PHr(IE,I1))                                  SLOPE106
      RD5(I2,IE)=EI(1,I1,IE)/(CC1*EI(5,I2,IE)+CC*EI(1,I1,IE))           SLOPE107
   80 IF(DABS(PH1(IE,I1)).GE.DABS(PHxM(IE,I1)).AND.(PH1(IE,I1)*PHxM(IE,ISLOPE108
     1I1)).GT.0.0) THEN                                                 SLOPE109
      FMxM(IE,I1)=FM1(IE,I1)                                            SLOPE110
      PHxM(IE,I1)=PH1(IE,I1)                                            SLOPE111
      ELSE                                                              SLOPE112
      ENDIF                                                             SLOPE113
      IF(IDAM(IE,I1) .EQ. 0) FMxxM(IE,I2)=FMx                           SLOPE114
      FMDA(IE,I1)=FM1(IE,I1)                                            SLOPE115
      PHDA(IE,I1)=PH1(IE,I1)                                            SLOPE116
      IDAM(IE,I1)=1                                                     SLOPE117
      IF(DABS(FMxM(IE,I1)).GT.DABS(BMIY(IE,I1))) INSLP(IE,I2)=0         SLOPE118
      RETURN                                                            SLOPE119
      END                                                               SLOPE120
      SUBROUTINE FNFQ (NEQ,ST,FM,M,W1,SHP1)                             FNFQ   1
      IMPLICIT REAL*8(A-H,O-Z)                                          FNFQ   2
      COMMON/WORK/A(2500)                                               FNFQ   3
      DIMENSION ST(1),FM(1),M(1),SHP1(1)                                FNFQ   4
      IWKAR=2500                                                        FNFQ   5
      MBAND=1                                                           FNFQ   6
      DO 10 I=2,NEQ                                                     FNFQ   7
      NBAND=M(I)-M(I-1)                                                 FNFQ   8
      IF(NBAND.GT.MBAND)MBAND=NBAND                                     FNFQ   9
   10 CONTINUE                                                          FNFQ  10
      NBAND=NEQ*MBAND-IWKAR                                             FNFQ  11
      IF(NBAND.LE.0)GO TO 15                                            FNFQ  12
      PRINT 100,NBAND                                                   FNFQ  13
  100 FORMAT(//' ** EXECUTION TERMINATED IN SUBROUTINE FRFQ ***',/,     FNFQ  14
     .' WORK AREA EXECEEDED BY ',I5)                                    FNFQ  15
      STOP                                                              FNFQ  16
   15 NBAND=NBAND+IWKAR                                                 FNFQ  17
      DO 20 I=1,NBAND                                                   FNFQ  18
   20 A(I)=0.                                                           FNFQ  19
      A(1)=ST(1)                                                        FNFQ  20
      NEQ1=NEQ-1                                                        FNFQ  21
      DO 30 I=2,NEQ                                                     FNFQ  22
      NN=M(I)-M(I-1)                                                    FNFQ  23
      DO 30 J=1,NN                                                      FNFQ  24
      JJ=M(I-1)+J                                                       FNFQ  25
      KK=I+(NN-J)*NEQ1                                                  FNFQ  26
   30 A(KK)=ST(JJ)                                                      FNFQ  27
      NSTIF=12                                                          FNFQ  28
      NMASS=13                                                          FNFQ  29
      NT=14                                                             FNFQ  30
      NF=1                                                              FNFQ  31
      COFQ=100.                                                         FNFQ  32
      IFPR=0                                                            FNFQ  33
      SCALE=1.E-8                                                       FNFQ  34
      ANORM=0.                                                          FNFQ  35
      DO 40 I=1,NEQ                                                     FNFQ  36
   40 ANORM=ANORM+ST(M(I))*SCALE                                        FNFQ  37
      ANORM=ANORM/NEQ                                                   FNFQ  38
      REWIND NSTIF                                                      FNFQ  39
      REWIND NMASS                                                      FNFQ  40
      WRITE(NSTIF)(A(I),I=1,NBAND)                                      FNFQ  41
      WRITE(NMASS)(FM(I),I=1,NEQ)                                       FNFQ  42
      CALL FREQS(NEQ,MBAND,NF,COFQ,IFPR,ANORM,NSTIF,NMASS,NT,A,IWKAR)   FNFQ  43
      TPI=8.*ATAN(1.0)                                                  FNFQ  44
      REWIND NT                                                         FNFQ  45
      READ(NT)W1                                                        FNFQ  46
      READ(NT)(SHP1(I),I=1,NEQ)                                         FNFQ  47
      W1=W1/TPI                                                         FNFQ  48
      DO 50 I=2,NEQ                                                     FNFQ  49
   50 SHP1(I)=SHP1(I)/SHP1(1)                                           FNFQ  50
      SHP1(1)=1.                                                        FNFQ  51
      RETURN                                                            FNFQ  52
      END                                                               FNFQ  53
      SUBROUTINE FREQS(NEQ,MBAND,NF,COFQ,IFPR,ANORM,NSTIF,NMASS,NT,A,   FREQS  1
     1IWKAR)                                                            FREQS  2
      IMPLICIT REAL*8(A-H,O-Z)                                          FREQS  3
      DIMENSION A(1)                                                    FREQS  4
      TPI=8.*ATAN(1.0)                                                  FREQS  5
      COFQ=COFQ*TPI                                                     FREQS  6
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      COFQ=COFQ*COFQ                                                    FREQS  7
      NIM=3                                                             FREQS  8
      NVM=6                                                             FREQS  9
      NC=NF+NIM                                                         FREQS 10
      NCA=NEQ*MAX0(MBAND,NC)                                            FREQS 11
      N2=1+NCA                                                          FREQS 12
      N3=N2+NEQ                                                         FREQS 13
      N4=N3+NEQ                                                         FREQS 14
      N5=N4+NEQ                                                         FREQS 15
      N6=N5+NEQ                                                         FREQS 16
      N7=N6+NEQ*NVM                                                     FREQS 17
      N8=N7+NEQ*NVM                                                     FREQS 18
      N9=N8+NC                                                          FREQS 19
      N10=N9+NC                                                         FREQS 20
      N11=N10+NC                                                        FREQS 21
      N12=N11+NC                                                        FREQS 22
      NNNN=N12+NC-IWKAR                                                 FREQS 23
      IF(NNNN.LE.0)GO TO10                                              FREQS 24
      PRINT 150,NNNN                                                    FREQS 25
  150 FORMAT(//' ** EXECUTION TERMINATED IN SUBROUTINE FREQS **',/,     FREQS 26
     .' WORK AREA EXCEEDED BY ',I5)                                     FREQS 27
      STOP                                                              FREQS 28
   10 CALL SECNTD(A(1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),             FREQS 29
     .A(N8),A(N9),A(N10),A(N11),A(N12),NEQ,MBAND,NF,NC,IFPR,            FREQS 30
     .ANORM,COFQ,NSTIF,NMASS,NT)                                        FREQS 31
      RETURN                                                            FREQS 32
      END                                                               FREQS 33
      SUBROUTINE SECNTD (A,B,V,MAXA,W,VV,WW,ROOT,TIM,ERRVL,ERRVR,       SECNT  1
     1NITE,N,MA,NROOT,NC,IFPR,ANORM,COFQ,NSTIF,NMASS,NT)                SECNT  2
      IMPLICIT REAL*8(A-H,O-Z)                                          SECNT  3
      DIMENSION A(N,NC),B(N),V(1),W(1),VV(N,1),WW(N,1),ROOT(1),         SECNT  4
     1TIM(1),ERRVL(1),ERRVR(1),NITE(1),MAXA(1)                          SECNT  5
C                                                                       SECNT  6
C     THE FOLLOWING TOLERANCES ARE SET FOR THE IBM 370                  SECNT  7
       ACTOL=1.0D-04                                                    SECNT  8
       RCBTOL=1.D-05                                                    SECNT  9
       RTOL=1.0D-10                                                     SECNT 10
       RQTOL=1.0D-12                                                    SECNT 11
C                                                                       SECNT 12
       NTF=5                                                            SECNT 13
       IITEM=10                                                         SECNT 14
       NITEM=60                                                         SECNT 15
       NVM=6                                                            SECNT 16
C                                                                       SECNT 17
       REWIND NT                                                        SECNT 18
       REWIND NMASS                                                     SECNT 19
       READ (NMASS) B                                                   SECNT 20
C                                                                       SECNT 21
       ETA=2.0                                                          SECNT 22
       NOV=0                                                            SECNT 23
       JR=1                                                             SECNT 24
       NSK=0                                                            SECNT 25
       NWA=N*MA                                                         SECNT 26
C                                                                       SECNT 27
C  CHECK FOR SINGLE DEGREE-OF-FREEDOM SYSTEM                            SECNT 28
C                                                                       SECNT 29
       IF (N.GT.1) GO TO 5                                              SECNT 30
      IF(B(1).GT.0.) GO TO 7                                            SECNT 31
      WRITE(6,3000)                                                     SECNT 32
      STOP                                                              SECNT 33
    7 REWIND NSTIF                                                      SECNT 34
      READ(NSTIF) A(1,1)                                                SECNT 35
      ROOT(1)=A(1,1)/B(1)                                               SECNT 36
      NSCH=1                                                            SECNT 37
      A(1,1)=1.0D0/DSQRT(B(1))                                          SECNT 38
      GO TO 950                                                         SECNT 39
C                                                                       SECNT 40
C  FIRST STARTING VALUE                                                 SECNT 41
C                                                                       SECNT 42
    5 CONTINUE                                                          SECNT 43
       RA=0.0                                                           SECNT 44
       RR=0.0                                                           SECNT 45
       CALL BANDET (A,B,V,MAXA,N,NWA,RA,NSCH,DETA,ISCA,1,NSTIF)         SECNT 46
       FA=DETA                                                          SECNT 47
      IA=ISCA                                                           SECNT 48
      IR=ISCA                                                           SECNT 49
      ISCR=ISCA                                                         SECNT 50
       FR=FA                                                            SECNT 51
       DETR=DETA                                                        SECNT 52
C                                                                       SECNT 53
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C   CHECK FOR ZERO EIGENVALUE(S)                                        SECNT 54
C                                                                       SECNT 55
      IF (A(N,1) .GT. ANORM)  GO TO 10                                  SECNT 56
      WRITE (6,3001)                                                    SECNT 57
      STOP                                                              SECNT 58
C                                                                       SECNT 59
C   INVERSE ITERATION FOR LOWER BOUND ON SMALLEST ROOT                  SECNT 60
C                                                                       SECNT 61
 10   IF (IFPR.EQ.1)                                                    SECNT 62
     * WRITE(6,2000)                                                    SECNT 63
      DO 100 I=1,N                                                      SECNT 64
 100  W(I)=B(I)                                                         SECNT 65
      RT=0.0                                                            SECNT 66
      IITE=0                                                            SECNT 67
      KK=2                                                              SECNT 68
 110  IITE=IITE+1                                                       SECNT 69
      DO 120 I=1,N                                                      SECNT 70
 120  V(I)=W(I)                                                         SECNT 71
      CALL BANDET (A,B,V,MAXA,N,NWA,RA,NSCH,DETA,ISCA,KK,NSTIF)         SECNT 72
      KK=2                                                              SECNT 73
      RQT=0.0                                                           SECNT 74
      DO 130 I=1,N                                                      SECNT 75
 130  RQT=RQT+W(I)*V(I)                                                 SECNT 76
      DO 180 I=1,N                                                      SECNT 77
 180  W(I)=B(I)*V(I)                                                    SECNT 78
      RQB=0.0                                                           SECNT 79
      DO 140 I=1,N                                                      SECNT 80
 140  RQB=RQB+W(I)*V(I)                                                 SECNT 81
      RQ=RQT/RQB                                                        SECNT 82
      IF (IFPR.EQ.1)                                                    SECNT 83
     * WRITE (6,2001) RQ                                                SECNT 84
     BS=DSQRT(RQB)                                                      SECNT 85
     TOL=DABS(RQ-RT)/RQ                                                 SECNT 86
      IF (TOL.LT.RCBTOL) GO TO 150                                      SECNT 87
      DO 160 I=1,N                                                      SECNT 88
 160  W(I)=W(I)/BS                                                      SECNT 89
      RT=RQ                                                             SECNT 90
      IF (IITE.LT.IITEM) GO TO 110                                      SECNT 91
C                                                                       SECNT 92
 150  DO 170 I=1,N                                                      SECNT 93
 170  V(I)=V(I)/BS                                                      SECNT 94
     RB=RQ*(1.0D0-DMIN1(1.0D-1,1.0D2*TOL))                              SECNT 95
      IS=0                                                              SECNT 96
 230  CALL BANDET (A,B,V,MAXA,N,NWA,RB,NSCH,DETB,ISCB,1,NSTIF)          SECNT 97
      IF (IFPR.EQ.1)                                                    SECNT 98
     * WRITE (6,2002) RB,NSCH                                           SECNT 99
      FB=DETB                                                           SECNT100
     IB=ISCB                                                            SECNT101
      IF (NSCH.EQ.0) GO TO 300                                          SECNT102
      IS=IS+1                                                           SECNT103
      IF (IS.LE.NTF) GO TO 240                                          SECNT104
     WRITE (6,3002) NTF                                                 SECNT105
      STOP                                                              SECNT106
 240  RB=RB/(NSCH+1)                                                    SECNT107
      GO TO 230                                                         SECNT108
C                                                                       SECNT109
C   ITERATION FOR INDIVIDUAL ROOTS                                      SECNT110
C                                                                       SECNT111
 300  IF (IFPR.EQ.1)                                                    SECNT112
     * WRITE (6,2003)                                                   SECNT113
      NITE(JR)=-1                                                       SECNT114
      IF (IFPR.EQ.1)                                                    SECNT115
     * WRITE (6,2004) JR,NITE(JR),RA,DETA,FA,ETA,ISCA                   SECNT116
      NITE(JR)=0                                                        SECNT117
      IF (IFPR.EQ.1)                                                    SECNT118
     * WRITE (6,2004) JR,NITE(JR),RB,DETB,FB,ETA,ISCB                   SECNT119
C                                                                       SECNT120
C   WE STOP WHEN WE HAVE THE REQUIRED NO OF ROOTS SMALLER THAN RC AND   SECNT121
C   NOV=0                                                               SECNT122
C                                                                       SECNT123
 310  IF (NSCH.GE.NROOT) GO TO 900                                      SECNT124
      IF (RB.GT.COFQ) GO TO 900                                         SECNT125
C                                                                       SECNT126
     DIF=FB-FA                                                          SECNT127
     IDIF=IA-IB                                                         SECNT128
      IF (DIF.NE.0.0) GO TO 320                                         SECNT129
     IF(IDIF.NE.0)GO TO 320                                             SECNT130
     WRITE (6,3003)                                                     SECNT131
      GO TO 900                                                         SECNT132
  320 DIF=FB-FA*10.**IDIF                                               SECNT133
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         DEL=FB*(RB-RA)/DIF                                            SECNT134
         RC=RB-ETA*DEL                                                 SECNT135
         TOL=RCBTOL*RC                                                 SECNT136
        IF (DABS(RC-RB) .GT. TOL) GO TO 330                            SECNT137
         IF (IFPR.EQ.1)                                                SECNT138
       * WRITE (6,2005)                                                SECNT139
         ROOT(JR)=RB                                                   SECNT140
         GO TO 400                                                     SECNT141
C                                                                      SECNT142
  330    CALL BANDET (A,B,V,MAXA,N,NWA,RC,NSCH,DETC,ISCC,1,NSTIF)      SECNT143
         FC=DETC                                                       SECNT144
        IC=ISCC                                                        SECNT145
         NITE(JR)=NITE(JR)+1                                           SECNT146
         IF (JR.EQ.1) GO TO 340                                        SECNT147
         JJ=JR-1                                                       SECNT148
         DO 350 K=1,JJ                                                 SECNT149
        FC=FC/(RC-ROOT(K))                                             SECNT150
   350 CALL EXPO(FC,IC)                                                SECNT151
  340    IF (IFPR.EQ.1)                                                SECNT152
       * WRITE (6,2004) JR,NITE(JR),RC,DETC,FC,ETA,ISCC                SECNT153
C                                                                      SECNT154
C   IF WE HAVE MORE SIGN CHANGES THAN EIGENVALUES SMALLER THAN RC WE   SECNT155
C   START INV. ITERATION                                               SECNT156
C                                                                      SECNT157
         NES=0                                                         SECNT158
         IF (JR.EQ.1) GO TO 380                                        SECNT159
         DO 360 I=1,JJ                                                 SECNT160
  360    IF (ROOT(I).LT.RC) NES=NES+1                                  SECNT161
  380    NOV=NSCH-NES                                                  SECNT162
         IF (NOV.EQ.0) GO TO 370                                       SECNT163
         IF (IFPR.EQ.1)                                                SECNT164
       * WRITE (6,2006) NOV                                            SECNT165
         ROOT(JR)=RC                                                   SECNT166
         IF (NOV.GT.1) NSK=1                                           SECNT167
C                                                                      SECNT168
         GO TO 400                                                     SECNT169
  370    RR=RA                                                         SECNT170
         FR=FA                                                         SECNT171
        IR=IA                                                          SECNT172
         DETR=DETA                                                     SECNT173
        ISCR=ISCA                                                      SECNT174
         RA=RB                                                         SECNT175
         FA=FB                                                         SECNT176
        IA=IB                                                          SECNT177
         DETA=DETB                                                     SECNT178
        ISCA=ISCB                                                      SECNT179
         RB=RC                                                         SECNT180
         FB=FC                                                         SECNT181
        IB=IC                                                          SECNT182
         DETB=DETC                                                     SECNT183
        ISCB=ISCC                                                      SECNT184
C                                                                      SECNT185
C   WE RESET ETA IF NECESSARY                                          SECNT186
C                                                                      SECNT187
        TOL=RB*ACTOL                                                   SECNT188
        IF (DABS(RA-RB) .LT. TOL) ETA=ETA*2.0D0                        SECNT189
         IF (NITE(JR).LE.NITEM) GO TO 310                              SECNT190
        WRITE (6,3004) JR,NITE(JR)                                     SECNT191
         GO TO 900                                                     SECNT192
C                                                                      SECNT193
C   CHECK FOR STORAGE                                                  SECNT194
  400    IF (JR.LE.NC) GO TO 405                                       SECNT195
         WRITE (6,3005)                                                SECNT196
         GO TO 900                                                     SECNT197
C                                                                      SECNT198
  405    NOR=JR-1                                                      SECNT199
         IF (NOR.GT.NVM) NOR=NVM                                       SECNT200
         IF (IFPR.EQ.1)                                                SECNT201
       * WRITE (6,2007) NOR                                            SECNT202
         IF (JR.EQ.1) GO TO 410                                        SECNT203
         DO 420 I=1,N                                                  SECNT204
  420    V(I)=1.0                                                      SECNT205
         KK=2                                                          SECNT206
  410    DO 430 I=1,N                                                  SECNT207
  430    W(I)=B(I)*V(I)                                                SECNT208
         IS=0                                                          SECNT209
         GO TO 510                                                     SECNT210
C                                                                      SECNT211
C   INVERSE ITERN                                                      SECNT212
C                                                                      SECNT213
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```
  440   NITE(JR)=NITE(JR)+1                                            SECNT214
        DO 450 I=1,N                                                   SECNT215
  450   V(I)=W(I)                                                      SECNT216
        CALL BANDET (A,B,V,MAXA,N,NWA,RC,NSCH,DETC,ISCC,KK,NSTIF)      SECNT217
        IF (IS.EQ.1) GO TO 460                                         SECNT218
        KK=2                                                           SECNT219
        RQT=0.0                                                        SECNT220
        DO 470 I=1,N                                                   SECNT221
  470   RQT=RQT+W(I)*V(I)                                              SECNT222
        DO 475 I=1,N                                                   SECNT223
  475   W(I)=B(I)*V(I)                                                 SECNT224
        RQB=0.0                                                        SECNT225
        DO 480 I=1,N                                                   SECNT226
  480   RQB=RQB+W(I)*V(I)                                              SECNT227
        RQ=RQT/RQB                                                     SECNT228
        RT=ROOT(JR)+RQ                                                 SECNT229
        IF (IFPR.EQ.1)                                                 SECNT230
      * WRITE (6,2004) JR,NITE(JR),RT,RQ                               SECNT231
        TOL=RT*RQTOL                                                   SECNT232
       IF (DABS(RT-RTA) .GT. TOL)  GO TO 510                           SECNT233
        IS=1                                                           SECNT234
        GO TO 440                                                      SECNT235
C                                                                      SECNT236
  510   RTA=RT                                                         SECNT237
       BS=DSQRT(RQB)                                                   SECNT238
        DO 490 I=1,N                                                   SECNT239
  490   W(I)=W(I)/BS                                                   SECNT240
        IF (NOR.EQ.0) GO TO 550                                        SECNT241
        DO 520 K=1,NOR                                                 SECNT242
        AL=0.0                                                         SECNT243
        DO 530 I=1,N                                                   SECNT244
  530   AL=AL+VV(I,K)*W(I)                                             SECNT245
        DO 540 I=1,N                                                   SECNT246
  540   W(I)=W(I)-AL*WW(I,K)                                           SECNT247
  520   CONTINUE                                                       SECNT248
C                                                                      SECNT249
  550   IF (NITE(JR).LE.NITEM) GO TO 440                               SECNT250
       WRITE (6,3004) JR,NITE(JR)                                      SECNT251
        GO TO 900                                                      SECNT252
C                                                                      SECNT253
  460   RQT=0.0                                                        SECNT254
        ERRT=RQB                                                       SECNT255
        DO 570 I=1,N                                                   SECNT256
  570   RQT=RQT+V(I)*W(I)                                              SECNT257
        DO 560 I=1,N                                                   SECNT258
  560   W(I)=B(I)*V(I)                                                 SECNT259
        RQB=0.0                                                        SECNT260
        DO 580 I=1,N                                                   SECNT261
  580   RQB=RQB+V(I)*W(I)                                              SECNT262
C                                                                      SECNT263
C   OBTAIN A RATHER LARGE ERROR BOUND                                  SECNT264
C                                                                      SECNT265
        RQ=RQT/RQB                                                     SECNT266
        ROOT(JR)=ROOT(JR)+RQ                                           SECNT267
       ERR=DSQRT(ERRT/RQB)                                             SECNT268
        ERRVL(JR)=ROOT(JR)-ERR                                         SECNT269
        ERRVR(JR)=ROOT(JR)+ERR                                         SECNT270
C                                                                      SECNT271
       BS=DSQRT(RQB)                                                   SECNT272
        DO 590 I=1,N                                                   SECNT273
        W(I)=W(I)/BS                                                   SECNT274
  590   V(I)=V(I)/BS                                                   SECNT275
        JJ=JR                                                          SECNT276
        IF (JJ.LE.NVM) GO TO 610                                       SECNT277
        WRITE (NT) (VV(J,1),J=1,N)                                     SECNT278
        DO 600 K=1,N                                                   SECNT279
        DO 600 L=2,NVM                                                 SECNT280
        WW(K,L-1)=WW(K,L)                                              SECNT281
  600   VV(K,L-1)=VV(K,L)                                              SECNT282
        JJ=NVM                                                         SECNT283
  610   DO 620 K=1,N                                                   SECNT284
        WW(K,JJ)=W(K)                                                  SECNT285
  620   VV(K,JJ)=V(K)                                                  SECNT286
C                                                                      SECNT287
C   DECIDE STRATEGY FOR ITERN TOWARDS NEXT ROOT                        SECNT288
C                                                                      SECNT289
        TOL=RTOL*ROOT(JR)                                              SECNT290
        IF (NOV.GT.0) GO TO 700                                        SECNT291
       IF (DABS(ROOT(JR)-RB) .GT. TOL) GO TO 710                       SECNT292
        IF (RA.GT.0.0) GO TO 720                                       SECNT293
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      RA=RB/2.                                                          SECNT294
      CALL BANDET (A,B,V,MAXA,N,NWA,RA,NSCH,DETA,ISCA,1,NSTIF)          SECNT295
      FA=DETA                                                           SECNT296
      IA=ISCA                                                           SECNT297
  720 RB=RA                                                             SECNT298
      FB=FA                                                             SECNT299
      IB=IA                                                             SECNT300
      DETB=DETA                                                         SECNT301
      ISCB=ISCA                                                         SECNT302
      RA=RR                                                             SECNT303
      FA=FR                                                             SECNT304
      IA=IR                                                             SECNT305
      DETA=DETR                                                         SECNT306
      ISCA=ISCR                                                         SECNT307
      GO TO 710                                                         SECNT308
C                                                                       SECNT309
  700 IF (ROOT(JR).GT.RC) NSK=1                                         SECNT310
      IF (NSK.EQ.1) GO TO 730                                           SECNT311
      IF (DABS(RC-ROOT(JR)) .LT. TOL) GO TO 740                         SECNT312
      IF (DABS(ROOT(JR)-RB) .LT. TOL) GO TO 750                         SECNT313
      RA=RB                                                             SECNT314
      FA=FB                                                             SECNT315
      IA=IB                                                             SECNT316
      DETA=DETB                                                         SECNT317
      ISCA=ISCB                                                         SECNT318
  750 RB=RC                                                             SECNT319
      FB=FC                                                             SECNT320
      IB=IC                                                             SECNT321
      DETB=DETC                                                         SECNT322
      ISCB=ISCA                                                         SECNT323
      GO TO 710                                                         SECNT324
  740 IF (DABS(ROOT(JR)-RB) .GT. TOL) GO TO 710                         SECNT325
      IF (RA.GT.0.0) GO TO 760                                          SECNT326
      RA=RB/2.                                                          SECNT327
      CALL BANDET (A,B,V,MAXA,N,NWA,RA,NSCH,DETA,ISCA,1,NSTIF)          SECNT328
      FA=DETA                                                           SECNT329
      IA=ISCA                                                           SECNT330
  760 RB=RA                                                             SECNT331
      FB=FA                                                             SECNT332
      IB=IA                                                             SECNT333
      DETB=DETA                                                         SECNT334
      ISCB=ISCA                                                         SECNT335
      RA=RR                                                             SECNT336
      FA=FR                                                             SECNT337
      IA=IR                                                             SECNT338
      DETA=DETR                                                         SECNT339
      ISCA=ISCR                                                         SECNT340
  710 FA=FA/(RA-ROOT(JR))                                               SECNT341
      CALL EXPO(FA,IA)                                                  SECNT342
      FB=FB/(RB-ROOT(JR))                                               SECNT343
      CALL EXPO(FB,IB)                                                  SECNT344
      JR=JR+1                                                           SECNT345
C                                                                       SECNT346
      ETA=2.0                                                           SECNT347
      GO TO 300                                                         SECNT348
C                                                                       SECNT349
  730 IF (RA.GT.0.0) GO TO 780                                          SECNT350
      RA=RB/2.                                                          SECNT351
      CALL BANDET (A,B,V,MAXA,N,NWA,RA,NSCH,DETA,ISCA,1,NSTIF)          SECNT352
      FA=DETA                                                           SECNT353
      IA=ISCA                                                           SECNT354
  780 IF (DABS(ROOT(JR)-RB).GT.TOL) GO TO 770                           SECNT355
      RB=RA                                                             SECNT356
      FB=FA                                                             SECNT357
      IB=IA                                                             SECNT358
      DETB=DETA                                                         SECNT359
      ISCB=ISCA                                                         SECNT360
      RA=RR                                                             SECNT361
      FA=FR                                                             SECNT362
      IA=IR                                                             SECNT363
      DETA=DETR                                                         SECNT364
      ISCA=ISCR                                                         SECNT365
  770 FA=FA/(RA-ROOT(JR))                                               SECNT366
      CALL EXPO(FA,IA)                                                  SECNT367
      FB=FB/(RB-ROOT(JR))                                               SECNT368
      CALL EXPO(FB,IB)                                                  SECNT369
      FR=FR/(RR-ROOT(JR))                                               SECNT370
      CALL EXPO(FR,IR)                                                  SECNT371
      IF(ROOT(JR).LE.RC)NOV=NOV-1                                       SECNT372
      JR=JR+1                                                           SECNT373
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         NITE(JR)=0                                                     SECNT374
         ROOT(JR)=RC                                                    SECNT375
         IF (NOV.GT.0) GO TO 400                                        SECNT376
         NSK=0                                                          SECNT377
         ETA=2.0                                                        SECNT378
         GO TO 300                                                      SECNT379
C                                                                       SECNT380
  900    NROOT=JR-1                                                     SECNT381
        IF(NROOT.GT.0) GO TO 902                                        SECNT382
        WRITE (6,3006)                                                  SECNT383
        STOP                                                            SECNT384
   902 CONTINUE                                                         SECNT385
         IF (IFPR.EQ.0) GO TO 905                                       SECNT386
         WRITE (6,2009) (NITE(J),J=1,NROOT)                             SECNT387
         WRITE (6,2010) (TIM(J),J=1,NROOT)                              SECNT388
         WRITE (6,2011)                                                 SECNT389
         WRITE (6,2001) (ERRVL(J),J=1,NROOT)                            SECNT390
         WRITE (6,2001) (ERRVR(J),J=1,NROOT)                            SECNT391
C                                                                       SECNT392
C   READ EIGENVECTORS INTO CORE                                         SECNT393
C                                                                       SECNT394
  905    IF (NROOT.LE.NVM) GO TO 906                                    SECNT395
         NDIF=NROOT - NVM                                               SECNT396
         REWIND NT                                                      SECNT397
         DO 904 L=1,NDIF                                                SECNT398
         READ (NT) (A(I,L),I=1,N)                                       SECNT399
  904    CONTINUE                                                       SECNT400
         GO TO 908                                                      SECNT401
  906    NDIF=0                                                         SECNT402
  908    NROOT=NROOT - NDIF                                             SECNT403
         DO 912 L=1,NROOT                                               SECNT404
         DO 912 I=1,N                                                   SECNT405
  912    A(I,L+NDIF)=VV(I,L)                                            SECNT406
C                                                                       SECNT407
C   ARRANGE EIGENVALUES AND VECTORS IN ASCENDING ORDER                  SECNT408
C                                                                       SECNT409
         IF (JR.EQ.2) GO TO 950                                         SECNT410
         JR=JR-2                                                        SECNT411
  910    IS=0                                                           SECNT412
         DO 920 I=1,JR                                                  SECNT413
         IF (ROOT(I+1).GE.ROOT(I)) GO TO 920                            SECNT414
         IS=IS+1                                                        SECNT415
         RT=ROOT(I+1)                                                   SECNT416
         ROOT(I+1)=ROOT(I)                                              SECNT417
         ROOT(I)=RT                                                     SECNT418
C                                                                       SECNT419
C  FORMAT                                                               SECNT420
C                                                                       SECNT421
 2000 FORMAT('1INVERSE ITERATION GIVES FOLLOWING APPROXIMATION TO',     SECNT422
     1' LOWEST EIGENVALUE')                                             SECNT423
 2001 FORMAT(1H0,6E20.12)                                               SECNT424
 2002 FORMAT('ORB =',E20.12,'  NSC=',I4)                                SECNT425
 2003 FORMAT(/////5X,'ROOT    NITE',18X,'RC',15X,'DER?????')            SECNT426
 2004 FORMAT(1H0,2(4X,I4),8X,3E22.14,F7.2,2I6)                          SECNT427
 2005 FORMAT('OR(RC-RB) IS SMALLER THAN TOL')                           SECNT428
 2006 FORMAT('OWE JUMPED OVER ',I4,'UNKNOWN ROOT(S)')                   SECNT429
 2007 FORMAT('1',34X,'ROOT',18X,'RQ',18X,'NOR=',I2)                     SECNT430
 2008 FORMAT('OTIME FOR INVERSE ITERATION =',F5.2)                      SECNT431
 2009 FORMAT('ONUMBER OF ITERATIONS FOR EACH EIGENVALUE',(/1X,6I20))    SECNT432
 2010 FORMAT(///'OTIME USED FOR EACH EIGENVALUE',/(/1X,6F20.2))         SECNT433
 2011 FORMAT('FOLLOWING ARE ERROR BOUNDS ON EIGENVALUES')               SECNT434
 2012 FORMAT(///'OWE SOLVED FOR THE FOLLOWING EIGENVALUES')             SECNT435
C                                                                       SECNT436
 3000 FORMAT(///'*** FATAL ERROR IN SECNTD',/,                          SECNT437
     1' ZERO MASS FOR SDOF SYSTEM')                                     SECNT438
 3001 FORMAT(///' *** FATAL ERROR IN SECNTD',/,                         SECNT439
     1' RIGID BODY MODE FOUND')                                         SECNT440
 3002 FORMAT(///' FATAL ERROR IN SECNTD',/,1X,I3,                       SECNT441
     1' FACTORIZATION PERFORMED TO FIND LOWER BOUND ON FIRST EIG.')     SECNT442
 3003 FORMAT(/' DEFLATED POLYNOMIAL HAS NO MORE ROOTS')                 SECNT443
 3004 FORMAT(//' PREMATURE EXIT FROM SECNTD',/,                         SECNT444
     1' ITERATION FOR ROOT NO.',I4,' ABANDONED AFTER',I4,               SECNT445
     2' ITERATIONS')                                                    SECNT446
 3005 FORMAT(//' PREMATURE EXIT FROM SECNTD')                           SECNT447
 3006 FORMAT(////' FATAL ERROR IN SECNTD',/,' NO EIGN. COMPUTED')       SECNT448
         DO 930 K=1,N                                                   SECNT449
         RT=A(K,I+1)                                                    SECNT450
         A(K,I+1)=A(K,I)                                                SECNT451
  930    A(K,I)=RT                                                      SECNT452
  920    CONTINUE                                                       SECNT453
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      IF (IS.GT.0) GO TO 910                                            SECNT454
C                                                                       SECNT455
  950 CONTINUE                                                          SECNT456
      NROOT=NSCH                                                        SECNT457
     IF(IFPR.EQ.1)WRITE(6,2012)                                         SECNT458
     IF(IFPR.EQ.1)WRITE(6,2001)(ROOT(J),J=1,NROOT)                      SECNT459
C                                                                       SECNT460
      REWIND NT                                                         SECNT461
      DO 970 I=1,NROOT                                                  SECNT462
  970 ROOT(I)=DSQRT(ROOT(I))                                            SECNT463
      WRITE (NT) (ROOT(I),I=1,NROOT)                                    SECNT464
      NWA=N*NROOT                                                       SECNT465
      WRITE (NT) (A(I,1),I=1,NWA)                                       SECNT466
      RETURN                                                            SECNT467
      END                                                               SECNT468
     SUBROUTINE BANDET (A,B,V,MAXA,NN,NWA,RA,NSCH,DET,ISCALE,KK,NSTIF)  BANDE   1
C  ROUTINE TO PERFORM TRIANGULAR FACTORIZATION AT A SHIFT, DETERMINAT   BANDE   2
C CALCULATION AND VECTOR ITERATION                                      BANDE   3
     IMPLICIT REAL*8(A-H,O-Z)                                           BANDE   4
     DIMENSION A(NWA),B(1),V(1),MAXA(1)                                 BANDE   5
C                                                                       BANDE   6
      NR=NN-1                                                           BANDE   7
      IF (KK-2) 100,700,800                                             BANDE   8
C                                                                       BANDE   9
  100 TOL=1.0E-10                                                       BANDE  10
      RTOL=1.0E-07                                                      BANDE  11
      NTF=3                                                             BANDE  12
      IS=1                                                              BANDE  13
  120 REWIND NSTIF                                                      BANDE  14
      READ (NSTIF) A                                                    BANDE  15
      DO 140 I=1,NN                                                     BANDE  16
  140 A(I)=A(I)-RA*B(I)                                                 BANDE  17
     IF(NWA.EQ.NN)GO TO 230                                             BANDE  18
      DO 200 N=1,NR                                                     BANDE  19
      IH=N+NWA-NN                                                       BANDE  20
  210 IF (A(IH)) 220,215,220                                            BANDE  21
  215 IH=IH-NN                                                          BANDE  22
      GO TO 210                                                         BANDE  23
  220 MAXA(N)=IH                                                        BANDE  24
      PIV=A(N)                                                          BANDE  25
     IF(PIV) 221,222,221                                                BANDE  26
  222 IS = IS+1                                                         BANDE  27
     IF(IS.GT.NTF) GO TO 1000                                           BANDE  28
     RT=RTOL*10**(IS-2)                                                 BANDE  29
     RA=RA*(1.0D0-RT)                                                   BANDE  30
     GO TO 120                                                          BANDE  31
  221 IL=N+NN                                                           BANDE  32
      L=N                                                               BANDE  33
      DO 240 I=IL,IH,NN                                                 BANDE  34
      L=L+1                                                             BANDE  35
      C=A(I)                                                            BANDE  36
      IF (C) 225,240,225                                                BANDE  37
  225 C=C/PIV                                                           BANDE  38
     IF (DABS(C) .LT. TOL) GO TO 235                                    BANDE  39
     GO TO 222                                                          BANDE  40
  235 J=L-I                                                             BANDE  41
      DO 260 K=I,IH,NN                                                  BANDE  42
  260 A(K+J)=A(K+J)-C*A(K)                                              BANDE  43
      A(I)=C                                                            BANDE  44
  240 CONTINUE                                                          BANDE  45
  200 CONTINUE                                                          BANDE  46
  230 IF (A(NN).NE.0.0) GO TO 280                                       BANDE  47
     AA=DABS(A(1))                                                      BANDE  48
      DO 290 I=2,NR                                                     BANDE  49
  290 AA=AA+DABS(A(I))                                                  BANDE  50
      A(NN)=-(AA/NR)*1.0E-16                                            BANDE  51
C                                                                       BANDE  52
C  COMPUTE CHARACTERISTIC POLYNOMIAL                                    BANDE  53
C  DET(A-RA*B)=DET*10**ISCALE                                           BANDE  54
C                                                                       BANDE  55
  280 NSCH=0                                                            BANDE  56
      DET=1.0                                                           BANDE  57
     ISCALE=0                                                           BANDE  58
      DO 300 I=1,NN                                                     BANDE  59
  320 DET=DET*A(I)                                                      BANDE  60
     CALL EXPO(DET,ISCALE)                                              BANDE  61
  300 IF (A(I).LT.0.) NSCH=NSCH+1                                       BANDE  62
     GO TO 900                                                          BANDE  63
C                                                                       BANDE  64
  700 IL=NN                                                             BANDE  65
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      DO 400 N=1,NR                                                     BANDE 66
      C=V(N)                                                            BANDE 67
      V(N)=C/A(N)                                                       BANDE 68
      IF (NWA-NN) 410,400,410                                           BANDE 69
  410 IL=IL+1                                                           BANDE 70
      IH=MAXA(N)                                                        BANDE 71
      K=N                                                               BANDE 72
      DO 420 I=IL,IH,NN                                                 BANDE 73
      K=K+1                                                             BANDE 74
  420 V(K)=V(K)-C*A(I)                                                  BANDE 75
  400 CONTINUE                                                          BANDE 76
      V(NN)=V(NN)/A(NN)                                                 BANDE 77
C                                                                       BANDE 78
  800 IF (NWA-NN) 430,900,430                                           BANDE 79
  430 N=NN                                                              BANDE 80
      DO 440 L=2,NN                                                     BANDE 81
      N=N-1                                                             BANDE 82
      IL=N+NN                                                           BANDE 83
      IH=MAXA(N)                                                        BANDE 84
      K=N                                                               BANDE 85
      DO 460 I=IL,IH,NN                                                 BANDE 86
      K=K+1                                                             BANDE 87
  460 V(N)=V(N)-A(I)*V(K)                                               BANDE 88
  440 CONTINUE                                                          BANDE 89
  900 RETURN                                                            BANDE 90
C                                                                       BANDE 91
 1000 WRITE(6,1001)NTF,RA                                               BANDE 92
 1001 FORMAT (37H0***ERROR   SOLUTION STOP IN *BANDET*, / 12X,          BANDE 93
     1       1H(,I3,37H) TRIANGULAR FACTORIZATIONS ATTEMPTED, / 12X,    BANDE 94
     2       16HCURRENT SHIFT = ,E20.14 / 1X)                           BANDE 95
      STOP                                                              BANDE 96
      END                                                               BANDE 97
      SUBROUTINE EXPO (A,IX)                                            EXPO   1
      IMPLICIT REAL*8(A-H,O-Z)                                          EXPO   2
      XM=DABS(A)                                                        EXPO   3
   10 IF(XM.LE.1.0D0)GO TO 20                                           EXPO   4
      XM=XM*0.1D0                                                       EXPO   5
      IX=IX+1                                                           EXPO   6
      GO TO 10                                                          EXPO   7
   20 IF(XM.GE.0.1D0)GO TO 30                                           EXPO   8
      XM=XM*10.D0                                                       EXPO   9
      IX=IX-1                                                           EXPO  10
      GO TO 20                                                          EXPO  11
   30 A=DSIGN(XM,A)                                                     EXPO  12
      RETURN                                                            EXPO  13
      END                                                               EXPO  14
      SUBROUTINE PRTFQ(WE,S,NJTS,NEQ,ID)                                PRTFQ  1
      IMPLICIT REAL*8(A-H,O-Z)                                          PRTFQ  2
      DIMENSION S(1),ID(NJTS,1),W(3)                                    PRTFQ  3
      PRINT 10,WE                                                       PRTFQ  4
   10 FORMAT('0FIRST NATUARAL FREQUENCY = ',E14.5,//,                   PRTFQ  5
     1' FIRST MODE SHAPE:',/,                                           PRTFQ  6
     2'     NODE               X                 Y                R')   PRTFQ  7
      DO 30 I=1,NJTS                                                    PRTFQ  8
      DO 20 J=1,3                                                       PRTFQ  9
   20 W(J)=S(ID(I,J))                                                   PRTFQ 10
      PRINT 40,I,W                                                      PRTFQ 11
   30 CONTINUE                                                          PRTFQ 12
   40 FORMAT(I8,3E20.4)                                                 PRTFQ 13
      RETURN                                                            PRTFQ 14
      END                                                               PRTFQ 15
      SUBROUTINE REINT(IEAR,IDSGN,NELG,NELN,ICOR,DEDIF,PDEDIF,IICHK,DA,SREINT  1
     1ECIN,STIN,CONIN,YBM,RHOM,DDIN,ITY,DMY)                            REINT  2
      IMPLICIT REAL*8(A-H,O-Z)                                          REINT  3
C                                                                       REINT  4
C     REINITIALIZE ALL THE ELEMENT DATA FOR SUBSEQUENT INPUT MOTIONS    REINT  5
C                                                                       REINT  6
      COMMON/CONTR/ NELGR,NEQ,MBAND,NPTH,NPTV,NSTO,JCOL,NSTORY,NBAY     REINT  7
      COMMON/GENINF/KCONT(10),KELEM(10),NELEM(10),NINF(10),NDOF(10)     REINT  8
     1             ,FCONT(3),NUMEM(10)                                  REINT  9
      COMMON/PASS/ IGR,ISTEP,NSTEPS,KVARY,NBLOK,KSTAT,KDDS,KM,IDUM(2),  REINT 10
     1             ISYM,ISYMD                                           REINT 11
      COMMON/STOR/ NAVST,NF1,NF2,NF3,NF4,NTST,KODST,KDATA,NF17          REINT 12
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,   REINT 13
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),          REINT 14
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),   REINT 15
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMF(2,2),PHx(2,2),FMp(2,2), REINT 16
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),       REINT 17
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,       REINT 18
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),   REINT 19
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     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,  REINT 20
     8    INSLP(2,2),DAM(2),FMFI(2,2),FAC(2,2),FMDA(2,2),IDAM(2,2),      REINT 21
     9    PHDA(2,2),FMxxM(2,2)                                           REINT 22
C                                                                        REINT 23
      DIMENSION ICOR(1),DEDIF(1),PDEDIF(1),IICHK(1),DA(1),SECIN(9,1),    REINT 24
     1STIN(6,1),CONIN(9,1),YBM(2,NELG,1),RHOM(2,NELG,1),DDIN(2,1),       REINT 25
     2ITY(3,1),DMY(NELG,1)                                               REINT 26
C                                                                        REINT 27
      DIMENSION COM(1)                                                   REINT 28
      EQUIVALENCE(IMEM,COM(1))                                           REINT 29
C                                                                        REINT 30
      NUM=0                                                              REINT 31
      DO 10 IGR=1,NELGR                                                  REINT 32
      NEL=NELEM(IGR)                                                     REINT 33
      NDATA=NINF(IGR)                                                    REINT 34
      DO 20 IEL=1,NEL                                                    REINT 35
      CALL STORE(COM,NDATA,NF17,1)                                       REINT 36
      IF(IEAR.EQ.1 .AND. IDSGN.GE.1)CALL REINELL(IEL,NUM,IDSGN,IGR,NELG,REINT 37
     1NELN,ICOR,DEDIF,PDEDIF,IICHK,DA,SECIN,STIN,CONIN,YBM,RHOM,DDIN,ITYREINT 38
     2,DMY)                                                              REINT 39
      CALL STORE(COM,NDATA,NF2,2)                                        REINT 40
   20 CONTINUE                                                           REINT 41
      IF(IGR.GE.1) NUM=NUM+NEL                                           REINT 42
   10 CONTINUE                                                           REINT 43
      REWIND NF17                                                        REINT 44
      REWIND NF2                                                         REINT 45
      DO 30 IGR=1,NELGR                                                  REINT 46
      NEL=NELEM(IGR)                                                     REINT 47
      NDATA=NINF(IGR)                                                    REINT 48
      DO 30 IEL=1,NEL                                                    REINT 49
      CALL STORE(COM,NDATA,NF2,1)                                        REINT 50
      CALL STORE(COM,NDATA,NF17,2)                                       REINT 51
   30 CONTINUE                                                           REINT 52
      REWIND NF17                                                        REINT 53
      REWIND NF2                                                         REINT 54
      RETURN                                                             REINT 55
      END                                                                REINT 56
      SUBROUTINE REINELL (IEL,NUM,IDSGN,IGR,NELG,NELN,ICOR,DEDIF,PDEDIF,REINE  1
     1IICHK,DA,SECIN,STIN,CONIN,YBM,RHOM,DDIN,ITY,DMY)                   REINE  2
      IMPLICIT REAL*8(A-H,O-Z)                                           REINE  3
C                                                                        REINE  4
      COMMON/GENINF/IIDUM(30),NINF(10),NDOFF(10),JJDUM(6),NUMEM(10)      REINE  5
      COMMON/INFEL/IMEM,IMEMD,KST,KSTD,LM(6),LMD(6),KGEOM,KGEOMD,PSH,    REINE  6
     1    KHYST,KHYSTD,FL,COSA,SINA,EAL,A(2,6),ST(2,2),ECC(4),           REINE  7
     2    KODY(2),XI(2),Q(2),ALPHAP(2,2),EI(5,2,2),PHF(2,2),PHY(2,2),    REINE  8
     3    PHU(2,2),PHI(2),FM1(2,2),PH1(2,2),FMF(2,2),PHx(2,2),FMp(2,2),  REINE  9
     4    PHp(2,2),PHr(2,2),RD3(2,2),RD4(2,2),RD5(2,2),FMxM(2,2),        REINE 10
     5    PHxM(2,2),BMIY(2,2),BMEP(2),HYS(2),PPH1(2,2),BMMP,PHMX,        REINE 11
     6    BMTOT(2),SFTOT(2),FTOT(2),PRTOT(2),SENP(8),SENN(8),TENP(8),    REINE 12
     7    TENN(8),PRACP(2),PRACN(2),SDACT(3),NODI,NODJ,KOUTDT,KOUTDTD,   REINE 13
     8    INSLP(2,2),DAM(2),FMFI(2,2),FAC(2,2),FMDA(2,2),IDAM(2,2),      REINE 14
     9    PHDA(2,2),FMxxM(2,2)                                           REINE 15
      COMMON/WORK/GA(6,6),SFF(8),SSFF(8),DD(6),FFEF(6),FF(6),            REINE 16
     1         FEF(35,7),KDFEF(36),FINIT(30,6),ECT(15,4),STYP(7,6),      REINE 17
     2         CONYP(7,9),SECYP(14,9),W1(6),                             REINE 18
     3    ES,PS,FSY,EPSSY,EPSSU,FSU,FC,RDD,EC,PC,FCY,EPSCY,EPSCU,FCU,    REINE 19
     4    EPSCM,PCP,F,FN,FN1,PS1,PC1,PH,FM,EPSS,EPSC,EPSSD,YY,PSP,W2(2),REINE 20
     5    DPR(2),NPW(2),FACTOR,FMY(2),PY(2),PHUL(2),PHIF(2),FMU(2),      REINE 21
     6    FMIF(2),W3(744)                                                REINE 22
      COMMON/AUTO/KAUTO,KAUTOD,KECO,KECOD,NDSGN,NDSGND,KFREQ,KFREQD,     REINE 23
     1 DBALL,DCALL,DBSTD,CONC,STEEL,IECO,BMAVG,BMDEV                     REINE 24
      COMMON/THIST/ITHOUT(10),THOUT(20),ITHP,ISAVE,NELTH,NSTH,NF7,ISE    REINE 25
C                                                                        REINE 26
      DIMENSION ICOR(1),DEDIF(1),PDEDIF(1),IICHK(1),DA(1),               REINE 27
     1SECIN(9,1),STIN(6,1),CONIN(9,1),YBM(2,NELG,1),DDIN(2,1),ITY(3,1),  REINE 28
     2RHOM(2,NELG,1),DMY(NELG,1)                                         REINE 29
C                                                                        REINE 30
      IM=NUM+IEL                                                         REINE 31
C                                                                        REINE 32
C     CORRECTIVE DESIGN FOR BEAMS EXCEEDING ALLOWABLE DAMAGE             REINE 33
C                                                                        REINE 34
      IF(IGR .EQ. 2) GO TO 10                                            REINE 35
      IF(IBMOK.EQ.0) IBMOK=0                                             REINE 36
      IF(ICOR(IM) .EQ. 0) GO TO 30                                       REINE 37
      DAL=DBALL                                                          REINE 38
      DDD=DSIGN(1.D0,DEDIF(IM))*DABS(DEDIF(IM))                          REINE 39
      PDD=DSIGN(1.D0,PDEDIF(IM))*DABS(PDEDIF(IM))                        REINE 40
      IF(IDSGN.GE.2) SIGNA=DDD/PDD                                       REINE 41
      IF(IICHK(IM).EQ.1) DA(IM)=DSIGN(1.D0,DDD)*0.05*SECIN(4,IM)         REINE 42
      IF(IICHK(IM).EQ.0)DA(IM)=DA(IM)*DSIGN(1.D0,SIGNA)*DABS(SIGNA)**1.5REINE 43
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         SECIN(4,IM)=SECIN(4,IM)+DA(IM)                                 REINE 44
         SECIN(8,IM)=SECIN(4,IM)                                        REINE 45
         IBMOK=1                                                        REINE 46
         GO TO 30                                                       REINE 47
      10 IF(IBMOK .EQ. 1) GO TO 20                                      REINE 48
         IF(ICOR(IM) .EQ. 0) GO TO 30                                   REINE 49
         DAL=DCALL                                                      REINE 50
         DDD=DSIGN(1.D0,DEDIF(IM))*DABS(DEDIF(IM))                      REINE 51
         PDD=DSIGN(1.D0,PDEDIF(IM))*DABS(PDEDIF(IM))                    REINE 52
         IF(IDSGN.GE.2) SIGNA=DDD/PDD                                   REINE 53
         IF(IICHK(IM).EQ.1) DA(IM)=DSIGN(1.D0,DDD)*0.05*SECIN(4,IM)     REINE 54
         IF(IICHK(IM).EQ.0)DA(IM)=DA(IM)*DSIGN(1.D0,SIGNA)*DABS(SIGNA)**1.5REINE 55
         SECIN(4,IM)=SECIN(4,IM)+DA(IM)                                 REINE 56
         SECIN(8,IM)=SECIN(4,IM)                                        REINE 57
         GO TO 30                                                       REINE 58
      20 YBI1=YBM(1,1,NODI)                                             REINE 59
         YBI2=YBM(2,1,NODI)                                             REINE 60
         YBJ1=YBM(1,1,NODJ)                                             REINE 61
         YBJ2=YBM(2,1,NODJ)                                             REINE 62
         YCI1=YBM(1,2,NODI)                                             REINE 63
         YCI2=YBM(2,2,NODI)                                             REINE 64
         YCJ1=YBM(1,2,NODJ)                                             REINE 65
         YCJ2=YBM(2,2,NODJ)                                             REINE 66
   C                                                                    REINE 67
         DM1=(YBI1+YBI2)/2.0                                            REINE 68
         IF(YBI1*YBI2 .EQ. 0.0) DM1=DMAX1(YBI1,YBI2)                    REINE 69
         DM2=(YBJ1+YBJ2)/2.0                                            REINE 70
         IF(YBJ1*YBJ2 .EQ. 0.0) DM2=DMAX1(YBJ1,YBJ2)                    REINE 71
         DBMY=DMAX1(DM1,DM2)                                            REINE 72
         YC=DMAX1(YCI1,YCJ2)                                            REINE 73
         DMRATIO=(1.25*DBMY-YC)/DMY(IGR,IEL)                            REINE 74
         SECIN(4,IM)=SECIN(4,IM)*(1+DMRATIO/100.)                       REINE 75
         SECIN(8,IM)=SECIN(8,IM)*(1+DMRATIO/100.)                       REINE 76
      30 IF(SECIN(4,IM).LE.RHOM(1,IGR,IMEM))SECIN(4,IM)=RHOM(1,IGR,IMEM) REINE 77
         IF(SECIN(8,IM).LE.RHOM(1,IGR,IMEM))SECIN(8,IM)=RHOM(1,IGR,IMEM) REINE 78
         IF(SECIN(4,IM).GE.RHOM(2,IGR,IMEM))SECIN(4,IM)=RHOM(2,IGR,IMEM) REINE 79
         IF(SECIN(8,IM).GE.RHOM(2,IGR,IMEM))SECIN(8,IM)=RHOM(2,IGR,IMEM) REINE 80
   C                                                                    REINE 81
   C     COMPUTE SECTION PROPERTIES                                     REINE 82
   C                                                                    REINE 83
   C     1) REINFORCING STEEL                                           REINE 84
         ES=STIN(1,IM)                                                  REINE 85
         PS=STIN(2,IM)                                                  REINE 86
         FSY=STIN(3,IM)                                                 REINE 87
         EPSSU=STIN(4,IM)                                               REINE 88
         EPSSY=STIN(5,IM)                                               REINE 89
         FSU=STIN(6,IM)                                                 REINE 90
   C     2) CONCRETE PROPERTIES                                         REINE 91
         FC=CONIN(1,IM)                                                 REINE 92
         EPSCO=CONIN(2,IM)                                              REINE 93
         RDD=CONIN(3,IM)                                                REINE 94
         FCY=CONIN(4,IM)                                                REINE 95
         EPSCY=CONIN(5,IM)                                              REINE 96
         FCU=CONIN(6,IM)                                                REINE 97
         EPSCU=CONIN(7,IM)                                              REINE 98
         EPSCM=CONIN(8,IM)                                              REINE 99
         SLR=CONIN(9,IM)                                                REINE100
   C     3) DIMENSION OF SECTION                                        REINE101
         II=1                                                           REINE102
         IF((SECIN(1,IM)) .LT. 0.)  II=-1                               REINE103
         HT=SECIN(1,IM)                                                 REINE104
         IF(II.LE.0) HT=-HT                                             REINE105
         BB=SECIN(2,IM)                                                 REINE106
         DCB=SECIN(3,IM)                                                REINE107
         ASB=SECIN(4,IM)                                                REINE108
         OMEGA=SECIN(5,IM)                                              REINE109
         BT=SECIN(6,IM)                                                 REINE110
         DCT=SECIN(7,IM)                                                REINE111
         AST=SECIN(8,IM)                                                REINE112
         AT=SECIN(9,IM)                                                 REINE113
   C                                                                    REINE114
   C     EXAMINE ACI-CODE FOR MINIMUM AND MAXIMUM STEEL                 REINE115
   C                                                                    REINE116
         RHO=ASB/(BT*(HT-DCB))                                          REINE117
         DELD=0.0                                                       REINE118
         RR=ASB/BT                                                      REINE119
         IF(RHO .LT. RHOM(1,IGR,IEL)) DELD=RR/(RHOM(1,IGR,IEL)-RHO)     REINE120
         IF(RHO .GT. RHOM(2,IGR,IEL)) DELD=RR/(RHOM(2,IGR,IEL)-RHO)     REINE121
         HT=HT-DELD                                                     REINE122
   C                                                                    REINE123
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C     COMPUTE SECTION PROPERTIES                                        REINE124
C                                                                       REINE125
      VOL=VOL+RFL*AT                                                    REINE126
      STL=STL+RFL*(AST+ASB)                                             REINE127
      EC=FCY/EPSCY                                                      REINE128
      PC=5./21.                                                         REINE129
C                                                                       REINE130
      PCP=(FCU-0.1*FC)/((EPSCM-EPSCU)*EC)                               REINE131
      FN=ES/EC                                                          REINE132
      FN1=FN-1                                                          REINE133
      PS1=1.-PS                                                         REINE134
      PC1=1.-PC                                                         REINE135
      AS=AST+ASB                                                        REINE136
      AC=AT-AS                                                          REINE137
      DDT=HT-DCB                                                        REINE138
      DDB=HT-DCT                                                        REINE139
      AXF=DDIN(1,IM)                                                    REINE140
      IF(IGR.EQ.2) AXF=-DDIN(2,IM)                                      REINE141
      PSP=1.5*PS                                                        REINE142
      CALL FMPHI(SLR,AXF,HT,BT,DCT,AST,DDT,ASB,FMY1,EI1,P1,PHIU1,PHIF1,FREINE143
     1MF1,FMU1,YNX1)                                                    REINE144
      IF(II.GE.0)THEN                                                   REINE145
      CALL FMPHI(SLR,AXF,HT,BB,DCB,ASB,DDB,AST,FMY2,EI2,P2,PHIU2,PHIF2, REINE146
     1FMF2,FMU2,YNX2)                                                   REINE147
      EII=.5*(EI1+EI2)                                                  REINE148
      PP=.5*(P1*EI1+P2*EI2)/EII                                         REINE149
      FMY1=FMY1*(1.-PP*EII/EI1)/(1.-PP)                                 REINE150
      FMY2=FMY2*(1.-PP*EII/EI2)/(1.-PP)                                 REINE151
      ELSE                                                              REINE152
      EII=EI1                                                           REINE153
      PP=P1                                                             REINE154
      FMY2=FMY1                                                         REINE155
      PHIU2=PHIU1                                                       REINE156
      FMU2=FMU1                                                         REINE157
      PHIF2=PHIF1                                                       REINE158
      FMF2=FMF1                                                         REINE159
      ENDIF                                                             REINE160
      ATN=CONIN(4,IM)*AT/HT*(DDT+DDB)/2.                                REINE161
      EA=EC*.5*(BB+BT)*HT+ES*(ASB+AST)                                  REINE162
      STR=(AS/AT)*100.D0                                                REINE163
      IF(STR.LT.0.75) STR=0.75                                          REINE164
      CFR=RDD                                                           REINE165
      IF(CFR.GT.2.) CFR=2.                                              REINE166
      PHUL(1)=PHIU1                                                     REINE167
      PHUL(2)=-PHIU2                                                    REINE168
      FMU(1)=FMU1                                                       REINE169
      FMU(2)=-FMU2                                                      REINE170
      PHIF(1)=PHIF1                                                     REINE171
      PHIF(2)=-PHIF2                                                    REINE172
      FMIF(1)=FMF1                                                      REINE173
      FMIF(2)=-FMF2                                                     REINE174
      FMY(1)=FMY1                                                       REINE175
      FMY(2)=-FMY2                                                      REINE176
      PY(1)=AS*FSY+.85*FC*AC                                            REINE177
      PY(2)=-(6.*AC*DSQRT(FC*1000.)/1000.+FSY*AS)                       REINE178
C                                                                       REINE179
      DO 610 I=1,2                                                      REINE180
      KODY(I)=1                                                         REINE181
      XI(I)=0.                                                          REINE182
      Q(I)=1.                                                           REINE183
      DO 610 J=1,2                                                      REINE184
      EI(1,I,J)=EII                                                     REINE185
      EI(2,I,J)=PP*EII                                                  REINE186
      EI(3,I,J)=0.0                                                     REINE187
      EI(4,I,J)=0.0                                                     REINE188
  610 EI(5,I,J)=0.0                                                     REINE189
      PSH=PP                                                            REINE190
      EAL=EA/FL                                                         REINE191
C                                                                       REINE192
      DO 630 J=1,2                                                      REINE193
      DO 630 IE=1,2                                                     REINE194
      PHF(IE,J)=PHIF(J)                                                 REINE195
      FMF(IE,J)=FMIF(J)                                                 REINE196
      PHU(IE,J)=PHUL(J)                                                 REINE197
      BMIY(IE,J)=FMY(J)                                                 REINE198
  630 PHY(IE,J)=FMY(J)/EII                                              REINE199
      DO 640 I=1,4                                                      REINE200
      IDAM(I,1)=0                                                       REINE201
      INSLP(I,1)=1                                                      REINE202
      FAC(I,1)=OMEGA                                                    REINE203
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      FMDA(I,1)=BMIY(I,1)                                               REINE204
      FMxxM(I,1)=BMIY(I,1)                                              REINE205
      FMxM(I,1)=BMIY(I,1)                                               REINE206
      PHDA(I,1)=PHY(I,1)                                                REINE207
      PPH1(I,1)=PHY(I,1)                                                REINE208
  640 PHxM(I,1)=PHY(I,1)                                                REINE209
C                                                                       REINE210
C     RESAVE DATA FOR DAMAGE ACCEPTANCE CRITERIA                        REINE211
C                                                                       REINE212
      CC=0.85*FC*YNX1*BT                                                REINE213
      CS=FSY*AST                                                        REINE214
      RHOMAX=(CC+CS)/FSY                                                REINE215
      RHOMIN=200.0/FSY                                                  REINE216
      IF(FSY .LE. 200.0) RHOMIN=RHOMIN/1000.0                           REINE217
      RHOM(1,IGR,IMEM)=RHOMIN                                           REINE218
      RHOM(2,IGR,IMEM)=RHOMAX                                           REINE219
C                                                                       REINE220
      YBM(1,IGR,NODI)=FMY(1)                                            REINE221
      YBM(2,IGR,NODJ)=FMY(1)                                            REINE222
C                                                                       REINE223
      IF(IMEM.EQ.1) PRINT 660                                           REINE224
      PRINT 680,IMEM,NODI,NODJ,ITY(2,IM),ITY(1,IM),ITY(3,IM),EII,STR,   REINE225
     1PP,SSR,CFR,(FMY(J),J=1,2),(FMU(J),J=1,2),(FMIF(J),J=1,2),         REINE226
     2FMY(1)/EII,PHUL(1),PHIF(1)                                        REINE227
  660 FORMAT(////36H*** COMPUTED MEMBER PROPERTIES  ***//               REINE228
     1       3HEL.,1X,4HNODE,3X,4HMATL,1X,7HYOUNG'S,3X,5HLONG.,         REINE229
     2       1X,6HHARDEN,1X,6HS/SPAN,1X,6HCONFIN,2X,13H YIELD MOMENT,4X,REINE230
     3       13HULT.  MOMENT ,4X,11HFAIL MOMENT,9X,'  CURVATURES'/,     REINE231
     5       3HNO.,1X,4H I/J,1X,8HCO/ST/SE,1X,7HMODULUS,1X,5HSTL %,     REINE232
     6       1X,6H RATIO,1X,6H RATIO,1X,6H RATIO,3X,13HPOSI.   NEGA ,3X,REINE233
     7       13HPOSI.  NEGA  ,5X,11HPOSI.  NEGA,5X,21HYIELD  MAX MO.  FAREINE234
     8IL /)                                                             REINE235
  680 FORMAT(/I2,1X,I2,'/',I2,1X,I1,'/',I1,'/',I1,1X,E9.3,1X,F5.3,1X,   REINE236
     1F6.4,1X,F5.2,1X,F6.3,2F9.2,2F9.2,1X,2F9.2,1x,2F7.4,1x,F7.4)       REINE237
      RETURN                                                            REINE238
      END                                                               REINE239
                                                                        REINE240
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NCEER-87-0011 "Seismic Probabilistic Risk Assessment and Seismic Margins Studies for Nuclear Power Plants," by Howard H.M. Hwang, 6/15/87, (PB88-134267/AS). This report is available only through NTIS (see address given above).

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