SEISMIC ANALYSIS CAPABILITY IN NASTRAN

Thomas G. Butler
BUTLER ANALYSES, Towson, Md.

Robert F. Strang
COMPUTER SCIENCES CORP., Silver Spring, Md.

INTRODUCTION

Seismic analysis is a technique which pertains to loading described in terms of boundary accelerations. Earthquake shocks to buildings is the type of excitation which usually comes to mind when one hears the word seismic, but this technique also applies to a broad class of acceleration excitations which are applied at the base of a structure such as vibration shaker testing or shocks to machinery foundations. Four different solution paths are available in NASTRAN for seismic analysis. They are: Direct Seismic Frequency Response, Direct Seismic Transient Response, Modal Seismic Frequency Response, and Modal Seismic Transient Response. This capability, at present, is invoked not as separate rigid formats, but as pre-packaged ALTER packets to existing Rigid Formats 8, 9, 11, and 12. These ALTER packets are included with the delivery of the NASTRAN program and are stored on the computer as a library of callable utilities. The user calls one of these utilities and merges it into the Executive Control Section of the data deck to perform any one of the four solutions. There are a number of options available in each solution. These options are invoked by setting parameter values in the bulk data. Each of these solutions operates sufficiently differently that instructions will be discussed individually in the following paragraphs after a general introduction. The only new bulk data cards needed to perform seismic solutions are simple parameters which will be explained in the context of each solution path. The theoretical basis for these solutions is taken up in the Theory Section. Associated with each seismic ALTER packet are a number of new functional modules. Their operations are described in the solution topics.

OPERATION OF SEISMIC SOLUTIONS

Taking Newton's law as it stands Force = Mass x Acceleration, the loading in all cases is organized by putting the spatial distribution of mass on DAREA cards and by putting the description of time-varying or frequency-varying accelerations on TABLED1 cards so that the assembler cards TLOAD or RLOAD will direct the combining of the mass with the acceleration to create force inputs at the indicated massive grid points. This is the heart of the whole seismic scheme. The user can be spared the drudgery of preparing these inputs by employing processors that are supplied to do the job automatically for him. A stand-alone program called TBLGEN will take a file of seismic accelerations and will prepare a file of TABLED1 card images that can be merged into the bulk data section of the data deck. New module RBTM and succeeding ALTER statements prepare a matrix of inertia coefficients, using the rigid body transformation matrix as a transfer function between points having inertias

coupled to a base point and that base point for the direct method and acts as a transfer function between the base reference and all superstructure points for the modal method. The module, called NRTS, automatically converts the matrix from RBTM into a data block of DAREA card images of masses. The assignment of masses to DAREA coefficients are made according to the coordinate direction in which they are to be accelerated. NRTS is guided by the user as to which direction to accelerate the inertias through the use of parameters NRTID"i". There are 6 parameters NRTID"i" $1 \leq i \leq 6$. $1 \leq i \leq 3$ represent the three translational directions of the basic coordinate system. $4 \leq i \leq 6$ represent the three rotational directions of the basic coordinate system. NRTS will generate a DAREA set for each parameter NRTID"i" that is included in a run. There must be at least one NRTID"i" in a run. NRTS can accomodate from one to six coordinate accelerations in a run. The user assigns set ID's on the NRTID"i" cards which NRTS transfers to the corresponding DAREA sets that it generates. These DAREA sets are never processed by the Input File Processor (IFP) module. NRTS formats the DAREA data according to the way it is usually output from IFP and incorporates these into the DYNAMICS data block in the form required later by module DPD. These automatically generated DAREA cards do not become part of the bulk data; however, the user is given the opportunity to confirm the DAREA data that was prepared by reading the listing that is automatically included in the output upon the execution of NRTS. The TLOAD and RLOAD cards are prepared by the user in the usual way by assembling ID's of DAREA, DPHASE, DELAY, and TABLEDi for the dynamic loading cases. The difference is that the set ID in field 3 refers to the DAREA set generated by NRTS instead of one contained in bulk data. The TABLED1 cards prepared by TBLGEN do become part of the bulk data so the ID in field 6 does refer to a set of accelerations that is contained in bulk data.

Beside load preparation another feature of seismic operation that is common to all solutions is the selection of options. Options are parameter controlled. They operate slightly differently in each rigid format. The three parameters URFIN, QRFIN, and ARFIN operate according to the sign of the value entered on PARAM bulk data cards. Negative values enable the operation and positive values disable their operation. URFIN controls the option to refine outputs (displacements, velocities, and accelerations) due to contributions from omitted d.o.f.'s. URFIN provides for recovery of displacements at loaded points of the structure which the analyst shunted to the omit set. The chance for loaded points being put into the omit set is much more likely in solutions by the modal method (where every massive point is loaded) than it is in solutions by the direct method. The recommendation is that if condensation is used, to always enable URFIN for modal solutions and do not do so in the direct solution unless important inertias are condensed and loaded. QRFIN controls the option to recover base forces due to the complete complement of stiffness coupling, damping coupling, mass coupling and base inertias. QRFIN augments the reporting of loads on base points, as is currently done in dynamic rigid formats, from just inertia loads to both inertia loads and reaction loads due to coupling. If QRFIN is not enabled, the Case Control request for OLOAD would limit the output on base points to only forces and moments derived from direct inertias. QRFIN does not affect the reporting of loads on points outside the base set. ARFIN controls the option to recover displacements in absolute coordinates.

Solutions differ from each other (1) in the way that loading is applied, (2) in the coordinate system that is used, (3) in the way that coupling is represented, and (4) in the way that data is recovered. Consequently, the descriptions of seismic modifications, from this point on, will be addressed on the basis of the way that the differential equation is solved—direct or modal.

INDIVIDUAL SEISMIC SOLUTIONS

Direct solutions (RF 8 & 9) are performed in absolute coordinates as free bodies. Modal solutions (RF 11 & 12) are performed in relative coordinates on fully clampled rigid bases.

DIRECT SEISMIC (FREQUENCY OR TRANSIENT) RESPONSE.

The features of Direct Seismic Frequency Response and Direct Seismic Transient Response are sufficiently common that they will be discussed in a combined topic.

Loading -- Loading consists of the acceleration of inertias on base points and on inertias that are coupled to base points. All degrees of freedom (d.o.f.'s) of base points being accelerated belong in the R-set. This is implemented by entering their ID's on SUPORT cards. The loading is almost completely general in that every boundary point, which is subject to acceleration, can be loaded with an individual acceleration history with individual time delays and individual phase delays. The proviso that keeps this loading from being completely general is that any point that is supplied with inertia solely via DMIG cards cannot engage in acceleration loading. All boundary accelerated points are classified as base points, but they need not physically be located at the base of a structure. Acceleration loading need not take place over a rigid surface; base points may be elastically linked. CAUTION!! since the K & B matrices are singular in the R dof's, it is imperative that all dof's in the mass matrix be non-singular, i.e. 2nd moment terms must appear for rotational dof's.

Structural Matrices -- The mass and stiffness matrices are not incorporated into the system of seismic equilibrium equations in the form that they leave the EMG & EMA modules. These matrices must be partitioned in order to honor equilibrium conditions. This is done automatically within the pre-packaged ALTER packet. When all the manipulation has transpired, the structural matrices enter the solution phase as unsymmetrical. Part of the mass matrix is moved to the right hand side to form the load. The base partitions of stiffness, mass and damping are used for base force recovery. The DMIG (direct input matrices) are partitioned according to the same pattern as the automatic matrices are. It is anticipated that DMIG masses will eventually be made part of the loading process, so the matrices that enter the solution phase are so partitioned in order to be consistent with the loading function. DMIG matrices do participate in the base force recovery process, so the DMIG matrices are almost completely general.
CAUTION: The direct seismic solutions are particularly sensitive to singularities in the R-set of mass matrices. In particular, extra effort must be made beyond the usual mass matrix genration to ensure that rotational degrees of freedom in the R-set be supplied with 2nd moments of inertia. Accuracy of load transmittal in this method is also sensitive to the modeling of elastic and damping coupling between base and superstructure.

Damping -- Every type of damping which NASTRAN makes available to solutions by the direct method are similarly available to seismic direct solutions. Every type of damping coupling, if present, can contribute to the recovery of base forces.

Boundaries -- The problem is solved as a free body so there are no boundary constraints. No SPC's are allowed except those entered on GRID cards. There is a physical reason for this. Solution takes place in absolute coordinates, and single point constraints in absolute coordinates means that there is a mechanism located in the absolute frame to which points can be tied which will hold them invariably to zero during the period of application of seismic load. Physically this implies that the mechanism must be anchored outside the seismic zone. To meet such a severe requirement the constraining mechanism would be something like an infinitely rigid sky-hook or a monstrous clamp implanted beyond the fault zone. In the case of a shaker it could be satisfied by a large structure surrounding the shaker. No conceivable reason exists for any such arrangements; therefore this is the logic for disallowing SPC's in solutions by the direct method.

Data Recovery -- All displacements are recovered in absolute coordinates, so the ARFIN option for recovery in absolute coordinates would be redundant. Only options URFIN and QRFIN pertain to solutions by the direct method. Except in special cases, the only option recommended to always consider for direct solutions is QRFIN. Using QRFIN in the direct method is the only way to recover base reactions, because the more usual route of SPC force requests does not apply to the base, since the base points are assigned to R-set. Reporting of seismic base forces is controlled in Case Control by the OLOAD statement.

Because element stress and force recovery involves differencing operations on displacements, and because solution by the direct method takes place in absolute coordinates, it is necessary to intervene to prevent errors that arise from taking small differences between large numbers. Total motion of superstructure points, away from the base, consists of a rigid body component due to actions of the base plus elastic deformations of the superstructure with respect to a reference in the base. The recovery of stresses could be improved by removing the rigid body component before doing the differencing; but obtaining the rigid body component poses a difficulty. In the direct method all points in the non-rigid base are excited, so that that which is called rigid body depends on the chosen reference. The way out of this dilemma is to relax concern for determining true rigid body motion. What is important is not that stress recovery should be represented in true relative coordinates, but that stress recovery should be accomplished in a system of numbers of reduced magnitude compared to the absolute deformations. How the reduction to a lesser magnitude is accomplished is not important, except that it should be done uniformly, so that relative sizes are preserved. Therefore, the reference base point for computing rigid body motion can be chosen arbitrarily, because all absolute displacemnts will be reduced in magnitude by removing the rigid body component as defined according to a single point. The analyst then is in control of which point is to be used as a reference. He designates one of the base points assigned to the R-set by entering its GP ID number on the parameter GRDPNT card.

MODAL SEISMIC (FREQUENCY AND TRANSIENT) RESPONSE

The features of Modal Seismic <u>Frequency</u> Response and Modal Seismic <u>Transient</u> Response are sufficiently common that they will be discussed in a combined topic.

Loading -- Loading consists of the acceleration of all inertias of the super-structure while the base is held fixed. This solution, then, determines the behavior of the structure relative to the base. A reference point in the base is required for constructing the rigid body transfer function from the base to superstructure points. How the reference is selected depends on whether the analyst wishes to recover absolute responses. If no absolute responses are wanted, any point in the base can be used, but preferably one in the center. The reference point is flagged by putting it on a PARAM GRDPNT card.

If absolute responses are to be recovered, a scaffold is used. A pair of points, connected by a bar, but disjoint from the structure under analysis, is to be used as a reference system for setting up the load. One point is co-located with a selected base point and is free of any constraints. This is the reference point. The other point is located below the base and is fully constrained. The free point is endowed with unity mass in all 6 dof's, but the bar is massless. (A CONM2 card can be used for this unity mass). Elastic properties of the bar are assigned so that this reed-like reference system has natural frequencies higher than any frequency of interest in the primary structure. The free point is flagged as the reference point by putting it on a PARAM GRDPNT card.

This is the extent of special preparations for load outside of the requirements as described in the paragraph entitled OPERATION OF SEISMIC SOLUTIONS.

Structural Matrices -- The structural matrices are left in the form that they are automatically generated so that they retain their symmetric character during the solution phase. Solution can proceed with maximum efficiency in the symmetric domain. Partitions are made on the matrices, however, to prepare them for recovery of base forces. The DMAP ALTER automatically prepares the partitioning vectors, does the partitioning, and the reassembly of matrices without further intervention by the analyst.

Damping -- In the ordinary modal solutions, only frequency dependent equivalent modal damping is provided for. No scalar dampers or structural damping is taken up in the symmetric path. If other damping is required, it can be supplied by direct input matrices (DMIG). This causes the solution to depart from the symmetric to the more time consuming non-symmetric route. If damping contributions to base forces are needed in the solution, then the only type of damping for which provision has been made is direct input matrices -- called B2PP.

Boundaries -- All base points for modal seismic solutions are assigned to the B-set by entering their ID's on SPC (Single Point Constraint) cards. All six dof's must be included in the base constraint set. No other SPC sets should be activated besides this base set. Having just one set enables the scheme to

distinguish the base points in the data recovery process.

Data Recovery -- Displacements are nominally recovered in relative coordinates. Stresses can be recovered directly from these relative responses without having to make further special provisions. If the user wants to recover displacements in absolute coordinates, special provisions are necessary. The rigid body component of displacement must be added to the relative displacements. Since the base is clamped, a base point does not report the acceleration which was applied there. The scaffold, described in the Loading section above does have a free point which does report the acceleration. Since unity mass was prescribed for the free point, the value of force is equal to the value of acceleration, so the report of acceleration in the form of NASTRAN internal data blocks is obtained from the load vector on the free reference point. Once the scaffold reed is installed, no further preparation by the analyst is needed except to include the PARAM ARFIN with a negative value. The only component of seismic transient response that can be recovered in absolute coordinates via the modal route is acceleration, but for seismic modal frequency response, absolute accelerations, velocities, and displacements can be recovered.

Condensations are logical to use with large structures. In the case of seismic solutions by the modal method where the load is distributed over all the superstructure, condensation could cause a considerable amount of inertia to be gathered into the omit-set. Normally the recovery of contributions to displacement response from the omit-set in dynamic rigid formats is limited to the GOD coefficient matrix without regard to the so-called Koo contribution. It is normally left to the user to be judicious in avoiding the condensation of sizeable inertias. Even a judicious regard by the user is not sufficient when a large accumulation of small inertias is involved as in seismic modal analyses. As a consequence, provision has been made to recover the Koo contribution of the omit-set to displacement response. The user invokes this capability by assigning a negative value to the URFIN parameter.

Recovery of base forces is governed by parameter QRFIN. Setting its value to negative automatically invokes the DMAP ALTER for including contributions to the base force from direct inertias, coupled inertias, coupled elasticity, and coupled DMIG damping. No contribution to base forces from frequency dependent modal damping can be recovered.

THEORY

The general dynamics equation for the seismic problem will be written in subscripted form to relate it to the way that NASTRAN would handle it. The subscript P designates the full set of Physical coordinates. It contains all geometric and scalar grid points in the G-set plus the Extra points used to represent transfer functions of attached features such as hydraulic systems.

$$[[MPP]p^2 + [BPP]p + [KPP]]\{UP\} = \{PP\} \qquad (1)$$

Let lower case p designate the operator d/dt for differentiation with respect to time. The M matrix represents the mass; the B matrix represents the damping; the K matrix represents the elasticity; and the P matrix represents the load. Since NASTRAN links the E-set only after

it has fully processed the G-set, the E coordinates will be partitioned off and the discussion of the method will start where NASTRAN starts it with the G-set.

$$\left[\begin{bmatrix} MGG & MGE \\ \hline MEG & MEE \end{bmatrix} p^2 + \begin{bmatrix} BGG & BGE \\ \hline BEG & BEE \end{bmatrix} p + \begin{bmatrix} KGG & KGE \\ \hline KEG & KEE \end{bmatrix} \right] \begin{Bmatrix} UG \\ \hline UE \end{Bmatrix} = \begin{Bmatrix} PG \\ \hline PE \end{Bmatrix} \quad (2)$$

Ignore the GE coupling for now and isolate the equation in the G-set.

$$[[MGG]p^2 + [BGG]p + [KGG]]\{UG\} = \{PG\} \quad (3)$$

Seismic load originates in the ground and therefore will produce loading in the base of the structure. If the loading were fully defined in terms of distributed forces, there would be no necessity of engaging in this present task, because NASTRAN is fully capable of analyzing structures under known time dependent forces. Since it is displacement histories that define a seismic disturbance in terms of acceleration or velocity or translations, this task is directed towards the development of an automatic method of determining the response to a seismic disturbance without requiring that the disturbance be converted to a set of forces before proceeding with the solution.

Implementation of seismic response has been carried out for four different types of solutions within NASTRAN. Two solutions use the direct method of integrating the differential equations and two solutions use the modal method of integration. In both types the set of two solutions involve excitation in the time domain for one and excitation in the frequency domain in the other. Specifically, these four solutions are:

DIRECT FREQUENCY RESPONSE -- R.F. 8
DIRECT TRANSIENT RESPONSE -- R.F. 9
MODAL FREQUENCY RESPONSE -- R.F.11
MODAL TRANSIENT RESPONSE -- R.F.12

The biggest difference in the theory amongst these four solutions lies between the direct approach and the modal approach. The direct solution takes place as a free body in absolute coordinates while the modal solution takes place as a structure clamped at the base and solved in terms of relative coordinates. The direct method will be taken up first.

DIRECT THEORY

That set of points which is assigned to the base where the disturbance acts is designated as the R-set. Partition the G-set into the base points and its complement say Y = R comp G.

$$\left[\begin{bmatrix} MYY & MYR \\ \hline MRY & MRR \end{bmatrix} p^2 + \begin{bmatrix} BYY & BYR \\ \hline BRY & BRR \end{bmatrix} p + \begin{bmatrix} KYY & KYR \\ \hline KRY & KRR \end{bmatrix} \right] \begin{Bmatrix} UY \\ \hline UR \end{Bmatrix} = \begin{Bmatrix} PY \\ \hline PR \end{Bmatrix} \quad (4)$$

$\{p^2 UR\}$ is the known acceleration on the base. The known forces

resulting from individual base masses are $[MYR]\{p^2 UR\}$ and $[MRR]\{p^2 UR\}$.

Isolate the upper partition depicting the behavior of the portion of the structure extending beyond the base.

$$[[MYY:MYR]p^2 + [BYY:BYR]p + [KYY:KYR]] \left\{ \begin{array}{c} UY \\ \hline UR \end{array} \right\} = \{PY\} \qquad (5)$$

Transfer known terms to the right hand side (RHS) of the equation.

$$[[MYY:0]p^2 + [BYY:BYR]p + [KYY:KYR]] \left\{ \begin{array}{c} UY \\ \hline UR \end{array} \right\} = \{PY - [MYR]\{p^2 UR\}\} \qquad (6)$$

Incorporate the remaining known forcing term $[MRR]\{p^2 UR\}$ by adding it to both sides of the equation.

$$\left[\begin{bmatrix} MYY & 0 \\ \hline 0 & MRR \end{bmatrix} p^2 + \begin{bmatrix} BYY & BYR \\ \hline 0 & 0 \end{bmatrix} p + \begin{bmatrix} KYY & KYR \\ \hline 0 & 0 \end{bmatrix}\right] \left\{ \begin{array}{c} UY \\ \hline UR \end{array} \right\} = \left\{ \begin{array}{c} PY - [MYR]\ \{p^2 UR\} \\ \hline [MRR]\ \{p^2 UR\} \end{array} \right\} \qquad (7)$$

When $\{UG\}$ is solved for, the original $p^2\{UR\}$ should be recovered. PY represents known force loading distinct from the base motion forcing. No such external loading is allowed on the points of the R-set. This is the equation that is presented to NASTRAN at the G-level for solution of the $\{UG\}$ response. Further details of the processing will be taken up later, but now turn to the lower partition which depicts the forces that develop on the base due to the inertias, damping coupling, and elastic coupling after the $\{UG\}$ are found from the solution of the upper partition.

$$[[MRY:MRR]p^2 + [BRY:BRR]p + [KRY:KRR]] \left\{ \begin{array}{c} UY \\ \hline UR \end{array} \right\} = \{PR\} \qquad (8)$$

$\{PR\}$ is the vector of unknown forces which are found by summing up the terms on the left hand side. There is a way of allowing $\{PR\}$ to contain both known external forces and unknown base forces that develop. The method would involve a looping through the modules DPD and TRSLG twice in order to isolate the direct load so as to subtract it during the solution of the base force. Such a scheme is not being implemented here.

Implementation can go various routes, i.e. rigid base vs. elastic

base, absolute coordinates vs. relative coordinates, exciting individual base points vs. exciting only a reference point, recover complete base force response vs. echo only input force, include direct matrix input contributions to load vs. only G-set contributions, refine displacement response with Koo portion or not, recover stresses via relative coordinates vs. stresses via absolute coordinates, external generation of loads vs. internal assembly, inertia only loading vs. inertia, damping, and elastic loading.

The primary decision was to opt for internal assembly of loads. The scheme is this. Put the masses from the coupling partition MYR and the base masses MRR in the coefficient positions on the DAREA cards and put the base accelerations on TABLED1 cards. When these DAREA and TABLED1 data are delivered to the DPD module, they are multiplied together to produce the time varying forces on the individual grid points. The module RBTM (Rigid Body Transformation Matrix) was designed to determine the orientation of the inertias at local grid points with respect to the orientation of the acceleration field operating on the base points. Acceleration field orientation is defined in terms of the basic coordinate system, consequently RBTM constructs the transformation between points of the structure in their global system and a nominal point in the basic system. This Gx6 transformation matrix [HAICH] is partitioned to Rx6 matrix [HRX6]. When the base partitions of the mass matrix [MRY] and [MRR] are multiplied into [HRX6], inertia terms coupled to the base points are picked up according to their orientations to form the spatial coefficients on DAREA loading cards.

$$\begin{bmatrix} MYR \\ --- \\ MRR \end{bmatrix} [HRX6] = [MSEIS]$$

The module NRTS was written to take the masses, as organized in MSEIS, to deploy them in DAREA format, and finally to assemble them into the sections reserved for them in the DYNAMICS data block amongst the loads that were assembled earlier into DYNAMICS by the IFP module.

Refer to equation (7) and note that the full matrices for M, B, and K cannot be delivered to the NASTRAN chain of matrix condensation without first removing those partitions which are no longer part of the L.H.S. in the equations of equilibrium. The solution will be essentially that of a free body with loads on base points responding in absolute coordinates. Base points will be allowed to be excited in all 6 dof's. Single point constraints imply that points are to be held fixed with respect to coordinates fixed in space, but this is almost physically impossible to do since the ground on which the structure is mounted is also suffering a seismic disturbance. A mechanical connection would be needed to tie the constrained points to the reference frame to maintain zero absolute displacement. But this frame would need to be outside the seismic zone in order to be free of seismic disturbance. Such a mechanical tie is physically unrealistic. The technique, developed here, for the direct method will allow a flexible base with each of its points

to be independently excited. All contributions to base forces will be recovered by implementating equation (8) completely. No contribution to loading from masses defined with DMIG input has been implemented. Every permitted form of damping in R.F. 9 is operational in this seismic analysis.

The modules of rigid format 9 are allowed to process the matrices, prepared as shown above for the L.H.S., down through the DPD module without intervention. When module GKAD goes into operation, it processes the DMIG matrices and assembles the E-points with the G-set to create the P-set. Here the full set of partitions indicated in equation (2) are restored to the system before condensing the P-set to D-size for solution.

The complete expression for the first step in the recovery of displacements from the condensed dynamic solution is:

$$\{UO\} = [GOD]\{UD\} + \{UOO\}, \text{ where } \{UOO\} = [KOO]^{-1}\{POT\}.$$

Currently in the four dynamics rigid formats the $\{UOO\}$ term is omitted from the data recovery sequence. An option is provided to include the $\{UOO\}$ term under the control of the parameter URFIN. Provision for this option was implemented by modifying the TRLG module to include the POT partition of the load vector PPT in its output complement. The strategy used was to allow the recovery of the uncorrected UPV response to proceed in module SDR1 from D-size back up to P-size, but then provide a correction following this step and add it to the UPV vector after it leaves module SDR1.

Several intermediate steps are necessary to recover this incremental correction to P-size to make it commensurable for adding to UPV. DMAP module SOLVE is called upon to find UOO from POT and KOO. UOO is first inflated to FE size by adding zeroes in the positions of the D-set, and then inflating to NE size.

$$\left\{ \begin{array}{c} 0 \\ \hline UOO \end{array} \right\} \implies \{UOOFE\} \qquad\qquad \left\{ \begin{array}{c} 0 \\ \hline UOOFE \end{array} \right\} \implies \{UOONE\}$$

The correction for multi-point contraints is applied next.

$$[GMD]\{UOONE\} = \{UOOM\}$$

The final P-sized correction is obtained by merging the M partition with the NE partition.

$$\left\{ \begin{array}{c} UOONE \\ \hline UOOM \end{array} \right\} \implies \{UOOP\}$$

UOOP is a vector of time varying translations only. Before the correction can be applied to UPV, it has to be converted to the same format as UPV; i.e., a column of translations followed by a column of velocities followed by a column of accelerations for every output time step. The module KREKU was written to differentiate UOOP twice, and reformat it, then add it to UPV.

Stress recovery becomes critical when a problem deals with large displacements, because the first step is the calculation of strain, which involves finding small differences between large numbers. In order to alleviate this hazard, it was decided to transform the response to relative coordinates before computing strains. To implement this idea, one point of the base is arbitrarily selected as a reference point. The absolute response of this one point is partitioned from the total solution. A rigid body transformation from this reference point gives the rigid body motion of the entire structure due to base forcing of this one point. This is not necessarily the true rigid body motion of the whole structure, because the selection of the single reference point was arbitrary and in the actual case many points could have been independently excited. This is of no consequence, because the purpose is not necessarily to determine the true rigid body motion, but to establish numbers on the order of rigid body motion to subtract uniformly from the absolute motion of every point so as to reduce the resulting quantities when differenced for strain computations. This is a correct procedure for all points except E-points. Because they are not geometric points, there is no such thing as a rigid body transformation of E-points. Therefore, E-points are excluded from the transformation to relative coordinates by partitioning from UPV before applying the transformation. The E-partition is merged back with the relative solution to restore it to P-size to satisfy the needs of the recovery module SDR2. The steps are:

$$\{UPV\} \implies \left\{ \begin{array}{c} UEV \\ \hline UGV \end{array} \right\}$$

$$\{UDVT\} \implies \left\{ \begin{array}{c} 0 \\ \hline UVWJVT \end{array} \right\}$$

$$[HGTOJ]\{UVWJVT\} = \{UGRIGD\}$$

$$\{UGV\} - \{UGRIGD\} = \{RELUGV\}$$

$$\left\{ \begin{array}{c} UEV \\ \hline RELUGV \end{array} \right\} \implies \{RELUPV\}. \quad \{RELUPV\} \text{ goes to SDR2 for stress recovery.}$$

Even though {UR} and p{UR} are known and even though force develops from known damping when multiplied into known velocity and force develops from known elasticity when multiplied into known translations, one cannot declare a known forcing function in this case. Damping and elastic forces arise from differences in motion between pairs of points and the history of only one of the two paired points is known. The history of the other of the two points has to be solved for before damping and elastic boundary forces can be determined. With an elastic base, however, differences in motion between pairs of points can be foretold and consequently damping and elastic boundary forces amongst pairs in the R-set can be gathered on the RHS as boundary forces. The lower partition of equation (7) would be augmented to this degree of adding these forces to both sides of the equation.

$$\left[\begin{bmatrix} MYY & 0 \\ \hline 0 & MRR \end{bmatrix} p^2 + \begin{bmatrix} BYY & BYR \\ \hline 0 & BRR \end{bmatrix} p + \begin{bmatrix} KYY & KYR \\ \hline 0 & KRR \end{bmatrix} \right] \left\{ \begin{matrix} UY \\ \hline UR \end{matrix} \right\} = \left\{ \begin{matrix} PY - [MYR]p2\{UR\} \\ \hline [MRRp2 + BRRp + KRR]\{UR\} \end{matrix} \right\} \quad (7A)$$

Equation (8) would remain for the recovery of base forces. No provision has been made in TBLGEN for preparing velocity and translation tables so an entirely elastic formulation has not been implemented in this task as equation (7A) was not followed; however, the groundwork has been laid for eventual implementation. What we have at this point is an elastic base subject to independent time distribution of accelerations over the base. This work in effect has provided an extension beyond that contracted for in that it goes beyond a purely rigid base for inertia forcing. In a rigid base, all points would move synchronously. That restriction has been lifted for inertia loading so that individual time histories with individual time delays at points can be assembled. This is well beyond the rigid body restriction.

The effect on solution times should be addressed. Notice the character of the coefficient matrices M, B, & K in equation (7). M is symmetric but B and K are unsymmetric. As a result, unsymmetric decomposition will be called for during the integration of this equation. Running times can be as much as 4 times longer than the time for similar problems formulated with symmetric matrices, depending on the extent of the coupling terms.

MODAL THEORY

The set of base points for the modal approach are constrained to zero displacement in all 6 d.o.f.'s and loading takes place as a consequence of the inertia reaction of all points extending beyond the base due to the rigid synchronous motion of the base. If recovery of absolute acceleration is required, a reference point is needed at the base which is not clamped (as all other base points are) so as to supply the input base motion in a NASTRAN data block organized in the same time intervals that the response results are in. This can be obtained by choosing a location that is to be used for reference; then duplicating this point and excluding it from the set of constrained base points. Associate unity inertia with each of the 6 d.o.f.'s for this reference point with a CONM2 bulk data card. Make an elastic connection to a

grounded point with a BAR element. This reed is completely disjoint from the primary structure. Put the point of the tip of this reed—that lies in the plane of the base—in the R-set by using the SUPORT bulk data card. Partition equation (3) into these components. First partition with respect to the base points; call these the B-set and call the complement of B-set with respect to G-set the X-set.

$$
\left[\begin{bmatrix} MXX & MXB \\ \hline MBX & MBB \end{bmatrix} p^2 + \begin{bmatrix} BXX & BXB \\ \hline BBX & BBB \end{bmatrix} p + \begin{bmatrix} KXX & KXB \\ \hline KBX & KBB \end{bmatrix} \right] \begin{Bmatrix} UX \\ \hline UB \end{Bmatrix} = \begin{Bmatrix} PX \\ \hline PB \end{Bmatrix} \tag{9}
$$

Next, partition the R-set from the X-set. Name the set that is the complement of the R-set with respect to the G-set the Y-set. And name the set that is the complement of the R-set with respect to the X-set the C-set.

$$
\left[\begin{bmatrix} MCC & MCR & MCB \\ MRC & MRR & MRB \\ MBC & MBR & MBB \end{bmatrix} p^2 + \begin{bmatrix} BCC & BCR & BCB \\ BRC & BRR & BRB \\ BBC & BBR & BBB \end{bmatrix} p + \begin{bmatrix} KCC & KCR & KCB \\ KRC & KRR & KRB \\ KBC & KBR & KBB \end{bmatrix} \right] \begin{Bmatrix} UC \\ UR \\ UB \end{Bmatrix} = \begin{Bmatrix} PC \\ PR \\ PB \end{Bmatrix} \tag{10}
$$

Introduce a relative set of coordinates between the reference point in the R-set and other parts of the structure with the capability of expressing total motion as being composed of that due to the motion of the base plus that due to the deformation with respect to the base; i.e., rigid body motion plus relative motion. Make three separate definitions for the three sets C, R, and B. First the C-set.

$$
\{UC\} = [HCR]\{UR\} + \{Uv\} \tag{11}.
$$

In words this equation says: the displacement of points in the C-set extending away from the reference point in the base consists of the rigid body motion of the C-set due to the enforced motion of the reference point [HCR]{UR} plus the deformation of the C-set away from the base reference {Uv}, where [HCR] is the rigid body transformation matrix between the R-set and the C-set. Next the R-set.

$$
\{UR\} = [IRR]\{UR\} \tag{12}.
$$

Base reference motion is equal to itself, where [IRR] is the identity matrix for the R-set. Third the B-set.

$$
\{UB\} = [HBR]\{UR\} + \{Ue\} \tag{13}.
$$

The displacement of points in the B-set, lying entirely in the base, consists of the rigid body motion of the B-set due to the enforced motion of the reference point [HBR]{UR} plus the deformation of the B-set away from the reference point {Ue}, where [HBR] is the rigid body transformation matrix between the R-set and the B-set. Impose the rigid body condition that there is no elastic deformation of the base; i.e., {Ue} = 0, which says that the base position is always known in terms of

the motion of the reference point. Combine these 3 statements into a single matrix.

$$\{UG\} = \begin{Bmatrix} UC \\ -- \\ UR \\ -- \\ UB \end{Bmatrix} = \begin{bmatrix} Ivv & HCR & 0 \\ \hline 0 & IRR & 0 \\ \hline 0 & HBR & Iee \end{bmatrix} \begin{Bmatrix} Uv \\ -- \\ UR \\ -- \\ Ue \end{Bmatrix} \qquad (14).$$

The product [Iee]{Ue} = 0; set the deformation {Ue} null. Retention of [Iee] preserves the integrity of the coefficient matrices for proper handling internally within NASTRAN. Apply this transformation matrix to the dynamic equation.

$$\left[\begin{bmatrix} MCC & MCR & MCB \\ \hline MRC & MRR & MRB \\ \hline MBC & MBR & MBB \end{bmatrix} p^2 + \begin{bmatrix} BCC & BCR & BCB \\ \hline BRC & BRR & BRB \\ \hline BBC & BBR & BBB \end{bmatrix} p + \begin{bmatrix} KCC & KCR & KCB \\ \hline KRC & KRR & KRB \\ \hline KBC & KBR & KBB \end{bmatrix} \right] \begin{bmatrix} Ivv & HCR & 0 \\ \hline 0 & IRR & 0 \\ \hline 0 & HBR & Iee \end{bmatrix} \begin{Bmatrix} Uv \\ -- \\ UR \\ -- \\ Ue \end{Bmatrix} = \begin{Bmatrix} PC \\ -- \\ PR \\ -- \\ PB \end{Bmatrix} (15)$$

Expand and recombine:

$$\left[\begin{bmatrix} (MCC^{\cdot}Ivv+MCR^{\cdot}0+MCB^{\cdot}0)(MCC^{\cdot}HCR+MCR^{\cdot}IRR+MCB^{\cdot}HBR)(MCC^{\cdot}0+MCR^{\cdot}0+MCB^{\cdot}Iee) \\ (MRC^{\cdot}Ivv+MRR^{\cdot}0+MRB^{\cdot}0)(MRC^{\cdot}HCR+MRR^{\cdot}IRR+MRB^{\cdot}HBR)(MRC^{\cdot}0+MRR^{\cdot}0+MRB^{\cdot}Iee) \\ (MBC^{\cdot}Ivv+MBR^{\cdot}0+MBB^{\cdot}0)(MBC^{\cdot}HCR+MBR^{\cdot}IRR+MBB^{\cdot}HBR)(MBC^{\cdot}0+MBR^{\cdot}0+MBB^{\cdot}Iee) \end{bmatrix} p^2 + \right.$$

$$\begin{bmatrix} (BCC^{\cdot}Ivv+BCR^{\cdot}0+BCB^{\cdot}0)(BCC^{\cdot}HCR+BCR^{\cdot}IRR+BCB^{\cdot}HBR)(BCC^{\cdot}0+BCR^{\cdot}0+BCB^{\cdot}Iee) \\ (BRC^{\cdot}Ivv+BRR^{\cdot}0+BRB^{\cdot}0)(BRC^{\cdot}HCR+BRR^{\cdot}IRR+BRB^{\cdot}HBR)(BRC^{\cdot}0+BRR^{\cdot}0+BRB^{\cdot}Iee) \\ (BBC^{\cdot}Ivv+BBR^{\cdot}0+BBB^{\cdot}0)(BBC^{\cdot}HCR+BBR^{\cdot}IRR+BBB^{\cdot}HBR)(BBC^{\cdot}0+BBR^{\cdot}0+BBB^{\cdot}Iee) \end{bmatrix} p +$$

$$\left. \begin{bmatrix} (KCC^{\cdot}Ivv+KCR^{\cdot}0+KCB.0)(KCC^{\cdot}HCR+KCR^{\cdot}IRR+KCB^{\cdot}HBR)(KCC^{\cdot}0+KCR^{\cdot}0+KCB^{\cdot}Iee) \\ (KRC^{\cdot}Ivv+KRR^{\cdot}0+KRB^{\cdot}0)(KRC^{\cdot}HCR+KRR^{\cdot}IRR+KRB^{\cdot}HBR)(KRC^{\cdot}0+KRR^{\cdot}0+KRB^{\cdot}Iee) \\ (KBC^{\cdot}Ivv+KBR^{\cdot}0+KBB^{\cdot}0)(KBC^{\cdot}HCR+KBR^{\cdot}IRR+KBB^{\cdot}HBR)(KBC^{\cdot}0+KBR^{\cdot}0+KBB^{\cdot}Iee) \end{bmatrix} \right] \begin{Bmatrix} Uv \\ UR \\ Ue=0 \end{Bmatrix}$$

$$= \begin{Bmatrix} PC \\ PR \\ PB \end{Bmatrix} \quad (16)$$

Observe that [Ijj] [MTX] = [MTX]. Delete zero products. Rewrite.

$$\left[\begin{bmatrix} MCC & (MCC^{\cdot}HCR + MCR^{\cdot}IRR + MCB^{\cdot}HBR) & MCB \\ MRC & (MRC^{\cdot}HCR + MRR^{\cdot}IRR + MRB^{\cdot}HBR) & MRB \\ MBC & (MBC^{\cdot}HCR + MBR^{\cdot}IRR + MBB^{\cdot}HBR) & MBB \end{bmatrix} p^2 + \right.$$

$$\begin{bmatrix} BCC & (BCC^{\cdot}HCR + BCR^{\cdot}IRR + BCB^{\cdot}HBR) & BCB \\ BRC & (BRC^{\cdot}HCR + BRR^{\cdot}IRR + BRB^{\cdot}HBR) & BRB \\ BBC & (BBC^{\cdot}HCR + BBR^{\cdot}IRR + BBB^{\cdot}HBR) & BBB \end{bmatrix} p +$$

$$\left. \begin{bmatrix} KCC & (KCC^{\cdot}HCR + KCR^{\cdot}IRR + KCB^{\cdot}HBR) & KCB \\ KRC & (KRC^{\cdot}HCR + KRR^{\cdot}IRR + KRB^{\cdot}HBR) & KRB \\ KBC & (KBC^{\cdot}HCR + KBR^{\cdot}IRR + KBB^{\cdot}HBR) & KBB \end{bmatrix} \right] \begin{Bmatrix} Uv \\ UR \\ Ue=0 \end{Bmatrix} = \begin{Bmatrix} PC \\ PR \\ PB \end{Bmatrix} \quad (17)$$

Interpret the term [BCC][HCR]p{UR}. Move the operator ahead of the constant matrix and look first at just the product [HCR]{UR}. This says that the position of the coordinates {UC} are precisely known according to the movement of coordinate {UR} by obeying the proscription of matrix [HCR]. This implies that as time goes by (p{UC} − p{UR}) remains invariant. The development of force within a damper depends on change in the relative positions of connecting points. Consequently, the complete term [BCC][HCR]p{UR} says that since BCC sees no change in (p{UC} − p{UR}), no force develops. The reasoning applies to all damping and elastic terms that are post multiplied by [HiR]{UR}. All of these null contributions can be removed from the dynamic equation.

Apply these observations and the dynamic equation becomes

$$
\left[\begin{bmatrix} MCC & (MCC^\cdot HCR + MCR^\cdot IRR + MCB^\cdot HBR) & MCB \\ MRC & (MRC^\cdot HCR + MRR^\cdot IRR + MRB^\cdot HBR) & MRB \\ MBC & (MBC^\cdot HCR + MBR^\cdot IRR + MBB^\cdot HBR) & MBB \end{bmatrix} p^2 + \begin{bmatrix} BCC & BCR & BCB \\ BRC & BRR & BRB \\ BBC & BBR & BBB \end{bmatrix} p + \right.
$$

$$
\left. + \begin{bmatrix} KCC & KCR & KCB \\ KRC & KRR & KRB \\ KBC & KBR & KBB \end{bmatrix}\right] \left\{\begin{matrix} Uv \\ UR \\ Ue=0 \end{matrix}\right\} = \left\{\begin{matrix} PC \\ PR \\ PB \end{matrix}\right\} \quad (18)
$$

Now interpret the inertia terms. The first term in parentheses

[MCC][HCR]p^2{UR} says that all inertias on the C-coordinates provide a force contribution to the dynamic equilibrium in the C-coordinates proportional to the amount of rigid body acceleration produced in the C-coordinates by enforced motion of the reference point. Skip the next

quantity in parentheses and look at the term [MCB][HBR]p^2{UR}. It says that all inertias on the C-coordinates due to coupling with the B coordinates provide a force contribution to the dynamic equilibrium in the C-coordinates proportional to the amount of rigid body acceleration acting in the B coordinates defined by the enforced motion of the reference point. Note that each part of these two products are known--the inertias, the transformation and the acceleration. These constitute the inertia loading of the structure. These two terms can be transformed to the R.H.S. of the equation as part of the known loading on the C-coordinates.

Before interpreting other inertia terms, reflect on the purpose of the reed scaffold that was synthetically introduced into the problem. The tip of the reed was to respond in exactly the same way that it was excited. The tip was given a mass and only that mass was to be accelerated with the loading specification.

106
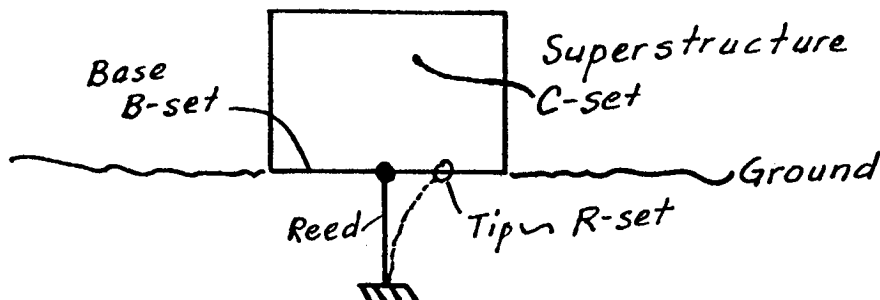
Looking at the diagram, one sees that the tip of the reed is the only thing in the R-set. If the user chooses to put intermediate points on the reed, those points would be grouped with the C-set. If the mass on the tip of the reed were supplied as a CONM2, and if the reed from tip to ground were massless, then the mass matrix for the reed would consist of the partition MRR only and would be devoid of MCR and MBR and so would their transposes; i.e., no mass coupling between the R-set and either the C or B sets. Apply these observations to the dynamic equation. The reed could also be modeled with no damping coupling between the C and R sets, but this is not mandatory. There would be no conceivable utility to have either damping or elastic coupling between the B-set and the R-set, however.

$$
\begin{bmatrix} \begin{bmatrix} MCC & MCR=0 & MCB \\ MRC=0 & MRR & MRB=0 \\ MBC & (MBC^{\cdot}HCR + MBR=0 + MBB^{\cdot}HBR) & MBB \end{bmatrix} p^2 + \begin{bmatrix} BCC & BCR & BCB \\ BRC & BRR & BRB \\ BBC & BBR & BBB \end{bmatrix} p + \\ \begin{bmatrix} KCC & KCR & KCB \\ KRC & KRR & KRB \\ KBC & KBR & KBB \end{bmatrix} \end{bmatrix} \begin{Bmatrix} Uv \\ UR \\ Ue=0 \end{Bmatrix} = \begin{Bmatrix} PC - [MCC^{\cdot}HCR + 0 + MCB^{\cdot}HBR] p^2 \{UR\} \\ PR \\ PB \end{Bmatrix} \quad (19)
$$

There are two things to notice at this point. First, all coefficient matrices are symmetric except the 3-2 term in the mass matrix. Second, the {PR} load on the reed mass is not defined. As to the first, the assymmetry comes about in the recovery of base loading. The unsymmetric [MBC$^{\cdot}$HCR + MBB$^{\cdot}$HBR] quantities need not be introduced during the solution phase of the execution. They can be introduced during data recovery. This is not a case of illegal tampering, because when the base constraints are imposed during the solution phase, the B-partition in relative coordinates is dormant (that is fully constrained by an SPC condition). Symmetry in the coefficient matrices can be preserved during the solution phase and all the solution efficiencies associated with symmetric matrices can be enjoyed.

Inflate MSIZB with zeroes in the Y positions to bring it to G-size

[0:MSIZB] ==> [MBRG].

If MBCG and MBRG are added, it will leave the resulting matrix null in the B positions. Since the {Ue} vector of relative displacements in the B-set is zero, it does not matter in equation (27) if the elements in the coefficient matrix to these terms is null.

[MBCG] + [MBRG] = [MFBG].

The technique that NASTRAN uses in the solution by the transient method is to handle the responses in displacements, velocities, and accelerations by combining them into a triplet at every time step. Notice in equation (23) that the accelerations, velocities, and displacements operate independently to recover base response forces. Consequently, the UPV matrix of solution responses will have to be split from their triplet format. The module KREKU

was written to do this job. It puts out 3 G-sized time varying components.
Now comes an explanation for setting up the auxiliary reed structure. Since
all base points were fully constrained to zero, they are not available as a
reference for the {UR} vector in equation (11). The mass at the tip of the
reed is co-located with one point chosen from the set of base points, and it
is accelerated with the specified time history—as the unconstrained mass
points in the principal structure are. A unit diagonal mass matrix is
assigned to the reed tip in the bulk data with a CONM2 card. When the load on
the tip of the reed is formed, it is numerically equal to the seismic
acceleration. Thus the R partition of the load vector PRT contains the
acceleration converted to a NASTRAN data block.

Partition the load vector on the reference point PRT from the
vector of loads on all physical points PPT.

$$\{PPT\} \implies \left\{ \begin{array}{c} PZT \\ \hline PRT \end{array} \right\}$$

In order to get the effect of absolute motion in the recovery of base forces,
the exciting acceleration needs to be restored to the R-set. Partition ACGVT
as it is output from KREKU and retain only the Y-set (ACYVT). Then merge in
the base acceleration PRT to restore the acceleration to G-size.

$$\{ACGV\} \stackrel{GYVEC}{\implies} \left\{ \begin{array}{c} ACYVT \\ \hline \end{array} \right\} \quad ; \quad \left\{ \begin{array}{c} ACYVT \\ \hline PRT \end{array} \right\} \stackrel{GYVEC}{\implies} \{ACCG\}$$

Form the base forcs from inertias per equation 27 with PRT substituted for UR.

[MFBG] [ACCG] = Base Inertia Forces,

and next the elastic component,

[KBG] [DIGV] = Base Elastic Forces.

Note, damping defined in terms of grid point partitions are available only
through DMIG input. Modal damping B(omega) is not available for base force
recovery, because it is not defined in terms of geometric coordinates. The
B2PP matrix can be partitioned and can be used for recovery of base forces
from

[B2BG] [VEGV] = Base Damping Forces.

All 3 forces sum to BASEF and are attached to the PPT vector for output
processing. Therefore, to get a listing of base force response, the user
inserts a command for OLOAD to include base points.

$$\{UGV\} \implies \left\{ \begin{array}{c} UYV \\ \hline URV \end{array} \right\}.$$ UYV is the relative response on the Y-coordinates.

Merge zeroes into UYV in the R-set locations to get a G-sized relative
response vector.

$$\left\{\begin{array}{c} UYV \\ \hline 0 \end{array}\right\} ==> \{UGREL\}$$

Now use the rigid body transformation matrix with respect to the reference point HAICH and reconstruct absolute response in accordance with equation (11).

$$\{UABSG\} = [HAICH]\{URV\} + \{UGREL\}.$$

Merge the E-partition back onto the G-set to get a P-sized absolute response vector ready to complete processing in modules SDR2, OFP, and PLOT. This method works only if the reed has a frequency content to match that of the load. Lacking sufficient spectral content in the reed gives values for URV far less than those of the input specification. This puts too much burden on the analyst to model the reed well for each different loading. Consequently, a substitute method has been implemented that is repeatable and dependable and is independent of the skill of the analyst. The method, however, is less general. Only absolute accelerations can be recovered instead of absolute displacements, absolute velocities and absolute accelerations. Tests were successful in producing the tabulations of load at the required solution time intervals. Since unity mass is to be used, these loads are numerically identical to the forcing accelerations and are therefore quite suitable as a set of reference values for recovery of absolute acceleration in the required organization to suit NASTRAN's bookkeeping.

Begin the process of recovering absolute accelerations by inflating the Y partittion of response with zeroes in the R-positions back to G-size.

$$\left\{\begin{array}{c} ACYVT \\ \hline 0 \end{array}\right\} \overset{GYVEC}{==>} \{RELACG\}$$

Use rigid body transformation between the reference R-set and all other points in the structure to reconstruct the rigid body accelerations throughout the structure, then add the relative accelerations to this result to obtain the absolute accelerations.

$$[HAICH]\{PRT] + \{RELACG\} = \{ABSACG\}.$$

Inflate ABSACG back to P-size and back to triplet format so as to be able to make the resulting ABSACPT data block acceptable to data recovery modules SDR2 and SDR3 and OFP for final output processing.

The resulting absolute accelerations can be passed to the XYPLOT module for answering plot requests in Case Control. DMAP alters have been incorporated into the seismic packet to accomplish this.

For the first time as a result of implementing this theory there is an acceleration loading capability in the public domain. In the following pages are packets of the DMAP ALTER's that were written to splice this capability into the four dynamic rigid formats.

```
$           DMAP ALTER PACKET PERTAINING TO R.F. 8 SIESMIC ANALYSIS
$                            SOLN8I.TXT
$
$SOLUTION TAKES PLACE IN ABSOLUTE COORDS IN THE FN. RESP. DIRECT RIGID
$
$FORMAT.   ALL COMPONENTS OF BASE POINTS TO BE ACCELERATED ARE ASSIGNED
$
$TO THE R-SET THRU THE USE OF THE SUPORT CARD.
$
$ASSIGN DAREA ID'S ON BULK PARAM NRTID# CARDS AND RLOAD CARDS.   ASSIGN
$
$TABLED1 ID'S TO RLOAD CARDS AND TO TABLED1 CARDS DIRECTLY OR TO TBLGEN
$
$FOR THE FOR THE DISPLACEMENT HISTORIES.   NRTID#'S WILL BE PICKED UP BY
$
$MODULE NRTS FOR INTERNAL GENERATION OF DAREA CARDS GIVING THE DISTRI-
$
$BUTION OF MASS MAGNITUDES.   THESE INTERNALLY GENERATED DAREA CARDS WILL
$
$BE PICKED UP BY THE RLOAD CARD FOR MULTIPLICATION AND ASSEMBLY WITH THE
$
$DISPLACEMENT HISTORIES THAT RLOAD PICKS UP FROM TABLED1 CARDS.
$
$SPC'S (ON OTHER THAN THE GRID CARDS) ARE PHYSICALLY UNREALISTIC, BE-
$
$CAUSE THEY RELATE TO ABSOLUTE COORDINATES WHICH IMPLIES BEING FIXED
$
$OUTSIDE THE SEISMIC ZONE.
$
$TWO OPTIONS ARE AVAILABLE:   REFINEMENT OF THE DISPLACEMENT RESPONSE BY
$
$   INCLUDING THE RECOVERY OF THE KOO PORTION OF THE O-SET, AND THE RE-
$
$   COVERY OF BASE FORCES WHICH REACT THE SPECIFIED INPUT TIME HISTORIES.
$
$FOR THE RECOVERY OF STRESSES, ONE OF THE POINTS IN THE R-SET MUST BE
$
$   NAMED ON A PARAM GRDPNT CARD TO BE USED AS A RIGID BODY REFERENCE FOR
$
$   SUBTRACTING THE LARGE BASE MOTION FROM ALL POINTS SO AS TO KEEP ALL
$
$   DIFFERENCING FORSTRESS RECOVERY A MATTER OF MUCH SMALLER NUMBERS.
$
$PARAMETER DEFINITIONS:
$
$NRTID1,2,3= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$           SPATIAL ARRANGEMENT OF INERTIAS ASSOCIATED WITH TRANSLATIONAL
$           ACCELERATIONS IN THE FIRST, SECOND, & THIRD COORD DIRECTIONS.
$NRTID4,5,6= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$           SPATIAL ARRANGEMENT OF INERTIAS ASSOCIATED WITH ROTATIONAL
$           ACCELERATIONS ABOUT THE FIRST, SECOND, & THIRD COORD DIRECTIONS.
```

$URFIN WHEN SET < OR = -1 ENABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$ MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.
$ WHEN SET > OR = 0 DISABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$ MENTS WITH CONTRIBUTIONS OMITTED SETS.   DEFAULT = + 1.
$QRFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER BASE FORCES FROM
$ STIFFNESS, DAMPING, & MASS COUPLING AND FROM BASE INERTIAS.
$ WHEN SET > OR = 0 DISABLES THE OPTION TO RECOVER THIS COMPONENT OF
$ BASE FORCE.   DEFAULT = + 1.
$GRDPNT IS DECLARED AS THE REFERENCE GP ON THE PARAM GRDPNT CARD.
$$***
$ USER PREPARATIONS   *
$ *
$ USER MUST SUPPLY SUPORT CARD FOR ALL EXCITED BASE POINTS   *
$ PARAM GRDPNT BASE REFERENCE POINT (ONE OF R-SET) *
$ PARAM NRTID(1-6) FOR DAREA REGARDING ACCELERATIONS*
$ RLOAD OF ACCEL FOR ALL BASE POINTS   *
$ ID's TO TBLGEN FOR TABLES OF ACCEL   *
$ USER MAY OVERIDE PARAM URFIN OPTION FOR KOO REFINEMENT   *
$ PARAM QRFIN OPTION FOR RECOVERY OF BASE REACTIONS *
$ USER MAY SUPPLY RLOAD FOR DIRECT LOAD ON ALL PTS XCP R-SET   *
$ E-POINTS FOR TFL   *
$ DAMPING TYPES VISC, DMIG(B2PP), MAT(G), OR AVG(G) *
$ *
$$***

```
ALTER   63 $ JUST BEFORE MCE
PARAM       //*NOT*/V,N,SEISLD/V,N,REACT $
COND        SYMX,SEISLD $
JUMP        FINIS  $
LABEL       SYMX  $
```
$$ CALL IN RBTM AT THIS POINT TO ACT AS A VEHICLE FOR ROUTING LOADS TO
$$ ALL POINTS WHICH ARE COUPLED TO THE BASE THROUGH INERTIA.
$$
```
RBTM        BGPDT,CSTM,EQEXIN,,USET/HAICH,,H1RY6,/C,Y,GRDPNT/+1/*DIRECT* $
```
$$
$$ NOTICE GRDPNT IS USED HERE AS A REFERENCE FOR TRANSFORMING FROM
$$ GLOBALTO BASIC COORDINATES AND AS A REFERENCE TO RECOVER STRESSES
$$ IN A QUASIRELATIVE COORDINATE SYSTEM.   IT IS NOT DECLARED OUTRIGHT
$$ AS A TRULY RELATIVE COORDINATE SYSTEM BECAUSE THE SELECTION OF THE
$$ REFERENCE GRID-POINT IS LEFT UP TO THE USER AS AN ARBITRARY CHOICE.
$$ THE STRESSES WILL BE THE SAME REGARDLESS OF THE POINT CHOSEN AS REF.
$$
```
VEC         USET/GYVEC/*G*/*COMP*/*R* $ 1'S ON R.  Y=R(COMP)G
COPY        GYVEC/GY1VEC $
PARTN       HAICH,,GYVEC/,HRX6,,/5/0 $ FRACTION OFF THE R ROWS OF HAICH.
```
$$
$$ THE HRR TRANSFORMATION MATRIX WILL BE USED BELOW IN THE DAREA
$$ PREPARATION SECTION

```
$$
$$REMOVE THE INERTIA COUPLING TERMS FROM THE LEFT HAND SIDE WHICH ARE
$$BEING USED ON THE RHS.   THE ZR INERTIA COUPLING TERMS MUST NOT BE
$$CONDENSED INTO THE DD SET, SO THE YR INERTIA COUPLING TERMS MUST BE
$$PARTITIONED OUT BEFORE MCE.   WHILE SO DOING THE WHOLE MATTER OF
$$SETTING UP THE EQUATION IN Y-ROWS AND R-ROWS CAN ALL BE DONE AT ONE
$$SITTING.
$******************ELASTICITY*********************************************
PARTN      KGG,GYVEC,  /KYY,KRY,KYR,KRR/-1/2/6/2/2/6 $
MERGE      KYY,,KYR, ,GYVEC,GYVEC/TKGG/+1/2/1 $ FOR CONDENSATION
MERGE      KRY,,KRR,,GYVEC, /KRG/5/2/2 $ FOR BASE FORCES
$*****************MASS***************************************************
PARTN      MGG,GYVEC,  /MYY,MRY,MYR,MRR/-1/2/6/2/2/6 $
MERGE      MYY,,,MRR,GYVEC, /TMGG/-1/2/6 $ FOR CONDENSATION
MERGE      MRY,,MRR,,GYVEC, /M1RG/5/2/2 $ FOR BASE FORCES
$***************VISCOUS DAMPING******************************************
PARTN      BGG,GYVEC,  /BYY,BRY,BYR,BRR/-1/2/6/2/2/6 $
MERGE      BYY,,BYR,,GYVEC,GY1VEC/TBGG/+1/2/1 $ FOR CONDENSATION
MERGE      BRY,,BRR,,GYVEC, /B1RG/5/2/2 $ FOR GASE FORCES
$***************DISTRIBUTED DAMPING**************************************
PARTN      K4GG,GYVEC,  /K4YY,K4RY,K4YR,K4RR/-1/2/6/2/2/6 $
MERGE      K4YY,,K4YR,,GYVEC,GY1VEC/TK4GG/+1/2/1 $ FOR CONDENSATION
MERGE      K4RY,,K4RR,,GYVEC,  /K4RG/5/2/2 $ FOR BASE FORCES
$***************SUMMARY**************************************************
$***************SUMMARY**************************************************
EQUIV      TKGG,KGG/SEISLD/TMGG,MGG/SEISLD/TBGG,BGG/SEISLD/
           TK4GG,K4GG/SEISLD $ FOR CONDENSATION OF STRUCTURAL MATRICES
$$NOW THAT THE INERTIA MATRIX HAS HAD THE YR COUPLING TERMS REMOVED,
$$CONDENSATION DOWN TO A-SIZE FOR GKAD CAN NOW BEGIN.
$
PARAMR     //*COMPLEX*/ /0.0/1.0/EYE/ / / $
PARAMR     //*COMPLEX*/ /1.0/C,Y,G/STRUD/ / / $
ADD        KRG,K4RG/K3RG/V,N,STRUD/V,N,EYE $ FOR BASE FORCES
$*****************PREPARE DAREA VALUES FOR DYNAMICS DATA BLOCK***********
MPYAD      MYR,HRX6, /MYY6/0/-1 $ NEGATIVE PRODUCT
MPYAD      MRR,HRX6, /MRR6/0/+1 $ POSITIVE PRODUCT
MERGE      MYY6,MRR6,,,,GYVEC/MSEIS/5/2/2 $  FOR LOAD
$***************LOAD SUMMARY*********************************************
ALTER   87 $ JUST BEFORE DPD
NRTS       MSEIS,DYNAMICS,EQEXIN/NRTSEIS/DEPOP/C,Y,NRTID1/C,Y,NRTID2/
           C,Y,NRTID3/C,Y,NRTID4/C,Y,NRTID5/C,Y,NRTID6 $
EQUIV      NRTSEIS,DYNAMICS/SEISLD $
$$   DATA BLOCK 'DYNAMICS' NOW HAS ALL DAREA ENTRIES FOR LOADING.
$$
ALTER 100 $ JUST AFTER MTRXIN.   PARTITION THE DMIG MATRICES.
VEC        USETD/PZVEC/*P*/*COMP*/*R* $ 1'S ON R.  Z=R,COMP,P.
COPY       PZVEC/PZ1VEC $
COND       AUTOM,NOM2PP $
PARTN      M2DPP,PZVEC, /M2DZZ,M2DRZ,M2DZR,M2DRR/-1/0/6/2/2/6 $
MERGE      M2DZZ,,,M2DRR,PZVEC, /TM2DPP/-1/0/6 $ FOR CONDENSATION
MERGE      M2DRZ,,M2DRR,,PZVEC, /M2DRP/5/0/2 $ FOR BASE FORCES
EQUIV      TM2DPP,M2DPP/SEISLD $ FOR CONDENSATION
LABEL      AUTOM $
```

```
COND        AUTOB, NOB2PP $
PARTN       B2PP, PZVEC, PZ1VEC/B2ZZ, B2RZ, B2ZR, B2RR/+1/0/0/0/0/0 $
MERGE       B2ZZ,, B2ZR,, PZVEC, PZ1VEC/TB2PP/+1/0/1 $ FOR CONDENSATION
MERGE       B2RZ,, B2RR,, PZVEC, /B2RP/5/0/2 $ FOR BASE FORCES
EQUIV       TB2PP, B2PP/SEISLD $ FOR CONDENSATION
LABEL       AUTOB $
COND        AUTOK, NOK2DPP $
PARTN       K2DPP, PZVEC, PZ1VEC/K2DZZ, K2DRZ, K2DZR, K2DRR/+1/0/0/0/0/0 $
MERGE       K2DZZ,, K2DZR,, PZVEC, PZ1VEC/TK2DPP/+1/0/1 $ FOR CONDENSATION
MERGE       K2DRZ,, K2DRR,, PZVEC, /K2DRP/5/0/2 $ FOR BASE FORCES
EQUIV       TK2DPP, K2DPP/SEISLD $ FOR CONDENSATION
LABEL       AUTOK $
$$$$$$$     GKAD TAKES CARE OF COMBINING THE REVISED MTRXIN DATA WITH
$$$$$$$      THE AUTO-STRUCTURAL MATRICES.
$$   GET MATRICES READY FOR BASE FORCE RECOVERY
ALTER 113
EQUIV       M1RG, M1RP/NOUE/B1RG, B1RP/NOUE/K3RG, K3RP/NOUE $
COND        BASEG, NOUE $
VEC         USETD/PGVEC/*P*/*G*/*E* $ 1'S ON E
$$   INFLATE RG MATRICES TO P-SIZE SO AS TO OPERATE WITH UPVC
MERGE       M1RG,,,, PGVEC, /M1RP/5/2/2 $
MERGE       B1RG,,,, PGVEC, /B1RP/5/0/2 $
MERGE       K3RG,,,, PGVEC, /K3RP/5/4/2 $
PURGE       M1RG, B1RG, K3RG/SEISLD $
LABEL       BASEG   $
EQUIV       M1RP, MRP/NOM2DPP/B1RP, BRP/NOB2PP/K3RP, KRP/NOK2DPP $
COND        BASO, NOM2DPP $
ADD         M1RP, M2DRP/MRP/ $
LABEL       BASO $
COND        BAS1, NOB2PP $
ADD         B1RP, B2RP/BRP/ $
LABEL       BAS1 $
COND        BAS2, NOK2DPP $
ADD         K3RP, K2DRP/KRP/ $
LABEL       BAS2 $
$$##@@!!*************************************************************************
$
ALTER 121, 121 $REPLACE FRRD
$
FRSLG       CASEXX, USETD, DLT, FRL, GMD, GOD, DIT, /PPF, PSF, PDF, POF, FOL, /
            *DIRECT*/FREQY=-1/APP=FREQ/S, N, FRQSET/S, N, NFREQ/
            S, N, NLOAD $
FRRD3       KDD, BDD, MDD, PDF, FRL/UDVF/C, N, DISP/C, N, DIRECT/
            V, N, NONCUP/FRQSET=2/V, N, NFREQ/V, N, NLOAD $
$
ALTER 123, 123 $ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE.
VDR         CASEXX, EQDYN, USETD, UDVF, FOL, XYCDB, /OUDVC1, /*FREQRESP*/
            *DIRECT*/S, N, SORT2/S, N, NOD/S, N, NOP/0 $ $
$ COMPUTE KOO REFINEMENT TO RESPONSE AND RECOVER BASE FORCES BEFORE
$ PROCESSING OUTPUT.
ALTER 139, 139 $
$$   DEFAULT VALUES OF PARAMETERS ARE SET HERE.     $
PARAM       //*NOP*/V, Y, QRFIN = + 1 $
PARAM       //*NOP*/V, Y, URFIN = + 1 $
```

```
PARAM      //*NOT*/XISTOMIT/OMIT $
PARAM      //*AND*/UORFIN/XISTOMIT/C,Y,URFIN $
COND       UMPRUV,UORFIN $
JUMP       UNRFIN $
LABEL      UMPRUV $
SOLVE      KOO,POF/RUOOF/0/+1/2/0 $
$RUOOF IS A VECTOR OF RELATIVE DISPLACEMENTS.   NO CONVERSION TO
$ ABSOLUTE COORDINATES IS NECESARY BECAUSE NASTRAN HAS ALREADY
$PROCESSED ONE CORRECTION FOR THE O-SET IN ABSOLUTE COORDINATES.
$INFLATE RUOOF TO P-SIZE TO BE COMMENSURATE WITH UPVC.
VEC        USETD/FEDVEC/*FE*/*D*/*O* $ 1'S ON O
MERGE,      ,RUOOF,,,,FEDVEC/UOOFFE/5/4/2 $
EQUIV      UOOFFE,UOOFNE/SINGLE $IT IS NOT ADVISABLE TO HAVE BOUNDARY
$ SPC'S IN THESE PROBLEMS.
COND       POSN1,SINGLE $
VEC        USETD/NEFEVEC/*NE*/*FE*/*S* $ 1'S ON S
MERGE      UOOFFE,,,,,NEFEVEC/UOOFNE/5/4/2 $
LABEL      POSN1 $
EQUIV      UOOFNE,UOOFP/MPCF1 $
COND       POSN2,MPCF1 $
MPYAD      GMD,UOOFNE, /UOOFM/0/+1 $
VEC        USETD/PNEVEC/*P*/*NE*/*M* $ 1'S ON M
MERGE      UOOFNE,UOOFM,,,,PNEVEC/UOOFP/5/4/2 $
LABEL      POSN2 $
ADD        UPVC,UOOFP/UMPRUVF/ $
EQUIV      UMPRUVF,UPVC/URFIN $
LABEL      UNRFIN $
$
$IF THE USER WANTS TO RECOVER BASE RESPONSE FORCES HE SETS QRFIN
$ = -1, HOWEVER IF HE SETS QRFIN=+1, ANY CASECC REQUEST FOR OLOAD
$ WILL CONTAIN ONLY THE EXCITATION INERTIA FORCES AND NOT THE TOTAL
$ SET OF BASE REACTIONS.
COND       OLOD,QRFIN $
JUMP       REGLR $
LABEL      OLOD $
$ THE RECOVERY OF BASE FORCES IS UNDER THE CONTROL OF CASECC OLOAD
$ REQUESTS.   A CALL TO KREKU AT THIS POINT WILL PROVIDE THE DIAGONAL
$ MATRIX [I*OMEGA] WHICH WILL BE USED TO DIFFERENTIATE RESPONSE
$ DISPLACEMENTS INTO VELOCITIES AND ACCELERATIONS BY MULTIPLYING IT
$ INTO UDVF BY IN SUCCEDDING OPERATIONS.
$
$ ARRANGE THE STRUCTURAL MATRICES FOR RECOVERY OF BASE RESPONSE
$ FORCES.   OF THE DAMPING AND ELASTIC MATRICES, ONLY THE COUPLED
$ PARTITION IS NON-ZERO.
$ WITH REGARD TO OTHER PARTITIONS OF BGG AND KGG, BECAUSE
$ [BRR]*[BASEACC] & [KRR]*[BASEACC] ACT ON RIGID MOTIONS WHICH
$ LEAVES ZERO DIFFERENTIAL AMONGST THE R SET, SO THE PRODUCTS ARE
$ NULL. THIS IS NOT THE CASE FOR INERTIA BECAUSE THEY ACT ON
$ [ISOLATED] GP MOTION AS OPPOSED TO [DIFFERENTIAL] GP MOTION
$
PARTN      PPF, ,PZVEC/PSIZF, , , /5/4/2 $
```

```
KREKU,      ,FOL,,/ ,IW,,,/V,N,OMIT/C,Y,QRFIN/*FREQRESP*/*DIRECT* $
MPYAD       UPVC,IW, /VEPVC/O/+1 $
SMPYAD      MRP,VEPVC,IW,,,/NRTCPLF/3/+1 $
PARAM       //*OR*/V,N,NO12B/NOBGG/NOB2PP $
COND        BAS3,NO12B $
MPYAD       BRP,VEPVC,NRTCPLF/TWOCPLF/O/+1/+1 $
EQUIV       TWOCPLF,NRTCPLF/SEISLD $
LABEL       BAS3 $
MPYAD       KRP,UPVC,NRTCPLF/BASPF/O/1/1 $
MERGE       PSIZF,BASPF,,,,PZVEC/PPFULL/5/4/2 $
EQUIV       PPFULL,PPF/QRFIN $
LABEL       REGLR $
$ NOW THE LOAD VECTOR PPF IS READY TO RESPOND TO CASECC OLOAD REQUESTS
$      FOR BASE FORCE RESPONSE HISTORY.
$****************DATA RECOVERY***********************************************
$ RECOVER DISPLACEMENTS AND FORCES (BUT NOT ELEMENT RESPONSES) WITH
$ ABSOLUTE MOTION.
$ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE IN SDR2.
$
SDR2        CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDP,FOL,QPC,UPVC,EST,
            XYCDB,PPF/OPPC1,OQPC1,OUPVC1,,,PUPVC1/*FREQRESP*/
            S,N,NOSORT2 $
$
$ REMOVE RIGID BODY MOTION TO RECOVER STRESSES IN RELATIVE MOTION
$ WITHOUT THE E-SET.
$
$
$ PARTITION UDVF WRT GRDPNT TO FIND REFERENCE MOTION OF GRDPNT ONLY.
SETPT       EQDYN,USETD/DJVEC/*D*/C,Y,GRDPNT $
PARTN       UDVF,,DJVEC/,UJVF,,/5/4//2 $
EQUIV       UPVC,UGVC/NOUE  $
COND        GSIZ,NOUE $
PARTN       UPVC,,PGVEC/UGVC,UEVC,,/5/4/2/2 $
LABEL       GSIZ $
PARTN       UGVC,,GYVEC/UYVC,,,/5/4/2 $
MPYAD       H1RY6,UJVF,UYVC/UYFREL/O/-1/+1 $
$ INFLATE UYFREL TO G-SIZE WITH ZEROES ON THE R-SET
MERGE       UYFREL,,,,,GYVEC/UGFREL/5/4/2 $
$ PUT THE NON-GEOMETRIC E-SET BACK TO ELEVATE THE RESPONSE TO P-SIZE.
EQUIV       UGFREL,UPVCREL/NOUE $
COND        GOUT,NOUE $
MERGE       UGFREL,UEVC,,,,PGVEC/UPVCREL/5/4/2 $RECOVER EL FORCE & STRESS
LABEL       GOUT  $
SDR2        CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDP,FOL,,UPVCREL,EST,
            XYCDB,/,,,OESC1,OEFC1,/*FREQRESP*/S,N,NOSORT2 $
ENDALTER
```

$THIS IS THE END OF THE ALTER PACKET FOR SEISMIC ANALYSIS FOR R.F. 8

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$           DMAP ALTER PACKET PERTAINING TO R.F. 9 SIESMIC ANALYSIS
$                            SOLN9I.TXT
$
$SOLUTION TAKES PLACE IN ABSOLUTE COORDS IN THE TRANSIENT DIRECT RIGID
$
$FORMAT.   ALL COMPONENTS OF BASE POINTS TO BE ACCELERATED ARE ASSIGNED
$
$TO THE R-SET THRU THE USE OF THE SUPORT CARD.
$
$ASSIGN DAREA ID'S ON BULK PARAM NRTID# CARDS AND RLOAD CARDS.   ASSIGN
$
$TABLED1 ID'S TO TLOAD CARDS AND TO TABLED1 CARDS DIRECTLY OR TO TBLGEN
$
$FOR THE FOR THE DISPLACEMENT HISTORIES.   NRTID#'S WILL BE PICKED UP BY
$
$MODULE NRTS FOR INTERNAL GENERATION OF DAREA CARDS GIVING THE DISTRIBU-
$
$TION OF MASS MAGNITUDES.   THESE INTERNALLY GENERATED DAREA CARDS WILL
$
$BE PICKED UP BY THE TLOAD CARD FOR MULTIPLICATION AND ASSEMBLY WITH THE
$
$DISPLACEMENT HISTORIES THAT RLOAD PICKS UP FROM TABLED1 CARDS.
$
$SPC'S (ON OTHER THAN THE GRID CARDS) ARE PHYSICALLY UNREALISTIC, BECAUSE
$
$   THEY RELATE TO ABSOLUTE COORDINATES WHICH IMPLIES BEING FIXED OUTSIDE
$
$   THE SEISMIC ZONE.
$
$TWO OPTIONS ARE AVAILABLE:   REFINEMENT OF THE DISPLACEMENT RESPONSE BY
$
$   INCLUDING THE RECOVERY OF THE KOO PORTION OF THE O-SET, AND THE RE-
$
$   COVERY OF BASE FORCES WHICH REACT THE SPECIFIED INPUT TIME HISTORIES.
$
$FOR THE RECOVERY OF STRESSES, ONE OF THE POINTS IN THE R-SET MUST BE
$
$   NAMED ON A PARAM GRDPNT CARD TO BE USED AS A RIGID BODY REFERENCE FOR
$
$   SUBTRACTING THE LARGE BASE MOTION FROM ALL POINTS SO AS TO KEEP ALL
$
$   DIFFERENCING FOR STRESS RECOVERY A MATTER OF MUCH SMALLER NUMBERS.
$
$PARAMETER DEFINITIONS:
$
$NRTID1,2,3= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$            SPATIAL ARRANGEMENT OF INERTIAS ASSOCIATED WITH TRANSLATIONAL
$            ACCELERATIONS IN THE FIRST, SECOND, & THIRD COORD DIRECTIONS.
$NRTID4,5,6= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$            SPATIAL ARRANGEMENT OF INERTIAS ASSOCIATED WITH ROTATIONAL
$            ACCELERATIONS ABOUT THE FIRST, SECOND, & THIRD COORD DIRECTIONS.
```

```
$URFIN WHEN SET < OR = -1 ENABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$       MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.
$       WHEN SET > OR = 0 DISABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$       MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.    DEFAULT = + 1.
$QRFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER BASE FORCES FROM
$       STIFFNESS, DAMPING, & MASS COUPLING AND FROM BASE INERTIAS.
$       WHEN SET > OR = 0 DISABLES THE OPTION TO RECOVER THIS COMPONENT
$       OF BASE FORCE.   DEFAULT = + 1.
$GRDPNT IS DECLARED THE PRIMARY REFERENCE ON THE PARAM GRDPNT CARD.
$$***********************************************************************
$                        USER PREPARATIONS                             *
$                                                                      *
$   USER MUST SUPPLY SUPORT CARD FOR ALL EXCITED BASE POINTS            *
$                    PARAM GRDPNT BASE REFERENCE POINT (ONE OF R-SET)   *
$                    PARAM NRTID(1-6) FOR DAREA REGARDING ACCELERATIONS*
$                    TLOAD OF ACCEL FOR ALL BASE POINTS                 *
$                    ID's TO TBLGEN FOR TABLES OF ACCEL                 *
$   USER MAY OVERIDE PARAM URFIN OPTION FOR KOO REFINEMENT              *
$                    PARAM QRFIN OPTION FOR RECOVERY OF BASE REACTIONS  *
$   USER MAY SUPPLY  TLOAD FOR DIRECT LOAD ON ALL PTS XCP R-SET         *
$                    E-POINTS FOR TFL.                                  *
$                    DAMPING TYPES VISC, DMIG(B2PP), MAT(G), OR AVG(G)  *
$                                                                      *
$***********************************************************************

ALTER  63 $ JUST BEFORE COND JUMP AROUND MCE
PARAM       //*NOT*/V,N,SEISLD/V,N,REACT $
COND        SYMX,SEISLD $
JUMP        FINIS  $
LABEL       SYMX  $
$$  CALL IN RBTM AT THIS POINT TO ACT AS A VEHICLE FOR ROUTING LOADS TO
$$  ALL POINTS WHICH ARE COUPLED TO THE BASE THROUGH INERTIA.
$$
RBTM        BGPDT,CSTM,EQEXIN,,USET/HAICH,,H1RY6,/C,Y,GRDPNT/+1/*DIRECT* $
$$
VEC         USET/GYVEC/*G*/*COMP*/*R* $ 1'S ON R.  Y=R(COMP)G
COPY        GYVEC/GY1VEC $
PARTN       HAICH,,GYVEC/,HRX6,,/5/0 $ FRACTION OFF THE R ROWS OF HAICH.
$$
$$  THE HRX6 TRANSFORMATION MATRIX WILL BE USED BELOW IN THE DAREA
$$  PREPARATION SECTION
$$
$$REMOVE THE INERTIA COUPLING TERMS FROM THE LEFT HAND SIDE WHICH ARE
$$BEING USED ON THE RHS.  THE ZR INERTIA COUPLING TERMS MUST NOT BE
$$CONDENSED INTO THE DD SET, SO THE YR INERTIA COUPLING TERMS MUST BE
$$PARTITIONED OUT BEFORE MCE.  WHILE SO DOING THE WHOLE MATTER OF
$$SETTING UP THE EQUATION IN Y-ROWS AND R-ROWS CAN ALL BE DONE AT ONE
$$SITTING.
$***************ELASTICITY**********************************************
PARTN       KGG,GYVEC, /KYY,KRY,KYR,KRR/-1/2/6/2/2/6 $
MERGE       KYY,,KYR, ,GYVEC,GY1VEC/TKGG/+1/2/1 $ FOR CONDENSATION
MERGE       KRY,,KRR,,GYVEC,/K1RG/5/2/2 $ FOR BASE FORCES
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$******************MASS********************************************************
PARTN      MGG,GYVEC,  /MYY,MRY,MYR,MRR/-1/2/6/2/2/6 $
MERGE      MYY,,,MRR,GYVEC,/TMGG/-1/2/6 $ FOR CONDENSATION
MERGE      MRY,,MRR,,GYVEC,/M1RG/5/2/2 $ FOR BASE FORCES
$****************VISCOUS DAMPING***********************************************
PARTN      BGG,GYVEC,  /BYY,BRY,BYR,BRR/-1/2/6/2/2/6 $
MERGE      BYY,,BYR,,GYVEC,GY1VEC /TBGG/+1/2/1 $ FOR CONDENSATION
$****************DISTRIBUTED DAMPING*******************************************
PARTN      K4GG,GYVEC,  /K4YY,K4RY,K4YR,K4RR/-1/2/6/2/2/6 $
MERGE      K4YY,,K4YR,,GYVEC,GY1VEC/TK4GG/+1/2/1 $ FOR CONDENSATION
$****************SUMMARY*******************************************************
PARAMR     //*DIV*/V,N,HHH/1.0/C,Y,W4//// $
PARAMR     //*COMPLEX*//HHH/0.0/JJJ/// $
PARAMR     //*DIV*/V,N,YYY/C,Y,G/C,Y,W3//// $
PARAMR     //*COMPLEX*//YYY/0.0/ZZZ/// $
EQUIV      TKGG,KGG/SEISLD/TMGG,MGG/SEISLD/TBGG,BGG/SEISLD/
           TK4GG,K4GG/SEISLD $ FOR CONDENSATION OF STRUCTURAL MATRICES
$$NOW THAT THE INERTIA MATRIX HAS HAD THE YR COUPLING TERMS REMOVED,
$$CONDENSATION DOWN TO A-SIZE FOR GKAD CAN NOW BEGIN.
$
ADD5       BRY,KRY,K4RY,,/TBRY/(1.0,0.0)/V,N,ZZZ/V,N,JJJ  $FOR BASE FORCE
ADD5       BRR,KRR,K4RR,,/TBRR/(1.0,0.0)/V,N,ZZZ/V,N,JJJ $FOR BASE FORCE
MERGE      TBRY,,TBRR,,GYVEC, /B1RG/5/0/2$ FOR BASE FORCE
$****************PREPARE DAREA VALUES FOR DYNAMICS DATA BLOCK***********
MPYAD      MYR,HRX6, /MYYR/0/-1 $ NEGATIVE PRODUCT
MPYAD      MRR,HRX6, /MRRR/0/+1 $ POSITIVE PRODUCT
MERGE      MYYR,MRRR,,,,GYVEC/MSEIS/5/2/2 $   FOR LOAD
$****************LOAD SUMMARY**************************************************
ALTER   87 $ JUST BEFORE DPD
NRTS       MSEIS,DYNAMICS,EQEXIN/NRTSEIS/DEPOP/C,Y,NRTID1/C,Y,NRTID2/
           C,Y,NRTID3/C,Y,NRTID4/C,Y,NRTID5/C,Y,NRTID6 $
EQUIV      NRTSEIS,DYNAMICS/SEISLD $
$$   DATA BLOCK 'DYNAMICS' NOW HAS ALL DAREA ENTRIES FOR LOADING.
$$
ALTER 98 $ JUST AFTER MTRXIN.   PARTITION THE DMIG MATRICES.
VEC        USETD/PZVEC/*P*/*COMP*/*R* $ 1'S ON R.   Z=R(COMP)P
COPY       PZVEC/PZ1VEC $
COND       AUTOM,NOM2DPP $
PARTN      M2DPP,PZVEC, /M2DZZ,M2DRZ,M2DZR,M2DRR/-1/2/6/2/2/6 $
MERGE      M2DZZ,,,M2DRR,PZVEC,/TM2DPP/-1/2/6 $ FOR CONDENSATION
MERGE      M2DRZ,,M2DRR,,PZVEC,/M2DRP/5/2/2 $ FOR BASE FORCES
EQUIV      TM2DPP,M2DPP/SEISLD $
LABEL      AUTOM $
COND       AUTOB,NOB2PP $
PARTN      B2PP,PZVEC, /B2ZZ,B2RZ,B2ZR,B2RR/-1/0/6/2/2/6 $
MERGE      B2ZZ,,B2ZR,,PZVEC,PZ1VEC/TB2PP/+1/0/1 $ FOR CONDENSATION
MERGE      B2RZ,,B2RR,,PZVEC,/B2RP/5/0/2 $ FOR BASE FORCES
EQUIV      TB2PP,B2PP/SEISLD $
LABEL      AUTOB $
COND       AUTOK,NOK2DPP $
PARTN      K2DPP,PZVEC, /K2DZZ,K2DRZ,K2DZR,K2DRR/-1/2/6/2/2/6 $
MERGE      K2DZZ,,K2DZR,,PZVEC,PZ1VEC/TK2DPP/+1/2/1 $ FOR CONDENSATION
MERGE      K2DRZ,,K2DRR,,PZVEC,/K2DRP/5/2/2 $ FOR BASE FORCES
EQUIV      TK2DPP,K2DPP/SEISLD $
LABEL      AUTOK $
```

```
$$$$$$$    GKAD TAKES CARE OF COMBINING THE REVISED MTRXIN DATA WITH
$$$$$$$    THE AUTO-STRUCTURAL MATRICES.
$ COMPUTE KOO REFINEMENT TO RESPONSE AND RECOVER BASE FORCES BEFORE
$ PROCESSING OUTPUT.
ALTER 123,123  $  REPLACE TRLG WITH TRSLG TO GET LOAD PARTITIONS
$
TRSLG      CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,,EST,
           MGG/PPT,PST,POT,PDT,PD,,TOL/S,N,NOSET/NCOL  $
$
$ THE RESPONSE OF THE STRUCTURE INCLUDING THE BASE IS SOLVED AS A
$ FREE BODY.
$$   DEFAULT VALUES OF PARAMETERS ARE SET HERE.  $
PARAM      //*NOP*/V,Y,QRFIN=+1  $
PARAM      //*NOP*/V,Y,URFIN=+1  $
PARAM      //*NOT*/XISTOMIT/OMIT  $
PARAM      //*AND*/UORFIN/V,N,XISTOMIT/C,Y,URFIN  $
COND       UMPRUV,UORFIN  $
JUMP       NOCHNG  $
LABEL      UMPRUV  $
SOLVE      KOO,POT/RUOO/0/+1/2/0  $
$$$$
$$$$    RUOO IS A TIME VARYING COMPONENT OF RELATIVE DISPLACEMENT (ONLY
$$$$    DISP--WITHOUT ACCELERATION OR VELOCITY) DUE TO THE EFFECTS OF
$$$$    OMITTED DOF'S.   IT NEEDS TO BE CONVERTED TO THE STANDARD TRIPLET
$$$$    FORM OF TRANSIENT DIRECT ANALYSIS.   NASTRAN TAKES CARE OF THE
$$$$    OTHER PARTITIONS AT THE P-LEVEL.   IN PREPARING IT FOR ADDING AT
$$$$    THE P-LEVEL, IT HAS TO BE INFLATED WITH ZEROES TO P-SIZE AND
$$$$    UNDERGO MULTIPLICATION BY RECOVERY COEFFICIENTS AS IT EXPANDS.
$$$$     INFLATE RUOO UP TO NE-SIZE IN TWO STEPS, 1ST TO FE-SIZE AND
$$$$     THEN UP TO NE-SIZE.
VEC        USETD/FEDVEC/*FE*/*D*/*O*  $ ONE'S ON THE O'S  $
MERGE,     ,RUOO,,,,FEDVEC/RUOOFE/5/2/2  $
VEC        USETD/NEFEVEC/*NE*/*FE*/*S*  $ ONE'S ON THE S'S.
MERGE      RUOOFE,,,,,NEFEVEC/RUOONE/5/2/2  $
MPYAD      GMD,RUOONE,/RUOOM/0/+1/0  $
VEC        USETD/PNEVEC/*P*/*NE*/*M*  $   1'S ON M
MERGE      RUOONE,RUOOM,,,,PNEVEC/RUOOP/5/2/2  $ TYPE=REAL SINGLE PREC
LABEL      NOCHNG  $$
ALTER 139,139  $ REPLACE SDR2
EQUIV      PZVEC,PYVEC/NOUE  $
COND       P2G,NOUE  $
VEC        USETD/PGVEC/*P*/*G*/*E*  $ 1'S ON E
ADD        PGVEC,PZVEC/PYVEC/  $ 1'S ON E AND R.
LABEL      P2G  $
PARAM      //*OR*/V,N,SOMFIN/C,Y,URFIN/C,Y,QRFIN  $
COND       TOKRK,SOMFIN  $
JUMP       REGLR  $$
LABEL      TOKRK  $
KREKU      RUOOP,TOL,USETD,UPV/UMPRUV,,ACPVT,VEPVT,DIPVT/
           V,N,OMIT/C,Y,QRFIN/*TRANSRESP*/*DIRECT*  $
EQUIV      UMPRUV,UPV/URFIN  $
```

```
$$$$    IF THE USER WANTS TO RECOVER BASE FORCES HE SETS QRFIN=-1.   IF HE
$$$$    SETS QRFIN=+1, ANY CASECC REQUEST FOR OLOAD WILL CONTAIN ONLY THE
$$$$    EXCITATION INERTIA FORCES AND NOT THE TOTAL SET OF BASE REACTIONS.
COND        BASEF, QRFIN $
JUMP        REGLR $
LABEL       BASEF $
EQUIV       M1RG, M1RP/NOUE/B1RG, B1RP/NOUE/K1RG, K1RP/NOUE $
COND        JUSG, NOUE $
MERGE       M1RG,,,,PGVEC,/M1RP/5/2/2 $ FOR BASE FORCE
MERGE       B1RG,,,,PGVEC,/B1RP/5/0/2 $ FOR BASE FORCE
MERGE       K1RG,,,,PGVEC,/K1RP/5/2/2 $ FOR BASE FORCE
LABEL       JUSG $
EQUIV       M1RP, MRP/NOM2DPP/B1RP, BRP/NOB2PP/K1RP, KRP/NOK2DPP $
COND        BASEO, NOM2DPP $
ADD         M1RP, M2DRP/MRP/ $
LABEL       BASEO $
COND        BASE1, NOB2PP $
ADD         B1RP, B2RP/BRP/ $
LABEL       BASE1 $
COND        BASE2, NOK2DPP $
ADD         K1RP, K2DRP/KRP/ $
LABEL       BASE2 $
PARTN       PPT, , PZVEC/PSIZT,,,/5/2/2 $REPLACE THE R-SET WITH BASE FORCES
MPYAD       MRP, ACPVT, /NRTCPL/0/+1/ $ BASE INERTIA FORCES
PARAM       //*ADD*/V, N, DMP2/V, N, NOBGG/V, N, NOK4GG $
PARAMR      //*FLOAT*/RDMP2/ / / / / /DMP2 $
PARAMR      //*MPY*/V, N, DMP3/V, N, RDMP2/C, Y, G $
PARAMR      //*LT*/ /0. 0/V, N, DMP3/ / / /V, N, NODMP $
COND        BASO, NODMP $
MPYAD       BRP, VEPVT, NRTCPL/TWOCPL/0/+1/+1/0 $ BASE FORCES OF
$$$$    COUPLED DAMPING ADDED TO BASE INERTIA FORCES.
EQUIV       TWOCPL, NRTCPL/QRFIN $
LABEL       BASO $
MPYAD       KRP, DIPVT, NRTCPL/BASP/0/+1/+1/0 $ BASE FORCES OF COUPLED
$$$$    ELASTICITY ADDED TO OTHERS TO GET TOTAL BASE FORCE.
MATPRN      BASP,,,,// $
MERGE       PSIZT, BASP,,,,PZVEC/PRESPNS/5/0 $
EQUIV       PRESPNS, PPT/QRFIN $ THE BASE RESPONSE FORCES ARE NOW
$$$$     IMBEDDEDIN THE DATA BLOCK PPT IN THE R-PARTITION SO THAT
$$$$     OFP WILL RECOVER THEM WHEN REQUESTED BY OLOAD.
LABEL       REGLR $
$ DELETE OESC1 AND OEFC1 FROM 1ST EXECUTION OF SDR2 AND USE ABSOLUTE
$ MOTION ON WHICH TO BASE THE RECOVERY OF DISPLACEMENTS AND GP FORCES.
SDR2        CASEXX, CSTM, MPT, DIT, EQDYN, SILD,,, BGPDP, TOL, QP, UPV, EST,
            XYCDB, PPT/OPP1, OQP1, OUPV1,,, PUGV/*TRANSRESP* $
EQUIV       UPV, UGV/NOUE $
COND        NORELP, NOUE $
$$$$    RECOVERY OF STRESSES WILL BE BASED ON RELATIVE DISPLACEMENTS
$$$$    AND CAN OPERATE WITH REFINED DISPLACEMENTS OR NOT AS CONTROLLED
$$$$    BY THE USER IN THE QUALITY OF THE UPV VECTOR THAT IS SUPPLIED.
$$$$    FIRST CONVERT UPV TO RELATIVE COORDINATES.
PARTN       UPV,, PGVEC/UGV, UEV,,/5/0/2/2
LABEL       NORELP $$
```

```
SETPT       EQDYN,USETD/DJVEC/*D*/C,Y,GRDPNT $
PARTN       UDVT,,DJVEC/ ,UVWJVT,,/5/0/0/2 $ UVWJVT IS THE RESPONSE
$$$$     TRIPLET OF ACC:VEL:DISP OF THE BASE REFERENCE POINT "GRDPNT"
$$$$     WHICH ACTS TO ESTABLISH QUASI-RELATIVE MOTION.
$
MPYAD       HAICH,UVWJVT,UGV/RELUGV/0/-1/+1 $
EQUIV       RELUGV,RELUPV/NOUE $
COND        RELG,NOUE $
MERGE       RELUGV,UEV,,,,PGVEC/RELUPV/5/0/2 $RESTORE E-PART'N TO P-SIZE.
LABEL       RELG $
$ HAND A P-SIZED TRIPLET OF RELATIVE RESPONSES TO SDR2 TO RECOVER
$ ELEMENT STRESSES AND FORCES THRU DATA BLOCKS OES1 & OEF1.
SDR2        CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDP,TOL,,RELUPV,EST,
            XYCDB,/,,,OES1,OEF1,/*TRANSRESP* $
ENDALTER
$END OF ALTER PACKET FOR SEISMIC SOLUTION BY RIGID FORMAT 9 INTERNAL
```

```
$*********     THESE ARE DMAP ALTERS FOR SEIRES      ***********
$*********     PERTAINING TO RIGID FORMAT  DMAP       ***********
$*********          SERIES  APR  82                   ***********
$                   SOLN11I.TXT
$
$*********                THIS IS SEISTM FOR RF 11              *****
$********* SOLUTION TAKES PLACE IN RELATIVE COORDS IN THE MODAL  *****
$********* FREQUENCY RESPONSE R.F.   ALL BASE POINTS ARE PUT INTO AN*****
$********* SPC SET.   NO OTHER SPC SETS ARE ALLOWED EXCEPT THOSE   *****
$********* CONSTRAINTS ON GRID CARDS.   IF ARFIN = +1, ONE OF THE  *****
$********* BASE POINTS CAN BE DESIGNATED AS PRIMARY REFERENCE IF A *****
$********* SCAFFOLD POINT IS NOT ALREADY SET UP.   IF RECOVERY IN  *****
$********* ABSOLUTE COORD IS DESIRED, (I.E. IF ARFIN = -1) THEN    *****
$********* ADDITIONAL STEPS ARE NECESSARY.   ONE OF THE BASE POINTS *****
$********* SHOULD BE DUPLICATED AND GIVEN A SEPARATE ID AND SHOULD *****
$********* BE ASSIGNED TO THE R-SET ON A SUPORT CARD.   IT IS SIMUL-*****
$********* TANEOUSLY ENTERED ON THE PARAM GRDPNT CARD TO INDICATE  *****
$********* IT IS THE PRIMARY REFERENCE POINT FOR LOAD GENERATION   *****
$********* AND FOR RECOVERY OF ABSOLUTE COORDS.   MAKE A HIGH FREQ *****
$********* QUENCY SEPARATE CANTILEVER BY APPLYING A 6X6 UNIT MASS  *****
$********* TO THE REFERENCE POINT WITH CONM2 AND CONNECTING IT     *****
$********* WITH A BAR TO A GROUNDED POINT.                        *****
$PARAMETER DEFINITIONS:
$
$NRTID1,2,3= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$           SPATIAL ARRANGEMENT OF TRANSLATIONAL ACCELERATIONS IN THE FIRST,
$           SECOND, & THIRD COORDINATE DIRECTIONS.
$NRTID4,5,6= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$           SPATIAL ARRANGEMENT OF ROTATIONAL ACCELERATIONS ABOUT THE FIRST,
$           SECOND, & THIRD COORDINATE DIRECTIONS.
$URFIN WHEN SET < OR = -1 ENABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$           MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.
$        WHEN SET  > OR = 0 DISABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$           MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.   DEFAULT = + 1.
$QRFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER BASE FORCES FROM
$     STIFFNESS, DAMPING, & MASS COUPLING AND FROM BASE INERTIAS.
$        WHEN SET  > OR = 0 DISABLES THE OPTION TO RECOVER THIS COMPONENT
$           OF BASE FORCE.   DEFAULT = + 1.
$ARFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER DISPLACEMENTS IN
$        ABSOLUTE COORDINATES.
$        WHEN SET  > OR = 0 DISABLES THE OPTION TO RECOVER DISPLACEMENTS
$           IN ABSOLUTE COORDINATES.   DEFAULT = + 1.
$B2PARM WHEN SET < OR = -1 ENABLES THE RECOGNITION OF DIRECT INPUT
$        DAMPING TO SUBSTITUTE FOR MODAL DAMPING DURING THE RECOVERY OF
$        BASE FORCES.   DEFAULT = + 1.
$$*******************************************************************
$                      USER PREPARATIONS                         *
$                                                                *
$  USER MUST SUPPLY SPC SET FOR ALL BASE POINTS                  *
$                   PARAM GRDPNT BASE REFERENCE POINT IF ARFIN < 0.  *
$                   OMIT PARAM MODACC OR MAKE IT NEG WHEN URFIN < 0  *
$                   RLOAD FOR ALL BASE POINTS                     *
$                   TBLGEN FOR TABLE OF BASE AMPLITUDES VS FREQUENCIES*
$                   PARAM NRTID'S FOR DAREA OF ACC LOAD           *
$                   IF ARFIN = -1, DEFINE GP COINCIDENT W REF PT AND *
$                     ASSIGN IT TO R-SET. CONNECT IT WITH A BAR TO A  *
$                     FULLY CONSTRAINED POINT. PUT UNITY MASS IN EVERY *
$                     DOF WITH CONM2. CALL THIS A SCAFFOLD POINT.  *
```

```
$                     MAKE PARAM GRDPNT = SCAFFOLD POINT WHEN ARFIN < 0*
$                     DMIG DAMPING FOR BASE FORCE RECOVERY NAME == B2DMIG*
$   USER MAY OVERIDE PARAM URFIN OPTION FOR KOO REFINEMENT             *
$                     PARAM QRFIN OPTION FOR RECOVERY OF BASE REACTIONS *
$                     PARAM ARFIN OPTION FOR RECOVERY OF ABS RESPONSES  *
$                     PARAM B2PARM FOR DAMPING BASE FORCE.              *
$*************************************************************************
$
$**********          THIS IS SEISTM FOR RF 11              *****
$********** IT IS POSSIBLE TO GET IMPROVED DISPLACEMENTS, BASE   *****
$********** FORCES, AND ABSOLUTE DISPLACEMENTS BY OPTION. EXCITATION*****
$********** IS PERMITTED TO STEM FROM  INERTIA EFFECTS.  DAMPING BY *****
$********** G(OMEGA) EFFECT WILL PROVIDE DAMPING IN THE PROBLEM AT  *****
$********** THE LEVEL OF MODAL MATRICES, BUT IS NOT AVAILABLE FOR   *****
$********** RECOVERY OF DAMPING CONTRIBUTIONS TO THE BASE FORCE.    *****
$********** DAMPING CONTRIBUTIONS TO BASE FORCE CAN BE OBTAINED BY  *****
$********** USING DISTRIBUTED STRUCTURAL DAMPING FROM DMIG INPUT OF *****
$********** B2DMIG.  SOLUTION IN THIS R.F. IS BY RELATIVE COORDS    *****
$********** THEREFORE ANY SPC RELATIONS ARE NOT FIXED IN SPACE BUT  *****
$********** ARE RELATED TO THE UNDEFORMED POSITIONS OF THE COORDS.  *****
$
$SECTION A
$
ALTER 50 $ JUST BEFORE MCE
PARAM        //*NOT*/SEISLD/SINGLE $
COND         SYMX,SEISLD $
JUMP         FINIS  $
LABEL        SYMX $
$$   CALL IN RBTM AT THIS POINT.
$
RBTM         BGPDT,CSTM,EQEXIN,MGG,USET/HAICH,MSEIS, ,HL6/C,Y,GRDPNT/-1/
             *MODAL* $
$
$$GET THE MASS AND STIFFNESS MATRICES READY FOR LOAD AND BASE FORCE
$$RECOVERY.
$$
VEC          USET/GXVEC/*G*/*COMP*/*SB* $ X=SB,COMP,G
VEC          USET/GYVEC/*G*/*COMP*/*R* $ 1'S ON R
ADD          GXVEC,GYVEC/GCVEC/ $ 1'S ON SB & R
$-----------------------------MATRICES--------------------------------**
PARTN        MGG,GCVEC,GXVEC/ ,MBC,,/5/2/0/2 $ FOR BASE FORCE
PARTN        MSEIS,,GXVEC/MSIZX,MSIZB,,/5/2/2/2 $ FOR LOAD & BASE FORCE
MERGE        MSIZX,,,,,GXVEC/MSIZG/5/2/2 $
PARTN        MSIZG, ,GCVEC/MSIZC,MSIZRB,,/5/2/2/2 $
ADD          MSIZC, /MMSIZC/(-1.0,0.0) $
MERGE        MMSIZC,MSIZRB,,,,GCVEC/MSIZ/5/2/2 $
$-------DAMPING MATRICES NOT AVAILABLE IN GEOMETRIC COORDS**********
$
$----------STIFFNESS MATRICES*************************************
$
PARTN        KGG, ,GXVEC/ ,KBG,,/5/2/0/2 $ FOR BASE FORCE
$
NRTS         MSIZ,DYNAMICS,EQEXIN/NRTSEIS/C,Y, DEPOP/C,Y,NRTID1/
             C,Y,NRTID2/C,Y,NRTID3/C,Y,NRTID4/C,Y,NRTID5/C,Y,NRTID6 $
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EQUIV        NRTSEIS, DYNAMICS/SEISLD $
$$  THE 'DYNAMICS' DATA BLOCK NOW HAS DAREA CARDS IN IT FOR THE IN-
$$  ERTIA LOAD AND IS READY TO BE PASSED TO DPD FOR SETTING UP THE
$$  LOAD ON THE RELATIVE X COORDS.   IT CONTAINS DAREA NOT JUST FOR
$$  THE BASE MOTION BUT FOR DIRECTLY APPLIED LOAD AS WELL.   RF11
$$  CAN NOW PROCEED WITH CONDENSATION FROM X-SIZE TO A-SIZE AND
$$  DEVELOP MODAL VECTORS FOR SOL'N IN FRRD3.
$
ALTER 99,99 $REPLACE FRRD
FRSLG        CASEXX, USETD, DLT, FRL, GMD, GOD, DIT, PHIDH/PPF, PSF, PDF, POF,
             FOL, PHF/*MODAL*/FREQY=-1/APP=FREQ/S, N, FRQSET/S, N, NFREQ/
             S, N, NLOAD $
FRRD3        KHH, BHH, MHH, PHF, FRL/UHVF/*DISP*/*MODAL*/
             V, N, NONCUP/V, N, FRQSET/V, N, NFREQ/V, N, NLOAD $
$
ALTER 101,101 $ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE.
VDR          CASEXX, EQDYN, USETD, UHVF, FOL, XYCDB, /OUHVC1, /*FREQRESP*/
             *MODAL*/S, N, SORT2/S, N, NOH/S, N, NOP/FMODE $ $
ALTER   114,114 $ THIS CAUSES OSCAR TO IGNORE A JUMP AROUND SDR1.
ALTER   116,117  $ THIS ELIMINATES ANY IMPROVEMENTS FROM MODACC.
$
$ COMPUTE KOO REFINEMENT TO RESPONSE AND RECOVER BASE FORCES BEFORE
$ PROCESSING OUTPUT.
ALTER 122,122   $
SETPT        EQEXIN, USET/GXREF/*G*/C, Y, GRDPNT $ 1'S ON GRDPNT. NEEDED
$ LATER IN QRFIN AND ARFIN.
$$ PARAMETER DEFAULTS ARE SET HERE.  $
PARAM        //*NOP*/V, Y, ARFIN = +1 $
PARAM        //*NOP*/V, Y, QRFIN = +1 $
PARAM        //*NOP*/V, Y, URFIN = +1 $
COND         P2G, NOUE $
VEC          USETD/PGVEC/*P*/*G*/*E* $ 1'S ON E
LABEL        P2G $
PARAM        //*NOT*/XISTOMIT/OMIT $
PARAM        //*AND*/UORFIN/XISTOMIT/C, Y, URFIN $
PARAM        //*NOT*/NOARFIN/C, Y, ARFIN $
COND         UMPRUV, UORFIN $
JUMP         UNRFIN $
LABEL        UMPRUV $
SOLVE        KOO, POF/RUOOF/+1/+1/2/0 $
$RUOOF IS A VECTOR OF RELATIVE DISPLACEMENTS.   NO CONVERSION TO
$ ABSOLUTE COORDINATES IS NECESARY BECAUSE NASTRAN HAS ALREADY
$PROCESSED ONE CORRECTION FOR THE O-SET IN ABSOLUTE COORDINATES.
$INFLATE RUOOF TO P-SIZE TO BE COMMENSURATE WITH UPVC.
VEC          USETD/FEDVEC/*FE*/*D*/*O* $ 1'S ON O
MERGE,       , RUOOF, , , , FEDVEC/UOOFFE/5/O $
EQUIV        UOOFFE, UOOFNE/SINGLE $
$ THESE PROBLEMS.
COND         POSN1, SINGLE $
VEC          USETD/NEFEVEC/*NE*/*FE*/*S* $ 1'S ON S
MERGE        UOOFFE, , , , , NEFEVEC/UOOFNE/5/O $
LABEL        POSN1 $
EQUIV        UOOFNE, UOOFP/MPCF1 $
COND         POSN2, MPCF1 $
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```
MPYAD       GMD, UOOFNE, /UOOFM/O/+1 $
VEC         USETD/PNEVEC/*P*/*NE*/*M* $ 1'S ON M
MERGE       UOOFNE, UOOFM,,,,PNEVEC/UOOFP/5/O $
LABEL       POSN2 $
ADD         UPVC, UOOFP/UMPRUVF/ $
EQUIV       UMPRUVF, UPVC/URFIN $
LABEL       UNRFIN $
$
$IF THE USER WANTS TO RECOVER BASE RESPONSE FORCES HE SETS QRFIN
$ = -1, HOWEVER IF HE SETS QRFIN=+1, ANY CASECC REQUEST FOR OLOAD
$ WILL CONTAIN ONLY THE EXCITATION INERTIA FORCES AND NOT THE TOTAL
$ SET OF BASE REACTIONS.
COND        SPCFALL, QRFIN  $
JUMP        REGLR  $
LABEL       SPCFALL  $
EQUIV       PPF, PGF/NOUE $
COND        GSIZ, NOUE $
PARTN       PPF,,PGVEC/PGF, PEF,,/5/O $
LABEL       GSIZ $
PARTN       PGF,,GXVEC/PXF,,,/+1 $
$ THE RECOVERY OF BASE FORCES IS UNDER THE CONTROL OF CASECC OLOAD
$ REQUESTS.
$ DIAGONAL MATRIX   I*OMEGA COMING FROM MODULE KREKU WILL
$ BE USED TO DIFFERENTIATE RESPONSE DISPLACEMENTS INTO VELOCITIES AND
$ ACCELERATIONS BY MULTIPLYING UDVF BY I*OMEGA.
$
KREKU,      ,FOL,,  /  ,IW,,,/V,N,OMIT/C,Y,QRFIN/*FREQRESP*/*MODAL* $
$
$ ARRANGE THE STRUCTURAL MATRICES FOR RECOVERY OF BASE RESPONSE
$ FORCES.   ONLY COUPLED DAMPING AND COUPLED ELASTIC TERMS ARE NON ZERO
$ BECAUSE [BRR]*[BASEACC] & [KRR]*[BASEACC] ACT ON RIGID MOTIONS WHICH
$ LEAVES ZERO DIFFERENTIAL AMONGST THE R SET, SO THE PRODUCTS ARE NULL.
$ THIS IS NOT THE CASE FOR INERTIA BECAUSE THEY ACT ON {ISOLATED} GP
$ MOTION AS OPPOSED TO {DIFFERENTIAL} GP MOTION
$
COPY        IW/IFREQ/-1 $ CLONE OF COMPLEX IW
MPYAD       IW, IFREQ, /WSQR/O/-1/O/O $(-)IW*IW =\(+W**2,0.0)\
DIAGONAL    WSQR/INVASQR/*SQUARE*/-1.0 $INVERSES OF REAL POS. DIAGONALS
ADD         INVASQR/INVWSQR/(-1.0,0.0) $INVERSES OF REAL NEG. DIAGONALS
EQUIV       UPVC, UGVC/NOUE $
COND        BASO, NOUE $
PARTN       UPVC,,PGVEC/UGVC, UEVC,,/+1/3/2/2 $
LABEL       BASO $
PARTN       UGVC,,GYVEC/UYVC,,,/5/3/2 $ SPLIT OFF THE REF DISP & KEEP COMP
VEC         USETD/PZVEC/*P*/*COMP*/*R* $ 1'S ON R'S.
PARTN       PPF,,PZVEC/,PRF,,/5/4/O/2 $ ISOLATE THE EXCITING ACCELERATION
MPYAD       PRF, INVWSQR,/URVC/O/+1 $
MERGE       UYVC, URVC,,,,GYVEC/UGBAS/5/O/2 $ RECONSTRUCT UG FOR BASE FORCES
MERGE       MBC,,,,GCVEC,/MBCG/5/2/2 $
MERGE,      ,,MSIZB, ,GXREF,/MBRG/5/O/2 $
ADD         MBCG, MBRG/MFBG/ $
MPYAD       UGBAS, IW, /VEGVC/O/+1 $
SMPYAD      MFBG, VEGVC, IW,,,/MCPLGF/3/+1 $
```

```
PARAM       //*MPY*/V,N,NOB2/C,N,-1/V,Y,B2PARM = +1 $
$$   THIS SETS THE DEFAULT VALUE OF NOB2 TO NEGATIVE ONE.   IF THE USER
$$   WANTS TO PUT IN DIRECT MATRIX DAMPING AS A GRID POINT EQUIVALENT
$$   SURROGATE FOR MODAL DAMPING, HE OVERRIDES THE DEFAULT BY ENTERING
$$   A BULK PARAM CARD FOR B2PARM SET TO -1 AND HE THEN ENTERS BULK DMIG
$$   CARDS FOR THE DAMPING VALUES USING A MATRIX NAME OF B2DMIG OF ORDER
$$   EQUAL TO P-SIZE.
PARAM       //*AND*/V,N,NODMP/V,N,NOB2/V,N,NOB2PP $
COND        BAS1,NODMP $
$$   IF BOTH B2PP AND B2DMIG ARE ABSENT, JUMP AROUND THE COMPUTATION OF
$$   DAMPING CONTRIBUTION TO BASE FORCES.
COND        BASB,NOB2 $
MTRXIN,     ,MATPOOL,EQDYN,,/B2DMIG,,/LUSETD/V,N,NOB2 $
EQUIV       B2PP,B2DMIG/NOB2PP $
COND        BASB,NOB2PP $
$$   IF B2DMIG IS ABSENT, JUMP AROUND INPUT OF THIS MATRIX, OTHERWISE
$$   INPUT THE MATRIX.   RETAIN THE NAME OF B2DMIG IF B2PP IS PRESENT,
$$   OTHERWISE EQUIVALENCE B2PP TO IT.
ADD         B2PP,B2DMIG/B2BOTH/ $
EQUIV       B2BOTH,B2PP/SEISLD $
LABEL       BASB $
$$   IF B2PP IS ABSENT, JUMP AROUND THE COMBINING OF B2DMIG WITH B2PP.
$$   AT THIS POINT, THE RESULT OF ANY OF THE OPTIONS IS NAMED B2PP.
$$   PROCEED WITH THE PROCESSING OF THE DAMPING FORCE CONTRIBUTION TO
$$   THE BASE FORCE RECOVERY.
PARTN       B2PP, PGVEC,/B2GG,,,/-1/0/6 $
PARTN       B2GG, ,GXVEC/ ,B2BG, ,/5/0/0/2 $
MPYAD       B2BG,VEGVC,MCPLGF/BCPLGF/0/+1/+1 $
EQUIV       BCPLGF,MCPFLGF/SEISLD $
LABEL       BAS1 $
MPYAD       KBG,UGVC,MCPLGF/BASEGF/0/+1/+1 $
MERGE       PXF,BASEGF,,,,GXVEC/PXBF/5/4/2 $
EQUIV       PXBF,PPBF/NOUE $
COND        JUSG,NOUE $
MERGE       PXBF,PEF,,,,PGVEC/PPBF/5/4/2 $
LABEL       JUSG $
EQUIV       PPBF,PPF/SEISLD $
LABEL       REGLR $
$$   PPF IS NOW COMPLETE AND IS READY TO BE PASSED TO SDR2 FOR RECOVERY
$$   OF BASE FORCES AS REQUESTED BY THE USER WITH OLOAD IN CASECC.
$ NOW THE LOAD VECTOR PPF IS READY TO RESPOND TO CASECC OLOAD REQUESTS
$        FOR BASE FORCE RESPONSE HISTORY.
$*************DATA RECOVERY**********************************************
$ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE.
SDR2        CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDP,FOL,QPC,UPVC,EST,
            XYCDB,PPF/OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,PUGV/*FREQ*/
            S,N,NOSORT2 $
$$   ALL OUTPUT RECOVERED UP TO THIS POINT HAS BEEN BASED ON RELATIVE
$$   COORDS.   IF DISP, VELO, AND ACCEL ARE NEEDED IN ABSOLUTE COORDS,
$$   SET PARAM ARFIN = -1. THE SCAFFOLD POINT IN THE R SET IS EXCITED
$$   TO SPECIFIED VALUES AND IT WILL BE USED FOR THE TRANSFORMATION TO
$$   ABSOLUTE COORDS.
```

```
COND       NOABS,NOARFIN $
MERGE      UYVC,,,,,GYVEC/UGCREL/5/3/2 $INFLATE THE RELATIVE COMPLIMENT
$$ TO G-SIZE.
MERGE,     ,,HAICH,,GXREF,/HAIG/5/1/2 $ INFLATES HAICH FROM GX6 TO GXG.
PARTN      HAIG,GYVEC,/,,HAIR,/5/1/0/0/2 $ EXTRACTS GXR PART'N OF HAICH.
MPYAD      HAIR,PRF ,UGCREL/UGCABS/0/+1/+1 $ TRANSFORMS TO ABS BY ADDING
$$   THE RIGID BODY MOTION TO THE RELATIVE MOTION.  G-SIZE.
EQUIV      UGCABS,UPCABS/NOUE $
COND       GABS,NOUE $
MERGE      UGCABS,UEVC,,,,,PGVEC/UPCABS/5/3/2 $E-SET AREN'T IN ABS COORDS.
$$ PUT BACK E-SET TO SATISFY SDR AND OFP.
LABEL      GABS $
SDR2       CASEXX,CSTM,,,EQDYN,SILD,,,,FOL,,UPCABS,,XYCDB,/
           ,,OUPCABS1,,,/*FREQRESP*/S,N,NOUABS2 $
COND       ABSOUT1,NOUABS2 $
SDR3,      ,,OUPCABS1,,,/,,OUPCABS2,,, $
OFPS       OUPCABS2,,,,,//CARDNO $
XYTRAN     XYCDB,,,OUPCABS2,,/XYCPLABS/*TRAN*/*PSET*/S,N,PFILE $
XYPLOT     XYCPLABS// $
JUMP       NOABS $
LABEL      ABSOUT1
OFPS       OUPCABS1,,,,,//CARDNO $
JUMP       LBL18 $
LABEL      NOABS $
ENDALTER
$THIS IS THE END OF THE MODIFICATION TO R.F.11.
```

```
$********* THESE ARE DMAP ALTERS FOR SEIRES      **********
$********* PERTAINING TO RIGID FORMAT  DMAP      **********
$*********          SERIES  APR  82              **********
$                  SOLN12I.TXT
$
$*********              THIS IS SEISTM FOR RF 12            *****
$********* SOLUTION TAKES PLACE IN RELATIVE COORDS IN THE MODAL  *****
$********* TRANSIENT RESPONSE R.F.  ALL BASE POINTS ARE PUT INTO AN*****
$********* SPC SET.  NO OTHER SPC SETS ARE ALLOWED EXCEPT THOSE  *****
$********* CONSTRAINTS ON GRID CARDS.  IF ARFIN = +1, ONE OF THE  *****
$********* BASE POINTS CAN BE DESIGNATED AS PRIMARY REFERENCE IF A *****
$********* SCAFFOLD POINT IS NOT ALREADY SET UP.  IF RECOVERY IN  *****
$********* ABSOLUTE COORD IS DESIRED, (I.E.  IF ARFIN = -1) THEN  *****
$********* ADDITIONAL STEPS ARE NECESSARY.  ONE OF THE BASE POINTS *****
$********* SHOULD BE DUPLICATED AND GIVEN A SEPARATE ID AND SHOULD *****
$********* BE ASSIGNED TO THE R-SET ON A SUPORT CARD.  IT IS SIMUL-*****
$********* TANEOUSLY ENTERED ON THE PARAM GRDPNT CARD TO INDICATE  *****
$********* IT IS THE PRIMARY REFERENCE POINT FOR LOAD GENERATION  *****
$********* AND FOR RECOVERY OF ABSOLUTE COORDS.  MAKE A HIGH FREQ -*****
$********* QUENCY SEPARATE CANTILEVER BY APPLYING A 6X6 UNIT MASS  *****
$********* TO THE REFERENCE POINT WITH CONM2 AND CONNECTING IT  *****
$********* WITH A BAR TO A GROUNDED POINT.                *****
$********* IT IS POSSIBLE TO GET IMPROVED DISPLACEMENTS, BASE  *****
$********* FORCES, AND ABSOLUTE DISPLACEMENTS BY OPTION. EXCITATION*****
$********* IS PERMITTED TO STEM FROM  INERTIA EFFECTS.  DAMPING BY *****
$********* G(OMEGA) EFFECT WILL PROVIDE DAMPING IN THE PROBLEM AT  *****
$********* THE LEVEL OF MODAL MATRICES, BUT IS NOT AVAILABLE FOR  *****
$********* RECOVERY OF DAMPING CONTRIBUTIONS TO THE BASE FORCE.  *****
$********* DAMPING CONTRIBUTIONS TO BASE FORCE CAN BE OBTAINED BY  *****
$********* USING DISTRIBUTED STRUCTURAL DAMPING FROM DMIG INPUT OF *****
$********* B2DMIG.  SOLUTION IN THIS R.F. IS BY RELATIVE COORDS,  *****
$********* THEREFORE ANY SPC RELATIONS ARE NOT FIXED IN SPACE BUT  *****
$********* ARE RELATED TO THE UNDEFORMED POSITIONS OF THE COORDS.  *****
$
$PARAMETER DEFINITIONS:
$
$NRTID1,2,3= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$         SPATIAL ARRANGEMENT OF TRANSLATIONAL ACCELERATIONS IN THE FIRST,
$         SECOND, & THIRD COORDINATE DIRECTIONS.
$NRTID4,5,6= SET ID'S TO BE ASSIGNED TO DAREA CARDS REPRESENTING THE
$         SPATIAL ARRANGEMENT OF ROTATIONAL ACCELERATIONS ABOUT THE FIRST,
$         SECOND, & THIRD COORDINATE DIRECTIONS.
$URFIN WHEN SET < OR = -1 ENABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$         MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.
$      WHEN SET  > OR = O DISABLES THE OPTION TO REFINE OUTPUT DISPLACE-
$         MENTS WITH CONTRIBUTIONS FROM OMITTED SETS.  DEFAULT = + 1.
$QRFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER BASE FORCES FROM
$         STIFFNESS, DAMPING, AND MASS COUPLING AND FROM BASE INERTIAS.
$      WHEN SET  > OR = O DISABLES THE OPTION TO RECOVER THIS COMPONENT
$         OF BASE FORCE.  DEFAULT = + 1.
$ARFIN WHEN SET < OR = -1 ENABLES THE OPTION TO RECOVER ACCELERATIONS IN
$         ABSOLUTE COORDINATES.
$      WHEN SET  > OR = O DISABLES THE OPTION TO RECOVER ACCELERATIONS
$         IN ABSOLUTE COORDINATES.  DEFAULT = + 1.
```

```
$B2PARM WHEN SET < OR = -1 ENABLES THE RECOGNITION OF DIRECT INPUT
$         DAMPING TO SUBSTITUTE FOR MODAL DAMPING DURING THE RECOVERY OF
$         BASE FORCE.   DEFAULT = + 1.
$$***********************************************************************
$                         USER PREPARATIONS                            *
$                                                                       *
$   USER MUST SUPPLY SPC SET FOR ALL BASE POINTS                        *
$                    PARAM GRDPNT BASE REFERENCE POINT IF ARFIN < O      *
$                    OMIT PARAM MODACC OR MAKE IT NEG WHEN URFIN < O     *
$                    TLOAD FOR ALL BASE POINTS                          *
$                    TBLGEN FOR TABLE OF BASE TIME HISTORIES            *
$                    PARAM NRTID'S FOR DAREA OF ACC LOAD               *
$                    IF ARFIN = -1, DEFINE GP COINCIDENT W REF PT AND    *
$                     ASSIGN IT TO R-SET. CONNECT IT WITH A BAR TO A    *
$                     FULLY CONSTRAINED POINT. PUT UNITY MASS IN EVERY  *
$                     DOF WITH CONM2. CALL THIS A SCAFFOLD POINT.       *
$                     SET RHO = 0.0 ON MAT1 SO AS TO BE A MASSLESS REED*
$                    DMIG DAMPING FOR BASE FORCE RECOVERY NAME IS B2DMIG*
$   USER MAY OVERIDE PARAM URFIN OPTION FOR KOO REFINEMENT              *
$                    PARAM QRFIN OPTION FOR RECOVERY OF BASE REACTIONS  *
$                    PARAM ARFIN OPTION:   RECOVERY OF ABS ACCELERATIONS*
$                    PARAM B2PARM FOR DAMPING BASE FORCE                *
$***********************************************************************
$
ALTER 49    $ JUST BEFORE MCE
PARAM       //*NOT*/SEISLD/SINGLE $
COND        SYMX,SEISLD $
JUMP        FINIS  $
LABEL       SYMX $
$$   CALL IN RBTM AT THIS POINT.
$
RBTM        BGPDT,CSTM,EQEXIN,MGG,USET/HAICH,MSEIS,,HL6/C,Y,GRDPNT/-1/
            *MODAL* $
$
$$GET THE MASS AND STIFFNESS MATRICES READY FOR LOAD AND BASE FORCE
$$RECOVERY.
$$
VEC         USET/GXVEC/*G*/*COMP*/*SB* $ X=SB,COMP,G
VEC         USET/GYVEC/*G*/*COMP*/*R* $ 1'S ON R
ADD         GXVEC,GYVEC/GCVEC/ $ 1'S ON SB & R
$-----------INERTIA MATRICES--------------------------------------------**
PARTN       MGG,GCVEC,GXVEC/ ,MBC,,/5/2/O/2 $ FOR BASE FORCE
PARTN       MSEIS,,GXVEC/MSIZX,MSIZB,,/5/2/2/2 $ FOR LOAD & BASE FORCE
MERGE       MSIZX,,,,,GXVEC/MSIZG/5/2/2 $
PARTN       MSIZG, ,GCVEC/MSIZC,MSIZRB,,/5/2/2/2 $
ADD         MSIZC, /MMSIZC/(-1.0,0.0) $
MERGE       MMSIZC,MSIZRB,,,,GCVEC/MSIZ/5/2/2 $
$
$-----------DAMPING MATRICES NOT AVAILABLE IN GEOMETRIC COORDS***********
$
$-----------STIFFNESS MATRICES******************************************
$
PARTN       KGG, ,GXVEC/ ,KBG,,/5/2/O/2 $ FOR BASE FORCE
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NRTS          MSIZ,DYNAMICS,EQEXIN/NRTSEIS/C,Y, DEPOP/C,Y,NRTID1/
              C,Y,NRTID2/C,Y,NRTID3/C,Y,NRTID4/C,Y,NRTID5/C,Y,NRTID6 $
EQUIV         NRTSEIS,DYNAMICS/SEISLD $
$$   THE 'DYNAMICS' DATA BLOCK NOW HAS DAREA CARDS IN IT FOR THE INERTIA
$$   LOAD AND IS READY TO BE PASSED TO DPD FOR SETTING UP THE LOAD ON
$$   THE RELATIVE X COORDS.   IT CONTAINS DAREA NOT JUST FOR THE BASE
$$   MOTION BUT FOR DIRECTLY APPLIED LOAD AS WELL.   RF12 CAN NOW PROCEED
$$   WITH CONDENSATION FROM X-SIZE TO A-SIZE AND DEVELOP MODAL VECTORS
$$   FOR SOLUTION IN THE TRD MODULE. MODULE TRSLG SUPPLIES THE LOAD
$$   VECTOR IN AN O-SIZED PARTITION TO ENTER LATER INTO DECOMP WITH KOO
$$   TO OBTAIN RELATIVE DISPLACEMENT CONTRIBUTIONS FROM OMITTED DOF'S.
$$   PREPARES INCREMENT OF DISPLACEMENT RECOVERY DUE TO OMITTED DOF'S.
$
ALTER 99,99 $  REPLACE TRLG WITH TRSLG.
TRSLG         CASECC,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,
              DIT,GMD,GOD,PHIDH,EST,MGG/PPT,PST,POT,PDT,PD,
              PH,TOL/S,N,NOSET/NCOL $
ALTER 113,113 $
$
$$ THIS CAUSES OSCAR TO IGNORE A JUMP AROUND SDR1
$
ALTER      121 $  JUST AFTER SDR1
SETPT      EQEXIN,USET/GXREF/*G*/C,Y,GRDPNT $ 1'S ON GRDPNT.   NEEDED FOR
$  BOTH QRFIN AND URFIN.
$$  PARAMETER DEFAULTS ARE SET HERE. $$
PARAM         //*NOP*/V,Y,ARFIN=+1 $
PARAM         //*NOP*/V,Y,QRFIN=+1 $
PARAM         //*NOP*/V,Y,URFIN=+1 $
COND          P2G,NOUE $
VEC           USETD/PGVEC/*P*/*G*/*E* $
LABEL         P2G $
VEC           USETD/PZVEC/*P*/*COMP*/*R* $ ONE'S ON R'S.  Z=R,COMP,P.
VEC           USETD/GNVEC/*G*/*N*/*M* $
VEC           USETD/NFVEC/*N*/*F*/*S* $
VEC           USETD/FAVEC/*F*/*A*/*O* $
PARAM         //*NOT*/XISTOMIT/V,N,OMIT $
PARAM         //*AND*/RFINBIZ/C,Y,URFIN/V,N,XISTOMIT $
PARAM         //*OR*/V,N,COLPTN/C,Y,QRFIN/C,Y,ARFIN $
COND          UMPRUV,RFINBIZ $
JUMP          AFTKOO $
LABEL         UMPRUV $
SOLVE         KOO,POT/RELUOO/+1/+1/2/2 $
$$   INFLATE RELUOO FROM O-SIZE TO N-SIZE.
MERGE,        ,RELUOO,,,,FAVEC/RUOOT/+5/2/2 $
MERGE         RUOOT,,,,,NFVEC/ROON/+5/2/2 $
$$ NOW MULTIPLY ROON BY GM TO GET THE M PARTITION OF THE UOO CORRECTION
MPYAD         GM,ROON,/ROOM/0/+1 $
$$ PUT THE M AND N PARTN'S BACK TOGETHER INTO A G-SIZED MATRIX.
MERGE         ROON,ROOM,,,,GNVEC/ROOG/5/2/2 $ ROOG IS SINGLE PREC FOR KREKU
LABEL         AFTKOO $
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$$$$     ROOG IS A TIME VARYING COMPONENT OF RELATIVE DISPLACEMENT (ONLY
$$$$     DISP--WITHOUT ACCELERATION OR VELOCITY) DUE TO THE EFFECTS OF
$$$$     OMITTED DOF'S.   IT NEEDS TO BE CONVERTED TO THE STANDARD TRIPLET
$$$$     FORM OFTRANSIENT DIRECT ANALYSIS.   KREKU MAKES THE CONVERSION AND
$$$$     OUTPUTS  THE DISPLACEMENTS AUGMENTED WITH KOO REFINEMENTS.
PARAM        //*OR*/V,N,QU/C,Y,QRFIN/C,Y,URFIN $
PARAM        //*OR*/V,N,AQU/V,N,QU/C,Y,ARFIN $
COND         TOKRK,AQU $
JUMP         REGLR $
LABEL        TOKRK $
$$   BREAK THE SOL'N VEC UPV INTO INDIVIDUAL ACCEL, VELO AND DISP VECTORS
$$   TO GET READY TO RECOVER BASE FORCES DUE TO INERTIA COUPLING, DAMPING
$$   COUPLING, AND ELASTIC COUPLING.
KREKU        ROOG,TOL,USETD,UPV/UMPRUV,,ACGVT,VEGVT,DIGVT/
             V,N,OMIT/V,N,COLPTN/*TRANSRESP*/*MODAL* $
EQUIV        PPT,PGT/NOUE $
COND         POZ1,NOUE $
PARTN        PPT, ,PGVEC/PGT,PET,,/5/2/2/2 $
LABEL        POZ1 $
PARTN        PGT,,GXVEC/PXT,,,/5/2/2 $
PARTN        PGT,,GYVEC/ ,PRT,,/5/2/0/2 $PRT IS THE REF FOR SPECIFIED ACCEL.
PURGE        PPT,PGT/COLPTN $
PARTN        ACGVT,,GYVEC/ACYVT,,,/5/2/0/2 $
MERGE        ACYVT,PRT,,,,GYVEC/ACCG/5/0/2 $
COND         QA,OMIT $
EQUIV        UMPRUV,UPV/URFIN $
LABEL        QA $
COND         QORA,COLPTN $
JUMP         REGLR $
LABEL        QORA $
COND         SPCFALL,QRFIN  $
JUMP         REGLR  $
LABEL        SPCFALL  $
MERGE        MBC,,,,GCVEC,/MBCG/5/2/2 $
MERGE,       ,,MSIZB, ,GXREF,/MBRG/5/2/2 $
ADD          MBCG,MBRG/MFBG/ $
MPYAD        MFBG,ACCG,/MCPLG/0/+1 $
PARAM        //*MPY*/V,N,NOB2/C,N,-1/V,Y,B2PARM = +1 $
$$   THIS SETS THE DEFAULT VALUE OF NOB2 TO NEGATIVE ONE.   IF THE USER
$$   WANTS TO PUT IN DIRECT MATRIX DAMPING AS A GRID POINT EQUIVALENT
$$   SURROGATE FOR MODAL DAMPING, HE OVERRIDES THE DEFAULT BY ENTERING
$$   A BULK PARAM CARD FOR B2PARM SET TO -1 AND HE THEN ENTERS BULK
$$   DMIGCARDS FOR THE DAMPING VALUES USING A MATRIX NAME OF B2DMIG OF
$$   ORDER EQUAL TO P-SIZE.
PARAM        //*AND*/V,N,NODMP/V,N,NOB2/V,N,NOB2PP $
COND         BAS1,NODMP $
$$   IF BOTH B2PP AND B2DMIG ARE ABSENT, JUMP AROUND THE COMPUTATION
$$   OF DAMPING CONTRIBUTION TO BASE FORCES.
COND         BASB,NOB2 $
MTRXIN,      ,MATPOOL,EQDYN,,/B2DMIG,,/LUSETD/V,N,NOB2 $
EQUIV        B2PP,B2DMIG/NOB2PP $
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```
COND        BASB,NOB2PP $
$$  IF B2DMIG IS ABSENT, JUMP AROUND INPUT OF THIS MATRIX, OTHERWISE
$$  INPUT THE MATRIX.  RETAIN THE NAME OF B2DMIG IF B2PP IS PRESENT,
$$  OTHERWISE EQUIVALENCE B2PP TO IT.
ADD         B2PP,B2DMIG/B2BOTH/ $
EQUIV       B2BOTH,B2PP/SEISLD $
LABEL       BASB $
$$  IF B2PP IS ABSENT, JUMP AROUND THE COMBINING OF B2DMIG WITH B2PP.
$$  AT THIS POINT, THE RESULT OF ANY OF THE OPTIONS IS NAMED B2PP.
$$  PROCEED WITH THE PROCESSING OF THE DAMPING FORCE CONTRIBUTION TO
$$  THE BASE FORCE RECOVERY.
PARTN       B2PP, PGVEC,/B2GG,,,/-1/0 $
PARTN       B2GG, ,GXVEC/ ,B2BG, ,/5/0 $
MPYAD       B2BG,VEGVT,MCPLG/BCPLG/0/+1/+1 $
EQUIV       BCPLG,MCPLG/SEISLD $
LABEL       BAS1 $
MPYAD       KBG,DIGVT,MCPLG/BASEG/0/+1/+1 $
MERGE       PXT,BASEG,,,,GXVEC/PXBT/5/2/2 $
MERGE       PXBT,PET,,,,PGVEC/PPBT/5/2/2 $
EQUIV       PPBT,PPT/SEISLD $
LABEL       REGLR $
$$  PPT IS NOW COMPLETE AND IS READY TO BE PASSED TO SDR2 FOR RECO-
$$  VERY OF BASE FORCES AS REQUESTED BY THE USER WITH OLOAD IN CASECC.
$
ALTER  135 $ JUST AFTER OFP FOLLOWING SDR3.
$$  ALL OUTPUT RECOVERED UP TO THIS POINT HAS BEEN BASED ON RELATIVE
$$  COORDS.  IF DISP, VELO, AND ACCEL ARE NEEDED IN ABSOLUTE COORDS,
$$  SET PARAM ARFIN = -1. THE SCAFFOLD POINT IN THE R SET IS EXCITED
$$  TO SPECIFIED VALUES AND IT WILL BE USED FOR THE TRANSFORMATION TO
$$  ABSOLUTE COORDS.
COND        ABSA,ARFIN $
JUMP        FINIS $
LABEL       ABSA $
MERGE       ACYVT,,,,,GYVEC/RELACG/5/1/2 $ RELATIVE ACCELERATION G-SIZE
MERGE,      ,,HAICH,,GXREF,/HAIG/5/1/2 $ INFLATES HAICH FROM GX6 TO GXG.
PARTN       HAIG,GYVEC,/,,HAIR,/5/1/0/0/2 $EXTRACTS GXR PARTN FROM HAICH.
MPYAD       HAIR,PRT,RELACG/ABSACG/0/+1/+1 $ABSOLUTE ACCELERATION G-SIZE
ACDR        ABSACG,USETD/ABSACGT/C,Y,ARFIN $ABS ACC. TRIPLET FORMAT P-SIZE
EQUIV       ABSACGT,ABSACPT/NOUE $
COND        GZZ,NOUE $
MERGE       ABSACGT,,,,,PGVEC/AGSACPT/5/1/2 $
LABEL       GZZ $
SDR2        CASEXX,CSTM,,,EQDYN,SILD,,,,TOL,,ABSACPT,,XYCDB,/
            ,,OACABSP1,,,/*TRANSRESP* $
SDR3,       ,,OACABSP1,,,/,,OACABSP2,,, $
OFPS        OACABSP2,,,,,//CARDNO $
```

```
$$   ALL PLOTS UP TO THIS POINT HAVE BEEN BASED ON RELATIVE COORDS.
$$   IF PLOTS OF ACCEL IN ABS COORDS ARE NEEDED SET ARFIN=-1
$
ALTER   141 $ AFTER XYPLOT
COND       ABSPLT,ARFIN $
JUMP       FINIS  $
LABEL      ABSPLT $
XYTRAN     XYCDB,,,OACABSP2,,/XYPLABS/*TRAN*/*PSET*/S,N,PFILE $
XYPLOT     XYPLABS// $
ENDALTER
$THIS IS THE END OF THE INTERNAL MODIFICATION TO R.F.12.
```