

## SEISMIC ANALYSIS CAPABILITY IN NASTRAN

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### 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  $\text{Force} = \text{Mass} \times \text{Acceleration}$ , 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 RBIM 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 accommodate 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 TABLEDi 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.

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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 clamped 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 generation 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 displacements 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 Frequency Response and Modal Seismic Transient 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.

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

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.

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

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

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

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  $Y = R \text{ comp } G$ .

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

$\{p^2_{UR}\}$  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.

$$[[MYY:MYR]p^2 + [BYY:BYR]p + [KYY:KYR]] \begin{Bmatrix} UY \\ \text{---} \\ UR \end{Bmatrix} = \{PY\} \quad (5)$$

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

$$[[MYY:0]p^2 + [BYY:BYR]p + [KYY:KYR]] \begin{Bmatrix} UY \\ \text{---} \\ UR \end{Bmatrix} = \{PY - [MYR]\{p^2_{UR}\}\} \quad (6)$$

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

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

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.

$$[[MR Y : MRR]p^2 + [BR Y : BR R]p + [KR Y : KR R]] \begin{Bmatrix} UY \\ \text{---} \\ UR \end{Bmatrix} = \{PR\} \quad (8)$$

$\{PR\}$  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  $G \times 6$  transformation matrix [HAICH] is partitioned to  $R \times 6$  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.

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

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

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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 TRIG 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.

$$\begin{Bmatrix} 0 \\ \text{-----} \\ UOO \end{Bmatrix} \Rightarrow \{UOOFE\} \qquad \begin{Bmatrix} 0 \\ \text{-----} \\ UOOFE \end{Bmatrix} \Rightarrow \{UOONE\}$$

The correction for multi-point constraints is applied next.

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

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

$$\begin{Bmatrix} UOONE \\ \text{-----} \\ UOOM \end{Bmatrix} \Rightarrow \{UOOP\}$$

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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:

$$\{UPV\} \implies \begin{pmatrix} UEV \\ \text{---} \\ UGV \end{pmatrix}$$

$$\{UDVT\} \implies \begin{pmatrix} 0 \\ \text{---} \\ UVWJVT \end{pmatrix}$$

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

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

$$\begin{pmatrix} UEV \\ \text{---} \\ RELUGV \end{pmatrix} \implies \{RELUPV\}. \quad \{RELUPV\} \text{ goes to SDR2 for stress recovery.}$$

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.

$$\left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \hline \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] p^2 + \left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \hline \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] p + \left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \hline \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] \begin{Bmatrix} \text{---} \\ \text{---} \end{Bmatrix} = \left\{ \begin{array}{l} \text{---} \\ \text{---} \end{array} \right\} \quad (7A)$$

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

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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.

$$\left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] p^2 + \left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] p + \left[ \begin{array}{c|c} \text{---} & \text{---} \\ \text{---} & \text{---} \\ \text{---} & \text{---} \end{array} \right] \begin{Bmatrix} \text{UX} \\ \text{---} \\ \text{UB} \end{Bmatrix} = \begin{Bmatrix} \text{PX} \\ \text{---} \\ \text{PB} \end{Bmatrix} \quad (9)$$

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.

$$\left[ \begin{array}{c|c|c} \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \end{array} \right] p^2 + \left[ \begin{array}{c|c|c} \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \end{array} \right] p + \left[ \begin{array}{c|c|c} \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \end{array} \right] \begin{Bmatrix} \text{UC} \\ \text{---} \\ \text{UR} \\ \text{---} \\ \text{UB} \end{Bmatrix} = \begin{Bmatrix} \text{PC} \\ \text{---} \\ \text{PR} \\ \text{---} \\ \text{PB} \end{Bmatrix} \quad (10)$$

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.

$$\{UC\} = [HCR]\{UR\} + \{Uv\} \quad (11).$$

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.

$$\{UR\} = [IRR]\{UR\} \quad (12).$$

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

$$\{UB\} = [HBR]\{UR\} + \{Ue\} \quad (13).$$

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

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

$$\{UG\} = \begin{Bmatrix} UC \\ \text{---} \\ UR \\ \text{---} \\ UB \end{Bmatrix} = \begin{bmatrix} I_{vv} & HCR & 0 \\ 0 & IRR & 0 \\ 0 & HBR & I_{ee} \end{bmatrix} \begin{Bmatrix} Uv \\ \text{---} \\ UR \\ \text{---} \\ Ue \end{Bmatrix} \quad (14).$$

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

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

Expand and recombine:

$$\begin{aligned} & \begin{bmatrix} (MCC \cdot I_{vv} + MCR \cdot 0 + MCB \cdot 0) & (MCC \cdot HCR + MCR \cdot IRR + MCB \cdot HBR) & (MCC \cdot 0 + MCR \cdot 0 + MCB \cdot I_{ee}) \\ (MRC \cdot I_{vv} + MRR \cdot 0 + MRB \cdot 0) & (MRC \cdot HCR + MRR \cdot IRR + MRB \cdot HBR) & (MRC \cdot 0 + MRR \cdot 0 + MRB \cdot I_{ee}) \\ (MBC \cdot I_{vv} + MBR \cdot 0 + MBB \cdot 0) & (MBC \cdot HCR + MBR \cdot IRR + MBB \cdot HBR) & (MBC \cdot 0 + MBR \cdot 0 + MBB \cdot I_{ee}) \end{bmatrix} p^2 + \\ & \begin{bmatrix} (BCC \cdot I_{vv} + BCR \cdot 0 + BCB \cdot 0) & (BCC \cdot HCR + BCR \cdot IRR + BCB \cdot HBR) & (BCC \cdot 0 + BCR \cdot 0 + BCB \cdot I_{ee}) \\ (BRC \cdot I_{vv} + BRR \cdot 0 + BRB \cdot 0) & (BRC \cdot HCR + BRR \cdot IRR + BRB \cdot HBR) & (BRC \cdot 0 + BRR \cdot 0 + BRB \cdot I_{ee}) \\ (BBC \cdot I_{vv} + BBR \cdot 0 + BBB \cdot 0) & (BBC \cdot HCR + BBR \cdot IRR + BBB \cdot HBR) & (BBC \cdot 0 + BBR \cdot 0 + BBB \cdot I_{ee}) \end{bmatrix} p + \\ & \begin{bmatrix} (KCC \cdot I_{vv} + KCR \cdot 0 + KCB \cdot 0) & (KCC \cdot HCR + KCR \cdot IRR + KCB \cdot HBR) & (KCC \cdot 0 + KCR \cdot 0 + KCB \cdot I_{ee}) \\ (KRC \cdot I_{vv} + KRR \cdot 0 + KRB \cdot 0) & (KRC \cdot HCR + KRR \cdot IRR + KRB \cdot HBR) & (KRC \cdot 0 + KRR \cdot 0 + KRB \cdot I_{ee}) \\ (KBC \cdot I_{vv} + KBR \cdot 0 + KBB \cdot 0) & (KBC \cdot HCR + KBR \cdot IRR + KBB \cdot HBR) & (KBC \cdot 0 + KBR \cdot 0 + KBB \cdot I_{ee}) \end{bmatrix} \begin{Bmatrix} Uv \\ \text{---} \\ UR \\ \text{---} \\ Ue=0 \end{Bmatrix} \\ & = \begin{Bmatrix} PC \\ \text{---} \\ PR \\ \text{---} \\ PB \end{Bmatrix} \quad (16) \end{aligned}$$

Observe that  $[I_{jj}][MTX] = [MTX]$ . Delete zero products. Rewrite.

$$\begin{aligned} & \begin{bmatrix} MCC & (MCC \cdot HCR + MCR \cdot IRR + MCB \cdot HBR) & MCB \\ MRC & (MRC \cdot HCR + MRR \cdot IRR + MRB \cdot HBR) & MRB \\ MBC & (MBC \cdot HCR + MBR \cdot IRR + MBB \cdot HBR) & MBB \end{bmatrix} p^2 + \\ & \begin{bmatrix} BCC & (BCC \cdot HCR + BCR \cdot IRR + BCB \cdot HBR) & BCB \\ BRC & (BRC \cdot HCR + BRR \cdot IRR + BRB \cdot HBR) & BRB \\ BBC & (BBC \cdot HCR + BBR \cdot IRR + BBB \cdot HBR) & BBB \end{bmatrix} p + \\ & \begin{bmatrix} KCC & (KCC \cdot HCR + KCR \cdot IRR + KCB \cdot HBR) & KCB \\ KRC & (KRC \cdot HCR + KRR \cdot IRR + KRB \cdot HBR) & KRB \\ KBC & (KBC \cdot HCR + KBR \cdot IRR + KBB \cdot HBR) & KBB \end{bmatrix} \begin{Bmatrix} Uv \\ \text{---} \\ UR \\ \text{---} \\ Ue=0 \end{Bmatrix} = \begin{Bmatrix} PC \\ \text{---} \\ PR \\ \text{---} \\ PB \end{Bmatrix} \quad (17) \end{aligned}$$

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

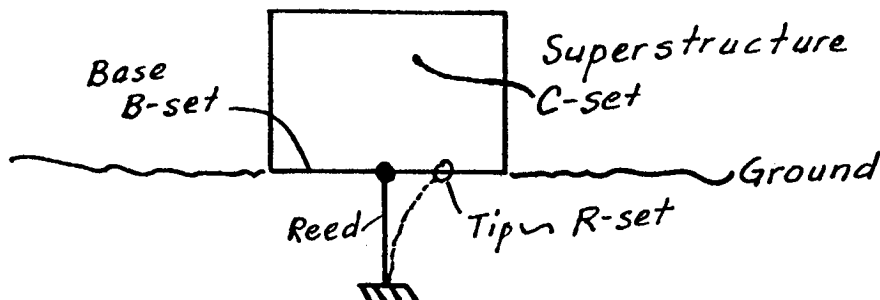
$$\begin{bmatrix} MCC (MCC \cdot HCR + MCR \cdot IRR + MCB \cdot HBR) & MCB \\ MRC (MRC \cdot HCR + MRR \cdot IRR + MRB \cdot HBR) & MRB \\ MBC (MBC \cdot HCR + MBR \cdot IRR + MBB \cdot HBR) & MBB \end{bmatrix} p^2 + \begin{bmatrix} BCC & BCR & BCB \\ BRC & BRR & BRB \\ BBC & BBR & BBB \end{bmatrix} p + \begin{bmatrix} KCC & KCR & KCB \\ KRC & KRR & KRB \\ KBC & KBR & KBB \end{bmatrix} \begin{Bmatrix} Uv \\ UR \\ Ue=0 \end{Bmatrix} = \begin{Bmatrix} PC \\ PR \\ PB \end{Bmatrix} \quad (18)$$

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.







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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.

$$\{PPT\} \Rightarrow \begin{Bmatrix} PZT \\ \text{---} \\ PRT \end{Bmatrix}$$

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.

$$\{ACGV\} \xRightarrow{GYVEC} \begin{Bmatrix} ACYVT \\ \text{---} \\ PRT \end{Bmatrix} ; \quad \begin{Bmatrix} ACYVT \\ \text{---} \\ PRT \end{Bmatrix} \xRightarrow{GYVEC} \{ACCG\}$$

Form the base forces 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.

$$\{UGV\} \Rightarrow \begin{Bmatrix} UYV \\ \text{---} \\ URV \end{Bmatrix}. \quad \text{UYV is the relative response on the Y-coordinates.}$$

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

$$\left\{ \begin{array}{c} \text{UYV} \\ \hline 0 \end{array} \right\} \Rightarrow \{\text{UGREL}\}$$

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

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

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 partition of response with zeroes in the R-positions back to G-size.

$$\left\{ \begin{array}{c} \text{ACYVT} \\ \hline 0 \end{array} \right\} \text{GYVEC} \Rightarrow \{\text{RELACG}\}$$

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.

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

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.

## SOLN8

\$ DMAP ALTER PACKET PERTAINING TO R.F. 8 SIEMIC 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 K00 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.
$GRFIN 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 OVERRIDE PARAM URFIN OPTION FOR KOO REFINEMENT *
$ PARAM GRFIN 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.
$$
RBTM BQPD, CSTM, EGEXIN, , USET/HAICH, , H1RY6, /C, Y, GRDPNT/+1/*DIRECT* $
$$
$$ NOTICE GRDPNT IS USED HERE AS A REFERENCE FOR TRANSFORMING FROM
$$ GLOBAL TO 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

```

SOLN8

\$\$

\$\$\$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, , KRY, , GYVEC, GYVEC/TKGG/+1/2/1 \$ FOR CONDENSATION  
 MERGE KRY, , KRR, , GYVEC, /KRG/5/2/2 \$ FOR BASE FORCES

\*\*\*\*\*MASS\*\*\*\*\*

PARTN MGG, GYVEC, /MYR, MRY, MYR, MRR/-1/2/6/2/2/6 \$  
 MERGE MYR, , 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 BYR, , 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, /MYR6/0/-1 \$ NEGATIVE PRODUCT  
 MPYAD MRR, HRX6, /MRR6/0/+1 \$ POSITIVE PRODUCT  
 MERGE MYR6, MRR6, , , GYVEC/MSEIS/5/2/2 \$ FOR LOAD

\*\*\*\*\*LOAD SUMMARY\*\*\*\*\*

ALTER B7 \$ JUST BEFORE DPD  
 NRTS MSEIS, DYNAMICS, EGEXIN/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 AUTDM, 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 AUTDM \$

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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
$$ INFLATE RG MATRICES TO P-SIZE SO AS TO OPERATE WITH UPVC
MERGE     M1RG,,,PGVEC,/M1RP/5/2/2 $
MERGE     B1RG,,,PGVEC,/B1RP/5/0/2 $
MERGE     K3RG,,,PGVEC,/K3RP/5/4/2 $
PURGE     M1RG,B1RG,K3RG/SEISLD $
LABEL     BASEG $
EQUIV     M1RP,MRP/NOM2DPP/B1RP,BRP/NOB2PP/K3RP,KRP/NOK2DPP $
COND      BASO,NOM2DPP $
ADD       M1RP,M2DRP/MRP/ $
LABEL     BASO $
COND      BAS1,NOB2PP $
ADD       B1RP,B2RP/BRP/ $
LABEL     BAS1 $
COND      BAS2,NOK2DPP $
ADD       K3RP,K2DRP/KRP/ $
LABEL     BAS2 $
$$$$#@! !*****
$
ALTER 121,121 $REPLACE FRRD
$
FRSLG     CASEXX,USETD,DLT,FRL,GMD,GOD,DIT,/PPF,PSF,PDF,POF,FOL,/
          *DIRECT*/FREQY=-1/APP=FREQ/S,N,FRQSET/S,N,NFREQ/
          S,N,NLOAD $
FRRD3     KDD,BDD,MDD,PDF,FRL/UDVF/C,N,DISP/C,N,DIRECT/
          V,N,NONCUP/FRQSET=2/V,N,NFREQ/V,N,NLOAD $
$
ALTER 123,123 $ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE.
VDR       CASEXX,EGDYN,USETD,UDVF,FOL,XYCDB,/DUDVC1,/*FREQRESP*/
          *DIRECT*/S,N, SORT2/S,N,NOD/S,N,NOP/O $ $
$ COMPUTE K00 REFINEMENT TO RESPONSE AND RECOVER BASE FORCES BEFORE
$ PROCESSING OUTPUT.
ALTER 139,139 $
$$ DEFAULT VALUES OF PARAMETERS ARE SET HERE. $
PARAM     /*NOP*/V,Y,GRFIN = + 1 $
PARAM     /*NOP*/V,Y,URFIN = + 1 $

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PARAM    /*NOT*/XISTOMIT/OMIT $
PARAM    /*AND*/UORFIN/XISTOMIT/C,Y,URFIN $
COND     UMPRUV,UORFIN $
JUMP     UNRFIN $
LABEL    UMPRUV $
SOLVE    KDD,PDF/RUOOF/O/+1/2/O $
$RUOOF IS A VECTOR OF RELATIVE DISPLACEMENTS. NO CONVERSION TO
$ ABSOLUTE COORDINATES IS NECESSARY 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/UOOFNE/5/4/2 $
EQUIV    UOOFNE,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    UOOFNE,,,,NEFEVEC/UOOFNE/5/4/2 $
LABEL    POSN1 $
EQUIV    UOOFNE,UOOFNE/MPCF1 $
COND     POSN2,MPCF1 $
MPYAD    GMD,UOOFNE,/UOOFM/O/+1 $
VEC      USETD/PNEVEC/*P*/NE/*M* $ 1'S ON M
MERGE    UOOFNE,UOOFM,,,,PNEVEC/UOOFM/5/4/2 $
LABEL    POSN2 $
ADD      UPVC,UOOFM/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     OLOAD,QRFIN $
JUMP     REGLR $
LABEL    OLOAD $
$ 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 SUCCEEDING 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 $

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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      /*DR*/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, / , , , QESC1, DEFC1, /*FREQRESP*/S, N, NOSORT2 $
ENDALTER

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

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SOLN9

DMAP ALTER PACKET PERTAINING TO R.F. 9 SIEMIC 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 DISTRIBUTION  
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 K00 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.

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$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 OVERRIDE 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) *
$ *
$*****

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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.
$$
RBTM BGPDT, CSTM, EGEXIN, , USET/HAICH, , H1RY6, /C, Y, GRDPNT/+1/*DIRECT* $
$$
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, /MYR/0/-1 $ NEGATIVE PRODUCT
MPYAD  MRR,HRX6, /MRR/0/+1 $ POSITIVE PRODUCT
MERGE  MYR,MRR,, ,GYVEC/MSEIS/5/2/2 $ FOR LOAD
*****LOAD SUMMARY*****
ALTER  87 $ JUST BEFORE DPD
NRTS   MSEIS,DYNAMICS,EGEXIN/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 $

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$$$$$$ GKAD TAKES CARE OF COMBINING THE REVISED MTRXIN DATA WITH
$$$$$$ THE AUTO-STRUCTURAL MATRICES.
$ COMPUTE KOO REFINEMENT TO RESPONSE AND RECOVER BASE FORCES BEFORE
$ PROCESSING OUTPUT.
ALTER 123,123 $ REPLACE TRLG WITH TRSLG TO GET LOAD PARTITIONS
$
TRSLG CASEXX, USETD, DLT, SLT, BGPDT, SIL, CSTM, TRL, DIT, GMD, GOD, , EST,
MGG/PPT, PST, POT, PDT, PD, , TOL/S, N, NOSET/NCOL $
$
$ THE RESPONSE OF THE STRUCTURE INCLUDING THE BASE IS SOLVED AS A
$ FREE BODY.
$$ 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/RUDD/0/+1/2/0 $
$$$$
$$$$ RUDD IS A TIME VARYING COMPONENT OF RELATIVE DISPLACEMENT (ONLY
$$$$ DISP--WITHOUT ACCELERATION OR VELOCITY) DUE TO THE EFFECTS OF
$$$$ OMITTED DOF'S. IT NEEDS TO BE CONVERTED TO THE STANDARD TRIPLET
$$$$ FORM OF TRANSIENT DIRECT ANALYSIS. NASTRAN TAKES CARE OF THE
$$$$ OTHER PARTITIONS AT THE P-LEVEL. IN PREPARING IT FOR ADDING AT
$$$$ THE P-LEVEL, IT HAS TO BE INFLATED WITH ZEROES TO P-SIZE AND
$$$$ UNDERGO MULTIPLICATION BY RECOVERY COEFFICIENTS AS IT EXPANDS.
$$$$ INFLATE RUDD UP TO NE-SIZE IN TWO STEPS, 1ST TO FE-SIZE AND
$$$$ THEN UP TO NE-SIZE.
VEC USETD/FEDVEC/*FE*/D/*0* $ ONE'S ON THE O'S $
MERGE, , RUDD, , , FEDVEC/RUDDFE/5/2/2 $
VEC USETD/NEFEVEC/*NE*/FE/*S* $ ONE'S ON THE S'S.
MERGE RUDDFE, , , NEFEVEC/RUDDONE/5/2/2 $
MPYAD GMD, RUDDONE, /RUDDOM/0/+1/0 $
VEC USETD/PNEVEC/*P*/NE/*M* $ 1'S ON M
MERGE RUDDONE, RUDDOM, , , PNEVEC/RUDDOP/5/2/2 $ TYPE=REAL SINGLE PREC
LABEL NOCHNG $$
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 RUDDOP, TOL, USETD, UPV/UMPRUV, , ACPVT, VEPVT, DIPVT/
V, N, OMIT/C, Y, QRFIN/*TRANSRESP*/DIRECT* $
EQUIV UMPRUV, UPV/URFIN $

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SOLN9

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$$$$ IF THE USER WANTS TO RECOVER BASE FORCES HE SETS QRFIN=-1. IF HE
$$$$ SETS QRFIN=+1, ANY CASECC REQUEST FOR OLOAD WILL CONTAIN ONLY THE
$$$$ EXCITATION INERTIA FORCES AND NOT THE TOTAL SET OF BASE REACTIONS.
COND BASEF,QRFIN $
JUMP REGLR $
LABEL BASEF $
EQUIV M1RG,M1RP/NOUE/B1RG,B1RP/NOUE/K1RG,K1RP/NOUE $
COND JUSG,NOUE $
MERGE M1RG,,,PGVEC,/M1RP/5/2/2 $ FOR BASE FORCE
MERGE B1RG,,,PGVEC,/B1RP/5/0/2 $ FOR BASE FORCE
MERGE K1RG,,,PGVEC,/K1RP/5/2/2 $ FOR BASE FORCE
LABEL JUSG $
EQUIV M1RP,MRP/NOM2DPP/B1RP,BRP/NOB2PP/K1RP,KRP/NOK2DPP $
COND BASE0,NOM2DPP $
ADD M1RP,M2DRP/MPR/ $
LABEL BASE0 $
COND BASE1,NOB2PP $
ADD B1RP,B2RP/BRP/ $
LABEL BASE1 $
COND BASE2,NOK2DPP $
ADD K1RP,K2DRP/KRP/ $
LABEL BASE2 $
PARTN PPT, ,PZVEC/PSIZT,,,/5/2/2 $REPLACE THE R-SET WITH BASE FORCES
MPYAD MRP,ACPV, /NRTCPL/0/+1/ $ BASE INERTIA FORCES
PARAM // *ADD*/V,N,DMP2/V,N,NOBGG/V,N,NOK4GG $
PARAMR // *FLOAT*/RDMP2/ / / / / /DMP2 $
PARAMR // *MPY*/V,N,DMP3/V,N,RDMP2/C,Y,G $
PARAMR // *LT*/ /O.0/V,N,DMP3/ / / / /V,N,NODMP $
COND BASO,NODMP $
MPYAD BRP,VEPVT,NRTCPL/TWOCPL/0/+1/+1/0 $ BASE FORCES OF
$$$$ COUPLED DAMPING ADDED TO BASE INERTIA FORCES.
EQUIV TWOCPL,NRTCPL/QRFIN $
LABEL BASO $
MPYAD KRP,DIPVT,NRTCPL/BASP/0/+1/+1/0 $ BASE FORCES OF COUPLED
$$$$ ELASTICITY ADDED TO OTHERS TO GET TOTAL BASE FORCE.
MATPRN BASP,,,,// $
MERGE PSIZT,BASP,,,,PZVEC/PRESPNS/5/0 $
EQUIV PRESPNS,PPT/QRFIN $ THE BASE RESPONSE FORCES ARE NOW
$$$$ IMBEDDED IN THE DATA BLOCK PPT IN THE R-PARTITION SO THAT
$$$$ OFF WILL RECOVER THEM WHEN REQUESTED BY OLOAD.
LABEL REGLR $
$ DELETE OESC1 AND DEFC1 FROM 1ST EXECUTION OF SDR2 AND USE ABSOLUTE
$ MOTION ON WHICH TO BASE THE RECOVERY OF DISPLACEMENTS AND GP FORCES.
SDR2 CASEXX,CSTM,MPT,DIT,EGDYN,SILD,,,BGPDP,TOL,QP,UPV,EST,
XYCDB,PPT/OPP1,OGP1,OUPV1,,,PUGV/*TRANSRESP* $
EQUIV UPV,UGV/NOUE $
COND NORELP,NOUE $
$$$$ RECOVERY OF STRESSES WILL BE BASED ON RELATIVE DISPLACEMENTS
$$$$ AND CAN OPERATE WITH REFINED DISPLACEMENTS OR NOT AS CONTROLLED
$$$$ BY THE USER IN THE QUALITY OF THE UPV VECTOR THAT IS SUPPLIED.
$$$$ FIRST CONVERT UPV TO RELATIVE COORDINATES.
PARTN UPV, ,PGVEC/UGV,UEV,,,/5/0/2/2
LABEL NORELP $$

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SOLN9

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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

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***** THESE ARE DMAP ALTERS FOR SEIRES *****
***** PERTAINING TO RIGID FORMAT DMAP *****
***** SERIES APR 82 *****
$
$ SOLN11I.TXT

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***** 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. *****

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\$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.
$B2PARAM 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.

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SOLN11

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$          MAKE PARAM GRDPNT = SCAFFOLD POINT WHEN ARFIN < 0*
$          DMIG DAMPING FOR BASE FORCE RECOVERY NAME == B2DMIG*
$  USER MAY OVERRIDE PARAM URFIN OPTION FOR KOO REFINEMENT      *
$          PARAM GRFIN OPTION FOR RECOVERY OF BASE REACTIONS *
$          PARAM ARFIN OPTION FOR RECOVERY OF ABS RESPONSES  *
$          PARAM B2PARAM 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 $
$$ CALL IN RBTM AT THIS POINT.
$
RBTM BQPD, CSTM, EGEXIN, MGG, USET/HAICH, MSEIS, , HL6/C, Y, GRDPNT/-1/
*MODAL* $
$
$$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, EGEXIN/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,/DUHVC1,/*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   EGEXIN,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 NECESSARY 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/UOOFNE/5/0 $
EQUIV   UOOFNE,UOOFNE/SINGLE $
$ THESE PROBLEMS.
COND    POSN1,SINGLE $
VEC     USETD/NEFEVEC/*NE*//*FE*//*S* $ 1'S ON S
MERGE   UOOFNE,,,,,NEFEVEC/UOOFNE/5/0 $
LABEL   POSN1 $
EQUIV   UOOFNE,UOOFNE/MPCF1 $
COND    POSN2,MPCF1 $

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SOLN11

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MPYAD      GMD,UOOFNE,/UOOFM/0/+1 $
VEC        USETD/PNEVEC/*P*/*NE*/*M* $ 1'S ON M
MERGE     UOOFNE,UOOFM,,,PNEVEC/UOOFM/5/0 $
LABEL     POSN2 $
ADD       UPVC,UOOFM/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,,/5/0 $
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,DMIT/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/0/-1/0/0 $(-)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,,/5/4/0/2 $ ISOLATE THE EXCITING ACCELERATION
MPYAD     PRF,INVWSQR,-/URVC/0/+1 $
MERGE     UYVC,URVC,,,GYVEC/UGBAS/5/0/2 $ RECONSTRUCT UG FOR BASE FORCES
MERGE     MBC,,,,GCVEC,/MBCG/5/2/2 $
MERGE     ,,MSIZB,,GXREF,/MBRG/5/0/2 $
ADD       MBCG,MBRG/MFBG/ $
MPYAD     UGBAS,IW,/VEGVC/0/+1 $
SMPYAD    MFBG,VEGVC,IW,,,/MCPLGF/3/+1 $

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## SOLN11

```

PARAM    // *MPY* /V, N, NOB2 /C, N, -1 /V, Y, B2PARAM = +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 B2PARAM 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
$$ OF BASE FORCES AS REQUESTED BY THE USER WITH OLOAD IN CASECC.
$ NOW THE LOAD VECTOR PPF IS READY TO RESPOND TO CASECC OLOAD REQUESTS
$ FOR BASE FORCE RESPONSE HISTORY.
*****DATA RECOVERY*****
$ USE FOL INSTEAD OF PPF FOR A FREQUENCY TEMPLATE.
SDR2     CASEXX, CSTM, MPT, DIT, EQDYN, SILD, , , BGPDP, FOL, QPC, UPVC, EST,
        XYCDB, PPF / OPPC1, OQPC1, OUPVC1, OESC1, ODFC1, PUGV / *FREQ* /
        S, N, NOSORT2 $
$$ 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.

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## SOLN11

```

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.

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*****
***** THESE ARE DMAP ALTERS FOR SEIRES *****
***** PERTAINING TO RIGID FORMAT DMAP *****
***** SERIES APR 82 *****
***** SOLN12I.TXT *****
$
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***** 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 = 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, AND 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 ACCELERATIONS IN
$ ABSOLUTE COORDINATES.
$ WHEN SET > OR = 0 DISABLES THE OPTION TO RECOVER ACCELERATIONS
$ IN ABSOLUTE COORDINATES. DEFAULT = + 1.

```

\$B2PARAM 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 < 0 \*  
 \$ OMIT PARAM MODACC OR MAKE IT NEG WHEN URFIN < 0 \*  
 \$ 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 OVERRIDE PARAM URFIN OPTION FOR KOO REFINEMENT \*  
 \$ PARAM QRFIN OPTION FOR RECOVERY OF BASE REACTIONS \*  
 \$ PARAM ARFIN OPTION: RECOVERY OF ABS ACCELERATIONS\*  
 \$ PARAM B2PARAM 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, EGEXIN, 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, , /5/2/0/2 \$ 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

## SOLN12

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NRTS      MSIZ, DYNAMICS, EGEXIN/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     EGEXIN, 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/O/+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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## SOLN12

```

$$$$ ROOG IS A TIME VARYING COMPONENT OF RELATIVE DISPLACEMENT (ONLY
$$$$ DISP--WITHOUT ACCELERATION OR VELOCITY) DUE TO THE EFFECTS OF
$$$$ OMITTED DOF'S. IT NEEDS TO BE CONVERTED TO THE STANDARD TRIPLET
$$$$ FORM OF TRANSIENT DIRECT ANALYSIS. KREKU MAKES THE CONVERSION AND
$$$$ OUTPUTS THE DISPLACEMENTS AUGMENTED WITH KOO REFINEMENTS.
PARAM // *OR*/V, N, QU/C, Y, QRFIN/C, Y, URFIN $
PARAM // *OR*/V, N, AQU/V, N, QU/C, Y, ARFIN $
COND TOKRK, AQU $
JUMP REGLR $
LABEL TOKRK $
$$ 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 GA, OMIT $
EQUIV UMPRUV, UPV/URFIN $
LABEL GA $
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, B2PARAM = +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 B2PARAM 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-
$$ VERY OF BASE FORCES AS REQUESTED BY THE USER WITH OLOAD IN CASECC.
$
ALTER 135 $ JUST AFTER OFF FOLLOWING SDR3.
$$ 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, /
        , , DACABSP1, , , , /*TRANSRESP* $
SDR3,    , , DACABSP1, , , , / , , DACABSP2, , , , $
OFFS     DACABSP2, , , , , //CARDNO $

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SOLN12

\$\$ 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,,,DACABSP2,,/XYPLABS/\*TRAN\*/PSET\*/S,N,PFILE \$  
XYPLOT XYPLABS// \$  
ENDALTER  
\$THIS IS THE END OF THE INTERNAL MODIFICATION TO R. F. 12.