A GENERAL PROCEDURE FOR FINITE ELEMENT MODEL CHECK AND MODEL IDENTIFICATION

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ABSTRACT

Dynamic loads analysis using finite element models is a major task in the structural design process. An error free model to predict accurate loads or responses is essential for designing a vehicle to meet its performance requirements. A systematic approach employing MSC/NASTRAN direct matrix algorithm program is developed to check the residual loads and the rigid body strain energy for identifying improper modeling. The modal effective mass of each system mode is also computed using rigid body modes for statically determinate structures or constraint modes for statically indeterminate structures to identify the significant modes of the structure with respect to the constrained interfaces. These significant modes are the target modes to be identified in the payload structural qualification modal survey for generating a test-verified dynamic model used in the verification loads analysis. Furthermore, the modal kinetic energy distribution per degree of freedom and the kinetic energy fraction for each superelement are computed to identify the important subsystem local modes in additional to the standard strain energy fraction provided by MSC/NASTRAN. An example is presented to demonstrate this systematic approach for analytical model check and model identification.

INTRODUCTION

Dynamic loads analysis using finite element models is a major task in the structural design process. An error free model to predict accurate loads or responses is essential for designing a vehicle to meet its performance requirements. Several techniques, such as a 1-G check, enforced displacement check, and Cholesky check are available to verify analytical models. However, these techniques are applied at the analysis set level (i.e. at the A-set level in terms of MSC/NASTRAN terminology) and are unable to identify the problem area at the upper stiffness assembly levels. In 1985, an MSC/NASTRAN multi-level rigid body strain energy check routine [1] was developed to provide a means for checking an analytical model at three model stiffness assembly levels. For large complicated structures which are modeled as superelements, this routine needs to be extended in order to pin-point the modeling problems for each superelement and to identify the important dynamic characteristics of the structures.

Several additional techniques to detect modeling problems which result from improperly applied constraints and stiffness distribution as well as the algorithms to identify the dynamic characteristics of large complex dynamic models have been developed for MSC/NASTRAN version 67.5 structural superelement analysis. The residual loads and the rigid body strain energy concept are applied on the three levels of the stiffness matrices associated with MSC/NASTRAN analysis sets to identify the modeling errors. The total weight of the model and the weight of each up-stream superelement is calculated for comparison with the Mass Property Report. The modal effective mass [2] of each system mode is computed using the rigid body modes for statically determinate structures or the constraint modes for statically indeterminate structures. The modal effective mass is used widely to identify the significant modes of the structure with respect to the interfaces [3,4]. These significant modes are the target modes to be identified during the structural qualification modal survey. The accumulated modal effective mass is usually used to establish the frequency range of interest for predicting the dynamic responses using the mode transformation approach. Furthermore, the modal kinetic energy distribution per degree of freedom [5] and the kinetic energy fraction for each superelement are computed to identify the important subsystem local modes in addition to the standard strain energy fraction provided by MSC/NASTRAN.

An example using the Version 67.5 application direct matrix abstraction program (DMAP) is presented in this paper to demonstrate this systematic approach for analytical model check and model identification.

MODEL CHECK

Several techniques, such as a 1-G check, enforced displacement check, and Cholesky check are available to verify the analytical model. However, these techniques are applied at the analysis set level and are unable to identify the problem area at the upper levels. The multi-level rigid body strain energy check provides a means to check the model thoroughly. The basic concepts and algorithm which have been coded in the DMAP presented are discussed in the following sections.

Residual Loads and Residual Displacements Check

MSC/NASTRAN is well laid out in the various analysis sets: the G-set level contains all the degrees of freedom (DOF's) of the model; the N-set contains all the DOF's after removing from the G-set all the dependent DOF's due to multiple-point-constraint equations (MPC's) and rigid elements; the F-set contains all the DOF's after the single-point-constraint equations (SPC's) have been removed from the N-set. The basic principle applied in the residual loads and the residual displacements (separation ratio) check technique uses the rigid-body modes [Φ_{rb}] to post-multiply the stiffness matrix [K_s] of the model for determining the residual constraint forces [P_{grnd}] associated with the rigid-body motion as shown in Eq. (1),

$$[K_s][\Phi_{rb}] = [P_{grnd}] \tag{1}$$

Note that the rigid body modes [Φ_{rb}] are determined from the structural geometry and have nothing to do with the rigid body modes computed in the later eigensolution process. Naturally, an ideal unconstrained model without errors would not have any constraint force associated with the rigid-body motion.

The residual displacement, [S_{ratio}], in a specific direction is defined as the normalized displacement with respect to the stiffness in that direction with the effects of the other DOF's ignored as shown in Eq. (2),

$$[S_{ratio}] = \frac{[P_{grnd}]}{\left[[Diag(K_s)]\{1\}^T\right]} \tag{2}$$

where

-	is the element-by-element division operator
{1}	is a unit column vector with 1's in all rows
Diag()	is a column vector containing the terms from the diagonals of the matrix enclosed in the parentheses

To minimize the numerical round-off error caused by dividing two small numbers in Eq. (2) the diagonal terms of [K_s] less than a pre-selected stiffness threshold (currently set to 10^{-5}) are reset to zero. By computing the residual loads and the residual displacements at each unique level, the type of the modeling problems and the DOF's associated with it can be identified.

In general, the residual loads and the residual displacements at each DOF should be small (typically $<10^{-5}$ for translational DOF's and $<10^{-3}$ for rotational DOF's) for an error-free model. Therefore, a relatively large value at different levels indicates certain modeling errors. In addition, comparison of the residual load and the residual displacement at the same DOF may provide some indication of the numerical round-off problem. The possible modeling problems at each level are summarized as follows:

G-level:

- Coordinate coupling, e.g. RBE of grid points with different output coordinates
- Ill-conditioning due to short beams
- Element coordinate for pin flag DOF's offsets from grid point output coordinate
- CELAS element between non-coincident points

N-level:

- Improper MPC equations

F-level:

- Over-constrained due to SPC's
- Normal rotational stiffness is non-zero for CQUAD4 or CTRIA3 elements while the parameter K6ROT is turned on

It is emphasized that the model is GROUNDED (or CONSTRAINED) only if non-zero values not in the G-set or the N-set occur in the F-level. Any non-zero values in the G-level or the N-level indicate geometry modeling error or numerical round-off error.

Multi-Level Rigid-Body Strain Energy Check

The multi-level rigid body strain energy check is a similar technique as that of the residual displacement check. It simply determines the strain energy of the model associated with the rigid-body motion at different levels,

$$[K_{se}] = [\Phi_{rb}]^T [K][\Phi_{rb}] \tag{3}$$

A large value (typically $>10^{-3}$ for translational direction and $>10^{1}$ for rotational direction) indicates modeling errors. The causes are the same as those summarized in the previous Section. The rigid body strain energy check is considered less important than the residual loads and the residual displacements check.

The residual displacements and the rigid-body strain energy computed by Eqs. (2) and (3) will be printed out for each superelement automatically. The residual loads of Eq. (1) will be printed out per user's request (parameter **PGPR**). The multi-level superelement approach to locate the possible modeling errors of smaller components is more efficient than the model check of the complete model.

Mass Property Check

The mass properties (total mass, inertia, and the location of the center of gravity) listed in the weight generation table of the MSC/NASTRAN output should agree with those specified in the updated mass property report. The weight table is generated for each superelement and can be used to verify the weight of tip superelements. If the superelement contains up-stream superelements the application DMAP will generate an additional weight table which includes the weights of all up-stream superelements. A special parameter (**WTONLY**) is available to perform the separation ratio and weight calculation without computing the frequencies of the components to minimize the computation cost.

Rigid-Body Frequency Check

The rigid body frequency check can be done on the residual superelement only. This is because the frequencies of the up-stream superelements are computed with respect to the boundary DOF's (similar to the Craig-Bampton modal model). However, the constrained normal modes computed for the up-stream superelement can be used to verify the minimum frequency requirement for that subsystem.

For an error-free unconstrained model, the first six modes should be rigid body modes. The frequencies of the six rigid-body modes in general should be five orders of magnitude less than the first elastic mode (the SUPORT entry should not be used in the Bulk Data when checking the rigid-body modes).

MODEL IDENTIFICATION

Determination of the structural fundamental frequency is a very important step in the design process. However, the identification of the mode shapes of a complex structure is always difficult. In addition, there is always a concern about how many modes should be kept if the mode transformation approach is to be used in determining the dynamic responses. The effective mass which represents the contribution of each mode to the system response may be used as an indicator for mode selection.

Effective Mass Using Rigid Body Modes

The conventional approach is to compute the modal effective mass with respect to the rigid body modes $[\Phi_{rb}]$ assuming the load path can be ignored. This requires the calculation of the modal participation factors matrix (MPF) as defined in Eq. (4)

$$[MPF] = [\Phi_e]^T [M_s][\Phi_{rb}] \tag{4}$$

where

$[\Phi_e]$	is the orthonormal mode shape matrix
$[M_s]$	is the system mass matrix

Then the modal effective mass of each mode ($Meff_{rb}\%$) with respect to the rigid body modes can be obtained as follows:

$$[Meff_{rb}\%] = \frac{\left[([\Phi_e]^T[M_s][\Phi_{rb}]) \otimes ([\Phi_e]^T[M_s][\Phi_{rb}])\right]}{\left[\{1\}[Diag([\Phi_{rb}]^T[M_s][\Phi_{rb}])]^T\right]} * 100 \tag{5}$$

where

$\otimes$	is the element-by element multiplication operator
-	is the element-by-element division operator
*	is the multiplication operator
$\{1\}$	is a unit column vector with 1's in all rows
Diag()	is a column vector containing the terms from the diagonals of the matrix enclosed in the parentheses

Effective Mass Using Constraint Modes

On the other hand, if the structure is statically indeterminate then the modal effective mass computed using rigid body mode approach is incorrect because the interface load path has not been taken into account. In this case the constraint mode set instead of the rigid body mode set has to be used. The constraint mode $[\Phi_{cm}]$ is determined from Eq. (6),

$$[\Phi_{cm}] = \begin{bmatrix} -K_{ii}^{-1}K_{ib} \\ I_{bb} \end{bmatrix} \tag{6}$$

where

$[K_{ii}]$	is the stiffness corresponding to non-interface DOF's
$[K_{ib}]$	is the stiffness corresponding to interface DOF's
$[I_{bb}]$	is an identity matrix corresponding to interface DOF's

The modal effective mass of each mode ($Meff_{cm}\%$) with respect to the constraint modes can be obtained from Eq. (7),

$$[Meff_{cm}\%] = \frac{\left[([\Phi_e]^T [M_s][\Phi_{cm}]) \otimes ([\Phi_e]^T [M_s][\Phi_{cm}])\right]}{\left[\{1\}[Diag([\Phi_{cm}]^T [M_s][\Phi_{cm}])]^T\right]} * 100 \qquad (7)$$

Ideally, if all the modes were included in the prediction of the dynamic response and the structure was linear, the total modal effective mass and inertia would be equal to the physical mass and inertia with respect to the reference point. In reality, the significant modes within the frequency range of interest are considered to have been included in the analysis if the ratio of the total modal effective mass to the physical mass is higher than 85%.

Two levels of modal effective masses, G-level and J-level, are computed for the superelement approach. The G-level modal effective mass, GMEFF%, includes the contribution from the up-stream superelements while the J-level modal effective mass, JMEFF%, is the contribution of that superelement only. By examining the modal effective mass of each mode in the translational and rotational directions, the motion of each mode can be identified and the significant modes of the structure can be selected. The total modal effective mass of the significant modes can be determined to check if they indeed contribute most to the dynamic responses of the structure. The calculation of modal effective mass is controlled by the parameter **MEFF**. The rigid body mode approach is the default method. The constraint mode approach is selected automatically by the DMAP if BSET cards defining the interface DOF's are used in the model.

Occasionally, the modal effective mass of a subsystem constrained at its interfaces is desired for validating the minimum frequency requirement for the secondary structure and for supporting the subsystem stand alone modal survey. A parameter, **CBMEFF**, can be turned on for each superelement to compute the modal effective mass corresponding to the component Craig-Bampton model.

Modal Kinetic Energy per DOF

The difficulty of mode identification of a dynamic model increases substantially as the model becomes larger and more complex. In order to assist the analyst in differentiating system modes and local modes, a concept of determining the modal kinetic energy per degree of freedom is developed. This modal kinetic energy check is based on the orthogonality principle as shown in Eq. (8),

$$[\Phi_e]^T [M_s][\Phi_e] = [I] \qquad (8)$$

where $[M_s]$ is the mass matrix of the system, $[\Phi_e]$ is the orthonormal mode shape matrix, and $[I]$ is the identity matrix.

Equation (8) can be expanded by using a special element-by-element multiplication operation and normalizing the diagonal terms to 100 to determine the percent modal kinetic energy distribution per DOF for each mode,

$$[KENG\%] = [\Phi_e] \otimes ([M_s][\Phi_e]) \qquad (9)$$

where $\otimes$ represents the element-by-element multiplication operator. In the modal kinetic energy matrix, [KENG%], the rows represent the DOF's of the model and the columns represent the calculated modes. The value at any location of [KENG%] is the percent contribution a particular DOF makes to the total kinetic energy of that mode. The summation of any column should be equal to 100. The modal kinetic energy per DOF exposes the specific directional behavior of the response. This is a remarkable improvement over standard NASTRAN element strain energy output which lumps all the DOF contribution for an element and does not distinguish between directional effects. The calculation of modal kinetic energy per DOF is activated by specifying the parameter **KE** in the bulk data or case control deck.

Similar to the effective mass calculation, two levels of kinetic energy per DOF, G-level and J-level, are computed for the superelement approach. The G-level kinetic energy per DOF, KENG%, includes the contribution from the up-stream superelements while the J-level, JKENG%, is the contribution of that superelement only. For superelement with up-stream superelements, the actual kinetic energy contribution of the DOF's are those listed in the JKENG%. The J-level kinetic energy per DOF, JKENG%, is also used widely in the industry to determine accelerometer locations for modal survey testing. Theoretically, the DOF's with higher kinetic energy respond more effectively to the dynamic environment. Consequently, the data collected at these locations are less biased and are better suited for use in modal parameter estimation.

Modal Kinetic Energy Fraction

The modal effective mass criteria used to identify the significant system modes is usually less sensitive for determining important local modes. To identify the significant local modes of a subsystem for improving the dynamic response prediction, the modal kinetic energy fraction of that subsystem, [KEF] is calculated. [KEF] is a measurement of the amount of system kinetic energy contained within each subsystem for any given mode. The modal kinetic energy fraction is computed based on Eq. (10),

$$[KEF] = \frac{\left[Diag([\Phi_c]^T[M_c][\Phi_c])\right]}{\left[Diag([\Phi_s]^T[M_s][\Phi_s])\right]} \tag{10}$$

where

$[\Phi_c]$	is the component partition of the system mode shape matrix
$[\Phi_s]$	is the system mode shape matrix
$[M_c]$	is the component mass matrix
$[M_s]$	is the system mass matrix
-	is the element-by-element division operator
Diag()	is a column vector containing the terms from the diagonals of the matrix enclosed in the parentheses

The modal kinetic energy fraction is usually employed in conjunction with the modal effective mass for selecting important modes. A rule of thumb is that if a mode has more than 50% of the modal kinetic energy of the whole system in any single subsystem, that mode is considered to be a significant local mode for that component. The calculation of modal kinetic energy fraction is controlled by the parameter **SEKEF**.

Modal Strain Energy Fraction

The modal strain energy fraction, [SEF], is similar to [KEF] in its calculation. [SEF] is a measurement of how much of the strain energy of the system is in each subsystem for any given mode. The modal strain energy fraction is computed using Eq. (11),

$$[SEF] = \frac{\left[Diag([\Phi_c]^T[K_c][\Phi_c])\right]}{\left[Diag([\Phi_s]^T[K_s][\Phi_s])\right]} \qquad (11)$$

where

$[\Phi_c]$	is the component partition of the system mode shape matrix
$[\Phi_s]$	is the system mode shape matrix
$[K_c]$	is the component mass matrix
$[K_s]$	is the system mass matrix
-	is the element-by-element division operator
Diag()	is a column vector containing the terms from the diagonals of the matrix enclosed in the parentheses

The calculation of modal strain energy fraction is controlled by the NASTRAN standard parameter **SESEF**. A rule of thumb is that if a mode has more than 50% of the modal strain energy of the whole system in any single subsystem, that mode is considered to be a significant local mode for that component.

DMAP IMPLEMENTATION

The application of the model check and model identification DMAP is straightforward. The diagnostic information of the model will be computed by simply inserting the DMAP in the MSC/NASTRAN Executive Deck. The application DMAP is shown in Appendix A. Users can define the following parameters in the Case Control or Bulk Data to activate the options available in the DMAP.

Parameters	**Default**	**Description**
WTONLY	No	If this parameter is selected (PARAM,WTONLY,YES), only the model check and the weight generation procedures are executed. This parameter is very useful for checking a free-free model before the effective masses are computed for the constrained configuration.
BGPTB	No	Print coordinate systems and grid point locations in basic coordinate system.
PGPR	No	Print residual loads.
PGFILTER	1.0E-3	Suppress the printing of residual loads smaller than PGFILTER.
MEFF	No	Compute modal effective mass. Rigid body mode approach is the default method. Constraint mode approach will be automatically activated if the interface degrees of freedom are defined in the B-Set in the residual superelement.
LMEFF%	2.0	Generate a column vector, MODEID, with a value of 1.0 at the rows whose modal effective mass is larger than LMEFF%.
CBMEFF	No	Compute modal effective mass for subsystems constrained at interfaces.

KE	No	Compute modal kinetic energy per DOF.
KEFILTER	1.0	Suppress the printing of any modal kinetic energy per DOF (KENG%) less than KEFILTER.
SEKEF	No	Compute subsystem modal kinetic energy fraction.

EXAMPLE

A Space Station integrated truss segment, S3/S4, as shown in Figure 1 was used to demonstrate the application of the model check and model identification DMAP. The segment is supported by flexure assemblies at the trunnions and keels to simulate the National Space Transportation System (NSTS) flight boundary conditions. The interface DOFs are 60200X, 60200Z, 57526Y, 60100X, 60100Z, 232097Y, 232091Z, and 232094Z and the Orbiter coordinate system is used to identify the direction. The system frequencies and modal effective mass, up to 50 Hz, for the segment S3/S4 are computed and compared for the rigid body mode approach and the constraint mode approach.

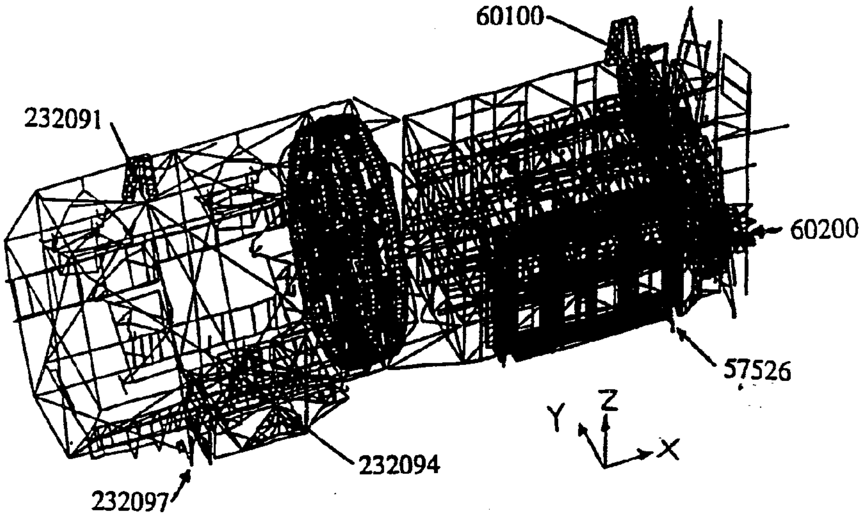

Figure 1. Segment S3/S4 Supported at Flexure Assembly

For the rigid body mode approach there are always six columns of modal effective mass, three translational and three rotational, associated with each mode. Table 1 shows the modal effective mass of the target modes (translational modal effective mass equal to or greater than 2%, or the kinetic energy fraction or the strain energy fraction greater than 50%) of segment S3/S4 using the conventional rigid body mode approach. Fourteen target modes are identified. The primary X mode has 78.14% modal effective mass at 8.36 Hz, the primary Y mode has modal effective mass 86.47% at 6.67 Hz, and the primary Z mode has 40.92% modal effective mass at 9.58 Hz. The total modal effective masses in the X-axis, Y-axis, and Z-axis are 95.56%, 93.17%, and 76.90%, respectively. The total modal effective mass in the Z direction is lower than that in the X or Y direction because more constraints (primary and secondary trunnions) are imposed in that direction.

KE	No	Compute modal kinetic energy per DOF.
KEFILTER	1.0	Suppress the printing of any modal kinetic energy per DOF (KENG%) less than KEFILTER.
SEKEF	No	Compute subsystem modal kinetic energy fraction.

EXAMPLE

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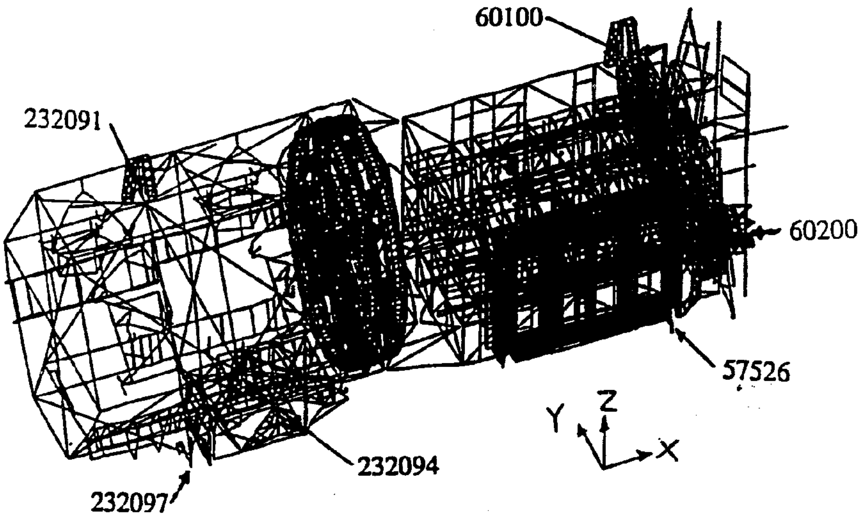

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On the other hand, Table 2 shows the modal effective mass computed from the constraint mode approach where the load path is taken into account. Each mode has a modal effective mass value corresponding to the constrained degree of freedom. For this example, which is constrained at eight interface degrees of freedom, there are eight columns of modal effective mass for each mode. The energy of each mode is transmitted differently to the interface based on the load path. However, the total modal effective mass of the target modes in the same vibratory direction at different interface locations should converge to a similar value. For this example X direction has 94.44% and 93.13%, Y direction has 97.02% and 92.36%, and Z direction has 82.04%, 81.50%, 84.59% and 85.21%. A total of twenty-one target modes are identified for S3/S4 using the constraint mode approach. The primary X mode has a maximum of 66.30% modal effective mass at 8.36 Hz, the primary Y mode has a maximum of 91.95% modal effective mass at 6.67 Hz, and the primary Z mode has a maximum of 41.15% modal effective mass at 6.67 Hz. The averaged total modal effective masses in X-, Y-, and Z-axis are about 94%, 94%, and 83%, respectively. It can be seen that the modal effective mass distribution for the target modes has been changed significantly and more target modes are selected for the constraint mode approach. The constraint mode approach is the recommended approach for computing the modal effective mass and selecting the target modes for statically indeterminate structures because it represents the actual flight conditions.

CONCLUSIONS

A systematic approach to identify the modeling errors and the dynamic characteristics of a structural model is developed and coded in DMAP for MSC/NASTRAN implementation. The modeling of each superelement is checked in three analysis levels such that improper modeling can be easily located. Two methods to select the significant structural modes for dynamic load prediction are included in the DMAP to accommodate different attachment schemes. The modeling and the dynamic behavior of a structural mathematical model can be assessed and fully understood by incorporating this DMAP.

REFERENCES

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[3] Osman, E. A. & Krausser, D. G., "A Generalized Form for the Modal Effective Mass," 63rd Shock & Vibration Symposium, Las Cruces, NM, October, 1992.

[4] Chung, Y. T. & Sernaker, M. L., "Assessment of Target Mode Selection Criteria for Payload Modal Survey," Proceeding of the 12th International Modal Analysis Conference, Jan. 1994, Honolulu, Hawaii.

[5] Parker, G. R. and Brown, J. J., "Kinetic Energy DMAP for Mode Identification," MSC/NASTRAN User's Conference, March 1982, Pasadena, CA.

Appendix A

Model Checkout and Model Identification DMAP

```
$
$            ********************************************
$       *    PRINT BGPDT AND CSTM TABLES               *
$            ********************************************
$
COMPILE SUBDMAP=PHASE0 SOUIN=MSCSOU,NOLIST,NOREF
ALTER 296
TYPE PARM,,CHAR3,Y,(BGPTB='NO ') $
$
$PVT      PVT,CASES/PVTS/ $
IF (BGPTB='YES') THEN $
TABPRT   BGPDTS//'BGPDT' $
TABPRT   CSTMS//'CSTM' $
ENDIF $ BGPTB='YES'
$
$           ********************************************
$      * GROUNDING CHECK - COMPUTE SEPARATION RATIO *
$           ********************************************
$
$ *** ADJUST WEIGHT GENERATION TABLE IF MODAL MODEL ARE      ***
$ *** USED FOR UP-STREAM SE'S AND/OR RESIDUAL SE       *     **
$ ***                                                        ***
$ *** NOTE: U6 SET (USET OR SEUSET) SHOULD BE DEFINED FOR    ***
$ ***     GRIDS IN DMIG REPRESENTING THE COMPONENT MODES     ***
$
COMPILE SUBDMAP=SEMG1, SOUIN=MSCSOU,NOREF,NOLIST
ALTER 11,12
$
$
COMPILE SUBDMAP=SEKR SOUIN=MSCSOU,NOLIST,NOREF
ALTER 50
TYPE DB,MJJ $
TYPE PARM,NDDL,I,Y,GRDPNT $
TYPE PARM,,RS,Y,WTMASS $
VEC    USET/V1U6SETG/'G'/'COMP'/'U6' $
PARTN   MJJ,V1U6SETG,/MJMINUSQ,,,/-1 $
MERGE   MJMINUSQ,,,,V1U6SETG,/MJJNOQ/-1 $
GPWG    BGPDTS,CSTMS,EQEXINS,MJJNOQ/OGPWGTSE/GRDPNT/WTMASS $
OFP     OGPWGTSE// $
$
ALTER 129  $ CRAY
TYPE DB,PVT $
TYPE PARM,,CHAR3,Y,(PGPR='NO ') $
TYPE PARM,NDDL,I,N,ZUZR1 $
TYPE PARM,,RS,Y,(PGFILTER=0.001) $
TYPE DB,ZUZR01 $
VECPLOT,   ,BGPDTS,EQEXINS,CSTMS,,/RBGTRANS/GRDPNT//4 $ RIGID BODY MODES
TRNSP      RBGTRANS/RBGQ $GLOBAL RIGID BODY MODES : G-SIZE ROWS X 6 COLS
$
$ REMOVE GENERALIZED COORDINATES (SEQSET) FROM RIGID-BODY MODES, IF ANY
VEC       USET/V1QSET/'G'/'COMP'/'Q'/ $
ADD       V1U6SETG,V1QSET/VGMINUSQ $
IF (NOUP> 0) THEN $
 DBVIEW KLAAUP=KLAA(WHERE SEID=*, AND WILDCARD=TRUE) $
 DBVIEW MAPSUP=MAPS(WHERE SEID=* AND WILDCARD=TRUE) $
 SEMA     EQEXINS,SLIST,EMAP,,KLAAUP,MAPSUP/KLAAG/SEID/
        LUSETS/QUAL='SEID'/0 $
 DIAGONAL  KLAAG/VQUPSE/'COLUMN'/1. $
 ADD      VGMINUSQ,VQUPSE/VGNOQ $
 EQUIVX   VGNOQ/VGMINUSQ/ALWAYS $
ENDIF $ NOUP>0
```

```
PARTN      RBGQ,,VGMINUSQ/RBGNOQ,,,/1 $
MERGE      RBGNOQ,,,,,VGMINUSQ/RBG/1 $
$
$ SAVE RBG IN DATA BASE FOR FUTURE USE IN OTHER SUBDMAP
ZUZR1 = SEID $
EQUIVX     RBG/ZUZR01/ALWAYS $
$
PVT        PVT,CASESX/PVTS/ $
$
$ COMPUTE G-LEVEL SEPARATION RATIO
MPYAD      KGG,RBG,/PGRNDG $  COMPUTE GROUNDING FORCES
DIAGONAL   KGG/KGGDX/'COLUMN'/ $
MATMOD      KGGDX,,,,,/KGGD,/2////1.0E-5 $
PARAML     KGGD//'TRAILER'/2/S,N,GSIZE $
MATGEN,    /VGONE/6/GSIZE/0/GSIZE $
ADD       VGONE,KGGD/KGGDI///2 $
PARAML     KGGDI//'TRAILER'/5/S,N,NZWDS $
IF (NZWDS>0) THEN $
 MATMOD     KGGDI,,,,,/KGGDINV,/28 $
 MPYAD     KGGDINV,PGRNDG,/SRATIOG $  G-LEVEL SEPARATION RATIOS
 IF (PGPR='YES') THEN $
  MATGPR    GPLS,USET,SILS,PGRNDG//'H'/'G'//PGFILTER $
 ENDIF $ (PGPR='YES')
 MATGPR    GPLS,USET,SILS,SRATIOG//'H'/'G'//1.E-5 $
ENDIF $ NZWDS>0
$
$ COMPUTE N-LEVEL SEPARATION RATIO
VEC       USET/NLINK/'G'/'COMP'/'N'  $ PUT 1'S IN G-SET FOR N-SET DOF'S
PARTN      RBG,,NLINK/,RBN,,/0 $GET N-SET ROWS OF RIGID BODY MATRIX
MPYAD      KNN,RBN,/PGRNDN $  COMPUTE GROUNDING FORCES
DIAGONAL   KNN/KNNDX/'COLUMN'/ $
MATMOD      KNNDX,,,,,/KNND,/2////1.0E-5 $
PARAML     KNND//'TRAILER'/2/S,N,NSIZE $
MATGEN,    /VNONE/6/NSIZE/0/NSIZE $
ADD       VNONE,KNND/KNNDI///2 $
PARAML     KNNDI//'TRAILER'/5/S,N,NZWDS $
IF (NZWDS>0) THEN $
 MATMOD     KNNDI,,,,,/KNNDINV,/28 $
 MPYAD     KNNDINV,PGRNDN,/SRATION $  N-LEVEL SEPARATION RATIOS
$
 IF (PGPR='YES') THEN $
  MATGPR    GPLS,USET,SILS,PGRNDN//'H'/'N'//PGFILTER $
 ENDIF $ (PGPR='YES')
 MATGPR    GPLS,USET,SILS,SRATION//'H'/'N'//1.E-5 $
ENDIF $ NZWDS>0
$
$ COMPUTE F-LEVEL SEPARATION RATIO
VEC       USET/FLINK/'G'/'COMP'/'F' $
PARTN      RBG,,FLINK/,RBF,,/0 $
MPYAD      KFF,RBF,/PGRNDF $
DIAGONAL   KFF/KFFDX/'COLUMN'/ $
MATMOD      KFFDX,,,,,/KFFD,/2////1.0E-5 $
PARAML     KFFD//'TRAILER'/2/S,N,FSIZE $
MATGEN,    /VFONE/6/FSIZE/0/FSIZE $
ADD       VFONE,KFFD/KFFDI///2 $
PARAML     KFFDI//'TRAILER'/5/S,N,NZWDS $
IF (NZWDS>0) THEN $
 MATMOD     KFFDI,,,,,/KFFDINV,/28 $
 MPYAD     KFFDINV,PGRNDF,/SRATIOF $ F-LEVEL SEPARATION RATIO
 IF (PGPR='YES') THEN $
  MATGPR    GPLS,USET,SILS,PGRNDF//'H'/'F'//PGFILTER $
 ENDIF $ (PGPR='YES')
 MATGPR    GPLS,USET,SILS,SRATIOF//'H'/'F'//1.E-5 $
ENDIF $ NZWDS>0
$
$ COMPUTE G-, N-, AND F-LEVEL STRAIN ENERGY
```

```
$
SMPYAD      RBG,KGG,RBG,,,/KGGSE/3////1//// $
SMPYAD      RBN,KNN,RBN,,,/KNNSE/3////1//// $
SMPYAD      RBF,KFF,RBF,,,/KFFSE/3////1//// $
MATPRN     KGGSE,KNNSE,KFFSE// $
$
$
$        ****************************************************
$    *  OUTPUT WEIGHT GENERATION TABLE FOR THE ENTIRE     *
$    *  MODEL, THEN STOP NASTRAN EXECUATION               *
$        ****************************************************
$
COMPILE SUBDMAP=SEMRM, SOUIN=MSCSOU,NOREF,NOLIST
ALTER 14
$
TYPE PARM,NDDL,I,Y,GRDPNT  $
TYPE PARM,,CHAR3,Y,(WTONLY='NO ')  $
TYPE PARM,,I,N,UPFM  $
ALTER 26
DBVIEW MAAUP=MAA (WHERE SEID=* AND WILDCARD=TRUE)  $
DBVIEW MAPUP=MAPS (WHERE SEID=* AND WILDCARD=TRUE)  $
IF (WTONLY='YES') THEN  $
$
$ COMPUTE TOTAL WEIGHT, THEN QUIT
 IF (NOUP>-1) THEN  $
 SEMA      EQEXINS,SLIST,EMAP,MJJ,MAAUP,MAPUP/MGGYT/
        SEID/LUSETS/'SEID'/UPFM  $
 GPWG      BGPDTS,CSTMS,EQEXINS,MGGYT/OGPWGT/GRDPNT/WTMASS  $
 MESSAGE   //' ' $
 MESSAGE   //' ' $
 MESSAGE  //'  +--------------------------------------+'/ $
 MESSAGE   //'   +                                     +'/ $
 MESSAGE   //'   + TOTAL WEIGHT TABLE INCLUDING UP-STREAM SES +'/ $
 MESSAGE   //'   + FOR SUPERELEMENT'/SEID/   '           +'/ $
 MESSAGE   //'   +                                     +'/ $
 MESSAGE  //'  +--------------------------------------+'/ $
 MESSAGE   //' ' $
 MESSAGE   //' ' $
 OFP       OGPWGT//  $
 ELSE $
 EQUIVX    MJJ/MGGYT/ALWAYS  $
 ENDIF  $ NOUP>-1
 IF (SEID=0) THEN  $
 EXIT  $
$ PROCEED TO NEXT SE
 ELSE  $
 RETURN  $
 ENDIF  $  SEID=0
ENDIF  $ WTONLY=YES
$
ALTER 48
IF (WTONLY='YES' AND SEID=0) THEN  $
EXIT $
ENDIF  $ WTONLY=YES AND SEID=0
$
$        ****************************************************
$    *  OUTPUT WEIGHT GENERATION TABLE FOR THE ENTIRE     *
$    *  MODEL                                             *
$        ****************************************************
$
COMPILE SUBDMAP=PHASE1, SOUIN=MSCSOU,NOREF, NOLIST
ALTER 63
$
$ CHECK IF UP-STREAM SE'S EXIST
IF (NOUP> 0) THEN  $
$
$ REMOVE GENERALIZED MASS (SEQSET) FROM MGG
  DBVIEW MLAAUP=MLAA(WHERE SEID=* AND WILDCARD=TRUE)  $
  DBVIEW MAPSUP=MAPS(WHERE SEID=* AND WILDCARD=TRUE)  $
  SEMA      EQEXINS,SLIST,EMAP,,MLAAUP,MAPSUP/MLAAG/SEID/
          LUSETS/QUAL='SEID'/0  $
  ADD       MGG,MLAAG/MGGYT//(-1.0,0.0)  $
  GPWG      BGPDTS,CSTMS,EQEXINS,MGGYT/OGPWGT/GRDPNT/WTMASS  $
  MESSAGE   //' ' $
  MESSAGE   //' ' $
  MESSAGE  //'  +--------------------------------------+'/ $
  MESSAGE   //'   +                                    +'/ $
  MESSAGE   //'   + TOTAL WEIGHT TABLE INCLUDING UP-STREAM SES +'/ $
  MESSAGE   //'   + FOR SUPERELEMENT'/SEID/   '          +'/ $
  MESSAGE   //'   +                                    +'/ $
  MESSAGE  //'  +--------------------------------------+'/ $
  MESSAGE   //' ' $
  MESSAGE   //' ' $
  OFP       OGPWGT//  $
ENDIF  $ NOUP>0
$
$
$     ****************************************************
$  * GENERATE AND SAVE CONSTRAINT MODES FOR COMPUTING *
$  * EFFECTIVE MASS FOR STATICALLY INDETERMINANT      *
$  * STRUCTURES                                       *
$     ****************************************************
$
COMPILE SUBDMAP=MODERS SOUIN=MSCSOU,NOLIST,NOREF
ALTER 6
TYPE PARM,,I,N,NASET,NBSET $
TYPE PARM,NDDL,I,Y,ZUZR2  $
TYPE DB,ZUZR04  $
$
PARAML   USET//'USET'//////'A'/S,N,NASET/'B'/S,N,NBSET/
        'R'/S,N,NRSET  $
IF (NRSET =0 AND (NASET>NBSET)) THEN  $
 VEC      USET/V1BSETA/'A'/'COMP'/'B'  $
 MATGEN,  /IDENTB/1/NBSET/0/2  $
 PARTN    MMAA,V1BSETA,/MII,MBI,MIB,MBB/-1  $
 PARTN    MKAA,V1BSETA,/KII,KBI,KIB,KBB/-1  $
 SOLVE    KII,KIB/PHICM/1/-1  $
 MERGE    PHICM,IDENTB,,,,V1BSETA/PHICMA/1  $
$ SAVE CONSTRAINT MODES OF RESIDUAL SUPERELEMENT, PHICMA
 ZUZR2=0  $
 EQUIVX   PHICMA/ZUZR04/ALWAYS  $
ELSE  $
 COPY     MMAA/MII/ALWAYS  $
 COPY     MKAA/KII/ALWAYS  $
ENDIF $ (NRSET=0 AND (NASET>NBSET))
$
$ GENERATE PARTITION VECTORS TO UPDATE RIGID-BODY MODES AND NULL MASS
$ DOF'S TO EXCLUDE THE B-SET
$
ALTER 22
IF (NRSET=0 AND (NASET>NBSET)) THEN  $
 PARTN    VACMPR,,V1BSETA/VCRSET,,,/1 $
ELSE  $
 EQUIVX   VACMPR/VCRSET/ALWAYS  $
ENDIF $ (NRSET=0 AND (NASET>NBSET))
ALTER 27,28
IF (NRSET=0 AND (NASET>NBSET)) THEN  $
 PARTN    VALCOMP,,V1BSETA/VCRSETL,,,/1 $
 PARTN    V1BSETA,,VALCOMP/VCSET,,,/1 $
 PARTN    DM,,VCSET/DMCSET,,,/1 $
ELSE  $
 EQUIVX   VALCOMP/VCRSETL/ALWAYS  $
```

```
 EQUIVX   DM/DMCSET/ALWAYS  $
ENDIF  $ (NRSET=0 AND (NASET>NBSET))
PARTN     VCRSETL,,VCRSET/VLQ,,,/1 $
MERGE     DMCSET,,,,,VLQ/DMLQ/1 $
ALTER 37,37
MATMOD   MII,KII,,,,/VAXW1,MATAA/12/S,N,NOARED/NMAT $
ALTER 41,42
PARTN     VAXW1,,VCRSET/VLQXW,,,/1 $
MERGE     VLQXW,,,,,VCRSET/VAXW/1 $
$
$ GENERATE NORMAL MODES (PHIN) FOR FIXED-INTERFACE C-B MODEL AND EXPAND
$ BACK TO A-SET SIZE (PHIA)
$
ALTER 46,47
EQUIVX   KII/KXX/NOARED  $
EQUIVX   MII/MXX/NOARED  $
ALTER 52,52
EQUIVX   VCRSET/VXCOMPR/NOARED  $
ALTER 57,58
IF (NRSET=0 AND (NASET>NBSET)) THEN  $
 MERGE     VAXW,,,,,V1BSETA/VAXWA/1 $
ELSE $
 EQUIVX   VAXW/VAXWA/ALWAYS  $
ENDIF  $ (NRSET=0 AND (NASET>NBSET))
MATGPR   GPLS,USET,SILS,VAXWA//'H'/'A'  $
ALTER 61,62
PARTN     MII,VAXW,/MXX,,,/-1 $
PARTN     KII,VAXW,/KXXBAR,KWX,,KWW1/-1 $
ALTER 74,74
PARTN     VCRSET,,VAXW/VXCOMPR,,,/1 $
ALTER 90,90
EQUIV    PHIX,PHIN/NOARED $
ALTER 93,93
MERGE     PHIX,PHIW,,,,VAXW/PHIN/0 $
ALTER 95
IF (NRSET=0 AND (NASET>NBSET)) THEN  $
 MERGE     PHIN,,,,,V1BSETA/PHIA/1 $
ELSE $
 EQUIVX   PHIN/PHIA/ALWAYS  $
ENDIF  $ (NRSET=0 AND (NASET>NBSET))
$
$
$   **************************************************************
$ *                                                              *
$ *    COMPUTE MODAL EFFECTIVE MASS OF EACH SUPERELEMENT         *
$ *                                                              *
$   **************************************************************
$
COMPILE SUBDMAP=SUPER3 SOUIN=MSCSOU,NOLIST,NOREF
$
$ PREPARE TAPE FOR OUTPUT2 DATA DUMP
ALTER 66
TYPE PARM,,CHAR3,Y,(NASTIPS='NO ')  $
TYPE PARM,,I,Y,(NASTAPE=99)  $
TYPE PARM,,CS,Y,CSEID  $
PVT    PVT,/PVTY/  $
$
$ INITIALIZE OUTPUT2 TAPE
OUTPUT2, ,,,,//-1/NASTAPE/  $
$
ALTER 144
TYPE DB,MJJ,MGG,MAA,KAA  $
TYPE,DB,MLAA,KLAA  $
TYPE DB,SLIST,GOA  $
TYPE PARM,,I,N,LUSETS,UPFM  $
TYPE PARM,NDDL,I,N,NOMGG  $
```

```
TYPE PARM,,I,N,NOM2GG  $
TYPE PARM,NDDL,RS,Y,WTMASS  $
TYPE PARM,,RS,N,MASSWT  $
TYPE PARM,,CS,N,CMASSWT,WTVALUE  $
TYPE PARM,,CHAR3,Y,(KE='NO ',KENORMPR='NO ')  $
TYPE PARM,,RS,Y,(KEFILTER=1.0) $
TYPE PARM,,RS,Y,(LKENORM%=1.0) $
TYPE PARM,,CHAR3,Y,(MEFF='NO ',CBMEFF='NO ')  $
TYPE PARM,,RS,Y,(LMEFF%=2.0) $
TYPE PARM,,I,Y,WTROW,WTINDEX,WTWORD  $
TYPE PARM,NDDL,I,N,ZUZR1,ZUZR2  $
TYPE  DB,ZUZR01,ZUZR02,ZUZR03,ZUZR04,ZUZR05   $
TYPE PARM,,I,N,NASET,NBSET $
TYPE PARM,,I,Y,NTDOF,NFIND,NZERO,IDXDOF,IDXDIR,DIRCODE $
TYPE PARM,,CS,Y,CDIRWT  $
TYPE PARM,,CHAR3,Y,(SDBC='YES')  $
$
$ FORMULATE WEIGHT-MASS CONVERSION FACTOR
MASSWT = 1.0/WTMASS  $
CMASSWT = CMPLX(MASSWT,0.0)  $
PARAML   MJJ//'PRESENCE'////S,N,NOMJJ  $
DBVIEW   USETYT=USET (WHERE SEID=0 AND WILDCARD=*)  $
PARAML   USETYT//'USET'//////'A'/S,N,NASET/'B'/S,N,NBSET/
      'Q'/S,N,NOQSET/'T'/S,N,NOTSET/'R'/S,N,NRSET  $
$
IF (MEFF='YES') THEN  $
$          ***************************************************
$      * CHECK THE APPROACH TO COMPUTE THE MOADL EFFECTIVE        *
$       * MASS                                                   *
$      *   CONSTRAINT MODES --- PHICMA IS REQUIRED               *
$      *   RIGID BODY MODES --- RBGG   IS REQUIRED               *
$          ***************************************************
$
DBVIEW PHICMAX=ZUZR04 (WHERE ZUZR2=0 AND WILDCARD=TRUE)  $
PARAML   PHICMAX//'PRESENCE'////S,N,NPHICMA  $
CALL SEGOA  GOAT,GOAQ/GOAX/NOOSET/NOQSET/NOTSET  $
IF (NPHICMA >=0 ) THEN  $
$
$       *******                                          *******
$       ******* CONSTRAINT MODE APPROACH                 *******
$       *******                                          *******
$
$ RETRIEVE/GENERATE CONSTRAINT MODES
 SDBC='NO '  $
  DBVIEW MAPSF=MAPS (WHERE SEID=* AND WILDCARD=TRUE)  $
  DBVIEW PHICMGX=ZUZR05 (WHERE ZUZR2=SEDWN AND WILDCARD=TRUE)  $
  DBVIEW EQEXINSD=EQEXINS (WHERE PEID=SEDWN)  $
  EXTRCV1=EXTRCV  $
  IF (SEDWN<>0) EXTRCV1=0  $
  DBVIEW EMAPX=EMAP (WHERE EXTRCV=EXTRCV1)  $
  SEDR    EMAPX,CASEX,PCDB,DRLIST,XYCDB,SLT,ETT,
       MAPSF,PHICMGX,EQEXINSD/PHICMABP,XCASEDR,XPCDBDR,
       XXYCDBDR/APP/SEID/S,N,XNOUP/S,N,XNOSRT1//
      S,N,XNOOUT/S,N,XNOPLOT/S,N,XNOXYPLT/'SEID'/NCUL  $
  IF (SEID=0) EQUIVX  PHICMAX/PHICMABP/ALWAYS  $
  SDR1    USET,,PHICMABP,,,GOAX,GM,,KFS,KSS,/
        PHICMG,,/1/APP1  $
$ SAVE CONSTRAINT MODES FOR EACH SUPERELEMENT
  ZUZR2=SEID  $
  EQUIVX  PHICMG/ZUZR05/ALWAYS  $
ELSE  $
$
 IF (SEID=0 AND (NRSET=0 AND NASET>NBSET)) THEN  $
$ GENERATE CONSTRAINT MODES OF RESIDUAL SUPERELEMENT
  IF (NOQSET=-1) THEN  $
   EQUIVX KAA/MKAAX/ALWAYS  $
```

```
 ELSE IF (NOTSET=-1) THEN  $
  EQUIVX  KLAA/MKAAX/ALWAYS  $
 ELSE  $
  ADD5    KAA,KLAA,,,/MKAAX  $
 ENDIF  $ (NOQSET=-1)
 ADD5     MLAA,MAA,,,/MMAAX  $
 VEC      USET/V1BSETA/'A'/'COMP'/'B'  $
 MATGEN,  /IDENTB/1/NBSET/0/2  $
 PARTN    MMAAX,V1BSETA,/MII,MBI,MIB,MBB/-1  $
 PARTN    MKAAX,V1BSETA,/KII,KBI,KIB,KBB/-1  $
 SOLVE    KII,KIB/PHICM/1/-1  $
 MERGE    PHICM,IDENTB,,,,,V1BSETA/PHICMA/1  $
 ZUZR2=0  $
 EQUIVX   PHICMA/ZUZR04/ALWAYS  $
 SDR1     USET,,PHICMA,,,GOAX,GM,,KFS,KSS,/
          PHICMG,,/1/APP1  $
ELSE  $
$
$        *******                                        *******
$        *******  RIGID BODY MODE APPROACH              *******
$        *******                                        *******
$
$ RETRIEVE/GENERATE RIGID-BODY MODES
$  ZUZR1=SEID  $
$  DBVIEW RBGXX=ZUZR01 (WHERE ZUZR1=SEID)  $
$$
$  PARAML   RBGXX//'PRESENCE'////S,N,NRBGG  $
$   IF (NRBGG>=0) THEN  $
$    COPY     RBGXX/RBGG/ALWAYS  $
$$
$  ELSE $
$
   PARAML     USET//'USET'//////'G'/S,N,LUSETS  $
$  GENERATE RIGID-BODY MODES FOR RESTART RUN
   VECPLOT,   ,BGPDTS,EQEXINS,CSTMS,,/RBGTRANS/GRDPNT//4 $ RIGID BODY MODES
   TRNSP      RBGTRANS/RBGQ $GLOBAL RIGID BODY MODES : G-SIZE ROWS X 6 COLS
$
$  REMOVE GENERALIZED COORDINATES (SEQSET) FROM RIGID-BODY MODES, IF ANY
   VEC        USET/VGMINUSQ/'G'/'COMP'/'Q'/  $
$
   IF (RSONLY) THEN  $
    $
   ELSE  $
    IF (NOUP> 0) THEN  $
     DBVIEW KLAAUP=KLAA(WHERE SEID=*, AND WILDCARD=TRUE)  $
     DBVIEW MAPSUP=MAPS(WHERE SEID=* AND WILDCARD=TRUE)  $
     SEMA     EQEXINS,SLIST,EMAP,,KLAAUP,MAPSUP/KLAAG/SEID/
              LUSETS/QUAL='SEID'/0  $
     DIAGONAL   KLAAG/VQUPSE/'COLUMN'/1.  $
     ADD        VGMINUSQ,VQUPSE/VGNOQ  $
     EQUIVX     VGNOQ/VGMINUSQ/ALWAYS  $
    ENDIF  $ (NOUP>0)
   ENDIF  $ (RSONLY)
   PARTN      RBGQ,,VGMINUSQ/RBGNOQ,,,/1  $
   MERGE      RBGNOQ,,,,,VGMINUSQ/RBGG/1  $
$
$  ENDIF  $ (NRBGG>=0)
 ENDIF  $ (SEID=0 AND (NRSET=0 AND NASET>NBSET))
ENDIF  $ (NPHICMA>=0)
$
$ GET NO OF B-SET DOF FOR EFFECTIVE MASS CALCULATION USING
$ CONSTRAINT MODE APPROACH
PARAML    PHICMG//'TRAILER'/1/S,N,NRSBSET  $
IF (SEID=0 AND (NRSET=0 AND NASET>NBSET)) TABPRT USET,EQEXINS/
                                 /'USET'/0/2097152  $
$
```

```
IF (RSONLY) THEN  $
 $
ELSE  $
IF (NOUP>0) THEN  $
$
$ CHECK THE PRESENCE OF THE PHYSICAL MASS MATRIX (MJJ)
 IF (NOMJJ >= 0 ) THEN  $
$
$   ****************************************************************
$ *     EFFECTIVE MASS WITH CONTRIBUTION OF UP-STREAM SE'S               *
$ *     (FOR RESIDUAL SE OR SE WITH UP-STREAM SUPERELEMENTS)             *
$ *                                                                      *
$ *  GMPF      <-- MODAL PARTICIPATION FACTOR WITH UP-STREAM SE'S        *
$ *  GMEFFMODE <-- EFFECTIVE MASS PER MODE WITH UP-STREAM SE'S           *
$ *  GMEFFSUM  <-- TOTAL EFFECTIVE MASS WITH UP-STREAM SE'S              *
$ *  GMEFF%    <-- PERCENT-EFFECTIVE MASS PER MODE WITH UP-STREAM        *
$ *               SE'S                                                   *
$ *  TGMEFF%   <-- PERCENT TOTAL EFFECTIVE MASS W/O UP-STREAM SE         *
$   ****************************************************************
$
$ COMPUTE MODAL PARTICIPATION FACTOR (GMPF) AND MODAL
$ EFFECTIVE MASS (GMEFFSUM) FOR UP-STREAM SE'S
$
 MPYAD    UG,MGG,/UGMGX/1  $
 IF (SDBC='NO ') THEN  $
  MPYAD    UGMGX,PHICMG,/GMPF  $
 ELSE  $
  MPYAD    UGMGX,RBGG,/GMPF  $
 ENDIF  $ (SDBC='NO ')
$
$   COMPUTE MODAL EFFECTIVE MASS FOR EACH MODE (GMEFFMOD).
 DIAGONAL GMPF/GMEFFSQD/'WHOLE'/2.0 $
 TRNSP    GMEFFSQD/GMODETEM $
 ADD      GMODETEM,/GMEFFMOD/CMASSWT/ $
$
$   COMPUTE TOTAL EFFECTIVE MASS AND INERTIA OF THE SYSTEM (GMEFFSUM),
$   AND CONVERT THEM TO WEIGHT UNIT.
 TRNSP    GMPF/GMPFT $
 MPYAD    GMPFT,GMPF,/GMEFFSQ $
 DIAGONAL GMEFFSQ/GMSUMTEM/'COLUMN'/1.0 $
 ADD      GMSUMTEM,/GMEFFSUM/CMASSWT/ $
$
$ COMPUTE % EFFECTIVE MASS OF EACH MODE
$
$ EXTRACT PHYSICAL MASS AND INERTIA FROM WEIGHT TABLE
 DBVIEW MAAUPG=MAA(WHERE SEID=* AND WILDCARD=TRUE)  $
 DBVIEW MAPSUPG=MAPS(WHERE SEID=* AND WILDCARD=TRUE)  $
 SEMA    EQEXINS,SLIST,EMAP,MJJ,MAAUPG,MAPSUPG/MGGYTX/
         SEID/LUSETS/'SEID'/UPFM  $
 GPWG     BGPDTS,CSTMS,EQEXINS,MGGYTX/OGPWGX/GRDPNT/WTMASS  $
$
$ GENERATE 6X1 VECTOR FOR PHYSICAL MASS AND INERTIA
 WTROW=6  $
 MATGEN,  /GWTSUM/7/6/1  $
 DO WHILE(WTROW>0)  $
  WTINDEX=6-WTROW  $
  WTWORD=WTINDEX*7+1  $
  WTROW=WTROW-1  $
  MATGEN,  /V1WT/6/6/WTINDEX/1  $
  PARAML   OGPWGX//'DTI'/2/WTWORD/S,N,WTDATA $
  WTVALUE = CMPLX(WTDATA,0.0)  $
  ADD      V1WT,/V2WT/WTVALUE/  $
  ADD      V2WT,GWTSUM/V3WT//  $
  EQUIVX   V3WT/GWTSUM/ALWAYS  $
 ENDDO  $
$
```

```
$ GENERATE TOTAL MASS/WEIGHT VECTOR FOR COMPUTING EFFECTIVE
$ MASS OF STATICALLY INDETERMINANT STRUCTURES
 IF (SDBC='NO ') THEN  $
  SMPYAD    PHICMG,MGGYTX,PHICMG,,,/GSIDMAT/3////1  $
  DIAGONAL  GSIDMAT/GSIDWTX/'COLUMN'/1.0  $
  ADD       GSIDWTX,/GSIDWT/CMASSWT/  $
  COPY      GSIDWT/GWTSUMX/ALWAYS  $
 ELSE  $
  COPY    GWTSUM/GWTSUMX/ALWAYS  $
 ENDIF  $ (SDBC='NO ')
$MATPRN  GWTSUM,GWTSUMX//  $
$
$ DETERMINE THE PERCENTAGE OF MODAL EFFECTIVE MASS
  PARAML   GMEFFMOD//'TRAILER'/1/S,N,NTGMODE   $
  MATGEN,  /IDGM/1/NTGMODE  $
  DIAGONAL IDGM/IDGCOL/'COLUMN'/1.0  $
  TRNSP    IDGCOL/IDGROW  $
  MPYAD    GWTSUMX,IDGROW,/GSUMMAT  $
  ADD      GMEFFMOD,GSUMMAT/GMEFF%/(100.0,0.0)//2  $
  ADD      GMEFFSUM,GWTSUMX/TGMEFF%/(100.0,0.0)//2  $
$
$ GENERATE MODE INDEX FOR MODES HAVING TRANSLATIONAL EFFECTIVE
$ MASS HIGHER THAN LMEFF% (DEFAULT IS 2%)
$
 IF (SDBC='NO ') THEN  $
  MATMOD   GMEFF%,,,,,/GMEFFTM,/2////LMEFF%  $
  MATGEN   ,/GVONE/6/NRSBSET/0/NRSBSET  $
 ELSE  $
  MATMOD   GMEFF%,,,,,/GMEFFS,/2////LMEFF%  $
  MATGEN   ,/GVXYZEFF/6/6/3/3  $
  MATGEN   ,/GVONE/6/3/0/3  $
  PARTN    GMEFFS,,GVXYZEFF/GMEFFTM,,,/1  $
 ENDIF  $ (SDBC='NO ')
  MPYAD    GVONE,GMEFFTM,/GVTMODES/1  $
  DIAGONAL GVTMODES/GMODEID/'WHOLE'/0.0  $
  ZUZR1=SEID  $
  EQUIVX   GMODEID/ZUZR03/ALWAYS  $
  MESSAGE  //'TARGET MODE INDEX FOR SE WITH UP-STREAM SE'/ $
  MATPRN   GMODEID//  $
$
$ PRINT EFFECTIVE MASS PER MODE, TOTAL EFFECTIVE MASS,
$ PERCENT EFFECTIVE MASS PER MODE, AND PERCENT TOTAL EFFECTIVE MASS
  MESSAGE  //'EFFECTIVE MASS PER MODE WITH UP-STREAM SE'/ $
  MATPRN   GMEFFMOD// $
  MESSAGE  //'TOTAL EFFECTIVE MASS WITH UP-STREAM SE'/ $
  MATPRN   GMEFFSUM// $
  MESSAGE  //'PERCENT EFFECTIVE MASS PER MODE WITH UP-STREAM SE'/ $
  MATPRN   GMEFF%//  $
  MESSAGE  //'PERCENT TOTAL EFFECTIVE MASS WITH UP-STREAM SE'/ $
  MATPRN   TGMEFF%//  $
 ENDIF  $ NOMJJ>=0
ENDIF  $ NOUP>0
ENDIF  $ RSONLY
$
$   *****************************************************************
$ *     EFFECTIVE MASS W/O CONTRIBUTION OF UP-STREAM SE'S            *
$ *                                                                  *
$ *  JMPF      <-- MODAL PARTICIPATION FACTOR W/O UP-STREAM SE'S     *
$ *  JMEFFMODE <-- EFFECTIVE MASS PER MODE W/O UP-STREAM SE'S        *
$ *  JMEFFSUM  <-- TOTAL EFFECTIVE MASS W/O UP-STREAM SE'S           *
$ *  JMEFF%    <-- PERCENT-EFFECTIVE MASS PER MODE W/O UP-STREAM     *
$ *  TJMEFF%   <-- PERCENT TOTAL EFFECTIVE MASS W/O UP-STREAM        *
$ *                                                                  *
$   *****************************************************************
$
$ **** COMPUTE EFFECTIVE MASS WITHOUT CONTRIBUTION OF UP-STREAM SES ****
```

```
$
$ CHECK THE PRESENCE OF THE PHYSICAL MASS MATRIX (MJJ)
IF (NOMJJ >= 0 ) THEN  $
 MPYAD    UG,MJJ,/UGMJX/1  $
 IF (SDBC='NO ') THEN  $
  MPYAD    UGMJX,PHICMG,/JMPF  $
 ELSE  $
  MPYAD    UGMJX,RBGG,/JMPF  $
 ENDIF  $ (SDBC='NO ')
$
$   COMPUTE MODAL EFFECTIVE MASS FOR EACH MODE (JMEFFMOD).
 DIAGONAL JMPF/JMEFFSQD/'WHOLE'/2.0 $
 TRNSP    JMEFFSQD/JMODETEM $
 ADD      JMODETEM,/JMEFFMOD/CMASSWT/ $
$
$   COMPUTE TOTAL EFFECTIVE MASS AND INERTIA OF THE SYSTEM (JMEFFSUM),
$   AND CONVERT THEM TO WEIGHT UNIT.
 TRNSP    JMPF/JMPFT $
 MPYAD    JMPFT,JMPF,/JMEFFSQ $
 DIAGONAL JMEFFSQ/JMSUMTEM/'COLUMN'/1.0 $
 ADD      JMSUMTEM,/JMEFFSUM/CMASSWT/ $
$
$ COMPUTE % EFFECTIVE MASS OF EACH MODE
$
 PARAML   GSUMMAT//'PRESENCE'////S,N,GWEIGHT  $
 IF (GWEIGHT >= 0) THEN  $
  COPY     GSUMMAT/JSUMMAT/ALWAYS  $
  COPY     GWTSUMX/JWTSUMX/ALWAYS  $
 ELSE $
$ EXTRACT MASS AND INERTIA W/O UP-STREAM SE'S CONTRIBUTION
  GPWG     BGPDTS,CSTMS,EQEXINS,MJJ/OGPWGJ/GRDPNT/WTMASS  $
$
$ GENERATE 6X1 VECTOR FOR PHYSICAL MASS AND INERTIA
  WTROW=6  $
  MATGEN,  /JWTSUM/7/6/1  $
  DO WHILE(WTROW>0)  $
   WTINDEX=6-WTROW  $
   WTWORD=WTINDEX*7+1  $
   WTROW=WTROW-1  $
   MATGEN,  /V1WTJ/6/6/WTINDEX/1  $
   PARAML   OGPWGJ//'DTI'/2/WTWORD/S,N,WTDATA $
   WTVALUE = CMPLX(WTDATA,0.0)  $
   ADD      V1WTJ,/V2WTJ/WTVALUE/  $
   ADD      V2WTJ,JWTSUM/V3WTJ//  $
   EQUIVX   V3WTJ/JWTSUM/ALWAYS  $
  ENDDO  $
$
$ GENERATE TOTAL MASS/WEIGHT VECTOR FOR COMPUTING EFFECTIVE
$ MASS OF STATICALLY INDETERMINANT STRUCTURES
  IF (SDBC='NO ') THEN  $
   SMPYAD    PHICMG,MJJ,PHICMG,,,/JSIDMAT/3////1  $
   DIAGONAL  JSIDMAT/JSIDWTX/'COLUMN'/1.0  $
   ADD       JSIDWTX,/JSIDWT/CMASSWT/  $
   COPY      JSIDWT/JWTSUMX/ALWAYS  $
  ELSE  $
   COPY    JWTSUM/JWTSUMX/ALWAYS  $
  ENDIF  $ (SDBC='NO ')
$MATPRN  JWTSUM,JWTSUMX//  $
$
$ DETERMINE THE PERCENTAGE OF MODAL EFFECTIVE MASS
  PARAML   JMEFFMOD//'TRAILER'/1/S,N,NTJMODE   $
  MATGEN,  /IDJM/1/NTJMODE  $
  DIAGONAL IDJM/IDJCOL/'COLUMN'/1.0  $
  TRNSP    IDJCOL/IDJROW  $
  MPYAD    JWTSUMX,IDJROW,/JSUMMAT  $
 ENDIF  $ (GWEIGHT >=0)
```

```
$
 ADD      JMEFFMOD,JSUMMAT/JMEFF%/(100.0,0.0)//2  $
 ADD      JMEFFSUM,JWTSUMX/TJMEFF%/(100.0,0.0)//2  $
$
$ GENERATE MODE INDEX FOR MODES HAVING TRANSLATIONAL EFFECTIVE
$ MASS HIGHER THAN LMEFF% (DEFAULT IS 2%)
$
 IF (SDBC='NO ') THEN  $
  MATMOD   JMEFF%,,,,,/JMEFFTM,/2////LMEFF%  $
  MATGEN   ,/JVONE/6/NRSBSET/0/NRSBSET  $
 ELSE  $
  MATMOD   JMEFF%,,,,,/JMEFFS,/2////LMEFF%  $
  MATGEN   ,/JVXYZEFF/6/6/3/3  $
  MATGEN   ,/JVONE/6/3/0/3  $
  PARTN    JMEFFS,,JVXYZEFF/JMEFFTM,,,/1  $
 ENDIF  $ (SDBC='NO ')
  MPYAD    JVONE,JMEFFTM,/JVTMODES/1  $
  DIAGONAL JVTMODES/JMODEID/'WHOLE'/0.0  $
  ZUZR1=SEID  $
  EQUIVX   JMODEID/ZUZR03/ALWAYS  $
  MESSAGE  //'TARGET MODE INDEX FOR SE W/O UP-STREAM SE'/ $
  MATPRN   JMODEID//  $
$
$ PRINT EFFECTIVE MASS PER MODE, TOTAL EFFECTIVE MASS,
$ PERCENT EFFECTIVE MASS PER MODE, AND PERCENT TOTAL
$ EFFECTIVE MASS W/O CONTRIBUTION OF UP-STREAM SES
 MESSAGE  //'EFFECTIVE MASS PER MODE W/O UP-STREAM SES'/  $
 MATPRN   JMEFFMOD// $
 MESSAGE  //'TOTAL EFFECTIVE MASS W/O UP-STREAM SES'/  $
 MATPRN   JMEFFSUM// $
 MESSAGE  //'PERCENT EFFECTIVE MASS PER MODE W/O UP-STREAM SES'/  $
 MATPRN   JMEFF%//  $
 MESSAGE  //'PERCENT TOTAL EFFECTIVE MASS W/O UP-STREAM SES'/  $
 MATPRN   TJMEFF%//  $
ENDIF  $ NOMJJ>=0
$
ENDIF  $ (MEFF='YES')
$
$   *****************************************************************
$ *     EFFECTIVE MASS OF COMPONENT W.R.T. ITS INTERFACES              *
$ *                                                                    *
$ *  CBFREQ  :  CANTILEVERED FREQUENCY MATRIX FOR C-B COMPONENT        *
$ *  CBMPF   :  MODAL PARTICIPATION FACTOR FOR C-B COMPONENT           *
$ *  CBMEFMOD:  EFFECTIVE MASS PER MODE FOR C-B COMPONENT MODES        *
$ *  CBMEFSUM:  TOTAL EFFECTIVE MASS FOR C-B COMPONENT MODES           *
$ *  CBMEFF% :  PERCENT-EFFECTIVE MASS PER MODE FOR C-B COMPONENT      *
$ *  TCBMEFF%:  TOTAL PERCENT-EFFECTIVE FOR C-B COMPONENT              *
$ *                                                                    *
$   *****************************************************************
$
$ **** COMPUTE EFFECTIVE MASS OF COMPONENT (UPSTREAM SE)    ****
$ **** CONSTRAINED AT INTERFACES (C-B MODEL EFFECTIVE MASS) ****
$
IF (CBMEFF='YES') THEN  $
IF(RSONLY) THEN  $
$
ELSE IF (SEID=0) THEN  $
$
 ELSE  $
  VEC     USET/V1ANOB/'A'/'COMP'/'Q'  $
  PARTN   GOAQ,V1ANOB,/,,GOQXN,/1  $
  MATMOD  GOQXN,,,,,/V1GOQ,/12/S,N,NULLGOQ  $
  IF (NULLGOQ > 0) THEN  $
   PARTN  GOQXN,V1GOQ,/GOQX,,,/1  $
  ELSE  $
   COPY   GOQXN/GOQX/ALWAYS  $
```

```
  ENDIF  $ (NULLGOQ > 0)
  VEC     USET/V1OTOG/'G'/'COMP'/'O'  $
  MERGE,  ,GOQX,,,,V1OTOG/GGQX1/1  $
$ RENORMALIZE COMPONENT MODES TO COMPONENT MASS MATRIX
  SMPYAD   GGQX1,MGG,GGQX1,,,/MGGSCB/3////1  $
  DIAGONAL MGGSCB/MCBSQRT/'SQUARE'/-0.5  $
  MPYAD    GGQX1,MCBSQRT,/GGQX  $
$
$ COMPUTE EFFECTIVE MASS OF C-B MODEL ELASTIC MODES
  MPYAD    GGQX,MGG,/GQMGX/1  $
  MPYAD    GQMGX,RBGG,/CBMPF  $
  DIAGONAL CBMPF/CBMEFSQD/'WHOLE'/2.0  $
  TRNSP    CBMEFSQD/CBMODETE  $
  ADD      CBMODETE,/CBMEFMOD/CMASSWT/  $
  TRNSP    CBMPF/CBMPFT  $
  MPYAD    CBMPFT,CBMPF,/CBMEFFSQ  $
  DIAGONAL CBMEFFSQ/CBMSUMTE/'COLUMN'/1.0  $
  ADD      CBMSUMTE,/CBMEFSUM/CMASSWT/  $
  ADD       CBMEFMOD,JSUMMAT/CBMEFF%/(100.0,0.0)//2  $
  ADD       CBMEFSUM,JWTSUMX/TCBMEFF%/(100.0,0.0)//2  $
$
$ RETRIEVE COMPONENT FREQUENCIES
  LAMX,    ,CMLAMA/CBLMAT/-1  $
  MATMOD   CBLMAT,,,,,/CBFREQ,/1/3  $
  MATPRN   CBFREQ//  $
$
$ PRINT EFFECTIVE MASS PER MODE, TOTAL EFFECTIVE MASS,
$ PERCENT EFFECTIVE MASS PER MODE, AND PERCENT TOTAL
$ EFFECTIVE MASS FOR COMPONENT C-B MODEL
 MESSAGE  //'EFFECTIVE MASS PER MODE OF C-B COMPONENT MODES'/  $
 MATPRN   CBMEFMOD// $
 MESSAGE  //'TOTAL EFFECTIVE MASS OF C-B COMPONENT MODES'/  $
 MATPRN   CBMEFSUM// $
 MESSAGE  //'PERCENT EFFECTIVE MASS PER MODE OF C-B COMPONENT'/  $
 MATPRN   CBMEFF%//  $
 MESSAGE  //'PERCENT TOTAL EFFECTIVE MASS OF C-B COMPONENT'/  $
 MATPRN   TCBMEFF%//  $
ENDIF  $ (RSONLY)
ENDIF  $  (CBMEFF='YES')
$
$          ****************************************************
$      *   COMPUTE THE MODAL KINETIC ENERGY PER DEGREE      *
$      *   OF FREEDOM FOR UP-STREAM SUPERELEMENT (MODE      *
$      *   SHAPES ARE NORMALIZED TO MASS MATRIX)            *
$          ****************************************************
$
$  ***  CHECK IF CALCULATION OF KINETIC ENERGY PER                     ***
$  ***  EACH DEGREE OF FREEDOM IS REQUESTED                            ***
IF (KE='YES') THEN  $
$
 DIAGONAL  KGG/VGSET/'COLUMN'/0.0  $
 IF (RSONLY) THEN  $
  $
 ELSE  $
 IF (NOUP>0) THEN  $
$
$ CHECK THE PRESENCE OF THE PHYSICAL MASS MATRIX (MJJ)
  PARAML   MJJ//'PRESENCE'////S,N,NOMJJ  $
  IF (NOMJJ >= 0 ) THEN  $
$ COMPUTE MODAL KINETIC ENERGY PER DOF (KEDOF) AND CHECK
$ GENERALIZED MASS (MSTAR)
   MPYAD    MGG,UG,/MPHI/  $
   ADD      UG,MPHI/KEDOF///1  $
   MPYAD    VGSET,KEDOF,/MSTAR/1  $
$   MATPRN   MSTAR//  $
$
```

```
$ DETERMINE THE LOCATION AND DIRECTION OF MAX KINETIC ENERGY FOR A
$ MODE, AND ITS PERCENT CONTRIBUTION TO THAT MODE.
  MATMOD    KEDOF,,,,,/KEDOFMAX,/7  $
  MATMOD    KEDOFMAX,,,,,/DIAKEMAX,/28 $
  NORM      KEDOF/KENORM  $
   ADD      KENORM,/KENORM%/(100.0,0.0)  $
   MATMOD   KENORM,,,,,/SCALEMAX,/2////0.9999  $
  MPYAD     SCALEMAX,DIAKEMAX,/KEMAX  $
   ADD      KEMAX,/KEMAX%/(100.0,0.0)  $
$  MATGPR   GPLS,USET,SILS,KEMAX%//'H'/'G'//KEFILTER  $
$
$ COMPUTE PERCENT CONTRIBUTION ON KINETIC ENERGY FOR EACH DOF
  MPYAD     KENORM,DIAKEMAX,/KENG/  $
   ADD      KENG,/KENG%/(100.0,0.0)  $
  MESSAGE //'KINETIC ENERGY PER DEGREE OF FREEDOM WITH UP-STREAM SE'/ $
  MATGPR    GPLS,USET,SILS,KENG%//'H'/'G'//KEFILTER  $
  IF (KENORMPR='YES') THEN  $
   MESSAGE //'KINETIC ENERGY PER DOF NORMALIZED TO MAX KE WITH SE '/ $
   MATGPR   GPLS,USET,SILS,KENORM%//'H'/'G'//LKENORM%  $
  ENDIF  $  (KENORMPR='YES')
$
$ CHECK THE TOTAL KINETIC ENERGY OF THE UP-STREAM SE
  MPYAD     VGSET,KENG%,/KESUMUP/1  $
  MATPRN    KESUMUP//  $
 ENDIF  $ NOMJJ>=0
 ENDIF  $ NOUP>0
 ENDIF  $ RSONLY
$
$ **** COMPUTE MODAL KINETIC ENERGY PER DOF (KEDOF) AND CHECK          ****
$ **** GENERALIZED MASS (MSTAR) W/O CONTRIBUTION OF UP-STREAM SE'S     ****
$
$
$ CHECK THE PRESENCE OF THE PHYSICAL MASS MATRIX (MJJ)
 IF (NOMJJ >= 0 ) THEN  $
  MPYAD     MJJ,UG,/JMPHI/  $
  ADD       UG,JMPHI/JKEDOF///1  $
  MPYAD     VGSET,JKEDOF,/JMSTAR/1  $
$  MATPRN   JMSTAR//  $
$
$ DETERMINE THE LOCATION AND DIRECTION OF MAX KINETIC ENERGY FOR A
$ MODE, AND ITS PERCENT CONTRIBUTION TO THAT MODE.
  MATMOD    JKEDOF,,,,,/JKEDOFMX,/7  $
  MATMOD    JKEDOFMX,,,,,/JDIAKEMX,/28 $
  NORM      JKEDOF/JKENORM  $
   ADD      JKENORM,/JKENORM%/(100.0,0.0)  $
   MATMOD   JKENORM,,,,,/JSCALEMX,/2////0.9999  $
  MPYAD     JSCALEMX,JDIAKEMX,/JKEMAX  $
   ADD      JKEMAX,/JKEMAX%/(100.0,0.0)  $
$  MATGPR   GPLS,USET,SILS,JKEMAX%//'H'/'G'//KEFILTER  $
$
$ COMPUTE PERCENT CONTRIBUTION ON KINETIC ENERGY FOR EACH DOF
  MPYAD     JKENORM,JDIAKEMX,/JKENG/  $
   ADD      JKENG,/JKENG%/(100.0,0.0)  $
  MESSAGE //'KINETIC ENERGY PER DEGREE OF FREEDOM W/O UP-STREAM SE'/ $
  MATGPR    GPLS,USET,SILS,JKENG%//'H'/'G'//KEFILTER  $
  IF (KENORMPR='YES') THEN  $
   MESSAGE //'KINETIC ENERGY PER DOF NORMALIZED TO MAX KE W/O SE'/ $
   MATGPR   GPLS,USET,SILS,JKENORM%//'H'/'G'//LKENORM%  $
  ENDIF  $  (KENORMPR='YES')
$
$ CHECK THE TOTAL KINETIC ENERGY OF THE UP-STREAM SE
  MPYAD     VGSET,JKENG%,/JKESUMUP/1  $
  MATPRN    JKESUMUP//  $
 ENDIF  $ NOMJJ>=0
ENDIF  $ KE=YES
$
```

```
$   **********************************************************
$ *  COMPUTE KINETIC ENERGY FRACTION FOR EACH SUPERELEMENT    *
$ *                                                           *
$ *  SEKEFA  <-- KINETIC ENERGY FRACTION OF TIP               *
$ *             SUPERELEMENTS                                 *
$ *  SEKEFG  <-- KINETIC ENERGY FRACTION W/O CONTRIBUTION     *
$ *             OF UP-STREAM SUPERELEMENTS                    *
$ *                                                           *
$   **********************************************************
$
COMPILE SUBDMAP=POSTREIG SOUIN=MSCSOU,NOLIST,NOREF
ALTER 15
TYPE DB,MAA,MLAA,MJJ  $
TYPE PARM,,CHAR3,Y,(NASTIPS='NO ')  $
TYPE PARM,,I,Y,(NASTAPE=99)  $
TYPE PARM,,CS,Y,CSEID  $
TYPE PARM,,CHAR3,Y,(SEKEF='NO ')  $
MATMOD  LAMMAT,,,,,/TKE,/1/4  $
$
ALTER  21,21
PVT     PVTS,CASEDR/PVTX/  $
$
ALTER 48
IF ( SEKEF ='YES' ) THEN $
 IF ( NOUP = -1 ) THEN   $ KINETIC ENERGY FRACTION PER MODE
  MESSAGE  //' DMAP INFORMATION MESSAGE 9046 (POSTREIG) -'/
  ' THE FRACTION OF TOTAL KINETIC ENERGY IN EACH OF THE'/
  ' RESIDUAL STRUCTURE MODES IN TIP SUPERELEMENT'/SEID  $
  ADD      MAA,MLAA/YMAA $
  MPYAD    YMAA,PHILS,/FAM $
  ADD      FAM,PHILS/FUM///1  $ EL. MPY
  MATGEN   ,/UAM/6/NOASET/0/NOASET $ UNIT COLUMN, A-SIZE
  MPYAD    FUM,UAM,/SEKEA/1  $
  ADD      SEKEA,TKE/SEKEFA///2 $ EL. DIV.
  MATPRN   SEKEFA//$   KINETIC ENERGY FRACTION FOR TIP
 ELSE $
  MESSAGE  //' DMAP INFORMATION MESSAGE 9046 (POSTREIG) -'/
  ' THE FRACTION OF TOTAL KINETIC ENERGY IN EACH OF THE'/
  ' RESIDUAL STRUCTURE MODES IN NON-TIP SUPERELEMENT'/SEID  $
  PARAML   MJJ//'PRESENCE'////S,N,NOMJJ $
  IF ( NOMJJ > -1 ) THEN $
   MPYAD    MJJ,PHG,/FGM $
   ADD      FGM,PHG/XGM///1 $
   MATGEN   ,/UGIM/6/NOGSET/0/NOGSET $
   MPYAD    XGM,UGIM,/SEKEG/1 $
   ADD      SEKEG,TKE/SEKEFG///2 $
   MATPRN   SEKEFG//$  KINETIC ENERGY FRACTION FOR NON-TIP
  ENDIF $   (NOMJJ > -1)
 ENDIF $ (NOUP=-1)
ENDIF $ (SEKEF='YES')
```