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EXPERIENCES WITH THE USE OF AXISYMMETRIC ELEMENTS IN COSMIC NASTRAN FOR STATIC ANALYSIS

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Abstract:

This paper discusses some recent finite element modeling experiences using the axisymmetric elements CONEAX, TRAPAX, and TRIAAX, from the COSMIC NASTRAN element library. These experiences were gained in the practical application of these elements to the static analysis of helicopter rotor force measuring systems (balances) for two design projects for the NASA Ames Research Center. These design projects were the Rotor Test Apparatus, and the Large Rotor Test Apparatus which are dedicated to basic helicopter research. Both analyses involved the successful coupling of an axisymmetric balance model to a non-axisymmetric flexure model.

In this paper a generic axisymmetric model is generated for illustrative purposes. Modeling considerations are discussed, and the advantages and disadvantages of using axisymmetric elements are presented. Asymmetric mechanical and thermal loads are applied to the structure, and single and multi-point constraints are addressed. An example that couples the axisymmetric model to a non-axisymmetric model is demonstrated, complete with DMAP alters. Recommendations for improving the elements and making them easier to use are offered.

1) Introduction:

Recently, there was an opportunity to use the axisymmetric elements CONEAX, TRAPAX,and TRIAAX, from the COSMIC NASTRAN element library for the static analysis of axisymmetric structures. Modeling experience was gained in the practical application of these elements to the static analysis of helicopter rotor force measuring systems (balances). These balances resulted from two design projects for the NASA Ames Research Center. This paper addresses the experiences gained using axisymmetric elements for these programs.

Two large dynamic rotor force measurement systems were designed as part of the Rotor Test Apparatus (RTA) and Large Rotor Test Apparatus (LRTA) programs. All the force generated by the rotor blades passes through four flexure bars that constitute the critical portion of the balance. These flexures rest on a very large axisymmetric base piece and are surmounted by a relatively large axisymmetric ring and axisymmetric mast. Thus, the structure is extensively axisymmetric with a relatively small portion which is not axisymmetric.

The flexures must satisfy strength, sensitivity, fatigue, and frequency constraints. The constraints are severe and contradictory. For example, high strength implies low sensitivity. Moreover, the balance geometry imposes coupling effects that could lead to measurement errors if not properly accounted for in the calibration.

It was necessary to perform a detailed static analysis of these balance systems to demonstrate that:

1) The flexures had sufficient strength.
2) The flexures were sensitive enough to measure small loads.
3) Linear coupling of loads among the flexures were predictable and accountable.

One method of analyzing this type of structure is to generate a conventional three dimensional model using many solid, plate, and bar elements. It is possible to take advantage of symmetry about one plane and thus reduce the number of degrees of freedom. Loads would be applied directly to the mast and reactions forces would be determined at the flexure boundaries.

Some advantages of a traditional type of model are:

- Model generation is straightforward.
- Application of loads and boundary conditions is direct.
- Reactions can be determined easily.
- Force distributions in the structure in the structure are readily determined.

The traditional type of model has several disadvantages:

- Very many elements are needed to represent the structure adequately.
- It is very time consuming to generate a model.
- Incompatible elements must be connected properly (solids have 3 degrees of freedom per node, plates have 5).
- It is time consuming to execute in the computer.

An alternative approach to analyzing this type of structure is to generate an axisymmetric finite element model to represent the relatively extensive axisymmetric parts. Two, three, and four noded elements would be used to model the cross section.

The axisymmetric model has several advantages:

- Fewer number of elements is needed to represent the structure.
- Much less time is required to generate a model.
- Less computer time needed to execute the program.

Some disadvantages of axisymmetric models are:

- Models of axisymmetric and non-axisymmetric portions are not currently compatible in NASTRAN.
- There are restrictions on the element connectivity.
- It is difficult to interpret results.

Since everything about the balances (except the flexures) was axisymmetric, it was decided to take advantage of the symmetry and generate axisymmetric models. The initial approach was to constrain the model at the load points and load the model at the flexure locations, which required only axisymmetric models to be generated. By using the principle of reciprocity, the reactions at the flexure locations (flexure loads) could be determined. The flexure deformations and internal loads were to be computed separately.

This approach was abandoned after it was realized that an axisymmetric model could be combined with a non-axisymmetric model by properly adding the stiffness matrices of each model. This idea was successfully applied to the analysis of each of the balances mentioned above. It is this approach that will be explained later in this paper.

2) Discussion of an axisymmetric finite element model:

A discussion of an axisymmetric finite element model is appropriate before the coupling approach is described. Information concerning axisymmetric element modeling can be found in sections 1.3.6.1 and 1.3.7.1 of the COSMIC NASTRAN User's manual, and sections 4.1, 5.9, and 5.11 of the COSMIC NASTRAN Theoretical manual.

The solution process for axisymmetric models involves expressing the displacements in terms of harmonic (Fourier) coefficients. Axisymmetric finite element models must have the AXIC card in the bulk data to flag NASTRAN that this is an axisymmetric model. The AXIC card specifies the number of harmonics to be used.

Grid points are defined on RINGAX cards which specify the radial (r) and axial (z) coordinates. These are not points in space but circumferential rings. The azimuthal location on the ring is specified by the coordinate θ.

There are three types of axisymmetric elements that can be used with non-axisymmetric loads. These are the two noded conical shell element, CONEAX, the three noded triangular solid element, TRIAAX, and the four noded trapezoidal solid element, TRAPAX. These elements are shown in figures 1a, 1b, and 1c.

The CONEAX element can have five degrees of freedom associated with each ring. These are radial displacement, $u(\theta)$, lateral displacement, $v(\theta)$, axial displacement, $w(\theta)$, rotation about the azimuth, $\Phi(\theta)$, and rotation about the radius, $\Psi(\theta)$. The TRIAAX and TRAPAX elements have three translational degrees of freedom associated with each ring, $u(\theta)$, $v(\theta)$, and $w(\theta)$.

The geometric properties for the conical shell element are defined on a PCONEAX card. These are membrane thickness, transverse shear thickness, and moment of inertia per unit width. There are no geometric properties associated with the triangular and trapezoidal solid elements. The material reference and stress recovery locations are defined on PTRIAAX and PTRAPAX cards.

Material properties are specified on MAT1 cards in the usual way.

Boundary conditions can be specified directly on RINGAX cards or alternatively, on SPCAX cards. Displacements specified on the RINGAX cards are constrained for all harmonics. On SPCAX cards specific harmonics of a displacement are specified to be constrained. RINGAX and SPCAX cards make it possible to constrain entire rings but not to constrain a specific point on the ring. Constraining a single point on a ring can be effected by use of multi-point constraints as will be subsequently discussed.

Multi-point constraints are designated on MPCAX cards. In addition to specifying the degree of freedom and a coefficient, MPCAX cards require the harmonic to be specified. Multi-point constraints are discussed in further detail in the section that addresses mixed models.

Point forces are applied to the model with FORCEAX cards. For harmonic zero loads it is the generalized load that is specified, not the distributed load (i.e. F = 2πRf where R is the radius, and f is the distributed line load.) For higher harmonic loads the generalized load is consistent with the definition of the Fourier coefficients (F = πRf).

Point moments are defined only for conical shell elements and are applied with MOMAX cards. Thermal loads are applied using TEMPAX cards.

POINTAX cards are used to compute the total displacements at various points around the azimuth.

The SPC set, MPC set, and LOAD set are called out as usual in the case control portion of the NASTRAN input file. In addition to these set identifications, the number of harmonics participating in the solution is listed on a HARMONICS card.

For conventional models, the nodal displacements and rotations become the degrees of freedom in the solution. However, for axisymmetric models, the nodal displacements are expanded in terms of Fourier series. The coefficients of the Fourier series are called harmonic coefficients, and it is these coefficients that become the degrees of freedom in the solution.

$$u(\theta) = u_0 + \sum_{n=1}^{N} u_n \cos(n\theta) + \sum_{n=1}^{N} u^*{}_n \sin(n\theta)$$

$$v(\theta) = v^*{}_0 + \sum_{n=1}^{N} v_n \sin(n\theta) - \sum_{n=1}^{N} v^*{}_n \cos(n\theta)$$

$$w(\theta) = w_0 + \sum_{n=1}^{N} w_n \cos(n\theta) + \sum_{n=1}^{N} w^*{}_n \sin(n\theta)$$

The series are subdivided further into symmetric and anti-symmetric displacements with respect to the $\theta = 0$ plane. The User's Manual refers to the symmetric and anti-symmetric series as the "unstarred" and "starred" series respectively. The "starred" series is indicated by the asterisk in the above equations. A complete solution to an arbitrary problem consists of both "starred" and "unstarred" solutions. The type of solution is specified on an AXISYM card, either "cosine" (unstarred) or "sine" (starred). These cannot be executed at the same time; these must be separate jobs. The results must be combined external to NASTRAN.

The trapezoidal ring element has some limitations in defining its connections. The four corner rings that define the element must be numbered counterclockwise. The bottom and top edges (R1 to R2, and R3 to R4) of the element must be parallel to the radial axis. The triangular ring element must have its corner rings specified counterclockwise. These limitations are not prohibitive, but they must be recognized in the planning stage.

Axisymmetric elements are not compatible with conventional elements in the COSMIC NASTRAN library. All the card images that can be used in an axisymmetric analysis are listed in the User's Manual on the page that describes the AXIC card (page 2.4-12). Nonetheless, the static solution uses rigid format 1 to assemble stiffness and load matrices, apply boundary conditions and multi-point constraints, solve the equations, and compute forces and stresses. This is because the NASTRAN Preface sets up an internally compatible numbering system. BANDIT is not used in this procedure.

The standard displacement output format is available to the user, but, the displacement output consists of the harmonic coefficients. Total displacements can be obtained at selected azimuthal positions specified on POINTAX cards.

Only the bending and shear forces are computed for the conical shell element. These include the bending moment about the azimuthal axis, bending moment about the radial axis, and the twisting moment. Also the radial and hoop shear forces are computed.

The radial, circumferential (hoop), and axial forces are computed at each ring location for the solid axisymmetric elements.

These force quantities are output in harmonic form, that is, they are essentially harmonic coefficients of a Fourier series of the force distribution. The 0^{th} harmonic term has a multiplier of $2\pi R$ and higher harmonics have a multiplier of πR. Additionally, the total force is computed at the locations around the azimuth which were specified on the PCONEAX card, PTRIAAX card, or PTRAPAX card.

The element stresses computed for the conical shell elements are the radial normal stress and the hoop normal stress, which include bending stresses, and in-plane shear stress. The element stresses computed for the solid axisymmetric elements are the three normal stresses, radial, hoop, and axial, and three shear stresses. Like the forces, all these stresses are output in harmonic form, but are summed for locations around the circumference that are specified on the property cards.

3) Discussion of the Finite Element Models:

Several finite element models were generated to illustrate the use of axisymmetric elements.

A simple thin-walled cylinder, shown in figure 2a, was modeled in two ways: first with conical shell elements, and then with two layers of trapezoidal solid elements (figures 2b & 2c). These two models illustrate the representation of a simple axisymmetric structure.

A model of a generic rotor balance was set-up to help explain how an axisymmetric model can be coupled to a non-axisymmetric model. The balance is shown in figure 3. The relatively extensive axisymmetric parts of the structure are the upper balance ring, a conical adaptor piece, and a top plate. Four flexure posts connect the upper balance ring to the grounded base. This flexure arrangement is not axisymmetric. A mast is connected to the top plate.

The flexures and the mast were modeled separately using bar elements as shown in figure 4. The stiffness matrix from this model is combined with the stiffness matrix of the balance model to obtain a unified solution.

3a) Modeling aspects:

Some important modeling aspects need to be considered when generating an axisymmetric finite element model. Some aspects are obvious and pertain to any finite element model. Others are specific to axisymmetric element modeling.

The finite element model should be detailed enough to represent sufficiently the stiffness of the structure. When planning the finite element model keep in mind the limitations of the finite elements. Axisymmetric solid elements need to be generated in a counterclockwise fashion with the upper and lower edges parallel to the radius. Conical shell elements have an extra degree of freedom (rotation) that is not defined in the solid elements. This degree of freedom will have to be accounted for.

The model should not contain so many degrees of freedom as to become excessively time consuming to solve. The total degrees of freedom are the number of degrees of freedom per ring, times the number of rings, times the number of harmonics. So even a simple finite element model can have very many degrees of freedom if the number of harmonics is large. Currently in NASTRAN, the user is compelled to include in the solution degrees of freedom corresponding to all harmonic numbers, up to and including the highest harmonic number specified. This means that the solution may involve lower harmonics that do not participate in the response.

There should be rings positioned at key locations on the model. These locations might be places where loads are applied or the model is bounded. Rings will be needed at levels where an axisymmetric portion of the structure is joined with a non-axisymmetric part. Still other points might be locations where displacements, loads, stresses, or some other computed output is desired.

3b) Simple cylinder model:

The two thin-walled cylinder models used to illustrate an axisymmetric finite element model are briefly described here (figures 2b and 2c). The cylinder has a 86.614 mm (22 inch) radius and is 0.984 mm (0.25 inches) thick and 1.575 mm (4.0 inches) high. It is made from steel with a modulus of elasticity of 196.5 GPa (28.5×10^6 psi), and a coefficient of thermal expansion of 10.8×10^{-6} m/m°C (6.0×10^{-6} in/in-°F). The cylinder is restrained from axial growth, but not from radial growth. Two loading conditions were applied to this structure, a uniform radial pressure of 172.37×10^3 Pa (25 psi), and a uniform temperature change of 55.6°C (100 °F).

The first model of the cylinder uses 20 conical shell elements to represent the structure. The second model uses 16 trapezoidal solid elements. Five harmonics (0 through 4) were specified for both analyses (though it was known that the structure would respond to these loads in the 0^{th} harmonic only).

Boundary conditions were specified on the RINGAX cards for both models. Axial displacement "w" was constrained at the mean radius for $z = 0$.

The pressure load was applied using FORCEAX point load cards. The generalized force on one element is the pressure times the element surface area: $F = (p)(2\pi R)(\Delta z)$. Half of this total element force is distributed at the nodes. For the shell model, the mean radius, 22 inches, was used in the analysis, and for the solid model, the inside radius, 21.875 inches, was used.

The temperature load was applied using TEMPAX cards. A reference temperature of 23.9°C (75°F) was specified on the MAT1 card. A uniform temperature of 79.5°C (175°F) was specified for each ring.

3c) Results from the cylinder models:

The theoretical radial displacement and hoop stress due to pressure is computed from reference 1.

$$\Delta R = pR^2/Et = 0.006688 \text{ mm} \quad (0.001698 \text{ inches})$$

$$\sigma_{hoop} = pR/t = 15.172\text{x}10^6 \text{ Pa } (2200 \text{ psi})$$

where p is the applied pressure, $172.37\text{x}10^3$Pa (25 psi)
R is the mean radius, 86.614 mm (22 inches)
t is the thickness, 0.984 mm (0.25 inches)
E is the modulus of elasticity, 196.5 GPa ($28.5\text{x}10^6$ psi)
ΔR is the radial displacement, inches
σ_{hoop} is the hoop stress, psi

The radial displacement due to temperature load is:

$$\Delta R = R\alpha\Delta T = 0.052 \text{ mm} \quad (0.0132 \text{ inches})$$

where α is the coefficient of thermal expansion, $10.8\text{x}10^{-6}$ m/m°C ($6.0\text{x}10^{-6}$ in/in-°F)
ΔT is the temperature change, 55.6°C (100 °F.)

The results are summarized in the following table where it is seen that the outcomes of finite element calculations are in precise agreement with the theory. This is certainly expected for such simple hoop like responses.

	Theoretical	Shell Model	Solid Model
ΔR,mm (in) σ_{hoop},MPa (psi) (pressure)	.006688 (.001698) 15.17 (2200)	.006681 (.001697) 15.29 (2218)	.006657(.001691) 15.12 (2193)
ΔR,mm (in) (temp)	.052 (.0132)	.052 (.0132)	.052 (.0132)

3d) Balance axisymmetric finite element model:

The upper balance ring is a five inch high, two inch thick cylinder with a mean radius of 39.37 mm (10 inches). The 1.476 mm (0.375 inch) conical adaptor section connects the balance ring to the 1.476 mm (0.375 inch) top plate, which has a hole in its center. The balance material is stainless steel.

There are 10 TRAPAX elements representing the upper balance ring, 8 CONEAX elements that model the conical adaptor piece, and 8 elements (5 TRAPAX and 3 TRIAAX) that make up the top plate. There are 39 rings and 4 harmonics specified (starting with harmonic zero). This makes a total of 591 unconstrained degrees of freedom. There are multi-point constraints between balance ring and cone, and between cone and top plate to relate the rotational degree of freedom of the conical shell elements to displacement degrees of freedom of the solid elements. Because the loads are symmetric with respect to the $\theta = 0$ plane, the cosine solution (unstarred series) is sufficient to solve the problem.

4) Mixed model procedure:

The overall approach to combining axisymmetric models with non-axisymmetric models is to compute the separate stiffness matrices, then combine them to solve the coupled problem. For this example two finite element models were generated, the axisymmetric balance model, (figure 3), and the cartesian mast/flexure model, (figure 4).

There are four steps to the procedure. DMAP alter sequences are listed in the appendix.

1) Assemble the axisymmetric balance model global stiffness matrix and output it to a file. Stop the solution process of this model at this point.

2) Specify external loads applied to the mast/flexure model and obtain the global load and stiffness matrices for both the mast and balance flexures.

3) Read the previously stored balance stiffness matrix into the mast/flexure model. Combine the stiffness matrices from both models using multi-point constraint equations to express compatibility, and solve the problem. Compute displacements and forces, and output the solution vector(s) to a file.

4) Read the solution vector(s) into the balance model. Continue the problem and compute the axisymmetric element forces and stresses.

The key to combining models is to create an array space in the cartesian model that corresponds to the size of the stiffness matrix of the axisymmetric model. This is done by adding phantom grid points to the cartesian model. (Phantom grid points are not connected to any structure; they just provide for space in the stiffness matrix.) Grid points that correspond to the non-axisymmetric structure should be removed from the solution set by OMIT cards. Grid points common to both structures are connected with MPC relations. The remaining degrees of freedom in the cartesian model should correspond exactly to those of the axisymmetric model.

For example, consider an axisymmetric problem with five harmonics specified in the solution (0 through 4) coupled to a non-axisymmetric model in cartesian space. Corresponding to a particular ring in the axisymmetric model, for instance ring number 4, there would be a set of phantom grid points in the cartesian model. These grid points would be numbered, 10004, 11004, 12004, 13004, 14004 in the cartesian model to represent the degrees of freedom of the five harmonics. Rotational degrees of freedom 4, 5, and 6 would be eliminated for all five "phantom" grid points, because axisymmetric solid elements do not have rotational degrees of freedom. Additionally, degree of freedom 2 for grid point 10004 is eliminated since it is not defined for the 0^{th} harmonic in the unstarred solution set. The remaining phantom degrees of freedom have no elements attached to them and are flagged as singularities in the solution. This is allowed because the solution process is modified by adding the stiffness matrix from the axisymmetric model. Stiffness becomes associated with each of these degrees of freedom.

This procedure is straightforward, but it has the disadvantage that file space for two very large matrices must be allocated.

Alternative approaches to combining axisymmetric and non-axisymmetric models were considered. These made use of partitioning routines to extract and combine the necessary information from the stiffness matrices. While these had the advantage of being able to choose the stiffness terms associated with specific harmonics (and thus store smaller matrices), these procedures were not as direct as the one outlined above.

4a) Multi-point constraints:

Two types of multi-point constraints are addressed here, MPC's at specific points around the azimuth, and MPC's at every point around the azimuth.

A) Specific points around the azimuth:

For example, a typical constraint equation relating a radial displacement, "u" of cartesian structure "c" to that of axisymmetric structure "a" at 33.75° around the azimuth might be, for four harmonics, as follows. (The superscript denotes the harmonic coefficient.)

$$u_c = u_a(\theta = 33.75°)$$

but $u_a(\theta) = u_a^{(0)} + u_a^{(1)}\cos(\theta) + u_a^{(2)}\cos(2\theta) + u_a^{(3)}\cos(3\theta) + u_a^{(4)}\cos(4\theta)$

so

$$-u_c + u_a^{(0)} + .83147\, u_a^{(1)} + .38268\, u_a^{(2)} - .19509\, u_a^{(3)} - .70711\, u_a^{(4)} = 0.$$

Similar constraints are developed for each point in common.

Each flexure has all six degrees of freedom, three translations and three rotations, that must be attached to the upper balance ring. The flexures are located at convenient positions: θ = 0, 90, 180, and 270 degrees. Many coefficients are zero or unity. From basic elasticity theory, (ref 2), the cone rotations are defined as follows:

- rotation about the radial axis:

$$\omega_r = \theta_4 = \frac{1}{2}\left(\frac{1}{R}\frac{\partial w}{\partial \theta} - \frac{\partial v}{\partial z}\right)$$

- rotation about the azimuthal axis:

$$\omega_\theta = \theta_5 = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial r}\right)$$

- rotation about the vertical axis:

$$\omega_z = \theta_6 = \frac{1}{2}\left(\frac{\partial v}{\partial r} - \frac{1}{R}\frac{\partial u}{\partial \theta} + \frac{v}{R}\right)$$

Derivatives with respect to the azimuthal coordinate, θ, can be carried out explicitly since the displacements are directly dependent on this variable. However, since the axisymmetric solid elements do not have explicit rotational degrees of freedom, derivatives with respect to "r" or "z" must be made numerically.

Due to the symmetric nature of the "unstarred" Fourier expansions, the azimuthal displacement of the 0 and 180 degree flexures is identically zero. Those relations specify the following:

$$v_c = v_a(\theta = 0)$$

but since

$$v_a(\theta) = v_a^{(1)}\sin(\theta) + v_a^{(2)}\sin(2\theta) + v_a^{(3)}\sin(3\theta) + v_a^{(4)}\sin(4\theta)$$

at $\theta = 0$ and 180, each coefficient is identically zero.

B) Every point around the azimuth:

The mast is modeled as a simple beam structure. It could have been modeled as an axisymmetric structure and included with the balance model. Assume for the moment that the mast is not axisymmetric. Then it could have been modeled as a three dimensional plate structure. This model would have definite grid points along the azimuth with which to connect to the axisymmetric model. Then the procedure to relate common points would be as described above.

Since the mast is modeled with bar elements, consider the following situations:

1) A uniform vertical translation of a mast rigidly connected at all locations around the azimuth has no choice but to translate the ring in a harmonic zero fashion.

2) A uniform lateral translation of the mast would cause the ring to translate laterally in a harmonic one mode.

3) A lateral rotation of the mast would cause the ring to translate vertically in a harmonic one manner.

For example, the constraint relations for grid point "c" of the cartesian structure which is rigidly attached to ring "a" of the axisymmetric structure would be:

$$u_c = u_a^{(1)}(1.0)$$

$$w_c = w_a^{(0)}(1.0)$$

$$\theta_c^5 = w_a^{(1)}(1.0)$$

4b) Results of the mixed model analysis:

Results are available to the analyst after the third step in the procedure. Cartesian displacements, forces, and stresses are computed directly in this step. Displacement harmonic coefficients of the axisymmetric model are also available. Axisymmetric model forces and stresses are computed when these coefficients are fed back to the axisymmetric model in the fourth step.

For the example problem discussed here, it is enough to examine the forces in flexures due to the applied loads. These are shown in the forces in the bar elements in output #4 in the Appendix.

5) Conclusions and recommendations:

Several conclusions about the practical use of axisymmetric elements for static analysis are made. Some recommendations for improving the elements and making them easier to use are offered.

1) Axisymmetric elements can be used to solve static problems involving axisymmetric structures with non-axisymmetric loads. Structures modeled with these elements can often be solved a good deal more efficiently than with more common elements.

However, axisymmetric elements can be intimidating to the user. This arises primarily from the (essential) use of Fourier coefficients as the degrees of freedom for axisymmetric elements. At the present level of automation in NASTRAN, skill in executing and interpreting various transformations between Fourier and Cartesian coordinates is required. Many users lack the skill to perform such transformations, and some painful experience may be involved to gain the necessary facility. Examples are lacking.

2) Restrictions on the element connectivity of the solid axisymmetric elements should be eliminated. A paper by Hurwitz, (ref 3), describes how these elements can be updated. Also, the documentation should be improved to make more clear how to prepare the input data, and how to interpret the results.

Other changes might include:

> 1) The capability to combine results from symmetric (unstarred) solutions with those of unsymmetric (starred) solutions.
> 2) The capability to specify harmonics to include or drop from the solution set.

The capability to specify harmonics would be very useful indeed. For example, trying to determine the bolt loads in an axisymmetric structure with a bolt pattern having 22 bolts is a practical problem. It is known in advance that the structure will respond in multiples of the 22^{nd} harmonic. Yet, in the analysis, harmonics 0 through 21 must be generated though those harmonic coefficients will be identically zero.

3) There is an error in the code that generates thermal loads for conical shell elements. The results (output #1 in the Appendix, subcase 2) show that for harmonic zero, the computations are correct, but there should be no higher harmonic components. This error should be corrected for the user community to have a high degree of confidence in these elements.

4) Axisymmetric models can be successfully combined with non-axisymmetric models to get unified results. A procedure for doing so is outlined above.

<u>References:</u>

1) Roark and Young, "Formulas for Stress and Strain", 5^{th} edition, 1975 McGraw-Hill, page 448, case 1b.

2) Adel S. Saada, "Elasticity Theory and Applications", 1974, Pergamon Press, page 141.

3) Myles Hurwitz, "Generalizing the TRAPRG and TRAPAX Finite Elements", Eleventh NASTRAN Users' Colloquium, NASA CP 2284, May 2-6, 1983, pages 76-81.

Figure 1a
Conical Shell Element, CONEAX

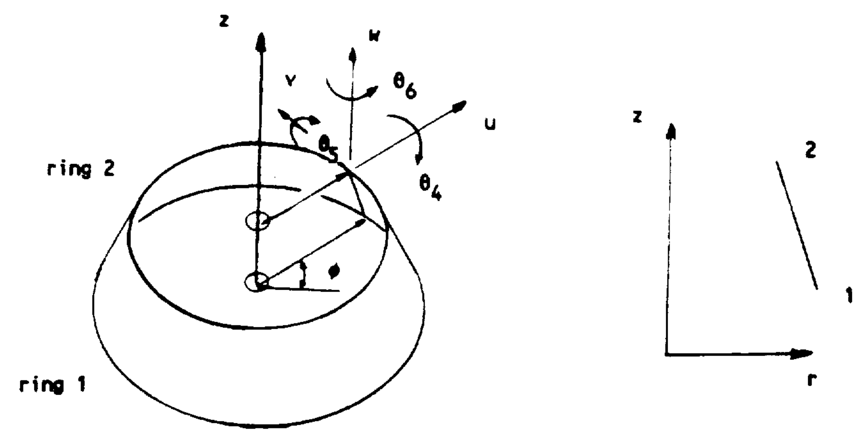


Figure 1b
Axisymmetric Triangular Element, TRIAAX

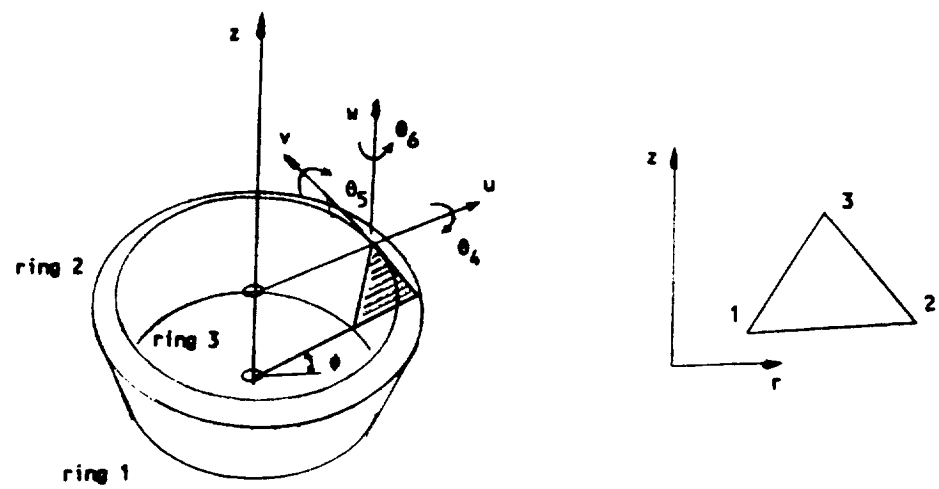


Figure 1c
Axisymmetric Trapezoidal Element, TRAPAX

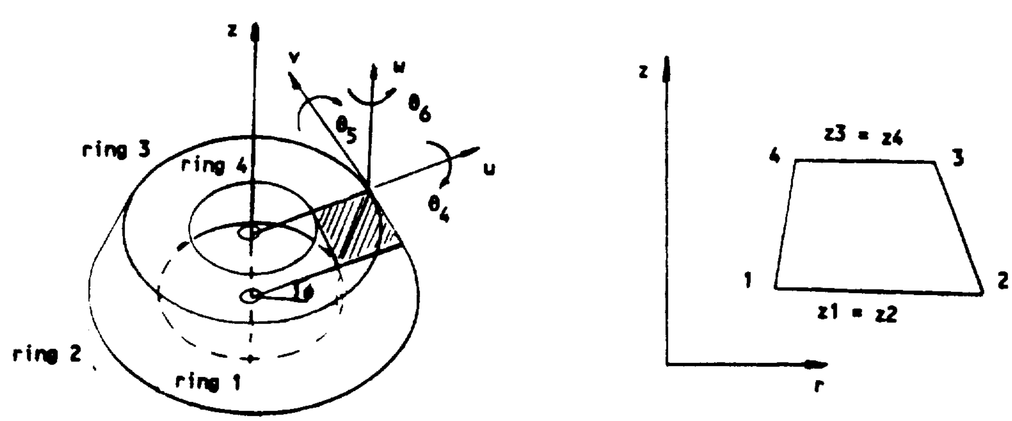


Figure 2a
Thin-walled Cylinder

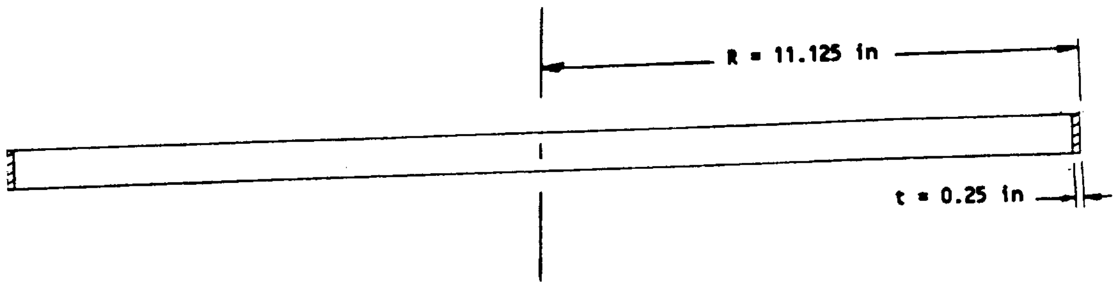


Figure 2b
Conical Shell Finite Element Model
of Thin-Walled Cylinder

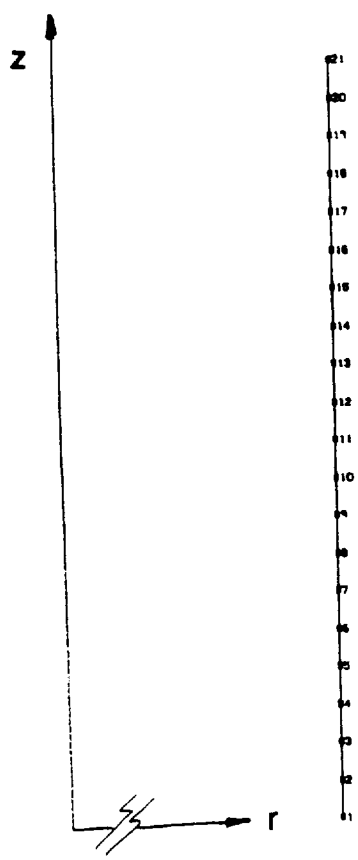


Figure 2c
Trapezoidal Solid Element Model
of Thin-Walled Cylinder

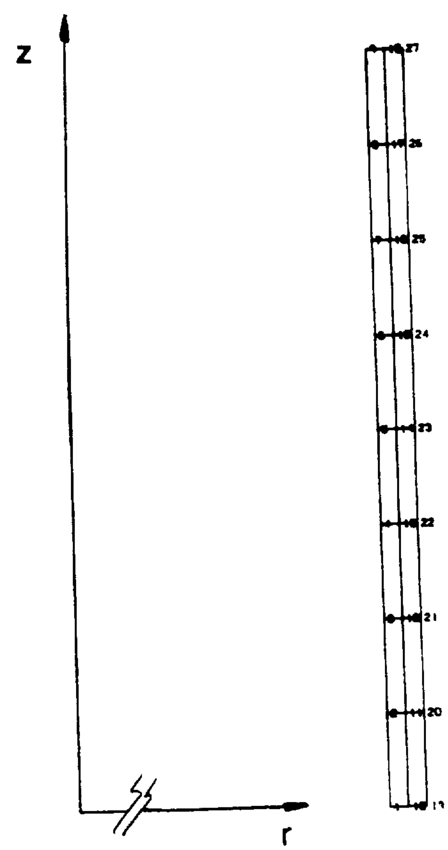


Figure 3
Sketch of Generic Balance and
Axisymmetric part of Finite Element Model

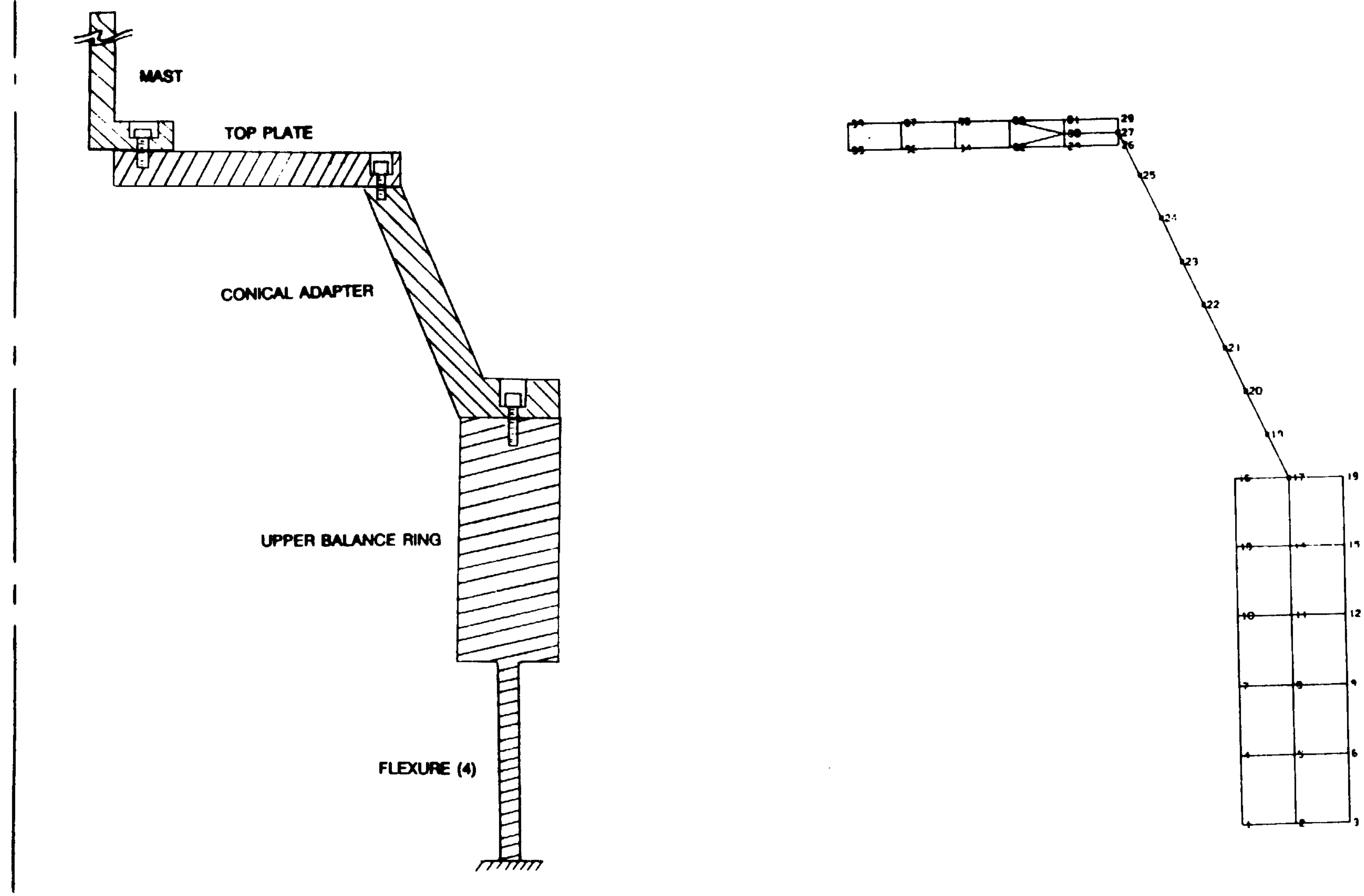
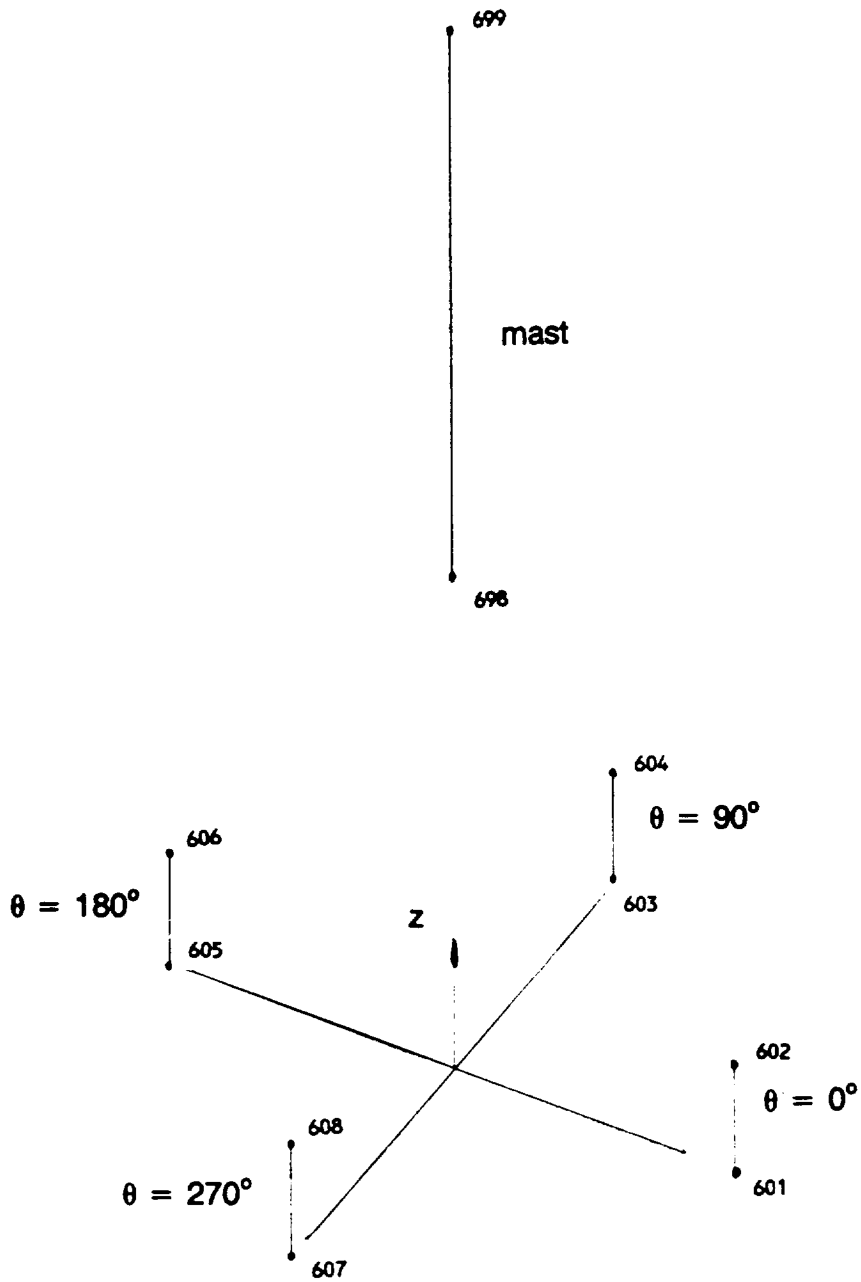


Figure 4
Finite Element Model of Flexures and Mast



APPENDIX

There are five edited files of NASTRAN output presented here for review. The first two files show the output from the thin-walled cylinder analysis. The last three files show the output, including DMAP Alter sequences for the mixed model analyses.

The output files were modified to save space. The author's comments are enclosed in double angle brackets, << >>.

1) This file contains the results from the thin-walled cylinder analysis using conical shell elements.

```
ID TSTCONE,FEM
APP  DISPLACEMENT
SOL 1,0
TIME 30
CEND
 TEST OF AXISYMM CONE ELEMENTS
                              C A S E   C O N T R O L   D E C K   E C H O
            CARD
            COUNT
             1       $
             2       TITLE = TEST OF AXISYMM CONE ELEMENTS
             3       SUBTITLE = FREE CYLINDER
             4       AXISYM = COSINE
             5       $
             6       OUTPUT
             7        DISP = ALL
             8        SPCFORCE = ALL
             9        HARMONICS = ALL
            10        ELFORCE = ALL
            11        ELSTRESS = ALL
            12       $
            13       SUBCASE 1
            14        LABEL = UNIFORM PRESSURE LOAD
            15        LOAD = 1
            16       SUBCASE 2
            17        LABEL = UNIFORM TEMPERATURE LOAD
            18        TEMP(LOAD) = 2
            19       $
            20       OUTPUT(PLOT)
            21       PLOTTER NASTPLT,D,1
            22       PAPER SIZE 11.0 X 8.5
            23       $
            24        SET 1 ALL
            25       $
            26        AXES X,Y,Z
            27        VIEW 90.,0.,0.
            28        FIND SCALE, ORIGIN 11, SET 1
            29       PLOT SET 1, ORIGIN 11, SYMBOL 2
            30       PLOT STATIC DEFORMATION 0,1 SET 1, ORIGIN 11, PEN 2, SHAPE
            31       $
            32       BEGIN BULK
 TEST OF AXISYMM CONE ELEMENTS
                                   S O R T E D   B U L K   D A T A   E C H O
            CARD
            COUNT        ---1--- +++2+++ ---3--- +++4+++ ---5--- +++6+++ ---7--- +++8+++
               1-        AXIC    4
               2-        CCONEAX 1       1       1       2
               3-        CCONEAX 2       1       2       3
               4-        CCONEAX 3       1       3       4
               5-        CCONEAX 4       1       4       5
               6-        CCONEAX 5       1       5       6
               7-        CCONEAX 6       1       6       7
               8-        CCONEAX 7       1       7       8
               9-        CCONEAX 8       1       8       9
              10-        CCONEAX 9       1       9       10
              11-        CCONEAX 10      1       10      11
```

```
CCONEAX 11      1       11      12
CCONEAX 12      1       12      13
CCONEAX 13      1       13      14
CCONEAX 14      1       14      15
CCONEAX 15      1       15      16
CCONEAX 16      1       16      17
CCONEAX 17      1       17      18
CCONEAX 18      1       18      19
CCONEAX 19      1       19      20
CCONEAX 20      1       20      21
FORCEAX 1       1       0       345.575 1.      0.      0.
FORCEAX 1       2       0       691.150 1.      0.      0.
FORCEAX 1       3       0       691.150 1.      0.      0.
FORCEAX 1       4       0       691.150 1.      0.      0.
FORCEAX 1       5       0       691.150 1.      0.      0.
FORCEAX 1       6       0       691.150 1.      0.      0.
FORCEAX 1       7       0       691.150 1.      0.      0.
FORCEAX 1       8       0       691.150 1.      0.      0.
FORCEAX 1       9       0       691.150 1.      0.      0.
FORCEAX 1       10      0       691.150 1.      0.      0.
FORCEAX 1       11      0       691.150 1.      0.      0.
FORCEAX 1       12      0       691.150 1.      0.      0.
FORCEAX 1       13      0       691.150 1.      0.      0.
FORCEAX 1       14      0       691.150 1.      0.      0.
FORCEAX 1       15      0       691.150 1.      0.      0.
FORCEAX 1       16      0       691.150 1.      0.      0.
FORCEAX 1       17      0       691.150 1.      0.      0.
FORCEAX 1       18      0       691.150 1.      0.      0.
FORCEAX 1       19      0       691.150 1.      0.      0.
FORCEAX 1       20      0       691.150 1.      0.      0.
FORCEAX 1       21      0       345.575 1.      0.      0.
MAT1    1       28.5+6          .27     0.285   6.0-6   75.
PCONEAX 1       1       .25     1       1.3021-3                        +PC
+PC     .125    -.125   .0      90.     180.
RINGAX  1               22.     0.                      346
RINGAX  2               22.     0.2                     46
RINGAX  3               22.     0.4                     46
RINGAX  4               22.     0.6                     46
RINGAX  5               22.     0.8                     46
RINGAX  6               22.     1.0                     46
RINGAX  7               22.     1.2                     46
RINGAX  8               22.     1.4                     46
RINGAX  9               22.     1.6                     46
RINGAX  10              22.     1.8                     46
RINGAX  11              22.     2.0                     46
RINGAX  12              22.     2.2                     46
RINGAX  13              22.     2.4                     46
RINGAX  14              22.     2.6                     46
RINGAX  15              22.     2.8                     46
RINGAX  16              22.     3.0                     46
RINGAX  17              22.     3.2                     46
RINGAX  18              22.     3.4                     46
RINGAX  19              22.     3.6                     46
RINGAX  20              22.     3.8                     46
RINGAX  21              22.     4.0                     46
TEMPAX  2       1       0.      175.    2       1       360.    175.
TEMPAX  2       2       0.      175.    2       2       360.    175.
TEMPAX  2       3       0.      175.    2       3       360.    175.
TEMPAX  2       4       0.      175.    2       4       360.    175.
TEMPAX  2       5       0.      175.    2       5       360.    175.
TEMPAX  2       6       0.      175.    2       6       360.    175.
TEMPAX  2       7       0.      175.    2       7       360.    175.
TEMPAX  2       8       0.      175.    2       8       360.    175.
TEMPAX  2       9       0.      175.    2       9       360.    175.
TEMPAX  2       10      0.      175.    2       10      360.    175.
TEMPAX  2       11      0.      175.    2       11      360.    175.
TEMPAX  2       12      0.      175.    2       12      360.    175.
TEMPAX  2       13      0.      175.    2       13      360.    175.
TEMPAX  2       14      0.      175.    2       14      360.    175.
TEMPAX  2       15      0.      175.    2       15      360.    175.
TEMPAX  2       16      0.      175.    2       16      360.    175.
TEMPAX  2       17      0.      175.    2       17      360.    175.
TEMPAX  2       18      0.      175.    2       18      360.    175.
TEMPAX  2       19      0.      175.    2       19      360.    175.
TEMPAX  2       20      0.      175.    2       20      360.    175.
TEMPAX  2       21      0.      175.    2       21      360.    175.
```

ENDDATA

*** USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO THE PRESENCE OF AXISYMMETRIC SOLID DATA

NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM

*** USER INFORMATION MESSAGE 3035
FOR SUBCASE NUMBER 1, EPSILON SUB E = 2.5381723E-13

FOR SUBCASE NUMBER 2, EPSILON SUB E = -2.9740320E-07

UNIFORM PRESSURE LOAD

SUBCASE 1

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	1.700627E-03	0.0	0.0	0.0	-3.704502E-06	0.0
2	0	1.699928E-03	0.0	-4.173392E-06	0.0	-3.289213E-06	0.0
3	0	1.699311E-03	0.0	-8.345169E-06	0.0	-2.879735E-06	0.0
4	0	1.698775E-03	0.0	-1.251553E-05	0.0	-2.480112E-06	0.0
5	0	1.698318E-03	0.0	-1.668468E-05	0.0	-2.092694E-06	0.0
6	0	1.697937E-03	0.0	-2.085279E-05	0.0	-1.718366E-06	0.0
7	0	1.697630E-03	0.0	-2.502007E-05	0.0	-1.356784E-06	0.0
8	0	1.697394E-03	0.0	-2.918667E-05	0.0	-1.006590E-06	0.0
9	0	1.697227E-03	0.0	-3.335278E-05	0.0	-6.656261E-07	0.0
10	0	1.697127E-03	0.0	-3.751857E-05	0.0	-3.311431E-07	0.0
11	0	1.697094E-03	0.0	-4.168419E-05	0.0	3.354394E-12	0.0
12	0	1.697127E-03	0.0	-4.584981E-05	0.0	3.311499E-07	0.0
13	0	1.697227E-03	0.0	-5.001560E-05	0.0	6.656331E-07	0.0
14	0	1.697394E-03	0.0	-5.418171E-05	0.0	1.006594E-06	0.0
15	0	1.697630E-03	0.0	-5.834831E-05	0.0	1.356789E-06	0.0
16	0	1.697937E-03	0.0	-6.251559E-05	0.0	1.718372E-06	0.0
17	0	1.698318E-03	0.0	-6.668371E-05	0.0	2.092700E-06	0.0
18	0	1.698775E-03	0.0	-7.085285E-05	0.0	2.480118E-06	0.0
19	0	1.699311E-03	0.0	-7.502321E-05	0.0	2.879737E-06	0.0
20	0	1.699928E-03	0.0	-7.919499E-05	0.0	3.289214E-06	0.0
21	0	1.700627E-03	0.0	-8.336838E-05	0.0	3.704504E-06	0.0

<< Displacements for higher harmonics were deleted since they were all zero. >>

UNIFORM TEMPERATURE LOAD

SUBCASE 2

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	1.320000E-02	0.0	0.0	0.0	-1.602749E-10	0.0
2	0	1.320000E-02	0.0	1.200000E-04	0.0	-1.635010E-10	0.0
3	0	1.320000E-02	0.0	2.400000E-04	0.0	-1.690184E-10	0.0
4	0	1.320000E-02	0.0	3.600001E-04	0.0	-1.718580E-10	0.0
5	0	1.320000E-02	0.0	4.800000E-04	0.0	-1.713591E-10	0.0
6	0	1.320000E-02	0.0	6.000001E-04	0.0	-1.688681E-10	0.0
7	0	1.320000E-02	0.0	7.200001E-04	0.0	-1.618791E-10	0.0
8	0	1.320000E-02	0.0	8.400001E-04	0.0	-1.552687E-10	0.0
9	0	1.320000E-02	0.0	9.600002E-04	0.0	-1.461382E-10	0.0
10	0	1.320000E-02	0.0	1.080000E-03	0.0	-1.394003E-10	0.0
11	0	1.320000E-02	0.0	1.200000E-03	0.0	-1.319788E-10	0.0
12	0	1.320000E-02	0.0	1.320000E-03	0.0	-1.250832E-10	0.0
13	0	1.320000E-02	0.0	1.440000E-03	0.0	-1.193989E-10	0.0
14	0	1.320000E-02	0.0	1.560000E-03	0.0	-1.190773E-10	0.0
15	0	1.320000E-02	0.0	1.680000E-03	0.0	-1.194626E-10	0.0
16	0	1.320000E-02	0.0	1.800000E-03	0.0	-1.192699E-10	0.0
17	0	1.320000E-02	0.0	1.920000E-03	0.0	-1.188989E-10	0.0
18	0	1.320000E-02	0.0	2.040000E-03	0.0	-1.186790E-10	0.0
19	0	1.320000E-02	0.0	2.160000E-03	0.0	-1.224091E-10	0.0
20	0	1.320000E-02	0.0	2.280000E-03	0.0	-1.250816E-10	0.0
21	0	1.320000E-02	0.0	2.400000E-03	0.0	-1.250580E-10	0.0

<< Displacements for higher harmonics are limited to the first five rings. The point in listing these higher harmonics is that there is an error in the code because these should be identically zero. >>

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	1	3.828026E+01	-3.829019E+01	0.0	0.0	4.608090E-05	0.0
2	1	3.828027E+01	-3.829019E+01	-8.993831E-05	0.0	4.498968E-05	0.0
3	1	3.828028E+01	-3.829019E+01	-1.798967E-04	0.0	4.397644E-05	0.0
4	1	3.828028E+01	-3.829019E+01	-2.698726E-04	0.0	4.309058E-05	0.0
5	1	3.828030E+01	-3.829020E+01	-3.598635E-04	0.0	4.236048E-05	0.0
1	2	3.418656E-03	-6.702370E-03	0.0	0.0	1.411114E-04	0.0
2	2	3.446886E-03	-6.703204E-03	-8.981951E-05	0.0	1.412205E-04	0.0
3	2	3.475164E-03	-6.705698E-03	-1.797000E-04	0.0	1.416164E-04	0.0

4	2	3.503561E-03	-6.709841E-03	-2.696334E-04	0.0	1.424383E-04	0.0
5	2	3.532173E-03	-6.715627E-03	-3.596119E-04	0.0	1.437620E-04	0.0
1	3	9.210605E-04	-3.664352E-03	0.0	0.0	3.069935E-04	0.0
2	3	9.824461E-04	-3.665628E-03	-8.963325E-05	0.0	3.069658E-04	0.0
3	3	1.043900E-03	-3.669423E-03	-1.793976E-04	0.0	3.077363E-04	0.0
4	3	1.105611E-03	-3.675709E-03	-2.692745E-04	0.0	3.095646E-04	0.0
5	3	1.167805E-03	-3.684461E-03	-3.592463E-04	0.0	3.125749E-04	0.0
1	4	-1.470954E-04	-2.502015E-03	0.0	0.0	5.189780E-04	0.0
2	4	-4.339249E-05	-2.503747E-03	-8.941032E-05	0.0	5.183037E-04	0.0
3	4	6.034414E-05	-2.508867E-03	-1.790392E-04	0.0	5.193919E-04	0.0
4	4	1.645048E-04	-2.517312E-03	-2.688528E-04	0.0	5.225801E-04	0.0
5	4	2.695243E-04	-2.529030E-03	-3.588200E-04	0.0	5.279839E-04	0.0

UNIFORM PRESSURE LOAD SUBCASE 1

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	-3.527417E-11	0.0	0.0	0.0

UNIFORM TEMPERATURE LOAD SUBCASE 2

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	1.193963E-09	0.0	0.0	0.0
1	1	0.0	0.0	4.233956E-05	0.0	0.0	0.0
1	2	0.0	0.0	-2.195207E+00	0.0	0.0	0.0
1	3	0.0	0.0	-3.430285E+01	0.0	0.0	0.0
1	4	0.0	0.0	-2.067654E+02	0.0	0.0	0.0

UNIFORM PRESSURE LOAD SUBCASE 1

F O R C E S   I N   A X I S - S Y M M E T R I C   C O N I C A L   S H E L L   E L E M E N T S   (CCONEAX)

ELEMENT ID.	HARMONIC NUMBER	POINT ANGLE	BEND-MOMENT V	BEND-MOMENT U	TWIST-MOMENT	SHEAR V	SHEAR U
1	0		-7.521445E-01	-2.030790E-01	0.0	0.0	0.0
1	1		0.0	0.0	0.0	0.0	0.0
1	2		0.0	0.0	0.0	0.0	0.0
1	3		0.0	0.0	0.0	0.0	0.0
1	4		0.0	0.0	0.0	0.0	0.0
1		0.0000	-7.521445E-01	-2.030790E-01	0.0	0.0	0.0
1		90.0000	-7.521445E-01	-2.030790E-01	0.0	0.0	0.0
1		180.0000	-7.521445E-01	-2.030790E-01	0.0	0.0	0.0

UNIFORM TEMPERATURE LOAD SUBCASE 2

F O R C E S   I N   A X I S - S Y M M E T R I C   C O N I C A L   S H E L L   E L E M E N T S   (CCONEAX)

ELEMENT ID.	HARMONIC NUMBER	POINT ANGLE	BEND-MOMENT V	BEND-MOMENT U	TWIST-MOMENT	SHEAR V	SHEAR U
1	0		2.401673E+01	6.484517E+00	0.0	0.0	0.0
1	1		-2.451984E+01	-5.926837E+00	-6.250000E-02	0.0	0.0
1	2		-1.796247E+01	-4.874458E+00	-3.707733E-01	0.0	0.0
1	3		-1.789051E+01	-4.644216E+00	-1.216523E+00	0.0	0.0
1	4		-1.777186E+01	-3.913975E+00	-2.745798E+00	0.0	0.0
1		0.0000	-5.412794E+01	-1.287497E+01	0.0	0.0	0.0
1		90.0000	2.420734E+01	7.445001E+00	1.154023E+00	0.0	0.0
1		180.0000	3.069276E+01	8.267138E+00	-9.905316E-07	0.0	0.0

UNIFORM PRESSURE LOAD SUBCASE 1

S T R E S S E S   I N   A X I S - S Y M M E T R I C   C O N I C A L   S H E L L   E L E M E N T S   (CCONEAX)

ELEMENT ID.	HARMONIC	POINT ANGLE	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM NORMAL-V	NORMAL-U	SHEAR-UV	PRINCIPAL STRESSES (ZERO SHEAR) ANGLE	MAJOR	MINOR	MAXIMUM SHEAR
1	0		1.250000E-01	-7.220625E+01	2.183123E+03	0.0				
			-1.250000E-01	7.220363E+01	2.222114E+03	0.0				
1	1		1.250000E-01	0.0	0.0	0.0				
			-1.250000E-01	0.0	0.0	0.0				
1	2		1.250000E-01	0.0	0.0	0.0				
			-1.250000E-01	0.0	0.0	0.0				
1	3		1.250000E-01	0.0	0.0	0.0				
			-1.250000E-01	0.0	0.0	0.0				
1	4		1.250000E-01	0.0	0.0	0.0				
			-1.250000E-01	0.0	0.0	0.0				
1		0.0000	1.250000E-01	-7.220625E+01	2.183123E+03	0.0	90.0000	2.183123E+03	-7.220630E+01	1.127665E+03
			-1.250000E-01	7.220363E+01	2.222114E+03	0.0	90.0000	2.222114E+03	7.220361E+01	1.074955E+03
1		90.0000	1.250000E-01	-7.220625E+01	2.183123E+03	0.0	90.0000	2.183123E+03	-7.220630E+01	1.127665E+03
			-1.250000E-01	7.220363E+01	2.222114E+03	0.0	90.0000	2.222114E+03	7.220361E+01	1.074955E+03
1		180.0000	1.250000E-01	-7.220625E+01	2.183123E+03	0.0	90.0000	2.183123E+03	-7.220630E+01	1.127665E+03

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                 -1.250000E-01  7.220363E+01  2.222114E+03  0.0          90.0000  2.222114E+03  7.220361E+01  1.074955E+03

   UNIFORM TEMPERATURE LOAD                                                                                  SUBCASE 2
         S T R E S S E S   I N   A X I S - S Y M M E T R I C   C O N I C A L   S H E L L   E L E M E N T S   (CCONEAX)
ELEMENT          POINT    FIBRE          STRESSES IN ELEMENT COORD SYSTEM          PRINCIPAL STRESSES (ZERO SHEAR)          MAXIMUM
  ID.  HARMONIC  ANGLE   DISTANCE       NORMAL-V       NORMAL-U      SHEAR-UV      ANGLE        MAJOR          MINOR          SHEAR
   1     0               1.250000E-01  2.573024E+04  2.404717E+04  0.0
                        -1.250000E-01  2.111908E+04  2.280215E+04  0.0
   1     1               1.250000E-01 -1.992134E+04 -1.816540E+04 -5.999923E+00
                        -1.250000E-01 -1.521359E+04 -1.702747E+04  5.999923E+00
   1     2               1.250000E-01 -1.929260E+04 -1.813068E+04 -3.659378E+01
                        -1.250000E-01 -1.584385E+04 -1.719479E+04  3.459378E+01
   1     3               1.250000E-01 -1.928362E+04 -1.819923E+04 -1.198160E+02
                        -1.250000E-01 -1.584869E+04 -1.730755E+04  1.137535E+02
   1     4               1.250000E-01 -1.926194E+04 -1.820866E+04 -2.695620E+02
                        -1.250000E-01 -1.584978E+04 -1.745718E+04  2.576245E+02
   1           0.0000    1.250000E-01 -5.202926E+04 -4.865680E+04  0.0          90.0000 -4.865680E+04 -5.202926E+04  1.686227E+03
                        -1.250000E-01 -4.163683E+04 -4.618484E+04  0.0           0.0000 -4.163683E+04 -4.618484E+04  2.274008E+03
   1          90.0000    1.250000E-01  2.576090E+04  2.396919E+04  1.138160E+02  3.6202  2.576810E+04  2.396199E+04  9.030555E+02
                        -1.250000E-01  2.111315E+04  2.253977E+04 -1.077535E+02 -85.7049 2.254786E+04  2.110506E+04  7.214023E+02
   1         180.0000    1.250000E-01  2.638067E+04  2.407247E+04 -9.727959E-05  0.0000  2.638067E+04  2.407247E+04  1.154101E+03
                        -1.250000E-01  2.048774E+04  2.248520E+04  9.290005E-05 90.0000  2.248520E+04  2.048774E+04  9.987314E+02

                                          * * * END OF JOB * * *
```

2) This file contains the results of the thin-walled cylinder analysis using the trapezoidal solid elements.

```
ID TSTCYL,FEM
APP  DISPLACEMENT
SOL 1,0
TIME 60
$
CEND
                                  C A S E    C O N T R O L    D E C K    E C H O
          CARD
          COUNT
            1      TITLE = TEST CYLINDER
            2      SUBTITLE = UNIFORM PRESSURE
            3      $
            4      AXISYM = COSINE
            5      OUTPUT
            6        DISPLACEMENTS = ALL
            7        SPCFORCES = ALL
            8        ELFORCES = ALL
            9        ELSTRESS = ALL
           10        HARMONICS = ALL
           11      $
           12      SUBCASE 1
           13       LABEL = PRESSURE LOAD
           14       LOAD = 1
           15      SUBCASE 2
           16       LABEL = UNIFORM TEMPERATURE LOAD
           17       TEMPERATURE(LOAD) = 2
           18      $
           19      OUTPUT(PLOT)
           20      PLOTTER NASTPLT,D,1
           21      PAPER SIZE 11.0 X 8.5
           22      $
           23       SET 1 ALL
           24      $
           25       AXES X,Y,Z
           26       VIEW 90.,90.,0.
           27       FIND SCALE, ORIGIN 11, SET 1
           28      PLOT SET 1, ORIGIN 11
           29      $
           30      BEGIN BULK
                                       S O R T E D    B U L K    D A T A    E C H O
          CARD
          COUNT        ---1--- +++2+++ ---3--- +++4+++ ---5--- +++6+++ ---7--- +++8+++ ---9--- +++10+++
             1-        AXIC    4
```

2-	CTRAPAX	1	1	1	10	11	2		
3-	CTRAPAX	2	1	2	11	12	3		
4-	CTRAPAX	3	1	3	12	13	4		
5-	CTRAPAX	4	1	4	13	14	5		
6-	CTRAPAX	5	1	5	14	15	6		
7-	CTRAPAX	6	1	6	15	16	7		
8-	CTRAPAX	7	1	7	16	17	8		
9-	CTRAPAX	8	1	8	17	18	9		
10-	CTRAPAX	9	1	10	19	20	11		
11-	CTRAPAX	10	1	11	20	21	12		
12-	CTRAPAX	11	1	12	21	22	13		
13-	CTRAPAX	12	1	13	22	23	14		
14-	CTRAPAX	13	1	14	23	24	15		
15-	CTRAPAX	14	1	15	24	25	16		
16-	CTRAPAX	15	1	16	25	26	17		
17-	CTRAPAX	16	1	17	26	27	18		
18-	FORCEAX	1	1	0	859.03	1.	0.	0.	
19-	FORCEAX	1	2	0	1718.06	1.	0.	0.	
20-	FORCEAX	1	3	0	1718.06	1.	0.	0.	
21-	FORCEAX	1	4	0	1718.06	1.	0.	0.	
22-	FORCEAX	1	5	0	1718.06	1.	0.	0.	
23-	FORCEAX	1	6	0	1718.06	1.	0.	0.	
24-	FORCEAX	1	7	0	1718.06	1.	0.	0.	
25-	FORCEAX	1	8	0	1718.06	1.	0.	0.	
26-	FORCEAX	1	9	0	859.03	1.	0.	0.	
27-	MAT1	1	28.5+6		.27	0.285	6.0-6	75.	
28-	PTRAPAX	1		1					
29-	RINGAX	1		21.875	0.			3456	
30-	RINGAX	2		21.875	0.5			456	
31-	RINGAX	3		21.875	1.0			456	
32-	RINGAX	4		21.875	1.5			456	
33-	RINGAX	5		21.875	2.0			456	
34-	RINGAX	6		21.875	2.5			456	
35-	RINGAX	7		21.875	3.0			456	
36-	RINGAX	8		21.875	3.5			456	
37-	RINGAX	9		21.875	4.0			456	
38-	RINGAX	10		22.	0.			456	
39-	RINGAX	11		22.	0.5			456	
40-	RINGAX	12		22.	1.0			456	
41-	RINGAX	13		22.	1.5			456	
42-	RINGAX	14		22.	2.0			456	
43-	RINGAX	15		22.	2.5			456	
44-	RINGAX	16		22.	3.0			456	
45-	RINGAX	17		22.	3.5			456	
46-	RINGAX	18		22.	4.0			456	
47-	RINGAX	19		22.125	0.			456	
48-	RINGAX	20		22.125	0.5			456	
49-	RINGAX	21		22.125	1.0			456	
50-	RINGAX	22		22.125	1.5			456	
51-	RINGAX	23		22.125	2.0			456	
52-	RINGAX	24		22.125	2.5			456	
53-	RINGAX	25		22.125	3.0			456	
54-	RINGAX	26		22.125	3.5			456	
55-	RINGAX	27		22.125	4.0			456	
56-	TEMPAX	2	1	0.	175.	2	1	360.	175.
57-	TEMPAX	2	2	0.	175.	2	2	360.	175.
58-	TEMPAX	2	3	0.	175.	2	3	360.	175.
59-	TEMPAX	2	4	0.	175.	2	4	360.	175.
60-	TEMPAX	2	5	0.	175.	2	5	360.	175.
61-	TEMPAX	2	6	0.	175.	2	6	360.	175.
62-	TEMPAX	2	7	0.	175.	2	7	360.	175.
63-	TEMPAX	2	8	0.	175.	2	8	360.	175.
64-	TEMPAX	2	9	0.	175.	2	9	360.	175.
65-	TEMPAX	2	10	0.	175.	2	10	360.	175.
66-	TEMPAX	2	11	0.	175.	2	11	360.	175.
67-	TEMPAX	2	12	0.	175.	2	12	360.	175.
68-	TEMPAX	2	13	0.	175.	2	13	360.	175.
69-	TEMPAX	2	14	0.	175.	2	14	360.	175.
70-	TEMPAX	2	15	0.	175.	2	15	360.	175.
71-	TEMPAX	2	16	0.	175.	2	16	360.	175.
72-	TEMPAX	2	17	0.	175.	2	17	360.	175.
73-	TEMPAX	2	18	0.	175.	2	18	360.	175.
74-	TEMPAX	2	19	0.	175.	2	19	360.	175.
75-	TEMPAX	2	20	0.	175.	2	20	360.	175.
76-	TEMPAX	2	21	0.	175.	2	21	360.	175.
77-	TEMPAX	2	22	0.	175.	2	22	360.	175.

```
          78-        TEMPAX  2       23      0.      175.    2       23      360.    175.
          79-        TEMPAX  2       24      0.      175.    2       24      360.    175.
          80-        TEMPAX  2       25      0.      175.    2       25      360.    175.
          81-        TEMPAX  2       26      0.      175.    2       26      360.    175.
          82-        TEMPAX  2       27      0.      175.    2       27      360.    175.
                     ENDDATA
*** USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO
    THE PRESENCE OF AXISYMMETRIC SOLID DATA
          **NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM**

*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     1, EPSILON SUB E =    1.4020696E-10
    FOR SUBCASE NUMBER     2, EPSILON SUB E =    2.1874433E-11

     PRESSURE LOAD                                                                            SUBCASE 1
                                          D I S P L A C E M E N T   V E C T O R
    SECTOR-ID
     POINT-ID
      RING-ID  HARMONIC       T1             T2             T3            R1            R2            R3
           1      0     1.693589E-03   0.0           0.0           0.0           0.0           0.0
           2      0     1.693747E-03   0.0          -1.031391E-05  0.0           0.0           0.0
           3      0     1.693858E-03   0.0          -2.062829E-05  0.0           0.0           0.0
           4      0     1.693924E-03   0.0          -3.094285E-05  0.0           0.0           0.0
           5      0     1.693946E-03   0.0          -4.125744E-05  0.0           0.0           0.0
           6      0     1.693924E-03   0.0          -5.157202E-05  0.0           0.0           0.0
           7      0     1.693858E-03   0.0          -6.188658E-05  0.0           0.0           0.0
           8      0     1.693747E-03   0.0          -7.220096E-05  0.0           0.0           0.0
           9      0     1.693589E-03   0.0          -8.251487E-05  0.0           0.0           0.0
          10      0     1.690910E-03   0.0          -4.547979E-08  0.0           0.0           0.0
          11      0     1.691068E-03   0.0          -1.034751E-05  0.0           0.0           0.0
          12      0     1.691179E-03   0.0          -2.065036E-05  0.0           0.0           0.0
          13      0     1.691245E-03   0.0          -3.095377E-05  0.0           0.0           0.0
          14      0     1.691267E-03   0.0          -4.125744E-05  0.0           0.0           0.0
          15      0     1.691245E-03   0.0          -5.156111E-05  0.0           0.0           0.0
          16      0     1.691179E-03   0.0          -6.186451E-05  0.0           0.0           0.0
          17      0     1.691068E-03   0.0          -7.216736E-05  0.0           0.0           0.0
          18      0     1.690910E-03   0.0          -8.246939E-05  0.0           0.0           0.0
          19      0     1.688300E-03   0.0          -9.079706E-08  0.0           0.0           0.0
          20      0     1.688458E-03   0.0          -1.038106E-05  0.0           0.0           0.0
          21      0     1.688569E-03   0.0          -2.067240E-05  0.0           0.0           0.0
          22      0     1.688634E-03   0.0          -3.096467E-05  0.0           0.0           0.0
          23      0     1.688656E-03   0.0          -4.125744E-05  0.0           0.0           0.0
          24      0     1.688634E-03   0.0          -5.155021E-05  0.0           0.0           0.0
          25      0     1.688569E-03   0.0          -6.184247E-05  0.0           0.0           0.0
          26      0     1.688458E-03   0.0          -7.213381E-05  0.0           0.0           0.0
          27      0     1.688300E-03   0.0          -8.242408E-05  0.0           0.0           0.0
<< Displacements for higher harmonics were deleted since they were all zero. >>

     UNIFORM TEMPERATURE LOAD                                                       SUBCASE 2
                                          D I S P L A C E M E N T   V E C T O R
    SECTOR-ID
     POINT-ID
      RING-ID  HARMONIC       T1             T2             T3            R1            R2            R3
           1      0     1.312525E-02   0.0           0.0           0.0           0.0           0.0
           2      0     1.312529E-02   0.0           2.999899E-04  0.0           0.0           0.0
           3      0     1.312532E-02   0.0           5.999847E-04  0.0           0.0           0.0
           4      0     1.312534E-02   0.0           8.999781E-04  0.0           0.0           0.0
           5      0     1.312535E-02   0.0           1.199972E-03  0.0           0.0           0.0
           6      0     1.312534E-02   0.0           1.499965E-03  0.0           0.0           0.0
           7      0     1.312532E-02   0.0           1.799959E-03  0.0           0.0           0.0
           8      0     1.312529E-02   0.0           2.099954E-03  0.0           0.0           0.0
           9      0     1.312525E-02   0.0           2.399944E-03  0.0           0.0           0.0
          10      0     1.320025E-02   0.0          -1.929753E-08  0.0           0.0           0.0
          11      0     1.320029E-02   0.0           2.999818E-04  0.0           0.0           0.0
          12      0     1.320032E-02   0.0           5.999781E-04  0.0           0.0           0.0
          13      0     1.320034E-02   0.0           8.999750E-04  0.0           0.0           0.0
          14      0     1.320035E-02   0.0           1.199972E-03  0.0           0.0           0.0
          15      0     1.320034E-02   0.0           1.499968E-03  0.0           0.0           0.0
          16      0     1.320032E-02   0.0           1.799965E-03  0.0           0.0           0.0
          17      0     1.320029E-02   0.0           2.099962E-03  0.0           0.0           0.0
          18      0     1.320025E-02   0.0           2.399963E-03  0.0           0.0           0.0
          19      0     1.327525E-02   0.0          -2.548948E-08  0.0           0.0           0.0
          20      0     1.327529E-02   0.0           2.999709E-04  0.0           0.0           0.0
          21      0     1.327532E-02   0.0           5.999721E-04  0.0           0.0           0.0
          22      0     1.327534E-02   0.0           8.999718E-04  0.0           0.0           0.0
          23      0     1.327535E-02   0.0           1.199972E-03  0.0           0.0           0.0
```

24	0	1.327534E-02	0.0	1.499972E-03	0.0	0.0	0.0
25	0	1.327532E-02	0.0	1.799971E-03	0.0	0.0	0.0
26	0	1.327529E-02	0.0	2.099973E-03	0.0	0.0	0.0
27	0	1.327525E-02	0.0	2.399969E-03	0.0	0.0	0.0

<< Displacements for higher harmonics were deleted since they were all zero.>>

PRESSURE LOAD SUBCASE 1

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	-3.782911E-07	0.0	0.0	0.0

UNIFORM TEMPERATURE LOAD SUBCASE 2

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	-8.986099E-07	0.0	0.0	0.0

PRESSURE LOAD SUBCASE 1

F O R C E S   I N   A X I S - S Y M M E T R I C   T R A P E Z O I D A L   R I N G   E L E M E N T S   (CTRAPAX)

ELEMENT ID.	HARMONIC NUMBER	POINT ANGLE	RADIAL (R)	CIRCUMFERENTIAL (THETA-T)	AXIAL (Z)	CHARGE
1	0		8.547845E+02	0.0	5.634766E+00	0.0
			-4.301514E+02	0.0	-1.556641E+00	0.0
			-4.293379E+02	0.0	1.242188E+00	0.0
			8.614746E+02	0.0	-5.189453E+00	0.0
1	1		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	2		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	3		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	4		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1		0.0000	8.547845E+02	0.0	5.634766E+00	0.0
			-4.301514E+02	0.0	-1.556641E+00	0.0
			-4.293379E+02	0.0	1.242188E+00	0.0
			8.614746E+02	0.0	-5.189453E+00	0.0

<< Force output for other elements was deleted. >>

UNIFORM TEMPERATURE LOAD SUBCASE 2

F O R C E S   I N   A X I S - S Y M M E T R I C   T R A P E Z O I D A L   R I N G   E L E M E N T S   (CTRAPAX)

ELEMENT ID.	HARMONIC NUMBER	POINT ANGLE	RADIAL (R)	CIRCUMFERENTIAL (THETA-T)	AXIAL (Z)	CHARGE
1	0		-1.277364E+06	0.0	-3.198784E+05	0.0
			1.284640E+06	0.0	-3.206322E+05	0.0
			1.284622E+06	0.0	3.206169E+05	0.0
			-1.277327E+06	0.0	3.198938E+05	0.0
1	1		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	2		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	3		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1	4		0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
			0.0	0.0	0.0	0.0
1		0.0000	-1.277364E+06	0.0	-3.198784E+05	0.0
			1.284640E+06	0.0	-3.206322E+05	0.0

```
                           1.284622E+06           0.0              3.206169E+05            0.0
                           1.277327E+06           0.0              3.198938E+05            0.0
<< Force output for other elements was deleted. >>

     PRESSURE LOAD                                                                                SUBCASE 1
    S T R E S S E S   I N   A X I S - S Y M M E T R I C   T R A P E Z O I D A L   R I N G   E L E M E N T S  (CTRAPAX)
ELEMENT   HARMONIC   POINT    RADIAL      AXIAL      CIRCUM.      SHEAR       SHEAR       SHEAR       F L U X   D E N S I T I E S
ID.       NUMBER     ANGLE     (R)         (Z)      (THETA-T)      (ZR)        (RT)        (ZT)        (R)         (Z)         (T)
   1         0               -1.511E+01  2.901E+00  2.203E+03 -5.352E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -2.221E+01 -3.674E+00  2.183E+03 -5.430E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -2.222E+01 -3.594E+00  2.184E+03  5.237E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -1.508E+01  2.963E+00  2.203E+03  5.317E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -1.865E+01 -3.777E-01  2.193E+03 -9.552E-03  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         1                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         2                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         3                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         4                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1                  0.0000 -1.511E+01  2.901E+00  2.203E+03 -5.352E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -2.221E+01 -3.674E+00  2.183E+03 -5.430E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -2.222E+01 -3.594E+00  2.184E+03  5.237E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -1.508E+01  2.963E+00  2.203E+03  5.317E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -1.865E+01 -3.777E-01  2.193E+03 -9.552E-03  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
<< Stress output for other elements was deleted. >>

     UNIFORM TEMPERATURE LOAD                                                         SUBCASE 2
    S T R E S S E S   I N   A X I S - S Y M M E T R I C   T R A P E Z O I D A L   R I N G   E L E M E N T S  (CTRAPAX)
ELEMENT   HARMONIC   POINT    RADIAL      AXIAL      CIRCUM.      SHEAR       SHEAR       SHEAR       F L U X   D E N S I T I E S
ID.       NUMBER     ANGLE     (R)         (Z)      (THETA-T)      (ZR)        (RT)        (ZT)        (R)         (Z)         (T)
   1         0               -6.641E-02 -5.781E-01  1.836E-01 -6.875E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              2.266E-01  2.188E-01  4.766E-01 -6.875E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              8.203E-02  2.070E-01  4.570E-01  3.047E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -3.164E-01 -5.781E-01  1.836E-01  3.066E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              2.578E-01 -3.086E-01  7.031E-02 -2.061E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         1                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         2                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         3                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1         4                0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
   1                  0.0000 -6.641E-02 -5.781E-01  1.836E-01 -6.875E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              2.266E-01  2.188E-01  4.766E-01 -6.875E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              8.203E-02  2.070E-01  4.570E-01  3.047E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                             -3.164E-01 -5.781E-01  1.836E-01  3.066E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
                              2.578E-01 -3.086E-01  7.031E-02 -2.061E-01  0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00
<< Stress output for other elements was deleted. >>
                                   * * * END OF JOB * * *
```

3) This file contains data for the axisymmetric finite element model of the generic balance. This is the first step in the mixed model procedure where the stiffness matrix is generated and output to a file.

```
ID BAL1,FEM
APP  DISPLACEMENT
SOL 1,0
$
$ WRITE MATRIX KAA TO FILE 14
$
ALTER 76
OUTPUT2 KAA,,,,//-1/14 $
EXIT
ENDALTER
$
TIME 60
$
CEND
                                 C A S E   C O N T R O L   D E C K   E C H O
            CARD
            COUNT
             1       TITLE = EXAMPLE PROBLEM: 20 INCH BALANCE
             2       SUBTITLE = PART 1: OUTPUT STIFFNESS MATRIX
             3       $
             4       AXISYM = COSINE
             5       MPC = 1
             6       OUTPUT
             7         DISPLACEMENTS = ALL
             8         SPCFORCES = ALL
             9         HARMONICS = ALL
            10       $
            11       SUBCASE 1
            12        LABEL = UNIT THRUST LOAD
            13        LOAD = 1
            14       $
            15       OUTPUT(PLOT)
            16       PLOTTER NASTPLT,D,1
            17       PAPER SIZE 11.0 X 8.5
            18       $
            19        SET 1 ALL
            20       $
            21        AXES X,Y,Z
            22        VIEW 90.,90.,0.
            23        FIND SCALE, ORIGIN 11, SET 1
            24       PLOT SET 1, ORIGIN 11
            25       $
            26       BEGIN BULK
                                        S O R T E D   B U L K   D A T A   E C H O
            CARD
            COUNT        ---1--- +++2+++ ---3--- +++4+++ ---5--- +++6+++ ---7--- +++8+++
               1-        AXIC    4
               2-        CCONEAX 11      2       17      19
               3-        CCONEAX 12      2       19      20
               4-        CCONEAX 13      2       20      21
               5-        CCONEAX 14      2       21      22
               6-        CCONEAX 15      2       22      23
               7-        CCONEAX 16      2       23      24
               8-        CCONEAX 17      2       24      25
               9-        CCONEAX 18      2       25      27
              10-        CTRAPAX 1       1       1       2       5       4
              11-        CTRAPAX 2       1       2       3       6       5
              12-        CTRAPAX 3       1       4       5       8       7
              13-        CTRAPAX 4       1       5       6       9       8
              14-        CTRAPAX 5       1       7       8       11      10
              15-        CTRAPAX 6       1       8       9       12      11
              16-        CTRAPAX 7       1       10      11      14      13
              17-        CTRAPAX 8       1       11      12      15      14
              18-        CTRAPAX 9       1       13      14      17      16
              19-        CTRAPAX 10      1       14      15      18      17
              20-        CTRAPAX 19      1       29      26      27      30
              21-        CTRAPAX 20      1       30      27      28      31
              22-        CTRAPAX 24      1       34      32      33      35
              23-        CTRAPAX 25      1       36      34      35      37
              24-        CTRAPAX 26      1       38      36      37      39
```

25-	CTRIAAX	21	1	32	29	30				
26-	CTRIAAX	22	1	32	30	33				
27-	CTRIAAX	23	1	33	30	31				
28-	FORCEAX	1	39	0	0.	0.	0.	1.		
29-	MAT1	1	30.0+6		.3					
30-	MPCAX	1				17	0	5	-2.	+MP001
31-	+MP001	17	0	1	1.	14	0	1	-1.	+MP002
32-	+MP002	16	0	3	.5	18	0	3	-.5	
33-	MPCAX	1				17	1	5	-2.	+MP101
34-	+MP101	17	1	1	1.	14	1	1	-1.	+MP102
35-	+MP102	16	1	3	.5	18	1	3	-.5	
36-	MPCAX	1				17	3	5	-2.	+MP301
37-	+MP301	17	3	1	1.	14	3	1	-1.	+MP302
38-	+MP302	16	3	3	.5	18	3	3	-.5	
39-	MPCAX	1				17	4	5	-2.	+MP401
40-	+MP401	17	4	1	1.	14	4	1	-1.	+MP402
41-	+MP402	16	4	3	.5	18	4	3	-.5	
42-	MPCAX	1				17	2	5	-2.	+MP201
43-	+MP201	17	2	1	1.	14	2	1	-1.	+MP202
44-	+MP202	16	2	3	.5	18	2	3	-.5	
45-	MPCAX	1				27	2	5	-2.	+MP203
46-	+MP203	28	2	1	2.66667	26	2	1	-2.66667	+MP204
47-	+MP204	30	2	3	1.	27	2	3	-1.	
48-	MPCAX	1				27	3	5	-2.	+MP303
49-	+MP303	28	3	1	2.66667	26	3	1	-2.66667	+MP304
50-	+MP304	30	3	3	1.	27	3	3	-1.	
51-	MPCAX	1				27	0	5	-2.	+MP003
52-	+MP003	28	0	1	2.66667	26	0	1	-2.66667	+MP004
53-	+MP004	30	0	3	1.	27	0	3	-1.	
54-	MPCAX	1				27	1	5	-2.	+MP103
55-	+MP103	28	1	1	2.66667	26	1	1	-2.66667	+MP104
56-	+MP104	30	1	3	1.	27	1	3	-1.	
57-	MPCAX	1				27	4	5	-2.	+MP403
58-	+MP403	28	4	1	2.66667	26	4	1	-2.66667	+MP404
59-	+MP404	30	4	3	1.	27	4	3	-1.	
60-	PCONEAX	2	1	0.375	1	4.3945-3				+PC1
61-	+PC1	0.1875	-.1875	0.	45.	90.	135.	180.		
62-	PTRAPAX	1		1						
63-	PTRIAAX	1		1						
64-	RINGAX	1		9.	3.			456		
65-	RINGAX	2		10.	3.			456		
66-	RINGAX	3		11.	3.			456		
67-	RINGAX	4		9.	4.			456		
68-	RINGAX	5		10.	4.			456		
69-	RINGAX	6		11.	4.			456		
70-	RINGAX	7		9.	5.			456		
71-	RINGAX	8		10.	5.			456		
72-	RINGAX	9		11.	5.			456		
73-	RINGAX	10		9.	6.			456		
74-	RINGAX	11		10.	6.			456		
75-	RINGAX	12		11.	6.			456		
76-	RINGAX	13		9.	7.			456		
77-	RINGAX	14		10.	7.			456		
78-	RINGAX	15		11.	7.			456		
79-	RINGAX	16		9.	8.			456		
80-	RINGAX	17		10.	8.			46		
81-	RINGAX	18		11.	8.			456		
82-	RINGAX	19		9.625	8.625			46		
83-	RINGAX	20		9.250	9.250			46		
84-	RINGAX	21		8.875	9.875			46		
85-	RINGAX	22		8.500	10.500			46		
86-	RINGAX	23		8.125	11.125			46		
87-	RINGAX	24		7.750	11.750			46		
88-	RINGAX	25		7.375	12.375			46		
89-	RINGAX	26		7.	12.8125			456		
90-	RINGAX	27		7.	13.0			46		
91-	RINGAX	28		7.	13.1875			456		
92-	RINGAX	29		6.	12.8125			456		
93-	RINGAX	30		6.	13.0			456		
94-	RINGAX	31		6.	13.1875			456		
95-	RINGAX	32		5.	12.8125			456		
96-	RINGAX	33		5.	13.1875			456		
97-	RINGAX	34		4.	12.8125			456		
98-	RINGAX	35		4.	13.1875			456		
99-	RINGAX	36		3.	12.8125			456		
100-	RINGAX	37		3.	13.1875			456		

```
          101-        RINGAX  38            2.      12.8125             456
          102-        RINGAX  39            2.      13.1875             456
                      ENDDATA

  USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO THE PRESENCE OF AXISYMMETRIC SOLID DATA
        **NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM**

*** USER INFORMATION MESSAGE 4114

   DATA BLOCK KAA      WRITTEN ON FORTRAN UNIT  14, TRLR  =      581     581     6     2     62     277

                                    * * * END OF JOB * * *
```

4) This file contains the data for the mast/flexure model. The DMAP Alter sequence for reading a matrix, adding it to an existing matrix, and outputing the solution is shown in the executive control.

```
ID BAL2,FEM
APP  DISPLACEMENT
SOL 1,0
DIAG 14
$
$ THIS DATA REPRESENTS FOUR SINGLE ELEMENT FLEXURES IN CYLINDRICAL
$ COORDINATES AND A MAST.  PHANTOM GRID POINTS HAVE BEEN ADDED TO
$ SIMULATE THE SIZE OF A MATRIX THAT COMES FROM AN ASSOCIATED AXISYMMETRIC
$ MODEL.  THE MAST GRIDS ARE OMITTED.
$
$ READ MATRIX KWW FROM TAPE
$ ADD TO MATRIX KAA
$ SOLVE THE PROBLEM
$ OUTPUT TO FILE THE SOLUTION SET VECTOR, ULV
$
ALTER 75
INPUTT2 /KWW,,,,/ -1 / 11 / $
ADD KAA,KWW/KMC/C,Y,ALPHA=(1.0,0.0)/C,Y,BETA=(1.0,0.0)  $
EQUIV  KMC,KAA/ALWAYS  $
ALTER 89
OUTPUT2  ULV,,,,//-1/14 $
ENDALTER
$
TIME 230
CEND
                                C A S E   C O N T R O L   D E C K   E C H O
           CARD
           COUNT
            1       TITLE = FLEXURES AND MAST FOR GENERIC BALANCE MODEL
            2       SUBTITLE = PART 2: ADD STIFFNESS MATRICIES AND SOLVE
            3       $
            4       SPC = 1
            5       MPC = 1
            6       $
            7       SET 1 = 601 THRU 604
            8       $
            9       OUTPUT
           10         DISPLACEMENTS = ALL
           11         SPCFORCES = ALL
           12         FORCES = 1
           13       SUBCASE 1
           14        LABEL = UNIT THRUST LOAD
           15        LOAD = 1
           16       $
           17       SUBCASE 2
           18        LABEL = UNIT PITCH MOMENT LOAD
           19        LOAD = 2
           20       $
           21       SUBCASE 3
           22        LABEL = UNIT AFT FORCE LOAD
           23        LOAD = 3
           24       $
           25       OUTPUT(PLOT)
           26       PLOTTER NASTPLT,D,1
           27       PAPER SIZE 11.0 X 8.5
```

```
$
 SET 1 ALL
$
 AXES X,Y,Z
 VIEW 60.,30.,0.
 FIND SCALE, ORIGIN 10, SET 1
PLOT SET 1, ORIGIN 10
PLOT STATIC DEFORMATION 0,1 SET 1, ORIGIN 10, PEN 2, SHAPE
$
BEGIN BULK
                              S O R T E D   B U L K   D A T A   E C H O
CARD
COUNT      ---1--- +++2+++ ---3--- +++4+++ ---5--- +++6+++ ---7--- +++8+++
   1-      BAROR                                   0.      0.      1.      1
   2-      CBAR    601     10      601     602     1.      0.      0.      1
   3-      CBAR    602     10      603     604     1.      0.      0.      1
   4-      CBAR    603     10      605     606     1.      0.      0.      1
   5-      CBAR    604     10      607     608     1.      0.      0.      1
   6-      CBAR    690     11      698     699     1.      0.      0.      1
   7-      CORD2C  1       0       0.      0.      0.      0.      0.      1.      +CORD1
   8-      +CORD1  1.      0.      1.
   9-      FORCE   1       699             1.0     0.      0.      1.
  10-      FORCE   3       699             1.0     1.      0.      0.
  11-      GRID    601     1       10.0    0.      0.      1
  12-      GRID    602     1       10.0    0.      3.0     1
  13-      GRID    603     1       10.0    90.     0.      1
  14-      GRID    604     1       10.0    90.     3.0     1
  15-      GRID    605     1       10.0    180.    0.      1
  16-      GRID    606     1       10.0    180.    3.0     1
  17-      GRID    607     1       10.0    270.    0.      1
  18-      GRID    608     1       10.0    270.    3.0     1
  19-      GRID    698     1       0.      0.      13.1875 1
  20-      GRID    699     1       0.      0.      28.     1
  21-      GRID    10001           0.      0.      0.
  22-      GRID    10002           0.      0.      0.
  23-      GRID    10003           0.      0.      0.
  24-      GRID    10004           0.      0.      0.
  25-      GRID    10005           0.      0.      0.
  26-      GRID    10006           0.      0.      0.
  27-      GRID    10007           0.      0.      0.
  28-      GRID    10008           0.      0.      0.
  29-      GRID    10009           0.      0.      0.
  30-      GRID    10010           0.      0.      0.
  31-      GRID    10011           0.      0.      0.
  32-      GRID    10012           0.      0.      0.
  33-      GRID    10013           0.      0.      0.
  34-      GRID    10014           0.      0.      0.
  35-      GRID    10015           0.      0.      0.
  36-      GRID    10016           0.      0.      0.
  37-      GRID    10017           0.      0.      0.
  38-      GRID    10018           0.      0.      0.
  39-      GRID    10019           0.      0.      0.
  40-      GRID    10020           0.      0.      0.
  41-      GRID    10021           0.      0.      0.
  42-      GRID    10022           0.      0.      0.
  43-      GRID    10023           0.      0.      0.
  44-      GRID    10024           0.      0.      0.
  45-      GRID    10025           0.      0.      0.
  46-      GRID    10026           0.      0.      0.
  47-      GRID    10027           0.      0.      0.
  48-      GRID    10028           0.      0.      0.
  49-      GRID    10029           0.      0.      0.
  50-      GRID    10030           0.      0.      0.
  51-      GRID    10031           0.      0.      0.
  52-      GRID    10032           0.      0.      0.
  53-      GRID    10033           0.      0.      0.
  54-      GRID    10034           0.      0.      0.
  55-      GRID    10035           0.      0.      0.
  56-      GRID    10036           0.      0.      0.
  57-      GRID    10037           0.      0.      0.
  58-      GRID    10038           0.      0.      0.
  59-      GRID    10039           0.      0.      0.
  60-      GRID    11001           0.      0.      0.
  61-      GRID    11002           0.      0.      0.
  62-      GRID    11003           0.      0.      0.
  63-      GRID    11004           0.      0.      0.
```

64-	GRID	11005	0.	0.	0.
65-	GRID	11006	0.	0.	0.
66-	GRID	11007	0.	0.	0.
67-	GRID	11008	0.	0.	0.
68-	GRID	11009	0.	0.	0.
69-	GRID	11010	0.	0.	0.
70-	GRID	11011	0.	0.	0.
71-	GRID	11012	0.	0.	0.
72-	GRID	11013	0.	0.	0.
73-	GRID	11014	0.	0.	0.
74-	GRID	11015	0.	0.	0.
75-	GRID	11016	0.	0.	0.
76-	GRID	11017	0.	0.	0.
77-	GRID	11018	0.	0.	0.
78-	GRID	11019	0.	0.	0.
79-	GRID	11020	0.	0.	0.
80-	GRID	11021	0.	0.	0.
81-	GRID	11022	0.	0.	0.
82-	GRID	11023	0.	0.	0.
83-	GRID	11024	0.	0.	0.
84-	GRID	11025	0.	0.	0.
85-	GRID	11026	0.	0.	0.
86-	GRID	11027	0.	0.	0.
87-	GRID	11028	0.	0.	0.
88-	GRID	11029	0.	0.	0.
89-	GRID	11030	0.	0.	0.
90-	GRID	11031	0.	0.	0.
91-	GRID	11032	0.	0.	0.
92-	GRID	11033	0.	0.	0.
93-	GRID	11034	0.	0.	0.
94-	GRID	11035	0.	0.	0.
95-	GRID	11036	0.	0.	0.
96-	GRID	11037	0.	0.	0.
97-	GRID	11038	0.	0.	0.
98-	GRID	11039	0.	0.	0.
99-	GRID	12001	0.	0.	0.
100-	GRID	12002	0.	0.	0.
101-	GRID	12003	0.	0.	0.
102-	GRID	12004	0.	0.	0.
103-	GRID	12005	0.	0.	0.
104-	GRID	12006	0.	0.	0.
105-	GRID	12007	0.	0.	0.
106-	GRID	12008	0.	0.	0.
107-	GRID	12009	0.	0.	0.
108-	GRID	12010	0.	0.	0.
109-	GRID	12011	0.	0.	0.
110-	GRID	12012	0.	0.	0.
111-	GRID	12013	0.	0.	0.
112-	GRID	12014	0.	0.	0.
113-	GRID	12015	0.	0.	0.
114-	GRID	12016	0.	0.	0.
115-	GRID	12017	0.	0.	0.
116-	GRID	12018	0.	0.	0.
117-	GRID	12019	0.	0.	0.
118-	GRID	12020	0.	0.	0.
119-	GRID	12021	0.	0.	0.
120-	GRID	12022	0.	0.	0.
121-	GRID	12023	0.	0.	0.
122-	GRID	12024	0.	0.	0.
123-	GRID	12025	0.	0.	0.
124-	GRID	12026	0.	0.	0.
125-	GRID	12027	0.	0.	0.
126-	GRID	12028	0.	0.	0.
127-	GRID	12029	0.	0.	0.
128-	GRID	12030	0.	0.	0.
129-	GRID	12031	0.	0.	0.
130-	GRID	12032	0.	0.	0.
131-	GRID	12033	0.	0.	0.
132-	GRID	12034	0.	0.	0.
133-	GRID	12035	0.	0.	0.
134-	GRID	12036	0.	0.	0.
135-	GRID	12037	0.	0.	0.
136-	GRID	12038	0.	0.	0.
137-	GRID	12039	0.	0.	0.
138-	GRID	13001	0.	0.	0.
139-	GRID	13002	0.	0.	0.

140-	GRID	13003	0.	0.	0.
141-	GRID	13004	0.	0.	0.
142-	GRID	13005	0.	0.	0.
143-	GRID	13006	0.	0.	0.
144-	GRID	13007	0.	0.	0.
145-	GRID	13008	0.	0.	0.
146-	GRID	13009	0.	0.	0.
147-	GRID	13010	0.	0.	0.
148-	GRID	13011	0.	0.	0.
149-	GRID	13012	0.	0.	0.
150-	GRID	13013	0.	0.	0.
151-	GRID	13014	0.	0.	0.
152-	GRID	13015	0.	0.	0.
153-	GRID	13016	0.	0.	0.
154-	GRID	13017	0.	0.	0.
155-	GRID	13018	0.	0.	0.
156-	GRID	13019	0.	0.	0.
157-	GRID	13020	0.	0.	0.
158-	GRID	13021	0.	0.	0.
159-	GRID	13022	0.	0.	0.
160-	GRID	13023	0.	0.	0.
161-	GRID	13024	0.	0.	0.
162-	GRID	13025	0.	0.	0.
163-	GRID	13026	0.	0.	0.
164-	GRID	13027	0.	0.	0.
165-	GRID	13028	0.	0.	0.
166-	GRID	13029	0.	0.	0.
167-	GRID	13030	0.	0.	0.
168-	GRID	13031	0.	0.	0.
169-	GRID	13032	0.	0.	0.
170-	GRID	13033	0.	0.	0.
171-	GRID	13034	0.	0.	0.
172-	GRID	13035	0.	0.	0.
173-	GRID	13036	0.	0.	0.
174-	GRID	13037	0.	0.	0.
175-	GRID	13038	0.	0.	0.
176-	GRID	13039	0.	0.	0.
177-	GRID	14001	0.	0.	0.
178-	GRID	14002	0.	0.	0.
179-	GRID	14003	0.	0.	0.
180-	GRID	14004	0.	0.	0.
181-	GRID	14005	0.	0.	0.
182-	GRID	14006	0.	0.	0.
183-	GRID	14007	0.	0.	0.
184-	GRID	14008	0.	0.	0.
185-	GRID	14009	0.	0.	0.
186-	GRID	14010	0.	0.	0.
187-	GRID	14011	0.	0.	0.
188-	GRID	14012	0.	0.	0.
189-	GRID	14013	0.	0.	0.
190-	GRID	14014	0.	0.	0.
191-	GRID	14015	0.	0.	0.
192-	GRID	14016	0.	0.	0.
193-	GRID	14017	0.	0.	0.
194-	GRID	14018	0.	0.	0.
195-	GRID	14019	0.	0.	0.
196-	GRID	14020	0.	0.	0.
197-	GRID	14021	0.	0.	0.
198-	GRID	14022	0.	0.	0.
199-	GRID	14023	0.	0.	0.
200-	GRID	14024	0.	0.	0.
201-	GRID	14025	0.	0.	0.
202-	GRID	14026	0.	0.	0.
203-	GRID	14027	0.	0.	0.
204-	GRID	14028	0.	0.	0.
205-	GRID	14029	0.	0.	0.
206-	GRID	14030	0.	0.	0.
207-	GRID	14031	0.	0.	0.
208-	GRID	14032	0.	0.	0.
209-	GRID	14033	0.	0.	0.
210-	GRID	14034	0.	0.	0.
211-	GRID	14035	0.	0.	0.
212-	GRID	14036	0.	0.	0.
213-	GRID	14037	0.	0.	0.
214-	GRID	14038	0.	0.	0.
215-	GRID	14039	0.	0.	0.

```
MAT1    1       30.0+6          .3
MOMENT  2       699             1.0     0.      1.      0.
MPC     1       602     3       -1.     10002   3       1.0     +MP1301
+MP1301         11002   3       1.0     12002   3       1.0     +MP1302
+MP1302         13002   3       1.0     14002   3       1.0
MPC     1       602     1       -1.     10002   1       1.0     +MP1101
+MP1101         11002   1       1.0     12002   1       1.0     +MP1102
+MP1102         13002   1       1.0     14002   1       1.0
MPC     1       602     4       -2.     10002   2       0.
MPC     1       602     5       -2.     10005   1       1.0     +MP1501
+MP1501         11005   1       1.0     12005   1       1.0     +MP1502
+MP1502         13005   1       1.0     14005   1       1.0     +MP1503
+MP1503         10002   1       -1.     11002   1       -1.     +MP1504
+MP1504         12002   1       -1.     13002   1       -1.     +MP1505
+MP1505         14002   1       -1.     10003   3       -.5     +MP1506
+MP1506         11003   3       -.5     12003   3       -.5     +MP1507
+MP1507         13003   3       -.5     14003   3       -.5     +MP1508
+MP1508         10001   3       0.5     11001   3       0.5     +MP1509
+MP1509         12001   3       0.5     13001   3       0.5     +MP1510
+MP1510         14001   3       0.5
MPC     1       602     2       -1.     10002   2       0.
MPC     1       602     6       -2.     10002   2       0.
MPC     1       604     1       -1.     10002   1       1.0     +MP2101
+MP2101         12002   1       -1.     14002   1       1.0
MPC     1       604     4       -2.     11002   3       -.1     +MP2401
+MP2401         13002   3       0.3     11005   2       -1.     +MP2402
+MP2402         13005   2       1.0     11002   2       1.0     +MP2403
+MP2403         13002   2       -1.
MPC     1       604     5       -2.     10005   1       1.0     +MP2501
+MP2501         12005   1       -1.     14005   1       1.0     +MP2502
+MP2502         10002   1       -1.     12002   1       1.0     +MP2503
+MP2503         14002   1       -1.     10003   3       -.5     +MP2504
+MP2504         12003   3       0.5     14003   3       -.5     +MP2505
+MP2505         10001   3       0.5     12001   3       -.5     +MP2506
+MP2506         14001   3       0.5
MPC     1       604     2       -1.     11002   2       1.0     +MP2201
+MP2201         13002   2       -1.
MPC     1       604     3       -1.     10002   3       1.0     +MP2301
+MP2301         12002   3       -1.     14002   3       1.0
MPC     1       604     6       -2.     11003   2       0.5     +MP2601
+MP2601         13003   2       -.5     11001   2       -.5     +MP2602
+MP2602         13001   2       0.5     11002   1       0.1     +MP2603
+MP2603         13002   1       -.3     11002   2       0.1     +MP2604
+MP2604         13002   2       -.1
MPC     1       606     4       -2.     11002   2       0.
MPC     1       606     3       -1.     10002   3       1.0     +MP3301
+MP3301         11002   3       -1.     12002   3       1.0     +MP3302
+MP3302         13002   3       -1.     14002   3       1.0
MPC     1       606     2       -1.     11002   2       0.
MPC     1       606     5       -2.     10005   1       1.0     +MP3501
+MP3501         11005   1       -1.     12005   1       1.0     +MP3502
+MP3502         13005   1       -1.     14005   1       1.0     +MP3503
+MP3503         10002   1       -1.     11002   1       1.0     +MP3504
+MP3504         12002   1       -1.     13002   1       1.0     +MP3505
+MP3505         14002   1       -1.     10003   3       -.5     +MP3506
+MP3506         11003   3       0.5     12003   3       -.5     +MP3507
+MP3507         13003   3       0.5     14003   3       -.5     +MP3508
+MP3508         10001   3       0.5     11001   3       -.5     +MP3509
+MP3509         12001   3       0.5     13001   3       -.5     +MP3510
+MP3510         14001   3       0.5
MPC     1       606     6       -2.     11002   2       0.
MPC     1       606     1       -1.     10002   1       1.0     +MP3101
+MP3101         11002   1       -1.     12002   1       1.0     +MP3102
+MP3102         13002   1       -1.     14002   1       1.0
MPC     1       608     6       -2.     11003   2       -.5     +MP4601
+MP4601         13003   2       0.5     11001   2       0.5     +MP4602
+MP4602         13001   2       -.5     11002   1       -.1     +MP4603
+MP4603         13002   1       0.3     11002   2       -.1     +MP4604
+MP4604         13002   2       0.1
MPC     1       608     3       -1.     10002   3       1.0     +MP4301
+MP4301         12002   3       -1.     14002   3       1.0
MPC     1       608     2       -1.     11002   2       -1.0    +MP4201
+MP4201         13002   2       1.0
MPC     1       608     1       -1.     10002   1       1.0     +MP4101
+MP4101         12002   1       -1.     14002   1       1.0
MPC     1       608     4       -2.     11002   3       0.1     +MP4401
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292-    +MP4401        13002   3     -.3      11005   2      1.0          +MP4402
293-    +MP4402        13005   2     -1.      11002   2      -1.          +MP4403
294-    +MP4403        13002   2     1.
295-    MPC     1      608     5     -2.      10005   1      1.0          +MP4501
296-    +MP4501        12005   1     -1.      14005   1      1.0          +MP4502
297-    +MP4502        10002   1     -1.      12002   1      1.0          +MP4503
298-    +MP4503        14002   1     -1.      10003   3      -.5          +MP4504
299-    +MP4504        12003   3     0.5      14003   3      -.5          +MP4505
300-    +MP4505        10001   3     0.5      12001   3      -.5          +MP4506
301-    +MP4506        14001   3     0.5
302-    MPC     1      698     3     -1.      10039   3      1.0
303-    MPC     1      698     1     -1.      11039   1      1.0
304-    MPC     1      698     5     -1.      11039   3      1.0
305-    OMIT    699    123456
306-    PBAR    10     1       0.8480  0.01985 0.18091 0.06283
307-    PBAR    11     1       100.    10.     10.     20.
308-    SPC1    1      46      11019   THRU    11025
309-    SPC1    1      46      12019   THRU    12025
310-    SPC1    1      46      13019   THRU    13025
311-    SPC1    1      46      14019   THRU    14025
312-    SPC1    1      246     698
313-    SPC1    1      246     10019   THRU    10025
314-    SPC1    1      456     11001   THRU    11017
315-    SPC1    1      456     11018
316-    SPC1    1      456     11026
317-    SPC1    1      456     11027   THRU    11039
318-    SPC1    1      456     12001   THRU    12017
319-    SPC1    1      456     12018
320-    SPC1    1      456     12026
321-    SPC1    1      456     12027   THRU    12039
322-    SPC1    1      456     13001   THRU    13017
323-    SPC1    1      456     13018
324-    SPC1    1      456     13026
325-    SPC1    1      456     13027   THRU    13039
326-    SPC1    1      456     14001   THRU    14017
327-    SPC1    1      456     14018
328-    SPC1    1      456     14026
329-    SPC1    1      456     14027   THRU    14039
330-    SPC1    1      2456    10001   THRU    10017
331-    SPC1    1      2456    10018
332-    SPC1    1      2456    10026
333-    SPC1    1      2456    10027   THRU    10039
334-    SPC1    1      123456  601     603     605     607
        ENDDATA

        **NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM**

*** USER WARNING MESSAGE 2015, EITHER NO ELEMENTS CONNECT INTERNAL GRID POINT          11
    OR IT IS CONNECTED TO A RIGID ELEMENT OR A GENERAL ELEMENT.

*** USER WARNING MESSAGE 3017
    ONE OR MORE POTENTIAL SINGULARITIES HAVE NOT BEEN REMOVED BY SINGLE OR MULTI-POINT CONSTRAINTS.
    (USER COULD REQUEST NASTRAN AUTOMATIC SPC GENERATION VIA A 'PARAM AUTOSPC 1' BULK DATA CARD)

            G R I D   P O I N T   S I N G U L A R I T Y   T A B L E      SPC        1  MPC        1
     POINT              SINGULARITY  LIST OF COORDINATE COMBINATIONS THAT WILL REMOVE SINGULARITY
     ID.    TYPE          ORDER      STRONGEST COMBINATION   WEAKER COMBINATION  WEAKEST COMBINATION
     10001   G              2            1     3
     10002   G              2            1     3
     10003   G              2            1     3
     10004   G              2            1     3
     10005   G              2            1     3
     10006   G              2            1     3
     10007   G              2            1     3
     10008   G              2            1     3
     10009   G              2            1     3
     10010   G              2            1     3
<< Output from the singularity table was limited to the first 10 phantom grid points. >>

*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     1, EPSILON SUB E =   5.0293249E-13
*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     2, EPSILON SUB E =   4.4364106E-14
*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     3, EPSILON SUB E =   2.4369392E-14
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*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     1, EPSILON SUB E =   0.0000000E+00
*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     2, EPSILON SUB E =   5.5511151E-17
*** USER INFORMATION MESSAGE 3035
    FOR SUBCASE NUMBER     3, EPSILON SUB E =   5.5511151E-17

*** USER INFORMATION MESSAGE 4114
    DATA BLOCK ULV      WRITTEN ON FORTRAN UNIT  14, TRLR  =     3     581     2     2     496     4044
```

UNIT THRUST LOAD

SUBCASE 1

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
601	G	0.0	0.0	0.0	0.0	0.0	0.0
602	G	-7.908970E-10	0.0	2.948113E-08	0.0	-1.242338E-09	0.0
603	G	0.0	0.0	0.0	0.0	0.0	0.0
604	G	-7.908970E-10	0.0	2.948113E-08	0.0	-1.242338E-09	0.0
605	G	0.0	0.0	0.0	0.0	0.0	0.0
606	G	-7.908970E-10	0.0	2.948113E-08	0.0	-1.242338E-09	0.0
607	G	0.0	0.0	0.0	0.0	0.0	0.0
608	G	-7.908970E-10	0.0	2.948113E-08	0.0	-1.242338E-09	0.0
698	G	0.0	0.0	3.862959E-06	0.0	0.0	0.0
699	G	0.0	0.0	3.867897E-06	0.0	0.0	0.0
10001	G	2.639826E-09	0.0	3.272975E-08	0.0	0.0	0.0
10002	G	2.598370E-09	0.0	3.418335E-08	0.0	0.0	0.0
10003	G	2.563580E-09	0.0	3.688345E-08	0.0	0.0	0.0
10004	G	7.270202E-10	0.0	3.260277E-08	0.0	0.0	0.0
10005	G	5.405373E-10	0.0	3.464026E-08	0.0	0.0	0.0
11001	G	0.0	0.0	0.0	0.0	0.0	0.0
11002	G	0.0	0.0	0.0	0.0	0.0	0.0
11003	G	0.0	0.0	0.0	0.0	0.0	0.0
11004	G	0.0	0.0	0.0	0.0	0.0	0.0
11005	G	0.0	0.0	0.0	0.0	0.0	0.0
12001	G	0.0	0.0	0.0	0.0	0.0	0.0
12002	G	0.0	0.0	0.0	0.0	0.0	0.0
12003	G	0.0	0.0	0.0	0.0	0.0	0.0
12004	G	0.0	0.0	0.0	0.0	0.0	0.0
12005	G	0.0	0.0	0.0	0.0	0.0	0.0
13001	G	0.0	0.0	0.0	0.0	0.0	0.0
13002	G	0.0	0.0	0.0	0.0	0.0	0.0
13003	G	0.0	0.0	0.0	0.0	0.0	0.0
13004	G	0.0	0.0	0.0	0.0	0.0	0.0
13005	G	0.0	0.0	0.0	0.0	0.0	0.0
14001	G	-3.246454E-09	3.098101E-09	-2.619861E-09	0.0	0.0	0.0
14002	G	-3.389266E-09	2.360525E-09	-4.702220E-09	0.0	0.0	0.0
14003	G	-3.418743E-09	1.552902E-09	-4.313459E-09	0.0	0.0	0.0
14004	G	-2.164515E-09	1.878403E-09	-2.997400E-09	0.0	0.0	0.0
14005	G	-2.586062E-09	1.122367E-09	-3.852546E-09	0.0	0.0	0.0

601	G	0.0	0.0	0.0	0.0	0.0	0.0
602	G	-5.610955E-09	0.0	1.174792E-08	0.0	-1.701747E-09	0.0
603	G	0.0	0.0	0.0	0.0	0.0	0.0
604	G	0.0	2.515618E-09	0.0	-1.900792E-09	0.0	6.087235E-10
605	G	0.0	0.0	0.0	0.0	0.0	0.0
606	G	5.610955E-09	0.0	-1.174792E-08	0.0	1.701747E-09	0.0
607	G	0.0	0.0	0.0	0.0	0.0	0.0
608	G	0.0	-2.515618E-09	0.0	1.900792E-09	0.0	-6.087235E-10
698	G	2.211418E-07	0.0	0.0	0.0	2.801197E-06	0.0
699	G	4.207956E-05	0.0	0.0	0.0	2.850572E-06	0.0
10001	G	0.0	0.0	0.0	0.0	0.0	0.0
10002	G	0.0	0.0	0.0	0.0	0.0	0.0
10003	G	0.0	0.0	0.0	0.0	0.0	0.0
10004	G	0.0	0.0	0.0	0.0	0.0	0.0
10005	G	0.0	0.0	0.0	0.0	0.0	0.0
11001	G	-3.030885E-09	3.937321E-09	1.178935E-08	0.0	0.0	0.0
11002	G	-3.041456E-09	3.963108E-09	1.370397E-08	0.0	0.0	0.0
11003	G	-3.053621E-09	3.963408E-09	1.611813E-08	0.0	0.0	0.0
11004	G	-5.128662E-09	5.348634E-09	1.174310E-08	0.0	0.0	0.0
11005	G	-5.201514E-09	5.350040E-09	1.388887E-08	0.0	0.0	0.0
12001	G	0.0	0.0	0.0	0.0	0.0	0.0
12002	G	0.0	0.0	0.0	0.0	0.0	0.0
12003	G	0.0	0.0	0.0	0.0	0.0	0.0
12004	G	0.0	0.0	0.0	0.0	0.0	0.0
12005	G	0.0	0.0	0.0	0.0	0.0	0.0
13001	G	-2.513659E-09	1.936496E-09	-1.237852E-09	0.0	0.0	0.0
13002	G	-2.569499E-09	1.447490E-09	-1.956046E-09	0.0	0.0	0.0

13003	G	-2.578819E-09	9.642203E-10	-2.183185E-09	0.0	0.0	0.0
13004	G	-2.009346E-09	1.463206E-09	-1.356308E-09	0.0	0.0	0.0
13005	G	-2.121217E-09	9.900493E-10	-1.803383E-09	0.0	0.0	0.0
14001	G	0.0	0.0	0.0	0.0	0.0	0.0
14002	G	0.0	0.0	0.0	0.0	0.0	0.0
14003	G	0.0	0.0	0.0	0.0	0.0	0.0
14004	G	0.0	0.0	0.0	0.0	0.0	0.0
14005	G	0.0	0.0	0.0	0.0	0.0	0.0

601	G	0.0	0.0	0.0	0.0	0.0	0.0
602	G	1.720547E-07	0.0	1.055128E-07	0.0	-1.454852E-08	0.0
603	G	0.0	0.0	0.0	0.0	0.0	0.0
604	G	0.0	-1.707720E-07	0.0	-1.016038E-08	0.0	1.681734E-09
605	G	0.0	0.0	0.0	0.0	0.0	0.0
606	G	-1.720547E-07	0.0	-1.055128E-07	0.0	1.454852E-08	0.0
607	G	0.0	0.0	0.0	0.0	0.0	0.0
608	G	0.0	1.707720E-07	0.0	1.016038E-08	0.0	-1.681734E-09
698	G	3.755716E-06	0.0	0.0	0.0	4.171387E-05	0.0
699	G	6.252536E-04	0.0	0.0	0.0	4.207956E-05	0.0
10001	G	0.0	0.0	0.0	0.0	0.0	0.0
10002	G	0.0	0.0	0.0	0.0	0.0	0.0
10003	G	0.0	0.0	0.0	0.0	0.0	0.0
10004	G	0.0	0.0	0.0	0.0	0.0	0.0
10005	G	0.0	0.0	0.0	0.0	0.0	0.0
11001	G	1.780936E-07	-1.738395E-07	1.002073E-07	0.0	0.0	0.0
11002	G	1.779452E-07	-1.712015E-07	1.147197E-07	0.0	0.0	0.0
11003	G	1.779890E-07	-1.741763E-07	1.338945E-07	0.0	0.0	0.0
11004	G	1.618966E-07	-1.623457E-07	9.972933E-08	0.0	0.0	0.0
11005	G	1.613971E-07	-1.634723E-07	1.165638E-07	0.0	0.0	0.0
12001	G	0.0	0.0	0.0	0.0	0.0	0.0
12002	G	0.0	0.0	0.0	0.0	0.0	0.0
12003	G	0.0	0.0	0.0	0.0	0.0	0.0
12004	G	0.0	0.0	0.0	0.0	0.0	0.0
12005	G	0.0	0.0	0.0	0.0	0.0	0.0
13001	G	-6.107248E-09	3.387790E-09	-5.048370E-09	0.0	0.0	0.0
13002	G	-5.890513E-09	-4.294931E-10	-9.206829E-09	0.0	0.0	0.0
13003	G	-5.440393E-09	1.292965E-09	-9.223636E-09	0.0	0.0	0.0
13004	G	-3.301694E-09	1.366286E-09	-5.586073E-09	0.0	0.0	0.0
13005	G	-3.683499E-09	1.212996E-09	-7.655163E-09	0.0	0.0	0.0
14001	G	0.0	0.0	0.0	0.0	0.0	0.0
14002	G	0.0	0.0	0.0	0.0	0.0	0.0
14003	G	0.0	0.0	0.0	0.0	0.0	0.0
14004	G	0.0	0.0	0.0	0.0	0.0	0.0
14005	G	0.0	0.0	0.0	0.0	0.0	0.0

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
601	G	-2.838843E-04	0.0	-2.500000E-01	0.0	-1.792222E-04	0.0
603	G	-2.838843E-04	0.0	-2.500000E-01	0.0	-1.792222E-04	0.0
605	G	-2.838843E-04	0.0	-2.500000E-01	0.0	-1.792222E-04	0.0
607	G	-2.838843E-04	0.0	-2.500000E-01	0.0	-1.792222E-04	0.0

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
601	G	8.094393E-04	0.0	-9.962239E-02	0.0	1.551956E-03	0.0
603	G	0.0	8.094393E-04	0.0	2.224564E-03	0.0	-1.471004E-04
605	G	-8.094393E-04	0.0	9.962239E-02	0.0	-1.551956E-03	0.0
607	G	0.0	-8.094393E-04	0.0	-2.224564E-03	0.0	1.471004E-04

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
601	G	-5.131291E-02	0.0	-8.947487E-01	0.0	-7.408148E-02	0.0
603	G	0.0	4.486871E-01	0.0	-6.546495E-01	0.0	-4.063975E-04
605	G	5.131291E-02	0.0	8.947487E-01	0.0	7.408148E-02	0.0
607	G	0.0	-4.486871E-01	0.0	6.546495E-01	0.0	4.063975E-04

FORCES IN BAR ELEMENTS (CBAR)

ELEMENT	BEND-MOMENT END-A		BEND-MOMENT END-B		- SHEAR -		AXIAL	
ID.	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	FORCE	TORQUE
601	1.792222E-04	0.0	-6.724306E-04	0.0	2.838843E-04	0.0	2.500000E-01	0.0
602	1.792222E-04	0.0	-6.724306E-04	0.0	2.838843E-04	0.0	2.500000E-01	0.0
603	1.792222E-04	0.0	-6.724306E-04	0.0	2.838843E-04	0.0	2.500000E-01	0.0
604	1.792222E-04	0.0	-6.724306E-04	0.0	2.838843E-04	0.0	2.500000E-01	0.0

FORCES IN BAR ELEMENTS (CBAR)

ELEMENT	BEND-MOMENT END-A		BEND-MOMENT END-B		- SHEAR -		AXIAL	

```
ID.        PLANE 1        PLANE 2        PLANE 1        PLANE 2        PLANE 1        PLANE 2        FORCE          TORQUE
     601  -1.551956E-03  0.0            8.763619E-04   0.0           -8.094392E-04   0.0            9.962239E-02   0.0
     602   0.0           2.224563E-03   0.0            4.652883E-03   0.0           -8.094398E-04   0.0            1.471004E-04
     603   1.551956E-03  0.0           -8.763619E-04   0.0            8.094392E-04   0.0           -9.962239E-02   0.0
     604   0.0          -2.224563E-03   0.0           -4.652883E-03   0.0            8.094398E-04   0.0           -1.471004E-04
```

```
                              F O R C E S   I N   B A R   E L E M E N T S        ( C B A R )
ELEMENT        BEND-MOMENT END-A               BEND-MOMENT END-B                 - SHEAR -                    AXIAL
  ID.       PLANE 1        PLANE 2        PLANE 1        PLANE 2        PLANE 1        PLANE 2        FORCE          TORQUE
     601   7.408148E-02   0.0           -7.985723E-02   0.0            5.131290E-02   0.0            8.947487E-01   0.0
     602   0.0           -6.546494E-01   0.0            6.914117E-01   0.0           -4.486870E-01   0.0            4.063975E-04
     603  -7.408148E-02   0.0            7.985723E-02   0.0           -5.131290E-02   0.0           -8.947487E-01   0.0
     604   0.0            6.546494E-01   0.0           -6.914117E-01   0.0            4.486870E-01   0.0           -4.063975E-04
                                        * * * END OF JOB * * *
```

5) This file contains the DMAP alter sequence for the last step in the procedure. The bulk data has been deleted because this model is the same one used in the first step of the procedure.

```
ID BAL3,FEM
APP  DISPLACEMENT
SOL 1,0
DIAG 14
DIAG 36
$
$ READ DISPLACEMENT SET AND COMPUTE ELEMENT FORCES
$
ALTER 75
INPUTT2 /UMC,,,,/ -1 / 11 / $
EQUIV   UMC,ULV/ALWAYS   $
ALTER 88
JUMP    LBL9  $
$ OUTPUT FORCE DATA
ALTER 108
OUTPUT2 OEF1,,,,//-1/12
ENDALTER
$
TIME 160
$
CEND
                                 C A S E   C O N T R O L   D E C K   E C H O
          CARD
          COUNT
           1      TITLE = GENERIC BALANCE MODEL
           2      SUBTITLE = PART 3: INPUT DISPLACEMENT SET VECTOR
           3      $
           4      AXISYM = COSINE
           5      $
           6      SET 1 = 2,17
           7      OUTPUT
           8        DISPLACEMENTS = ALL
           9        GPFORCES = 1
          10        ELFORCES = ALL
          11        HARMONICS = ALL
          12      $
          13      SUBCASE 1
          14       LABEL = UNIT THRUST LOAD
          15       LOAD = 1
          16      $
          17      SUBCASE 2
          18       LABEL = UNIT PITCH MOMENT
          19       LOAD = 2
          20      $
          21      SUBCASE 3
          22       LABEL = UNIT AFT LOAD
          23       LOAD = 3
          24      $
          25      OUTPUT(PLOT)
          26      PLOTTER NASTPLT,D,1
          27      PAPER SIZE 11.0 X 8.5
```

```
$
 SET 1 ALL
$
 AXES X,Y,Z
 VIEW 90.,90.,0.
 FIND SCALE, ORIGIN 11, SET 1
PLOT SET 1, ORIGIN 11
$
BEGIN BULK
```

<< The bulk data for this file is exactly the same as file listing #3 in this appendix, because these are the same finite element models. The bulk data has been deleted. >>

*** USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO THE PRESENCE OF AXISYMMETRIC SOLID DATA

NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM

*** USER INFORMATION MESSAGE 4105, DATA BLOCK UMC RETRIEVED FROM FORTRAN TAPE 11
NAME OF DATA BLOCK WHEN PLACED ON FORTRAN TAPE WAS ULV .

UNIT THRUST LOAD SUBCASE 1

G R I D   P O I N T   F O R C E   B A L A N C E

POINT-ID	ELEMENT-ID	SOURCE	T1	T2	T3	R1	R2	R3
1000002	1001	TRAPAX	-1.962777E-01	0.0	4.697984E-01	0.0	0.0	0.0
1000002	2001	TRAPAX	1.987579E-01	0.0	5.302037E-01	0.0	0.0	0.0
1000002		*TOTALS*	2.480194E-03	0.0	1.000002E+00	0.0	0.0	0.0
1000017	11001	CONEAX	3.862712E+01	0.0	-4.880019E+01	0.0	2.665097E+00	0.0
1000017	9001	TRAPAX	-1.411920E-02	0.0	-4.058314E-01	0.0	0.0	0.0
1000017	10001	TRAPAX	3.094939E+01	0.0	4.290217E+00	0.0	0.0	0.0
1000017		*TOTALS*	6.956239E+01	0.0	-4.491580E+01	0.0	2.665097E+00	0.0
2000002	1002	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
2000002	2002	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
2000002		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
2000017	11002	CONEAX	0.0	0.0	0.0	0.0	0.0	0.0
2000017	9002	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
2000017	10002	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
2000017		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
3000002	1003	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
3000002	2003	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
3000002		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
3000017	11003	CONEAX	0.0	0.0	0.0	0.0	0.0	0.0
3000017	9003	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
3000017	10003	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
3000017		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
4000002	1004	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
4000002	2004	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
4000002		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
4000017	11004	CONEAX	0.0	0.0	0.0	0.0	0.0	0.0
4000017	9004	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
4000017	10004	TRAPAX	0.0	0.0	0.0	0.0	0.0	0.0
4000017		*TOTALS*	0.0	0.0	0.0	0.0	0.0	0.0
5000002	1005	TRAPAX	-3.393911E-01	-6.053476E-02	-2.903760E-01	0.0	0.0	0.0
5000002	2005	TRAPAX	-1.026829E+00	6.023814E-01	-1.034488E+00	0.0	0.0	0.0
5000002		*TOTALS*	-1.366220E+00	5.418466E-01	-1.324864E+00	0.0	0.0	0.0
5000017	11005	CONEAX	2.364401E-01	-3.854312E-01	-2.812054E-01	0.0	3.798493E-02	0.0
5000017	9005	TRAPAX	-1.272544E+00	-7.269861E-01	-1.453672E+00	0.0	0.0	0.0
5000017	10005	TRAPAX	9.631046E-01	-3.777996E-01	-1.490628E+00	0.0	0.0	0.0
5000017		*TOTALS*	-7.299960E-02	-1.490217E+00	-3.225505E+00	0.0	3.798493E-02	0.0

<< Grid point force balance has been limited to subcase 1 only. >>

*** USER INFORMATION MESSAGE 4114

DATA BLOCK OEF1 WRITTEN ON FORTRAN UNIT 12, TRLR = 63 1 16 91 6 1

<< Displacement output is limited to the first 10 rings. >>

UNIT THRUST LOAD SUBCASE 1

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	2.639826E-09	0.0	3.272975E-08	0.0	0.0	0.0
2	0	2.598370E-09	0.0	3.418335E-08	0.0	0.0	0.0
3	0	2.563580E-09	0.0	3.688345E-08	0.0	0.0	0.0
4	0	7.270202E-10	0.0	3.260277E-08	0.0	0.0	0.0
5	0	5.405373E-10	0.0	3.464026E-08	0.0	0.0	0.0
6	0	3.569469E-10	0.0	3.680350E-08	0.0	0.0	0.0
7	0	-1.464268E-09	0.0	3.276735E-08	0.0	0.0	0.0
8	0	-1.509579E-09	0.0	3.495903E-08	0.0	0.0	0.0
9	0	-1.593410E-09	0.0	3.708061E-08	0.0	0.0	0.0
10	0	-3.688067E-09	0.0	3.298806E-08	0.0	0.0	0.0
1	1	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.0	0.0	0.0	0.0	0.0
3	1	0.0	0.0	0.0	0.0	0.0	0.0
4	1	0.0	0.0	0.0	0.0	0.0	0.0
5	1	0.0	0.0	0.0	0.0	0.0	0.0
6	1	0.0	0.0	0.0	0.0	0.0	0.0
7	1	0.0	0.0	0.0	0.0	0.0	0.0
8	1	0.0	0.0	0.0	0.0	0.0	0.0

SUBCASE 1

UNIT THRUST LOAD

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
9	1	0.0	0.0	0.0	0.0	0.0	0.0
10	1	0.0	0.0	0.0	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0
2	2	0.0	0.0	0.0	0.0	0.0	0.0
3	2	0.0	0.0	0.0	0.0	0.0	0.0
4	2	0.0	0.0	0.0	0.0	0.0	0.0
5	2	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.0	0.0	0.0	0.0	0.0
7	2	0.0	0.0	0.0	0.0	0.0	0.0
8	2	0.0	0.0	0.0	0.0	0.0	0.0
9	2	0.0	0.0	0.0	0.0	0.0	0.0
10	2	0.0	0.0	0.0	0.0	0.0	0.0
1	3	0.0	0.0	0.0	0.0	0.0	0.0
2	3	0.0	0.0	0.0	0.0	0.0	0.0
3	3	0.0	0.0	0.0	0.0	0.0	0.0
4	3	0.0	0.0	0.0	0.0	0.0	0.0
5	3	0.0	0.0	0.0	0.0	0.0	0.0
6	3	0.0	0.0	0.0	0.0	0.0	0.0
7	3	0.0	0.0	0.0	0.0	0.0	0.0
8	3	0.0	0.0	0.0	0.0	0.0	0.0
9	3	0.0	0.0	0.0	0.0	0.0	0.0
10	3	0.0	0.0	0.0	0.0	0.0	0.0
1	4	-4.313459E-09	-2.164515E-09	1.878403E-09	0.0	0.0	0.0
2	4	-2.997400E-09	-2.586062E-09	1.122367E-09	0.0	0.0	0.0
3	4	-3.852546E-09	-2.885780E-09	3.676892E-10	0.0	0.0	0.0
4	4	-4.461612E-09	-1.659919E-09	9.673008E-10	0.0	0.0	0.0
5	4	-2.800361E-09	-1.834405E-09	3.971995E-10	0.0	0.0	0.0
6	4	-3.380789E-09	-1.939248E-09	-2.364189E-10	0.0	0.0	0.0
7	4	-4.078494E-09	-1.117116E-09	3.087811E-10	0.0	0.0	0.0
8	4	-2.572755E-09	-1.178822E-09	-1.237397E-10	0.0	0.0	0.0
9	4	-3.080942E-09	-1.204106E-09	-5.844617E-10	0.0	0.0	0.0
10	4	-3.677761E-09	-6.553869E-10	-2.791431E-10	0.0	0.0	0.0

SUBCASE 2

UNIT PITCH MOMENT

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	0.0	0.0	0.0	0.0
2	0	0.0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0	0.0
5	0	0.0	0.0	0.0	0.0	0.0	0.0
6	0	0.0	0.0	0.0	0.0	0.0	0.0
7	0	0.0	0.0	0.0	0.0	0.0	0.0
8	0	0.0	0.0	0.0	0.0	0.0	0.0
9	0	0.0	0.0	0.0	0.0	0.0	0.0
10	0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	1.178935E-08	-3.041456E-09	3.963108E-09	0.0	0.0	0.0

2	1	1.370397E-08	-3.053621E-09	3.963408E-09	0.0	0.0	0.0
3	1	1.611813E-08	-5.128662E-09	5.348634E-09	0.0	0.0	0.0
4	1	1.174310E-08	-5.201514E-09	5.350040E-09	0.0	0.0	0.0
5	1	1.388887E-08	-5.271955E-09	5.360884E-09	0.0	0.0	0.0
6	1	1.608736E-08	-7.336571E-09	6.839640E-09	0.0	0.0	0.0
7	1	1.180696E-08	-7.354734E-09	6.779539E-09	0.0	0.0	0.0
8	1	1.401556E-08	-7.388014E-09	6.715505E-09	0.0	0.0	0.0
9	1	1.619888E-08	-9.560636E-09	8.350312E-09	0.0	0.0	0.0
10	1	1.188170E-08	-9.552582E-09	8.208898E-09	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0
2	2	0.0	0.0	0.0	0.0	0.0	0.0
3	2	0.0	0.0	0.0	0.0	0.0	0.0
4	2	0.0	0.0	0.0	0.0	0.0	0.0
5	2	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.0	0.0	0.0	0.0	0.0
7	2	0.0	0.0	0.0	0.0	0.0	0.0
8	2	0.0	0.0	0.0	0.0	0.0	0.0
9	2	0.0	0.0	0.0	0.0	0.0	0.0
10	2	0.0	0.0	0.0	0.0	0.0	0.0
1	3	-2.578819E-09	9.642203E-10	-2.183185E-09	0.0	0.0	0.0
2	3	-2.009346E-09	1.463206E-09	-1.356308E-09	0.0	0.0	0.0
3	3	-2.121217E-09	9.900493E-10	-1.803383E-09	0.0	0.0	0.0
4	3	-2.178755E-09	5.026283E-10	-2.206326E-09	0.0	0.0	0.0
5	3	-1.639812E-09	1.025641E-09	-1.347159E-09	0.0	0.0	0.0
6	3	-1.693739E-09	6.213332E-10	-1.718476E-09	0.0	0.0	0.0
7	3	-1.708921E-09	2.049921E-10	-2.120450E-09	0.0	0.0	0.0
8	3	-1.278950E-09	6.394917E-10	-1.320283E-09	0.0	0.0	0.0
9	3	-1.300843E-09	3.035907E-10	-1.657742E-09	0.0	0.0	0.0
10	3	-1.295482E-09	-3.866900E-11	-2.021836E-09	0.0	0.0	0.0
1	4	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.0	0.0	0.0	0.0	0.0
3	4	0.0	0.0	0.0	0.0	0.0	0.0
4	4	0.0	0.0	0.0	0.0	0.0	0.0
5	4	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.0	0.0	0.0	0.0	0.0
7	4	0.0	0.0	0.0	0.0	0.0	0.0
8	4	0.0	0.0	0.0	0.0	0.0	0.0
9	4	0.0	0.0	0.0	0.0	0.0	0.0
10	4	0.0	0.0	0.0	0.0	0.0	0.0

UNIT AFT LOAD

SUBCASE 3

D I S P L A C E M E N T   V E C T O R

SECTOR-ID POINT-ID RING-ID	HARMONIC	T1	T2	T3	R1	R2	R3
1	0	0.0	0.0	0.0	0.0	0.0	0.0
2	0	0.0	0.0	0.0	0.0	0.0	0.0
3	0	0.0	0.0	0.0	0.0	0.0	0.0
4	0	0.0	0.0	0.0	0.0	0.0	0.0
5	0	0.0	0.0	0.0	0.0	0.0	0.0
6	0	0.0	0.0	0.0	0.0	0.0	0.0
7	0	0.0	0.0	0.0	0.0	0.0	0.0
8	0	0.0	0.0	0.0	0.0	0.0	0.0
9	0	0.0	0.0	0.0	0.0	0.0	0.0
10	0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	1.002073E-07	1.779452E-07	-1.712015E-07	0.0	0.0	0.0
2	1	1.147197E-07	1.779890E-07	-1.741763E-07	0.0	0.0	0.0
3	1	1.338945E-07	1.618966E-07	-1.623457E-07	0.0	0.0	0.0
4	1	9.972933E-08	1.613971E-07	-1.634723E-07	0.0	0.0	0.0
5	1	1.165638E-07	1.606930E-07	-1.628763E-07	0.0	0.0	0.0
6	1	1.339398E-07	1.443895E-07	-1.515336E-07	0.0	0.0	0.0
7	1	1.001407E-07	1.443175E-07	-1.523106E-07	0.0	0.0	0.0
8	1	1.179267E-07	1.439687E-07	-1.532900E-07	0.0	0.0	0.0
9	1	1.354955E-07	1.262950E-07	-1.400403E-07	0.0	0.0	0.0
10	1	1.007155E-07	1.264366E-07	-1.416957E-07	0.0	0.0	0.0
1	2	0.0	0.0	0.0	0.0	0.0	0.0
2	2	0.0	0.0	0.0	0.0	0.0	0.0
3	2	0.0	0.0	0.0	0.0	0.0	0.0
4	2	0.0	0.0	0.0	0.0	0.0	0.0
5	2	0.0	0.0	0.0	0.0	0.0	0.0
6	2	0.0	0.0	0.0	0.0	0.0	0.0
7	2	0.0	0.0	0.0	0.0	0.0	0.0
8	2	0.0	0.0	0.0	0.0	0.0	0.0
9	2	0.0	0.0	0.0	0.0	0.0	0.0
10	2	0.0	0.0	0.0	0.0	0.0	0.0
1	3	-5.440393E-09	1.292965E-09	-9.223636E-09	0.0	0.0	0.0

2	3	-3.301694E-09	1.366286E-09	-5.586073E-09	0.0	0.0	0.0
3	3	-3.683499E-09	1.212996E-09	-7.655163E-09	0.0	0.0	0.0
4	3	-4.111131E-09	-5.739011E-10	-9.287293E-09	0.0	0.0	0.0
5	3	-1.839876E-09	4.981898E-10	-5.437970E-09	0.0	0.0	0.0
6	3	-1.950501E-09	-1.892448E-10	-6.959178E-09	0.0	0.0	0.0
7	3	-2.077800E-09	-7.417547E-10	-8.568358E-09	0.0	0.0	0.0
8	3	-4.745768E-10	-7.674623E-10	-5.218832E-09	0.0	0.0	0.0
9	3	-4.650081E-10	-1.047147E-09	-6.521891E-09	0.0	0.0	0.0
10	3	-5.085589E-10	-1.359747E-09	-7.921546E-09	0.0	0.0	0.0
1	4	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.0	0.0	0.0	0.0	0.0
3	4	0.0	0.0	0.0	0.0	0.0	0.0
4	4	0.0	0.0	0.0	0.0	0.0	0.0
5	4	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.0	0.0	0.0	0.0	0.0
7	4	0.0	0.0	0.0	0.0	0.0	0.0
8	4	0.0	0.0	0.0	0.0	0.0	0.0
9	4	0.0	0.0	0.0	0.0	0.0	0.0
10	4	0.0	0.0	0.0	0.0	0.0	0.0

* * * END OF JOB * * *