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THERMAL STRESS ANALYSIS OF REUSABLE SURFACE INSULATION FOR SHUTTLE

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FINAL REPORT

GRUMMAN

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THERMAL STRESS ANALYSIS OF REUSABLE SURFACE INSULATION FOR SHUTTLE

FINAL REPORT

Prepared for
National Aeronautics and Space Administration
Langley Research Center
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FOREWORD

The work reported herein was performed by the Grumman Aerospace Corporation under the NASA/Langley Master Agreement and Contract No. NAS 1-10635 for the Development and Implementation of Space Shuttle Structural Dynamics Modeling Technology. The Work Statement of Task Order No. 19, "Development of a Thermal Stress Analysis Program For Reusable Surface Insulation for Shuttle", authorized and specified the tasks to be performed in this study. The period of performance was for 13 months starting in August of 1973.

The overall supervision of programs under the Master Agreement is provided by Mr. E. F. Baird, Master Agreement Program Manager. The Task Order No. 19 Project Manager was Dr. I. U. Ojalvo. Many individuals at Grumman contributed to the work reported herein. However, the authors wish to specifically acknowledge the significant efforts of Mrs. Patricia Ogilvie for greatly assisting in the development of the associated computer program.

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I. INTRODUCTION

The integrity of a reusable space shuttle system is strongly dependent upon protecting the orbiting vehicle from reentry heating in a manner which does not require significant refurbishment between missions. The thermal protection system (TPS) selected to fulfill this need is a nonstructural reusable surface insulation (RSI) material shaped into individual tiles which cover almost all of the orbiter surface area. Most of the tiles are square in planform and measure 15 x 15 or 20 x 20 cm. (6 x 6 or 8 x 8 in.), with thicknesses which vary roughly between 1.2 and 7.5 cm. (0.5 and 3 in.). Since loss of a single tile could be catastrophic, RSI tile stresses must be accurately determined for the anticipated static, dynamic and thermal environments.

This report describes an iterative procedure for accurately determining tile stresses associated with static mechanical and thermally induced internal loads. The necessary conditions for convergence of the method are derived in Appendix A. A user-oriented computer program based upon the present method of analysis was developed. The program, which is titled RESIST (for REusable Surface Insulation STresses) is capable of analyzing multi-tiled panels and determining the associated RSI stresses. Typical numerical results from this computer program are presented. A user's manual to facilitate its implementation is presented as Appendix B.

Because of the complex geometry, nonuniform anisotropic material properties, and detailed three-dimensional stress states, the TPS was idealized by finite element assemblages with up to 2500 degrees of freedom per tile. Since a number of tiles affixed to a given structural panel will, in general, interact with one another, application of the standard direct stiffness method would require simultaneous equation systems involving excessive numbers of unknowns. The present iteration scheme overcomes this problem by treating each tile separately. An important byproduct of this approach is that it avoids conditioning problems associated with combining low-stiffness tile isolation elements ($E \approx 50$ psi) with high-stiffness primary structure elements ($E \approx 10 \times 10^6$ psi).

A related effort for obtaining tile stresses associated with typical shuttle-panel lower frequency modes, Reference 1, is being extended further to accommodate acoustic response problems.

II. TECHNICAL APPROACH

A. STRUCTURAL CONFIGURATION

The design configuration for which an analysis procedure is presented is shown in Figure 1. It consists of a stringer-stiffened flat rectangular panel which supports a nonstructural thermal protection system (TPS).

The TPS is composed of a series of rigidized (RSI) tiles. The tiles are undercut on all four sides to accommodate "filler-strips". The purpose of the nonrigidized filler-strip insulation is to prevent severe heat penetration through the gaps between adjacent tiles.

The RSI material is not bonded directly to the primary structure, but to a thin, stiff, strain arrestor plate first, and then, in turn, to a soft strain isolator material. The function of both these items is to help isolate the primary-structure strains from the low-strength RSI tiles, for the wide range of loading environments which the vehicle must sustain.

B. GENERAL SOLUTION PROCEDURE

Because of the detailed complexity of the structural configuration and the dependence of material properties upon temperature, an analysis procedure based upon finite element methods was selected. However, direct application of the standard direct stiffness finite element procedure, to obtain accurate three-dimensional tile stresses, would require equation systems involving excessive numbers of unknowns. The reason for this is that many tiles affixed to a given structural panel may interact. Since each one is a three dimensional body requiring a detailed structural idealization, their simultaneous consideration requires the solution of large systems of equations. To overcome this problem a rapidly convergent iteration scheme, which treats each tile separately, was developed. The basis for the method is that the TPS is non-structural but its stress levels, which are critical, must be computed. Thus, it becomes possible to neglect the stiffness of the TPS initially to determine approximate primary-structure static deflections. In these initial calculations, the external mechanical loads acting upon the tile are applied to the primary structure directly. The logic flow for an efficient computer program which employs this procedure is presented in Figure 2.

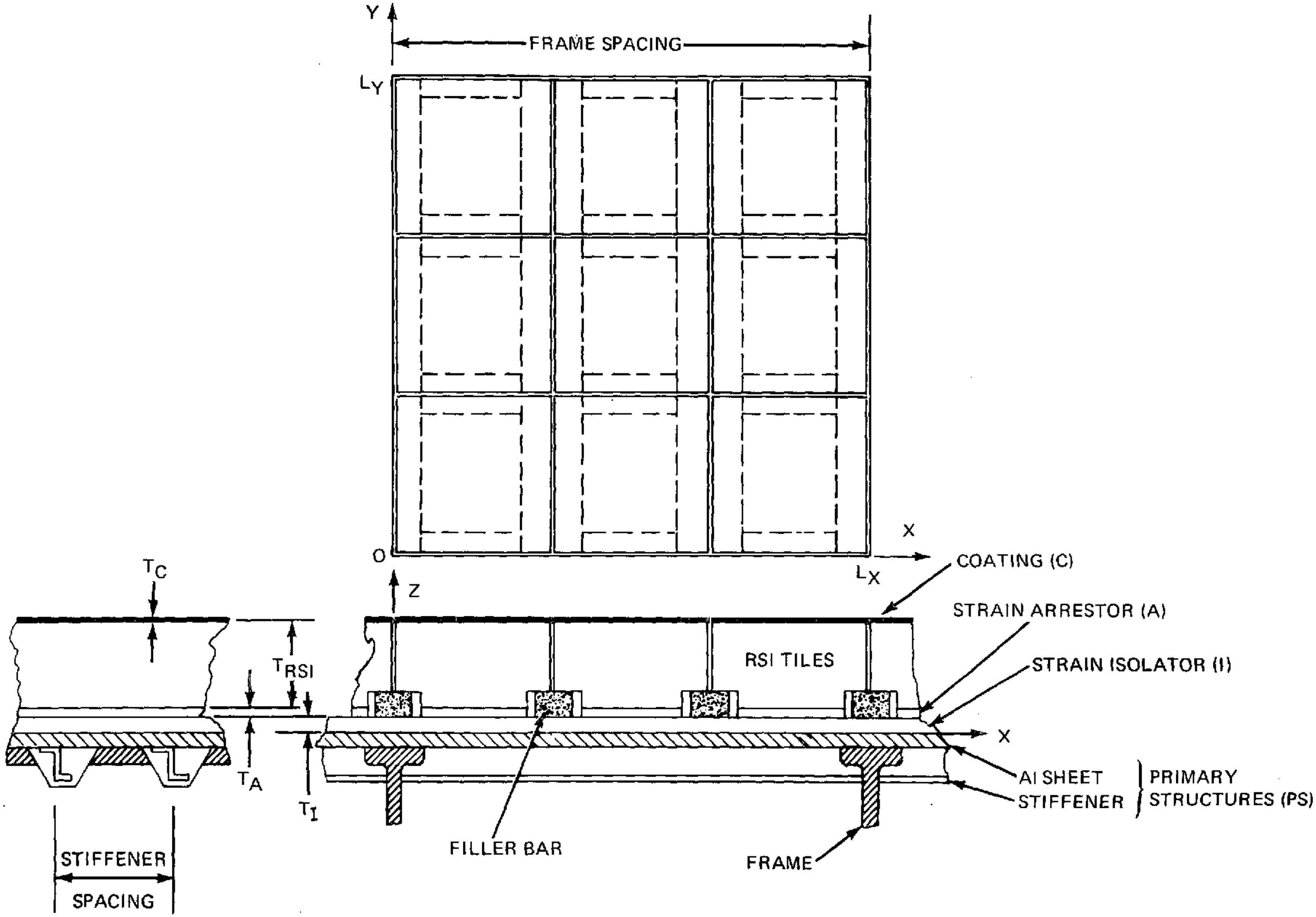


Figure 1. Typical Design Configuration for Shuttle Thermal Protection System

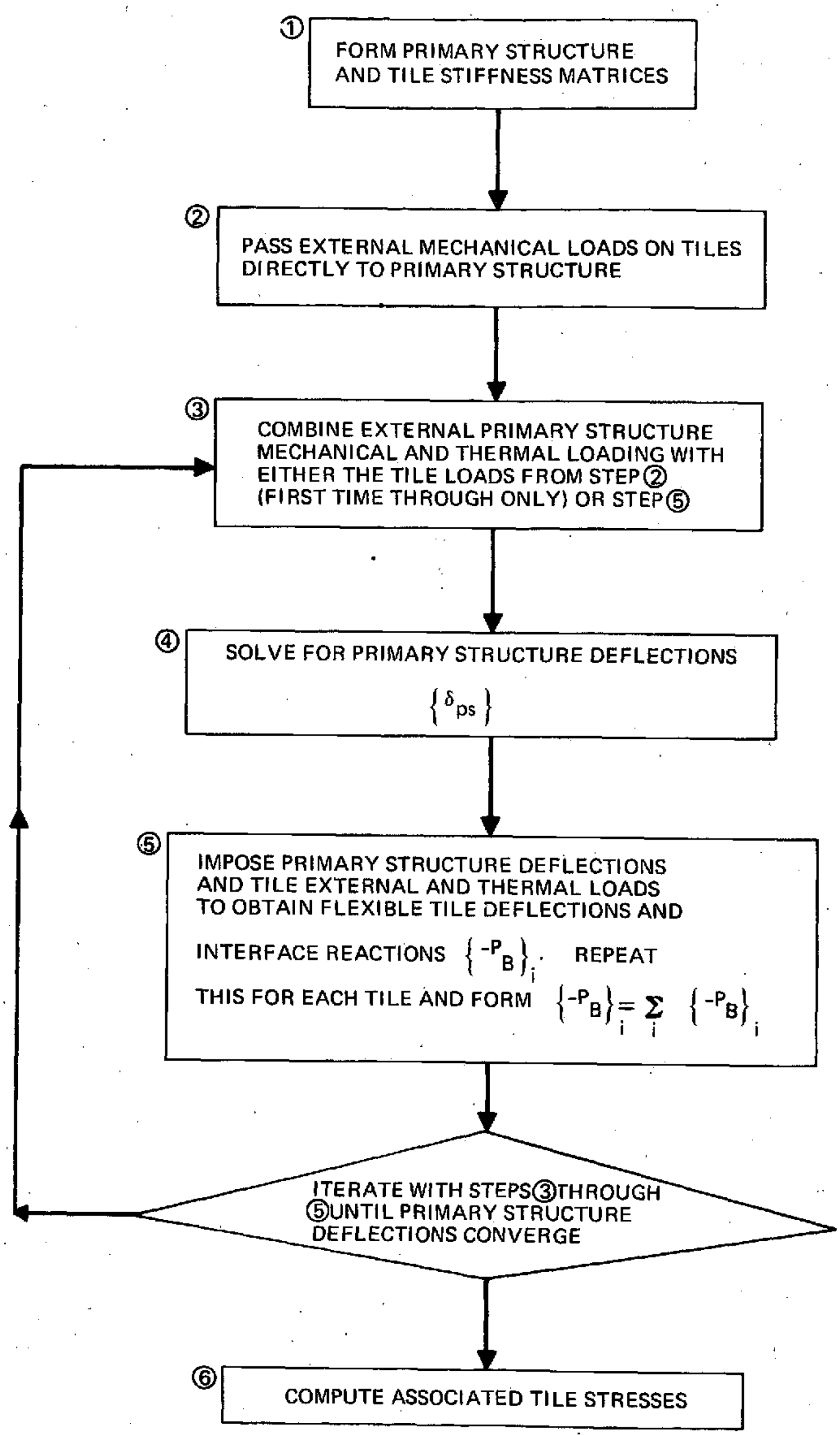


Figure 2 Program Logic for Solution Procedure

An iteration procedure is performed where, in each step, the resulting primary structure deflections are imposed individually upon each tile at the tile/primary-structure interface, and the tile deflections and interface boundary loads are obtained. The tile interface loads obtained are then assembled and their reactions are applied to the primary structure.

New primary structure deflections are obtained and compared to the previous set. By this method each tile is temporarily assumed uncoupled from all others. Although this is not strictly true, the coupling involved is sufficiently weak to insure accurate approximate results and rapid convergence as well. A discussion on the conditions for convergence is presented in Section II.F and Appendix A.

It should be noted that an important byproduct of the present tile-by-tile solution procedure is that, unlike the direct stiffness method, it avoids numerical precision problems associated with directly combining a low finite element stiffness (E= 50 psi) with a high primary structure stiffness element ($E = 10^7$ psi).

C. STRUCTURAL IDEALIZATION

A pictorial representation of the four finite element types incorporated in the RESIST computer program is presented in Appendix C. A brief description of these elements and how each type is used in the overall structural idealization is presented below.

Primary Structure

The primary structure stiffness idealization is based upon two finite elements contained in the Grumman program library described in Reference 2. The panel surface is represented by flat rectangular membrane-bending elements. The elements possess three deflections and two rotations at each node, for a total of 20 independent nodal degrees of freedom per element. The stiffeners are represented by beam elements which bend, stretch and twist. These elements possess 6 degrees of freedom per node, for a total of 12 degrees of freedom per element.

In general, the stiffeners do not attach to the plate nodes at the beam centroids. The stringer attachment points actually used coincide with the plate node which is closest to the centroid of each beam element. The assumption associated with this connection is that the attachment point and beam centroid move as two points on the same rigid body. Furthermore, the principal axes of the beam cross section may make an arbitrary angle with the plate surface.

Thermal Protection System (TPS) Tiles

The basic stiffness element used for the RSI tiles and strain isolator is the anisotropic hexahedron, first proposed in References 3. The extended version of this element (see Reference 4) which is contained in RESIST has 3 deflection degrees of freedom per node and 8 nodes per element (the more general version which is available permits up to 20 nodes per element). A typical undercut tile with element and node numbering is shown in Figure 3. The top layer of each tile also has a coating material which is idealized by rectangular membrane elements. The bottom two layers of each tile comprise the strain isolator and strain arrestor, respectively. The undercut regions of each tile are filled with soft nonrigidized insulation material. This has a negligible effect upon the stresses within the rigidized tile material. Thus, for purposes of computing the tile deflections and stresses, the undercut regions are treated as empty voids.

Automatic Grid Generators

To reduce the quantity of input data significantly, two automatic mesh generating schemes were developed. The first scheme generates the primary structure geometry, node and element numbering system, material properties, and boundary conditions; the second does exactly the same thing for the TPS. Each requires a minimum of information, such as overall dimensions, stringer pitch, material properties (as a function of temperature) and TPS material temperatures and element properties from which data may be interpolated (see Appendix B for details).

D. FLEXIBLE TILE SOLUTIONS

The effects of tile stiffness are neglected for the first primary structure solution. However, for determining tile stress states it is necessary to account for their stiffness. This is achieved by imposing the primary-structure/TPS interface deflections $\{\delta_B\}$, and external mechanical and thermal loads to each tile. Then the associated tile deflections, $\{\delta_A\}$, are computed to obtain tile stresses and reactions, $\{-P_B\}$. As described earlier, this is done in an iterative manner until convergence is obtained.

Referring to Figure 4, the associated partitioned matrix equations governing each tile are:

$$\begin{bmatrix} K_{BB} & K_{BA} \\ K_{AB} & K_{AA} \end{bmatrix} \begin{Bmatrix} \delta_B \\ \delta_A \end{Bmatrix}_i = \begin{Bmatrix} P_B + \overline{P}_B \\ P_A + \overline{P}_A \end{Bmatrix}_i \qquad (5)$$

where the barred P's refer to thermal loading terms.

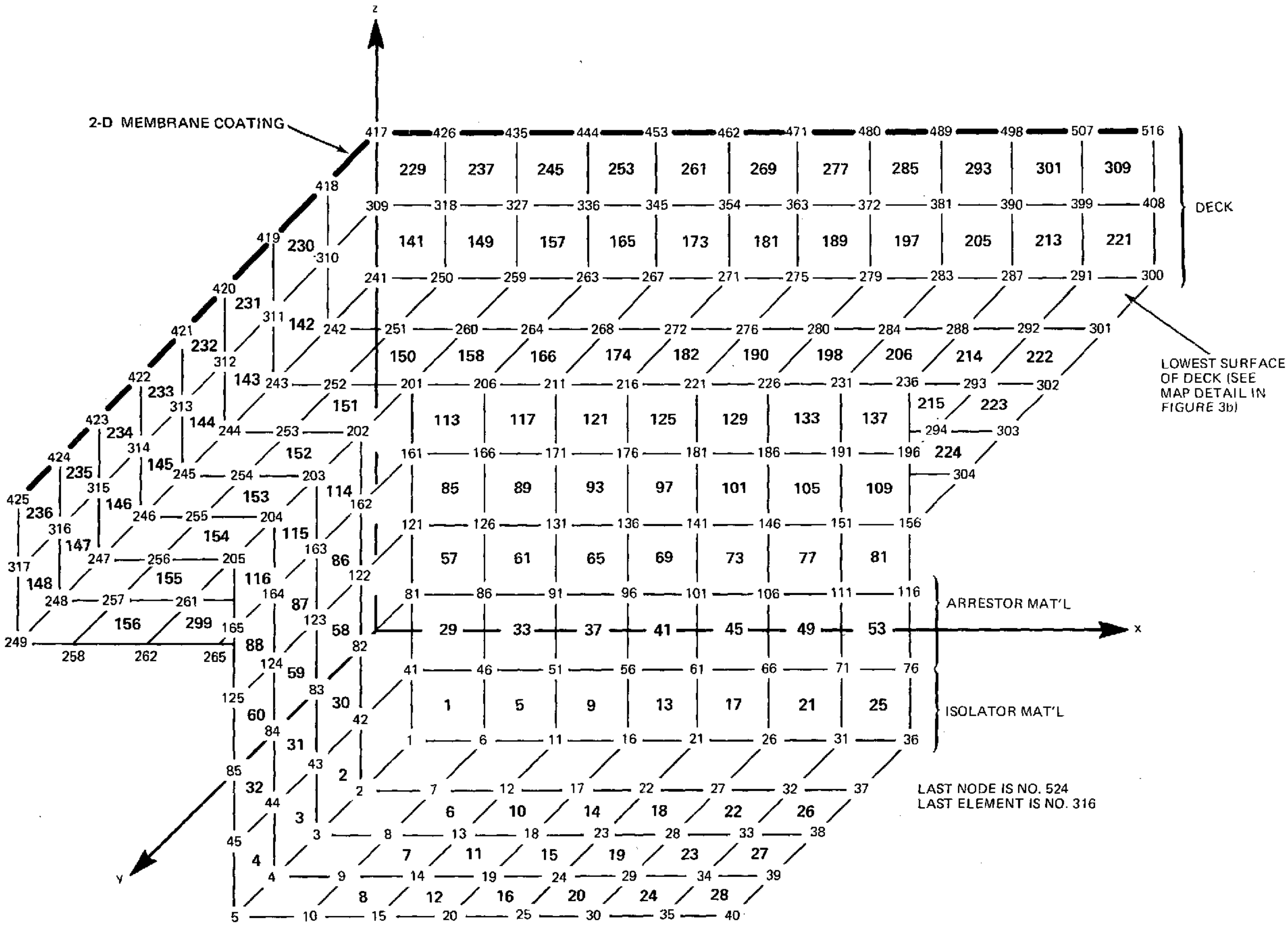


Figure 3a Typical Finite Element Idealization of Shuttle RSI Tile

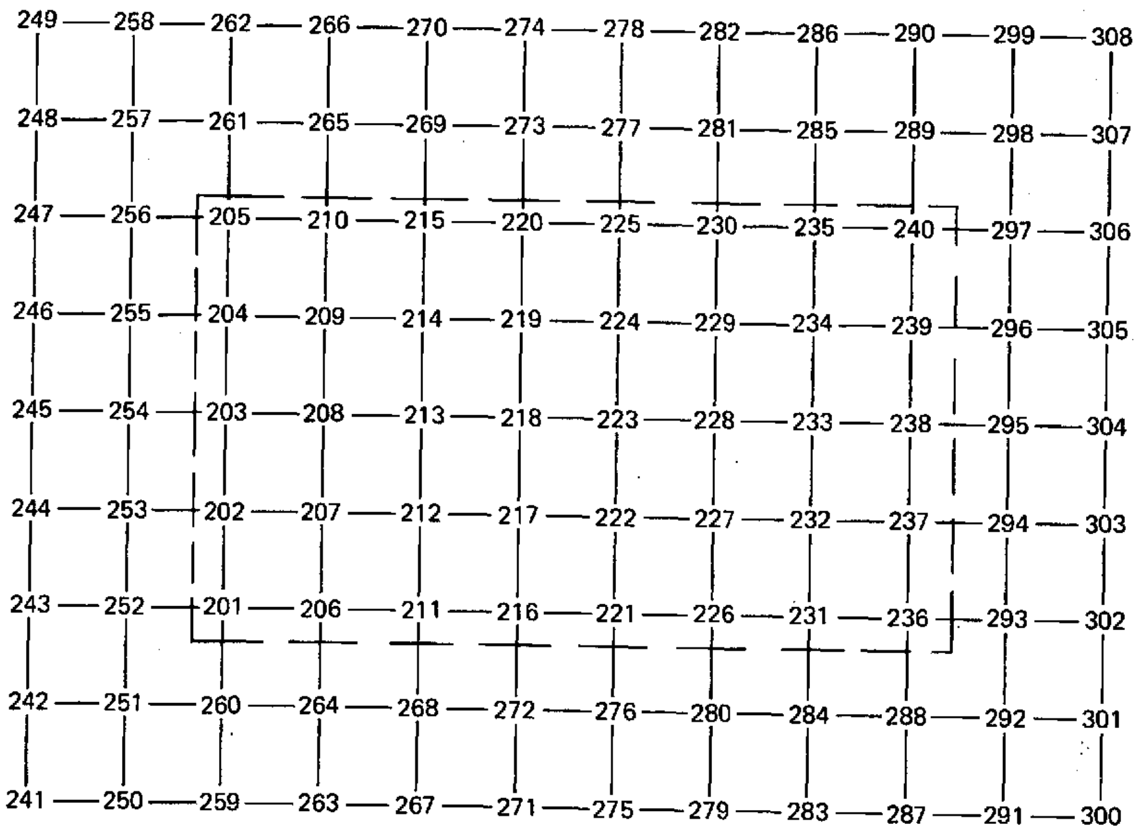


Figure 3b. Top View of Lowest Surface of Deck

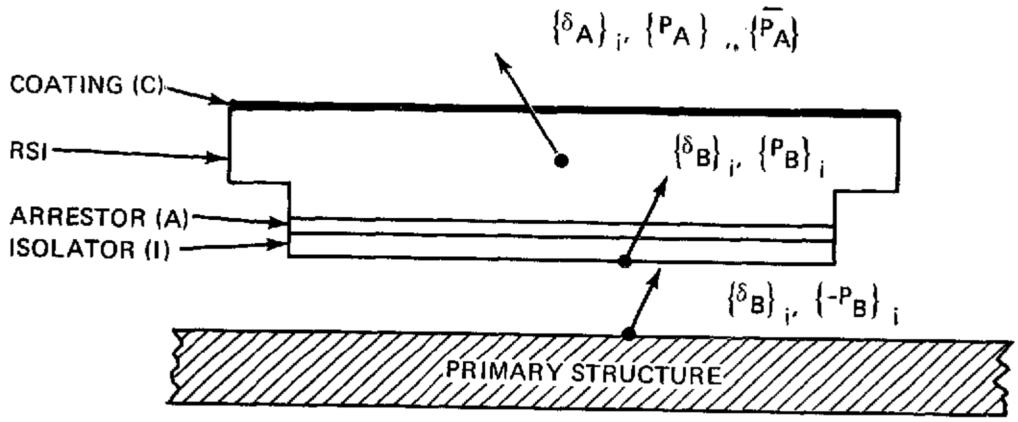


Figure 4. Notation for Flexible Tile Solution Approach

This equation is then expressed as:

$$\left[K_{AA}\right]\left\{\delta_A\right\} = -\left[K_{AB}\right]\left\{\delta_B\right\}_i + \left\{P_A + \overline{P}_A\right\} \tag{6}$$

$$\left\{-P_B\right\}_i = -\left[K_{BB}\right]\left\{\delta_B\right\}_i - \left[K_{BA}\right]\left\{\delta_A\right\}_i + \left\{\overline{P}_B\right\} \tag{7}$$

Equation (6) is next solved for $\left\{\delta_A\right\}_i$ which is then substituted into Equation (7) for $\left\{-P_B\right\}_i$. Once convergence of the $\left\{\delta_B\right\}$ have been achieved, the tile stresses are computed from the hexahedron stress recovery equations (Ref. 4).

E. PRIMARY-STRUCTURE DEFLECTIONS

The original primary-structure deflections are computed on the basis of ignoring the tile stiffnesses. Thus, they are approximate and may require correction. To effect this, the tile boundary reactions, $\left\{-P_B\right\}_i$, are collected for all the tiles and applied to the primary-structure, to yield new primary structure deflections $\left\{\delta_{ps}\right\}$. The process is repeated until the convergence test:

$$\text{max elem}\left|\delta_{ps}\right|_{\text{present}} \cdot \boldsymbol{\varepsilon} \geq \text{max element of}\left|\left\{\delta_{ps}\right\}_{\text{present}} - \left\{\delta_{ps}\right\}_{\text{previous}}\right|$$

is satisfied, where $\boldsymbol{\varepsilon}$ is a small positive quantity specified by the program user. To obtain greater accuracy, a smaller value of $\boldsymbol{\varepsilon}$ should be specified; however, this would probably require more iterations and consequently greater computer time.

F. CONVERGENCE CONDITION

It is shown in Appendix A that the mathematical condition for absolute convergence of the present iteration procedure is that the maximum eigenvalue, λ_{max}, of the equation

$$\left[K_{ps}\right]^{-1}\left[K'_T\right]\left\{x_i\right\} = \lambda_i \left\{x_i\right\} \tag{8}$$

must be less than 1, where

$$\left[K'_T\right] \equiv \left[\overline{K}_{BB}\right] - \left[\overline{K}_{BA}\right]\left[\overline{K}_{AA}\right]^{-1}\left[\overline{K}_{AB}\right] \tag{9}$$

and the barred matrices are similar to the unbarred terms of Eq. (5), except that they pertain to the assembly of all tiles, rather than just a single tile, in contact with the primary structure.

G. DETERMINATION OF TILE THERMAL STRESSES

At any instant in time, each tile affixed to a given structural panel is assumed to have the same three dimensional transient temperature distribution. Thus, it is only necessary to input data for a single typical tile. Starting with any desired number of coordinates and corresponding temperature inputs, Lagrangian interpolation formulas may be used to compute the temperatures at arbitrary points within the tiles. Another temperature distribution option available to the program user is one in which each structural nodal temperature is specified.

To obtain finite element deflection solutions, a mechanically equivalent thermal loading vector is computed. In computing this vector, the assumption is made that the temperature is uniform within each element. The temperature selected for this calculation is the average of each element's 8 nodal temperatures.

While the uniform temperature assumption is usually adequate for computing thermal strains within an element, it is not sufficiently accurate for determining thermal stresses. The reason for this is that the thermal loading, from which deflections and strains are computed, is dependent upon integrated element temperatures. However, the element thermal stresses depend upon nonintegrated local temperatures. A rigorous proof of these statements may be found in Reference 5. As a result of this, the present program computes accurate tile thermal stresses using the local temperatures rather than the average element nodal temperatures.

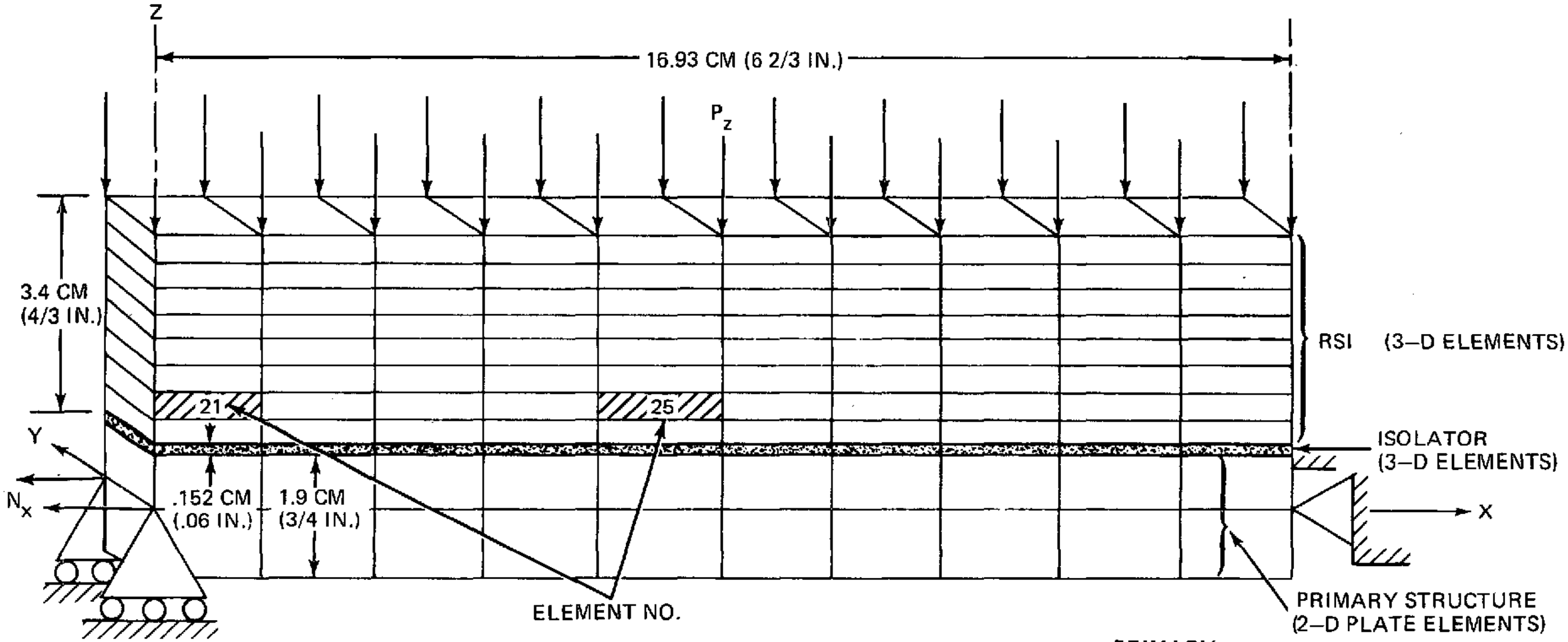
III. NUMERICAL RESULTS

To demonstrate the numerical convergence properties of the proposed iteration scheme, several examples were run. The material properties and loading conditions used, while not precise in a specific design sense, are representative of the problem parameters the method is intended to accommodate.

Figure 5 shows the configuration, finite element idealization, and material properties for an example with three separate load cases. The largest primary structure nodal deflections and average stress components for certain RSI elements are presented as a function of iteration number in Table 1. Although the stress levels appear quite low, it should be noted that the RSI material direct stress allowables are in the 30 psi range for the x, y directions and even lower for the z direction and shear allowables. Table 1 reveals a rapid convergence rate and a high level of accuracy for the initial approximation (in that the maximum error for the first iteration is less than 3% in all cases).

These observations are further strengthened by the more realistic shuttle tile example (Example 4) shown in Figure 6. This problem consists of a -170°F cold soak of three 6x6 inch tiles, each of which are 2 inches thick and have 1 x $\frac{1}{2}$ inch edge undercuts. The primary structure is a .041 inch aluminum plate with offset stringers spaced half an inch apart. Two opposite boundaries were held against out-of-plane deflection with the other two ends free. To permit free thermal contractions, in-plane plate motion was permitted.

The resulting direct stresses for the first and fourth iterations are plotted in Figure 7 for tiles 1 and 2. Because the differences were so slight, second and fourth iteration values for σ_x are listed in Table 2. Running time for this realistic type problem on an IBM 370 averaged 1 1/3 CPU minutes per tile plus a fixed time of 8 minutes. Thus, four iterations of the three tiled configuration required approximately 24 CPU minutes.



RSI MATERIAL PROPERTIES

E = 414 MN/M ^{2} (60 X 10^3 psi)
E′ = 41.4 MN/M ^{2} (6 X 10^3 psi)
G′ = 220 MN/M ^{2} (32 X 10^3 psi)
υ = .50
υ' = .01
α = .625 X 10^{-6}°C^{-1} (.347 X 10^{-6}°F^{-1})

ISOLATOR PROPERTIES

E = .620 MN/M ^{2} (90 psi)
υ = .49
α = 488 X 10^{-6}°C^{-1} (271 X 10^{-6}°F^{-1})

PRIMARY STRUCTURE PROPERTIES

E = 73 X 10^3 MN/M ^{2} (10.6 X 10^6 psi)
υ = .30
α = 23.58 X 10^{-6}°C^{-1} (13.1 X 10^{-6}°F^{-1})

Figure 5 Sample Problem Used to Demonstrate Numerical Convergence of Iteration Scheme

TABLE 1

CRITICAL DEFLECTIONS AND STRESSES

VS

ITERATION NUMBER

(REFER TO FIGURE 5)

EXAMPLE 1:	N_x = 40,125 lb/in, P_z = 0, ΔT = 0		
ITERATION NO.	Avg. σ_{xx}^* (psi) ELEM. NO. 25	Avg. σ_{xz} (psi) ELEM. NO. 21	PRIM. STRUCT. u(x = 0) x10^2in.
1	17.33	3.497	-3.566
2	17.51	3.503	-3.565
3	17.51	3.503	-3.565
4	17.51	3.503	-3.565

EXAMPLE 2:	P_z = 100 psi, N_x = 0, ΔT = 0		
ITERATION NO.	Avg. σ_{xx}^* (psi) ELEM. NO. 25	Avg. σ_{xz} (psi) ELEM. NO. 21	PRIM. STRUCT. w(x=3 1/3 in) x 10^3 in
1	38.62	-3.145	-7.222
2	37.90	-3.068	-7.017
3	37.90	-3.068	-7.022
4	37.90	-3.068	-7.022

EXAMPLE 3:	ΔT = -325°F, N_x = 0, P_z = 0		
ITERATION NO.	Avg. σ_{xx}^* (psi) ELEM. NO. 25	Avg. σ_{xz} (psi) ELEM. NO. 21	u(x=0) x 10^2 in.
1	-16.38	-3.935	2.838
2	-16.75	-3.889	2.837
3	-16.74	-3.891	2.837
4	-16.74	-3.890	2.837

*Direct stress allowables for the RSI material in the x and y direction are of the order of 30 psi.

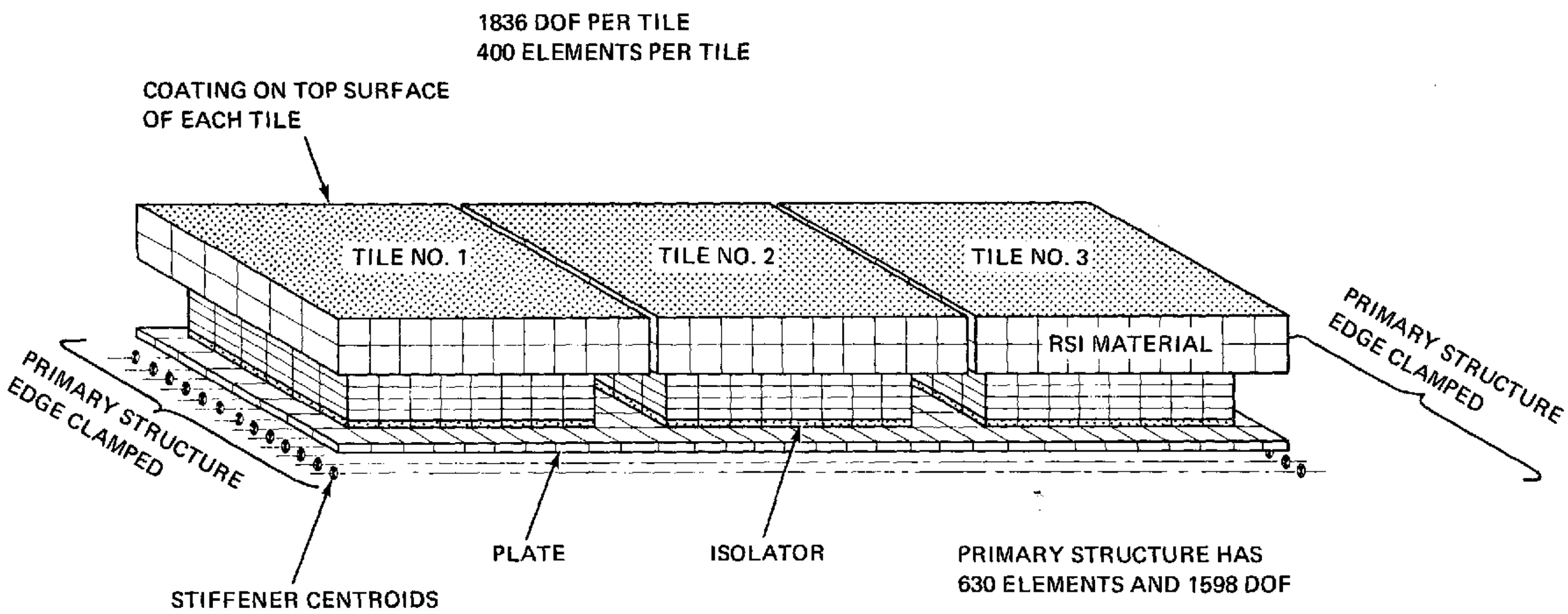


Figure 6 Example 4: Typical Configuration That Computer Program is Capable of Analyzing

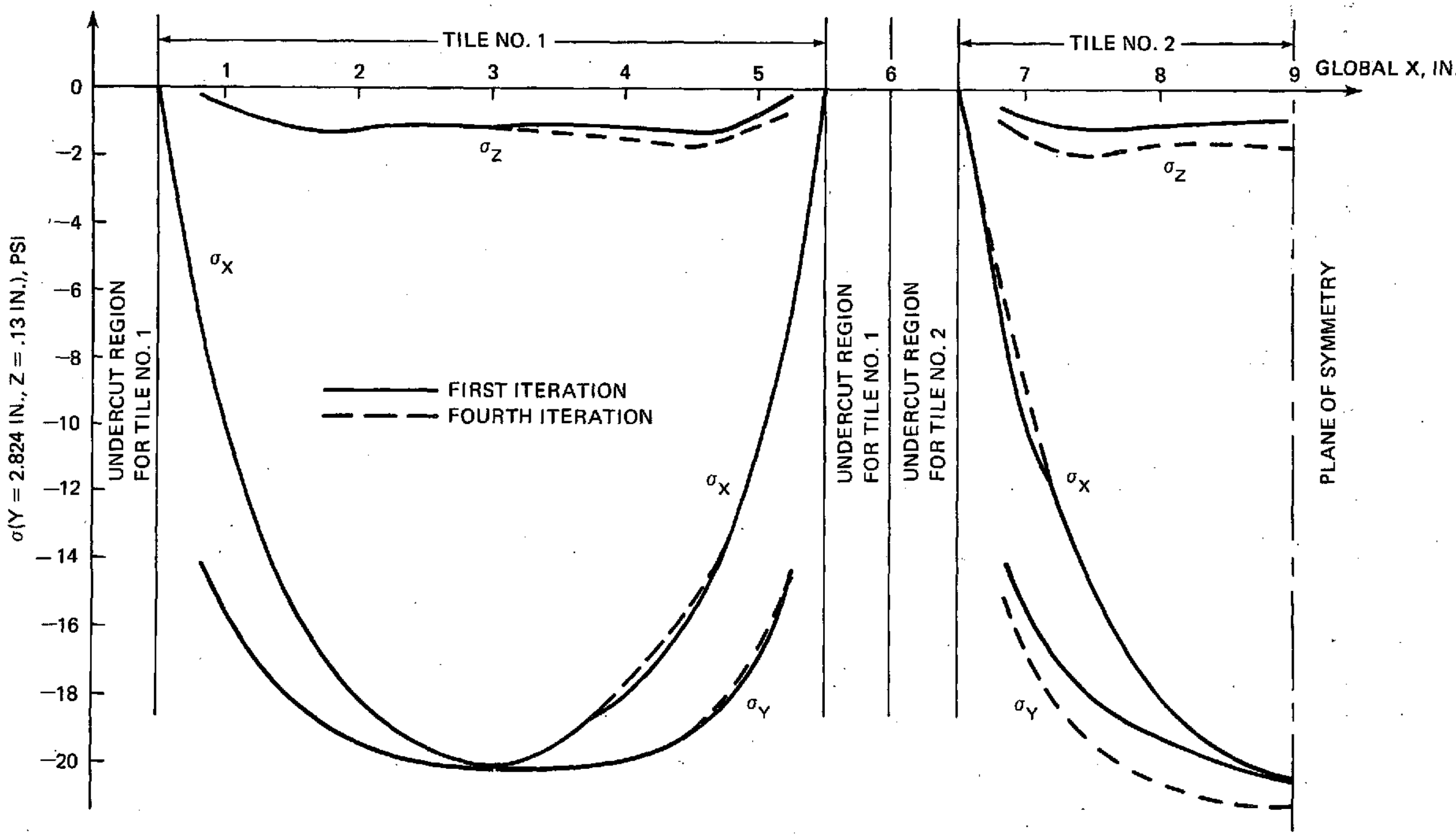


Figure 7 Example 4: Direct Stresses for Tiles 1 and 2 Caused by −170°F Cold Soak

TABLE 2

SOME VALUES OF σ_{xx} FOR ITERATIONS 1, 2, & 4 OF EXAMPLE 4 (Refer to Figs 6 and 7).

σ_{xx}(psi) for y = 2.82 in, z = .13 in.					
x or x - 6(in.)	First Iteration Tiles 1, 2, and 3	TILE NO. 1		TILE NO. 2	
		Second Iteration	Fourth Iteration	Second Iteration	Fourth Iteration
.50	0	0	0	0	0
.63	-7.3	-7.3	-7.3	-7.3	-7.4
.99	-8.0	-8.0	-8.0	-8.2	-8.2
1.26	-15.2	-15.3	-15.3	-15.6	-15.7
1.62	-14.6	-14.7	-14.7	-14.9	-15.0
1.88	-18.4	-18.6	-18.6	-19.0	-19.1
2.24	-18.1	-18.3	-18.3	-18.6	-18.7
2.51	-20.0	-20.1	-20.2	-20.6	-20.7
2.87	-19.8	-20.0	-20.1	-20.4	-20.5
3.13	-19.8	-20.0	-20.1	-20.4	-20.5
3.49	-19.9	-20.2	-20.3	-20.6	-20.7
3.76	-18.1	-18.3	-18.4	-18.6	-18.7
4.12	-18.4	-18.8	-18.8	-19.0	-19.1
4.38	-14.6	-14.8	-14.8	-14.9	-15.0
4.74	-15.2	-15.5	-15.5	-15.6	-15.6
5.01	-8.0	-8.1	-8.1	-8.2	-8.2
5.37	-7.3	-7.3	-7.3	-7.4	-7.4
5.50	0	0	0	0	0

IV.

CONCLUSIONS AND RECOMMENDATIONS

An efficient iterative procedure for the static mechanical and thermal stress analysis of RSI multi-tiled shuttle panels has been developed. The method, which is quite general, is rapidly convergent and highly useful for this application. Conditions under which the general technique will converge absolutely have also been presented.

A user-oriented computer program based upon this procedure and titled RESIST has been prepared and successfully tested. RESIST, which uses finite element methods, obtains three dimensional tile stresses in the isolator, arrestor (if any), and RSI materials. Two-dimensional stresses are obtained in the tile coating and the stringer-stiffened primary-structure plate. A special feature of the program is that all the usual detailed finite element grid data is generated internally from a minimum of input data.

The program may be used in an iterative mode to obtain detailed results, or, becuase of the extremely accurate results obtained from the first iterate, as a design tool for parametric studies. This is achieved by having the program analyze certain specific tiles of a multi-tiled panel only once while ignoring less critically stressed tiles.

At present the program can accommodate tile idealizations with up to 850 nodes (2,550 degrees-of-freedom) and primary structure idealizations with a maximum of 15,000 degrees-of-freedom. In addition, the tile pattern must begin and end at a structural frame and the isolator material must be isotropic. Should such restrictions, or any similar ones, require alteration as the shuttle TPS design changes, it would appear logical to update RESIST.

V.

NOMENCLATURE

E	Modulus of elasticity
E'	Modulus of elasticity in thickness (z) direction
G	Shear modulus
G'	Shear modulus for thickness shear (xz and yz) directions
ν	Poisson's ratio
ν'	Poisson's ratio for thickness (z) direction
N_X	Primary structure membrane stretching load
P_Z	Normal pressure upon RSI tiles
ΔT	Uniform change in structural temperature from reference temperature
t_c	Thickness of coating
t_p	Plate thickness
u	Deflection in x direction
x, y, z	Global coordinates
x', y', z'	Local coordinates
α	Coefficient of thermal expansion
σ_{xx}	Direct stress in x direction
σ_{xz}	Shear stress

$[K_{ps}]$	Primary structure stiffness matrix
$[K_T]$	Tile stiffness matrix
$[K_T']$	Defined by Eq. 9
$[K_{AA}]$,$[K_{AB}]$, $[K_{BA}]$, $[K_{BB}]$	Matrix partitions of $[K_T]$
$[\Lambda]$	Diagonal eigenvalue matrix of $[K_{ps}]^{-1}\ [K_T']$
$\{P_A\}$	Mechanical tile loading associated with degrees of freedom which are not in contact with the primary structure
$\{P_A\}$	Mechanical equivalent of thermal loading associated with degrees of freedom which are not in contact with the primary structure
$\{P_B\}_i$	Mechanical tile/primary-structure interface loading acting upon i^{th} tile
$\{-P_B\}$	Reaction of all tiles acting upon primary structure
$\{x_i\}$	Eigenvector associated with λ_i
$\{\delta_{ps}\}$	Primary structure deflections
$\{\delta_A\}_i$	Node deflections associated with degrees of freedom of i^{th} tile not in contact with primary structure
$\{\delta_B\}_i$	Deflections of i^{th}tile at node points which are in common with primary structure
ϵ	Primary structure deflections convergence parameter
λ_i	Element of diagonal matrix $[\Lambda]$
$(\ )^{(j)}$	Superscript indicates the j^{th} iteration
$[\overline{\ \ }]$	Similar to unbarred matrix except that it applies to the assembly of <u>all</u> tiles

VI.

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APPENDIX A

CONVERGENCE CONDITION PROOF

In Section II.F it was stated that the condition for convergence of the present iteration procedure is that the maximum eigenvalue, λ_{max}, of the equation

$$\left[K_{ps}\right]^{-1}\left[K'_T\right]\{x_i\} = \lambda_i \{x_i\} \tag{A.1}$$

must be less than 1, where

$$\left[K'_T\right] \equiv \left[\overline{K}_{BB}\right] - \left[\overline{K}_{BA}\right]\left[\overline{K}_{AA}\right]^{-1}\left[\overline{K}_{AB}\right] \tag{A.2}$$

and the barred matrices are similar to the unbarred terms of Eq. (5), Section II.D, except that they pertain to the assembly of all tiles rather than just a single tile, in contact with the primary structure. The proof of this statement proceeds as follows:

The load-deflection relation for all tiles is

$$\begin{bmatrix} \overline{K}_{BB} & \overline{K}_{BA} \\ \overline{K}_{AB} & \overline{K}_{AA} \end{bmatrix} \begin{Bmatrix} \delta_B^{(j)} \\ \delta_A^{(j)} \end{Bmatrix} = \begin{Bmatrix} P_B^{(j)} + \overline{P}_B \\ P_A^{(j)} + \overline{P}_A \end{Bmatrix} \tag{A.3}$$

where the superscript j indicates that the equation is being applied for the j^{th} iteration. If $\{\delta_A^{(j)}\}$ is eliminated from Eq. (A.3), the following relationship for the interface load $\{P_B^{(j)}\}$ is obtained:

$$\{P_B^{(j)}\} = [K'_T]\{\delta_B^{(j)}\} + \{P'\} \tag{A.4}$$

where $[K'_T]$ is given by Eq. (9) and

$$\{P'\} \equiv [\overline{K}_{BA}][\overline{K}_{AA}]^{-1}\{P_A + \overline{P}_A\} - \{\overline{P}_B\} \tag{A.5}$$

The load-deflection relation for the primary structure is

$$\left\{ \delta_B^{(j+1)} \right\} = - \left[K_{ps} \right]^{-1} \left\{ P_B^{(j)} \right\} \tag{A.6}$$

The general solution procedure discussed in Section II.B is accomplished by repetitive application of Eqs. (A.4) and (A.5). An equivalent recursion relation is obtained by substituting Eq. (A.4) into Eq. (A.5); viz,

$$\left\{ \delta_B^{(j+1)} \right\} = - [K_{ps}]^{-1} [K'_T] \left\{ \delta_B^{(j)} \right\} - [K_{ps}]^{-1} \{P'\} \tag{A.7}$$

Since Eqs (A.4) and (A.5) are satisfied simultaneously by the exact solution, $\{\delta_B\}$ (i.e., for $\left\{ \delta_B^{(j)} \right\} = \left\{ \delta_B^{(j+1)} \right\} = \{\delta_B\}$), Eq. (A.7) is identically satisfied by this solution. Thus,

$$\{\delta_B\} = - [K_{ps}]^{-1} [K'_T] \{\delta_B\} - [K_{ps}]^{-1} \{P'\} \tag{A.8}$$

To determine how an error in the j^{th} iteration will propagate, $\{\delta_B^{(j)}\}$ is written as follows:

$$\left\{ \delta_B^{(j)} \right\} = \{\delta_B\} + \{\epsilon^{(j)}\} \tag{A.9}$$

where the error $\{\epsilon^{(j)}\}$ is simply defined as the difference between the j^{th} iteration and the exact solution. Substitution of Eq (A.9) into (A.7), and successive application of Eq. (A.7), using Eq. (A.8), yields

$$\left\{ \delta_B^{(j+n)} \right\} = \{\delta_B\} + (-1)^n \left([K_{ps}]^{-1} [K'_T] \right)^n \{\epsilon^{(j)}\} \tag{A.10}$$

Next, $[K_{ps}]^{-1} [K'_T]$ is expressed in terms of its eigenvector matrix $[X]$ with rows $\{x_i\}$ and its eigenvalue matrix $[\Lambda]$ (which has the eigenvalues λ_i on the diagonal)

$$[K_{ps}]^{-1} [K'_T] = [X] [\Lambda] [X]^{-1} \tag{A.11}$$

Since

$$\left([K_{ps}]^{-1}\,[K'_T\,]\right)^n = [X]\,[\Lambda]^n\,[X]^{-1} \tag{A.12}$$

and the eigenvalues of a positive-definite or semidefinite matrix must be non-negative, Eq. (A.10) shows that the iteration procedure will be convergent for all errors $\{\varepsilon\}$ if and only if all eigenvalues of $[K_{ps}]^{-1}\,[K'_T]$ are less than unity.

To obtain some physical insight into this convergence criterion, assume that deflections corresponding to any eigenvector, $\{x_i\}$, are applied to the tiles of the primary structure interface points and that these are the only points that are loaded. Eq. (A.4) shows that the load on the tiles is $[K'_T]\,\{x_i\}$. Next, suppose that an equal and opposite load is applied to the primary structure. Eq. (A.6) shows that the resulting deflection is

$$[K_{ps}]^{-1}\,[K'_T]\,\{x_i\} = \lambda_i\,\{x_i\} \tag{A.13}$$

Thus, the primary-structure deflection is λ_i times the imposed tile deflection $\{x_i\}$. Consequently, if $0 \le \lambda_i < 1$, the tiles may be considered to be more flexible than the primary structure in the i^{th} mode. Since the convergence criterion requires that $\lambda_{i\ max} < 1$, the procedure will be convergent when the tile-system is more "flexible", so to speak, with respect to the lower boundary, than the primary structure.

APPENDIX B

USER'S MANUAL FOR

RE*S*I*ST

(STATIC AND DYNAMIC REUSABLE SURFACE INSULATION STRESS PROGRAM)

A. INTRODUCTION

This Appendix describes the use of a finite element based structural computer program for determining the static response and natural vibrations of TPS protected shuttle panels. The program is titled "RESIST" for static and dynamic REusable Surface Insulation Stresses. The logic flor for RESIST is presented in Figure B-1.

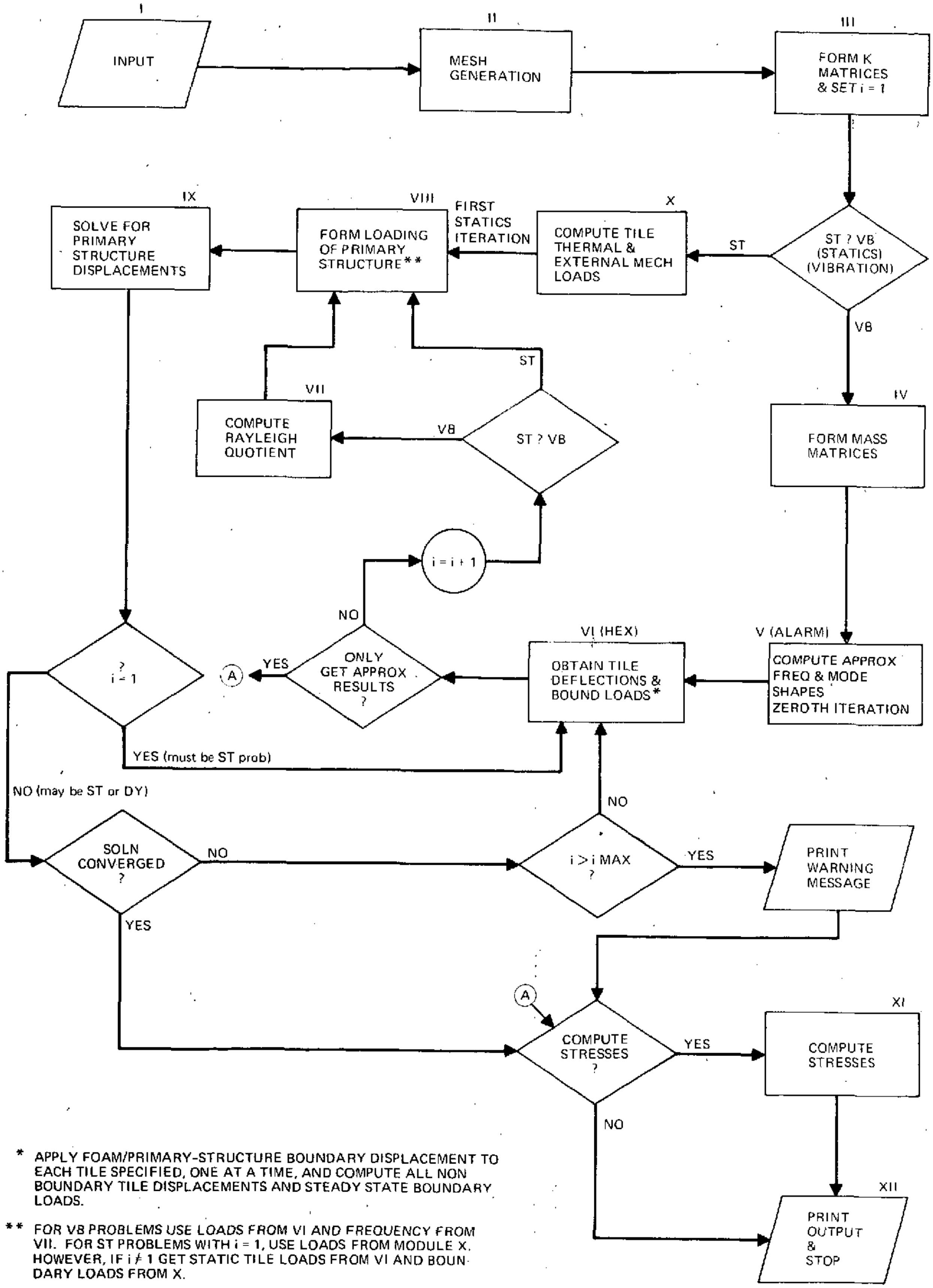
The basis for the method is that the TPS is nonstructural but its stress levels, which are critical, must be computed. Thus, it becomes possible to neglect the stiffness of the TPS initially, but not its mass in the vibration, to determine approximate primary structure deflections.

An iterative procedure is then performed where, for each step, the primary structure deflections are imposed individually upon each tile at the tile/primary-structure interface, and the tile deflections and interface boundary loads are obtained. For the vibration option, the frequency is updated by computing a Rayleigh Quotient, using the latest non-rigid tile displacements in addition to the corresponding primary structure displacements. The individual tile boundary loads obtained are then assembled and their reactions are applied to the primary structure. New Primary structure deflections are obtained and compared to the previous set. This process is repeated until convergence is obtained.

B. PROGRAM LIMITATIONS

The usual assumptions for programs based upon the linear elastic finite element method are applicable to RESIST. However, to facilitate the preparation of program input, a number of simplifications regarding the configuration and loadings have been made. Thus, the generation of a voluminous quantity of finite element input data has been greatly reduced by inclusion of a series of data preprocessing subroutines within RESIST. The restrictions upon which these subroutines are based follows:

1. Boundary conditions and edge loadings are assumed uniform along the four rectangular plate edges defined by $x = 0$, L_x and $y = 0$, L_y.
2. The primary structure plate temperature and properties are all uniform.



* APPLY FOAM/PRIMARY-STRUCTURE BOUNDARY DISPLACEMENT TO EACH TILE SPECIFIED, ONE AT A TIME, AND COMPUTE ALL NON BOUNDARY TILE DISPLACEMENTS AND STEADY STATE BOUNDARY LOADS.

** FOR VB PROBLEMS USE LOADS FROM VI AND FREQUENCY FROM VII. FOR ST PROBLEMS WITH i = 1, USE LOADS FROM MODULE X. HOWEVER, IF i ≠ 1 GET STATIC TILE LOADS FROM VI AND BOUNDARY LOADS FROM X.

Figure B-1 Flow Chart for RSI Stress Analysis Program "Resist"

3. The stringers are equally spaced with temperatures and properties which are all uniform.

4. All tiles are geometrically identical as are their temperature distributions and uniform pressure loadings.

5. The boundary conditions must be selected such that the primary structure is statically stable.

The remaining limitations are primarily concerned with the program's capacity and should be adhered to by the user. These limitations are as follows:

6. Maximum number of nodes in a tile = 850.

7. Maximum number of finite elements running in any one direction in a tile = 20.

8. Maximum number of nodes in primary structure = 2500.

9. Maximum number of primary structure nodes along x or y direction = 1,000.

10. Maximum number of degrees of freedom in primary structure

$$= \begin{cases} 10{,}000 \text{ for vibration option.} \\ 15{,}000 \text{ for statics option.} \end{cases}$$

11. Maximum number of natural mode shapes = 50.

12. Maximum number of stringers = 15.

13. To avoid a singular stiffness matrix, I_z, and $\sin \beta$ must not both be zero for a given stringer.

A violation of restrictions 6-13, inclusive, will cause the program to stop and an appropriate warning message to appear.

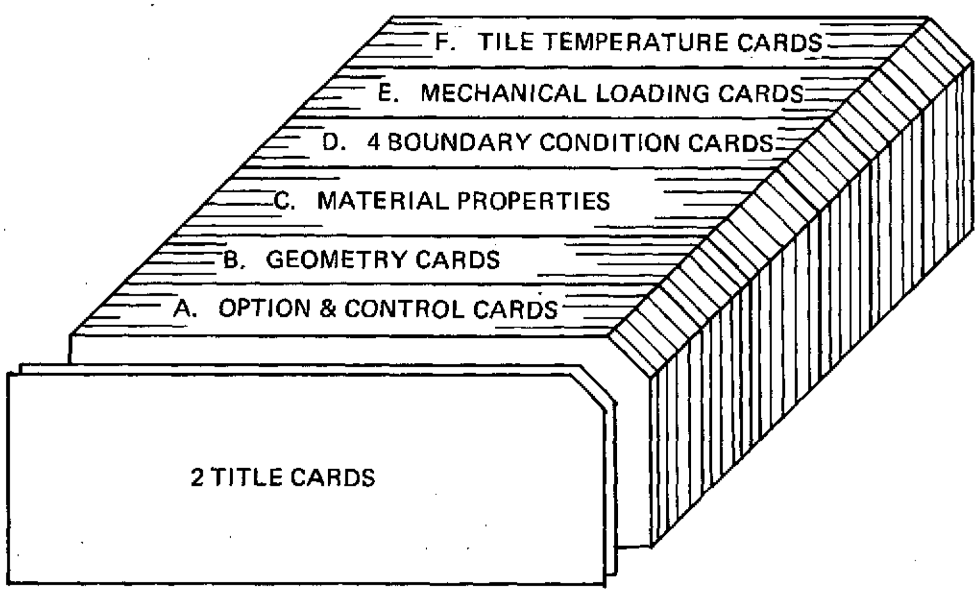
To insure symmetry of solutions for panels which are symmetric with regard to stringer locations about $y = L_y/2$, care should be taken wtih the input data to see that the plate nodes associated with the stringers are symmetric about $y = L_y/2$. Thus, the number of primary structure finite elements in the y direction should not be odd if the number of panel stringers is even.

C. INPUT INSTRUCTIONS

A description of the card input for the IBM 370 and CDC 6600 versions of this program is presented in this section.

In addition to the first two input cards which contain literal data, such as special program title and date, in columns 1 through 80, inclusive; there are six groups of input cards containing the following information:

- Group A - Instructions regarding the type of problem being performed, number of iteratious desired, and type of output information.
- Group B - Details of the geometric configuration and finite element mesh of the primary structure and tiles. (Card B.4 is omitted if there are no tiles)
- Group C - Defines the primary structure and RSI temperature dependent material properties. If there is no TPS, cards C.3 through C.11 are omitted.
- Group D - Specifies the primary structure boundary conditions
- Group E - Describes the mechanical loading upon the primary structure as well as its temperature. These cards are omitted when the vibration option is used
- Group F - Defines the RSI temperature distribution. These cards are omitted if there is no TPS.



A. PROGRAM OPTIONS AND CONTROL – Sheet 1 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
A.1	1-5	I5	-	-	1 in col. 5 denotes that a statics problem is being treated. Skip cols. 6-25 in such cases 2 in col. 5 denotes that a natural vibration problem is being treated.
	6-10	I5	N_D	-	Number of desired mode shapes (50 is the maximum permitted).
	16-20	I5	$\bar{s}$	-	Number of reorthogonalizations for eigenvalue algorithm. A min of 2 and a max. of 5 is suggested with 3 as an adequate compromise for most problems. The run should be repeated with greater values for $\bar{s}$ or N_D if the frequency error bound of a desired mode is greater than 1%.
	21-25	I5	-	-	Vibration mode number for which tile modes are desired.
	26-30	I5	i_{max}	-	Maximum number of iterations
	31-40	E10.0	ϵ	{in. or rad.	Convergence parameter. Maximum primary structure deflection or rotation difference between iterations divided by magnitude of largest element.
	46-50	I5	-	-	0 in col. 50 indicates that primary structure stresses and strains are not required. 1 in col. 50 indicates that only midplate strains and stresses of primary structure are required. 2 in col. 50 indicates that only top of plate strains and stresses of primary structure are required. 3 in col. 50 indicates that only bottom of plate strains and stresses of primary structure are required. 4 in col. 50 indicates that only mid and top of plate strains and stresses of primary structure are required. 5 in col. 50 indicates that only mid and bottom of plate strains and stresses of primary structure are required. 6 in col. 50 indicates that only top and bottom of plate strains and stresses of primary structure are required. 7 in col. 50 indicates that top, bottom, and mid plate strains and stresses of primary structure are required.
	51-60	E10.0	–	lb-in-sec^2	Overhung rotatory mass inertia associated with each stringer. Used if plate overhange x = 0 and x = L_x boundaries.

A. PROGRAM OPTIONS AND CONTROL – Sheet 2 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
A.2	1-5	I5	-	-	0 in col. 5 indicates that tile stresses are not required. 1 in col. 5 indicates that tile stresses are to be computed after each iteration is performed. 2 in col. 5 indicates that tile stresses are to be computed only after last iteration is performed or only after convergence is obtained.
	6-10	I5	-	-	0 in col. 10 if primary structure stresses and strains were not requested in column 50 of Card A.1. 1 in col. 10 indicates that primary structure stresses and strains are required after each iteration. 2 in col. 10 indicates that primary structure stresses and strains are required only after last iteration or, only after convergence.
	11-15	I5	-	-	0 in col. 15 indicates no tiles on the primary structure. Skip card A.3* 1 in col. 15 indicates that there are tiles on the primary structure.
	16-20	I5	-	-	1 in col. 20 indicates tile node map printout desired. 0 = no node map printout.
	21-25	I5	-	-	1 in col. 25 indicates tile element map printout desired. 0 = no element map printout.
	26-30	I5	-	-	1 in col. 30 indicates tile nodal coordinate, temp. and nodes per element printout. 0 in col. 30 indicates suppression of this printout.
	31-35	I5	-	-	1 in col. 35 indicates printout of element stiffness matrices. 0 = no element stiffness matrices.
	36-40	I5	-	-	1 in col. 40 indicates printout of assembled stiffness matrices and ALARM reorthog. info. 0 in col. 40 indicates suppression of this printout.
	41-45	I5	-	-	1 in col. 45 indicates printout of unit no., file no., and matrix storage info. for program debugging. 0 in col. 45 indicates suppression of this printout.
A.3	1-4, 5-8, 9-12, etc.	I4 I4 I4	- - -	- - -	This card is used to indicate which tile stress states are desired. User may specifically request up to 20 tile stress states (see Figure A.2 for tile numbering scheme). A zero in col. 4 indicates that stress states for all tiles are desired.

* If there are no tiles then $\overline{n}_x$ and $\overline{n}_y$, together with n_{B2} and n_{D2}, are still required since they determine the primary structure finite element grid. In analyzing panels without tiles, leave out cards B.4, C.3 through C.10 and all "F" cards.

B. GEOMETRIC CONFIGURATION – Sheet 1 of 2 (See Figure B-2)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
B.1	1-10	2E10.0	L_x	inches	Panel dimension
	11-20		L_y	inches	Panel dimension
	21-30		t_p	inches	Panel thickness
B.2	1-10	8E10.0	Y_1	inches	Position of first stringer centroid. If there are no stringers, set $Y_1 > L_y$ and skip to next card.
	11-20		Z_s	inches	Distance of stringer centroid below plate middle surface
	21-30		Y_s	inches	Discrete stiffener spacing
	31-40		A_s	$in.^2$	Stringer cross sectional area
	41-50		$I_{y'}$	$in.^4$	Stiffener principal mom. of inertia about y' axis
	51-60		$I_{z'}$	$in.^4$	Stiffener principal mom. of inertia about z' axis
	61-70		$J_{x'}$	$in.^4$	Stiffener twisting stiffness geometric parameter
	71-80		β_s	Degrees	Angle between z and z' axis measured positive clockwise along x
B.3	1-10	I10	$\bar{n}_x$	-	Integer number of tiles between x = 0 and L_x*
	11-20	I10	$\bar{n}_y$	-	Integer number of tiles between y = 0 and L_y*

* If there are no tiles then $\bar{n}_x$ and $\bar{n}_y$, together with n_{B2} and n_{D2}, are still required since they determine the primary structure finite element grid. In analyzing panels without tiles, leave out cards B.4, C.3 through C.10 and all "F" cards.

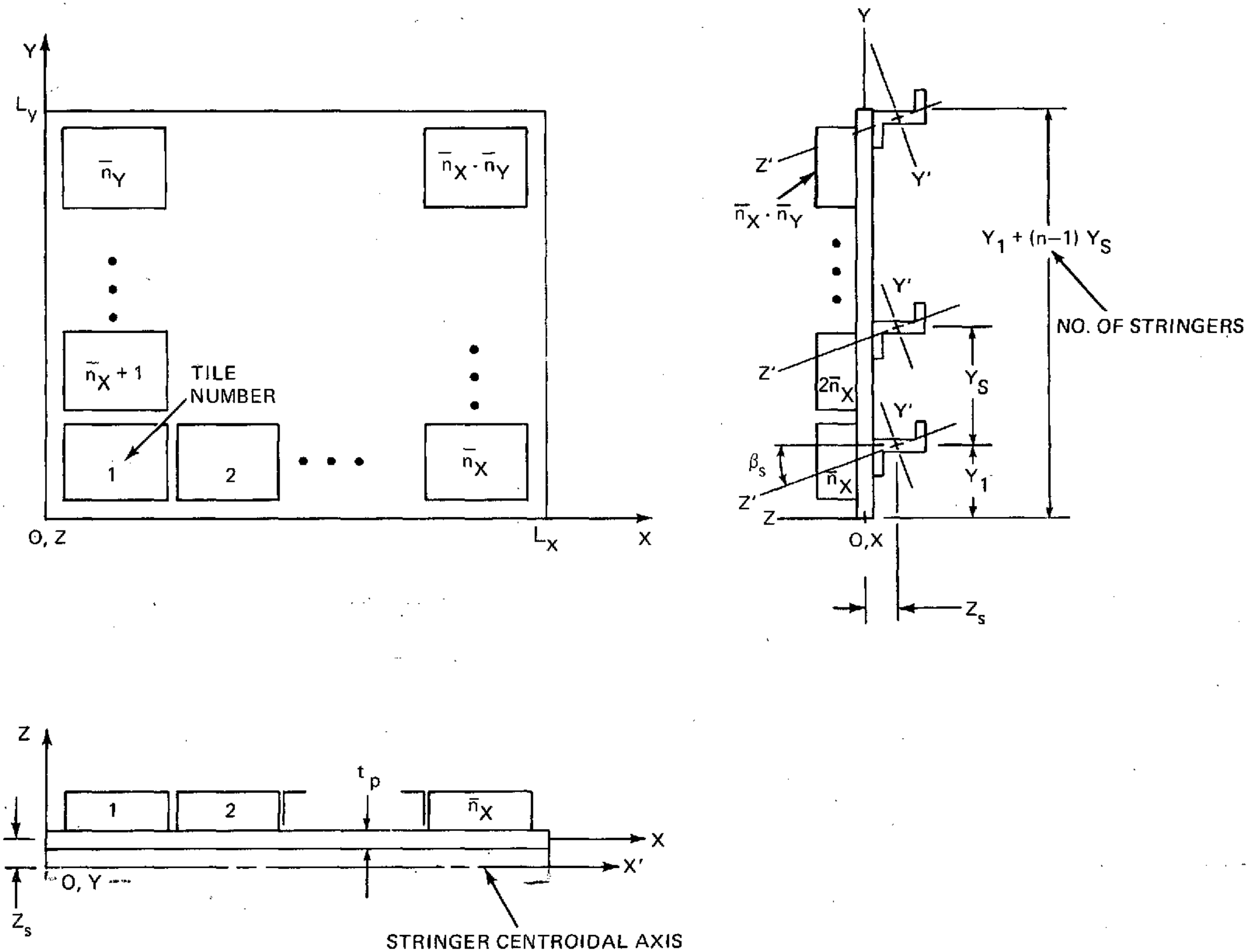
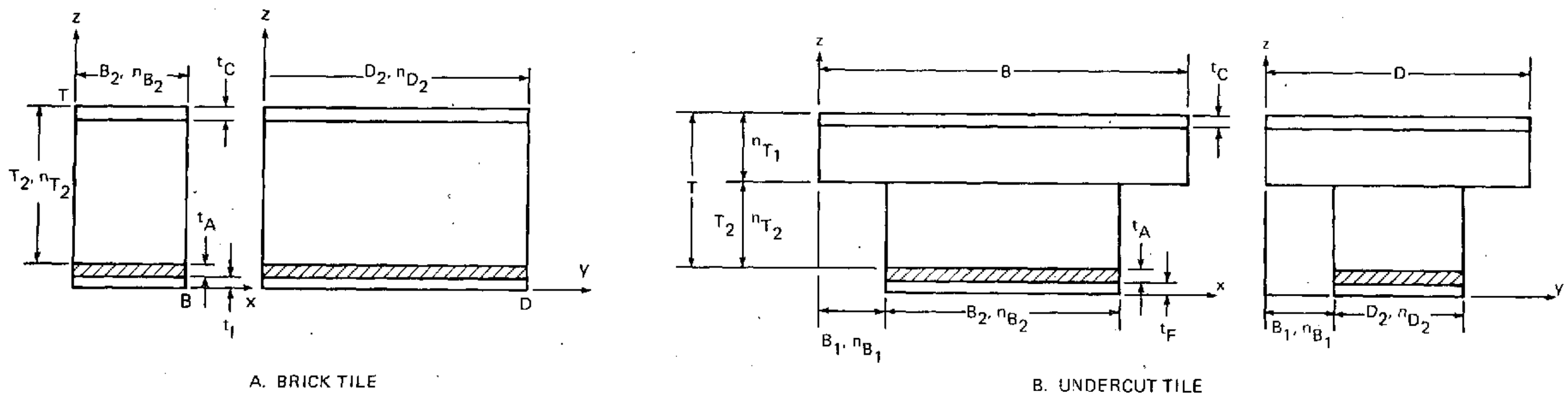


Figure B-2 TPS Configuration on Stiffened Primary Structure

B. GEOMETRIC CONFIGURATION – Sheet 2 of 2 (See Figure B-3)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
B.4	1-10	6E10.0	T	inches	Undercut RSI tile thickness. Leave blank if tile is brick shaped or if there are no tiles.
	11-20	↓	B_1	inches	Tile undercut dimension. Leave blank if tile is brick shaped.
	21-30	↓	T_2	inches	Tile undercut dimension or, height of brick shaped tile.
	31-40	↓	t_A	inches	Strain arrestor plate (SAP) thickness. May replace with layer of isolator, RSI or bond material if no SAP.
	41-50	↓	t_I	inches	Strain isolator thickness (SIP)
	51-60	↓	t_c	inches	Coating thickness. Leave blank if no tile coating.
B.5	1-5	I5	n_{B_1}	-	Number of elements along B_1. Leave blank if tile is brick shaped or if there are no tiles.
	6-10	↓	n_{B_2}	-	Number of elements along B_2.
	11-15	↓	n_{D_2}	-	Number of elements along D_2.
	16-20	↓	n_{T_1}	-	Number of elements along T-T_2. Leave blank if tile is brick shaped.
	21-25	↓	n_{T_2}	-	Number of elements along T_2.



NOTE: SUBSCRIPTED SYMBOLS BEGINNING WITH "n" ARE THE NUMBER OF ELEMENTS WHICH SUBDIVIDE THE INDICATED SPAN. THE OTHER SYMBOLS ARE DIMENSIONS.

Figure B-3 RSI Tile Parameters

C. MATERIAL PROPERTIES — Sheet 1 of 2 (See Figure B-4)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
C.1	1-10	4E10.0	E_p	psi	Isotropic plate modulus of elasticity
	11-20		ν_p	-	Poisson's ratio for plate
	21-30		γ_p	lb/in^3	Weight density for plate
	31-40		α_p	$^\circ F^{-1}$	Coefficient of thermal expansion for plate
C.2	1-10	4E10.0	E_s	psi	Stringer modulus of elasticity (enter zero if no stringers)
	11-20		ν_s	-	Poisson's ratio for stringer
	21-30		γ_s	lb/in^3	Weight density for stringer
	31-40		α_s	$^\circ F^{-1}$	Coefficient of thermal expansion for stringer
C.3	1-10	6E10.0	E_x	psi	Arrestor x direction orthotropic stiffness
	11-20		E_y	psi	Arrestor y direction orthotropic stiffness
	21-30		E_z	psi	Arrestor z direction orthotropic stiffness
	31-40		ν_{xy}	-	See Figure A.4
	41-50		ν_{yz}	-	See Figure A.4
	51-60		ν_{zx}	-	See Figure A.4
C.4	1-10	7E10.0	G_{xy}	psi	See Figure A.4
	11-20		G_{yz}	psi	See Figure A.4
	21-30		G_{zx}	psi	See Figure A.4
	31-40		γ_A	lb/in^3	Weight density for arrestor
	41-50		α_{AX}	$^\circ F^{-1}$	X coefficient of thermal expansion for arrestor
	51-60		α_{AY}	$^\circ F^{-1}$	Y coefficient of thermal expansion for arrestor
	61-70		α_{AZ}	$^\circ F^{-1}$	Z coefficient of thermal expansion for arrestor

$$
\begin{Bmatrix} \epsilon_x \\ \epsilon_y \\ \epsilon_z \\ \gamma_{xy} \\ \gamma_{yz} \\ \gamma_{zx} \end{Bmatrix}
=
\left[
\begin{array}{ccc|ccc}
\frac{1}{E_x} & -\frac{\nu_{xy}}{E_y} & -\frac{\nu_{xz}}{E_z} & & & \\
-\frac{\nu_{yx}}{E_x} & \frac{1}{E_y} & -\frac{\nu_{yz}}{E_z} & & \text{NULL} & \\
-\frac{\nu_{zx}}{E_x} & -\frac{\nu_{zy}}{E_y} & \frac{1}{E_z} & & & \\
\hline
& & & \frac{1}{G_{xy}} & 0 & 0 \\
& \text{NULL} & & 0 & \frac{1}{G_{yz}} & 0 \\
& & & 0 & 0 & \frac{1}{G_{zx}}
\end{array}
\right]
\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \sigma_z \\ \sigma_{xy} \\ \sigma_{yz} \\ \sigma_{zx} \end{Bmatrix}
$$

NOTE: This matrix is symmetric; thus, the program insures that

$$\frac{\nu_{xy}}{E_y} = \frac{\nu_{yx}}{E_x}$$

$$\frac{\nu_{xz}}{E_z} = \frac{\nu_{zx}}{E_x}$$

$$\frac{\nu_{zy}}{E_y} = \frac{\nu_{yz}}{E_z}$$

Figure B-4 Orthotropic Stress-Strain Law for 3-Dimensional Elements

C. MATERIAL PROPERTIES — Sheet 2 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS		UNITS
C.5	1-10	4E10.0	E_I	psi	Isolator modulus of elasticity
	11-20	↓	ν_I	-	Poisson's ratio for isolator (Note:max ν_I=.499)
	21-30	↓	γ_I	lb/in^3	Weight density for isolator
	31-40	↓	α_I	$^oF^{-1}$	Coefficient of thermal expansion for isolator
C.6	1-10	E10.0	γ_R	lb/in^3	Weight density of RSI material
	11-20	E10.0	α_y/α_x	-	RSI coefficient of thermal expansion in y direction (^oF $^{-1}$) divided by coefficient of thermal expansion in x direction (α_x)
	21-30	E10.0	α_z/α_x	-	RSI coeffient of thermal expansion ratio in z vs. x direction

C. TEMPERATURE DEPENDENT MATERIAL PROPERTIES Sheet 1 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
C.7.1	1-5	I5	-	-	Number of entry sets in the following table of E_R vs. temperature (°F)
C.8.1	1-10	E10.0	T_1	°F	Temperature (absolute, not relative) corresponding to following value of E_R
	11-20	E10.0	$E_R(T_1)$	psi	Value of E_R (RSI modulus - refer to equations below*) associated with previous temp.
	31-30 etc.	E10.0 etc.	T_2 etc.	°F etc.	Repeat above set of data as often as necessary, 4 sets to a card.
					Program uses closest 3 data pts. for 2nd order Langrangian interpolation of properties if element temp. is within data specified temp. range and at least 3 data-points are input. Program uses closest data-point properties for element temp. outside range. Uniform property value is used for any given property if only one value of that property is specified. Thus, program requires a minimum of 1 or 3 value(s) per property for proper execution.

C. TEMPERATURE DEPENDENT MATERIAL PROPERTIES — Sheet 2 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
C.7.2 & C.8.2					Repeat above two card sets for E'_R *
C.7.3 & C.8.3 through C.7.6 & C.8.6					Repeat above card sets for remaining RSI properties in following order: G'_R, ν_R, ν'_R,* and α_x* where α_x = RSI coefficient of thermal expansion in x direction.
C.9.1 & C.10.1 through C.9.3 & C.10.3					Repeat above card sets for coating properties in following order: E_c, ν_c, α_c

* For RSI
(refer to Figure B-4)

$$E_x = E_y = E_R \qquad G_{xy} = G_{yx} = \frac{E_R}{2(1 + \nu_R)}$$

$$E_z = E'_R \qquad G_{yz} = G_{zy} = G_{zx} = G_{xz} = G'_R$$

$$\nu_{xy} = \nu_{yx} = \nu_R \qquad \nu_{xz} = \nu_{yz} = \nu'_R$$

$$\nu_{zx} = \nu_{zy} = \frac{E_R}{E'_R} \nu'_R$$

D. BOUNDARY CONDITIONS — Sheet 2 of 3 (See Figure B-5)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
D.1–D-4, (continued)	31	A1	-	-	0 denotes edge is <u>not held</u> from <u>in-plane</u> deflections 1 denotes edge is <u>held</u> from <u>in-plane</u> deflections 2 denotes edge is not held for y deflection, but is held for x deflection (PARTIALLY HELD) 4 denotes edge is not held for x deflection, but is held for y deflection (PARTIALLY HELD) 3 denotes edge is <u>flexibly held</u> for <u>in-plane</u> deflections NOTE: For non-vibratory heated or cooled primary structure problems, refer to special instructions on bottom of page
	32-40	E9.0	K_{uu}	lb/in^2	In-plane x force per unit length on an edge caused by in-plane x direction unit deflection
	41-49	↓	K_{uv} or K_{vu}	lb/in^2	In-plane x force per unit length on an edge caused by in-plane y direction unit deflection or In-plane y force per unit length on an edge caused by in-plane x direction unit deflection
	50-58	↓	K_{vv}	lb/in^2	In-plane y force per unit length on an edge caused by in-plane y direction unit deflection

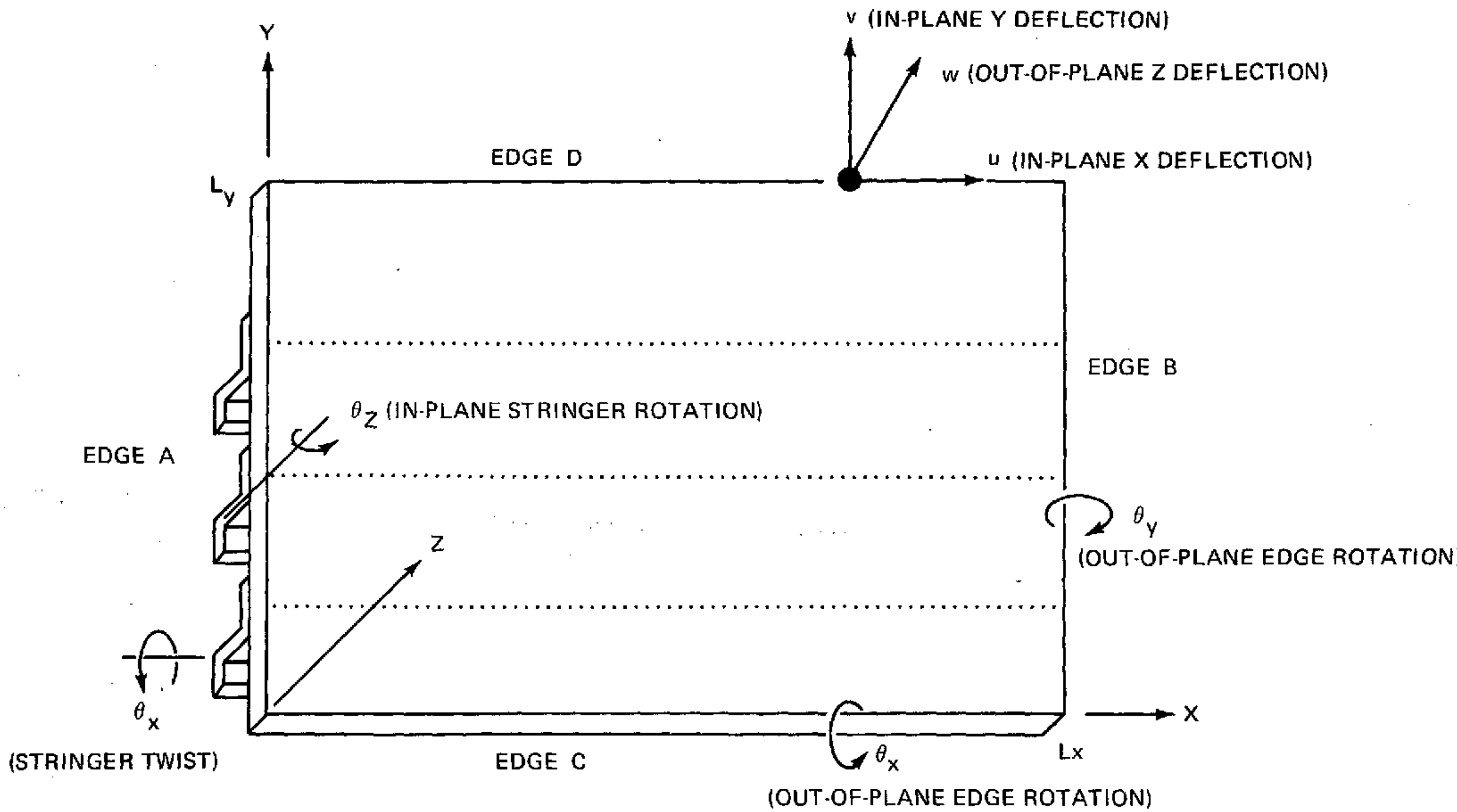


Figure B-5 Primary Stucture Boundary Condition Notation

D. BOUNDARY CONDITIONS – Sheet 1 of 3 (See Figure B-5)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
D.1, D.2, D.3, D.4	1	A1	-	-	A denotes the x=0 edge of the plate (CARD D.1)
					B denotes the $x=L_x$ edge of the plate (CARD D.2)
These are four similar boundary condition cards					C denotes the y=0 edge of the plate (CARD D.3)
					D denotes the $y=L_y$ edge of the plate (CARD D.4)
	2	A1	-	-	0 indicates that the plate edge is free to deflect and rotate out of the z=0 plane (FREE)
					1 indicates that the plate edge is not free to deflect or rotate out of the z=0 plane (CLAMPED)
					2 indicates that the plate edge is not free to deflect but is free to rotate out of the z=0 plane (PINNED)
					3 indicates that the plate edge is flexibly held with regard to out of plane motion
	3-11	E9.0	K_{ww}	lb/in^2	Out-of-plane force per unit edge-length caused by out-of-plane unit deflection
	12-20		$K_{w\theta}$ or $K_{\theta w}$	lb/in	Out-of-plane force per unit edge-length caused by out-of plane unit rotation or Out-of-plane moment per unit edge-length caused by out-of-plane unit deflection
	21-29		$K_{\theta\theta}$	lb.	Out-of-plane moment per unit edge-length caused by out-of plane unit rotation

D. BOUNDARY CONDITIONS – Sheet 1 of 3 (See Figure B-5)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
Add'l info. for cards D1 and D2 only.	60	A1		-	0 denotes stringer edge not held for in-plane rotation (θ_z) 1 denotes stringer edge held for in-plane rotation ($\theta_z = 0$) 3 denotes stringer edge flexibly held for in-plane rotation Note θ_z is not a primary structure degree of freedom unless a stringer element is also present at a particular plate node
	61-69	E9.0	$K_{s\theta_z}$	in-lb.	In-plane stringer edge moment produced by unit rotation θ_z
	71	A1	-	-	0 denotes stringer edge free to twist (θ_x) 1 denotes stringer edge not free to twist ($\theta_x = 0$) 3 denotes stringer edge flexibly held against twist
	72-80	E9.0	$K_{s\theta_x}$	in-lb.	Twist moment on end of stringer for a unit twist-rotation

Special Instructions for running a thermal stress problem when the primary structure is at a uniform temperature other than the reference temperature are required to permit free in-plane thermal straining; e.g.:

1. Permit the x=0 boundary to move freely or be elastically held in-plane
2. Permit the $x=L_x$ boundary to move freely in the y direction but not the x direction if free, or be elastically held if elastically held along x=0.
3. Permit the y=0 boundary to move freely or be elastically held in-plane.
4. Permit the $y=L_y$ boundary to move freely in the x direction but not the y direction if free, or be elastically held if elastically held along y=0.

See pages B-53 and B-57 for a typical example of the above instructions.

E. PRIMARY STRUCTURE LOADING (See Figure B-6)

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
E.1	1-10	E10.0	N_x	lb/in	Uniform, direct cover-plate running load in x direction on x = 0 edge (see Figure 7)
	11-20		N_y	lb/in	Uniform, direct cover-plate running load in y direction on y = 0 edge (see Figure 7)
	21-30		N_{xy}	lb/in	Uniform, shearing cover-plate running load on x = 0 edge (see Figure 7)
	31-40		N_{yx}	lb/in	Uniform, shearing cover-plate running load on y = 0 edge (see Figure 7)
	41-50		P_z	psi	Uniform external normal pressure acting upon tiles
	51-60		T	lb	Tension force acting upon centroid of each stiffener at x = 0
	61-70		M	in-lb	Out-of-plane bending moment acting upon each stiffener
	71-80		V	lb	Shear load acting upon each stiffener
					Note, boundary conditions for B and D edges should be selected carefully to produce desired effect, e.g. to produce a uniform primary structure tension in the x direction, $\sigma_x = \bar{\sigma}$ and $\sigma_y = 0$: set $N_x = t_p \bar{\sigma}$, $T = A_s \bar{\sigma}$, and P_z, M and V all equal to zero; then hold plate edge B from in plane x, but not y, motion and also hold the stringers at edge B; next, make edges C and D free for X motion, and only hold one of these edges against y motion.
E.2	1-10	E10.0	ΔT_p	F^o	Temperature difference of plate from T_{Ref}.
	11-20	E10.0	ΔT_s	F^o	Temperature difference of stringers from T_{Ref}.

Note: Leave out cards E.1 and E.2 if vibration option is used

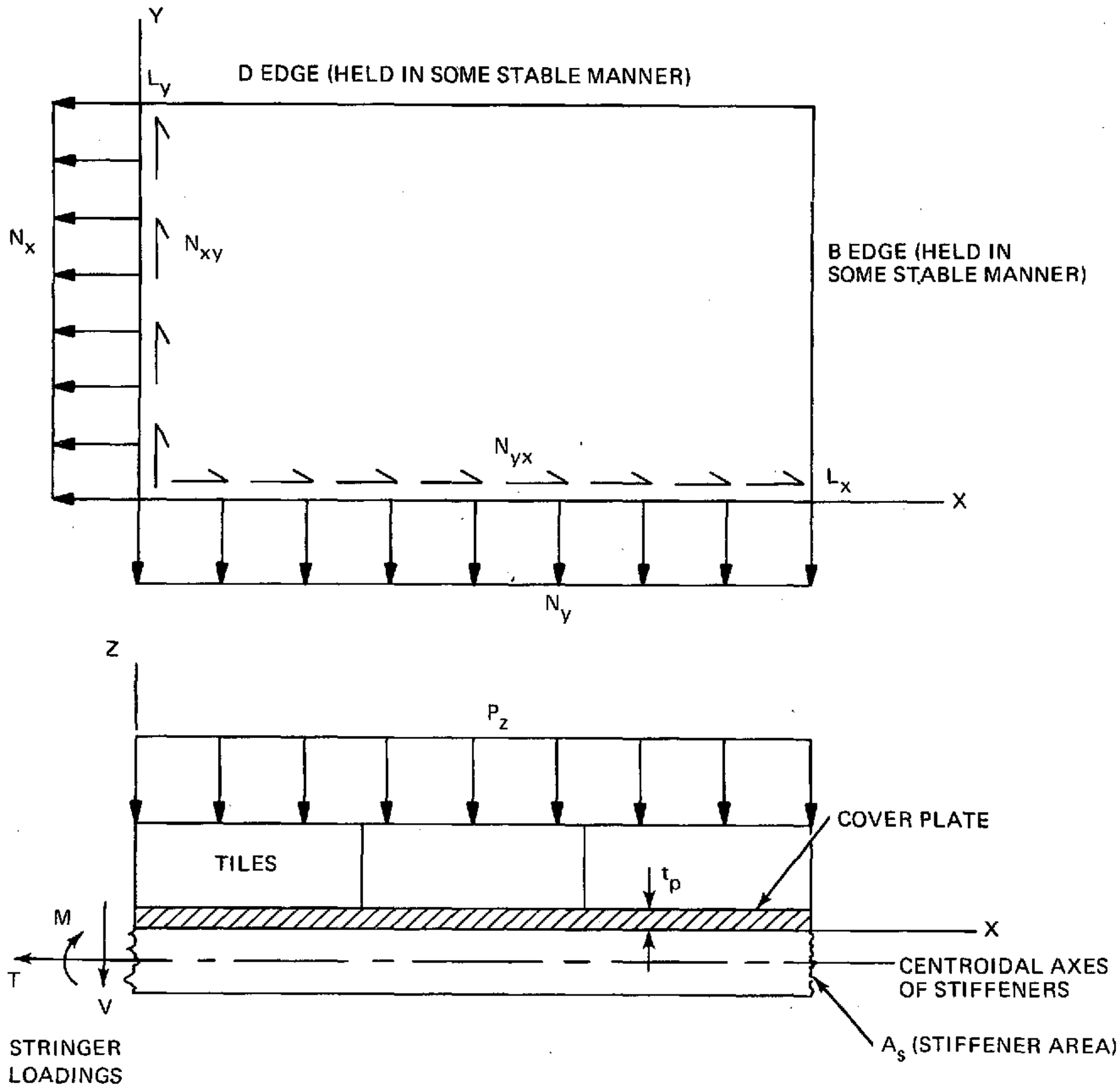


Figure B-6 Possible Static Mechanical Loadings Upon Panel

F. TILE TEMPERATURE DISTRIBUTIONS – Sheet 1 of 2

Each tile is assumed to have the same temperature distribution. There are 3 temperature distribution options, each of which is considered separately below. Tile temperature differences, rather than absolute tile temperatures, are required for each of these options (since thermal strains depend upon temperature differences). However, since temperature-dependent material property data are presented in terms of absolute temperature scales, a reference temperature (which is also input) is added to the differences to obtain absolute temperatures for internally computing material properties.

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
F.1	5	I1	-	-	0 in col.5 of this card indicates no thermal static loading effects will be considered. But material properties used in forming the TPS stiffness properties will be based upon the specified temperature distribution. 1 in col. 5 indicates that thermal static loading will be considered in the analysis. In such cases, refer to bottom of following page for special instructions regarding boundary condition cards (D.1 through D.4).
	10	I1	-	-	1 in col. 10 indicates that each tile is at the same uniform temperature. 2 in col. 5 indicates that each tile temperature distribution is governed by Lagrangian interpolation formulas. 3 in col. 5 indicates that each tile temperature distribution is input by consecutive finite element node-temperature differences from the reference temperature.
	11-20	E10.0	T_{Ref}	^{o}F	Panel reference temperature (added to temp. differences when obtaining mat'l. properties)

F. TILE TEMPERATURE DISTRIBUTIONS – Sheet 2 of 2

CARD(S)	COL(S)	FORMAT	SYMBOLS	UNITS	DESCRIPTION
UNIFORM TEMPERATURE OPTION (1)					
F.2	1-10	E10-1	ΔT_u	F^o	Uniform temperature difference from T_{Ref}
or LAGRANGIAN INTERPOLATION TEMPERATURE OPTION (2)					
F.2.1	1-5	2I5	-	-	Number of x coordinates through which temperature differences will be interpolated.
	6-10		-	-	Order of Lagrangian interpolation polynominal in x direction. Must be at lease 1 less than number of coords given in col. 5.
F.3.1	1-10	E10.0	x_i	inches	The local x coordinates used in the x direction temperature difference interpolation. Eight to a card until all are accounted for.
F.2.2– 3.2					Repeat card types F.2.1 and F.3.1 for the y coordinates
F.2.3– 3.3					Repeat card types F.2.1 and F.3.1 for the z coordinates
or ELEMENT NODE TEMPERATURE OPTION (3)					
F.2	1-10 11-20 etc.	E10.0	ΔT_R	F^o	Temperature differences above reference temperatures, node by node, in consecutive order. Seven temperature differences to a card until all nodes are accounted for. Cols. 71-80 of each card are reserved for user's card identification.

D. DESCRIPTION OF OUTPUT

Output from a typical run of the RESIST computer program is explained below in outline form. References in parentheses refer to pages in this Appendix.

1. Program title and date indicating latest update of program version which was run.

INPUT INFORMATION

2. Listing of input cards, the first two of which are the title assigned to any given run by the user.

3. User selected input options are listed.

4. Plate, stringer and tile geometry and specification of finite element grids for primary structure and tiles (pp. B.8 - B.11).

5. Plate, stringer, strain isolator and arrestor material properties (p. B.12). Note, if there is no strain arrestor, RSI or isolator material properties may be used for the arrestor. If this is done, the thickness dimension of the usual isolator or RSI should be appropriately reduced to compensate for this addition.

6. Temperature-dependent RSI material property data used for generating curves used internally by program to compute RSI average finite element properties.

7. Plate and stringer boundary conditions (pp. B.16-B.21).

8. Applied primary structure static mechanical and thermal loading if not a vibration problem.

9. RSI temperature distribution input data. Used for property data (item 6 above) and thermal loading if a statics problem.

OUTPUT INFORMATION

10. Map showing typical tiles three dimensional finite element ordering, by layers. Top, or first layer also corresponds to two-dimensional tile coating elements as well.

11. Map showing ordering of a typical tiles finite element nodes by layers.

12. Position and temperatures for a typical tile in a local coordinate system (reference Figures 3.a &.b).

13. Global geometry of primary structure nodes and plate nodal degree-of-freedom numbering . D_x, D_y and D_z refer to nodal deflections, and R_x, R_y and R_z are the nodal rotations. Nodes with no degrees-of-freedom are used to define the stringer centroids and axes.

14.a. Statics Option: Primary structure nodal deflections by iteration number. Nodes with the same x coordinate are grouped together. These groups are separated with dashed lines.

14.b. Vibration Option: Mode numbers, approximate frequencies and corresponding modal error bound (which should be less than 2% to be a reliable approximate mode). This is followed by the primary structure mode shapes with a similar nodal deflection format as for the Statics Option.

15. If requested by the user, the computed convergence parameter is printed out along with the input quantity it was tested against. This is done for each iteration after the first for the Static Option. The primary structure degree-of-freedom with the largest change from the previous iteration is also identified.

16. Tile nodal displacements by tile and iteration number. For a vibration option, this calculation and the subsequent ones are performed only for the user-specified vibration mode.

17. Three dimensional tile stresses and strains for the bottom two layers of elements by element number. These quantities are computed at each element's 8 Gauss integration points. Gauss point stresses are believed to be more accurate than nodal values and provide more detail than simply the element's average stresses.

18. Three dimensional element average stresses and strains (by tile and iteration number).

19. Two-dimensional element average coating stresses. Coating element numbers correspond to three dimensional element numbering directly below them.

20.a. Statics Option: Repeat of items 16-19 for each tile. Repeat of item 14.a and 15 for each iteration.

20.b. Vibrations Option: Computation of Rayleigh Quotient (OMEGA SQUARED) if all tiles have been treated. Repeat of items 16-19 for each iteration. Repeat of items 14.b, 15 and Rayleigh Quotient until convergence or last iteration is performed.

21. Plate element stresses and strains for mid and/or top and/or bottom surfaces. This computation is done after each iteration if requested by the user. Otherwise, it is computed only after convergence or the last iteration is performed.

E. SAMPLE PROBLEMS

Output for three sample problems, one vibration case and two statics cases, are presented in the remaining pages of this report. Only portions of the output for each problem are shown. However, the pages presented are representative of the types of information, and their respective formats, which the RESIST Program can deliver.

S T A T I C   A N D   D Y N A M I C

REUSABLE SURFACE INSULATION STRESSES

```
RRRRRRRRRR     EEEEEEEEEEE          SSSSSSSSS          IIIIIIIII           SSSSSSSSS    TTTTTTTTTTTTT
RRRRRRRRRRR    EEEEEEEEEEE         SSSSSSSSSS          IIIIIIIII          SSSSSSSSSS    TTTTTTTTTTTTT
RRR     RRRR   EEE                SSSSS                   III            SSSSS              TTT
RRR      RRR   EEE                SSSS                    III            SSSS               TTT
RRR     RRRR   EEE                 SSSSS                  III             SSSSS             TTT
RRRRRRRRRRR    EEEEEEEE     **      SSSSS        **       III       **     SSSSS            TTT
RRRRRRRRRR     EEEEEEEE     **        SSSSS      **       III       **       SSSSS          TTT
RRR   RRR      EEE                     SSSSS              III                 SSSSS         TTT
RRR    RRR     EEE                       SSSS             III                   SSSS        TTT
RRR     RRR    EEE                      SSSSS             III                  SSSSS        TTT
RRR      RRR   EEEEEEEEEEE        SSSSSSSSSS           IIIIIIIII         SSSSSSSSSS         TTT
RRR       RRR  EEEEEEEEEEE        SSSSSSSSS            IIIIIIIII         SSSSSSSSS          TTT

GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG
GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG
                                        GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG
                                          GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG
                                           GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG
                                            GGGGGGGGGGGGGGGGGGGGGGGGGGG
                                              GGGGGGGGGGGGGGGGGGGGGG
                                             GGGGGGGGGGGGGGGGGGGGG
                                           GGGGGGGGGGGGGGGGGGGGG
                                         GGGGGGGGGGGGGGGGGGGGG
                                        GGGGGGGGGGGGGGGGGGGG
                                        GGGGGGGGGGGGGGGGGG
                                        GGGGGGGGGGGGGGGG
                                        GGGGGGGGGGGGGG
                                        GGGGGGGGGGGG
                                        GGGGGGGGGG
                                        GGGGGGGG
                                        GGGGGG
                                        GGGG
                                        GG
```

VERSION DATE

AUGUST 31, 1974

PREPARED BY

I. OJALVO, P. OGILVIE, A. LEVY AND F. AUSTIN

OF GRUMMAN AEROSPACE CORPORATION

FOR

THE LANGLEY RESEARCH CENTER

PROGRAM LISTING OF INPUT DATA CARDS

```
.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

SAMPLE PROBLEM I  -  VIBRATION OF THREE (3) SIMPLE TILES
    AUGUST 21, 1974
    2    5         2    1    4    .05            7       0.0
    1    2    1    1    1    1    0    0    0
   0
       13.    .33333       .75
       1.0
         3         1
                       1.16667    .16667       .05
        10    1         7
     10.E6        .3       .01
         0
     60.E3     60.E3      6.E3         .5        .1       .01
     20.E3     32.E3     32.E3      .005
       90.       .49      .035
      .005
    1
       70.     60.E3
    1
       70.      6.E3
    1
       70.     32.E3
    1
       70.        .5
    1
       70.       .01
    1
       70.        0.
    1
       70.        0.
    1
       70.        0.
    1
       70.        0.
A2                            0
B2                            2
C0                            0
D0                            4
         1       70.
        0.

.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

OPTIONS

FREE VIBRATION MODES NO. DESIRED MODES = 5 NO. REORTHOGONALIZATIONS = 2 MODE NO. = 1

MAXIMUM NO. ITERATIONS = 4 CONVERGENCE PARAMETER = 5.0000E-02

OVERHUNG ROTATORY MASS INERTIA ASSOCIATED WITH EACH STRINGER = 0.0

PRIMARY STRUCTURE STRESSES PRESENTED AFTER LAST ITERATION AT PLATE MID, TOP AND BOTTOM SURFACES

TILES ON PRIMARY STRUCTURE

TILE STRESSES PRESENTED AFTER EACH ITERATION

TILE NODE MAP REQUIRED

TILE ELEMENT MAP REQUIRED

TILE NODE COORDINATES REQUIRED

DO NOT PRINT ELEMENT STIFFNESS MATRICES

DO NOT PRINT ASSEMBLED STIFFNESS MATRICES

DO NOT PRINT FILE DEBUGGING INFORMATION

COMPUTE STRESSES FOR ALL TILES

G E O M E T R Y

PLATE	LX = 1.80000E 01	LY = 3.33330E-01	TP = 7.50000E-01	
STRINGERS	Y1 = 1.00000E 00	ZS = 0.0	YS = 0.0	AS = 0.0
	IY' = 0.0	IZ' = 0.0	JX' = 0.0	BETA S = 0.0
TILES	NXB = 3	NYB = 1		
	T = 0.0	B1 = 0.0	T2 = 1.16667E 00	
	TA = 1.66670E-01	TI = 5.00000E-02	TC = 0.0	
BRICK	NB1 = 0	NB2 = 10	ND2 = 1	
	NT1 = 0	NT2 = 7		

M A T E R I A L   P R O P E R T I E S

PLATE	EP = 1.00000E 07	NU P = 3.00000E-01	GAMMA P = 1.00000E-02	ALPHA P = 0.0
STRINGERS	ES = 0.0	NU S = 0.0	GAMMA S = 0.0	ALPHA P = 0.0
ARRESTOR	EX = 6.00000E 04	EY = 6.00000E 04	EZ = 6.00000E 03	
OR RSI	NU XY = 5.00000E-01	NU YZ = 1.00000E-01	NU ZX = 1.00000E-02	
	GXY = 2.00000E 04	GYZ = 3.20000E 04	GZX = 3.20000E 04	
	GAMMA A = 5.00000E-03			
	ALPHA X = 0.0	ALPHA Y = 0.0	ALPHA Z = 0.0	
ISOLATOR	EI = 9.00000E 01	NU I = 4.90000E-01	GAMMA I = 3.50000E-02	ALPHA I = 0.0
RSI	GAMMA R = 5.00000E-03			
	ALPHA RY / ALPHA RX = 0.0		ALPHA RZ / ALPHA RX = 0.0	

TEMPERATURE DEPENDENT MATERIAL PROPERTIES

		TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY
1	ER	ALL	6.000E 04						
1	ER'	ALL	6.000E 03						
1	GR'	ALL	3.200E 04						
1	NU R	ALL	5.000E-01						
1	NU R'	ALL	1.000E-02						
1	ALPHA R	ALL	0.0						
1	EC	ALL	0.0						
1	NU C	ALL	0.0						
1	ALPHA C	ALL	0.0						

BOUNDARY CONDITIONS

EDGE	PLATE OUT OF PLANE	PLATE IN PLANE	STRINGERS	
A	PINNED	FREE	FREE	FREE
B	PINNED	U HELD, V FREE	FREE	FREE
C	FREE	FREE		
D	FREE	V HELD, U FREE		

RST TEMPERATURES

NO STATIC THERMAL LOADING

UNIFORM TEMPERATURE OPTION

T REFERENCE = 7.0000E 01

DEL T U = T - T REF = 0.0

NODE MAP

SURFACE 1

200	202	204	206	208	210	212	214	216	218	220
199	201	203	205	207	209	211	213	215	217	219

N O D E M A P

SURFACE 2

178	180	182	184	186	188	190	192	194	196	198
177	179	181	183	185	187	189	191	193	195	197

E L E M E N T   M A P

LAYER 1
RSI

81 82 83 84 85 86 87 88 89 90

ELEMENT MAP

LAYER 9
ISOLATOR

1 2 3 4 5 6 7 8 9 10

TILE MESH ELEMENT	TILE NODES			
1	1	2	24	23
	3	4	26	25
2	3	4	26	25
	5	6	28	27
3	5	6	28	27
	7	8	30	29
4	7	8	30	29
	9	10	32	31
5	9	10	32	31
	11	12	34	33
6	11	12	34	33
	13	14	36	35
7	13	14	36	35
	15	16	38	37
8	15	16	38	37
	17	18	40	39
9	17	18	40	39
	19	20	42	41
10	19	20	42	41
	21	22	44	43
11	23	24	46	45
	25	26	48	47
12	25	26	48	47
	27	28	50	49
13	27	28	50	49
	29	30	52	51
14	29	30	52	51
	31	32	54	53
15	31	32	54	53
	33	34	56	55
16	33	34	56	55
	35	36	58	57
17	35	36	58	57
	37	38	60	59
18	37	38	60	59
	39	40	62	61
19	39	40	62	61
	41	42	64	63

NODE	LOCAL TILE COORDINATES X	Y	Z	TEMPERATURE
1	0.0	0.0	0.0	0.0
2	0.0	3.33330E-01	0.0	0.0
3	6.00000E-01	0.0	0.0	0.0
4	6.00000E-01	3.33330E-01	0.0	0.0
5	1.20000E 00	0.0	0.0	0.0
6	1.20000E 00	3.33330E-01	0.0	0.0
7	1.80000E 00	0.0	0.0	0.0
8	1.80000E 00	3.33330E-01	0.0	0.0
9	2.40000E 00	0.0	0.0	0.0
10	2.40000E 00	3.33330E-01	0.0	0.0
11	3.00000E 00	0.0	0.0	0.0
12	3.00000E 00	3.33330E-01	0.0	0.0
13	3.60000E 00	0.0	0.0	0.0
14	3.60000E 00	3.33330E-01	0.0	0.0
15	4.20000E 00	0.0	0.0	0.0
16	4.20000E 00	3.33330E-01	0.0	0.0
17	4.80000E 00	0.0	0.0	0.0
18	4.80000E 00	3.33330E-01	0.0	0.0
19	5.40000E 00	0.0	0.0	0.0
20	5.40000E 00	3.33330E-01	0.0	0.0
21	6.00000E 00	0.0	0.0	0.0
22	6.00000E 00	3.33330E-01	0.0	0.0
23	0.0	0.0	5.00000E-02	0.0
24	0.0	3.33330E-01	5.00000E-02	0.0
25	6.00000E-01	0.0	5.00000E-02	0.0
26	6.00000E-01	3.33330E-01	5.00000E-02	0.0
27	1.20000E 00	0.0	5.00000E-02	0.0
28	1.20000E 00	3.33330E-01	5.00000E-02	0.0
29	1.80000E 00	0.0	5.00000E-02	0.0
30	1.80000E 00	3.33330E-01	5.00000E-02	0.0
31	2.40000E 00	0.0	5.00000E-02	0.0
32	2.40000E 00	3.33330E-01	5.00000E-02	0.0
33	3.00000E 00	0.0	5.00000E-02	0.0
34	3.00000E 00	3.33330E-01	5.00000E-02	0.0
35	3.60000E 00	0.0	5.00000E-02	0.0
36	3.60000E 00	3.33330E-01	5.00000E-02	0.0
37	4.20000E 00	0.0	5.00000E-02	0.0
38	4.20000E 00	3.33330E-01	5.00000E-02	0.0
39	4.80000E 00	0.0	5.00000E-02	0.0
40	4.80000E 00	3.33330E-01	5.00000E-02	0.0
41	5.40000E 00	0.0	5.00000E-02	0.0
42	5.40000E 00	3.33330E-01	5.00000E-02	0.0
43	6.00000E 00	0.0	5.00000E-02	0.0
44	6.00000E 00	3.33330E-01	5.00000E-02	0.0
45	0.0	0.0	2.16670E-01	0.0
46	0.0	3.33330E-01	2.16670E-01	0.0
47	6.00000E-01	0.0	2.16670E-01	0.0
48	6.00000E-01	3.33330E-01	2.16670E-01	0.0
49	1.20000E 00	0.0	2.16670E-01	0.0
50	1.20000E 00	3.33330E-01	2.16670E-01	0.0

PRIMARY STRUCTURE
GLOBAL GEOMETRY

NODE	X	Y	Z
1	0.0	0.0	0.0
2	0.0	3.333300E-01	0.0
3	6.000000E-01	0.0	0.0
4	6.000000E-01	3.333300E-01	0.0
5	1.200000E 00	0.0	0.0
6	1.200000E 00	3.333300E-01	0.0
7	1.799999E 00	0.0	0.0
8	1.799999E 00	3.333300E-01	0.0
9	2.400000E 00	0.0	0.0
10	2.400000E 00	3.333300E-01	0.0
11	2.999999E 00	0.0	0.0
12	2.999999E 00	3.333300E-01	0.0
13	3.599999E 00	0.0	0.0
14	3.599999E 00	3.333300E-01	0.0
15	4.199999E 00	0.0	0.0
16	4.199999E 00	3.333300E-01	0.0
17	4.799999E 00	0.0	0.0
18	4.799999E 00	3.333300E-01	0.0
19	5.400000E 00	0.0	0.0
20	5.400000E 00	3.333300E-01	0.0
21	5.999999E 00	0.0	0.0
22	5.999999E 00	3.333300E-01	0.0
23	6.599999E 00	0.0	0.0
24	6.599999E 00	3.333300E-01	0.0
25	7.199999E 00	0.0	0.0
26	7.199999E 00	3.333300E-01	0.0
27	7.799999E 00	0.0	0.0
28	7.799999E 00	3.333300E-01	0.0
29	8.399999E 00	0.0	0.0
30	8.399999E 00	3.333300E-01	0.0
31	8.999999E 00	0.0	0.0
32	8.999999E 00	3.333300E-01	0.0
33	9.599999E 00	0.0	0.0
34	9.599999E 00	3.333300E-01	0.0
35	1.020000E 01	0.0	0.0
36	1.020000E 01	3.333300E-01	0.0
37	1.080000E 01	0.0	0.0
38	1.080000E 01	3.333300E-01	0.0
39	1.140000E 01	0.0	0.0
40	1.140000E 01	3.333300E-01	0.0
41	1.200000E 01	0.0	0.0
42	1.200000E 01	3.333300E-01	0.0
43	1.260000E 01	0.0	0.0
44	1.260000E 01	3.333300E-01	0.0
45	1.320000E 01	0.0	0.0
46	1.320000E 01	3.333300E-01	0.0
47	1.380000E 01	0.0	0.0
48	1.380000E 01	3.333300E-01	0.0
49	1.440000E 01	0.0	0.0
50	1.440000E 01	3.333300E-01	0.0
51	1.500000E 01	0.0	0.0

DEGREES OF FREEDOM

DX	DY	DZ	RX	RY	RZ
1	2	0	3	4	0
5	0	0	6	7	0
8	9	10	11	12	0
13	0	14	15	16	0
17	18	19	20	21	0
22	0	23	24	25	0
26	27	28	29	30	0
31	0	32	33	34	0
35	36	37	38	39	0
40	0	41	42	43	0
44	45	46	47	48	0
49	0	50	51	52	0
53	54	55	56	57	0
58	0	59	60	61	0
62	63	64	65	66	0
67	0	68	69	70	0
71	72	73	74	75	0
76	0	77	78	79	0
80	81	82	83	84	0
85	0	86	87	88	0
89	90	91	92	93	0
94	0	95	96	97	0
98	99	100	101	102	0
103	0	104	105	106	0
107	108	109	110	111	0
112	0	113	114	115	0
116	117	118	119	120	0
121	0	122	123	124	0
125	126	127	128	129	0
130	0	131	132	133	0
134	135	136	137	138	0
139	0	140	141	142	0
143	144	145	146	147	0
148	0	149	150	151	0
152	153	154	155	156	0
157	0	158	159	160	0
161	162	163	164	165	0
166	0	167	168	169	0
170	171	172	173	174	0
175	0	176	177	178	0
179	180	181	182	183	0
184	0	185	186	187	0
188	189	190	191	192	0
193	0	194	195	196	0
197	198	199	200	201	0
202	0	203	204	205	0
206	207	208	209	210	0
211	0	212	213	214	0
215	216	217	218	219	0
220	0	221	222	223	0
224	225	226	227	228	0

ORDER OF UNREDUCED PROBLEM = 273
NUMBER OF DESIRED MODES = 5
NUMBER OF REORTHOGONALIZATIONS = 2

MODE NUMBER	FREQUENCY (RAD / SEC)	FREQUENCY (HERTZ)	FREQ. SQRD. ERROR BOUND (PERCENT)
1	3.204729E 03	5.100483E 02	7.609798E-14
2	1.096583E 04	1.745266E 03	2.610086E-13
3	2.262648E 04	3.601117E 03	4.191322E-06
4	2.400171E 04	3.819991E 03	9.051610E-06
5	3.946659E 04	6.281301E 03	1.497426E-01
6	4.502263E 04	7.165570E 03	9.145379E-02
7	6.271878E 04	9.982004E 03	4.056820E 00
8	7.672000E 04	1.221037E 04	7.066792E 01

PRIMARY STRUCTURE MODE SHAPE 1 ITERATION NO. 0

NODE	DX	DY	DZ	RX	RY	RZ
1	-2.372677E-07	4.973345E-08		1.429838E-06	-3.161962E-02	
2	-2.371768E-07			-1.400851E-06	-3.162404E-02	
3	-2.104755E-07	4.944270E-08	1.893834E-02	-2.142981E-05	-3.144493E-02	
4	-2.104363E-07		1.894102E-02	3.746948E-05	-3.144924E-02	
5	-1.839400E-07	4.864863E-08	3.766652E-02	-4.241391E-05	-3.092045E-02	
6	-1.838706E-07		3.767179E-02	7.399049E-05	-3.092459E-02	
7	-1.578119E-07	4.731215E-08	5.597616E-02	-6.385770E-05	-3.005014E-02	
8	-1.577289E-07		5.598381E-02	1.099205E-04	-3.005387E-02	
9	-1.323493E-07	4.545071E-08	7.366067E-02	-8.621626E-05	-2.883692E-02	
10	-1.322388E-07		7.367039E-02	1.444587E-04	-2.884041E-02	
11	-1.077374E-07	4.307981E-08	9.051722E-02	-1.059153E-04	-2.729557E-02	
12	-1.076069E-07		9.052908E-02	1.770441E-04	-2.729934E-02	
13	-8.423490E-08	4.024713E-08	1.063567E-01	-1.229580E-04	-2.545035E-02	
14	-8.406460E-08		1.063711E-01	2.091781E-04	-2.545403E-02	
15	-6.193574E-08	3.697092E-08	1.210015E-01	-1.404429E-04	-2.331475E-02	
16	-6.175992E-08		1.210180E-01	2.392771E-04	-2.331808E-02	
17	-4.107149E-08	3.328104E-08	1.342834E-01	-1.547958E-04	-2.091386E-02	
18	-4.085534E-08		1.343020E-01	2.659557E-04	-2.091752E-02	
19	-2.174171E-08	2.925146E-08	1.460547E-01	-1.638929E-04	-1.828836E-02	
20	-2.152723E-08		1.460758E-01	2.906900E-04	-1.829213E-02	
21	-4.124917E-09	2.494605E-08	1.561939E-01	-1.707078E-04	-1.548051E-02	
22	-3.875034E-09		1.562172E-01	3.108683E-04	-1.548352E-02	
23	1.178755E-08	2.042313E-08	1.646020E-01	-1.776280E-04	-1.252230E-02	
24	1.202399E-08		1.646270E-01	3.271538E-04	-1.252472E-02	
25	2.589176E-08	1.570584E-08	1.711965E-01	-1.823899E-04	-9.440076E-03	
26	2.615315E-08		1.712228E-01	3.403833E-04	-9.441860E-03	
27	3.814886E-08	1.085576E-08	1.759129E-01	-1.862148E-04	-6.268606E-03	
28	3.841612E-08		1.759400E-01	3.483910E-04	-6.269876E-03	
29	4.851601E-08	5.917776E-09	1.787075E-01	-1.877103E-04	-3.038223E-03	
30	4.878820E-08		1.787353E-01	3.546302E-04	-3.039023E-03	
31	5.697272E-08	9.227483E-10	1.795518E-01	-1.892887E-04	2.286215E-04	
32	5.724280E-08		1.795799E-01	3.578272E-04	2.281881E-04	

PRIMARY STRUCTURE NODES ASSOCIATED WITH TILE NO. 1

1	3	5	7	9	11	13	15	17	19	21
2	4	6	8	10	12	14	16	18	20	22

TPS DISPLACEMENTS FOR TILE NO. 1 AND ITERATION NO. 1

NODE	X COMPONENT(U)	Y COMPONENT(V)	Z COMPONENT(W)
1	-1.1857588E-02	-4.8645558E-07	0.0
2	-1.1859249E-02	5.2531914E-07	0.0
3	-1.1792056E-02	8.0856189E-06	1.8938344E-02
4	-1.1793669E-02	-1.4051055E-05	1.8941015E-02
5	-1.1595350E-02	1.5953861E-05	3.7666518E-02
6	-1.1596903E-02	-2.7746428E-05	3.7671786E-02
7	-1.1268958E-02	2.3993940E-05	5.5976156E-02
8	-1.1270355E-02	-4.1220163E-05	5.5983808E-02
9	-1.0813974E-02	3.2376542E-05	7.3660672E-02
10	-1.0815281E-02	-5.4172007E-05	7.3670387E-02
11	-1.0235939E-02	3.9761304E-05	9.0517223E-02
12	-1.0237359E-02	-6.6391527E-05	9.0529084E-02
13	-9.5439628E-03	4.6149493E-05	1.0635674E-01
14	-9.5453411E-03	-7.8441793E-05	1.0637110E-01
15	-8.7430887E-03	5.2703050E-05	1.2100154E-01
16	-8.7443367E-03	-8.9728899E-05	1.2101799E-01
17	-7.8427382E-03	5.8081714E-05	1.3428342E-01
18	-7.8441054E-03	-9.9733385E-05	1.3430196E-01
19	-6.8581514E-03	6.1489074E-05	1.4605474E-01
20	-6.8595633E-03	-1.0900875E-04	1.4607584E-01
21	-5.8051944E-03	6.4040360E-05	1.5619385E-01
22	-5.8063194E-03	-1.1657560E-04	1.5621716E-01
23	1.4547564E-02	-6.3910964E-04	1.2398793E-03
24	1.4194820E-02	-8.7081082E-04	1.4891145E-03
25	1.4519908E-02	-5.0962073E-05	1.9550174E-02
26	1.4168963E-02	-1.9416506E-04	1.9783165E-02
27	1.4426317E-02	4.8901746E-04	3.8002007E-02
28	1.4112670E-02	4.4811238E-04	3.8206004E-02
29	1.4063966E-02	9.4013475E-04	5.6169845E-02
30	1.3832748E-02	1.0023818E-03	5.6362256E-02
31	1.3425775E-02	1.2302890E-03	7.3761225E-02
32	1.3346210E-02	1.3694626E-03	7.3977292E-02
33	1.2545496E-02	1.2185425E-03	9.0547383E-02
34	1.2709964E-02	1.4096978E-03	9.0835929E-02
35	1.1494834E-02	7.3654414E-04	1.0633683E-01
36	1.1997625E-02	9.4610523E-04	1.0675156E-01
37	1.0387622E-02	-3.6612875E-04	1.2097675E-01
38	1.1290297E-02	-1.8315547E-04	1.2157196E-01
39	9.3781725E-03	-2.1629541E-03	1.3437933E-01
40	1.0673009E-02	-2.0691841E-03	1.3517231E-01
41	8.6540468E-03	-4.5677647E-03	1.4652973E-01
42	1.0241371E-02	-4.6631880E-03	1.4751375E-01
43	8.3580688E-03	-7.3843338E-03	1.5772128E-01
44	1.0027479E-02	-7.7313706E-03	1.5879726E-01
45	9.5742457E-03	-8.5340976E-04	2.1167265E-03
46	9.2171617E-03	-9.4800652E-04	2.4438321E-03
47	9.5377490E-03	-2.2878307E-04	2.0108391E-02
48	9.1875307E-03	-2.8696889E-04	2.0416472E-02
49	9.4466731E-03	3.5078474E-04	3.8306460E-02
50	9.1335960E-03	3.4779799E-04	3.8583938E-02

STRESSES FOR ISOLATOR AND ARRESTOR FOR TILE NO. 1 AND ITERATION NO. 1

	LOCAL COORDINATES X	Y	Z	STRESSES XX	YY	ZZ	XY	YZ	ZX
ELEMENT NUMBER 1									
1	4.7320E-01	2.6289E-01	3.9434E-02	2.6906E 01	2.6883E 01	2.8029E 01	8.8016E-04	-1.6162E-01	1.6666E 01
2	4.7320E-01	7.0441E-02	3.9434E-02	2.2899E 01	2.2876E 01	2.3860E 01	-1.0059E-03	-1.1118E-01	1.6789E 01
3	1.2679E-01	2.6289E-01	3.9434E-02	3.7726E 01	3.7696E 01	3.9298E 01	8.0522E-04	-3.9381E-01	1.6698E 01
4	1.2679E-01	7.0441E-02	3.9434E-02	3.3534E 01	3.3504E 01	3.4934E 01	-1.0808E-03	-3.2088E-01	1.6821E 01
5	4.7320E-01	2.6289E-01	1.0566E-02	2.7413E 01	2.7399E 01	2.8531E 01	-2.2875E-04	-1.7388E-01	1.6685E 01
6	4.7320E-01	7.0441E-02	1.0566E-02	2.3408E 01	2.3395E 01	2.4363E 01	-2.4156E-04	-1.2343E-01	1.6807E 01
7	1.2679E-01	2.6289E-01	1.0566E-02	3.8398E 01	3.8385E 01	3.9965E 01	-2.5049E-04	-4.0664E-01	1.6717E 01
8	1.2679E-01	7.0441E-02	1.0566E-02	3.4207E 01	3.4194E 01	3.5603E 01	-2.6328E-04	-3.3371E-01	1.6839E 01
ELEMENT NUMBER 2									
1	1.0732E 00	2.6289E-01	3.9434E-02	1.6174E 01	1.6165E 01	1.6847E 01	1.5363E-03	2.2179E-01	1.6533E 01
2	1.0732E 00	7.0441E-02	3.9434E-02	1.2621E 01	1.2613E 01	1.3152E 01	-6.7633E-04	2.2994E-01	1.6645E 01
3	7.2679E-01	2.6289E-01	3.9434E-02	2.1127E 01	2.1109E 01	2.2009E 01	-3.2834E-06	3.3251E-03	1.6624E 01
4	7.2679E-01	7.0441E-02	3.9434E-02	1.7262E 01	1.7246E 01	1.7990E 01	-2.2154E-03	3.6417E-02	1.6744E 01
5	1.0732E 00	2.6289E-01	1.0566E-02	1.6621E 01	1.6599E 01	1.7278E 01	-2.8976E-05	2.1105E-01	1.6542E 01
6	1.0732E 00	7.0441E-02	1.0566E-02	1.3099E 01	1.3077E 01	1.3614E 01	-1.6293E-04	2.1920E-01	1.6654E 01
7	7.2679E-01	2.6289E-01	1.0566E-02	2.1757E 01	2.1734E 01	2.2624E 01	-4.4361E-04	-8.3737E-03	1.6633E 01
8	7.2679E-01	7.0441E-02	1.0566E-02	1.7924E 01	1.7901E 01	1.8635E 01	-5.7781E-04	2.4718E-02	1.6752E 01
ELEMENT NUMBER 3									
1	1.6732E 00	2.6289E-01	3.9434E-02	1.0661E 01	1.0681E 01	1.1127E 01	3.2492E-03	5.5905E-01	1.6188E 01
2	1.6732E 00	7.0441E-02	3.9434E-02	7.3571E 00	7.3810E 00	7.6956E 00	1.0171E-03	5.2378E-01	1.6274E 01
3	1.3268E 00	2.6289E-01	3.9434E-02	1.3076E 01	1.3088E 01	1.3648E 01	-1.5320E-04	3.7069E-01	1.6405E 01
4	1.3268E 00	7.0441E-02	3.9434E-02	9.6336E 00	9.6495E 00	1.0073E 01	-2.3854E-03	3.6053E-01	1.6508E 01
5	1.6732E 00	2.6289E-01	1.0566E-02	1.1327E 01	1.1300E 01	1.1756E 01	4.4718E-04	5.4923E-01	1.6192E 01
6	1.6732E 00	7.0441E-02	1.0566E-02	8.0929E 00	8.0672E 00	8.3925E 00	3.0674E-04	5.1397E-01	1.6278E 01
7	1.3268E 00	2.6289E-01	1.0566E-02	1.3925E 01	1.3898E 01	1.4461E 01	-4.7055E-04	3.6045E-01	1.6410E 01
8	1.3268E 00	7.0441E-02	1.0566E-02	1.0554E 01	1.0529E 01	1.0954E 01	-6.1104E-04	3.5029E-01	1.6512E 01
ELEMENT NUMBER 4									
1	2.2732E 00	2.6289E-01	3.9434E-02	7.8198E 00	7.8658E 00	8.1889E 00	5.8366E-03	8.0050E-01	1.5616E 01
2	2.2732E 00	7.0441E-02	3.9434E-02	4.1944E 00	4.2473E 00	4.4296E 00	4.2046E-03	7.2903E-01	1.5654E 01
3	1.9268E 00	2.6289E-01	3.9434E-02	8.9758E 00	9.0158E 00	9.3979E 00	-4.2068E-04	6.7421E-01	1.5955E 01
4	1.9268E 00	7.0441E-02	3.9434E-02	5.5634E 00	5.6104E 00	5.8604E 00	-2.0530E-03	6.2252E-01	1.6024E 01
5	2.2732E 00	2.6289E-01	1.0566E-02	8.7375E 00	8.7054E 00	9.0500E 00	1.1650E-03	7.8995E-01	1.5618E 01
6	2.2732E 00	7.0441E-02	1.0566E-02	5.2418E 00	5.2115E 00	5.4154E 00	1.1814E-03	7.1847E-01	1.5656E 01
7	1.9268E 00	2.6289E-01	1.0566E-02	1.0039E 01	1.0007E 01	1.0404E 01	-5.1494E-04	6.6431E-01	1.5957E 01
8	1.9268E 00	7.0441E-02	1.0566E-02	6.7561E 00	6.7260E 00	6.9916E 00	-4.9875E-04	6.1262E-01	1.6026E 01
ELEMENT NUMBER 5									
1	2.8732E 00	2.6289E-01	3.9434E-02	6.9006E 00	6.9647E 00	7.2467E 00	9.1163E-03	8.6863E-01	1.4849E 01
2	2.8732E 00	7.0441E-02	3.9434E-02	2.1431E 00	2.2185E 00	2.3179E 00	8.0453E-03	7.7022E-01	1.4808E 01
3	2.5268E 00	2.6289E-01	3.9434E-02	7.0614E 00	7.1217E 00	7.4180E 00	-9.5026E-04	8.5259E-01	1.5291E 01
4	2.5268E 00	7.0441E-02	3.9434E-02	2.9963E 00	3.0677E 00	3.2098E 00	-2.0213E-03	7.6860E-01	1.5298E 01
5	2.8732E 00	2.6289E-01	1.0566E-02	8.0533E 00	8.0143E 00	8.3259E 00	2.0526E-03	8.5493E-01	1.4850E 01
6	2.8732E 00	7.0441E-02	1.0566E-02	3.5047E 00	3.4688E 00	3.5978E 00	2.1828E-03	7.5652E-01	1.4809E 01
7	2.5268E 00	2.6289E-01	1.0566E-02	8.3200E 00	8.2815E 00	8.6030E 00	-6.4047E-04	8.4102E-01	1.5291E 01
8	2.5268E 00	7.0441E-02	1.0566E-02	4.4638E 00	4.4283E 00	4.5955E 00	-5.1022E-04	7.5703E-01	1.5300E 01

STRESSES AND DIRECT STRAINS FOR TILE NO. 1 AND ITERATION NO. 1

MEM	TEMP	LOCAL COORDINATES X	Y	Z	* STRAINS XX	YY	ZZ *	STRESSES XX	YY	ZZ	XY	YZ	ZX *
1	0.	0.30	0.17	0.02	3.234E-05	-2.970E-04	2.091E-02	3.056E 01	3.054E 01	3.182E 01	-1.733E-04	-2.531E-01	1.675E 01
2	0.	0.90	0.17	0.02	1.015E-04	-1.875E-04	1.162E-02	1.707E 01	1.706E 01	1.777E 01	-3.217E-04	1.173E-01	1.664E 01
3	0.	1.50	0.17	0.02	4.441E-06	-6.568E-05	7.209E-03	1.058E 01	1.057E 01	1.101E 01	1.742E-04	4.485E-01	1.635E 01
4	0.	2.10	0.17	0.02	-8.944E-05	3.724E-05	4.898E-03	7.166E 00	7.173E 00	7.467E 00	1.112E-03	7.014E-01	1.581E 01
5	0.	2.70	0.17	0.02	-1.502E-04	1.032E-04	3.722E-03	5.430E 00	5.445E 00	5.664E 00	2.159E-03	8.087E-01	1.506E 01
6	0.	3.30	0.17	0.02	-1.579E-04	1.275E-04	3.488E-03	5.107E 00	5.124E 00	5.327E 00	3.080E-03	6.764E-01	1.413E 01
7	0.	3.90	0.17	0.02	-8.861E-05	9.413E-05	4.449E-03	6.587E 00	6.598E 00	6.861E 00	3.630E-03	2.052E-01	1.308E 01
8	0.	4.50	0.17	0.02	7.243E-05	-1.763E-05	7.477E-03	1.115E 01	1.115E 01	1.160E 01	3.314E-03	-6.779E-01	1.199E 01
9	0.	5.10	0.17	0.02	3.389E-04	-2.475E-04	1.440E-02	2.146E 01	2.143E 01	2.231E 01	2.243E-03	-1.978E 00	1.093E 01
10	0.	5.70	0.17	0.02	6.651E-04	-5.952E-04	3.010E-02	4.469E 01	4.462E 01	4.647E 01	-4.048E-04	-3.614E 00	9.993E 00
11	0.	0.30	0.17	0.13	-4.985E-05	-3.958E-04	4.535E-03	-1.098E 00	3.234E 00	2.753E 01	8.851E-02	-1.630E-01	1.170E 01
12	0.	0.90	0.17	0.13	-1.229E-04	-1.840E-04	2.811E-03	-5.491E 00	3.418E 00	1.720E 01	5.288E-02	1.013E-01	2.029E 01
13	0.	1.50	0.17	0.13	-4.461E-04	6.061E-05	1.627E-03	-2.664E 01	5.855E-02	9.742E 00	5.416E-01	3.229E-01	1.916E 01
14	0.	2.10	0.17	0.13	-7.918E-04	2.861E-04	9.667E-04	-4.807E 01	-1.244E 00	5.628E 00	1.432E 00	4.998E-01	1.798E 01
15	0.	2.70	0.17	0.13	-1.072E-03	4.517E-04	6.049E-04	-6.545E 01	-2.283E 00	3.336E 00	2.375E 00	5.264E-01	1.622E 01
16	0.	3.30	0.17	0.13	-1.241E-03	5.412E-04	4.851E-04	-7.593E 01	-2.955E 00	2.539E 00	3.089E 00	3.452E-01	1.390E 01
17	0.	3.90	0.17	0.13	-1.259E-03	5.281E-04	6.761E-04	-7.714E 01	-3.226E 00	3.657E 00	3.282E 00	-8.202E-02	1.107E 01
18	0.	4.50	0.17	0.13	-1.095E-03	3.783E-04	1.402E-03	-6.698E 01	-2.716E 00	8.073E 00	2.644E 00	-7.877E-01	7.748E 00
19	0.	5.10	0.17	0.13	-7.355E-04	3.815E-05	3.189E-03	-4.440E 01	-9.126E-01	1.900E 01	1.313E 00	-1.602E 00	3.380E 00
20	0.	5.70	0.17	0.13	-3.018E-04	-4.679E-04	6.799E-03	-1.473E 01	5.936E 00	4.137E 01	-1.089E 00	-2.552E 00	-1.602E-01
21	0.	0.30	0.17	0.30	-6.129E-05	-1.187E-04	3.741E-03	-5.188E 00	-7.484E 00	2.232E 01	2.389E-01	-1.448E-01	1.003E 01
22	0.	0.90	0.17	0.30	-1.123E-04	-3.359E-05	2.569E-03	-7.267E 00	-4.119E 00	1.530E 01	4.555E-01	5.484E-02	2.092E 01
23	0.	1.50	0.17	0.30	-2.869E-04	9.123E-05	1.546E-03	-1.749E 01	-2.363E 00	9.080E 00	7.577E-01	1.650E-01	2.282E 01
24	0.	2.10	0.17	0.30	-5.154E-04	2.263E-04	8.677E-04	-3.120E 01	-1.536E 00	4.879E 00	1.205E 00	2.657E-01	2.101E 01
25	0.	2.70	0.17	0.30	-7.053E-04	3.332E-04	4.927E-04	-4.259E 01	-1.054E 00	2.520E 00	1.556E 00	2.460E-01	1.784E 01
26	0.	3.30	0.17	0.30	-8.065E-04	3.879E-04	3.527E-04	-4.868E 01	-9.017E-01	1.620E 00	1.566E 00	7.629E-02	1.338E 01
27	0.	3.90	0.17	0.30	-7.854E-04	3.714E-04	5.143E-04	-4.745E 01	-1.180E 00	2.599E 00	1.068E 00	-2.480E-01	7.850E 00
28	0.	4.50	0.17	0.30	-6.249E-04	2.682E-04	1.226E-03	-3.787E 01	-2.148E 00	6.957E 00	9.900E-02	-7.801E-01	1.354E 00
29	0.	5.10	0.17	0.30	-3.538E-04	7.557E-05	2.958E-03	-2.179E 01	-4.611E 00	1.748E 01	-1.123E 00	-1.099E 00	-5.193E 00
30	0.	5.70	0.17	0.30	-1.143E-04	-1.549E-04	6.226E-03	-7.900E 00	-9.526E 00	3.718E 01	-1.904E 00	-1.987E 00	-6.264E 00
31	0.	0.30	0.17	0.47	-6.970E-05	-5.609E-06	2.903E-03	-2.321E 00	2.425E-01	1.740E 01	2.789E-01	-1.721E-01	8.899E 00
32	0.	0.90	0.17	0.47	-8.825E-05	1.626E-05	2.139E-03	-3.850E 00	3.306E-01	1.280E 01	6.089E-01	-6.557E-03	2.024E 01
33	0.	1.50	0.17	0.47	-1.549E-04	6.190E-05	1.348E-03	-8.314E 00	3.578E-01	8.010E 00	8.797E-01	5.269E-02	2.392E 01
34	0.	2.10	0.17	0.47	-2.669E-04	1.241E-04	7.430E-04	-1.552E 01	1.140E-01	4.304E 00	1.169E 00	1.141E-01	2.244E 01
35	0.	2.70	0.17	0.47	-3.679E-04	1.781E-04	3.820E-04	-2.190E 01	-5.709E-02	2.073E 00	1.297E 00	8.583E-02	1.824E 01
36	0.	3.30	0.17	0.47	-4.109E-04	2.009E-04	2.453E-04	-2.459E 01	-1.222E-01	1.224E 00	1.055E 00	-4.768E-02	1.212E 01
37	0.	3.90	0.17	0.47	-3.710E-04	1.797E-04	4.017E-04	-2.206E 01	-2.472E-02	2.190E 00	3.277E-01	-2.899E-01	4.505E 00
38	0.	4.50	0.17	0.47	-2.492E-04	1.123E-04	1.084E-03	-1.417E 01	2.926E-01	6.366E 00	-8.144E-01	-6.771E-01	-3.944E 00
39	0.	5.10	0.17	0.47	-9.591E-05	2.014E-05	2.634E-03	-3.712E 00	9.297E-01	1.577E 01	-1.895E 00	-7.515E-01	-1.077E 01
40	0.	5.70	0.17	0.47	-1.614E-05	-5.794E-05	5.228E-03	2.673E 00	1.001E 00	3.141E 01	-1.967E 00	-1.633E 00	-8.722E 00
41	0.	0.30	0.17	0.63	-6.777E-05	1.395E-07	2.143E-03	-2.850E 00	-1.335E-01	1.283E 01	3.006E-01	-2.072E-01	7.679E 00
42	0.	0.90	0.17	0.63	-5.228E-05	1.809E-07	1.673E-03	-2.171E 00	-7.304E-02	1.002E 01	6.591E-01	-7.188E-02	1.868E 01
43	0.	1.50	0.17	0.63	-3.368E-05	2.188E-06	1.109E-03	-1.279E 00	1.559E-01	6.641E 00	9.287E-01	-3.529E-02	2.317E 01
44	0.	2.10	0.17	0.63	-4.072E-05	1.219E-05	6.309E-04	-2.016E 00	1.001E-01	3.766E 00	1.156E 00	-1.788E-03	2.220E 01
45	0.	2.70	0.17	0.63	-5.501E-05	2.296E-05	3.249E-04	-3.098E 00	2.031E-02	1.919E 00	1.160E 00	-3.242E-02	1.754E 01
46	0.	3.30	0.17	0.63	-4.825E-05	2.097E-05	2.136E-04	-2.770E 00	-1.445E-03	1.254E 00	8.102E-01	-1.240E-01	1.037E 01
47	0.	3.90	0.17	0.63	-7.965E-06	-7.870E-08	3.722E-04	-1.939E-01	1.216E-01	2.232E 00	6.924E-03	-2.995E-01	1.529E 00
48	0.	4.50	0.17	0.63	5.175E-05	-3.639E-05	9.840E-04	3.873E 00	3.480E-01	5.946E 00	-1.195E 00	-5.589E-01	-7.619E 00
49	0.	5.10	0.17	0.63	8.224E-05	-6.734E-05	2.249E-03	6.599E 00	6.158E-01	1.357E 01	-2.105E 00	-4.902E-01	-1.357E 01
50	0.	5.70	0.17	0.63	4.201E-05	-8.478E-05	4.128E-03	4.932E 00	-1.396E-01	2.481E 01	-1.873E 00	-1.329E 00	-9.161E 00

```
SUM TILE DEN =    2.18633D-06

P.S. DEN =    1.87988D-06

SUM DEN =    4.06620D-06

OMEGA SQUARED =    7.12655E 06
OMEGA =    2.66956E 03
```

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 1

NODE	DX	DY	DZ	RX	RY	RZ
33	6.681679E-05	-1.673227E-06	1.785551E-01	-5.587914E-05	3.189787E-03	
34	6.680365E-05		1.786259E-01	4.809038E-04	3.191435E-03	
35	5.671559E-05	-1.613901E-06	1.756771E-01	-5.725912E-05	6.399900E-03	
36	5.670004E-05		1.757467E-01	4.751717E-04	6.402336E-03	
37	4.701459E-05	-1.536437E-06	1.708824E-01	-5.781297E-05	9.573631E-03	
38	4.699403E-05		1.709508E-01	4.673784E-04	9.576578E-03	
39	3.779292E-05	-1.429681E-06	1.642013E-01	-5.394027E-05	1.267944E-02	
40	3.776843E-05		1.642683E-01	4.556030E-04	1.268287E-02	
41	2.907454E-05	-1.320172E-06	1.556897E-01	-4.895801E-05	1.566771E-02	
42	2.905251E-05		1.557546E-01	4.377079E-04	1.567218E-02	
43	2.120507E-05	-1.232098E-06	1.454340E-01	-3.918960E-05	1.847837E-02	
44	2.116353E-05		1.454960E-01	4.109822E-04	1.848471E-02	
45	1.428868E-05	-1.067070E-06	1.335610E-01	-3.102203E-05	2.105218E-02	
46	1.423488E-05		1.336186E-01	3.767714E-04	2.106069E-02	
47	8.377575E-06	-8.915556E-07	1.202210E-01	-2.576198E-05	2.336588E-02	
48	8.321829E-06		1.202730E-01	3.377073E-04	2.337612E-02	
49	3.536151E-06	-7.026549E-07	1.055738E-01	-2.197572E-05	2.540788E-02	
50	3.477969E-06		1.056194E-01	2.953170E-04	2.541899E-02	
51	-1.711983E-07	-5.027475E-07	8.978516E-02	-1.980127E-05	2.716987E-02	
52	-2.311038E-07		8.982366E-02	2.503702E-04	2.718170E-02	
53	-2.682518E-06	-2.934773E-07	7.302600E-02	-1.593972E-05	2.863894E-02	
54	-2.743862E-06		7.305735E-02	2.037658E-04	2.865112E-02	
55	-3.945375E-06	-7.611419E-08	5.547747E-02	-1.253485E-05	2.979947E-02	
56	-4.007697E-06		5.550126E-02	1.549640E-04	2.981209E-02	
57	-3.919061E-06	1.474601E-07	3.732768E-02	-8.887214E-06	3.064273E-02	
58	-3.986332E-06		3.734367E-02	1.049516E-04	3.065582E-02	
59	-2.587715E-06	3.967929E-07	1.876834E-02	-5.443265E-06	3.116091E-02	
60	-2.646495E-06		1.877641E-02	5.384142E-05	3.117428E-02	
61		5.462543E-07		1.710423E-06	3.133634E-02	
62				-1.713168E-06	3.134975E-02	

MAXIMUM DEFLECTION = 1.79574E-01 FOR DOF 140

MAXIMUM DEFLECTION DIFFERENCE = 7.54654E-06 FOR DOF 194

MID-POINT PLATE MEMBER STRAINS AND STRESSES FOR ITERATION NO. 1

MEMBER	COORDINATES X	Y	STRAINS EPS X	EPS Y	EPS XY	STRESSES SIG X	SIG Y	SIG XY
1	3.0000E-01	1.6666E-01	-1.1270E-06	2.8437E-07	7.6610E-09	-1.1447E 01	-5.9034E-01	5.4721E-02
2	9.0000E-01	1.6666E-01	-3.0212E-06	8.1109E-07	-1.0723E-08	-3.0526E 01	-1.0468E 00	-7.6596E-02
3	1.5000E 00	1.6666E-01	-4.9522E-06	1.4223E-06	5.0875E-10	-4.9731E 01	-6.9658E-01	3.6339E-03
4	2.1000E 00	1.6666E-01	-6.8412E-06	1.9951E-06	-4.9761E-10	-6.8601E 01	-6.2947E-01	-3.5543E-03
5	2.7000E 00	1.6666E-01	-8.6617E-06	2.5449E-06	9.8254E-10	-8.6794E 01	-5.8923E-01	7.0181E-03
6	3.3000E 00	1.6666E-01	-1.0390E-05	3.0682E-06	2.7056E-09	-1.0406E 02	-5.3562E-01	1.9326E-02
7	3.9000E 00	1.6666E-01	-1.2010E-05	3.5613E-06	4.5449E-09	-1.2024E 02	-4.5776E-01	3.2463E-02
8	4.5000E 00	1.6666E-01	-1.3517E-05	4.0194E-06	6.7660E-09	-1.3529E 02	-3.9400E-01	4.8329E-02
9	5.1000E 00	1.6666E-01	-1.4923E-05	4.4374E-06	3.0466E-09	-1.4936E 02	-4.3319E-01	2.1761E-02
10	5.7000E 00	1.6666E-01	-1.6246E-05	4.7443E-06	1.6097E-08	-1.6289E 02	-1.4233E 00	1.1498E-01
11	6.3000E 00	1.6666E-01	-1.7193E-05	4.9652E-06	-4.2749E-09	-1.7257E 02	-2.1183E 00	-3.0535E-02
12	6.9000E 00	1.6666E-01	-1.7465E-05	5.1359E-06	-1.0357E-08	-1.7499E 02	-1.1392E 00	-7.3980E-02
13	7.5000E 00	1.6666E-01	-1.7671E-05	5.2154E-06	-9.4432E-09	-1.7699E 02	-9.4382E-01	-6.7451E-02
14	8.1000E 00	1.6666E-01	-1.7738E-05	5.2276E-06	-7.2482E-09	-1.7769E 02	-1.0326E 00	-5.1773E-02
15	8.7000E 00	1.6666E-01	-1.7630E-05	5.1821E-06	-4.0846E-09	-1.7666E 02	-1.1764E 00	-2.9176E-02
16	9.3000E 00	1.6666E-01	-1.7330E-05	5.0826E-06	-4.9312E-10	-1.7368E 02	-1.2776E 00	-3.5223E-03
17	9.9000E 00	1.6666E-01	-1.6837E-05	4.9307E-06	3.1968E-09	-1.6877E 02	-1.3237E 00	2.2834E-02
18	1.0500E 01	1.6666E-01	-1.6173E-05	4.7256E-06	5.1882E-09	-1.6214E 02	-1.3868E 00	3.7058E-02
19	1.1100E 01	1.6666E-01	-1.5373E-05	4.4492E-06	1.0692E-08	-1.5426E 02	-1.7868E 00	7.6369E-02
20	1.1700E 01	1.6666E-01	-1.4529E-05	4.1248E-06	1.0737E-08	-1.4606E 02	-2.5688E 00	7.6691E-02
21	1.2300E 01	1.6666E-01	-1.3132E-05	3.8284E-06	-1.0975E-08	-1.3169E 02	-1.2216E 00	-7.8394E-02
22	1.2900E 01	1.6666E-01	-1.1538E-05	3.4488E-06	-2.7438E-09	-1.1542E 02	-1.3707E-01	-1.9598E-02
23	1.3500E 01	1.6666E-01	-9.8535E-06	2.9380E-06	-9.0353E-09	-9.8594E 01	-1.9858E-01	-6.4538E-02
24	1.4100E 01	1.6666E-01	-8.0711E-06	2.3913E-06	-6.7381E-09	-8.0809E 01	-3.2947E-01	-4.8129E-02
25	1.4700E 01	1.6666E-01	-6.1804E-06	1.8081E-06	-5.2718E-09	-6.1955E 01	-5.0534E-01	-3.7656E-02

PROGRAM LISTING OF INPUT DATA CARDS

```
.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

SAMPLE PROBLEM II  -  STATICS COLD SOAK
    AUGUST 21, 1974
    1                        3        0.         7
    2    1    1         1    1    0    0    0
   0
   6.66667   .33333     .75
        .4
         1         1
                       1.16667   .16667       .05
        10    1         7
     10.E6        .3             13.1E-6
         0
     60.E3     60.E3      6.E3        .5        .1       .01
     20.E3     32.E3     32.E3                   1.E-6     1.E-6     1.E-6
       90.       .49             271.E-6
                  1.        1.
    1
       70.     60.E3
    1
       70.      6.E3
    1
       70.     32.E3
    1
       70.        .5
    1
       70.       .01
    1
       70.   .347E-6
    1
       70.        0.
    1
       70.        0.
    1
       70.        0.
A2                            0                            0          0
B2                            2                            0          0
C0                           .0
D0                            4
         0.        0.        0.        0.        0.        0.        0.        0.
     -325.
    1    1        70.
     -325.

.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
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O P T I O N S

STATICS PROBLEM

MAXIMUM NO. ITERATIONS = 3 CONVERGENCE PARAMETER = 0.0

PRIMARY STRUCTURE STRESSES PRESENTED AFTER EACH ITERATION AT PLATE MID, TOP AND BOTTOM SURFACES

TILES ON PRIMARY STRUCTURE

TILE STRESSES PRESENTED AFTER LAST ITERATION

TILE NODE MAP NOT REQUIRED

TILE ELEMENT MAP REQUIRED

TILE NODE COORDINATES REQUIRED

DO NOT PRINT ELEMENT STIFFNESS MATRICES

DO NOT PRINT ASSEMBLED STIFFNESS MATRICES

DO NOT PRINT FILE DEBUGGING INFORMATION

COMPUTE STRESSES FOR ALL TILES

GEOMETRY

PLATE	LX = 6.66667E 00	LY = 3.33330E-01	TP = 7.50000E-01	
STRINGERS	YI = 4.00000E-01	ZS = 0.0	YS = 0.0	AS = 0.0
	IY' = 0.0	IZ' = 0.0	JX' = 0.0	BETA S = 0.0
TILES	NXB = 1	NYB = 1		
	T = 0.0	B1 = 0.0	T2 = 1.16667E 00	
	TA = 1.66670E-01	TI = 5.00000E-02	TC = 0.0	
BRICK	NB1 = 0	NB2 = 10	ND2 = 1	
	NT1 = 0	NT2 = 7		

MATERIAL PROPERTIES

PLATE	EP = 1.00000E 07	NU P = 3.00000E-01	GAMMA P = 0.0	ALPHA P = 1.31000E-05
STRINGERS	ES = 0.0	NU S = 0.0	GAMMA S = 0.0	ALPHA P = 0.0
ARRESTOR OR RSI	EX = 6.00000E 04	EY = 6.00000E 04	EZ = 6.00000E 03	
	NU XY = 5.00000E-01	NU YZ = 1.00000E-01	NU ZX = 1.00000E-02	
	GXY = 2.00000E 04	GYZ = 3.20000E 04	GZX = 3.20000E 04	
	GAMMA A = 0.0			
	ALPHA X = 9.99999E-07	ALPHA Y = 9.99999E-07	ALPHA Z = 9.99999E-07	
ISOLATOR	EI = 9.00000E 01	NU I = 4.90000E-01	GAMMA I = 0.0	ALPHA I = 2.71000E-04
RSI	GAMMA R = 0.0			
		ALPHA RY / ALPHA RX = 1.00000E 00		ALPHA RZ / ALPHA RX = 1.00000E 00

TEMPERATURE DEPENDENT MATERIAL PROPERTIES

		TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY
1	ER	ALL	6.000E 04						
1	ER'	ALL	6.000E 03						
1	GR'	ALL	3.200E 04						
1	NU R	ALL	5.000E-01						
1	NU R'	ALL	1.000E-02						
1	ALPHA R	ALL	3.470E-07						
1	EC	ALL	0.0						
1	NU C	ALL	0.0						
1	ALPHA C	ALL	0.0						

BOUNDARY CONDITIONS

EDGE	PLATE OUT OF PLANE	PLATE IN PLANE	STRINGERS	
A	PINNED	FREE	FREE	FREE
B	PINNED	U HELD, V FREE	FREE	FREE
C	FREE	FREE		
D	FREE	V HELD, U FREE		

STATIC LOADING

NX = 0.0 NY = 0.0 NXY = 0.0 NYX = 0.0

PZ = 0.0 T = 0.0 M = 0.0 V = 0.0

DEL TEMP P = -3.25000E 02 DEL TEMP S = 0.0

RST TEMPERATURES

STATIC THERMAL LOADING

UNIFORM TEMPERATURE OPTION

T REFERENCE = 7.0000E 01

DEL T U = T - T REF = -3.2500E 02

ELEMENT MAP

LAYER 1
RSI

81	82	83	84	85	86	87	88	89	90

TILE MESH ELEMENT	TILE NODES			
1	1	2	24	23
	3	4	26	25
2	3	4	26	25
	5	6	28	27
3	5	6	28	27
	7	8	30	29
4	7	8	30	29
	9	10	32	31
5	9	10	32	31
	11	12	34	33
6	11	12	34	33
	13	14	36	35
7	13	14	36	35
	15	16	38	37
8	15	16	38	37
	17	18	40	39
9	17	18	40	39
	19	20	42	41
10	19	20	42	41
	21	22	44	43
11	23	24	46	45
	25	26	48	47
12	25	26	48	47
	27	28	50	49
13	27	28	50	49
	29	30	52	51
14	29	30	52	51
	31	32	54	53
15	31	32	54	53
	33	34	56	55
16	33	34	56	55
	35	36	58	57
17	35	36	58	57
	37	38	60	59
18	37	38	60	59
	39	40	62	61
19	39	40	62	61
	41	42	64	63

NODE	LOCAL TILE COORDINATES X	Y	Z	TEMPERATURE
1	0.0	0.0	0.0	-3.25000E 02
2	0.0	3.33330E-01	0.0	-3.25000E 02
3	6.66667E-01	0.0	0.0	-3.25000E 02
4	6.66667E-01	3.33330E-01	0.0	-3.25000E 02
5	1.33333E 00	0.0	0.0	-3.25000E 02
6	1.33333E 00	3.33330E-01	0.0	-3.25000E 02
7	2.00000E 00	0.0	0.0	-3.25000E 02
8	2.00000E 00	3.33330E-01	0.0	-3.25000E 02
9	2.66667E 00	0.0	0.0	-3.25000E 02
10	2.66667E 00	3.33330E-01	0.0	-3.25000E 02
11	3.33333E 00	0.0	0.0	-3.25000E 02
12	3.33333E 00	3.33330E-01	0.0	-3.25000E 02
13	4.00000E 00	0.0	0.0	-3.25000E 02
14	4.00000E 00	3.33330E-01	0.0	-3.25000E 02
15	4.66667E 00	0.0	0.0	-3.25000E 02
16	4.66667E 00	3.33330E-01	0.0	-3.25000E 02
17	5.33334E 00	0.0	0.0	-3.25000E 02
18	5.33334E 00	3.33330E-01	0.0	-3.25000E 02
19	6.00000E 00	0.0	0.0	-3.25000E 02
20	6.00000E 00	3.33330E-01	0.0	-3.25000E 02
21	6.66667E 00	0.0	0.0	-3.25000E 02
22	6.66667E 00	3.33330E-01	0.0	-3.25000E 02
23	0.0	0.0	5.00000E-02	-3.25000E 02
24	0.0	3.33330E-01	5.00000E-02	-3.25000E 02
25	6.66667E-01	0.0	5.00000E-02	-3.25000E 02
26	6.66667E-01	3.33330E-01	5.00000E-02	-3.25000E 02
27	1.33333E 00	0.0	5.00000E-02	-3.25000E 02
28	1.33333E 00	3.33330E-01	5.00000E-02	-3.25000E 02
29	2.00000E 00	0.0	5.00000E-02	-3.25000E 02
30	2.00000E 00	3.33330E-01	5.00000E-02	-3.25000E 02
31	2.66667E 00	0.0	5.00000E-02	-3.25000E 02
32	2.66667E 00	3.33330E-01	5.00000E-02	-3.25000E 02
33	3.33333E 00	0.0	5.00000E-02	-3.25000E 02
34	3.33333E 00	3.33330E-01	5.00000E-02	-3.25000E 02
35	4.00000E 00	0.0	5.00000E-02	-3.25000E 02
36	4.00000E 00	3.33330E-01	5.00000E-02	-3.25000E 02
37	4.66667E 00	0.0	5.00000E-02	-3.25000E 02
38	4.66667E 00	3.33330E-01	5.00000E-02	-3.25000E 02
39	5.33334E 00	0.0	5.00000E-02	-3.25000E 02
40	5.33334E 00	3.33330E-01	5.00000E-02	-3.25000E 02
41	6.00000E 00	0.0	5.00000E-02	-3.25000E 02
42	6.00000E 00	3.33330E-01	5.00000E-02	-3.25000E 02
43	6.66667E 00	0.0	5.00000E-02	-3.25000E 02
44	6.66667E 00	3.33330E-01	5.00000E-02	-3.25000E 02
45	0.0	0.0	2.16670E-01	-3.25000E 02
46	0.0	3.33330E-01	2.16670E-01	-3.25000E 02
47	6.66667E-01	0.0	2.16670E-01	-3.25000E 02
48	6.66667E-01	3.33330E-01	2.16670E-01	-3.25000E 02
49	1.33333E 00	0.0	2.16670E-01	-3.25000E 02
50	1.33333E 00	3.33330E-01	2.16670E-01	-3.25000E 02

PRIMARY STRUCTURE
GLOBAL GEOMETRY

NODE	X	Y	Z
1	0.0	0.0	0.0
2	0.0	3.333300E-01	0.0
3	6.666670E-01	0.0	0.0
4	6.666670E-01	3.333300E-01	0.0
5	1.333334E 00	0.0	0.0
6	1.333334E 00	3.333300E-01	0.0
7	2.000001E 00	0.0	0.0
8	2.000001E 00	3.333300E-01	0.0
9	2.666668E 00	0.0	0.0
10	2.666668E 00	3.333300E-01	0.0
11	3.333335E 00	0.0	0.0
12	3.333335E 00	3.333300E-01	0.0
13	4.000002E 00	0.0	0.0
14	4.000002E 00	3.333300E-01	0.0
15	4.666669E 00	0.0	0.0
16	4.666669E 00	3.333300E-01	0.0
17	5.333336E 00	0.0	0.0
18	5.333336E 00	3.333300E-01	0.0
19	6.000003E 00	0.0	0.0
20	6.000003E 00	3.333300E-01	0.0
21	6.666670E 00	0.0	0.0
22	6.666670E 00	3.333300E-01	0.0

DEGREES OF FREEDOM

DX	DY	DZ	RX	RY	RZ
1	2	0	3	4	0
5	0	0	6	7	0
8	9	10	11	12	0
13	0	14	15	16	0
17	18	19	20	21	0
22	0	23	24	25	0
26	27	28	29	30	0
31	0	32	33	34	0
35	36	37	38	39	0
40	0	41	42	43	0
44	45	46	47	48	0
49	0	50	51	52	0
53	54	55	56	57	0
58	0	59	60	61	0
62	63	64	65	66	0
67	0	68	69	70	0
71	72	73	74	75	0
76	0	77	78	79	0
80	81	82	83	84	0
85	0	86	87	88	0
0	89	0	90	91	0
0	0	0	92	93	0

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 1

NODE	DX	DY	DZ	RX	RY	RZ
1	2.838170E-02	1.419157E-03		0.0	0.0	
2	2.838172E-02			0.0	0.0	
3	2.554341E-02	1.419158E-03	0.0	0.0	0.0	
4	2.554342E-02		0.0	0.0	0.0	
5	2.270516E-02	1.419166E-03	0.0	0.0	0.0	
6	2.270516E-02		0.0	0.0	0.0	
7	1.986694E-02	1.419171E-03	0.0	0.0	0.0	
8	1.986694E-02		0.0	0.0	0.0	
9	1.702876E-02	1.419175E-03	0.0	0.0	0.0	
10	1.702876E-02		0.0	0.0	0.0	
11	1.419059E-02	1.419178E-03	0.0	0.0	0.0	
12	1.419060E-02		0.0	0.0	0.0	
13	1.135245E-02	1.419182E-03	0.0	0.0	0.0	
14	1.135246E-02		0.0	0.0	0.0	
15	8.514322E-03	1.419182E-03	0.0	0.0	0.0	
16	8.514334E-03		0.0	0.0	0.0	
17	5.676214E-03	1.419185E-03	0.0	0.0	0.0	
18	5.676214E-03		0.0	0.0	0.0	
19	2.839105E-03	1.419186E-03	0.0	0.0	0.0	
20	2.839105E-03		0.0	0.0	0.0	
21		1.419186E-03		0.0	0.0	
22				0.0	0.0	

PRIMARY STRUCTURE NODES ASSOCIATED WITH TILE NO. 1

1	3	5	7	9	11	13	15	17	19	21
2	4	6	8	10	12	14	16	18	20	22

MID-POINT PLATE MEMBER STRAINS AND STRESSES FOR ITERATION NO. 1

MEMBER	COORDINATES X	COORDINATES Y	STRAINS EPS X	STRAINS EPS Y	STRAINS EPS XY	STRESSES SIG X	STRESSES SIG Y	STRESSES SIG XY
1	3.3333E-01	1.6666E-01	-4.2574E-03	-4.2575E-03	2.5495E-08	6.5625E-01	8.2031E-02	1.8211E-01
2	1.0000E 00	1.6666E-01	-4.2574E-03	-4.2575E-03	1.4232E-08	1.3516E 00	1.6406E-01	1.0166E-01
3	1.6667E 00	1.6666E-01	-4.2573E-03	-4.2575E-03	1.8335E-09	1.8008E 00	8.2031E-02	1.3097E-02
4	2.3333E 00	1.6666E-01	-4.2573E-03	-4.2576E-03	7.0723E-09	2.3750E 00	1.2500E-01	5.0516E-02
5	3.0000E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	1.2049E-08	2.6211E 00	1.2500E-01	8.6065E-02
6	3.6667E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	1.5629E-08	2.9063E 00	8.2031E-02	1.1163E-01
7	4.3333E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	1.6939E-08	3.2344E 00	1.2500E-01	1.2099E-01
8	5.0000E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	9.5170E-09	3.3555E 00	1.2500E-01	6.7979E-02
9	5.6667E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	1.7462E-10	3.5195E 00	8.2031E-02	1.2473E-03
10	6.3333E 00	1.6666E-01	-4.2572E-03	-4.2576E-03	8.7311E-11	3.5195E 00	8.2031E-02	6.2365E-04

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 2

NODE	DX	DY	DZ	RX	RY	RZ
1	2.837436E-02	1.419182E-03		1.110410E-08	-4.857246E-05	
2	2.837437E-02			-1.107075E-08	-4.856790E-05	
3	2.553628E-02	1.419224E-03	3.204057E-05	-2.494943E-07	-4.696766E-05	
4	2.553628E-02		3.203745E-05	2.304330E-07	-4.696350E-05	
5	2.269858E-02	1.419286E-03	6.173004E-05	-6.444173E-07	-4.118166E-05	
6	2.269857E-02		6.172433E-05	6.098011E-07	-4.117824E-05	
7	1.986120E-02	1.419325E-03	8.592271E-05	-9.869391E-07	-3.059379E-05	
8	1.986119E-02		8.591506E-05	9.408456E-07	-3.059104E-05	
9	1.702403E-02	1.419350E-03	1.017259E-04	-1.215332E-06	-1.628358E-05	
10	1.702403E-02		1.017165E-04	1.158402E-06	-1.628164E-05	
11	1.413696E-02	1.419358E-03	1.072070E-04	-1.294960E-06	2.458277E-08	
12	1.413696E-02		1.071368E-04	1.233488E-06	2.492761E-08	
13	1.134991E-02	1.419356E-03	1.016948E-04	-1.215301E-06	1.632443E-05	
14	1.134991E-02		1.016850E-04	1.155909E-06	1.632320E-05	
15	8.512773E-03	1.419335E-03	8.587058E-05	-9.875703E-07	3.061576E-05	
16	8.512788E-03		8.586222E-05	9.369464E-07	3.061310E-05	
17	5.675480E-03	1.419303E-03	6.167241E-05	-6.426225E-07	4.117301E-05	
18	5.675491E-03		6.166630E-05	6.055278E-07	4.116938E-05	
19	2.837912E-03	1.419248E-03	3.200154E-05	-2.472392E-07	4.692137E-05	
20	2.837926E-03		3.199824E-05	2.270913E-07	4.691687E-05	
21		1.419209E-03		1.092928E-08	4.850829E-05	
22				-1.089510E-08	4.850344E-05	

MAXIMUM DEFLECTION = 2.83744E-02 FOR DOF 5

MAXIMUM DEFLECTION DIFFERENCE = 1.07207E-04 FOR DOF 46

MAXIMUM CONVERGENCE PARAMETER = 3.77830E-03

SOLUTION HAS NOT CONVERGED

TPS DISPLACEMENTS FOR TILE NO. 1 AND ITERATION NO. 3

NODE	X COMPONENT(U)	Y COMPONENT(V)	Z COMPONENT(W)
1	2.8356735E-02	1.4191780E-03	0.0
2	2.8356742E-02	4.0737547E-09	0.0
3	2.5519237E-02	1.4193156E-03	3.1108400E-05
4	2.5519237E-02	-8.4500016E-08	3.1105301E-05
5	2.2683658E-02	1.4195214E-03	5.9920829E-05
6	2.2683650E-02	-2.2263924E-07	5.9915212E-05
7	1.9850120E-02	1.4196830E-03	8.3383013E-05
8	1.9850120E-02	-3.4235200E-07	8.3375431E-05
9	1.7018143E-02	1.4197913E-03	9.8699835E-05
10	1.7018139E-02	-4.2083934E-07	9.8690522E-05
11	1.4186997E-02	1.4198280E-03	1.0401016E-04
12	1.4186997E-02	-4.4781825E-07	1.0400009E-04
13	1.1355862E-02	1.4197964E-03	9.8668752E-05
14	1.1355866E-02	-4.1985641E-07	9.8659031E-05
15	8.5239187E-03	1.4196937E-03	8.3330786E-05
16	8.5239336E-03	-3.4091357E-07	8.3322491E-05
17	5.6904666E-03	1.4195368E-03	5.9863130E-05
18	5.6904779E-03	-2.2099863E-07	5.9857077E-05
19	2.8549971E-03	1.4193379E-03	3.1069256E-05
20	2.8550087E-03	-8.3249518E-08	3.1065982E-05
21	1.7662009E-05	1.4192052E-03	0.0
22	1.7660204E-05	4.0019721E-09	0.0
23	1.5587583E-02	7.6064793E-04	-1.2956962E-02
24	1.5587766E-02	6.7323772E-04	-1.2960125E-02
25	1.5338384E-02	7.7265571E-04	-1.2648195E-02
26	1.5338622E-02	6.6036545E-04	-1.2651250E-02
27	1.5057739E-02	7.7850767E-04	-1.2551006E-02
28	1.5057940E-02	6.5354165E-04	-1.2553982E-02
29	1.4790334E-02	7.8239455E-04	-1.2500148E-02
30	1.4790516E-02	6.4887037E-04	-1.2503054E-02
31	1.4522307E-02	7.8311702E-04	-1.2469962E-02
32	1.4522433E-02	6.4758677E-04	-1.2472779E-02
33	1.4252145E-02	7.8328699E-04	-1.2460098E-02
34	1.4252219E-02	6.4697629E-04	-1.2462813E-02
35	1.3981856E-02	7.8261830E-04	-1.2470119E-02
36	1.3981912E-02	6.4715929E-04	-1.2472767E-02
37	1.3713460E-02	7.8135147E-04	-1.2500532E-02
38	1.3713501E-02	6.4798188E-04	-1.2503073E-02
39	1.3445472E-02	7.7666598E-04	-1.2551751E-02
40	1.3445560E-02	6.5199099E-04	-1.2554195E-02
41	1.3163764E-02	7.6972460E-04	-1.2649726E-02
42	1.3164002E-02	6.5793912E-04	-1.2652103E-02
43	1.2913782E-02	7.5655989E-04	-1.2960803E-02
44	1.2914129E-02	6.6979486E-04	-1.2963068E-02
45	1.5435152E-02	7.4291974E-04	-1.3182126E-02
46	1.5435338E-02	6.9463020E-04	-1.3186198E-02
47	1.5249137E-02	7.4337330E-04	-1.2763843E-02
48	1.5249390E-02	6.9318269E-04	-1.2767781E-02
49	1.5013330E-02	7.4224360E-04	-1.2597803E-02
50	1.5013553E-02	6.9324533E-04	-1.2601636E-02

STRESSES FOR ISOLATOR AND ARRESTOR FOR TILE NO. 1 AND ITERATION NO. 3

	LOCAL COORDINATES			STRESSES					
	X	Y	Z	XX	YY	ZZ	XY	YZ	ZX
			ELEMENT NUMBER	1					
1	5.2578E-01	2.6289E-01	3.9434E-02	1.5710E 01	1.5712E 01	3.9111E-01	-2.5630E-04	2.3283E-01	-6.4684E 00
2	5.2578E-01	7.0441E-02	3.9434E-02	1.5762E 01	1.5765E 01	4.4556E-01	2.5833E-04	-2.2482E-01	-6.4685E 00
3	1.4088E-01	2.6289E-01	3.9434E-02	1.1014E 01	1.1019E 01	-4.4983E 00	-2.5844E-04	2.3546E-01	-7.3711E 00
4	1.4088E-01	7.0441E-02	3.9434E-02	1.1068E 01	1.1073E 01	-4.4426E 00	2.5608E-04	-2.2715E-01	-7.3712E 00
5	5.2578E-01	2.6289E-01	1.0566E-02	8.8938E 00	8.3943E 00	-6.2898E 00	-7.0354E-05	2.3299E-01	-6.4757E 00
6	5.2578E-01	7.0441E-02	1.0566E-02	8.9462E 00	8.9467E 00	-6.2353E 00	7.1774E-05	-2.2466E-01	-6.4758E 00
7	1.4088E-01	2.6289E-01	1.0566E-02	4.1617E 00	4.1628E 00	-1.1216E 01	-7.0902E-05	2.3563E-01	-7.3784E 00
8	1.4088E-01	7.0441E-02	1.0566E-02	4.2153E 00	4.2165E 00	-1.1160E 01	7.1195E-05	-2.2699E-01	-7.3784E 00
			ELEMENT NUMBER	2					
1	1.1925E 00	2.6269E-01	3.9434E-02	1.8934E 01	1.8937E 01	3.7536E 00	-1.3370E-04	2.2992E-01	-4.9285E 00
2	1.1925E 00	7.0441E-02	3.9434E-02	1.8986E 01	1.8988E 01	3.8067E 00	1.2957E-04	-2.2252E-01	-4.9286E 00
3	8.0755E-01	2.6289E-01	3.9434E-02	1.7791E 01	1.7795E 01	2.5626E 00	-1.3235E-04	2.3134E-01	-5.8195E 00
4	8.0755E-01	7.0441E-02	3.9434E-02	1.7843E 01	1.7846E 01	2.6164E 00	1.3126E-04	-2.2358E-01	-5.8196E 00
5	1.1925E 00	2.6289E-01	1.0566E-02	1.2201E 01	1.2201E 01	-2.8461E 00	-3.8826E-05	2.3008E-01	-4.9303E 00
6	1.1925E 00	7.0441E-02	1.0566E-02	1.2252E 01	1.2253E 01	-2.7928E 00	3.8103E-05	-2.2236E-01	-4.9304E 00
7	8.0755E-01	2.6289E-01	1.0566E-02	1.1039E 01	1.1040E 01	-4.0554E 00	-3.8010E-05	2.3150E-01	-5.8213E 00
8	8.0755E-01	7.0441E-02	1.0566E-02	1.1091E 01	1.1092E 01	-4.0015E 00	3.8951E-05	-2.2342E-01	-5.8214E 00
			ELEMENT NUMBER	3					
1	1.8591E 00	2.6289E-01	3.9434E-02	1.9995E 01	1.9995E 01	4.8571E 00	-8.9503E-05	2.2807E-01	-3.3817E 00
2	1.8591E 00	7.0441E-02	3.9434E-02	2.0045E 01	2.0045E 01	4.9088E 00	8.8453E-05	-2.2118E-01	-3.3817E 00
3	1.4742E 00	2.6289E-01	3.9434E-02	1.9544E 01	1.9545E 01	4.3867E 00	-8.8828E-05	2.2905E-01	-4.2765E 00
4	1.4742E 00	7.0441E-02	3.9434E-02	1.9594E 01	1.9595E 01	4.4392E 00	8.9128E-05	-2.2188E-01	-4.2766E 00
5	1.8591E 00	2.6289E-01	1.0566E-02	1.3270E 01	1.3270E 01	-1.7334E 00	-2.6462E-05	2.2823E-01	-3.3824E 00
6	1.8591E 00	7.0441E-02	1.0566E-02	1.3320E 01	1.3320E 01	-1.6818E 00	2.6609E-05	-2.2103E-01	-3.3824E 00
7	1.4742E 00	2.6289E-01	1.0566E-02	1.2807E 01	1.2807E 01	-2.2163E 00	-2.6672E-05	2.2920E-01	-4.2773E 00
8	1.4742E 00	7.0441E-02	1.0566E-02	1.2857E 01	1.2857E 01	-2.1638E 00	2.6465E-05	-2.2172E-01	-4.2773E 00
			ELEMENT NUMBER	4					
1	2.5258E 00	2.6289E-01	3.9434E-02	2.0503E 01	2.0503E 01	5.3864E 00	-2.1043E-05	2.2733E-01	-1.8335E 00
2	2.5258E 00	7.0441E-02	3.9434E-02	2.0551E 01	2.0551E 01	5.4366E 00	2.1278E-05	-2.2082E-01	-1.8336E 00
3	2.1409E 00	2.6289E-01	3.9434E-02	2.0252E 01	2.0252E 01	5.1250E 00	-1.8680E-05	2.2761E-01	-2.7276E 00
4	2.1409E 00	7.0441E-02	3.9434E-02	2.0301E 01	2.0301E 01	5.1761E 00	2.3528E-05	-2.2090E-01	-2.7277E 00
5	2.5258E 00	2.6289E-01	1.0566E-02	1.3789E 01	1.3789E 01	-1.1932E 00	-7.4484E-06	2.2748E-01	-1.8339E 00
6	2.5258E 00	7.0441E-02	1.0566E-02	1.3838E 01	1.3837E 01	-1.1431E 00	7.4247E-06	-2.2067E-01	-1.8340E 00
7	2.1409E 00	2.6289E-01	1.0566E-02	1.3536E 01	1.3535E 01	-1.4574E 00	-6.8578E-06	2.2776E-01	-2.7280E 00
8	2.1409E 00	7.0441E-02	1.0566E-02	1.3585E 01	1.3584E 01	-1.4063E 00	8.2584E-06	-2.2075E-01	-2.7281E 00
			ELEMENT NUMBER	5					
1	3.1924E 00	2.6289E-01	3.9434E-02	2.0698E 01	2.0697E 01	5.5891E 00	-9.6340E-06	2.2703E-01	-2.8710E-01
2	3.1924E 00	7.0441E-02	3.9434E-02	2.0744E 01	2.0744E 01	5.6376E 00	6.6029E-06	-2.2079E-01	-2.8712E-01
3	2.8075E 00	2.6289E-01	3.9434E-02	2.0620E 01	2.0620E 01	5.5086E 00	-7.8339E-06	2.2717E-01	-1.1802E 00
4	2.8075E 00	7.0441E-02	3.9434E-02	2.0668E 01	2.0667E 01	5.5582E 00	8.7405E-06	-2.2079E-01	-1.1802E 00
5	3.1924E 00	2.6289E-01	1.0566E-02	1.3990E 01	1.3989E 01	-9.8430E-01	-3.5045E-06	2.2717E-01	-2.8722E-01
6	3.1924E 00	7.0441E-02	1.0566E-02	1.4037E 01	1.4036E 01	-9.3584E-01	2.1825E-06	-2.2065E-01	-2.8724E-01
7	2.8075E 00	2.6289E-01	1.0566E-02	1.3912E 01	1.3911E 01	-1.0660E 00	-2.9841E-06	2.2732E-01	-1.1803E 00
8	2.8075E 00	7.0441E-02	1.0566E-02	1.3959E 01	1.3959E 01	-1.0164E 00	2.7209E-06	-2.2064E-01	-1.1803E 00

STRESSES AND DIRECT STRAINS FOR TILE NO. 1 AND ITERATION NO. 3

MEM	TEMP	LOCAL COORDINATES X	Y	Z	* STRAINS XX	YY	ZZ	* STRESSES XX	YY	ZZ	XY	YZ	ZX *
1	-325.	0.33	0.17	0.02	-2.315E-03	-2.279E-03	-2.564E-01	9.971E 00	9.973E 00	-5.376E 00	4.430E-07	4.162E-03	-6.923E 00
2	-325.	1.00	0.17	0.02	-2.337E-03	-2.307E-03	-2.529E-01	1.502E 01	1.502E 01	-1.196E-01	-5.625E-07	3.872E-03	-5.375E 00
3	-325.	1.67	0.17	0.02	-2.326E-03	-2.324E-03	-2.520E-01	1.643E 01	1.643E 01	1.349E 00	-7.735E-08	3.593E-03	-3.830E 00
4	-325.	2.33	0.17	0.02	-2.325E-03	-2.332E-03	-2.516E-01	1.704E 01	1.704E 01	1.990E 00	7.876E-07	3.383E-03	-2.281E 00
5	-325.	3.00	0.17	0.02	-2.326E-03	-2.334E-03	-2.514E-01	1.733E 01	1.733E 01	2.286E 00	-6.610E-07	3.229E-03	-7.337E-01
6	-325.	3.67	0.17	0.02	-2.326E-03	-2.334E-03	-2.514E-01	1.733E 01	1.733E 01	2.286E 00	-2.496E-06	3.092E-03	8.124E-01
7	-325.	4.33	0.17	0.02	-2.325E-03	-2.332E-03	-2.516E-01	1.704E 01	1.704E 01	1.987E 00	-2.890E-06	2.960E-03	2.359E 00
8	-325.	5.00	0.17	0.02	-2.326E-03	-2.323E-03	-2.520E-01	1.642E 01	1.642E 01	1.341E 00	-3.417E-06	2.805E-03	3.908E 00
9	-325.	5.67	0.17	0.02	-2.338E-03	-2.307E-03	-2.529E-01	1.499E 01	1.500E 01	-1.440E-01	-3.052E-06	2.572E-03	5.453E 00
10	-325.	6.33	0.17	0.02	-2.315E-03	-2.278E-03	-2.564E-01	9.904E 00	9.907E 00	-5.445E 00	-2.173E-06	2.244E-03	7.001E 00
11	-325.	0.33	0.17	0.13	-3.264E-04	-2.236E-04	-1.025E-03	1.280E 00	2.803E 00	-3.919E 00	-1.090E-03	4.053E-03	-5.748E 00
12	-325.	1.00	0.17	0.13	-3.874E-04	-2.523E-04	-4.899E-04	-2.601E 00	2.297E 00	-7.626E-01	-1.588E-03	3.457E-03	-6.509E 00
13	-325.	1.67	0.17	0.13	-3.888E-04	-2.692E-04	-2.060E-04	-2.163E 00	3.311E 00	1.043E 00	-6.566E-04	3.457E-03	-3.888E 00
14	-325.	2.33	0.17	0.13	-3.913E-04	-2.793E-04	-9.189E-05	-2.304E 00	3.315E 00	1.728E 00	-2.841E-04	3.576E-03	-2.252E 00
15	-325.	3.00	0.17	0.13	-3.948E-04	-2.820E-04	-4.342E-05	-2.485E 00	3.364E 00	2.023E 00	-1.690E-03	3.695E-03	-7.064E-01
16	-325.	3.67	0.17	0.13	-3.950E-04	-2.819E-04	-4.357E-05	-2.495E 00	3.363E 00	2.022E 00	-3.353E-03	3.338E-03	8.361E-01
17	-325.	4.33	0.17	0.13	-3.918E-04	-2.790E-04	-9.254E-05	-2.335E 00	3.314E 00	1.724E 00	-3.544E-03	2.980E-03	2.380E 00
18	-325.	5.00	0.17	0.13	-3.896E-04	-2.686E-04	-2.078E-04	-2.213E 00	3.310E 00	1.032E 00	-3.818E-03	2.742E-03	4.013E 00
19	-325.	5.67	0.17	0.13	-3.885E-04	-2.514E-04	-4.947E-04	-2.676E 00	2.287E 00	-7.920E-01	-2.240E-03	1.907E-03	6.642E 00
20	-325.	6.33	0.17	0.13	-3.273E-04	-2.224E-04	-1.034E-03	1.213E 00	2.787E 00	-3.977E 00	-1.364E-03	2.980E-03	5.857E 00
21	-325.	0.33	0.17	0.30	-2.380E-04	-1.005E-04	-4.711E-04	-9.988E 00	-4.439E 00	-2.295E 00	-2.021E-03	2.980E-03	-3.986E 00
22	-325.	1.00	0.17	0.30	-3.212E-04	-8.401E-05	-2.611E-04	-1.575E 01	-6.259E 00	-1.110E 00	-1.639E-03	3.219E-03	-5.603E 00
23	-325.	1.67	0.17	0.30	-3.582E-04	-7.308E-05	1.225E-05	-1.795E 01	-6.541E 00	5.053E-01	-7.451E-04	2.980E-03	-3.971E 00
24	-325.	2.33	0.17	0.30	-3.681E-04	-7.187E-05	1.521E-04	-1.853E 01	-6.675E 00	1.337E 00	-1.495E-03	3.099E-03	-2.166E 00
25	-325.	3.00	0.17	0.30	-3.725E-04	-7.136E-05	2.035E-04	-1.879E 01	-6.748E 00	1.642E 00	-1.937E-03	3.219E-03	-6.657E-01
26	-325.	3.67	0.17	0.30	-3.727E-04	-7.129E-05	2.034E-04	-1.881E 01	-6.750E 00	1.641E 00	-2.231E-03	3.099E-03	8.199E-01
27	-325.	4.33	0.17	0.30	-3.685E-04	-7.165E-05	1.516E-04	-1.855E 01	-6.674E 00	1.334E 00	-2.305E-03	2.503E-03	2.324E 00
28	-325.	5.00	0.17	0.30	-3.589E-04	-7.270E-05	1.052E-05	-1.799E 01	-6.540E 00	4.945E-01	-2.361E-03	2.623E-03	4.129E 00
29	-325.	5.67	0.17	0.30	-3.219E-04	-8.349E-05	-2.651E-04	-1.579E 01	-6.250E 00	-1.134E 00	-5.588E-04	1.550E-03	5.754E 00
30	-325.	6.33	0.17	0.30	-2.387E-04	-1.000E-04	-4.770E-04	-1.003E 01	-4.483E 00	-2.330E 00	-8.428E-04	3.576E-03	4.108E 00
31	-325.	0.33	0.17	0.47	-1.777E-04	-6.794E-05	-2.998E-04	-3.628E 00	7.613E-01	-1.151E 00	-2.151E-03	2.861E-03	-1.843E 00
32	-325.	1.00	0.17	0.47	-2.614E-04	-3.473E-05	-2.810E-04	-8.990E 00	7.767E-02	-1.098E 00	-1.942E-03	2.384E-03	-4.232E 00
33	-325.	1.67	0.17	0.47	-3.192E-04	-8.676E-06	-7.657E-05	-1.233E 01	9.059E-02	9.486E-02	-6.193E-04	2.861E-03	-3.621E 00
34	-325.	2.33	0.17	0.47	-3.409E-04	1.133E-06	6.578E-05	-1.351E 01	1.740E-01	9.390E-01	-1.653E-03	2.861E-03	-2.110E 00
35	-325.	3.00	0.17	0.47	-3.478E-04	4.116E-06	1.230E-04	-1.387E 01	2.067E-01	1.278E 00	-1.527E-03	2.623E-03	-6.378E-01
36	-325.	3.67	0.17	0.47	-3.479E-04	4.163E-06	1.228E-04	-1.388E 01	2.046E-01	1.277E 00	-8.801E-04	2.623E-03	7.788E-01
37	-325.	4.33	0.17	0.47	-3.412E-04	1.269E-06	6.515E-05	-1.352E 01	1.736E-01	9.340E-01	-1.830E-03	2.146E-03	2.254E 00
38	-325.	5.00	0.17	0.47	-3.196E-04	-8.469E-06	-7.826E-05	-1.236E 01	8.846E-02	8.438E-02	-2.710E-03	2.027E-03	3.772E 00
39	-325.	5.67	0.17	0.47	-2.618E-04	-3.448E-05	-2.840E-04	-9.013E 00	7.962E-02	-1.117E 00	9.313E-06	1.311E-03	4.374E 00
40	-325.	6.33	0.17	0.47	-1.782E-04	-6.778E-05	-3.034E-04	-3.666E 00	7.495E-01	-1.173E 00	-1.537E-03	3.457E-03	1.953E 00
41	-325.	0.33	0.17	0.63	-1.483E-04	-8.901E-05	-1.901E-04	-1.991E 00	3.824E-01	-4.803E-01	-2.105E-03	2.623E-03	-8.664E-01
42	-325.	1.00	0.17	0.63	-2.146E-04	-5.971E-05	-2.433E-04	-6.194E 00	2.433E-03	-8.448E-01	-1.621E-03	1.669E-03	-2.751E 00
43	-325.	1.67	0.17	0.63	-2.779E-04	-3.150E-05	-1.197E-04	-9.986E 00	-1.306E-01	-1.425E-01	-1.262E-03	2.027E-03	-2.969E 00
44	-325.	2.33	0.17	0.63	-3.096E-04	-1.692E-05	4.422E-06	-1.180E 01	-8.924E-02	5.843E-01	-1.886E-03	2.027E-03	-1.930E 00
45	-325.	3.00	0.17	0.63	-3.205E-04	-1.185E-05	6.278E-05	-1.240E 01	-5.117E-02	9.288E-01	-1.448E-03	1.907E-03	-6.021E-01
46	-325.	3.67	0.17	0.63	-3.206E-04	-1.183E-05	6.261E-05	-1.241E 01	-5.335E-02	9.277E-01	-9.360E-04	2.027E-03	7.418E-01
47	-325.	4.33	0.17	0.63	-3.097E-04	-1.687E-05	3.785E-06	-1.180E 01	-8.835E-02	5.805E-01	-2.473E-03	1.788E-03	2.073E 00
48	-325.	5.00	0.17	0.63	-2.780E-04	-3.143E-05	-1.211E-04	-9.995E 00	-1.320E-01	-1.511E-01	-3.404E-03	1.311E-03	3.108E 00
49	-325.	5.67	0.17	0.63	-2.147E-04	-5.961E-05	-2.454E-04	-6.201E 00	3.664E-03	-8.580E-01	-1.225E-03	8.345E-04	2.875E 00
50	-325.	6.33	0.17	0.63	-1.487E-04	-8.896E-05	-1.921E-04	-2.017E 00	3.711E-01	-4.925E-01	-1.462E-03	3.099E-03	9.724E-01

C-2

BOTTOM-POINT PLATE MEMBER STRAINS AND STRESSES FOR ITERATION NO. 3

MEMBER	COORDINATES X	COORDINATES Y	STRAINS EPS X	STRAINS EPS Y	STRAINS EPS XY	STRESSES SIG X	STRESSES SIG Y	STRESSES SIG XY
1	3.3333E-01	1.6666E-01	-4.2580E-03	-4.2574E-03	1.6214E-08	-5.2813E 00	-5.3125E-01	1.1581E-01
2	1.0000E 00	1.6666E-01	-4.2597E-03	-4.2569E-03	1.3421E-08	-2.2148E 01	-1.6406E-01	9.5864E-02
3	1.6667E 00	1.6666E-01	-4.2619E-03	-4.2562E-03	5.1156E-09	-4.3762E 01	-2.8516E-01	3.6540E-02
4	2.3333E 00	1.6666E-01	-4.2636E-03	-4.2557E-03	4.1084E-09	-6.0832E 01	-2.4609E-01	2.9345E-02
5	3.0000E 00	1.6666E-01	-4.2645E-03	-4.2554E-03	-9.7114E-10	-7.0004E 01	-2.4609E-01	-6.9367E-03
6	3.6667E 00	1.6666E-01	-4.2645E-03	-4.2554E-03	2.2289E-09	-6.9676E 01	-2.4609E-01	1.5920E-02
7	4.3333E 00	1.6666E-01	-4.2635E-03	-4.2557E-03	8.6426E-09	-6.0016E 01	-2.0313E-01	6.1733E-02
8	5.0000E 00	1.6666E-01	-4.2617E-03	-4.2563E-03	1.1266E-08	-4.2246E 01	-2.4609E-01	8.0474E-02
9	5.6667E 00	1.6666E-01	-4.2595E-03	-4.2569E-03	2.4381E-09	-2.0102E 01	-1.6406E-01	1.7415E-02
10	6.3333E 00	1.6666E-01	-4.2577E-03	-4.2575E-03	1.1365E-09	-2.6602E 00	-5.3125E-01	8.1179E-03

PROGRAM LISTING OF INPUT DATA CARDS

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.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

SAMPLE PROBLEM III  -  NORMAL PRESSURE
    AUGUST 21, 1974
    1                        3       .05         6
    2    2    1    1    0    0    0    0    0
   0
   6.66667    .33333      .75
        .5
         1         1
                       1.16667    .16667       .05
        10    1         7
     10.E6        .2
         0
     60.E3     60.E3      6.E3        .5        .1       .01
     20.E3     32.E3     32.E3
       90.       .49
        0.
    1
        0.     60.E3
    1
        0.      6.E3
    1
        0.     32.E3
    1
        0.        .5
    1
        0.       .01
    1
        0.        0.
    1
        0.        0.
    1
        0.        0.
    1
        0.        0.
A2                            0                            0          0
B2                            2                            0          0
C0                            4
D0                            0
        0.        0.        0.        0.      100.        0.        0.        0.
        0.        0.
    0    1        0.
        0.

.........1.........2.........3.........4.........5.........6.........7.........8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
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O P T I O N S

STATICS PROBLEM

MAXIMUM NO. ITERATIONS = 3 CONVERGENCE PARAMETER = 5.0000E-02

PRIMARY STRUCTURE STRESSES PRESENTED AFTER LAST ITERATION AT PLATE TOP AND BOTTOM SURFACES

TILES ON PRIMARY STRUCTURE

TILE STRESSES PRESENTED AFTER LAST ITERATION

TILE NODE MAP REQUIRED

TILE ELEMENT MAP NOT REQUIRED

TILE NODE COORDINATES NOT REQUIRED

DO NOT PRINT ELEMENT STIFFNESS MATRICES

DO NOT PRINT ASSEMBLED STIFFNESS MATRICES

DO NOT PRINT FILE DEBUGGING INFORMATION

COMPUTE STRESSES FOR ALL TILES

G E O M E T R Y

PLATE	LX = 6.66667E 00	LY = 3.33330E-01	TP = 7.50000E-01	
STRINGERS	Y1 = 5.00000E-01	ZS = 0.0	YS = 0.0	AS = 0.0
	IY' = 0.0	IZ' = 0.0	JX' = 0.0	BETA S = 0.0
TILES	NXB = 1	NYB = 1		
	T = 0.0	B1 = 0.0	T2 = 1.16667E 00	
	TA = 1.66670E-01	TI = 5.00000E-02	TC = 0.0	
BRICK	NB1 = 0	NB2 = 10	ND2 = 1	
	NT1 = 0	NT2 = 7		

M A T E R I A L   P R O P E R T I E S

PLATE	EP = 1.00000E 07	NU P = 3.00000E-01	GAMMA P = 0.0	ALPHA P = 0.0
STRINGERS	ES = 0.0	NU S = 0.0	GAMMA S = 0.0	ALPHA P = 0.0
ARRESTOR OR RSI	EX = 6.00000E 04	EY = 6.00000E 04	EZ = 6.00000E 03	
	NU XY = 5.00000E-01	NU YZ = 1.00000E-01	NU ZX = 1.00000E-02	
	GXY = 2.00000E 04	GYZ = 3.20000E 04	GZX = 3.20000E 04	
	GAMMA A = 0.0			
	ALPHA X = 0.0	ALPHA Y = 0.0	ALPHA Z = 0.0	
ISOLATOR	EI = 9.00000E 01	NU I = 4.90000E-01	GAMMA I = 0.0	ALPHA I = 0.0
RSI	GAMMA R = 0.0			
		ALPHA RY / ALPHA RX = 0.0		ALPHA RZ / ALPHA RX = 0.0

TEMPERATURE DEPENDENT MATERIAL PROPERTIES

		TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY	TEMPERATURE	PROPERTY
1	ER	ALL	6.000E 04						
1	ER'	ALL	6.000E 03						
1	GR'	ALL	3.200E 04						
1	NU R	ALL	5.000E-01						
1	NU R'	ALL	1.000E-02						
1	ALPHA R	ALL	0.0						
1	EC	ALL	0.0						
1	NU C	ALL	0.0						
1	ALPHA C	ALL	0.0						

B O U N D A R Y   C O N D I T I O N S

EDGE	PLATE OUT OF PLANE	PLATE IN PLANE	STRINGERS	
A	PINNED	FREE	FREE	FREE
B	PINNED	U HELD, V FREE	FREE	FREE
C	FREE	V HELD, U FREE		
D	FREE	FREE		

S T A T I C   L O A D I N G

NX = 0.0	NY = 0.0	NXY = 0.0	NYX = 0.0
PZ = 1.000000E 02	T = 0.0	M = 0.0	V = 0.0

DEL TEMP P = 0.0

DEL TEMP S = 0.0

R S I   T E M P E R A T U R E S

NO STATIC THERMAL LOADING

UNIFORM TEMPERATURE OPTION

T REFERENCE = 0.0

DEL T U = T - T REF = 0.0

NODE MAP

SURFACE 1

200	202	204	206	208	210	212	214	216	218	220
199	201	203	205	207	209	211	213	215	217	219

NODE MAP

SURFACE 2

178	180	182	184	186	188	190	192	194	196	198
177	179	181	183	185	187	189	191	193	195	197

PRIMARY STRUCTURE GLOBAL GEOMETRY

NODE	X	Y	Z
1	0.0	0.0	0.0
2	0.0	3.333300E-01	0.0
3	6.666670E-01	0.0	0.0
4	6.666670E-01	3.333300E-01	0.0
5	1.333334E 00	0.0	0.0
6	1.333334E 00	3.333300E-01	0.0
7	2.000001E 00	0.0	0.0
8	2.000001E 00	3.333300E-01	0.0
9	2.666668E 00	0.0	0.0
10	2.666668E 00	3.333300E-01	0.0
11	3.333335E 00	0.0	0.0
12	3.333335E 00	3.333300E-01	0.0
13	4.000002E 00	0.0	0.0
14	4.000002E 00	3.333300E-01	0.0
15	4.666669E 00	0.0	0.0
16	4.666669E 00	3.333300E-01	0.0
17	5.333336E 00	0.0	0.0
18	5.333336E 00	3.333300E-01	0.0
19	6.000003E 00	0.0	0.0
20	6.000003E 00	3.333300E-01	0.0
21	6.666670E 00	0.0	0.0
22	6.666670E 00	3.333300E-01	0.0

DEGREES OF FREEDOM

DX	DY	DZ	RX	RY	RZ
1	0	0	2	3	0
4	5	0	6	7	0
8	0	9	10	11	0
12	13	14	15	16	0
17	0	18	19	20	0
21	22	23	24	25	0
26	0	27	28	29	0
30	31	32	33	34	0
35	0	36	37	38	0
39	40	41	42	43	0
44	0	45	46	47	0
48	49	50	51	52	0
53	0	54	55	56	0
57	58	59	60	61	0
62	0	63	64	65	0
66	67	68	69	70	0
71	0	72	73	74	0
75	76	77	78	79	0
80	0	81	82	83	0
84	85	86	87	88	0
0	0	0	89	90	0
0	91	0	92	93	0

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 1

NODE	DX	DY	DZ	RX	RY	RZ
1	0.0			-1.473518E-06	3.456739E-03	
2	0.0	0.0		1.470131E-06	3.456733E-03	
3	0.0		-2.264617E-03	2.863919E-05	3.268892E-03	
4	0.0	0.0	-2.264618E-03	-2.864301E-05	3.268868E-03	
5	0.0		-4.286710E-03	5.041329E-05	2.744951E-03	
6	0.0	0.0	-4.286692E-03	-5.027156E-05	2.744913E-03	
7	0.0		-5.870827E-03	6.620480E-05	1.969881E-03	
8	0.0	0.0	-5.870786E-03	-6.595705E-05	1.969814E-03	
9	0.0		-6.877355E-03	7.583386E-05	1.027109E-03	
10	0.0	0.0	-6.877262E-03	-7.522025E-05	1.027037E-03	
11	0.0		-7.222328E-03	7.908084E-05	2.700736E-07	
12	0.0	0.0	-7.222202E-03	-7.829435E-05	2.323126E-07	
13	0.0		-6.877705E-03	7.592475E-05	-1.026573E-03	
14	0.0	0.0	-6.877575E-03	-7.511086E-05	-1.026564E-03	
15	0.0		-5.871460E-03	6.644083E-05	-1.969688E-03	
16	0.0	0.0	-5.871363E-03	-6.583716E-05	-1.969655E-03	
17	0.0		-4.287299E-03	5.057774E-05	-2.745199E-03	
18	0.0	0.0	-4.287232E-03	-5.013507E-05	-2.745150E-03	
19	0.0		-2.264980E-03	2.877529E-05	-3.269351E-03	
20	0.0	0.0	-2.264944E-03	-2.853607E-05	-3.269293E-03	
21				-1.470409E-06	-3.457324E-03	
22		0.0		1.468549E-06	-3.457266E-03	

PRIMARY STRUCTURE NODES ASSOCIATED WITH TILE NO. 1

1	3	5	7	9	11	13	15	17	19	21
2	4	6	8	10	12	14	16	18	20	22

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 2

NODE	DX	DY	DZ	RX	RY	RZ
1	-3.901913E-06			-1.457974E-06	3.361257E-03	
2	-3.897959E-06	7.973046E-08		1.453203E-06	3.361257E-03	
3	-3.676207E-06		-2.201482E-03	2.826525E-05	3.175853E-03	
4	-3.671434E-06	6.345107E-08	-2.201487E-03	-2.829292E-05	3.175835E-03	
5	-3.351139E-06		-4.164275E-03	4.925889E-05	2.661913E-03	
6	-3.346494E-06	4.207058E-08	-4.164264E-03	-4.916536E-05	2.661876E-03	
7	-2.938193E-06		-5.699161E-03	6.429966E-05	1.907061E-03	
8	-2.935175E-06	2.713396E-08	-5.699124E-03	-6.406714E-05	1.906994E-03	
9	-2.460804E-06		-6.673034E-03	7.339950E-05	9.932443E-04	
10	-2.459236E-06	1.782072E-08	-6.672934E-03	-7.276067E-05	9.931689E-04	
11	-1.949114E-06		-7.006560E-03	7.645463E-05	2.626637E-07	
12	-1.949119E-06	1.465368E-08	-7.006425E-03	-7.562677E-05	2.205044E-07	
13	-1.437492E-06		-6.673370E-03	7.350260E-05	-9.927261E-04	
14	-1.439067E-06	1.783919E-08	-6.673235E-03	-7.263929E-05	-9.927156E-04	
15	-9.603064E-07		-5.699780E-03	6.455116E-05	-1.906876E-03	
16	-9.633204E-07	2.717687E-08	-5.699676E-03	-6.391277E-05	-1.906838E-03	
17	-5.476637E-07		-4.164848E-03	4.944927E-05	-2.662152E-03	
18	-5.523403E-07	4.207477E-08	-4.164778E-03	-4.899905E-05	-2.662102E-03	
19	-2.230393E-07		-2.201836E-03	2.841215E-05	-3.176297E-03	
20	-2.280736E-07	6.385153E-08	-2.201798E-03	-2.817533E-05	-3.176240E-03	
21				-1.454991E-06	-3.361825E-03	
22		7.931072E-08		1.452934E-06	-3.361768E-03	

MAXIMUM DEFLECTION = -3.36177E-03 FOR DOF 93

MAXIMUM DEFLECTION DIFFERENCE = 2.15776E-04 FOR DOF 50

MAXIMUM CONVERGENCE PARAMETER = 6.41853E-02

SOLUTION HAS NOT CONVERGED

PRIMARY STRUCTURE DEFLECTIONS FOR ITERATION NO. 3

NODE	DX	DY	DZ	RX	RY	RZ
1	-3.838843E-06			-1.455582E-06	3.364080E-03	
2	-3.834992E-06	7.958687E-08		1.455494E-06	3.364078E-03	
3	-3.615079E-06		-2.203349E-03	2.828105E-05	3.178601E-03	
4	-3.610429E-06	6.373557E-08	-2.203352E-03	-2.829883E-05	3.178587E-03	
5	-3.294500E-06		-4.167896E-03	4.928574E-05	2.664377E-03	
6	-3.289982E-06	4.291585E-08	-4.167885E-03	-4.920547E-05	2.664342E-03	
7	-2.888414E-06		-5.704246E-03	6.433637E-05	1.908939E-03	
8	-2.885486E-06	2.840901E-08	-5.704213E-03	-6.412840E-05	1.908872E-03	
9	-2.419676E-06		-6.679095E-03	7.343816E-05	9.942634E-04	
10	-2.418157E-06	1.937944E-08	-6.679010E-03	-7.286872E-05	9.941910E-04	
11	-1.917612E-06		-7.012971E-03	7.650600E-05	2.646018E-07	
12	-1.917616E-06	1.631173E-08	-7.012848E-03	-7.574550E-05	2.219912E-07	
13	-1.415613E-06		-6.679438E-03	7.356293E-05	-9.937447E-04	
14	-1.417140E-06	1.939791E-08	-6.679308E-03	-7.272129E-05	-9.937328E-04	
15	-9.470772E-07		-5.704869E-03	6.458355E-05	-1.908754E-03	
16	-9.500015E-07	2.845171E-08	-5.704772E-03	-6.399328E-05	-1.908718E-03	
17	-5.412911E-07		-4.168469E-03	4.946388E-05	-2.664619E-03	
18	-5.458402E-07	4.292060E-08	-4.168406E-03	-4.905126E-05	-2.664571E-03	
19	-2.211529E-07		-2.203700E-03	2.842055E-05	-3.179051E-03	
20	-2.260555E-07	6.412620E-08	-2.203666E-03	-2.818723E-05	-3.178995E-03	
21				-1.455612E-06	-3.364645E-03	
22		7.917902E-08		1.453408E-06	-3.364590E-03	

MAXIMUM DEFLECTION = -3.36459E-03 FOR DOF 93

MAXIMUM DEFLECTION DIFFERENCE = 6.42240E-06 FOR DOF 50

MAXIMUM CONVERGENCE PARAMETER = 1.90882E-03

SOLUTION HAS CONVERGED

TPS DISPLACEMENTS FOR TILE NO. 1 AND ITERATION NO. 3

NODE	X COMPONENT(U)	Y COMPONENT(V)	Z COMPONENT(W)
1	1.2576911E-03	5.4584314E-07	0.0
2	1.2576941E-03	-4.6622353E-07	0.0
3	1.1883602E-03	-1.0605394E-05	-2.2033486E-03
4	1.1883595E-03	1.0675798E-05	-2.2033518E-03
5	9.9584647E-04	-1.8482140E-05	-4.1678958E-03
6	9.9583808E-04	1.8494960E-05	-4.1678846E-03
7	7.1296352E-04	-2.4126130E-05	-5.7042465E-03
8	7.1294140E-04	2.4076551E-05	-5.7042129E-03
9	3.7042890E-04	-2.7539310E-05	-6.6790953E-03
10	3.7040329E-04	2.7345130E-05	-6.6790096E-03
11	-1.8183864E-06	-2.8689741E-05	-7.0129707E-03
12	-1.8343690E-06	2.8420851E-05	-7.0128478E-03
13	-3.7406967E-04	-2.7586095E-05	-6.6794381E-03
14	-3.7406664E-04	2.7289876E-05	-6.6793077E-03
15	-7.1672956E-04	-2.4218825E-05	-5.7048686E-03
16	-7.1671931E-04	2.4025925E-05	-5.7047717E-03
17	-9.9977315E-04	-1.8548948E-05	-4.1684695E-03
18	-9.9975988E-04	1.8437131E-05	-4.1684061E-03
19	-1.1923651E-03	-1.0657704E-05	-2.2036997E-03
20	-1.1923490E-03	1.0634339E-05	-2.2036657E-03
21	-1.2617419E-03	5.4585439E-07	0.0
22	-1.2617209E-03	-4.6584898E-07	0.0
23	-1.9288964E-03	-3.6905985E-04	-3.7478809E-03
24	-1.9288959E-03	3.6939513E-04	-3.7476560E-03
25	-1.7317173E-03	-3.4020585E-04	-5.6907944E-03
26	-1.7317629E-03	3.4074089E-04	-5.6905597E-03
27	-1.4811209E-03	-3.0802726E-04	-7.4508972E-03
28	-1.4811754E-03	3.0878210E-04	-7.4506365E-03
29	-1.0883159E-03	-2.7959980E-04	-8.8769421E-03
30	-1.0883401E-03	2.8061983E-04	-8.8766739E-03
31	-5.7616225E-04	-2.6274496E-04	-9.7944960E-03
32	-5.7614408E-04	2.6372983E-04	-9.7941980E-03
33	-1.3282192E-07	-2.5708741E-04	-1.0110635E-02
34	-1.1892917E-07	2.5797938E-04	-1.0110315E-02
35	5.7595852E-04	-2.6276428E-04	-9.7948052E-03
36	5.7593780E-04	2.6369118E-04	-9.7944811E-03
37	1.0882213E-03	-2.7955766E-04	-8.8774636E-03
38	1.0881955E-03	2.8062542E-04	-8.8771619E-03
39	1.4811466E-03	-3.0784123E-04	-7.4514151E-03
40	1.4810888E-03	3.0894089E-04	-7.4511021E-03
41	1.7317953E-03	-3.3979258E-04	-5.6911409E-03
42	1.7316977E-03	3.4115440E-04	-5.6909099E-03
43	1.9289383E-03	-3.6838348E-04	-3.7480451E-03
44	1.9288501E-03	3.7009967E-04	-3.7478020E-03
45	-1.4385977E-03	-1.6514414E-04	-6.8438686E-03
46	-1.4386380E-03	1.6520663E-04	-6.8435557E-03
47	-1.3081105E-03	-1.4886331E-04	-8.5816644E-03
48	-1.3081587E-03	1.4912240E-04	-8.5813478E-03
49	-1.1065099E-03	-1.2930391E-04	-1.0192931E-02
50	-1.1065663E-03	1.2975477E-04	-1.0192588E-02

STRESSES FOR ISOLATOR AND ARRESTOR FOR TILE NO. 1 AND ITERATION NO. 3

	LOCAL COORDINATES X	Y	Z	STRESSES XX	YY	ZZ	XY	YZ	ZX
			ELEMENT NUMBER	1					
1	5.2578E-01	2.6289E-01	3.9434E-02	-1.0207E 02	-1.0199E 02	-1.0637E 02	-5.3123E-04	1.1811E-01	-1.8883E 00
2	5.2578E-01	7.0441E-02	3.9434E-02	-1.0208E 02	-1.0199E 02	-1.0637E 02	5.3182E-04	-1.1782E-01	-1.8883E 00
3	1.4088E-01	2.6289E-01	3.9434E-02	-1.0642E 02	-1.0633E 02	-1.1089E 02	-5.3092E-04	1.2610E-01	-1.9813E 00
4	1.4088E-01	7.0441E-02	3.9434E-02	-1.0642E 02	-1.0633E 02	-1.1090E 02	5.3209E-04	-1.2589E-01	-1.9813E 00
5	5.2578E-01	2.6289E-01	1.0566E-02	-1.0416E 02	-1.0413E 02	-1.0844E 02	7.0903E-05	1.1810E-01	-1.8952E 00
6	5.2578E-01	7.0441E-02	1.0566E-02	-1.0417E 02	-1.0414E 02	-1.0845E 02	-7.1102E-05	-1.1783E-01	-1.8951E 00
7	1.4088E-01	2.6289E-01	1.0566E-02	-1.0863E 02	-1.0860E 02	-1.1309E 02	7.1124E-05	1.2609E-01	-1.9881E 00
8	1.4088E-01	7.0441E-02	1.0566E-02	-1.0863E 02	-1.0860E 02	-1.1309E 02	-7.0886E-05	-1.2590E-01	-1.9881E 00
			ELEMENT NUMBER	2					
1	1.1925E 00	2.6289E-01	3.9434E-02	-9.5839E 01	-9.5761E 01	-9.9871E 01	-6.1842E-04	1.0427E-01	-1.6344E 00
2	1.1925E 00	7.0441E-02	3.9434E-02	-9.5843E 01	-9.5766E 01	-9.9875E 01	6.1785E-04	-1.0382E-01	-1.6344E 00
3	8.0755E-01	2.6289E-01	3.9434E-02	-9.9211E 01	-9.9129E 01	-1.0339E 02	-6.1797E-04	1.1226E-01	-1.7890E 00
4	8.0755E-01	7.0441E-02	3.9434E-02	-9.9215E 01	-9.9133E 01	-1.0339E 02	6.1828E-04	-1.1191E-01	-1.7889E 00
5	1.1925E 00	2.6289E-01	1.0566E-02	-9.7959E 01	-9.7921E 01	-1.0197E 02	-1.6868E-05	1.0426E-01	-1.6398E 00
6	1.1925E 00	7.0441E-02	1.0566E-02	-9.7963E 01	-9.7925E 01	-1.0197E 02	1.3852E-05	-1.0383E-01	-1.6398E 00
7	8.0755E-01	2.6289E-01	1.0566E-02	-1.0145E 02	-1.0141E 02	-1.0560E 02	-1.6456E-05	1.1224E-01	-1.7943E 00
8	8.0755E-01	7.0441E-02	1.0566E-02	-1.0145E 02	-1.0142E 02	-1.0561E 02	1.4265E-05	-1.1192E-01	-1.7943E 00
			ELEMENT NUMBER	3					
1	1.8591E 00	2.6289E-01	3.9434E-02	-9.1963E 01	-9.1902E 01	-9.5846E 01	-5.5080E-04	9.2099E-02	-1.2399E 00
2	1.8591E 00	7.0441E-02	3.9434E-02	-9.1967E 01	-9.1906E 01	-9.5850E 01	5.5449E-04	-9.1456E-02	-1.2399E 00
3	1.4742E 00	2.6289E-01	3.9434E-02	-9.3739E 01	-9.3674E 01	-9.7699E 01	-5.5190E-04	9.8869E-02	-1.4756E 00
4	1.4742E 00	7.0441E-02	3.9434E-02	-9.3743E 01	-9.3678E 01	-9.7704E 01	5.5337E-04	-9.8341E-02	-1.4756E 00
5	1.8591E 00	2.6289E-01	1.0566E-02	-9.4213E 01	-9.4172E 01	-9.8061E 01	-4.2444E-05	9.2087E-02	-1.2428E 00
6	1.8591E 00	7.0441E-02	1.0566E-02	-9.4217E 01	-9.4176E 01	-9.8065E 01	3.8778E-05	-9.1469E-02	-1.2428E 00
7	1.4742E 00	2.6289E-01	1.0566E-02	-9.6090E 01	-9.6048E 01	-1.0001E 02	-4.2228E-05	9.8856E-02	-1.4785E 00
8	1.4742E 00	7.0441E-02	1.0566E-02	-9.6094E 01	-9.6052E 01	-1.0002E 02	3.9002E-05	-9.8354E-02	-1.4785E 00
			ELEMENT NUMBER	4					
1	2.5258E 00	2.6289E-01	3.9434E-02	-8.9875E 01	-8.9827E 01	-9.3683E 01	-3.3072E-04	8.4091E-02	-7.2296E-01
2	2.5258E 00	7.0441E-02	3.9434E-02	-8.9879E 01	-8.9831E 01	-9.3687E 01	3.2842E-04	-8.3348E-02	-7.2297E-01
3	2.1409E 00	2.6289E-01	3.9434E-02	-9.0789E 01	-9.0738E 01	-9.4637E 01	-3.3245E-04	8.8140E-02	-1.0210E 00
4	2.1409E 00	7.0441E-02	3.9434E-02	-9.0793E 01	-9.0742E 01	-9.4642E 01	3.2670E-04	-8.7439E-02	-1.0210E 00
5	2.5258E 00	2.6289E-01	1.0566E-02	-9.2246E 01	-9.2203E 01	-9.6009E 01	-2.8702E-05	8.4080E-02	-7.2446E-01
6	2.5258E 00	7.0441E-02	1.0566E-02	-9.2250E 01	-9.2207E 01	-9.6013E 01	1.9976E-05	-8.3359E-02	-7.2447E-01
7	2.1409E 00	2.6289E-01	1.0566E-02	-9.3220E 01	-9.3177E 01	-9.7023E 01	-2.9040E-05	8.8128E-02	-1.0225E 00
8	2.1409E 00	7.0441E-02	1.0566E-02	-9.3224E 01	-9.3181E 01	-9.7027E 01	1.9641E-05	-8.7451E-02	-1.0225E 00
			ELEMENT NUMBER	5					
1	3.1924E 00	2.6289E-01	3.9434E-02	-8.9055E 01	-8.9013E 01	-9.2836E 01	-1.1282E-04	8.0732E-02	-1.3450E-01
2	3.1924E 00	7.0441E-02	3.9434E-02	-8.9058E 01	-8.9016E 01	-9.2839E 01	1.1020E-04	-7.9979E-02	-1.3451E-01
3	2.8075E 00	2.6289E-01	3.9434E-02	-8.9336E 01	-8.9293E 01	-9.3129E 01	-1.1276E-04	8.2106E-02	-4.6519E-01
4	2.8075E 00	7.0441E-02	3.9434E-02	-8.9340E 01	-8.9297E 01	-9.3133E 01	1.1025E-04	-8.1349E-02	-4.6521E-01
5	3.1924E 00	2.6289E-01	1.0566E-02	-9.1501E 01	-9.1458E 01	-9.5232E 01	-1.1352E-05	8.0721E-02	-1.3496E-01
6	3.1924E 00	7.0441E-02	1.0566E-02	-9.1505E 01	-9.1461E 01	-9.5236E 01	5.7775E-06	-7.9989E-02	-1.3498E-01
7	2.8075E 00	2.6289E-01	1.0566E-02	-9.1802E 01	-9.1759E 01	-9.5546E 01	-1.1707E-05	8.2095E-02	-4.6566E-01
8	2.8075E 00	7.0441E-02	1.0566E-02	-9.1806E 01	-9.1762E 01	-9.5549E 01	5.4171E-06	-8.1360E-02	-4.6567E-01

STRESSES AND DIRECT STRAINS FOR TILE NO. 1 AND ITERATION NO. 3

MEM	TEMP	LOCAL COORDINATES X	Y	Z	* STRAINS XX	YY	ZZ *	STRESSES XX	YY	ZZ	XY	YZ	ZX *
1	0.	0.33	0.17	0.02	9.585E-05	1.080E-03	-7.235E-02	-1.053E 02	-1.053E 02	-1.097E 02	2.936E-07	1.191E-04	-1.938E 00
2	0.	1.00	0.17	0.02	4.356E-05	1.017E-03	-6.770E-02	-9.862E 01	-9.856E 01	-1.027E 02	-6.192E-07	1.937E-04	-1.714E 00
3	0.	1.67	0.17	0.02	8.245E-05	9.467E-04	-6.455E-02	-9.400E 01	-9.395E 01	-9.791E 01	-1.578E-07	2.368E-04	-1.359E 00
4	0.	2.33	0.17	0.02	1.272E-04	8.923E-04	-6.288E-02	-9.153E 01	-9.149E 01	-9.534E 01	-3.234E-06	3.552E-04	-8.729E-01
5	0.	3.00	0.17	0.02	1.528E-04	8.652E-04	-6.213E-02	-9.043E 01	-9.038E 01	-9.419E 01	-2.106E-06	3.723E-04	-3.001E-01
6	0.	3.67	0.17	0.02	1.529E-04	8.651E-04	-6.213E-02	-9.042E 01	-9.038E 01	-9.419E 01	-3.797E-07	3.805E-04	3.021E-01
7	0.	4.33	0.17	0.02	1.272E-04	8.923E-04	-6.288E-02	-9.153E 01	-9.149E 01	-9.534E 01	1.979E-06	3.943E-04	8.749E-01
8	0.	5.00	0.17	0.02	8.240E-05	9.467E-04	-6.455E-02	-9.400E 01	-9.395E 01	-9.791E 01	-1.086E-07	3.910E-04	1.361E 00
9	0.	5.67	0.17	0.02	4.353E-05	1.017E-03	-6.770E-02	-9.862E 01	-9.856E 01	-1.027E 02	1.093E-06	4.068E-04	1.717E 00
10	0.	6.33	0.17	0.02	9.583E-05	1.080E-03	-7.235E-02	-1.053E 02	-1.053E 02	-1.097E 02	1.797E-06	4.678E-04	1.941E 00
11	0.	0.33	0.17	0.13	2.457E-04	1.536E-03	-1.796E-02	6.900E 00	-1.350E 01	-1.091E 02	3.719E-04	0.0	-6.084E-01
12	0.	1.00	0.17	0.13	3.391E-04	1.391E-03	-1.690E-02	1.298E 01	-1.269E 01	-1.026E 02	1.630E-05	0.0	-4.286E 00
13	0.	1.67	0.17	0.13	5.160E-04	1.245E-03	-1.517E-02	2.434E 01	-1.127E 01	-9.814E 01	1.440E-03	1.192E-04	-3.681E 00
14	0.	2.33	0.17	0.13	6.702E-04	1.134E-03	-1.575E-02	3.398E 01	-1.055E 01	-9.555E 01	-9.354E-04	3.576E-04	-2.308E 00
15	0.	3.00	0.17	0.13	7.545E-04	1.076E-03	-1.557E-02	3.921E 01	-1.022E 01	-9.441E 01	-6.228E-04	1.192E-04	-7.972E-01
16	0.	3.67	0.17	0.13	7.546E-04	1.076E-03	-1.557E-02	3.922E 01	-1.022E 01	-9.441E 01	2.296E-04	-2.384E-04	7.973E-01
17	0.	4.33	0.17	0.13	6.703E-04	1.133E-03	-1.575E-02	3.399E 01	-1.055E 01	-9.555E 01	9.764E-04	0.0	2.309E 00
18	0.	5.00	0.17	0.13	5.161E-04	1.245E-03	-1.617E-02	2.435E 01	-1.127E 01	-9.814E 01	-2.149E-03	0.0	3.683E 00
19	0.	5.67	0.17	0.13	3.392E-04	1.391E-03	-1.690E-02	1.298E 01	-1.269E 01	-1.026E 02	6.519E-05	-4.768E-04	4.289E 00
20	0.	6.33	0.17	0.13	2.457E-04	1.536E-03	-1.796E-02	6.899E 00	-1.351E 01	-1.091E 02	-3.591E-04	3.576E-04	6.114E-01
21	0.	0.33	0.17	0.30	1.795E-04	5.480E-04	-1.809E-02	1.466E 01	2.940E 01	-1.081E 02	8.804E-06	9.537E-04	-3.354E 00
22	0.	1.00	0.17	0.30	2.667E-04	4.739E-04	-1.712E-02	1.985E 01	2.613E 01	-1.022E 02	-1.496E-04	4.763E-04	-6.014E 00
23	0.	1.67	0.17	0.30	3.802E-04	3.934E-04	-1.650E-02	2.645E 01	2.698E 01	-9.849E 01	5.023E-04	1.192E-03	-5.991E 00
24	0.	2.33	0.17	0.30	4.846E-04	3.278E-04	-1.611E-02	3.267E 01	2.640E 01	-9.606E 01	-7.947E-04	1.550E-03	-3.981E 00
25	0.	3.00	0.17	0.30	5.452E-04	2.917E-04	-1.593E-02	3.629E 01	2.615E 01	-9.497E 01	-9.113E-04	9.537E-04	-1.382E 00
26	0.	3.67	0.17	0.30	5.452E-04	2.916E-04	-1.593E-02	3.629E 01	2.615E 01	-9.497E 01	-3.716E-04	5.960E-04	1.381E 00
27	0.	4.33	0.17	0.30	4.847E-04	3.278E-04	-1.611E-02	3.268E 01	2.640E 01	-9.606E 01	5.352E-04	1.669E-03	3.982E 00
28	0.	5.00	0.17	0.30	3.802E-04	3.934E-04	-1.650E-02	2.646E 01	2.698E 01	-9.849E 01	-2.003E-03	1.073E-03	5.992E 00
29	0.	5.67	0.17	0.30	2.667E-04	4.739E-04	-1.712E-02	1.985E 01	2.814E 01	-1.022E 02	1.150E-03	2.384E-04	6.016E 00
30	0.	6.33	0.17	0.30	1.796E-04	5.460E-04	-1.809E-02	1.466E 01	2.940E 01	-1.081E 02	-1.303E-03	1.073E-03	3.353E 00
31	0.	0.33	0.17	0.47	1.630E-04	1.687E-04	-1.776E-02	-1.525E 00	-1.298E 00	-1.066E 02	-9.051E-05	1.073E-03	-4.480E 00
32	0.	1.00	0.17	0.47	2.020E-04	1.397E-04	-1.700E-02	1.345E 00	-1.144E 00	-1.020E 02	-4.547E-06	5.960E-04	-7.424E 00
33	0.	1.67	0.17	0.47	2.617E-04	1.036E-04	-1.647E-02	5.318E 00	-1.006E 00	-9.879E 01	-1.585E-04	9.537E-04	-7.283E 00
34	0.	2.33	0.17	0.47	3.185E-04	7.112E-05	-1.614E-02	8.972E 00	-9.214E-01	-9.675E 01	-4.950E-04	-1.192E-03	-5.087E 00
35	0.	3.00	0.17	0.47	3.537E-04	5.197E-05	-1.598E-02	1.122E 01	-8.512E-01	-9.578E 01	-8.814E-04	-5.125E-03	-1.790E 00
36	0.	3.67	0.17	0.47	3.537E-04	5.197E-05	-1.598E-02	1.122E 01	-8.499E-01	-9.578E 01	-8.726E-04	-6.437E-03	1.784E 00
37	0.	4.33	0.17	0.47	3.185E-04	7.112E-05	-1.514E-02	8.973E 00	-9.205E-01	-9.674E 01	2.467E-04	-2.503E-03	5.085E 00
38	0.	5.00	0.17	0.47	2.617E-04	1.036E-04	-1.647E-02	5.319E 00	-1.005E 00	-9.879E 01	-1.462E-03	2.384E-04	7.280E 00
39	0.	5.67	0.17	0.47	2.020E-04	1.397E-04	-1.700E-02	1.347E 00	-1.143E 00	-1.020E 02	9.932E-04	7.153E-04	7.429E 00
40	0.	6.33	0.17	0.47	1.631E-04	1.687E-04	-1.776E-02	-1.523E 00	-1.297E 00	-1.066E 02	-1.930E-03	9.537E-04	4.479E 00
41	0.	0.33	0.17	0.63	1.591E-04	1.841E-04	-1.748E-02	-8.900E-01	1.132E-01	-1.049E 02	3.851E-04	6.343E-04	-4.093E 00
42	0.	1.00	0.17	0.63	1.495E-04	1.784E-04	-1.695E-02	-1.240E 00	-8.444E-02	-1.017E 02	-4.912E-04	-1.431E-03	-7.991E 00
43	0.	1.67	0.17	0.63	1.549E-04	1.700E-04	-1.652E-02	-6.298E-01	-2.678E-02	-9.913E 01	-6.954E-05	-6.557E-03	-7.885E 00
44	0.	2.33	0.17	0.63	1.668E-04	1.603E-04	-1.625E-02	2.548E-01	-1.831E-03	-9.750E 01	-4.433E-04	-6.914E-03	-5.598E 00
45	0.	3.00	0.17	0.63	1.760E-04	1.541E-04	-1.612E-02	9.046E-01	2.884E-02	-9.671E 01	-8.515E-04	-6.199E-03	-2.003E 00
46	0.	3.67	0.17	0.63	1.760E-04	1.541E-04	-1.612E-02	9.059E-01	2.921E-02	-9.672E 01	-1.047E-03	-7.510E-03	1.997E 00
47	0.	4.33	0.17	0.63	1.668E-04	1.603E-04	-1.625E-02	2.546E-01	-2.365E-03	-9.750E 01	4.299E-04	-6.795E-03	5.593E 00
48	0.	5.00	0.17	0.63	1.549E-04	1.700E-04	-1.652E-02	-6.299E-01	-2.676E-02	-9.913E 01	-1.312E-03	-7.272E-03	7.880E 00
49	0.	5.67	0.17	0.63	1.496E-04	1.784E-04	-1.695E-02	-1.238E 00	-3.260E-02	-1.017E 02	8.567E-04	-2.361E-03	7.993E 00
50	0.	6.33	0.17	0.63	1.591E-04	1.841E-04	-1.748E-02	-8.856E-01	1.147E-01	-1.049E 02	-1.027E-03	-2.742E-03	4.090E 00

TOP-POINT PLATE MEMBER STRAINS AND STRESSES FOR ITERATION NO. 3

MEMBER	COORDINATES X	COORDINATES Y	STRAINS EPS X	STRAINS EPS Y	STRAINS EPS XY	STRESSES SIG X	STRESSES SIG Y	STRESSES SIG XY
1	3.3333E-01	1.6666E-01	-1.0400E-04	3.0404E-05	-1.7294E-09	-1.0426E 03	-8.7436E 00	-1.2353E-02
2	1.0000E 00	1.6666E-01	-2.8878E-04	8.7388E-05	-2.8538E-08	-2.8853E 03	8.3048E 00	-2.0384E-01
3	1.6667E 00	1.6666E-01	-4.2433E-04	1.2777E-04	-4.6300E-08	-4.2418E 03	5.1730E 00	-3.3071E-01
4	2.3333E 00	1.6666E-01	-5.1380E-04	1.5463E-04	-9.0042E-08	-5.1364E 03	5.3959E 00	-6.4315E-01
5	3.0000E 00	1.6666E-01	-5.5836E-04	1.6799E-04	-5.9231E-08	-5.5820E 03	5.3321E 00	-4.2308E-01
6	3.6667E 00	1.6666E-01	-5.5836E-04	1.6798E-04	-2.0045E-08	-5.5821E 03	5.1957E 00	-1.4318E-01
7	4.3333E 00	1.6666E-01	-5.1398E-04	1.5468E-04	4.8764E-08	-5.1382E 03	5.3562E 00	3.4832E-01
8	5.0000E 00	1.6666E-01	-4.2456E-04	1.2785E-04	4.8311E-08	-4.2440E 03	5.2606E 00	3.4508E-01
9	5.6667E 00	1.6666E-01	-2.8889E-04	8.7419E-05	5.5284E-08	-2.8864E 03	8.2066E 00	3.9489E-01
10	6.3333E 00	1.6666E-01	-1.0406E-04	3.0421E-05	6.6454E-08	-1.0432E 03	-8.7649E 00	4.7467E-01

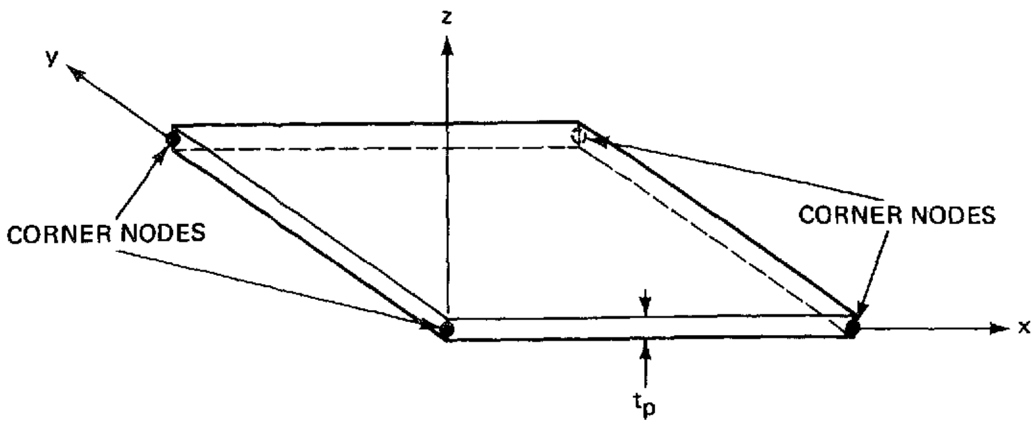
BOTTOM-POINT PLATE MEMBER STRAINS AND STRESSES FOR ITERATION NO. 3

MEMBER	COORDINATES X	COORDINATES Y	STRAINS EPS X	STRAINS EPS Y	STRAINS EPS XY	STRESSES SIG X	STRESSES SIG Y	STRESSES SIG XY
1	3.3333E-01	1.6666E-01	1.0467E-04	-2.9974E-05	2.5926E-09	1.0514E 03	1.5686E 01	1.8519E-02
2	1.0000E 00	1.6666E-01	2.8974E-04	-8.7068E-05	2.6673E-08	2.8969E 03	-1.6196E 00	1.9052E-01
3	1.6667E 00	1.6666E-01	4.2555E-04	-1.2756E-04	4.6589E-08	4.2559E 03	1.1875E 00	3.3278E-01
4	2.3333E 00	1.6666E-01	5.1521E-04	-1.5449E-04	8.9941E-08	5.1523E 03	8.0867E-01	6.4243E-01
5	3.0000E 00	1.6666E-01	5.5987E-04	-1.6789E-04	5.9203E-08	5.5989E 03	8.0227E-01	4.2288E-01
6	3.6667E 00	1.6666E-01	5.5987E-04	-1.6787E-04	2.0064E-08	5.5989E 03	9.3916E-01	1.4331E-01
7	4.3333E 00	1.6666E-01	5.1539E-04	-1.5454E-04	-4.8651E-08	5.1541E 03	8.4617E-01	-3.4751E-01
8	5.0000E 00	1.6666E-01	4.2578E-04	-1.2763E-04	-4.8670E-08	4.2581E 03	1.0976E 00	-3.4764E-01
9	5.6667E 00	1.6666E-01	2.8985E-04	-8.7097E-05	-5.3558E-08	2.8980E 03	-1.5727E 00	-3.8256E-01
10	6.3333E 00	1.6666E-01	1.0473E-04	-2.9991E-05	-6.2518E-08	1.0520E 03	1.5701E 01	-4.4656E-01

APPENDIX C

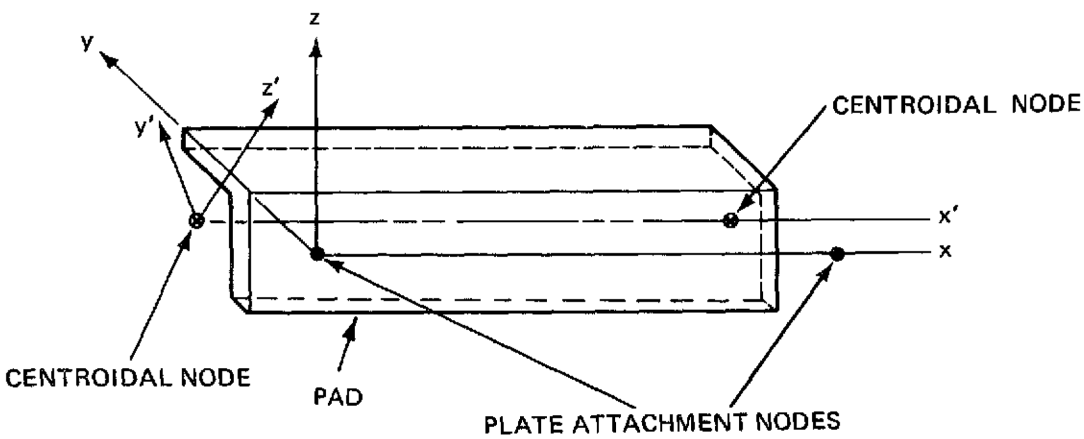
FINITE ELEMENT TYPES USED IN RE*S*I*ST

The active degrees-of-freedom (dof) for an element are defined as the dof for which there is at least one nonzero term in the corresponding row of the element stiffness matrix. The nodes and active dof per node, for each type element included in the RESIST computer program, are defined in (Figures C-1 through C-4).



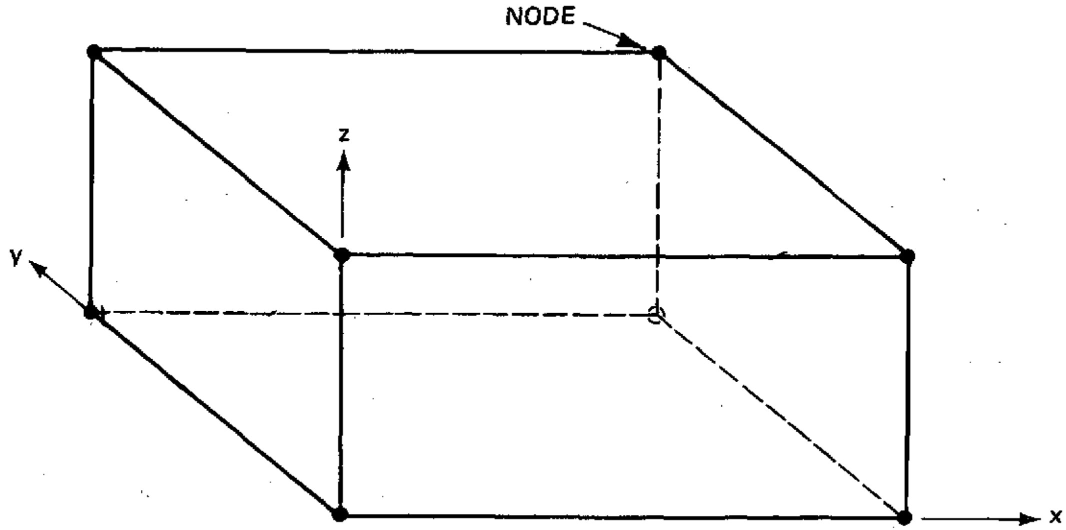
- BENDING AND MEMBRANE STIFFNESS
- FOUR NODES AT PLATE MIDDLE SURFACE
- ACTIVE DOF PER NODE ARE x, y AND z DEFLECTIONS AND x AND y ROTATIONS
- LUMPED MASSES AT NODES

Figure C-1 Primary Structure Isotropic Plate Element



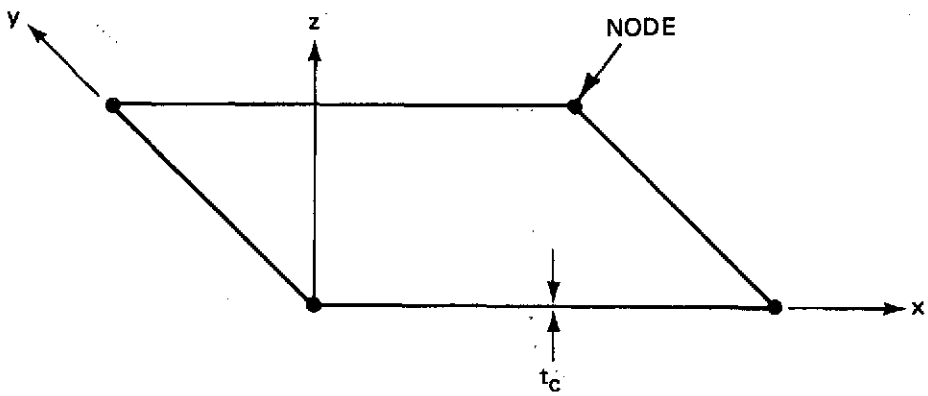
- ARBITRARY CROSS SECTION BENDING, TWISTING AND AXIAL STIFFNESS
- TWO CENTROIDAL NODES AND TWO ATTACHMENT NODES
- ACTIVE DOF ARE x, y AND z DEFLECTIONS AND ROTATIONS AT ATTACHMENT NODES ONLY. NO ACTIVE DOF AT CENTROIDAL NODES
- LUMPED MASSES AT CENTROIDAL NODES

Figure C-2 Primary Structure Uniform Stiffener Element



- THREE DIMENSIONAL STIFFNESS ELEMENT
- EIGHT CORNER NODES
- ACTIVE DOF PER NODE ARE x, y AND z DEFLECTIONS
- LUMPED MASSES AT CORNER NODES

Figure C-3 Three Dimensional Orthotropic TPS Element



- TWO DIMENSIONAL MEMBRANE ELEMENT
- FOUR CORNER NODES
- ACTIVE DOF PER NODE ARE x AND y DEFLECTIONS ONLY
- INERTIA EFFECTS NEGLECTED FOR THESE ELEMENTS

Figure C-4 TPS Thin Membrane Coating Element