August 1965 M-77-65-6

Technical Report

JUNCTURE STRESS FIELDS IN MULTICELLULAR SHELL STRUCTURES

Final Report

Nine Volumes

Vol. V Influence Coefficients of Segmental Shells

by

P. Stern

C. T. Chen

Contract NAS 8-11480 to National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Huntsville, Alabama

FOREWORD

This report is the result of a study on the numerical analysis of stiffness influence coefficients for cylindrical, conical and spherical shell segments. Work on this study was performed by staff members of Lockheed Missiles & Space Company in cooperation with the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration under Contract NAS 8-11480. Contract technical representative was H. Coldwater.

This volume is the fifth of a nine-volume final report of studies conducted by the department of Solid Mechanics, Aerospace Sciences Laboratory, Lockheed Missiles & Space Company. Project Manager was K. J. Forsberg; E. Y. W. Tsui was Technical Director for the work.

The nine volumes of the final report have the following titles:

Vol. I	Numerical Methods of Solving Large Matrices
Vol. II	Stresses and Deformations of Fixed-Edge Segmental Cylindrical Shells
Vol. III	Stresses and Deformations of Fixed-Edge Segmental Conical Shells
Vol. IV	Stresses and Deformations of Fixed-Edge Segmental Spherical Shells
Vol. V	Influence Coefficients of Segmental Shells
Vol. VI	Analysis of Multicellular Propellant Pressure Vessels by the Stiffness Method
Vol. VII	Buckling Analysis of Segmental Orthotropic Cylinders under Uniform Stress Distribution
Vol. VIII	Buckling Analysis of Segmental Orthotropic Cylinders under Non-uniform Stress Distribution
Vol. IX	Summary of Results and Recommendations

SUMMARY

16721

This volume presents a technique using the modified digital programs developed for intermediate loads or thermal gradients to determine stiffness influence coefficients of cylindrical, conical and spherical shell segments. The problem is solved numerically by the finite difference method, using a direct method for solving a large system of simultaneous equations. For completeness as a self-contained report, a portion of the information presented in Vol. II, III and IV is repeated here.

Author

CONTENTS

NOTATION

a_i, b_i, c_i, A, B, C, $\varkappa$	nondimensional parameters defined in text
D	flexural rigidity of shell = $Eh^3/12(1 - \nu^2)$
E	modulus of elasticity
F	nondimensionalized force vector
F_i	boundary force at Station i
F^f	boundary forces of fixed-edge shell due to applied forces or thermal gradients
G	shear modulus
$\hat{h}$	thickness of shell
i, j	dummy subscripts
k	stiffness matrix
k_{ij}	stiffness influence coefficients
$\overline{M}_{(\ )}$, $\overline{N}_{(\ )}$	moments and stress resultants
$\overline{Q}_{(\ )}$	transverse shears
u, v, w	displacement components
ξ, η	orthogonal coordinates along boundaries of shell
δ	nondimensionalized displacement vector
δ_i	boundary deformations (displacements or rotations) of Station i
$\omega_{(\ )}$	rotations of the normal at the middle-surface
$(\ )_{,x}$	$\frac{\partial(\ )}{\partial x}$

$\hat{(\ )}$	dimensional quantities
μ	dimensionalizing matrix for displacements diagonal matrix $\hat{\delta} = \mu\delta$
λ	dimensionalizing matrix for forces diagonal matrix $\hat{F} = \lambda F$

Additional notations and symbols are defined in the text.

Section 1

INTRODUCTION

As a results of an investigation of juncture stress fields peculiar to the multicellular pressure vessels (Fig. 1), a theory for the prediction of the membrane and bending stresses and the corresponding deformations for such shell structures was formulated.*

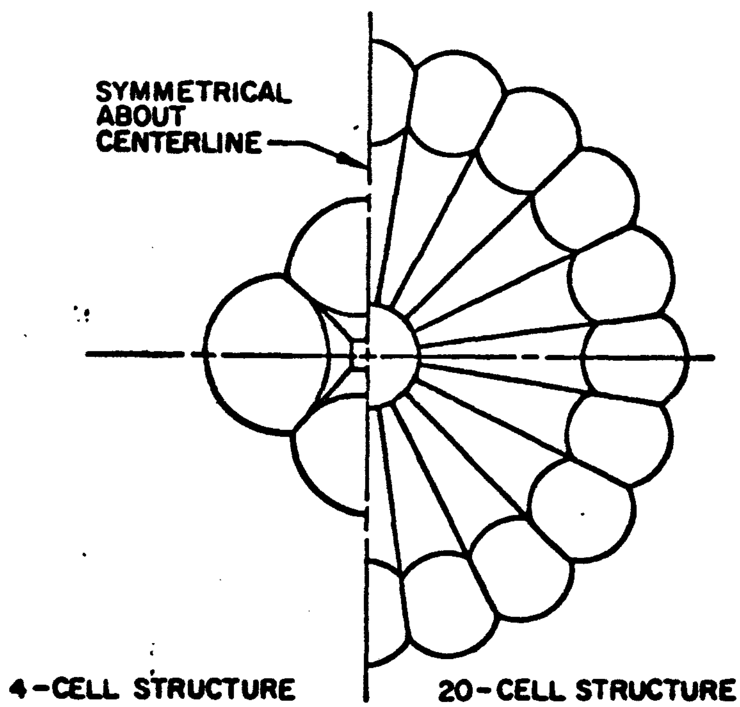


Fig. 1 Multicellular Shell Structure

*"Investigation of Juncture Stress Fields in Multicellular Shell Structures," by E. Y W. Tsui, F. A. Brogan, J. M. Massard, P. Stern, and C. E. Stuhlman, Technical Report M-03-63-1, Lockheed Missiles & Space Company, Sunnyvale, Calif., Feb 1964 - NASA CR-61050.

Since analytic solutions are still lacking, it was decided to solve the problem numerically by means of a finite-difference technique. To ensure the feasibility of such a numerical solution, a direct method of solving large matrices with a high-speed digital computer was also developed.

According to the previous work, if the stiffness or displacement method is used, the total forces and hence the corresponding stresses along the juncture of the shell segments (Fig. 2) may be expressed concisely in the following matrix form

$$F = k\delta + F^f \tag{1.1}$$

where k is the stiffness matrix, δ are the deformations, and F^f are the fixed-end forces due to applied loads or thermal gradients. In view of this situation, it is logical to solve the problem systematically by the established general procedure of analysis already described. This procedure may be stated briefly as follows:

1. Determination of the fixed-end forces, F^f, along the boundary as well as stresses and deformations in the interior of shell segments due to loads
2. Determination of the influence coefficients, k_{ij}, along the boundaries of shell segments, i.e., the induced forces at points i due to unit deformations ($\delta = 1$) at points j
3. Determination of the actual deformations, δ, along the shell boundaries; this requires the satisfaction of both compatibility and equilibrium conditions at the junctures of the structure

Once all the work involved in these three steps is completed, the total stresses and deformations in the specific discrete interior locations may be obtained.

This volume presents results of the work involved in Step 2 to determine the local stiffness influence coefficients k_{ij} of cylindrical, conical, and spherical shell segments. The problem is formulated as a homogeneous

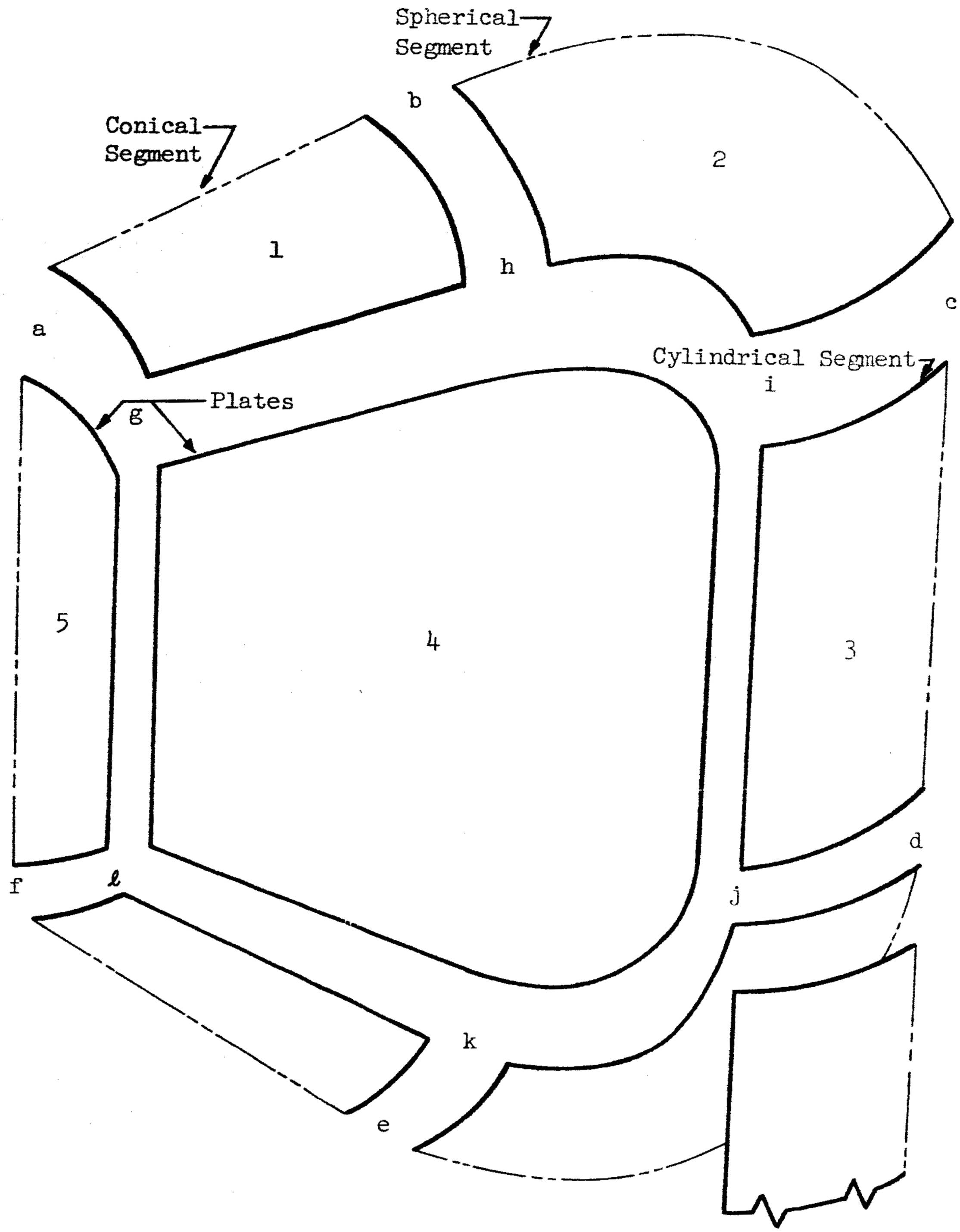


Fig. 2 Basic Shell Elements of Multicellular Structure

differential equation with inhomogeneous boundary conditions. The numerical technique of finite differences is used to obtain a solution to this problem.

The operation of three digital programs is given and three numerical examples are presented to demonstrate the program input and output.

It should be noted that influence coefficients for rectangular plates can be determined by the program for cylinders if the radius $(\hat{R})$ is increased appropriately.

Section 2

FORMULATION OF THE PROBLEM

2.1 General Considerations

The basic equations governing segmental cylindrical, conical, and spherical shells subjected to intermediate loads such as pressure, temperature, etc., are formulated in Vols. II, III, and IV. In order to mathematically join two or more of these continuous elastic shell segments together to form a multicellular structural shape, it is necessary to establish the constitutive boundary equations for each of the segments. These equations relate the boundary loads to boundary displacements as a function of the boundary coordinate η . If boundary displacements are known then the boundary loads can be uniquely determined by these linear relations.

One technique to accomplish this is known as the stiffness method which describes the boundary force as a function of the boundary coordinate due to unit deformations introduced at a point s on the boundary. For an element the constitutive equations can be written as

$$F = k\delta \tag{2.1}$$

where F and δ are column vectors defined by

$$F = \begin{Bmatrix} \bar{N}_\eta \\ \bar{N}_\zeta \\ \bar{Q} \\ \bar{M} \end{Bmatrix} \quad ; \quad \delta = \begin{Bmatrix} u_\eta \\ u_\zeta \\ w \\ \omega_\eta \end{Bmatrix}$$

and k is a stiffness matrix which is a function of the boundary coordinate and the point at which the displacements are applied. A general load can be obtained by superposition of the effects of a given boundary displacement. To establish the stiffness matrix, unit values of the displacement components are applied at a point on the shell boundary. At all other points the displacement vector is set to zero. This boundary-value problem involves solving a set of homogeneous differential equations subjected to homogeneous boundary conditions except at the point at which the unit displacement is applied.

2.2 Governing Differential Equations

The governing differential equations required to find the stiffness matrix of a segmental cylindrical, conical, and spherical shell are given in Vols. II, III, and IV. All that must be done is to set the right hand terms to zero.

The governing equations for a cylindrical shell become [see Eqs. (2.8a-c, Vol. II)]:

$$a_1 u,_{xx} + a_2 u,_{\theta\theta} + a_3 v,_{x\theta} + a_4 w,_{xxx} + a_5 w,_x = 0 \qquad (2.2a)$$

$$b_1 u,_{x\theta} + b_2 v,_{xx} + b_3 v,_{\theta\theta} + b_4 w,_{xx\theta} + b_5 w,_{\theta\theta\theta} + b_6 w,_\theta = 0 \qquad (2.2b)$$

$$c_1 u,_{xxx} + c_2 u,_x + c_3 v,_{xx\theta} + c_4 v,_{\theta\theta\theta} + c_5 v,_\theta + c_6 w,_{xxxx} + c_7 w,_{xx\theta\theta}$$

$$+ c_8 w,_{\theta\theta\theta\theta} + c_9 w,_{\theta\theta} + c_{10} w = 0 \qquad (2.2c)$$

For a conical shell, the homogeneous equations are given by:

$$a_1 u,_{xx} + a_2 u,_{\theta\theta} + a_3 u,_x + a_4 u + a_5 v,_{x\theta} + a_6 v,_\theta + a_7 w,_x + a_8 w = 0 \qquad (2.3a)$$

$$b_1 u,_{x\theta} + b_2 u,_\theta + b_3 v,_{xx} + b_4 v,_{\theta\theta} + b_5 v,_x + b_6 v + b_7 w,_{xx\theta} + b_8 w,_{\theta\theta\theta}$$

$$+ b_9 w,_{x\theta} + b_{10} w,_\theta = 0 \qquad (2.3b)$$

$$c_1 u,_x + c_2 u + c_3 v,_{xx\theta} + c_4 v,_{\theta\theta\theta} + c_5 v,_{x\theta} + c_6 v,_\theta + c_7 w,_{xxxx}$$

$$+ c_8 w,_{xx\theta\theta} + c_9 w,_{\theta\theta\theta\theta} + c_{10} w,_{xxx} + c_{11} w,_{x\theta\theta} + c_{12} w,_{xx}$$

$$+ c_{13} w,_{\theta\theta} + c_{14} w,_x + c_{15} w = 0 \qquad (2.3c)$$

The corresponding equations for spherical shells are:

$$a_1 u,_{\varphi\varphi} + a_2 u,_{\theta\theta} + a_3 u,_\varphi + a_4 u + a_5 v,_{\varphi\theta} + a_6 v,_\theta + a_7 w,_{\varphi\varphi\varphi}$$

$$+ a_8 w,_{\varphi\theta\theta} + a_9 w,_{\varphi\varphi} + a_{10} w,_{\theta\theta} + a_{11} w,_\varphi = 0 \qquad (2.4a)$$

$$b_1 u,_{\varphi\theta} + b_2 u,_\theta + b_3 v,_{\varphi\varphi} + b_4 v,_{\theta\theta} + b_5 v,_\varphi + b_6 v + b_7 w,_{\varphi\varphi\theta}$$

$$+ b_8 w,_{\theta\theta\theta} + b_9 w,_{\varphi\theta} + b_{10} w,_\theta = 0 \qquad (2.4b)$$

$$c_1 u,_{\varphi\varphi\varphi} + c_2 u,_{\varphi\theta\theta} + c_3 u,_{\varphi\varphi} + c_4 u,_{\theta\theta} + c_5 u,_\varphi + c_6 u + c_7 v,_{\varphi\varphi\theta}$$

$$+ c_8 v,_{\theta\theta\theta} + c_9 v,_{\varphi\theta} + c_{10} v,_\theta + c_{11} w,_{\varphi\varphi\varphi\varphi}$$

$$+ c_{12} w,_{\varphi\varphi\theta\theta} + c_{13} w,_{\theta\theta\theta\theta} + c_{14} w,_{\varphi\varphi\varphi} + c_{15} w,_{\varphi\theta\theta}$$

$$+ c_{16} w,_{\varphi\varphi} + c_{17} w,_{\theta\theta} + c_{18} w,_\varphi + c_{19} w = 0 \qquad (2.4c)$$

All of the a_i , b_i , c_i coefficients of the preceding equations are given in Vols. II, III, and IV and are not repeated in this volume.

2.3 Boundary Conditions

It has been established previously (see Sect. 2.2, Vol. II) that four boundary conditions are required at each point on the shell boundary. Consider a general shell boundary given in Fig. 3. The boundary coordinates are given as

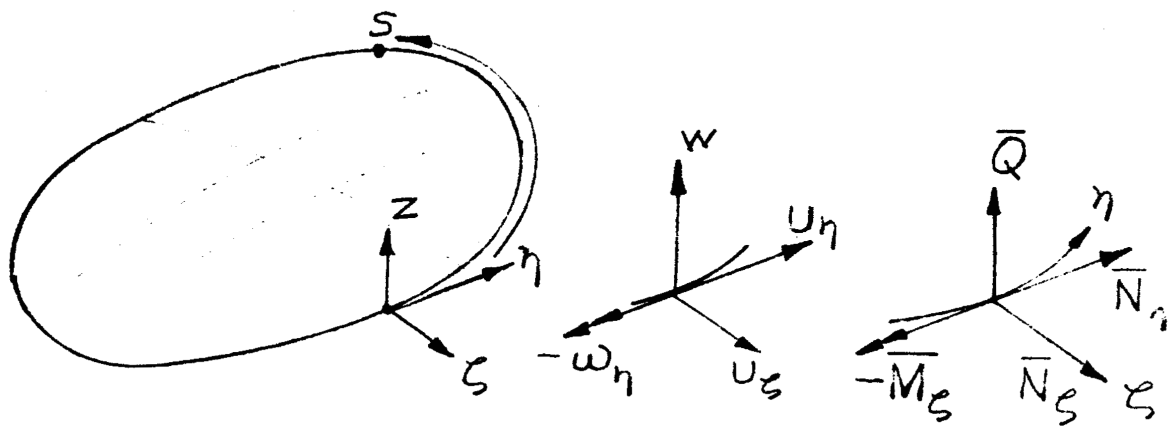


Fig. 3 Boundary Coordinates, Deformations, and Forces

ζ , η , z ; positive deformations u_ζ , u_η , w , ω_η and their corresponding forces $\bar{N}_\zeta$, $\bar{N}_\eta$, $\bar{Q}$, $\bar{M}$ are defined as shown. The boundary constitutive equations [Eqs. (1)] can be written as

$$\begin{Bmatrix} \bar{N}_\eta \\ \bar{N}_\zeta \\ \bar{Q} \\ \bar{M} \end{Bmatrix} = \begin{bmatrix} k_{11} & \cdots & & \\ k_{21} & \cdots & & \\ k_{31} & \cdots & & \\ k_{41} & \cdots & & k_{44} \end{bmatrix} \begin{Bmatrix} u_\eta \\ u_\zeta \\ w \\ \omega_\eta \end{Bmatrix} \qquad (2.5)$$

where k_{ij} are **functions** of the coordinate η and the point s at which the displacement is specified.

In order to find k_{11}, k_{21}, k_{31}, and k_{41}, the required boundary conditions are

$$\begin{aligned} u_\zeta &= w = \omega_\eta = 0 && \text{for all } \eta \\ u_\eta &= 1.0 && \text{for } \eta = s,\ 0 \le s \le \ell \\ u_\eta &= 0 && \text{for } \eta \neq s \end{aligned} \tag{2.6}$$

where ℓ is the total length of the boundary curve. With the above boundary conditions the governing equations must be solved for the boundary forces which are the desired stiffness functions. The other stiffness functions are found in a similar manner.

For the cylindrical, conical, and spherical elements of the multicellular shell structure, the boundary curves are shown in Fig. 4. The nondimensional displacement vector and the corresponding force vector for these shapes are shown respectively in Tables 1 and 2.

The pertinent differential equations have been nondimensionalized so as to cover a wide range of shell parameters. Once the stiffness matrix is found in nondimensional form, it can be transformed to dimensional quantities if it is so desired. The nondimensional boundary loads and displacements can be converted to dimensional values by the following multiplications

$$\hat{F} = \lambda F = \begin{bmatrix} \lambda_{11} & & & 0 \\ & \lambda_{22} & & \\ & & \lambda_{33} & \\ 0 & & & \lambda_{44} \end{bmatrix} \begin{Bmatrix} \bar{N}_\eta \\ \bar{N}_\zeta \\ \bar{Q} \\ \bar{M} \end{Bmatrix} \tag{2.7}$$

$$\hat{\delta} = \mu\delta = \begin{bmatrix} \mu_{11} & & & 0 \\ & \mu_{22} & & \\ & & \mu_{33} & \\ 0 & & & \mu_{44} \end{bmatrix} \begin{Bmatrix} u_\eta \\ u_\zeta \\ w \\ \omega_\zeta \end{Bmatrix} \tag{2.8}$$

where λ and μ are diagonal matrices. The coefficients of these matrices are given in Tables 3 and 4 for the cylinder, cone, and sphere.

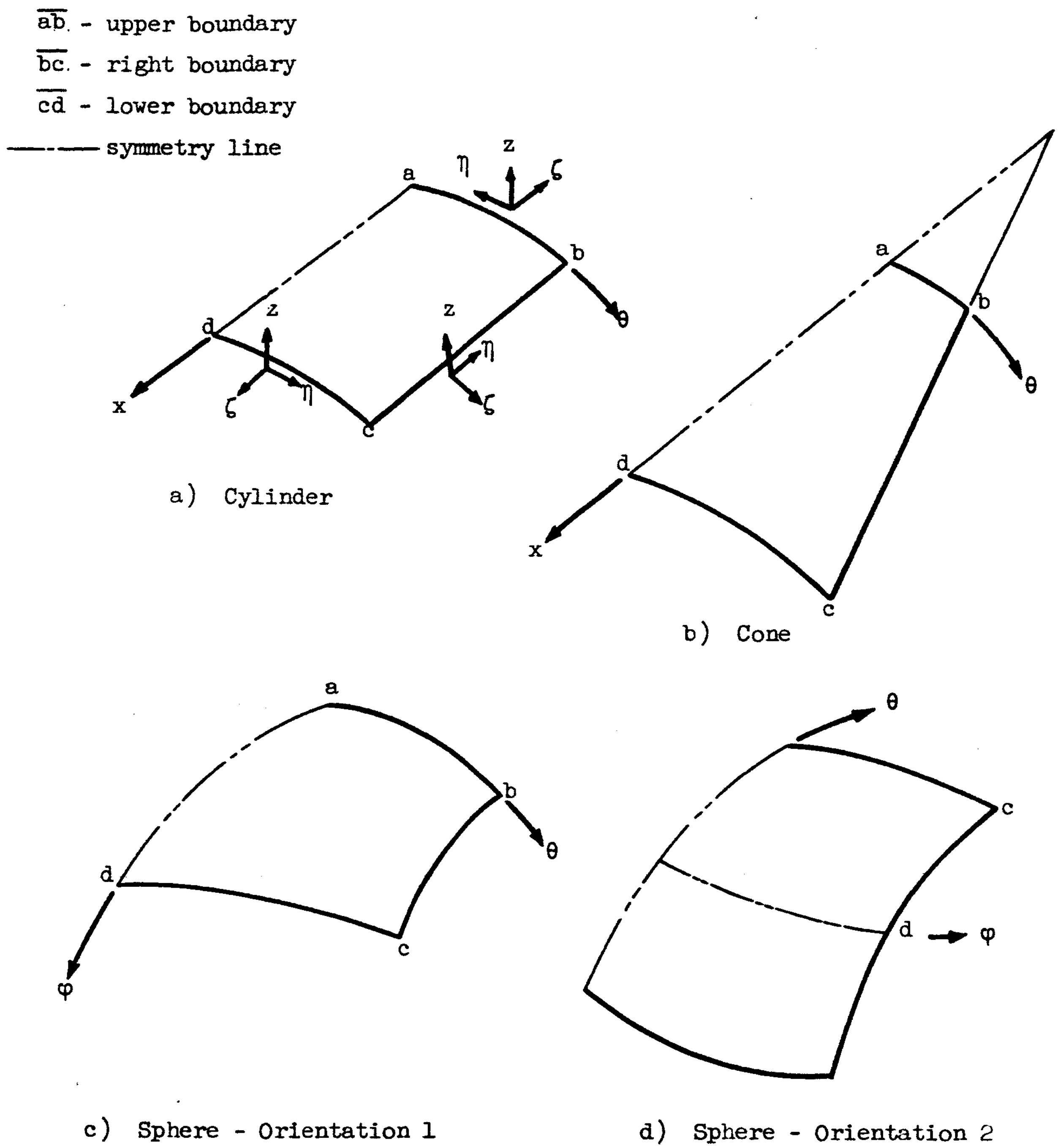


Fig. 4 Boundary Curves for Cylindrical, Conical and Spherical Segments of Multicellular Structure

	δ	Cylinder	Cone	Sphere
$\overline{ab}$	u_η	$-v$	$-v$	$-v$
	u_ζ	$-u$	$-u$	$-u$
	w	w	w	w
	ω_η	$+(\rho/\theta_c)w,_x$	$+w,_x$	$-u + w,_\varphi$
$\overline{bc}$	u_η	$-u$	$-u$	$-u$
	u_ζ	v	v	v
	w	w	w	w
	ω_η	$v - (1/\theta_c)w,_\theta$	$v/x \tan \varphi_3 - w,_\theta/x\theta_c \sin \varphi_3$	$v - (1/\sin \varphi)w,_\theta$
$\overline{cd}$	u_η	v	v	v
	u_ζ	u	u	u
	w	w	w	w
	ω_η	$-(\rho/\theta_c)w,_x$	$-w,_x$	$u - w,_\varphi$

Table 1 Nondimensional Displacement Components Corresponding to the Boundary Displacement δ

	F	Cylinder	Cone	Sphere
$\overline{ab}$	$\overline{N}_\eta$	$N_{x\theta} + M_{x\theta}$	$N_{x\theta} + \frac{h^2}{6x(1 - \nu) \tan \varphi_3} M_{x\theta}$	$N_{\varphi\theta} + 2\varkappa M_{\varphi\theta}$
	$\overline{N}_\zeta$	N_x	N_x	N_φ
	$\overline{Q}$	$- \left[Q_x + \frac{1}{\theta_c} M_{x\theta,\theta}\right]$	$- \left[Q_x + \frac{1}{x\theta_c \sin \varphi_3} M_{x\theta,\theta}\right]$	$- \left[Q_\varphi + \frac{(1 - \nu)}{\sin \varphi} M_{\varphi\partial,\theta}\right.$
	$\overline{M}_\zeta$	M_x	M_x	M_φ
$\overline{bc}$	$\overline{N}_\eta$	$- N_{\theta x}$	$- N_{\theta x}$	$- N_{\theta\varphi} - 2\varkappa M_{\varphi\theta}$
	$\overline{N}_\zeta$	N_θ	N_θ	N_θ
	$\overline{Q}$	$[Q_\theta + \frac{\rho}{\theta_c} M_{\theta x,x}]$	$[Q_\theta + M_{\theta x,x}]$	$Q_\theta + (1 - \nu)M_{\varphi\theta,\varphi}$
	$\overline{M}_\zeta$	M_θ	M_θ	M_θ
$\overline{cd}$	$\overline{N}_\eta$	$N_{x\theta} + M_{x\theta}$	$N_{x\theta} + \frac{h^2}{6x(1 - \nu) \tan \varphi_3} M_{x\theta}$	$N_{\varphi\theta} + 2\varkappa M_{\varphi\theta}$
	$\overline{N}_\zeta$	N_x	N_x	N_φ
	$\overline{Q}$	$Q_x + \frac{1}{\theta_c} M_{x\theta,\theta}$	$Q_x + \frac{1}{x\theta_c \sin \varphi_3} M_{x\theta,\theta}$	$Q_\varphi + \frac{(1 - \nu)}{\sin \varphi} M_{\varphi\theta,\theta}$
	$\overline{M}_\zeta$	M_x	M_x	M_φ

Table 2 Nondimensional Boundary Forces Corresponding to the Boundary Force F

	Cylinder	Cone	Sphere
λ_{11}	Eh	$Eh/2(1 + \nu)$	$E\hat{h}/2(1 + \nu)$
λ_{22}	Eh	$Eh/(1 - \nu^2)$	$E\hat{h}/(1 - \nu^2)$
λ_{33}	Eh	D/X_L^2	D/R^2
λ_{44}	EhR	D/X_L	D/R

Table 3 Components of λ which Dimensionalizes the Boundary Forces of Cylindrical, Conical, and Spherical Shell Segments

	Cylinder	Cone	Sphere
μ_{11}	R	X_L	R
μ_{22}	R	X_L	R
μ_{33}	R	X_L	R
μ_{44}	1.0	1.0	1.0

Table 4 Components of μ which Dimensionalize the Boundary Displacements of Cylindrical, Conical and Spherical Shell Segments

To dimensionalize the stiffness matrix requires

$$\hat{F} = \lambda F = \lambda k \delta = (\lambda k \mu^{-1}) \hat{\delta}$$

Thus the dimensional stiffness matrix is

$$\hat{k} = \lambda k \mu^{-1} \tag{2.9}$$

and each component can be found by

$$\hat{k}_{ij} = \lambda_{ii} k_{ij} \frac{1}{\mu_{jj}} \tag{2.10}$$

Section 3
NUMERICAL ANALYSIS

3.1 General

The boundary value problem formulated in Section 2 for the determination of the stiffness matrix will be solved by the finite-difference method. This method is described in Vols. II, III, and IV for the analysis of cylindrical, conical and spherical shell segments with fixed edges and subjected to surface and thermal loads. This numerical method of solution replaces the continuous coordinate system defining the shell segments by a finite number of coordinate points. To accomplish this discretization, the continuous two-dimensional domain of the shell reference surface is covered by a rectangular net. Lattice points of this net which fall on the boundary curve are called boundary points, and all other lattice points interior to the boundary are called mesh points. At these lattice points the dependent variables (u, v, w) of the governing differential equations are replaced by discrete variables.

The difference equations which are a set of algebraic relations representing the governing equations and boundary conditions are formed by first approximating the derivatives at a given point by a function of the variable at neighboring points. These functions replace the derivatives of the governing equations. Thus, at each mesh point three algebraic equations can be written in terms of neighboring points. When the boundary conditions are accounted for in these equations the resulting set of simultaneous algebraic equations

$$\underset{\sim}{A}X = \underset{\sim}{B}$$

replaces the continuous problem. The solution of this set of algebraic equations can be accomplished by methods described in Vol. I.

Difference equations for interior points of the shell segments under consideration are available in Vols. II, III, and IV and are not repeated in this volume. As noted in Section 2 the only difference is that the right hand side is zero. The main concern in this section is the presentation of the boundary conditions necessary to generate the stiffness matrix and a description of the procedure to find this matrix.

3.2 Stiffness Matrix

The stiffness matrix given in Section 2 which relates the boundary displacements to the boundary forces as a function of the boundary coordinate η and the point s at which unit displacements are applied. The discretization of this problem by finite differences leads to a stiffness matrix defined by the boundary points.

Figure 5 represents a shell segment covered by a rectangular net required for a finite difference solution of the problem. Instead of the continuum boundary coordinate η , the boundary curve is defined by a sequence of points denoted by $i = 1, 2, 3 \ldots n$ as shown.

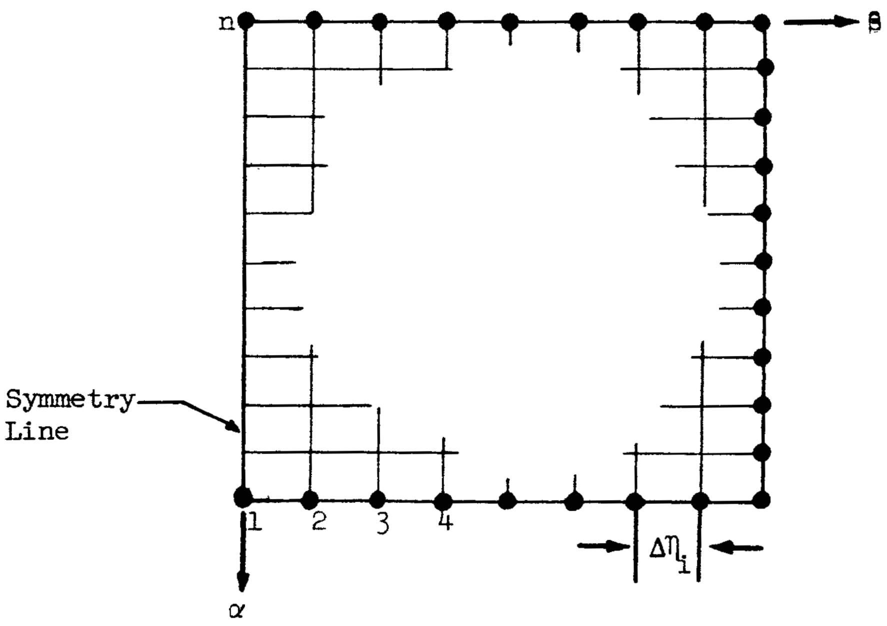


Fig. 5 Boundary of a Shell Segment for a Finite Difference Solution

At each point i four boundary forces and four displacement quantities are given as

$$F_i = \Delta\eta_i \begin{Bmatrix} \overline{N}_\eta \\ \overline{N}_\zeta \\ \overline{Q} \\ \overline{M} \end{Bmatrix}_i \quad , \qquad \delta_i = \begin{Bmatrix} u_\eta \\ u_\zeta \\ w \\ \omega_\eta \end{Bmatrix}_i \tag{3.1}$$

The boundary point is considered to be the mid-point of a small line segment $\Delta\eta_i$ over which the load and displacement act.

In general the constitutive boundary equation in matrix form is

$$F = k\,\delta$$

For the shell segment shown in Fig. 5 this equation in an expanded form becomes

$$\begin{Bmatrix} F_1 \\ F_2 \\ \cdot \\ F_n \end{Bmatrix} = \begin{bmatrix} K_{11} & K_{12} & \cdots\cdots & K_{1n} \\ K_{21} & K_{22} & \cdots\cdots & \\ & & & \\ \cdots & \cdots & \cdots\cdots & K_{nn} \end{bmatrix} \begin{Bmatrix} \delta_1 \\ \delta_2 \\ \cdot \\ \delta_n \end{Bmatrix} \tag{3.2}$$

where K_{ij} are 4 x 4 submatrices.

The coefficients of the submatrices can be defined by four indices as $k_{i,j}^{\ell,m}$. The subscript i denotes the point at which the force is acting, j shows the point the displacement is applied. The superscript k and m clarify the boundary forces and displacements, $\ell = 1$ designates the load $\overline{N}_\eta$, $\ell = 2, 3, 4$ designates $\overline{N}_\zeta$, $\overline{Q}$ and $\overline{M}$ respectively. The superscript m = 1, 2, 3, or 4 shows that the load is due to a displacement u_η, u_ζ, w, or ω_η

respectively. Thus $k^{2,3}_{i.j}$ is the boundary force $\overline{N}_\zeta$ at point i due to a unit displacement of w at point j . From the above matrix it is evident that the boundary forces can be obtained once the displacements are known.

3.3 Boundary Conditions

To find the influence coefficients of a fixed edge segmental shell, a unit value of u_η , u_ζ , w , or ω_η is applied at a boundary point j while the other boundary displacements are set to zero. The influence coefficients are then equal to the respective forces due to the unit displacement.

In specific to find the influence coefficients due to a unit displacement, the boundary conditions u_η are

$$
\begin{aligned}
u_\eta &= 0 \qquad \text{at points } i = 1,2\ldots j-1,\ j+1\ldots n \\
&= 1 \qquad \text{at} \quad i = j \qquad\qquad (3.3) \\
u_\zeta &= w = \omega_\eta = 0 \text{ at all points}
\end{aligned}
$$

With the above boundary conditions, the boundary forces obtained by solving the governing equations yield the influence coefficients

$$k^{\ell,1}_{i,j} \qquad \text{for } \ell = 1,\ 2,\ 3,\ 4 \text{ and } i = 1,\ 2,\ 3\ldots\eta$$

This is equivalent to a complete column of the influence matrix k . The other columns are obtained by giving u_ζ , w , ω_η unit values at all boundary points in a manner similar to that for u_η .

Section 4
DIGITAL PROGRAMS

4.1 General Description

The digital programs for fixed-edge cylindrical, conical, and spherical shell segments described in Vols. II, III and IV have been modified so as to allow unit nondimensional displacements (u, v, w) and rotation (ω_η) to be prescribed on the segment boundary at specified locations. Output of the programs consist of the boundary forces ($\overline{N}_\eta$, $\overline{N}_\zeta$, $\overline{Q}$, $\overline{M}_\zeta$) resulting from the boundary disturbance. As shown in Section 3, these boundary forces are the local stiffness coefficients k_{ij} . This information along with identification can be outputed on a reserve tape (B6) for use in the overall juncture problem. This detail will be explained in Vol. VI.

The program modification consisted of changes in the difference equations at specific points and their neighboring points where unit displacements are introduced. To write an efficient program for the solution of the simultaneous equation system

$$\underset{\sim}{A}\, X = \underset{\sim}{B}$$

the right hand term $\underset{\sim}{B}$ was expanded to 61 columns. Since $\underset{\sim}{A}$ is factored this permits 61 right hand vectors to be solved in a minimum of time. These 61 columns correspond to 15 points at which the boundary can be disturbed and the case of intermediate loads. Displacements can only be applied at the intersection of the mesh lines and the boundary. Likewise the boundary forces are computed at all boundary points. When a point is chosen to yield the boundary displacement, all four quantities u, v, w, and ω_η are given a unit value consecutively. In the program these can be applied along the upper, right, and lower boundaries. Figure 4 defines these boundary lines for the cylinder, cone, and sphere.

The finite-difference mesh network is specified completely by prescribing the number of rows and columns exclusive of the boundaries, together with the grading options which have been chosen. Rows in the finite-difference mesh are parallel to the θ-axis, and columns are parallel to the x- or φ-axis. The number of rows may vary from 4 to 24 and the number of columns from 4 to 80. Thus, a maximum of 5760 unknowns can be solved. Greater accuracy near the boundaries can often be obtained by selecting grading. By this means, it is possible to use a mesh spacing at the boundary as little as 1/32 of that at the middle portion of the panel.

There are certain restrictions on the use of the grading option. When such an option is used, a separate input card is required to specify a mesh spacing exponent MM(J) for each row J . The finite-difference equations written along row J , then use the mesh spacing XH/2**MM(J) . This distance must be the least of the two distances from row J to the row above and the row below. XH is the basic input mesh spacing along the x-direction. For any row J , MM(J) and MM(J+1) must not differ by more than 1 . Also, three consecutive rows cannot have three distinct exponents. MM(J) may vary from 0 to 5.

The description of symbols, and input data for the cylindrical, conical and spherical shell segments are given in Tables 5 and 6.

Table 5

DESCRIPTION OF SYMBOLS

Symbol		Description
		Cylinder
IOPT1	0	Isotropic cylinder
	1	Orthotropic cylinder
IOPT2	0	Row 1 of mesh is symmetry line, $x = 0.5$
	1	Row 1 of mesh is adjacent to boundary
IOPT3	0	Uniform mesh spacing
	1	Graded mesh spacing in x-direction
RHO		Shape factor $(R\theta_c/L)$
THC		Half angle of segment (see Fig. 3)
R1H		Radius to thickness ratio (R/h)
D1H		Depth of stiffener to thickness ratio (d/h)
D1B		Ratio of depth to spacing of stiffeners (d/b)
T1H		Ratio of stiffener width to skin thickness (t/h)
C1H		Ratio of eccentricity of stiffener to skin thickness (c/h)
		Cone
IOPT1	0	Uniform mesh spacing
	1	Graded mesh spacing in x-direction
THC		Half angle of segment (see Fig. 3)
HBO		Nondimensional reference thickness $(\hat{h}_o/\hat{X}_L)$
H1		Rate of change of thickness in x
XOXL		Nondimensional distance (see Fig. 3) $(=\hat{x}_\theta/\hat{X}_L)$
PH3		Half cone angle

Table 5

DESCRIPTION OF SYMBOLS (cont'd)

Symbol		Description
		Sphere
IOPT1	0	Uniform mesh spacing
	1	Graded mesh spacing in φ-direction
IOPT2	0	Symmetry in the φ-direction Row 1 is symmetry line
	1	Row 1 is adjacent to boundary
THC		Half angle of segment θ_c
PH1		Angle φ of upper boundary
FF		Ratio of angle of φ of lower boundary to φ or upper boundary
RH		Radius to thickness ratio, R/h
		Common to All Programs
RECORD		Hollerith information describing problem
ROW		Number of rows in the finite-difference mesh
COL		Number of columns in the finite-difference mesh
XH		Basic distance between rows in the mesh
XK		Basic distance between columns in the mesh
ZNU		Poisson's ratio
MM(J), J=1, ROW		Grading mesh constants; mesh spacing used for difference equations on row J is equal to XH/2.**MM(J)
NIB		Number of points at which unit displacements are specified on upper boundary
NJB		Number of points at which unit displacements are specified on right boundary
NKB		Number of points at which unit displacements are specified on lower boundary
IB		Column number at which unit displacements are specified on upper boundary

Table 5

DESCRIPTION OF SYMBOLS (conc'd)

Symbol		Description
JB		Row number at which unit displacements are specified on right boundary
KB		Column number at which unit displacements are specified on lower boundary
ICAS		Case Identification
IREC		Number of records previously written on data tape
ITP	-1	Transfer old records from reserve tape A6 to reserve tape B6
	+1	Skip old records on reserve tape B6
IEND	0	The program expects more records to be read on data tape
	1	Data tape B6 is unloaded from the machine

Table 6

INPUT DATA SEQUENCE AND FORMAT

Cylinder

Card	Fortran Symbol	Format
1	RECORD	72H
2	IOPT1, IOPT2, IOPT3	5I1
3	ROW, COL, XH, XK	6E12.8
4	ZNU, RHO, THC, R1H	6E12.8
5(a)	D1B, D1H, T1H, C1H	6E12.8
6(b)	MM(J), J=1, ROW	35I2
7	NIB, NJB	2I2
8(c)	IB(I), I=1, NIB	36I2
9(d)	JB(I), I=1, NJB	36I2
10	ICAS, IREC, ITP, IEND	4I4

(a) Omitted unless IOPT1 = 1

(b) Omitted unless IOPT3 = 1

(c) Omitted if NIB = 0

(d) Omitted if NJB = 0

Table 6

INPUT DATA SEQUENCE AND FORMAT (cont'd)

Cone

Card	Fortran Symbol	Format
1	RECORD	72H
2	IOPT1	3I1
3	ROW, COL, XH, XK	3E12.8
4	ZNU, THC, HBO, H1, XOXL, PH3	6E12.8
5[(a)]	MM(J),J=1, ROW	35I2
6	NIB, NJB, NKB	3I2
7[(b)]	IB(I), I=1, NIB	36I2
8[(c)]	JB(I), I=1, NJB	36I2
9[(d)]	KB(I), I=1, NKB	36I2
10	ICAS, IREC, ITP, IEND	4I4

(a) Omitted unless IOPT1 = 1

(b) Omitted if NIB = 0

(c) Omitted if NJB = 0

(d) Omitted if NKB = 0

Table 6

INPUT DATA SEQUENCE AND FORMAT (conc'd)

Sphere

Card	Fortran Symbol	Format
1	RECORD	72H
2	IOPT1, IOPT2, IOPT3, IOPT4, IOPT5	10I1
3	ROW, COL, XH, XK	3E12.8
4	ZNU, THC, PH1, FF, RH	6E12.8
5[(a)]	MM(J), J=1, ROW	35I2
6	NIB, NJB, NKB	3I2
7[(b)]	IB(I), I=1, NIB	36I2
8[(c)]	JB(I), I=1, NJB	36I2
9[(d)]	KB(I), I=1, NKB	36I2
10	ICAS, IREC, ITP, IEND	4I4

(a) Omitted unless IOPT1 = 1

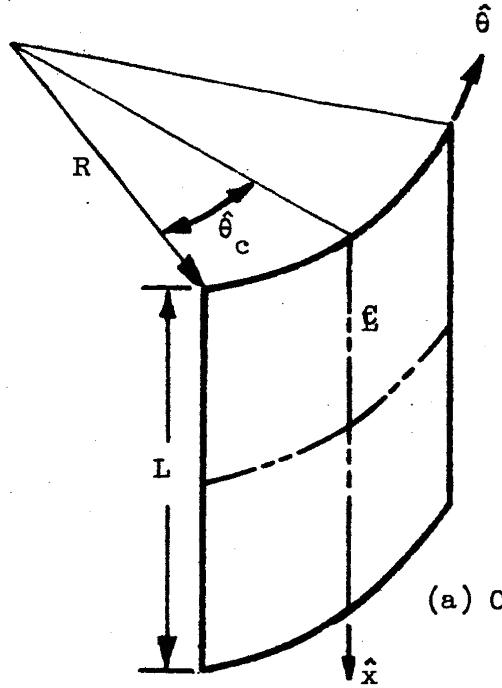
(b) Omitted if NIB = 0

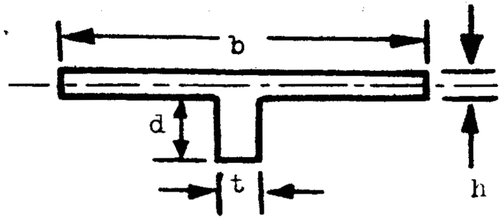
(c) Omitted if NJB = 0

(d) Omitted if NKB = 0

4.2 Numerical Examples

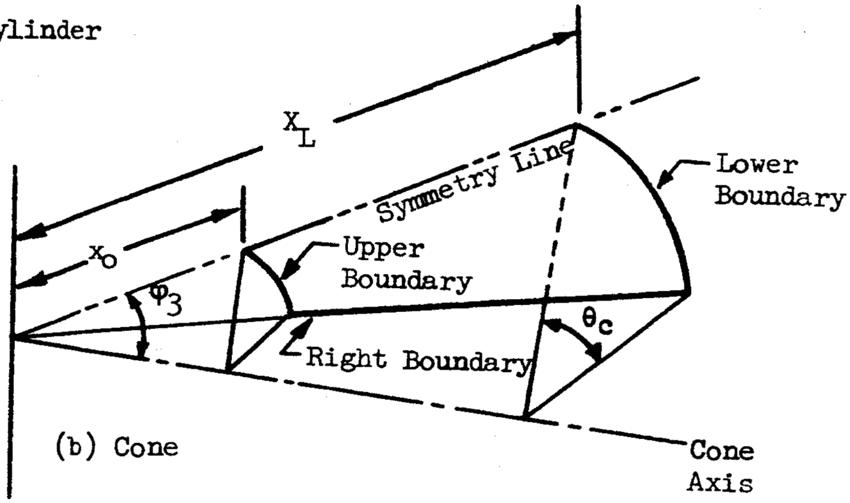
Output of the influence coefficient programs is demonstrated for cylindrical, conical, and spherical shell elements shown in Fig. 6. Sample output for the three elements given in Table 7 consists of the boundary stress resultants noted as NTAN, NNORM, Q, and M ($\overline{N}_{\eta}$, $\overline{N}_{\xi}$, $\overline{Q}$, $\overline{M}_{\xi}$) is printed out at each boundary mesh point denoted by a row and column number. These stress resultants are due to a unit value of u_{ξ}, u_{η}, w or ω_{η} (u, v, w, w*) introduced at a boundary point which is also given in the print out. As shown in Section 3 the boundary stress resultants correspond to stiffness influence coefficients. The program always computes the boundary resultants at each boundary point specified in the order u, v, w, w*. The cylindrical element has two lines of symmetry and in the finite difference mesh ten columns and fifteen rows with grading are used. Results shown in Table 7 for this element are for deformations introduced on the upper row corresponding to column 3, row 15. The conical element has seventeen rows and ten columns and the deformations are introduced on the lower boundary corresponding to column 3, row 0. For the sphere thirteen rows and ten columns are used and the deformations are introduced on the lower boundary corresponding to column 3, row 0. Due to grading and the column spacing of the examples, accuracy of the boundary resultants vary along different boundary lines.





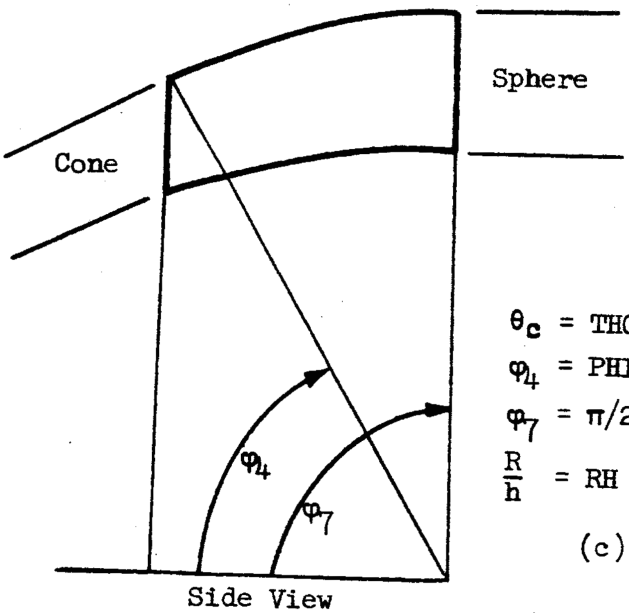
$L = 51.5$ in.
$R = 35.5$ in.
$\hat{\theta}_c = .91$
$t = 0.221$ in.
$b = 6.82$ in.
$d = 0.603$ in.
$h = 0.147$ in.

(a) Cylinder



θ_c = THC = 0.61 radians
h_o/X_L = HBφ = 0.0045
φ_3 = PH3 = 0.497 radians
x_o/X_L = XφXL = 0.3
h_1 = H_1 = 0.0

(b) Cone



θ_c = THC = 0.61 radians
φ_4 = PHI = 1.0297 radians
$\varphi_7 = \pi/2$
$\frac{R}{h}$ = RH = 100

(c) Sphere

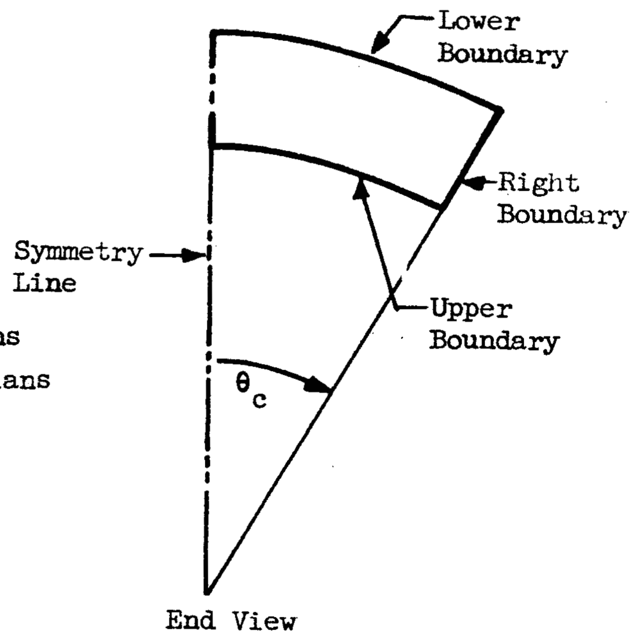


Fig. 6 Configurations of shells in the numerical examples

Table 7

Sample Output of Influence Coefficients - Cylinder

COL 3 ROW 15 U= -1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
15.	1	0.	-9.0222E-01	-1.5998E-01	-9.2569E-04
15.	2	-1.3355E 00	-3.1935E 00	-2.3816E-01	-8.9420E-05
15.	3	-6.0558E-02	8.6910E 00	1.9975E-01	-6.3680E-03
15.	4	1.2271E 00	-3.0156E 00	-8.0657E-02	1.8081E-03
15.	5	-6.6651E-02	-4.0185E-01	5.8793E-03	6.3627E-04
15.	6	-6.9635E-02	-1.1362E-01	1.0013E-01	1.4712E-03
15.	7	-5.5749E-02	-4.3395E-03	1.1364E-01	1.5277E-03
15.	8	-3.7963E-02	3.3326E-02	9.6847E-02	1.2600E-03
15.	9	-2.2407E-02	3.6860E-02	6.5395E-02	8.3474E-04
15.	10	-1.1557E-02	2.5179E-02	2.8230E-02	3.5110E-04
15.	11	0.	0.	-7.0119E-07	-0.
15.	11				
15.	11	-0.	0.	0.	-0.
14.	11	6.9335E-04	2.0095E-03	5.2537E-07	-1.3148E-06
13.	11	1.2679E-03	3.5461E-03	1.8371E-05	-8.5504E-07
12.	11	2.1916E-03	5.9968E-03	7.3118E-05	1.9774E-06
11.	11	2.9859E-03	7.6058E-03	1.5408E-04	7.4666E-06
10.	11	3.6715E-03	8.6119E-03	2.5252E-04	1.4743E-05
9.	11	4.8553E-03	9.8314E-03	4.6869E-04	3.1247E-05
8.	11	5.8192E-03	1.0146E-02	7.0549E-04	4.9932E-05
7.	11	7.4301E-03	9.8311E-03	1.1982E-03	8.9270E-05
6.	11	8.5517E-03	8.8183E-03	1.7010E-03	1.2933E-04
5.	11	1.0111E-02	6.8135E-03	2.7074E-03	2.0803E-04
4.	11	1.0494E-02	6.0139E-03	3.7405E-03	2.7935E-04
3.	11	9.0161E-03	7.1269E-03	5.7412E-03	4.0590E-04
2.	11	4.9961E-03	1.0160E-02	7.0846E-03	4.8230E-04
1.	11	-0.	1.1648E-02	7.5441E-03	5.0738E-04

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cylinder

COL 3 ROW 15 V= -1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
15.	1	0.	-1.6527E-01	-6.1761E-01	-8.6327E-03
15.	2	-2.9738E 00	7.7381E-01	-6.3036E-01	-9.9001E-03
15.	3	8.8930E 00	-6.2660E-02	-5.8934E-04	-2.2181E-04
15.	4	-3.1587E 00	-8.6651E-01	1.3692E-01	3.6905E-03
15.	5	-5.2397E-01	5.2075E-02	2.4820E-01	3.4944E-03
15.	6	-2.3587E-01	4.7437E-02	2.0429E-01	2.7276E-03
15.	7	-1.1710E-01	4.5939E-02	1.4952E-01	1.9677E-03
15.	8	-5.8196E-02	3.8646E-02	9.9867E-02	1.3015E-03
15.	9	-2.6903E-02	2.7840E-02	5.7673E-02	7.4469E-04
15.	10	-1.0868E-02	1.6476E-02	2.2671E-02	2.8744E-04
15.	11	0.	0.	-6.5574E-07	-0.
15.	11				
15.	11	-0.	0.	0.	-0.
14.	11	5.0757E-04	1.8791E-03	-1.0144E-06	-1.3507E-06
13.	11	9.0761E-04	3.3968E-03	9.8821E-06	-1.2933E-06
12.	11	1.5031E-03	5.9593E-03	4.4641E-05	3.3020E-07
11.	11	1.9636E-03	7.8521E-03	9.7292E-05	4.0786E-06
10.	11	2.3089E-03	9.2381E-03	1.6184E-04	9.2790E-06
9.	11	2.8024E-03	1.1283E-02	3.0409E-04	2.1328E-05
8.	11	3.0463E-03	1.2247E-02	4.6069E-04	3.5362E-05
7.	11	3.2295E-03	1.2605E-02	7.8799E-04	6.5579E-05
6.	11	3.0401E-03	1.1013E-02	1.1062E-03	9.5040E-05
5.	11	2.6430E-03	5.9429E-03	1.7097E-03	1.4998E-04
4.	11	2.3492E-03	3.6876E-03	2.2672E-03	1.8563E-04
3.	11	1.4594E-03	4.9901E-03	3.3175E-03	2.3178E-04
2.	11	5.2706E-04	9.1188E-03	3.9200E-03	2.4811E-04
1.	11	-0.	1.0881E-02	4.0862E-03	2.5088E-04

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cylinder

COL 3 ROW 15 W= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
15.	1	0.	9.8734E-04	5.2553E-02	6.9594E-04
15.	2	1.3910E-01	-2.0642E-02	-1.2157E-01	-1.5999E-03
15.	3	-1.8303E-02	1.4618E-01	7.8872E-01	1.0676E-02
15.	4	-1.8295E-01	-2.2180E-02	-1.1550E-01	-1.5238E-03
15.	5	-8.2147E-02	6.4510E-03	3.8968E-02	5.1218E-04
15.	6	-3.4978E-02	1.1512E-02	2.9290E-02	3.8626E-04
15.	7	-1.7541E-02	8.7393E-03	2.1495E-02	2.8050E-04
15.	8	-8.8091E-03	6.6128E-03	1.4529E-02	1.8825E-04
15.	9	-4.1358E-03	4.5697E-03	8.5025E-03	1.0926E-04
15.	10	-1.7051E-03	2.6539E-03	3.3954E-03	4.2847E-05
15.	11	0.	0.	-1.0320E-07	-0.
15.	11				
15.	11	-0.	0.	0.	-0.
14.	11	8.0805E-05	2.9704E-04	-2.1336E-07	-2.1979E-07
13.	11	1.4499E-04	5.3817E-04	1.4215E-06	-2.2668E-07
12.	11	2.4175E-04	9.4629E-04	6.7143E-06	-1.0794E-08
11.	11	3.1748E-04	1.2484E-03	1.4804E-05	5.2951E-07
10.	11	3.7534E-04	1.4696E-03	2.4760E-05	1.2926E-06
9.	11	4.6061E-04	1.7940E-03	4.6754E-05	3.0751E-06
8.	11	5.0724E-04	1.9435E-03	7.0966E-05	5.1663E-06
7.	11	5.5312E-04	1.9892E-03	1.2143E-04	9.6847E-06
6.	11	5.3914E-04	1.7366E-03	1.6931E-04	1.4064E-05
5.	11	5.0419E-04	9.5598E-04	2.5775E-04	2.2164E-05
4.	11	4.7398E-04	5.5718E-04	3.3671E-04	2.7353E-05
3.	11	3.4109E-04	6.2437E-04	4.8266E-04	3.3927E-05
2.	11	1.4700E-04	1.1230E-03	5.5081E-04	3.6089E-05
1.	11	-0.	1.3200E-03	5.6602E-04	3.6468E-05

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cylinder

COL 3 ROW 15 W*= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
15.	1	0.	1.5359E-03	1.0410E-03	1.2722E-05
15.	2	4.2671E-03	3.5108E-03	-2.0270E-03	-3.5636E-05
15.	3	-3.6495E-04	7.2915E-03	1.2007E-01	1.6081E-03
15.	4	-5.1618E-03	3.2174E-03	-2.0864E-03	-3.6226E-05
15.	5	-1.6026E-03	8.4927E-04	7.1016E-04	8.8313E-06
15.	6	-7.2826E-04	4.5910E-04	5.7449E-04	7.3054E-06
15.	7	-3.5301E-04	2.3933E-04	3.7818E-04	4.8494E-06
15.	8	-1.6652E-04	1.2544E-04	2.2632E-04	2.9157E-06
15.	9	-7.2070E-05	6.3752E-05	1.1798E-04	1.5212E-06
15.	10	-2.6279E-05	3.0237E-05	4.3311E-05	5.5323E-07
15.	11	0.	0.	-1.5695E-09	-0.
15.	11				
15.	11	-0.	0.	0.	-0.
14.	11	9.9735E-07	4.4834E-06	-4.3720E-09	-3.5769E-09
13.	11	1.7571E-06	8.2647E-06	1.1247E-08	-4.4429E-09
12.	11	2.8247E-06	1.4886E-05	6.4157E-08	-3.2453E-09
11.	11	3.5583E-06	2.0090E-05	1.4698E-07	2.1573E-09
10.	11	4.0062E-06	2.4153E-05	2.4951E-07	1.0500E-08
9.	11	4.4175E-06	3.0496E-05	4.7619E-07	3.0724E-08
8.	11	4.1818E-06	3.3803E-05	7.2378E-07	5.5416E-08
7.	11	2.9796E-06	3.5497E-05	1.2345E-06	1.1023E-07
6.	11	9.6550E-07	3.0690E-05	1.6524E-06	1.6017E-07
5.	11	-2.2608E-06	1.3919E-05	2.2885E-06	2.4522E-07
4.	11	-3.6468E-06	4.5749E-06	2.6605E-06	2.6620E-07
3.	11	-4.8563E-06	3.8886E-06	3.2643E-06	2.3389E-07
2.	11	-3.7482E-06	1.2205E-05	2.9458E-06	1.6620E-07
1.	11	-0.	1.5192E-05	2.6238E-06	1.3484E-07

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cylinder

COL 3 ROW 15 W** 1.0

BOUNDARY STRESS RESULTANTS,

ROW	COL	NTAN	NNORM	Q	M
15,	1	0.	1.5359E-03	1.0410E-03	1.2722E-05
15,	2	4.2671E-03	3.5108E-03	-2.0270E-03	-3.5636E-05
15,	3	-3.6495E-04	7.2915E-03	1.2007E-01	1.6081E-03
15,	4	-5.1618E-03	3.2174E-03	-2.0864E-03	-3.6226E-05
15,	5	-1.6026E-03	8.4927E-04	7.1016E-04	8.8313E-06
15,	6	-7.2826E-04	4.5910E-04	5.7449E-04	7.3054E-06
15,	7	-3.5301E-04	2.3933E-04	3.7818E-04	4.8494E-06
15,	8	-1.6652E-04	1.2544E-04	2.2632E-04	2.9157E-06
15,	9	-7.2070E-05	6.3752E-05	1.1798E-04	1.5212E-06
15,	10	-2.6279E-05	3.0237E-05	4.3311E-05	5.5323E-07
15,	11	0.	0.	-1.5695E-09	-0.
15,	11				
15,	11	-0.	0.	0.	-0.
14,	11	9.9735E-07	4.4834E-06	-4.3720E-09	-3.5769E-09
13,	11	1.7571E-06	8.2647E-06	1.1247E-08	-4.4429E-09
12,	11	2.8247E-06	1.4886E-05	6.4157E-08	-3.2453E-09
11,	11	3.5583E-06	2.0090E-05	1.4698E-07	2.1573E-09
10,	11	4.0062E-06	2.4153E-05	2.4951E-07	1.0500E-08
9,	11	4.4175E-06	3.0496E-05	4.7619E-07	3.0724E-08
8,	11	4.1818E-06	3.3803E-05	7.2378E-07	5.5416E-08
7,	11	2.9796E-06	3.5497E-05	1.2345E-06	1.1023E-07
6,	11	9.6550E-07	3.0690E-05	1.6524E-06	1.6017E-07
5,	11	-2.2608E-06	1.3919E-05	2.2885E-06	2.4522E-07
4,	11	-3.6468E-06	4.5749E-06	2.6605E-06	2.6620E-07
3,	11	-4.8563E-06	3.8886E-06	3.2643E-06	2.3389E-07
2,	11	-3.7482E-06	1.2205E-05	2.9458E-06	1.6620E-07
1,	11	-0.	1.5192E-05	2.6238E-06	1.3484E-07

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cone

COL 3 ROW 0 U= -1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14.	1	0.	9.8612E-02	1.2647E 01	-3.1626E 00
14.	2	-9.8625E-04	9.7266E-02	1.2511E 01	-2.7781E 00
14.	3	-3.1281E-03	9.2780E-02	1.1337E 01	-1.7036E 00
14.	4	-5.6108E-03	8.3909E-02	8.3033E 00	-1.6490E-01
14.	5	-6.9966E-03	7.2536E-02	4.2417E 00	1.5009E 00
14.	6	-7.1992E-03	6.0227E-02	6.6365E-01	2.9025E 00
14.	7	-6.8720E-03	4.8018E-02	-1.6471E 00	3.6727E 00
14.	8	-6.5531E-03	3.6196E-02	-2.7434E 00	3.5653E 00
14.	9	-6.0299E-03	2.4544E-02	-3.1873E 00	2.5735E 00
14.	10	-4.2914E-03	1.2639E-02	-3.6243E 00	1.0731E 00
14.	11	-0.	0.	-2.4277E 00	0.
14.	11				
14.	11	-0.	0.	0.	-0.
13.	11	1.9954E-01	6.1583E-02	4.3781E 03	8.4094E 01
12.	11	3.2332E-01	8.7633E-02	7.0938E 03	1.7209E 02
11.	11	3.2227E-01	7.6278E-02	7.6181E 03	2.2661E 02
10.	11	2.4830E-01	4.0139E-02	6.2024E 03	2.0940E 02
9.	11	1.4278E-01	2.2022E-03	3.5865E 03	1.4569E 02
8.	11	9.6302E-02	-1.0773E-02	2.2835E 03	1.0460E 02
7.	11	5.7290E-02	-1.3918E-02	1.0797E 03	5.7082E 01
6.	11	4.0562E-02	-1.4257E-02	6.3103E 02	3.6722E 01
5.	11	2.5965E-02	-1.3511E-02	3.1116E 02	1.9662E 01
4.	11	1.9236E-02	-1.2293E-02	1.8081E 02	1.2246E 01
3.	11	1.2845E-02	-9.9897E-03	8.6043E 01	6.3086E 00
2.	11	6.5298E-03	-6.0856E-03	2.8685E 01	2.1880E 00
1.	11	3.3306E-03	-3.4645E-03	7.8911E 00	6.3808E-01
0.	11	-0.	0.	0.	-0.
0.	11				
0.	11	-0.	0.	9.5225E-01	0.
0.	10	-1.9643E-02	-2.8511E-02	2.9410E 03	3.9854E 01
0.	9	2.0599E-02	-6.8008E-02	9.8975E 03	1.2595E 02
0.	8	1.2623E-01	-1.5099E-01	1.7031E 04	2.1551E 02
0.	7	3.0062E-01	-3.3188E-01	2.2429E 04	2.8409E 02
0.	6	5.6733E-01	-7.4613E-01	2.4322E 04	3.0775E 02
0.	5	1.0776E 00	-1.6760E 00	1.9117E 04	2.3054E 02
0.	4	-6.2818E 00	-9.9173E 00	-2.6229E 04	-1.9874E 02
0.	3	3.6010E-01	2.8084E 01	5.8898E 04	4.1602E 02
0.	2	7.0597E 00	-1.0503E 01	-2.7352E 04	-2.1306E 02
0.	1	0.	-3.6404E 00	1.1375E 04	1.2271E 02

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cone

COL 3 ROW 0 V= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14,	1	0,	1.5574E-02	-1,3083E 01	-2,9384E-01
14,	2	6,1686E-03	1.3667E-02	-1,2265E 01	-2,5117E-01
14,	3	1,1847E-02	8,9544E-03	-9,7317E 00	-1,3402E-01
14,	4	1,6215E-02	4.1469E-03	-5,4107E 00	2,7775E-02
14,	5	1,8092E-02	1.6024E-03	1.9057E-01	1,9303E-01
14,	6	1,6797E-02	1.6701E-03	5,6796E 00	3,1946E-01
14,	7	1.2818E-02	3.2157E-03	9,3681E 00	3,7410E-01
14,	8	7,5989E-03	4.6190E-03	1.0071E 01	3,4225E-01
14,	9	2,9273E-03	4.6915E-03	7,6156E 00	2,3442E-01
14,	10	2,5666E-04	3.0593E-03	3,2086E 00	9,2866E-02
14,	11	-0,	0.	8,9584E-04	0,
14,	11				
14,	11	-0.	0.	0.	-0,
13,	11	5,4237E-03	2,5378E-03	3,4813E 02	7,2661E 00
12,	11	-2,4602E-02	-9.8219E-03	-5,0740E 02	-1,0140E 01
11,	11	-6,3617E-02	-3.0945E-02	-2,5775E 03	-7,1167E 01
10,	11	-6,0536E-02	-3.0077E-02	-3,2757E 03	-1,0406E 02
9,	11	-3,6316E-02	-1,8699E-02	-3,1544E 03	-1,1969E 02
8,	11	-2,1648E-02	-2.1517E-02	-2,6774E 03	-1,0887E 02
7,	11	-2,3946E-03	-3,7749E-02	-1,6960E 03	-7,2851E 01
6,	11	7,3383E-03	-4.2398E-02	-1.1925E 03	-5,2471E 01
5,	11	1,3806E-02	-3.9621E-02	-6,6152E 02	-2,9754E 01
4,	11	1,5197E-02	-3.5471E-02	-4,2514E 02	-1,9375E 01
3,	11	1.3818E-02	-2.7823E-02	-2,2496E 02	-1,0407E 01
2,	11	8,6537E-03	-1.5823E-02	-7,7820E 01	-3,6548E 00
1,	11	4,9513E-03	-8.6283E-03	-2,2810E 01	-1,0891E 00
0,	11	-0.	0.	-0.	-0,
0,	11				
0,	11	0.	0.	3,7636E 00	0,
0,	10	-8,5643E-02	-3,9073E-02	-5,1561E 03	-6,6371E 01
0,	9	-2,4147E-01	-6.1842E-02	-1,3640E 04	-1,7182E 02
0,	8	-5,3518E-01	-8.2636E-02	-2,3180E 04	-2,9166E 02
0,	7	-1.0714E 00	-9.0708E-02	-3,4196E 04	-4,2980E 02
0,	6	-2,1420E 00	-5,0197E-02	-4,8115E 04	-5,9991E 02
0,	5	-4,7694E 00	1.6578E-01	-6,8847E 04	-8,1398E 02
0,	4	-2,3595E 01	3.0438E 00	-1.3191E 05	-1,0552E 03
0,	3	7,1994E 01	5.7372E-02	3,7078E 04	4,6251E 02
0,	2	-2,1896E 01	-2,9707E 00	2,0842E 05	2,0227E 03
0,	1	-0,	-3.1113E-01	1,6430E 05	1,9651E 03

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cone

COL 3 ROW 0 W= 1,0

BOUNDARY STRESS RESULTANTS,

ROW	COL	NTAN	NNORM	Q	M
14,	1	0,	1,7458E-03	1,4760E 00	-7,7389E-02
14,	2	-4,6212E-04	1,6438E-03	1,3614E 00	-6,9391E-02
14,	3	-8,6457E-04	1,4300E-03	1,0270E 00	-4,6980E-02
14,	4	-1,1292E-03	1,2057E-03	5,2360E-01	-1,4693E-02
14,	5	-1,1970E-03	1,0359E-03	-3,6429E-02	2,0653E-02
14,	6	-1,0736E-03	8,5088E-04	-5,1752E-01	5,1066E-02
14,	7	-6,1508E-04	6,1841E-04	-8,0605E-01	6,8909E-02
14,	8	-5,1302E-04	3,7639E-04	-8,3961E-01	6,8894E-02
14,	9	-2,5504E-04	1,8140E-04	-6,3487E-01	5,0560E-02
14,	10	-8,9100E-05	5,9980E-05	-3,0303E-01	2,1302E-02
14,	11	-0,	0,	-5,2064E-02	0,
14,	11				
14,	11	-0,	0,	0,	-0,
13,	11	4,3444E-03	1,3406E-03	8,8283E 01	1,6698E 00
12,	11	9,1098E-03	2,8961E-03	2,3153E 02	5,5704E 00
11,	11	1,0948E-02	4,0330E-03	3,9160E 02	1,1546E 01
10,	11	8,7577E-03	2,9588E-03	4,0032E 02	1,3546E 01
9,	11	5,0244E-03	6,8278E-04	3,3248E 02	1,3883E 01
8,	11	3,2705E-03	1,2547E-03	2,7011E 02	1,2323E 01
7,	11	1,0014E-03	3,4193E-03	1,6668E 02	6,1378E 00
6,	11	-1,7980E-04	4,0950E-03	1,1572E 02	5,8216E 00
5,	11	-1,0374E-03	3,9406E-03	6,3582E 01	3,2829E 00
4,	11	-1,2777E-03	3,5692E-03	4,0533E 01	2,1285E 00
3,	11	-1,2343E-03	2,8227E-03	2,1259E 01	1,1384E 00
2,	11	-7,9916E-04	1,6098E-03	7,3224E 00	3,9913E-01
1,	11	-4,6484E-04	8,7835E-04	2,1311E 00	1,1862E-01
0,	11	-0,	0,	0,	-0,
0,	11				
0,	11	-0,	0,	-3,8780E-01	0,
0,	10	8,7908E-03	3,7831E-03	5,5569E 02	7,2359E 00
0,	9	2,6227E-02	6,6238E-03	1,5935E 03	2,0185E 01
0,	8	6,0302E-02	1,0153E-02	2,9053E 03	3,6713E 01
0,	7	1,2236E-01	1,3985E-02	4,6189E 03	5,8162E 01
0,	6	2,3865E-01	1,6837E-02	7,1278E 03	8,6407E 01
0,	5	5,1355E-01	1,3244E-02	1,3895E 04	1,0686E 02
0,	4	1,1206E 00	-9,3345E-02	-7,3086E 04	-8,9062E 02
0,	3	1,2076E-01	1,3268E-01	2,3941E 05	3,0127E 03
0,	2	-8,3023E-01	-9,0315E-02	-6,9772E 04	-8,5250E 02
0,	1	0,	1,2792E-02	2,4167E 04	1,6797E 02

Table 7 (cont'd)

Sample Output of Influence Coefficients - Cone

COL 3 ROW 0 K= 1.0

BOUNDARY STRESS RESULTANTS,

ROW	COL	NTAN	NNORM	Q	M
14,	1	0,	1,8073E-05	2,4752E-02	-1,0371E-03
14,	2	-7,6726E-06	1,6665E-05	2,2747E-02	-9,3916E-04
14,	3	-1,4284E-05	1,3625E-05	1,6950E-02	-6,6448E-04
14,	4	-1,8564E-05	1,0531E-05	8,3000E-03	-2,6789E-04
14,	5	-1,9569E-05	8,2599E-06	-1,3001E-03	1,6816E-04
14,	6	-1,7352E-05	6,0460E-06	-9,5187E-03	5,4696E-04
14,	7	-1,2883E-05	3,4724E-06	-1,4359E-02	7,7600E-04
14,	8	-7,7346E-06	1,0360E-06	-1,4735E-02	7,9104E-04
14,	9	-3,4379E-06	-4,9656E-07	-1,0923E-02	5,8581E-04
14,	10	-9,0692E-07	-7,7710E-07	-4,8674E-03	2,4782E-04
14,	11	-0,	0,	-5,8786E-04	0,
14,	11				
14,	11	-0,	0,	0,	-0,
13,	11	5,1292E-05	1,6032E-05	1,0333E 00	1,9427E-02
12,	11	1,1820E-04	4,0323E-05	3,2838E 00	7,9088E-02
11,	11	1,4585E-04	6,0903E-05	6,0724E 00	1,7948E-01
10,	11	1,1535E-04	4,5943E-05	6,4906E 00	2,1923E-01
9,	11	5,8888E-05	1,7879E-05	5,9122E 00	2,3875E-01
8,	11	3,0801E-05	2,8239E-05	5,0020E 00	2,1600E-01
7,	11	-4,2257E-06	6,5688E-05	3,1738E 00	1,4405E-01
6,	11	-2,1258E-05	7,6967E-05	2,2343E 00	1,0360E-01
5,	11	-3,1064E-05	7,3514E-05	1,2382E 00	5,8697E-02
4,	11	-3,2380E-05	6,6610E-05	7,9476E-01	3,8196E-02
3,	11	-2,8495E-05	5,2915E-05	4,1973E-01	2,0500E-02
2,	11	-1,7542E-05	3,0465E-05	1,4494E-01	7,1962E-03
1,	11	-9,9597E-06	1,6734E-05	4,2355E-02	2,1429E-03
0,	11	-0,	0,	0,	-0,
0,	11				
0,	11	-0,	0,	-7,4227E-03	0,
0,	10	1,7068E-04	8,2829E-05	1,0112E 01	1,3062E-01
0,	9	4,7635E-04	1,4404E-04	2,7644E 01	3,4832E-01
0,	8	1,0375E-03	2,1639E-04	4,7863E 01	6,0015E-01
0,	7	1,9837E-03	2,8922E-04	6,9293E 01	8,5807E-01
0,	6	3,5659E-03	3,3241E-04	8,3865E 01	9,6963E-01
0,	5	6,5880E-03	2,3936E-04	3,4573E 01	-7,3646E-02
0,	4	3,4172E-03	-4,6623E-04	-1,2313E 02	-1,2827E 01
0,	3	1,9376E-03	6,1453E-04	8,4356E 03	1,3030E 02
0,	2	1,0030E-03	-4,2410E-04	-1,0298E 02	-1,2658E 01
0,	1	0,	1,8995E-04	7,3602E 00	-9,2483E-01

Table 7 (cont'd)

Sample Output of Influence Coefficients - Sphere

COL 3 ROW 0 U= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14,	1	0.	1,3763E-01	4,7462E 02	3,6565E 01
14,	2	-9,9868E-03	1,4741E-01	4,7490E 02	3,6323E 01
14,	3	-2,8676E-02	1,6966E-01	4,7125E 02	3,4621E 01
14,	4	-4,4474E-02	1,2452E-01	4,6159E 02	2,9554E 01
14,	5	-4,6420E-02	8,8871E-02	4,1067E 02	2,3130E 01
14,	6	-4,3637E-02	6,4787E-02	3,3317E 02	1,7078E 01
14,	7	-3,7394E-02	4,7068E-02	2,5276E 02	1,2119E 01
14,	8	-2,8501E-02	3,2800E-02	1,8319E 02	8,2257E 00
14,	9	-1,8557E-02	2,1288E-02	1,2606E 02	5,0135E 00
14,	10	-9,3547E-03	1,1681E-02	7,2055E 01	2,1227E 00
14,	11	0.	0.	-1,8206E-01	-0.
14,	11				
14,	11	-0.	0.	1,5717E-01	0.
13,	11	2,8057E-02	8,5952E-03	7,6629E 01	5,7043E 00
12,	11	5,0054E-02	8,6125E-03	7,1942E 01	5,3948E 00
11,	11	5,6083E-02	7,5590E-03	3,0547E 01	2,0839E 00
10,	11	4,1540E-02	3,1938E-03	-1,5886E 01	-1,2877E 00
9,	11	3,1158E-02	-1,4525E-03	-3,0562E 01	-2,2938E 00
8,	11	2,0455E-02	-6,9996E-03	-2,7669E 01	-2,0075E 00
7,	11	1,5527E-02	-8,8109E-03	-2,2805E 01	-1,6333E 00
6,	11	1,0849E-02	-8,9641E-03	-1,4205E 01	-1,0083E 00
5,	11	8,4962E-03	-8,2758E-03	-9,8344E 00	-6,9149E-01
4,	11	5,9930E-03	-6,6481E-03	-5,5745E 00	-3,8396E-01
3,	11	4,6729E-03	-5,5316E-03	-3,6014E 00	-2,4081E-01
2,	11	3,2562E-03	-4,0806E-03	-1,9475E 00	-1,2015E-01
1,	11	1,7107E-03	-2,2542E-03	-7,9784E-01	-3,5122E-02
0,	11	0.	0.	-1,5101E-01	0.
0,	11				
0,	11	-0.	-0.	8,3037E-02	-0.
0,	10	-1,9314E-02	-1,4983E-02	-1,0995E 02	-3,8645E 00
0,	9	-3,4542E-02	-3,1835E-02	-3,0090E 02	-8,8485E 00
0,	8	-5,6964E-02	-6,1673E-02	-5,6817E 02	-1,5298E 01
0,	7	-9,2699E-02	-1,2005E-01	-9,6466E 02	-2,3082E 01
0,	6	-1,5091E-01	-2,4894E-01	-1,5262E 03	-2,9026E 01
0,	5	-2,6217E-01	-5,7823E-01	-2,0923E 03	-2,2194E 01
0,	4	-4,8324E 00	-4,1010E 00	-1,0046E 04	-3,4467E 00
0,	3	-8,0612E-02	1,0972E 01	4,0048E 04	6,2078E 02
0,	2	4,6512E 00	-4,2748E 00	-3,8526E 03	-1,3218E 01
0,	1	-0.	-1,0933E 00	-3,0257E 03	-2,7190E 01

Table 7 (cont'd)

Sample Output of Influence Coefficients - Sphere

COL 3 ROW 0 V= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14.	1	0.	2.6398E-02	8.3172E 01	1.1485E 01
14.	2	2.9931E-02	2.3504E-02	1.1746E 02	1.0013E 01
14.	3	5.2320E-02	7.3411E-03	1.2238E 02	6.1353E 00
14.	4	6.5180E-02	-7.8173E-03	9.2618E 01	1.6691E 00
14.	5	6.7209E-02	-8.2424E-03	4.3777E 01	-1.7018E 00
14.	6	6.0483E-02	-5.7284E-03	-6.6452E-01	-3.6315E 00
14.	7	4.9350E-02	-4.3269E-03	-3.1183E 01	-4.4068E 00
14.	8	3.6032E-02	-4.0579E-03	-4.8645E 01	-4.3301E 00
14.	9	2.2232E-02	-4.4477E-03	-5.5212E 01	-3.4656E 00
14.	10	1.0067E-02	-4.6089E-03	-4.5687E 01	-1.7843E 00
14.	11	0.	0.	1.3028E-01	-0.
14.	11				
14.	11	-0.	0.	-6.5705E-02	0.
13.	11	-1.2180E-02	-1.2090E-02	-8.0858E 01	-4.8137E 00
12.	11	-1.8586E-02	-2.0945E-02	-1.4318E 02	-8.7958E 00
11.	11	-2.0979E-02	-2.9255E-02	-1.8105E 02	-1.1455E 01
10.	11	-1.5642E-02	-3.5156E-02	-1.7309E 02	-1.1357E 01
9.	11	-1.0097E-02	-3.4427E-02	-1.4622E 02	-9.6868E 00
8.	11	-2.9320E-03	-2.9025E-02	-9.4369E 01	-6.2357E 00
7.	11	3.5086E-04	-2.4191E-02	-6.7532E 01	-4.4479E 00
6.	11	2.3770E-03	-1.7329E-02	-4.0024E 01	-2.6272E 00
5.	11	2.8536E-03	-1.3484E-02	-2.6817E 01	-1.7547E 00
4.	11	2.6481E-03	-9.2746E-03	-1.4712E 01	-9.5960E-01
3.	11	2.3452E-03	-7.0774E-03	-9.1521E 00	-5.9360E-01
2.	11	1.8212E-03	-4.7969E-03	-4.5546E 00	-2.9044E-01
1.	11	1.0500E-03	-2.4379E-03	-1.4142E 00	-8.1896E-02
0.	11	0.	0.	-6.7217E-02	0.
0.	11				
0.	11	-0.	-0.	1.7247E-01	-0.
0.	10	-2.6136E-02	-3.5458E-03	-2.2226E 02	-9.3098E 00
0.	9	-7.1519E-02	2.5244E-03	-5.5635E 02	-1.9562E 01
0.	8	-1.5675E-01	8.8278E-03	-9.1747E 02	-3.1974E 01
0.	7	-3.2268E-01	1.4791E-02	-1.4883E 03	-5.1890E 01
0.	6	-6.8954E-01	1.3327E-02	-2.5395E 03	-8.5319E 01
0.	5	-1.6749E 00	-4.6969E-02	-4.6458E 03	-1.3822E 02
0.	4	-1.1931E 01	1.3024E 00	-1.6704E 04	-2.2662E 02
0.	3	3.3447E 01	-1.8773E-02	-5.2308E 02	5.5850E 01
0.	2	-1.1369E 01	-1.3338E 00	1.7572E 04	3.5339E 02
0.	1	-0.	7.8168E-02	1.2174E 04	3.1104E 02

Table 7 (cont'd)

Sample Output of Influence Coefficients - Sphere

COL 3 ROW 0 W= 1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14.	1	0.	1.4487E-02	5.2860E 01	4.0013E 00
14.	2	-1.4747E-03	1.5445E-02	5.3209E 01	4.0256E 00
14.	3	-5.4012E-03	1.8814E-02	5.5300E 01	3.9225E 00
14.	4	-9.0683E-03	1.2868E-02	5.3836E 01	3.3333E 00
14.	5	-9.5494E-03	9.3669E-03	4.5940E 01	2.5847E 00
14.	6	-8.5011E-03	7.0535E-03	3.6007E 01	1.9189E 00
14.	7	-6.8375E-03	5.1350E-03	2.7158E 01	1.4021E 00
14.	8	-4.9551E-03	3.5535E-03	2.0265E 01	1.0017E 00
14.	9	-3.0882E-03	2.3425E-03	1.4825E 01	6.4989E-01
14.	10	-1.4670E-03	1.3759E-03	9.1736E 00	2.9229E-01
14.	11	0.	0.	-2.4459E-02	-0.
14.	11				
14.	11	-0.	0.	1.8358E-02	0.
13.	11	3.2580E-03	1.4864E-03	1.1438E 01	7.8639E-01
12.	11	5.5464E-03	1.9590E-03	1.4042E 01	9.4605E-01
11.	11	6.0923E-03	2.2951E-03	1.1895E 01	7.7823E-01
10.	11	4.4420E-03	2.2491E-03	6.9819E 00	4.9451E-01
9.	11	3.2330E-03	1.8254E-03	4.3028E 00	3.2281E-01
8.	11	1.9244E-03	1.0670E-03	2.0759E 00	1.6193E-01
7.	11	1.3218E-03	6.5548E-04	1.2239E 00	9.8143E-02
6.	11	8.0631E-04	2.6458E-04	6.6763E-01	5.4126E-02
5.	11	5.7566E-04	1.0456E-04	4.2086E-01	3.4544E-02
4.	11	3.6919E-04	-4.0693E-06	2.1601E-01	1.8363E-02
3.	11	2.7128E-04	-3.9976E-05	1.2347E-01	1.1058E-02
2.	11	1.7775E-04	-5.4077E-05	4.8999E-02	5.2005E-03
1.	11	8.7659E-05	-4.2351E-05	3.7478E-05	1.3596E-03
0.	11	0.	0.	-9.1847E-03	0.
0.	11				
0.	11	-0.	-0.	-3.2619E-03	-0.
0.	10	-1.7190E-04	-1.0886E-03	1.3810E 00	1.6310E-01
0.	9	1.2787E-03	-2.8096E-03	3.1835E 00	3.8804E-01
0.	8	5.0179E-03	-5.5001E-03	6.6353E 00	9.5049E-01
0.	7	1.4063E-02	-1.0024E-02	3.3231E 01	2.7340E 00
0.	6	3.6913E-02	-1.8004E-02	1.4738E 02	7.5655E 00
0.	5	9.7414E-02	-3.3513E-02	2.5756E 03	2.1409E 01
0.	4	3.6916E-01	-1.1819E-01	-1.4697E 04	-2.1394E 02
0.	3	1.4112E-02	6.4658E-01	3.7237E 04	8.8205E 02
0.	2	-3.2737E-01	-1.2934E-01	-6.5630E 03	-2.0723E 02
0.	1	-0.	-6.1073E-02	3.5344E 03	4.2344E 01

Table 7 (conc'd)

Sample Output of Influence Coefficients - Sphere

COL 3 ROW 0 W*= -1.0

BOUNDARY STRESS RESULTANTS.

ROW	COL	NTAN	NNORM	Q	M
14.	1	0.	2.3290E-04	8.9316E-01	6.5352E-02
14.	2	-3.4449E-05	2.4524E-04	9.0623E-01	6.5543E-02
14.	3	-1.0627E-04	2.8439E-04	9.3913E-01	6.3541E-02
14.	4	-1.7272E-04	2.0330E-04	9.0049E-01	5.4466E-02
14.	5	-1.8578E-04	1.5059E-04	7.6117E-01	4.2795E-02
14.	6	-1.6673E-04	1.1407E-04	5.9388E-01	3.2257E-02
14.	7	-1.3370E-04	8.3100E-05	4.4901E-01	2.3987E-02
14.	8	-9.6112E-05	5.7585E-05	3.3923E-01	1.7484E-02
14.	9	-5.9250E-05	3.8431E-05	2.5394E-01	1.1579E-02
14.	10	-2.7673E-05	2.3353E-05	1.6170E-01	5.3026E-03
14.	11	0.	0.	-4.3857E-04	-0.
14.	11				
14.	11	-0.	0.	3.1184E-04	0.
13.	11	5.5375E-05	2.8660E-05	2.1214E-01	1.4272E-02
12.	11	9.2522E-05	4.0140E-05	2.8223E-01	1.8605E-02
11.	11	1.0059E-04	4.9547E-05	2.7369E-01	1.7739E-02
10.	11	7.1639E-05	5.2564E-05	2.0260E-01	1.4009E-02
9.	11	5.0387E-05	4.6099E-05	1.4955E-01	1.0654E-02
8.	11	2.7616E-05	3.1915E-05	8.6652E-02	6.2313E-03
7.	11	1.7372E-05	2.3316E-05	5.8321E-02	4.2070E-03
6.	11	9.2465E-06	1.3925E-05	3.3731E-02	2.4311E-03
5.	11	5.8937E-06	9.4751E-06	2.2217E-02	1.6012E-03
4.	11	3.2842E-06	5.5000E-06	1.1976E-02	8.6806E-04
3.	11	2.1716E-06	3.7026E-06	7.2954E-03	5.3261E-04
2.	11	1.2509E-06	2.1468E-06	3.4577E-03	2.5754E-04
1.	11	5.2510E-07	8.9064E-07	8.6731E-04	7.1059E-05
0.	11	0.	0.	-8.3640E-05	0.
0.	11				
0.	11	-0.	-0.	-1.5161E-04	-0.
0.	10	1.4368E-05	-1.2870E-05	1.5613E-01	8.2054E-03
0.	9	6.4164E-05	-3.9915E-05	4.1367E-01	1.8419E-02
0.	8	1.7069E-04	-7.8702E-05	7.6706E-01	3.4808E-02
0.	7	3.9155E-04	-1.3705E-04	1.6974E 00	6.8254E-02
0.	6	8.6507E-04	-2.2369E-04	4.8210E 00	1.2044E-01
0.	5	1.9065E-03	-3.4662E-04	3.8988E 01	6.5059E-02
0.	4	4.5375E-03	-6.7300E-04	-5.9100E 02	-4.5678E 00
0.	3	3.8072E-04	6.2792E-03	2.6097E 03	7.3145E 01
0.	2	-3.5318E-03	-7.9682E-04	2.5083E 02	-4.4838E 00
0.	1	-0.	-6.0482E-04	2.3406E 01	1.0227E-01