NASA Contractor Report 2853

A Program for Calculating Load Coefficient Matrices Utilizing the Force Summation Method, L218 (LOADS)

Volume I: Engineering and Usage

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1.0 SUMMARY

This document describes the theoretical formulation and use of L218 (LOADS), a digital computer program to calculate load coefficient matrices. The program calculates load coefficient matrices utilizing the force summation technique. The particular field of application of the program is the calculation of load matrices for the analysis of airplane flight loads due to air turbulence (both random and discrete).

The structural mode shapes, inertia data, and aerodynamic forces of the vehicle must be formulated outside L218 (LOADS) and read as program input data from either cards or magnetic files. The load coefficient matrices are then calculated and stored on magnetic files for use in other programs. The type of load coefficient matrices calculated are:

- Translational and rotational accelerations, velocities, and displacements (AVD)
- Aerodynamic panel loads on lifting surfaces (PLDS)
- Net panel loads on lifting surfaces (NPLDS)
- Shears and moments (VBMT)

The sensor equations, used in the equations of motion when using active controls, have the same form as the AVD loads. Thus, AVD loads can be used to add sensor equations to the equations of motion.

2.0 INTRODUCTION

The computer program L218 (LOADS) was developed for use either as a standalone program or as a module of a program system called DYLOFLEX developed for NASA under contract NAS1-13918 (ref. 1). The LOADS program (L218) was designed to meet the DYLOFLEX contract requirements as defined in reference 2. These requirements specify the need for a program to calculate dynamic load coefficient matrices for use in calculating design loads and/or for use as sensors in active control analyses.

The objective of this volume is to aid those persons wishing to use this program to calculate load coefficient matrices. To meet this objective, the following items are presented:

- The theoretical formulation of the problem
- The design and structure of the program
- Instructions to use the program

A sample problem is also included in this volume to aid the user in execution of the program.

3.0 SYMBOLS AND ABBREVIATIONS

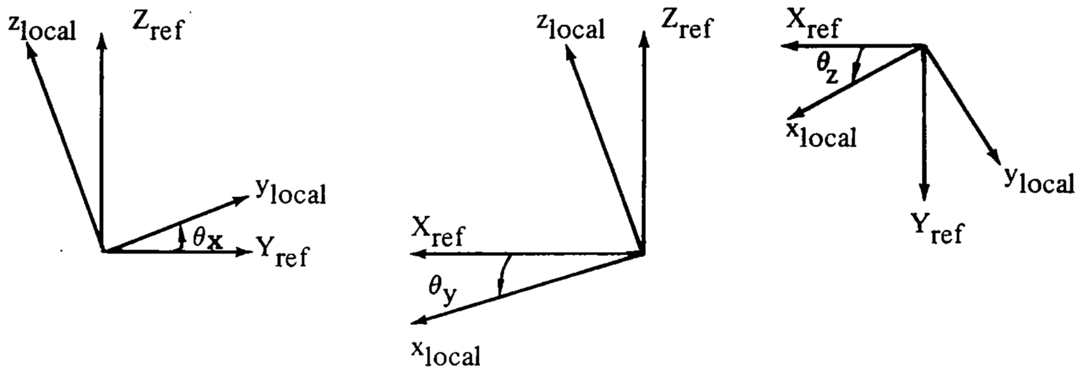
BS	Body station, length
BBL	Body buttock line, length
WL	Water line, length
c	Load coefficient matrix for the excitation function
F	Force
$F_{PL}(\dot{q}, \ddot{q})$	Response aerodynamic force
$F_{PL}(\dot{\alpha}_g)$	Gust aerodynamic force
f_{ℓ}	Streamwise distance from the reference point first encountering a gust to the points encountering the gust later, length
F_{PLDS}	Aerodynamic panel loads
F_{NPLDS}	Net panel loads
I	Mass moment of inertia
$[J_1]$	Mass and static moment matrix
$[J_2]$	Static moment and moment of inertia matrix
L	Load
m	Lumped mass
M	Moment
$\overline{M}_1, \overline{M}_2, \overline{M}_3$	Load coefficient matrices (nonaerodynamic) of the generalized coordinate displacement, rate, and acceleration, respectively
$\overline{M}_4, \overline{M}_5$	Load coefficient matrices (aerodynamic) of the generalized coordinate rate and acceleration convoluted with the Wagner function
T	Euler transformation matrix
$q, \dot{q}, \ddot{q}$	Generalized coordinate displacement, velocity and acceleration, respectively
V	Shear
V_T	True velocity
α_g	Gust angle
Ψ	Küssner indicial lift growth function
Φ	Wagner indicial lift growth function
Ω	Spatial frequency (ω/V_T)
$\overline{\tilde{\phi}}$	Load coefficient matrix with gust penetration for the excitation function

ϕ	Modal displacement
ϕ'	Modal slope in streamwise direction
ϕ_θ	Modal slope
$\overline{\phi}$	Mode shape (includes ϕ and ϕ_θ).
*	Indicates convolution

4.0 ENGINEERING AND MATHEMATICAL DESCRIPTION

4.1 AXIS SYSTEM

All mode shapes used as input to the LOADS program are assumed to be in the local motion axis system of each node and the coordinate locations of the nodes for which modes are defined are in the reference axis system. The local axis system is related to the reference axis system by the rotation of the reference axis system about its three axes into the local axis system using the Eular transformation triad. The following illustrates these angles in their positive sense:



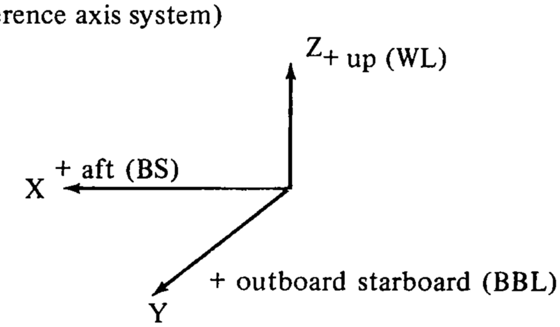
That is, (+) dihedral, θ, is (+) rotation; (+) incidence, ϕ, is (+) rotation; (+) sweep, Ω, is (-) rotation.

For a more detailed description of the axis systems used in DYLOFLEX, the user is referred to appendix B of the DYLOFLEX summary document (ref. 1).

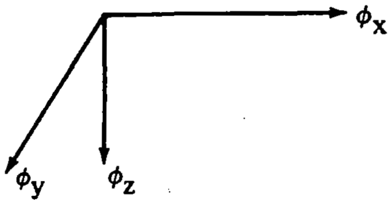
4.2 SIGN CONVENTION

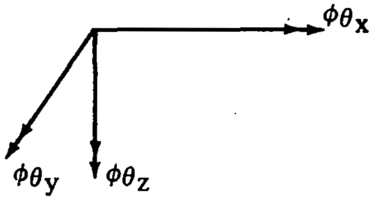
The LOADS program requires the input data be consistent with the following sign conventions:

Position (reference axis system)

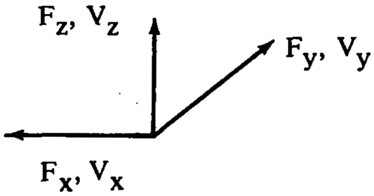


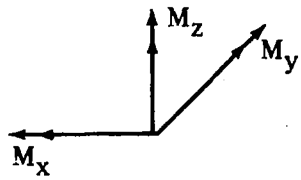
Mode shapes (motion axis system)





Forces, shears, moments (force axis system)





The force axis system is defined as a left-handed axis system for convenience in calculating inertia forces and moments and in calculating the work done by external forces.

4.3 LOAD EQUATIONS

The load equations are formed using the force summation method described in reference 3. The general form os the load equations is similar to that of the equations of motion presented in reference 4. The general form of the load equations without gust penetration is:

$$\left\{L\right\} = [\overline{M}_1] \left\{q\right\} + [\overline{M}_2] \left\{\dot{q}\right\} + [\overline{M}_3] \left\{\ddot{q}\right\} + [\overline{M}_4] \left\{\dot{q}\right\} * \Phi + [\overline{M}_5] \left\{\ddot{q}\right\} * \Phi + \left\{\overline{C}_3\right\} \dot{\alpha}_g * \Psi \qquad (1)$$

where:

$[\overline{M}_1]$ $[\overline{M}_2]$ and$[\overline{M}_3]$ = Load coefficients matrices (usually nonaerodynamic)† for the generalized coordinate displacement, rate, and acceleration, respectively;

$[\overline{M}_4]$ and $[\overline{M}_5]$ = Load coefficients matrices (usually aerodynamic) for the generalized coordinate rate and acceleration convoluted with the Wagner function

$\left\{\overline{C}_3\right\}$ = Load coefficient matrix for the excitation function (usually gust angle) convoluted with the Küssner function

Φ = Wagner indicial lift growth function

†One exception to this is the load coefficient matrices due to the noncirculatory aerodynamic terms of strip theory aerodynamics.

Ψ = Küssner indicial lift growth function

$\dot{q}, \ddot{q}, q$ = Generalized coordinate displacement, velocity, and acceleration responses, respectively.

α_g = Gust angle

Relating these matrices in a physical sense, $[\overline{M}_1]$, $[\overline{M}_2]$, and $[\overline{M}_3]$ are associated with the load resulting from structural response. $[\overline{M}_4]$ and $[\overline{M}_5]$ are associated with the load resulting from aerodynamic response.

With gust penetration, the excitation function of equation (1) is frequency dependent and is defined as:

$$\{\overline{C}_3\}\ \dot{\alpha}_g = [\overline{\overline{\phi}}] \Big/ \cos\left(\Omega\ \{f_\ell\}\right) - i\ [\overline{\overline{\phi}}]\ \sin\left(\Omega\ \{f_\ell\}\right) \qquad (2)$$

where:

Ω = ω/V_T, spatial frequency

$\{f_\ell\}$ = streamwise distance from point or points first encountering gust to the points encountering the gust later

$[\overline{\overline{\phi}}]$ = lifting panels contribution to gust loads at designated gradual penetration load stations

The load equations program, LOADS, (L218) generates the $[\overline{M}_1]$ to $[\overline{M}_5]$ matrices and the $[\overline{\overline{\phi}}]$ matrix. Gust penetration is always considered to be present in DYLOFLEX, since the no-gust penetration problem is a special case of the gust penetration problem with only one gust panel, i.e., $[\overline{\overline{\phi}}]$ degenerates into $\{\overline{\overline{\phi}}\}$ and f_ℓ is a single scaler.

Four different types of loads are available in LOADS, namely:

- Transational and rotational acceleration, velocities, and displacement
- Aerodynamic panel loads
- Net panel loads
- Shears and moments

4.3.1 ACCELERATION, VELOCITY AND DISPLACEMENT (AVD)

Acceleration, velocity and displacement equations can be used as either load equations or as sensor equations. The AVD equations contain both translational and rotational motions and are written as follows:

Translational acceleration or accelerometer equation $= \text{SCALR1}\ [\phi]\ \{\ddot{q}\} = [\overline{M}_3]\ \{\ddot{q}\}$

Translational velocity $= \text{SCALR2}\ [\phi]\ \{\dot{q}\} = [\overline{M}_2]\ \{\dot{q}\}$ (3)

Translational displacement	$= \text{SCALR2}\,[\phi]\,\{q\} = [\overline{M}_1]\,\{q\}$
Rotational acceleration	$= \text{SCALR3}\,[\phi_\theta]\,\{\ddot{q}\} = [\overline{M}_3]\,\{\ddot{q}\}$
Rotational velocity or rate gyro equationw	$= \text{SCALR3}\,[\phi_\theta]\,\{\dot{q}\} = [\overline{M}_2]\,\{\dot{q}\}$ (3)
Rotational displacement	$= \text{SCALR3}\,[\phi_\theta]\,\{q\} = [\overline{M}_1]\,\{q\}$

where:

$[\phi]$	= Matrix of modal displacement
$[\phi_\theta]$	= Matrix of modal slopes
SCALR1, SCALR2, SCALR3	= Scaler multipliers

The scaler multipliers are included only for user program flexibility, such as changing acceleration loads from inches/sec/sec to g's or for changing rotational velocity from radians/sec to degrees/sec, etc.

The AVD load coefficient matrices $\overline{M}_1$, $\overline{M}_2$, and $\overline{M}_3$ are only a function of the mode shapes, with the direction of the loads being a function of the axis system used in defining the modes. All input mode shapes to DYLOFLEX are in the local motion axis system for each structural node. In order to obtain AVD loads in different axis systems from the local motion axis system, a transformation from the local motion axis system to some arbitrary axis system is performed by:

$$\begin{bmatrix} \phi_x \\ \phi_y \\ \phi_z \end{bmatrix}_{\text{arbitrary axis}} = \begin{bmatrix} \; T \; \end{bmatrix} \begin{bmatrix} \phi_x \\ \phi_y \\ \phi_z \end{bmatrix}_{\text{local axis}}$$

and (4)

$$\begin{bmatrix} \phi\theta_x \\ \phi\theta_x \\ \phi\theta_z \end{bmatrix}_{\text{arbitrary axis}} = \begin{bmatrix} \; T \; \end{bmatrix} \begin{bmatrix} \phi\theta_x \\ \phi\theta_y \\ \phi\theta_z \end{bmatrix}_{\text{local axis}}$$

where [T] is the Euler transformation triad defined as:

$$[T] = [X]\ [Y]\ [Z]$$

or some other combination of [X], [Y], [Z] and where:

$$
\begin{bmatrix} X \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_x & \sin\theta_x \\ 0 & -\sin\theta_x & \cos\theta_x \end{bmatrix}
$$

$$
\begin{bmatrix} Y \end{bmatrix} = \begin{bmatrix} \cos\theta_y & 0 & \sin\theta_y \\ 0 & 1 & 0 \\ -\sin\theta_y & 0 & \cos\theta_y \end{bmatrix} \tag{5}
$$

$$
\begin{bmatrix} Z \end{bmatrix} = \begin{bmatrix} \cos\theta_z & \sin\theta_z & 0 \\ -\sin\theta_z & \cos\theta_z & 0 \\ 0 & 0 & 1 \end{bmatrix}
$$

In addition, if the input mode shapes are not at the desired location for a load station (location where load coefficients are calculated), interpolation of the mode shapes to a load station is required. Interpolation on thin bodies can be performed using the interpolation array generated in INTERP (ref. 5). However, the interpolation methods used in INTERP are not directly applicable for calculating mode shapes at load stations on slender bodies. Consequently, two interpolation methods for use on slender bodies are available, one which utilizes a linear interpolation scheme between points and the other which is similar to the motion point interpolation method in INTERP. The latter method attaches rigid links from the node of known motion to the node where interpolation is required.

To interpolate to a point x on a slender body, given two reference structural node points I and I+1 and their coordinate locations (BS, BBL, WL):

$$
\begin{array}{ccc} I & x & I+1 \\ \bullet & \bullet & \bullet \end{array}
$$

$$
\begin{aligned}
A &= \left(BS_x - BS_I\right) / \left(BS_{I+1} - BS_I\right) \\
\phi x_x &= \phi x_I \\
\phi y_x &= A\left(\phi y_{I+1} - \phi y_I\right) + \phi y_I + LTT\left(\phi\theta_{x_x}\right) \\
\phi z_x &= A\left(\phi z_{I+1} - \phi z_I\right) + \phi z_I + LT\left(\phi\theta_{x_x}\right) \\
\phi\theta_{x_x} &= A\left(\phi\theta_{x_{I+1}} - \phi\theta_{x_I}\right) + \phi\theta_{x_I} \\
\phi\theta_{y_x} &= A\left(\phi\theta_{y_{I+1}} - \phi\theta_{y_I}\right) + \phi\theta_{y_I} \\
\phi\theta_{z_x} &= A\left(\phi\theta_{z_{I+1}} - \phi\theta_{z_I}\right) + \phi\theta_{z_I}
\end{aligned} \tag{6}
$$

where:

$LT = BBL_x - BBL_I$

$LTT = WL_x - WL_I$

To interpolate to a point x on a slender body, given only one reference structural node point I and its coordinate locations (BS, BBL, WL):

$$\overset{I}{\bullet}\!\!-\!\!-\!\!-\!\!-\!\!-\!\!-\!\!\overset{x}{\bullet}$$

$$
\begin{aligned}
\phi x_x &\doteq \phi x_I \\
\phi y_x &= \phi y_I - LB\,(\phi\theta_{z_I}) + LTT\,(\phi\theta_{x_x}) \\
\phi z_x &= \phi z_I + LB\,(\phi\theta_{y_I}) + LT\,(\phi\theta_{x_x}) \\
\phi\theta_{x_x} &= \phi\theta_{xI} \\
\phi\theta_{y_x} &= \phi\theta_{yI} \\
\phi\theta_{z_x} &= \phi\theta_{zI}
\end{aligned}
\qquad (7)
$$

where:

$LB \quad = BS_x - BS_I$

$LT \quad = BBL_x - BBL_I$

$LTT \quad = WL_x - WL_I$

These interpolated modes are used to calculate the AVD load coefficient matrices $\overline{M}_1$, $\overline{M}_2$, and $\overline{M}_3$ in equation (3).

4.3.2 AERODYNAMIC PANEL LOADS (PLDS)

The aerodynamic panel loads are the loads produced on the panels of a thin body by the aerodynamics from the structural and gust response of the vehicle. The equation for the aerodynamic panel loads is:

$$
\begin{aligned}
\{F_{PLDS}\} &= SCALR2\ [F_{PL}\,(\dot{q})]\{\dot{q}\} * \Phi + SCALR2\ [F_{PL}\,(\ddot{q})]\{\ddot{q}\} * \Phi \\
&\quad + SCALR3\ [F_{PL}\,(\alpha_g)]\ \{\dot{\alpha}_g\} * \Psi
\end{aligned}
\qquad (8)
$$

or

$$\{F_{PLDS}\} = [\overline{M}_4]\ \{\dot{q}\} *\Phi + [\overline{M}_5]\ \{\ddot{q}\} *\Phi + [\overline{\phi}]\ \{\dot{\alpha}_g\} *\psi$$

where:

SCALR2,SCALR3 = Scaler multipliers

F_{PL} = Matrices of aerodynamic panel forces on thin bodies

Φ $\begin{cases} = \text{Wagner indicial lift growth function} \\ = 1 \text{ if unsteady aerodynamics is used} \end{cases}$

$$\Psi \quad \begin{cases} = \text{Küssner indicial lift growth function} \\ = 1 \text{ if unsteady aerodynamic is used} \end{cases}$$

The coefficient matrices of aerodynamic panel forces used in the formulation of the aerodynamic panel loads are generated in L217 (EOM) (ref. 4) in order to calculate the generalized aerodynamic forces. These aerodynamic panel force matrices are saved on file for use in L218 (LOADS). In this program, the user specifies the aerodynamic panels where the panel aerodynamic loads are to be calculated. This program will sort the aerodynamic panel force matrices for these panels and assemble the appropriate matrices $[\overline{M}_4]$, $[\overline{M}_5]$ and $[\overline{\overline{\phi}}]$. The scaler multipliers are included only for user flexibility in the program use, such as changing the resulting load units.

4.3.3 NET PANEL LOADS (NPLDS)

The modeling of a flight vehicle in DYLOFLEX for calculating dynamic loads requires the vehicle be represented as a number of structural and aerodynamic panels. In order to obtain net panel loads on thin bodies, it is necessary to sum aerodynamic and inertia forces on each panel. The expression can be simply stated as:

$$\left\{F_{NPLDS}\right\} = SCALR_1\ [m]\ [\phi]\ \{\ddot{q}\} + \left\{F_{PLDS}\right\}$$

or

$$\left\{F_{NPLDS}\right\} = [\overline{M}_3]\ \{\ddot{q}\} + [\overline{M}_4]\ \{\dot{q}\} * \Phi + [\overline{M}_5]\ \{\ddot{q}\} * \Phi + [\overline{\overline{\phi}}]\ \{\dot{\alpha}_g\} * \Psi \qquad (9)$$

where:

$[m]$ = mass matrix

SCALR1 = scaler multiplier

The most convenient panel representation of the vehicle would be that the structural and aerodynamic panels be identical. Practically, this usually is not the case, and consequently, interpolation of the aerodynamic panel forces may be necessary to match the structural panels. Two interpolation methods are included in L218 (LOADS) to interpolate the aerodynamic panel forces to the structural nodes (locations where inertia forces are calculated).

The first interpolation method requires a manual calculation of 1) which aerodynamic panels are to be used and 2) the percent of the aerodynamic panel forces to be added to each structural panel where the net panel force is required. This data is used to calculate a matrix called a weighting factor matrix, P, which is multiplied times the aerodynamic force matrices $F_{PL}(\dot{q})$, $F_{PL}(\ddot{q})$, and $F_{PL}(\dot{\alpha}_g)$. From this matrix calculation, it can be seen that the size of the weighting factor matrix must be the number of structural panels where net panel forces are required per surface by the total number of aerodynamic panel forces on this surface. (The aerodynamic panel force coefficient matrices are generated in L217 (EOM) and include all of the aerodynamic panels on a surface.) As an example, to calculate the panel aerodynamic force at the structural node (which covers the area outlined by the dashed line) requires the aerodynamic panels 2, 3, 4, 6, 7, and 8 with only 0.5, 1.0, 0.25, 0.5, and 0.5 of each aerodynamic panel forces, respectively (see fig. 1).

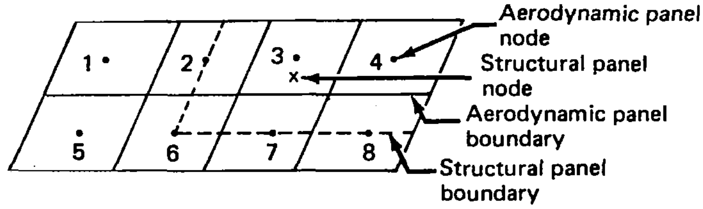


Figure 1.—Net Panel Load Example With Dissimilar Structural and Aerodynamic Panels

A weighting factor matrix can be generated that would have dimensions 1 by 8 and would appear as:

$$[P] = [0\ 0.5\ \ 1.0\ \ 1.0\ \ 0\ \ 0.25\ \ 0.5\ \ 0.5]$$

The aerodynamic panel force applied to the structural panel would now be

$$[P]\ [F_{PL}\,(\dot{q}, \ddot{q}, \dot{\alpha}_g)]$$

substituting this into equation (9) yields

$$\{F_{NPLDS}\} = \text{SCALR1}\ [M]\ [\phi]\ \{\ddot{q}\} + \text{SCALR2}\ [P]\ [F_{PL}\,(\dot{q})]\ \{\dot{q}\} * \Phi$$
$$+ \text{SCALR2}\ [P]\ [F_{PL}\,(\ddot{q})]\ \{\ddot{q}\} * \Phi + \text{SCALR3}\ [P]\ [F_{PL}(\dot{\alpha}_g)]\ \{\dot{\alpha}_g\} * \Psi \qquad (10)$$

or

$$\{F_{NPLDS}\} = [\overline{M}_3]\ \{\ddot{q}\} + [\overline{M}_4]\ \{\dot{q}\} * \Phi + [\overline{M}_5]\ \{\ddot{q}\} * \Phi + [\overline{\phi}]\ \{\dot{\alpha}_g\} * \Psi$$

It is important to note that [P] in this example is a 1 by 8 matrix because the net panel load is only required at one structural node and the [m] would be only the mass for the structural node. If the net panel load is required at three structural nodes, the size of [P] would be a 3 by 8 matrix and the mass matrix would be a diagonal 3 by 3. In this program, and for this option, the user specifies the structural panels where net panel loads are to be calculated and the weighting factor matrix. The program will sort the structural panels to be used, calculate the inertia forces on these panels to form $[\overline{M}_3]$, calculate the aerodynamic forces using the weighting factor matrix to be applied to the aerodynamic at these structural nodes, and form $[\overline{M}_4]$, $[\overline{M}_5]$, and $[\overline{\phi}]$. The scaler multipliers, SCALR1, SCALR2, and SCALR3, are included only for user program flexibility, such as changing units. For example, if the mass matrix is actually input as weight, SCALR1 could be used to change the resulting inertia force matrix $\overline{M}_3$ to the proper units.

The second interpolation method is similar to the previous method since it calculates new aerodynamic panel forces that are applied to the structural panels. This interpolation method requires as input the structural areas that each structural node encompasses and where net panel loads are required to be calculated. The method calculates the aerodynamic pressures applied to each aerodynamic panel node on a surface by dividing the aerodynamic panel force with the aerodynamic areas. These aerodynamic pressures at the aerodynamic nodes are interpolated to the structural nodes using the surface spline interpolation routine from L215 (INTERP). These interpolated aerodynamic pressures are then assumed constant over the structural panel. Thus, to calculate the aerodynamic forces at the structural nodes, the interpolated aerodynamic pressures are multiplied by the structural areas. These new interpolated aerodynamic panel forces are then used in equation (9) for calculating net panel loads. It is apparent from this interpolation scheme that if the pressure gradient varies rapidly, the accuracy of the results degenerates rapidly. Thus, this interpolation method is only valid over regions where dp^2/dx^2 and dp^2/dy^2 are equal, or approximately equal, to zero.

4.3.4 SHEARS AND MOMENTS (VBMT)

The basic equations to calculate shears and moments at a point are, respectively:

$$\begin{aligned} \text{Shear} &= \Sigma \quad \text{forces} \\ \text{Moments} &= \Sigma \quad \text{moment arms x forces} + \Sigma \text{ moments} \end{aligned} \qquad (11)$$

The forces and moments of equation (11) consist of both structural inertia forces and moments and aerodynamic forces.

The structural inertia forces at a structural node (i) where the mode shapes are calculated and in the force axis system oriented in the local axis system are given as:

$$\begin{Bmatrix} F_x \\ F_y \\ F_z \end{Bmatrix}_i = \begin{bmatrix} m & 0 & 0 & 0 & -mz & -my \\ 0 & m & 0 & mz & 0 & -mx \\ 0 & 0 & m & my & mx & 0 \end{bmatrix}_i \begin{Bmatrix} \phi_x \\ \phi_y \\ \phi_z \\ \phi\theta_x \\ \phi\theta_y \\ \phi\theta_z \end{Bmatrix}_i \{\ddot{q}\} \qquad (12)$$

$$= [J_1]_i [\phi]_i \{\ddot{q}\}$$

where:

m = Lumped mass at node i

x,y,z = Distance from the structural node to the mass c.g.

The sign convention used for the arms (x,y,z) is:

$$\left.\begin{array}{l} +\text{aft} \\ +\text{up} \\ +\text{outbd} \end{array}\right\} \text{measured from the structural node to the mass cg location and in the local axis system}$$

The moments at this structural node (i) and in the force axis system oriented in the local axis system are also given as:

$$\begin{Bmatrix} M_x \\ M_y \\ M_z \end{Bmatrix} = \begin{bmatrix} 0 & mz & my & I_{xx} & mxy & -mxz \\ -mz & 0 & mx & mxy & Iyy & myz \\ -my & -mx & 0 & -mxz & myz & Izz \end{bmatrix} \begin{Bmatrix} \phi_x \\ \phi_y \\ \phi_z \\ \phi\theta_x \\ \phi\theta_y \\ \phi\theta_z \end{Bmatrix}_i \{\ddot{q}\} \tag{13}$$

$$= [J_2]_i \, [\bar{\phi}]_i \, \{\ddot{q}\}$$

The inertia matrices J_1 and J_2 are the mass and rotary inertia data transferred from the inertia cg location to the structural node location.

That is:

$$I_{xx} = I_{xx_{cg}} + my^2 + mz^2$$

$$I_{yy} = I_{yy_{cg}} + mx^2 + mz^2$$

$$I_{zz} = I_{zz_{cg}} + mx^2 + my^2$$

These structural inertia forces and moments in the force axis system are transformed from the local oriented axis to the inertia oriented axis system by an Euler transformation matrix.

$$\begin{Bmatrix} F_x \\ F_y \\ F_z \end{Bmatrix}_{i_{inertia}} = \left[T_{inertia}\right]_i \begin{Bmatrix} F_x \\ F_y \\ F_z \end{Bmatrix}_{i_{local}} \tag{14}$$

and

$$\begin{Bmatrix} M_x \\ M_y \\ M_z \end{Bmatrix}_{i_{inertia}} = \left[T_{inertia}\right]_i \begin{Bmatrix} M_x \\ M_y \\ M_z \end{Bmatrix}_{i_{local}} \tag{15}$$

Where $[T_{inertia}]$ is the Eular transformation matrix for the structural inertia forces and moments at structural node (i).

The aerodynamic forces at aerodynamic node (i) in the force axis system transformed from the local oriented axis to the inertia oriented axis system are:

$$\begin{Bmatrix} F_{PL_x} & (\dot{q}) \\ F_{PL_y} & (\dot{q}) \\ F_{PL_z} & (\dot{q}) \end{Bmatrix}_{i_{inertia}} = \left[T_{aero}\right] \begin{Bmatrix} 0 \\ 0 \\ F_{PL}(\dot{q}) \end{Bmatrix}_{i_{local}} \tag{16}$$

similarly for $F_{PL}(\ddot{q})$ and $F_{PL}(\dot{\alpha}_g)$

where $[T_{aero}]$ is the Eular transformation matrix for the aerodynamic forces at aerodynamic node (i).

To obtain shears and moments at any point, equations (12), (13), (14), and (15) are substituted into (11) for the inertia loads and equation (16) is substituted into (11) for the aerodynamic loads and summed over the required nodes for the load in the force axis system oriented in the inertia axis system. The resulting equations for shear and moment are:

$$\begin{aligned} \{Shear\}_{force\ axis} &= \Sigma\left([T_{inertia}]\ [J_1]\ [\overline{\phi}]\ \{\ddot{q}\}\right) \\ &\quad + \Sigma\ [T_{aero}]\left([F_{PL}(\dot{q})]\ \{\dot{q}\} * \Phi \right. \\ &\quad \left. + [F_{PL}(\ddot{q})]\ \{\ddot{q}\} * \Phi + [F_{PL}(\dot{\alpha}_g)]\{\dot{\alpha}_g\} * \Psi\right) \\ &= [\overline{M}_3]\ \{\ddot{q}\} + [\overline{M}_4]\ \{\dot{q}\} * \Phi + [\overline{M}_5]\ \{\ddot{q}\} * \Phi \\ &\quad + [\overline{\overline{\phi}}]\{\dot{\alpha}_g\} * \Psi \end{aligned} \tag{17}$$

$$\begin{aligned} \text{Moment}_{\ force\ axis} &= \Sigma\left(\left[\text{Moment arms}\right]\ [T_{inertia}]\ [J_1]\ [\overline{\phi}] \right. \\ &\quad \left. + [T_{inertia}]\ [J_2]\ [\overline{\phi}]\right)\{\ddot{q}\} \\ &\quad + \Sigma\ [\text{Moment arms}]\ [T_{aero}] \\ &\qquad \left([F_{PL}(\dot{q})]\ \{\dot{q}\} * \Phi + [F_{PL}(\ddot{q})]\ \{\ddot{q}\} * \Phi \right. \\ &\quad \left. + [F_{PL}(\dot{\alpha}_g)]\ \{\dot{\alpha}_g\} * \Psi\right) \\ &= [\overline{M}_3]\ \{\ddot{q}\} + [\overline{M}_4]\ \{\dot{q}\} * \Phi + [\overline{M}_5]\ \{\ddot{q}\} * \Phi + [\overline{\overline{\phi}}]\{\dot{\alpha}_g\} * \Psi \end{aligned} \tag{18}$$

To calculate loads on the various airplane components, the most efficient technique is to sum the shear and moment loads on each component up to the intersection of its supporting component (defined as a dummy node), and then transfer the dummy load on to the second component and add it to the loads carried directly on that component. For example, the shear forces and bending moments at the root of the fin are applied as discrete forces and moments at the fin-body junction, and then summed along with the forces and moments carried directly on the body in calculating body loads (fig. 2).

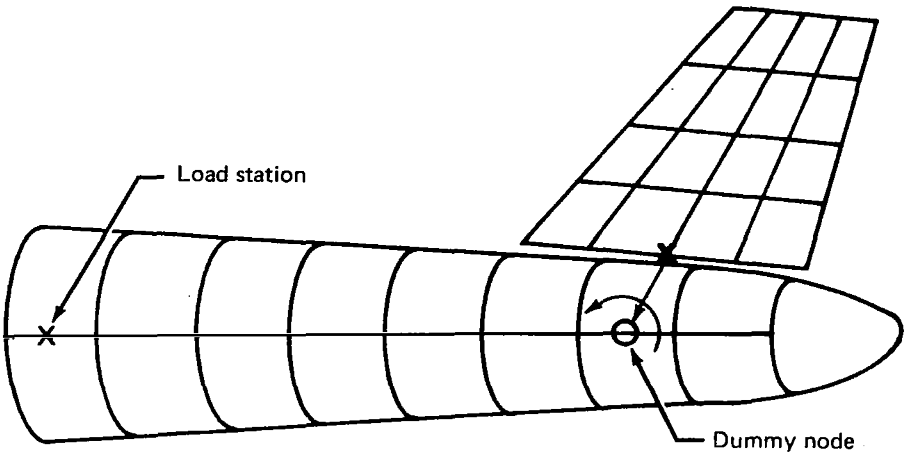


Figure 2.—Dummy Node Representation

The VBMT module of the LOADS program is designed and coded to calculate shears and moments by modeling the vehicle as a number of distinct surfaces (as shown in fig. 2) whose loads are transferred from one surface to another by the use of dummy loads located at dummy nodes. The choice of the number and location of the dummy nodes is the user's responsibility.

The general form of the shear and moment equation is shown in equations (17)and (18). However, for user flexibility, equations (14) and (15), and (16) are multiplied by a scalar multiplier SCALS and SCALA, respectively, for each structural and aerodynamic node (i). The scaler multiplier is used in calculating the amount of structural inertia load and aerodynamic load at each node to be used in the shear and moment calculation. SCALS and SCALA are made equal to one by the program for structural and aerodynamic nodes, respectively, to be included and equal to zero for the nodes not to be included, when using load panel summation card 6.9.2 (sec. 6.3). By using load panel summation card 6.9.3, SCALS and SCALA can equal any fractional percent for panels whose fractional loads are to be used in the shear and moment calculation. Card 6.9.3 requires that the values of SCALS and SCALA be manually calculated and input for each structural and aerodynamic nodes where fractional loads are to be included.

In addition, for user flexibility, scaler multipliers SCALE1, SCALE2, and SCALE3 can be used to multiply the load coefficient matrices $\overline{M}_3$, $\overline{M}_4$ and $\overline{M}_5$, and $\overline{\Phi}$, respectively, for each surface using card 6.4. These scalers can be used to change units. For example, if the inertia matrix is input in weight units, SCALE1 can be used to multiply $\overline{M}_3$ by $1/g$ so that $\overline{M}_3$ will still be a force.

Referring to figure 2 to calculate loads at the load station, the shear and moment equations (17) and (18) respectively would appear as

$$\text{Shear} = \Sigma \text{ aft fuselage forces} + \text{dummy load forces at the dummy node} \quad (19)$$

$$\text{Moment} = \Sigma \text{ moments due to aft fuselage forces and moments} + \Sigma \text{ moments due to dummy load forces and moments at the dummy node} \quad (20)$$

The summation of the forces and moments due to the dummy loads can also be multiplied by a scaler SCALED, which can equal any fractional percentage of the dummy load to be included in the calculation of the loads at a load station. SCALED must be manually calculated and input for each dummy load to be included in a load calculation using card 6.9.4. Of particular significance are two values of SCALED: –2, and 2. In load calculations, cases will arise, for example, when the loads from the horizontal stabilizer for both the left and right sides need to be included in calculating aft body loads. In a symmetric analysis, the force F_y and moments M_x and M_z on the left and right horizontal stabilizer will counteract each other, resulting in zero load, and the F_x, F_z, and M_y will add to each other. Consequently, the program is designed so that if SCALED = 2 for a dummy load, F_y, M_x, and M_z are set equal to zero and F_x, F_z, and M_y are doubled. Thus, when calculating symmetric aft body loads that include the horizontal stabilizer, only the right horizontal stabilizer is used as a dummy load and SCALED = 2 for this dummy load. Similarly, for an antisymmetric analysis, SCALED = –2 and F_x, F_z, and M_y are set equal to zero and F_y, M_x, and M_z are doubled for the specific dummy load.

A problem also exists when using aerodynamic slender bodies for loads calculations. The problem is that the aerodynamic modeling of slender bodies does not match the structure model (see fig. 3). The aerodynamic model is a straight tube, whereas the structure model will differ from this (i.e., in an upswept aft fuselage). The aerodynamic force locations are on the centerline of the aerodynamic model. These locations may not even exist on the structural model. The purpose of calculating shear and moments at a specific load station is for use in determining whether the structure is strong enough to carry the load. Consequently, the load stations are located on the structure and the external forces must be what the structure feels. It is obvious that if the aerodynamic forces are located at points not on the structure, the structure will not feel the proper loads. To adjust for the aerodynamic modeling, it is recommended that the aerodynamic force be moved vertically without producing a moment, to the centerline or elastic axis location of the fuselage or store (if the slender body is a store). This shifting of the z coordinates of the aerodynamic force locations on slender bodies can be performed by using card 6.6.

Once the shears and moments have been calculated in the force axis system and oriented in the inertial axis system, the shears and moments can be transformed to any orientation using the inverse of the Eular transformation and the angles as input by card 6.7. The shears and moments in any orientation is given as:

$$\begin{Bmatrix} V_x \\ V_g \\ V_z \end{Bmatrix}_{\substack{\text{requested} \\ \text{orientation}}} = [T]^{-1} \begin{Bmatrix} V_x \\ V_y \\ V_z \end{Bmatrix}_{\substack{\text{inertia} \\ \text{axis}}} \tag{21}$$

$$\begin{Bmatrix} M_x \\ M_y \\ M_z \end{Bmatrix}_{\substack{\text{requested} \\ \text{orientation}}} = [T]^{-1} \begin{Bmatrix} M_x \\ M_y \\ M_z \end{Bmatrix}_{\substack{\text{inertia} \\ \text{axis}}} \tag{22}$$

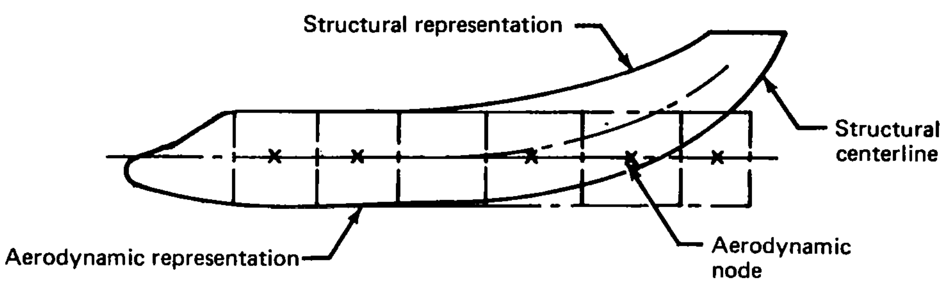


Figure 3.—Vertical Correction for Fuselage Load Station

5.0 PROGRAM STRUCTURE AND DESCRIPTION

The program is structured as a system of five overlays (fig. 4):

Main Overlay	(L218,0,0)	Program L218vc
Primary Overlay	(L218,1,0)	Program RGEN
Primary Overlay	(L218,2,0)	Program AVD
Primary Overlay	(L218,3,0)	Program NPLDS/PLDS
Primary Overlay	(L218,4,0)	Program VBMT

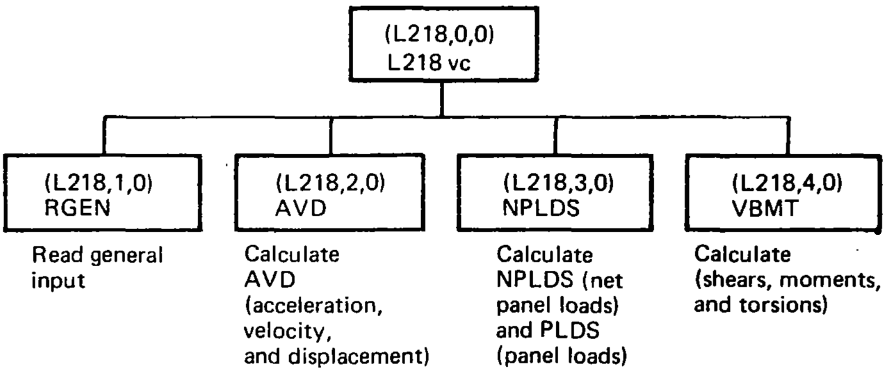


Figure 4.—Overlay Structure of L218 (LOADS)

The (0,0) main overlay, L218vc, controls reading of general data cards by the primary overlay (1,0) and calls the proper primary overlay to perform the execution requested. The main overlay does not read input cards.

The (1,0) primary overlay, RGEN, reads the general input data and the module cards ($AVD, $NPLDS, $PLDS, or $VBMT) which select the primary overlay for execution.

The (2,0) primary overlay, AVD, reads the AVD card and tape input data, performs the AVD calculations, and writes the AVDTAP input tape.

The (3,0) primary overlay, NPLDS/PLDS, reads the NPLDS (or PLDS) card and tape input data, performs the NPLDS (or PLDS) calculations, and writes the NPTAP (or PTAP) output tape.

The (4,0) primary overlay, VBMT, reads and VBMT card and tape input data, performs the VBMT calculations, and writes the LTAP output tape.

The input/output files for the overlays are shown in figure 5.

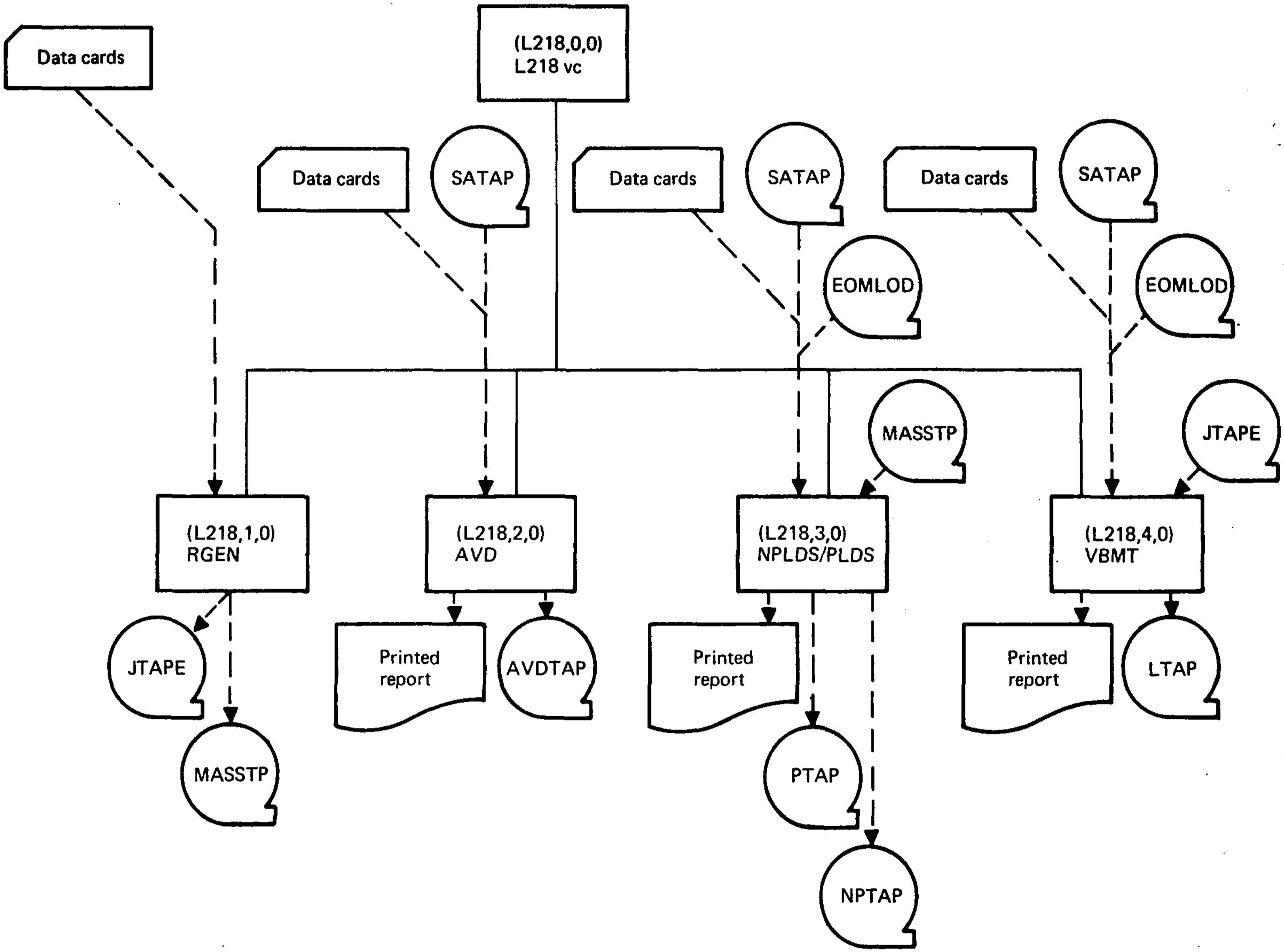


Figure 5.—Input/Output of L218 Overlays

Although L218 (LOADS) serves as a module of the DYLOFLEX system, it can be operated as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by L218 (see sec. 6.4 for file formats). When used as a module in DYLOFLEX, L218 will receive input from L215 (INTERP) and L217 (EOM) (refs. 5 and 4, respectively).

5.1 PROGRAM RGEN

The first overlay called into execution by L218 is always the 1,0 primary overlay named RGEN. Program RGEN, overlay (L218,1,0) reads and interprets general input data from cards and determine the type of execution to be performed. RGEN will also perform the following optional operations:

- Rename any of the input or output files.
- Read mass data from cards and write a diagonal mass matrix file or nondiagonal J matrix file for use in overlays (L218,3,0) and (L218,4,0). These data files may also be saved for subsequent use in L218 (LOADS).
- Redefine the order of rotation of the Euler angles.

5.2 PROGRAM AVD

Program AVD (acceleration, velocity, and displacement), overlay (L218,2,0) processes modal deflections (ϕ), geometry data (BS, BBL, WL, θ_x, θ_y, θ_z) at required node numbers, and scalers to generate the appropriate coefficient matrices for use by L219 (EQMOD) or L221 (TEV156) (refs. 6 and 7, respectively). The coefficient matrices are used to calculate loads consisting of translational and/or rotational accelerations, velocities, and displacements at selected points on the structure.

The axis system which defines the direction of the AVD loads may be either in the local motion axis system (the axis system in which the input mode shapes are defined), the inertia axis system (the axis system defined relative to the local motion axis system by the angular data θ_x, θ_y, and θ_z in the geometry input from INTERP), or any arbitrary axis system (an axis system defined relative to the reference axis system by θ_x, θ_y, and θ_z from card input). The transformation of the modal data from the local motion axis to the inertia or arbitrary axis systems uses the Eular transformation triad and requires that each mode-shape ϕ_x, ϕ_y, ϕ_z, ϕ_{θ_x}, ϕ_{θ_y}, and ϕ_{θ_z} exists at each required node. If any one of these mode shapes do not exist in the input data, they are assumed to have zero mode shape.

The modal data can also be interpolated to arbitrary locations. When the interpolation option is selected, axis transformation (rotational) is not allowed. Interpolational is performed in the local axis system to any point specified by reference axis coordinates.

There are three interpolation methods available, one method for thin bodies, and two methods for slender bodies.

The interpolation method for thin bodies uses the interpolation method from INTERP for the specified thin bodies. The mode shapes ϕ_x, ϕ_y, and ϕ_{θ_z} are assumed zero. Mode shapes ϕ_z, ϕ_{θ_x}, ϕ_{θ_y} are interpolated using the appropriate SA array from INTERP and the results multiplied by -1 to retain the proper sign convention of the modes. The first interpolation method for slender bodies uses a linear interpolation method between two given reference structural nodes or from one given structural node to any node using rigid links (see sec. 4.3.1). This method is suitable for elastic axes which are straight and preferably parallel to the reference axis. The second interpolation method for slender bodies uses a linear interpolation method which interpolates to a node using rigid links attached to a reference node. The equations are the same as the first method; however, the length of the rigid links LB, LT, and LTT and the reference structural node number (I) is input from cards.

5.3 PROGRAM NPLDS/PLDS

Program NPLDS/PLDS, overlay (L218,3,0) reads the specific card input data for net panel loads or aerodynamic panel loads. NPLDS (net panel loads) uses the modal deflection (ϕ_z) with the mass matrix and scaler multiplier to obtain the inertia forces ($\overline{M}_3$ matrix) on each surface. It also uses the aerodynamic force matrices generated in L217 (EOM) (ref. 4) from which selected nodes are extracted and multiplied by a scaler to form the $\overline{M}_4$, $\overline{M}_5$, and $\overline{\Phi}$ matrices. Only the modal deflection ϕ_z is used since net panel loads (also aerodynamic panel loads) are loads that act perpendicular to a lifting surface (thin body). PLDS (aerodynamic panel loads) is identifical to NPLDS except that the $[\overline{M}_3]$ matrix is omitted. A net panel loads run will result in loads coefficient matrices written on file (NPTAP) and a panel loads run will result in load coefficient matrices written on file (PTAP).

If the aerodynamic and structural panels are not identical when calculating net panel loads, two interpolation methods are available that interpolate the aerodynamic panel forces to the structural nodes. One method requires a weighting function matrix be manually calculated and input while the second method requires input of the structural areas corresponding to the structural nodes.

For each requested surface and the selected structural nodes, the program calculates $[\overline{M}_3]$, writes it on NPTAP, forms $[\overline{M}_4]$, $[\overline{M}_5]$ and $[\overline{\Phi}]$ for all frequencies (k), and writes them on NPTAP (also on PTAP if requested). For a more detailed description of the computer program steps in calculating $[\overline{M}_3]$, $[\overline{M}_4]$, $[\overline{M}_5]$, and $[\overline{\Phi}]$, the user should refer to volume II of this document.

5.4 PROGRAM VBMT

Program VBMT, overlay (L218,4,0) reads specific card input data and calculates shears and moments coefficient matrices for use in subsequent programs. All forces and moments are transformed to the inertia axis system before shears and bending moments are calculated. After all calculations are performed, the shears and moments are rotated to the desired orientation.

The calculation of the $\overline{M}_3$ load coefficient matrix, which consists of shears and moments due to inertia forces and moments, requires the mode shapes from the SATAP generated in L215 (INTERP) and the J matrix input in LOADS. The calculation of the $\overline{M}_4$, $\overline{M}_5$, and $\overline{\phi}$ load coefficient matrices requires the aerodynamic force coefficient matrices F_{PL} $(\dot{q})$, $(\ddot{q})$, $\dot{\alpha}_g$ from the EOMLOD tape generated in L217 (EOM).

For each load set and each requested surface and selected load, the program calculates $[\overline{M}_3]$, $[\overline{M}_4]$, $[\overline{M}_5]$ and $[\overline{\phi}]$ for all frequencies (k) and writes them on LTAP.

For a detailed description of the computer program steps in calculating $[\overline{M}_3]$, $[\overline{M}_4]$, $[\overline{M}_5]$, and $[\overline{\phi}]$, the user should refer to volume II of this document.

6.0 COMPUTER PROGRAM USAGE

The program was designed for use on the CDC 6600. The machine requirements to execute L218 (LOADS) are:

Card reader	–	To read control cards and card input data.
Printer	–	To print standard output information, optional intermediate results and diagnostic messages.
Disk storage	–	All magnetic files not specifically defined as magnetic tapes are assumed to be disk files used for input, output, and temporary data storage.
Tape drive	–	For "permanent" storage of data. Magnetic files are copied to and from magnetic tapes with control cards before and after program exeuction.

The program L218 (LOADS) is written in FORTRAN and may be compiled with either the RUN and FTN compiler. L218 may be executed on either the KRONOS 2.1 or NOS operating system.

6.1 CONTROL CARDS

The following list is a typical set of control cards used to execute L218 (LOADS) using the absolute binaries from the program's master tape.

```
Job Card
Account Card
      .
      .
      .
REQUEST (MASTER, F=I, LB=KL, VSN=66XXXX)      Retrieve the
REWIND (MASTER)                               program from its
SKIPF (MASTER)                                master tape
      .
      .                                       Prepare optional
      .                                       input data files
L218.
      .                                       Execute L218 (LOADS)
      .                                       Save optional output
      .                                       data files.
```

EXIT.
DMP (0, field length)
REWIND (IOUT)
COPYBF (IOUT, OUTPUT)
— End-of-record

Card Input
Data

— End-of-File

The following list is a typical set of control cards used to execute L218 (LOADS) using the relocatable binaries from the program's master tape.

```
Job Card
Account Card
      .
      .
      .
REQUEST (MASTER, F=I, LB=KL, VSN=66XXXX)        Retrieve the
REWIND (MASTER)                                 program from
SKIPF (MASTER, 2)                               its master tape
COPYBF (MASTER , REL218)
RETURN (MASTER)
      .                                         Prepare optional
      .                                         input data files.
      .                                         Retrieve DYLOFLEX
      .                                         alternate subroutine
      .                                         library, DYLIB.
LOAD (REL218, DYLIB)                            Load and execute
NOGO.                                           L218 (LOADS)
L218.
      .
      .
      .
EXIT.
DMP (0, field length)
REWIND (IOUT)
COPYBF (IOUT, OUTPUT)
–End-of-record

Card Input
Data

–End-of-file
```

6.2 RESOURCE ESTIMATES

Field Length

The core required for L218 is dynamic and changes with each input case. The following guidelines are given for each module:

AVD – Required core is approximately 116000 octal
+ (9) (NODES) + (6) (NODES) (MXNOE)

where:
NODES is the number of nodes requested and MXMODE is the number of modes from the SATAP tape. For thin body interpolation, an additional core is required which is the larger of 2 (NODES) + (NODES+3) (MXMODE)
or (NODES+3) (NODES+4)

NPLDS/PLDS – Required core is approximately 130150 octal
+ (NODES) (6+MXMODE) + (NAERO) (3+NLOAD+MXMOE) + NK

where:
NODES and MXMODE are as defined above, NAERO is the number of aero panels from the equations of motion tape, NLOAD is the number of structural loads, and NK is the number of frequencies.

VBMT – Required core is approximately 122400 octal
+ (60) (NK) + (5) (NAERO) + (NODES) (18+ (6) (MXMODE))
+ (MXLOAD) (10+(9) (NK) + (2) (NAERO))

where:
NK, NAERO, NODES, MXMODE are as defined above, and MXLOAD is the number of loads for a given load-set.

Each module computes the total core requirement for a given run and prints it in octal as:

REQUIRED DYNAMIC STORAGE=

Thus, for similar problems, core can be set equal to the maximum required after the first run.

If core is insufficient, a probably indication will be a CPU-01 error (address out of range).

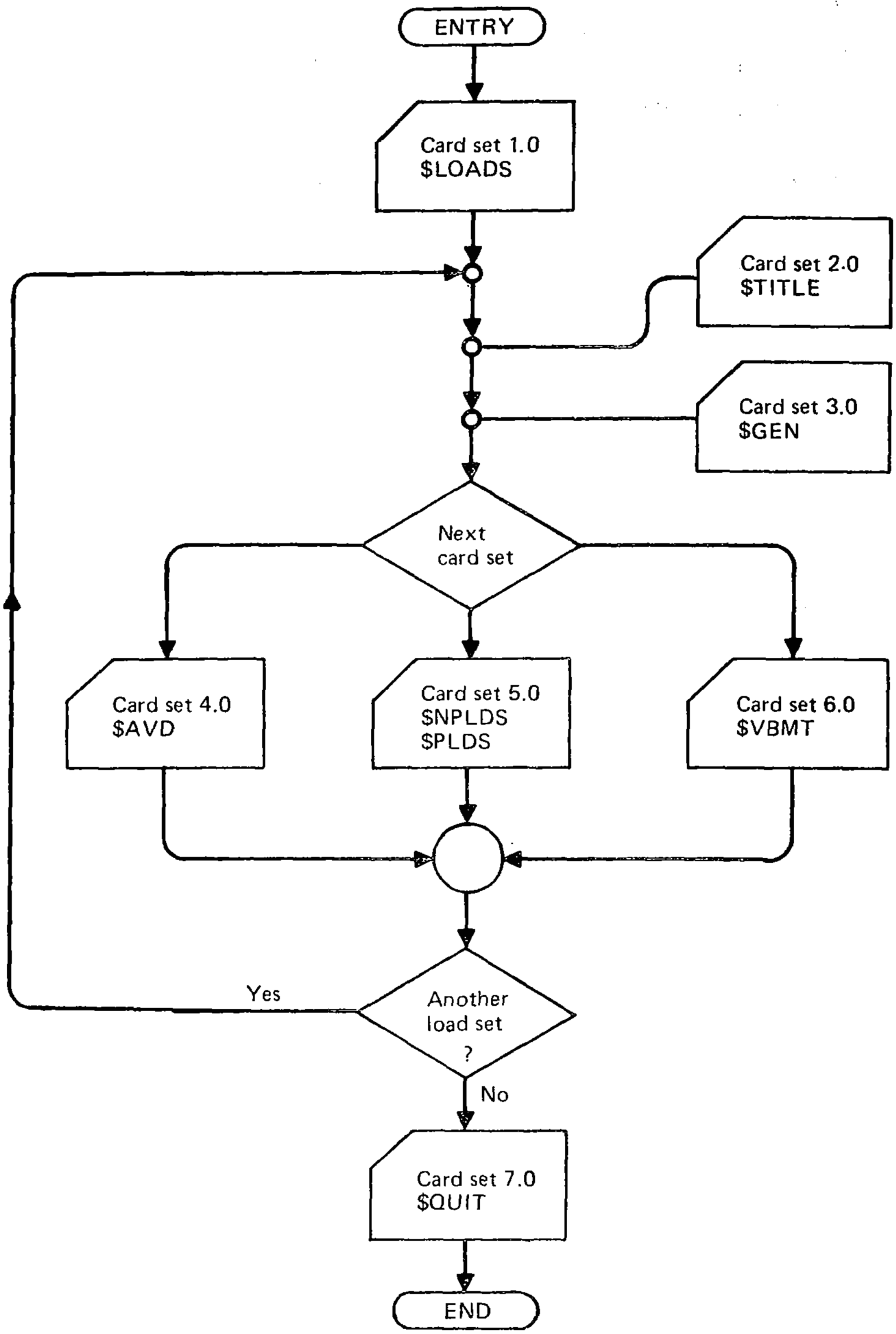


Figure 6.—Flow of L218 Card Input Data

6.3.1 PROGRAM RGEN

The primary overlay RGEN reads program directive cards to:

1. Assure that the data being read is intended for L218 (LOADS)

2. Determine which section of code (primary overlay) of L218 is to be executed next

3. Determine what data and results are to be printed

4. Determine input and output magnetic file names

Program RGEN reads and processes card sets 1.0, 2.0, 3.0 and 7.0. RGEN also reads the "$" card of card sets 4.0, 5.0 and 6.0 and sets the control flag (KMOD) to cause L218 to execute the appropriate overlay to process the rest of that card set.

Card sets 1.0, 2.0 and 7.0 are simply the cards $LOADS, $TITLE and $QUIT. The order of input for card set 3.0 is displayed in figure 7.

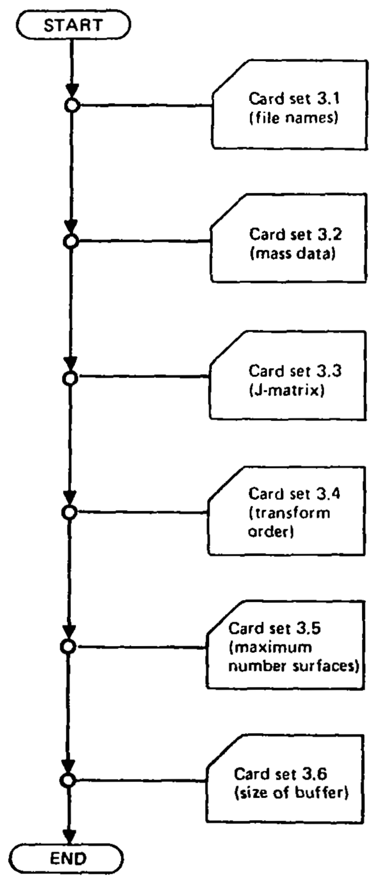


Figure 7.—Flow of Card Set 3.0 Input Data

Card Set 1.0 – Introduce L218 (LOADS) Card Input Data

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$LOADS	A10	Keyword introducing LOADS input.

Card Set 2.0 – Title Card (Optional)

Repeat the title card as desired to label the printed output.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$TITLE	A10	Keyword identifying title card.
11-70	Title	6A10	Job title which can provide description of the job.

Card Set 3.0 – Introduce General Loads Input Data (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$GEN	A10	Keyword introducing general loads input.

Card 3.1 – File Names (Optional)

Input names of files (tape or disk units) to be used for input/output data.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	IFILE (1)*	A10	Keyword indicating the file to be named.
11-20	INAME (1)	A10	Name given to the file. (Maximum of 6 characters)
⋮	⋮		
41-50	IFILE (3)	A10	Keyword indicating the file to be named.
51-60	INAME (3)	A10	Name given to the file.
			Use additional cards if necessary.

* NOTE:

IFILE (Keyword)	DEFAULT NAME	DESCRIPTION OF FILE
AVDTAP	AVDTAP	Final AVD output tape.
NPTAP	NPTAP	Final NPLDS output tape.
PTAP	PTAP	Final PLDS output tape.
LTAP	LTAP	Final VBMT output tape.
EOMLOD	EOMLOD	Equations of motion input tape for LOADS.
SATAP	SATAP	INTERP input tape for LOADS.
MASSTP	MASSTP	Diagonal Mass matrix input tape for LOADS.
JTAPE	JTAPE	J-Matrix input tape for LOADS.

Card 3.2 – Introduce Mass Data (Optional)

The mass data is input on card 3.2.2 for surfaces defined on card 3.2.1.

The mass data may be saved on tape MASSTP (card 3.1) for subsequent usage.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MASS	A10	Keyword introducing the mass matrix data.

Repeat cards 3.2.1 and 3.2.2 for each surface until all surfaces have been input. The surfaces must be input sequentially beginning with surface 1 and continuing until all surfaces have been input. A null surface should be input with zero's.

Card 3.2.1 – Mass Data Surface Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Surface	A10	Keyword to introduce a surface's mass matrix.
11-15	IS	I5	Integer defining the surface number of the mass matrix which follows.

Card 3.2.2 – Diagonal Mass Matrix Elements

Repeat card 3.2.2 until all elements for surface IS is defined.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	XMASS (1)	7E10.0	Diagonal mass matrix elements for surface IS (as defined in Card 3.2.1) in weight or mass units.
11-20	XMASS (2)		
21-30	XMASS (3)		
31-40	XMASS (4)		
41-50	XMASS (5)		
51-60	XMASS (6)		
61-70	XMASS (7)		

Card 3.3 – Introduce Inertia Data (Optional)

The inertia data is input on cards 3.3.3 and 3.3.4 for surfaces defined on card 3.3.1. The inertia data may be saved on tape JTAPE (card 3.1) for subsequent useage.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	JMAT	A10	Keyword introducing the J-matrix data.

Repeat cards 3.3.1, 3.3.2, and either 3.3.3 or 3.3.4 for each surface until the inertia data for all surfaces are defined. The surfaces must be input sequentially beginning with surface 1 and continuing until all surfaces have been input. If a surface is omitted, it is assumed to be null.

Card 3.3.1 – Inertia Data Surface Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Surface	A10	Keyword to introduce a surface's J-matrix.
11-15	IS	I5	Integer defining the surface number of the J-matrix which follows.
21-30	NODes	A10	Keyword to introduce the number of structural nodes.
31-35	INODE	I5	The number of structural nodes in this surface.

Card 3.3.2 – Inertia Data Type and Format

Repeat cards 3.3.2, and 3.3.3 or 3.3.4 as necessary to read all components of the J-matrix inertia data for surface IS (card 3.3.1).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	JTYPE	A10	Keyword identifying the type of J-matrix data to follow. The keyword must be one of the following: MASs, MX, MY, MZ, IXX, IYY, IZZ, MXY, MXZ, MYZ. The order must be followed as listed. However, if one or more is null, it is omitted.
11-20	MATYP	A10	Keyword FUL1 or SPArse indicating a full diagonal matrix or a sparse diagonal matrix. This will determine the format for the matrix data which follows: Card 3.3.3 or 3.3.4.

The J-matrix can be partitioned into a number of diagonal matrices (MASs, MX, MY, MZ, IXX, etc.). These diagonal matrices may be full or sparse.

Card 3.3.3 – Full Diagonal J-Matrix

Omit this card if the diagonal J-matrix is sparse (MATYP=SPArse on card 3.3.2).

Repeat this card until INODE elements have been read for surface IS (card 3.3.1).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	XJMAT (1)	7E10.0	J-matrix data for JTYPE matrix defined in Card 3.3.2. This is a full diagonal matrix format (designated by MATYP in Card 3.3.2).
. . .	. . .		
61-70	XJMAT (7)		

Card 3.3.4 – Sparse Diagonal J-Matrix

Omit this card if the diagonal J-matrix is full (MATYP=FULl on card 3.3.2).

Repeat this card as necessary to read all desired nodes on surface IS (card 3.3.1).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	NODE (1)	I5	Structural node number (I)
11-20	XJMAT (1)	E10.0	J-matrix value for node (I) and JTYPE matrix defined in Card 3.3.2.
. . .	. . .	. . .	. . .
41-45	NODE (3)	I5	. . .
51-60	XJMAT (3)	E10.0	

Card 3.4 – Euler Angle Rotation Order (Optional)

Transformation order for AVD and/or VMBT (see section 4.3).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	TRANsform	A10	Keyword introducing the rotation order of the Euler transformation matrix for AVD and/or VBMT.
11-20	IORDER	A10	Keyword XYZ, XZY, YXZ, YZX, ZXY, or ZYX, indicating the rotation order of the Euler transformation matrix (See Section 4). (Default = XYZ) XYZ is the order of the matrix multiplication which means rotation about Z first, then Y, and lastly X.

Card 3.5 – Maximum Number of Surfaces (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	MAXSUR	A10	Keyword introducing a non-standard value of ISMAX.
11-15	ISMAX	I5	New value for ISMAX (maximum number of surfaces). (Default = 20)

ISMAX may be changed as required. A larger value of ISMAX will result in more dynamic storage being used.

Card 3.6 – Temporary File Buffer Size (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	LBUF	A10	Keyword introducing a non-standard buffer size.
11-15	LBUF	I5	New value for LBUF. This is the buffer size used by FETADD for temporary files. (Default = 100)

For large problems requiring excessive disk storage, it may be desirable to increase LBUF. This would directly increase the dynamic storage required but may significantly decrease the number of required disk accesses.

Card 3.7 – End of General Card Input

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicates the end of Card Set 3.0.

Program RGEN reads the following load option card and transfers control to the main overlay which calls the proper overlay. The following are the card sets for the corresponding load options.

Card Set	Keyword	Load Option
4.0	$AVD	Accelerations, velocity, and displacements (Requests overlay (L218, 2, 0)
5.0	$NPLDS	Net panel loads/panel loads (Requests overlay (L218, 3, 0)
5.0	$PLDS	Panel loads (Requests overlay (L218, 3, 0)
6.0	$VBMT	Shears, bending moments, and torsion ((Requests overlay (L218, 4, 0)

Program RGEN also reads the $QUIT card (card set 7.0) and transfers control to the main overlay to terminate the program execution.

6.3.2 PROGRAM AVD

Card set 4.0 contains instructions and data required to form load coefficient matrices used to calculate accelerations, velocities, and displacements. These load coefficient matrices may be used as sensor equations in L219 (EQMOD) (ref. 6), or as load equations in L219 (EQMOD), and/or L221 (TEV156) (ref. 7). Each of the load coefficient matrices cannot exceed a size of 100 x 70 (100 loads, 70 degrees of freedom). If more loads are required, the user must repeat card set 4.0. The $AVD card terminates the previous load set (if any) and begins another load set. The final output file has successive load sets separated by end-of-file marks.

The order of input for card set 4.0 is displayed in figure 8.

Omit card set 4.0 if no acceleration, velocity, or displacement coefficient matrices are required.

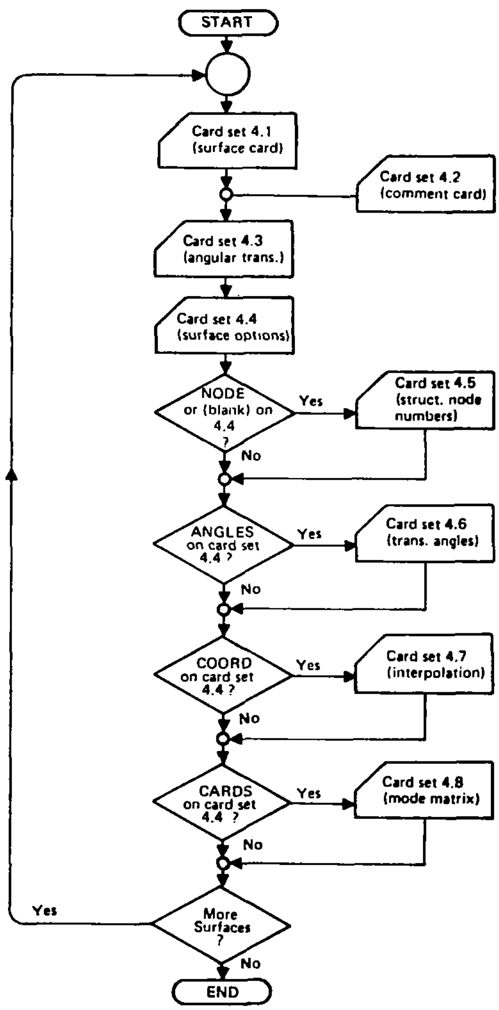


Figure 8.—Flow of Card Set 4.0 Input Data

Card Set 4.0 – AVD Load Option

Request AVD execution and introduce the AVD card set.

Repeat card set 4.0 for each load set when multiple load sets are required (limit of 100 loads per load set).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$AVD	A10	Keyword requesting the AVD path of the LOAD Module and introducing the AVD card input.
11-20	print or no-print	A10	Visual keyword* indicating that a print key may appear in Col. 21-23, 31-38 or 41-48. If printing is desired a keyword must appear in the appropriate column(s).
21-30	MAP	A10	Keyword requesting the general print summary.
31-40	MATrices	A10	Keyword requesting the general print summary and the output matrices as placed on AVDTAP.
41-50	CHEckout	A10	Keyword requesting the general print summary, the output matrices as placed on AVDTAP, and intermediate calculations.

*Note: All visual keywords are optional and are not read by the program.

Repeat cards 4.1-4.8 as required.

Card 4.1 – Surface Definition

The surface card (Card 4.1) may be repeated with the same surface number IS if necessary.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Surface	A10	Keyword to introduce the surface number.
11-15	IS	I5	Surface number requested (a default maximum number of 20, see Card 3.5 for increase).
16-20		5X	Not Used.
21-30	CARDS * or TAPE	A10	Keyword indicating the source of the mode shapes. Keyword CARDS means the mode matrices will be read from cards (Card 4.8). Keyword TAPE means the mode matrices will be input from the file SATAP. Default : TAPE
31-35	IROWS	I5	If Col. 21-30 contains CARDS, Irows is the number of rows in the mode matrix (number of nodes on surface IS). IROWS is left blank if Col. 21-30 contains TAPE.
36-40	ICOLS	I5	If Col. 21-30 contains CARDS, ICOLS is the number of columns in the mode matrix (number of modes defined). ICOLS is left blank if Col. 21-30 contains TAPE.

*See note following card 4.4.

Card 4.2 – Comment (Optional)

Repeat card 4.2 as desired to label the card data and printed output.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-2	C	A2	Keyword indicating a comment card that will be printed.
3-80		A8,6A10	Available for comments.

Card 4.3. – Angular/Translational Matrix Selection Card

Defines the type of AVD load and $\overline{M}$ matrix to be generated.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	A-F	6(A2,1X A3,4X)	Keyword, where A is one of the following for surface IS
11-20	A-F		<u>TA</u> - for translational acceleration matrix
⋮	⋮		<u>TV</u> - for translational velocity matrix <u>TD</u> - for translational displacement matrix <u>RA</u> - for angular acceleration matrix <u>RV</u> - for angular velocity matrix
51-60	A-F		<u>RD</u> - for angular displacement matrix and where F is one of: <u>XYZ</u>, <u>XY</u>, <u>XZ</u>, <u>YZ</u>, <u>X</u>, <u>Y</u>, <u>Z</u> where X, Y or Z defines the X, Y or Z mode component to be used in generating the matrix. For example: TA-X would be a keyword to generate the $\overline{M}_3$ matrix for translational acceleration in the x direction using the ϕ_x mode deflection. RV-XYZ would be a keyword to generate the $\overline{M}_2$ matrix for angular velocity in the x, y, z directions using the $\phi_{\theta_x}, \phi_{\theta_y}, \phi_{\theta_z}$ mode shapes.

Card 4.4 – Surface Options

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	NODE * or NODE-ALL or COORD	A10	Keyword indicating which nodes of surface IS will be used to calculate the type of load defined on Card 4.3. Keyword NODE means only specific structural node numbers will be read by Card 4.5. Keyword NODE-ALL means all structural nodes defined in INTERP (L215) will be used (Omit Card 4.5). Keyword COORD means nodal coordinates (X,Y,Z) will be read on Card 4.7. Default : NODE
11-20	LOCAL * or INERT or ANGLES	A10	Keyword indicating the resultant load axis system (See Section 4.0). Keyword LOCAL means the local axis option is selected. Keyword INERT means the inertia axis option is selected. Keyword ANGLES means arbitrary rotation angles θ_x, θ_y, θ_z will be read with Card 4.6. Default : LOCAL
21-30	SCALR1	E10.0	Scale factor on TA Default: SCALR1 = 1.0
31-40	SCALR2	E10.0	Scale factor on TV and TD Default: SCALR2 = 1.0
41-50	SCALR3	E10.0	Scale factor on RA, RV, RD Default: SCALR3 = 1.0
51-60	PRINT or NO-print	A10	A keyword to define the sequential print option after each surface calculation. Keyword PRINT prints surface number, (X, Y, Z) reference coordinate, node number, type of load, and matrix coefficients. Keyword NO indicates no printing unless selected on $AVD (Card Set 4.0) Default : PRINT

*See note next page.

Note: The following table summarizes valid combinations of keywords from cards 4.1 and 4.4. If the user chooses an invalid combination of keywords, the user will get fatal error diagnostic.

VALID KEYWORD COMBINATIONS		
Card 4.1	Card 4.4	
CARDS	COORD	LOCAL
TAPE	NODE	ANGLES LOCAL INERT
	NODE-ALL	ANGLES LOCAL INERT
	COORD	LOCAL

Card 4.5 – Structural Node Numbers, (Optional)

This card is included only if the first keyword on card 4.4 is NODE or blank.

Repeat card 4.5 as necessary until all structural nodes to be used as AVD loads.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	IINODE (1)	I4I5	Numbers of nodes (monotonic-increasing) specifically requested to calculate the AVD loads requested on Card 4.3. For example: 1 3 5 7 would include nodes 1, 3, 5, 7. If a string of nodes is required in addition to some selected nodes, it might be requested by 1 3 5 -10 13 14 where 5 -10 is interpreted to mean nodes 5, 6, 7, 8, 9, and 10.
⋮	⋮		
66-70	IINODE (14)		

Card 4.6 – Transformation Angles (Optional)

This card is included only if the second keyword on card 4.4 is ANGLES.

Repeat card 4.6 for all structural nodes retained.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	THETAX	3E10.0	Thetax(θ_{x_i}, Thetay(θ_{y_i}), Thetaz(θ_{z_i}) defines a set of
11-20	THETAY		axis rotation angles for node i. The order of rotation is
21-30	THETAZ		as specified in Card 3.4.

Card 4.7 – Interpolation* (Optional)

This card is included only if the first keyword on card 4.4 is COORD.

Repeat card 4.7 for each coordinate location desired.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION	
1-10	X	E10.0	BS	Coordinates in the reference axis
11-20	Y	E10.0	BBL	system of the point at which AVD
21-30	Z	E10.0	WL	loads are to be calculated.
31-40	ALB	E10.0	LB (interpolation coefficient) = $BS-BS_{ISUB}$ Omit if ISUB = blank	
41-50	ALT	E10.0	LT (interpolation coefficient) = $BBL-BBL_{ISUB}$ Omit if ISUB = blank	
51-60	ALTT	E10.0	LTT (interpolation coefficient) = $WL-WL_{ISUB}$ Omit if ISUB = blank	
61-65	ACODE	A5	Interpolation option code*. blank or PAR Omit if ISUB > 0	
66-70	ISUB	I5	Reference structural node number (ISUB)	

*Interpolation Methods (see section 4.3.1).

ACODE/ISUB	METHOD	APPLICATION
blank/blank	Interpolation method used in INTERP (L215)	Thin bodies
PAR/blank	Linear interpolation between structural nodes or extra-polation from a structural node.	Slender bodies with elastic axis parallel to reference axis.
blank/ref.node no. ISUB	Interpolates to a node using rigid links of lengths ALB, ALT, and ALTT attached to the reference structural node ISUB	Slender bodies

Note: For cases using LB, LT, LTT, a particular reference node (ISUB card 4.7) can be used only once for a surface calculation. If more than one reference to the same node is required, the surface data must be repeated for each additional reference (card 4.1).

Card 4.8 – Card Input of Mode Matrix (Optional)

This card is included only if the keyword on card 4.1 is CARDS.

Card 4.8 is repeated only for each mode matrix required, as determined by card 4.3, and in the order $[\phi_x]$, $[\phi_y]$, $[\phi_z]$, $[\phi\theta_x]$, $[\phi\theta_y]$, $[\phi\theta_z]$.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	ϕ (1)	7E10.0	i^{th} row of the mode shape matrix. The mode shape matrix will be read by rows, repeating this card as necessary. Each row begins as a new card.
⋮	⋮		
61-70	ϕ (7)		

Card 4.9 – End of AVD Card Input

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicates the end of Card Set 4.0.

6.3.3 PROGRAM NPLDS/PLDS

Card set 5.0 contains instructions and data required to form net panel loads or aerodynamic panel loads using data read from the Interpolation (L215) tape (SATAP) (ref. 3), and the equations of motion (L217 tape EOMLOD) (ref. 5).

Each of the load coefficient matrices cannot exceed a size of 100 x 70 (100 loads, 70 degrees of freedom). If more loads are required, the user must repeat card set 5.0. The $PLDS or $NPLS card terminates the previous load set (if any) and begins another load set. The final output file has successive load sets separated by end-of-file marks.

The order of input for card set 5.0 is displayed in figure 9.

Omit card set 5.0 if *no* net panel load or panel load coefficient matrices are required.

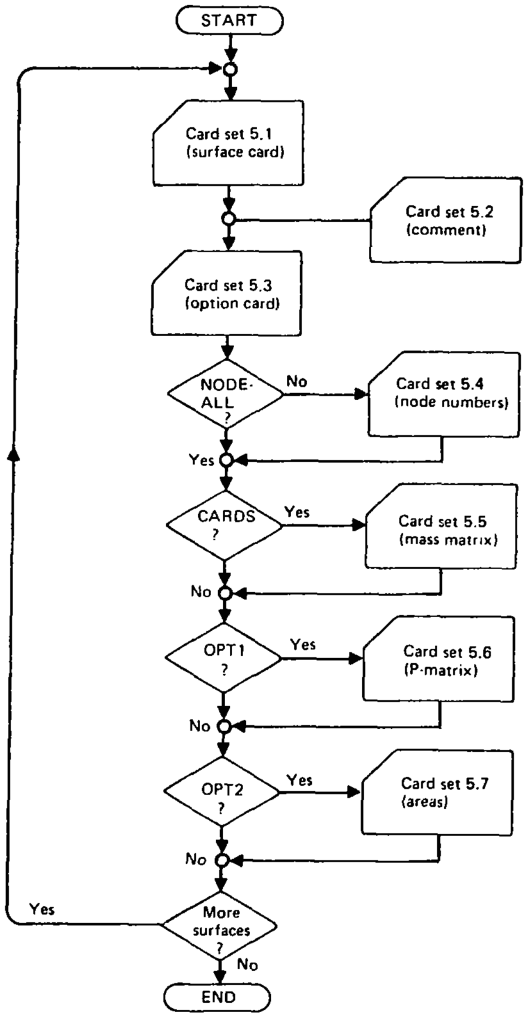


Figure 9.—Flow of Card Set 5.0 Input Data

Card Set 5.0 – NPLDS/PLDS Load Option

Repeat card set 5.0 for each load set when multiple load sets are required (limitation of 100 loads per load set).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$NPLDS or $PLDS	A10	Keyword requesting the NPLDS or PLDS path of the LOAD module and introduces the NPLDS/PLDS card input.
11-20	print or no-print	A10	Visual keyword indicating that a print key may appear in Col. 21-30, 31-40 or 41-50. If printing is desired a keyword must appear in the appropriate column(s).
21-30	MAP	A10	Keyword requesting the general print summary.
31-40	MATrices	A10	Keyword requesting the general print summary and the output matrices (as placed on NPTAP or PTAP).
41-50	CHEckout	A10	Keyword requesting the general print summary, output matrices (as placed on NPTAP or PTAP), and intermediate calculations.

Repeat cards 5.1 through 5.6 for each required surface.

Card 5.1 – Surface Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Surface	A10	Keyword to identify the surface.
11-15	IS	I5	Surface number requested. (A default maximum number of 20. See Card 3.5 for increase)
16-20		5X	Not Used
21-30	CARDS or TAPE or blank	A10	Keyword indicating the source of the mass data for surface IS. Keyword CARDS will cause the mass matrix to be read in Card 5.5. . Keyword TAPE will cause the mass matrix to be read from the tape name defined in the General Loads Input for MASSTP. The field is left blank if $PLDS is used on Card Set 5.0.

Card 5.2 – Comment (Optional)

Repeat card 5.2 as desired to label the card data and printed output.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-2	C	A2	Keyword indicating a comment card that will be printed.
3-70		A8,6A10	Available for comments

Card 5.3 – Surface Option Card

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	NODE or NODE-ALL	A10	Keyword indicating which structural nodes of surface IS will be used to calculate PLDS or NPLDS. Keyword NODE means that specific nodes will be read on Card 5.4. Keyword NODE-ALL means all nodes defined in INTERP (L215) (Ref. 5) will be used.
11-20	OPT1* or OPT2** or blank or PLDS	A10	Keyword defining the aerodynamic force interpolation method. Keyword OPT1 requires the P matrix to be read using Card 5.6. Program NPLDS is used. Keyword OPT2 requires the area of the structural panels to be read using Card 5.7. Program NPLDS is used. If the keyword is left blank, the structural and aero node locations are assumed to be the same. Keyword PLDS indicates that the structural and aero node locations are assumed to be the same and final results are written on the PLDS tape (without $[\bar{M}_3]$) as well as the NPLDS tape. If Card Set 5.0 is $PLDS, this keyword is left blank.
21-30	SCALR1	E10.0	Scale factor to be applied to $[\bar{M}_3]$ Default: SCALR1 = 1.0
31-40	SCALR2	E10.0	Scale factor to be applied to $[\bar{M}_4]$ and $[\bar{M}_5]$ Default : SCALR2 = 1.0
41-50	SCALR3	E10.0	Scale factor to be applied to $[\bar{\phi}]$. Default : SCALR3 = 1.0
51-60	PRINT or NO-print	A10	A keyword to define the sequential print option after each surface calculation is performed. Keyword NO indicates no printing unless selected on $NPLDS/$PLDS (Card Set 5.0). Default : PRINT

*OPT1 interpolates using a weighting factor matrix P.

**OPT2 interpolates using a form of surface spline and requires the areas of the structural nodes to be input.

Card 5.4 – Structural Node Numbers (Optional)

Omit card 5.4 if keyword on card 5.3 is NODE-ALL.

Repeat card 5.4 as necessary until all nodes required are defined.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	IINODE (1)	14I5	Numbers of structural nodes (monotonic-increasing) specifically requested to calculate PLDS and/or NPLDS loads.
6-10	IINODE (2)		For example: 1 3 5 7 would include 1,3,5,7. If a string of nodes is required in addition to some selected nodes, it might be requested by 1 3 5 -10 13 14 where 5 -10 is interpreted to mean nodes 5,6,7,8,9 and 10.
⋮	⋮		
66-70	IINODE (14)		

Card 5.5 – Diagonal Elements of Mass Matrix (Optional)

This card is included only if keyword on card 5.1 is CARDS.

Repeat card 5.5 as necessary until all mass data required is used.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	XMASS (1)	7E10.0	Diagonal mass matrix elements for surface IS corresponding to node numbers requested on Card 5.4 and/or Card 5.3. Repeat until all elements are defined.
⋮	⋮		
61-70	XMASS (7)		

Card 5.6 – Weighting Factor Matrix P for Interpolation of Aero Forces to Structural Nodes* (Optional)

This card is included if keyword on card 5.3 is OPT1*.

The P-matrix (matrix relating aerodynamic nodes to structural load locations) is input as a sparse matrix. This card is repeated as necessary to include all rows and all columns per row required for the P-matrix (the P-matrix is an N x M matrix where N = the number of structural nodes and M = the number of aero panels on surface IS).

Repeat card 5.6 as necessary until all P-matrix nonzero elements are read.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	IROW	I5	Row number
6-10		5X	Not Used
11-15	IC1	I5	Column number
16-20		5X	Not Used
21-30	P1	E10.0	P-matrix element corresponding to column IC1**.
31-35	IC2	I5	Column number
36-40		5X	Not Used
41-50	P2	E10.0	P-matrix element corresponding to column IC2.
51-55	IC3	I5	Column number
56-60		5X	Not Used
61-70	P3	E10.0	P-matrix element corresponding to column IC3.

*See section 4.3.3, program NPLDS.

**P_{ij} is a fraction of aerodynamic force at node j acting on structural node i.

Card 5.7 – Structural Node Areas for Interpolation of Aerodynamic Forces to Structural Nodes* (Optional)

This card is included only if keyword on card 5.3 is OPT2*.

Repeat card 5.7 as necessary until all areas of structural nodes requested are input.

COLS.	KEYWORDS/ VARIABLE	FORMAT	DESCRIPTION
1-10	AREA (1)	7E10.0	Structural node areas corresponding to the node numbers requested, for surface IS.
11-20	AREA (2)		
21-30	AREA (3)		
. . .	. . .		Repeat as necessary to include all areas for structural nodes defined by Cards 5.4 and/or 5.3.
61-70	AREA (7)		*Warning* This option is only valid over regions where $\frac{d^2p}{dx^2}$ and $\frac{d^2p}{dy^2}$ are equal to or approximately equal to zero

*See section 4.3.3 program NPLDS.

Card 5.8 – End of NPLDS/PLDS Card Input

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicates the end of Card Set 5.0.

6.3.4 PROGRAM VBMT

Card set 6.0 contains instructions and data required to form shears and bending moment loads using data read from the interpolation (L215) tape (SATAP), (ref. 5), and the equations of motion (L217) tape (EOMLOD), (ref. 4).

Each of the load coefficient matrices cannot exceed a size of 100 x 70 (100 loads, 70 degrees of freedom). If more loads are required, the user must use more load set cards (card 6.3). The final output file has successive load sets separated by end-of-file marks.

The order of input for each set 6.0 is displayed in figure 10.

Omit card set 6.0 if no shear nor bending moment load coefficient matrices are required.

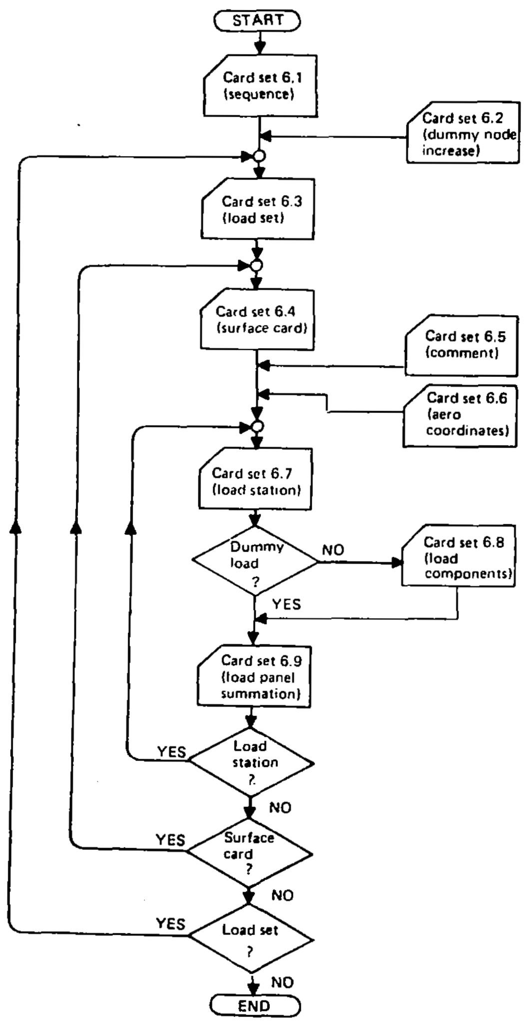


Figure 10.—Flow of Card Set 6.0 Input Data

Card Set 6.0 – VBMT Load Option

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$VBMT	A10	Keyword requesting the VBMT path of the LOADS module and introducing the VBMT card input.
11-15	print or no-print	A10	Visual keyword indicating that a print key may appear in Col. 21-30, 31-40 or 41-50. If printing is desired a keyword must appear in the appropriate column(s).
21-30	MAP	A10	Keyword requesting the general print summary.
31-40	MATrices	A10	Keyword requesting the general print summary and the output matrices (as placed on LTAP).
41-50	CHEckout	A10	Keyword requesting the general print summary, output matrices (as placed on LTAP), and intermediate calculations.

Card 6.1 – Surface Sequence

This sequence order of surfaces is used as a guide and a check on the order of card 6.4. The sequence order is variable except that if a dummy load defined and calculated on surface "n" is used in calculating loads on surface "m", the surface sequence order must have surface n before m. This is necessary so that the dummy load is defined and calculated before being used in other load calculations. The required calculation sequence for surfaces is also the sequence for the final output tape.

Repeat this card as necessary.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-20	Surface sequence	A10,10X	Keyword to identify the surface sequence card.
21-25	ISEQ (1)	10I5	Surface numbers indicating the surface numbers to be processed and the proper sequence to calculate the desired loads. (A default maximum number of 20 surfaces. See Card 3.5 for increase)
. . .	. . .		
66-70	ISEQ (10)		

Card 6.2 – Dummy Node Increase (Optional)

This card increases the number of permitted dummy nodes.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Maxdum	A10	Keyword requesting an increase in the maximum number of permitted dummy nodes.
11-15	MXDUM	I5	The number of dummy nodes permitted in this VBMT run. Default : MXDUM = 20

Repeat cards 6.3 through 6.9.4 for successive load sets.

Card 6.3 – Load Set

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	LOAD-set	A10	Keyword LOAD-set introduces the beginning of data cards for a new load-set.
11-15	ILS	I5	Load-set number.

Repeat cards 6.4 through 6.9.4 as necessary to calculate loads on all surfaces.

Card 6.4 – Surface Definition

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	SURface	A10	Keyword to introduce the surface number.
11-15	IS	I5	Surface number requested. (A default maximum number of 20. See Card 3.5 for increase)
21-30	SCALE1	E10.0	Scale factor applied to all structural node-summed shears and moments for $[\overline{M}_3]$ (not applied to dummy nodes). Default :SCALE1 = 1.0
31-40	SCALE2	E10.0	Scale factor applied to all aerodynamic node response force summed shears and moments for $[\overline{M}_4]$ $[\overline{M}_5]$ (not applied to dummy nodes). Default :SCALE2 = 1.0
41-50	SCALE3	E10.0	Scale factor applied to all aerodynamic node gust force summed shears and moments for $[\overline{\Phi}]$ (not applied to dummy nodes). Default :SCALE3 = 1.0
51-60	PRINT or NO-print	A10	Keyword to define the sequential print option after each surface calculation is performed. Keyword NO indicates no printing unless selected on $VBMT (Card Set 6.0) Default : PRINT

Card 6.5 – Comment (Optional)

Repeat card 6.5 as desired to label the card data and printed output.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-2	C	A2	Keyword indicating a comment card which will simply be printed.
3-70		A8,6A10	Available for comments.

Card 6.6 – Aero Panel Force Node Z Coordinate Overwrite (Optional).

Aerodynamic slender bodies and interference bodies are modeled as straight tubes. This option will replace the Z coordinates of the aero panel nodes from the equations of motion file, EOMLOD, with Z coordinates input on cards (normally, the actual structural locations). This does not change the magnitude or direction of the slender body and interference body forces.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Z Coord	A10	Keyword introducing the card to input the Z coordinates which will override selected aero-nodes received from EOM for surface IS.
11-20	ALL	A10	Keyword indicating the z overwrite option for the nodes on surface IS. Keyword ALL indicates all nodes to be overwritten using Card 6.6.1 Default (blank) indicates only some nodes to be overwritten using Card 6.6.2

Card 6.6.1 – Z Coordinates for All Aerodynamic Nodes

This card is included only if 2nd keyword on card 6.6 is ALL.

Repeat this card as required to define all nodes on surface IS.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	Z (1)	7E10.0	The overwrite Z coordinates (reference axis) for all aerodynamic node numbers for surface IS.
⋮	⋮		
61-70	Z (7)		

Card 6.6.2 – Z Coordinates for Specified Aerodynamic Nodes

This card is included only if 2nd keyword on card 6.6 is blank. Repeat this card as required.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-5	NODE (1)*	I5	Aerodynamic node numbers
11-20	Z (1)	E10.0	The overwrite Z coordinate (reference axis) for aerodynamic node (1).
21-25	⋮	I5	⋮
31-40		E10.0	
41-45	NODE (3)	I5	⋮
51-60	Z (3)	E10.0	

*Note: Node (1) is the first aerodynamic node number to be overwritten.

Repeat cards 6.7 through 6.9 for all load numbers and dummy load numbers for surface IS.

One or more of cards 6.9.1, 6.9.2, 6.9.3, and 6.9.4 is required with each card 6.7.

Card 6.7 – Load Station/Dummy Station

The load/dummy load numbers must increase monatonically beginning with 1 for the total VBMT run.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION	
1-5	Load or Dload	A5	Keyword Load indicates a load station. Keyword Dload indicates a dummy load station (no transformation, no output) (maximum number of 20 dummy stations, see Card 6.2 for increase).	
6-10	LNODE	I5	Load / dummy load number.	
11-20	AX *	6E10.0	BS	load station/dummy station coordinates in reference axis system
21-30	AY		BBL	
31-40	AZ		WL	
41-50	ATHETX		Thetax (rotation of load relative to reference axis system) (deg) - not required for dummy node	
51-60	ATHETY		Thetay (rotation of load relative to reference axis system) (deg) - not required for dummy node	
61-70	ATHETZ		Thetaz (rotation of load relative to reference axis system) (deg) - not required for dummy node (Default value for Thetax, Thetay, Thetaz = 0 degrees)	

*Note: Columns 11-70 give the location and orientation of the load station.

Angles of the load axis system θ_x, θ_y, and θ_z are measured from the reference axis to the load axis using the Eular rotation order defined in card 3.4.

Card 6.8 – Load Components

Omit this card if keyword of card 6.7 is Dload.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	IKEY (1)*	6(A2,8X)	Keyword indicating the load components required after the transformation, for the final output. The keyword can be any IKEY(I) or combination of IKEY(I)s in order of VX, VY, VZ, MXX, MYY, MZZ.
.	.		
.	.		
.	.		
51-60	IKEY (6)		

*

IKEY (Keyword)	Description
VX	Shear, x direction (load axis).
VY	Shear, y direction (load axis).
VZ	Shear, z direction (load axis).
MXX	Bending moment, about the x axis (load axis).
MYY	Bending moment, about the y axis (load axis).
MZZ	Bending moment, about the z axis (load axis).

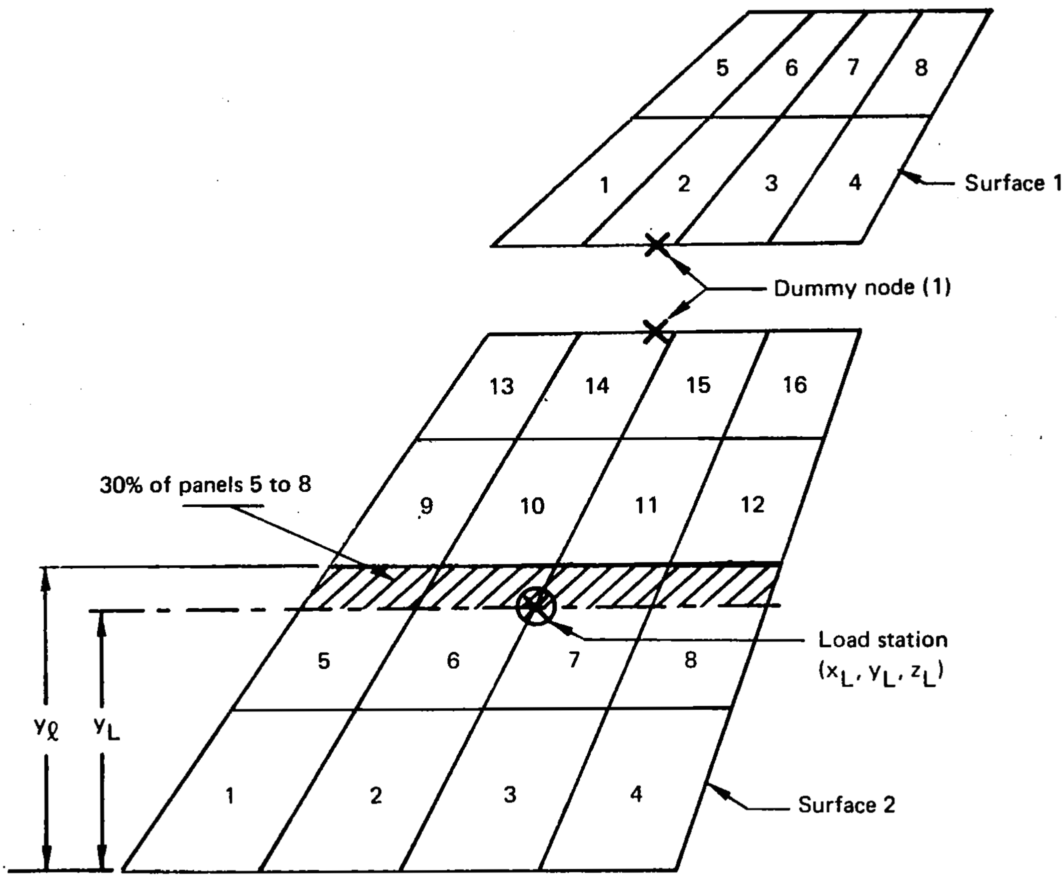
Card 6.9 – Load Panel Summation Direction

Use cards 6.9.1 or 6.9.2, 6.9.3 and 6.9.4 or combinations of same.

See figure 11 for load panel summation example.

Card 6.9.1 – Load Panel Summation–All (Optional)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	<u>ALL</u>	A10	Keyword indicating all nodes/surface IS are to be summed for LOAD or DLOAD number (LNODE) defined on Card 6.7.



Load at x_L, y_L, z_L on surface 2 uses the relationships
y greater than y_ℓ (Card 6.9.4)

+ 0.30 X aerodynamic forces at aeordynamic nodes (5-8) (Card 6.9.2)

+ Dummy load at dummy node (1) to calculate the required loads. (Card 6.9.3)

Figure 11.—VBMT Panel Summation Example

Card 6.9.2 – Load Panel Summation (Optional) (see fig. 11)

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	A.F.	A5,5X	Keyword indicating which nodes on surface IS will be included in the LOAD (or DLOAD) calculation for load LNODE (defined on Card 6.7). The periods are part of the keyword and the table below shows the possible choices for A and F. The A in the keyword indicates a direction along one of the axis in the reference axis system. The F in the keyword indicates which nodes in the A direction will be included in the load calculation* (see example below).
11-20	XYZ	E10.0	The value of the x, y, or z coordinate (reference axis system) indicated by the A portion of the keyword above* (see example below).
21-30	A.F.	A5,5X	
31-40	XYZ	E10.0	
41-50	A.F.	A5,5X	
51-60	XYZ	E10.0	

A may be	F may be
x = x direction	LT = less than
y = y direction	LE = less than or equal
z = z direction	EQ = equal
	GE = greater than or equal
	GT = greater than

Example:
X.GT. 10.0 This means all nodes which have an x coordinate (reference axis) greater than 10.0 will be included in the load calculation.

*Note: The user can limit the choice of nodes in the x, y, and z direction by using combinations of x, y, and z for A. However, banding of coordinates is illegal, i.e.; Y.GT. and Y.LT. on same card 6.9.2.

Card 6.9.3 – Load Panel Summation–Specific Panels (Optional)

Repeat this card as necessary.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	STRucturep or AERop	A10	Keyword defining Structural Panel or Aero Panel.
11-20	SCALE	E10.0	A scale factor applied to the loads from nodes defined in Col. 21-60. Default : SCALE = 1.0
21-25 ⋮ 66-70	IINODE (1) ⋮ IINODE (10)	10I5	Nodes/surface IS to be used in summing for shears and moments for LOAD or DLOAD number (LNODE) defined on Card 6.7. Each node required is input (monatonically increasing). A negative number may be used to indicate a string of numbers; e.g., 1 -5 would mean node numbers 1, 2, 3, 4, 5.

Card 6.9.4 – Load Panel Summation–Dummy Nodes (Optional)

Repeat this card if necessary.

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	ADD dload	A10	Keyword identifying a dummy load which must be included in the summation for LOAD or DLOAD number (LNODE) defined on Card 6.7.
11-15	LNODED (1)	I5,	Dummy node number which must be included.
21-30	SCALED (1)	E10.0	Scale factor to be applied to the dummy load.
31-35	LNODED (2)	I5,	Default : SCALED = 1.0
41-50	SCALED (2)	E10.0	
51-55	LNODED (3)	I5,	
61-70	SCALED (3)	E10.0	

Note: If SCALED = +2.0 (symmetric case), the program sets F_{yD}, M_{xD}, M_{zD}, $\Delta_y = 0$ and multiplies F_{xD}, F_{zD}, and M_{yD} by 2.00 where F = force, M = moment, D = dummy load, X, Y, Z is direction or axis.

If SCALED = -2.0 (anti-symmetric case), the program sets F_{xD}, F_{zD}, $M_{yD} = 0$ and multiplies F_{yD}, M_{xD}, and M_{zD} by 2.0.

This will properly sum the left and right thin bodies for total fuselage loads for the symmetric or anti-symmetric analyses, i.e., sums left and right horizontal stabilizer onto aft body.

Card 6.10 – End of VBMT Card Input

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$END	A10	Keyword indicates the end of Card Set 6.0.

Card Set 7.0 – Job Terminator

Always the last card of L218 (LOADS).

COLS.	KEYWORD/ VARIABLE	FORMAT	DESCRIPTION
1-10	$QUIT	A10	Keyword indicating the last data for the LOADS module has been read (signals end of execution).

6.3.5 Summary of Card Input Data

Requirements or Function	Key Words and/or Variables	Card Format	Reference Card Set CS
	$LOADS	A10	1.0
	$TITLE Title	A10,6A10	2.0
	$GEN	A10	3.0
Input/Output File Names	IFILE INAME IFILE INAME IFILE INAME	6A10	3.1
Introduce Mass Data	MASS	A10	3.2
Surface Card	Surface IS	A10,I5	3.2.1
Mass Data	XMASS(1) XMASS(2) . . . XMASS(i)	7E10.0	3.2.2
Introduce Inertia Data	JMAT	A10	3.3
Surface Card	SURface IS NODes INODE	A10,I5,5X A10,I5	3.3.1
Inertia Data Type and Format	JTYPE {FUL1, SPArse}	2A10	3.3.2
Inertia Data for JTYPE FUL1 on CS 3.3.2	XJMAT(1) XJMAT(2) . . . XJMAT(i)	7E10.0	3.3.3
Inertia Data For JTYPE SPArse on CS 3.3.2	NODE(1) XJMAT(1) . . . NODE(i) XJMAT(i)	3(I5,5X,E10.0)	3.3.4
Transformation Order	TRANsform IORDER	2A10	3.4
Increase Maximum Number of Surfaces	MAXSUR ISMAX	A10,I5	3.5
Non-standard Buffer Size	LBUF LBUF	A10,I5	3.6
End of General Card Input	$END	A10	3.7

Requirements or Function	Key Words and/or Variables	Card Format	Reference Card Set(CS)
AVD Option Summary Print Option	\$AVD print / no-print MAP MATrices CHEckout	5A10	4.0
Surface Card Input Option	Surface IS CARDS / TAPE IROWS ICOLS	A10,I5,5X A10,2I5	4.1
	C Comment	A2,A8,6A10	4.2
Matrix Selection	A-F (A=TA,TV,TD,RA,RV,RD and F=XYZ,XY,XZ,YZ,X,Y,Z)	6(A2,1X,A3,4X)	4.3
Surface Options	NODE / NODE-ALL / COORD LOCAL / INERT / ANGLES SCALR1 SCALR2 SCALR3 PRINT / NO-print	2A10,3E10.0, A10	4.4
Structural Node Numbers NODE on CS 4.4	IINODE(1) IINODE(2) . . . IINODE(i)	14I5	4.5
Transformation Angles ANGLES on CS 4.4	THETAX THETAY THETAZ	3E10.0	4.6
Interpolation Option COORD on CS 4.4	X Y Z ALB ALT ALTT ACODE ISUB	6E10.0,A5,I5	4.7
Modal Data CARDS on CS 4.1	$\phi(1)$ $\phi(2)$ . . . $\phi(i)$	7E10.0	4.8
End of AVD Card Input	\$END	A10	4.9

Requirements or Function	Key Words and/or Variable	Card Format	Reference Card Set CS
NPLDS/PLDS Option Summary Print Option	$NPLDS / $PLDS print / no-print MAP MATrices CHEckout	5A10	5.0
Surface Definition	Surface IS CARDS / TAPE	A10,I5,5X,A10	5.1
	C Comment	A2,A8,6A10	5.2
Surface Options	NODE / NODE-ALL OPT1 / OPT2 / PLDS SCALR1 SCALR2 SCALR3 PRINT / NO-print	2A10,3E10.0, A10	5.3
Structural Node Numbers NODE on CS 5.3	IINODE(1) IINODE(2) . . . IINODE(i)	14I5	5.4
Diagonal Mass Data CARDS on CS 5.1	XMASS(1) XMASS(2) . . . XMASS(i)	7E10.0	5.5
Weighting Factor Matrix OPT1 on CS 5.3	IROW IC1 P1 IC2 P2 IC3 P3	I5,5X, 3(I5,5X,E10.0)	5.6
Structural Node Areas OPT2 on CS 5.3	AREA(1) AREA(2) . . . AREA(i)	7E10.0	5.7
End of NPLDS/PLDS Card Input	$END	A10	5.8

Requirements or File	Key Words and/or Variables	Card Format	Reference Card Set CS
VBMT Option Summary Print Option	$VBMT print / no-print MAP MATrices CHEckout	5A10	6.0
Surface Sequence	Surface sequence ISEQ(1) ISEQ(2) . . . ISEQ(i)	A10,10X,10I5	6.1
Increase Maximum Number of Dummy Nodes	Maxdum MXDUM	A10,I5	6.2
	LOAD-set ILS	A10,I5	6.3
Surface Definition	SURface IS SCALE1 SCALE2 SCALE3 PRINT / NO-print	A10,I5,5X, 3E10.0,A10	6.4
	C Comment	A2,A8,6A10	6.5
Z Overwrite	Z Coord ALL / blank	2A10	6.6
Z Coordinates ALL on CS 6.6	Z(1) Z(2) . . . Z(i)	7E10.0	6.6.1
Z Coordinates blank on CS 6.6	NODE(1) Z(1) NODE(2) Z(2) ... NODE(i) Z(i)	3(I5,5X,E10.0)	6.6.2
Load Station/ Dummy Station	Load / Dload LNODE AX AY AZ ATHETX ATHETY ATHETZ	A5,I5,6E10.0	6.7
Load Components	IKEY(1) (VX,VY,VZ,MXX,MYY,MZZ) . . . IKEY(i)	6(A2,8X)	6.8
Load Panel Summation	ALL	A10	6.9.1
	A-F (A =X,Y,Z and F =LT,LE,EQ,GE,GT)	3(A5,5X,E10.0)	6.9.2
	STRucturep / AERop SCALE IINODE(1) . . . IINODE(i)	A10,E10.0,10I5	6.9.3
	ADD dload LNODED(1) SCALED(1) ... LNODED(i) SCALED(i)	A10,3(I5,5X, E10.0)	6.9.4
End of VBMT Card Input	$END	A10	6.10
Job Terminator	$QUIT	A10	7.0

6.4 MAGNETIC FILES (TAPE OR DISK) INPUT DATA

6.4.1 EOMLOD

L218 (LOADS) reads aerodynamic force matrices from the file EOMLOD which is generated by the program L217 (EOM) (ref. 4). L217 (EOM) writes the matrices on EOMLOD in the WRTETP format (see ref. 1) with one logical file per surface. Surface one is in file one, surface two in file two, etc. The structure of a typical file is displayed in figure 12. Please note that $[F_{PL}\,\dot{\alpha}_g]$ is stored in the standard FORTRAN COMPLEX fashion.

Size	Matrix	Description	
NNODES x 2	$[x, y]$	x and y local corrdinates of the surfaces nodes	
NNODES x 1	$[A]$	Areas of surface elements	
NNODES x NMODES	$[F_{PL}\dot{q}]$	Real part of aerodynamic forces	Repeat per reduced frequency
NNODES x NMODES	$[F_{PL}\ddot{q}]$	Imaginary part of aerodynamic forces	
2 (NNOES) x NMODES	$[F_{PL}\dot{\alpha}_g]$	Gust forces (complex)	
	EOF		

where:

NNODES = Number of nodes on the surface $\leqslant 100$

NMODES = Number of modes $\leqslant 70$

Figure 12.—Contents of a File on EOMLOD

6.4.2 SATAP

L218 (LOADS) reads modal data from the file SATAP which is generated by the program L215 (INTERP) (ref. 5). L215 (INTERP) writes the modal data matrices onto SATAP in the WRTETP format (see ref. 1) with one logical file per surface. Surface one is in file one, surface two in file two, etc. The structure of a typical file is displayed in figure 13.

Size	Matrix	Description
NNODES x NMODES	$[\phi_x]$	Modal translation
NNODES x NMODES	$[\phi_y]$	Modal translation y
NNODES x NMODES	$[\phi_z]$	Modal translation z
NNODES x NMODES	$[\phi_{\theta_x}]$	Modal rotation about x-axis
NNODES x NMODES	$[\phi_{\theta_y}]$	Modal rotation about y-axis
NNODES x NMODES	$[\phi_{\theta_z}]$	Modal rotation about z-axis
NNODEX x 6	[GEOM]	BS, BBL, WL, θ_x, θ_y, and θ_z for each node on the surface
Variables x 1	[SA]	Modal interpolation definition (see ref. 5 for description and length of the array)
	EOF	

where:

NNODES = Number of nodes on the surface $\leqslant 100$

NMODES = Number of modes $\leqslant 70$

Figure 13.—Contents of a File on SATAP

6.4.3 MASSTP

The mass data for surface IS is found in logical file IS of MASSTP. Figure 14 displays the required matrix for a surface with N nodes. The program can select a subset of the N nodes via card input data. The matrix is in the READTP/WRTETP format described in reference 1. The mass data appears as a column matrix because only the diagonal elements are defined.

Note: MASSTP may be the same as JMAT (sec. 6.4.4). The first matrix in each logical file of both is a mass matrix.

Size	Matrix	Description
N x 1	{MASS}	Masses of the N nodes on surface IS
	•	
	•	
	•	
	EOF	

Figure 14.—Contents of a File on MASSTP

6.4.4 JTAPE

The inertia (J matrix) data for surface IS is found in logical file IS of JMAT. All matrices are in the READTP/WRTETP format described in reference 1. Figure 15 displays the matrices required for a surface with N nodes. All arrays must be present. The program can select a subset of the N nodes via card input.

6.5 OUTPUT DATA

6.5.1 PRINTED OUTPUT

Normal sequential output is automatic unless suppressed in the submodule input (see card 4.4 for AVD, card set 5.3 for NPLDS/PLDS, and card set 6.4 for VBMT).

General output is a print summary selected by card set 4.0, 5.0, and 6.0 of each submodule, respectively, (AVD, NPLDS/PLDS, VBMT). MAP gives the general print summary for a given submodule. MATRICES will print, in addition to the general print summary, the matrices as they are written on the final output tapes.

During job execution, the general output is written on the file IOUT. The last item L218 does is copy IOUT to the regular output. In case of a program or system error, the contents of OUT should be copied to output (see sec. 6.1 on control cards and notice the cards following EXIT).

The printed output is illustrated in section 7.0 (sample problem).

Size	Matrix	Description
NN x 1	{MASS}	Mass data at structural nodes
NN x 1	{MX}	Mass static moments at structural nodes
NN x 1	{MZ}	
NN x 1	{IXX}	Rotary mass moments at inertia at structural nodes
NN x 1	{IYY}	
NN x 1	{IZZ}	
NN x 1	{MXY}	Mass products of inertia at structural nodes
NN x 1	{MXZ}	
NN x 1	{MYZ}	
	EOF	

$1 \leqslant NN \leqslant N$ for a given matrix

Figure 15.—Contents of a File on JTAPE

6.5.2 MAGNETIC FILES (TAPE OR DISK) OUTPUT DATA

L218 (LOADS) can generate different magnetic files. Each is described in one of the following subsections. All are written in the READTP/WRTETP format described in reference 1.

6.5.2.1 AVDTAP

The AVD loads path generates AVDTAP. There is one logical file for each load set. A typical logical file is displayed in figure 16.

The physical size of the matrices $\overline{M}_1$, $\overline{M}_2$ and $\overline{M}_3$ are equal and are appropriately loaded with zero rows as illustrated on the following page.

Size	Matrix	Description
30 x 1	[HEADER]	DYLOFLEX header matrix described in table 1
NLD x NMODES	$[\overline{M}_1]$	Displacement load coefficient matrix
NLD x NMODES	$[\overline{M}_2]$	Rate load coefficient matrix
NLD x NMODES	$[\overline{M}_3]$	Acceleration load coefficient matrix
	EOF	

where:

NLD = Number of loads $\leqslant 100$

NMODES = Number of modes $\leqslant 70$

Figure 16.—Contents of a File on AVDTAP

In general there may be several surfaces in a load set. Then:

$$
[\overline{M}_1] = \begin{bmatrix} 0 \\ 0 \\ \overline{M}_{1_{\text{surface 1}}} \\ 0 \\ 0 \\ \overline{M}_{1_{\text{surface 2}}} \\ 0 \\ \vdots \end{bmatrix} ; \; [\overline{M}_2] = \begin{bmatrix} 0 \\ \overline{M}_{2_{\text{surface 2}}} \\ 0 \\ 0 \\ \overline{M}_{2_{\text{surface 2}}} \\ 0 \\ 0 \\ \vdots \end{bmatrix}
$$

Table 1. — DYLOFLEX Header Matrix Contents

Word	Contents		
1	7HYDLOFLX		
2	6HL218VC		
3	Run Date (YR/MO/DAY)		
4	Number of modes		
5	Number of load equations		
6	Number of gust penetration zones		
7	Number of frequencies at which aerodynamics are defined		
8	0		
9	0		
10	0		
11	0		
12	0		
13	0		
14	0		
15	0		
16	0		
17	0		
18	0		
19	0		
20	0		
21	i for M_1	$i > 0$	indicates that the matrix
22	i for M_2		is in the file
23	i for M_3		
24	i for M_4		
25	i for M_5		
26	0	$i = 0$	indicates that the matrix
27	0		is null and is not in the file
28	0		
29	0		
30	i for ϕ		

$$[\overline{M}_3] = \begin{bmatrix} \overline{M}_{3_{\text{surface 1}}} \\ 0 \\ 0 \\ \overline{M}_{3_{\text{surface 2}}} \\ 0 \\ 0 \\ \overline{M}_{3_{\text{surface 3}}} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \end{bmatrix}$$

6.5.2.2 NPTAP/PTAP

The NPLDS loads path generates NPTAP. The PLDS loads path generates PTAP. NPTAP and PTAP are identical, except PTAP does not contain $[\overline{M}_3]$. There is one logical file for each load set. A load set is the result of processing all surfaces requested following $NPLDS/$PLDS card, but before the next $ card. A typical logical file is displayed in figure 17.

6.5.2.3 LTAP

The VBMT loads path generates LTAP. There is one logical file for each load set. A load set is the result of processing all surfaces requested following the LOAD-SET card, but before the next LOAD-SET or $ card. A typical logical file is displayed in figure 18.

6.6 RESTRICTIONS

1. The maximum size of any final output matrix is 100 x 70

2. The maximum size of any input matrix is 100 x 70

3. Units in L218 must be consistent with units from SATAP/EOMLOD

4. The maximum number of reduced frequencies (k) is 20

5. The maximum number of gust panels is 35

Size	Matrix	Description	
30 x 1	[HEADER]	DYLOFLEX header matrix described in table 1	
NLD x NMODES	$[\bar{M}_3]$ *	Acceleration load coefficient matrix	
NLD x NMODES	$[\bar{M}_4]$	Load coefficient for generalized coordinate rate	Repeat for each frequency K=1, NK
NLD x NMODES	$[\bar{M}_5]$	Load coefficient for generalized coordinate acceleration	
2 (NLD) x NGCP	$[\bar{\bar{\phi}}]$	Load coefficient for excitation function force (complex)	
	EOF		

where:

NLD = Number of loads ≤ 100

NMODES = Number of modes ≤ 70

NGCP = Number of gust zones ≤ 35

$$\text{and } [\bar{M}_3] = \begin{bmatrix} \bar{M}_3 \\ \bar{M}_3 \\ \bullet \\ \bullet \\ \bullet \\ \bar{M}_3 \end{bmatrix} \begin{matrix} \text{Surface 1} \\ \text{Surface 2} \\ \bullet \\ \bullet \\ \bullet \\ \text{Surface last} \end{matrix}$$

similarly for $[\bar{M}_4]$, $[\bar{M}_5]$ and $[\bar{\bar{\phi}}]$

*Only on NPTAP

Figure 17.—Contents of a File on NPTAP/PTAP

Size	Matrix	Description	
30 x 1	[HEADER]	DYLOFLEX header matrix described in table 1	
NLD x NMODES	$[\bar{M}_3]$	Acceleration load coefficient matrix (see fig. 19 for contents)	
NLD x NMODES	$[\bar{M}_4]$	Load coefficient for generalized coordinate rate	Repeat for each frequency K=1, NK
NLD	$[\bar{M}_5]$	Load coefficient for generalized coordinate acceleration	
2 (NLD) x NGP	$[\tilde{\bar{\phi}}]$	Load coefficient for excitation function force (complex)	
	EOF		

where:

NLD = Number of loads $\leqslant$ 100

NMODES = Number of modes $\leqslant$ 70

NGCP = Number of gust zones $\leqslant$ 35

Figure 18.—Contents of a File on LTAP

$$[\bar{M}_3] = \left[\begin{array}{c} V_{x_1} \\ \bullet \\ \bullet \\ \bullet \\ V_{x_m} \\ \bullet \\ \bullet \\ \bullet \\ M_{z_1} \\ \bullet \\ \bullet \\ \bullet \\ M_{z_m} \\ V_{x_1} \\ \bullet \\ \bullet \\ \bullet \\ M_{z_m} \\ \bullet \\ \bullet \\ \bullet \\ \\ \end{array}\right] \begin{array}{l} \left.\begin{array}{l} \text{point}_1 \\ \\ \\ \\ \text{point}_m \\ \\ \\ \\ \text{point}_1 \\ \\ \\ \\ \text{point}_m \end{array}\right\} \text{Surface 1} \\ \left.\begin{array}{l} \text{point}_1 \\ \\ \\ \\ \text{point}_m \end{array}\right\} \text{Surface 2} \\ \\ \\ \left.\begin{array}{l} \\ \\ \end{array}\right\} \text{Surface NS} \end{array}$$

Similary for $[\bar{M}_4]$, $[\bar{M}_5]$ and $[\bar{\phi}]$ at all frequencies.

Figure 19.—Contents of $\overline{M}_3$ on File LTAP

6.7 DIAGNOSTICS

The following diagnostics are printed by the program when errors are encountered.

6.7.1 RGEN DIAGNOSTICS (GENERAL INPUT)

Fatal Errors

1 FETADD ERROR WHILE SETTING IOUT IN RGEN, IRR=

2 THIS SHOULD HAVE BEEN A $LOADS CARD, BUT AMOD=

3 FETADD ERROR - JTAPE, IRR=

4 FETADD ERROR WHILE SETTING MASSTP IN RGEN, IRR=

5 TRANSFORM CARD ILLEGAL, TXYZ=

6 ERROR IN RGEN 1, THE CARD READ WAS NOT A SURFACE CARD, AIS=

7 CALLED FROM RGEN 2
THIS SHOULD HAVE BEEN A SURFACE CARD

8 CALLED FROM RGEN 2
J-MATRIX INPUT, SURFACE NO. LE. PREVIOUS NO.-IS, ISP=

9 CALLED FROM RGEN 2
TYPE OF J-MATRIX (SPARSE OR FULL) NOT SPECIFIED, AMOD, TYPE=

10 CALLED FROM RGEN 2
J-MATRIX, KEYWORD MASS, MX, IXX, ETC. BAD, AMOD=

11 CALLED FROM RGEN 2
J-MATRIX, IKEY CARD ERROR, IKEY, IKEYP=

12 CALLED FROM RGEN 2
J-MATRIX, FULL MATRIX SPECIFIED, NODES=

13 CALLED FROM RGEN 2
NODES EXCEEDS 100, NODES=

14 CALLED FROM RGEN 2
WRTETP ERROR, IRR=

Warning Errors

1 ERROR IN RGEN 1, ENCOUNTERED IN WRTETP, IR=

2 CALLED FROM RGEN 2
THE NO. ROWS IN THE J-MATRIX EXCEEDS NODES SPECIFIED NODES, IROW=

6.7.2 AVD DIAGNOSTICS

AVD Program Diagnostics

1 FATAL ERROR
PROGRAM AVD ERROR NUMBER (IR)
FETADD ERROR, IRR=
where IR = 1 for file IFM1
2 for file IFM2
3 for file IFM3
4 for file IDISK

AVDTAP Subroutine Diagnostics

1 FATAL ERROR
AVDTAP CAN NOT WRITE FINAL TAPE, FET IRR=
(for file IAVD 1)

2 WARNING MESSAGE
AVDTAP DETECTS AN ERROR IN NUMBER OF
ROWS FOR FINAL MATRIX
I2, ITOTAL= ___ ___

DISK Subroutine Diagnostics

1 DYNAMIC STORAGE REQUIRES ___ LOCATIONS

DISK 1 Subroutine Diagnostics

1 CALLED FROM DISK 1

DISK 2 Subroutine Diagnostics

1 CALLED FROM DISK 2

DISKS 5 Subroutine Diagnostics

Warning Message Errors

1 ERROR IN DISK WHILE READING MATRICES.
LOCATION INDICATOR = ___ IRR= ___

2 A NULL MATRIX WAS READ, THE LOCATION INDICATOR = ______

3 THE NUMBER OF MODES READ IN MATRIX DOES NOT AGREE WITH PREVIOUS MODES, MXMODE = _____ MXMOD = ______
THE LOCATION INDICATOR = ________

Note: IRR is the READTP error indicator
MXMODE = current matrix
MXMOD = previous matrix
The location indicator defines;

1	–	PHI-X matrix
2	–	PHI-Y matrix
3	–	PHI-Z matrix
4	–	PHI-THETA-X matrix
5	–	PHI-THETA-Y matrix
6	–	PHI-THETA-Z matrix
7	–	Geometry matrix
8	–	SA matrix
9	–	Geometry matrix
10	–	Not used
11	–	PHI-X matrix
12	–	PHI-Y matrix
13	–	PHI-Z matrix
14	–	PHI-THETA-X matrix
15	–	PHI-THETA-Y matrix
16	–	PHI-THETA-Z matrix
17	–	Geometry matrix
18	–	Geometry matrix

MERGE Subroutine Diagnostics

1 WARNING MESSAGE
THE NUMBER OF ROWS IN THIS LOAD-SET EXCEEDS THE MAXIMUM 100
PERMITTED' ITOTAL= ______

MERGE 1 Subroutine Diagnostics

(none)

NTERP Subroutine Diagnostics

1 WARNING MESSAGE
ERROR CONDITION, INTER. GT. 6
DETECTED IN SUB. NTERP

NTERP 1, NTERP 5 or NTERP 6 Subroutine Diagnostics

(none)

RAVD Subroutine Diagnostics

1 DISK ERROR, CALLED FROM RAVD, IRR=______

RAVD 1 Subroutine Diagnostics

1 TEMP 1 (I) =_____ (keyword from input card)

EAVD1A Subroutine Diagnostics

1 ERROR IN RAVD 1, TEMP =_____ (keyword from input)

RAVD 2 Subroutine Diagnostics

(none)

RAVD 3 Subroutine Diagnostics

1 ERROR IN RAVD 3, NODES = ______
NUMBER OF ANGLES =______

RAVD 4, RAVD 5, RAVD 5A, RAVD 5B, Diagnostics

(none)

RAVD 6 Subroutine Diagnostics

(this is the error diagnostic subroutine for RAVD and associated routines)

1 ERROR NUMBER___IN RAVD

2 SURFACE CARD DID NOT HAVE S IN COLUMN 1

3 ILLEGAL INFORMATION ON KEYWORD CARD

4 END-OF-FILE ENCOUNTERED WHILE READING NODE CARDS

5 END-OF-FILE ENCOUNTERED WHILE READING ANGLES CARDS

6 END-OF-FILE ENCOUNTERED WHILE READING COORDINATE CARDS

7 ILLEGAL OPTION (ANODE), NODE-AXIS CARD, CALLED FROM RAVD

8 DISK READ ERROR, NODE-ALL OPTION, CALLED FROM RAVD

9 RAVD 1A TEST ON XYZ NOT SATISFIED

10 RAVD 3, NODE INPUT INCONSISTENT WITH ANGULAR INPUT

6.7.3 NPLDS/PLDS DIAGNOSTICS

NPLDS Program Diagnostics

1 FATAL ERROR
SUBROUTINE NPLDS ERROR NUMBER ______
FETADD ERRO, IRR = ______

ERROR NUMBER	1	file IEOMLD
	2	file IDISK
	3	file NPTAP
	4	file MERGMB

NPLDA Subroutine Diagnostics

1 FATAL ERROR
PROGRAM NPLDA, ERROR NUMBER ______
FETADD ERROR, IRR=______

ERROR NUMBER	1	file MASSTP
	2	file IPTAP

2 FATAL ERROR CALLED FROM NPLDA
THE P-MATRIX WAS REQUESTED BUT NOT INPUT.
GO TO THE NEXT INPUT.

3 READTP ERROR, CALLED FROM NPLDA, IRR = _______

NPLDA 1 Subroutine Diagnostics

(none)

NPLDA 2 Subroutine Diagnostics

1 CALLED FROM NPLDA 2, READING MASS TAPE, IRR = _______

NPLDA 3, NPLDA 4 Subroutine Diagnostics

(none)

NPLDA 6 Subroutine Diagnostics

(this is the error diagnostic subroutine for NPLDA and associated routine)

1 ERROR NUMBER ____IN RAVD

2 A SURFACE CARD DOES NOT HAVE AN S IN COLUMN 1

3 ILLEGAL NODE OPTION (ANODE).

4 ERROR READING DISK OR IEOMLD TO GET NODES.

5 EOF ENCOUNTERED WHILE READING NODE CARDS.

6 ERROR READING MASSTP TO GET MASS.

7 EOR ENCOUNTERED WHILE READING P-MATRIX.

8 IROW FROM MASSTP NOT EQUAL TO NODES.

NPLDB Subroutine Diagnostics

1 WARNING MESSAGE CALLED FROM NPLDB
ERROR WHILE READING PZ IN NPLDB, IRR = _______

2 WARNING MESSAGE CALLED FROM NPLDB
ERROR WHILE READING GEOMETRY IN NPLDB, IRR = _______

3 FATAL ERROR CALLED FROM NPLDB
ERROR IN READING SATAP, IRR = _______

4 FATAL ERROR CALLED FROM NPLDB
ERROR IN READING EOMLOD, IRR = _______

NPLDB 1, NPLDB 2 Subroutines Diagnostics

(none)

NPLDD Subroutine Diagnostics

WARNING MESSAGE CALLED FROM NPLDD

1 ERROR IN READING LOCAL AERO COORDINATES FROM FILE IEOMLD, ICOL = ________

2 ERROR IN READING LOCAL AREAS FROM IEOMLD, ICOL = ______

3 ERROR IN READING K-FREQUENCIES FROM IEOMLD, ICOL = ________

4 THE NUMBER OF FREQUENCIES READ FROM IEOMLD EXCEEDS 20, NK = ________

5 SURFACE NUMBER = ________
AERO AND STRUCTURAL NODES ARE ASSUMED IDENTICAL

6 THIS OPTION (OPT 2) IS ONLY VALID OVER REGIONS WHERE DP/DX AND DP/DY ARE EQUAL OR APPROXIMATELY EQUAL TO CONSTATS.
FATAL ERROR CALLED FROM NPLDD NODES = _____NAERO = ______
(when this diagnostic occurs it is in connection with number 5 above)

NPLDD 1 Subroutine Diagnostics

1 WARNING MESSAGE CALLED FROM NPLDP 1 ERROR IN DISK WHILE READING MATRICES. LOCATION INDICATOR = ______

2 WARNING MESSAGE CALLED FROM NDLPP 1 A NULL MATRIX WAS READ, THE LOCATION INDICATOR = ________

LOCATION INDICATOR	1	get local (x, y) coordinate
	2	get local area
	3	get frequencies
	4	get (Fpl) matrix for $\overline{M}_4$
	5	get (fpl) matrix for $\overline{M}_5$
	6	get (Fpl) matrix for $\overline{\overline{\phi}}$ (location indicator is incremented for each (Fpl) matrix until matrices for all frequencies have been read)

NPLDD 2 Subroutine Diagnostics

(none)

NPLDD 3 Subroutine Diagnostics

There are 3 diagnostics, each preceded by
WARNING MESSAGE CALLED FROM NPLDD 3

1 TAPE READ ERROR ON IDISK WHILE READING SA FOR P-MATRIX CALC., IRR = ______

2 PLATE 1 ERROR, INDS = ________

3 NODES MUST BE .LE. NAERO.
NODES, NAERO = ________ ________

NPLDD 4 Subroutine Diagnostics

There are 2 diagnostics, each preceded by

WARNING MESSAGE CALLED FROM NPLDD 4

1 ERROR IN READING THE FORCE COEFFICIENT MATRIX.
IROW, NAERO, K, I = _________

2 ERROR IN READING THE FORCE COEFFICIENT MATRIX.
ICOL, MXMODE, K, I = _________

NPLDH Subroutine Diagnostics

1 WARNING MESSAGE

ERROR WRITING NPTAP, CALLED FROM NPLDH, IR, HL = ________

NL	Location	File
-1	NPLDS	PTAP
-2	PLDS	PTAP
1	$\overline{M}_3$	NPTAP
2	$\overline{M}_4$	PTAP or NPTAP
4	$\overline{M}_5$	PTAP or NPTAP
6	$\overline{\tilde{\phi}}$	PTAP or NPTAP

6.7.4 VBMT DIAGNOSTICS

VBMT Program Diagnostics

1 FATAL ERROR
SUBROUTINE VBMT ERROR NUMBER _____
SUBROUTINE VBMT ERROR NUMBER _____
FETADD ERROR, IRR = _____

ERROR NUMBER	0	file JTAPE
	1	file IEOMLD
	2	file IDISK
	3	file LTAP
	4	file MERGMB
	5	file INTMP

VBMTA Subroutine Diagnostics

Each of these diagnostics is preceded with

FATAL ERROR CALLED FROM VBMTA

1 AN EOF WAS ENCOUNTERED IN THE INPUT, CHECK YOUR INPUT

2 AN S, C, Z, L OR D SHOULD HAVE BEEN IN COL 1 OF THIS CARD

3 THE SURFACE NUMBER IS OUT OF SEQUENCE

4 EXCEEDED MAX DUMMY NODES, ILD, MXDUM =

VBMTA 1 Subroutine Diagnostics

1 FATAL ERROR CALLED FROM VBMTA 1
EOF ENCOUNTERED WHILE READING Z COORD

VBMTA 2 Subroutine Diagnostic

Each of these diagnostics is preceded with
FATAL ERROR CALLED FROM VBMTA 2

1 ERROR IN LOAD PANEL SUMMATION CARD, AIS = _____ _____

2 ONLY ONE (C. F.) CARD ALLOWED

3 A (C. F.) CARD WAS READ, BUT NO NODES SELECTED

4 (ADD DLOAD) WAS NOT DEFINED BY A DLOAD CARD

5 LOAD SUMMATION INPUT ERROR, NODES, NAERO = ______ ______

VBMTA 3 Subroutine Diagnostics

Each of these diagnostic is preceded with

FATAL ERROR CALLED FROM VBMTA 3

1 ERROR IN READING IDISK, IRR = ______

2 ERROR IN READING SATAP, IRR = ______

3 ERROR IN READING EOMLOD, IRR = ______

VBMTC Subroutine Diagnostics

(none)

VBMTC 1 Subroutine Diagnostics

Each of these diagnostics is preceded with

FATAL ERROR CALLED FROM VBMTC 1

1 ERROR IN READING JTAPE, IRR = ______

2 ERROR IN READING JTAPE, ICOL, IROW = ______ ______

3 ERROR IN READING INTERP TAPE, IRR = ______

4 ERROR IN READING INTERP TAPE
IROW, ICOL, MXNODE, MXMODE = ______

VBMTC 2 Subroutine Diagnostic

1 FATAL ERROR CALLED FROM VBMTC 2 DUMMY NODE REQUESTED NOT DEFINED, NODED = ______

VBMTC 3, VBMTC 4 Subroutine Diagnostics

(none)

VBMTD Subroutine Diagnostics

1 WARNING MESSAGE CALLED FROM VBMTD ERROR IN READING K-FREQUENCIES FROM IEOMLD, ICOL = ______

2 WARNING MESSAGE CALLED FROM VBMTD THE NUMBER OF FREQUENCIES READ FROM IEOMLD EXCEEDS 20, NK = ______

VBMTD 1 Subroutine Diagnostics

1 WARNING MESSAGE CALLED FROM VBMTD 1 ERROR IN DISK WHILE READING MATRICES. LOCATION INDICATOR = ____ IRR = ______

2 WARNING MESSAGE CALLED FROM VBMTD 1 A NULL MATRIX WAS READ, THE LOCATION INDICATOR = ______
LOCATION INDICATOR 1 read frequencies

4 read(Fpl) matrix for M_4

5 read (Fpl) matrix for M_5

6 read (Fpl) matrix for
(the location indicator is incremented for each (Fpl) matrix until matrices for all frequencies have been read)

VBMTD 2 Subroutine Diagnostic

(none)

VBMTD 3 Subroutine Diagnostics

1 WARNING MESSAGE CALLED FROM VBMTD 3 ERROR IN READING THE FORCE COEFFICIENT MATRIX. IROW, NAERO, I, I = ______

2 WARNING MESSAGE CALLED FROM VBMTD 3 ERROR READING THE FORCE COEFFICIENT MATRIX. ICOL, MXMODE, K, I = ________

VBMTD 4 Subroutine Diagnostics

1 FATAL ERROR CALLED FROM VBMTD 4 DUMMY NODE REQUESTED NOT DEFINED, NODED = ______

VBMTF Subroutine Diagnostics

1 WARNING MESSAGE
ERROR WRITING LTAP, CALLED FROM VBMTF, IR, NL = _______ _______

7.0 SAMPLE PROBLEM

In order to exercise most of the options in this program, a very simple, fictitious airplane was modeled. The airplane modeled was a wing mounted two engined T-tail transport airplane. The airplane is shown in figure 20 with the lumped masses and aerodynamic grid superimposed. The inertia data, structural node numbers, and coordinate locations are given in table 2: the mode shapes for the corresponding node numbers in table 3; and the aerodynamic node number, coordinate locations, and forces in table 4. The structural data magnetic file was generated with L215 (INTERP). The aerodynamic data was written onto a magnetic file in the format normally generated by L217 (EOM).

The inertia data was read into L218 (LOADS) by the RGEN module. AVD, PLDS, NPLDS, and VBMT load coefficient matrices were generated on all applicable surfaces by exercising their respective modules for a vertical gust analysis. The analysis consisted of two rigid body degrees of freedom (vertical translation and pitch) and one elastic degree of freedom. The printed output for all of the load matrices was edited to reduced the amount of pages, but yet to yield a representative sample.

Boeing Commercial Airplane Company
P.O. Box 3707
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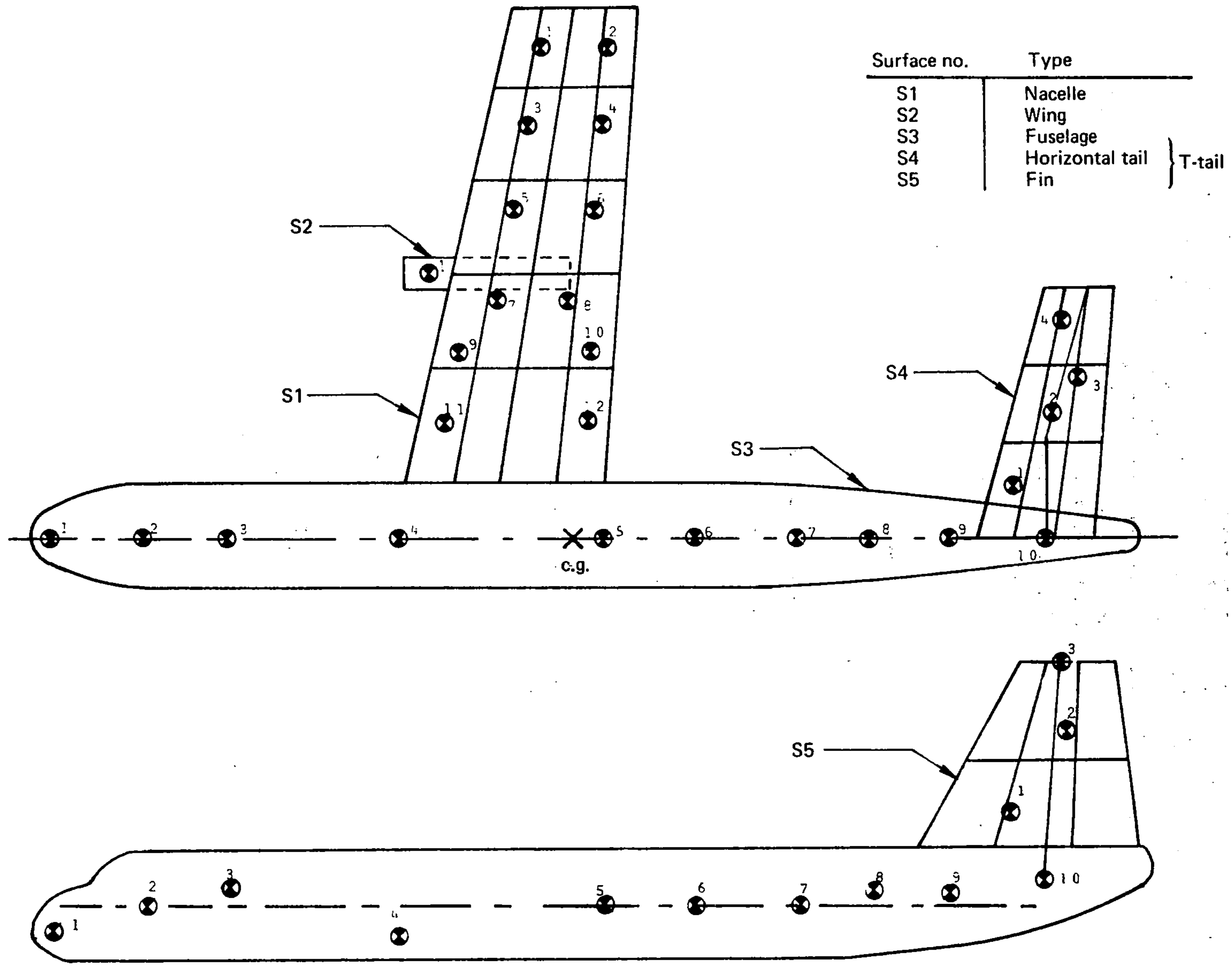

Figure 20.—Airplane Configuration of Sample Problem

Table 2. — Sample Problem—Structural Data

Node No.	Structural Nodes			θ_z	W	Wx	Wz	Ixx	Iyy	Izz
	B.S.	B.B.L	W.L.	degs.	lbs	in lbs	in lbs	lb-in^2	lb-in^2	lb-in^2
Surface 1 *										
1	1000	500	180	0.	1000	0	0	1X10^5	2X10^5	4X10^5
Surface 2 *										
1	1250	1000	200	0.	100	0	0	0	0	0
2	1350	1000	200	0.	100	0	0	0	0	0
3	1200	800	200	0.	200	0	0	0	0	0
4	1350	800	200	0.	250	0	0	0	0	0
5	1150	600	200	0.	200	0	0	0	0	0
6	1300	600	200	0.	300	0	0	0	0	0
7	1100	450	200	0.	400	0	0	0	0	0
8	1250	450	200	0.	450	0	0	0	0	0
9	1000	300	200	0.	600	0	0	0	0	0
10	1250	300	200	0.	700	0	0	0	0	0
11	900	150	200	0.	1000	0	0	0	0	0
12	1200	150	200	0.	1200	0	0	0	0	0

* See Figure 18

Table 2. — (Concluded)

Surface 3*(total fuselage)

Node No.	Structural Nodes B.S.	B.B.L.	W.L.	θ_z degs.	W lbs	Wx in lbs	Wz in lbs	Ixx lb-in^2	Iyy lb-in^2	Izz lb-in^2
1	250	0	200	0.	50	0	-12000	.5X10^3	5X10^3	5X10^3
2	400	0	200	0.	200	0	0	1X10^3	2X10^4	2X10^4
3	600	0	200	0.	600	0	1200	1X10^4	6X10^4	6X10^4
4	850	0	200	0.	1000	0	-20000	2X10^4	1X10^5	1X10^5
5	1250	0	200	0.	1000	0	0	2X10^4	1X10^5	1X10^5
6	1500	0	200	0.	1000	0	0	2X10^4	1X10^5	1X10^5
7	1800	0	200	0.	700	0	-21000	2X10^4	7X10^4	7X10^4
8	2050	0	210	0.	600	0	6000	1X10^4	6X10^4	6X10^4
9	2250	0	230	0.	400	0	0	1X10^4	4X10^4	4X10^4
10 (included vert. fin)	2450	0	250	0.	300	0	15000	2X10^4	2.5X10^4	2.5X10^4

Surface 4*

Node No.	B.S.	B.B.L.	W.L.	θ_z degs.	W lbs	Wx in lbs	Wz in lbs	Ixx lb-in^2	Iyy lb-in^2	Izz lb-in^2
1	2450	50	400	0.	70	-3500	0	7X10^3	1X10^4	1X10^4
2	2460	150	400	-4.	50	-500	0	5X10^3	1X10^4	1X10^4
3	2470	300	400	-4.	50	1500	0	5X10^3	1X10^4	1X10^4
4	2480	450	400	-4.	20	-600	0	2X10^3	.4X10^4	.4X10^4

Surface 5*

Not required for vertical gust analysis.

*See Figure 20

Table 3. — Structural Mode Shapes

Surface 1*

Node No.	Mode			
	Type	Degrees of Freedom		
		h	θ	$\phi_{elastic}$
1	ϕx	0.	10.	.1
1	ϕy	0.	0.	.1
1	ϕz	1.	-200.	.4
1	$\phi \theta x$	0.	0.	.01
1	$\phi \theta y$	0.	1.	.02
1	$\phi \theta z$	0.	0.	.001

Surface 2*

$\phi_x = \phi_y = \phi_{\theta_x} = \phi_{\theta_y} = \phi_{\theta_z} = 0$				
1	ϕ_z	1.	50.	1.
2		1.	150.	.8
3		1.	0.	.8
4		1.	150.	.7
5		1.	-50.	.5
6		1.	100.	.4
7		1.	-100.	.3
8		1.	50.	.3
9		1.	-200.	.1
10		1.	50.	.1
11		1.	-300.	-.1
12		1.	0.	-.1

*See Figure 20

Table 3. — (Continued)

Surface 3*

$\phi_x = \phi_y = \phi_{\theta_x} = \phi_{\theta_z} = 0$				
	Mode			
		Degrees of Freedom		
Node No.	Type	h	θ	$\phi_{elastic}$
1	ϕ_z	1.	-950.	.5
2	↓	1.	-800.	.3
3		1.	-600.	.1
4		1.	-350.	-.1
5		1.	50.	-.1
6		1.	300.	-.05
7		1.	500.	0.0
8		1.	850.	.1
9		1.	1050.	.3
10		1.	1250.	.7
1	ϕ_{θ_y}	0.	1.	-.03
2	↓	0.	1.	-.02
3		0.	1.	-.01
4		0.	1.	0.0
5		0.	1.	0.0
6		0.	1.	.001
7		0.	1.	.01
8		0.	1.	.02
9		0.	1.	.04
10		0.	1.	.07

*See Figure 20

Table 3. — (Concluded)

Surface 4*

$\phi_x = \phi_y = \phi_{\theta_z} = 0$				
Node No.	Mode			
	Type	Degrees of Freedom		
		h	θ	$\phi_{elastic}$
1	ϕ_z	1.	1250.	.7
2	↓	1.	1260.	.6
3		1.	1270.	.4
4		1.	1280.	.1

1	ϕ_{θ_x}	0.	0.0	-.01
2	↓	0.	.07	-.02
3		0.	.07	-.03
4		0.	.07	-.05

1	ϕ_{θ_y}	0.	1.	0.0
2	↓	0.	1.	.01
3		0.	1.	.02
4		0.	1.	.03

*See Figure 20

Table 4. — Aerodynamics — Node Locations and Forces

Surface 1*

Aero Node No.	B.S.	B.B.L.	W.L.	k = 0											
				Fy(q)			Fy($\dot{q}$)			Fz(q)			Fz($\dot{q}$)		
1	950	500	180	0	0	5.	0	0	.1	0	200	10	20	2.	.1
2	1100	500	180	0	0	2.	0	0	.05	0	100	5.	10	1.	.05

				k = 1											
1	950	500	180	0	0	4.	0	0	.1	0	150	10	15	1.	.05
2	1100	500	180	0	0	2.	0	0	.05	0	100	4.	5.	.5	.01

				k = 0				k = 1			
				Fy(gust)		Fz(gust)		Fy(gust)		Fz(gust)	
				R	I	R	I	R	I	R	I
1	950	500	180	0	0	20	0	0	0	15	0
2	1100	500	180	0	0	10	0	0	0	5	0

*See Figure 20

**These aerodynamic forces are for the three degrees of freedoms

Table 4. — (Continued)

Surface 2*

Aero Node No.	B.S.	B.B.L.	W.L.	k = 0							
				F(q)			F($\dot{q}$)			Fz(gust) R	Fz(gust) I
1	1200	1000	200	0	1000	-10	1	0	.1	1.	0
2	1250	1000	200	0	200	-7	.2	0	.07	.2	0
3	1310	1000	200	0	100	-7	.1	0	.07	.1	0
4	1380	1000	200	0	50	-5	.05	0	.05	.05	0
5	1150	750	200	0	1000	-8	1	-.1	.08	1.	0
6	1210	750	200	0	200	-5	.2	-.01	.06	.2	0
7	1280	750	200	0	100	-4	.1	0	.04	.1	0
8	1350	750	200	0	50	-2	.05	0	.02	.05	0
9	1080	550	200	0	800	-9	.8	-.02	.08	.8	0
10	1150	550	200	0	200	-6	.2	-.01	.06	.2	0
11	1240	550	200	0	200	-4	.2	0	.04	.2	0
12	1300	550	200	0	100	-2	.1	.01	.02	.1	0
13	1000	400	200	0	1200	-4	1.2	-.04	.04	1.2	0
14	1100	400	200	0	600	-4	.6	-.02	.04	.6	0
15	1200	400	200	0	300	-2	.3	-.02	.02	.3	0
16	1270	400	200	0	100	-1	.1	-.01	.01	.1	0
17	900	200	200	0	1400	0	1.4	-.05	0	1.4	0
18	1030	200	200	0	700	0	.7	-.03	0	.7	0
19	1120	200	200	0	400	0	.4	-.02	0	.4	0
20	1200	200	200	0	200	0	.2	-.01	0	.2	0

*See Figure 20

Table 4. — (Continued)

Surface 2* (Concluded)

Aero Node No.	B.S.	B.B.L.	W.L.	k = 1							
				F(q)			F($\dot{q}$)			Fz(gust)	
										R	I
1	1200	1000	200	0	100	-1	1	0	.1	1	.1
2	1250	1000	200	0	20	-.7	.2	0	.07	.2	.1
3	1310	1000	200	0	10	-.7	.1	0	.07	.1	.1
4	1380	1000	200	0	5	-.5	.05	0	.05	.05	.1
5	1150	750	200	0	100	-.8	1	-.1	.08	1	.2
6	1210	750	200	0	20	-.6	.2	-.01	.06	.2	.2
7	1280	750	200	0	10	-.4	.1	0	.04	.1	.2
8	1350	750	200	0	5	-.2	.05	0	.02	.05	.2
9	1080	550	200	0	80	-.8	.8	-.02	.08	.8	.1
10	1150	550	200	0	20	-.6	.2	-.01	.06	.2	.1
11	1240	550	200	0	20	-.4	.2	0	.04	.2	.1
12	1300	550	200	0	10	-.2	.1	.01	.02	.1	.1
13	1000	400	200	0	120	-.4	1.2	-.04	.04	1.2	0
14	1100	400	200	0	60	-.4	.6	-.02	.04	.6	0
15	1200	400	200	0	30	-.2	.3	-.02	.02	.3	0
16	1270	400	200	0	10	-.1	.1	-.01	.01	.1	0
17	900	200	200	0	140	0	1.4	-.05	0	1.4	0
18	1030	200	200	0	70	0	.7	-.03	0	.7	0
19	1120	200	200	0	40	0	.4	-.02	0	.4	0
20	1200	200	200	0	20	0	.2	-.01	0	.2	0

*See Figure 20

Table 4 (Continued)

Surface 3*

Aero Node No.	B.S.	B.B.L.	W.L.	F(q)			$F(\dot{q})$			Fz(gust) R	Fz(gust) I
				k = 0							
1	400	0	200	0	3000	-100	3	-20	1	3	0
2	600	0	200	0	200	-20	.2	-2	.1	.2	0
3	800	0	200	0	10	-10	.01	0	0	.01	0
4	1400	0	200	0	-30	-10	-.3	0	0	-.3	0
5	1800	0	200	0	-20	-5	-.2	.5	0	-.2	0
6	2300	0	200	0	70	0	.7	1	.1	.7	0
				k = 1							
1	400	0	200	.01	300	-100	.3	-2	1	.3	.3
2	600	0	200	.01	200	-20	.2	-.2	0	.2	.2
3	800	0	200	.01	10	-10	.01	0	0	.01	.01
4	1400	0	200	.01	-3	-5	-.003	0	0	-.003	-.003
5	1800	0	200	.01	-2	0	-.002	.05	0	-.002	-.002
6	2300	0	200	.01	7	10	.007	.1	.1	.007	.007

*See Figure 20

Table 4. — (Concluded)

Surface 4*

Aero Node No.	B.S.	B.B.L.	W.L.	F(q)			F($\dot{q}$)			Fz(gust) R	Fz(gust) I
				k = 0							
1	2450	450	400	0	200	1	.2	200	-50	.2	0
2	2490	450	400	0	50	.2	.05	50	-10	.05	0
3	2530	450	400	0	10	.1	.01	10	-5	.01	0
4	2420	150	400	0	300	2	.3	300	-30	.3	0
5	2470	150	400	0	100	.4	.1	100	-5	.1	0
6	2520	150	400	0	20	.2	.02	20	0	.02	0
7	2380	40	400	0	300	2	.3	300	-20	.3	0
8	2430	40	400	0	100	.4	.1	100	0	.1	0
9	2500	40	400	0	20	.2	.02	20	5	.02	0
				k = 1							
1	2450	450	400	0	200	1	.2	100	-5	.2	-.2
2	2490	450	400	0	50	.2	.05	20	-1	.05	-.05
3	2530	450	400	0	10	.1	.01	10	-.5	.01	-.01
4	2420	150	400	0	300	2	.3	100	-3	.3	-.3
5	2470	150	400	0	100	.4	.1	20	-.5	.1	-.1
6	2520	150	400	0	20	.2	.02	10	0	.02	-.02
7	2380	40	400	0	300	1	.3	100	-2	.3	-.3
8	2430	40	400	0	100	.2	.1	20	0	.1	-.1
9	2500	40	400	0	20	.1	.02	10	.5	.02	-.02

*See Figure 20

```
$LOADS
$TITLE
$TITLE   VERIFICATION TEST CASES FOR L218.
$TITLE
$GEN
SATAP    SATAP1    EOMLOD    EOMLD1    MASSTP    JMAT
JMAT
SURFACE      1     NODES        1
MASS     FULL
1000.
IXX      FULL
100000.
IYY      FULL
200000.
IZZ      FULL
400000.
SURFACE      2     NODES       12
MASS     FULL
100.     100.      200.      250.      200.      300.      400.
450.     600.      700.      1000.     1200.
SURFACE      3     NODES       10
MASS     FULL
50.      200.      600.      1000.     1000.     1000.     700.
600.     400.      300.
MZ       FULL
-12000.  0.        12000.    -20000.   0.        0.        -21000.
6000.    0.        15000.
IXX      FULL
500.     1000.     10000.    20000.    20000.    20000.    20000.
10000.   10000.     20000.
IYY      FULL
5000.    20000.    60000.    100000.   100000.   100000.   70000.
60000.   40000.    25000.
IZZ      FULL
5000.    20000.    60000.    100000.   100000.   100000.   70000.
60000.   40000.    25000.
SURFACE      4     NODES        4
MASS     FULL
70.      50.       50.       20.
MX       FULL
-3500.   -500.     1500.     -600.
IXX      FULL
7000.    5000.     5000.     2000.
IYY      FULL
10000.   10000.    10000.    4000.
IZZ      FULL
10000.   10000.    10000.    4000.
SURFACE      5     NODES        3
MASS     SPARSE
    1    100.          2     50.           3     50.
MX       FULL
-5000.   1250.     0.
IXX      FULL
1000.    500.      500.
IYY      FULL
2000.    1000.     1000.
```

```
IZZ        FULL                                                                        VERT   58
2000.      1000.      1000.                                                            VERT   59
$END       GEN                                                                         VERT   60
$AVD       MAP        MATRICES                                                         VERT   61
SURFACE        2      CARDS          2    3                                            VERT   62
TA-Z       TV-Z       TD-Z                                                             VERT   63
COORD                 .00259    1.                                                     VERT   64
1250.      1000.      200.                                                             VERT   65
1350.      1000.      20C.                                                             VERT   66
1.         50.        1.                                                               VERT   67
1.         150.       .8                                                               VERT   68
SURFACE        1      CARDS          1    3                                            VERT   69
TA-X       TV-X                                                                        VERT   70
COORD      LOCAL      1.        1.                                                     VERT   71
1000.      500.       18C.                                                             VERT   72
0.         10.        .1                                                               VERT   73
SURFACE        1      CARDS          1    3                                            VERT   74
TV-Y       TD-Y                                                                        VERT   75
COORD                           1.                                                     VERT-  76
1000.       500.       180.                                                            VERT   77
0.         0.         .1                                                               VERT   78
SURFACE        1      CARDS          1    3                                            VERT   79
TA-Z                                                                                   VERT   80
COORD                 .00259                                                           VERT   81
1000.       500.       180.                                                            VERT   82
1.         -200.      .4                                                               VERT   83
SURFACE        1      CARDS          1    3                                            VERT   84
RV-X                                                                                   VERT   85
COORD                                       1.                                         VERT   86
1000.       500.       180.                                                            VERT   87
0.         0.         .01                                                              VERT   88
SURFACE        1      CARDS          1    3                                            VERT   89
RA-Y       RD-Y                                                                        VERT   90
COORD                                                                                  VERT   91
1000.       500.       180.                                                            VERT   92
0.         1.         .02                                                              VERT   93
SURFACE        1      CARDS          1    3                                            VERT   94
RA-Z       RV-Z       RD-Z                                                             VERT   95
COORD                                       1.                                         VERT   96
1000.      500.       18C.                                                             VERT   97
0.         0.         .001                                                             VERT   98
$END       GENERAL                                                                     VERT   99
$AVD       MAP        MATRICES                                                         VERT  100
SURFACE        1      TAPE                                                             VERT  101
TA-XYZ     RV-XYZ                                                                      VERT  102
COORD                                                                                  VERT  103
900.       500.       28C.                                          PAR                VERT  104
SURFACE        2      TAPE                                                             VERT  105
TA-Z       TD-Z                                                                        VERT  106
NODE-ALL   LOCAL                                                                       VERT  107
SURFACE        3      TAPE                                                             VERT  108
TA-Z                                                                                   VERT  109
COORD                                                                                  VERT  110
150.          0.        250.      -100.      0.        50.                1             VERT  111
1000.      0.         200.      150.      0.        0.                  4              VERT  112
SURFACE        3      TAPE                                                             VERT  113
```

```
TA-Z        RV-Y                                                                                            VERT    114
NODE        LOCAL                                                                                           VERT    115
     1     3     4      7  -10                                                                              VERT    116
SURFACE          4      TAPE                                                                                VERT    117
TA-Z        RV-XY       RD-X                                                                                VERT    118
NODE        ANGLES                                                                                          VERT    119
     1     3                                                                                                VERT    120
0.          0.          -4.                                                                                 VERT    121
0.          0.          -4.                                                                                 VERT    122
$END        AVD                                                                                             VERT    123
$AVD        MAP         MATRICES                                                                            VERT    124
SURFACE          2      TAPE                                                                                VERT    125
TA-Z                                                                                                        VERT    126
COORD       LOCAL                                                                                           VERT    127
1300.       1000.       20C.                                                                                VERT    128
1350.       900.        20C.                                                                                VERT    129
1000.       100.        200.                                                                                VERT    130
900.        150.        200.                                                                                VERT    131
1000.       150.        200.                                                                                VERT    132
$END        AVD                                                                                             VERT    133
$PLDS       MAP         MATRICES                                                                            VERT    134
SURFACE          2      TAPE                                                                                VERT    135
NODE-ALL                                                            PRINT                                   VERT    136
SURFACE          4      TAPE                                                                                VERT    137
NODE                                                                PRINT                                   VERT    138
     1    -3     5      7   -9                                                                              VERT    139
SURFACE          1      TAPE                                                                                VERT    140
NODE-ALL                                                            PRINT                                   VERT    141
$END        AVD                                                                                             VERT    142
$NPLDS      MAP         MATRICES                                                                            VERT    143
SURFACE          2      TAPE                                                                                VERT    144
NODE-ALL    OPT2                                                    PRINT                                   VERT    145
330.        335.        330.        335.        330.        335.        330.                                VERT    146
335.        330.        335.        330.        335.                                                        VERT    147
SURFACE          4      TAPE                                                                                VERT    148
NODE        OPT1                                                    PRINT                                   VERT    149
     1    -3                                                                                                VERT    150
     1           4      .5               5      .5                6     .5                                  VERT    151
     1           7      1.               8      1.                9     1.                                  VERT    152
     2           1      .5               2      .5                3     .5                                  VERT    153
     2           4      .5               5      .5                6         .5                              VERT    154
     3           1      .5               2      .5                3     .5                                  VERT    155
$END        NPLDS                                                                                           VERT    156
$TITLE      VBMT TEST CASE                                                                                  VERT    157
$VBMT       MAP         MATRICES                                                                            VERT    158
SURFACE SEQUENCE             1     2     4     3                                                            VERT    159
LOAD-SET         1                                                                                          VERT    160
SURFACE          1      .00259                                                                              VERT    161
C VERTICAL GUST   747 AIRPLANE CHECK CASE NO.1                                                              VERT    162
C NACELLE                                                                                                   VERT    163
LOAD        1 1100.     50C.        200.                                                                    VERT    164
VX          VY          VZ          MXX         MYY         MZZ                                             VERT    165
ALL                                                                                                         VERT    166
DLOAD      11200.       500.        200.                                                                    VERT    167
ALL                                                                                                         VERT    168
SURFACE          2      .00259                                                                              VERT    169
```

```
C WING                                                                          VERT  170
LOAD       21200.      500.       200.      5.        0.        -20.            VERT  171
VX         VY          VZ         MXX       MYY       MZZ                       VERT  172
Y.GT.      500.                                                                 VERT  173
LOAD       3 1050.     150.       200.                                          VERT  174
VX         VY          VZ         MXX       MYY       MZZ                       VERT  175
Y.GT.      200.                                                                 VERT  176
STRUCTUREP .3              11   12                                              VERT  177
AEROP         .5           17  -20                                              VERT  178
ADD CLOAD      1                                                                VERT  179
SURFACE        4       .0C259                                                   VERT  180
C HORIZONTAL STABILIZER                                                         VERT  181
LOAD       4 2430.     0.         400.                                          VERT  182
VX         VY          VZ         MXX       MYY       MZZ                       VERT  183
ALL                                                                             VERT  184
DLOAD      2 2430.        0.         400.                                       VERT  185
ALL                                                                             VERT  186
SURFACE        3       .00259                                                   VERT  187
C BODY                                                                          VERT  188
Z COORD                                                                         VERT  189
    6        240.                                                               VERT  190
LOAD       5 800.      0.         200.                                          VERT  191
VX         VZ          MYY        MZZ                                           VERT  192
X.LT.      800.                                                                 VERT  193
LOAD       6 1800.     0.         200.                                          VERT  194
VY         VZ          MXX        MYY                                           VERT  195
X.GT.      1800.                                                                VERT  196
STRUCTUREP .5               7                                                   VERT  197
AEROP      .5               5                                                   VERT  198
ADD CLOAD     2        2.                                                       VERT  199
LOAD       7 1200.        0.      200.                                          VERT  200
VZ         MYY                                                                  VERT  201
X.GT       1200.                                                                VERT  202
ADD DLOAD     2        2.                                                       VERT  203
$END       VBMT                                                                 VERT  204
$QUIT                                                                           VERT  205
```

```
*****************************************************
*                                                   *
*   PROGRAM L218A1  VERSION APR 20, 77 NOW RUNNING.  *
*   THE PROGRAM IS PART OF THE DYLOFLX SYSTEM        *
*   DEVELOPED FOR NASA UNDER CONTRACT NAS1-13918.    *
*   DATE OF RUN IS  77/04/27.                        *
*   TIME OF RUN IS  19.29.32.                        *
*                                                   *
*****************************************************


 ($LOADS                                                                      )
 ($TITLE                                                                      )
 ($TITLE    VERIFICATION TEST CASES FOR L218.                                 )
 ($TITLE                                                                      )
 ($GEN                                                                        )
 ($ATAP     SATAP1    EOMLOD    EOMLD1    MASSTP    JMAT                      )

      TAPE FILE NAMES WERE READ. THOSE NAMES TO BE USED ARE
      AVDTAP    NFTAP     PTAP      LTAP      EOMLD1    SATAP1    JMAT      JTAPE

 (JMAT                                                                        )
 (SURFACE       1     NODES         1                                         )
      J-MATRIX DATA FOR SURFACE    1 ARE BEING READ
 (MASS       FULL                                                             )
         .1000E+04
 (IXX        FULL                                                             )
         .1000E+06
 (IYY        FULL                                                             )
         .2000E+06
 (IZZ        FULL                                                             )
         .4000E+06
 (SURFACE       2     NODES        12                                         )
      J-MATRIX DATA FOR SURFACE    2 ARE BEING READ
 (MASS       FULL                                                             )
         .1000E+03   .10C0E+03   .2000E+03   .2500E+03   .2000E+03   .3000E+03   .4000E+03   .4500E+03   .6000E+03   .7000E+03
         .1000E+04   .1200E+04
 (SURFACE       3     NODES        10                                         )
      J-MATRIX DATA FOR SURFACE    3 ARE BEING READ
 (MASS       FULL                                                             )
         .5000E+02   .2000E+03   .6000E+03   .1000E+04   .1000E+04   .1000E+04   .7000E+03   .6000E+03   .4000E+03   .3000E+03
 (MZ         FULL                                                             )
        -.1200E+05  0.           .1200E+05  -.2000E+05  0.          0.         -.2100E+05   .6000E+04  0.           .1500E+05
 (IXX        FULL                                                             )
         .5000E+03   .1000E+04   .1000E+05   .2000E+05   .2000E+05   .2000E+05   .2000E+05   .1000E+05   .1000E+05   .2000E+05
 (IYY        FULL                                                             )
         .5000E+04   .20C0E+05   .6000E+05   .1000E+06   .1000E+06   .1000E+06   .7000E+05   .6000E+05   .4000E+05   .2500E+05
 (IZZ        FULL                                                             )
         .5000E+04   .2000E+05   .6000E+05   .1000E+06   .1000E+06   .1000E+06   .7000E+05   .6000E+05   .4000E+05   .2500E+05
 (SURFACE       4     NODES         4                                         )
      J-MATRIX DATA FOR SURFACE    4 ARE BEING READ
 (MASS       FULL                                                             )
         .7000E+02   .50C0E+02   .5000E+02   .2000E+02
```

```
(MX         FULL
         -.3500E+04  -.50C0E+03   .1500E+C4  -.6000E+03
(IXX        FULL
          .7000E+04   .50C0E+04   .5000E+04   .2000E+04
(IYY        FULL
          .1000E+05   .10C0E+C5   .1000E+05   .4000E+04
(IZZ        FULL
          .1000E+05   .10C0E+05   .1000E+C5   .4000E+04
(SURFACE         5      NODES          3
      J-MATRIX DATA FOR SURFACE      5 ARE BEING READ
(MASS       SPARSE
          .1000E+03   .50C0E+02   .5000E+02
(MX         FULL
         -.5000E+04   .1250E+04  0.
(IXX        FULL
          .1000E+04   .50C0E+03   .5000E+03
(IYY        FULL
          .2000E+04   .10C0E+04   .1000E+04
(IZZ        FULL
          .2000E+04   .10C0E+04   .1000E+04
($END       GEN

      THE J-MATRIX HAS BEEN INPUT BY CARDS
```

LOAD-SET 1

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	RCW NO.
2	1	1250.0	1C00.0	200.0			TZ	1.
	2	1350.0	1C00.0	2C0.0			TZ	2.
2	1	1250.0	1C00.0	2C0.0		TZ		3.
	2	1350.0	1C00.0	200.0		TZ		4.
2	1	1250.0	1C00.0	2C0.0	TZ			5.
	2	1350.0	1C00.0	200.0	TZ			6.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	RCW NO.
1	1	1000.0	500.0	180.0			TX	7.
1	1	1000.0	500.0	180.0		TX		8.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	RCW NO.
1	1	1000.0	500.0	180.0		TY		9.
1	1	1000.0	500.0	180.0	TY			10.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
1	1	1000.0	500.0	180.0			TZ	11.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
1	1	1000.0	500.0	180.0		RX		12.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
1	1	1000.0	500.0	180.0			RY	13.
1	1	1000.C	500.0	180.0	RY			14.

SURFACE NO.	NODE NO.	REF. COORDINATES (CM) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
1	1	1000.0	500.0	180.0			RZ	15.
1	1	1000.0	500.0	180.0		RZ		16.
1	1	1000.0	500.0	180.0	RZ			17.

M1	1	0.	0.	0.
M1	2	0.	0.	C.
M1	3	0.	0.	C.
M1	4	0.	0.	0.
M1	5	.10000E+01	.50000E+02	.10000E+01
M1	6	.10000E+01	.15000E+03	.80000E+00
M1	7	0.	0.	0.
M1	8	0.	0.	0.
M1	9	0.	0.	0.
M1	10	0.	0.	.1000CE+00
M1	11	0.	0.	0.
M1	12	0.	0.	0.
M1	13	0.	0.	0.
M1	14	0.	.1C000E+01	.20000E-01
M1	15	0.	0.	0.
M1	16	0.	0.	0.
M1	17	0.	0.	.10000E-02

M2	1	0.	0.	0.
M2	2	0.	0.	C.
M2	3	.10000E+01	.5000CE+02	.10000E+01
M2	4	.10000E+01	.15000E+03	.8000CE+00
M2	5	0.	0.	0.
M2	6	0.	0.	0.
M2	7	0.	0.	0.
M2	8	0.	.10000E+02	.1C00CE+00

M2	9	0.	0.	.10000E+00
M2	10	0.	0.	0.
M2	11	0.	0.	C.
M2	12	0.	0.	.10000E-01
M2	13	0.	0.	0.
M2	14	0.	0.	C.
M2	15	0.	0.	C.
M2	16	0.	0.	.1000CE-02
M2	17	0.	0.	0.

M3	1	.25900E-02	.1295CE+00	.259CCE-02
M3	2	.25900E-02	.38850E+00	.20720E-02
M3	3	0.	0.	0.
M3	4	0.	0.	0.
M3	5	0.	0.	0.
M3	6	0.	0.	0.
M3	7	0.	.10000E+02	.1000CE+00
M3	8	0.	0.	C.
M3	9	0.	0.	C.
M3	10	0.	0.	0.
M3	11	.25900E-02	-.5180CE+00	.10360E-02
M3	12	0.	0.	0.
M3	13	0.	.10000E+01	.2000CE-01
M3	14	0.	0.	0.
M3	15	0.	0.	.1000CE-02
M3	16	0.	0.	0.
M3	17	0.	0.	0.

LOAD-SET 2

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
1	1	900.0	500.0	280.0			TX	1.
1	1	900.C	500.0	280.0			TY	2.
1	1	900.0	500.0	280.0			TZ	3.
1	1	900.0	500.0	280.0		RX		4.
1	1	900.0	500.0	280.0		RY		5.
1	1	900.0	500.0	280.0		RZ		6.

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
2	1	1250.0	1C00.0	200.0			TZ	7.
	2	1350.0	1C00.0	200.0			TZ	8.
	3	1200.0	800.0	2C0.0			TZ	9.
	4	1350.0	800.0	2C0.0			TZ	10.
	5	1150.0	600.0	20C.0			TZ	11.
	6	1300.0	600.0	2C0.0			TZ	12.
	7	1100.0	450.0	200.0			TZ	13.
	8	1250.0	450.0	2C0.0			TZ	14.
	9	1000.0	300.0	200.0			TZ	15.
	10	1250.0	300.0	200.0			TZ	16.
	11	900.0	150.0	2C0.0			TZ	17.
	12	1200.0	150.0	2C0.0			TZ	18.
2	1	1250.0	1C00.0	200.0	TZ			19.
	2	1350.0	1C00.0	200.0	TZ			20.
	3	1200.0	800.0	200.0	TZ			21.
	4	1350.0	800.0	2C0.0	TZ			22.
	5	1150.0	600.0	2C0.0	TZ			23.
	6	1300.0	600.0	200.0	TZ			24.
	7	1100.0	450.0	200.0	TZ			25.
	8	1250.0	450.0	2C0.0	TZ			26.
	9	1000.0	3C0.0	200.0	TZ			27.
	10	1250.0	300.0	2C0.0	TZ			28.

	11	900.0	150.0	200.0	TZ			29.
	12	1200.0	150.0	200.0	TZ			30.

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
3	1	150.0	0.0	250.0			TZ	31.
	4	1000.0	0.0	200.0			TZ	32.

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
3	1	250.0	0.0	200.0			TZ	33.
	3	600.0	0.0	200.0			TZ	34.
	4	850.0	0.0	200.0			TZ	35.
	7	1800.0	0.0	200.0			TZ	36.
	8	2050.0	0.0	210.0			TZ	37.
	9	2250.0	0.0	230.0			TZ	38.
	10	2450.0	0.0	250.0			TZ	39.
3	1	250.0	0.0	200.0		RY		40.
	3	600.0	0.0	200.0		RY		41.
	4	850.0	0.0	200.0		RY		42.
	7	1800.0	0.0	200.0		RY		43.
	8	2050.0	0.0	210.0		RY		44.
	9	2250.0	0.0	230.0		RY		45.
	10	2450.0	0.0	250.0		RY		46.

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.	ROTATION ANGLES (DEG) THETAX	THETAY	THETAZ
4	1	2450.0	50.0	400.0			TZ	47.	0.0	0.0	-4.0
	3	2470.0	300.0	400.0			TZ	48.	0.0	0.0	-4.0
4	1	2450.0	50.0	400.0		RX		49.	0.0	0.0	-4.0
	3	2470.0	300.0	400.0		RX		50.	0.0	0.0	-4.0
4	1	2450.0	50.0	400.0		RY		51.	0.0	0.0	-4.0
	3	2470.0	300.0	400.0		RY		52.	0.0	0.0	-4.0
4	1	2450.0	50.0	400.0	RX			53.	0.0	0.0	-4.0
	3	2470.0	300.0	400.0	RX			54.	0.0	0.0	-4.0

M1	1	0.	0.	0.
M1	2	0.	0.	0.
M1	3	0.	0.	0.
M1	4	0.	0.	0.
M1	5	0.	0.	0.

M1	6	0.	0.	C.
M1	7	0.	0.	0.
M1	8	0.	0.	0.
M1	9	0.	0.	0.
M1	10	0.	0.	C.
M1	11	0.	0.	0.
M1	12	0.	0.	0.
M1	13	0.	0.	0.
M1	14	0.	0.	0.
M1	15	0.	0.	0.
M1	16	0.	0.	0.
M1	17	0.	0.	0.
M1	18	0.	0.	0.
M1	19	.10000E+01	.5C00CE+02	.1000CE+01
M1	20	.10000E+01	.15000E+03	.8000CE+00
M1	21	.10000E+01	0.	.8000CE+00
M1	22	.10000E+01	.15000E+03	.7000CE+00
M1	23	.10000E+01	-.5C000E+02	.5000CE+00
M1	24	.10000E+01	.1C000E+03	.4000CE+00
M1	25	.10000E+01	-.10000E+03	.30000E+00
M1	26	.10000E+01	.5C000E+02	.20C0CE+00
M1	27	.10000E+01	-.2000CE+03	.10C0CE+00
M1	28	.10000E+01	.5C000E+02	.1000CE+00
M1	29	.10000E+01	-.30000E+03	.1000CE+00
M1	30	.10000E+01	0.	-.10000E+00
M1	31	0.	0.	0.
M1	32	0.	0.	0.
M1	33	0.	0.	0.
M1	34	0.	0.	0.
M1	35	0.	0.	0.
M1	36	0.	0.	0.
M1	37	0.	0.	0.
M1	38	0.	0.	0.
M1	39	0.	0.	0.
M1	40	0.	0.	C.
M1	41	0.	0.	0.
M1	42	0.	0.	C.
M1	43	0.	0.	0.
M1	44	0.	0.	C.
M1	45	0.	0.	0.
M1	46	0.	0.	C.
M1	47	0.	0.	C.
M1	48	0.	0.	0.
M1	49	0.	0.	0.
M1	50	0.	0.	C.
M1	51	0.	0.	0.
M1	52	0.	0.	0.
M1	53	0.	-.69756E-01	-.59756E-02
M1	54	0.	.73010E-04	-.31322E-01

M2	1	0.	0.	0.
M2	2	0.	0.	0.
M2	3	0.	0.	C.
M2	4	0.	0.	.1000CE-01

M2	5	0.	.10000E+01	.20000E-01
M2	6	0.	0.	.10000E-02
M2	7	0.	0.	0.
M2	8	0.	0.	C.
M2	9	0.	0.	C.
M2	10	0.	0.	C.
M2	11	0.	0.	0.
M2	12	0.	0.	0.
M2	13	0.	0.	0.
M2	14	0.	0.	0.
M2	15	0.	0.	C.
M2	16	0.	0.	C.
M2	17	0.	0.	C.
M2	18	0.	0.	C.
M2	19	0.	0.	0.
M2	20	0.	0.	0.
M2	21	0.	0.	0.
M2	22	0.	0.	0.
M2	23	0.	0.	0.
M2	24	0.	0.	0.
M2	25	0.	0.	0.
M2	26	0.	0.	0.
M2	27	0.	0.	0.
M2	28	0.	0.	0.
M2	29	0.	0.	0.
M2	30	0.	0.	0.
M2	31	0.	0.	0.
M2	32	0.	0.	0.
M2	33	0.	0.	0.
M2	34	0.	0.	0.
M2	35	0.	0.	0.
M2	36	0.	0.	0.
M2	37	0.	0.	0.
M2	38	0.	0.	0.
M2	39	0.	0.	0.
M2	40	0.	.1C000E+01	-.3000CE-01
M2	41	0.	.10000E+01	-.10000E-01
M2	42	0.	.10000E+01	0.
M2	43	0.	.1C000E+01	.10000E-01
M2	44	0.	.1C000E+01	.20000E-01
M2	45	0.	.10000E+01	.40000E-01
M2	46	0.	.10000E+01	.70000E-01
M2	47	0.	0.	0.
M2	48	0.	0.	C.
M2	49	0.	-.6S756E-01	-.99756E-02
M2	50	0.	.7301CE-04	-.31322E-01
M2	51	0.	.99756E+00	-.69756E-03
M2	52	0.	.1C024E+01	.17859E-01
M2	53	0.	0.	0.
M2	54	0.	0.	0.

M3	1	0.	.1C000E+02	.1000CE+0C
M3	2	0.	0.	.12000E+01
M3	3	.10000E+01	-.30000E+03	-.16CCCE+01

M3	4	0.	0.	0.
M3	5	0.	0.	0.
M3	6	0.	0.	0.
M3	7	.10000E+01	.5C00CE+02	.1000CE+01
M3	8	.10000E+01	.15000E+03	-.800CCE+00
M3	9	.10000E+01	0.	.80000E+00
M3	10	.10000E+01	.15000E+03	.7000CE+00
M3	11	.10000E+01	-.50000E+02	.5000CE+00
M3	12	.10000E+01	.1C000E+03	.40000E+00
M3	13	.10000E+01	-.1C00CE+03	.30000E+00
M3	14	.10000E+01	.50000E+02	.2000CE+00
M3	15	.10000E+01	-.20000E+03	.10CCCE+00
M3	16	.10000E+01	.5C000E+02	.1000CE+00
M3	17	.10000E+01	-.30000E+03	.10000E+00
M3	18	.10000E+01	0.	-.10000E+00
M3	19	0.	0.	0.
M3	20	0.	0.	C.
M3	21	0.	0.	0.
M3	22	0.	0.	0.
M3	23	0.	0.	0.
M3	24	0.	0.	0.
M3	25	0.	0.	0.
M3	26	0.	0.	0.
M3	27	0.	0.	0.
M3	28	0.	0.	0.
M3	29	0.	0.	0.
M3	30	0.	0.	0.
M3	31	.10000E+01	-.10500E+04	.35000E+01
M3	32	.10000E+01	-.2C000E+03	-.10000E+00
M3	33	.10000E+01	-.95000E+03	.5000CE+00
M3	34	.10000E+01	-.60000E+03	.1000CE+00
M3	35	.10000E+01	-.35000E+03	-.10000E+00
M3	36	.10000E+01	.5C000E+03	0.
M3	37	.10000E+01	.8500CE+03	.10000E+00
M3	38	.10000E+01	.10500E+04	.30000E+00
M3	39	.10000E+01	.1250CE+04	.70000E+00
M3	40	0.	0.	0.
M3	41	0.	0.	0.
M3	42	0.	0.	0.
M3	43	0.	0.	0.
M3	44	0.	0.	0.
M3	45	0.	0.	0.
M3	46	0.	0.	0.
M3	47	.10000E+01	.12500E+04	.7000CE+00
M3	48	.10000E+01	.12700E+04	.40000E+00
M3	49	0.	0.	0.
M3	50	0.	0.	0.
M3	51	0.	0.	0.
M3	52	0.	0.	0.
M3	53	0.	0.	0.
M3	54	0.	0.	0.

LOAD-SET 3

SURFACE NO.	NODE NO.	REF. COORDINATES (IN) BS/X	BBL/Y	WL/Z	M1	M2	M3	ROW NO.
2	1	1300.0	1CC0.0	200.0			TZ	1.
	2	1350.0	900.0	2C0.0			TZ	2.
	3	1000.0	100.0	200.0			TZ	3.
	4	900.0	150.0	200.0			TZ	4.
	5	1000.0	150.0	200.0			TZ	5.

M3	1	-.10000E+01	-.10000E+03	-.88989E+00
M3	2	-.10000E+01	-.15000E+03	-.75318E+00
M3	3	-.10000E+01	.2000CE+03	.13858E+0C
M3	4	-.10000E+01	.30000E+03	-.10000E+00
M3	5	-.10000E+01	.2C000E+03	.82320E-01

LOAD-SET 4

PANEL LOADS (NORMAL TO SURFACE)
LOAD-SET= 4
FREQUENCIES = 0.000 2.000

SURFACE NO.	AERO ROW NO.	NODE NO.	REF. COORDINATES(IN) BS/X	BBL/Y	WL/Z
2	1.	1	1200.0	1000.0	200.0
	2.	2	1250.0	1000.0	200.0
	3.	3	1310.0	1000.0	200.0
	4.	4	1380.0	1000.0	200.0
	5.	5	1150.0	750.0	200.0
	6.	6	1210.0	750.0	200.0
	7.	7	1280.0	750.0	200.0
	8.	8	1350.0	750.0	200.0
	9.	9	1080.0	550.0	200.0
	10.	10	1150.0	550.0	200.0
	11.	11	1240.0	550.0	200.0
	12.	12	1300.0	550.0	200.0
	13.	13	1000.0	400.0	200.0
	14.	14	1100.0	400.0	200.0
	15.	15	1200.0	400.0	200.0
	16.	16	1270.0	400.0	200.0
	17.	17	900.0	200.0	200.0
	18.	18	1030.0	200.0	200.0
	19.	19	1120.0	200.0	200.0
	20.	20	1200.0	200.0	200.0
4	21.	1	2450.0	450.0	400.0
	22.	2	2490.0	450.0	400.0
	23.	3	2530.0	450.0	400.0
	24.	5	2470.0	150.0	400.0
	25.	7	2380.0	40.0	400.0
	26.	8	2430.0	40.0	400.0
	27.	9	2500.0	40.0	400.0

M4 BAR MATRIX MERGED FREQUENCY 1= 0.000 CPS PLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	0.	.1COCOE+04	-.10000E+02
2	2.	0.	.2CCCOE+03	-.70000E+01
3	3.	0.	.10000E+03	-.70000E+01
4	4.	0.	.5COCCE+02	-.500COE+01
5	5.	0.	.1C000E+04	-.80000E+01
6	6.	0.	.2COCOE+03	-.60000E+01
7	7.	0.	.1COCOE+03	-.40000E+01
8	8.	0.	.5COCOE+02	-.20000E+01
9	9.	0.	.8C000E+03	-.8000CE+01
10	10.	0.	.200COE+03	-.6COCOE+C1
11	11.	0.	.2COCCE+03	-.40000E+C1
12	12.	0.	.1C000E+03	-.20000E+01
13	13.	0.	.120COE+04	-.20000E+01
14	14.	0.	.600COE+03	-.40000E+01
15	15.	0.	.30000E+03	-.20000E+01
16	16.	0.	.10000E+03	-.10000E+C1
17	17.	0.	.14000E+04	0.
18	18.	0.	.7COCOE+03	0.
19	19.	0.	.4C000E+03	0.
20	20.	0.	.2COCCE+03	0.
21	21.	0.	.2C000E+03	.100COE+01
22	22.	0.	.5COCOE+02	.2000CE+C0
23	23.	0.	.1COCOE+02	.10000E+00
24	24.	0.	.10000E+03	.40000E+00
25	25.	0.	.3C000E+03	.20000E+C1
26	26.	0.	.100COE+03	.40000E+00
27	27.	0.	.2COCOE+02	.20000E+00

M5 BAR MATRIX MERGED FREQUENCY 1= 0.000 CPS PLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	.10000E+01	0.	.100C0E+00
2	2.	.2000CE+0C	0.	.70000E-01
3	3.	.10000E+00	0.	.700CCE-C1
4	4.	.5000CE-01	0.	.50000E-01
5	5.	.10000E+01	-.1C000E+00	.80000E-01
6	6.	.20000E+00	-.1C0C0E-01	.60000E-01
7	7.	.10000E+00	0.	.40000E-01
8	8.	.50000E-01	0.	.200C0E-01
9	9.	.80000E+00	-.20000E-01	.80000E-C1
10	10.	.20000E+0C	-.1C000E-01	.60000E-01
11	11.	.20000E+00	0.	.40000E-01
12	12.	.10000E+0C	.1C0C0E-01	.20000E-01
13	13.	.12000E+01	-.4C0C0E-01	.40000E-01
14	14.	.60000E+00	-.2C0C0E-01	.40000E-01
15	15.	.30000E+0C	-.2C000E-01	.20000E-01
16	16.	.10000E+00	-.1C0C0E-01	.10000E-01
17	17.	.140CCE+01	-.5C0CCE-01	0.
18	18.	.70000E+00	-.3C0CCE-01	0.
19	19.	.40000E+00	-.2CCC0E-01	0.
20	20.	.2000CE+0C	-.1CC0CE-01	0.
21	21.	.2000CE+00	.2C000E+03	-.50000E+C2
22	22.	.5000CE-01	.5C000E+02	-.10000E+02
23	23.	.100CCE-01	.1C0C0E+02	-.50000E+01
24	24.	.10000E+00	.10000E+03	-.50000E+01
25	25.	.300J0E+0C	.300C0E+03	-.20000E+02
26	26.	.10000E+0C	.100C0E+03	0.
27	27.	.20000E-01	.20000E+02	.50000E+C1

C3 BAR (OR PHI-TILDA BAR) MATRIX MERGED   FREQUENCY 1=   0.000 CPS   PLOS OPTION

TAPE ORDER	LOAD SEQ.		
1	1.	.1000E+01	0.
2	2.	.2000E+00	0.
3	3.	.1000E+00	0.
4	4.	.5000E-01	0.
5	5.	.1000E+01	0.
6	6.	.2000E+00	0.
7	7.	.1000E+00	0.
8	8.	.5000E-01	0.
9	9.	.8000E+00	0.
10	10.	.2000E+00	0.
11	11.	.2000E+00	0.
12	12.	.1000E+00	0.
13	13.	.1200E+01	0.
14	14.	.6000E+00	0.
15	15.	.3000E+00	0.
16	16.	.1000E+00	0.
17	17.	.1400E+01	0.
18	18.	.7000E+00	0.
19	19.	.4000E+00	0.
20	20.	.2000E+00	0.
21	21.	.2000E+00	0.
22	22.	.5000E-01	0.
23	23.	.1000E-01	0.
24	24.	.1000E+00	0.
25	25.	.3000E+00	0.
26	26.	.1000E+00	0.
27	27.	.2000E-01	0.

M4 BAR MATRIX MERGED FREQUENCY 2= 2.000 CPS PLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	0.	.1C000E+03	-.10000E+01
2	2.	0.	.2CCC0E+02	-.70000E+00
3	3.	0.	.100C0E+02	-.70000E+00
4	4.	0.	.500CCE+01	-.500CCE+00
5	5.	0.	.100C0E+03	-.800CCE+00
6	6.	0.	.20000E+02	-.600C0E+00
7	7.	0.	.1CCC0E+02	-.40000E+00
8	8.	0.	.5C0C0E+01	-.20000E+00
9	9.	0.	.8C0C0E+02	-.8000CE+00
10	10.	0.	.200C0E+02	-.60000E+00
11	11.	0.	.20000E+02	-.400C0E+00
12	12.	0.	.1C0C0E+02	-.20000E+00
13	13.	0.	.120C0E+03	-.40000E+00
14	14.	0.	.600C0E+02	-.400C0E+00
15	15.	0.	.3C0C0E+02	-.20000E+00
16	16.	0.	.100C0E+02	-.10000E+00
17	17.	0.	.140C0E+03	0.
18	18.	0.	.7C000E+02	0.
19	19.	0.	.4C0C0E+02	0.
20	20.	0.	.2C0C0E+02	0.
21	21.	0.	.2C0C0E+03	.10000E+01
22	22.	0.	.500C0E+02	.2000CE+00
23	23.	0.	.1C000E+02	.10000E+00
24	24.	0.	.1C0C0E+03	.40000E+00
25	25.	0.	.30000E+03	.10000E+01
26	26.	0.	.1C000E+03	.20000E+00
27	27.	0.	.20000E+02	.10000E+00

M5 BAR MATRIX MERGED FREQUENCY 2= 2.000 CPS PLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	.10000E+01	0.	.10000E+00
2	2.	.20000E+00	0.	.70000E-01
3	3.	.10000E+00	0.	.70000E-01
4	4.	.50000E-01	0.	.50000E-01
5	5.	.10000E+01	-.10000E+00	.80000E-01
6	6.	.20000E+00	-.10000E-01	.60000E-01
7	7.	.10000E+00	0.	.40000E-01
8	8.	.50000E-01	0.	.20000E-01
9	9.	.80000E+00	-.20000E-01	.80000E-01
10	10.	.20000E+00	-.10000E-01	.60000E-01
11	11.	.20000E+00	0.	.40000E-01
12	12.	.10000E+00	.10000E-01	.20000E-01
13	13.	.12000E+01	-.40000E-01	.40000E-01
14	14.	.60000E+00	-.20000E-01	.40000E-01
15	15.	.30000E+00	-.20000E-01	.20000E-01
16	16.	.10000E+00	-.10000E-01	.10000E-01
17	17.	.14000E+01	-.50000E-01	0.
18	18.	.70000E+00	-.30000E-01	0.
19	19.	.40000E+00	-.20000E-01	0.
20	20.	.20000E+00	-.10000E-01	0.
21	21.	.20000E+00	.10000E+03	-.50000E+01
22	22.	.50000E-01	.20000E+02	-.10000E+01
23	23.	.10000E-01	.10000E+02	-.50000E+00
24	24.	.10000E+00	.20000E+02	-.50000E+00
25	25.	.30000E+00	.10000E+03	-.20000E+01
26	26.	.10000E+00	.20000E+02	0.
27	27.	.20000E-01	.10000E+02	.50000E+00

C3 BAR (OR PHI-TILDA BAR) MATRIX MERGED   FREQUENCY 2=   2.000 CPS   PLDS OPTION

TAPE ORDER	LOAD SEQ.		
1	1.	.1000E+01	.10C0E+00
2	2.	.2000E+00	.10CCE+C0
3	3.	.1000E+00	.10C0E+C0
4	4.	.5000E-01	.10C0E+00
5	5.	.1000E+01	.20C0E+00
6	6.	.2000E+00	.20C0E+00
7	7.	.1000E+00	.20C0E+00
8	8.	.5000E-01	.20C0E+C0
9	9.	.8000E+00	.10CCE+C0
10	10.	.2000E+00	.1000E+00
11	11.	.2000E+00	.10C0E+00
12	12.	.1000E+00	.10C0E+00
13	13.	.1200E+01	0.
14	14.	.6000E+00	C.
15	15.	.3000E+00	0.
16	16.	.1000E+00	0.
17	17.	.1400E+01	0.
18	18.	.7000E+00	0.
19	19.	.400CE+00	0.
20	20.	.200CE+00	0.
21	21.	.2000E+00	-.20C0E+C0
22	22.	.5000E-01	-.50C0E-01
23	23.	.1000E-01	-.10C0E-01
24	24.	.1000E+00	-.1000E+C0
25	25.	.3000E+00	-.3000E+00
26	26.	.1000E+00	-.10CCE+00
27	27.	.2000E-01	-.2CCCE-01

LOAD-SET 5

ET PANEL LOADS (NORMAL TO SURFACE)
LOAD-SET= 5
FREQUENCIES = 0.000 2.000

SURFACE NO.	ROW NO.	STRUCT. NODE NO.	REF COORDINATES(IN) BS/X	BBL/Y	WL/Z
2	1.	1	1250.0	1000.0	200.0
	2.	2	1350.0	1000.0	200.0
	3.	3	1200.0	800.0	200.0
	4.	4	1350.0	800.0	200.0
	5.	5	1150.0	600.0	200.0
	6.	6	1300.0	600.0	200.0
	7.	7	1100.0	450.0	200.0
	8.	8	1250.0	450.0	200.0
	9.	9	1000.0	300.0	200.0
	10.	10	1250.0	300.0	200.0
	11.	11	900.0	150.0	200.0
	12.	12	1200.0	150.0	200.0
4	13.	1	2450.0	90.0	400.0
	14.	2	2460.0	150.0	400.0
	15.	3	2470.0	300.0	400.0

M3 BAR MERGED MATRIX

LOAD SEQ.			
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.
11	0.	0.	0.
12	0.	0.	0.
13	.10000E+01	.12500E+04	.70000E+00
14	.20000E+01	.25200E+04	.12000E+01
15	.30000E+01	.38100E+06	.12000E+01

M4 BAR MATRIX MERGED FREQUENCY 1= 0.000 CPS NPLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	0.	.66000E+01	-.23100E+00
2	2.	0.	.25945E+01	-.19994E+00
3	3.	0.	.12526E+02	-.19146E+00
4	4.	0.	.15075E+01	-.70303E-01
5	5.	0.	.73734E+01	-.16552E+00
6	6.	0.	.27072E+01	-.56163E-01
7	7.	0.	.11660E+02	-.11277E+00
8	8.	0.	.36522E+01	-.39578E-01
9	9.	0.	.18270E+02	-.12771E-01
10	10.	0.	.17227E+01	-.47207E-02
11	11.	0.	.15988E+02	.17610E-01
12	12.	0.	.21701E+01	.12299E-01
13	13.	0.	.63000E+03	.39000E+01
14	14.	0.	.34000E+03	.19500E+01
15	15.	0.	.13000E+03	.65000E+00

MS BAR MATRIX MERGED FREQUENCY 1. 0.000 CPS NPLDS OPTION

TAPE ORDER	LOAD SEQ.			
1	1.	.66000E-02	-.86651E-17	.23100E-02
2	2.	.25945E-02	.41940E-05	.19987E-02
3	3.	.12526E-01	-.12307E-02	.19137E-02
4	4.	.15075E-02	-.93262E-04	.70237E-03
5	5.	.73734E-02	-.45726E-03	.16393E-02
6	6.	.27072E-02	.19265E-03	.56128E-03
7	7.	.11660E-01	-.31537E-03	.11364E-02
8	8.	.36522E-02	-.11390E-03	.39579E-03
9	9.	.18270E-01	-.61136E-03	.35871E-03
10	10.	.17227E-02	-.19914E-03	.48509E-04
11	11.	.19988E-01	-.76517E-03	-.21928E-03
12	12.	.21701E-02	-.13626E-03	-.13178E-03
13	13.	.63000E+00	.63000E+03	-.32500E+02
14	14.	.34000E+00	.34000E+03	-.50000E+02
15	15.	.13000E+00	.13000E+03	-.32500E+02

C3 BAR (OR PHI-TILDA BAR) MATRIX MERGED FREQUENCY 1= 0.000 CPS NPLDS OPTION

TAPE ORDER	LOAD SEQ.		
1	1.	.6600E-02	0.
2	2.	.2594E-02	0.
3	3.	.1253E-01	0.
4	4.	.1507E-02	0.
5	5.	.7373E-02	0.
6	6.	.2707E-02	C.
7	7.	.1166E-01	0.
8	8.	.3652E-02	C.
9	9.	.1827E-01	0.
10	10.	.1723E-02	0.
11	11.	.1999E-01	0.
12	12.	.2170E-02	0.
13	13.	.6300E+00	0.
14	14.	.3400E+00	0.
15	15.	.1300E+00	0.

LOAD-SET 6

ROW NO.	SURFACE NO.	LOAD SEQ. NO.	REF COORDINATES (IN) BS/X	BBL/Y	WL/Z	AXIS ORIENTATION (DEG) THETX	THETY	THETZ	LOAD TYPE
1	1	1.	1100.0	900.0	200.0	0.0	0.0	0.0	VX
2		1.	1100.0	900.0	200.0	0.0	0.0	0.0	VY
3		1.	1100.0	900.0	200.0	0.0	0.0	0.0	VZ
4		1.	1100.0	900.0	200.0	0.0	0.0	0.0	MXX
5		1.	1100.0	900.0	200.0	0.0	0.0	0.0	MYY
6		1.	1100.0	900.0	200.0	0.0	0.0	0.0	MZZ
7	2	2.	1200.0	900.0	200.0	5.0	0.0	-20.0	VX
8		3.	1050.0	150.0	200.0	0.0	0.0	0.0	VX
9		2.	1200.0	900.0	200.0	5.0	0.0	-20.0	VY
10		3.	1050.0	150.0	200.0	0.0	0.0	0.0	VY
11		2.	1200.0	900.0	200.0	5.0	0.0	-20.0	VZ
12		3.	1050.0	150.0	200.0	0.0	0.0	0.0	VZ
13		2.	1200.0	900.0	200.0	5.0	0.0	-20.0	MXX
14		3.	1050.0	150.0	200.0	0.0	0.0	0.0	MXX
15		2.	1200.0	900.0	200.0	5.0	0.0	-20.0	MYY
16		3.	1050.0	150.0	200.0	0.0	0.0	0.0	MYY
17		2.	1200.0	900.0	200.0	5.0	0.0	-20.0	MZZ
18		3.	1050.0	150.0	200.0	0.0	0.0	0.0	MZZ
19	4	4.	2430.0	0.0	400.0	0.0	0.0	0.0	VX
20		4.	2430.0	0.0	400.0	0.0	0.0	0.0	VY
21		4.	2430.0	0.0	400.0	0.0	0.0	0.0	VZ
22		4.	2430.0	0.0	400.0	0.0	0.0	0.0	MXX
23		4.	2430.0	0.0	400.0	0.0	0.0	0.0	MYY
24		4.	2430.0	0.0	400.0	0.0	0.0	0.0	MZZ
25	3	5.	800.0	0.0	200.0	0.0	0.0	0.0	VX
26		6.	1800.0	0.0	200.0	0.0	0.0	0.0	VY
27		5.	800.0	0.0	200.0	0.0	0.0	0.0	VZ
28		6.	1000.0	0.0	200.0	0.0	0.0	0.0	VZ
29		7.	1200.0	0.0	200.0	0.0	0.0	0.0	VZ
30		6.	1000.0	0.0	200.0	0.0	0.0	0.0	MXX
31		5.	800.0	0.0	200.0	0.0	0.0	0.0	MYY
32		6.	1000.0	0.0	200.0	0.0	0.0	0.0	MYY
33		7.	1200.0	0.0	200.0	0.0	0.0	0.0	MYY
34		5.	800.0	0.0	200.0	0.0	0.0	0.0	MZZ

ROW NO.	M3 BAR MERGED MATRIX COEFFICIENTS			NUMBER OF NODES= 3
1	0.	.25900E+02	.25900E+00	
2	0.	0.	.25900E+00	
3	.25900E+01	-.51800E+03	.10360E+01	
4	0.	0.	-.25900E+01	
5	-.25900E+03	.52836E+05	-.88060E+02	
6	0.	0.	.26936E+02	
7	-.88786E-01	-.59834E+01	-.56746E-01	
8	0.	.25900E+02	.25900E+00	
9	-.24394E+00	-.16439E+02	-.15591E+00	
10	0.	0.	.25900E+00	
11	.29672E+01	.19996E+03	.18964E+01	
12	.12846E+02	-.81585E+03	.38047E+01	
13	.76202E+03	.66845E+05	.56153E+03	
14	.38526E+04	-.97449E+05	.17903E+04	
15	-.64560E+02	.75897E+04	-.66406E+02	
16	.11111E+04	.16226E+06	.44444E+03	
17	.17494E+02	.26242E+04	.11343E+02	
18	0.	-.90650E+04	-.76664E+02	
19	0.	0.	0.	
20	0.	0.	0.	
21	.49210E+00	.61254E+03	.27972E+00	
22	.90650E+02	.11480E+06	.35172E+02	
23	.72520E+01	.92489E+04	.29526E+01	
24	0.	0.	0.	
25	0.	0.	-.62160E+00	
26	0.	0.	0.	
27	.22015E+01	-.14658E+04	.37555E+00	
28	.52577E+01	.50583E+04	.15695E+01	
29	.11344E+02	.64180E+04	.11810E+01	
30	0.	0.	0.	
31	-.58923E+03	.42012E+06	-.13183E+03	
32	.19943E+04	.22439E+07	.10424E+04	
33	.65993E+04	.57909E+07	.19335E+04	
34	0.	0.	0.	

M4 BAR MATRIX MERGED

FREQUENCY 1 0.000 CPS

ROW NO.			
1	0.	0.	0.
2	0.	0.	.7C000E+01
3	0.	.30000E+03	.19000E+02
4	0.	0.	-.14000E+03
5	0.	-.30000E+C5	-.15000E+04
6	0.	0.	.75000E+03
7	0.	-.11924E+C3	.20568E+01
8	0.	0.	0.
9	0.	-.32760E+03	.56511E+01
10	0.	0.	.70000E+01
11	0.	.39048E+C4	-.60737E+02
12	0.	.78900E+C4	-.63000E+02
13	0.	.98160E+C6	-.19741E+05
14	0.	.32000E+C7	-.41790E+05
15	0.	-.45325E+06	.57008E+04
16	0.	.44850E+C6	-.13120E+05
17	0.	-.78876E+C4	-.12202E+03
18	0.	0.	.40000E+03
19	0.	0.	0.
20	0.	0.	0.
21	0.	.11C00E+C4	.69000E+01
22	0.	.19680E+C6	.1C790E+04
23	0.	-.28000E+04	-.30000E+02
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	0.	.32000E+C4	-.12000E+03
28	0.	.22600E+04	.10500E+02
29	0.	.22200E+C4	-.20000E+01
30	0.	0.	0.
31	0.	-.12400E+07	.44000E+05
32	0.	.14154E+C7	.81300E+04
33	0.	.27594E+07	.10930E+05
34	0.	0.	0.

HS BAR MATRIX MERGED FREQUENCY 1. 0.000 CPS

ROW NO.			
1	0.	0.	0.
2	0.	0.	.15000E+00
3	.30000E+02	.30000E+C1	.15000E+00
4	0.	0.	-.300C0E+01
5	-.30000E+04	-.30C00E+C3	-.15000E+02
6	0.	0.	.15000E+02
7	-.11924E+00	.38752E-C2	-.20568E-01
8	0.	0.	0.
9	-.32760E+00	.10647E-01	-.56511E-01
10	0.	0.	.15000E+00
11	.39848E+01	-.12951E+00	.68737E+00
12	.37550E+02	.27250E+C1	.95000E+00
13	.98168E+03	-.23783E+C2	.19741E+03
14	.13595E+05	.95C75E+C3	.52350E+03
15	-.45325E+03	.17985E+02	-.57008E+02
16	-.10365E+04	-.16230E+03	.11520E+03
17	-.78876E+01	.76697E+00	.12202E+01
18	0.	0.	.75000E+01
19	0.	0.	0.
20	0.	0.	C.
21	.11000E+01	.11C00E+C4	-.11500E+03
22	.19680E+03	.19680E+G6	-.35100E+05
23	-.28000E+01	-.28000E+C4	-.65000E+03
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	.32000E+01	-.22000E+02	.11000E+01
28	.28000E+01	.22013E+C4	-.22990E+03
29	.24000E+01	.22015E+C4	-.22990E+03
30	0.	0.	0.
31	-.12400E+04	.84C00E+C4	-.42000E+03
32	.17304E+04	.13809E+07	-.14615E+06
33	.32904E+04	.27C18E+07	-.28409E+06
34	0.	0.	0.

C3 BAR (OR PHI-TILDA BAR) MATRIX MERGED FREQUENCY 1= 0.000 CPS

ROW NO.		
1	0.	0.
2	0.	0.
3	.3000E+02	0.
4	0.	0.
5	-.3000E+04	0.
6	0.	0.
7	-.1192E+00	0.
8	0.	0.
9	-.3276E+00	0.
10	0.	0.
11	.3985E+01	0.
12	.3755E+02	0.
13	.9817E+03	0.
14	.1360E+05	0.
15	-.4532E+03	0.
16	-.1037E+04	0.
17	-.7888E+01	0.
18	0.	0.
19	0.	0.
20	0.	0.
21	.1100E+01	0.
22	.1968E+03	0.
23	-.2800E+01	0.
24	0.	0.
25	0.	0.
26	0.	0.
27	.3200E+01	0.
28	.2800E+01	0.
29	.2400E+01	0.
30	0.	0.
31	-.1240E+04	0.
32	.1730E+04	0.
33	.3290E+04	0.
34	0.	0.

M4 BAR MATRIX MERGED FREQUENCY 2= 2.000 CPS

ROW NO.			
1	0.	C.	0.
2	0.	0.	.60000E+01
3	0.	.25C00E+C3	.14000E+02
4	0.	0.	-.120C0E+03
5	0.	-.22500E+C5	-.15000E+04
6	0.	0.	.60000E+03
7	0.	-.11924E+C2	.20568E+00
8	0.	0.	0.
9	0.	-.32760E+C2	.56511E+00
10	0.	0.	.60000E+01
11	0.	.39848E+C3	-.68737E+01
12	0.	.10050E+C4	.60000E+01
13	0.	.98168E+C5	-.19741E+04
14	0.	.39700E+C6	.40000E+02
15	0.	-.45325E+05	.57008E+03
16	0.	.36350E+C5	-.20270E+04
17	0.	-.78876E+03	-.12202E+02
18	0.	0.	.30000E+03
19	0.	C.	0.
20	0.	0.	C.
21	0.	.11C00E+C4	.52000E+01
22	0.	.19680E+C6	.10270E+04
23	0.	-.28000E+04	.13000E+02
24	0.	0.	0.
25	0.	C.	0.
26	0.	0.	0.
27	.20000E-01	.50000E+C3	-.120CCE+03
28	.15000E-01	.22060E+C4	.204C0E+02
29	.30000E-01	.22020E+04	.15400E+02
30	0.	0.	0.
31	-.60000E+01	-.16C00E+C6	.44000E+05
32	.50000E+01	.13E39E+C7	.11578E+05
33	.19000E+02	.27063E+07	.22818E+05
34	0.	0.	0.

MS BAR MATRIX MERGED FREQUENCY 2. 2.000 CPS

ROW NO.			
1	0.	0.	0.
2	0.	0.	.15000E+00
3	.20000E+02	.15000E+01	.60000E-01
4	0.	0.	-.30000E+01
5	-.22500E+04	-.19000E+03	-.75000E+01
6	0.	0.	.15000E+02
7	-.11924E+00	.30792E-02	-.20568E-01
8	0.	0.	0.
9	-.32760E+00	.10047E-01	-.56511E-01
10	0.	0.	.15000E+00
11	.39840E+01	-.12551E+00	.68737E+00
12	.27550E+02	.12250E+01	.86000E+00
13	.98168E+03	-.23783E+02	.19741E+03
14	.10095E+05	.42575E+03	.49200E+03
15	-.45325E+03	.17985E+02	-.57008E+02
16	-.78650E+03	-.87300E+02	.11820E+03
17	-.78876E+01	.76697E+00	.12202E+01
18	0.	0.	.75000E+01
19	0.	0.	0.
20	0.	0.	0.
21	.11000E+01	.39000E+03	-.11500E+02
22	.19680E+03	.83200E+05	-.35100E+04
23	-.28000E+01	.60000E+03	-.65000E+02
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	.50000E+00	-.22000E+01	.10000E+01
28	.22060E+01	.78013E+03	-.22900E+02
29	.22020E+01	.78015E+03	-.22900E+02
30	0.	0.	0.
31	-.16000E+03	.84000E+03	-.40000E+03
32	.13839E+04	.49265E+06	-.14570E+05
33	.27063E+04	.96074E+06	-.28310E+05
34	0.	0.	0.

C3 BAR (OR PHI-TILDA BAR) MATRIX MERGED   FRECUENCY 2=   2.000 CPS

ROW NO.		
1	0.	0.
2	0.	0.
3	.2000E+C2	0.
4	0.	0.
5	-.2250E+04	0.
6	0.	0.
7	-.1192E+00	-.4769E-01
8	0.	0.
9	-.3276E+00	-.131CE+00
10	0.	0.
11	.3985E+01	.1594E+01
12	.2755E+02	.160CE+01
13	.9817E+03	.4182E+C3
14	.1010E+05	.9800E+03
15	-.4532E+03	-.7906E+C2
16	-.7865E+03	.309CE+C3
17	-.7888E+C1	.6014E+C1
18	0.	0.
19	0.	0.
20	0.	0.
21	.1100E+01	-.110CE+C1
22	.1968E+03	-.1968E+03
23	-.2800E+01	.280CE+C1
24	0.	0.
25	0.	0.
26	0.	0.
27	.5000E+00	.50CCE+00
28	.2206E+01	-.2194E+01
29	.2202E+01	-.2198E+C1
30	0.	0.
31	-.1600E+03	-.160CE+03
32	.1384E+04	-.1377E+C4
33	.2706E+04	-.2695E+04
34	0.	0.

REFERENCES

1. Miller, R. D.; Kroll, R. I.; and Clemmons, R. E.: Dynamic Loads Analysis System (DYLOFLEX) Summary. NASA CR-2846-1, 1979.

2. Miller, R. D.; Richard, M.; and Rogers, J. T.: Feasibility of Implementing Unsteady Aerodynamics Into the FLEXSTAB Computer Program System. NASA CR-132530, October 1974.

3. Bisplinghoff, R. L.; Ashley, H.; and Halfman, R. L.: Aeroelasticity. Addison-Wesley (Reading, Mass), 1955.

4. Kroll, R.I.; and Clemmons, R. E.: A Computer Program To Generate Equations of Motion Matrices - L217 (EOM), Volume I: Engineering and Usage. NASA CR-2851, 1979.

5. Kroll, R. I.; and Hirayama, M. Y.: Modal Interpolation Program, L215 (INTERP). Volume I: Engineering and Usage. NASA CR-2847, 1979.

6. Miller, R. D.; Fraser, R. J.; Hirayama, M. Y.; and Clemmons, R. E.: Equation Modifying Program - L219 (EQMOD). Volume I: Engineering and Usage. NASA CR-2855, 1979.

7. Miller, R. D.; and Graham, M. L.: Random Harmonic Analysis Program, L221 (TEV156). Volume I: Engineering and Usage. NASA CR-2857, 1979.

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Topical Report

16. Abstract

This document describes the LOADS program L218, a digital computer program that calculates dynamic load coefficient matrices utilizing the force summation method. The load equations are derived for a flight vehicle in straight and level flight and excited by gusts and/or control motions. In addition, sensor equations are calculated for use with an active control system.

The load coefficient matrices are calculated for the following types of loads:

- Translational and rotational accelerations, velocities, and displacements
- Panel aerodynamic forces
- Net panel forces
- Shears and moments

Program usage and a brief description of the analysis used are presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those who will maintain and/or modify the program in the future.

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