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ATLAS – An Integrated Structural Analysis and Design System

System Demonstration Problems

R. A. Samuel

Boeing Commercial Airplane Company
Seattle, Washington 98124

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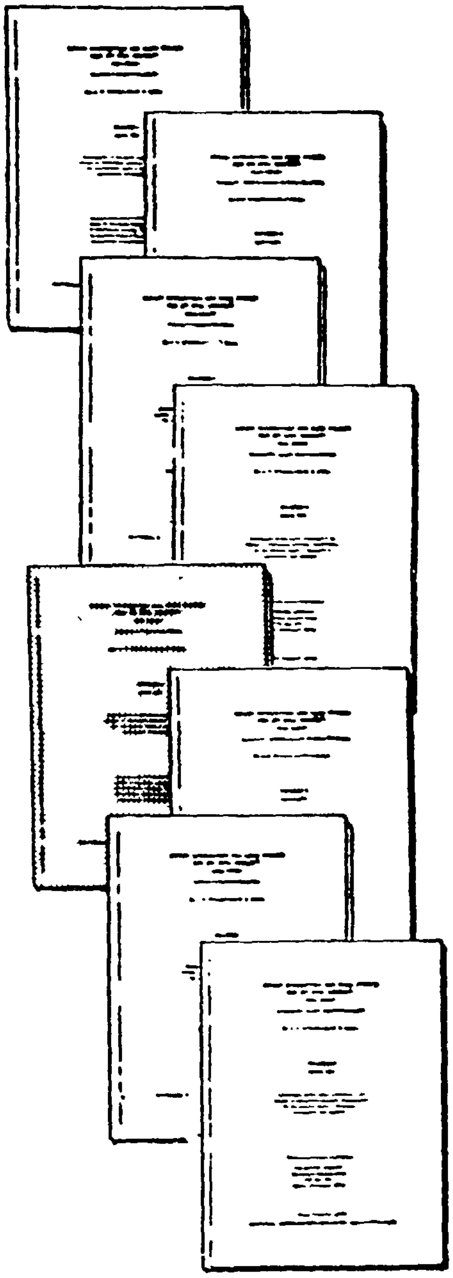
ATLAS SYSTEM DOCUMENTATION



VOLUME I
ATLAS User's Guide
NASA CR-159041

VOLUME II
System Design Document
NASA CR-159042

VOLUME III
User's Manual-Input and Execution Data
NASA CR-159043

VOLUME IV
Random Access File Catalog
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System Demonstration Problems
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VOLUME VI
DESIGN Module Theory
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VOLUME VII
LOADS Module Theory
Boeing Commercial Airplane Company
D6-25400-0101

VOLUME VIII
SNARK User's Manual
Boeing Computer Services
BCS-G0686

FOREWORD

Development of the ATLAS integrated structural analysis and design system was initiated by The Boeing Commercial Airplane Company in 1969. Continued development efforts have resulted in the release and application of several extended versions of the system to aerospace and civilian structures. Those capabilities of the current ATLAS version developed under the NASA Langley Contract No. NAS1-12911 include the following: geometry control, thermal stress, fuel generation/management, payload management, loadability curve generation, flutter solution, residual flexibility, strength design of composites, thermal fully stressed design, and interactive graphics. The monitor of this contract was G. L. Giles. The inertia loading capability was developed under the Army Contract No. DAAG46-75-C-0072.

This document is one volume of a series of documents describing the ATLAS System. The remaining documents present details regarding the input data and program execution, data management, system design, and the engineering method used by the computational modules.

The key responsibilities for development of ATLAS have been within the Integrated Analysis/Design Systems Group of the Structures Research Unit of BCAC and the ATLAS System Group of the Boeing Computer Services Company (BCS) Integrated Systems and Systems Technology Unit. R. E. Miller, Jr. was the Program Manager of ATLAS until 1976 after which K. H. Dickenson assumed this position. The current ATLAS System is the result of the combined efforts of many Boeing engineering and programming personnel. Those who contributed directly to the current version of ATLAS are as follows:

B. F. Backman	H. B. Hansteen	C. D. Mounier
G. N. Bates	B. A. Harrison	F. D. Nelson
L. C. Carpenter	J. M. Held	M. C. Redman
R. E. Clemmons	M. Y. Hirayama	R. A. Samuel
R. L. Dreisbach	J. R. Hogley	M. Tamekuni
W. J. Erickson	H. E. Huffman	G. von Limbach
S. H. Gadre	D. W. Johnson	S. O. Wahlstrom
F. P. Gray	A. S. Kawaguchi	R. A. Woodward
D. W. Halstead		K. K. Yagi

ABSTRACT

This document is one of a series of documents describing the ATLAS System for structural analysis and design. This volume describes a set of problems that demonstrate the various analysis and design capabilities of the ATLAS System proper as well as capabilities available by means of interfaces with other computer programs.

Input data and results for each demonstration problem are discussed. Results are compared to theoretical solutions or experimental data where possible. Listings of all input data are included.

CONTENTS

FIGURES

TABLES

101. INTRODUCTION

This document describes the set of ATLAS System demonstration problems. A list of the problem decks and a brief description of each are presented in table 101-1.

The 200-series sections of this document discuss the problem used to demonstrate capabilities of the ATLAS System proper, whereas the 300-series sections discuss several analytical capabilities available to ATLAS users by means of interfaces with other computer programs.

The discussion of each demonstration problem is comprised of the following parts:

- Description of the analysis (model, loading, analysis performed, etc.)

- Presentation and discussion of results

- Listing of Control Program and input data

The features demonstrated by each deck are summarized in table 101-2. Reference 101-1 should be consulted for descriptions of system capabilities and input data formats.

Other documentation of ATLAS usage in production environments include that presented in references 101-2 through 101-7. The stress analysis of a large sports stadium (3400 nodes, 9600 elements, 20 000 freedoms, 70 million words of storage), and a detailed three-dimensional stress analysis of a gas turbine engine blade (3200 nodes, 350 solid elements, 9500 freedoms, 15 million words of storage) are described in references 101-2, 101-3 and 101-4, respectively, in terms of problem definition, solution approach, data management and cost. The automated strength resizing of an arrow-wing supersonic cruise aircraft (ref. 101-5) with approximately 20 000 design variables demonstrated the practicality of using ATLAS in the earliest stages of the interdisciplined aeroelastic design process. Use of those methods implemented in ATLAS during its continued development to automate the strength/stiffness (flutter) aeroelastic design process for metallic and composite structural components are described in references 101-6 and 101-7.

Table 101-1. Description of Demonstration Decks

Deck Number	Document Section	Description
1	204	Substructured stress and vibration analyses of an SST
2	203	Non-substructured stress and vibration analyses of an SST
3	209	Fully stressed design and composite optimization
4	211	Flutter analysis of an SST
5	301	ATLAS to FLEXSTAB interface
6	301	FLEXSTAB to ATLAS interface
7	303	NASA-LaRC Configuration Program interface to ATLAS
8	206	Normal mode analyses of cantilever beams
9	302	ATLAS-NASTRAN interfaces
10	202	Stress, vibration and flutter analyses of a delta wing
11	201	Substructured stress and vibration analyses of a transmission tower
12	213	Stress analysis of a rotating disk
13	207	Frame buckling and superposition
14	212	Flutter analysis of a T-tail aircraft
15	205	Vibration analysis of the FIREBEE Drone
16	208	Fuel and payload management
17	210	Thermal fully stressed design

Table 101-2. Summary of Capabilities Demonstrated

CAPABILITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	DECK NUMBER																
CONTROL PROGRAM PROCEDURES																	
Static Stress Analysis, STRESS		x							x	x		x	x				
Static Stress Analysis, R-STRESS						x							x				
Reduced Stiffness Matrix, K-REDUCE				x				x		x				x	x		
Reduced Flexibility Matrix, F-REDUCE					x												
Reduced Stiffness and Mass Matrices, REDUCE		x						x									
Substructure Procedures	x										x						
Design, DESIGN			x														
STRUCTURE DEFINITION																	
Geometry							x										
Local Analysis Frames												x		x	x		
Special Materials												x		x	x		x
Composite Materials			x														
BC Specification	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x
Stiffness Elements:																	
ROD					x	x			x		x			x	x		x
BEAM	x	x	x	x	x	x		x	x		x	x	x	x	x		
SPAR	x	x	x	x	x	x				x							
COVER		x	x	x	x	x				x							
PLATE									x						x		
GPLATE									x						x		
BRICK								x				x					
SPLATE					x	x			x						x		
CCOVER			x														
Subsets	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Substructures	x										x						
STATIC LOADING																	
Nodal Loading	x	x	x						x		x	x	x				x
Element Loading										x		x	x				
Rotational Inertia Loading												x					
Thermal Loading												x					x
Support Displacements													x				
Superposition													x				
External Nodal Loads Matrix						x											
WEIGHTS & DYNAMIC MODELING																	
Structural Mass	x	x						x		x	x						
Non-Structural Mass																	
Mass Elements	x	x		x	x	x									x	x	
Concentrated Mass					x			x						x	x		
Fuel																x	
Payload																x	
Substructures	x										x						
Fuel and Payload Management																x	
Weight Calculation Only						x										x	x
Reduced Matrix Calculation by Mass Processor:																	
Diagonal					x			x		x							
Non-Diagonal				x				x			x			x	x		
Element Mass Matrices	x	x						x				x					

Table continued on next page

Table 101-2. Summary of Capabilities Demonstrated (Cont'd.)

CAPABILITY	DECK NUMBER																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
BUCKLING													X				
DESIGN																	
Fully-stressed Resize			X														
Thermal Design																	X
Composite Optimization			X														
History			X														X
UNSTEADY AERODYNAMICS & FLUTTER																	
Doublet Lattice				X						X				X			
Mach Box				X													
AF1														X			
RHO3				X													
Residual Flexibility				X													
Flutter				X						X				X			
PRINTED OUTPUT																	
Material Data															X		
Nodal Data	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Stiffness Data	X	X	X	X	X			X	X	X	X	X	X	X	X		X
BC Data		X	X	X	X			X	X	X		X	X	X	X		
Mass																	
Input	X			X	X			X						X		X	
Output	X			X		X				X				X	X	X	
Loads																	
Input										X		X					
Output	X	X				X						X	X				
Design																	
Input			X														
Output			X														X
Add/Interpolate Output				X													
AF1																	
Input														X			
Output														X			
Doublet Lattice																	
Input				X										X			
Output				X										X			
FLEXAIR Output				X													
Flutter																	
Input				X										X			
Output				X						X				X			
Mach Box																	
Input				X													
Output				X													
RHO3																	
Input				X													
Output				X													
Interact Data	X										X						
Stresses:																	
Element	X	X				X			X	X	X	X	X				
Brick Nodal Stresses												X					

Table continued on next page

Table 101-2. Summary of Capabilities Demonstrated (Cont'd)

CAPABILITY	DECK NUMBER																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PRINTED OUTPUT (Cont'd)																	
Displacements	X	X				X			X	X	X	X	X				
Reactions	X	X							X	X	X	X					
Vibration Output	X	X		X				X		X	X			X	X		
Buckling Output													X				
GRAPHICAL OUTPUT																	
Structural Grid		X	X	X	X		X	X		X		X	X	X	X		X
Mass Elements				X	X											X	
Stiffness Element Properties		X															
Element Stress Contours										X							
Static Displacements													X				
Vibration Mode Shapes		X						X		X					X		
Buckling Mode Shapes													X				
Margins of Safety:																	
Strength			X														
Thermal																	X
Loadability Diagrams																X	
Element Stress vs. Loadcase													X				
V-g and V-f Graphs				X						X				X			
Exploded Geometry Plots	X										X						
SYSTEM INTERFACES																	
ATLAS-NASTRAN									X								
ATLAS-FLEXSTAB					X	X											
ATLAS/LaRC Configuration							X										

201. SUBSTRUCTURED STRESS AND VIBRATION ANALYSES OF A TRANSMISSION TOWER (DECK 11)

201.1 DESCRIPTION OF ANALYSES

The structure analyzed in this demonstration problem is a power transmission tower as shown in figure 201-1.

The structural model consists of four substructures as shown in figure 201-2. The interaction tree is shown schematically in figure 201-3. The legs of the tower were modelled with BEAM elements, the diagonals with ROD elements. Masses are obtained from the stiffness finite elements. All translational freedoms at the base are supported. Nodal loads are applied at the six hanger points.

The vibration analysis for natural frequencies and mode shapes is performed on the top level substructure using reduced stiffness and mass matrices. All translational freedoms (except TZ at the intersection of the bottom panel diagonals) are retained. The reduced mass matrices for the lowest level substructures are calculated directly by the Mass Processor.

To obtain an alternate solution, a NASTRAN (ref. 201-1) model of the same structure was made and analyzed. ROD and BAR elements were used for the structural model. All mass was specified as concentrated masses. The NASTRAN model was not substructured.

201.2 RESULTS

Nodal displacements, element stresses and reactions from the ATLAS analysis agree exactly with the corresponding quantities from the NASTRAN analysis.

Natural frequencies obtained from ATLAS are compared with the corresponding NASTRAN values in table 201-1.

201.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CCNTRCL PROGRAM DEMO11
      PROBLEM IC(CEMO11 - SUBSTRUCTURED STRESS/VIBRATICN ANALYSES)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATEC BY
C                    THIS DECK ARE
C                       1. SUBSTRUCTURED STRESS ANALYSIS
C                       2. SUBSTRUCTURED VIBRATION ANALYSIS
C                       3. EXPLODED GEOMETRY PLOTS
C
C     AUTHOR         M. TAMEKUNI
C
C     CORE           130K (OCTAL)
C
C
C     ************************************************************
C     *                                                          *
C     *  THIS EXAMPLE REPRESENTS AN ATLAS RUN TO PERFCRM STRESS  *
C     *  AND VIBRATICN ANALYSES FCR A TRANSMISSION TOWER WHICH   *
C     *  IS MOCELEC AS   FCUR SUBSTRUCTURES, SS=1 TO 4.  SS=5 IS *
C     *  FORMEC BY INTERACTING SS=1 TO 4.                        *
C     *                                                          *
C     *                                                          *
C     *  THE EXECUTICN SEQUENCE IS                               *
C     *                                                          *
C     *    1)  REAC INPUT ......... THE INPUT DATA ARE           *
C     *                             PREPROCESSED, AND WRITTEN    *
C     *                             CN THE DATA FILE.  SS=1 TO 4 *
C     *                             ARE DEFINED AS STIFFNESS/MASS*
C     *                             SETS 1 TO 4. SS=5 IS DEFINED *
C     *                             AS SET=5 FOR VIBRATION       *
C     *                             ANALYSIS.                    *
C     *                                                          *
C     *    2)  EXECUTE STIFFNESS, . COMPUTE ELEMENTAL STIFFNESSES*
C     *        MASS                 ANC THE NON-DIAGONAL MASS    *
C     *                             MATRICES FOR THE RETAINEC    *
C     *                             FREEDOMS FOR SETS 1 TO 4.    *
C     *                                                          *
C     *    3)  EXECUTE LCADS ...... PROCESS LCADS FOR            *
C     *                             SUBSTRUCTURES 1 AND 3.  NO   *
C     *                             LOADS ARE APPLIEC TC         *
C     *                             SUBSTRUCTURES 2 ANC 4.       *
C     *                                                          *
C     *    4)  PERFCRM SS-MERGE, .. FORM GRCSS STIFFNESS ANC LOAD*
C     *        STIF,LOAD            MATRICES FOR SS=1 TO 4.      *
C     *                                                          *
C     *    5)  PERFCRM SS-REDU, ... REDUCE GRCSS STIFFNESS AND   *
C     *        STIF,LCAC            LCADS MATRICES FOR SS=1 TO 4.*
C     *                                                          *
C     *    6)  PERFCRM SS-MERGE, .. FORM GRCSS STIFFNESS,LOADS   *
C     *        STIF,LCAD,MASS       AND MASS MATRICES FCR SS=5.  *
C     *                                                          *
C     *    7)  PERFCRM SS-VSCL .... COMPUTE RECUCED STIFFNESS AND*
C     *                             MASS MATRICES FOR SS=5 TO    *
C     *                             PERFORM SUBSEQUENT VIBRATION *
C     *                             ANALYSIS.                    *
C     *                                                          *
C     *    8)  EXECUTE MASS ....... COMPUTE MASS PROPERTIES FOR  *
C     *                             TOTAL STRUCTURE. (SET=5)     *
C     *                                                          *
C     *    9)  EXECUTE VIBRATION .. COMPUTE THE FIRST 5 FRECUEN- *
C     *                             CIES AND MODES.              *
C     *                                                          *
C     *   10)  PERFCRM SS-SSCL .... COMPUTE DISPLACEMENTS FOR    *
C     *                             SS=5.                        *
C     *                                                          *
```

```
C    *    11)  PERFCRM ............ FROM THE CISPLACEMENT MATRI- *
C    *         SS-PARTITION         CES FOR SS=5, EXTRACT DISPLA-*
C    *                              CEMENTS AT RETAINEC FREEDOMS *
C    *                              FOR SS=1 TO 4.               *
C    *                                                           *
C    *    12)  PERFCRM SS-BACK .... PERFORM BACK SUBSTITUTICN TC *
C    *                              COMPUTE ALL DISPLACEMENTS AND*
C    *                              REACTIONS FCR SS=1 TO 4.     *
C    *                                                           *
C    *    13)  EXECUTE STRESS, .... CCMPUTE ELEMENTAL STRESSES   *
C    *         PRINT STRESSES,      AND PRINT STRESSES,          *
C    *         DISPLACEMENTS        CISPLACEMENTS AND REACTIONS  *
C    *         ANC REACTIONS        FOR SUBSTRUCTURES 1 TO 4     *
C    *                                                           *
C    *    14)  PRINT INPUT, ....... PRINT NOCAL AND STIFFNESS    *
C    *         NOCAL AND            INPUT DATA FOR SETS 1 TO 4   *
C    *         STIFFNESS                                         *
C    *                                                           *
C    *    15)  EXECLTE GRAPHICS ... PLCT TOTAL STRUCTLRE ANC     *
C    *                              COMPONENT SUBSTRUCTURES      *
C    *                                                           *
C    *    16)  PRINT INPUT, ....... PRINT INTERACT DATA FOR      *
C    *         INTERACT             ALL SUBSTRUCTURES.           *
C    *                                                           *
C    *    17)  PRINT OUTPUT, ...... PRINT FRECUENCIES ANC MODE   *
C    *         VIBRATICN            SHAPES.                      *
C    *                                                           *
C    *    18)  ERRCR PRCCEDURE .... SAVE CATA FILES IF AN ERROR  *
C    *                              IS ENCOUNTERED DURING        *
C    *                              EXECUTICN.                   *
C    *                                                           *
C    *                                                           *
C    *************************************************************
      USER CCMMON (K)
C  -----    1)  -----
      READ INPUT
C  -----    2)  -----
      DO 10 K=1,4
      EXECUTE STIFFNESS (SET=K)
      EXECUTE MASS (SET=K,CPTION=3,CONDITION=1)
   10 CCNTINUE
C  -----    3)  -----
      EXECUTE LOACS (SS=(1,3))
C  -----    4)  -----
      PERFORM SS-MERGE (STIF,LOAD,SS=1 TO 4)
C  -----    5)  -----
      PERFORM SS-RECU (STIF,LOAD,SS=1 TO 4)
C  -----    6)  -----
      PERFORM SS-MERGE (STIF,LOAD,MASS,SS=5)
C  -----    7)  -----
      PERFORM SS-VSCL  (SS=5)
C  -----    8)  -----
      EXECUTE MASS (SET=5,CCNDITION=1)
C  -----    9)  -----
      EXECUTE VIBRATION (STIF=KREDC05,MASS=MRED005,NFREQS=5,SET=5)
C  -----   10)  -----
      PERFORM SS-SSCL (SS=5)
C  -----   11)  -----
      PERFORM SS-PARTITICN (SS=5)
C  -----   12)  -----
      PERFORM SS-BACK (SS=1 TO 4)
C  -----   13)  -----
      CO 20 K=1,4
      EXECUTE STRESS(SS=K)
      PRINT OUTPUT(STRESS,SS=K)
      PRINT CUTPUT(CISP,SS=K)
      PRINT CLTPUT(REACTICNS,EGCHK,SS=K)
   20 CONTINUE
C  -----   14)  -----
      CO 30 K=1,4
      PRINT INPUT (NOCAL,SET=K)
      PRINT INPUT (STIFFNESS,SET=K)
```

```
   30 CONTINUE
C  -----  15)  -----
      EXECUTE EXTRACT(EXNAME=SS1,LSUB=KGRID,KSET=1,ESUB=E1,NSUB=N2)
      EXECUTE EXTRACT(EXNAME=SS2,LSUB=KGRID,KSET=2,ESUB=E1,NSUB=N1)
      EXECUTE EXTRACT(EXNAME=SS3,LSUB=KGRID,KSET=3,ESUB=E1,NSUB=N1)
      EXECUTE EXTRACT(EXNAME=SS4,LSUB=KGRIC,KSET=4,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,CFFLINE=CALCOMP,EXPLODE,TYPE=ORTH,
     X                   SIZE=(15,15),EXNAME=(SS1,SS2,SS3,SS4))
      EXECUTE GRAPHICS(GNAME=GEOM,EXPLODE,TYPE=ORTH,SIZE=(15,15),
     X                TX=-250.,EXNAME=SS1,TX=0.,TY=100.,EXNAME=SS2,
     X                TX=50.,TY=0.,EXNAME=SS3,TX=0.,TY=-250.,
     X                EXNAME=SS4)
C  -----  16)  -----
      PRINT INPUT (INTERACT,NODE,SS=1 TO 5)
      PRINT INPUT (INTERACT,CONN,SS=1 TO 4)
      PRINT INPUT (INTERACT,RETA,SS=1 TO 4)
      PRINT INPUT (INTERACT,BC,SS=1 TO 5)
      PRINT INPUT (INTERACT,LOADS,SS=1 TO 5)
C  -----  17)  -----
      PRINT OUTPUT (VIBRATION)
      ERROR PROCEDURE
      SAVE FILES
      END CONTROL PROGRAM
```

```
*/ ********************************************************** /
 BEGIN NOCAL CATA                                              /
        1 165.0  148.0  634.5                                  /
        2 169.0  190.0  634.5                                  /
      400 112.8  169.C   96.0                                  /
     1001 1CC.0   *     40E.0  TO  1003  100.0  169.0  600.0   /
      101 1CG.0  100.0    0.0  TO   106  148.0   *=    360.0
                               OF  8.0,7.0,6.C,5.0,4.0         /
      401  *     238.0    *2        406  148.0  190.0   **     /
      106                      TO   116  148.0  148.0   600.0  /
      406                      *    416   *     190.0   **     /
   RECRDER  FRGM  101                                          /
  SET 2                                                        /
*/ ********************************************************** /
        2 169.C  150.0  634.5                                  /
      300  *     225.2   56.0                                  /
      301 238.0   *=      0.0  TO   306  190.0   *=    360.0
                               CF  8.0,7.0,6.0,5.0,4.0         /
      401 100.0   *3                406  148.0          **     /
      306                      TO   316  190.0  190.0  600.0   /
      406                      *    416  148.0          **     /
   RECRDER  FRCM  301                                          /
  SET 3                                                        /
        1 165.C  148.0  634.5                                  /
        2   *    190.0   *                                     /
      200 225.2  165.0   56.0                                  /
     2C01 238.C   *     408.0  TO  2003  238.0  169.0  600.0   /
      201   *    1C0.0   0.0   *    206  190.0  148.0  360.0
                               OF   8.,7.,6.,5.,4.0            /
      301   *    238.0    *2        306   *     190.0  **      /
      206                      TO   216  190.0  148.0  600.0   /
      306                      *    316   *     190.0   **     /
   RECRCER  FRCM  201                                          /
  SET  4                                                       /
*/ ********************************************************** /
        1 165.0  148.0  634.5                                  /
      1CC  *     112.8   56.0                                  /
      101 100.0  *=      0.0   TO   106  148.0   *=    360.0
                               CF   8.0,7.0 6. 5.,4.0          /
      201 238.C           *3        206  190.0  **             /
      106                      TO   116 148.0  148.C  600.0    /
      206                      *   216  190.0          **      /
   RECRDER  FRCM  101                                          /
 ENC NOCAL CATA                                                /
 BEGIN ST -FNESS CATA                                          /
   BEGIN PRCPERTY CATA                                         /
      P1  5.75  C.  0.  39.8  19.9  *=                         /
      P2  3.75  C.  0.  11.2  5.6  5.6                         /
      P3  2.11 C. C. 3.6 1.8 1.8 2.11 0. 0. 3.6 1.8 1.8 111.0  /
      P4  2.11  2.11                                           /
      P5  1.15  *=                                             /
      P6  3.25  3.25                                           /
   ENC PROPERTY CATA                                           /
   BEGIN ELEMENT CATA                                          /
      BEAM  MP  1C1  102  400  P1  TO  105  106  400  BY 1 1 0 /
       *        4C1  4C2  400  P1  TO  405  406  400  BY 1 1 0 /
       *        1C   1C7  406  P2  TO  115  116  406  **       /
       *        4.6  407  106  P2  TO  415  416  106  **       /
       *        416    2  116  P2                              /
       *        116    1  416  P2                              /
       *        4C2  400  403  P3                              /
       *        102  4CC  1C3  P3                              /
      ROD       401  400       P4                              /
       *        1C1  400       *                               /
       *        4C3  400       *                               /
       *        1C3  400       *                               /
       *        4C3  1C3       P5  TO  416  116                /
       *        1C3  404       *2      115  416   BY  2  2     /
       *        4C4  1C5       *2      414  115   **           /
       *          1    2       P5                              /
       *          1  416       *                               /
       *       1001  108       P6  TO 1003  116   BY  1  4     /
```

```
         *        *    408        *    *    *     416    **            /
         *        *    109        *                                    /
         *        *    409        *                                    /
         *      1002   113        *                                    /
         *        *    413        *                                    /
         *      1003     1        *                                    /
         *        *      2        *                                    /
     END ELEMENT DATA                                                  /
   SET  2                                                              /
*/ ************************************************************** /
     BEGIN PROPERTY DATA                                               /
        P3  2.11 C. C. 3.6 1.8 1.8 2.11 0. C. 3.6 1.8 1.8 111.0        /
        P4  2.11  2.11                                                 /
        P5  1.15  *=                                                   /
     END PROPERTY DATA                                                 /
     BEGIN ELEMENT DATA                                                /
        BEAM  ME  302  300  303  P3                                    /
        BEAM      402  300  403  P3                                    /
        ROD       301  300       P4                                    /
        ROD       401  300       *                                     /
        ROD       303   *        *                                     /
        ROD       403   *        *                                     /
        ROD       303  403       P5   TO  316  416                     /
        ROD       403  304       *2       415  316       BY  2  2      /
        ROD       304  405       *2       314  415       **            /
     END ELEMENT DATA                                                  /
   SET  3                                                              /
*/ ************************************************************** /
     BEGIN PROPERTY DATA                                               /
        P1  5.75  C.  0.  39.8  19.9  *=                               /
        P2  3.75  C.  0.  11.2  5.6  5.6                               /
        P3  2.11 C. C. 3.6 1.8 1.8 2.11 0. 0. 3.6 1.8 1.8 111.0        /
        P4  2.11  2.11                                                 /
        P5  1.15  *=                                                   /
        P6  3.25  3.25                                                 /
     END PROPERTY DATA                                                 /
     BEGIN ELEMENT DATA                                                /
        BEAM  ME  201  202  200  P1  TO  205  206  200  BY 1 1 0       /
         *        301  302  200  P1  TO  305  306  200  BY 1 1 0       /
         *        206  207  306  P2  TO  215  216  306  **             /
         *        306  307  206  P2  TO  315  316  206  **             /
         *        216    1  316  P2                                    /
         *        316    2  216  *                                     /
         *        202  200  203  P3                                    /
         *        302  200  303  P3                                    /
       ROD        201  200       P4                                    /
         *        301   *        *                                     /
         *        203   *        *                                     /
         *        303   *        *                                     /
         *        203  303       P5  TO  216  316                      /
         *        303  204       *   *   315  216   BY  2  2           /
         *        204  305       *   *   214  315   **                 /
         *        216    2       *                                     /
         *       2001  208       P6  TO 2003  216   BY  1  4           /
         *         *   308       *   *   *    316   **                 /
         *         *   209       P6                                    /
         *         *   309       *                                     /
         *       2002  213       *                                     /
         *         *   313       *                                     /
         *       2003    1       *                                     /
         *         *     2       *                                     /
     END ELEMENT DATA                                                  /
   SET  4                                                              /
*/ ************************************************************** /
     BEGIN PROPERTY DATA                                               /
        P3  2.11 C. C. 3.6 1.8 1.8 2.11 0. C. 3.6 1.8 1.8 111.0        /
        P4  2.11  2.11                                                 /
        P5  1.15  *=                                                   /
     END PROPERTY DATA                                                 /
     BEGIN ELEMENT DATA                                                /
        BEAM  ME  102  100  103  P3                                    /
         *        202  100  203  P3                                    /
        ROD       101  100       P4                                    /
```

```
       *        201  100        *                                          /
       *        1C3  1C0        *                                          /
       *        2C3  10C        *                                          /
       *        1C3  2C3        P5  TO  116  216                           /
       *        2C3  104        *2      215  116    BY  2  2               /
       *        1C4  2C5        *2      114  215    **                     /
    ENC ELEMENT CATA                                                       /
   END STIFFNESS CATA                                                      /
 */                                                                        /
   BEGIN BC CATA                                                           /
    SET  1                                                                 /
     RETAIN TX TY TZ  FCR  1C01  TC  1003                                  /
     RETAIN TX TY     FCR   4C0                                            /
     SUPPORT ALL FCR  101   4C1                                            /
    SET  2                                                                 /
     RETAIN TX TY     FCR   300                                            /
     SUPPORT ALL FCR  301   4C1                                            /
    SET  3                                                                 /
     RETAIN TX TY TZ  FCR  2CC1  TC  2003                                  /
     RETAIN TX TY     FCR   200                                            /
     SUPPORT ALL FCR  2C1   3C1                                            /
    SET  4                                                                 /
     RETAIN TX TY     FCR   1C0                                            /
     SUPPORT ALL FCR  101   201                                            /
   END BC DATA                                                             /
 */                                                                        /
   BEGIN MASS CATA                                                         /
    SET  1                                                                 /
      BEGIN CONCITICN DATA                                                 /
        STAGE  1   CCNDITION  1                                            /
      ENC CONCITICN CATA                                                   /
   END MASS DATA                                                           /
   BEGIN MASS CATA                                                         /
    SET  2                                                                 /
      BEGIN CONCITICN DATA                                                 /
        STAGE  1   CCNCITICN  1                                            /
      ENC CONCITICN CATA                                                   /
   ENC MASS CATA                                                           /
   BEGIN MASS CATA                                                         /
    SET  3                                                                 /
      BEGIN CONCITICN DATA                                                 /
        STAGE  1   CCNCITICN  1                                            /
      ENC CONCITICN CATA                                                   /
   END MASS CATA                                                           /
   BEGIN MASS CATA                                                         /
    SET  4                                                                 /
      BEGIN CONCITICN CATA                                                 /
        STAGE  1   CCNCITICN  1                                            /
      ENC CONCITION CATA                                                   /
   END MASS DATA                                                           /
 */                                                                        /
   BEGIN LOACS CATA                                                        /
    SET  1                                                                 /
      BEGIN NOCAL LCAC CATA                                                /
        CASE  1                                                            /
           CRDER  FX FY FZ                                                 /
             1CC1  TC  1C03  10CC0.0 *= 20000.0                            /
      ENC NODAL LOAC DATA                                                  /
    SET  3                                                                 /
      BEGIN NOCAL LCAC CATA                                                /
        CASE  1                                                            /
           ORCER  FX FY FZ                                                 /
             20C1  TC  2C03  10000.0 *= 20000.0                            /
      ENC NOCAL LCAC CATA                                                  /
   END LOACS CATA                                                          /
 */                                                                        /
   BEGIN SUBSET DEFINITICN                                                 /
     SUBSETS OF STIFFNESS SET 1                                            /
        E1 = ALL                                                           /
        E6 = E1                                                            /
        N1 = 1CC1  TC  1CC3                                                /
        E5 = OPEN  IN  N1                                                  /
```

```
      EXCLUCE  E5  FRGM  E6                                                  /
      N2 = ALL                                                               /
   SUBSETS OF STIFFNESS SET 2                                                /
      E1 = ALL                                                               /
      N1 = ALL                                                               /
   SUBSETS CF STIFFNESS SET 3                                                /
      E1 = ALL                                                               /
      N1 = ALL                                                               /
   SUBSETS GF STIFFNESS SET 4                                                /
      E1 = ALL                                                               /
      N1 = ALL                                                               /
 ENC SUBSET CEFINITION                                                       /
 BEGIN INTERACT CATA                                                         /
   CEFINE  SS 1 AS SET 1 STAGE 1                                             /
   CEFINF  SS 2 AS SET 2 STAGE 1                                             /
   CEFINE  SS 3 AS SET 3 STAGE 1                                             /
   CEFINE  SS 4 AS SET 4 STAGE 1                                             /
   SS 5                                                                      /
   INTERACT 1 2 3 4                                                          /
   BEGIN BC CHANGES                                                          /
     SS 5                                                                    /
       REFERENCE SS 1                                                        /
          RETAIN  TX  TY  FCR  102  TO  116                                  /
          *4                   402  TG  416                                  /
          *4                   1  2                                          /
       REFERENCE SS 3                                                        /
          RETAIN  TX  TY  FCR  202  TO  216                                  /
          *4                   302  TO  316                                  /
   ENC BC CHANGES                                                            /
   CEFINE HIGHEST SS 5 AS SET 5                                              /
 END INTERACT CATA                                                           /
ENC PRCBLEM CATA                                                             /
```

Table 201-1. Comparison of Natural Frequencies for Transmission Tower

(1) Mode Number	Frequency (Hertz) (2) NASTRAN	Frequency (Hertz) (3) ATLAS	(4) $\frac{(3)-(2)}{(2)} \times 100$ (%)
1	7.783 87	7.813 51	0.4
2	7.851 53	7.855 62	0.4
3	10.293 9	10.834 7	5.3
4	10.294 0	10.834 8	5.3
5	10.320 3	10.862 8	5.3

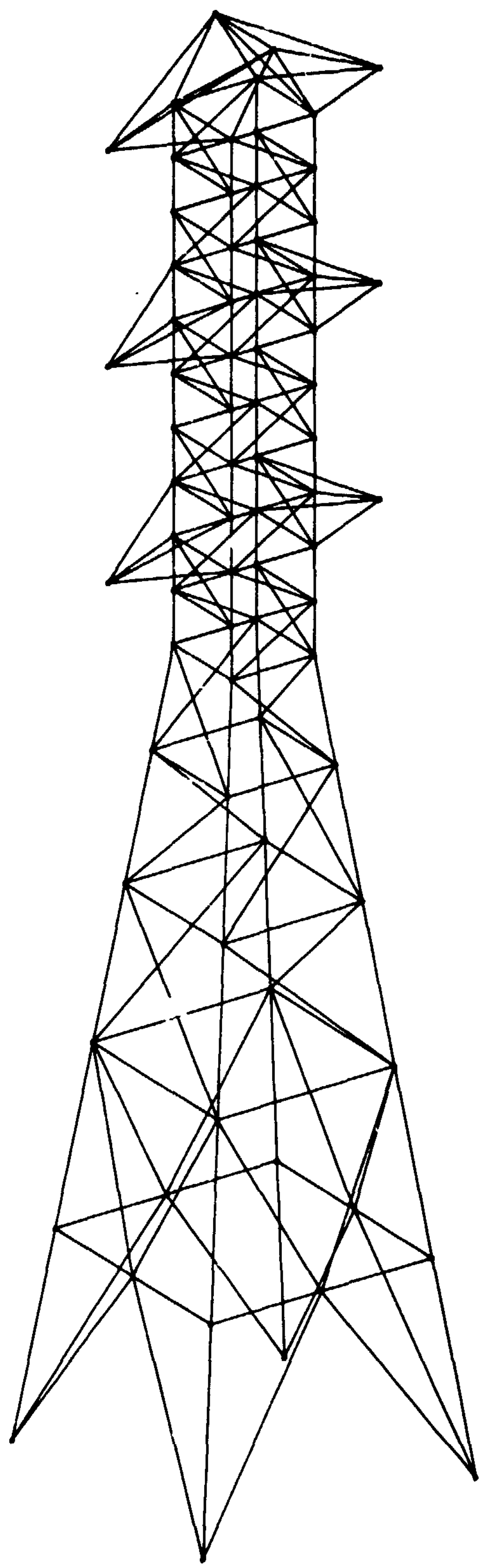


Figure 201-1. Transmission Tower

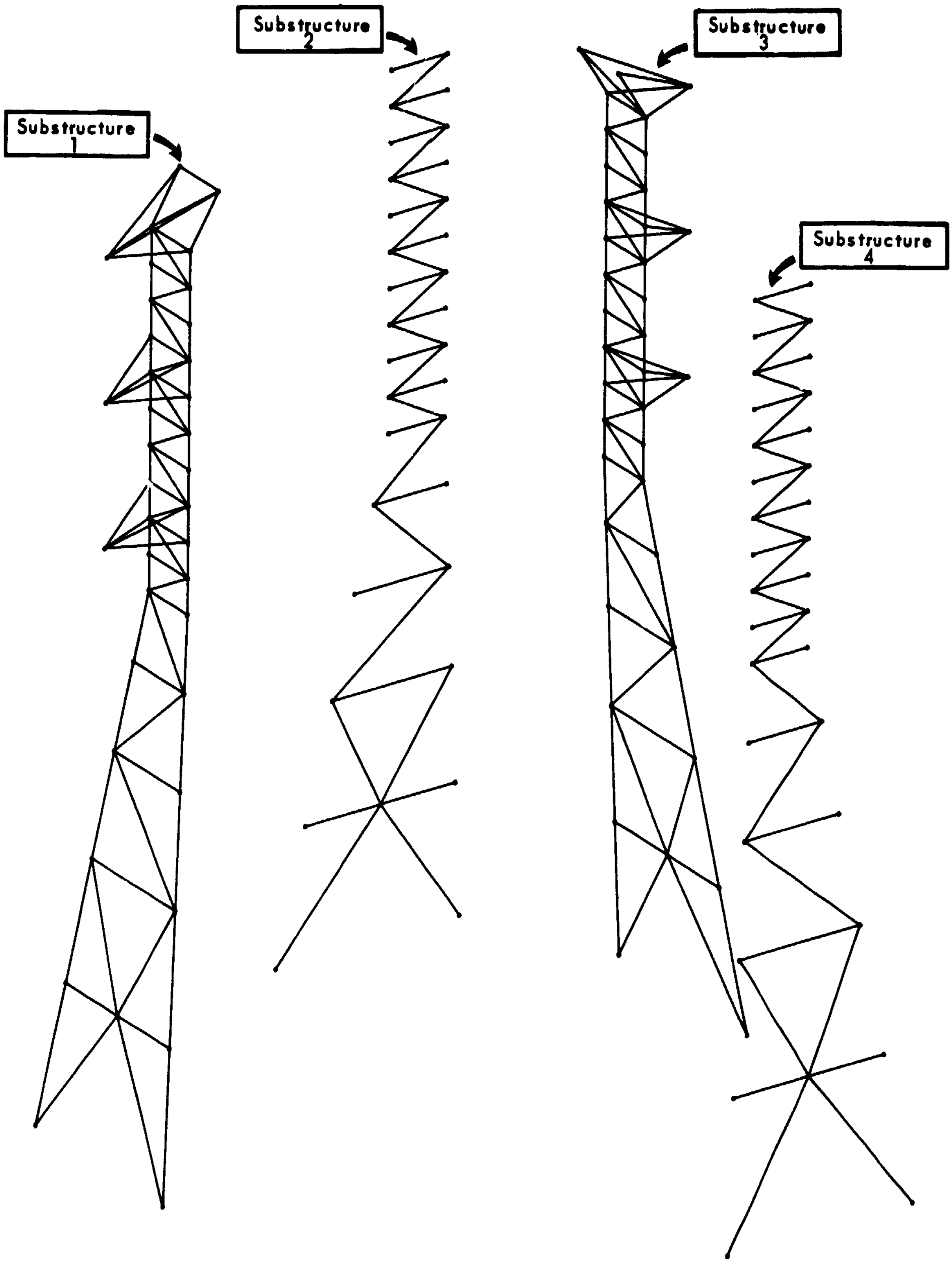


Figure 201-2. Substructure Models, Transmission Tower

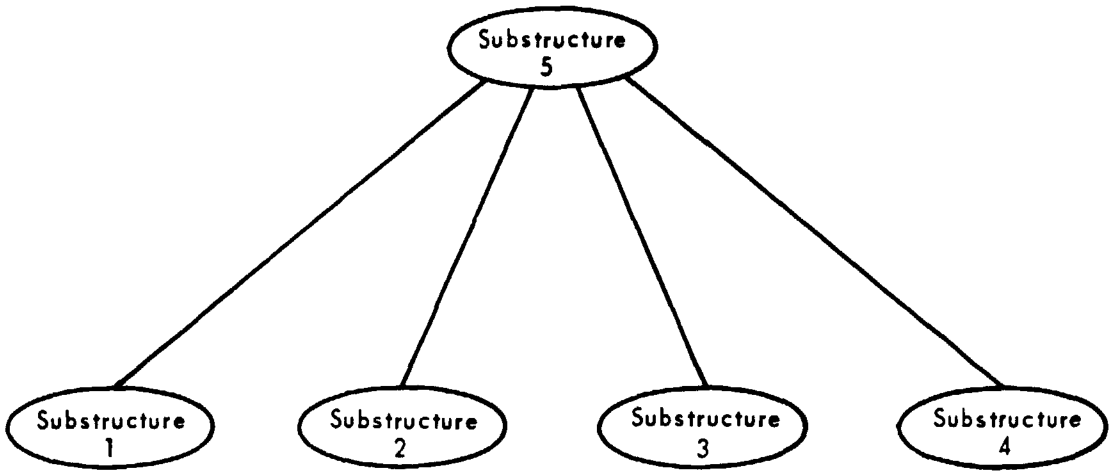


Figure 201-3. Substructure Interaction Tree,Transmission Tower

202. STRESS, VIBRATION AND FLUTTER ANALYSES OF A DELTA WING (DECK 10)

202.1 DESCRIPTION OF ANALYSES

Three analyses of a 45° delta wing are performed in this demonstration problem:

- Normal mode analysis for symmetric modes
- Flutter analysis using symmetric modes and DUBLAT aerodynamics
- Stress analysis of a cantilever wing subject to pressure loading

The structure being analyzed is a small-scale structural model of a delta wing as described in reference 202-1. The ATLAS structural model is comprised of mid-surface nodes with SPAR and COVER elements. Because the structure is symmetric about the plane Y=0 only one-half of the structure is modelled. A plan view of the structural model is shown in figure 202-1. The same structural model is used for each of the three analyses.

202.1.1 Normal Mode Analysis

The mass model consists of the mass of the stiffness finite elements plus SCALAR mass finite elements representing the concentrated weights described in reference 202-1. A diagonal mass matrix is produced directly by the Mass Processor. The panels for which weights are calculated are shown in figure 202-2.

Boundary conditions are applied to the plane Y=0 to enforce symmetric behavior. Rigid body translation in the X-direction is eliminated by supporting TX at node 195. All Z-direction translational freedoms are retained.

The Vibration Processor is executed using reduced stiffness and mass matrices. All natural frequencies and mode shapes are calculated.

202.1.2 Flutter Analysis

The first seven vibration modes obtained in the first part of this demonstration problem are used together with DUBLAT aerodynamics to obtain flutter speeds. The Doublet Lattice box grid is shown in figure 202-3 along with a flow chart of the flutter analysis.

202.1.3 Stress Analysis

Pressure loading is applied as element loads uniformly distributed over each COVER. The pressure magnitudes vary from a maximum at Y=16 to a minimum at the wing tip. All freedoms are supported in the plane Y=0.

202.2 RESULTS

202.2.1 Normal Mode Analysis

The mass of the ATLAS model is compared to the experimentally obtained value in table 202-1. Natural frequencies of the five lowest symmetrical modes from ATLAS are compared with experimentally obtained values in table 202-2. The first mode shape along spar 2 from this analysis is compared to the shape given in reference 202-1 in figure 202-4.

202.2.2 Flutter Analysis

The results of the flutter analysis are presented as velocity vs. damping (V-g) and velocity vs. frequency (V-f) plots in figures 202-5 and 202-6.

202.2.3 Stress Analysis

Contour plots of upper surface stresses are presented in figure 202-7. Lower surface stresses are equal in magnitude and opposite in sign because of the structural symmetry and the loading antisymmetry about the wing mid-surface.

202.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO10
      PROBLEM IC(DEMO10 - STRESS/FLUTTER ANALYSES OF A DELTA WING)
C
C     PURPOSE        THE PRINCIPAL ATLAS CAPABILITIES DEMONSTRATED BY
C                    THIS DECK ARE
C                       1. NORMAL MODE ANALYSIS
C                       2. PLOT OF VIBRATION MODE SHAPE
C                       3. FLUTTER ANALYSIS - DUBLAT AERODYNAMICS
C                       4. V-G AND V-F PLOTS
C                       5. STRESS ANALYSIS
C                       6. STRESS CONTOUR PLOTS
C
C     AUTHOR         F.P.GRAY
C
C     CORE           130K (OCTAL)
C
C     METHOD         THE SYSTEM IS EXECUTED TO DEMONSTRATE THE
C                    PROCEDURE TO OBTAIN STRESSES,DISPLACEMENTS, AND A
C                    FLUTTER SOLUTION FOR A DELTA WING.
C
C     ******************************************************************
C     *                                                                *
C     *  THIS DECK DEMONSTRATES AN ATLAS ANALYSIS OF THE 45 DEGREE     *
C     *  DELTA WING DESCRIBED IN NACA TN 3999.                         *
C     *                                                                *
C     *  THE PROBLEM TO BE EXECUTED CONTAINS                           *
C     *                                                                *
C     *       117 STRUCTURAL NODES                                     *
C     *       154 SPAR ELEMENTS                                        *
C     *       102 COVER ELEMENTS                                       *
C     *                                                                *
C     ******************************************************************
C
      READ INPUT
C
C         PRINT THE STIFFNESS AND LOADS INPUT DATA.  PLOT GEOMETRY.
C
      PRINT INPUT (NODAL,SUBSETS,N1=INPUT,N2)
      PRINT INPUT (STIFFNESS,SUBSETS,E10,E20,E30)
      PRINT INPUT(LOADS,STAGE=2)
      EXECUTE EXTRACT(EXNAME=NACA1,LSUB=KGRID,ESUB=E10,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=PLANVIEW,OFFLINE=CALCOMP,TYPE=(ORTH,
     X                 POINT),LABEL=N,SCALE=.05,VIEW=100,EXNAME=NACA1)
      EXECUTE EXTRACT(EXNAME=NACA2,LSUB=KGRID,ESUB=E25,NSUB=N25)
      EXECUTE GRAPHICS(GNAME=REARSPAR,TYPE=ORTH,LABEL=N+E,SCALE=.10,
     X                 VIEW=1000000,EXNAME=NACA2)
C
C         GENERATE THE REDUCED STIFFNESS MATRIX.
C
      PERFORM K-REDUCE
      PRINT INPUT(BC)
C
C         GENERATE AND PRINT THE DIAGONAL MASS MATRIX,PANEL WEIGHT
C         MATRIX,AND WEIGHT STATEMENT.
C
      EXECUTE MASS (OPTION=2)
      PRINT OUTPUT(MASS,STATEMENT,SUMMARY,MDC=MDC****)
C
C         GENERATE AND PRINT THE MODES,FREQUENCIES,GENERALIZED MASS,AND
C         GENERALIZED STIFFNESS.  PRODUCE MODE SHAPE PLOT.
C
      EXECUTE VIBRATION(STIF=KRED,MASS=MDC001A,NMODES=7,SUBSETS=(N1,
     X                 N29))
```

```
      PRINT OUTPUT(VIBRATION,SUBSETS=(N1,N29))
      EXECUTE EXTRACT(EXNAME=SPAR2,LSUB=VMODE,VSET=1,NSUB=N29,MODE=3,
     X              BSUB=ON2)
      EXECUTE GRAPHICS(GNAME=MODES,TYPE=ORTH,SCALE=.1,VX=-1.,
     X               VECTOR3=VMODE,VSCALE=60.,EXNAME=SPAR2)
C
C         GENERATE,PRINT,AND PLOT THE FLUTTER DATA.
C
      EXECUTE INTERPOLATION(N1=(SURFSPLINE,CMOD),DOF=1000)
      EXECUTE DUBLAT(COND=1,MACH=.5,KVAL=(35.0,14.2,5.0,2.2,1.0),
     1             BREF=112.0)
      EXECUTE ADDINT(ID=FCHCK,INT,DUBLAT,IGAIN=9,MACH=.5)
      EXECUTE FLUTTER(GAFID=FCHCK)
      PRINT OUTPUT(FLUTTER)
      EXECUTE EXTRACT(EXNAME=FCASE1,LSUB=VGVF)
      EXECUTE GRAPHICS(GNAME=FLUTTER,TYPE=GRAPH,SIZE=(10,10),
     X               X=V,Y1=G,Y2=F,XMIN=0.,XMAX=3000.,Y1MIN=-.2,
     X               Y2MIN=0.,Y1MAX=.1,Y2MAX=200.,EXNAME=FCASE1)
C
C         GENERATE AND PRINT THE ELEMENT STRESSES,NODAL DISPLACEMENTS,
C         AND REACTIONS.  PLOT STRESS CONTOURS.
C
      PERFORM STRESS(STAGE=2,[K]=[S])
      PRINT OUTPUT(STRESSES,STAGE=2)
      PRINT OUTPUT(DISPLACE,STAGE=2)
      PRINT OUTPUT(REACTIONS,STAGE=2,R3=R31,EQCHK)
      EXECUTE EXTRACT(EXNAME=NACA3,LSUB=STRESS,ESUB=E10,NSUB=N1,
     X              STAGE=2,BSUB=ON1)
      EXECUTE GRAPHICS(GNAME=CONTOURS,TYPE=CONTOUR,SIZE=(15,15),
     X                    SCALAR=COVSIGMA1U,FLEV=-250.,LLEV=0.,
     X               INTLEV=25.,EXNAME=NACA3)
      EXECUTE GRAPHICS(GNAME=CONTOURS,TYPE=CONTOUR,SIZE=(15,15),
     X                    SCALAR=COVSIGMA2U,FLEV=-60.,LLEV=30.,
     X               INTLEV=10.,EXNAME=NACA3)
C
C         INDEX THE RANDOM ACCESS FILES.
C
      CALL PRNTCAT
      INDEX FILES
      END
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
BEGIN NODAL DATA                                                                    /
     */    STRUCTURAL NODES                                                                /
           15 196.0    0.0    0.0    2.72  TO   195 100.0   0.0    0.0    2.72 BY 15 /
     **2  -1   0.0    8.0    0.0    0.0    0    -1    0.0    8.0    0.0    0.0    0  0 /
            1 196.0 112.0    0.0    0.844 TO   193                             BY 16 /
            1                              TO    13                                    /
     **11 16                               0    15                                     /
     */  AUXILIARY PANEL NODES                                                         /
          310  196.    0.   0.   TO 316  100.      0.  0.                              /
          320    *    16.        *2  326      *    16.  0.                             /
          330    *    28.        *2  336  112.     28.  0.                             /
          340    *    40.        *2  346  124.     40.  0.                             /
          350    *    40.        *2  354  124.     40.  0.                             /
          360    *    56.        *2  364  140.     56.  0.                             /
          370    *    72.        *2  374  156.     72.  0.                             /
          380    *    88.        *2  382  172.     88.  0.                             /
          390    *   112.   0.                                                         /
END NODAL DATA                                                                    /
BEGIN STIFFNESS DATA                                                              /
   BEGIN ELEMENT DATA                                                                  /
     */    RIB ELEMENTS                                                                /
           SPAR M01   15,30  0.0254  .01905   TO  180,195   BY   15,15                 /
           *2         14,29  0.0508  .03810   TO  179,194   **                         /
           *2         13,28  0.1412  .12355   TO  178,193   **                         /
           *2         12,27  0.0508  .03810   TO  162,177   **                         /
     **9    0.0       -1,-1  010     .0       0   -16,-16    0,0,0                     /
           *2          2,17  *2                                                        /
     */    SPAR ELEMENTS                                                               /
           SPAR     1   2  0.0695  0.201362  TO     3   4                              /
           *        4   5  0.0695  0.474579  TO    14  15                              /
           *       49  50  0.0701  0.477268  TO    59  60                              /
           *       97  98  0.0718  1.498695  TO   104 105                              /
           *      145 146  0.0720  0.205169  TO   149 150                              /
           *      193 194  0.0706  0.039597  TO   194 195                              /
           *        1  17  0.0706  0.039597  TO   177 193  BY  16  16                  /
     */    COVER ELEMENTS                                                              /
           COVER N1001  1 2 17     0.0696 0.0281 0. TO N1166 177 178 193
                  BY N15 16 16 16                                                      /
           COVER N1002  2 3 18 17 0.0696 0.0281 0. TO N1014  14  15  30  29           /
     **11     0      15 16 *=3     0.      0.      0.  0      14  15  *=3              /
   END ELEMENT DATA                                                                    /
END STIFFNESS DATA                                                                     /
*/                                                                                     /
BEGIN BC DATA                                                                          /
   STAGE 1                                                                             /
      RETAIN TZ FOR 1 TO 195                                                           /
      SUPPORT TX FOR 195                                                               /
      SUPPORT ASYM IN SURFACE 2 THROUGH 15                                             /
   STAGE 2                                                                             /
      SUPPORT ALL FOR 15 TO 195 BY 15                                                  /
END BC DATA                                                                            /
*/                                                                                     /
BEGIN MASS DATA                                                                        /
   BEGIN MASS ELEMENT DATA                                                             /
      SCALAR    F2    NODE002       2      .003                                        /
      SCALAR    F2    NODE003       3      .003                                        /
      SCALAR    F2    NODE004       4      .003                                        /
      SCALAR    F2    NODE005       5      .008                                        /
      SCALAR    F2    NODE006       6      .009                                        /
      SCALAR    F2    NODE007       7      .012                                        /
      SCALAR    F2    NODE008       8      .014                                        /
      SCALAR    F2    NODE009       9      .017                                        /
      SCALAR    F2    NODE010      10      .020                                        /
      SCALAR    F2    NODE011      11      .022                                        /
      SCALAR    F2    NODE012      12      .025                                        /
      SCALAR    F2    NODE013      13      .058                                        /
      SCALAR    F2    NODE014      14      .026                                        /
      SCALAR    F2    NODE015      15      .013                                        /
      SCALAR    F2    NODE017      17      .003                                        /
      SCALAR    F2    NODE033      33      .003                                        /
      SCALAR    F2    NODE049      49      .003                                        /
      SCALAR    F2    NODE050      50      .008                                        /
      SCALAR    F2    NODE051      51      .009                                        /
```

```
      SCALAR    F2    NODE052        52      .012                                      /
      SCALAR    F2    NODE053        53      .014                                      /
      SCALAR    F2    NODE054        54      .017                                      /
      SCALAR    F2    NODE055        55      .020                                      /
      SCALAR    F2    NODE056        56      .022                                      /
      SCALAR    F2    NODE057        57      .025                                      /
      SCALAR    F2    NODE058        58      .058                                      /
      SCALAR    F2    NODE059        59      .026                                      /
      SCALAR    F2    NODE060        60      .013                                      /
      SCALAR    F2    NODE065        65      .004                                      /
      SCALAR    F2    NODE081        81      .004                                      /
      SCALAR    F2    NODE097        97      .006                                      /
      SCALAR    F2    NODE098        98      .014                                      /
      SCALAR    F2    NODE099        99      .017                                      /
      SCALAR    F2    NODE100       100      .020                                      /
      SCALAR    F2    NODE101       101      .022                                      /
      SCALAR    F2    NODE102       102      .025                                      /
      SCALAR    F2    NODE103       103      .058                                      /
      SCALAR    F2    NODE104       104      .026                                      /
      SCALAR    F2    NODE105       105      .013                                      /
      SCALAR    F2    NODE113       113      .006                                      /
      SCALAR    F2    NODE129       129      .007                                      /
      SCALAR    F2    NODE145       145      .008                                      /
      SCALAR    F2    NODE146       146      .008                                      /
      SCALAR    F2    NODE147       147      .010                                      /
      SCALAR    F2    NODE148       148      .020                                      /
      SCALAR    F2    NODE149       149      .010                                      /
      SCALAR    F2    NODE150       150      .005                                      /
      SCALAR    F2    NODE161       161      .008                                      /
      SCALAR    F2    NODE177       177      .010                                      /
      SCALAR    F2    NODE193       193      .288                                      /
      SCALAR    F2    NODE194       194      .010                                      /
      SCALAR    F2    NODE195       195      .2445                                     /
   END MASS ELEMENT DATA                                                                 /
   BEGIN CONDITION DATA                                                                  /
      STAGE 1 CONDITION 1                                                                /
      PANEL DATA 1 CONDITION 2                                                           /
   END CONDITION DATA                                                                    /
   BEGIN PANEL DATA 1                                                                    /
      1  315 316 326 325   TO    6  BY   1 -1 **3                                        /
   **2 6   10  10  10  10    0    6   0   **5                                            /
      19  353 354 364 363  TO   22  **                                                   /
   **1 4   10  10  10  10    0    4   0   **5                                            /
      27  372 374 382 381  TO   28  BY   1 -2 -2 -1 -1                                   /
      29  380 382 390                                                                    /
   END PANEL DATA                                                                        /
   BEGIN LABEL DATA                                                                      /
      LEVEL1       ** TOTAL WING STRUCTURE      *                                        /
        EK10       ** COVER MATERIAL            *                                        /
        EK30       ** RIB MATERIAL              *                                        /
        LEVEL2     ** SPAR MATERIAL             *                                        /
          EK21     ** SPAR 1 (FS)               *                                        /
          EK22     ** SPAR 2                    *                                        /
          EK23     ** SPAR 3                    *                                        /
          EK24     ** SPAR 4                    *                                        /
          EK25     ** SPAR 5 (RS)               *                                        /
   END LABEL DATA                                                                        /
END MASS DATA                                                                            /
BEGIN LOADS DATA                                                                         /
   STAGE 2                                                                               /
   LOAD CASE ID AIRLOAD **PRESSURE LOAD ON ENTIRE WING SURFACE*                          /
   BEGIN ELEMENT LOAD DATA                                                               /
      CASE AIRLOAD                                                                       /
         DIRECTION GLOBAL 0. 0. 1.                                                       /
         1014 TO 1168 BY 14    .2                                                        /
         1013 TO 1167 BY 14    .15                                                       /
         1012 TO 1166 BY 14    .10                                                       /
   **10     -1  0  -15  0  0  -.01                                                       /
         1001                 .005                                                       /
   END ELEMENT LOAD DATA                                                                 /
END LOADS DATA                                                                           /
```

```
BEGIN SUBSET DEFINITION                                                         /
      SUBSETS OF STIFFNESS SET 1                                                /
      */  SUBSETS OF ALL STRUCTURAL NODES AND ELEMENTS                          /
          E1   = ALL                                                            /
          N1 = ALL                                                              /
          N2 = 300 TO 400                                                       /
          EXCLUDE N2 FROM N1                                                    /
      */  SUBSET OF ALL COVER ELEMENTS                                          /
          E10  = COVERS                                                         /
      */  SUBSETS OF ELEMENTS FOR THE WING SPARS                                /
          N21  = 1 TO 193 BY 16 194 195                                         /
          E21  = IN N21                                                         /
          E22  = SLAB  X  124.0                                                 /
      **3   1  0    0  0   24.0                                                 /
          N25 = NODES IN E25                                                    /
      */  SUBSET OF ALL WING SPARS                                              /
          E20  = E21 U E22 U E23 U E24 U E25                                    /
      */  SUBSET OF ALL SPAR ELEMENTS                                           /
          E100 = SPARS                                                          /
      */  SUBSET OF ALL WING RIBS                                               /
          E30  = E100                                                           /
          EXCLUDE  E20                                                          /
      */  RETAINED NODES ON SPAR 2                                              /
          N29 = 45 TO 60                                                        /
      */  BOUNDARY SUBSET FOR STRESS CONTOUR PLOTS                              /
          ON1 = 1 TO 15, 30 TO 195 BY 15, 194, 193 TO 17 BY -16                 /
      */  SUBSET FOR MODE SHAPE PLOT                                            /
          ON2 = 49 **11+1                                                       /
END SUBSET DEFINITION                                                           /
BEGIN FLUTTER DATA                                                              /
   CASE 1    ** NACA DELTA WING *                                               /
      ALTITUDE  500.0                                                           /
END FLUTTER DATA                                                                /
*/                                                                              /
BEGIN DUBLAT DATA                                                               /
   BEGIN GEOMETRY DATA                                                          /
      LIFTING SURFACE DATA                                                      /
      PANEL WING1  100.0 196.0 100.0 196.0 0. 16.0 0. 0.                        /
         CHORD DIV  0. 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0                  /
         SPAN  DIV  0. 1.0                                                      /
      PANEL WING2  100.0 196.0 190.0 196.0 16.0 112.0 0. 0.                     /
         CHORD DIV  0. 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0                  /
         SPAN  DIV  0. 0.1 0.2 0.3 0.4 0.5 0.57 0.64 0.7 0.75 0.8
                    0.85 0.88 0.92 0.95 0.98 1.0                                /
   END GEOMETRY DATA                                                            /
   BEGIN SUBSET DATA                                                            /
      SUBSETS OF BOXES                                                          /
         SUBSET SS 1 TO 170                                                     /
   END SUBSET DATA                                                              /
   BEGIN MODAL DATA                                                             /
      USE CMOD WITH LIFTING SURFACE SS                                          /
   END MODAL DATA                                                               /
END DUBLAT DATA                                                                 /
END PROBLEM DATA                                                                /
```

Table 202-1. Mass Comparison for Delta Wing

Experimental (ref. 202-1)	185.330 kg (408.583 lb)
ATLAS	185.298 kg (408.514 lb)

Table 202-2. Comparison of Natural Frequencies for Symmetric Modes of Delta Wing

(1)	Frequency (Hertz)		(4)
Mode	(2)	(3)	$\frac{(3)-(2)}{(2)} \times 100$
	Experimental (ref. 202-1)	ATLAS	(%)
1	43.3	47.7	10.2
2	88.8	91.4	2.9
3	122.8	127.5	3.8
4	164.2	169.0	2.9
5	179.7	191.4	0.9

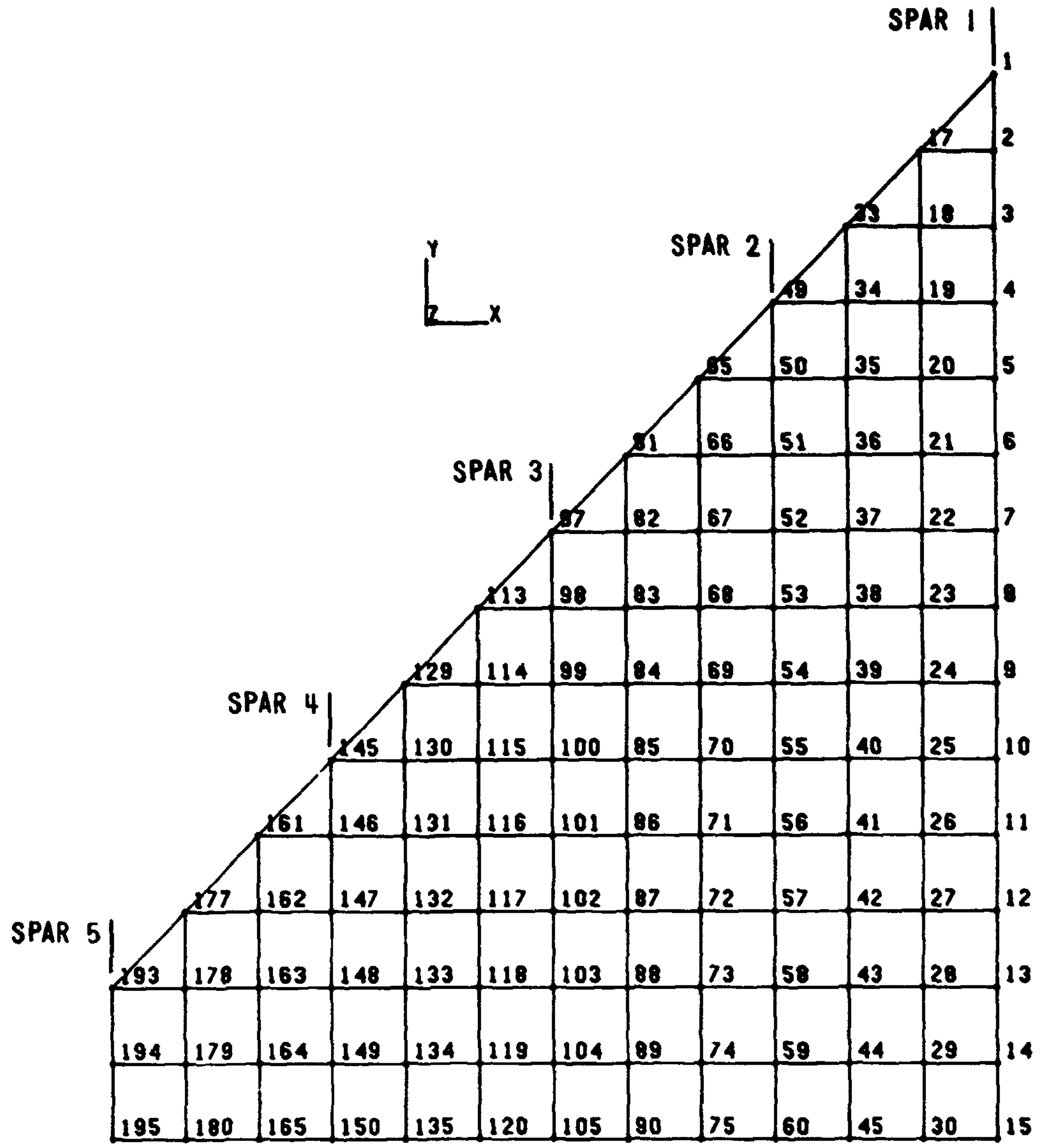
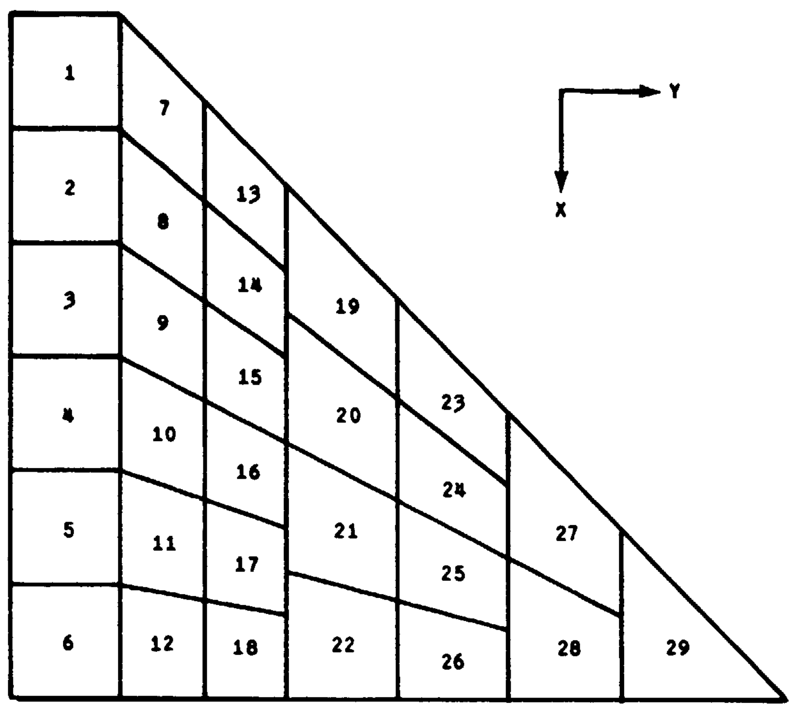


Figure 202-1. Delta Wing Structural Grid with Node Numbers



AIRLOAD PANELS

Figure 202-2. Delta Wing Weights Panels

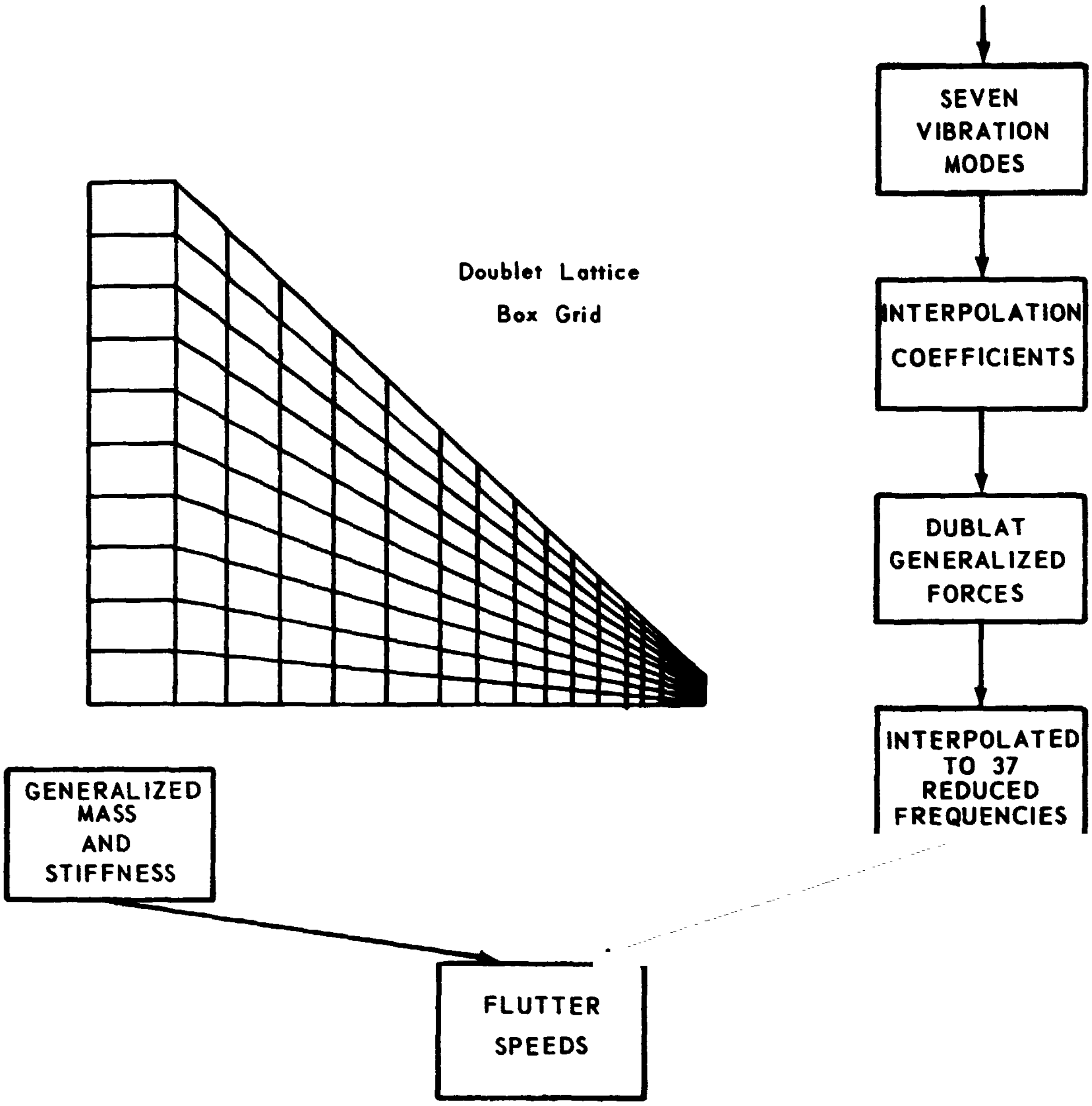


Figure 202-3. Flutter Analysis of Delta Wing

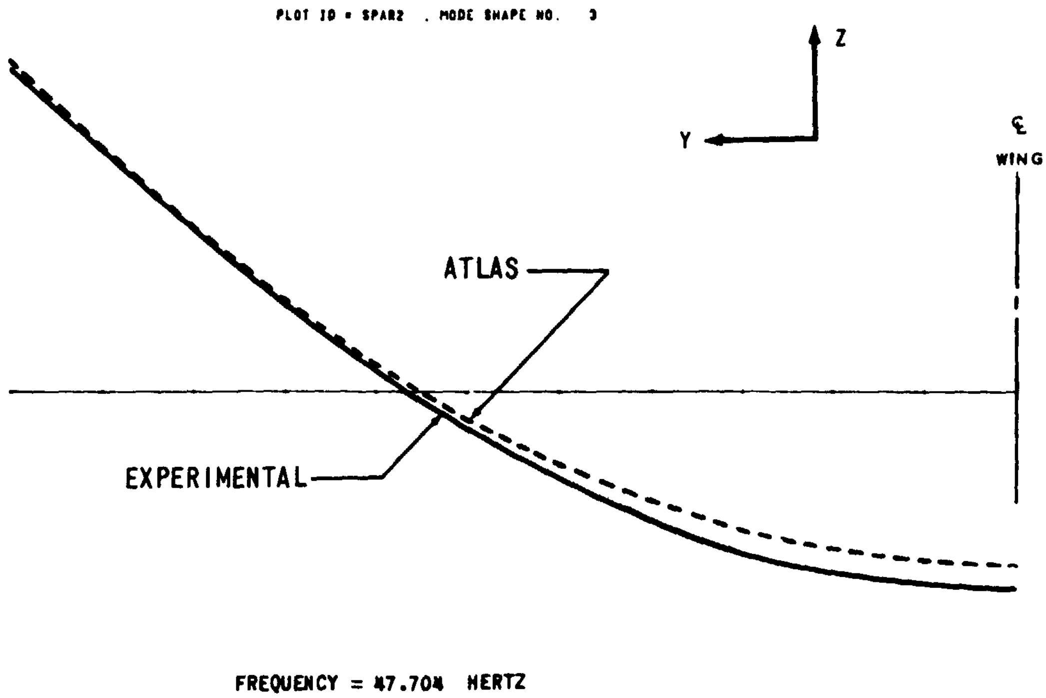


Figure 202-4. First Flexible Mode Shape along Spar 2 of Delta Wing

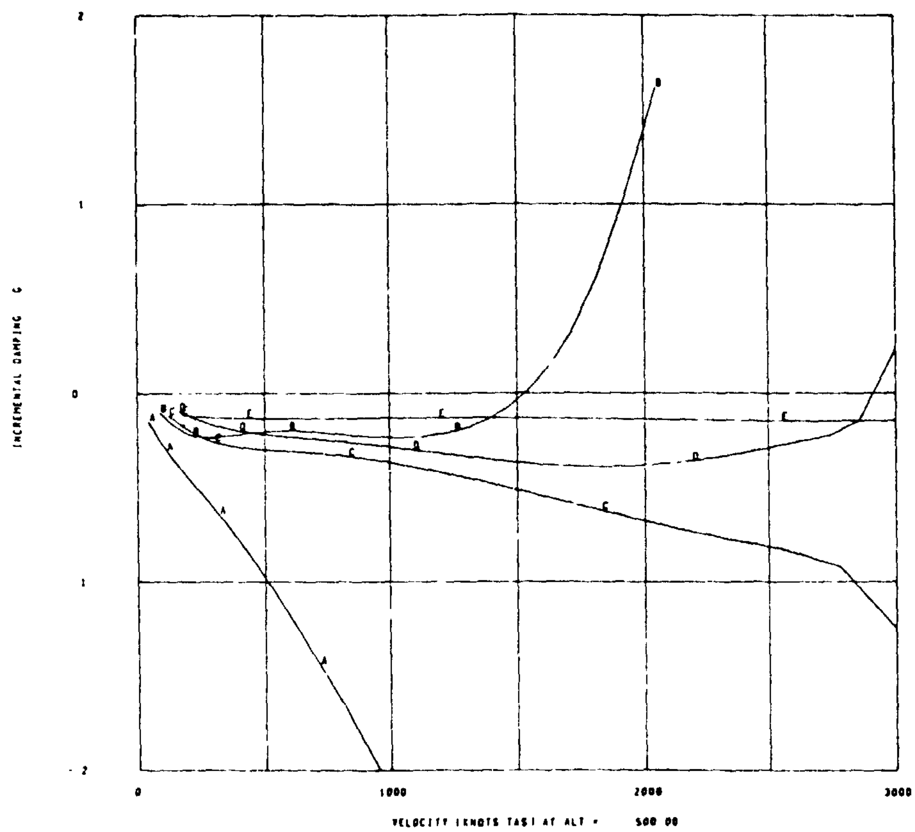


Figure 202-5. Flutter V-g Plot,Delta Wing

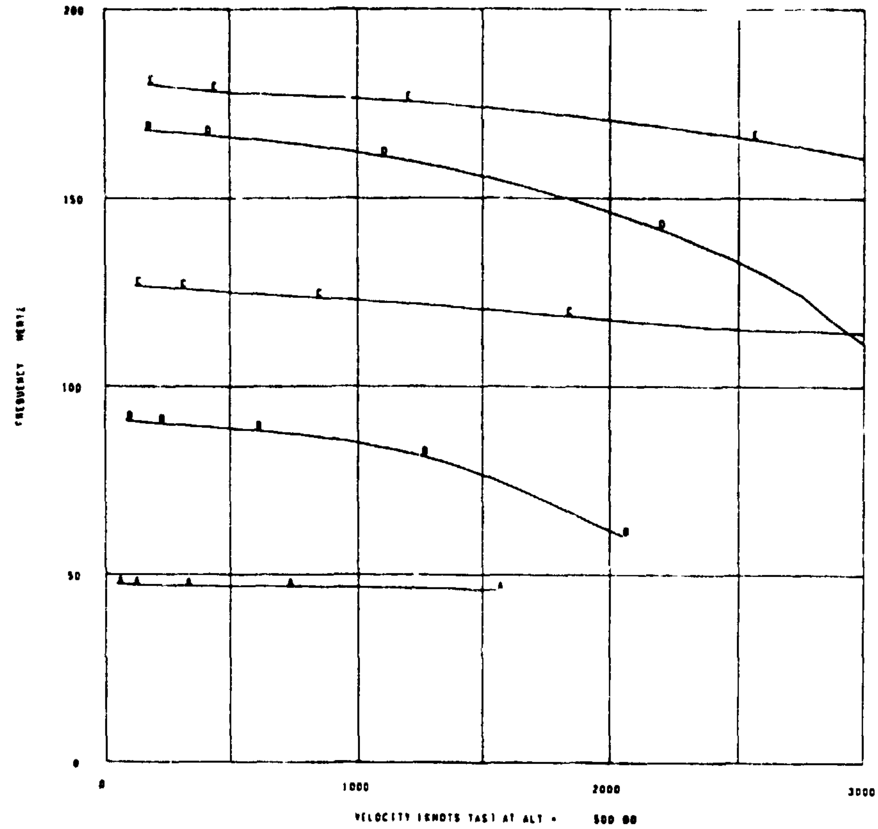


Figure 202-6. Flutter V-f Plot,Delta Wing

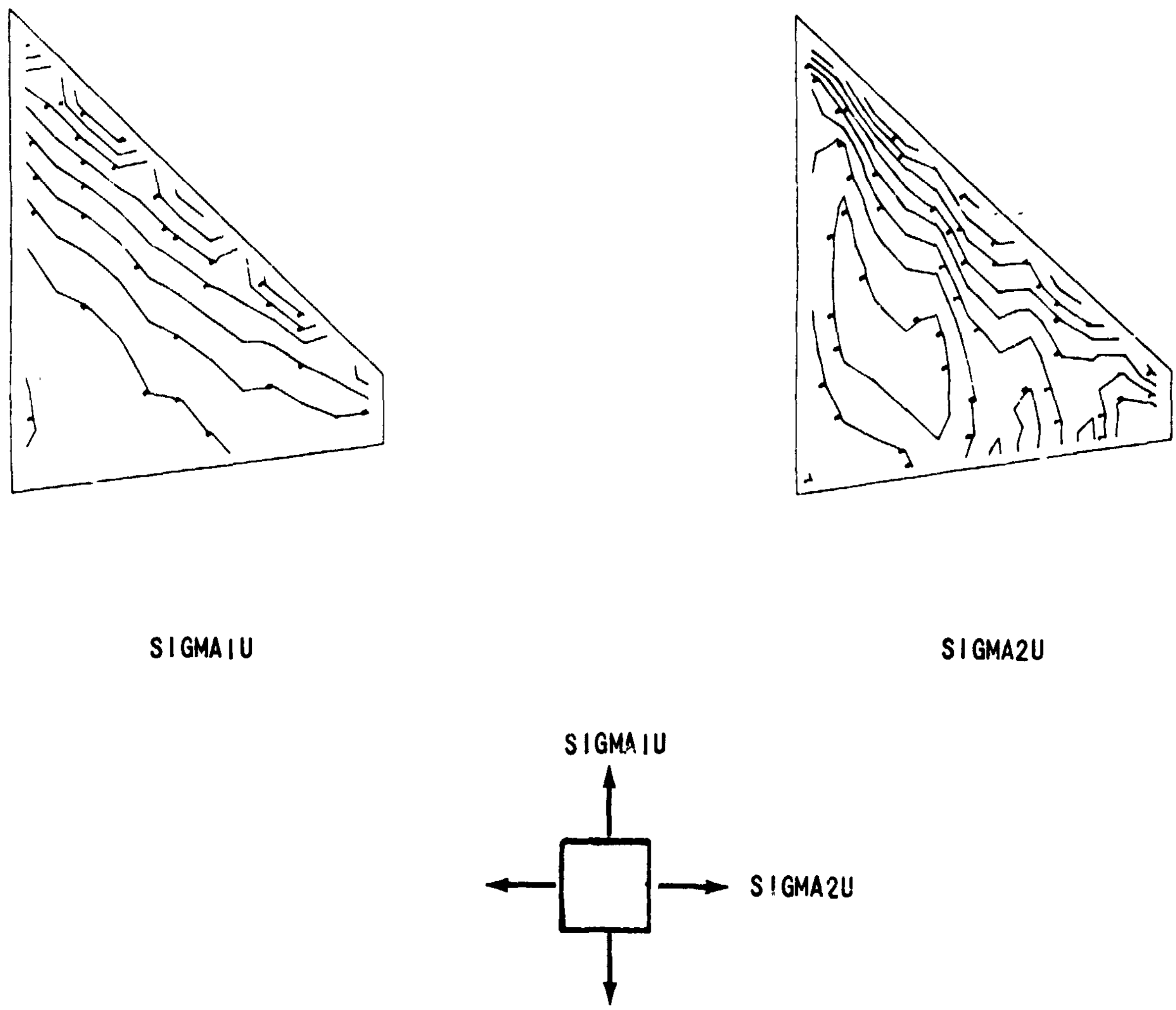


Figure 202-7. Delta Wing Upper Surface Stress Contours - Pressure Loading

203. STRESS AND VIBRATION ANALYSES OF AN SST AIRCRAFT (DECK 2)

203.1 DESCRIPTION OF ANALYSES

An SST aircraft is analyzed to obtain symmetric vibration modes and stresses due to pressure loads applied to the wings. Because of structural symmetry only one half of the aircraft is modelled.

The stiffness finite element model is shown in figure 203-1. Mid-surface nodes with SPAR and COVER elements are used for the wing, wing fin and horizontal tail. The body is modelled with BEAM elements the properties of which are shown in figure 203-2. Mass is obtained from the stiffness finite elements.

203.1.1 Vibration Analysis

Symmetric boundary conditions are applied in the plane Y=0. The degrees of freedom retained in the normal mode analysis are shown in figure 203-3. Rotational degrees of freedom are retained only at control surfaces. Rigid body translation in the X-direction is eliminated by supporting TX at the aftmost body node. The pitching and Z-translation rigid body modes are included in the analysis.

The analysis is performed using a reduced stiffness matrix and a reduced mass matrix obtained by Guyan reduction of the merged elemental mass matrices.

203.1.2 Stress Analysis

Symmetric boundary conditions are applied in the plane Y=0. Rigid body motions are eliminated by supporting X and Z-direction translations and rotation about the Y axis at the aftmost body node. The pressure loading is simulated with nodal loads.

203.2 RESULTS

Natural frequencies of the first eight modes are given in table 203-1. The third mode shape is shown in figure 203-4; this is the first flexible mode.

203.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO02
      PROBLEM ID(DEMO02 - STRESS/VIBRATION ANALYSES OF AN SST)
C
C     PURPOSE       THE PRINCIPAL CAPABILITIES DEMONSTRATED BY
C                   THIS DECK ARE
C                      1. STRESS ANALYSIS
C                      2. NORMAL MODE ANALYSIS
C                      3. ELEMENT PROPERTY PLOTS
C                      4. VIBRATION MODE SHAPE PLOTS
C
C     AUTHOR        R.A. SAMUEL
C
C     CORE          150K (OCTAL)
C
C     METHOD        THE RESULTS OBTAINED FROM THIS DECK SHOULD BE THE
C                   SAME AS THOSE FROM DECK DEMO01.
C
C
      READ INPUT
      PRINT INPUT (NODAL)
      PRINT INPUT(STIFFNESS)
      EXECUTE EXTRACT(EXNAME=GEOM,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOMETRY,OFFLINE=CALCOMP,TYPE=(ORTH,
     X                     POINT),SIZE=(20.,20.),RZ=30.,RX=0.,RY=20.,
     X                 EXNAME=GEOM)
      EXECUTE EXTRACT(EXNAME=PROPS,LSUB=KPROP,ESUB=E2,NSUB=N2)
      EXECUTE GRAPHICS(GNAME=BODY,TYPE=ORTH,SIZE=(10,10),
     X                 SCALAR=BMIZ(1),SSCALE=.002,EXNAME=PROPS)
      EXECUTE GRAPHICS(GNAME=BODY,TYPE=ORTH,SIZE=(10,10),
     X                 SCALAR=BMA(1),SSCALE=5.,EXNAME=PROPS)
      PERFORM REDUCE
      PRINT INPUT(BC)
      EXECUTE VIBRATION (STIF=KRED,MASS=MRED,NFREQS=8)
      PRINT OUTPUT (VIBRATION)
      EXECUTE EXTRACT(EXNAME=MODE3,LSUB=VMODE,VSET=1,MODE=3,BSUB=ON1)
      EXECUTE GRAPHICS(GNAME=VMODES,TYPE=ORTH,SIZE=(20,20),
     X                 RX=0.,RZ=20.,RY=20.,VECTOR2=VMODE,VSCALE=100.,
     X                 EXNAME=MODE3)
     PURGE FILES(STIFRNF,MERGRNF,MASSRNF,MULTRNF,CHOLRNF,VIBRRNF)
     PERFORM STRESS(STAGE=2)
     PRINT INPUT(BC,STAGE=2)
     PRINT OUTPUT(LOADS,STAGE=2)
     PRINT OUTPUT(STRESS,STAGE=2)
     PRINT OUTPUT(DISP,STAGE=2)
     PRINT OUTPUT(REACTIONS,STAGE=2,EQCHK)
     END CONTROL PROGRAM
```

```
*/ MODE2 /
  BEGIN NODAL DATA
*/
*/ BODY NODES
*/
           1   20.     0.   0.         TO    25   9[illegible].    0.   0.         BY  2
          27  1060.    0.   0.   30.0  TO    45  1780.    0.   0.   42.5  BY  2
   **1   200     0.   65.   0.    0.    0   200     0.   65.              **
          45                           TO    55  2180.    0.   0.   31.0  BY  2
   **1   200                            0   200     0.   65.              **
          55                           TO    63  2500.    0.   0.   13.5  BY  2
   **1   200                            0   200     0.   65.              **
          65  2580.    0.   0.         TO    77  3060.    0.   0.         BY  2
          79  3140.    0.   0.    3.0
   **1   200     0.   65.         **
          81  3220.    0.   0.    6.5
   **1   200     0.   65.         **
          83  3300.    0.   0.    7.0
   **1   200     0.   65.         **
          85  3380.    0.   0.    2.0
   **1   200     0.   65.         **
          87  3460.    0.   0.
          89  3540.    0.   0.
*/
*/ WING NODES
*/
         427  1060.   65.   0.   30.0  TO   435  1380.  180.  0.   17.5  BY  2
         435                           TO   445  1780.  180.  0.   27.5  BY  2
         445                           TO   455  2180.  180.  0.   25.0  BY  2
         455                           TO   463  2500.  180.  0.   13.0  BY  2
         635  1380.  180.   0.   17.5  TO   641  1620.  265.  0.   10.0  BY  2
         641                           TO   655  2180.  265.  0.   22.5  BY  2
         655                           TO   663  2500.  265.  0.   12.5  BY  2
         841  1620.  265.   0.   10.0  TO   847  1971.  380.  0.    9.0  BY  2
         847                           TO   855  2291.  380.  0.   17.0  BY  2
         855                           TO   863  2611.  380.  0.   10.0  BY  2
        1047  1971.  380.   0.    9.0  TO  1051  2205.  455.  0.    8.5  BY  2
        1051                           TO  1059  2525.  455.  0.   15.0
        1059                           TO  1063  2685.  455.  0.    8.0
        1251  2205.  455.   0.    8.5  TO  1254  2409.  538.  0.    6.5
        1254                           TO  1259  2609.  538.  0.   11.0
        1259                           TO  1263  2769.  538.  0.    5.5
        1454  2409.  538.   0.    6.5  TO  1456  2545.  594.  0.    5.0
        1456                           TO  1459  2665.  594.  0.    7.5
        1459                           TO  1463  2825.  594.  0.    3.5
        1656  2545.  594.   0.    5.0  TO  1658  2710.  680.  0.    3.0
        1658                           TO  1663  2910.  680.  0.    3.0
        1858  2710.  680.   0.    3.0  TO  1860  2875.  765.  0.    1.5
        1860                           TO  1863  2995.  765.  0.    2.5
*/
*/ WING TRAILING EDGE NODES
*/
        3001  2500.   65.   0.   13.5  TO  3005  2580.   65.  0.    1.0   BY 2
        3101  2500.  180.   0.   13.0  TO  3105  2580.  180.  0.    1.0   **
        3201  2500.  265.   0.   12.5  TO  3205  2580.  265.  0.    1.0   **
        3305  2830.  538.   0.    1.0  TO  3605  3045.  765.  0.    1.0
                                         BY 100 OF 56. 86. 85.
*/
*/ WING FIN NODES
*/
      REC  WINGFIN 0. 594. 0., 1. 594. 0., 0. -1. 0.
        2056  2545.      .1 0.    3.5  TO  2456  2830.  100.  0.    2.5  BY  200
        2058  2625.      .1 0.    3.5  TO  2458  2842.  100.  0.    3.0  **
        2061  2745.      .1 0.    4.0  TO  2461  2859.  100.  0.    3.0  **
        2063  2825.      .1 0.    4.0  TO  2463  2870.  100.  0.    3.0  **
*/
*/ HORIZONTAL TAIL NODES
*/
      RESUME GLOBAL
         279                           TO   679  3365.  200.  0.    2.0  BY  200
         281                           TO   681  3388.  200.  0.    2.5  **
         283                           TO   683  3412.  200.  0.    2.5  **
         285                           TO   685  3435.  200.  0.    1.0  **
  END NODAL DATA
```

```
BEGIN STIFFNESS DATA
  BEGIN PROPERTY DATA
      P1    .05    1.     *(WING FIN SPARS AND RIBS)
      P2   2.      0.    0.   .2   .2   .2 *(WING FIN ATTACHMENT BEAMS - TYPE 1)
      P3  10.      0.    0. 100. 100. 100. *(WING FIN ATTACHMENT BEAMS - TYPE 2)
      P4    .15   .50                      *(CONTROL SURFACE RIBS)
      P5   0.   *=2 100. 100.   0. 10. *(BEAMS AT 455 RIB TO PICK UP SPARS)
  END PROPERTY DATA
  BEGIN ELEMENT DATA
*/
*/ WING  FRONT  SPAR
*/
      SPAR   M5  N2003      227  429       .12   2.
       *2        N2205      429  431       .12   2.  TO  N2605      433  435       +
                                                     BY  N200         2    2
       *2        N2805      435  637       .12   2.
       *2        N3007      637  639       .12   2.  TO  N3207      639  641       +
                                                     BY  N200         2    2
       *2        N3407      641  843       .12   2.
       *2        N3609      843  845       .12   2.  TO  N3809      845  847       +
                                                     BY  N200         2    2
       *2        N4009      847 1049       .12   2.
       *2        N4211     1049 1051             **
       *2        N4411     1051 1253             **
       *2        N4613     1253 1254             **
       *2        N4713     1254 1455             **
       *2        N4815     1455 1456             **
       *2        N4915     1456 1657             **
       *2        N5017     1657 1658             **
       *2        N5117     1658 1859             **
       *2        N5219     1859 1860             **
*/
*/ WING REAR SPAR
*/
      SPAR   M5  N5603      263  463       .40  12.
       *2        N5605      463  663       .40  12.
       *2        N5607      663  863       .34  12.
       *2        N5609      863 1063       .34  12.
       *2        N5611     1063 1263       .30   8.
       *2        N5613     1263 1463       .30   8.
       *2        N5615     1463 1663       .30   4.
       *2        N5617     1663 1863       .30   4.
*/
*/ WING INTERMEDIATE SPARS
*/
      SPAR   M5  N2203      229  429       .20   2.  TO  N3603      243  443       +
                                                     BY  N200         2    2
       *2        N3803      245  445       .36   2.
       *2        N4803      255  455       .60  12.
       *2        N5003      257  457       .24  12.  TO  N5403      261  461       +
                                                     BY  N200         2    2
       *2        N3005      437  637       .20   2.  TO  N3605      443  643       +
                                                     BY  N200         2    2
       *2        N3805      445  645       .36   2.
       *2        N4005      447  647       .20   4.  TO  N4605      453  653       +
                                                     BY  N200         2    2
       *2        N4805      455  655       .60  12.
       *2        N5005      457  657       .24  12.  TO  N5405      461  661       +
                                                     BY  N200         2    2
       *2        N3607      643  843       .20   2.  TO  N3807      645  845       +
                                                     BY  N200         2    2
       *2        N4007      647  847       .20   4.  TO  N4607      653  853       +
                                                     BY  N200         2    2
       *2        N4807      655  855       .20   8.
       *2        N5007      657  857       .20  10.  TO  N5407      661  861       +
                                                     BY  N200         2    2
       *2        N4209      849 1049       .20   4.  TO  N4609      853 1053       +
                                                     BY  N200         2    2
       *2        N4809      855 1055       .20   8.
       *2        N5009      857 1057       .20  10.  TO  N5409      861 1061       +
                                                     BY  N200         2    2
       *2        N4611     1053 1253       .12   4.  TO  N4811     1055 1255       +
                                                     BY  N100         1    1
```

```
     *2          N4911     1056 1256        .06    4.  TO  N5511     1062 1262        +
                                                       BY  N100         1    1
     *2          N4813     1255 1455        .12    4.
     *2          N4913     1256 1456        .06    4.  TO  N5513     1262 1462        +
                                                       BY  N100         1    1
     *2          N5015     1457 1657        .06    2.  TO  N5515     1462 1662        +
                                                       BY  N100         1    1
     *2          N5217     1659 1859        .06    2.  TO  N5517     1662 1862        +
                                                       BY  N100         1    1
*/
*/ WING IN-BODY SPARS
*/
    SPAR    M5   N2001       27  227       1.00   10.  TO  N3601       43  243        +
                                                       BY  N200         2    2
     *2          N3801       45  245       1.80   10.  TO  N4601       53  253        +
                                                       BY  N200         2    2
     *2          N4801       55  255       3.00   60.
     *2          N5001       57  257       1.20   60.  TO  N5401       61  261        +
                                                       BY  N200         2    2
     *2          N5601       63  263       2.00   60.
*/
*/ WING RIBS
*/
    SPAR    M5   N6001      227  229        .25    4.  TO  N6035      261  263        +
                                                       BY  N2           2    2
     *2          N6109      436  437        .30    4.  TO  N6135      461  463        +
                                                       BY  N2           2    2
     *2          N6215      641  643        .20    3.  TO  N6235      661  663        +
                                                       BY  N2           2    2
     *2          N6425     1051 1053        .20    4.
     *2          N6426     1053 1054        .20    4.  TO  N6435     1062 1063
     *2          N6629     1456 1457        .12    2.  TO  N6635     1462 1463
     *2          N6833     1860 1861        .30    1.4 TO  N6835     1862 1863
*/
*/ WING COVERS
*/
    COVER   M5   N7003      229  429  227          .06
     *2          N7203      229  429  431  231     .06                         TO     +
                 N8603      243  443  445  245         BY  N200      2    *=3
     *2          N8803      245  445  447  247     .12  .00                    TO     +
                 N9603      253  453  455  255         BY  N200      2    *=3
     *2          N9803      255  455  457  257     .10  .14
     *2          N10003     257  457  459  259           **
     *2          N10203     259  459  461  261     .26  .14  .22  .00
     *2          N10403     261  461  463  263           **
     *2          N7805      437  637  435          .06
     *2          N8005      437  637  639  439     .06                         TO     +
                 N9605      453  653  655  455         BY  N200      2    *=3
     *2          N9805      455  655  657  457     .10  .14
     *2          N10005     457  657  659  459           **
     *2          N10205     459  659  661  461     .26  .14  .22  .00
     *2          N10405     461  661  663  463           **
     *2          N8407      643  843  641          .06
     *2          N8607      643  843  845  645     .06                         TO     +
                 N9607      653  853  855  655         BY  N200      2    *=3
     *2          N9807      655  855  857  657     .10  .08
     *2          N10007     657  857  859  659           **
     *2          N10207     659  859  861  661     .30  .14  .20  .00
     *2          N10407     661  861  863  663           **
     *2          N9009      849 1049  847          .06
     *2          N9209      849 1049 1051  851     .06                         TO     +
                 N9609      853 1053 1055  855         BY  N200      2     *=3
     *2          N9809      855 1055 1057  857     .10  .08
     *2          N10009     857 1057 1059  859           **
     *2          N10209     859 1059 1061  861     .30  .14  .20  .00
     *2          N10409     861 1061 1063  863           **
     *2          N9411     1053 1253 1051          .30  .14  .22  .12
     *2          N9611     1053 1253 1254 1054     .30  .14  .22  .12          TO     +
                 N10511    1062 1262 1263 1063         BY  N100      1     *=3
     *2          N9713     1255 1455 1254          .30  .14  .22  .12
     *2          N9813     1255 1455 1456 1256     .30  .14  .22  .12          TO     +
                 N10513    1262 1462 1463 1263         BY  N100      1     *=3
```

```
         *2         N9915      1457 1657 1456           .08
         *2         N10015     1457 1657 1658 1458      .08                              TO        *
                    N10515     1462 1662 1663 1463           BY   N100      1       *=3
         *2         N10117     1659 1859 1658           .08
         *2         N10217     1659 1859 1860 1660      .08                              TO        *
                    N10517     1662 1862 1863 1663           BY   N100      1       *=3
*/
*/ WING IN-BODY COVERS
*/
       COVER  M5    N7001        27  227  229   29      .30                              TO        *
                    N8601        43  243  245   45           BY   N200      2       *=3
         *2         N8801        45  245  247   47      .60                              TO        *
                    N9601        53  253  255   55           BY   N200      2       *=3
         *2         N9801        55  255  257   57      .70
         *2         N10001       57  257  259   59      .70
         *2         N10201       59  259  261   61     1.30   .70 1.10   .00
         *2         N10401       61  261  263   63             **
*/
*/ WING FIN SPARS
*/
       SPAR   M5    N11001     2056 2256           P1
         *2         N11003     2256 2456           *
         *2         N11201     2058 2258           *
         *2         N11203     2258 2458           *
         *2         N11501     2061 2261           *
         *2         N11503     2261 2461           *
         *2         N11701     2063 2263           *
         *2         N11703     2263 2463           *
*/
*/ WING FIN RIBS
*/
       SPAR   M5    N12001     2256 2258           P1
         *2         N12003     2258 2261           *
         *2         N12005     2261 2263           *
         *2         N12201     2456 2458           *
         *2         N12203     2458 2461           *
         *2         N12205     2461 2463           *
*/
*/ WING FIN COVERS
*/
       COVER  M5    N13001     2056 2256 2258 2058      .05
         *2         N13003     2058 2258 2261 2061       *
         *2         N13005     2061 2261 2263 2063       *
         *2         N13201     2256 2456 2458 2258       *
         *2         N13203     2258 2458 2461 2261       *
         *2         N13205     2261 2461 2463 2263       *
*/
*/ WING FIN ATTACHMENT BEAMS
*/
       BEAM   Z5    N20001     1456 2056 1463  P2
         *2         N20003     1458 2058 1463  *
         *2         N20005     1461 2061 1463  *
         *2         N20007     1463 2063 1461  *
         *2         N21001     1456 1458       P3
         *2         N21003     1458 1461       *
         *2         N21005     1461 1463       *
*/
*/ WING TRAILING EDGE CONTROL SURFACE RIBS
*/
       SPAR   M5    N101        263 3003           P4
    *+2   0    0       2        200  100           0
         *2         N102       3003 3005           *
    *+2   0    0       2        100  100           0
         *2         N107       1263 3305           *
    *+3   0    0       1        200  100           *
*/
*/ WING TRAILING EDGE CONTROL SURFACE COVERS
*/
       COVER  M5    N151        263  463 3103 3003      .10
         *2         N153        463  663 3203 3103       *
         *2         N152       3003 3103 3105 3005       *
         *2         N154       3103 3203 3205 3105       *
         *2         N155       1263 1463 3405 3305       *
    *+2   0    0       1        200  200  100  100       *
```

```
*/
*/ HORIZONTAL TAIL SPARS
*/
      SPAR  M5   N14003     279  479      .10   1.2
       *2        N14005     479  679             **
       *2        N14103     281  481      .05   1.8
       *2        N14105     481  681             **
       *2        N14203     283  483      .05   1.6
       *2        N14205     483  683             **
       *2        N14303     285  485      .20   2.6
       *2        N14305     485  685             **
*/
*/ HORIZONTAL TAIL RIBS
*/
      SPAR   M5  N14401     279  281      .15   2.0 TO  N14405   283  285      +
                                                    BY  N2         2    2
       *2        N14501     479  481      .10   1.2 TO  N14505   483  485      +
                                                    BY  N2         2    2
       *2        N14601     679  681      .10   1.2 TO  N14605   683  685      +
                                                    BY  N2         2    2
*/
*/ HORIZONTAL TAIL IN-BODY SPARS
*/
      SPAR   M5  N14001      79  279      .50   6.0
       *2        N14101      81  281      .25   9.0
       *2        N14201      83  283      .25   8.0
       *2        N14301      85  285     1.00  13.0
*/
*/ HORIZONTAL TAIL COVERS
*/
      COVER  M5  N15003     279  479  481  281  .16
   *+2   0   0      200       2  *=3            0.
      COVER  M5  N15005     479  679  681  481  .07
   *+2   0   0      200       2  *=3            0.
*/
*/ HORIZONTAL TAIL IN-BODY COVERS
*/
      COVER  M5  N15001      79  279  281   81  .80                  TO        +
                 N15401      83  283  285   85       BY  N200    2   *=3
*/
*/ BODY BEAMS
*/
      BEAM   M5  N1001        1    3   5.   0.  *=3  16000.  10. 0. *=3  30000.
   *+30  0   0        2       2    2   5.       *4   14000.   5.    *4   14000.
       *2        N1063       63   65 160.       *4  450000. 148.    *4  416000.
   *+12  0   0        2       2    2 -12.       *4  -34000. -12.    *4  -34000.
*/
*/ BEAMS AT 455 RIB TO PICK UP DISCONTINUED SPARS
*/
      BEAM   M5  N30002    1053 1054         P5
   *+4   0   0        2       2    2         *
      BEAM   M5  N30011    1063 1062         P5
   *+4   0   0       -2      -2   -2         *
  END ELEMENT DATA
END STIFFNESS DATA
BEGIN MASS DATA
 BEGIN MASS ELEMENT DATA
      BEAM  1456 2056 1463 .1 .1 *=3
      BEAM 1458 2058 1463 **
      BEAM 1461 2061 1463 **
      BEAM 1463 2063 1461 **
  END MASS ELEMENT DATA
END MASS DATA
BEGIN BC DATA
  STAGE 1      *(FOR VIBRATION ANALYSIS)
      ORDER RETAIN BY INTERNALID
      SUPPORT ASYM IN SURFACE 2
      SUPPORT TX FOR 89
      RETAIN TZ FOR 1 7 13 19 27 45 55 63 67 73 79 85 89
      RETAIN TZ FOR 227 237 245 255 435 441 445 451 455
      RETAIN TZ FOR 641 645 649 655 659 847 851 855 859 863 1051 *=3+4
      RETAIN TZ FOR 1254 1259 1456 1459 1658 1661 1859 1860 1861
```

```
        RETAIN TZ FOR 3003 3005 3103 3105 3203 3205
        RETAIN TZ FOR 3305 3405 3505 3605
        RETAIN TZ FOR 279 479 679
        RETAIN TY FOR 2058 2061 2258 2261 2458 2461
        RETAIN TZ RX RY FOR 263 463 663 1263 1463 1663 1863 285 485 685 83 +
              283 483 683
     STAGE 2       *(FOR STRESS ANALYSIS )
        SUPPORT ASYM IN SURFACE 2
        SUPPORT TX TZ RY FOR 89
  END BC DATA
  BEGIN LOAD DATA
    SET 1 STAGE 2
    LOAD CASE ID SYMM **SYMMETRIC AIRLOADS*
    BEGIN NODAL LOAD DATA
      ORDER FZ
      CASE SYMM
           3    -2275.
           9    -6110.
          15    -4970.
          23    -3255.
          31     -245.
          39    -5400.
          45     -380.
          53    -3830.
          61      140.
          67     -165.
          75    -6365.
          83    -3495.
          87    -3160.
          85     -150.
          89     -150.
      ORDER FZ FY
        2056     -125.      1220.
        2456     -100.      1360.
        2458     -100.      -410.
        2058     -125.       955.
        2061     -125.      1075.
        2461     -100.      7665.
        2463     -100.     -4960.
        2063     -125.      -660.
      ORDER FZ
         431    13475.
         231    -8500.
         637     8030.
         237    -7750.
         245   -11770.
         655    -4640.
         255    -5330.
         663     1565.
         263     5445.
         843    36405.
         645   -20790.
        1051    21130.
         649     3435.
        1055     3365.
        1063     1435.
        1456    13820.
        1459    21815.
        1463     6155.
        1860      860.
        1861    14395.
        1863     2762.
         659     -450.
        1059    -8710.
        1461   -10695.
        1862    -5190.
         279    -5060.
         679    -4040.
         681    -7375.
         281    -5415.
         283    -1620.
```

```
      683     -865.
      685     -1725.
      285     -3425.
    END NODAL LOAD DATA
END LOAD DATA
BEGIN SUBSET DEFINITION
  SUBSETS  OF STIFFNESS SET 1
    */ SUBSETS FOR GEOMETRY PLOTS
      E1 = ALL
      N1 = ALL
    */ SUBSETS FOR BODY PROPERTY PLOTS
      N2 = 1 TO 89
      E2 = BEAMS IN N2
    */ SUBSETS FOR STRESS CONTOUR PLOTS
      N10 = TUBE 227 1860 1863 *=8-200 DIRECTION 0 0 1
      N11 = SLAB Z 0.
      N12 = N10 I N11
      E12 = COVERS IN N12
      ON2 = 227  435  641  847 1051 1254 1456 1658 1859 *=4+1                 +
              *=8-200 *=17-2
    */ SUBSET FCR VMODE PLOT
      ON1 =   1    7   13   19   27  227  237  245  255  263 3003 3005        +
           3105 3103  463  455  451  445  441  435  641  645  649  655        +
            659  663 3203 3205 3105 3103  463  663  863  859  855  851        +
            847 1051 1055 1059 1063 1263 1259 1254 1456 1459 1463 3405        +
           3305 1263 1463 1663 1661 1658 1859 1860 1861 1863 3605 3505        +
           3405 3505 1663 1863 1861 1860 1859 1658 1456 1254 1051  847        +
            641  435  227   27   45   55   63  263  463  663  863 1063        +
           1263 1463 1459 2058 2258 2458 2461 2261 2258 2261 2061 1463        +
           1263 1063  863  663  463  263   63   67   73   79   83   85        +
             89   85  285  485  685  583  679  479  279   79   83   85        +
            285  283  279  479  483  485
END SUBSET DEFINITION
END PROBLEM DATA
```

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OF POOR QUALITY

Table 203-1. Natural Frequencies for SST Aircraft

Mode No.	Frequency (Hertz)
1	0.
2	0.
3	2.754
4	3.627
5	5.428
6	7.595
7	9.444
8	10.768

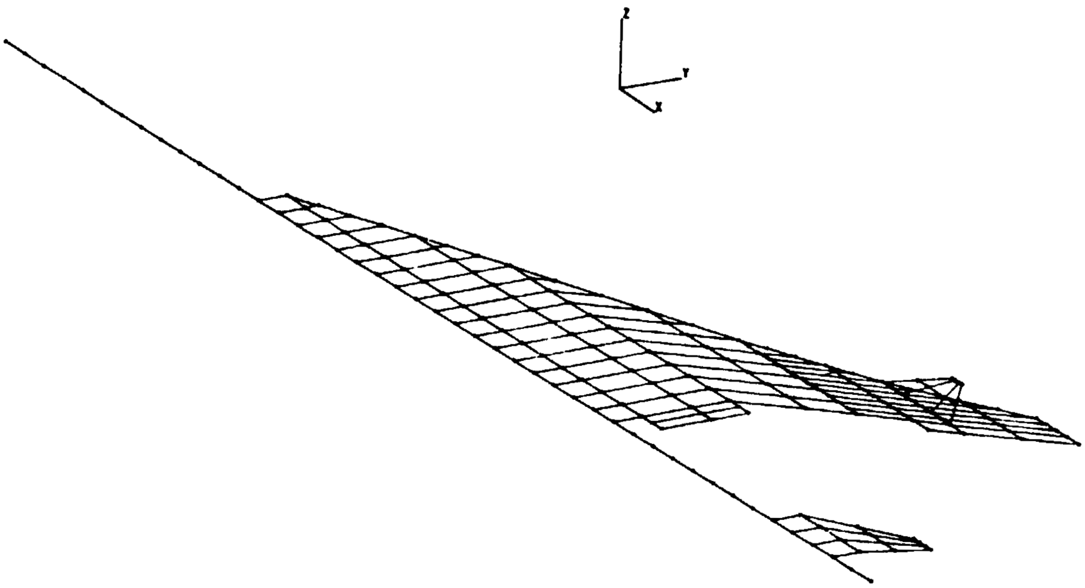
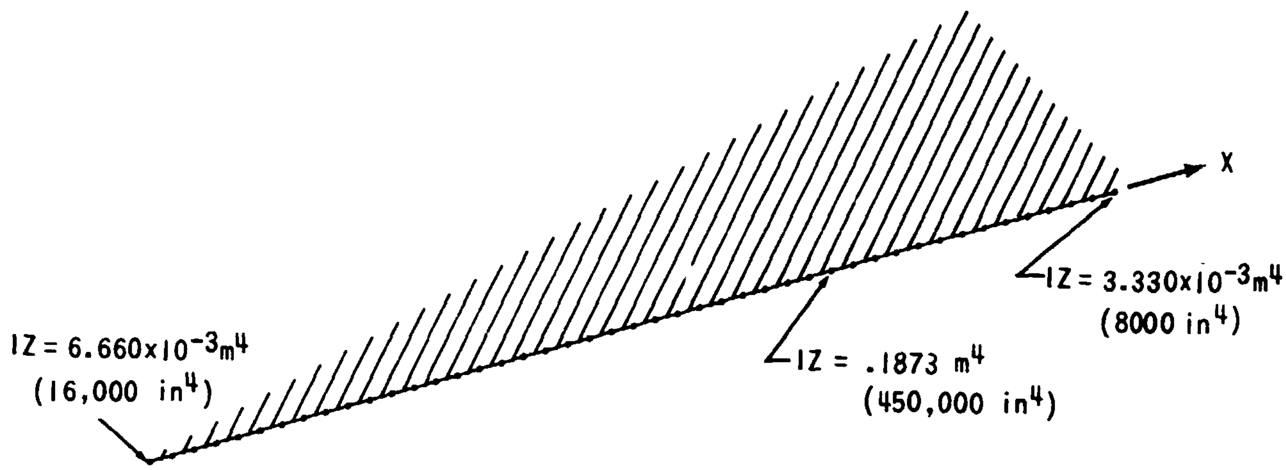


Figure 203-1. SST Structural Model

PROPERTY BMA(1)



PROPERTY BMIZ(1)

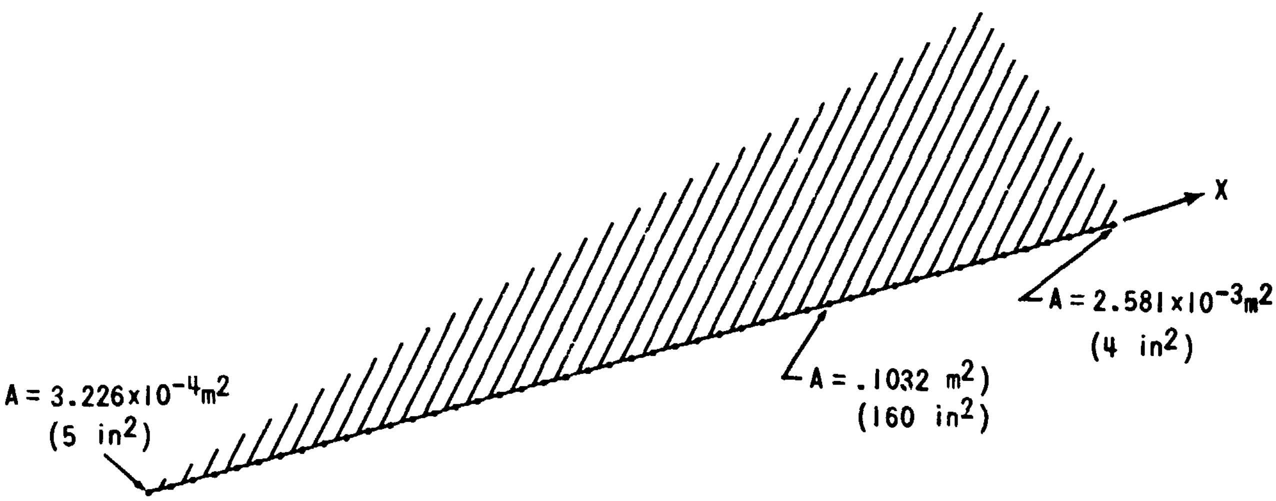


Figure 203-2. SST Body Stiffness Properties

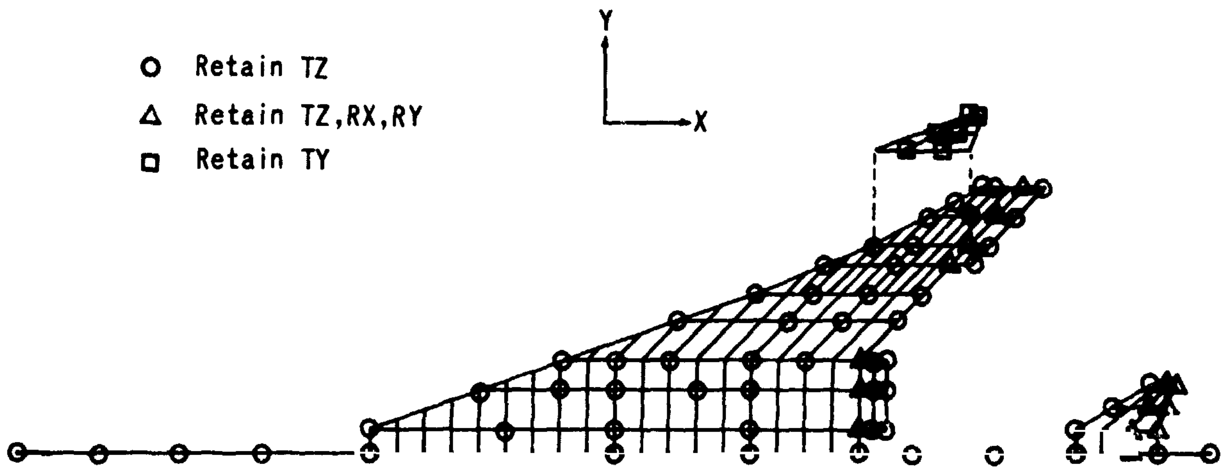


Figure 203-3. Freedoms Retained in SST Vibration Analysis

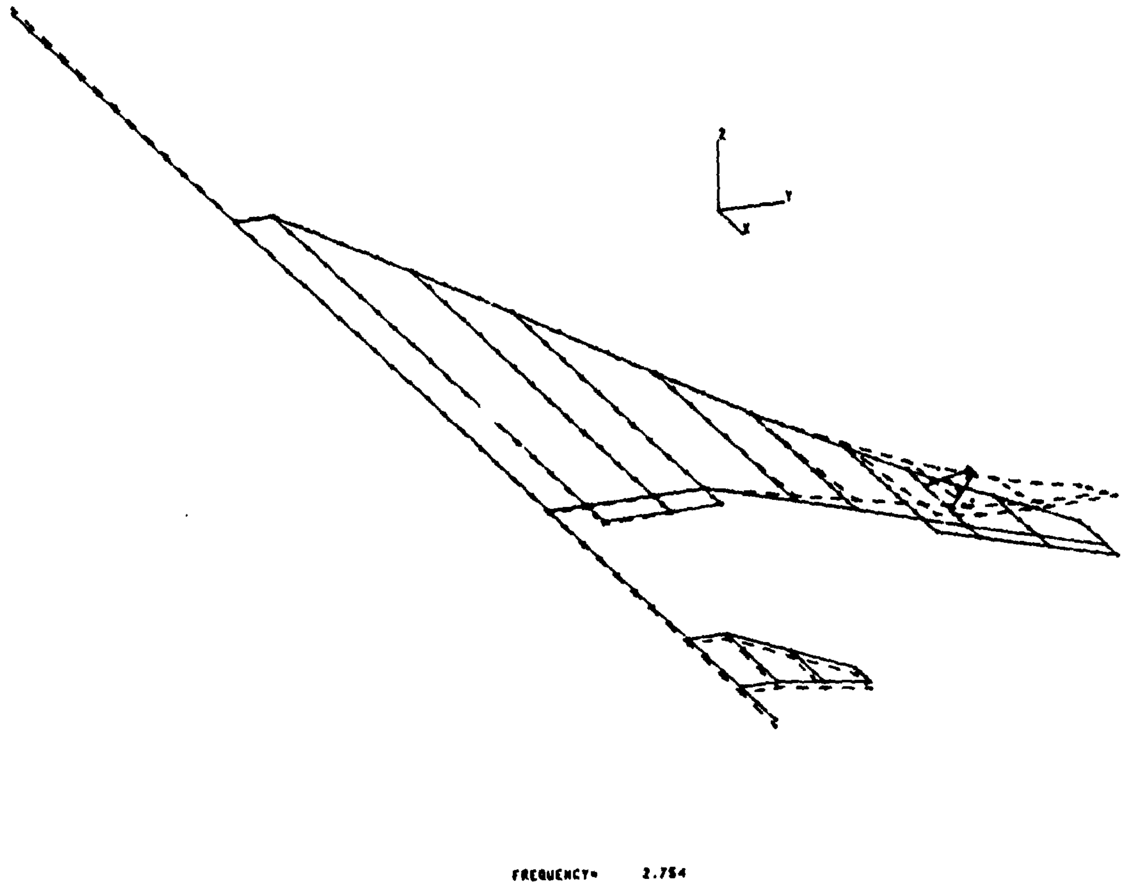


Figure 203-4. Third Mode Shape, SST

204. SUBSTRUCTURED STRESS AND VIBRATION ANALYSES OF AN SST AIRCRAFT (DECK 1)

204.1 DESCRIPTION OF ANALYSES

The SST aircraft described in section 203 is analyzed using substructures. The same vibration and stress analyses are performed. The half-model of section 203 is modelled as three substructures: body, wing and horizontal tail as shown in figure 204-1. These three substructures are interacted in a single step to obtain the highest level substructure (substructure 4).

204.2 RESULTS

Natural frequencies, mode shapes, displacements and stresses obtained in this problem are identical to those obtained in section 203.

204.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO01
      PROBLEM ID(DEMO01 - SUBSTRUCTURED STRESS/VIBRATION ANALYSES)
C
C     PURPOSE       THE PRIMARY CAPABILITIES DEMONSTRATED BY THIS
C                   DECK ARE
C                           1. SUBSTRUCTURED STRESS ANALYSIS
C                           2. SUBSTRUCTURED VIBRATION ANALYSIS
C                           3. EXPLODED PLOT OF MODEL
C
C     AUTHOR        R.A. SAMUEL
C
C     CORE          150K (OCTAL)
C
C     METHOD        STRESS AND VIBRATION ANALYSES ARE PERFORMED ON A
C                   SUBSTRUCTURED HALF-AIRPLANE MODEL OF AN SST.
C                   DISPLACEMENTS, STRESSES, NATURAL FREQUENCIES AND
C                   MODE SHAPES ARE COMPARED WITH RESULTS OF A
C                   NON-SUBSTRUCTURED MODEL.
C
      USER COMMON(1)
C
      READ INPUT
      DO 10 I = 1,3
      PRINT INPUT(STIFFNESS,SET=I)
      PRINT INPUT (NODAL,SET=I)
      PRINT INPUT(MASS,SET=I)
   10 CONTINUE
      EXECUTE EXTRACT(EXNAME=SS1,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE EXTRACT(EXNAME=SS2,LSUB=KGRID,KSET=2,ESUB=E1,NSUB=N1)
      EXECUTE EXTRACT(EXNAME=SS3,LSUB=KGRID,KSET=3,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOMETRY,OFFLINE=CALCOMP,TYPE=(ORTH,
     X                 POINT),SIZE=(20.,20.),EXPLODE,RZ=30.,RY=20.,
     X              RX=0.,EXNAME=SS1,TY=100.,EXNAME=(SS2,SS3))
C
C  VIBRATION ANALYSIS
C
      DO 20 I = 1,4
      PRINT INPUT(INTERACT,SS=I,NODES,RETAINS,CONN,BC)
   20 CONTINUE
      DO 30 I = 1,3
      EXECUTE STIFFNESS(SET=I)
      EXECUTE MASS(SET=I,OPTION=4,CONDITION=1)
   30 CONTINUE
      PERFORM SS-MERGE(STIF,MASS,SS=1 TO 3)
      PERFORM SS-REDU(STIF,MASS,SS=1 TO 3)
      PERFORM SS-MERGE(STIF,MASS,SS=4)
      EXECUTE MASS(SET=4,OPTION=4,CONDITION=1)
      PRINT OUTPUT(MASS,SET=4,SUMMARY)
      PERFORM SS-VSOL(SS=4)
```

```
      EXECUTE VIBRATION (STIF=KRED004,MASS=MRED004,NFREQS=8,SET=4)
      PRINT OUTPUT (VIBRATION)
      PURGE FILES(MERGRNF,MULTRNF,VIBRRNF,MASSRNF,CHOLRNF)
C
C  STRESS ANALYSIS
C
      DO 40 I = 11,14
      PRINT INPUT(INTERACT,SS=I,NODES,RETAINS,CONN,BC,LOADS)
   40 CONTINUE
      EXECUTE LOADS(SS=(11,12,13))
      PERFORM SS-MERGE(STIF,LOADS,SS=11 TO 13)
      PERFORM SS-REDU(STIF,LOADS,SS=11 TO 13)
      PERFORM SS-MERGE(STIF,LOADS,SS=14)
      PERFORM SS-SSOL(SS=14)
      PERFORM SS-PART(SS=14)
      PERFORM SS-BACK(SS=11 TO 13)
      DO 45 I = 11,13
      EXECUTE STRESS(SS=I)
   45 CONTINUE
      DO 50 I = 11,13
      PRINT OUTPUT(DISP,SS=I)
      PRINT OUTPUT(STRESS,SS=I)
      PRINT OUTPUT(LOADS,SS=I)
      PRINT OUTPUT(REACTIONS,SS=I)
   50 CONTINUE
      END CONTROL PROGRAM
```

```
*/ MODE2 /
  BEGIN NODAL DATA
SET 1        *(BODY)
          1    20.     0.  0.         TO    25   980.    0.  0.         BY  2
         27  1060.     0.  0.   30.0  TO    45  1780.    0.  0.   42.5  BY  2
   *+1  200     0.    65.  0.   0.    0    200    0.    65.               **
         45                           TO    55  2180.    0.  0.   31.0  BY  2
   *+1  200                           0    200    0.    65.               **
         55                           TO    63  2500.    0.  0.   13.5  BY  2
   *+1  200                           0    200    0.    65.               **
         65  2580.     0.  0.         TO    77  3060.    0.  0.         BY  2
         79  3140.     0.  0.   3.0
   *+1  200     0.    65.       **
         81  3220.     0.  0.   6.5
   *+1  200     0.    65.       **
         83  3300.     0.  0.   7.0
   *+1  200     0.    65.       **
         85  3380.     0.  0.   2.0
   *+1  200     0.    65.       **
        .87  3460.     0.  0.
         89  3540.     0.  0.
  END NODAL DATA
BEGIN STIFFNESS DATA
  BEGIN ELEMENT DATA
*/
*/ BODY BEAMS
*/
      BEAM   M5   N1001        1     3   5.     0.   *=3  16000.  10. 0. *=3  30000.
   *+30  0    0       2        2     2   5.          *4   14000.   5.     *4   14000.
     *2           N1063       63    65 160.          *4  450000. 148.     *4  416000.
   *+12  0    0       2        2     2 -12.          *4  -34000. -12.     *4  -34000.
*/
*/ WING IN-BODY SPARS
*/
      SPAR   M5   N2001       27   227       1.00  10.  TO  N3601      43  243         +
                                                        BY  N200        2    2
       *2         N3801       45   245       1.50  10.  TO  N4601      53  253         +
                                                        BY  N200        2    2
       *2         N4801       55   255       3.00  60.
       *2         N5001       57   257       1.20  60.  TO  N5401      61  261         +
                                                        BY  N200        2    2
       *2         N5601       63   263       2.00  60.
*/
*/ S.O.B. RIB - WING
*/
      SPAR   M5   N6001      227   229        .25   4.  TO  N6035     261  263         +
                                                        BY  N2          2    2
*/
*/ WING IN-BODY COVERS
*/
      COVER  M5   N7001       27   227  229    29  .30                        TO       +
                  N8601       43   243  245    45       BY  N200      2      *=3
       *2         N8801       45   245  247    47  .60                        TO       +
                  N9601       53   253  255    55       BY  N200      2      *=3
       *2         N9801       55   255  257    57  .70
       *2         N10001      57   257  259    59  .70
       *2         N10201      59   259  261    61 1.30   .70 1.10   .00
       *2         N10401      61   261  263    63          **
*/
*/ S.O.B. RIB - HORIZONTAL TAIL
*/
      SPAR   M5   N14401     279   281        .15   2.0 TO  N14405    283  285         +
                                                        BY  N2          2    2
*/
*/ HORIZONTAL TAIL IN-BODY SPARS
*/
      SPAR   M5   N14001      79   279        .50   6.0
       *2         N14101      81   281        .25   9.0
       *2         N14201      83   283        .25   8.0
       *2         N14301      85   285       1.00  13.0
*/
```

```
*/ HORIZONTAL TAIL IN-BODY COVERS
*/
      COVER  M5  N15001       79  279  281   81  .80                         TO        *
                 N15401       83  283  285   85        BY   N200      2     *=3
  END ELEMENT DATA
END STIFFNESS DATA
  BEGIN NODAL DATA
SET 2     *(WING)
        327  1060.    65.  0.  30.0  TO   345  1780.   65.  0.  42.5  BY  2
        345                          TO   355  2180.   65.  0.  31.0  BY  2
        355                          TO   363  2500.   65.  0.  13.5  BY  2
        427  1060.    65.  0.  30.0  TO   435  1380.  180.  0.  17.5  BY  2
        435                          TO   445  1760.  180.  0.  27.5  BY  2
        445                          TO   455  2180.  180.  0.  25.0  BY  2
        455                          TO   463  2500.  180.  0.  13.0  BY  2
        635  1380.   180.  0.  17.5  TO   641  1620.  265.  0.  10.0  BY  2
        641                          TO   655  2180.  265.  0.  22.5  BY  2
        655                          TO   663  2500.  265.  0.  12.5  BY  2
        841  1620.   265.  0.  10.0  TO   847  1971.  380.  0.   9.0  BY  2
        847                          TO   855  2291.  380.  0.  17.0  BY  2
        855                          TO   863  2611.  380.  0.  10.0  BY  2
       1047  1971.   380.  0.   9.0  TO  1051  2205.  455.  0.   8.5  BY  2
       1051                          TO  1059  2525.  455.  0.  15.0
       1059                          TO  1063  2685.  455.  0.   8.0
       1251  2205.   455.  0.   8.5  TO  1254  2409.  538.  0.   6.5
       1254                          TO  1259  2609.  538.  0.  11.0
       1259                          TO  1263  2769.  538.  0.   5.5
       1454  2409.   538.  0.   6.5  TO  1456  2545.  594.  0.   5.0
       1456                          TO  1459  2665.  594.  0.   7.5
       1459                          TO  1463  2925.  594.  0.   3.5
       1656  2545.   594.  0.   5.0  TO  1658  2710.  680.  0.   3.0
       1658                          TO  1663  2910.  680.  0.   3.0
       1858  2710.   680.  0.   3.0  TO  1860  2875.  765.  0.   1.5
       1860                          TO  1863  2995.  765.  0.   2.5
*/
*/ WING TRAILING EDGE NODES
*/
       3001  2500.    65.  0.  13.5  TO  3005  2580.   65.  0.   1.0   BY 2
       3101  2500.   130.  0.  13.0  TO  3105  2580.  180.  0.   1.0   **
       3201  2500.   265.  0.  12.5  TO  3205  2580.  265.  0.   1.0   **
       3305  2830.   538.  0.   1.0  TO  3605  3045.  765.  0.   1.0          *
                                    BY 100 OF 56. 86. 85.
*/
*/ WING FIN NODES
*/
      REC  WINGFIN 0. 594. 0., 1. 594. 0., 0. -1. 0.
       2056  2545.      .1 0.   3.5  TO  2456  2830.  100.  0.   2.5  BY  200
       2058  2625.      .1 0.   3.5  TO  2458  2942.  100.  0.   3.0  **
       2061  2745.      .1 0.   4.0  TO  2461  2859.  100.  0.   3.0  **
       2063  2825.      .1 0.   4.0  TO  2463  2870.  100.  0.   3.0  **
  END NODAL DATA
BEGIN STIFFNESS DATA
SET 2     *(WING)
  BEGIN PROPERTY DATA
      P1    .05   1.    *(WING FIN SPARS AND RIBS)
      P2   2.     0.    0.   .2   .2   .2 *(WING FIN ATTACHMENT BEAMS - TYPE 1)
      P3  10.     0.    0. 100. 100. 100. *(WING FIN ATTACHMENT BEAMS - TYPE 2)
      P4    .15  .50                      *(CONTROL SURFACE RIBS)
      P5   0.  *=2 100. 100.   0.    10. *(BEAMS AT 455 RIB TO PICK UP SPARS)
  END PROPERTY DATA
```

```
  BEGIN ELEMENT DATA
*/
*/ WING  FRONT  SPAR
*/
      SPAR    M5  N2003      327  429       .12    2.
       *2         N2205      429  431       .12    2.  TO  N2605     433  435        +
                                                       BY  N200        2    2
       *2         N2805      435  637       .12    2.
       *2         N3007      637  639       .12    2.  TO  N3207     639  641        +
                                                       BY  N200        2    2
       *2         N3407      641  843       .12    2.
       *2         N3609      843  845       .12    2.  TO  N3809     845  847        +
                                                       BY  N200        2    2
       *2         N4009      847 1049       .12    2.
       *2         N4211     1049 1051              **
       *2         N4411     1051 1253              **
       *2         N4613     1253 1254              **
       *2         N4713     1254 1455              **
       *2         N4815     1455 1456              **
       *2         N4915     1456 1657              **
       *2         N5017     1657 1658              **
       *2         N5117     1658 1859              **
       *2         N5219     1859 1860              **
*/
*/ WING REAR SPAR
*/
      SPAR    M5  N5603      363  463       .40   12.
       *2         N5605      463  663       .40   12.
       *2         N5607      663  863       .34   12.
       *2         N5609      863 1063       .34   12.
       *2         N5611     1063 1263       .30    8.
       *2         N5613     1263 1463       .30    8.
       *2         N5615     1463 1663       .30    4.
       *2         N5617     1603 1663       .30    4.
*/
*/ WING INTERMECIATE SPARS
*/
      SPAR    M5  N2203      329  429       .20    2.  TO  N3603     343  443        +
                                                       BY  N200        2    2
       *2         N3803      345  445       .36    2.
       *2         N4803      355  455       .60   12.
       *2         N5003      357  457       .24   12.  TO  N5403     361  461        +
                                                       BY  N200        2    2
       *2         N3005      437  637       .20    2.  TO  N3605     443  643        +
                                                       BY  N200        2    2
       *2         N3805      445  645       .36    2.
       *2         N4005      447  647       .20    4.  TO  N4605     453  653        +
                                                       BY  N200        2    2
       *2         N4805      455  655       .60   12.
       *2         N5005      457  657       .24   12.  TO  N5405     461  661        +
                                                       BY  N200        2    2
       *2         N3607      643  843       .20    2.  TO  N3807     645  845        +
                                                       BY  N200        2    2
       *2         N4007      647  847       .20    4.  TO  N4607     653  853        +
                                                       BY  N200        2    2
       *2         N4807      655  855       .20    9.
       *2         N5007      657  857       .20   10.  TO  N5407     661  861        +
                                                       BY  N200        2    2
       *2         N4209      849 1049       .20    4.  TO  N4609     853 1053        +
                                                       BY  N200        2    2
       *2         N4809      855 1055       .20    8.
       *2         N5009      857 1057       .20   10.  TO  N5409     861 1061        +
                                                       BY  N200        2    2
       *2         N4611     1053 1253       .12    4.  TO  N4811    1055 1255        +
                                                       BY  N100        1    1
       *2         N4911     1056 1256       .06    4.  TO  N5511    1062 1262        +
                                                       BY  N100        1    1
       *2         N4813     1255 1455       .12    4.
       *2         N4913     1256 1456       .06    4.  TO  N5513    1262 1462        +
                                                       BY  N100        1    1
       *2         N5015     1457 1657       .06    2.  TO  N5515    1462 1662        +
                                                       BY  N100        1    1
       *2         N5217     1659 1859       .06    2.  TO  N5517    1662 1862        +
                                                       BY  N100        1    1
```

```
*/
*/ WING RIBS
*/
     SPAR        N6109       435  437       .30    4.  TO   N6135      461   463      +
                                                       BY   N2           2     2
      *2         N6215       641  643       .20    3.  TO   N6235      661   663      +
                                                       BY   N2           2     2
      *2         N6425      1051 1053       .20    4.
      *2         N6425      1053 1054       .20    4.  TO   N6435     1062  1063
      *2         N6629      1456 1457       .12    2.  TO   N6635     1462  1463
      *2         N6833      1860 1861       .30    1.4 TO   N6835     1862  1863
*/
*/ BEAMS AT 455 RIB TO PICK UP DISCONTINUED SPARS
*/
     BEAM   M5   N30002     1053 1054       P5
  **4    0    0       2       2    2        *
     BEAM   M5   N30011     1063 1062       P5
  **4    0    0      -2      -2   -2        *
*/
*/ WING COVERS
*/
     COVER  M5   N7003       329  429  327        .06
      *2         N7203       329  429  431  331   .06                            TO      +
                 N8603       343  443  445  345        BY  N200       2     *=3
      *2         N8803       345  445  447  347   .12   .00                      TO      +
                 N9603       353  453  455  355        BY  N200       2     *=3
      *2         N9803       355  455  457  357   .10   .14
      *2         N10003      357  457  459  359          **
      *2         N10203      359  459  461  361   .26   .14   .22   .00
      *2         N10403      361  461  463  363          **
      *2         N7805       437  637  435        .06
      *2         N8005       437  637  639  439   .06                            TO      +
                 N9605       453  653  655  455        BY  N200       2     *=3
      *2         N9805       455  655  657  457   .10   .14
      *2         N10005      457  657  659  459          **
      *2         N10205      459  659  661  461   .26   .14   .22   .00
      *2         N10405      461  661  663  463          **
      *2         N8407       643  843  641        .06
      *2         N8607       643  843  845  645   .06                            TO      +
                 N9607       653  853  855  655        BY  N200       2     *=3
      *2         N9807       655  855  857  657   .10   .08
      *2         N10007      657  857  859  659          **
      *2         N10207      659  859  861  661   .30   .14   .20   .00
      *2         N10407      661  861  863  663          **
      *2         N9009       849 1049  847        .06
      *2         N9209       849 1049 1051  851   .06                            TO      +
                 N9609       853 1053 1055  855        BY  N200       2     *=3
      *2         N9809       855 1055 1057  857   .10   .08
      *2         N10009      857 1057 1059  859          **
      *2         N10209      859 1059 1061  861   .30   .14   .20   .00
      *2         N10409      861 1061 1063  863          **
      *2         N9411      1053 1253 1051        .30   .14   .22   .12
      *2         N9611      1053 1253 1254 1054   .30   .14   .22   .12      TO      +
                 N10511     1062 1262 1263 1063        BY  N100       1     *=3
      *2         N9713      1255 1455 1254        .30   .14   .22   .12
      *2         N9813      1255 1455 1456 1256   .30   .14   .22   .12      TO      +
                 N10513     1262 1462 1463 1263        BY  N100       1     *=3
      *2         N9915      1457 1657 1456        .08
      *2         N10015     1457 1657 1658 1458   .08                            TO      +
                 N10515     1462 1662 1663 1463        BY  N100       1     *=3
      *2         N10117     1659 1859 1658        .08
      *2         N10217     1659 1859 1860 1660   .08                            TO      +
                 N10517     1662 1862 1863 1663        BY  N100       1     *=3
*/
*/ WING FIN SPARS
*/
     SPAR   M5   N11001     2056 2256       P1
      *2         N11003     2256 2456       *
      *2         N11201     2058 2258       *
      *2         N11203     2258 2458       *
      *2         N11501     2061 2261       *
      *2         N11503     2261 2461       *
      *2         N11701     2063 2263       *
      *2         N11703     2263 2463       *
*/
```

```
*/ WING FIN RIBS
*/
      SPAR    M5   N12001     2256 2258          P1
       *2          N12003     2258 2261          *
       *2          N12005     2261 2263          *
       *2          N12201     2456 2458          *
       *2          N12203     2458 2461          *
       *2          N12205     2461 2463          *
*/
*/ WING FIN COVERS
*/
      COVER   M5   N13001     2056 2256 2258 2058   .05
       *2          N13003     2058 2258 2261 2061    *
       *2          N13005     2061 2261 2263 2063    *
       *2          N13201     2256 2456 2458 2258    *
       *2          N13203     2258 2458 2461 2261    *
       *2          N13205     2261 2461 2463 2263    *
*/
*/ WING FIN ATTACHMENT BEAMS
*/
      BEAM    Z5   N20001     1456 2056 1463  P2
       *2          N20003     1458 2058 1463  *
       *2          N20005     1461 2061 1463  *
       *2          N20007     1463 2063 1461  *
       *2          N21001     1456 1458       P3
       *2          N21003     1458 1461       *
       *2          N21005     1461 1463       *
*/
*/ WING TRAILING EDGE CONTROL SURFACE RIBS
*/
      SPAR    M5   N101        363 3003          P4
   **+1   0     0     2        100  100          0
   **+1   0     0     2        200  100          0
       *2          N102       3003 3005          *
   **+2   0     0     2        100  100          0
       *2          N107       1263 3305          *
   **+3   0     0     1        200  100          *
*/
*/ WING TRAILING EDGE CONTROL SURFACE COVERS
*/
      COVER   M5   N151        363  463 3103 3003   .10
       *2          N153        463  663 3203 3103    *
       *2          N152       3003 3103 3105 3005    *
       *2          N154       3103 3203 3205 3105    *
       *2          N155       1263 1463 3405 3305    *
   **+2   0     0     1        200  200  100  100    *
  END ELEMENT DATA
END STIFFNESS DATA
  BEGIN NODAL DATA
SET 3     *(HORIZONTAL TAIL)
         379  3140.0   65.0  0.   3.0
         479  3252.5  132.5  0.   2.5
         679  3365.0  200.0  0.   2.0
         381  3220.0   65.0  0.   6.5
         481  3304.   132.5  0.   4.5
         681  3388.0  200.0  0.   2.5
         383  3300.0   65.0  0.   7.0
         483  3356.0  132.5  0.   4.75
         683  3412.0  200.0  0.   2.5
         385  3380.0   65.0  0.   2.0
         485  3407.5  132.5  0.   1.5
         685  3435.0  200.0  0.   1.0
  END NODAL DATA
BEGIN STIFFNESS DATA
SET 3     *(HORIZONTAL TAIL)
  BEGIN ELEMENT DATA
*/
*/ HORIZONTAL TAIL SPARS
*/
      SPAR  M5     N14003      379  479        .10     1.2
       *2          N14005      479  679                 **
       *2          N14103      381  481        .05     1.8
       *2          N14105      481  681                 **
       *2          N14203      383  483        .05     1.6
```

```
       *2          N14205     483  683               **
       *2          N14303     385  485       .20    2.6
       *2          N14305     485  685               **
*/
*/ HORIZONTAL TAIL RIBS
*/
      SPAR         N14501     479  481       .10    1.2 TO  N14505     483  485        +
                                                        BY  N2           2    2
       *2          N14601     679  681       .10    1.2 TO  N14605     683  685        +
                                                        BY  N2           2    2
*/
*/ HORIZONTAL TAIL COVERS
*/
      COVER  M5  N15003     379  479  481  381  .16
   *+2    0   0     200       2  *=3            0.
      COVER  M5  N15005     479  679  681  481  .07
   *+2    0   0     200       2  *=3            0.
  END ELEMENT DATA
END STIFFNESS DATA
BEGIN MASS DATA
 SET 2
  BEGIN MASS ELEMENT DATA
      BEAM 1456 2056 1463 .1 *=4
      BEAM 1458 2058 1463 **
      BEAM 1461 2061 1463 **
      BEAM 1463 2063 1461 **
  END MASS ELEMENT DATA
END MASS DATA
BEGIN SUBSET DEFINITION
   SUBSETS OF STIFFNESS SET 1
*/
*/    E1 - BODY ELEMENTS
*/
      E1 = ALL
   SUBSETS OF STIFFNESS SET 2
*/
*/    E1 - WING ELEMENTS
*/    E2 - WING FIN ELEMENTS
*/
      E1 = SLAB Z 0.
      E2 = SLAB Z .1 TO 500.
   SUBSETS OF STIFFNESS SET 3
*/
*/    E1 - HORIZONTAL TAIL ELEMENTS
*/
      E1 = ALL
END SUBSET DEFINITION
BEGIN BC DATA
*/
*/  STAGE 1   FOR VIBRATION ANALYSIS
*/  STAGE 2   FOR STRESS ANALYSIS
*/
  SET 1 STAGE 1
      SUPPORT ASYM IN SURFACE 2
      SUPPORT TX FOR 89
      SUPPORT RZ FOR 227 TO 263 BY 2, 279 TO 285 BY 2
      RETAIN TZ FOR 1 7 13 19 27 45 55 63 67 73 79 85 89
      RETAIN TZ RX RY FOR 83
  SET 2 STAGE 1
      SUPPORT ALL FOR 427 3001
      SUPPORT RZ FOR 327 TO 363 BY 2
      RETAIN TZ FOR  435 441 445 451 455
      RETAIN TZ FOR 641 645 649 655 659 847 851 855 859 863 1051 1055 1059 1063
      RETAIN TZ FOR 1254 1259       1456 1459 1658 1661 1859 1860 1861
      RETAIN TZ FOR 3003 3005 3103 3105 3203 3205
      RETAIN TZ FOR 3305 3405 3505 3605
      RETAIN TY FOR 2058 2061 2258 2261 2458 2461
      RETAIN TZ RX RY FOR 463 663 1263 1463 1663 1863
  SET 3 STAGE 1
      SUPPORT RZ FOR 379 TO 385 BY 2
      RETAIN TZ FOR 479 679
      RETAIN TZ RX RY FOR 483 683 485 685
```

```
  SET 1 STAGE 2
      SUPPORT ASYM IN SURFACE 2
      SUPPORT RZ FOR 227 TO 263 BY 2, 279 TO 285 BY 2
      SUPPORT ALL FOR 89
  SET 2 STAGE 2
      SUPPORT ALL FOR 427 3001
      SUPPORT RZ FOR 327 TO 363 BY 2
  SET 3 STAGE 2
      SUPPORT RZ FOR 379 TO 385 BY 2
END BC DATA
BEGIN LOAD DATA
  SET 1 STAGE 2
  LOAD CASE ID SYMM **SYMMETRIC AIRLOADS*
  BEGIN NODAL LOAD DATA
    ORDER FZ
    CASE SYMM
         3    -2275.
         9    -6110.
        15    -4970.
        23    -3255.
        31     -245.
        39    -5400.
        45     -380.
        53    -3830.
        61      140.
        67     -165.
        75    -6365.
        83    -3495.
        87    -3160.
        85     -150.
        89     -150.
    END NODAL LOAD DATA
  SET 2 STAGE 2
  LOAD CASE ID SYMM **SYMMETRIC AIRLOADS*
  BEGIN NODAL LOAD DATA
    ORDER FZ FY
            CASE SYMM
      2056     -125.      1220.
      2456     -100.      1360.
      2458     -100.      -410.
      2058     -125.       955.
      2061     -125.      1075.
      2461     -100.      7665.
      2463     -100.     -4960.
      2063     -125.      -660.
    ORDER FZ
       431    13475.
       331    -8500.
       637     8030.
       337    -7750.
       345   -11770.
       655    -4640.
       355    -5330.
       663     1565.
       363     5445.
       843    36405.
       645   -20790.
      1051    21130.
       649     3435.
      1055     3365.
      1063     1435.
      1456    13820.
      1459    21815.
      1463     6155.
      1860      860.
      1861    14395.
      1863     2762.
       659     -490.
      1059    -8710.
      1461   -10695.
      1862    -5190.
  END NODAL LOAD DATA
```

```
  SET 3 STAGE 2
          LOAD CASE ID SYMM **SYMMETRIC AIRLOADS*
  BEGIN NODAL LOAD DATA
            ORDER FZ
            CASE SYMM
       379    -5060.
       679    -4040.
       681    -7375.
       381    -5415.
       383    -1620.
       683     -865.
       685    -1725.
       385    -3425.
    END NODAL LOAD DATA
END LOAD DATA
BEGIN SUBSET DEFINITION
      SUBSETS OF STIFFNESS SET 1
          E1 = ALL
          N1 = ALL
      SUBSETS OF STIFFNESS SET 2
          E1 = ALL
          N1 = ALL
      SUBSETS OF STIFFNESS SET 3
          E1 = ALL
          N1 = ALL
END SUBSET DEFINITION
BEGIN INTERACT DATA
      DEFINE  SS  1  AS  SET  1  STAGE  1          *(BODY)
      DEFINE  SS  2  AS  SET  2  STAGE  1          *(WING)
      DEFINE  SS  3  AS  SET  3  STAGE  1          *(HORIZONTAL TAIL)
      SS  4
          INTERACT  1  2  3
   BEGIN  BC  CHANGES
      SS  4
        REFERENCE  SS  1
          RETAIN TZ          FOR 227 237 245 255 279
          RETAIN TZ RX RY    FOR 263 283 285
   END  BC  CHANGES
      DEFINE  HIGHEST  SS  4  AS  SET  4
END INTERACT DATA
BEGIN INTERACT DATA
      DEFINE  SS 11  AS  SET  1  STAGE  2          *(BODY)
      DEFINE  SS 12  AS  SET  2  STAGE  2          *(WING)
      DEFINE  SS 13  AS  SET  3  STAGE  2          *(HORIZONTAL TAIL)
      SS  14
          INTERACT  11  12  13
      DEFINE  HIGHEST  SS  14
END INTERACT DATA
END PROBLEM DATA
```

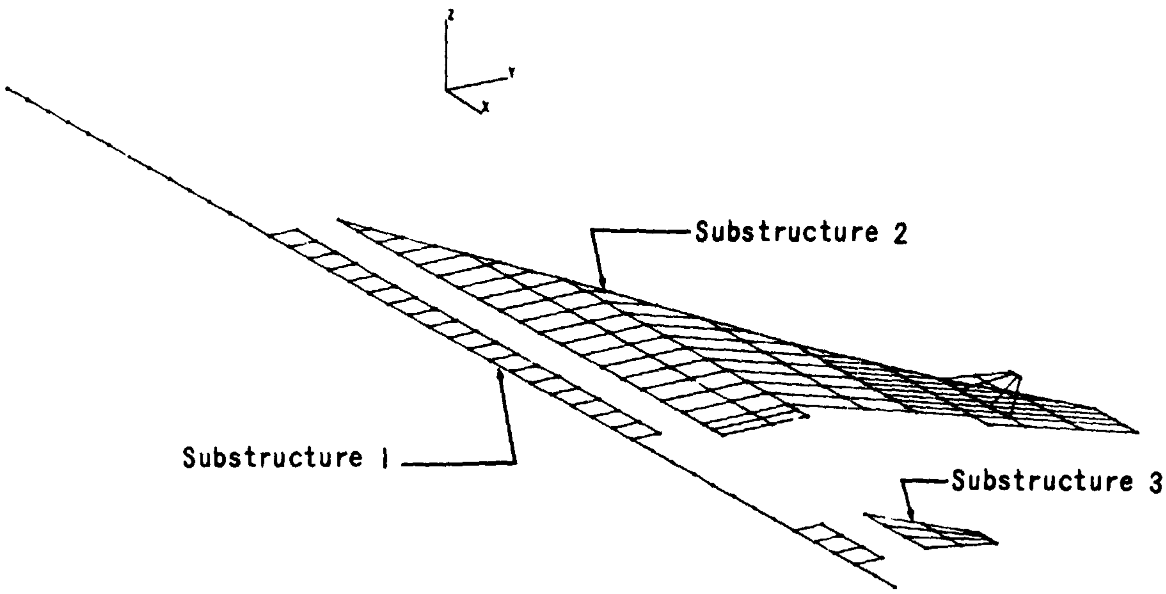


Figure 204-1. Substructured Model of SST

205. VIBRATION ANALYSIS OF THE FIREBEE DRONE (DECK 15)

205.1 DESCRIPTION OF ANALYSIS

An analysis is performed to determine symmetrical modes of vibration of the FIREBEE Drone. Because of structural symmetry, only one half of the Drone is modelled. The wing model is based upon the supercritical wing (ARW-1); the fuselage and horizontal tail models are based upon the data reported in reference 205-1.

The outboard wing is modelled using SPLATE and ROD elements. The wing center section is modelled using GPLATE and BEAM elements and the fuselage and horizontal tail are modelled using BEAM elements. The total structural model is shown in figure 205-1. More detailed views of the model are presented in figures 205-2 through 205-6.

The number of degrees of freedom retained in the analysis is 107. Z-direction translations are retained at outboard wing upper surface, fuselage and horizontal tail nodes. Rotations about the Y axis are retained at fuselage and horizontal tail nodes; rotations about the X axis are retained at horizontal tail nodes. Symmetry is imposed on the plane Y=0. Rigid body translation in the X-direction is restrained near the center of the fuselage.

The reduced mass matrix is a nondiagonal matrix produced directly by the Mass Processor. The wing mass is obtained exclusively from the stiffness finite elements; the fuselage and horizontal tail mass exclusively from concentrated masses.

205.2 RESULTS

The natural frequencies of the first ten modes are presented in table 205-1. The first two modes are rigid body modes. The mode shapes for modes 4 and 6 are shown in figures 205-7 and 205-8.

The third mode shape closely resembles the first mode shape of a cantilever wing. The frequency and mode shape for this mode are similar to the results obtained from a NASTRAN analysis of a cantilever wing.

Modes 4 and 5 are the first two fuselage bending modes and mode 8 is the first horizontal tail bending mode. The results for these three modes compare favorably with those reported in reference 205-1.

205.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO15
      PROBLEM  C(DEMO15 - VIBRATION ANALYSIS OF THE FIREBEE DRONE)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. GENERATION OF NON-DIAGONAL MASS MATRIX BY
C                          MASS PROCESSOR
C                       2. VIBRATION ANALYSIS
C                       3. PLOTS OF VIBRATION MODE SHAPES
C
C     AUTHOR         M. TAMEKUNI
C
C     CORE           150 K (OCTAL)
C
C
      READ INPUT
      PRINT INPUT (NODAL)
      PRINT INPUT (STIFFNESS)
      PRINT INPUT(MATERIAL)
      EXECUTE EXTRACT(EXNAME=TOTAL,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=CALCOMP,TYPE=ORTH,
     X               SIZE=(20.,20.),VIEW=100,EXNAME=TOTAL)
      EXECUTE EXTRACT(EXNAME=BODY,LSUB=KGRID,ESUB=E2,NSUB=N2)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,SIZE=(25,25),LABEL=N,
     X          RY=0,RZ=90,RX=-90,EXNAME=BODY)
      EXECUTE EXTRACT(EXNAME=UPRSURF,LSUB=KGRID,ESUB=E4,NSUB=N4)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,SIZE=(20.,20.),LABEL=N,
     X               VIEW=100,EXNAME=UPRSURF)
      EXECUTE EXTRACT(EXNAME=LWRSURF,LSUB=KGRID,ESUB=E5,NSUB=N5)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,SIZE=(20.,20.),LABEL=N,
     X               VIEW=100,EXNAME=LWRSURF)
      EXECUTE EXTRACT(EXNAME=WNGBDY,LSUB=KGRID,ESUB=E6,NSUB=N6)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,SIZE=(20.,20.),LABEL=N+T,
     X               VIEW=100,EXNAME=WNGBDY)
      EXECUTE EXTRACT(EXNAME=TAIL,LSUB=KGRID,ESUB=E3,NSUB=N3)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,SIZE=(20.,20.),LABEL=N,
     X               VIEW=100,EXNAME=TAIL)
      PERFORM K-REDUCE
      PRINT INPUT(BC)
      EXECUTE MASS(OPTION=3)
      PRINT OUTPUT (MASS,MDC=MDC****,SUMMARY)
      EXECUTE VIBRATION(MASS=MDC001A,STIF=KRED,VSET=1,NMODES=20)
      PRINT OUTPUT(VIBRATION,VSET=1)
      EXECUTE EXTRACT (EXNAME=DRONE,LSUB=VMODE,VSET=1,
     X               BSUB=ON1,MODE=1 TO 10)
      EXECUTE GRAPHICS(GNAME=MODES,TYPE=ORTH,SIZE=(20.,20.),RZ=60.,
     X               RY=-35.,RX=0.,VECTOR2=VMODE,VSCALE=15.,
     X               EXNAME=DRONE)
      END CONTROL PROGRAM
```

```
BEGIN MATERIAL DATA /
M51  .05 /
 0 .228E+07  0.  .695E+06  0.  /
M52  .1 /
    0    .10500000E+08    .31250000E+00    .40000000E+07   0.              /
  M53   0.             /
  0  .228E+07  0.  .695E+06  0.   /
  M54   0.             /
    0    .10500000E+08    .31250000E+00    .40000000E+07   0.              /
M55  .285 /
    0    .29000000E+08    .31818182E+00    .11000000E+08   0.              /
END MATERIAL DATA /
BEGIN NODAL DATA /
  REC WING -1.01 0. 0.  1. 0. 0.  -1.01 0. 1.  /
        1      310.6360000       85.5000000        1.4070000  /
        2      310.6360000       85.5000000         .9100000  /
        3      311.8520000       85.5000000        1.6630000  /
        4      311.8520000       85.5000000         .8630000  /
        5      313.8790000       85.5000000        1.9310000  /
        6      313.8790000       85.5000000         .9790000  /
        7      316.2430000       85.5000000        2.1750000  /
        8      316.2430000       85.5000000        1.2410000  /
        9      318.6080000       85.5000000        2.3940000  /
       10      318.6080000       85.5000000        1.5980000  /
       11      321.9860000       85.5000000        2.5950000  /
       12      321.9860000       85.5000000        2.2870000  /
       13      323.6740000       85.5000000        2.4240000  /
       21      304.5500000       79.2500000        1.3600000  /
       22      304.5500000       79.2500000         .7860000  /
       23      305.9200000       79.2500000        1.6310000  /
       24      305.9200000       79.2500000         .7440000  /
       25      308.2000000       79.2500000        1.9300000  /
       26      308.2000000       79.2500000         .8720000  /
       27      310.8700000       79.2500000        2.2110000  /
       28      310.8700000       79.2500000        1.1400000  /
       29      313.5300000       79.2500000        2.4560000  /
       30      313.5300000       79.2500000        1.5280000  /
       31      317.3400000       79.2500000        2.6550000  /
       32      317.3400000       79.2500000        2.3210000  /
       33      319.2480000       79.2500000        2.4395000  /
       41      297.8290000       72.3490000        1.3470000  /
       42      297.8290000       72.3490000         .6630000  /
       43      298.6570000       71.5980000        1.6320000  /
       44      298.6570000       71.5980000         .6170000  /
       45      300.0[illegible]0000       70.3040000        1.9740000  /
       46      300.0810000       70.3040000         .7250000  /
       47      301.8190000       68.7260000        2.3630000  /
       48      301.8190000       68.7260000         .9750000  /
       49      303.6430000       67.0700000        2.5820000  /
       50      303.6430000       67.0700000        1.3870000  /
       51      306.4150000       64.5530000        2.7630000  /
       52      306.4150000       64.5530000        2.3580000  /
       53      307.8[illegible]90000       63.2230000        2.4530000  /
       61      289.4500000       63.7470000        1.3680000  /
       62      289.4500000       63.7470000         .5720000  /
       63      290.3930000       62.8920000        1.6950000  /
       64      290.3930000       62.8920000         .4990000  /
       65      292.0140000       61.4200000        2.0760000  /
       66      292.0140000       61.4200000         .5870000  /
       67      293.9920000       59.6240000        2.4190000  /
       68      293.9920000       59.6240000         .8340000  /
       69      296.0670000       57.7400000        2.6840000  /
       70      296.0670000       57.7400000        1.2720000  /
       71      299.2210000       54.8760000        2.8070000  /
       72      299.2210000       54.8760000        2.3480000  /
       73      300.8870000       53.3630000        2.4410000  /
       81      281.0740000       55.1450000        1.4420000  /
       82      281.0740000       55.1450[illegible]         .5280000  /
       83      282.1300000       54.186[illegible]        1.8160000  /
       84      282.1300000       54.1[illegible]         .4080000  /
       85      283.9470000       52.5360000        2.2320000  /
       86      283.9470000       52.5360000         .4560000  /
       87      286.1650000       50.5220000        2.5640000  /
```

ORIGINAL PAGE IS
OF POOR QUALITY

88	286.1650000	50.5220000	.6960000	/
89	288.4920000	48.4100000	2.7900000	/
90	288.4920000	48.4100000	1.1530000	/
91	292.0270000	45.1990000	2.8370000	/
92	292.0270000	45.1990000	2.3210000	/
93	293.8960000	43.5030000	2.4230000	/
101	272.6970000	46.5430000	1.5510000	/
102	272.6970000	46.5430000	.5090000	/
103	273.8670000	45.4810000	1.9720000	/
104	273.8670000	45.4810000	.3320000	/
105	275.8800000	43.6520000	2.4100000	/
106	275.8800000	43.6520000	.3290000	/
107	278.3380000	41.4210000	2.7170000	/
108	278.3380000	41.4210000	.5580000	/
109	280.9160000	39.0800000	2.8960000	/
110	280.9160000	39.0800000	1.0340000	/
111	284.8340000	35.5220000	2.8680000	/
112	284.8340000	35.5220000	2.2940000	/
113	286.9040000	33.6420000	2.4040000	/
121	264.3190000	37.9410000	1.7230000	/
122	264.3190000	37.9410000	.4270000	/
123	265.6030000	36.7750000	2.1280000	/
124	265.6030000	36.7750000	.2560000	/
125	267.8140000	34.7680000	2.5870000	/
126	267.8140000	34.7680000	.2010000	/
127	270.5110000	32.3190000	2.8710000	/
128	270.5110000	32.3190000	.4200000	/
129	273.3400000	29.7500000	3.0020000	/
130	273.3400000	29.7500000	.9150000	/
131	277.6400000	25.8450000	2.8980000	/
132	277.6400000	25.8450000	2.2660000	/
133	279.9130000	23.7820000	2.3850000	/
141	255.9420000	29.3390000	1.7790000	/
142	255.9420000	29.3390000	.4720000	/
143	257.3400000	28.0690000	2.2850000	/
144	257.3400000	28.0690000	.1300000	/
145	259.7470000	25.8840000	2.7650000	/
146	259.7470000	25.8840000	.0730000	/
147	262.6830000	23.2170000	3.0240000	/
148	262.6830000	23.2170000	.2830000	/
149	265.7650000	20.4200000	3.1090000	/
150	265.7650000	20.4200000	.7960000	/
165	251.6800000	17.0000000	2.9430000	/
166	251.6800000	17.0000000	-.0550000	/
167	254.8560000	14.1160000	3.1770000	/
168	254.8560000	14.1160000	.1450000	/
169	258.1890000	11.0900000	3.2150000	/
170	258.1890000	11.0900000	.6770000	/
174	251.6800000	17.0000000	1.9480000	/
176	258.1890000	11.0900000	1.9480000	/
200	243.3000000	9.0000000	1.9480000	/
201	244.4200000	9.0000000	1.9480000	/
202	251.6300000	9.0000000	1.9480000	/
203	258.1800000	9.0000000	1.9480000	/
204	259.9800000	9.0000000	1.9480000	/
205	263.3300000	9.0000000	1.9480000	/
206	268.1500000	9.0000000	1.9480000	/
207	272.3900000	9.0000000	1.9480000	/
208	275.0500000	9.0000000	1.9480000	/
223	258.1800000	4.3500000	1.9480000	/
225	263.3300000	4.3500000	1.9480000	/
226	268.1500000	4.3500000	1.9480000	/
227	272.3900000	4.3500000	1.9480000	/
242	245.7800000	.0000000	1.9480000	/
243	258.1800000	.0000000	1.9480000	/
245	263.3300000	.0000000	1.9480000	/
246	268.1500000	.0000000	1.9480000	/
247	272.3900000	.0000000	1.9480000	/

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*/ BODY NODES /
 REC BODY 0. 0. 1.948 1. 0. 1.948 0. 0. 10. /
 302 100.   0. 0. /
 304 120.   0. 0. /
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306 130.    0. 0. /
308 140.    0. 0. /
310 150.    0. 0. /
312 160.    0. 0. /
314 170.    0. 0. /
316 180.    0. 0. /
318 190.    0. 0. /
320 200.    0. 0. /
322 210.    0. 0. /
324 220.    0. 0. /
326 232.    0. 0. /
328 241.    0. 0. /
330 250.    0. 0. /
332 280.    0. 0. /
334 290.    0. 0. /
336 294.4   0. 0. /
338 300.5   0. 0. /
340 312.    0. 0. /
342 319.1   0. 0. /
344 326.    0. 0. /
346 332.7   0. 0. /
348 340.    0. 0. /
350 344.2   0. 0. /
352 350.    0. 0. /
354 356.5   0. 0. /
356 359.56  0. 0. /
358 368.    0. 0. /
360 376.    0. 0. /
362 394.5   0. 0. /
364 400.    0. 0. /
366 408.1   0. 0. /
*/  HORIZONTAL TAIL NODES /
 401 359.56 9.9  0. /
 408 373.411 34.234 0. /
 REC HT 401 408 359.56 9.9 10.0 /
 ANALYSIS FRAME HT /
 401 0. 0. 0. TO 408 28. 0. 0.   /
 411 0.  .6823 0. /
 412 4.  2.519 0. /
 413 8.  1.978 0. /
 414 12. 1.417 0. /
 415 16. .887  0. /
 416 20. .1567 0. /
417 24. -.5425 0. /
418 28. -1.306 0. /
END NODAL DATA /
BEGIN BC DATA /
*/  RETAINED FREEDOMS  /
*/ WING    /
 RETAIN TZ FOR 165 167 169    /
 RETAIN TZ FOR 141 TO 149 BY 2  /
 RETAIN TZ FOR 121 TO 133 BY 2  /
*+6 0 0 0 -20 0 -20 0 0 /
*/   FUSELAGE    /
 RETAIN TZ FOR 304 310 316 322 328 243 247
               338 344 352 356 360 364   /
 RETAIN RY FOR 304 310 316 322 328 243 247
               338 344 352 356 360 364   /
*/   HORIZONTAL TAIL    /
 RETAIN TZ FOR 401 TO 408   /
 RETAIN RX FOR 401 TO 408   /
 RETAIN RY FOR 401 TO 408   /
 SUPPORT ASYM IN SURFACE 2 /
 SUPPORT TX FOR 247  /
END BC DATA /
BEGIN STIFFNESS DATA /
  BEGIN ELEMENT DATA /
  BEAM  M52  T+0000      N4000            165        174        145
    .12200000E+01   0.                  0.                 0.
    .27100000E+00    .25000000E+00              0.0 /
  BEAM  M52  T+0000      N4001            166        174        146
    .12200000E+01   0.                  0.                 0.
    .27100000E+00    .25000000E+00              0.0 /
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BEAM  M52  T+0000     N4002          169      176      149
  .12200000E+01   0.           0.                  0.
  .27100000E+00   .25000000E+00            0.0 /
BEAM  M52  T+0000     N4003          170      176      150
  .12200000E+01   0.           0.                  0.
  .27100000E+00   .25000000E+00            0.0 /
BEAM  M52  T+0000     N4005          174      176      242
  .18750000E+01   0.           0.               .28500000E+00
  .57700000E+00   .87900000E-01            0.0 /
BEAM  M52  T+0000     N4006          174      202      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4007          174      201      242
  .37500000E+01   0.           0.               .17610000E+01
  .19530000E+01   .70300000E+00            0.0 /
BEAM  M52  T+0000     N4008          200      201      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4009          201      202      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4010          203      204      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4011          204      205      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4012          205      206      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4013          206      207      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4014          207      208      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4015          201      242      243
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4016          202      242      243
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4017          202      243      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4018          223      225      242
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4019          225      226      242
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4020          226      227      242
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4021          242      243      201
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4022          243      245      201
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4023          245      246      201
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4024          246      247      201
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
BEAM  M52  T+0000     N4025          203      223      242
  .31250000E+01   0.           0.               .11180000E+01
  .16280000E+01   .40700000E+00            0.0 /
BEAM  M52  T+0000     N4026          205      225      242
  .12500000E+01   0.           0.               .91000000E-01
  .65100000E+00   .26000000E-01            0.0 /
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BEAM  M52  T+0000      N4027            206        226        242
  .12500000E+01   0.              0.                     .91000000E-01
  .65100000E+00    .26000000E-01               0.0 /
BEAM  M52  T+0000      N4028            207        227        242
  .12500000E+01   0.              0.                     .91000000E-01
  .65100000E+00    .26000000E-01               0.0 /
BEAM  M52  T+0000      N4029            223        243        242
  .31250000E+01   0.              0.                     .11180000E+01
  .16280000E+01    .40700000E+00               0.0 /
BEAM  M52  T+0000      N4030            225        245        242
  .12500000E+01   0.              0.                     .91000000E-01
  .65100000E+00    .26000000E-01               0.0 /
BEAM  M52  T+0000      N4031            226        246        242
  .12500000E+01   0.              0.                     .91000000E-01
  .65100000E+00    .26000000E-01               0.0 /
BEAM  M52  T+0000      N4032            227        247        242
  .12500000E+01   0.              0.                     .91000000E-01
  .65100000E+00    .26000000E-01               0.0 /
BEAM  M54  T+0000      N8000            202        204        242
  .40000000E+01   0.              0.                     .40000000E+01
  .20000000E+03    .20000000E+03               0.0 /
ROD   M53   T+0000   N2000          1        21     .60000000E-01 /
ROD   M53   T+0000   N2001          3        23     .98000000E-01 /
ROD   M53   T+0000   N2002          5        25     .67000000E-01 /
ROD   M53   T+0000   N2003          7        27     .13400000E+00 /
ROD   M53   T+0000   N2004          9        29     .18800000E+00 /
ROD   M53   T+0000   N2005         11        31     .15900000E+00 /
ROD   M53   T+0000   N2006         13        33     .15500000E+00 /
ROD   M53   T+0000   N2007         12        32     .15900000E+00 /
ROD   M53   T+0000   N2008         10        30     .18800000E+00 /
ROD   M53   T+0000   N2009          8        28     .13400000E+00 /
ROD   M53   T+0000   N2010          6        26     .67000000E-01 /
ROD   M53   T+0000   N2011          4        24     .98000000E-01 /
ROD   M53   T+0000   N2012          2        22     .60000000E-01 /
ROD   M53   T+0000   N2013         21        41     .52000000E-01 /
ROD   M53   T+0000   N2014         23        43     .10400000E+00 /
ROD   M53   T+0000   N2015         25        45     .12200000E+00 /
ROD   M53   T+0000   N2016         27        47     .15700000E+00 /
ROD   M53   T+0000   N2017         29        49     .20700000E+00 /
ROD   M53   T+0000   N2018         31        51     .18600000E+00 /
ROD   M53   T+0000   N2019         33        53     .18200000E+00 /
ROD   M53   T+0000   N2020         32        52     .18600000E+00 /
ROD   M53   T+0000   N2021         30        50     .20700000E+00 /
ROD   M53   T+0000   N2022         28        48     .15700000E+00 /
ROD   M53   T+0000   N2023         26        46     .12200000E+00 /
ROD   M53   T+0000   N2024         24        44     .10400000E+00 /
ROD   M53   T+0000   N2025         22        42     .52000000E-01 /
ROD   M53   T+0000   N2026         41        61     .51000000E-01 /
ROD   M53   T+0000   N2027         43        63     .11400000E+00 /
ROD   M53   T+0000   N2028         45        65     .16000000E+00 /
ROD   M53   T+0000   N2029         47        67     .18000000E+00 /
ROD   M53   T+0000   N2030         49        69     .23200000E+00 /
ROD   M53   T+0000   N2031         51        71     .21400000E+00 /
ROD   M53   T+0000   N2032         53        73     .20800000E+00 /
ROD   M53   T+0000   N2033         52        72     .21400000E+00 /
ROD   M53   T+0000   N2034         50        70     .23200000E+00 /
ROD   M53   T+0000   N2035         48        68     .18000000E+00 /
ROD   M53   T+0000   N2036         46        66     .16000000E+00 /
ROD   M53   T+0000   N2037         44        64     .11400000E+00 /
ROD   M53   T+0000   N2038         42        62     .51000000E-01 /
ROD   M53   T+0000   N2039         61        81     .58000000E-01 /
ROD   M53   T+0000   N2040         63        83     .12900000E+00 /
ROD   M53   T+0000   N2041         65        85     .18000000E+00 /
ROD   M53   T+0000   N2042         67        87     .20300000E+00 /
ROD   M53   T+0000   N2043         69        89     .26200000E+00 /
ROD   M53   T+0000   N2044         71        91     .24200000E+00 /
ROD   M53   T+0000   N2045         73        93     .23500000E+00 /
ROD   M53   T+0000   N2046         72        92     .24200000E+00 /
ROD   M53   T+0000   N2047         70        90     .[illegible]5200000E+00 /
ROD   M53   T+0000   N2048         68        88     .20300000E+00 /
ROD   M53   T+0000   N2049         66        86     .18000000E+00 /
ROD   M53    +0000   N2050         64        84     .12900000E+00 /
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ROD	M53	T+0000	N2051	62	82	.58000000E-01	/
ROD	M53	T+0000	N2052	81	101	.64000000E-01	/
ROD	M53	T+0000	N2053	83	103	.14300000E+00	/
ROD	M53	T+0000	N2054	85	105	.20100000E+00	/
ROD	M53	T+0000	N2055	87	107	.22600000E+00	/
ROD	M53	T+0000	N2056	89	109	.29200000E+00	/
ROD	M53	T+0000	N2057	91	111	.26900000E+00	/
ROD	M53	T+0000	N2058	93	113	.26200000E+00	/
ROD	M53	T+0000	N2059	92	112	.26900000E+00	/
ROD	M53	T+0000	N2060	90	110	.29200000E+00	/
ROD	M53	T+0000	N2061	88	108	.22600000E+00	/
ROD	M53	T+0000	N2062	86	106	.20100000E+00	/
ROD	M53	T+0000	N2063	84	104	.14300000E+00	/
ROD	M53	T+0000	N2064	82	102	.64000000E-01	/
ROD	M53	T+0000	N2065	101	121	.71000000E-01	/
ROD	M53	T+0000	N2066	103	123	.14900000E+00	/
ROD	M53	T+0000	N2067	105	125	.23000000E+00	/
ROD	M53	T+0000	N2068	107	127	.25000000E+00	/
ROD	M53	T+0000	N2069	109	129	.32200000E+00	/
ROD	M53	T+0000	N2070	111	131	.29700000E+00	/
ROD	M53	T+0000	N2071	113	133	.28900000E+00	/
ROD	M53	T+0000	N2072	112	132	.29700000E+00	/
ROD	M53	T+0000	N2073	110	130	.32200000E+00	/
ROD	M53	T+0000	N2074	108	128	.25000000E+00	/
ROD	M53	T+0000	N2075	106	126	.23000000E+00	/
ROD	M53	T+0000	N2076	104	124	.14900000E+00	/
ROD	M53	T+0000	N2077	102	122	.71000000E-01	/
ROD	M53	T+0000	N2078	121	141	.77000000E-01	/
ROD	M53	T+0000	N2079	123	143	.16400000E+00	/
ROD	M53	T+0000	N2080	125	145	.25100000E+00	/
ROD	M53	T+0000	N2081	127	147	.27300000E+00	/
ROD	M53	T+0000	N2082	129	149	.14000000E+00	/
ROD	M53	T+0000	N2083	130	150	.14000000E+00	/
ROD	M53	T+0000	N2084	128	148	.27300000E+00	/
ROD	M53	T+0000	N2085	126	146	.25100000E+00	/
ROD	M53	T+0000	N2086	124	144	.16400000E+00	/
ROD	M53	T+0000	N2087	122	142	.77000000E-01	/
ROD	M53	T+0000	N2088	145	165	.14500000E+00	/
ROD	M53	T+0000	N2089	147	167	.29500000E+00	/
ROD	M53	T+0000	N2090	149	169	.15200000E+00	/
ROD	M53	T+0000	N2091	150	170	.15200000E+00	/
ROD	M53	T+0000	N2092	148	168	.29500000E+00	/
ROD	M53	T+0000	N2093	146	166	.14500000E+00	/
ROD	M52	T+0000	N2102	47	67	.40000000E-01	/
ROD	M52	T+0000	N2103	67	87	.44800000E-01	/
ROD	M52	T+0000	N2104	87	107	.48300000E-01	/
ROD	M52	T+0000	N2105	107	127	.51300000E-01	/
ROD	M52	T+0000	N2106	127	147	.53500000E-01	/
ROD	M52	T+0000	N2112	48	68	.40000000E-01	/
ROD	M52	T+0000	N2113	68	88	.44800000E-01	/
ROD	M52	T+0000	N2114	88	108	.48300000E-01	/
ROD	M52	T+0000	N2115	108	128	.51300000E-01	/
ROD	M52	T+0000	N2116	128	148	.53500000E-01	/
ROD	M52	T+0000	N2117	148	168	.55300000E-01	/
ROD	M51	T+0000	N2120	1	3	.19700000E-01	/
ROD	M51	T+0000	N2121	3	5	.31200000E-01	/
ROD	M51	T+0000	N2122	5	7	.33200000E-01	/
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ROD	M52	T+0000	N2144	29	31	.17200000E+00	/
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ROD	M52	T+0000	N2183	67	69	.32400000E-01	/
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ROD	M52	T+0000	N2191	62	64	.25300000E-01	/
ROD	M52	T+0000	N2200	81	83	.28400000E-01	/
ROD	M52	T+0000	N2201	83	85	.37400000E-01	/
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ROD	M52	T+0000	N2222	105	107	.39700000E-01	/
ROD	M52	T+0000	N2223	107	109	.38500000E-01	/
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ROD	M52	T+0000	N2225	111	113	.11500000E-01	/
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ROD	M52	T+0000	N2243	127	129	.41300000E-01	/
ROD	M52	T+0000	N2244	129	131	.34200000E-01	/
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ROD	M52	T+0000	N2251	122	124	.33800000E-01	/
ROD	M52	T+0000	N2260	141	143	.36100000E-01	/
ROD	M52	T+0000	N2261	143	145	.46800000E-01	/
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ROD	M52	T+0000	N2263	147	149	.43900000E-01	/

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   .25000000E+00    .25000000E+00    0.                     /
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   .25000000E+00    .25000000E+00    0.                     /
GPLATE   M52   T+0000   N5502           245       225        226       246
   .25000000E+00    .25000000E+00    0.                     /
GPLATE   M52   T+0000   N5503           225       205        206       226
   .25000000E+00    .25000000E+00    0.                     /
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   .25000000E+00    .25000000E+00    0.                     /
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   .25000000E+00    .25000000E+00    0.                     /
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SPLATE	M51	T+0000	N1142	165	145	147	167	.70000000E-01 /
SPLATE	M51	T+0000	N1143	167	147	149	169	.70000000E-01 /
SPLATE	M51	T+0000	N1148	170	150	148	168	.70000000E-01 /
SPLATE	M51	T+0000	N1149	168	148	146	166	.70000000E-01 /
SPLATE	M51	T+0000	N1200	1	3	4	2	.70000000E-01 /
SPLATE	M51	T+0000	N1201	3	5	6	4	.70000000E-01 /
SPLATE	M51	T+0000	N1202	5	7	8	6	.70000000E-01 /
SPLATE	M51	T+0000	N1203	7	9	10	8	.70000000E-01 /
SPLATE	M51	T+0000	N1204	9	11	12	10	.70000000E-01 /
SPLATE	M52	T+0000	N1205	21	23	24	22	.16400000E+01 /
SPLATE	M52	T+0000	N1206	23	25	26	24	.16400000E+01 /
SPLATE	M52	T+0000	N1207	25	27	28	26	.16400000E+01 /
SPLATE	M52	T+0000	N1208	27	29	30	28	.16400000E+01 /
SPLATE	M52	T+0000	N1209	29	31	32	30	.16400000E+01 /
SPLATE	M52	T+0000	N1210	41	43	44	42	.50000000E-01 /
SPLATE	M52	T+0000	N1211	43	45	46	44	.50000000E-01 /
SPLATE	M52	T+0000	N1212	45	47	48	46	.50000000E-01 /
SPLATE	M52	T+0000	N1213	47	49	50	48	.50000000E-01 /
SPLATE	M52	T+0000	N1214	49	51	52	50	.50000000E-01 /
SPLATE	M52	T+0000	N1215	61	63	64	62	.50000000E-01 /
SPLATE	M52	T+0000	N1216	63	65	66	64	.50000000E-01 /
SPLATE	M52	T+0000	N1217	65	67	68	66	.50000000E-01 /
SPLATE	M52	T+0000	N1218	67	69	70	68	.50000000E-01 /
SPLATE	M52	T+0000	N1219	69	71	72	70	.50000000E-01 /

```
SPLATE  M52  T+0000  N1220        81    83    84    82    .50000000E-01 /
SPLATE  M52  T+0000  N1221        83    85    86    84    .50000000E-01 /
SPLATE  M52  T+0000  N1222        85    87    88    86    .50000000E-01 /
SPLATE  M52  T+0000  N1223        87    89    90    88    .50000000E-01 /
SPLATE  M52  T+0000  N1224        89    91    92    90    .50000000E-01 /
SPLATE  M52  T+0000  N1225       101   103   104   102    .50000000E-01 /
SPLATE  M52  T+0000  N1226       103   105   106   104    .50000000E-01 /
SPLATE  M52  T+0000  N1227       105   107   108   106    .50000000E-01 /
SPLATE  M52  T+0000  N1228       107   109   110   108    .50000000E-01 /
SPLATE  M52  T+0000  N1229       109   111   112   110    .50000000E-01 /
SPLATE  M52  T+0000  N1230       121   123   124   122    .50000000E-01 /
SPLATE  M52  T+0000  N1231       123   125   126   124    .50000000E-01 /
SPLATE  M52  T+0000  N1232       125   127   128   126    .50000000E-01 /
SPLATE  M52  T+0000  N1233       127   129   130   128    .50000000E-01 /
SPLATE  M52  T+0000  N1234       129   131   132   130    .50000000E-01 /
SPLATE  M52  T+0000  N1235       141   143   144   142    .50000000E-01 /
SPLATE  M52  T+0000  N1236       143   145   146   144    .50000000E-01 /
SPLATE  M52  T+0000  N1237       145   147   148   146    .50000000E-01 /
SPLATE  M52  T+0000  N1238       147   149   150   148    .50000000E-01 /
SPLATE  M52  T+0000  N1239       165   167   168   166    .80000000E-01 /
SPLATE  M52  T+0000  N1240       167   169   170   168    .80000000E-01 /
SPLATE  M55  T+0000  N1301        45    25    26    46    .10000000E+00 /
SPLATE  M55  T+0000  N1302        65    45    46    66    .10000000E+00 /
SPLATE  M55  T+0000  N1303        85    65    66    86    .10000000E+00 /
SPLATE  M55  T+0000  N1304       105    85    86   106    .10000000E+00 /
SPLATE  M55  T+0000  N1305       125   105   106   126    .10000000E+00 /
SPLATE  M55  T+0000  N1306       145   125   126   146    .10000000E+00 /
SPLATE  M55  T+0000  N1307       165   145   146   166    .10000000E+00 /
SPLATE  M55  T+0000  N1311        49    29    30    50    .10000000E+00 /
SPLATE  M55  T+0000  N1312        69    49    50    70    .10000000E+00 /
SPLATE  M55  T+0000  N1313        89    69    70    90    .10000000E+00 /
SPLATE  M55  T+0000  N1314       109    89    90   110    .10000000E+00 /
SPLATE  M55  T+0000  N1315       129   109   110   130    .10000000E+00 /
SPLATE  M55  T+0000  N1316       149   129   130   150    .10000000E+00 /
SPLATE  M55  T+0000  N1317       169   149   150   170    .10000000E+00 /
GPLATE  M52  T+0000  N5000       202   176   203
  .25000000E+01    .25000000E+01    0.          /
GPLATE  M52  T+0000  N5001       201   202   242
  .25000000E+00    .25000000E+00    0.          /
GPLATE  M52  T+0000  N5002       202   243   242
  .25000000E+00    .25000000E+00    0.          /
GPLATE  M52  T+0000  N5003       202   203   243
  .25000000E+00    .25000000E+00    0.          /
*/   ADDITIONAL ELEMENTS    /
 ROD M53 TO N7003  5  6 .01   /
 ROD        N7004  9 10 .01  /
 ROD M54 TO N7005 25 26 .01  /
 ROD M54 TO N7006 29 30 .01  /
 SPLATE     N7001  5  6 26 25  .1  /
 SPLATE     N7002  9 10 30 29  .1  /
 PLATE M54 TO N7007 11 12 13 .05  /
 PLATE        N7008 31 32 33 .05  /
 PLATE        N7009 51 52 53 .05  /
 PLATE        N7010 71 72 73 .05  /
 PLATE        N7011 91 92 93 .05  /
 PLATE        N7012 111 112 113 .05  /
 PLATE        N7013 131 132 133 .05  /
*/  FUSELAGE  BEAMS  /
 BEAM M54 TO N6001 304 308 0. *=4    9.524   0. *=4  52.381  /
 BEAM         N6002 308 310 0. *=4   52.381   0. *=4  59.524  /
 BEAM         N6003 310 316 0. *=4   59.524   0. *=4  80.952  /
 BEAM         N6004 316 320 0. *=4   80.952   0. *=4 126.190  /
 BEAM         N6005 320 322 0. *=4  126.190   0. *=4 106.101  /
 BEAM         N6006 322 326 0. *=4  106.101   0. *=4  61.905  /
 BEAM         N6007 326 328 0. *=4   61.905   0. *=4 100.000  /
 BEAM         N6008 328 242 0. *=4  100.000   0. *=4 106.625  /
 BEAM         N6009 242 243 0. *=4  106.625   0. *=4 123.810  /
 BEAM         N6010 243 246 0. *=4  123.810   0. *=4 116.667  /
 BEAM         N6011 246 247 0. *=4  116.667   0. *=4 164.286  /
 BEAM         N6012 247 334 0. *=4  164.286   0. *=4 169.048  /
 BEAM         N6013 334 338 0. *=4  169.048   0. *=4 181.548  /
 BEAM         N6014 338 340 0. *=4  181.548   0. *=4 195.238  /
 BEAM         N6015 340 344 0. *=4  195.238   0. *=4 140.476  /
```

```
 BEAM        N6016 344 348 0. *=4 140.476  0. *=4  33.333  /
 BEAM        N6017 348 352 0. *=4  33.333  0. *=4  47.619  /
 BEAM        N6018 352 356 0. *=4  47.619  0. *=4  33.709  /
 BEAM        N6019 356 358 0. *=4  33.709  0. *=4  21.429  /
 BEAM        N6020 358 360 0. *=4  21.429  0. *=4  26.191  /
 BEAM        N6021 360 364 0. *=4  26.191  0. *=4   9.524  /
*/  HORIZONTAL TAIL BEAMS   /
 BEAM M54 TO N8001 356 401 0. 0. 0. 100. 0. 100.  /
 BEAM        N8002 401 402 0. 0. 0. 1.330 0. .5635
   0. 0. 0. 1.033   0. .427         /
 BEAM        N8003 402 403 0. 0. 0. 1.033  0. .427
   0. 0. 0. .7418   0. .2949       /
 BEAM        N8004 403 404 0. 0. 0. .7418  0. .2949
   0. 0. 0. .4873   0. .181        /
 BEAM        N8005 404 405 0. 0. 0. .4873  0. .181
   0. 0. 0. .2825   0. .0981       /
 BEAM        N8006 405 406 0. 0. 0. .2825  0. .0981
   0. 0. 0. .1575   0. .04856      /
 BEAM        N8007 406 407 0. 0. 0. .1575  0. .04856
   0. 0. 0. .0775   0. .02286      /
 BEAM        N8008 407 408 0. 0. 0. .0775  0. .02286
   0. 0. 0. .03     0. .00762      /
END ELEMENT DATA /
  END STIFFNESS DATA /
BEGIN MASS DATA /
 BEGIN CONDITION DATA  /
 STAGE 1 CONDITION 1 0 0 1 /
 END CONDITION DATA  /
 BEGIN MASS ELEMENT DATA   /
*/  FUSELAGE MASSES  /
 SCALAR  F2  N326  326  29.3   /
 SCALAR  F2  N328  328  35.7   /
 SCALAR  F2  N330  330  42.6   /
 SCALAR  F2  N243  243  56.5   /
 SCALAR  F2  N246  246  30.2   /
 SCALAR  F2  N247  247  30.3   /
 SCALAR  F2  N332  332  18.0   /
 END MASS ELEMENT DATA   /
 BEGIN CONCENTRATED MASS DATA 1  /
*/  FUSELAGE WEIGHTS  /
 CM302  304  302   2.4   /
 CM304  304  304  27.2   /
 CM306  304  306  11.3   /
 CM308  310  308  16.4   /
 CM310  310  310  18.5   /
 CM312  310  312  19.0   /
 CM314  316  314  24.8   /
 CM316  316  316  18.7   /
 CM318  316  318  18.2   /
 CM320  322  320  21.8   /
 CM322  322  322  29.6   /
 CM324  322  324  36.8   /
 CM336  338  336  10.8   /
 CM338  338  338  221.0  0.  57450.   /
 CM342  344  342  11.0   /
 CM346  344  346  11.8   /
 CM350  352  350  16.1   0.  .01   /
 CM354  356  354  17.8   /
 CM356  356  356  15.6   /
 CM360  360  360  36.1   0.  .01   /
 CM362  364  362  12.9   /
 CM366  364  366   5.9   /
*/  HORIZONTAL TAIL WEIGHTS  /
 CM411  401  411  I=HT  1.920  11.406  2.56  /
 CM412  402  412  I=HT  1.588  19.544  2.12  /
 CM413  403  413  I=HT  1.335  15.368  1.78  /
 CM414  404  414  I=HT  1.080  11.482  1.44  /
 CM415  405  415  I=HT  0.868   8.627  1.16  /
 CM416  406  416  I=HT  0.702   6.623  0.94  /
 CM417  407  417  I=HT  0.553   4.987  0.74  /
 CM418  408  418  I=HT  0.245   1.662  0.33  /
 END CONCENTRATED MASS DATA  /
END MASS DATA /
```

```
BEGIN SUBSET DEFINITION  /
SUBSETS OF STIFFNESS SET 1  /
    N1 = ALL    /
    N2 = 242 TO 247 302 TO 366 /  FUSELAGE NODES
    N3 = 401 TO 418   352 TO 360  /  HORIZ. TAIL NODES
    N4 = 1 TO 169 BY 2    /  UPPER WING SURFACE
    N5 = 2 TO 170 BY 2  13 TO 133 BY 20  / LOWER WING SURFACE
    N6 = 174 TO 247  /  WING-BODY
    E1 = ALL    /
    E2 = CLOSED IN N2  /
    E3 = CLOSED IN N3  /
    E4 = CLOSED IN N4  /
    E5 = CLOSED IN N5  /
    E6 = CLOSED IN N6  /
 ON1 = 304 310 316 322 328 165 145 143 141 TO 1 BY -20 +
 3 TO 143 BY 20 145 TO 5 BY -20 7 TO 167 BY 20 +
 169 TO 9 BY -20 11 TO 131 BY 20 133 TO 13 BY -20 +
 11 TO 1 BY -2 21 TO 33 BY 2 53 TO 41 BY -2 61 TO 73 BY 2  +
 93 TO 81 BY -2 101 TO 113 BY 2    +
 133 TO 121 BY -2 141 TO 149 BY 2 169 167 165 328 243 169 243 +
247 338 344 352 356 360 364 360 356 401 TO 408 /
END SUBSET DEFINITION   /
END PROBLEM DATA /
```

Table 205-1. Natural Frequencies for FIREBEE Drone

Mode No.	Frequency (Hertz)	Description
1	0.	Rigid body
2	0.	Rigid body
3	10.05	Wing bending
4	17.41	Fuselage bending
5	42.86	Fuselage bending
6	46.15	Wing bending
7	52.81	Wing twisting
8	63.76	Horizontal tail bending
9	73.05	Coupled wing, fuselage and tail
10	106.3	Wing twisting

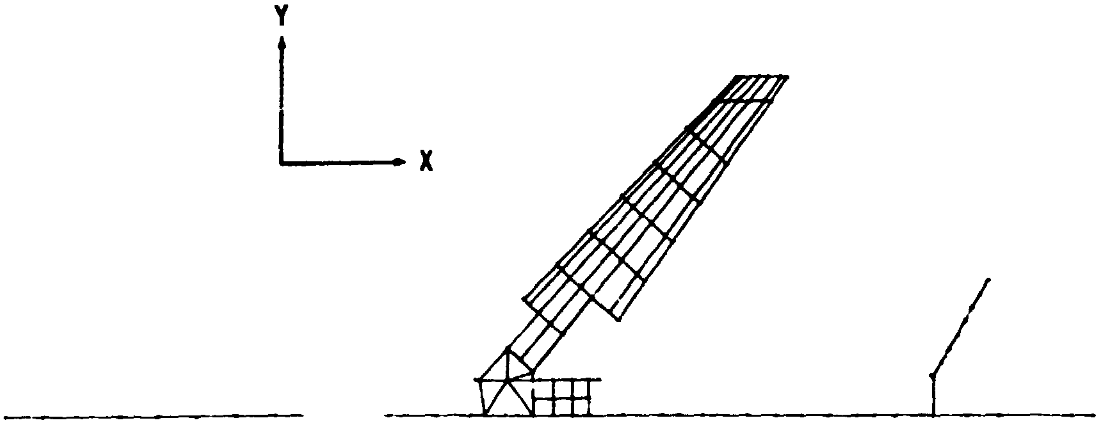

Figure 205-1. Total FIREBEE Structural Model

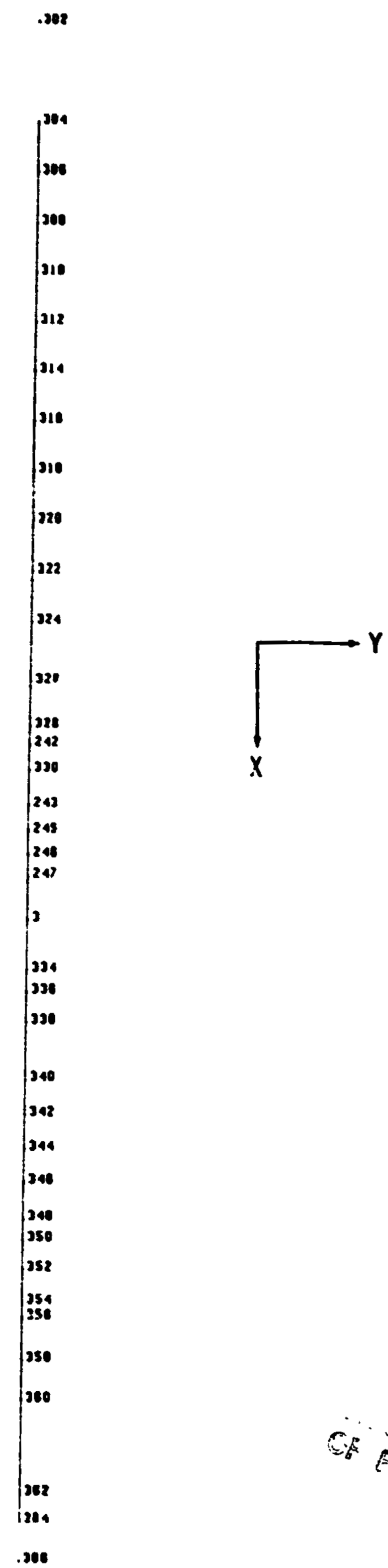

Figure 205-2. Fuselage Model, FIREBEE Drone

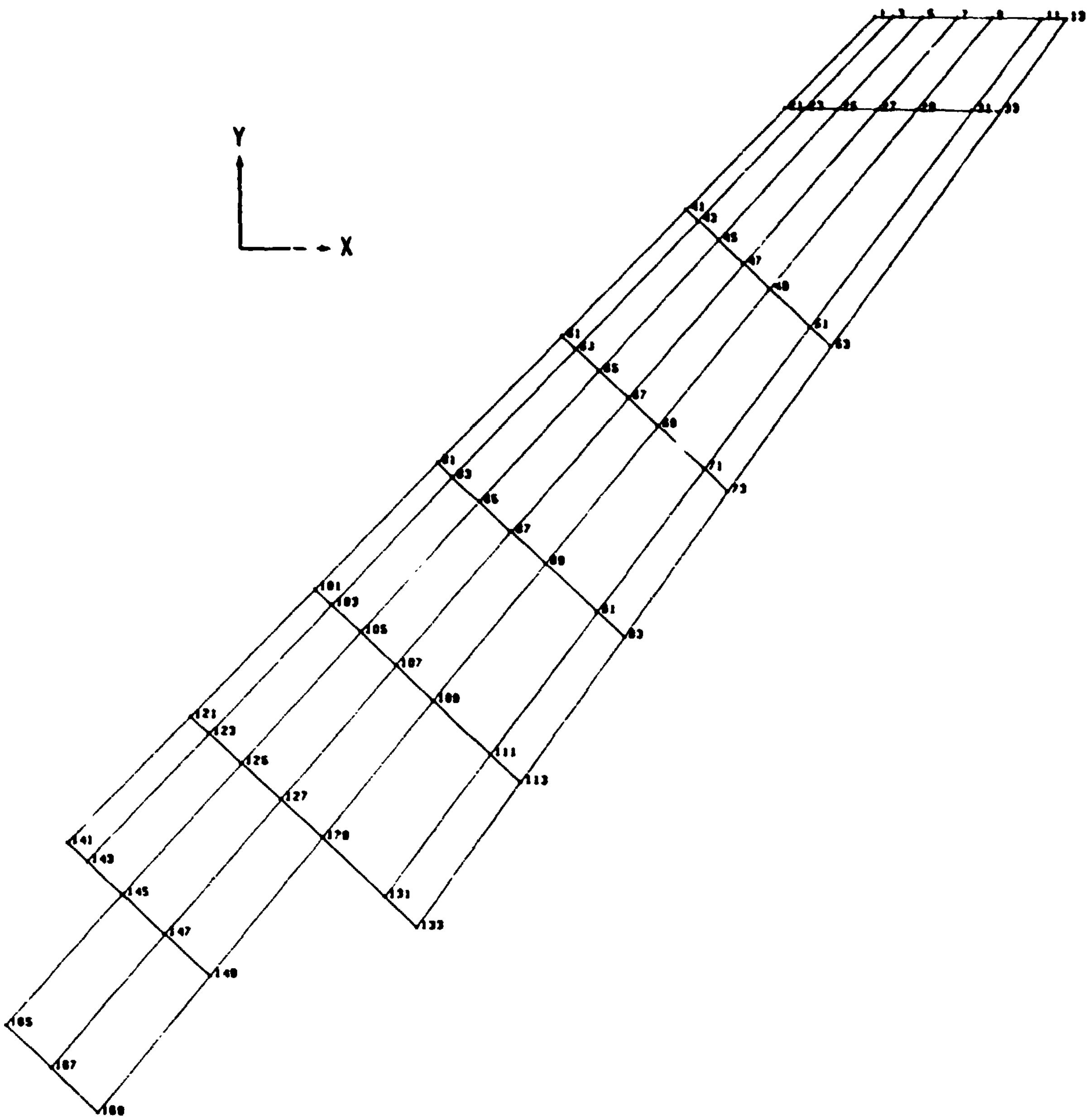

Figure 205-3. Wing Upper Surface Model, FIREBEE Drone

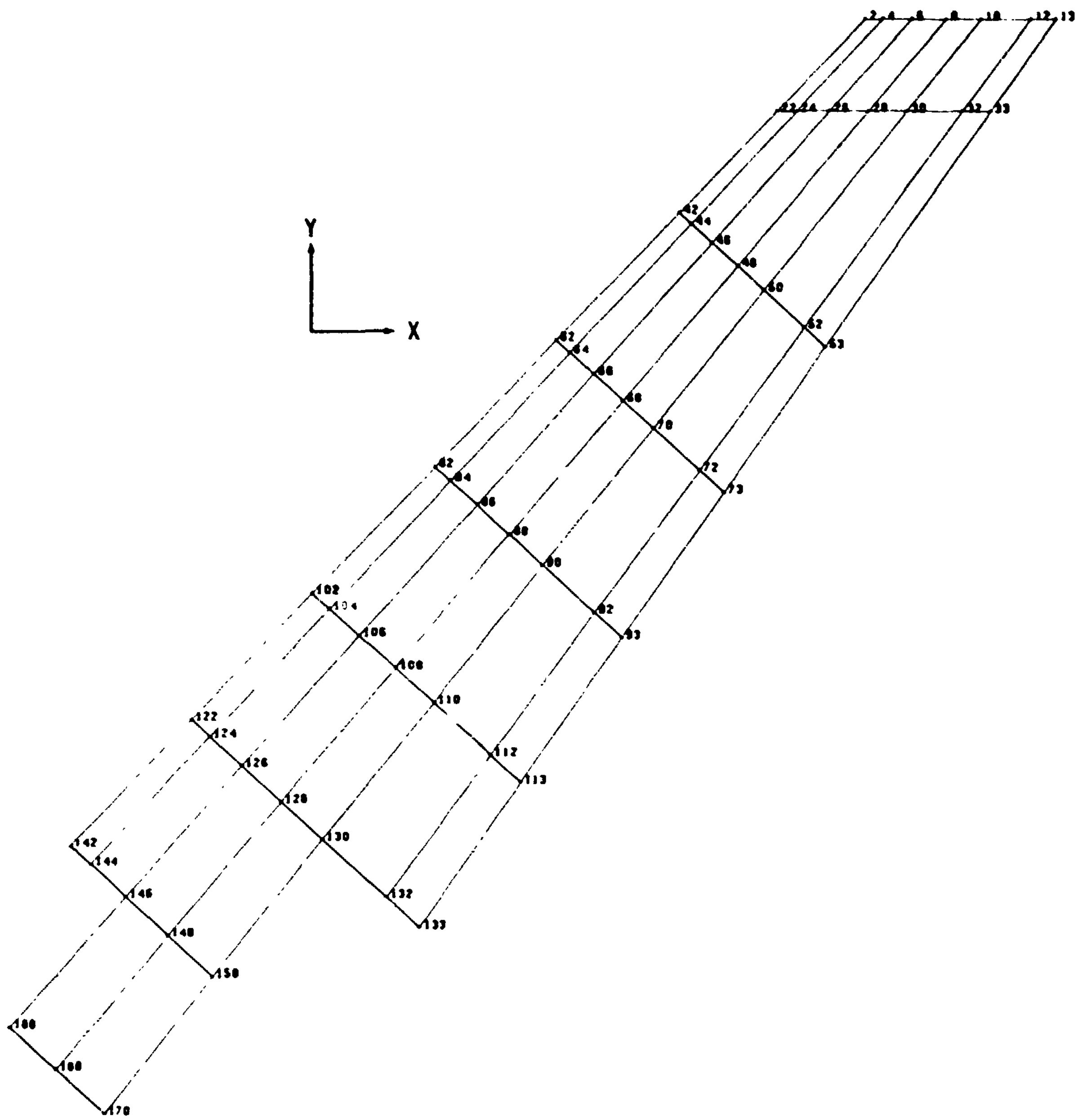

Figure 205-4. Wing Lower Surface Model, FIREBEE Drone

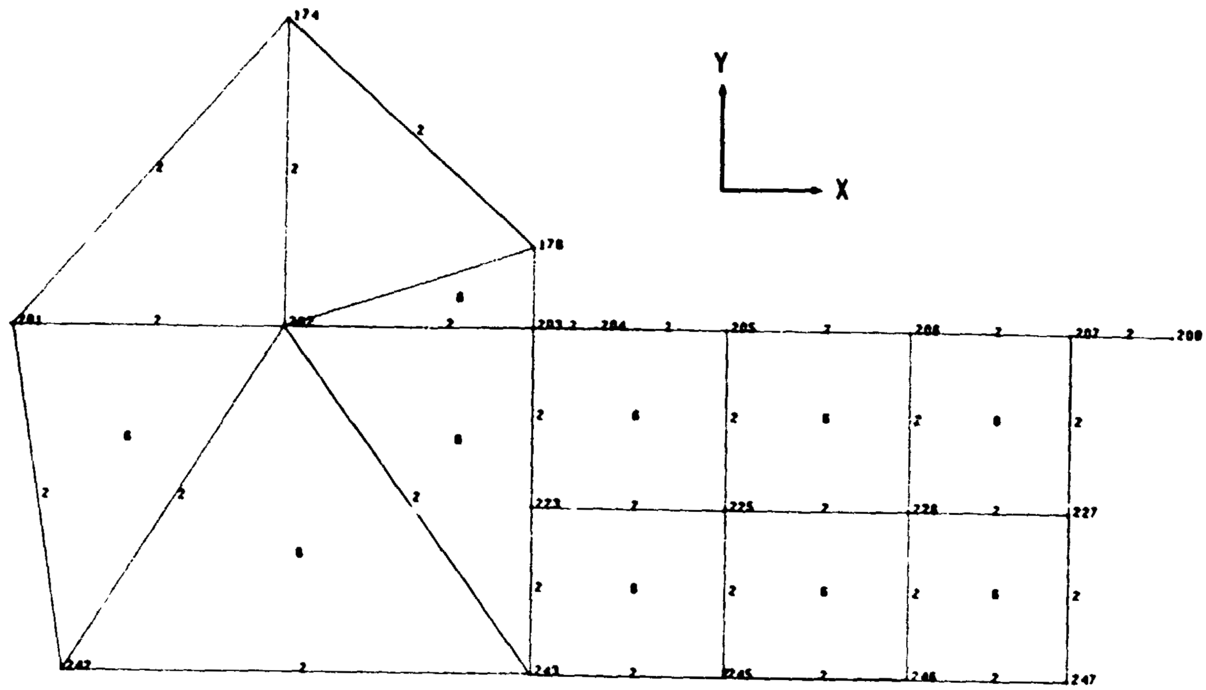

Figure 205-5. Wing-Body Intersection Model, FIREBEE Drone

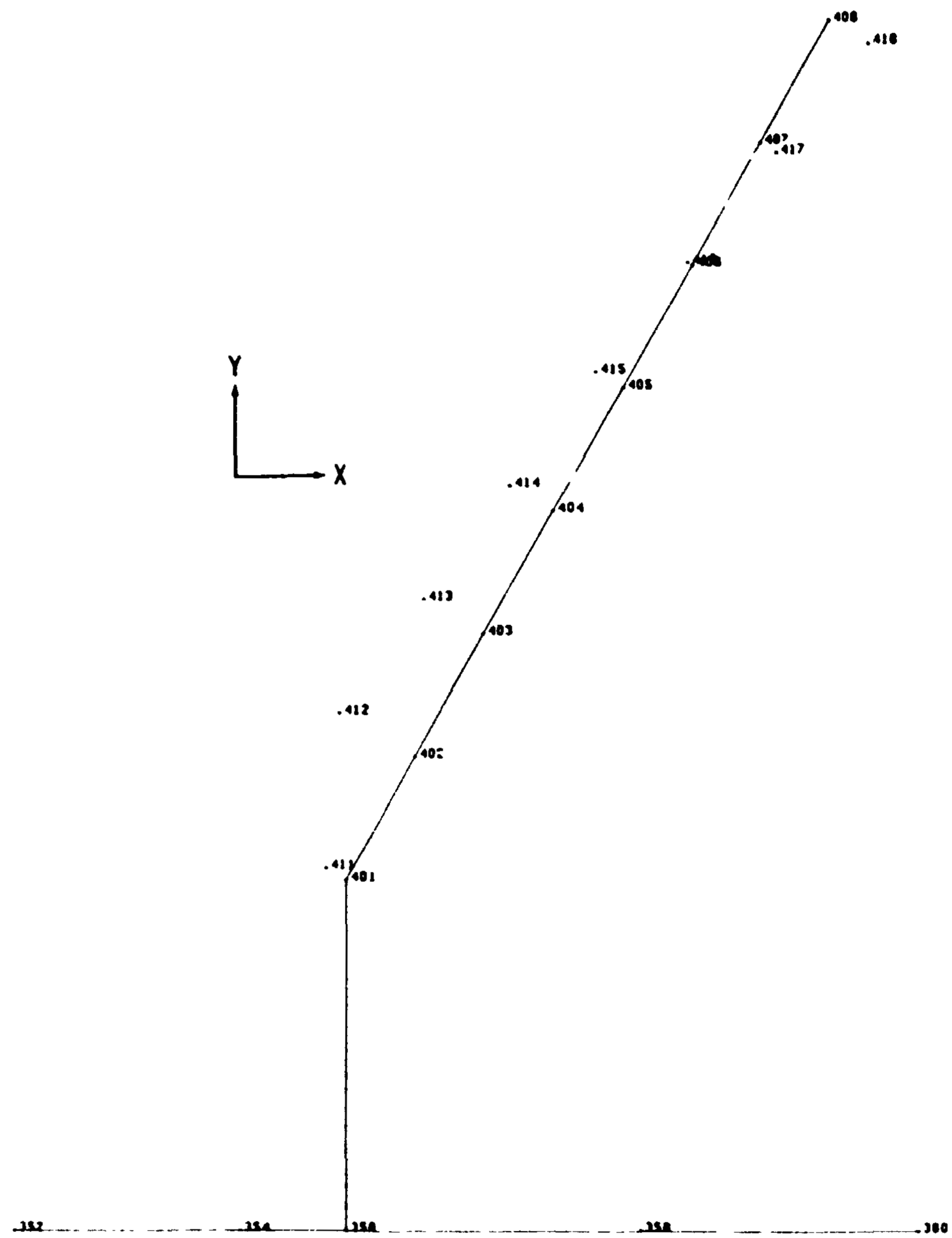

Figure 205-6. Horizontal Tail Model, FIREBEE Drone

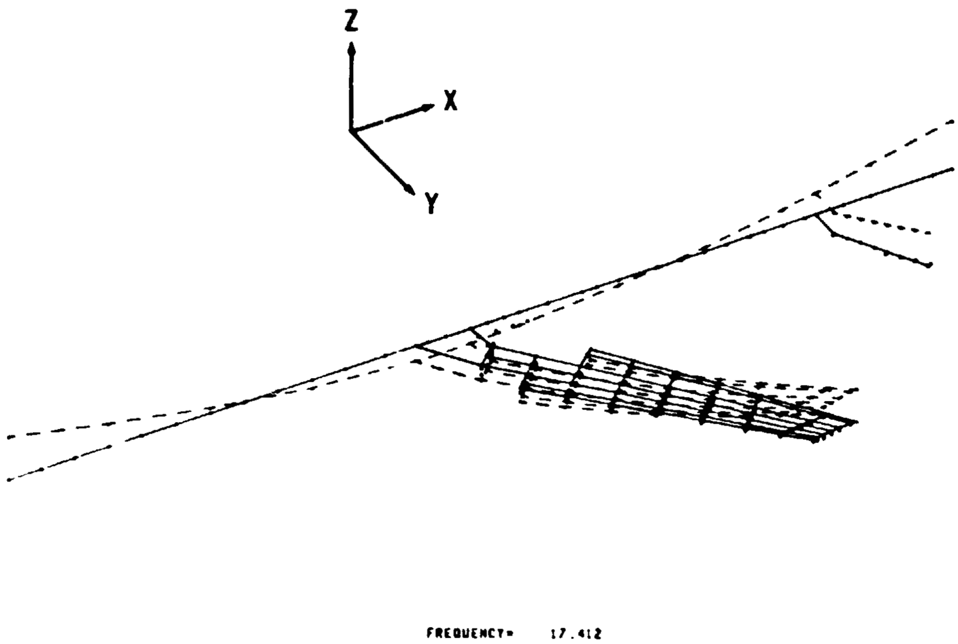

Figure 205-7. Fourth Mode Shape, FIREBEE Drone

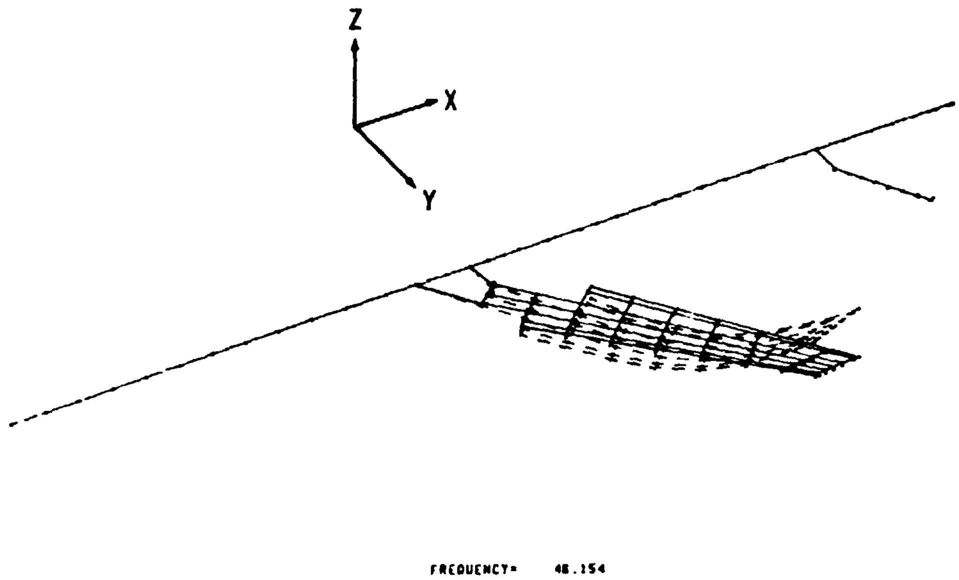

Figure 205-8. Sixth Mode Shape, FIREBEE Drone

206. BEAM VIBRATION (DECK 8)

206.1 DESCRIPTION OF ANALYSES

This problem demonstrates the various ATLAS mass matrix generation capabilities by using models of two cantilever beams:

- A beam with a straight elastic axis, uniform stiffness properties and concentrated masses offset from the elastic axis

- A beam of constant width and linearly varying depth along its span

206.1.1 Beam with Offset Concentrated Masses

The stiffness of this structure is modelled in two ways, both employing BEAM stiffness finite elements and concentrated masses:

- Structural nodes are located at the concentrated mass locations and the BEAMs are offset to the elastic axis. This model, SET 1, is shown in figure 206-1

- Structural nodes are located along the elastic axis and the concentrated masses are offset. This model, SET 2, is shown in figure 206-2

Four different mass matrices are calculated for each of these stiffness models and a normal mode analysis performed with each. The mass matrices used are:

- Guyan reduced mass matrix considering only the concentrated masses

- Guyan reduced mass matrix considering only the mass of the stiffness model

- Guyan reduced mass matrix considering both concentrated masses and stiffness element mass

- Reduced mass matrices produced directly by the Mass Processor considering only the concentrated masses

In all cases the retained freedoms are the translation in the Z-direction and rotations about the X and Y axes.

206.1.2 Tapered Beam

The structure analyzed is shown in figure 206-3. The stiffness of the structure is modelled in two ways: (1) with BEAM elements and (2) with 20-node BRICK elements.

The BEAM model, SET 3, is shown in figure 206-4. Three different mass matrices are calculated using the mass of the stiffness elements and normal mode analyses performed. The mass matrices used are:

- Guyan reduced mass matrix
- Diagonal mass matrix produced directly by the Mass Processor
- Nondiagonal mass matrix produced directly by the Mass Processor

For all three analyses the retained degrees of freedom are translation in the Z-direction and rotation about the Y axis.

The BRICK model, SET 4, is shown in figure 206-5. The mass matrix is obtained by Guyan reduction from the merged consistent elemental matrices. The retained degrees of freedom are the X- and Z-direction translations at the BRICK corner nodes.

206.2 RESULTS

206.2.1 Beam with Offset Concentrated Masses

First mode frequencies for the eight vibration analyses are presented in table 206-1. It can be seen that, as expected, identical results are obtained from SET 1 and SET 2 when the same procedure is used to generate the mass matrix. Frequencies for the beam without concentrated masses are compared with exact values in table 206-2. The fourth mode shape for this case is compared with the exact shape in figure 206-6. Exact values for frequency and mode shape were obtained using the methods of reference 206-1.

206.2.2 Tapered Beam

Frequencies obtained from the three BEAM element analyses and the BRICK element analysis are compared with exact values given in reference 206-2 in table 206-3. The mode shape for the third mode is shown in figure 206-7 for the BEAM element stiffness model and Guyan reduced mass matrix.

206.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL  PROGRAM DEMOO8
      PROBLEM ID(DEMOO8 - VIBRATION ANALYSES WITH VARIOUS MASS MATRICES)
C
C     PURPOSE       THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                   DECK ARE
C                      1. DIAGONAL REDUCED MASS MATRIX GENERATED BY
C                         MASS PROCESSOR
C                      2. NON-DIAGONAL REDUCED MASS MATRIX GENERATED
C                         BY MASS PROCESSOR
C                      3. GUYAN-REDUCED MASS MATRIX
C                      4. VIBRATION ANALYSES USING BOTH REDUCED
C                         STIFFNESS AND REDUCED FLEXIBILITY MATRICES
C
C     AUTHOR        F. P. GRAY
C
C     CORE           130K (OCTAL)
C
      READ INPUT
C
C     U N I F O R M   B E A M   W I T H   O F F S E T   M A S S E S
C
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(MASS)
      EXECUTE EXTRACT(EXNAME=SET1,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=CALCOMP,VIEW=100,TYPE=ORTH,
     X                 SIZE=(20.,20.),LABEL=N+E,EXNAME=SET1)
C
C     GUYAN REDUCED MASS MATRIX, STIFFNESS ELEMENTS ONLY
C
      PERFORM REDUCE(SET=1)
      PRINT INPUT(BC)
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=1)
      PRINT OUTPUT(VIBRATION)
      PRINT INPUT(NODAL,SET=2)
      PRINT INPUT(STIFFNESS,SET=2)
      PRINT INPUT(MASS,SET=2)
      EXECUTE EXTRACT(EXNAME=SET2,LSUB=KGRID,KSET=2,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,VZ=-1,TYPE=ORTH,LABEL=N+E,
     X                 SIZE=(20.,20.),EXNAME=SET2)
      PERFORM REDUCE(SET=2)
      PRINT INPUT(BC,SET=2)
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=2,VSET=2,
     X                  SUBSETS=N2)
      PRINT OUTPUT(VIBRATION,VSET=2)
      EXECUTE EXTRACT(EXNAME=MODE4,LSUB=VMODE,VSET=2,NSUB=N2,MODE=4,
     X                 ESUB=DN1)
      EXECUTE GRAPHICS(GNAME=MODES,TYPE=ORTH,VECTOR2=VMODE,SCALE=0.1,
     X                 VSCALE=15,VX=5,VY=-70,EXNAME=MODE4)
C
C     SAME ANALYSIS USING REDUCED FLEXIBILITY MATRIX
C
      EXECUTE CHOLESKY(DECO,KRED=DKRED)
      EXECUTE CHOLESKY(IFOR,DKRED,DFRED)
      EXECUTE MULTIPLY(FRED=[DFRED(T)*DFRED])
      EXECUTE VIBRATION(FLEX=FRED,MASS=MRED,NFREQS=10,SET=2,VSET=2)
      PRINT OUTPUT(VIBRATION,VSET=2)
      PURGE FILES(MASSRNF)
C
C     GUYAN REDUCED MASS MATRIX, CONCENTRATED MASSES ONLY
```

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```
C
      PERFORM REDUCE(SET=1,[4]=[4,STIFELEM=0],
     1      [MASS]=[MASS,CONMASS=1])
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=1)
      PRINT OUTPUT(VIBRATION)
      PERFORM REDUCE(SET=2,[4]=[4,STIFELEM=0],
     1      [MASS]=[MASS,CONMASS=1])
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFRECS=10,SET=2,VSET=2)
      PRINT OUTPUT(VIBRATION,VSET=2)
      PURGE FILES(MASSRNF)
C
C     GUYAN REDUCED MASS MATRIX, STIFFNESS ELEMENTS + CONCENTRATED MASS
C
      PERFORM REDUCE(SET=1,[MASS]=[MASS,CONMASS=1])
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=1)
      PRINT OUTPUT(VIBRATION)
      PERFORM REDUCE(SET=2,[MASS]=[MASS,CONMASS=1])
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=2,VSET=2)
      PRINT OUTPUT(VIBRATION,VSET=2)
      PURGE FILES(MASSRNF)
C
C     DIAGONAL MASS MATRIX, CONCENTRATED MASSES ONLY
C
      PERFORM K-REDUCE
      EXECUTE MASS(SET=1,OPTION=2)
      EXECUTE VIBRATION(STIF=KRED,MASS=MDC001A,NFREQS=10,SET=1)
      PRINT OUTPUT(VIBRATION)
C
C     NON-DIAGONAL MASS MATRIX, CONCENTRATED MASSES ONLY
C
      PURGE FILES(MASSRNF)
      PERFORM K-REDUCE(SET=2)
      EXECUTE MASS(SET=2,OPTION=3)
      EXECUTE VIBRATION(STIF=KRED,MASS=MDC001B,NFREQS=10,SET=2,VSET=2)
      PRINT OUTPUT(VIBRATION,VSET=2)
C
C     T A P E R E D      B E A M
C
C     BEAM ELEMENTS  -  GUYAN REDUCED MASS MATRIX
C
      PRINT INPUT(NODAL,SET=3)
      PRINT INPUT(STIFFNESS,SET=3)
      EXECUTE EXTRACT(EXNAME=SET3,LSUB=KGRID,KSET=3,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,VIEW=100,TYPE=ORTH,LABEL=N,
     X          SIZE=(20.,20.),EXNAME=SET3)
      PERFORM REDUCE(SET=3)
      PRINT INPUT(BC,SET=3)
      EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=3,VSET=3)
      PRINT OUTPUT(VIBRATION,VSET=3)
C
C     BEAM ELEMENTS  -  DIAGONAL MASS MATRIX
C
      EXECUTE MASS(SET=3,OPTION=2)
      EXECUTE VIBRATION(STIF=KRED,MASS=MDC001C,NFREQS=10,SET=3,VSET=3)
      PRINT OUTPUT(VIBRATION,VSET=3)
C
C     BEAM ELEMENTS  -  NON-DIAGONAL MASS MATRIX
C
      EXECUTE MASS(SET=3,OPTION=3)
      EXECUTE VIBRATION(STIF=KRED,MASS=MDC001C,NFREQS=10,SET=3,VSET=3)
      PRINT OUTPUT(VIBRATION,VSET=3,NOGSTIF,NOGMASS)
      EXECUTE EXTRACT(EXNAME=MODE3,LSUB=VMODE,VSET=3,MODE=3,BSUB=ON1
      EXECUTE GRAPHICS(GNAME=MODES,TYPE=ORTH,VIEW=1000,VECTOR2=VMODE,
     X              SCALE=0.1,VSCALE=25.,EXNAME=MODE3)
C
C     BRICK ELEMENTS  -  GUYAN REDUCED MASS MATRIX
C
      PRINT INPUT(NODAL,SET=4)
      PRINT INPUT(STIFFNESS,SET=4)
      EXECUTE EXTRACT(EXNAME=SET4,LSUB=KGRID,KSET=4,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=ORTH,LABEL=E,SIZE=(20,20),
     X          RZ=60,RX=0,RY=30,EXNAME=SET4)
```

```
PERFORM RECUCE(SET=4)
PRINT INPUT(BC,SET=4)
EXECUTE VIBRATION(STIF=KRED,MASS=MRED,NFREQS=10,SET=4,VSET=99)
PRINT OUTPUT(VIBRATION,VSET=99)
CALL PRNTCAT
INDEX FILES(DATARNF,VIBRRNF)
END
```

```
*/                                                                      /
*/                                                                      /
*/ U N I F O R M   B E A M   W I T H   O F F S E T   M A S S E S        /
*/                                                                      /
*/    STRUCTURAL NODES AT CONCENTRATED MASS LOCATIONS                   /
*/                                                                      /
BEGIN NODAL DATA /
1 0. 0. 0. TO 15 70. 5. 0. /
21 0. 8. 0. /
22 4. 7. 0. /
23 11. 7. 0. /
24 17. 4. 0. /
25 23. 6. 0. /
26 26. 4. 0. /
27 31. 3. 0. /
28 34. 7. 0. /
29 39. 6. 0. /
30 47. 4. 0. /
31 51. 3. 0. /
32 54. 2. 0. /
33 60. 4. 0. /
34 66. 6. 0. /
35 71. 6. 0. /
END NODAL DATA /
BEGIN STIFFNESS DATA /
BEGIN ELEMENT DATA /
BEAM 21 22  1 2 1. 0. 0. .15 .15 .20 TO 34 35 14 15 /
END ELEMENT DATA /
END STIFFNESS DATA /
BEGIN MASS DATA /
BEGIN CONDITION DATA /
STAGE 1 CONDITION 1 0 0 1    /
END CONDITION DATA /
BEGIN CONCENTRATED MASS DATA 1 /
 21 1.0 *=3 /
 22 2.5 4. 4. 4. /
5*13 1 -.1 *=3 /
END CONCENTRATED MASS DATA /
END MASS DATA /
BEGIN BC DATA /
SUPPORT TX TY TZ RX RY RZ FOR 21 /
RETAIN TZ RX RY FOR 22 TO 35          /
END BC DATA /
*/                                                                      /
*/    STRUCTURAL NODES ALONG ELASTIC AXIS                               /
*/                                                                      /
BEGIN NODAL DATA   /
SET 2 /
1 0. 0. 0. TO 15 70. 5. 0. /
21 0. 8. 0. /
22 4. 7. 0. /
23 11. 7. 0. /
24 17. 4. 0. /
25 23. 6. 0. /
26 26. 4. 0. /
27 31. 3. 0. /
```

```
28 34. 7. 0. /
29 39. 6. 0. /
30 47. 4. 0. /
31 51. 3. 0. /
32 54. 2. 0. /
33 60. 4. 0. /
34 66. 6. 0. /
35 71. 6. 0. /
END NODAL DATA      /
BEGIN STIFFNESS DATA /
SET 2 /
BEGIN ELEMENT DATA /
BEAM 1 2 1.0 0. 0. .15 .15 .20 TO 14 15      /
END ELEMENT DATA    /
END STIFFNESS DATA /
BEGIN MASS DATA     /
SET 2     /
BEGIN CONDITION DATA     /
STAGE 1 CONDITION 1 0 0 1     /
END CONDITION DATA /
BEGIN CONCENTRATED MASS DATA 1      /
 1 21 1.0 *=3 /
2 22 2.5 4. 4. 4.   /
*+13 1 1 -.1 *=3    /
END CONCENTRATED MASS DATA    /
END MASS DATA       /
BEGIN BC DATA       /
SET 2     /
SUPPORT TX TY TZ RX RY RZ FOR 1     /
RETAIN  TZ RX RY  FOR 2 TO 15      /
END BC DATA         /
*/                                                                                          /
*/                                                                                          /
*/ T A P E R E D    B E A M                                                                 /
*/                                                                                          /
*/     BEAM ELEMENT MODEL                                                                   /
*/                                                                                          /
BEGIN NODAL DATA    /
SET 3 /
100 0. 0. 0. TO 120 100. 0. 0.     /
END NODAL DATA      /
BEGIN STIFFNESS DATA /
SET 3 /
BEGIN ELEMENT DATA /
BEAM 100 101 10. 0. 0. 0. 0. 83.3333 9.6 0. 0. 0. 0. 73.728     /
     101 102 9.6     *4        73.728  9.2     *4        64.8907    /
   * 102 103 9.2     *4        64.8907 8.8     *4        56.7893    /
   * 103 104 8.8     *4        56.7893 8.4     *4        49.3920    /
   * 104 105 8.4     *4        49.3920 8.0     *4        42.6667    /
   * 105 106 8.0     *4        42.6667 7.6     *4        36.5813    /
   * 106 107 7.6     *4        36.5813 7.2     *4        31.1041    /
   * 107 108 7.2     *4        31.1040 6.8     *4        26.2027    /
   * 108 109 6.8     *4        26.2027 6.4     *4        21.8453    /
   * 109 110 6.4     *4        31.8453 6.0     *4        18.0000    /
   * 110 111 6.0     *4        18.0000 5.6     *4        14.6347    /
   * 111 112 5.6     *4        14.6347 5.2     *4        11.7173    /
   * 112 113 5.2     *4        11.7173 4.8     *4        9.2160     /
   * 113 114 4.8     *4        9.216   4.4     *4        7.0987     /
   * 114 115 4.4     *4        7.0987  4.0     *4        5.3323     /
   * 115 116 4.0     *4        5.3333  3.6     *4        3.8880     /
   * 116 117 3.6     *4        3.8880  3.2     *4        2.7307     /
   * 117 118 3.2     *4        2.7307  2.8     *4        1.8293     /
   * 118 119 2.8     *4        1.8293  2.4     *4        1.1520      /
   * 119 120 2.4     *4        1.1520  2.0     *4        .6667      /
END ELEMENT DATA    /
END STIFFNESS DATA  /
BEGIN BC DATA       /
SET 3     /
RETAIN TZ RY FOR 102 TO 120 BY 2 /
SUPPORT TX TY TZ RX RY RZ FOR 100    /
END BC DATA    /
BEGIN MASS DATA     /
SET 3     /
```

```
BEGIN CONCITIUN DATA     /
STAGE 1 CONDITION 1           /
END CONDITION DATA       /
END MASS DATA        /
*/                                                                              /
*/     BRICK ELEMENT MODEL                                                      /
*/                                                                              /
BEGIN NODAL DATA          /
SET 4 /
REC  JUNK 1. 0. 0. 2. 0. 0. 0. 0. 1.    /
100 0. -.5  5. TO 120 100. -.5  1.      /
200 0.  .5  5. TO 220 100.  .5  1.      /
300 0.  .5 -5. TO 320 100.  .5 -1.      /
400 0. -.5 -5. TO 420 100. -.5 -1.      /
500 0. 0.   5. TO 510 100. 0.   1.      /
600 0.  .5  0. TO 610 100.  .5  0.      /
700 0. 0.  -5. TO 710 100. 0.  -1.      /
800 0   .5  0. TO 810 100. -.5  0.      /
ENC N C . DATA      /
BEGIN STIFFNESS DATA /
SET 4 /
BEGIN ELEMENT DATA /
BRICK 1C0 200 300 400 102 202 302 402 500 600 700 800
      501 601 701 801 101 201 301 401   /
*+9 0  2 *=7 1 *=7 2 *=3                /
ENC ELEMENT CATA   /
END STIFFNESS CATA /
BEGIN BC DATA        /
SET 4      /
ORDER RETAIN BY INTERNALID   /
RETAIN TX TZ FOR 102 TO 120 BY 2        /
*+3  0 *=3        1C0  0 1C0  0 0       /
SUPPORT TX TY TZ RX RY RZ FOR 100 TO 800 BY 100  /
SUPPORT TY FOR 100 TO 100C        /
END BC DATA         /
BEGIN SUBSET DEFINITION                                                         /
   SUBSETS OF STIFFNESS SET 1                                                   /
      N1 = ALL                                                                  /
      E1 = ALL                                                                  /
   SUBSETS OF STIFFNESS SET 2                                                   /
      N1 = ALL                                                                  /
      E1 = ALL                                                                  /
      N2 = 1 TO 15                                                              /
      ON1 = 2 TO 15                                                             /
   SUBSETS OF STIFFNESS SET 3                                                   /
      N1 = ALL                                                                  /
      E1 = ALL                                                                  /
      ON1 = 102 TO 120 BY 2                                                     /
   SUBSETS OF STIFFNESS SET 4                                                   /
      N1 = ALL                                                                  /
      E1 = ALL                                                                  /
END SUBSET DEFINITION                                                           /
END PROBLEM CATA /
```

Table 206-1. First Mode Frequencies for Uniform Beam with Offset Masses

Mass Matrix		Stiffness Model	
		SET 1	SET 2
Guyan Reduced Matrix	Concentrated masses only	5.518 179	5.518 179
	Stiffness elements only	10.182 41	10.182 41
	Concentrated masses + Stiffness elements	4.852 565	4.852 565
Concentrated masses only produced by Mass Processor		5.518 179	5.518 179

Frequencies in Hertz

Table 206-2. Natural Frequencies of Uniform Beam without Concentrated Masses

(1) Mode No.	Frequency (Hertz)		(4) Difference $\frac{(3)-(2)}{(2)} \times 100$ (%)
	(2) Exact	(3) ATLAS	
1	10.181 5	10.182 4	0.0
2	63.806 4	63.584 6	-0.3
3	178.660	176.658	-1.1
4	350.104	341.924	-2.3

Table 206-3. Natural Frequencies of Tapered Beam

Stiffness Model	Mass Matrix	Frequency (Hertz)					
		Mode 1 f_{exact}=39.5196		Mode 2 f_{exact}=144.931		Mode 3 f_{exact}=339.566	
		ATLAS	%Error	ATLAS	%Error	ATLAS	%Error
BEAM	Diagonal Lumped	39.1177	-1.0	138.441	-4.5	307.584	-9.4
BEAM	Non-Diagonal Lumped	39.5951	0.2	144.394	-0.4	332.875	-2.0
BEAM	Guyan	39.5294	0.0	144.566	-0.3	336.253	-1.0
BRICK	Guyan	41.4888	6.2	150.553	3.9	347.329	2.3

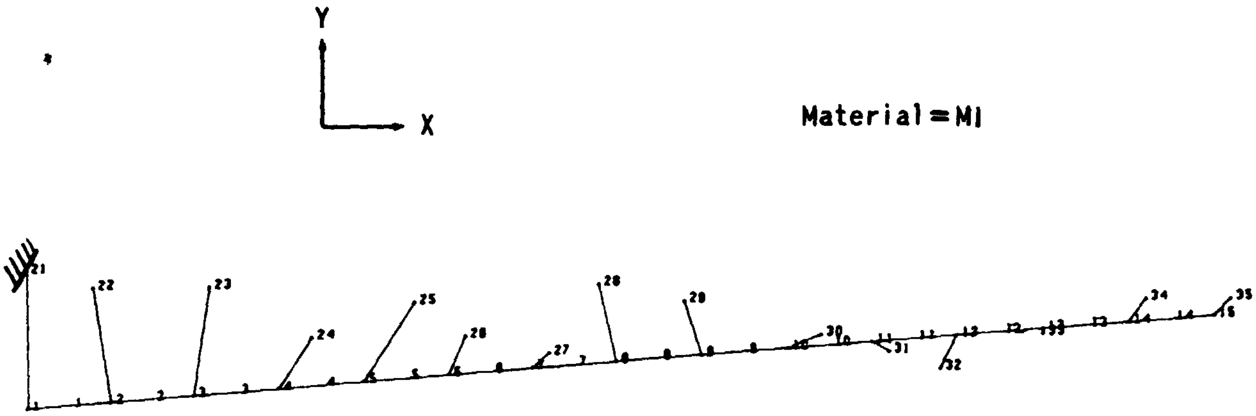

Figure 206-1. Beam Model with Structural Nodes at Concentrated Mass C.G.'s (SET 1)

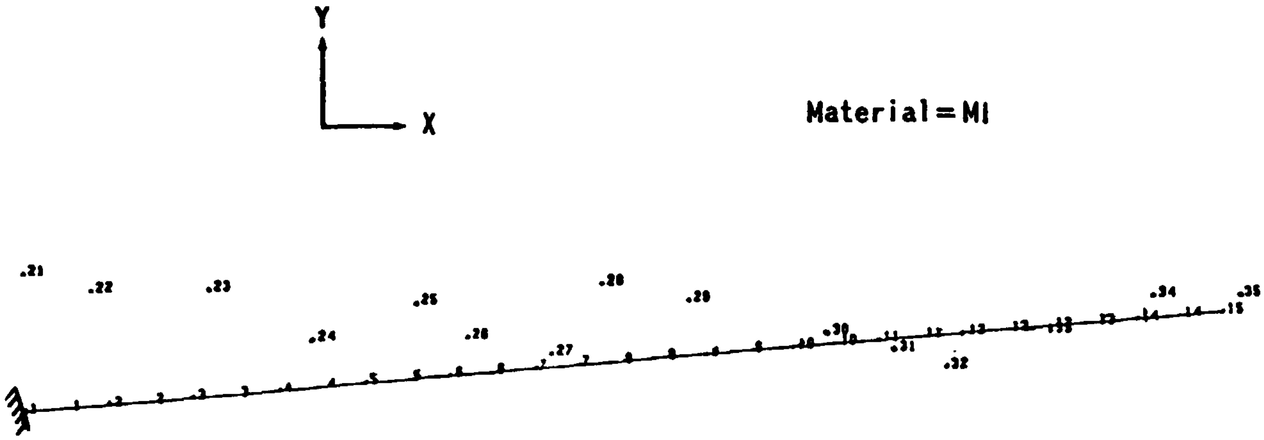

Figure 206-2. Beam Model with Structural Nodes at Elastic Axis (SET 2)

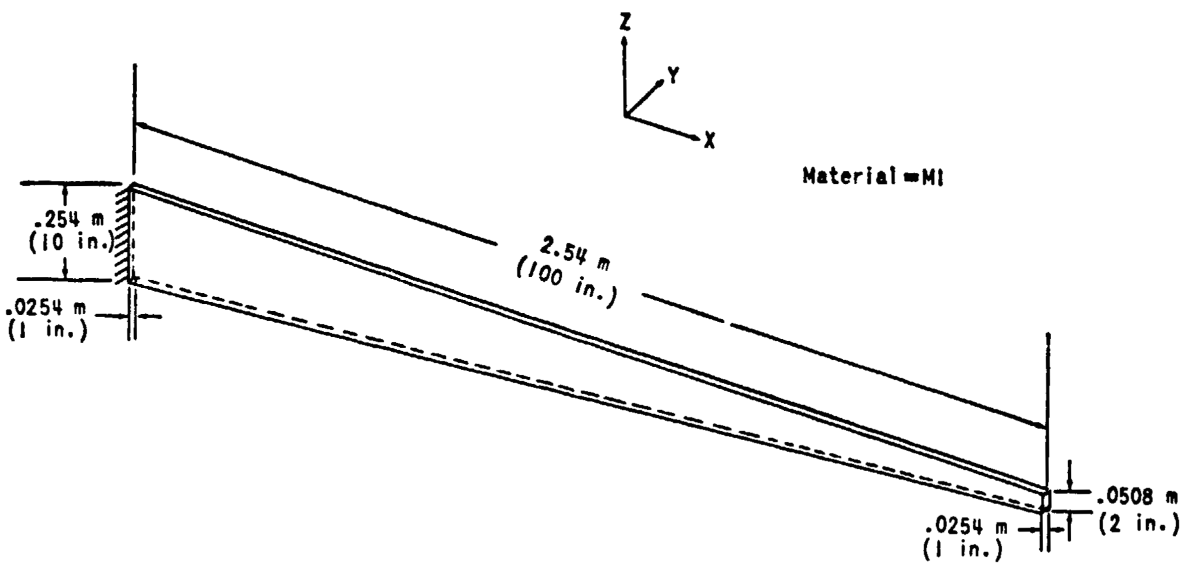

Figure 206-3. Tapered Beam

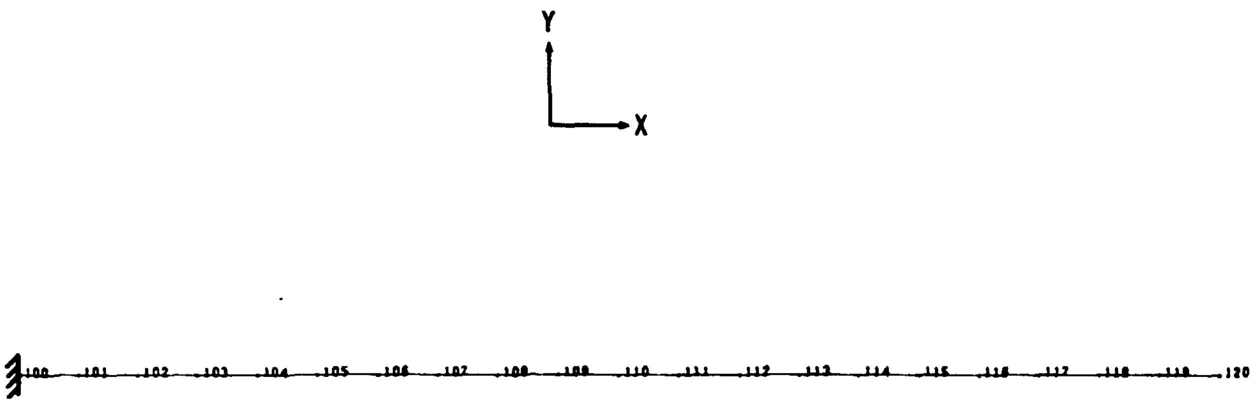

Figure 206-4. BEAM Element Model of Tapered Beam (SET 3)

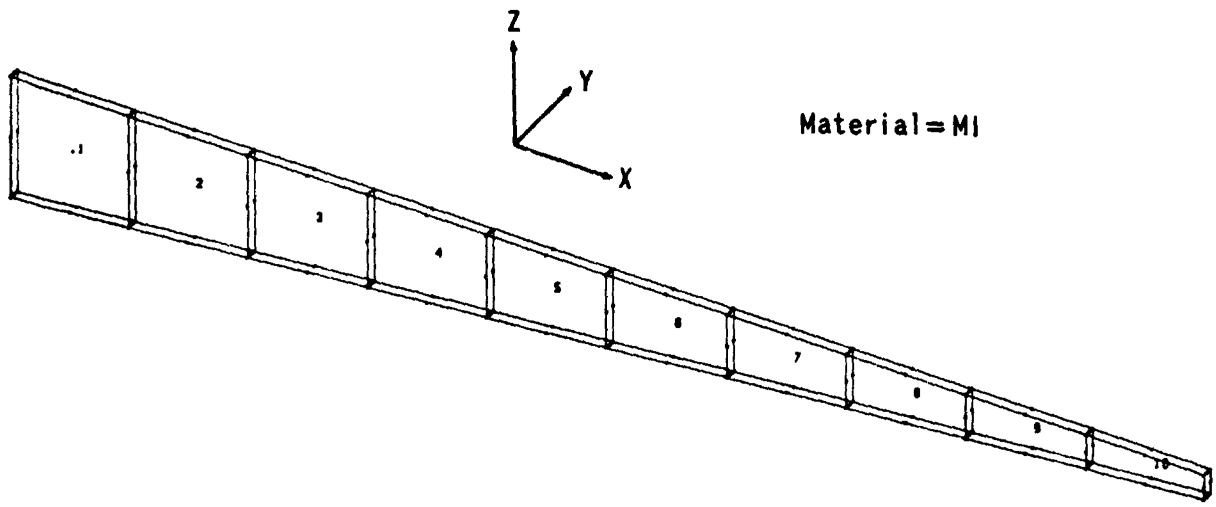

Figure 206-5. BRICK Element Model of Tapered Beam (SET 4)

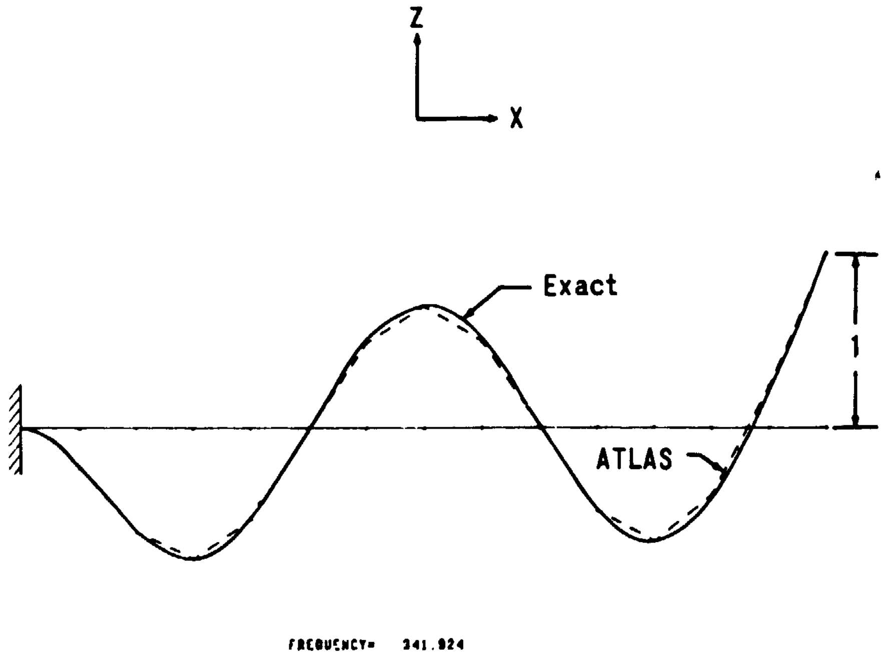

Figure 206-6. Fourth Mode Shape, Uniform Beam without Concentrated Masses (SET 2)

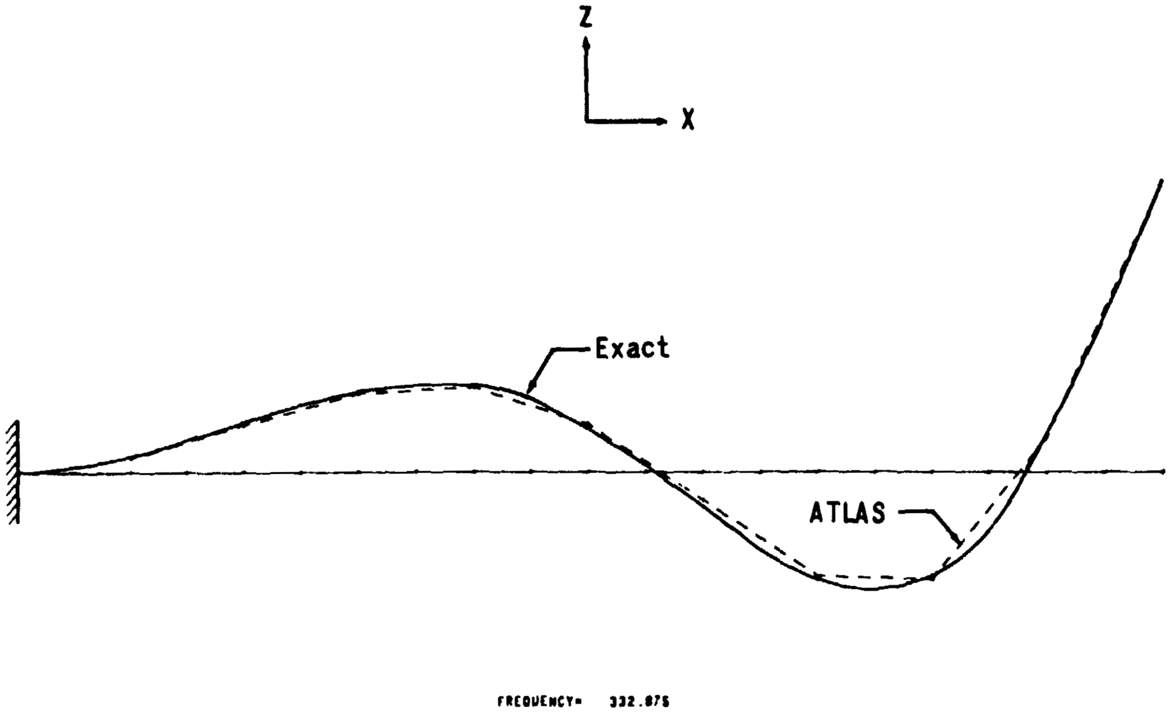

Figure 206-7. Third Mode Shape, Tapered Beam (SET 3)

207. BUCKLING AND SUPERPOSITION (DECK 13)

207.1 DESCRIPTION OF ANALYSES

Two separate analyses are performed in this demonstration problem. The first is a buckling analysis and the second is a stress analysis demonstrating the ATLAS superposition capability.

Buckling loads are calculated for a plane frame with equal concentrated loads at the column tops. The model and loading are shown in figure 207-1. Translations in the X and Y-directions and rotation about the Z axis are retained at all nodes except where a freedom is supported.

Superposition is demonstrated by performing a stress analysis of the structure in figure 207-1 loaded as shown in figure 207-2 in two ways. The first analysis is performed using the total model and total loads as shown in figure 207-2. The second analysis takes advantage of the symmetry of the structure. SET 2 is defined as shown in figure 207-3. STAGE 1 is defined to have symmetry on section A-A with the symmetric load components applied. STAGE 2 is defined to have antisymmetry on section A-A with the antisymmetric load components applied. The total solution is obtained by adding 5 times the solution from STAGE 1 to 2 times the solution from STAGE 2.

In addition to the two analysis capabilities described a' this problem is used to demonstrate the capability to produc graphs of element stress vs. load case and plots of displacements. Four loadcases were added to SET 1 to demonstrate stress vs. loadcase graphs (BEAM1, BEAM2, BEAM3 and BEAM4). These cases consist of distributed loading along part or all of the horizontal beam. To demonstrate displacement plots loadcase MOVE1 was added. This case consists of a unit displacement in the X-direction at node 1.

207.2 RESULTS

Critical buckling loads for the first six modes were calculated and are presented in table 207-1. Also presented are analytical solutions obtained using the techniques of reference 207-1. The buckled shape for the third mode is shown in figure 207-4 along with the shape obtained using the techniques of reference 207-1.

Nodal displacements and element stresses calculated by superimposing STAGES 1 and 2 of SET 2 are identical to those calculated from SET 1 within the accuracy of the computer.

Figure 207-5 presents a graph of bending moment at the left end of the beam vs. loadcase for loadcases BEAM1 through BEAM4.

Displacements due to motion of the left support are shown in figure 207-6.

207.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO13
      PROBLEM ID(DEMO13 - BUCKLING AND SUPERPOSITION)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                         1. BUCKLING
C                         2. SUPERPOSITION
C                         3. PLOTS OF BUCKLING MODE SHAPES
C                         4. PLOTS OF STRESS VS. LOADCASE
C                         5. PLOTS OF STATIC DISPLACEMENTS
C
C     AUTHOR         R. A. SAMUEL
C
C     CORE           130K (OCTAL)
C
      READ INPUT(MODE2)
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(NODAL,SET=2)
      PRINT INPUT(STIFFNESS,SET=2)
      EXECUTE EXTRACT(EXNAME=TOTAL,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOMETRY,OFFLINE=CALCOMP,VIEW=100,
     X                 TYPE=ORTH,LABEL=N+E,SIZE=(10,15),EXNAME=TOTAL)
      EXECUTE EXTRACT(EXNAME=HALF,LSUB=KGRID,ESUB=E1,NSUB=N1,KSET=2)
      EXECUTE GRAPHICS(GNAME=GEOMETRY,VIEW=100,TYPE=ORTH,LABEL=N+E,
     X                 SIZE=(10,15),EXNAME=HALF)
C
C     BUCKLING  A N D      S T R E S S    A N A L Y S E S
C                        S E T    1
C
      PERFORM R-STRESS
      PRINT INPUT(BC)
      PRINT OUTPUT(LOADS,L2=L21)
      PRINT OUTPUT(DISP)
      PRINT OUTPUT(STRESS)
      EXECUTE EXTRACT(EXNAME=BEAM4,LSUB=STRESS,LC=BEAM1 TO BEAM4,
     X   ESUB=E2,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=MOMENT,TYPE=GRAPH,X=LC,Y1=BMMZ(1),
     X     XMIN=1,XMAX=6,Y1MIN=0.,Y1MAX=40.,SIZE=(10,10),
     X     EXNAME=BEAM4)
      EXECUTE EXTRACT(EXNAME=DEFL,LSUB=DISGRID,ESUB=E1,NSUB=N1,
     X                 LC=MOVE1)
      EXECUTE GRAPHICS(GNAME=DISPL,TYPE=ORTH,SCALE=.2,VIEW=100,
     X                 VECTOR2=DISP,VSCALE=1.,EXNAME=DEFL)
      EXECUTE STIFFNESS(LC=COLMLD,BSET=1)
      EXECUTE MERGE(GSTIF,BSET=1,KG22=22)
      EXECUTE BUCKLING(STIF=KRED,KG=KG22,BSET=1)
      PRINT OUTPUT(BUCKLING,BSET=1)
      EXECUTE EXTRACT(EXNAME=MODE3,LSUB=BMODE,BSET=1,MODE=3,BSUB=ON1)
      EXECUTE GRAPHICS(GNAME=BUCKLING,    TYPE=ORTH,VIEW=100,
     X                 SCALE=.2,VECTOR2=BMODE,VSCALE=3.,
     X                 EXNAME=MODE3)

C
C       S T R E S S    A N A L Y S I S    -    S E T    2
C             ( S U P E R P O S I T I O N )
C
        PURGE FILES(MERGRNF,MULTRNF,CHOLRNF)
        PERFORM STRESS(SET=2)
        PRINT INPUT(BC,SET=2,STAGE=1)
        PRINT OUTPUT(LOADS,SET=2,L1=L11)
        PURGE FILES(MERGRNF,MULTRNF,CHOLRNF)
        PERFORM STRESS(SET=2,STAGE=2)
        PRINT INPUT(BC,SET=2,STAGE=2)
        PRINT OUTPUT(LOADS,SET=2,STAGE=2,L1=L11)
```

```
EXECUTE STRESS(SET=2,SUPSTAGE=3)
PRINT OUTPUT(DISP,SET=2,STAGE=3)
PRINT OUTPUT(STRESS,SET=2,STAGE=3)
END CONTROL PROGRAM
```

```
BEGIN NODAL DATA
   SET 1  / COMPLETE MODEL
      1   0.   0.   0.   TO   4   0.   12.   0.
      4                  TO   8  24.   12.   0.
      8                  TO  11  24.    0.   0.
      REORDER FROM -1
   SET 2  / HALF MODEL
      1   0.   0.   0.   TO   4   0.   12.   0.
      4                  TO   6  12.   12.   0.
      REORDER FROM -1
END NOCAL DATA
BEGIN STIFFNESS DATA
   SET 1  / COMPLETE MODEL
  BEGIN ELEMENT DATA
      BEAM N1 1 2 11 10000. 1.   TO  N3 3 4 11
      BEAM N4 4 5 11 10000. 2.   TO  N7 7 8 11
      BEAM N8 8 9  1 10000. 1.   TO  N10 10 11 1
  END ELEMENT DATA
   SET 2  / HALF MODEL
  BEGIN ELEMENT DATA
      BEAM N1 1 2  6 10000. 1.   TO  N3 3 4  6
      BEAM N4 4 5  1 10000. 2.   TO  N5 5 6  1
  END ELEMENT DATA
END STIFFNESS DATA
BEGIN BC DATA
   SET 1 STAGE 1 / BC FOR BUCKLING AND STRESS ANALYSES
      SUPPORT TX TY       FOR  1 11
      RETAIN  TX TY RZ    FOR  2 TO 10
      RETAIN  RZ          FOR  1 11
   SET 2 STAGE 1 / SYMMETRIC BC
      SUPPORT TX TY       FOR  1
      SUPPORT ASYM  IN SURFACE 1 THROUGH 6
   SET 2 STAGE 2 / ANTISYMMETRIC BC
      SUPPORT TX TY       FOR  1
      SUPPORT SYMM  IN SURFACE 1 THROUGH 6
END BC DATA
BEGIN LOADS CATA
   SET 1 STAGE 1
   LOAD CASE IC COLMLD **UNIT LOAD CONDITION FOR BUCKLING ANALYSIS*
   LOAD CASE ID TOTAL  **LOAD CASE FOR SUPERPOSITION DEMONSTRATION*
   LOAD CASE ID BEAM1  **1 LB/INCH LOAD ON BEAM 4                  *
   LOAD CASE ID BEAM2  **1 LB/INCH LOAD ON BEAMS 4 AND 5           *
   LOAD CASE ID BEAM3  **1 LB/INCH LOAD ON BEAMS 4, 5 AND 6        *
   LOAD CASE ID BEAM4  **1 LB/INCH LOAD ON BEAMS 4, 5, 6 AND 7*
   LOAD CASE ID MOVE1 **UNIT X DISPLACEMENT AT NODE 1*
   BEGIN NODAL LOAD DATA
      CASE COLMLD
          4 8  FY  -1.
      CASE TOTAL
          4  FX  1.   FY  -3.
          8  FX -3.   FY  -7.
   END NODAL LOAD DATA
   BEGIN ELEMENT LOAD DATA
      DIRECTION  0. 1. 0.
          CASE BEAM1
               4    1.
```

```
         CASE BEAM2
              4 5  1.
         CASE BEAM3
              4 5 6 1.
         CASE BEAM4
              4 TO 7 1.
   END ELEMENT LOAD DATA
   BEGIN SUPPORT DISPLACEMENT DATA
      CASE MOVE1
           1 TX 1.
   END SUPPORT DISPLACEMENT DATA
   SET 2 STAGE 1
   LOAD CASE ID SYMPART **SYMMETRIC PART OF LOADCASE TOTAL*
   BEGIN NODAL LOAD DATA
      CASE SYMPART
           4  FX   .4  FY  -1.
   END NODAL LOAD DATA
   SET 2 STAGE 2
   LOAD CASE ID ASMPART **ANTISYMMETRIC PART OF LOADCASE TOTAL*
   BEGIN NODAL LOAD DATA
      CASE ASMPART
           4  FX  -.5  FY   1.
   END NODAL LOAD DATA
END LOADS DATA
BEGIN STRESS DATA
   SET 2
     SUPSTAGE 3
          TOTAL     1  5. SYMPART , 2  2. ASMPART
   LOAD CASE ID TOTAL **SAME AS LOADCASE TOTAL IN SET 1 *
END STRESS DATA
BEGIN SUBSET DEFINITION
   SUBSETS OF STIFFNESS SET 1
      E1 = ALL
      E2 = 4
      N1 = ALL
      ON1 = 1 *=10+1
   SUBSETS OF STIFFNESS SET 2
      E1 = ALL
      N1 = ALL
END SUBSET DEFINITION
END PROBLEM DATA
```

Table 207-1. Critical Load Values for Plane Frame

(1) Mode Number	(2) K (Ref. 207-1)	(3) K (ATLAS)	(4) $\frac{(3)-(2)}{(2)} \times 100$ (%)
1	1.349 553	1.349 558	0.0
2	3.590 681	3.594 686	0.1
3	4.111 618	4.118 577	0.2
4	6.566 437	6.638 602	1.1
5	6.992 352	7.073 246	1.2
6	9.625 433	10.654 702	10.7

$$P_{cr} = \frac{K^2 EI}{\ell^2}$$

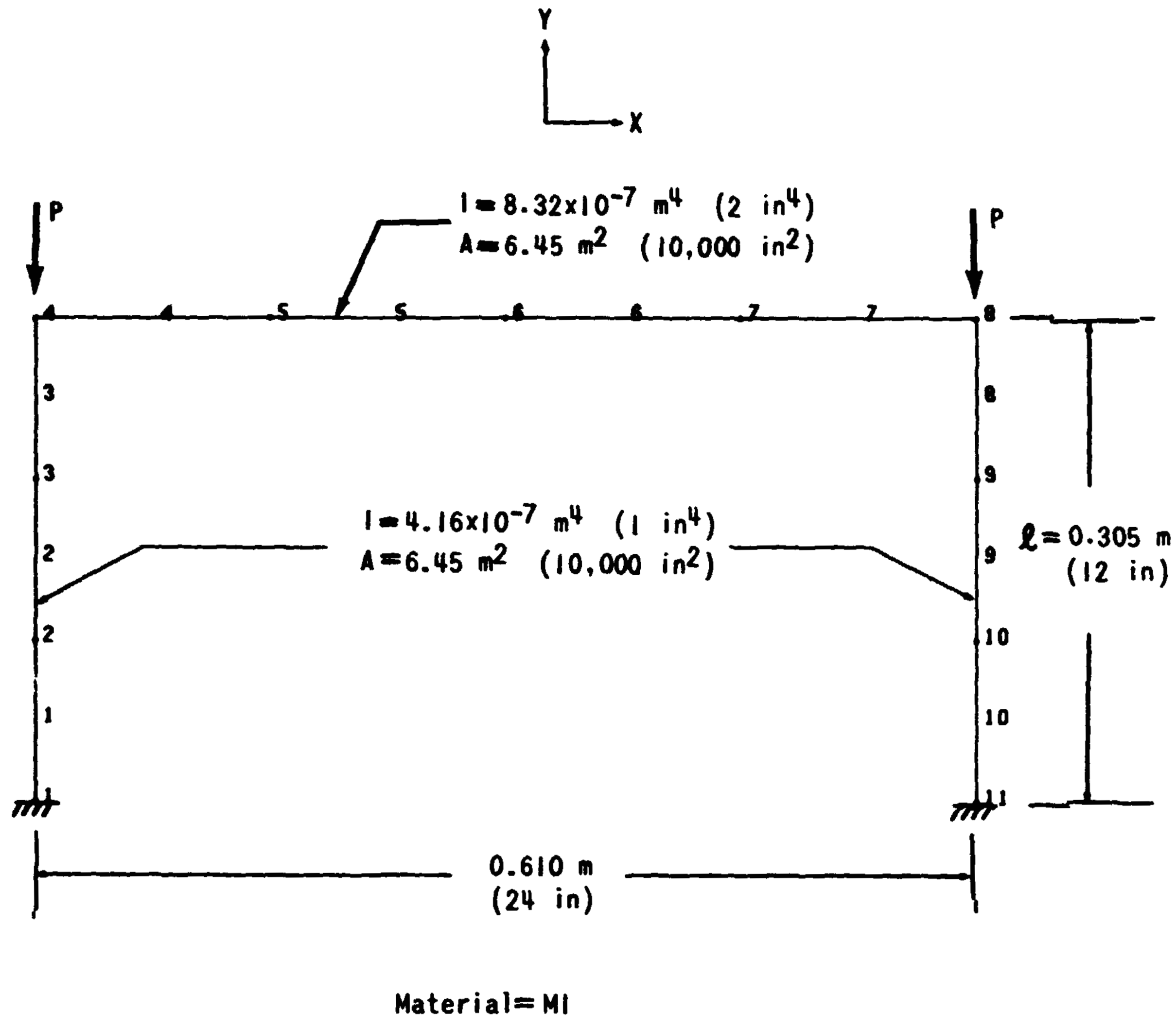

Figure 207-1. Structural Model and Loading for Buckling Analysis (SET 1)

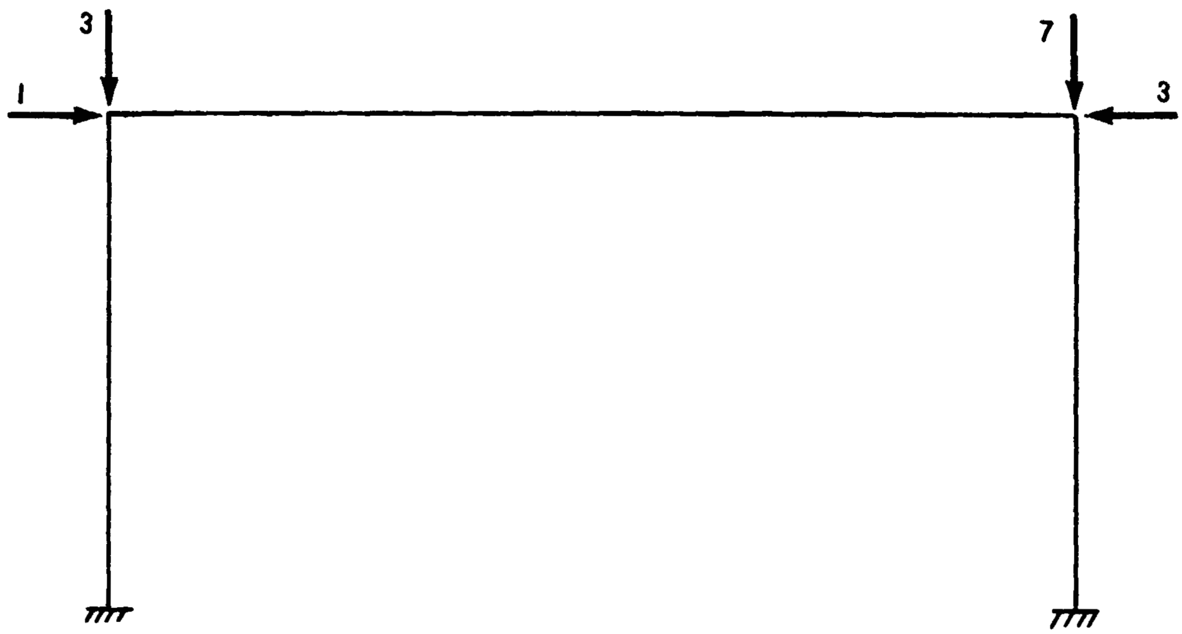

Figure 207-2. Loading for Superposition Demonstration

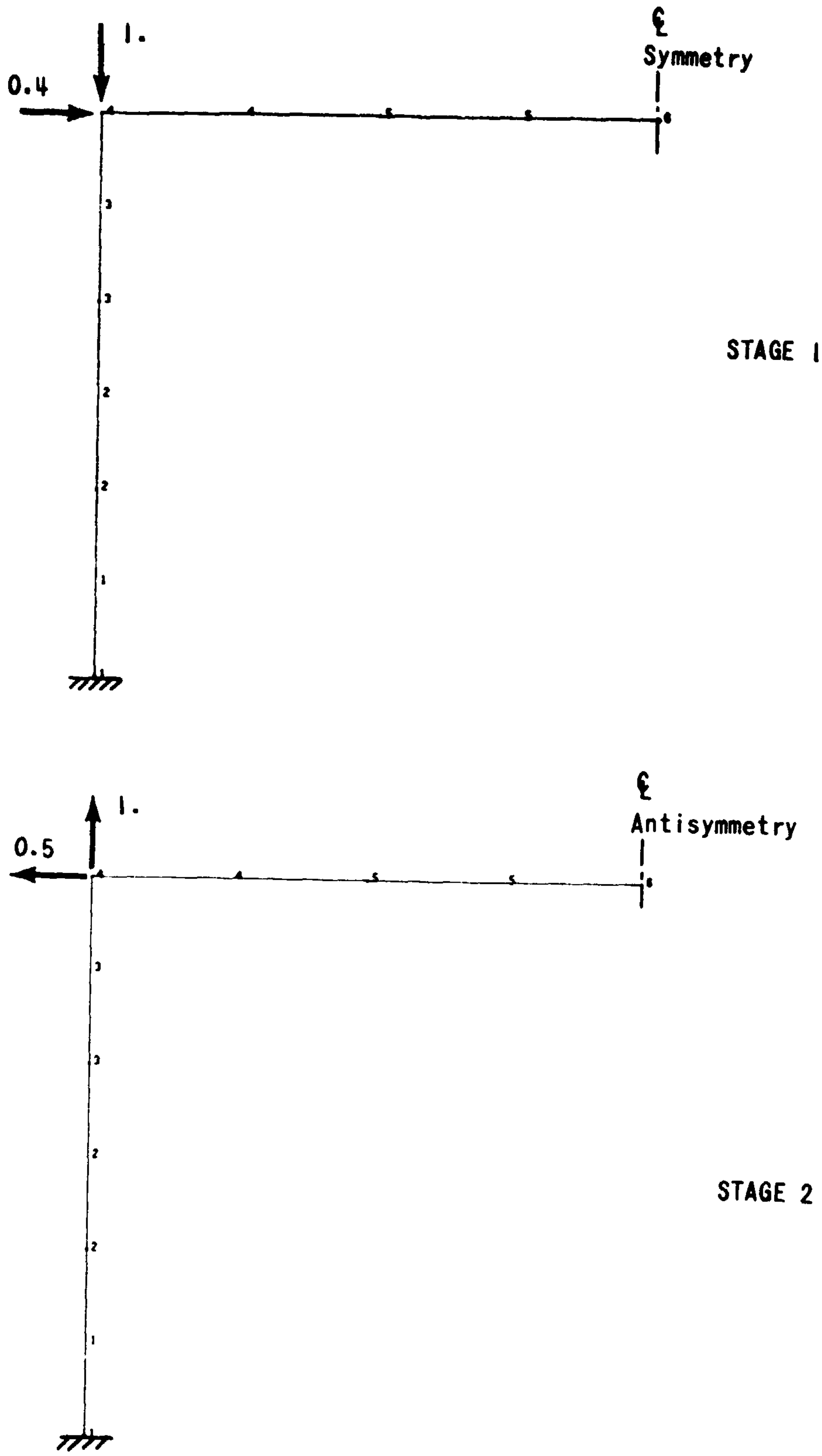

Figure 207-3. Half-Models for Superposition Demonstration (SET 2)

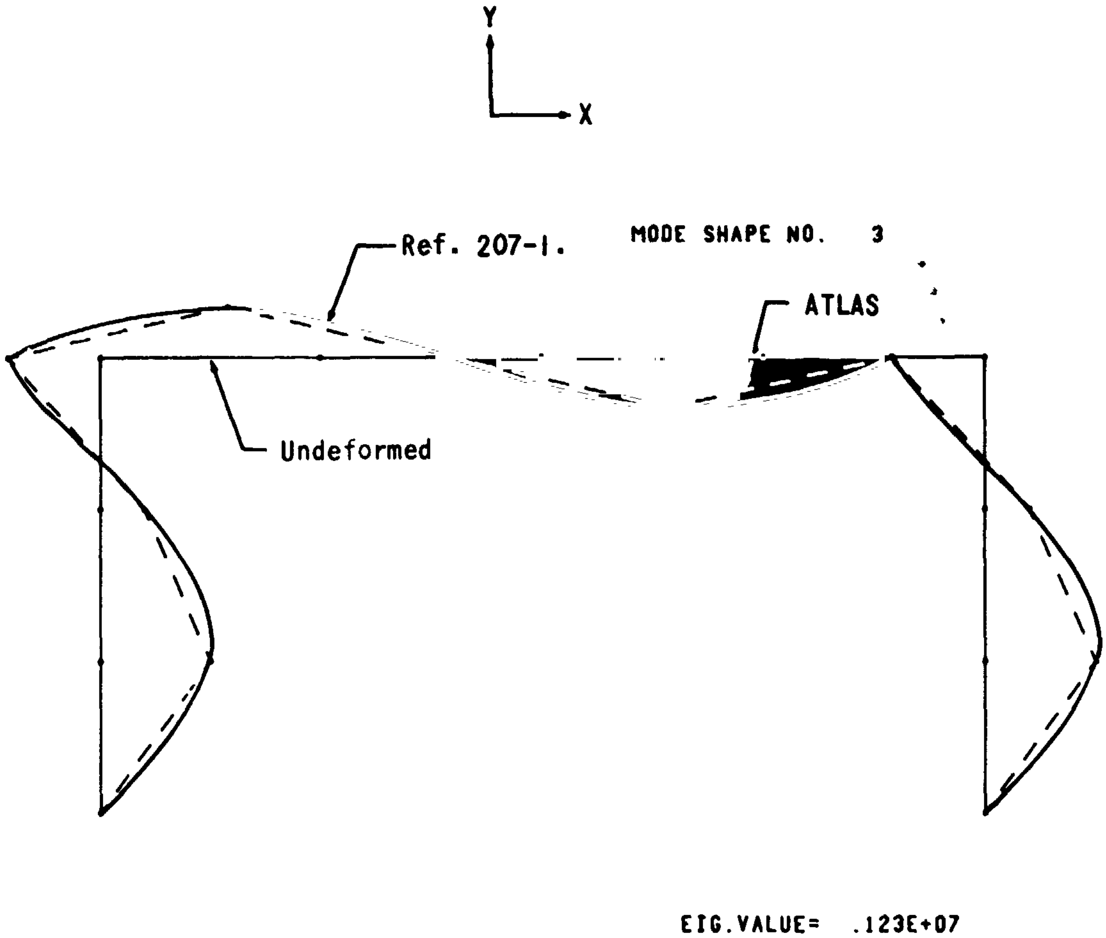

Figure 207-4. Buckled Shape for Third Mode of Frame

For Beam 4

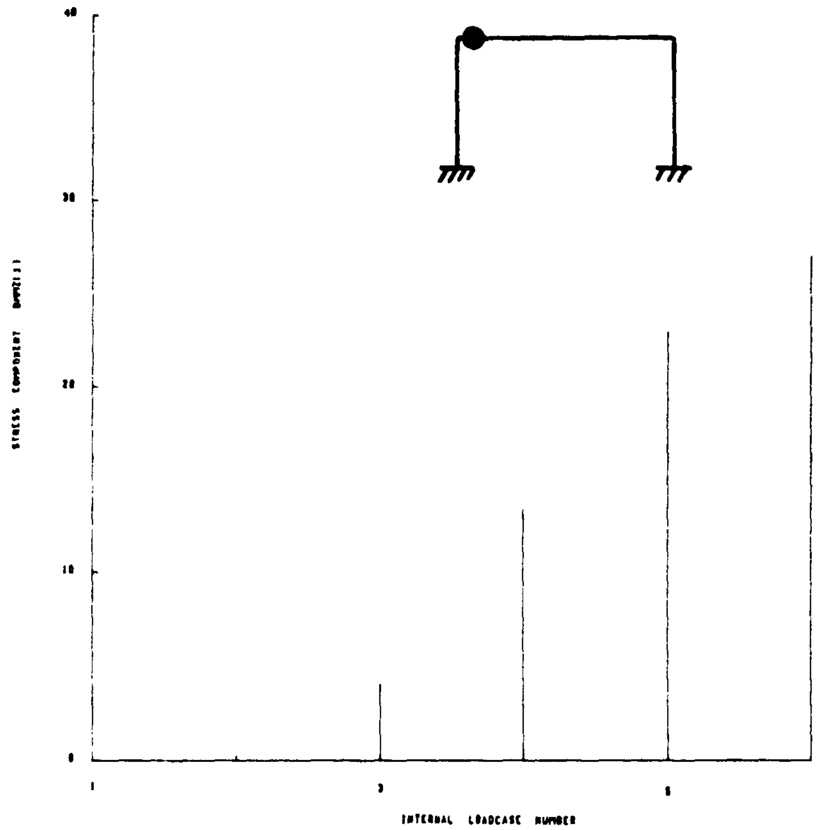

Figure 207-5. Bending Moment at End of Beam

Case BEAM4

Figure 207-6. Frame Displacements Due to Support Motion (Loadcase MOVE1)

208. FUEL AND PAYLOAD MANAGEMENT (DECK 16)

208.1 DESCRIPTION OF ANALYSIS

This problem demonstrates the ATLAS capabilities for calculating weights based upon user specified management sequences for fuel and payload.

The mass model is shown in figure 208-1; no stiffness element model is used. Locations of the fuel tanks and body cargo holds are shown in figure 208-2. Passenger seating is two abreast in the half airplane model spaced at 1.02 m (40 in).

The first fuel management sequence is as follows:

- The tanks are loaded until not quite full such that the weight ratio of tanks 11 and 12 is 4:3 and tanks 21 and 22 is 1:1
- Fuel is used from tanks 11 and 12 in proportion to their weights until their total equals the total of tanks 21, 22 and 31
- All fuel in tank 12 is transferred to tank 11
- Fuel is used from tanks 11, 21 and 22 at rates in the ratio of 2:1:1 until the weight of fuel in tank 21 is 6803.9kg (15 000 lb)
- Fuel is used from tanks 11, 21 and 31 in rough proportion to their weights until all are empty

The second sequence loads all tanks until full to demonstrate the system's ability to calculate fuel capacities.

The payload sequence specifies that the cargo holds are partially loaded from the bottom with the forward hold being loaded before the aft hold. Passengers are loaded from each end.

In addition to the fuel and payload sequences described above, two loading sequences are defined for the purpose of generating a loadability diagram. In the first of these sequences passengers are loaded from fore to aft with all window seats loaded before any aisle seats. Cargo is also loaded from fore to aft. The second sequence is similar to the first except that loading occurs in the aft to forward direction.

208.2 RESULTS

The loadability diagram resulting from the last two loading sequences is shown in figure 208-3.

208.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTRCL PROGRAM DEMO16
      PROBLEM ID(DEMO16 - FUEL AND PAYLOAD MANAGEMENT)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. FUEL AND PAYLOAD MANAGEMENT
C                       2. LOADABILITY DIAGRAM GENERATION
C
C     AUTHOR         R. A. WOODWARD
C
C     CORE           130K (OCTAL)
C
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(MASS)
      EXECUTE EXTRACT(EXNAME=MASSGRD,LSUB=MGRID,ESUB=E5,NSUB=
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=CALCOMP,TYPE=(ORTH,P[illegible]),
     X               SIZE=(20,20),RZ=30,RX=0,RY=20,EXNAME=MASSGRD)
      EXECUTE MASS (OPTION=1)
      PRINT OUTPUT (MASS,FUEL,TABLES,TANKS=22,PAYLOAD=22,MDC=MDC***A)
      EXECUTE EXTRACT(EXNAME=LOADAB,LSUB=LOADAB,PCOND=20,PCOND=30,
     1               CCOND=20,CCOND=30,FCOND=15,FCOND=15)
      EXECUTE GRAPHICS(GNAME=LOADAB,SIZE=(10,10),
     1               LWLNE=540000.,WTINC=20000.,FCGLNE=6.,LCGLNE=36.,
     2               DATUM=21.,CGINC=3.,LEMAC=1600.,MAC=1100.,
     3               FUELFAC=2.,PASSFAC=2.,CARGOFAC=2.,CGTOL=1.,
     4               OEWFAC=2.,EXNAME=LOADAB,    TYPE=GRAPH)
      END CONTROL PROGRAM
```

```
*/MODE2/
BEGIN NODAL CATA
1      20.    0.       1.       TO 9      340.     0.       65.      BY  2
101    20.    0.      -1.       TO 109    340.     0.      -65.      BY  2
201    20.    1.       0.       TO 209    340.     65.      0.       BY  2
11     420.   0.       65.      TO 83     3300.    0.       65.      BY  2
111    420.   0.      -65.      TO 169    3540.    0.      -65.      BY  2
211    420.   65.      0.       TO 225    780.     65.      0.       BY  2
265    2580.  65.      0.       TO 277    3060.    65.      0.       BY  2
287    3460.  65.      0.       TO 289    3540.    65.      0.       BY  2
*/   WING  COORDINATES
227    1060.  65.   0.   26.25  TO 245    1780.    65.    0.  36.35  BY  2
245                             TO 255    2180.    65.    0.  28.6   BY  2
255                             TO 263    2300.    65.    0.  12.0   BY  2
327    1060.  65.   0.   26.25  TO 341    1620.    265.   0.   8.85  BY  2
445    1780.  195.  0.   22.65  TO 455    2180.    195.   0.  20.15  BY  2
541    1620.  265.  0.    8.85  TO 551    2205.    455.   0.   5.75  BY  2
651    2205.  455.  0.    5.75  TO 656    2545.    594.   0.   3.2
756    2545.  594.  0.    3.2   TO 760    2875.    765.   0.    .95
760                             TO 763    2995.    765.   0.   1.85
341                             TO 355    2180.    255.   0.  20.15  BY  2
355                             TO 363    2500.    265.   0.  11.25  BY  2
551                             TO 559    2525.    455.   0.  10.0
559                             TO 563    2685.    455.   0.   5.0
656                             TO 659    2665.    594.   0.   4.85
659                             TO 663    2825.    594.   0.   2.45
*/  HORIZONTAL TAIL
279 3140. 65. 0.  1.80
779 3140. 65. 0.  1.80   TO 979 3365. 200. 0.  1.25  BY 100
281 3220. 65. 0.  4.25
781 3220. 65. 0.  4.25   TO 981 3388. 200. 0.  1.75  BY 100
283 3300. 65. 0.  4.55
783 3300. 65. 0.  4.55   TO 983 3412. 200. 0.  1.80  BY 100
285 3380. 65. 0.  1.40
785 3380. 65. 0.  1.40   TO 985 3435. 200. 0.   .80  BY 100
*/  VERTICAL TAIL
REC  REC1 0. 0. 0. 1. 0. 0. 0. -1. 0.
85 3380. 65. 0.      3.25
87 3460. 65. 0.      2.40
1085 3460. 140. 0.  1.50
1087 3500. 140. 0.  1.80
*/   WING FIN
1156 2545. .1 -594. 2.40 TO 1356 2830. 100. -594. 1.80 BY 100
1158 2625. .1 -594. 2.40 TO 1358 2842. 100. -594. 1.90 BY 100
1161 2745. .1 -594. 2.80 TO 1361 2859. 100. -594. 1.95 BY 100
1163 2825. .1 -594. 2.80 TO 1363 2870. 100. -594. 2.05 BY 100
RESUME GLOBAL
89     3540. 0.      65.
*/     AIRLOAD PANEL NODES
*/     BODY
       5100     0.   0.        0.  TO   5112  3564.   0.   0.
       5251     0.  26.1279   0.
       5252   297.  26.1279   0.
       5253   297.  63.5215   0.
       5254   594.  63.5215   0.
       5202   594.  65.1       0.  TO   5212  3564.  65.1  0.
*/     WING
       5400   741.          65.1  0.   TO 5405  2715.         65.1  0.
       5410   1017.7530  146.6  0.   TO  5415  2705.9945  146.6  0.
       5420   1294.1665  228.   0.   TO  5425  2697.      228.   0.
       5430   1677.8854  341.   0.   TO  5435  2722.8855  341.   0.
       5440   2065.       455.   0.   TO  5445  2749.      455.   0.
       5450   2487.        594.   0.  TO  5455  2874.059   594.   0.
       5460   2689.47     696.   0.   TO  5465  2965.8289  696.   0.
       5470   2884.       794.   0.   TO  5475  3054.      794.   0.
*/     HOR TAIL
       5500   3124.         65.1  0.   TO  5502  3417.       65.1  0.
       5510   3255.0804  146.6  0.   TO  5512  3440.5144  146.6  0.
       5520   3386.       228.   0.   TO  5522  3464.      228.   0.
*/     VERT WING FIN
       5313   2487.  594.  0.  TO  5315  2880.  594.  134.
       5316   2680.5  594.  0.  TO  5318  2910.  594.  134.
       5319   2874.059  594.  0.  TO  5321  2940.  594.  134.
```

```
*/     WEIGHT PANELS - BODY
       6001  0.   0.  0.  TO  6016  3564.   0.  0.
       6021  0.  65.  0.  TO  6036  3564.  65.  0.
*/     WEIGHT PANELS - WING
       6100   741.0   65.0  0.  TO  6220  2487.0  594.0  0.  BY  20
       6100                     TO  6260  2487.0  594.0  0.  BY  80
       6180                     TO  6240  2487.0  594.0  0.  BY  20
       6260                     TO  6320  2884.0  794.0  0.  BY  20
       6110  2715.0   65.0  0.  TO  6170  2715.0  329.5  0.  BY  20
       6189  2715.0  329.5  0.  TO  6249  2874.0  594.0  0.  BY  20
       6266  2874.0  594.0  0.  TO  6326  3054.0  794.0  0.  BY  20
       6100  TO  6110
*+3     20   0    20
       6180  TO  6189
*+3     20   0    20
       6260  TO  6266
*+3     20   0    20
*/     WEIGHT PANELS - HOR TAIL
       6400  3124.   65.1  0.  TO  6403  3417.   65.1  0.
       6410  3386.  228.0  0.  TO  6413  3464.  228.0  0.
*/     WEIGHT PANELS - VERT FIN
       6501  3374.6  0.   92.8
       6502  3472.   0.   92.8
       6503  3458.7  0.  149.8
       6504  3514.6  0.  149.8
*/     WEIGHT PANELS - WING VERT FIN
       6601  2487.     594.  0.  TO  6603  2880.  594.  134.
       6604  2874.059  594.  0.  TO 6606  2940.  594.  134.
*/     NODES FOR CARGO HOLDS          /
       7001      400.       0.      -55.
       7002      400.      20.      -55.
       7003      400.      50.      -20.
       7004      400.       0.      -20.
       7005      650.       0.      -55.
       7006      650.      20.      -55.
       7007      650.      50.      -20.
       7008      650.       0.      -20.
       7011     2800.       0.      -55.
       7012     2800.      20.      -55.
       7013     2800.      50.      -20.
       7014     2800.       0.      -20.
       7015     2950.       0.      -55.
       7016     2950.      20.      -55.
       7017     2950.      50.      -20.
       7018     2950.       0.      -20.
END NODAL DATA
BEGIN MASS DATA
BEGIN CONDITION DATA
       PANEL DATA 1 CONDITION 1 11 11 0
       PANEL DATA 1 CONDITION 2 12 11 0
       PANEL DATA 1 CONDITION 3 20 12 0
       PANEL DATA 1 CONDITION 4 20 13 0
END CONDITION DATA
BEGIN MASS ELEMENT DATA
 PLATE F2  B-1     6001 6002 6022       3495.
 PLATE F2  B-2     6002 6003 6023 6022  5955.
 PLATE F2  B-3     6003 6004 6024 6023  2589.
 PLATE F2  B-4     6004 6005 6025 6024  3440.
 PLATE F2  B-5     6005 6006 6026 6025  5420.
 PLATE F2  B-6     6006 6007 6027 6026  3280.
 PLATE F2  B-7     6007 6008 6028 6027  3306.
 PLATE F2  B-8     6008 6009 6029 6028  4346.
 PLATE F2  B-9     6009 6010 6030 6029  4507.
 PLATE F2  B-10    6010 6011 6031 6030  4486.
 PLATE F2  B-11    6011 6012 6032 6031  3619.
 PLATE F2  B-12    6012 6013 6033 6032  4730.
 PLATE F2  B-13    6013 6014 6034 6033  3982.
 PLATE F2  B-14    6014 6015 6035 6034   947.
 PLATE F2  B-15    6015 6016 6036 6035  1788.
 PLATE F2  VT-1    6501 6502 6504 6503   600.
 PLATE F2  W-1     6100 6101 6121 6120   768.
 PLATE F2  W-2     6101 6102 6122   21  1151.
 PLATE F2  W-3     6102 6103 6123 ..22  1667.
```

PLATE	F2	W-4	6103	6104	6124	6123	1112.
PLATE	F2	W-5	6104	6105	6125	6124	1190.
PLATE	F2	W-6	6105	6106	6126	6125	1659.
PLATE	F2	W-7	6106	6107	6127	6126	1988.
PLATE	F2	W-8	6107	6108	6128	6127	2467.
PLATE	F2	W-9	6108	6109	6129	6128	1335.
PLATE	F2	W-10	6109	6110	6130	6129	338.
PLATE	F2	W-11	6120	6121	6141	6140	795.
PLATE	F2	W-12	6121	6122	6142	6141	1415.
PLATE	F2	W-13	6122	6123	6143	6142	813.
PLATE	F2	W-14	6123	6124	6144	6143	1259.
PLATE	F2	W-15	6124	6125	6145	6144	1248.
PLATE	F2	W-16	6125	6126	6146	6145	1720.
PLATE	F2	W-17	6126	6127	6147	6146	1494.
PLATE	F2	W-18	6127	6128	6148	6147	1888.
PLATE	F2	W-19	6128	6129	6149	6148	498.
PLATE	F2	W-20	6129	6130	6150	6149	126.
PLATE	F2	W-21	6140	6141	6161	6160	508.
PLATE	F2	W-22	6141	6142	6162	6161	1279.
PLATE	F2	W-23	6142	6143	6163	6162	536.
PLATE	F2	W-24	6143	6144	6164	6163	532.
PLATE	F2	W-25	6144	6145	6165	6164	559.
PLATE	F2	W-26	6145	6146	6166	6165	1055.
PLATE	F2	W-27	6146	6147	6167	6166	1405.
PLATE	F2	W-28	6147	6148	6168	6167	1953.
PLATE	F2	W-29	6148	6149	6169	6168	274.
PLATE	F2	W-30	6149	6150	6170	6169	172.
PLATE	F2	W-31	6180	6181	6201	6200	614.
PLATE	F2	W-32	6181	6182	6202	6201	1286.
PLATE	F2	W-33	6182	6183	6203	6202	562.
PLATE	F2	W-34	6183	6184	6204	6203	786.
PLATE	F2	W-35	6184	6185	6205	6204	1386.
PLATE	F2	W-36	6185	6186	6206	6205	1649.
PLATE	F2	W-37	6186	6187	6207	6206	1649.
PLATE	F2	W-38	6187	6188	6208	6207	421.
PLATE	F2	W-39	6188	6189	6209	6208	255.
PLATE	F2	W-40	6200	6201	6221	6220	207.
PLATE	F2	W-41	6201	6202	6222	6221	497.
PLATE	F2	W-42	6202	6203	6223	6222	692.
PLATE	F2	W-43	6203	6204	6224	6223	755.
PLATE	F2	W-44	6204	6205	6225	6224	816.
PLATE	F2	W-45	6205	6206	6226	6225	843.
PLATE	F2	W-46	6206	6207	6227	6226	687.
PLATE	F2	W-47	6207	6208	6228	6227	136.
PLATE	F2	W-48	6208	6209	6229	6228	94.
PLATE	F2	W-49	6220	6221	6241	6240	136.
PLATE	F2	W-50	6221	6222	6242	6241	522.
PLATE	F2	W-51	6222	6223	6243	6242	516.
PLATE	F2	W-52	6223	6224	6244	6243	536.
PLATE	F2	W-53	6224	6225	6245	6244	555.
PLATE	F2	W-54	6225	6226	6246	6245	580.
PLATE	F2	W-55	6226	6227	6247	6246	704.
PLATE	F2	W-56	6227	6228	6248	6247	119.
PLATE	F2	W-57	6228	6229	6249	6248	91.
PLATE	F2	W-58	6260	6261	6281	6280	289.
PLATE	F2	W-59	6261	6262	6282	6281	306.
PLATE	F2	W-60	6262	6263	6283	6282	244.
PLATE	F2	W-61	6263	6264	6284	6283	507.
PLATE	F2	W-62	6264	6265	6285	6284	116.
PLATE	F2	W-63	6265	6266	6286	6285	76.
PLATE	F2	W-64	6280	6281	6301	6300	216.
PLATE	F2	W-65	6281	6282	6302	6301	144.
PLATE	F2	W-66	6282	6283	6303	6302	245.
PLATE	F2	W-67	6283	6284	6304	6303	365.
PLATE	F2	W-68	6284	6285	6305	6304	86.
PLATE	F2	W-69	6285	6286	6306	6305	71.
PLATE	F2	W-70	6300	6301	6321	6320	184.
PLATE	F2	W-71	6301	6302	6322	6321	160.
PLATE	F2	W-72	6302	6303	6323	6322	126.
PLATE	F2	W-73	6303	6304	6324	6323	273.
PLATE	F2	W-74	6304	6305	6325	6324	66.
PLATE	F2	W-75	6305	6306	6326	6325	66.
PLATE	F2	HT-1	6400	6401	6411	6410	283.

```
  PLATE F2  HT-2   6401 6402 6412 6411  212.
  PLATE F2  HT-3   6402 6403 6413 6412  522.
  PLATE F2  WF-1   6601 6602 6605 6604   500.
  PLATE F2  WF-2   6602 6603 6606 6605   400.
 END MASS ELEMENT DATA
 BEGIN FUEL DATA
    TANK  11
      POLYGON  20    95. PERCENT
         237  337  339  239  TO  243  343  345  245  BY 2 2 2 2
         445  345  347  447  TO  449  349  351  451  BY 2 2 2 2
    TANK  12
      POLYGON  20    97. PERCENT
         451  351  353  453
         453  353  355  455
         255  355  357  257  TO  261  361  363  263  BY 2 2 2 2
    TANK  21
      POLYGON  30    90. PERCENT
         347  547  549  349  TO  353  553  555  355  BY 2 2 2 2
    TANK  22
      POLYGON  30    90. PERCENT
         355  555  557  357  TO  361  561  563  363  BY 2 2 2 2
    TANK  31
      POLYGON  20    85. PERCENT
         553  653  654  554  TO  562  662  663  563
    MANAGEMENT SEQUENCE  10
        LOAD TANKS 21 22                    UNTIL  70000.
        LOAD TANKS 11 12 31 RATIO 8. 6. 1.  UNTIL 220000. TOTAL
        LOAD TANKS       31                 UNTIL    31
        USE  TANKS 11 12    RATIO 1. .75    UNTIL 11 12 EQUALS 2. 21 31
        TRANSFER 100. PERCENT 12 TO 11
        USE  TANKS 11 21 22 RATIO 2. 1. 1.  UNTIL  22 15000.
        TRANSFER 15000. FROM 22 TO 21
        USE  TANKS 11 21 31 RATIO 3. 2. 1.  UNTIL 60000.
        USE  TANKS 11 21 31 RATIO 3. 2. 1.  UNTIL      0. TOTAL
    MANAGEMENT SEQUENCE  20
        LOAD TANKS 11 12 21                 UNTIL    11
        LOAD TANKS    22 31                 UNTIL    22
    CONDITION 11 180000.  10
    CONDITION 12 120000.  10
    CONDITION 15 100000.  10
    CONDITION 20      0.  20
  END FUEL DATA
BEGIN PAYLOAD DATA
    BEGIN SEAT LOCATION DATA
      101  400. -10.  54.  TO  166 3000. -10.  54.
      201  400. -10.  34.  TO  266 3000. -10.  34.
    END SEAT LOCATION DATA
    HOLD  1 BRICK .05
      7001 7002 7003 7004 7005 7006 7007 7008
    HOLD  2  BRICK  .05
      7011 7012 7013 7014 7015 7016 7017 7018
    LOADING SEQUENCE  1
        LOAD SEATS 101 166 201 266 TO 133 134 233 234 BY 1 -1 1 -1
        LOAD CARGO HOLD   1 IN DIRECTION +Z UNTIL 10000. LOADED
        LOAD CARGO HOLD   2 IN DIRECTION +Z UNTIL  5000. LOADED
    LOADING SEQUENCE 10
        LOAD SEATS 101 TO 166
        LOAD SEATS 201 TO 266
        LOAD CARGO HOLD  1 IN DIRECTION +X UNTIL FULL
        LOAD CARGO HOLD  2 IN DIRECTION +X UNTIL FULL
    LOADING SEQUENCE 11
        LOAD SEATS 166 TO 101 BY -1
        LOAD SEATS 266 TO 201 BY -1
        LOAD CARGO HOLD  2 IN DIRECTION -X UNTIL FULL
        LOAD CARGO HOLD  1 IN DIRECTION -X UNTIL FULL
    CONDITION 11 SEQUENCE  1  80  14000.
    CONDITION 12 SEQUENCE  1 132      0.
    CONDITION 13 SEQUENCE  1   0  15000.
    CONDITION 20 SEQUENCE 11 132 24500.
    CONDITION 30 SEQUENCE 10 132 24500.
  END PAYLOAD DATA
```

```
      BEGIN PANEL CATA 1
*/    BODY
      MASS SUBSETS   1
      FUEL,PAYLCAC
        DIRECTICN  Z
                1  5100 5251 5252 5101
                2  5101 5253 5254 5102
                3  5202 5203 5103 5102  TO  12
*/    WING FIN
      MASS SUBSETS   2
        DIRECTICN  Y
          13  5313 5316 5317 5314
          14  5316 5319 5320 5317
          15  5314 5317 5318 5315
          16  5317 5320 5321 5318
*/    WING
      MASS SUBSETS   3
      FUEL,PAYLOAC
        DIRECTICN  Z
          17  5400 5401 5411 5410  TO  21
**6        5     10  *=3               0   5
*/    HOR TAIL
      MASS SUBSETS   4
        DIRECTICN  Z
          52  5500 5501 5511 5510  TO  53
**1        2     10  *=3               0   2
      END PANEL CATA 1
END MASS DATA
BEGIN SUBSET DEFINITION
SUBSETS OF MASS SET 1
      N1 = 6001 TO 6036 6501 TO 6504
      E1 = ALL IN N1
      N2 = 6601 TO 6606
      E2 = ALL IN N2
      N3 = 6100 TO 6325
      E3 = ALL IN N3
      N4 = 6400 TO 6413
      E4 = ALL IN N4
      N5 = 6001 TO 6606
      E5 = ALL IN N5
END SUBSET DEFINITION
END PROBLEM DATA
```

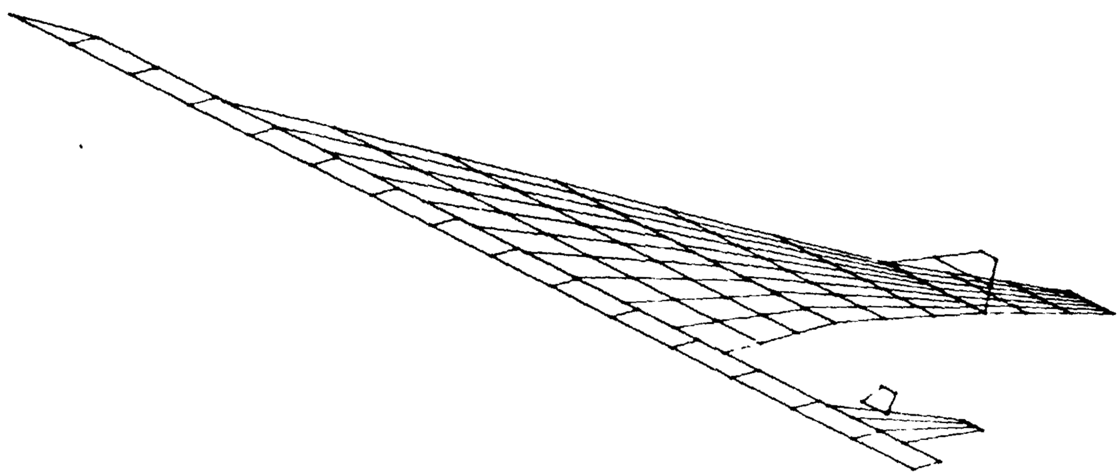

Figure 208-1. Mass Model for Fuel and Payload Demonstration

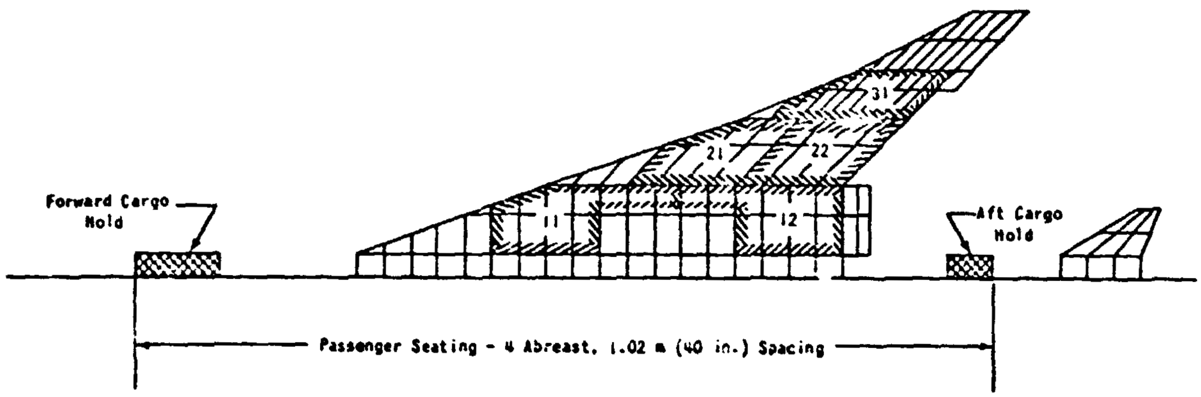

Figure 208-2. Location of Fuel Tanks,Cargo Holds and Seating

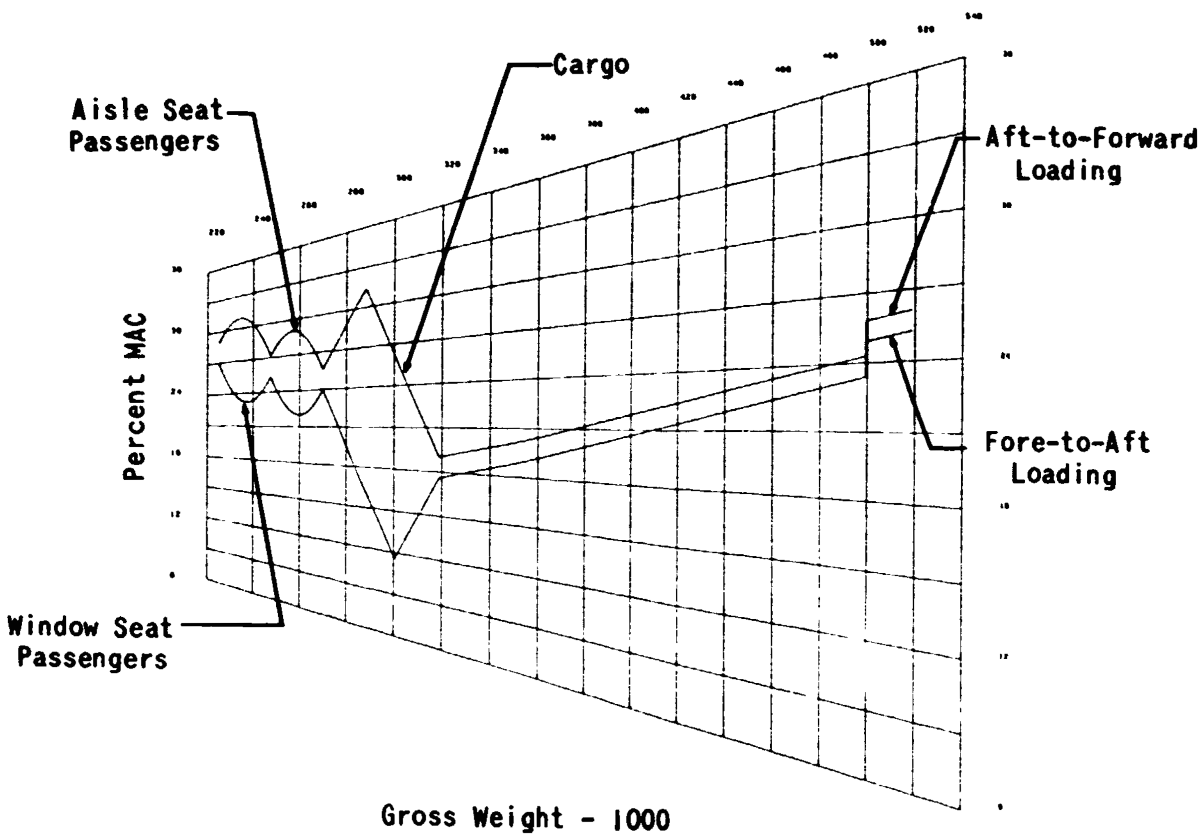

Figure 208-3. Loadability Diagram, Fuel and Payload Demonstration

209. FULLY-STRESSED DESIGN AND COMPOSITE OPTIMIZATION (DECK 3)

209.1 DESCRIPTION OF PROBLEM

This problem demonstrates the fully-stressed design and composite optimization capabilities of the Design Module. The structural model, shown in figure 209-1, is the same as that described in section 203 with the addition of several CCOVER elements (element subset 200 as shown in figure 209-2). These CCOVERs have upper surfaces only with a stackup of (0/+45/90). The symmetric loading described in section 203 is factored by ten to obtain the design loading condition (except as shown in table 209-1).

All the CCOVER elements constitute a single optimization problem. A separate execution of the Design Module produces an optimized lay-up based upon the strains in a subregion consisting of one element.

The subsets used to define the design problem are shown in figures 209-2 and 209-3. The design options employed are summarized in table 209-1.

209.2 RESULTS

Two resize cycles were executed. The total weight at each cycle is shown in figure 209-4. As an example, upper and lower surface basic plate thicknesses before and after resize are shown in figure 209-5 for element subset 121. Margins of safety for this subset for the two cycles are shown in figures 209-6 and 209-7.

The composite optimization converged after 7 local and 2 global iterations producing the number of layers shown in table 209-2.

209.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTRCL MATRIX PROGRAM DEMO03
      PROBLEM ID(DEMO03 - FULLY-STRESSED DESIGN/COMPOSITE OPTIMIZATION)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. FULLY-STRESSED DESIGN
C                       2. COMPOSITE OPTIMIZATION
C                       3. STRENGTH MARGIN OF SAFETY PLOTS
C
C     AUTHOR         BJORN BACKMAN
C
C     CORE            170K (OCTAL)
C
      INTEGER BEGCYCL,ENDCYCL,CURCYCL
      DIMENSION CONVERG(17)
      USER COMMON (BEGCYCL,ENDCYCL,CURCYCL,CONVERG,ISET,ISTAGE,IPOS)
C
      BEGCYCL=1
      ENDCYCL=2
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(BC,STAGE=2)
      EXECUTE EXTRACT(EXNAME=TOTAL,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=CALCOMP,RZ=30,RX=0,RY=20,
     X              TYPE=(ORTH,POINT),SIZE=(20,20),EXNAME=TOTAL)
      PERFORM DESIGN (STAGE=2)
      PRINT INPUT(DESIGN,SET=1)
      EXECUTE DESIGN(HISTORY,SET=1,STAGE=2,CYCLE=(1,2),IELN=(1,3,16,18,
     119,21,29))
      EXECUTE DESIGN(COMPOSITE,SET=1,STAGE=2,CYCLE=3)
      PRINT OUTPUT(DESIGN,SET=1)
      PRINT OUTPUT(DESIGN,HISTORY,SET=1)
      EXECUTE EXTRACT(EXNAME=MARGINS,LSUB=SMS,STAGE=2,CYCLE=(1,2),
     X              ESUB=E121,NSUB=N121)
      EXECUTE GRAPHICS(GNAME=DESIGN,TYPE=ORTH,SIZE=(15,15),
     X              VIEW=100,SCALAR=COVSMS,SSCALE=100,EXNAME=MARGINS)
      END CONTROL PROGRAM
```

```
*/ MODE2 /
BEGIN MATERIAL DATA
COMPOSITE MATERIAL DATA
C01 .0052 3.77E-4
70 30.0E6 2.7E6 .21 .7E6 1.E-6 *= 1.28E5 2.E4 1.28E5 2.E4 6.4E4 *=5
500 29.E6 2.6E6 .20 .6E6 .9E-6 *= 1.18E5 1.9E4 1.18E5 1.9E4 6.3E4 *=5
END MATERIAL DATA
  BEGIN NODAL DATA
*/
*/ BODY NODES
*/
          1    20.     0.  0.        TO    25   980.     0.  0.         BY  2
         27  1060.     0.  0.  30.0  TO    45  1780.     0.  0.  42.5   BY  2
   *+1  200     0.    65.  0.   0.    0   200     0.    65.             **
         45                          TO    55  2180.     0.  0.  31.0   BY  2
   *+1  200                           0   200     0.    65.             **
         55                          TO    63  2500.     0.  0.  13.5   BY  2
   *+1  200                           0   200     0.    65.             **
         65  2580.     0.  0.        TO    77  3060.     0.  0.         BY  2
         79  3140.     0.  0.   3.0
   *+1  200     0.    65.       **
         81  3220.     0.  0.   6.5
   *+1  200     0.    65.       **
         83  3300.     0.  0.   7.0
   *+1  200     0.    65.       **
         85  3380.     0.  0.   2.0
   *+1  200     0.    65.       **
         87  3460.     0.  0.
         89  3540.     0.  0.
*/
*/ WING NODES
*/
        427  1060.    65.  0.  30.0  TO   435  1380.   180.  0.  17.5   BY  2
        435                          TO   445  1780.   180.  0.  27.5   BY  2
        445                          TO   455  2180.   180.  0.  25.0   BY  2
        455                          TO   463  2500.   180.  0.  13.0   BY  2
        635  1380.   180.  0.  17.5  TO   641  1620.   265.  0.  10.0   BY  2
        641                          TO   655  2180.   265.  0.  22.5   BY  2
        655                          TO   663  2500.   265.  0.  12.5   BY  2
        841  1620.   265.  0.  10.0  TO   847  1971.   380.  0.   9.0   BY  2
        847                          TO   855  2291.   380.  0.  17.0   BY  2
        855                          TO   863  2611.   380.  0.  10.0   BY  2
       1047  1971.   380.  0.   9.0  TO  1051  2205.   455.  0.   8.5   BY  2
       1051                          TO  1059  2525.   455.  0.  15.0
       1059                          TO  1063  2685.   455.  0.   8.0
       1251  2205.   455.  0.   8.5  TO  1254  2409.   538.  0.   6.5
       1254                          TO  1259  2609.   538.  0.  11.0
       1259                          TO  1263  2769.   538.  0.   5.5
       1454  2409.   538.  0.   6.5  TO  1456  2545.   594.  0.   5.0
       1456                          TO  1459  2665.   594.  0.   7.5
       1459                          TO  1463  2825.   594.  0.   3.5
       1656  2545.   594.  0.   5.0  TO  1658  2710.   680.  0.   3.0
       1658                          TO  1663  2910.   680.  0.   3.0
       1858  2710.   680.  0.   3.0  TO  1860  2875.   765.  0.   1.5
       1860                          TO  1863  2995.   765.  0.   2.5
*/
*/ WING TRAILING EDGE NODES
*/
       3001  2500.    65.  0.  13.5  TO  3005  2715.    65.  0.   1.0   BY 2
       3101  2500.   180.  0.  13.0  TO  3105  2715.   180.  0.   1.0   **
       3201  2500.   265.  0.  12.5  TO  3205  2715.   265.  0.   1.0   **
       3405  2874.   594.  0.   1.0  TO  3605  3027.9 765.  0.   1.0
                                       BY 100 OF 86. 85.
*/
*/ WING FIN NODES
*/
      REC  WINGFIN 0. 594. 0., 1. 594. 0., 0. -1. 0.
       2056  2545.      .1 0.   3.5  TO  2456  2830.   100.  0.   2.5   BY  200
       2058  2625.      .1 0.   3.5  TO  2458  2842.   100.  0.   3.0   **
       2061  2745.      .1 0.   4.0  TO  2461  2859.   100.  0.   3.0   **
       2063  2825.      .1 0.   4.0  TO  2463  2870.   100.  0.   3.0   **
*/
```

```
*/ HORIZONTAL TAIL NODES
*/
     RESUME GLOBAL
       279                          TO   679  3365.  200.  0.   2.0  BY  200
       281                          TO   681  3388.  200.  0.   2.5  **
       283                          TO   683  3412.  200.  0.   2.5  **
       285                          TO   685  3435.  200.  0.   1.0  **
  END NODAL DATA
BEGIN STIFFNESS DATA
  BEGIN PROPERTY DATA
     P1    .05    1.     *(WING FIN SPARS AND RIBS)
     P2  2.       0.     0.    .2    .2    .2 *(WING FIN ATTACHMENT BEAMS - TYPE 1)
     P3  10.      0.     0. 1001 100. 100. *(WING FIN ATTACHMENT BEAMS - TYPE 2)
     P4    .15  .50                        *(CONTROL SURFACE RIBS)
     P5   0.   *=2 100. 100.    0.    10. *(BEAMS AT 455 RIB TO PICK UP SPARS)
  END PROPERTY DATA
  BEGIN ELEMENT DATA
*/
*/ WING  FRONT  SPAR
*/
      SPAR   M5   N2003      227  429      .12   2.
       *2         N2205      429  431      .12   2.  TO  N2605    433  435     +
                                                     BY  N200       2    2
       *2         N2805      435  637      .12   2.
       *2         N3007      637  639      .12   2.  TO  N3207    639  641     +
                                                     BY  N200       2    2
       *2         N3407      641  843      .12   2.
       *2         N3609      843  845      .12   2.  TO  N3809    845  847     +
                                                     BY  N200       2    2
       *2         N4009      847 1049      .12   2.
       *2         N4211     1049 1051            **
       *2         N4411     1052 1253            **
       *2         N4613     1253 1254            **
       *2         N4713     1254 1455            **
       *2         N4815     1455 1456            **
       *2         N4915     1456 1657            **
       *2         N5017     1657 1658            **
       *2         N5117     1658 1859            **
       *2         N5219     1859 1860            **
*/
*/ WING REAR SPAR
*/
      SPAR   M5   N5603      263  463      .40  12.
       *2         N5605      463  663      .40  12.
       *2         N5607      663  863      .34  12.
       *2         N5609      863 1063      .34  12.
       *2         N5611     1063 1263      .30   8.
       *2         N5613     1263 1463      .30   8.
       *2         N5615     1463 1663      .30   4.
       *2         N5617     1663 1863      .30   4.
*/
*/ WING INTERMEDIATE SPARS
*/
      SPAR   M5   N2203      229  429      .20   2.  TO  N3603    243  443     +
                                                     BY  N200       2    2
       *2         N3803      245  445      .36   2.
       *2         N4803      255  455      .60  12.
       *2         N5003      257  457      .24  12.  TO  N5403    261  461     +
                                                     BY  N200       2    2
       *2         N3005      437  637      .20   2.  TO  N3605    443  643     +
                                                     BY  N200       2    2
       *2         N3805      445  645      .36   2.
       *2         N4005      447  647      .20   4.  TO  N4605    453  653     +
                                                     BY  N200       2    2
       *2         N4805      455  655      .60  12.
       *2         N5005      457  657      .24  12.  TO  N5405    461  661     +
                                                     BY  N200       2    2
       *2         N3607      643  843      .20   2.  TO  N3807    645  845     +
                                                     BY  N200       2    2
       *2         N4007      647  847      .20   4.  TO  N4607    653  853     +
                                                     BY  N200       2    2
       *2         N4807      655  855      .20   8.
```

```
            *2          N5007     657  857      .20   10.  TO  N5407      661  861       +
                                                           BY  N200         2    2
            *2          N4209     849 1049      .20    4.  TO  N4609      853 1053       +
                                                           BY  N200         2    2
            *2          N4809     855 1055      .20    8.
            *2          N5009     857 1057      .20   10.  TO  N5409      861 1061       +
                                                           BY  N200         2    2
            *2          N4611    1053 1253      .12    4.  TO  N4811     1055 1255       +
                                                           BY  N100         1    1
            *2          N4911    1056 1256      .06    4.  TO  N5511     1062 1262       +
                                                           BY  N100         1    1
            *2          N4813    1255 1455      .12    4.
            *2          N4913    1256 1456      .06    4.  TO  N5513     1262 1462       +
                                                           BY  N100         1    1
            *2          N5015    1457 1657      .06    2.  TO  N5515     1462 1662       +
                                                           BY  N100         1    1
            *2          N5217    1659 1859      .06    2.  TO  N5517     1662 1862       +
                                                           BY  N100         1    1
*/
*/ WING IN-BODY SPARS
*/
       SPAR    M5   N2001      27  227     1.00   10.  TO  N3601       43  243       +
                                                           BY  N200         2    2
            *2          N3801      45  245     1.80   10.  TO  N4601       53  253       +
                                                           BY  N200         2    2
            *2          N4801      55  255     3.00   60.
            *2          N5001      57  257     1.20   60.  TO  N5401       61  261       +
                                                           BY  N200         2    2
            *2          N5601      63  263     2.00   60.
*/
*/ WING RIBS
*/
       SPAR    M5   N6001     227  229      .25    4.  TO  N6035      261  263       +
                                                           BY  N2           2    2
            *2          N6109     435  437      .30    4.  TO  N6135      461  463       +
                                                           BY  N2           2    2
            *2          N6215     641  643      .20    3.  TO  N6235      661  663       +
                                                           BY  N2           2    2
            *2          N6425    1051 1053      .20    4.
            *2          N6426    1053 1054      .20    4.  TO  N6435     1062 1063
            *2          N6629    1456 1457      .12    2.  TO  N6635     1462 1463
            *2          N6833    1860 1861      .30    1.4 TO  N6835     1862 1863
*/
*/ WING COVERS
*/
       COVER   M5   N7003     229  429  227         .06
            *2          N7203     229  429  431  231  .06                          TO       +
                        N8603     243  443  445  245       BY  N200      2    *=3
CCOVER T70 N27203 229 429 431 231 0. A0 TO L1 C01 A-45. A45. A90. +
       TO N28603 243 443 445 245 BY N200 2 *=3
COVER M5 N8803 245 445 447 247 .12 .00  TO +
                        N9603     253  453  455  255       BY  N200      2    *=3
            *2          N9803     255  455  457  257  .10  .14
            *2          N10003    257  457  459  259       **
            *2          N10203    259  459  461  261  .26  .14  .22  .00
            *2          N10403    261  461  463  263       **
            *2          N7805     437  637  435       .06
            *2          N8005     437  637  639   39  .06                          TO       +
                        N9605     453  653  655  455       BY  N200      2    *=3
            *2          N9805     455  655  657  457  .10  .14
            *2          N10005    457  657  659  459       **
            *2          N10205    459  659  661  461  .26  .14  .22  .00
            *2          N10405    461  661  663  463       **
            *2          N8407     643  843  641       .06
            *2          N8607     643  843  845  645  .06                          TO       +
                        N9607     653  853  855  655       BY  N200      2    *=3
            *2          N9807     655  855  857  657  .10  .08
            *2          N10007    657  857  859  659       **
            *2          N10207    659  859  861  661  .30  .14  .20  .00
            *2          N10407    661  861  863  663       **
            *2          N9009     849 1049  847       .06
            *2          N9209     849 1049 1051  851  .06                          TO       +
                        N9609     853 1053 1055  855       BY  N200      2    *=3
```

```
      *2          N9809      855 1055 1057  857  .10  .08
      *2          N10009     857 1057 1059  859        **
      *2          N10209     859 1059 1061  861  .30  .14  .20  .00
      *2          N10409     861 1061 1063  863        **
      *2          N9411     1053 1253 1051       .30  .14  .22  .12
      *2          N9611     1053 1253 1254 1054  .30  .14  .22  .12     TO       +
                  N10511    1062 1262 1263 1063       BY   N100     1   *=3
      *2          N9713     1255 1455 1254       .30  .14  .22  .12
      *2          N9813     1255 1455 1456 1256  .30  .14  .22  .12     TO       +
                  N10513    1262 1462 1463 1263       BY   N100     1   *=3
      *2          N9915     1457 1657 1456       .08
      *2          N10015    1457 1657 1658 1458  .08                    TO       +
                  N10515    1462 1662 1663 1463       BY   N100     1   *=3
      *2          N10117    1659 1859 1658       .08
      *2          N10217    1659 1859 1860 1660  .08                    TO       +
                  N10517    1662 1862 1863 1663       BY   N100     1   *=3
*/
*/ WING IN-BODY COVERS
*/
     COVER  M5    N7001       27  227  229   29  .30                    TO       +
                  N8601       43  243  245   45       BY   N200     2   *=3
      *2          N8801       45  245  247   47  .60                    TO       +
                  N9601       53  253  255   55       BY   N200     2   *=3
      *2          N9801       55  255  257   57  .70
      *2          N10001      57  257  259   59  .70
      *2          N10201      59  259  261   61 1.30   .70 1.10  .00
      *2          N10401      61  261  263   63         **
*/
*/ WING FIN SPARS
*/
     SPAR   M5    N11001    2056 2256           P1
      *2          N11003    2256 2456           *
      *2          N11201    2058 2258           *
      *2          N11203    2258 2458           *
      *2          N11501    2061 2261           *
      *2          N11503    2261 2461           *
      *2          N11701    2063 2263           *
      *2          N11703    2263 2463           *
*/
*/ WING FIN RIBS
*/
     SPAR   M5    N12001    2256 2258           P1
      *2          N12003    2258 2261           *
      *2          N12005    2261 2263           *
      *2          N12201    2456 2458           *
      *2          N12203    2458 2461           *
      *2          N12205    2461 2463           *
*/
*/ WING FIN COVERS
*/
     COVER  M5    N13001    2056 2256 2258 2058  .05
      *2          N13003    2058 2258 2261 2061   *
      *2          N13005    2061 2261 2263 2063   *
      *2          N13201    2256 2456 2458 2258   *
      *2          N13203    2258 2458 2461 2261   *
      *2          N13205    2261 2461 2463 2263   *
*/
*/ WING FIN ATTACHMENT BEAMS
*/
     BEAM   25    N20001    1456 2056 1463  P2
      *2          N20003    1458 2058 1463  *
      *2          N20005    1461 2061 1463  *
      *2          N20007    1463 2063 1461  *
      *2          N21001    1458 1458       P3
      *2          N21003    1458 1461       *
      *2          N21005    1462 1463       *
*/
```

```
*/ WING TRAILING EDGE CONTROL SURFACE RIBS
*/
     SPAR    M5   N101        263 3003         P4
   *+2   0    0      2        200  100         0
      *2          N102       3003 3005         *
   *+2   0    0      2        100  100         0
      *2          N108       1463 3405         *
   *+2   0    0      1        200  100         *
*/
*/ WING TRAILING EDGE CONTROL SURFACE COVERS
*/
     COVER   M5   N151        263  463 3103 3003   .10
      *2          N153        463  663 3203 3103   *
      *2          N152       3003 3103 3105 3005   *
      *2          N154       3103 3203 3205 3105   *
      *2          N156       1463 1663 3505 3405   *
   *+1   0    0      1        200  200  100  100   *
*/
*/ HORIZONTAL TAIL SPARS
*/
     SPAR   M5    N14003      279  479        .10   1.2
      *2          N14005      479  679              **
      *2          N14103      281  481        .05   1.8
      *2          N14105      481  681              **
      *2          N14203      283  483        .05   1.6
      *2          N14205      483  683              **
      *2          N14303      285  485        .20   2.6
      *2          N14305      485  685              **
*/
*/ HORIZONTAL TAIL RIBS
*/
     SPAR    M5   N14401      279  281        .15   2.0 TO  N14405     283   285        +
                                                        BY  N2           2     2
      *2          N14501      479  481        .10   1.2 TO  N14505     483   485        +
                                                        BY  N2           2     2
      *2          N14601      679  681        .10   1.2 TO  N14605     683   685        +
                                                        BY  N2           2     2
*/
*/ HORIZONTAL TAIL IN-BODY SPARS
*/
     SPAR    M5   N14001       79  279        .50   6.0
      *2          N14101       81  281        .25   9.0
      *2          N14201       83  283        .25   8.0
      *2          N14301       85  285       1.00  13.0
*/
*/ HORIZONTAL TAIL COVERS
*/
     COVER   M5   N15003      279  479  481  281   .16
   *+2    0   0    200          2  *=3            0.
     COVER   M5   N15005      479  679  681  481   .07
   *+2    0   0    200          2  *=3            0.
*/
*/ HORIZONTAL TAIL IN-BODY COVERS
*/
     COVER   M5   N15001       79  279  281   81   .80                           TO       +
                  N15401       83  283  285   85       BY  N200       2       *=3
*/
*/ BODY BEAMS
*/
     BEAM    M5   N1001         1    3   5.    0.   *=3  16000.   10. 0.  *=3  30000.
   *+30  0    0      2          2    2   5.         *4   14000.    5.     *4   14000.
      *2          N1063        63   65 160.         *4  450000.  148.     *4  416000.
   *+12  0    0      2          2    2 -12.         *4  -34000.  -12.     *4  -34000.
*/
*/ BEAMS AT 455 RIB TO PICK UP DISCONTINUED SPARS
*/
     BEAM    M5   N30002     1053 1054         P5
   *+4   0    0      2          2    2         *
     BEAM    M5   N30011     1063 1062         P5
   *+4   0    0     -2         -2   -2         *
  END ELEMENT DATA
END STIFFNESS DATA
```

```
BEGIN BC DATA
  STAGE 2
      SUPPORT ASYM IN SURFACE 2
      SUPPORT TX TZ RY FOR 89
END BC DATA
BEGIN LOAD DATA
  SET 1 STAGE 2
  LOAD CASE ID SYMM **SYMMETRIC AIRLOADS*
  BEGIN NODAL LOAD DATA
    ORDER FZ
    CASE SYMM
          3    -2275.
          9    -6110.
         15    -4970.
         23    -3255.
         31     -245.
         39    -5400.
         45     -380.
         53    -3830.
         61      140.
         67     -165.
         75    -6365.
         83    -3495.
         87    -3160.
         85     -150.
         89     -150.
    ORDER FZ FY
      2056      -125.     1220.
      2456      -100.     1360.
      2458      -100.     -410.
      2058      -125.      955.
      2061      -125.     1075.
      2461      -100.     7665.
      2463      -100.    -4960.
      2063      -125.     -660.
    ORDER FZ
       431    13475.
       231    -8500.
       637     8030.
       237    -7750.
       245   -11770.
       655    -4640.
       255    -5330.
       663     1565.
       263     5445.
       843    36405.
       645   -20790.
      105     21130.
       649     3435.
      1055     3365.
      1063     1435.
      1456    13820.
      1459    21815.
      1463     6155.
      1860      860.
      1861    14395.
      1863     2762.
       659     -490.
      1059    -8710.
      1461   -10695.
      1862    -5190.
       279    -5060.
       679    -4040.
       681    -7375.
       281    -5415.
       283    -1620.
       683     -865.
       685    -1725.
       285    -3425.
    END NODAL LOAD DATA
END LOAD DATA
```

```
*/MODEL /
BEGIN SUBSET DEFINITION /
SUBSETS OF STIFFNESS SET 1 /
 */                    /
 */ SUBSETS FOR GEOMETRY PLOTS /
E1 = ALL /
N1 = ALL /
 */                    /
 */ELEMENT SUBSETS FOR DESIGN /
 */ALL SUBSETS ARE IN THE RANGE E100 TO E199 /
 */                    /
 */                    /
 */                    /
 */                    /
 */   G R O U P  1   /
 */   BODY SUBSET /
E100 = 1027 TO 1073 BY 2 /
 */                    /
 */   G R O U P  2  /
 */   WING SUBSETS /
 */STARTING WITH THE SPAR ELEMENTS REPRESENTING SPARS /
 */BEGINNING AT FRONT SPAR AND CONTINUING AFT  /
E101 = 2001 2003 2205 TO 2805 BY 200 3007 TO 3407 BY 200
       3609 TO 4009 BY 200 4211 4411 4613 4713 4815 4915
       5017 5117 5219 / FRONT SPAR
E102 = 2201 2203 2401 2403 2601 2603 2801 2803 / 1 TO 4 INT SPARS
E103 = 3001 TO 3005 BY 2 3201 TO 3205 BY 2 3401 TO 3405 BY 2
       3601 TO 3607 BY 2 / 5 TO 8 INT SPAR
E104 = 3801 TO 3807 BY 2 4001 TO 4007 BY 2 4201 TO 4209 BY 2
       4401 TO 4409 BY 2 / 9 TO 12 INT SPAR
E105 = 4601 TO 4609 BY 2 4801 TO 4809 BY 2 5001 TO 5009 BY 2
       5201 TO 5209 BY 2 5401 TO 5409 BY 2 / 13 TO 17 INT SPAR TO FINE GRID
E106 = 5601 TO 5617 BY 2 / REAR SPAR
E107 = 4611 TO 5511 BY 100 4813 TO 5513 BY 100
       5015 TO 5515 BY 100 5217 TO 5517 BY 100 / OUTBOARD INT SPARS
 */                    /
 */SPAR ELEMENTS REPRESENTING RIBS /
 */BEGINNING INBOARD /
E108 = 6001 TO 6035 BY 2 / SIDE OF BODY RIB
E109 = 6109 TO 6135 BY 2 / FIRST OUTBOARD RIB
E110 = 6215 TO 6235 BY 2 / SECOND OUTBOARD RIB
E111 = 6425 TO 6435 / THIRD OUTBOARD RIB
E112 = 6629 TO 6635 / FOURTH OUTBOARD RIB
E113 = 6833 TO 6835 / TIP RIB
 */                    /
 */AUXILIARY BEAMS /
E114 = 30002 TO 30011 / BEAMS AT THIRD RIB (455 RIB)
E115 = 20001 TO 20007 BY 2 21001 TO 21005 BY 2 / FIN ATTACHMENT BEAM
 */                   /
 */   G R O U P  3    /
 */   WING COVERS     /
 */STARTING INBOARD   /
E116 = 7001 TO 10401 BY 200 / CENTER SECTION
E117 = 7003 TO 7603 BY 200 / FIRST BAY FS TO INT4
E118 = 7803 TO 8403 BY 200 7805 TO 8405 BY 200 8407 / INT4 TO INT8 TO FS
E119 = 8603 TO 9203 BY 200 8605 TO 9205 BY 200
       8607 TO 9207 BY 200 9009 9209 / INT8 TO INT12 TO FS
E120 = 9403 TO 9803 BY 200 9405 TO 9805 BY 200
       9405 TO 9805 BY 200 9407 TO 9807 BY 200
       9409 TO 9809 BY 200 / INT12 TO INT15 TO RIB 455
E121 = 10003 TO 10403 BY 200 10005 TO 10405 BY 200
       10007 TO 10407 BY 200 10009 TO 10409 BY 200 / INT14 TO RS TO 455
N121 = NODES IN E121      /
E122 = 9411 TO 10511 BY 100 9313 TO 10513 BY 100 /  2 BAYS OUTBOARD 455
E123 = 9915 TO 10515 BY 100 10117 TO 10517 BY 100 / 2 OUTBOARD BAYS
 */                   /
 */   G R O U P  4   /
 */   CONTROL SURFACES  /
E124 = 107 TO 110 155 TO 157 / OUTBOARD
E125 = 101 TO 106 151 TO 154 / INBOARD
 */                   /
```

```
*/   G R O U P  5   /
*/   E004 IS THE HORIZONTAL TAIL /
*/   E002 IS THE VERTICAL WING FIN /
E2 = SLAB Y 594.  /
E4 = SPARS COVERS TUBE 79 279 679 685 85 DIRE. ON 0. 0. 1.  /
*/ E200 AND E201 ARE COMPOSITE SUBSETS /
E200 = 27203 TO 28603 BY 200  /
E201 = 27203 /
END SUBSET DEFINITION /
BEGIN MATERIAL DATA /
M51 .16  /
60 1. *=11  170.E3 168.E3 166.E3 140.E3 138.E3 136.E3 100.E3 98.E3 96.E3
            50.E3 *=8  /
120 *12     165.E3 163.E3 161.E3 135.E3 133.E3 131.E3  95.E3 93.E3 91.E3
            48.E3 *=8  /
200 *12     160.E3 158.E3 156.E3 130.E3 128.E3 126.E3  90.E3 88.E3 86.E3
            46.E3 *=8  /
500 *12     130.E3 128.E3 126.E3 100.E3  98.E3  96.E3  60.E3 58.E3 56.E3
            26.E3 *=8  /
M52 .10 /
50 1. *=11   90.E3  88.E3  86.E3  70.E3  68.E3  66.E3  50.E3 48.E3 46.E3
            13.E3 *=8  /
200 *12      80.E3  78.E3  76.E3  60.E3  58.E3  56.E3  40.E3 38.E3 36.E3
            12.E3 *=8  /
600 *12      70.E3  68.E3  66.E3  50.E3  48.E3  46.E3  30.E3 28.E3 26.E3
            11.E3 *=8  /
END MATERIAL DATA /
BEGIN DESIGN DATA /
MODE 1 /
BEGIN TABLE DATA /
BC51  60  .04 .08 .12 .30  110.E3 115.E3  120.E3  130.E3  /
BC51 120   *4  105.E3  110.E3 115.E3 125.E3  /
BC51 200   *4  100.E3 105.E3 110.E3 120.E3  /
BC51 500   *4   80.E3  85.E3  90.E3 100.E3  /
BC52  60   *4   50.E3  52.E3  54.E3  55.E3  /
BC52 200   *4   48.E3  50.E3  52.E3  53.E3  /
BC52 500   *4   25.E3  26.E3  27.E3  27.5E3 /
BS51  60   *4   70.E3  75.E3  80.E3  83.E3  /
BS51 180   *4   60.E3  65.E3  70.E3  72.E3  /
BS51 540   *4   30.E3  35.E3  40.E3  41.E3  /
BS52  60   *4   35.E3  37.5E3 40.E3  41.5E3 /
BS52 180   *4   30.E3  32.5E3 35.E3  36.E3  /
BS52 540   *4   15.E3  17.5E3 20.E3  20.5E3 /
END TABLE DATA /
SET 1 /
BEGIN PROPERTY DATA /
BEAMS .5 /
END PROPERTY DATA /
BEGIN FIXED DATA /
E117  0 0 .04 .03 .03 0 0 .04 .03 .03 /
END FIXED DATA /
BEGIN LOWER BOUND DATA /
E118  0 0 .06 0 0 0 0 .05 0 0 /
E119  0 0 .06 0 0 0 0 .06 0 0 /
E120  0 0 .07 .04 0 0 0 .06 .03 0 /
E121  .5 0 .06 .04  0 .5 0 .06 .04 0 /
E122  .5 C .09 0  0  0 0 .09 0 0 /
E123  0 0 .045 0 C 0 0 .045 0 0 /
SPARS .04 .7 *=3 .5 /
END LOWER BOUND DATA /
BEGIN UPPER BOUND DATA /
E123  0 0  .15 0 0 0 0 .12 0 0 /
END UPPER BOUND DATA /
BEGIN MARGIN DATA /
E120 .15 /
E4 SPARS .20 /
N6833  .35 /
END MARGIN DATA /
BEGIN SIZING DATA /
M5 /
M51 E121 BC51 BS51 .5 /
M52 E122 BC52 B  .65 /
M51 SPARS B BS52 /
END SIZING DATA /
```

```
BEGIN RESTRAIN SIZING DATA /
E116 /
E125  /
E4 COVERS /
BEAMS /
E124 /
E2 /
END RESTRAIN SIZING DATA /
BEGIN OPTIMIZATION DATA /
CCOVER E200 E201 /
END OPTIMIZATION DATA /
STAGE 2 1 1 /
BEGIN LOADS DATA /
CASE SYMM 10. /
 CASE SYMM 20. T400 E121 /
CASE SYMM 15. T350 E122 /
CASE SYMM 10. T300 E123 /
CASE SYMM 15. E105 /
CASE SYMM 30. E107 /
CASE SYMM 30. E106 /
CASE SYMM 2000. E200 /
END LOADS DATA /
BEGIN SUPERPOSITION DATA /
CASE HEAVY 15. SYMM 15. SYMM E106 /
END SUPERPOSITION DATA /
END DESIGN DATA /
END PROBLEM DATA /
```

Table 209-1. Summary of Design Options Used

ELEMENT SUBSET NO.	ELEMENT TYPES	LOWER BOUND	UPPER BOUND	FIXED	SPECIFIED MARGIN	SIZING RESTRAINED	LOAD FACTOR	TEMPERATURE	COMPOSITE OPTIMIZATION
2	SPARs &				X (SPARs)	X (COVERs)			
4	COVERs					X			
105							15		
106	SPARs						30		
107							30		
116						X			
117				X					
118		X							
119		X							
120	COVERs	X			X				
121		X					20	400°F	
122		X					15	350°F	
123		X	X					300°F	
124						X			
125						X			
—	SPARs	X							
—	BEAMs					X			
200	CCOVERs						2000		X

Table 209-2. Optimum Number of Layers per Lamina

Fiber Angle	Number of Layers
0°	10
+45°	1
-45°	1
90°	48

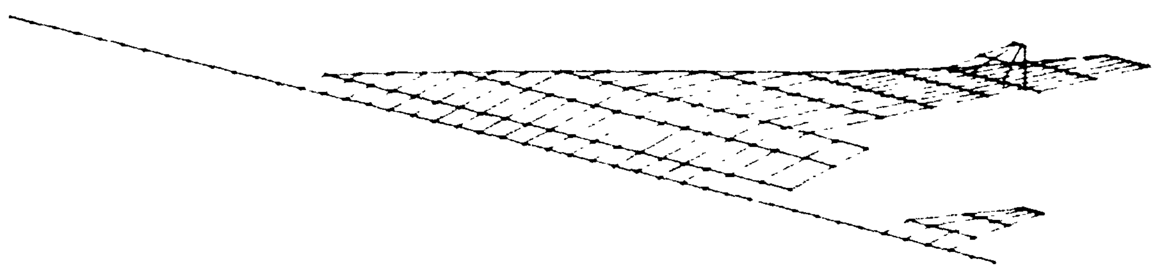

Figure 209-1. Structural Model,Design Demonstration

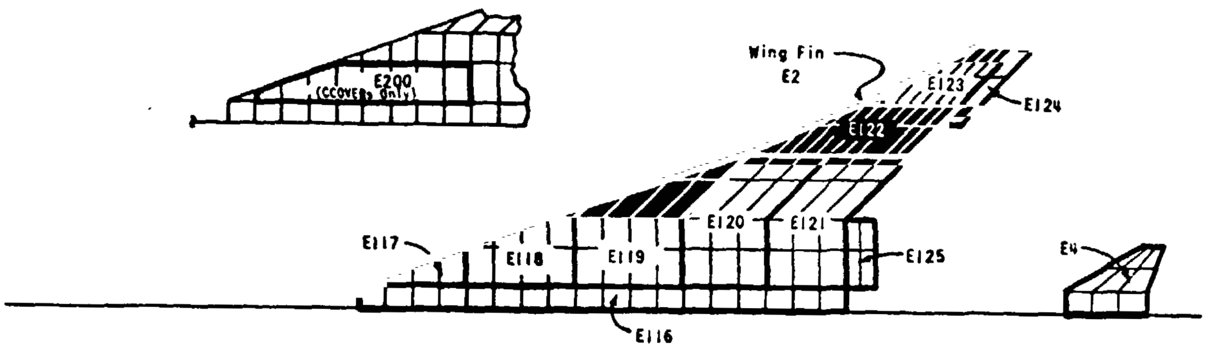

Figure 209-2. Element Subsets for Design

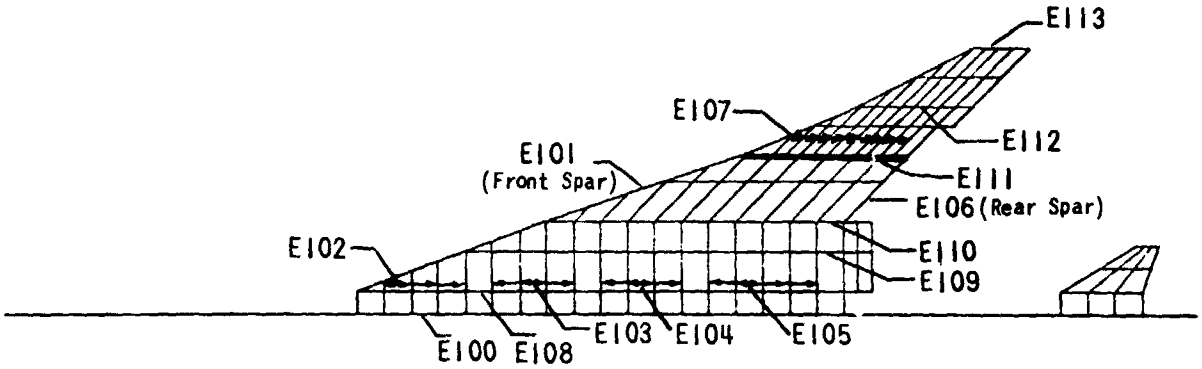

Figure 209-3. SPAR Element Subsets for Design

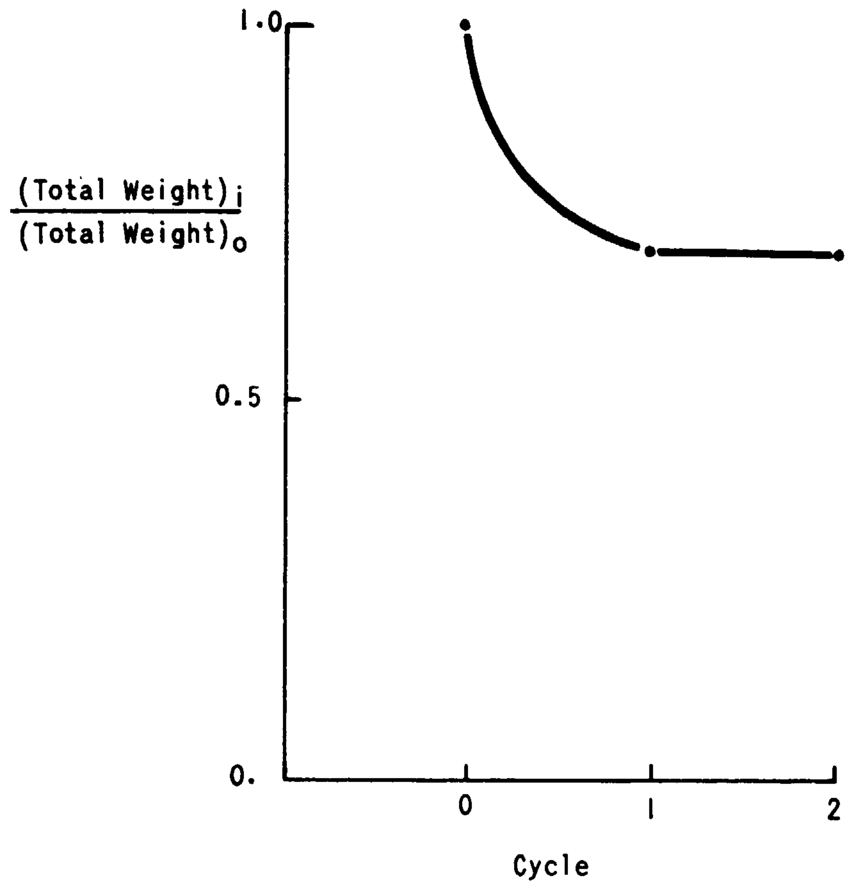

FIGURE 209-4. Total Weight vs. Cycle,Design Demonstration

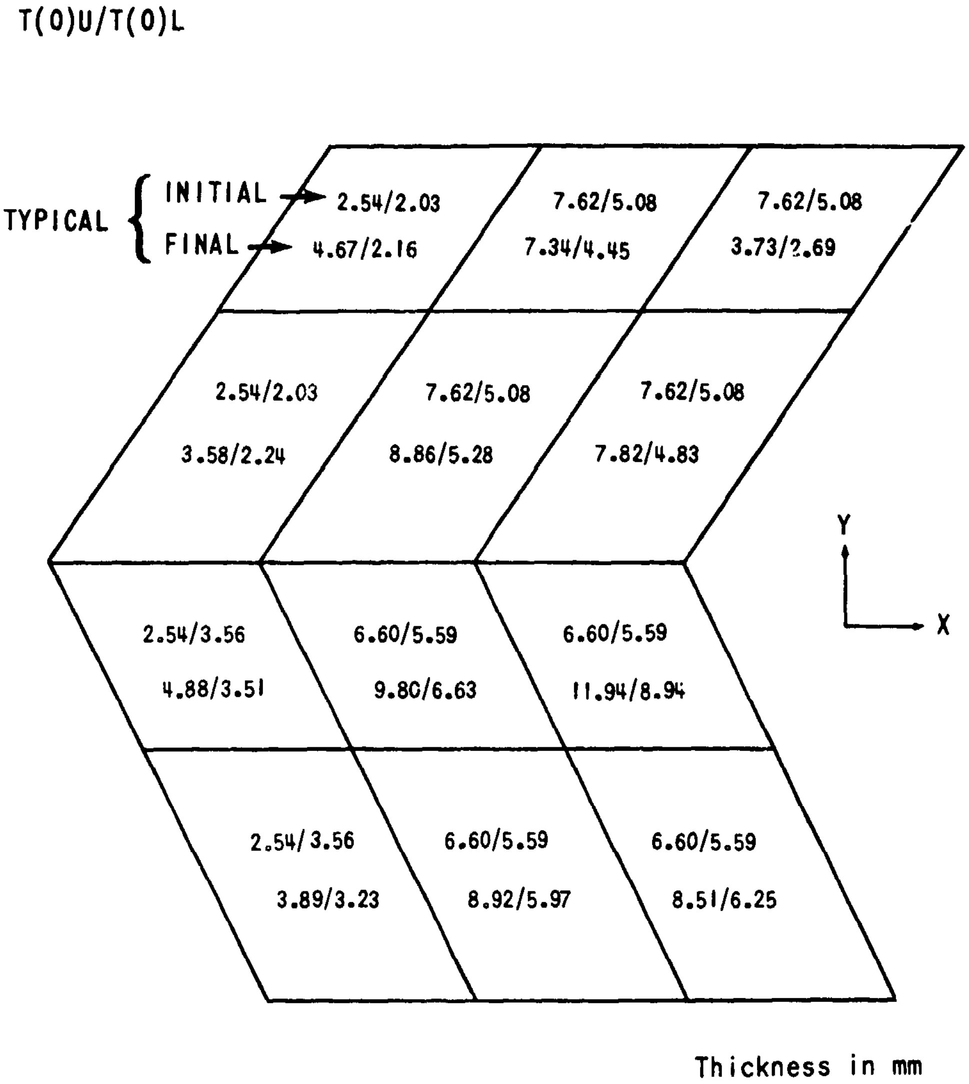

Figure 209-5. Surface Thickness Changes, Element Subset 121

PLOT ID = MARGINS. COVSMS .CYCLE = 1

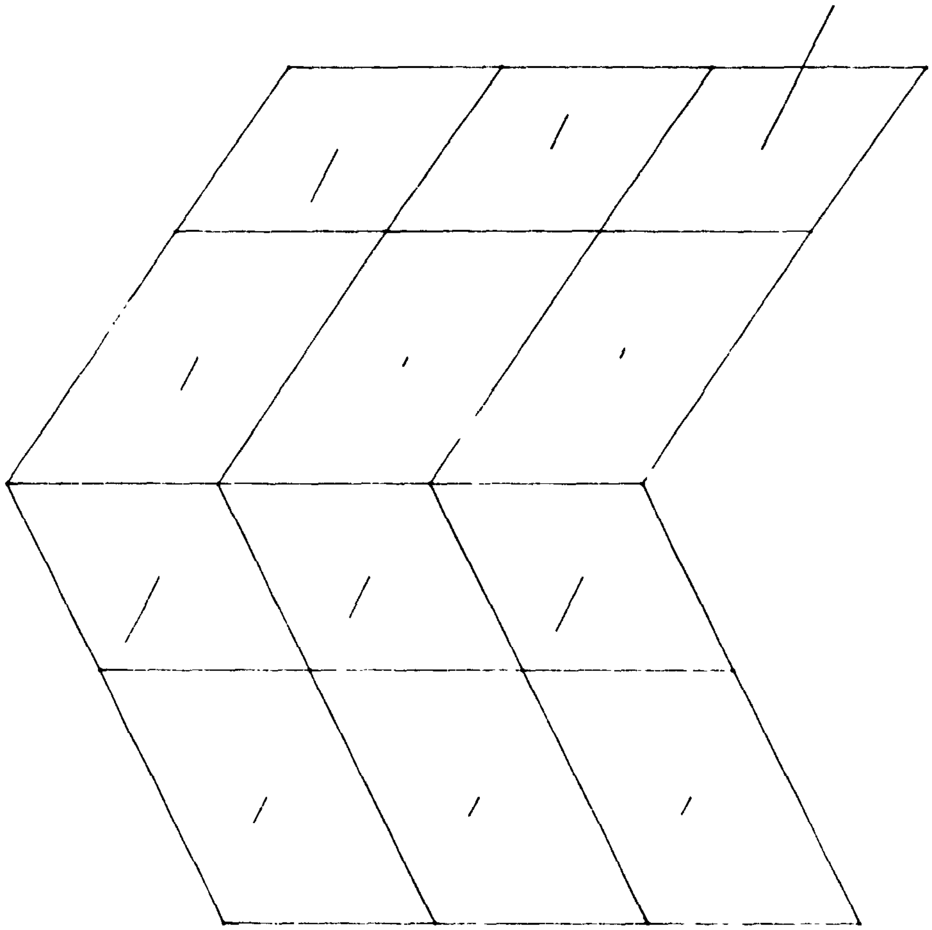

Figure 209-6. Margins of Safety,Cycle 1. Element Subset 121

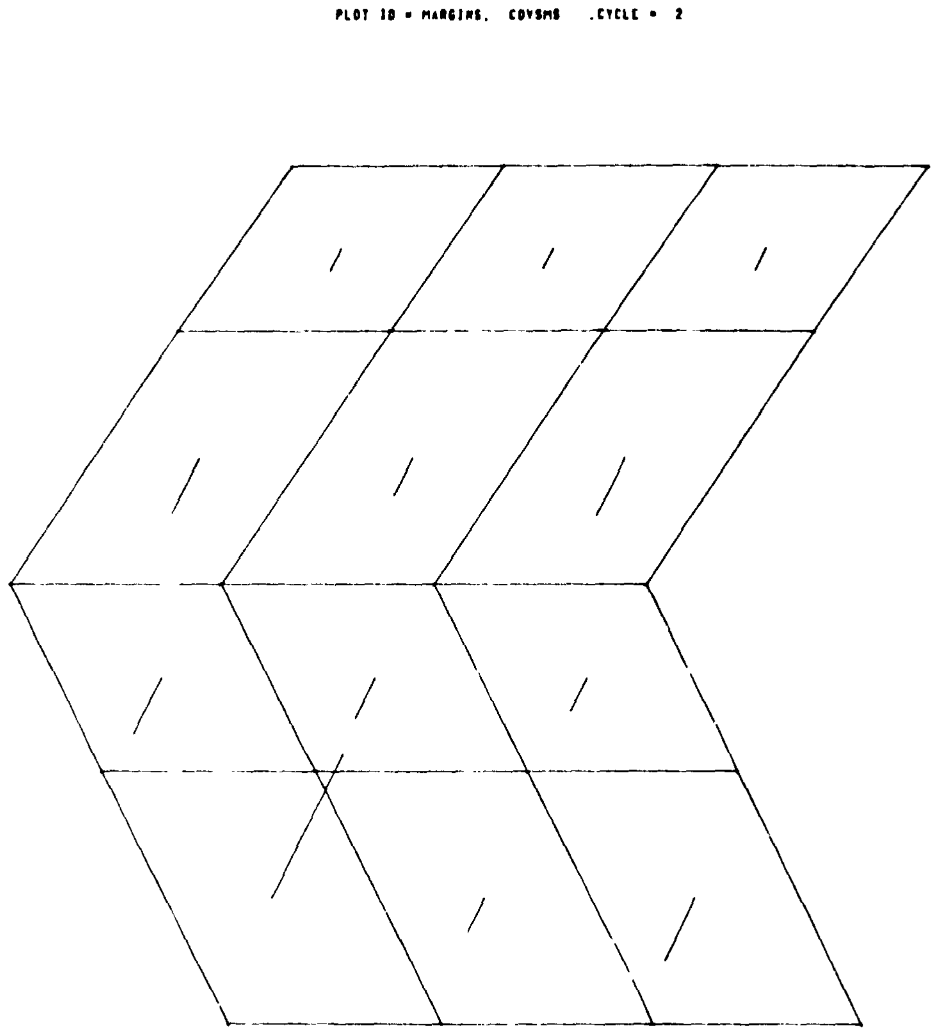

Figure 209-7. Margins of Safety,Cycle 2, Element Subset 121

210. THERMAL FULLY STRESSED DESIGN (DECK 17)

210.1 DESCRIPTION OF PROBLEM

This demonstration problem consists of a thermal fully stressed design of the well-known 25-bar transmission tower. The model and loading are based upon the information shown in reference 210-1. The loading consists of nodal loads at four nodes and thermal loads at each node. The model is shown in figure 210-1.

The design is performed iteratively and terminated when the relative weight change is less than 5%. The starting point for the design variables is unit area for all 25 ROD elements.

210.2 RESULTS

The analysis stabilized after two iterations to a relative weight change of less than 5%. The total weight compares quite favorably with that reported in reference 210-1. A plot of weight vs. design cycle is shown in figure 210-1. Thermal margins of safety for the elements on one face of the tower are shown in figure 210-3.

210.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL MATRIX PROGRAM DEMO17
      PROBLEM ID(DEMO17 - THERMAL DESIGN OF A 25-BAR TRUSS)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. THERMAL DESIGN
C                       2. PLOTS OF THERMAL MARGINS OF SAFETY
C
C     AUTHOR         BJORN BACKMAN
C
C     CORE            145K (OCTAL)
C
      USER COMMON (BEGCYCL,ENDCYCL,CURCYCL,CONVERG,ISET,ISTAGE,IPCS)
      INTEGER BEGCYCL,CURCYCL,ENDCYCL
      DIMENSION CONVERG(17)
      CONVERG(15) = .05
      CONVERG(16) = 1.0
      ENDCYCL = 5
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      EXECUTE EXTRACT(EXNAME=GEOM,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=CALCOMP,TYPE=ORTH,SIZE=(15.,
     X              15.),LABEL=N,RZ=20.,RY=10.,RX=0.,EXNAME=GEOM)
      IF(BEGCYCL .LT. 1) BEGCYCL=1
      IF(ENDCYCL .LT. BEGCYCL ) ENDCYCL=BEGCYCL
      CURCYCL = BEGCYCL
      IF(BEGCYCL .EQ. 1) GO TO 70001
C
C  THIS IS A RESTART,
C  LOAD RANDOM FILES FROM SAVESS4
C
      LOAD FILES(SAVESS4=REWIND)
      SAVE MATRIX(SAVESS4=REWIND,MERGRNF,D31)
      GO TO 70002
70001 CONTINUE
C
C  BEGCYCL = 1,
C  COMPUTE AND PRINT INITIAL WEIGHT
C
      EXECUTE MASS(SET=1)
70002 CONTINUE
      CALL DESCONS
      IF(CURCYCL .EQ. 0) CALL EXIT
C
C  DESIGN CYCLES BEGCYCL THROUGH ENDCYCL
C
70003 CONTINUE
      EXECUTE STIFFNESS(SET=1,LUMP=0.0)
      EXECUTE MERGE(STIFFNESS,SET=1,STAGE=1,K11=11,K13=13,K33=33)
      EXECUTE LOADS(SET=1,STAGE=1,LC=ALL,MATERIAL=CONSTANT)
      EXECUTE MERGE(LOADS,SET=1,STAGE=1,L11=11,L31=31)
      IF(CURCYCL .GT. 1) GO TO 70004
C
C     FIRST CYCLE, MERGE AND SAVE SUPPORT DISPLACEMENTS
C
      EXECUTE MERGE(DISPLACEME,SET=1,STAGE=1,D31=31)
      SAVE MATRIX(SAVESS4=REWIND,MERGRNF,D31)
70004 CONTINUE
      EXECUTE MULTIPLY(TEMP=[L11-K13*D31])
      EXECUTE CHOLESKY(SOLVE,K11,D11,TEMP)
      IF(CURCYCL .EQ. ENDCYCL) GO TO 70005
```

```
C
C   INTERMEDIATE CYCLE, ASSEMBLE DISPLACEMENTS AND
C   COMPUTE STRESSES IN INTERNAL ORDER
C
      EXECUTE STRESS(SET=1,STAGE=1,INTERNAL,D1=D11,D3=D31)
      GO TO 70006
70005 CONTINUE
C
C   LAST CYCLE, ASSEMBLE DISPLACEMENTS AND
C   COMPUTE STRESSES IN USER ORDER
C
      EXECUTE STRESS(SET=1,STAGE=1,D1=D11,D3=D31)
70006 CONTINUE
      EXECUTE DESIGN(SET=1,STAGE=1,CYCLE=CURCYCL,PROCEDURE=1,TFSD,NCFSD)
      EXECUTE MASS(SET=1)
      CALL DESCONS
      IF(CURCYCL .GE. ENDCYCL) GO TO 70007
      PURGE FILES(MERGRNF,CHOLRNF,MULTRNF,STIFRNF,LOADRNF,STRERNF,
     X            MASSRNF)
      LOAD FILES(SAVESS4=REWIND)
      CURCYCL =  CURCYCL + 1
      GO TO 70003
70007 CONTINUE
C
C   LAST CYCLE,
C   COMPUTE REACTIONS AND PREPARE SAVESS4
C
      EXECUTE MULTIPLY(R31=[-L31+K13(T)*D11+K33*D31])
      SAVE MATRIX(SAVESS4,MULTRNF,R31)
      SAVE MATRIX(SAVESS4,MASSRNF,TOTLWT*)
      SAVE FILES(SAVESS4,DATARNF,DESIRNF,LOADRNF,STRERNF)
      PRINT OUTPUT (DESIGN)
      PRINT OUTPUT(DESIGN,HISTORY,CYCLE=BEGCYCL TO ENDCYCL)
      EXECUTE EXTRACT(EXNAME=MARGIN,LSUB=TMS,CYCLE=(1,2,3),ESUB=E2,
     X           NSUB=N2)
      EXECUTE GRAPHICS(GNAME=MARGIN,TYPE=ORTH,SIZE=(20.,20.),
     X                 SCALAR=RCTMS,SSCALE=3,VY=-1,EXNAME=MARGIN)
      END CONTROL PROGRAM
```

```
BEGIN MATERIAL DATA /
 M51 .101 /
  0 1.E7 .3  3.8E6  0.  1.E7  .3  3.8E6  0. 1.E7 .3  3.8E6  .0
    40.E3 *=17 /
  500  1.E7 .3  3.8E6  6.4E-3  1.E7 .3  3.8E6 6.4E-3 1.E7 .3  3.8E6
       6.4E-3 40.E3 *=17 /
END MATERIAL DATA /
BEGIN NODAL DATA /
 1    0.   -25.  200. /
 2    0.   +25.  200. /
 3  -37.5   37.5 100. /
 4   37.5   37.5 100. /
 5   37.5  -37.5 100. /
 6  -37.5  -37.5 100. /
 7 -100.   100.    0. /
 8  100.   100.    0. /
 9  100.  -100.    0. /
10 -100.  -100.    0. /
END NODAL DATA /
BEGIN STIFFNESS DATA /
BEGIN ELEMENT DATA /
ROD M51 N1    1  2  1. /
ROD M51 N2    1  4  1. /
ROD M51 N3    2  3  1. /
ROD M51 N4    1  5  1. /
ROD M51 N5    2  6  1. /
ROD M51 N6    2  4  1. /
ROD M51 N7    2  5  1. /
ROD M51 N8    1  3  1. /
ROD M51 N9    1  6  1. /
ROD M51 N10   3  6  1. /
ROD M51 N11   4  5  1. /
ROD M51 N12   3  4  1. /
ROD M51 N13   5  6  1. /
ROD M51 N14   3 10  1. /
ROD M51 N15   6  7  1. /
ROD M51 N16   4  9  1. /
ROD M51 N17   5  6  1. /
ROD M51 N18   4  7  1. /
ROD M51 N19   3  8  1. /
ROD M51 N20   5 10  1. /
ROD M51 N21   6  9  1. /
ROD M51 N22   6 10  1. /
ROD M51 N23   3  7  1. /
ROD M51 N24   5  9  1. /
ROD M51 N25   4  8  1. /
END ELEMENT DATA /
END STIFFNESS DATA /
BEGIN BC DATA /
 SET 1 STAGE 1 /
      SUPPORT TX TY TZ FOR  7 8 9 10 /
END BC DATA /
BEGIN LOADS DATA /
 SET 1 STAGE 1 /
  BEGIN NODAL LOADS DATA /
      FREEDOM FX1 FY1 FZ1 FX2 FY2 FZ2 FX3 FX6 /
     1 1000.  10000.  -5000. 1000. 10000. -5000. 500. 500. /
  END NODAL LOADS DATA /
  BEGIN NODAL THERMAL LOADS DATA /
CASE 2 /
      1      2     100.              /
      3 TO  6       30.              /
      7 TO 10      -35.              /
END NODAL THERMAL LOADS DATA /
END LOADS DATA /
BEGIN SUBSET DEFINITION              /
   SUBSETS OF STIFFNESS SET 1        /
      E1  =  ALL                     /
      N1  =  ALL                     /
      N2  = 1 5 6 9 10               /
      E2  =  ALL IN N2               /
END SUBSET DEFINITION                /
```

```
BEGIN DESIGN DATA /
 MODE 1 /
 SET 1 /
BEGIN SIZING DATA /
 N51 /
END SIZING DATA /
STAGE 1 1 0 TH1 /
BEGIN THERMAL DATA /
CASE UFF  U  1. 1 1. 2  /
END THERMAL DATA /
END DESIGN DATA /
END PROBLEM DATA /
```

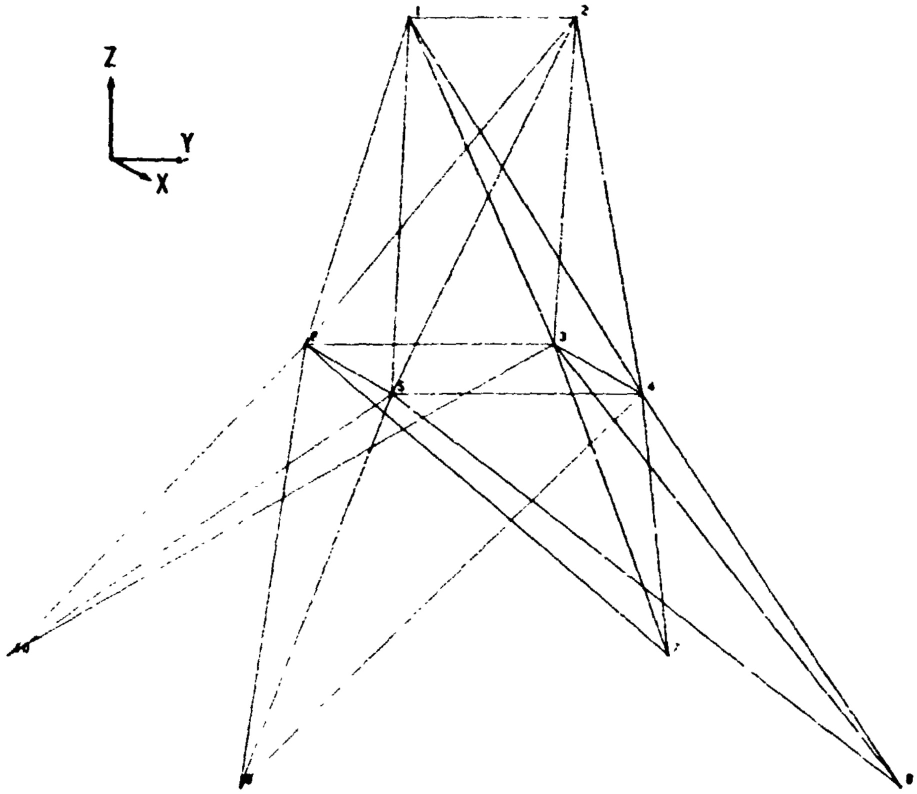

Figure 210-1. 25-Bar Transmission Tower Model

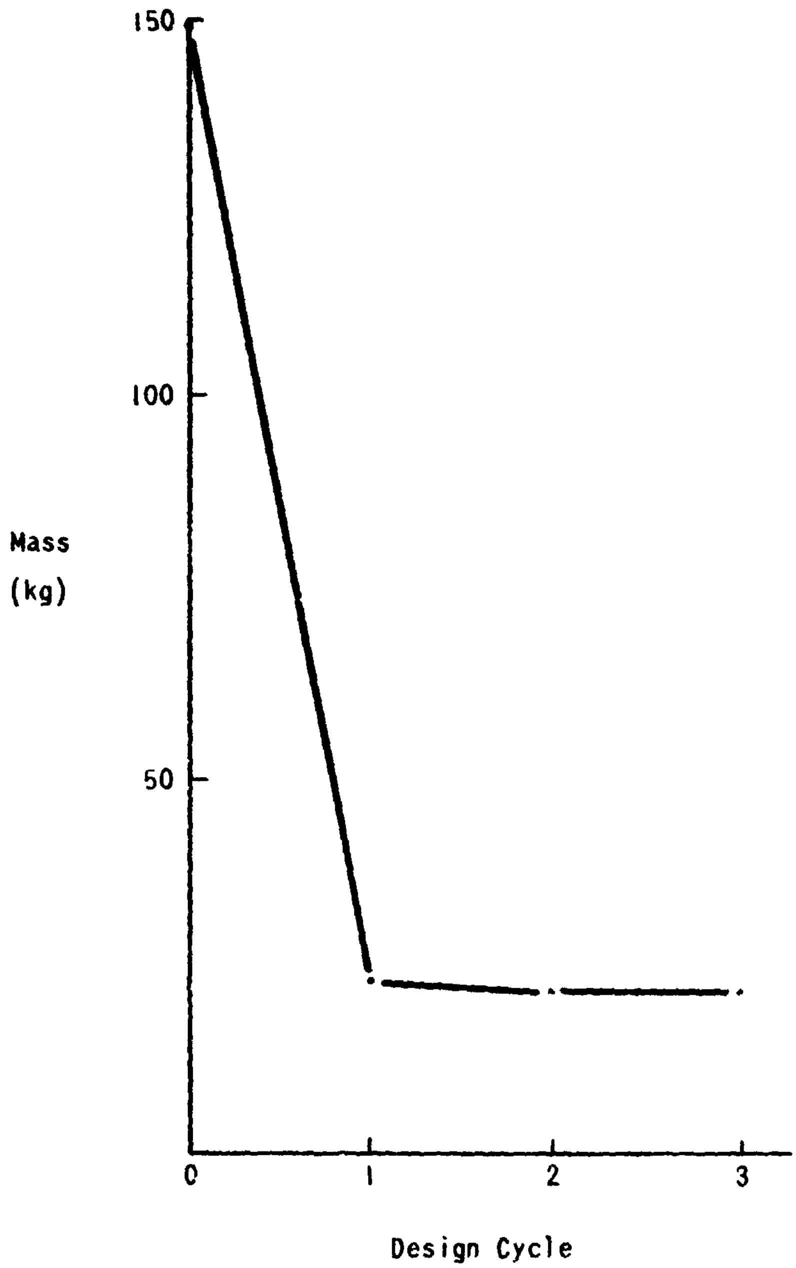

Figure 210-2. Total Mass vs. Design Cycle, 25-Bar Transmission Tower

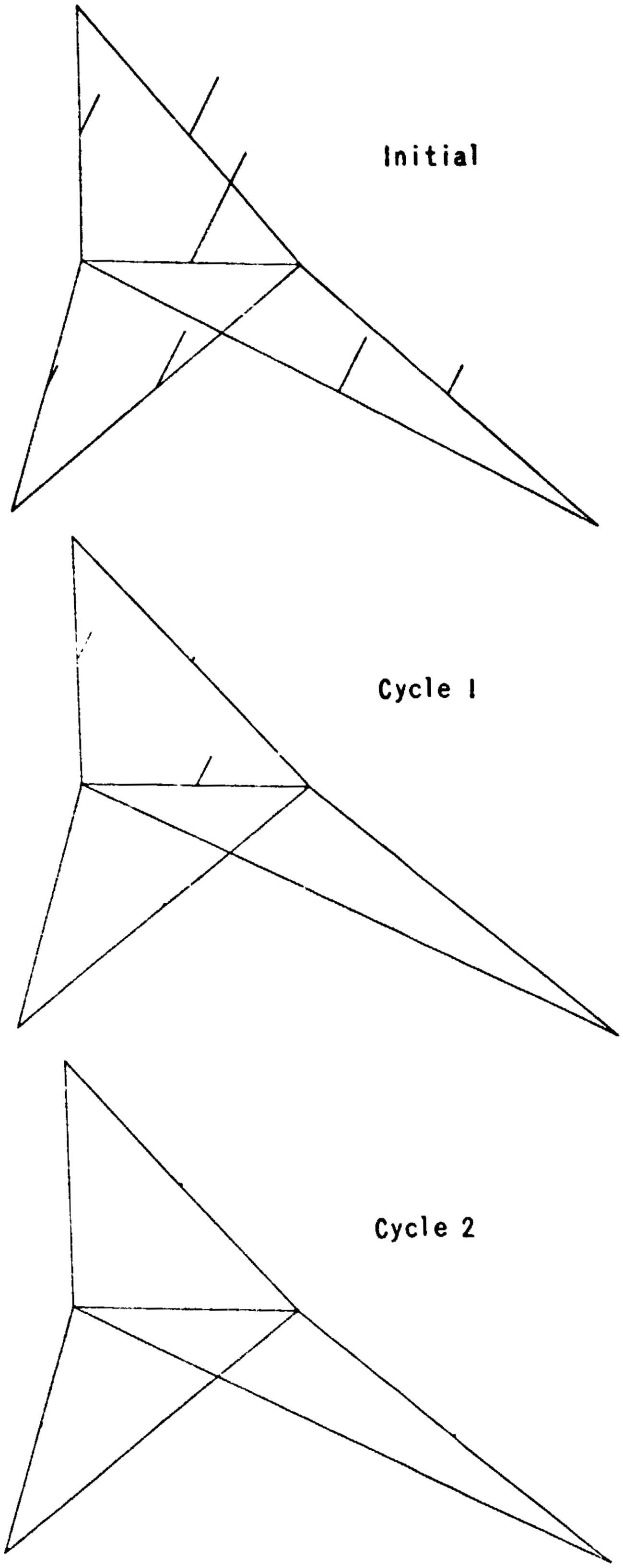

Figure 210-3. Thermal Margins of Safety, 25-Bar Transmission Tower

211. FLUTTER ANALYSIS OF AN SST AIRCRAFT (DECK 4)

211.1 DESCRIPTION OF ANALYSIS

Four separate flutter analyses of an SST aircraft are performed in this demonstration problem. The structural model, shown in figure 211-1, is the same as that described in section 203. The same degrees of freedom are retained in the vibration analysis; only the symmetric modes are considered.

The mass is modelled using mass plate elements as shown in figure 211-2. The mass of the stiffness elements is ignored.

The vibration analysis is performed using a reduced stiffness matrix and a non-diagonal reduced mass matrix produced directly by the Mass Processor.

All four flutter analyses employ the same set of generalized coordinates which are equivalent to the first twenty free-free symmetric vibration modes. The first flutter analysis, performed at Mach 0.8, is based on an aerodynamic model of the wing and tail using only the tail oscillations. Doublet Lattice airforce theory is used. Aerodynamic influence coefficients are obtained for four reduced frequencies. They are produced by FLEXAIR to obtain two sets of generalized airforces; the first set includes the effects of the flexibility of the truncated higher frequency modes of vibration, while the second set does not. V-g and V-f plots are obtained for both sets of generalized airforces. This analysis is shown schematically in figure 211-3.

The second flutter analysis is also based on the Doublet Lattice theory, but includes the wing, body and tail in the aerodynamic representation. Only the first ten generalized oordinates are used in the flutter analysis. This analysis is shown schematically in figure 211-4.

The third flutter analysis is performed at Mach 1.526 using Mach Box aerodynamics including the aerodynamic influence of the wing upon the tail. Only the lowest ten vibration modes are used. A consistent flutter speed and altitude consistent with the Mach number (matched point) is calculated. This analysis is shown schematically in figure 211-5.

The fourth flutter analysis is performed at Mach 0.8 using RHO3 aerodynamics for the wing and control surfaces. Doublet Lattice aerodynamics are used for the tail with inter-surface aerodynamic interaction ignored. The flutter analysis is performed for several combinations of generalized coordinates. This analysis is shown schematically in figure 211-6.

211.2 RESULTS

Results of the flutter analyses are presented as V-g and V-f plots. Results of the first analysis are presented in figures 211-7 to 211-10. RESULTS of the second analysis are presented in figures 211-11 and 211-12.

211.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO04
      PROBLEM ID(DEMO04 - FLUTTER ANALYSES OF AN SST AIRCRAFT)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. DUBLAT AERODYNAMICS
C                       2. RESIDUAL FLEXIBILITY (FLEXAIR)
C                       3. MACHBOX AERODYNAMICS
C                       4. RHO3 AERODYNAMICS
C                       5. FLUTTER ANALYSES
C                       6. V-G AND V-F PLOTS
C
C     AUTHOR         JOHN HOGLEY
C
C     CORE           260K (OCTAL)
C
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(MASS)
      EXECUTE EXTRACT(EXNAME=KGRID,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=GERBER,
     X                TYPE=(ORTH,POINT),SIZE=(30,20),RZ=30,RY=20,RX=0,
     X                EXNAME=KGRID)
      EXECUTE EXTRACT(EXNAME=MGRID,LSUB=MGRID,ESUB=E2,NSUB=N2)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=(ORTH,POINT),SIZE=(30,20),
     X                RZ=30,RY=20,RX=0,EXNAME=MGRID)
C
C     CALCULATE NORMAL MODES
C
      PERFORM K-REDUCE
      PRINT INPUT(BC)
      EXECUTE MASS (OPTION=3)
      PRINT OUTPUT (MASS, MDC=MDC****)
      EXECUTE VIBRATION (STIF=KRED,MASS=MDC001A,NFREQS=16,
     A  SUBSETS=(N51,N42,N43,N53,N44,N45,N55,N46,N56,N57,N67,N62,N99))
      PRINT OUTPUT (VIBRATION,
     A  SUBSETS=(N51,N42,N43,N53,N44,N45,N55,N46,N56,N57,N67,N62,N99))
C
C     INTERPOLATE MODE SHAPES
C
      EXECUTE INTERP (N62=(BEAMSPLINE,C062), DOF=1000, BEAMO=N064,
     A BEAM = (N063,N065,N066), BEAMI = (N068 TO N070, N061))
      EXECUTE INTERP (
     A N51=(MOTIONAXIS,C51),DOF=1000,DEFNPTS=(1,89),ANGLES=(90.0,90.0),
     B N42=(SURFSPLINE),DOF=1000,
     C N43,DOF=1000,
     D N53=MOTIONAXIS,DOF=1110,DEFNPTS=(83,283,483,683),
     E N44=SURFSPLINE,DOF=10000,
     F N45,DOF=1000)
      EXECUTE INTERP (
     G N55=(MOTIONAXIS,C55),DOF=1110,DEFNPTS=(263,663),
     H N56,DOF=1110,DEFNPTS=(1463,1663,1863),
     I N57,DOF=1110,DEFNPTS=(285,685),
     J N46=(SURFSPLINE,C46),DOF=1000,
     K N67=(MOTIONPT),DOF=1110,
     Z )
```

```
      EXECUTE INTERP (
     L  N57=(POLYNOMIAL,C77),MODE,A00=1.0,MODE,MODE,A10=10.0)
      EXECUTE INTERP ( AIC=N99,
     A N42=(1,CA42), DOF=1000,
     D N43=(1,CA43), DOF=1000)
C
C     FLUTTER ANALYSIS USING DUBLAT WITH AND WITHOUT FLEXAIR
C
      EXECUTE DUBLAT ( CASE=3, MACH=0.8, KVAL = (.005,.002,.0006,.0001))
      EXECUTE FLEXAIR ( ID=FL01, DUBLAT, CASE=3, ALT=(0.0, 10000.0),
     A    FREEDOMS= (TZ263, RY263), SUBSET=N99)
      PRINT OUTPUT (FLEXAIR, ID=FL01, ALT=0.0, KVAL= (.005.,002,.0001))
      EXECUTE FLEXAIR ( ID=FL02, DUBLAT, CASE=3,
     A    FLUTFREQ=0.0, FREEDOMS=(TZ263, RY263), SUBSET=N99, ALT=0.0)
      PRINT OUTPUT (FLEXAIR, ID=FL02)
      EXECUTE ADDINT (ID=AFD, INT, FLEXAIR=FL01)
      EXECUTE FLUTTER (GAFID= AFD, COND=4,             VMAX=2000.0)
      PRINT OUTPUT (FLUTTER, CASE=1, COND=4)
      EXECUTE EXTRACT (EXNAME=FLPL4D, LSUB=VGVF, COND=4)
      EXECUTE GRAPHICS (GNAME=FLPL4D,      TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1 XMIN=0.0, XMAX=1000.0, Y1MIN=-.1, Y1MAX=.1, Y2MIN=0.0, Y2MAX=9.0,
     2   SIZE=(6,6),EXNAME=FLPL4D)
      EXECUTE ADDINT (ID=AFE, INT, FLEXAIR=FL02)
      EXECUTE FLUTTER (GAFID= AFE, COND=5,             VMAX=2000.0)
      PRINT OUTPUT (FLUTTER, CASE=1, COND=5)
      EXECUTE EXTRACT (EXNAME=FLPL4E, LSUB=VGVF, COND=5)
      EXECUTE GRAPHICS (GNAME=FLPL4E,      TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1 XMIN=0.0, XMAX=1000.0, Y1MIN=-.1, Y1MAX=.1, Y2MIN=0.0, Y2MAX=9.0,
     2 EXNAME=FLPL4E)
C
C     FLUTTER ANALYSIS USING DUBLAT FOR WING, TAIL, AND BODY.
C     ADDITIONAL AIRFORCES FROM ADDINT.
C
      PRINT INPUT (DUBLAT, CASE=2 )
      EXECUTE  DUBLAT (CASE=2 , MACH=0.8, BREF=1000.0, QUASI=NT,
     A KVAL= (5.0, 2.0, 1.0, 0.6, 0.2))
      PRINT OUTPUT (DUBLAT, CASE=2, LEVEL= (1,2,3,4,5))
      EXECUTE ADDINT ( ID = AFB,INT,DUBLAT,CASE=2,GET=73 )
      PRINT OUTPUT (ADDINT, ID=AFB, KVAL= (2.0, 1.2, 0.6, 0.3))
      EXECUTE FLUTTER (GAFID=AFB, COND=2,
     A STILL,NMODES=10,ITER=3,DENSITY=.0020482)
      PRINT OUTPUT (FLUTTER, CASE=1, COND=2)
      EXECUTE EXTRACT (EXNAME=FLPL4B, LSUB=VGVF, COND=2)
      EXECUTE GRAPHICS (GNAME=FLPL4B,    TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1 XMIN=0.,XMAX=1000.,Y1MIN=-1.,Y1MAX=1.,Y2MIN=0.,Y2MAX=10.,
     2 EXNAME=FLPL4B)
C
C     FLUTTER ANALYSIS USING MACHBOX FOR 2 NON-COPLANAR SURFACES
C         WITH SUBSONIC LEADING EDGES
C
      PRINT INPUT (MACHBOX)
      EXECUTE MACHBOX ( MACH=1.5, COND=1,  BREF=1000.0 ,
     A    KVAL = (  10.0, 2.0, 1.0, 0.4 , 0.15 ))
      PRINT OUTPUT (MACHBOX, LEVEL=(1,4))
      EXECUTE ADDINT (ID=AFC,INT,MACHBOX,IGET=140)
      PRINT OUTPUT (ADDINT,ID=AFC)
      PRINT INPUT(FLUTTER)
      EXECUTE FLUTTER (GAFID=AFC, COND=3,
     B EVEC=FLUTTER, AVEC=FLUTTER,
     A  NMODES=10,NRF=40,MPS=5000.0,NALT=3)
      PRINT OUTPUT (FLUTTER, CASE=1, COND=3)
      EXECUTE EXTRACT (EXNAME=FLPL4C, LSUB=VGVF, COND=3)
      EXECUTE GRAPHICS (GNAME=FLPL4C,    TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1  XMIN=420.,XMAX=2000.,Y1MIN=-.237,Y1MAX=.568,Y2MIN=1.,Y2MAX=5.,
     2 EXNAME=FLPL4C)
C
```

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```
C     FLUTTER ANALYSIS USING RHO3 FOR WING WITH CONTROL SURFACES AND
C         DUBLAT FOR TAIL.  RESULTS COMBINED USING ADDINT.
C
      PRINT INPUT (RHO3)
      EXECUTE RHO3   ( MACH = 0.8,
     A KVALUES = ( 0.005,  0.002, 0.001, 0.0007,  0.0004,0.0001))
      PRINT OUTPUT (RHO3)
      PRINT INPUT (DUBLAT )
      EXECUTE DUBLAT (MACH=0.8,KVALUE=(5.0,2.0,1.0,0.7,0.4,0.1),
     A   BREF=1000.0, QUASI=TO )
      PRINT OUTPUT (DUBLAT, LEVEL= (1,2,5))
      EXECUTE ADDINT (ID= AFA,ADD,INT,RHO3,DUBLAT,IGAIN=25 )
      PRINT OUTPUT (ADDINT, ID=AFA, KVAL= (.005, .001, .00076, .000025))
      EXECUTE FLUTTER (GAFID=AFA, DENSITY=.0020482, GCROSS=(.03,.0,.05),
     A VMIN= 500.0, VMAX=1500.0, FMIN=2.8, FMAX=3.5,
     A EVAL=(1 TO 126 BY 20), EVEC=(FLUTTER, 1, 51, 101), AVEC=FLUTTER)
      PRINT OUTPUT (FLUTTER, COND=1)
      EXECUTE EXTRACT (EXNAME=FLPL4A, LSUB=VGVF,COND=1)
      EXECUTE GRAPHICS (GNAME=FLPL4A,     TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1 XMIN=0., XMAX=2000., Y1MIN=-.1, Y1MAX=.1, Y2MIN=0., Y2MAX=10.0,
     3 EXNAME=FLPL4A)
      EXECUTE GRAPHICS (GNAME=FLPL4A1,  TYPE=GRAPH, X=V, Y1=G, Y2=F,
     1 XMIN=500.,XMAX=1500.,Y1MIN=-.05, Y1MAX=.05, Y2MIN=2.8, Y2MAX=3.5,
     2 EXNAME=FLPL4A)
      END CONTROL PROGRAM
```

```
*/ MODE2 /
BEGIN MACHBOX DATA
LABEL  DEMONSTRATION PROBLEM - BOTH SURFACES
BEGIN GEOM
BOX  12  XCENTER 2710.0
SURFACE 1
LEADING EDGE  510.0 0.0 741.0 65.1 2065.0 455.0 2487.0 594.0  2884.0 794.0
TRAILING EDGE 2715.0 0.0 2715.0 65.1 2697.0 228.0 2749.0 455.0 2874.059 594.0 +
              3054.0 794.0
SURFACE 2 0.0  20.0  0.2
LEADING EDGE  2985.0 0.0 3124.0 65.1 3386.0 228.0
TRAILING EDGE 3400.0 0.0 3417.0 65.1 3464.0 228.0
END GEOM
BEGIN MODAL DATA
USE C062 WITH SURFACE 1
USE C053 WITH SURFACE 2
END MODAL DATA
END MACHBOX DATA
BEGIN RHO3   DATA
BEGIN GEOMETRY DATA
MAIN SURFACE MS1
LEADING EDGE  510.0 0.0 741.0 65.1 2065.0 455.0  2487.0 594.0  2884.0 794.0
TRAILING EDGE 2715.0 0.0 2715.0 65.1 2697.0 228.0 2749.0 455.0 2874.059 594.0 +
              3054.0 794.0
DOWNWASH BAR  +
CHORD 0.2    -0.86 -0.64 -0.3 0.3 0.64 0.86   +
CHORD 0.45   -0.86 -0.64 -0.3 0.3 0.64 0.86   +
CHORD 0.65   -0.86 -0.64 -0.3 0.3 0.64 0.86   +
CHORD 0.78   -0.86 -0.64 -0.3 0.3 0.64 0.86   +
CHORD 0.88   -0.86 -0.64 -0.3 0.3 0.64 0.86   +
CHORD 0.95   -0.86 -0.64 -0.3 0.3 0.64 0.86
CONTROL SURFACE CS1 HINGE  2500.0  65.0 2500.0 265.0 +
   MODE  1 0.0 0.0 0.0 0.0 +
   MODE  2 0.0 0.0 0.0 0.0 +
   MODE  3 0.0 0.0 0.0 0.0 +
   MODE  4 0.0 0.0 0.0 0.0 +
   MODE  5 0.0 0.0 0.0 0.0 +
   MODE  6 0.0 0.0 0.0 0.0 +
   MODE  7 0.0 0.0 0.0 0.0 +
   MODE  8 0.0 0.0 0.0 0.0 +
   MODE  9 0.0 0.0 0.0 0.0 +
   MODE 10 0.0 0.0 0.0 0.0 +
   MODE 11 0.0 0.0 0.0 0.0 +
   MODE 12 0.0 0.0 0.0 0.0 +
   MODE 13 0.0 0.0 0.0 0.0 +
   MODE 14 0.0 0.0 0.0 0.0 +
   MODE 15 0.0 0.0 0.0 0.0 +
   MODE 16 0.0 0.0 0.0 0.0
CONTROL SURFACE CS2 HINGE  2769.0 538.0 2995.0 765.0
END GEOMETRY DATA
BEGIN MODAL DATA
USE C042 WITH MAIN SURFACE
USE C55 WITH CONTROL SURFACE CS1
USE C056 WITH CONTROL SURFACE CS2
END MODAL DATA
BEGIN OPTION DATA
LABEL DEMONSTRATION PROBLEM - TWO CONTROL SURFACES
SECTIONAL FORCES
PRESSURE REPORT
VELOCITY PROFILE DLE1 1. DTE1 1. 0.0 1.00001 0.5 1.00002 1.0 1.0
END OPTION DATA
END RHO3   DATA
BEGIN DUBLAT DATA
CASE 1
BEGIN GEOMETRY DATA
LIFTING SURFACE DATA
PANEL T1 2985.0  3365.0  3386.0  3446.0 0.0  228.0  0.0  0.0
```

```
CHORD DIV  0.0  0.2  0.4 0.6 0.8 1.0
SPAN DIV   0.0  0.25 0.5 0.75 1.0
PANEL T2 3365.0  3400.0  3446.0  3464.0 0.0  228.0  0.0  0.0
CHORD DIV 0.0 1.0
SPAN DIV   0.0  0.25 0.5 0.75 1.0
END GEOMETRY DATA
BEGIN SUBSET DATA
SUBSETS OF BOXES
SUBSET 1 1 TO 20
SUBSET 2 21 TO 24
END SUBSET DATA
BEGIN MODAL DATA
USE C053 WITH LIFTING SURFACE 1
USE C057 WITH LIFTING SURFACE 2
END MODAL DATA
CASE 2
BEGIN GEOMETRY DATA
LIFTING SURFACE DATA
PANEL  W1  741.0 2500.0 1419.8 2500.0 65.1 265.0 0.0 0.0
CHORD DIV 0.0 0.25 0.5 0.75 1.0
SPAN DIV   0.0 1.0
PANEL W2 1419.8 2500.  2028.0 2500.0 265.0 329.5 0.0 0.0
CHORD DIV 0.0 0.25 0.5 0.75 1.0
SPAN DIV   0.0 1.0
PANEL W2A 2500.0 2715.0 2500.0 2715.0 265.0 329.5 0.0 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 1.0
PANEL W3 2028.0 2500.0 2487.0 2825.0 329.5 594.0 0.0 0.0
CHORD DIV 0.0 0.25 0.5 0.75 1.0
SPAN DIV 0.0 0.4 0.7 0.9 1.0
PANEL W3A 2500.0 2715.0 2825.0 2874.0 329.5 594.0 0.0 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 0.4 0.7 0.9 1.0
PANEL W4 2487.0 2825.0 2884.0 3023.087 594.0 794.0 0.0 0.0
CHORD DIV 0.0 0.25 0.5 0.75 1.0
SPAN DIV   0.0 0.5 0.8 1.0
PANEL CS1 2500.0 2715.0 2500.0 2715.0 65.1 265.0 0.0 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0  1.0
PANEL CS2 2825.0 2874.0 3023.087 305 .0 594.0 794.0 0.0 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 0.5 0.8 1.0
PANEL WF 2487.0 2874.0 2880.0 2940.0 594.0 594.0 0.0 134.0
CHORD DIV 0.0 0.5 1.0
SPAN DIV 0.0 0.65 1.0
PANEL T1 3124.0 3380.0 3386.0 3446.0 65.1 228.0 0.0 0.0
CHORD DIV 0.0 0.5 1.0
SPAN DIV 0.0 0.7 1.0
PANEL T2 3380.0 3417.0 3446.0 3464.0 65.1 228.0 0.0 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 0.7 1.0
INTERFERENCE SURFACE DATA
BODY B1
PANEL B1 0.0 600.0 594.0 600.0 0.0 65.1 -65.1 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 1.0
PANEL B2 0.0 600.0 594.0 600.0 0.0 65.1  65.1 0.0
CHORD DIV 0.0 1.0
SPAN DIV 0.0 1.0
PANEL B3 600.0 3654.0 600.0 3654.0 0.0 65.1 -65.1 0.0
CHORD DIV 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
SPAN DIV 0.0 1.0
PANEL B4 600.0 3654.0 600.0 3654.0 0.0 65.1  65.1 0.0
CHORD DIV 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
SPAN DIV 0.0 1.0
DOUBLET DATA
BODY B1 ZDOUBLET
AXIS DIV 0.0 600.0 3564.0
RADII 0.0 65.1 65.1
END GEOMETRY DATA
```

```
BEGIN SUBSET DATA
SUBSETS OF BOXES
SUBSET B1 1 TO 41
SUBSET B2 42
SUBSET B3 43 TO 45
SUBSET B4 46 TO 49
SUBSET B5 50 TO 53
SUBSET B6 54 TO 55
SUBSETS OF STRIPS
SUBSET S1 1 15
END SUBSET DATA
BEGIN MODAL DATA
USE C042 WITH LIFTING SURFACE B1
USE C053 WITH LIFTING SURFACE B5
USE C044 WITH LIFTING SURFACE B4
USE C045 WITH LIFTING SURFACE B2
USE C056 WITH LIFTING SURFACE B3
USE C057 WITH LIFTING SURFACE B6
USE C51 WITH BODY DOUBLET B1
USE C51 WITH INTERF BODY B1
END MODAL DATA
BEGIN OPTION DATA
VELOCITY PROFILES
PROFILE P1 0.0 1.0 0.3 1.2 0.6 1.1 1.0 1.0
USE P1 ON S1
PRESSURE CORRECTIONS
USE 0.85 0.0 AS SCALAR ON B3 B4
END OPTION DATA
CASE 3
BEGIN GEOMETRY DATA
LIFTING SURFACE DATA
PANEL W0   510.0 2715.0  741.0 2715.0    0.0  65.1 0.0  0.0
CHORD DIV  0.0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 1.0
PANEL W1 741.0 2715.0 2065.0 2749.0 65.1 455.0  0.0 0.0
CHORD DIV 0.0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 0.3 0.5 0.65 0.8 0.9 1.0
PANEL W2 2065.0 2749.0 2487.0 2874.0 455.0 594.0 0.0  0.0
CHORD DIV 0.0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 0.4 0.7 0.9 1.0
PANEL W3  2487.0 2874.0 2884.0 3054.0    594.0 794.0 0.0 0.0
CHORD DIV   .0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 0.4 0.7 0.9 1.0
PANEL T0 2965.0 3400.0 3124.0 3417.0 0.0 65.1 0.0  0.0
CHORD DIV 0.0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 1.0
PANEL T1  3124.0  3417.0 3366.0   3464.0 65.1 228.0  0.0  0.0
CHORD DIV 0.0 0.2 0.4 0.6 0.8 1.0
SPAN DIV 0.0 0.4 0.65  0.85 1.0
END GEOMETRY DATA
BEGIN SUBSET DATA
SUBSETS OF BOXES
SUBSET WING 1 TO 75
SUBSET TAIL 76 TO 100
END SUBSET DATA
BEGIN MODAL DATA
USE C443 WITH LIFTING SURFACE TAIL
END MODAL DATA
END DUBLAT DATA
BEGIN FLUTTER DATA
CASE 1
ALTITUDE 0. 10000.
DAMPING 0. 0. 0.02 0.02 0.05
CASE 2
RSET 1 1 2 3 4 5 6 7 8
RSET 2 1 2 3 4 5 6 7 8 9 10 11 12
RSET 3 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
RSET 4 3 4 5 6 7 8
CSET 1 *& NOMINAL CASE &
RSET 1 2 3 4
```

```
ALT  10000.0  50000.0
CSET 2 *C WITH ADDED STIFFNESS IN MODES 3 AND 4 C
STIFF SS 3 3 TO 4 4        BY 1 1         1.2
RSET 1
END FLUTTER DATA
  BEGIN NODAL DATA
*/
*/ BODY NODES
*/
           1    20.     0.  0.          TO    25   980.    0.  0.          BY  2
          27  1060.     C.  0.   30.0   TO    45  1780.    0.  0.   42.5   BY  2
   **1   200     0.    65.  0.     0.    0   200     0.   65.             **
          45                            TO    55  2180.    0.  0.   31.0   BY  2
   **1   200                             0   200     C.   65.             **
          55                            TO    63  2500.    0.  0.   13.5   BY  2
   **1   200                             0   200     0.   65.             **
          65  2580.     C.  0.          TO    77  3060.    0.  0.          BY  2
          79  3140.     C.  0.    3.0                                          *
   **1   200     0.    65.       **
          81  3220.     C.  0.    6.5
   **1   200     0.    65.       **
          83  3300.     C.  0.    7.0
   **1   200     0.    65.       **
          85  3390.     C.  0.    2.0
   **1   200     0.    65.       **
          87  3460.     C.  0.
          89  3540.     C.  0.
*/
*/ WING NUDES
*/
         427  1060.    65.  0.   30.0   TO   435  1380.  180.  0.   17.5   BY  2
         435                            TO   445  1760.  180.  0.   27.5   BY  2
         445                            TO   455  2180.  180.  0.   25.0   BY  2
         455                            TO   463  2500.  180.  0.   13.0   BY  2
         635  1380.   180.  0.   17.5   TO   641  1620.  265.  0.   10.0   BY  2
         641                            TO   655  2180.  265.  0.   22.5   BY  2
         655                            TO   663  2500.  265.  0.   12.5   BY  2
         841  1620.   265.  0.   10.0   TO   847  1971.  380.  0.    9.0   BY  2
         847                            TO   855  2291.  380.  0.   17.0   BY  2
         855                            TO   863  2611.  380.  0.   10.0   BY  2
        1047  1971.   380.  0.    9.0   TO  1051  2205.  455.  0.    8.5   BY  2
        1051                            TO  1059  2525.  455.  0.   15.0
        1059                            TO  1063  2685.  455.  0.    8.0
        1251  2205.   455.  0.    8.5   TO  1254  2409.  538.  0.    6.5
        1254                            TO  1259  2609.  538.  0.   11.0
        1259                            TO  1263  2769.  538.  0.    5.5
        1454  2409.   538.  0.    6.5   TO  1456  2545.  594.  0.    5.0
        1456                            TO  1459  2665.  594.  0.    7.5
        1459                            TO  1463  2825.  594.  0.    3.5
        1656  2545.   594.  0.    5.0   TO  1658  2710.  680.  0.    3.0
        1658                            TO  1663  2910.  680.  0.    3.0
        1858  2710.   680.  0.    3.0   TO  1860  2875.  765.  0.    1.5
        1860                            TO  1863  2995.  765.  0.    2.5
*/
*/ WING TRAILING EDGE NUDES
*/
        3001  2500.    65.  0.   13.5   TO  3005  2715.    65.  0.    1.0   BY 2
        3101  2500.   180.  0.   13.0   TO  3105  2715.  180.  0.    1.0   **
        3201  2500.   265.  0.   12.5   TO  3205  2715.  265.  0.    1.0   **
        3405  2874.   594.  0.    1.0   TO  3605  3027.9 765.  0.    1.0
                                           BY 100 OF 86. 85.
*/
*/ WING FIN NODES
*/
      REC  WINGFIN 0. 594. 0., 1. 594. 0., 0. -1. 0.
        2056  2545.     .1 0.    3.5   TO  2456  2830.  100.  0.    2.5   BY  200
        2058  2625.     .1 0.    3.5   TO  2458  2642.  100.  0.    3.0   **
        2061  2745.     .1 0.    4.0   TO  2461  2859.  100.  0.    3.0   **
        2063  2825.     .1 0.    4.0   TO  2463  2870.  100.  0.    3.0   **
*/
```

```
*/ HORIZONTAL TAIL NODES
*/
      RESUME GLOBAL
        279                          TO    679  3365.  200.  0.    2.0  BY  200
      . 281                          TO    681  3388.  200.  0.    2.5  **
        283                          TO    683  3412.  200.  0.    2.5  **
        285                          TO    685  3435.  200.  0.    1.0  **
*/
*/     WEIGHT PANEL NODES - BODY
*/
       6001  0.   0.  0.  TO  6016  3564.   0.  0.
       6021  0.  65.  0.  TO  6036  3564.  65.  0.
*/
*/     WEIGHT PANEL NODES - WING
*/
       6100   741.0   65.0  0.   TO  6220  2487.0  594.0  0.  BY  20
       6100                      TO  6260  2487.0  594.0  0.  BY  80
       6180                      TO  6240  2487.0  594.0  0.  BY  20
       6260                      TO  6320  2884.0  794.0  0.  BY  20
       6110  2715.0   65.0  0.   TO  6170  2715.0  329.5  0.  BY  20
       6189  2715.0  329.5  0.   TO  6249  2874.0  594.0  0.  BY  20
       6266  2874.0  594.0  0.   TO  6326  3054.0  794.0  0.  BY  20
       6100  TO  6110
*+3     20   0    20
       6180  TO  6189
*+3     20   0    20
       6260  TO  6266
*+3     20   0    20
*/
*/     WEIGHT PANEL NODES - HORIZONTAL TAIL
*/
       6400  3124.   65.1  0.  TO  6403  3417.   65.1  0.
       6410  3386.  228.0  0.  TO  6413  3464.  228.0  0.
*/
*/     WEIGHT PANEL NODES - VERTICAL TAIL
*/
       6501  3374.6  0.    92.8
       6502  3472.0  0.    92.8
       6503  3458.7  0.   149.8
       6504  3514.6  0.   149.8
*/
*/     WEIGHT PANEL NODES - WING FIN
*/
       6601  2487.0     594.  0.  TO  6603  2880.0  594.  134.
       6604  2874.059   594.  0.  TO  6606  2940.0  594.  134.
    END NODAL DATA
  BEGIN STIFFNESS DATA
    BEGIN PROPERTY DATA
       P1    .05   1.    *(WING FIN SPARS AND RIBS)
       P2   2.     0.    0.   .2   .2   .2 *(WING FIN ATTACHMENT BEAMS - TYPE 1)
       P3  10.     0.    0. 100. 100. 100. *(WING FIN ATTACHMENT BEAMS - TYPE 2)
       P4    .15  .50                      *(CONTROL SURFACE RIBS)
       P5   0.  *=2 100. 100.   0.    10.  *(BEAMS AT 455 RIB TO PICK UP SPARS)
    END PROPERTY DATA
    BEGIN ELEMENT DATA
*/
*/ WING  FRONT  SPAR
*/
       SPAR   M5  N2003     227  429     .12   2.
        *2        N2205     429  431     .12   2.  TO  N2605     433  435     *
                                                   BY  N200        2    2
        *2        N2805     435  637     .12   2.
        *2        N3007     637  639     .12   2.  TO  N3207     639  641     *
                                                   BY  N200        2    2
        *2        N3407     641  843     .12   2.
        *2        N3609     843  845     .12   2.  TO  N3809     845  847     *
                                                   BY  N200        2    2
        *2        N4009     847 1049     .12   2.
        *2        N4211    1049 1051           **
```

```
       *2         N4411     1051 1253             **
       *2         N4613     1253 1254             **
       *2         N4713     1254 1455             **
       *2         N4815     1455 1456             **
       *2         N4915     1456 1657             **
       *2         N5017     1657 1658             **
       *2         N5117     1658 1859             **
       *2         N5219     1859 1860             **
*/
*/ WING REAR SPAR
*/
      SPAR   M5   N5603      263  463     .40   12.
       *2         N5605      463  663     .4C   12.
       *2         N5607      663  863     .34   12.
       *2         N5609      863 1063     .34   12.
       *2         N5611     1063 1263     .30    8.
       *2         N5613     1263 1463     .30    8.
       *2         N5615     1463 1663     .30    4.
       *2         N5617     1663 1863     .30    4.
*/
*/ WING INTERMEDIATE SPARS
*/
      SPAR   M5   N2203      229  429     .20    2.  TO  N3603     243  443      +
                                                     BY  N200        2    2
       *2         N3803      245  445     .36    2.
       *2         N4803      255  455     .60   12.
       *2         N5003      257  457     .24   12.  TO  N5403     261  461      +
                                                     BY  N200        2    2
       *2         N3005      437  637     .20    2.  TO  N3605     443  643      +
                                                     BY  N200        2    2
       *2         N3805      445  645     .36    2.
       *2         N4005      447  647     .20    4.  TO  N4605     453  653      +
                                                     BY  N200        2    2
       *2         N4805      455  655     .60   12.
       *2         N5005      457. 657     .24   12.  TO  N5405     461  661      +
                                                     BY  N200        2    2
       *2         N3607      643  843     .20    2.  TO  N3807     645  845      +
                                                     BY  N200        2    2
       *2         N4007      647  847     .20    4.  TO  N4607     653  853      +
                                                     BY  N200        2    2
       *2         N4807      655  855     .20    8.
       *2         N5007      657  857     .20   10.  TO  N5407     661  861      +
                                                     BY  N200        2    2
       *2         N4209      849 1049     .20    4.  TO  N4609     853 1053      +
                                                     BY  N200        2    2
       *2         N4809      855 1055     .2[illegible]    8.
       *2         N5009      857 1057     .20   10.  TO  N5409     861 1061      +
                                                     BY  N200        2    2
       *2         N4611     1053 1253     .12    4.  TO  N4811    1055 1255      +
                                                     BY  [illegible]    1    1
       *2         N4911     1056 1256     .06    4.  TO  [illegible]1    1062 1262      +
                                                     BY  N[illegible]    1    1
       *2         N4813     1255 1455     .12    4.
       *2         N4913     1256 1456     .06    4.  TO  N5513    1262 1462      +
                                                     BY  N100        1    1
       *2         N5015     1457 1657     .06    2.  TO  N5515    1462 1662      +
                                                     BY  N100        1    1
       *2         N5217     1659 1859     .06    2.  TO  N5517    1662 1862      +
                                                     BY  N100        1    1
*/
*/ WING IN-BODY SPARS
*/
      SPAR   M5   N2001       27  227    1.00   10.  TO  N3601      43  243      +
                                                     BY  N200        2    2
       *2         N3801       45  245    1.80   10.  TO  N4601      53  253      +
                                                     BY  N200        2    2
       *2         N4801       55  255    3.00   60.
       *2         N5001       57  257    1.20   60.  TO  N5401      61  261      +
                                                     BY  N200        2    2
       *2         N5601       63  263    2.00   60.
```

```
*/
*/ WING RIBS
*/
     SPAR    M5  N6001      227  229       .25    4.  TO  N6035      261  263      +
                                                      BY  N2           2    2
      *2         N6109      435  437       .30    4.  TO  N6135      461  463      +
                                                      BY  N2           2    2
      *2         N6215      641  643       .20    3.  TO  N6235      661  663      +
                                                      BY  N2           2    2
      *2         N6425     1051 1053       .20    4.
      *2         N6426     1053 1054       .20    4.  TO  N6435     1062 1063
      *2         N6629     1456 1457       .12    2.  TO  N6635     1462 1463
      *2         N6833     1860 1861       .30    1.4 TO  N6835     1862 1863
*/
*/ WING COVERS
*/
     COVER   M5  N7003      229  429  227         .06
      *2         N7203      229  429  431  231    .06                         TO     +
                 N8603      243  443  445  245        BY  N200      2      *=3
      *2         N8803      245  445  447  247    .12  .00                    TO     +
                 N9603      253  453  455  255        BY  N200      2      *=3
      *2         N9803      255  455  457  257    .10  .14
      *2         N10003     257  457  459  259          **
      *2         N10203     259  459  461  261    .26  .14  .22  .00
      *2         N10403     261  461  463  263          **
      *2         N7805      437  637  435         .06
      *2         N8005      437  637  639  439    .06                         TO     +
                 N9605      453  653  655  455        BY  N200      2      *=3
      *2         N9805      455  655  657  457    .10  .14
      *2         N10005     457  657  659  459          **
      *2         N10205     459  659  661  461    .26  .14  .22  .00
      *2         N10405     461  661  663  463          **
      *2         N8407      643  843  641         .06
      *2         N8607      643  843  845  645    .06                         TO     +
                 N9607      653  853  855  655        BY  N200      2      *=3
      *2         N9807      655  855  857  657    .10  .08
      *2         N10007     657  857  859  659          **
      *2         N10207     659  859  861  661    .30  .14  .20  .00
      *2         N10407     661  861  863  663          **
      *2         N9009      849 1049  847         .06
      *2         N9209      849 1049 1051  851    .06                         TO     +
                 N9609      853 1053 1055  855        BY  N200      2      *=3
      *2         N9809      855 1055 1057  857    .10  .08
      *2         N10009     857 1057 1059  859          **
      *2         N10209     859 1059 1061  861    .30  .14  .20  .00
      *2         N10409     861 1061 1063  863          **
      *2         N9411     1053 1253 1051         .30  .14  .22  .12
      *2         N9611     1053 1253 1254 1054    .30  .14  .22  .12          TO     +
                 N10511    1062 1262 1263 1063        BY  N100      1      *=3
      *2         N9713     1255 1455 1254         .30  .14  .22  .12
      *2         N9813     1255 1455 1456 1256    .30  .14  .22  .12          TO     +
                 N10513    1262 1462 1463 1263        BY  N100      1      *=3
      *2         N9915     1457 1657 1456         .08
      *2         N10015    1457 1657 1658 1458    .08                         TO     +
                 N10515    1462 1662 1663 1463        BY  N100      1      *=3
      *2         N10117    1659 1859 1658         .08
      *2         N10217    1659 1859 1860 1660    .08                         TO     +
                 N10517    1662 1862 1863 1663        BY  N100      1      *=3
*/
*/ WING IN-BODY COVERS
*/
     COVER   M5  N7001       27  227  229   29    .30                         TO     +
                 N8601       43  243  245   45        BY  N200      2      *=3
      *2         N8801       45  245  247   47    .60                         TO     +
                 N9601       53  253  255   55        BY  N200      2      *=3
      *2         N9801       55  255  257   57    .70
      *2         N10001      57  257  259   59    .70
      *2         N10201      59  259  261   61  1.30  .70 1.10  .00
      *2         N10401      61  261  263   63          **
*/
```

```
*/ WING FIN SPARS
*/
        SPAR    M5  N11001    2056 2256        P1
         *2         N11003    2256 2456        *
         *2         N11201    2058 2258        *
         *2         N11203    2258 2458        *
         *2         N11501    2061 2261        *
         *2         N11503    2261 2461        *
         *2         N11701    2063 2263        *
         *2         N11703    2263 2463        *
*/
*/ WING FIN RIBS
*/
        SPAR    M5  N12001    2256 2258        P1
         *2         N12003    2258 2261        *
         *2         N12005    2261 2263        *
         *2         N12201    2456 2458        *
         *2         N12203    2458 2461        *
         *2         N12205    2461 2463        *
*/
*/ WING FIN COVERS
*/
        COVER   M5  N13001    2056 2256 2258 2058    .05
         *2         N13003    2058 2258 2261 2061     *
         *2         N13005    2061 2261 2263 2063     *
         *2         N13201    2256 2456 2458 2258     *
         *2         N13203    2258 2458 2461 2261     *
         *2         N13205    2261 2461 2463 2263     *
*/
*/ WING FIN ATTACHMENT BEAMS
*/
        BEAM    Z5  N20001    1456 2056 1463   P2
         *2         N20003    1458 2058 1463   *
         *2         N20005    1461 2061 1463   *
         *2         N20007    1463 2063 1461   *
         *2         N21001    1456 1458        P3
         *2         N21003    1458 1461        *
         *2         N21005    1461 1463        *
*/
*/ WING TRAILING EDGE CONTROL SURFACE RIBS
*/
        SPAR    M5  N101       263 3003        P4
    **2   0     0     2        200  100        0
         *2         N102      3003 3005        *
    **2   0     0     2        100  100        0
         *2         N108      1463 3405        *
    **2   0     0     1        200  100        *
*/
*/ WING TRAILING EDGE CONTROL SURFACE COVERS
*/
        COVER   M5  N151       263  463 3103 3003    .10
         *2         N153       463  663 3203 3103     *
         *2         N152      3003 3103 3105 3005     *
         *2         N154      3103 3203 3205 3105     *
         *2         N156      1463 1663 3505 3405     *
    **1   0     0     1        200  200  100  100     *
*/
*/ HORIZONTAL TAIL SPARS
*/
        SPAR  M5    N14003     279  479         .10    1.2
         *2         N14005     479  679                **
         *2         N14103     281  481         .05    1.8
         *2         N14105     481  681                **
         *2         N14203     283  483         .05    1.6
         *2         N14205     483  683                **
         *2         N14303     285  485         .20    2.6
         *2         N14305     485  685                **
*/
```

```
*/ HORIZONTAL TAIL RIBS
*/
    SPAR   M5  N14401    279  281      .15    2.0 TO  N14405   283  285
                                                  BY  N2         2    2
     *2        N14501    479  481      .10    1.2 TO  N14505   483  485
     *2        N14601    679  681      .10    1.2 TO  N14605   683  685    *
                                                  BY  N2         2    2
*/
*/ HORIZONTAL TAIL IN-BODY SPARS
*/
    SPAR   M5  N14001     79  279      .50    6.0
     *2        N14101     81  281      .25    9.0
     *2        N14201     83  283      .25    8.0
     *2        N14301     85  285     1.00   13.0
*/
*/ HORIZONTAL TAIL COVERS
*/
    COVER  M5  N15003    279  479  481  281  .16
  *+2   0   0     200      2  *=3            0.
    COVER  M5  N15005    479  679  681  481  .07
  *+2   0   0     200      2  *=3            0.
*/
*/ HORIZONTAL TAIL IN-BODY COVERS
*/
    COVER  M5  N15001     79  279  281   81  .80                      TO    *
               N15401     83  283  285   85      BY  N200     2    *=3
*/
*/ BODY BEAMS
*/
    BEAM   M5  N1001       1    3    5.    0.  *=3  16000.  10. 0. *=3  30000.
  *+30  0   0      2       2    2    5.        *4   14000.   5.    *4  14000.
     *2        N1063      63   65 160.         *4  450000. 148.    *4 416000.
  *+12  0   0      2       2    2 -12.         *4  -34000. -12.    *4 -34000.
*/
*/ BEAMS AT 455 RIB TO PICK UP DISCONTINUED SPARS
*/
    BEAM   M5  N30002   1053 1054        P5
  *+4   0   0      2       2    2        *
    BEAM   M5  N30011   1063 1062        P5
  *+4   0   0     -2      -2   -2        *
  END ELEMENT DATA
END STIFFNESS DATA
BEGIN MASS DATA
BEGIN CONDITION DATA
    STAGE 1  CONDITION 1
END CONDITION DATA
BEGIN MASS ELEMENT DATA
    PLATE F2  B-1      6001 6002 6022        3495.
    PLATE     B-2      6002 6003 6023 6022   5955.
    PLATE     B-3      6003 6004 6024 6023   2589.
    PLATE     B-4      6004 6005 6025 6024   3440.
    PLATE     B-5      6005 6006 6026 6025   5420.
    PLATE     B-6      6006 6007 6027 6026   3280.
    PLATE     B-7      6007 6008 6028 6027   3306.
    PLATE     B-8      6008 6009 6029 6028   4346.
    PLATE     B-9      6009 6010 6030 6029   4507.
    PLATE     B-10     6010 6011 6031 6030   4486.
    PLATE     B-11     6011 6012 6032 6031   3619.
    PLATE     B-12     6012 6013 6033 6032   4730.
    PLATE     B-13     6013 6014 6034 6033   3982.
    PLATE     B-14     6014 6015 6035 6034    947.
    PLATE     B-15     6015 6016 6036 6035   1788.
    PLATE     VT-1     6501 6502 6504 6503    600.
    PLATE     W-1      6100 6101 6121 6120    766.
    PLATE     W-2      6101 6102 6122 6121   1151.
    PLATE     W-3      6102 6103 6123 6122   1667.
    PLATE     W-4      6103 6104 6124 6123   1112.
    PLATE     W-5      6104 6105 6125 6124   1190.
    PLATE     W-6      6105 6106 6126 6125   1659.
    PLATE     W-7      6106 6107 6127 6126   1988.
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PLATE	W-8	6107	6108	6128	6127	2467.
PLATE	W-9	6108	6109	6129	6128	1335.
PLATE	W-10	6109	6110	6130	6129	339.
PLATE	W-11	6120	6121	6141	6140	795.
PLATE	W-12	6121	6122	6142	6141	1415.
PLATE	W-13	6122	6123	6143	6142	813.
PLATE	W-14	6123	6124	6144	6143	1259.
PLATE	W-15	6124	6125	6145	6144	1248.
PLATE	W-16	6125	6126	6146	6145	1720.
PLATE	W-17	6126	6127	6147	6146	1494.
PLATE	W-18	6127	6128	6148	6147	1888.
PLATE	W-19	6128	6129	6149	6148	498.
PLATE	W-20	6129	6130	6150	6149	126.
PLATE	W-21	6140	6141	6161	6160	508.
PLATE	W-22	6141	6142	6162	6161	1279.
PLATE	W-23	6142	6143	6163	6162	536.
PLATE	W-24	6143	6144	6164	6163	532.
PLATE	W-25	6144	6145	6165	6164	559.
PLATE	W-26	6145	6146	6166	6165	1055.
PLATE	W-27	6146	6147	6167	6166	1405.
PLATE	W-28	6147	6148	6168	6167	1953.
PLATE	W-29	6148	6149	6169	6168	274.
PLATE	W-30	6149	6150	6170	6169	172.
PLATE	W-31	6180	6181	6201	6200	614.
PLATE	W-32	6181	6182	6202	6201	1286.
PLATE	W-33	6182	6183	6203	6202	562.
PLATE	W-34	6183	6184	6204	6203	786.
PLATE	W-35	6184	6185	6205	6204	1386.
PLATE	W-36	6165	6186	6206	6205	1649.
PLATE	W-37	6186	6187	6207	6206	1649.
PLATE	W-38	6187	6188	6208	6207	421.
PLATE	W-39	6188	6189	6209	6208	255.
PLATE	W-40	6200	6201	6221	6220	207.
PLATE	W-41	6201	6202	6222	6221	497.
PLATE	W-42	6202	6203	6223	6222	692.
PLATE	W-43	6203	6204	6224	6223	765.
PLATE	W-44	6204	6205	6225	6224	816.
PLATE	W-45	6205	6206	6226	6225	843.
PLATE	W-46	6206	6207	6227	6226	687.
PLATE	W-47	6207	6208	6228	6227	136.
PLATE	W-48	6208	6209	6229	6228	94.
PLATE	W-49	6220	6221	6241	6240	136.
PLATE	W-50	6221	6222	6242	6241	522.
PLATE	W-51	6222	6223	6243	6242	516.
PLATE	W-52	6223	6224	6244	6243	536.
PLATE	W-53	6224	6225	6245	6244	555.
PLATE	W-54	6225	6226	6246	6245	580.
PLATE	W-55	6226	6227	6247	6246	704.
PLATE	W-56	6227	6228	6248	6247	119.
PLATE	W-57	6228	6229	6249	6248	91.
PLATE	W-58	6260	6261	6281	6280	289.
PLATE	W-59	6261	6262	6282	6281	306.
PLATE	W-60	6262	6263	6283	6282	244.
PLATE	W-61	6263	6264	6284	6283	507.
PLATE	W-62	6264	6265	6285	6284	116.
PLATE	W-63	6265	6266	6286	6285	76.
PLATE	W-64	6280	6281	6301	6300	216.
PLATE	W-65	6281	6282	6302	6301	144.
PLATE	W-66	6282	6283	6303	6302	245.
PLATE	W-67	6283	6284	6304	6303	365.
PLATE	W-68	6284	6285	6305	6304	86.
PLATE	W-69	6285	6286	6306	6305	71.
PLATE	W-70	6300	6301	6321	6320	184.
PLATE	W-71	6301	6302	6322	6321	160.
PLATE	W-72	6302	6303	6323	6322	126.
PLATE	W-73	6303	6304	6324	6323	273.
PLATE	W-74	6304	6305	6325	6324	66.
PLATE	W-75	6305	6306	6326	6325	66.
PLATE	HT-1	6400	6401	6411	6410	283.
PLATE	HT-2	6401	6402	6412	6411	212.

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         PLATE      HT-3    6402 6403 6413 6412    522.
         PLATE      WF-1    6601 6602 6605 6604    500.
         PLATE      WF-2    6602 6603 6606 6605    400.
*/ PLATES REPRESENTING FUEL
         PLATE F2   F-1     6102 6103 6123 6122    129.6
         PLATE      F-2     6103 6104 6124 6123   8637.2
         PLATE      F-3     6104 6105 6125 6124  12852.9
         PLATE      F-4     6106 6107 6127 6126   5531.1
         PLATE      F-5     6107 6108 6128 6127   6919.3
         PLATE      F-6     6108 6109 6129 6128    107.1
         PLATE      F-7     6124 6125 6145 6144    442.8
         PLATE      F-8     6125 6126 6146 6145   5450.7
         PLATE      F-9     6126 6127 6147 6146   6537.6
         PLATE      F-10    6128 6129 6149 6148   2604.5
         PLATE      F-11    6129 6130 6150 6149   4011.2
         PLATE      F-12    6140 6141 6161 6160   5762.0
         PLATE      F-13    6144 6145 6165 6164   1128.9
         PLATE      F-14    6145 6146 6166 6165   2470.2
         PLATE      F-15    6147 6148 6168 6167   1825.8
         PLATE      F-16    6148 6149 6169 6168   4994.1
         PLATE      F-17    6149 6150 6170 6169   2341.4
         PLATE      F-18    6180 6181 6201 6200   3598.6
         PLATE      F-19    6184 6185 6205 6204    268.5
         PLATE      F-20    6185 6186 6206 6205   1691.6
         PLATE      F-21    6186 6187 6207 6206   3248.9
         PLATE      F-22    6187 6188 6208 6207   2531.0
         PLATE      F-23    6188 6189 6209 6208   4235.0
         PLATE      F-24    6200 6201 6221 6220    775.4
         PLATE      F-25    6204 6205 6225 6224    457.0
         PLATE      F-26    6205 6206 6226 6225   1190.8
         PLATE      F-27    6206 6207 6227 6226   1393.2
         PLATE      F-28    6207 6208 6228 6227   1501.2
         PLATE      F-29    6208 6209 622  6228   1555.2
         PLATE      F-30    6220 6221 6241 6240    140.4
         PLATE      F-31    6224 6225 6245 6244     54.0
         PLATE      F-32    6225 6226 6246 6245    442.8
         PLATE      F-33    6226 6227 6247 6246    658.8
         PLATE      F-34    6227 6228 6248 6247    648.0
         PLATE      F-35    6228 6229 6249 6248    583.2
*/ PLATES REPRESENTING PAYLOAD
         PLATE F2   P-1     6002 6003 6023 6022   680.
         PLATE      P-2     6003 6004 6024 6023  2295.
         PLATE      P-3     6004 6005 6025 6024  3585.
         PLATE      P-4     6005 6006 6026 6025  2200.
         PLATE      P-5     6006 6007 6027 6026  3390.
         PLATE      P-6     6007 6008 6028 6027  3475.
         PLATE      P-7     6008 6009 6029 6028  2965.
         PLATE      P-8     6009 6010 6030 6029  2040.
         PLATE      P-9     6010 6011 6031 6030  2125.
         PLATE      P-10    6011 6012 6032 6031  2125.
         PLATE      P-11    6012 6013 6033 6032  1190.
END MASS ELEMENT DATA
BEGIN FACTOR DATA
         EXCLUDE STIFFNESS ELEMENTS
END FACTOR DATA
END MASS DATA
BEGIN SUBSET DEFINITION
   SUBSETS OF NODAL SET 1
   */
   */  SUBSETS FOR PLOTS
   */
         N1 = 1 TO 3605  / NODES FOR STIFFNESS MODEL
         N2 = 6001 TO 6606  / NODES FOR MASS MODEL
*/
*/  SUBSETS FOR AERODYNAMICS
*/
         N51 = 1 7 13 19 27 45 55 63 67 75 79 83 85 89
         N42 = 227 237 245 255 263 435 441 445 451 455 463 641 649 655 659 663    +
         847 851 855 859 863 1051 1055 1059 1063 1254 1259 1263 1459            +
               1463 1658 1661 1663 1859 1860 1861 1863
```

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```
      N43 = 279 283 285 479 483 485 679  683 685
      N53 = 83 283 483 683
      N44 = 2058 2061 2261 2458 2461
      N45 = 263 3003 3005 463 3103 3105 663 3203 3205
      N55 = 263 463 663
      N46 = 1463 3405 1663 3505 1863 3605
      N56 = 1463 1663 1863
      N57 = 285 485 685
      N67 = 485
      N81 = 3003 3103 3203
      N82 = 3005 3105 3205
      N83 = 3405 3505 3605
      N91 = 641 649 663
N99 = N42 U N43
N63 = 663 863 1063 1263 1463 1863
N64 = 655 855 1055
N65 = 435 641 847 1051 1254 1456 1658 1859
N66 = 659 859 1059 1259 1459
N61 = 63 263 463 663
N68 = 55  255 455 655
N69 = 245 445
N70 = 227 435
N62 = N63 U N64 U N65 U N66 U N61 U N68 U N69 U N70
   SUBSETS OF STIFFNESS SET 1
   */
   */  SUBSETS FOR PLOTS
   */
      E1 = ALL
    SUBSETS OF MASS SET 1
*/
*/  SUBSETS FOR PLOTS
*/
      E2 = ALL
END SUBSET DEFINITION
BEGIN BC DATA
  STAGE 1      *(FOR VIBRATION/FLUTTER ANALYSIS)
      ORDER RETAIN BY INTERNALID
      SUPPORT ASYM IN SURFACE 2
      SUPPORT TX FOR 89
RETAIN TZ FOR 1 7 13 19 27 45 55 63 67 73 79 85 89
      RETAIN TZ FOR 227 237 245 255 435 441 445 451 455
RETAIN TZ FOR 641 645 649 655 659 847 851 855 859 863 1051 1055 1059 1063
RETAIN TZ FOR 1254 1259 1456 1459 1658 1661  1859 1860 1861
      RETAIN TZ FOR 3003 3005 3103 3105 3203 3205
RETAIN TZ FOR 3305 3405 3505 3605
RETAIN TZ FOR 279 479 679
      RETAIN TY FOR 2058 2061 2258 2261 2458 2461
RETAIN TZ RX RY FOR 263 463 663 1263 1463 1663 1863 285 485 685 83 +
            283 483 683
END BC DATA
END PROBLEM DATA
```

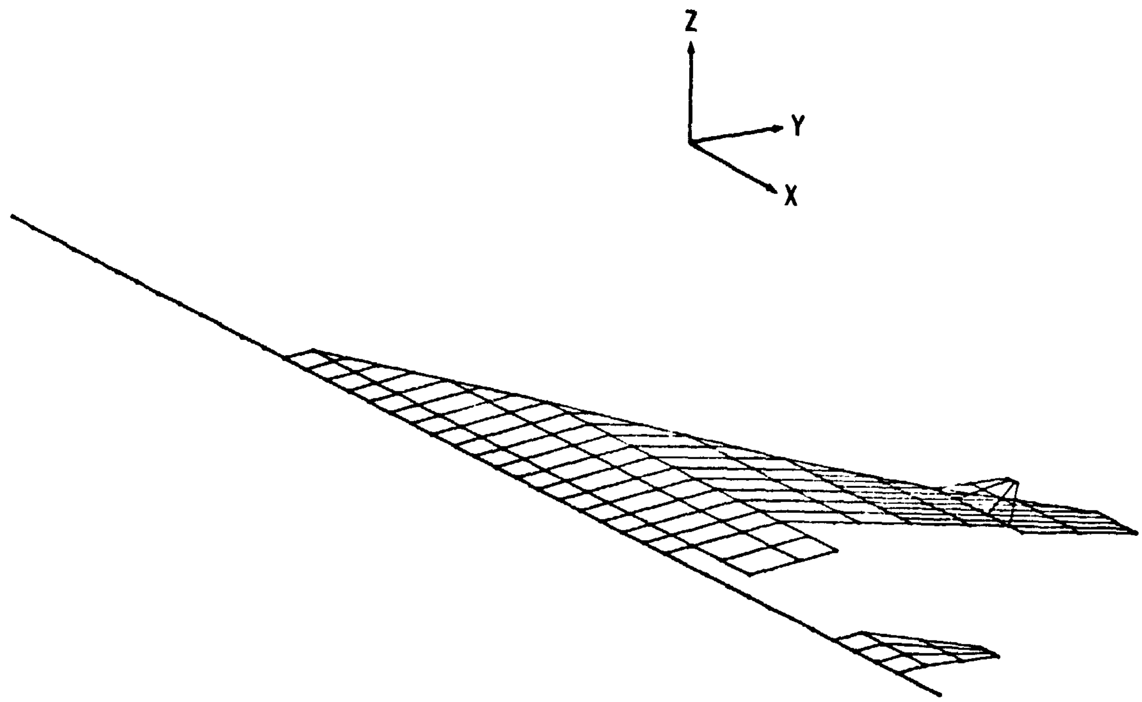

Figure 211-1. Structural Model for Flutter Demonstration

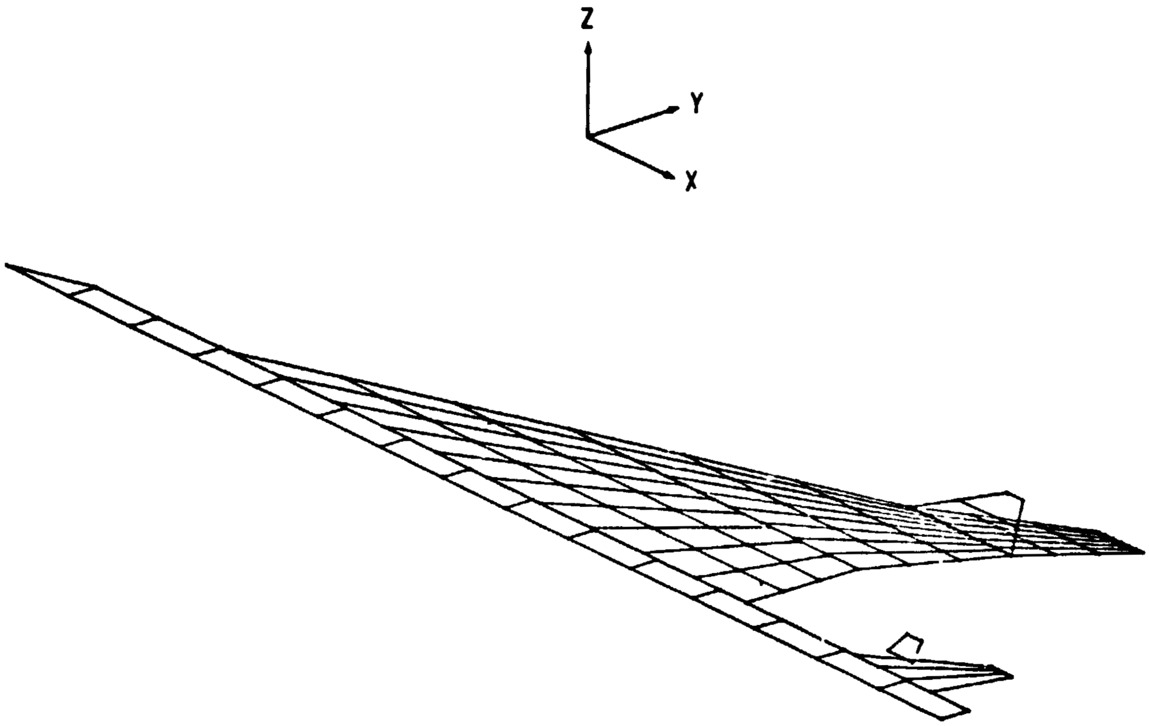

Figure 211-2. Mass Model for Flutter Demonstration

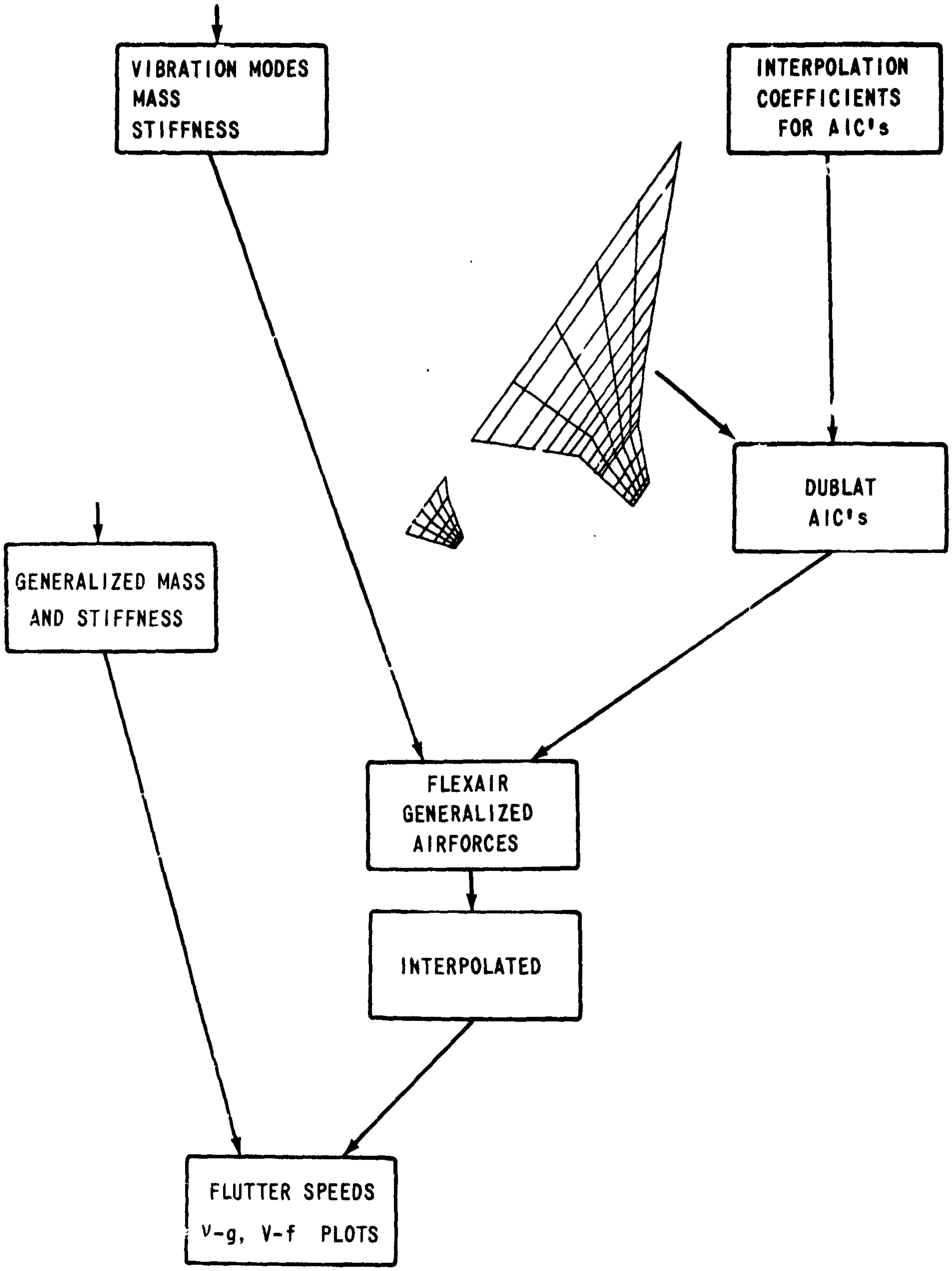

Figure 211-3. First Flutter Analysis, Mach = 0.8 Using Aerodynamic Influence Coefficients

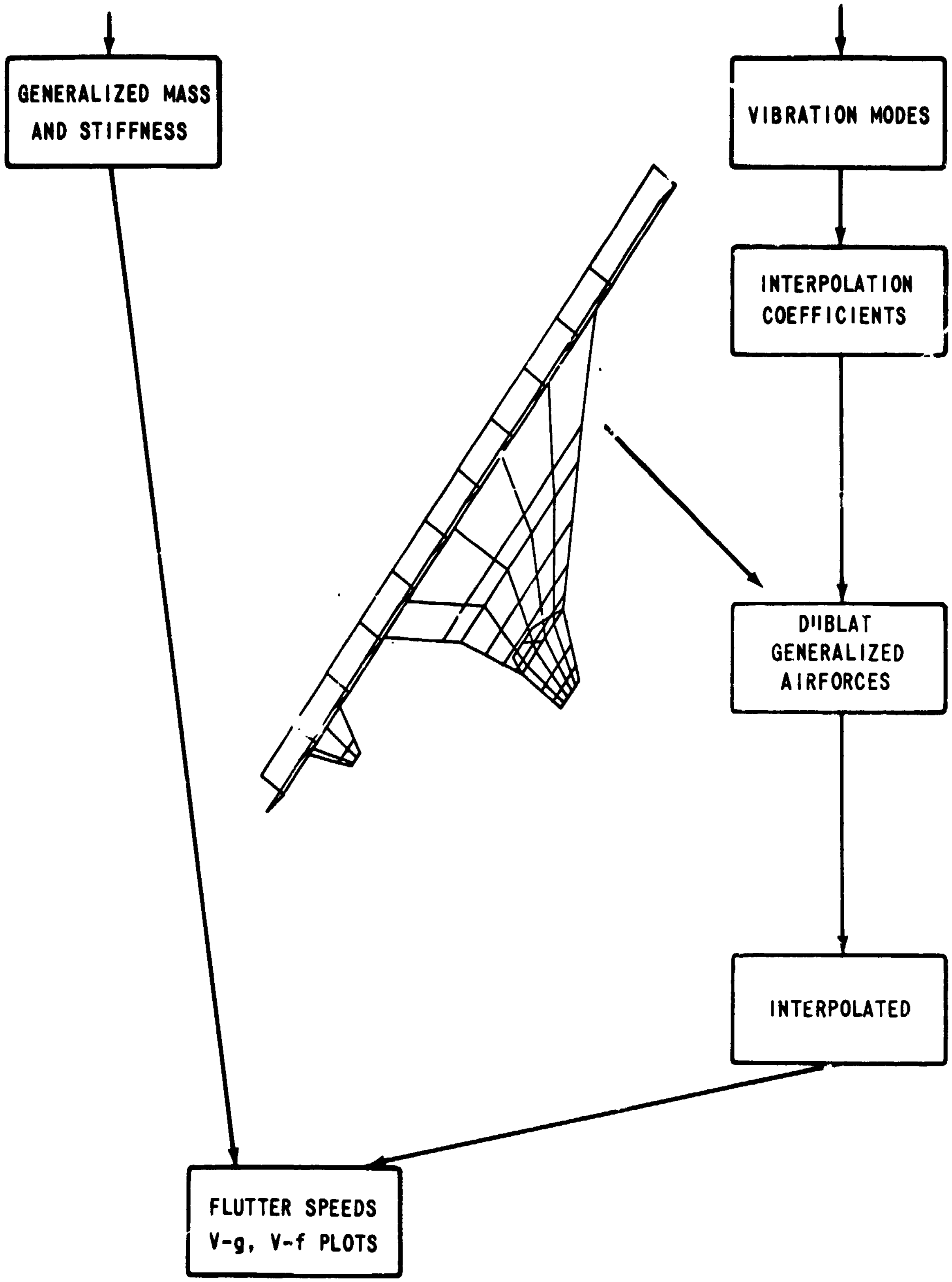

Figure 211-4. Second Flutter Analysis, Mach = 0.8

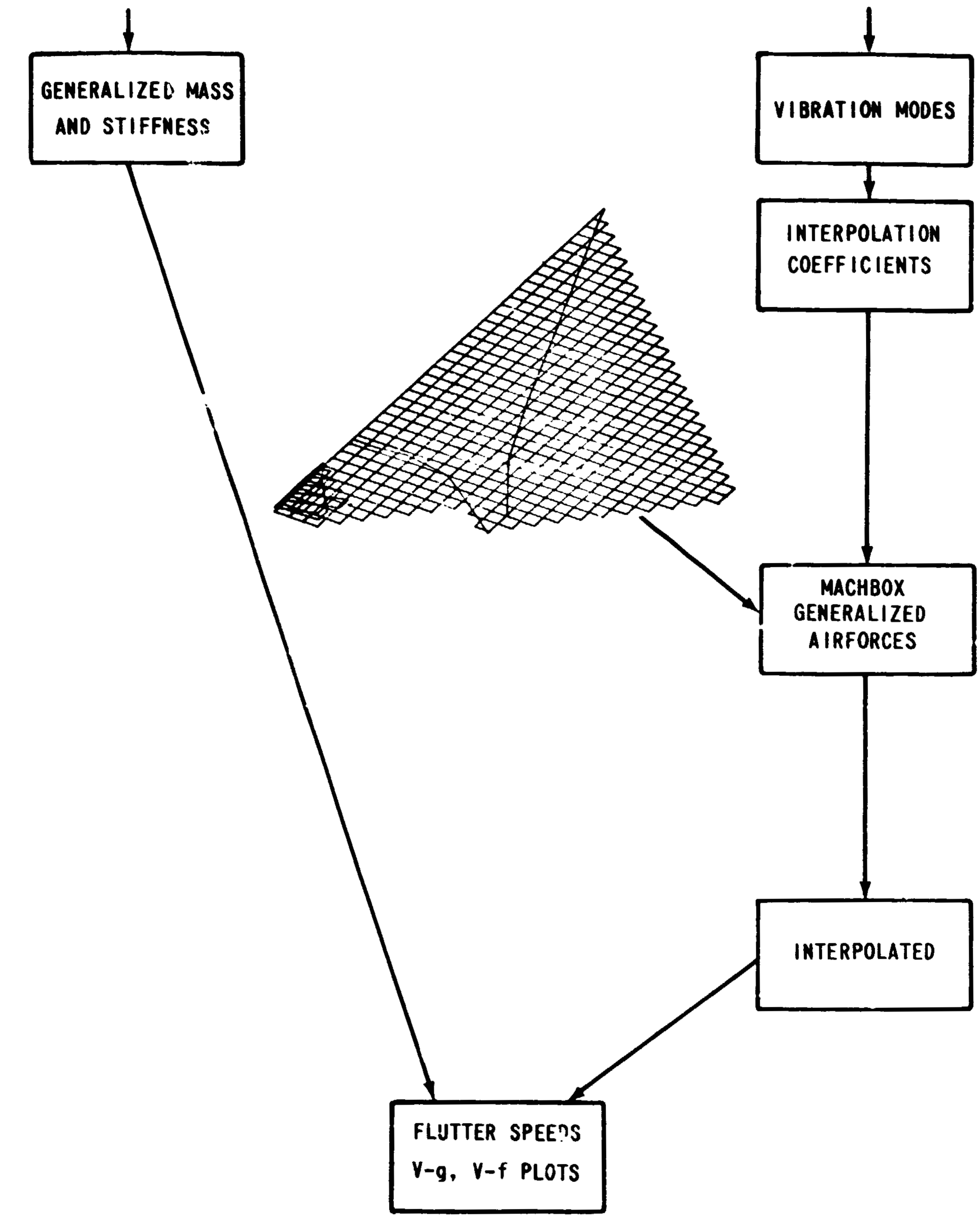

Figure 211-5. Third Flutter Analvsis, Mach = 1.526

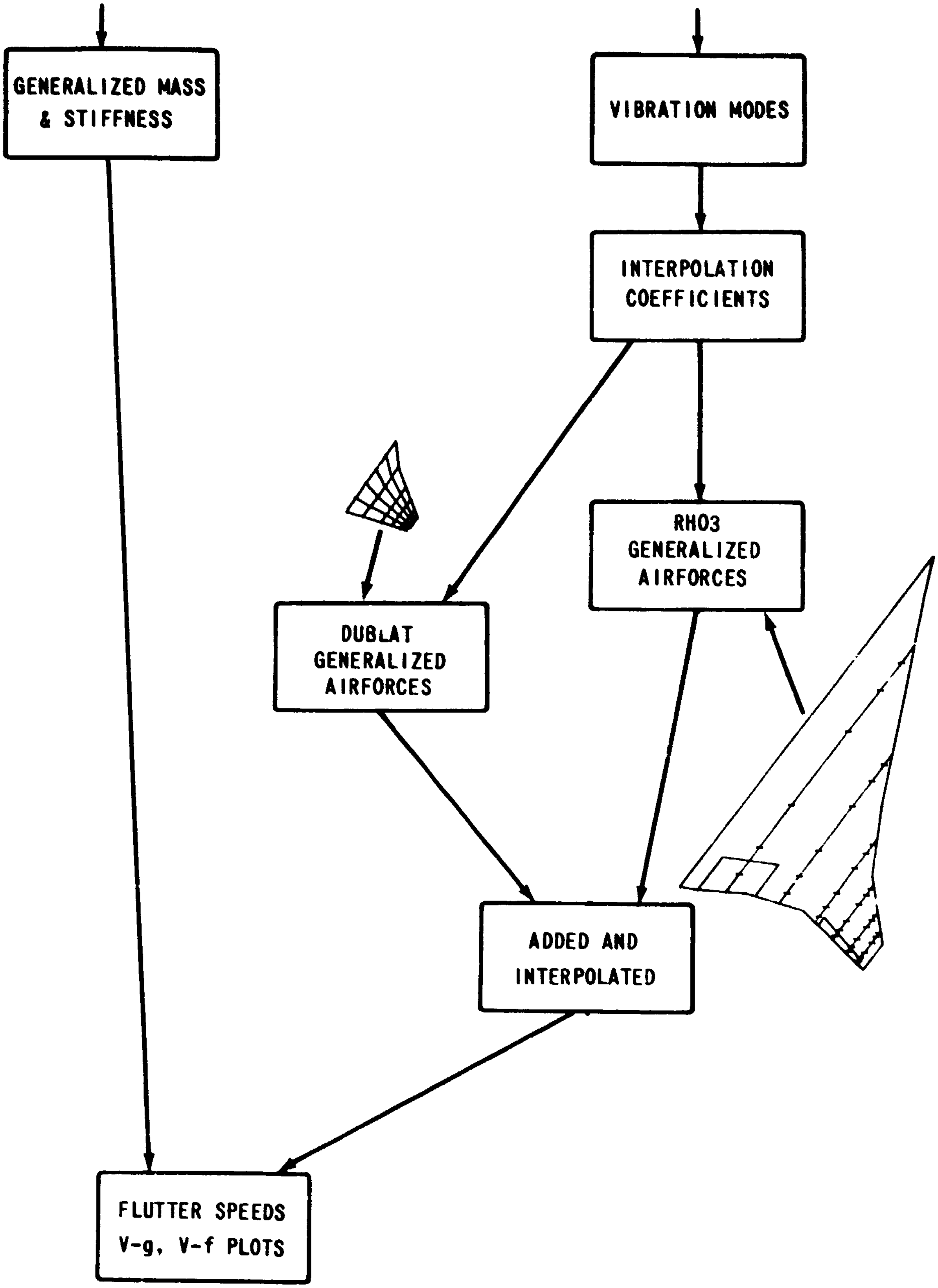

Figure 211-6. Fourth Flutter Analysis, Mach= 0.8

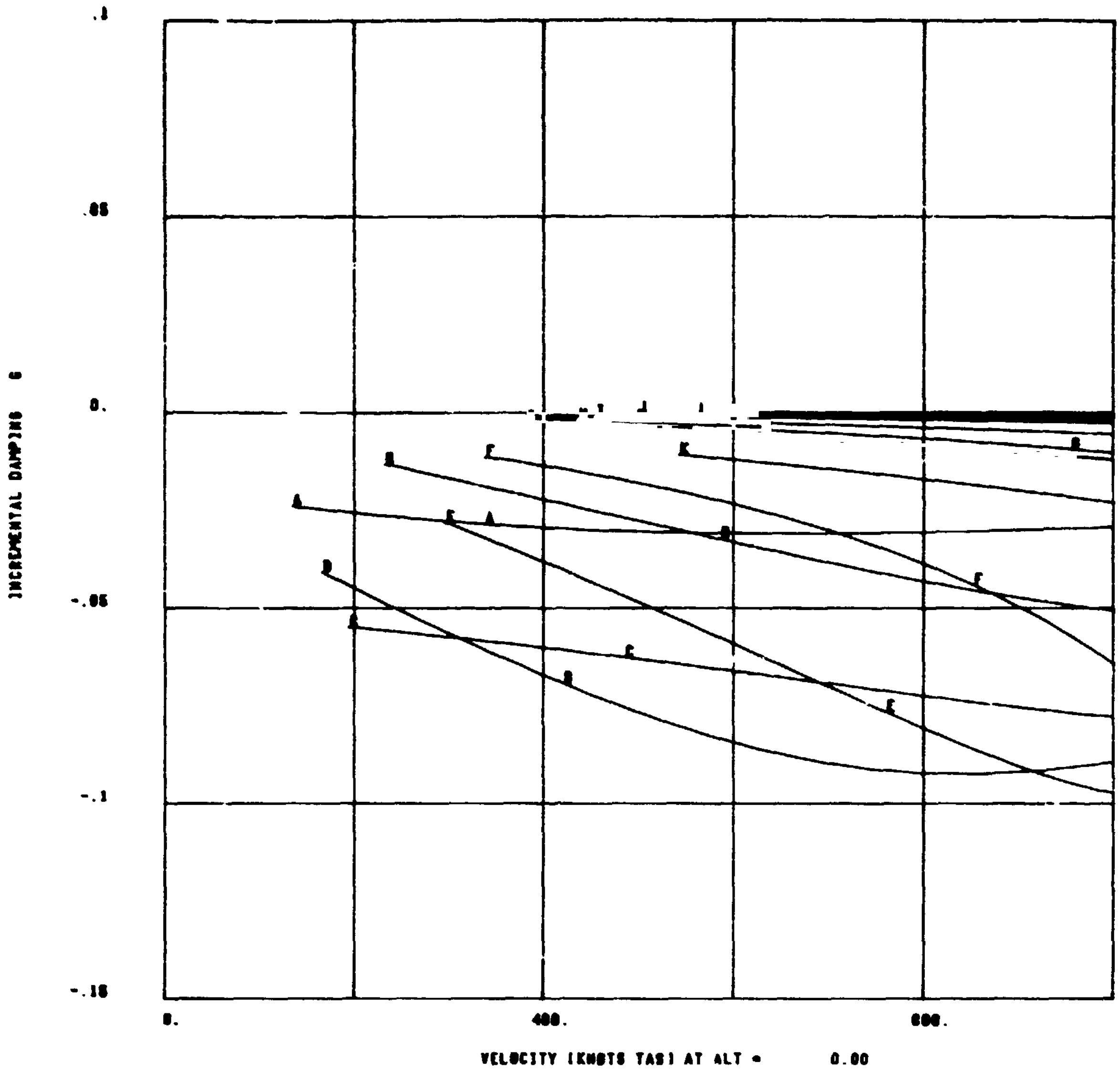

Figure 211-7. V-g Plot, First Flutter Analysis Including Residual Flexibility Effects

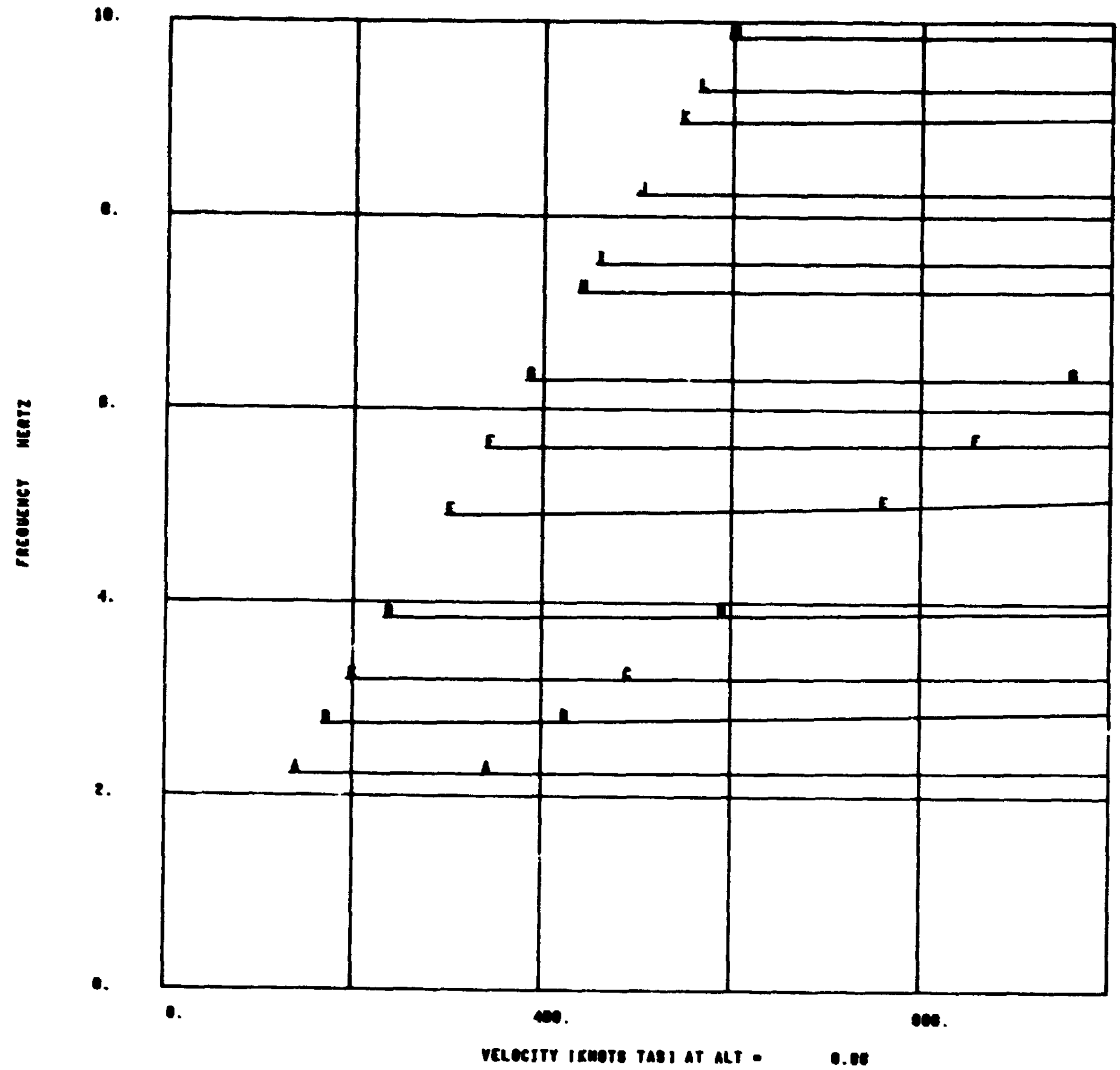

Figure 211-8. V-f Plot, First Flutter Analysis Including Flexibility Effects

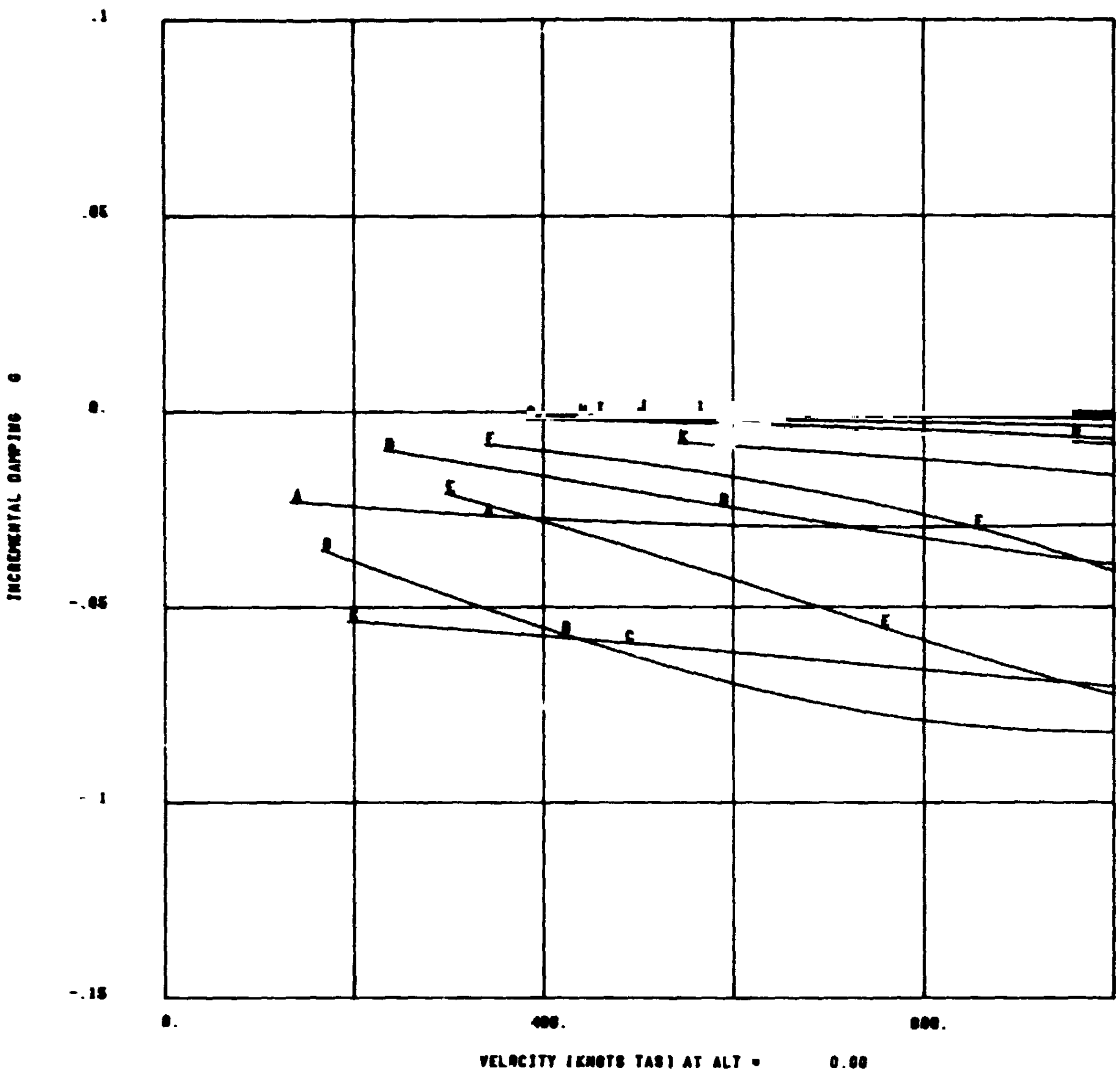

Figure 211-9. V-g Plot, First Flutter Analysis Without Residual Flexibility Effects

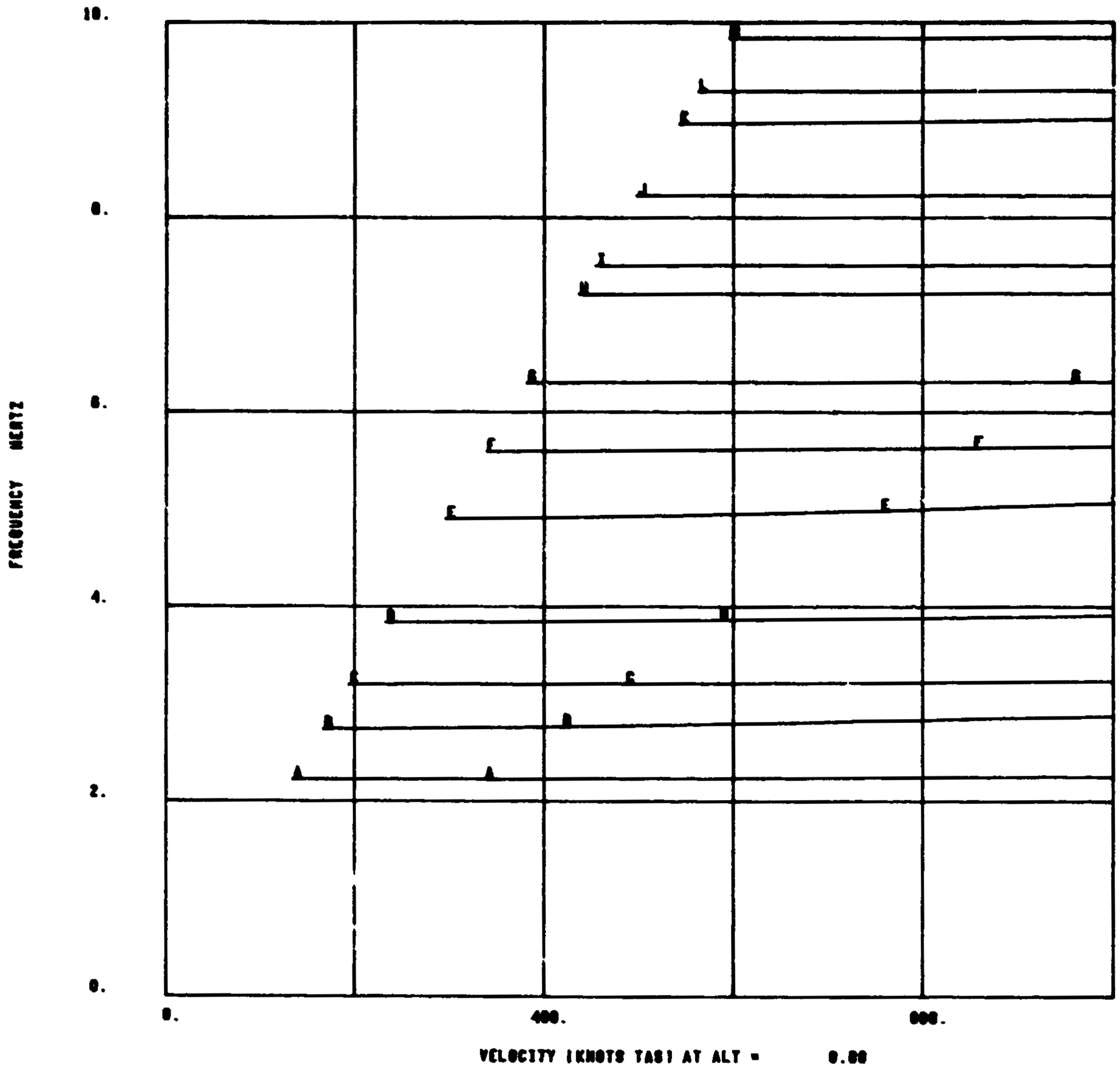

Figure 211-10. V-f Plot, First Flutter Analysis Without Residual Flexibility Effects

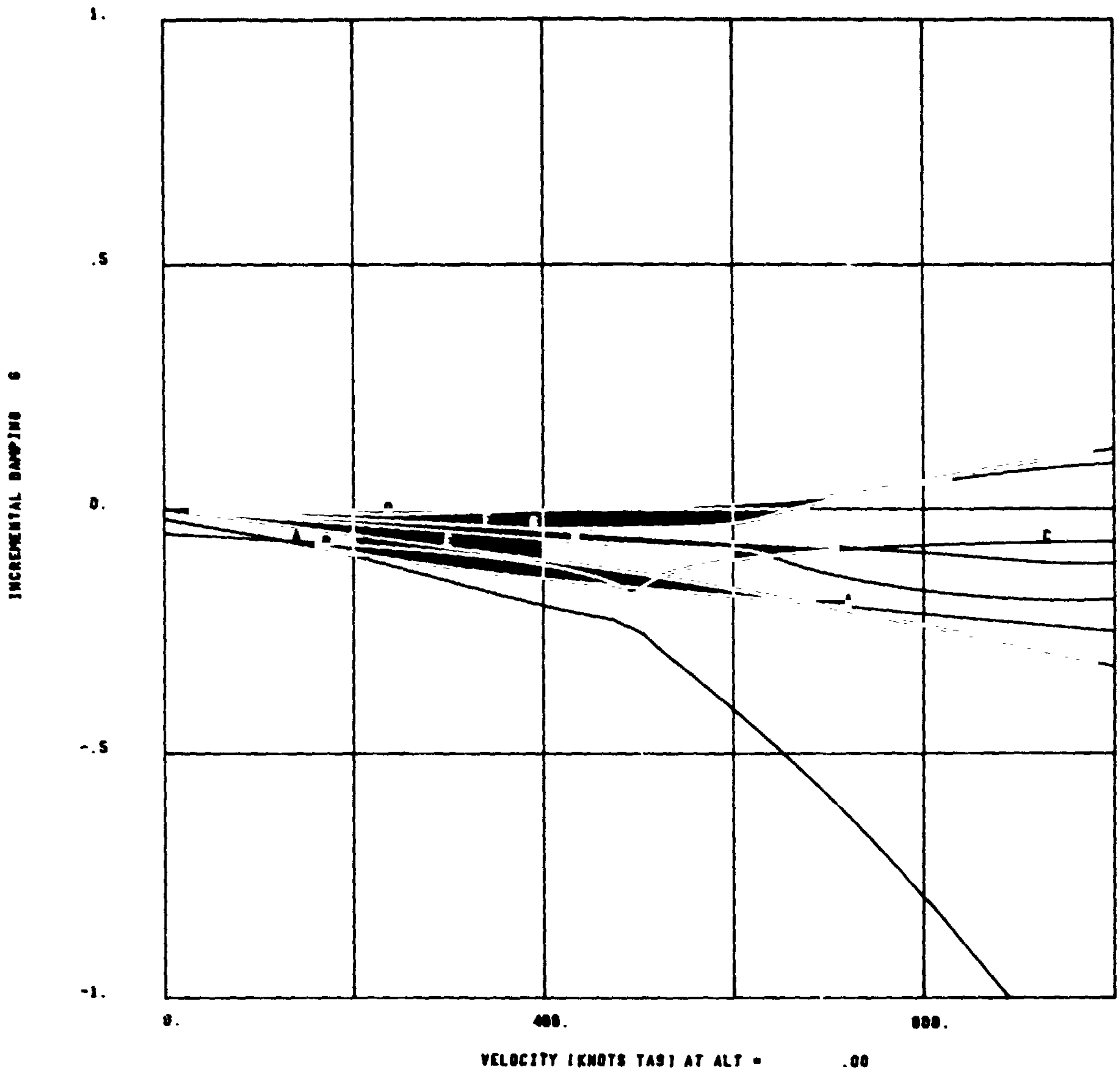

Figure 211-11. V-g Plot, Second Flutter Analysis

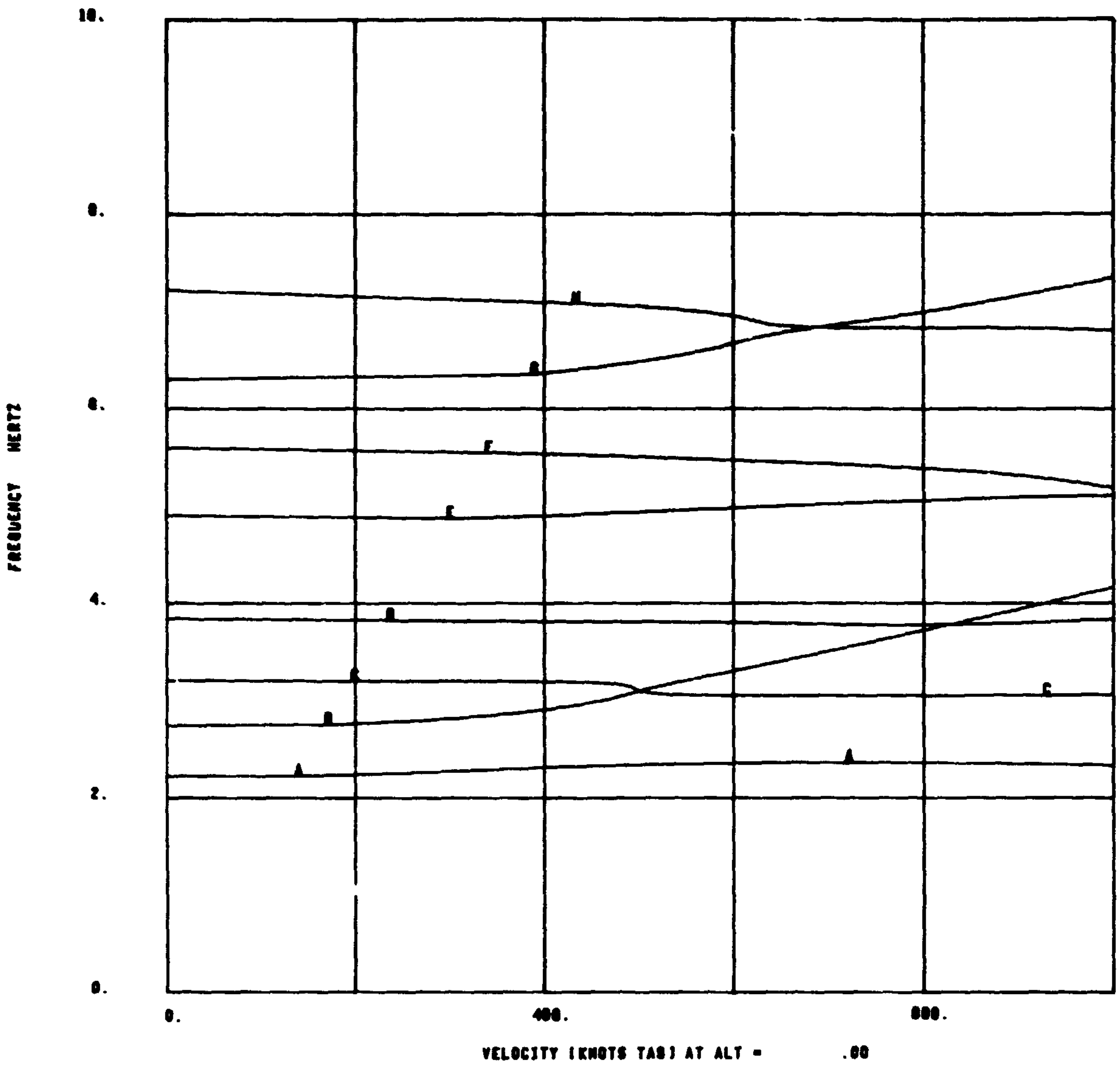

Figure 211-12. V-f Plot Second Flutter Analysis

212. FLUTTER ANALYSIS OF A T-TAIL AIRCRAFT (DECK 14)

212.1 DESCRIPTION OF ANALYSIS

This problem demonstrates the subsonic flutter analysis of the empennage of a T-tail aircraft, the YC-14. The structural model, shown in figure 212-1, is comprised of BEAM and ROD elements. All mass is defined as concentrated masses and a nondiagonal mass matrix is produced directly by the Mass Processor. The X-Y plane is defined as a plane of anti-symmetry and the empennage is cantilevered from the forward end. The model is described in more detail in reference 212-1.

Doublet Lattice aerodynamics, modified to match experimentally obtained steady state aerodynamic derivatives, are used. The aerodynamic modelling is shown in figure 212-2.

212.2 RESULTS

The five lowest natural frequencies obtained in this problem are compared with experimental values from reference 212-1 in table 212-1. Flutter analysis results are presented in the form of V-g and V-f graphs in figures 212-3 and 212-4. The experimental flutter speed is 123 knots.

212.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO14
      PROBLEM ID(DEMO14 - FLUTTER OF SUBSONIC T-TAIL AIRPLANE)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. DUBLAT AERODYNAMICS
C                       2. AF1 AERODYNAMICS
C                       3. FLUTTER ANALYSIS
C                       4. V-G AND V-F PLOTS
C
C     AUTHOR         J. HOGLEY (MODEL BY YC-14 STAFF)
C
C     CORE           260K (OCTAL)
C
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(MASS)
      PRINT INPUT(BC,NODEORDER = INTERNAL )
      EXECUTE EXTRACT(EXNAME=EMP,LSUB=KGRID,NSUB=N4,ESUB=E4)
      EXECUTE GRAPHICS(GNAME=GEOM,OFFLINE=GERBER,
     X                TYPE=ORTH,SIZE=(20,20),RZ=125,RY=25,RX=0,
     X                EXNAME=EMP)
      EXECUTE MASS (OPTION=3)
      PERFORM K-REDUCE
      PRINT OUTPUT(MASS,SUMMARY,MDC=MDC****)
      EXECUTE VIBRATION ( STIF=KRED, MASS=MDC001A, NFREQS=15, NMODES=10,
     X  SUBSETS=N001 TO N003)
      PRINT OUTPUT (VIBRATION)
      EXECUTE INTERPOLATION ( N003 = ( MOTIONAXIS,C0003 ), DOF = 001110,
     X DEFNPTS = ( 1501,169 ), ANGLES = ( 0.,0.  ))
      EXECUTE INTERPOLATION ( N002 = ( MOTIONAXIS,C0002 ), DOF = 010101,
     X DEFNPTS = (  74,112,118,121 ),ANGLES = ( -25.,-25.,-25.,-25. ) )
      EXECUTE INTERPOLATION ( N001 = ( MOTIONAXIS,C0001 ), DOF = 010101,
     X DEFNPTS = (  59,77  ), ANGLES = ( 90.,90. ) )
      PRINT INPUT(DUBLAT)
      EXECUTE DUBLAT(MACH=0.0, KVALUE=(.4,.05,.01,.005),
     XY=ANTISYMM,Z=NONSYMM,QUASI=D1 )
      PRINT OUTPUT (DUBLAT, LEVEL =(1,2,3,4,5))
      EXECUTE ADDINT(ID=GAFEM,INT,DUBLAT,MACH=0.0, GET=200  )
      PRINT INPUT (FLUTTER )
      EXECUTE FLUTTER (GAFID=GAFEM,DENSITY=.00237692,STILL)
      PRINT INPUT(AF1)
      EXECUTE AF1 (KVAL= (.4, .05, .01, .005), Y=ANTI)
      PRINT OUTPUT (AF1, LEVEL= (1,2,3,4,5,6,7))
      EXECUTE ADDINT (ID=GAFAF, AF1, IGAIN=20)
      EXECUTE FLUTTER (GAFID=GAFAF, EVAL=(1 TO 61 BY 7), STILL, COND=2)
      PRINT OUTPUT(FLUTTER )
      EXECUTE EXTRACT (EXNAME=FLDEM18,LSUB=VGVF,CASE=1)
      EXECUTE GRAPHICS(GNAME=FLUT,TYPE=GRAPH,SIZE=(15,15),X=V,Y1=G,
     X                Y2=F,XMIN=0.,XMAX=250.,Y2MIN=0.,Y2MAX=50.,
     X                Y1MIN=-.2,Y1MAX=.1,EXNAME=FLDEM18)
      END CONTROL PROGRAM
```

```
BEGIN MATERIAL DATA  /
  M51  0.0      /
   70   10.4E6   .30   4.0E6  0.0    /
*/ BODY AND FIN SPAR MATERIAL PROPERTIES    /
  M60   0.0  /
   70    5.2E6  .3  2.0E6  0.0  / .5 STIFFNESS FOR BODY-FIN
*/  STABILIZER SPAR STIFFNESS   /
 M70    0.0   /
   70    10.4E6    .3    4.0E6  0.0    /
END MATERIAL DATA  /
BEGIN NODAL DATA   /
*/  MID BODY SPAR NODES  /
REC    BODYSM      49.0  0.0  12.112    100.  0.0  12.112  49.0 0.0 20. /
  50    0.0    0.0  0.0  /
 501    0.0  1.0  0.0   / ROOT NODE PITCH
 502   1.0  0.0   0.0  / ROOT NODE ROLL
 503   0.0  0.0   1.0  / ROOT NODE YAW
  51    2.24  0.0  0.0  /
  52    4.48  0.0  0.0  /
  53    6.72  0.0  0.0  /
  54    8.96  0.0  0.0  /
  55    9.80  0.0  0.0  /
  56   11.20  0.0  0.0  /
  57   12.88  0.0  0.0  /
  58   14.56  0.0  0.0  /
  801  0.0  0.0  -1.0   /
  811 11.20 0.0  -1.0   /
*/  AFT BODY SPAR NODES  /
REC    BODYSA   49.26225 0.0 9.360988  63.56 0.0 12.112  49. 0. 12.112    /
  59   16.77  0.0  0.0  /
  60   19.98  0.0  0.0  /
  61   21.189 0.0  0.0  /
  62   23.399 0.0  0.0  /
  63   25.409 0.0  0.0  /
  64   27.427 0.0  0.0  /
  65   29.444 0.0  0.0  /
  66   31.454 0.0  0.0  /
  67   33.236 0.0  0.0  /
  68   35.018 0.0  0.0  /
  69   36.808 0.0  0.0  /
  70   38.583 0.0  0.0  /
  71   40.40  0.0  0.0  /
  72   42.25  0.0  0.0  /
  73    40.40  0.0  1.36      /  BASE OF FIN SPAR MOUNT
  74    41.40  0.0  1.36      /
  75    42.25  0.0  1.36      /
 77    45.50  0.0  0.0   /
 771    45.50  -3.5  0.0   /
 772    45.50   3.5  0.0   /
  78    48.55  0.0  -0.6   /
  821 23.399 0.0 -1.0    /
  831 31.454 0.0 -1.0    /
  841 38.583 0.0 -1.0    /
*/  FIN SPAR NODES   /
REC    FINSPL   91.33 0.0  21.905  97.48  0.0  35.094   85.  0.0  35.    /
  76   -.80    0.0    0.0    /
 101    0.0    0.0  0.0  /
 102    1.087 0.0  0.0  /
 103    1.782 0.0  0.0  /
 104    2.863 0.0  0.0  /
 105    3.740 0.0  0.0  /
 106    5.18  0.0  0.0  /
 107    6.45  0.0  0.0  /
 108    7.497 0.0  0.0  /
 109    8.27  0.0  0.0  /
 110    9.14  0.0  0.0  /
 111   10.587 0.0  0.0  /
 112   11.84  0.0  0.0  /
 113   12.904 0.0  0.0  /
 114   13.676 0.0  0.0  /
 115    14.552  0.0  0.0    /
```

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```
REC  FINSPU  87.88069  0.0  24.15718 97.4798 0. 35.0936  85. 0. 35.  /
 116  15.824 0.0  0.0  /
 117  16.574 0.0  0.0  /
 118  17.331 0.0  0.0  /
 119  18.152 0.0  0.0  /
 120  19.084 0.0  0.0  /
 121  19.475  0.0  0.0  /
 122  17.454  0.0  1.34  / LOWER PIVOT FOR STABILIZER LEAD SCREW
   1221  17.40   0.0   0.0     /     STAB PITCH MECH ATT. TO FIN SPAR.
 123  19.475  1.0   0.0   /
 124  19.475 -1.0   0.0   /
*/  STABILIZER PIVOT MECHANISM  /
RESUME GLOBAL   /
 125  101.858 1.0   40.082   /
 126  101.858 -1.0  40.082   /
 127  101.858  .675 40.082   /
 128  101.858 -.675 40.082   /
 129  100.758  .675 40.082   /
 130  100.758 -.675 40.082   /
 137  100.758  0.0  40.082   /
 131  101.108  0.0  40.082   /       STABILIZER ROLL-YAW-PITCH MECHANISM
 132  100.358  0.0  40.082   /
 133   99.108  0.0  40.082   /
 134   98.388  0.0  40.082   /
 135  102.608  0.0  40.082   /
 136  102.608  0.0  41.249   /
 360     101.858  .675  41.082      /
 361     101.858 -.675  41.082      /
 362     102.858  .675  40.082      /
 363     102.858 -.675  40.082      /
 364     101.858  .675  40.082      /
 365     101.858 -.675  40.082      /
*/ FUSELAGE SHELL CGS    /
 80         54.67    0.0   12.06     /  SECT 6
 81         65.95    0.0   12.81     /  SECT 7
 82         76.09    0.0   15.02     /  SECT 8
 83         83.72    0.0   16.50     /  SECT 9
 84         90.09    0.0   18.29     /  SECT 10-11
*/ SPAR CG     /
 85         54.44    0.0   12.11     /  SPAR SECT 6
 86         65.49    0.0   12.49     /  SPAR SECT 7
 87         75.97    0.0   14.50     /  SPAR SECT 8
 88         83.58    0.0   15.96     /  SPAR SECT 9
 89         89.00    0.0   17.08     /  SPAR SECT 10-11
*/ OTHER ITEMS             /
 79         98.16    0.0   17.94     / TRIM MOTOR
 90         50.79    0.0    9.45     / SECT 6 BASIC WT
 91         68.85    0.0   10.33     / SECT76 BASIC WT
 92         90.17    0.0   19.55     / 1270-50  BODY-FIN CONNECTION
*/ FIN SECTION CG LOCATIONS      /
 203           91.86  0.0  23.21    /
 207           96.09  0.0  26.78    /
 212           98.56  0.0  31.77    /
 218          100.44  0.0  37.21    /
 221      103.89  0.0  40.31    /
  500     130.  0.0    30.     /  ORENTATION NODE
*/  HORIZONTAL STABILIZER NODES   /
REC  STAB 101.858 0.0 41.249  201.858 0.0 41.249  101.858 6.993 [illegible]2449 /4ANH
RESUME GLOBAL /
150 101.858 0.0 41.249 /STAB SPAR ROOT
REC   HTAIL  101.858  0.0  41.249  201.858 -4.76975 41.249 101.858 6.993
    141.249  / 4DEG ANHEDRIAL
ANALYSIS FRAME STAB  /
1501 0.0 .2 0.0 /
 151   0.0   1.261 0.0   /
 152   0.0   2.698 0.0   /
 153   0.0   4.135 0.0   /
 154   0.0   5.571 0.0   /
 155   0.0   7.008 0.0   /
 156   0.0   8.059 0.0   /
```

```
 157   0.0   9.075 0.0   /
 158   0.0  10.162 0.0   /
 159   0.0  11.072 0.0   /
 160   0.0  11.914 0.0   /
 161   0.0  13.105 0.0   /
 162   0.0  14.016 0.0   /
 163   0.0  15.137 0.0   /
 164   0.0  16.118 0.0   /
 165   0.0  17.169 0.0   /
 166   0.0  18.221 0.0   /
 167   0.0  19.202 0.0   /
 168   0.0  20.323 0.0   /
 169   0.0  21.144 0.0   /
 170   0.0  22.425 0.0   /
 171   10.0  15.0  0.0   /  ORENTATION NODE
*/ STABILIZER PANEL-SPAR CG NODES    /
REC   STABCG    0.0  0.0  41.249   100. 0.0 41.249   0.0 6.993 141.249  /
  252   103.6300   2.6400  0.0   /
  254   103.4850   5.5350  0.0   /
  257   103.887    8.761   0.0   /
  261   104.1900  12.7600  0.0   /
  265   104.2100  16.9200  0.0   /
  269   103.9850  21.8400  0.0   /
RESUME GLOBAL   /
ANALYSIS FRAME GLOBAL /
 250    101.71  0.0  40.63    /
 REC  M1    91.33 0.0 21.905 97.48 0.0 35.094 85.0 0.0 35.0 /
9999  0. 0. 0.    /
RESUME GLOBAL   /
END NODAL DATA  /
BEGIN STIFFNESS DATA  /
BEGIN PROPERTY DATA  /
P1    1.0 *=2    20.0  1.0  1.0   /  RIGID ELEMENT PROPERTY
P2   .013 *=2    20.0 .132E-4 *=1 111100. /FWD RIGID SHELL LINKS
P3  1.0 *=2  20.  1.  1.  100.  / AFT ATTACHMENT OF BODY SHELLS
END PROPERTY DATA /
BEGIN ELEMENT DATA  /
*/  ELEMENTS FOR MID BODY SPAR  /
BEAM  Z60 N50                    50 51 2.6269 *=2 .815796 .695927 .568320
                                       2.6491 *=2 .816595 .705220 .599445 /
 *2  N501   50 501  20. *=2  7.0  500.  500.  110. /PITCH SPRING-ROOT
 *2  N502   50 502  20. *=2  2.385  500.  500.  110.  / ROLL SPRING ROOT
 *2  N503   50 503 58 20. *=2  6.45  500.  500.  110.  / YAW SPRING ROOT
   *2     N51                    51 52 2.6491 *=2 .816595 .705220 .599445
                                       2.6551 *=2 .817135 .699525 .613247 /
   *2     N52                    52 53 2.6551 *=2 .817135 .699525 .613247
                                       2.6330 *=2 .809515 .684153 .596283 /
   *2     N53                    53 54 2.6330 *=2 .809515 .684153 .596283
                                       2.5034 *=2 .737986 .655574 .500569 /
   *2     N54                    54 55 2.5034 *=2 .737986 .655574 .500569
                                       2.3667 *=2 .630967 .647414 .447574 /
   *2     N55                    55 56 2.3667 *=2 .630967 .647414 .447574
                                       2.0209 *=2 .390787 .621932 .356925 /
   *2     N56                    56 57 1.2524 *=2 .453769 .621646 .356187
                                       1.1928 *=2 .420834 .595791 .325931 /
   *2     N57                    57 58 1.1928 *=2 .420834 .595791 .325931
                                       1.1295 *=2 .387686 .566946 .294410 /
*/  NOMINAL AFT BODY SPAR ELEMENTS  /
BEAM  Z60 N58                    58 59 1.3246 *=2 .372488 .567341 .294149
                                       1.2313 *=2 .331577 .525907 .255016 /
   *2     N59                    59 60 1.2313 *=2 .331577 .525907 .255016
                                       1.1440 *=2 .295293 .479277 .224486 /
   *2     N60                    60 61 1.1440 *=2 .295293 .479277 .224486
                                       1.0588 *=2 .262771 .432032 .195999 /
   *2     N61                    61 62 1.0588 *=2 .262771 .432032 .195999
                                        .9776 *=2 .233375 .389427 .169770 /
   *2     N62                    62 63  .9776 *=2 .233375 .389427 .169770
                                        .9035 *=2 .207377 .353343 .147466 /
   *2     N63                    63 64  .9035 *=2 .207377 .353343 .147466
                                        .8390 *=2 .184401 .323113 .130984 /
```

```
   *2      N64                  64 65  .8399 *=2 .184401 .323113 .130984
                                       .7836 *=2 .165980 .297177 .117099 /
   *2      N65                  65 66  .7836 *=2 .165980 .297177 .117099
                                       .7305 *=2 .147913 .272751 .106055 /
   *2      N66                  66 67  .7305 *=2 .147913 .272751 .106055
                                       .6887 *=2 .133266 .254542 .098681 /
   *2      N67                  67 68  .6887 *=2 .133266 .254542 .098681
                                       .6554 *=2 .123573 .239385 .091087 /
   *2      N68                  68 69  .7228 *=2 .118307 .239431 .091145
                                       .6945 *=2 .111666 .227279 .085127 /
   *2      N69                  69 70  .6945 *=2 .111666 .227279 .085127
                                       .6688 *=2 .104231 .218352 .080636 /
   *2      N70                  70 71  .6688 *=2 .104231 .218352 .080636
                                       .4620 *=2 .099621 .054947 .077282 /
   *2      N71                  71 72  .4620 *=2 .099621 .054947 .077282
                                       .4557 *=2 .098064 .055313 .074358 /
   *2                           72 77     .0745 *=2  .01336  .00668 .00668 /
   *2                           77 78     .0745 *=2  .01336  .00668 .00668 /
  *2                   77 771  .04925 *=2  .00766  .002370  .009413   /
  *2                   77 772  .04925 *=2  .00766  .002370  .009413   /
*/  NOMINAL FIN SPAR ELEMENTS  /
BEAM  Z60  N101               101  102 500 .2911 *=2 .020029 .009823 .038493
                                           .2909 *=2 .020031 .009746 .038200 /
   *2     N102                102  103 500 .2729 *=2 .017623 .009769 .038224
                                           .2719 *=2 .017525 .009683 .037999 /
   *2     N103                103  104 500 .4039 *=2 .016419 .009818 .038120
                                           .4015 *=2 .016248 .009734 .037279 /
   *2     N104                104  105 500 .4015 *=2 .016248 .009734 .037279
                                           .3990 *=2 .016077 .009651 .036283 /
   *2     N105                105  106 500 .3990 *=2 .016077 .009651 .036283
                                           .3943 *=2 .015792 .009535 .034248 /
   *2     N106                106  107 500 .3943 *=2 .015792 .009535 .034248
                                           .3906 *=2 .015567 .009437 .032634 /
   *2     N107                107  108 500 .3906 *=2 .015567 .009437 .032634
                                           .3880 *=2 .015402 .009355 .031695 /
   *2     N108                108  109 500 .3880 *=2 .015402 .009355 .031695
                                           .3865 *=2 .015288 .009322 .031254 /
   *2     N109                109  110 500 .3865 *=2 .015288 .009322 .031254
                                           .3844 *=2 .015125 .009242 .030768 /
   *2     N110                110  111 500 .3844 *=2 .015125 .009242 .030768
                                           .3815 *=2 .014907 .009145 .030003 /
   *2     N111                111  112 500 .3815 *=2 .014907 .009145 .030003
                                           .3781 *=2 .014637 .009033 .029247 /
   *2     N112                112  113 500 .3781 *=2 .014637 .009033 .029247
                                           .3759 *=2 .014479 .008954 .028646 /
   *2     N113                113  114 500 .3759 *=2 .014479 .008954 .028646
                                           .3744 *=2 .014369 .008922 .028235 /
   *2     N114                114  115 500 .3744 *=2 .014369 .008922 .028235
                                           .3723 *=2 .014213 .008844 .027715 /
   *2     N115                115  116 500 .3723 *=2 .014213 .008844 .027715
                                           .3686 *=2 .014029 .008409 .027266 /
   *2     N116                116  117 500 .3686 *=2 .014029 .008409 .027266
                                           .3541 *=2 .013917 .008112 .018519 /
   *2     N117                117  118 500 .3541 *=2 .013917 .008112 .018519
                                           .3466 *=2 .013769 .007849 .015641 /
   *2     N118  118  122      118 1221 500 .3466 *=2 .013769 .007849 .015641
                                           .3466 *=2 .013769 .007849 .015641 /
   *2     N123  122 119      1221 119 500 .3466 *=2 .013769 .007849 .015641
                                           .3062 *=2 .011182 .007548 .008782 /
   *2     N119                119  120 500 .3062 *=2 .011182 .007548 .008782
                                           .2650 *=2 .008361 .009163 .003737 /
   *2     N120                120 121  500 .2650 *=2 .008361 .009163 .003737  /
*/ ELEMENTS FOR FIN SPAR MOUNT     /
BEAM Z60               71 73 500   P1   /
  *2                   73 74       P1   /
  *2                   74 75       P1   /
  *2                   72 75 500   P1   /
  *2                   76 101 500  P1   /
  *2                   74  76 500  .378 *=2  .220340  139503 .1     / 1270-50
```

```
*/ ELEMENTS FUR PITCH-ROLL-YAW MECHANISM    /
 BEAM  Z60  N123  121 123  P1 /
   *2        N124  121  12. P1 /
   *2        N125  123 125   .2 *=2  .0033470 .0010420  .0106670
                            .075 *=2  .003000  .001465  .0123800  /
   *2        N126  124 126   *12  /
     *2   N160     127 360  362   P1    /
     *2   N161     128 361  363   P1    /
     *2            364 360  362   1.0 *=2 .00058 1.0  1.0    10.  /
     *2            365 361  363   1.0 *=2 .00058 1.0  1.0    10.  /
     *2   N162     127 362  360   P1    /
     *2   N164     128 363 361    P1    /
     *2            364 362  360   1.0 *=2 .00037 1.0  1.0    10.  /
     *2            365 363  361   1.0 *=2 .00037 1.0  1.0    10.  /
     *2   N127     125 364        1.0 *=2  20.   1.0  1.0   111.  /
     *2   N128     126 365        1.0 *=2  20.   1.0  1.0  1000111. /
   *2        N129  129 127  .074 *=2  .0023775   .000309  .00995
                            .049 *=2  .001109  .00030395  .0018156  / ROLL CAGE
   *2        N130  130 128  *12   /
   *2              130 137  P1    /
   *2              129 137  P1    /
   *2              137 131  P1    /
   *2              137 132  P1    /
  *2      N132       132 133     .1845 *=2  .004577 .002093 .003844 /PITCH SPRING
  *2      N133       133 134     1.0  *=2  20.0  .125  .125        /
ROD   Z60 N122       122 134     .01615              /  LEAD SC-EW
BEAM  Z60  131 135  .2547 *=2  .006738 .002697 .011277  /-2 SPRING
  *2      N136       135 136 500 1.0  *=2  20.0  .125  .125   /
  *2      N1361      136 150     1.0  *=2  20.0  .125  .125   /
  *2      N1351      135 150     1.0  *=2  20.0  .125  .125   /
*/  MASS ATTACHMENT ARMS          /
BEAM Z1   N80      56 80     P3          /
  *2  N801  80 801  P1  /
 *2         801 50 80  P2  /
  *2      N81      62 81     P3          /
 *2  N811  81 811     P1   /
 *2        811 56 81  P2  /
  *2      N82      66 82     P3          /
 *2  N821  82 821     P1   /
 *2        821 62 82  P2  /
  *2      N83      70 83     P3          /
 *2  N831  83 831     P1   /
 *2        831 66 83  P2  /
 *2     771 84  P3  /
 *2     772 84  P3  /
 *2  N841  84 841     P1   /
 *2        841 70 84  P2  /
*/  STABILIZER ELEMENT DATA  /
BEAM Z70 150 1501 171 1.0 *=2 20. 1. 1.  /
BEAM Z70  1501 151 171   1.0 *=2 20. 1. 1. .2543 *=2 .006348 .003096 .01544     /
  *2      N151                151 152 171 .2543 *=2 .006348 .003096 .015440
                                          .2456 *=2 .005999 .002715 .013552 /
   *2     N152                152 153 171 .2456 *=2 .005999 .002715 .013552
                                          .2445 *=2 .005537 .002316 .011436 /
   *2     N153                153 154 171 .2445 *=2 .005537 .002316 .011436
                                          .2249 *=2 .005132 .001973 .009842 /
   *2     N154                154 155 171 .2249 *=2 .005132 .001973 .009842
                                          .2098 *=2 .004613 .001631 .008158 /
   *2     N155                155 156 171 .2098 *=2 .004613 .001631 .008158
                                          .1887 *=2 .003967 .001415 .006221 /
   *2     N156                156 157 171 .1887 *=2 .003967 .001415 .006221
                                          .1836 *=2 .003253 .001238 .007143 /
   *2     N157                157 158 171 .1836 *=2 .003253 .001238 .007143
                                          .1659 *=2 .002741 .001092 .005447 /
   *2     N158                158 159 171 .1659 *=2 .002741 .001092 .005447
                                          .1570 *=2 .002446 .000986 .004886 /
   *2     N159                159 160 171 .1570 *=2 .002446 .000986 .004886
                                          .1494 *=2 .002200 .000899 .004474 /
   *2     N160                160 161 171 .1494 *=2 .002200 .000899 .004474
                                          .1402 *=2 .001923 .000797 .003980 /
```


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  *2     N161              161 162 171 .1402 *=2 .001923 .000797 .003980
                                 .1332 *=2 .001711 .000738 .003680 /
  *2     N162              162 163 171 .1332 *=2 .001711 .000738 .003680
                                 .1266 *=2 .001527 .000682 .003389 /
  *2     N163              163 164 171 .1266 *=2 .001527 .000682 .003389
                                 .1201 *=2 .001352 .000625 .003110 /
  *2     N164              164 165 171 .1201 *=2 .001352 .000625 .003110
                                 .1131 *=2 .001184 .000558 .002794 /
  *2     N165              165 166 171 .1131 *=2 .001184 .000558 .002794
                                 .1071   *=2 .001025 .000526 .002619 /
  *2     N166              166 167 171 .1071   *=2 .001025 .000526 .00261
                                 .1015 *=2 .000903 .000482 .002386 /
  *2     N167              167 168 171 .1015 *=2 .000903 .000482 .002386
                                 .0953 *=2 .000778 .000430 .002135 /
  *2     N168              168 169 171 .0953 *=2 .000778 .000430 .002135
                                 .0906 *=2 .000683 .000401 .001985 /
  *2     N169              169 170 171 .0906 *=2 .000683 .000401 .001985
                                 .0830 *=2 .000546 .000344 .001707 /
END ELEMENT DATA  /
END STIFFNESS DATA   /
BEGIN BC DATA  /
SUPPORT SYMM IN SURFACE 2 THROUGH 50    /
SUPPORT TX TY TZ RX RY RZ FOR 50 501 502 503   /
FREE    RX RY RZ FOR 50 /
RETAIN  TY RX RZ FOR 51 53 56 59 60 62 64 66 68 70 71 77 78 /
RETAIN  TY RX RZ FOR 80 81 82 83 84   74 /
RETAIN  TY RX RZ FOR 103 107 112 118 121 /
RETAIN  TX TY TZ RX RY RZ FOR 1501 152 154 157 161 165 169  /
END BC DATA /
BEGIN MASS DATA     /
BEGIN CONDITION DATA  /
STAGE 1 CONDITION 1 0 C 1 /
END CONDITION DATA      /
BEGIN CONCENTRATED MASS DATA 1     /
*/ FIN MASS DATA              /
  FINP1 103 203  I=M1  .1591   .3415   .8430    .6080      /
  FINP2 107 207  I=M1  .2029   .9505  5.0475   4.3955      /
  FINP3 112 212  I=M1  .2459   .7300  4.8615   4.5360      /
  FINP4 118 218  I=M1  .3666  1.0165  5.7665   5.1225      /
  FINP5 121 221  I=M1  .2543  1.2115  4.4285   3.6400      /
*/ BODY MASS DATA            /
  ABSEC6SH     80         .3125 15.0625 12.5485  14.7025      /
  ABSEC7SH     81         .2675 12.5555 11.5425  12.2730      /
  ABSEC8SH     82         .1115  3.3330  2.6840   3.0415      /
  ABSEC9SH     83         .1570  3.2900  2.8550   3.2485      /
  ABSEC10SH    84         .1215  1.3095  8.6950   9.4100      /
  ABSEC6SP     53   85  1.4360   .7255 14.7140  14.8205      /
  ABSEC7SP     59   86   .8935   .9550  9.6910   9.7735      /
  ABSEC8SP     64   87   .3440   .2420  1.9250   1.8990      /
  ABSEC9SP     68   88   .2495   .1525  1.0920   1.0865      /
  ABSEC10SP    71   89   .1210   .0675    4190    .4025      /
  BASIC6       51   90  1.2965  5.5090   .7155   2.8245      /
  BASIC7       60   91   .2840   .4665   .3615    .1490      /
  VTATT        74   92   .2000   .8530   .6980    .2750      /
  MOTOR        78   79   .1507   .0165   .0935    .0935      /
  MOTORSUP     77        .1068   .23025  .58005   .4973      /
  SEC6ATT      56        .0005   .00005  .00005   .00005     /
  SEC7ATT      62        .0005   .00005  .00005   .00005     /
  SEC8ATT      66        .0005   .00005  .00005   .00005     /
  SEC9ATT      70        .0005   .00005  .00005   .00005     /
*/  STABILIZER MASS DATA    /
SPANEL0 1501 250 .25335 .1465 .2634  .23855  /
SPANEL1 152 252     .247     .269222  1.527759  1.716580      /
SPANEL2 154 254     .1358    .173      1.088-49  1.169249      /
SPANEL3 157 257 .2419 .358 1.26  1.56522       /
SPANEL4 161 261     .2609    .368475   .821968  1.129243      /
SPANEL5 165 265     .1961    .269449   .526398   .759347      /
SPANEL6 169 269     .1489    .275112   .342002   .574814      /
      END CONCENTRATED MASS DATA /
      BEGIN FACTOR        DATA    /
```

```
EXCLUDE STIFFNESS ELEMENTS  /
      END FACTOR        DATA /
      END MASS DATA   /
BEGIN SUBSET DEFINITION        /
SUBSETS OF STIFFNESS  SET  1  /
N001 =   59 60 62 64 66 68 70 71 77      /     BODY
N002 = 74 103 107 112 118 121   /                FIN
N003 = 1501 152 154 157 161 165 169     /              STAB
N004 = ALL    /  PLOT SET
  EXCLUDE 500 171 FROM N004  /
E004 = ALL   / ELEMENT PLOT SET
END SUBSET DEFINITION  /
BEGIN DUBLAT DATA  /
CASE 1 /
BEGIN GEOMETRY DATA /
LIFTING SURFACE DATA /
PANEL HTAIL  98.155 110.454 101.107 107.257 0.0 23.062 41.249 39.6363   /
CHORD DIV  0. .1 .2  .4  .62 .81 1.0  /
SPAN  DIV  0. .1 .2  .3  .4  .5  .6  .7  .8  .9  1.0   /
PANEL  TAILF  93.15 114.37  93.15  113.278  0. 0. 43.5 41.249   /
CHORD DIV  0. .1 .2487 .310 .3709  .4931 .6275 .7436 .8597 1.0 /
SPAN  DIV  0. .5  1.0   /
PANEL  TAILU  93.15  113.278  93.15  112. 0. 0. 41.249  38.5 /
CHORD DIV  0. .1 .2487 .310 .3709  .4931 .6275 .7436 .8597 1.0 /
SPAN  DIV  0. .5  1.0   /
PANEL  TAILM  93.15  112.  91.55  110.45  0. 0. 38.5  35.094 /
CHORD DIV  0. .1 .2487 .310 .3709  .4931 .6275 .7436 .8597 1.0 /
SPAN  DIV  0. .5  1.0   /
PANEL  TAILL  91.55  110.45  85.404 104.280  0. 0. 35.094  21.905  /
CHORD DIV  0. .1 .2487 .310 .3709  .4931 .6275 .7436 .8597 1.0 /
SPAN  DIV  0.  .125  .25  .375  .50  .625  .75  .875  1.0  /
INTERFERENCE SURFACE DATA  /
BODY  ABODY          /
PANEL TOPBD  60.2 111.1 60.2 111.1 0. 1.45 21.905  21.905   /
CHORD  DIV      .0 .2365 .3919 .4952 .5323 .5874 .6101 .6327 .6780
       .7279 .7709 .8140 .8660 1.0  /
SPAN   DIV      0.  1.0   /
PANEL USIDE  60.2 111.1 60.2 111.1 1.450 3.5 21.905  19.855   /
CHORD  DIV      .0 .2365 .3919 .4952 .5323 .5874 .6101 .6327 .6780
       .7279 .7709 .8140 .8660 1.0  /
SPAN  DIV  0. 1.0  /
PANEL VSIDE  60.2 111.1 60.2 111.1 3.5 3.5 19.855  16.955   /
CHORD  DIV      .0 .2365 .3919 .4952 .5323 .5874 .6101 .6327 .6780
       .7279 .7709 .8140 .8660 1.0  /
SPAN   DIV      0.      1.0 /
PANEL LSIDE  60.2 111.1 60.2 111.1 3.5 1.450 16.955  14.905   /
CHORD  DIV      .0 .2365 .3919 .4952 .5323 .5874 .6101 .6327 .6780
       .7279 .7709 .8140 .8660 1.0  /
SPAN  DIV  0. 1.0  /
PANEL BOT3D  60.2 111.1 60.2 111.1 1.45 0. 14.905  14.905   /
CHORD  DIV      .0 .2365 .3919 .4952 .5323 .5874 .6101 .6327 .6780
       .7279 .7709 .8140 .6660 1.0  /
SPAN  DIV  0. 1.0  /
DOUBLET DATA  /
BODY  ABODY   0.  18.247  YDOUBLET  /
AXIS DIV   60.2  72.24  89.15  85.404 87.2916 90.0985 91.2556 92.4061
  94.7118 97.2487 99.44 101.6317 104.28 111.1   /
 RADII  0.1 2. 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 0.1  /
END GEOMETRY DATA  /
BEGIN SUBSET DATA  /
SUBSETS OF BOXES    /
SUBSET S1 1 TO 6 /
SUBSET S2 7 TO 60 /
SUBSET F1 61 TO 78 /
SUBSET F2 79 TO 87 /
SUBSET F3 88 TO 96 /
SUBSET F4 97 TO 141 /
SUBSET F5 142 TO 186 /
SUBSET  UPBOD  187 TO 199 BY 1   /
SUBSET  USBOD  200 TO 212 BY 1   /
SUBSET  SIBOD  213 TO 225 BY 1   /
```

```
SUBSET  LSBOD  226 TO 238 BY 1   /
SUBSET  BOBOD  239 TO 251 BY 1   /
SUBSETS OF STRIPS  /
SUBSET SS1 1 /
SUBSET SS2 2 /
SUBSET SS3 3 /
SUBSET SS4 4 /
SUBSET SS5 5 /
SUBSET SS6 6  /
SUBSET SS7 7 /
SUBSET SS8 8 /
SUBSET SS9 9 /
SUBSET SS10 10 /
SUBSET FS1 11 /
SUBSET FS2 12 /
SUBSET FS3 13 /
SUBSET FS4 14 /
SUBSET FS5 15 /
SUBSET FS6 16 /
SUBSET FS7 17 /
SUBSET FS8 18 /
SUBSET FS9 19 /
SUBSET FS10 20 /
SUBSET FS11 21 /
SUBSET FS12 22 /
SUBSET FS13 23 /
SUBSET FS14 24 /
END SUBSET DATA  /
BEGIN MODAL DATA /
USE C0002 WITH LIFTING SURFACE  F1 F2 F3 F4 F5         /
USE C0003 WITH LIFTING SURFACE  S1 S2       /
USE C0001 WITH INTERF  BODY  ABODY       /
USE C0001 WITH BODY DOUBLET  ABODY     /
END MODAL DATA  /
BEGIN OPTION DATA /
VELOCITY PROFILES  /
PROFILE VPROH DLE1 160. DTE1 -64. 0. 0. .005 .843 .0125 1. .025 1.095
.05 1.17 .075 1.166 .1 1.153 .125 1.14 .15 1.14 .175 1.14 .2 1.145
.25 1.149 .3 1.158 .35 1.158 .4 1.153 .5 1.127 .6 1.086 .7 1.039
.75 1.02 .8 1.005 .85 .99 .9 .964 .95 .927 .975 .854 .99 .742 1. 0. /
PROFILE VPROF DLE1 160. DTE1 -64. 0. 0. .005 .775 .0125 1. .025 1.118
.05 1.204 .075 1.192 .1 1.17 .125 1.158 .15 1.158 .175 1.158 .2 1.162
.25 1.166 .3 1.17 .35 1.17 .4 1.166 .5 1.14 .6 1.091 .7 1.044 .75 1.02
.8 1.005 .85 .975 .9 .938 .95 .90 .975 .877 .99 .854 1. 0. /
USE VPROH ON SS1 SS2 SS3 SS4 SS5 SS6 SS7 SS8 SS9 SS10 /
USE VPROF ON       FS1 FS2 FS3 FS4 FS5 FS6 FS7 FS8 FS9 FS10 FS11 FS12 FS13
   FS14    /
PRESSURE CORRECTIONS /
USE .4092 0.0 AS SCALAR ON S1 /
USE .8930 0.0 AS SCALAR ON S2 /
USE .775  0.0 AS SCALAR ON F2 /
USE .8700 0.0 AS SCALAR ON F3   /
END OPTION DATA   /
END DUBLAT DATA  /
BEGIN AF1 DATA /
CASE 1 /
BEGIN GEOMETRY DATA /
MAIN SURFACE HTAIL  /
LEADING EDGE 98.155 0.0 41.249 101.107 23.062 39.6363   /
TRAILING EDGE 110.454 0.0 41.249 107.257 23.062 39.6363    /
STRIP FRACTIONS .1 .2 .3 .4 .5 .6 .7 .8 .9 /
MAIN SURFACE VTAIL /
LEADING EDGE 93.15 0.0 43.5 93.15 0.0 38.5 91.55 0.0 35.094
             85.404 0.0 21.905 /
TRAILING EDGE 114.37 0.0 43.5 113.278 0.0 41.249 112.0 0.0 38.5
             110.45 0.0 35.054 104.28 0.0 21.905 /
STRIP DISTANCES 1.1255 3.6255 6.703 10.0546 11.7033 13.3519 15.0005
             16.649 18.2978 19.9464 /
END GEOMETRY DATA /
BEGIN MODAL DATA /
USE C0002 WITH MAIN SURFACE VTAIL /
```

```
USE C0003 WITH MAIN SURFACE HTAIL /
END MODAL DATA /
END AFI DATA /
  BEGIN FLUTTER DATA     /
CASE  1  /
ALTITUDE    0.0     /
END FLUTTER DATA    /
END PROBLEM DATA /
```

Table 212-1. Natural Frequencies, YC-14 Empennage

(1) Mode Number	Frequency (Hertz) (2) Experimental	(3) ATLAS	(4) $\frac{(3)-(2)}{(2)} \times 100$ (%)
1	4.87	4.90	0.6
2	6.90	6.77	-1.9
3	11.30	11.22	-0.7
4	26.60	28.62	7.6
5	41.55	41.98	1.0

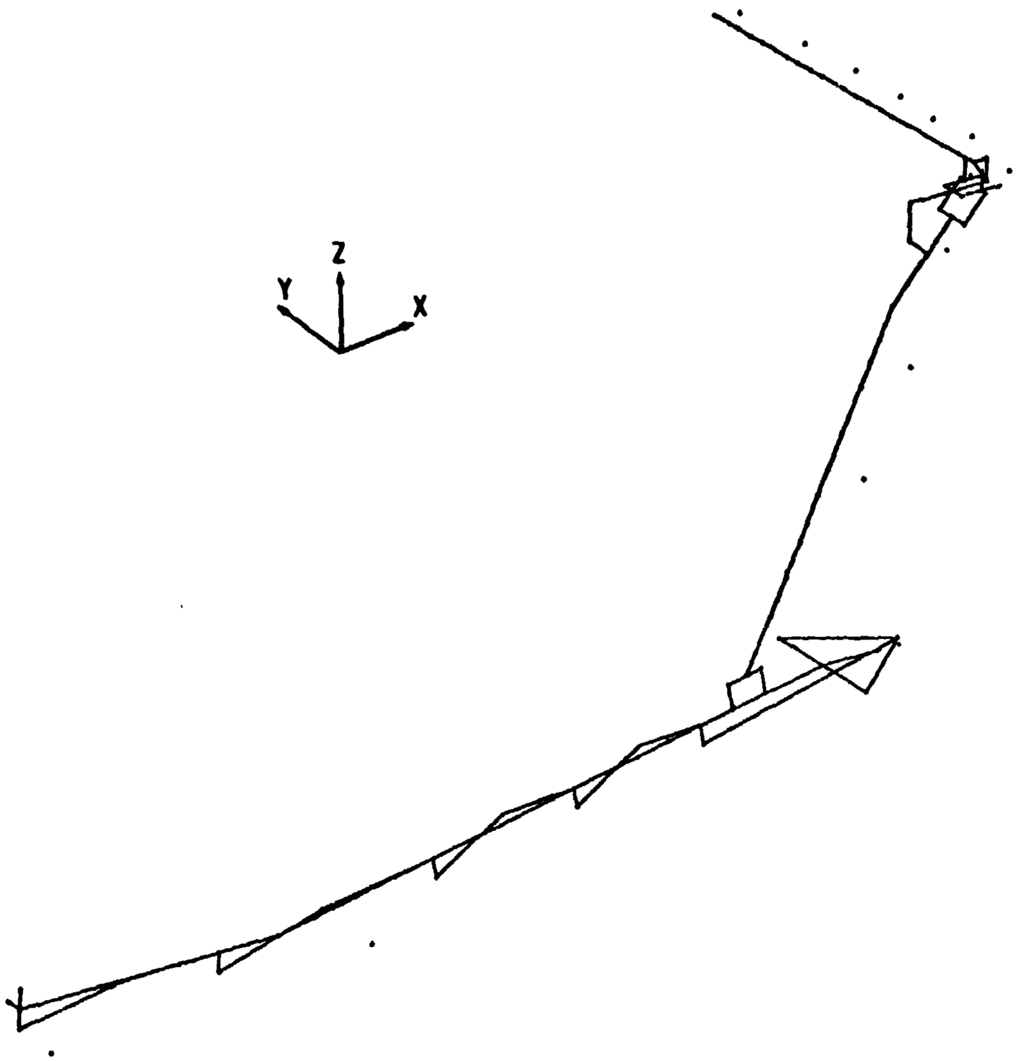

Figure 212-1. Structural Model, YC-14 Empennage

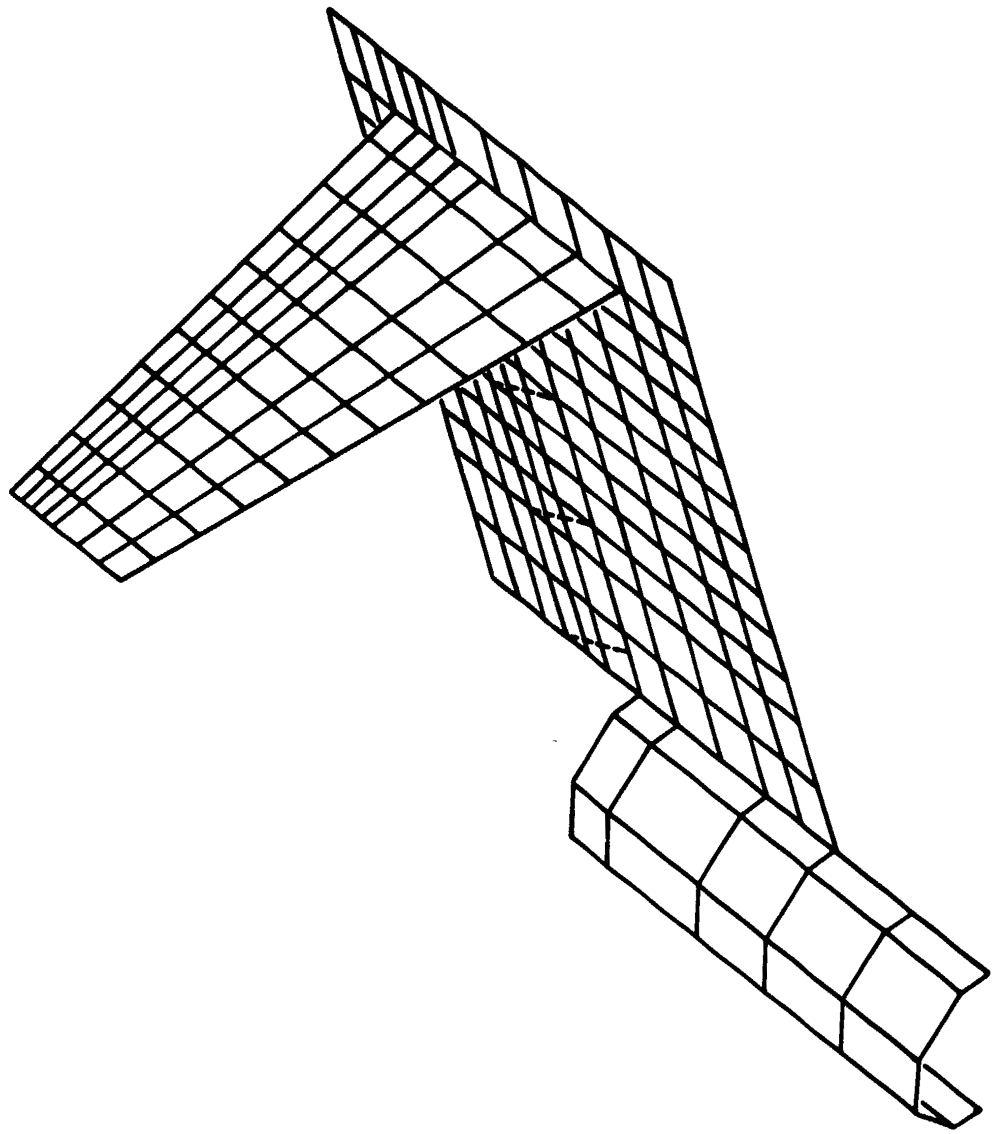

Figure 212-2. Aerodynamic Modeling for YC-14 Empennage Surfaces

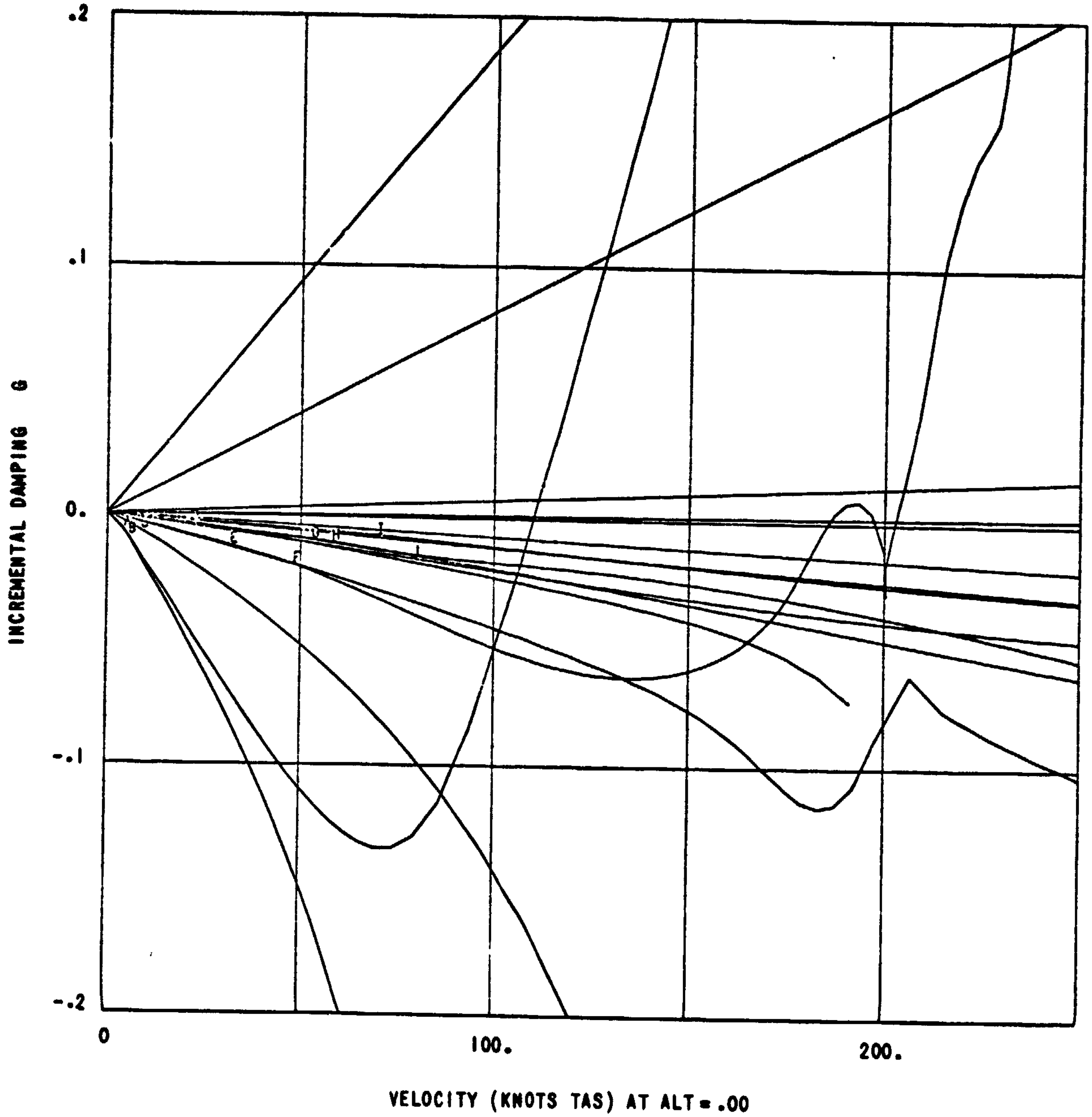

Figure 212-3. V-g Plot, YC-14 Empennage

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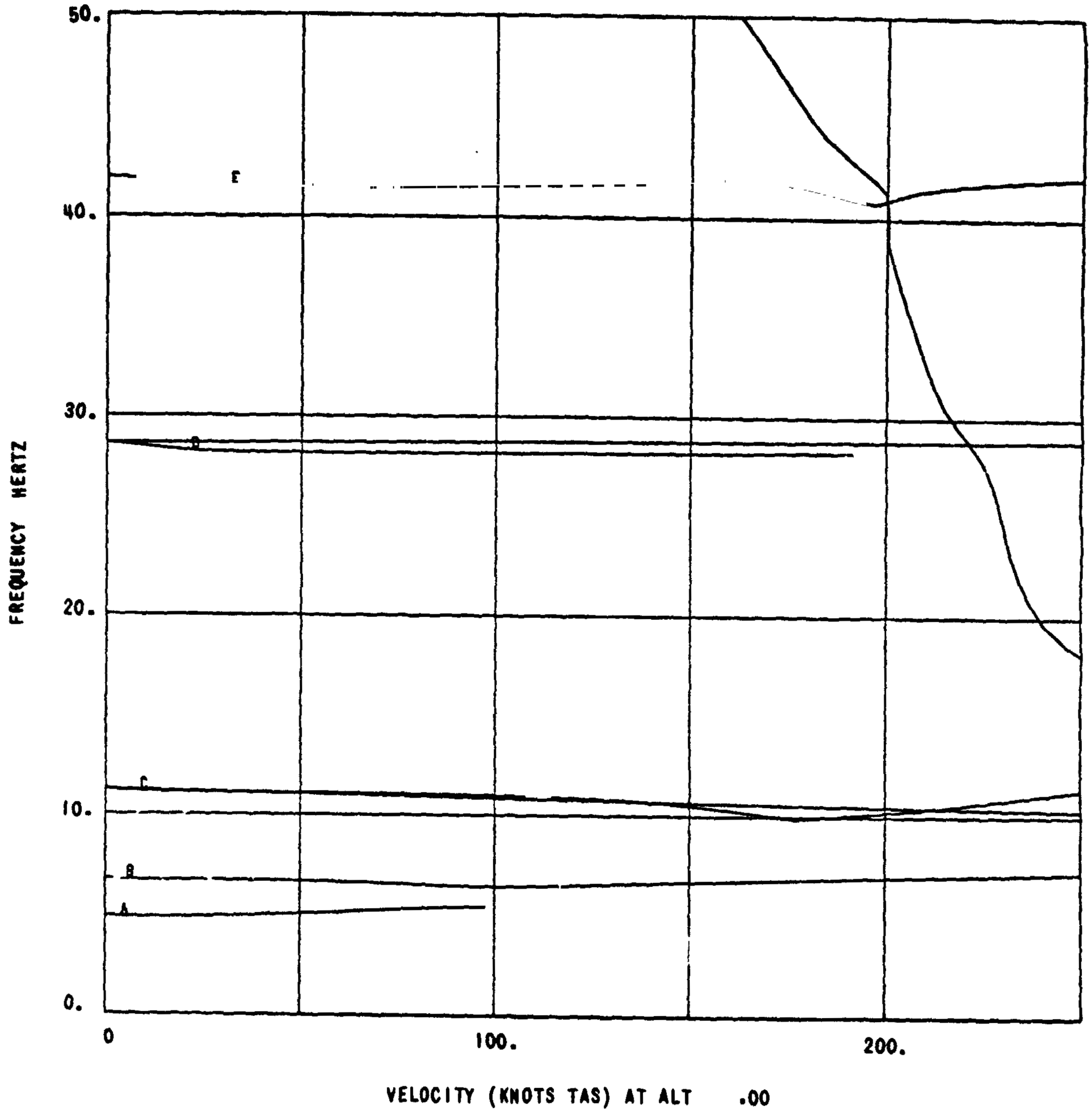


Figure 212-4. V-f Plot, YC-14 Empennage

213. 3D STRESS ANALYSIS OF A ROTATING DISK (DECK 12)

213.1 DESCRIPTION OF ANALYSIS

A 3D stress analysis is performed on a rotating disk subjected to the following loads:

- Inertia loads due to angular velocity and acceleration
- Pressure in central hole and on rim
- Thermal loading

The disk is shown in figure 213-1. Rotation is about an axis perpendicular to the plane of the disk. The pressures act in the plane of the disk and are uniform through the thickness of the disk. Two thermal loadcases are applied: a uniform temperature increase and a temperature increase varying linearly in the radial direction and uniform through the thickness.

A 30° sector of the disk is modelled using 20-node BRICK elements. Only one-half of the thickness is modelled and symmetry enforced upon the mid-surface. The model is shown in figure 213-2.

213.2 RESULTS

Radial and tangential stress components due to constant angular velocity, ω, are presented in figure 213-3. The solid lines represent the theory of elasticity solution (ref. 213-1).

Shear stresses due to angular acceleration, α, are presented in figure 213-4. The solid line represents the theory of elasticity solution (ref. 213-2).

Radial and tangential stress components due to pressure loading in the bore and on the rim are presented in figures 213-5 and 213-6, respectively. The solid lines represent the theory of elasticity solution (ref. 213-1).

Element stresses due to the uniform temperature increase are zero within the accuracy of the computer. Displacements are also exact within machine accuracy. Radial and tangential stress components due to the radial temperature gradient are presented in figure 213-7. The solid lines represent the theory of elasticity solution (ref. 213-1).

213.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL PROGRAM DEMO12
      PROBLEM ID(DEMO12 - 3D STRESS ANALYSIS OF A ROTATING DISK)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. 3D STRESS ANALYSIS
C                       2. THERMAL LOADING
C                       3. INERTIA LOADING
C
C     CORE           140K (OCTAL)
C
C     AUTHOR         R. A. SAMUEL
C
      READ INPUT(MODE2)
      PRINT INPUT (NODAL)
      PRINT INPUT(MATERIAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(BC)
      PRINT INPUT(LOADS)
      EXECUTE EXTRACT(EXNAME=DISK,LSUB=KGRID,ESUB=E1,NSUB=N1)
      EXECUTE GRAPHICS(GNAME=BRICKS,OFFLINE=CALCOMP,RZ=30,RX=0,RY=20,
     X            TYPE=ORTH,SIZE=(20.,20.),LABEL=E,EXNAME=DISK)
      EXECUTE MASS(OPTION=4)
      PERFORM STRESS
      PRINT OUTPUT(LOADS)
      PRINT OUTPUT(DISP,CYL)
      PRINT OUTPUT(STRESS)
      PRINT OUTPUT(REACTIONS,EQCHK)
      PRINT INPUT(BC,STAGE=2)
      PRINT INPUT(LOADS,STAGE=2)
      EXECUTE LOADS(STAGE=2)
      EXECUTE MERGE(STIFFNESS,STAGE=2,KK11=11,KK13=13)
      EXECUTE MERGE(LOADS,STAGE=2,LL11=11,LL31=31)
      EXECUTE CHOLESKY(SOLVE,KK11,DD11,LL11)
      EXECUTE STRESS(STAGE=2,D1=DD11)
      EXECUTE MULTIPLY(RR31=[-LL31+KK13(T)*DD11])
      PRINT OUTPUT(LOADS,L11=LL11,L31=LL31,STAGE=2)
      PRINT OUTPUT(DISP,STAGE=2,CYL)
      PRINT OUTPUT(STRESS,STAGE=2)
      PRINT OUTPUT(REACTIONS,R31=RR31,EQCHK,STAGE=2)
      PURGE FILES(STIFRNF,STRERNF,LOADRNF)
      EXECUTE STIFFNESS(BIGBRICK)
      EXECUTE LOADS
      EXECUTE STRESS(D1=D11)
      PRINT OUTPUT(STRESS)
      PRINT OUTPUT(STRESS,BIGBRICK=NODAL)
      EXECUTE LOADS(STAGE=2)
      EXECUTE STRESS(STAGE=2,D1=DD11)
      PRINT OUTPUT(STRESS,STAGE=2)
      PRINT OUTPUT(STRESS,STAGE=2,BIGBRICK=NODAL)
      END CONTROL PROGRAM
```

```
BEGIN MATERIAL DATA
  M51 .1
  -200  11.3E6  .3  4.34E6  -.003
   400   9.3E6  .3  3.58E6   .003
END MATERIAL DATA
BEGIN NODAL DATA
ANALYSIS FRAME INPUT
 CYL CAN 0. 0. 0., 5. 0. 0., 0. 0. 5.
   1  .375 0. 0.   TO  3  .375  30.  0.
**2 11 .5  0. 0.    0 11  .5      0.  0.
**2 11 1.  0. 0.    0 11   1.     0.  0.
**1 11 1.375 0. 0. 0 11 1.375    0.  0.
  141  .375 0. .15 TO 143 .375 30. .15
**2 11 .5  0. 0.    0 11  .5      0.  0.
**2 11 1.  0. 0.    0 11   1.     0.  0.
**1 11 1.375 0. 0. 0 11 1.375    0.  0.
    8  .625 0. 0. TO  9 .625  30. 0.
**1 11 .5  0. 0.    0 11  .5      0.  0.
**1 11 .75  0. 0.   0 11 .75  0.  0.
**1 11 1.  0. 0.    0 11   1.     0.  0.
**1 11 1.125 0. 0. 0 11 1.125  0. 0.
   148 .625 0. .15 TO 149 .625 30. .15
**1 11 .5  0. 0.    0 11  .5      0.  0.
**1 11 .75  0. 0.   0 11 .75  0.  0.
**1 11 1.  0. 0.    0 11   1.     0.  0.
**1 11 1.125 0. 0. 0 11 1.125  0. 0.
    71 .375 0. .075 TO 73 .375 30. .075 BY 2
**2 11 .5 0. 0. 0 11 .5 0. 0. **
**2 11 1. 0. 0. 0 11 1. 0. 0. **
**1 11 1.375 0. 0. 0 11 1.375 0. 0. **
RESUME GLOBAL
  210  0.  0.  -1.
  211  0.  0.   1.
212  -9.7  -.26  .075
REORDER FROM 212
END NODAL DATA
BEGIN STIFFNESS DATA
BEGIN ELEMENT DATA
BRICK M51 1 3 143 141 12 14 154 152 2 73 142 71 13 84 153 82 8 9 149 148
**4 0 0 11 **19
BEAM N200 210 211  1 1.
END ELEMENT DATA
END STIFFNESS DATA
BEGIN BC DATA
  SET 1 STAGE 1 / SYMMETRIC BC
  SUPPORT TZ FOR 210
      SUPPORT  TT  FOR  1  TO  198
      SUPPORT ASYM IN SURFACE 3 THROUGH 1
  SET 1 STAGE 2 / ANTISYMMETRIC BC
      SUPPORT  TR  FOR  1  TO  198
      SUPPORT ASYM IN SURFACE 3 THROUGH 1
      SUPPORT TT FOR 1 TO 3 71 73 141 TO 143
SUPPORT TZ FOR 210
END BC DATA
BEGIN LOADS DATA
    LOAD CASE ID INTPRES ** PRESSURE IN HOLE *
    LOAD CASE ID RIMPRES ** PRESSURE ON RIM  *
    LOAD CASE ID OMEGA   ** CONSTANT OMEGA = 2000 *
    LOAD CASE ID THERM ** UNIFORM DELTA(T) *
    LOAD CASE ID THRMLIN ** DELTA(T) = 120*R - 270 *
    LOAD CASE ID BEAMLD ** AXIAL LOAD ON BEAM *
  BEGIN INERTIA LOAD DATA
     AXIS 210 211
       CASE OMEGA
          2000.
  END INERTIA LOAD DATA
  BEGIN ELEMENT LOAD DATA
     DIRECTION ELEMENT -1. 0. 0.
       CASE INTPRES
          1  1 10000.
       CASE RIMPRES
          5  2 789.
  END ELEMENT LOAD DATA
```

```
BEGIN ELEMENT THERMAL LOAD DATA
      CASE THERM
          1 TO 5  200.
END ELEMENT THERMAL LOAD DATA
BEGIN NCDAL THERMAL LOAD DATA
  CASE THRMLIN
    1 TO 3 71 73 141 TO 143  -225.
    8 9 148 149  -195.
    12 TO 14 82 84 152 TO 154 -165.
    19 20 159 160  -135.
    23 TO 25 93 95 163 TO 165 -105.
    30 31 170 171  -45.
    34 TO 36 104 106 174 TO 176  15.
    41 42 181 182 75.
    45 TO 47 115 117 185 TO 187 135.
    52 53 192 193  210.
    56 TO 58 126 128 196 TO 198 300.
END NCDAL THERMAL LOAD DATA
BEGIN NODAL LOAD CATA
  CASE BEAMLD
     211 FZ  1000.
ENC NODAL LOAD DATA
SET 1 STAGE 2
    LOAD CASE ID ALPHA    ** ALPHA = 5000 *
  BEGIN INERTIA LOAD DATA
     AXIS 210 211
       CASE ALPHA
          0.  5000.
  END INERTIA LOAC DATA
END LOACS DATA
BEGIN SUBSET DEFINITION
   SUBSETS OF STIFFNESS SET 1
      E1 = BRICKS
      N1 = ALL
      EXCLUDE 212 FROM N1
ENC SUBSET DEFINITION
ENC PROBLEM CATA
```

ν = Poisson's ratio
ρ = Mass density
ω = Angular velocity
α = Angular acceleration
T = Temperature
β = Coefficient of thermal expansion

a = 0.00953 m (0.375 in.)

b = 0.121 m (4.75 in.)

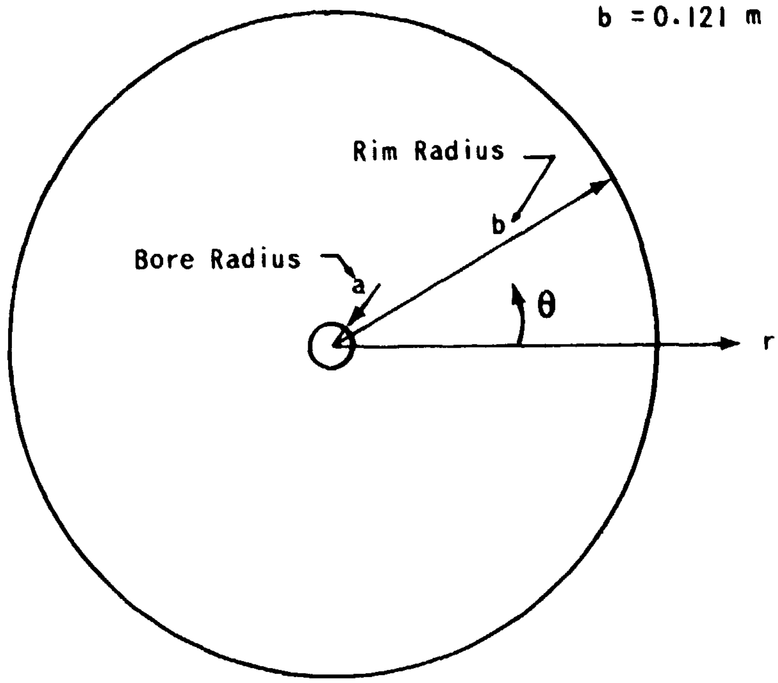


Figure 213-1. Disk

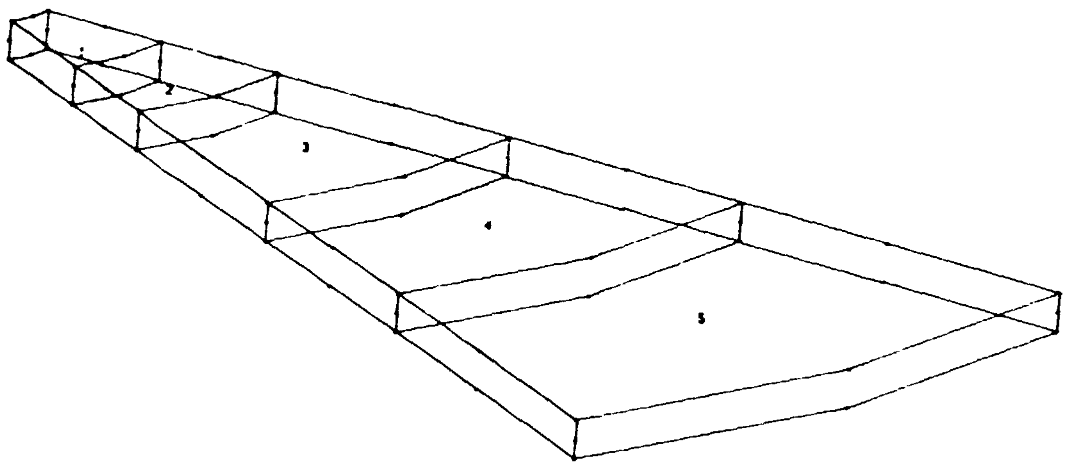


Figure 213-2. Model of Disk Segment

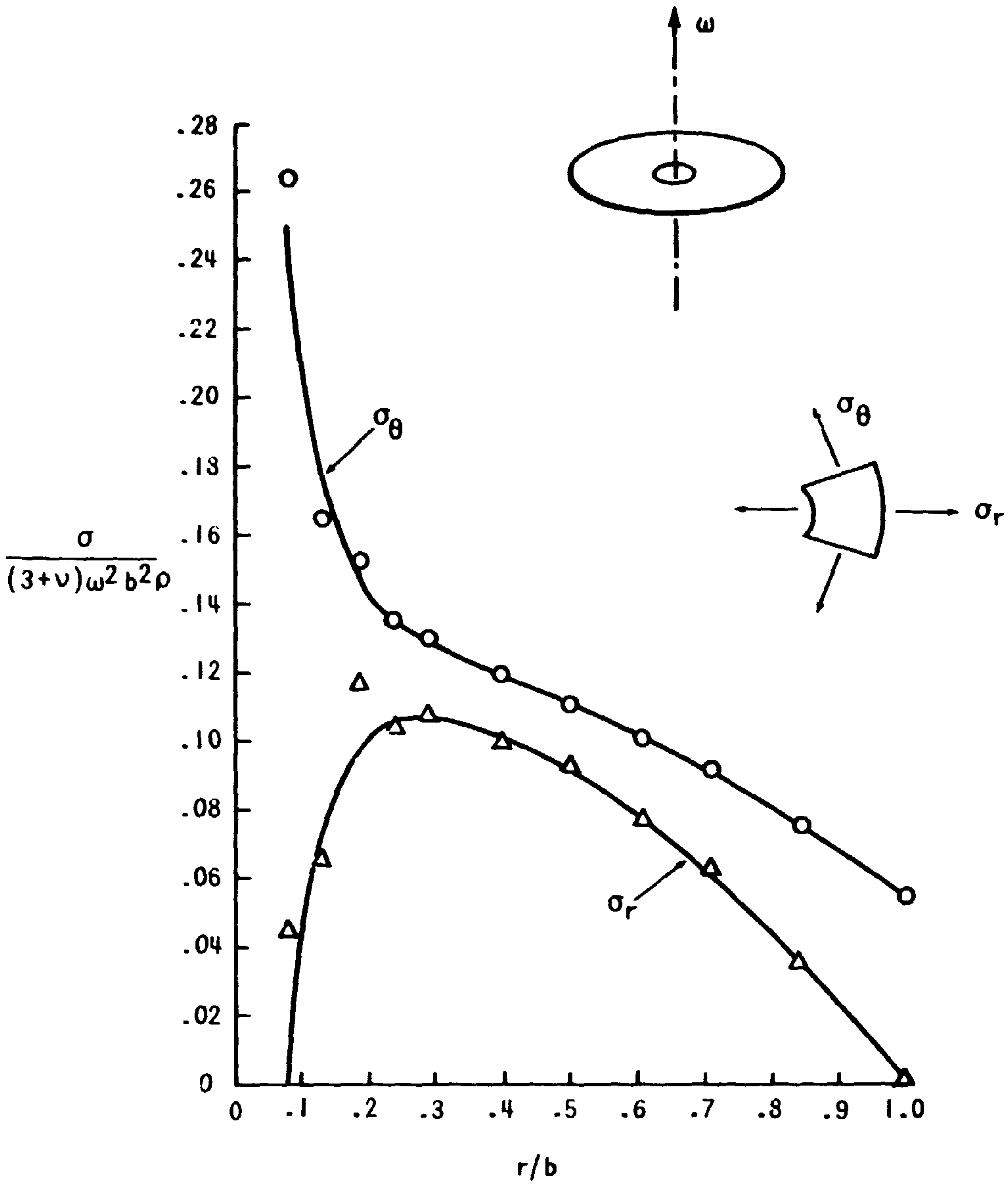


Figure 213-3. Stresses Due to Angular Velocity

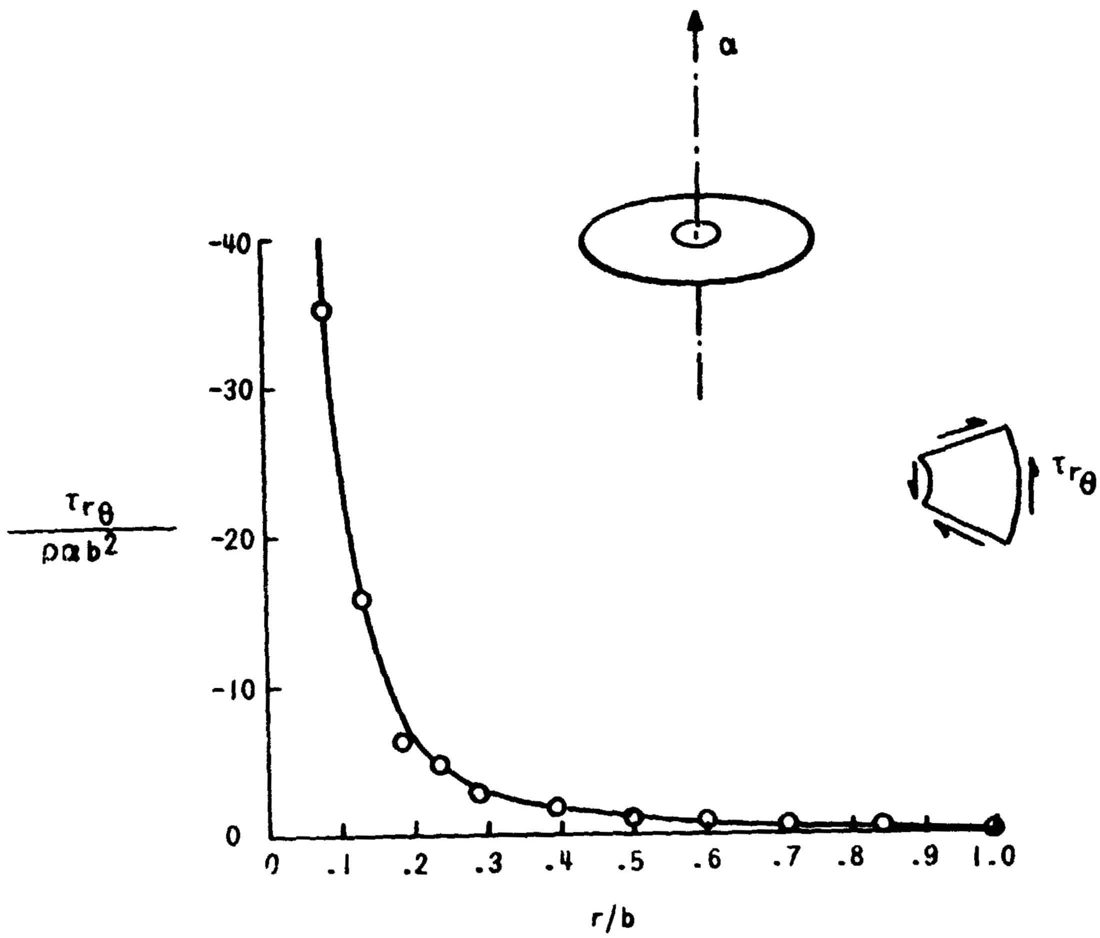


Figure 213-1. Stresses Due to Angular Acceleration

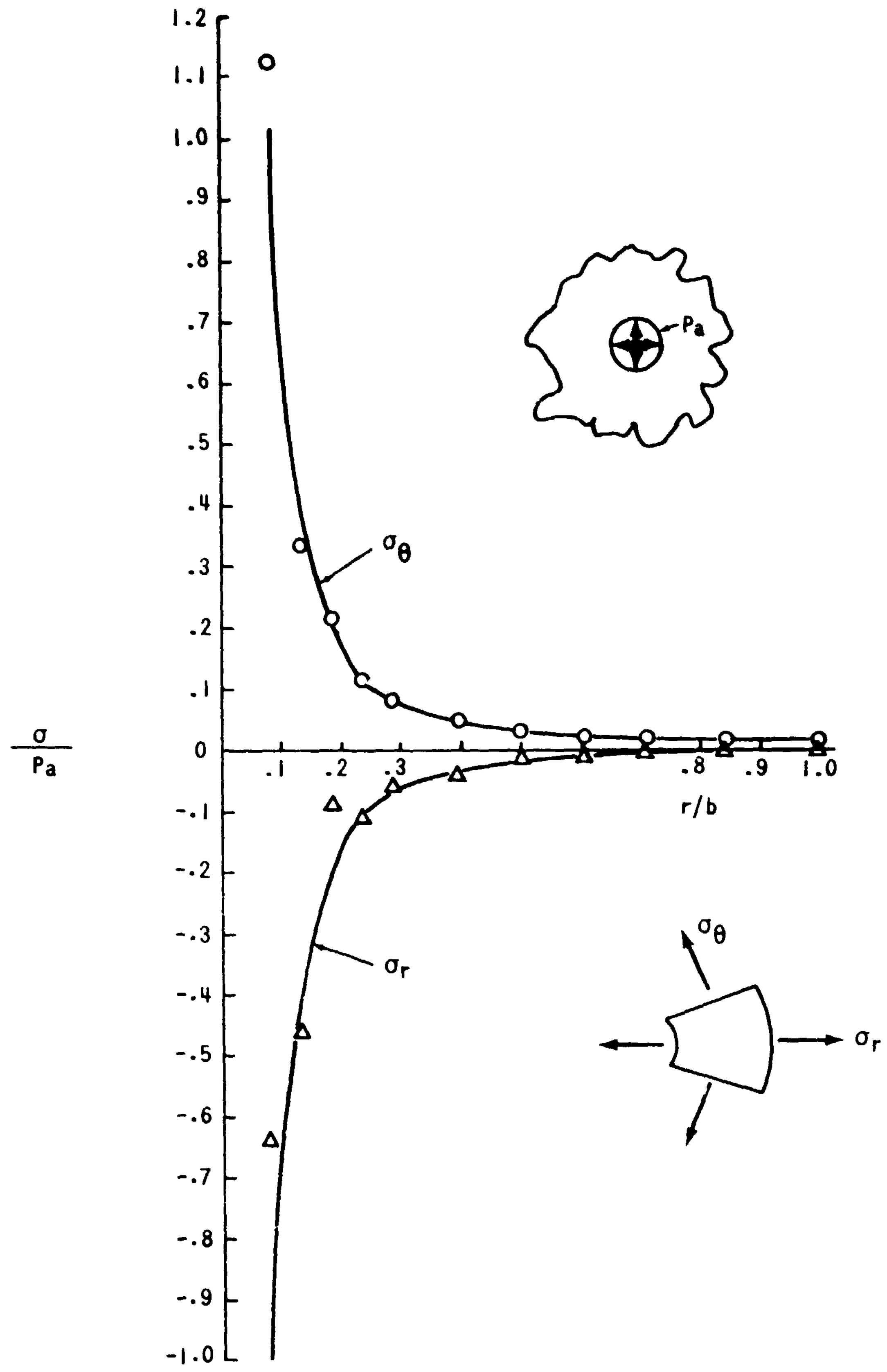


Figure 213-5. Stresses Due to Bore Pressure

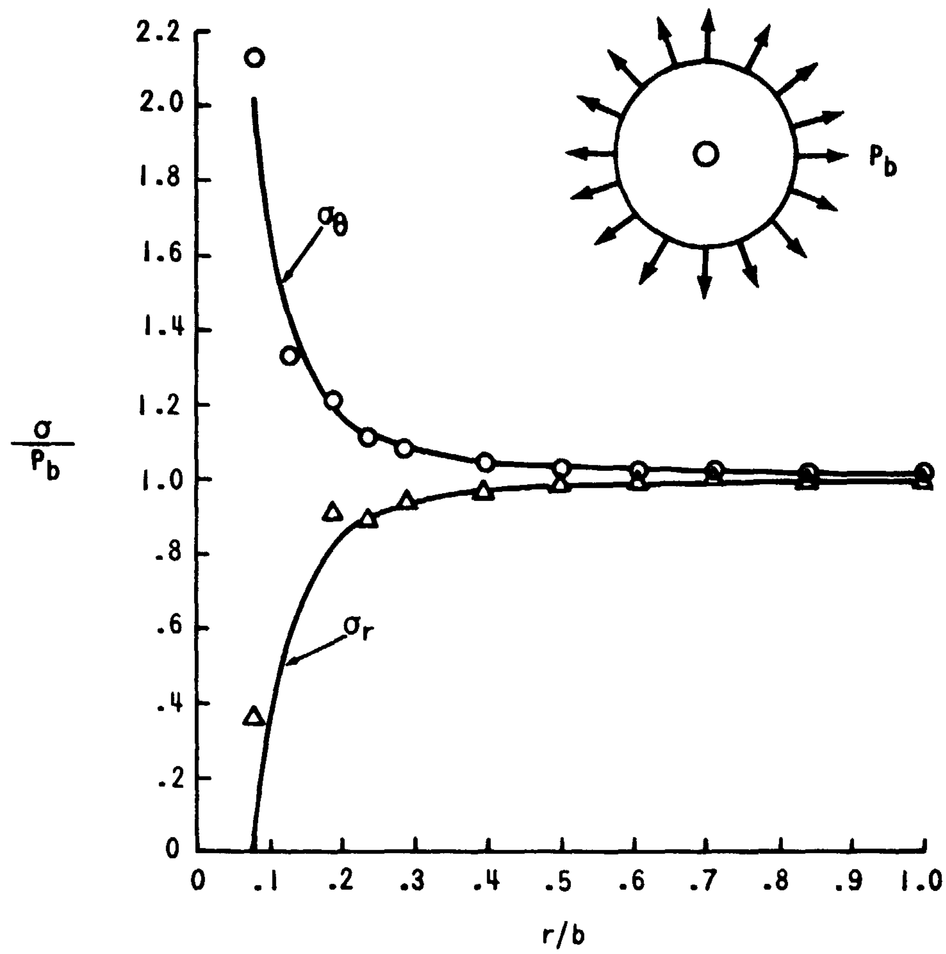
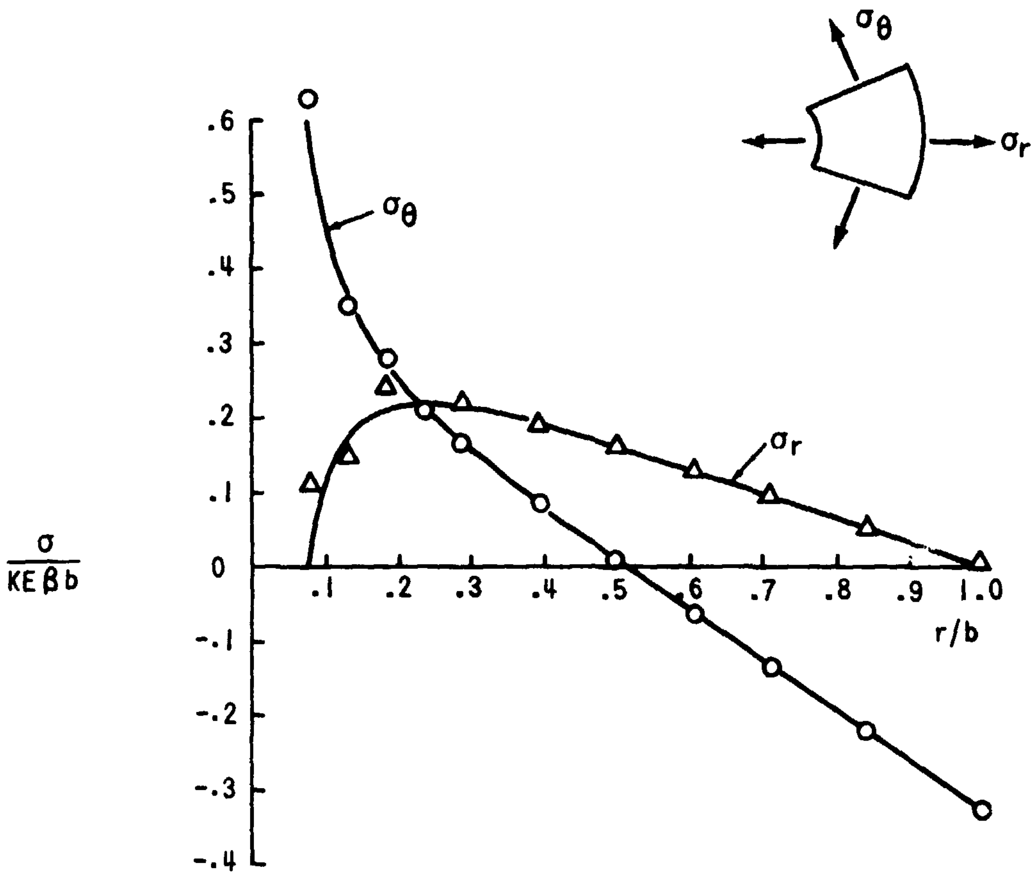


Figure 213-6. Stresses Due to Rim Pressure



Linear thermal gradient from center to rim,

$\Delta T = Kr$

Figure 213-7. Stresses Due to Thermal Loading

301. ATLAS/FLEXSTAB INTERFACES (DECKS 5 AND 6)

301.1 DESCRIPTION OF DEMONSTRATION

The method used to demonstrate the ATLAS-to-FLEXSTAB and FLEXSTAB-to-ATLAS interfaces is shown schematically in figure 301-1. The structural model is shown in figure 301-2. The body is modelled using BEAMs for the frames, RODs for stringers and SPLATEs for the surfaces. The wing is modelled using SPAR and COVER elements. All mass is obtained from a separate mass model consisting of mass PLATE elements and concentrated masses. The mass model is shown in figure 301-3. Symmetric and antisymmetric boundary conditions are imposed in the plane Y=0.

A reduced flexibility matrix is generated for each boundary condition stage. A diagonal mass matrix is produced directly by the Mass Processor. The interface routines MASSFIL and FLEXFIL are then executed to create the FLEXSTAB input tape NASTAP.

The FLEXSTAB system is executed, producing nodal loads for two symmetric conditions on the SDSS output tape. These nodal loads are read by the interface routine STREFIL and written onto the file DATARNF. The nodal loads are read from DATARNF by the Loads Preprocessor and used to perform an ATLAS stress analysis.

In addition to the stress analysis, the Mass Processor is executed to produce panel weights corresponding to the FLEXSTAB aerodynamic panels. These panel weights, together with airloads data from the SDSS output tape, are used by the routine VAMAT to calculate net shear, moment and torsion at various cuts along the wing and body. These net loads for each condition are searched by the routine VAMSCN to obtain the minimum and maximum values at each cut.

301.2 RESULTS

FLEXSTAB detected no errors while reading the ATLAS-generated NASTAP tape. The airloads calculated by FLEXSTAB appeared reasonable. No errors were detected by ATLAS while using the FLEXSTAB-generated SDSS tape. Displacements and stresses appeared reasonable.

Comparison of the VAMAT and VAMSCN results confirmed that the correct maxima and minima were found. The body bending moment, as calculated by VAMAT, is shown in figure 301-3.

301.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL MATRIX PROGRAM DEMO05
      PROBLEM ID (DEMO05 - ATLAS-TO-FLEXSTAB INTERFACE)
C
C     PURPOSE          THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                      DECK ARE
C                         1. ATLAS-TO-FLEXSTAB INTERFACE
C                         2. PLOTS OF MASS MODEL
C
C     AUTHOR           F. P. GRAY
C
C     CORE             130K (OCTAL)
C
      DIMENSION FET (100,3),FETS(550)
C
      READ INPUT
      PRINT INPUT(NODAL)
      PRINT INPUT(STIFFNESS)
      PRINT INPUT(MASS)
      EXECUTE EXTRACT(EXNAME=STIF,LSUB=KGRID,ESUB=E1,NSUB=N5)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=(ORTH,POINT),SIZE=(30.,20.),
     X                 OFFLINE=GERBER,RZ=30.,RX=0.,RY=20.,EXNAME=STIF)
      EXECUTE EXTRACT(EXNAME=MASS,LSUB=MGPID,ESUB=E4,NSUB=N6)
      EXECUTE GRAPHICS(GNAME=GEOM,TYPE=(ORTH,POINT),SIZE=(30.,20.),
     X                 RZ=30.,RX=0.,RY=20.,EXNAME=MASS)
      EXECUTE MASS(OPTION=2)
      PERFORM F-REDUCE(STAGE=1,[K]=[K1],[FRED]=[FLEX1])
      PERFORM F-REDUCE(STAGE=2,[K]=[K2],[FRED]=[FLEX2])
      PRINT INPUT(BC)
      CALL FILEADD(FET,MULTRNF,MASSRNF,DATARNF)
      CALL FETADD(SAVESSF,FETS,550,1,0,IRR)
      REWIND SAVESSF
      N=1
      CALL MASSFIL(7LMOD001A,N,N)
      CALL FLEXFIL(5LFLEX1)
      CALL FLEXFIL(5LFLEX2)
      END
```

```
BEGIN NODAL DATA /
1     20.    0.      1.       TO 9      340.      0.       65.      BY  2     /
101   20.    0.     -1.       TO 109    340.      0.      -65.      BY  2     /
201   20.    1.      0.       TO 209    340.      65.      0.       BY  2     /
11    420.   0.      65.      TO 83     3300.     0.       65.      BY  2     /
111   420.   0.     -65.      TO 189    3540.     0.      -65.      BY  2     /
211   420.   65.     0.       TO 225    980.      65.      0.       BY  2     /
265   2580.  65.     0.       TO 277    3060.     65.      0.       BY  2     /
287   3460.  65.     0.       TO 289    3540.     65.      0.       BY  2     /
*/   WING  COORDINATES    /
227   1060.  65.   0.  26.25  TO 245    1780.   65.    0.  36.35   BY  2     /
245                           TO 255    2180.   65.    0.  28.8    BY  2     /
255                           TO 263    2500.   65.    0.  12.0    BY  2     /
327   1060.  65.   0.  26.25  TO 341    1620.   265    0.   8.85   BY  2     /
445   1780.  195.  0.  22.65  TO 455    2180.   195.   0.  20.15   BY  2     /
541   1620.  265.  0.   8.85  TO 551    2205.   455.   0.   5.75   BY  2     /
651   2205.  455.  0.   5.75  TO 656    2545.   594.   0.   3.2              /
756   2545.  594.  0.   3.2   TO 760    2875.   765.   0.    .95             /
760                           TO 763    2995.   765.   0.   1.85             /
341                           TO 355    2180.   255.   0.  20.15   BY  2     /
355                           TO 363    2500.   265.   0.  11.25   BY  2     /
551                           TO 559    2525.   455.   0.  10.0              /
559                           TO 563    2685.   455.   0.   5.0              /
656                           TO 659    2665.   594.   0.   4.85             /
659                           TO 663    2825.   594.   0.   2.45             /
*/  HORIZONTAL TAIL  /
279 3140. 65. 0.  1.80                                                     /
779 3140. 65. 0.  1.80  TO 979 3365. 200. 0.  1.25  BY 100        /
281 3220. 65. 0.  4.25                                                     /
781 3220. 65. 0.  4.25  TO 981 3388. 200. 0.  1.75  BY 100        /
283 3300. 65. 0.  4.55                                                     /
783 3300. 65. 0.  4.55  TO 983 3412. 200. 0.  1.80  BY 100        /
285 3380. 65. 0.  1.40                                                     /
785 3380. 65. 0.  1.40  TO 985 3435. 200. 0.   .80  BY 100        /
*/  VERTICAL TAIL     /
REC  RECI 0. 0. 0. 1. 0. 0. 0. -1. 0.    /
85 3380. 65. 0.      3.25 /
87 3460. 65. 0.      2.40 /
1085 3460. 140. 0.  1.50 /
1087 3500. 140. 0.  1.80 /
*/   WING FIN            /
1156 2545. .1 -594. 2.40 TO 1356 2830. 100. -594. 1.80 BY 100          /
1158 2625. .1 -594. 2.40 TO 1358 2842. 100. -594. 1.90 BY 100          /
1161 2745. .1 -594. 2.80 TO 1361 2850. 100. -594. 1.95 BY 100          /
1163 2825. .1 -594. 2.80 TO 1363 2870. 100. -594. 2.05 BY 100          /
     RESUME GLOBAL                                                     /
89    3540.  0.       65.                                              /
*/    WEIGHT PANELS - BODY                                             /
      6001  0.    0.   0.  TO   6016  3564.   0.   0.                  /
      6021  0.   65.   0.  TO   6036  3564.  65.   0.                  /
*/    WEIGHT PANELS - WING                                             /
      6100    741.0    65.0  0.   TO   6220  2487.0  594.0  0.   BY  20  /
      6100                        TO   6260  2487.0  594.0  0.   BY  80  /
      6180                        TO   6240  2487.0  594.0  0.   BY  20  /
      6260                        TO   6320  2884.0  794.0  0.   BY  20  /
      6110  2715.0   65.0   0.    TO   6170  2715.0  329.5  0.   BY  20  /
      6189  2715.0  329.5   0.    TO   6249  2874.0  594.0  0.   BY  20  /
      6266  2874.0  594.0   0.    TO   6326  3054.0  794.0  0.   BY  20  /
      6100  TO  6110                                                   /
*+3     20    0     20                                                 /
      6180  TO  6189                                                   /
*+3     20    0     20                                                 /
      6260  TO  6266                                                   /
*+3     20    0     20                                                 /
*/    WEIGHT PANELS - HOR TAIL                                         /
      6400  3124.   65.1  0.  TO  6403  3417.   65.1  0.               /
      6410  3386.  228.0  0.  TO  6413  3464.  228.0  0.               /
END NODAL DATA  /
```

```
BEGIN STIFFNESS DATA /
BEGIN ELEMENT DATA /
*/    WING  SPARS     /
SPAR  M5              227  329         .06  1.                                    /
SPAR   M5    247  447    .10  2.0     TO  253   453   BY 2 2                      /
SPAR  M5              329  331         .06  1.    TO     339   341   BY   2 2     /
SPAR  M5              341  543         .06  1.                                    /
SPAR  M5              543  545         .06  1.    TO     549   55.   BY   2 2     /
SPAR  M5              551  653         .06  1.                                    /
SPAR  M5              653  655         .06  1.                                    /
SPAR  M5              655  656         .06  1.                                    /
SPAR  M5              656  757         .06  1.                                    /
SPAR  M5              757  758         .06  1.    TO     759   760                /
SPAR  M5              263  363         .20  6.                                    /
SPAR  M5              363  563         .17  6.                                    /
SPAR  M5              563  663         .15  4.                                    /
SPAR  M5              663  763         .15  2.                                    /
SPAR  M5              229  329         .1   1.    TO     243   343   BY   2 2     /
SPAR  M5              245  445         .18  1.                                    /
SPAR  M5              445  345         .18  1.                                    /
SPAR  M5              447  347         .1   2.    TO     453   353   BY   2 2     /
SPAR  M5              255  455         .3   6.                                    /
SPAR  M5              455  353         .3   6.                                    /
SPAR  M5              257  357         .12  6.    TO     261   361   BY   2 2     /
SPAR  M5              343  543         .1   1.    TO     345   545   BY   2 2     /
SPAR  M5              347  547         .1   2.    TO     353   553   BY   2 2     /
SPAR  M5              355  555         .1   4.                                    /
SPAR  M5              357  557         .1   5.    TO     361   561   BY   2 2     /
SPAR  M5              553  653         .06  2.    TO     555   655   BY   2 2     /
SPAR  M5              556  656         .03  2.    TO     562   662                /
SPAR  M5              657  757         .03  1.    TO     662   762                /
*/   WING   RIBS /
SPAR  M5              445  447         .17  2.    TO     453   455   BY   2 2     /
SPAR  M5              341  343         .10  1.5   TO     361   363   BY   2 2     /
SPAR  M5              551  553         .10  2.    TO     553   555   BY   2 2     /
SPAR  M5              555  556         .10  2.    TO     562   563                /
SPAR  M5              656  657         .06  1.    TO     662   663                /
SPAR  M5              760  761         .15  .7    TO     762   763                /
*/    WING COVERS     /
COVER      M5    229 329 227      .03                                                  /
COVER      M5    229 329 331 231 .03                TO 241 341 343 243 BY 2 *=3   /
COVER      M5    243 343 445 245 .03                                               /
COVER      M5    445 345 343      .03                                              /
COVER  M5    245  247  447  445  .06  .0   TO 253 255 455 453 BY 2 *=3    /
COVER      M5    445 345 347 447 .03                TO 453 353 355 455 BY 2 *=3   /
COVER      M5    255 455 357 257 .05 .07                                           /
COVER      M5    455 355 357     .05 .07                                           /
COVER      M5    257 357 359 259 .05 .07                                           /
COVER      M5    259 359 361 261 .13 .07 .11 .0   TO 261 361 363 263 BY 2 *=3   /
COVER      M5    343 543 341      .03                                              /
COVER      M5    343 543 545 345 .03                TO 353 553 555 355 BY 2 *=3   /
COVER      M5    355 555 557 357 .05 .04            TO 357 557 559 359 BY 2 *=3   /
COVER      M5    359 559 561 361 .15 .07 .10 .0   TO 361 561 563 363 BY 2 *=3   /
COVER      M5    553 653 551      .15 .07 .11 .06                                  /
COVER      M5    553 653 655 555 .15 .07 .11 .06                                   /
COVER      M5    555 655 656 556 .15 .07 .11 .06 TO 562 662 663 563               /
COVER      M5    657 757 656      .04                                              /
COVER      M5    657 757 758 658 .04                TO 662 762 763 663            /
*/  HORIZONTAL  TAIL   /
SPAR  M5         279 879 .05 .6  /
SPAR  M5         879 979 .05 .6  /
SPAR  M5         281 881 .025 .9 /
SPAR  M5         881 981 .025 .9 /
SPAR  M5         283 883 .025 .8 /
SPAR  M5         883 983 .025 .8 /
SPAR  M5         285 885 .10  1.3 /
SPAR  M5         885 985 .10  1.3 /
SPAR  M5         879 881 .05 .6  TO 883 885 BY 2 2   /
SPAR  M5         979 981 .05 .6  TO 983 985 BY 2 2   /
COVER M5         279 879 891 281 .08    /
*+2 0 0   2 *=3   0.   /
COVER M5         879 979 981 881 .035 /
*+2 0 0   2 *=3   0.   /
*/ WING FIN       /
```

```
SPAR  M5       1156 1256 .025 .5  TO  1256 1356 BY 100 100  /
SPAR  M5       1158 1258 .025 .5  TO  1258 1358 BY 100 100  /
SPAR  M5       1161 1261 .025 .5  TO  1261 1361 BY 100 100  /
SPAR  M5       1163 1263 .025 .5  TO  1263 1363 BY 100 100  /
SPAR  M5       1256 1258 .025 .5  TO    1356 1358 BY 100 100  /
SPAR  M5       1258 1261 .025 .5  TO    1358 1361 BY 100 100  /
SPAR  M5       1261 1263 .025 .5  TO    1361 1363 BY 100 100  /
COVER M5       1156 1256 1258 1158 .025 TO 1256 1356 1358 1258
      BY 100 100 100 100         /
COVER M5       1158 1258 1261 1161 .025 TO 1258 1358 1361 1261
      BY 100 100 100 100         /
COVER M5       1161 1261 1263 1163 .025 TO 1261 1361 1363 1263
      BY 100 100 100 100         /
*/  VERTICAL TAIL  /
COVER M5          85 1085 1087   87 .0   0.035    /
BEAM M5 85 1085  0.5  0.1  0.1  50.  50.  50.    /
BEAM M5 1085 1087  0.5  0.1  0.1  50.  50.  50.    /
BEAM M5 87 1087  0.5  0.1  0.1  50.  50.  50.    /
*/    BODY   /
*/    STRINGERS      /
ROD    M5        1   3 2.37  TO  23 25 BY  2 2 /
*+2  0  0 100 100 0. 0 100 100 0 0 0 /
*+1  0 *=3 0. 0 *=5 /
ROD    M5        25 27 4.    TO 43 45 BY 2 2 /
*+2  0  0 100 100 0. 0 100 100 0 0 0 /
*+1  0 *=3 0. 0 *=5 /
ROD    M5        45 47 5.35 TO 67 69 BY 2 2 /
*+2  0  0 100 100 0. 0 100 100 0 0 0 /
*+1  0 *=3 0. 0 *=5 /
ROD    M5        69 71 4. TO 75 77 BY 2 2 /
*+2  0  0 100 100 0. 0 100 100 0 0 0 /
*+1  0 *=3 0. 0 *=5 /
ROD    M5        77 79 2.37 TO 87 89 BY 2 2 /
*+2  0  0 100 100 0. 0 100 100 0 0 0 /
*+1  0 *=3 0. 0 *=5 /
SPLATE M5      1    3 203 201 .04 TO 25 27 227 225 BY 2 **3 /
SPLATE M5    201 203 103 101 .04 TO 225 227 127 125 ** /
SPLATE M5     27   29 229 227 .06   TO  43  45 245 243 **  /
SPLATE M5    227 229 129 127 .06 TO 243 245 145 143 **  /
SPLATE M5     45   47 247 245 .08   TO  67   69 269 267  ** /
SPLATE M5    245 247 147 145 .08   TO 267 269 169 167   **  /
SPLATE M5     69   71 271 269 .06   TO  75   77 277 275   **  /
SPLATE M5    269 271 171 169 .06   TO 275 277 177 175   **  /
SPLATE M5     77   79 279 277 .04   TO   87 89 289 287   **  /
SPLATE M5    277 279 179 177 .04   TO 287 289 189 187   **  /
*/ BODY FRAMES     /
BEAM  M5    1 201   3. 0. 0. 50. 50. 50.   TO   27 227   BY  2 2    /
*+1 0 0 100 0 0. *=5 0 100 0 *=3    /
BEAM  M5  29 229 4.5 0. 0. 50. 50. 50.   TO  45 245   BY  2 2    /
*+1 0 0 100 0 0. *=5 0 100 0 *=3    /
BEAM  M5  47 247   6. 0. 0. 50. 50. 50.   TO  69 269   BY  2 2    /
*+1 0 0 100 0 0. *=5 0 100 0 *=3    /
BEAM  M5  71 271 4.5 0. 0. 50. 50. 50.   TO  77 277   BY  2 2    /
*+1 0 0 100 0 0. *=5 0 100 0 *=3    /
BEAM  M5  79 279   3. 0. 0. 50. 50. 50.   TO  89 289   BY  2 2    /
*+1 0 0 100 0 0. *=5 0 100 0 *=3    /
BEAM   9  209  14.0 0. 0. 75. 75. 75.    /
*+1 0 100 0 0. *=5  /
BEAM  27   227  14.0 0. 0. 75. 75. 75.    /
*+1 0 100 0 0. *=5  /
BEAM  45   245   62.  0. 0.  450. 450. 450.   /
*+1 0 100 0 0. *=5  /
BEAM  55   255   62.  0. 0.  450. 450. 450.   /
*+1 0 100 0 0. *=5  /
BEAM  63   263   62.  0. 0.  450. 450. 450.   /
*+1 0 100 0 0. *=5  /
BEAM  79   279  14. 0. 0. 75. 75. 75.    /
*+1 0 100 0 0. *=5  /
BEAM  85   285  14. 0. 0. 75. 75. 75.    /
*+1 0 100 0 0. *=5  /
```

```
*/   ATTACHMENT OF WING FIN    /
BEAM Z5 656 1156 663 1. 0. C. .1 .1 .1 /
BEAM Z5 658 1158 363 1. 0. C. .1 .1 .1 /
BEAM Z5 661 1161 663 1. 0. C. .1 .1 .1 /
BEAM Z5 663 1163 661 1. 0. C. .1 .1 .1 /
BEAM  Z5  656 658  10. 0. 0. 100. 100. 100.        /
BEAM  Z5  658 661  10. 0. 0. 100. 100. 100.        /
BEAM  Z5  661 663  10. 0. 0. 100. 100. 100.        /
BEAM Z5 89 289 0. 0. 0. 10000. **2    /
BEAM Z5 189 289  **     /
END ELEMENT DATA /
END STIFFNESS DATA  /
BEGIN BC DATA      /
*/ORDER BODY,FIN,WING-FIN,WING HORIZONTAL TAIL                          /
STAGE  1    /
     RETAIN TZ FOR 3 9 15 23 31 39 45 53 61 67 75 83 87 85 1085 1087  /
     RETAIN TZ TY FOR 1156 1356 1358 1158 1161 1361 1363 1163          /
     RETAIN TZ FOR 223 331 231 337 237 245 355 255 363 263
                   267 543 345 551 349 555 563 656 659 663
                   760 761 763 359 559 661 762 279 979 981
                   281 283 983 985 285                                  /
     SUPPORT TX TZ RY FOR 89                                            /
     SUPPORT ASYM IN SURFACE 2 THROUGH 1                                /
STAGE  2    /
     RETAIN TY TZ FOR 3 9 15 23 31 39 45 53 61 67 75 83 87              /
     RETAIN TZ TY FOR 85 1085 1087                                      /
     RETAIN TZ TY FOR 1156 1356 1358 1158 1161 1361 1363 1163           /
     RETAIN TZ FOR 223 331 231 337 237 245 355 255 363 263
                   267 543 345 551 349 555 563 656 659 663
                   760 761 763 359 559 661 762 279 979 981
                   281 283 983 985 285                                  /
     SUPPORT TX TY TZ RX RY RZ FOR 89                                   /
     SUPPORT SYMM IN SURFACE 2 THROUGH 1                                /
END BC DATA    /
BEGIN MASS DATA                                                          /
BEGIN CONDITION DATA                                                     /
      STAGE 1 CONDITION 1 0 0 1                                         /
END CONDITION DATA                                                      /
BEGIN MASS ELEMENT DATA       /
      PLATE F2  B-1    6001 6002 6022         3495.                          /
      PLATE F2  B-2    6002 6003 6023 6022    5955.                          /
      PLATE F2  B-3    6003 6004 6024 6023    2589.                          /
      PLATE F2  B-4    6004 6005 6025 6024    3440.                          /
      PLATE F2  B-5    6005 6006 6026 6025    5420.                          /
      PLATE F2  B-6    6006 6007 6027 6026    3280.                          /
      PLATE F2  B-7    6007 6008 6028 6027    3306.                          /
      PLATE F2  B-8    6008 6009 6029 6028    4346.                          /
      PLATE F2  B-9    6009 6010 6030 6029    4507.                          /
      PLATE F2  B-10   6010 6011 6031 6030    4486.                          /
      PLATE F2  B-11   6011 6012 6032 6031    3619.                          /
      PLATE F2  B-12   6012 6013 6033 6032    4730.                          /
      PLATE F2  B-13   6013 6014 6034 6033    3982.                          /
      PLATE F2  B-14   6014 6015 6035 6034     947.                          /
      PLATE F2  B-15   6015 6016 6036 6035    1788.                          /
      PLATE F2  W-1    6100 6101 6121 6120     768.                          /
      PLATE F2  W-2    6101 6102 6122 6121    1151.                          /
      PLATE F2  W-3    6102 6103 6123 6122    1667.                          /
      PLATE F2  W-4    6103 6104 6124 6123    1112.                          /
      PLATE F2  W-5    6104 6105 6125 6124    1190.                          /
      PLATE F2  W-6    6105 6106 6126 6125    1659.                          /
      PLATE F2  W-7    6106 6107 6127 6126    1988.                          /
      PLATE F2  W-8    6107 6108 6128 6127    2467.                          /
      PLATE F2  W-9    6108 6109 6129 6128    1335.                          /
      PLATE F2  W-10   6109 6110 6130 6129     338.                          /
      PLATE F2  W-11   6120 6121 6141 6140     795.                          /
      PLATE F2  W-12   6121 6122 6142 6141    1415.                          /
      PLATE F2  W-13   6122 6123 6143 6142    1813.                          /
      PLATE F2  W-14   6123 6124 6144 6143    1259.                          /
      PLATE F2  W-15   6124 6125 6145 6144    1248.                          /
      PLATE F2  W-16   6125 6126 6146 6145    1720.                          /
      PLATE F2  W-17   6126 6127 6147 6146    1494.                          /
      PLATE F2  W-18   6127 6128 6148 6147    1988.                          /
      PLATE F2  W-19   6128 6129 6149 6148     498.                          /
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    PLATE F2  W-20    6129 6130 6150 6149    126.                    /
    PLATE F2  W-21    6140 6141 6161 6160    508.                    /
    PLATE F2  W-22    6141 6142 6162 6161   1279.                    /
    PLATE F2  W-23    6142 6143 6163 6162    536.                    /
    PLATE F2  W-24    6143 6144 6164 6163    532.                    /
    PLATE F2  W-25    6144 6145 6165 6164    559.                    /
    PLATE F2  W-26    6145 6146 6166 6165   1055.                    /
    PLATE F2  W-27    6146 6147 6167 6166   1405.                    /
    PLATE F2  W-28    6147 6148 6168 6167   1953.                    /
    PLATE F2  W-29    6148 6149 6169 6168    274.                    /
    PLATE F2  W-30    6149 6150 6170 6169    172.                    /
    PLATE F2  W-31    6180 6181 6201 6200    614.                    /
    PLATE F2  W-32    6181 6182 6202 6201   1286.                    /
    PLATE F2  W-33    6182 6183 6203 6202    562.                    /
    PLATE F2  W-34    6183 6184 6204 6203    786.                    /
    PLATE F2  W-35    6184 6185 6205 6204   1386.                    /
    PLATE F2  W-36    6185 6186 6206 6205   1849.                    /
    PLATE F2  W-37    6186 6187 6207 6206   1649.                    /
    PLATE F2  W-38    6187 6188 6208 6207    421.                    /
    PLATE F2  W-39    6188 6189 6209 6208    255.                    /
    PLATE F2  W-40    6200 6201 6221 6220    207.                    /
    PLATE F2  W-41    6201 6202 6222 6221    497.                    /
    PLATE F2  W-42    6202 6203 6223 6222    692.                    /
    PLATE F2  W-43    6203 6204 6224 6223    765.                    /
    PLATE F2  W-44    6204 6205 6225 6224    816.                    /
    PLATE F2  W-45    6205 6206 6226 6225    843.                    /
    PLATE F2  W-46    6206 6207 6227 6226    687.                    /
    PLATE F2  W-47    6207 6208 6228 6227    136.                    /
    PLATE F2  W-48    6208 6209 6229 6228     94.                    /
    PLATE F2  W-49    6220 6221 6241 6240    136.                    /
    PLATE F2  W-50    6221 6222 6242 6241    522.                    /
    PLATE F2  W-51    6222 6223 6243 6242    516.                    /
    PLATE F2  W-52    6223 6224 6244 6243    536.                    /
    PLATE F2  W-53    6224 6225 6245 6244    555.                    /
    PLATE F2  W-54    6225 6226 6246 6245    580.                    /
    PLATE F2  W-55    6226 6227 6247 6246    704.                    /
    PLATE F2  W-56    6227 6228 6248 6247    119.                    /
    PLATE F2  W-57    6228 6229 6249 6248     91.                    /
    PLATE F2  W-58    6260 6261 6281 6280    289.                    /
    PLATE F2  W-59    6261 6262 6282 6281    306.                    /
    PLATE F2  W-60    6262 6263 6283 6282    244.                    /
    PLATE F2  W-61    6263 6264 6284 6283    507.                    /
    PLATE F2  W-62    6264 6265 6285 6284    116.                    /
    PLATE F2  W-63    626  6266 6286 6285     76.                    /
    PLATE F2  W-64    6280 6281 6301 6300    216.                    /
    P  TE F2  W-65    6281 6282 6302 6301    144.                    /
    PLATE F2  W-66    6282 6283 6303 6302    245.                    /
    PLATE F2  W-67    6283 6284 6304 6303    365.                    /
    PLATE F2  W-68    6284 6285 6305 6304     86.                    /
    PLATE F2  W-69    6285 6286 6306 6305     71.                    /
    PLATE F2  W-70    6300 6301 6321 6320    184.                    /
    PLATE F2  W-71    6301 6302 6322 6321    160.                    /
    PLATE F2  W-72    6302 6303 6323 6322    126.                    /
    PLATE F2  W-73    6303 6304 6324 6323    273.                    /
    PLATE F2  W-74    6304 6305 6325 6324     66.                    /
    PLATE F2  W-75    6305 6306 6326 6325     66.                    /
    PLATE F2  HT-1    6400 6401 6411 6410    283.                    /
    PLATE F2  HT-2    6401 6402 6412 6411    212.                    /
    PLATE F2  HT-3    6402 6403 6413 6412    522.                    /
*/ PLATES REPRESENTING FUEL                                       /
    PLATE F2  F-1     6102 6103 6123 6122    129.6                   /
    PLATE F2  F-2     6103 6104 6124 6123   8637.2                   /
    PLATE F2  F-3     6104 6105 6125 6124  12852.9                   /
    PLATE F2  F-4     6106 6107 6127 6126   5531.1                   /
    PLATE F2  F-5     6107 6108 6128 6127   6919.3                   /
    PLATE F2  F-6     6108 6109 6129 6128    107.1                   /
    PLATE F2  F-7     6124 6125 6145 6144    442.8                   /
    PLATE F2  F-8     6125 6126 6146 6145   5450.7                   /
    PLATE F2  F-9     6126 6127 6147 6146   6537.8                   /
    PLATE F2  F-10    6128 6129 6149 6148   2604.5                   /
    PLATE F2  F-11    6129 6130 6150 6149   4011.2                   /
    PLATE F2  F-12    6140 6141 6161 6160    762.0                   /
    PLATE F2  F-13    6144 6145 6165 6164    .28.9                   /
```

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      PLATE F2  F-14   6145 6146 6166 6165  2470.2                  /
      PLATE F2  F-15   6147 6148 6168 6167  1825.8                  /
      PLATE F2  F-16   6148 6149 6169 6168  4994.1                  /
      PLATE F2  F-17   6149 6150 6170 6169  2341.4                  /
      PLATE F2  F-18   6180 6181 6201 6200  3598.6                  /
      PLATE F2  F-19   6184 6185 6205 6204   268.5                  /
      PLATE F2  F-20   6185 6186 6206 6205  1691.6                  /
      PLATE F2  F-21   6186 6187 6207 6206  3248.9                  /
      PLATE F2  F-22   6187 6188 6208 6207  2531.0                  /
      PLATE F2  F-23   6188 6189 6209 6208  4235.0                  /
      PLATE F2  F-24   6200 6201 6221 6220   775.4                  /
      PLATE F2  F-25   6204 6205 6225 6224   457.0                  /
      PLATE F2  F-26   6205 6206 6226 6225  1190.8                  /
      PLATE F2  F-27   6206 6207 6227 6226  1393.2                  /
      PLATE F2  F-28   6207 6208 6228 6227  1501.2                  /
      PLATE F2  F-29   6208 6209 6229 6228  1555.2                  /
      PLATE F2  F-30   6220 6221 6241 6240   140.4                  /
      PLATE F2  F-31   6224 6225 6245 6244    54.0                  /
      PLATE F2  F-32   6225 6226 6246 6245   442.8                  /
      PLATE F2  F-33   6226 6227 6247 6246   658.8                  /
      PLATE F2  F-34   6227 6228 6248 6247   648.0                  /
      PLATE F2  F-35   6228 6229 6249 6248   583.2                  /
*/ PLATES REPRESENTING PAYLOAD                                  /
      PLATE F2  P-1    6002 6003 6023 6022   680.                   /
      PLATE F2  P-2    6003 6004 6024 6023  2295.                   /
      PLATE F2  P-3    6004 6005 6025 6024  3585.                   /
      PLATE F2  P-4    6005 6006 6026 6025  2200.                   /
      PLATE F2  P-5    6006 6007 6027 6026  3390.                   /
      PLATE F2  P-6    6007 6008 6028 6027   3475.                  /
      PLATE F2  P-7    6008 6009 6029 6028  2965.                   /
      PLATE F2  P-8    6009 6010 6030 6029  2040.                   /
      PLATE F2  P-9    6010 6011 6031 6030  2125.                   /
      PLATE F2  P-10   6011 6012 6032 6031  2125.                   /
      PLATE F2  P-11   6012 6013 6033 6032  1190.                   /
END MASS ELEMENT DATA     /
BEGIN CONCENTRATED MASS DATA 1          /
      1156  125.                        /
      1356  100.                        /
      1358  100.                        /
      1158  125.                        /
      1161  125.                        /
      1361  100.                        /
      1363  100.                        /
      1163  125.                        /
      85    150.                        /
      87    150.                        /
      1085  150.                        /
      1087  150.                        /
END CONCENTRATED MASS DATA 1            /
BEGIN LUMPING DATA  /
LUMP MASS SUBSETS 1 AT NODE SUBSET 1  /
*+2 0   0       0 1  0     0      0 1  /
END LUMPING DATA  /
BEGIN FACTOR DATA                                          /
      MASS FACTOR 32.17         /
     EXCLUDE STIFFNESS ELEMENTS                                    /
END FACTOR DATA                                            /
END MASS DATA   /
BEGIN SUBSET DEFINITION  /
SUBSETS OF NODAL SET 1  /
N1 = 3 TO 87  /
N2 = 223 TO 267 331 TO 763  /
N3 = 279 281 283 285 979 981 983 985  /
N5 = ALL        /
N6 = 6000 TO 6499  /
EXCLUDE N6 FROM N5        /
N10 = 6000 TO 6099  /
N11 = 6100 TO 6399  /
N12 = 6400 TO 6499  /
SUBSETS OF STIFFNESS SET 1  /
E1 = ALL        /
```

```
SUBSETS OF MASS SET 1  /
E1 = IN N10  /
E2 = IN N11  /
E3 = IN N12  /
E4 = ALL          /
END SUBSET DEFINITION  /
END PROBLEM DATA /
BEGIN SLENDER BODY DATA /
   0.   0.    1    1    1   13    1    2    Y    Z                /
END DATA /
BEGIN VERTICAL THIN BODY DATA  /
   0.   0.   0.    1.570796 14   14    1    3    1   14  2 Y    Z    /
BEGIN PANEL DEFINITION DATA  /
    1    2    2    2    3    2    0    0    /
END DATA /
BEGIN VERTICAL THIN BODY DATA /
   0. 594.   0.    1.570796 17   17    0    8    3   17  2 Y    Z    /
BEGIN PANEL DEFINITION DATA  /
     5    3    6    3    7    3    8    3    /
     4    3    3    3    6    3    5    3    /
     1    3    2    3    3    3    4    3    /
END DATA /
BEGIN HORIZONTAL THIN BODY DATA    /
   0.   0.   0.   0.   33   33    0   27   19   33    1    Z         /
BEGIN PANEL DEFINITION DATA  /
     1    4    2    4    3    4    0    0    /
     3    4    2    4    4    4    5    4    /
     5    4    4    4   13    4    6    4    /
     6    4   13    4   15    4    3    4    /
     8    4   15    4    7    4    0    0    /
     8    4    7    4   24    4    0    0    /
     8    4   24    4    9    4   10    4    /
    10    4    9    4   11    4    0    0    /
     4    4   12    4   13    4    0    0    /
    13    4   12    4   14    4   15    4    /
    15    4   14    4   16    4    7    4    /
     7    4   16    4   25    4   24    4    /
    24    4   25    4   17    4    9    4    /
    14    4   18    4   19    4   16    4    /
    16    4   19    4   26    4   25    4    /
    25    4   26    4   20    4   17    4    /
    18    4   21    4   22    4   19    4    /
    19    4   22    4   27    4   26    4    /
    26    4   27    4   23    4   20    4    /
END DATA /
BEGIN HORIZONTAL THIN BODY DATA    /
   0.   0.   0.   0.   60   60    0    8    3   60    1    Z    /
BEGIN PANEL DEFINITION DATA  /
     1    5    2    5    3    5    4    5    /
     4    5    3    5    6    5    5    5    /
     5    5    6    5    7    5    8    5    /
END DATA /
END FLEXSTAB DATA  /
```

```
      BEGIN CONTROL MATRIX PROGRAM DEMO06
      PROBLEM ID(DEMO06 - FLEXSTAB-TO-ATLAS INTERFACE, VAMAT/VAMSCN)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. FLEXSTAB-TO-ATLAS INTERFACE
C                       2. SHEAR, MOMENT AND TORSION CALCULATION VIA
C                              VAMAT
C                       3. SUMMARY OF CRITICAL LOADS USING VAMSCN
C
C     AUTHOR         F. P. GRAY
C
C     CORE            130K (OCTAL)
C
      DIMENSION FET(300),FET1(550),FET2(550),FET3(550),FET4(550)
C
     CALL FILEADD(FET,DATARNF)
     CALL FETADD(SAVESSF,FET1,550,1,C,IRR)
     CALL STREFIL
     PRINT MATRIX(DATARNF,Q******)
     READ INPUT
     PERFORM R-STRESS
     PRINT OUTPUT(LOADS)
     PRINT OUTPUT(STRESSES)
     PRINT OUTPUT(DISPLACE)
     EXECUTE MASS
     PRINT OUTPUT (MASS,MDC=MDC****,SUMMARY)
     CALL FILEADD(FET,DATARNF,MASSRNF)
     CALL FETADD(SAVESSF,FET1,550,1,0,IRR)
     CALL FETADD(SAVESS1,FET2,550,1,0,IRR)
     CALL FETADD(SC00SSF,FET3,550,1,C,IRR)
     CALL FETADD(SC01SSF,FET4,550,1,0,IRR)
     CALL VAMAT
     CALL VAMSCN
     END
```

```
*/ MODE2 /
BEGIN NODAL DATA
1     20.    0.      1.      TO 9     340     0.      65.     BY  2
101   20.    0.     -1.      TO 109   340.    0.     -65.     BY  2
201   20.    1.      0.      TO 209   340.    65.     0.      BY  2
11    420.   0.      65.     TO 83    3300.   0.      65.     BY  2
111   420.   0.     -65.     TO 189   3540.   0.     -65.     BY  2
211   420.   65.     0.      TO 225   980.    65.     0.      BY  2
265   2580.  65.     0.      TO 277   3060.   65.     0.      BY  2
287   3460.  65.     0.      TO 289   3540.   65.     0.      BY  2
*/   WING  COORDINATES
227   1060.  65.   0.  26.25 TO 245   1780.  65.    0.  36.35  BY  2
245                          TO 255   2180.  65.    0.  28.8   BY  2
255                          TO 263   2500.  65.    0.  12.0   BY  2
327   1060.  65.   0.  26.25 TO 341   1620.  265.   0.   8.85  BY  2
445   1780.  195.  0.  22.65 TO 455   2180.  195.   0.  20.15  BY  2
541   1620.  265.  0.   8.85 TO 551   2205.  455.   0.   5.75  BY  2
651   2205.  455.  0.   5.75 TO 656   2545.  594.   0.   3.2
756   2545.  594.  0.   3.2  TO 760   2875.  765.   0.    .95
760                          TO 763   2995.  765.   0.   1.85
341                          TO 355   2180.  255.   0.  20.15  BY  2
355                          TO 363   25 0.  265.   0.  11.25  BY  2
551                          TO 559   2525.  455.   0.  10.0
559                          TO 563   2685.  455.   0.   5.0
656                          TO 659   2605.  594.   0.   4.85
659                          TO 663   2825.  594.   0.   2.45
*/  HORIZONTAL TAIL
279 3140. 65. 0.  1.80
779 3140. 65. 0.  1.80  TO 979 3365. 200. 0.  1.25  BY 100
281 3220. 65. 0.  4.25
781 3220. 65. 0.  4.25  TO 981 3388. 200. 0.  1.75  BY 100
283 3300. 65. 0.  4.55
783 3300. 65. 0.  4.55  TO 983 3412. 200. 0.  1.80  BY 100
285 3380. 65. 0.  1.40
785 3380. 65. 0.  1.40  TO 985 3435. 200. 0.   .80  BY 100
*/  VERTICAL TAIL
REC  REC1 0. 0. 0. 1. 0. 0. 0. -1. 0.
85 3380. 65. 0.      3.25
37 3460. 65. 0.      2.40
1085 3460. 140. 0.  1.50
1087 3500. 140. 0.  1.90
*/   WING FIN
1156 2545. .1 -594. 2.40 TO 1356 2830. 100. -594. 1.80 BY 100
1158 2625. .1 -594. 2.40 TO 1358 2842. 100. -594. 1.90 BY 100
1161 2745. .1 -594. 2.80 TO 1361 2859. 100. -594. 1.95 BY 100
1163 2825. .1 -594. 2.80 TO 1363 2870. 100. -594. 2.05 BY 100
RESUME GLOBAL
89     3540.  0.       65.
*/     AIRLOAD PANEL NODES
*/     BODY
       5100    0.    0.         0.   TO   5112   3564.   0.   0.
       5251    0.   26.1279   0.
       5252  297.   26.1279   0.
       5253  297.   63.5215   0.
       5254  594.   63.5215   0.
       5202  594.   65.1      0.   TO   5212   3564.  65.1  0.
*/     WING
       5400    741.        65.1  0.   TO 5405  2715.        65.1  0.
       5410  1017.7530   146.6  0.   TO  5415  2705.9945  146.6  0.
       5420  1294.1665   228.   0.   TO  5425  2697.      228.   0.
       5430  1677.8854   341.   0.   TO  5435  2722.8855  341.   0.
       5440  2065.       455.   0.   TO  5445  2749.      455.   0.
       5450  2487.        594.   0.   TO  5455  2874.059   594.   0.
       5460  2689.47    696.   0.   TO  5465  2965.8289  696.   0.
       5470  2884.      794.   0.   TO  5475  3054.      794.   0.
*/     HOR TAIL
       5500  3124.        65.1  0.   TO  5502  3417.       65.1  0.
       5510  3255.0804  146.6  0.   TO  5512  3440.5144  146.6  0.
       5520  3386.      228.   0.   TO  5522  3464.      228.   0.
*/     VERT WING FIN
       5313  2487.  594.  0.  TO  5315  2880.  594.  134.
       5316  2680.5  594.  0.  TO  5318  2910.  594.  134.
       5319  2874.059  594.  0.  TO  5321  2940.  594.  134.
```

```
*/     WEIGHT PANELS - BODY
       6001  0.   0.  0.  TO  6016  3564.   C.  0.
       6021  0.  65.  0.  TO  6036  3564.  65.  0.
*/     WEIGHT PANELS - WING
       6100   741.0    65.0  C.   TO   6220  2487.0  594.0  0.  BY  20
       6100                       TO   626C  2487.0  594.0  0.  BY  80
       6180                       TO   6240  2487.0  594.0  0.  BY  20
       6260                       TO   6320  2884.0  794.0  0.  BY  20
       6110  2715.0   65.0  0.   TO   6170  2715.0  329.5  0.  BY  20
       6189  2715.0  329.5  C.   TO   6249  2874.0  594.0  0.  BY  20
       6266  2874.0  594.0  C.   TO   6326  3054.0  794.0  0.  BY  20
       6100  TO  6110
*+3     20   0    20
       6180  TO  6189
*+3     20   0    20
       6260  TO  6266
*+3     20   0    20
*/     WEIGHT PANELS - HOR TAIL
       6400  3124.   65.1  0.  TO  6403  3417.   65.1  0.
       6410  3386.  228.0  0.  TO  6413  3464.  228.0  0.
*/     WEIGHT PANELS - VERT FIN
       6501  3374.6  0.   92.8
       6502  3472.   0.   92.8
       6503  3458.7  0.  149.8
       6504  3514.6  0.  149.8
*/     WEIGHT PANELS - WING VERT FIN
       6601  2487.      594.  0.  TO  6603  2880.  594.  134.
       6604  2874.059  594.  0.  TO 6606  2940.  594.  134.
END NODAL DATA
BEGIN STIFFNESS DATA
BEGIN ELEMENT DATA
*/     WING  SPARS
SPAR  M5              227  329       .06  1.
SPAR   M5   247  447   .10  2.0    TO  253   453  BY 2 2
SPAR  M5              329  331       .06  1.    TO   339  341  BY  2 2
SPAR  M5              341  543       .06  1.
SPAR  M5              543  545       .06  1.    TO   549  551  BY  2 2
SPAR  M5              551  653       .06  1.
SPAR  M5              653  655       .06  1.
SPAR  M5              655  656       .06  1.
SPAR  M5              656  757       .06  1.
SPAR  M5              757  758       .06  1.    TO   759  760
SPAR  M5              263  363       .20  6.
SPAR  M5              363  563       .17  6.
SPAR  M5              563  663       .15  4.
SPAR  M5              663  763       .15  2.
SPAR  M5              229  329       .1   1.    TO   243  343  BY  2 2
SPAR  M5              245  445       .18  1.
SPAR  M5              445  345       .18  1.
SPAR  M5              447  347       .1   2.    TO   453  353  BY  2 2
SPAR  M5              255  455       .3   6.
SPAR  M5              455  353       .3   6.
SPAR  M5              257  357       .12  6.    TO   261  361  BY  2 2
SPAR  M5              343  543       .1   1.    TO   345  545  BY  2 2
SPAR  M5              347  547       .1   2.    TO   353  553  BY  2 2
SPAR  M5              355  555       .1   4.
SPAR  M5              357  557       .1   5.    TO   361  561  BY  2 2
SPAR  M5              553  653       .06  2.    TO   555  655  BY  2 2
SPAR  M5              556  656       .03  2.    TO   562  662
SPAR  M5              657  757       .03  1.    TO   662  762
*/    WING  RIBS
SPAR  M5              445  447       .17  2.    TO   453  455  BY  2 2
SPAR  M5              341  343       .10  1.5   TO   361  363  BY  2 2
SPAR  M5              551  553       .10  2.    TO   553  555  BY  2 2
SPAR  M5              555  556       .10  2.    TO   562  563
SPAR  M5              656  657       .06  1.    TO   662  663
SPAR  M5              760  761       .15  .7    TO   762  763
*/     WING COVERS
COVER      M5   229 329 227      .03
COVER      M5   229 329 331 231 .03              TO 241 341 343 243 BY 2 *=3
COVER      M5   243 343 445 245 .03
COVER      M5   445 345 343      .03
COVER  M5   245  247  447  445  .06  .0  TO 253 255 455 453 BY 2 *=3
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COVER      M5    445 345 347 447 .03                     TO 453 353 355 455 BY 2 *=3
COVER      M5    255 455 357 257 .05 .07
COVER      M5    455 355 357     .05 .07
COVER      M5    257 357 359 259 .05 .07
COVER      M5    259 359 361 261 .13 .07 .11 .0  TO 261 361 363 263 BY 2 *=3
COVER      M5    343 543 341     .03
COVER      M5    343 543 545 345 .03                     TO 353 553 555 355 BY 2 *=3
COVER      M5    355 555 557 357 .05 .04                 TO 357 557 559 359 BY 2 *=3
COVER      M5    359 559 561 361 .15 .07 .10 .0  TO 361 561 563 363 BY 2 *=3
COVER      M5    553 653 551     .15 .07 .11 .06
COVER      M5    553 653 655 555 .15 .07 .11 .06
COVER      M5    555 655 656 556 .15 .07 .11 .06 TO 562 662 663 563
COVER      M5    657 757 656     .04
COVER      M5    657 757 758 658 .04                     TO 662 762 763 663
*/  HORIZONTAL TAIL
SPAR  M5         279 879 .05 .6
SPAR  M5         879 979 .05 .6
SPAR  M5         281 881 .025 .9
SPAR  M5         881 981 .025 .9
SPAR  M5         283 883 .025 .8
SPAR  M5         883 983 .025 .8
SPAR  M5         285 885 .10  1.3
SPAR  M5         885 985 .10  1.3
SPAR  M5         879 881 .05 .6  TO 883 885 BY 2 2
SPAR  M5         979 981 .05 .6  TO 983 985 BY 2 2
COVER M5         279 879 881 281 .08
**2 0 0  2 *=3  0.
COVER M5         879 979 981 881 .035
**2 0 0  2 *=3  0.
*/ WING FIN
SPAR  M5         1156 1256 .025 .5  TO  1256 1356 BY 100 100
SPAR  M5         1158 1258 .025 .5  TO  1258 1358 BY 100 100
SPAR  M5         1161 1261 .025 .5  TO  1261 1361 BY 100 100
SPAR  M5         1163 1263 .025 .5  TO  1263 1363 BY 100 100
SPAR  M5         1256 1258 .025 .5  TO    1356 1358 BY 100 100
SPAR  M5         1258 1261 .025 .5  TO    1356 1361 BY 100 100
SPAR  M5         1261 1263 .025 .5  TO    1361 1363 BY 100 100
COVER M5         1156 1256 1258 1158 .025 TO 1256 1356 1358 1258     +
      BY 100 100 100 100
COVER M5         1158 1258 1261 1161 .025 TO 1258 1358 1361 1261     +
      BY 100 100 100 100
COVER M5         1161 1261 1263 1163 .025 TO 1261 1361 1363 1263     +
      BY 100 100 100 100
*/  VERTICAL TAIL
COVER M5           85 1085 1087   87 .0   0.035
SPAR M5 85 1085 0. 0. .5 .0 .0
SPAR M5 87 1087 0. 0. .5 .0 .0
SPAR M5 1085 1087 0. 0. .5 .0 .0
*/      BODY
*/      STRINGERS
ROD    M5         1  3 2.37 TO 23 25 BY 2 2
**2 0 0 100 100 0. 0 100 100 0 0 0
**1 0 *=3 0. 0 *=5
ROD    M5         25 27 4.    TO 43 45 BY 2 2
**2 0 0 100 100 0. 0 100 100 0 0 0
**1 0 *=3 0. 0 *=5
ROD    M5         45 47 5.35 TO 67 69 BY 2 2
**2 0 0 100 100 0. 0 100 100 0 0 0
**1 0 *=3 0. 0 *=5
ROD    M5         69 71 4. TO 75 77 BY 2 2
**2 0 0 100 100 0. 0 100 100 0 0 0
**1 0 *=3 0. 0 *=5
ROD    M5         77 79 2.37 TO 87 89 BY 2 2
**2 0 0 100 100 0. 0 100 100 0 0 0
**1 0 *=3 0. 0 *=5
SPLATE M5       1    3 203 201 .04 TO 25 27 227 225 BY 2 *=3
SPLATE M5     201 203 103 101 .04 TO 225 227 127 125 **
SPLATE M5      27   29 229 227 .06   TO  43  45 245 243 **
SPLATE M5     227 229 129 127 .06 TO 243 245 145 143 **
SPLATE M5      45   47 247 245 .08   TO  67  69 269 267  **
SPLATE M5     245 247 147 145 .08   TO 267 269 169 167  **
SPLATE M5      69   71 271 269 .06   TO  75  77 277 275  **
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SPLATE M5    269 271 171 169 .06  TO 275 277 177 175  **
SPLATE M5     77  79 279 277 .04  TO  87 89 289 287  **
SPLATE M5    277 279 179 177 .04  TO 287 285 189 187  **
*/ BODY FRAMES
BEAM  M5   1 201  3. 0. 0. 50. 50. 50.  TO  27 227  BY  2 2
*+1 0 0 100 0 0. *=5 0 100 0 *=3
BEAM  M5  29 229 4.5 0. 0. 50. 50. 50.  TO  45 245  BY  2 2
*+1 0 0 100 0 0. *=5 0 100 0 *=3
BEAM  M5  47 247  6. 0. 0. 50. 50. 50.  TO  69 269  BY  2 2
*+1 0 0 100 0 0. *=5 0 100 0 *=3
BEAM  M5  71 271 4.5 0. 0. 50. 50. 50.  TO  77 277  BY  2 2
*+1 0 0 100 0 0. *=5 0 100 0 *=3
BEAM  M5  79 279  3. 0. 0. 50. 50. 50.  TO  89 289  BY  2 2
*+1 0 0 100 0 0. *=5 0 100 0 *=3
BEAM   9  209  14.0 0. 0. 75. 75. 75.
*+1 0 100 0 0. *=5
BEAM  27  227  14.0 0. 0. 75. 75. 75.
*+1 0 100 0 0. *=5
BEAM  45  245  62.  0. 0.  450. 450. 450.
*+1 0 100 0 0. *=5
BEAM  55  255  62.  0. 0.  450. 450. 450.
*+1 0 100 0 0. *=5
BEAM  63  263  62.  0. 0.  450. 450. 450.
*+1 0 100 0 0. *=5
BEAM  79  279  14. 0. 0. 75. 75. 75.
*+1 0 100 0 0. *=5
BEAM  85  285  14. 0. 0. 75. 75. 75.
*+1 0 100 0 0. *=5
*/   ATTACHMENT OF WING FIN
BEAM Z5 656 1156 663 1. 0. 0. .1 .1 .1
BEAM Z5 658 1158 663 1. 0. 0. .1 .1 .1
BEAM Z5 661 1161 663 1. 0. 0. .1 .1 .1
BEAM Z5 663 1163 661 1. 0. 0. .1 .1 .1
BEAM  Z5  656 658  10. 0. 0. 100. 100. 100.
BEAM  Z5  658 661  10. 0. 0. 100. 100. 100.
BEAM  Z5  661 663  10. 0. 0. 100. 100. 100.
BEAM Z5 89 289 0. 0. 0. 10000. *=2
BEAM Z5 189 289  **
END ELEMENT DATA
END STIFFNESS DATA
BEGIN BC DATA
*/ORDER BODY,FIN,WING-FIN,WING HORIZONTAL TAIL
STAGE  1
RETAIN TZ FOR 3 9 15 23 31 39 45 53 61 67 75 83 87 95 1085 1087
RETAIN TZ TY FOR 1156 1356 1358 1158 1161 1361 1363 1163
RETAIN TZ FOR 223 331 231 337 237 245 355 255 363 263    +
              267 543 345 551 349 555 563 656 659 663    +
              760 761 763 359 559 661 762 279 979 981    +
              281 283 983 985 285
SUPPORT TX TZ RY FOR 89
SUPPORT ASYM IN SURFACE 2 THROUGH 1
END BC DATA
BEGIN LOAD DATA
STAGE 1
READ NODAL LOADS FROM DATARNF WITH INDEX QSYMM**
END LOAD DATA
BEGIN MASS DATA
BEGIN CONDITION DATA
     PANEL DATA 1 CONDITION 1
END CONDITION DATA
BEGIN MASS ELEMENT DATA
 PLATE F2  B-1    6001 6002 6022        3495.
 PLATE F2  B-2    6002 6003 6023 6022   5955.
 PLATE F2  B-3    6003 6004 6024 6023   2589.
 PLATE F2  B-4    6004 6005 6025 6024   3440.
 PLATE F2  B-5    6005 6006 6026 6025   5420.
 PLATE F2  B-6    6006 6007 6027 6026   3280.
 PLATE F2  B-7    6007 6008 6028 6027   3306.
 PLATE F2  B-8    6008 6009 6029 6028   4346.
 PLATE F2  B-9    6009 6010 6030 6029   4507.
 PLATE F2  B-10   6010 6011 6031 6030   4486.
 PLATE F2  B-11   6011 6012 6032 6031   3619.
 PLATE F2  B-12   6012 6013 6033 6032   4730.
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PLATE	F2	B-13	6013	6014	6034	6033	3982.
PLATE	F2	B-14	6014	6015	6035	6034	947.
PLATE	F2	B-15	6015	6016	6036	6035	1788.
PLATE	F2	VT-1	6501	6502	6504	6503	600.
PLATE	F2	W-1	6100	6101	6121	6120	768.
PLATE	F2	W-2	6101	6102	6122	6121	1151.
PLATE	F2	W-3	6102	6103	6123	6122	1667.
PLATE	F2	W-4	6103	6104	6124	6123	1112.
PLATE	F2	W-5	6104	6105	6125	6124	1190.
PLATE	F2	W-6	6105	6106	6126	6125	1659.
PLATE	F2	W-7	6106	6107	6127	6126	1988.
PLATE	F2	W-8	6107	6108	6128	6127	2467.
PLATE	F2	W-9	6108	6109	6129	6128	1335.
PLATE	F2	W-10	6109	6110	6130	6129	338.
PLATE	F2	W-11	6120	6121	6141	6140	795.
PLATE	F2	W-12	6121	6122	6142	6141	1415.
PLATE	F2	W-13	6122	6123	6143	6142	813.
PLATE	F2	W-14	6123	6124	6144	6143	1259.
PLATE	F2	W-15	6124	6125	6145	6144	1248.
PLATE	F2	W-16	6125	6126	6146	6145	1720.
PLATE	F2	W-17	6126	6127	6147	6146	1494.
PLATE	F2	W-18	6127	6128	6148	6147	1888.
PLATE	F2	W-19	6128	6129	6149	6148	498.
PLATE	F2	W-20	6129	6130	6150	6149	126.
PLATE	F2	W-21	6140	6141	6161	6160	508.
PLATE	F2	W-22	6141	6142	6162	6161	1279.
PLATE	F2	W-23	6142	6143	6163	6162	536.
PLATE	F2	W-24	6143	6144	6164	6163	532.
PLATE	F2	W-25	6144	6145	6165	6164	559.
PLATE	F2	W-26	6145	6146	6166	6165	1055.
PLATE	F2	W-27	6146	6147	6167	6166	1405.
PLATE	F2	W-28	6147	6148	6168	6167	1953.
PLATE	F2	W-29	6148	6149	6169	6168	274.
PLATE	F2	W-30	6149	6150	6170	6169	172.
PLATE	F2	W-31	6180	6181	6201	6200	614.
PLATE	F2	W-32	6181	6182	6202	6201	1286.
PLATE	F2	W-33	6182	6183	6203	6202	562.
PLATE	F2	W-34	6183	6184	6204	6203	786.
PLATE	F2	W-35	6184	6185	6205	6204	1386.
PLATE	F2	W-36	6165	6186	6206	6205	1849.
PLATE	F2	W-37	6186	6187	6207	6206	1649.
PLATE	F2	W-38	6187	6188	6208	6207	421.
PLATE	F2	W-39	6188	6189	6209	6208	255.
PLATE	F2	W-40	6200	6201	6221	6220	207.
PLATE	F2	W-41	6201	6202	6222	6221	497.
PLATE	F2	W-42	6202	6203	6223	6222	692.
PLATE	F2	W-43	6203	6204	6224	6223	765.
PLATE	F2	W-44	6204	6205	6225	6224	816.
PLATE	F2	W-45	6205	6206	6226	6225	843.
PLATE	F2	W-46	6206	6207	6227	6226	687.
PLATE	F2	W-47	6207	6208	6228	6227	136.
PLATE	F2	W-48	6208	6209	6229	6228	94.
PLATE	F2	W-49	6220	6221	6241	6240	136.
PLATE	F2	W-50	6221	6222	6242	6241	522.
PLATE	F2	W-51	6222	6223	6243	6242	516.
PLATE	F2	W-52	6223	6224	6244	6243	536.
PLATE	F2	W-53	6224	6225	6245	6244	555.
PLATE	F2	W-54	6225	6226	6246	6245	580.
PLATE	F2	W-55	6226	6227	6247	6246	704.
PLATE	F2	W-56	6227	6228	6248	6247	119.
PLATE	F2	W-57	6228	6229	6249	6248	91.
PLATE	F2	W-58	6260	6261	6281	6280	289.
PLATE	F2	W-59	6261	6262	6282	6281	306.
PLATE	F2	W-60	6262	6263	6283	6282	244.
PLATE	F2	W-61	6263	6264	6294	6283	507.
PLATE	F2	W-62	6264	6265	6285	6284	116.
PLATE	F2	W-63	6265	6266	6286	6285	76.
PLATE	F2	W-64	6280	6281	6301	6300	216.
PLATE	F2	W-65	6281	6282	6302	6301	144.
PLATE	F2	W-66	6282	6283	6303	6302	245.
PLATE	F2	W-67	6283	6284	6304	6303	365.
PLATE	F2	W-68	6284	6285	6305	6304	86
PLATE	F2	W-69	6285	6286	6306	6305	71.

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 PLATE F2  W-70     6300 6301 6321 6320    184.
 PLATE F2  W-71     6301 6302 6322 6321    169.
 PLATE F2  W-72     6302 6303 6323 6322    126.
 PLATE F2  W-73     6303 6304 6324 6323    273.
 PLATE F2  W-74     6304 6305 6325 6324     66.
 PLATE F2  W-75     6305 6306 6326 6325     66.
 PLATE F2  HT-1     6400 6401 6411 6410   283.
 PLATE F2  HT-2     6401 6402 6412 6411   212.
 PLATE F2  HT-3     6402 6403 6413 6412   522.
 PLATE F2  WF-1     6601 6602 6605 6604    500.
 PLATE F2  WF-2     6602 6603 6606 6605    400.
*/ PLATES REPRESENTING FUEL
 PLATE F2  F-1      6102 6103 6123 6122    129.6
 PLATE F2  F-2      6103 6104 6124 6123   8637.2
 PLATE F2  F-3      6104 6105 6125 6124 12852.9
 PLATE F2  F-4      6106 6107 6127 6126   5531.1
 PLATE F2  F-5      6107 6108 6128 6127   6919.3
 PLATE F2  F-6      6108 6109 6129 6128    107.1
 PLATE F2  F-7      6124 6125 6145 6144    442.8
 PLATE F2  F-8      6125 6126 6146 6145   5450.7
 PLATE F2  F-9      6126 6127 6147 6146   6537.8
 PLATE F2  F-10     6128 6129 6149 6148   2604.5
 PLATE F2  F-11     6129 6130 6150 6149   4011.2
 PLATE F2  F-12     6140 6141 6161 6160   5762.0
 PLATE F2  F-13     6144 6145 6165 6164   1128.9
 PLATE F2  F-14     6145 6146 6166 6165   2470.2
 PLATE F2  F-15     6147 6148 6168 6167   1825.8
 PLATE F2  F-16     6148 6149 6169 6168   4994.1
 PLATE F2  F-17     6149 6150 6170 6169   2341.4
 PLATE F2  F-18     6180 6181 6201 6200   3598.6
 PLATE F2  F-19     6184 6185 6205 6204    258.5
 PLATE F2  F-20     6185 6186 6206 6205   1691.6
 PLATE F2  F-21     6186 6187 6207 6206   3248.9
 PLATE F2  F-22     6187 6188 6208 6207   2531.0
 PLATE F2  F-23     6188 6189 6209 6208   4235.0
 PLATE F2  F-24     6200 6201 6221 6220    775.4
 PLATE F2  F-25     6204 6205 6225 6224    457.0
 PLATE F2  F-26     6205 6206 6226 6225   1190.8
 PLATE F2  F-27     6206 6207 6227 6226   1393.2
 PLATE F2  F-28     6207 6208 6228 6227   1501.2
 PLATE F2  F-29     6208 6209 6229 6228   1555.2
 PLATE F2  F-30     6220 6221 6241 6240    140.4
 PLATE F2  F-31     6224 6225 6245 6244     54.0
 PLATE F2  F-32     6225 6226 6246 6245    442.8
 PLATE F2  F-33     6226 6227 6247 6246    658.8
 PLATE F2  F-34     6227 6228 6248 6247    648.0
 PLATE F2  F-35     6228 6229 6249 6248    583.2
*/ PLATES REPRESENTING PAYLOAD
 PLATE F2  P-1      6002 6003 6023 6022    680.
 PLATE F2  P-2      6003 6004 6024 6023   2295.
 PLATE F2  P-3      6004 6005 6025 6024   3585.
 PLATE F2  P-4      6005 6006 6026 6025   2200.
 PLATE F2  P-5      6006 6007 6027 6026   3390.
 PLATE F2  P-6      6007 6008 6028 6027    3475.
 PLATE F2  P-7      6008 6009 6029 6028   2965.
 PLATE F2  P-8      6009 6010 6030 6029   2040.
 PLATE F2  P-9      6010 6011 6031 6030   2125.
 PLATE F2  P-10     6011 6012 6032 6031   2125.
 PLATE F2  P-11     6012 6013 6033 6032   1190.
END MASS ELEMENT DATA
      BEGIN PANEL DATA 1
*/    BODY
      MASS SUBSETS    1
        DIRECTION  Z
                 1  5100 5251 5252 5101
                 2  5101 5253 5254 5102
                 3  5202 5203 5103 5102   TO  12
*/    WING FIN
      MASS SUBSETS    2
        DIRECTION  Y
           13  5313 5316 5317 5314
           14  5316 5319 5320 5317
           15  5314 5317 5318 5315
           16  5317 5320 5321 5318
```

```
*/     WING
       MASS SUBSETS   3
         DIRECTION  Z
           17  5400 5401 5411 5410  TO  21
**6         5    10  *=3                0   5
*/     HOR TAIL
       MASS SUBSETS   4
         DIRECTION  Z
           52  5500 5501 5511 5510  TO  53
**1         2    10  *=3                0   2

        END PANEL DATA 1
BEGIN FACTOR DATA
        EXCLUDE STIFFNESS ELEMENTS
        MASS FACTOR 32.17
END FACTOR DATA
END MASS DATA
BEGIN SUBSET DEFINITION
SUBSETS OF MASS SET 1
        N1 = 6001 TO 6036 6501 TO 6504
        E1 = ALL IN N1
        N2 = 6601 TO 6606
        E2 = ALL IN N2
        N3 = 6100 TO 6326
        E3 = ALL IN N3
        N4 = 6400 TO 6413
        E4 = ALL IN N4
END SUBSET DEFINITION
END PROBLEM DATA
*/ MODEZ /
BEGIN VAMAT DATA
BODY              12          2          2
FIN                0          2          8
WING-FIN           4          3          2
WING              35          3          3
HR-TAIL            4          3          3
       55         33          1
        6         1.         20         24          1          1
       13         16         25         33
1.        0.        .00001
200.      0.        .00001
400.      0.        .00001
600.      0.        .00001
800.      0.        .00001
1000.     0.        .00001
1200.     0.        .00001
1400.     0.        .00001
1600.     0.        .00001
1800.     0.        .00001
2000.     0.        .00001
3599.     0.        0.
3400.     0.        0.
3200.     0.        0.
3000.     0.        0.
2800.     0.        0.
2600.     0.        0.
2400.     0.        0.
2200.     0.        0.
2000.     0.        0.
2985.     793.      -9999.
2855.3    696.      -9999.
2720.     595.      -9999.
2641.8236 594.      -9999.
2718.     593.      -9999.
2600.     525.      -9999.
2475.4    455.      -9999.
2390.     398.      -9999.
2304.9    341.      -9999.
2220.     285.      -9999.
2136.     228.      -9999.
2030.7    146.6     -9999.
1925.4     65.1     -9999.
```

```
 *≠ FORE BODY ≠
 *≠ AFT BODY ≠
 *≠ OUTBOARD WING ≠
 *≠ WING FIN ≠
 *≠ INBOARD WING ≠
 *≠ HORIZONTAL STABILIZER ≠
        11        20        23        24        33        0
0 0 0 0 3 0 0 0 0 0 0 1 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2
        14
        17  0.  18  0.  19  C.  20  0.
        22  0.  23  0.  24  0.  25  0.
        27  0.  28  0.  29  0.  32  0.
        33  0.  37  0.
        17  51  0.
        52  55  0.
MDC001A
END VAMAT DATA
BEGIN VAMSCN DATA
2   2   1
1
2   1
 *≠GROUP 1 - PASS 1≠
1   2
 *≠GROUP 2 - PASS 1≠
1
2
 *≠GROUP 1 - PASS 2≠
1   2
END VAMSCN DATA
```

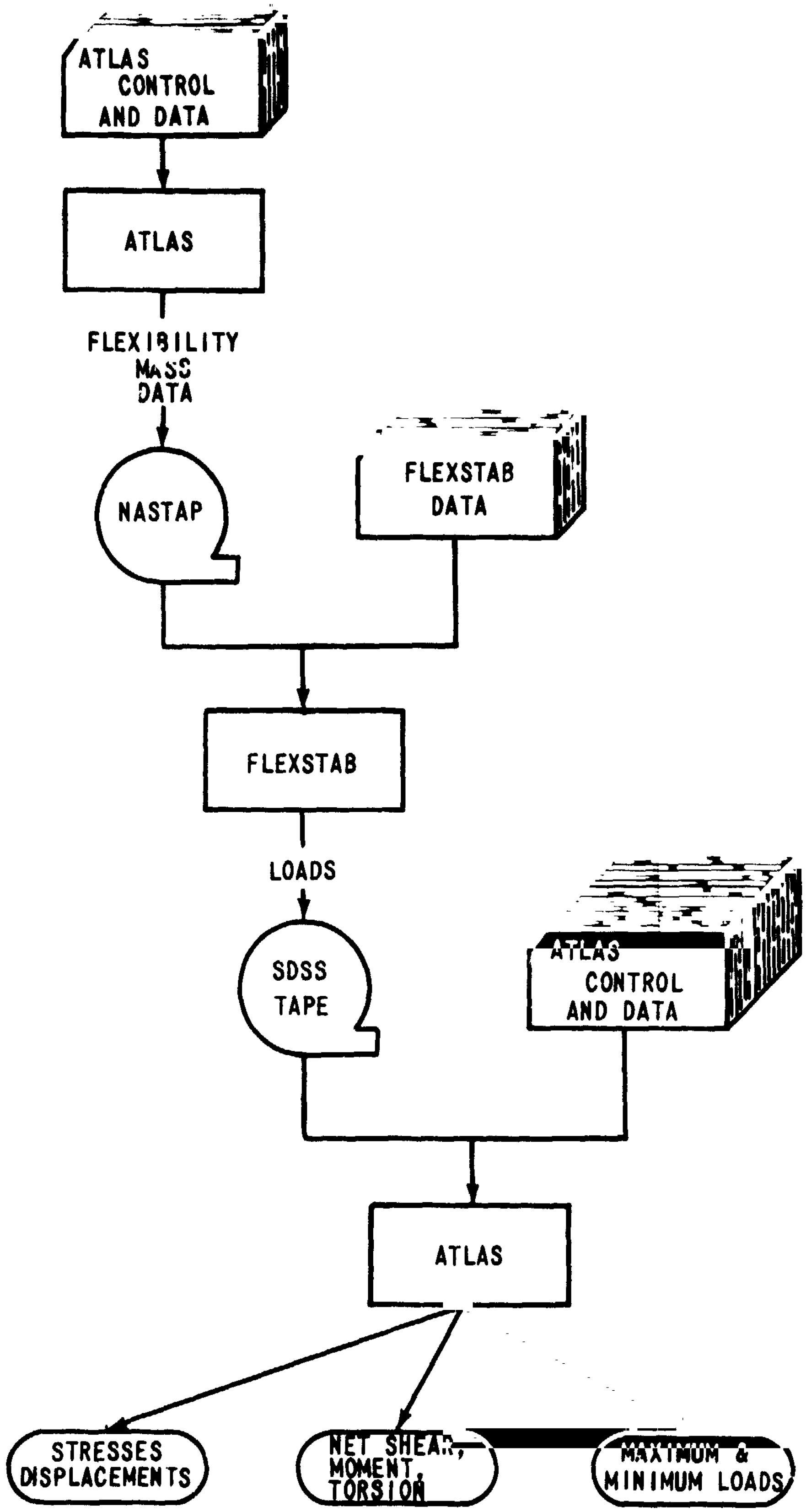

Figure 301-1. Schematic of ATLAS/FLEXSTAB Interface Demonstration

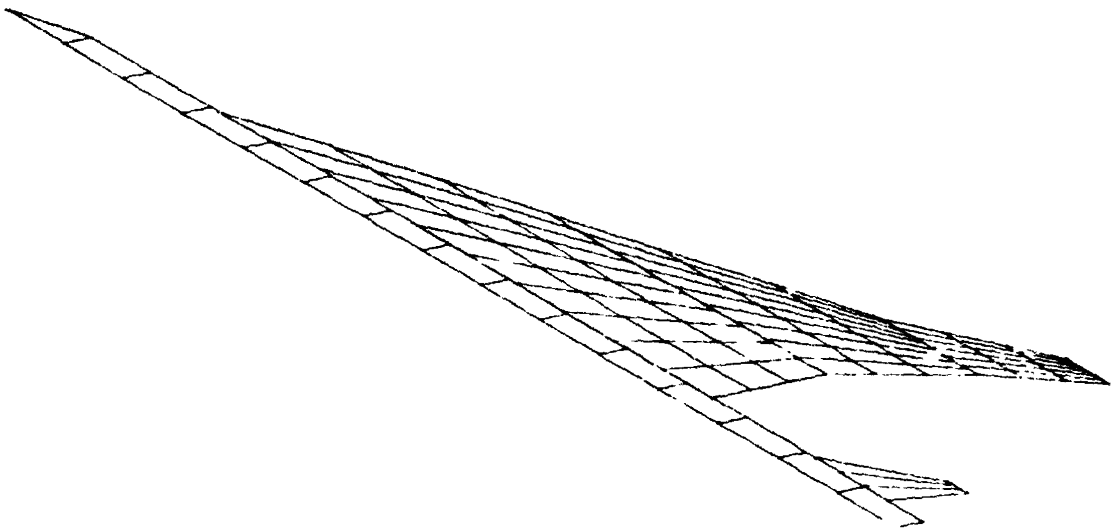

Figure 301-2. Structural Model

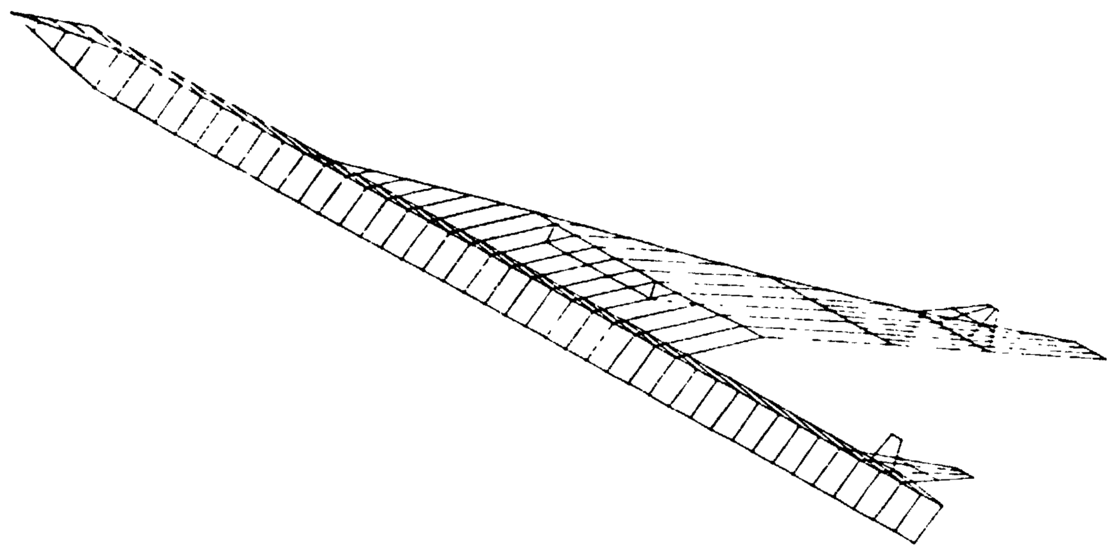

Figure 301-3. Mass Model

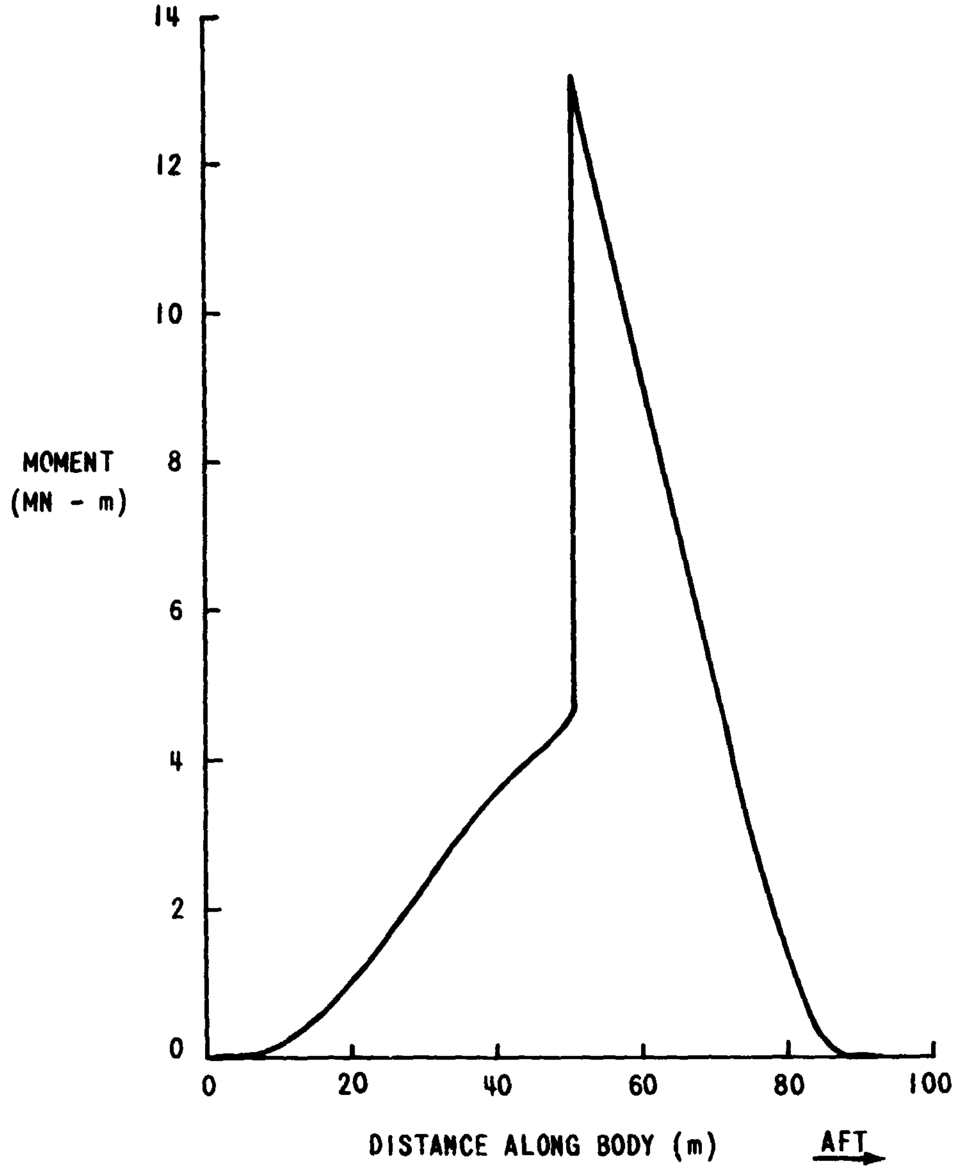

Figure 301-4. Body Bending Moment

302. ATLAS/NASTRAN INTERFACES (DECK 9)

302.1 DESCRIPTION OF DEMONSTRATION

The method used to demonstrate the ATLAS-NASTRAN interfaces is shown schematically in figure 302-1. An ATLAS model consisting of ROD, BEAM, PLATE, SPLATE and GPLATE elements was prepared. Only nodal loads are applied. An ATLAS stress analysis is performed and the data are converted to NASTRAN (ref. 201-1) bulk data. Nonconvertible NASTRAN bulk data cards and the Executive and Case Control decks are added. This complete NASTRAN problem deck is then used to perform a NASTRAN stress analysis.

The complete NASTRAN bulk data deck is then processed through the NASTRAN-to-ATLAS interface. The resulting ATLAS data deck is then used to perform a stress analysis.

302.2 RESULTS

NASTRAN detected no data errors while reading and checking the bulk data produced by the ATLAS-to-NASTRAN interface. The stress analysis results of the two ATLAS executions are equal within the accuracy of the data being converted. The NASTRAN stress analysis results agree with the ATLAS results as closely as expected considering the somewhat different behavior of the NASTRAN and ATLAS plate elements.

302.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL MATRIX PROGRAM DEMO09
      PROBLEM ID(DEMO09 - PART I. ATLAS-TO-NASTRAN DATA CONVERSION)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. ATLAS-TO-NASTRAN DATA CONVERSION
C                       2. NASTRAN-TO-ATLAS DATA CONVERSION
C
C     AUTHOR         M. TAMEKUNI
C
C     CORE           140K (OCTAL)
C
      DIMENSION FET(100,5)
      DIMENSION A1(200),A3(200),A4(200),A5(200),A6(200)
      INTEGER D31,STAGE,SET
      READ INPUT
      PRINT INPUT(NODAL,SET=3)
      PRINT INPUT(STIFFNESS,SET=3)
      PRINT INPUT(BC,SET=3)
      PERFORM STRESS (SET=3)
      PRINT OUTPUT (DISPLACE,SET=3)
      PRINT OUTPUT (STRESSES,SET=3)
      PRINT OUTPUT (REACTIONS,SET=3)
C
       CALL FILEADD(FET,DATARNF,MERGRNF,MASSRNF,STIFRNF,SCOORNF)
       CALL FETADD (SAVESS1,A1,200,1,0,IRR)
       CALL FETADD (SC00SSF,A3,200,1,0,IRR)
       CALL FETADD (SC01SSF,A4,200,1,0,IRR)
       CALL FETADD (SC02SSF,A5,200,1,0,IRR)
       CALL FETADD (SC03SSF,A6,200,1,0,IRR)
C
       LOUT1 = SAVESS1
       L11 = 3LL11
       L21 = 3LL21
       L31 = 3LL31
       D31 = 3LD31
       STAGE = 1
       SET   = 3
       NCOND = 0
       NELEM = 1
       NNODE = 1
       NBCLD = 1
       NMASS = 0
C
       CALL ATNA(SET,NCOND,NELEM,NNODE,NMASS,LOUT1,STAGE,L11,L21,L31,D31
      X,NBCLD)
       END CONTROL PROGRAM
```

```
*/ MODE2 /
BEGIN NODAL DATA
SET 3
 1 0. 0. 0. TO 21 20. 0. 0. BY 10
 2 0. 10. 0. TO 22 20. 10. 0. BY 10
 3 0. 10. 10.  TO 23 20. 10. 10. BY 10
 4 0.  0. 10.  TO 24 20.  0. 10. BY 10
END NODAL DATA
BEGIN STIFFNESS DATA
SET 3
BEGIN ELEMENT DATA
 ROD 1 11 3.
**3 0 1 1 0.
 ROD 11 21 2.
**3 0 1 1 0.
 BEAM N100 11 12 13 1. .2 .3 .4 .5 .6
  *   N101 12 13 14  **
  *   N102 13 14 11  **
  *   N103 14 11 12  **
 BEAM N104 1 11 22 **
*  N105 2 12 1 **
*  N106 3 13 1 **
 * N107 4 14 1 **
 *  N201 11 21 2 **
 *  N202 12 22 1 **
 *  N203 13 23 2 **
 * N204 14 24 1 **
 PLATE N110 1 11 12 2  .1
  *     N111 4 14 13 3  **
  *     N112 11 21 22 12  .15
  *     N113 14 24 23 13  .20
  *     N114  3  4 14  .05
 SPLATE N120 1 11 14 4 .05
   *     N121 2 12 13 3 .05
   *     N122 11 21 24 14 .07
   *     N123 12 22 23 13 .07
 GPLATE N130 21 22 23 24 .06 .06 30.
   *     N4 T150 N131 11 12 14 .07
   *       *  *   N132 12 13 14 .07
END ELEMENT DATA
END STIFFNESS DATA
BEGIN BC DATA
 SET 3 STAGE 1
 SUPPORT ALL FOR 1 TO 4
END BC DATA
BEGIN LOADS DATA
 SET 3 STAGE 1
 BEGIN NODAL LOAD DATA
 CASE C8
  21 TO 24 FX 1000.
 END NODAL LOAD DATA
END LOADS DATA
END PROBLEM DATA
```

```
BEGIN CONTROL MATRIX PROGRAM DEMO09
PROBLEM ID(DEMO09 - PART II . NASTRAN-TO-ATLAS DATA CONVERSION)
DIMENSION A1(1000),A2(1000),A3(1000)
CALL FETADD(SCO0SSF,A1,1000,1,0,IRR)
CALL FETADD(SCO1SSF,A2,1000,1,0,IRR)
CALL FETADD(SAVESS2,A3,1000,1,0,IRR)
LOUT2 = SAVESS2
CALL NASTATL (LOUT2)
END CONTROL PROGRAM
```

```
BEGIN CONTROL PROGRAM DEMO09
PROBLEM ID(DEMO09 - PART III. ATLAS STRESS ANALYSIS)
READ INPUT
PRINT INPUT(NODAL)
PRINT INPUT(STIFFNESS)
PRINT INPUT(BC)
PERFORM STRESS (SET=1)
PRINT OUTPUT (DISPLACE,SET=1)
PRINT OUTPUT (STRESSES,SET=1)
PRINT OUTPUT (REACTIONS,SET=1)
END CONTROL PROGRAM
```

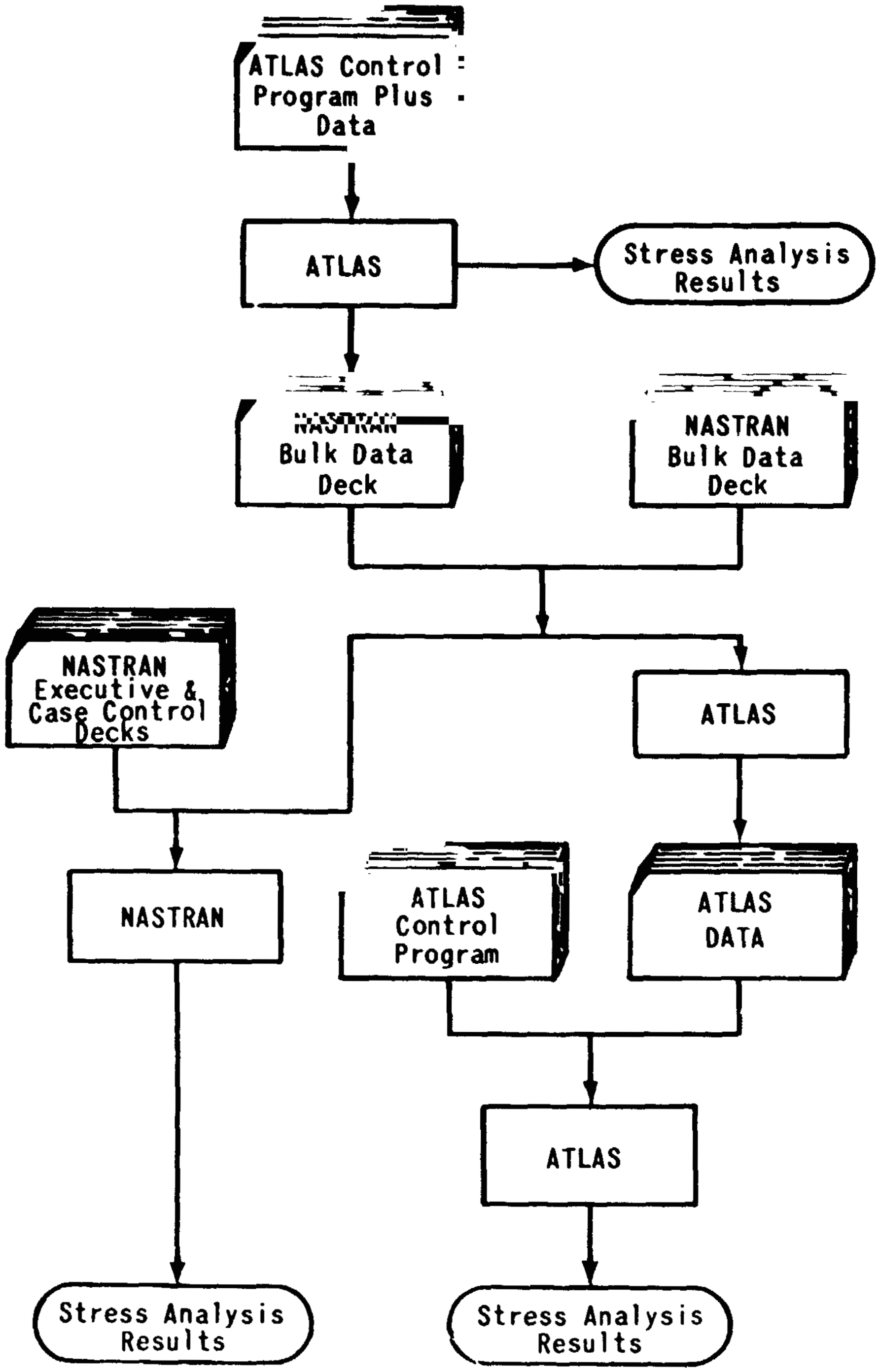

Figure 302-1. Schematic of ATLAS/NASTRAN Interface Demonstration

303. ATLAS/NASA-LaRC AIRPLANE CONFIGURATION PROGRAM INTERFACE (DECK 7)

303.1 DESCRIPTION OF DEMONSTRATION

This deck demonstrates the data interface between ATLAS and the NASA-LaRC airplane configuration plot program (ref. 303-1) and the NASA Aerodynamic Design and Analysis System for Supersonic Aircraft (ref. 303-2). The demonstration makes use of two airplane configurations documented in reference 303-1, viz.,

- A cambered circular body SST configuration (fig. 303-1)
- A blended wing-body fighter aircraft (fig. 303-3)

These examples illustrate each type of airplane component that can be defined by the LaRC configuration program.

The demonstration proceeds as shown schematically in figure 303-5. The LaRC configuration program data for the SST aircraft are processed by the ATLAS library subroutine LRCGEOM to produce geometry data in the format expected by the Geometry Preprocessor. Since the SST is symmetrical about the X-Z plane, each LaRC configuration component produces two ATLAS geometry components (right and left sides). The generated data are read by the Geometry Preprocessor and stored on DATARNF. ATLAS nodal data defining the model are read by the Nodal Preprocessor which interrogates the geometry data to obtain nodal coordinates. Surface nodes are defined for the body and pod components, and mid-surface nodes are defined for the wing, fin and canard components. The same process is then repeated for the fighter aircraft.

303.2 RESULTS

Nodal coordinates for both aircraft were printed by the Nodal Postprocessor and compared with the original airplane configuration data to confirm the correct operation of the interface. The ATLAS nodal data for the SST aircraft were plotted and are displayed in figure 303-2. The ATLAS nodal data for the fighter aircraft are displayed in figure 303-4.

303.3 LISTING OF CONTROL PROGRAM AND DATA

```
      BEGIN CONTROL MATRIX PROGRAM DEMO07
      PROBLEM ID(DEMO07 - NASA/LARC CONFIGURATION PROGRAM INTERFACE)
C
C     PURPOSE        THE PRINCIPAL CAPABILITIES DEMONSTRATED BY THIS
C                    DECK ARE
C                       1. NASA/LARC CONFIGURATION PROGRAM-TO-ATLAS
C                          INTERFACE
C                       2. GEOMETRY PREPROCESSOR
C
C     AUTHOR         R. L. DREISBACH
C
C     CORE           20CK (OCTAL)
C
      DIMENSION A1(100)
C
      CALL FILEADD(A1,SAVESS1)
C
C     S S T   C O N F I G U R A T I O N
C
      CALL LRCGEOM(5LINPUT,SAVESS1)
      REWIND SAVESS1
      READ INPUT(I=SAVESS1)
      READ INPUT
      PRINT INPUT(NODAL,SET=5)
      EXECUTE EXTRACT(EXNAME=SET5,LSUB=NODES,KSET=5,NSUB=N5)
      EXECUTE GRAPHICS(GNAME=NODEPLOT,TYPE=(ORTH,POINT),OFFLINE=CALCOMP,
     X  RZ=60,RY=45,PX=0,SIZE=(30,20),EXNAME=SET5)
      PURGE FILES(DATARNF)
C
C     F I G H T E R   C O N F I G U R A T I O N
C
      CALL FILEADD(A1,SAVESS1)
      REWIND SAVESS1
      CALL LRCGEOM(5LINPUT,SAVESS1)
      REWIND SAVESS1
      READ INPUT(I=SAVESS1)
      READ INPUT
      PRINT INPUT(NODAL,SET=10)
      EXECUTE EXTRACT(EXNAME=SET10,LSUB=NODES,KSET=10,NSUB=N10)
      EXECUTE GRAPHICS(GNAME=NODEPLOT,TYPE=(ORTH,POINT),SIZE=(30,20),
     X              RZ=-150,RY=35,PX=0,EXNAME=SET10)
      END CONTROL PROGRAM
```

SST CONFIGURATION WITH CAMBERED CIRCULAR BODY

```
 1  1 -1  1  1  0  0 12 13  1 17 26                              2 10  3 10
9494.                                                                          REFA
0.       .1       .6       10.      20.      30.      40.      50.      60.      70.       XAF    10
80.      90.      100.                                                         XAF    13
82.30    5.05     0.       180.10                                              WAFORG 1
93.80    6.60     0.       166.201                                             WAFORG 2
114.199  9.90     -.45     142.351                                             WAFORG 3
130.629  13.20    -1.40    124.670                                             WAFORG 4
157.98   19.80    -1.85    98.570                                              WAFORG 5
181.29   26.40    -1.15    78.510                                              WAFORG 6
202.41   33.00    -.35     61.241                                              WAFORG 7
221.63   39.60    -1.60    47.319                                              WAFORG 8
239.18   46.20    -2.80    36.719                                              WAFORG 9
255.00   52.80    -3.75    25.35                                               WAFORG10
269.23   59.40    -4.30    15.670                                              WAFORG11
282.00   66.00    -4.40    7.400                                               WAFORG12
3.60     3.70     3.90     3.75     2.75     .95      -1.35    -3.45    -5.30    -6.80     TZORD  1
-8.20    -9.10    -9.40                                                        TZORD  1
 .10     .50      1.75     2.00     2.10     1.20     -.05     -1.85    -3.25    -4.70     TZORD  2
-6.30    -7.70    -8.80                                                        TZORD  2
 0.      .35      .90      1.20     1.35     .70      -.20     -1.20    -2.35    -3.45     TZORD  3
-4.55    -5.75    -6.80                                                        TZORD  3
0.       .165     .72      .93      1.0      .6875    .15      -.56     -1.35    -2.205    TZORD  4
-3.07    -3.9375-4.801                                                         TZORD  4
0.       .10      .45      .60      .72      .695     .40      .0875    -.295    -.7825    TZORD  5
-1.15    -1.685  -2.173                                                        TZORD  5
0.       .05      .285     .42      .5925    .625     .47      .0125    .12      -.10      TZORD  6
-.345    -.6175  -.8989                                                        TZORD  6
0.       .04      .1935    .2765    .3950    .4395    .4330    .3860    .3085    .2075     TZORD  7
.0915    -.0390  -.1820                                                        TZORD  7
0.       .0225    .1085    .160     .249     .2980    .3135    .3040    .2780    .2380     TZORD  8
.185     .1235    .0563                                                        TZORD  8
0.       .02      .1055    .1580    .248     .2858    .305     .311     .308     .2995     TZORD  9
.2845    .2635    .2385                                                        TZORD  9
0.       .0085    .049     .0695    .1175    .144     .155     .158     .1595    .1585     TZORD 10
.1545    .148     .1398                                                        TZORD 10
0.       -.003    -.014    -.023    -.043    -.061    -.077    -.090    -.1005   -.110     TZORD 11
-.1155   -.1190   -.1224                                                       TZORD 11
0.       -.0025   -.010    -.017    -.0325   -.047    -.062    -.075    -.088    -.100     TZORD 12
-.1115   -.1220   -.1324                                                       TZORD 12
0.       .304     .491     .803     1.069    1.280    1.430    1.518    1.550    1.451     WAFORD 1
1.162    .678     0.0                                                          WAFORD 1
0.0      .265     .423     .710     .962     1.156    1.296    1.373    1.396    1.294     WAFORD 2
1.028    .593     0.0                                                          WAFORD 2
0.0      .226     .338     .635     .889     1.079    1.204    1.272    1.263    1.136     WAFORD 3
.886     .506     0.0                                                          WAFORD 3
0.       .204     .274     .596     .870     1.074    1.20     1.250    1.234    1.083     WAFORD 4
.832     .472     0.                                                           WAFORD 4
0.       .144     .175     .559     .886     1.111    1.246    1.294    1.242    1.087     WAFORD 5
.828     .466     0.0                                                          WAFORD 5
0.0      .066     .09      .522     .886     1.145    1.289    1.341    1.285    1.125     WAFORD 6
.852     .48      0.                                                           WAFORD 6
0.0      .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD 7
.880     .495     0.0                                                          WAFORD 7
0.       .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD 8
.880     .495     0.0                                                          WAFORD 8
0.0      .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD 9
.880     .495     0.                                                           WAFORD 9
0.0      .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD10
.880     .495     0.                                                           WAFORD10
0.0      .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD11
.880     .495     0.                                                           WAFORD11
0.0      .006     .033     .495     .880     1.155    1.320    1.357    1.320    1.155     WAFORD12
.880     .495     0.                                                           WAFORD12
0.       20.      40.      50.      60.      70.      80.      90.      100.     120.      XFUS   10
130.     140.     150.     160.     180.     200.     220.     230.     240.     250.      XFUS   20
260.     270.     280.     290.     300.     312.                                XFUS   26
7.4      7.4      7.4      7.4      7.4      7.4      7.       6.15     5.       2.5       ZFUS   10
1.25     0.       -1.3     -2.5     -5.      -7.45    -9.2     -9.75    -10.     -10.15    ZFUS   20
-10.2    -10.2    -10.2    -10.2    -10.2    -10.2                             ZFUS   26
```

```
0.      18.5    48.     65.     83.     96.     95.5    92.2    95.5    96.         AFUS   10
98.     100.7   101.    98.     89.5    79.     70.     68.5    68.5    67.3        AFUS   20
62.     50.5    37.     24.     11.5    0.                                          AFUS   26
236.8   7.50    -11.55                                                              PODORG 1
0.      4.      8.      12.     16.     20.     24.     28.     32.     34.5        XPOD   1
2.292   2.477   2.644   2.791   2.915   3.012   3.076   3.097   3.100   3.100       PODR   1
241.0   31.75   -3.60                                                               PODORG 2
0.      4.      8.      12.     16.     20.     24.     28.     32.     34.5        XPOD   2
2.292   2.477   2.644   2.791   2.915   3.012   3.076   3.097   3.100   3.100       PODR   2
252.0   47.0    -2.95   35.3    285.36  47.0    6.31    4.77                        FINORG 1
0.0     10.0    20.0    30.     40.     50.     60.     70.     90.     100.        XFIN   1
0.0     0.311   0.564   0.759   0.897   0.977   0.999   0.927   0.427   0.0         FINORD 1
277.9   0.      -6.77   35.3    311.3   0.      2.49    4.77                        FINORG 2
0.0     10.     20.     30.     40.     50.     60.     70.     90.     100.        XFIN   2
0.      0.311   0.564   0.759   0.897   0.977   0.999   0.927   0.427   0.0         FINORD 2
312.    0.      -10.?   0.      277.9   0.      -6.77   35.3                        FINORG 3
0.      10.     20.     30.     40.     50.     60.     70.     90.     100.        XFIN   3
0.      0.311   0.564   0.759   0.397   0.977   0.999   0.927   0.427   0.0         FINORD 3
*/      DEFINE NODES FOR SST CONFIGURATION -- EXAMPLE 1. /
BEGIN NODAL DATA /
  SET 5 /
*/      DEFINE A LOCAL INPUT FRAME FOR EACH GEOMETRY COMPONENT. /
    REC WINGR  0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC WINGL  0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC BODYA  0. 0. 0.  0. -1.  0.  0.  0.  1. /
    REC PODAR  0. 0. 0.  0. -1.  0.  0.  0.  1. /
    REC PODAL  0. 0. 0.  0. -1.  0.  0.  0.  1. /
    REC PODBR  0. 0. 0.  0. -1.  0.  0.  0.  1. /
    REC PODBL  0. 0. 0.  0. -1.  0.  0.  0.  1. /
    REC FINAR  0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINAL  0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINB   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINC   0. 0. 0.  1.  0.  0.  0. -1.  0. /
  BEGIN EXTRACT /
*/      DEFINE MID-SURFACE NODES FOR WING COMPONENTS -- 13 NODES PER SECTION AS
        DEFINED BY THE GEOMETRY DATA.  THE NODES ARE LOCATED SUCH THAT THEY
        COINCIDE WITH THE LONGITUDINAL CONTROL CURVES DEFINED BY THE ENRICH DATA
        RECORD IN THE GEOMETRY DATA SET. /
    COMPONENT WINGR /
  MIDSURFACE NODES IN SECTION  70.  5.05 -10. 290.  5.05 -10. 70.  5.05 70. /
        1 TO  13 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70.  6.60 -10. 290.  6.60 -10. 70.  6.60 70. /
       14 TO  26 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70.  9.90 -10. 290.  9.90 -10. 70.  9.90 70. /
       27 TO  39 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 13.2  -10. 290. 13.2  -10. 70. 13.2  70. /
       40 TO  52 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 19.8  -10. 290. 19.8  -10. 70. 19.8  70. /
       53 TO  65 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 26.4  -10. 290. 26.4  -10. 70. 26.4  70. /
       66 TO  78 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 33.0  -10. 290. 33.0  -10. 70. 33.0  70. /
       79 TO  91 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 39.6  -10. 290. 39.6  -10. 70. 39.6  70. /
       92 TO 104 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 46.2  -10. 290. 46.2  -10. 70. 46.2  70. /
      105 TO 117 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 52.8  -10. 290. 52.8  -10. 70. 52.8  70. /
      118 TO 130 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 59.4  -10. 290. 59.4  -10. 70. 59.4  70. /
      131 TO 143 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70. 66.0  -10. 290. 66.0  -10. 70. 66.0  70. /
      144 TO 156 OF .001 .005 .094 .1 *=8 /
*/                        /
    COMPONENT WINGL /
  MIDSURFACE NODES IN SECTION  70.  -5.05 -10. 290.  -5.05 -10. 70.  -5.05 70. /
      201 TO 213 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70.  -6.60 -10. 290.  -6.60 -10. 70.  -6.60 70. /
      214 TO 226 OF .001 .005 .094 .1 *=8 /
  MIDSURFACE NODES IN SECTION  70.  -9.90 -10. 290.  -9.90 -10. 70.  -9.90 70. /
      227 TO 239 OF .001 .005 .094 .1 *=8 /
```

```
MIDSURFACE NODES IN SECTION  70. -13.2  -10. 290. -13.2  -10. 70. -13.2  70. /
     240 TO 252 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -19.8  -10. 290. -19.8  -10. 70. -19.8  70. /
     253 TO 265 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -26.4  -10. 290. -26.4  -10. 70. -26.4  70. /
     266 TO 278 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -33.0  -10. 290. -33.0  -10. 70. -33.0  70. /
     279 TO 291 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -39.6  -10. 290. -39.6  -10. 70. -39.6  70. /
     292 TO 304 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -46.2  -10. 290. -46.2  -10. 70. -46.2  70. /
     305 TO 317 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -52.8  -10. 290. -52.8  -10. 70. -52.8  70. /
     318 TO 330 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -59.4  -10. 290. -59.4  -10. 70. -59.4  70. /
     331 TO 343 OF .001 .005 .094 .1 *=8 /
MIDSURFACE NODES IN SECTION  70. -66.0  -10. 290. -66.0  -10. 70. -66.0  70. /
     344 TO 356 OF .001 .005 .094 .1 *=8 /
*/                    /
*/    DEFINE 30 EQUALLY-SPACED NODES PER SECTION OF THE BODY. /
    COMPONENT BODYA /
  SURFACE NODES IN SECTION -6. 1.     -20. 6. 1.     -20. -6. 1.     15. /
     1001 TO 1030 /
    SURFACE NODES IN SECTION  -6.   20.  -20.  6.   20. -20. -6.  20.  15. /
     1031 TO 1060 /
    SURFACE NODES IN SECTION  -6.   40.  -20.  6.   40. -20. -6.  40.  15. /
     1061 TO 1090 /
    SURFACE NODES IN SECTION  -6.   50.  -20.  6.   50. -20. -6.  50.  15. /
     1091 TO 1120 /
    SURFACE NODES IN SECTION  -6.   60.  -20.  6.   60. -20. -6.  60.  15. /
     1121 TO 1150 /
    SURFACE NODES IN SECTION  -6.   70.  -20.  6.   70. -20. -6.  70.  15. /
     1151 TO 1180 /
    SURFACE NODES IN SECTION  -6.   80.  -20.  6.   80. -20. -6.  80.  15. /
     1181 TO 1210 /
    SURFACE NODES IN SECTION  -6.   90.  -20.  6.   90. -20. -6.  90.  15. /
     1211 TO 1240 /
    SURFACE NODES IN SECTION  -6.  100.  -20.  6.  100. -20. -6. 100.  15. /
     1241 TO 1270 /
    SURFACE NODES IN SECTION  -6.  120.  -20.  6.  120. -20. -6. 120.  15. /
     1271 TO 1300 /
    SURFACE NODES IN SECTION  -6.  130.  -20.  6.  130. -20. -6. 130.  15. /
     1301 TO 1330 /
    SURFACE NODES IN SECTION  -6.  140.  -20.  6.  140. -20. -6. 140.  15. /
     1331 TO 1360 /
    SURFACE NODES IN SECTION  -6.  150.  -20.  6.  150. -20. -6. 150.  15. /
     1361 TO 1390 /
    SURFACE NODES IN SECTION  -6.  160.  -20.  6.  160. -20. -6. 160.  15. /
     1391 TO 1420 /
    SURFACE NODES IN SECTION  -6.  180.  -20.  6.  180. -20. -6. 180.  15. /
     1421 TO 1450 /
    SURFACE NODES IN SECTION  -6.  200.  -20.  6.  200. -20. -6. 200.  15. /
     1451 TO 1480 /
    SURFACE NODES IN SECTION  -6.  220.  -20.  6.  220. -20. -6. 220.  15. /
     1481 TO 1510 /
    SURFACE NODES IN SECTION  -6.  230.  -20.  6.  230. -20. -6. 230.  15. /
     1511 TO 1540 /
    SURFACE NODES IN SECTION  -6.  240.  -20.  6.  240. -20. -6. 240.  15. /
     1541 TO 1570 /
    SURFACE NODES IN SECTION  -6.  250.  -20.  6.  250. -20. -6. 250.  15. /
     1571 TO 1600 /
    SURFACE NODES IN SECTION  -6.  260.  -20.  6.  260. -20. -6. 260.  15. /
     1601 TO 1630 /
    SURFACE NODES IN SECTION  -6.  270.  -20.  6.  270. -20. -6. 270.  15. /
     1631 TO 1660 /
    SURFACE NODES IN SECTION  -6.  280.  -20.  6.  280. -20. -6. 280.  15. /
     1661 TO 1690 /
    SURFACE NODES IN SECTION  -6.  290.  -20.  6.  290. -20. -6. 290.  15. /
     1691 TO 1720 /
    SURFACE NODES IN SECTION  -6.  300.  -20.  6.  300. -20. -6. 300.  15. /
     1721 TO 1750 /
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 SURFACE NODES IN SECTION -6. 311.     -20. 6. 311.     -20. -6. 311.     15. /
    1751 TO 1780 /
*/              /
*/    DEFINE 25 EQUALLY-SPACED NODES PER SECTION OF EACH NACELLE. /
   COMPONENT PODAR /
   SURFACE NODES IN SECTION  -20. 236.8  -13.   -4. 236.8  -13. -20. 236.8 -2. /
     2001 TO 2025 /
   SURFACE NODES IN SECTION  -20. 240.8  -13.   -4. 240.8  -13. -20. 240.8 -2. /
     2026 TO 2050 /
   SURFACE NODES IN SECTION  -20. 244.8  -13.   -4. 244.8  -13. -20. 244.8 -2. /
     2051 TO 2075 /
   SURFACE NODES IN SECTION  -20. 248.8  -13.   -4. 248.8  -13. -20. 248.8 -2. /
     2076 TO 2100 /
   SURFACE NODES IN SECTION  -20. 252.8  -13.   -4. 252.8  -13. -20. 252.8 -2. /
     2101 TO 2125 /
   SURFACE NODES IN SECTION  -20. 256.8  -13.   -4. 256.8  -13. -20. 256.8 -2. /
     2126 TO 2150 /
   SURFACE NODES IN SECTION  -20. 260.8  -13.   -4. 260.8  -13. -20. 260.8 -2. /
     2151 TO 2175 /
   SURFACE NODES IN SECTION  -20. 264.8  -13.   -4. 264.8  -13. -20. 264.8 -2. /
     2176 TO 2200 /
   SURFACE NODES IN SECTION  -20. 268.8  -13.   -4. 268.8  -13. -20. 268.8 -2. /
     2201 TO 2225 /
   SURFACE NODES IN SECTION  -20. 271.3  -13.   -4. 271.3  -13. -20. 271.3 -2. /
     2226 TO 2250 /
   COMPONENT PODAL /
   SURFACE NODES IN SECTION    4.  236.8  -13.   20. 236.8  -13.    4. 236.8 -2. /
     2251 TO 2275 /
   SURFACE NODES IN SECTION    4.  240.8  -13.   20. 240.8  -13.    4. 240.8 -2. /
     2276 TO 2300 /
   SURFACE NODES IN SECTION    4.  244.8  -13.   20. 244.8  -13.    4. 244.8 -2. /
     2301 TO 2325 /
   SURFACE NODES IN SECTION    4.  248.8  -13.   20. 248.8  -13.    4. 248.8 -2. /
     2326 TO 2350 /
   SURFACE NODES IN SECTION    4.  252.8  -13.   20. 252.8  -13.    4. 252.8 -2. /
     2351 TO 2375 /
   SURFACE NODES IN SECTION    4.  256.8  -13.   20. 256.8  -13.    4. 256.8 -2. /
     2376 TO 2400 /
   SURFACE NODES IN SECTION    4.  260.8  -13.   20. 260.8  -13.    4. 260.8 -2. /
     2401 TO 2425 /
   SURFACE NODES IN SECTION    4.  264.8  -13.   20. 264.8  -13.    4. 264.8 -2. /
     2426 TO 2450 /
   SURFACE NODES IN SECTION    4.  268.8  -13.   20. 268.8  -13.    4. 268.8 -2. /
     2451 TO 2475 /
   SURFACE NODES IN SECTION    4.  271.3  -13.   20. 271.3  -13.    4. 271.3 -2. /
     2476 TO 2500 /
   COMPONENT PODBR /
   SURFACE NODES IN SECTION  -8.0 241.0  -36.0  0. 241.0  -36.0 -8. 241.0 -28./
     2501 TO 2525 /
   SURFACE NODES IN SECTION  -8.0 245.0  -36.0  0. 245.0  -36.0 -8. 245.0 -28./
     2526 TO 2550 /
   SURFACE NODES IN SECTION  -8.0 249.0  -36.0  0. 249.0  -36.0 -8. 249.0 -28./
     2551 TO 2575 /
   SURFACE NODES IN SECTION  -8.0 253.0  -36.0  0. 253.0  -36.0 -8. 253.0 -28./
     2576 TO 2600 /
   SURFACE NODES IN SECTION  -8.0 257.0  -36.0  0. 257.0  -36.0 -8. 257.0 -28./
     2601 TO 2625 /
   SURFACE NODES IN SECTION  -8.0 261.0  -36.0  0. 261.0  -36.0 -8. 261.0 -28./
     2626 TO 2650 /
   SURFACE NODES IN SECTION  -8.0 265.0  -36.0  0. 265.0  -36.0 -8. 265.0 -28./
     2651 TO 2675 /
   SURFACE NODES IN SECTION  -8.0 269.0  -36.0  0. 269.0  -36.0 -8. 269.0 -28./
     2676 TO 2700 /
   SURFACE NODES IN SECTION  -8.0 273.0  -36.0  0. 273.0  -36.0 -8. 273.0 -28./
     2701 TO 2725 /
   SURFACE NODES IN SECTION  -8.0 275.5  -36.0  0. 275.5  -36.0 -8. 275.5 -28./
     2726 TO 2750 /
```

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COMPONENT PODBL/
    SURFACE NODES IN SECTION   0.  241.0  -36.0  8.0 241.0 -36.0  0. 241.0 -28./
      2751 TO 2775 /
    SURFACE NODES IN SECTION   0.  245.0  -36.0  8.0 245.0 -36.0  0. 245.0 -28./
      2776 TO 2800 /
    SURFACE NODES IN SECTION   0.  249.0  -36.0  8.0 249.0 -36.0  0. 249.0 -28./
      2801 TO 2825 /
    SURFACE NODES IN SECTION   0.  253.0  -36.0  8.0 253.0 -36.0  0. 253.0 -28./
      2826 TO 2850 /
    SURFACE NODES IN SECTION   0.  257.0  -36.0  8.0 257.0 -36.0  0. 257.0 -28./
      2851 TO 2875 /
    SURFACE NODES IN SECTION   0.  261.0  -36.0  8.0 261.0 -36.0  0. 261.0 -28./
      2876 TO 2900 /
    SURFACE NODES IN SECTION   0.  265.0  -36.0  8.0 265.0 -36.0  0. 265.0 -28./
      2901 TO 2925 /
    SURFACE NODES IN SECTION   0.  269.0  -36.0  8.0 269.0 -36.0  0. 269.0 -28./
      2926 TO 2950 /
    SURFACE NODES IN SECTION   0.  273.0  -36.0  8.0 273.0 -36.0  0. 273.0 -28./
      2951 TO 2975 /
    SURFACE NODES IN SECTION   0.  275.5  -36.0  8.0 275.5 -36.0  0. 275.5 -28./
      2976 TO 3000 /
*/    DEFINE MID-SURFACE NODES FOR FIN COMPONENTS -- 10 NODES PER SECTION AS
      DEFINED BY THE GEOMETRY DATA.  THE NODES ARE LOCATED SUCH THAT THEY
      COINCIDE WITH THE LONGITUDINAL CONTROL CURVES DEFINED BY THE ENRICH DATA
      RECORD IN THE GEOMETRY DATA SET. /
*/                  /
    COMPONENT FINAR /
 MIDSURFACE NODES IN SECTION  250. -2.95 -48. 300. -2.95 -48. 250. -2.95 -45. /
      4001 TO 4010 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.   .14 -48. 300.   .14 -48. 250.   .14 -45. /
      4011 TO 4020 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.  3.23 -48. 300.  3.23 -48. 250.  3.23 -45. /
      4021 TO 4030 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.  6.31 -48. 300.  6.31 -48. 250.  6.31 -45. /
      4031 TO 4040 OF .1 *=6 .2 .1 /
    COMPONENT FINAL /
 MIDSURFACE NODES IN SECTION  250. -2.95  45. 300. -2.95  45. 250. -2.95  48. /
      4041 TO 4050 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.   .14  45. 300.   .14  45. 250.   .14  48. /
      4051 TO 4060 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.  3.23  45. 300.  3.23  45. 250.  3.23  48. /
      4061 TO 4070 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION  250.  6.31  45. 300.  6.31  45. 250.  6.31  48. /
      4071 TO 4080 OF .1 *=6 .2 .1 /
*/                  /
    COMPONENT FINB  /
 MIDSURFACE NODES IN SECTION 270. -6.77 -1. 318. -6.77 -1. 270. -6.77 1. /
      5001 TO 5010 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270. -3.68 -1. 318. -3.68 -1. 270. -3.68 1. /
      5011 TO 5020 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270.  -.59 -1. 318.  -.59 -1. 270.  -.59 1. /
      5021 TO 5030 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270.  2.49 -1. 318.  2.49 -1. 270.  2.49 1. /
      5031 TO 5040 OF .1 *=6 .2 .1 /
*/                  /
    COMPONENT FINC /
 MIDSURFACE NODES IN SECTION 270. -10.2 -1. 318. -10.2 -1. 270. -10.2 1. /
      5051 TO 5060 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270. -9.06 -1. 318. -9.06 -1. 270. -9.06 1. /
      5061 TO 5070 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270. -7.92 -1. 318. -7.92 -1. 270. -7.92 1. /
      5071 TO 5080 OF .1 *=6 .2 .1 /
 MIDSURFACE NODES IN SECTION 270. -6.77 -1. 318. -6.77 -1. 270. -6.77 1. /
      5081 TO 5090 OF .1 *=6 .2 .1 /
  END EXTRACT /
END NODAL DATA /
*/                /
*/    DEFINE NODE SUBSETS FOR PRINT AND PLOT DISPLAYS. /
BEGIN SUBSET DEFINITION /
  SUBSETS OF NODAL SET 5 /
      N5 = ALL /
END SUBSET DEFINITION /
END PROBLEM DATA /
```

BLENDED WING-BODY-FIGHTER --- DATA FOR ATLAS GEOMETRY INTERFACE

1 -1 1 1 1 11 13 1 19 15 5 10 2 10

637.94										REFA
0.	.5	10.	20.	30.	40.	50.	60.	70.	80.	XAF 10
90.	95.	100.								XAF 13
14.	3.0	0.	31.							WORG 1
24.	4.0	0.	21.1							WORG 2
28.	5.	0.	17.7							WORG 3
30.	6.	0.	16.2							WORG 4
33.3	8.	0.	13.5							WORG 5
36.	10.	0.	11.5							WORG 6
38.5	12.	0.	9.6							WORG 7
41.2	14.	0.	7.6							WORG 8
44.2	16.	0.	5.2							WORG 9
48.	17.6	0.	2.							WORG 10
50.	18.	0.	0.							WORG 11
0.	.95	1.8	3.2	4.2	4.8	5.0	4.8	4.2	3.2	WORD 1
1.8	.95	0.								WORD 1
0.	.655	1.26	2.24	2.94	3.36	3.5	3.36	2.94	2.24	WORD 2
1.26	.655	0.								WORD 2
0.	.57	1.08	1.92	2.52	2.88	3.0	2.88	2.52	1.92	WORD 3
1.08	.57	0.								WORD 3
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 4
.9	.475	0.								WORD 4
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 5
.9	.475	0.								WORD 5
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 6
.9	.475	0.								WORD 6
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 7
.9	.475	0.								WORD 7
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 8
.9	.475	0.								WORD 8
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 9
.9	.475	0.								WORD 9
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 10
.9	.475	0.								WORD 10
0.	.475	.9	1.6	2.1	2.4	2.5	2.4	2.1	1.6	WORD 11
.9	.475	0.								WORD 11
0.	2.0	4.	6.	12.	16.	20.	24.	28.	32.	XFUS 10
36.	40.	48.	52.	65.						XFUS 15
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	Y 1
0.	0.	0.	0.	0.	0.	0.	0.	0.		Y 1
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	Z 1
0.	0.	0.	0.	0.	0.	0.	0.	0.		Z 1
0.	.061	.124	.18	.276	.375	.476	.637	.793	.887	Y 2
.793	.637	.476	.375	.276	.18	.124	.061	0.		Y 2
-.336	-.335	-.331	-.316	-.306	-.275	-.221	-.127	-.007	0.	Z 2
.007	.127	.221	.275	.306	.316	.331	.335	.336		Z 2
0.	.138	.272	.427	.582	.754	.985	1.179	1.394	1.488	Y 3
1.394	1.179	.985	.754	.582	.427	.272	.138	0.		Y 3
-.743	-.735	-.716	-.684	-.634	-.549	-.428	-.228	-.022	0.	Z 3
.002	.228	.428	.549	.634	.684	.716	.735	.743		Z 3
0.	.185	.383	.602	.81	1.077	1.363	1.66	1.924	2.028	Y 4
1.924	1.66	1.363	1.077	.81	.602	.383	.165	0.		Y 4
-1.032	-1.02	-.981	-.938	-.873	-.754	-.548	-.273	-.067	0.	Z 4
.067	.273	.245	.754	.873	.938	.981	1.02	1.032		Z 4
0.	.294	.6	.935	1.283	1.664	2.049	2.466	2.789	2.905	Y 5
2.789	2.466	2.049	1.664	1.283	.935	.6	.294	0.		Y 5
-1.655	-1.637	-1.581	-1.494	-1.368	-1.168	-.882	-.473	-.005	0.	Z 5
.005	.473	.882	1.168	1.368	1.494	1.581	1.637	1.655		Z 5
0.	.35	.725	1.125	1.575	2.0	2.475	3.0	3.0	3.0	Y 6
3.0	3.0	2.475	2.0	1.575	1.125	.725	.35	0.		Y 6
-2.05	-2.04	-2.0	-1.95	-1.825	-1.65	-1.425	-1.05	-.5	0.	Z 6
.5	1.05	1.425	1.65	1.825	1.95	2.0	2.04	2.05		Z 6
0.	.35	.725	1.15	1.575	2.05	2.55	3.0	3.0	3.0	Y 7
3.0	3.0	2.55	2.05	1.575	1.15	.725	.35	0.		Y 7
-2.0	-2.0	-1.975	-1.95	-1.85	-1.7	-1.45	-1.1	-.5	0.	Y 7
.5	1.1	1.45	1.7	1.85	1.95	1.975	2.	2.		Z 7
0.	.35	.725	1.15	1.65	2.2	3.0	3.0	3.0	3.0	Y 8
3.0	3.0	3.0	2.2	1.65	1.15	.725	.35	0.		Y 8

```
-2.0     -2.0    -2.     -2.     -1.95   -1.85   -1.5    -1.05   -.5     0.      Y 8
.5       1.05    1.5     1.85    1.95    2.      2.      2.      2.              Z 8
0.       .35     .725    1.15    1.65    2.15    3.0     3.0     3.0     3.0     Y 9
3.0      3.0     3.0     2.15    1.65    1.15    .725    .35     0.                Y 9
-2.0     -2.0    -2.     -2.     -1.95   -1.8    -1.5    -1.05   -.5     0.      Y 9
.5       1.05    1.5     1.8     1.95    2.      2.      2.      2.              Z 9
0.       .35     .725    1.15    1.65    2.15    3.0     3.0     3.0     3.0     Y 10
3.0      3.0     3.0     2.15    1.65    1.15    .725    .35     0.                Y 10
-2.0     -2.0    -2.     -2.     -1.95   -1.8    -1.5    -1.05   -.5     0.      Y 10
.5       1.05    1.5     1.8     1.95    2.      2.      2.      2.              Z 10
0.       .35     .725    1.15    1.65    2.15    3.0     3.0     3.0     3.0     Y 11
3.0      3.0     3.0     2.15    1.65    1.15    .725    .35     0.                Y 11
-2.0     -2.0    -2.     -2.     -1.95   -1.8    -1.5    -1.05   -.5     0.      Y 11
.5       1.05    1.5     1.8     1.95    2.      2.      2.      2.              Z 11
0.       .35     .725    1.15    1.65    2.15    2.5     3.0     3.0     3.0     Y 12
3.0      3.0     2.5     2.15    1.65    1.15    .725    .35     0.                Y 12
-2.0     -2.0    -2.     -2.     -1.95   -1.8    -1.4    -1.05   -.5     0.      Y 12
.5       1.05    1.4     1.8     1.95    2.      2.      2.      2.              Z 12
0.       .35     .725    1.15    1.65    2.15    2.5     2.875   2.95    3.0     Y 13
2.95     2.875   2.5     2.15    1.65    1.15    .725    .35     0.                Y 13
-2.0     -2.0    -2.     -2.     -1.95   -1.8    -1.4    -.975   -.5     0.      Y 13
.5       .975    1.4     1.8     1.95    2.      2.      2.      2.              Z 13
0.       .35     .725    1.125   1.525   1.9     2.25    2.55    2.8     3.0     Y 14
2.8      2.55    2.25    1.9     1.525   1.125   .725    .35     0.                Y 14
-2.0     -2.0    -2.     -1.95   -1.8    -1.6    -1.275  -.9     -.5     0.      Y 14
.5       .9      1.275   1.6     1.9     1.95    2.      2.      2.              Z 14
0.       .35     .725    1.125   1.525   1.9     2.25    2.55    2.8     3.0     Y 15
2.8      2.55    2.25    1.9     1.525   1.125   .725    .35     0.                Y 15
-2.0     -2.0    -2.     -1.95   -1.8    -1.6    -1.275  -.9     -.5     0.      Y 15
.5       .9      1.275   1.6     1.8     1.95    2.      2.      2.              Z 15
53.091   0.      2.0     12.162 62.215  0.      8.483   6.129                   VTORG 1
0.       10.     20.     30.     40.     50.     60.     70.     80.     100.    XFIN
0.       .72     1.28    1.68    1.92    2.0     1.92    1.68    1.28    0.      FINORD
62.215   0.      8.483   6.129  64.662  0.      10.18   0.                      VTORG 2
0.       10.     20.     30.     40.     50.     60.     70.     80.     100.    XFIN
0.       .72     1.28    1.68    1.92    2.0     1.92    1.68    1.28    0.      FINORD
55.774   0.      -4.481  0.      55.026  0.      -3.948  3.495                   VORG 3
0.       13.722  20.     30.     40.     50.     60.     70.     86.278  100.
0.       1.49    1.49    1.49    1.49    1.49    1.49    1.49    1.49    0.      VORD
55.026   0.      -3.948  8.498 53.073   0.      -2.455 11.473                   VORG 4
0.       13.722  20.     30.     40.     50.     60.     70.     86.278  100.
0.       1.49    1.49    1.49    1.49    1.49    1.49    1.49    1.49    0.      VORD
53.073   0.      -2.455 11.473 52.481   0.      -2.0   12.066                   VORG 5
0.       13.722  20.     30.     40.     50.     60.     70.     86.278  100.
0.       1.49    1.49    1.49    1.49    1.49    1.49    1.49    1.49    0.      VORD
57.473   3.0     0.      8.567 66.868 11.315    0.      3.413                   CANORG 1
0.       10.     20.     30.     40.     50.     60.     70.     80.     100.    XCAN
0.       .72     1.28    1.68    1.92    2.0     1.92    1.68    1.28    0.      CANORD
66.868 11.315    0.      3.413 63.115 12.419    0.      0.                      CANORG 2
0.       10.     20.     30.     40.     50.     60.     70.     80.     100.    XCAN
0.       .72     1.28    1.68    1.92    2.0     1.92    1.68    1.28    0.      CANORD
*/    DEFINE NODES FOR BLENDED WING-BODY FIGHTER -- EXAMPLE 2. /
BEGIN NODAL DATA /
  SET 10 /
*/    DEFINE A LOCAL INPUT FRAME FOR EACH GEOMETRY COMPONENT. /
    REC WINGR  0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC WINGL  0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC BODYA  0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC FINA   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINB   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINC   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FIND   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC FINE   0. 0. 0.  1.  0.  0.  0. -1.  0. /
    REC CANFDAR 0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC CANFDAL 0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC CANRDAR 0. 0. 0.  1.  0.  0.  0.  0.  1. /
    REC CANRDBL 0. 0. 0.  1.  0.  0.  0.  0.  1. /
```

```
  BEGIN EXTRACT /
*/    DEFINE MID-SURFACE NODES FOR WING COMPONENTS -- 13 NODES PER SECTION AS
      DEFINED BY THE GEOMETRY DATA.  THE NODES ARE LOCATED SUCH THAT THEY
      COINCIDE WITH THE LONGITUDINAL CONTROL CURVES DEFINED BY THE ENRICH DATA
      RECORD IN THE GEOMETRY DATA SET. /
    COMPONENT WINGR /
  MIDSURFACE NODES IN SECTION  13.  3.0  -1.  55.  3.0  -1.  13.  3.0  20. /
        1 TO  13 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  4.0  -1.  55.  4.0  -1.  13.  4.0  20. /
      14 TO  26 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  5.0  -1.  55.  5.0  -1.  13.  5.0  20. /
      27 TO  39 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  6.0  -1.  55.  6.0  -1.  13.  6.0  20. /
      40 TO  52 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  8.0  -1.  55.  8.0  -1.  13.  8.0  20. /
      53 TO  65 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. 10.0  -1.  55. 10.0  -1.  13. 10.0  20. /
      66 TO  78 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. 12.0  -1.  55. 12.0  -1.  13. 12.0  20. /
      79 TO  91 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. 14.0  -1.  55. 14.0  -1.  13. 14.0  20. /
      92 TO 104 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. 16.0  -1.  55. 16.0  -1.  13. 16.0  20. /
     105 TO 117 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. 17.6  -1.  55. 17.6  -1.  13. 17.6  20. /
     118 TO 130 OF .005 .095 .1 *=7 .05 .05 /
 MIDSURFACE NODES IN SECTION 13. 17.999 -1. 55. 17.999 -1. 13. 17.999  20. /
     131 TO 143 OF .005 .095 .1 *=7 .05 .05 /
*/                 /
    COMPONENT WINGL /
  MIDSURFACE NODES IN SECTION  13.  -3.0 -1. 55.  -3.0 -1. 13.  -3.0 20. /
     201 TO 213 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  -4.0 -1. 55.  -4.0 -1. 13.  -4.0 20. /
     214 TO 226 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  -5.0 -1. 55.  -5.0 -1. 13.  -5.0 20. /
     227 TO 239 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  -6.0 -1. 55.  -6.0 -1. 13.  -6.0 20. /
     240 TO 252 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13.  -8.0 -1. 55.  -8.0 -1. 13.  -8.0 20. /
     253 TO 265 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. -10.0 -1. 55. -10.0 -1. 13. -10.0 20. /
     266 TO 278 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. -12.0 -1. 55. -12.0 -1. 13. -12.0 20. /
     279 TO 291 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. -14.0 -1. 55. -14.0 -1. 13. -14.0 20. /
     292 TO 304 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. -16.0 -1. 55. -16.0 -1. 13. -16.0 20. /
     305 TO 317 OF .005 .095 .1 *=7 .05 .05 /
  MIDSURFACE NODES IN SECTION  13. -17.6 -1. 55. -17.6 -1. 13. -17.6 20. /
     318 TO 330 OF .005 .095 .1 *=7 .05 .05 /
 MIDSURFACE NODES IN SECTION 13. -17.999 -1. 55. -17.999 -1. 13. -17.999 20. /
     331 TO 343 OF .005 .095 .1 *=7 .05 .05 /
*/                 /
*/    DEFINE NODES AT THE INTERSECTION POINTS OF THE LONGITUDINAL CONTROL
      CURVES WITH THE BODY SECTIONS.  FOR THIS CASE, THERE WILL BE 37
      NODES PER SECTION OF THE BODY. /
    COMPONENT BODYA /
  SURFACE NODES IN SECTION  2. -10. -10.  2. 10. -10.  2. -10. 10. /
     1001 TO 1037 AT CURVES /
  SURFACE NODES IN SECTION  4. -10. -10.  4. 10. -10.  4. -10. 10. /
     1038 TO 1074 AT CURVES /
  SURFACE NODES IN SECTION  6. -10. -10.  6. 10. -10.  6. -10. 10. /
     1075 TO 1111 AT CURVES /
  SURFACE NODES IN SECTION 12. -10. -10. 12. 10. -10. 12. -10. 10. /
     1112 TO 1148 AT CURVES /
  SURFACE NODES IN SECTION 16. -10. -10. 16. 10. -10. 16. -10. 10. /
     1149 TO 1185 AT CURVES /
  SURFACE NODES IN SECTION 20. -10. -10. 20. 10. -10. 20. -10. 10. /
     1186 TO 1222 AT CURVES /
  SURFACE NODES IN SECTION 24. -10. -10. 24. 10. -10. 24. -10. 10. /
```

```
    1223 TO 1259 AT CURVES /
SURFACE NODES IN SECTION 28. -10. -10. 28. 10. -10. 28. -10. 10. /
    1260 TO 1296 AT CURVES /
SURFACE NODES IN SECTION 32. -10. -10. 32. 10. -10. 32. -10. 10. /
    1297 TO 1333 AT CURVES /
SURFACE NODES IN SECTION 36. -10. -10. 36. 10. -10. 36. -10. 10. /
    1334 TO 1370 AT CURVES /
SURFACE NODES IN SECTION 40. -10. -10. 40. 10. -10. 40. -10. 10. /
    1371 TO 1407 AT CURVES /
SURFACE NODES IN SECTION 48. -10. -10. 48. 10. -10. 48. -10. 10. /
    1408 TO 1444 AT CURVES /
SURFACE NODES IN SECTION 52. -10. -10. 52. 10. -10. 52. -10. 10. /
    1445 TO 1481 AT CURVES /
SURFACE NODES IN SECTION 65. -10. -10. 65. 10. -10. 65. -10. 10. /
    1482 TO 1518 AT CURVES /
*/          /
*/    DEFINE MID-SURFACE NODES FOR FIN COMPONENTS -- 10 NODES PER SECTION.
      THE NODES ARE LOCATED SUCH THAT THEY COINCIDE WITH THE LONGITUDINAL
      CONTROL CURVES DEFINED BY THE ENRICH DATA RECORD IN THE GEOMETRY
      DATA SET. /
  COMPONENT FINA /
MIDSURFACE NODES IN SECTION 50. 2.0   5.0  70. 2.0   5.0  50. 2.0   -5.0 /
    4001 TO 4010 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. 4.0   5.0  70. 4.0   5.0  50. 4.0   -5.0 /
    4011 TO 4020 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. 6.0   5.0  70. 6.0   5.0  50. 6.0   -5.0 /
    4021 TO 4030 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. 8.483 5.0  70. 8.483 5.0  50. 8.483 -5.0 /
    4031 TO 4040 OF .1 *=7 .2 /
  COMPONENT FINB /
MIDSURFACE NODES IN SECTION 50. 8.483 5.0  70. 8.483 5.0  50. 8.483 -5.0 /
    4041 TO 4050 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. 10.18 5.0  70. 10.18 5.0  50. 10.18 -5.0 /
    4051 TO 4060 OF .1 *=7 .2 /
  COMPONENT FINC /
MIDSURFACE NODES IN SECTION 50. -4.481 5. 70. -4.481 5. 50. -4.481 -5. /
    4061 TO 4070 OF .1372 .0628 .1 *=4 .1628 .1372 /
MIDSURFACE NODES IN SECTION 50. -3.948 5. 70. -3.948 5. 50. -3.948 -5. /
    4071 TO 4080 OF .1372 .0628 .1 *=4 .1628 .1372 /
  COMPONENT FIND /
MIDSURFACE NODES IN SECTION 50. -2.455 5. 70. -2.455 5. 50. -2.455 -5. /
    4081 TO 4090 OF .1372 .0628 .1 *=4 .1628 .1372 /
  COMPONENT FINE /
MIDSURFACE NODES IN SECTION 50. -2.0 5. 70. -2.0 5. 50. -2.0 -5. /
    4091 TO 4100 OF .1372 .0628 .1 *=4 .1628 .1372 /
*/          /
*/    DEFINE MID-SURFACE NODES FOR CANARD COMPONENTS -- 10 NODES PER SECTION.
      THE NODES ARE LOCATED SUCH THAT THEY COINCIDE WITH THE LONGITUDINAL
      CONTROL CURVES DEFINED BY THE ENRICH DATA RECORD IN THE GEOMETRY
      DATA SET. /
  COMPONENT CANRDAR /
MIDSURFACE NODES IN SECTION 50.   3.0   -1. 70.   3.0   -1. 50.   3.0   1. /
    5001 TO 5010 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50.   6.0   -1. 70.   6.0   -1. 50.   6.0   1. /
    5011 TO 5020 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. 11.315 -1. 70. 11.315 -1. 50. 11.315 1. /
    5021 TO 5030 OF .1 *=7 .2 /
  COMPONENT CANRDAL /
MIDSURFACE NODES IN SECTION 50.  -3.0   -1. 70.  -3.0   -1. 50.  -3.0   1. /
    5041 TO 5050 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50.  -6.0   -1. 70.  -6.0   -1. 50.  -6.0   1. /
    5051 TO 5060 OF .1 *=7 .2 /
MIDSURFACE NODES IN SECTION 50. -11.315 -1. 70. -11.315 -1. 50. -11.315 1. /
    5061 TO 5070 OF .1 *=7 .2 /
  COMPONENT CANRDBR /
MIDSURFACE NODES IN SECTION 50. 12.319 -1. 70. 12.319 -1. 50. 12.319 1. /
    5031 TO 5040 OF .1 *=7 .2 /
  COMPONENT CANRDBL /
MIDSURFACE NODES IN SECTION 50. -12.319 -1. 70. -12.319 -1. 50. -12.319 1. /
    5071 TO 5080 OF .1 *=7 .2 /
END EXTRACT /
```

```
END NUDAL DATA /
*/              /
*/    DEFINE NODE SUBSETS FOR PRINT AND PLOT DISPLAYS. /
BEGIN SUBSET DEFINITION /
  SUBSETS OF NODAL SET 10 /
      N10 = ALL /
END SUBSET DEFINITION /
END PROBLEM DATA /
```

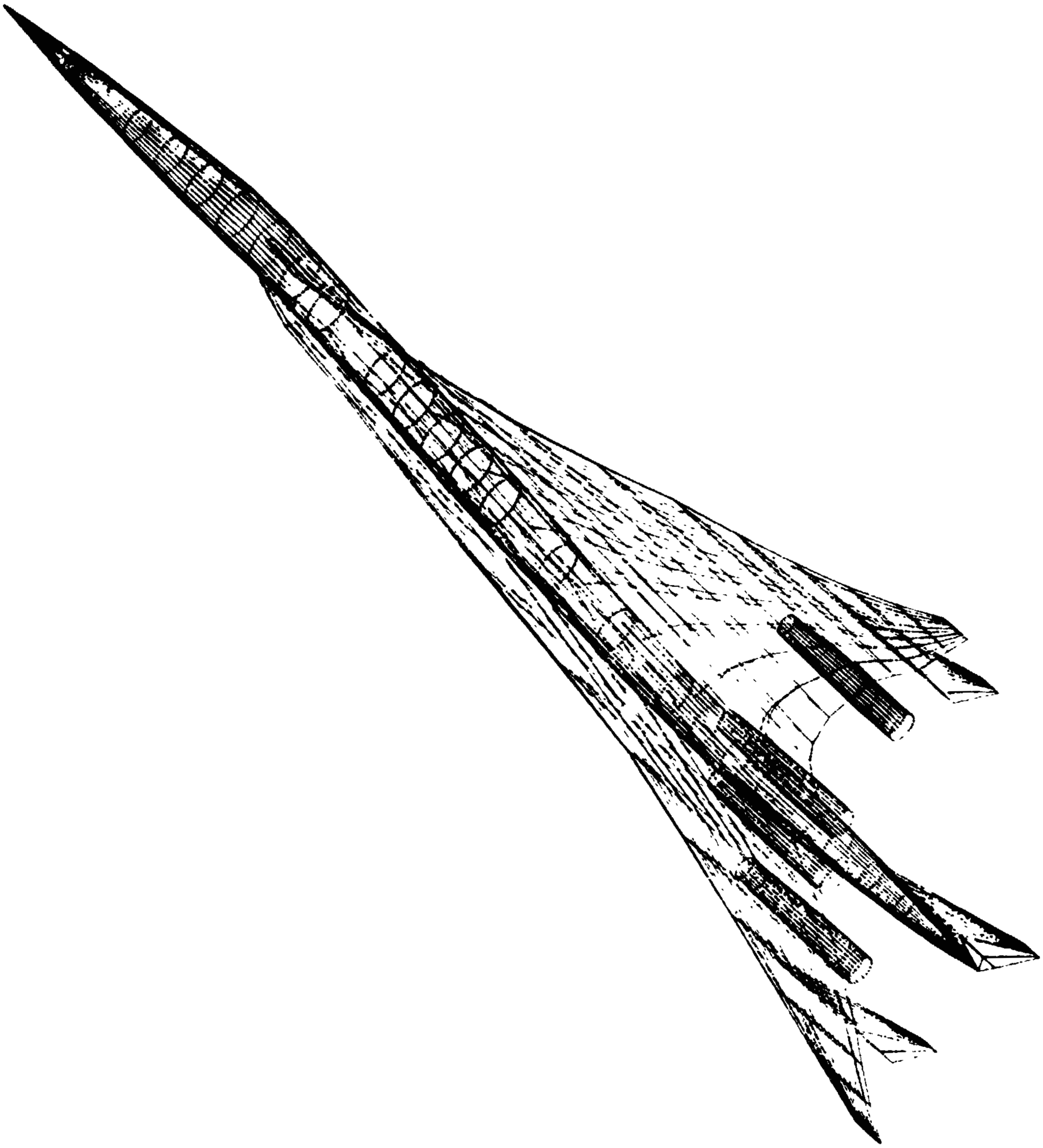

Figure 303-1. SST Configuration

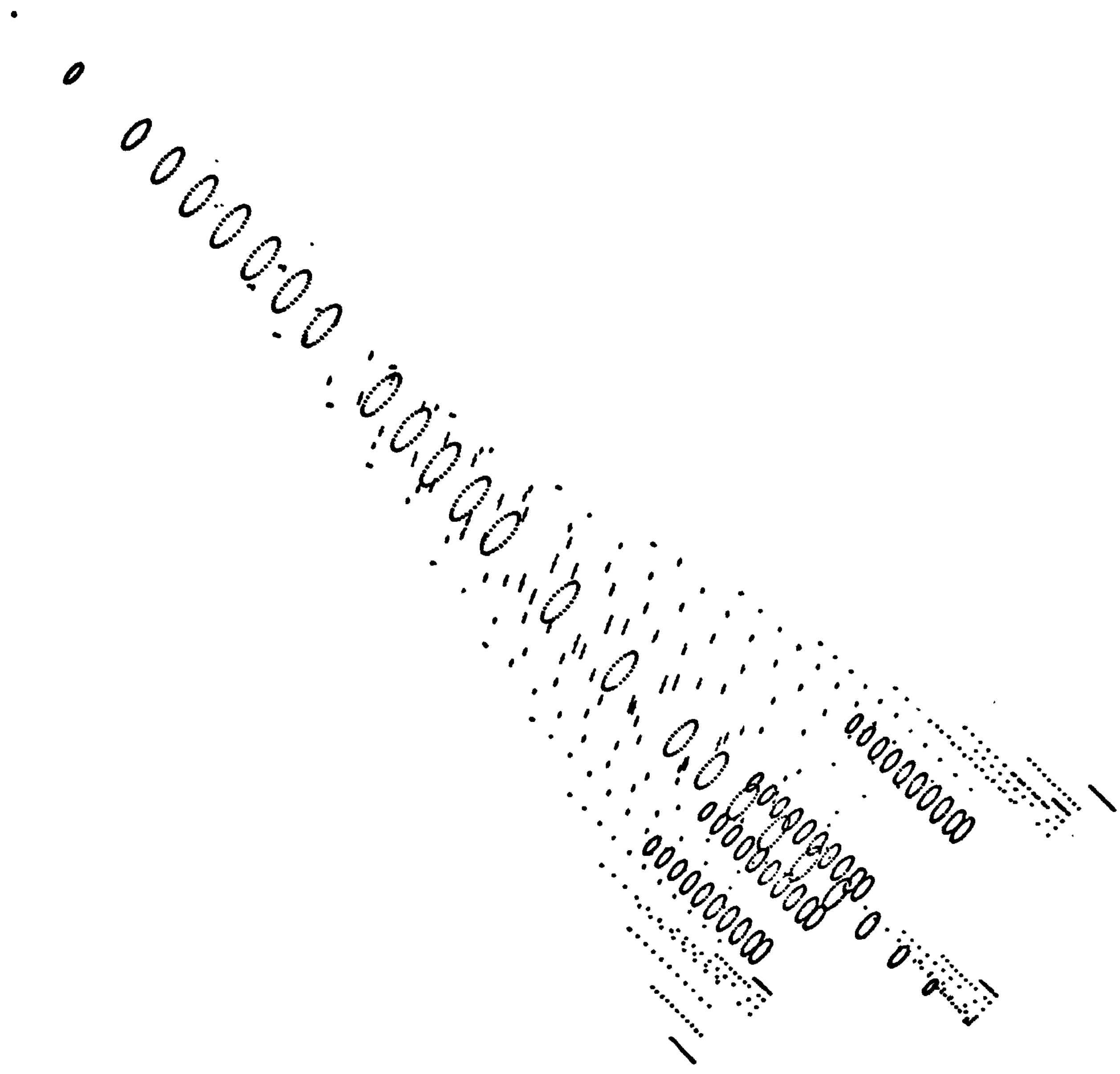

Figure 303-2. ATLAS Nodal Data for SST Aircraft

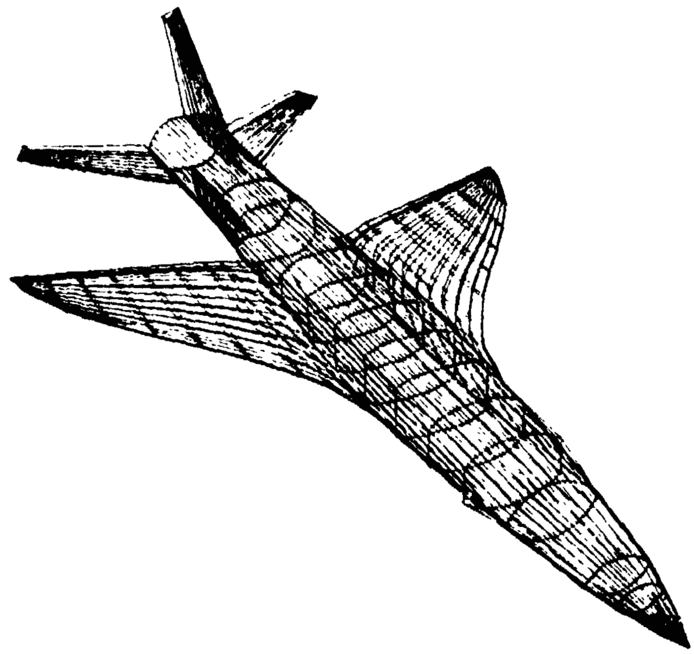

Figure 303-3. Fighter Aircraft Configuration

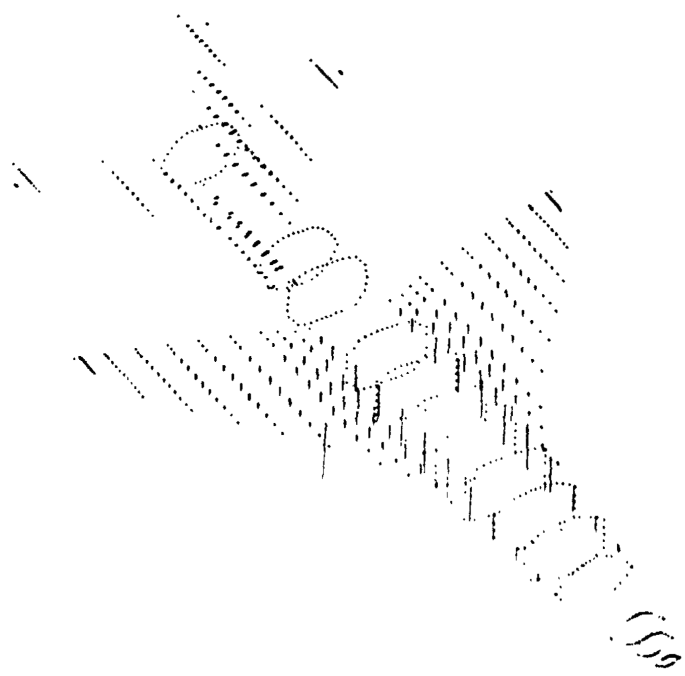

Figure 303-4. ATLAS Nodal Data for Fighter Aircraft

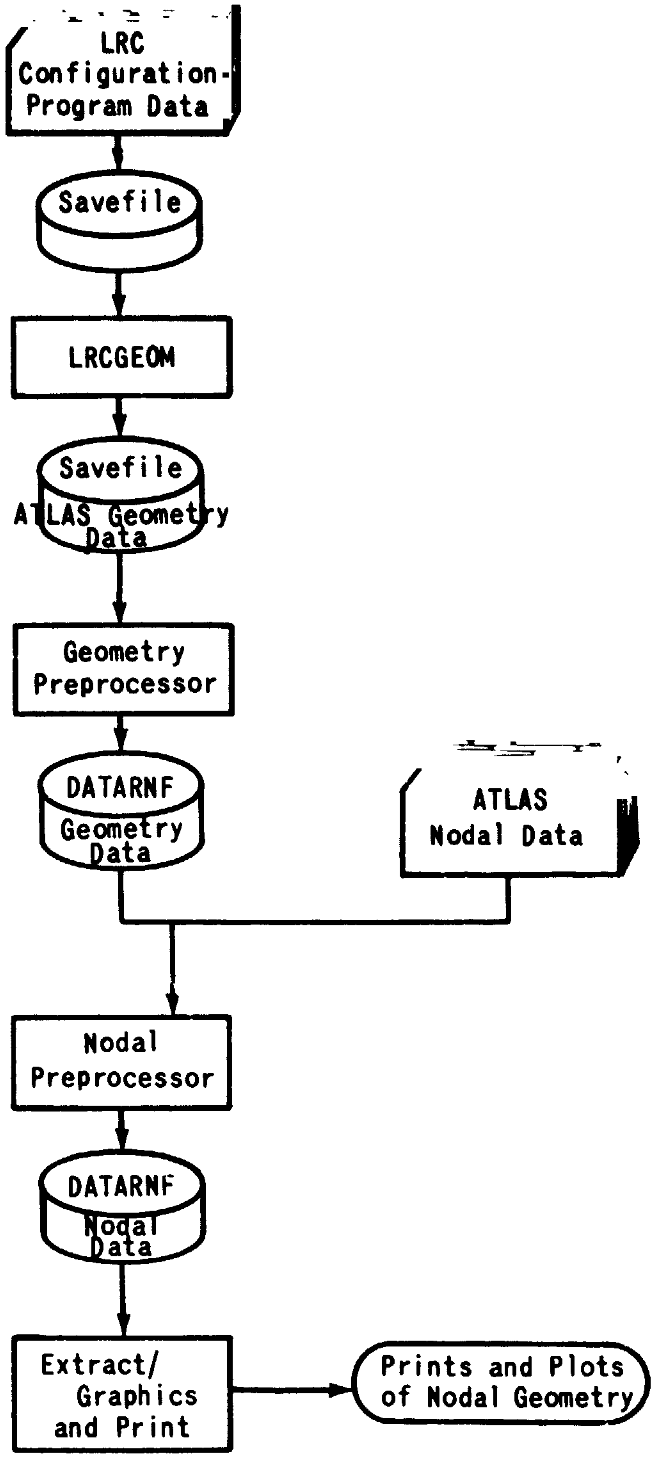

Figure 303-5. Schematic of ATLAS/ LaRC Airplane Configuration Program Interface Demonstration

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