APPENDIX D

BENDING PROGRAM LISTING

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C   PROGRAM NAME:  FULLFIN.FOR

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C   This program will calculate the fin bending spring rate for the
C   stainless steel core of the AdKEM control fin assuming a constant
C   distributed load (dynamic pressure) on the fin.  First of all the
C   fin geometry is input to the program.  This includes the span,
C   various thicknesses, and the root and tip lengths.  Then a
C   loop is used to calculate the moment and slope at each point along
C   the span and solve for the stiffness measured in in-lbf/rad.
C   The equation is
C
C           K(Y) = dMOMENT/dTHETA

C   VARIABLE    DESCRIPTION

C   THKFACT     Thickness multiplier for variable thicknesses
C   LR1         Trailing wedge length at root (in)
C   LR2         Mid-section length at root (in)
C   LR3         Leading wedge length at root (in)
C   LRTOT       Total fin length at root (in)
C   TROOT       Mid-section thickness at root (in)
C   LT1         Trailing wedge length at tip (in)
C   LT2         Mid-section length at tip (in)
C   LT3         Leading wedge length at tip (in)
C   LTTOT       Total fin tip length (in)
C   TSPAN       Mid-section thickness at span (in)
C   LSPAN       Length of span (in)
C   TSLE        Thickness of leading edge at span (in)
C   TRLE        Thickness of leading at root (in)
C   TSTE        Thickness of trailing edge at span (in)
C   TRTE        Thickness of trailing edge at root (in)
C   ATOT        Total fin root area (in2)
C   MOM1        Bending moment at fin root (in-lbf)

      IMPLICIT REAL (I ,K-M)
      DOUBLE PRECISION THETA1, THETA2, DELTHT, XDEF, DY
      OPEN(4, FILE='FULL.DAT', STATUS = 'NEW')
      THKFACT = 1.0

C     ***** INPUT FIN GEOMETRY SPECIFICATIONS *****
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C    ROOT GEOMETRY (ALL DIMENSIONS IN INCHES)
          LR1  =  .699
          LR2  =  .822
          LR3  =  .674
          LRTOT  =  LR1 + LR2 + LR3
          TROOT  =  THKFACT * 0.1

C    TIP GEOMETRY
          LT1  =  .299
          LT2  =  .444
          LT3  =  .357
          LTTOT  =  LT1 + LT2 + LT3
          TSPAN  =  THKFACT * 0.057

C    SPAN LENGTH
          LSPAN  =  1.80

C    LEADING AND TRAILING EDGE THICKNESSES AT ROOT AND SPAN
          TSLE  =  THKFACT  *  .017
          TRLE  =  THKFACT  *  .025
          TSTE  =  THKFACT  *  .025
          TRTE  =  THKFACT  *  .025

C    CALCULATE TOTAL FIN AREA AND BENDING MOMENT AT Y=0
          ATOT  =  LSPAN/2. *  (LRTOT + LTTOT)
          MOM1  =  LSPAN/6. *  (LSPAN*(LTTOT + 2.*LRTOT) – 6.*ATOT)

C    ***** OTHER VARIABLES *****
C    FIN COEFFICIENT OF ELASTICITY (psi)
          E  =  28.5E06
C    INTEGRATION STEP SIZE
          DY  =  .001
C    DO LOOP TERMINATION VALUE CALCULATION
          JDY  =  LSPAN/DY
C    LOOP INITIALIZATION
          SUMMOI  =  .0
          THETA1  =  .0
          ZDEF  =  .0
          JPRINT  =  1

C    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C    !!!!!!!!!!!!!!!!!!!!DON'T MESS WITH ANYTHING BELOW HERE!!!!!!!!!!!!!!!!!!
C    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

C    ***** BEGIN NUMERICAL INTEGRATION TO SOLVE FOR STIFFNESS *****
          DO 10 J  =  1, JDY–9
          Y  =  J*DY

C    ***** CALCULATE CROSS-SECTIONAL INERTIA OF FIN AT Y *****
C    CALCULATE TRAILING SECTION PARAMETERS
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            B1 = (LT1-LR1)*Y/LSPAN + LR1
            T1 = (TSPAN-TROOT)*Y/LSPAN + TROOT
            TTE = (TSTE-TRTE)*Y/LSPAN + TRTE
            MZ1 = (T1-TTE)/(2.*B1)
            BZ1 = TTE/2.

C     CALCULATE TRAILING SECTION INERTIA
C     (RECTANGULAR PORTION)
            XI1R = (1/12.)*B1*(TTE**3)
C     (TRIANGULAR PORTION)

      XIIT = B1*( ( (MZ1*B1)**3)/6. + (2.*BZ1/3. )*(MZ1*B1)**2 +
     &           MZ1*B1*BZ1**2)
C     TOTAL
            XI1 = XI1R + XIIT

C     CALCULATE MIDDLE SECTION INERTIA
            C1 = (LT2-LR2)*Y/LSPAN + LR2
            C2 = ((TSPAN-TROOT)*Y/LSPAN + TROOT)**3
            C3 = 1/12. XI2 = C3*C1*C2

C     CALCULATE LEADING SECTION PARAMETERS
            B3 = (LT3-LR3)*Y/LSPAN + LR3
            T3 = (TSPAN-TROOT)*Y/LSPAN + TROOT
            TLE = (TSLE-TRLE)*Y/LSPAN + TRLE
            MZ3 = (T3-TLE)/(2.*B3)
            BZ3 = TLE/2.

C     CALCULATE LEADING SECTION INERTIA
C     (RECTANGULAR PORTION)
            XI3R = (1/12.)*B3*(TLE**3)
C (TRIANGULAR PORTION)
            XI3T = B3*(((MZ3*B3)**3)/6. + (2.*BZ3/3.)*(MZ3*B3)**2 +
     &           MZ3*B3*BZ3**2)
C     TOTAL
            XI3 = XI3R + XI3T
C     TOTAL INERTIA OF CROSS-SECTION
            XITOT = XI1 + XI2 + XI3
C     ***** CALCULATE BENDING STIFFNESS *****
C     CALCULATE MOMENT/DYNAMIC PRESSURE AT Y AND CHANGE IN
            MOMENT M0M2 = ATOT*(Y-LSPAN) - LRTOT/2.*(Y**2.-LSPAN**2.) -
     &      (LTTOT-LRTOT)*(Y**3.-LSPAN**3.)/(6.*LSPAN)
            DELMOM = MOM2 - MOM1
C     CALCALUTE THETA/DYNAMIC PRESSURE AT Y AND CHANGE IN THETA
            RAT = MOM2/XITOT
            SUMMOI = SUMMOI + (MOM2/XITOT)*DY
            THETA2 = SUMMOI/E
            DELTHT = THETA2 - THETA1
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C    CALCULATE DEFLECTION/DYNAMIC PRESSURE
          ZDEF = ZDEF + THETA2*DY

C    CALCULATE FIN STIFFNESS
          KFINY = ABS(DELMOM DELTHT)

MOM1 = MOM2 THETA1 = THETA2

C    ***** WRITE DATA TO FILE *****
C    PRINT EVERY 10th DATA POINT
          IF (JPRINT .EQ. 10) THEN

C    WRITE SPRING RATE AT Y TO FILE
          WR1TE(4, 100)Y, KFINY, MOM2, THETA2, ZDEF
 100    FORMAT(2X, F6.4, 2X, E15.3, 2X, F11.3, 2X, E15.3, 2X, E15.3)

          JPRINT = 0
       ENDIF

       JPRINT = JPRINT+1

  10   CONTINUE

       END
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