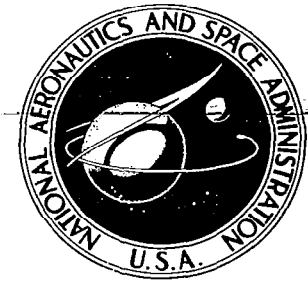
NASA CONTRACTOR REPORT



N-A-S-A-CR-2

NASA CR-2799

DESAP 2 - A STRUCTURAL DESIGN PROGRAM WITH STRESS AND BUCKLING CONSTRAINTS

Volume III: Program Listing

J. Kiusalaas and G. B. Reddy

Prepared by
THE PENNSYLVANIA STATE UNIVERSITY
University Park, Pa. 16802
for George C. Marshall Space Flight Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION · WASHINGTON, D. C. · MARCH 1977

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-2799		

4. TITLE AND SUBTITLE	5. REPORT DATE
DESAP 2 - A Structural Design Program with Stress and Buckling Constraints. Vol. III: Program Listing	March 1977
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT #
J. Kiusalaas and G. B. Reddy	M-207

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Department of Engineering Science and Mechanics The Pennsylvania State University University Park, Pennsylvania 16802	11. CONTRACT OR GRANT NO. NCA-8-71/72
	13. TYPE OF REPORT & PERIOD COVERED Contractor Report Final
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was done under the sponsorship of the Structures and Propulsion Laboratory of the Marshall Space Flight Center, Alabama.

16. ABSTRACT

DFSAP 2 is a finite element program for computer-automated, minimum weight design of elastic structures with constraints on stresses (including local instability criteria) and buckling loads. No limits are placed on the number of load conditions for stress-constrained design, but only one of these load conditions can be chosen as the potential buckling load. A substantial portion of DESAP 2, particularly the analysis of the prebuckling state, is derived from the SOLID SAP finite element program developed at the University of California, Berkeley. The stress-constrained design is based on the classical stress ratio method, which drives the design toward a fully stressed state. The constraints on the buckling load are handled by solving the appropriate optimality criterion by successive iterations. During each iteration, the element sizes determined by the stress ratio method are used as the minimum size constraints. The element subroutines have been organized in a manner that permits the user to make additions and changes with a minimal programming effort. Consequently, DESAP 2 can readily be changed into a special-purpose program to handle the user's specific design requirements and failure criteria.

DFSAP 2 is a companion program of DESAP 1: "A Structural Design Program with Stress and Displacement Constraints." With the exception of a few cards the same input data deck can be used for both programs.

This is Volume III of three volumes.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
	STAR Category 39

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	113	$5.50

* For sale by the National Technical Information Service, Springfield, Virginia 22161

TABLE OF CONTENTS

VOLUME 3

```
C*************************************************************************MAIN0000
C*************************************************************************MAIN0010
C**                                                                     **MAIN0020
C**    DESAP2---AN AUTOMATED DESIGN PROGRAM WITH STRESS AND             **MAIN0030
C**    BUCKLING      CONSTRAINTS BASED ON SAP2 ANALYSIS PROGRAM          **MAIN0040
C**                                                                     **MAIN0050
C**          BY  J.KHUSALAAS  AND  G.B.REDDY       (MAY , 1976 )       **MAIN0060
C**                                                                     **MAIN0070
C*************************************************************************MAIN0080
C*************************************************************************MAIN0090
      COMMON /BLNK / HED(20),BLN(348)                                    MAIN0100
      COMMON/EM/OOO(5548)                                                MAIN0110
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             MAIN0120
      COMMON /ELPAR/ MPAR(14),NUMNP,MBAND,NELTYP,NL,N2,N3,N4,N5,MTOT,NEQMAIN0130
     1,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQB,NBLOCK                           MAIN0140
      COMMON/CONTR/ ICYCL,NCYCL,ISCALE,MSCALE,KSCALE,KOMVG,IDESN,IWTMIN,MAIN0150
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,LBUCK,NVEC,NMODE,LB1,ALPA,INDET  MAIN0160
     2,KPRINT,OMEGA,COEFFT,SMAX,BMAX,NBUCK,SF,IS ,KOD ,NBCUND           MAIN0170
C*************************************************************************MAIN0180
C-----PROGRAM CAPACITY CONTROLLED BY THE FOLLOWING THREE STATEMENTS      MAIN0190
C*************************************************************************MAIN0200
      DIMENSION A(1500)                                                  MAIN0210
      REAL*8 AD(750)                                                     MAIN0220
      EQUIVALENCE (A(1),AD(1))                                           MAIN0230
      MTOT=1500                                                          MAIN0240
C*************************************************************************MAIN0250
C-----INPUT-OUTPUT UNIT ASSIGNMENTS                                      MAIN0260
C*************************************************************************MAIN0270
      IR=5                                                               MAIN0280
      IW=6                                                               MAIN0290
      IP=7                                                               MAIN0300
      I1=1                                                               MAIN0310
      I2=2                                                               MAIN0320
      I3=3                                                               MAIN0330
      I8=8                                                               MAIN0340
      I9=9                                                               MAIN0350
      I10=10                                                             MAIN0360
      I11=11                                                             MAIN0370
      I12=12                                                             MAIN0380
      I13=13                                                             MAIN0390
C*************************************************************************MAIN0400
C-----PROGRAM CONTROL DATA                                               MAIN0410
C                                                                        MAIN0420
C-----NUMNP   = NUMBER OF NODE POINTS                                    MAIN0430
C-----NELTYP  = NUMBER OF ELEMENT TYPES                                  MAIN0440
C-----LL      = NUMBER OF LOAD CONDITIONS                                MAIN0450
C-----NUMDV   = NUMBER OF INDEPENDENT DESIGN VARIABLES                   MAIN0460
C-----MBAND   = BANDWIDTH OF STIFFNESS MATRIX                            MAIN0470
C-----NUMEL   = TOTAL NO. OF ELEMENTS                                    MAIN0480
C-----MPAR    = CONTROL PARAMETERS FOR EACH ELEMENT GROUP                MAIN0490
C-----NEQB    = NO. OF EQUATIONS PER BLOCK OF STIFFNESS MATRIX           MAIN0500
C-----NBLOCK  = NO. OF BLOCKS OF EQUILIBRIUM EQUATIONS                   MAIN0510
C-----MTOT    = NO. OF STORAGE LOCATIONS OF COMMON ARRAY A                MAIN0520
C*************************************************************************MAIN0530
    5 READ(IR,1000)HED,NUMNP,NELTYP,LL,NUMDV                             MAIN0540
      IF (NUMNP.EQ.0) STOP                                               MAIN0550
      WRITE (IW,2000)HED,NUMNP,NELTYP,LL,NUMDV.                          MAIN0560
C*************************************************************************MAIN0570
C-----DESIGN CONTROL DATA                                                MAIN0580
C                                                                        MAIN0590
```

```
C-----KPRINT = PRINT OUT CODE                                                  MAIN0600
C              =0 MODAL DISPLACEMENTS NOT PRINTED                              MAIN0610
C              =1 MODAL DISPLACEMENTS ARE PRINTED                              MAIN0620
C-----KPUNCH = PUNCH OUT CODE FOR RESTART DECK                                 MAIN0630
C              =0 NO RESTART DECK PUNCHED                                      MAIN0640
C              =1 PUNCHES RESTART DECK FOR DESIGN VARIABLE DATA                MAIN0650
C-----LBUCK  = CODE FOR BUCKLING CONSTRAINTS                                   MAIN0660
C              =0 NO BUCKLING CONSTRAINT IS PRESENT                            MAIN0670
C              =N BUCKLING CONSTRAINT IS PRESENT FOR N'TH LOAD CONDITION       MAIN0680
C-----NMODE  = NO. OF LOWEST BUCKLING MODES  FOR WHICH BUCKLING                MAIN0690
C                CONSTRAINT APPLIES                                            MAIN0700
C-----NVEC   = NO. OF ITERATION VECTORS FOR BUCKLING CONSTRAINTS               MAIN0710
C              (NMODE.LE.NVEC.LE.4 )                                           MAIN0720
C-----IDESN  = CURRENT DESIGN NO.                                              MAIN0730
C-----ICYCL  = CURRENT CRITICAL DESIGN NO.                                     MAIN0740
C-----NCYCL  = MAX. ALLOWABLE NUMBER OF CRITICAL DESIGNS                       MAIN0750
C-----KONVG  = DESIGN CONVERGENCE CODE                                         MAIN0760
C              =1 DESIGN IS NOT CRITICAL                                       MAIN0770
C              =2 DESIGN IS CRITICAL FOR BUCKLING CONSTRAINTS                  MAIN0780
C              =3 DESIGN IS CRITICAL FROM STRESS CONSTRAINTS                   MAIN0790
C              =4 DESIGN IS ACCEPTABLE                                         MAIN0800
C-----DELTA  = DEFINES BAND OF CRITICAL DESIGNS AND                            MAIN0810
C              USED IN CHECKING OPTIMALITY FOR BUCKLING CONSTRAINTS            MAIN0820
C-----EPSIL  = DEFINES ALLOWABLE WEIGHT INCREASE OVER WTMIN                    MAIN0830
C-----WTMIN  = MIN WEIGHT CRITICAL DESIGN                                      MAIN0840
C-----IWTMIN = DESIGN NUMBER OF MIN. WT. CRITICAL DESIGN                       MAIN0850
C-----ISCALE = SCALING OPERATION NUMBER                                        MAIN0860
C-----NSCALE = MAX. ALLOWABLE NUMBER OF SUCCESSIVE SCALING OPERATIONS          MAIN0870
C-----KSCALE = CODE FOR SCALING OPERATION                                      MAIN0880
C              =-1 SCALING SHOULD NOT BE USED                                  MAIN0890
C              =0 SCALING IS APPROXIMATE. REANALYSE SCALED STRUCTURE           MAIN0900
C              =1 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO SIZE          MAIN0910
C              =2 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO (SIZE)**2     MAIN0920
C              =3 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO (SIZE)**3     MAIN0930
C              =4 SCALING IS EXACT. STIFFNESS IS PROPORTIONAL TO (SIZE)**4     MAIN0940
C                 AND SO ON                                                    MAIN0950
C-----ALPA   = RELAXATION PARAMETER IN BUCKLING      REDESIGN                  MAIN0960
C-----COEFFT = BUCKLING LOAD COEFFICIENT                                       MAIN0970
C-----MODEIN = CODE FOR READING IN STARTING VECTORS FOR BUC. ANALYSIS          MAIN0980
C              =0 GENERATE RANDOM NO.S                                         MAIN0990
C              =1 READ IN APPROXIMATE MODE SHAPES                              MAIN1000
C-----INDET  = CODE FOR DETERMINACY OF THE STRUCTURE                           MAIN1010
C              =0 INDETERMINATE STRUCTURE - BUCKLING ANALYSIS PERFORMED        MAIN1020
C                 FOR EVERY DESIGN                                             MAIN1030
C              =1 STRUCTURE IS DETERMINATE - NO REANALYSIS FOR BUCKLING        MAIN1040
C-----LB1    = NO. OF DISPLACEMENT VECTORS THAT CAN BE STORED IN               MAIN1050
C              COMMON AREA 'A' DURING BUCKLING DERIVATIVES COMPUTATION         MAIN1060
C-----OMEGA  = FACTOR FOR DECIDING POTENTIALLY ACTIVE BUCK. CONSTRAINTS        MAIN1070
C-----SMAX   = MAX. STRESS RATIO                                               MAIN1080
C-----RMAX   = RATIO COEFF1/LOWEST BUCKLING LOAD                               MAIN1090
C-----NBUCK  = NO. OF POSSIBLE ACTIVE BUCKLING CONSTRAINTS                     MAIN1100
C-----SF     = SCALE FACTOR                                                    MAIN1110
C*****************************************************************************MAIN1120
      IDESN=0                                                                  MAIN1130
      ICYCL=0                                                                  MAIN1140
      ISCALE=0                                                                 MAIN1150
      WTMIN=1.0E20                                                             MAIN1160
      IWTMIN=0                                                                 MAIN1170
      READ(IR,100)) NCYCL,NSCALE,KSCALE,DELTA,EPSIL,KPUNCH,KPRINT,LBUCK       MAIN1180
      IF(NSCALE.EQ.0) NSCALE=3                                                 MAIN1190
```

```
      IF(DELTA.EQ.0.0) DELTA=0.05                                          MAIN1200
      IF(EPSIL.EQ.0.0) EPSIL=0.1                                           MAIN1210
      DELTA1=1.0-DELTA                                                     MAIN1220
      DELTA2=1.0+DELTA                                                     MAIN1230
      WRITE(IW,2001) NCYCL,KSCALE,DELTA,EPSIL,LBUCK                        MAIN1240
C*********************************************************************MAIN1250
C-----INITIALISE UNIT WEIGHT COEFFICIENTS                                  MAIN1260
C*********************************************************************MAIN1270
      DO 100 I=1,NUMDV                                                     MAIN1280
  100 A(I)=0.0                                                             MAIN1290
C*********************************************************************MAIN1300
C-----NODE DATA---ID ARRAY STORED ON IR                                    MAIN1310
C*********************************************************************MAIN1320
      M1=1                                                                 MAIN1330
      N1=M1+NUMDV                                                          MAIN1340
      N2=N1+6*NUMNP                                                        MAIN1350
      N3=N2+NUMNP                                                          MAIN1360
      N4=N3+NUMNP                                                          MAIN1370
      N5=N4+NUMNP                                                          MAIN1380
      NA=N5+NUMNP                                                          MAIN1390
      IF(NA.GT.MTOT) CALL ERROR(NA-MTOT)                                   MAIN1400
      CALL INPUTJ(A(N1),A(N2),A(N3),A(N4),A(N5),NUMNP,NEQ,IR,IR,IW)        MAIN1410
C*********************************************************************MAIN1420
C-----ELEMENT DATA --- UNIT STIFFNESS AND LOAD DATA ON I12                  MAIN1430
C     UNIT STRESS RECOVERY DATA ON IR                                      MAIN1440
C     UNIT GEOMETRIC STIFFNESS DATA ON UNIT 11                             MAIN1450
C*********************************************************************MAIN1460
      MBAND=0                                                              MAIN1470
      NUMEL=0                                                              MAIN1480
      REWIND 11                                                            MAIN1490
      REWIND 12                                                            MAIN1500
      NBOUND=0                                                             MAIN1510
      DO 900 M=1,NELTYP                                                    MAIN1520
      READ(IR,1002) NPAR                                                   MAIN1530
      WRITE(IW,2002)NPAR                                                   MAIN1540
      NUMEL=NUMEL+NPAR(2)                                                  MAIN1550
      MTYPE=NPAR(1)                                                        MAIN1560
      IF(MTYPE.EQ.7) NBOUND=NPAR(2)                                        MAIN1570
  900 CALL ELTYPE (A,MTOT,MTYPE,IW)                                        MAIN1580
C*********************************************************************MAIN1590
C-----WRITE UNIT WEIGHT ARRAY ON IR AND REARRANGE STORAGE OF ID           MAIN1600
C*********************************************************************MAIN1610
      CALL UNITWT (A(M1),IR,NUMDV)                                         MAIN1620
      J=6*NUMNP                                                            MAIN1630
      DO 121  I=1,J                                                        MAIN1640
  121 A(I)=A(NUMDV+I)                                                      MAIN1650
C*********************************************************************MAIN1660
C-----STRUCTURE LOAD MULTIPLIERS---STORED ON UNIT 11                       MAIN1670
C*********************************************************************MAIN1680
      M1=1                                                                 MAIN1690
      N2=N1+6*NUMNP                                                        MAIN1700
      CALL ELMULT(A(N2),LL,IR,IW,11 )                                      MAIN1710
      M=LL                                                                 MAIN1720
      IF(LBUCK.EQ.0) GO TO 110                                             MAIN1730
C*********************************************************************MAIN1740
C-----READ BUCKLING CONTROL DATA                                           MAIN1750
C*********************************************************************MAIN1760
      READ (IR,1003) COEFFI,MODEIN,NMODE,INDET,NVEC,ALPA,OMEGA             MAIN1770
      IF(COEFFI.EQ.0.0) COEFFI=1.0                                         MAIN1780
      IF(NMODE.LE.0) NMODE=1                                               MAIN1790
```

```
      IF(NMODE.GT.2) NMODE=2                                                    MAIN1800
      IF(NVEC.LT.NMODE) NVEC=2                                                  MAIN1810
      IF(NVEC.GT.2) NVEC=2                                                      MAIN1820
      WRITE(IW,2005) COEFF1,MODEIN,NMODE,INDET,NVEC,ALPA,OMEGA                  MAIN1830
      IF(M.LT.NVEC) M=NVEC                                                      MAIN1840
  110 NEQBA=(MTOT-4*LL)/((MBAND+LL)*4)                                          MAIN1850
      NEQB=MTOT/((MBAND+M)*4+1)                                                 MAIN1860
      IF (NEQBA.LT.NEQB) NEQB=NEQBA                                             MAIN1870
      IF(NEQB.GT.NEQ) NEQB=NEQ                                                  MAIN1880
      NBLOCK=(NEQ-1)/NEQB+1                                                     MAIN1890
C*****************************************************************************MAIN1900
C-----NODAL LOADS --- STORED ON UNIT I12                                        MAIN1910
C*****************************************************************************MAIN1920
      N3=N2+6*LL                                                                MAIN1930
      ND3=(N3-1)/2+1                                                            MAIN1940
      N4=(ND2+NEQB*LL   )*2                                                     MAIN1950
      IF(N4.GT.MTOT) CALL ERROR(N4-MTOT)                                        MAIN1960
      CALL INL(A(N1),A(N2),A(ND3),        NUMNP,NEQB,LL,IR,IW,I12)              MAIN1970
C*****************************************************************************MAIN1980
C-----READ OR GENERATE BUCKLING MODE SHAPES - WRITE ON UNIT I13                 MAIN1990
C*****************************************************************************MAIN2000
      IF(LBUCK.NE.0) CALL INPUT2(A(N1),NEQB,NBLOCK,NVEC,MODEIN,NEQ .            MAIN2010
     1 I13,IR)                                                                  MAIN2020
C*****************************************************************************MAIN2030
C-----DESIGN VARIABLE DATA---ADLO AND AMIN ON I1                                MAIN2040
C*****************************************************************************MAIN2050
      N2=N1+NUMDV                                                               MAIN2060
      CALL DEVAR (A(N1),A(N2),NUMDV,I1,IR,IW)                                   MAIN2070
      WRITE (IW,2002)                                                           MAIN2080
      WRITE (IW,2003)NEQ,MBAND,NEQB,NBLOCK                                      MAIN2090
      WRITE (IW,2002)                                                           MAIN2100
C*****************************************************************************MAIN2110
C-----FORM ELEMENT STIFFNESS AND LOAD VECTOR AND WRITE ON UNIT I10              MAIN2120
C*****************************************************************************MAIN2130
  995 N1=1                                                                      MAIN2140
      CALL ELSTIF (A(N1),NUMDV,NUMEL,I1,I2     ,I12)                            MAIN2150
C*****************************************************************************MAIN2160
C-----FORM STRUCTURAL STIFFNESS AND LOAD VECTORS AND WRITE ON UNIT I10          MAIN2170
C*****************************************************************************MAIN2180
      NE2B=2*NEQB                                                               MAIN2190
      ND2=N1+NE2B*MBAND                                                         MAIN2200
      ND3=ND2+NE2B *LL                                                          MAIN2210
      N3=(ND3-1)*2+1                                                            MAIN2220
      N4=N3+4*LL                                                                MAIN2230
      IF(N4.GT.MTOT) CALL ERROR(N4-MTOT)                                        MAIN2240
      CALL ADDSTF(A(N1),A(ND2),A(N3),NUMEL,NBLOCK,NE2B,LL,MBAND,                MAIN2250
     1 I1,I2,I9,I10,I12)                                                        MAIN2260
C*****************************************************************************MAIN2270
C-----SOLVE FOR DISPLACEMENT UNKNOWNS                                           MAIN2280
C*****************************************************************************MAIN2290
      NSB=(MBAND+LL    )*NEQB                                                   MAIN2300
      N2=N1+NEQB                                                                MAIN2310
      ND2=N2/2+1                                                                MAIN2320
      ND3=ND2+NSB                                                               MAIN2330
      CALL USOL  (A(N1),A(ND2),A(ND3),NEQB,MBAND,LL,NBLOCK,NSB,I10,I3,MAIN2340
     1 I9,I2,IW)                                                                MAIN2350
C*****************************************************************************MAIN2360
C-----PRINT NODAL DISPLACEMENTS                                                 MAIN2370
C*****************************************************************************MAIN2380
      N2=N1+NUMNP*6                                                             MAIN2390
```

```
      N3=N2+6*LL                                                        MAIN2400
      ND3=N3/2+1                                                        MAIN2410
      WRITE(IW,2004)IDESN                                               MAIN2420
      CALL PRINTD(A(N1),A(N2),AD(ND3),NEQB,NUMNP,LL,                    MAIN2430
     1 NBLOCK,NEQ,I2,I8,IW,1,KPRINT)                                    MAIN2440
C*****************************************************************    MAIN2450
C-----COMPUTE STRESSES AND CARRY OUT FULLY STRESSED DESIGN             MAIN2460
C-----COMPUTE GEOMETRIC STIFFNESS MATRIX AND WRITE ON UNIT I3          MAIN2470
C*****************************************************************    MAIN2480
      M1=1                                                              MAIN2490
      M2=M1+NUMDV                                                       MAIN2500
      M3=M2+NUMDV                                                       MAIN2510
      N1=M3+NUMDV                                                       MAIN2520
      N2=N1+4*LL                                                        MAIN2530
      ND2=N2/2+1                                                        MAIN2540
      N3=(ND2  +NEQB*LL)*2+1                                            MAIN2550
      LB=(MTOT-N3)/NEQ                                                  MAIN2560
      IF (LB.GE.1) GO TO 31                                             MAIN2570
      MM=NEQ+N3                                                         MAIN2580
      CALL ERROR (MM-MTOT)                                              MAIN2590
   31 IF(LB.GT.LL)LB=LL                                                 MAIN2600
      CALL STRESS(A(M1),A(M2),A(M3),A(N1),AD(ND2),A(N3),LL,LB,NEQ,NUMDV,MAIN2610
     1 NEQB,A,MTOT,LBUCK,INDET,IDESN,I1,I2,I3,I8,I11,IW)                MAIN2620
C*****************************************************************    MAIN2630
C-----BUCKLING ANALYSIS                                                MAIN2640
C*****************************************************************    MAIN2650
      MTOT2=MTOT/2                                                      MAIN2660
      IF(LBUCK.NE.0) CALL BANAL(A,AD,MTOT,MTOT2)                        MAIN2670
      IF (NCYCL.EQ.0) GO TO 996                                         MAIN2680
C*****************************************************************    MAIN2690
C-----EVALUATE CURRENT DESIGN AND PERFORM  REDESIGN                    MAIN2700
C*****************************************************************    MAIN2710
      N1=1                                                              MAIN2720
      N2=N1+NUMDV                                                       MAIN2730
      N3=N2+NUMDV                                                       MAIN2740
      N4=N3+NUMDV                                                       MAIN2750
      N5=N4+NUMDV                                                       MAIN2760
      II=I8                                                             MAIN2770
      IF(KPRINT.EQ.0) GO TO 835                                         MAIN2780
      II=I9                                                             MAIN2790
      REWIND II                                                         MAIN2800
  835 CALL DESIGN (A(N1),A(N2),A(N3),A(N4),A(N5),NUMDV,LL,II)           MAIN2810
      IDESN=IDESN+1                                                     MAIN2820
      IF(KONVG.EQ.4) GO TO 996                                          MAIN2830
      IF(NBUCK.EQ.0) GO TO 995                                          MAIN2840
C*****************************************************************    MAIN2850
C-----BUCKLING DERIVATIVES                                             MAIN2860
C*****************************************************************    MAIN2870
      N=4*LL                                                            MAIN2880
      REWIND I1                                                         MAIN2890
      READ(I1) (A(I),I=1,N)                                             MAIN2900
      LB1=(MTOT-NUMDV-NEQB*NMODE*2)/(NEQ+NUMDV)                         MAIN2910
      N=2*NUMDV+NEQ+NEQB*NMODE*2-MTOT                                   MAIN2920
      IF(LB1.LT.1) CALL ERROR(N)                                        MAIN2930
      IF(LB1.GT.NBUCK) LB1=NBUCK                                        MAIN2940
      N2=N1+NUMDV                                                       MAIN2950
      N3=N2+NUMDV*LB1                                                   MAIN2960
      N4=N3+NEQ*LB1                                                     MAIN2970
      ND4=N4/2+1                                                        MAIN2980
      CALL DERV(  A(N1),A(N2),A(N3),AD(ND4),LB1,NBUCK,NEQB,NBLOCK,NEQ,  MAIN2990
```

```
     1 NUMDV,NMODE,LL,NUMEL,I1,I2,I3,I12,IR,IW)                          MAIN3000
C*********************************************************************MAIN3010
C-----PERFORM BUCKLING REDESIGN                                         MAIN3020
C*********************************************************************MAIN3030
      M1=1                                                              MAIN3040
      M2=M1+NUMDV                                                       MAIN3050
      M3=M2+NUMDV*NBUCK                                                 MAIN3060
      M4=M3+NUMDV                                                       MAIN3070
      M5=M4+NUMDV                                                       MAIN3080
      M6=M5+NUMDV                                                       MAIN3090
      M7=M6+NUMDV                                                       MAIN3100
      M8=M7+NUMDV                                                       MAIN3110
      N=(6+NBUCK)*NUMDV+4*LL-MTOT                                       MAIN3120
      IF(N.GT.0) CALL ERROR(N)                                          MAIN3130
      CALL REDESN  (A(M1),A(M2),A(M3),A(M4),A(M5),A(M6),A(M7),A(M8),    MAIN3140
     1 NUMDV,IU,LL,NBUCK)                                               MAIN3150
      IF(KONVG.NE.4) GO TO 995                                          MAIN3160
  996 STOP                                                              MAIN3170
 1000 FORMAT(20A4/6I5)                                                  MAIN3180
 1001 FORMAT(3I5,2E10.0,3I5)                                            MAIN3190
 1002 FORMAT (14I5)                                                     MAIN3200
 1003 FORMAT(E10.0,4I5,2E10.0)                                          MAIN3210
 2000 FORMAT(1H1,20A4//                                                 MAIN3220
     .  28H  NUMBER OF NODAL POINTS    =  ,I5/                         MAIN3230
     .  28H  NUMBER OF ELEMENT TYPES   =  ,I5/                         MAIN3240
     .  28H  NUMBER OF LOAD CASES      =,I5/                           MAIN3250
     .  28H  NUMBER OF DES. VARIABLES =,I5   )                          MAIN3260
 2001 FORMAT(// 22H  DESIGN CONTROL DATA //                             MAIN3270
     1            9H  NCYCL =,I5/                                       MAIN3280
     2            9H  KSCALE=,I5/                                       MAIN3290
     3            9H  DELTA =,E12.4/                                    MAIN3300
     4            9H  EPSIL =,E12.4/                                    MAIN3310
     5            9H  LBUCK =,I5   )                                    MAIN3320
 2002 FORMAT(//)                                                        MAIN3330
 2003 FORMAT(34H  TOTAL NUMBER OF EQUATIONS       =,I5,                 MAIN3340
     1       /34H  BANDWIDTH                      =,I5,                 MAIN3350
     2       /34H  NUMBER OF EQUATIONS IN A BLOCK =,I5,                 MAIN3360
     3       /34H  NUMBER OF BLOCKS               =,I5)                 MAIN3370
 2004 FORMAT(31H1*******************************/                       MAIN3380
     1        26H ANALYSIS OF DESIGN NUMBER,I4  /                       MAIN3390
     2        31H *******************************//)                   MAIN3400
 2005 FORMAT(// 22H BUCKLING CONTROL DATA  //                           MAIN3410
     .            9H COEFF =,E10.5/                                     MAIN3420
     1            9H MODEIN =,I5/                                       MAIN3430
     2            9H NMODE  =,I5/                                       MAIN3440
     3            9H INDET  =,I5/                                       MAIN3450
     4            9H NVEC   =,I5/                                       MAIN3460
     5            9H ALPA   =,E10.5 /                                   MAIN3470
     6            9H OMEGA  =,E10.5)                                    MAIN3480
      END                                                               MAIN3490
```

```
      SUBROUTINE INPUT(ID,X,Y,Z,T,NUMNP,NEQ,IR,IW)                      MAIN3500
C*****************************************************************************MAIN3510
C-----READ OR  GENERATE NODAL POINT DATA                                MAIN3520
C*****************************************************************************MAIN3530
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6),T(NUMNP)         MAIN3540
      REWIND IR                                                         MAIN3550
      WRITE(IW,2000)                                                    MAIN3560
      WRITE(IW,2001)                                                    MAIN3570
      NOLD=0                                                            MAIN3580
   10 READ (IR,1000)N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),KN,T(N)            MAIN3590
      WRITE(IW,2002)N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),KN,T(N)            MAIN3600
C*****************************************************************************MAIN3610
C-----CHECK IF GENERATION IS REQUIRED                                   MAIN3620
C*****************************************************************************MAIN3630
      IF(NOLD)50,50,20                                                  MAIN3640
      DO 20 I=1,6                                                       MAIN3650
      IF(ID(N,I).EQ.0.AND.ID(NOLD,I).LT.0) ID(N,I)=ID(NOLD,I)           MAIN3660
   20 CONTINUE                                                          MAIN3670
      IF(KN.EQ.0) GO TO 50                                              MAIN3680
      NUM=(N-NOLD)/KN                                                   MAIN3690
      NUMN=NUM-1                                                        MAIN3700
      IF(NUMN.LT.1) GO TO 50                                            MAIN3710
      XNUM=NUM                                                          MAIN3720
      DX=(X(N)-X(NOLD))/XNUM                                            MAIN3730
      DY=(Y(N)-Y(NOLD))/XNUM                                            MAIN3740
      DZ=(Z(N)-Z(NOLD))/XNUM                                            MAIN3750
      DT=(T(N)-T(NOLD))/XNUM                                            MAIN3760
      K=NOLD                                                            MAIN3770
      DO 30 I=1,NUMN                                                    MAIN3780
      KK=K                                                              MAIN3790
      K=K+KN                                                            MAIN3800
      X(K)=X(KK)+DX                                                     MAIN3810
      Y(K)=Y(KK)+DY                                                     MAIN3820
      Z(K)=Z(KK)+DZ                                                     MAIN3830
      T(K)=T(KK)+DT                                                     MAIN3840
      DO 30 J=1,6                                                       MAIN3850
      ID(K,J)=ID(KK,J)                                                  MAIN3860
      IF (ID(K,J).GT.1) ID(K,J)=ID(KK,J)+KN                             MAIN3870
   30 CONTINUE                                                          MAIN3880
   50 NOLD=N                                                            MAIN3890
      IF(N.NE.NUMNP) GO TO 10                                           MAIN3900
C*****************************************************************************MAIN3910
C-----PRINT ALL NODAL POINT DATA                                        MAIN3920
C*****************************************************************************MAIN3930
      WRITE (IW,2003)                                                   MAIN3940
      WRITE (IW,2001)                                                   MAIN3950
      WRITE (IW,2005) (N,(ID(N,I),I=1,6),X(N),Y(N),Z(N),T(N),N=1,NUMNP) MAIN3960
C*****************************************************************************MAIN3970
C-----NUMBER UNKNOWNS AND SET MASTER NODES NEGATIVE                     MAIN3980
C*****************************************************************************MAIN3990
      NEQ=0                                                             MAIN4000
      DO 60 N=1,NUMNP                                                   MAIN4010
      DO 60 I=1,6                                                       MAIN4020
      ID(N,I)=IABS(ID(N,I))                                             MAIN4030
      IF(ID(N,I)-1) 57,58,59                                            MAIN4040
   57 NEQ=NEQ+1                                                         MAIN4050
      ID(N,I)=NEQ                                                       MAIN4060
      GO TO 60                                                          MAIN4070
   58 ID(N,I)=0                                                         MAIN4080
      GO TO 60                                                          MAIN4090
```

```
   59 ID(N,I)=-ID(N,I)                                                  MAIN4100
   60 CONTINUE                                                          MAIN4110
      WRITE(IW,2004) (N,(ID(N,I),I=1,6),N=1,NUMNP)                      MAIN4120
      WRITE(IR) ID                                                      MAIN4130
      RETURN                                                            MAIN4140
 1000 FORMAT (7I5,3E10.0,I5,E10.0)                                      MAIN4150
 2000 FORMAT(// 23H NODAL POINT INPUT DATA )                            MAIN4160
 2001 FORMAT (5HONODE,3X,24HBOUNDARY CONDITION CODES,3X,                MAIN4170
     139H/------NODAL POINT COORDINATES---------//,                     MAIN4180
     27H NUMBER,2X,1HX,4X,1HY,4X,1HZ,3X,2HXX,3X,2HYY,3X,2HZZ,12X,       MAIN4190
     31HX,12X,1HY,12X,1HZ,12X,1HT/)                                     MAIN4200
 2002 FORMAT (I5,6I5,3E13.3,I5,E13.3)                                   MAIN4210
 2003 FORMAT (// 21H GENERATED NODAL DATA)                              MAIN4220
 2004 FORMAT (// 17H EQUATION NUMBERS//                                 MAIN4230
     1 35H    N    X    Y    Z   XX   YY   ZZ  / (7I5))                MAIN4240
 2005 FORMAT (I5,6I5,4E13.3)                                            MAIN4250
      END                                                               MAIN4260


      SUBROUTINE INTERP (F,FF,NUMTC,NUMMAT,NUM1,NUM2,NT,MAT,TEMP)       MAIN4270
C*********************************************************************MAIN4280
C-----INTERPOLATES MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE  MAIN4290
C*********************************************************************MAIN4300
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN4310
      REAL*4 F                                                          MAIN4320
      DIMENSION F(NUMTC,NUM1,NUMMAT),FF(NUM2)                           MAIN4330
      IF(NT.NE.1) GO TO 220                                             MAIN4340
      DO 210 KK=1,NUM2                                                  MAIN4350
  210 FF(KK)=F(1,KK+1,MAT)                                              MAIN4360
      GO TO 260                                                         MAIN4370
  220 DO 230 I=2,NT                                                     MAIN4380
      II=I                                                              MAIN4390
      T1=F(I-1,1,MAT)                                                   MAIN4400
      T2=F(I,1,MAT)                                                     MAIN4410
      IF(T2.GE.TEMP) GO TO 240                                          MAIN4420
  230 CONTINUE                                                          MAIN4430
  240 RI=(T2-TEMP)/(T2-T1)                                              MAIN4440
      RJ=(TEMP-T1)/(T2-T1)                                              MAIN4450
      DO 250 KK=1,NUM2                                                  MAIN4460
  250 FF(KK)=F(II-1,KK+1,MAT)*RI+F(II,KK+1,MAT)*RJ                      MAIN4470
  260 RETURN                                                            MAIN4480
      END                                                               MAIN4490


      SUBROUTINE ERROR(N)                                               MAIN4500
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             MAIN4510
      WRITE (IW,2000) N                                                 MAIN4520
      STOP                                                              MAIN4530
 2000 FORMAT (// 20H STORAGE EXCEEDED BY ,I6)                           MAIN4540
      END                                                               MAIN4550
```

```
      SUBROUTINE ELTYPE (A,MTOT,MTYPE,IW)                                MAIN4560
C*****************************************************************************MAIN4570
C-----CALL APPROPRIATE ELEMENT SUBROUTINE TO DEVELOP ELEMENT MATRICES    MAIN4580
C*****************************************************************************MAIN4590
      DIMENSION A(MTOT)                                                  MAIN4600
      GO TO (1,2,3,4,5,6,7,8),MTYPE                                      MAIN4610
C*****************************************************************************MAIN4620
C-----THREE DIMENSIONAL TRUSS ELEMENTS                                   MAIN4630
C*****************************************************************************MAIN4640
    1 CALL TRUSS (A,MTOT)                                                MAIN4650
      GO TO 900                                                          MAIN4660
C*****************************************************************************MAIN4670
C-----THREE DIMENSIONAL BEAM ELEMENTS                                    MAIN4680
C*****************************************************************************MAIN4690
    2 CALL BEAM (A,MTOT)                                                 MAIN4700
      GO TO 900                                                          MAIN4710
C*****************************************************************************MAIN4720
C-----PLANE STRESS ELEMENTS                                              MAIN4730
C*****************************************************************************MAIN4740
    3 CALL PLANE (A,MTOT)                                                MAIN4750
      GO TO 900                                                          MAIN4760
C*****************************************************************************MAIN4770
C-----SHEAR PANEL ELEMENTS                                               MAIN4780
C*****************************************************************************MAIN4790
    4 CALL SHEAR (A,MTOT)                                                MAIN4800
      GO TO 900                                                          MAIN4810
C*****************************************************************************MAIN4820
C-----PROVISION FOR OTHER TYPES OF ELEMENTS                              MAIN4830
C*****************************************************************************MAIN4840
    5 CALL NOELEM(MTYPE,0,IW)                                            MAIN4850
      GO TO 900                                                          MAIN4860
C*****************************************************************************MAIN4870
C-----PLATE/SHELL ELEMENTS                                               MAIN4880
C*****************************************************************************MAIN4890
    6 CALL SHELL (A,MTOT)                                                MAIN4900
      GO TO 900                                                          MAIN4910
C*****************************************************************************MAIN4920
C-----BOUNDARY ELEMENTS                                                  MAIN4930
C*****************************************************************************MAIN4940
    7 CALL BOUND (A,MTOT)                                                MAIN4950
      GO TO 900                                                          MAIN4960
C*****************************************************************************MAIN4970
C-----PROVISION FOR OTHER TYPES OF ELEMENTS                              MAIN4980
C*****************************************************************************MAIN4990
    8 CALL NOELEM(MTYPE,0,IW)                                            MAIN5000
  900 RETURN                                                             MAIN5010
      END                                                                MAIN5020
```

```
      SUBROUTINE NOELEM (MTYPE,KODE,IW)                                 MAIN5030
C*************************************************************************MAIN5040
C-----PRINT THE MESSAGE THAT REQUIRED ELEMENT SUBROUTINE IS MISSING      MAIN5050
C*************************************************************************MAIN5060
      WRITE (IW,100) MTYPE                                              MAIN5070
      IF (KODE.NE.0) WRITE (IW,101) KODE                                MAIN5080
      STOP                                                              MAIN5090
  100 FORMAT (//46H THE FOLLOWING ELEMENT HAS NOT BEEN PROGRAMED:       MAIN5100
     1         14H ELEMENT TYPE=,I2)                                    MAIN5110
  101 FORMAT(   14H CONSTRN CODE=,I2)                                   MAIN5120
      END                                                               MAIN5130
```

```
      SUBROUTINE CALBAN(NDIF,LM,S,P,ST,IT,NU,NV,NS,ND,NW,IDVAR,IEX,ERC) MAIN5140
C*************************************************************************MAIN5150
C-----CALCULATE BANDWIDTH  OF STRUCTURE STIFFNESS MATRIX                 MAIN5160
C-----WRITE UNIT STRESS RECOVERY MATRICES AND STRESS-CORRECTION MATRICESMAIN5170
C     ON TAPE I8                                                        MAIN5180
C-----WRITE UNIT STIFFNESS AND LOAD VECTOR ON TAPE I12                  MAIN5190
C*************************************************************************MAIN5200
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5210
      REAL*4 ERC                                                        MAIN5220
      DIMENSION LM(ND),S(ND,ND,NU),P(ND,4,NV),ST(NS,ND,NU),TT(NS,4,NW), MAIN5230
     1 IS(6)                                                            MAIN5240
      COMMON/ELPAR/MPAR(14),NUMMP,MBAND,IELP(17)                        MAIN5250
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             MAIN5260
      MIN=100000                                                        MAIN5270
      MAX=0                                                             MAIN5280
      DO 800 L=1,ND                                                     MAIN5290
      IF (LM(L).EQ.0) GO TO 800                                         MAIN5300
      IF (LM(L).GT.MAX) MAX=LM(L)                                       MAIN5310
      IF (LM(L).LT.MIN) MIN=LM(L)                                       MAIN5320
  800 CONTINUE                                                          MAIN5330
      NDIF=MAX-MIN+1                                                    MAIN5340
      IF (NDIF.GT.MBAND) MBAND=NDIF                                     MAIN5350
      LRD=4+ND*(1+NU+ND+NV*4)                                           MAIN5360
      IS(1)=NU                                                          MAIN5370
      IS(2)=NW                                                          MAIN5380
      IS(3)=NS                                                          MAIN5390
      IS(4)=ND                                                          MAIN5400
      IS(5)=IDVAR                                                       MAIN5410
      IS(6)=IEX                                                         MAIN5420
      WRITE(I8 ) IS,ERC,LM,ST,TT                                        MAIN5430
      IS(1)=LRD                                                         MAIN5440
      IS(2)=NU                                                          MAIN5450
      IS(3)=NV                                                          MAIN5460
      IS(4)=ND                                                          MAIN5470
      WRITE(I12) IS,ERC,LM,S ,P                                         MAIN5480
      RETURN                                                            MAIN5490
      END                                                               MAIN5500
```

```
      SUBROUTINE ELGSUM(G,NSG,ND,NG,I11)                                MAIN5510
C*********************************************************************MAIN5520
C-----WRITE ELEMENT UNIT GEOMETRIC STIFFNESS MATRICES ON TAPE I11       MAIN5530
C*********************************************************************MAIN5540
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5550
      DIMENSION G(ND,ND,NG),NSG(NG)                                     MAIN5560
      WRITE(I11) NG,G,NSG                                               MAIN5570
      RETURN                                                            MAIN5580
      END                                                               MAIN5590


      SUBROUTINE VECTOR(V,XI,YI,ZI,XJ,YJ,ZJ)                           MAIN5600
C*********************************************************************MAIN5610
C-----CALCULATE COMPONENTS OF A VECTOR                                  MAIN5620
C*********************************************************************MAIN5630
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5640
      DIMENSION V(4)                                                    MAIN5650
      X=XJ-XI                                                           MAIN5660
      Y=YJ-YI                                                           MAIN5670
      Z=ZJ-ZI                                                           MAIN5680
      V(4)=DSQRT(X*X+Y*Y+Z*Z)                                           MAIN5690
      V(3)=Z/V(4)                                                       MAIN5700
      V(2)=Y/V(4)                                                       MAIN5710
      V(1)=X/V(4)                                                       MAIN5720
      RETURN                                                            MAIN5730
      END                                                               MAIN5740


      SUBROUTINE CROSS(A,B,C)                                           MAIN5750
C*********************************************************************MAIN5760
C-----CROSS PRODUCT OF TWO VECTORS                                      MAIN5770
C*********************************************************************MAIN5780
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5790
      DIMENSION A(4),B(4),C(4)                                          MAIN5800
      X=A(2)*B(3)-A(3)*B(2)                                             MAIN5810
      Y=A(3)*B(1)-A(1)*B(3)                                             MAIN5820
      Z=A(1)*B(2)-A(2)*B(1)                                             MAIN5830
      C(4)=DSQRT(X*X+Y*Y+Z*Z)                                           MAIN5840
      C(3)=Z/C(4)                                                       MAIN5850
      C(2)=Y/C(4)                                                       MAIN5860
      C(1)=X/C(4)                                                       MAIN5870
      RETURN                                                            MAIN5880
      END                                                               MAIN5890


      REAL FUNCTION DOT*8 (A,B)                                         MAIN5900
C*********************************************************************MAIN5910
C-----DOT PRODUCT OF TWO VECTORS                                        MAIN5920
C*********************************************************************MAIN5930
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5940
      DIMENSION A(4),B(4)                                               MAIN5950
      DOT=A(1)*B(1)+A(2)*B(2)+A(3)*B(3)                                 MAIN5960
      RETURN                                                            MAIN5970
      END                                                               MAIN5980
```

```
      SUBROUTINE REARAN(S,SS,NM1,NM2,NM3,N1,N2,N3,N4)                    MAIN5990
C*********************************************************************MAIN6000
C-----REARRANGE MATRIX S                                                 MAIN6010
C*********************************************************************MAIN6020
      IMPLICIT REAL*8 (A-H,O-Z)                                          MAIN6030
      DIMENSION S(NM1,NM2,NM3),SS(N4)                                    MAIN6040
      II=0                                                               MAIN6050
      DO 10 K=1,N3                                                       MAIN6060
      DO 10 J=1,N2                                                       MAIN6070
      DO 11 I=1,N1                                                       MAIN6080
   11 SS(II+I)=S(I,J,K)                                                  MAIN6090
   10 II=II+N1                                                           MAIN6100
      RETURN                                                             MAIN6110
      END                                                                MAIN6120



      SUBROUTINE UNITWT(UWT,IR,NUMDV)                                    MAIN6130
C*********************************************************************MAIN6140
C-----WRITE UNIT WEIGHT ON TAPE IR                                       MAIN6150
C*********************************************************************MAIN6160
      DIMENSION UWT(NUMDV)                                               MAIN6170
      WRITE(IR)UWT                                                       MAIN6180
      RETURN                                                             MAIN6190
      END                                                                MAIN6200



      SUBROUTINE ELMULT(STR,LL,IR,IW,II )                                MAIN6210
C*********************************************************************MAIN6220
C-----READ IN STRUCTURE LOAD MULTIPLIERS                                 MAIN6230
C*********************************************************************MAIN6240
      DIMENSION STR(4,LL)                                                MAIN6250
      REWIND II                                                          MAIN6260
      WRITE(IW,2000)                                                     MAIN6270
      DO 50 I=1,LL                                                       MAIN6280
      READ(IR,1002) (STR(I,L),I=1,4)                                     MAIN6290
   50 WRITE(IW,2002) L,(STR(I,L),I=1,4)                                  MAIN6300
      WRITE (II ) STR                                                    MAIN6310
      RETURN                                                             MAIN6320
 1002 FORMAT (4E10.0)                                                    MAIN6330
 2000 FORMAT(//10H STRUCTURE,12X,26HSTRUCTURE LOAD MULTIPLIERS/          MAIN6340
     . 10H LOAD CASE,9X,1HA,9X,1HB,9X,1HC,9X,1HD/ )                      MAIN6350
 2002 FORMAT (I6,7X,4E10.3)                                              MAIN6360
      END                                                                MAIN6370
```

```
      SUBROUTINE INLOID,TR,B,NUMNP,NEQB,LL,IR,IW,I12)                    MAIN6380
C*********************************************************************MAIN6390
C-----INPUT NODAL LOADS                                                 MAIN6400
C*********************************************************************MAIN6410
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN6420
      REAL*4 TR                                                         MAIN6430
      DIMENSION ID(NUMNP,6),TR(6,LL),B(NEQB,LL)                         MAIN6440
      COMMON/JUNK/R(6),JUN(356)                                         MAIN6450
      KSHF=0                                                            MAIN6460
      WRITE (IW,2002)                                                   MAIN6470
      DO 750 I=1,NEQB                                                   MAIN6480
      DO 750 K=1,LL                                                     MAIN6490
  750 B(I,K)=0.0                                                        MAIN6500
      DO 900 NN=1,NUMNP                                                 MAIN6510
      DO 100 I=1,6                                                      MAIN6520
      DO 100 J=1,LL                                                     MAIN6530
  100 TR(I,J)=0.0                                                       MAIN6540
      IF(NN.EQ.1) GO TO 300                                             MAIN6550
  150 IF(N.NE.NN) GO TO 400                                             MAIN6560
      DO 200 I=1,6                                                      MAIN6570
  200 TR(I,L)=R(I)                                                      MAIN6580
  300 READ (IR,1001) N,L,R                                              MAIN6590
      IF (N.EQ.0) GO TO 150                                             MAIN6600
      WRITE(IW,2001) N,L,R                                              MAIN6610
      GO TO 150                                                         MAIN6620
  400 DO 800 J=1,6                                                      MAIN6630
      II=ID(NN,J)-KSHF                                                  MAIN6640
      IF (II) 800,800,500                                               MAIN6650
  500 DO 600  K=1,LL                                                    MAIN6660
  600 B(II,K)=TR(J,K)                                                   MAIN6670
  610 IF(II.NE.NEQB) GO TO 800                                          MAIN6680
      WRITE(I12) B                                                      MAIN6690
      KSHF=KSHF+NEQB                                                    MAIN6700
      DO 700 I=1,NEQB                                                   MAIN6710
      DO 700 K=1,LL                                                     MAIN6720
  700 B(I,K)=0.0                                                        MAIN6730
  800 CONTINUE                                                          MAIN6740
  900 CONTINUE                                                          MAIN6750
      WRITE(I12) B                                                      MAIN6760
      RETURN                                                            MAIN6770
 1001 FORMAT (2I5,7E10.4)                                               MAIN6780
 2001 FORMAT (2I5,6E13.3)                                               MAIN6790
 2002 FORMAT(//18H NODAL POINT LOADS // 10H NODE LOAD,23X      ,        MAIN6800
     . 14HAPPLIED LOADS              / 10H NO. CASE ,9X, 2HRX, 11X,     MAIN6810
     .  2HRY,11X,2HRZ,11X,2HMX,11X,2HMY,11X,2HMZ )                      MAIN6820
      END                                                               MAIN6830



      SUBROUTINE INPUTZ(Z,NEQB,NBLOCK,NVEC,MODEIN,NEQ,I13,IR)           MAIN6840
C*********************************************************************MAIN6850
C-----READ IN OR GENERATE THE COORDINATE VECTORS AND WRITE ON TAPE I13  MAIN6860
C-----C1 =(2**31)-1                                                     MAIN6870
C-----C2 =1/(2**31)                                                     MAIN6880
C*********************************************************************MAIN6890
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN6900
      DIMENSION Z(NEQB,NVEC)                                            MAIN6910
      DATA C1/2147483647.D0/,C2/7.3920000000000000/                     MAIN6920
      REWIND I13                                                        MAIN6930
```

```
      ZZ=1                                                              MAIN6940
      L1=NEOR                                                           MAIN6950
      DO 200 L=1,NBLOCK                                                 MAIN6960
      DO 100 I=1,NEOR                                                   MAIN6970
      DO 100 J=1,NVEC                                                   MAIN6980
  100 Z(I,J)=0.0                                                        MAIN6990
      IF(L.EQ.NBLOCK) L1=NEQ-NEOR*(NBLOCK-1)                            MAIN7000
      IF(MODE(N,NE.0) GO TO 300                                         MAIN7010
C*******************************************************************************MAIN7020
C-----GENERATE RANDOM STARTING VECTORS USING ZZ AS SEED                 MAIN7030
C-----UNIFORM PSEUDO-RANDOM NUMBER GENERATER BETWEEN-0.5 AND 0.5        MAIN7040
C*******************************************************************************MAIN7050
      DO 500 I=1,L1                                                     MAIN7060
      DO 500 J=1,NVEC                                                   MAIN7070
      ZZ=DMOD(16807.D0*ZZ,C1)                                           MAIN7080
  500 Z(I,J)=ZZ*C2-0.5                                                  MAIN7090
      GO TO 250                                                         MAIN7100
C*******************************************************************************MAIN7110
C-----READ IN STARTING COORDINATE VECTORS                               MAIN7120
C*******************************************************************************MAIN7130
  300 READ(IR,2000 ) ((Z(I,J),J=1,NVEC),I=1,L1)                         MAIN7140
  250 CONTINUE                                                          MAIN7150
      WRITE(IW,3) Z                                                     MAIN7160
  200 CONTINUE                                                          MAIN7170
      RETURN                                                            MAIN7180
 2000 FORMAT(8F10.5)                                                    MAIN7190
      END                                                               MAIN7200
```

```
      SUBROUTINE DEVAR(AOLD,AMIN,NUMDV,II,IR,IW)                        MAIN7210
C*******************************************************************************MAIN7220
C-----READ OR GENERATE DESIGN VARIABLE DATA                             MAIN7230
C*******************************************************************************MAIN7240
      DIMENSION AOLD(NUMDV),AMIN(NUMDV)                                 MAIN7250
      NOLD=0                                                            MAIN7260
      WRITE (IW,100)                                                    MAIN7270
    9 READ(IR,101)N,AOLD(N),AMIN(N)                                     MAIN7280
      NN=N-1                                                            MAIN7290
      IF(NN.EQ.NOLD)GO TO 11                                            MAIN7300
      KK=NOLD+1                                                         MAIN7310
      DO 10 I=KK,NN                                                     MAIN7320
      AOLD(I)=AOLD(N)                                                   MAIN7330
   10 AMIN(I)=AMIN(N)                                                   MAIN7340
   11 NOLD=N                                                            MAIN7350
      IF(N.LT.NUMDV) GO TO 9                                            MAIN7360
      DO 13 N=1,NUMDV                                                   MAIN7370
      IF(AOLD(N).LT.AMIN(N))AOLD(N)=AMIN(N)                             MAIN7380
   13 WRITE(IW,102)N,AOLD(N),AMIN(N)                                    MAIN7390
      WRITE(II ) AMIN                                                   MAIN7400
      WRITE (II) AOLD                                                   MAIN7410
      RETURN                                                            MAIN7420
  100 FORMAT(// 35H DESIGN VARIABLE INPUT DATA          //              MAIN7430
     1          33H  DESIGN                          /                 MAIN7440
     2          35H  VARIABLE    INITIAL  MIN ALLOWABLE/               MAIN7450
     3          35H  NUMBER       VALUE       VALUE     /)             MAIN7460
  101 FORMAT(I5,2F10.0)                                                 MAIN7470
  102 FORMAT(I6,2X,2E13.4)                                              MAIN7480
      END                                                               MAIN7490
```

```
      SUBROUTINE ELSTIF (ADLD,NUMDV,NUMEL,I1,I2     ,I12)                  MAIN7500
C*****************************************************************************MAIN7510
C-----FORM ELEMENT STIFFNESS FROM UNIT STIFFNESS MATRICES                   MAIN7520
C*****************************************************************************MAIN7530
      IMPLICIT REAL*8 (A-H,O-Z)                                             MAIN7540
      REAL*4 ADLD,ERC                                                       MAIN7550
      DIMENSION ADLD (NUMDV) ,S1(24,24),S2(24,24),P1(24,4),P2(24,4)         MAIN7560
      COMMON/EM/LM(24),S(24,24,2),P(24,4,2),EM1(1418)                       MAIN7570
      EQUIVALENCE (S1,S),(S2,S(577)),(P1,P),(P2,P(97))                      MAIN7580
      BACKSPACE I1                                                          MAIN7590
      READ(I1) ADLD                                                         MAIN7600
      REWIND I2                                                             MAIN7610
      REWIND I12                                                            MAIN7620
      DO 100 M=1,NUMEL                                                      MAIN7630
      READ(I12) LRD,ND,MV,MD,IDVAR,IEX,ERC,(LM(I),I=1,ND),(((S(I,J,K),      MAIN7640
     1 I=1,ND),J=1,ND),K=1,MD),(((P(I,J,K),I=1,ND),J=1,4),K=1,MV)           MAIN7650
      IF(IDVAR.EQ.0) GO TO 106                                              MAIN7660
      AREA=ADLD(IDVAR)*ERC                                                  MAIN7670
      XINERT=AREA**IEX                                                      MAIN7680
      DO 101 I=1,ND                                                         MAIN7690
      DO 102 J=1,4                                                          MAIN7700
  102 P1(I,J)=P1(I,J)*AREA                                                  MAIN7710
      DO 101 J=1,ND                                                         MAIN7720
  101 S1(I,J)=S1(I,J)*AREA                                                  MAIN7730
      IF(MD.EQ.1) GO TO 105                                                 MAIN7740
      DO 104 I=1,ND                                                         MAIN7750
      DO 104 J=1,ND                                                         MAIN7760
  104 S1(I,J)=S1(I,J)+S2(I,J)*XINERT                                        MAIN7770
  105 IF(MV.EQ.1) GO TO 106                                                 MAIN7780
      DO 107 I=1,ND                                                         MAIN7790
      DO 107 J=1,4                                                          MAIN7800
  107 P1(I,J)=P1(I,J)+P2(I,J)                                               MAIN7810
  106 LRD=ND*(ND+4)                                                         MAIN7820
      IF(ND.EQ.24) GO TO 200                                                MAIN7830
      NN=ND*ND                                                              MAIN7840
      CALL REARAN(S1,S1,24,24,1,ND,ND,1,NN)                                 MAIN7850
      NN=ND*4                                                               MAIN7860
      CALL REARAN(P1,P1,24,4,1,ND,4,1,NN)                                   MAIN7870
  200 CALL ELSTEW(LRD,ND,LM,S1,P1,I2)                                       MAIN7880
  100 CONTINUE                                                              MAIN7890
      RETURN                                                                MAIN7900
      END                                                                   MAIN7910
```

```
      SUBROUTINE ELSTEW(LRD,ND,LM,S1,P1,I2)                                 MAIN7920
C*****************************************************************************MAIN7930
C-----WRITE ELEMENT STIFFNESSES ON TAPE I2                                  MAIN7940
C*****************************************************************************MAIN7950
      IMPLICIT REAL*8 (A-H,O-Z)                                             MAIN7960
      DIMENSION LM(ND),S1(ND,ND),P1(ND,4)                                   MAIN7970
      WRITE(I2) LRD,ND,LM,S1,P1                                             MAIN7980
      RETURN                                                                MAIN7990
      END                                                                   MAIN8000
```

```
      SUBROUTINE ADDSTF(A,B,STR,NUMEL,NBLOCK,NF2B,LL,MBAND,I1,I2,I9,I10,MAINR010
     1 I12)                                                              MAINR020
C*********************************************************************MAINR030
C-----FORMS GLOBAL EQUILIBRIUM EQUATIONS IN BLOCKS                      MAINR040
C*********************************************************************MAINR050
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAINR060
      REAL*4 STR                                                        MAINR070
      DIMENSION STR(4,LL),A(NF2B,MBAND),B(NF2B,LL)                      MAINR080
      COMMON/EM/LM(24),SS(672),EMM(2090)                                MAINR090
      NF0B=NF2B/2                                                       MAINR100
      K=NF0B+1                                                          MAINR110
      X=NBLOCK                                                          MAINR120
      MB=DSQRT(X)                                                       MAINR130
      MB=MB/2+1                                                         MAINR140
      NFBB=MB*NF2B                                                      MAINR150
      MM=1                                                              MAINR160
      NUM9=0                                                            MAINR170
      NSHIFT=0                                                          MAINR180
      REWIND I10                                                        MAINR190
C*********************************************************************MAINR200
C-----READ STRUCTURE LOAD MULTIPLIERS                                   MAINR210
C*********************************************************************MAINR220
      REWIND I1                                                         MAINR230
      READ(I1) STR                                                      MAINR240
C*********************************************************************MAINR250
C-----FORM EQUATIONS IN BLOCKS      ( 2 BLOCKS AT A TIME)               MAINR260
C*********************************************************************MAINR270
      DO 1000 M=1,NBLOCK ,2                                             MAINR280
      DO 100 I=1,NF2B                                                   MAINR290
      DO 100 J=1,MBAND                                                  MAINR300
  100 A(I,J)=0.                                                         MAINR310
      READ(I12)((B(I,L),I=1,NF0B),L=1,LL)                               MAINR320
      IF (M.EQ.NBLOCK) GO TO 200                                        MAINR330
      READ(I12)((B(I,L),I=K,NF2B),L=1,LL)                               MAINR340
  200 REWIND I9                                                         MAINR350
      REWIND I2                                                         MAINR360
      NA=I9                                                             MAINR370
      NUME=NUM9                                                         MAINR380
      IF (MM.NE.1) GO TO 75                                             MAINR390
      NA=I2                                                             MAINR400
      NUME=NUMEL                                                        MAINR410
      NUM9=0                                                            MAINR420
   75 DO 700 N=1,NUME                                                   MAINR430
      READ (NA) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                   MAINR440
      DO 600 I=1,ND                                                     MAINR450
      LMM=1-LM(I)                                                       MAINR460
      II=LM(I)-NSHIFT                                                   MAINR470
      IF (II.LE.0.OR.II.GT.NF2B) GO TO 600                              MAINR480
      DO 300 L=1,LL                                                     MAINR490
      DO 300 J=1,4                                                      MAINR500
      KK=ND*(ND+J-1)                                                    MAINR510
  300 B(II,L)=B(II,L)+SS(I+KK)*STR(J,L)                                 MAINR520
      DO 500 J=1,ND                                                     MAINR530
      JJ=LM(J)+LMM                                                      MAINR540
      IF(JJ) 500,500,390                                                MAINR550
  390 KK=ND*J-ND                                                        MAINR560
      A(II,JJ)=A(II,JJ)+SS(I+KK)                                        MAINR570
  500 CONTINUE                                                          MAINR580
  600 CONTINUE                                                          MAINR590
C*********************************************************************MAINR600
```

```
C-----DETERMINE IF STIFFNESS IS TO BE PLACED ON UNIT 19                  MAIN8610
C*************************************************************************MAIN8620
      IF (MM.GT.1) GO TO 700                                             MAIN8630
      DO 650 I=1,ND                                                      MAIN8640
      II=LM(I) -NSHIFT                                                   MAIN8650
      IF(II.GT.NE2B.AND.II.LE.NEBB) GO TO 660                            MAIN8660
  650 CONTINUE                                                           MAIN8670
      GO TO 700                                                          MAIN8680
  660 WRITE(19) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                    MAIN8690
      NUM9=NUM9+1                                                        MAIN8700
  700 CONTINUE                                                           MAIN8710
      WRITE(110)((A(I,J),I=1,NEQB),J=1,MBAND),((B(I,L),I=1,NEQB),L=1,LL)MAIN8720
      IF(M.EQ.NBLOCK) GO TO 1000                                         MAIN8730
      WRITE(110)((A(I,J),I=K,NE2B),J=1,MBAND),((B(I,L),I=K,NE2B),L=1,LL)MAIN8740
      IF (MM.EQ.MB) MM=0                                                 MAIN8750
      MM=MM+1                                                            MAIN8760
 1000 NSHIFT=NSHIFT+NE2B                                                 MAIN8770
      RETURN                                                             MAIN8780
      END                                                                MAIN8790



      SUBROUTINE USOL (MAXB,A,B,NEQB,MB,LL,NBLOCK,NSB,NORG,NBKS,NT1,     MAIN8800
     1 NT2,IW)                                                           MAIN8810
C*************************************************************************MAIN8820
C-----THIS SUBPROGRAM SOLVES SIMULTANEOUS EQUATIONS FOR DISPLACEMENTS    MAIN8830
C-----TAPES USED ARE AS FOLLOW                                          MAIN8840
C-----A AND B (TWO BLOCKS OF STRUCTURAL STIFFNESS AND LOAD VECTORS) ARE MAIN8850
C     STORED ON TAPE NORG                                               MAIN8860
C-----SCRATCH ON NBKS , NT1 , NT2                                       MAIN8870
C-----RESULTS ARE ON TAPE NT2                                           MAIN8880
C*************************************************************************MAIN8890
      IMPLICIT REAL*8 (A-H,O-Z)                                          MAIN8900
      DIMENSION A(NSB),B(NSB),MAXB(NEQB)                                 MAIN8910
      MC=MB+LL                                                           MAIN8920
      NBR=(MB-1)/NEQB+1                                                  MAIN8930
      INC=NEQB-1                                                         MAIN8940
      NMR=NEQB*MB                                                        MAIN8950
      N2=NT2                                                             MAIN8960
      N1=NT1                                                             MAIN8970
      REWIND NORG                                                        MAIN8980
      REWIND NBKS                                                        MAIN8990
C*************************************************************************MAIN9000
C-----REDUCE EQUATIONS BLOCK-BY-BLOCK                                   MAIN9010
C*************************************************************************MAIN9020
      DO 900 N=1,NBLOCK                                                  MAIN9030
      IF (N.GT.1.AND.NBR.EQ.1) GO TO 110                                 MAIN9040
      IF (NBR.EQ.1) GO TO 105                                            MAIN9050
      REWIND N1                                                          MAIN9060
      REWIND N2                                                          MAIN9070
  105 N1=N1                                                              MAIN9080
      IF(N.EQ.1) N1=NORG                                                 MAIN9090
      READ (N1) A                                                        MAIN9100
  110 DO 300 I=1,NEQB                                                    MAIN9110
      D=A(I)                                                             MAIN9120
      IF(D) 115,300,120                                                  MAIN9130
  115 M=NEQB*(N-1)+I                                                     MAIN9140
      WRITE (IW,116) M,D                                                 MAIN9150
  120 II=I                                                               MAIN9160
```

```
      DO 125 J=2,NC                                                    MAIN9170
      II=II+NEQB                                                       MAIN9180
  125 A(II)=A(II)/D                                                    MAIN9190
      DO 130 J=I,NMB,NEQB                                              MAIN9200
      IF (A(J).NE.0.) MAXB(I)=J                                        MAIN9210
  130 CONTINUE                                                         MAIN9220
      JL=I+1                                                           MAIN9230
      IF (JL.GT.NEQB) GO TO 300                                        MAIN9240
      II=I                                                             MAIN9250
      DO 200 J=JL,NEQB                                                 MAIN9260
      II=II+NEQB                                                       MAIN9270
      IF(II.GT.NMB) GO TO 200                                          MAIN9280
      C=A(II)                                                          MAIN9290
      IF (C.EQ.0.0) GO TO 200                                          MAIN9300
      C=C*A(I)                                                         MAIN9310
      KK=J-II                                                          MAIN9320
      MAX=MAXB(I)                                                      MAIN9330
      DO 150 JJ=II,MAX,NEQB                                            MAIN9340
  150 A(JJ+KK)=A(JJ+KK)-C*A(JJ)                                        MAIN9350
      KK=J+NMB                                                         MAIN9360
      JJ=I+NMB                                                         MAIN9370
      DO 175 L=1,LL                                                    MAIN9380
      A(KK)=A(KK)-C*A(JJ)                                              MAIN9390
      KK=KK+NEQB                                                       MAIN9400
  175 JJ=JJ+NEQB                                                       MAIN9410
  200 CONTINUE                                                         MAIN9420
  300 CONTINUE                                                         MAIN9430
      WRITE (NRKS) A,MAXB                                              MAIN9440
C*******************************************************************************MAIN9450
C-----SUBSTITUTE INTO REMAINING EQUATIONS                              MAIN9460
C*******************************************************************************MAIN9470
      DO 800 NN=1,NBR                                                  MAIN9480
      IF(N+NN.GT.NBLOCK) GO TO 800                                     MAIN9490
      NI=N1                                                            MAIN9500
      IF(N.EQ.1) NI=NORG                                               MAIN9510
      IF(NN.EQ.NBR) NI=NORG                                            MAIN9520
      READ (NI) B                                                      MAIN9530
      IL=1+NN*NEQB*NEQB                                                MAIN9540
      DO 700 I=1,NEQB                                                  MAIN9550
      II=IL                                                            MAIN9560
      DO 690 K=1,NEQB                                                  MAIN9570
      IF (II.GT.NMB) GO TO 690                                         MAIN9580
      C=A(II)                                                          MAIN9590
      IF (C.EQ.0.0) GO TO 690                                          MAIN9600
      C=C*A(K)                                                         MAIN9610
      MAX=MAXB(K)                                                      MAIN9620
      KK=I-II                                                          MAIN9630
      DO 640 JJ=II,MAX,NEQB                                            MAIN9640
  640 B(JJ+KK)=B(JJ+KK)-C*A(JJ)                                        MAIN9650
      KK=I+NMB                                                         MAIN9660
      JJ=K+NMB                                                         MAIN9670
      DO 650 L=1,LL                                                    MAIN9680
      B(KK)=B(KK)-C*A(JJ)                                              MAIN9690
      KK=KK+NEQB                                                       MAIN9700
  650 JJ=JJ+NEQB                                                       MAIN9710
  690 II=II-INC                                                        MAIN9720
  700 IL=IL+NEQB                                                       MAIN9730
      IF(NBR.NE.1) GO TO 750                                           MAIN9740
      DO 740 I=1,NSB                                                   MAIN9750
  740 A(I)=B(I)                                                        MAIN9760
```

```
      GO TO 800                                                          MAIN9770
750   WRITE (N2) B                                                       MAIN9780
800   CONTINUE                                                           MAIN9790
      M=N1                                                               MAIN9800
      N1=N2                                                              MAIN9810
  900 N2=M                                                               MAIN9820
C*********************************************************************** MAIN9830
C-----BACKSUBSTITUTION - RESULTS ON TAPE NT2                             MAIN9840
C*********************************************************************** MAIN9850
      LS=LL*NEQB                                                         MAIN9860
      NER=NEQB*(NBR+1)                                                   MAIN9870
      NUM=NBR*NEQB                                                       MAIN9880
      MAX=NER*LL                                                         MAIN9890
      DO 905 I=1,MAX                                                     MAIN9900
  905 B(I)=0.                                                            MAIN9910
      REWIND NT2                                                         MAIN9920
      DO 1000 N=1,NBLOCK                                                 MAIN9930
      BACKSPACE NBKS                                                     MAIN9940
      READ (NBKS) A,MAXB                                                 MAIN9950
      BACKSPACE NBKS                                                     MAIN9960
      DO 910 L=1,LL                                                      MAIN9970
      K=L*NER                                                            MAIN9980
      DO 910 J=1,NUM                                                     MAIN9990
      I=K-NEQB                                                           MAIN0000
      B(K)=B(I)                                                          MAIN0010
  910 K=K-1                                                              MAIN0020
      I=NMB                                                              MAIN0030
      DO 920 L=1,LL                                                      MAIN0040
      K=(L-1)*NER                                                        MAIN0050
      DO 920 J=1,NEQB                                                    MAIN0060
      I=I+1                                                              MAIN0070
      K=K+1                                                              MAIN0080
  920 B(K)=A(I)                                                          MAIN0090
      DO 955 I=1,NEQB                                                    MAIN0100
      J=NEQB+1-I                                                         MAIN0110
      MAX=MAXB(J)                                                        MAIN0120
      IF (A(J).EQ.0.) GO TO 955                                          MAIN0130
      DO 950 L=1,LL                                                      MAIN0140
      KK=J+(L-1)*NER                                                     MAIN0150
      JJ=KK+1                                                            MAIN0160
      II=J+NEQB                                                          MAIN0170
      C=B(KK)                                                            MAIN0180
      DO 940 II=II,MAX,NEQB                                              MAIN0190
      C=C-A(II)*B(JJ)                                                    MAIN0200
  940 JJ=JJ+1                                                            MAIN0210
  950 B(KK)=C                                                            MAIN0220
  955 CONTINUE                                                           MAIN0230
      I=0                                                                MAIN0240
      DO 960 L=1,LL                                                      MAIN0250
      K=(L-1)*NER                                                        MAIN0260
      DO 960 J=1,NEQB                                                    MAIN0270
      K=K+1                                                              MAIN0280
      I=I+1                                                              MAIN0290
  960 A(I)=B(K)                                                          MAIN0300
      WRITE(NT2) (A(I),I=1,LS)                                           MAIN0310
 1000 CONTINUE                                                           MAIN0320
      RETURN                                                             MAIN0330
  116 FORMAT (33HOSET OF EQUATIONS MAY BE SINGULAR   /                   MAIN0340
     .  26H DIAGONAL TERM OF EQUATION  ,I8,  8H  EQUALS  ,1PE12.4)       MAIN0350
      END                                                                MAIN0360
```

```
      SUBROUTINE PRINID(ID,D,B,NEQB,NUMNP,LL,NBLOCK,NEQ,I2,IB,IW,KODE,   MAIN0370
     1 KPRINT)                                                           MAIN0380
C*********************************************************************MAIN0390
C-----PRINT NODAL DISPLACEMENTS  OR BUCKLING MODESHAPES                 MAIN0400
C*********************************************************************MAIN0410
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN0420
      REAL*4 D                                                          MAIN0430
      DIMENSION ID(NUMNP,6),D(6,LL),B(NEQB,LL)                          MAIN0440
      REWIND IB                                                         MAIN0450
      READ (IB) ID                                                      MAIN0460
      IF(KPRINT.EQ.0) RETURN                                            MAIN0470
      GO TO (1,2),KODE                                                  MAIN0480
    1 WRITE(IW,2003)                                                    MAIN0490
      GO TO 3                                                           MAIN0500
    2 WRITE(IW,2005)                                                    MAIN0510
    3 REWIND I2                                                         MAIN0520
      M=NEQ                                                             MAIN0530
      NN=NEQB*NBLOCK                                                    MAIN0540
      N=NUMNP                                                           MAIN0550
      DO 500 KK=1,NUMNP                                                 MAIN0560
      I=6                                                               MAIN0570
      DO 250 II=1,6                                                     MAIN0580
      DO 100 L=1,LL                                                     MAIN0590
  100 D(I,L)=0.                                                         MAIN0600
      IF(M.GT.NN) GO TO 150                                             MAIN0610
      IF (M.EQ.0) GO TO 150                                             MAIN0620
      READ(I2) B                                                        MAIN0630
      NN=NN-NEQB                                                        MAIN0640
  150 IF(ID(N,I).LT.1) GO TO 250                                        MAIN0650
      K=M-NN                                                            MAIN0660
      M=M-1                                                             MAIN0670
      DO 200 L=1,LL                                                     MAIN0680
  200 D(I,L)=B(K,L)                                                     MAIN0690
  250 I=I-1                                                             MAIN0700
      WRITE(IW,2004) N,(L,(D(I,L),I=1,6),L=1,LL)                        MAIN0710
  500 N=N-1                                                             MAIN0720
      RETURN                                                            MAIN0730
 2003 FORMAT (34H NODAL DISPLACEMENTS AND ROTATIONS//                   MAIN0740
     1  5H NODE ,5H LOAD ,11X ,1HX ,11X ,1HY ,11X ,1HZ ,10X ,2HXX,     MAIN0750
     2 10X ,2HYY ,10X ,2HZZ/ 5H  NO. , 5H CASE /)                      MAIN0760
 2004 FORMAT (1H ,I4,I5,1P3E12.3,3E12.4/(10X,3E12.3,3E12.4))           MAIN0770
 2005 FORMAT(//21H BUCKLING MODE SHAPES  //                             MAIN0780
     1  5H NODE ,5H MODE ,11X ,1HX ,11X ,1HY ,11X ,1HZ ,10X ,2HXX,     MAIN0790
     2 10X ,2HYY ,10X ,2HZZ/ 5H  NO. , 5HSHAPE /)                      MAIN0800
      END                                                               MAIN0810
```

```
      SUBROUTINE STRESS(ADLD,ASTR,LOAD,STR,B,D,LL,LB,NEQ,NUMDV,NEQB   ,  MAIN0820
     1 A,MTOT,LBUCK,INDET,IDESN,I1,I2,I3,IB,I11,IW)                     MAIN0830
C*********************************************************************MAIN0840
C-----CALCULATE STRESSES                                               MAIN0850
C*********************************************************************MAIN0860
      DIMENSION STR(4,LL),D(NEQ,LB),LOAD(NUMDV),ADLD(NUMDV),ASTR(NUMDV) MAIN0870
     1 ,A(MTOT)                                                         MAIN0880
      REAL*8 B(NEQB,LL)                                                 MAIN0890
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTTT,   MAIN0900
     1 ELP(9),NBLOCK                                                    MAIN0910
      COMMON/LINK/LT,LH,JUN(366)                                        MAIN0920
      REWIND I1                                                         MAIN0930
      READ(I1) STR                                                      MAIN0940
      READ(I1) ASTR                                                     MAIN0950
      READ(I1) ADLD                                                     MAIN0960
      IF(LBUCK.EQ.0) GO TO 200                                          MAIN0970
      IF(INDET.NE.0.AND.IDESN.GT.0) GO TO 200                           MAIN0980
      REWIND I11                                                        MAIN0990
      REWIND I3                                                         MAIN1000
  200 CONTINUE                                                          MAIN1010
C*********************************************************************MAIN1020
C-----PRINT DESIGN VARIABLE ARRAY FOR CURRENT DESIGN                   MAIN1030
C*********************************************************************MAIN1040
      CALL DPRINT (ADLD,NUMDV,IW)                                       MAIN1050
      DO 111 I=1,NUMDV                                                  MAIN1060
  111 LOAD(I)=0                                                         MAIN1070
      NT=(LL-1)/LB +1                                                   MAIN1080
      LH=0                                                              MAIN1090
      DO 1000 II=1,NT                                                   MAIN1100
C*********************************************************************MAIN1110
C-----MOVE DISPLACEMENTS INTO CORE FOR LB LOAD CONDITIONS               MAIN1120
C*********************************************************************MAIN1130
      CALL MOVED(B,D,NEQB,NBLOCK,NEQ,LL,LB,LH,LT,I2)                    MAIN1140
C*********************************************************************MAIN1150
C-----CALCULATE ELEMENT STRESSES AND PERFORM FULLY STRESSED  DESIGN    MAIN1160
C     FOR LB LOAD CONDITIONS                                            MAIN1170
C*********************************************************************MAIN1180
      DO 1000 M=1,NELTYP                                                MAIN1190
      READ (I8) NPAR                                                    MAIN1200
      MTYPE=NPAR(1)                                                     MAIN1210
      NPAR(1)=0                                                         MAIN1220
      CALL ELTYPE (A,MTOT,MTYPE,IW)                                     MAIN1230
 1000 CONTINUE                                                          MAIN1240
      WRITE(I1) ASTR,LOAD                                               MAIN1250
      RETURN                                                            MAIN1260
      END                                                               MAIN1270
```

```
      SUBROUTINE DPRINT (A,NV,IW)                                       MAIN1280
C*************************************************************************MAIN1290
C-----PRINT DESIGN VARIABLE ARRAY                                       MAIN1300
C*************************************************************************MAIN1310
      DIMENSION A(NV)                                                   MAIN1320
      WRITE(IW,1006)                                                    MAIN1330
      NROW=(NV-1)/10+1                                                  MAIN1340
      DO 220 N=1,NROW                                                   MAIN1350
      M=(N-1)*10                                                        MAIN1360
      ISTART=M+1                                                        MAIN1370
      ISTOP=M+10                                                        MAIN1380
      IF(ISTOP.GT.NV) ISTOP=NV                                          MAIN1390
  220 WRITE(IW,1007) M,(A(I),I=ISTART,ISTOP)                            MAIN1400
      RETURN                                                            MAIN1410
 1006 FORMAT(///28H VALUES OF DESIGN VARIABLES //                       MAIN1420
     1125H           1           2           3           4           5 MAIN1430
     2           6           7           8           9          10     / )MAIN1440
 1007 FORMAT(1H ,I5,10F12.4)                                            MAIN1450
      END                                                               MAIN1460
```

```
      SUBROUTINE MOVED(B,D,NEQR,NBLOCK,NEQ,LL,LR,LH,LT,I2)              MAIN1470
C*************************************************************************MAIN1480
C-----MOVE DISPLACEMENTS INTO CORE FOR LR LOAD CONDITIONS FROM TAPE NT  MAIN1490
C*************************************************************************MAIN1500
      DIMENSION D(NEQ,LR)                                               MAIN1510
      REAL*8 B(NEQR,LL)                                                 MAIN1520
      REWIND I2                                                         MAIN1530
      LT=LH+1                                                           MAIN1540
      LLT=1-LT                                                          MAIN1550
      LH=LT+LR-1                                                        MAIN1560
      IF(LH.GT.LL ) LH=LL                                               MAIN1570
      NQ=NEQR*NBLOCK                                                    MAIN1580
      DO 200 NN=1,NBLOCK                                                MAIN1590
      READ(I2) B                                                        MAIN1600
      N=NEQR                                                            MAIN1610
      IF (NN.EQ.1) N=NEQ-NQ+NEQR                                        MAIN1620
      NQ=NQ-NEQR                                                        MAIN1630
      DO 200 J=1,N                                                      MAIN1640
      I=NQ+J                                                            MAIN1650
      DO 200 L=LT,LH                                                    MAIN1660
      K=L+LLT                                                           MAIN1670
  200 D(I,K)=B(J,L)                                                     MAIN1680
      RETURN                                                            MAIN1690
      END                                                               MAIN1700
```

```
      SUBROUTINE STRSC (ADLD,STR,D,NEQ,NUMDV,LL,LB,NTAG)                MAIN1710
C*********************************************************************MAIN1720
C-----SET UP STRESS MATRIX AND CALCULATE STRESSES                       MAIN1730
C*********************************************************************MAIN1740
      REAL*8 P1,P2,ST1,ST2,ST,P ,G1,G                                   MAIN1750
      DIMENSION STR(4,LL),D(NEQ,LB),ADLD(NUMDV),P1(15,4),P2(15,4),      MAIN1760
     1 ST1(15,24),ST2(15,24),G1(24,24)                                  MAIN1770
      COMMON/JUNK/LT,LH,L,SG(27),IDVAR,IEX,ERC,AREA,XINERT,DESINE(333)  MAIN1780
      COMMON/EM/NU,NW,NS,ND,LM(24),ST(15,24,2),P(15,4,2),G(24,24,3),    MAIN1790
     1 NSG(3),EM1(381)                                                  MAIN1800
      COMMON/CONTR/IC(6),IDESN,IC2(6),LBUCK,IC3(4),INDET,IC4(10)        MAIN1810
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             MAIN1820
      EQUIVALENCE (P1,P),(P2,P(61)),(ST,ST1),(ST(361),ST2) ,(G1,G)      MAIN1830
      IF (NTAG.EQ.0) GO TO 800                                          MAIN1840
      NL=L-LT+1                                                         MAIN1850
      DO 300 I=1,NS                                                     MAIN1860
      SG(I)=0.0                                                         MAIN1870
      DO 300 J=1,4                                                      MAIN1880
  300 SG(I)=SG(I)+P1(I,J)*STR(J,L)                                      MAIN1890
      DO 500 J=1,ND                                                     MAIN1900
      JJ=LM(J)                                                          MAIN1910
      IF(JJ.EQ.0) GO TO 500                                             MAIN1920
      DO 400 I=1,NS                                                     MAIN1930
  400 SG(I)=SG(I)+ST1(I,J)*D(JJ,NL)                                     MAIN1940
  500 CONTINUE                                                          MAIN1950
      IF(LBUCK.NE.L) RETURN                                             MAIN1960
      IF(IDVAR.EQ.0) RETURN                                             MAIN1970
      IF(INDET.NE.0.AND.IDESN.GT.0) RETURN                              MAIN1980
      DO 700 I=1,ND                                                     MAIN1990
      DO 700 J=I,ND                                                     MAIN2000
      SS=0.                                                             MAIN2010
      DO 750 K=1,NG                                                     MAIN2020
      KK=NSG(K)                                                         MAIN2030
  750 SS=SS+G(I,J,K)*SG(KK)                                             MAIN2040
      G1(I,J)=SS                                                        MAIN2050
  700 G1(J,I)=SS                                                        MAIN2060
      NN=ND*ND                                                          MAIN2070
      IF(ND.NE.24) CALL REARAN(G1,G1,24,24,1,ND,ND,1,NN)                MAIN2080
      CALL FLGSTW(ND,LM,G,I3)                                           MAIN2090
      RETURN                                                            MAIN2100
  800 READ(IR) NU,NW,NS,ND,IDVAR,IEX,ERC,(LM(I),I=1,ND),(((ST(I,J,K),   MAIN2110
     1 I=1,NS),J=1,ND),K=1,NU),( ((P(I,J,K),I=1,NS),J=1,4),K=1,NW)      MAIN2120
      IF(IDVAR.EQ.0) RETURN                                             MAIN2130
      IF(LBUCK.EQ.0) GO TO 120                                          MAIN2140
      IF (INDET.NE.0.AND.IDESN.GT.0) GO TO 120                          MAIN2150
      READ(I11) NG,( ((G(I,J,K),I=1,ND),J=1,ND),K=1,NG),(NSG(I),I=1,NG) MAIN2160
  120 AREA= ADLD(IDVAR)*ERC                                             MAIN2170
      XINERT=AREA**IEX                                                  MAIN2180
      DO 100 I=1,NS                                                     MAIN2190
      DO 101 J=1,4                                                      MAIN2200
  101 P1(I,J)=P1(I,J)*AREA                                              MAIN2210
      DO 100 J=1,ND                                                     MAIN2220
  100 ST1(I,J)=ST1(I,J)*AREA                                            MAIN2230
      READ(IR) NI,(DESINE(I),I=1,NI)                                    MAIN2240
      IF (NU.EQ.1) GO TO 900                                            MAIN2250
      DO 104 I=1,NS                                                     MAIN2260
      DO 104 J=1,ND                                                     MAIN2270
  104 ST1(I,J)=ST1(I,J)+ST2(I,J)*XINERT                                 MAIN2280
  900 IF(NW.EQ.1) RETURN                                                MAIN2290
      DO 105 I=1,NS                                                     MAIN2300
```

```
      DO 105 J=1,4                                                      MAIN2310
  105 P1(I,J)=P1(I,J)+P2(I,J)                                           MAIN2320
      RETURN                                                            MAIN2330
      END                                                               MAIN2340


      SUBROUTINE FLGSTW(ND,LM,G,I3)                                     MAIN2350
C*********************************************************************MAIN2360
C-----WRITE GEOMETRIC STIFFNESS MATRIX ON TAPE I3                       MAIN2370
C*********************************************************************MAIN2380
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN2390
      DIMENSION LM(ND),G(ND,ND)                                         MAIN2400
      LRD=ND*ND                                                         MAIN2410
      WRITE(I3) LRD,ND,LM,G                                             MAIN2420
      RETURN                                                            MAIN2430
      END                                                               MAIN2440
```

```
      SUBROUTINE BANAL (A,AD,MTOT,MTOT2)                                MAIN2450
C*****************************************************************MAIN2460
C-----BUCKLING ANALYSIS AND DERIVATIVES                               MAIN2470
C*****************************************************************MAIN2480
      DIMENSION A(MTOT)                                                 MAIN2490
      REAL*8 AD(MTOT2),S,EV,EVEC ,G,EVAL                                MAIN2500
      COMMON/CONTR/ ICYCL,NCYCL,ISCALE,NSCALE,KSCALE,KONVG,IDESN,IWTMIN,MAIN2510
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,LBUCK,NVEC,NMODE,LB1,ALPA,INDET  MAIN2520
     2,KPRINT,OMEGA,COFEET,SMAX,AMAX,NBUCK,SF,IS,KOD ,NBOUND            MAIN2530
      COMMON/ELPAR/NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQ, MAIN2540
     1 NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQB,NBLOCK                           MAIN2550
      COMMON/UNITS/ IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             MAIN2560
      COMMON/JUNK/EV(4),S(4,4),G(4,4),EVEC(4,4),EVAL(4),JUN(256)        MAIN2570
      DO 99 I=1,NMODE                                                   MAIN2580
   99 EVAL(I)=0.0                                                       MAIN2590
      N1=1                                                              MAIN2600
      IF(INDET.NE.0.AND.IDESN.GT.0) GO TO 100                           MAIN2610
C*****************************************************************MAIN2620
C-----ASSEMBLE GEOMETRIC STIFFNESS MATRIX                             MAIN2630
C*****************************************************************MAIN2640
      IG=I10                                                            MAIN2650
      IF(INDET.EQ.0) GO TO 101                                          MAIN2660
      IG=I11                                                            MAIN2670
      REWIND IG                                                         MAIN2680
  101 CONTINUE                                                          MAIN2690
      NE2R=NEQB*2                                                       MAIN2700
      NUME=NUMEL-NBOUND                                                 MAIN2710
      CALL ADGSTF(AD(N1),NUME ,NBLOCK,NE2R,MBAND,I3,I9,IG)              MAIN2720
C*****************************************************************MAIN2730
C-----FIND(OUT Z TRANSPOSE * K * Z                                    MAIN2740
C*****************************************************************MAIN2750
  100 CONTINUE                                                          MAIN2760
  900 MM=(NEQB+MBAND-1)/NEQB+1                                          MAIN2770
      MM=MM*NEQB                                                        MAIN2780
      M=MBAND+LL                                                        MAIN2790
      ND2=N1+NEQB*M                                                     MAIN2800
      ND3=ND2+(MM*NVEC)                                                 MAIN2810
      N4=(ND2+MM*NVEC)*2+1                                              MAIN2820
      IF(N4.GT.MTOT) CALL ERROR(N4-MTOT)                                MAIN2830
      REWIND I10                                                        MAIN2840
      CALL MULBAN(AD(N1),AD(ND2),AD(ND3),NBLOCK,MBAND,M,NVEC,NEQB,MM,   MAIN2850
     1 I10,I13,I9,S)                                                    MAIN2860
C*****************************************************************MAIN2870
C-----FIND THE PRODUCT Z TRANSPOSE * G * Z                            MAIN2880
C*****************************************************************MAIN2890
      IF(INDET.NE.0) REWIND IG                                          MAIN2900
      CALL MULBAN(AD(N1),AD(ND2),AD(ND3),NBLOCK,MBAND,NVEC,NEQB,       MAIN2910
     1 MM,IG,I13,I9,G)                                                  MAIN2920
C*****************************************************************MAIN2930
C-----COMPUTE EIGENVALUES (EV) AND EIGENVECTORS (EVEC)                MAIN2940
C*****************************************************************MAIN2950
      CALL EIGJAC(S,G,EV,EVEC,NVEC)                                     MAIN2960
C*****************************************************************MAIN2970
C-----CHECK IF EIGENVALUES HAVE CONVERGED                             MAIN2980
C*****************************************************************MAIN2990
      NC=0                                                              MAIN3000
      DO 200 I=1,NMODE                                                  MAIN3010
      IF(DABS(EV(I)-EVAL(I)).GT.DABS(EV  (I)/200))NC=1                  MAIN3020
  200 CONTINUE                                                          MAIN3040
C*****************************************************************MAIN3040
```

```
C-----COMPUTE IMPROVED COORDINATE VECTORS 7                                    MAIN3050
C*****************************************************************************MAIN3060
      DO 250 I=1,NVEC                                                         MAIN3070
  250 EVAL(I)=EV(I)                                                           MAIN3080
      ND2=N1+NEQB*MBAND                                                       MAIN3090
      ND3=ND2+NEQB*NVEC                                                       MAIN3100
      MM=MBAND+LL                                                             MAIN3110
      NN=MBAND+NVEC                                                           MAIN3120
      CALL SETE (AD(N1),AD(N1),AD(ND2),AD(ND3),EVEC,NEQB,NVEC,NBLOCK,         MAIN3130
     1 MM,NN,MBAND,I3,I9,I10)                                                 MAIN3140
      NSB=NEQB*(MBAND+NVEC)                                                   MAIN3150
      N2=N1+NEQB                                                              MAIN3160
      ND2=N2/2+1                                                              MAIN3170
      ND3=ND2+NSB                                                             MAIN3180
      CALL USOL(A(N1),AD(ND2),AD(ND3),NEQB,MBAND,NVEC,NBLOCK,NSB,             MAIN3190
     1 I3,I13,I9,I2,IW)                                                       MAIN3200
C*****************************************************************************MAIN3210
C-----TRANSFER IMPROVED COORDINATE VECTORS (7) FROM TAPE I2 TO TAPE I13       MAIN3220
C*****************************************************************************MAIN3230
      REWIND I13                                                              MAIN3240
      NN=NEQB*NVEC                                                            MAIN3250
      DO 400 N=1,NBLOCK                                                       MAIN3260
      BACKSPACE I2                                                            MAIN3270
      READ(I2) (AD(I),I=1,NN)                                                 MAIN3280
      WRITE(I13) (AD(I),I=1,NN)                                               MAIN3290
  400 BACKSPACE I2                                                            MAIN3300
      IF(NC.NE.0) GO TO 900                                                   MAIN3310
C*****************************************************************************MAIN3320
C-----EIGENVALUES HAVE CONVERGED  -  PRINT THEM                               MAIN3330
C-----COMPUTE STRUCTURE MODE SHAPES                                           MAIN3340
C*****************************************************************************MAIN3350
      WRITE(IW,1001) (EV(I),I=1,NVEC)                                         MAIN3360
      ND2=N1+NEQB*NVEC                                                        MAIN3370
      CALL SMODE (AD(N1),AD(ND2),EVEC,NEQB,NVEC,NBLOCK,NMODE,I3,I2 )          MAIN3380
      IF(KPRINT.EQ.0) RETURN                                                  MAIN3390
C*****************************************************************************MAIN3400
C-----PRINT MODE SHAPES                                                       MAIN3410
C*****************************************************************************MAIN3420
      N2=N1+NUMNP*6                                                           MAIN3430
      N3=N2+6*NMODE                                                           MAIN3440
      ND3=N3/2+1                                                              MAIN3450
      READ(I8) (A(I),I=1,NUMDV)                                               MAIN3460
      REWIND I9                                                               MAIN3470
      WRITE(I9) (A(I),I=1,NUMDV)                                              MAIN3480
      CALL PRINTD(A(N1),A (N2 ),AD(ND3),NEQB,NUMNP,NMODE,NBLOCK,NEQ,          MAIN3490
     1 I3,I8,IW,2,KPRINT)                                                     MAIN3500
      RETURN                                                                  MAIN3510
 1001 FORMAT(//25H BUCKLING LOAD PARAMETERS  //(1X,6E20.5))                   MAIN3520
      END                                                                     MAIN3530
```

```
      SUBROUTINE ADGSTF(A,NUMEL,NBLOCK,NE2B,MBAND,I3,I9,IG)              MAIN3540
C*********************************************************************MAIN3550
C-----ASSEMBLE GEOMETRIC STIFFNESS MATRICES                            MAIN3560
C*********************************************************************MAIN3570
      IMPLICIT REAL*8 (A-H,O-Z)                                          MAIN3580
      DIMENSION A(NE2B,MBAND)                                            MAIN3590
      COMMON/EM/LM(24),SS(672),EMM(2090)                                 MAIN3600
      NEOB=NE2B/2                                                        MAIN3610
      K=NEOB+1                                                           MAIN3620
      X=NBLOCK                                                           MAIN3630
      MB=DSQRT(X)/2+1                                                    MAIN3640
      NEBB=MB*NE2B                                                       MAIN3650
      MM=1                                                               MAIN3660
      NUMS=0                                                             MAIN3670
      NSHIFT=0                                                           MAIN3680
      DO 1000 M=1,NBLOCK ,2                                              MAIN3690
      DO 100 I=1,NE2B                                                    MAIN3700
      DO 100 J=1,MBAND                                                   MAIN3710
  100 A(I,J)=0.                                                          MAIN3720
      REWIND I9                                                          MAIN3730
      REWIND I3                                                          MAIN3740
      NA=I9                                                              MAIN3750
      NUMF=NUMS                                                          MAIN3760
      IF (MM.NE.1) GO TO 75                                              MAIN3770
      NA=I3                                                              MAIN3780
      NUMF=NUMEL                                                         MAIN3790
      NUMS=0                                                             MAIN3800
   75 DO 700 N=1,NUMF                                                    MAIN3810
      READ (NA) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                    MAIN3820
      DO 600 I=1,ND                                                      MAIN3830
      LMN=1-LM(I)                                                        MAIN3840
      II=LM(I)-NSHIFT                                                    MAIN3850
      IF (II.LE.0.OR.II.GT.NE2B) GO TO 600                               MAIN3860
      DO 500 J=1,ND                                                      MAIN3870
      JJ=LM(J)+LMN                                                       MAIN3880
      IF(JJ) 500,500,390                                                 MAIN3890
  390 KK=ND*J-ND                                                         MAIN3900
      A(II,JJ)=A(II,JJ)+SS(I+KK)                                         MAIN3910
  500 CONTINUE                                                           MAIN3920
  600 CONTINUE                                                           MAIN3930
C*********************************************************************MAIN3940
C-----DETERMINE IF STIFFNESS IS TO BE PLACED ON UNIT I9                 MAIN3950
C*********************************************************************MAIN3960
      IF (MM.GT.1) GO TO 700                                             MAIN3970
      DO 650 I=1,ND                                                      MAIN3980
      II=LM(I) -NSHIFT                                                   MAIN3990
      IF(II.GT.NE2B.AND.II.LE.NEBB) GO TO 660                            MAIN4000
  650 CONTINUE                                                           MAIN4010
      GO TO 700                                                          MAIN4020
  660 WRITE(I9) LRD,ND,(LM(I),I=1,ND),(SS(I),I=1,LRD)                    MAIN4030
      NUMS=NUMS+1                                                        MAIN4040
  700 CONTINUE                                                           MAIN4050
      WRITE(IG ) ((A(I,J),I=1,NEOB),J=1,MBAND)                           MAIN4060
      IF(M.EQ.NBLOCK) GO TO 1000                                         MAIN4070
      WRITE(IG ) ((A(I,J),I=K,NE2B),J=1,MBAND)                           MAIN4080
      IF (MM.EQ.MB) MM=0                                                 MAIN4090
      MM=MM+1                                                            MAIN4100
 1000 NSHIFT=NSHIFT+NE2B                                                 MAIN4110
      RETURN                                                             MAIN4120
      END                                                                MAIN4130
```

```
      SUBROUTINE MULBAN(A,B,C,NBLOCK,MBAND,M,NVEC,NEQR,MM,NT,I13,I9,D)  MAIN4140
C*********************************************************************MAIN4150
C-----MULTIPLICATION OF THE PRODUCT Z TRANSPOSE * (K OR G) * Z         MAIN4160
C-----M IS NO. OF COLUMNS OF A TO BE READ FROM TAPE NT                 MAIN4170
C-----MM IS NO. OF ROWS OF B AND C TO BE KEPT IN CORE FOR              MAIN4180
C     MULTIPLICATION A*B                                              MAIN4190
C*********************************************************************MAIN4200
      IMPLICIT REAL*8 (A-H,O-Z)                                       MAIN4210
      DIMENSION A(NEQR,M),B(MM,NVEC),C(MM,NVEC),D(NVEC,NVEC)          MAIN4220
      M3=MM-NEQR                                                      MAIN4230
      REWIND I9                                                       MAIN4240
      REWIND I13                                                      MAIN4250
C*********************************************************************MAIN4260
C-----INITIALISE MATRICES B AND C                                      MAIN4270
C*********************************************************************MAIN4280
      DO 500 I=1,MM                                                   MAIN4290
      DO 500 J=1,NVEC                                                 MAIN4300
      B(I,J)=0.0                                                      MAIN4310
  500 C(I,J)=0.0                                                      MAIN4320
C*********************************************************************MAIN4330
C-----MATRIX MULTIPLICATION A*B IN BLOCKS                              MAIN4340
C*********************************************************************MAIN4350
      DO 40 L=1,NBLOCK                                                MAIN4360
      READ(NT) A                                                      MAIN4370
      IF(L.GT.1) GO TO 70                                             MAIN4380
      M2=MM/NEQR                                                      MAIN4390
      IF(M2.GT.NBLOCK) M2=NBLOCK                                      MAIN4400
      DO 20 L1=1,M2                                                   MAIN4410
      L2=(L1-1)*NEQR                                                  MAIN4420
   20 READ(I13) ((B(L2+I,J),I=1,NEQR),J=1,NVEC )                      MAIN4430
      GO TO 100                                                       MAIN4440
   70 M2=M2+1                                                         MAIN4450
C*********************************************************************MAIN4460
C-----MOVE MATRICES B AND C UP BY ONE BLOCK LENGTH                     MAIN4470
C*********************************************************************MAIN4480
      DO 80 I=1,M3                                                    MAIN4490
      DO 80 J=1,NVEC                                                  MAIN4500
      C(I,J)=C(I+NEQR,J)                                              MAIN4510
   80 B(I,J)=B(I+NEQR,J)                                              MAIN4520
      DO 81 I=1,NEQR                                                  MAIN4530
      DO 81 J=1,NVEC                                                  MAIN4540
      C(I+M3,J)=0.0                                                   MAIN4550
   81 B(I+M3,J)=0.0                                                   MAIN4560
      IF(M2.GT.NBLOCK) GO TO 100                                      MAIN4570
      READ (I13) ((B(I+M3,J),I=1,NEQR) ,J=1,NVEC)                     MAIN4580
  100 CONTINUE                                                        MAIN4590
C*********************************************************************MAIN4600
C-----MATRIX MULTIPLICATION A*B                                        MAIN4610
C*********************************************************************MAIN4620
      DO 120 L3=1,NVEC                                                MAIN4630
      DO 120 L1= 1,NEQR                                               MAIN4640
      DO 140 L2=1,MBAND                                               MAIN4650
      L12=L1+L2-1                                                     MAIN4660
  140 C(L1,L3)=C(L1,L3)+A(L1,L2)*B(L12,L3)                            MAIN4670
      DO 120  L2=2,MBAND                                              MAIN4680
      L12=L1+L2-1                                                     MAIN4690
  120 C(L12,L3)=C(L12,L3)+A(L1,L2)*B(L1,L3)                           MAIN4700
C*********************************************************************MAIN4710
C-----WRITE ONE BLOCK OF C ON TAPE I9                                  MAIN4720
C*********************************************************************MAIN4730
```

```
      WRITE ( 19  )  ((C(I,J),I=1,NEQB),J=1,NVEC )                    MAIN4740
   40 CONTINUE                                                        MAIN4750
C*********************************************************************MAIN4760
C-----FORM MATRIX PRODUCT B TRANSPOSE A*B                             MAIN4770
C-----RESULT IS MATRIX D                                              MAIN4780
C*********************************************************************MAIN4790
      REWIND 13                                                       MAIN4800
      REWIND 19                                                       MAIN4810
      DO 550 I=1,NVEC                                                 MAIN4820
      DO 550 J=1,NVEC                                                 MAIN4830
  550 D(I,J)=0.0                                                      MAIN4840
      DO 200 L=1,NBLOCK                                               MAIN4850
      READ (13) ((B(I,J),I=1,NEQB),J=1,NVEC)                          MAIN4860
      READ( 19) ((C(I,J),I=1,NEQB) ,J=1,NVEC)                         MAIN4870
C*********************************************************************MAIN4880
C-----MATRIX MULTIPLICATION B TRANSPOSE *     C                       MAIN4890
C*********************************************************************MAIN4900
      DO 250 L1=1,NVEC                                                MAIN4910
      DO 250 L2=1,NEQB                                                MAIN4920
      DO 250 L3=1,NVEC                                                MAIN4930
  250 D(L1,L3)=D(L1,L3)+B(L2,L1)*C(L2,L3)                             MAIN4940
  200 CONTINUE                                                        MAIN4950
      RETURN                                                          MAIN4960
      END                                                             MAIN4970
```

```
      SUBROUTINE EIGJAC (S,G,EV,EVEC,NVEC)                            MAIN4980
      IMPLICIT REAL*8 (A-H,O-Z)                                       MAIN4990
C*********************************************************************MAIN5000
C-----COMPUTE EIGENVALUES AND NORMALISED EIGEN VECTORS                MAIN5010
C*********************************************************************MAIN5020
      DIMENSION S(NVEC,NVEC),G(NVEC,NVEC),EV(NVEC) ,EVEC(NVEC,NVEC)   MAIN5030
      IF(NVEC.GT.1) GO TO 300                                         MAIN5040
      EV(1)=-S(1,1)/G(1,1)                                            MAIN5050
      G1=-1.0/G(1,1)                                                  MAIN5060
      IF(G(1,1).GT.0) G1=-G1                                          MAIN5070
      EVEC(1,1)=DSQRT(G1)                                             MAIN5080
      GO TO 400                                                       MAIN5090
  300 DET=G(1,1)*G(2,2)-G(2,1)**2                                     MAIN5100
      G1=S(1,1)*G(2,2)+S(2,2)*G(1,1)-2.0*S(1,2)*G(1,2)                MAIN5110
      G2=S(1,1)*S(2,2)-S(1,2)**2                                      MAIN5120
      D=DSQRT(G1*G1-4.0*DET*G2)                                       MAIN5130
      EV(1)=(-G1-D)/(2.0*DET)                                         MAIN5140
      EV(2)=(-G1+D)/(2.0*DET)                                         MAIN5150
      DO 60 I=1,2                                                     MAIN5160
      RAT=-(S(1,1)+EV(I)*G(1,1))/(S(1,2)+EV(I)*G(1,2))                MAIN5170
      G1=G(1,1)+2.0*G(1,2)*RAT+G(2,2)*RAT**2                          MAIN5180
      IF(G1.LT.0.) G1=-G1                                             MAIN5190
      EVEC(1,I)= DSQRT( 1.0/G1)                                       MAIN5200
   60 EVEC(2,I)=RAT*EVEC(1,I)                                         MAIN5210
  400 CONTINUE                                                        MAIN5220
      RETURN                                                          MAIN5230
      END                                                             MAIN5240
```

```
      SUBROUTINE SETE (SK,SK1,E,C,EVEC,NEQR,NVEC,NBLOCK,MM,NN,MBAND),I3,  MAIN5250
     1 I9,I10)                                                            MAIN5260
C*********************************************************************MAIN5270
C-----SETUP STRUCTURE STIFFNESS MATRIX AND E=G*Z*Q FOR SOLVING          MAIN5280
C     IMPROVED COORDINATE VECTORS USING SUBROUTINE USOL                  MAIN5290
C*********************************************************************MAIN5300
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5310
      DIMENSION SK(NEQR,MM),SK1(NEQR,NN),E(NEQR,NVEC),C(NVEC),          MAIN5320
     1 EVEC(NVEC,NVEC)                                                  MAIN5330
      REWIND I3                                                         MAIN5340
      REWIND I9                                                         MAIN5350
      REWIND I10                                                        MAIN5360
      DO 500 N=1,NBLOCK                                                 MAIN5370
      READ(I10) SK                                                      MAIN5380
C*********************************************************************MAIN5390
C-----CALCULATE THE PRODUCT G*Z*EVEC                                    MAIN5400
C*********************************************************************MAIN5410
      READ(I9) E                                                        MAIN5420
      DO 100 I=1,NEQR                                                   MAIN5430
      DO 150 J=1,NVEC                                                   MAIN5440
      C(J)=0.0                                                          MAIN5450
      DO 150 K=1,NVEC                                                   MAIN5460
  150 C(J)=C(J)+E(I,K)*EVEC(K,J)                                        MAIN5470
      DO 200 J=1,NVEC                                                   MAIN5480
  200 E(I,J)=C(J)                                                       MAIN5490
  100 CONTINUE                                                          MAIN5500
  500 WRITE(I3) SK1                                                     MAIN5510
      RETURN                                                            MAIN5520
      END                                                               MAIN5530
```

```
      SUBROUTINE SMODE (Z,Y,EVEC,NEQR,NVEC,NBLOCK,NMODE,I3,I2 )         MAIN5540
C*********************************************************************MAIN5550
C-----CALCULATE MODESHAPES    Y=Z*EVEC                                  MAIN5560
C*********************************************************************MAIN5570
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5580
      DIMENSION Z(NEQR,NVEC),Y(NEQR,NMODE),EVEC(NVEC,NVEC)              MAIN5590
      REWIND I3                                                         MAIN5600
      REWIND I2                                                         MAIN5610
      DO 100 N=1,NBLOCK                                                 MAIN5620
      READ (I2) Z                                                       MAIN5630
      DO 200 I=1,NEQR                                                   MAIN5640
      DO 200 J=1,NMODE                                                  MAIN5650
      C1=0.                                                             MAIN5660
      DO 250 K=1,NVEC                                                   MAIN5670
  250 C1=C1+Z(I,K)*EVEC(K,J)                                            MAIN5680
  200 Y(I,J)=C1                                                         MAIN5690
  100 WRITE(I3) Y                                                       MAIN5700
      RETURN                                                            MAIN5710
      END                                                               MAIN5720
```

```
      SUBROUTINE DERV(AOLD,O,D,B,LB1,NBUCK,NEQB,NBLOCK,NEQ,NUMDV,NMODE,  MAIN5730
     1 LL,NUMEL,I1,I2,I3,I12,IR,IW)                                      MAIN5740
C*********************************************************************MAIN5750
C-----CALCULATE BUCKLING DERIVATIVES                                    MAIN5760
C*********************************************************************MAIN5770
      IMPLICIT REAL*8 (A-H,O-Z)                                         MAIN5780
      REAL*4 D,AOLD,O,ERC                                               MAIN5790
      DIMENSION B(NEQB,NMODE),S1(24,24),S2(24,24)                       MAIN5800
      DIMENSION D(NEQ,LB1)  ,AOLD(NUMDV),O(NUMDV,LB1)                   MAIN5810
      COMMON /FM/LM(24),S(24,24,2),P(24,4,2),C(4,24) ,FM1(1322)         MAIN5820
      EQUIVALENCE (S1,S),(S2,S(577))                                    MAIN5830
      READ(I1) AOLD                                                     MAIN5840
      READ (I1) AOLD                                                    MAIN5850
      MT=(NBUCK-1)/LB1+1                                                MAIN5860
      L1=LB1                                                            MAIN5870
      LH=0                                                              MAIN5880
      REWIND I2                                                         MAIN5890
      REWIND I3                                                         MAIN5900
      DO 10 II=1,MT                                                     MAIN5910
C*********************************************************************MAIN5920
C-----MOVE BUCKLING MODESHAPES INTO CORE FOR LB1 MODES                  MAIN5930
C*********************************************************************MAIN5940
      CALL MOVED (B,D,NEQB,NBLOCK,NEQ,NMODE,LB1,LH,LT,I3)               MAIN5950
      DO 50 J=1,LB1                                                     MAIN5960
      DO 50 I=1,NUMDV                                                   MAIN5970
   50 O(I,J)=0.0                                                        MAIN5980
      REWIND I12                                                        MAIN5990
      DO 100 MM=1,NUMEL                                                 MAIN6000
C*********************************************************************MAIN6010
C-----CALCULATE STIFFNESS MATRIX DERIVATIVES                            MAIN6020
C*********************************************************************MAIN6030
      READ (I12) LRD,NII,NV,ND,IDVAR,IEX,ERC,(LM(I),I=1,ND),(((S(I,J,K), MAIN6040
     1 I=1,ND),J=1,ND),K=1,NII),( ((P(I,J,K),I=1,ND),J=1,4),K=1,NV)     MAIN6050
      IF(IDVAR.EQ.0) GO TO 100                                          MAIN6060
      IF(NII.EQ.1) GO TO 501                                            MAIN6070
      ER=IEX*(ERC*AOLD(IDVAR))**(IEX-1)                                 MAIN6080
      DO 502 I=1,ND                                                     MAIN6090
      DO 502 J=I,ND                                                     MAIN6100
      S1(I,J)=S1(I,J)+S2(I,J)*ER                                        MAIN6110
  502 S1(J,I)=S1(I,J)                                                   MAIN6120
  501 DO 300 I=1,ND                                                     MAIN6130
      DO 300 J=I,ND                                                     MAIN6140
      S1(I,J)=S1(I,J)*ERC                                               MAIN6150
  300 S1(J,I)=S1(I,J)                                                   MAIN6160
C*********************************************************************MAIN6170
C-----CALCULATE THE BUCKLING DERIVATIVES                                MAIN6180
C*********************************************************************MAIN6190
      IF(II.EQ.MT) L1=NBUCK-(II-1)*LB1                                  MAIN6200
      DO 950 I=1,L1                                                     MAIN6210
      DO 950 J=1,ND                                                     MAIN6220
  950 C(I,J)=0.0                                                        MAIN6230
      DO 610 K=1,ND                                                     MAIN6240
      MM=LM(K)                                                          MAIN6250
      IF(MM.LE.0) GO TO 610                                             MAIN6260
      DO 600 I=1,L1                                                     MAIN6270
      DO 600 J=1,ND                                                     MAIN6280
  600 C(I,J)=C(I,J)+D(MM,I)*S1(K,J)                                     MAIN6290
  610 CONTINUE                                                          MAIN6300
      DO 700 I=1,ND                                                     MAIN6310
      MM=LM(I)                                                          MAIN6320
```

```
      IF(MM.LE.0) GO TO 700                                             MAIN6330
      DO 710 K=1,L1                                                     MAIN6340
  710 O(IDVAR,K)=O(IDVAR,K)+C(K,I)*D(MM,K)                              MAIN6350
  700 CONTINUE                                                          MAIN6360
  100 CONTINUE                                                          MAIN6370
      DO 850 J=1,L1                                                     MAIN6380
  850 WRITE(12) (O(K,J),K=1,NUMDV)                                      MAIN6390
   10 CONTINUE                                                          MAIN6400
      RETURN                                                            MAIN6410
      END                                                               MAIN6420
```

```
      SUBROUTINE DESIGN(AOLD,ASTR,LOAD,UWT,STR,NUMDV,LL,IU)              MAIN6430
C*********************************************************************MAIN6440
C-----EVALUATE THE CURRENT DESIGN AND PERFORM REDESIGN OPERATION        MAIN6450
C*********************************************************************MAIN6460
      REAL*8 EV                                                          MAIN6470
      DIMENSION AOLD(NUMDV),ASTR(NUMDV),LOAD(NUMDV),UWT(NUMDV),STR(4,11 )MAIN6480
      COMMON/CONTR/ICYCL,NCYCL,ISCALE,NSCALE,KSCALE,KONVG,IDESN,IWTMIN, MAIN6490
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,LBUCK,NVEC,NMODE,LB1,ALPA,INDET  MAIN6500
     2,KPRINT,CONST,COEFFT,SMAX,DMAX,NBUCK,SF,IS ,KODE ,NBOUND          MAIN6510
      COMMON/LINK/EV(4),DRAT(4) ,EVP(4),JUN(352)                         MAIN6520
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12  ,I13             MAIN6530
      REWIND II                                                          MAIN6540
      READ (II) STR                                                      MAIN6550
      READ (II) AOLD                                                     MAIN6560
      READ (II) AOLD                                                     MAIN6570
      READ (II) ASTR ,LOAD                                               MAIN6580
      READ (IU) UWT                                                      MAIN6590
      KONVG=1                                                            MAIN6600
      SMAX=0.                                                            MAIN6610
      SMIN=1.0E20                                                        MAIN6620
      DMAX=0.                                                            MAIN6630
      NBUCK=0                                                            MAIN6640
      IS=0                                                               MAIN6650
      KODE=0                                                             MAIN6660
      WT=0.                                                              MAIN6670
      RCONST=2.0                                                         MAIN6680
      DO 221 I=1,NUMDV                                                   MAIN6690
  221 WT=WT+AOLD(I)*UWT(I)                                               MAIN6700
C*********************************************************************MAIN6710
C-----COMPUTE MAX. AND MIN. STRESS RATIOS AND PRINT  THEM               MAIN6720
C*********************************************************************MAIN6730
      DO 68 I=1,NUMDV                                                    MAIN6740
      R=ASTR(I)/AOLD(I)                                                  MAIN6750
      IF(R.LE.SMAX) GO TO 69                                             MAIN6760
      SMAX=R                                                             MAIN6770
      IMAX=I                                                             MAIN6780
      LMAX=LOAD(I)                                                       MAIN6790
   69 IF(R.GE.SMIN) GO TO 68                                             MAIN6800
      SMIN=R                                                             MAIN6810
      IMIN=I                                                             MAIN6820
      LMIN=LOAD(I)                                                       MAIN6830
   68 CONTINUE                                                           MAIN6840
      WRITE(IW,1000)IDESN,SMAX,LMAX,IMAX,SMIN,LMIN,IMIN                  MAIN6850
      IF(LBUCK.EQ.0) GO TO 80                                            MAIN6860
C*********************************************************************MAIN6870
C-----PRINT BUCKLING LOAD RATIOS                                        MAIN6880
C*********************************************************************MAIN6890
      WRITE(IW,2002)                                                     MAIN6900
      DO 79 I=1,NMODE                                                    MAIN6910
      DRAT(I)=COEFFT/EV(I)                                               MAIN6920
   79 WRITE(IW,2001) DRAT(I),LBUCK                                       MAIN6930
C*********************************************************************MAIN6940
C-----CALCULATE NO. OF POSSIBLE ACTIVE BUCKLING CONSTRAINTS             MAIN6950
C*********************************************************************MAIN6960
      DO 70 I=1,NMODE                                                    MAIN6970
      ABD=DRAT(I)                                                        MAIN6980
      IF(ABD.LE.0.) GO TO 71                                             MAIN6990
      IF(KSCALE.GT.0) ABD=(ABD)**(1.0/KSCALE)                            MAIN7000
      R=ABD/SMAX                                                         MAIN7010
      IF(R.LT.CONST) GO TO 71                                            MAIN7020
```

```
      NBUCK=NBUCK+1                                                     MAIN7030
      IF(ARD.GT.DMAX) DMAX=ARD                                          MAIN7040
      EVP(NBUCK)=EV(I)                                                  MAIN7050
      GO TO 70                                                          MAIN7060
   71 DRAT(I)=0.                                                        MAIN7070
   70 CONTINUE                                                          MAIN7080
   80 SE=SMAX                                                           MAIN7090
      IF(SE.LT.DMAX) SE=DMAX                                            MAIN7100
      IF(SE.LT.DELTA1.OR.SE.GT.DELTA2) GO TO 305                        MAIN7110
      IF(SMIN.LT.DELTA1.OR.SMIN.GT.DELTA2) GO TO 83                     MAIN7120
      WRITE(IW,1004)                                                    MAIN7130
      KONVG=4                                                           MAIN7140
      WRITE(IW,1008) WT                                                 MAIN7150
      GO TO 85                                                          MAIN7160
   83 WRITE(IW,1003)                                                    MAIN7170
      WRITE(IW,1008) WT                                                 MAIN7180
   84 WRITE(IW,2005)                                                    MAIN7190
      KONVG=2                                                           MAIN7200
      IF(DMAX.GT.SMAX) KONVG=2                                          MAIN7210
      ISCALE=0                                                          MAIN7220
      ICYCL=ICYCL+1                                                     MAIN7230
      IF(ICYCL.LE.NCYCL) GO TO 86                                       MAIN7240
      KONVG=4                                                           MAIN7250
      WRITE(IW,1005) NCYCL                                              MAIN7260
      GO TO 85                                                          MAIN7270
  305 IF(KSCALE.GE.0.AND.SE.LT.RCONST) GO TO 101                        MAIN7280
      WRITE(IW,1002)                                                    MAIN7290
      KODE=1                                                            MAIN7300
      GO TO 84                                                          MAIN7310
  101 IF(KSCALE.EQ.0) GO TO 803                                         MAIN7320
      IS=1                                                              MAIN7330
      DO 103 I=1,NUMOV                                                  MAIN7340
  103 AOLD(I)=AOLD(I)*SE                                                MAIN7350
      WRITE(IW,2004)                                                    MAIN7360
      CALL MESG(SMAX,DMAX,DMAX,IW)                                      MAIN7370
      WRITE(IW,2006)                                                    MAIN7380
      CALL DPRINT (AOLD,NUMOV,IW)                                       MAIN7390
      WT=WT*SE                                                          MAIN7400
      WRITE(IW,1008) WT                                                 MAIN7410
      GO TO 84                                                          MAIN7420
  803 WRITE(IW,1002)                                                    MAIN7430
      WRITE(IW,2004)                                                    MAIN7440
      SE=SMAX                                                           MAIN7450
      ISCALE=ISCALE+1                                                   MAIN7460
      IF(ISCALE.GT.MSCALE) GO TO 203                                    MAIN7470
      IF(NBUCK.NE.0) RETURN                                             MAIN7480
      DO 239 I=1,NUMOV                                                  MAIN7490
  239 AOLD(I)=AOLD(I)*SE                                                MAIN7500
      REWIND 11                                                         MAIN7510
      READ(11) STR                                                      MAIN7520
      READ (11) ASTR                                                    MAIN7530
      WRITE(11) AOLD                                                    MAIN7540
      CALL MESG(SMAX,SMAX,SMAX,IW)                                      MAIN7550
      RETURN                                                            MAIN7560
  203 KONVG=4                                                           MAIN7570
      WRITE(IW,1001) MSCALE                                             MAIN7580
      GO TO 85                                                          MAIN7590
   86 IF(KODE.EQ.1) GO TO 502                                           MAIN7600
      IF(WT.LT.WTMIN) GO TO 502                                         MAIN7610
      R=(WT-WTMIN)/WTMIN                                                MAIN7620
```

```
      IF(R.LT.EPSIL) GO TO 503                                          MAIN7630
      KONVG=4                                                           MAIN7640
      WRITE(IW,1009) IWTMIN                                             MAIN7650
      GO TO 85                                                          MAIN7660
  502 WTMIN=WT                                                          MAIN7670
      IWTMIN=IDESN                                                      MAIN7680
  503 IF(NBUCK.NE.0) RETURN                                             MAIN7690
      REWIND 11                                                         MAIN7700
      READ (11) STR                                                     MAIN7710
      READ (11) AOLD                                                    MAIN7720
      WRITE(11) ASTR                                                    MAIN7730
      RETURN                                                            MAIN7740
   85 IF(KPUNCH.EQ.0) RETURN                                            MAIN7750
      REWIND 11                                                         MAIN7760
      READ (11) STR                                                     MAIN7770
      READ (11) ASTR                                                    MAIN7780
      DO 250 I=1,NUMDV                                                  MAIN7790
  250 WRITE(IP,1010) I,AOLD(I),ASTR(I)                                  MAIN7800
      RETURN                                                            MAIN7810
 1000 FORMAT (// 32H ********************************/                  MAIN7820
     1           28H EVALUATION OF DESIGN NUMBER,I4  /                  MAIN7830
     2            32H ********************************///               MAIN7840
     350H           STRESS RATIO   LOAD COND   DES VARIABLE/,           MAIN7850
     4 4H MAX,F18.4,I10,I13,                              /             MAIN7860
     5  4H MIN,F18.4,I10,I13                             / )            MAIN7870
 1001 FORMAT(49H TERMINAL DESIGN---NUMBER OF SCALING OPERATIONS= ,I4//) MAIN7880
 1002 FORMAT(//23H DESIGN IS NOT CRITICAL//)                            MAIN7890
 1003 FORMAT(//23H DESIGN IS CRITICAL    //)                            MAIN7900
 1004 FORMAT(//23H DESIGN IS ACCEPTABLE  //)                            MAIN7910
 1005 FORMAT(//48H TERMINAL DESIGN---NUMBER OF CRITICAL DESIGNS  =,I5//)MAIN7920
 1008 FORMAT(//19H STRUCTURAL WEIGHT=,F11.4)                            MAIN7930
 1009   FORMAT(60H TERMINAL DESIGN---LIGHTEST CRITICAL DESIGN IS DESIGN MAIN7940
     1NUMBER,I4//)                                                      MAIN7950
 1010 FORMAT(I5,2E10.6)                                                 MAIN7960
 2001 FORMAT(7X,E13.4,2I10)                                             MAIN7970
 2002 FORMAT(48H         MAX BUCK RATIOS   LOAD COND              / )   MAIN7980
 2004 FORMAT(//1X,33HUNIFORM SCALING OPERATION FOLLOWS)                 MAIN7990
 2005 FORMAT(//1X,26HREDESIGN OPERATION FOLLOWS)                        MAIN8000
 2006 FORMAT(//1X,48HDESIGN VARIABLES OF SCALED (CRITICAL) DESIGN ARE)  MAIN8010
      END                                                               MAIN8020
```

```
      SUBROUTINE BDESIN (AOLD,ORT,ID1,ASTR,ABUC,UWT,OPTIN,STR,NUMDV,IU,  MAIN8030
     1 LL,NBUCK)                                                         MAIN8040
C*********************************************************************MAIN8050
C-----BUCKLING CONSTRAINT REDESIGN OR SCALING                           MAIN8060
C*********************************************************************MAIN8070
      REAL*8 EV                                                         MAIN8080
      DIMENSION ID1(NUMDV),AOLD(NUMDV),ASTR(NUMDV),ABUC(NUMDV),         MAIN8090
     1ORT(NUMDV,NBUCK),UWT(NUMDV) ,STR(4,LL)  ,OPTIN(NUMDV)             MAIN8100
      COMMON/CONTR/ ICYCL,NCYCL,ISCALE,NSCALE,KSCALE,KONVG,IDESN,IWTMIN,MAIN8110
     1WTMIN,EPSIL,DELTA1,DELTA2,KPUNCH,LBUCK,NVEC,NMODE,LB1,ALPA,INDET  MAIN8120
     2,KPRINT,CONST,CDEFET,SMAX,DMAX,NBUCKK,SF,IS,KODE,NBOUND           MAIN8130
      COMMON/JUNK/EV(4),DRAT(4),EVP(4),D(4,4),R(4),AMDA(4),S(4),JUN(324)MAIN8140
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12  ,I13            MAIN8150
      DATA TAG1,TAG2/3HACT,4HPASS/                                      MAIN8160
      DEL5=5.0*(1.0-DELTA1)                                             MAIN8170
      DEL11=1.0-DEL5                                                    MAIN8180
      DEL22=1.0+DEL5                                                    MAIN8190
      BACKSPACE IU                                                      MAIN8200
      READ(IU) UWT                                                      MAIN8210
      REWIND I1                                                         MAIN8220
      READ(I1) STR                                                      MAIN8230
      READ(I1) AOLD                                                     MAIN8240
      READ (I1)AOLD                                                     MAIN8250
      REWIND I2                                                         MAIN8260
      DO 61 I=1,NBUCK                                                   MAIN8270
   61 READ(I2)  (ORT(J,I),J=1,NUMDV)                                    MAIN8280
   60 IF(KONVG.EQ.1) GO TO 501                                          MAIN8290
C*********************************************************************MAIN8300
C-----BUCKLING     CONSTRAINT REDESIGN                                  MAIN8310
C*********************************************************************MAIN8320
      READ(I1) ASTR                                                     MAIN8330
      REWIND I1                                                         MAIN8340
      IF(IS.NE.1) GO TO 101                                             MAIN8350
C*********************************************************************MAIN8360
C-----CONVERT BUCKLING RATIOS AND DERIVATIVES TO THE SCALED DESIGN      MAIN8370
C*********************************************************************MAIN8380
      DO 99 I=1,NUMDV                                                   MAIN8390
   99 AOLD(I)=AOLD(I)*SF                                                MAIN8400
      SFF=SF**KSCALE                                                    MAIN8410
      SFFF=SF**(KSCALE-1)                                               MAIN8420
      DO 102 I=1,NBUCK                                                  MAIN8430
      EVP(I)=EVP(I)*SFF                                                 MAIN8440
      DO 102 J=1,NUMDV                                                  MAIN8450
  102 ORT(J,I)=ORT(J,I)*SFFF                                            MAIN8460
C*********************************************************************MAIN8470
C-----CLASSIFY DESIGN VARIABLES EITHER AS ACTIVE OR PASSIVE             MAIN8480
C-----DESIGN VARIABLES WITH THEIR DERIVATIVES FOR ALL POTENTIALLY ACTIVEMAIN8490
C     BUCKLING MODES AS POSITIVE ARE PASSIVE VARIABLES                  MAIN8500
C*********************************************************************MAIN8510
  101 DO 50 I=1,NUMDV                                                   MAIN8520
      DO 51 J=1,NBUCK                                                   MAIN8530
      IF(ORT(I,J).GT.0.) GO TO 49                                       MAIN8540
   51 CONTINUE                                                          MAIN8550
      ID1(I)=0                                                          MAIN8560
      GO TO 50                                                          MAIN8570
   49 ID1(I)=1                                                          MAIN8580
   50 CONTINUE                                                          MAIN8590
C*********************************************************************MAIN8600
C-----ITERATION TO FIND OUT ACTIVE/PASSIVE CLASSIFICATION OF DESIGN     MAIN8610
C     VARIABLES                                                         MAIN8620
```

```
C*************************************************************************MAIN8630
  700 MAC=1                                                                 MAIN8640
C*************************************************************************MAIN8650
C-----CHECK IF ALL DESIGN VARIABLES ARE PASSIVE                             MAIN8660
C*************************************************************************MAIN8670
      DO 52 I=1,NUMDV                                                       MAIN8680
      IF(ID1(I).EQ.1) GO TO 599                                             MAIN8690
   52 CONTINUE                                                              MAIN8700
C*************************************************************************MAIN8710
C-----ALL DESIGN VARIABLES ARE PASSIVE. MAKE THEM ACTIVE FOR NEXT CYCLE    MAIN8720
C*************************************************************************MAIN8730
      ICON=0                                                                MAIN8740
      GO TO 602                                                             MAIN8750
C*************************************************************************MAIN8760
C-----CALCULATE RIGHT HAND SIDES OF SIMULTANEOUS EQUATIONS FOR LAMBDAS      MAIN8770
C*************************************************************************MAIN8780
  599 DO 80 I=1,4                                                           MAIN8790
      R(I)=0.                                                               MAIN8800
      AMDA(I)=0.                                                            MAIN8810
      DO 80 J=1,4                                                           MAIN8820
   80 D(I,J)=0.                                                             MAIN8830
      DO 100 I=1,NBUCK                                                      MAIN8840
      DP=0.0                                                                MAIN8850
      DA=0.0                                                                MAIN8860
      DO 110 J=1,NUMDV                                                      MAIN8870
      IF(ID1(J).EQ.1) GO TO 120                                             MAIN8880
      DP=DP+DR1(J,I)*(ASTR(J)-ADLD(J))                                      MAIN8890
      GO TO 110                                                             MAIN8900
  120 DA=DA+DR1(J,I)*ADLD(J)                                                MAIN8910
  110 CONTINUE                                                              MAIN8920
  100 R(I)=(1-ALPA)*DA+COEFF-EVP(I)-DP                                      MAIN8930
C*************************************************************************MAIN8940
C-----DEVELOP COEFFICIENT MATRIX FOR LAMBDAS                                MAIN8950
C*************************************************************************MAIN8960
      DO 250 I=1,NBUCK                                                      MAIN8970
      DO 250 J=1,NBUCK                                                      MAIN8980
      DO 260 K=1,NUMDV                                                      MAIN8990
      IF(ID1(K).EQ.1) D(I,J)=D(I,J)+DR1(K,I)*DR1(K,J)*ADLD(K)/UWT(K)        MAIN9000
  260 CONTINUE                                                              MAIN9010
      D(I,J)= D(I,J)*(1-ALPA)                                               MAIN9020
  250 D(J,I)=D(I,J)                                                         MAIN9030
C*************************************************************************MAIN9040
C-----ITERATION TO FIND ACTIVE  BUCKLING    CONSTRAINTS(IF +VE LAMBDA'S)    MAIN9050
C*************************************************************************MAIN9060
      CALL DISP(R,D,AMDA,NBUCK,ICON)                                        MAIN9070
      IF(ICON.NE.0) GO TO 601                                               MAIN9080
  602 WRITE(IW,1006) ICON                                                   MAIN9090
      REWIND 11                                                             MAIN9100
      READ(11) STR                                                          MAIN9110
      READ(11) ADLD                                                         MAIN9120
      WRITE(11) ASTR                                                        MAIN9130
      RETURN                                                                MAIN9140
C*************************************************************************MAIN9150
C-----CALCULATE REDESIGN FROM BUCKLING CONSTRAINTS                          MAIN9160
C*************************************************************************MAIN9170
  601 DO 500 I=1,NUMDV                                                      MAIN9180
      C=0.                                                                  MAIN9190
      DO 510 J=1,NBUCK                                                      MAIN9200
  510 C=C+AMDA(J)*DR1(I,J)                                                  MAIN9210
      DPTIN(I)=C/UWT(I)                                                     MAIN9220
```

```
      C=(ALPA+(1.0-ALPA)*OPTIN(I))*AOLD(I)                              MAIN9230
      IF(C.GE.ASTR(I)) GO TO 520                                        MAIN9240
      IF(ID1(I).EQ.1) MAC=0                                             MAIN9250
      ID1(I)=0                                                          MAIN9260
      ABUC(I)=ASTR(I)                                                   MAIN9270
      GO TO 500                                                         MAIN9280
  520 ABUC(I)=C                                                         MAIN9290
      IF(ID1(I).EQ.0) MAC=0                                             MAIN9300
      ID1(I)=1                                                          MAIN9310
  500 CONTINUE                                                          MAIN9320
C***********************************************************************MAIN9330
C-----CHECK FOR ANY CHANGE IN ACTIVE/PASSIVE CLASSIFICATION OF DESIGN   MAIN9340
C     VARIABLES                                                         MAIN9350
C***********************************************************************MAIN9360
      IF(MAC.EQ.0) GO TO 700                                            MAIN9370
C***********************************************************************MAIN9380
C-----PRINT OPTIMALITY INDEX                                            MAIN9390
C***********************************************************************MAIN9400
      WRITE(IW,2002)                                                    MAIN9410
      DO 750 I=1,NUMDV                                                  MAIN9420
      TAG=TAG1                                                          MAIN9430
      IF(ID1(I).EQ.0) TAG=TAG2                                          MAIN9440
  750 WRITE(IW,2003) I,TAG,OPTIN(I)                                     MAIN9450
      WRITE(IW,1006) ICON                                               MAIN9460
      IF(SE.GT.DELTA2.OR.SE.LT.DELTA1) GO TO 701                        MAIN9470
      IF(DMAX.GT.DELTA2.OR.DMAX.LT.DELTA1) GO TO 701                    MAIN9480
C***********************************************************************MAIN9490
C-----CHECK FOR   BUCKLING   DESIGN CONVERGENCE.                        MAIN9500
C***********************************************************************MAIN9510
      DO 702 I=1,NUMDV                                                  MAIN9520
      IF(ID1(I).EQ.0) GO TO 702                                         MAIN9530
      C=OPTIN(I)                                                        MAIN9540
      IF(C.GT.DELT22.OR .C.LT.DELT11) GO TO 701                         MAIN9550
  702 CONTINUE                                                          MAIN9560
      KONVG=4                                                           MAIN9570
      WRITE(IW,2001)                                                    MAIN9580
      RETURN                                                            MAIN9590
C***********************************************************************MAIN9600
C-----CALCULTE SCALE FACTOR FOR UNIFORM SCALING FROM  BUCK. CONSTRAINTS MAIN9610
C***********************************************************************MAIN9620
  501 DO 503 J=1.    NBUCK                                              MAIN9630
      S(J)=0                                                            MAIN9640
      DO 502 I=1,NUMDV                                                  MAIN9650
  502 S(J)=S(J)+DBI(I,J)*AOLD(I)                                        MAIN9660
  503 S(J)=( COEFF1-EVP(J))/S(J)+1.0                                    MAIN9670
      DE=0.                                                             MAIN9680
      DO 504 I=1,NBUCK                                                  MAIN9690
      IF(S(I).GT.DE)DE=S(I)                                             MAIN9700
  504 CONTINUE                                                          MAIN9710
      CALL MESG(SE,DE,DE,IW)                                            MAIN9720
      IF(DE.GT.SE)SE=DE                                                 MAIN9730
      DO 505 I=1,NUMDV                                                  MAIN9740
  505 ABUC(I)=AOLD(I)*SE                                                MAIN9750
  701 REWIND 11                                                         MAIN9760
      READ (11) STR                                                     MAIN9770
      READ (11) AOLD                                                    MAIN9780
      WRITE(11) ABUC                                                    MAIN9790
      RETURN                                                            MAIN9800
 1006 FORMAT(/ 1X,42HNO. OF ACTIVE BUCKLING CONSTRAINTS      ARE ,I5)   MAIN9810
 2001 FORMAT(43H BUCKLING - CRITICAL DESIGN HAS CONVERGED          //)  MAIN9820
```

```
 2002 FORMAT(//62H OPTIMALITY INDEX OF DESIGN VARIABLES FOR BUCKLING CONMAIN9830
     1STRAINTS  //5X,5HDV NO,1X,7HACT/PAS,4X,5HINDEX  /)                MAIN9840
 2003 FORMAT(5X,I5,A10,E15.5)                                           MAIN9850
      END                                                               MAIN9860



      SUBROUTINE DISP(R,D,AMDA,NDISP,ICON    )                        MAIN9870
C*************************************************************************MAIN9880
C-----FIND OUT ACTIVE LAMBDAS(IE +VE DISP. CONSTRAINTS)                 MAIN9890
C*************************************************************************MAIN9900
      DIMENSION R(4),D(4,4),AMDA(4)                                     MAIN9910
      ICON=NDISP                                                        MAIN9920
      IF(NDISP.GT.1) GO TO 900                                          MAIN9930
      AMDA(1)=R(1)/D(1,1)                                               MAIN9940
      IF(AMDA(1).GT.0.) RETURN                                          MAIN9950
      AMDA(1)=0.                                                        MAIN9960
      ICON=0                                                            MAIN9970
      RETURN                                                            MAIN9980
  900 IF(D(2,2).NE.0.) GO TO 10                                         MAIN9990
      IF(D(1,1).NE.0.) GO TO 11                                         MAIN0000
      AMDA(1)=0.                                                        MAIN0010
      AMDA(2)=0.                                                        MAIN0020
      ICON=0                                                            MAIN0030
      RETURN                                                            MAIN0040
   11 AMDA(1)=R(1)/D(1,1)                                               MAIN0050
      AMDA(2)=0.                                                        MAIN0060
      ICON=1                                                            MAIN0070
      IF(AMDA(1).GT.0.) RETURN                                          MAIN0080
      AMDA(1)=0.                                                        MAIN0090
      ICON=0                                                            MAIN0100
      RETURN                                                            MAIN0110
   10 IF(D(1,1).NE.0.) GO TO 20                                         MAIN0120
      AMDA(1)=0.                                                        MAIN0130
      AMDA(2)=R(2)/D(2,2)                                               MAIN0140
      ICON=1                                                            MAIN0150
      IF(AMDA(2).GT.0.) RETURN                                          MAIN0160
      AMDA(2)=0.                                                        MAIN0170
      ICON=0                                                            MAIN0180
      RETURN                                                            MAIN0190
   20 DEL=D(1,1)*D(2,2)-D(1,2)*D(1,2)                                   MAIN0200
      C1=D(1,1)*D(2,2)*1.0E-06                                          MAIN0210
      IF(ABS(DEL).GT.C1) GO TO 30                                       MAIN0220
      A1=R(1)/D(1,1)                                                    MAIN0230
      A2=R(2)/D(2,2)                                                    MAIN0240
      IF(A1.LE.0..AND.A2.LE.0.) GO TO 40                                MAIN0250
      IF(A2.GT.A1) GO TO 50                                             MAIN0260
      AMDA(1)=A1                                                        MAIN0270
      AMDA(2)=0.                                                        MAIN0280
      ICON=1                                                            MAIN0290
      RETURN                                                            MAIN0300
   50 AMDA(1)=0.                                                        MAIN0310
      AMDA(2)=A2                                                        MAIN0320
      ICON=1                                                            MAIN0330
      RETURN                                                            MAIN0340
   40 AMDA(1)=0.                                                        MAIN0350
      AMDA(2)=0.                                                        MAIN0360
      ICON=0                                                            MAIN0370
```

```
      RETURN                                                            MAIN0380
   30 AMDA(1)=(D(2,2)*R(1)-D(1,2)*R(2))/DEL                             MAIN0390
      AMDA(2)=(-D(2,1)*R(1)+D(1,1)*R(2))/DEL                            MAIN0400
      IF(AMDA(1).GT.0..AND.AMDA(2).GT.0.) RETURN                        MAIN0410
      IF(AMDA(1).GT.AMDA(2)) GO TO 60                                   MAIN0420
      AMDA(1)=0.                                                        MAIN0430
      AMDA(2)=R(2)/D(2,2)                                               MAIN0440
      ICON=1                                                            MAIN0450
      IF(AMDA(2).GT.0.) RETURN                                          MAIN0460
      AMDA(2)=0.                                                        MAIN0470
      ICON=0                                                            MAIN0480
      RETURN                                                            MAIN0490
   60 AMDA(1)=R(1)/D(1,1)                                               MAIN0500
      AMDA(2)=0.                                                        MAIN0510
      ICON=1                                                            MAIN0520
      IF(AMDA(1).GT.0.) RETURN                                          MAIN0530
      AMDA(1)=0.                                                        MAIN0540
      ICON=0                                                            MAIN0550
      RETURN                                                            MAIN0560
      END                                                               MAIN0570
```

```
      SUBROUTINE MESG(SF,DF,SEE,IW)                                     MAIN0580
C*****************************************************************************MAIN0590
C-----PRINT SCALE FACTOR FOR SCALED DESIGN                               MAIN0600
C*****************************************************************************MAIN0610
      IF(SF.GE.DF) GO TO 550                                            MAIN0620
      WRITE(IW,1003) SEE                                                MAIN0630
      WRITE(IW,1004)                                                    MAIN0640
      GO TO 551                                                         MAIN0650
  550 WRITE(IW,1003) SF                                                 MAIN0660
      WRITE(IW,1005)                                                    MAIN0670
  551 RETURN                                                            MAIN0680
 1003 FORMAT(//1X,15HSCALE FACTOR IS,F7.3,17HAND DETERMINED BY)         MAIN0690
 1004 FORMAT(1H+,40X     ,24HBUCKLING      CONSTRAINTS  )              MAIN0700
 1005 FORMAT(1H+,40X,18HSTRESS CONSTRAINTS )                            MAIN0710
      END                                                               MAIN0720
```

```
      SUBROUTINE TRUSS (A,MTOT)                                          TRUS0000
C*********************************************************************TRUS0010
C-----THREE DIMENSIONAL BAR ELEMENTS                                     TRUS0020
C*********************************************************************TRUS0030
      DIMENSION A(MTOT)                                                  TRUS0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MRAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQTRUS0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LB     ,NEQB,NBLOCK                      TRUS0060
      COMMON/LINK/         LT,LH,L,SIG(27),IDVAR,IEX,ERC,AREA,JUN1(334) TRUS0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13               TRUS0080
      NUME=NPAR(2)                                                       TRUS0090
      KODE=NPAR(5)                                                       TRUS0100
      IF(NPAR(1).EQ.0)GO TO 500                                          TRUS0110
      GO TO (1,1,2),KODE                                                 TRUS0120
C*********************************************************************TRUS0130
C-----KODE =1  INERTIA IS PROPPORTIONAL TO AREA FOR  LOCAL BUCKLING      TRUS0140
C           2 INERTIA IS PROPPORTIONAL TO AREA**2 FOR LOCAL BUCKLING     TRUS0150
C*********************************************************************TRUS0160
    1 NUMMAT=NPAR(3)                                                     TRUS0170
      NUMGEO=NPAR(4)                                                     TRUS0180
      NUMTC=NPAR(6)                                                      TRUS0190
      N6=N5+NUMNP                                                        TRUS0200
      N7=N6+NUMMAT                                                       TRUS0210
      N8=N7+NUMMAT                                                       TRUS0220
      N9=N8+NUMMAT*NUMTC*5                                               TRUS0230
      MM=N9+NUMGEO*2-MTOT                                                TRUS0240
      IF(MM.GT.0)CALL ERROR(MM)                                          TRUS0250
      CALL RUSS (A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),        TRUS0260
     1A(N8),A(N9),NUMDV,NUMNP,NUMMAT,NUMTC,NUMGEO,KODE,NUME)             TRUS0270
      RETURN                                                             TRUS0280
C*********************************************************************TRUS0290
C-----PROVISION FOR SPECIAL TRUSS ELEMENT                                TRUS0300
C*********************************************************************TRUS0310
    2 CALL NOELEM (NPAR(1),NPAR(5),IW)                                   TRUS0320
      RETURN                                                             TRUS0330
  500 WRITE (IW,2002)  KODE                                              TRUS0340
      DO 800 MM=1,NUME                                                   TRUS0350
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,0)                    TRUS0360
      WRITE (IW,2005) MM,AREA                                            TRUS0370
      DO 800 I=LT,LH                                                     TRUS0380
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,I)                    TRUS0390
      IF(L.GT.1) WRITE(IW,2004)                                          TRUS0400
      WRITE(IW,2003)  L,SIG(I)                                           TRUS0410
      GO TO (3,3,4),KODE                                                 TRUS0420
C*********************************************************************TRUS0430
C-----DESIGN OF BAR ELEMENTS FOR STRESS AND LOCAL BUCKLING               TRUS0440
C*********************************************************************TRUS0450
    3 CALL DTRUSS (A(M1),A(M2),A(M3),NUMDV)                              TRUS0460
      GO TO 800                                                          TRUS0470
C*********************************************************************TRUS0480
C-----PROVISION FOR DESIGN OF SPECIAL TRUSS ELEMENT                      TRUS0490
C*********************************************************************TRUS0500
    4 CONTINUE                                                           TRUS0510
  800 CONTINUE                                                           TRUS0520
      RETURN                                                             TRUS0530
 2002 FORMAT(//42H ANALYSIS OF TRUSS ELEMENTS, CONSTRN CODE=,I2    //    TRUS0540
     1          47H ELEMENT  X-SECT AREA  LOAD COND    AXIAL FORCE  /)   TRUS0550
 2003 FORMAT(1H+,24X,I5,4X,E12.4)                                        TRUS0560
 2004 FORMAT(/)                                                          TRUS0570
 2005 FORMAT(17,2X,E12.4)                                                TRUS0580
      END                                                                TRUS0590
```

```
      SUBROUTINE RUSS (IDT,ID,X,Y,Z,T,NTC,WT,PMAT,PGEO,NUMDV,NUMNP,      TRUS0600
     1 NUMMAT,NUMTC,NUMGEO,KODE,NUME)                                    TRUS0610
C*********************************************************************TRUS0620
C-----UNIFORM CROSS SECTION BAR ELEMENTS                                TRUS0630
C*********************************************************************TRUS0640
      IMPLICIT REAL*8 (A-H,O-Z)                                         TRUS0650
      REAL*4 X,Y,Z,T,WT,PMAT,PGEO,IDT,ERC,BUCKYY,BUCKZZ,EE3,EE4         TRUS0660
      DIMENSION ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),T(NUMNP),        TRUS0670
     1NTC(NUMMAT),WT(NUMMAT),PMAT(NUMTC,5,NUMMAT),PGEO(NUMGEO,2),       TRUS0680
     2 IDT(NUMDV)                                                       TRUS0690
      COMMON/EM/LM(6),S(6,6),P(6,4),ST(6),TT(4),XM(6),G(6,6),EM1(2659)  TRUS0700
      COMMON/JUNK/EMUL(4,4),EE(4),RHO,TEMP,XX(2),YY(2),ZZ(2),V(4),      TRUS0710
     1 JUN(304)                                                         TRUS0720
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                TRUS0730
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13             TRUS0740
C*********************************************************************TRUS0750
C-----CONTROL INFORMATION                                               TRUS0760
C*********************************************************************TRUS0770
      MU=1                                                              TRUS0780
      MV=1                                                              TRUS0790
      MW=1                                                              TRUS0800
      MD=6                                                              TRUS0810
      MS=1                                                              TRUS0820
      MT=4                                                              TRUS0830
      MG=1                                                              TRUS0840
      MSG=1                                                             TRUS0850
      IEX=KODE                                                          TRUS0860
      WRITE(IW,2000)NUME,KODE    ,NUMMAT,NUMTC,NUMGEO                   TRUS0870
C*********************************************************************TRUS0880
C-----MATERIAL PROPERTY CARDS                                           TRUS0890
C*********************************************************************TRUS0900
      WRITE(IW,2001)                                                    TRUS0910
      DO 10 I=1,NUMMAT                                                  TRUS0920
      READ (IR,1001)N,NTC(N),WT(N)                                      TRUS0930
      IF (NTC(N).EQ.0) NTC(N)=1                                         TRUS0940
      WRITE(IW,2002)N,NTC(N),WT(N)                                      TRUS0950
C*********************************************************************TRUS0960
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                         TRUS0970
C*********************************************************************TRUS0980
      NT=NTC(N)                                                         TRUS0990
      DO 10 J=1,NT                                                      TRUS1000
      READ (IR,2008) (PMAT(J,K,N),K=1,5)                                TRUS1010
      IF(PMAT(J,5,N).LE.0) PMAT(J,5,N)=PMAT(J,4,N)                      TRUS1020
      IF (J.NE.1) WRITE(IW,2009)                                        TRUS1030
   10 WRITE (IW,2010) (PMAT(J,K,N),K=1,5)                               TRUS1040
C*********************************************************************TRUS1050
C-----GEOMETRIC PROPERTY CARDS                                          TRUS1060
C*********************************************************************TRUS1070
      WRITE(IW,2006)                                                    TRUS1080
      DO 51 I=1,NUMGEO                                                  TRUS1090
      READ (IR,1006)N,AREA,(PGEO(N,J),J=1,2)                           TRUS1100
      IF(AREA.LE.0.0)AREA=1.0                                           TRUS1110
      DO 80 J=1,2                                                       TRUS1120
   80 IF (PGEO(N,J).LE.0.) PGEO(N,J)=1000000.                           TRUS1130
      WRITE(IW,2007)N,AREA,(PGEO(N,J),J=1,2)                           TRUS1140
      AA=AREA**IEX                                                      TRUS1150
      DO 51 J=1,2                                                       TRUS1160
   51 PGEO(N,J)=9.8696*PGEO(N,J)/AA                                     TRUS1170
C*********************************************************************TRUS1180
C-----ELEMENT LOAD MULTIPLIERS                                          TRUS1190
```

```
C*********************************************************************TRUS1200
      READ(IR,1003)EMUL                                                TRUS1210
      WRITE(IW,2003)EMUL                                               TRUS1220
C*********************************************************************TRUS1230
C-----ELEMENT CARDS                                                    TRUS1240
C*********************************************************************TRUS1250
      WRITE(IW,2005)                                                   TRUS1260
      N=1                                                              TRUS1270
  100 READ(IR,1004) IEL,II,JJ,IMAT,IGEO,IDV  ,ERC,REFT,ELPYY,ELPZZ,INC TRUS1280
      IF(IEL.LT.N) GO TO 700                                           TRUS1290
      IF(ERC.LE.0.0) ERC=1.0                                           TRUS1300
      IF(INC.EQ.0) INC=1                                               TRUS1310
      IF(ELPYY.LE.0.0) ELPYY=1.0                                       TRUS1320
      IF(ELPZZ.LE.0.0) ELPZZ=1.0                                       TRUS1330
      KK=INC*(IEL-N)                                                   TRUS1340
      I=II-KK                                                          TRUS1350
      J=JJ-KK                                                          TRUS1360
      DO 500 NEL=N,IEL                                                 TRUS1370
      XX(1)=X(I)                                                       TRUS1380
      XX(2)=X(J)                                                       TRUS1390
      YY(1)=Y(I)                                                       TRUS1400
      YY(2)=Y(J)                                                       TRUS1410
      ZZ(1)=Z(I)                                                       TRUS1420
      ZZ(2)=Z(J)                                                       TRUS1430
C*********************************************************************TRUS1440
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   TRUS1450
C*********************************************************************TRUS1460
      TEMP=0.5*(T(I)+T(J))                                             TRUS1470
      CALL INTERP(PMAT,EE,NUMJC,NUMMAT,5,4,NJC(IMAT),IMAT,TEMP)        TRUS1480
C*********************************************************************TRUS1490
C-----FORM ELEMENT UNIT MATRICES AND LOAD VECTORS                       TRUS1500
C*********************************************************************TRUS1510
      RHO=WT(IMAT)                                                     TRUS1520
      TEMP=TEMP-REFT                                                   TRUS1530
      CALL ETRUSS                                                      TRUS1540
      IF(LBUCK.EQ.0) GO TO 300                                         TRUS1550
      CALL TGEOM(V(1),V(2),V(3),V(4))                                  TRUS1560
      CALL ELGSUW(G,NSG,ND,NG,III)                                     TRUS1570
  300 HH=EE(1)/(V(4)*V(4))                                             TRUS1580
      BUCKYY=PGEO(IGEO,1)*HH*ELPYY                                     TRUS1590
      BUCKZZ=PGEO(IGEO,2)*HH*ELPZZ                                     TRUS1600
      EE3=EE(3)                                                        TRUS1610
      EE4=EE(4)                                                        TRUS1620
      DWT(IDV)=DWT(IDV)+RHO*V(4)*ERC                                   TRUS1630
C*********************************************************************TRUS1640
C-----FORM LOCATION MATRIX AND COMPUTE BAND WIDTH                       TRUS1650
C*********************************************************************TRUS1660
      DO 400 L=1,3                                                     TRUS1670
      LM(L)=ID(I,L)                                                    TRUS1680
  400 LM(L+3)=ID(J,L)                                                  TRUS1690
      CALL CALRAN(NDIF,LM,S,P,ST,II,ND,NV,MS,ND,NW,IDV,IFX,ERC)        TRUS1700
      WRITE (IW) NI,BUCKYY,BUCKZZ,EE3,EE4                              TRUS1710
      WRITE(IW,2004) NEL,I,J,IMAT,IGEO,IDV,ERC,REFT,ELPYY,ELPZZ,NDIF   TRUS1720
C*********************************************************************TRUS1730
C-----CHECK FOR MORE ELEMENTS                                          TRUS1740
C*********************************************************************TRUS1750
      I=I+INC                                                          TRUS1760
      J=J+INC                                                          TRUS1770
  500 CONTINUE                                                         TRUS1780
      N=IEL+1                                                          TRUS1790
```

```
      IF(N.LE.NUME) GO TO 100                                          TRUS1800
      RETURN                                                           TRUS1810
  700 WRITE(IW,2011)                                                   TRUS1820
      STOP                                                             TRUS1830
 1001 FORMAT(2I5,F10.0)                                                TRUS1840
 1003 FORMAT(4F10.0)                                                   TRUS1850
 1004 FORMAT(6I5,4F10.0,I5)                                            TRUS1860
 1006 FORMAT(I5,5X,3F10.0)                                             TRUS1870
 2000 FORMAT(44H1NUMBER OF TRUSS ELEMENTS                    =,I5/     TRUS1880
     1       44H CONSTRUCTION CODE                           =,I5/     TRUS1890
     2       44H NUMBER OF MATERIALS                         =,I5/     TRUS1900
     3       44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5/       TRUS1910
     4       44H NUMBER OF DIFFERENT GEOMETRIES PROPS GIVEN=,I5)       TRUS1920
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                         TRUS1930
     191H MATERIAL   NUMBER    SPECIFIC                 YOUNGS    COEFFTRUS1940
     2 OF /--ALLOWABLE STRESSES--/ /                                   TRUS1950
     391H  NUMBER   OF TEMPS    WEIGHT       TEMP      MODULUS   THERM ETRUS1960
     4XPAN   TENSION   COMPRESSION /)                                  TRUS1970
 2002 FORMAT(I6,5X,I5,F12.4)                                           TRUS1980
 2003 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS / 20X,1HA,14X,1HB,14X,1HC, TRUS1990
     1 14X,1HD,/6H X-DIR,4E15.6/ 6H Y-DIR,4E15.6/ 6H Z-DIR,4E15.6/     TRUS2000
     2 6H  TEMP,4E15.6)                                                TRUS2010
 2004 FORMAT(I7,1X,5I7,4E13.4,I7)                                      TRUS2020
 2005 FORMAT(// 23H PROCESSED ELEMENT DATA//                           TRUS2030
     1116H ELEMENT  /-NODE NOS-/  /--ELEMENT ID NOS-/   DESIGN VAR  REFETRUS2040
     2RENCE      END FIXITY COEFFICIENTS      BAND          /         TRUS2050
     3116H  NUMBER     I       J      MATL  GEOMY  D VAR     FRACTION      TTRUS2060
     4EMP          YY          ZZ         WIDTH             /)         TRUS2070
 2006 FORMAT(// 25H GEOMETRIC PROPERTY CARDS//                         TRUS2080
     146H GEOMETRY      X-SECT   /--MOMENTS OF INERTIA--/ /             TRUS2090
     245H  NUMBER       AREA          YY          ZZ      /)           TRUS2100
 2007 FORMAT(I6,2X,3E12.4)                                             TRUS2110
 2008 FORMAT(5E10.0)                                                   TRUS2120
 2009 FORMAT(/)                                                        TRUS2130
 2010 FORMAT(104,30X,5E12.4)                                           TRUS2140
 2011 FORMAT(28H TRUSS ELEMENT CARD IN ERROR )                         TRUS2150
      END                                                              TRUS2160
```

```
      SUBROUTINE ETRUSS                                                TRUS2170
C*****************************************************************************TRUS2180
C-----FORM TRUSS ELEMENT MATRICES                                      TRUS2190
C*****************************************************************************TRUS2200
      IMPLICIT REAL*8 (A-H,O-Z)                                        TRUS2210
      COMMON/EM/LM(6),S(6,6),P(6,4),SI(6),II(4),XM(6),G(6,6),EM1(2659) TRUS2220
      COMMON/JUNK/EMU(4,4),E(4),RHO,TEMP,X(2),Y(2),Z(2),V(4),JUN(304)  TRUS2230
      DIMENSION EMM(112)                                               TRUS2240
      EQUIVALENCE (S,EMM)                                              TRUS2250
      DO 5 I=1,112                                                     TRUS2260
    5 EMM(I)=0.                                                        TRUS2270
C*****************************************************************************TRUS2280
C-----COMPUTE UNIT STIFFNESS AND LOAD MATRICES                         TRUS2290
C*****************************************************************************TRUS2300
      CALL VECTOR (V,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                    TRUS2310
      DO 10 I=1,3                                                      TRUS2320
      SI(I)=-V(I)/V(4)                                                 TRUS2330
   10 SI(I+3)=-SI(I)                                                   TRUS2340
```

```
      DO 300 L=1,6                                                      TRUS2350
      YY=ST(L)*F(1)*V(4)                                                TRUS2360
      DO 250 K=L,6                                                      TRUS2370
      S(K,L)=ST(K)*YY                                                   TRUS2380
  250 S(L,K)=S(K,L)                                                     TRUS2390
  300 ST(L)=F(1)*S(L)                                                   TRUS2400
C*********************************************************************TRUS2410
C-----GRAVITY AND THERMAL LOADS                                         TRUS2420
C*********************************************************************TRUS2430
      FT=-TEMP*E(1)*E(2)                                                TRUS2440
      F=0.5*RHO*V(4)                                                    TRUS2450
      DO 350 L=1,4                                                      TRUS2460
      HH=EMIL(L,4)*FT                                                   TRUS2470
      TT(L)=HH                                                          TRUS2480
      DO 350 M=1,3                                                      TRUS2490
      P(M,L)=EMIL(L,M)*F+HH*V(M)                                        TRUS2500
  350 P(M+3,L)=EMIL(L,M)*F-HH*V(M)                                      TRUS2510
      RETURN                                                            TRUS2520
      END                                                               TRUS2530
```

```
      SUBROUTINE TGEOM(DX,DY,DZ,XL)                                     TRUS2540
C*********************************************************************TRUS2550
C-----FORM TRUSS ELEMENT UNIT GEOMETRIC STIFFNESS MATRIX IN GLOBAL      TRUS2560
C     COORDINATES                                                       TRUS2570
C*********************************************************************TRUS2580
      IMPLICIT REAL*8 (A-H,O-Z)                                         TRUS2590
      COMMON/EM/LM(6),S(6,6),P(6,4),ST(6),TT(4),XM(6),G(6,6),EM(2659)   TRUS2600
      G(1,1)=(1.0-DX*DX)/XL                                             TRUS2610
      G(1,2)=-DX*DY/XL                                                  TRUS2620
      G(1,3)=-DX*DZ/XL                                                  TRUS2630
      G(2,2)=(1.0-DY*DY)/XL                                             TRUS2640
      G(2,3)=-DY*DZ/XL                                                  TRUS2650
      G(3,3)=(1.0-DZ*DZ)/XL                                             TRUS2660
      G(2,1)=G(1,2)                                                     TRUS2670
      G(3,1)=G(1,3)                                                     TRUS2680
      G(3,2)=G(2,3)                                                     TRUS2690
      DO 100 I=1,3                                                      TRUS2700
      DO 100 J=1,3                                                      TRUS2710
      G(I+3,J+3)=G(I,J)                                                 TRUS2720
      G(I,J+3)=-G(I,J)                                                  TRUS2730
  100 G(I+3,J)=-G(I,J)                                                  TRUS2740
      RETURN                                                            TRUS2750
      END                                                               TRUS2760
```

```
      SUBROUTINE OTRUSS(AOLD,ANEW,LOAD,NUMDV)                          TRUS2770
C*********************************************************************TRUS2780
C-----FULLY STRESSED DESIGN FOR TRUSS ELEMENTS                         TRUS2790
C*********************************************************************TRUS2800
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                    TRUS2810
      COMMON/JUNK/          LT,LH,L,SG(27),IDVAR,IEX,ERC,AREA,XINERT,RYY,TRUS2820
     1 RZZ,TENS,COMP,JUNK(329)                                         TRUS2830
      P=SG(1)                                                          TRUS2840
      IF(P.GT.0.0)GO TO 100                                            TRUS2850
      P1=COMP*AREA                                                     TRUS2860
      P2=0.5*P1                                                        TRUS2870
      P=-P                                                             TRUS2880
      PEY=XINERT*RYY                                                   TRUS2890
      XLY=P/PEY                                                        TRUS2900
      RMAX=SQRT(XLY)                                                   TRUS2910
      CALL JOHNS (IEX,P,P1,P2,PEY,R)                                   TRUS2920
      IF (R.GT.RMAX) RMAX=R                                            TRUS2930
      PEZ=XINERT*RZZ                                                   TRUS2940
      XLZ=P/PEZ                                                        TRUS2950
      P=SQRT(XLZ)                                                      TRUS2960
      IF (R.GT.RMAX) RMAX=R                                            TRUS2970
      CALL JOHNS (IEX,P,P1,P2,PEZ,R)                                   TRUS2980
      IF (R.GT.RMAX) RMAX=R                                            TRUS2990
      GO TO 110                                                        TRUS3000
  100 P1=TENS*AREA                                                     TRUS3010
      RMAX=P/P1                                                        TRUS3020
  110 AA=RMAX*AOLD(IDVAR)                                              TRUS3030
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                   TRUS3040
      ANEW(IDVAR)=AA                                                   TRUS3050
      LOAD(IDVAR)=L                                                    TRUS3060
   60 CONTINUE                                                         TRUS3070
      RETURN                                                           TRUS3080
      END                                                              TRUS3090
```

```
      SUBROUTINE JOHNS (I,A,B,C,D,AA)                                  TRUS3100
C*********************************************************************TRUS3110
C-----JOHNSON'S PARABOLA USED FOR REDESIGN UNDER COMPRESSIVE FORCE      TRUS3120
C*********************************************************************TRUS3130
      GO TO (1,2,3),I                                                  TRUS3140
    1 AA=B-(B-C)*C/D                                                   TRUS3150
      IF (AA.LT.0.00001) GO TO 50                                      TRUS3160
      AA=A/AA                                                          TRUS3170
      RETURN                                                           TRUS3180
   50 AA=0.0                                                           TRUS3190
      RETURN                                                           TRUS3200
    2 AA=(A+(B-C)*C/D))/B                                              TRUS3210
      RETURN                                                           TRUS3220
    3 AA=SQRT(A**2+(4*B*C*(B-C)/D))                                    TRUS3230
      AA=(AA+A)/2/B                                                    TRUS3240
      RETURN                                                           TRUS3250
      END                                                              TRUS3260
```

```
      SUBROUTINE BEAM(A,MTOT)                                                BEAM0000
C*************************************************************************BEAM0010
C-----THREE DIMENSIONAL BEAM ELEMENTS                                        BEAM0020
C*************************************************************************BEAM0030
      DIMENSION A(MTOT)                                                      BEAM0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MRAND,NELTYP,N1,N2,N3,N4,N5,MTTT,NEQBEAM0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQB,NBLOCK                                BEAM0060
      COMMON/JUNK/LT,LH,L,SIG(27),IDVAR,IEX,ERC,AREA,JUN1(334)               BEAM0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13                   BEAM0080
      NUME=NPAR(2)                                                           BEAM0090
      KODE=NPAR(5)                                                           BEAM0100
      IF(NPAR(1).EQ.0) GO TO 500                                             BEAM0110
      GO TO (1,1,2),KODE                                                     BEAM0120
C*************************************************************************BEAM0130
C-----BEAM ELEMENTS WITH     INSTABILITY CONSTRAINTS                         BEAM0140
C-----KODE =1 INERTIAS AND MODULI ARE PROPORTIONAL TO AREA                   BEAM0150
C            2 INERTIAS AND MODULI ARE PROPORTIONAL TO AREA**2 AND          BEAM0160
C              AREA**1.5 RESPECTIVELY                                        BEAM0170
C*************************************************************************BEAM0180
    1 NUMMAT=NPAR(3)                                                         BEAM0190
      NUMGEO=NPAR(4)                                                         BEAM0200
      NUMFIX=NPAR(6)                                                         BEAM0210
      IF (NUMFIX.EQ.0) NUMFIX=1                                              BEAM0220
      N6=N5+NUMNP                                                            BEAM0230
      N7=N6+NUMGEO                                                           BEAM0240
      N8=N7+NUMGEO*9                                                         BEAM0250
      N9=N8+NUMMAT                                                           BEAM0260
      N10=N9+NUMMAT*5                                                        BEAM0270
      MM=N10+NUMFIX*12-MTOT                                                  BEAM0280
      IF(MM.GT.0)CALL ERROR(MM)                                              BEAM0290
      CALL BEAM (A(M1),A(N1),A(N2),A(N3),A(N4),A(N6),A(N7),A(N8),A(N9),      BEAM0300
     1A(N10),NUMDV,NUMNP,NUMGEO,NUMMAT,NUMFIX,KODE,NUME,NPAR(6))             BEAM0310
      RETURN                                                                 BEAM0320
C*************************************************************************BEAM0330
C-----PROVISION FOR SPECIAL BEAM ELEMENTS                                    BEAM0340
C*************************************************************************BEAM0350
    2 CALL NDELEM(NPAR(1),KODE,IW)                                           BEAM0360
      RETURN                                                                 BEAM0370
  500 WRITE (IW,2008) KODE                                                   BEAM0380
      DO 800 MM=1,NUME                                                       BEAM0390
      CALL STRSC(A(M1),A(N1),A(N2),NEQ,NUMDV,LL,LR,0)                        BEAM0400
      WRITE (IW,2005) MM,AREA                                                BEAM0410
      DO 800 L=LT,LH                                                         BEAM0420
      CALL STRSC(A(M1),A(N1),A(N2),NEQ,NUMDV,LL,LR,1)                        BEAM0430
      IF(L.GT.LT) WRITE(IW,2006)                                             BEAM0440
      WRITE(6,2007)    L,(SIG(I),I=1,12)                                     BEAM0450
      GO TO (3,3,4),KODE                                                     BEAM0460
C*************************************************************************BEAM0470
C-----DESIGN OF BEAM ELEMENTS FOR STRESS AND LOCAL BUCKLING CONSTRAINTS     BEAM0480
C*************************************************************************BEAM0490
    3 CALL DBEAM(A(M1),A(M2),A(M3),NUMDV)                                    BEAM0500
      GO TO 800                                                              BEAM0510
C*************************************************************************BEAM0520
C-----PROVISION FOR REDESIGN OF SPECIAL BEAM ELEMENTS                        BEAM0530
C*************************************************************************BEAM0540
    4 CONTINUE                                                               BEAM0550
  800 CONTINUE                                                               BEAM0560
      RETURN                                                                 BEAM0570
 2008 FORMAT(//41H ANALYSIS OF BEAM ELEMENTS, CONSTRN CODE= ,I2//            BEAM0580
     1104H ELEMENT X-SECT AREA  LOAD COND     AXIAL RX     SHEAR RY    SHEBEAM0590
```

```
     2AR RZ    TORQUE MX    MOMENT MY    MOMENT MZ /)                          BEAM0600
 2005 FORMAT(I7,F13.4)                                                          BEAM0610
 2006 FORMAT(/)                                                                 BEAM0620
 2007 FORMAT(1H+,20X,I5,6X,6F12.4/32X,6F12.4)                                   BEAM0630
      END                                                                       BEAM0640



      SUBROUTINE BEAM(IWT,ID,X,Y,Z,KSEC,PGEO,WT,PMAT,SET,NUMDV,NUMNP,    BEAM0650
     1NUMGEO,NUMMAT,NUMELX,KODE,NUME,NUMEX)                                    BEAM0660
C*************************************************************************BEAM0670
C-----UNIFORM CROSS-SECTION BEAM ELEMENTS                                    BEAM0680
C*************************************************************************BEAM0690
      IMPLICIT REAL*8 (A-H,O-Z)                                                 BEAM0700
      REAL*4 IWT,X,Y,Z, PGEO ,PMAT,SET,ERC                                      BEAM0710
      DIMENSION IWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),      BEAM0720
     1 KSEC(NUMGEO), PGEO (NUMGEO,9),PMAT(NUMMAT,6),SET(NUMELX,12)      BEAM0730
     2 ,WT(NUMMAT)                                                      BEAM0740
      COMMON/EM/LM(24),S(24,24,2),P(24,4,2),ST(12,24,2),TT(12,4,2),     BEAM0750
     1 XM(24),G(24,24),EM1(146)                                         BEAM0760
      COMMON/LINK/EMIL(3,4),T(3,3),LC(4),JC(12),XX(3),YY(3),ZZ(3),IF(3),BEAM0770
     1 IX(3),U(3),DL,JUN(278)                                           BEAM0780
      COMMON/CONTR/IC(13),LBUCK,IC2(15)                                 BEAM0790
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              BEAM0800
C*************************************************************************BEAM0810
C-----CONTROL INFORMATION                                                   BEAM0820
C*************************************************************************BEAM0830
      MH=2                                                                  BEAM0840
      MV=2                                                                  BEAM0850
      MS=12                                                                 BEAM0860
      MW=2                                                                  BEAM0870
      MI=10                                                                 BEAM0880
      MG=1                                                                  BEAM0890
      MSG=7                                                                 BEAM0900
      IEX=KODE                                                              BEAM0910
      WRITE(IW,2005) NUME,KODE,NUMMAT,NUMGEO,NUMEX                          BEAM0920
C*************************************************************************BEAM0930
C-----MATERIAL PROPERTY CARDS                                               BEAM0940
C*************************************************************************BEAM0950
      WRITE (IW,2001)                                                       BEAM0960
      DO 10 I=1,NUMMAT                                                      BEAM0970
      READ(IR,1001) N,WT(N),(PMAT(N,J),J=1,5)                               BEAM0980
      IF(PMAT(N,4).LE.0.) PMAT(N,4)=PMAT(N,3)                               BEAM0990
      IF(PMAT(N,5).LE.0.) PMAT(N,5)=0.577*PMAT(N,3)                         BEAM1000
      WRITE(IW,2002) N,WT(N),(PMAT(N,J),J=1,5)                              BEAM1010
   10 PMAT(N,2)=0.5*PMAT(N,1)/(1.0+PMAT(N,2))                               BEAM1020
C*************************************************************************BEAM1030
C-----GEOMETRIC PROPERTY CARDS                                              BEAM1040
C*************************************************************************BEAM1050
      WRITE (IW,2003)                                                       BEAM1060
      DO 30 I=1,NUMGEO                                                      BEAM1070
      READ (IR,1002) N,KSEC(N),AREA,( PGEO (N,J),J=1,9)                     BEAM1080
      IF(AREA.LE.0.) AREA=1.0                                               BEAM1090
      IF (KSEC(N).EQ.0) KSEC(N)=1                                           BEAM1100
      IF(KSEC(N).NE.3) GO TO 15                                             BEAM1110
      PGEO(N,3)=PGEO(N,2)                                                   BEAM1120
      PGEO(N,6)=0.                                                          BEAM1130
      PGEO(N,7)=0.                                                          BEAM1140
```

```
      PGEO(N,8)=0.                                                      BEAM1150
      PGEO(N,9)=0.                                                      BEAM1160
   15 WRITE(IW,2004) N,KSEC(N),AREA,( PGEO (N,J),J=1,9)                 BEAM1170
      AA=AREA**IEX                                                      BEAM1180
      AAA=DSQRT(AREA*AA)                                                BEAM1190
      DO 11 J=1,3                                                       BEAM1200
   11 PGEO(N,J)=PGEO(N,J)/AA                                            BEAM1210
      DO 12 J=4,9                                                       BEAM1220
   12 PGEO(N,J)=PGEO(N,J)/AAA                                           BEAM1230
   30 CONTINUE                                                          BEAM1240
C*********************************************************************BEAM1250
C-----ELEMENT LOAD MULTIPLIERS                                          BEAM1260
C*********************************************************************BEAM1270
      READ (IR,1006) ((EMUL(I,J),J=1,4),I=1,3)                          BEAM1280
      WRITE(IW,2006) ((EMUL(I,J),J=1,4),I=1,3)                          BEAM1290
C*********************************************************************BEAM1300
C-----FIXED-END FORCES                                                  BEAM1310
C*********************************************************************BEAM1320
      IF(NUMFX .EQ.0) GO TO 56                                          BEAM1330
      WRITE (IW,2010)                                                   BEAM1340
      DO 55 I=1,NUMFX                                                   BEAM1350
      READ (IR,1005) N,(SET(N,J),J=1,12)                                BEAM1360
   55 WRITE(IW,2011) N,(SET(N,J),J=1,12)                                BEAM1370
C*********************************************************************BEAM1380
C-----ELEMENT CARDS                                                     BEAM1390
C*********************************************************************BEAM1400
   56 WRITE (IW,4000)                                                   BEAM1410
      N=1                                                               BEAM1420
  100 READ(IR,3000) IEL,IE,IMAT,IGEO,IDV  ,ERC,LC,JC,INC                BEAM1430
      IF(ERC.LE.0.) ERC=1.                                              BEAM1440
      IF (INC.EQ.0) INC=1                                               BEAM1450
      KK=INC*(IEL-N)                                                    BEAM1460
      IX(1)=IE(1)-KK                                                    BEAM1470
      IX(2)=IE(2)-KK                                                    BEAM1480
      IX(3)=IE(2)                                                       BEAM1490
      DO 500 NEL=N,IEL                                                  BEAM1500
      DO 120 I=1,3                                                      BEAM1510
      II=IX(I)                                                          BEAM1520
      XX(I)=X(II)                                                       BEAM1530
      YY(I)=Y(II)                                                       BEAM1540
  120 ZZ(I)=Z(II)                                                       BEAM1550
C*********************************************************************BEAM1560
C-----COMPUTE ELEMENT MATRICES                                          BEAM1570
C*********************************************************************BEAM1580
      RHO=WT(IMAT)                                                      BEAM1590
      E   =PMAT(IMAT,1)                                                 BEAM1600
      GG  =PMAT(IMAT,2)                                                 BEAM1610
      AAX=PGEO(IGEO,1)                                                  BEAM1620
      AAY=PGEO(IGEO,2)                                                  BEAM1630
      AAZ=PGEO(IGEO,3)                                                  BEAM1640
      CALL NEWBM(E,GG,RHO,AAX,AAY,AAZ,SET,NUMFIX,NEL,IW)                BEAM1650
      IF(LBUCK.NE.0) CALL BGEOM                                         BEAM1660
      WT(IDV)=WT(IDV)+DL*RHO*ERC                                        BEAM1670
C*********************************************************************BEAM1680
C-----FORM ELEMENT LOCATION MATRIX                                      BEAM1690
C*********************************************************************BEAM1700
      I=IX(1)                                                           BEAM1710
      J=IX(2)                                                           BEAM1720
      DO 170 M=1,6                                                      BEAM1730
      LM(M)=ID(I,M)                                                     BEAM1740
```

```
      IM(M+12)=0                                                        BEAM1750
      IM(M+18)=0                                                        BEAM1760
  170 IM(M+6)=ID(J,M)                                                   BEAM1770
C***********************************************************************BEAM1780
C-----TRANSFORM TO MASTER DEGREES OF FREEDOM  AND REARRANGE MATRICES     BEAM1790
C***********************************************************************BEAM1800
      ND=12                                                             BEAM1810
      CALL SLAVE (X,Y,Z,ID,NUMNP,IX(1),IX(2),ND,NS,LBUCK)               BEAM1820
      NN=ND*ND*NU                                                       BEAM1830
      CALL REARAN( S, S,24,24,2,ND,ND,NU,NN)                            BEAM1840
      NN=NS*ND*NU                                                       BEAM1850
      CALL REARAN(ST,ST,12,24,2,NS,ND,NU,NN)                            BEAM1860
      NN=ND*4*NV                                                        BEAM1870
      CALL REARAN( P, P,24, 4,2,ND, 4,NV,NN)                            BEAM1880
C***********************************************************************BEAM1890
C-----PLACE ELEMENT INFORMATION ON TAPES                                 BEAM1900
C***********************************************************************BEAM1910
      CALL CALRAN(NDIF,IM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)         BEAM1920
      IF(LBUCK.EQ.0) GO  TO 749                                         BEAM1930
      NN=ND*ND*NG                                                       BEAM1940
      CALL REARAN(G,G,24,24,1,ND,ND,NG,NN)                              BEAM1950
      CALL ELGSUM(G,NSG,ND,NG,III)                                      BEAM1960
  749 WRITE(18) NL,(PGEO(IGEO,I),I=4,9),(PMAT(IMAT,I),I=3,5),KSEC(IGEO) BEAM1970
      WRITE (IW,4001) NEL,IX,IMAT,IGEO,IDV  ,ERC,LC,JC,NDIF            BEAM1980
C***********************************************************************BEAM1990
C-----CHECK FOR LAST ELEMENT                                            BEAM2000
C***********************************************************************BEAM2010
      IX(1)=IX(1)+INC                                                   BEAM2020
      IX(2)=IX(2)+INC                                                   BEAM2030
  500 CONTINUE                                                          BEAM2040
      N=IEL+1                                                           BEAM2050
      IF(N.LE.NUME ) GO TO 100                                          BEAM2060
      RETURN                                                            BEAM2070
 1001 FORMAT(15,5X,6E10.0)                                              BEAM2080
 1002 FORMAT(2I5,4E10.0/6E10.0)                                         BEAM2090
 1005 FORMAT(I5,6E10.0/E15.0,5E10.0)                                    BEAM2100
 1006 FORMAT (4E10.0)                                                   BEAM2110
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                          BEAM2120
     1X3H MATERIAL      SPECIFIC      YOUNGS     POISSONS  /--------ALLOWABBEAM2130
     2LE STRESSES--------/ /                                            BEAM2140
     3X3H  NUMBER        WEIGHT      MODULUS      RATIO        TENSION   COMBEAM2150
     4RESSION     SHEAR     )                                           BEAM2160
 2002 FORMAT(I6,4X,6E12.4)                                              BEAM2170
 2003 FORMAT(// 25H GEOMETRIC PROPERTY CARDS//                          BEAM2180
     1X6H PROPERTY  X-SECT     X-SECT  /------PROPERTIES OF X-SECTION----BEAM2190
     2-/ /                                                              BEAM2200
     3X6H  NUMBER     CODE       AREA        X-AXIS       Y-AXIS       Z-AXISBEAM2210
     4   ))                                                             BEAM2220
 2004 FORMAT(I6,4X,I5,4E12.4,22H MOMENTS OF INERTIA      /              BEAM2230
     1            27X,3E12.4,24H SECT MODULI FOR POINT A/               BEAM2240
     2            27X,3E12.4,24H SECT MODULI FOR POINT B)               BEAM2250
 2005 FORMAT(32H1THREE DIMENSIONAL BEAM ELEMENTS//                      BEAM2260
     1         32H NUMBER OF BEAM ELEMENTS          =,I5/               BEAM2270
     2         32H CONSTRUCTION CODE                =,I5/               BEAM2280
     3         32H NUMBER OF MATERIALS              =,I5/               BEAM2290
     4         32H NUMBER OF GEOMETRIC PROPERTIES=,I5/                  BEAM2300
     5         32H NUMBER OF FIXED-END FORCE SETS=,I5)                  BEAM2310
 2006 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS / 20X,1HA,14X,1HB,14X,1HC, BEAM2320
     1 14X,1HD,/4H X-DIR,4E15.6/ 6H Y-DIR,4E15.6/ 6H Z-DIR,4E15.6/ )    BEAM2330
 2010 FORMAT(1H1,40H FIXED END FORCES IN LOCAL COORDINATES               BEAM2340
```

```
     1//50H TYPE    NODE        FORCE X      FORCE Y      FORCE Z           BEAM2350
     2                      35H MOMENT X     MOMENT Y     MOMENT Z          )BEAM2360
 2011 FORMAT(1H ,I3,6X,1HT,3X,6F12.3/1H ,9X,1HL,2X,6F12.3/)                BEAM2370
 3000 FORMAT (7I5,F10.0,4I5,I2I1,I3)                                       BEAM2380
 4000 FORMAT(// 23H PROCESSED ELEMENT DATA//                               BEAM2390
     1 106H ELEMENT  /---NODE NOS--/  /--ELEMENT ID NOS-/  DESIGN VAR      BEAM2400
     2 FIXED END-FORCE ID  END RELEASE CODES   BAND      /                 BEAM2410
     3 107H  NUMBER       I    J     K    MAT'L  GEOMY  D VAR   FRACTION  BEAM2420
     4   A     B     C     D       I            J    WIDTH        /)       BEAM2430
 4001 FORMAT(I7,2X,3I5,3I7,F12.4,2X,4I5,5X,6I1,5X,6I1,I6)                  BEAM2440
      END                                                                  BEAM2450



      SUBROUTINE CBRT (A0,A1,A2,A3,Z)                                      BEAM2460
C*************************************************************************BEAM2470
C-----COMPUTES THE LARGEST REAL ROOT Z OF                                  BEAM2480
C       A0+A1*Z+A2*Z**2+A3*Z**3=0                                          BEAM2490
C*************************************************************************BEAM2500
      A0=A0/A3                                                             BEAM2510
      A1=A1/A3                                                             BEAM2520
      A2=A2/A3                                                             BEAM2530
      Q=A1/3.0-A2**2/9.0                                                   BEAM2540
      R=(A1*A2-3.0*A0)/6.0-A2**3/27.0                                      BEAM2550
      P=Q**3+R**2                                                          BEAM2560
      IF (P.LT.0.0) GO TO 200                                              BEAM2570
      P=SQRT (P)                                                           BEAM2580
      RP=R+P                                                               BEAM2590
      IF(RP.LT.0.) GO TO 50                                                BEAM2600
      S1=RP**0.3333333                                                     BEAM2610
      GO TO 60                                                             BEAM2620
   50 S1=-(-RP)**0.3333333                                                 BEAM2630
   60 RP=R-P                                                               BEAM2640
      IF(RP.LT.0.) GO TO 70                                                BEAM2650
      S2=RP**0.3333333                                                     BEAM2660
      GO TO 80                                                             BEAM2670
   70 S2=-(-RP)**0.3333333                                                 BEAM2680
   80 Z=S1+S2-A2/3.0                                                       BEAM2690
      RETURN                                                               BEAM2700
  200 P=-P                                                                 BEAM2710
      P=SQRT(P)                                                            BEAM2720
      SRAR=SQRT(R**2+P**2)                                                 BEAM2730
      COS3=R/SRAR                                                          BEAM2740
      SIN3=P/SRAR                                                          BEAM2750
      W=ATAN(SIN3/COS3)                                                    BEAM2760
      W=W/3.0                                                              BEAM2770
      C=COS(W)                                                             BEAM2780
      S=SIN(W)                                                             BEAM2790
      IF (S.LT.0.)  S=-S                                                   BEAM2800
      SRAR=SRAR**0.3333333                                                 BEAM2810
      Z=2.0*SRAR*C-A2/3.0                                                  BEAM2820
      R=-SRAR*C-A2/3.0+1.732051*SRAR*S                                     BEAM2830
      IF (R.GT.Z) Z=R                                                      BEAM2840
      RETURN                                                               BEAM2850
      END                                                                  BEAM2860
```

```
      SUBROUTINE NEWBM (E,GG,WT,AAX,AAY,AAZ,SET,NUMEIX, NEL,IW)          BEAM2870
C*************************************************************************BEAM2880
C-----CALCULATE ELEMENT MATRICES                                          BEAM2890
C*************************************************************************BEAM2900
      IMPLICIT REAL*8 (A-H,O-Z)                                           BEAM2910
      REAL*4 SET                                                          BEAM2920
      COMMON/EM/ELM(24),S1(24,24),S2(24,24),P1(24,4),P2(24,4),ST1(12,24),BEAM2930
     1 ST2(12,24),TT1(12,4),TT2(12,4),XM(24),G(24,24),S(12,12),EM(2)     BEAM2940
      COMMON/JUNK/EMUL(3,4),T(3,3),LC(4),JC(12),XX(3),YY(3),ZZ(3),IF(3),BEAM2950
     1 IX(3),U(4),V(4),W(4),R(12),JUM(238)                                BEAM2960
      DIMENSION SET(NUMEIX,12),EMM(2040)                                  BEAM2970
      EQUIVALENCE (S),EMM)                                                BEAM2980
      DO 5 I=1,2040                                                       BEAM2990
    5 EMM(I)=0.                                                           BEAM3000
      DO 6 I=1,12                                                         BEAM3010
      DO 6 J=1,12                                                         BEAM3020
    6 S(I,J)=0.                                                           BEAM3030
C*************************************************************************BEAM3040
C-----FORM GLOBAL TO LOCAL COORDINATE TRANSFORMATION.                     BEAM3050
C*************************************************************************BEAM3060
      CALL VECTOR(U,XX(1),YY(1),ZZ(1),XX(2),YY(2),ZZ(2))                  BEAM3070
      CALL VECTOR(V,XX(1),YY(1),ZZ(1),XX(3),YY(3),ZZ(3))                  BEAM3080
      HH=DOT(U,V)                                                         BEAM3090
      IF(DABS(HH*HH-1.0),1.0,0.01 ) GO TO 40                              BEAM3100
      CALL CROSS(U,V,W)                                                   BEAM3110
      CALL CROSS(W,U,V)                                                   BEAM3120
      DO 30 I=1,3                                                         BEAM3130
      T(1,I)=U(I)                                                         BEAM3140
      T(2,I)=V(I)                                                         BEAM3150
   30 T(3,I)=W(I)                                                         BEAM3160
C*************************************************************************BEAM3170
C-----FIXED END FORCES IN LOCAL COORDINATES                               BEAM3180
C*************************************************************************BEAM3190
      DO 73 N=1,4                                                         BEAM3200
      M=LC(N)                                                             BEAM3210
      IF(M.LE.0) GO TO 73                                                 BEAM3220
      DO 72 I=1,12                                                        BEAM3230
   72 TT2(I,N)=SET(M,I)                                                   BEAM3240
   73 CONTINUE                                                            BEAM3250
C*************************************************************************BEAM3260
C-----ELEMENT UNIT STIFFNESS MATRIX IN LOCAL COORDINATES S(I,J)           BEAM3270
C*************************************************************************BEAM3280
      DL=U(4)                                                             BEAM3290
      ZY=E/(DL*DL)                                                        BEAM3300
      COMMY=ZY*AAY                                                        BEAM3310
      COMMZ=ZY*AAZ                                                        BEAM3320
      S(1,1)=E/DL                                                         BEAM3330
      S(2,2)= COMMZ*12./DL                                                BEAM3340
      S(3,3)= COMMY*12./DL                                                BEAM3350
      S(4,4)= GG*AAX/DL                                                   BEAM3360
      S(5,5)= COMMY* 4.*DL                                                BEAM3370
      S(6,6)= COMMZ* 4.*DL                                                BEAM3380
      S(2,6)= COMMZ* 6.                                                   BEAM3390
      S(3,5)=-COMMY* 6.                                                   BEAM3400
      DO 102 I=1,6                                                        BEAM3410
      J=I+6                                                               BEAM3420
  102 S(J,J)=S(I,I)                                                       BEAM3430
      DO 104 I=1,4                                                        BEAM3440
      J=I+6                                                               BEAM3450
  104 S(I,J)=-S(I,I)                                                      BEAM3460
```

```
      S(5,11)= S(5,5)*0.5                                                   BEAM3470
      S(6,12)= S(6,6)*0.5                                                   BEAM3480
      S(2,12)= S(2,6)                                                       BEAM3490
      S(6, 8)=-S(2,6)                                                       BEAM3500
      S(8,12)=-S(2,6)                                                       BEAM3510
      S(3,11)= S(3,5)                                                       BEAM3520
      S(5, 9)=-S(3,5)                                                       BEAM3530
      S(9,11)=-S(3,5)                                                       BEAM3540
      DO 106 I=2,12                                                         BEAM3550
      K=I-1                                                                 BEAM3560
      DO 106 J=1,K                                                          BEAM3570
  106 S(I,J)=S(J,I)                                                         BEAM3580
C***********************************************************************BEAM3590
C-----MODIFY S AND TT2 FOR ZERO END-FORCES                                  BEAM3600
C***********************************************************************BEAM3610
      DO 110 I=1,12                                                         BEAM3620
      DO 110 J=1,12                                                         BEAM3630
  110 G(I,J)=S(I,J)                                                         BEAM3640
      DO 140 I=1,12                                                         BEAM3650
      SI=S(I,I)                                                             BEAM3660
      IF(JC(I).LE.0.OR.SI.EQ.0.) GO TO 140                                  BEAM3670
      DO 125 M=1,12                                                         BEAM3680
  125 R(M)=S(I,M)                                                           BEAM3690
      DO 126 M=1,4                                                          BEAM3700
  126 W(M)=TT2(I,M)                                                         BEAM3710
      DO 135 M=1,12                                                         BEAM3720
      CM=S(M,I)/SI                                                          BEAM3730
      DO 130 N=1,12                                                         BEAM3740
  130 S(M,N)=S(M,N)-CM*R(N)                                                 BEAM3750
      DO 135 N=1,4                                                          BEAM3760
  135 TT2(M,N)=TT2(M,N)-CM*W(N)                                             BEAM3770
  140 CONTINUE                                                              BEAM3780
C***********************************************************************BEAM3790
C-----UNIT STIFFNESS AND FORCE RECOVERY MATRICES DUE TO STRETCHING           BEAM3800
C***********************************************************************BEAM3810
      DO 200 I=1,3                                                          BEAM3820
      DO 201 J=1,3                                                          BEAM3830
      X=T(1,I)*T(1,J)                                                       BEAM3840
      S1(I  ,J  )=X*S(1,1)                                                  BEAM3850
      S1(I  ,J+6)=X*S(1,7)                                                  BEAM3860
      S1(I+6,J  )=X*S(7,1)                                                  BEAM3870
  201 S1(I+6,J+6)=X*S(7,7)                                                  BEAM3880
      ST1(I  ,I  )=T(1,I)*S(1,1)                                            BEAM3890
      X=T(1,I)*S(1,7)                                                       BEAM3900
      ST1(I  ,I+6)=X                                                        BEAM3910
      ST1(I+6,I  )=X                                                        BEAM3920
  200 ST1(I+6,I+6)=T(1,I)*S(7,7)                                            BEAM3930
      DO 202 I=1,7,6                                                        BEAM3940
      DO 202 J=1,7,6                                                        BEAM3950
  202 S1(I,J)=0.                                                            BEAM3960
C***********************************************************************BEAM3970
C-----UNIT FORCE RECOVERY MATRIX DUE TO BENDING AND TWISTING                BEAM3980
C***********************************************************************BEAM3990
      DO 150 LA=1,10,3                                                      BEAM4000
      LB=LA+2                                                               BEAM4010
      DO 150 MA=1,10,3                                                      BEAM4020
      MB=MA-1                                                               BEAM4030
      DO 150 I=LA,LB                                                        BEAM4040
      DO 150 JM=1,3                                                         BEAM4050
      J=JM+MB                                                               BEAM4060
```

```
      X=0.                                                                  BEAM4070
      DO 151 K=1,3                                                          BEAM4080
  151 X =X +S(I,K+MB)*T(K,JM)                                               BEAM4090
  150 ST2(I,J)=X                                                            BEAM4100
C*************************************************************************BEAM4110
C-----COORDINATE TRANSFORMATION OF UNIT BENDING AND TWISTING STIFFNESS     BEAM4120
C*************************************************************************BEAM4130
      DO 160 LA=1,10,3                                                      BEAM4140
      LB=LA-1                                                               BEAM4150
      DO 160 MA=1,10,3                                                      BEAM4160
      MB=MA+2                                                               BEAM4170
      DO 160 IL=1,3                                                         BEAM4180
      I=IL+LB                                                               BEAM4190
      DO 160 J=MA,MB                                                        BEAM4200
      X=0.                                                                  BEAM4210
      DO 161 K=1,3                                                          BEAM4220
  161 X=X+T(K,IL)*ST2(K+LB,J)                                               BEAM4230
  160 S2(I,J)=X                                                             BEAM4240
C*************************************************************************BEAM4250
C-----TRANSFORMATION OF ELEMENT LOAD VECTOR DUE TO FIXED END FORCES        BEAM4260
C     TO GLOBAL COORDINATES                                                BEAM4270
C*************************************************************************BEAM4280
      DO 165 LA=1,10,3                                                      BEAM4290
      LB=LA-1                                                               BEAM4300
      DO 165 IL=1,3                                                         BEAM4310
      I=IL+LB                                                               BEAM4320
      DO 165 N=1,4                                                          BEAM4330
      X=0.                                                                  BEAM4340
      DO 162 K=1,3                                                          BEAM4350
  162 X=X-T(K,IL)*T12(K+LB,N)                                               BEAM4360
  165 P2(I,N)=X                                                             BEAM4370
C*************************************************************************BEAM4380
C-----ELEMENT MASS MATRIX                                                   BEAM4390
C*************************************************************************BEAM4400
      X  =WT*DL/2.                                                          BEAM4410
      DO 180 M=1,3                                                          BEAM4420
      XM(M)=X                                                               BEAM4430
      XM(M+3)=0.                                                            BEAM4440
      XM(M+9)=0.                                                            BEAM4450
  180 XM(M+6)=X                                                             BEAM4460
C*************************************************************************BEAM4470
C-----COMPUTE GRAVITY LOADING ( POINT LOADS ONLY )                          BEAM4480
C*************************************************************************BEAM4490
      DO 190 I=1,3                                                          BEAM4500
      DO 190 J=1,4                                                          BEAM4510
      P1(I  ,J)=P1(I  ,J)+EMUL(I,J)*XM(I  )                                 BEAM4520
  190 P1(I+6,J)=P1(I+6,J)+EMUL(I,J)*XM(I+6)                                 BEAM4530
      RETURN                                                                BEAM4540
   40 WRITE(IW,4002) NEI                                                    BEAM4550
      STOP                                                                  BEAM4560
 4002 FORMAT (9HOBEAM NO.,I5, 26H     K NODE ON BEAM X-AXIS                 BEAM4570
     . 26H......EXECUTION TERMINATED )                                      BEAM4580
      END                                                                   BEAM4590
```

```
      SUBROUTINE SLAVE (X,Y,Z,ID,NUMNP,NI,NJ,ND,NS,LBUCK)                BEAM4600
C*****************************************************************************BEAM4610
C-----PERFORMS SLAVE ...MASTER DISPLACEMENT TRANSFORMATION                 BEAM4620
C        ( FOR NODES CONNECTED TO BEAM ELEMENTS ONLY)                      BEAM4630
C*****************************************************************************BEAM4640
      IMPLICIT REAL*8 (A-H,O-Z)                                           BEAM4650
      REAL*4 X,Y,Z                                                       BEAM4660
      COMMON/EM/LM(24),S(24,24,2),P(192),ST(12,24,2),TT(96),XM(24),      BEAM4670
     1 G(24,24),EM(46)                                                   BEAM4680
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6)                   BEAM4690
C*****************************************************************************BEAM4700
C-----DETERMINE REQUIRED TRANSLATION DEGREES OF FREEDOM                   BEAM4710
C*****************************************************************************BEAM4720
      DO 54 NF=1,12,6                                                    BEAM4730
      NOD=NI                                                             BEAM4740
      IF (NF.EQ.7) NOD=NJ                                                BEAM4750
      DO 30 K=1,3                                                        BEAM4760
      I=K+NF-1                                                           BEAM4770
      IF (LM(I).GE.0) GO TO 30                                           BEAM4780
      M=-LM(I)                                                           BEAM4790
      LM(I)=ID(M,K)                                                      BEAM4800
      N1=NOD+1                                                           BEAM4810
      N2=NOD+2                                                           BEAM4820
      IF(K-2) 35,45,55                                                   BEAM4830
   35 D1=-(Y(NOD)-Y(M))                                                  BEAM4840
      D2=   Z(NOD)-Z(M)                                                  BEAM4850
      LM(N1)=ID(M,6)                                                     BEAM4860
      LM(N2)=ID(M,5)                                                     BEAM4870
      GO TO 50                                                           BEAM4880
   45 D1=-(Z(NOD)-Z(M))                                                  BEAM4890
      D2=   X(NOD)-X(M)                                                  BEAM4900
      LM(N1)=ID(M,4)                                                     BEAM4910
      LM(N2)=ID(M,6)                                                     BEAM4920
      GO TO 50                                                           BEAM4930
   55 D1=-(X(NOD)-X(M))                                                  BEAM4940
      D2=   Y(NOD)-Y(M)                                                  BEAM4950
      LM(N1)=ID(M,5)                                                     BEAM4960
      LM(N2)=ID(M,4)                                                     BEAM4970
   50 CONTINUE                                                           BEAM4980
C*****************************************************************************BEAM4990
C-----TRANSFORMATION...ARRAYS INCREASE IN SIZE                            BEAM5000
C*****************************************************************************BEAM5010
      DO 80 J=1,2                                                        BEAM5020
      DO 60 I=1,ND                                                       BEAM5030
      S(N1,I,J)=S(I,II,J)*D1                                             BEAM5040
      S(N2,I,J)=S(I,II,J)*D2                                             BEAM5050
      S(I,N1,J)=S(N1,II,J)                                               BEAM5060
   60 S(I,N2,J)=S(N2,II,J)                                               BEAM5070
      S(N1,N1,J)=S(I,I,J)*D1*D1                                          BEAM5080
      S(N1,N2,J)=S(I,I,J)*D1*D2                                          BEAM5090
      S(N2,N1,J)=S(N1,N2,J)                                              BEAM5100
      S(N2,N2,J)=S(I,I,J)*D2*D2                                          BEAM5110
      DO 70 I=1,NS                                                       BEAM5120
      ST(I,N1,J)=ST(I,I,J)*D1                                            BEAM5130
   70 ST(I,N2,J)=ST(I,I,J)*D2                                            BEAM5140
   80 CONTINUE                                                           BEAM5150
      XM(N1)=XM(I)*D1*D1                                                 BEAM5160
      XM(N2)=XM(I)*D2*D2                                                 BEAM5170
      IF(LBUCK.EQ.0) GO TO 91                                            BEAM5180
      DO 90 I=1,ND                                                       BEAM5190
```

```
      G(M1,II)=G(I,II)*D1                                                BEAM5200
      G(M2,II)=G(I,II)*D2                                                BEAM5210
      G(II,M1)=G(M1,II)                                                  BEAM5220
   90 G(II,M2)=G(M2,II)                                                  BEAM5230
      G(M1,M1)=G(I,I)*D1*D1                                              BEAM5240
      G(M1,M2)=G(I,I)*D1*D2                                              BEAM5250
      G(M2,M1)=G(M1,M2)                                                  BEAM5260
      G(M2,M2)=G(I,I)*D2*D2                                              BEAM5270
   91 ND=ND+2                                                            BEAM5280
   30 CONTINUE                                                           BEAM5290
C*********************************************************************BEAM5300
C-----SET ROTATIONS                                                      BEAM5310
C*********************************************************************BEAM5320
      DO 54 J=1,3                                                        BEAM5330
      K=NF+J+2                                                           BEAM5340
      IF(LM(K).GE.0)  GO TO 54                                           BEAM5350
      M=-LM(K)                                                           BEAM5360
      LM(K)=ID(M,J+3)                                                    BEAM5370
   54 CONTINUE                                                           BEAM5380
      RETURN                                                             BEAM5390
      END                                                                BEAM5400
```

```
      SUBROUTINE BGEOM                                                   BEAM5410
C*********************************************************************BEAM5420
C-----GEOMETRIC STIFFNESS MATRIX OF BEAM ELEMENT                         BEAM5430
C*********************************************************************BEAM5440
      IMPLICIT REAL*8 (A-H,O-Z)                                          BEAM5450
      COMMON/FM/LM(24),SS(1152),P(192),ST(576),TT(96),XM(24),G(24,24),   BEAM5460
     1 S(12,12),FMM(2)                                                   BEAM5470
      COMMON/JUNK/FMUL(3,4),T(3,3),LC(4),JC(12),X (3),Y (3),Z (3),IF(3),BEAM5480
     1 IX(3),II(3),DL,C(3,3),R(12),JUN(236)                              BEAM5490
      DO 10 I=1,12                                                       BEAM5500
      DO 10 J=1,12                                                       BEAM5510
   10 S(I,J)=0.                                                          BEAM5520
      D1=1.2/DL                                                          BEAM5530
      D2=0.13333333*DL                                                   BEAM5540
      D3=0.03333333*DL                                                   BEAM5550
      D4=0.1                                                             BEAM5560
      S(2,2)=D1                                                          BEAM5570
      S(3,3)=D1                                                          BEAM5580
      S(5,5)=D2                                                          BEAM5590
      S(6,6)=D2                                                          BEAM5600
      DO 11 I=2,6                                                        BEAM5610
   11 S(I+6,I+6)=S(I,I)                                                  BEAM5620
      S(2,6)=D4                                                          BEAM5630
      S(2,8)=-D1                                                         BEAM5640
      S(2,12)=D4                                                         BEAM5650
      S(3,5)=-D4                                                         BEAM5660
      S(3,9)=-D1                                                         BEAM5670
      S(3,11)=-D4                                                        BEAM5680
      S(5,9)=D4                                                          BEAM5690
      S(5,11)=-D3                                                        BEAM5700
      S(6,8)=-D4                                                         BEAM5710
      S(6,12)=-D3                                                        BEAM5720
      S(8,12)=-D4                                                        BEAM5730
      S(9,11)=D4                                                         BEAM5740
```

```
      DO 20 I=2,12                                                      BEAM5750
      II=I-1                                                            BEAM5760
      DO 20 J=1,II                                                      BEAM5770
   20 S(I,J)=S(J,I)                                                     BEAM5780
C*********************************************************************BEAM5790
C-----MODIFY S(I,J) FOR ZERO END FORCES                                 BEAM5800
C*********************************************************************BEAM5810
      DO 140 I=1,12                                                     BEAM5820
      IF(JC(I).LE.0) GO TO 140                                          BEAM5830
      SI=S(I,I)                                                         BEAM5840
      IF(SI.EQ.0.) GO TO 140                                            BEAM5850
      IF(G(I,I).EQ.0.) GO TO 140                                        BEAM5860
      DO 135 M=1,12                                                     BEAM5870
  135 R(M)=S(I,M)                                                       BEAM5880
      DO 130 M=1,12                                                     BEAM5890
      DO 130 N=1,12                                                     BEAM5900
  130 S(M,N)=S(M,N)-(G(N,I)*R(M)+G(N,I)*R(N))/G(I,I)                    BEAM5910
     1               +G(M,I)*G(N,I)*SI/(G(I,I)*G(I,I))                  BEAM5920
      DO 141 M=1,12                                                     BEAM5930
      S(I,M)=0.                                                         BEAM5940
  141 S(M,I)=0.                                                         BEAM5950
  140 CONTINUE                                                          BEAM5960
C*********************************************************************BEAM5970
C-----TRANSFORM TO GLOBAL COORDINATES                                   BEAM5980
C*********************************************************************BEAM5990
      DO 150 I=1,24                                                     BEAM6000
      DO 150 J=1,24                                                     BEAM6010
  150 G(I,J)=0.                                                         BEAM6020
      DO 250 II=1,4                                                     BEAM6030
      II=(II-1)*3                                                       BEAM6040
      DO 250 JJ=1,II                                                    BEAM6050
      JJ=(JJ-1)*3                                                       BEAM6060
      DO 260 I=1,3                                                      BEAM6070
      DO 260 K=1,3                                                      BEAM6080
      H=0.                                                              BEAM6090
      DO 270 J=1,3                                                      BEAM6100
  270 H=H+S(II+I,JJ+J)*T(J,K)                                           BEAM6110
  260 G(I,K)=H                                                          BEAM6120
      DO 280 I=1,3                                                      BEAM6130
      DO 280 K=1,3                                                      BEAM6140
      H=0.                                                              BEAM6150
      DO 290 J=1,3                                                      BEAM6160
  290 H=H+T(J,I)*G(J,K)                                                 BEAM6170
  280 G(II+I,JJ+K)=H                                                    BEAM6180
  250 CONTINUE                                                          BEAM6190
      DO 300 I=1,12                                                     BEAM6200
      DO 300 J=1,I                                                      BEAM6210
  300 G(J,I)=G(I,J)                                                     BEAM6220
      RETURN                                                            BEAM6230
      END                                                               BEAM6240
```

```
      SUBROUTINE BREAM (AOLD,ANEW,LOAD,NUMDV)                                BEAM6250
C*************************************************************************BEAM6260
C-----DESIGN OF BEAM ELEMENTS                                                BEAM6270
C*************************************************************************BEAM6280
      COMMON/JUNK/          LT,LH,L,SIG(27),IDVAR,IEX,FRC,AREA,XINERT,     BEAM6290
     1 ZEE(6),TENS,COMP,SHEAR,KSEC,SECMOD(12),JUNK(311)                     BEAM6300
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                          BEAM6310
      DELTA=0.001                                                            BEAM6320
      KMAX=6                                                                 BEAM6330
      RMAX=0.                                                                BEAM6340
      AA=AREA                                                                BEAM6350
      IF(IEX.EQ.2) AA=SQRT(AA**3)                                            BEAM6360
      IF(KSEC.GT.1) GO TO 20                                                 BEAM6370
C*************************************************************************BEAM6380
C-----SET UP SECTION MODULUS ARRAY SECMOD(I) FOR ALL                         BEAM6390
C     FOUR STRESS POINTS OF X-SECTION AT NODE I                              BEAM6400
C*************************************************************************BEAM6410
      DO 10 I=1,3                                                            BEAM6420
      SECMOD(I)=ZEE(I)*AA                                                    BEAM6430
      SECMOD(I+3)=SECMOD(I)                                                  BEAM6440
      SECMOD(I+6)=-ZEE(I+3)*AA                                               BEAM6450
   10 SECMOD(I+9)=SECMOD(I+6)                                                BEAM6460
      SECMOD(2)=-SECMOD(2)                                                   BEAM6470
      SECMOD(11)=-SECMOD(11)                                                 BEAM6480
      GO TO 25                                                               BEAM6490
C*************************************************************************BEAM6500
C-----SET UP SECMOD(I) FOR Z-SECTION OR TUBE                                 BEAM6510
C*************************************************************************BEAM6520
   20 DO 15 I=1,3                                                            BEAM6530
      SECMOD(I)=ZEE(I)*AA                                                    BEAM6540
      SECMOD(I+3)=-SECMOD(I)                                                 BEAM6550
      SECMOD(I+6)=ZEE(I+3)*AA                                                BEAM6560
   15 SECMOD(I+9)=-SECMOD(I+6)                                               BEAM6570
      SECMOD(2)=-SECMOD(2)                                                   BEAM6580
      SECMOD(5)=-SECMOD(5)                                                   BEAM6590
      IF (KSEC.NE.3) GO TO 25                                                BEAM6600
      SECMOD(8)=0.                                                           BEAM6610
      SECMOD(11)=0.                                                          BEAM6620
C*************************************************************************BEAM6630
C-----OBTAIN AXIAL FORCE X AND MOMENTS XX,YY,ZZ.                             BEAM6640
C     FIRST FOR NODE I, THEN FOR NODE J                                      BEAM6650
C*************************************************************************BEAM6660
   25 X=SIG(7)                                                               BEAM6670
      DO 30 N=1,7,6                                                          BEAM6680
      IF (N.EQ.1) GO TO 26                                                   BEAM6690
      DO 27 I=1,12                                                           BEAM6700
   27 SECMOD(I)=-SECMOD(I)                                                   BEAM6710
   26 XX=SIG(N+3)                                                            BEAM6720
      YY=SIG(N+4)                                                            BEAM6730
      ZZ=SIG(N+5)                                                            BEAM6740
C*************************************************************************BEAM6750
C-----MODIFY MOMENTS FOR TUBE                                                BEAM6760
C*************************************************************************BEAM6770
      IF (KSEC.NE.3) GO TO 40                                                BEAM6780
      YY=SQRT(YY*YY+ZZ*ZZ)                                                   BEAM6790
      ZZ=0.                                                                  BEAM6800
   40 SAXIAL=X/AREA                                                          BEAM6810
C*************************************************************************BEAM6820
C-----COMPUTE STRESSES AT FOUR STRESS POINTS IN X-SECTION                    BEAM6830
C*************************************************************************BEAM6840
```

```
      DO 35 I=1,10,3                                                    BEAM6850
      SSHEAR=0.                                                         BEAM6860
      IF (SECMOD(I).NE.0.) SSHEAR=XX/SECMOD(I)                          BEAM6870
      SBEND=0.                                                          BEAM6880
      IF (SECMOD(I+1).NE.0.) SBEND=YY/SECMOD(I+1)                       BEAM6890
      IF (SECMOD(I+2).NE.0.) SBEND=SBEND+ZZ/SECMOD(I+2)                 BEAM6900
      STOT=SAXIAL+SBEND                                                 BEAM6910
      SSTAR=TENS                                                        BEAM6920
      IF (STOT.LT.0.) SSTAR=-COMP                                       BEAM6930
C*********************************************************************BEAM6940
C-----APPLY REDESIGN EQUATIONS                                          BEAM6950
C*********************************************************************BEAM6960
      IF(IEX.EQ.2) GO TO 81                                             BEAM6970
      R=SQRT( (STOT/SSTAR)**2+(SSHEAR/SHEAR)**2)                        BEAM6980
      GO TO 82                                                          BEAM6990
   81 ITEST=1                                                           BEAM7000
      TEST=(SSHEAR/SHEAR)**2-2.0*ABS(SAXIAL*SBEND)/SSTAR**2             BEAM7010
C*********************************************************************BEAM7020
C-----CHECK IF SHEAR STRESS DOMINATES                                   BEAM7030
C*********************************************************************BEAM7040
      IF (TEST.GT.0.) ITEST=2                                           BEAM7050
      KOUNT=0                                                           BEAM7060
      RR=1.                                                             BEAM7070
      R=0.                                                              BEAM7080
      C=-SAXIAL/SSTAR                                                   BEAM7090
   85 GO TO (1,2),ITEST                                                 BEAM7100
    1 AA=(SSHEAR/SHEAR/RR**3)**2                                        BEAM7110
      IF (AA.GT.1.) AA=0.                                               BEAM7120
      A=SQRT(1.0-AA)                                                    BEAM7130
      B=-SBEND/SSTAR                                                    BEAM7140
      GO TO 70                                                          BEAM7150
    2 A=1.                                                              BEAM7160
      B=-(SBEND/SSTAR)**2+(SSHEAR/SHEAR)**2+2.0*SAXIAL*SBEND/(SSTAR**2*BEAM7170
     1SQRT(RR)))                                                        BEAM7180
   70 CALL CBRT(D,C,B,A,R)                                              BEAM7190
C*********************************************************************BEAM7200
C-----CHECK FOR CONVERGENCE                                             BEAM7210
C*********************************************************************BEAM7220
      IF (R.LT.0.000001) GO TO 80                                       BEAM7230
      DR=ABS( (R-RR)/R)                                                 BEAM7240
      IF (DR.LT.DELTA.OR.KOUNT.EQ.KMAX) GO TO 80                        BEAM7250
      KOUNT=KOUNT+1                                                     BEAM7260
      RR=R                                                              BEAM7270
      GO TO 85                                                          BEAM7280
   80 IF (ITEST.EQ.1) R=R**R                                            BEAM7290
   82 IF (R.GT.RMAX) RMAX=R                                             BEAM7300
   35 CONTINUE                                                          BEAM7310
   30 CONTINUE                                                          BEAM7320
C*********************************************************************BEAM7330
C-----RECORD NEW DESIGN VARIABLE AND CORRESPONDING LOAD CONDITION       BEAM7340
C*********************************************************************BEAM7350
      AA=RMAX*AOLD(IDVAR)                                               BEAM7360
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                    BEAM7370
      ANEW(IDVAR)=AA                                                    BEAM7380
      LOAD(IDVAR)=I                                                     BEAM7390
   60 CONTINUE                                                          BEAM7400
      RETURN                                                            BEAM7410
      END                                                               BEAM7420
```

```
      SUBROUTINE PLANE(A,MTOT)                                          PLAN0000
C*********************************************************************PLAN0010
C-----PLANE STRESS ELEMENTS                                             PLAN0020
C*********************************************************************PLAN0030
      DIMENSION A(MTOT),STRLAB(5)                                       PLAN0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,M111,NEQPLAN0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQR,NBLOCK                           PLAN0060
      COMMON/EM/MU,NW,NS,ND ,EM(5544)                                   PLAN0070
      COMMON/JUNK/          LT,LH,L,SG(20),SIG(7),IDV,IEX,ERC,AREA,XINERTPLAN0080
     1 DESTNE(333)                                                      PLAN0090
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              PLAN0100
      DATA STRLAB/3HGEN,3HL-I,3HJ-K,3HI-J,3HK-L/                        PLAN0110
      NUME=NPAR(2)                                                      PLAN0120
      KODE=NPAR(5)                                                      PLAN0130
      IF(NPAR(1).EQ.0)GO TO 500                                         PLAN0140
      N6=N5+NUMNP                                                       PLAN0150
      NUMMAT=NPAR(3)                                                    PLAN0160
      NUMTC=NPAR(4)                                                     PLAN0170
      GO TO (1,2,3),KODE                                                PLAN0180
C*********************************************************************PLAN0190
C-----UNIDIRECTIONALLY STIFFENED PANEL                                  PLAN0200
C*********************************************************************PLAN0210
    1 NUMGEO=NPAR(7)                                                    PLAN0220
      N7=N6+NUMMAT                                                      PLAN0230
      N8=N7+NUMMAT                                                      PLAN0240
      N9=N8+NUMGEO*5                                                    PLAN0250
      M10=N9+NUMMAT*NUMTC*8                                             PLAN0260
      MM=M10-MTOT                                                       PLAN0270
      IF(MM.GT.0) CALL ERROR(MM)                                        PLAN0280
      CALL PLMAX1(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),PLAN0290
     1A(N9),NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME,NUMGEO)                  PLAN0300
      RETURN                                                            PLAN0310
C*********************************************************************PLAN0320
C-----ISOTROPIC PLANE MEMBRANE                                          PLAN0330
C*********************************************************************PLAN0340
    2 N7=N6+NUMMAT                                                      PLAN0350
      N8=N7+NUMMAT                                                      PLAN0360
      N9=N8+NUMMAT*NUMTC*7                                              PLAN0370
      MM=N9-MTOT                                                        PLAN0380
      IF(MM.GT.0) CALL ERROR(MM)                                        PLAN0390
      CALL PLMAX2(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),PLAN0400
     1 NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME)                              PLAN0410
      RETURN                                                            PLAN0420
C*********************************************************************PLAN0430
C-----PROVISION FOR SPECIAL MEMBRANE ELEMENT                            PLAN0440
C*********************************************************************PLAN0450
    3 CALL NOELEM (NPAR(1),KODE,IW)                                     PLAN0460
      RETURN                                                            PLAN0470
  500 WRITE (IW,2008) KODE                                              PLAN0480
      DO 800 MM=1,NUME                                                  PLAN0490
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,0)                   PLAN0500
      WRITE (IW,2005) MM,AREA                                           PLAN0510
```

```
      IF(NS.EQ.1) GO TO 800                                                 PLAN0520
      DO 700 I=IT,LH                                                        PLAN0530
      CALL STRSC(A(M1),A(M1),A(M3),NEQ,NUMDV,LL,LR,1)                       PLAN0540
      IF(L.GT.IT) WRITE(IW,2007)                                            PLAN0550
      IT=0                                                                  PLAN0560
      DO 600 KK=1,NS,3                                                      PLAN0570
      IF(KK.GT.1) WRITE(IW,2007)                                            PLAN0580
      DO 520 I=1,3                                                          PLAN0590
  520 SIG(I)=SG(KK-1+I)                                                     PLAN0600
      IT=IT+1                                                               PLAN0610
      NP=3                                                                  PLAN0620
      IF(IT.GT.1) GO TO 530                                                 PLAN0630
      NP=6                                                                  PLAN0640
      ANG=DESINE(1)                                                         PLAN0650
      IF(ANG.NE.0.) GO TO 540                                               PLAN0660
      DO 550 I=1,3                                                          PLAN0670
  550 SIG(I+3)=SIG(I)                                                       PLAN0680
      GO TO 530                                                             PLAN0690
  540 ANG=ANG/57.2957795                                                    PLAN0700
      SI=SIN(ANG)                                                           PLAN0710
      CO=COS(ANG)                                                           PLAN0720
      SC=SI*CO                                                              PLAN0730
      SI=SI*SI                                                              PLAN0740
      CO=CO*CO                                                              PLAN0750
      X1=SIG(1)*CO+SIG(2)*SI                                                PLAN0760
      X2=2.0*SIG(3)*SC                                                      PLAN0770
      SIG(4)=X1+X2                                                          PLAN0780
      SIG(5)=X1-X2                                                          PLAN0790
      SIG(6)=(SIG(2)-SIG(1))*SC+SIG(3)*(CO-SI)                              PLAN0800
  530 GO TO (4,5,6),KODE                                                    PLAN0810
C*******************************************************************************PLAN0820
C-----DESIGN OF STIFFENED MEMBRANE ELEMENT                                  PLAN0830
C*******************************************************************************PLAN0840
    4 IF(IT.GT.1) GO TO 600                                                 PLAN0850
      CALL DPLAN1 (A(M1),A(M2),A(M3),NUMDV)                                 PLAN0860
      GO TO 600                                                             PLAN0870
C*******************************************************************************PLAN0880
C-----DESIGN OF ISOTROPIC MEMBRANE ELEMENT                                  PLAN0890
C*******************************************************************************PLAN0900
    5 CALL DPLAN2(A(M1),A(M2),A(M3),NUMDV)                                  PLAN0910
      GO TO 600                                                             PLAN0920
C*******************************************************************************PLAN0930
C-----PROVISION FOR DESIGN OF SPECIAL MEMBRANE ELEMENT                      PLAN0940
C*******************************************************************************PLAN0950
    6 CONTINUE                                                              PLAN0960
  600 WRITE (IW,2009) L,STRLAB(IT),(SIG(I),I=1,NP)                          PLAN0970
  700 CONTINUE                                                              PLAN0980
  800 CONTINUE                                                              PLAN0990
C*******************************************************************************PLAN1000
      RETURN                                                                PLAN1010
 2005 FORMAT(1X,I5,F14.4)                                                   PLAN1020
 2008 FORMAT(//45H ANALYSIS OF MEMBRANE ELEMENTS. CONSTRN CODE=,I12//       PLAN1030
     1117H              SHEET     LOAD              /---MEMBRANE FORCES IN PLAN1040
     2LOCAL COORDS---//--MEMBRANE FORCES IN MATERIAL COORDS-/    /          PLAN1050
     3117H ELEMENT    THICKNESS    COND  LOCATION          NXX           NYY PLAN1060
     4          NXY           M11           M22           M12        /)     PLAN1070
 2009 FORMAT(11H+,20X,I5,6X,A3,4X,6E13.4)                                   PLAN1080
 2007 FORMAT(/)                                                             PLAN1090
      END                                                                   PLAN1100
```

```
      SUBROUTINE PLAW(BETA)                                                  PLAN1110
C*************************************************************************PLAN1120
C-----STRESS /STRAIN RELATION MATRIX                                         PLAN1130
C*************************************************************************PLAN1140
      IMPLICIT REAL*8 (A-H,O-Z)                                              PLAN1150
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),D(3,3),XX(4),YY(4),ZZ(4),TMP(4),PLAN1160
     1 ALP(3),TTT(3),PRESS,PEET,MS,NSG(3),T(3,3),DD(3,3),JUNK(214)          PLAN1170
      IF (BETA.EQ.0.0) GO TO 500                                             PLAN1180
      ANG=BETA/57.2957795                                                    PLAN1190
      SS=DSIN(ANG)                                                           PLAN1200
      CO=DCOS(ANG)                                                           PLAN1210
      C2=CO*CO                                                               PLAN1220
      S2=SS*SS                                                               PLAN1230
      SC=SS*CO                                                               PLAN1240
C*************************************************************************PLAN1250
C-----SET D FOR SIG(O)=D*SIG(G)                                              PLAN1260
C*************************************************************************PLAN1270
      T(1,1)=C2                                                              PLAN1280
      T(1,2)=S2                                                              PLAN1290
      T(1,3)=2.*SC                                                           PLAN1300
      T(2,1)=S2                                                              PLAN1310
      T(2,2)=C2                                                              PLAN1320
      T(2,3)=-2.*SC                                                          PLAN1330
      T(3,1)=-SC                                                             PLAN1340
      T(3,2)=SC                                                              PLAN1350
      T(3,3)=C2-S2                                                           PLAN1360
      DO 300 I=1,3                                                           PLAN1370
      DO 300 J=1,3                                                           PLAN1380
      SUM=0.                                                                 PLAN1390
      DO 280 M=1,3                                                           PLAN1400
  280 SUM=SUM+T(M,I)*D(M,J)                                                  PLAN1410
  300 DD(I,J)=SUM                                                            PLAN1420
      DO 350 I=1,3                                                           PLAN1430
      DO 350 J=1,3                                                           PLAN1440
      SUM=0.                                                                 PLAN1450
      DO 330 M=1,3                                                           PLAN1460
  330 SUM=SUM+DD(I,M)*T(M,J)                                                 PLAN1470
      D(I,J)=SUM                                                             PLAN1480
  350 D(J,I)=SUM                                                             PLAN1490
      A1=ALP(1)                                                              PLAN1500
      A2=ALP(2)                                                              PLAN1510
      ALP(1)=C2*A1+S2*A2                                                     PLAN1520
      ALP(2)=S2*A1+C2*A2                                                     PLAN1530
      ALP(3)=2.0*SC*(A1-A2)                                                  PLAN1540
  500 CALL PDSINV(D)                                                         PLAN1550
      DO 670 I=1,3                                                           PLAN1560
      TTT(I)=0.                                                              PLAN1570
      DO 670 M=1,3                                                           PLAN1580
  670 TTT(I)=TTT(I)+D(I,M)*ALP(M)                                            PLAN1590
      RETURN                                                                 PLAN1600
      END                                                                    PLAN1610
```

```
      SUBROUTINE QUAD(RHO,THICK)                                        PLAN1620
C*********************************************************************PLAN1630
C-----FORM ELEMENT MATRICES                                             PLAN1640
C*********************************************************************PLAN1650
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN1660
      COMMON/EM/LM(12),S(12,12),P1(12,4),P2(12,4),XM(12),ST(15,12),     PLAN1670
     1 TT(15,4),G1(12,12),G2(12,12),G3(12,12),BB(12,12),EML(1700)       PLAN1680
      COMMON/LINK/IE(4),IX(4),EMU(4,5),D(3,3),X(4),Y(4),Z(4),TM(4),EL   PLAN1690
     1 ALP(3),TT1(3),PRESS,REET,NS,NSG(3),BR(4),ZZ(4),PP1(12),          PLAN1700
     2 U(4),V(4),W(4),H(6),HP(6),HZ(6),EAC,G(4),F(4),JUN(132)           PLAN1710
      COMMON/ELPAR/NPAR(14),TELP(19)                                    PLAN1720
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                PLAN1730
      DIMENSION SS(2),SSS(5),IEE(5),IVECT(4),JVECT(4),EMM(1068)         PLAN1740
      EQUIVALENCE (S,EMM)                                               PLAN1750
      DATA SS/-0.57735026918963,0.57735026918963/                       PLAN1760
      DATA SSS/0.,-1.,1.,0.,0./, TT1/0.,0.,0.,-1.,1./                   PLAN1770
      DATA IVECT/4,2,1,3/,JVECT/1,3,2,4/                                PLAN1780
      DO 10 I=1,1068                                                    PLAN1790
   10 EMM(I)=0.                                                         PLAN1800
      DO 20 I=1,12                                                      PLAN1810
   20 PP1(I)=0.                                                         PLAN1820
C*********************************************************************PLAN1830
C-----COMPUTE ELEMENT AXES SYSTEM AND CORNER COORDINATES                PLAN1840
C*********************************************************************PLAN1850
      CALL VECTOR(U,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                      PLAN1860
      CALL VECTOR(E,X(1),Y(1),Z(1),X(4),Y(4),Z(4))                      PLAN1870
      CALL CROSS(U,E,W)                                                 PLAN1880
      CALL CROSS(W,U,V)                                                 PLAN1890
      CALL VECTOR(G,X(1),Y(1),Z(1),X(3),Y(3),Z(3))                      PLAN1900
      BR(1)=0.0                                                         PLAN1910
      ZZ(1)=0.0                                                         PLAN1920
      BR(2)=U(4)                                                        PLAN1930
      ZZ(2)=0.0                                                         PLAN1940
      BR(3)=G(4)*DOT(G,U)                                               PLAN1950
      ZZ(3)=G(4)*DOT(G,V)                                               PLAN1960
      BR(4)=E(4)*DOT(E,U)                                               PLAN1970
      ZZ(4)=E(4)*DOT(E,V)                                               PLAN1980
C*********************************************************************PLAN1990
C-----FORM UNIT STIFFNESS MATRIX , THERMAL LOAD VECTOR AND MASS MATRIX  PLAN2000
C*********************************************************************PLAN2010
      DO 500 II=1,2                                                     PLAN2020
      DO 500 JJ=1,2                                                     PLAN2030
      CALL FORMBB(SS(II),SS(JJ),BB)                                     PLAN2040
      ETP=H(1)*TM(1)+H(2)*TM(2)+H(3)*TM(3)+H(4)*TM(4)-REET              PLAN2050
      DO 400 J=1,12                                                     PLAN2060
      B1=BB(1,J)*EAC                                                    PLAN2070
      B2=BB(2,J)*EAC                                                    PLAN2080
      B3=BB(3,J)*EAC                                                    PLAN2090
      D1=D(1,1)*B1+D(1,2)*B2+D(1,3)*B3                                  PLAN2100
      D2=D(2,1)*B1+D(2,2)*B2+D(2,3)*B3                                  PLAN2110
      D3=D(3,1)*B1+D(3,2)*B2+D(3,3)*B3                                  PLAN2120
      PP1(J)=PP1(J)+ETP*(D1*ALP(1)+D2*ALP(2)+D3*ALP(3))                 PLAN2130
      DO 400 I=J,12                                                     PLAN2140
      S(I,J)=S(I,J)+BB(1,I)*D1+BB(2,I)*D2+BB(3,I)*D3                    PLAN2150
  400 S(J,I)=S(I,J)                                                     PLAN2160
      DO 450 I=1,4                                                      PLAN2170
  450 XM(I)=XM(I)+EAC*THICK*H(I)                                        PLAN2180
      IF(LBUCK.EQ.0) GO TO 500                                          PLAN2190
C*********************************************************************PLAN2200
C-----FORM UNIT GEOMETRIC STIFFNESS MATRICES                            PLAN2210
```

```
C*****************************************************************************PLAN2220
      DO 850 I=1,4                                                              PLAN2230
      DO 850 J=1,4                                                              PLAN2240
      I4=I+4                                                                    PLAN2250
      J4=J+4                                                                    PLAN2260
      I8=I+8                                                                    PLAN2270
      J8=J+8                                                                    PLAN2280
      XX=HR(I)*HR(J)*FAC                                                        PLAN2290
      YY=HZ(I)*HZ(J)*FAC                                                        PLAN2300
      XY=HR(I)*HZ(J)*FAC                                                        PLAN2310
      YX=HZ(I)*HR(J)*FAC                                                        PLAN2320
      G1(I,J)=G1(I,J)+YY                                                        PLAN2330
      G1(I,J4)=G1(I,J4)-YX                                                      PLAN2340
      G1(J4,I)=G1(I,J4)                                                         PLAN2350
      G1(I4,J4)=G1(I4,J4)+XX                                                    PLAN2360
      G1(I8,J8)=G1(I8,J8)+XX                                                    PLAN2370
      G2(I8,J8)=G2(I8,J8)+YY                                                    PLAN2380
  850 G3(I8,J8)=G3(I8,J8)+XY+YX                                                 PLAN2390
  500 CONTINUE                                                                  PLAN2400
      IF(IBUCK.EQ.0) GO TO 900                                                  PLAN2410
      DO 950 I=1,8                                                              PLAN2420
      DO 950 J=1,8                                                              PLAN2430
      G1(I,J)=G1(I,J)*.25                                                       PLAN2440
  950 G2(I,J)=G1(I,J)                                                           PLAN2450
      CALL PLANCT (G1,BB,U,V,W)                                                 PLAN2460
      CALL PLANCT (G2,BB,U,V,W)                                                 PLAN2470
      CALL PLANCT (G3,BB,U,V,W)                                                 PLAN2480
C*****************************************************************************PLAN2490
C-----FORM STRESS DISPLACEMENT MATRIX                                           PLAN2500
C*****************************************************************************PLAN2510
  900 LL=NS/3                                                                   PLAN2520
      DO 530 L=1,LL                                                             PLAN2530
      CALL FORMB(SSS(L),TTT(L),BB)                                              PLAN2540
      ETP=H(1)*TM(1)+H(2)*TM(2)+H(3)*TM(3)+H(4)*TM(4)-REFT                      PLAN2550
      DO 530 II=1,3                                                             PLAN2560
      I=II+3*(L-1)                                                              PLAN2570
      TT(I,4)=-TTT(II)*ETP                                                      PLAN2580
      DO 530 J=1,12                                                             PLAN2590
      DO 530 K=1,3                                                              PLAN2600
  530 ST(I,J)=ST(I,J)+D(II,K)*BB(K,J)                                           PLAN2610
C*****************************************************************************PLAN2620
C-----ELIMINATE EXTRA DEGREES OF FREEDOM                                        PLAN2630
C*****************************************************************************PLAN2640
      IF ( IX(3) .EQ. IX(4) ) GO TO 560                                         PLAN2650
      IF(NPAR(6).NE.0) GO TO 560                                                PLAN2660
      DO 550 NN=1,4                                                             PLAN2670
      L=12-NN                                                                   PLAN2680
      K=L+1                                                                     PLAN2690
      C=PP1(K)/S(K,K)                                                           PLAN2700
      DO 535 J=1,NS                                                             PLAN2710
  535 TT(J,4)=TT(J,4)+C*ST(J,K)                                                 PLAN2720
      DO 550 I=1,L                                                              PLAN2730
      C=S(I,K)/S(K,K)                                                           PLAN2740
      PP1(I)=PP1(I)-C*PP1(K)                                                    PLAN2750
      DO 540 J=1,NS                                                             PLAN2760
  540 ST(J,I)=ST(J,I)-C*ST(J,K)                                                 PLAN2770
      DO 550 J=1,L                                                              PLAN2780
  550 S(I,J)=S(I,J)-C*S(K,J)                                                    PLAN2790
C*****************************************************************************PLAN2800
C-----ROTATE STRESS-DISPLACEMENT TRANSFORMATION TO GIVE STRESSES                PLAN2810
```

```
C     NORMAL AND PARALLEL TO SIDES - SIMILARLY ROTATE INITIAL STRESSES PLAN2820
C*************************************************************************PLAN2830
  560 NSET=LL-1                                                           PLAN2840
      IF ( NSET .LE. 0 ) GO TO 730                                        PLAN2850
      DO 720 L=1,NSET                                                     PLAN2860
      IV=IVEC(L)                                                          PLAN2870
      JV=JVEC(L)                                                          PLAN2880
      CALL VECTORIG(RR(IV),ZZ(IV),0.000,RR(JV),ZZ(JV),0.000)             PLAN2890
      S2=G(1)*G(1)                                                        PLAN2900
      C2=G(2)*G(2)                                                        PLAN2910
      SC=-G(1)*G(2)                                                       PLAN2920
      I1=3*L+1                                                            PLAN2930
      I2=I1+1                                                             PLAN2940
      I3=I1+2                                                             PLAN2950
      T1=TT(I1,4)                                                         PLAN2960
      T2=TT(I2,4)                                                         PLAN2970
      T3=TT(I3,4)                                                         PLAN2980
      T4=2.0*SC*T3                                                        PLAN2990
      TT(I1,4)=C2*T1+S2*T2+T4                                             PLAN3000
      TT(I2,4)=S2*T1+C2*T2-T4                                             PLAN3010
      TT(I3,4)=SC*(T2-T1)+(C2-S2)*T3                                      PLAN3020
      DO 710 J=1,8                                                        PLAN3030
      B1=ST(I1,J)                                                         PLAN3040
      B2=ST(I2,J)                                                         PLAN3050
      B3=ST(I3,J)                                                         PLAN3060
      B4=2.0*SC*B3                                                        PLAN3070
      ST(I1,J)=C2*B1+S2*B2+B4                                             PLAN3080
      ST(I2,J)=S2*B1+C2*B2-B4                                             PLAN3090
  710 ST(I3,J)=SC*(B2-B1)+(C2-S2)*B3                                      PLAN3100
  720 CONTINUE                                                            PLAN3110
  730 IF(MPAR(5).NE.2) GO TO 150                                          PLAN3120
C*************************************************************************PLAN3130
C-----CALCULATE PRESSURE LOADS ON I-J FACE IN GLOBAL COORDINATES         PLAN3140
C*************************************************************************PLAN3150
      XX=0.5*PRESS*RR(2)                                                  PLAN3160
      DO 185 I=1,3                                                        PLAN3170
      II=(I-1)*4+1                                                        PLAN3180
      DO 185 L=1,4                                                        PLAN3190
      P2(II,L)=XX*V(I)*EMIL(L,2)                                          PLAN3200
  185 P2(II+1,L)=P2(II,1)                                                 PLAN3210
C*************************************************************************PLAN3220
C-----COORDINATE TRANSFORMATION                                           PLAN3230
C*************************************************************************PLAN3240
  150 DO 190 I=1,3                                                        PLAN3250
      DO 190 K=1,4                                                        PLAN3260
      KK=4*(I-1)+K                                                        PLAN3270
      DO 180 J=I,3                                                        PLAN3280
      DO 180 L=1,4                                                        PLAN3290
      LL=4*(J-1)+L                                                        PLAN3300
  180 RR(KK,LL)=U(I)*(S(K  ,L)*U(J)+S(K  ,L+4)*V(J))+                     PLAN3310
     1            V(I)*(S(K+4,L)*U(J)+S(K+4,L+4)*V(J))                   PLAN3320
      X1=U(I)*PP1(K)+V(I)*PP1(K+4)                                        PLAN3330
      DO 190 L=1,4                                                        PLAN3340
  190 P1(KK,L)=X1*EMIL(L,1)                                               PLAN3350
      DO 195 I=1,12                                                       PLAN3360
      DO 195 J=I,12                                                       PLAN3370
      S(I,J)=RR(I,J)                                                      PLAN3380
  195 S(J,I)=S(I,J)                                                       PLAN3390
      DO 210 K=1,NS                                                       PLAN3400
      DO 200 I=1,4                                                        PLAN3410
```

```
      DO 200 J=1,3                                                      PL AN3420
      LL=4*(J-1)+L                                                      PL AN3430
  200 PP1(LL)=ST(K,L)*U(J)+ST(K,L+4)*V(J)                               PL AN3440
      DO 210 J=1,12                                                     PL AN3450
  210 ST(K,J)=PP1(J)                                                    PL AN3460
      DO 220 I=1,4                                                      PL AN3470
      XX=XM(I)*RHO                                                      PL AN3480
      DO 220 L=1,4                                                      PL AN3490
      P1(I  ,L)=P1(I  ,L)+XX*EMUL(L,3)                                  PL AN3500
      P1(I+4,L)=P1(I+4,L)+XX*EMUL(L,4)                                  PL AN3510
  220 P1(I+8,L)=P1(I+8,L)+XX*EMUL(L,5)                                  PL AN3520
      DO 600 L=1,4                                                      PL AN3530
      DO 600 I=1,NS                                                     PL AN3540
  600 TT(I,L)=TT(I,4)*EMUL(L,1)                                         PL AN3550
      RETURN                                                            PL AN3560
      END                                                               PL AN3570
```

```
      DO 200 J=1,3                                                      PLAN3420
      LL=4*(J-1)+L                                                      PLAN3430
  200 PP1(LL)=ST(K,L)*U(J)+ST(K,L+4)*V(J)                               PLAN3440
      DO 210 J=1,12                                                     PLAN3450
  210 ST(K,J)=PP1(J)                                                    PLAN3460
      DO 220 I=1,4                                                      PLAN3470
      XX=XM(I)*RHO                                                      PLAN3480
      DO 220 L=1,4                                                      PLAN3490
      P1(I  ,L)=P1(I  ,L)+XX*EMUL(L,3)                                  PLAN3500
      P1(I+4,L)=P1(I+4,L)+XX*EMUL(L,4)                                  PLAN3510
  220 P1(I+8,L)=P1(I+8,L)+XX*EMUL(L,5)                                  PLAN3520
      DO 600 L=1,4                                                      PLAN3530
      DO 600 I=1,NS                                                     PLAN3540
  600 TT(I,L)=TT(I,4)*EMUL(L,1)                                         PLAN3550
      RETURN                                                            PLAN3560
      END                                                               PLAN3570
```

```
      SUBROUTINE PLANCT(S,B ,U,V,W)                                     PLAN3580
C*********************************************************************PLAN3590
C-----COORDINATE TRANSFORMATION OF STIFFNESS MATRIX FOR MEMBRANE ELEMENTPLAN3600
C*********************************************************************PLAN3610
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN3620
      DIMENSION S(12,12),B (12,12),U(4),V(4),W(4)                       PLAN3630
      DO 190 I=1,3                                                      PLAN3640
      DO 190 K=1,4                                                      PLAN3650
      KK=4*(I-1)+K                                                      PLAN3660
      DO 190 J=I,3                                                      PLAN3670
      DO 190 L=1,4                                                      PLAN3680
      LL=4*(J-1)+L                                                      PLAN3690
  190 B(KK,LL)=U(I)*(S(K  ,L )*U(J)+S(K  ,L+4)*V(J))+                   PLAN3700
     1          V(I)*(S(K+4,L)*U(J)+S(K+4,L+4)*V(J))+W(I)*S(K+8,L+8)*W(J)PLAN3710
      DO 196 I=1,12                                                     PLAN3720
      DO 196 J=I,12                                                     PLAN3730
      S(I,J)=B(I,J)                                                     PLAN3740
  196 S(J,I)=S(I,J)                                                     PLAN3750
      RETURN                                                            PLAN3760
      END                                                               PLAN3770
```

```
      SUBROUTINE POSINV(A)                                              PLAN3780
C*********************************************************************PLAN3790
C                                                                       PLAN3800
C*********************************************************************PLAN3810
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN3820
      DIMENSION A(3,3)                                                  PLAN3830
      DO 200 N=1,3                                                      PLAN3840
      D=A(N,N)                                                          PLAN3850
      DO 100 J=1,3                                                      PLAN3860
  100 A(N,J)=-A(N,J)/D                                                  PLAN3870
      DO 150 I=1,3                                                      PLAN3880
      IF(N-I) 110,150,110                                               PLAN3890
  110 DO 140 J=1,3                                                      PLAN3900
      IF(N-J) 120,140,120                                               PLAN3910
  120 A(I,J)=A(I,J)+A(I,N)*A(N,J)                                       PLAN3920
  140 CONTINUE                                                          PLAN3930
  150 A(I,N)=A(I,N)/D                                                   PLAN3940
      A(N,N)=1.0/D                                                      PLAN3950
  200 CONTINUE                                                          PLAN3960
      RETURN                                                            PLAN3970
      END                                                               PLAN3980
```

```
      SUBROUTINE FORMB(S,T,B)                                           PLAN3990
C*********************************************************************PLAN4000
C-----FORM SHAPE-FUNCTION DERIVATIVES AND STRAIN-DISPLACEMENT  MATRIX   PLAN4010
C*********************************************************************PLAN4020
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN4030
      DIMENSION B(12,12),II(6),JJ(6)                                    PLAN4040
      COMMON/JUNK/IE(4),X(4),EMIL(4,5),D(3,3),X (4),Y (4),Z (4),TMP(4), PLAN4050
     1 ALP(3),TTI(3),PRESS,REFT,NS,NSG(3),RR(4),ZZ(4),PPI(12),          PLAN4060
     2 U(4),V(4),W(4),H(6),HR(6),HZ(6),XJ,HS(6),HT(6),JUN(124)          PLAN4070
      DATA II/1,2,3,4,9,10/,JJ/5,6,7,8,11,12/                           PLAN4080
      SM=1.0-S                                                          PLAN4090
      SP=1.0+S                                                          PLAN4100
      TM=1.0-T                                                          PLAN4110
      TP=1.0+T                                                          PLAN4120
      H(1)=SM*TM*.25                                                    PLAN4130
      H(2)=SP*TM*.25                                                    PLAN4140
      H(3)=SP*TP*.25                                                    PLAN4150
      H(4)=SM*TP*.25                                                    PLAN4160
      H(5)=(1.0-S*S)                                                    PLAN4170
      H(6)=(1.0-T*T)                                                    PLAN4180
      HS(1)=-TM*.25                                                     PLAN4190
      HS(2)=-HS(1)                                                      PLAN4200
      HS(3)=TP*.25                                                      PLAN4210
      HS(4)=-HS(3)                                                      PLAN4220
      HS(5)=-2.*S                                                       PLAN4230
      HS(6)=0.0                                                         PLAN4240
      HT(1)=-SM*.25                                                     PLAN4250
      HT(2)=-SP*.25                                                     PLAN4260
      HT(3)=-HT(2)                                                      PLAN4270
      HT(4)=-HT(1)                                                      PLAN4280
      HT(5)=0.0                                                         PLAN4290
      HT(6)=-2.*T                                                       PLAN4300
      PZT=HT(3)*ZZ(3)+HT(4)*ZZ(4)                                       PLAN4310
      PZS=HS(3)*ZZ(3)+HS(4)*ZZ(4)                                       PLAN4320
      PRS=HS(2)*RR(2)+HS(3)*RR(3)+HS(4)*RR(4)                           PLAN4330
      PRT=HT(2)*RR(2)+HT(3)*RR(3)+HT(4)*RR(4)                           PLAN4340
      IF(DABS(ZZ(3)-ZZ(4)).LE.1.0E-10) PZS=0.                           PLAN4350
      IF(DABS(RR(2)-RR(3)).LE.1.0E-10.AND.DABS(RR(4)).LE.1.0E-10) PRT=0.PLAN4360
      XJ=PRS*PZT-PRT*PZS                                                PLAN4370
      PSR=PZT/XJ                                                        PLAN4380
      PTR=-PZS/XJ                                                       PLAN4390
      PSZ=-PRT/XJ                                                       PLAN4400
      PTZ=PRS/XJ                                                        PLAN4410
      DO 100 I=1,6                                                      PLAN4420
      HR(I)=PSR*HS(I)+PTR*HT(I)                                         PLAN4430
  100 HZ(I)=PSZ*HS(I)+PTZ*HT(I)                                         PLAN4440
C*********************************************************************PLAN4450
C-----FORM STRAIN DISPLACEMENT MATRIX                                   PLAN4460
C*********************************************************************PLAN4470
      DO 200 K=1,6                                                      PLAN4480
      I=II(K)                                                           PLAN4490
      J=JJ(K)                                                           PLAN4500
      B(1,I)=HR(K)                                                      PLAN4510
      B(2,J)=HZ(K)                                                      PLAN4520
      B(3,I)=HZ(K)                                                      PLAN4530
  200 B(3,J)=HR(K)                                                      PLAN4540
      RETURN                                                            PLAN4550
      END                                                               PLAN4560
```

```
      SUBROUTINE PLNAX1(HWT,ID,X,Y,Z,T,NTC,WT,PGEO,PMAT,NUMDV,NUMNP,     PLAN4570
     1NUMMAT,NUMTC,KODE,NUME,NUMGEO)                                     PLAN4580
C*********************************************************************PLAN4590
C-----STIFFENED MEMBRANE ELEMENT                                        PLAN4600
C*********************************************************************PLAN4610
      IMPLICIT REAL*8 (A-H,O-Z)                                          PLAN4620
      REAL*4 HWT,X,Y,Z,T,PGEO,WT,PMAT,BET,E4,E5,E6,E7,SBC,PBC,GBC,ERC    PLAN4630
      DIMENSION HWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),       PLAN4640
     1 T(NUMNP),NTC(NUMMAT),WT(NUMMAT),PGEO(NUMMAT,5),                   PLAN4650
     2 PMAT(NUMTC,8,NUMMAT)                                              PLAN4660
      COMMON/EM/ELM(12),S(12,12),P1(12,4),P2(12,4),XM(12),ST(15,12),     PLAN4670
     1 TT(15,4),G(12,12,3),BB(12,12),EM(1700)                            PLAN4680
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),C(3,3),XX(4),YY(4),ZZ(4),IMP(4),PLAN4690
     1 ALP(3),TTI(3),PRESS,BET,NS,NSG(3),X1,X2,X3,X4,Y1,Y2,Y3,Y4,FE(7),PLAN4700
     2 JUN(204)                                                          PLAN4710
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                 PLAN4720
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13               PLAN4730
C*********************************************************************PLAN4740
C-----CONTROL INFORMATION                                               PLAN4750
C*********************************************************************  PLAN4760
      MU=1                                                               PLAN4770
      NV=1                                                               PLAN4780
      ND=12                                                              PLAN4790
      MN=1                                                               PLAN4800
      NT=9                                                               PLAN4810
      IEX=3                                                              PLAN4820
      NG=3                                                               PLAN4830
      DO 5 I=1,3                                                         PLAN4840
    5 NSG(I)=I                                                           PLAN4850
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMGEO,NUMTC                        PLAN4860
      WRITE(IW,2019)                                                     PLAN4870
      DO 60 M=1,NUMMAT                                                   PLAN4880
      READ(IR,1010) N,NTC(N),WT(N)                                       PLAN4890
      IF(NTC(N).LE.0) NTC(N)=1                                           PLAN4900
      WRITE(IW,2020) N,NTC(N),WT(N)                                      PLAN4910
C*********************************************************************PLAN4920
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                         PLAN4930
C*********************************************************************PLAN4940
      NT=NTC(N)                                                          PLAN4950
      READ(IR,1005) ( (PMAT(I,J,N),J=1,8),I=1,NT)                        PLAN4960
      DO 10 I=1,NT                                                       PLAN4970
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                      PLAN4980
      IF(PMAT(I,7,NT).LE.0.) PMAT(I,7,N)=PMAT(I,5,N)*0.577               PLAN4990
      IF(PMAT(I,8,NT).LE.0.) PMAT(I,8,N)=PMAT(I,6,N)                     PLAN5000
   10 CONTINUE                                                           PLAN5010
   60 WRITE(IW,2010) ( (PMAT(I,J,N),J=1,8),I=1,NT)                       PLAN5020
C*********************************************************************PLAN5030
C-----GEOMETRIC PROPERTY CARDS                                          PLAN5040
C*********************************************************************PLAN5050
      WRITE(IW,2011)                                                     PLAN5060
      DO 70 I=1,NUMGEO                                                   PLAN5070
      READ(IR,1006) N,TH,W,SA,SI,D,WE                                    PLAN5080
      IF(WE.LE.0.) WE=W                                                  PLAN5090
      PGEO(N,1)=1.0+SA/(W*TH)                                            PLAN5100
      PGEO(N,2)=W/TH                                                     PLAN5110
      PGEO(N,3)=WE/TH                                                    PLAN5120
      DB=SA*D/(W*TH+SA)                                                  PLAN5130
      BI=W*TH**3/12.0+W*TH*DB*DB+SI+SA*(D/PGEO(N,1))**2                  PLAN5140
      PGEO(N,4)=BI/TH**4                                                 PLAN5150
      C1=12.0*SI*0.925/(W*TH**3)                                         PLAN5160
```

```
      C2=SA*D*D/SI                                                      PLAN5170
      C3=1.0+C2/(0.88*PGEO(N,1)+0.12)                                   PLAN5180
      PGEO(N,5)=2.0*PGEO(N,2)**2*(DSQRT(1.0+C1*C3)+1.0)                 PLAN5190
   70 WRITE(IW,2012) N,TH,W,SA,SI,D,WF                                  PLAN5200
C*********************************************************************PLAN5210
C-----ELEMENT LOAD MULTIPLIERS                                          PLAN5220
C*********************************************************************PLAN5230
      DO 131 I=1,4                                                      PLAN5240
      READ(IR,1002) EMUL(I,1),(EMUL(I,J),J=3,5)                         PLAN5250
  131 EMUL(I,2)=0.                                                      PLAN5260
      WRITE(IW,2004)(EMUL(I,1),(EMUL(I,J),J=3,5) ,I=1,4)                PLAN5270
C*********************************************************************PLAN5280
C-----ELEMENT CARDS                                                     PLAN5290
C*********************************************************************PLAN5300
      WRITE (6,2002)                                                    PLAN5310
      N=1                                                               PLAN5320
  130 READ(IR,1003) IEL,IE,IMAT,IDV,ERC,REET,AA,AR,BETA,EEC,NS,INC      PLAN5330
      IF (ERC.LE.0.) ERC=1.                                             PLAN5340
      IF (EEC.LE.0) EEC=1.                                              PLAN5350
      IF(INC.EQ.0) INC=1                                                PLAN5360
      IF(NS.EQ.0) NS=2                                                  PLAN5370
      IF(NS.LT.3) NS=1                                                  PLAN5380
      IF( (IE(3) .EQ. IE(4)) .AND. (NS.EQ. 15) ) NS=12                  PLAN5390
      ANG=BETA/57.2957795                                               PLAN5400
      RHO=WI(IMAT)                                                      PLAN5410
      THICK=PGEO(IMAT,1)                                                PLAN5420
      BET=BETA                                                          PLAN5430
      KK=INC*(IEL-N)                                                    PLAN5440
      DO 142 I=1,4                                                      PLAN5450
  142 IX(I)=IE(I)-KK                                                    PLAN5460
      DO 500 NEL=N,IEL                                                  PLAN5470
      TEMP=0.                                                           PLAN5480
      DO 501 I=1,4                                                      PLAN5490
      II=IX(I)                                                          PLAN5500
      TEMP=TEMP+T(II)*0.25                                              PLAN5510
      XX(I)=X(II)                                                       PLAN5520
      YY(I)=Y(II)                                                       PLAN5530
  501 ZZ(I)=Z(II)                                                       PLAN5540
C*********************************************************************PLAN5550
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   PLAN5560
C*********************************************************************PLAN5570
      CALL INTERP(PMAT,EE,NUMTC,NUMMAT,8,7,NTC(IMAT),IMAT,TEMP)         PLAN5580
      E4=EE(4)                                                          PLAN5590
      E5=EE(5)                                                          PLAN5600
      E6=EE(6)                                                          PLAN5610
      E7=EE(7)                                                          PLAN5620
      C1=EE(1)*9.8696                                                   PLAN5630
      C2=C1/(3.0*(1.0-EE(2)**2))                                        PLAN5640
C*********************************************************************PLAN5650
C-----FORM CONSTITUTIVE LAW AND COMPUTE THERMAL STRESSES                PLAN5660
C*********************************************************************PLAN5670
      DO 265 I=1,3                                                      PLAN5680
      DO 265 J=1,3                                                      PLAN5690
  265 C(I,J)=0.                                                         PLAN5700
      C(2,2)=1.0/EE(1)                                                  PLAN5710
      C(1,1)=C(2,2)/THICK                                               PLAN5720
      C(1,2)=-C(1,1)*EE(2)                                              PLAN5730
      C(2,1)=C(1,2)                                                     PLAN5740
      C(3,3)=C(2,2)*2.0*(1.0+EE(2))                                     PLAN5750
      ALP(1)=EE(3)                                                      PLAN5760
```

```
      ALP(2)=FF(3)                                                          PLAN5770
      ALP(3)=0.                                                             PLAN5780
      CALL FLAW(BETA)                                                       PLAN5790
C*************************************************************************PLAN5800
C-----FORM ELEMENT LOCATION MATRIX AND COMPUTE ELEMENT MATRICES             PLAN5810
C*************************************************************************PLAN5820
      DO 170 I=1,4                                                          PLAN5830
      II=IX(I)                                                              PLAN5840
      TMP(I)=T(II)                                                          PLAN5850
      LM(I)=ID(II,1)                                                        PLAN5860
      LM(I+4)=ID(II,2)                                                      PLAN5870
  170 LM(I+8)=ID(II,3)                                                      PLAN5880
      CALL QUAD(RHO,THICK)                                                  PLAN5890
      AREA=XM(1)+XM(2)+XM(3)+XM(4)                                          PLAN5900
      UWT(IDV)=UWT(IDV)+AREA*RHO*FRC                                        PLAN5910
C*************************************************************************PLAN5920
C-----COMPUTE ELEMENT DESIGN INFORMATION                                    PLAN5930
C*************************************************************************PLAN5940
      IF(AA.LE.0)AA=.5*((X2+X3-X1-X4)*DCOS(ANG)-(Y2+Y3-Y1-Y4)*DSIN(ANG))PLAN5950
      IF(AB.LE.0)AB=.5*((X3+X4-X1-X2)*DSIN(ANG)+(Y3+Y4-Y1-Y2)*DCOS(ANG))PLAN5960
      SBC=C1*FFC*PGED(IMAT,4)/(AA*AA*PGED(IMAT,2))                          PLAN5970
      PBC=C2*THICK/ PGED(IMAT,3)**2                                         PLAN5980
      GBC=C2*0.25*PGED(IMAT,5)/AB**4                                        PLAN5990
C                                                                           PLAN6000
C*************************************************************************PLAN6010
C-----CALCULATE BANDWIDTH AND WRITE ELEMENT INFO. ON TAPES                  PLAN6020
C*************************************************************************PLAN6030
      IF(NS.EQ.15) GO TO 600                                                PLAN6040
      NN=NS*ND*NU                                                           PLAN6050
      CALL REARAN (ST,ST,15,12,1,NS,ND,NU,NN)                               PLAN6060
      NN=NS*4*NW                                                            PLAN6070
      CALL REARAN(TT,TT,15,4,1,NS,4,NW,NN)                                  PLAN6080
  600 CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,FRC)             PLAN6090
      IF(LBUCK.NE.0) CALL FLGSUM(G,NSG,ND,NG,III)                           PLAN6100
      WRITE (IB) NI,BET ,E4,E5,E6,E7,PGED(IMAT,1),SBC,PBC,GBC               PLAN6110
      WRITE(IW,2003) NEL,IX,IMAT,IDV,FRC,REFT,AA,AB,BETA,FFC,NS,NDIF        PLAN6120
      DO 450 I=1,4                                                          PLAN6130
  450 IX(I)=IX(I)+INC                                                       PLAN6140
  500 CONTINUE                                                              PLAN6150
      N=IEL+1                                                               PLAN6160
      IF(N.LE.NUME) GO TO 130                                               PLAN6170
      RETURN                                                                PLAN6180
 1002 FORMAT(4E10.0)                                                        PLAN6190
 1003 FORMAT(715,5X,4E10.0/2E10.0,215)                                      PLAN6200
 1005 FORMAT (8E10.0)                                                       PLAN6210
 1006 FORMAT(I5,6E10.0)                                                     PLAN6220
 1010 FORMAT(2I5, E10.0)                                                    PLAN6230
 2000 FORMAT(43H1NUMBER OF MEMBRANE ELEMENTS                =,I5/         PLAN6240
     1       44H CONSTRUCTION KODE                          =,I5/         PLAN6250
     2       44H NUMBER OF MATERIALS                        =,I5/         PLAN6260
     3       44H NUMBER OF GEOMETRIC PROPERTIES             =,I5/         PLAN6270
     4       44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)          PLAN6280
 2002 FORMAT(// 23H PROCESSED ELEMENT DATA//                                PLAN6290
     1121H ELEMT/-------NODES------//-ID NOS-/     DES VAR   REFERENCE   PLAN6300
     2MAX LENGTH      WIDTH      ANGLE TO   END FIXITY  PRNT  BAND     / PLAN6310
     3121H NUMBR     I    J    K    L  MAT    DV    FRACTION      TEMP    PLAN6320
     4DE STEENR  OF ELEMENT  PRINC DIRN    COEFF1    CODE  WDTH      )PLAN6330
 2003 FORMAT(1X,715,6E12.4,216)                                             PLAN6340
 2004 FORMAT(23H ELEMENT LOAD FRACTIONS /59H LOAD CASE TEMPERATURE  X-DIPLAN6350
     1RECTION Y-DIRECTION Z-DIRECTION /9X,1HA,4E12.3/                       PLAN6360
```

```
     2 9X,1HB,4E12.3/ 9X,1HC,4E12.3/ 9X,1HD,4E12.3)                    PLAN6370
2010 FORMAT(1H+,25X,8E13.4/(26X,8E14.4))                               PLAN6380
2011 FORMAT(/91H GEOMETRY      SHEET       SPACING OF  /----------STIFFENPLAN6390
    1ER PROPERTIES----------/     WIDTH OF /                           PLAN6400
     2 91H  NUMBER    THICKNESS      STIFFENERS        AREA          INERTIA PLAN6410
     4    DIST OF CGG       SHEET     )                               PLAN6420
2012 FORMAT(1X,I5,6E14.4)                                              PLAN6430
2019 FORMAT(// 25H MATERIAL PROPERTY CARDS    /                        PLAN6440
     1/125H  MATL  NO OF    SPECIFIC                        YOUNGS       POIPLAN6450
     2SSONS      COEFFT OF    /-----------ALLOWABLE STRESSES----------/  PLAN6460
     3/121H  NBR    TEMP      WEIGHT       TEMPERATURE      MODULUS        RPLAN6470
     4ATIO      THERM EXPN        TENS     COMP     SHEAR    CRIPLING      //PLAN6480
2020 FORMAT(1X,I4,I6,2X,F14.4)                                         PLAN6490
     END                                                               PLAN6500
```

```
      SUBROUTINE DPLAN1 (ADLD,ANEW,LOAD,NUMDV)                         PLAN6510
C*****************************************************************************PLAN6520
C-----DESIGN OF STIFFENED MEMBRANE ELEMENT                             PLAN6530
C*****************************************************************************PLAN6540
      DIMENSION ADLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                    PLAN6550
      COMMON/JUNK/          LT,LH,L,SG(20),SIG(7),IDVAR,IFX,FRC,AREA,  PLAN6560
     1 XINERT,BETA,TENS,COMP,SHEAR,CRUSH,TAU,SRC,PRC,GRC,JUNK(324)     PLAN6570
      PX=SIG(4)                                                        PLAN6580
      PY=SIG(5)                                                        PLAN6590
      PXY=SIG(6)                                                       PLAN6600
C*****************************************************************************PLAN6610
C-----FULLY STRESSED DESIGN                                            PLAN6620
C*****************************************************************************PLAN6630
      P1=COMP*TAU*AREA                                                 PLAN6640
      P2=COMP*AREA                                                     PLAN6650
      P12=SHEAR*AREA                                                   PLAN6660
      IF (PX.GT.0.0) P1=TENS*TAU*AREA                                  PLAN6670
      IF (PY.GT.0.0) P2=TENS*AREA                                      PLAN6680
      RMAX=(PX/P1)**2+(PY/P2)**2-(PX/P1)*(PY/P2)+(PXY/P12)**2          PLAN6690
      RMAX=SQRT(RMAX)                                                  PLAN6700
      IF (PX.GE.0.0) GO TO 100                                         PLAN6710
C*****************************************************************************PLAN6720
C-----STIFFENER FAILURE                                                PLAN6730
C*****************************************************************************PLAN6740
      P=-PX                                                            PLAN6750
      PF=SRC*XINERT                                                    PLAN6760
      R=(P/PF)/(1.0/IFX)                                               PLAN6770
      IF (R.GT.RMAX) RMAX=R                                            PLAN6780
      P1=CRUSH*TAU*AREA                                                PLAN6790
      P2=0.5*P1                                                        PLAN6800
      CALL JOHNS (IFX,P,P1,P2,PF,R)                                    PLAN6810
      IF (R.GT.RMAX) RMAX=R                                            PLAN6820
C*****************************************************************************PLAN6830
C-----SHEET BUCKLING BETWEEN STIFFENERS                                PLAN6840
C*****************************************************************************PLAN6850
  100 PX=-PX                                                           PLAN6860
      PY=-PY                                                           PLAN6870
      AA=PX+4.0*PY/TAU                                                 PLAN6880
      BB=1.495*PXY/TAU                                                 PLAN6890
      R=0.5*(AA+SQRT(AA**2+BB**2))/PRC                                 PLAN6900
      IF (R.GT.RMAX) RMAX=R                                            PLAN6910
```

```
C*************************************************************************PL AN6920
C-----GENERAL BUCKLING OF PANEL                                           PL AN6930
C*************************************************************************PL AN6940
      IF (PX.LT.0.0) GO TO 118                                            PL AN6950
      PE=GRC*XINERT*AREA*AREA                                             PL AN6960
      AA=PX/PE                                                            PL AN6970
      R=AA**0.2                                                           PL AN6980
      IF (R.GT.RMAX) RMAX=R                                               PL AN6990
  118 AA=RMAX*ANEW(IDVAR)                                                 PL AN7000
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                      PL AN7010
      ANEW(IDVAR)=AA                                                      PL AN7020
      LOAD(IDVAR)=L                                                       PL AN7030
   60 CONTINUE                                                            PL AN7040
      RETURN                                                              PL AN7050
      END                                                                 PL AN7060
```

```
      SUBROUTINE PLNAX2(IWT,ID,X,Y,Z,T,NTC,WT,PMAT,NUMDV,NUMNP,NUMMAT,   PLAN7070
     1 NUMTC,KODE,NUME)                                                  PLAN7080
C*********************************************************************PLAN7090
C-----PLANE ISOTROPIC MEMBRANE ELEMENTS                                 PLAN7100
C*********************************************************************PLAN7110
      IMPLICIT REAL*8 (A-H,O-Z)                                         PLAN7120
      REAL*4 IWT,X,Y,Z,T,WT,PMAT,BET,E4,E5,E6,ERC                       PLAN7130
      DIMENSION IWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),      PLAN7140
     1T(NUMNP),NTC(NUMMAT),WT(NUMMAT),PMAT(NUMTC,7,NUMMAT)              PLAN7150
      COMMON/EM/LM(12),S(12,12),P(12,4,2),XM(12),ST(15,12),TT(15,4),    PLAN7160
     1 G(12,12,3),BB(12,12),EM1(1700)                                   PLAN7170
      COMMON/JUNK/IE(4),IX(4),EMUL(4,5),D(3,3),XX(4),YY(4),ZZ(4),TMP(4),PLAN7180
     1 ALP(3),III(3),PRESS,BEET,NS,NSG(3),EE(6),JUN(238)                PLAN7190
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                PLAN7200
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              PLAN7210
C*********************************************************************PLAN7220
C-----CONTROL INFORMATION                                               PLAN7230
C*********************************************************************PLAN7240
      NH=1                                                              PLAN7250
      ND=12                                                             PLAN7260
      NV=2                                                              PLAN7270
      NW=1                                                              PLAN7280
      NT=4                                                              PLAN7290
      NG=3                                                              PLAN7300
      DO 5 I=1,3                                                        PLAN7310
    5 NSG(I)=1                                                          PLAN7320
      IEX=0                                                             PLAN7330
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMTC                              PLAN7340
C*********************************************************************PLAN7350
C-----MATERIAL PROPERTY CARDS                                           PLAN7360
C*********************************************************************PLAN7370
      WRITE(IW,2019)                                                    PLAN7380
      DO 60 M=1,NUMMAT                                                  PLAN7390
      READ(IR,1010) N,NTC(N),WT(N)                                      PLAN7400
      IF(NTC(N).LE.0) NTC(N)=1                                          PLAN7410
      WRITE(IW,2020) N,NTC(N),WT(N)                                     PLAN7420
C*********************************************************************PLAN7430
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                         PLAN7440
C*********************************************************************PLAN7450
      NT=NTC(N)                                                         PLAN7460
      READ(IR,1005) ((PMAT(I,J,N),J=1,7),I=1,NT)                        PLAN7470
      DO 10 I=1,NT                                                      PLAN7480
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                     PLAN7490
   10 CONTINUE                                                          PLAN7500
   60 WRITE(IW,2010) ((PMAT(I,J,N),J=1,7),I=1,NT)                       PLAN7510
C*********************************************************************PLAN7520
C-----ELEMENT LOAD MULTIPLIERS                                          PLAN7530
C*********************************************************************PLAN7540
      READ (IR,1002) ((EMUL(I,J),J=1,5),I=1,4)                          PLAN7550
      WRITE(IW,2004) ((EMUL(I,J),J=1,5),I=1,4)                          PLAN7560
C*********************************************************************PLAN7570
C-----ELEMENT CARDS                                                     PLAN7580
C*********************************************************************PLAN7590
      WRITE (6,2002)                                                    PLAN7600
      N=1                                                               PLAN7610
  130 READ(IR,1003) IEL,IE,IMAT,IDV,ERC,BEET,PRESS,BETA,NS,INC          PLAN7620
      IF (ERC.LE.0.) ERC=1.                                             PLAN7630
      IF(INC.EQ.0) INC=1                                                PLAN7640
      IF(NS.EQ.0) NS=3                                                  PLAN7650
      IF(NS.LT.3) NS=1                                                  PLAN7660
```

```
      IF( (IF(3) .EQ. IF(4)) .AND. (NS.EQ. 15) ) NS=12                  PLAN7670
      RHO=WT(IMAT)                                                      PLAN7680
      BET=BETA                                                          PLAN7690
      KK=INC*(IEL-N)                                                    PLAN7700
      DO 142 I=1,4                                                      PLAN7710
  142 IX(I)=IF(I)-KK                                                    PLAN7720
      DO 500 NEL=N,IEL                                                  PLAN7730
      TEMP=0.                                                           PLAN7740
      DO 501 I=1,4                                                      PLAN7750
      II=IX(I)                                                          PLAN7760
      TEMP=TEMP+T(II)*0.25                                              PLAN7770
      XX(I)=X(II)                                                       PLAN7780
      YY(I)=Y(II)                                                       PLAN7790
  501 ZZ(I)=Z(II)                                                       PLAN7800
C*********************************************************************PLAN7810
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   PLAN7820
C*********************************************************************PLAN7830
      CALL INTERP(PMAT,FF,NUMTC,NUMMAT,7,6,NTC(IMAT),IMAT,TEMP)         PLAN7840
      E4=FF(4)                                                          PLAN7850
      E5=FF(5)                                                          PLAN7860
      E6=FF(6)                                                          PLAN7870
C*********************************************************************PLAN7880
C-----FORM CONSTITUTIVE LAW AND COMPUTE THERMAL STRESSES                PLAN7890
C*********************************************************************PLAN7900
      DO 265 I=1,3                                                      PLAN7910
      DO 265 J=1,3                                                      PLAN7920
  265 D(I,J)=0.                                                         PLAN7930
      D(2,2)=1.0/FF(1)                                                  PLAN7940
      D(1,1)=D(2,2)                                                     PLAN7950
      D(1,2)=-D(1,1)*FF(2)                                              PLAN7960
      D(2,1)=D(1,2)                                                     PLAN7970
      D(3,3)=D(2,2)*2.0*(1.0+FF(2))                                     PLAN7980
      ALP(1)=FF(3)                                                      PLAN7990
      ALP(2)=FF(3)                                                      PLAN8000
      ALP(3)=0.                                                         PLAN8010
      CALL FLAW(0.000)                                                  PLAN8020
C*********************************************************************PLAN8030
C-----FORM ELEMENT LOCATION MATRIX AND COMPUTE ELEMENT MATRICES         PLAN8040
C*********************************************************************PLAN8050
      DO 170 I=1,4                                                      PLAN8060
      II=IX(I)                                                          PLAN8070
      TMP(I)=T(II)                                                      PLAN8080
      LM(I)=ID(II,1)                                                    PLAN8090
      LM(I+4)=ID(II,2)                                                  PLAN8100
  170 LM(I+8)=ID(II,3)                                                  PLAN8110
      CALL QUAD(RHO, 1.000)                                             PLAN8120
      AREA=XM(1)+XM(2)+XM(3)+XM(4)                                      PLAN8130
      UWT(IDV)=UWT(IDV)+AREA*RHO*ERC                                    PLAN8140
      IF(NS.EQ.15) GO TO 600                                            PLAN8150
      NM=NS*ND*NU                                                       PLAN8160
      CALL REARAN (ST,ST,15,12,1,NS,ND,NU,NN)                           PLAN8170
      NN=NS*4*NW                                                        PLAN8180
      CALL REARAN(TT,TT,15,4,1,NS,4,NW,NN)                              PLAN8190
  600 CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)         PLAN8200
      IF(LBUCK.NE.0) CALL ELGSUM(G,NSG,ND,NG,III)                       PLAN8210
      WRITE (IR) NI,BET ,E4,E5,E6                                       PLAN8220
      WRITE(IW,2003) NEL,IX,IMAT,IDV,ERC,REET,PRESS,BETA,NS,NDIF        PLAN8230
      DO 450 I=1,4                                                      PLAN8240
  450 IX(I)=IX(I)+INC                                                   PLAN8250
  500 CONTINUE                                                          PLAN8260
```

```
      N=IEL+1                                                                  PLANR270
      IF(N.LE.NUME) GO TO 130                                                  PLANR280
      RETURN                                                                   PLANR290
 1002 FORMAT(5E10.0)                                                           PLANR300
 1003 FORMAT(7I5,F5.0,3E10.0,2I5)                                              PLANR310
 1005 FORMAT (7E10.0)                                                          PLANR320
 1010 FORMAT(2I5, E10.0)                                                       PLANR330
 2000 FORMAT(44H1NUMBER OF MEMBRANE ELEMENTS                  =,I5  /          PLANR340
     1       44H CONSTRUCTION KODE                           =,I5/            PLANR350
     2       44H NUMBER OF MATERIALS                         =,I5/            PLANR360
     3       44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)              PLANR370
 2002 FORMAT(/ /23H PROCESSED ELEMENT DATA//                                   PLANR380
     1 97H ELEM1/-------NODES------//-ID NOS-/   DES VAR    REFERENCE         PLANR390
     2                        PRNT  BAND  ,/                                  PLANR400
     3 97H NUMBR  I    J    K    L   MAT  DV    FRACTION       TEMP          PLANR410
     4PRESSURE      BETA       CODE  WDTH     /)                             PLANR420
 2003 FORMAT(1X,7I5,4E12.4,2I6)                                                PLANR430
 2004 FORMAT(23H ELEMENT LOAD FRACTIONS//71H LOAD CASE TEMPERATURE    PREPLANR440
     1SSURE  X-DIRECTION Y-DIRECTION Z-DIRECTION /                             PLANR450
     2 6X ,1HA ,3X ,5E12.3/ 6X ,1HB ,3X ,5E12.3/ 6X ,1HC ,3X ,5E12.3/          PLANR460
     3 6X ,1HD ,3X ,5E12.3  )                                                  PLANR470
 2010 FORMAT(1H+,27X,7E14.4 /(28X,7E14.4))                                     PLANR480
 2019 FORMAT(// 25H MATERIAL PROPERTY CARDS   /                                PLANR490
     1/125H  MATL  NO OF   SPECIFIC                        YOUNGS       POIPLANR500
     2SSONS     COEFFI OF   /-----------ALLOWABLE STRESSES-----------/  PLANR510
     3/121H  NBR   TEMP     WEIGHT      TEMPERATURE      MODULUS        RPLANR520
     4ATIO     THERM EXPN       TENSION      COMPRESSION      SHEAR/)     PLANR530
 2020 FORMAT(1X,I4,I6,2X,E14.4)                                                PLANR540
      END                                                                      PLANR550


      SUBROUTINE DPLAN2 (APLD,ANEW,LOAD,NUMDV)                                 PLANR560
C*************************************************************************PLANR570
C-----STRESS DESIGN OF  ISOTROPIC MEMBRANE ELEMENT                            PLANR580
C*************************************************************************PLANR590
      DIMENSION APLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                            PLANR600
      COMMON/JUNK/        LT,LH,L,SG(20),SIG(7),IDVAR,IEX,FRC,AREA,            PLANR610
     1 XINER1,BETA,TENS,COMP,SHEAR,JUNK(329)                                   PLANR620
      CC=(SIG(1)+SIG(2))*0.5                                                   PLANR630
      BB=(SIG(1)-SIG(2))*0.5                                                   PLANR640
      CR=SQRT(BB*BB+SIG(3)**2)                                                 PLANR650
      PX=CC+CR                                                                 PLANR660
      PY=CC-CR                                                                 PLANR670
      P1=COMP*AREA                                                             PLANR680
      P2=COMP*AREA                                                             PLANR690
      IF (PX.GT.0.0) P1=TENS    *AREA                                          PLANR700
      IF (PY.GT.0.0) P2=TENS*AREA                                              PLANR710
      RMAX=(PX/P1)**2+(PY/P2)**2-(PX/P1)*(PY/P2)                               PLANR720
      RMAX=SQRT(RMAX)                                                          PLANR730
      IF(SHEAR.EQ.0.) GO TO 50                                                 PLANR740
      PXY=CR/(AREA*SHEAR)                                                      PLANR750
      IF(RMAX.LT.PXY) RMAX=PXY                                                 PLANR760
   50 AA=RMAX*APLD(IDVAR)                                                      PLANR770
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                           PLANR780
      ANEW(IDVAR)=AA                                                           PLANR790
      LOAD(IDVAR)=L                                                            PLANR800
   60 RETURN                                                                   PLANR810
      END                                                                      PLANR820
```

```
      SUBROUTINE SHEAR(A,MTOT)                                          SHER0000
C*********************************************************************SHER0010
C-----SHEAR PANEL ELEMENTS                                              SHER0020
C*********************************************************************SHER0030
      DIMENSION A(MTOT)                                                 SHER0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,MELTYP,N1,N2,N3,N4,N5,M111,NEQSHER0050
     1,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQR,NBLOCK                           SHER0060
      COMMON/JUNK/LT,LH,L,SIG(27),IDVAR,IEX,ERC,AREA,XINERT,JUNI(333)   SHER0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              SHER0080
      NUME=NPAR(2)                                                      SHER0090
      KODE=NPAR(5)                                                      SHER0100
      IF(NPAR(1).EQ.0)GO TO 500                                         SHER0110
      N6=N5+NUMNP                                                       SHER0120
      GO TO (1,2),KODE                                                  SHER0130
C*********************************************************************SHER0140
C-----SHEAR PANEL WITH STRESS AND BUCKLING CONSTRAINTS                  SHER0150
C*********************************************************************SHER0160
    1 NUMMAT=NPAR(3)                                                    SHER0170
      NUMTC=NPAR(4)                                                     SHER0180
      N7=N6+NUMMAT                                                      SHER0190
      N8=N7+NUMMAT                                                      SHER0200
      N9=N8+NUMMAT*NUMTC*4                                              SHER0210
      MM=N9-MTOT                                                        SHER0220
      IF(MM.GT.0)CALL ERROR(MM)                                         SHER0230
      CALL PANEL(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),       SHER0240
     1 A(N8),NUMDV,NUMNP,NUMMAT,NUMTC,KODE,NUME)                        SHER0250
      RETURN                                                            SHER0260
C*********************************************************************SHER0270
C-----PROVISION FOR SPECIAL SHEAR PANEL ELEMENT                         SHER0280
C*********************************************************************SHER0290
    2 CALL NOELEM (NPAR(1),NPAR(5),IW)                                  SHER0300
      RETURN                                                            SHER0310
  500 WRITE (IW,2002)  KODE                                             SHER0320
      DO 800 MM=1,NUME                                                  SHER0330
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,0)                   SHER0340
      AA=A(IDVAR)*ERC                                                   SHER0350
      WRITE (IW,2005) MM,AA                                             SHER0360
      DO 800 L=LT,LH                                                    SHER0370
      IF(L.GT.LT ) WRITE(IW,2006)                                       SHER0380
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,1)                   SHER0390
      SIG(5) = (SIG(1)+SIG(2)+SIG(3)+SIG(4))  *0.25                     SHER0400
      WRITE (IW,2007) L,(SIG(I),I=1,5)                                  SHER0410
      IF(L.NE.LH)WRITE (IW,2006)                                        SHER0420
      GO TO (3,4),KODE                                                  SHER0430
C*********************************************************************SHER0440
C-----DESIGN OF SHEAR PANEL WITH STRESS AND BUCKLING CONSTRAINTS        SHER0450
C*********************************************************************SHER0460
    3 CALL DPANEL (A(M1),A(M2),A(M3),NUMDV)                             SHER0470
      GO TO 800                                                         SHER0480
C*********************************************************************SHER0490
C-----PROVISION FOR DESIGN OF SPECIAL SHEAR PANEL ELEMENT               SHER0500
C*********************************************************************SHER0510
    4 CONTINUE                                                          SHER0520
  800 CONTINUE                                                          SHER0530
      RETURN                                                            SHER0540
 2002 FORMAT(//40H ANALYSIS OF SHEAR PANELS, CONSIPN CODE=,I2 //        SHER0550
     1 92H                          LOAD  /--------------SHEAR FLOW AT NOSHER0560
     2DES--------------/   AVERAGE    /                                 SHER0570
     3 92H ELEMENT    THICKNESS      COND          I           J        SHER0580
     4K           I       SHEAR FLOW /)                                SHER0590
```

```
 2005 FORMAT(I6,1X,F15.4)                                                SHER0600
 2006 FORMAT(/)                                                          SHER0610
 2007 FORMAT(1H+,23X,I5,1X,5E12.4)                                       SHER0620
      END                                                                SHER0630


      SUBROUTINE PANEL(IWT,ID,X,Y,Z,T,NTC,WT ,PMAT,NUMDV,NUMNP,NUMMAT,   SHER0640
     1 NUMTC,KODE,NUME)                                                  SHER0650
C*************************************************************************SHER0660
C-----SHEAR PANEL ELEMENTS                                               SHER0670
C*************************************************************************SHER0680
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHER0690
      REAL*4 IWT,X,Y,Z,T,WT,PMAT,ERC,E3,SHCR                             SHER0700
      DIMENSION IWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),       SHER0710
     1T(NUMNP),NTC(NUMMAT),WT (NUMMAT),PMAT(NUMTC,4,NUMMAT),CC(6,2)      SHER0720
     COMMON/EM/LM(12),S(12,12),P(12,4),ST(4,12),TT(4,4),XM(12),          SHER0730
     1 G(12,12),EM1(2356)                                                SHER0740
      COMMON/JUNK/EMUL(3,4),TE(4),TX(4),XX(4),YY(4),ZZ(4),EE(3),AREA,     SHER0750
     1       TE(4,2),U(4),V(4),O(4),D(4),P1,P2 ,JUN1(252)                SHER0760
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                 SHER0770
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13               SHER0780
      DATA CC/5.35 , 8.99 , 8.99 , 5.35 , 5.35 , 7.07 ,                  SHER0790
     1        3.99 , 5.72 , 3.29 , 7.25 , 5.63 , 3.91 /                  SHER0800
C*************************************************************************SHER0810
C-----CONTROL INFORMATION                                                SHER0820
C*************************************************************************SHER0830
      ND=12                                                              SHER0840
      NU=1                                                               SHER0850
      NV=1                                                               SHER0860
      NW=1                                                               SHER0870
      NS=4                                                               SHER0880
      NT=2                                                               SHER0890
      IEX=3                                                              SHER0900
      NG=1                                                               SHER0910
      NSG=1                                                              SHER0920
      WRITE(IW,2000)NUME,KODE,NUMMAT,NUMTC                               SHER0930
C*************************************************************************SHER0940
C-----MATERIAL PROPERTY CARDS                                            SHER0950
C*************************************************************************SHER0960
      WRITE(IW,2001)                                                     SHER0970
      DO 5  M=1,NUMMAT                                                   SHER0980
      READ(IR,1001) N,NTC(N),WT(N)                                       SHER0990
      IF (NTC(N).EQ.0) NTC(N)=1                                          SHER1000
      WRITE(IW,2002) N,NTC(N),WT(N)                                      SHER1010
C*************************************************************************SHER1020
C-----TEMPERATURE DEPENDENT MATERIAL PROPERTIES                          SHER1030
C*************************************************************************SHER1040
      NT=NTC(N)                                                          SHER1050
      DO 5 J=1,NT                                                        SHER1060
      READ (IR,5001) (PMAT(J,K,N),K=1,4)                                 SHER1070
      IF (J.NE.1) WRITE (IW,6002)                                        SHER1080
    5 WRITE (IW,6003) (PMAT(J,K,N),K=1,4)                                SHER1090
C*************************************************************************SHER1100
C-----ELEMENT LOAD MULTIPLIERS                                           SHER1110
C*************************************************************************SHER1120
      READ (IR,1003) ((EMUL(I,J),J=1,4),I=1,3)                           SHER1130
      WRITE(IW,2003) ((EMUL(I,J),J=1,4),I=1,3)                           SHER1140
C*************************************************************************SHER1150
C-----ELEMENT CARDS                                                      SHER1160
C*************************************************************************SHER1170
```

```
      WRITE(IW,2005)                                                    SHER1180
      N=1                                                               SHER1190
    6 READ(IR,1004) IEL,IE,IMAT,IDV,ISU,ERC,AL,BL,INC                   SHER1200
      IF(INC.EQ.0) INC=1                                                SHER1210
      IF(ERC.LE.0.0) ERC=1.0                                            SHER1220
      IF(IMAT.EQ.0) IMAT=1                                              SHER1230
      RHO=WT(IMAT)                                                      SHER1240
      KK=INC*(IEL-N)                                                    SHER1250
      DO 50 I=1,4                                                       SHER1260
   50 IX(I)=IE(I)-KK                                                    SHER1270
      DO 500 NEL=N,IEL                                                  SHER1280
      TEMP=0.                                                           SHER1290
      DO 100 I=1,4                                                      SHER1300
      II=IX(I)                                                          SHER1310
      XX(I)=X(II)                                                       SHER1320
      YY(I)=Y(II)                                                       SHER1330
      ZZ(I)=Z(II)                                                       SHER1340
  100 TEMP=TEMP+T(II)*0.25                                              SHER1350
C*********************************************************************SHER1360
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE   SHER1370
C*********************************************************************SHER1380
      CALL INTERP(PMAT,EE,NUMTC,NUMMAT,4,3,NTC(IMAT),IMAT,TEMP)         SHER1390
      E3=EE(3)                                                          SHER1400
C*********************************************************************SHER1410
C-----FORM ELEMENT UNIT MATRICES AND LOAD VECTORS                       SHER1420
C*********************************************************************SHER1430
      SMOD=0.5*EE(1)/(1.0+EE(2))                                        SHER1440
      CALL EPANEL(SMOD,EE(2),RHO,XL,YL,NEL,IW)                          SHER1450
      IF(LBUCK.EQ.0) GO TO 343                                          SHER1460
      CALL SPGEOM(G)                                                    SHER1470
      CALL ELGSUW(G,NSG,ND,NG,III)                                      SHER1480
C*********************************************************************SHER1490
C-----COMPUTE BUCKLING DATA                                             SHER1500
C*********************************************************************SHER1510
  343 SHCR=0.                                                           SHER1520
      IF(ISU.EQ.0) GO TO 121                                            SHER1530
      IF(XL.GE.YL) GO TO 120                                            SHER1540
      H=YL                                                              SHER1550
      YL=XL                                                             SHER1560
      XL=H                                                              SHER1570
  120 IF(AL.LE.0.) AL=XL                                                SHER1580
      IF(BL.LE.0.) BL=YL                                                SHER1590
      H=CC(ISU,1)+CC(ISU,2)*BL*BL/(AL*AL)                               SHER1600
      SHCR=H*9.8696*EE(1)/(12.0*BL*BL*(1.0-EE(2)*EE(2)))                SHER1610
  121 UWT(IDV)=UWT(IDV)+RHO*AREA*ERC                                    SHER1620
C*********************************************************************SHER1630
C-----FORM LOCATION MATRIX AND COMPUTE BAND WIDTH                       SHER1640
C*********************************************************************SHER1650
      DO 470 I=1,4                                                      SHER1660
      II=IX(I)                                                          SHER1670
      DO 470 J=1,3                                                      SHER1680
      IJ=(II-1)*3+J                                                     SHER1690
  470 LM(IJ)=ID(II,J)                                                   SHER1700
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)         SHER1710
      WRITE(IR) NT,E3,SHCR                                              SHER1720
      WRITE(IW,2004) NEL,IX,IMAT,IDV,ISU,ERC,AL,BL,NDIF                 SHER1730
C*********************************************************************SHER1740
C-----CHECK FOR MORE ELEMENTS                                           SHER1750
C*********************************************************************SHER1760
      DO 450 I=1,4                                                      SHER1770
```

```
  450 IX(I)=IX(I)+INC                                                    SHER1780
  500 CONTINUE                                                           SHER1790
      N=IEL+1                                                            SHER1800
      IF(N.LE.NUME) GO TO 6                                              SHER1810
      RETURN                                                             SHER1820
 1001 FORMAT(2I5,F10.0)                                                  SHER1830
 1003 FORMAT(4E10.0)                                                     SHER1840
 1004 FORMAT(8I5,3E10.0,I5)                                              SHER1850
 2000 FORMAT(44H1NUMBER OF SHEAR PANEL ELEMENTS              =,I5/       SHER1860
     1        44H CONSTRUCTION CODE                          =,I5/       SHER1870
     2        44H NUMBER OF MATERIALS                        =,I5/       SHER1880
     4        44H NUMBER OF TEMPS FOR WHICH MATL PROPS GIVEN=,I5)       SHER1890
 2001 FORMAT(// 25H MATERIAL PROPERTY CARDS //                           SHER1900
     19H MATERIAL   NUMBER     SPECIFIC                  YOUNGS    POISSNSHER1910
     2        ALLOWABLE          /                                      SHER1920
     39H  NUMBER   OF TEMPS    WEIGHT       TEMP       MODULUS   RATIO  SHER1930
     4          SHEAR             /)                                    SHER1940
 2002 FORMAT(I6,5X,I5,F12.4)                                             SHER1950
 2003 FORMAT(// 25H ELEMENT LOAD MULTIPLIERS //20X,1HA,14X,1HB,14X,1HC,  SHER1960
     1 14X,1HD,/6H X-DIR,4F15.6/ 6H Y-DIR,4F15.6/ 6H Z-DIR,4F15.6 )      SHER1970
 2004 FORMAT(I7,2X,4I6,3I7,3E12.4,I6)                                    SHER1980
 2005 FORMAT(// 23H PROCESSED ELEMENT DATA//                             SHER1990
     196H ELEMENT  /-------NODE NOS------//--EL ID NOS-/  BOUND    DES VSHER2000
     2AR /--EFFECT PANEL DIMNS--/  BAND   /                              SHER2010
     396H  NUMBER       I     J     K     L   MATL  D VAR   CODE   FRACTISHER2020
     4ON     LONGER     SHORTER   WIDTH   /)                            SHER2030
 5001 FORMAT(4E10.0)                                                     SHER2040
 6002 FORMAT(/)                                                          SHER2050
 6003 FORMAT(1H+,30X,4E12.4)                                             SHER2060
      END                                                                SHER2070


      SUBROUTINE SPGEOM (G)                                              SHER2080
C*********************************************************************SHER2090
C-----COMPUTE UNIT GEOMETRIC STIFFNESS MATRICES                         SHER2100
C*********************************************************************SHER2110
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHER2120
      DIMENSION G(12,12)                                                 SHER2130
      COMMON/JUNK/EMOD(3,4),IE(4),IX(4),XX(4),YY(4),ZZ(4),EE(3),AREA,    SHER2140
     1        TE(4,2),U(4),V(4),O(4),D(4),P1,P2,AJ1(3),AJ2(3),JUN1(240)  SHER2150
      DO 10 I=1,3                                                        SHER2160
      AJ1(I)=-TE(I,1)*V(1)+TE(I,2)*U(1)                                  SHER2170
   10 AJ2(I)=-TE(I,1)*V(2)+TE(I,2)*U(2)                                  SHER2180
      DO 15 I=1,12                                                       SHER2190
      DO 15 J=1,12                                                       SHER2200
   15 G(I,J)=0.                                                          SHER2210
      DO 20 I=1,3                                                        SHER2220
      DO 20 J=1,3                                                        SHER2230
      X1=(AJ1(I)*AJ1(J)+D(I)*D(J))*O(1)*P1/P2                            SHER2240
      X2=(AJ2(I)*AJ2(J)+D(I)*D(J))*O(2)*P1/P2                            SHER2250
      G(I  ,J  )= X1                                                     SHER2260
      G(I  ,J+6)=-X1                                                     SHER2270
      G(J+6,I  )=-X1                                                     SHER2280
      G(I+6,J+6)= X1                                                     SHER2290
      G(I+3,J+3)= X2                                                     SHER2300
      G(I+3,J+9)=-X2                                                     SHER2310
      G(J+9,I+3)=-X2                                                     SHER2320
   20 G(I+9,J+9)= X2                                                     SHER2330
      RETURN                                                             SHER2340
      END                                                                SHER2350
```

```
      SUBROUTINE EPANEL(G,GG,RHO,XL,YL,MK,IW)                          SHER2360
C*********************************************************************SHER2370
C-----FORM SHEAR PANEL ELEMENT MATRICES                                SHER2380
C*********************************************************************SHER2390
      IMPLICIT REAL*8 (A-H,O-Z)                                        SHER2400
      COMMON/LINK/EMIL(3,4),IE(4),IX(4),X(4),Y(4),Z(4),EE(3),AREA,     SHER2410
     1       TE(4,2),U(4),V(4),O(4),D(4),P1,P2,VD1(4),VD2(4),V12(4),   SHER2420
     2 V41(4),VP12(4),TT(3),TJ(3),JUNK(200)                           SHER2430
      COMMON/EM/ELM(12),S(12,12),P(12,4),ST(4,12),TT(4,4),XM(12),      SHER2440
     1 EMM(2500)                                                       SHER2450
C*********************************************************************SHER2460
C-----UNIT VECTORS ALONG DIAGONALS ,SIDES AND NORMAL TO THE MEANPLANE   SHER2470
C*********************************************************************SHER2480
      CALL VECTOR (VD1,X(1),Y(1),Z(1),X(3),Y(3),Z(3))                  SHER2490
      CALL VECTOR (VD2,X(2),Y(2),Z(2),X(4),Y(4),Z(4))                  SHER2500
      CALL VECTOR (V12,X(1),Y(1),Z(1),X(2),Y(2),Z(2))                  SHER2510
      CALL VECTOR (V41,X(4),Y(4),Z(4),X(1),Y(1),Z(1))                  SHER2520
      CALL CROSS (VD1,VD2,O)                                           SHER2530
      AREA=0.5*VD1(4)*VD2(4)*O(4)                                      SHER2540
C*********************************************************************SHER2550
C-----FORM TRANSFORMATION MATRIX TE                                    SHER2560
C*********************************************************************SHER2570
      HH=DOT(V12,O)                                                    SHER2580
      DO 10 I=1,3                                                      SHER2590
   10 VP12(I)=(V12(I)-HH*O(I))*V12(4)                                  SHER2600
      VP12(4)=DSQRT(VP12(1)*VP12(1)+VP12(2)*VP12(2)+VP12(3)*VP12(3))   SHER2610
      DO 20 I=1,3                                                      SHER2620
   20 TE(I,1)=VP12(I)/VP12(4)                                          SHER2630
      CALL CROSS(O,TE,TE(1,2))                                         SHER2640
C*********************************************************************SHER2650
C-----COMPUTE ELEMENT CORNER COORDINATES IN LOCAL AXES SYSTEM           SHER2660
C*********************************************************************SHER2670
      X1=0.0                                                           SHER2680
      Y1=0.0                                                           SHER2690
      X2=VP12(4)                                                       SHER2700
      Y2=0.0                                                           SHER2710
      X3=DOT(TE,VD1)*VD1(4)                                            SHER2720
      Y3=DOT(TE(1,2),VD1)*VD1(4)                                       SHER2730
      X4=-DOT(TE,V41)*V41(4)                                           SHER2740
      Y4=-DOT(TE(1,2),V41)*V41(4)                                      SHER2750
      XL=0.5*(X2-X1+X3-X4)                                             SHER2760
      YL=0.5*(Y3+Y4)                                                   SHER2770
      X34=X3-Y3*X4/Y4                                                  SHER2780
      X42=X4-X2+(X2-X3)*Y4/Y3                                          SHER2790
      IF(Y3.LT..01.OR.Y4.LT..01.OR.X34.LT..01.OR.X42.GT..01) GO TO 2006 SHER2800
      GO TO 57                                                         SHER2810
 2006 WRITE (IW,2007) MK                                               SHER2820
      STOP                                                             SHER2830
C*********************************************************************SHER2840
C-----TEST FOR PARALLEL SIDES                                          SHER2850
C*********************************************************************SHER2860
   57 A1=DABS((Y3-Y4)/(X3-X4))                                         SHER2870
      A2=DABS(Y4*(X3-X2)-Y3*X4)/(Y4*(X2-X2)+Y4*Y3)                     SHER2880
      IF(A1.LE..01.AND.A2.LE..01) GO TO 40                             SHER2890
      IF(A1.LE..01) GO TO 20                                           SHER2900
      IF(A2.LE..01) GO TO 35                                           SHER2910
      GO TO 45                                                         SHER2920
C*********************************************************************SHER2930
C-----CASE WHEN SIDES 1 AND 3 ARE PARALLEL                             SHER2940
C*********************************************************************SHER2950
```

```
   30 YP=X2*Y3*Y4/(Y3*X4-Y4*(X3-X2))                                    SHER2960
      P1=YP-Y1                                                          SHER2970
      P2=YP-Y2                                                          SHER2980
      P3=YP-Y3                                                          SHER2990
      P4=YP-Y4                                                          SHER3000
      XP=X2*Y3*X4/(Y3*X4-Y4*(X3-X2))                                    SHER3010
      AA=(X2-XP)/YP                                                     SHER3020
      CC=(X1-XP)/YP                                                     SHER3030
      H=P1*P2*AREA/(P3*P4*2.0*G)                                        SHER3040
      H=H+H*(AA*AA+AA*CC+CC*CC)/(1.5*(1.0+GG))                          SHER3050
      GO TO 46                                                          SHER3060
C*********************************************************************SHER3070
C-----CASE WHEN SIDES 2 AND 4 ARE PARALLEL                             SHER3080
C*********************************************************************SHER3090
   35 DD=-0.5*(X4/Y4+(X3-X2)/Y3)                                        SHER3100
      X0=X4-(X3-X4)*Y4/(Y3-Y4)                                          SHER3110
      A0=1.0/DSQRT(1.0+DD*DD)                                           SHER3120
      P1=(X0-X1-Y1*DD)*A0                                               SHER3130
      P2=(X0-X2-Y2*DD)*A0                                               SHER3140
      P3=(X0-X3-Y3*DD)*A0                                               SHER3150
      P4=(X0-X4-Y4*DD)*A0                                               SHER3160
      BB=(X0-X4)*DD+Y4)/(X0-X4-Y4*DD)                                   SHER3170
      H=P1*P2*AREA/(P3*P4*2.0*G)                                        SHER3180
      H=H+H*(BB*BB+BB*DD+DD*DD)/(1.5*(1.0+GG))                          SHER3190
      GO TO 46                                                          SHER3200
C*********************************************************************SHER3210
C-----PARALLELOGRAM CASE                                               SHER3220
C*********************************************************************SHER3230
   40 P1=1.0                                                            SHER3240
      P2=1.0                                                            SHER3250
      P3=1.0                                                            SHER3260
      P4=1.0                                                            SHER3270
      DD=-0.5*(X4/Y4+(X3-X2)/Y3+(Y3-Y4)/(X3-X4))                        SHER3280
      H=0.5*AREA*(1.0+2.0*DD*DD/(1.0+GG))/G                             SHER3290
      GO TO 46                                                          SHER3300
C*********************************************************************SHER3310
C-----CASE WHEN NO PARALLEL SIDES ARE PRESENT                          SHER3320
C*********************************************************************SHER3330
   45 X0=X4-(X3-X4)*Y4/(Y3-Y4)                                          SHER3340
      XP=X2*X4*Y3/(Y3*X4-Y4*(X3-X2))                                    SHER3350
      YP=X2*Y3*Y4/(Y3*X4-Y4*(X3-X2))                                    SHER3360
      DIS=DSQRT((X0-XP)*(X0-XP)+YP*YP)                                  SHER3370
      DD=(X0-XP)/YP                                                     SHER3380
      P1=YP*(X0-X1-Y1*DD)/DIS                                           SHER3390
      P2=YP*(X0-X2-Y2*DD)/DIS                                           SHER3400
      P3=YP*(X0-X3-Y3*DD)/DIS                                           SHER3410
      P4=YP*(X0-X4-Y4*DD)/DIS                                           SHER3420
      CC=DIS/P1-DD                                                      SHER3430
      BB=DIS/P4-CC                                                      SHER3440
      AA=DIS/P2-DD                                                      SHER3450
      F=(AA+BB+(AA**3+BB**3)/1.5+0.2*(AA**5+BB**5))*DLOG(DABS(AA+BB))   SHER3460
     1 +(CC+DD+(CC**3+DD**3)/1.5+0.2*(CC**5+DD**5))*DLOG(DABS(CC+DD))   SHER3470
     2-(BB+CC+(BB**3+CC**3)/1.5+0.2*(BB**5+CC**5))*DLOG(DABS(BB+CC))    SHER3480
     3-(DD+AA+(DD**3+AA**3)/1.5+0.2*(DD**5+AA**5))*DLOG(DABS(DD+AA))    SHER3490
     4+0.1*((AA*AA-CC*CC)*(BB**3-DD**3)+(BB*BB-DD*DD)*(AA**3-CC**3))    SHER3500
     5-0.2*(AA-CC)*(BB**4-DD**4)+(BB-DD)*(AA**4-CC**4))                 SHER3510
      F=F*P1*P2*P3*P4*0.5/(DIS*DIS)                                     SHER3520
      H=0.5*P1*P2*(AREA+4.0*(F-AREA/1.5)/(1.0+GG))/(P3*P4*G)            SHER3530
C*********************************************************************SHER3540
C-----DEVELOP UNIT STIFFNESS MATRIX                                    SHER3550
```

```
C*************************************************************************SHER3560
   46 DF13=DSQRT(X3*X3+Y3*Y3)                                               SHER3570
      DF24=DSQRT((X4-X2)*(X4-X2)+Y4*Y4)                                     SHER3580
      U(1)=X3/DF13                                                          SHER3590
      U(2)=(X4-X2)/DF24                                                     SHER3600
      V(1)=Y3/DF13                                                          SHER3610
      V(2)=Y4/DF24                                                          SHER3620
      DO 47 I=3,4                                                           SHER3630
      U(I)=U(I-2)                                                           SHER3640
   47 V(I)=V(I-2)                                                           SHER3650
      O(1)=-X2*Y4*DF13*0.5/(X4*Y3-X3*Y4)                                    SHER3660
      O(2)=X2*Y3*DF24*0.5/(X4*Y3-X3*Y4-X2*(Y3-Y4))                          SHER3670
      O(3)=-O(1)                                                            SHER3680
      O(4)=-O(2)                                                            SHER3690
      DO 100 I=1,4                                                          SHER3700
      DO 100 J=1,I                                                          SHER3710
      OI,J= O(I)*O(J)*0.5/H                                                 SHER3720
      DO 150 L=1,3                                                          SHER3730
      TJ(L)=TE(L,1)*U(I)+TE(L,2)*V(I)                                       SHER3740
  150 TJ(L)=U(J)*TE(L,1)+V(J)*TE(L,2)                                       SHER3750
      DO 160 L=1,3                                                          SHER3760
      DO 160 NN=1,3                                                         SHER3770
      II=3*(I-1)+L                                                          SHER3780
      JJ=3*(J-1)+NN                                                         SHER3790
  160 S (II,JJ  )=TJ(L)*TJ(NN)*OI,J                                         SHER3800
  100 CONTINUE                                                              SHER3810
      DO 180 L=1,12                                                         SHER3820
      DO 180 M=L,12                                                         SHER3830
  180 S(L,M)=S(M,L)                                                         SHER3840
C*************************************************************************SHER3850
C-----DEVELOP UNIT FORCE (STRESS) RECOVERY MATRIX                           SHER3860
C*************************************************************************SHER3870
      DO 300 I=1,4                                                          SHER3880
      II=(I-1)*3                                                            SHER3890
      SN=-O(I)*0.5/H                                                        SHER3900
      ST(1,II+1  )=SN*(U(I)*TE(1,1)+V(I)*TE(1,2))                           SHER3910
      ST(1,II+2  )=SN*(U(I)*TE(2,1)+V(I)*TE(2,2))                           SHER3920
  300 ST(1,II+3  )=SN*(U(I)*TE(3,1)+V(I)* TE(3,2))                          SHER3930
      DO 400 J=1,12                                                         SHER3940
      ST.J=ST(1,J)                                                          SHER3950
      ST(2,J)=ST.J*P1/P2                                                    SHER3960
      ST(3,J)=ST.J*P1*P2/(P3*P3)                                            SHER3970
      ST(4,J)=ST.J*P1*P2/(P4*P4)                                            SHER3980
  400 ST(1,J)=ST.J*P2/P1                                                    SHER3990
C*************************************************************************SHER4000
C-----GRAVITY AND INERTIA LOADS                                             SHER4010
C*************************************************************************SHER4020
      A1=0.5*X2*Y4                                                          SHER4030
      A2=0.5*X2*Y3                                                          SHER4040
      A3=AREA-A1                                                            SHER4050
      A4=AREA-A2                                                            SHER4060
      WTT=RHO/3.0                                                           SHER4070
      F1=(A4+A1+A2)*WTT                                                     SHER4080
      F2=(A1+A2+A3)*WTT                                                     SHER4090
      F3=(A2+A3+A4)*WTT                                                     SHER4100
      F4=(A3+A4+A1)*WTT                                                     SHER4110
      DO 450 I=1,3                                                          SHER4120
      XM(I)=F1                                                              SHER4130
      XM(I+3)=F2                                                            SHER4140
      XM(I+6)=F3                                                            SHER4150
```

```
      XM(I+9)=F4                                                        SHER4160
      DO 450 L=1,4                                                      SHER4170
      HH=EMOI(I,L)                                                      SHER4180
      P(I  ,L)=HH*F1                                                    SHER4190
      P(I+3,L)=HH*F2                                                    SHER4200
      P(I+6,L)=HH*F3                                                    SHER4210
  450 P(I+9,L)=HH*F4                                                    SHER4220
      DO 460 L=1,4                                                      SHER4230
      DO 460 I=1,4                                                      SHER4240
  460 TT(I,L)=0.0                                                       SHER4250
      RETURN                                                            SHER4260
 2007 FORMAT(1X,'ONE OF THE INTERIOR ANGLES FOR SHEAR PANEL NO.=', I5,' SHER4270
     1 IS GREATER THAN 180 DEGREES.')                                   SHER4280
      END                                                               SHER4290
```

```
      SUBROUTINE DPANEL(AOLD,ANEW,LOAD,NUMDV)                           SHER4300
C*********************************************************************SHER4310
C-----DESIGN OF SHEAR PANEL ELEMENTS                                    SHER4320
C*********************************************************************SHER4330
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                     SHER4340
      COMMON/JUNK/         LT,LH,L,SG(27),IDVAR,IEX,ERC,AREA,XINERT,    SHER4350
     1 SHEAR,SHCR,JUNJ(331)                                             SHER4360
C*********************************************************************SHER4370
C-----CHECK SHEAR STRESS                                                SHER4380
C*********************************************************************SHER4390
      SHELW=ABS(SG(5))                                                  SHER4400
      RMAX=SHELW/(SHEAR*AREA)                                           SHER4410
C*********************************************************************SHER4420
C-----CHECK BUCKLING                                                    SHER4430
C*********************************************************************SHER4440
      IF (SHCR.LE.0.0) GO TO 4                                          SHER4450
      R=SHELW/(SHCR*XINERT)                                             SHER4460
      R=R**0.333333                                                     SHER4470
    3 IF (RMAX.LT.R) RMAX=R                                             SHER4480
C*********************************************************************SHER4490
C-----FULLY STRESSED DESIGN                                             SHER4500
C*********************************************************************SHER4510
    4 AA=RMAX*AOLD(IDVAR)                                               SHER4520
      IF(AA.LT.ANEW(IDVAR)) GO TO 60                                    SHER4530
      ANEW(IDVAR)=AA                                                    SHER4540
      LOAD(IDVAR)=L                                                     SHER4550
   60 CONTINUE                                                          SHER4560
      RETURN                                                            SHER4570
      END                                                               SHER4580
```

```
      SUBROUTINE SHELL (A,MTOT)                                          SHEL0000
C*********************************************************************SHEL 0010
C-----PLATE/SHELL ELEMENTS                                               SHEL0020
C*********************************************************************SHEL0030
      DIMENSION A(MTOT)                                                  SHEL0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQSHEL0050
     . ,NUMEL,NUMDV,M1,M2,M3,LL,LR,NEQB,NBLOCK                           SHEL0060
      COMMON/JUNK/          LT,LH,L,SG(20) ,SIG(7),IDV,IEX,ERC,THICK,    SHEL0070
     1 XINERT,TEN,COMP,SHEAR,BETA,JUNK(329)                              SHEL0080
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12 ,I13              SHEL0090
      NUME= NPAR(2)                                                      SHEL0100
      KODE=NPAR(5)                                                       SHEL0110
      IF(NPAR(1).EQ.0) GO TO 500                                         SHEL0120
      NUMMAT=NPAR(3)                                                     SHEL0130
      NUMTC=NPAR(4)                                                      SHEL0140
      N6=N5+NUMNP                                                        SHEL0150
      N7=N6+NUMMAT                                                       SHEL0160
      N8=N7+NUMMAT                                                       SHEL0170
      GO TO (1,2),KODE                                                   SHEL0180
C*********************************************************************SHEL0190
C-----ISOTROPIC PLATE/SHELL ELEMENTS                                     SHEL0200
C*********************************************************************SHEL0210
    1 N9=N8+NUMMAT*NUMTC*7                                               SHEL0220
      MM=N9-MTOT                                                         SHEL0230
      IF(MM.GT.0) CALL ERROR(MM)                                         SHEL0240
      CALL PLATE1(A(M1),A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),A(N8),SHEL0250
     1 NUMDV,NUMNP,NUME,NUMMAT,NUMTC,KODE)                               SHEL0260
      RETURN                                                             SHEL0270
C*********************************************************************SHEL0280
C-----ORTHOTROPIC PLATE/SHELL ELEMENTS                                   SHEL0290
C*********************************************************************SHEL0300
    2 CALL NOELEM(NPAR(1),KODE,IW)                                       SHEL0310
      RETURN                                                             SHEL0320
  500 WRITE(IW,2002) KODE                                                SHEL0330
      DO 800  MM=1,NUME                                                  SHEL0340
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,0)                    SHEL0350
      WRITE(IW,2001) MM,THICK                                            SHEL0360
      TETA=BETA/57.2957795                                               SHEL0370
      CB=COS(TETA)                                                       SHEL0380
      SB=SIN(TETA)                                                       SHEL0390
      CSB=CB*SB                                                          SHEL0400
      CB=CB*CB                                                           SHEL0410
      SB=SB*SB                                                           SHEL0420
      DO 800 L=LT,LH                                                     SHEL0430
      IF(L.GT.LT) WRITE(IW,2004)                                         SHEL0440
      CALL STRSC(A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LR,1)                    SHEL0450
      IF(BETA.NE.0.) GO TO 20                                            SHEL0460
      DO 30 I=1,6                                                        SHEL0470
   30 SIG(I)=SG(I)                                                       SHEL0480
      GO TO 40                                                           SHEL0490
   20 DO 10 I=1,4,3                                                      SHEL0500
      C1=SG(I)*CB+SG(I+1)*SB                                             SHEL0510
      C2=2.0*SG(I+2)*CSB                                                 SHEL0520
      SIG(I)= C1+C2                                                      SHEL0530
      SIG(I+1)=C1-C2                                                     SHEL0540
   10 SIG(I+2)=(-SG(I)+SG(I+1))*CSB+SG(I+2)*(CB-SB)                      SHEL0550
   40 WRITE(IW,2003) L,(SIG(I),I=1,6)                                    SHEL0560
      GO TO (3,4),KODE                                                   SHEL0570
C*********************************************************************SHEL0580
C-----DESIGN OF ISOTROPIC PLATE/SHELL ELEMENTS                           SHEL0590
```

```
C*************************************************************************SHEL0600
    3 CALL DSHELI(A(M1),A(M2),A(M3),NUMDV    )                             SHEL0610
      GO TO 800                                                            SHEL0620
C*************************************************************************SHEL0630
C-----DESIGN OF ORTHOTROPIC SHELL ELEMENTS                                 SHEL0640
C*************************************************************************SHEL0650
    4 CONTINUE                                                             SHEL0660
  800 CONTINUE                                                             SHEL0670
      RETURN                                                               SHEL0680
C*************************************************************************SHEL0690
 2001 FORMAT(1X,I7,F14.4)                                                  SHEL0700
 2002 FORMAT(//49H ANALYSIS OF PLATE/SHELL ELEMENTS ,CONSTRN CODE =,I9//SHEL0710
     1          113H ELEMENT    ELEMENT      LOAD /-------------MEMBRANE FOSHEL0720
     2RCES-------------//--------BENDING/TWISTING MOMENTS--------/  /     SHEL0730
     3         113H  NUMBER    THICKNESS     COND        NXX             NYY  SHEL0740
     4          NXY             MXX           MYY             MXY      / )  SHEL0750
 2003 FORMAT(1H+,20X,I7,6E14.4)                                            SHEL0760
 2004 FORMAT(/)                                                            SHEL0770
      END                                                                  SHEL0780
```

```
      SUBROUTINE PLATE1(DWT,ID,X,Y,Z,T,WT,NTC,PMAT,NUMDV,NUMNP,NUME,      SHEL0790
     1 NUMMAT,NUMTC,KODE)                                                  SHEL0800
C*************************************************************************SHEL0810
C-----ISOTROPIC PLATE/SHELL ELEMENTS - C.A.FELIPPA'S SHELL ELEMENT         SHEL0820
C-----NOTE (1) PROGRAM INCLUDES TEMP. GRADIENT LOAD VECTORS AND STRESSESSHEL0830
C-----     (2) PROGRAM IS WRITTEN FOR GENERAL ORTHOTROPIC MAT. PROPERTIESHEL0840
C-----THESE ARE NOT USED IN THE PRESENT PROGRAM                            SHEL0850
C*************************************************************************SHEL0860
      IMPLICIT REAL*8 (A-H,O-Z)                                            SHEL0870
      REAL*4 DWT,X,Y,Z,T,WT,PMAT,ERC,E4,E5,E6,BET                          SHEL0880
      DIMENSION DWT(NUMDV),ID(NUMNP,6),X(NUMNP),Y(NUMNP),Z(NUMNP),         SHEL0890
     1 T(NUMNP),WT(NUMMAT),NTC(NUMMAT),PMAT(NUMTC,7,NUMMAT)               SHEL0900
      COMMON/JUNK/                                                         SHEL0910
     1IO(3,3),MEN,NTRI,IX(4),IE(4),PRESS,TEMP,DTEMP,EMUL(5,4),NSG(3),JU,SHEL0920
     2 RHO ,R1(30),R2(30),ST1(6),ST2(6),XX(5),YY(5),ZZ(5),CM(3,3),        SHEL0930
     3 ALFA(3), EE(16),AREA ,JUN1(56)                                     SHEL0940
      COMMON/EM/LM(24),S(30,30,2),P(24,4,3),XM(24),ST(6,30,2),TT(6,4,2),SHEL0950
     1 EM1(248)                                                           SHEL0960
      COMMON/COMPL/A(3,4),B(3,4),T1(9,4),T2(9,4),T3(9,4),LOC(3,4) ,       SHEL0970
     1 COM(288)                                                           SHEL0980
      COMMON/CONTR/IC1(13),LBUCK,IC2(15)                                   SHEL0990
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12 ,I13               SHEL1000
      DIMENSION G(30,30,3),IPERMO(4),SC(6,24)                              SHEL1010
      EQUIVALENCE (G ,S  ),(SC,R1)                                         SHEL1020
      DATA  IPERMO/2,3,4,1/                                                SHEL1030
C*************************************************************************SHEL1040
C-----CONTROL INFORMATION                                                  SHEL1050
C*************************************************************************SHEL1060
      MU=2                                                                 SHEL1070
      MV=2                                                                 SHEL1080
      MW=1                                                                 SHEL1090
      NS=6                                                                 SHEL1100
      NI=4                                                                 SHEL1110
      IEX=3                                                                SHEL1120
      NG=3                                                                 SHEL1130
      DO 5 I=1,3                                                           SHEL1140
```

```
    5 MSG(I)=I                                                          SHEL1150
      DTEMP =0.                                                         SHEL1160
      WRITE(IW,2000) NUME ,NUMMAT,NUMTC,KODE                            SHEL1170
C*********************************************************************SHEL1180
C-----READ AND PRINT OF MATERIAL PROPERTIES                            SHEL1190
C*********************************************************************SHEL1200
      WRITE(IW,2001)                                                    SHEL1210
      DO 10 M=1,NUMMAT                                                  SHEL1220
      READ(IR,1000) N,NTC(N),WT(N)                                      SHEL1230
      IF(NTC(N).EQ.0) NTC(N)=1                                          SHEL1240
      WRITE(IW,2002) N,NTC(N),WT(N)                                     SHEL1250
      NT=NTC(N)                                                         SHEL1260
      DO 11 I=1,NT                                                      SHEL1270
      READ(IR,1003) (PMAT(I,J,N),J=1,7)                                 SHEL1280
      IF(PMAT(I,6,N).LE.0.) PMAT(I,6,N)=PMAT(I,5,N)                     SHEL1290
      IF(PMAT(I,7,N).LE.0.) PMAT(I,7,N)=PMAT(I,5,N)*0.577               SHEL1300
   11 CONTINUE                                                          SHEL1310
      WRITE(IW,2009) (PMAT(I,J,N),J=1,7)                                SHEL1320
      IF(NT.GT.1) WRITE(IW,2008) ( (PMAT(I,J,N),J=1,7),I=2,NT)          SHEL1330
   10 CONTINUE                                                          SHEL1340
C*********************************************************************SHEL1350
C-----READ AND PRINT OF ELEMENT LOAD MULTIPLIERS                       SHEL1360
C*********************************************************************SHEL1370
      WRITE(IW,2006)                                                    SHEL1380
      READ(IR,1002) ( (EMUL(I,J),J=1,4),I=1,5)                          SHEL1390
      WRITE(IW,2007)(J,(EMUL(I,J),I=1,5),J=1,4)                         SHEL1400
C*********************************************************************SHEL1410
C-----READ AND PRINT OF ELEMENT DATA                                   SHEL1420
C*********************************************************************SHEL1430
      WRITE(IW,2003)                                                    SHEL1440
      N=1                                                               SHEL1450
  100 READ(IR,1001) IEL,IE,IMAT,INC,IDV,PRESS,REET,ERC,BETA             SHEL1460
      IF(IEL.LT.N) GO TO 600                                            SHEL1470
      IF(INC.EQ.0) INC=1                                                SHEL1480
      IF(ERC.EQ.0.) ERC=1.                                              SHEL1490
      IF(IMAT.EQ.0) IMAT=1                                              SHEL1500
      NEN=4                                                             SHEL1510
      ND=24                                                             SHEL1520
      NTRI=4                                                            SHEL1530
      N3=5                                                              SHEL1540
      IF(IE(4).NE.0) GO TO 46                                           SHEL1550
      NEN=3                                                             SHEL1560
      ND=18                                                             SHEL1570
      NTRI=1                                                            SHEL1580
       N3=3                                                             SHEL1590
      IX(4)=0                                                           SHEL1600
   46 RHO=WT(IMAT)                                                      SHEL1610
      BET=BETA                                                          SHEL1620
      KK=INC*(IEL-N)                                                    SHEL1640
      DO 45 I=1,NEN                                                     SHEL1640
   45 IX(I)=IE(I)-KK                                                    SHEL1650
      DO 500 NEL=N,IEL                                                  SHEL1660
      TEMP=0.                                                           SHEL1670
      DO 40 I=1,NEN                                                     SHEL1680
      J=IX(I)                                                           SHEL1690
      TEMP=TEMP+T(J)                                                    SHEL1700
      XX(I)=X(J)                                                        SHEL1710
      YY(I)=Y(J)                                                        SHEL1720
   40 ZZ(I)=Z(J)                                                        SHEL1730
      TEMP=TEMP/NEN                                                     SHEL1740
```

```
      IF(NEN.NE.4) GO TO 75                                                  SHEL1750
      XX(5)=0.25*(XX(1)+XX(2)+XX(3)+XX(4))                                   SHEL1760
      YY(5)=0.25*(YY(1)+YY(2)+YY(3)+YY(4))                                   SHEL1770
      ZZ(5)=0.25*(ZZ(1)+ZZ(2)+ZZ(3)+ZZ(4))                                   SHEL1780
C*************************************************************************SHEL1790
C-----INTERPOLATE MATERIAL PROPERTIES FOR AVERAGE ELEMENT TEMPERATURE    SHEL1800
C*************************************************************************SHEL1810
   75 CALL INTERP (PMAT,EE,NUMTC,NUMMAT,7,6,NTC(IMAT),IMAT,TEMP)           SHEL1820
      TEMP=TEMP-REFT                                                         SHEL1830
      ALFA(1)=EE(3)                                                          SHEL1840
      ALFA(2)=EE(3)                                                          SHEL1850
      ALFA(3)=0.                                                             SHEL1860
      CON=EE(1)/(1.0-EE(2)*EE(2))                                            SHEL1870
      CM(1,1)=CON                                                            SHEL1880
      CM(1,2)=CON*EE(2)                                                      SHEL1890
      CM(2,1)=CM(1,2)                                                        SHEL1900
      CM(2,2)=CON                                                            SHEL1910
      CM(3,3)=EE(1)*0.5/(1.0+EE(2))                                          SHEL1920
      CM(1,3)=0.                                                             SHEL1930
      CM(2,3)=0.                                                             SHEL1940
      CM(3,1)=0.                                                             SHEL1950
      CM(3,2)=0.                                                             SHEL1960
      E4=EE(4)                                                               SHEL1970
      E5=EE(5)                                                               SHEL1980
      E6=EE(6)                                                               SHEL1990
C*************************************************************************SHEL2000
C-----COMPUTE DIRECTION COSINE MATRIX TO OF LOCAL ELEMENT SYSTEM         SHEL2010
C*************************************************************************SHEL2020
      CALL ODCOS (NTRI,XX,YY,ZZ,TO)                                          SHEL2030
C*************************************************************************SHEL2040
C-----COMPUTE DIRECTION COSINES OF LOCAL TRIANGLE SYSTEM                  SHEL2050
C     AND THE TRIANGLE PROJECTIONS A,B ONTO IT                           SHEL2060
C*************************************************************************SHEL2070
      DO 700 I=1,NTRI                                                        SHEL2080
      N1=I                                                                   SHEL2090
      N2=IPERMO(N1)                                                          SHEL2100
      LOC(1,I)=N1*6 -6                                                       SHEL2110
      LOC(2,I)= N2*6-6                                                       SHEL2120
      LOC(3,I)=N3*6-6                                                        SHEL2130
  700 CALL TDCOS(N1,N2,N3,XX,YY,ZZ,A(1,I),B(1,I),T1(1,I),T2(1,I),T3(1,I)SHEL2140
     1 ,TO,NTRI )                                                          SHEL2150
C*************************************************************************SHEL2160
C-----FORM SHELL GLOBAL STIFFNESS MATRIX,MASS MATRIX,STRESS/DISPLACEMENTSHEL2170
C-----FORM SHELL ELEMENT MATRICES                                        SHEL2180
C*************************************************************************SHEL2190
      AREA=0.                                                                SHEL2200
      CALL DTSHEL  (ND,NS)                                                   SHEL2210
C*************************************************************************SHEL2220
C-----FORM LM ARRAY                                                      SHEL2230
C*************************************************************************SHEL2240
      DO 410 I=1,NEN                                                         SHEL2250
      J=6*I-6                                                                SHEL2260
      L=IX(I)                                                                SHEL2270
      DO 410 K=1,6                                                           SHEL2280
  410 LM(J+K)=ID(L,K)                                                        SHEL2290
      IWT(IDV)=IWT(IDV)+AREA*RHO*ERC                                         SHEL2300
      IF(LBUCK.NE.0.AND.NTRI.EQ.4) CALL SH2221 (SC,S(1,1,2))                 SHEL2310
C*************************************************************************SHEL2320
C-----COMPUTE BAND WIDTH AND WRITE ELEMENT INFO. ON TAPES                 SHEL2330
C*************************************************************************SHEL2340
```

```
      NN=ND*ND*NU                                                       SHEL2350
      CALL REARAN(S,S,30,30,2,ND,ND,NU,NN)                              SHEL2360
      NN=NS*ND*NU                                                       SHEL2370
      CALL REARAN(ST,ST,6,30,2,NS,ND,NU,NN)                             SHEL2380
      NN=ND*4*NV                                                        SHEL2390
      CALL REARAN(P,P,24,4,3,ND,4,NV,NN)                                SHEL2400
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,ERC)         SHEL2410
      WRITE(IW) MT,E4,E5,E6,BET                                         SHEL2420
      IF(LBUCK.EQ.0) GO TO 650                                          SHEL2430
C*********************************************************************SHEL2440
C-----COMPUTE UNIT GEOMETRIC STIFFNESS MATRICES                        SHEL2450
C*********************************************************************SHEL2460
      CALL SHELG1(SC,TO,NIRT)                                           SHEL2470
      NN=ND*ND*NG                                                       SHEL2480
      CALL REARAN(G,G,30,30,3,ND,ND,NG,NN)                              SHEL2490
      CALL ELGSUM(G,NSG,ND,NG,111)                                      SHEL2500
  650 WRITE(IW,2004) NEL,IX,IMAT,IDV,PRESS,REFT,ERC,BETA,NDIF          SHEL2510
      DO 450 MM=1,NEN                                                   SHEL2520
  450 IX(MM)=IX(MM)+INC                                                 SHEL2530
  500 CONTINUE                                                          SHEL2540
      N=IEL+1                                                           SHEL2550
      IF(N.LE.NUME) GO TO 100                                           SHEL2560
      RETURN                                                            SHEL2570
  600 WRITE(IW,2005) N                                                  SHEL2580
      STOP                                                              SHEL2590
 1000 FORMAT(2I5 ,E10.0 )                                               SHEL2600
 1001 FORMAT(8I5,4E10.0)                                                SHEL2610
 1002 FORMAT (4E10.0)                                                   SHEL2620
 1003 FORMAT(7E10.0)                                                    SHEL2630
 2000 FORMAT (50H1T H I N   P L A T E / S H E L L   E L E M E N T S. // SHEL2640
     2         22H NUMBER OF ELEMENTS  =, I5 /                         SHEL2650
     3         22H NUMBER OF MATERIALS =, I5 /,                        SHEL2660
     4         22H NUMBER OF TEMP CARDS=, I5/,                         SHEL2670
     5         22H CONSTRN CODE        =,  I5//  )                     SHEL2680
 2001 FORMAT (24H MATERIAL PROPERTY TABLE, //                           SHEL2690
     1       124H MATERIAL NUM OF   SPECIFIC    TEMP         YOUNGS    POSHEL2700
     2ISSONS'S    COEFFT OF  /------------ALLOWABLE STRESSES------------SHEL2710
     3-/   / )17H NUMBER    TEMP      WEIGHT                  MODULUS    SHEL2720
     4RATIO        THERM EXPN     TENSION      COMPRESSION       SHEAR  )SHEL2730
 2002 FORMAT(I5,19,E10.5)                                               SHEL2740
 2003 FORMAT(/32H THIN  PLATE/SHELL  ELEMENT DATA, // 8H ELEMENT, 32X,  SHEL2750
     1 8HMATERIAL,4X,7HDES VAR,4X,6HNORMAL,4X,9HREFERENCE ,5X,7HDES VAR,SHEL2760
     ,5X,4HBETA,8X,4HBRAND  /                                           SHEL2770
     2 7H NUMBER,2X,6HNODE-I,2X,6HNODE-J,1X,6HNODE-K,2X,6HNODE-L,       SHEL2780
     3          3X,6HNUMBER,5X,6HNUMBER,4X,8HPRESSURE,2X,11HTEMPERATURE,SHEL2790
     4 3X,8HERACTION,16X,5HWIDTH /)                                     SHEL2800
 2004 FORMAT(I5,4I8,2I9,3X,4E12.4 ,E10)                                 SHEL2810
 2005 FORMAT (19HDCARD FOR ELEMENT (,I5,14H) IS IN ERROR., / 1X)        SHEL2820
 2006 FORMAT(/30H ELEMENT LOAD CASE MULTIPLIERS, // 13H ELEMENT LOAD,   SHEL2830
     1 4X,8HPRESSURE,5X,7HTHERMAL,13X,2HX-,13X,2HY-,13X,2HZ-, /         SHEL2840
     2 13H  CASE NUMBER,17X,7HEFFECTS, 3(3X,12HACCELERATION), / 1X)     SHEL2850
 2007 FORMAT (6X,I1,6X,2E12.3,3E15.3)                                   SHEL2860
 2008 FORMAT(26X,E10.3,1PE14.5,0PE10.3,1PE14.5,0P3E14.2)                SHEL2870
 2009 FORMAT(1H+,25X,E10.3,1PE14.5,0PE10.3,1PE14.5,0P3E14.2)            SHEL2880
      END                                                               SHEL2890
```

```
      SUBROUTINE QDCOS (N,X,Y,Z,T)                                      SHEL2900
C*********************************************************************SHEL2910
C-----THIS SUBROUTINE COMPUTES THE DIRECTION COSINES OF THE LOCAL       SHEL2920
C     ELEMENT SYSTEM OF A QUADRILATERAL(N=4) OR SINGLE TRIANGLE(N=1)    SHEL2930
C*********************************************************************SHEL2940
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL2950
      DIMENSION X(5),Y(5),Z(5),T(9)                                     SHEL2960
      X1 = X(2)+X(3)-X(N)-X(1)                                          SHEL2970
      Y1 = Y(2)+Y(3)-Y(N)-Y(1)                                          SHEL2980
      Z1 = Z(2)+Z(3)-Z(N)-Z(1)                                          SHEL2990
      X2 = X(3)+X(N)-X(1)-X(2)                                          SHEL3000
      Y2 = Y(3)+Y(N)-Y(1)-Y(2)                                          SHEL3010
      Z2 = Z(3)+Z(N)-Z(1)-Z(2)                                          SHEL3020
      S1 = X1**2+Y1**2+Z1**2                                            SHEL3030
      C  = (X1*X2+Y1*Y2+Z1*Z2)/S1                                       SHEL3040
      X2 = X2-C*X1                                                      SHEL3050
      Y2 = Y2-C*Y1                                                      SHEL3060
      Z2 = Z2-C*Z1                                                      SHEL3070
      S1=DSQRT(S1)                                                      SHEL3080
      S2=DSQRT(X2*X2+Y2*Y2+Z2*Z2)                                       SHEL3090
      X1=X1/S1                                                          SHEL3100
      Y1=Y1/S1                                                          SHEL3110
      Z1=Z1/S1                                                          SHEL3120
      X2=X2/S2                                                          SHEL3130
      Y2=Y2/S2                                                          SHEL3140
      Z2=Z2/S2                                                          SHEL3150
      T(1) = X1                                                         SHEL3160
      T(2) = X2                                                         SHEL3170
      T(3) = Y1*Z2-Y2*Z1                                                SHEL3180
      T(4) = Y1                                                         SHEL3190
      T(5) = Y2                                                         SHEL3200
      T(6) = Z1*X2-Z2*X1                                                SHEL3210
      T(7) = Z1                                                         SHEL3220
      T(8) = Z2                                                         SHEL3230
      T(9) = X1*Y2-X2*Y1                                                SHEL3240
      RETURN                                                            SHEL3250
      END                                                               SHEL3260


      SUBROUTINE TDCOS(N1,N2,N3,X,Y,Z,A,B,T1,T2,T3,T,NTRI)              SHEL3270
C*********************************************************************SHEL3280
C-----THIS SUBROUTINE COMPUTES THE DIRECTION COSINES OF THE LOCAL       SHEL3290
C     SYSTEM AND THE PROJECTED DIMENSIONS OF A  SUBTRIANGLE  COMPONENT  SHEL3300
C*********************************************************************SHEL3310
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL3320
      DIMENSION X(5),Y(5),Z(5),A(3),B(3),T1(9),T2(9),T3(9),T(9)         SHEL3330
      A1  = X(N1)-X(N3)                                                 SHEL3340
      B1  = Y(N1)-Y(N3)                                                 SHEL3350
      C1  =Z(N1)-Z(N3)                                                  SHEL3360
      A2 = X(N2)-X(N3)                                                  SHEL3370
      B2 = Y(N2)-Y(N3)                                                  SHEL3380
      C2 = Z(N2)-Z(N3)                                                  SHEL3390
      IF(NTRI.EQ.4) GO TO 300                                           SHEL3400
      DO 350 I=1,3                                                      SHEL3410
      T1(I)=T(I*3-2)                                                    SHEL3420
      T1(I+3)=T1(I)                                                     SHEL3430
      T1(I+6)=T1(I)                                                     SHEL3440
      T2(I)=T(I*3-1)                                                    SHEL3450
```

```
      T2(I+3)=T2(I)                                                    SHEL 3460
      T2(I+6)=T2(I)                                                    SHEL 3470
      T3(I)=T(I+3)                                                     SHEL 3480
      T3(I+3)=T3(I)                                                    SHEL 3490
  350 T3(I+6)=T3(I)                                                    SHEL 3500
      GO TO 400                                                        SHEL 3510
  300 T31 = B1*C2-B2*C1                                                SHEL 3520
      T32 = C1*A2-C2*A1                                                SHEL 3530
      T33 = A1*B2-A2*B1                                                SHEL 3540
      S =DSQRT (T31**2+T32**2+T33**2)                                  SHEL 3550
      T31 = T31/S                                                      SHEL 3560
      T32 = T32/S                                                      SHEL 3570
      T33 = T33/S                                                      SHEL 3580
      T11= T33*T(5)-T32*T(8)                                           SHEL 3590
      T12= T31*T(8)-T33*T(2)                                           SHEL 3600
      T13= T32*T(2)-T31*T(5)                                           SHEL 3610
      S =DSQRT(T11**2+T12**2+T13**2)                                   SHEL 3620
      T11=T11/S                                                        SHEL 3630
      T12=T12/S                                                        SHEL 3640
      T13=T13/S                                                        SHEL 3650
      T21= T13*T32-T12*T33                                             SHEL 3660
      T22= T11*T33-T13*T31                                             SHEL 3670
      T23=T12*T31-T11*T32                                              SHEL 3680
      T1(1)=T11                                                        SHEL 3690
      T1(2)=T12                                                        SHEL 3700
      T1(3)=T13                                                        SHEL 3710
      T2(1)=T21                                                        SHEL 3720
      T2(2)=T22                                                        SHEL 3730
      T2(3)=T23                                                        SHEL 3740
      T3(1)=T31                                                        SHEL 3750
      T3(2)=T32                                                        SHEL 3760
      T3(3)=T33                                                        SHEL 3770
      DO 100 I=1,3                                                     SHEL 3780
      J=I+3                                                            SHEL 3790
      K=I+6                                                            SHEL 3800
      T1(J)=T1(I)                                                      SHEL 3810
      T2(J)=T2(I)                                                      SHEL 3820
      T3(J)=T3(I)                                                      SHEL 3830
      CI=T(I)                                                          SHEL 3840
      CJ=T(J)                                                          SHEL 3850
      CK=T(K)                                                          SHEL 3860
      T1(K)=T11*CI+T12*CJ+T13*CK                                       SHEL 3870
      T2(K)=T21*CI+T22*CJ+T23*CK                                       SHEL 3880
  100 T3(K)=T31*CI+T32*CJ+T33*CK                                       SHEL 3890
  400 A(1)= -T1(1)*A2-T1(2)*B2-T1(3)*C2                                SHEL 3900
      A(2)=  T1(1)*A1+T1(2)*B1+T1(3)*C1                                SHEL 3910
      A(3)= -A(1)-A(2)                                                 SHEL 3920
      B(1)=  T2(1)*A2+T2(2)*B2+T2(3)*C2                                SHEL 3930
      B(2)= -T2(1)*A1-T2(2)*B1-T2(3)*C1                                SHEL 3940
      B(3)=-B(1)-B(2)                                                  SHEL 3950
      RETURN                                                           SHEL 3960
      END                                                              SHEL 3970
```

```
      SUBROUTINE OTSHEL   (ND,NS)                                       SHEL 3980
C*********************************************************************SHEL 3990
C-----THIS SUBROUTINE EVALUATES                                         SHEL 4000
C                     STIFFNESS MATRIX                                  SHEL 4010
C                     STRESS/DISPLACEMENT TRANSFORMATION MATRIX         SHEL 4020
C                     NODAL FORCE VECTOR DUE TO DISTRIBUTED LATERAL LOADSHEL 4030
C                     NODAL FORCE VECTOR DUE TO THERMAL STRAINS         SHEL 4040
C                     STRESS CORRECTION MATRIX DUE TO THERMAL STRAINS   SHEL 4050
C                 AND MASS MATRIX                                       SHEL 4060
C     OF A SHALLOW QUADRILATERAL SHELL ELEMENT ASSEMBLED WITH FOUR FLAT SHEL 4070
C     TRIANGLES OR OF A SINGLE TRIANGULAR SHELL ELEMENT                 SHEL 4080
C-----S1  : UNIT STIFFNESS PROPORTIONAL TO THICKNESS                    SHEL 4090
C           (DUE TO MEMBRANE ACTION)                                    SHEL 4100
C-----S2  : UNIT STIFFNESS PROPORTIONAL TO (THICKNESS)**3               SHEL 4110
C           (DUE TO BENDING ACTION)                                     SHEL 4120
C-----P1  : UNIT NODAL FORCE VECTOR PROPORTIONAL TO THICKNESS           SHEL 4130
C           (DUE TO GRAVITY LOADS -POINT LOADS ONLY COMPUTED ,          SHEL 4140
C            AND DUE TO MEAN TEMPERATURE DIFFERENCE  )                  SHEL 4150
C-----P2  : UNIT NODAL FORCE VECTOR  AND IS CONSTANT                    SHEL 4160
C           (DUE TO NORMAL PRESSURE LOADS-LUMPED LOADS ONLY COMPUTED )  SHEL 4170
C-----P3  : UNIT NODAL FORCE VECTOR PROPORTIONAL TO (THICKNESS)**3      SHEL 4180
C           (DUE TOTEMPERATURE GRADIENT ACROSS THICKNESS)               SHEL 4190
C-----XM  : MASS MATRIX PROPORTIONAL TO THICKNESS -LUMPED MASSES ONLY   SHEL 4200
C-----SA1 : UNIT STRESS MATRIX PROPORTIONAL TO THICKNESS                SHEL 4210
C           (DUE TO MEMBRANE ACTION)                                    SHEL 4220
C-----SA2 : UNIT STRESS MATRIX PROPORTIONAL TO (THICKNESS)**3           SHEL 4230
C           (DUE TO BENDING ACTION)                                     SHEL 4240
C-----TT1 : UNIT STRESS CORRECTION VECTOR PROPORTIONAL TO THICKNESS     SHEL 4250
C           (DUE TO MEAN TEMPERATURE DIFFERENCE - MEMBRANE STRESSES)    SHEL 4260
C-----TT2 : STRESS CORRECTION VECTOR PROPORTIONAL TO (THICKNESS)**3     SHEL 4270
C           (DUE TO TEMPERATURE GRADIENT ACROSS THICKNESS)              SHEL 4280
C*********************************************************************SHEL 4290
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 4300
      COMMON/JUNK/                                                      SHEL 4310
     1IO(3,3),NEN,NTRI,IX(4),IE(4),PRESS,TEMP,DTEMP,EMUL(5,4),NSG(3),JU,SHEL 4320
     2 RHO ,R1(30),R2(30),ST1(6),ST2(6),X (5),Y (5),Z (5),CM(3,3),      SHEL 4330
     3 ALFA(3), EE(6),AREA ,JUNI(56)                                    SHEL 4340
      COMMON/COMPL/A(3,4),B(3,4),T1(9,4),T2(9,4),T3(9,4),LOC(3,4)       SHEL 4350
     1,AREAT,SMT(3),BMT(3) ,COM(28))                                    SHEL 4360
      COMMON/EM/LM(24),S1(30,30),S2(30,30),P1(24,4),P2(24,4),P3(24,4),  SHEL 4370
     1XM(24),SA1(6,30),SA2(6,30),TT1(6,4),TT2(6,4),E1(9),C1(3,9),ST(9,9)SHEL 4380
     1 ,EM1(131)                                                        SHEL 4390
      DIMENSION EMM(2700)                                               SHEL 4400
      EQUIVALENCE (EMM,S1)                                              SHEL 4410
      WG=1.0                                                            SHEL 4420
      IF(NTRI.EQ.4) WG=0.25                                             SHEL 4430
      DO 50 I=1,2700                                                    SHEL 4440
   50 EMM(I)=0.                                                         SHEL 4450
      DO 51 I=1,30                                                      SHEL 4460
      R1(I)=0.                                                          SHEL 4470
   51 R2(I)=0.                                                          SHEL 4480
C*********************************************************************SHEL 4490
C-----THERMAL STRESS CORRECTION MATRIX                                  SHEL 4500
C*********************************************************************SHEL 4510
      DT=DTEMP/12.                                                      SHEL 4520
      DO 160 I=1,3                                                      SHEL 4530
      CC=CM(I,1)*ALFA(1)+CM(I,2)*ALFA(2)+CM(I,3)*ALFA(3)                SHEL 4540
      SMT(I) =-CC*TEMP                                                  SHEL 4550
      BMT(I) =-CC*DT                                                    SHEL 4560
      DO 160 J=1,4                                                      SHEL 4570
```

```
      T1(I,J)=SMT(I)*EMUL(2,J)                                          SHEL 4580
  160 T2(I+3,J)=SMT(I)*EMUL(2,J)                                        SHEL 4590
C*************************************************************************SHEL 4600
C-----LOOP OVER THE NTRI TRIANGLE COMPONENTS                            SHEL 4610
C*************************************************************************SHEL 4620
      DO 700  NT = 1,NTRI                                               SHEL 4630
C*************************************************************************SHEL 4640
C-----FORM MASS MATRIX AND NODAL FORCE VECTOR DUE TO NORMAL PRESSURE     SHEL 4650
C      AND GRAVITY LOADS IN GLOBAL COORDINATES                          SHEL 4660
C*************************************************************************SHEL 4670
      AREAT=(A(3,NT)*B(2,NT)-A(2,NT)*B(3,NT))*0.5                       SHEL 4680
      AREA=AREA+AREAT                                                   SHEL 4690
      IF(NTRI.EQ.1) GO TO 345                                           SHEL 4700
      FAC=AREAT*PRESS*0.5                                               SHEL 4710
      XMM=AREAT*RHO *0.5                                                SHEL 4720
      DO 340 I=1,2                                                      SHEL 4730
      K=LOC(I,NT)                                                       SHEL 4740
      DO 340 J=1,3                                                      SHEL 4750
      K=K+1                                                             SHEL 4760
      DO 341 L=1,4                                                      SHEL 4770
      P1(K,L)=P1(K,L)+XMM*EMUL(J+2,L)                                   SHEL 4780
  341 P2(K,L)=P2(K,L)+FAC*EMUL(1,L)*T3(J,NT)                            SHEL 4790
  340 XM(K)=XM(K)+XMM                                                   SHEL 4800
      GO TO 350                                                         SHEL 4810
  345 FAC=AREAT*PRESS/3.                                                SHEL 4820
      XMM=AREAT*RHO /3.                                                 SHEL 4830
      DO 360 I=1,3                                                      SHEL 4840
      K=LOC(I,NT)                                                       SHEL 4850
      DO 360 J=1,3                                                      SHEL 4860
      K=K+1                                                             SHEL 4870
      DO 361 L=1,4                                                      SHEL 4880
      P1(K,L)=P1(K,L)+XMM*EMUL(J+2,L)                                   SHEL 4890
  361 P2(K,L)=P2(K,L)+FAC*EMUL(1,L)*T3(J,NT)                            SHEL 4900
  360 XM(K)=XM(K)+XMM                                                   SHEL 4910
C*************************************************************************SHEL 4920
C-----MEMBRANE CONTRIBUTION                                             SHEL 4930
C*************************************************************************SHEL 4940
  350 CALL SLST (CM,FT,CT,ST,NT )                                       SHEL 4950
C*************************************************************************SHEL 4960
C-----COORDINATE TRANSFORMATION OF TRAINGLE ELEMENT MEMBRANE STIFFNESS  SHEL 4970
C*************************************************************************SHEL 4980
      LT=0                                                              SHEL 4990
      DO 400 JJ=1,3                                                     SHEL 5000
      J = JJ + JJ                                                       SHEL 5010
      M = LOC(JJ,NT)                                                    SHEL 5020
      DO 400 L=1,3                                                      SHEL 5030
      M = M + 1                                                         SHEL 5040
      LT=LT+1                                                           SHEL 5050
      C1=T1(LT,NT)                                                      SHEL 5060
      C2=T2(LT,NT)                                                      SHEL 5070
      KT=0                                                              SHEL 5080
      DO 390 II=1,JJ                                                    SHEL 5090
      I = II + II                                                       SHEL 5100
      KK=3                                                              SHEL 5110
      IF (II.EQ.JJ)  KK = 1                                             SHEL 5120
      H1 = ST(I-1,J-1)*C1 + ST(I-1,J)*C2                                SHEL 5130
      H2 = ST(I  ,J-1)*C1 + ST(I  ,J)*C2                                SHEL 5140
      N = LOC(II,NT)                                                    SHEL 5150
      DO 390 K=1,KK                                                     SHEL 5160
      N = N + 1                                                         SHEL 5170
```

```
      KT=KT+1                                                           SHEL 5180
      SO= S1(N,M)+T1(KT,NT)*H1+T2(KT,NT)*H2                             SHEL 5190
      S1(N,M)=SO                                                        SHEL 5200
  390 S1(M,N)=SO                                                        SHEL 5210
  400 CONTINUE                                                          SHEL 5220
C*******************************************************************SHEL 5230
C-----COORDINATE TRANSFORMATION OF STRESS MATRIX AND THERMAL LOAD VECTORSHEL 5240
C*******************************************************************SHEL 5250
      DO 410 JJ=1,3                                                     SHEL 5260
      M=LOC(JJ,NT)                                                      SHEL 5270
      J=JJ+JJ                                                           SHEL 5280
      DO 410 L=1,3                                                      SHEL 5290
      C1=T1(L,NT)                                                       SHEL 5300
      C2=T2(L,NT)                                                       SHEL 5310
      M = M+1                                                           SHEL 5320
      R1(M)=R1(M)+C1    *ET(J-1)+C2    *ET(J)                           SHEL 5330
      DO 410 K=1,3                                                      SHEL 5340
  410 SA1(K,M)=SA1(K,M)+(CT(K,J-1)*C1     +CT(K,J)*C2    )*WG            SHEL 5350
C*******************************************************************SHEL 5360
C-----PLATE BENDING CONTRIBUTION                                        SHEL 5370
C*******************************************************************SHEL 5380
      CALL SLCCT (CM,ET,CT,ST,NT,NTRI)                                  SHEL 5390
C*******************************************************************SHEL 5400
C-----COORDINATE TRANSFORMATION OF TRIANGLE ELEMENT BENDING STIFFNESS   SHEL 5410
C*******************************************************************SHEL 5420
      CALL SHLCT1(S2,ST,T1,T2,T3,LOC,NT)                                SHEL 5430
C*******************************************************************SHEL 5440
C-----COORDINATE TRANSFORMATION OF MOMENT RESULTANT MATRIX AND          SHEL 5450
C     THERMAL LOAD VECTOR                                               SHEL 5460
C*******************************************************************SHEL 5470
      DO 680 JJ=1,3                                                     SHEL 5480
      M=LOC(JJ,NT)                                                      SHEL 5490
      J=(JJ-1)*3+1                                                      SHEL 5500
      DO 686 L=1,3                                                      SHEL 5510
      M = M+1                                                           SHEL 5520
      C3=T3(L,NT)                                                       SHEL 5530
      R2(M)=R2(M)+ET(J)*C3                                              SHEL 5540
      DO 686 K=1,3                                                      SHEL 5550
  686 SA2(K+3,M)=SA2(K+3,M)+CT(K,J)*C3*WG                               SHEL 5560
      DO 680 L=1,3                                                      SHEL 5570
      M=M+1                                                             SHEL 5580
      C1=T1(L,NT)                                                       SHEL 5590
      C2=T2(L,NT)                                                       SHEL 5600
      R2(M)=R2(M)+ET(J+1)*C1    +ET(J+2)*C2                             SHEL 5610
      DO 680 K=1,3                                                      SHEL 5620
  680 SA2(K+3,M)=SA2(K+3,M)+(CT(K,J+1)*C1+CT(K,J+2)*C2)*WG              SHEL 5630
  700 CONTINUE                                                          SHEL 5640
      IF(NTRI.EQ.1) GO TO 900                                           SHEL 5650
C*******************************************************************SHEL 5660
C-----CHECK FOR POSSIBLE INTERNAL STIFFNESS SINGULARITY (FLAT          SHEL 5670
C     OR NEARLY FLAT QUADRILATERAL) AND TRANSFORM STIFFNESS AT 5TH NODESHEL 5680
C     TO GLOBAL COORDINATES                                             SHEL 5690
C*******************************************************************SHEL 5700
      IF(S1(27,27).GT.(S1(25,25)+S1(26,26))*1.0E-07) GO TO 690          SHEL 5710
      DO 691 I=1,27                                                     SHEL 5720
      S1(I,27)=0.0                                                      SHEL 5730
  691 S1(27,I)=0.0                                                      SHEL 5740
  690 DO 510 II=1,27                                                    SHEL 5750
      DO 511 J=1,3                                                      SHEL 5760
  511 ET(J)=S1(II,25)*T0(1,J)+S1(II,26)*T0(2,J)+S1(II,27)*T0(3,J)       SHEL 5770
```

```
      DO 510 J=1,3                                                      SHEL 5780
  510 S1(II,J+24)=ET(J)                                                 SHEL 5790
      DO 520 JJ=25,27                                                   SHEL 5800
      DO 521 I=1,3                                                      SHEL 5810
  521 ET(I)=TO(1,I)*S1(25,JJ)+TO(2,I)*S1(26,JJ)+TO(3,I)*S1(27,JJ)       SHEL 5820
      DO 520 I=1,3                                                      SHEL 5830
  520 S1(24+I,JJ)=ET(I)                                                 SHEL 5840
      DO 530 I=1,24                                                     SHEL 5850
      DO 530 J=25,27                                                    SHEL 5860
  530 S1(J,I)=S1(I,J)                                                   SHEL 5870
      CALL SHLCT2(S2,TO,ET,ET(4),ET(7))                                 SHEL 5880
C*******************************************************************SHEL 5890
C-----CONDENSATION OF INTERNAL DEGREES OF FREEDOM                       SHEL 5900
C*******************************************************************SHEL 5910
      CALL SHLCD1 (1,3,S1,R1,SA1,ST1)                                   SHEL 5920
      CALL SHLCD1 (4,6,S2,R2,SA2,ST2)                                   SHEL 5930
      DO 851 I=1,6                                                      SHEL 5940
      DO 851 J=1,4                                                      SHEL 5950
      TT1(I,J)=TT1(I,J)+ST1(I)*EMUL(2,J)                                SHEL 5960
  851 TT2(I,J)=TT2(I,J)+ST2(I)*EMUL(2,J)                                SHEL 5970
  900 DO 850 I=1,ND                                                     SHEL 5980
      DO 850 J=1,4                                                      SHEL 5990
      P1(I,J)=P1(I,J)+R1(I)*EMUL(2,J)                                   SHEL 6000
  850 P3(I,J)=R2(I)*EMUL(2,J)                                           SHEL 6010
      RETURN                                                            SHEL 6020
      END                                                               SHEL 6030
```

```
      SUBROUTINE SHLCD1(NN,MM,S,R,SA,ST)                                SHEL 6040
C*******************************************************************SHEL 6050
C-----CONDENSATION OF INTERNAL DEGREES OF FREEDOM                       SHEL 6060
C*******************************************************************SHEL 6070
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 6080
      DIMENSION S(30,30),R(30),SA(6,30),ST(6)                           SHEL 6090
      DO 850 I=1,6                                                      SHEL 6100
  850 ST(I)=0.                                                          SHEL 6110
      DO 800 J=1,6                                                      SHEL 6120
      L=30-J                                                            SHEL 6130
      M=L+1                                                             SHEL 6140
      PIV=S(M,M)                                                        SHEL 6150
      IF(PIV.LE.0) GO TO 800                                            SHEL 6160
      RL=R(M)/PIV                                                       SHEL 6170
      DO 820 K=1,L                                                      SHEL 6180
      R(K)=R(K)-S(K,M)*RL                                               SHEL 6190
      SS=S(M,K)/PIV                                                     SHEL 6200
      DO 830 I=1,K                                                      SHEL 6210
  830 S(K,I)=S(K,I)-S(M,I)*SS                                           SHEL 6220
      DO 820 I=NN,MM                                                    SHEL 6230
  820 SA(I,K)=SA(I,K)-SA(I,M)*SS                                        SHEL 6240
      DO 810 I=NN,MM                                                    SHEL 6250
  810 ST(I)=ST(I)-SA(I,M)*RL                                            SHEL 6260
  800 CONTINUE                                                          SHEL 6270
      DO 900 I=2,24                                                     SHEL 6280
      II=I-1                                                            SHEL 6290
      DO 900 J=1,II                                                     SHEL 6300
  900 S(J,I)=S(I,J)                                                     SHEL 6310
      RETURN                                                            SHEL 6320
      END                                                               SHEL 6330
```

```
      SUBROUTINE SLST(C,FT,CT,ST,NT)                                    SHEL 6340
C*********************************************************************SHEL 6350
C-----THIS SUBROUTINE FORMS THE STIFFNESS MATRIX ,THERMAL LOAD VECTOR,  SHEL 6360
C     AND STRESS MATRIX OF A CONSTANT STRAIN TRIANGLE                   SHEL 6370
C*********************************************************************SHEL 6380
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 6390
      DIMENSION C(3,3),FT(9),CT(3,9),ST(9,9)                            SHEL 6400
      COMMON/COMPL/A(3,4),B(3,4),TT(108),LOC(3,4),AREA ,SMT(3),BMT(3) , SHEL 6410
     1 COM(281)                                                         SHEL 6420
      FAC=0.25/AREA                                                     SHEL 6430
      FAC1=0.5/AREA                                                     SHEL 6440
      C11 = C(1,1)*FAC                                                  SHEL 6450
      C22 = C(2,2)*FAC                                                  SHEL 6460
      C33 = C(3,3)*FAC                                                  SHEL 6470
      C12 = C(1,2)*FAC                                                  SHEL 6480
      C13 = C(1,3)*FAC                                                  SHEL 6490
      C23 = C(2,3)*FAC                                                  SHEL 6500
      DO 200 J=1,3                                                      SHEL 6510
      L=J+J                                                             SHEL 6520
      AJ=A(J,NT)                                                        SHEL 6530
      BJ=B(J,NT)                                                        SHEL 6540
C*********************************************************************SHEL 6550
C-----THERMAL LOAD VECTOR                                               SHEL 6560
C*********************************************************************SHEL 6570
      FT(L-1)=(-BJ  *SMT(1)-AJ  *SMT(3))*0.5                            SHEL 6580
      FT(L   )=(-AJ  *SMT(2)-BJ  *SMT(3))*0.5                           SHEL 6590
C*********************************************************************SHEL 6600
C-----STRESS DISPLACEMENT TRANSFORMATION MATRIX                         SHEL 6610
C*********************************************************************SHEL 6620
      DO 300 I=1,3                                                      SHEL 6630
      CT(I,L-1)= (C(I,1)*BJ  +C(I,3)*AJ  )*FAC1                         SHEL 6640
  300 CT(I,L) = (C(I,2)*AJ  +C(I,3)*BJ  )*FAC1                         SHEL 6650
C*********************************************************************SHEL 6660
C-----STIFFNESS MATRIX IN TRIANGLE LOCAL COORDINATES                    SHEL 6670
C*********************************************************************SHEL 6680
      DO 200 I=1,J                                                      SHEL 6690
      K=I+I                                                             SHEL 6700
      AA=A(I,NT)*AJ                                                     SHEL 6710
      AB=A(I,NT)*BJ                                                     SHEL 6720
      BB=B(I,NT)*BJ                                                     SHEL 6730
      BA=B(I,NT)*AJ                                                     SHEL 6740
      ABA=AB+BA                                                         SHEL 6750
      ST(K-1,L-1)=C11*BB+C13*ABA+C33*AA                                 SHEL 6760
      ST(K-1,L)=C12*BA+C13*BB+C23*AA+C33*AB                             SHEL 6770
      ST(K,L-1)= C12*AB+C13*BB+C23*AA+C33*BA                            SHEL 6780
  200 ST(K,L)= C22*AA+C23*ABA+C33*BB                                    SHEL 6790
      DO 400 I=3,6                                                      SHEL 6800
      DO 400 J=1,I                                                      SHEL 6810
  400 ST(I,J)=ST(J,I)                                                   SHEL 6820
      RETURN                                                            SHEL 6830
      END                                                               SHEL 6840
```

```
      SUBROUTINE SLCCT(CM,FT,CT,ST,NT,NTRI)                              SHEL6850
C*********************************************************************SHEL6860
C-----FORM PLATE BENDING STIFFNESS AND LOAD VECTOR DUE TO               SHEL6870
C     THERMAL GRADIENT OF A LINEAR CURVATURE COMPATIBLE TRIANGLE(LCCT-9)SHEL6880
C     NORMAL SLOPES AT MID SIDE NODES ARE ELIMINATED USING              SHEL6890
C     THETA(NN) AT NODE 4 = THETA(NN) AT NODE 1 + THETA(NN) AT NODE2 ETCSHEL6900
C*********************************************************************SHEL6910
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL6920
      DIMENSION CM(3,3),FT(9),CT(3,9),ST(9,9) ,IPERM(3)                 SHEL6930
      COMMON/COMPL/A(3,4),B(3,4),TT(108),LOC(3,4),AREA,SMT(3),BMT(3),   SHEL6940
     1 U(3),TX(3),TY(3),O(3,6),P(21,9),G(21),HT(3) ,COM(41)             SHEL6950
      DATA IPERM/2,3,1/                                                 SHEL6960
      FAC1=AREA/432.                                                    SHEL6970
      FAC2=1./12.                                                       SHEL6980
      DO 150 I=1,3                                                      SHEL6990
      J = IPERM(I)                                                      SHEL7000
      K = IPERM(J)                                                      SHEL7010
      A1=A(I,NT)                                                        SHEL7020
      A2=A(J,NT)                                                        SHEL7030
      B1=B(I,NT)                                                        SHEL7040
      B2=B(J,NT)                                                        SHEL7050
      X=A1*A1+B1*B1                                                     SHEL7060
      U(I)=-(A1*A2+B1*B2)/X                                             SHEL7070
      X=DSQRT(X)                                                        SHEL7080
      Y=4.*AREA/X                                                       SHEL7090
      HT(I) =2.*Y                                                       SHEL7100
      TX(I)= Y*A1/X                                                     SHEL7110
      TY(I)=-Y*B1/X                                                     SHEL7120
      A1=0.5*A1   /AREA                                                 SHEL7130
      A2=0.5*A2   /AREA                                                 SHEL7140
      B1=0.5*B1   /AREA                                                 SHEL7150
      B2=0.5*B2   /AREA                                                 SHEL7160
      O(1,I)    =  B1*B1                                                SHEL7170
      O(2,I)    =  A1*A1                                                SHEL7180
      O(3,I)    =  2.*A1*B1                                             SHEL7190
      O(1,I+3)  =  2.*B1*B2                                             SHEL7200
      O(2,I+3)  =  2.*A1*A2                                             SHEL7210
      O(3,I+3)  =  2.*(A1*B2+A2*B1)                                     SHEL7220
  150 CONTINUE                                                          SHEL7230
C*********************************************************************SHEL7240
C-----CURVATURE - DISPLACEMENT RELATIONS FOR 3 SUBTRIANGLE REGIONS      SHEL7250
C*********************************************************************SHEL7260
      DO 200 I=1,3                                                      SHEL7270
      J=IPERM(I)                                                        SHEL7280
      K=IPERM(J)                                                        SHEL7290
      II=3*I                                                            SHEL7300
      JJ=3*J                                                            SHEL7310
      KK=3*K                                                            SHEL7320
      A1=A(I,NT)                                                        SHEL7330
      A2=A(J,NT)                                                        SHEL7340
      A3=A(K,NT)                                                        SHEL7350
      B1=B(I,NT)                                                        SHEL7360
      B2=B(J,NT)                                                        SHEL7370
      B3=B(K,NT)                                                        SHEL7380
      U1=U(I)                                                           SHEL7390
      U2=U(J)                                                           SHEL7400
      U3=U(K)                                                           SHEL7410
      W1=1.-U1                                                          SHEL7420
      W2=1.-U2                                                          SHEL7430
      W3=1.-U3                                                          SHEL7440
```

```
      B1D=B1+B1                                                          SHEL 7450
      B2D=B2+B2                                                          SHEL 7460
      B3D=B3+B3                                                          SHEL 7470
      A1D=A1+A1                                                          SHEL 7480
      A2D=A2+A2                                                          SHEL 7490
      A3D=A3+A3                                                          SHEL 7500
      C21 = B1-B3*U3          +TX(K)                                     SHEL 7510
      C31 = A1-A3*U3          +TY(K)                                     SHEL 7520
      C51 = B3*W3-B2          +TX(K)                                     SHEL 7530
      C61 = A3*W3-A2          +TY(K)                                     SHEL 7540
      C81 = B3-B2D-B2*U2      +TX(J)                                     SHEL 7550
      C91 = A3-A2D-A2*U2      +TY(J)                                     SHEL 7560
      C22=-B1D+B2*W2+B3*U3 + TX(J)-TX(K)                                 SHEL 7570
      C32=-A1D+A2*W2+A3*U3+TY(J)-TY(K)                                   SHEL 7580
      C52 = B2D-B3*W3-B1*U1   +TX(I)-TX(K)                               SHEL 7590
      C62 = A2D-A3*W3-A1*U1   +TY(I)-TY(K)                               SHEL 7600
      C82 = B1D-B3+B1*W1      +TX(I)                                     SHEL 7610
      C92 = A1D-A3+A1*W1      +TY(I)                                     SHEL 7620
      DO 200 N=1,3                                                       SHEL 7630
      L= 6*(I-1)+N                                                       SHEL 7640
      O11=O(N,I)                                                         SHEL 7650
      O22=O(N,J)                                                         SHEL 7660
      O33=O(N,K)                                                         SHEL 7670
      O12=O(N,I+3)                                                       SHEL 7680
      O23=O(N,J+3)                                                       SHEL 7690
      O31=O(N,K+3)                                                       SHEL 7700
      O2333=O23-O33                                                      SHEL 7710
      O3133=O31-O33                                                      SHEL 7720
      P(L    ,II-2) = 6.*(-O11+W2*O33+U3*O2333)                          SHEL 7730
      P(L    ,II-1) = C21*O23+C22*O33-B2D*O12+B2D*O31                    SHEL 7740
      P(L    ,II   ) = C31*O23+C32*O33-A3D*O12+A2D*O31                   SHEL 7750
      P(L    ,JJ-2) = 6.*(O22+W3*O2333)                                  SHEL 7760
      P(L    ,JJ-1) = C51*O2333+B3D*O22                                  SHEL 7770
      P(L    ,JJ   ) = C61*O2333+A3D*O22                                 SHEL 7780
      P(L    ,KK-2) = 6.*(1.+U2)*O33                                     SHEL 7790
      P(L    ,KK-1) = C81*O33                                            SHEL 7800
      P(L    ,KK   ) = C91*O33                                           SHEL 7810
      P(L+3  ,II-2) = 6.*(O11+U3*O3133)                                  SHEL 7820
      P(L+3  ,II-1) = C21*O3133-B3D*O11                                  SHEL 7830
      P(L+3  ,II   ) = C31*O3133-A3D*O11                                 SHEL 7840
      P(L+3  ,JJ-2) = 6.*(-O22+U1*O33+W3*O3133)                          SHEL 7850
      P(L+3  ,JJ-1) = C51*O31+C52*O33+B3D*O12-B1D*O23                    SHEL 7860
      P(L+3  ,JJ   ) = C61*O31+C62*O33+A3D*O12-A1D*O23                   SHEL 7870
      P(L+3  ,KK-2) = 6.*(1.+W1)*O33                                     SHEL 7880
      P(L+3  ,KK-1) = C82*O33                                            SHEL 7890
      P(L+3  ,KK   ) = C92*O33                                           SHEL 7900
      P(N+18,II-2) = 2.*(O11+U3*O12+W2*O31)                              SHEL 7910
      P(N+18,KK-1) = ((B1D-B2D)*O33+C82*O23+C81*O31)/3.                  SHEL 7920
      P(N+18,KK   ) = ((A1D-A2D)*O33+C92*O23+C91*O31)/3.                 SHEL 7930
  200 CONTINUE                                                           SHEL 7940
C*************************************************************************SHEL 7950
C-----STIFFNESS MATRIX AND THERMAL LOAD VECTOR                           SHEL 7960
C*************************************************************************SHEL 7970
      DO 400 J=1,9                                                       SHEL 7980
      FT(J)=0.                                                           SHEL 7990
      DO 340 L=1,3                                                       SHEL 8000
      II=L                                                               SHEL 8010
      KK=L+18                                                            SHEL 8020
      P3=P(KK,J)                                                         SHEL 8030
      G(KK)=0.                                                           SHEL 8040
```

```
      DO 340 N=1,3                                                      SHEL8050
      JJ=II+2                                                           SHEL8060
      SUM=P(II,J)+P(JJ,J)+P3                                            SHEL8070
        G(II)=SUM+P(II,J)                                               SHEL8080
      G(JJ)=SUM+P(JJ,J)                                                 SHEL8090
      G(KK)=G(KK)+SUM+P3                                                SHEL8100
      FT(J)=FT(J)-SUM*BMT(L)*AREA/9.0                                   SHEL8110
      II=II+6                                                           SHEL8120
  340 CONTINUE                                                          SHEL8130
      DO 360 N=1,19,3                                                   SHEL8140
      G1=G(N)                                                           SHEL8150
      G2=G(N+1)                                                         SHEL8160
      G3=G(N+2)                                                         SHEL8170
      G(N  )=CM(1,1)*G1+CM(1,2)*G2+CM(1,3)*G3                           SHEL8180
      G(N+1)=CM(1,2)*G1+CM(2,2)*G2+CM(2,3)*G3                           SHEL8190
  360 G(N+2)=CM(1,3)*G1+CM(2,3)*G2+CM(3,3)*G3                           SHEL8200
      DO 390 I=1,J                                                      SHEL8210
      X=0.                                                              SHEL8220
      DO 380 N=1,21                                                     SHEL8230
  380 X=X+G(N)*P(N,I)                                                   SHEL8240
      X=X*FAC1                                                          SHEL8250
      ST(I,J)=X                                                         SHEL8260
  390 ST(J,I)=X                                                         SHEL8270
  400 CONTINUE                                                          SHEL8280
C*************************************************************************SHEL8290
C-----CURVATURE - DISPLACEMENT RELATION AT ELEMENT CENTRE                SHEL8300
C*************************************************************************SHEL8310
      IF (NTRI.EQ.1) GO TO 551                                          SHEL8320
      DO 550 J=1,9                                                      SHEL8330
      P(19,J)=(P(10,J)+P(13,J))*0.5                                     SHEL8340
      P(20,J)=(P(11,J)+P(14,J))*0.5                                     SHEL8350
  550 P(21,J)=(P(12,J)+P(15,J))*0.5                                     SHEL8360
C*************************************************************************SHEL8370
C-----MOMENT - DISPLACEMENT RELATION                                     SHEL8380
C*************************************************************************SHEL8390
  551 DO 600 I=1,3                                                      SHEL8400
      DO 600 J=1,9                                                      SHEL8410
      SUM=0.                                                            SHEL8420
      DO 610 K=1,3                                                      SHEL8430
  610 SUM=SUM+CM(I,K)*P(K+18,J)                                         SHEL8440
  600 CT(I,J)=-FAC2*SUM                                                 SHEL8450
      RETURN                                                            SHEL8460
      END                                                               SHEL8470
```

```
      SUBROUTINE SHLCT1(S2,ST,T1,T2,T3,LOC,NT)                          SHEL 8480
C*********************************************************************SHEL 8490
C-----COORDINATE TRANSFORMATION OF TRIANGLE ELEMENT BENDING STIFFNESS   SHEL 8500
C*********************************************************************SHEL 8510
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 8520
      DIMENSION T1(9,4),T2(9,4),T3(9,4),S2(30,30),LOC(3,4) ,ST(9,9)     SHEL 8530
      DO 500 JJ = 1,3                                                   SHEL 8540
      JT = 3*JJ-3                                                       SHEL 8550
      J = JT + 1                                                        SHEL 8560
      DO 480 II = 1,JJ                                                  SHEL 8570
      IT = 3*II-3                                                       SHEL 8580
      I = IT + 1                                                        SHEL 8590
      KK=6                                                              SHEL 8600
      DO 480 L=1,6                                                      SHEL 8610
      IF (II.EQ.JJ) KK = L                                              SHEL 8620
      M = LOC(JJ,NT)+L                                                  SHEL 8630
      L3 = L - 3                                                        SHEL 8640
      IF (L3.GT.0) GO TO 460                                            SHEL 8650
      C3=T3(JT+L,NT)                                                    SHEL 8660
      H1 = ST(I  ,J)*C3                                                 SHEL 8670
      H2 = ST(I+1,J)*C3                                                 SHEL 8680
      H3 = ST(I+2,J)*C3                                                 SHEL 8690
      GO TO 470                                                         SHEL 8700
  460 C1=T1(JT+L3,NT)                                                   SHEL 8710
      C2=T2(JT+L3,NT)                                                   SHEL 8720
      H1 = ST(I  ,J+1)*C1 + ST(I  ,J+2)*C2                              SHEL 8730
      H2 = ST(I+1,J+1)*C1 + ST(I+1,J+2)*C2                              SHEL 8740
      H3 = ST(I+2,J+1)*C1 + ST(I+2,J+2)*C2                              SHEL 8750
  470 N = LOC(II,NT)                                                    SHEL 8760
      DO 480 K = 1,KK                                                   SHEL 8770
      N = N + 1                                                         SHEL 8780
      K3 = K - 3                                                        SHEL 8790
      K1 = IT + K                                                       SHEL 8800
      K2 = IT + K3                                                      SHEL 8810
      IF (K3.LE.0)  S0 =S2(N,M) + T3(K,NT)*H1                           SHEL 8820
      IF (K3.GT.0)  S0 =S2(N,M) + T1(K2,NT)*H2+T2(K2,NT)*H3             SHEL 8830
      S2(N,M)= S0                                                       SHEL 8840
  480 S2(M,N)= S0                                                       SHEL 8850
  500 CONTINUE                                                          SHEL 8860
      RETURN                                                            SHEL 8870
      END                                                               SHEL 8880

      SUBROUTINE SHLCT2(S,T0,C1,C2,C3)                                  SHEL 8890
C*********************************************************************SHEL 8900
C-----TRANSFORM THE STIFFNESS MATRIX AT 5TH NODE TO GLOBAL COORDINATES SHEL 8910
C*********************************************************************SHEL 8920
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL 8930
      DIMENSION S(30,30),T0(3,3),C1(3),C2(3),C3(3)                      SHEL 8940
      IF(S (25,25).GT. S (27,27)*1.0E-07) GO TO 692                     SHEL 8950
      DO 693 I=1,30                                                     SHEL 8960
      S (I,25)=0.0                                                      SHEL 8970
  693 S (25,I)=0.0                                                      SHEL 8980
  692 IF(S (26,26).GT.S (27,27)*1.0E-07) GO TO 694                      SHEL 8990
      DO 695 I=1,30                                                     SHEL 9000
      S (I,26)=0.0                                                      SHEL 9010
  695 S (26,I)=0.0                                                      SHEL 9020
  694 IF(S (30,30).GT.(S (29,29)+S (28,28))*1.0E-08) GO TO 730          SHEL 9030
      DO 710 I=1,30                                                     SHEL 9040
      S (I,30)=0.                                                       SHEL 9050
```

```
  710 S (30,I)=0.                                                        SHEL 9060
  730 DO 10 II=1,30                                                      SHEL 9070
      DO 11 I=1,3                                                        SHEL 9080
      C1(I)=S(II,25)*T0(1,I)+S(II,26)*T0(2,I)+S(II,27)*T0(3,I)           SHEL 9090
   11 C2(I)=S(II,28)*T0(1,I)+S(II,29)*T0(2,I)+S(II,30)*T0(3,I)           SHEL 9100
      DO 10 J=1,3                                                        SHEL 9110
      S(II,J+24)=C1(J)                                                   SHEL 9120
   10 S(II,J+27)=C2(J)                                                   SHEL 9130
      DO 20 JJ=25,27                                                     SHEL 9140
      J3=JJ+3                                                            SHEL 9150
      DO 21 I=1,3                                                        SHEL 9160
      T1=T0(1,I)                                                         SHEL 9170
      T2=T0(2,I)                                                         SHEL 9180
      T3=T0(3,I)                                                         SHEL 9190
      C1(I)=T1*S(25,JJ)+T2*S(26,JJ)+T3*S(27,JJ)                          SHEL 9200
      C2(I)=T1*S(25,J3)+T2*S(26,J3)+T3*S(27,J3)                          SHEL 9210
   21 C3(I)=T1*S(28,J3)+T2*S(29,J3)+T3*S(30,J3)                          SHEL 9220
      DO 20 I=1,3                                                        SHEL 9230
      S(I+24,JJ)=C1(I)                                                   SHEL 9240
      S(I+24,J3)=C2(I)                                                   SHEL 9250
      S(J3,I+24)=C2(I)                                                   SHEL 9260
   20 S(I+27,J3)=C3(I)                                                   SHEL 9270
      DO 30 I=1,24                                                       SHEL 9280
      DO 30 J=25,30                                                      SHEL 9290
   30 S(J,I)=S(I,J)                                                      SHEL 9300
      RETURN                                                             SHEL 9310
      END                                                                SHEL 9320


      SUBROUTINE SH2221 (SC,S2)                                          SHEL 9330
C*************************************************************************SHEL 9340
C-----COMPUTE K22 INVERSE * K21 FOR CONDENSATION OF GEOMETRIC STIFFNESS  SHEL 9350
C     IN CASE OF QUADRILATERAL PLATE/SHELL ELEMENT                       SHEL 9360
C*************************************************************************SHEL 9370
      IMPLICIT REAL*8 (A-H,O-Z)                                          SHEL 9380
      DIMENSION SC(6,24),S2(30,30)                                       SHEL 9390
      DO 710 I=25,30                                                     SHEL 9400
      IF(S2(I,I).EQ.0.) GO TO 710                                        SHEL 9410
      PIV=1.0/S2(I,I)                                                    SHEL 9420
      DO 720 J=1,24                                                      SHEL 9430
  720 S2(I,J)=S2(I,J)*PIV                                                SHEL 9440
      I1=I+1                                                             SHEL 9450
      IF(I1.GT.30) GO TO 710                                             SHEL 9460
      DO 730 J=I1,30                                                     SHEL 9470
      IF(S2(J,I).EQ.0.) GO TO 730                                        SHEL 9480
      DO 740 K=1,24                                                      SHEL 9490
  740 S2(J,K)=S2(J,K)-S2(J,I)*S2(I,K)                                    SHEL 9500
  730 CONTINUE                                                           SHEL 9510
  710 CONTINUE                                                           SHEL 9520
      DO 750 I=25,30                                                     SHEL 9530
      IF(S2(I,I).EQ.0.) GO TO 770                                        SHEL 9540
      DO 760 J=1,24                                                      SHEL 9550
  760 SC(I-24,J)=S2(I,J)                                                 SHEL 9560
      GO TO 750                                                          SHEL 9570
  770 DO 780 J=1,24                                                      SHEL 9580
  780 SC(I-24,J)=0.                                                      SHEL 9590
  750 CONTINUE                                                           SHEL 9600
      RETURN                                                             SHEL 9610
      END                                                                SHEL 9620
```

```
      SUBROUTINE DSHELL(AOLD,ANEW,LOAD,NUMDV    )                          SHEL 9630
C*************************************************************************SHEL 9640
C-----DESIGN OF PLATE/SHELL ELEMENTS FOR STRESS CONSTRAINTS                 SHEL 9650
C*************************************************************************SHEL 9660
      DIMENSION AOLD(NUMDV),ANEW(NUMDV),LOAD(NUMDV)                        SHEL 9670
      COMMON/JUNK/          LT,LH,L,SG(20),EX,EY,EXY,SMX,SMY,SMXY,SIG,     SHEL 9680
     1 IDVAR,IEX,FRC,H,XINERT,TEN,COMP,SHEAR,BETA,HP(2),JUNK(327)          SHEL 9690
      EXY1=EXY/(SHEAR*H)                                                   SHEL 9700
      SMXY1=6.0*SMXY/(SHEAR*H*H)                                           SHEL 9710
      CC=-1.0                                                              SHEL 9720
      DO 200 I=1,2                                                         SHEL 9730
      IF(I.EQ.2) CC=1.0                                                    SHEL 9740
      C1=EX/H+CC*6.0*SMX/(H*H)                                             SHEL 9750
      C2=EY/H+CC*6.0*SMY/(H*H)                                             SHEL 9760
      AX=TEN                                                               SHEL 9770
      AY=TEN                                                               SHEL 9780
      IF(C1.LT.0.) AX=COMP                                                 SHEL 9790
      IF(C2.LT.0.) AY=COMP                                                 SHEL 9800
      EX1=EX/(AX*H)                                                        SHEL 9810
      EY1=EY/(AY*H)                                                        SHEL 9820
      SMX1=6.0*SMX/(AX*H*H)                                                SHEL 9830
      SMY1=6.0*SMY/(AY*H*H)                                                SHEL 9840
      CXX= EX1*EX1+EY1*EY1+EXY1*EXY1-EX1*EY1                               SHEL 9850
      CX=2.0*(EX1*SMX1+EY1*SMY1+EXY1*SMXY1)- EX1*SMY1-EY1*SMX1             SHEL 9860
      CX=CX*CC                                                             SHEL 9870
      C= SMX1*SMX1+SMY1*SMY1+SMXY1*SMXY1-SMX1*SMY1                         SHEL 9880
      HP(I)=H                                                              SHEL 9890
      DO 100 J=1,10                                                        SHEL 9900
      HHH=(CXX+CX*H/HP(I))*0.5                                             SHEL 9910
      HHH=HHH+SQRT(HHH*HHH+C)                                              SHEL 9920
      HHH=SQRT(HHH)*H                                                      SHEL 9930
      IF(ABS(HHH-HP(I)).LT.0.001) GO TO 200                                SHEL 9940
  100 HP(I)=HHH                                                            SHEL 9950
  200 HP(I)=HHH                                                            SHEL 9960
      HH=HP(1)                                                             SHEL 9970
      IF(HH.LT.HP(2)) HH=HP(2)                                             SHEL 9980
      HH=HH/FRC                                                            SHEL 9990
      IF(HH.LE.ANEW(IDVAR)) GO TO 400                                      SHEL 0000
      ANEW(IDVAR) =HH                                                      SHEL 0010
      LOAD(IDVAR) =L                                                       SHEL 0020
  400 RETURN                                                               SHEL 0030
      END                                                                  SHEL 0040
```

```
      SUBROUTINE SHELG1(SC    ,TD,NTRI)                                    SHEL0050
C*****************************************************************************SHEL0060
C-----CALCULATE UNIT GEOMETRIC STIFFNESS MATRICES OF SHELL ELEMENT         SHEL0070
C*****************************************************************************SHEL0080
      IMPLICIT REAL*8 (A-H,O-Z)                                            SHEL0090
      DIMENSION SC(6,24),TD(9)                                             SHEL0100
      COMMON/COMPL/A(12),B(12),T1(36),T2(36),T3(36),LOC(12),G1(9,9),       SHEL0110
     1 G2(9,9),G3(9,9), C1(3),C2(3),C3(3) ,COM(36)                         SHEL0120
      COMMON/EM/LM(24),GU1(30,30),GU2(30,30),GU3(30,30) ,EM1(62)           SHEL0130
      DO 200 I=1,30                                                        SHEL0140
      DO 200 J=1,30                                                        SHEL0150
      GU1(I,J)=0.                                                          SHEL0160
      GU2(I,J)=0.                                                          SHEL0170
  200 GU3(I,J)=0.                                                          SHEL0180
      DO 100 NT=1,NTRI                                                     SHEL0190
C*****************************************************************************SHEL0200
C-----FORM UNIT GEOMETRIC STIFFNESS MATRICES  IN LOCAL COORDINATES         SHEL0210
C*****************************************************************************SHEL0220
      CALL SHELG2(NT)                                                      SHEL0230
C*****************************************************************************SHEL0240
C-----TRANSFORM TO GLOBAL COORDINATES                                      SHEL0250
C*****************************************************************************SHEL0260
      CALL SHLCT1(GU1,G1,T1,T2,T3,LOC,NT)                                  SHEL0270
      CALL SHLCT1(GU2,G2,T1,T2,T3,LOC,NT)                                  SHEL0280
  100 CALL SHLCT1(GU3,G3,T1,T2,T3,LOC,NT)                                  SHEL0290
      IF (NTRI.EQ.1) RETURN                                                SHEL0300
C*****************************************************************************SHEL0310
C-----CHECK FOR FLAT OR NEARLY FLAT QUADRILATERAL ELEMENT AND              SHEL0320
C     TRANSFORM STIFFNESS AT 5TH NODE TO GLOBAL COORDINATES                SHEL0330
C*****************************************************************************SHEL0340
      CALL SHLCT2(GU1,TD,C1,C2,C3)                                         SHEL0350
      CALL SHLCT2(GU2,TD,C1,C2,C3)                                         SHEL0360
      CALL SHLCT2(GU3,TD,C1,C2,C3)                                         SHEL0370
C*****************************************************************************SHEL0380
C-----CONDENSATION OF INTERNAL DEGREES OF FREEDOM OF UNIT GEOMETRIC        SHEL0390
C     STIFFNESS MATRICES                                                   SHEL0400
C*****************************************************************************SHEL0410
      CALL SHLCD2(GU1,SC)                                                  SHEL0420
      CALL SHLCD2(GU2,SC)                                                  SHEL0430
      CALL SHLCD2(GU3,SC)                                                  SHEL0440
      RETURN                                                               SHEL0450
      END                                                                  SHEL0460
```

```
      SUBROUTINE SHELG2(NT)                                                 SHEL0470
C*********************************************************************SHEL0480
C-----FIND UNIT GEOMETRIC STIFFNESS MATRICES CORRESPONDING TO           SHEL0490
C     MEMBRANE STRESS RESULTANTS N(XX),N(YY) AND N(XY) IN LOCAL         SHEL0500
C     COORDINATES FOR THE TRIANGULAR ELEMENT COMPONENT                  SHEL0510
C*********************************************************************SHEL0520
      IMPLICIT REAL*8 (A-H,O-Z)                                         SHEL0530
      DIMENSION Z(7,3),H(7),IPM(3)                                      SHEL0540
      COMMON/COMPL/A(3,4),B(3,4),TT(108),LOC(12),G1(9,9),G2(9,9),G3(9,9)SHEL0550
     1,D(3,9),DX(9),DY(9)                                               SHEL0560
      DATA Z/0.333333333333333 ,0.059715871789770 ,0.470142064105115 ,  SHEL0570
     1       0.470142064105115 ,.797426985353087 ,0.101286507323456 ,   SHEL0580
     2       0.101286507323456 ,0.333333333333333 ,0.470142064105115 ,  SHEL0590
     3       0.059715871789770 ,0.470142064105115 ,.101286507323456 ,   SHEL0600
     4       0.797426985353087 ,0.101286507323456 ,0.333333333333333 ,  SHEL0610
     5       0.470142064105115 ,0.470142064105115 ,.059715871789770 ,   SHEL0620
     6       0.101286507323456 ,0.101286507323456 ,0.797426985353087 /  SHEL0630
      DATA H/.225,.132394152788506 ,.132394152788506 ,.132394152788506 ,SHEL0640
     1            .125939180544827 ,.125939180544827 ,.125939180544827 /SHEL0650
      DATA IPM/2,3,1/                                                   SHEL0660
      DO 5 I=1,9                                                        SHEL0670
      DO 5 J=1,9                                                        SHEL0680
      G1(I,J)=0.                                                        SHEL0690
      G2(I,J)=0.                                                        SHEL0700
    5 G3(I,J)=0.                                                        SHEL0710
      A1=A(1,NT)                                                        SHEL0720
      A2=A(2,NT)                                                        SHEL0730
      A3=A(3,NT)                                                        SHEL0740
      B1=B(1,NT)                                                        SHEL0750
      B2=B(2,NT)                                                        SHEL0760
      B3=B(3,NT)                                                        SHEL0770
      AREA4=(A3*B2-A2*B3)*2                                             SHEL0780
      DO 100 IP=1,7                                                     SHEL0790
      HI=H(IP)                                                          SHEL0800
C*********************************************************************SHEL0810
C-----FIND SHAPE FUNCTION DERIVATIVES W.R.T NATURAL COORDINATES (D) AND SHEL0820
C     W.R.T X AND Y COORDINATES (DX,DY) AT INTEGRATION POINT IP         SHEL0830
C*********************************************************************SHEL0840
      DO 10 I=1,3                                                       SHEL0850
      J=IPM(I)                                                          SHEL0860
      K=IPM(J)                                                          SHEL0870
      II=I*3-2                                                          SHEL0880
      JJ=J*3-2                                                          SHEL0890
      KK=K*3-2                                                          SHEL0900
      AI=A(I,NT)                                                        SHEL0910
      AJ=A(J,NT)                                                        SHEL0920
      AK=A(K,NT)                                                        SHEL0930
      BI=B(I,NT)                                                        SHEL0940
      BJ=B(J,NT)                                                        SHEL0950
      BK=B(K,NT)                                                        SHEL0960
      Z1=Z(IP,I)                                                        SHEL0970
      Z2=Z(IP,J)                                                        SHEL0980
      Z3=Z(IP,K)                                                        SHEL0990
      Z11=Z1*Z1                                                         SHEL1000
      Z22=Z2*Z2                                                         SHEL1010
      Z33=Z3*Z3                                                         SHEL1020
      Z12=Z1*Z2                                                         SHEL1030
      Z23=Z2*Z3                                                         SHEL1040
      Z13=Z1*Z3                                                         SHEL1050
      D(I,II  )=1.0-Z22-Z33+2*(Z12+Z13)                                 SHEL1060
```

```
      D(I,II+1)=2*(BJ*Z13-BK*Z12)+0.5*(BJ-BK)*Z23                    SHEL 1070
      D(I,II+2)=2*(AJ*Z13-AK*Z12)+0.5*(AJ-AK)*Z23                    SHEL 1080
      D(I,JJ   )=Z22-2*Z12                                          SHEL 1090
      D(I,JJ+1)=BK*Z22+0.5*(BK-BI)*Z23                              SHEL 1100
      D(I,JJ+2)=AK*Z22+0.5*(AK-AI)*Z23                              SHEL 1110
      D(I,KK   )=Z33-2*Z13                                          SHEL 1120
      D(I,KK+1)=-BJ*Z33+0.5*(BI-BJ)*Z23                             SHEL 1130
   10 D(I,KK+2)=-AJ*Z33+0.5*(AI-AJ)*Z23                             SHEL 1140
      DO 20 I=1,9                                                   SHEL 1150
      DX(I)= D(1,I)*B1+D(2,I)*B2+D(3,I)*B3                          SHEL 1160
   20 DY(I)= D(1,I)*A1+D(2,I)*A2+D(3,I)*A3                          SHEL 1170
C*****************************************************************SHEL 1180
C-----FIND CONTRIBUTION TO UNIT GEOMETRIC STIFFNESS MATRIX FROM     SHEL 1190
C     INTEGRATION POINT IP                                          SHEL 1200
C*****************************************************************SHEL 1210
      DO 30 I=1,9                                                   SHEL 1220
      DO 30 J=1,I                                                   SHEL 1230
      G1(I,J)=G1(I,J)+DX(I)*DX(J)*H1                                SHEL 1240
      G2(I,J)=G2(I,J)+DY(I)*DY(J)*H1                                SHEL 1250
   30 G3(I,J)=G3(I,J)+(DX(I)*DY(J)+DY(I)*DX(J))*H1                  SHEL 1260
  100 CONTINUE                                                      SHEL 1270
      DO  40 I=1,9                                                  SHEL 1280
      DO 40 J=1,I                                                   SHEL 1290
      G1(I,J)=G1(I,J)/AREA4                                         SHEL 1300
      G2(I,J)=G2(I,J)/AREA4                                         SHEL 1310
      G3(I,J)=G3(I,J)/AREA4                                         SHEL 1320
      G1(J,I)=G1(I,J)                                               SHEL 1330
      G2(J,I)=G2(I,J)                                               SHEL 1340
   40 G3(J,I)=G3(I,J)                                               SHEL 1350
      RETURN                                                        SHEL 1360
      END                                                           SHEL 1370
```

```
      SUBROUTINE SHLCD2(G,SC)                                       SHEL 1380
C*****************************************************************SHEL 1390
C-----CONDENSATION OF INTERNAL D.O.F. OF GEOMETRIC STIFFNESS MATRIX SHEL 1400
C*****************************************************************SHEL 1410
      IMPLICIT REAL*8 (A-H,O-Z)                                     SHEL 1420
      DIMENSION G(30,30) ,SC(6,24)                                  SHEL 1430
      DO 50 I=25,30                                                 SHEL 1440
      DO 50 J=1,24                                                  SHEL 1450
      SUM=0.                                                        SHEL 1460
      DO 60 K=25,30                                                 SHEL 1470
   60 SUM=SUM+G(I,K)*SC(K-24,J)                                     SHEL 1480
   50 G(I,J)=-SUM+G(I,J)                                            SHEL 1490
      DO 70 I=1,24                                                  SHEL 1500
      DO 70 J=1,I                                                   SHEL 1510
      SUM=0.                                                        SHEL 1520
      DO 80 K=1,6                                                   SHEL 1530
   80 SUM=SUM-SC(K,I)*G(K+24,J)-G(I,K+24)*SC(K,J)                   SHEL 1540
      G(I,J)=G(I,J)+SUM                                             SHEL 1550
   70 G(J,I)=G(I,J)                                                 SHEL 1560
      RETURN                                                        SHEL 1570
      END                                                           SHEL 1580
```

```
      SUBROUTINE  BOUND (A,MTOT)                                        BOUN0000
C*****************************************************************************BOUN0010
C-----BOUNDARY ELEMENTS                                                 BOUN0020
C*****************************************************************************BOUN0030
      DIMENSION A(MTOT)                                                 BOUN0040
      COMMON /ELPAR/ NPAR(14),NUMNP,MBAND,NELTYP,N1,N2,N3,N4,N5,MTOT,NEQBOUN0050
     . ,NUMEL,NUMDV,M1,M2,M3,LL,LB,NEQR,NBLOCK                          BOUN0060
      COMMON/JUNK/LT,LH,L,SG(27),JUNK(338)                              BOUN0070
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              BOUN0080
      NUME=NPAR(2)                                                      BOUN0090
      IF (NPAR(1).EQ.0) GO TO 500                                       BOUN0100
      CALL CLAMP(A(N1),A(N2),A(N3),A(N4),NUME,NUMNP)                    BOUN0110
      RETURN                                                            BOUN0120
  500 WRITE(IW,2002)                                                    BOUN0130
      DO 800 MM=1,NUME                                                  BOUN0140
      CALL STRSC (A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,0)                  BOUN0150
      DO 800 L=LT,LH                                                    BOUN0160
      CALL STRSC (A(M1),A(N1),A(N3),NEQ,NUMDV,LL,LB,1)                  BOUN0170
      WRITE(IW,3002) MM,L,(-SG(I),I=1,2)                                BOUN0180
  800 CONTINUE                                                          BOUN0190
      RETURN                                                            BOUN0200
 2002 FORMAT(//50H ANALYSIS OF BOUNDARY ELEMENTS - CONSTRAINT FORCES // BOUN0210
     .54H CONST NUMBER    LOAD CASE          FORCE          MOMENT//)  BOUN0220
 3002 FORMAT (1X,2I10,4X,2E15.5)                                        BOUN0230
      END                                                               BOUN0240
```

```
      SUBROUTINE CLAMP(ID,X,Y,Z,NUME,NUMNP)                             BOUN0250
C*****************************************************************************BOUN0260
C-----BOUNDARY ELEMENT MATRICES                                         BOUN0270
C*****************************************************************************BOUN0280
      IMPLICIT REAL*8 (A-H,O-Z)                                         BOUN0290
      REAL*4 X,Y,Z,ERC                                                  BOUN0300
      DIMENSION X(NUMNP),Y(NUMNP),Z(NUMNP),ID(NUMNP,6),EMM(86)          BOUN0310
      COMMON/EM/LM(6),S(6,6),P(6,4),XM(6),ST(2,6),TT(2,4),EM1(2685)     BOUN0320
      COMMON/JUNK/R(6),EMUL(4),T(4),IE(5),IX(5),XX(5),YY(5),ZZ(5),U(4), BOUN0330
     1 V(4),JUN1(284)                                                   BOUN0340
      COMMON/UNITS/IR,IW,IP,I1,I2,I3,I8,I9,I10,I11,I12,I13              BOUN0350
      EQUIVALENCE (EMM,S)                                               BOUN0360
      DO 10 I=1,86                                                      BOUN0370
   10 EMM(I)=0.                                                         BOUN0380
C*****************************************************************************BOUN0390
C-----CONTROL INFORMATION                                               BOUN0400
C*****************************************************************************BOUN0410
      NU=1                                                              BOUN0420
      ND=6                                                              BOUN0430
      NS=2                                                              BOUN0440
      NV=1                                                              BOUN0450
      NW=1                                                              BOUN0460
      IDV=0                                                             BOUN0470
      IEX=0                                                             BOUN0480
      ERC=0.                                                            BOUN0490
      WRITE(IW,2000) NUME                                               BOUN0500
      READ(IR,1005) EMUL                                                BOUN0510
      WRITE(IW,2005) EMUL                                               BOUN0520
C*****************************************************************************BOUN0530
C-----ELEMENT CARDS                                                     BOUN0540
```

```
C*********************************************************************BDUN0550
      WRITE(IW,2001)                                                  BDUN0560
      N=1                                                             BDUN0570
  200 READ(IR,1000) IEL,IF,KD,KR,INC,SD,SR,TRACE                     BDUN0580
      IF(KD.NE.1) KD=0                                                BDUN0590
      IF(KR.NE.1) KR=0                                                BDUN0600
      IF(INC.EQ.0) INC=1                                              BDUN0610
      IF(TRACE.EQ.0.) TRACE= 1.0E 10                                  BDUN0620
      KK=INC*(IEL-N)                                                  BDUN0630
      DO 100 I=1,5                                                    BDUN0640
  100 IX(I)=IF(I)-KK                                                  BDUN0650
      IF(IF(3).NE.0) GO TO 210                                        BDUN0660
      DO 101 I=3,5                                                    BDUN0670
  101 IX(I)=0                                                         BDUN0680
  210 DO 550 NEL=N,IEL                                                BDUN0690
      DO 110 I=1,5                                                    BDUN0700
      II=IX(I)                                                        BDUN0710
      IF(II.EQ.0) GO TO 110                                           BDUN0720
      XX(I)=X(II)                                                     BDUN0730
      YY(I)=Y(II)                                                     BDUN0740
      ZZ(I)=Z(II)                                                     BDUN0750
  110 CONTINUE                                                        BDUN0760
      IF(IX(3).EQ.0) GO TO 250                                        BDUN0770
      CALL VECTOR(U,XX(2),YY(2),ZZ(2),XX(3),YY(3),ZZ(3))              BDUN0780
      CALL VECTOR(V,XX(4),YY(4),ZZ(4),XX(5),YY(5),ZZ(5))              BDUN0790
      CALL CROSS(U,V,T)                                               BDUN0800
      GO TO 260                                                       BDUN0810
  250 CALL VECTOR(T,XX(1),YY(1),ZZ(1),XX(2),YY(2),ZZ(2))              BDUN0820
  260 DO 50 J=1,3                                                     BDUN0830
      ST(1,J  )=T(J)*TRACE*KD                                         BDUN0840
      ST(2,J+3)=T(J)*TRACE*KR                                         BDUN0850
      R(J  )=T(J)*TRACE*SD*KD                                         BDUN0860
      R(J+3)=T(J)*TRACE*SR*KR                                         BDUN0870
      DO 50 I=1,J                                                     BDUN0880
      S(I  ,J  )=T(I)*T(J)*TRACE*KD                                   BDUN0890
   50 S(I+3,J+3)=T(I)*T(J)*TRACE*KR                                   BDUN0900
      DO 500 I=2,6                                                    BDUN0910
      II=I-1                                                          BDUN0920
      DO 500 J=1,II                                                   BDUN0930
  500 S(I,J)=S(J,I)                                                   BDUN0940
      DO 520 J=1,4                                                    BDUN0950
      TT(1,J)=-TRACE*KD*SD*FMUL(J)                                    BDUN0960
      TT(2,J)=-TRACE*KR*SR*FMUL(J)                                    BDUN0970
      DO 520 I=1,6                                                    BDUN0980
  520 P(I,J)=R(I)*FMUL(J)                                             BDUN0990
      II=IX(I)                                                        BDUN1000
      DO 600 I=1,6                                                    BDUN1010
  600 LM(I)=ID(II,I)                                                  BDUN1020
      CALL CALBAN(NDIF,LM,S,P,ST,TT,NU,NV,NS,ND,NW,IDV,IEX,FRC)       BDUN1030
      WRITE(IW,2100) NEL,IX,KD,KR,SD,SR,TRACE                         BDUN1040
      IX(1)=IX(1)+INC                                                 BDUN1050
      IX(2)=IX(2)+INC                                                 BDUN1060
      IF(IX(3).EQ.0) GO TO 550                                        BDUN1070
      DO 650 I=3,5                                                    BDUN1080
  650 IX(I)=IX(I)+INC                                                 BDUN1090
  550 CONTINUE                                                        BDUN1100
      N=IEL+1                                                         BDUN1110
      IF(N.LE.NUME) GO TO 200                                         BDUN1120
      RETURN                                                          BDUN1130
 1000 FORMAT(915,5X,3E10.0)                                           BDUN1140
```

```
 1005 FORMAT (4E10.0)                                                    BOUN1150
 2000 FORMAT(34H1 B O U N D A R Y  E L E M E N T S //                     BOUN1160
     1 23H NUMBER OF ELEMENTS    =,I5  )                                 BOUN1170
 2001 FORMAT(//22H BOUNDARY ELEMENT DATA //                              BOUN1180
     1 5X,5HCONST,5X,4HNODE,42H /--NODES DEFINING CONSTRAINT DIRECTION--BOUN1190
     2/,5X,5HCODES, 8X,5HDISPL,5X,8HROTATION,4X,5HSTIFF /               BOUN1200
     3 4X,6HNUMBER,6X,1HN,8X,2HNI,8X,2HNJ,8X,2HNK,8X,2HNL,6X,2HKD,3X,   BOUN1210
     4 2HKR,11X       ,1HD,11X,1HR,11X,1HS  )                           BOUN1220
 2005 FORMAT (//   25H ELEMENT LOAD MULTIPLIERS//                        BOUN1230
     . 9X,1HA,9X,1HB,9X,1HC,9X,1HD /4E10.4)                              BOUN1240
 2100 FORMAT(I7,5I10,3X,2I5,5X,1P3E12.2)                                 BOUN1250
      END                                                                BOUN1260
```

```
      SUBROUTINE TRUSS  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE TRUSS     '//)
      END


      SUBROUTINE BEAM  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE (6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE BEAM      '//)
      END


      SUBROUTINE  PLANE (A,MTOT)
      DIMENSION A(MTOT)
      WRITE  (6,202 )
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE PLANE     '//)
      END


      SUBROUTINE SHEAR  (A,MTOT)
      DIMENSION A(MTOT)
      WRITE  (6,202 )
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE SHEAR     '//)
      END


      SUBROUTINE SHELL(A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE SHELL     '//)
      END


      SUBROUTINE BOUND(A,MTOT)
      DIMENSION A(MTOT)
      WRITE(6,202)
      STOP
  202 FORMAT(1X,' PROGRAM ENTERED DUMMY SUBROUTINE BOUND     '//)
      END
```