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ภาคผนวก ก

รายละเอียดโปรแกรมย่อยชิ้นส่วนย่อยเปลือกบาง 8 ชั้น

```
$LARGE
$DEBUG
C
      SUBROUTINE ELMT18(IX,S,NDF,NDM,NST,ISW)
      IMPLICIT REAL*8(A-H,O-Z)                                          ELM00020
C     GENERIC                                                           ELM00030
C                                                                       ELM00040
C     *** BILINEAR SHELL ELEMENT - BY WORSAK KANOKNUKULCHAI -6/77 ******ELM00050
C     ******************************************************************ELM00060
C     *** REVISION:                                                     ELM00070
C     ***      (1)  NOV.-DEC.1981 FOR ETA PROJECT, BY PRAPAT TANTIPRABHA ELM00080
C     ***      (2)  JAN.1984 FOR THESIS, BY LEE WANN-HER                ELM00090
C     ***      (3)  APRIL'1989 FOR THESIS AT CHULALONGKORN UNIVERSITY,BY
C                   ATTAPHON SANGTHEERAKIJ
C     ****************************************************************** ELM00100
C     ADDITIONAL INFORMATION                                            ELM00110
C         REV 1: - TWO ADDED SUBROUTINES ARE "BDSTRS" AND "PRSIGN"      ELM00120
C                - OUTPUT INCLUDES AXIAL,SHEAR,BENDING MOMENT AND TORQUEELM00130
C                  FOR DEEP BEAM ELEMENT                                ELM00140
C                - SEE CHANGE INPUT VARIABLES BELOW                      ELM00150
C                - FOR DEEP BEAM, INTEGRATION SCHEME MUST BE 424        ELM00160
C         REV 2: - PROGRAM IS EXPANDED TO BE ABLE TO SOLVE THE FREE     ELM00170
C                  VIBRATION AND ELASTIC STABILITY PROBLEMS             ELM00180
C                - GEOMETRIC STIFFNESS MATRIX IS FORMULATED IN ISW = 7  ELM00190
C                  USING MACRO COMMAND STAB                             ELM00200
C                - ADDED SUBROUTINE IS BMS, ADDED VARIABLES ARE LMS,IGBSELM00210
C                  AND KTRANV                                           ELM00220
C         REV 3: - PROGRAM IS DEVELOPED TO BE A CURVED 8-NODES ISOPARAMETRIC
C                  ELEMENT WITH QUADRATIC SHAPE FUNCTIONS.
C                - NUMBER OF GAUSS POINT FOR TRANSVERSE SHEAR MUST BE 4,
C                  SO INTEGRATION SCHEME MUST BE 444.
C                - TORSIONAL CONSTANT MAY NOT BE NECESSARY.
C                - PROGRAM SHOULD BE TESTED BY USERS BEFORE USING TO
C                  SOLVE EACH TYPE OF PROBLEMS.
C     ******************************************************************ELM00230
C     GEOMETRY   - 4-NODED QUADRI-LATERAL IN 3-D SPACE (HYPERBOLIC      ELM00240
C                  PARABOLOID)                                          ELM00250
C                - IT WAS DEVELOPED TO 8-NODE CURVED ELEMENT (REV.3)
C     VARIABLES  - 6 DOF/NODE,3 DISPLACEMENTS AND 3 ROTATIONS           ELM00260
C     INTERPOLATION FUNCTION                                            ELM00270
C                - BILINEAR FUNCTION FOR GEOMETRY AND ALL VARIABLES      ELM00280
C                  (ISO-PARAMETRIC ELEMENT)                             ELM00290
C                - CHANGED TO QUADRATIC FUNCTION (REV.3).
C     CAPACITIES - 1) LINEAR ELASTIC ISOTROPIC MATERIAL                 ELM00300
C                - 2) THICK/THIN SHELL WITH USER,S ASSIGNED QUADRATURES ELM00310
C                  ON BENDING,INPLANE SHEAR AND TRANVERSESHEAR ENERGIES ELM00320
C                - 3) FICTITIOUS TORSONAL SPRING MAY BE ADDED IN CASE   ELM00330
C                  OF WEAK-COUPLING SIXTH DOF.(IE. CYLINDRICAL SHELL)   ELM00340
C                - 4) 4 TYPES OF LOADS BUILT IN                         ELM00350
C                  A)GRAVITY ACTION(OPPOSITE TO GLOBAL Z3 DIRECTION)    ELM00360
C                  B)UNIFORM LOAD (IN Z3 DIRECTION)                     ELM00370
C                  C) NORMAL PRESSURE(IN LOCAL X3 DIRECTION)            ELM00380
C                  D) WATER PRESSURE (IN LOCAL X3 DIRECTION)            ELM00390
C     INPUT DATA                                                        ELM00400
C     D(1)-D(4),D(7),D(10),D( 9),LBS,LST   /D(5),D(6) (ONLY D(4).NE.0)  ELM00410
```

```
C     FORMAT(7F10.0,2I5/2F10.0)
C                - LST=0 STRESS REPORTED AT SHEAR   GAUSS POINTS
C                    =1 STRESS REPORTED AT BENDING GAUSS POINTS
C                    =2 STRESS REPORTED AT SHEAR   GAUSS POINTS
C                    >2 NO STRESS REPORTED
C                - D(1)=E
C                - D(2)=POISSON*S RATIO
C                - D(3)=UNIFORM THICKNESS (IF=0,THICKNESS IS INPUT FOR
C                  EACH NODE IN USER,S ESTABLISHED NUMNP-SIZED ARRAY
C                  *VECT* (SEE MANUAL SECTION 6)
C                - D(4)=1 -GRAVITY ACTION, 2 -UNIFORM LOAD
C                  3 -NORMAL PRESSURE, 4 -WATER PRESSURE
C                - D(7) TORSONAL DEFORMATION COEFFICIENT , WHERE
C                  TORS.ENERGY=D(7)*MU*TT*INT(RELATIVE TORS ROTATION)**2
C                  RECOMMENDED VALUE = 0.1
C                - D(10).NE.0 ONLY INPLANE EFFECT CONSIDERED(DIAPHRAGME)
C                - D( 9)=MATERIAL DENSITY (FOR LUMPED MASS MATRIX)
C                - LBS=INTEGRATION SCHEME, IE, LBS=441 MEANS USING
C                  TOTAL 4 ,4,1 POINTS FOR BENDING, INPLANE SHEAR
C                  INVARIENCES (LAM*TR(E)**2,2*MU*TR(E*E) ) AND
C                  TRANSVERSE SHEAR RESPECTIVELY (DF. LBS=441)
C                - FOR 8-NODE ELEMENT,LBS=444 (REV.3)
C                - D(5)=LOAD INTENSITY CORRESPONDING TO 1)SPECIFIC WEIGH
C                  2) UNIFORM LOAD/PROJECTED AREA IN GLOBAL Z3 DIRECTION
C                  3)NORMAL PRESSURE  4) WATER SPECIFIC WEIGHT
C                - D(6)=WATER TABLE IN GLOBAL Z3 DIRECTION (CASE 4 ONLY)
C                - LMS=1 FORM CONSISTENT MASS MATRIX
C                     =2 FORM LUMPED MASS MATRIX
C                - IGBS : GAUSS POINTS INDEX
C                     =41 IS RECOMMENDED FOR ELASTIC STABILITY PROBLEMS,
C                          I.E., 4 POINTS FOR BENDING AND INPLANE SHEAR,
C                          1 POINT FOR TRANSVERSE SHEAR.
C                - KTRANV : INDEX FOR GEOMETRIC STIFFNESS MATRIX
C                    .EQ.0  INCLUDING TRANSVERSE SHEAR EFFECT
C                    .NE.0  NEGLECT TRANSVERSE SHEAR EFFECT
C
C     ****************************************************************
C
C                MODULAR SUBROUTINES INCLUDE 1)BMTRIX 2)CROSSP
C                3)JACOBI 4)LOAD 5)LOCALX 6)TRIMUL 7)SPACKD
C
C
      COMMON/HEADER/ O,HEAD(20)
      COMMON /ELDATA/ N,MS,IEL,NEL
      COMMON/ELEMENT/XL(3,27),UL(10,27),UDL(10,27),
     *           DL(10),TL(27),P(270),LD(10,27)
      DIMENSION S(NST,1),IX(1,1)
      DIMENSION X(3,27),D(10),T(27),U(10,27)
      EQUIVALENCE (XL,X),(DL,D),(TL,T),(UL,U),(MA,MS)
C
      DIMENSION PP(3),OHN(3,3),EPS(5),CHI(3),RG(4),QG(4)
      DIMENSION UDDL(1,1)
      COMMON/STRESS/XN(5),XM(3),TT
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),
     1 CR(3,3,8),CT(3,3)
```

```
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),Q(8)          ELM00900
      COMMON/FIXINC/ CB                                                 ELM00910
      LOGICAL NPR,NPL,ISW6,DDC,BEAM                                     ELM00920
      R(1)=-1.0                                                         ELM00930
      R(2)=1.0                                                          ELM00940
      R(3)=1.0                                                          ELM00950
      R(4)=-1.0                                                         ELM00960
      R(5)=0.0
      R(6)=1.0
      R(7)=0.0
      R(8)=-1.0
      Q(1)=-1.0                                                         ELM00970
      Q(2)=-1.0                                                         ELM00980
      Q(3)=1.0                                                          ELM00990
      Q(4)=1.0                                                          ELM01000
      Q(5)=-1.0
      Q(6)=0.0
      Q(7)=1.0
      Q(8)=0.0
      DATA RG/-1.0,-1.0,1.0,1.0/,QG/-1.0,1.0,-1.0,1.0/                  ELM01010
C                                                                       ELM01020
      IF(ISW.LE.2)GO TO 999                                             ELM01030
C                                                                       ELM01040
C     COMMON ROUTE                                                      ELM01050
C                                                                       ELM01060
      LBS1=D(8)                                                         ELM01070
      RO=D(9)                                                           ELM01080
      SQ=SQRT(3.0)                                                      ELM01090
C                                                                       ELM01100
C     IF OUT-OF-PLANE EFFECT NEGLECTED,BZERO=0.0                        ELM01110
C                                                                       ELM01120
      BZERO=1.0                                                         ELM01130
      IF(D(10).NE.0.0)BZERO=0.0                                         ELM01140
      IF(D(3).EQ.0.0)GO TO 902                                          ELM01150
      DO 901 I=1,NEL                                                    ELM01160
  901 T(I)=D(3)                                                         ELM01170
C                                                                       ELM01180
C     COMPUTE *NORMAL* AT 8 NODES IN V3                                 ELM01190
C                                                                       ELM01200
  902 DO 903 I=1,NEL                                                    ELM01210
      SS=Q(I)                                                           ELM01220
      RR=R(I)                                                           ELM01230
      CALL LOCALX(RR,SS,TT,X,T,NDM,OHM)                                 ELM01240
      V3(1,I)=OHM(1,3)                                                  ELM01250
      V3(2,I)=OHM(2,3)                                                  ELM01260
  903 V3(3,I)=OHM(3,3)                                                  ELM01270
C                                                                       ELM01280
  999 GO TO (1,2,3,4,5,6,7),ISW                                         ELM01290
C                                                                       ELM01300
    1 READ(5,1100)(D(I),I=1,4),D(7),D(10),D(9 ),LBS,LST                 ELM01310
      READ(5,1111) LMS,IGBS,KTRANV                                      ELM01320
C.....  LST=0 STRESS REPORTED AT SHEAR   GAUSS POINTS                   ELM01330
C.....  LST=1 STRESS REPORTED AT BENDING GAUSS POINTS                   ELM01340
C.....  LST=2 STRESS REPORTED AT ALL     GAUSS POINTS                   ELM01350
C.....  LST>2 NO STRESS REPORTED                                        ELM01360
```

```
      IF(D(4)   .NE.0.)READ(5,1100)D(5)   ,D(6)
      TEMP=1.2
   11 LB=LBS/100
      LPS=MOD(LBS,100)/10
      LS=MOD(LBS,10)
      IF(LB.EQ.0) LB=4
      IF(LS .EQ.0)LS =1
      IF(LPS.EQ.0)LPS=LB
      WRITE(6,2100)(D(I)   ,I=1,2),D( 9)   ,TEMP,LB,LPS,LS,LST
      IF(LMS.NE.0) WRITE(6,2111) LMS
      IF(IGBS.NE.0) WRITE(6,2112) IGBS
      IF(KTRANV.NE.0) WRITE(6,2113) KTRANV
      IF(D(10)   .NE.0.0)WRITE(6,2101)
      IF(D(3)    .NE.0.0) WRITE(6,2102) D(3)
      IF(D(4)    .NE.0.0)WRITE(6,2103)D(4)   ,D(5)   ,D(6)
      LBS1=LST*1000+LBS
      D(8)=LBS1
      WRITE(6,2104)D(7)
      C6=0.0
C
    2 RETURN
    3 LBS=MOD(LBS1,1000)
      LX(1)=LBS/100
      LX(2)=MOD(LBS,10)
      LX(3)=MOD(LBS,100)/10
      IF(LX(1).EQ.0)LX(1)=4
      IF(LX(2).EQ.0)LX(2)=1
      IF(LX(3).EQ.0)LX(3)=LX(1)
C
C     ENERGIES SPLIT LOOP - ISP=(1,3)=(VOLUMETRIC,INPLANE SHEAR INVARI.)
C                          ISP= 2   =TRANSVERSE SHEAR ENERGY
C
      ISPLT=3
      IF(LX(3).EQ.LX(1))ISPLT=2
      DO 399 ISP=1,ISPLT
      IBS=ISP
      IF(ISP.EQ.3)IBS=1
      LL=LX(ISP)
      LR=1
      IF(LL.EQ.4)LR=2
      LS=2
      IF(LL.EQ.1)LS=1
      GR=(LR/2)/SQ
      GS=(LS/2)/SQ
      WT=(3.0-LR)*(3.0-LS)
      CALL SPACKD(D(1),CT,ISP,ISPLT)
C
C     GAUSS POINTS LOOP
C
      DO 312 L=1,LL
      RR=RG(L)*GR
      SS=QG(L)*GS
      CALL LOCALX(RR,SS,TT,X,T,NDM,OHM)
      CALL JACOBN(RR,SS,X,T,NDM,OHM)
      DO 304 I=1,NEL
```

```
  304 CALL BMTRIX(RR,SS,TT,T,NDM,OHM,I,IBS)
      WW=XJAC*WT*2.0
      SJAC=SQRT(RJAC(1,3)**2+RJAC(2,3)**2+RJAC(3,3)**2)*XJAC
      DO 302 I=1,3
      DO 302 J=1,I
      RJAC(I,J)=CT(I,J)*WW
  302 RJAC(J,I)=RJAC(I,J)
      IS=4-IBS
      J1=0
      DO 364 IJ=1,NEL
      K1=0
      DO 362 IK=1,IJ
      CALL TRIMUL(BU(1,1,IJ),RJAC,BU(1,1,IK),S(J1+1,K1+1),1.D0,IS,NST)
      IF(BZERO.NE.0.0)
     1CALL TRIMUL(BR(1,1,IJ),RJAC,BR(1,1,IK),S(J1+4,K1+4),3.D0,IS,NST)
      IF(IBS.EQ.1)GO TO 362
      CALL TRIMUL(CR(1,1,IJ),RJAC,CR(1,1,IK),S(J1+4,K1+4),1.D0,2,NST)
      CALL TRIMUL(BU(1,1,IJ),RJAC,CR(1,1,IK),S(J1+1,K1+4),1.D0,2,NST)
      CALL TRIMUL(CR(1,1,IJ),RJAC,BU(1,1,IK),S(J1+4,K1+1),1.D0,2,NST)
  362 K1=K1+NDF
  364 J1=J1+NDF
  312 CONTINUE
      IF(BZERO.EQ.0.0)GO TO 398
      IF(ISP.NE.2)GO TO 399
C
C     TORSONAL ENERGY BY 1-POINT QUADRATURE IF D(7) .GT.0
C
      IF(D(7)   .NE.0.)CALL TORSON(D(1)   ,S,SJAC,TT,OHM,NST,NEL,NDF)
  399 CONTINUE
  398 DO 382 J=1,NST
      DO 382 K=1,J
  382 S(K,J)=S(J,K)
  389 IF(ISW.EQ.6) GO TO 6361
      IF(C6.EQ.0.0)RETURN
      GO TO 5
 3531 DO 390 I=1,NST
  390 S(I,I)=S(I,I)+C6*PP(I)
      RETURN
C
4     LST=LBS1/1000
      IF(LST.GT.2) RETURN
      LBS=MOD(LBS1,1000)
      LPS=MOD(LBS,100)/10
      LB=LBS/100
      IF (LPS.EQ.0) LPS=LB
      BEAM = .FALSE.
      IF(LPS.EQ.2) BEAM=.TRUE.
      IF(LST.EQ.1) GO TO 420
      LLF=1
      IF (BEAM) LLF=2
      DO 405 LLL=1,LLF
      RR=0.0
      SS=(LLF/2)*QG(LLL)/SQ
      CALL BDSTRS(RR,SS,D,UL,X,T,OHM,BZERO,NDF,NDM,NST,LLL,BEAM,ISW)
405   CONTINUE
```

```
  304 CALL BMTRIX(RR,SS,TT,T,NDM,OHM,I,IBS)
      WW=XJAC*WT*2.0
      SJAC=SQRT(RJAC(1,3)**2+RJAC(2,3)**2+RJAC(3,3)**2)*XJAC
      DO 302 I=1,3
      DO 302 J=1,I
      RJAC(I,J)=CT(I,J)*WW
  302 RJAC(J,I)=RJAC(I,J)
      IS=4-IBS
      J1=0
      DO 364 IJ=1,NEL
      K1=0
      DO 362 IK=1,IJ
      CALL TRIMUL(BU(1,1,IJ),RJAC,BU(1,1,IK),S(J1+1,K1+1),1.D0,IS,NST)
      IF(BZERO.NE.0.0)
     1CALL TRIMUL(BR(1,1,IJ),RJAC,BR(1,1,IK),S(J1+4,K1+4),3.D0,IS,NST)
      IF(IBS.EQ.1)GO TO 362
      CALL TRIMUL(CR(1,1,IJ),RJAC,CR(1,1,IK),S(J1+4,K1+4),1.D0,2,NST)
      CALL TRIMUL(BU(1,1,IJ),RJAC,CR(1,1,IK),S(J1+1,K1+4),1.D0,2,NST)
      CALL TRIMUL(CR(1,1,IJ),RJAC,BU(1,1,IK),S(J1+4,K1+1),1.D0,2,NST)
  362 K1=K1+NDF
  364 J1=J1+NDF
  312 CONTINUE
      IF(BZERO.EQ.0.0)GO TO 398
      IF(ISP.NE.2)GO TO 399
C
C     TORSONAL ENERGY BY 1-POINT QUADRATURE IF D(7) .GT.0
C
      IF(D(7)   .NE.0.)CALL TORSON(D(1)   ,S,SJAC,TT,OHM,NST,NEL,NDF)
  399 CONTINUE
  398 DO 382 J=1,NST
      DO 382 K=1,J
  382 S(K,J)=S(J,K)
  389 IF(ISW.EQ.6) GO TO 6361
      IF(C6.EQ.0.0)RETURN
      GO TO 5
 6361 DO 390 I=1,NST
  390 S(I,I)=S(I,I)+C6*PP(I)
      RETURN
C
4     LST=LBS1/1000
      IF(LST.GT.2) RETURN
      LBS=MOD(LBS1,1000)
      LPS=MOD(LBS,100)/10
      LB=LBS/100
      IF (LPS.EQ.0) LPS=LB
      BEAM = .FALSE.
      IF(LPS.EQ.2) BEAM=.TRUE.
      IF(LST.EQ.1) GO TO 420
      LLF=1
      IF (BEAM) LLF=2
      DO 405 LLL=1,LLF
      RR=0.0
      SS=(LLF/2)*QG(LLL)/SQ
      CALL BDSTRS(RR,SS,D,UL,X,T,OHM,BZERO,NDF,NDM,NST,LLL,BEAM,ISW)
405   CONTINUE
```

```
      IF (LST.EQ.0) RETURN
420   DO 445 LLL=1,4
      RR=RG(LLL)/SQ
      SS=QG(LLL)/SQ
      CALL BDSTRS(RR,SS,D,UL,X,T,OHM,BZERO,NDF,NDM,NST,LLL,BEAM,ISW)
445   CONTINUE
      RETURN
C
C.... FORM MASS MATRIX  LMS = 1 ...CONSISTENT MASS
C....                   LMS = 2 ...EQUALLY LUMPED MASS (NEGLECT ROTARY)
C
5     W2=0.0
      W3=0.0
      DO 512 L = 1,4
      RR = RG(L)/SQ
      SS = QG(L)/SQ
      CALL LOCALX (RR,SS,TT,X,T,NDM,OHM)
      CALL JACOBN (RR,SS,X,T,NDM,OHM)
      W3 = W3 + RO*XJAC*2.0
      J1 = 0
      GO TO (501,502),LMS
501   DO 550 I = 1,NEL
      K1 = 0
      DO 545 J = 1,I
      AM1 = 2.0*RO*SHP(3,I)*SHP(3,J)*XJAC
      AM2 = AM1*T(I)*T(J)/12.0
      CALL BMS(I,J,0,AM1,S(J1+1,K1+1),NST)
      CALL BMS(I,J,2,AM2,S(J1+4,K1+4),NST)
545   K1 = K1 + NDF
550   J1 = J1 + NDF
      GO TO 512
502   IF(L.NE.4) GO TO 512
      DO 508 IJ = 1,NEL
      DO 507 JJ = 1,3
507   S(J1+JJ,J1+JJ) = S(J1+JJ,J1+JJ) + W3*0.25
508   J1 = J1 + NDF
512   CONTINUE
      IF (ISW.EQ.3) GO TO 3531
      IF (ISW.EQ.6) GO TO 6561
      IF (LMS.EQ.1) GO TO 570
      DO 520 I=1,24
520   P(I)=S(I,I)
570   DO 560 I = 1,NST
      DO 560 J = 1,NST
560   S(I,J) = S(J,I)
      RETURN
C
6     IF(D(4)   .EQ.0.0)GO TO 63
C     FORM ELEMENT-GENERATED LOAD
C
      DO 610 L=1,4
      RR=RG(L)/SQ
      SS=QG(L)/SQ
      CALL LOCALX(RR,SS,TT,X,T,NDM,OHM)
      CALL JACOBN(RR,SS,X,T,NDM,OHM)
```

```
      SJAC=SQRT(RJAC(1,3)**2+RJAC(2,3)**2+RJAC(3,3)**2)*XJAC
  610 CALL LOAD(NDM,NDF,X,D(4), D(5)   ,D(6)   ,SJAC,TT,OHM,P)
   63 IF(CB.EQ.0.) GO TO 65
      DO 630 I=1,NEL
      DO 630 J=1,NDF
  630 IF(UL(J,I).NE.0.0)GO TO 3
      GO TO 65
C
C     FORM INTERNAL FORCE  K(U)
C
 6361 K1=0
      DO 633 K=1,NEL
      DO 632 I=1,NDF
      TP=UL(I,K)
      DO 631 J=1,NST
  631 P(J)  =P(J)  -S(J,K1+I)*TP
  632 CONTINUE
  633 K1=K1+NDF
   65 IF(C6.EQ.0.0)RETURN
      DO 650 I=1,NEL
      DO 650 J=1,NDF
  650 IF(UDDL(J,I).NE.0.0) GO TO 5
      RETURN
C
C     FORM INERTIAL FORCE M*UDDL
C
 6561 K1=0
      DO 653 K=1,NEL
      DO 652 I=1,NDF
      TP=UDDL(I,K)
      DO 651 J=1,NST
  651 P(J)=P(J)-PP(J)*TP
  652 CONTINUE
  653 K1=K1+NDF
      RETURN
C
C     FORM GEOMETRIC STIFFNESS MATRIX
C
7     LX(1) = IGBS/10
      LX(2) = MOD(IGBS,10)
      IF(LX(1).EQ.0) LX(1) = 4
      IF(LX(2).EQ.0) LX(2) = 1
C.... ENERGY SPLIT LOOP --- ISP = 1 ;  INPLANE FORCE EFFECT
C                          ISP = 2 ;  TRANSVERSE FORCE EFFECT
C     IF KTRANV .NE. 0 , TRANSVERSE SHEAR EFFECT IS NEGLECTED
C
      IN = 2
      IF (KTRANV.NE.0) IN = 1
      DO 790 ISP = 1,IN
      LL = LX(ISP)
      LR = 1
      IF(LL.EQ.4) LR = 2
      LS = 2
      IF(LL.EQ.1) LS = 1
      GR = (LR/2)/SQ
```

```
      GS = (LS/2)/SQ
      WT = (3.0 - LR) * (3.0 - LS)
C...  GAUSS POINTS LOOP
      DO 790 L = 1,LL
      RR = RG(L) * GR
      SS = QG(L) * GS
      CALL BDSTRS(RR,SS,D,UL,X,T,OHM,BZERO,NDF,NDM,NST,LL,.FALSE.,ISW)
      WW = XJAC * WT
      J1 = 0
      DO 785 II = 1,NEL
      K1 = 0
      DO 780 JJ = 1,II
      IF(ISP.EQ.2) GO TO 720
      B1 = B(1,II) * B(1,JJ) * WW
      B2 = B(2,II) * B(2,JJ) * WW
      B3 = (B(2,II) * B(1,JJ) + B(1,II) * B(2,JJ)) * WW
      B11 = - 2.0 * (XN(1)*B1 + XN(2)*B2 + XN(3)*B3)/TT
      B12 = - 2.0 * T(JJ)*(XM(1)*B1 + XM(2)*B2 + XM(3)*B3)/TT**2
      B21 = B12 * T(II)/T(JJ)
      B22 = T(II) * T(JJ) * B11/12.0
      GO TO 730
720   B12 = -(3.0-TT)*T(JJ)*SHP(3,JJ)*BN/TT/2.0*(XN(4)*B(1,II)+XN(5)
     1      *B(2,II))*WW
      B21 = -(3.0-TT)*T(II)*SHP(3,II)*BN/TT/2.0*(XN(4)*B(1,JJ)+XN(5)
     1      *B(2,JJ))*WW
730   CALL BMS(JJ,II,1,B12,S(J1+1,K1+4),NST)
      CALL BMS(II,JJ,-1,B21,S(J1+4,K1+1),NST)
      IF(ISP.EQ.2) GO TO 780
      CALL BMS(II,JJ,0,B11,S(J1+1,K1+1),NST)
      CALL BMS(II,JJ,2,B22,S(J1+4,K1+4),NST)
780   K1 = K1 + NDF
785   J1 = J1 + NDF
790   CONTINUE
      DO 795 J = 1,NST
      DO 795 K = 1,J
795   S(K,J) = S(J,K)
      RETURN
C
C ... FORMATS
C
 1100 FORMAT(7F10.0,2I5)
 1111 FORMAT(3I5)
 2100 FORMAT(/5X,7HMODULUS,13X,1H=,G13.4
     1       /5X,13HPOISSON RATIO ,7X,1H=,G13.4
     3       /5X,20HMASS DENSITY          1H=,G13.4,17H LUMPED MASS ONLY
     2       /5X,17HCONSTRAINT FACTOR,3X,1H=,G13.4
     4       /5X,20HNO OF GAUSS POINT
     5       /5X,20HBENDING             ,1H=,I5
     5       /5X,20HINPLANE SHEAR       ,1H=,I5
     5       /5X,20HTRANSVERSE SHEAR    ,1H=,I5
     5       /5X,20HSTRESS OUTPUT CODE  ,1H=,I5    )
 2101 FORMAT(5X,50HOUT-OF-SURFACE EFFECT NEGLECTED(MEMBRANE ELEMENT)    )
 2102 FORMAT(5X,17HUNIFORM THICKNESS,3X,1H=,G13.4)
 2103 FORMAT(5X,12HLOADING CODE,8X,1H=,F10.1/5X,14HLOAD INTENSITY,6X,
     1 1H=,G13.4/27X,77H(1-SPECIFIC WEIGHT,2-UNIF.LOAD/PROJ.AREA, 3-NORM
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     1AL PRESSURE,4-WATER PRESSURE)/5X,20HWATER TABLE AT Z3   ,1H=,G13.4ELM04120
     2 ,13H(ONLY CODE=4)      )                                          ELM04130
 2104 FORMAT(5X,35HCOEFFICIENT FOR TORSONAL ENERGY =  ,G13.4)            ELM04140
 2105 FORMAT(5X,18HREPEAT INTERVAL =  ,I5)                               ELM04150
 2111 FORMAT(5X,20HMASS MATRIX INDEX   ,1H=,I5)                          ELM04160
 2112 FORMAT(5X,20HGAUSS PT. INDEX IGBS,1H=,I5,5X,'FOR STAB. PROB ONLY')ELM04170
 2113 FORMAT(5X,20HTRANS. EFFECT KTRANV,1H=,I5,5X,'FOR STAB. PROB ONLY')ELM04180
      END                                                                ELM04190
C                                                                        ELM04200
      SUBROUTINE BMTRIX(RR,SS,TT,T,NDM,OHM,I,ISW)                        ELM04210
      IMPLICIT REAL*8(A-H,O-Z)                                           ELM04220
C     GENERIC                                                            ELM04230
C     SUBROUTINE TO COMPUTE BMU, BMR  WHERE                              ELM04240
C                  EM= BMU*U+Z*BMR*ROTATION                              ELM04250
      DIMENSION OHM(3,3),T(1)                                            ELM04260
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BMU(3,3,8),BMR(3,3,8)      ELM04270
     1,CR(3,3,8),CT(3,3)                                                 ELM04280
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),S(8)           ELM04290
      GO TO (1,100),ISW                                                  ELM04300
    1 DO 20 J=1,3                                                        ELM04310
      DO 20 K=1,3                                                        ELM04320
      IF(J.EQ.3) GO TO 10                                                ELM04330
      BMU(J,K,I)=B(J,I)*OHM(K,J)                                         ELM04340
      BMR(J,K,I)=0.0                                                     ELM04350
      DO 5 L=1,3                                                         ELM04360
      IF(L.EQ.K) GO TO 5                                                 ELM04370
      SIGN=1.0                                                           ELM04380
      IF(L.GT.K)SIGN=-1.0                                                ELM04390
      LK=6-L-K                                                           ELM04400
      BC=V3(LK,I)                                                        ELM04410
      IF(LK.EQ.2)BC=-BC                                                  ELM04420
      BMR(J,K,I)=BMR(J,K,I)+OHM(L,J)*BC*SIGN*T(I)/2.0                    ELM04430
    5 CONTINUE                                                           ELM04440
      GO TO 20                                                           ELM04450
   10 BMU(3,K,I)=B(2,I)*OHM(K,1)+B(1,I)*OHM(K,2)                         ELM04460
      BMR(3,K,I)=B(1,I)*BMR(2,K,I)+B(2,I)*BMR(1,K,I)                     ELM04470
   20 CONTINUE                                                           ELM04480
      DO 30 J=1,2                                                        ELM04490
      DO 30 K=1,3                                                        ELM04500
   30 BMR(J,K,I)=BMR(J,K,I)*B(J,I)                                       ELM04510
      RETURN                                                             ELM04520
C        ES=BSU*U+Z*BSR*R+CSR*ROTATION                                   ELM04530
  100 FAC=BN*SHP(3,I)                                                    ELM04540
      DO 60 J=1,3                                                        ELM04550
      DO 60 K=1,3                                                        ELM04560
      CR(J,K,I)=0.0                                                      ELM04570
      DO 65 L=1,3                                                        ELM04580
      IF(L.EQ.K)GO TO 65                                                 ELM04590
      SIGN=1.0                                                           ELM04600
      IF(L.GT.K)SIGN=-1.0                                                ELM04610
      LK=6-L-K                                                           ELM04620
      BC=V3(LK,I)                                                        ELM04630
      IF(LK.EQ.2)BC=-BC                                                  ELM04640
      CR(J,K,I)=CR(J,K,I)+OHM(L,J)*BC*SIGN*T(I)/2.0                      ELM04650
   65 CONTINUE                                                           ELM04660
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      IF(J.LT.3)CR(J,K,I)=CR(J,K,I)*FAC
   60 BNU(J,K,I)=B(J,I)*OHM(K,3)
      DO 70 J=1,2
      DO 70 K=1,3
   70 BMR(J,K,I)=B(J,I)*CR(3,K,I)
      RETURN
      END
C
      SUBROUTINE BDSTRS(RR,SS,D,UL,X,T,OHM,BZERO,NDF,NDM,NST,LLL,BEAM,
     1                 ISW)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
      LOGICAL BEAM
      DIMENSION D(1),UL(10 ,1),X(3  ,1),T(1),OHM(3,3),EPS(5),
     1          CHI(3),XX(3,2)
      COMMON/STRESS/XN(5),XM(3),TT
      COMMON/HEADER/ O,HEAD(20)
      COMMON/ELDATA/N,MS,IEL,NEL
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),
     1 CR(3,3,8),CT(3,3)
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),Q(8)
      EQUIVALENCE (MA,MS)
      DO 450 J=1,5
      EPS(J)=0.0
  450 CHI(J)=0.0
C
C     COMPUTE STRAIN AND CURVATURE AT CENTER
C
      CALL LOCALX(RR,SS,TT,X,T,NDM,OHM)
      CALL JACOBN(RR,SS,X,T,NDM,OHM)
      TEMP=2.0/TT
      DO 470 I=1,NEL
      CALL BMTRIX(RR,SS,TT,T,NDM,OHM,I,1)
      DO 460 K=1,3
      TP=UL(K,I)
      TQ=UL(K+3,I)*TEMP
      DO 460 J=1,3
      EPS(J)=EPS(J)+BU(J,K,I)*TP
  460 IF(BZERO.NE.0.)CHI(J)=CHI(J)+BR(J,K,I)*TQ
      IF(BZERO.EQ.0.0)GO TO 470
      CALL BMTRIX(RR,SS,TT,T,NDM,OHM,I,2)
      DO 465 K=1,3
      TP=UL(K,I)
      TQ=UL(K+3,I)
      DO 465 J=1,2
  465 EPS(3+J)=EPS(3+J)+BU(J,K,I)*TP      + CR(J,K,I)*TQ
  470 CONTINUE
C
C     COMPUTE STRESS-RESULTANT, COUPLES AT CENTERS
C
      CALL SPACKD(D(1)    ,CT,1,2)
      TEMP=TT**3/12.0
      DO 475 J=1,3
      V(J)=0.0
      DO 473 II=1,NEL
```

```
  473 V(J)=V(J)+SHP(3,II)*X(J,II)
      XN(J)=0.0
      XM(J)=0.0
      DO 474 K=1,3
      XN(J)=XN(J)+CT(J,K)*EPS(K)*TT
  474 XM(J)=XM(J)+CT(J,K)*CHI(K)*TEMP
  475 CONTINUE
      CALL SPACKD(D(1)    ,CT,2,2)
      DO 480 J=1,2
      XN(3+J)=0.0
      DO 480 K=1,2
  480 XN(3+J)=XN(3+J)+TT*CT(J,K)*EPS(3+K)
      IF (ISW.EQ.7) RETURN
      MCT=MCT-1
      IF(MCT.GT.0) GO TO 490
      IF(N.EQ.1) CALL PRSIGN
      WRITE(6,2401) O,HEAD
      MCT=50
  490 WRITE(6,2402) N,MA,( V(J),J=1,3),EPS,( OHM(1,J),J=1,3),
     1              XN,( OHM(2,J),J=1,3),CHI,( OHM(3,J),J=1,3),XM
      IF(.NOT.BEAM) RETURN
      IF(MOD(LLL,2).EQ.0) GO TO 60
      AXIAL = 0.
      BMOMT = 0.
      SHEAR = 0.
60    ITOP = 2-MOD(LLL,2)
      DO 61 J=1,3
61    XX(J,ITOP)=V(J)
      AXIAL = AXIAL+XN(1)
      SIGN = 1.
      IF(ITOP.EQ.1) SIGN=-1.
      BMOMT = BMOMT+SIGN*XN(1)
      SHEAR = SHEAR+XN(3)
      IF(ITOP.EQ.1) RETURN
      XLENG=0.
      DO 75 J=1,3
75    XLENG=XLENG+(XX(J,2)-XX(J,1))**2
      XLENG=SQRT(XLENG*3)
      SHEAR = 5./12.*XLENG*SHEAR
      BMOMT = BMOMT*XLENG*XLENG*SQRT(3.)/12.
      AXIAL = AXIAL*XLENG*0.5
C...TORQUE = 1/3*G*ALPHA*T**3*H1
C...FIND ALPHA, FIRST TRANFORM U TO LOCAL AXIS
      DO 90 I=1,NEL
      XN(I)=0.
      DO 95 J=1,3
95    XN(I)=XN(I)+OHM(J,3)*UL(J,I)
90    CONTINUE
      H1=XLENG
      XLENG=0.
      DO 100 I=1,NDM
100   XLENG=XLENG+(X(I,2)-X(I,1))**2
      XLENG=SQRT(XLENG)
      ALPHA=(XN(3)-XN(2)-XN(4)+XN(1))/H1/XLENG
      GG = CT(1,1)*1.2
```

```
      TORQUE=-(1./3.-0.21*TT/H1*(1.-(TT/H1)**4/12.))*GG*ALPHA*TT**3*H1
      DO 80 J=1,3
80    XX(J,1)=0.5*(XX(J,1)+XX(J,2))
      WRITE(6,2403) ( XX(J,1) ,J=1,3),AXIAL,SHEAR,BMOMT,TORQUE
 2401 FORMAT(A1,18A4,//5X,22HBILINEAR SHELL ELEMENT//9H ELM MATL,3X,
     1       7H1-COORD,4X,7H2-COORD,4X,7H3-COORD,4X,11H1-DIRECTION,4X,
     2       11H2-DIRECTION,7X,8H12-SHEAR,7X,8H13-SHEAR,7X,8H23-SHEAR//)
 2402 FORMAT(2I4,3F11.3,/6X,18H DIRECTION COSINES,6X,
     1       11HEPS-STRAINS    ,5E15.5/6X,3F6.2,6X
     2       11HRESULTANTS     ,5E15.5/6X,3F6.2,6X
     2       11HCHI-STRAINS    ,3E15.5/6X,3F6.2,6X
     2       11HCOUPLES         3E15.5)
 2403 FORMAT(7X,19HBEAM RESULTANTS AT ,3F9.3, 4X,11HAXIAL FORCE,
     1       4X,11HSHEAR FORCE, 4X,14HBENDING MOMENT,2X,6HTORQUE,/,
     2       53X,4E15.5)
      RETURN
      END
C
      SUBROUTINE CROSSP(A,B,C,IN)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
C      SUBROUTINE TO FINE CROSS-PRODUCT (A*B)=C, AND NORMALIZED IF IN=0
      DIMENSION C(3),B(3),A(3)
      C(1)=A(2)*B(3)-A(3)*B(2)
      C(2)=A(3)*B(1)-A(1)*B(3)
      C(3)=A(1)*B(2)-A(2)*B(1)
      IF(IN.NE.0)RETURN
      CNORM=SQRT(C(1)*C(1)+C(2)*C(2)+C(3)*C(3))
      DO 1 I=1,3
    1 C(I)=C(I)/CNORM
      RETURN
      END
C
      SUBROUTINE JACOBN(RR,SS,XO,T,NDM,OHM)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
      COMMON/LOCL1/AJAC(3,7),VA(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),
     1 CR(3,3,8),CT(3,3)
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),S(8)
      DIMENSION OHM(3,3),T(1),XO(3  ,1),I1(3),I2(3)
      DATA I1/2,3,1/,I2/3,1,2/
C     FIND JACOBIAN MATRIC, DETERMINANT AND INVERSE,AJAC,XJAC,RJAC
      DO 35 K=1,NDM
      AJAC(K,3)=0.0
      DO 35 J=1,2
      AJAC(K,J)=0.0
      DO 30 I=1,8
   30 AJAC(K,J)=AJAC(K,J)+SHP(J,I)*XO(K,I)
   35 CONTINUE
      DO 20 I=1,8
      TP=SHP(3,I)*T(I)/2.0
      DO 25 K=1,3
   25 AJAC(K,3)=AJAC(K,3)+V3(K,I)*TP
   20 CONTINUE
      XJAC=0.0
```

```
      DO 40 J=1,NDM
      J2=I1(J)
      J3=I2(J)
   40 XJAC=XJAC+AJAC(1,J)*(AJAC(2,J2)*AJAC(3,J3)-AJAC(2,J3)*AJAC(3,J2))
      CALL CROSSP(AJAC(1,2),AJAC(1,3),RJAC(1,1),1)
      CALL CROSSP(AJAC(1,3),AJAC(1,1),RJAC(1,2),1)
      CALL CROSSP(AJAC(1,1),AJAC(1,2),RJAC(1,3),1)
      DO 50 J=1,NDM
      DO 50 K=1,NDM
   50 RJAC(J,K)=RJAC(J,K)/XJAC
C
C     TO DETERMINE B=L(N) AND BN=B(ZETA)
C     B(1,I)=OHM(1).(N(I)),X
C     B(2,I)=OHM(2).(N(I)),X
C     BN=OHM(3).(ZETA),X
C
      DO 14 J=1,2
      DO 14 I=1,8
      B(J,I)=0.0
      DO 12 K=1,3
      VA(K)=0.0
      DO 10  L=1,2
   10 VA(K)  =VA(K)+RJAC(K,L)*SHP(L,I)
   12 B(J,I)=B(J,I)+VA(K)*OHM(K,J)
   14 CONTINUE
      BN=0.0
      DO 15 J=1,3
   15 BN=BN+OHM(J,3)*RJAC(J,3)
      RETURN
      END
C
      SUBROUTINE LOAD(NDM,NDF,XO,TYPE,F,XR,WW,TT,OHM,P)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
C     SUBROUTINE TO COMPUTE GENERALIZED LOAD CORRESPONDING TO EACH LOAD
C     CASES
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),
     1 CR(3,3,8),CT(3,3)
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),S(8)
      DIMENSION OHM(3,3) ,P(1),XO(3  ,1)
      NJ=1
      JJ=0
      IF(TYPE.GE.3.0)NJ=3
      H=1.0
      IF(TYPE.LE.3.0)GO TO 20
      H=0.0
      DO 25 I=1,8
   25 H=H+SHP(3,I)*XO(3,I)
      H=(XR-H)
      IF(H.LT.0.0)H=0.0
   20 DO 32 I=1,8
      DO 30 K=1,NJ
      J=4-K
      A=OHM(J,3)*H
      IF(TYPE.EQ.2.0)A=ABS(OHM(3,3))
```

```
      IF(TYPE.EQ. 1.0)A=-TT                                             ELM06860
   30 P(JJ+J)=P(JJ+J)+SHP(3,I)*F*WW*A                                   ELM06870
   32 JJ=JJ+NDF                                                         ELM06880
      RETURN                                                            ELM06890
      END                                                               ELM06900
C                                                                       ELM07220
      SUBROUTINE PRSIGN                                                 ELM07230
      WRITE(6,2000)                                                     ELM07240
 2000 FORMAT(1H1//,1X,60HS I G N  C O N V E N S I O N  F O R  B D S  S TELM07250
     1 R E S S E S ,/////,40X,2HZ3,15X,3HN13,/,40X,1HO,15X,1HO,/,       ELM07260
     2 2(40X,1H.,15X,1H+,/),40X,1H.,15X,1H+,6X,1H*,/,                   ELM07270
     3 20X,1H.,19(1H-),1H.,13(1H-),1H.,1X,1H+,7X,1H.,/,                 ELM07280
     4 20X,1HI,19X    ,1H.,13X    ,1HI,1X,1H+,8X,1H.,/,                 ELM07290
     5 10X,10HNODES 1,4 ,1HO,19X,1H*,6(1H.),1HO,1X,2HZ1,3X,2HI*,6(1H+), ELM07300
     6     1HO,3X,1H.,1X,2HOO,4(1H+),1H*,/,                             ELM07310
     7 20X,1HI,33X,1HI,1X,1H+,3X,3HN11,2X,1H.,4X,3HM12,/,               ELM07320
     8 20X,1H.,33(1H-),1H.,1X,1H+,7X,1H.,/,                             ELM07330
     9 56X,1H+,5X,2HO.,/,56X,1H*,4X,3HM11,/)                            ELM07340
      WRITE(6,2001)                                                     ELM07350
 2001 FORMAT(/10X,46HPOSITIVE CONVENTION OF PLATE STRESS RESULTANTS)    ELM07360
      WRITE(6,2002)                                                     ELM07370
 2002 FORMAT(/////40X,2HZ2,/ 40X,1HO/40X,1H.,15X,1HV/40X,1H.,15X,1HO/   ELM07380
     1 17X,1H4,2X,1HO,19(1H-),1H.,13(1H-),1H.,1X,1H+/                   ELM07390
     2 20X,1HI,19X,1H.,13X,1H.,1X,1H+,6X,1H*/                           ELM07400
     3 20X,1HI,19X,1H.,13X,1HI,1X,1H+,7X,1H./                           ELM07410
     4 20X,1HI,19X,1H.,13X,1HI,1X,1H+,8X,1H./                           ELM07420
     5 20X,1HI,19X,1HO,6(1H.),1HO,1X,2HZ1,3X,2HI*,6(1H+),1HO,3X,1H.,1X, ELM07430
     6     2HOO,4(1H+),1H*,/                                            ELM07440
     7 20X,1HI,33X,1HI,1X,1H+,4X,1HP,3X,1H.,3X,6HTORQUE,/               ELM07450
     8 20X,1HI,33X,1HI,1X,1H+,7X,1H./                                   ELM07460
     9 20X,1HI,33X,1HI,1X,1H+,5X,2HO./                                  ELM07470
     1 17X,1H1,2X,1HO,33(1H-),1HO,1X,1H*,5X,1HM,/  )                    ELM07480
      WRITE(6,2003)                                                     ELM07490
 2003 FORMAT( /10X,45HPOSITIVE CONVENTION OF BEAM STRESS RESULTANTS/1H1)ELM07500
      RETURN                                                            ELM07510
      END                                                               ELM07520
                                                                        ELM07530
      SUBROUTINE SPACKD(D,CT,K,L)                                       ELM07540
      IMPLICIT REAL*8(A-H,O-Z)                                          ELM07550
C     GENERIC                                                           ELM07560
      DIMENSION D(1),CT(3,3)                                            ELM07570
      SLAM=D(1)*D(2)/(1.0-D(2)*D(2))                                    ELM07580
      TMU=D(1)/(1.0+D(2))                                               ELM07590
      DO 5 I=1,3                                                        ELM07600
      DO 5 J=1,3                                                        ELM07610
    5 CT(I,J)=0.0                                                       ELM07620
      IF(K.EQ.2)GO TO 10                                                ELM07630
      IF(L.EQ.2)GO TO 20                                                ELM07640
      GO TO (30,10,40),K                                                ELM07650
   30 CT(1,1)=2.0*SLAM*TMU/(SLAM+2.0*TMU)                               ELM07660
      CT(2,2)=CT(1,1)                                                   ELM07670
      CT(1,2)=CT(1,1)                                                   ELM07680
      CT(2,1)=CT(1,1)                                                   ELM07690
      RETURN                                                            ELM07700
   40 CT(1,1)=TMU                                                       ELM07710
```

```
      CT(2,2)=CT(1,1)
      CT(3,3)=CT(1,1)/2.4
      RETURN
   20 CT(1,1)=SLAM+TMU
      CT(1,2)=SLAM
      CT(2,1)=SLAM
      CT(2,2)=CT(1,1)
      CT(3,3)=TMU/2.0
      RETURN
   10 CT(1,1)=TMU/2.4
      CT(2,2)=CT(1,1)
      RETURN
      END

      SUBROUTINE TORSON(D,S,WS,TT,OHM,NST,NEL,NDF)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
      DIMENSION D(1),S(NST,1),OHM(3,3)
      COMMON/LOCL2/XJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),Q(8)
      COMMON/LOCL1/VA(3,8),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),
     1 CR(3,3,8),CT(3,3)
      GG=CT(1,1)*1.2
      GW=WS*GG*TT*D(7)*4.0
      DO 10  IJ=1,NEL
      DO 10 K=1,3
   10 VA(K,IJ)=0.5*(OHM(K,1)*B(2,IJ)-OHM(K,2)*B(1,IJ))
      J1=0
      DO 1 IJ=1,NEL
      K1=0
      DO 20 IK=1,IJ
      GW2=GW*SHP(3,IJ)*SHP(3,IK)
      DO 40 J=1,3
      DO 40 K=1,3
      S(J1+J,K1+K)=S(J1+J,K1+K)+VA(J,IJ)*VA(K,IK)*GW
      S(J1+3+J,K1+3+K)=S(J1+3+J,K1+3+K)+OHM(J,3)*OHM(K,3)*GW2
      S(J1+J  ,K1+3+K)=S(J1+J  ,K1+3+K)+VA(J,IJ)*SHP(3,IK)*OHM(K,3)*GW
   40 S(J1+J+3,K1+K  )=S(J1+J+3,K1+K  )+SHP(3,IJ)*OHM(J,3)*VA(K,IK)*GW
   20 K1=K1+NDF
    1 J1=J1+NDF
      RETURN
      END

      SUBROUTINE TRIMUL(A,B,C,ABC,FAC,IB,NST)
      IMPLICIT REAL*8(A-H,O-Z)
C     GENERIC
      DIMENSION A(3,3),B(3,3),C(3,3),ABC(NST,3),S(3)
      DO 250 L=1,3
      DO 150 J=1,IB
      TEMP=0.0
      DO 100 K=1,IB
  100 TEMP=TEMP+B(J,K)*C(K,L)
  150 S(J)=TEMP
      DO 250 I=1,3
      TEMP=0.0
      DO 200 J=1,IB
```

```
  200 TEMP=TEMP+A(J,I)*S(J)                                          ELM0B270
  250 ABC(I,L)=ABC(I,L)+TEMP/FAC                                     ELM0B280
      RETURN                                                         ELM0B290
      END                                                            ELM0B300
                                                                     ELM0B310
      SUBROUTINE PRINTR(A,M,N,HEAD)                                  ELM0B320
      IMPLICIT REAL*8(A-H,O-Z)                                       ELM0B330
C     GENERIC                                                        ELM0B340
      DIMENSION A(M,1)                                               ELM0B350
      WRITE(6,1000) HEAD                                             ELM0B360
      DO 10 MM=1,M                                                   ELM0B370
   10 WRITE(6,1001)(A(MM,NN),NN=1,N)                                 ELM0B380
 1000 FORMAT(//1X,A10/)                                              ELM0B390
 1001 FORMAT(8E14.5/(5X,8E14.5))                                     ELM0B400
      RETURN                                                         ELM0B410
      END                                                            ELM0B420
C                                                                    ELM0B430
      SUBROUTINE BMS(II,JJ,KK,B,PHI,NST)                             ELM0B440
      IMPLICIT REAL*8(A-H,O-Z)                                       ELM0B450
C     GENERIC                                                        ELM0B460
      DIMENSION PHI(NST,3)                                           ELM0B470
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),   ELM0B480
     1 CR(3,3,8),CT(3,3)                                             ELM0B490
C...  *** FIND PHI,PHIT,PHIT*PHI ***                                  ELM0B500
C     WRITE(6,1002) KK                                               ELM0B510
C     DO 9 I = 1,3                                                   ELM0B520
C9    WRITE(6,1001)(PHI(I,J),J = 1,3)                                ELM0B530
C     DO 8 I = 1,3                                                   ELM0B540
C8    WRITE(6,1001)(V3(I,J),J = 1,4)                                 ELM0B550
      IF(KK.EQ.0) GO TO 20                                           ELM0B560
      IF(KK.EQ.2) GO TO 30                                           ELM0B570
      DO 17 I = 1,3                                                  ELM0B580
      DO 17 J = 1,3                                                  ELM0B590
      IF(I.EQ.J) GO TO 17                                            ELM0B600
      MM = 1                                                         ELM0B610
      IF(I.GT.J) MM = -1                                             ELM0B620
      DO 10 K = 1,3                                                  ELM0B630
      IF(K.EQ.I) GO TO 10                                            ELM0B640
      IF(K.EQ.J) GO TO 10                                            ELM0B650
      NN = 1                                                         ELM0B660
      IF (K.EQ.2) NN= -1                                             ELM0B670
      PHI(I,J) = V3(K,II)*KK*B*MM*NN + PHI(I,J)                      ELM0B680
 10   CONTINUE                                                       ELM0B690
 17   CONTINUE
 C    DO 11 I = 1,3                                                  ELM0B700
 C11  WRITE(6,1001)(PHI(I,J),J = 1,3)                                ELM0B710
      RETURN                                                         ELM0B720
 20   DO 25 I = 1,3                                                  ELM0B730
 25   PHI(I,I) = PHI(I,I) + B                                        ELM0B740
 C..  WRITE(6,1003) NST                                              ELM0B750
 C..  DO 24 I = 1,3                                                  ELM0B760
 C..  WRITE(6,1001)(PHI(I,J),J = 1,3)                                ELM0B770
      RETURN                                                         ELM0B780
 30   IT = 0                                                         ELM0B790
      DO 47 I = 1,3                                                  ELM0B800
```

```
      DO 47 J = 1,3                                                     ELM08810
      IF(I.EQ.J) GO TO 80                                               ELM08820
60    PHI(I,J) = PHI(I,J) - V3(I,JJ)*V3(J,II)*B                         ELM08830
      GO TO 47                                                          ELM08840
80    IT = IT + 1                                                       ELM08850
      DO 40 K =1,3                                                      ELM08860
      IF(K.EQ.IT) GO TO 40                                              ELM08870
      PHI(I,I)= PHI(I,I) + V3(K,II)*V3(K,JJ)*B                          ELM08880
40    CONTINUE                                                          ELM08890
47    CONTINUE
C     DO 41 I = 1,3                                                     ELM08900
C41   WRITE(6,1001)(PHI(I,J),J = 1,3)                                   ELM08910
      RETURN                                                            ELM08920
1001  FORMAT(5X,4(E15.5))                                               ELM08930
1002  FORMAT(5X,10HINDEX  KK ,1H=,I5)                                   ELM08940
1003  FORMAT(5X,10HMARK INDEX,2I5)                                      ELM08950
1111  FORMAT(5X,10HINDEX SIGN,I5)                                       ELM08960
1112  FORMAT(5X,10HTESTINGGGG)                                          ELM08970
      END                                                               ELM08980
```

```
$LARGE
$DEBUG
C
      SUBROUTINE LOCALX(RR,SS,TT,X0,T,NOM,OHM)                          ELM06920
      IMPLICIT REAL*8(A-H,O-Z)                                          ELM06930
C     GENERIC                                                           ELM06940
      COMMON/LOCL1/VA(3,7),V(3),LX(3),V3(3,8),BU(3,3,8),BR(3,3,8),      ELM06950
     1 CR(3,3,8),C(3,3)                                                 ELM06960
      COMMON/LOCL2/DJAC,RJAC(3,3),SHP(3,8),BN,B(2,8),R(8),S(8)          ELM06970
      DIMENSION OHM(3,3),X0(3  ,1),T(1)                                 ELM06980
      TT=0.0                                                            ELM06990
      DO 1  I=1,8                                                       ELM07000
      IF (I.GT.4) GOTO 33
      SHP(1,I)=0.25*(2*RR*R(I)**2+R(I)*SS*S(I))*(1+SS*S(I))             ELM07010
      SHP(2,I)=0.25*(2*SS*S(I)**2+S(I)*RR*R(I))*(1+RR*R(I))             ELM07020
      SHP(3,I)=0.25*(1.0+RR*R(I))*(1+SS*S(I))*(RR*R(I)+SS*S(I)-1)       ELM07030
      GOTO 1
   33 GOTO(36,34,36,34),I-1
   34 SHP(1,I)=-0.5*(2*RR)*(1+SS*S(I))
      SHP(2,I)=0.5*(1-RR**2)*S(I)
      SHP(3,I)=0.5*(1-RR**2)*(1+SS*S(I))
      GOTO 1
   36 SHP(1,I)=0.5*(1-SS**2)*R(I)
      SHP(2,I)=-0.5*(2*SS)*(1+RR*R(I))
      SHP(3,I)=0.5*(1-SS**2)*(1+RR*R(I))
    1 TT=TT+SHP(3,I)*T(I)                                               ELM07040
C     FIND DIRECTION COSINE OF LOCAL AXES BETWEEN ANY POINT(RR,SS) AND  ELM07050
C     GLOBAL  AXIS                                                      ELM07060
      DO 10 J=1,NOM                                                     ELM07070
      OHM(J,1)=0.0                                                      ELM07080
      OHM(J,2)=0.0                                                      ELM07090
      DO 10 I=1,8                                                       ELM07100
      OHM(J,1)=OHM(J,1)+SHP(1,I)*X0(J,I)                                ELM07110
   10 OHM(J,2)=OHM(J,2)+SHP(2,I)*X0(J,I)                                ELM07120
      CALL CROSSP(OHM(1,1),OHM(1,2),OHM(1,3),0)                         ELM07130
C     DO 12 J=1,NOM                                                     ELM07140
C     OHM(J,1)=0.0                                                      ELM07150
C     DO 12 I=1,8                                                       ELM07160
C     FACTOR = 0.0
C     IF (I.EQ.6.OR.I.EQ.8) FACTOR = 1.0
C  12 OHM(J,1)=OHM(J,1)+R(I)*0.5*X0(J,I)*FACTOR                         ELM07170
      OHM(1,2)=0
      OHM(2,2)=1
      OHM(3,2)=0
      CALL CROSSP(OHM(1,2),OHM(1,3),OHM(1,1),0)                         ELM07180
      CALL CROSSP(OHM(1,3),OHM(1,1),OHM(1,2),0)                         ELM07190
      RETURN                                                            ELM07200
      END                                                               ELM07210
```

ภาคผนวก ข

ตัวอย่างการเตรียมข้อมูล และผลลัพธ์

```
                                   STARTING TIME (SEC.)>>>>        0.


IMAGE OF DATA CARDS
============================


                                        C O L U M N   N U M B E R
                   CARD           1         2         3         4         5         6         7         8
                  NUMBER 12345678901234567890123456789012345678901234567890123456789012345678901234567890
                  -------- --------------------------------------------------------------------------------
                         1 JOB
                         2 TEST05
                         3 MESH
                         4 FEAP / CIRCULAR PLATE BENDING
                         5    16    3    1    3    6    8
                         6 COOR
                         7     1            0.0       0.0
                         8     2                      1.0
                         9     3            1.0
                        10     4                      2.0
                        11     5         0.7654    1.8478
                        12     6         1.4142    1.4142
                        13     7         1.8478    0.7654
                        14     8            2.0
                        15     9                      3.0
                        16    10         2.1213    2.1213
                        17    11            3.0
                        18    12                      4.0
                        19    13         1.5307    3.6955
                        20    14         2.8284    2.8284
                        21    15         3.6955    1.5307
                        22    16            4.0
                        23
                        24 ELEM
                        25     1    1    1    8    6    4    3    7    5    2
                        26     2    1    6   14   12    4   10   13    9    5
                        27     3    1    6    8   16   14    7   11   15   10
                        28
                        29 BOUN
                        30     1         1    1    0    1    1    1
                        31     2         1                   1    1
                        32     3              1         1         1
                        33     4         1                   1    1
                        34     8              1         1         1
                        35     9         1                   1    1
                        36    11              1         1         1
                        37    12         1    1    1    1    1    1
                        38    13         1    1    1    1    1    1
                        39    14         1    1    1    1    1    1
                        40    15         1    1    1    1    1    1
                  -------- --------------------------------------------------------------------------------
                    CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
            NUMBER              1         2         3         4         5         6         7         8
                                                COLUMN NUMBER
1




                                                COLUMN  NUMBER
             CARD               1         2         3         4         5         6         7         8
            NUMBER     12345678901234567890123456789012345678901234567890123456789012345678901234567890
           --------    --------------------------------------------------------------------------------
               41         16         1    1    1    1    1    1
               42
               43      MATE
               44         1   18
               45      2350000000          0.15           2         .1                        444     1
               46
               47      -1000.0000
               48
               49      END
               50      LINE
               51      TANG
               52      FORM
               53      SOLV
               54      DISP
               55      STRE
               56      END
               57      STOP
           --------    --------------------------------------------------------------------------------
             CARD      12345678901234567890123456789012345678901234567890123456789012345678901234567890
            NUMBER              1         2         3         4         5         6         7         8
                                                COLUMN NUMBER



                                                 END OF DATA
1
0
 FEAP / CIRCULAR PLATE BENDING
     NUMBER OF NODAL POINTS      =     16
     NUMBER OF ELEMENTS          =      3
     NUMBER OF MATERIAL SETS     =      1
     DIMENSION OF COORDINATE SPACE=     3
     DEGREE OF FREEDOMS / NODE   =      6
     NODES PER ELEMENT (MAXIMUM) =      8
     EXTRA DEGREE OF FREEDOM     =      0

0FEAP / CIRCULAR PLATE BENDING


     NODAL COORDINATES


      NODE      1 COORD      2 COORD      3 COORD
         1        .0000        .0000        .0000
         2        .0000       1.0000        .0000
         3       1.0000        .0000        .0000
         4        .0000       2.0000        .0000
```

5	.7654	1.8478	.0000
6	1.4142	1.4142	.0000
7	1.8478	.7654	.0000
8	2.0000	.0000	.0000
9	.0000	3.0000	.0000
10	2.1213	2.1213	.0000
11	3.0000	.0000	.0000
12	.0000	4.0000	.0000
13	1.5307	3.6955	.0000
14	2.8284	2.8284	.0000
15	3.6955	1.5307	.0000
16	4.0000	.0000	.0000

OFEAP / CIRCULAR PLATE BENDING

ELEMENTS

ELEMENT	MATERIAL	1 NODE	2 NODE	3 NODE	4 NODE	5 NODE	6 NODE	7 NODE	8 NODE
1	1	1	8	6	4	3	7	5	2
2	1	6	14	12	4	10	13	9	5
3	1	6	8	16	14	7	11	15	10

OFEAP / CIRCULAR PLATE BENDING

NODAL B.C.

NODE

NODAL B.C.

NODE	1 B.C.	2 B.C.	3 B.C.	4 B.C.	5 B.C.	6 B.C.
1	1	1	0	1	1	1
2	1	0	0	0	1	1
3	0	1	0	1	0	1
4	1	0	0	0	1	1
8	0	1	0	1	0	1
9	1	0	0	0	1	1
11	0	1	0	1	0	1
12	1	1	1	1	1	1
13	1	1	1	1	1	1
14	1	1	1	1	1	1
15	1	1	1	1	1	1
16	1	1	1	1	1	1

OFEAP / CIRCULAR PLATE BENDING

MATERIAL PROPERTIES

MATERIAL SET 1 FOR ELEMENT TYPE18

```
MODULUS              =    .2350E+10
POISSON RATIO        =    .0000
MASS DENSITY         =    .0000     LUMPED MASS ONLY
CONSTRAINT FACTOR    =    1.200
NO OF GAUSS POINT
BENDING              =    4
INPLANE SHEAR        =    4
```

```
TRANSVERSE SHEAR     =    4
STRESS OUTPUT CODE   =    1
UNIFORM THICKNESS    =    .1500
LOADING CODE         =       2.0
LOAD INTENSITY       =    -1000.
                        (1-SPECIFIC WEIGHT,2-UNIF.LOAD/PROJ.AREA, 3-NORMAL PRESSURE,4-WATER PRESSURE)
WATER TABLE AT Z3    =    .0000    (ONLY CODE=4)
COEFFICIENT FOR TORSONAL ENERGY =       .1000
                                                  M-STORAGE =        317
                                                  M-STORAGE =        168
                                                  R-STORAGE =       3439


****************** MACRO COMMANDS ******************
*                                                  *
*        TANG          .00000         .00000       *
*        FORM          .00000         .00000       *
*        SOLV          .00000         .00000       *
*        DISP          .00000         .00000       *
*        STRE          .00000         .00000       *
*        END           .00000         .00000       *
*                                                  *
****************************************************

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> TANG

                                        CURRENT  TIME (SEC.)>>>>       44.


CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> FORM

                                        CURRENT  TIME (SEC.)>>>>      573.


CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> SOLV

                                        CURRENT  TIME (SEC.)>>>>      618.


CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> DISP

                                        CURRENT  TIME (SEC.)>>>>      661.


  NODAL DISPLACEMENTS AT TIME      1.00000
```

NODE	1 DISPL	2 DISPL	3 DISPL	4 DISPL	5 DISPL	6 DISPL
1	.0000E+00	.0000E+00	-.5689E-02	.0000E+00	.0000E+00	.0000E+00
2	.0000E+00	.0000E+00	-.5133E-02	.1260E-02	.0000E+00	.0000E+00
3	.0000E+00	.0000E+00	-.5133E-02	.0000E+00	-.1260E-02	.0000E+00
4	.0000E+00	.0000E+00	-.3366E-02	.2100E-02	.0000E+00	.0000E+00
5	.0000E+00	.0000E+00	-.3364E-02	.1944E-02	-.9131E-03	.0000E+00
6	.0000E+00	.0000E+00	-.3322E-02	.1529E-02	-.1529E-02	.0000E+00
7	.0000E+00	.0000E+00	-.3364E-02	.9131E-03	-.1944E-02	.0000E+00
8	.0000E+00	.0000E+00	-.3366E-02	.0000E+00	-.2100E-02	.0000E+00

9	.0000E+00	.0000E+00	-.1167E-02	.2054E-02	.0000E+00	.0000E+00
10	.0000E+00	.0000E+00	-.1111E-02	.1395E-02	-.1395E-02	.0000E+00
11	.0000E+00	.0000E+00	-.1167E-02	.0000E+00	-.2054E-02	.0000E+00
12	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
13	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
14	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
15	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
16	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> STRE

CURRENT TIME (SEC.)>>>>> 664.

0
FEAP / CIRCULAR PLATE BENDING
1

S I G N C O N V E N S I O N F O R B D S S T R E S S E S

```
                                  Z3                N13
                                  0                 0
                                  .                 +
                                  .                 +
                                  .                 +       *
            .---------------------.-------------.   +        .
            I                     .             I   +         .
  NODES 1,4 0                     *......0 Z1   I*******0      . 00+++++
            I                                   I   +   N11   .    M12
            .-----------------------------------.   +        .
                                                    +      0.
                                                    *     M11
```

POSITIVE CONVENTION OF PLATE STRESS RESULTANTS

```
                                  Z2
                                  0
                                  .                 V
                                  .                 0
          4 0---------------------.-------------.   +
            I                     .             .   +       *
            I                     .             I   +        .
            I                     .             I   +         .
            I                     0......0 Z1   I*******0      . 00+++++
            I                                   I   +    P    .   TORQUE
            I                                   I   +        .
            I                                   I   +      0.
          1 0-----------------------------------0   *      M
```

POSITIVE CONVENTION OF BEAM STRESS RESULTANTS

1

OFEAP / CIRCULAR PLATE BENDING

BILINEAR SHELL ELEMENT

ELM	MATL	1-COORD	2-COORD	3-COORD		1-DIRECTION	2-DIRECTION	12-SHEAR	13-SHEAR	23-SHEAR
1	1	.425	.425	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	-.28110E-05	-.36285E-05
		.99	.13	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	-.41286E+03	-.53294E+03
		-.13	.99	.00	CHI-STRAINS	-.12710E-02	-.12513E-02	.75996E-04		
		.00	.00	1.00	COUPLES	-.84003E+03	-.82706E+03	.25114E+02		
1	1	.375	1.562	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	.30344E-04	.54513E-05
		.99	.13	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	.44567E+04	.80066E+03
		-.13	.99	.00	CHI-STRAINS	-.12164E-02	-.81859E-03	-.11551E-04		
		.00	.00	1.00	COUPLES	-.80398E+03	-.54103E+03	-.38171E+01		
1	1	1.562	.375	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	-.23043E-05	.30743E-04
		.99	.13	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	-.33845E+03	.45154E+04
		-.13	.99	.00	CHI-STRAINS	-.84063E-03	-.11944E-02	.18242E-03		
		.00	.00	1.00	COUPLES	-.55561E+03	-.78940E+03	.60283E+02		
1	1	1.318	1.318	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	-.22545E-05	-.29103E-05
		.99	.13	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	-.33114E+03	-.42745E+03
		-.13	.99	.00	CHI-STRAINS	-.87437E-03	-.82569E-03	.18860E-03		
		.00	.00	1.00	COUPLES	-.57790E+03	-.54573E+03	.62328E+02		
2	1	1.398	1.977	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	.81831E-05	-.10698E-04
		.38	-.92	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	.12019E+04	-.15713E+04
		.92	.38	.00	CHI-STRAINS	.33330E-04	-.81346E-03	-.43244E-03		
		.00	.00	1.00	COUPLES	.22029E+02	-.53765E+03	-.14291E+03		
2	1	.409	2.386	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	-.11702E-05	.32400E-04
		.38	-.92	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	-.17187E+03	.47588E+04
		.92	.38	.00	CHI-STRAINS	-.45202E-04	-.10041E-02	.30963E-03		
		.00	.00	1.00	COUPLES	-.29876E+02	-.66368E+03	.10232E+03		
2	1	2.064	2.919	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	.85765E-05	-.90229E-05
		.38	-.92	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	.12597E+04	-.13252E+04
		.92	.38	.00	CHI-STRAINS	.19668E-02	-.16340E-03	-.10415E-02		
		.00	.00	1.00	COUPLES	.13000E+04	-.10800E+03	-.34417E+03		
2	1	.604	3.524	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	.15237E-04	-.39711E-05
		.38	-.92	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	.22380E+04	-.58325E+03
		.92	.38	.00	CHI-STRAINS	.20266E-02	-.19789E-03	.99979E-03		
		.00	.00	1.00	COUPLES	.13395E+04	-.13079E+03	.33040E+03		
3	1	1.977	1.398	.000						
DIRECTION COSINES					EPS-STRAINS	.00000E+00	.00000E+00	.00000E+00	-.10698E-04	.81834E-05
		.38	.92	.00	RESULTANTS	.00000E+00	.00000E+00	.00000E+00	-.15713E+04	.12019E+04

```
   -.92   .38   .00      CHI-STRAINS    -.81347E-03    .33344E-04   -.43238E-03
    .00   .00  1.00      COUPLES        -.53765E+03    .22038E+02   -.14289E+03
 3   1      2.919     2.064       .000
   DIRECTION COSINES     EPS-STRAINS     .00000E+00    .00000E+00    .00000E+00   -.90226E-05    .85768E-05
    .38   .92   .00      RESULTANTS      .00000E+00    .00000E+00    .00000E+00   -.13252E+04    .12597E+04
   -.92   .38   .00      CHI-STRAINS    -.16343E-03    .19669E-02   -.10413E-02
    .00   .00  1.00      COUPLES        -.10802E+03    .13000E+04   -.34413E+03
 3   1      2.386      .409       .000
   DIRECTION COSINES     EPS-STRAINS     .00000E+00    .00000E+00    .00000E+00    .32400E-04   -.11712E-05
    .38   .92   .00      RESULTANTS      .00000E+00    .00000E+00    .00000E+00    .47588E+04   -.17202E+03
   -.92   .38   .00      CHI-STRAINS    -.10041E-02   -.45212E-04    .30969E-03
    .00   .00  1.00      COUPLES        -.66367E+03   -.29882E+02    .10234E+03
 3   1      3.524      .604       .000
   DIRECTION COSINES     EPS-STRAINS     .00000E+00    .00000E+00    .00000E+00   -.39706E-05    .15237E-04
    .38   .92   .00      RESULTANTS      .00000E+00    .00000E+00    .00000E+00   -.58318E+03    .22380E+04
   -.92   .38   .00      CHI-STRAINS    -.19786E-03    .20266E-02    .99993E-03
    .00   .00  1.00      COUPLES        -.13077E+03    .13395E+04    .33045E+03
                                    ENDING   TIME (SEC.)>>>>       758.

*********** NORMAL EXIT FROM MAIN PROGRAM *********
```

STARTING TIME (SEC.)>>>> 0.

0

FEAP/SHELL ELEMENT TEST EXAMPLE

NUMBER OF NODAL POINTS = 21
NUMBER OF ELEMENTS = 4
NUMBER OF MATERIAL SETS = 1
DIMENSION OF COORDINATE SPACE= 3
DEGREE OF FREEDOMS / NODE = 6
NODES PER ELEMENT (MAXIMUM) = 8
EXTRA DEGREE OF FREEDOM = 0

0FEAP/SHELL ELEMENT TEST EXAMPLE

NODAL COORDINATES

NODE	1 COORD	2 COORD	3 COORD
1	.0000	.0000	5.8489
2	.0000	6.2500	5.8489
3	.0000	12.5000	5.8489
4	.0000	18.7500	5.8489
5	.0000	25.0000	5.8489
6	4.3412	.0000	5.4691
7	4.3412	12.5000	5.4691
8	4.3412	25.0000	5.4691
9	8.5505	.0000	4.3412
10	8.5505	6.2500	4.3412
11	8.5505	12.5000	4.3412
12	8.5505	18.7500	4.3412
13	8.5505	25.0000	4.3412
14	12.5000	.0000	2.4995
15	12.5000	12.5000	2.4995
16	12.5000	25.0000	2.4995
17	16.0697	.0000	.0000
18	16.0697	6.2500	.0000
19	16.0697	12.5000	.0000
20	16.0697	18.7500	.0000
21	16.0697	25.0000	.0000

0FEAP/SHELL ELEMENT TEST EXAMPLE

ELEMENTS

ELEMENT	MATERIAL	1 NODE	2 NODE	3 NODE	4 NODE	5 NODE	6 NODE	7 NODE	8 NODE
1	1	1	9	11	3	6	10	7	2
2	1	9	17	19	11	14	18	15	10
3	1	3	11	13	5	7	12	8	4
4	1	11	19	21	13	15	20	16	12

0FEAP/SHELL ELEMENT TEST EXAMPLE

NODAL B.C.

NODE

NODAL B.C.

NODE	1 B.C.	2 B.C.	3 B.C.	4 B.C.	5 B.C.	6 B.C.
1	1	0	1	0	1	1
2	1	0	0	0	1	1
3	1	0	0	0	1	1
4	1	0	0	0	1	1
5	1	1	0	1	1	1
6	1	0	1	0	1	0
8	0	1	0	1	0	1
9	1	0	1	0	1	0
13	0	1	0	1	0	1
14	1	0	1	0	1	0
16	0	1	0	1	0	1
17	1	0	1	0	1	1
21	0	1	0	1	0	1

```
OFEAP/SHELL ELEMENT TEST EXAMPLE

    MATERIAL PROPERTIES

    MATERIAL SET  1 FOR ELEMENT TYPE18

    MODULUS              =    .4320E+06
    POISSON RATIO        =    .3000
    MASS DENSITY         =    .0000    LUMPED MASS ONLY
    CONSTRAINT FACTOR    =    1.200
    NO OF GAUSS POINT
    BENDING              =    4
    INPLANE SHEAR        =    4
    TRANSVERSE SHEAR     =    4
    STRESS OUTPUT CODE   =    1
    UNIFORM THICKNESS    =    .2500
    LOADING CODE         =      1.0
    LOAD INTENSITY       =    .3600
                             (1-SPECIFIC WEIGHT,2-UNIF.LOAD/PROJ.AREA, 3-NORMAL PRESSURE,4-WATER PRESSURE)
    WATER TABLE AT Z3    =    .0000    (ONLY CODE=4)
    COEFFICIENT FOR TORSONAL ENERGY =      .1000
                                                  M-STORAGE =       416
                                                  M-STORAGE =       247
                                                  R-STORAGE =      5232


******************* MACRO COMMANDS *******************
*                                                    *
*       TANG          .00000        .00000           *
*       FORM          .00000        .00000           *
*       SOLV          .00000        .00000           *
*       DISP          .00000        .00000           *
*       STRE          .00000        .00000           *
*       END           .00000        .00000           *
*                                                    *
******************************************************

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> TANG

                                         CURRENT  TIME (SEC.)>>>>       35.
```

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> FORM

CURRENT TIME (SEC.)>>>> 880.

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> SOLV

CURRENT TIME (SEC.)>>>> 941.

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> DISP

CURRENT TIME (SEC.)>>>> 1131.

NODAL DISPLACEMENTS AT TIME 1.00000

NODE	1 DISPL	2 DISPL	3 DISPL	4 DISPL	5 DISPL	6 DISPL
1	.0000E+00	.2213E-03	.0000E+00	.3856E-02	.0000E+00	.0000E+00
2	.0000E+00	.1541E-03	.1698E-01	.5600E-02	.0000E+00	.0000E+00
3	.0000E+00	.2056E-03	.3247E-01	.2925E-02	.0000E+00	.0000E+00
4	.0000E+00	.9024E-04	.4193E-01	.2143E-02	.0000E+00	.0000E+00
5	.0000E+00	.0000E+00	.4517E-01	.0000E+00	.0000E+00	.0000E+00
6	.0000E+00	.7641E-03	.0000E+00	.2605E+00	.0000E+00	.1489E+01
7	-.2552E-02	.5839E-03	.8861E-02	-.2156E+00	.1097E-01	-.1217E+01
8	-.3632E-02	.0000E+00	.1192E-01	.0000E+00	.1538E-01	.0000E+00
9	.0000E+00	.2572E-02	.0000E+00	.1297E+00	.0000E+00	.3691E+00
10	-.1130E-01	.2516E-02	-.3105E-01	.3036E+00	.1047E-01	.8440E+00
11	-.2083E-01	.1825E-02	-.5633E-01	.1035E+00	.1938E-01	.2923E+00
12	-.2645E-01	.1008E-02	-.7258E-01	.1452E+00	.2489E-01	.4035E+00
13	-.2920E-01	.0000E+00	-.7921E-01	.0000E+00	.2705E-01	.0000E+00
14	.0000E+00	.6072E-03	.0000E+00	-.1852E-02	.0000E+00	.2349E-01
15	-.5990E-01	.3653E-03	-.1406E+00	-.9950E-01	.2306E-01	-.1548E+00
16	-.8292E-01	.0000E+00	-.1952E+00	.0000E+00	.3132E-01	.0000E+00
17	.0000E+00	-.1245E-01	.0000E+00	-.2699E-01	.0000E+00	.0000E+00
18	-.6503E-01	-.1108E-01	-.1226E+00	-.2185E+00	.1315E-01	-.2290E+00
19	-.1204E+00	-.8434E-02	-.2252E+00	.1447E+01	.2426E-01	.1751E+01
20	-.1519E+00	-.4418E-02	-.2871E+00	.4512E+00	.3032E-01	.5509E+00
21	-.1639E+00	.0000E+00	-.3085E+00	.0000E+00	.3202E-01	.0000E+00

CURRENT LINEAR MACRO-COMMAND INSTRUCTION >>>>>>>>>>>>>>> STRE

CURRENT TIME (SEC.)>>>> 1136.

0

FEAP/SHELL ELEMENT TEST EXAMPLE

1

S I G N C O N V E N S I O N F O R B D S S T R E S S E S

```
                Z3                 N13
                O                  O
                .                  +
                .                  +
                .                  +       *
  .-------------------.-------------.  +       .
  I                 .             I +        .
NODES 1,4 O         *......O Z1   I*******O    . OO+++++
  I                               I +   N11   .    M12
  .---------------------------------.  +       .
                                   +     O.
                                   *     M11
```

POSITIVE CONVENTION OF PLATE STRESS RESULTANTS

```
                Z2
                O
                .                  V
                .                  O
   4  O-----------------.-------------.  +
      I          .              .  +       *
      I          .              I +        .
      I          .              I +         .
      I          O......O Z1    I*******O    . OO+++++
      I                         I +    P    .   TORQUE
      I                         I +         .
      I                         I +     O.
   1  O---------------------------------O *     M
```

POSITIVE CONVENTION OF BEAM STRESS RESULTANTS

1
OFEAP/SHELL ELEMENT TEST EXAMPLE

BILINEAR SHELL ELEMENT

```
ELM NATL   1-COORD    2-COORD   3-COORD   1-DIRECTION   2-DIRECTION     12-SHEAR     13-SHEAR      23-SHEAR


  1   1      1.851      2.642     5.780
      DIRECTION COSINES         EPS-STRAINS   -.38969E-04    .86819E-06   -.57504E-05  -.10968E-03   .44580E-05
       1.00   .00   .07         RESULTANTS    -.45940E+01   -.12844E+01   -.23886E+00  -.37968E+01   .15432E+00
        .00  1.00   .00         CHI-STRAINS    .59760E-03   -.35562E-03    .18438E-02
       -.07   .00  1.00         COUPLES        .30345E+00   -.10900E+00    .39891E+00
  1   1      1.851      9.858     5.780
      DIRECTION COSINES         EPS-STRAINS   -.16161E-04   -.66650E-05    .45361E-04   .72090E-04   .96259E-05
       1.00   .00   .07         RESULTANTS    -.21553E+01   -.13664E+01    .18842E+01   .24954E+01   .33320E+00
        .00  1.00   .00         CHI-STRAINS    .20741E-02    .35370E-03    .15261E-02
       -.07   .00  1.00         COUPLES        .13477E+01    .60326E+00    .33017E+00
```

```
1  1    6.788     2.642     4.909
   DIRECTION COSINES   EPS-STRAINS   .18292E-05   .73582E-05   .72217E-04   .74904E-04  -.49865E-05
    .96   .00   .27    RESULTANTS    .47907E+00   .93841E+00   .29998E+01   .25928E+01  -.17261E+00
    .00  1.00   .00    CHI-STRAINS   .45760E-03  -.32170E-03   .18376E-02
   -.27   .00   .96    COUPLES       .22320E+00  -.11399E+00   .39756E+00
1  1    6.788     9.858     4.909
   DIRECTION COSINES   EPS-STRAINS  -.20409E-04  -.80693E-04   .30249E-04  -.54235E-04   .28355E-06
    .96   .00   .27    RESULTANTS   -.52952E+01  -.10303E+02   .12565E+01  -.18774E+01   .98152E-02
    .00  1.00   .00    CHI-STRAINS   .15460E-02   .95190E-04   .15493E-02
   -.27   .00   .96    COUPLES       .97327E+00   .34553E+00   .33519E+00
2  1   10.266     2.642     3.643
   DIRECTION COSINES   EPS-STRAINS  -.27335E-04  -.57746E-04   .21170E-03  -.48758E-04   .96038E-05
    .91   .00   .41    RESULTANTS   -.53001E+01  -.78266E+01   .87935E+01  -.16878E+01   .33244E+00
    .00  1.00   .00    CHI-STRAINS   .20224E-03  -.26199E-04   .38831E-02
   -.41   .00   .91    COUPLES       .12015E+00   .21309E-01   .84009E+00
2  1   10.266     9.858     3.643
   DIRECTION COSINES   EPS-STRAINS   .32089E-04  -.10084E-03   .15293E-03   .24938E-04   .66167E-05
    .91   .00   .41    RESULTANTS    .21806E+00  -.10825E+02   .63525E+01   .86322E+00   .22904E+00
    .00  1.00   .00    CHI-STRAINS   .71212E-03  -.45716E-03   .31917E-02
   -.41   .00   .91    COUPLES       .35541E+00  -.15053E+00   .69052E+00
2  1   14.607     2.642     1.137
   DIRECTION COSINES   EPS-STRAINS   .27880E-04   .60498E-04   .15044E-03   .12329E-04  -.10001E-04
    .81   .00   .58    RESULTANTS    .54629E+01   .81727E+01   .62490E+01   .42678E+00  -.34620E+00
    .00  1.00   .00    CHI-STRAINS   .69888E-04   .31336E-04   .38701E-02
   -.58   .00   .81    COUPLES       .49011E-01   .32330E-01   .83728E+00
2  1   14.607     9.858     1.137
   DIRECTION COSINES   EPS-STRAINS  -.10404E-03   .22075E-03   .10568E-03  -.97113E-05  -.12392E-04
    .81   .00   .58    RESULTANTS   -.44878E+01   .22495E+02   .43899E+01  -.33616E+00  -.42895E+00
    .00  1.00   .00    CHI-STRAINS   .20520E-03  -.97865E-03   .32403E-02
   -.58   .00   .81    COUPLES      -.54642E-01  -.56688E+00   .70103E+00
3  1    1.851    15.142     5.780
   DIRECTION COSINES   EPS-STRAINS  -.24290E-04  -.18919E-04  -.49523E-04  -.48274E-04  -.29860E-05
   1.00   .00   .07    RESULTANTS   -.35564E+01  -.31102E+01  -.20571E+01  -.16710E+01  -.10336E+00
    .00  1.00   .00    CHI-STRAINS   .28984E-02  -.32487E-04   .10167E-02
   -.07   .00  1.00    COUPLES       .17856E+01   .51740E+00   .21996E+00
3  1    1.851    22.358     5.780
   DIRECTION COSINES   EPS-STRAINS  -.21531E-04  -.22712E-04   .60376E-04   .11394E-04   .82785E-05
   1.00   .00   .07    RESULTANTS   -.33640E+01  -.34621E+01   .25079E+01   .39440E+00   .28656E+00
    .00  1.00   .00    CHI-STRAINS   .34940E-02   .18023E-03   .33909E-03
   -.07   .00  1.00    COUPLES       .21932E+01   .75933E+00   .73361E-01
3  1    6.788    15.142     4.909
   DIRECTION COSINES   EPS-STRAINS   .15862E-04  -.82199E-04   .67461E-04   .25954E-04  -.65915E-05
    .96   .00   .27    RESULTANTS   -.10441E+01  -.91908E+01   .28022E+01   .89840E+00  -.22817E+00
    .00  1.00   .00    CHI-STRAINS   .21659E-02  -.22243E-03   .98960E-03
   -.27   .00   .96    COUPLES       .12975E+01   .26415E+00   .21410E+00
3  1    6.788    22.358     4.909
   DIRECTION COSINES   EPS-STRAINS   .35289E-05  -.10902E-03  -.17593E-04  -.15996E-04   .43879E-05
    .96   .00   .27    RESULTANTS   -.34627E+01  -.12813E+02  -.73077E+00  -.55369E+00   .15189E+00
    .00  1.00   .00    CHI-STRAINS   .25845E-02  -.11521E-03   .35982E-03
   -.27   .00   .96    COUPLES       .15762E+01   .40806E+00   .77845E-01
4  1   10.266    15.142     3.643
   DIRECTION COSINES   EPS-STRAINS   .19204E-04  -.16222E-03   .84526E-04  -.26195E-04   .68515E-05
    .91   .00   .41    RESULTANTS   -.34967E+01  -.18569E+02   .35111E+01  -.90675E+00   .23717E+00
    .00  1.00   .00    CHI-STRAINS   .94875E-03  -.34856E-03   .19859E-02
   -.41   .00   .91    COUPLES       .52182E+00  -.39522E-01   .42965E+00
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4  1     10.266     22.358      3.643
     DIRECTION COSINES      EPS-STRAINS     .41364E-04    -.17433E-03     .50842E-04    -.35876E-05    -.14076E-05
       .91   .00   .41      RESULTANTS     -.12978E+01    -.19217E+02     .21119E+01    -.12419E+00    -.48723E-01
       .00  1.00   .00      CHI-STRAINS     .10385E-02    -.54162E-03     .58893E-03
      -.41   .00   .91      COUPLES         .54149E+00    -.14222E+00     .12741E+00
4  1     14.607     15.142      1.137
     DIRECTION COSINES      EPS-STRAINS    -.66275E-04     .27999E-03     .56665E-04     .28783E-05    -.57496E-06
       .81   .00   .58      RESULTANTS      .21033E+01     .30870E+02     .23538E+01     .99634E-01    -.19902E-01
       .00  1.00   .00      CHI-STRAINS     .24908E-03    -.85300E-03     .19604E-02
      -.58   .00   .81      COUPLES        -.42134E-02    -.48108E+00     .42412E+00
4  1     14.607     22.358      1.137
     DIRECTION COSINES      EPS-STRAINS    -.10680E-03     .33109E-03     .12219E-04    -.27961E-05    -.67154E-05
       .81   .00   .58      RESULTANTS     -.88646E+00     .35492E+02     .50757E+00    -.96787E-01    -.23246E+00
       .00  1.00   .00      CHI-STRAINS     .17191E-03    -.10368E-02     .51617E-03
      -.58   .00   .81      COUPLES        -.86005E-01    -.60902E+00     .11167E+00
                                        ENDING   TIME (SEC.)))))     1274.

*********** NORMAL EXIT FROM MAIN PROGRAM *********
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ประวัติ

นายอรรณพล แสงธีรกิจ เกิดเมื่อวันที่ 10 ตุลาคม พ.ศ. 2503 ที่กรุงเทพมหานคร สำเร็จการศึกษาชั้นมัธยมศึกษาตอนปลาย (ม.ศ. 5) จากโรงเรียนเตรียมอุดมศึกษา ในเดือนมีนาคม พ.ศ. 2522 สำเร็จการศึกษาวิศวกรรมศาสตร์บัณฑิตสาขาวิศวกรรมโยธาจากจุฬาลงกรณ์มหาวิทยาลัย ในเดือนเมษายน พ.ศ. 2526 ทำงานครั้งแรกด้านการออกแบบโครงสร้าง กับ บ. นันทวันจำกัด และได้ทำงานทางด้านวิศวกรที่ปรึกษาและออกแบบโครงสร้างกับอีกหลายบริษัท ได้แก่ บ. เมโทรโปลิแตนท์ เอ็นจิเนียริงก์ คอนซัลแตนท์ จำกัด, บ. เฟอร์คอนดีเวลล็อปเมนท์ จำกัด, บ. อรุณ ชัยเสรี คอนซัลติงก์ เอ็นจิเนียร์ จำกัด ต่อมาเป็นวิศวกร บ. ผลิตภัณฑ์และวัตถุก่อสร้างจำกัด